

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
	3	0	0	0	0	Supplementary comment related to the very first comment above (p. 4, lines 1-9). There is a thorough review about carbon in this chapter, but no mention to the nitrogen cycle, which is also important in global climate interactions (via N2O emissions). Is the absence of this topic related to the lack of supportive evidence, or it was an editorial choice when drafting the outline? [APECS Group Review, Germany]	Taken into account: there are a number of scientific areas that could not be assessed in this chapter, due to both considerations relating to the volume of literature available, editorial decisions concerning how best to use the limited page space available, and also guidance from the report/chapter scoping.
18755	3	0	0	0	0	Annex 1 - Glossary. ALBEDO. I would add 'clear surfaces' (as clouds, snow and ice) and 'dark surfaces' (as vegetation and ocean surface). Otherwise we don't really make the link between surface properties and reflected radiation. [APECS Group Review, Germany]	Taken into account. Glossary entries are formulated by IPCC TSU.
18757	3	0	0	0	0	Annex 1 - Glossary. FROZEN GROUND. I would add a mention ('see also') to the definition of PERMAFROST (p. 22). [APECS Group Review, Germany]	Taken into account. Glossary entries are formulated by IPCC TSU.
18771	3	0	0	0	0	<p>The original outline mentioned ~50 pages and the chapter is now more than 100 pages excluding the references and appendix. However, a few points mentioned in the outline are somewhat underrepresented. There is for example almost nothing about changes in the atmospheric and ocean circulation and the paleo perspective, raised under this same bullet point, does also not become clear and could be more substantial. The section title of Terrestrial cryosphere (in section 3.4) is a bit ambiguous, because it would potentially also include polar glaciers and ice sheets which already form part of section 3.3. Importance of indigenous knowledge and indigenous experiences on the other hand, has been embedded in the chapter quite convincingly, but is perhaps not so prominent in the outline.</p> <p>Some concerns were raised about structuring and consistency. Though various sections in the report address human dimension, they weren't addressed systematically throughout the report or in the same way (e.g. 3.2.4 Impacts on Social-Ecological System vs. 3.4.3 Consequences and Impacts vs. 3.5 Human Responses) and should be better integrated as there is significant overlap. In addition to the current IPCC outline, a reminder of different socio-economic and human dimension (e.g. subsistence, shipping, fishing), and a reminder of the different regions (e.g. Arctic (and various countries), Antarctic) would help the structure.</p> <p>In some of the language throughout the report (e.g. section 3.5.3, 3.5.3.4 vs 3.5.3.5) assumed to be in the Arctic context but the differentiations between Arctic and Antarctic are not clear. General references of human responses to climate change are made (e.g. table on p.3-91), but some are only relevant in either Arctic or Antarctic context. The text sometimes makes assumptions that readers will know this is Arctic only context, but other times explicitly points out that it is Arctic only: it would be helpful to have greater consistency throughout the chapter. With concern to lawmakers it also makes it confusing to have to keep re-adjusting understanding of how processes operate in global vs region-specific context. [APECS Group Review, Germany]</p>	Taken into account. It is important to note that the page limit within which we are operating is in final IPCC formatted pages, not draft pages. However, the chapter was still too lengthy by that metric, and we have worked to condense to the appropriate level. The palaeo perspective has been strengthened throughout, in particular by entraining a new CA to embed appropriate material (Dr Nerilie Abram). We have clarified the text in the necessary places concerning the distinction between Arctic and Antarctic material, and have included an extra figure showing the demarcation of these areas.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

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18773	3	0	0	0	0	We found that the differences between the two polar regions (the Arctic vs. the Antarctic) were strongly highlighted throughout the chapter, contrasting changes in the two regions and steps for mitigation. Sections examining changes in the carbon cycle in the terrestrial cryosphere dominantly focused on changes in the organic portion of the carbon cycle (e.g. release of organic carbon stores) and could include more research on the inorganic portion of the carbon cycle (e.g. exposure of minerals to weathering or increasing groundwater contributions and its impact on inorganic carbon dynamics). It was difficult to develop a synthetic view of the changes in the carbon cycle since it was referred to in many sections with little or no cross references to the other section. It would help to show a diagram of the carbon cycle in the arctic that could be referenced to see how changes in different areas (e.g. ground ice, freshwater) can impact the whole. Similarly, there was a lot of overlap in the content between Chapter 5 and Chapter 3 and it would be good to ensure there is adequate cross-referencing between the topics when discussing overlapping topics, and that overlapping material is covered in different ways. For example: Chapter 3 provides a more geographic focus on socio-ecological aspects of the polar regions while Chapter 5 provides a more thematic focus. So if an overlapping topic is touched on in a geographic context in Chapter 3, it would be good to make sure it is cross-referenced to a more in-depth view in Chapter 5, rather than simply repeated in Chapter 5. [APECS Group Review, Germany]	Taken into account. Under the approach adopted, material on e.g. carbon does indeed feature in many places throughout the chapter; space precludes including an extra section synthesising those elements, however we have included better cross-referencing (both within chapter and to other chapters) to help the reader garner the full assessment.
18775	3	0	0	0	0	In section 3.5, the writing style changed and less references were used. However, we acknowledge that this could be due to a change from topics in the natural sciences to socio-ecological topics. We do think that the tone and terminology need to be more consistent in reference to the polar regions/socio-ecological topics throughout the chapter. These changes dominantly occur in section 3.5, but are present throughout Chapter 3. One example is the language in Section 3.2.4.2, such as “vanishing landscapes” appears to clash acknowledgement of indigenous presence on the landscape elsewhere in the chapter. Another example is Table 3.7 that sometimes highlights responses only relevant to the Arctic and doesn’t explicitly differentiate between the Arctic and Antarctic. [APECS Group Review, Germany]	Taken into account. We made language and use of terms more consistent across the chapter. Some differences remain because of disciplinary differences of the language and style in the underlying disciplinary material

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

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18777	3	0	0	0	0	We generally found the chapter enjoyable and a positive experience to read and review, especially in context of the interdisciplinary nature of the polar regions and the collaborative research between the social and natural sciences. As this report is designed to be read by non-experts, we agreed that further clarification could be enhanced for important concepts and abbreviations, making the overall chapter more self-understandable by experts and non-experts alike. The addition of 'cross-chapter boxes' greatly strengthened the utility of the report by providing additional references, figures, and highlighting key concepts in further detail and importance. We are concerned about the consistency of tone and language throughout the chapter, especially in regards to the social sciences sections (e.g., 3.1, 3.5, and 3.6), where specific word choice may be insensitive to the community/research of discussion (e.g., "legitimacy" and "abandonment" are strongly loaded terms questioning the validity of scientific merit). In regards to tone, much of the information provided in Section 3.5 is written in depth, but does not consistently match the material and literature provided in Sections 3.1 and 3.6. The information provided in these specific three sections could be better cross-referenced to prevent redundant overlap. Section 3.5 also uses fewer confidence levels throughout the discussion, but this may be inherently tied to the nature of the research undertaken. [APECS Group Review, Germany]	Taken into account. We made language and use of terms more consistent across the chapter. Cross-referencing between sections was also strengthened and redundant text was cut. Some differences in style remain because of disciplinary differences of the language in the underlying disciplinary material.
27509	3	0	0	0	0	I would like to suggest that a paper I am coauthor on (Mottram et al., in revision/submitted) may be useful to this chapter as it provides an overview of a range of remote sensing data produced by the ESA CCI for the Greenland ice sheet including altimetry, ice velocity, outlet glacier retreat and GRACE data as well as some analysis of both modelled ice dynamics and SMB. The article has been through one set of reviews already and will hopefully be accepted before the spring deadline. Authors are: Ruth Mottram, Sebastian B. Simonsen, Synne Høyer Svendsen, Valentina R. Barletta, Louise Sandberg Sørensen, Thomas Nagler, Jan Wuite, Andreas Groh, Martin Horwarth, Job Rosier and Rene Forsberg Title: An Integrated View of Greenland Ice Sheet Mass Changes Based on Models and Satellite Observations. Available from: https://www.researchgate.net/publication/328358798_An_Integrated_View_of_Greenland_Ice_Sheet_Mass_Changes_Based_on_Models_and_Satellite_Observations [accessed Jan 11 2019]. [Ruth Mottram, Denmark]	Not published before deadline.
29191	3	0	0	0	0	Chapters 3 and 5 should be looked at carefully to ensure consistency (e.g. Chapter 5 and overall Exec Summary highlights SO as a region showing the largest oxygen change, but SO oxygen change is not mentioned in Ch 3). [Stephen Rintoul, Australia]	Accepted; we have increased cross-referencing with the relevant elements of chapter 5. Some of these (e.g. dissolved oxygen) naturally sit better in one chapter in their entirety, based on volume of material available. Others have presence in both chapters, but are written to avoid duplication and cross-referenced to help the reader. The cross-chapter box on Southern Ocean circulation unified material on this aspect between Chapter 3 and 5.
29201	3	0	0	0	0	It would be useful to have a very careful look at the use of the uncertainty language, throughout the chapter. In some cases, uncertainty language is associated with statements of fact (e.g. p 23, line 17: "direct observational evidence is difficult to obtain (low confidence)", or the statement of level of certainty is in the wrong place in the sentence. [Stephen Rintoul, Australia]	Accepted; we have re-examined the confidence language used, and altered where warranted.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
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714	3	0	0	0		Because of the memories of ocean and cryosphere, some slow processes, e.g., deep ocean warming, can be very important on timescales longer than a century or the timespan of most CMIP5 experiments. I think these processes can be more highlighted in this chapter by including longer CMIP5 experiments extending to 2300 or more paleoclimate findings. [Mengxi Wu, United States of America]	Accepted. We have strengthened the palaeo aspects of the chapter, by including a new CA (Dr. Nerilie Abram) who has embedded relevant material in the appropriate places to provide a longer time-horizon perspective.
1037	3	0	0	0		The report is clearly written, presents the evidence appropriately, and appropriately evaluates the degree of certainty for the statements it makes. This is a very strong effort and a great contribution to the field. Having a definitive summary of climate change and the polar regions, in one place, is extremely valuable. I have only a few minor comments below. Thank you to all the authors for their hard work and commitment to the assessment process. [Henry Huntington, United States of America]	Noted, with thanks.
2431	3	0	0	0		It is surprising that this chapter avoids the pre-industrial climate history which is well known for the polar regions for the late Holocene and Holocene. Why are key papers such as Stenni et al. 2017 (doi: 10.5194/cp-13-1609-2017) not mentioned? Those authors have presented Antarctic climate variability for the past 2000 years but are being fully ignored in this chapter on polar regions? How can this be? The same is true for Greenland for which e.g. Kobashi et al. 2011, 2013a, 2013b have published temperature histories of the past 4000 years (doi:10.1029/2011GL049444; doi:10.5194/cp-9-583-2013; doi:10.5194/cp-9-2299-2013). One would think that this is key material for climate context to compare modern trends against. But again, any mention of the pre-industrial climate history is missing in this chapter. This weakens the chapter significantly. This is like building a house on weak foundations, which will eventually collapse because of this. I strongly recommend to chapter authors to add a thoroughly compiled section on pre-industrial climate change in polar regions in order to rectify this major deficiency. If authors decide against this, please justify the decision in detail, keeping in mind that review protocols and chapter author replies will eventually be published shortly after the report itself. [Sebastian Luening, Portugal]	Accepted. The long-period palaeo perspective of changes in the polar regions has been strengthened in the chapter, in particular by the inclusion of a new CA (Dr. Nerilie Abram) who has embedded the relevant material in the appropriate places. We considered a stand-alone chapter box on palaeo aspects, but concluded that the material would sit better directly alongside the corresponding material on contemporary change, so that the long-term context of such changes could be best appreciated.
11003	3	0	0	0		Consider including content about the expected changes in microbial diversity within Polar ecosystems. [Karen Cameron, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account. We agree that microbial loops are an important aspect of polar ecosystems but space did not allow us to fully discuss all ecosystem components. Reference to predicted impacts of ocean acidification on microbial communities has been clarified in
11887	3	0	0	0		There is no mention of microbial community (including protists and bacteria) in this chapter. Microbes are the main drivers of biogeochemical cycles and the major producers and consumers of carbon dioxide and other greenhouse gases. Since the changes in the	Taken into account. We agree that microbial loops are an important aspect of polar ecosystems but space did not allow us to fully discuss all ecosystem components. Reference to predicted impacts
11889	3	0	0	0		Please express the word "in situ" in the text in a uniform style. For example, some are expressed in italic style, some has dash bar. Check whether it is italic or not. [Jun Sun, China]	Editorial - copyedit to be completed prior to publication
16283	3	0	0	0		Congratulations to the Chapter authors on an impressive SOD, their very hard work is much appreciated! The figures, in particular the overview schematics, are very nicely put together. Also, the consequent and clear AR5 departure point for the Chapter assessment is very helpful. Overall, provided comments are mostly minor. [Alexander Nauels, Germany]	Noted with thanks

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
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16285	3	0	0	0		The ES reads very well. While the headings help to structure the content, it is worth discussing if a consistent ES format adopted across Chapters should be prioritised. This also holds for the synthesis section that is very useful in itself but could/should be moved (to Introduction)? [Alexander Nauels, Germany]	Accepted. The CH3 ES has been restructured - along with those of the other SROCC chapters- to correspond to the structure of the SPM. The syntesis section has been removed.
17707	3	0	0	0		I found the chapter well written, easy to follow and I far as my knowledge goes, very complete [Eva Cougnon, Australia]	Noted with thanks
18759	3	0	0	0		Section 3.4.3.3 Impacts on Social-Ecological Systems and Section 3.5 Human Responses should be better integrated as there is significant overlap [APECS Group Review, Germany]	Taken into account: these sections have been revised to reduce overlap
18761	3	0	0	0		General coment for subsection 3.5 >> The overall structure of chapter 3 should be more systematic between subsections - in particular with respect to considerations of "impacts on socio-ecological systems". For example, within Subsection 3.2 there is 3.2.4 "Impacts on Socio-Ecological Systems" while Subsection 3.4 there is 3.4.3 "Consequences and Impacts". The development and structure leading to the "human dimension" should be harmonized between subsections of the Chapter. Furthermore, Subsection 3.5 which bears an expliit societal focus should clearly and directly respond to the socio-ecoloigcal impacts highlighted in each of the subsections. These need to be better harmonized and integrated. [APECS Group Review, Germany]	Taken into account; these sections have been integrated better. Section 3.5 was connected better to the impacts section in 3.2 and 3.4
18763	3	0	0	0		General coment for subsection 3.5 >> entire subsection would benefit from thorough and careful review by anthropological/social scientist to pick up on cultural nuances and sensitivities of how some of the text is currently phrased. [APECS Group Review, Germany]	Taken into account. 3.5 has been further refined with care. Care is taken to refelct cultural nuances, howeve, Section 3.5 handles many more dimension than social science (e.g. international governance) and this is reflected in some of teh subsections.
18765	3	0	0	0		General comment. The use of "-" between "sea" and "ice" is not consistent or is misused in many places in the part of the chapter I reviewed. Please, check throught the chapter/report that there is consistency in the use of it, i.e., only when it works as an adjective. [APECS Group Review, Germany]	Editorial - copyedit to be completed before publication
18767	3	0	0	0		General comment on Sect 3.2.3: This section should be more linked to previous sections in some points (see my further specific comments) and I believe it should be also linked to Chapter 5. At least in this section there is no reference to it. [APECS Group Review, Germany]	Accepted. Links to previous sections were added
18769	3	0	0	0		General comment on Sect 3.2.3: I believe this chapter lacks a proper presentation and description of the sympagic system in light of the importance we nowadays know that it has. See my further specific comments/suggestions. [APECS Group Review, Germany]	Accepted. Text on especially ice algae has been included in our section in 3.2.3 on primary production and plankton.
21649	3	0	0	0		Robust evidences of human impacts (anthropogenic) on Polar regions are not highlighted properly. Possibly the lead authors feel that it is more appropriate to 'Climate Change' rather than 'Change in Cryospheric Environment' itself? [Government of Republic of Korea, Republic of Korea]	Unclear what is being suggested. While there are many impacts from anthropogenic activities, SROCC Ch 3 is assessing climate change impacts and risks on and from cryosphere and ocean change in the polar regions. Where these impacts interact with those from human activities in the regions we clearly say so; in fact the structure of the chapter assessing climate change impacts on (human use and activity) sectors, or social-ecological systems, was deliberately set up to enable assessment of combined and/or cascading impacts and responses.

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23333	3	0	0	0		I congratulate the authors for the second order draft. I have provided comments to the SPM that are relevant for executive summaries of all chapters. The use of the IPCC calibrated language is still missing in the expression of key findings at the end of sections; I urge chapter 3 to have a more systematic presentation in each section / subsection of what is new since AR5 and what are the key findings at the end ("In summary, ... with systematic use of the confidence language"). Several figures of chapter 3 which introduce the processes or mechanisms at play are more designed in a text book style than in an assessment style. Consider providing more information such as characteristic time scales, level of scientific understanding, within these figures. [Valerie Masson-Delmotte, France]	1. taken into account - we refined the traceable account, including the use of assessment language across the chapter; however, we not always place the statement at the end of paragraphs; this is also the case for included references to AR5. 3. Taken into account: We have included assessment aspects in several figures and tables
23339	3	0	0	0		Each section needs to provide a conclusion (in summary...), using confidence language, used in the ES. This is missing repeatedly in several sections (e.g. 3.2; 3.3). [Valerie Masson-Delmotte, France]	Taken into account - see 23333
23341	3	0	0	0		Some elements on recent updated estimates of ocean heat uptake, carbon sink from the polar oceans should be conveyed in the ES (eg pages 17, page 19) as they have global relevance. [Valerie Masson-Delmotte, France]	Accepted; quantitative information for Southern Ocean heat uptake now included in the ES. Material on carbon uptake has been strengthened, including CMIP5 projections.
23347	3	0	0	0		What is the outcome of the assessment in terms of acceleration of ice sheet mass loss? This could be explicitly assessed and reported. [Valerie Masson-Delmotte, France]	Changes in mass loss reported in chapter and ES, though not formally defined as acceleration (which has specific statistical requirements).
23355	3	0	0	0		Several sections in 3.5 have detailed lists of items but miss a summary statement expressing the outcome of the assessment. [Valerie Masson-Delmotte, France]	Accepted. this has been improved across 3.5 and also further summarised for 3.5.4 as a table
24013	3	0	0	0		Robust evidences of human impacts (anthropogenic) on Polar regions are not highlighted properly. Possibly the lead authors feel that it is more appropriate to 'Climate Change' rather than 'Change in Cryospheric Environment' itself? [WON SANG LEE, Republic of Korea]	see response to 21649
25079	3	0	0	0		The precipitation and temperature changes in the Arctic area and high-latitudes will have marked impact on e.g. transport and water resources (including hydropower) over the land areas. Perhaps discussion on these topics could be enlarged, however, keeping in mind the large uncertainties related especially to the scenarios of precipitation changes. [Government of Finland, Finland]	Taken into account: As noted in this comment, there are major uncertainties in historical precipitation observations and future projections for the Arctic. This is discussed in Sections 3.4.1.1.3 and 3.4.2.3.
27193	3	0	0	0		How have polar air-sea-ice heat fluxes changed in response to sea ice reductions (Taylor et al., 2018)? This significant topic doesn't appear to have been assessed. In particular, Fig. 3.2. has an arrow for changing ice-albedo feedback but doesn't recognise the major release of heat by the ocean to the atmosphere that has occurred following ice retreat due to new exposure of open water. Taylor, B.M. Hegyi, R.C. Boeke, L.N. Boisvert, 2018 : On the increasing importance of air-sea exchanges in a thawing Arctic: a review, Atmosphere, 9 (2018), pp. 1-39, 10.3390/atmos9020041 [Sion Josey, United Kingdom (of Great Britain and Northern Ireland)]	Accepted: Figure 3.2 is revised; citation added and importance of sensible and latent heat fluxes is noted in Section 3.2.1.1.1.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

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27215	3	0	0	0		The statements of the expected changes can be stronger and should be streamlined [Christian Bock, Germany]	This statement (without page and line reference) is not providing sufficient information to formulate a response. If it is about Executive Summary statement on projections: Taken into account. we have strengthened both material and ES statements on projections.
27217	3	0	0	0		The physical-oceanographical-glaciological parts are more detailed and can be further streamlined in comparison to the biological text [Christian Bock, Germany]	Taken into account. We have edited the chapter to limit the presented information to what is needed for making all important assessment statements linked to impacts, risk and responses
27219	3	0	0	0		Try to avoid overlong sentences [Christian Bock, Germany]	Accepted and actioned.
27563	3	0	0	0		Would it be good to make reference to the SR1.5 findings that were specifically relevant to polar regions early on in chapter 3, for instance in the introduction? Many readers will remember SR 1,5 statements on the impacts and risks to natural, managed and human system in the Arctic, impacts on sea ice etc, and may find it helpful to see it referenced early on. [Government of Norway, Norway]	Taken into account; we have flagged the important SR1.5 findings early in the chapter in the appropriate places. We do not wish to include overtly in the Introduction, which is more about the concept/remit for the chapter, but we have mentioned at the start of each relevant section.
27569	3	0	0	0		In general, the executive summary of chapter 3 could be much more to the point, with concrete numbers and quantifications on the observed changes and what different mitigation scenarios would mean for these changes and their impacts. The fact that the Arctic will have a distinctly different environment by mid-century is not coming through, neither how different mitigation scenarios will shape the future Arctic throughout the second half of the 21st century. The statement on page 9, line 14-15, says that stabilizing global temperature rise near 2C could slow, but not halt further change -- this is an important message, together with information on which parts of the chryosphere and oceans that are expected to continue changing, and which that could stabilize. [Government of Norway, Norway]	Accepted; we have greatly revised the ES to make it more concrete and quantitative. Various aspects of the points raised have been adopted by so doing.
29645	3	0	0	0		It seems to me that the chapter simply has to have a box that explains how large cryospheric change has occurred in the past, making very clear how large the changes can be, from having the equivalent of almost a present Antarctic ice sheet located on North America 20,000 years ago and also almost the same amount piled on Eurasia--so a total of roughly 120 m of sea level equivalent. And these amounts melted away as the global average temperature rose about 6 C from 20ka to 8ka when the CO2 concentration was less than 300 ppm and so there was considerably less back IR radiation than will be the case in the future. It should also be pointed out that if one goes back a few tens of millions of years, there was no Greenland ice sheet and the one in the Antarctic was quite small, and that is the equivalent of about 70 meters of SL rise. There is a very mistaken view that these ice sheets are vast and mostly stable and unchangeable, and this is simply not consistent with Earth's climate history. A box like this is needed to set the stage for the chapter and not just focus on recent changes, totaling avoiding the issue of what the expected change in the equilibrium would be. Also, Earth's climate history makes clear that ice sheets decay far faster than they build up (consistent with the documentary "Chasing Ice") and that once started, it is very hard to stop. Yes, the cooling rebounded a bit in the Younger Dryas, but no way did the ice mass get back to what would seem to have been the equilibrium value--just not a sufficiently long period for build up. I don't get any sense that paleoclimatic lessons have been reflected in the analyses here, or at least the long-term implications for society of the changes that have started. Inserting a box on this would greatly help public understanding. [Michael MacCracken, United States of America]	Taken into account. We considered creating a standalone palaeo box, and drafted some material to this effect. However, we found that that material was then quite disconnected within the chapter from the other material that it related to (in terms of context, drivers, contemporary changes and projections), and this lessened the impact overall. We thus opted instead to strengthen the palaeo material throughout the chapter (in particular by entraining a new CA with a strong palaeo background; Dr Nerilie Abram), but to have that material inserted at the places where it could complement the existing material most strongly.

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29681	3	0	0	0		It seems to me this chapter needs to have some geography-defining maps for both polar regions, with labels mentioning all of the locations that are mentioned. Not all readers will be familiar with what is where, and how close, etc. [Michael MacCracken, United States of America]	Accepted; we have included such a map in the revised version
29707	3	0	0	0		I may have missed it, but I did not see any discussion of the various suggestions, many perhaps naïve but some serious, for undertaking climate intervention in the Arctic as an approach to slowing the changes that are occurring. My personal views on this are include in a paper (MacCracken, M.C., 2016: The rationale for accelerating regionally focused climate intervention research, Earth's Future 4, 649-657, doi:10.1002/2016EF000450). Yes, unless global action, regional efforts will ultimately be fruitless, but the Arctic may well be a place to start the climate intervention needed so the increase in global average temperature really can be kept to less than 1.5 C and, better yet, returned to less than 0.5 C, for unless this is done, the Arctic as we know it will surely be gone, and I think a good bit faster than has yet to be scientifically proven at this point. The IPCC 1.5 report rather summarily dismissed the whole idea and is proposing to rely on society going to zero emissions within the next couple of decades to save the world--both unrealistic and unlikely to meet the UNFCCC objective. I'd urge the Arctic community, which is already experiencing very dramatic changes to look more broadly at possibilities. [Michael MacCracken, United States of America]	Taken into account. We have included a short reference to such discussions in 3.5, with key references. SROCC's mandate is not on mitigation measures (including SRM) so we have approached this point through the lens of restoration and sea ice management. We made explicit that the field is not mature enough for assessing it in our chapter.
30237	3	0	0	0		This chapter would benefit from a map showing what you count as 'Polar'. There are various sections where I become confused because they are implied polar but looking at the references, they refer more to sub-Arctic regions. For example, there is some work around the Kluane Yukon Area and in southern Alaska that counts (only just) as Arctic for funding purposes but is not 'Polar' by normal definition (e.g. Myers-Smith and Hik (2013)). Similarly, Alaska and the Yukon are mentioned in Line 37, P71. I would have thought the work in those regions would be more suited for the High Mountain Areas chapter. [Christine Dow, Canada]	Accepted. There is, of course, no single definition for such things that all parties find acceptable or appropriate, thus we adopt a purposefully flexible approach. Nonetheless, we have included a map figure in the revised version to help the reader, as suggested.
30907	3	0	0	0		Whenever you refer to "AR5" and specific sections within, please specify which Working Group report (WGI AR5, WGII AR5, WGIII AR5, SPM, ...) you refer and provide appropriate citation. [Hans-Otto Poertner and WGII TSU, Germany]	Accepted; we have actioned this wherever possible
30953	3	0	0	0		Highlight what is new since AR5 and SR15! [Hans-Otto Poertner and WGII TSU, Germany]	Accepted; this has been made explicit where possible
31017	3	0	0	0		Make sure confidence statements are given for key findings, and that traceability back to the literature is given. [Hans-Otto Poertner and WGII TSU, Germany]	Accepted and actioned
31019	3	0	0	0		Provide quantitative information (how much, how many, by when, etc) wherever possible. [Hans-Otto Poertner and WGII TSU, Germany]	Accepted and actioned
31021	3	0	0	0		Acronyms: there are many redundant acronyms in this chapter. Please carefully check which acronyms are really necessary and where full term can be provided only. The use of acronyms vs full terms should be consistent throughout sections/chapter (at the moment this is quite random). [Hans-Otto Poertner and WGII TSU, Germany]	Accepted; we have reduced the number of acronyms substantially
31023	3	0	0	0		This chapter developed well compared to the First Order Draft and improved a lot in terms of structure, clarity, and balance of content. Congratulation to the author team. [Hans-Otto Poertner and WGII TSU, Germany]	Noted, with thanks

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
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10153	3	0	0	0		Chapter 6-3, line 33 says The largest changes in the frequency of MHWs are projected for the Arctic Ocean and the western tropical Pacific (medium confidence). Yet the polar regions chapter doesn't mention MHWs. [Lisa Speer, United States of America]	Noted. An editorial decision was made to include detailed material on MHWs in other chapters, rather than Chapter 3, so as to enable a more focussed assessment.
27803	3	0	0	0		Thanks to the authors for doing a great job at addressing most of my earlier comments. It is really good to see how this draft has evolved since FOD. [Dirk Notz, Germany]	Noted, with thanks
949	3	0	0	0		I think the definition of Polar regions is unrepresentative and overvalued for the Arctic; The 3rd pole (Hindu Kush Himalaya) and the permafrost regions of the world are also missing [Falk Huettmann, United States of America]	We are unclear of what is being proposed. The chapter's given scope was to assess cryosphere and ocean in both polar regions - we explain how and why we delieate the domains on teh basis of relevant science. SROCC Chapter 2 asseses high mountain regions, including in Asia.
955	3	0	0	0		Huettmann and Schmid (2014) Biodiversity Climate Predictions in: Antarctic Biogeography Atlas [Falk Huettmann, United States of America]	see response to 949
2325	3	0	0	0		Bjerke, J. et al., 2017 [Scott Goetz, United States of America]	Rejected; the context of this comment is not clear, and it cannot be actioned
2761	3	0	0	0		The Chapter 3 lacks a careful consideration and sufficient referencing of existing key publications on geomorphological effects of changes in the cryosphere. How does projected changes of the cryosphere affects geomorphological Earth surface processes: surface stability and denudation; and connected to this fluvial transport of nutrients, solutes and sediments? How does denudational processes - and accelerated/increased denudation - affect the cryosphere and ongoing changes of the cryosphere? In my eyes, Chapter 2 has considered these aspects quite well; but Chapter 3 would need some additions addressing these important issues. [Achim A. Beylich, Norway]	Rejected: these topics are out of scope for chapter 3. Landscape impacts of permafrost change are captured in Section 3.4.1.2 and 3.4.3.2.
3049	3	0	0	0		The chapter in general seemd much improved from the FOD. Well done to the CLAs and LAs. One comment would be that I found the choice of confidence levels in the text not always transparent particularly around low and medium confidence and wonder if these could be tightened up? Eg, in some cases a single study is given low confidence (or no confidence statement) and sometimes given medium confidence. [Helene Hewitt, United Kingdom (of Great Britain and Northern Ireland)]	Accepted; we have clarified the selection of confidence statements. Sometimes material cited can contain multiple lines of evidence, and the agreement/weight of that evidence dictates confidence. In other circumstances, papers develop material presented in AR5/SR1.5, and whilst we cite only the new papers since then (along with the previous IPCC report(s)), it is the cumulative weight/agreement that dictates confidence. Text has been revised in various places to clarify.
3079	3	0	0	0		As commented in detail elsewhere, I think in some of the sections describing observed and modelled changes in sea ice and oceans, it might be good to construct a table so that the observed and projected changes can be seen easily along with confidence levels [Helene Hewitt, United Kingdom (of Great Britain and Northern Ireland)]	Accepted. We have included a table relating to Southern Ocean heat content in the revised version, it being a key climate-relevant property.
5015	3	0	0	0		There are only three references to the East Africa mountain region even though it is highligted as one of the regions covered in the report in Fig 2,2, [Debra Roberts and Durban Team, South Africa]	Misplaced comment.
11335	3	0	0	0		The sections within my area of expertise are well done and complete to the extent of my knowledge. I have indicated only two additional references to be considered for inclusion (listed below). [Torsten Geldsetzer, Canada]	Noted, with thanks for the positive input

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
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17021	3	0	0	0		Some concern remain about the bias this chapter shows in certain sections towards self citations with a strong geographical bias. However, it seems improved in the second draft without this reviewer having had the time to go through it in detail. [Torben R. Christensen, Sweden]	Noted; we have carefully scrutinised references chosen to ensure that they are the most germane to the assessment being undertaken.
23099	3	0	0	0		I congratulate the authors for the second order draft. I have provided comments to the SPM that are relevant for executive summaries of all chapters. The use of the IPCC calibrated language is still missing in the expression of key findings at the end of sections; I urge chapter 3 to have a more systematic presentation in each section / subsection of what is new since AR5 and what are the key findings at the end ("In summary, ... with systematic use of the confidence language"). Several figures of chapter 3 which introduce the processes or mechanisms at play are more designed in a text book style than in an assessment style. Consider providing more information such as characteristic time scales, level of scientific understanding, within these figures. [Valerie Masson-Delmotte, France]	See response to 23333
24443	3	0	0	0		Figures 3.4 and 3.5. These two figures need revision. As they stand now they are more illustrations than having a fast overview of the processes they intend to show. F 3.4 is very busy and seems most species relates to each other. Perhaps reduce the number of species to clean the figure. I guess it may be well motivated to select a few key species /groups. Figure 3.5 do not seem to show the responses from the biota on the driving stressors as the text promise. [veijo pohjola, Sweden]	Taken into account. Figures have been updated and revised.
25761	3	0	0	0		This chapter is fine, no major changes are needed. [Praveen Kumar Thakur, India]	Noted, with thanks
31143	3	0	0	0		Please respect the original page allocations in the government approved outline. In the text please focus on the policy relevant issues and those aspects that help developing a clear, coherent and comprehensive picture, and condense textbook like or review elements simply describing the system under study. [Hans-Otto Poertner and WGII TSU, Germany]	Accepted; we have condensed the chapter insofar as possible, and have drawn out more fully the assessment aspects and minimised textbook-style descriptions.
31167	3	0	0	0		It seems the chapter is not so successful in distinguishing observations from projections in its impact and governance sections. Such distinction should guide the assessment in all sections. For observations, this should follow the principles of detection and attribution. [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account. We have been more systematically including projections across our impacts sections. We have also refined statements on attribution. In terms of the governance aspect, our assessment target the capacity of polar governance systems to respond to observed and anticipated changes.
33411	3	0	0	0		This entire chapter misses one of the biggest advances in understanding of climate change in the presence of internal climate variability since AR5: initial condition large ensembles. See for example the CESM Large Ensemble Kay et al. 2015 and all of the polar-related citations. While included in this chapter in some ways, this chapter is overly deterministic and not reflecting the huge amounts of knowledge gained from running climate model simulations that enable for the first time characterization of the signal (forced response to increased greenhouse gases) from the noise (chaotic and unpredictable internal climate variability). The text seems to primarily be taking the view that observations bash the models and show that they are wrong. Where is the capacity to learn from modeling and use that to inform the future of the cryosphere? Keep deterministic views in check. It is so important as the world warms to not ignore that the chaotic nature of the climate system controls the evolution and we are just one ensemble member. [Government of United States of America, United States of America]	Taken into account: Large ensemble experiments are important for determining the role of natural variability in historical simulations and future projections. These citations are captured with respect to sea ice and seasonal snow cover.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
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33413	3	0	0	0		There appears to be no Key Finding that summarizes current understanding of the physical drivers of Arctic amplification. A statement on the current scientific viewpoints on the relative roles of local (sea ice albedo, clouds, surface turbulent fluxes, and lapse rate feedback) vs. remote forcing (atmospheric and oceanic heat transport from lower latitudes) should be discussed. [Government of United States of America, United States of America]	Taken into account: this is now better captured in Executive Summary finding #1, with traceability back to Section 3.2.1.1, 3.4.1.1, and 3.4.3.1.2, and up to the SPM.
33415	3	0	0	0		At present the text is quite hard to follow since it jumps back and forth between the Arctic and Antarctic regions almost in the same thought. [Government of United States of America, United States of America]	Accepted; we have minimised this insofar as possible, and made explicit in the writing when we change polar regions.
33417	3	0	0	0		There's a change in the use of uncertainty qualifiers at the beginning of Section 3.3 (Polar Ice Sheets and Glaciers). All of a sudden qualifiers for evidence and agreement (e.g., medium evidence, medium agreement) are being used, which was not in Section 3.2 or elsewhere in the chapter. There must be consistency in the way confidence is conveyed. Does medium evidence and medium agreement equal medium confidence? How about limited evidence and medium agreement, is that low-medium confidence? [Government of United States of America, United States of America]	Agreed and changed.
33419	3	0	0	0		The authors should be recognized for their efforts to put the cryospheric changes, the impacts on humans and ecosystems, governance, and responses/adaptation measures in a single chapter. However, it seems that putting all of this information together only matters if a "normal" person would be able to sit down and read it in its entirety. In this current format, that is not possible. There are too many specifics that cloud the bigger picture and connections that could be made. It would be useful to add a bit more information in the synthesis paragraph to capture what has been learned from putting these topics together. It would be helpful to layout more specifically what potential future directions are necessary to tackle the challenging problems that outlined. [Government of United States of America, United States of America]	Noted - thank you. Assessing both polar regions fully in 50 IPCC pages results in very dense information. We have structured the chapter in ways that allow numerous kinds of access to information, including through a visual content figure. There was no space to summarise other than in the Executive Summary.
33421	3	0	0	0		A recent follow up study by Screen et al. 2018 (Consistency and discrepancy in the atmospheric response to Arctic sea-ice loss across climate models) compares mid latitude atmospheric response to Arctic sea ice loss in different model settings. Although there is some confidence in direction of the change, the magnitude is still uncertain, and warrants coordinated experiments in future. [Government of United States of America, United States of America]	Taken into account: the new standalone Box 3.2 better captures Arctic/mid-latitude linkages.
33423	3	0	0	0		What exactly is meant by "weak"/"medium"/"strong" mitigation (e.g., on pg.4-line6, pg.4-line36, pg.4-line38)? Seems like they should be defined similar to the levels of confidence and evidence, in the footnotes. Or, perhaps the authors have defined these mitigation levels in a previous part of the report and, if so, that can be cross-referenced at the beginning of the chapter. [Government of United States of America, United States of America]	Accepted; we have changed the way we refer to climate scenarios
957	3	1	0	1		Publications to add and consider for sure I attached extra [Falk Huettmann, United States of America]	We have not received additional material from this reviewer, other than those he lists in his more detailed comments (see responses there)

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
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2609	3	1	0	174		Overall nicely written. Description about the Figure 3.10 is now clear in this version. So no more changes required. [Pushp Raj Tiwari, United Kingdom (of Great Britain and Northern Ireland)]	Noted, with thanks
13839	3	1	0	174		Overarching point. Could be worth including reference to the opportunities presented by the UN Decade of Ocean Science for Sustainable Development (2021-2030). The Decade, which will be delivered by UNESCO-IOC, could be a valuable way of fostering international science collaboration in areas related to those mentioned throughout the document. [Government of United Kingdom (of Great Britain and Northern Ireland), United Kingdom (of Great Britain and Northern Ireland)]	Taken into account; this is a good suggestion, but we couldn't find an
28367	3	1	0	174		In chapter 6, the acronym for the Greenland Ice sheet is GrIS. This is by far the most common acronym in the literature partly because GIS is another commonly used acronym for Geographical Information System. It is good practice to use same acronyms throughout the report and I would encourage you to adopt GrIS not GIS [Jonathan Bamber, United Kingdom (of Great Britain and Northern Ireland)]	Understood, though it was an IPCC decision to use GIS.
29181	3	1	0	174		I do not have any additional comment but I'd like to congratulate all authors and contributors of this chapter on the excellent job they have done! [Ge Peng, United States of America]	Noted, with thanks
26389	3	1	1	0		In general, there seems to be a large amount of overlap between this chapter and Chapter 5. Two major sections stand out: the discussion of changes in Arctic and Southern Ocean circulation and biogeochemistry, and changes in polar marine ecosystems. While it is not terrible that sections are repeated, key pieces of the conversation are not duplicated between chapters. These sections should either be consistent across chapters, or confined to one chapter or the other. [Ethan Pierce, United States of America]	Accepted. The overlap on circulation is addressed with inclusion of a cross-chapter box. We have streamlined the material on ecosystems, and cross-refer to avoid duplication.
4391	3	1	1	1	1	This is a very well written chapter! Congratulations. [The UBern Team Group Review, Switzerland]	Noted, with thanks
25991	3	1	1	102	14	This chapter should greatly reduce the number of acronyms. Some only occur a couple of times but even those occurring more often should be reduced (either spelled out or often they can just be deleted or shortened - in most cases the context makes clear what it is (e.g. if a section is only about the Greenland ice sheet, one can just say 'ice sheet' and it is clear. Avoiding acronyms is important for all IPCC reports which should be easily readable for broad audience, and in particular this report which covers both physical and social sciences. Also IPCC report chapters are seldom read from start to end, so individual sections should be readable without flipping back and forth. For example, AP, AIS, GIS, SMB, ASE [Regine Hock, United States of America]	accepted. We have reduced the number of acronyms and made sure that those used are explained at the beginning of subsections

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

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1009	3	1	1	170	1	<p>Falk Huettmann, University of Alaska Fairbanks Climate Change polar publications</p> <p>Young B.D., John Yarie, David Verbyla, Falk Huettmann, F. Stuart Chapin III (2018) Mapping Aboveground Biomass of Trees Using Forest Inventory Data and Public Environmental Variables within the Alaskan Boreal Forest. In: G. Humphries, D.R. Magness and F. Huettmann. Machine Learning for Ecology and Sustainable Natural Resource Management. pp 141-160.</p> <p>Huettmann F. (2018) Advanced Data Mining (Cloning) of Predicted Climate-Scapes and Their Variances Assessed with Machine Learning: An Example from Southern Alaska Shows Topographical Biases and Strong Differences. In: G. Humphries, D.R. Magness and F. Huettmann. Machine Learning for Ecology and Sustainable Natural Resource Management. pp 227-241.</p> <p>Huettmann F. (2017) Climate Change Effects on Terrestrial Mammals: A Review of Global Impacts of Ecological Niche Decay in Selected Regions of High Mammal Importance. Encyclopedia of the Anthropocene, Volume 2, 2018, Pages 123-130</p> <p>Huettmann F., E. E. Magnuson and K. Hueffer (2017) Ecological niche modeling of rabies in the changing Arctic of Alaska. Acta Veterinaria Scandinavica 201759:18-31 DOI: 10.1186/s13028-017-0285-0</p> <p>Baltensperger A., J. Morton and F. Huettmann (2017) Expansion of American marten (<i>Martes americana</i>) distribution in response to climate and landscape change on the Kenai Peninsula, Alaska. Journal of Mammalogy; DOI:10.1093/jmammal/gyx011</p> <p>Young, B, J. Yarie, D. Verbyla, F. Huettmann, K. Herrick and F.S. Chapin (2017) Modeling and mapping forest diversity within the boreal forest of interior Alaska. Landscape Ecology 32: 397-413</p> <p>Jiao S., F. Huettmann, Y. Guoc, X Li and Y Ouyang (2016) Advanced long-term bird banding and climate data mining in spring confirm passerine population declines for the Northeast Chinese-Russian flyway. Global and Planetary Change 144 C: 17-33 DOI: 10.1016/j.gloplacha.2016.06.015</p> <p>Huettmann F., T. Riehl and K. Meissner (2016) Paradise lost already? A naturalist interpretation of the pelagic avian and marine mammal detection database of the IceAGE cruise off Iceland and Faroe Islands in fall 2011. Environment, Systems and Decisions DOI: 10.1007/s10669-015-9583-0</p> <p>Mi C., F. Huettmann and Yu Guo (2016) Climate envelope predictions indicate an enlarged suitable wintering distribution for Great Bustards (<i>Otis tarda dybowski</i>) in</p>	unclear what is being suggested here
22375	3	1	1	174	1	<p>This is a very clearly written chapter and the author team should be congratulated on what they have achieved so far. As a general comment, it often wasn't clear from the text what the point of departure was from AR5. It might be helpful at the start of sections to quote the headline findings from AR5 before then presenting the new evidence since then and the SROCC assessment (and whether this deviates from AR5 or further strengthens the AR5 findings). [Abram Nerilie, Australia]</p>	Taken into account. We have strengthened reference to AR5 in places where this was deemed important
22403	3	1	1	174	1	<p>In the executive summary and text it didn't always come across clearly that there are discrepancies between observations and model simulations of Antarctic surface climate/sea ice changes. There are multiple papers since AR5 that demonstrate this and provide possible explanations. The apparent lack of Antarctic warming, or the expansion of Antarctic sea ice are still commonly brought up in climate change denial arguments (including in political discussions) and so a careful treatment of this topic should be done. This could be a good topic for a Box in chapter 3. [Abram Nerilie, Australia]</p>	Accepted: we did not add a new box, but Antarctic sea ice text was revised in Section 3.2.1.1 and 3.2.2.1 with new citations. Chapter key messages were also revised.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
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22197	3	1	1	174	28	Thank you very much to the authors of the Chapter 3 for taking into account my suggested changes from the first order draft. I only made very limited comments on Chapter 3 for the first order draft, on points I have direct expertise on, but the points I identified have been improved beyond what I had suggested. The latest version of Chapter 3 is very comprehensive and readable. [Inga Smith, New Zealand]	Noted, with thanks
218	3	1	1	174	70	Too many schematics, and not enough data-driven figures! Where are sea ice thickness? Projections? Seasonal sea ice? Seasonality of snow cover? Seasonally frozen soils? There are many data that are overlooked for presentation. [Baylor Fox-Kemper, United States of America]	Taken into account. With a finite page limit, it is not possible to include data plots for every dataset that is mentioned. We have revised the figures to include more assessment-style information in them, however.
226	3	1	1	174	70	Overall, there is an inconsistent level of quantitative information. No quantitative information is included in the executive summary, and some sections are intensely quantitative while others are very qualitative. It would be helpful somehow to outline the thinking behind these choices in the early sections or introduction. [Baylor Fox-Kemper, United States of America]	Accepted. Quantitative information is included now in the appropriate places of the ES. Other quantitative information is included throughout the chapter.
232	3	1	1	174	70	Overall, projections are underplayed graphically in comparison to observations. This emphasis is perhaps due to the fact that CMIP6 is not assessed here and CMIP5 was already assessed, but ice sheet modeling in particular has evolved much in offline mode since CMIP5, and some of the CMIP5 results were not well understood at the time of AR5. [Baylor Fox-Kemper, United States of America]	Taken into account. CMIP5 projections were included graphically in the previous version (e.g. SST, sea ice etc); we have added projections for aragonite undersaturation for this version. Projections of sea level rise are the domain of Chapter 4; see also the cross chapter box
234	3	1	1	174	70	Overall, paleoclimate evidence is underutilized in this chapter. Polar amplification in paleoproxies is one of the clearest signals (see AR5, box 5.1). I am surprised that this is not revisited here. [Baylor Fox-Kemper, United States of America]	Accepted; we have strengthened the palaeo aspects of the chapter, in particular by drawing in new material from a new CA (Dr Nerilie Abram)
236	3	1	1	174	70	There are no graphics illustrating sea ice thickness or sea ice age, although datasets on these variables are available. [Baylor Fox-Kemper, United States of America]	Noted; with a finite page limit, it is not possible to include graphics for every dataset under consideration.
238	3	1	1	174	70	There are no graphics illustrating seasonal sea ice cover or ranges. [Baylor Fox-Kemper, United States of America]	Accepted; the revised figure 3.3 shows March and September sea ice variables, thus giving information on winter/summer differences in change.
23101	3	3	0	3		I suggest to separate bullets for the Arctic and the Antarctic and be more specific about the differences. This could allow to separate for instance impacts of already changing sea ice area (Arctic) from those not already observed but projected for Antarctica. [Valerie Masson-Delmotte, France]	Accepted - new ES statements on Arctic and Antarctic sea ice changes
22453	3	3	0	6		Suggest including a statement in the Executive Summary about the East Antarctic ice sheet. Currently within the Executive Summary, Antarctica is not referred very much. In particular, the degree of certainty associated with some of the largest potential impacts (sea-level rise from glacial melt) is shown to be not well known – except in "regions of West Antarctica". Yet most of the ice is contained in East Antarctica. [Government of Australia, Australia]	Tight space limits mean that there isn't an ES message specifically on East Antarctica, though it is treated specifically in the main chapter.
27847	3	3	0	6		Fabulous Executive Summary! The storyline is easy to follow and the findings authors chose to highlight are compelling and accessible. Good work. [Ko Barrett, United States of America]	Noted, with thanks
724	3	3	1	0		At least some most important numbers should be included in the executive summary, such as the rates of change in polar ocean and cryosphere. [Mengxi Wu, United States of America]	Accepted; the ES has been extensively revised, including new quantifications of the type suggested

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
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26357	3	3	1	0		The Executive Summary should include quantitative results. Mass balance, melt loss, changes in sea ice extent/thickness/volume, changes in permafrost depth and extent, glacier inventories, etc. are all valuable quantities to compare between IPCC reports. [Ethan Pierce, United States of America]	see response to 724
23911	3	3	1	102	18	We suggest that once an abbreviation is introduced, it be used throughout the document. (e.g. Southern Annular Mode (SAM), Antarctic Peninsula (AP)) [Government of Japan, Japan]	Editorial - chapter to be copyedited after completion.
29647	3	3	1	5	21	It seems to me that much more emphasis is needed on how the consequences of climate change in the Arctic will affect the rest of the world, by the effects on weather, sea level rise, migration of species, shifts in ranges that can impact biodiversity, and likely, due to unsymmetric patterns of Arctic and Antarctic warming and conditions, the location of the ITCZ (which varies in location and so shifts the location of equatorial precipitation so as to balance the amount of the excess (solar) energy deposited in the low latitudes). Yes, what happens in the polar regions is key, but there are far more people located around the world and the impacts on them need much more attention and mention. [Michael MacCracken, United States of America]	Accepted. A goal of the chapter is indeed to assess the global implications of polar change, not just the local implications. We have revised the chapter in many places in order to emphasise this, e.g. creation of a separate box on Arctic influence on mid-latitude weather. The most important assessment findings are mentioned in teh ES
29649	3	3	1	5	21	It seems there was also too little attention to the potential for relatively sudden collapse of various of the glacial streams in the Antarctic, explaining how much sea level equivalent they contain, typically of order several meters, and of how rapidly such a collapse could occur (is it years or decades or what?). Even if such risks are explained in a later chapter, the need to be mentioned here where people are reading about what is projected to be happening in the polar regions and what it will likely mean for them--don't force them to have to also be reading some other chapter. [Michael MacCracken, United States of America]	Ice sheet projections are dealt with in chapter 4 and a cross-chapter box in chapter 3. Both deal with the issue of rapid and potentially irreversible ice sheet collapse.
3983	3	3	1	6	22	The executive suummary is excellent. I now skip to section 3.5 [Stuart Chapin, United States of America]	Noted; with thanks
4649	3	3	1	6	22	It is suggested to re-arrange the ES structure to make it much clearer and more consistent. At the present version, it is not very clear to distinguish "changes" from "impacts", and somewhere they are mixed together. One recommendation for re-organizing the structure is to write in the order of "change (present and future)"-"impacts"-"Actions". [botao zhou, China]	Taken into account. The ES has been extensively revised, with a new structure that closely parallels that used in the Summary for Policymakers (SPM). This allows traceability of statements between SPM and chapter text, an important aspect of the robustness of the assessment.
1569	3	3	1	6	24	Could there be an explicit bullet point in this chapter on abrupt/irreversible changes and tipping points in polar regions? [Matthew Collins, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account; we stopped short of a general bullet re abrupt/irreversible polar changes, but have included a KM on the potential for irreversible ice sheet decline.
3159	3	3	1	6	24	The Executive Summary provided little quantitative data to support the overall points being made. Since this is the first section that people will read, and might be only the thing that some people will read, it may be benefiical to include some quantitative results from existing studies. [Sloane Garelick, United States of America]	see response to 724

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
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31089	3	3	3	0		The executive summary gives a nice general, mostly qualitative overview but would be more punchy if key findings could be detailed (specified and quantified), also and especially with respect to solution options by adaptation and mitigation efforts. This would also help the development of the SPM as a stand-alone document. I have indicated where such question marks come up when reading the present ES. If quantitative statements are not possible for global scale they may still be possible for key regional examples (case studies). Providing semi-quantitative estimates or orders of magnitude would also help to understand better and e.g. differentiate between whether projected mean global or regional changes are by e.g. 5 or 95 %. [Hans-Otto Poertner and WGII TSU, Germany]	Accepted. We have included more quantification directly in the ES, where possible.
1849	3	3	3	3	3	"opposing ends of the planet": strange formulation; mathematically all points on the surface of a sphere are endpoints [Solfrid Sætre Hjøllø, Norway]	Accepted; that sentence formulation has been removed.
15521	3	3	3	3	3	Strange to use the term 'ends of the planet'. Where is the end of a sphere? [EUCE, Belgium]	see response to 1849
16859	3	3	3	3	3	Strange to use the term 'ends of the planet'. Where is the end of a sphere? [Louise Sandberg Soerensen, Denmark]	see response to 1849
9493	3	3	3	3	5	The sentence construction gives the impression that ecological and social systems are shared by polar regions, which is not true. [Government of France, France]	Accepted; sentence has been removed
18779	3	3	3	3	5	The first sentence of the Executive Summary can and may be misleading for readers without extensive polar scientific knowledge. The wording of the first clause oversimplifies general polar science by making it seem as if despite being on the opposite side of the	Accepted; sentence has been removed
1553	3	3	3	3	9	There is an opportunity here for a clear (and quantitative) statement about polar amplification e.g. Arctic is the region of maximum observed and projected surface warming. [Matthew Collins, United Kingdom (of Great Britain and Northern Ireland)]	Accepted; we have crafted a KM to make this point
9019	3	3	9	0		I would expect a semi-colon at the end of this sentence. What about rephrasing to: "Key findings from this chapter follow." [Nina Hunter, South Africa]	Editorial - chapter to be copyedited after completion
15523	3	3	9	3	11	It is suggested to change or re-phrasing line 11 so that it is not formulated as a question but rather as a statement. [EUCE, Belgium]	Accepted; statement has been revised and is now not a question.
16861	3	3	9	3	11	Suggest to change the re-phrasing line 11 so that it is not formulated as a question but rather as a statement. [Louise Sandberg Soerensen, Denmark]	see response to 15523
31091	3	3	11	0		If maintained it should be made clear across chapters that all of them use these structuring questions. [Hans-Otto Poertner and WGII TSU, Germany]	see response to 15523
474	3	3	11	3	11	I suggest to split this question, and the underlying subsequent messages, into two: one about how the regions are changing and one about why it matters. As it stands right now, many of the subsequent key messages are difficult to understand, because they try to answer two very different questions in one answer. [Cecilie Mauritzen, Norway]	Taken into account; the structure of the ES has been changed and the material parsed differently.
23913	3	3	11	3	11	The first part of the Executive summary includes not only the importance and the changes for the polar regions, but also the projections and impact of their changes. Thus, the title could also reflect those points. [Government of Japan, Japan]	Taken into account; the structure of the ES has been changed and the material parsed differently.
27571	3	3	11	3	11	Consider to write ", globally and regionally,..." since the following key messages start with one on global matters. Alternatively; start the key messages with the regional changes, and add in the global matters further down. [Government of Norway, Norway]	Taken into account; Exec Summary has been revised extensively since SOD.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
11211	3	3	11	3	28	<p>line 11 has the question "Why do the polar regions matter, regionally and globally, and how are they changing?" There can be a headline included about Antarctic sea ice decline.</p> <p>My suggestion is:</p> <p>"Three consecutive summers with below-average Antarctic sea-ice area have observed (very high confidence¹). What is driving the changes and the sea ice cover variability are not yet determined. Understanding the processes, regional changes in sea ice and seasonal snow cover are high priority. [Burcu Ozsoy, Turkey]</p>	Accepted: New ES key message on observed Antarctic sea ice trend
722	3	3	11	4	27	<p>I think the little-understood changes in Antarctic sea ice should also be included in the executive summary, because it is an important knowledge gap, which is mentioned in Section 3.6 on p. 100. [Mengxi Wu, United States of America]</p>	Accepted: New ES key message on observed Antarctic sea ice trend
27573	3	3	11	4	27	<p>The list of key messages could be sorted in a way that makes it easier to read -- as it is now, several of the key messages links to global consequences and impacts. It may be easier if these first key messages gives clear statements about the regional changes and their regional consequences, preferably adding concrete numbers on respective decreases and increases. These key messages could then be followed by separate bullet(s) on global consequences [Government of Norway, Norway]</p>	Taken into account. The ES has been revised extensively, to match better the structure of the Summary for Policymakers (SPM) and therefore strengthen the traceability of the assessment. We have included more quantification of the assessment where possible.
17327	3	3	11	6	10	<p>There should be one Indigenous specific paragraph under each section of the Executive Summary (ie. 3 distinct paragraphs specifically about Indigenous Peoples, one for "Why do the polar regions matter", another under "What are the impacts and risks of the observed and projected changes and who will be affected?", and a final one under "What are the options for responding to polar change that reduce risk and support resilience?"). Polar regions matter for intrinsic value and the continuation of livelihoods, cultures, and health of Arctic Indigenous Peoples. Furthermore, Indigenous Peoples are the first to bear the brunt of the impacts and risks whether it be on food security, safety, natural and built infrastructure, etc. and Indigenous Peoples should be specifically recognized as an important population that not only WLL be affected but has already been significantly affected for over a decade in a multitude of ways. Lastly, in options for responding, the ongoing innovation and adaptation action that is being led by Indigenous communities must be recognized. There is a plethora of examples to support this. Just looking at Inuit, they have massively contributed to Indigenous-led adaptation action with innovative technologies (eg. SIKU, an Inuit knowledge wiki and social mapping platform (https://arcticeider.com/en/about), SmartIce (https://www.smartice.org/)) and practices that have been created and sustained by Inuit communities. The Executive Summary is incomplete without this information. [Joanna MacDonald, Canada]</p>	<ol style="list-style-type: none"> 1. reject. SROCC is concerned with assessing the available knowledge (from IPCC-admissbale publicaitons) and in Chapter 3 we have used IK, where available, to formulate assessment statements. IN the ES we summarise those statements, independent of the source /knowledge system. 2. taken into account. we do mention impacts on Indigenous and local Artci communities in ES statements. 3. Taken into account - the suggested material was considered for assessing responses in 3.5. The inclusion at the suggested level of detail is not possible in the ES.
462	3	3	13	3	17	<p>This statement is extremely vague and should therefore be removed. The message is repeated in two sentences, and references are made to many boxes and sections, but the reader does not learn anything about what these impacts might be. An alternative to removing the paragraph might be to include in the paragraph what the impacts are. [Cecilie Mauritzen, Norway]</p>	Accept; statement removed
1555	3	3	13	3	17	<p>Global consequences are mentioned twice here without any examples of what they might be, [Matthew Collins, United Kingdom (of Great Britain and Northern Ireland)]</p>	Accept: KM has been revised

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
27575	3	3	13	3	17	The key message does not tell you what the consequences and impacts are. Is it possible to add detail to give the reader an indication of what consequences and impacts we are talking about? [Government of Norway, Norway]	Accept; statement removed
31081	3	3	13	3	17	Can the changes and their consequences as well as the linkages be addressed in more detail in the first sentence of this paragraph, ideally with a focus on what is new since AR5? As an alternative, please also see my suggestion above to integrate the first two-three paragraphs (as of line 13) into the introductory paragraph of this Executive Summary. [Hans-Otto Poertner and WGII TSU, Germany]	Accept; ES revised extensively.
26359	3	3	13	3	23	Both of these points are fine for the smaller summary paragraph above, but are not specific enough for their own section in the Executive Summary. It is more clear when bold face font indicates specific, direct results from one distinct component of the cryosphere, as that allows for quick identification of the major points contained within. As it stands, I would have to consult the entire chapter to find the exact major conclusions for any given	Accept; ES revised extensively.
31079	3	3	13	3	23	Because the first two-three paragraphs of this Executive Summary read like an introduction, especially compared to the following ones that are far more specific and useful, I would like to suggest to integrate this rather general "scene-setting" information into the introductory paragraph (lines 3-9). [Hans-Otto Poertner and WGII TSU, Germany]	Accept; ES revised extensively and this point actioned
33071	3	3	14	0		The phrase "There is strong evidence" would be more clear and consistent if the summary terms for available evidence listed in the footnote ("limited, medium, or robust") were used instead of "strong". [Government of United States of America, United States of America]	Accept; statement removed
11151	3	3	14	3	14	I strongly disagree with the notion that there is „very high confidence“ that the global impacts of polar changes are evident now in the climate system. Indeed, this chapter itself states in box 3.1 that „full understanding has not yet been developed“ for atmospheric linkages, and I believe the same is true for marine linkages. In AR6, we will most likely not agree with this level of confidence. [Dirk Notz, Germany]	Accept; statement removed as part of ES revisions
27535	3	3	15	0		It would be a good idea to indicate/clarify terrestrial and/or snow on sea ice changes because there is less certainty in the trends of snow on sea ice thus making it perhaps a bit misleading to indicate snow loss in the same sentence as sea ice loss without indicating if it is terrestrial and/or snow on sea ice. [Benjamin A. Lange, Canada]	Taken into account; ES statements revised extensively
31093	3	3	19	0		Can this "markedly different state" be specified in a crisp way and the difference be quantified? [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account; statement removed
27577	3	3	19	3	19	Can "the coupled Arctic ocean/cryosphere system" be expressed in an easier/more accessible way? [Government of Norway, Norway]	Taken into account; statement removed
33073	3	3	19	3	19	The term "different state" gets used a lot but for a scientific document it should be defined. [Government of United States of America, United States of America]	Taken into account; statement removed
464	3	3	19	3	20	This sentence is very vague and should be removed. The paragraph relates to temperature, so stick with that. Or include in the paragraph what the other state changes are. [Cecilie Mauritzen, Norway]	Accepted; sentence removed
23579	3	3	19	3	20	While it is correct that the system has changed, "state change" may not fully convey that the system is still undergoing/in ongoing change. I.e., it is not in a new (stable) state. [Government of Sweden, Sweden]	Accepted; sentence removed
15519	3	3	19	3	21	The 2 paragraphs should be lifted in the SPM. It states with very high confidence the very worrying acceleration of change in particular in the polar regions [EUCE, Belgium]	Taken into account; sentence removed

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
879	3	3	19	3	23	This section covers ICE but should really cover the atmopshere,please mention! It all sits in the cold air! [Falk Huettmann, United States of America]	Noted. SROCC CH 3 does not have a mandate to assess the atmosphere. However, we do cover cryosphere - climate interactions in Box 3.1 with references to the atmosphere and include an ES statement from this material.
1557	3	3	19	3	23	This is a very strong statement that the world has changed so much in 20 years. Some quantitave evidence would strengthen the statement even further. [Matthew Collins, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account; sentence actually removed during ES revisions
22711	3	3	19	3	23	Antarctic equivalent summary is missing. This sentence could be followed by a sentence regarding the state of Antarctica ocean and cryosphere or if there is not enough research or evidence to draw conclusions from, should state the need to build more knowledge [Greenpeace Group Review, Republic of Korea]	Taken into account; sentence actually removed during ES revisions
29631	3	3	19	3	23	Why is the comparison of the present state of the climate system to just the end of the 20th century? I understand that this does make clear that current changes are quite rapid, but it seems to me that it is worthwhile to also point out how different the climate is now for virtually all the 20th century, and indeed back over a good number of past centuries, indeed, back to the times when orbital elements were different and so were forced to be different by natural forcings. [Michael MacCracken, United States of America]	Taken into account; sentence removed
3833	3	3	20	0		surface temperature -> average surface air temperature [Zhaomin Wang, China]	Accept; text revised
10105	3	3	20	0		Is it possible to describe a few of the major state changes besides surface temp (loss of ice, shifts in sp composition/distribution,etc. In this leadoff para? [Lisa Speer, United States of America]	Taken into account; sentence actually removed during ES revisions
11153	3	3	20	3	20	Our models do not reproduce many of the observed changes. This makes me wonder whether we really can have „very high confidence“ that the state is markedly different. I suggest to change this to „high confidence“, given our limited understanding of internal variability of polar processes. [Dirk Notz, Germany]	Taken into account; sentence actually removed during ES revisions
3505	3	3	20	3	21	Suggest: "Evidence for this state change, INCLUDING increases in surface temperature at approximately twice the rate of the global average (very high confidence), is derived from..." if the temperature changes are one aspect or "Evidence of increases in surface temperature at approximately twice the rate of the global average (very high confidence) is derived from" if this is the primary/only evidence. [Richard Allan, United Kingdom (of Great Britain and Northern Ireland)]	this statement has been removed from the Executive Sumamry
4393	3	3	20	3	21	Does this apply to annual mean surface temperatures? Or only summer/winter-time temperatures? Should be clarified. [The UBern Team Group Review, Switzerland]	Accepted; clarified in revised text
11155	3	3	21	3	21	I strongly disagree that we have „very high confidence“ that the Arctic is warming at twice the rate of the global average. Data coverage is very sparse, so I actually find we can have rather limited confidence in any quantitative assessment of Arctic warming. We will most likely not share this level of confidence in AR6. [Dirk Notz, Germany]	Taken into account; we have considered this extensively in consultation with expert CAs, and revised the confidence statement accordingly.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
11213	3	3	21	3	22	".....is derived from multiple individual and linked Arctic regional changes and their consequences and impacts....." I suggest to be changed to ".....is derived from multiple individual and linked Arctic regional changes with their consequences and impacts....." [Burcu Ozsoy, Turkey]	Taken into account; statement revised greatly during ES revisions
13845	3	3	23	7	40	Suggest using simpler and more explicit language to define the Arctic and Antarctica and the differences between the two poles. For example Antarctica, a land mass covered and surrounded by ice and sea, no permanent human population, governed by Treaty system. The Arctic, an ocean surrounded by land covered by sea-ice (that is declining), a permanent population across eight nations, governed by eight nations who have territorial jurisdiction over the vast majority of the region complemented by international agreements and treaties. [Government of United Kingdom (of Great Britain and Northern Ireland), United Kingdom (of Great Britain and Northern Ireland)]	Taken into account. We accept the need for simple, explicit statements concerning the differences between the polar regions, but the ES is not the place. We have included this information in the revised introduction.
31095	3	3	25	0		As an example, clear, upfront, more concise statements on the nature of changes including impacts would be more illustrative, e.g. Heat and carbon content as well as ecosystems of the polar oceans are changing more rapidly... In other word, the nature of changes should be mentioned upfront, replacing mysterious general formulations. [Hans-Otto Poertner and WGII TSU, Germany]	Accepted; we have modified this KM significantly. The consequences alluded to are climatic; ecosystems consequences come through in a separate KM now.
31083	3	3	25	3	25	Can the "changes" be specified in the first sentence? As an alternative, please also see my suggestion above to integrate the first two-three paragraphs (as of line 13) into the introductory paragraph of this Executive Summary. [Hans-Otto Poertner and WGII TSU, Germany]	Accepted; this KM has been revised to be more specific.
33075	3	3	25	3	25	"more rapidly". This may be so, but how is this defined and measured? Does the report document and support such a blanket statement? [Government of United States of America, United States of America]	Accepted; this KM has been revised to be more specific.
3835	3	4	25	4	27	it is not clear what leads to "limiting their potential ...". [Zhaomin Wang, China]	This statement has now been removed.
27579	3	4	25	4	27	This information is difficult to understand and seems to be somehow contradicting the information about the past where it is stated that the sea level rise is mainly linked to glaciers and polar ice sheets. [Government of Norway, Norway]	This statement has now been removed.
466	3	3	25	3	31	This is the third paragraph the includes BOTH statements about change in the Polar regions (oceans in this case) AND impacts. This one even includes attribution statements. I suggest to make the messages clearer and simpler by separating key messages about observed changes, key messages about impacts and key messages about attribution. [Cecilie Mauritzen, Norway]	Taken into account. We have revised the ES, and this KM has been reworked extensively. The new ES structure matches onto that of the Summary for Policymakers, in order to ensure traceability of the assessment statements.
550	3	3	25	3	31	The actual rates or rate changes should be included here to give the magnitude, not just direction of change. [Jenna Pearson, United States of America]	Accepted; statement has been revised to include quantification
1559	3	3	25	3	31	Can these statements be quantified? [Matthew Collins, United Kingdom (of Great Britain and Northern Ireland)]	Accepted; statement has been revised to include quantification
1633	3	3	25	3	31	Are there quantitative estimates for regional ocean temperature changes and acidification? And is there a quantitative summary for how heat uptake has increased in the Southern Ocean that can be included in this summary? [Nora Richter, United States of America]	Accepted; statement has been revised to include quantification

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
10201	3	3	25	3	31	Suggest providing the amount of heat and carbon uptake by polar oceans as compared to global ocean. [SAI MING LEE, China]	Accepted; statement has been revised to include quantification
22377	3	3	25	3	43	From the statements here my expectation would be that the sea surface of both polar oceans is warming rapidly. This isn't the case for observations of the surface southern ocean (e.g. Figure 3.3c), and this should be made clearer in the wording of these headline statements. [Abram Nerilie, Australia]	Taken into account. A key issue we are assessing is heat content, since it is of strong global climatic influence, and this is increasing in both polar oceans. These KMs have been extensively revised, including reflecting better this point, and also the complexity. A new KM has been included specifically noting Antarctic sea ice trends (or lack thereof).
2429	3	3	26	3	28	You write: "The amounts of heat and carbon stored in the polar oceans have increased in recent decades, with marked ocean warming in both polar regions...". Unfortunately, my comment on the FOD has been ignored. Therefore again, this statement is misleading. Later in the text you are explaining and are illustrating (e.g. p. 22, Fig. 3.7 in FOD) that the Antarctic polar ocean has been cooling in the past decades. Why not mention this important fact here? Fast readers should know that Antarctic climate is more complex than elsewhere in the world. It should also be stated that Antarctic temperatures as a whole have probably not warmed during the past 100 years (e.g. Ludescher et al. 2016, doi: 10.1007/s00382-015-2582-5). Ludescher et al. 2016 still remains uncited in the SOD. In Figure 3.7b of the FOD one can also see that Antarctic sea ice in many coastal areas around Antarctica has been growing. Needs to be mentioned in the summary, even though it may appear inconvenient. [Sebastian Luening, Portugal]	Taken into account. The key parameter we are assessing in this KM is heat content, not temperature at one level (the surface). The former is of key importance in global climate, and warrants assessment. The latter is also important, but is regional and is understood as a response in circulation (of ocean currents and/or sea ice) to changing wind forcing - it does not negate the former. We have now included a new KM noting the lack of a trend in Antarctic sea ice over the satellite era (indeed, its small but significant increase in extent up to ~3 years ago), strongly related to the surface temperature trend.
24067	3	3	26	3	28	"The amounts of heat and carbon stored in the polar oceans have increased in recent decades, with marked ocean warming and acidification in both polar regions and reinvigoration of the Southern Ocean carbon sink since the early 2000s". You describe the effect of the storage of heat (ocean warming), likewise you could describe the effect of the storage of carbon (ocean acidification), which is not irrelevant. [Peter Thor, Sweden]	Accepted; we have revised the ES and include a new KM that includes detail on acidification and its impacts.
28499	3	3	26	3	31	Why aren't there confidence indicators on individual statements in this paragraph as there are for most of the other points? [Yvonne Firing, United Kingdom (of Great Britain and Northern Ireland)]	Accepted; statements now included in the revised KMs
27581	3	3	27	2	27	Please add the definition of "polynyas" in the Glossary [Government of Norway, Norway]	Taken into account but inclusion of terms in the Glossary has specific requirements set by TSU
16863	3	3	27	3	27	It is not clear to me what is meant with services in 'climate and ecosystem services' [Louise Sandberg Soerensen, Denmark]	Accepted; KM has been revised and that statement removed
23581	3	3	28	3	28	"reinvigoration of the Southern Ocean carbon sink since the early 2000s" may be overly detailed - the main point here is surely carbon uptake (and whether its efficiency has changed for the polar oceans in substantive terms). [Government of Sweden, Sweden]	Accepted; KM has been revised with emphasis on decadal variability in carbon uptake
27583	3	3	28	3	28	Please consider to change the word reinvigoration. The amounts of heat and carbon stored in the polar oceans have increased in recent decades, with marked ocean warming in both polar regions and "reinvigoration" (strengthening/increase?) of the Southern Ocean carbon sink since the early 2000s. [Government of Norway, Norway]	Accepted; KM has been revised and this word omitted

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
13847	3	94	29	94	30	The sentence starting "In 2013, the Council...." is irrelevant unless it adds background such as "The Arctic Council is made up of the eight Arctic States. Six Permanent Participants give a voice to indigenous peoples groups of the Arctic. Observers range from non-Arctic states, intergovernmental bodies, civil society groups and NGOs. In 2013, China, South Korea, Italy, Japan, India and Singapore joined the France, Germany, the Netherlands, Poland, Spain and the UK as Observers states to the Arctic Council; Switzerland was granted Observer status in 2017.". Either add background as described, and add a line on why it matter that this select group of countries were granted observer status, or remove the sentence entirely. [Government of United Kingdom (of Great Britain and Northern Ireland), United Kingdom (of Great Britain and Northern Ireland)]	Accepted. A sentence is added
10107	3	3	31	3	31	Isn't this true for the Arctic Ocean as well? [Lisa Speer, United States of America]	Taken into account. The Southern Ocean attribution statement is now removed from the ES; see comment 23583.
23583	3	3	31	3	31	Not sure this adds to the understanding of the key finding: "most notably the influence of greenhouse gases". Rather, it confuses as it raises a question on which the other processes are. Please consider deletion. [Government of Sweden, Sweden]	Accept; comment deleted.
27259	3	3	31	3	31	I suggest the inclusion of a citation concerning green house gas effects on Antartica-Rintoul et al. 2018- Naturevolume 558, pages233–241 (2018) [Gleyci Moser, Brazil]	Reject; it is not IPCC format to include references in the Executive Summary.
Rejected. This	3	93	32	94	35	There isn't strong evidence in the report to say that because the Arctic Council has undertaken three binding agreements they are preparing to take on a regulatory role to respond to climate change. The Arctic Council is in the middle of developing its first Strategy and suggestions are that there will be no change in its function as a consensus body. Some of the Arctic states would be quite resistant to a regulatory approach. [Government of United Kingdom (of Great Britain and Northern Ireland), United Kingdom (of Great Britain and Northern Ireland)]	Rejected. This comment is not corresponding to the current state of the art of the new shifing landcape in law and governance. In addition the text has not been read with attention: 1)We say the Council "IS PREPARING a regulatory role" and we have to point out this because it is a very important part of the legal assessment and shows a change compared to the past 5 years. 2) The first sentence starts with "Despite lacking the role to enact hard law" (present tense in English)
10109	3	3	33	0		Add "snow" after "sea ice." (loss of snow cover on sea ice affects denning of some seals) [Lisa Speer, United States of America]	Rejected: we don't assess changes to snow depth on sea ice in the context of biological impacts.
31097	3	3	33	0	43	The same (lack of clear specific statements) is true here, be specific and quantitative right away on what you mean. Quantitative could also mean just being clear on the order of magnitude, e.g. in shifts or biomass. The term «several», «further shifts», «projected range expansion» leave this completely open. [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account. This KM has been reformulated (and split into observed and projected changes) in the revised draft. Statements have been quantified and made specific where possible.
881	3	3	33	2	43	This must mention MAJOR changes with the text as examples only. Reality is MUCH WORSE [Falk Huettmann, United States of America]	Unclear. The ES statements summarise the key assessment finding from the chapter, which are based on the body of published literature.
468	3	3	33	3	35	Which part of this sentence has "high confidence"? Suggest to split and use confidence language on each part. [Cecilie Mauritzen, Norway]	Accepted. We split the confidence statements

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
22713	3	3	33	3	35	The headline statement of the paragraph does not justify the skewdness of the shifts towards the negative for both fisheries activities and conservation that the climate induced changes in both polar oceans, sea ice and cryosphere will face. Suggestion to add wordings to address this misrepresentation. [Greenpeace Group Review, Republic of Korea]	Rejected. We feel the statement is neutral with examples of habitat expansion and contraction.
33077	3	3	33	3	35	This sentence does not make it clear whether these shifts are observed/happening now, or are projections regarding future shifts. [Government of United States of America, United States of America]	Taken into account. We now split our key messages into observed and projected statements.
2517	3	3	33	3	43	Level of detail in this paragraph notably greater than in the others on this page. [Michiel Van den Broeke, Netherlands]	Taken into account. We now split our key messages into observed and projected statements.
29789	3	3	33	3	43	For both poles, I think it is important to also add that retraction of seoice opens shallow seafloor habitats for colonization by e.g. macroalgae and associated species. References for the Arctic: e.g. Krause-Jensen et al. 2012, Krause-Jensen & Duarte 2014, Kortsch et al 2012. [Dorte Krause-Jensen, Denmark]	Noted. There was not space to address this issue. It is addressed in the chapter text.
30325	3	3	35	3	35	Please add the appropriate word(s) after the stand-alone pronoun "This" to clarify its antecedent. [Paul Glaser, United States of America]	Accepted. We split the confidence statements
676	3	3	35	3	37	It may be unnecessary to include such a specific example of the Barents Sea which also seems less important than the following examples in the executive summary. [Mengxi Wu, United States of America]	Rejected. The example from the Barents Sea is one of the most well documented and thus we kept it.
17345	3	3	36	3	36	Snow crab invasion may be caused by climate change. Invasion of king crab has other cause than climate. It was an anthropogenically introduced species in the 1960s that subsequently expanded its habitat [Svein Sundby, Norway]	Noted. We agree that red king crab were introduced to the Barents Sea, however, this statement refers specifically to species responses to habitat expansion or contraction and thus, the origins of the species in a region are not the subject of the statement.
10111	3	3	37	0		This sentence should also reflect observed shifts in cod and pollock in the Bering Sea [Lisa Speer, United States of America]	Rejected. Previous reports reported findings of Mueter. We cite new work of Stevenson et al in the chapter. The time series of observations in the northern Bering Sea are much shorter and thus as an example, we thought that the Barents Sea example was best
470	3	3	37	3	43	I presume these statements depend on which scenario is used? Please be more specific if you intend to use confidence language. [Cecilie Mauritzen, Norway]	Noted. We agree that scenarios will be important and this is discussed in the text.
17071	3	3	38	3	41	Something needs to be said about the cooling observed in th northern tip of the Antarctic Peninsula since mid90s. [Jorge Carrasco, Chile]	Taken into account. Contrasting changes in habitats in northern and southern regions of the West Antarctic Peninsula is discussed in Section 3.2.3.2
10113	3	3	39	0		Add "and in the ocean," after "on land" as the same is true for high Arctic marine species (e.g., Arctic cod) [Lisa Speer, United States of America]	Rejected. While we agree that habitat for Arctic cod will contract, we do not have reliable projections of oceanographic and hydrographic changes in ocean conditions for shelf regions of the high Arctic. Therefore we limited our statement to land.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
17699	3	3	39	0		In this paragraph there is mention of loss of Antarctic seafloor communities, therefore I was hoping to hear about the impact of iceberg scouring along the the Antarctic continental shelf but I could not see any information in the Chapter. I would suggest to add a mention (maybe just a sentence) on the impact of iceberg scouring on the seafloor communities in section 3.2.3.2.5 (p3-39 l.41). In the chapter, there is already a good reference on this topic used in Table 3.1 (p.3-36) "Barnes and Souster 2011" and I think this reference could be used to refer to iceberg scouring and seafloor communities. This field has very limited studies, therefore the confidence level might be very low, so I will leave you with making the decision whether or not it is worth mentioning it in this report [Eva Cougnon, Australia]	Rejected. This issue was not covered due to space limitations and the year of the relevant reference (2011).
33079	3	3	39	3	43	These last two sentences seem to be redundant; they say the same thing but in reversed order. Paraphrasing these two sentences: the first says high-Arctic species will be outcompeted by southerly species, whereas the second sentence says subarctic species will expand northward and compete with high-Arctic species. Suggest combining these sentences into one or rewording one of them. [Government of United States of America, United States of America]	Taken into account. Impacts on land and ocean have been separated
10253	3	3	40	3	44	Burton-Johnson et al. (2016) suggest that all areas of the Antarctic that are not covered in perennial ice and snow are "exposed rock areas." However, this is misleading as many ice-free Antarctic areas are covered by soils/sediments (Bockheim et al., 2013). For example, the exposed area, the McMurdo Dry Valleys, at 4500 km ² (or >20% of the total) (Levy, 2012), is largely floored by soils, with bedrock representing a minority of the exposed area. These soils accumulate soil carbon and participate in carbon cycling (Burkins et al., 2001). They may become more active carbon sinks as Antarctic soils warm and become wetter (Ball & Levy, 2015). A more nuanced statement would be, "Permafrost in the Southern Hemisphere polar region occurs in ice-free exposed rock AND SOIL areas, 0.18% of the total land area of Antarctica (Burton-Johnson et al., 2016)." Refs: Ball, B.A., & Levy, J. (2015) The role of water tracks in altering biotic and abiotic soil properties and processes in a polar desert in Antarctica. Journal of Geophysical Research-Biogeosciences, 120(2), 270-279. Bockheim, J.G. (2013) Soil formation in the Transantarctic Mountains from the Middle Paleozoic to the Anthropocene. Paleogeography, Paleoclimatology, Paleoecology, 381-382(C), 98-109. Burkins, M.B., Virginia, R.A., and Wall, D.H. (2001) Organic carbon cycling in Taylor Valley, Antarctica: quantifying soil reservoirs and soil respiration. Global Change Biology, 7(1), 113-125. Levy, J. (2012) How big are the McMurdo Dry Valleys? Estimating ice-free area using Landsat image data. Antarctic Science, 25(1) 119-120. [Joseph Levy, United States of America]	Taken into account. Impacts on land and ocean have been separated
30327	3	3	41	3	41	There is a problem with parallel construction with regard to "and very limited refugia exist" [Paul Glaser, United States of America]	Taken into account. This KM has been edited
10115	3	3	45	0		Why limit effects to summer ice and spring snow? Winter ice loss (e.g., lowest ice cover in Bering Sea since 1850 in 2018) may also have these effects. Take out the words "summer" and "snow?" [Lisa Speer, United States of America]	Accepted: Key message re-worded to note loss of sea ice in all months.
15525	3	3	45	3	46	This sentence is misleading. As it is phrased, it reads that the last decade is not part of the period of satellite measurements. [EUCE, Belgium]	Taken into account: key message reworded so this phrase no longer appears.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
16865	3	3	45	3	46	This sentence is phrased so that it sounds like the last decade is not part of the period of satellite measurements. [Louise Sandberg Soerensen, Denmark]	Taken into account: key message reworded so this phrase no longer appears.
1561	3	3	45	3	49	Can this be quantified in terms of area/extent and perhaps number of record minimum years in e.g. last 20 years. [Matthew Collins, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account: key message revised, quantitative information added
27585	3	3	45	3	49	Consider to add numbers/quantifications for summer sea ice decline and snow cover, cf quantifications on page 11, from line 34 and onwards. [Government of Norway, Norway]	Taken into account: key message revised, quantitative information added
552	3	3	45	3	51	An example of at least one example of years of abnormally large decline, or an average rate of decline should be presented. [Jenna Pearson, United States of America]	Taken into account: key message revised, quantitative information added
883	3	3	45	3	51	Summer ice is declining massively in the Arctic, yes, but it's not possible that winter and winter ice remains; say so please [Falk Huettmann, United States of America]	Accepted: Key message re-worded to note loss of sea ice in all months.
1635	3	3	45	3	51	Are there quantitative estimates for how much Arctic snow extent and sea ice extent and thickness have declined that can be included? [Nora Richter, United States of America]	Taken into account: key message revised, quantitative information added
4127	3	3	45	3	51	Please include Antarctic sea ice trend which show slight increase since 1979 with low confidence. [Seong-Joong Kim, Republic of Korea]	Taken into account: key message added on Antarctic sea ice

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
10203	3	3	45	3	51	Suggest providing the rate of decrease of summer Arctic sea ice and spring snow cover and the projected timing of ice-free summer and snow-free spring under different RCP scenarios. [SAI MING LEE, China]	Taken into account: key message revised, quantitative information added
11057	3	3	45	3	51	In the sea ice paragraph only the Arctic is discussed. I suggest to add a short text on sea ice in the Antarctic. [Peter Lemke, Germany]	Accepted: key message on Antarctic sea ice added
13841	3	3	45	3	51	It is not clear from the text that declines in Arctic summer sea ice and snow cover are reinforcing the global warming trend - suggest this is clarified in this statement. [Government of United Kingdom (of Great Britain and Northern Ireland), United Kingdom (of Great Britain and Northern Ireland)]	Accepted: key message revised
13843	3	3	45	3	51	It would very helpful to included % estimates of Arctic summer sea ice and snow cover extent decline over the satellite era in this statement. [Government of United Kingdom (of Great Britain and Northern Ireland), United Kingdom (of Great Britain and Northern Ireland)]	Taken into account: key message revised, quantitative information added
22715	3	3	45	3	51	Antarctic equivalent summary is missing. This sentence could be followed by a sentence regarding Anatarctic sea ice or if there is not enough research or evidence to draw conclusions from, should state the need to build more knowledge [Greenpeace Group Review, Republic of Korea]	Accepted: key message on Antarctic sea ice added

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
27537	3	3	45	3	51	Indicate/clarify terrestrial snow or snow on sea ice because there is less certainty in the trends of snow on sea ice thus making it perhaps a bit misleading to indicate snow cover extent declines in the same sentence as sea ice declines without indicating if it is terrestrial snow or snow on sea ice. [Benjamin A. Lange, Canada]	Taken into account: key message revised
19535	3	3	46	3	46	I think you can use the terminology 'very high confidence' for this statement instead of 'high confidence'. See Section 3.2.1.1.1 (P11 L36-37), where you mention 'very high confidence' for the decline in Arctic sea-ice extent for all months. There is indeed robust evidence and high agreement. [APECS Group Review, Germany]	Accepted: confidence language changed for consistency in the chapter
11215	3	3	47	3	48	"Observed and projected reductions in snow extent and sea ice extent and thickness affect the global climate....." I suggest to be changed to "Observed and projected reductions in snow extent, sea ice extent and thickness affect the global climate....." [Burcu Ozsoy, Turkey]	Taken into account: key message revised (wording no longer appears)
3507	3	3	47	3	49	Suggest: "projected future reductions" and "albedo decreases that affect the surface energy budget." to improve clarity. [Richard Allan, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account: key message revised (wording no longer appears)
4651	3	3	47	3	49	Note that here shows the observation, so please delete "projected". [botao zhou, China]	Taken into account: key message revised (wording no longer appears)
9021	3	3	49	0		Should it not be "the" surface energy budget? [Nina Hunter, South Africa]	Taken into account: key message revised (wording no longer appears)
11157	3	3	49	3	49	In my opinion we have limited understanding of the Arctic energy balance to assess with „very high confidence“ that their changes affect the global climate system. For example, TOA albedo changes both in observations and in model simulations are quite low in years of low sea-ice coverage, because most of the radiation is reflected by clouds. Hence, the global impacts might be quite low. Besides, there is huge spread in CMIP5 simulations regarding the Arctic energy budget, which again makes it difficult to justify the term „very high confidence“. We will not use this level of confidence for AR6. [Dirk Notz, Germany]	Taken into account: key message revised (wording no longer appears)
12071	3	3	49	3	51	Emerging evidence indicates that changes in Arctic sea ice can influence weather outside the Arctic on timescales of weeks to month (low confidence). {3.3.1.1; 3.4.1.1; Box 3.1} There are many studies that have revealed the impact of Arctic sea ice on weather and climate at mid-latitudes. So please check why this conclusion is of low confidence. [Government of China, China]	Taken into account: we agree that there is a large body of literature, but we apply low confidence to this statement because we assess that the specific mechanisms and the specific cases for which changes in Arctic sea ice have already driven midlatitude weather are not clear.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
14989	3	3	49	3	51	This statement seems very cautious, given recent observations and substantive new research indicating a strong influence of changes in the Polar-mid lat temperature gradient (with sea ice being an important factor) on persistent weather conditions, summer and winter extremes in Northern mid-latitudes (see, e.g., https://www.nature.com/articles/s41467-018-05256-8 for a recent review, or http://advances.sciencemag.org/content/4/10/eaat3272 , https://www.nature.com/articles/srep45242 more specifically). While these interactions may not yet be well-enough understood or described to constitute a robust finding, there is emerging evidence for a potentially high-impact risk to society. Please consider to include a more substantial discussion in the text, e.g. Box 3.1, with conclusions being lifted to the ES and SPM. [Government of Germany, Germany]	Taken into account: see comment 12071. New chapter box added to address this issue.
18781	3	3	49	3	51	I believe section 3.3.1.1 is miss-referenced in this statement [APECS Group Review, Germany]	Accepted: change made
9023	3	3	50	0		month' should be plural [Nina Hunter, South Africa]	Accepted: change made
31099	3	3	50	0		The changes in weather outside the Arctic need quantification to the extent possible (e.g. lowering of winter temperatures, stagnant heat waves) even if anecdotal for regional trend with an evaluation of the changing likelihood of their occurrence. [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account: now better captured in new standalone Box 3.2
28109	3	3	50	3	50	Change month to months. [Peter Barrett, New Zealand]	Accepted: change made
3701	3	3	50	3	51	the Executive Summary is no place for a "low confidence" statement; either delete the low confidence portion or rephrase it to enable a higher confidence. [Dee Williams, United States of America]	Rejected: low confidence statements can appear in the ES
23915	3	3	51	3	51	The reference to Chapter 3.3.1.1 could be deleted because this chapter only describes about Antarctic sea ice. [Government of Japan, Japan]	Accepted: change made
31101	3	4	1	0		To be more illustrative can the change or projection in permafrost temperature levels and area affected (cf. SR1.5) be quantified (even if in regional examples)? [Hans-Otto Poertner and WGII TSU, Germany]	Accepted: change made
27845	3	4	1	0	9	This discussion of permafrost carbon is compelling and should be mirrored in the High Mountain chapter which does not include this type of compelling discussion. [Ko Barrett, United States of America]	Noted-this material is more relevant and more important in Polar regions as compared to high mountains
30121	3	4	1	4	1	Paper by Biskaborn et al in press 2019 in Nature Communications (Permafrost is warming at a global scale) finds clear trends of global warming for all permafrost types (Arctic continuous, Arctic discontinuous, Antarctic, and Mountain permafrost) based on analysis of 124 borehole records of the Global Terrestrial Network for Permafrost for the decade from 2007-2016. This indicates "very high confidence" instead of just "high confidence" for the statement "Permafrost temperatures have continued to increase to record high levels" in the report. [Guido Grosse, Germany]	Accepted-these revisions have been made
10205	3	4	1	4	8	Suggest providing the estimated area of permafrost that has thawed and the associated carbon emissions, and the projected area of permafrost thaw under different RCP scenarios. [SAI MING LEE, China]	Accepted-these revisions have been made

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
1563	3	4	1	4	9	Some overlap with Chapter 2 here. [Matthew Collins, United Kingdom (of Great Britain and Northern Ireland)]	Noted
14991	3	4	1	4	9	It would be very helpful to complement this statement by estimates about the magnitude of potential carbon loss. IPCC SR1,5 indicates up to 100 Gt CO2 uncertainty in the 2100 carbon budget coming from permafrost and wetland feedbacks (cf. IPCC SR1,5 Chapter 2.2.2.2, p 107 and Annex to chapter 2). We are aware that these estimates are highly uncertain but would appreciate an order of magnitude to better assess implications. Also, given that many governments will recall the recent estimates from SR1,5, it would be helpful to build on that assessment, update or reference it here for consistency and transparency. [Government of Germany, Germany]	Accepted-these revisions have been made
18783	3	4	1	4	9	This paragraph reports on global climate impacts of permafrost thawing across Arctic and boreal systems. It only mentions the the (organic) carbon cycle, thus the widely studied greenhouse gases CO2 and CH4. However, the nitrogen cycle is also affected by permafrost thawing. Hence the greenhouse gas N2O (up to 300x warming potential compared with CO2 on a 100-year timescale), although much less concentrated in the atmosphere, is also contributing to global climate change. Maybe this could be added in this paragraph, at least it should be highlighted in the corresponding section (3.4.1)? [APECS Group Review, Germany]	Noted-this section is about carbon feedbacks and space constraints do not allow for extended discussion of the nitrogen cycle
22717	3	4	2	4	4	This sentence should be a part of the headline statement also [Greenpeace Group Review, Republic of Korea]	KM has been restructured
31103	3	4	4	0		The influence on global climate would also need to be quantified / qualified to the extent possible, cf. In SR1.5 this was done through an estimate of the contribution of permafrost carbon to the residual carbon budget by 2100. Orders of magnitude of methane release should at least be presented based on chapter text. [Hans-Otto Poertner and WGII TSU, Germany]	Accepted-these revisions have been made

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
472	3	4	5	4	5	Evidence is the wrong word, since nothing has been observed yet in the year 2100 [Cecilie Mauritzen, Norway]	Rejected-'evidence' is anything presented in support of an assertion. It does not imply physical evidence
23585	3	4	7	4	8	Some further information would be useful concerning "There is low confidence concerning the level to which increased plant growth will compensate these losses.", as it does not give any indication on whether such compensation might be relevant/significant/matter, or suchlike. [Government of Sweden, Sweden]	Noted-space constraints prevent extended discussion here, but this topic is covered in main text 3.4
33081	3	4	11	0		Capitalize "ice sheet" to be consistent with the form in following sentences. [Government of United States of America, United States of America]	Now capitalised when a proper noun.
554	3	4	11	4	11	The rates of mass loss have increased to what numbers? [Jenna Pearson, United States of America]	Now added.
17689	3	4	11	4	13	the use of "has" in this paragraph, without an end date specified suggests (to me) a sort of monotonic increase, whereas the rates have increased and decreased over this period depending on the window you choose. [Matt King, Australia]	Now revised.
1565	3	4	11	4	17	Can these mass losses be quantified? [Matthew Collins, United Kingdom (of Great Britain and Northern Ireland)]	Now quantified.
1637	3	4	11	4	17	If we know that mass loss has increased since 2000, do we have data that can be briefly summarized to support this conclusion (e.g., how much mass was lost from the Greenland ice sheet and polar glaciers before 2000 and since 2000)? [Nora Richter, United States of	Done

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
10207	3	4	11	4	17	Suggest providing the rates of ice loss of the Greenland and Antarctic Ice Sheets for different periods of time, similar to Section B.3 of AR5 SPM, so that the readers can appreciate the accelerated ice loss. [SAI MING LEE, China]	Done
26361	3	4	11	4	17	Why is this report measuring ice sheet mass loss from the early 2000's? The literature on Greenland mass loss usually sets the reference point at the early 1990's (most often 1992, from my understanding). [Ethan Pierce, United States of America]	Reporting periods now harmonised with IPCC AR5.
27587	3	4	11	4	17	Add quantifications for ice sheet loss [Government of Norway, Norway]	Done.
27589	3	4	11	4	17	Consider to add a short sentence on the link between ice sheet loss and sea level rise [Government of Norway, Norway]	Done in revised ES key message on ice sheet change.
29633	3	4	11	4	17	It would be helpful if the text indicated the baseline for the comparison/conclusion. It seems to me that it would be useful to say something like compared to their average mass amount over the last thousand years or more. [Michael MacCracken, United States of America]	Observation periods now specified explicitly. Longer term context given in chapter where possible.
11533	3	4	11	4	27	This passage, and all references to the Antarctic Ice Sheet in the report as whole, need to better distinguish between the West Antarctic Ice Sheet and East Antarctic Sheet. Though this passage notes correctly that overall AIS mass loss is dominated by the WAIS, it should note that uncertainties in the sign of the EAIS mass balance mean the data available allow for a positive mass balance for the EAIS. Also that projections suggest parts of the EAIS may see increasing accumulation under near-term warming: e.g. Zwally, H. J., J. Li, J. W. Robbins, J. L. Saba, D. Yi, and A. C. Brenner (2015), Mass gains of the Antarctic ice sheet exceed losses, J. Glaciol., 61(230), 1019-1036, doi:10.3189/2015JoG15J071. [William Howard, Australia]	Space constraints in the ES have precluded explicit discussion of EAIS here, but the EAIS uncertainties and the issues raised by the suggested citation are now covered in the chapter text.
22455	3	4	11	4	27	Suggest clarifying this passage, and all references to the Antarctic Ice Sheet in the report as whole. Suggest they better distinguish between the West Antarctic Ice Sheet and East Antarctic Sheet. Though this passage notes correctly that overall AIS mass loss is dominated by the WAIS, it should note that uncertainties in the sign of the EAIS mass balance mean the data available allow for a positive mass balance for the EAIS. Also suggest noting that projections indicate that parts of the EAIS may see increasing accumulation under near-term warming: e.g. Zwally et al (2015), Mass gains of the Antarctic ice sheet exceed losses, J. Glaciol., 61(230), 1019-1036, doi:10.3189/2015JoG15J071. [Government of Australia, Australia]	Space constraints in the ES have precluded explicit discussion of EAIS here, but the EAIS uncertainties and the issues raised by the suggested citation are now covered in the chapter text.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
29643	3	4	11	4	27	It seems to me that the discussion here is far too sanguine about the potential for mass loss from the Greenland and Antarctic ice sheets. From paleoclimatic data, it is quite plausible that the equilibrium sea level sensitivity is roughly 15-20 meters per degree C-- that has been the rough amount from peak interglacial to present and over Earth history-- what is it that gives high confidence this is not the case. At the Last Glacial Maximum, in addition to present ice amounts, there was roughly a mass of ice on North America equivalent to the mass of ice now on Antarctica--and it melted away in roughly 4000 years when the global average temperature was increasing no more than 5-6 C and the CO2 concentration was less than 300 ppm. How is it that even warmer conditions and a higher CO2 concentration (which influences how much IR is coming downward) won't lead to very serious rapid loss of mass from Greenland, and also a lot from Antarctica. There was also at Last Glacial Maximum there was also almost equivalent of the present Antarctic ice sheet on Eurasia, and it also went quickly. From 20ka to 8ka, sea level rose on average a meter per century when the global average temperature was rising 1 C per 2000 years and the CO2 concentration was less than 300 ppm--now we are warming at least 40X as rapidly and with a CO2 concentration over 400 ppm. It is really hard to understand how the likelihood of SL rise well above 1 m/century is not considered as a very serious risk to society. I just think this section is far too sanguine about the risks that are developing. [Michael MacCracken, United States of America]	Ice sheet projections are in chapter 4.
9025	3	4	13	0		The symbol after "around" is not necessary as "around" already describes it. [Nina Hunter, South Africa]	Changed.
3509	3	4	13	4	13	No need for "~" symbol before "2000" as already state "around the year" [Richard Allan, United Kingdom (of Great Britain and Northern Ireland)]	Changed.
10117	3	4	15	4	17	Take out this sentence. Similar qualifiers re unambiguous are not included in other sections with "very high confidence". By adding it here and not anywhere else, it conveys the impression that the finding is not robust. [Lisa Speer, United States of America]	Agreed and changed.
27591	3	4	15	4	17	Check this statement with statement on page 14, line 7-9. Are they contradictory? Useful quantifications available for anthropogenic influence on ice sheet loss can be found in: Box et al 2019, Key Indicators for Arctic Climate Change. Environmental research letters (submitted) [Government of Norway, Norway]	Agreed and changed. Section now added to chapter that discusses evidence for anthropogenic forcing.
28115	3	4	15	4	17	"..unambiguous attribution of mass loss from ice sheets to anthropogenic influence is currently not available." This may be true but is misleading to leave unqualified. Also the statement can be cited out of context as an indication of a lack of IPCC knowledge on the whole issue. As the Summary for Policymakers states "Glaciers and polar ice sheets are	Agreed and changed. Section now added to chapter that discusses evidence for anthropogenic forcing.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
29039	3	4	15	4	17	Authors and reviewer editors need to seriously consider deleting this sentence from both the SPM (per comment in Row 2, above), and this ES. On what basis arises the need to highlight in both headliner sections this statement on no "unambiguous attribution"? "Unambiguous" is a high standard standard not typically used in IPCC products. More appropriate and consistent would be the scientifically defensible statement that current observed ice mass loss (as opposed to this reference to models to explain the loss, which is a different issue) is "likely" (or appropriate level) due to anthropogenic climate change and then the appropriate level of certainty (even if assigned "medium" or even "low" confidence). SROCC authors should not ignore the reality that the placement of the current statement in the SPM and Ch 2 ES will be used to argue that current ice mass loss from the great ice sheets is actually a natural phenomenon. [Pam Pearson, Sweden]	Agreed and changed. Section now added to chapter that discusses evidence for anthropogenic forcing.
31105	3	4	16	0	17	Yes, but because this is important it must be possible to include a current estimate and a confidence level, even if low. Not even giving an order of magnitude does not seem a viable option. [Hans-Otto Poertner and WGII TSU, Germany]	Agreed and changed. Section now added to chapter that discusses evidence for anthropogenic forcing.
15527	3	4	16	4	17	This sentence may be scientifically accurate, but policy-wise it is unfortunate. The end of this sentence would suggest loss from ice sheets cannot be linked to emissions. The lack of availability of attribution science should be perhaps put into context of what we know about these processes. [EUCE, Belgium]	Agreed and changed. Section now added to chapter that discusses evidence for anthropogenic forcing.
23587	3	4	16	4	17	"unambiguous attribution of mass loss from ice sheets to anthropogenic influence is currently not available." appears a bit complicated. Does it say that attribution at 100% certainty is not possible? Or that no attribution can be done? Of interest would be what kind of attribution statement is possible. [Government of Sweden, Sweden]	Agreed and changed. Section now added to chapter that discusses evidence for anthropogenic forcing.
3511	3	4	19	0		"available" --> "possible"? [Richard Allan, United Kingdom (of Great Britain and Northern Ireland)]	Section revised.
13851	3	4	19	4	21	...under the influence' - phrasing is unclear, rephrase to 'mainly due to the influence of warm ocean waters'? [Government of United Kingdom (of Great Britain and Northern Ireland), United Kingdom (of Great Britain and Northern Ireland)]	Section revised.
14993	3	4	19	4	27	Line 25-27: "Greenland Ice Sheet..." Section treats only Antarctica. Greenland doesn't fit here. Move last sentence to paragraph before. [Government of Germany, Germany]	Section revised.
26363	3	4	19	4	27	AR5 discussed "tipping points" relative to Greenland mass loss (in the 1.5-2.5 degrees C range). It may be worth referencing that directly in the clause about atmosphere-induced surface melt, as the idea of a Greenland ice sheet tipping point has since permeated beyond the scientific community. [Ethan Pierce, United States of America]	Ice sheet projections are in chapter 4.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
29043	3	4	19	4	27	Also per the above comment, suggest a reference to low v. high emissions scenarios affecting not only Greenland melt rates, but also the scale and speed of potential unstable WAIS retreat, per for example model work in Joughin et al (2014). For example, "The degree and speed of such WAIS retreat or Greenland loss will be affected by emissions trajectories and related degrees of temperature rise by the end of this century, and even more so in the long term." This might be only low confidence due to modeling uncertainties, but an important reference. [Pam Pearson, Sweden]	Ice sheet projections are in chapter 4.
29637	3	4	19	4	27	If there is medium confidence of a risk of unstable retreat, how is it that the uncertainty limits for future sea level rise are not significantly larger than indicated in this assessment (such as in the figure in Chapter 1)? [Michael MacCracken, United States of America]	Key-message statement substantially revised.
29635	3	4	20	4	20	It seems to me that most readers won't understand what is meant by "warm" given how cold the waters actually are. I'd suggest instead saying "warming", so give direction of change instead of suggesting that waters so cold no one could survive in for of order minutes are "warm" [Michael MacCracken, United States of America]	Agreed that this is a difficult one to communicate briefly. In the end we wanted to avoid suggesting that the waters had warmed (when it is likely instead that 'warm' waters have shoaled), and so didn't use 'warming' in the revised statement.
15529	3	4	20	4	21	The statement 'this demonstrates the potential for accelerated rates of future ice sheet loss and sea level rise' is not associated with a confidence level. [EUCE, Belgium]	Now revised.
16867	3	4	20	4	21	The statement 'this demonstrates the potential for accelerated rates of future ice sheet loss and sea level rise' is not associated with a confidence level. [Louise Sandberg Soerensen, Denmark]	Now revised.
17691	3	4	20	4	21	how does the current changes "demosntrate the potential for accelerated..." - this is not true - the past or present is not a predictor of the future without some theoretical framework [Matt King, Australia]	Now revised.
23103	3	4	21	4	22	Nice statement about new evidence, typically what needs to be conveyed at the level of SPM. [Valerie Masson-Delmotte, France]	(No action needed)
33085	3	4	23	0		The phrase "unstable retreat" should perhaps be explained or reworded since "unstable" means something different in vernacular and regarding ice sheet retreat. [Government of United States of America, United States of America]	This statement now substantially revised and expanded (new message 13).
31107	3	4	23	0	25	Yes, but because this is important it must be possible to include a current estimate and a confidence level, even if low. Not even giving an order of magnitude does not seem a viable option. It would already help to say what has changed in quantitative terms since AR5. To be consistent across reports starting point should also be what the SR1.5 has to say about this. [Hans-Otto Poertner and WGII TSU, Germany]	This statement now substantially revised and expanded (new message 13).
25227	3	4	23	4	25	This sentence is a bit confusing because it begins with "It is not currently clear ..." and ends with "medium confidence." I would expect that something that is not currently clear is an assertion with low confidence. I suggest changing the wording to state that "it is possible that unstable retreat is underway" with "medium confidence" or leave the statement that "it is not currently clear" but downgrade to "low confidence" (whichever the reviewed literature supports). [Denis Felikson, United States of America]	This statement now substantially revised and expanded (new message 13).

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
33083	3	4	23	4	25	This sentence isn't clear as written. It contains two pieces of information: 1) it's unclear whether or not unstable retreat of the WAIS is underway, 2) there is potential for accelerated rates of ice sheet discharge and (consequently) a higher probability of higher (then currently estimated?) future sea level rise. The sentiment that's trying to be communicated here is that, if (1) is true, then (2) may happen. But it's confusing as written. Is the medium confidence on the latter thought conditional (i.e., if (1) occurs than we have med. conf. that (2) will occur)? [Government of United States of America, United States of America]	This statement now substantially revised and expanded (new message 13).
28257	3	4	25	0		Same comment as above. The use of the word 'dominated by atmosphere-induced surface melt' for ice loss in Greenland seems to suggest that dynamic changes can be neglected. This is inconsistent with the fact these have accounted for some 40% of ice loss over the last two decades (as stated in this chapter) which imply that dynamic changes are still a substantial player even if not the largest. Similarly I am not sure that we can say that greenland changes will not increase from both SMB and dynamic changes over the next 100 years - as suggested by the next sentence. I don't think the dynamic ice sheets models are at a place where we can say this yet. [Straneo Fiamma, United States of America]	Agreed, now revised.
15531	3	4	25	4	27	some further explanation is needed here. It is not clear why an ice sheet that is dominated by atmosphere-induced surface melt cannot have the potential to cause large increases in the projected rate of future sea-level rise. [EUCE, Belgium]	Agreed, now revised.
16905	3	4	25	4	27	some further explanation is needed here. It is not clear why an ice sheet that is dominated by atmosphere-induced surface melt cannot have the potential to cause large increases in the projected rate of future sea-level rise. [Louise Sandberg Soerensen, Denmark]	Agreed, now revised.
11077	3	4	26	4	26	According to page 47, line 29 shouldn't it be "medium confidence"? [Peter Lemke, Germany]	Statement on Greenland melt now revised and expanded.
29041	3	4	26	4	27	What is meant by "limited" -- given the strong tie to atmospheric temperature, does this not indicate instead that rates from Greenland sources might increase substantially, even by 2100 under high emissions scenarios, with not only the related rise in temperature but increased length of melt season both temporally and at higher altitudes on Greenland? It would be more accurate to state here that "rates of mass loss will increase under high emissions scenarios given higher atmospheric temperatures, and would be constrained by lower temperature increase under low emissions scenarios." If the constaining factor is instead simply the amount of ice mass that can be lost during any given melt season, this should be stated instead, and perhaps add, "since melt loss occurs only seasonally, during periods of above-zero atmospheric temperature." [Pam Pearson, Sweden]	Statement on Greenland melt now revised and expanded.
556	3	4	29	4	29	This is an excellent section to include. [Jenna Pearson, United States of America]	Noted, with thanks
10119	3	4	31	0		Take out "terrestrial," snow loss also has effects in sea ice environments. [Lisa Speer, United States of America]	Rejected: this key message is focused on terrestrial snow, not snow on sea ice

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
11561	3	4	31	4	31	"Projected warming will result in continued loss of Arctic sea ice ..." Need to cautious saying something *will* happen in general. The magnitude of trends projected here are scenario-dependent, so it's not always appropriate to say what "will" happen. 1) We don't know what "will" happen; 2) Saying something "will" happen presents it as a foregone conclusion we can't do anything about. That is not the message IPCC is trying to send I think. Say instead "Projected warming is likely to result in continued loss of Arctic sea ice ..." [William Howard, Australia]	Accepted: wording revised
22457	3	4	31	4	31	Suggest avoiding terms such as *will*. For example, "Projected warming will result in continued loss of Arctic sea ice ...". The magnitude of trends projected here are scenario-dependent, so it's not always appropriate to say what *will* happen. Suggest instead "Projected warming is likely to result in continued loss of Arctic sea ice ..." [Government of Australia, Australia]	Accepted: wording revised
1567	3	4	31	4	41	Again, some numbers would be good here. Surprised that great mass loss from Arctic glaciers under RCP8.5 when compared to RCP2.6 is only medium confidence. [Matthew Collins, United Kingdom (of Great Britain and Northern Ireland)]	Accepted: key message revised
11059	3	4	31	4	41	In this paragraph only the Arctic is presented. I suggest to add a short text on the Antarctic. [Peter Lemke, Germany]	Accepted: key message added on Antarctic sea ice
4653	3	4	33	4	34	Here and elsewhere: to be accurate, please clarify that it is for the middle of the 21st century and the end of the 21st century. [botao zhou, China]	Accepted: text revised
31109	3	4	34	0	35	To be consistent across reports starting point should also be what the SR1.5 has to say about this. [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account: sea ice projections KM is consistent with SR1.5
29639	3	4	35	4	37	It seems to me the phrasing here is going to tend to further polarize the discussion on the Arctic rather than moderate it. The way it is phrased here, this strictly means, I presume, that there is low likelihood that there will be no Arctic sea ice (or less than 1M square km) lasting all three summer months without a break, and this is not a comment on how often there will be no ice in just September, which seems to be the major interpretation being argued in the press. It just seems to me that there needs to be a very clear explanation of what is meant by the statement here and how it compares to the public discussion interpretation of all of this. Please make the statement clearer by explicitly defining terms being used, etc. [Michael MacCracken, United States of America]	Accepted: wording clarified
18785	3	4	35	4	39	It's unclear here if the mitigation includes any stabilized global warming making this first sentence a bit confusing; it needs the context from within the report which as a summary it shouldn't need. [APECS Group Review, Germany]	Taken into account: wording revised
31111	3	4	36	0		To be consistent across reports starting point should also be what the SR1.5 has to say about this. In light of that the term «infrequent» is not a sufficient quantifier. [Hans-Otto Poertner and WGII TSU, Germany]	Accepted: text revised to include quantification of 'infrequent'
15533	3	4	36	4	36	Please, clarify or define what is meant by 'infrequent' [EUCE, Belgium]	Accepted: text revised to include quantification of 'infrequent'

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
16869	3	4	36	4	36	Be more clear here about what is meant by 'infrequent' [Louise Sandberg Soerensen, Denmark]	Accepted: text revised to include quantification of 'infrequent'
27593	3	4	36	4	36	Is it possible to use another term than "infrequent"? The original text on page 25, line 34, says "individual ice free years are still projected to occur" -- makes more sense than "infrequent". [Government of Norway, Norway]	Accepted: text revised to include quantification of 'infrequent'
29045	3	4	36	4	37	Change second half of sentence to read, "...infrequent and limited to the August-September time frame; at temperatures above 2 degrees, ice-free conditions are anticipated every year and often stretching from July to October." per extensive published literature cited here. Perhaps add also, "This will enhance regional warming and related loss of Greenland ice mass and seasonal snow cover." [Pam Pearson, Sweden]	Accepted: text revised
28505	3	4	37	0		Clarify: phrase "stabilization of ... losses" = rate of loss becomes constant (such that snow cover keeps decreasing year-on-year at a fixed rate), but I think you mean (in the medium mitigation case) loss goes to zero and *levels* stabilize. [Yvonne Firing, United Kingdom (of Great Britain and Northern Ireland)]	Accepted: text revised
3513	3	4	40	0		"Mass loss of Arctic glaciers will be greater under RCP8.5 than RCP2.6 (medium confidence)." seems obvious. Can an estimated magnitude difference be added or otherwise perhaps this could be removed. [Richard Allan, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account. Our new cross chapter box provides updated glacier projections and confidence language, including an explanation for why confidence is medium.
31113	3	4	40	0	41	Can this be put on a timescale and be quantified to the extent possible (rate, factor, order of magnitude etc.)? [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account. Our new cross chapter box provides updated glacier projections and confidence language, including an explanation for why confidence is medium.
14995	3	4	40	4	41	Last sentence is obvious. Medium confidence seems too weak. Mass loss of glaciers should be expected to be greater in scenario RCP 8.5 than for RCP 2.6! Please specify the findings and what the confidence assessments refer to. [Government of Germany, Germany]	Taken into account. Our new cross chapter box provides updated glacier projections and confidence language, including an explanation for why confidence is medium.
10121	3	4	41	0		only medium confidence in this? [Lisa Speer, United States of America]	Taken into account. Our new cross chapter box provides updated glacier projections and confidence language, including an explanation for why confidence is medium.
9495	3	4	41	4	41	Acronym RCP (Representative Concentration Pathway) should be introduced in this chapter. [Government of France, France]	Rejected. RCPs are defined in the SROCC Glossary
29641	3	4	41	4	41	The word "greater" seems a serious understatement--there will be far less glacial mass in the even of strong versus weak mitigation--very large difference. And this will be a great difference in the ice sheets too. [Michael MacCracken, United States of America]	Taken into account. Our new cross chapter box provides updated glacier projections and confidence language, including an explanation for why confidence is medium.
1639	3	4	43	4	49	What specific climate changes are leading to these changes in primary production? [Nora Richter, United States of America]	Taken into account. We added the primary factors underlying change.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
29791	3	4	43	4	49	In the summary, but more so in the related main text, I think it is important to also mention the likelihood of increase importance of benthic primary production due primarily to the retraction of seaice, and to warming. This is often entirely neglected even though the Arctic has a huge coastline, representing about 34% of the worlds coastline (Lantuit et al., 2012), with large potential for expanding benthic primary producers in a warmer future (Krause-Jensen & Duarte 2014). So please do not neglect benthic primary production! [Dorte Krause-Jensen, Denmark]	Noted. These issues are discussed in the main text.
33087	3	4	43	4	49	Are the Antarctic primary production increases due to increased warming due to climate change? Recent studies suggest that the controls of phytoplankton growth in the Ross Sea are still unknown. See quote: "However, our understanding of the environmental controls on phytoplankton growth and standing stocks is still incomplete, and to date, current variations that affect the pelagic food web remain mostly unknown [8, 9]. Therefore, these topics are included in the list of the 80 priority scientific questions for future Antarctic research, as identified by the 1st Scientific Committee on Antarctic Research, Antarctic and Southern Ocean Science Horizon Scan." (Mangoni O, Saggiomo V, Bolinesi F, Margiotta F, Budillon G, Cotroneo Y, et al. (2017) Phytoplankton blooms during austral summer in the Ross Sea, Antarctica: Driving factors and trophic implications. PLoS ONE 12(4):e0176033.https://doi.org/10.1371/journal.pone.0176033) [Government of United States of America, United States of America]	Taken into account. This KM has been split into observed and projected changes in primary production in the revised draft, and the drivers of observed change have been clarified. Uncertainty regarding drivers of change in Southern Ocean primary production at the regional scale are discussed in the main text (Section 3.2.3.2.1).
33089	3	4	43	4	49	There should be mention of the sensitivity of ecosystem impact projections to which mitigation/emissions scenario occurs, as in the previous paragraph (pg.4, lines39-41). [Government of United States of America, United States of America]	Rejected. Detailed coupled bio-physical models of polar ecosystems have been completed in only a few regions and thus, we did not address differences by scenario.
28501	3	4	44	4	49	Why aren't there confidence indicators on individual statements in this paragraph as there are for most of the other points? [Yvonne Firing, United Kingdom (of Great Britain and Northern Ireland)]	Accepted. We added these statements into the key message
15535	3	4	44	5	7	Confidence levels are not indicated in the section but only in the headlines. Please, clarify. [EUCE, Belgium]	as above
16871	3	4	44	5	7	Why are onfidence levels not indicated in these section but only in the headlines? [Louise Sandberg Soerensen, Denmark]	as above
13853	3	4	46	4	46	Please clarify what the 'spatial distribution' refers to, is it the distribution of organisms/species? [Government of United Kingdom (of Great Britain and Northern Ireland), United Kingdom (of Great Britain and Northern Ireland)]	Taken into account. This statement refers to the impacts of shifting hotspots of production and the associated responses of predators.
33091	3	4	47	4	48	The statement, "In the Antarctic, primary production is projected to increase in regions near to the Antarctic continent," should have a confidence label attached to it. [Government of United States of America, United States of America]	Noted. This KM has been removed in the revised Exec Summary
23105	3	4	49	4	49	repetition of Antarctic in the same sentence [Valerie Masson-Delmotte, France]	Accepted. We added these statements into the key message

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
27261	3	4	49	4	49	Krill biomass is known to undergo 5- to 6-year population cycles, with large variation between population minima and maxima. These oscillations have been postulated to be driven by periodic climatological factors (Ryabov et al., 2017). Ryabov, A. B., de Roos, A. M., Meyer, B., Kawaguchi, S., & Blasius, B. (2017). Competition-induced starvation drives large-scale population cycles in Antarctic krill. <i>Nature Ecology & Evolution</i> , 1, 0177. [Gleyci Moser, Brazil]	Rejected. This is a very specific comment at a level of detail more appropriate for consideration in the main text than in the executive summary. Unfortunately due to space limitations we were not able to incorporate the paper referenced by the reviewer.
27263	3	4	49	4	49	Changes in PP and krill due to climate changes also affects migration patterns of Megaptera novaeanglaeae- (Gian -Reto et al. 2002- <i>Nature</i> volume 416, pages 389–395 (28 March 2002); Changes were documented for birds and seals- Nicol Stephen, Worby Anthony, Leaper Rebecca (2008) Changes in the Antarctic sea ice ecosystem: potential effects on krill and baleen whales. <i>Marine and Freshwater Research</i> 59, 361-382. [Gleyci Moser, Brazil]	Rejected. As above, this is a very specific comment at a level of detail more appropriate for consideration in the main text than in the executive summary. Unfortunately due to space limitations we were not able to incorporate the papers referenced by the reviewer.
31115	3	4	51	0	52	Can the impact on fisheries be quantified in relation to scenarios? [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account. There are only a few regions where coupled biophysical models that include fisheries have been completed. The results of these studies are discussed in the chapter. See also chapter 5
11563	3	4	51	4	51	"The cascading effects will have impacts on fisheries ..." We don't know what *will* happen, or that cascading effects *will* actually occur. Reword as "possible cascading effects present risk for fisheries ..." or similar wording [William Howard, Australia]	This comment was accepted.
22459	3	4	51	4	51	Suggest avoiding terms such as *will*. For example, "The cascading effects will have impacts on fisheries ...". Suggest rewording as "possible cascading effects present risks for fisheries ..." or similar. [Government of Australia, Australia]	This comment was accepted.
885	3	4	51	4	52	Wide understatement, again. Reality is already much worse. [Falk Huettmann, United States of America]	Reject. The ES statements summarise the key assessment finding from the chapter, which are based on the body of published literature.
1641	3	4	51	5	7	What climate changes are the most important and will have the largest impact on fisheries? [Nora Richter, United States of America]	Rejected. Projected impacts of climate change will effect fish distribution and abundance in multiple ways and no single factor can be assigned as the most important factor.
10123	3	4	51	5	7	This is a crucially important point. [Lisa Speer, United States of America]	Noted. We agree
13855	3	4	51	5	7	Please make clear the timescale over which these impacts are projected for - end of century or sooner? [Government of United Kingdom (of Great Britain and Northern Ireland), United Kingdom (of Great Britain and Northern Ireland)]	Rejected. There are only a few regions where coupled biophysical models that include fisheries have been completed. Therefore it is challenging to fully address when these impacts will be realized.
27595	3	4	51	5	7	Consider to add findings on ocean acidification in this key message [Government of Norway, Norway]	Taken into account. We've added key messages for ocean acidification.
27597	3	4	51	5	7	The key message links climate impacts to marine ecosystems and fisheries and the global supply of fish and shellfish. Have you considered using the term food security here, with referenve to 3.4.3.3.1? [Government of Norway, Norway]	Rejected. These issues were addressed in Chapter 5.
23383	3	5	0	5		There is a need to harmonise ES statements across chapters linked to projections. "higher emission scenarios" is vague (which ones? Which levels of warming? When?) [Valerie	Accepted; we have clarified such statements

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
33093	3	5	1	0		What does responsiveness mean in the phrase "the responsiveness of precautionary management approaches"? Are the precautionary approaches responding to something and, if so, to what (to new observations; to new projections; to fluctuations in the economy)? Are the precautionary management approaches already in place? Suggest clarifying this sentence. Perhaps something similar but less wordy than: "the implementation of precautionary management approaches and their responsiveness to new scientific findings." [Government of United States of America, United States of America]	Taken into account. This is addressed in the chapter text.
887	3	5	1	5	3	There is no precautionary approach I know of. Wrong assumption. Reality is much worse. [Falk Huettmann, United States of America]	We disagree; in both the Antarctic and Arctic there are strong limits on fish and shellfish removals that are consistent with the notion of the precautionary approach. The point made here is about the utility and limitation of this approach for sustaining fisheries under rapid ecosystem change..
2519	3	5	1	5	3	Awkward sentence [Michiel Van den Broeke, Netherlands]	Taken into account. We edited this KM
28503	3	5	1	5	7	Why aren't there confidence indicators on individual statements in this paragraph as there are for most of the other points? [Yvonne Firing, United Kingdom (of Great Britain and Northern Ireland)]	Accepted. Confidence statements were added
31117	3	5	2	0		Measurable is not a satisfying quantifier. [Hans-Otto Poertner and WGII TSU, Germany]	Accepted. Agree the word was removed
33095	3	5	4	0		The use of 'degree' in "degree of climate change" is a poor wording choice, since it can refer to a specific temperature. Perhaps change this to level, magnitude, extent, or intensity "of climate change". [Government of United States of America, United States of America]	Accepted. We agree we changed this word
10125	3	5	5	5	6	This is true even under lower emissions scenarios given warmth already in the system Suggest ending sentence after "fisheries." [Lisa Speer, United States of America]	Rejected. We disagree, this statement now has low confidence.
33097	3	5	5	5	7	A confidence label should be attached to the first statement. The last sentence overstates its conclusion and is not entirely consistent with the previous sentence. The first sentence says "current management strategies may not sustain... fisheries under higher emissions scenarios." This does not logically lead to the definitive conclusion that "existing ...management frameworks" have limited ability to address change. Rather, it implies that existing management frameworks "[may]" have limited ability to address change. [Government of United States of America, United States of America]	Accepted. We added confidence to this statement.
31119	3	5	6	0		Can the limits to management, i.e. limits to adaptation be quantified in relation to a climate scenario, timeline? [Hans-Otto Poertner and WGII TSU, Germany]	Rejected. Coupled biophysical models that include fisheries and human responses are under development and thus linking this to a scenario would be challenging.
27599	3	5	9	5	10	consider to use other terminology than "disturbance regimes", as this will not be known to all -- alternatively add examples (fires, floods, insect and pathogen outbreaks? etc). [Government of Norway, Norway]	Accepted-these revisions have been made

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
2521	3	5	9	5	11	Again awkward formulation. Climate-related, probably meant is: Climate-change-related? Freshwater ice, is glaciers? Disturbance regimes?? [Michiel Van den Broeke, Netherlands]	Accepted: key messages re-worded
29793	3	5	9	5	11	regarding the vegetation: I suppose this is expected to be expanding, which could help increase food security... [Dorte Krause-Jensen, Denmark]	Accepted: key messages re-worded
27601	3	5	9	5	17	Would be beneficial if you could be more specific on what types of changes that are expected, such as changes in growing season, greening/browning, etc [Government of Norway, Norway]	Accepted: key messages re-worded
31121	3	5	10	0	11	The linkages between these aspects and the water and food security for people are blurred and would need to be disentangled. [Hans-Otto Poertner and WGII TSU, Germany]	Accepted: key messages re-worded
31085	3	5	11	5	11	Can "...in the region" be added to this sentence to increase clarity (in contrast to consequences that will be felt around the world, which are addressed in many other paragraphs of this Executive Summary)? [Hans-Otto Poertner and WGII TSU, Germany]	Accepted: key messages re-worded
31123	3	5	12	0		Can this be quantified in light of recent collapse of caribou? [Hans-Otto Poertner and WGII TSU, Germany]	Accepted: key messages re-worded
31125	3	5	15	0		Can limits to adaptation be quantified, possibly also in relation to a climate scenario, timeline? [Hans-Otto Poertner and WGII TSU, Germany]	Accepted: key messages re-worded
33099	3	5	15	5	16	This sentence reads like the adaptation measures are constraining benefits from new opportunities. The intent is to say that the limits are what constrain benefits. An example of something that limits the adaptation success should perhaps be given here as well. [Government of United States of America, United States of America]	Accepted: key messages re-worded
27603	3	5	16	5	16	Not sure everyone will know what subsistence activities are. Consider to explain/give examples. [Government of Norway, Norway]	Accepted: key messages re-worded
5005	3	5	19	5	19	There is need to be precise about what is meant by "permafrost change" as "change" can be in any direction. Rather consider "permafrost thaw"... [Debra Roberts and Durban Team, South Africa]	Accepted: key messages re-worded
27605	3	5	19	5	23	Consider to add potential release of carbon from permafrost -- it is needed somewhere in the key messages, and this may be a place for it (with reference to faq 3.1, page 101). [Government of Norway, Norway]	Accepted: key messages re-worded
31127	3	5	20	0	21	Be more specific here, while the next half sentence is exactly what is needed. [Hans-Otto Poertner and WGII TSU, Germany]	Accepted: key messages re-worded
5007	3	5	20	5	21	Consider specifying the actual RCP scenario being referred to here. "weak scenario" is a bit ambiguous. [Debra Roberts and Durban Team, South Africa]	Accepted: key messages re-worded
22721	3	5	20	5	22	Throughout the summary there are several ways in which projections are identified: "higher emission scenarios" or in this sentence "weaker climate mitigation scenarios". These may be open to subjective interpretation and therefore it is suggested, especially in this sentence where specific values and timeline is given, exactly which RCP or temperature scenarios are used. [Greenpeace Group Review, Republic of Korea]	Accepted: key messages re-worded
33101	3	5	22	5	23	A confidence label is probably needed when saying that basing requirements and codes on past records is "not sufficient". Or the authors could say "unlikely to be sufficient". [Government of United States of America, United States of America]	Accepted: key messages re-worded

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
10127	3	5	25	5	31	Very important point (that regulatory controls are not keeping pace with changes). [Lisa Speer, United States of America]	Taken into account: we retain this language
22719	3	5	25	5	31	The headline statement only addresses a part of the whole and omits the potential risk for such increased marine transport and tourism activities. Suggestion to include wording of the headlines statement to reflect associated risks. [Greenpeace Group Review, Republic of Korea]	Taken into account: we retain risk language in the body of the key message
31129	3	5	28	0		It must be possible to quantify these implications, e.g time savings, fuel savings, tradeoffs. [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account: key message revised
9027	3	5	29	0		Replace 'they' with 'this'; change 'create' to 'creates' [Nina Hunter, South Africa]	Accepted: text revised
889	3	5	29	5	30	Create risks ? Real world impacts instead [Falk Huettmann, United States of America]	Rejected: meaning not clear
19537	3	5	30	5	30	I think you should give some specific examples of environmental risks for the Arctic (e.g. pollution of the ocean and air from ships). This paragraph emphasizes the economic opportunities arising from an ice-free Arctic, but these should be balanced by the environmental risks. Currently, this paragraph reads like having an ice-free Arctic is a good thing. I think it should be much more balanced. [APECS Group Review, Germany]	Accepted: text revised
29047	3	5	33	5	35	Suggest an extremely useful addition to the ES (and consider more broadly for SPM) would be a paragraph making the following point, either as the first or last message in this section (first sentence bolded): "The most important means to constrain risk to polar regions, ecosystem services and populations, especially indigenous peoples comprise high mitigation (or low emissions) pathways. These regions are changing so quickly, with limited possibility for especially indigenous culture as well as vulnerable high polar species to adapt, that effective adaptation to high levels of warming as well as acidification under weak mitigation scenarios is to some degree not possible or feasible. The first line of risk reduction is therefore a rapid and strong mitigation pathway, consistent with the SR1.5." [Pam Pearson, Sweden]	Reject. SROCC does not have a mandate to include mitigation discussions other than through referring to risk, impacts and adaptation options for scenario analyses from the literature. Only very few are available wrt e.g. differentiation between 1.5 and 2 degrees warming. Therefore ES and SPM statements in SROCC relating to emission scenarios have to be very specific. This was taken in to account in writing chapter, ES and SPM
1643	3	5	33	6	10	Use of indigenous knowledge is not stressed in this summary although it is later mentioned as a key component for understanding the past climate and is important for developing solutions. [Nora Richter, United States of America]	Reject. Use of IK features in the Executive Summary
2523	3	5	33	6	10	These paragraphs excel in generalities, making them hard to read or to make sense of them. As a result, the confidence statements come across as somewhat ludicrous and not very scientific. [Michiel Van den Broeke, Netherlands]	Taken into account, the language in this section has been made more specific. However, confidence language for the social science assessment in the is chapter is coherent with the expert assessment framework used in IPCC report; the unique opportunities and assessment power that come with cooperative products needs both science communities to be open and unprejudiced.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
2803	3	5	33	6	10	I'm surprised that mitigation of GHG emissions is not mentioned as an "option for responding to polar change". Presumably this is the single most important measure that needs to be taken to "reduce risk" [Neil Swart, Canada]	Reject. SROCC does not have a mandate to include mitigation discussions other than through referring to risk, impacts and adaptation options for scenario analyses from the literature. Only very few are available wrt e.g. differentiation between 1.5 and 2 degrees warming. Therefore ES and SPM statements in SROCC relating to emission scenarios have to be very specific. This was taken into account in writing chapter, ES and SPM
31131	3	5	35	0	36	Can a climate future be identified where adaptation limits, (to be quantified to the extent possible), are not surpassed? [Hans-Otto Poertner and WGII TSU, Germany]	Reject. The available literature doesn't provide a basis for assessing adaptation limits, except for in very specific cases (CCB 9 material) - limitations, barriers and transformation are considered in Ch 3 according to the available literature
16287	3	5	36	5	39	Could you better describe what is meant with 'harvesters of renewable natural resources'? Supposedly, this includes indigenous people and local communities? If yes, please highlight them explicitly. [Alexander Nauels, Germany]	Taken into account. Polar systems have indigenous and non indigenous harvesters of living resources. Thus we are general in this description. We do note the presence of Indigenous people and their culture connection to land and resources
10129	3	5	37	0		After "seasonality," add ", distribution, abundance of target species," [Lisa Speer, United States of America]	Reject because of extremely limited space we cannot accompany all details in these statements. However, this aspect is captured in the chapter
10131	3	5	38	0		Substituting "collapsing" for "thawing" permafrost may make the connection with infrastructure stability clearer. [Lisa Speer, United States of America]	taken into account over revisions of this statement
31133	3	5	40	0		So how high is the risk of maladaptation, are there examples? [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account. Text in the chapter and Executive Summary represents the available literature
5011	3	5	44	5	49	Line of sight required. [Debra Roberts and Durban Team, South Africa]	Unclear what is being suggested here
28507	3	5	44	5	57	Combine into one paragraph/point. They are related, and combining would make it clear what innovative approaches are better *than*. Also right now lines 44-49 don't have any reference to where they are explored in more detail in the rest of the report, which brings up the question of where they're coming from/why they're in the summary. [Yvonne Firing, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account over revisions of these statements; we have distinguished more clearly between the two statements
31135	3	5	45	0		This bullet point lacks specificity. What are the short-term adaptation measures, which longer-term measures would enhance resilience? Specific, possibly quantifiable examples would be illustrative. [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account over revisions, we have added specificity
33103	3	5	45	5	46	Regarding "known future impacts and surprises", how are surprises known? [Government of United States of America, United States of America]	accepted, changed to "expected and unexpected impacts"
23109	3	5	46	5	46	What is meant by "surprises". Be more explicit. What are "known future surprises"? [Valerie Masson-Delmotte, France]	accepted, changed to "expected and unexpected impacts"
33105	3	5	47	0		What does resilience to the "complexity... of climate change" mean? How can one be resilient to complexity? Instead, one wants to be resilient to changes, regardless of the characteristics of those changes. Perhaps this could be reworded for clarity -- e.g., "...resilience to climatic change given its scale, complexity, and uncertainty...". [Government of United States of America, United States of America]	accepted, sentence revised

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
33107	3	5	48	0		"dual focus" of what two things? Does this refer to short-term vs. long-term? Perhaps explicitly stating these two foci will help clarify this sentence's meaning to readers. [Government of United States of America, United States of America]	accepted, sentence revised
5009	3	5	48	5	48	By "dual focus", do you mean short- and long-term focus? [Debra Roberts and Durban Team, South Africa]	accepted, sentence revised
9029	3	5	49	0		Replace 'to' the scale with 'of' the scale [Nina Hunter, South Africa]	taken into account, sentence revised
3703	3	5	49	5	49	this key finding provides no corresponding sections from the chapter where the subject is treated; it is anomalous from the other key findings in this regard, and should be added. [Dee Williams, United States of America]	accepted, section reference added
10133	3	5	51	0		the sentence as written isn't clear. What kinds of "innovative approaches" are being referred to. And what are they better than? Maybe start the para with the last sentence, which explains what is being talked about. [Lisa Speer, United States of America]	accepted, sentence revised
31137	3	5	51	0		This bullet point lacks specificity. What are the innovative approaches, that are emerging; an illustrative example would help. Which government systems need refinement? Specific, possibly quantifiable examples would be illustrative. What have existing governance systems accomplished (observations), how will they operate in the future (under climate change). Which gaps are projected be closed by innovative approaches? [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account over revisions, we have added specificity
891	3	5	51	5	57	lacks entirely the concept of moving away from Carbon and Fuel society [Falk Huettmann, United States of America]	Reject. SROCC does not have a madate to include mitigation discussions other than through referring to risk, impacts and adaptation options for scenario analyses from the literature
5013	3	5	51	5	57	Why is there no confidence statement in the texts associated with the HS? [Debra Roberts and Durban Team, South Africa]	accepted, confidence added
33109	3	5	54	0		Since attention is insufficient for readying society, here is a suggested addition (in brackets): "...the attention of [and action by] decision makers." [Government of United States of America, United States of America]	This statement has been extensively revised
27607	3	5	56	5	56	Consider to add "adaptive management" to glossary. [Government of Norway, Norway]	Accepted: suggested to include (Adaptive governance is already included)
23111	3	6	0	6		I am not convinced by the added value of this synthesis section, it seems to include value judgments reported without the rigor of the confidence language. Some looks prescriptive. [Valerie Masson-Delmotte, France]	accepted. Synthesis seccion droppped

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
31139	3	6	2	0		<p>What are the specifics of polar government systems, can you provide an example? Which specific adaptation measures are needed to reduce the cascading risk, can risk assessment be done to quantify the risk and its reduction by adaptation? [Hans-Otto Poertner and WGII TSU, Germany]</p>	<p>Accepted the first part (to provide examples and to communicate the specifics). The second part of the comment is Rejected. The specifics of Polar Govern systems (not government which has another meaning) in tackling the effect of climate change cannot be handled without a holistic multi-level regulatory approach (local, national, regional, and global) and a combination of different genres of disciplines (law, political science, elements of climatology, probabilistic equation reasoning and agent based modelling). The present international legal framework for Polar Governance is not adequate for governing societal challenges and risk assessment/ management particularly in relation to the precautionary approach in response to high level of exposure of environmental risks and to cascading effect.</p> <p>With regards to adaptation in relation to cascading risks and how to reduce the latter, this is still a dark ground full of uncertainties and gaps when it comes to governance and international law. Cascading is clearly critical to the Polar systems and there is almost nothing in law and governance especially on how that is theorized – where does it manifest itself – It is not know yet if there are objects that epitomise the cause and or effect of cascading such as fish or minerals. We do not know if cascading can be accelerated and even de-accelerated. We even do not know about the genealogical history of the term “cascade” and when it was first applied to places like the Arctic. So the role of the ideational is really interesting but very difficult to catch from an international law and governance point of view. There is almost nothing but for sure a new future, crucial and fascinating new path of research for governance and legal scholars. Things that we do not know (can be included in gaps and uncertainties) and that are not covered by scientific literature on governance and international law are, for example: what analytically does cascading offer that say non-cascading does not? Are we going to be tease out unequal power dynamics, for example. Will cascading highlight unequal experiences of risk,</p>
1645	3	6	2	6	10	<p>Are there proposed scenarios or solutions to help respond more effectively to climate change (and have been proven to work in other scenarios or on a smaller scale)? [Nora Richter, United States of America]</p>	<p>Such detail is provided in the chapter itself</p>
24905	3	6	2	6	10	<p>I suggest to include in this paragraph at least one sentence pointing out that the governance of the Arctic and Antarctic are quite different, e.g. the Antarctic Treaty System only apply in the Southern Hemisphere.</p> <p>By another hand, the same paragraph says: "...with informal organisations playing an increasingly active role in shaping climate-change relevant regulations", I think that this assertion is not very representative of the governance system intended to respond to the climate change consequences in Antarctica. For example, regarding this point it was recently created the Subsidiary Group on Climate Change Response (SGCCR). For more information, please see: https://www.ats.aq/e/cep.htm. [Hernan Edgardo Sala, Argentina]</p>	<p>Taken into account in revisions, however, such detail is provided in the chapter itself, here, we are summarising assesment findings relevant for both polar regions.</p>

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
10135	3	6	3	0		Insert "or robust enough" after rapid? [Lisa Speer, United States of America]	Accepted. The change will be inserted
9031	3	6	5	0		Insert "being" before "challenged" [Nina Hunter, South Africa]	Accepted. More accurate
10137	3	6	7	6	8	Substitute "making" for "driving, and add "more urgent" at the end of the sentence. [Lisa Speer, United States of America]	Rejected. It changes the meaning of the sentence
10139	3	6	8	6	10	Not clear what point this sentence is trying to make? [Lisa Speer, United States of America]	Accepted. We will make it more clear
3705	3	6	10	6	10	Add Section 3.5.5 to the list of sections that support the finding. [Dee Williams, United States of America]	Accepted. It reinforces the statement. Very good advise
31141	3	6	12	0		This structural element would need to be adopted by all chapters if maintained. Alternatively, it could be a start-up bullet point at the beginning of the ES, then complemented by more specific bullet points to follow. [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account; this synthesis paragraph has been removed
31087	3	6	13	6	13	Can the reference to AR5 be made a little more specific? I think this refers to new scientific knowledge about changes in the polar regions that has been gained since AR5 (not the changes themselves)? [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account; this synthesis paragraph has been removed
11159	3	6	13	6	14	Please be more specific about „This chapter provides strong evidence of many substantial changes in the Arctic and Antarctic since AR5,“. This is a very strong statement (given that AR5 is just 5 years old), and needs to be made more concrete to be credible. [Dirk Notz, Germany]	Taken into account; this synthesis paragraph has been removed
1647	3	6	13	6	22	This doesn't seem to add anything to the summary...Maybe summarize the main/key changes, impacts, and projected adaptation strategies to drive home the key points? [Nora Richter, United States of America]	Accepted; this synthesis paragraph has been removed
30331	3	6	13	6	22	You might want to mention role of remote sensing imagery (especially satellite imagery) as a means of monitoring environmental change in polar regions. [Paul Glaser, United States of America]	Taken into account; this synthesis paragraph has been removed
214	3	6	14	6	14	"Several" here is a very weakening modifier. It would be much better to offer a brief list of the categories or a non-comprehensive list of examples. [Baylor Fox-Kemper, United States of America]	Taken into account; this synthesis paragraph has been removed
216	3	6	14	6	14	The numbers in the circles are too small to be comfortably read. Numbers on their own outside of the little balls could be much larger and more legible without affecting the overall design. [Baylor Fox-Kemper, United States of America]	Noted; we believe this is a comment on Figure 3.1 rather than ES. Figure 3.1 redrafted by TSU graphics.
30329	3	6	14	6	14	Please change the stand-alone pronoun "these" to "these changes" to clarify the antecedent of "these." [Paul Glaser, United States of America]	Taken into account; this synthesis paragraph has been removed
33111	3	6	14	6	15	Suggested reordering of this sentence to ease readability (changes in brackets): "Many of these [changes, via sea level rise and climate feedbacks,] have consequences for human populations across the globe, including [] impacts on commercial and industrial operations."" [Government of United States of America, United States of America]	Taken into account; this synthesis paragraph has been removed

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
26175	3	6	17	6	18	IK&LK is important and SROCC, especially the box in Chapter 1 illustrates nicely its value, however, the space this occupies in the synthesis (and intro) is in stark contrast and disproportionate to how much of the advances since AR5 in this chapter are actually based on IKL. Almost all knowledge advances shown in the chapters come from scientific observations (insitu/satellite); very few examples (often just referring to the box) are given in this chapter. This is natural given the existing literature but the presentation of IKLK should not occupy disproportionate space (see also P7, 42-49: especially considering that this chapter does not really do what's written there). P11, 28-29 mentions an IKLK example, but does not demonstrate the 'benefits' but just refers to the box in ch. 1. Also the reasoning in L16-19 (p6) seems odd. INSITU observations are sparse but advances in satellite remote sensing have been enormous and lots of data are available. P7, 42-49 is repetition of what is in chapter 1. Why a framing chapter if all chapters repeat what is written there. The report in general suffers from endless repetitions between chapters. So, overall, better to really illustrate the benefits of IKLK where there are good examples than repeatedly just advocating for it (which seems more adequate in a review or position paper than an IPCC report where advances in knowledge should be shown no matter the source). [Regine Hock, United States of America]	Comment seems misplaced, at least partly, seems to be "overarching". While the critique of redundancy of this topic across the report accepted (and actions have been taken to resolve this (the representation of IK in CH 3 introduction is revised, the introduction and synthesis sections of the Executive Summary have been removed), Ch 3 includes a substantial number of citations that include IK next to scientific knowledge citations across sections; this is (deliberately) not always made explicit and so may have escaped a reviewer who is unfamiliar with the field (so this chapter does exactly what is written here; hence reject)
17329	3	6	17	6	19	Great to see recognition of importance of Indigenous Knowledge especially in the context of the Arctic. Very encouraging! [Joanna MacDonald, Canada]	Noted. Whilst the synthesis paragraph at this location has been removed, the key information is retained elsewhere in the chapter.
33113	3	6	17	6	19	How is this measured or otherwise known and what level of confidence is assigned to this statement? Does the report provide any evidence for it. [Government of United States of America, United States of America]	Taken into account; this synthesis paragraph has been removed
33115	3	6	19	6	20	"changes that will require management at the regional level": What kind of management? This needs to be more specific, since there already is management at the regional level for some things. Perhaps it would be prudent to at least expand this to "adaptive management". [Government of United States of America, United States of America]	Taken into account; this synthesis paragraph has been removed
10141	3	6	22	0		Substitute "is essential" for "can serve as an exemplar." [Lisa Speer, United States of America]	Taken into account; this synthesis paragraph has been removed
951	3	7	0	0		There are THREE polar regions and where most snow and ice sits, Antarctica is the biggest one. This report widely misses those details [Falk Huettmann, United States of America]	Taken into account. The scope of this chapter are the northern and southern polar regions. The region of the Himalaya and Tibetan plateau that is sometimes nicknamed "the third pole" is covered in Ch 2.
5167	3	7	0	40		The almost 35 pages of dense scientific text is a real barrier for most policy makers - could some of the detail be reduced with just the main messages of change/impact being conveyed? That would also help in reducing the length of the chapter. [Debra Roberts and Durban Team, South Africa]	Taken into account. Based on the scoping document, there is a great deal of science that requires coverage in chapter 3, with full traceable support to the literature. We have condensed it and simplified the language as much as possible, without distorting the meaning.
23117	3	7	0	7		This introduction is too long. Please focus more and be more explicit (eg second paragraph, or line 42). The treatment of IK looks "demonstrative" rather than providing an assessment, and should be reformulated carefully. [Valerie Masson-Delmotte, France]	Taken into account: introduction shortened and paragraph on Indigenous knowledge revised

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
25979	3	7	1	7	57	This sections is very wordy and could be shortened. Some of it is valid for all chapters (e.g. Lines 42-49) and suggest to either delete or shorten those parts. Otherwise what is the point of a framing chapter if all chapters then repeat basic principles that are common to all chapters? [Regine Hock, United States of America]	taken into account. Introduction shortened
25981	3	7	1	8	40	I miss a figure (map) that shows the domain covered in this chapter. Different components covered in this chapter over spatially different domains which makes it even more important to show what the geographic extent is for which component. A map outlining the diffrent domains could do just that. Also, only then numbers as e.g. given in Lines 8-10 make sense. E.g. does the 69% world glacier area refer to all area that is not covered in chapter 2 or other polar domain definitions typically adoped in other assessments (e.g. SWIPA). [Regine Hock, United States of America]	Accepted; we have included maps in the revised chapter
32353	3	7	3	7	5	This paragraph is true of all chapters in SROCC and could be deleted to save words. [Andrew Constable, Australia]	accepted
558	3	7	4	7	4	remove 'not least' [Jenna Pearson, United States of America]	text has been removed
3207	3	7	7	7	11	There have also been major Arctic assessments that should be mentioned, for example the AMAP SWIPA 2017 and regional AACA reports which cover both impacts and adaptation aspects of changing climate in the Arctic, including oceans and cryosphere. [Sharon Smith, Canada]	rejected. Space limits keep us from listing specific assessments in the introduction.
18789	3	7	7	7	7	IPCC needs to be expanded (ignore if already expanded at first mention in the document). [APECS Group Review, Germany]	Editorial - chapter to be copyedited after completion, and IPCC will be expanded based upon that.
33117	3	7	10	0		Suggested addition (in brackets): "identify [improved] responses" [Government of United States of America, United States of America]	accepted
3205	3	7	16	7	18	Presumably this is material relevant to changes to ocean and cryosphere, not all changes that might be occurring. [Sharon Smith, Canada]	accepted, clarified context of "climate change" in revised material
31145	3	7	18	0	21	This is a great mission which would be accomplished once impacts and losses are quantified, and risk levels and their reduction by specific adaptation measures determined in a more quantitative way. Limits to adaptation and resisual risks also need quantification, at least by order of magnitude, and qualification to the extent possible. [Hans-Otto Poertner and WGII TSU, Germany]	noted. We have continued our effort to illustrate and quantify where possible the linkages between climate drivers, consequences and impacts, and to qualify how adaptation measures rduce risk and build resilience.
32355	3	7	18	7	21	While difficult to read and repetitive of the earlier sentences in this paragraph (repetition should be minimised), this sentence indicates a structure and aspiration for the chapter. I would recommend that the sentence be phrased as an introduction to the structure of the chapter. [Andrew Constable, Australia]	accepted. this element has been emphasized over revisions
33119	3	7	18	7	21	This is a run-on sentence with an unclear meaning. In particular, it is unclear to what "responses to enhance resilience" is associated. Furthermore, are the "impacts and risks" being related to "adaptation options and limits", or are "cause and consequence" being related to "adaptation options and limits"? Suggest that authors break this into two sentences. [Government of United States of America, United States of America]	accepted. Sentence split in two
3837	3	7	23	0		it is not appropriate to say "The polar regions are the two integrated parts of the Earth system", as 'the polar region' is a [Zhaomin Wang, China]	Accepted; wording changed
3839	3	7	23	0		geographic concept and the Earth system is not [Zhaomin Wang, China]	Accepted; wording changed

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
9497	3	7	23	7	25	The sentence construction gives the impression that ecological and social systems are shared by polar regions, which is not true. [Government of France, France]	Accepted; sentence revised
17347	3	7	23	7	25	Yes, interactions occur through ocean and atmosphere, but ecosystems are evolved through adaptations to specific local and regional conditions. They are to a much lesser degree interacting among each other. This is often a general misunderstanding in climate-change literature that ecosystems "interact". They are all regional components that separately respond to the REGIONAL climate changes, not to GLOBAL climate change. They may respond by changing, by adapting or by going extinct. [Svein Sundby, Norway]	Rejected. While the point raised by the reviewer is partly correct, the connectedness of the polar regions ecosystems to the rest of the planet (e.g. through an extraordinary high proportion of migrating species/populations and already occurring range shifts from southern species into polar regions) clearly demonstrates this "shared" ecosystems dimension.
32357	3	7	23	7	40	These paragraph are difficult to read. The figure is good to show that the processes are similar despite Arctic being land-locked and Antarctic being sea-locked, but with Arctic having people present. I would suggest that the paragraphs be simplified to better frame this point and then to indicate that the impacts and adaptation relating to residents will apply only in the Arctic. It is also important to emphasise that the interest in the well-being of the Arctic and Antarctic is equal however. The examples indicating the importance of the Arctic appear to inflate the comparative importance of that region when the only difference between them is in residential populations. All other matters are of similar concern. Global interest in Antarctica is just as great despite no residential populations being there. A notable exception other than population is the degree to which shipping traffic will increase in the Arctic and the risks that will entail from that. Concern over increased opportunities for mineral resources will be similar between the two regions. [Andrew Constable, Australia]	Accepted. The introduction has been shortened and simplified. The differences between the Arctic and the Antarctic have been made more prominent.
30333	3	7	24	7	24	Delete the semi-colon and begin a new sentence with "notably, they play key roles" [Paul Glaser, United States of America]	Editorial; chapter will be copyedited prior to publication
33121	3	7	24	7	25	Regarding "they play key roles as important components": It is redundant to say "key roles" and "important components", unless these roles are defined with respect to something different. If these are referring to different systems then that could be stated explicitly. For example, "...they play key roles in human social systems as important components of the global climate system." [Government of United States of America, United States of America]	Taken into account. Sentence revised
29171	3	7	27	7	27	"a systems approach" is not a common terminology - considering to ellabotate a bit. [Ge Peng, United States of America]	accepted. revised to "...a systems approach that emphasises the interactions ..."
23989	3	7	35	7	37	Antarctica is the non-replacable home for non human animal populations, a less anthropo-centered point of view could thus be adopted [Patricia Martinerie, France]	rejected. this part of the paragraph is to clarify the differences in the human dimension between the two polar regions. the uniqueness of the ecology of each polar region is not denied.
18787	3	7	37	0		...for whom the region is home - should this read 'permanent home' instead? It seems a mistake to gloss over the fact of inhabitation in Antarctica by many for long periods, even if generally as employees and not on a completely permanent basis. While it is true that there are many socio-economic and cultural differences between the polar regions, the working/visiting population of Antarctica is not insubstantial and the use of 'home' to describe the lives of Arctic communities only seems problematic. [APECS Group Review, Germany]	accepted. revised as sugested

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
893	3	7	42	7	42	Not all literature has been seen or reviewed, e.g. Protection of Three Poles, and many others [Falk Huettmann, United States of America]	Reject. The reviewer seems to point to a 2012 book publication, which is out of scope for SROCC
11875	3	7	42	7	49	The paragraph says that (quote) "this chapter seeks to demonstrate the benefit of incorporating the multiple ways of knowing for assessing climate change impacts and responses". This is strange. The aim of an IPCC report must be to assess the science. It should not have any other agenda. If alternative ways of knowing prove to be beneficial, use them in the report. If not, do not. But you should not use an IPCC report for promotional purposes. [Gerhard Krinner, France]	Taken into account. The revised paragraph is more careful to not create the impression of promotion
24437	3	7	42	7	49	Consider to rewrite this paragraph. As it now reads one may understand that the parallelism in this section between traditional / local knowledge and science gives TLK equal weight to scientific methods in this assessment. I hope this is not the case. TLK can bring valuable perspectives on local level / specific issues and point to consequences to society, but monitoring / detecting / is a scientific task. [veijo pohjola, Sweden]	Accepted. Paragraph revised to not create the impression of a priori equal weight
33123	3	7	42	7	49	This report could add more about mechanisms through which the US government (and international governments) could work with indigenous people through work groups such as the US Environmental Protection Agency Tribal Science Council or another mechanism such as the American Indian/Alaskan Native Working Group Lead for the NASA Science Mission Directorate. STEM activities and coordination with tribal schools such as Haskell Indian Nations University might also be good ways to get feedback from tribal nations. [Government of United States of America, United States of America]	Taken into account. Whilst the Executive Summary is not the place to elaborate on these details, section 3.5 assesses response options, including tools and practices for building resilience that are clearly relevant for mechanisms listed in this comment.
30335	3	7	43	7	47	But how can anecdotal Indigenous Knowledge be quantified so it is comparable to instrumental and other data published in scientific literature? I will be very curious to find out. [Paul Glaser, United States of America]	Noted. We refer to Cross-Chapter Box 3 in Chapter 1, where these issues are presented in detail.
33125	3	7	43	7	47	There is no question that indigenous knowledge can facilitate a better understanding of the challenges facing Indigenous People. To what degree "multiple ways of knowing" broadens and strengthens the knowledge base requires substantiation. It is troubling to see it presented here as complementary to the peer-reviewed scientific knowledge of the IPCC process. [Government of United States of America, United States of America]	taken into account. Specific mentioning of broadening the knowledge base deleted
33127	3	7	45	7	47	Seems like this sentence is very much oriented from the perspective of one-way interaction with Indigenous Peoples. Suggest incorporating the idea of mutual cooperation and/or participation of Indigenous Peoples in the development, identification, and decision making process for adaptation strategies. [Government of United States of America, United States of America]	accepted. mutual /cooperation dimension added
560	3	7	47	7	49	This sentence could be reworded, since incorporating both lines of knowledge is mentioned twice. [Jenna Pearson, United States of America]	Taken into account. Sentence revised
32359	3	7	51	7	54	This paragraph is not needed. It is covered in the paragraph that first introduces figure 3.1 [Andrew Constable, Australia]	Taken into account. Paragraph deleted and some elements incorporated in text near reference to Figure 3.1
32361	3	7	56	7	57	What does this sentence mean? Are the Arctic and Antarctic connected? Is the sentence needed? [Andrew Constable, Australia]	Taken into account, sentences are revised
33129	3	7	56	8	11	Another common definition of the Arctic is the 10 C July 2 m air temperature isotherm. May be worth adding this since it's another flexible definition. [Government of United States of America, United States of America]	Rejected: while an accepted and flexible delineation, the 10deg Jul isotherm was not practical because this chapter assesses the cryosphere literature

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
9499	3	8	0	0		The (2) is missing on the Arctic schema, on the green arrow. [Government of France, France]	Accepted. The Figure has been revised. Details were refined, corrected, enlarged, and added
9501	3	8	0	0		The (4) is missing on the Arctic shema, under the two Indigenous people. [Government of France, France]	Accepted. The Figure has been revised. Details were refined, corrected, enlarged, and added
895	3	8	0	0		Figure 3.1. misses entirely the atmosphere as THE transport and driver in this, highly connected [Falk Huettmann, United States of America]	Reject. CH 3 does not have a remit to assess cahnges in the atmosphere of the polar regions
21651	3	8	0	0		Figure 3.1; It looks informative but needs more work. Barely seen each element. 9, 10, and 11 are not well represented. [Government of Republic of Korea, Republic of Korea]	Accepted. The Figure has been revised. Details were refined, corrected, enlarged, and added
24011	3	8	0	0		Figure 3.1; It looks informative but needs more work. Barely seen each element. 9, 10, and 11 are not well represented. [WON SANG LEE, Republic of Korea]	Accepted. The Figure has been revised. Details were refined, corrected, enlarged, and added
28509	3	8	0	0		Can the arrows that go with the (1)s be a different color/darker so it doesn't look like (1) is about mountains? [Yvonne Firing, United Kingdom (of Great Britain and Northern Ireland)]	Accepted. The Figure has been revised. Details were refined, corrected, enlarged, and added
28511	3	8	0	0		(7) and (8) could apply to the Antarctic as well, albeit less dramatically and with less impact on people [Yvonne Firing, United Kingdom (of Great Britain and Northern Ireland)]	Accepted. The Figure has been revised. Details were refined, corrected, enlarged, and added
278	3	8	0	8		Fig. 3.1: is the left drawing really representing Arctic mountains? I would suppose the landscape to be more smooth in general [Sabine Baumann, Germany]	Accepted. The Figure has been revised. Details were refined, corrected, enlarged, and added
280	3	8	0	8		Fig. 3.1 caption: number (4) not included in the drawing [Sabine Baumann, Germany]	Accepted; Figure redrawn by TSU graphics
8601	3	8	0	8		Figure 3.1: Some numbers are missing in the "Arctic" panel of the figure: number 2 and number 4. [Deborah Verfaillie, Spain]	Accepted. The Figure has been revised. Details were refined, corrected, enlarged, and added
23119	3	8	0	8		Please provide outcomes of an assesemtn in this figure, for instance the level of scientific understanding of these processes. [Valerie Masson-Delmotte, France]	Rejected. The purpose of this schematic is to recognise processes and allow tracing to chapter sections, not to describe the magnitude of processes or present the assessment
22359	3	8	1	8	3	Although obvious, it should probably be explicitly said that the southern polar region includes Antarctica (and the sub Antarctic islands?) [Abram Nerilie, Australia]	Accepted. The Figure has been revised. Details were refined, corrected, enlarged, and added
18797	3	8	3	0		(CCAMLR, 2017c) citation has a typo in References on page 110 line 40 = only appears as CCAMLR, 2017 (even though CCAMLR, 2017a and CCAMLR, 2017b listed above). [APECS Group Review, Germany]	Editorial - chapter to be copyedited after completion
22357	3	8	4	8	7	I'm not sure that the Greenland ice sheet fits into this definition of the terrestrial Arctic. [Abram Nerilie, Australia]	accepted, glacial ice added
18793	3	8	7	8	7	I couldn't find the footnote #3. [APECS Group Review, Germany]	Noted; it is present at the bottom of the page

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
2525	3	8	10	8	10	Ice sheets are also glaciers [Michiel Van den Broeke, Netherlands]	accepted. revised sentence to make that clear
18801	3	8	10	8	11	There are land areas that are snow covered that wouldn't be classed as polar regions, maybe specify that it's land above a certain latitude. [APECS Group Review, Germany]	taken into account. Added "most" to "land areas that are entirely snow covered in winter"
18799	3	8	12	8	15	Difficult to read numbers on Fig 3.1 - should be larger to be more clear to the reader [APECS Group Review, Germany]	Accepted. The Figure has been revised. Details were refined, corrected, enlarged, and added
32025	3	8	12	8	15	Left panel "Arctic": Labels "2" and "4" are missing. Right panel "Antarctic": Should label "6" on the ice sheet be "7"? [Christian Reuten, Canada]	Accepted. The Figure has been revised. Details were refined, corrected, enlarged, and added
24033	3	8	12	8	39	Figure 3.1: The substantial difference in fresh-water runoff to the two Polar regions should be pointed out. E.g.: in Figure 3.2 Changes in fresh water discharge from the rivers in the Arctic is mentioned. [Svein Sundby, Norway]	Rejected. The purpose of this schematic is to recognise processes and allow tracing to chapter sections, not to describe the magnitude of processes or present the assessment
30903	3	8	12	8	39	This Figure 3.1 is really nice and a useful guidance through the chapter. However, the numbering and/or caption text need some revision: In line 21 it says «The polar oceans» but no. 2 is only in Antarctic part. Does this mean that only southern ocean serves as heat and carbon drawdown and storage? Please clarify description or add no. 2 also to Arctic panel. Same for No. 7 which is only shown in Arctic panel though figure caption says «The polar terrestrial regions...»; either include no.7 in Antarctic or clarify in caption that this refers to north polar regions only. No. 4 is missing in the Arctic panel. No. 9 occurs twice in Arctic and No. 6 twice in Antarctic panel - is that on purpose? [Hans-Otto Poertner and WGII TSU, Germany]	Accepted. The Figure has been revised. Details were refined, corrected, enlarged, and added
31615	3	8	13	0		Figure 3.1. Figure missing the number for label 4. [Hans-Otto Poertner and WGII TSU, Germany]	Accepted. The Figure has been revised. Details were refined, corrected, enlarged, and added
31617	3	8	13	0		Figure 3.1. Perhaps it may be better to replace the numbers with letters, because in the caption it says that the relevant sections are numbered -but this seems to be in accordance to the list in the caption, not the sections within the chapter - so perhaps using letter would to make the difference 100% clear. [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account; figure redrawn by TSU.
23917	3	8	13	8	13	In the left figure of Figure 3.1, suggest numbering heat and carbon flow from atmosphere to ocean. [Government of Japan, Japan]	Accepted. The Figure has been revised. Details were refined, corrected, enlarged, and added
23919	3	8	13	8	13	No.4 which expressed the local culture area cannot be found in Figure 3.1. [Government of Japan, Japan]	Accepted. The Figure has been revised. Details were refined, corrected, enlarged, and added
33131	3	8	13	8	13	For Figure 3.1, authors should consider adding the (2) to the arctic diagram due to North Atlantic Deep Water Formation. Should (7) be added to the Antarctic diagram (Dry Valleys)? Specifically, this report could have significantly more added about areas of the land in the Antarctic such as the McMurdo Dry Valleys and the importance of them to the biodiversity and ecosystem. [Government of United States of America, United States of America]	Taken into account; the figure has been completely redrafted by IPCC graphics unit.
3535	3	8	13	8	14	The right hand panel (Antarctic) has a label (6) adjacent to some mammals on land. There is no label (7) on this panel. I believe this label should be changed from (6) (polar ocean ecosystems) to (7) (terrestrial ecosystems). [Sonya Legg, United States of America]	Accepted. The Figure has been revised. Details were refined, corrected, enlarged, and added
3537	3	8	13	8	14	The left hand panel (Arctic) has an arrow pointing down into the ocean which is not labeled. In the right panel (Antarctic), a similar arrow is labeled (2) (ocean drawdown of heat from atmosphere). The Arctic arrow should also be labeled (2). [Sonya Legg, United States of America]	Accepted. The Figure has been revised. Details were refined, corrected, enlarged, and added

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
21337	3	8	13	8	14	Figure 3.1. The Antarctic schematic does not reflect adequately the retrograde slope below many of the ice sheets which effectively means that grounding line retreat will enable warm water to penetrate below the ice sheet - especially important for WAIS. [Steven Chown, Australia]	Taken into account; the figure has been completely redrafted by IPCC graphics unit.
26365	3	8	13	8	14	This schematic is not useful in its current form. If it is intended to serve as a process-based table of contents, the section numbers should be incorporated into the graphic itself. As it stands, it takes too much effort to flip back and forth between the schematic and the text, in which case most people will likely skip the figure entirely. [Ethan Pierce, United States of America]	Accepted; the figure has been completely redrafted by IPCC graphics unit.
23921	3	8	13	8	15	It is hard to see the mechanisms by which the cryosphere and ocean in the polar regions influence climate, ecological and social systems in the Figure 3.1. It is preferable to illustrate permafrost in the left illustration (Arctic). In addition, number 4 could be added to the left panel, and number 7 to the right panel to complete the figure. [Government of Japan, Japan]	Accepted; the figure has been completely redrafted by IPCC graphics unit.
29173	3	8	13	8	15	The icon for (2) seems to be missing from the left (Arctic) of Figure 3.1. [Ge Peng, United States of America]	Accepted. The Figure has been revised. Details were refined, corrected, enlarged, and added
29175	3	8	13	8	15	The icon for (4) seems to be missing from the left (Arctic) of Figure 3.1. [Ge Peng, United States of America]	Accepted. The Figure has been revised. Details were refined, corrected, enlarged, and added
3209	3	8	13	8	29	Fig 3.1 - The maps outlining the Arctic and Antarctic regions could be larger so that it is clear to the reader the regions that are considered in this report. [Sharon Smith, Canada]	Accepted. The maps are now presented as a separate new figure
11919	3	8	13	8	39	Point 2 and 4 are missing in figure 1 (Arctic region). Point 7 is missing in figure 2 (Antarctic region) [Jun Sun, China]	Accepted. The Figure has been revised. Details were refined, corrected, enlarged, and added
18791	3	8	13	8	39	This figure appears to be missing some of the coordinating number labels. I do not see #3 in the Arctic and #4 is not present anywhere. [APECS Group Review, Germany]	Accepted. The Figure has been revised. Details were refined, corrected, enlarged, and added
18795	3	8	13	8	39	Figure 3.1. I see that this figure has been modified since the FOD (maps, Arctic vs. Antarctic). On the left panel (Arctic), numbers 2 (heat/carbon storage) and 4 (Indigenous populations) are not shown. [APECS Group Review, Germany]	Accepted. The Figure has been revised. Details were refined, corrected, enlarged, and added
30263	3	8	13	8	39	Sea ice feedbacks are not mentioned in this figure. These are such an important part of temperature regulation that they should be included. [Christine Dow, Canada]	Accepted. The figure has been revised completely by IPCC graphics unit.
678	3	8	14	8	14	The schematic currently does not help too much in understanding the contents of the figure caption. The figure itself contains little information that can be easily understood without the long caption. [Mengxi Wu, United States of America]	Accepted. The figure has been revised completely by IPCC graphics unit.
24293	3	8	14	8	14	The mechanisms numbered from 1 to 11 in the figure caption are not all appearing on the schematic itself. Number 4 is missing and could be added on the left-hand side panel [Rym MSADEK, France]	Accepted. The Figure has been revised. Details were refined, corrected, enlarged, and added
33133	3	8	14	8	15	(2) is missing from the Arctic panel of the figure, (4) may be mislabeled, (7) is missing from the Antarctic panel, and the numbering in the figure could be a little larger. [Government of United States of America, United States of America]	Accepted. The Figure has been revised. Details were refined, corrected, enlarged, and added

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
1649	3	8	14	8	39	The arrows are hard to see. What about changes in Arctic sea ice? Can this figure be expanded or compressed into one figure of polar regions? As it is now, it is difficult to read and understand what the main points are. [Nora Richter, United States of America]	Taken into account. The Figure has been revised. Details were refined, corrected, enlarged, and added. The differences in the ARctic and Antarctic that justify two panels are emphasized
16289	3	8	16	8	16	Figure 3.1 provides a very nice visual introduction to the Chapter assessment. Please increase the map insets though and consider providing the bullets more prominently as part of the figure instead of the caption content. [Alexander Nauels, Germany]	Accepted. The Figure has been revised. Details were refined, corrected, enlarged, and added. The maps are now presented as a separate new figure.
22361	3	8	16	8	16	Great introduction and great figure! I couldn't see #4 labelled on the figure, and the #2 label is missing for the North Atlantic [Abram Nerilie, Australia]	Accepted. The Figure has been revised. Details were refined, corrected, enlarged, and added
22363	3	8	16	8	16	For the inset maps, does the black shading show the location of terrestrial Arctic/Antarctic and darker blue shading show the approximately ocean boundaries for "polar regions" used in this chapter? I couldn't see this described in the caption. [Abram Nerilie, Australia]	Accepted. The maps are now presented as a separate new figure and teh requested information was added to the caption
562	3	8	16	8	39	I always find it useful to have 1-2 words attached to the numbers to get a quick assessment of the diagram. It's difficult to put all the pieces together without some label to refer to even after the caption is read. Some of the processes, like ocean circulation are hinted at from the pictures, but others, like 7 or 8 are not clear without digging into the details. [Jenna Pearson, United States of America]	Taken into account; the figure has been revised completely by IPCC TSU graphics unit.
3163	3	8	16	8	39	Including a schematic seems very helpful. However, this figure is somewhat unclear and difficult to read. The figure makes it seem as if similar processes are occurring in the Arctic and Antarctic. Is it possible to consolidate these two schematics into one, showing general polar region processes? Similarly, the current figure is somewhat confusing because there are some processes that occur in "polar regions" (according to the caption) but are only shown on the figure in either the Arctic or Antarctic, but not both (e.g., 2 and 9). It may be helpful to either clarigy the captions or include the appropriate numbers on the figure. [Sloane Garelick, United States of America]	Taken into account. The Figure has been revised. Details were refined, corrected, enlarged, and added. The differences in the ARctic and Antarctic that justify two panels are emphasized
10495	3	8	16	8	39	Explain the light blue shading in the maps of the polar regions in Figure 3.1. Do they delineate the spatial footprint of the rgions under consideration? Also, what do the black regions over land indicate? [James Renwick, New Zealand]	Taken into account. The maps are now presented as a separate new figure and the requested information was added to the caption
25983	3	8	16	8	39	The figure is not very effective. Without the explanation of each number the figure does not say much, but with all that information in the caption the figure loses what the purpose of a figure usually is: illustrate something so that some content is easily understandable in one glance rather compared to having the same information described in the text. Here one has to go back and forth between figure and caption to understand the figure. I suggest that the figure is made bigger and the information that belongs to each number is put on the figure itself (perhaps somewhat shortened). The text could be put in circles that are placed where they belong or a bit off if they don't fit. The total size of the figure would probably be the same since the caption will be much smaller. As it is the figure would be useless on a slide in a presentation. The goal should be to turn the figure into something that can make a meaningful slide. [Regine Hock, United States of America]	Accepted. Figure has been revised completely by TSU.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
13857	3	8	21	8	21	Missing number '2' on Arctic diagram? [Government of United Kingdom (of Great Britain and Northern Ireland), United Kingdom (of Great Britain and Northern Ireland)]	Accepted. The Figure has been revised. Details were refined, corrected, enlarged, and added
17701	3	8	21	8	22	On the figure 3.1, the item (2) that appears on the "Antarctic" panel, could also appear on the left panel "Arctic" in the green wide arrow, just as it is done in the right panel "Antarctic" [Eva Cougnon, Australia]	Accepted. The Figure has been revised. Details were refined, corrected, enlarged, and added
19601	3	8	21	8	22	Number 2 (drawdown and storage of heat and carbon) is not present in the left panel (Arctic) of Fig. 3.1. [APECS Group Review, Germany]	Accepted. The Figure has been revised. Details were refined, corrected, enlarged, and added
33135	3	8	21	8	22	The Arctic figure is missing a number (2) to go along with the heat / carbon storage arrow. [Government of United States of America, United States of America]	Accepted. The Figure has been revised. Details were refined, corrected, enlarged, and added
33137	3	8	23	8	24	It should probably be also mentioned that polar ocean processes have a significant impact on the dynamics and overall mass balance (and hence sea level contribution from) of the Antarctic ice sheet (and less so for the Greenland ice sheet, but still relevant). [Government of United States of America, United States of America]	Taken into account; the figure has been completely redrafted by IPCC graphics unit.
9033	3	8	25	0		"life" should be "lives" [Nina Hunter, South Africa]	Taken into account; figure has been redrafted completely by TSU
18803	3	8	25	8	25	I cannot find number 4 (fourth point) in the Figure 3.1. There is no mention of sea ice (a major climate factor); sea ice reflects sunlight back into the atmosphere thus changing the heat budget of the earth. This must be mentioned. [APECS Group Review, Germany]	Accepted. The Figure has been revised. Details were refined, corrected, enlarged, and added
2771	3	8	25	8	26	4 does not seem to appear in the diagram itself (i.e. no label 4) [Neil Swart, Canada]	Accepted. The Figure has been revised. Details were refined, corrected, enlarged, and added
3161	3	8	25	8	26	The caption of this figure lists numbers 1 to 11, which correspond to the numbers on the figure, but there is no number 4 labeled on the figure to correspond to the description of 4 in the caption. [Sloane Garelick, United States of America]	Accepted. The Figure has been revised. Details were refined, corrected, enlarged, and added
17703	3	8	25	8	26	Figure 3.1, the item (4) does not appear on the left panel "Arctic", while it should as its description is specifically about the Arctic [Eva Cougnon, Australia]	Accepted. The Figure has been revised. Details were refined, corrected, enlarged, and added
19603	3	8	25	8	26	Number 4 (local populations) is not present in the left panel (Arctic) of Figure 3.1. [APECS Group Review, Germany]	Accepted. The Figure has been revised. Details were refined, corrected, enlarged, and added

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
33139	3	8	26	8	30	On line 26, the section references in parentheses are separated by a semicolon and then a comma. On line 28, the section references in parentheses are separated by two commas. On line 30, the section references are separated by a semicolon. This seems unintentional, and should probably be made consistent with either all commas or all semicolons. [Government of United States of America, United States of America]	Editorial. Chapter will be copyedited prior to publication.
9035	3	8	30	8	38	Semi-colon missing at end [Nina Hunter, South Africa]	Editorial. Chapter will be copyedited prior to publication.
33141	3	8	33	8	33	Clarify which aspect of snow is changing: e.g. "Changing snow cover..." [Government of United States of America, United States of America]	Taken into account; figure has been redrafted completely by TSU
33143	3	8	35	8	35	Also mention the impacts of ecosystems such as the Antarctica dry valleys in this figure. Example citation: Soil Moisture Controls the Thermal Habitat of Active Layer Soils in the McMurdo Dry Valleys, Antarctica A. N. Wlostowski M. N. Gooseff, B. J. Adams https://doi.org/10.1002/2017JG004018 [Government of United States of America, United States of America]	Taken into account; figure has been redrafted completely by TSU
9037	3	8	39	0		Full-stop missing at end [Nina Hunter, South Africa]	Editorial. Chapter will be copyedited prior to publication.
13859	3	8	39	8	39	Please define 'subglacial discharge' in figure caption. [Government of United Kingdom (of Great Britain and Northern Ireland), United Kingdom (of Great Britain and Northern Ireland)]	Taken into account; figure has been redrafted completely by TSU
9503	3	8	40	8	40	Can be added a (12): Southern Ocean displays an unique endemic biodiversity with morphological adaptation affected by climate change. [Government of France, France]	Taken into account; figure has been redrafted completely by TSU
17711	3	9	0	11		For including two figures supporting Arctic linkages with the mid-latitudes, there should be at least a low-to-medium confidence or evidence statement supporting the connections, perhaps best fit for the "Potential for Polar Regions and Mid-Latitude Weather Linkages" section. [Thomas Ballinger, United States of America]	Accepted, statement added (figures have been removed)

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
28513	3	9	0	11		Reorganise? Now the first part of Box 3.1 addresses trends (but not linkages) in the Arctic, and both trends and atmosphere-to-polar region linkages in the Antarctic; then the subsection on "potential for polar regions and mid-latitude weather linkages" addresses Arctic-atmosphere and atmosphere-Arctic linkages, plus Antarctic-atmosphere linkages. Perhaps move p10 l10-25 to the Arctic part of p9, so that trends and how they are influenced by atmospheric patterns are addressed first, more evenly for both poles, and then the later subsection is just about the influence of polar regions on mid-latitude weather. [Yvonne Firing, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account in revising the structure of the box. Separated into a trends and a linkage section. Also separated box into two, one on climate trends, the other on mid-latitude weather linkages.
23121	3	9	0	9		Check coherency with SR15. Why focus on the last 2 decades for Arctic temperature amplification? What is "state change" (define). What is meant by "unprecedented", having in mind paleoclimate information? What is meant by "previous experience"? Text to be sharpened. [Valerie Masson-Delmotte, France]	Accepted. Revised and sharpened the text based on historical record and normals.
14997	3	9	1	11	10	Box 3.1 addresses links to atmospheric changes outside the polar regions. If this topic is considered appropriate within the scope of this special report, the discussion in Box 3.1 should be deepened and expanded in order to more clearly relate the state of the underlying science (see, e.g. , https://www.nature.com/articles/s41467-018-05256-8 for a recent review). While it is certainly relevant to include emerging evidence on high-risk or high-impact relationships, care must be taken to ensure consistent reporting of uncertainty. Please provide confidence language for each of the findings here, and note maturity and robustness of the underlying research. [Government of Germany, Germany]	Accepted. Separated box into two, one on climate trends, the other on mid-latitude weather linkages. Confidence language added to text in new Box 3.2
22365	3	9	1	11	10	Box 3.1 could benefit from an improved treatment of the Antarctic. It might help to restructure the text to group all of the Arctic information together (Arctic changes and their links to mid-latitude climate/weather), and then to do the same for the Antarctic. The mid-latitude weather linkages for the southern hemisphere should also be expanded from their current treatment. In particular, the well defined trends in the SAM have significant impacts on rainfall in the southern hemisphere mid-latitude countries. For Australia the decline in rainfall in southwest WA is a particularly robust rainfall trends in observations and models, and is linked to the positive trend in the SAM and changes in ZW3. [Abram Nerilie, Australia]	Taken into account in separating the box into two and revising material. However, the box is assessing the impact of cryosphere changes on mid-latitude weather so we restrict our SH literature to the impact of sea-ice changes on the mid-latitudes. Context for large -scale atmospheric circulation is found in the Appendix.
22367	3	9	1	11	10	It might also be of benefit to say that amplification of the climate change signal (as in the Arctic) is not yet seen in the Antarctic. [Abram Nerilie, Australia]	Accepted; revised as suggested
32363	3	9	1	11	10	This box is important. I would suggest that it not be couched as separate to the purpose of SROCC but more that the local atmosphere has an important role in what happens in ocean and cryosphere, and that the local atmosphere is affected by the global atmospheric circulation. A difficulty I had with the box is the jargon used. The local atmosphere interacts with the ocean and cryosphere through mediation of radiation, heat, precipitation and wind. It would be good if this box discussed how these were mediated by atmospheric processes rather than just assuming knowledge about the links between named phenomena and those processes. I would encourage a vastly simpler language than that presented here. I did not find the box figure 1 very helpful. For Figure 2, why is there not a comparative figure for the Antarctic? [Andrew Constable, Australia]	Taken into account: technical terms reduced and explained, processes listed, figures removed. However, SROCC CH 3 doesn't have a mandate to assess atmospheric circulation. This box actually provides the basis for putting local atmospheric consequences in context throughout the chapter.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
11395	3	9	1	11	12	I'm a bit surprised there's no discussion on the effects of changing radiative forcing/energetics in polar regions on tropical rainfall. This linkage has been investigated in many modeling studies (e.g. Cabre et al. 2017 -- J. Climate Global Atmospheric Teleconnections and Multidecadal Climate Oscillations Driven by Southern Ocean Convection; Hwang et al. 2017 -- Geophys. Res. Lett. Connecting tropical climate change with Southern Ocean heat uptake; Wang et al. 2018-- Geophys. Res. Lett. Fast Response of the Tropics to an Abrupt Loss of Arctic sea ice via Ocean dynamics) and is relevant to the discussion of this Box. [Anson Cheung, United States of America]	This box is assessing the impact of the polar cryosphere on the atmosphere so we restrict our literature for the SH to the impact of sea-ice changes on the mid-latitudes. Context for large -scale atmospheric circulation is found in the Appendix.
11401	3	9	1	11	12	This box is framed in a way that it sounds like it's a matter of atmospheric changes and is less related to this report. However, the details discussed in this box is clearly related to consequences of polar changes, specifically on how polar changes affect lower latitude climate via teleconnections. Hence, I think it is worthy to dedicate more on this topic. [Anson Cheung, United States of America]	Taken into account. Separated the box into two, one on climate trends, the other on mid-latitude weather linkages. SROCC CH 3 doesn't have a mandate to assess atmospheric circulation. Relevant context is found in the Appendix
11403	3	9	1	11	12	There are many paleoclimate evidence and some paleoclimate modeling evidence showing low latitude response to high latitude forcing change, e.g. Hughen et al. 1996 Nature, Haug et al. 2001 Science, Kennett and Ingram 1995 Nature, Chiang and Bitz 2005. I think these studies are worthy to discuss because they demonstrate large radiative forcing changes can in fact affect low latitude climate. [Anson Cheung, United States of America]	Taken into account - added new reference.
2773	3	9	1	9	57	It seems obvious, but box 3.1 does not clearly say "the Arctic has been warming", and this should be stated, especially if this is to appear at the start of the chapter, as it currently does. Mentioning the context of global mean warming would also be helpful here. [Neil Swart, Canada]	Accepted. Language strengthened
33147	3	9	4	0		The SROCC acronym does not appear to be defined in this chapter. Perhaps it should be defined here? [Government of United States of America, United States of America]	Taken into account: text removed
17079	3	9	4	9	7	Two if the sentences in this paragraph start with the word 'Whilst'. This could be reworded. [Samuel Morin, France]	Taken into account: text removed
33145	3	9	4	9	7	"Whilst" is rather uncommon (at least in American English). [Government of United States of America, United States of America]	Taken into account: text removed
30337	3	9	5	9	5	WORD ORDER: change the position of the adverb "also" from the end of the sentence so it precedes the verb "requires" (= "also requires knowledge of..."). [Paul Glaser, United States of America]	Taken into account: text removed
9039	3	9	8	0		Semi-colon should be a comma [Nina Hunter, South Africa]	Taken into account: text removed
9041	3	9	9	0		also' not necessary as is stated in 'including' [Nina Hunter, South Africa]	Taken into account: text removed
3211	3	9	11	9	11	Do you mean the temperature "increase" has been double the global average? [Sharon Smith, Canada]	accepted as suggested
3607	3	9	11	9	11	"Arctic surface air temperature change has been double the global average", this sentence should be changed into "The surface warming in the Arctic is 2–3 times faster than the global average (Serreze and Barry 2011; Andry et al. 2017)". [Bingyi Wu, China]	taken into account. Now reads "more than double"

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
3609	3	9	11	9	11	<p>“Arctic surface air temperature change has been double the global average”, this sentence should be changed into “The surface warming in the Arctic is 2–3 times faster than the global average (Serreze and Barry 2011; Andry et al. 2017)”. Serreze, M., and R. Barry, 2011: Processes and impacts of Arctic amplification: A research synthesis. Global Planet. Change, 77, 85–96, doi:10.1016/j.gloplacha.2011.03.004 Andry, O., R. Bintanja, and W. Hazeleger, 2017: Time-dependent variations in the Arctic’s surface albedo feedback and the link to seasonality in sea ice. J. Climate, 30, 393–410, doi:10.1175/JCLI-D-15-0849.1. [Bingyi Wu, China]</p>	taken into account. Now reads "more than double"
10449	3	9	11	9	12	References exist for this subject are quite limited, its better to include such as; Screen and Simmonds (2010, Nature), Serreze et al. (2009, Cryosphere) [Takashi Yamanouchi, Japan]	Reject: we cite more recent references, in line with SROCC scope to update AR5
33149	3	9	14	9	14	Mechanisms of Arctic Amplification are not all that well understood and a number of competing and complementary ideas exists. Cite Stuecker et al. 2018 [Government of United States of America, United States of America]	Taken into account. Now reads: "Mechanisms for Arctic amplification are still debated, but include..."
10451	3	9	14	9	15	The sentence, "Stabilizing global Arctic climate system (AMAP, 2017)", should be located at the end of this paragraph, since the message of this sentence is future prediction. [Takashi Yamanouchi, Japan]	Accepted as suggested
18805	3	9	14	9	15	The sentence about stabilizing global temperature is confusing here because it's in a paragraph about Arctic Amplification but it is unclear how this sentence is specifically related to Arctic Amplification. [APECS Group Review, Germany]	Accepted as suggested
11877	3	9	15	9	15	It is a bit tricky to refer to the AMAP 2017 report here because it is difficult to track down where exactly in that not-so-short report this is written. If possible, it would be preferable to cite original papers instead, or at least alongside the report. [Gerhard Krinner, France]	this text is now removed
10475	3	9	15	9	19	Add "and the seasonality of Arctic amplification was explained by Yoshimori et al. (2014a, Cli. Dynamics; 2014b, J. Clim.)", at the end of the sentence. [Takashi Yamanouchi, Japan]	reject, too detailed information and not needed here
15537	3	9	15	9	19	References are missing for these statements. [EUCE, Belgium]	reject: reference to appendix exists, where this is discussed with references. There is no space and limited overall SROCC mandate to go into these process details here.
16873	3	9	15	9	19	References missing for these statements [Louise Sandberg Soerensen, Denmark]	reject: reference to appendix exists, where this is discussed with references. There is no space and limited overall SROCC mandate to go into these process details here.
3841	3	9	17	0		probably no clear evidence for changes in total cloudiness in summer and its role in driving Arctic amplification [Zhaomin Wang, China]	Taken into account. Sentence now starts with "Mechanisms for Arctic amplification are still debated, but include..."
10453	3	9	19	9	21	As for the refence to this sentence, another papers, Yoshimori et al. (2017, Climate Dynamics) and Graverson and Burtu (2016, J. Q. S. R. T.), should be included, since these papers clearly explain the role of heat transport in the Arctic warming. [Takashi Yamanouchi, Japan]	reject, current references are sufficient

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
28523	3	9	19	9	21	Is this lower rate not just due to factors already mentioned (surface temperature, cloud cover, atmospheric moisture content)? [Yvonne Firing, United Kingdom (of Great Britain and Northern Ireland)]	noted. Yes, it is
18807	3	9	23	9	24	Overland and Wang showed 2m T for Dec. and January only. I read through the paper and did not see in there that the Annual mean or timeseries also exceeded previous records. Please clarify the wording of this sentence. [APECS Group Review, Germany]	accepted. changed the reference.
33151	3	9	23	9	28	"state change" is not defined. The statement that the events listed in this sentence "indicate" a "state change" much less so. It is difficult enough to link extreme events to specific hypotheses (such as anthropogenic warming); vague hypotheses don't make this any better. [Government of United States of America, United States of America]	Accepted. replaced the term "state change"
3213	3	9	23	9	36	At the beginning of this paragraph it should be clear what is meant by "all previous records" - what time period is being considered here - give time frame. [Sharon Smith, Canada]	accepted. Added base line
11397	3	9	23	9	36	A number of studies also showed that Arctic temperature can change as a result of natural climate variability that stems from Pacific and Atlantic (Screen and Francis 2016 -- Nature Climate Change; Svendsen et al. 2018 -- Nature Climate Change) [Anson Cheung, United States of America]	Taken into account. "Pacific and Atlantic" was and is mentioend in the text
11399	3	9	23	9	36	Some recent studies also suggested that there's large internal variability in the Arctic atmosphere (Ding, Q et al. 2017 -- Nature Climate Change; Ding, Q et al. 2018 -- Nature Geoscience) [Anson Cheung, United States of America]	Taken into account. Variability is discussed towards the end of new Box 3.2
17081	3	9	26	9	26	I don't think "double" is appropriate when it refers to temperature, because temperature changes are more appropriately referred to in additive/negative values than multiplicative (in contrast, e.g., to precipitation). [Samuel Morin, France]	reject. use is common for anomalies
23923	3	9	27	9	27	Suggest modification of "vortex" to "polar vortex". [Government of Japan, Japan]	accepted as suggested
33153	3	9	27	9	27	The connection between stratospheric events, SSW, vortex splits to global warming is at best tenuous. It should be characterized as such. Suggest sticking to evidence that is much more solid to reflect whatever is meant by a "state change" (e.g. temperature, sea ice). [Government of United States of America, United States of America]	taken into account. "state" not used
28529	3	9	27	9	28	How does this indicate state changes? What is the strength of evidence and/or level of confidence for the idea that these stochastic vortex splitting events were more likely because of changes in the broader climate system? [Yvonne Firing, United Kingdom (of Great Britain and Northern Ireland)]	taken into account. "state" not used
9043	3	9	28	0		It would be useful if 'advection' could be defined [Nina Hunter, South Africa]	accepted . replaced with "transport"
18809	3	9	28	9	29	the phrasing "advection of temperataure" is misleading since you can have warm or cold air advection. Specify "advection of warm air" or "advection of warmer temperaures" [APECS Group Review, Germany]	accepted. text refined

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
10455	3	9	28	9	30	For the message in the first part of the sentence should be supported by the reference, Yamanouchi (2018, Polar Science, https://doi.org/10.1016/j.polar.2018.10.009). [Takashi Yamanouchi, Japan]	reject: current references are sufficient.
2379	3	9	31	9	31	the Bering Sea should be included as a sub-arctic region; it is seasonally ice covered, and supports a number of arctic species such as polar bears, ice seals ivory gull and polar cod (Boreogadus) [George Hunt, United States of America]	Noted, but the main Pacific region showing delayed freeze-up was the Chukchi Sea
2527	3	9	31	9	32	Please do not use warmer/colder temperatures, but higher/lower temperatures. Also page 10. I. 33 & 34 and throughout. [Michiel Van den Broeke, Netherlands]	reject . "warm" is now acceptable
10457	3	9	32	9	32	The final part of the sentence should be supported also by another reference, Moore (2016, Sci. Rep., 6, 39084, https://doi.org/10.1038/srep39084) [Takashi Yamanouchi, Japan]	reject. current reference is adequate and sufficient
680	3	9	32	9	34	It will be very helpful if the recently observed low winter maximum sea ice is presented with a long-term record (if possible). This is a new result since AR5, but I cannot tell whether it is a significant long-term trend from this sentence. [Mengxi Wu, United States of America]	reject. This is not a sea ice section: these details are discussed later in the chapter
18811	3	9	35	9	35	Specify both the atmosphere and sea ice are in new states. Basically multiple components of the earth system show the new state. [APECS Group Review, Germany]	taken into account. "state" not used
3215	3	9	38	9	38	Do you mean spatially or regionally uniform? [Sharon Smith, Canada]	Noted. All of the above - Antarctic warming has been less spatially, regionally and temporally uniform but difficult to fit all those words in.
10459	3	9	38	9	40	Additional reference, Steig et al. (2009, Nature), was the first to point this message. [Takashi Yamanouchi, Japan]	Reject. We are focusing on literature since AR5 so restrict our citations primarily to post-2012
22461	3	9	39	9	40	Suggest clarifying this section. The statement on "weak cooling over East Antarctica" is not supported by either reference cited. Furthermore this is also revisited at page 50, line 6 which states "little change". The references would also indicate that East Antarctic trends are not homogenous with some regional cooling and some warming. Suggest stating that there is "no significant overall change". [Government of Australia, Australia]	Accepted. Revised as suggested
3217	3	9	41	9	41	By "internal variability" do you mean "interannual variability" (obscures long-term trend?) [Sharon Smith, Canada]	Clarified. Internal variability refers to natural internal variability which can be on interannual and interdecadal timescales
18813	3	9	41	9	41	I think it might be clearer to say "large regional internal variability." [APECS Group Review, Germany]	Clarified.
3843	3	9	41	9	43	suggest to delete Pacific at line 42, as tropical Atlantic sea surface temperature can influence Antarctic temperature change [Zhaomin Wang, China]	Accepted as suggested
3845	3	9	41	9	43	(Li, X., D. M. Holland, E. P. Gerber and C. Yoo, 2014: Impacts of the north and tropical Atlantic Ocean on the Antarctic [Zhaomin Wang, China]	Accepted. Reference included as suggested
3847	3	9	41	9	43	Peninsula and sea ice. Nature, 505, 538, doi:10.1038/nature12945.) [Zhaomin Wang, China]	Accepted. Reference included as suggested

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
18815	3	9	41	9	48	this entire sentence is extremely confusing. Tropical SST impacts teperature and the ice shelf? And mid-latitude circulation and the sea ice extent? This whole sentence could be clarified. I also wonder if you should explicitly discuss the record drop in Antarctic sea ice extent in 2016 after years of increasing trends and how this may be internal variability. Turner et al. 2017b is already cited and they looked into the ice decline and the single event is so dramatic it may be worth mentioning. [APECS Group Review, Germany]	Taken into account. Focus is now on atmospheric and temperature changes, references to ice sheets and sea ice have been removed
22463	3	9	41	9	48	Suggest "medium confidence" be upgraded to "high confidence" and cite the following: Yuan, X., M.R. Kaplan, and M.A. Cane, 2018: The Interconnected Global Climate System—A Review of Tropical–Polar Teleconnections. J. Climate, 31, 5765–5792, https://doi.org/10.1175/JCLI-D-16-0637.1 Ferster, Brady S., Subrahmanyam, Bulusu, Macdonald, Alison M., "Confirmation of ENSO-Southern Ocean teleconnections using satellite-derived SST", Remote Sensing 10 (2018): 331, DOI:10.3390/rs10020331, https://hdl.handle.net/1912/10234 Pope, J. O., P. R. Holland, A. Orr, G. J. Marshall, and T. Phillips (2017), The impacts of El Niño on the observed sea ice budget of West Antarctica, Geophys. Res. Lett., 44, 6200–6208, doi:10.1002/2017GL073414. [Government of Australia, Australia]	Taken into account. Have added Yuan et al 2018 but not included ones that focus on sea ice which no longer part of the box.
11413	3	9	50	9	54	Abram et al. 2014 -- Nature Climate Change reconstructed SAM and showed that recent change is highly unusual over the past millennium and is likely due to anthropogenic forcing and ozone depletion. [Anson Cheung, United States of America]	Accepted. Reference included as suggested
23993	3	9	50	9	56	This section is written in a hard to understand technical way, with a logically questioning main message because the ozone hole did not disappear in 1990. It could be combined with more detailed explanations p 14 33-50. [Patricia Martinerie, France]	Taken into account. Rewritten
18817	3	9	53	9	53	While ozone has driven the SAM modes, I think it should be noted that ozone depletion is NOT a likely driver of regional sea ice trends around the Antarctic. (Landrum et al. 2017, https://doi.org/10.1002/2017GL075618) [APECS Group Review, Germany]	Taken into account. Rewritten with sea ice no longer included.
10461	3	9	53	9	55	Add the most original paper by Thompson and Solomon (2002, Science), Polvani et al. (2011, GRL) who compared the greenhouse gas cooling with the ozone hole, and Yang et al. (2014, Advances Atmos. Sci.) who discussed the radiative effect of ozone depletion. [Takashi Yamaneuchi, Japan]	Focus is on recent literature since AR5
29049	3	9	53	9	55	Assume this refers to the role of ozone depletion in potentially strengthening the SAM and thus insultating the continent to some degree from transport of warming from southern mid-latitudes; if so, would be helpful to make this more explicit. [Pam Pearson, Sweden]	Accepted, langauge refined
11411	3	9	54	9	54	Cite Polvani et al. 2011 J Climate -- Stratospheric Ozone Depletion: The Main Driver of Twentieth-Century Atmospheric Circulation Changes in the Southern Hemisphere [Anson Cheung, United States of America]	Reject. We are focusing on literature since AR5 and restrict our citations accordingly
3849	3	9	55	9	56	suggest to cite Wang et al. 2015, as this paper documented the clear linkage between SAM and surface temperature [Zhaomin Wang, China]	noted, but unfortunately unclear which reference this is referring to
3851	3	9	55	9	56	averaged over NH and the tropical region since the 1940s (Wang et al. An atmospheric origin of the multi-decadal bipolar seesaw, Scientific Reports 5, 8909; DOI:10.1038/srep08909 (2015)). [Zhaomin Wang, China]	reject. current references are sufficient
9505	3	10	0	0		About page layout : shouldn't we put this figure after the next paragraph ? [Government of France, France]	The figure was removed

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
23123	3	10	0	10		Missing level of confidence or level of scientific understanding in figure. Arctic amplification also occurs due to natural variability (e.g. paleoclimate). To check carefully. [Valerie Masson-Delmotte, France]	The figure was removed
23125	3	10	0	10		"Arctic forcing" : check the use of "forcing" in this context. Forcing or feedback? [Valerie Masson-Delmotte, France]	The figure was removed
3853	3	10	1	0		I think that "Fall Eurasian snow cover increase" needs to be further verified. [Zhaomin Wang, China]	The figure was removed
31619	3	10	1	0		Box 3.1, Figure 1. The boxes "Arctic amplification" and "Global Climate Change" are both of the same color, and there is one box with red letters. These coloring details are not explained in the caption. I suggest to simplify this coloring scheme. [Hans-Otto Poertner and WGII TSU, Germany]	The figure was removed
31621	3	10	1	0		Box 3.1, Figure 1. The name of the mb unit will be helpful here. [Hans-Otto Poertner and WGII TSU, Germany]	The figure was removed
1651	3	10	1	10	11	This figure fails to mention how melting glacial ice (contribute to changes in ocean circulation) and permafrost (large source of potential carbon) will contribute to changes in the North Hemisphere and could influence mid-latitude weather. [Nora Richter, United States of America]	The figure was removed
3165	3	10	1	10	11	This figure is somewhat confusing. The caption doesn't describe the meaning of the different colored boxes in the figure. Although the caption addresses the meaning of the double boxes, it is still unclear what these signify and how this relates to the arrows between different pathways. [Sloane Garelick, United States of America]	The figure was removed
11405	3	10	1	10	11	I don't understand why each box is colored differently. [Anson Cheung, United States of America]	The figure was removed
11407	3	10	1	10	11	The term global climate change is very ambiguous here, does it mean radiative forcing change or increase in CO2 or change in ozone or everything that is a result of human activities? [Anson Cheung, United States of America]	The figure was removed
11409	3	10	1	10	11	If there's a feedback between Arctic amplification and NH cryosphere changes, and between Polar Vortex and changes in storm tracks, jet stream, planetary waves (affected by Arctic amplification), why isn't there a double box for NH cryosphere changes and Polar vortex? [Anson Cheung, United States of America]	The figure was removed
14999	3	10	1	10	11	Figure 1 does not contribute to a better understanding. It is of poor illustrative quality and seems to convey strong causal relationships where actually links are still not scientifically established, e.g. solar cycle links to storm tracks. We strongly urge the authors to find a clearer and more differentiated graphic representation of these complex interactions, or else remove the figure. [Government of Germany, Germany]	The figure was removed
26367	3	10	1	10	2	This figure could be reorganized. A logical flow would start with "global climate change" and "natural variability" (forcing processes) at the same side of the figure and continue through the intermediate boxes until "Northern hemisphere mid-latitude weather" (the final "result" process). Currently, there is no clear flow in the visual design, which makes interpretation difficult for non-specialists. The aim of the figure is to show how Arctic processes influence mid-latitude weather; that aim should come across clearly in the visual logic. [Ethan Pierce, United States of America]	The figure was removed

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
682	3	10	2	10	2	It is not very clear how the figure matches the caption. What is the double box of "Arctic Amplification" intended for? I think it is used to represent some effects of Arctic amplification based on the caption, but I do not know what effects exactly. [Mengxi Wu, United States of America]	The figure was removed
31025	3	10	4	10	11	Please use autumn rather than fall [Hans-Otto Poertner and WGII TSU, Germany]	The figure was dropped
33155	3	10	4	10	4	This figure does not capture the complexity of high latitude / mid latitude interactions. Improve or delete it. [Government of United States of America, United States of America]	The figure was dropped
33157	3	10	7	10	9	Rephrase to increase readability: e.g. "Two additional causes of change, which do not involve Arctic amplification, are also represented..." [Government of United States of America, United States of America]	The figure was dropped
33159	3	10	14	10	14	This whole section needs a lot of work! It doesn't clarify anything. [Government of United States of America, United States of America]	Noted. This material has been revised over moving it to a new Box on polar cryosphere influence on mid-latitude weather
11415	3	10	14	10	25	Shouldn't there be slightly more discussion on the relationship between amplified planetary waves and weather extremes? There have been multiple studies discussing about this relationship and might be a result of polar amplification (e.g. Petoukhov et al. 2013 PNAS, Screen and Simmonds 2014 Nature Climate Change, Coumou et al. 2014 PNAS, Mann et al. 2017 Scientific Reports) [Anson Cheung, United States of America]	Reject. The chapter does not have a mandate to assess the atmosphere, and so the discussion on mid-latitude linkages has to be extremely brief. Some of the desired information is touched on in the appendix. We have also
17507	3	10	16	10	25	Other potentially useful references: Francis J. A. & Vavrus S. J. (2015) Evidence for a wavier jet stream in response to rapid Arctic warming, ENVTL. RESEARCH LETTERS 10(014005):1–12; Francis J. A. & Vavrus S. J. (2012) Evidence linking Arctic amplification to extreme weather in mid-latitudes, GEOPHYSICAL RESEARCH LETTERS 39(L06801):1–6; Screen J. A. & Simmonds I. (2013) Exploring links between Arctic amplification and mid-latitude weather, GEOPHYSICAL RESEARCH LETTERS 40:959–964; Cohen J., et al. (2018) Warm Arctic episodes linked with increased frequency of extreme winter weather in the United States, NATURE COMMUNICATIONS 9(869):1–12; Cvijanovic I., et al. (2017) Future loss of Arctic sea-ice cover could drive a substantial decrease in California's rainfall, NATURE COMMUNICATIONS 8(1947):1–10. [Kristin Campbell, United States of America]	noted, thank you, but the material is sufficiently referenced as is
17609	3	10	16	10	25	Other potentially useful references: Francis J. A. & Vavrus S. J. (2015) Evidence for a wavier jet stream in response to rapid Arctic warming, ENVTL. RESEARCH LETTERS 10(014005):1–12; Francis J. A. & Vavrus S. J. (2012) Evidence linking Arctic amplification to extreme weather in mid-latitudes, GEOPHYSICAL RESEARCH LETTERS 39(L06801):1–6; Screen J. A. & Simmonds I. (2013) Exploring links between Arctic amplification and mid-latitude weather, GEOPHYSICAL RESEARCH LETTERS 40:959–964; Cohen J., et al. (2018) Warm Arctic episodes linked with increased frequency of extreme winter weather in the United States, NATURE COMMUNICATIONS 9(869):1–12; Cvijanovic I., et al. (2017) Future loss of Arctic sea-ice cover could drive a substantial decrease in California's rainfall, NATURE COMMUNICATIONS 8(1947):1–10. [Durwood Zaelke, United States of America]	noted, thank you, but the material is sufficiently referenced as is

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
10209	3	10	16	10	35	Suggest including the findings of these studies which show the linkage between Arctic warming and mid-latitude extreme weather: 1. D. Coumou, G. Di Capua, S. Vavrus, L. Wang, S. Wang (2018): The influence of Arctic amplification on mid-latitude summer circulation. Nature Communications [DOI:10.1038/s41467-018-05256-8] 2. V. Petoukhov, S. Petri, K. Kornhuber, K. Thonicke, D. Coumou, H.J. Schellnhuber (2018): Alberta wildfire 2016: Apt contribution from anomalous planetary wave dynamics. Nature Scientific Reports [DOI:10.1038/s41598-018-30812-z] 3. Judah Cohen, Karl Pfeiffer & Jennifer A. Francis, Nature Communications volume 9, Article number: 869 (2018): Warm Arctic episodes linked with increased frequency of extreme winter weather in the United States [SAI MING LEE, China]	noted, thank you, but the material is sufficiently referenced as is
33161	3	10	17	10	17	How does Figure 1 support this statement? [Government of United States of America, United States of America]	The figure was dropped
15539	3	10	19	10	19	What is meant by the assessment being 'controversial' ? Please, clarify. [EUCE, Belgium]	taken into account. changed to: " recent assessments are inconsistent"
16875	3	10	19	10	19	What is meant by the assessment being 'controversial' ? [Louise Sandberg Soerensen, Denmark]	taken into account. changed to: " recent assessments are inconsistent"
4121	3	10	19	10	20	Mori et al. (2014, Nat. Geo., DOI: 10.1038/NGEO2277), Nakamura et al. (2016, Geophys. Res., Lett., doi:10.1002/2016GL068330), and Ogawa et al. (2018, Geophys. Res., Lett., doi:10.1002/2017GL076502) can be added as references for the fact that the mechanisms of Arctic and mid-latitude weather connections have been emerged to be understood, though some parts of the conclusions are remained to be controversial. [Kumiko Takata, Japan]	Reject. Existing references already cover this aspect.
27533	3	10	20	10	20	When referring to "snow loss" here and elsewhere (see other comments below), it would be a good idea to indicate/clarify terrestrial or snow on sea ice because there is less certainty in the trends of snow on sea ice thus making it perhaps a bit misleading to indicate snow loss in the same sentence as sea ice loss without indicating if it is terrestrial or snow on sea ice. [Benjamin A. Lange, Canada]	accepted. text added
33163	3	10	20	10	24	"Arctic Forcing". This is vague and requires a clear definition. The "increasing" requires a time reference. Suggest simplifying by stating that this is an area of ongoing research. A summary of what the current positions are and why they may exist (models, data) should be possible. Relying on attempts to reconcile what is known (e.g. Screen et al. 2017) and what isn't should be reflected. The "controversy" isn't really explained. [Government of United States of America, United States of America]	taken into account. Added: "...but a full understanding of complex inter-connected physical processes is lacking"
4129	3	10	25	10	25	Please include the sentence after "with highly nonlinear responses to the Arctic warming (Overland et al., 2016)." Overland et al. (Nature Climate Change, 6, 992-999, 2016) [Seong-Joong Kim, Republic of Korea]	Accepted, revised as suggested
10463	3	10	27	10	27	Please include "Barents Sea", so it will be written as ... from sea ice loss in the Barents and Kara Sea. [Takashi Yamanouchi, Japan]	Accepted, revised as suggested
18819	3	10	27	10	27	Rewording this to be "potential for cold episodes in eastern Asia resulting from sea ice loss in the Kara Sea" [APECS Group Review, Germany]	Accepted, revised as suggested

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
4655	3	10	27	10	28	Here, only the impact of sea ice change in the Kara Sea on cold events over East Asia is mentioned. In fact, the effects of the Arctic and Antarctic sea ice changes on China climate has also been documented and reviewed by Qin et al (Qin D., B. Zhou, C. Xiao, 2014: Progress in studies of cryospheric changes and their impacts on climate of China. Journal of Meteorological Reaserch, 28 (5): 732-746). So, this reference is suggested to be added and assessed in the Special Report. [botao zhou, China]	rejected. China is in east Asia, so covered by existing references.
10465	3	10	27	10	28	Add the phrase, "which is most reliable compared to other regions such as eastern North America or Europe, including stratospheric path way," after "...eastern Asia". [Takashi Yamanouchi, Japan]	reject. This addition is too wordy given the limited space available
10467	3	10	27	10	28	Add refences, Honda et al. (2009, GRL), Inoue et al. (2012, J Clim.), Mori et al. (2014, Nature Geo.) and Nakamura et al. (2015, JGR; 2016, GRL), in the end of the sentence. [Takashi Yamanouchi, Japan]	reject. the material is sufficiently references as is
17713	3	10	27	10	35	Ocean forcing (low-to-no cold season regional sea ice coverage and warm SSTs) on amplified polar jet stream ridging is one proposed, intermittent mechanism that additionally supports a high-to-low latitude (and vice versa) air mass advection and hence an Arctic-mid latitude linkages. See new paper by Jennifer Francis et al --> Francis, J.A, S.J. Vavrus, and J. Cohen, 2017: Amplified Arctic warming and mid-latitude weather: New perspectives on emerging connections. WIREs Climate Change, doi: 10.1002/wdd.474. [Thomas Ballinger, United States of America]	reject. This addition would be too detailed given the limited space available
9507	3	10	28	10	28	Are those two references "reviews" of the extensive literature ? If yes, it should be specified. If not, why just two references are given, while there are five references in the paragraph below (p.11, l.6 : Only few studies on the potentiel impact of Antarctic..). [Government of France, France]	taken into account. We provide representative but not all references. We reduced the number of references in the Antarctic section
18821	3	10	28	10	28	This also is confusing. What change, precisely, do you mean and how exactly do you mean between Greenland and the Chuckchi sea? Do you mean the Beaufort sea (which is between the two locations). [APECS Group Review, Germany]	accepted. refined sentence
3539	3	10	28	10	29	The phrase "There is some analysis of cases between change in the Chukchi Sea and west of Greenland..." doesn't make sense to me. I think "cases" should be "connections" or "links". [Sonya Legg, United States of America]	Accepeted, refined sentence
33165	3	10	30	10	30	"seem to be episodic": What does this mean in this context? What does the lack of increase of cold events have to do with it? If it has nothing to do with climate change and is just an interesting process, why is this in SROCC? [Government of United States of America, United States of America]	Taken into account. Refined sentence and flow of argument.
4131	3	10	31	10	31	Cohen et al. (2014) showed since year 2000, coldest minimum temperatire, number of icing days have decreases, whereas percent of cold winter months have increased. Thus, this results should be included in the statement in line 31. [Seong-Joong Kim, Republic of Korea]	reject. Material is sufficiently referenced
18823	3	10	32	10	33	Does this December 2017 event require a reference (evidence tracking?) [APECS Group Review, Germany]	text and figure removed
2775	3	10	32	10	35	There is no citation for this "North American" example. Is it published or a new, unreviewed claim? If new, should unpublished material be included? [Neil Swart, Canada]	text and figure removed

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
24399	3	10	32	10	35	This statement is highly speculative, and no confidence limits are given (or can be given). Suggestion: remove this sentence. [Rejected. NGOs is an institution and an informal actor. IAATO is important and hsi section assesse "internatioanl copoeration" including formal and informal actors. It is written that IAATO is an "International Association" not an international governmental body. , Denmark]	text and figure removed
9045	3	10	33	0		Insert 'a' before 'record' [Nina Hunter, South Africa]	accepted. Changed as suggested
23127	3	11	0	11		Box missing clear conclusion linked with text in ES. [Valerie Masson-Delmotte, France]	accepted. We have mapped main assessment points from the box (now two boxes) to the Executive Sumamry
12147	3	11	0	43		Section 3.2 'Polar Oceans and Sea Ice: Changes, Consequences and Impacts' does not mention the issue of methane release from shelf sea sediments at all. While this is a controversial issues with a wide disparity of views on its significance, it does merit some reference to it. Curiously, this issue is mentioned in section 3.4 'Terrestrial Cryosphere: Changes, Consequences and Impacts' - in the 3rd paragraph of sub-section 3.4.1.2.3 in lines 16-25 on page 63 and briefly in the 3rd paragraph of sub-section 3.4.3.1.1 in lines 32-33 and 47-49 on page 68. It is also mentioned in Chapter 5 in lines 15-26 on page 50 and in Chapter 6 in Table 6.1 on page 8. Potential text in cell below taken from a GESAMP report in press. This text probably needs an additional mention of permafrost now submerged on shallow Arctic shelves that was exposed as a terrestrial ecosystem during the last glacial maximum. [Christopher Vivian, United Kingdom (of Great Britain and Northern Ireland)]	Accepted: key messages re-worded

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
12149	3	11	0	43		<p>Methane gas hydrates are stable at the high pressures and low temperatures found in sediment beneath the sea. They form naturally in sediments where adequate supplies of methane and seawater can combine in a location with both high pressure and relatively low temperature. The methane is created in situ by the decomposition of organic carbon, and then the methane generally migrates upward through water-laden sediment. Under the right conditions, the methane combines with water to form gas hydrate. Most sedimentary marine gas hydrate deposits found so far have been in continental margin and slope sediments. The global inventory of gas hydrates appears to be very large with recent estimates ranging from 1500 to 15,000 gigatonnes of carbon (Beaudoin et al., 2014). Some scientists (e.g. Shakhova et al., 2010; Shakhova et al., 2013; Shakhova et al., 2015; Whiteman et al., 2013 and Glikson, 2018) have raised serious concerns, due to the much higher global warming potential of methane, about the potential release of vast amounts of methane from the Arctic, particularly the seabed, as the Arctic warms. Hence, there may be a potential need for methane capture and/or degradation (such as by 'flaring' with concomitant CO2 release) to minimise the additional warming of the atmosphere via methane release. However, most scientists working on this matter have discounted the likelihood of significant large-scale methane releases from Arctic sediments driven by warming (e.g. Archer et al., 2009; Pohlman et al., 2017; Ruppel and Kessler, 2017). It should be noted that there have been proposals to extract the methane in hydrate deposits by replacing the methane with CO2, thus simultaneously storing the CO2 and recovering the methane for use as a fuel or feed stock (Babu et al., 2014; Ersland et al., 2009; Goel, 2006; Park et al., 2006). A small-scale deep-sea field test of this concept was carried out by Brewer et al. (2014). However, concerns have been raised about the risks of massive methane releases caused by destabilizing the hydrates during the process of injecting the CO2 and recovering the methane (Marshall, 2009; Zhang and Zhai, 2015). [Christopher Vivian, United Kingdom (of Great Britain and Northern Ireland)]</p>	Accepted-key citations referenced in 3.4 and ES modified
12151	3	11	0	43		References: [Christopher Vivian, United Kingdom (of Great Britain and Northern Ireland)]	Accepted-key citations referenced in 3.4 and ES modified
12153	3	11	0	43		Archer, D. (2005). Fate of fossil fuel CO 2 in geologic time. Journal of Geophysical Research, 110(C9), C09S05. https://doi.org/10.1029/2004JC002625 [Christopher Vivian, United Kingdom (of Great Britain and Northern Ireland)]	Accepted-key citations referenced in 3.4 and ES modified

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
12155	3	11	0	43		Babu, P., Yang, S. H. B., Dasgupta, S., & Linga, P. (2014). Methane production from natural gas hydrates via carbon dioxide fixation. <i>Energy Procedia</i> , 61, 1776–1779. https://doi.org/10.1016/j.egypro.2014.12.210 [Christopher Vivian, United Kingdom (of Great Britain and Northern Ireland)]	Accepted-key citations referenced in 3.4 and ES modified
12157	3	11	0	43		Beaudoin, Y. C., Boswell, R., Dallimore, S. R., & Waite, W. (eds). (2014). Frozen heat: A UNEP Global Outlook on Methane Gas Hydrates. United Nations Environment Programme, GRID-Arendal. Executive Summary. https://gridarendal-website-live.s3.amazonaws.com/production/documents/:s_document/65/original/gashydrates_summary_screen.pdf?1483646439 [Christopher Vivian, United Kingdom (of Great Britain and Northern Ireland)]	Accepted-key citations referenced in 3.4 and ES modified
12159	3	11	0	43		Brewer, P. G., Peltzer, E. T., Walz, P. M., Coward, E. K., Stern, L. A., Kirby, S. H., & Pinkston, J. (2014). Deep-Sea Field Test of the CH ₄ Hydrate to CO ₂ Hydrate Spontaneous Conversion Hypothesis. <i>Energy & Fuels</i> , 28(11), 7061–7069. https://doi.org/10.1021/ef501430h [Christopher Vivian, United Kingdom (of Great Britain and Northern Ireland)]	Accepted-key citations referenced in 3.4 and ES modified
12161	3	11	0	43		Ersland, G., Husebø, J., Graue, A., & Kvamme, B. (2009). Transport and storage of CO ₂ in natural gas hydrate reservoirs. <i>Energy Procedia</i> , 1(1), 3477–3484. https://doi.org/10.1016/j.egypro.2009.02.139 [Christopher Vivian, United Kingdom (of Great Britain and Northern Ireland)]	Accepted-key citations referenced in 3.4 and ES modified
12163	3	11	0	43		Glikson, A. (2018). The methane time bomb. <i>Energy Procedia</i> , 146, 23–29. https://doi.org/https://doi.org/10.1016/j.egypro.2018.07.004 [Christopher Vivian, United Kingdom (of Great Britain and Northern Ireland)]	Accepted-key citations referenced in 3.4 and ES modified
12165	3	11	0	43		Goel, N. (2006). In situ methane hydrate dissociation with carbon dioxide sequestration: Current knowledge and issues. <i>Journal of Petroleum Science and Engineering</i> , 51(3–4), 169–184. https://doi.org/10.1016/j.petrol.2006.01.005 [Christopher Vivian, United Kingdom (of Great Britain and Northern Ireland)]	Accepted-key citations referenced in 3.4 and ES modified
12167	3	11	0	43		Marshall, M. (2009). Ice that burns could be a green fossil fuel. <i>New Scientist</i> , (26 March 2009). Retrieved from https://www.newscientist.com/article/dn16848-ice-that-burns-could-be-a-green-fossil-fuel/ [Christopher Vivian, United Kingdom (of Great Britain and Northern Ireland)]	Accepted-key citations referenced in 3.4 and ES modified

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
12169	3	11	0	43		Park, Y., Kim, D.-Y., Lee, J.-W., Huh, D.-G., Park, K.-P., Lee, J., & Lee, H. (2006). Sequestering carbon dioxide into complex structures of naturally occurring gas hydrates. Proceedings of the National Academy of Sciences of the United States of America, 103(34), 12690–12694. https://doi.org/10.1073/pnas.0602251103 [Christopher Vivian, United Kingdom (of Great Britain and Northern Ireland)]	Accepted-key citations referenced in 3.4 and ES modified
12171	3	11	0	43		Pohlman, J. W., Greinert, J., Ruppel, C., Silyakova, A., Vielstädte, L., Casso, M., ... Bünz, S. (2017). Enhanced CO ₂ uptake at a shallow Arctic Ocean seep field overwhelms the positive warming potential of emitted methane. Proceedings of the National Academy of Sciences, 114(21), 5355–5360. https://doi.org/10.1073/pnas.1618926114 [Christopher Vivian, United Kingdom (of Great Britain and Northern Ireland)]	Accepted-key citations referenced in 3.4 and ES modified
12173	3	11	0	43		Ruppel, C. D., & Kessler, J. D. (2017). The interaction of climate change and methane hydrates. Reviews of Geophysics, 55(1), 126–168. https://doi.org/10.1002/2016RG000534 [Christopher Vivian, United Kingdom (of Great Britain and Northern Ireland)]	Accepted-key citations referenced in 3.4 and ES modified
12175	3	11	0	43		Shakhova, N., Semiletov, I., Salyuk, A., Yusupov, V., Kosmach, D., & Gustafsson, Ö. (2010). Extensive methane venting to the atmosphere from sediments of the East Siberian Arctic Shelf. Science, 327(5970), 1246–1250. https://doi.org/10.1126/science.1182221 [Christopher Vivian, United Kingdom (of Great Britain and Northern Ireland)]	Accepted-key citations referenced in 3.4 and ES modified
12177	3	11	0	43		Shakhova, N., Semiletov, I., et al. (2013) Ebullition and storm-induced methane release from the East Siberian Arctic Shelf. Nature Geoscience, 7, 64-70. https://doi.org/10.1038/ngeo2007 . [Christopher Vivian, United Kingdom (of Great Britain and Northern Ireland)]	Accepted-key citations referenced in 3.4 and ES modified
12179	3	11	0	43		Shakhova, N., Semiletov, I., et al. (2015) The East Siberian Arctic Shelf: towards further assessment of permafrost-related methane fluxes and role of sea ice. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences 373 (2052), 20140451. https://doi.org/10.1098/rsta.2014.0451 . [Christopher Vivian, United Kingdom (of Great Britain and Northern Ireland)]	Accepted-key citations referenced in 3.4 and ES modified

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
12181	3	11	0	43		Whiteman, G., Hope, C., & Wadhams, P. (2013). Vast costs of Arctic change. <i>Nature</i> , 499, 401-403. http://dx.doi.org/10.1038/499401a [Christopher Vivian, United Kingdom (of Great Britain and Northern Ireland)]	Accepted-key citations referenced in 3.4 and ES modified
12183	3	11	0	43		Zhang, Y., & Zhai, W.-D. (2015). Shallow-ocean methane leakage and degassing to the atmosphere: triggered by offshore oil-gas and methane hydrate explorations. <i>Frontiers in Marine Science</i> . https://www.frontiersin.org/article/10.3389/fmars.2015.00034 [Christopher Vivian, United Kingdom (of Great Britain and Northern Ireland)]	Accepted-key citations referenced in 3.4 and ES modified
684	3	11	1	11	1	This figure is not so necessary since it is only used to illustrate an uncertain example. [Mengxi Wu, United States of America]	The figure was removed
22369	3	11	1	11	10	Its not clear what message is trying to conveyed with Box 3.1 figure 2, and I would question whether this is accessible to a non-expert reader. [Abram Nerilie, Australia]	The figure was removed
26369	3	11	1	11	2	This figure requires more thorough scientific explanation. It is not clear what is being shown and why it is important. [Ethan Pierce, United States of America]	The figure was removed
564	3	11	1	11	3	A symmetric colorbar here would be helpful for quickly assessing magnitudes of change between red and blue, as well as a title. The deepest blue is not as negative as the deepest red. Also, it is not clear what the point of this figure is, even in the caption. This should be improved so that the reader only needs to look into the text for a more detailed explanation of the figure. [Jenna Pearson, United States of America]	The figure was removed
11921	3	11	1	11	3	Region name (Arctic) should be mentioned in this figure legends [Jun Sun, China]	The figure was removed
15541	3	11	1	11	3	Reference /data information missing in Fig 2. [EUCE, Belgium]	The figure was removed
16877	3	11	1	11	3	Reference /data information missing in Fig 2. [Louise Sandberg Soerensen, Denmark]	The figure was removed
16291	3	11	2	11	2	Could you show a full Arctic map for both air temp and geopotential height, as these teleconnections are also crucial for European weather? [Alexander Nauels, Germany]	The figure was removed
17083	3	11	2	11	2	This figure lacks referencing. [Samuel Morin, France]	The figure was removed
18837	3	11	2	11	3	Box 3.1. Figure 2. The source reference for the figure is missing. [APECS Group Review, Germany]	The figure was removed
726	3	11	15	0		Overall, there seems to be too many schematics and too few plots of observed or projected data. I think some less important schematics can be deleted, and Figure 3.4 might be one of them. [Mengxi Wu, United States of America]	Taken into account: Figures were revised between the SOD and final draft, including the removal of figures. Observed and projected data are shown in Figures 3.3, 3.6, 3.10, etc.
11419	3	11	15	15	39	Seasonality of sea ice is mentioned multiple times in this text. It would be beneficial if there's at least one figure that demonstrates how sea ice of each season is changing over time. [Anson Cheung, United States of America]	Accepted: Figure 3.3 was modified to show observed and projected time series of sea ice extent (both polar regions) for March and September.
696	3	11	17	0		In addition to schematics in this section (3.2.1), a multi-panel figure of the observed and projected changes (time series and spatial patterns) in important ocean properties, such as temperature, salinity and pH, will be helpful. [Mengxi Wu, United States of America]	Noted; unfortunately with a finite page limit we are restricted on the information we can display graphically.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
3827	3	11	17	16	56	The topic is intensively covered by Thomas DN (ed) (2017) Sea Ice, 3rd Edition, John Wiley & Sons, Ltd, Oxford. It should be referenced. [Marthan Bester, South Africa]	Rejected: we prefer to cite the individual papers instead of a single reference document
33167	3	11	19	11	19	Suggest that the impact of sea ice on primary production including sea ice algae should be included this report. See, for example: van Leeuwe, M., Tedesco, L., Arrigo, K.R., Assmy, P., Campbell, K., Meiners, K.M., Rintala, J.-M., Selz, V., Thomas, D.N. and Stefels, J., 2018. Microalgal community structure and primary production in Arctic and Antarctic sea ice: A synthesis. Elem Sci Anth, 6(1), p.4. DOI: http://doi.org/10.1525/elementa.267 ""Sea ice is a very diverse and potentially very productive habitat, with primary production estimated to amount to 2-24% of total production in sea-ice covered marine areas (Arrigo, 2017)."" [Government of United States of America, United States of America]	Taken into account: see section 3.2.3.1.1
18825	3	11	21	11	21	The word "incident" is hard to understand, change or remove? [APECS Group Review, Germany]	Accepted: changed to 'incoming'
33169	3	11	21	11	22	Consider rephrasing to include two-way feedbacks -- e.g., "provides thermal insulation between the ocean and the atmosphere" [Government of United States of America, United States of America]	Accepted: wording changed
32365	3	11	21	11	30	A point that is sort of covered but can be more explicit is that the expansion of sea ice in winter in the Arctic is limited by land, whereas the expansion of sea ice in the Antarctic is limited by its interaction with the Antarctic Circumpolar Current. Both are influenced by atmospheric processes. In this paragraph and subsequent text, there is no clear explanation of the difference in the dynamics of sea ice production and loss. A diagram would help that understanding and therefore help the reader understand the discussion on changes in the drivers of the dynamics of sea ice. It is certainly not clear to me. A figure in this introductory section showing the differences in sea ice dynamics between the regions will help set up the section. For example, why was multi-year sea ice a feature of the Arctic and not the Antarctic? [Andrew Constable, Australia]	Accepted: wording changed. An additional schematic figure could not be added due to length limitations, but some aspects are illustrated in the new Figure 3.1.
33171	3	11	21	11	30	Minor point: Should explain the difference between Arctic and Antarctic sea ice; Antarctic being seasonal; Arctic being in basin, chance for multiyear ice to form... [Government of United States of America, United States of America]	Accepted: wording changed
3051	3	11	21	16	30	To ensure consistency with AR6 chapter 9 (and possibly chapters 2,3 and 4) it will help to facilitate cross-report discussions on the confidence levels applied to the sea ice as it isn't always clear to me how the confidence levels have been applied [Helene Hewitt, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account: confidence language has been checked and discussed with AR6 chapter 9 authors for consistency. This process will occur again through the SPM drafting process.
9047	3	11	22	0		It would be useful if 'thermohaline' could be defined [Nina Hunter, South Africa]	Taken into account: term is defined in the glossary
22371	3	11	22	11	22	"limits access to the polar regions": this isn't always true, for example in the case of highways on sea ice it provides access to polar regions [Abram Nerilie, Australia]	Taken into account: text no longer present
33173	3	11	22	11	22	Specify which type of access -- e.g., "maritime shipping access" or something to that effect -- given that this sentence also includes ocean physical properties and marine species which are not necessarily concerned by this 'limited access'. [Government of United States of America, United States of America]	Taken into account: text no longer present

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
33175	3	11	23	11	27	One major difference is that the Arctic sea ice is thick and contains multi-year ice. But the Antarctic sea ice is thin and mostly is first-year ice, extending to a large area. This difference is important and could be stated here. [Government of United States of America, United States of America]	Accepted: wording changed
9049	3	11	24	0		differ' not 'differs' [Nina Hunter, South Africa]	Accepted: wording changed
33177	3	11	24	11	24	"differs" should be "differ" [Government of United States of America, United States of America]	Accepted: wording changed
33179	3	11	24	11	27	The Antarctic sea ice is also strongly influenced by atmospheric circulation. [Government of United States of America, United States of America]	Taken into account: mention of atmospheric forcing removed
19539	3	11	25	11	25	I would remove 'forced largely by the atmosphere' since sea ice is forced by the atmosphere not only in the Arctic but also in Antarctica. [APECS Group Review, Germany]	Accepted: wording changed
19541	3	11	26	11	26	Rephrase: 'surrounded by ocean and sea ice, which interact together'. The Antarctic continent is not only surrounded by sea ice, but mostly by ocean... [APECS Group Review, Germany]	Accepted: wording changed
2777	3	11	27	11	28	I don't think the causes of the differing trends in sea-ice in the Nh/SH are well known, so this statement seems over confident to me. [Neil Swart, Canada]	Accepted: sentence removed
18829	3	11	29	11	29	E1a - "changes", but changes to what? Long term permanent change? Annual change? Please specify [APECS Group Review, Germany]	Accepted: wording changed
26187	3	11	32	11	46	When discussing Arctic sea ice extent development, I suggest to consider also including the findings of Comiso et al. (2017; JGR Oceans; doi:10.1002/2017JC012768) in the discussion (this is a different paper than the one by Comiso et al. 2017 that already is included in the SROCC). In that paper, the effect of using different algorithms on the same passive microwave datasets for Arctic sea ice is discussed. [Sebastian Gerland, Norway]	Accepted: wording changed and reference added
1653	3	11	32	14	56	There is little to no mention of how measurements/observations were made and how reliable they are. [Nora Richter, United States of America]	Accepted: wording change to explicitly note satellite passive microwave measurements and reference added to Comiso et al (2017) paper on trend consistency.
18831	3	11	35	11	35	E1a - Please define "sea-ice concentration". The term is brought up for the first time here without explicit definition. I don't think it is immediately obvious to the reader what sea ice concentration refers to (unlike extent, which is more obvious) [APECS Group Review, Germany]	Taken into account: term is defined in the glossary
18833	3	11	36	11	36	C5 - I cannot access this reference to check it (+ no DOI?). Maybe consider whether it is needed, or if it is accessible. [APECS Group Review, Germany]	Rejected: not clear which reference is being referred to
18827	3	11	37	11	37	Add summer/winter since it is difficult to know that these are considered summer/winter months for someone not working in the Arctic: "with September trends (_summer_ month with the 38 lowest sea ice cover; 1979 to 2017) of -83,000 km2 yr-1 (-13.0% per decade relative to 1981-2010 mean), 39 and -41,000 km2 yr-1 (-2.7% per decade relative to 1981-2010 mean) for March (_winter_ month with the greatest..." [APECS Group Review, Germany]	Accepted: wording changed

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
27511	3	11	37	11	40	The reported ranges for sea ice decline are very similar to but not quite the same as those produced by OSISAF and available here: http://ocean.dmi.dk/arctic/icecover_30y.uk.php There are of course a number of other analyses too - it may be worth pointing out that other estimates exist but that they basically agree within uncertainty estimates to avoid disagreements. [Ruth Mottram, Denmark]	Accepted: reference added to Comiso et al (2017) paper on trend consistency.
11161	3	11	38	11	39	These numbers on the specific trends of sea ice must be qualified with uncertainty information [Dirk Notz, Germany]	Accepted: trend +/- values added
9051	3	11	40	0		Onarheim reference should be in its own bracket and remove the semi-colon [Nina Hunter, South Africa]	Accepted: changed
11891	3	11	41	11	42	The change of sea ice extent and concentration in polar region is very important component in identifying global climate change. The authors addressed regions of Arctic where the large sea ice loss has been found. More information for the extent of sea ice loss in those regions is needed here. [Jun Sun, China]	Rejected: spatial trend maps of sea ice reduction across the Arctic are in Figure 3.3
19543	3	11	42	11	42	I think Onarheim and Arthun (2017) should be replaced by Onarheim et al. (2018), mentioned in the previous sentence. [APECS Group Review, Germany]	Accepted: reference corrected
22373	3	11	42	11	46	Paleoclimate evidence could be included here for longer term perspectives covering the last millennium and the full Holocene that give additional context/confidence in the significance of the recent Arctic sea ice decline. [Abram Nerilie, Australia]	Accepted: additional text and references added
33181	3	11	43	11	46	The final sentence reads: "Reconstructions of the sea ice cover back to 1850 using earlier satellite observations, ship and aircraft observations, ice charts, and whaling records shows that the Arctic ice loss over the past 2 decades is likely unprecedented in at least 150 years (Walsh et al., 2017)". This omits several recent paleoclimatic studies of the Arctic, including those of Polyak et al. (2010) and Kinnard et al. (2011), and serves to dilute the significance of 21st century Arctic sea ice loss in Earth's recent history. In particular, Kinnard et al. (2011) found that recent losses in Arctic sea ice are exceptional in at least the last 1450 years. Even if the IPCC authors are limiting their analysis to 1850 onwards, these paleoclimatic studies should be mentioned in the report. It may be that, due to the broad confidence limits on Kinnard et al.'s proxies, the IPCC authors may wish to place a low confidence bound on this result, but it is still important to mention. The scientific community is looking past the very recent history of the Arctic, and that needs to be conveyed to non-experts (references: Kinnard, C. et al., 2011, Nature, 479(7374), 509-512. doi:10.1038/nature10581; Polyak, L. et al., 2010, Quaternary Science Reviews, 29(15-16), 1757--1778. doi:10.1016/j.quascirev.2010.02.010). [Government of United States of America, United States of America]	Accepted: additional text and references added
31147	3	11	44	0	46	Giving overall percent changes compared to a reference period would be most illustrative and support intuitive understanding for sea ice cover change, more than an absolute change in surface area. Certainly, such estimates may be more useful in different contexts. [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account: trends are reported in absolute values and % per decade
33183	3	11	44	11	46	It's very likely that the past 2 decades have been the lowest in at least the last 150 years. The Walsh climatology doesn't show any extents near the recent extents in the satellite record. The Walsh product is not complete and there may be some biases relative to the satellite record, but "very likely" is a more appropriate assessment than "likely". [Government of United States of America, United States of America]	Accepted: additional citations and text added to strengthen the paleo perspective. Confidence language revised.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
9053	3	11	45	0		show' not 'shows' [Nina Hunter, South Africa]	Taken into account: text no longer present
11163	3	11	45	11	45	In my opinion it is „very likely“ that the recent ice loss is unprecedented in the past 150 years. The only other period during which substantial ice loss has been reported are the 1930s, and ice maps from that period are probably sufficiently reliable to warrant „very likely“. [Dirk Notz, Germany]	Accepted: additional citations and text added to strengthen the paleo perspective. Confidence language revised.
18835	3	11	45	11	45	C3 - I assume that the uncertainty term "likely" here is due to the exception of the Bering Sea. Please make this clear if so, as otherwise would it be "very likely"? [APECS Group Review, Germany]	Accepted: likelihood language revised
23129	3	12	0	12		Missing level of confidence or level of scientific understanding in figure. Does not convey any conclusion of assessment, more inspired by a text book approach than to provide outcomes of the assessment. [Valerie Masson-Delmotte, France]	Accepted: figure removed
3167	3	12	1	1	16	This is a helpful schematic but it is slightly confusing to follow. It may be easier to understand if the text from the caption were on the figure itself next to the corresponding number. There isn't much text so it might be able to fit on the figure. Also, the caption implies the meaning of the different colors in the ocean, but it may be helpful to include a legend that explicitly defines the meaning of each color. [Sloane Garelick, United States of America]	Accepted: figure removed
1655	3	12	1	12	17	These figures are somewhat difficult to read. The arrows are hard to see and it's unclear how much relevant information each of the individual figures actually provides. Can this be summarized in two larger figures? [Nora Richter, United States of America]	Taken into account: figure removed
23925	3	12	1	12	2	It seems that the lower two illustrations could be combined in the Figure 3.2, since only a few factors are included. It may be helpful to illustrate the factors in a season in one illustration. If the authors intended to concentrate on the physical changes in the polar ocean, it should be pointed out in the title of the figure, e.g., "Schematic of some of the major physical changes in the Arctic ocean." Otherwise, it would seem that the changes in marine ecosystem should be included in the illustrations, since a considerable part of the text has been devoted to it. [Government of Japan, Japan]	Taken into account: figure removed
26371	3	12	1	12	2	Could these four schematics combine into one? At the very least, there is certainly room for text within each schematic, instead of the unwieldy captioning below. [Ethan Pierce, United States of America]	Taken into account: figure removed
686	3	12	2	12	2	What are the colors in the top-right panel? They seem to indicate the retreating sea ice, but it is not clear from the caption. In addition, there are arrows that seem to represent the difference in absorbed solar radiation. Because of a higher albedo, I think the arrows should be smaller over the remaining sea ice. [Mengxi Wu, United States of America]	Taken into account: figure removed
566	3	12	3	12	16	One-two words per number to indicate the process, and perhaps an arrow to indicate the sign could be useful on the figure. What do the different colors represent? This, in combination with Figure 3.2, seem to schematize too much separately...is there anyway to combine them? [Jenna Pearson, United States of America]	Taken into account: figure removed
30023	3	12	3	12	16	Adding names of the regions that you mention in the text (e.g., Beaufort sea) to the figure would be a great help. [Ronja Reese, Germany]	Taken into account: figure removed
16293	3	12	3	12	3	Again, great overview figure! As for Figure 3.1, the figure would benefit from a more prominent inclusion of the numbered bullets in the graphic. [Alexander Nauels, Germany]	Taken into account: figure removed

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
18839	3	12	3	12	3	What is efflux? Word not mentioned elsewhere in text. [APECS Group Review, Germany]	Taken into account: figure removed
25985	3	12	3	2	16	As Figre 3.1.(see previous comment) the figure is not very effective. Put information in caption into the figure. [Regine Hock, United States of America]	Taken into account: figure removed
28525	3	12	4	12	16	I guess these subsection references should all be 3.2.something rather than 3.3.something. [Yvonne Firing, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account: figure removed
18841	3	12	4	12	4	Referring to the wrong section (3.2.1.3 is about ocean circulation) [APECS Group Review, Germany]	Taken into account: figure removed
18847	3	12	4	12	4	I'm sorry if this is part of the copyediting process, but the Section references on this page are incorrect. They should be: (1) 3.2.1.3; (2) 3.4.1.3.2; (3) 3.2.1.1.4; (4) 3.3.1.4; (5) 3.2.1.1.1; (6,7) CORRECT; (8) 3.2.1.1.4; (9) 3.2.1.2.1; (10) 3.2.1.2.1; (11) 3.2.1.2.1; (12) 3.2.1.2.4; (13) 3.2.3.1.1 [APECS Group Review, Germany]	Taken into account: figure removed
8603	3	12	5	12	5	Figure 3.2: I would include the freshwater coming from the melting of the Greenland ice sheet in point number 2. Something like: "increasing discharge of freshwater from rivers and from glacial meltwater to the Arctic Ocean". [Deborah Verfaillie, Spain]	Taken into account: figure removed
18843	3	12	8	12	8	Specify what kind of transport: "strengthening transport within the Transpolar Drift" [APECS Group Review, Germany]	Taken into account: figure removed
4301	3	12	10	12	10	The sketched solar radiation appears un-physical. The ice loss should give a larger absorption in affected areas, but there is certainly not stronger downward solar radiation over the ice as indicated now. [Lars Smedsrud, Norway]	Taken into account: figure removed
18845	3	12	11	12	11	Add "solar": heating of surface layers via _solar_ insolation. Also cannot find section 3.3.1.2.1) [APECS Group Review, Germany]	Taken into account: figure removed
19605	3	12	12	12	12	It is not clear in the bottom left panel of Figure 3.2 that the arrows of Number 9 (Atlantic Ocean heat transport) are directed towards the Arctic. I think you could decrease the width of the main pathway of the Norwegian Atlantic Current (red color) to highlight the arrows directed to Fram Strait and Barents Sea. [APECS Group Review, Germany]	Taken into account: figure removed
9055	3	12	14	0		It would be useful if 'insolation' could be defined [Nina Hunter, South Africa]	Taken into account: figure removed
28527	3	12	15	0		Increasing drawdown? [Yvonne Firing, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account: figure removed
11165	3	13	0	0		I suggest to add different observational records at least to the time series in this plot to visualize the observational uncertainty [Dirk Notz, Germany]	Accepted: Four datasets are now utilized

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
8605	3	13	0	13		Figure 3.3: labels of the colorbars are a bit too close to each other, especially for the sea surface temperature trend bar. Either reduce the size of labels or represent only one out of two labels. For the sea ice trend bar, why refining to +-4.5 between +4 and +5? [Deborah Verfaillie, Spain]	Taken into account: figure revised
8607	3	13	0	13		Stippling in panels a-d is not explained in the figure caption. [Deborah Verfaillie, Spain]	Accepted: caption revised
688	3	13	1	13	1	It might be helpful to have thicker coastlines, especially in panel (b) where both sea ice and land snow are shown. And the colors for different scenarios need to be adjusted in the lower panels. Now the model spread cannot be clearly distinguished. [Mengxi Wu, United States of America]	Accepted: figure revised
3169	3	13	1	13	1	The choice of colors for the the data presented on the maps and the data of the model outputs in the plots below the maps in Figure 3.3 is slightly confusing. The colors of the model output lines are similar to those used in the color gradients for the maps so it makes it seem as if those are related. [Sloane Garelick, United States of America]	Taken into account: figure revised
11417	3	13	1	13	1	It is very confusing to use the same colormap for sea surface temperature trend and snow cover duration difference [Anson Cheung, United States of America]	Taken into account: the domain for snow cover duration was changed to include only land areas north of 60
17085	3	13	1	13	1	It could be appropriate to include also terrestrial snow cover extent on the Figure 3.3.f (or subdivide it in two) [Samuel Morin, France]	Rejected: snow extent is included in Figure 3.10
17087	3	13	1	13	1	I think the red/blue color scale for terrestrial snow cover in Figure 3.3.b. is reverse at what it should be. Indeed, while positive temperature deviations to the reference are OK in red, positive snow cover deviations should be in blue (more snow) and negative deviations for snow cover should be in red. The visual perception of the current form of the graph could be considered misleading. [Samuel Morin, France]	Taken into account: Figure modified and snow information removed
18853	3	13	1	13	1	Lowest bar, change "see ice trend" to "sea ice _concentration_ trend" [APECS Group Review, Germany]	Accepted: Figure revised
18855	3	13	1	13	1	Maybe add clarification that the dashed circle is the polar circle in the figure caption? [APECS Group Review, Germany]	Accepted: caption revised
19607	3	13	1	13	14	It is not mentioned in the figure caption what the dots in the panels stand for (white dots in Figs. 3.3a and 3.3c, and black dots in Figs. 3.3b and 3.3d). These are probably grid points where there is no statistical significance in the trends, but this should be explicitly mentioned in the caption of this figure (with the associated level of significance). [APECS Group Review, Germany]	Accepted: caption revised
19609	3	13	1	13	14	For clarity, you should put the latitude of the Arctic and Antarctic Circles in Figs. 3.3a-d, or put another latitude (e.g. 50 or 60°N). [APECS Group Review, Germany]	Accepted: caption revised
19611	3	13	1	13	14	I think you should remove the difference in climatological snow cover duration in Fig. 3.3b for two main reasons: (1) it can introduce confusion with the color scale of the sea-ice concentration trend; (2) Section 3.2 focusses on polar oceans and sea ice (not on terrestrial snow). [APECS Group Review, Germany]	Rejected: Arctic and Antarctic circle are now noted in the caption
19613	3	13	1	13	14	The label of sea ice trend should be 'sea-ice concentration trend'. 'Sea ice trend' is vague, it could be sea-ice thickness, concentration, drift, etc. [APECS Group Review, Germany]	Taken into account: the domain for snow cover duration was changed to include only land areas north of 60
30265	3	13	1	13	14	The legends in e-h) should include the black line referring to data. Why are the CMIP5 results not tied to these known data? [Christine Dow, Canada]	See #18853
30267	3	13	1	13	14	In panel b) I think it's confusing having snow cover extent as the same color bar as the sea ice extent. [Christine Dow, Canada]	Taken into account: Figure modified and snow information removed

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
26373	3	13	1	13	2	The color scheme on the RCP scenarios is too similar to the spatial data. Also, is sea ice trend in units of extent or volume? [Ethan Pierce, United States of America]	Accepted: Figure revised
390	3	13	1	14	4	Fig. 3.3 c and d: Could you label the different regions of Antarctica to provide context for the Antarctic sectors plotted in Fig. 3.6 (W. Antarctica, E. Antarctica, Antarctic Peninsula)? That would get double mileage out of this figure, since it is the only plan-view map of Antarctica in the chapter. [Ethan Kyzivat, United States of America]	Accepted: Figure revised
568	3	13	3	13	14	What does the stippling indicate on the figures? Why are Greenland and Antarctica white? This is not a very colorblind friendly figure, and the coloring of (e-h) is too close to the colorbars. It leads the eye to think they are related. Perhaps symbols would be a more appropriate choice, or a different selection of colors in general. [Jenna Pearson, United States of America]	Accepted: caption revised; Greenland and Antarctica are white because ice sheet information is not contained in this figure
24295	3	13	3	13	14	White and black dots are shown on figures a, b, c and d but their meaning is not given in the figure caption. One can guess that they represent the lack of significant trend but it should be mentioned explicitly [Rym MSADEK, France]	Accepted: caption revised
29349	3	13	3	13	14	Panel (a) of Figure 3.3 shows trends in NOAA optimum interpolation sea surface temperature (OISST) over 1982-2016. This is the one of the main supporting pieces of evidence for the statement in SPM A1.4 that with very high confidence, Arctic sea surface temperature has increased at approximately twice the rate of average global temperature. Nowhere in the caption or text do the authors note that there are no SST measurements in regions covered by sea ice. In sea ice covered regions SST in the OISST dataset shown is simply estimated from a statistical regression model fitted to sea ice concentration (Reynolds et al., 2007). In other sources showing trends in SSTs in the Arctic the region covered by sea ice is masked out for this reason - for example in Timmermans et al. (2017), which the chapter cites. [Government of Canada, Canada]	Accepted; the figure has been redrafted to include seasonal SST trends, with areas covered by ice marked as absent data.
33185	3	13	3	13	14	The stippled regions in the map view figures are areas where the trends fall below some confidence interval? Explain in the caption. [Government of United States of America, United States of America]	Accepted: caption revised
18849	3	13	3	13	3	Add abbreviation SST since it is used in the figure: Linear trends of Arctic annual-mean sea surface temperature <u>_(SST)_</u> [APECS Group Review, Germany]	Accepted: caption revised
18865	3	13	3	13	3	E1a - Define what the black line in Fig 3.3e,f,g,h represents more clearly (i.e. 1982-2016 data?) (maybe in the key at the base of each of these subfigures). Also, make two different scales on blue->red color map clearer that referring to two different things. [APECS Group Review, Germany]	Accepted: caption revised
710	3	13	3	14	4	There are clear offsets between observations and model hindcasts. Although the SST and sea ice trend in the northern hemisphere is well simulated, the offset still requires more discussion somewhere because it is difficult for readers to interpret. [Mengxi Wu, United States of America]	Taken into account: disagreement between observations and historical simulations are in the text in Sections 3.2.1.1.1 and 3.2.2.1
18867	3	13	3	14	4	E1a - Consider shortening this caption, as it is rather challenging to follow/understand. [APECS Group Review, Germany]	Taken into account: caption revised but length is necessary
16295	3	13	9	13	10	Given the bias between mean CMIP5 model outputs and observations, it may be worth elaborating on these differences in the text. Please refer to discussion in caption and comment/explain in the text based on CMIP5 specifics and issues. [Alexander Nauels, Germany]	Taken into account: disagreement between observations and historical simulations are in the text in Sections 3.2.1.1.1 and 3.2.2.1

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
18851	3	13	9	13	9	Black line is defined as "observations", but why is it so different from the other colored lines? Should be clarified. [APECS Group Review, Germany]	Observations and historical climate model simulations do not always agree
18857	3	13	16	13	18	This sentence is confusing (perhaps because I am not an expert in snow-ice feedback). Specifically, I do not understand how the first half of the sentence relates to the "later ice freeze-up" second half. Perhaps this sentence also needs a reference. [APECS Group Review, Germany]	Taken into account: text revised
18859	3	13	24	13	26	Please specify the reference to the sub-Figure (d) within Figure 3.3 (also in L34 of the same page). It would be useful to label the locations of the Weddell and Amundsen seas in addition to the two that are already shown in Figure 3.3d (Bellingshausen, Ross) for those who don't know where they are. [APECS Group Review, Germany]	Accepted: Figure revised
18861	3	13	26	13	28	The second half of this sentence needs a reference; perhaps move (Holland, 2014) to the end of the sentence since the citation does cover the Western Ross sea. [APECS Group Review, Germany]	Accepted: text revised
18863	3	13	52	13	56	The "high confidence" of this statement is somewhat ironic/contradictory with the "modest" decline. Seeing as that the "decrease in overall Antarctic sea ice cover" has been attributed with a "medium confidence), then would the "high confidence" in the second half of the sentence be attributed to the lack of separation from natural variability? I may suggest removing the "high confidence" altogether (as currently the confidence is attributed to a 'lack' of attribution rather than an attribution altogether), or rewording this part of the sentence to have a clear attribution to the statement. [APECS Group Review, Germany]	Accepted: confidence language revised
17089	3	14	1	14	1	As reported in FOD, please note that the correct reference for Brun et al. is : Brun, E., V. Vionnet, A. Boone, B. Decharme, Y. Peings, R. Valette, F. Karbou and S. Morin, Simulation of northern Eurasian local snow depth, mass and density using a detailed snowpack model and meteorological reanalyses, J. Hydrometeorol., 14, 203–219, doi :10.1175/JHM-D-12-012.1, 2013. [Samuel Morin, France]	Accepted: reference corrected
570	3	14	1	14	18	More should be included on sea-ice thickness's role in the climate system, specifically it's control on albedo. [Jenna Pearson, United States of America]	Rejected: insufficient space to add general text of this nature
3053	3	14	1	14	4	Can you clarify whether HadGEM2 had the necessary data to be included in figure 3.3? [Helene Hewitt, United Kingdom (of Great Britain and Northern Ireland)]	HadGEM2 was included in Figure 3.3
244	3	14	7	14	20	I understand the author's effort not to separate Arctic and Antarctic in this section, but for the reader (particularly those who only skim the first sentence of the paragraphs) it takes 2 or 3 lines before he/she recognises if the topic of the paragraph is Arctic or Antarctic. I do not have a good way around but it could discourage those quick readers who are only interested in one Pole. We could label the paragraph by [A] and [S] or use paragraph heading as in Box 3.2. [Katsuro Katsumata, Japan]	Accepted: we have increased the use of the terms 'Arctic' and 'Antarctic' throughout the sea ice sections to improve clarity

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
17509	3	14	7	14	20	Note that evidence of declining Arctic sea ice from 1979 to 2011—a 40% reduction— has resulted in a decline in albedo such that the change in forcing was equivalent to 25% that of CO2 in the same timeframe; see Pistone K., et al. (2014) Observational Determination of Albedo Decrease Caused by Vanishing Arctic Sea Ice, PROC. NAT'L. ACAD. SCI. 111(9):3322–3326. [Kristin Campbell, United States of America]	Accepted: text modified and reference added
17611	3	14	7	14	20	Note that evidence of declining Arctic sea ice from 1979 to 2011—a 40% reduction— has resulted in a decline in albedo such that the change in forcing was equivalent to 25% that of CO2 in the same timeframe; see Pistone K., et al. (2014) Observational Determination of Albedo Decrease Caused by Vanishing Arctic Sea Ice, PROC. NAT'L. ACAD. SCI. 111(9):3322–3326, 3325 (“The change in annual-mean global-mean surface temperature is 0.69 °C during 1979–2011...we find that during 1979–2011 the Arctic darkened sufficiently to cause an increase in solar energy input into the Arctic Ocean region of 6.4 ± 0.9 W/m ² , equivalent to an increase of 0.21 ± 0.03 W/m ² averaged over the globe. This implies that the albedo forcing due solely to changes in Arctic sea ice has been 25% as large globally as the direct radiative forcing from increased carbon dioxide concentrations, which is estimated to be 0.8 W/m ² between 1979 and 2011. The present study shows that the planetary darkening effect of the vanishing sea ice represents a substantial climate forcing that is not offset by cloud albedo feedbacks and other processes. Together, these findings provide direct observational validation of the hypothesis of a positive feedback between sea ice cover, planetary albedo, and global warming.”). This will be more dramatic with even less sea ice, which could happen within 15 years, according to Overland and Wang (2013) When will the summer Arctic be nearly sea ice free?, GEOPHYSICAL RESEARCH LETTERS 40:2097–2101, 2097 (“Time horizons for a nearly sea ice-free summer for these three approaches [for estimating future ice loss covered in the study] are roughly 2020 or earlier, 2030 \pm 10 years, and 2040 or later.”). Also include the implications of increased climate forcing from reduced Arctic sea ice, which will be more extreme as less and less ice exists in the Arctic; see Pistone K., et al. (2014) Observational Determination of Albedo Decrease Caused by Vanishing Arctic Sea Ice, PROC. NAT'L. ACAD. SCI. 111(9):3322–3326. [Durwood Zaelke, United States of America]	Accepted: see #17509
22379	3	14	7	14	7	Specify that you are referring to Arctic sea ice loss. [Abram Nerilie, Australia]	Accepted: text modified
33187	3	14	7	14	7	Where does the 50-60% number come from? Pick one and say approximately. [Government of United States of America, United States of America]	Accepted: text revised.
3855	3	14	7	14	8	How to get this statement? If by models, I do not think that there is a high confidence for this statement. [Zhaomin Wang, China]	Rejected: the estimate comes from large initial condition ensemble climate model simulations and other experiments from multiple studies.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
29651	3	14	7	14	9	A bit more explanation is needed here. Basically, there is a fraction that is clearly associated with human activities. About the rest, proving it is due to natural factors makes a presumption that all that is not provably human-induced to a high confidence level is due to natural factors, when, in fact, we really don't have anything close to convincing evidence the changes are natural rather than are simply not yet linked convincingly to human activities. There continue to discoveries of pathways of how human activities are influencing the system (or the system is responding to human activities) and there is not proof at all that this situation has ended. So, the statement really needs to be clarified, indicating that there is a percentage that is very clearly related to human activities, and this is quite likely a minimum attribution fraction. To be able to give an affirmative attribution to natural forcings, one has to have a clear understanding of what the mechanism and that there are no human influences on whatever mechanism is identified. Given how the global temperature is changing and this is affecting the circulation, etc. it seems very unlikely that a total exclusion of human activities on these aspects can be proven. If I may, consider the MDO role, for example--is that all natural, or has that been influenced by human activities such as changes in sulfate aerosol loadings over the Atlantic going through a period of building up during part of the second half of the 20th century over the Atlantic and then going down (timed in a way that fits between major volcanic eruptions of Krakatoa and Pinatubo). And now the sulfate burden has shifted to southern and eastern Asia and causing a perturbation there. Thus, to assert that what is not proven to be human-induced yet is definitively due to natural variability seems to me to be overstated, and a more cautious statement should be made. [Michael MacCracken, United States of America]	Accepted: while we are limited by space to address this in further detail, wording was clarified.
33189	3	14	7	14	9	50-60% of Arctic sea ice loss is due to increased GHGs is not known at high confidence. This should be medium confidence. [Government of United States of America, United States of America]	Accepted: confidence level revised
33191	3	14	8	14	8	"Natural" variability is misleading here. The variability is not entirely natural. Replace with "internal climate variability". When sea ice thins, it exhibits more extent variability (see, e.g., Swart et al. 2015 Nature Climate Change). [Government of United States of America, United States of America]	Accepted: wording revised
19545	3	14	8	14	9	While I agree that Kay et al. (2011) and Notz and Marotzke (2012) are appropriate here, I don't think the 3 next references are really linked to this statement. Stroeve et al. (2012b), Stroeve and Notz (2015) and Notz and Stroeve (2016) do not really quantify the contributions from both the external driver (GHG concentrations) and internal variability, while the 50-60% contribution from GHG concentration mentioned in the text clearly comes from Kay et al. (2011). [APECS Group Review, Germany]	Accepted: references removed
19547	3	14	9	14	20	Do you put all these specific processes (i.e. summer atmospheric circulation patterns, ice-albedo feedback, ice growth-thickness feedback) into the natural climate variability that you mention in the beginning of this paragraph? Or are there processes involving both the external driver and the internal variability? You should be more explicit to be coherent with the objective of this paragraph. [APECS Group Review, Germany]	Accepted: text revised

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
11167	3	14	9	14	9	I doubt that we have „high confidence“ that 50 to 60 % of the observed sea-ice loss is driven by anthropogenic forcing. As almost no CMIP5 model simulates the correct sensitivity of the sea-ice cover to changes in forcing, I doubt that we can attach „high confidence“ to any of their D&A results. We will most likely not agree with this level of confidence in AR6. [Dirk Notz, Germany]	Accepted: confidence level revised
12115	3	14	11	14	20	Cloudiness modulates more than just longwave radiation; the shortwave radiation absorption has been noted to increase substantially over regions of sea ice loss, as the cloud feedback between sea ice loss and more cloud formation appears to be weak during the Arctic summer (Kay et al., 2016). Also, the shortwave cooling/warming effect under cloud cover is highly variable and depends on e.g. surface albedo. Please note the cloud impacts besides longwave radiation enhancement in the text, and note that our understanding of the cloudiness effects and trends remains limited at this time. [Aku Riihelä, Finland]	Taken into account: text revised
33193	3	14	12	14	14	This is a very selective sampling. This section should acknowledge that the specific processes that have been driving sea ice loss are actually not all that well understood. This is true for both the anthropogenic part and the natural/internal part. Because of the relatively small changes in energy involved in melting the ice, it is a very difficult problem. Listing a few fairly narrow studies that suggest one potential process or another doesn't provide a good summary of the current understanding. A sentence that reflects the recognition of the role of internal variability (Notz many, Jahn et al. 2016, Ding et al. 2017, 2018, Meehl et al. 2018) and the attempts to better understand that part should be included. [Government of United States of America, United States of America]	Accepted: text revised
29653	3	14	12	14	16	How can the set of causes of increased downward IR not include the increase in the CO2 concentration (also keeping in mind that the increased CO2 leads to warming that increase the atmospheric water vapor concentration so the humidity mentioned here)--and, who knows, could also be leading to the effects on cloudiness? By not saying that the change is largely driven, at least, by the direct and indirect effects of the higher CO2 concentration, the statement fails to really indicate what the problem is and that it is under societal control. It is a very serious omission not to be mentioning that it is the higher CO2 concentration driving virtually all of this. [Michael MacCracken, United States of America]	Taken into account: review comments the role of direct CO2 forcing versus internal variability on sea ice loss were inconsistent. Text was revised.
33195	3	14	12	14	20	The description of these feedbacks is not clear. [Government of United States of America, United States of America]	Accepted: text revised
33197	3	14	12	19	16	It is completely unclear here what season you are referring to with regard to cloud changes. Seasonality matters! Observations show that there is a seasonal difference in the cloud response to sea ice loss. There is no evidence for a summer cloud response to sea ice loss, but in the non-summer months clouds increase. Kay and Gettelman (2009) and more recent studies have confirmed such. See Morrison, A. L., Kay, J. E., Chepfer, H., Guzman, R. and V. Yettella (2018), Isolating the Liquid Cloud Response to Recent Arctic Sea Ice Variability Using Spaceborne Lidar Observations, Journal of Geophysical Research - Atmospheres, 123, 473–490, DOI:10.1002/2017JD027248 [Government of United States of America, United States of America]	Accepted: text revised

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
33199	3	14	16	14	18	Make clear why the delayed freeze-up and thinner snow is a negative feedback. Readers not versed in the details of sea ice growth may not make the connection that snow insulates the ice and slows growth. So a thinner snowpack increases the ice growth rate, which is the negative feedback. [Government of United States of America, United States of America]	Accepted: text revised
33201	3	14	16	14	18	"Once air temperatures drop below freezing ... leading to a thinner snowpack." It's not immediately clear how the two processes discussed in this sentence constitute "two negative feedbacks" (as discussed in next sentence). Some more discussion may be required (e.g., does a thinner snowpack on top of later forming ice lead to less insulation by the overlying snowpack, and thus faster ice growth? It looks like this is in fact the case and explicitly stated -- but for the first time? -- farther down, on page 16, lines 33-34). [Government of United States of America, United States of America]	Accepted: text revised
25217	3	14	16	14	20	The description here is a bit confusing. In particular, the "two negative feedbacks" are not clearly described. The reader may wonder why a thinner snowpack on the sea ice is a negative feedback (a brief explanation along the lines of Sect. 3.2.1.1.6 would be helpful here). In fact, I wonder if the two processes described in Lines 16-17 are really "two (independent) negative feedbacks" or rather if it would be more accurate to state that the combination of these two phenomena produces one negative feedback. [Sergio Henrique Faria, Spain]	Accepted: text revised
29163	3	14	17	14	18	Here a citation for the thinner snow cover should be provided. [Polona Itkin, Norway]	Accepted: citation added
2093	3	14	18	14	18	Sea ice loss is not irreversible, that has been shown many times, but not in Stroeve and Notz (2015) (e.g., Armour et al. 2011). Armour, K. C., I. Eisenman, E. Blanchard-Wrigglesworth, K. E. McCusker, and C. M. Bitz (2011), The reversibility of sea ice loss in a state-of-the-art climate model, Geophys. Res. Lett., 38, L16705, doi:10.1029/2011GL048739. [Alexandra Jahn, United States of America]	Accepted: citation changed
33203	3	14	18	14	18	There are excessive references to Stroeve. Sea ice is responsive on 5-10 year timescales and it will come back if greenhouse gases decrease. Other papers show the reversibility of sea ice loss and should be cited -- e.g., https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2011GL048739#grl28444-bib-0037 [Government of United States of America, United States of America]	Accepted: citation changed
29165	3	14	20	14	20	More literature is showing an increase of storminess and potentially moisture intrusions in the Atlantic sector of the Arctic: Rinke et al, 2017 (http://iopscience.iop.org/article/10.1088/1748-9326/aa7def/pdf) , Graham et al, 2017 (https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2017GL073395) [Polona Itkin, Norway]	Taken into account: text revised and we have multiple citations
30103	3	14	22	14	23	The 2016 and 2017 departures are ongoing and should be discussed more. Meehl et al NCC 2019 and Wang et al NCC 2019 discuss the role of atmospheric and ocean variability in recent Antarctic sea ice records [Julie Arblaster, Australia]	Accepted: text revised and citations added
11061	3	14	22	14	24	The remote sensing data on sea ice extent goes back to 1973. I wonder, why these data are not used. These data show a reduction of sea ice extent in the mid seventies and (as noted in the chapter) an increase from 1979 to 2015, such that the overall trend since 1973 is more or less zero. This should be mentioned. [Peter Lemke, Germany]	Taken into account: we note the longer satellite record in this section, but don't cite continuous trends from 1973 due to challenges with dataset homogeneity.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
28111	3	14	22	14	24	The average sea ice extent for 2018 is now known and looks to be the lowest on record (NASA's website Fig 6 for Antarctic sea ice extent from 2007 to 2018 https://neptune.gsfc.nasa.gov/csb/index.php?section=234 . This needs to be added to the comment about 2016 and 2017. [Peter Barrett, New Zealand]	Accepted: trends updated through 2018
28113	3	14	22	14	24	It's interesting that the inset in the Fig 6 at https://neptune.gsfc.nasa.gov/csb/index.php?section=234 , a plot of summer extent rather than average extent, shows quite a different pattern (decline from 10 m sq km in 2007 to 7.5 in 2010, following by rise to 10 in 2014 and fall to 6 in 2018) than the average extent reported in the text (increase from 1979 to 2017 with strong negative departures in 2016 and 2017). This will be relevant for biological activity that is sea ice dependent eg krill, and deserves additional comment. [Peter Barrett, New Zealand]	Accepted: we now show March and September trends in Figure 3.3
246	3	14	22	14	32	This increase in sea ice extent seems not reproduced by simulations (fig.3.3 (h)), though the increase is within the model spread. This difference stands out in the panels of Fig.3.3. and it might warrant a comment or two. Is this totally a result of natural variability? Any bias in the wind in the simulations? [Katsuro Katsumata, Japan]	Taken into account: this is addressed in Section 3.2.2.1
11879	3	14	22	14	32	Recent Meehl et al. Paper in Nat Comm about the 2016 "anomaly": Does this add anything to the trend discussion here? Are there reasons to think that these are only anomalies or that trend changes are occurring? [Gerhard Krinner, France]	Accepted: citation to the Meehl et al paper added. We do not comment on short duration 'trends' but rather report on trends over the complete passive microwave record (1979-2018)
29655	3	14	22	14	50	It seems to me that the discussion here is a bit backward. It should be stated up front, in the report, in the chapter, etc., that what happens in the world is due to several factors, both natural and human-induced. So, in the Antarctic, the human-induced stratospheric ozone depletion is another human influence. Too many people (and especially CO2 critics) seem to think that the observed climate should be responding everywhere just as the CO2 concentration curve (or forcing) is changing, and this is just not the case. The actual system is responding to all forcings, and what seems evident in the Antarctic region is that ozone depletion exerted and earlier and strong effect and is only now starting to be overtaken by the GHG warming influence. So, the impacts do not all have to be monotonic and perfectly correlated with the CO2 concentration curve, etc. It is really an opportunity to explain all of this to the public, but instead it is gotten to, rather vaguely, at the end of the second paragraph. The points need to be made right at the start of discussion of detection-attribution analyses, not sort of hidden at the back end. [Michael MacCracken, United States of America]	Taken into account: these paragraphs have been revised and we have added new text on the emerging evidence for Antarctic sea ice reductions.
26185	3	14	22	14	56	For the discussion of the recent negative departure in Antarctic sea ice extent (as written in line 23 on the same page about, with reference to Turner et al. 2017), I suggest consideration of two new publications by Meehl et al. 2019 (doi: 10.1038/s41467-018-07865-9), and Wang et al. 2019 (doi: 10.1038/s41467-018-07689-7), both in Nature Comm., which deal with the attribution of the recent changes. [Sebastian Gerland, Norway]	Accepted: text revised and citations added
22467	3	14	23	14	23	Suggest citing Kusahara, Kazuya & Reid, Phillip & Williams, Guy & Massom, Rob & Hasumi, Hiroyasu. (2018). An ocean-sea ice model study of the unprecedented Antarctic sea ice minimum in 2016. Environmental Research Letters. 13. 10.1088/1748-9326/aad624. [Government of Australia, Australia]	Accepted: citation added

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
30147	3	14	23	14	23	P3-14. L23. In 2018 also, strong negative departure is observed in sea ice extent in Antarctica (NSIDC, 2018). This can also be included in this line. Everything else looks good as far as sea ice thickness sections are concerned, which is my main expertise. [Mukesh Gupta, Canada]	Accepted: text revised and citations added
12241	3	14	23	23	14	The 2018 minima was also the second lowest in the satellite record. It might be worth adding this to the current analysis. It is also entirely possible that 2019 will see another very low minima given it is currently tracking below the equivalent value for 2017. [James Pope, United Kingdom (of Great Britain and Northern Ireland)]	Accepted: trends updated through 2018
33205	3	14	24	14	25	"rapid ice loss" and "rapid ice growth": Rapid compared to what? It's more the larger magnitude of change -- i.e., large losses in Amund-Bell offset by large gains in the Weddell and Ross, so a net small increase. [Government of United States of America, United States of America]	Accepted: text revised
690	3	14	28	14	32	There are limited references supporting this argument which may be insufficient for medium confidence. [Mengxi Wu, United States of America]	Taken into account: text no longer appears
19549	3	14	30	14	31	Replace 'along with differing cloud and lapse rate feedbacks' by 'along with a less positive lapse rate feedback and a more negative cloud feedback relative to the Arctic'. This is more accurate, see p. 7 and Fig. 3b of Goosse et al. (2018). [APECS Group Review, Germany]	Taken into account: text no longer appears
11063	3	14	30	14	32	Besides the reasons mention in the text, the existence of the huge inert ice sheet producing cold air, which flows down the ice sheet onto the surrounding Southern Ocean is a dominant reason for a delayed response to global warming. [Peter Lemke, Germany]	Rejected: references needed to add this material
30105	3	14	30	14	32	Isn't a primary reason the large interannual and interdecadal variability in Antarctic sea ice in contrast to the Arctic? [Julie Arblaster, Australia]	Taken into account: paragraph has been heavily revised and we do now note variability
19551	3	14	34	14	34	I think you should be more precise by saying 'Antarctic sea-ice concentration trends'. 'Sea ice trend' is very vague, as it could be trend in sea-ice concentration, thickness, motion, etc. [APECS Group Review, Germany]	Accepted: text revised
2779	3	14	34	14	50	A potentially important mechanism influencing Antarctic sea ice which has not been mentioned here is the effect of ice sheet melt water, e.g. Bintanja et al. 2013, Swart and Fyfe, 2013, Pauling et al. 2017. I note these are mentioned later in the chapter (p.g. 53 under impacts), but it might be more appropriate here (or both). Missing it here seems like an omission. [Neil Swart, Canada]	Rejected: text was consolidated in the impacts section for the SOD to reduce duplication
2781	3	14	34	14	50	Another important mechanism which has not been mentioned is internal variability, see e.g. Swart et al. 2013 and Gagne et al. 2015. [Neil Swart, Canada]	Taken into account: see #2783
17387	3	14	34	14	50	Hobbs, W. R., Massom, R., Stammerjohn, S., Reid, P., Williams, G., & Meier, W. (2016). A review of recent changes in Southern Ocean sea ice, their drivers and forcings. Global and Planetary Change, 143, 228–250. https://doi.org/10.1016/j.gloplacha.2016.06.008 I believe the above review article should be included as a reference in this section, as it covers many of the points discussed in the text. [Amna JRRAR, Jordan]	Accepted: reference added

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
22381	3	14	34	14	50	Also new evidence that southern ocean freshening and the circulation changes this invokes could explain observed Antarctic sea ice increase (Purich et al 2017) [Abram Nerilie, Australia]	Accepted: reference added
30119	3	14	34	14	50	Chapter 5 of the 2018 Ozone Assessment includes a good discussion of ozone and Antarctic sea ice changes which might be useful here https://www.esrl.noaa.gov/csd/assessments/ozone [Julie Arblaster, Australia]	Taken into account: additional details cannot be provided due to space limitations
28515	3	14	37	14	42	"A drives B" is not consistent with "we can't say that A is one of the causes of B" [Yvonne Firing, United Kingdom (of Great Britain and Northern Ireland)]	Accepted: sentence no longer appears
19553	3	14	40	14	42	I think there is a confusion here as Lecomte et al. (2017) do not find similar results as the studies presented in the previous sentences of this paragraph (i.e. wind-driven trends): they find that the recent increase in Ross Sea ice concentration is rather due to a positive feedback relating ice production and ocean heat storage. According to Lecomte et al. (2017), wind trends may amplify this feedback, but this feedback may also occur without wind trends. I suggest that the authors have a look at Lecomte et al. (2017) and balance a bit more the strong statement that Ross sea-ice expansion is due to wind trends. [APECS Group Review, Germany]	Accepted: wording clarified. This sentence describes ocean-ice feedbacks, which are not wind driven
30107	3	14	40	14	42	Not sure what 'evidence of a trigger' refers to. Tropical Pacific variability is a natural mode of variability in the system so doesn't need a trigger to explain it? [Julie Arblaster, Australia]	Accepted: sentence no longer appears
4133	3	14	42	14	42	Please include following statement after "... trends." "The sea ice increase in the Ross Sea sector is significantly correlated with the depth of Amundesen Sea Low (ALS), which has deepened since 1979 (Turner et al., 2015). Turner et al. (Philosophical Transactions of The Royal Society A, 373, 20140163, 2015). [Seong-Joong Kim, Republic of Korea]	Rejected: sentence no longer appears
27195	3	14	42	14	43	Strengthening circumpolar westerly winds...'. Some quantitative detail is needed here, by how much have the winds strengthened? [Sion Josey, United Kingdom (of Great Britain and Northern Ireland)]	Rejected: estimates vary and a full assessment is out of scope
4395	3	14	42	14	44	Strengthening of the westerlies is also linked to increases in greenhouse gases, not only ozone depletion. See for example Thompson et al. (2011, Nature Geosciences) [The UBern Team Group Review, Switzerland]	Accepted: text revised based on comment 32013
3857	3	14	42	14	45	not just ozone depletion, as global warming also plays a role. [Zhaomin Wang, China]	Accepted: text revised based on comment 32013
3821	3	14	43	14	43	Southern Annual Mode' should be 'Southern Annular Mode'. [Marthan Bester, South Africa]	Accepted: text revised
30109	3	14	43	14	43	annual ->annular [Julie Arblaster, Australia]	Accepted: text revised
32013	3	14	44	14	44	This relevant reference is missing here: Lee and Feldstein 2013, doi 10.1126/science.1225154 [Pedro J. Llanillo, Chile]	Accepted: text revised and reference added

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
17389	3	14	45	14	45	Two more recent studies than Ferreira et al, 2015 also investigated the time scale of SAM response & ozone changes. Considering that we are stating a medium confidence in the initial expansion followed by a delayed sea ice decrease, Kostove et al., 2017 & Seviour et al., should be included as well. Kostov, Y., Marshall, J., Hausmann, U., Armour, K. C., Ferreira, D., & Holland, M. M. (2017). Fast and slow responses of Southern Ocean sea surface temperature to SAM in coupled climate models. <i>Climate Dynamics</i> , 48(5-6), 1595–1609. https://doi.org/10.1007/s00382-016-3162-z Seviour, W. J., Gnanadesikan, A., Waugh, D., & Pradal, M. A. (2017). Transient response of the Southern Ocean to changing ozone: Regional responses and physical mechanisms. <i>Journal of Climate</i> , 30(7), 2463–2480. https://doi.org/10.1175/JCLI-D-16-0474.1 [Amna JRRAR, Jordan]	Accepted: Kostov et al reference added
22383	3	14	52	14	52	Murphy et al 2014, would be better described as early observation data (based on South Orkney fast ice observations), rather than a proxy reconstruction [Abram Nerilie, Australia]	Accepted: text revised
22465	3	14	52	14	54	Suggest citing the first study on proxy sea ice reconstructions which shows the decrease referred to in this section and integrates de la Mare too: Curran et al., <i>Science</i> , 2003. [Government of Australia, Australia]	Rejected: emphasis is on post-AR5 literature; Curran et al is cited in de la Mare et al
2783	3	14	52	14	56	A reference to Gagne et al. 2015 might be appropriate here: Gagné, M.-È., N. P. Gillett, and J. C. Fyfe (2015), Observed and simulated changes in Antarctic sea ice extent over the past 50 years, <i>Geophys. Res. Lett.</i> , 41, 90–95, doi:10.1002/2014GL062231. [Neil Swart, Canada]	Accepted: reference added
1657	3	14	54	14	56	Why is this presented as "high confidence" when there is only one reference to support this statement? [Nora Richter, United States of America]	Accepted: text revised to make intended meaning more clear
15543	3	15	2	15	2	Please, specify what is meant by 'now'. This year? The last 5 years? [EUCE, Belgium]	Accepted: text revised
16879	3	15	2	15	2	specify what is meant by 'now'. This year? The last 5 years? [Louise Sandberg Soerensen, Denmark]	Accepted: text revised
19555	3	15	2	15	3	I suggest to add a brief description on the methodology used by Stroeve and Notz (2018; not Stroeve and Dirk...) to retrieve ice age, i.e. from Lagrangian tracking of ice parcels using satellite-derived ice motion vectors. [APECS Group Review, Germany]	Rejected: technical details of this nature are out of scope
19557	3	15	2	15	3	The recent paper by Kwok (2018) confirms the finding that multi-year sea ice now covers less than one third of the Arctic Ocean, based on scatterometers (QuikSCAT and ASCAT). It seems important to add this reference to strengthen this finding. Reference: Kwok, R. (2018). Arctic sea ice thickness, volume, and multiyear ice coverage: losses and coupled variability (1958–2018). <i>Environmental Research Letters</i> , doi: 10.1088/1748-9326/aae3ec. [APECS Group Review, Germany]	Accepted: reference added
27609	3	15	2	15	4	Changes in first and multiyear ice -- could this be entered as a key message, linking it to impacts ice dependent species, food-chain and ecosystem impacts, as well as impacts on communities that rely on species linked to ice as food source? [Government of Norway, Norway]	Accepted: information on changing ice conditions captured in executive summary and is being fed into the Summary for Policy Makers
2529	3	15	3	14	3	Citation must be Stroeve and Notz (2018) [Michiel Van den Broeke, Netherlands]	Accepted: citation corrected
11169	3	15	3	15	3	Should be „Stroeve and Notz“ [Dirk Notz, Germany]	Accepted: citation corrected

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
27539	3	15	3	15	3	Citation should be "(Stroeve and Notz, 2018)" also change in references [Benjamin A. Lange, Canada]	Accepted: citation corrected
33207	3	15	3	15	3	Stroeve and Dirk 2018? Stroeve and Notz? [Government of United States of America, United States of America]	Accepted: citation corrected
33209	3	15	4	15	4	Could add the most recent reference for ice age: Tschudi, Mark A.; Stroeve, Julienne C.; Stewart, J. S. 2016. "Relating the Age of Arctic Sea Ice to its Thickness, as Measured during NASA's ICESat and IceBridge Campaigns." Remote Sens. 8, no. 6: 457, doi:10.3390/rs8060457. [Government of United States of America, United States of America]	Rejected: most recent ice age statistics are in Stroeve and Notz, 2018
1659	3	15	6	15	18	Why are there declines in multi-year ice? It might be more useful to incorporate this section in with the previous discussion of Arctic sea ice extent and concentration. [Nora Richter, United States of America]	Accepted: added pointer to other relevant sections
26375	3	15	6	15	18	This section should also include the effects of sea ice age on albedo. [Ethan Pierce, United States of America]	Rejected: out of scope
27543	3	15	6	15	18	Include new paper by Kwok 2018 where applicable here (likely published after this was written). Kwok, R. (2018), Arctic sea ice thickness, volume, and multiyear ice coverage: losses and coupled variability (1958–2018), Environmental Research Letters, 13(10), doi:10.1088/1748-9326/aae3ec. [Benjamin A. Lange, Canada]	Accepted: reference added
27545	3	15	6	15	18	Include paper by Haas et al., (2017), already in ref list, about thinning also observed in MYI. Haas, C., J. Beckers, J. King, A. Silis, J. Stroeve, J. Wilkinson, B. Notenboom, A. Schweiger, and S. Hendricks (2017), Ice and snow thickness variability and change in the high Arctic Ocean observed by in-situ measurements, Geophys. Res. Lett., 44, 10,462–410,469, doi:10.1002/2017GL075434. [Benjamin A. Lange, Canada]	Accepted: reference added
29167	3	15	6	15	18	Also mention that FYI surface is more smooth and has larger melt pond fraction – e.g. Nicolaus et al, 2012 (https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2012GL053738) [Polona Itkin, Norway]	Accepted: text revised and reference added
33211	3	15	6	15	23	This paragraph needs an update to reflect more recent work. The change to thinner ice has wider consequences that just vulnerability to cycones and increased susceptibility to ocean swells. [Government of United States of America, United States of America]	Taken into account: additional text in this area is out of scope, but text was revised and reference added in response to #29167.
18869	3	15	6	15	6	Add "Arctic basin" to clarify that this is for the Arctic: There is very high confidence that the ice _in the Arctic Basin_ has thinned... " [APECS Group Review, Germany]	Rejected: not all these studies focus on central Arctic sea ice, some are in the marginal seas
29657	3	15	6	15	8	Oh come now--this is not attribution. We are getting more young ice because the CO2 concentration has been the cause of melting away the ice and so naturally one ends up with younger ice, and when sampled this gives the thinning. The true and fundamental cause of the change needs to be stated, and then one can talk about how the processes connect to make the end result happen. The way things are phrased here would be sort of like saying that the stock markets went down in 2008 because there were more stocks that whose share were not worth as much before instead of saying that the mortgage crisis caused a loss of confidence and loss of values of the securities. Focus on getting back to the very well established fundamental cause. [Michael MacCracken, United States of America]	Accepted: the text mistakenly gave the impression that the reduction in ice thickness was due only to sea ice age change. Text revised.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
19559	3	15	7	15	7	Replace Kwok et al. (2009) by the update from Kwok (2018). Reference: Kwok, R. (2018). Arctic sea ice thickness, volume, and multiyear ice coverage: losses and coupled variability (1958–2018). Environmental Research Letters, doi: 10.1088/1748-9326/aae3ec. [APECS Group Review, Germany]	Accepted: citation updated
3171	3	15	8	15	12	This ice thickness data is an example of the type of quantitative evidence that might be helpful to include in the executive summary. [Sloane Garelick, United States of America]	Taken into account: executive summary (and by extension, the Summary for Policy Makers) will include ice age/thickness content.
19561	3	15	9	15	12	The recent paper from Kwok (2018) should update the findings from Lindsay and Schweiger (2015). It is more accurate as the time series is extended. Furthermore, Kwok (2018) provides estimates of sea-ice volume, which might be integrated here. Reference: Kwok, R. (2018). Arctic sea ice thickness, volume, and multiyear ice coverage: losses and coupled variability (1958–2018). Environmental Research Letters, doi: 10.1088/1748-9326/aae3ec. [APECS Group Review, Germany]	Accepted: citation updated
33213	3	15	10	15	10	Add and update with data from Kwok (2018). [Government of United States of America, United States of America]	Accepted: citation updated
19563	3	15	18	15	18	The last sentence of this paragraph is not very well suited to this paragraph. It is a different and isolated finding. I propose to remove it. [APECS Group Review, Germany]	Accepted: text revised
21653	3	15	20	0		Needed to change In-situ with In-situ or in situ [Government of Republic of Korea, Republic of Korea]	Accepted: text revised

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
11217	3	15	20	15	23	<p>In-situ observations of Antarctic sea ice thickness are extremely sparse (Worby et al., 2008). There are no consistent long-term observations from which trends in ice volume may be derived. Calibrated model simulations suggest that ice thickness trends closely follow those of ice concentration (Massonnet et al., 2013; Holland et al., 2014) (low confidence).</p> <p>My suggestion is:</p> <p>Numerous field techniques have been applied to measure sea ice thickness including surface drilling (Ackley, 1979; Perovich et al., 2004) and ship-based observations (Xie et al., 2011; Ozsoy-Cicek et al., 2011). In-situ observations of Antarctic sea ice thickness are however extremely sparse (Worby et al., 2008). There are some isostatic approaches applied (Zwally et al., 2008; Ozsoy-Cicek et al., 2013) based on in situ measurements. Retrieval using satellite altimetry is still in a developmental state for Antarctic sea ice thickness. There are no consistent long-term observations from which trends in ice volume may be derived. Calibrated model simulations suggest that ice thickness trends closely follow those of ice concentration (Massonnet et al., 2013; Holland et al., 2014) (low confidence).</p> <p>Ackley, S. F. (1979), Mass balance aspects of Weddell Sea pack ice, <i>J. Glaciol.</i>, 24(90), 391–405.</p> <p>Perovich, D. K., B. C. Elder, K. J. Claffey, S. Stammerjohn, R. Smith, S. F. Ackley, H. R. Krouse, and A. J. Gow (2004), Winter sea-ice properties in Marguerite Bay, Antarctica, <i>Deep Sea Res., Part II</i>, 51, 2023–2039.</p> <p>Xie, H., S. F. Ackley, D. Yi, J. H. Zwally, P. Wagner, B. Weissling, M. Lewis, and K. Ye (2011), Sea ice thickness distribution of the Bellingshausen Sea from surface measurements and ICESat altimetry, <i>Deep Sea Res., Part II</i>, 58(9–10), 1039–1051</p> <p>Ozsoy-Cicek, B., S. Kern, S. F. Ackley, H. Xie, and A. E. Tekeli (2011), Intercomparisons of Antarctic sea properties from ship observations, active and passive microwave satellite observations in the Bellingshausen Sea, <i>Deep Sea Res., Part II</i>, 58(9–10), 1092–1111,</p>	<p>Taken into account: this paragraph was revised to take into account emerging satellite altimeter measurements. Emphasis is on post-AR5 publications.</p>
32045	3	15	25	15	39	<p>Units of days per unit time (decade or year) are inconsistent in the two paragraphs and need to be provided in either days per decade or days per year in both paragraphs. This is required for the two poles to be comparable. [John Runcie, Australia]</p>	<p>Accepted: text revised</p>
33215	3	15	26	15	26	<p>For melt onset, could add most recent reference: Bliss, A.C., J.A. Miller, and W.N. Meier, 2017. Comparison of passive microwave-derived early melt onset records on Arctic sea ice, <i>Remote Sensing</i>, 9, 199, doi:10.3390/rs9030199. [Government of United States of America, United States of America]</p>	<p>Rejected: the suggested paper only examines data through 2012.</p>

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
29659	3	15	26	15	33	So, that the additional solar uptake due to the open water is a pretty clear explanation for why the freeze-ups are occurring later. On why the surface melting is starting earlier could be due to warming, but it could also be that reducing the sulfate loadings entering the Arctic from the Atlantic sector as part of the effort to reduce acid precipitation led to a reduction in cloud brightening and so let more solar reach the surface earlier and stronger in the spring, so contributing to the earlier melting of the ice. So, again, it would help to be explaining potential causal factors, etc. and not just give explanations that are focus on process interactions rather than driving forces. [Michael MacCracken, United States of America]	Accepted: text revised to make a clearer link with extent and thickness changes.
11337	3	15	28	15	29	Consider adding: Schröder, D., Feltham, D. L., Flocco, D., & Tsamados, M. (2014). September Arctic sea-ice minimum predicted by spring melt-pond fraction. Nature Climate Change, 4(5), 353. [Torsten Geldsetzer,]	Rejected: this citation was in an earlier draft but was removed as we cut text to reduce length.
19615	3	15	29	15	35	C1 - Does this paragraph add much? It also has a high uncertainty. Consider keeping the first sentence (with refs) only, and putting in another paragraph. [APECS Group Review,]	Rejected: not clear what sentence or what confidence statement this comment is referring to.
18875	3	15	30	15	31	C3 - Replace "length" with "duration" (twice) in this sentence, as measuring time by length rather than duration is potentially confusing/unclear for the reader. [APECS Group Review,]	Accepted: wording revised
4135	3	15	36	15	37	Put "summer and autumn" after "...from 1979-2011". The sea ice reduction in the Amundsen/Bellinghausen Sea only occurs in summer and autumn, while the sea ice increase in the Ross Sea occurs year-round. [Seong-Joong Kim,]	Accepted: wording revised
32027	3	15	37	15	38	Either the units or the values are unrealistic. Should it be 3.1+- 1 and 2.5 +- 0.4 days per decade rather than year? [Christian Reuten,]	Accepted: wording revised
33217	3	15	42	15	45	Lots of new evidence about role of sea ice motion in modulating ocean processes in the gyre. Dewey et al. 2017, Zhong et al. 2017, Menghello et al. 2017,2018 [Government of United States of America,]	Accepted: recent Beaufort Gyre citations added
17511	3	15	42	15	51	Reduced Arctic sea ice allows greater swell of waves in the Arctic Ocean, which can further disrupt sea ice and accelerate breaking up of ice, becoming a positive feedback; see Thomson J. & Rogers W. E. (2014) Swell and sea in the emerging Arctic Ocean, GEOPHYSICAL RESEARCH LETTERS 41:3136–3140. At the same time, reduced sea ice provides favorable conditions for cyclone development and increased intensity of cyclones, which can also facilitate break-up of sea ice; see Day J. J. & Hodges K. I. (2018) Growing Land-Sea Temperature Contrast and the Intensification of Arctic Cyclones, GEOPHYSICAL RESEARCH LETTERS 45:3673–3681. [Kristin Campbell,]	Taken into account: this is captured in the final paragraph of Section 3.2.1.1.2, including citation of the Thomson and Rogers paper.
17613	3	15	42	15	51	The loss of remaining Arctic sea ice is not necessarily going to be a linear process; younger sea ice, which makes up most of the Arctic sea ice now, is more susceptible to break up. Perovich D., et al. (2018) Sea Ice, in ARCTIC REPORT CARD 2018, 28 ("Older ice tends to be thicker and is thus more resilient to changes in atmospheric and oceanic heat content compared to younger, thinner ice. The oldest ice (>4 years old) continues to make up a small fraction of the Arctic ice pack in March, when the sea ice extent has been at its maximum in most years of the satellite record. In 1985, the oldest ice comprised 16% of the ice pack (Fig. 3a), whereas in March of 2018 old ice only constituted 0.9% of the ice pack (Fig. 3b). Therefore, the oldest ice extent declined from 2.54 million km2 in March 1985 to 0.13 million km2 in March 2018, representing a 95% reduction."). [Durwood Zaelke, United States of America]	Taken into account: not clear what this comment is requesting. No assessment is made of linearity of sea ice loss.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
17615	3	15	42	15	51	Reduced Arctic sea ice allows greater swell of waves in the Arctic Ocean, which can further disrupt sea ice and accelerate breaking up of ice, becoming a positive feedback; see Thomson J. & Rogers W. E. (2014) Swell and sea in the emerging Arctic Ocean, GEOPHYSICAL RESEARCH LETTERS 41:3136–3140, 3136 (“Ocean surface waves (sea and swell) are generated by winds blowing over a distance (fetch) for a duration of time. In the Arctic Ocean, fetch varies seasonally from essentially zero in winter to hundreds of kilometers in recent summers. Using in situ observations of waves in the central Beaufort Sea, combined with a numerical wave model and satellite sea ice observations, we show that wave energy scales with fetch throughout the seasonal ice cycle. Furthermore, we show that the increased open water of 2012 allowed waves to develop beyond pure wind seas and evolve into swells. The swells remain tied to the available fetch, however, because fetch is a proxy for the basin size in which the wave evolution occurs. Thus, both sea and swell depend on the open water fetch in the Arctic, because the swell is regionally driven. This suggests that further reductions in seasonal ice cover in the future will result in larger waves, which in turn provide a mechanism to break up sea ice and accelerate ice retreat.”). At the same time, reduced sea ice provides favorable conditions for cyclone development and increased intensity of cyclones, which can also facilitate break-up of sea ice; see Day J. J. & Hodges K. I. (2018) Growing Land-Sea Temperature Contrast and the Intensification of Arctic Cyclones, GEOPHYSICAL RESEARCH LETTERS 45:3673–3681, 3680 (“Further, because climate change is increasing land-sea contrasts in the Arctic, it seems highly likely that the circulation patterns typical of years with strong AFZ will become more common as the climate warms. Indeed, strengthening of the mean temperature gradients in the AFZ is a robust feature of future climate projections as is an increase in the strength of the Arctic Front Jet (Mann et al., 2017; Nishii et al., 2014). This study shows that this linkage between surface temperature gradients and atmospheric circulation is important for Arctic cyclones, adding weight to previous studies.”). [Durwood Zaelke, United States of America]	Taken into account: see #17511
18871	3	15	43	15	43	The word "sequester" is hard to understand, change or remove? [APECS Group Review, Germany]	Accepted: wording revised
19565	3	15	43	15	44	Rephrase: 'and export sea ice out of the Arctic through Fram Strait'. [APECS Group Review, Germany]	Accepted: wording revised
19567	3	15	45	15	48	I would add the reference to Olason and Notz (2014) at the end of the sentence (after 'wind forcing'), as the focus of this paper is the causes of changes in sea-ice drift speed. [APECS Group Review, Germany]	Accepted: citation moved
19569	3	15	45	15	48	I would add a confidence level at the end of this sentence: high confidence seems appropriate as the evidence of sea-ice drift speed increase is robust and the degree of agreement is medium to high. [APECS Group Review, Germany]	Accepted: wording revised; high confidence statement included
19571	3	15	45	15	48	I would add a time period over which sea-ice drift speed has increased. There is medium confidence (medium evidence, medium agreement) that drift speed has increased since the 1950s (Hakkinen, S., A. Proshutinsky, I. Ashik (2008). Sea ice drift in the Arctic since the 1950s. Geophysical Research Letters, doi: 10.1029/2008GL034791.). There is very high confidence (robust evidence, high agreement) that drift speed has increased since 1979 (Rampal et al., 2009; Vihma et al., 2012; Olason and Notz, 2014). [APECS Group Review, Germany]	Accepted: wording revised

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
29661	3	15	47	15	47	Of course, thinner ice and reduced ice are both due to CO2 induced warming, and quite possibly also the wind response (indirectly due to changes in surface temperature patterns, etc.). I would just note that I think it important to be going back again and again to the driving force and not the driving process. [Michael MacCracken, United States of America]	Taken into account: importance of thinner ice and reduced ice concentration are noted.
33219	3	15	47	15	47	Spreen et al. (2011) paper indicates that the wind forcing was not changing, or at least the wind forcing changes didn't explain the changes in ice motion. [Government of United States of America, United States of America]	Accepted: Spreen et al citation shifted to after the statement about thinning ice.
18873	3	15	48	15	51	This sentence is difficult to understand, rewrite? [APECS Group Review, Germany]	Accepted: wording revised
18877	3	15	48	15	51	E1a - Sentence is unclear, due to use of two sets of brackets. Consider adding "medium confidence" before "because" in L49 to make it clear what the uncertainty statement is based upon (otherwise confidence estimate statement origin is unclear). [APECS Group Review, Germany]	Accepted: sentence revised
26189	3	15	48	15	51	A recent publication by Ricker et al. (2018; The Cryosphere, doi: 10.5194/tc-12-3017-2018) discusses sea ice volume export in Fram Strait. This could be included in the discussion where sea ice export in area (km2) in the same region is discussed. [Sebastian Gerland, Norway]	Accepted: new sentence with reference added
33221	3	15	48	15	51	This sentence is a little awkward. The "because" refers to the reason for the range in values, but it starts to read as the "because" explaining the actual reason for the export. Maybe split into two sentences or reword for clarity. [Government of United States of America, United States of America]	Accepted: sentence revised
9057	3	15	49	0		Insert bracket after "2017)" [Nina Hunter, South Africa]	Accepted: sentence revised
33223	3	15	49	15	49	Missing ")" [Government of United States of America, United States of America]	Accepted: sentence revised
33225	3	15	50	15	52	Defining "shoaling" would be helpful for readers who aren't oceanographers. [Government of United States of America, United States of America]	Incorrect page and line reference?
29169	3	15	51	15	51	Add that due to thinner ice cover and faster motion, sea ice deformation is increasing (Rampal et al, 2008, Itkin et al, 2017 https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2016JC012403). Although this increases the sea ice volume on a short term (winter), thin ice in the leads and deformed ice is more susceptible to melt and will melt faster in summer. [Polona Itkin, Norway]	Accepted: sentence and reference added
26191	3	16	2	16	10	In the context of Arctic landfast sea ice changes, a new publication by Pavlova et al. (in press) is coming out in the next months (Pavlova et al.: "Changes in Sea-Ice Extent and Thickness in Kongsfjorden, Svalbard (2003–2016)". in press; in: Advances in Polar Ecology 2, The Ecosystem of Kongsfjorden, Svalbard. Springer, see https://www.springer.com/us/book/9783319464237). It gives an update on Kongsfjorden (Svalbard) sea ice changes, and the findings include (among other) negative trends in annual maximum of the seasonal sea ice thickness and thickness of the snow cover on the sea ice in the fjord. If the time of publication would be within the time limits of SROCC, I would suggest considering to mention/discuss results from it in the report in this section. [Sebastian Gerland, Norway]	Rejected: helpful suggestion but this did not make the SROCC publication deadline

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
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1661	3	16	3	16	5	There are no studies listed to support the statement of "high confidence" in thinning trends of landfast sea ice. [Nora Richter, United States of America]	Accepted: text revised
18883	3	16	5	16	5	C1 - Need references to back up uncertainty statement of "high confidence", or make clearer that following text is what backs this up. (I am unsure of whether this confidence is based upon the later text or an unsubstantiated statement). [APECS Group Review, Germany]	Accepted: text revised
15545	3	16	5	16	7	Please, clarify form what type of measurements/data these trends are derived. [EUCE, Belgium]	Accepted: text revised
16881	3	16	5	16	7	Make it clear what kind of measurements/data are these trends derived from. [Louise Sandberg Soerensen, Denmark]	Accepted: text revised
18879	3	16	14	16	14	The wording "advent of observations" is hard to understand, change? [APECS Group Review, Germany]	Accepted: text revised
9059	3	16	21	0		Insert 'of lanfast sea ice' after 'importance' [Nina Hunter, South Africa]	Accepted: text revised
9061	3	16	27	0		It would be useful if 'polynyas' could be defined [Nina Hunter, South Africa]	Taken into account: defined in glossary
18885	3	16	27	16	27	E1a - Should "polynyas" be defined? Maybe it is too specific a term to be understood by a general reader without a simple definition? [APECS Group Review, Germany]	Taken into account: defined in glossary
28517	3	16	29	16	30	Remove either "low confidence" or "reported". (Presently this sentence doesn't contain statements about the ocean/cryosphere, but about the state of our knowledge; we can have perfect confidence in the statement that "there isa high degree of regional variability in reported trends in A" even while having low confidence in the statement that "trends in A have a high degree of regional variability".) [Yvonne Firing, United Kingdom (of Great Britain and Northern Ireland)]	Accepted: text revised
9063	3	16	34	0		inhibit' not 'inhibits' [Nina Hunter, South Africa]	Rejected: 'inhibits' is correct usage
Comment	3	16	34	16	34	Light is not only important for under-ice biota, but also for in-ice biota. [Peter Lemke, Germany]	Accepted: text revised
9065	3	16	35	0		Insert 'from' before 'reaching' [Nina Hunter, South Africa]	Accepted: text revised
27547	3	16	35	16	35	There are other more pioneering studies on the role of snow for sea ice that probably should also be cited here. E.g., among others: Gosselin, M., L. Legendre, J. C. Therriault, S. Demers, and M. Rochet (1986), Physical control of the horizontal patchiness of sea-ice microalgae, Mar. Ecol. Prog. Ser., 29(3), 289-298, doi:10.3354/meps029289. [Benjamin A. Lange, Canada]	Rejected: emphasis is on post-AR5 literature
30905	3	16	35	16	39	Is there any further consequence of this depression of sea ice below sea level and snow-ice formation (e.g. for stability, or sea ice organisms)? Should be mentioned here. [Hans-Otto Poertner and WGII TSU, Germany]	Accepted: text and new citation added
18881	3	16	36	0		Would the formation of snow-ice increase or decrease the thickness of sea ice in measurements, and in future years? This would be important to mention if possible (could be simply a few more words at the end of the sentence that states what aspect(s) of sea ice is affected). [APECS Group Review, Germany]	Rejected: additional text is out of scope

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
26193	3	16	41	16	42	A new publication by Webster et al. (2018, Nature Climate Change, doi: 10.1038/s41558-018-0286-7) gives an updated overview on the processes, importance and gaps related to snow on sea ice. I suggest to consider this update in the discussion. [Sebastian Gerland, Norway]	Accepted: reference added
11339	3	16	42	16	42	Consider adding: Webster, M., Gerland, S., Holland, M., Hunke, E., Kwok, R., Lecomte, O., ... & Sturm, M. (2018). Snow in the changing sea-ice systems. Nature Climate Change, 1. [Torsten Geldsetzer, Canada]	Accepted: reference added
18887	3	16	43	16	44	E1a - Consider restructuring this sentence as it is confusing. Consider changing to: "The primary source of information for snow depth on Arctic sea ice is..." [APECS Group Review, Germany]	Accepted: text revised
30339	3	16	44	16	44	I suggest changing "climatologies" to "climatic records" [Paul Glaser, United States of America]	Rejected: the Warren et al dataset noted here is a climatology
3055	3	16	46	0		Ref is Stroeve and Notz [Helene Hewitt, United Kingdom (of Great Britain and Northern Ireland)]	Accepted: reference corrected
4303	3	16	46	16	46	Stroeve and Dirk (2018) citation is wrong last name on second author. [Lars Smedsrud, Norway]	Accepted: reference corrected
11171	3	16	46	16	46	Should be „Stroeve and Notz“ [Dirk Notz, Germany]	Accepted: reference corrected
11219	3	16	53	16	56	<p>Although there are regional estimates of snow depth on Antarctic sea ice from satellite (Kern and Ozsoy Çiçek, 2016), airborne remote sensing (Kwok and Maksym, 2014), in situ field measurements (Massom et al., 2001) and ship-based observations (Worby et al., 2008), data are not sufficiently extensive in time nor space to assess changes in snow accumulation on Antarctic sea ice.</p> <p>My suggestion is:</p> <p>Snow depth on sea ice are difficult to measure over large scale. Although there are regional estimates of snow depth on Antarctic sea ice from satellite (Kern and Ozsoy Çiçek, 2016), airborne remote sensing (Kwok and Maksym, 2014), in situ field measurements (Massom et al., 2001) and ship-based observations (Worby et al., 2008), data are not sufficiently extensive in time nor space to assess changes in snow accumulation on Antarctic sea ice. Additionally, flooding of the ice-snow interface has been observed on Antarctic sea ice quite frequently (Ozsoy-Cicek et al., 2013).</p> <p>Ozsoy-Cicek, B., S. F. Ackley, H. Xie, D. Yi, J. Zwally, "Sea ice thickness retrieval algorithms based on in situ surface elevation and thickness values for application to altimetry", Journal of Geophysical Research: Oceans, No. 8, 2013, s. 3807-3822, ISSN: 2169-9275 doi: 10.1002/jgrc.20252 [Burcu Ozsoy, Turkey]</p>	Rejected: snow ice is addressed earlier in the section
21655	3	16	54	0		in situ should be consistent with In-situ in page 15, line 20 [Government of Republic of Korea, Republic of Korea]	Accepted: text revised

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
19579	3	17	1	21	5	My general feeling about Sections 3.2.1.2 and 3.2.1.3 is that something is missing about ocean heat transport in the Arctic and Southern Oceans, and its potential influence on sea ice. There is a sub-section on ocean temperature (3.2.1.2.1) and one on ocean circulation (3.2.1.3), but nothing is said in terms of the resulting ocean heat transport, which is critical in driving changes to the polar regions, especially in the Arctic. I suggest to add at least a paragraph about the changes in ocean heat transport. References: 1) Arthun, M. et al. (2012). Quantifying the Influence of Atlantic Heat on Barents Sea Ice Variability and Retreat. Journal of Climate, doi: 10.1175/JCLI-D-11-00466.1. 2) Carmack, E. et al. (2015). Towards quantifying the increasing role of oceanic heat in sea ice loss in the new Arctic. BAMS, doi: 10.1175/BAMS-D-13-00177.1. [APECS Group Review, Germany]	Accepted - heat transport has been described in section 3.2.1.2.1. We have added the added Arthun et al. reference to this section (see also later response). We have also added a sentence and the Carmack et al. (2015) reference at the start of the section. Southern Ocean?
26377	3	17	3	17	5	It may be worth including a schematic of the major oceanic water masses and their circulation through the polar regions. Or, one from another chapter could be referenced here. [Ethan Pierce, United States of America]	Rejected; we do not have space for a graphic of this type.
11421	3	17	7	18	2	Cheng et al. 2017 -- Science Advances has newest estimate of OHC in surface, subsurface, and deep Southern Ocean. [Anson Cheung, United States of America]	Accepted; we have strengthened the material on heat content in the Southern Ocean, including a new table
29351	3	17	8	17	10	The assessment of AR5 on this topic is less confident than indicated here. Section 3.2.2 includes the sentence 'Arctic surface waters have also warmed, at least in the Canada basin, from 1993 to 2007 (Jackson et al., 2010).' i.e. it is a statement based on a single study, and just applies to the Canada basin, not the whole Arctic. [Government of Canada, Canada]	Accepted - noted "Canada Basin".
33227	3	17	8	17	28	Not sure exactly where it fits, but it seems like this paper is worth noting: Steele, M., and S. Dickinson (2016), The phenology of Arctic Ocean surface warming, J. Geophys. Res. Oceans, 121, 6847--6861, doi:10.1002/2016JC012089. [Government of United States of America, United States of America]	Accepted - cited at the start of section 3.2.1.2.1.
23979	3	17	8	18	2	It would seem beneficial for ease of understanding to use the same unit for the trend (degree C per decade or degree C per year) within the same subsection of 3.2.1.2.1. [Government of Japan, Japan]	Accepted - change made
18889	3	17	9	17	9	E1a - Must have a comma after "warming", otherwise sentence doesn't make sense. [APECS Group Review, Germany]	Editorial - copyedit to be completed prior to publication
33229	3	17	14	17	15	If authors are referring to the increase in absorbed solar radiation across the Arctic Ocean, then this statement is virtually certain. If authors contend that the number is virtually certain, it is not. Clarify. [Government of United States of America, United States of America]	Accepted - text clarified.
33231	3	17	15	17	15	To what does "virtually certain" refer? It is virtually certain that there is an increase in solar energy input. The number of 6.4 Wm ⁻² is much less than virtually certain. Associating a single paper with the statement "virtually certain" doesn't appear to be wise. [Government of United States of America, United States of America]	Accepted - text revised.
2785	3	17	19	17	20	Is a comment like "temperatures have stabilized" on short term (10 year) trends, relevant/clear enough in the face of large internal variability? Perhaps some context should be given to avoid confusion. [Neil Swart, Canada]	Accepted - text revised.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
33233	3	17	19	17	20	Polyakov et al. (2017) do not suggest that the volume inflows have increased. The Atlantic Water layer temperatures continue to increase at the Barents Sea (Lind et al., 2018) and the Eurasian Basin (Polyakov et al., 2017). The total heat content continues to increase, not due to increased volume inflows but mostly to increased temperature (Oldenburg et al., 2018). (References: Lind S, Ingvaldsen RB, Furevik T. Arctic warming hotspot in the northern Barents Sea linked to declining sea-ice import. Nat Clim Chang. 2018, 8(7):634-639. doi:10.1038/s41558-018-0205-y; Oldenburg D, Armour KC, Thompson L, Bitz CM. Distinct Mechanisms of Ocean Heat Transport Into the Arctic Under Internal Variability and Climate Change. Geophys Res Lett. 2018;45(15):7692-7700. doi:10.1029/2018GL078719.) [Government of United States of America, United States of America]	Noted - the clause has been removed and the other references have been added (see later responses).
1851	3	17	19	17	28	For the northern Barents Sea, Lind et al, Nature Climate Change volume 8, pages 634–639 (2018)) show a sharp increase in ocean temperature and salinity from the mid-2000s, linked to a recent decline in sea-ice import and a corresponding loss in freshwater, leading to weakened ocean stratification, enhanced vertical mixing and increased upward fluxes of heat and salt that prevent sea-ice formation and increase ocean heat content. [Solfrid Sætre Hjøllø, Norway]	Noted - the clause has been removed and the other references have been added (see later responses).
11893	3	17	19	17	28	Large increases in heat fluxes and transport in the some regions of the Arctic Ocean were mentioned (Eurasian Basin, Canada Basin, and Bering Strait). Can the authors provide information about recent changes in heat flux in the East Siberian Sea, which is experiencing significant sea ice loss? [Jun Sun, China]	Noted - unfortunately there are limited subsurface observations from these regions; year-round mooring data are not available and hydrographic data are not sufficient to infer trends. We do refer to changing SSTs quantified by satellite observations, which include the East Siberian Sea.
19575	3	17	19	17	28	I would separate more clearly the changes in Atlantic Water (L19-24) from the changes in Pacific Water (L24-28) by either adding an introduction sentence in this paragraph, or by having two different paragraphs. [APECS Group Review, Germany]	Accepted - split these paragraphs.
19573	3	17	21	17	21	Please provide a reference for 'atlantification'. My suggestion: Arthun, M. et al. (2012). Quantifying the Influence of Atlantic Heat on Barents Sea Ice Variability and Retreat. Journal of Climate, doi: 10.1175/JCLI-D-11-00466.1. [APECS Group Review, Germany]	Accepted - added Arthun et al. reference.
33235	3	17	21	17	21	Add "the Northern Barents Sea (Lind et al., 2018) and" in front of "the Eurasian Basin" [Government of United States of America, United States of America]	Accepted - text revised.
33237	3	17	23	17	24	Replace "Polyakov et al. (2017) estimate 2 to 4 times larger heat fluxes in 2014-2015 compared with 2007-2008 (medium confidence)." by "The northern Barents Sea may soon transform to a well-mixed Atlantic-dominated regime (Lind et al., 2018), and the Eurasian Basin experienced 2 to 4 times larger heat fluxes from the Atlantic water layer in 2014-2015 compared with 2007-2008 (medium confidence) (Polyakov et al., 2017)." [Government of United States of America, United States of America]	Noted - this reference has been added earlier although we choose not to add this specific text because "may soon transform" is too ambiguous.
3057	3	17	25	17	26	Is Medium confidence too high for the heat content change? Presumably observations are somewhat limited regionally and seasonally in the Arctic and therefore infilling has probably been heavily applied to produce integrated heat content. See for example Gregory et al. (2004) GRL on effects of infills or more recent work by Matt Palmer and co-authors [Helene Hewitt, United Kingdom (of Great Britain and Northern Ireland)]	Noted - in this particular case, there are sufficient data for sufficiently robust estimates of the trends; an analysis similar to bootstrapping has been applied.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
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4305	3	17	26	17	28	The observed trend by Woodgate should be given in TW, not as %. 60% appears as a large change, while the Ocean Heat Transport Variability is dominated by the Atlantic Inflow. Onarheim et al (2015) documents recent changes of +/- 15 TW in the Barents Sea Opening, for example. Similar values should at least be included for Fram Strait, where a 100% change could be cited between 1998 and 2004 (20 TW - 40 TW, Schauer and Beszczynska-Moller Ocean Sci., 5, 487-494, 2009 www.ocean-sci.net/5/487/2009/) Onarheim et al (2015), Skillful prediction of Barents Sea ice cover, Geophys. Res. Lett., 42, 5364-5371, doi:10.1002/2015GL064359. [Lars Smedsrud, Norway]	Accepted - added values in TW.
34219	3	17	26	174	28	The citations are studies of the Bering Strait inflow. Whereas there is clear variability, perhaps a trend, in the largely mooring-based observations of the inflow from the Bering Sea into the Arctic Ocean, the calculation of heat transports through a single passage with a significant net volume transport is highly questionable. This at least deserves a qualifying sentence or set the statement to "low confidence". (see also Problems with estimation and interpretation of oceanic heat transport – conceptual remarks for the case of Fram Strait in the Arctic Ocean, U. Schauer and A. Beszczynska-Möller, Ocean Sci., 5, 487-494, https://doi.org/10.5194/os-5-487-2009 , 2009). [Benjamin Rabe, Germany]	Accepted - changed to low confidence.
3061	3	17	30	0		I'm not sure that high confidence in 67-98% is a useful way of presenting the contribution of the Southern Ocean heat uptake. Maybe high confidence that the Southern Ocean contributes at least 67% of the global heat uptake? [Helene Hewitt, United Kingdom (of Great Britain and Northern Ireland)]	Accepted. This section has been greatly revised, with this point acted on.
3063	3	17	30	18	2	I wonder if this section of text can be refined so it jumps about less- eg, heave is referred to in one paragraph and then the causes of isopycnal depth changes then discussed in the next without reference to the first. I also wonder if a table might be useful to summarise all the changes [Helene Hewitt, United Kingdom (of Great Britain and Northern Ireland)]	Accepted; this section has been modified and simplified, with a new table included
23927	3	17	34	17	34	It would be helpful to clarify whether this sentence refers to the period between 1982 – 2012. [Government of Japan, Japan]	Accepted. Text revised with clarification on dates now made
28531	3	17	34	17	38	Is the confidence for lines 34-35 also high? [Yvonne Firing, United Kingdom (of Great Britain and Northern Ireland)]	Accepted; text revised

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
28533	3	17	34	17	38	Shouldn't the citation of Armour et al. (2016) move to the end (to apply to the recent cooling as well) [Yvonne Firing, United Kingdom (of Great Britain and Northern Ireland)]	Accepted; text revised
19577	3	17	35	17	35	I would remove the reference to Fig. 2 of Appendix 3.A, as the warming in the upper 2000m is not really seen in this figure (but rather in Fig. 3). [APECS Group Review, Germany]	Rejected: Figure 2 shows depth integrated heat uptake. This is stated to be greatest in the top 2000 m and so is relevant to the cited sentence. It give a valuable regional view of ocean heat uptake, and compliments figure 3 which looks at a meridional slice.
22469	3	17	35	17	38	Suggest downscaling the "high confidence" associated with the trend of 0.02C for the Southern Ocean, south of the ACC since 1950. Suggest it be "medium confidence". [Government of Australia, Australia]	Taken into account; text has been substantially revised, including changed confidence statements
11857	3	17	43	17	46	I beleive there is an error when reporting the results from Gao et al., 2018 in this sentence, which challenge the sentence and the "medium confidence" level ascribed by the author. E.g. Gao states: "The observation that the SAMW layer thickened as well as deepened shows that the response is not solely due to heaving of a fixed pycnocline", which appear directly contradictory to the assessment in this sentence. I think the author should reconsider their conclusion and confidence level. [Jean baptiste SALLEE, France]	Accepted: This issues arises from a different interpretation of 'heave' and 'thickening' in Gao et al., 2018 vs Desbruyeres et al. 2017. In Desbruyeres a thickening of the SAMW with little change to SAMW temperature will be interpreted as heave and have little water mass change 'spiciness' component. We have rewritten this section to make it clear that most of the heat uptake in the extratropics north of the ACC is probably due to a wind driven thickening and deepening of the SAMW layer. This is consistent with Desbruyeres, so we maintain an assessment of medium confidence.
33239	3	17	44	17	45	Refer to the original study. The relevant reference is: Gille, 2008: Decadal-scale temperature trends in the Southern hemisphere ocean. J. Clim. doi:10.1175/2008JCLI2131.1. [Government of United States of America, United States of America]	Rejected. The modus operandi of SROCC is to update on assessments made previously in AR5 (and SR1.5 where relevant); we do not generally re-cite papers already assessed and cited in those assessments.
3059	3	17	45	0		Can you comment on the cause of heave changes for the lay-reader ie, either changes in water mass formation or changes in windstress? Is there evidence to suggest either of these? I wonder if this paragraph needs more explanation of the implications of change on isopycnals versus heave referencing Bindoff and McDougall> Or whether it should be simplified a little. [Helene Hewitt, United Kingdom (of Great Britain and Northern Ireland)]	Accepted: This section has been modified significantly to improve clarity (see also comment 11857). We have simplified the text to avoid the heave/spice (pure heave/warming etc) question and clarified the role of winds in driving thickened SAMW layers and dominating heat uptake in the extra tropics north of the ACC.
3859	3	17	46	17	47	The statement is a bit misleading, as no significant warming was observed on the shelf around the Antarctic except for [Zhaomin Wang, China]	Accepted: Text revised to make it clear that while warming of deep water does extend well south of the ACC (Schmidtke et al., 2014, Fig 2d) it only extends onto the shelf in a statistically significant way into the ABS sector.
3861	3	17	46	17	47	the ABS sector. [Zhaomin Wang, China]	Accepted: See comment 3859
23981	3	17	46	17	48	It is suggested that "Amundsen-Bellingshausen Sea" be corrected to "Bellingshausen Sea" and "0.03 degC yr-1", to "0.01 degC yr-1 (or 0.1 degC per dec)", as the trend in Amundsen Sea is not derived from 1975 and recent studies (Jenkins et al., 2016/2018) strongly suggests a dominance of decadal signal and high probability of aliasing. [Government of Japan, Japan]	Taken into account: text has been modified to indicate the range of temperature trends in the ABS indicated in Schmidtke et al. 2014 Figure 1c. and the date range amended to reflect the observational data range in their Fig 1e. Similarly the decadal variability in Jenkins et al. 2018 is noted, see comment 32187.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
32187	3	17	49	17	49	I would include the following: "... (medium confidence). This warming has been explained by the shoaling of the relatively warm UCDW induced by the poleward migration of the westerly wind jet and the weakening of the Antarctic Slope Front (Spence et al., 2014)." Spence et al 2014 doi: 10.1002/2014GL060613 [Pedro J. Llanillo, Chile]	Taken into account: Text has been modified to include the reference to Spence et al. 2014 and reflect the role that wind stress appears to play in driving warming in the ABS. Also noted here is the significant interdecadal variability in shelf ocean temperatures noted by Jenkins et al. 2018.
248	3	17	56	18	2	The word "property" sounds strongly associated with the temperature and salinity. The movement of density surfaces could be caused by "heaving" or vertical movement of water masses without changing its "property". AABW reduction is linked with warming and freshening but can be clearly separated. [Katsuro Katsumata, Japan]	Accepted: This section was written unclearly and failed to separate heave and isopycnal change properly. The text on bottom water has been revised considerably to make the drivers of change clearer.
15547	3	18	4	18	40	It would be relevant to assess and cite the following paper in this section. It concerns the freshwater fluxes from Greenland into the Arctic Ocean. Bamber, J, Tedstone, A, King, MD, Howat, IM, Enderlin, EM, Broeke, MRVD & Noel, B, 2018, 'Land Ice Freshwater Budget of the Arctic and North Atlantic Oceans. Part I: Data, Methods and Results'. Journal of Geophysical Research: Oceans. [EUCE, Belgium]	Taken into account; that paper is assessed in the ice sheets/glaciers section, which is now referenced here.
16907	3	18	4	18	40	I think that it would be relevant to use and cite the following paper in this section. It concerns the freshwater fluxes from Greenland into the Arctic Ocean. Bamber, J, Tedstone, A, King, MD, Howat, IM, Enderlin, EM, Broeke, MRVD & Noel, B, 2018, 'Land Ice Freshwater Budget of the Arctic and North Atlantic Oceans. Part I: Data, Methods and Results'. Journal of Geophysical Research: Oceans. [Louise Sandberg Soerensen, Denmark]	see response to 15547
1853	3	18	6	18	8	Processes included in the term "Freshwater discharge" should be listed here (probably river runoff, land and sea ice import/export, formation/melting, water mass import, precipitation etc ?) [Solfrid Sætre Hjøllø, Norway]	Taken into account; we now reference other sections that provide further quantification on freshwater discharge
33241	3	18	6	18	8	"Changes in salinity are induced by changes in freshwater discharged to the ocean ...". This is true, but other factors are just as significant depending on where you are (e.g., sea ice formation and melting, evaporation and precipitation, sub-ice shelf melting). For clarity, do these other processes need mentioning here too? Maybe these processes are implicit here, but "discharge" implies from rivers (i.e., from land). These processes are listed in the discussion that follows, but not into this sentence. [Government of United States of America, United States of America]	Accepted - text revised.
34221	3	18	6	18	8	Changes in the total salinity of the ocean, frozen or liquid, are induced not only by "discharge" (i.e. continental runoff) but also by lateral moisture transport in the atmosphere and associated precipitation / evaporation. In the Arctic, in particular, the sea ice and ocean can exchange freshwater due to the balance between freezing, melting and advection of sea ice and water masses. I would at least add a couple of sentences to this introductory paragraph to that effect. [Benjamin Rabe, Germany]	Accepted - text revised.
3065	3	18	10	18	23	Why are the salinity/frershwater changes assigned medium confidence while the temperature changes are assigned high confidence given that this is supported by a number of publications. [Helene Hewitt, United Kingdom (of Great Britain and Northern Ireland)]	Noted - a continuous record of satellite sea-surface temperatures contribute significantly to the temperature record.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
11895	3	18	10	18	23	It is evident that a large increase in freshwater was observed in the Beaufort Gyre region, which was linked to a rapid reduction in sea ice content in the region. However, the authors pointed out a drastic decline in sea ice content in the region of Chukchi, Laptev and Kara Seas (in page 11) and, a decrease in freshwater observed in the East Siberian, Laptev, Chukchi and Kara Seas needs to be further explained. Because the freshwater decrease in these regions could be closely related to river runoff as well as sea ice change. [Jun Sun, China]	Noted - the increase in Beaufort Gyre freshwater largely relates to sustained anticyclonic atmospheric forcing centered over the gyre; this wind/ice forcing drives a convergence of surface freshwater.
3067	3	18	10	18	40	Can the changes in the Arctic and Southern Ocean be reported consistently-ie, either in salinity change or freshwater change [Helene Hewitt, United Kingdom (of Great Britain and Northern Ireland)]	see response to 22385
22385	3	18	10	18	40	It is confusing to have freshening in different units for the Arctic (km ³ yr ⁻¹) and the Antarctic (yr ⁻¹) [Abram Nerilie, Australia]	Taken into account; we have unified units insofar as possible, noting that it is not possible in all cases depending on information provided in the source papers
33243	3	18	10	18	40	No mention is made regarding freshening from increasing land ice (either as solid discharge (icebergs), or subglacial runoff, or as sub-ice shelf melting). [Government of United States of America, United States of America]	Taken into account; we now mention these processes, and reference the relevant sections where quantifications of them reside
18895	3	18	13	18	14	E1a - Move "(medium confidence)" to end of sentence. [APECS Group Review, Germany]	Accepted - text revised.
15549	3	18	14	18	14	It was not possible to trace back all the provided numbers in Carmack et al. (2016) and some are given with incorrect units. The quoted numbers of Gardner et al. Carmack et al. have summed up the Mass budget numbers (provided in Gt/Yr) from Table 1 in Gardner et al. e.g. Canada north & south (-33 + -27= -60 Gt/yr), Iceland (10 Gt/yr) & Russian Arctic (11 Gt/yr) are also given the table. However, it is not clear at all how Carmack et al then end up with this 226 km ³ /yr number that they provide. Also it seems like they confuse the units Gt/y and km ³ /yr. The numbers from Bamber for Greenland seem correctly quoted, but it was not possible to find the figure 1291 +- 50 km ³ /yr in Enderlin et al. Also these numbers are estimates for complete Greenland and not just for the regions draining towards the Arctic basin. [EUCE, Belgium]	Noted - it's unclear what the reviewer is referring to here. We have reviewed the text and ensured the units quoted are correct.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
16909	3	18	14	18	14	I was not able to trace back all the provided numbers in Carmark et al. (2016) and some are given with incorrect units. The quoted numbers of Gardner et al. Carmack et al. have summed up the Mass budget numbers (provided in Gt/Yr) from Table 1 in Gardner et al. e.g. Canada north & south (-33 + -27= -60 Gt/yr), Iceland (10 Gt/yr) & Russian Arctic (11 Gt/yr) are also given the table. But it is not clear at all how Carmack et al then end up with this 226 km3/yr number that they provide. Also it seems like they confuse the units Gt/y and km3/yr. The numbers from Bamber for Greenland seem correctly quoted, but I could not find the number 1291 +- 50 km3/yr in Enderlin et al. Also these numbers are estimates for complete Greenland and not just for the regions draining towards the Arctic basin. [Louise Sandberg Soerensen, Denmark]	See response to 15549
3863	3	18	17	0		For the freshwater accumulation over the Arctic, freshwater water transport associated with sea ice needs to be examined, [Zhaomin Wang, China]	Noted - sea ice is discussed in another section.
3865	3	18	17	0		rather than just 'related to sea ice melt'. [Zhaomin Wang, China]	Noted - sea ice is discussed in another section.
1855	3	18	23	18	23	Lind et al 2018: The freshwater content in the upper 100 m declined (-32%) over the northern Barents Sea (2010-2016 mean compared to 1970-1999) [Solfrid Sætre Hjøllø, Norway]	Accepted - we have added this.
18891	3	18	28	18	28	"in mode and intermediate waters" is difficult to understand. Explain what it is somewhere? [APECS Group Review, Germany]	Accepted: Slight rewording to clarify what these water masses are
18897	3	18	28	18	28	E1a - is the trend a fraction? Could benefit from stating this clearly or need additional units if not. [APECS Group Review, Germany]	Rejected: It is unknown what this query refers to, but we believe the reviewer is confused by the units here. Salinity does not have a unit (being a mass ratio) and so trends in salinity will simply include a time component. As here (y-1). This is standard convention.
22471	3	18	31	18	31	Suggest clarification on the statement "This trend intensifies over Antarctic shelves..." . Does it refer to the continental shelves (in which case it should state this) or under the Antarctic ice shelves? [Government of Australia, Australia]	Accepted: Text revised to make it clear that it is referring to continental shelves.
9067	3	18	32	0		Insert 'of' before 'up' [Nina Hunter, South Africa]	Accepted
2787	3	18	32	18	40	Changes in P-E, which are very large over the Southern Ocean, should be mentioned. e.g. Pauling et al. 2016: Pauling, A.G., C.M. Bitz, I.J. Smith, and P.J. Langhorne, 2016: The Response of the Southern Ocean and Antarctic Sea Ice to Freshwater from Ice Shelves in an Earth System Model. J. Climate, 29, 1655–1672, https://doi.org/10.1175/JCLI-D-15-0501.1 [Neil Swart, Canada]	Taken into account: Text has been changed to note the influence of E-P. While climate models do indicate that this has increased, observational records are too sparse and uncertain to ascribe such a change with confidence. The text now reflects this, with appropriate references, including Pauling et al., 2016.
11859	3	18	34	18	34	There is a typo here: It is an increase of 20±10 % and not 20±10 Sv (it would be high ! :). [Jean baptiste SALLEE, France]	Accepted and altered
9069	3	18	40	0		Should 'see section 3.3.3' not be in brackets? [Nina Hunter, South Africa]	Editorial - copyedit to be completed prior to publication

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
33245	3	18	42	19	4	It worth mentioning somewhere the finding by Rippeth et al. (2015) that tide-generated turbulent mixing can locally be large enough to bring significant amounts of heat upward to the surface layer of the Arctic Ocean. The enhanced dissipation can be more than 50 W m ⁻² , compared with the generally weak vertical heat flux within the Arctic Basin of 0.05-0.3 W m ⁻² . But not sure in which subsection it should be. In the Temperature (3.2.1.2.1), or Stratification (3.2.1.2.3), or Ocean Circulation (3.2.1.3). (Reference: Rippeth TP, Lincoln BJ, Lenn Y-D, Green JAM, Sundfjord A, Bacon S. Tide-mediated warming of Arctic halocline by Atlantic heat fluxes over rough topography. Nat Geosci. 2015, 8(3):191-194. doi:10.1038/ngeo2350.) [Government of United States of America, United States of America]	Rejected - space considerations preclude detailed discussions of each of the different mechanisms responsible for such fluxes.
29663	3	18	43	18	56	It would really help readers to give an indication of how thick these various layers are in terms of meters, etc. Where is the "base of the surface mixed layer?" What dept is a "mixed layer shoaling" and "mixed layer deepening" and so on. This is all of interest to more than the most involved experts on the topics. And the comment could be applied to even more text--try to avoid the jargon and give a sense to those not as expert. [Michael MacCracken, United States of America]	Accepted - we have added an introductory statement on mixed-layer depths.
18893	3	18	44	18	44	Give some examples to what "climatically-important properties" could be? A bit vague formulation. [APECS Group Review, Germany]	Accepted - text revised.
32443	3	18	45	18	46	I would include the following: "... in determining nutrient availability and thus, the rates and distributions of marine primary production". [Pedro J. Llanillo, Chile]	Accepted - text revised not exactly as suggested as "nutrients" has been added earlier in the sentence.
34223	3	18	51	18	55	Worth also citing Korhonen et al. (reference given at end of comment), who analysed over a decade of T/S profile data in the Arctic Basin. Time and space variability of freshwater content, heat content and seasonal ice melt in the Arctic Ocean from 1991 to 2011, M. Korhonen, B. Rudels, M. Marnela, A. Wisotzki, and J. Zhao, Ocean Sci., 9, 1015-1055, https://doi.org/10.5194/os-9-1015-2013 , 2013 [Benjamin Rabe, Germany]	Rejected - this paper refers to conditions described in AR5.
3069	3	18	52	18	57	What are the confidence levels associated with mechanisms of stratification changes? [Helene Hewitt, United Kingdom (of Great Britain and Northern Ireland)]	Noted - this is not straight forward as they are highly dependent on season and region, as well as the availability of concurrent measurements of the sea-ice/ocean/atmosphere system.
1663	3	19	2	19	4	It might be useful to provide more background and state what the current stratification is in the Southern Ocean, and what role it plays in ocean circulation [Nora Richter, United States of America]	Rejected - space constraints prevent us from spending much space on background where no significant changes have occurred since AR5. However the cross chapter Box 5 does give some background on the overturning circulation which is intimately connected with stratification.
1665	3	19	6	19	39	There is no mention of seasonal-to-decadal variability in the Arctic. Does this not play a role? Could this play a role in the future with melting sea ice? [Nora Richter, United States of America]	Taken into account Seasonal-to-decadal variability is important, sparse information covering seasonal-to-decadal variability in the Arctic was reported during a review period. A sentence was added to make the point.
27265	3	19	6	19	57	Suggestion- Include some regional data concerning antarctic Coastal waters and carbon distribution - Cunha etal. 2018- discuss the organic carbon distribution in Gerlache Strait.- Deep-Sea Research Part II 149 (2018) 206–217 [Gleyci Moser, Brazil]	Reject; space limitations restrict us including all information at such local scales

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
18901	3	19	7	19	7	C3 - Consider a sentence at the beginning of this section/paragraph stating why carbon and ocean acidification is significant, important and relevant. [APECS Group Review, Germany]	Taken into account The order of the sentences was changed in the first paragraph to address the reviewer's comment.
33247	3	19	9	19	10	"... which upon dissociation, causes a decrease in pH (acidification) and also [A DECREASE IN?] the carbonate ion concentration." [as written, the "decrease" in carbonate is not explicit if that is what is meant] [Government of United States of America, United States of America]	Accepted text was revised
29665	3	19	15	19	15	Fine to give the change, but one can't tell if 100 m is significant or not without having at least an indication of what the average dept was where this occurred--at 100, 500, or 1000 meters or what? [Michael MacCracken, United States of America]	Rejected. The 100m in desirable habitat loss is important for organisms living in the layer regardless of the depth of the water.
19581	3	19	19	19	21	You should provide a reference for this statement. [APECS Group Review, Germany]	Taken into account The sentence was moved so that the reference appears closely.
25775	3	19	19	19	21	Despite regional and seasonal variability, riverine bicarbonate fluxes can also act to buffer pH of the coastal Arctic ocean (Tank et al. 2012). Briefly considering these effects could enrich the discussion here. Tank, S. E., Raymond, P. A., Striegl, R. G., McClelland, J. W., Holmes, R. M., Fiske, G. J., & Peterson, B. J. (2012). A land-to-ocean perspective on the magnitude, source and implication of DIC flux from major Arctic rivers to the Arctic Ocean. <i>Global Biogeochemical Cycles</i> , 26(4), 1–15. https://doi.org/10.1029/2011GB004192 [Scott Zolkos, United States of America]	Accepted Since the referred work was reported outside the review period, a more recent work was also added.
11897	3	19	23	19	39	It is an important issue how CO2 concentrations in the Arctic surface water may change in response to sea ice melt. The estimates the production of organic carbon using conservative tracers, such as $\delta^{18}O$ and salinity has been conducted in the regions of the Arctic Ocean. More information is needed here. [Jun Sun, China]	Noted O-18 and salinity relationship to elucidate the freshwater sources was used to identify sea-ice melt water in many of the listed studies, such as Robbins, Qi, Azetsu-Scott, Yamamoto-Kawai.
18903	3	19	33	19	34	E1a - Difficult to follow this sentence, consider restructuring. [APECS Group Review, Germany]	Accepted; sentence revised
9071	3	19	34	0		Remove 'including' before 'via' [Nina Hunter, South Africa]	Accepted; revised as suggested
30909	3	19	35	19	35	"Ikaite" might not be so well known, so I suggest to provide a brief explanation what it is. [Hans-Otto Poertner and WGII TSU, Germany]	Accepted; brief explanation included
9073	3	19	41	0		Insert 'the' before 'understanding' [Nina Hunter, South Africa]	Accepted
30341	3	19	41	19	45	The verb in this long and complex sentence tends to get lost. Would it be possible to simplify or break up this long sentence? [Paul Glaser, United States of America]	Accepted; have clarified the verb tense
26379	3	19	41	20	4	The discussion of Southern Ocean ingassing and outgassing should reference Gray et al. (2018) for an updated estimate (esp. with regard to seasonality of pCO2 flux). [Ethan Pierce, United States of America]	Accepted; Gray et al., 2018 already cited separately, but again now here
9075	3	19	45	0		into' instead of 'to' after 'insight' [Nina Hunter, South Africa]	Accepted; done
2789	3	19	45	19	46	I find the "model based" wording here problematic, because it is unclear. Le Quere et al. 2007 was primarily based on atmospheric inversions, which used all the data available at the time. [Neil Swart, Canada]	Accepted; clarified that this is inversion-based model

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
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9077	3	19	48	0		Remove full-stop after '2017' [Nina Hunter, South Africa]	Editorial - copyedit to be completed prior to publication
18899	3	19	52	19	52	Is it possible to use another word instead of "ingassing". It is difficult to understand and the word is also not mentioned in the reference (Conrad and Lovenduski, 2015). [APECS Group Review, Germany]	Accepted; term changed
25279	3	19	56	19	57	It is misleading to say that "changes in the buffering capacity" is "an additional driver that has emerged from increasing atmospheric CO2 fluxes". We have known about about the effect of anthropogenic CO2 uptake on the buffer factor since the 1950s, and it has been taken into account, very precisely, in global ocean models since the 1990s (e.g., Sarmiento et al, 1992). [James Orr, France]	Taken into account. What was meant here is that its effect has emerged - not that our knowledge of it has emerged - have clarified it
19583	3	20	2	20	4	This is confusing: what is finally the confidence in decadal modes? I think you need to rephrase this sentence. [APECS Group Review, Germany]	Accepted; have removed the confidence on the mechanisms
9079	3	20	8	0		of' not 'on' [Nina Hunter, South Africa]	Accepted
18907	3	20	11	20	11	C3 - Just need to make sure that the confidence level here is decided upon in due course. [APECS Group Review, Germany]	Taken into account; actioned
9081	3	20	15	0		Take out bracket after '2017' [Nina Hunter, South Africa]	Accepted
28535	3	20	15	0		30-100% of what? [Yvonne Firing, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account; removed 30-100% - focus is on the strengthening and weakening of the storage shown in Appendix 3A. Table 1. It shows in the explanation columns that two independent methods of assessing storage (DeVries2017 and Tanhua2017) show decadal variability in that range with natural and anthropogenic storage being out of phase
27197	3	20	17	20	17	Again, quantitative detail is lacking making the text vague here. How big are the meridional shifts in wind stress? [Sion Josey, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account; Uncertainties in the choice of re-analysis as well as model eddy parameterization make it difficult to quantify this - particularly the decadal variability (Swart et al., 2014;2015a). However, in the text we have added a constraint from Swart et al., 2015 and slightly edited the sentence to say that that the meridionally separated SAMW and AAIW, which largely drive carbon storage, point to a sensitivity of C-storage to shifts in the mid-latitude jet.
31149	3	20	23	0	28	Such quantitative information on ocean acidification and impacts seems relevant for the ES. [Hans-Otto Poertner and WGII TSU, Germany]	Accepted; we have strengthened the ES material on OA and impacts
18905	3	20	26	20	26	The word "invigoration" is hard to understand, change or remove? [APECS Group Review, Germany]	Reject; the term is quite common
19585	3	20	30	20	30	As you only assess Arctic Ocean circulation in this sub-section, I would rename it '3.2.1.3 Arctic Ocean circulation'. [APECS Group Review, Germany]	Rejected - the section includes a pointer to the Cross-Chapter Box on Southern Ocean circulation, so the more open title helps the reader navigate.
30911	3	20	35	20	35	Please specify to which section in Chapter 6 you refer here. [Hans-Otto Poertner and WGII TSU, Germany]	Accepted
30913	3	20	36	20	36	«operation» of marine ecosystem sounds weird. Suggest «functioning» [Hans-Otto Poertner and WGII TSU, Germany]	Accepted - text changed.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
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2791	3	20	39	20	44	Short term trends like this need to be put in the context of internal variability. [Neil Swart, Canada]	Rejected - it's unclear what is meant by internal variability. The largest-scale geostrophic circulation of the Beaufort Gyre is described here; it would not be appropriate to compare this to (for example) eddies or waves.
19587	3	20	40	20	41	I would provide the numbers in terms of volume transports to support your statement related to the strengthening of the Beaufort Gyre and Fram Strait southward flow. [APECS Group Review, Germany]	Rejected - it's not possible to convert the geostrophic flow to volume transport since we cannot quantify the barotropic transport; further, any relationship between the Beaufort Gyre freshwater export and Fram Strait flow involves the ageostrophic component of the flow - a much more difficult estimate.
33249	3	20	41	20	41	Add "accordingly (Zhong et al., 2018)," after "doubled". (Referece: Zhong W, Steele M, Zhang J, Zhao J. Greater Role of Geostrophic Currents in Ekman Dynamics in the Western Arctic Ocean as a Mechanism for Beaufort Gyre Stabilization. J Geophys Res Ocean. 2018, 123(1):149-165. doi:10.1002/2017JC013282.) [Government of United States of America, United States of America]	Noted - this model paper uses the original dynamic ocean topography from Armitage et al. (2017) which has been cited already.
9083	3	20	46	0		It would be useful if 'mesoscale eddies' could be defined [Nina Hunter, South Africa]	Accepted - text revised.
18911	3	21	3	21	4	C3 - Is this confidence level based upon Armitage 2017? If so, would be clearer to have confidence stated nearer reference. [APECS Group Review, Germany]	Accepted - text revised.
31151	3	21	10	0		A large fraction of this CC Box holds elements of review that are quite distant from an assessment of climate change and impacts. There are other sections of chapter where this applies. [Hans-Otto Poertner and WGII TSU, Germany]	Accepted; we have worked to bring out more clearly the assessment aspects of the XCB, including in the figure
22473	3	21	10	25	3	This Boxed section is nicely written. However, we suggest including a statement on the Antarctic Coastal Current. [Government of Australia, Australia]	Noted, with thanks for the positive words. Unfortunately, with finite space, not all aspects of Southern Ocean circulation can be covered in the XCB.
19589	3	21	12	21	13	I suggest to remove the names of the authors of this cross-chapter box and make sure that these names rather appear in the beginning of the chapter. Otherwise, you need to also specify the author names for the different specific sub-sections of the report. [APECS Group Review, Germany]	Editorial. Guidance from IPCC Technical Support Unit was followed in this regard
19591	3	21	15	21	15	Remove 'disproportionately' as it does not make sense. What is the reference of an 'important ocean'? The Arctic Ocean is also very important. [APECS Group Review, Germany]	Rejected: Disproportionately is appropriate to use here. As stated in the text below this line, and in the remainder of the cross-chapter Box, the SO takes up a much greater fraction of the global ocean heat and carbon than its proportionate size would suggest. Additionally it is the only point in the global ocean where the three main basins can easily communicate with one another.
18913	3	21	17	21	17	E1a - Remove "relatively", as no comparison of what relative to. [APECS Group Review, Germany]	Accepted and edited
19593	3	21	17	21	17	Remove 'relatively'. Relative to what? [APECS Group Review, Germany]	See response to 18913
28519	3	21	18	21	21	These two sentences misleadingly suggest that the "sinuous, braided jets" are invariant in time, and all time variability is in eddies (and not in the Reynolds averaging sense; "features known as eddies" suggests closed circulations). [Yvonne Firing, United Kingdom (of Great Britain and Northern Ireland)]	Accepted: The sentence has been revised to reflect the temporally varying nature of the fronts, beyond just the presence of mesoscale eddies.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
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3411	3	21	21	21	25	Split into two or more sentences - separate the multiple factors driving the ACC. [Patrick Orenstein, United States of America]	Accepted: The factors driving the ACC are now in a separate sentence from the discussion of the geostrophic balance. Space constraints prevent a greater expansion on the complex relationship between wind and buoyancy forcing of the ACC.
29667	3	21	22	21	22	It sounds very strange to say "approximately 173.3 plus/minus 8.7 times 10**6" and then be using four significant figures is just not scientifically sound presentation of information unless the variability is really, really small (and this is unlikely to be the case). What would seem appropriate would be "approximately 170 million ..." . Or, you could say something like "observations averaged over ten years indicate that the ACC carries 173.3" but how it is now is just not appropriate. [Michael MacCracken, United States of America]	Rejected: The value given here (erroneously, the error should be 10.7 Sv, see comment 33251) does not reflect the variability of the current, rather the uncertainty in the measured mean, including error variance contributions from various sources (Donohue et al., 2016 section 5)
33251	3	21	22	21	22	Donohue et al 2016 gives "173.3 ± 10.7 Sv" as a final estimate of ACC transport (see their Section 6). If the "± 8.7" currently included is not a typo, justify that value. [Government of United States of America, United States of America]	Accepted: Value adjusted.
18909	3	21	22	21	24	173.3 +/- 8.7 x 10^6 m^3 s^-1 of water? The first half of the sentence is confusing: is the geostrophic balance in respect to the Antarctic waters alone, or between that and the subtropical gyres north of the ACC? [APECS Group Review, Germany]	Accepted: 'of water' added to make it clear that an ocean current transports water. The wording around the geostrophic balance has also been revised to show that it is between the waters south and north of the ACC.
3413	3	21	29	21	32	Split into multiple sentences [Patrick Orenstein, United States of America]	Accepted
28521	3	21	39	0		Instead of unused (ever?) do you perhaps mean available, excess, residual? [Yvonne Firing, United Kingdom (of Great Britain and Northern Ireland)]	Accepted: Sentence revised to remove the inappropriate 'unused'.
31027	3	21	39	21	39	rather than used specify brings nutrients from deeper layers to surface waters [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account: See comment 28521
31029	3	21	45	21	45	do you mean the antarctic marine ecosystem or the ecosystem of the ACC? [Hans-Otto Poertner and WGII TSU, Germany]	Accepted: Changed to polar and subpolar.
33253	3	21	45	21	47	Rephrase and split into two sentences to increase readability -- e.g., specify "by determining habitat ranges, and controlling connectivity across a range of spatial scales. The strong meridional..." [Government of United States of America, United States of America]	Accepted and edited
21339	3	21	46	21	47	The statement on invasive species is surprising. At the minimum the qualification should be 'marine invasive species.', but the data and analyses are so sparse that there should be a low confidence statement here. [Steven Chown, Australia]	Taken into account; we have included the word "marine" however it is not the intention to conduct the assessment at this location, but rather in the section referenced. This sentence is designed to point the reader interested in such issues to that section.
31031	3	21	47	21	47	Specify how, does this reduce or increase vulnerability? What is the confidence level? [Hans-Otto Poertner and WGII TSU, Germany]	see response to 21339
22223	3	22	0	22		Figure CB5.1: Beautiful figure. Well done! [Sergio Henrique Faria, Spain]	Noted, with thanks

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
23131	3	22	0	22		Missing level of confidence or level of scientific understanding in figure. Does not convey any conclusion of assessment, more inspired by a text book approach than to provide outcomes of the assessment. It is not Ok if the key messages about climate change are in the caption and not visible (e.g. have increased and contracted poleward). [Valerie Masson-Delmotte, France]	Accepted; the figure has been revised to draw out the assessment results more clearly
23139	3	22	0	22		Why is this figure needed for this report? What are the climate change specificities and outcomes of an assessment in terms of relative importance, feedbacks, impacts etc? [Valerie Masson-Delmotte, France]	Accepted; the figure has been revised to draw out the assessment results more clearly
694	3	22	1	22	1	The changes in pH, carbonate undersaturation, primary productivity and CO2 uptake can be added to this schematic if possible. [Mengxi Wu, United States of America]	Rejected; the figure already contains a good amount of information, and this would overload it
19617	3	22	1	22	14	I would make the warming of surface waters (4) with a much darker color (dark red). [APECS Group Review, Germany]	Accepted; the figure has been revised
30917	3	22	1	22	14	For traceability it would be useful to indicate in the caption where exactly in Chapter 3 and 5 the shown changes are discussed. [Hans-Otto Poertner and WGII TSU, Germany]	Accepted; the relevant sections are now included on the figure text
26381	3	22	1	22	3	This schematic is very useful context for the previous section. Consider moving it to an earlier point in the chapter. [Ethan Pierce, United States of America]	Taken into account; the XCB will be positioned optimally once the report is finalised
25987	3	22	3	22	14	As Figre 3.1. and 3.2 (see previous comments) the figure is not very effective. Put information in caption into the figure (as e.g. nicely done in Fig. 3.5.) [Regine Hock, United States of America]	Accepted; assessment detail now included in the figure directly
572	3	22	3	22	29	1-2 labels for numbers. What do the colors indicate? [Jenna Pearson, United States of America]	Taken into account; the figure has been substantially revised
16297	3	22	3	22	3	As for the other schematics, please consider including the numbered bullets in the graphic itself. It would then also be easier to use the graphic stand-alone post approval. [Alexander Nauels, Germany]	Accepted; this has been done
9085	3	22	5	22	14	Suggest full stops at end of each sentence. [Nina Hunter, South Africa]	Editorial - the chapter will be copyedited before publication
5017	3	22	6	22	11	Drop the following acronyms: "AAIW", "SAMW", "AABW" and "CDW" as they are not used anywhere else in this chapter. [Debra Roberts and Durban Team, South Africa]	Accepted; acronyms dropped
19619	3	22	6	22	6	You forgot to specify what is the associated change in horizontal circumpolar flow (2), i.e. no significant change. Even if not significant, I think you should mention it. [APECS Group Review, Germany]	Accepted; now included
3867	3	22	8	0		warming occurred at much lower latitudes (see Fig. 3.3c) than as indicated in this figure [Zhaomin Wang, China]	Accepted; figure altered
33255	3	22	8	22	8	"toward" is unnecessarily vague. Replace with "in northern part" or "on the northern side". [Government of United States of America, United States of America]	Accepted; text altered

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
11861	3	22	14	22	14	I have an issue with this schematic. I find that some aspects are not entirely supported by the text. First it should be clarified in the caption whether the changes that are represented are historical change or predicted future changes. It seems that it is historical change based on eddy field comment "in recent decades". But then I am confused by the strengthening of the upper cell, where the text assessed that upper cell has been subject to decadal variability. That should be clarified. I am also confused by the "reduction in export of deep and abyssal waters in the lower cell", while it is not assessed in the text. Instead the text assesses a reduction in volume. I understand the authors, but I would suggest to be consistent between the text and the schematics to avoid any confusion. If publication exists supporting reduction in the export of AABW, then assess it in the text after commenting on the reudction of volume. If not, represent the reduction of volume of AABW rather than the slowing of the lower cell. [Jean baptiste SALLEE, France]	Accepted; the points raised are all germane, and the text and figure have been modified to address them.
692	3	22	17	22	18	This increase in westerly winds needs references, e.g., AR5. [Mengxi Wu, United States of America]	Accepted: Swart et al., 2015 reference added
11277	3	22	17	22	20	The Donohue et al paper gives a more detailed discussion on changes estimates than reflected here. It contains an update with a 30% increase. This matches older estimates if the same revised Barotropic transport estimate is used. So, the conclusion is then the total transport has not changed assuming the barotropic transport has not changed. However, we don't know whether the barotropic transport has not changed in response to changing winds. I have discussed this with Bryden and Firing and they also do not agree with the statement that the ACC transport has not changed. We agree with the idea that eddy saturation, partially, or even for the largest part, offsetting the response to increased winds but claiming that the compensation is 100% cannot be supported. Please revise the text. [Sybren Drijfhout, Netherlands]	Accepted: The text has been revised to reflect the uncertainty in trends in the barotropic component of the ACC transport. We accept that while eddy saturation appears to strongly compensate for increases in momentum forcing, it need not not 100% efficient. The key change is to move from medium confidence in insensitivity of the ACC, to medium confidence in only weak sensitivity to changes in winds.
15551	3	22	18	22	20	It is not clear if the 'medium confidence' refers to the fact that the wind stress changes has altered the ACC transport or the fact that the annual mean value has menained stable. [EUCE, Belgium]	Taken into account: See comment 11277 and revised text clarifying wording pertaining to the confidence.
16883	3	22	18	22	20	It is not clear if the 'medium confidence' is refres to the fact that the wind stress changes has altered the ACC transport or the fact that the annual mean value has menained stable. [Louise Sandberg Soerensen, Denmark]	Taken into account: See comment 11277 and revised text clarifying wording pertaining to the confidence.
11863	3	22	18	22	23	The authors states that the ACC strenght has been remarkably stable with medium confidence and that the ACC is insensitive to wind. I would reconsider these statements. Donohue present a much higher estimates that previous authors. We agree that the revised estimate is due to methodological/observation progress rather than change. But given this recent change it is difficult to say with "medium confidence" that the ACC is stable and insensitive to winds. Even Donohue do not rule out increase in their discussions. But limited increase if at all. Theoretical work also suggest a weak sensitivity rather than no sensitivity. I would propose to replace insentivity by weak sensitivity, which I beleive reflect better our current status of knowledge. [Jean baptiste SALLEE, France]	Accepted: Medium confidence in insensitivity has been replaced with medium confidence in only weak sensitivity. See comment 11277 and rewording of section to further reflect this change.
3415	3	22	19	22	19	Odd use of "remarkably" - consistent with Medium Confidence? [Patrick Orenstein, United States of America]	Taken into account: See comment 11277 and revised text clarifying wording pertaining to the confidence.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
33257	3	22	21	22	25	Eddy saturation is noted here; should eddy compensation also be noted? Call this out explicitly, since this issue is not yet fully resolved (certainly not resolved to the point of not needing a reference for sentences like this one). [Government of United States of America, United States of America]	Rejected: Eddy compensation refers to the role of eddies in the vertical/meridional overturning circulation, while this section of text is discussing only zonal ACC transport. Eddy saturation and eddy compensation are indeed intimately linked, but we feel to introduce eddy compensation here in a context where it is not directly relevant risks increasing reader confusion.
11279	3	23	4	23	11	If the increase in inferred overturning between 1990-2000 is likely due to a decadal modulation, then why giving lowing confidence in assessing an acceleration? Why not saying it is impossible to determine whether there has been an acceleration? [Sybren Drijfhout, Netherlands]	Accepted: The weak nature of the evidence, as well as suggestions of aliasing by decadal variability, means we cannot realistically state there has been a change in overturning. Text has been altered accordingly
30915	3	23	4	23	11	When you state that something was incorrectly reported in a previous IPCC report (in this case the slowing of the upper cell of the overturning circulation) you should have convincing evidence. Here, two studies suggesting an increase in overturning based on indirect evidence are given as proof that AR5 was wrong, but then in the next sentences it is concluded that there is low confidence in this increase due to significant variability in overturning and methodology of the estimates. This is, as it is currently written, not very convincing. I suggest revision of this paragraph. Apart from that, please clearly say in which chapter & Working Group report of AR5 this incorrect assessment has been done. [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account: AR5 made their assessment in Chapter 3 (3.6.4) based on one paper (Vaughn et al., 2013). However, they misinterpreted this paper. The paper argues for an increase in the overturning circulation, while AR5 interpreted it (incorrectly) as arguing for a decrease. Clarification of inaccurate reporting, rather than changes in scientific evidence has been added to the text.
18915	3	23	4	23	5	C3 - Where are the confidence level and supporting literature for this statement? [APECS Group Review, Germany]	Taken into account: See comment 30915
31033	3	23	5	23	5	Please be careful with phrasing here, do you mean the authors misread and reported the information incorrectly or the authors reported the current state of knowledge at the time which has subsequently been modified as new information emerges? [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account: See comment 30915 (but yes, we mean the former).
11865	3	23	15	23	15	Figure 5.3 do not support the statement "this reduction in volume has continued in recent years". If the authors leaves this statement it should be supported by a reference or another figure. [Jean baptiste SALLEE, France]	Taken into account; Figure 5.3 (now renumbered 5.4) contains data updated to 2018, hence the reduction in volume remains apparent even up to present day. We have clarified the writing to remove ambiguity.
31035	3	23	23	23	23	Give examples of species [Hans-Otto Poertner and WGII TSU, Germany]	Accepted: 'King penguins' added.
29183	3	23	29	23	30	The statement "large-scale trends in sea surface height due to steric change" needs a reference. In addition, what is meant by 'steric change' in this context? A shift of a baroclinic front is a steric change. Does steric change here mean a response to surface fluxes (i.e. warming)? Is there a study that shows that the spatial distribution and magnitude of the sea surface height variations (ie trend and variability) in the Southern Ocean can be explained by steric changes driven by warming or freshening alone? (there are some big SSH decadal trends in the SO, implying changes in water properties over a substantial depth range). If due to another factor (e.g. increased eddy flux), does the spatial pattern and magnitude explain the SSH variability? Perhaps some discussion of trends/change in SSH would be appropriate in this chapter, given that it provides the longest circumpolar record of SO change that we have. [Stephen Rintoul, Australia]	Accepted: Text modified to include a reference and clarify the use of the word steric. Additionally the uncertainty in attribution of warming driven expansion (eg an increase in eddy transport, surface heat flux etc) is explicitly acknowledged.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
27199	3	23	30	23	32	The authors find that it is unlikely there has been a statistically significant southward movement of the ACC position. A likelihood statement is also needed for whether there has been a statistically significant southward movemnet of the circumpolar winds. The authors imply this is the case earlier in the text but the paper by Swart et al., 2015 cited in the report finds insignificant trends in the annual mean wind position across all atmospheric reanalyses considered. So, can the authors please clearly state that there is no observational evidence for a significant southward shift in the annual mean wind position? Swart, N. C., J. C. Fyfe, N. Gillett and G. J. Marshall, 2015: Comparing Trends in the Southern Annular Mode and Surface Westerly Jet. Journal of Climate, 28 (22), 8840-8859, doi:10.1175/JCLI-D-14-00716.s1. [Sion Josey, United Kingdom (of Great Britain and Northern Ireland)]	Accepted: Text modified with the sentence: While wind speeds do increase over the Southern Ocean, reanalysis products show no shift in the annual mean latitude of zonal wind jets between 1979-2009 (Swart et al., 2015)
9087	3	23	36	0		Remove 'of' [Nina Hunter, South Africa]	Accepted
19595	3	23	36	23	36	Precise that this is 'sea ice' to avoid confusion with continental ice. [APECS Group Review, Germany]	Accepted: Additionally explicit reference to ice sheet and shelf melt is now added to the following paragraph.
33259	3	23	37	23	41	Additional references are needed here. [Government of United States of America, United States of America]	Accepted: References added to Morrison and Hogg 2013, Munday et al., 2013 and Abernathy et al.. 2015.
33261	3	23	40	23	40	Specify which aspects of the flow are included in this statement -- e.g., "ACC transport and position will remain..." [Government of United States of America, United States of America]	Accepted and actioned
11281	3	23	40	23	41	See my comment above (page 22) on the "stability" of the ACC transport. [Sybren Drijfhout, Netherlands]	Accepted: Text revised to read '...and likely that the mean position and strength of the ACC flow will remain only weakly sensitive to winds.'
11867	3	23	40	23	41	Consistent with my comment above, I would rephrase "that the mean ACC flow will remain insensitive to wind" to something more along the lines that the ACC increase will be weak. [Jean baptiste SALLEE, France]	Taken into account: See response to comment 11281
29189	3	23	43	23	43	While I'd agree that the spread and biases of CMIP5 models mean that there is little that can be said about future circulation changes in the Southern Ocean from models. However, the work of Armour et al, Morrison et al and others, provide some dynamical insight into what we might expect in the future (as an example, see Rintoul, Nature, 2018). [Stephen Rintoul, Australia]	Taken into account: See response to comment 33259. This paragraph deals with the model based projections, improvements in our dynamical understanding of what is likely to happen are now cited in the previous paragraph.
3071	3	23	43	23	54	Is it worth commenting on why the Southern Ocean is poorly represented in climate models? Bottom water formation processes, atmospheric forcing errors (see for example Hyder et al., Nature comms, 2018 on the atmosphere model errors) [Helene Hewitt, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account; space precludes such discussion here, but it is factored into later text alluded to gaps and uncertainties, albeit in more generalist form.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
11869	3	23	44	23	46	If I am not mistaken Russel et al., 2018 do not have projected changes in their paper. Therefore the sentence has no ground on published literature: "projected changes are strongly correlated with model biases". There are a few variables where we found that in the "BAS SO CMIP5 series" : Meijers et al. 2012; Bracegirdle et al., 2013; Sallée et al., 2013a, b. But that was not a general result I believe, so I do not know papers that would support such sentence. [Jean baptiste SALLEE, France]	Accepted: Text has been revised to read "Some of the differences in projected changes have been found to be are strongly correlated with biases in the various models' ability to simulate the historical state of the Southern Ocean (e.g mixed layer depth, (Sallee et al., 2013), wind jet latitude (Bracegirdle et al., 2013)). This suggests that bias reduction against observed historical metrics (Russell et al., 2018) in future generations of coupled models (e.g., CMIP6) should lead to improved confidence in some aspects of projected changes in the Southern Ocean.
11871	3	23	48	23	49	Is that an increase of the upper cell? If so, it would be clearer to say it, and maybe support the message by our finding in Sallée et al., 2013 on SO water masses circulation. [Jean baptiste SALLEE, France]	Accepted: Text has been revised to read: CMIP5 models suggest that the subduction of mode and intermediate water will increase (Sallee et al., 2013) and the overall transport of the Southern Ocean upper overturning cell will increase by up to 20% in future (Downes and Hogg, 2013), but model performance is limited by the representation of eddy processes (Gent, 2016; Downes et al., 2018)
29669	3	23	49	23	49	The word "may" is not in the IPCC lexicon and can mean anything. It is generally agreed that words like may, might could, etc. need to be avoided and taking the leap into the IPCC lexicon (and the whole chapter should be scrubbed for such words and replace them). [Michael MacCracken, United States of America]	Accepted: May removed.
33263	3	23	52	23	54	Should it be noted that some of these issues are related to insufficient resolution to appropriately resolve the eddies, e.g., the Rossby Radius of deformation? [Government of United States of America, United States of America]	Accepted: Text revised to read : '...but model performance is limited by the inability to explicitly resolve eddy processes (Gent, 2016; Downes et al., 2018). '
31037	3	23	53	23	54	Could you conclude with a sentence of the implications for climate change processes [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account; a single statement of this sort is not possible, since the subject is broad and pervasive; the intention of the XCB is to centralise material that both Chapters 3 and 5 can draw upon to build separate (but complementary) statements. We cite those chapters for this information.
19597	3	24	1	25	4	It is a bit strange to have references at the end of the section. I suggest to put all references at the end of the chapter. [APECS Group Review, Germany]	Rejected; this was following IPCC TSU guidance.
33265	3	24	60	24	60	Incorrect DOI. The relevant DOI for Waugh 2014 is doi:10.1098/rsta.2013.0269 [Government of United States of America, United States of America]	Editorial - copyedit to be completed prior to publication
2101	3	25	0	26		This should include a citation to Jahn et al. (2016) (for internal variability) [Alexandra Jahn, United States of America]	Reject; we presume this refers to sea ice aspects, which are covered separately, but it is not clear which paper is actually being alluded to.
33267	3	25	2	25	2	Incorrect DOI. The relevant DOI for Waugh et al 2013 is doi:10.1126/science.1225411 [Government of United States of America, United States of America]	Editorial - copyedit to be completed prior to publication

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
32367	3	25	9	26	4	With respect to Antarctic projections, there is discussion about the confidence in the projections. While there may be low confidence in the models at present, it is worth explaining why these models may have low confidence and the improvements expected in CMIP6. Given the low confidence, can it be presumed that the sea ice in the Antarctic might increase in perpetuity. I think there is high confidence that sea ice will decline in the Antarctic over the next century with consequent changes in the ocean. however the rate of decline is uncertain as well as the spatial variability in the rates of change. [Andrew Constable, Australia]	Taken into account: first paragraph on Antarctic projections revised for clarity. Updates on CMIP6 simulations will appear in AR6 Chapter 9. Expert judgement may point towards a decrease in Antarctic sea ice in the future, but further comments on projected decreases are speculative.
9509	3	25	11	25	11	Although it is defined in the Glossary, we suggest to introduce a definition of CMIP5 in this chapter. [Government of France, France]	Editorial - definition of CMIP5 already provided in the chapter
18929	3	25	11	25	12	Approximate? Or "reproduce well" or similar? [APECS Group Review, Germany]	Accepted: text revised
18917	3	25	11	25	15	The phrase indicates that SI thickness approximates observations, but then goes on to indicate that sea ice thickness patterns are not well simulated. This statement seems counterintuitive. Is it the mean thickness that approximates observations? If so, it might be useful to change the first reference of 'thickness' to 'volume' to improve clarity. [APECS Group Review, Germany]	Accepted: the point is that overall averaged ice thickness is captured by models, but not the spatial pattern. Wording clarified.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
29671	3	25	11	25	15	<p>First the sentence seems to say models are doing well and then it doesn't. Model simulations have been lagging what has been observationally--at the very least, the observations are at the very lower edge of what models have been suggesting. In response, modelers have seemed to simply insist they are properly representing the physics of sea ice, while observationalists suggest that the observed state is a good bit worse than is included in the data sets (e.g., ice is thinner and of poorer quality)--and so there has been quite a controversy. The other general character of an answer that no one involved seems to want to consider is that the forcings being given to the models might be incomplete even though this seems quite plausible. For example, might it be that sulfate pollution moving into the Arctic from the Atlantic since the mid-20th century when nations around the Atlantic went to tall stacks to widely disperse their SO2 emissions led to cloud brightening and then the sharp reductions of such emissions toward the end of the 20th century led to less emissions and less bright clouds, especially in the spring, allowing more solar radiation to reach the surface in spring, starting melting earlier and more strongly, and so setting the stage for faster loss of sea ice. This quite possible change in forcing on the sea ice has not really been included in the models, until perhaps very recently, because the issues of emissions heights of SO2 has been a hard issue to represent and yet is critical in determining sulfate lifetime, etc. Another possible forcing factor change might well also be changes in black carbon forcing into the Arctic, especially in the Pacific region given the growing emissions of black carbon from China and elsewhere. The text in the paragraph indicates some other options as well, though based on internal processes rather than external forcings. Some further clarification and explanation here could help bring together the quite different views of the modeling community, and also of the observational community represented by Peter Wadhams (and there seems to be no reference to his work), etc.--it just might be that both the model designers/physicists and the observationalists are right--and it is an insufficient, problematic representation of the forcing that is the problem--and then some effort and analysis could be put in to overall improvement of the situation (as is happening as the issues of ocean heat uptake are getting resolved through a thorough search for potential problems). In any case, this sentence and paragraph needs some work to be more helpful in pointing to a strategy to take that will ease the controversy. [Michael MacCracken, United States of America]</p>	<p>Taken into account: the text explains that CMIP5 models capture the general observed trend of reduced Arctic sea ice extent and thickness when multiple models are averaged across the entire Arctic. But when examined more closely, there are deficiencies with respect to spatial patterns, simulated ice motion, etc. We simply lack the space to provide additional scope. No suggested references provided.</p>
17617	3	25	11	25	20	<p>Timing of when the Arctic will be ice free should be noted and emphasized for its close proximity in the Summary for Policymakers. Loss of Arctic sea ice is estimated to occur within 15 years, according to Overland and Wang (2013) When will the summer Arctic be nearly sea ice free?, GEOPHYSICAL RESEARCH LETTERS 40:2097–2101, 2097 (“Time horizons for a nearly sea ice-free summer for these three approaches [for estimating future ice loss covered in the study] are roughly 2020 or earlier, 2030 ± 10 years, and 2040 or later.”). Also include the implications of increased climate forcing from reduced Arctic sea ice, which will be more extreme as less and less ice exists in the Arctic; see Pistone K., et al. (2014) Observational Determination of Albedo Decrease Caused by Vanishing Arctic Sea Ice, PROC. NAT'L. ACAD. SCI. 111(9):3322–3326. [Durwood Zaelke, United States of America]</p>	<p>Taken into account: Overland and Wang (2013) paper is cited in this section. For consistency with SR1.5, we adopted a probabilistic approach to estimates of ice free summers. Text on climate forcing, including the Pistone reference was added to Section 3.2.1.1.1.</p>

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
33269	3	25	11	25	20	See a new paper by Ding et al. 2018 in Nature Climate Change https://www.nature.com/articles/s41561-018-0256-8 . It shows that freely evolving models -- when forced by the increased greenhouse gases and with randomly occurring ensemble members that have similar-to-observed atmospheric circulation trends -- can reproduce the observed sea ice loss. This paper when combined with papers showing the large internal climate variability in Arctic sea ice trends (Kay et al. 2011; Swart et al. 2015 Nature Climate Change) is the end of the "Faster than forecast" (https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2007GL029703). It is also the end of the sea ice sensitivity arguments (e.g., Rosenblum and Eisenman paper cited here). Global mean temperature trends and Arctic sea ice trends are not controlled by the same factors on 30 year timescales. The Arctic sea ice trends have a huge contribution from internal atmospheric circulation variability within the Arctic. Global mean temperature trends are not affected by the Arctic circulation trends. [Government of United States of America, United States of America]	Accepted: new text added on the importance of internal variability, including references to Swart and Ding papers.
33271	3	25	13	25	13	Sea ice thickness distributions are well simulated by some models (e.g., CCSM4 Jahn et al. 2012; CESM1 Hurrell et al. 2013). The text lumps together models and seems to be extremely dismissive of them. The text here ignores that nature is one ensemble member and that models vary widely in their ability to reproduce observations of sea ice. [Government of United States of America, United States of America]	Accepted: text revised to better capture the nuance of model performance; reference to Jahn et al 2012 added.
2793	3	25	13	25	14	I don't agree with that the rates of sea-ice change "are not well simulated". The observations are well within the simulated rates of change, when you properly account for internal variability, e.g. Swart et al. 2015b [Neil Swart, Canada]	Accepted: text revised
2107	3	25	14	25	14	"ice-drift rates" It was shown in Tandon et al 2018 that an earlier paper on underestimated ice-drift rates was actually not accurate, as different temporal sampling was used between observations and models. For CMIP5 models, Tandon et al showed that the models simulate ice drift speeds consistent with observations. Tandon, N. F., Kushner, P. J., Docquier, D., Wettstein, J. J., & Li, C. (2018). Reassessing sea ice drift and its relationship to long-term Arctic sea ice loss in coupled climate models. Journal of Geophysical Research: Oceans, 123, 4338–4359. https://doi.org/10.1029/2017JC013697 [Alexandra Jahn, United States of America]	Taken into account: Tandon paper is cited, and still shows there is uncertainty in simulated ice drift. ("There is still considerable intermodel scatter in climatological drift speed...")
4657	3	25	14	25	14	Suggest to specific the description "general features of Arctic atmospheric circulation". For instance, which features can not be well simulated. [botao zhou, China]	Taken into account: text no longer appears
33273	3	25	14	25	14	"not well simulated": Clarify what is meant by this statement. What does Stroeve et al. (2014b) show? Is it still relevant now 4 years later? The sentences are long and hard to follow. What aspects are not well simulated and why does it matter? Is that one paper enough to totally discount all of the modeling efforts that are underway? [Government of United States of America, United States of America]	Accepted: wording revised
18919	3	25	15	25	15	The reference to aerosols seems out of place and the article referenced seems to be very specifically about the early part of the SI observation record. It may be better incorporated into the next sentence about observational uncertainty. [APECS Group Review, Germany]	Accepted: sentence revised
33275	3	25	15	25	15	"aerosol have influenced historical sea ice trends...": While this is important research, the level of certainty does not justify this statement. [Government of United States of America, United States of America]	Accepted: sentence revised

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
18935	3	25	15	25	17	I think the logic of this paragraph is clearer if you start with 'Reductions in sea ice...' and leave the 'although aerosols have influenced historical sea ice trends to the end of the sentence. Seems like superfluous information [APECS Group Review, Germany]	Accepted: sentence revised
33277	3	25	17	25	17	There are questions whether sea ice sensitivity is a good constraint of climate models. See, e.g., Winton et al. (2011) or Ding et al. (2018). [Government of United States of America, United States of America]	Accepted: text revised to reflect the results from Ding et al (2018)
18931	3	25	17	25	18	Define 'sensitivity' in the first usage in the sentence. [APECS Group Review, Germany]	Accepted: text revised
2095	3	25	17	25	20	The recent paper by Ding et al (2018) show that is NOT true. (Nature Geoscience, doi: https://doi.org/10.1038/s41561-018-0256-8) [Alexandra Jahn, United States of America]	Accepted: text revised to reflect the results from Ding et al (2018)
18933	3	25	17	25	20	The point of this sentence is not immediately clear. I am interpreting this to say 'We know that the models underestimate the sea ice sensitivity due to their systematic underestimation of downwelling long wave radiation, however, we cannot say to what extent they are underestimating due to large uncertainties in observational sea ice sensitivities.' This was NOT immediately clear as the point of the sentence (nor am I sure that I actually have this right). Please re-phrase so that a non-sea ice scientist like myself can interpret this correctly [APECS Group Review, Germany]	Taken into account: text no longer appears
18937	3	25	17	25	20	Be more specific - the observational sea ice sensitivity is the relationship between sea ice extent and temperature [APECS Group Review, Germany]	Accepted: wording clarified
33279	3	25	17	25	20	This seems to be an atmospheric issue and it is not clear how the underestimation of downwelling longwave has bearing on the sensitivity of sea ice. [Government of United States of America, United States of America]	Taken into account: text no longer appears
33281	3	25	22	25	37	This information should be updated to reflect the 1.5°C Special Report and papers since then. [Government of United States of America, United States of America]	Taken into account: this section is consistent with SR1.5
18921	3	25	23	25	23	The reference to 'large' spread in the timing in an ice free summer could benefit from an actual value if possible, particularly because there are specific time frames mentioned in the following sentences. [APECS Group Review, Germany]	Taken into account: this is explained in the following sentences
17619	3	25	28	25	37	Timing of when the Arctic will be ice free should be noted and emphasized for its close proximity in the Summary for Policymakers. Loss of Arctic sea ice is estimated to occur within 15 years, according to Overland and Wang (2013) When will the summer Arctic be nearly sea ice free?, GEOPHYSICAL RESEARCH LETTERS 40:2097–2101, 2097 ("Time horizons for a nearly sea ice-free summer for these three approaches [for estimating future ice loss covered in the study] are roughly 2020 or earlier, 2030 ± 10 years, and 2040 or later."). Also include the implications of increased climate forcing from reduced Arctic sea ice, which will be more extreme as less and less ice exists in the Arctic; see Pistone K., et al. (2014) Observational Determination of Albedo Decrease Caused by Vanishing Arctic Sea Ice, PROC. NAT'L. ACAD. SCI. 111(9):3322–3326. [Durwood Zaelke, United States of America]	See #17619
2103	3	25	29	25	30	The linear relationship only works for long-term averages, not the first time this may happen. So to be correct, this should say "The clear link between the summer sea ice extent and cumulative CO2 emissions provide a basis for when consistent ice-free conditions may be expected" [Alexandra Jahn, United States of America]	Accepted: wording clarified

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
18939	3	25	30	25	32	Is this '10 years of stabilized warming RESULTING in 2C global temperature increase' starting today? Or 10 years warming aiming to hit 2C increase at some later date? One article says that sea ice is linked to 2C warming, but the others seem to project longer time periods than 10 years... Make this clearer please, these numbers tend to get a lot of attention [APECS Group Review, Germany]	Taken into account: wording consistent with SR1.5; refers to stabilized warming of 1.5 versus 2 degrees from pre-industrial.
11173	3	25	30	25	35	I suggest to change the assessment of „very likely“ to „likely“. This is because all these estimates depend on the bias correction of model simulations to match the observed sensitivity, but we show in Niederrenk and Notz (2018) that the observed sensitivity is quite uncertain. All studies cited here do not take this into account, and only use a limited subset of the observational record of sea-ice evolution and temperature evolution. This uncertainty should be spelled out here. [Dirk Notz, Germany]	Accepted: confidence language revised; further discussion is beyond scope.
2097	3	25	32	25	32	This should be Jahn 2018, NOT Jahn et al., 2016 here [Alexandra Jahn, United States of America]	Accepted: citation corrected
29051	3	25	32	25	32	Suggest for clarity and completeness add, "September every year, with occasional ice-free years stretching from July to October (Mahlstein..." [Pam Pearson, Sweden]	Rejected: not our intended meaning
9123	3	25	33	0		Insert 'a' before '1.5' [Nina Hunter, South Africa]	Taken into account: text no longer appears
23133	3	25	33	25	33	I suggest to remove "target". The only target of the Paris Agreement is well below 2°C (1.5°C is aspirational). Just remove target here. [Valerie Masson-Delmotte, France]	Accepted: text revised
2105	3	25	33	25	34	There a chance of not seeing any ice-free conditions, as shown in both Sigmond et al (2018) and Jahn (2018), so I think that should be made clear here. Rather than saying "but individual ice-free years are still projected to occur", it should say "but individual ice-free years are still possible", as that's what is shown in all of these studies. [Alexandra Jahn, United States of America]	Accepted: text revised
18923	3	25	33	25	34	A probability for the potential of an ice free Sept would be useful and make the sentence clearly comparable to the previous sentence. Jahn, 2018 estimates the probability of an ice free Sept to be 30% at 1.5°C. [APECS Group Review, Germany]	Rejected: Jahn et al 2018 does not claim 30% chance of ice-free conditions at 1.5 degrees global warming
18925	3	25	35	25	37	Is this in reference to 2 or 1.5°C or both? [APECS Group Review, Germany]	Accepted: text clarified; text refers to both targets
29673	3	25	35	25	37	I'd suggest that this sentence needs some qualification. Were the situation just about the ice possibly reforming, that is mainly what has been tested. But a lot more will go on if the temperature overshoots that will have an effect. For example, the melt rate of Greenland will significantly increase and it is not at all clear that the effects of this will be reversible given that the altitude of the ice sheet will be getting lower and lower, so warmer and warmer. The increasing release of freshwater will lead to changes in the ocean circulation that may have effects (and apologies here for not sticking to the IPCC lexicon--we simply don't know much about this--at not that I am aware of). There can also then be questions relating to stability-related issues, etc. And then there are issues of possible changes in runoff from land--warmer temperatures affecting evaporation and affect circulation. Increased wildfires due to heat and drying may be depositing black carbon. I'd suggest assigning this finding "high confidence" suggests a good bit more confidence than is justified given there will be a pathway the global climate follows that may well have an effect, and it is not just a question of the sea ice re-forming when the conditions are identical to those at present. [Michael MacCracken, United States of America]	Accepted: wording modified

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
2099	3	25	36	25	37	Also shown in Jahn 2018, for 1.5C overshoot simulations [Alexandra Jahn, United States of America]	Accepted: text clarified; text refers to both targets
17391	3	25	39	25	39	It should be Turner et al., 2013 as this is when it was actually published. Turner, John; Bracegirdle, Thomas J.; Phillips, Tony; Marshall, Gareth J.; Hosking, J. Scott. 2013 An initial assessment of Antarctic Sea ice extent in the CMIP5 models. Journal of Climate, 26 (5). 1473-1484. https://doi.org/10.1175/JCLI-D-12-00068.1 [Amna JRRAR, Jordan]	Accepted: citation corrected
30113	3	25	39	25	57	These two paragraphs overlap somewhat in topic but disagree e.g. in terms of attribution of observed sea ice trends [Julie Arblaster, Australia]	Accepted: reduced text somewhat and added pointers to Section 3.2.1.1.1
30117	3	25	39	25	57	Some overlap with 3.2.1.1.1 here, might be better to point to that section and limit discussion here [Julie Arblaster, Australia]	Accepted: reduced text somewhat and added pointers to Section 3.2.1.1.1
23983	3	25	41	25	42	It would seem necessary to clarify if this description is still applicable to the strong negative departures in 2016/2017. Please note that recent studies suggest that sea ice models can fundamentally reproduce and predict Antarctic sea ice behavior if the correct atmospheric conditions are given (Kusahara et al., 2018; Env. Res. Lett.) [Government of Japan, Japan]	Accepted: text revised to note the change in the historical trend; Kusahara et al citation added to Section 3.2.1.1.1
33283	3	25	41	25	42	Is it still true that the model variability is higher than observations after (1) including the swing to very low values in 2016 and 2017, and (2) the large range in extents from the early Nimbus satellite data in 1964 (very high) and 1966 (very low) (Gallaher et al., 2014)? [Government of United States of America, United States of America]	Taken into account: we feel the findings of Zunz et al (2013) justify this statement.
29675	3	25	46	25	47	This sentence seems to be written with no indication of uncertainty or other factors playing a role. I'm not familiar with all of this, but what is the confidence level to be associated with this very definitive statement? Should not one be provided? [Michael MacCracken, United States of America]	Taken into account: this sentence was removed as part of other edits
30111	3	25	46	25	47	Rephrase. Even if the models included the tropical Pacific SSTs, they may not simulate the correct teleconnections in sea ice [Julie Arblaster, Australia]	Taken into account: this sentence was removed as part of other edits
33285	3	25	52	25	56	The meaning of this sentence is unclear. In particular, it is not clear which (or if all) of the things mentioned is "limiting the sea ice response in the regions with the greatest observed trends". [Government of United States of America, United States of America]	Accepted: editorial error corrected
18927	3	25	52	25	57	This reference may be a too late, but is relevant: Zhang et al., 2018: Natural variability of Southern Ocean convection as a driver of observed climate trends, Nature Climate Change) [APECS Group Review, Germany]	Accepted: reference added
32029	3	25	52	25	57	Break this sentence up and clarify the relationship between the different elements of the sentence. [Christian Reuten, Canada]	Accepted: sentence revised
29677	3	25	53	25	53	I'd urge rewording to indicate in a more understanding way that there are multiple human forcings (stratospheric ozone, GHGs) as well as the inertial effects of the oceans (thermal lag and connections via the circulation to the deeper ocean) and glacial ice and the natural variability that are all interacting at the same time, and so it is not surprising that it is taking a while to sort things out, especially as the ozone hole is decreasing in intensity and GHG effect is increasing, etc. So, while this does not mean that understanding of the overall GHG path we are on is wrong, it should not be surprising that in some regions there is still limited understanding. [Michael MacCracken, United States of America]	Accepted: new text added
30115	3	25	54	25	55	See also Purich et al J Climate 2018 [Julie Arblaster, Australia]	Accepted: citation added

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
3073	3	25	55	0		Include Hyder et al 2018 for cloud/atmospheric process uncertainty [Helene Hewitt, United Kingdom (of Great Britain and Northern Ireland)]	Accepted: citation added
23135	3	26	0	27		A conclusion from this box could be used in the ES if available. [Valerie Masson-Delmotte, France]	Taken into account: will look to feed into sea ice components of the ES
18963	3	26	1	26	1	What is the definition of 'sea ice biases'? Models can exhibit biases in sea ice extent... Would it be more correct to say that sea ice extent affects Antarctic temperature and precipitation trends? [APECS Group Review, Germany]	Accepted: text clarified
18965	3	26	2	26	2	Is the 'they' in this sentence again referring to the uncertainty? It would be clearer to identify this 'they', (e.g. 'The biases in projections in sea ice extent may also impact...') [APECS Group Review, Germany]	Accepted: text clarified
18967	3	26	2	26	2	Is 'Southern Hemisphere atmosphere jet' the most common term? I think I have only hear it referred to as the 'southern polar jet stream'. Would be good to check with an atmospheric scientist as to most common understandable terminology [APECS Group Review, Germany]	Accepted: text clarified
18969	3	26	4	26	4	Would be nice to write out the ACC, not sure what IPCC convention is on acronyms first explained in Cross-chapter boxes. [APECS Group Review, Germany]	Accepted: text clarified
31047	3	26	7	0		In this section and others, please give details, eg shifts over what time period? In what direction? By how much? What %? And confidence in attribution to climate change [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account: text revised through entire Box
26383	3	26	9	27	48	This box should discuss the effects of polynyas on regional climate. And, van Westen and Dijkstra (2018) suggest that the Weddell polynya did in fact re-appear in 2017. [Ethan Pierce, United States of America]	Rejected: Space limitations mean we cannot expand the scope of the box; text states that the Weddell polynya appeared in 2016 and 2017
18943	3	26	11	27	48	The chapter about Polynyas has very few calibrated language statements compared to the others. Especially the subchapter about Arctic Coastal Polynyas is completely missing a confidence statement. [APECS Group Review, Germany]	Accepted: text revised and confidence statements added
18959	3	26	11	27	50	The organization of the box by Arctic and Antarctic polynas leads to a substantial amount of repeated information. Polynas in both hemishperes are nutrient rich hot spots that act as sources of sea ice formation. I suggest a fairly simple, but perhaps extensive, revision of this box that focuses on the similarities and differences: 1. Polyna formation (2 paragraphs describing formation and how formation is different in the two hemispheres). 2. Polynas under changing climate conditions (discuss growth and/or reduction), 2b Weddell Sea Polyna, 3. Polyna biology and value (paragraphs explaining the biology of Arctic and Antarctic polynas). 4 a final paragraph emphasizing the economic and cultural value of Arctic polynas to Native Peoples. I think this reorganization will result in a simpler, more digestable bit of information on polynas. [APECS Group Review, Germany]	Taken into account: this is an interesting suggestion but we will stay with the current format. We have revised the text through the entire box to remove repetition.
17073	3	26	13	0		Does polynias include "leads"? Formation of polynias are caused by... [Jorge Carrasco, Chile]	We consider only polynyas, not leads in this box.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
33287	3	26	15	26	17	"The warm and exposed ocean surface creates very high heat fluxes and sea ice formation rates in winter ...": Is some more explanation required here, as it's slightly counterintuitive that high heat fluxes lead to high sea ice formation rates. Presumably authors mean in the case of high rates of sea ice export from the polynya region (e.g. in the presence of wind)? [Government of United States of America, United States of America]	Accepted: revised text to specify 'new sea ice formation'
18945	3	26	27	26	28	The phrase '... which ...recent decades...' can and should be removed. [APECS Group Review, Germany]	Accepted: text revised
3219	3	26	28	26	29	Does this extend to Canadian portion of Beaufort or is it limited to Alaska? [Sharon Smith, Canada]	Taken into account: text no longer appears
18947	3	26	29	26	30	the phrasing at the end of this sentence makes the statement ambiguous. I believe it should read 'while the Siberian coast is projected to maintain approximately 6 months of sea ice cover (reference).' [APECS Group Review, Germany]	Taken into account: text no longer appears
18949	3	26	31	26	32	the last part of this sentence is ambiguous as to the mechanism referenced - are the fluxes referenced an increase in solid discharge? Or liquid discharge? And how, mechanistically would these processes trigger further polynya formation? A reference would clarify this statement, though I couldn't find one in a cursory search. [APECS Group Review, Germany]	Taken into account: text no longer appears
2531	3	26	34	26	34	solar insolation -> insolation. This par is mainly descriptive with old references, really necessary? [Michiel Van den Broeke, Netherlands]	Taken into account: text no longer appears
18951	3	26	34	26	34	In spring, polynas are the first ocean areas exposed to solar insolation. [APECS Group Review, Germany]	Taken into account: text no longer appears
18971	3	26	34	26	34	This sentence seems vague. Technically, the sea ice is exposed to solar insolation at the same time as the polynyas. I think what is meant to be said here is something like 'polynyas are able to convert the solar insolation to heat energy in the ocean rather than to melting sea ice'. [APECS Group Review, Germany]	Taken into account: text no longer appears
18953	3	26	34	26	38	This simple revision says the same thing, but is more straightforward: In spring, polynyas are the first areas exposed to solar insolation, resulting in an earlier onset of the phytoplankton bloom. Further, because the ocean is well-ventilated and often nutrient rich, the entire trophic range, from phytoplankton to marine mammals, thrives in polynya waters (Stirling, 1997; Arrigo and van Dijken, 2004; Karnovsky et al., 2009). [APECS Group Review, Germany]	Accepted: sentence revised
18955	3	26	42	26	43	The abundance of marine food resources, including fish, seals, and whales, have made polynas regular hunting areas for Arctic peoples for thousands of years. [APECS Group Review, Germany]	Accepted: sentence revised
9125	3	26	43	0		Insert 'for' before 'thousands' [Nina Hunter, South Africa]	Accepted: sentence revised
33289	3	26	43	0		typo: "Arctic peoples [for] thousands" [Government of United States of America, United States of America]	Accepted: sentence revised
18941	3	26	43	26	43	The sentence is missing a word in between "peoples" and "thousand". [APECS Group Review, Germany]	Accepted: sentence revised
18973	3	26	43	26	43	Phrasing is a bit strange. they have been 'regular hunting areas for Arctic peoples for thousands...' or even 'Arctic peoples have hunted regularly in these areas for thousands of years' [APECS Group Review, Germany]	Accepted: sentence revised

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
18957	3	26	45	26	45	I can not immediately think of non-renewable resources associated with polynas. It may be useful to indicate them here or remove the phrase. [APECS Group Review, Germany]	Accepted: sentence revised
33291	3	26	52	26	53	Katabatic winds also play a role in some polynya formation, correct? [Government of United States of America, United States of America]	Accepted: sentence revised
11221	3	26	52	27	57	<p>The Antarctic continent is surrounded by coastal polynyas, which form in the lee of coastal features that protrude into the westward coastal current (Tamura et al., 2008; Nihashi and Ohshima, 2015). Intense ice growth within these polynyas contributes to the production of Antarctic Bottom Water, the densest and most voluminous water mass in the global ocean (Jacobs, 2004; Nicholls et al., 2008; Orsi and Wiederwohl, 2009; Ohshima et al., 2013). Sea ice production is greatest in polynyas of the Ross and Weddell seas and around East Antarctica (Tamura et al., 2008; Drucker et al., 2011; Nihashi and Ohshima, 2015).</p> <p>My suggestion is:</p> <p>The Antarctic continent is surrounded by coastal polynyas, which form in the lee of coastal features that protrude into the westward coastal current (Tamura et al., 2008; Nihashi and Ohshima, 2015). Intense ice growth within these polynyas contributes to the production of Antarctic Bottom Water, the densest and most voluminous water mass in the global ocean (Jacobs, 2004; Nicholls et al., 2008; Orsi and Wiederwohl, 2009; Ohshima et al., 2013). There is a considerable formation of Antarctic sea ice in coastal polynyas (Drucker et al., 2011; Tamura et al., 2016). Sea ice production is greatest in polynyas of the Ross and Weddell seas and around East Antarctica (Tamura et al., 2008; Drucker et al., 2011; Nihashi and Ohshima, 2015).</p> <p>Tamura, T., K. I. Ohshima, A. D. Fraser, and G. D. Williams (2016), Sea ice production variability in Antarctic coastal polynyas, J. Geophys. Res. Oceans, 121, 2967–2979, doi:10.1002/2015JC011537. [Burcu Ozsoy, Turkey]</p>	Accepted: 2008 citation replaced with 2016 citation
18961	3	26	56	26	57	Why, mechanistically, do these polynas produce the most sea ice, is it a relatively higher wind speeds or ocean-atmopshere temperature conditions? [APECS Group Review, Germany]	Rejected: Additional process-related details are out of scope
29185	3	27	1	27	2	Tamura et al (2016) should be cited here. Is "high confidence" justified given that Tamura et al show a reduction in ice production by the Ross Sea, over the same time interval? [Stephen Rintoul, Australia]	Accepted: 2008 citation replaced with 2016 citation
33293	3	27	2	27	2	Haumann et al. (2016) mainly focus on "Our finding that northward sea-ice freshwater transport is also a key determinant of the mean salinity distribution in the Southern Ocean further underpins the importance of the sea-ice-induced freshwater flux. Through its influence on the density structure of the ocean, this process has critical consequences for the global climate by affecting the exchange of heat, carbon and nutrients between the deep ocean and surface waters." Is it possible the reference cited here should refer to Haumann et al. (2014)? [Government of United States of America, United States of America]	Accepted: text revised and citation removed

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
33295	3	27	4	27	4	Other recent publications on Ross Sea primary production should be considered, such as: Ainley DG, Ballard G, Jones RM, Jongsomjit D, Pierce SD, Smith WO Jr, Veloz S(2015) Trophic cascades in the western Ross Sea, Antarctica: revisited. Mar Ecol Prog Ser 534:1-16. https://doi.org/10.3354/meps11394 . In addition, there are additional recent references that could support the claim about iron and impacts on primary production. This section could be expanded to explain the important role of MCDW, for example: The relative roles of modified circumpolar deep water and benthic sources in supplying iron to the recurrent phytoplankton blooms above Pennell and Mawson Banks, Ross Sea, Antarctica. Mariko Hatta, Chris I. Measures, Phoebe J. Lam, Daniel C. Ohnemus , Maureen E. Auro , Maxime M. Grand, Karen E. Selph : https://doi.org/10.1016/j.jmarsys.2016.07.009 [Government of United States of America, United States of America]	Accepted: text revised and citations added
18975	3	27	6	27	8	clarify that the supply of iron from glacial ice melt is associated with subglacial sediments. Further, to my understanding the primary iron source can vary substantially based on the region in Antarctica, so perhaps this statement should be revised (e.g. McGillicuddy et al., 2015) [APECS Group Review, Germany]	Accepted: text revised and citation added
33297	3	27	6	27	8	This sentence references an Arctic paper instead of an Antarctic paper. For discussion of Antarctic iron supply in polynyas, instead suggest referencing Arrigo, van Dijken, and Strong, 2015, "Environmental controls of marine productivity hot spots around Antarctica" (which may have been the intention). Regardless, this conclusion is stated with too much certainty since other research, particularly in the important Ross Sea polynya, contradicts this conclusion that ice shelves are the primary iron supplier. There is strong evidence from observations and modeling that wintertime mixing and melting sea ice are primary sources of iron in the Ross Sea (McGillicuddy, et al, 2015, "Iron supply and demand in an Antarctic shelf ecosystem"). [Government of United States of America, United States of America]	Accepted: Arrigo et al citation changed and McGillicuddy et al reference added (see #18975)
33299	3	27	7	27	19	A recently published paper Boeke and Taylor (2018; Nature Communications) explains the CMIP5 inter-model differences in Arctic Amplification due to the seasonality of ocean heat storage where summer-time absorbed solar radiation is stored in the ocean and released as surface turbulent fluxes in fall. The magnitude of the change in this heat transfer strongly relates to the magnitude of projected Arctic warming. Both the ocean mixed layer depth and redistribution of heat by the atmosphere are explained as important processes. It seems appropriate to add this perspective here. Moreover, a recent paper by Stuecker et al. (2018; Nature Climate Change) argues that ocean heat transport changes contribute minimally to Arctic warming, but that local processes are the primary cause of enhanced warming. Ocean heat transport is shown to provide a warming contribution but not a significant one. References: Stuecker, M. et al. Nat. Clim. Change https://doi.org/10.1038/s41558-018-0339-y (2018) and Boeke, R. C. and P. C. Taylor, 2018: Seasonal energy exchange in sea ice retreat regions contributes to differences in projected Arctic warming, Nature Communications volume 9, Article number: 5017 (2018) [Government of United States of America, United States of America]	Accepted: new standalone Box 3.1 provides additional content on Arctic amplification. Added Stuecker et al reference.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
29187	3	27	8	27	8	how general is the statement that melting ice shelves dominates iron input to polynyas? Surely it depends on the polynya and the magnitude of melt input? Is the statement consistent with Marsay et al 2017 arguing that lithogenic sources dominate iron supply to Ross Sea? [Stephen Rintoul, Australia]	Accepted: text revised and new citations added
18977	3	27	10	27	10	This sentence needs clarification. It seems that locally, primary production would increase, but in other areas (i.e. further out where the ice edge and polynya used to be might see a reduction in primary production). [APECS Group Review, Germany]	Taken into account: text clarified
33301	3	27	21	27	25	Are there any model projections that could be included in addition to the "could increase" statement based on incubation experiments? Expand the evidence offered to include observed trends and extrapolations from incubations, as well as modeled projections, as is done in other sections of this chapter. For example, both Rickard and Behrens (2016, "CMIP5 Earth System Models with biogeochemistry: a Ross Sea assessment") and Kaufman et al. (2017, "Climate change impacts on southern Ross Sea phytoplankton composition, productivity, and export") offer 21st century projections that suggest increasing primary productivity in the Ross Sea. [Government of United States of America, United States of America]	Accepted: text revised and citations added
30919	3	27	23	27	23	Terms such as «dramatically» are not appropriate in this context. I suggest replacing with «significantly» or "drastically" [Hans-Otto Poertner and WGII TSU, Germany]	Accepted: text revised
33303	3	27	24	27	25	The reference here to "Arrigo and van Dijken, 2015" points to a paper discussing the Arctic instead of the Antarctic. [Government of United States of America, United States of America]	Accepted: Arrigo et al citation changed
2751	3	27	26	27	34	The examples are more or less case specific without consideration of the generalized response to climate change and without consideration of potential improvement with modern technology and investment. A lot of efforts in high mountain Asian countries where snow cover and glaciers are undergoing shrinkage have been taken to adapt to either the increase or decrease in meltwater runoff. New water resource regulation systems have been constructed and irrigation technology has been applied in the arid northwest China. The summarization is expected to assess the advantage and disadvantage of all various measures to adapt to high variability of water resources resulted from cryospheric changes. [Shiyin Liu, China]	Incorrect page reference?
33305	3	27	27	27	48	This section could include more research from the Long Term Ecological Research (LTER) program which has synthesized research along the West Antarctic Peninsula, including citations such as: Decadal variability in coastal phytoplankton community composition in a changing West Antarctic Peninsula Oscar Schofield et al 2017. https://doi.org/10.1016/j.dsr.2017.04.014 This citation highlights ""Sea ice distributions in Antarctic Peninsula affect phytoplankton biomass/composition"" among other results. Another example: Hobbs, W.R., Massom, R., Stammerjohn, S., Reid, P., Williams, G., and Meier, W., A review of recent changes in Southern Ocean sea ice, their drivers and forcings. Global and Planetary Change, 2016. DOI http://dx.doi.org/10.1016/j.gloplacha.2016.06.008 . Palmer LTER Contribution #0526. [Government of United States of America, United States of America]	Rejected: not clear how these references pertain to the Weddell Sea polynya?
3869	3	27	29	27	40	suggest to add that the deep convection associated with the WP contributes to the formation of AABW (see Gordon AL [Zhaomin Wang, China]	See #3875
3871	3	27	29	27	40	(1982) Weddell Deep Water variability. J Mar Res 40: 199-217; Zhaomin Wang, Yang Wu, Xia Lin, Chengyan Liu, [Zhaomin Wang, China]	See #3875

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
3873	3	27	29	27	40	Zelin Xie, Impacts of open-ocean deep convection in the Weddell Sea on coastal and bottom water temperature, <i>Climate</i> [Zhaomin Wang, China]	See #3875
3875	3	27	29	27	40	Dynamics, 2016, doi:10.1007/s00382-016-3244-y) [Zhaomin Wang, China]	Rejected: the suggested paper is a model-based process study which would require additional text to explain.
3877	3	27	32	0		For "An area of low sea ice concentration ...", I think that "with a much smaller size than that of the WP during the [Zhaomin Wang, China]	See #3879
3879	3	27	32	0		mid-1970s" should be added. [Zhaomin Wang, China]	Taken into account: sentence no longer appears
33307	3	27	32	27	33	An important formation mechanism for Weddell/Maud Rise polynyas has recently been reported by Kurtakoti et al. (2018; see also Alverson and Owens 1996) and that is the preconditioning to deep convection represented by the Taylor cap associated with the Maud Rise seamount. If the stratification is weak enough in the upper ocean (and that is mostly determined by upper ocean salinity), then the Taylor cap is allowed to tap into the surface ocean, bringing warm Weddell Sea water upward and preventing sea-ice to form. Because of this, an additional reason why CMIP5 models do not properly simulate Maud Rise and Weddell Sea polynyas is the low-resolution in their ocean model components, which does not allow for a proper representation of Taylor caps and associated recirculations/eddies around the Maud Rise seamount. Referenced papers are: 1) Kurtakoti et al. 2018. Preconditioning and Formation of Maud Rise Polynyas in a High-Resolution Earth System Model. <i>JCLI</i> 31, 9659-9678; 2) Alverson and Owens 1996. Topographic preconditioning of open-ocean deep convection. <i>JPO</i> 26, 2196-2213. [Government of United States of America, United States of America]	Rejected: the suggested paper is a model-based process study which would require additional text to explain.
22475	3	27	33	27	33	Suggest citation following text "...in spring 2016 and 2017..." Swart et al 2018: Return of the Maud Rise Polynya: Climate litmus or sea ice anomaly [in "State of the Climate in 2017"]. <i>Bull. Amer. Meteor. Soc.</i> , 99 (8), S188-S189. [Government of Australia, Australia]	Taken into account: we have added some citations to recent papers here instead of the short note from Swart et al.
33309	3	27	33	27	36	A couple more recent references could be relevant here in regards to Maud Rise: Lindsay, R. W., R. Kwok, L. de Steur, and W. Meier (2008), Halo of ice deformation observed over the Maud Rise seamount, <i>Geophys. Res. Lett.</i> , 35, L15501, doi:10.1029/2008GL034629. - and perhaps also- Kurtakoti, P., M. Veneziani, A. StvÉ?ssel, and W. Weijer, 2018: Preconditioning and Formation of Maud Rise Polynyas in a High-Resolution Earth System Model. <i>J. Climate</i> , 31, 9659--9678, https://doi.org/10.1175/JCLI-D-18-0392.1 [Government of United States of America, United States of America]	Rejected: the suggested paper is a model-based process study which would require additional text to explain.
11067	3	27	33	27	40	An extensive discussion of the processes for creation and maintenance of open ocean polynyas is given in Lemke, P., 1987: A coupled one-dimensional sea ice - ocean model. <i>J.Geophys.Res.</i> 92, 13164-13172; Lemke, P., W.B. Owens and W.D. Hibler, 1990: A coupled sea ice - mixed layer - pycnocline model for the Weddell Sea. <i>J.Geophys.Res.</i> 95, 9513-9525; and Timmermann, R., P. Lemke and C. Kottmeier, 1999: Formation and Conservation of a polynya in the Weddell Sea, <i>J. Phys. Oceanogr.</i> , 29(6) 1251-1264. [Peter Lemke, Germany]	Rejected: Emphasis is on publications since AR5
3881	3	27	46	27	48	Biases in other processes should also be mentioned; otherwise, readers would have an impression that biases in the [Zhaomin Wang, China]	Accepted: text revised
3883	3	27	46	27	48	simulated ocean stratification were only caused by the lack of freshwater input from ice shelf basal melting. [Zhaomin Wang, China]	Combined with #3881?

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
897	3	27	49	0		There are many other upwellings not mentioned but should [Falk Huettmann, United States of America]	Not clear what this comment is referring to
18979	3	28	7	28	19	This paraprah is really difficult to parse and the only thing that I can reliably take away is the medium confidence from the first sentence. Could it be reworked to emphasize the processes emphasized in each of the papers in a more general way with a figure or table laying out what studies use how many CMIP models under what RCPs and what regions are impacted? Maybe a map with regions shaded by their potential change under a specific RCPs with citations and CMIP numbers listed in the vicinity? Or instead of a figure or reference to the number of CMIP models used in each study, could a confidence be applied based on that? [APECS Group Review, Germany]	Taken into account, and revised. The increased ocean transport (of medium confidence) is clearly illustrated here. The "confusion" arises because some models do not simulate such an increase, and the warming is produced by a decrease in the heat loss at the surface instead. Despite this difference, the physical mechanism is for the Barents Sea well understood and clear.
30343	3	28	8	28	10	The think the comparison was made with 20 and 26 "CMIP5 model "simulations" not 20 and 26 different "CMIP5 models" The distinction is important! Otherwise the models would have different names. [Paul Glaser, United States of America]	Accepted - text revised, "simulations" added. The model names are not straightforward. For the 26 different model simulations used in Burgard & Notz (2017) there are 62 different ensembles, but really only 16 different models. For example does the NorESM come in two different resolutions; NorESM1-M and NorESM1-ME.
3075	3	28	13	0		Given that it is a single study, should low confidence be assigned to the Barents Sea heat transport? I think that there is too much text given to this mechanism [Helene Hewitt, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account. The confidence is based on the well understood mechanism, and the fact that a large part of the increased ocean heat transport can be explained by the general warming.
15553	3	28	17	28	19	There is no referecne for this statement. [EUCE, Belgium]	Accepted – text revised. This is also based on Koenigk and Brodeau, 2014
16885	3	28	17	28	19	What is the reference for this statement? [Louise Sandberg Soerensen, Denmark]	Accepted – text revised. This is also based on Koenigk and Brodeau, 2014. Same as comment id 15553.
2795	3	28	21	28	22	What about snow, permafrost, and Greenland melt contributions to freshening? [Neil Swart, Canada]	Taken into account; Greenland melt etc dealt with separately in this report
33311	3	28	22	28	24	There is a competing effect of elevated vertical mixing during ice-free periods due to decline in sea ice, which reduces stratification and brings heat upward. This competing effect may play a more significant role in future decades in the Eurasian Basin (Davis et al., 2016). Here, this competing effect should be mentioned and which is more important in the changing Arctic Ocean is actually debatable. (Reference: Davis PED, Lique C, Johnson HL, Guthrie JD. Competing Effects of Elevated Vertical Mixing and Increased Freshwater Input on the Stratification and Sea Ice Cover in a Changing Arctic Ocean. J Phys Oceanogr. 2016;46(5):1531-1553. doi:10.1175/JPO-D-15-0174.1.) [Government of United States of America, United States of America]	Taken into account; a good point, but there are no simulations available, to our knowledge, where the mixing below the mixed layer increases in the future. Guthrie, J. D., J. H. Morison, and I. Fer, 2013: Revisiting internal waves and mixing in the Arctic Ocean. J. Geophys. Res. Oceans, 118, 3966–3977, doi:10.1002/jgrc.20294.
18981	3	28	24	28	24	~1 PSU? [APECS Group Review, Germany]	Rejected: salinity (as measured) is a ratio and thus is dimensionless and unitless
33313	3	28	24	28	24	Insert "psu" whenever refer to any salinty change. [Government of United States of America, United States of America]	Rejected: salinity (as measured) is a ratio and thus is dimensionless and unitless

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
3077	3	28	24	28	27	I'm not sure that it is helpful at this point to reference salinity errors in forced ocean models particularly as in this mode, these models are run with salinity relaxation at the surface. I think it is sufficient to reference coupled model errors in Arctic salinity (relaxation is not prescribed in these models) [Helene Hewitt, United Kingdom (of Great Britain and Northern Ireland)]	Noted. This is a fair point, but the bias is comparable in coupled models (Ding et al, 2016). This could, however, be due to a much larger number of causes. When there are systematic bias in models under the same forcing, it gives a better grasp on the confidence in these models.
18983	3	28	29	28	40	Some mention of whether the CMIP5 models suffer from the same salinity bias in the Arctic would be a useful comparison. [APECS Group Review, Germany]	Rejected: The salinity bias of the Arctic is already discussed on the same page
33315	3	28	30	28	30	Modify the reference to (Sallee et al, 2013a). [Government of United States of America, United States of America]	Editorial - copyedit to be completed prior to publication
18993	3	28	35	28	35	What is 'shoaling mixed layer depths'? Can this be made clearer/easier to understand? [APECS Group Review, Germany]	Accepted: changed
23749	3	28	42	29	31	Ocean acidification progress at the fastest rates in the Arctic and are projected to be more severe here than in any other region including the Southn Ocean. OA is therefore very much an arctic problem. Earth system models continually show this (Steinacher et al. 2009, Denman et al. 2011, Steiner et al. 2014). It would be correct to mention this in the beginning of this section (3.2.2.3). Refs: Denman, K., J. R. Christian, N. Steiner, H.-O. Pörtner, and Y. J. I. J. o. M. S. Nojiri. 2011. Potential impacts of future ocean acidification on marine ecosystems and fisheries: current knowledge and recommendations for future research. 68:1019-1029. Steinacher, M., F. Joos, T. L. Frölicher, G. K. Plattner, and S. C. Doney. 2009. Imminent ocean acidification in the Arctic projected with the NCAR global coupled carbon cycle-climate model. Biogeosciences 6:515-533. Steiner, N., J. Christian, K. D. Six, A. Yamamoto, and M. J. J. o. G. R. O. Yamamoto-Kawai. 2014. Future ocean acidification in the Canada Basin and surrounding Arctic Ocean from CMIP5 earth system models. 119:332-347. [Government of Sweden, Sweden]	Accepted the sentence was revised and older references outside this review period were represented by AR5 report.
24051	3	28	42	29	31	Ocean acidification progress at the fastest rates in the Arctic and are projected to be more severe here than in any other region including the Southern Ocean. OA is therefore very much an arctic problem. Earth system models continually project far higher levels of ocean acidification in the Arctic (Steinacher et al. 2009, Denman et al. 2011, Steiner et al. 2014). It would be correct to mention this in the beginning of this section (3.2.2.3). Refs: Denman, K., J. R. Christian, N. Steiner, H.-O. Pörtner, and Y. J. I. J. o. M. S. Nojiri. 2011. Potential impacts of future ocean acidification on marine ecosystems and fisheries: current knowledge and recommendations for future research. 68:1019-1029. Steinacher, M., F. Joos, T. L. Frölicher, G. K. Plattner, and S. C. Doney. 2009. Imminent ocean acidification in the Arctic projected with the NCAR global coupled carbon cycle-climate model. Biogeosciences 6:515-533. Steiner, N., J. Christian, K. D. Six, A. Yamamoto, and M. J. J. o. G. R. O. Yamamoto-Kawai. 2014. Future ocean acidification in the Canada Basin and surrounding Arctic Ocean from CMIP5 earth system models. 119:332-347. [Peter Thor, Sweden]	see response to 23749
24053	3	28	42	29	31	Given my comment above it is unfortunate that the text focus more on the Southern Ocean than the Arctic [Peter Thor, Sweden]	Taken into account; the revised text contains more balance

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
18985	3	28	44	28	46	This sentence needs to be revised to reflect the goals of the paragraph and to improve clarity. Polar ocean acidification occurs as sea ice extent decreases due to an increase in fresh water flux and increase in CO2 uptake due to increased air-ocean gas exchange (Yamamoto et al., 2012). Modeling studies in AR5 demonstrate a decline in pH and aragonite saturation in association with the projected decline in sea ice extent. High resolution regional models project regionally-dependent rates of ocean acidification. [APECS Group Review, Germany]	Accepted, The text was revised, however, the word "regional" was removed following comments IDs 25281 and 25283.
18987	3	28	44	28	48	I think it is important to clarify that sea ice decline is associated with increased polar ocean acidification, but isn't the direct cause since the decline in sea ice allows for more extensive air ocean gas exchange. I also think that here, or later, it would be relevant to mention that changes in ocean water transport can also increase acidification rates (e.g. Chen et al., 2017: Increase in acidifying water in the western Arctic Ocean, Nature Climate Change). [APECS Group Review, Germany]	Taken into account, combined with comment ID 18985. The reviewer's suggested reference "Chen et al., 2017" is actually "Qi et al., 2017". The study by Qi et al. was referenced already. Contribution of water transport to OA was added where this reference appears.
29679	3	28	44	28	53	It might be useful here or in a box to explain what ocean acidification is and means, not just in terms of the chemistry, but the implications for biological and ecological consequences. Or maybe a figure could be useful giving an indication of what this will all mean in addition to explaining terms like aragonite saturation. Indeed, this whole section needs to have a box or figure to help readers understand better what the potential significance of these chemical changes is and will be. [Michael MacCracken, United States of America]	Taken into account. The length restriction precludes including a further box, however the text has been modified to include more relevant detail. Information on biological/ecological consequences comes in the subsequent section.
31039	3	28	45	28	45	Please explain this, what is the process? [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account, combined with comment ID 18985.
18989	3	28	46	28	47	This is a direct copy of a sentence in the abstract of Popva et al., 2014 without including the reference to the central Arctic. It should be modified for the obvious reason and because it is unclear in the current context as to whether it is referring to current observations or future projections. [APECS Group Review, Germany]	Accepted; text revised
25281	3	28	46	28	48	Popova et al. (2014) used a GLOBAL model, not a REGIONAL model, in contrast to what was implied by the 1st sentence of this paragraph. The model has higher resolution in the Arctic because the grid is contorted, but it still does not qualify as an eddying model resolution. Therefore, although the focus of this study is on the Arctic, it is not made with a regional model nor with a resolution in a global model that is close to that of a state-of-the-art regional model. [James Orr, France]	Accepted; "regional" removed and text revised
25283	3	28	50	28	50	Stenier et al (2014) also used global models (earth system models from CMIP5). They did not use regional models as implied by the topic sentence of this paragraph. [James Orr, France]	Taken into account, combined with comment ID 25281
18995	3	28	50	28	53	It would be best to be specific about the forcing that Skogen et al., 2014 used - the A1B emission scenario - and fix the text to say 'projected in the Nordic sea, AND a simulated pH changed in the surface water OF' (saying 'with a simulated...' makes me think that that is what forced their model even though it is an output) [APECS Group Review, Germany]	Accepted; text revised as suggested
25285	3	28	51	28	53	Please provide the name of the forcing scenario used by Skogan et al. [James Orr, France]	Taken into account; combined with 18995
9127	3	28	52	0		Remove 'is' [Nina Hunter, South Africa]	Accepted

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
25287	3	28	55	28	55	"CMIP5 models project" under what scenario? Statements about projections that do not specify the scenario are ambiguous. [James Orr, France]	Accepted; specific added
4397	3	28	55	28	57	Please specify under which future greenhouse gas scenario. [The UBern Team Group Review, Switzerland]	Accepted; specific added
18991	3	28	56	28	57	This phrase is unclear. I assume that the rate of uptake will level off, not that uptake will stop by 2070, as is suggested in the next sentence. [APECS Group Review, Germany]	Accepted; have clarified that it refers to uptake rate
25289	3	29	3	29	4	Mongwe et al. (2018) assessed biases in seasonal variability. The previous line is referring to the long-term trend. It has not been established that there is any link between model skill in simulating the seasonal cycle (largely variability in the natural carbon cycle) and skill in assessing long-term trends that are mostly driven by the atmospheric CO2 increase. Although the seasonal cycle may be the dominant model of variability in ocean pCO2 today, that will be overwhelmed by the change due to the trend by the end of the century. And the two are disconnected. Therefore it is unwarranted to assign confidence, good or bad, to future projections of the annual-mean trend based on model skill for the seasonal cycle. [James Orr, France]	Taken into account. This is correct but the seasonal cycle incorporates the mechanisms that drive the long term trends - (Lenton et al., 2013; Mongwe et al., 2018) and a follow up paper Mongwe et al., 2019 makes the link between the SC biases and long term trends
18997	3	29	6	29	14	Ocean hypercapnia is very relevant to fisheries, but there is no reference to this in the paragraph or the paragraph below. Any non-expert reader would completely miss the link. Consider better motivating this paragraph. [APECS Group Review, Germany]	Taken into account. Such impacts are handled in the following section.
19017	3	29	7	29	7	I believe this should read 'of the seasonal cycle' not 'on the seasonal cycle' [APECS Group Review, Germany]	Accepted
25291	3	29	8	29	10	It is wrong to say that the decreasing buffer capacity amplifies the seasonal cycle of pH. None of the 3 cited papers (Hauck and Volker, 2015; McNeil and Sasse, 2016; Landschützer et al., 2018) even mentions changes in the seasonal cycle of pH. The only study to assess changes in the seasonal cycle of pH is that from Kwiatkowski and Orr (2018, Nature Climate Change), who found that the seasonal amplitude of pH actually DECLINED by 16 +/- 7% during the 21st century based on results from 9 CMIP5 models forced under the RCP8.5 scenario. Conversely, the seasonal amplitude of the hydrogen ion concentration [H+] increases by 81 +/- 16%. Kwiatkowski and Orr explain this counterintuitive result. I would recommend to fix the problem in sentence that is referred to by removing "and pH", and I would add 2 new sentences on pH and [H+] just before the last sentence of the paragraph: "Unlike for pCO2, the seasonal amplitude of pH is projected to decline during the 21st century in nine CMIP5 models forced under the RCP8.5 scenario, while the seasonal amplitude of hydrogen ion concentration [H+] nearly doubles (Kwiatkowski and Orr, 2018). This contrast exists because a change in pH represents a relative change in H, i.e., ΔpH is proportional to Δ[H+] / [H+], and the increase in the numerator (the seasonal amplitude of [H+] amplitude) is less than that of the denominator (the annual mean [H+])." [James Orr, France]	Taken into account: suggested edit made changed pH to [H+] - but even though the evidence for weakening of seasonal cycle of pH in the Southern Ocean is not uniformly strong, added explanation on why the amplification of the SC of pCO2 is not accompanied by a comparable amplification of pH
31153	3	29	9	0	14	Amplification of ocean acidification as quantified seems relevant for the ES. [Hans-Otto Poertner and WGII TSU, Germany]	Accepted; the ES has been strengthened in relation to OA
21341	3	29	10	29	12	Nearly 2 decades ahead of atmospheric forcing is mentioned, but no year is given. Even though the timing confidence is medium here, a year estimate would be helpful. The first sentence of the previous paragraph suggests that the earlier timing could be 2080 or 2050. The difference is important enough to be explicit about. [Steven Chown, Australia]	Accepted; year added

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
18999	3	29	11	29	11	Clarify the 'atmospheric forcing' [APECS Group Review, Germany]	Accepted; changed atmospheric to direct anthropogenic CO2 forcing
30345	3	29	24	29	24	Change "This" to "this threshold" [Paul Glaser, United States of America]	Accepted
21343	3	29	24	29	25	Growing evidence that is acceptable within the date range for papers for this report suggests that organisms are able to effect repair and adapat to conditions. This work is not adequately reflected in this statement. See for example work by Cross et al. 2015 JEMBE. At the very least a medium confidence statement is required. [Steven Chown, Australia]	Taken into account; ecosystems impacts are considered in subsequent section
26385	3	29	28	29	31	These confidence levels are not clearly supported by the evidence given. The intuition makes sense, but it is not yet transparent with the provided references. [Ethan Pierce, United States of America]	Accepted; have clarified the confidence of the timing
32369	3	29	32	29	32	Changes in radiation budget are not discussed in this report. Presumably, changes in sea ice, ice shelves and in cloud dynamics will result in a change in the radiation input to the surface of the ocean. This will impact the heat budget of the ocean as well as ecosystems. Some attention to this would be worthwhile. This would help explain to the reader why increased and earlier primary production occurs with a reduction in winter sea ice cover. [Andrew Constable, Australia]	Taken into account; the section on Arctic physics includes discussion of the solar radiation impacts. Length restrictions preclude detailed separate sections on radiation, clouds etc.
31155	3	29	33	40	21	The magnitudes of changes in ecosystems are not identified in most of this section on ecosystem impacts. [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account. We agree, but this is hard to deal with. Some numbers are now provided for Bering, Barents and Chukchi sea where possible. For example, we have added numbers to the change in distribution of Atlantic mackerell from a recent paper (in Box 3.4). Data is very limited in most regions of the Arctic.
30939	3	29	33	43	21	In this entire impact section, please indicate where findings are new since WGII AR5 and in particular where the new findings contradicts previous reports (if this is the case). [Hans-Otto Poertner and WGII TSU, Germany]	Accepted. We now highlight where new evidence since AR5 is presented. For instance of borealization of the Arctic.
5649	3	29	39	0		It would be useful if "pelagic" and "benthic" could be defined briefly. [Nina Hunter, South Africa]	Accepted. Pelagic and benthic are now defined in the glossary.
19001	3	29	39	29	39	How about sympagic, i.e., sea ice-associated? I would suggest changing this in the following way: "consequences at different trophic levels in the sympagic, pelagic and benthic realms". [APECS Group Review, Germany]	Accepted. We agree that the sypagic realm was covered to too little degree in our SOD. We have strengthened this several places.
24049	3	29	40	29	42	Of the changes affecting Arctic marine life the disapperance of multi year sea ice is one of the most profound. I would advice to discuss this here. The multi year sea ice support the entire under ice Arctic ecosystem [Peter Thor, Sweden]	Accepted. In this ecosystem section we cannot discuss the physical aspects, but we now several places refer to reduction in multi-year ice coverage instead of just ice coverage.
19019	3	29	43	29	43	This sentence is vague. What does this exactly have to do with 'marine impacts' - maybe give some examples from the cited papers. [APECS Group Review, Germany]	Taken into account. The whole section has been rewritten
19003	3	29	43	29	44	It woul be more informative to expand on this and specify in which way modulation is expected to manifest. [APECS Group Review, Germany]	Taken into account. The whole section has been rewritten
19005	3	29	44	29	46	This sentence is vague/unclear, possibly to be rephrased? [APECS Group Review, Germany]	Taken into account. The whole section has been rewritten
19007	3	29	48	29	48	What is "watermass layering"? I think I understand what the authors mean but I am not sure this is the right/best way to express it. [APECS Group Review, Germany]	Accepted. We now write "stratification" and refer to section 3.2.1.2 where this is discussed in depth

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
19009	3	29	48	29	49	First, I would place a "-" between pelagic and benthic, i.e., "pelagic-benthic". Second, it is missing sympagic as well, i.e. "sympagic-pelagic-benthic". See my comments above and more below about the lack of description of the sympagic community in this chapter/section. [APECS Group Review, Germany]	Accepted. Rewritten as suggested. The sympagic realm is now generally better covered.
19011	3	29	50	29	50	What are the "system level" responses? [APECS Group Review, Germany]	Accepted. "system" has been changed to "ecosystem". There are many different responses, we give examples.
29795	3	29	51	29	54	The text here, and elsewhere, only seems to consider benthic secondary production and not benthic primary production which is projected to increase with warming and associated melting of sea ice, though increased turbidity may to some extent locally counteract this. [Dorte Krause-Jensen, Denmark]	Noted. Benthic primary production is not ignored, but we agree that (due to space limitations) the coverage is weaker than we would like. Please note that we in the online supplementary material have the subchapter 3.A.2.6 Climate Change Impacts on Arctic Kelp Forests. Chapter 5 also has a good coverage of kelp
30921	3	29	51	29	54	In this sentence it does not become clear why less of the primary production will reach the benthic realm because of thinning sea ice and/or earlier ice retreat. Please clarify here or refer to section where details are given. [Hans-Otto Poertner and WGII TSU, Germany]	The mechanisms underlying this statement regarding benthic pelagic coupling are described in Moore et al. 2016 and Stasko et al 2018. There was insufficient room to fully describe the complex processes in this assessment report.
9129	3	29	52	0		Insert 'the' before 'Chukchi' [Nina Hunter, South Africa]	Accepted. Done.
19013	3	29	53	29	54	Why is it so? Cause of changes in species composition?Or? [APECS Group Review, Germany]	We added Stasko et al 2018 that provides additional detail regarding the processes underlying export of organic matter to the benthos.
19021	3	29	54	29	57	Sentence is phrased incorrectly. should say '...ocean acidification are expected to...'	Accepted. Content is as before, but rephrased
32031	3	29	54	29	57	Not clear what this sentence is stating: Is the word "As" missing at the beginning of the sentence? [Christian Reuten, Canada]	Accepted. Content is as before, but rephrased
19015	3	29	56	29	56	The part of the sentence before the comma seems to be disconnected by that before the comma. [APECS Group Review, Germany]	Accepted. Content is as before, but rephrased
19023	3	30	1	30	1	It would be more informative to provide at least an example for direct and one for indirect pathways. [APECS Group Review, Germany]	Added reference to Figure 3.4 and the subsequent sections which examples of direct and indirect impacts.
19025	3	30	2	30	2	It is missing a reference at the end of this sentence. [APECS Group Review, Germany]	Added reference to Figure 3.4 and the subsequent sections which examples of direct and indirect impacts.
19027	3	30	6	30	6	Rather than "derived" I would say "participating to". [APECS Group Review, Germany]	Taken into consideration. Rewritten
9131	3	30	7	0		"Kara Seas" should be "Kara Sea" [Nina Hunter, South Africa]	Taken into consideration. Change to "Bering, Chukchi, Barents and Kara seas"
19029	3	30	8	30	10	This sentence should be better linked to earlier sections of this chapter where CMIP5 are presented/discussed. At least by referring to them. [APECS Group Review, Germany]	Taken into consideration. Reference to Fig. 3.3 given.
9133	3	30	10	0		Replace 'impacts' with 'impact' [Nina Hunter, South Africa]	Accepted
21659	3	30	12	0		3.2.3.1.1 Plankton and primary production. Ice algae within the sea ice play very important roles in polar marine ecosystems. They are one of the most vulnerable organisms in Polar Oceans under ongoing climate change. However, too little portion for ice algae is described in the section of 3.2.3.1.1. Especially, it would be great if the authors include various melt ponds ecosystems on arctic sea ice. [Government of Republic of Korea, Republic of Korea]	Accepted. The sympagic realm is now generally better covered. Although briefly, melt ponds are now mentioned.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
26387	3	30	12	0		How will changes in dust deposition affect primary production in the Arctic? This is mentioned in Chapter 5, but is also relevant to the discussion here. [Ethan Pierce, United States of America]	Rejected. We agree it may be relevant, but do not have space to cover it here, but leave it for the more general Ch. 5.
19031	3	30	12	30	12	The title of this section could change for "algal primary production" to include also sympagic production. Or sympagic production could be presented in a separate subsection. [APECS Group Review, Germany]	Taken into consideration. The title "Plankton and primary production" does not indicate a restriction to pelagic primary production, but also includes ice algae. The sympagic realm is now generally better covered.
29683	3	30	12	30	12	I think that somewhere in the section there is a need to explain where the nutrients for the blooms are coming from. Were they in the ocean all along, and what was lacking was light? Are they from atmospheric deposition, with some component due to human influences? Do they accumulate on ice and then end up coming off melting ice in the melt water? What? Why was the phytoplankton not there before? There is a lot in the section about what is happening and observed, but not about why. [Michael MacCracken, United States of America]	Accepted. These mechanisms are discussed in the cited literature. We added reference to Moore et al. 2018
29797	3	30	12	30	12	ing to read e.g.: [Dorte Krause-Jensen, Denmark]	Rejected. Part of the comment is unfortunately missing?
11901	3	30	12	31	3	Impacts of potentially harmful species should be assessed under scenarios of increased water temperature within coastal waters of the Arctic Ocean. For example, the potential for blooms species, such as Phaeocystis spp., may increase in Arctic waters as surface water temperatures increase. [Jun Sun, China]	Rejected. We do not disagree that this potentially may be important, but do to strict length restrictions we have not included HABs.
11903	3	30	12	31	3	A subsurface primary production maximum (SPM) during the summer in the Arctic Ocean is an important characteristic which largely contribute to the overall primary productivity. The recent studies considered the contribution of SPM to total Primary production estimates (Popova et al. 2010; Ardyna et al., 2013; Martini et al., 2016; Hill et al., 2018). Popova et al. (2010) estimated that the SPM accounts for 46% of annual Arctic Ocean production. In addition, Martin et al., (2013) observed 65 to 90% of annual IPP in the Beaufort Sea occurring at the SPM, driven by stratification and surface oligotrophic conditions. Therefore, the contribution to the SPM in APP estimates is still an important subject to talking. [Jun Sun, China]	Taken into account. We agree that subsurface primary production is an important element of the overall energy budget of Arctic marine ecosystems. We address the role of thinner ice and light on production. There was insufficient space to extend this discussion to subsurface production.
11899	3	30	13	31	3	Changes in the diversity and productivity of the sea ice algae combined with changes of the timing and regions of ice melt and formation will impact on Arctic primary productivity. [Jun Sun, China]	We did not change our sentence. We felt the issues included in the suggested change were adequately incorporated by the existing sentence.
29799	3	30	14	30	14	I suggest substituting "lower trophic levels" with "primary producers" to make it more clear what is in focus. [Dorte Krause-Jensen, Denmark]	Accepted. "Primary producers" is indeed better and more precise
28263	3	30	15	30	18	contrary result: long term decrease in phytoplankton standing stock in the Arctic https://www.nature.com/articles/nature09268 [Benedikt Ehrenfels, Switzerland]	Rejected. The results of this paper from 2010 doesn't affect the validity of our conclusions. The paper looks at long term (100 year) trends, we are more interested in recent developments. The validity of the results of this paper has also been questioned.
21657	3	30	17	0		in situ should be consistent with previous one [Government of Republic of Korea, Republic of Korea]	Rejected. We can't find anything wrong in this sentence.
29801	3	30	23	30	23	I suggest adding a section on changes in benthic primary production or referring to a section reporting this (e.g. the benthic section 3.2.3.1.2). There are several relevant studies e.g. from Greenland and Svalbard. [Dorte Krause-Jensen, Denmark]	Rejected. There are other sections on benthos, and although (as written above) we would have liked to have more room for information on benthic primary production there is some material presented.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
953	3	30	24	0		There are many phytoplankton blooms due to nitrogen release and contamination in the ocean and rivers; that should be mentioned, Barrow in Alaska is a classic case [Falk Huettmann, United States of America]	Rejected. There are other sections on benthos, and although (as written above) we would have liked to have more room for information on benthic primary production there is some material presented.
27551	3	30	24	30	43	Sea ice ridges are briefly introduced here but I suggest expanding on this with a couple sentence to paragraph indicating that sea ice ridges may become more important algal hotspots with increased drift speeds and deformation (e.g., Itkin et al., 2017;2018). In addition to Fernandez-Mendez et al., 2017, Also, include first study to report high biomass ridges within the Arctic Ocean (Lange et al., 2017). Itkin, P., G. Spreen, B. Cheng, M. Doble, F. Girard-Ardhuin, J. Haapala, N. Hughes, L. Kaleschke, M. Nicolaus, and J. Wilkinson (2017), Thin ice and storms: Sea ice deformation from buoy arrays deployed during N-ICE2015, Journal of Geophysical Research: Oceans, 122(6), 4661-4674, doi:10.1002/2016jc012403. Itkin, P., G. Spreen, S. M. Hvidegaard, H. Skourup, J. Wilkinson, S. Gerland, and M. A. Granskog (2018), Contribution of Deformation to Sea Ice Mass Balance: A Case Study From an N-ICE2015 Storm, Geophys. Res. Lett., 45(2), 789-796, doi:10.1002/2017gl076056. Lange, B. A., C. Katlein, M. Fernández-Méndez, M. Nicolaus, I. Peeken, and H. Flores (2017), Assessing spatial variability of Arctic sea ice-algal biomass and primary production using under-ice horizontal profiling platforms, Frontiers in Marine Science: Ocean Observation, doi:10.3389/fmars.2017.00349. [Benjamin A. Lange, Canada]	We added a sentence and referenced Lange et al 2017.
27553	3	30	24	30	43	It would also be worthwhile to mention that our estimates of MYI NPP may be substantially underestimated due to presence of previously overlooked high biomass features and the lack of studies present within the MYI covered ocean (Lange et al., 2017). Lange, B. A., et al. (2017), Pan-Arctic sea ice-algal chl a biomass and suitable habitat are largely underestimated for multi-year ice, Global Change Biol., doi:10.1111/gcb.13742. [Benjamin A. Lange, Canada]	We added a reference to Lange et al. 2017.
19033	3	30	26	30	26	Are both values in brackets referred to means or peaks? Could it be possible to specify it? [APECS Group Review, Germany]	Corrected, it was peak value
13191	3	30	26	30	34	The effects of ocean acidification on the zooplankton community are not well covered, this chapter is a very poor representation of what we know of the effects of ocean acidification on pelagic zooplankton community. At the moment, only pteropods are mentioned but this is not sufficient because it neglects existing knowledge and does not provide real assessment of the current and future effects. This should be expanded. [NINA BEDNARSEK, United States of America]	Accepted. This section was revised to provide a more balanced review of the literature.
19039	3	30	28	30	32	The phrasing of this sentence should be cleaned up so that it flows better - right now the phrases between commas are not joined by a common idea ('areas of... a large amount of cracks' does not make sense). [APECS Group Review, Germany]	Taken into account. We have added a ",". Otherwise we think the sentence, although complex is correct.
13193	3	30	29	30	32	The reference for pteropods are misleading. There are more studies on pteropods not just from Peck, the most notable being Lishka et al., 2011, 2012, 2016. The results from Lischka shows that all the pteropod responses will be negatively affected and this is significantly different from Peck, which is currently represented as the only reference. All Lischka references need to be included to balance this area and the low confidence should be replaced with the medium confidence for their sensitivity. [NINA BEDNARSEK, United States of America]	Accepted. This section was revised to provide a more balanced review of the literature.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
13195	3	30	29	30	32	Howes is not a correct reference here because it is a review paper. The original reference needs to be included. [NINA BEDNARSEK, United States of America]	The sentence was changed to be general therefore use of a review paper here was appropriate to save space.
19041	3	30	30	30	30	My understanding is that the authors of this study sampled 2 separate areas: first year ridges and the snow-ice interface, NOT just the snow-ice interface at first year ridges. The phrasing should be made to reflect this if this is the conclusion the authors have come to [APECS Group Review, Germany]	Taken into account. The present phrasing should cover this well.
9511	3	30	35	30	35	NPP (Northwest Passage Project) is not in the Glossary. Acronyms should be defined. [Government of France, France]	Rejected. NPP is Net Primary Production and it is defined earlier in the same section.
29685	3	30	35	30	35	"may" needs to be replaced by words from the IPCC lexicon, even if saying "it is possible that". I'll stop making these comments every time--a scrub of the chapter needs to be done. [Michael MacCracken, United States of America]	Accepted. Confidence levels have been added in this paragraph and the "may" replaced
19035	3	30	42	30	43	Why? Not all the readers might be aware that this is because usually smaller cell algae require less nutrients. It would be appropriate to specify it. [APECS Group Review, Germany]	Accepted. This information now included.
19037	3	30	45	30	50	This is the only part of this chapter that discusses, though little, changes related to sympagic dynamics. I would suggest to change/extend this paragraph in the following way: "In addition to its impact on phytoplankton bloom dynamics, the decline in the proportion of multiyear sea ice and proliferation of a thinner first year sea ice cover may favor growth of microalgae within the ice due to increased light availability (medium confidence). Sea-ice algae form a large fraction of sea-ice (sympagic) biomass (Poulin et al., 2010). Prior to phytoplankton blooming, sea ice provides a critical habitat and sea-ice algae the sole food source for upper trophic levels, while together with sub-ice phytoplankton, they represent the foundation of ecological interactions in the sea-ice biome (Post et al., 2013). Recent studies suggest that the contribution of sea ice algae to total Arctic NPP is higher now than values measured previously (Song et al., 2016), accounting for nearly 10% of total NPP (ice+water) and as much as 60% in places like the central Arctic (Fernández-Méndez et al., 2015). Tedesco et al. (Under Evaluation) investigated future changes in timing and intensity of algal primary production in Arctic first-year ice using a combination of 18 CMIP5 and sea-ice biogeochemistry models under RCP 8.5 scenario. Overall, model results suggest a general increase in sea-ice primary production during this century with non-linear projected phenological changes across latitudes and explained by changes in physical drivers such as snow cover, photoperiods and time windows of growth, suggesting potential consequences for the Arctic marine food web beyond the ones being previously envisaged." Reference: Tedesco, L., Vichi, M., Scoccimarro, E., Under Evaluation. Sea-ice phenology in a warmer Arctic. Science Advances; M. Poulin, N. Daugbjerg, R. Gradinger, L. Ilyash, T. Ratkova, C. von Quillfeldt, The pan-Arctic biodiversity of marine pelagic and sea-ice unicellular eukaryotes: a first-attempt assessment. Mar. Biodivers. 41, 13–28 (2010). [APECS Group Review, Germany]	Taken into account. We thank the reviewers for thorough input. We have included a short paragraph and reference to Fernández-Méndez (2015) based on it. Space limitation does not allow us to be more detailed.
27549	3	30	47	30	50	I'm not sure I agree with this statement. Gosselin et al., 1997 showed a similar range of ice algal NPP contributions during the early 90s. Perhaps rephrase and/or include this study somehow. [Benjamin A. Lange, Canada]	Taken into account. Our statement reads "Observed in detail for the first time in the Arctic in 2011" so we don't rule out that a single occurrence has been described earlier. In this report one should generally not refer to work from before AR5 (ca 2014)

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
30925	3	30	57	31	1	When referring to the appendix for the impact on macroalgae, maybe also refer to 3.2.3.1.2 (benthic communities; p31-32), as (indirect) impact on kelp is briefly mentioned there. [Hans-Otto Poertner and WGII TSU, Germany]	Accepted. Reference to 3.2.3.1.2 and Ch 5 included.
29803	3	31	1	30	1	Macroalgae are mentioned in a paranthesis here. It is unclear what is being referred to. Please ensure proper focus on macroalgae/benthic vegetation here or in the benthic section (e.g. Seek inspiration from the excellent chapter on macroalgae in Chapter 5, which also to some extent covers polar macroalgae.) [Dorte Krause-Jensen, Denmark]	Accepted. Reference to 3.2.3.1.2 and Ch 5 included.
19045	3	31	1	31	3	This is an interesting point that would deserve to be further expanded. [APECS Group Review, Germany]	Rejected. Due to strict length restrictions and need to cut text this sentence has been removed. This also because it did not fit in with the rest of the paragraph. Impacts of cidification is covered elsewhere.
28265	3	31	5	31	5	one additional paragraph (or at least sentence) about the coupling of phyto- and zooplankton would be important to address the energy transfer efficiencies across trophic levels under changing environmental conditions. such a part could start as follows: 'Regardless of changes in NPP, temporal decoupling of phytoplankton blooms and zooplankton life cycles will lead to decreasing energy transfer efficiencies from primary productivity to higher trophic levels...' See: - on bottom up control of marine ecosystems: http://science.sciencemag.org/content/308/5726/1280 - coupling of Arctic marine phytoplankton and zooplankton: http://www.nrcresearchpress.com/doi/abs/10.1139/cjfas-2012-0401 ; https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1365-2486.2010.02175.x ; - coupling of phytoplankton and zooplankton in a lake: https://esajournals.onlinelibrary.wiley.com/doi/abs/10.1890/04-0151 [Benedikt Ehrenfels, Switzerland]	Taken into account. This is now partly covered. We underline the importance of this coupling, but do not include the suggested references (they are from some years back, pre AR5 references are very seldom included).
9135	3	31	9	0		for the' to replace 'to' [Nina Hunter, South Africa]	Accepted.
23751	3	31	11	31	14	While the Ershova study do indeed show increased biomass in Chukchi Sea, neither the Hunt or the Rutzen/Hopcroft study show any long term climate related increase in biomass in the central basin. Please check and revise as appropriate. [Government of Sweden, Sweden]	Taken into account and revised.
24055	3	31	11	31	14	While the Ershova study do indeed show increased biomass in Chukchi Sea, neither the Hunt or the Rutzen/Hopcroft study show any long term climate related increase in biomass in the central basin. [Peter Thor, Sweden]	Taken into account and revised.
9513	3	31	16	31	16	SRES (Special Report on Emissions Scenarios) is not in the Glossary. Acronyms should be defined. [Government of France, France]	Taken into account. This paragraph has been rewritten and shortened. Reference to (the somewhat old) SRES has been deleted.
30923	3	31	16	31	16	provide full title for SRES and indicate what characterises scenario A1B. [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account. This paragraph has been rewritten and shortened. Reference to (the somewhat old) SRES has been deleted.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
1859	3	31	16	31	24	I suggest to include som cautioness of the impacts of cc on biological production. For example in the Barents Sea: Using the A1B scenario Skaret et al 2014 found increased primary (+36%) and secondary production (+23%) production. Using the RCP4.5 scenario and comparing a regional downsclng with its driving global climate model, Skogen et al 2018 show that despite spatial differences, for the Barents Sea both models show no future change in primary production. Slagstad et al (2015) predicts a general decrease in primary production except for areas where ice retreats in 2100 under A1B using the SINMOD model and climate forcing from MPI-ECHAM5. Slagstad D., Wassmann P., Ellingsen I. 2015. Physical constrains and productivity in the future Arctic Ocean. Frontiers in Marine Science , 2: 85. Skaret G., Dalpadado P., Hjøllø S., Skogen M., Strand E. 2014. Calanus finmarchicus abundance, production and population dynamics in the Barents Sea in a future climate. Progress in Oceanography , 125: 26. MD Skogen, SS Hjøllø, AB Sandø, J Tjiputra (2018). Future ecosystem changes in the Northeast Atlantic: a comparison between a global and a regional model system ICES Journal of Marine Science [Solfrid Sætre Hjøllø, Norway]	Taken into account. We thank the reviewer for good and thorough input. We think the text now is more cautious on changes both for primary production and zooplankton.Unfortunately word limitations prohibits us from adding substantial new text and the references suggested.
31041	3	31	17	31	27	Can you provide a direction - positive or negative change? [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account. This paragraph has been rewritten and shortened and the sentence refered to deleted.
19047	3	31	20	31	21	I believe the first comma is misplaced cause the sentence seems a bit disconnected. [APECS Group Review, Germany]	Accepted. Rewritten.
5019	3	31	22	31	24	True for all warming scenarios? [Debra Roberts and Durban Team, South Africa]	Taken into account. We can unfortunately deal properly with this as the authors of the Dalpadado et al. paper did not consider specific scenarios, but only a more vague continuation of the observed trend.
1861	3	31	26	31	34	I think important here is as reported as key message in "The AMAP Assessment 2018:Arctic Ocean Acidification" : some species will respond positively while others negatively to OA, but that Arctic Marine ecosystems will undergo significant changes. [Solfrid Sætre Hjøllø, Norway]	Accepted.
28267	3	31	26	31	34	More sources on combined effects of warming and ocean acidification on calcifying organisms like pteropods: - https://academic.oup.com/icesjms/article/65/3/414/789605 - https://oceanrep.geomar.de/10179/ - https://www.nature.com/articles/nature04095 - https://www.frontiersin.org/articles/10.3389/fmars.2018.00486/full - https://www.nature.com/articles/s41467-017-02692-w [Benedikt Ehrenfels, Switzerland]	Rejected. We thank the reviewer for providing information, but strict length restrictions prohibit us to cover such combined effects.
28269	3	31	26	31	34	emphasize that the expected impacts of aragonite undersaturated waters are negative (the original sentence is neutral) [Benedikt Ehrenfels, Switzerland]	Taken into account. Some more text on this topic has been added showing that that the severity of effects are dependent on emission scenarios and the species sensitivity and adaptive capacity.
28271	3	31	26	31	34	A paragraph or a few sentences could be added with respect to the trophic implications of changing plankton communities. Many studies show that the provision of different essential fatty acids for example depends on a diverse phytoplankton community, because the plankton taxa all have different fatty acid and lipid signatures. [Benedikt Ehrenfels, Switzerland]	Taken into account. Due to the restricted word count we can not go into this in any detail, but it is now touched upon.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
23753	3	31	28	31	34	The knowledge on the effects of ocean acidification on Arctic zooplankton would seem to be severely underrepresented in the text, see for example the newly published report on Arctic Ocean Acidification by the Arctic Monitoring and Assessment Programme: https://www.amap.no/documents/doc/AMAP-Assessment-2018-Arctic-Ocean-Acidification/1659 and references therein. Specifically the chapter on biological effects. [Government of Sweden, Sweden]	Taken into account. Some more text on this topic has been added. Due to page limitations it is unfortunately not possible to discuss all of the various studies given in these comments. We added a reference to Falkenberg.
23755	3	31	28	31	34	The notion of resiliens of pteropods in the Arctic may need some further crafting, see the recent AMAP report and references therein (https://www.amap.no/documents/doc/amap-assessment-2018-arctic-ocean-acidification/1659): "... pteropods have been suggested to be particularly sensitive to forecasted ocean acidification as their shells are made of aragonite, a relatively soluble form of biogenic calcium carbonate (Manno et al. 2017). Many of the studies considering the response of the Arctic members of this group have focused on <i>Limacina helicina</i> . Under ocean acidification, these pteropods have demonstrated increased mortality (Lischka et al. 2011, but no effect in Comeau et al. 2012), reduced shell size (Lischka et al. 2011), reduced shell extension (Comeau et al. 2012), decreased precipitation of calcium carbonate (correlated to the aragonite saturation state) (Comeau et al. 2010), increased shell degradation (Lischka et al. 2011, Lischka & Riebesell 2012), unchanged respiration rates and gut clearance rates (Comeau et al. 2010), and lower egg organogenesis (Manno et al. 2016). The species <i>Limacina retroversa</i> has shown similar patterns of increased shell degradation under ocean acidification (Lischka & Riebesell 2012)... In addition to considering physiological responses of individual organisms, it will also be necessary to assess effects at the population and community level (discussed further below). In terms of copepods, mesocosm studies have shown that despite clear ocean acidification effects on <i>C. glacialis</i> copepodites in laboratory studies such as those described above, no differences were found in stage development during the summer growth season for organisms held in experimental mesocosms deployed in the Kongsfjord, West Svalbard (Niehoff et al. 2013). This mesocosm study also showed that copepod species composition did not change under acidification treatments. Thus, other effects, biotic or abiotic, may have countered the direct effects of increased pCO ₂ . For instance, acidification effects may have been mitigated by elevated food intake as primary production, and hence the availability of phytoplankton prey, increased with pCO ₂ (Engel et al. 2013)." Etc. [Government of Sweden, Sweden]	This sentence and others were revised to provide a more balanced review of the literature
24057	3	31	28	31	34	Our knowledge on the effects of ocean acidification on Arctic zooplankton is severely underrepresented in the text. This is a major error! Refer to the newly published report on Arctic Ocean Acidification by the Arctic Monitoring and Assessment Programme: https://www.amap.no/documents/doc/AMAP-Assessment-2018-Arctic-Ocean-Acidification/1659 and references therein. Specifically the chapter on biological effects (Falkenberg et al. 2018). Ref: Falkenberg, L.J., A. Jelmert, F.C. Mark, B. Rost, K.G. Shulz, P. Thor (2018) Biological responses to ocean acidification. In: AMAP Assessment 2018: Arctic Ocean Acidification.pp. 15-41. Arctic Monitoring and Assessment Programme (AMAP), Tromsø, Norway. [Peter Thor, Sweden]	Taken into account. We now cite Falkenberg. Due to page limitations it is not possible to discuss all of the various studies.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
24059	3	31	28	31	34	<p>From Falkenberg et al. 2018: "... pteropods have been suggested to be particularly sensitive to forecasted ocean acidification as their shells are made of aragonite, a relatively soluble form of biogenic calcium carbonate (Manno et al. 2017). Many of the studies considering the response of the Arctic members of this group have focused on <i>Limacina helicina</i>. Under ocean acidification, these pteropods have demonstrated increased mortality (Lischka et al. 2011, but no effect in Comeau et al. 2012), reduced shell size (Lischka et al. 2011), reduced shell extension (Comeau et al. 2012), decreased precipitation of calcium carbonate (correlated to the aragonite saturation state) (Comeau et al. 2010), increased shell degradation (Lischka et al. 2011, Lischka & Riebesell 2012), unchanged respiration rates and gut clearance rates (Comeau et al. 2010), and lower egg organogenesis (Manno et al. 2016). The species <i>Limacina retoversa</i> has shown similar patterns of increased shell degradation under ocean acidification (Lischka & Riebesell 2012)." [Peter Thor, Sweden]</p>	Accepted. This report is now cited
24061	3	31	28	31	34	<p>from Falkenberg et al. 2018: "A particular focus has been placed on <i>Calanus</i> spp., specifically the Arctic copepod <i>Calanus glacialis</i>. In this species, ocean acidification effects vary with developmental stage. The developmental rate of nauplius larvae appears largely unaffected by acidification, probably as a result of physiological buffering by changes to the universal stress response (including DNA repair, redox regulation, protein folding, proteolysis) and upregulation of cellular ion transport, particularly sodium/proton antiporters (Bailey et al. 2016, Bailey et al. 2017). In contrast, the copepodite stages seem more sensitive. In the early copepodite stages (CII-CIII), ocean acidification seems to induce increased costs of biosynthesis (Thor et al. 2016). In copepodites from the Kongsfjord, Thor et al (2016) found a 2.5 times greater increase in metabolic rates due to feeding at elevated pCO₂. Further studies have shown that the relationship between metabolic rate and ingestion rate is similarly affected in the later CIV stage: in <i>C. glacialis</i> from two fjords on the Svalbard west coast scope for growth (a measure of the energy available for growth calculated as ingestion rate times gut absorption efficiency minus metabolic rate) decreased by up to 50% under increased pCO₂ (Thor et al. 2018). Such changes to both early and late copepodite stages would have serious implications for the <i>C. glacialis</i> population. Reductions in scope for growth on this scale will prolong stage development time and reduce the individual body size of the developing copepodites and ultimately also reduce adult body size. In contrast to the effects on earlier copepodite stages, the last copepodite stage (CV) seems unresponsive to increased pCO₂. Several studies have shown no effects on rates of ingestion and metabolism in this stage (Hildebrandt et al. 2014, Hildebrandt et al. 2015, Thor et al. 2016). This non-response likely occurs as CV copepodites are metabolically different than the earlier stages. That is, while somatic growth is the main response in the preceding stages, metabolism is largely reconfigured to accommodate overwintering diapause in CVs. During diapause, <i>C. glacialis</i> CV experience extracellular pH as low as 5.5 (possibly as a result of metabolic depression during hibernation) (Freese et al. 2015). In adult <i>C. glacialis</i> fecundity also seems unaffected by high pCO₂ both in terms of egg production and egg hatching success and timing (Weydmann et al. 2012, Thor et al. 2018).</p> <p>In addition to considering physiological responses of individual organisms, it will also be necessary to assess effects at the population and community level (discussed further below). In terms of copepods, mesocosm studies have shown that despite clear ocean acidification effects on <i>C. glacialis</i> copepodites in laboratory studies such as those</p>	Accepted. This report is now cited

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
1857	3	31	29	31	29	Luckman et al., 2014: wrong reference? [Solfrid Sætre Hjølo, Norway]	Accepted. The reviewer is right. We have deleted this citation.
19043	3	31	29	31	29	The Luckmann (2014) paper is not an appropriate reference for the preceeding statement. [APECS Group Review, Germany]	Accepted. The reviewer is right. We have deleted this citation.
29805	3	31	36	31	36	"Benthic communities": Please in the title and text specify that "benthic communities" here refers to both primary and secondary producers. If benthic primary production is not included in the previous section (3.2.3.1.1) then please add it here. Please also expand discuss potential changes in the composition/diversity of the benthic primary producers - currently there is only 1 sentence mentioning biomass changes on kelps in Svalbard. There are many relevant studies on changes in benthic vegetation with climate change also from e.g. Greenland (e.g. Krause-jensen et al. 2012, Krause-jensen & Duarte 2014, Marba et al 2017, Olesen et al 2015 [Dorte Krause-Jensen, Denmark]	Taken into account. Benthic primary production is not ignored, but we agree that (due to space limitations) the coverage is weaker than we would like. Please note that we in the online supplementary material have the subchapter 3.A.2.6 Climate Change Impacts on Arctic Kelp Forests. Chapter 5 also has a good coverage of kelp
24069	3	31	36	32	14	The present knowledge on the effects of ocean acidification is ignored for benthic organisms. [Peter Thor, Sweden]	Accepted. This section was revised to provide a more balanced review of the literature.
24071	3	31	36	32	14	from Falkenberg et al 2018 on coraline algae "For example, where a Svalbard population of Lithothamnion glaciale was considered, the relative net calcification rate decreased under elevated pCO2 conditions – suggesting conditions are currently near the peak of the parabola, with any change sufficient to drive a shift past a tipping point such that a reduction is observed (Büdenbender et al. 2011). The response observed can, however, be dependent upon the experimental period considered; in laboratory cultures L. glaciale maintained growth rates when exposed for 3 months (Ragazzola et al. 2012), but rates were reduced if exposed for 10 months (Ragazzola et al. 2013)." [Peter Thor, Sweden]	Accepted. This section was revised to provide a more balanced review of the literature.
24073	3	31	36	32	14	from Falkenberg et al on cold water corals: "under longer-term exposures of weeks to months L. pertusa from a range of locations have been found to maintain calcification rates (e.g. Form & Riebesell 2012, Maier et al. 2013a, Maier et al. 2013b, Hennige et al. 2014, Movilla et al. 2014, Hennige et al. 2015), suggesting that Arctic L. pertusa may also be able to calcify under persistent ocean acidification if they have enough food to meet their metabolic costs (Rodolfo-Metalpa et al. 2015). The cold-water coral M. oculata has also been found to be able to maintain calcification rates under ocean acidification scenarios in a range of locations (e.g. Movilla et al. 2014)." [Peter Thor, Sweden]	Accepted. This section was revised to provide a more balanced review of the literature.
24075	3	31	36	32	14	from Falkenberg et al 2018 on bivalves: "the bivalves, which include clams, oysters, and scallops. Of these, the responses of Macoma calcarea, Astarte montagui, and Astarte borealis (clams) from the Pacific Arctic have been experimentally investigated in the context of ocean acidification. At the completion of the experiment, it was found that the shells of A. borealis showed a decrease in length, with the other species unaffected. In addition, wet weight and oxygen consumption were not significantly different for any of the species, although there was a trend for these features to be negatively affected (Goethel et al. 2017). Other Arctic bivalves, Chlamys islandica and Ciliatocardium ciliatum, have also been investigated (Iglikowska et al. 2017). In a field study, there was a subtle difference in the aragonitic content of the bivalve shells linked to depth and, consequently, also with water ion concentration, pH and CO2 content (Iglikowska et al. 2017)." [Peter Thor, Sweden]	Accepted. This section was revised to provide a more balanced review of the literature.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
24077	3	31	36	32	14	fromk Falkberg et al 2018 on brittlestars: "). ...brittlestars have also shown little change in terms of oxygen consumption (Wood et al. 2010), metabolism (Wood et al. 2008), mobility (Wood et al. 2010), and the percentage calcium and magnesium in arm (Wood et al. 2010). It is worth noting, however, that ocean acidification has been linked to increased larval mortality (Dupont et al. 2008, Chan et al. 2015), reduced larval swimming speeds (Chan et al. 2015), abnormal development and skeletogenesis (Dupont et al. 2008), reduced arm regeneration (Hu et al. 2014a), considerable muscle wastage (Wood et al. 2008), reduced metabolic rates (potentially reflecting uncompensated acidosis) (Hu et al. 2014a), and increased ammonium excretion rates (Hu et al. 2014a)." [Peter Thor, Sweden]	Accepted. This section was revised to provide a more balanced review of the literature.
24079	3	31	36	32	14	from Flakenberg et al 2018 on sea stars: "Sea stars from polar environments have been found to respond negatively to ocean acidification scenarios. That is, while reduced pH may have little effect on fertilization (Gonzalez-Bernat et al. 2013), it can affect the larvae by reducing survival, normal development, and morphology (i.e. shape and size) (Gonzalez-Bernat et al. 2013, Karelitz et al. 2017)." [Peter Thor, Sweden]	Accepted. This section was revised to provide a more balanced review of the literature.
24081	3	31	36	32	14	from Falkenberg et al 2018: "Arctic crabs appear sensitive to ocean acidification. In the spider crab, <i>Hyas araneus</i> , greatly increased pCO ₂ (3000 µatm; in contrast to the current of 380 µatm) caused increased development time and reduced survival of zoea I larvae in the Kongsfjord (Walther et al. 2011, Schiffer et al. 2014). Similarly, even at a more moderate pCO ₂ (710 µatm) effects were observed, although they were less pronounced (Walther et al. 2011). Moreover, physiological processes may be impaired in <i>H. araneus</i> larvae exposed to acidification. Larvae from the Kongsfjord showed lower capacity for calcium incorporation at high pCO ₂ than those from other regions, suggesting that crab larvae developing at the cold end of the species distribution range may be more sensitive to ocean acidification than those in temperate regions (Walther et al. 2011). " In the northern shrimp <i>Pandalus borealis</i> , larval development is also negatively affected by increased pCO ₂ . A study on <i>P. borealis</i> from the Norwegian coast (59° latitude) showed that while egg hatching is unaffected, the development of all tested zoea larval stages (II, III, and IV) was significantly slower at ca. 1200 µatm CO ₂ (Bechmann et al. 2011, Arnberg et al. 2013). These effects may be alleviated at higher temperature (increase from 6.7 to 9.5 °C), so direct pCO ₂ effects may be masked by future climate change (Arnberg et al. 2013). [Peter Thor, Sweden]	Accepted. This section was revised to provide a more balanced review of the literature.
19049	3	31	42	31	42	In which way impactic benthic species composition? [APECS Group Review, Germany]	Species responses differ with respect to their sensitivity to, and scope for adaptation to, climate change. There was insufficient space to discuss individual species responses.
9137	3	31	43	0		Insert 'the' before 'introduction' [Nina Hunter, South Africa]	Accepted.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
16167	3	31	55	31	57	"By using A1B scenario, Wallhead et al. (2018) found sea urchin biomass and harvest in the Northern Norway could reduce by a factor of seven over the next 30 years under ocean warming and acidification. Citation: Wallhead, P.J., Chen, W., Falkenberg, L., Norling, M., Bellerby, R., Dupont, S., Fagerli, C., Dale, T., Hancke, K., Christie, H., 2018. Annex 2: Urchin harvesting and kelp regrowth in northern Norway under ocean acidification and warming. In: AMAP Assessment 2018: Arctic Ocean Acidification. pp. 79-90 Arctic Monitoring and Assessment Programme (AMAP), Tromsø, Norway." [Wenting Chen, Norway]	This section was revised to provide a more balanced review of the literature. There was not space to discuss individual species responses.
16169	3	31	55	31	57	"Through long period field work and monitoring, Christie et al. (2019) find multitrophic interactions such as northern movement of Cancer crabs which prey on sea urchins under ocean warming may contribute to recovery of large scale kelp recovery (Citation: H. Christie, H. Gundersen, E. Rinde, K. Filbee-Dexter, K. M. Noderhaug, T. Pedersen, T. Bekkby, J. K. Gitmark and C. W. Fagerli(2019). "Can multitrophic interaction and ocean warming influence large-scale kelp recovery?", Ecology and Evolution , Upcoming issue.)" [Wenting Chen, Norway]	Rejected. We thank the reviewer, but due to severe length restrictions we were not able to include this. Kelp issues are dealt with more thoroughly in chapter 5.
31623	3	32	1	0		Figure 3.4. Being a foodweb, some elements like mining, tourist and CO2 seem misplaced. If the relationship between these misplaced elements and the foodweb is meant to be depicted, then the corresponding arrows or connections need to be more clear. [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account. The figure is totally remade.
9515	3	32	4	32	4	It is not "bardi" but "bairdi". [Government of France, France]	Accepted.
29807	3	32	5	32	5	Please change "are also stressed" to "are also affected" [Dorte Krause-Jensen, Denmark]	Accepted.
30927	3	32	13	32	14	Talking about "thermal behavior" of a species sounds weird. I would suggest something like thermal niche, thermal window, temperature preferences, temperature tolerance, ... [Hans-Otto Poertner and WGII TSU, Germany]	Accepted. This has been rewritten
2819	3	32	16	0		Numerous literatures have pointed out that the distribution range and habitat depth of arctic fish have shifted due to climate changes. For example, Fossheim et al. (2015) indicated that boreal fish communities are expanding northwards in Barents Sea. Therefore, a text regarding the impact climate changes have on arctic fish diversity pattern is suggested to be added in the session. Fossheim M , Primicerio R , Johannesen E , et al. Recent warming leads to a rapid borealization of fish communities in the Arctic[J]. Nature Climate Change, 2015, 5(7), 673-677. [Hai Li, China]	Rejected. No need to change as this is in Box 3.4, which also is referred to here.
2821	3	32	16	0		The distribution range of arctic fishes shifted due to climate changes, correspondingly, the structure and function of arctic marine food web alters. For example, Kortsch et al. (2015) indicated that the structure of arctic marine food web greatly influenced due to the boreal generalists poleward movement, which had a profound impact on arctic marine ecosystem dynamics and functions. Therefore, a text regarding the impact climate changes have on ecological dynamics of arctic fishes is suggested to be added in the session. Kortsch S, Primicerio R, Fossheim M, et al. Climate change alters the structure of arctic marine food webs due to poleward shifts of boreal generalists[J]. Proceedings of Royal Society B, 2015, 282(1814): 11-20. [Hai Li, China]	Rejected. No need to change as this is in Box 3.4, which also is referred to here.
23995	3	32	16	34	5	With a non specialist reading, I could not understand the overall perspective for Arctic fisheries from this section, the SPM section (see first comment), the Chapter summary (p3 33-43) and Box 3.3. The overall consistency should be checked. [Patricia Martinerie, France]	Rejected. We do not fully understand the comment

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
16165	3	32	23	32	25	"AMAP (2018) chap. 3 has found the Atlantic cod stock and hence harvest in the Barents sea could potentially reduce due to juvenile cod is sensitive to ocean acidification change. Ref. MAP, 2018. AMAP Assessment 2018: Arctic Ocean Acidification. Arctic Monitoring and Assessment Programme (AMAP), Tromsø, Norway. " [Wenting Chen, Norway]	Taken into consideration. There is not substantial enough evidence to include such a strong and severe conclusion (harvest), but potential future effects on cod larvae of acidification including two references are now included.
30929	3	32	23	32	25	Did the suitable feeding areas for species such as Atlantic cod really «expand» or have they just been shifted northwards? [Hans-Otto Poertner and WGII TSU, Germany]	Taken into consideration, but not changed. The suitable feeding area has indeed expanded for the Barents Sea cod (covered in Box 3.4). For Atlantic cod as a species the distribution can be considered to have moved northwards as several of the southern populations are in decline.
27555	3	32	25	32	31	The discussion on <i>Boreogadus saida</i> should include discussions additional relevant studies and the role of sea ice in the life cycle of this fish. E.g.,: David, C., B. Lange, T. Krumpen, F. Schaafsma, J. A. van Franeker, and H. Flores (2015), Under-ice distribution of polar cod <i>Boreogadus saida</i> in the central Arctic Ocean and their association with sea-ice habitat properties, <i>Polar Biol.</i> , doi:10.1007/s00300-015-1774-0. Kohlbach, D., F. L. Schaafsma, M. Graeve, B. Lebreton, B. A. Lange, C. David, M. Vorkamp, and H. Flores (2017), Strong linkage of polar cod (<i>Boreogadus saida</i>) to sea ice algae-produced carbon: evidence from stomach content, fatty acid and stable isotope analyses, <i>Prog. Oceanogr.</i> , 152, 62-74, doi:10.1016/j.pcean.2017.02.003. [Benjamin A. Lange, Canada]	Rejected. Much as we would like to include more on this important species the space limitation does not allow this.
17349	3	32	28	32	31	The particular adaptation of high-latitude herbivorous zooplankton to extreme seasonal primary production results in intensive feeding and lipid accumulation during spring/summer and overwintering at larger depths becoming less available for planktivorous fish. This has a trophically cascading effect on high-latitude ecosystems consisting of boreal and Arctic/Antarctic species. Climate change with poleward displacement of marine species has been predicted to decrease abundance of marine species and diversity at low latitudes and increase abundance of marine species at high latitudes. However, at the highest latitudes this can only happen if invasive planktivorous species from lower latitudes are able to change their life cycle by increasing the lipid content during spring/summer enough to sustain life during the winter without enough primary production. This fact has not been considered in present climate change predictions, but the idea has been outlined by Sundby et al. (2016) (Sundby, S., Drinkwater, K. and Kjesbu, OS. 2016. The North Atlantic spring-bloom system - where the changing climate meets the winter dark. <i>Frontiers in Marine Science</i> 3:28. doi: 10.3389/fmars.2016.00028) where critical latitudes are defined polewards of 64 to 66 degrees. [Svein Sundby, Norway]	Taken into consideration. This information and the reference is now included in Box 3.4
9139	3	32	30	0		Insert 'the' before 'reduced' [Nina Hunter, South Africa]	Rejected. We think the original wording is correct (as is the suggested change)
23757	3	32	38	32	43	Knowledge on ocean acidification effects on Arctic fish stocks should also be considered. For instance, cod larvae, <i>Gadus morhua</i> , have shown increased mortality at RCP8.5 year 2100 OA levels (Stiasny et al 2016). Stiasny, M. H., F. H. Mittermayer, M. Sswat, R. Voss, F. Jutfelt, M. Chierici, V. Puvanendran, A. Mortensen, T. B. H. Reusch, and C. Clemmesen. 2016. Ocean Acidification Effects on Atlantic Cod Larval Survival and Recruitment to the Fished Population. <i>PLoS ONE</i> 11:e0155448. [Government of Sweden, Sweden]	Accepted. Text and two references on this are now included.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
24063	3	32	38	32	43	It is unfortunate that our knowledge on ocean acidification effects on Arctic fish stocks are not represented. For instance, cod larvae, <i>Gadus morhua</i> , have shown increased mortality at RCP8.5 year 2100 OA levels (Stiasny et al 2016). Stiasny, M. H., F. H. Mittermayer, M. Sswat, R. Voss, F. Jutfelt, M. Chierici, V. Puvanendran, A. Mortensen, T. B. H. Reusch, and C. Clemmesen. 2016. Ocean Acidification Effects on Atlantic Cod Larval Survival and Recruitment to the Fished Population. PLoS ONE 11:e0155448. [Peter Thor, Sweden]	Accepted. Text and two references on this are now included.
23137	3	32	41	32	43	example of sentence which is so generic that it is true but lacks substance. [Valerie Masson-Delmotte, France]	Accepted. The whole paragraph is deleted
9517	3	33	0	0		Seems that the suspension feeders are not well represented. They eat microbial food, but also phyto and zooplankton. [Government of France, France]	Taken into account. Figure 3.4 has been entirely remade
3173	3	33	1	33	1	This figure is confusing with all of the arrows. It might be helpful to make some sort of predator/prey flow chart to demonstrate the food web relationships. [Sloane Garelick, United States of America]	Taken into account. Figure 3.4 has been entirely remade
3449	3	33	1	33	1	Extremely cluttered - perhaps group together taxa which fill similar ecological niches to reduce the number of arrows. [Patrick Orenstein, United States of America]	Taken into account. Figure 3.4 has been entirely remade
3451	3	33	1	33	1	Clarify the caption: this is referred to as a food web but includes other elements such as CO2 input and the effect of mining, both of which impact the ecosystem but are not predators or prey [Patrick Orenstein, United States of America]	Taken into account. Figure 3.4 has been entirely remade
26391	3	33	1	33	4	This food web schematic is not exhaustive enough to be a strong reference figure and not clear enough to be a strong introductory figure. The non-ecosystem processes seem to be chosen at random. The connections are too complex to convey any meaningful information. [Ethan Pierce, United States of America]	Taken into account. Figure 3.4 has been entirely remade
27557	3	33	1	33	4	There is a critical piece missing from this diagram and I am quite surprised this was pulished in the CAFF 2017 report. This should include a key pathway from ice algae to zooplankton. Numerous studies show the importance of ice algae produced carbon to the diet of zooplankton (both sympagic and pelagic species). This carbon has also been documented to transfer to higher trophic levels and almost all components of this diagram. Noteworth are the polar bears, seals, polar cod and whales. Refer to the wealth of information on the transfer of ice algal produced carbon to Arctic foodwebs found in papers listed in my next comment. [Benjamin A. Lange, Canada]	Taken into account. Figure 3.4 has been entirely remade
31043	3	33	1	33	4	Could this be modified to show how the food web may change under climate change eg highlight most vulnerable links? [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account. Figure 3.4 has been entirely remade

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
27559	3	33	1	40	21	<p>This section 3.2.3 Impacts on Marine Ecosystems should include appropriate discussion on the importance of ice algal produced carbon within polar food webs and the possible consequences for projected changes of sea ice habitat and sea ice associated primary production. I strongly suggest reviewing the following studies and possibly invite one of the authos/specialists in sympagic foodweb ecology to join in contributing to this report section "3.2.3 Impacts on Marine Ecosystems". I can recommend the following experts in this field: Shiway Wang, Suzanne Budge, Doreen Kohlbach, Hauke Flores, Janne Sorreide and Thomas Brown. Wang, S. W., S. M. Budge, K. Iken, R. R. Gradinger, A. M. Springer, and M. J. Wooller (2015), Importance of sympagic production to Bering Sea zooplankton as revealed from fatty acid-carbon stable isotope analyses, <i>Mar. Ecol. Prog. Ser.</i>, 518, 31-50, doi:10.3354/meps11076. Wang, S. W., A. M. Springer, S. M. Budge, L. Horstmann, L. T. Quakenbush, and M. J. Wooller (2016), Carbon sources and trophic relationships of ice seals during recent environmental shifts in the Bering Sea, <i>Ecol. Appl.</i>, 26(3), 830-845, doi:10.1890/14-2421. Budge, S. M., M. J. Wooller, A. M. Springer, S. J. Iverson, C. P. McRoy, and G. J. Divoky (2008), Tracing carbon flow in an arctic marine food web using fatty acid-stable isotope analysis, <i>Oecologia</i>, 157(1), 117-129, doi:10.1007/s00442-008-1053-7. Søreide, J. E., M. L. Carroll, H. Hop, W. G. Ambrose, E. N. Hegseth, and S. Falk-Petersen (2013), Sympagic-pelagic-benthic coupling in Arctic and Atlantic waters around Svalbard revealed by stable isotopic and fatty acid tracers, <i>Mar. Biol. Res.</i>, 9(9), 831-850, doi:10.1080/17451000.2013.775457. Kohlbach, D., M. Graeve, B. A. Lange, C. David, I. Peeken, and H. Flores (2016), The importance of ice algae-produced carbon in the central Arctic Ocean ecosystem: food web relationships revealed by lipid and stable isotope analyses, <i>Limnol. Oceanogr</i>, 61(6), 2027-2044, doi:10.1002/lno.10351. Kohlbach, D., M. Graeve, B. A. Lange, C. David, F. L. Schaafsma, J. A. van Franeker, M. Vortkamp, A. Brandt, and H. Flores (2018), Dependency of Antarctic zooplankton species on ice algae-produced carbon suggests a sea ice-driven pelagic ecosystem during winter, <i>Glob Chang Biol</i>, 24(10), 4667-4681, doi:10.1111/gcb.14392. Brown, T. A., M. P. Galicia, G. W. Thiemann, S. T. Belt, D. J. Yurkowski, and M. G. Dyck (2018), High contributions of sea ice derived carbon in polar bear (<i>Ursus maritimus</i>) tissue, <i>PLoS One</i>, 13(1), e0191631, doi:10.1371/journal.pone.0191631. Schmidt, K, Brown, TA, Belt, ST, Ireland, LC, Taylor, KWR, Thorpe, SD, Ward, P, Atkinson. A (2018) Do pelagic grazers benefit from sea ice? Insights from the Antarctic sea ice proxy IPSO25. <i>Biogeosciences: 1987-2006</i>. Jia Z, Swadling KM, Meiners KM, Kawaguchi S, Virtue P (2016) The zooplankton food web under East Antarctic pack ice–A stable isotope study. <i>Deep Sea Res (II Top Stud Oceanogr)</i> 131:</p>	<p>Accepted. We thank the reviewer for valuable input. Our word limit doesn't allow for a full new section on ice algae and their role in carbon production, but we have introduced some text on the topic and included some of the references given by this reviewer.</p>
220	3	33	1	40	70	<p>Figures 3.4 and 3.5 are inconsistent graphically. 3.4 has an insane number of arrows connecting the different parts of the food web, while 3.5 has almost none. Important taxa, phenomena & societal effects are named in both, but they are graphically inconsistent. Also, 3.5 is in partial 3D while 3.4 is in 2D. I'm not sure why you have so many schematics, but they should have overall goals and design consistency at least. [Baylor Fox-Kemper, United States of America]</p>	<p>Taken into consideration. We discussed ways of making the two figures more similar. The complexity and regional heterogeneity of impacts made adding detail to Figure 3.4 challenging</p>
16299	3	33	3	33	3	<p>If the (adverse) relationship between foodweb and mining/drilling is not covered in the assessment, it is probably better not to show the oil rig. It may be appropriate, however, to briefly discuss indirect effect of climate change -> more sea ice free area -> potentially more fossil resource extraction -> negative impact on ecosystem. You cover e.g. transportation effects under 3.2.4, maybe there this issue can be elaborated on. [Alexander Nauels, Germany]</p>	<p>Taken into account. Figure 3.4 has been entirely remade</p>

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
574	3	33	3	33	4	The thin white fonts of the labels is hard to read, and in some cases too small (e.g. copepod) in general. Maybe insets could be used for these so that they organisms and text do not have to be so small. It's also a more representative of the actual sizes. Perhaps this level of detail is not necessary, and is expressed well in Figure 3.5 [Jenna Pearson, United States of America]	Taken into account. Figure 3.4 has been entirely remade
19051	3	33	3	33	4	From Fig. 3.4 one would think that the only connection for sea ice algae is with benthic communities.. [APECS Group Review, Germany]	Taken into account. Figure 3.4 has been entirely remade
9141	3	33	13	0		invertebrates' should be singular [Nina Hunter, South Africa]	Accepted
1863	3	33	23	33	23	"The indirect effects of changing ocean conditions include impacts on prey quality and distribution." Does "distribution" refer to distribution in time and space to include possible changes in timing of blooms and match-mismatch between prey and fish (juveniles or larvae), and can any conclusions be drawn? [Solfrid Sætre Hjøllø, Norway]	Rejected. We haven't gone into match-mismatch relations in detail.
5021	3	34	4	34	4	Drop "IBM" as it is not used anywhere else in the chapter [Debra Roberts and Durban Team, South Africa]	Accepted
24439	3	34	7	34	24	section 3.2.3.1.4 is pelted with references. One argument has nine! References listed. Normally 3 references per argument is generous. Probably good idea to edit references generally. [veijo pohjola, Sweden]	Accepted. The section has been rewritten so no statements have too many references.
30931	3	34	7	35	21	Uncertainty language/likelihood rarely used in entire section. Please check whether confidence/likelihood can be assigned to some more statements. [Hans-Otto Poertner and WGII TSU, Germany]	Accepted. Our CA for this section has revised and now included confidence language.
30347	3	34	8	34	14	The authors may also want to cite some recent publications by Mallory and his colleagues on changing sea bird populations in "hotspots" for species diversity and also the role of sea birds in transporting contaminants (e.g. plastics) from marine environments inland. [Paul Glaser, United States of America]	Taken into account, but rejected for reasons of lack of space.
899	3	34	10	39	30	Already modeled and stated please use and see citation: [Falk Huettmann, United States of America]	Rejected. Part of the comment is missing and it relates to 5 pages so impossible to follow up on.
5635	3	34	12	0		Change "by especially" to "especially by" [Nina Hunter, South Africa]	Taken into account. Sentence has been rewritten so this is no longer an issue.
31045	3	34	14	34	14	So what happened to the kittiwakes? [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account. Sentence expanded to include information on what happened (abrupt decline in many populations following warming event, while gradual warming in a different period had little effect)
9519	3	34	44	34	44	It is not "Eschrichtus", but "Eschrichtius" [Government of France, France]	Accepted
27611	3	34	47	35	21	Would it make sense to add information here about the linkages between climate change and chemicals here? Material can be found in the AMAP report "biological effects of contaminants on arctic wildlife and fish" (2018). [Government of Norway, Norway]	Taken into account, but rejected for reasons of lack of space.
5287	3	34	47	35	4	I would add a comment about how changing sea ice conditions are changing the feeding habits of polar bears (Dey et al. 2018). They show that with earlier melt and later freeze-up, the bears feed on eider eggs. This is stabilizing the common eider population which was increasing due to sea ice conditions. That study emphasizes the importance of considering many interacting factors when studying Arctic wildlife. Dey C. J., Semeniuk C. A. D., Iverson S. A., Richardson E., McGeachy D. and Gilchrist G. 2018. Biological Conservation, vol. 220, pp. 94-103. [Benoit Montpetit, Canada]	Taken into account, but rejected for reasons of lack of space.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
33317	3	34	54	34	57	See also Regehr at al. The statement some populations are stable because "protective management measures have been succesful" is not correct. Some populations simply haven't been affected yet because food sources have been accessible despite changing ice conditions. Check this. [Government of United States of America, United States of America]	Rejected. We thank the reviewer for the additional information, but consider the evidence backing our statement to be strong. E.g., for some population hunting is generally prohibited and this has had a positive effect. Note that the statement says "some populations", we don't claim this is the case for all.
24441	3	35	0	0		Table 3.1 not intitutive. I understand the blue symbols show increase/decrease but as a function of what? Increase or decrease of the parameters on the column head? It says in the text that relation show positibve/negative relation with the column header. Write that our more clear, to avoid confusion. [veijo pohjola, Sweden]	Taken into account. Table deleted in FD version based on review comments. Information on direct effects of changes in physical parameters incorporated into Figure 3.6.
16301	3	35	6	35	15	Please remove redundant sentence and merge. [Alexander Nauels, Germany]	Accepted. Something went wrong in the editing of the SOD. This two paragraphs have been edited and redundant information removed.
19057	3	35	6	35	19	This section is repetitive. Cut the sentences that say the same things. [APECS Group Review, Germany]	Accepted. Something went wrong in the editing of the SOD. This two paragraphs have been edited and redundant information removed.
2381	3	35	6	35	21	Most of the material in the first paragraph is repeated in the second. Delete the first paragraph while "rescuing" anything of interest that is not in the second paragraph. [george Hunt, United States of America]	Accepted. Something went wrong in the editing of the SOD. This two paragraphs have been edited and redundant information removed.
19053	3	35	12	35	13	I think those two paragraphs shoul be not separated. [APECS Group Review, Germany]	Accepted. Something went wrong in the editing of the SOD. This two paragraphs have been edited and redundant information removed.
29687	3	35	13	35	14	How is it known that the diets are not changing because the temperature change leads to different food opportunities due to relocation of fisheries, etc.? Is it really temperature that is that factor, or something resulting because of the change in temperature? Some clarification of causal trends would be useful. [Michael MacCracken, United States of America]	Taken into account. We just point to a link to temperature. No space for discussing mechanisms, unfortunately.
19055	3	35	36	35	36	Why there is "-" between" ice" and "berg"? [APECS Group Review, Germany]	Editorial. Changed to iceberg
33319	3	35	46	35	57	Suggest that the caption for Table 3.1 should be more clear as to the triangle slopes. Since the blue triangles aren't placed within graphs with axes, the phrase "upwards sloping triangle" may not be clear to all. Especially since some readers' native language may proceed from right to left, suggest being explicit and expanding the phrase to, e.g., "upper sloping [left-to-right] triangle". [Government of United States of America, United States of America]	Taken into account. Table deleted in FD version based on review comments. Information on direct effects of changes in physical parameters incorporated into Figure 3.6.
30935	3	35	46	36	1	(i) I see why you changed it, but for me table was clearer and much easier to understand before (FOD version with the arrows), showing the response to expected change. Now it is difficult to read and less easy to understand what is expected to happen. (ii) it should say «Notothenioid Fish» (guess you want to include the icefishes, right?). (iii) Why are macroalgae not considered? They play an important role in bays of several islands. [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account. Table deleted in FD version based on review comments. Information on direct effects of changes in physical parameters incorporated into Figure 3.6.
19059	3	36	0	36		Table 3.1: I find this table a bit hard to follow with this kind of geometric symbols. [APECS Group Review, Germany]	Taken into account. Table deleted in FD version based on review comments. Information on direct effects of changes in physical parameters incorporated into Figure 3.6.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
23141	3	36	0	36		Missing level of confidence or level of scientific understanding. [Valerie Masson-Delmotte, France]	Taken into account. Table deleted in FD version based on review comments. Information on direct effects of changes in physical parameters incorporated into Figure 3.6 (with associated levels of confidence).
712	3	36	1	36	1	Perhaps a table is a better and easier way to present the information than a figure. [Mengxi Wu, United States of America]	Taken into account. Table deleted in FD version based on review comments. Information on direct effects of changes in physical parameters incorporated into Figure 3.6 (with associated levels of confidence).
3447	3	36	1	36	1	Does not show relative biomass or compare ecological importance of the taxons to the polar ecosystem. [Patrick Orenstein, United States of America]	Taken into account. Table deleted in FD version based on review comments. Information on direct effects of changes in physical parameters incorporated into Figure 3.6 (with associated levels of confidence).
11423	3	36	1	36	1	The shapes shown are incredible unhelpful. It would be easier to use "+", "-", or "o" for positive, negative, nonlinear relationship instead of using ambiguous shapes that don't portray the message in a straightforward way. [Anson Cheung, United States of America]	Taken into account. Table deleted in FD version based on review comments. Information on direct effects of changes in physical parameters incorporated into Figure 3.6 (with associated levels of confidence).
13201	3	36	1	36	1	The table is very confusing with the stars that actually confirm the patterns while the text below the table indicates the variation. EG. Bednarsek et al., 2012 confirm negative OA effects but with the asterisk in that box, the reader might interpret t this as a variation to the pattern. This needs changes for the unequivocal interpretation. [NINA BEDNARSEK, United States of America]	Taken into account. Table deleted in FD version based on review comments. Information on direct effects of changes in physical parameters incorporated into Figure 3.6 (with associated levels of confidence).
21345	3	36	1	36	1	Table 3.1 is not up to the standard expected from IPCC reports and in keeping with Mastrandrea et al's (2010) guidance for IPCC authors. In almost every case there are examples of studies that suggest greater uncertainty than proposed by the Table and trends that are either different to those shown or are spatially variable. The citations used do not reflect the state of current knowledge. The Table is unhelpful and in fact just an inaccurate cartoon. [Steven Chown, Australia]	Taken into account. Table deleted in FD version based on review comments. Information on direct effects of changes in physical parameters incorporated into Figure 3.6 (with associated levels of confidence).
33321	3	36	1	36	1	In Table 3-1, remove 'n' in "ocean acidificonnn". Suggest the authors consider modifying this figure for diatoms and Phaeocystis. See S. Trimborn, S. Thoms, T. Brenneis, J.P. Heiden, S. Beszteri, K. Bischof Two Southern Ocean diatoms are more sensitive to ocean acidification and changes in irradiance than the prymnesiophyte Phaeocystis antarctica. Physiol. Plant. (2017). [Government of United States of America, United States of America]	Taken into account. Table deleted in FD version based on review comments. Information on direct effects of changes in physical parameters incorporated into Figure 3.6 (with associated levels of confidence). A reference to the findings from Trimborn et al. (2017) has been added to section 3.2.3.2.1 on plankton.
26393	3	36	1	36	2	This figure would benefit from a depiction of the relative magnitude of each forcing. Perhaps a summary figure for each row, showing the best guess of net changes to biomass? It is also not clear how the rows are organized. Is this by total biomass? Again, some indication of the relative magnitude/importance of each row would improve the utility of this figure. [Ethan Pierce, United States of America]	Taken into account. Table deleted in FD version based on review comments. Information on direct effects of changes in physical parameters incorporated into Figure 3.6 (with associated levels of confidence).
29809	3	36	1	36	4	please include benthic vegetation! I suggest splitting the last row of the table in two: one for benthic vegetation, one for benthic fauna... Temperature and sea ice retreat is expected to stimulate the distribution of benthic flora (e.g. Krause-Jensen et al. 2014). [Dorte Krause-Jensen, Denmark]	Taken into account. Table deleted in FD version based on review comments. Information on direct effects of changes in physical parameters incorporated into Figure 3.6 (with associated levels of confidence).

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
30933	3	36	3	36	4	It is not clear what you want to say with this note. Which original version of the table? [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account. Table deleted in FD version based on review comments. Information on direct effects of changes in physical parameters incorporated into Figure 3.6 (with associated levels of confidence).
19061	3	36	7	36	7	As for the Arctic case, I would suggest to change the title for "Algal primary production" to include at least a short description of the sympagic dynamis, at the moment totally missing. I would suggest to add a short paragraph as I suggested above for Arctic sea ice algae. [APECS Group Review, Germany]	Rejected. Antarctic sea ice algae are not missing from this section - the text includes an assessment of the effects of acidification on sea ice algae. The title for this section has been changed to Plankton and pelagic primary production.
29811	3	36	7	36	7	The section is called "Plankton and primary production". Please consider if it should be "Plankton and pelagic primary production" (here and in the section in general), opening up for benthic primary production being treated in another section or if the section should also include benthic primary production, which it currently does not. In any case I suggest specifying throughout whether primary production and NPP refers to pelagic, benthic or sea ice algae. There are several studies reporting colonization of Antarctic seafloors upon retraction of glaciers/seaiice, e.g. Quarantino et al. 2013, Deregibus et al. 2016.. [Dorte Krause-Jensen, Denmark]	Taken into account. The text clearly refers to column-integrated phytoplankton biomass and to column-integrated primary production. Further clarifications that this section refs to pelagic primary production have been added in the revised draft and the title for the section has been changed. Changes in benthic algal communities are treated in section 3.2.3.2.5.
27267	3	36	7	37	12	Suggestion: Include more data concerning changes on phytoplankton in Guerlach Strai and West Antarctic Pe n insula- Mendes et al. 2018 EEP-SEA RESEARCH PART II-TOPICAL STUDIES IN OCEANOGRAPHY, v. 149, p. 161-170, 2018- Deep Sea research- ; Lange et al. Antarctic Science (Print), v. 37, p. 1-15, 2014. and Vanzan et al.Polar Biology (Print), v. 38, p. 1267-1284, 2015. [Gleyci Moser, Brazil]	Taken into account. Some additional findings regarding changes in phytoplankton and primary production in the WAP region have been included in the revised draft, however we are constrained by space and required to focus on key updates in understanding since IPCC AR5.
19063	3	36	11	36	11	inclusive seems to be disconnected by the rest of the sentence. [APECS Group Review, Germany]	Accepted. The word 'inclusive' has been deleted.
21347	3	36	14	36	17	The WAP statements fail to reflect the very different upper mixed layer depth changes through time between the northern and southern parts of the WAP. These spatial dynamics are a critical element of the system and need to be mentioned. Schofield has several papers dealing with them. See the same issue of Phil Trans R Soc A that Kim et al.'s 2018 paper is in. [Steven Chown, Australia]	Accepted. A reference to Schofield et al. (2018) and an asesment statement for the north-south differences in mixed layer depth and associated phytoplankton productivity has been included in the revised draft.
19065	3	37	0	37		Table 3.2. I find this table too full of text that I am not sure whether it would be easier to understand if just discussed within the text. [APECS Group Review, Germany]	Taken into account. The text in this table has been shortened in the revised draft.
23143	3	37	0	37		Missing level of confidence or level of scientific understanding. [Valerie Masson-Delmotte, France]	Accepted. Confidence levels are included in the revised draft.
33323	3	37	7	37	13	Westwood et al. (2018) indicate that it's an important implication of acidification to consider that, overall, OA may reduce production in Antarctic coastal waters, thereby reducing food availability to higher trophic levels and reducing draw-down of atmospheric CO2, thus forming a positive feedback to climate change. It may be useful to add discussion about species-specific effects of acidification on diatoms and Phaeocytis here: S. Trimborn, S. Thoms, T. Brenneis, J.P. Heiden, S. Beszteri, K. BischofTwo Southern Ocean diatoms are more sensitive to ocean acidification and changes in irradiance than the prymnesiophyte Phaeocystis Antarctica. Physiol. Plant. (2017). [Government of United States of America, United States of America]	A reference to findings from Trimborn et al. (2017) has been included in the revised draft. The ecosystem implications of possible OA-related changes in production in coastal waters is considered very low confidence and so is not referred to in the text.
21661	3	37	10	0		in situ should be consistent with previuos one [Government of Republic of Korea, Republic of Korea]	Editorial. Unclear what this comment is referring to - editorial? 'In situ' has been italicized in the revised draft.
21663	3	37	13	0		"from" should be removed here [Government of Republic of Korea, Republic of Korea]	Editorial. The citation style has been changed in the revised text.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
27179	3	37	22	37	28	I am not sure Medium Confidence is appropriate in this statement. I would suggest it would be Low Confidence as it is written. However, the sentence would benefit from rewording to clarify the issues. As stated, it is unclear whether the confidence relates to the decline or a discontinuous change. Both are useful points. Although an important point, the discontinuous change point should probably be low confidence given the limited sources. [Eugene Murphy, United Kingdom (of Great Britain and Northern Ireland)]	Accepted. The statements have been reworded to better clarify the two separate points and their associated references and levels of confidence.
30941	3	37	26	37	28	Please provide the references supporting these confidence statements. [Hans-Otto Poertner and WGII TSU, Germany]	Accepted. These statements have been clarified and appropriately referenced.
21351	3	37	30	37	32	Here and elsewhere in the Chapter, Trebilco et al in review is mentioned. The work is not published and is in consequence not accessible. I checked the Methods in Ecology & Evolution site at 10h46 AEST 11/01/2019 and found no evidence of the work. It is not acceptable to cite work that nobody has access to. [Steven Chown, Australia]	Taken into account. We followed IPCC guidelines in citing this work (the cut-off date for submitted papers to be cited in the second order draft was 15th October and all 'in review' papers cited in our text were submitted before this date). All cited 'in review' manuscripts are provided to the IPCC TSU following IPCC guidelines so that they are available for reviewers to access on request. References to this particular paper have been deleted from the FD because the manuscript is still in the final review stages.
27181	3	37	32	0		Additional reference - a modelling study which considered circumpolar controls (including temperature) on growth of krill around the Southern Ocean, and also included points about impacts of warming. Murphy, E.J., Thorpe, S.E., Tarling, G.A., Watkins, J.L., Fielding, S. & Underwood, P. 2017 Restricted regions of enhanced growth of Antarctic krill in the circumpolar Southern Ocean. Sci Rep 7, 14. (doi:10.1038/s41598-017-07205-9). [Eugene Murphy, United Kingdom (of Great Britain and Northern Ireland)]	Accepted. Additional reference to Murphy et al. 2017 has been included.
29689	3	37	34	37	34	But there are limits to moving southward due to the presence of the Antarctic continent/ice sheet, and to shrinking area in more southerly latitude belt. Something about this and its consequences might be said--it is like running out of space as species try to keep cool by moving to higher altitudes--pretty soon one hits the mountaintop, and then what? [Michael MacCracken, United States of America]	Rejected. In the Peninsula region (where warming is most rapid) there is greater scope for southwards movement (to a point) than in other regions. The point at which krill might 'run out of space' is currently unclear/undocumented.
15001	3	37	39	37	40	Please replace "and is also the area of operation of the krill fishery" with (New:) "and is also the predominant area..." [Government of Germany, Germany]	Taken into account. Changed to "the main area of operation...".
30943	3	37	40	37	42	Was fishing included in the modelled warming scenarios? Please clarify [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account. This sentence has been shortened and simplified in the revised version.
5637	3	37	41	0		Elsewhere it would be cited "RCP8.5" not "8.5". Suggest changing. [Nina Hunter, South Africa]	Accepted. Changed to RCP8.5
30945	3	37	44	37	44	What are «simple scenarios for change»? please specify. [Hans-Otto Poertner and WGII TSU, Germany]	Accepted. Scenarios have been specified in the revised text.
23145	3	38	0	39		Missing conclusions at the end of sections that can be traced back and forth to the ES. [Valerie Masson-Delmotte, France]	Accepted. Concluding statements have been added to the end of section 3.2.3.2 that are directly traceable to the ES.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
27185	3	38	16	0		Modelling reference on potential impact implications of warming on fish population connectivity. Young, E.F., Tyskland, N., Meredith, M.P., de Bruyn, M., Belchier, M., Murphy, E.J. & Carvalho, G.R. 2018 Stepping stones to isolation: Impacts of a changing climate on the connectivity of fragmented fish populations. <i>Evol. Appl.</i> 11, 978-994. (doi:10.1111/eva.12613). [Eugene Murphy, United Kingdom (of Great Britain and Northern Ireland)]	Accepted. Findings from this paper have been included in the revised text.
5639	3	38	19	0		Additional bracket missing after "2017"; Remove semi-colon after "concentrations" [Nina Hunter, South Africa]	Editorial. Edited as suggested.
32371	3	38	21	38	21	Icefish in marginal habitats - it is worth providing an example of marginal habitats, i.e. the presence of icefish around subantarctic islands, particularly in shallow shelf habitats may be vulnerable. [Andrew Constable, Australia]	Accepted. Clarified as suggested.
30937	3	38	23	38	23	The currently accepted name is <i>Peuragramma antarctica</i> (not <i>antarcticum</i>), please change! (I made this comment already on previous drafts). [Hans-Otto Poertner and WGII TSU, Germany]	Accepted. Apologies. This has been changed again.
27183	3	38	28	38	32	Useful reference for section. Freer, J.J., Partridge, J.C., Tarling, G.A., Collins, M.A. & Genner, M.J. 2018 Predicting ecological responses in a changing ocean: the effects of future climate uncertainty. <i>Mar. Biol.</i> 165, 18. (doi:10.1007/s00227-017-3239-1). [Eugene Murphy, United Kingdom (of Great Britain and Northern Ireland)]	Accepted. Findings from this paper have been included in the revised text.
21353	3	38	29	38	32	The Swart et al. 2018 (<i>Nature Geosci</i>) paper shows that warming is not associated with frontal position change, the basis for the predictions (made with no analysis or data) by Constable et al. (2014). The current statement is therefore out of alignment with the physical changes section of this chapter. The confidence statement given no comprehensive modelling in the Constable et al. 2014 work needs to change to very low. [Steven Chown, Australia]	Taken into account. The references to predicted ocean warming driven habitat shifts for myctophids from the Constable et al. (2014) review paper has been replaced with a more recent species distribution modelling study (Freer et al. 2018) for <i>Electrona antarctica</i> that predicts habitat loss for this species under RCP4.5 and RCP8.5.
31049	3	38	32	38	33	Observed effects - to be clear you are talking historically [Hans-Otto Poertner and WGII TSU, Germany]	Accepted. The word 'observed' has been added as suggested.
31051	3	38	32	38	33	Please add the year range over which this observation holds [Hans-Otto Poertner and WGII TSU, Germany]	Accepted. Year range has been added as requested.
5641	3	38	33	0		Semi-colon should be a colon [Nina Hunter, South Africa]	Editorial. Edited as suggested.
21355	3	38	42	38	44	Here several review papers are cited, of which several have no real comprehensive analysis. At the very least Lynch et al. 2012 <i>Ecology</i> deserves inclusion along with work by Jenouvrier and colleagues. And in particular since they are neglected in favour of an unpublished work by Trebbico that is unavailable. [Steven Chown, Australia]	Taken into account. The review papers are cited to justify the statement regarding regional differences, and the various drivers and consequences are then unpacked (with references) in the subsequent sentences
21357	3	38	42	39	39	The entire section seems to have missed work by Henri Weimerskirch and colleagues, among which is some of the strongest support for changes to seabird populations in the Indian sector of the Southern Ocean and with long enough time series for reasonable attributions. The omission of this work is a substantial oversight. Just the work on wandering albatross, for example, is exceptional by comparison with several of the other studies cited. [Steven Chown, Australia]	Agreed. Work by Weimerskirch and Jenouvrier is cited in this section of the chapter. Sentence expanded to include additional information and we thank the reviewer for the additional information.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
9521	3	38	53	39	2	What condition is the report referring to ? [Government of France, France]	Accepted. We thank the reviewer for spotting the issue: we are referring to body condition.
33325	3	39	4	39	18	Included the following research: Oceanographic mechanisms and penguin population increases during the Little Ice Age in the southern Ross Sea, Antarctica Yang et al 2018 https://doi.org/10.1016/j.epsl.2017.10.027 : ""A new model indicates strong coupling between penguin ecology and atmospheric/oceanic conditions."" [Government of United States of America, United States of America]	Taken into account, but rejected for reasons of lack of space.
5643	3	39	6	0		Commas missing before "Chinstrap" and "King" [Nina Hunter, South Africa]	Accepted. We thank the reviewer for spotting the issue.
31053	3	39	10	39	12	What are the conclusions for climate change? [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account: trends in predator populations related to climate change should be interpreted with caution when data sources or the level of knowledge is incomplete. We have not elaborated further for lack of space/word counts.
5645	3	39	17	0		Bracket missing after "melanophris"); "Jenouvrier" reference should be in same bracket as other references [Nina Hunter, South Africa]	Accepted. We thank the reviewer for spotting the issue regarding the separation of references. The bracket is editorial and will be fixed prior to publication.
9523	3	39	17	39	17	Should be written "antarctica" Species names always are in lowercase letters. [Government of France, France]	Accepted. We thank the reviewer for spotting the issue: it happened likely due to the automatic spell checker somewhere down the line.
32373	3	39	20	39	25	The links between predators and prey are largely hypothesised with few studies undertaking synoptic surveys of prey to determine their aggregation. I would suggest this is medium confidence rather than high confidence. [Andrew Constable, Australia]	Accepted. We thank the reviewer for spotting the issue.
5647	3	39	24	0		Insert "the" after "of" [Nina Hunter, South Africa]	Accepted. We thank the reviewer for spotting the issue.
3829	3	39	28	39	31	True, but regionally such population estimates exist: For the Eastern Weddell Sea (sensu lato) it is presented by GURARIE, E., BENGTON, J., BESTER, M.N., BLIX, A., BORNEMANN, H., CAMERON, M., NORDØY, E., PLÖTZ, J., STEINHAGE, D. & BOVENG, P. 2017. Distribution, density and abundance of Antarctic ice seals in Queen Maud Land and the eastern Weddell Sea. Polar Biology 40:1149–1165. For the Amundsen and Ross Sea it is presented by BENGTON, J.L., LAAKE, J.L., BOVENG, P., CAMERON, M.F. & STEWART, B.S. 2011. Distribution and abundance of Weddell, Ross, crabeater, and leopard seals in the Amundsen and Ross Seas, Antarctica. Deep-Sea Res 58:1261–1276. [Marthan Bester, South Africa]	Taken into account. We have edited the text to refer to regional population estimates. We thank the reviewer for the comment but consider the evidence backing our statement to be strong.
21359	3	39	28	39	31	The Constable et al. 2017 citation is to a report for which the evidence of peer review is not clear. Moreover, the citation link in the references section does not work. The appropriate citation here is Southwell CJ, Bengston J, Bester MN, Blix AS, Bornemann H, et al. 2012. A review of data on abundance, trends in abundance, habitat use and diet of ice-breeding seals in the Southern Ocean. CCAMLR Science 19:49-74 [Steven Chown, Australia]	Accepted. Sentence modified and include new reference. We thank the reviewer for the input
3823	3	39	29	39	29	Species names should be 'Ommatophoca rossii' and 'Lobodon carcinophaga' [Marthan Bester, South Africa]	Accepted. We thank the reviewer for spotting the issues: it happened likely due to the automatic spell checker somewhere down the line.
9525	3	39	29	39	29	It is "Ommatophoca" and not "Omatophoca". [Government of France, France]	Accepted. We thank the reviewer for spotting the issue: it happened likely due to the automatic spell checker somewhere down the line.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
9527	3	39	30	39	30	It is "Leptonychotes" et not "Leptonichotes". [Government of France, France]	Accepted. We thank the reviewer for spotting the issue: it happened likely due to the automatic spell checker somewhere down the line.
3831	3	39	30	39	31	Likely climate change impacts on these Antarctic seal species are summarised by BESTER, M.N., BORNEMANN, H. & McINTYRE T. 2017. Antarctic Marine Mammals and Sea Ice. In: Thomas, D.N. (ed), Sea Ice, 3rd Edition, John Wiley & Sons, Ltd, Oxford. Pp 534-555. [Marthan Bester, South Africa]	Taken into account. Sentence modified to include additional information yet we stand by our findings that there are no unified studies for PIS which attended IPCC specifications: we consider the evidence backing
32375	3	39	35	39	39	That populations increase with food is a truism. The substantial increases in humpback whales is difficult to explain in relation to climate change when they are also recovering from over-exploitation. Some indication of the difficulty in understanding the drivers of this change is needed here. [Andrew Constable, Australia]	Taken into account. Sentence expanded to include additional information
3825	3	39	40	39	40	Species name should be 'Leptonychotes weddellii' [Marthan Bester, South Africa]	Accepted. We thank the reviewer for spotting the issue: it happened likely due to the automatic spell checker somewhere down the line.
31161	3	39	41	0		The description seems incomplete, missing the invasion of benthic crustaceans and the projected conversion of unique ecosystem structure by these crushing predators. [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account. The potential invasion of shell-crushing crabs is treated in Box 3.4 on Invasive Species.
29813	3	39	41	40	17	If following the same logic as for the Arctic section, this chapter should be moved forward. [Dorte Krause-Jensen, Denmark]	Taken into account. The subsections in this section have been restructured in the revised text.
32033	3	39	44	39	50	Figure 3.4 for the Arctic is great. Could a similar figure be created for this section to visualize the different trophic pathways in the Antarctic? There is a reference to Figure 3.5, which is also great to have, but it does not show the trophic pathways adequately. [Christian Reuten, Canada]	Taken into account. We have revised Figure 3.5 (now Figure 3.6) and also included a figure showing foodweb structures for the Antarctic marine ecosystem in the Appendix.
30947	3	39	50	39	53	Please clarify whether fishing is included the modelled warming scenarios. [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account. This sentence has been shortened and simplified in the revised version.
19067	3	40	0	0		Section 3.2.4. How about industry and urbanization in the Arctic? Are those to be mentioned here as possibly further expanding? I am just wondering if this section should also include presentation and discussion of those topics or if those are discussed somewhere else? [APECS Group Review, Germany]	Rejected. The strict word limit doesn't permit us to deal with topics beyond the ones chosen. However, industry is briefly mentioned at several places in ch 3.5.
23147	3	40	0	40		Missing level of confidence or level of scientific understanding, relative importance of these processes, or information on processes better understood in this report than at the time of AR5 [Valerie Masson-Delmotte, France]	Taken into account. This figure has been updated to include levels of confidence. Information on the relative importance of processes is not available, however the revised figure is more directly linked to changes (observed and predicted) described in the main text such that there is increased clarity on which processes are better understood than in AR5.
29815	3	40	13	40	17	Is the confidence low for this statement? There are several other studies as well e.g. Quarantino et al. 2013, Deregibus et al. 2016.. P. 55, l. 23-25 says there is medium evidence for the creation of new marine habitats upon ice-shelf retreat. [Dorte Krause-Jensen, Denmark]	Taken into account. This statement and its associated confidence level relates to light-driven regime shifts from invertebrate communities to macroalgal beds (for which the assessed level of confidence is low). The confidence level for creation of new marine habitats as a result of ice-shelf retreat is assessed separately (in Section 3.3.3.4 as the reviewer identifies).
11425	3	40	18	40	18	Why isn't there a foodweb like Figure 3.4? [Anson Cheung, United States of America]	Taken into account. A foodweb figure is now included in the Appendix for the chapter.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
22387	3	40	18	40	21	The surface warming shown on figure 3.5 is at odds with the observed surface temperature cooling trends in the southern ocean shown in figure 3.3c [Abram Nerilie, Australia]	Accepted. Edited to indicate ocean warming more generally.
30949	3	40	18	40	21	Please indicate in Figure caption what +, ++, +/- should say. This figure is not yet conclusive. [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account. These symbols have been removed from the revised figure.
5651	3	40	19	0		"Figure" in incorrect position [Nina Hunter, South Africa]	Editorial. Edited as suggested.
31625	3	40	19	0		Figure 3.5. In the caption, brief explanation of the story being told with this figure would be helpful here. [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account. Both the figure and the caption have been edited to make the messaging clearer in the revised version.
3175	3	40	19	40	19	This schematic is intended to show the same information as Figure 3.4, but for the Southern Ocean, rather than the Arctic Ocean. It may be easier to compare the two regions if the information is presented in a standardized way (e.g., either creating some sort of table or making the figures more visually similar) [Sloane Garelick, United States of America]	Taken into account. Figures 3.4 and 3.5 (now 3.5 and 3.6) are not intended to show the same information. This is because the nature of these two systems and the level of knowledge is markedly different between the Arctic and the Southern Ocean. While we considered adopting a consistent graphic format, this proved to be impossible given the differences. Instead the two figures present available information. A foodweb schematic for the Southern Ocean has been added to the Appendix of the revised draft.
29817	3	40	19	40	21	Please add benthic primary producers (and associated communities) in this figure. [Dorte Krause-Jensen, Denmark]	Accepted. A representation of benthic primary producers (coastal macroalgae) has been included in the revised figure.
26067	3	40	21	40	21	annual maximum snow water ... or what variable exactly? [Regine Hock, United States of America]	JMT: unclear which section of text this comment refers to
32377	3	41	4	41	6	I suggest simplifyin this sentence to 'The impacts of climate change on marine fisheries will depend upon how future management of those fisheries responds to the risks to the stocks, as well as how the fishers advance capture technologies and how the markets adjust to changes in product quantity and quality'. [Andrew Constable, Australia]	Taken into account. While the suggested sentence is not included directly the content was considered when we did the final rewriting.
3221	3	41	7	41	15	Isn't there some limit with respect to what can be done with management? If warming continues wouldn't new species move into these regions - would the fishing industry adjust and shift to new species? [Sharon Smith, Canada]	Taken into account. We agree and feel that this aspect now is covered.
15003	3	41	13	41	15	Suggestion to delete lines 12-15. Rationale: Example of the Norwegian cod fishery: Is historic climate variability as extreme as the recent changes due to anthropogenic influences? Probably this is not a good comparison. [Government of Germany, Germany]	Rejected. However, while we have kept this example to highlight that there may be positive effects of climate change, we have modified the text and the following paragraph is more negative. The development of the cod fishery under climate change will depend upon the time horizon and RCP. We also refer to other parts of the chapter for nuances.
5653	3	41	14	0		Insert "a" before "thousand" [Nina Hunter, South Africa]	Accepted.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
2383	3	41	23	41	26	There is only 1 sentence on the potential impact of climate warming on the fisheries of the Bering Sea, with no citations. This is unacceptably weak, even given the reference to Section 3.2.3.1.3.. There are numerous refereed papers and reports showing that in warm years with little ice, the production of large lipid-rich zooplankton is severely reduced, and the survival of age-0 pollock (and possibly cod) is poor. The discussion of this material in 3.1.1.1 is not sufficient to cover these issues. [george Hunt, United States of America]	Taken into account. We agree with the reviewer that a more through coverage of the well-studied (eastern) Bering Sea would be advantageous. Unfortunately we are limited by the number of words permitted. The Bering Sea is no less covered than other areas. Actually the Bering Sea is one of only two areas specifically mentioned (the other being the Barents). Citations for the Bering Sea statements are now given (Haynie et al 2012; Holsman et al. 2018;
5655	3	41	25	0		"of" not "if" [Nina Hunter, South Africa]	Accepted. Editorial change done.
2005	3	41	26	41	29	Changes in river conditions such as increased sediment or low water levels will also affect overwintering spawning populations. See AACAC, page 31. A combination of lower precipitation and increased erosion along the riverbanks since the late 1980s and early 1990s results in the chum salmon not having enough places to spawn and a lower salmon return. With rivers eroding, the silt is deposited in eddies or river channels, smothering the salmon eggs. Two years ago, there was barely any snow, and the little snow we had melted and flowed downriver on top of the river ice. It took a while for the river ice to melt, so the fish just stayed out in the ocean until we got some warmer weather. But once the salmon started going upriver, they didn't have enough water. [Laura Eerkes-Medrano, Canada]	Rejected. The comment seems misplaced and is too detailed for us to have space to include.
29819	3	41	30	41	30	please consider adding a potential for exploitation of kelps via sustainable harvest or seaweed aquaculture. In e.g. Norway & Canada there is high focus on this possibility. [Dorte Krause-Jensen, Denmark]	Rejected. We do not disagree that exploitation of kelp may have a potential in polar regions. However, due to strict limits on number of words kelp is not discussed here. Chapter 5 has a more thorough coverage of kelp.
13199	3	41	38	41	39	The other responses from pteropod communities have been observed due to ocean acidification (not just shell dissolution), including physiological and population responses. [NINA BEDNARSEK, United States of America]	JMT: Misplaced comment? Unclear which specific section this relates to (and no references provided)
5657	3	41	40	0		Should it not be "predators" ? [Nina Hunter, South Africa]	Editorial. Edited as suggested.
5659	3	41	50	0		Semi-colon should be a colon [Nina Hunter, South Africa]	Editorial. Edited as suggested.
15005	3	41	52	41	52	What is meant with geopolitics in the context of this sentence? None part of the Southern Ocean falls under a national jurisdiction. The meaning is therefore unclear. Please delete "geopolitics" or clarify. [Government of Germany, Germany]	Accepted. Deleted as suggested,
25729	3	42	4	42	40	The section on tourism could also include information from Himalayan region. [Government of India, India]	Rejected: not relevant to polar regions chapter
30951	3	42	4	43	21	Maybe the risks for ecosystems involved in increased tourism and transport could be elaborated a bit more. [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account: the issue is touched on in the text but not elaborated further due to space limitations
15007	3	42	11	42	11	Please replace "purpose-built polar cruise" by "more purpose-built polar cruise" [Government of Germany, Germany]	Accepted: text revised

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
15009	3	42	13	42	14	New numbers are available: 51,707 tourists visited Antarctica during the 2017/2018-season (source: IAATO, ATCM 41, IP 71, „IAATO Overview of Antarctic Tourism: 2017-18 Season and Preliminary Estimates for 2018-19 Season”, 2018; URL: https://iaato.org/documents/10157/2398215/IAATO+overview/bc34db24-e1dc-4eab-997a-4401836b7033) [Government of Germany, Germany]	Accepted: text updated
11223	3	42	13	42	16	In Antarctica, almost 37,000 predominantly shipborne tourists visited in 2016/17. Due to accessibility and convenience, these tourism operations are mostly based around the few ice-free areas of Antarctica, concentrated on the Antarctic Peninsula (Pertierra et al., 2017). My suggestion is: In Antarctica, almost 37,000 predominantly shipborne tourists visited in 2016/17. 2017/18 activities, reported by the International Association of Antarctica Tour Operators (IAATO) to ATCM XL, under Article III (2) of the Antarctic Treaty, indicated that the 2017-18 Antarctic tourism season, the total number of visitors travelling with IAATO Operators was 51,707 representing an increase of 17% compared to the previous season (ATCM, 2018). Due to accessibility and convenience, these tourism operations are mostly based around the few ice-free areas of Antarctica, concentrated on the Antarctic Peninsula (Pertierra et al., 2017). [Burcu Ozsoy, Turkey]	Accepted: text updated
27187	3	42	13	42	16	Relevant reference on Antarctic tourism and penguin colonies, which is probably worth including here. Dunn, M.J., Forcada, J., Jackson, J.A., Waluda, C.M., Nichol, C. & Trathan, P.N. 2019 A long-term study of gentoo penguin (<i>Pygoscelis papua</i>) population trends at a major Antarctic tourist site, Goudier Island, Port Lockroy. Biodiversity and Conservation 28, 37-53. (doi:10.1007/s10531-018-1635-6). [Eugene Murphy, United Kingdom (of Great Britain and Northern Ireland)]	Accepted: text updated and reference added
2007	3	42	18	42	18	Perhaps the confidence level should be medium. There are several things that need to be address for the cruise tourism to grow. (1) lack of infrastructure: from port facilities, bunkering facilities, and limited access points for passenger transfers from southern Canada to the ships themselves; (2) complex bureaucracy in permitting: it is very challenging to carry permits over a multi-year period despite limited change in the shipboard operation; (3) limited search, rescue, and ice escort capability: the Canadian Coast Guard is stretched to its limits and is therefore unable to meet the demands placed upon it by the Canadian Arctic marine industry. See AACA-C report on page 32. see Perspective Q: Arctic Expedition: Cruise Tourism https://www.amap.no/documents/doc/Adaptation-Actions-for-a-Changing-Arctic-Perspectives-from-the-Bering-Chukchi-Beaufort-Region/1615 [Laura Eerkes-Medrano, Canada]	Taken into account: confidence level remains at high but wording changed to improve clarity.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
2011	3	42	18	42	18	The confidence level should be medium as ice variability will always exist. While the ice thickness and cover have diminished in the Arctic region, it still shifts on an hourly and daily basis See Perspective N in AACA-C report. In some years the ice formation in certain areas can happen earlier or ice melt can happen later than expected and navigational plans have to be adjusted or cancelled See Perspective N AACA-C (https://www.amap.no/documents/doc/Adaptation-Actions-for-a-Changing-Arctic-Perspectives-from-the-Bering-Chukchi-Beaufort-Region/1615). This year all seven cruise ships expected to arrive in Gjoa Haven were cancelled due to ice conditions. https://nunavutnews.com/nunavut-news/ice-spoils-cruise-ship-season-in-some-communities/ [Laura Eerkes-Medrano, Canada]	Taken into account: confidence level remains at high but wording changed to improve clarity.
2009	3	42	18	42	20	The section could be amended to reflect that the greatest barrier to growth in the Canadian region is the lack of single gateway for permitting. If this problem could be solved, more operators could move into the region. See AACA-C report on page 32, perspective Q, https://www.amap.no/documents/doc/Adaptation-Actions-for-a-Changing-Arctic-Perspectives-from-the-Bering-Chukchi-Beaufort-Region/1615 , see Perspective Q: Arctic Expedition: Cruise Tourism [Laura Eerkes-Medrano, Canada]	Taken into account: confidence level remains at high but wording changed to improve clarity.
15011	3	42	18	42	20	Please add the text in bold: "...due to continued sea ice reduction, more cruise ships being built and anticipated..." Rationale: In the coming decade almost two dozen new expedition cruise ships will be available on the market for polar cruises. This is an important growth factor for Arctic cruise tourism as well and should be mentioned. [Government of Germany, Germany]	Taken into account: we note in the first paragraph of this section that "more purpose-built polar cruise vessels are being constructed"
15013	3	42	23	42	26	Please modify the sentence as follows: "The anticipated implications of future climate change have become a driver for polar tourism. The phenomenon has become known as 'last chance tourism': tourists explicitly seek.." Rationale: It should not be understood as a separate niche market within the cruise industry. Polar cruise tourism actually is mainstream already. [Government of Germany, Germany]	Accepted: text revised
17719	3	42	28	42	40	Specify how tourism may affect financial security across communities in Arctic [Crystal Gong, Canada]	Rejected: beyond scope to address this issue
31055	3	42	29	42	29	Security of what? Please be more specific [Hans-Otto Poertner and WGII TSU, Germany]	Accepted: text revised
21361	3	42	32	42	35	The citations here are to modelling studies or to discussions only. They miss the hard empirical data which shows that per person, tourists carry the lowest number of alien propagules, but because of total numbers have risks equivalent to science for introduction of alien species. They also miss the data showing establishment probability. These data are available in the studies cited below. The hard data mean that a confidence statement can be included here that is high, at the very least. Chown SL, Huiskes AHL, Gremmen NJM, Lee JE, Terauds A, et al. 2012. Continent-wide risk assessment for the establishment of nonindigenous species in Antarctica. Proceedings of the National Academy of Sciences of the United States of America 109:4938-43. Huiskes AHL, Gremmen NJM, Bergstrom DM, Frenot Y, Hughes KA, et al. 2014. Aliens in Antarctica: Assessing transfer of plant propagules by human visitors to reduce invasion risk. Biological Conservation 171:278-84 [Steven Chown, Australia]	Accepted: text revised and citations added
5661	3	42	35	0		Remove "the" before "humans"; insert comma after "trampling" [Nina Hunter, South Africa]	Taken into account: text no longer appears

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
16919	3	42	36	42	40	The fact that cruise ships 'purposfully travel off regular corridors' is not the only reason that specific and tailored regulation has been suggested. As a result a suggested change could be: "Because the sector relies on, yet cruise ships purposfully travel off regular shipping corridors and serve a very differnet purpose than other vessel types, a need for appropieate" [Jackie Dawson, Canada]	Accepted: text revised
16921	3	42	44	42	47	This first sentence of the trnasportaion section is very long and is a bit awkward. Suggest splitting it or changign the word 'while' to something like 'at the same time'. [Jackie Dawson, Canada]	Accepted: text revised
5663	3	42	48	0		Insert "the" before "Arctic" and "Transpolar" for consistency [Nina Hunter, South Africa]	Accepted: text revised
1039	3	42	52	42	56	It may be an overstatement to say the reduction of sea ice is a main driver of Arctic shipping. First, it's not clear yet whether trans-shipping will increase or remain a novelty, despite some breathless "predictions" of Arctic routes competing with the Suez Canal. Second, shipping to and from Arctic destinations, such as the Sabetta port and the Yamal LNG project, are driven more by economics than sea ice. Daewoo is building Arctic-ready ships for the Yamal LNG project, not waiting for sea ice to become a non-factor. The Northern Sea Route had more activity in the 1980s than at present. The simplest solution is to delete the word "main" in line 52, so that sea ice reduction is simply a "driver" of shipping trends, along with the other factors mentioned later in the sentence. Sea ice does present a new opportunity, but it is not yet clear whether that opportunity is attractive economically, technically, politically, etc. [Henry Huntington, United States of America]	Accepted: text revised to remote sea ice as the 'main' driver and emphasize the importance of economics, etc.
17513	3	42	52	43	8	Increased shipping and other traffic within the Arctic will also increase local pollution, especially of particularly harmful short-lived climate pollutants like black carbon and methane. Stephenson S. R., et al. (2018) Climatic responses to future trans-Arctic shipping, GEOPHYSICAL RESEARCH LETTERS 45:9898–9908; Arctic Monitoring and Assessment Programme (AMAP) (2017) ADAPTATION ACTIONS FOR A CHANGING ARCTIC: PERSPECTIVES FROM THE BARENTS AREA; Arctic Council Secretariat (2017) EXPERT GROUP ON BLACK CARBON AND METHANE: SUMMARY OF PROGRESS AND RECOMMENDATIONS 2017. [Kristin Campbell, United States of America]	See #17621

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
17621	3	42	52	43	8	<p>Must emphasize that the risks and additional climate impacts far outweigh the benefits that may be gained from shipping, tourism, or other transit through the Arctic. Increased shipping and other traffic within the Arctic will also increase local pollution, especially of particularly harmful short-lived climate pollutants like black carbon and methane.</p> <p>Stephenson S. R., et al. (2018) Climatic responses to future trans-Arctic shipping, GEOPHYSICAL RESEARCH LETTERS 45:9898–9908, 9898 (“Because warming favors increased shipping traffic, previous studies have focused on the potential for ship emissions of black carbon (BC) and other particulates to enhance warming by lowering the otherwise high albedo of ice and snow (Browse et al., 2013; Corbett et al., 2010; Ødemark et al., 2012; Sand et al., 2016). The source of emissions is an important factor in determining the magnitude of this feedback and their ultimate climatic impact. Unlike BC transported to the Arctic from these midlatitude sources in Russia and Asia (Winiger et al., 2017; Wobus et al., 2016), strong surface inversions in the Arctic boundary layer make it more likely that BC emitted in the Arctic will be deposited on ice and snow, thereby maximizing its impact on surface temperature.”); Arctic Monitoring and Assessment Programme (AMAP) (2017) ADAPTATION ACTIONS FOR A CHANGING ARCTIC: PERSPECTIVES FROM THE BARENTS AREA, 1 (“Changes in climate will have direct impacts on snow and ice, as well as on terrestrial, freshwater and marine ecosystems. In addition to climate change, the region’s ecosystems are also influenced by several other impacts of human activities, such as chemical pollution, invasive species, and increased shipping and industrial developments. The end result is cumulative and cascading impacts on ecosystems and societies in the area.”); Arctic Council Secretariat (2017) EXPERT GROUP ON BLACK CARBON AND METHANE: SUMMARY OF PROGRESS AND RECOMMENDATIONS 2017, 17 (“Arctic shipping currently accounts for about 5 percent of black carbon emissions within the Arctic; absent emission controls, shipping emissions within the Arctic could double by 2030 under some projections of Arctic vessel traffic.”). [Durwood Zaelke, United States of America]</p>	Accepted text revised and citations to Arctic Council report and Sand et al (2013) added
16923	3	42	57	43	3	<p>Suggest "It is projected that shipping activity will continue to rise ..., although the influence of potential changes to insurance premiums are not clear [add] and this could play a significant role in future traffic volume. [Jackie Dawson, Canada]</p>	Accepted: text revised
3081	3	43	0	0		<p>I found it awkward that the ice sheet section presents Antarctica first and then Greenland when previous sections have discussed Arctic and then Southern Ocean [Helene Hewitt, United Kingdom (of Great Britain and Northern Ireland)]</p>	Existing cross-referencing between chapters and sections makes this tricky - will wait for final drafting to determine whether to do this.
3085	3	43	0	0		<p>In the ice sheet section, the assessment statements include comments on agreement and evidence which are not used in other parts of the chapter [Helene Hewitt, United Kingdom (of Great Britain and Northern Ireland)]</p>	Statements revised.
901	3	43	0	43		<p>Many details are published by Huettmann et al. 2011 for the Arctic, shipping and seabirds [Falk Huettmann, United States of America]</p>	Rejected: what is the full reference?
3083	3	43	0	44		<p>If it is possible to combine tables 3.3, 3.4 and 3.5 I think that would improve the presentation [Helene Hewitt, United Kingdom (of Great Britain and Northern Ireland)]</p>	Done. Tables now combined.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
25861	3	43	0	46		I also wonder if many of the references in the text to Shepherd et al. (2018) (which from the bibliography is Shepherd, A., Fricker, H. A., & Farrell, S. L. (2018). Trends and connections across the Antarctic cryosphere. Nature, 558(7709), 223. https://doi.org/10.1038/s41586-018-0171-6 .) are not meant to be references to The IMBIE Team, Shepherd, A., Ivins, E., Rignot, E., Smith, B., van den Broeke, M., et al. (2018). Mass balance of the Antarctic Ice Sheet from 1992 to 2017. Nature, 558, 219–222. as it seems strange for this recent relevant large collaboration (~80 authors) not to be directly cited except in table Appendix 3.A Table 4, and there are insufficient details in the 'Trends...' paper. For example, in Tables 3.3, p43 and Table 4, p44, the data appear to come from Table 1 of the IMBIE team (2018) paper. [Elizabeth Petrie, United Kingdom (of Great Britain and Northern Ireland)]	Yes, done.
3223	3	43	4	43	7	While there may be limited infrastructure there now wouldn't this change over time as traffic increases? (same thing for charting etc.). Also, there has been recent mining development in northern Canada which also would result in increased infrastructure etc. [Sharon Smith, Canada]	Accepted: wording clarified to indicate this is the present situation
26005	3	43	8	50	39	The headings are somewhat confusing. Obviously 3.3.1.1 is about mass changes and 3.3.1.3 is about the mechanisms but the former only has the region and the latter has topic and region. This is not symmetric. Perhaps better: 3.3.1.1 West Antarctica and Antarctic Peninsula mass change; similar for 3.3.1.2 and then 3.3.1.3 Mechanisms of Antarctic ice sheet mass change. Otherwise one can misunderstand. I first thought that 3.3.1.3 is about the mechanisms for Antarctic and 3.3.1.4 is about the mechanisms for Greenland. I would also suggest to combine 3.3.1.1 and 3.3.1.2 into one section: Antarctic Ice Sheet Mass Changes; the section is not long and this would further avoid misunderstanding. [Regine Hock, United States of America]	Yes, done.
17515	3	43	10	43	17	While pledges have been made by the IMO and individual shipping companies, these policies must be implemented across the board to limit the impact that black carbon and other pollutants can have on the region. Stephenson S. R., et al. (2018) Climatic responses to future trans-Arctic shipping, GEOPHYSICAL RESEARCH LETTERS 45:9898–9908; Arctic Monitoring and Assessment Programme (AMAP) (2017) ADAPTATION ACTIONS FOR A CHANGING ARCTIC: PERSPECTIVES FROM THE BARENTS AREA; Arctic Council Secretariat (2017) EXPERT GROUP ON BLACK CARBON AND METHANE: SUMMARY OF PROGRESS AND RECOMMENDATIONS 2017; Sand M., et al. (2013) Arctic surface temperature change to emissions of black carbon within Arctic or midlatitudes, J. GEOPHYSICAL RESEARCH 118(14):7788–7798; see also Stohl A., et al. (2013) Black carbon in the Arctic: the underestimated role of gas flaring and residential combustion emissions, ATMOS. CHEM. PHYS. 13:8833–8855. [Kristin Campbell, United States of America]	See #17623

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
17623	3	43	10	43	17	While pledges have been made by the IMO and individual shipping companies, these policies must be implemented across the board to limit the impact that black carbon and other pollutants can have on the region. Stephenson S. R., et al. (2018) Climatic responses to future trans-Arctic shipping, GEOPHYSICAL RESEARCH LETTERS 45:9898–9908, 9898 (“Because warming favors increased shipping traffic, previous studies have focused on the potential for ship emissions of black carbon (BC) and other particulates to enhance warming by lowering the otherwise high albedo of ice and snow (Browse et al., 2013; Corbett et al., 2010; Ødemark et al., 2012; Sand et al., 2016). The source of emissions is an important factor in determining the magnitude of this feedback and their ultimate climatic impact. Unlike BC transported to the Arctic from these midlatitude sources in Russia and Asia (Winiger et al., 2017; Wobus et al., 2016), strong surface inversions in the Arctic boundary layer make it more likely that BC emitted in the Arctic will be deposited on ice and snow, thereby maximizing its impact on surface temperature.”); Arctic Monitoring and Assessment Programme (AMAP) (2017) ADAPTATION ACTIONS FOR A CHANGING ARCTIC: PERSPECTIVES FROM THE BARENTS AREA, 1 (“Changes in climate will have direct impacts on snow and ice, as well as on terrestrial, freshwater and marine ecosystems. In addition to climate change, the region’s ecosystems are also influenced by several other impacts of human activities, such as chemical pollution, invasive species, and increased shipping and industrial developments. The end result is cumulative and cascading impacts on ecosystems and societies in the area.”); Arctic Council Secretariat (2017) EXPERT GROUP ON BLACK CARBON AND METHANE: SUMMARY OF PROGRESS AND RECOMMENDATIONS 2017, 17 (“Arctic shipping currently accounts for about 5 percent of black carbon emissions within the Arctic; absent emission controls, shipping emissions within the Arctic could double by 2030 under some projections of Arctic vessel traffic.”); Sand M., et al. (2013) Arctic surface temperature change to emissions of black carbon within Arctic or midlatitudes, J. GEOPHYSICAL RESEARCH 118(14):7788–7798, 7788 (“The climate model includes a snow model to simulate the climate effect of BC deposited on snow. We find that BC emitted within the Arctic has an almost five times larger Arctic surface temperature response (per unit of emitted mass) compared to emissions at midlatitudes. Especially during winter, BC emitted in North-Eurasia is transported into the high Arctic at low altitudes. A large fraction of the surface temperature response from BC is due to increased absorption when BC is deposited on snow and sea ice with associated feedbacks.”); see also Stohl A., et al. (2013) Black carbon in the Arctic: the underestimated role of gas flaring and residential combustion emissions, ATMOS. CHEM.	Accepted text revised and citations to Arctic Council report and Sand et al (2013) added
16925	3	43	11	43	12	In the bracketed examples for security I suggest adding local security - i.e. (trafficking, terrorism, and local) [Jackie Dawson, Canada]	Accepted: text revised
15015	3	43	16	43	17	Please amend the sentence along the following lines: ", however an overall ban of HFO as fuel for ships, as already applied in Antarctica and the waters around Svalbard under Norwegian jurisdiction, might be more effective." Rationale: Only the use of scrubbers is not sufficient. Please also make sure this issue is covered appropriately in the underlying chapter. [Government of Germany, Germany]	Accepted: text revised
23149	3	43	20	43	21	"less predictable" than when? Why? This could be expanded if relevant. [Valerie Masson-Delmotte, France]	Accepted: text revised

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
3707	3	43	22	43	22	The 3.2.4 section on "impacts" includes fisheries, tourism, and transportation, but has nothing about increased military and security operations. This strikes me as incomplete, especially since the subject is taken up later on p. 93, line 50; the subject would be strengthened with prior reference to increased concern over national security concerns. [Dee Williams, United States of America]	Rejected: out of scope
1667	3	43	24	43	24	Show a topographic map of the basin area under the ice sheets to show why mass loss could have detrimental impacts and/or a figure showing current melting rates across the whole ice sheet. It would be nice to visualize this rather than just read tables/numbers. [Nora Richter, United States of America]	Agreed, and considered updated figures like AR5 4.13 and 4.14, but on this scale, the changes since AR5 would barely be visible. An overview location map is being added though. Would be nice to add basal topography but more specifically relevant to the projections in chapter 4 rather than the observations here.
16303	3	43	24	51	2	This section of the assessment is key and provides very important new information on recent dynamics of both Antarctic and Greenland ice sheets. Is the author team in a position to compile most recent spatial mass change information for both ice sheets and provide a map visualising recent obs, something like updated AR5 WGI Figures 4.13 and 4.14? These kinds of figures were very well received and it can be expected that IPCC stakeholders will ask for similar information. [Alexander Nauels, Germany]	Considered updated figures like AR5 4.13 and 4.14 but on this scale, the changes since AR5 would barely be visible. An overview location map is being added though.
19599	3	43	24	55	35	Most of the references given in this section cannot be found in the references at the end of Chapter 3. Please go through them again, there were too many to list them here. [APECS Group Review, Germany]	References updated.
30955	3	43	24	55	35	Reduce the use of acronyms to the most necessary. Make sure that each acronym is explained at first mention in each main section and additionally in each figure/table caption. [Hans-Otto Poertner and WGII TSU, Germany]	Done.
19081	3	43	26	0		This section (3.3.1) is lacking in a "projections" subsection, meanwhile the polar glacier changes (3.3.2) does have one. It seems like an oversight and would much improve the section to give an idea of what is expected into the future. At least a short summary of some of the information in the cross-chapter box, and then pointing to it would seem helpful to a reader. [APECS Group Review, Germany]	Ice sheet projections are in chapter 4. Now moving polar-glacier projections to a new cross-chapter box with projections for all other global glaciers, in chapter 2.
26007	3	43	26	50	39	This section needs rewriting/major editing. The information is there but it is not easy to follow one gets lost a bit. Also lots of repetition. [Regine Hock, United States of America]	Now rewritten and edited.
2533	3	43	28	43	28	complimentary -> complementary [Michiel Van den Broeke, Netherlands]	Done
15555	3	43	28	43	28	As none of the three geodetic methods actually measure ice mass change directly, it is suggested to replace 'measure' with 'derive' . [EUCE, Belgium]	Gravimetry measures mass change. Have changed to derived anyway.
16887	3	43	28	43	28	As none of the three geodetic methods actually measure ice mass change directly, I suggest to rewrite to e.g.'measure' -> 'derive' [Louise Sandberg Soerensen, Denmark]	Gravimetry measures mass change. Have changed to derived anyway.
26231	3	43	28	43	28	there is many years between 'satellite era' and 'pre-20th century; what about those? [Regine Hock, United States of America]	This statement removed.
26233	3	43	28	43	28	mentioning 3 methods but without saying what these are is not very useful for a reader [Regine Hock, United States of America]	Changed to: "Changes in ice sheet mass have been derived repeatedly over the satellite era using complementary methods based on time series of satellite altimetry to measure volume change, ice-flux measurements combined with modelled surface mass balance to calculate mass inputs and outputs, and satellite gravimetry to measure regional mass change...."

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
19069	3	43	28	43	30	This sentence is too long and not very logical. I suggest replacing it by: Satellites have monitored ice sheet mass changes since 1992. Three complimentary methods can be applied to the measured data to investigate ice sheet mass changes. For insights into earlier periods, firn/ice core and geological evidence are used. [APECS Group Review, Germany]	Changed to: "Changes in ice sheet mass have been derived repeatedly over the satellite era using complementary methods based on time series of satellite altimetry to measure volume change, ice-flux measurements combined with modelled surface mass balance to calculate mass inputs and outputs, and satellite gravimetry to measure regional mass change...."
28369	3	43	28	43	30	Sentence is a bit confusing. Describes satellite era (need to define epoch) which is probably 1992-present and then mentions pre-20th which means that for 1900-1992 there is nothing, which is not really correct. Also, sentence implies that mass change has been deduced from firn/ice cores and geology but with no references and nothing in appendix 3.a.3.1 that I could see [Jonathan Bamber, United Kingdom (of Great Britain and Northern Ireland)]	Changed to: "Changes in ice sheet mass have been derived repeatedly over the satellite era using complementary methods based on time series of satellite altimetry to measure volume change, ice-flux measurements combined with modelled surface mass balance to calculate mass inputs and outputs, and satellite gravimetry to measure regional mass change...."
25993	3	43	28	61	43	Use of confidence language needs adjustments and homogenization within the glacier/ice sheet parts (and probably beyond). (1) To my understanding confidence language should only be used for statements based on MULTIPLE LINES OF EVIDENCE and not for the results of ONE single study which is frequently done in these sections. (2) Some sections use the phrase '... with ... confidence consistently each time (e.g. p45, L24), while all others are different, probably indicating a different author for these sections using 'with'. Or section 3.3.3.4 uses consistently the formulation "... agreement ... based on XXX evidence". This should stylistically be made homogenous across the chapter (and report). (3) use confidence language or a combination of evidence and agreement. The combination of the latter 2 indicators make up the level of confidence, however, a number of times this is mixed, e.g. p.44 L10: medium confidence with high agreement (or p46, L13). (4) Sometimes clear facts, e.g. an observation that has no doubt (e.g. the existence of a firm aquifer or p61, L25) is accompanied by confidence language, which should not be done. In some of these case it can be misunderstood that this report questions the observation itself (e.g. the measurement method leaves doubts about the validity of the statement). [Regine Hock, United States of America]	Agreed and now revised.
19071	3	43	29	43	29	pre-20th century is unfortunately formulated. What about the period between 1900 and 1992 (beginning of satellite era)? [APECS Group Review, Germany]	Changed to: "Changes in ice sheet mass have been derived repeatedly over the satellite era using complementary methods based on time series of satellite altimetry to measure volume change, ice-flux measurements combined with modelled surface mass balance to calculate mass inputs and outputs, and satellite gravimetry to measure regional mass change...."
19073	3	43	34	43	34	Which previous assessments are meant here? Is it implicit that earlier IPCC assessment reports are meant by that? [APECS Group Review, Germany]	Have added the statement: "This extends and reinforces previous findings {IPCC AR5}."
28537	3	43	34	43	49	I think in lines 35-36 you are saying that *rates of loss* increased ("cumulative loss increased further" doesn't quite make this clear, but it's what the references, tables and figure support). In that case, lines 34-38 and 46-49 seem to be saying about the same thing and could be combined into one paragraph. [Yvonne Firing, United Kingdom (of Great Britain and Northern Ireland)]	Agreed, paragraphs combined.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
24907	3	43	35	43	35	Ice mass loss in the Antarctic Peninsula has been documented even to the 1970s. For instance, please see: Rott, H., P. Skvarca and T. Nagler. 1996. Rapid collapse of northern Larsen Ice Shelf, Antarctica. Science, 271(5250), 788–792. DOI: 10.1126/science.271.5250.788. Bindschadler, R., Fahnestock, M., Skvarca, P., & Scambos, T. (1994). Surface-velocity field of the northern Larsen Ice Shelf, Antarctica. Annals of Glaciology, 20, 319-326. doi:10.3189/172756494794587294 [Hernan Edgardo Sala, Argentina]	True, but these studies do not provide total Antarctic Peninsula mass balances. They are localised and focus on dynamic mass loss.
404	3	43	38	43	38	A reference is made to Shepherd et al 2018, they are consistently citing the wrong paper, which should be the IMBIE2 paper, citation is on page 3-148, because, on page 3-45 figure 2 on page 220 is used of: Mass balance of the Antarctic Ice Sheet from 1992-2017, IMBIE team. 14-june-2018, Vol 558, Nature [Ernst Schrama, Netherlands]	Yes, done.
19083	3	43	42	43	43	There seems to be a missing element of understanding between the two clauses of this statement; why do the methods now all agree with the multi-model mean if there is disagreements between these methods? What has changed in these methods to now cause agreement, esp. if response magnitude and measurement uncertainties are an issue [APECS Group Review, Germany]	Agreed, modified this assertion. Reworded to "From medium evidence, there is high agreement in the sign and medium agreement in the magnitude of both WAIS and AP mass change between the complementary satellite methods..."
25863	3	43	44	43	44	If the Shepherd et al (2018) paper on this line is actually the IMBIE team (2018) paper, the AP value in that paper seems to be -20 +- 15 Gt yr-1, rather than -27 +- 15Gt yr-1 : 'At the Antarctic Peninsula, the 25-year average rate of ice-sheet mass balance is -20 ± 15 Gt yr -1 , with an increase of about 15 Gt yr -1 in losses since 2000.' page 219, or Table 4, where WAIS is also given as -94+-27 rather than -93+- 26. [Elizabeth Petrie, United Kingdom (of Great Britain and Northern Ireland)]	This section now reworded without reference to this value. The values referred to originally came from Extended Data Table 4 of the IMBIE Team (2018) paper.
19079	3	43	46	43	47	Instead of saying "the decade since 2007" and "the decade since 1992" it would be more concise and clearer to say 2007-2016/7 and 1992-2001/2. [APECS Group Review, Germany]	Agreed, wording now changed.
19075	3	43	46	43	49	This sentence is not clear. I suggest reformulating along the lines of: [...] mass loss between 2007 and 2017 is larger than between 1992 and 2002. This is reported by two multi-method studies conducted over [...] and supported by estimates from separate, overlapping studies. [APECS Group Review, Germany]	Agreed, this sentence now changed to: "It is virtually certain that the Antarctic Peninsula (AP) and West Antarctic Ice Sheet (WAIS) combined have cumulatively lost mass since widespread measurements began in 1992, and that the rate of loss has increased since around the year 2006 and continued post-AR5{Bamber, 2018 #637;The-IMBIE-Team, 2018 #1659;Martin-Español, 2016 #639;Gardner, 2018 #641;Rignot, 2019 #640}Zwally et al., 2015 doi.org/10.3189/2015JoG15J071, extending and reinforcing previous findings {IPCC, 2013 #1660} ..."
9529	3	43	52	43	52	It should be possible to read Figures and Tables regardless of the text. Acronyms should be defined in titles. Here : WAIS (West Antarctic Ice Sheet) [Government of France, France]	Yes, done.
11905	3	43	52	43	53	The legends and the contents of the table should be shown in consistent order. I recommend that the order of table contents has to be changed in Shepherd et al. (2018) and then Bamber et al. (2018), since it is presented in the order of Shepherd et al. (2018) and Bamber et al. (2018) in table legends. [Jun Sun, China]	Agreed, now changed in merged Table 3.3.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
12205	3	43	52	43	53	The title of the table refers to (Shepherd et al., 2018) followed by (Bamber et al., 2018) but the order is different on the table. It might be good to reorder for better and faster reading. [Dorothee Vallot, Sweden]	Agreed, now changed in merged Table 3.3.
15557	3	43	52	43	53	Please, clarify why the five year periods in the table end in two years e.g. 1992-1996/97 [EUCE, Belgium]	Was originally due to different reporting by the two main studies. Now changed to 1992-1996 etc, where these years are inclusive.
16889	3	43	52	43	53	Clarify why the five year periods in the table end in two years e.g. 1992-1996/97 [Louise Sandberg Soerensen, Denmark]	Was originally due to different reporting by the two main studies. Now changed to 1992-1996 etc, where these years are inclusive.
19077	3	43	52	43	53	It would be clearer if the table and description had the same order for citations (Bamber then Shepherd or Shepherd then Bamber). [APECS Group Review, Germany]	Was originally due to different reporting by the two main studies. Now changed to 1992-1996 etc, where these years are inclusive.
19085	3	43	52	44	14	I would recommend combining Tables 3.3 and 3.4, and adding a column denoting geographic area covered for each mass balance estimate listed. In Table 3.3, the Bamber et al. (2018) values are WAIS + a portion of AP, while Shepard et al. (2018) estimates for WAIS and Table 3.4 is explicitly just for AP estimates. Combining the two tables together would highlight that much of the mass balance loss is in fact originating from the WAIS, with a smaller, significant portion from the AP, while also providing some context for how much of the Bamber et al. (2018) "portion of the AP" estimate can be delineated between AP and WAIS. [APECS Group Review, Germany]	Done. Tables now combined.
30957	3	43	52	44	14	Tables 3.3 and 3.4 should be merged. Maybe could be merged even with Table 3.5. [Hans-Otto Poertner and WGII TSU, Germany]	Done. Tables now combined.
25995	3	43	52	62	33	Tables with just one line are not very efficient. I suggest you combine Tables 3.3 and 3.4 and 3.5. It would also be good to add the total Ant ice sheet mass loss since this is ultimately what is relevant for sea-level rise. [Regine Hock, United States of America]	Done. Tables now combined.
25997	3	43	53	43	53	years: better 1996/97 instead of 1996/7 to avoid confusion. Also elsewhere [Regine Hock, United States of America]	Done.
25999	3	43	53	43	53	plus a portion of the AP': how big? Important to know what the relative differences in total area are to evaluate the differences in mass change [Regine Hock, United States of America]	Simplified by combining AP and WAIS in new Table 3.3 for these values. Bamber et al. include AP in WAIS, IMBIE reports them separately, but combined when combined these regions are equivalent.
3453	3	43	53	45	1	Multiple 1-line tables seem to imply that the same information could have been included in the text. Is this information also going to be in the revised version of Figure 3.6? [Patrick Orenstein, United States of America]	Done. Tables now combined.
392	3	44	1	44	3	Fig. 3.6: The inexperienced reader may not know where these regions of Antarctica are located (W. Antarctica, E. Antarctica, Antarctic Peninsula). I commented that Fig 3.3 c and d could be labeled with these region names, thus eliminating the need to add an additional map figure. [Ethan Kyzivat, United States of America]	A new placenames figure 3.2 added.
394	3	44	1	44	3	Fig. 3.6: The analagous plot (Fig. 3.7) for Greenland is partitioned differently (by ablation type, rather than region). Could you present the same data for both ice sheets? [Ethan Kyzivat, United States of America]	Unfortunately only two datasets are available on time-series AIS mass balance components. One (Rignot et al., 2019) has total mass change at one extreme of the consensus view, while the other (Martin-Espanol et al., 2016) covers only 2003-2013. Not enough to make an assessment comparable to the Greenland one.
11881	3	44	3	44	3	Repetitive wording: "In agreement with blabla, there is high agreement..." [Gerhard Krinner, France]	Wording now changed.
19087	3	44	3	44	3	Again: Which previous assessments are meant here? Is it implicit that earlier IPCC assessment reports are meant by that? [APECS Group Review, Germany]	Citation added.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
33327	3	44	9	44	9	This line reads like snowfall and melting are the only important terms in the surface mass balance, but sublimation is also important for Antarctica. [Government of United States of America, United States of America]	This revised sentence now reads: "AIS mass changes are dominated by changes in snowfall and glacier flow. The WAIS and AP loss trends in recent decades are dominated by glacier flow acceleration...". Note that this refers to the dominant causes of change. Sublimation is not one of these.
17693	3	44	10	44	10	While I know you cannot keep saying that changes are not uniform across all glaciers in a region, this is especially true in the AP where southern AP (Palmer Land) has seen major increases while northern AP (Graham Land) has seen lots of switching and changing and recently a reduction in loss (Roth et al TC). we don't want to propagate the myth that because one glacier or set of glaciers are thinning everything is thinning. [Matt King, Australia]	Agreed, and new paragraph added on AP mass loss, particularly on the Belligshausen Sea (south west AP) coast.
9531	3	44	13	44	13	It should be possible to read Figures and Tables regardless of the text. Acronyms should be defined in titles. Here : AP (Antarctic Peninsula) [Government of France, France]	Yes, done.
1669	3	44	13	44	14	Why is this table not incorporated with Table 3.3? [Nora Richter, United States of America]	Done. Tables now combined.
24937	3	44	16	44	16	Consider changing 'techniques' by 'mechanisms' [Frank Pattyn, Belgium]	This statement on agreement between techniques/mechanisms now removed because the revised confidence statement ("high confidence") implies high agreement between multiple studies.
12189	3	44	16	44	17	Total AIS mass balance is summarized in appendix. This is also repeated in lines 43-44. Why not having a full paragraph on that, '3.3.1.3. Antarctica Ice sheet', including the Figure 3.6 and some explanatory text? [Dorothee Vallot, Sweden]	Agreed, new summary statement added: "Overall, 2012-2016 AIS mass losses were extremely likely greater than those from 2002-2011 and likely greater than from 1992-2001, and it is extremely likely that the negative 2012-2016 AIS mass balance was dominated by losses from WAIS (Table 3.3)."
33329	3	44	19	44	44	Is there a reason the Zwally et al. (2015) paper is not mentioned here? It was quite controversial when published and perhaps has been refuted, in which case it may not warrant a reference. However, because it did get a lot of attention, it may be worth addressing here. Mass gains of the Antarctic ice sheet exceed losses Zwally, H. J., Li, J., Robbins, J. W., Saba, J. L., Yi, D., & Brenner, A. C. (2015). Mass gains of the Antarctic ice sheet exceed losses. Journal of Glaciology. DOI: http://dx.doi.org/10.3189/2015JoG15J071 [Government of United States of America, United States of America]	Agreed, reference now made to this study, with discussion of the disagreement in results in section 3.3.1.1.
19099	3	44	21	44	24	Seems to me that this statement could be supported with a likelihood assessment even though it will be "unlikely." In general in this section I find there is a bias toward positive likelihood and a lack of negative likelihood statements (i.e. Unlikely that something is changing). There is medium evidence and high agreement for this statement and likelihood is determined for WAIS and AP mass changes (lines 34-38 section 3.3.1.1), so why not for EAIS? [APECS Group Review, Germany]	This statement now reads: "In contrast to the mass losses observed in the WAIS and AP, there is medium confidence that East Antarctic Ice Sheet (EAIS) mass balance has remained close to zero, with large interannual variability and no clear trend over the satellite record (Table 3.3, Figure 3.6, Appendix 3.A.3.1.2). Mass balance may currently be positive or negative." This wording gives greater clarity to the statement of little detectable trend in mass.
21665	3	44	21	44	24	The authors describes that there is no clear interannual variability in EAIS. In this sense, 'Memin et al., 2015' is not relevant to be added here. [Government of Republic of Korea, Republic of Korea]	Agreed, Memin reference removed.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
24015	3	44	21	44	24	The authors describes that ther is no clear interannual variability in EAIS. In this sense, 'Memin et al., 2015' is not relevant to be added here. [WON SANG LEE, Republic of Korea]	Agreed, Memin reference removed.
19097	3	44	21	44	42	This section on EAIS mass balance doesn't convince me of mass balance being likely near zero. Spatial and temporal variability are strongly highlighted in the discussion, but the balance estimates provided throughout do not emphasize this key message. The only evidence that points to this is the 2012-2016/7 estimates of Bamber and Shepard provided in Table 3.5. Is this where the take away message comes from? [APECS Group Review, Germany]	This discussion of EAIS near balance and the associated uncertainties revised to "The East Antarctic Ice Sheet (EAIS, covering 85% of the AIS) has remained close to balance, with large interannual variability and no clear mass trend over the satellite record (medium confidence) (Table 3.3, Figure 3.7, Appendix 3.A.3.1.2), and relatively large observation uncertainties (Appendix 3.A.3.1) {Velicogna, 2014 #644; Martin-Español, 2017 #645; Bamber, 2018 #637}. Surface mass balance (SMB) trends are particularly ambiguous, leading to disagreement between one altimetry and one flux-based estimate of +136 ±43 Gt a-1 (spanning 1992-2008) Zwally et al., 2015 doi.org/10.3189/2015JoG15J071, and -41 ±8 Gt a-1 (1979-2017) Rignot et al., 2019 doi.org/10.1073/pnas.1812883116 respectively. Both differ from the multi-method averages reported here (Table 3.3)." "
11883	3	44	23	44	24	This apparent periodicity could warrant assessment. Do you believe in this? [Gerhard Krinner, France]	This statement now removed as not directly relevant to the assessment.
21773	3	44	23	44	24	Doesn't seem too relevant, without more context? [Susheel Adusumilli, United States of America]	Agreed, Memin reference removed.
33331	3	44	23	44	24	"The mass signal has an apparent 4.7-year periodicity." This seems like an odd sentence to include and end this paragraph on without any further discussion or explanation given. [Government of United States of America, United States of America]	Agreed, Memin reference removed.
5667	3	44	28	0		A definition of "firn" would be useful [Nina Hunter, South Africa]	Firn definition now added to glossary.
33333	3	44	28	44	28	What is the reference for 25 m/yr grounding line retreat being the average rate since Last Glacial Max? [Government of United States of America, United States of America]	It is the Konrad study (https://www.nature.com/articles/s41561-018-0082-z (doi:10.1038/s41561-018-0082-z)): "...retreated at rates faster than 25 myr ⁻¹ (the average pace since the Last Glacial Maximum {Konrad, 2018 #655}), with highest rates along the Amundsen and Bellingshausen Sea coasts, and around Totten Glacier, Wilkes Land, EAIS {Konrad, 2018 #655}"
9533	3	44	32	44	32	It should be possible to read Figures and Tables regardless of the text. Acronyms should be defined in titles. Here : EAIS (East Antarctic Ice Sheet) [Government of France, France]	Yes, done.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
28567	3	44	35	44	37	What region do the positive values refer to? Since this sentence takes about spatial variations I was expecting a different region to be named towards the end of the sentence. [Pippa Whitehouse, United Kingdom (of Great Britain and Northern Ireland)]	Agreed and reworded.
2535	3	44	35	44	38	This sentence is unclear; which basins are compared, what do the accelerations mean? [Michiel Van den Broeke, Netherlands]	Basins now clarified, accelerations removed.
19095	3	44	35	44	38	Based on Velicogna et al. (2014), the +63 Gt/yr estimate is for Queen Maud Land, not the Totten/Moscow/Frost region of EAIS, which is how the sentence currently reads as. [APECS Group Review, Germany]	Agreed, now clarified.
25207	3	44	35	44	38	This purpose of this sentence is probably to show that mass balance varies not only temporally but also spatially, however it is only mentioning that the -17 Gt/yr number comes from the TMF system, and fails to note that the +63 Gt/yr value comes from Queen Maud Land (QML). Suggestion: "... to +63 ± 6 Gt yr ⁻¹ in Queen Maud Land...", see reference (Velicogna et al., 2014). [Jan Wuite, Austria]	Agreed, now clarified.
19093	3	44	36	44	36	I believe Fox Glacier here should be replaced with Frost Glacier based on Velicogna et al. (2014). Fox Glacier is in NZ. [APECS Group Review, Germany]	Agreed, now corrected.
25205	3	44	36	44	36	"Totten/Moscow University/Fox Glacier" is mentioned, however the reference for this (Velicogna et al., 2014) mentions "Totten/Moscow/Frost" and nowhere "Fox". With "Moscow" being short for "Moscow University", I am not sure Fox and Frost are the same. Please check. (Note: on page 45, line 30 "Frost" is used.) [Jan Wuite, Austria]	Agreed, now corrected.
19089	3	44	37	44	37	Not clear. I suggest reformulating: "indicating that different regions contribute differently to [what?]" [APECS Group Review, Germany]	This statement removed. Replaced with "EAIS mass gains on the Siple Coast and Dronning Maud Land (e.g., +63 ± 6 Gt yr ⁻¹ from 2003–2013 {Velicogna, 2014 #644}) contrast with Wilkes Land losses e.g., from -17 ± 4 Gt yr ⁻¹ from the Totten Glacier area, 2003–2013 {Velicogna, 2014 #644}"
22477	3	44	37	44	37	Suggest reviewing this sentence. Currently the sentence reads poorly suggesting something is missing. After "to +63±6 Gt yr ⁻¹ " there would seem a need to add "in the X glacier area" so as to indicate the region that has shown this basin scale growth. [Government of Australia, Australia]	This statement removed. Replaced with "EAIS mass gains on the Siple Coast and Dronning Maud Land (e.g., +63 ± 6 Gt yr ⁻¹ from 2003–2013 {Velicogna, 2014 #644}) contrast with Wilkes Land losses e.g., from -17 ± 4 Gt yr ⁻¹ from the Totten Glacier area, 2003–2013 {Velicogna, 2014 #644}"
19101	3	44	42	44	43	This statement about Wilkes Land Sector is untraceable. In the previous paragraph, the talk of Wilkes Land only refers to paleo evidence no current changes. [APECS Group Review, Germany]	This statement removed. Replaced with "EAIS mass gains on the Siple Coast and Dronning Maud Land (e.g., +63 ± 6 Gt yr ⁻¹ from 2003–2013 {Velicogna, 2014 #644}) contrast with Wilkes Land losses e.g., from -17 ± 4 Gt yr ⁻¹ from the Totten Glacier area, 2003–2013 {Velicogna, 2014 #644}"
23929	3	44	42	44	44	It may be valuable to note that the mass balance can be either positive or negative, although the absolute value is likely close to zero and not so large. [Government of Japan, Japan]	Modified to "The East Antarctic Ice Sheet (EAIS, covering 85% of the AIS) has remained close to balance, with large interannual variability and no clear mass trend over the satellite record (medium confidence) (Table 3.3, Figure 3.7, Appendix 3.A.3.1.2), and relatively large observation uncertainties (Appendix 3.A.3.1) {Velicogna, 2014 #644; Martin-Español, 2017 #645; Bamber, 2018 #637}. "

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
26003	3	44	42	44	44	When? All mass changes should be reported with the time period they refer to [Regine Hock, United States of America]	Agreed, time periods added.
19091	3	44	42	45	3	I would add an additional sentence to the summary paragraph on page 3-44 that emphasizes the results of Figure 3.6 (page 3-45), especially to include a one-sentence summary of the WAIS ice losses. The paragraph as is discusses mass balance of the EAIS, then jumps to total AIS mass balance. There should be a sentence between these to remind the reader of the WAIS losses. The take home message of the summary should highlight this figure - that the largest contributor of ice sheet mass balance loss in Antarctica is from the WAIS; also will wrap up this discussion nicely. [APECS Group Review, Germany]	Now added to the revised concluding statement: "Overall, 2012-2016 AIS mass losses were extremely likely greater than those from 2002-2011 and likely greater than from 1992-2001, and it is extremely likely that the negative 2012-2016 AIS mass balance was dominated by losses from WAIS (Table 3.3)."
13127	3	44	55	0		Idem [David Crookall, France]	Comment unclear.
32035	3	45	1	45	1	It seems that in the legend the labels for "Antarctica" and "Antarctic Peninsula" are swapped. [Christian Reuten, Canada]	This placeholder figure was unmodified from the original citation, I believe the legend is correct.
25229	3	45	2	45	3	I see the note that this figure will be redrafted and this may already be the plan but it would be nice to update this with the latest IMBIE results, rather than the 2012 IMBIE results. [Denis Felikson, United States of America]	Done.
33335	3	45	3	45	10	This is a 7-line sentence. Break into smaller chunks that are easier to follow. [Government of United States of America, United States of America]	Page or line numbers appear incorrect in this comment, 7-line sentence not here.
9959	3	45	8	45	10	I was surprised not to see the direct contribution of basal melting of ice shelves mentioned along with SMB and dynamic losses here, even if to say the volume is negligible (if this is the case). Basal melting of shelves is only discussed on the context of grounding line retreat and the associated influence on dynamic loss. [Gwenn Flowers, Canada]	This section is primarily meant to explain changes to the grounded ice sheet. This is now clarified: "AIS mass changes are dominated by changes in snowfall and glacier flow..." There is extensive discussion of ice shelf basal melt in the 'components' and 'drivers' sections.
11427	3	45	8	45	10	Citation needed [Anson Cheung, United States of America]	Citations are not provided in this assessment for issues of established fact.
19111	3	45	8	45	10	This sentence should be rearranged to list changes in glacier flow rate first and then SMB changes to appropriately reflect order of discussion in the following paragraphs of Section 3.3.1.3. [APECS Group Review, Germany]	Done.
12191	3	45	8	45	13	The paragraph above presents the contributors to mass change as equal in importance but this sentence affirms that there is difference. It might be easier for the reader to add that the importance of each mechanism depends on the location. [Dorothee Vallot, Sweden]	Opening paragraph now changed to: "AIS mass changes are dominated by changes in snowfall and glacier flow..."
26009	3	45	8	50	40	The distinction between mechanisms and drivers need to be clearer since they can be understood as at least partially the same thing. I appears that what is meant under mechanisms is the partitioning into different components (without explaining why they change). In that case it may be clearer to call this section "Components of mass change ...". This is also something that could be shown much clearer, perhaps with a table, How large are the components of the observed mass changes (SMB, calving, submarine melt, land-based subglacial melt ...etc)? At the moment there are numbers all over the place and it is hard to see the forest for the trees. [Regine Hock, United States of America]	"Mechanisms" changed to "Components". Components quantified where there is sufficient evidence for a balanced and ice-sheet-wide assessment (i.e. for GIS SMB versus dynamic losses).
19103	3	45	9	45	9	not clear what is meant by "snowfall (not melting)" [APECS Group Review, Germany]	"(not melting)" now removed,

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
228	3	45	13	45	13	Fig. 3.6 doesn't include projections, why not? [Baylor Fox-Kemper, United States of America]	Projections are in chapter 4.
19105	3	45	13	45	13	I suggest avoiding brackets here: not clear to me if that means it is not important or is the equivalent of glacier flow acceleration [APECS Group Review, Germany]	Now made explicit: "...(also known as dynamic thinning)..."
25865	3	45	14	45	14	The Martin-Espanol (2016) paper has -112+-12Gt/yr in the results section and +-10 in the abstract and conclusions. (n.b. there is also a repeated paragraph on page 45, see lines 24, 34)). Either check with the lead author or use 12Gt as the higher uncertainty? [Elizabeth Petrie, United Kingdom (of Great Britain and Northern Ireland)]	Changed to +-12 and repeated paragraph removed.
30349	3	45	15	45	15	It would probably be a good idea to define "ASE" again to avoid confusion. I realize it has been defined above but the term is used repeatedly in the text below (along with many others). It would also be a good idea to include a separate list of definitions for the numerous abbreviations used in this chapter since there are so many. This section of Chapter 3 contains a large number of abbreviations some of which (e.g. GIS) have other more commonly used definitions. In addition, there are many such abbreviations that will interfere with communicating the findings of this excellent and comprehensive summary to non-specialists in polar science [Paul Glaser, United States of America]	ASE redefined. GIS is the agreed IPCC acronym for Greenland Ice Sheet. Will try to remove unnecessary acronyms, but word limits are tight.
19107	3	45	24	45	24	Can the authors elaborate one or two sentences on the link between dynamic thinning and grounding line retreat? Not clear to me: is one of them necessarily causing the other? [APECS Group Review, Germany]	Clarified with: "Reduction or loss of ice-shelf buttressing has dominated AIS dynamic thinning (high confidence). Ice shelves buttress 90% of AIS outflow..." and further detail in section 3.3.1.2.
8609	3	45	24	45	42	The last paragraph of this page appears twice. [Deborah Verfaillie, Spain]	Corrected.
15559	3	45	24	45	42	repeated section [EUCE, Belgium]	Yes, done.
16891	3	45	24	45	42	repeated section [Louise Sandberg Soerensen, Denmark]	Corrected.
24469	3	45	24	45	42	Line 24-32 is almost identically repeated in line 34-42. [Eef van Dongen, Switzerland]	Corrected.
33337	3	45	24	45	42	There is a repeated section here. [Government of United States of America, United States of America]	Yes, done.
33339	3	45	24	45	42	The last two paragraphs are the same. [Government of United States of America, United States of America]	Yes, done.
5665	3	45	28	45	38	Insert "respectively" after "AP" [Nina Hunter, South Africa]	Inserted.
1535	3	45	34	45	42	This paragraph has been duplicated. It is the same as the paragraph above. [Kaitlin Naughten, United Kingdom (of Great Britain and Northern Ireland)]	Yes, done.
12193	3	45	34	45	42	Repeat of previous paragraph [Dorothee Vallot, Sweden]	Yes, done.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
15017	3	45	34	45	42	This paragraph is a duplication of the preceding paragraph (ln 24-32), please delete. [Government of Germany, Germany]	Yes, done.
19109	3	45	34	45	42	Delete this paragraph, it is a duplicate of the previous one [APECS Group Review, Germany]	Yes, done.
19113	3	45	34	45	42	This paragraph appears to be a repeat of the previous paragraph (lines 24-32, same page) [APECS Group Review, Germany]	Yes, done.
21667	3	45	34	45	42	Repeated, should be removed. [Government of Republic of Korea, Republic of Korea]	Yes, done.
22479	3	45	34	45	42	Suggest deleting the repetition in paragraph lines 24-32 [Government of Australia, Australia]	Yes, done.
24017	3	45	34	45	42	Repeated, should be removed. [WON SANG LEE, Republic of Korea]	Yes, done.
25209	3	45	34	45	42	This paragraph is a rather obvious duplication of the previous paragraph (page 45, line 24-32) [Jan Wuite, Austria]	Yes, done.
28371	3	45	34	45	42	repeated text from above [Jonathan Bamber, United Kingdom (of Great Britain and Northern Ireland)]	Yes, done.
32037	3	45	34	45	42	This paragraph is identical to the previous paragraph. [Christian Reuten, Canada]	Yes, done.
398	3	45	34	45	43	This paragraph is erroneously duplicated. [Ethan Kyzivat, United States of America]	Yes, done.
22481	3	45	35	45	35	Suggest citing Roberts et al., 2017 (also cited in box, p3-59 line28) as this deals with the important pinning point on Totten. [Government of Australia, Australia]	Citation added here and in 'Drivers of ice sheet change' section.
26001	3	45	41	45	41	remove 'previously' (the period is mentioned in the sentence) [Regine Hock, United States of America]	Done
19117	3	46	1	46	1	Clarification: does "dynamic" apply to both thinning and retreat, or should this be "Dynamic thinning and grounding line retreat" [APECS Group Review, Germany]	Clarified to the latter of these.
30025	3	46	1	46	3	This is formulated ambiguously, since Paolo et al. found a 70% increase in ice volume loss, but the current text could be read as a 70% increase in basal melting. [Ronja Reese, Germany]	Changed to : "Reduction or loss of ice-shelf buttressing has dominated AIS dynamic thinning (high confidence). Ice shelves buttress 90% of AIS outflow {Depoorter, 2013 #719;Rignot, 2014 #652;Fürst, 2016 #720;Reese, 2018 #721}, and ice-shelf thinning increased in WAIS by 70% in the decade to 2012..."
11429	3	46	6	46	24	It might make more sense to put this subsection right after description of the Antarctica and Arctic changes. That way, this section could flow better, where it goes from observation, mechanisms, drivers, and forcings. [Anson Cheung, United States of America]	Not clear which section this refers to (possible wrong page number?). The 'mechanisms, drivers and forcings' section now revised to Antarctic mass change, Antarctic components, Greenland mass change, Greenland components, drivers of change for both, evidence of anthropogenic and natural forcing for both. Hopefully this is satisfactory.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
21775	3	46	6	46	7	"A decadal cycle" was not my interpretation of Jenkins et al. (2018). I think "potentially large variability in melt rates from interannual to decadal time scales" (Jenkins et al. 2018, Paolo et al. 2018) could be better phrasing [Susheel Adusumilli, United States of America]	Agreed, changed as suggested.
29691	3	46	7	46	8	Again, need to rephrase to take out "may" and use the IPCC lexicon [Michael MacCracken, United States of America]	Use of 'may' checked, confidence statements revised to agree with IPCC lexicon.
25211	3	46	12	46	16	This comments concerns the references cited in this paragraph. The paragraph deals with the dynamic mass loss and SMB in the Antarctic Peninsula (AP) and should in my opinion therefore not fail to mention Wuite et al. (2015) and/or Rott et al. (2018). These studies use state-of-the-art methods to give detailed accounts of recent changes in ice velocity, volume change, discharge, mass balance and SMB of the glaciers formerly draining into the Prince Gustav Channel, Larsen A and Larsen B ice shelves. Although only being a small part of AP, this region is of particular importance since the collapse of these ice shelves significantly changed the boundary conditions of these former tributary glaciers (which are now effectively marine terminating), leading to a significant dynamic speed up. This development could be a precedent for other regions in AP further south and WAIS/EAIS. The references given for glaciers in Graham Land (Pritchard et al., 2012; Mouginit et al., 2014) do NOT deal with these topics. Instead Pritchard et al deals with basal melting of ice shelves (based on elevation changes), and Mouginit et al does not even concern the AP, but Amundsen Sea Embayment instead. Added to that, while Martín-Español et al and Wouters et al are good studies, they both use only indirect measurements of ice dynamics (based on altimetry and gravity). I would therefore strongly suggest to include a recent ice dynamical study here as well, suggested references: (1) Wuite, J., Rott, H., Hetzenecker, M., Floricioiu, D., De Rydt, J., Gudmundsson, G. H., Nagler, T., and Kern, M.: Evolution of surface velocities and ice discharge of Larsen B outlet glaciers from 1995 to 2013, The Cryosphere, 9, 957-969, https://doi.org/10.5194/tc-9-957-2015 , 2015. (2) Rott, H., Abdel Jaber, W., Wuite, J., Scheiblauer, S., Floricioiu, D., van Wessem, J. M., Nagler, T., Miranda, N., and van den Broeke, M. R.: Changing pattern of ice flow and mass balance for glaciers discharging into the Larsen A and B embayments, Antarctic Peninsula, 2011 to 2016, The Cryosphere, 12, 1273-1291, https://doi.org/10.5194/tc-12-1273-2018 , 2018. [Jan Wuite, Austria]	Agreed, and changed to: "Mass gains due to increased snowfall have somewhat offset dynamic-thinning losses (high confidence). On the AP, snowfall began to increase in the 1930s, accelerated in the 1990s...". See revised 3.3.1.2.
25213	3	46	12	46	16	Mentioned in previous comment, but put seperately here for clarity: Mouginit et al., 2014 does not deal with the Antarctic Peninsula as the paragraph start suggest (Line 12 "On the AP..."). [Jan Wuite, Austria]	Changed as above.
25215	3	46	15	46	15	Martin-Español et al., 2017 deals primarily with East Antarctica and should likely be Martin-Español et al., 2016 which specifically mentions the Bellinghausen Sea coast. [Jan Wuite, Austria]	Changed as above.
19119	3	46	15	46	16	has gone from being close to balance is too vague; "which has transitioned from approximate mass balance equilibrium" is clearer [APECS Group Review, Germany]	This now removed and observations covered in previous section only.
19123	3	46	18	46	20	Should clarify what "recent years" means in terms of a year range, and how that connects to "on these timescales" [APECS Group Review, Germany]	Now clarified to "at least since 1979".
19115	3	46	19	46	19	Serreze et al. 2016 is incorrectly cited - this is a paper about the Arctic, not EAIS [APECS Group Review, Germany]	Citation removed.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
19129	3	46	23	46	25	It seems to me that a negative likelihood categorization could be used here instead, i.e. "very unlikely" that there is trend in accumulation. "Very likely" that there is NO trend seems counterintuitive and skews the language to positive sounding... [APECS Group Review, Germany]	This section and confidence statements now revised: "Mass gains due to increased snowfall have somewhat offset dynamic-thinning losses (high confidence). On the AP, snowfall began to increase in the 1930s, accelerated in the 1990s {Thomas, 2015 #668; Goodwin, 2016 #671}, and now offsets sea-level rise by 6.2 ± 1.7 mm per century Medley and Thomas, 2018 doi: 10.1038/s41558-018-0356-x. EAIS and WAIS snowfall increases offset 20th century sea-level rise by 7.7 ± 4.0 mm and 2.8 ± 1.7 mm respectively Medley and Thomas, 2018 doi: 10.1038/s41558-018-0356-x (medium confidence). AIS snowfall increased by +4 ± 1 then +14 ± 1 Gt per decade over the 19th and 20th centuries, of which EAIS contributed 10% {Thomas, 2017 #670}. Longer records suggest either an AIS snowfall decrease over the last 1000 years {Thomas, 2017 #1671} or a statistically negligible change over the last 800 years (low confidence){Frezzotti, 2013 #673}."
24939	3	46	23	46	25	Philippe et al. (2016) Ice core evidence for a 20th century increase in surface mass balance in coastal Dronning Maud Land, East Antarctica, The Cryosphere 10: 2501-2516 show a distinct increase in accumulation during the 20th century in coastal Dronning Maud Land, East Antarctica. This is also a site that is much more closer to the ocean (ice rise) than other ice/firn cores in the database used to make the statement that there is not clear trend in DML. [Frank Pattyn, Belgium]	Citation added, message adjusted accordingly.
17695	3	46	25	46	31	Does the reference to DML and Altnau et al contradict the next paragraph and also the Thomas et al 2018 Nature letter? At the least it needs an edit to make it clearer if regional differences exist (Thomas et al study DML also) [Matt King, Australia]	Section revised to clarify: "Mass gains due to increased snowfall have somewhat offset dynamic-thinning losses (high confidence). On the AP, snowfall began to increase in the 1930s, accelerated in the 1990s {Thomas, 2015 #668; Goodwin, 2016 #671}, and now offsets sea-level rise by 6.2 ± 1.7 mm per century Medley and Thomas, 2018 doi: 10.1038/s41558-018-0356-x. EAIS and WAIS snowfall increases offset 20th century sea-level rise by 7.7 ± 4.0 mm and 2.8 ± 1.7 mm respectively Medley and Thomas, 2018 doi: 10.1038/s41558-018-0356-x (medium confidence). AIS snowfall increased by +4 ± 1 then +14 ± 1 Gt per decade over the 19th and 20th centuries, of which EAIS contributed 10% {Thomas, 2017 #670}. Longer records suggest either an AIS snowfall decrease over the last 1000 years {Thomas, 2017 #1671} or a statistically negligible change over the last 800 years (low confidence){Frezzotti, 2013 #673}."
16523	3	46	29	46	31	Statements about the growth or shrinking of Antarctica cannot be made simply by reference to the study of Thomas et al. (2017) since this paper does not consider ice dynamics. This statement should be amended to refer to an increase in surface mass balance, not snowfall-driven growth of Antarctica. According to Thomas et al. (2017) Antarctica has experienced a growth in snowfall since 1800, but that is not the same as snowfall-driven growth. [Robert Arthern, United Kingdom (of Great Britain and Northern Ireland)]	Statement revised.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
19127	3	46	34	46	37	Is "mitigate" the right word to use here? Would "counter" work better? Is there a value estimate of SMB (Gt) that could strengthen this sentence, something like "EAIS SMB estimates of X Gt countered 21st century sea level rise by Y mm" [APECS Group Review, Germany]	"Mitigated" changed to "reduced". Gt values of SMB are now in the preceeding paragraph.
19121	3	46	37	46	40	For continuity and clarity, should state which Antarctic region each of these ice core groupings came from (AP/EAIS/WAIS) because the rates of change have been discussed as different between regions [APECS Group Review, Germany]	Now specified by ice sheet location.
19125	3	46	38	46	39	Need to explicitly state where in Antarctica/which region (EAIS? WAIS? AP?) these long-time scale ice core records originated from, especially when four cores indicate an accumulation decrease and 67 cores indicate no change (are the four cores in the 67?), otherwise this paragraph is slightly contradictory [APECS Group Review, Germany]	Now specified by ice sheet location.
21777	3	46	43	47	3	Is there any evidence of subglacial hydrology affecting basal melting in Antarctica? [Susheel Adusumilli, United States of America]	Little evidence, and largely decoupled from surface mass balance/ climate forcing.
28373	3	46	44	46	44	There is a large uncertainty on the 65 Gt, which is poorly constrained and a model output. Need to mention this or provide some sort of error/uncertainty on the number if possible (realise error is difficult)... [Jonathan Bamber, United Kingdom (of Great Britain and Northern Ireland)]	"Low confidence" statement now attached.
30241	3	46	48	46	52	Advances in subglacial hydrology modeling of Antarctic lakes demonstrate catchment-scale hydrological connections between lake systems along with growth and shrinkage of basal channels and should be cited. This is the first time these processes have been modeled without forcing lake growth and drainage so provides important new insight into the drivers of lake accumulation and drainage and the impact on ice dynamics. See Dow et al, 2016, The Cryosphere and Dow et al, 2018, JGR Earth Surface. [Christine Dow, Canada]	Citation added.
5169	3	47	0	76		The almost 30 pages of dense scientific text is a real barrier for most policy makers - could some of the detail be reduced with just the main messages of change being conveyed? That would also help in reducing the length of the chapter. [Debra Roberts and Durban Team, South Africa]	Please see the chapter Executive Summary and the report's Summary for Policymakers. The detail here is to demonstrate rigour and strength of evidence that is not possible in summary statements.
33341	3	47	2	47	4	"Despite medium agreement about the importance of subglacial hydrology for ice sheet dynamics, there is limited evidence of how the subglacial hydrological system of the polar ice sheets will respond to climate change, and how it may affect ice dynamics and mass balance." The work of Bougamont et al. (2015) may be relevant to consider here (Bougamont, M., P. Christoffersen, and S. F. Price, 2015: Reactivation of Kamb Ice Stream tributaries triggers century-scale reorganization of Siple Coast ice flow in West Antarctica. Geophysical Research Letters, doi:10.1002/(ISSN)1944-8007.) [Government of United States of America, United States of America]	The Bougamont study kept surface mass balance and temperatures constant, with no climate forcing.
30351	3	47	4	47	4	How does GIA (glacial isostatic adjustment) affect satellite based measurements in Antarctica. Does GIA represent a serious or minor source of error for using satellite-based measurements of surface based mass? [Paul Glaser, United States of America]	GIA is an important component of gravimetry signals and a minor component of altimetry signals. It is routinely considered in detail in gravimetry studies of total mass change and is included in the uncertainty estimates from them.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
432	3	47	6	47	23	The evolution of the Greenland ice sheet will be greatly determining sea-level rise, as well as Northern Hemisphere climate in the current century. A general description of why this is the case should be beneficial before analyzing specifics about mass loss (e.g. interaction of Greenlandic orography with polar atmospheric circulation, disturbance of polar vortex, Sudden Stratospheric Warmings, NAO, etc., preferably accompanied by an illustration). [Charalampos Charalampidis, Germany]	Please see introductory chapter 1.
25233	3	47	6	47	25	I would add a figure for Greenland similar to Figure 3.6 for Antarctica to show the agreement between the methods compared within IMBIE to supports the assertion that it is virtually certain that Greenland has lost mass since the 1990s. Additionally, please cite Shepherd et al. (2018) here to support this, just as has been done in the corresponding Antarctica section. [Denis Felikson, United States of America]	Unfortunately insufficient space to include additional figures relating to performance of contributing methods of observation, but the extent of agreement between methods in the multi-method approaches is represented in the uncertainties in the figure, in the values presented within the text and in the strength of the confidence statements.
430	3	47	6	48	16	I am aware that such a report needs to be concise and generally accessible to a wide range of readers, however the one-page long material on the Greenland ice sheet look meagre in comparison to sections such as sea ice or Antarctica. The material as is, fails to reflect the introductory statement that the Greenland ice sheet “currently represents the largest single contributor to ongoing mean sea level rise”. The Greenland ice sheet has been experiencing structural changes since the 2000s, and these changes have been reflected on mass loss especially during the last decade. Since AR5, a substantial amount of primary research on positive feedbacks of Greenland mass loss has become available, and it is likely that such mechanisms will enhance Greenland’s contribution to sea level rise. Regional climate and ice sheet models have not yet fully incorporated such processes in their estimates, therefore I propose the elaboration in 3.3.1.4 on such positive melt feedbacks and the uncertainty they introduce in future projections. [Charalampos Charalampidis, Germany]	GIS material now substantially increased, see revised sections 3.3.1.4, 3.3.1.5, 3.3.1.6, 3.3.1.7.
808	3	47	6	48	16	Please, incorporate also the recent study of Trusel et al. (2018), doi: 10.1038/s41586-018-0752-4 [Charalampos Charalampidis, Germany]	Trusel et al. now cited.
406	3	47	8	47	20	Section 3.3.14 refers on page 3-47 lines 8 to 20 to the results of van den Broeke, 2017 which is on the input output method. Also, there is a reference to Kjeldsen et al 2015 which is a geodetic survey. I miss here the results of GRACE which has observed ice sheet changes. There should be plenty of papers explaining the acceleration of the GIS mass loss, for instance one could cite (Schrama et al 2014) (see chapter 4) and (Velicogna et al 2014) (cited in this chapter). [Ernst Schrama, Netherlands]	Agreed , GRACE citations added.
26011	3	47	8	47	25	Mass change numbers are given in the text and then from another author in Table 3.6. This should all be combined in one table rather than sprinkling this information in different formats across this section. [Regine Hock, United States of America]	Summary mass changes for all ice sheeets now combined into one table with consistent authors.
26013	3	47	8	47	25	Can these numbers be reported for the SROCC time periods? [Regine Hock, United States of America]	Now in Table 3.3.
400	3	47	8	47	8	The literature primarily uses GrIS, not GIS, as an abbreviation for the Greenland Ice Sheet since the latter is the acronym for the Geographic Information System. [Ethan Kyzivat, United States of America]	GIS is the agreed IPCC acronym.
25257	3	47	8	47	8	In other chapter I noticed that the Abbreviation for Greenland Ice Sheet is GrIS - please use this rather than the current GIS [Kristian K. Kjeldsen, Denmark]	GIS is the agreed IPCC acronym.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
28375	3	47	8	47	8	see first comment about use of GIS [Jonathan Bamber, United Kingdom (of Great Britain and Northern Ireland)]	GIS is the agreed IPCC acronym.
30027	3	47	8	47	9	This seems to contradict Table 4.1 in which thermal expansion is the largest contributor between 2005-2015. [Ronja Reese, Germany]	Changed to say "...largest terrestrial contributor..."
25231	3	47	9	47	10	"Recent results support previous assessments ..." I've noticed this wording used throughout this chapter. If the distinction of recent versus previous is really referring to post-AR5 and pre-AR5, I would suggest changing the wording to "post-AR5" and "pre-AR5" to be more specific than "recent" and "previous." Moreover, in the introduction section of this chapter (page 7, line 13), it is stated that the goal is to "assess ... literature published since AR5". To support this, it would make the report stronger to specify that the "recent" literature being assessed is the "post-AR5" literature, throughout this section. [Denis Felikson, United States of America]	Specific date ranges now provided and reference to 'previous assessments' removed.
19135	3	47	9	47	12	While I am not an expert of Ice mass changes, the evidence presented and the classification of "robust evidence, high agreement" by the authors suggests that the classification should be "very high confidence" and not just "high confidence" on this statement. [APECS Group Review, Germany]	Agreed, changed.
24401	3	47	9	47	12	It should be mentioned that the robust negative mass balance does not exclude that there are individual melting seasons, even following each other (2017 and 2018), with a near zero mass balance, see e.g. www.polarportal.org. [Martin Stendel, Denmark]	Agreed, now added: "GIS mass balance is characterised by large interannual variability ..."
27513	3	47	9	47	16	See comment on line 21 - this would seem an obvious place to cite the paper as the results confirm Bamber and van den Broeke using a range of evidence. ("I would like to suggest that a paper I am coauthor on (Mottram et al., in revision/submitted) may be useful to this chapter as it provides an overview of a range of remote sensing data produced by the ESA CCI for the Greenland ice sheet including altimetry, ice velocity, outlet glacier retreat and GRACE data as well as some analysis of both modelled ice dynamics and SMB. The article has been through one set of reviews already and will hopefully be accepted before the spring deadline. Authors are: Ruth Mottram, Sebastian B. Simonsen, Synne Høyer Svendsen, Valentina R. Barletta, Louise Sandberg Sørensen, Thomas Nagler, Jan Wuite, Andreas Groh, Martin Horwarth, Job Rosier and Rene Forsberg Title: An Integrated View of Greenland Ice Sheet Mass Changes Based on Models and Satellite Observations. Available from: https://www.researchgate.net/publication/328358798_An_Integrated_View_of_Greenland_Ice_Sheet_Mass_Changes_Based_on_Models_and_Satellite_Observations [accessed Jan 11 2019].") [Ruth Mottram, Denmark]	Paper not accepted in time.
15561	3	47	9	47	9	Relevant reference: Group, W. C. R. P. G. S. L. B., Cazenave, A., Meyssignac, B., Ablain, M., Balmaseda, M., Bamber, J., ... Wouters, B. (2018). Global sea-level budget 1993 - present. Earth System Science Data, 10(3), 1551-1590. DOI: 10.5194/essd-10-1551-2018 [EUCE, Belgium]	Agreed, now cited.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
16915	3	47	9	47	9	Relevant reference: Group, W. C. R. P. G. S. L. B., Cazenave, A., Meyssignac, B., Ablain, M., Balmaseda, M., Bamber, J., ... Wouters, B. (2018). Global sea-level budget 1993 - present. Earth System Science Data, 10(3), 1551-1590. DOI: 10.5194/essd-10-1551-2018 [Louise Sandberg Soerensen, Denmark]	Agreed, now cited.
29693	3	47	12	47	20	To me, this suggests that the ice sheets are quite responsive to the temperature and conditions that they face. If this is the case, then how can thinking about stabilizing the climate at 1.5 to 2 C, with possible overshoot first, not mean that there is a very high risk of very substantial changes in the Greenland (and Antarctic) ice sheets that will lead to very substantial rates of sea level rise (meters per century)? From 20 ka to 8 ka, sea level rose 120 meters (so average 1 meter per century) while the global average temperature increased rate of roughly 1 C per thousand years. We are on track to be going up at least 1 C every 50 years--the likelihood, based on past Earth system behavior, that the rate of sea level rise will be less than 1 m/century seems very low to me, and the risk of it being a few meters per century quite high. I am basically very surprised at how sanguine the overall chapter and report are regarding both the likely trends to 2100 (and the trends beyond also need to be given) and the ultimate equilibrium sea level response to the proposed new stabilization level of 1.5 to 2 C. It seems to me based on the type of result described here that the scientific community has a responsibility to very clearly state that the risk of very significant sea level rise is substantial and that stabilizing at 1.5 to 2 C will not meet the objective of the UNFCCC (both in terms of avoiding dangerous anthropogenic interference and in terms of the three subconditions indicated), in that the sea level rise that seems quite plausible/likely will over coming decades to centuries lead to a lot of coastal inundation (and overwash of islands) that will be very impactful. The scientific community needs to speak up clearly and frankly about the projected consequences of sea level rise--based on the summary here of how responsive the ice mass is proving to be. [Michael MacCracken, United States of America]	This report seeks neither to be sanguine or alarmist but to present the best evidence and projections in a balanced and rigorous way. Any deviation from this would devalue it in the eyes of readers and must be avoided. Please see Chapter 4 for ice sheet and sea level projections.
32039	3	47	13	47	23	I suggest displaying the results from both Kjeldsen et al. (2015) and Bamber et al. (2018) in Table 3.6. [Christian Reuten, Canada]	Kjeldsen results reported in text but time periods cannot be split to match those of Bamber et al or the chosen IPCC reporting periods.
25259	3	47	15	47	16	losses consistently occurred in the northwest-,southeast- and Jakobshavn Isbrae, with some local areas in the southwest also losing mass throughout, and in more recent time spread to the remainder of the ice sheet. [Kristian K. Kjeldsen, Denmark]	Text updated with this correction.
23997	3	47	18	47	20	This brief mention of paleo climate studies could be extended and for example refer to a recently published study relating Greenland ice sheet formation to atmospheric CO2 (https://www.nature.com/articles/s41467-018-07206-w), or results of the PAGES-QUIGS group on interglacials (http://pastglobalchanges.org/ini/wg/quigs/intro) [Patricia Martinerie, France]	Palaeo context now expanded in sections 3.3.1.5, 3.3.1.6 and 3.3.1.7, though not as far back as past interglacials. Main focus is on Holocene/post-industrial.
9535	3	47	23	47	23	It should be possible to read Figures and Tables regardless of the text. Acronyms should be defined in titles. Here : GIS (Greenland Ice Sheet) [Government of France, France]	Yes, done.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
19137	3	47	26	47	26	This section seems weaker compared to the similar AIS section (3.3.1.3) on mechanisms of mass change. First, I think it could be easier for the reader to use consistent language (e.g. In AIS section there is talk of "dynamic thinning", where as in the GIS section "glacier acceleration" is used--which I understand are the same things; also SMB is used in the AIS section while surface melting in GIS section). Second, there are a lot more parameters discussed in the AIS section, such as basal melting, accumulation rates, ground line retreat, is this data not available for the GIS or has it just been left out? I feel that there should be similar attention and similar style in each section. [APECS Group Review, Germany]	More detail now given to the major changes in surface warming, melt and runoff as the major factors in SMB change, and more on their palaeo context. 'Dynamic thinning' used instead of 'glacier acceleration'. Grounding line retreat not discussed for GIS as very few glaciers discharge through ice shelf systems, but dynamic signals discussed in section 3.3.1.5.
434	3	47	26	48	16	Recent warming has been reported across the ice sheet (e.g., MacGrath et al., 2013), while links of the ice sheet to synoptic circulation and relevant trends are available in recent literature (e.g., Hanna et al., 2018). Given that ice-sheet mass loss occurs in recent years primarily via surface processes, a tighter link to atmospheric processes (e.g., Bennartz et al., 2013; Fausto et al., 2017; Van Tricht et al., 2016) is deemed necessary. I propose also that the authors pay the required attention to the fact that 2012 was for Greenland a year of unprecedented melt and extraordinary conditions (e.g., Nghiem et al. 2012; Keegan et al. 2014) bound to become more frequent in a warming climate. References: Bennartz et al. (2013), doi: 10.1038/Nature12002; Fausto et al. (2016), doi: 10.1002/2016GL067720; Hanna et al. (2018), doi: 10.5194/tc-12-3287-2018; Keegan et al. (2014), doi: 10.1073/pnas.1405397111; MacGrath et al. (2013), doi: 10.1002/grl.50456; Nghiem et al. (2012), doi: 10.1029/2012GL053611; Van Tricht et al. (2016), doi: 10.1038/ncomms10266 [Charalampos Charalampidis, Germany]	McGrath and Hanna now cited. Exceptional 2012 melt not covered in detail as space too limited to discuss extreme events relative to longer trends. More detail on GIS SMB observations, components and drivers added (sections 3.3.1.5, 3.3.1.6, 3.3.1.7). See e.g. statement: "These drivers culminated in July 2012 in exceptional warmth and surface melt up to the ice sheet summit {Hanna, 2016 #790;McLeod, 2016 #791;Nghiem, 2012 #792;Tedesco, 2013 #793;Hanna, 2014 #794}."
438	3	47	26	48	16	Medium-scale features such as firn cracks, supraglacial streams, lakes, moulins, etc. are important components of the hydrological network of the ice sheet (Chu, 2013; Flowers, 2018). Evidence from extreme-melt years suggested that such features in a warming climate would be forming earlier in the melt season and releasing accumulated meltwater from higher on the ice sheet (Fitzpatrick et al. 2014). Such meltwater discharge through the ice sheet and via the bedrock (Smith et al. 2015), combined with the subsequent cryohydrologic warming (Phillips et al. 2010), could eventually alter the ice-sheet properties not only at the surface (e.g. De la Pena et al. 2015; Machguth et al. 2016), but also at greater depths, leading to the dynamic acceleration at – and discharge from – substantial part of the ice sheet (Pattyn et al. 2018). It is also worth mentioning that the dynamic response of the Greenland ice sheet to the recent atmospheric warming might be already underestimated (e.g., Doyle et al. (2015); Mougnot et al. 2015). References: Chu (2013), doi: 10.1177/0309133313507075; De la Peña et al. (2015), doi: 10.5194/tc-9-1203-2015; Doyle et al. (2015), doi: 10.1038/ngeo2482; Fitzpatrick et al. (2014), doi: 10.5194/tc-8-107-2014; Flowers (2018), doi: 10.1038/s41467-018-05002-0; Machguth et al. (2016), doi: 10.1038/nclimate2899; Mougnot et al. (2015), doi: 10.1126/science.aac7111; Pattyn et al. (2018), doi: 10.1038/s41558-018-0305-8; Phillips et al. (2010), doi: 10.1029/2010GL044397; Smith et al. (2015), doi: 10.1073/pnas.1413024112 [Charalampos Charalampidis, Germany]	Multiple observational studies indicate that increased meltwater supply to the bed of GIS has had a limited effect on the dynamic mass balance component on the ice sheet spatial scale and multi-annual temporal scale. Response has mostly limited to catchments with grounded margins or to the slow-flowing ice sheet interior. Evolution of both channelised and distributed drainage systems to increase drainage efficiency is expected. These observations indicate that this has not been a first-order control on GIS MB. See also chapter 4 for projections.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
318	3	47	28	47	36	<p>This section should take a longer temporal perspective, at least with regard to net snow accumulation that has observational evidence spanning the past centuries. Since the end of the Little Ice Age, there is evidence from Greenland ice cores of a 15% increase in Greenland ice sheet snow accumulation over the period 1900– 1999 (Box et al., 2013; Mernild et al., 2015).</p> <p>Box, J.E., N. Cressie, D.H. Bromwich, J. Jung, M. van den Broeke, J.H. van Angelen, R.R. Forster, C. Miège, E. Mosley-Thompson, B. Vinther and J.R. McConnell, 2013. Greenland ice sheet mass balance reconstruction. Part I: net snow accumulation (1600-2009). Journal of Climate, 26:3919-3934.</p> <p>Mernild, S.H., E. Hanna, J.R. McConnell, M. Sigl, A.P. Beckerman, J.C. Yde, J. Cappelen and K. Steffen, 2015. Greenland precipitation trends in a long- term instrumental climate context (1890–2012): Evaluation of coastal and ice core records. International Journal of Climatology, 35:303-320. [Jason Box, Denmark]</p>	These citations included and others to give a stonger long-term perspective (see section 3.3.1.5).
27515	3	47	28	47	36	<p>This is also supported by analysis in Langen et al., 2015 (10.1175/JCLI-D-14-00271.1) and 2017 (10.3389/feart.2016.00110) and Mottram et al. 2017 (10.14943/lowtemsci.). Note that the Langen et al 2015 compares results from three different RCMs for a specific region and finds agreement in the SMB but some significant differences in the components, this may be significant when tryign to work out what the SMB of the ice sheet is! [Ruth Mottram, Denmark]</p>	Section on observed role of warming and melting on SMB change substantially increased. Unfortunately little scope here to present furtehr analysis of model development and performance.
26015	3	47	30	47	31	<p>pfrecise percentages (with no range or uncertainty) are given, but 4 different references. Do all 4 come up independently with exactly the same numbers? Or do 3 of the 4 references just take the numbers from the 4th in which case 3 references should be eliminated here. [Regine Hock, United States of America]</p>	Citations moved to better locations.
25261	3	47	33	47	33	<p>Colgan et al, 2015, assess the mass balance of the high elevation part of the ice sheet, not the entire ice sheet [Kristian K. Kjeldsen, Denmark]</p>	Corrected.
25235	3	47	34	47	34	<p>I would remove the word "modelled" from "modelled GIS surface melt". Instead, I would add a clause to the end of the sentence such as "GIS surface melt ..., as assessed by climate model reanalyses." [Denis Felikson, United States of America]</p>	Changed.
29695	3	47	34	47	34	<p>Compared to what baseline--given values going from quite low and then increasing, I'm not sure percentages are very helpful. Might a figure make clearer how the rate of change is accelerating? [Michael MacCracken, United States of America]</p>	Wording changed. Time periods clarified.
19133	3	47	38	47	39	<p>Is there an estimate that extends this warming past 2010? Especially when the post-1990s period is the critical point of this statement [APECS Group Review, Germany]</p>	Section expanded and now includes post-2010 climate results.
22389	3	47	38	47	44	<p>The new Trusel et al., 2018 Natue paper given important paleoclimate context for the non-linear increase in Geenland surface melting. The NEEM 2013 Nature paper is also relevant for putting limits on how much ice loss from greenland was feasible in the last interglacial warm period, when temperatures were similar to present day. [Abram Nerilie, Australia]</p>	Trusel citation now added along with other Holocene palaeo information (though not LIG due to lack of space).

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

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402	3	47	40	47	44	I agree that runoff totals remain uncertain, but this is due to more than just model grids not being able to resolve fine-scale processes at the margins. One hypothesis in the literature is the inability of RCMs to accurately model depth-dependent firm density and englacial storage (Smith et al. 2017). I would also submit that there is a knowledge gap on englacial and subglacial meltwater flow routing due sparse or non-existent measurements. For example, uncertainties in the ratio of ice overburden pressures: to pore water pressure (k-value) can lead to multiple interpretations of drainage basin delineation (Lindbäck et al. 2015). Direct measurements of Greenland meltwater runoff [1] Laurence C. Smith, Kang Yang, Lincoln H Pitcher, Brandon T. Overstreet, Vena W. Chu, Åsa K. Rennermalm, Jonathan C. Ryan, Matthew G. Cooper, Colin J. Gleason, Marco Tedesco, Jeyavinoth Jeyaratnam, Dirk van As, Michiel R. van den Broeke, Willem Jan van de Berg, Brice Noël, Peter L. Langen, Richard I. Cullather, Bin Zhao, Michael J. Willis, Alun Hubbard, Jason E. Box, Brittany A. Jenner, Alberto E. Behar. [2] Lindbäck, K., R. Pettersson, A. L. Hubbard, S. H. Doyle, D. van As, A. B. Mikkelsen, and A. A. Fitzpatrick (2015), Subglacial water drainage, storage, and piracy beneath the Greenland ice sheet, Geophys. Res. Lett., 42, 7606–7614, doi: 10.1002/2015GL065393. Proceedings of the National Academy of Sciences Dec 2017, 114 (50) E10622-E10631; DOI: 10.1073/pnas.1707743114 [Ethan Kyzivat, United States of America]	This section removed. Not central to key messages, insufficient space within the allocation for this section.
33343	3	47	41	47	41	Many sentences are unclear. Here is one example of what to avoid: "however, because although". This long sentence can easily be made into two shorter sentences. [Government of United States of America, United States of America]	Many sentences changed, including this one.
33345	3	47	42	47	42	Authors apply RCM acronym then use it only two more times. Spell out 'regional climate model' in all cases. [Government of United States of America, United States of America]	Yes, done.
27517	3	47	42	47	45	Herman et al., 2018, 10.1029/2017JF004408 showed that some of the uncertainties mentioned here may actually come from model schemes that tend to overestimate precipitation at the ice sheet margin, which in turn suppresses melt rates in summer due to a lack of albedo feedbacks. In addition, the analysis in the Mottram et al submitted paper shows that performance of RCM produced SMB compares well overall with GRACE gravimetric balance but there are some significant regional discrepancies. A model that performs well with observations in one area may not perform as well elsewhere. In addition, the effect of albedo schemes is important. Significant improvement in HIRHAM SMB is given by assimilating observed albedo from MODIS and albedo is still the largest uncertainty in calculating melt rates. [Ruth Mottram, Denmark]	This section removed. Not central to key messages, insufficient space within the allocation for this section.
25237	3	47	43	47	44	I would clarify the assertion that RCMs "do not currently resolve the narrow coastal outlet glaciers where melt is greatest," by adding that downscaling methods, such as the one used in Noël et al. (2016) are able to resolve outlet glaciers. And, while RCMs underestimate melt within these narrow glaciers, the downscaling techniques are doing a better job at getting the melt correct. For example, although the observations are limited, the most recent RACMO2.3p2 model data look like SMB in the ablation zone matches observations better than the RACMO2.3p1 data (see Figure 9a in Noël et al., 2018). [Denis Felikson, United States of America]	This section removed. Not central to key messages, insufficient space within the allocation for this section.
26017	3	47	44	47	44	replace RCM by 'modeled' [Regine Hock, United States of America]	Changed.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
26019	3	47	46	47	46	Why medium confidence? Do you not trust the observation? This observation is a fact and does not need a confidence statement. There may be reduced confidence in the extent, depth or other variables but as this is formulated this is simply a fact. [Regine Hock, United States of America]	It was 'medium evidence', now removed.
436	3	47	46	47	54	Meltwater retention appears incomplete, since firn aquifers are a characteristic only of the southeastern part of the Greenland ice sheet, caused by the high winter accumulation (i.e. efficient pore-volume renewal and insulation of the temperate subsurface from the subfreezing atmosphere) and increased summer melt. It has been shown that over several other areas on the ice sheet with lower winter accumulation (i.e. inefficient pore-volume renewal and insulation of the temperate subsurface from the subfreezing atmosphere) and reduced summer melt, meltwater percolation is not as deep as previously thought (e.g. Charalampidis et al., 2016; Heilig et al., 2018). Subsequently, because of the recent atmospheric warming (MacGrath et al., 2013) and increased surface melt, a build-up of near-surface ice layers has been reported in the western, and other parts of the ice sheet (i.e., De la Pena et al. 2015), hence substantial amount of firn is virtually unavailable for meltwater storage. During the extreme 2012 melt season, the most pronounced in the observational record (Nghiem et al. 2012), these ice layers were shown to hamper meltwater percolation at elevations as high as 1840 m above sea level (Machguth et al 2016). Meltwater saturation of the ice-sheet surface resulted in 9 % lower summer albedo or 28 % additional absorbed solar radiation of which 71 % was translated into melt; meltwater runoff was calculated to at least 36 % of total meltwater production at that elevation (Charalampidis et al. 2015). Such near-surface layers are bound to expand upglacier in a warming climate given the amplified amount of melt by the ice sheet's hypsometry, i.e., area increase with elevation (e.g., Van As et al. 2017), and will likely enable runoff from the wide interior of the ice sheet (MacFerrin et al., Nature, in review). References: Charalampidis et al. (2015), doi: 10.5194/tc-9-2163-2015; Charalampidis et al. (2016), doi: 10.1017/aog.2016.2; De la Peña et al. (2015), doi: 10.5194/tc-9-1203-2015; Heilig et al. (2018), doi: 10.5194/tc-12-1851-2018; MacFerrin et al. (in review), Nature.; Machguth et al. (2016), doi: 10.1038/nclimate2899; McGrath et al. (2013), doi: 10.1002/grl.50456; Nghiem et al. (2012), 10.1029/2012GL053611; Van As et al. (2017), doi: 10.5194/tc-11-1371-2017 [Charalampos Charalampidis, Germany]	This section rewritten to: "Only around half of the 1960-2014 surface melt ran off, most of the rest being retained in firn and snow{Steger, 2017 #1691}, particularly in recently-observed firn aquifers in south and west Greenland{Humphrey, 2012 #706;Forster, 2013 #707;Kuipers Munneke, 2014a #708;Poinar, 2017 #709} that cover up to 5% of GIS {Miège, 2016 #710;Steger, 2017 #1691} and stored around a fifth of the meltwater increase since the late 1990s {Noël, 2017 #712} (medium confidence). While potential aquifer storage is equivalent to about a quarter of annual GIS melt production {Koenig, 2014 #231;Van den Broeke, 2016 #701}and aquifers have spread to higher altitudes {Steger, 2017 #1691}, their potential to buffer runoff has been reduced by firn densification {Polashenski, 2014 #713}, diversion of water to the bed via crevasses {Poinar, 2017 #709}, and the formation of ice layers that prevent drainage and promote surface ponding on the firn {Charalampidis, 2016 #1692} (high confidence). Such ponding lowers the firn albedo, promoting further melting (high confidence) {e.g., Charalampidis, 2015 #1693}, but the extent of bare ice is a fivefold stronger control on melt {Ryan, 2019 #1694}. Bare ice produced ~78% of runoff from 1960-2014, and its extent is expected to increase non-linearly as snow cover retreats to higher, flatter areas of ice sheet {Steger, 2017 #1691}. This extent is not well reproduced in climate models, however, with biases of -6% to +13% {Ryan, 2019 #1694}."

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

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19131	3	47	46	47	54	<p>There has been significant investigation into the perennial firn aquifer in S and SW Greenland since the first draft of this MS has been written. that shows that meltwater exists not only in thick firn layers around the ELA (e.g. Forster et al. 2013, Miller et al. 2017, Montgomery et al. 2017), but also in the bare ice layers at lower elevations (e.g. Cooper et al. 2018, Kendrick et al. 2018). Therefore, I would argue that the amount of new evidence since 2017 would warrant the first sentence statement (L46-48) to be more than "medium confidence". [APECS Group Review, Germany]</p>	<p>This section rewritten to: "Only around half of the 1960-2014 average annual GIS surface melt ran off, with most of the rest being retained in firn and snow [Steger et al., 2017 doi.org/10.3389/feart.2017.00003]. Extensive sub-surface meltwater storage and transport in perennial firn aquifers has recently been observed in south and west GIS (Humphrey, 2012 #706;Forster, 2013 #707;Kuipers Munneke, 2014a #708; Poinar, 2017 #709), covering between 22,000 km2 {Miège, 2016 #710} and 90,000 km2 (5% of GIS) [Steger et al., 2017 doi.org/10.3389/feart.2017.00003]. This storage has buffered the GIS runoff response to increased melting (medium confidence) by storing around a fifth of the meltwater increase since the late 1990s {Noël, 2017 #712}. Potential aquifer storage is equivalent to about a quarter of annual GIS melt production {Koenig, 2014 #231;Van den Broeke, 2016 #701}, but a reduction in firn storage would lead to more meltwater running off [Machguth et al., 2017 doi.org/10.3389/feart.2018.00105] and the percolation regime has been changing (high confidence). While aquifers have spread to higher altitudes {Steger, 2017 #711}, their storage potential has been reduced by firn densification (causing firn warming of up to +6°C between 1951/2 and 2013 {Polashenski, 2014 #713}) and the formation of ice layers, which instead promote surface ponding and runoff [Machguth et al., 2016 doi: 10.1017/aog.2016.2; Charalampidis et al., 2016 doi: 10.1017/aog.2016.2] and the drainage of water to the ice sheet bed through crevasses {Poinar, 2017 #709}. Surface water lowers the ice sheet albedo, so this process acts as a positive feedback that promotes further melting and reduction in firn storage (high confidence) (e.g., [Charalampidis et al., 2015 doi.org/10.5194/tc-9-2163-2015])." Also Kendrick citation added.</p>

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

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26021	3	47	46	47	54	<p>A major advancement in knowledge since AR5 is missing here: the paper by Machguth et al., 2016 Nature, which shows the complexity between storage capacity and runoff. They show that huge ice lenses inhibit the melt water to reach deeper firn and thus cause enhance runoff rather than storage in deeper firn layers. These findings should be incorporated. [Regine Hock, United States of America]</p>	<p>This section rewritten to: "Only around half of the 1960-2014 average annual GIS surface melt ran off, with most of the rest being retained in firn and snow [Steger et al., 2017 doi.org/10.3389/feart.2017.00003]. Extensive sub-surface meltwater storage and transport in perennial firn aquifers has recently been observed in south and west GIS (Humphrey, 2012 #706;Forster, 2013 #707;Kuipers Munneke, 2014a #708; Poinar, 2017 #709), covering between 22,000 km2 (Miège, 2016 #710) and 90,000 km2 (5% of GIS) [Steger et al., 2017 doi.org/10.3389/feart.2017.00003]. This storage has buffered the GIS runoff response to increased melting (medium confidence) by storing around a fifth of the meltwater increase since the late 1990s (Noël, 2017 #712). Potential aquifer storage is equivalent to about a quarter of annual GIS melt production (Koenig, 2014 #231;Van den Broeke, 2016 #701), but a reduction in firn storage would lead to more meltwater running off [Machguth et al., 2017 doi.org/10.3389/feart.2018.00105] and the percolation regime has been changing (high confidence). While aquifers have spread to higher altitudes (Steger, 2017 #711), their storage potential has been reduced by firn densification (causing firn warming of up to +6°C between 1951/2 and 2013 (Polashenski, 2014 #713)) and the formation of ice layers, which instead promote surface ponding and runoff [Machguth et al., 2016 doi: 10.1017/aog.2016.2; Charalampidis et al., 2016 doi: 10.1017/aog.2016.2] and the drainage of water to the ice sheet bed through crevasses (Poinar, 2017 #709). Surface water lowers the ice sheet albedo, so this process acts as a positive feedback that promotes further melting and reduction in firn storage (high confidence) (e.g., [Charalampidis et al., 2015 doi.org/10.5194/tc-9-2163-2015])."</p>

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

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33347	3	47	48	47	51	<p>This sentence implies that the estimates for firn-storage of meltwater (140 Gt) should be compared with the estimates for total melt minus runoff (435-260 Gt/yr from 1961-1990)? If that is the case -- i.e., the implication is that the two match / should match / roughly match - perhaps authors should be more explicit. As written it is not entirely clear what the significance of this sentence and these numbers are (435-260=175 Gt/yr of potential storage ... is the implication that the estimates for current storage in firn are low and thus there must be other large aquifers not accounted for?). [Government of United States of America, United States of America]</p>	<p>This section rewritten to: "Only around half of the 1960-2014 average annual GIS surface melt ran off, with most of the rest being retained in firn and snow [Steger et al., 2017 doi.org/10.3389/feart.2017.00003]. Extensive sub-surface meltwater storage and transport in perennial firn aquifers has recently been observed in south and west GIS (Humphrey, 2012 #706;Forster, 2013 #707;Kuipers Munneke, 2014a #708; Poinar, 2017 #709), covering between 22,000 km2 {Miège, 2016 #710} and 90,000 km2 (5% of GIS) [Steger et al., 2017 doi.org/10.3389/feart.2017.00003]. This storage has buffered the GIS runoff response to increased melting (medium confidence) by storing around a fifth of the meltwater increase since the late 1990s {Noël, 2017 #712}. Potential aquifer storage is equivalent to about a quarter of annual GIS melt production {Koenig, 2014 #231;Van den Broeke, 2016 #701}, but a reduction in firn storage would lead to more meltwater running off [Machguth et al., 2017 doi.org/10.3389/feart.2018.00105] and the percolation regime has been changing (high confidence). While aquifers have spread to higher altitudes {Steger, 2017 #711}, their storage potential has been reduced by firn densification (causing firn warming of up to +6°C between 1951/2 and 2013 {Polashenski, 2014 #713}) and the formation of ice layers, which instead promote surface ponding and runoff [Machguth et al., 2016 doi: 10.1017/aog.2016.2; Charalampidis et al., 2016 doi: 10.1017/aog.2016.2] and the drainage of water to the ice sheet bed through crevasses {Poinar, 2017 #709}. Surface water lowers the ice sheet albedo, so this process acts as a positive feedback that promotes further melting and reduction in firn storage (high confidence) (e.g., [Charalampidis et al., 2015 doi.org/10.5194/tc-9-2163-2015])."</p>

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

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27519	3	47	52	47	54	<p>Whilst I do not disagree with the references cited, it may be important to note that a series of high snowfall winters and cooler summers may well have "recharged" the firn reservoir for both meltwater and refreezing compared to the articles cited. I am not sure we can conclude that the firn capacity for retention is being reduced as a result. I do not have a reference for this to hand, but the special issue in frontiers on retention in firn, or perhaps the Promice group at GEUS may be able to help resolve this...</p> <p>https://www.frontiersin.org/research-topics/4880/melt-water-retention-processes-in-snow-and-firn-on-ice-sheets-and-glaciers-observations-and-modeling [Ruth Mottram, Denmark]</p>	<p>This section now reads: "</p> <p>Only around half of the 1960-2014 average annual GIS surface melt ran off, with most of the rest being retained in firn and snow [Steger et al., 2017 doi.org/10.3389/feart.2017.00003]. Extensive sub-surface meltwater storage and transport in perennial firn aquifers has recently been observed in south and west GIS (Humphrey, 2012 #706; Forster, 2013 #707; Kuipers Munneke, 2014a #708; Poinar, 2017 #709), covering between 22,000 km2 (Miège, 2016 #710) and 90,000 km2 (5% of GIS) [Steger et al., 2017 doi.org/10.3389/feart.2017.00003]. This storage has buffered the GIS runoff response to increased melting (medium confidence) by storing around a fifth of the meltwater increase since the late 1990s (Noël, 2017 #712). Potential aquifer storage is equivalent to about a quarter of annual GIS melt production (Koenig, 2014 #231; Van den Broeke, 2016 #701), but a reduction in firn storage would lead to more meltwater running off [Machguth et al., 2017 doi.org/10.3389/feart.2018.00105] and the percolation regime has been changing (high confidence). While aquifers have spread to higher altitudes (Steger, 2017 #711), their storage potential has been reduced by firn densification (causing firn warming of up to +6°C between 1951/2 and 2013 (Polashenski, 2014 #713)) and the formation of ice layers, which instead promote surface ponding and runoff [Machguth et al., 2016 doi: 10.1017/aog.2016.2; Charalampidis et al., 2016 doi: 10.1017/aog.2016.2] and the drainage of water to the ice sheet bed through crevasses (Poinar, 2017 #709). Surface water lowers the ice sheet albedo, so this process acts as a positive feedback that promotes further melting and reduction in firn storage (high confidence) (e.g., [Charalampidis et al., 2015 doi.org/10.5194/tc-9-2163-2015])." Here, some evidence for aquifer change and storage loss is presented.</p>
27521	3	47	52	47	54	<p>Also the text mentions firn aquifers but not ice slabs - these are the subject of a paper in revision by MacFerrin et al for Nature which I expect will meet the deadline and which may have been identified by othe reviewers. Macferrin's paper looks at widespread iceslabs that prevent percolation deeper into the snowpack and are also relevant in reducing capacity for retention of meltwater [Ruth Mottram, Denmark]</p>	<p>The Machguth study now cited also does this.</p>
25051	3	48	0	48		<p>Figure 3.7: For transparency, please define explicitly the displayed uncertainty (supposedly standard "one-sigma"). It would be nice to have a secondary vertical axis indicating the equivalent seal level contribution, similar to Fig. 3.6. [Sergio Henrique Faria, Spain]</p>	<p>Both now done.</p>
9961	3	48	1	48	1	<p>Flowers (2018) is not the original source. See citation within Flowers (2018) for 1991-2015 dynamic losses from GrIS: van den Broeke, M. R. et al. On the recent contribution of the Greenland Ice Sheet to sea level change. Cryosphere 10, 1933–1946 (2016). [Gwenn Flowers, Canada]</p>	<p>Citation corrected.</p>

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
26023	3	48	1	48	1	Why 40%? According to earlier this should be 32% [Regine Hock, United States of America]	Note the time periods referred to for SMB and dynamics respectively.
33349	3	48	1	48	9	The increased importance of surface melt to the GrIS SMB is an important point. Authors mention that subglacial drainage network evolve to cope with the additional water, but give no indication of the confidence level and how much this may be affecting GrIS mass loss. Additionally, in the previous section on AIS, the role of subglacial hydrology is noted as a key uncertainty, however there is no discussion of the uncertainty for GrIS. This uncertainty appears to be very relevant given what authgors are stating about subglacial drainage networks below GrIS. Include an assessment of uncertainty here. [Government of United States of America, United States of America]	Confidence statement now included in the revised statement: "Furthermore, there is now high confidence that for most of the GIS, increased surface melt has not led to sustained increases in glacier flux on annual timescales because subglacial drainage networks have evolved to drain away the additional water inputs (e.g., \Nienow, 2017 #715;Tedstone, 2015 #716;Sole, 2013 #717;Stevens, 2016 #718;King, 2018 #1678)."
2537	3	48	2	48	2	Since 2000...until when? And the number of -739 Gt is at odds with Fig. 3.7 (blue line). [Michiel Van den Broeke, Netherlands]	Until 2012, now added. The -739 value is as reported in the text of this study (Enderlin et al.) and in its figure 1. Checking with authors why this disagrees with its figure 3 (figure 3.7 here). Author response: not an error. GIS was out of balance at the start of the time series and this, compounded cumulatively, explains the apparent discrepancy.
25263	3	48	2	48	2	The appropriate reference to use is van den Broeke et al, 2016, which Flower, 2018, cited specifically for the numbers provide in the present text [Kristian K. Kjeldsen, Denmark]	Citation corrected.
15563	3	48	3	48	3	It would be relevant to name the four glaciers. [EUCE, Belgium]	Now named
16893	3	48	3	48	3	It would be relevant to name the four glaciers [Louise Sandberg Soerensen, Denmark]	Now named
28377	3	48	3	48	3	This reference and the figure 3.7 have been updated or superseded by King et al, Cryosphere 2018, https://doi.org/10.5194/tc-12-3813-2018 . This covers more glaciers, for a longer time period and with seasonal resohn. [Jonathan Bamber, United Kingdom (of Great Britain and Northern Ireland)]	King et al. now cited.
29203	3	48	4	48	4	The statement that melt rates in the Amundsen/Bellingshausen are two orders of magnitude higher than elsewhere around the continent is inconsistent with Rignot et al. (2013) and Depoorter et al. (2013) (both of which would seem to be more appopriate references here than a paper from 1996 and a study limited to the Amundsen). [Stephen Rintoul, Australia]	Statement changed to one order of magnitude, citations updated.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
182	3	48	6	48	9	<p>There are observations of a mean annual ice flow speed-up induced by an increased melt-rate (e.g. Zwally and others, 2002; Shepherd and others, 2009; Bartholomew and others, 2010; Doyle and others, 2014). Hence, this text should be modulated and may be restricted to the low elevation parts of the Greenland Ice Sheet. How higher elevation parts of GIS are influenced by an increase in surface runoff is not so clear. Higher surface melt rate arising at higher elevations might extend the influence of water over larger area of the bed in a near future (Gagliardini and Werder, 2018). Moulins, which allow the water to reach the glacier base, might form at higher elevations in the future, because of supraglacial lake drainage (Hoffman and others, 2018; Christoffersen and others, 2018) or the propagation of changes in ice flow (Gagliardini and Werder, 2018). Observations (Meierbachtol and others, 2013) and modeling (de Fleurian et al., 2016; Gagliardini and Werder, 2018) indicate a limited extend of the efficient drainage system (channels) with the consequence that water reaching the bed upstream the channelized area will flow through an inefficient system with high water pressure. A better understanding of the complex coupling between increased surface runoff and its influence on modulating ice flow, will require the development of hydrology models (de Fleurian et al., 2018) and their coupling with ice flow models (Hewitt 2013, Hoffman and Price 2014, Gagliardini & Werder 2018), as well as complementary observations over longer periods.</p> <p>References: Bartholomew I and 5 others (2010) Seasonal evolution of subglacial drainage and acceleration in a Greenland outlet glacier. Nat. Geosci., 3(6), 408 Christoffersen P and 5 others (2018) Cascading lake drainage on the Greenland ice sheet triggered by tensile shock and fracture. Nat. Commun., 9(1), 1064 Doyle SH and 6 others (2014) Persistent flow acceleration within the interior of the Greenland ice sheet. Geophys. Res. Lett., 41(3), 899–905 de Fleurian B and 8 others (2016) A modeling study of the effect of runoff variability on the effective pressure beneath Russell Glacier, West Greenland. J. Geophys. Res. Earth. Surf., 121 (10), 1834–1848 de Fleurian, B., M. Werder, S. Beyer, D. Brinkerhoff, I. Delaney, C. Dow, C., J. Dows, O. Gagliardini, M.J. Hoffman, R. LeB Hooke, J. Seguinot, A.N. Sommers, 2018. SHMIP The subglacial hydrology model intercomparison Project. Journal of Glaciology, 1-20. doi:10.1017/jog.2018.78 Gagliardini O. and M. Werder, 2018. Influence of increasing surface melt over decadal</p>	Citation to Gagliardini and Werder (2018) added. Qualifier added that statement applies to 'most of the GIS'. Multiple lines of observational evidence indicate that sustained and widespread acceleration does not result from increased runoff. This cited paper is useful but relates to land-terminating glaciers draining 10% of the GIS by volume.
19143	3	48	6	48	9	I feel that this phrase could use a confidence assessment as it is consequential for section 3.3.1.6.1 and 3.3.2.1 [APECS Group Review, Germany]	High confidence statement added.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
30243	3	48	6	48	9	The subglacial hydrological evolution allowing efficient water evacuation only applies to the near-margin systems of Greenland (i.e. within 40km). Further inland, dye tracing (Chandler et al, 2013), and modeling studies (Banwell et al, 2016, JGR; Dow et al, 2015, JGR) shows persistence of an inefficient drainage system largely due to the shallow surface slopes preventing fast flow of basal water. It's currently unclear what the impacts would be for inland speed up due to increasing water inputs relative to marginal ice slow down due to increasingly efficient drainage. [Christine Dow, Canada]	An extensive review by Nienow et al. (cited) notes that 'inefficient' distributed drainage systems can also evolve to become more efficient, that speedup effects apply to high-altitude, slow-flowing areas and that this is likely a transition to greater efficiency. The most detailed GIS-wide observational study available to-date (King et al., 2018, now cited) finds "Neither maximum seasonal runoff or annual runoff totals are correlated to annual discharge, which suggests that larger annual quantities of runoff do not relate to increased annual discharge." and it is annual GIS discharge that is of most interest to this report (as opposed to shorter-term, smaller-scale effects). This is supported by multiple other observations.
9963	3	48	8	48	9	References to Sole et al, etc should be preceded with "e.g." since there have been others to point out the negative feedback on flow [Gwenn Flowers, Canada]	Done.
31627	3	48	11	0		Figure 3.7. Assumingly, the values within the figure correspond to the mean within those years. It would be good to make this clear in the caption; In the caption, spell out GIS. [Hans-Otto Poertner and WGII TSU, Germany]	They are annual totals by calendar year. Now rewritten as "Greenland Ice Sheet cumulative annual mass change..." to clarify. GIS spelt out.
396	3	48	11	48	16	Fig 3.7: The analagous plot (Fig. 3.6) for Antarctica is partioned differently (by region, rather than ablation type). Could you present the same data for both ice sheets? [Ethan Kyzivat, United States of America]	There is a study that reports the mass balance components for AIS (Rignot et al., 2019) but this uses only one method (input-output) and produces a total cumulative AIS mass change that is larger than that of the multi-method studies cited. When plotted cumulatively as in this figure, relatively small biases in the SMB or discharge components are compounded, but the source of the bias that produces differing total mass change is not clear. While the component contributions can be rescaled so that the total of the Rignot study agrees with that of the combined multi-method studies, it is not clear how to scale the components and their uncertainties, and a consensus has not yet been reached on this. For that reason, we do not present the AIS cumulative components in the same way as the GIS ones, which are better known.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
3177	3	48	12	48	12	The visual representation of the cumulative mass change in the Greenland ice sheets (Figure 3.7) and the Antarctica ice sheets (Figure 3.6) are helpful. However, these two figures are presented in different ways, which makes it more difficult to compare the changes in the two regions. It may be helpful to either make the two plots more visually similar, or make the plots for Antarctica and Greenland next to each other so that it is easier to compare the changes. Also, it may be beneficial to include the sea-level contribution of the mass change in Greenland, which is included for Antarctic in Figure 3.6. [Sloane Garelick, United States of America]	GIS mass changes now plotted with AIS, WAIS, EAIS and AP masss changes in Figure 3.7, with sea level equivalent. Regarding the components of mass balance change as for GIS in Figure 3.7: There is a study that reports the mass balance components for AIS (Rignot et al., 2019) but this uses only one method (input-output) and produces a total cumulative AIS mass change that is larger than that of the multi-method studies cited. When plotted cumulatively as in this figure, relatively small biases in the SMB or discharge components are compounded, but the source of the bias that produces differing total mass change is not clear. While the component contributions can be rescaled so that the total of the Rignot study agrees with that of the combined multi-method studies, it is not clear how to scale the components and their uncertainties, and a consensus has not yet been reached on this. For that reason, we do not present the AIS cumulative components in the same way as the GIS ones, which are better known. See however Appendix 3.A Figure 8 for the components over a shorter time period.
222	3	48	13	48	13	Do not abbreviate GIS in the caption. Please spell it out. Also, consistency with labeling, etc., of Fig. 3.6 would be appreciated. [Baylor Fox-Kemper, United States of America]	Done.
230	3	48	13	48	13	Fig. 3.7 doesn't include projections, why not? [Baylor Fox-Kemper, United States of America]	Projections are in chapter 4.
26025	3	48	13	48	15	Is there only one single study showing these components? [Regine Hock, United States of America]	Now citing Enderlin et al., 2014, van den Broeke et al., 2016 and King et al., 2018 regarding GIS-wide components of mass balance. Figure 3.7 now uses those of King et al.
29053	3	48	19	51	2	For this section (3.3.1.6), as well as 3.3.1.7, please see Trusel et al (2018). Non-linear rise in Greenland runoff in response to post-industrial Arctic warming. Nature 564:104-108. It appears not to be cited (would have been In Publication) for this chapter, and should be considered in the decision by the drafting group not to attribute recent acceleration in ice sheet mass loss at either pole to anthropogenic climate change and to highlight this for policy makers in the SPM and ES. Again, if this is the uncontested scientific consensus, so be it; but the decision to highlight this lack of attribution in the SPM and Ch 3 Summary should be carefully considered, per above comments. [Pam Pearson, Sweden]	Agreed, now cited.
19139	3	48	19	55	35	In these sections, there is a lot of "hopping" between Antarctica and the Arctic, would it be possible to keep subsections dividing the two in all sections? That would make the structure clearer [APECS Group Review, Germany]	The sections on 'observations of change' and 'components of change' are now segregated by ice sheet. The sections on 'drivers (ocean vs atmosphere)' and 'forcings (natural or anthropogenic)' are shared because these relate to global processes and phenomena that have commonality between the two poles. Hopefully separation is now more clearly signposted.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
33351	3	48	21	48	24	A recent and extensive review of ice sheet feedbacks with the earth system is given in Fyke et al., 2018, Reviews of Geophysics, 56, pp 361-407, doi.org/10.1029/2018RG000600. [Government of United States of America, United States of America]	Citation added.
28569	3	48	23	48	23	Should mention that feedbacks can also damp (as well as amplify) the response to forcing. [Pippa Whitehouse, United Kingdom (of Great Britain and Northern Ireland)]	This statement now removed.
19141	3	48	27	48	29	missing references, where does this "very likely" come from? [APECS Group Review, Germany]	This general statement removed in order to devolve confidence statements to individual sections below.
28249	3	48	28	0		Holland et al. 2008 describes a single glacier. Better references is Straneo et al. 2012 (Annals of Glaciology, 53, 2012) which describes Atlantic waters at the margins of glaciers all around Greenland. [Straneo Fiamma, United States of America]	Citation added.
17517	3	48	31	48	36	Additional citations: Joughin I., et al. (2014) Marine Ice Sheet Collapse Potentially Under Way for the Thwaites Glacier Basin, West Antarctica, SCIENCE 344:735–738; Favier L., et al. (2014) Retreat of Pine Island Glacier controlled by marine ice-sheet instability, NATURE CLIMATE CHANGE 4:117–121. [Kristin Campbell, United States of America]	This citation already provided in section 3.3.1.3 to which this paragrap refers.
17625	3	48	31	48	36	Additional citations: Joughin I., et al. (2014) Marine Ice Sheet Collapse Potentially Under Way for the Thwaites Glacier Basin, West Antarctica, SCIENCE 344:735–738,735 ("Glaciers along the Amundsen Coast of Antarctica are thinning, producing the majority of Antarctica's contribution to sea-level rise. Much of this thinning is probably a response to the increased presence of warm modified Circumpolar Deep Water (CDW) on the adjacent continental shelf, which is melting and thinning the floating ice shelves that buttress the ice sheet."); Favier L., et al. (2014) Retreat of Pine Island Glacier controlled by marine ice-sheet instability, NATURE CLIMATE CHANGE 4:117–121, 117 ("Over the past 40 years Pine Island Glacier in West Antarctica has thinned at an accelerating rate, so that at present it is the largest single contributor to sea-level rise in Antarctica."). [Durwood Zaelke, United States of America]	This citation already provided in section 3.3.1.3 to which this paragrap refers.
30239	3	48	38	49	7	There is no mention of factors that destabilize ice shelves other than basal melt. For example, rifting is an important process for reducing the mass of ice shelves and in turn, their buttressing effect. Dow et al (2018, Science Advances) showed that transverse rifts are forming over basal channels in ice shelves and lead to calving events. The basal channels also direct surface water into rivers due to hydrostatic balance and those rivers can exacerbate rifting of those transverse fractures due to hydrofracture processes. [Christine Dow, Canada]	Statement changed to "The reduction of ice-shelf buttressing that has dominated AIS mass loss (3.3.1.2) has been driven primarily by increases in sub-ice-shelf melting {Khazendar, 2013 #727;Cook, 2016 #728;Rintoul, 2016 #729;Walker, 2017 #730;Pollard, 2015 #731;Adusumilli, 2018 #732;Minchew, 2018 #733;Dow, 2018 #1696}(high confidence)."
9537	3	48	43	48	43	It should be possible to read Figures and Tables regardless of the text. Acronyms should be defined in titles. Here : GIS (Greenland Ice Sheet) [Government of France, France]	Yes, done.
30353	3	49	2	49	2	I suggest changing "further" to "farther," which is preferred for indicating greater distance, whereas further is reserved for figurative or abstract sense. [Paul Glaser, United States of America]	Changed.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
33353	3	49	4	49	7	Would it be more appropriate to discuss changes in the "draft" of the CDW layer, or "shoaling" of the CDW layer rather than its "thickness"? It's not clear that the actual thickness of the layer is changing (increasing/decreasing) as opposed to the elevation of its interface with colder surface waters (e.g., shoaling of the interface in response to changes in wind stress). Similar content applies to the next two lines (9-10) on the same page. [Government of United States of America, United States of America]	Agreed, changed to i) shoaling and ii) depth.
19145	3	49	14	49	14	SAM needs to be explained in full words here as it is the first time it appears in this section [APECS Group Review, Germany]	Done.
3087	3	49	22	49	30	Paragraph mixes observations and modelling-make clear? [Helene Hewitt, United Kingdom (of Great Britain and Northern Ireland)]	Changed to; "Around Greenland, an anomalous inflow of subtropical water driven by wind changes, multi-decadal natural ocean variability {Andresen, 2012 #743}, and a long-term increase in the North Atlantic's upper ocean heat content since the 1950s {Cheng, 2017 #744}, all contributed to a warming of the subpolar North Atlantic {Häkkinen, 2013 #745} (medium confidence). Water temperatures near the grounding zone of GIS outlet glaciers are critically important to their calving rate {O'Leary, 2013 #746} (medium confidence), and warm waters have been observed interacting with major GIS outlet glaciers (high confidence){e.g., \Holland, 2008 #747;Straneo, 2017 #1699}."
30355	3	49	23	49	26	Please make sure that the locations of all these place names on are shown on a map. [Paul Glaser, United States of America]	Agreed, new locations map being added (Figure 3.2).
24471	3	49	32	49	33	I would also expect a reference to the work by Todd et al (2018, Journal of Geophysical Research: Earth Surface) which contains a new calving model, the three-dimensional follow up of Todd and Christoffersen, 2014. [Eef van Dongen, Switzerland]	Added.
27523	3	49	32	49	40	Rathmann et al 2017 GRL10.1002/2017GL074368 is a nice study that shows how neighbouring glaciers can respond very differently to the same forcing and is relevant here. [Ruth Mottram, Denmark]	Citation added.
25239	3	49	35	49	35	I would write "these are understood with low confidence" in the parentheses. [Denis Felikson, United States of America]	Changed.
22391	3	49	43	49	52	For SAM reconstructions: Villabla et al 2013, Nature Geoscience and Datwyler et al 2017 produce reconstructions of summer SAM. Abram et al., 2014 and Datwyler et al., 2017 produce reconstructions of the mean annual SAM. In all reconstructions the recent positive SAM trend is unusual in the context of the past 600-1000 years (the length of the reconstructions). [Abram Nerilie, Australia]	Abram reference added to substantially-revised section on 'Evidence for natural and anthropogenic forcing'.
29697	3	49	47	49	47	It seems to me that it would help the reader if the acronym SAM were occasionally again defined. At this point, the readers is 35 pages after the term was first defined and it has been used only intermittently since. Somehow, I'd suggest a bit more frequent helping the reader by repeating the full term--maybe in each major section of the report. [Michael MacCracken, United States of America]	Agreed, redefined in this section.
19147	3	49	54	49	55	contrast is not clear enough. Need a sentence break. I suggest "...AIS mass balance. However, melting..." [APECS Group Review, Germany]	Changed.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
22393	3	49	54	50	20	Paleoclimate evidence for the acceleration of summer surface melt on the northern Antarctic Peninsula gives context over the last 1000 years, and highlights the non-linearity of this process (Abram et al., 2013, Nature Geoscience). Trusel et al., 2015, Nature Geoscience gives further assessment over the satellite era, and future projections under different RCPs [Abram Nerilie, Australia]	This millennial context added.
903	3	50	1	50	40	Lacks the reference to human CO2 and such cultures and industry, should be very clear on it [Falk Huettmann, United States of America]	Please see revised section 3.3.1.7
30245	3	50	2	50	3	Surface rivers don't necessarily stabilise ice shelves. They are driven by the location of basal channels which can cause transverse fractures due to thin ice - the rivers exacerbate full thickness rifts due to hydrofracture and can lead to large calving events (Dow et al, 2018, Science Advances). [Christine Dow, Canada]	This section largely removed, only observed changes covered. New statement: "During the 1990s, WAIS experienced record surface warmth relative to the past 200 years, though similar conditions occurred for 1% of the preceding 2000 years {Steig, 2013 #774}, and WAIS surface melting remains limited. In contrast, AP surface melting has intensified since the mid-20th century and the last three decades were unprecedented over 1000 years {Abram, 2013 #1703}. The northeast AP began warming 600 years ago and past-century rates were unusual over 2000 years {Mulvaney, 2012 #775;Stenni, 2017 #1702}. Increased föhn winds due to the more positive SAM {Cape, 2015 #777} caused increased surface melting on the Larsen ice shelves {Grosvenor, 2014 #778;Luckman, 2014 #392;Elvidge, 2015 #779} and after 11,000 years intact, the 2002 melt-driven collapse of the Larsen B ice shelf followed strong warming between the mid-1950s and the late 1990s {Domack, 2005 #776} (medium confidence)."
17075	3	50	6	50	10	Something needs to be said about the cooling observed in the northern tip of the Antarctic Peninsula since mid90s. [Jorge Carrasco, Chile]	See later in same paragraph.
22395	3	50	6	50	20	Paleoclimate context for Antarctic temperatures in Antarctic continent and regional-scale reconstructions in Stenni et al 2017, Climate of the Past. Reconstructions demonstrate a significant cooling trend from 0 to 1900 CE. Since 1900 CE significant warming trends identified for West Antarctic ice sheet, Dronning Maud Land coast and Antarctic Peninsula. Large range of natural variability means that only for the Antarctic Peninsula is the warming trend over the last century unusual in the context of trends over the last 2000 years. [Abram Nerilie, Australia]	This information and citation added.
22399	3	50	6	50	40	Additional paleoclimate context in Abram et al., 2016 Nature, where the onset of continent-scale warming trends was assessed. At a continent scale, significant warming is not yet detected over Antarctica (but some regional areas are warming significantly - Stenni et al 2017, Climate of the Past; Jones et al., 2016 Nature Climate Change), and this is at odds with climate model simulations. For the Arctic, paleoclimate data and models indicates that surface atmospheric warming began in the mid 19th Century. [Abram Nerilie, Australia]	Stenni regional signals now included. Abram citation added.
28571	3	50	13	50	13	The collapse of the Larsen B ice shelf in 2002 is not really 'unprecedented' over the last 11,000 years. For other examples of ice shelf collapse events in recent decades see the text and references on page 52, lines 2-4. [Pippa Whitehouse, United Kingdom (of Great Britain and Northern Ireland)]	'Unprecedented' applies to Larsen B. Text clarified.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
23349	3	50	17	50	17	Interesting observation about change in trend of AP temperature, relevant for ES / SPM I think. These challenges about attribution should also be conveyed in the conclusions. [Valerie Masson-Delmotte, France]	Yes, and attribution section now substantially revised.
22397	3	50	17	50	20	The AP cooling since the late 1990s is phrased so it reads like the interpretation is now that AP warming isn't being driven by global temperature change. But that disregards the longer term warming trend that exists in station data and ice core evidence. Even the Turner paper stated that they expected the cooling to be a short term phenomenon and that long-term warming would recommence when the decadal forcing transitions. The way that the text here is currently laid out is analagous to the "global warming stopped in 1998" arguement. [Abram Nerilie, Australia]	Wording changed to clarify that the strong natural variability affects trend detection on relatively short, decadal timescales.
33355	3	50	28	50	30	Authors state that there is high confidence that the GrIS SMB is influenced by variability in the large-scale atmospheric circulation then go on to cite two papers from the same author. This does not convey high confidence. In contrast, there seems to be many more citations around statements that convey high uncertainty/low confidence. Shouldn't statements of high confidence be associated with more citations backing the claim than the statements of low confidence? One additional reference that indicates the influence of the large-scale atmospheric circulation on the broader Arctic surface energy budget is Hegyi and Taylor (2017; GRL, doi: 10.1002/2017GL073281) [Government of United States of America, United States of America]	The supporting citations in the rest of the paragraph now rearranged and added to.
17519	3	50	28	50	39	The warmer Arctic also affects the general atmospheric flow that leads to enhanced warming over Greenland, which can allow even more warming on Greenland; at the same time, cloud patterns have shifted in such as away as to allow greater solar radiation that also contributes to greater surface melt. Tedesco M., et al. (2016) Arctic cut-off high drives the poleward shift of a new Greenland melting record, NATURE COMMUNICATIONS 7(11723):1–6; Hofer S., et al. (2017) Decreasing cloud cover drives the recent mass loss on the Greenland Ice Sheet, SCIENCE ADVANCES 3(e1700584):1–8. [Kristin Campbell, United States of America]	Thanks, this info and citation added.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
17627	3	50	28	50	39	The warmer Arctic also affects the general atmospheric flow that leads to enhanced warming over Greenland, which can allow even more warming on Greenland; at the same time, cloud patterns have shifted in such as away as to allow greater solar radiation that also contributes to greater surface melt. Tedesco M., et al. (2016) Arctic cut-off high drives the poleward shift of a new Greenland melting record, NATURE COMMUNICATIONS 7(11723):1–6, 1 (“Here, using reanalysis data and the outputs of a regional climate model, we show that the persistence of an exceptional atmospheric ridge, centred over the Arctic Ocean, was responsible for a poleward shift of runoff, albedo and surface temperature records over the Greenland during the summer of 2015. New records of monthly mean zonal winds at 500hPa and of the maximum latitude of ridge peaks of the 5,700±50m isohypse over the Arctic were associated with the formation and persistency of a cutoff high. The unprecedented (1948–2015) and sustained atmospheric conditions promoted enhanced runoff, increased the surface temperatures and decreased the albedo in northern Greenland, while inhibiting melting in the south, where new melting records were set over the past decade.”); Hofer S., et al. (2017) Decreasing cloud cover drives the recent mass loss on the Greenland Ice Sheet, SCIENCE ADVANCES 3(e1700584):1–8, 4 (“Therefore, the exceptional melt of the GrIS since the mid-1990s has appeared to be a result of increases in both of the “external” drivers of the surface energy balance, LWD and SWD. Whereas previous studies have focused on the role of rising temperatures as the main cause of the current melt increase and albedo decline over the GrIS [for example, (15, 16)], our results strongly indicate that it is rather a combination of increased SWD due to reduced cloud cover in summer combined with an increase in LWD due to higher free-atmosphere temperatures causing melt and surface darkening. Therefore, the decrease in surface albedo due to the melt-albedo feedback (8), which increases surface melt by increasing the ratio of absorbed solar radiation, has also been partly driven by a recent decrease in summer cloud cover enhancing the melt-albedo feedback (see also fig. S4) and not only by temperature anomalies.”). [Durwood Zaelke, United States of America]	Thanks, this info and citations added.
5389	3	50	30	50	30	I suggest to add this: GIS SMB changes (Ding et al., 2014; Ding et al., 2017) "and future GrIS SMB projections (delhasse et al., 2018)." Ref: Delhasse, A., Fettweis, X., Kittel, C., Amory, C., and Agosta, C.: Brief communication: Impact of the recent atmospheric circulation change in summer on the future surface mass balance of the Greenland Ice Sheet, The Cryosphere, 12, 3409-3418, https://doi.org/10.5194/tc-12-3409-2018 , 2018. [Xavier Fettweis, Belgium]	This section focuses only on observed change rather than projections.
27525	3	50	31	50	31	As there has been a succession of summers with NAO positive summers since, I think it is better to say " An 31 increase in negative NAO conditions explain about 70% of summer warming 2003-2013" [Ruth Mottram, Denmark]	Thanks, clarification made.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
24403	3	50	34	50	37	But note that the opposite took place in 2018, which was cold in the Arctic, although there was a similar blocking pattern. It depends on where exactly the blocking position is. [Martin Stendel, Denmark]	Paragraph substantially reworded. Now reads: "Evidence exists for an anthropogenic role in the atmospheric circulation (NAO) changes that have driven GIS mass loss (3.3.1.5.2) (medium confidence), although this awaits formal attribution testing {e.g., \Easterling, 2016 #1708}. Arctic amplification of anthropogenic warming {e.g., \Serreze, 2009 #1709} affects atmospheric circulation {Mann, 2017 #1710;Francis, 2015 #1711} and has reduced sea-ice extent (3.2.1.1.1), feeding back to exacerbate both warming and NAO changes {Screen, 2010 #1713} that impact GIS mass balance. Negative-NAO wind patterns increased GIS melt observed in a 40-year runoff signal {Ahlstrom, 2017 #1690}, and an increase in melting beginning in the mid-1800s closely followed the onset of industrial-era Arctic warming and emerged beyond the range of natural variability in the last few decades {Trusel, 2018 #1685;Graeter, 2018 #1686} (3.3.1.4)."
810	3	50	37	50	39	In the lower accumulation area of the southwestern Greenland ice sheet in 2012, the reduced snowcover combined with the hindering of meltwater percolation by near-surface ice layers led to meltwater saturation of the ice-sheet surface; summer albedo was reduced by 9 %, leading to 28 % additional absorbed solar radiation at the ice-sheet surface, of which 71 % was translated into melt. Reference: Charalampidis et al. (2015), doi: 10.5194/tc-9-2163-2015 [Charalampos Charalampidis, Germany]	This section reworded to include the combination of albedo feedbacks, and this citation added.
24405	3	50	37	50	39	Add reference Ryan et al. (2018). Ryan, J.C., Hubbard, A., Stibal M., Irvine-Flynn, T.D., Cook, J., Smith, L.C., Cameron, K. and Box, J. Dark zone of the Greenland Ice Sheet controlled by distributed biologically-active impurities. Nature Communications 9, 10.1038/s41467-018-03353-2. [Martin Stendel, Denmark]	Citation added.
322	3	50	39	50	39	the following not-cited study strongly reinforces the role of surface ice algae as the dominant darkening factor Ryan, J.C., A. Hubbard, M. Stibal, T.D. Irvine-Fynn, J. Cook, L.C. Smith, K. Cameron, and J.E. Box, Dark zone of the Greenland Ice Sheet controlled by distributed biologically-active impurities, Nature Communications, DOI:10.1038/s41467-018-03353-2 [Jason Box, Denmark]	Citation added.
28379	3	50	41	51	2	I felt this section was quite weak and although there is not a wealth of evidence there are various lines that can be drawn including, e.g. Kinnard et al 2011, 10.1038/nature10581 and Trusel et al 2018, 10.1038/s41586-018-0752-4. They are not specifically on attribution but provide a historical/paleo context. There are other papers that could be added here that would do the same or touch on attribution, e.g. Mann et al 2017, doi:10.1038/srep45242, Notz and Stroeve 2016 etc. [Jonathan Bamber, United Kingdom (of Great Britain and Northern Ireland)]	Agreed, this section substantially revised and these citations included.
5669	3	50	45	0		Remove "of" before "atmosphere" [Nina Hunter, South Africa]	Done.
19149	3	50	45	50	45	"of coupled atmosphere-ice-ocean processes" instead of "of coupled of atmosphere-ice-ocean processes" [APECS Group Review, Germany]	Done.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
30357	3	50	46	50	46	Is GIA (Glacial Isostatic Adjustment) a significant source of error for measuring SMB based on satellite altimetry? I would suspect that unloading due to a large loss of ice mass could potentially limit the accuracy of satellite measurements so it might be a good idea to evaluate this potential source of error. [Paul Glaser, United States of America]	This is accounted for as an important signal in the uncertainty assessments of satellite gravimetry. It is small relative to the variability in elevation due to SMB.
33357	3	50	51	50	53	Should the importance of tropical Atlantic variability also be noted here (e.g., Li et al., 2014, Nature, vol. 505, doi:10.1038/nature12945)? [Government of United States of America, United States of America]	Agreed, now cited.
17521	3	50	56	51	2	Greater warming in the Arctic has been shown to allow more melting on the Greenland Ice Sheet, and because some of this warming is anthropogenic in nature, there is an argument to be made about the anthropogenic influence on Greenland. [Kristin Campbell, United States of America]	Agreed and this now expanded upon in this section.
17629	3	50	56	51	2	Greater warming in the Arctic has been shown to allow more melting on the Greenland Ice Sheet, and because some of this warming is anthropogenic in nature, there is an argument to be made about the anthropogenic influence on Greenland. Tedesco M., et al. (2016) Arctic cut-off high drives the poleward shift of a new Greenland melting record, NATURE COMMUNICATIONS 7(11723):1–6, 1 (“Here, using reanalysis data and the outputs of a regional climate model, we show that the persistence of an exceptional atmospheric ridge, centred over the Arctic Ocean, was responsible for a poleward shift of runoff, albedo and surface temperature records over the Greenland during the summer of 2015. New records of monthly mean zonal winds at 500hPa and of the maximum latitude of ridge peaks of the 5,700±50m isohypse over the Arctic were associated with the formation and persistency of a cutoff high. The unprecedented (1948–2015) and sustained atmospheric conditions promoted enhanced runoff, increased the surface temperatures and decreased the albedo in northern Greenland, while inhibiting melting in the south, where new melting records were set over the past decade.”); Hofer S., et al. (2017) Decreasing cloud cover drives the recent mass loss on the Greenland Ice Sheet, SCIENCE ADVANCES 3(e1700584):1–8, 4 (“Therefore, the exceptional melt of the GrIS since the mid-1990s has appeared to be a result of increases in both of the “external” drivers of the surface energy balance, LWD and SWD. Whereas previous studies have focused on the role of rising temperatures as the main cause of the current melt increase and albedo decline over the GrIS [for example, (15, 16)], our results strongly indicate that it is rather a combination of increased SWD due to reduced cloud cover in summer combined with an increase in LWD due to higher free-atmosphere temperatures causing melt and surface darkening. Therefore, the decrease in surface albedo due to the melt-albedo feedback (8), which increases surface melt by increasing the ratio of absorbed solar radiation, has also been partly driven by a recent decrease in summer cloud cover enhancing the melt-albedo feedback (see also fig. S4) and not only by temperature anomalies.”). [Durwood Zaelke, United States of America]	Agreed, this section substantially revised and these citations included.
19151	3	50	56	51	2	The classification of "medium confidence" at the end of this statement is confusing and seemingly contradictory. Is it medium confidence that there is to limited evidence to assign confidence to in GIS melt loss to anth. Climate change? If there is such limited evidence my understanding is that confidence assessments should not be used. [APECS Group Review, Germany]	This section revised to include substantially more evidence relating to the role of anthropogenic forcing. Confidence statements also revised.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
33359	3	50	56	51	2	This section seems to be a good place to make a statement about the ongoing efforts and future advances that are being enabled by the explosion of Large Ensembles that are enabling a much cleaner separation between internal climate variability and the forced response. Significant progress has been made along these lines (see Kay et al. 2015; BAMS, The Community Earth System Model Large Ensemble Project and other more recent efforts). [Government of United States of America, United States of America]	Very promising though most suited to chapter 4 on projections. More on the role of natural variability has now been added to section 3.3.1.7 though.
33361	3	50	56	51	2	It might also be useful to note there that interannual variability in surface mass balance itself (as opposed to just atmospheric circulation variability) is also expected to increase in response to future warming and growth of the ablation area, with potential impacts for detection and attribution (Fyke et al., 2014, GRL, 41, doi:10.1002/2013GL058172). [Government of United States of America, United States of America]	More specifically relevant to ice sheet projections in chapter 4.
29699	3	50	56	51	3	This statement seems unduly pessimistic. I don't know of any suggestions that what is happening to the GIS is just like some earlier natural occurrences that were not driven (or at least really associated with) the changes in climate induced by some natural forcing (e.g., orbital element changing). There is no association of the GIS changes with changes in solar radiation or the absence of volcanic eruptions, etc.--the association is clearly with the overall GHG-induced changes on the atmosphere (not only on temperature, but also on the IR forcing, and so on). So, how is this statement justified? Okay, there is variability in the interannual weather, so attribution on that time scale has lots of noise, but if one were to take running 30-year periods (given that we are interested in what is happening to the climate--and this means a multi-decadal period), would not the human influence on Greenland be quite clear? This statement just seems to me needs a lot more consideration and explanation--looking at interannual weather variability in order to search for a climate signal just does not seem appropriate to me (it is what climate skeptics do, but is just not an appropriate analysis approach to looking for the GHG effect). [Michael MacCracken, United States of America]	This statement now substantially revised, including further evidence of anthropogenic attribution not previously cited.
3089	3	51	0	0		Include ice sheet projections? [Helene Hewitt, United Kingdom (of Great Britain and Northern Ireland)]	See chapter 4.
5391	3	51	2	51	2	I suggest to this at the end of §: to anthropogenic or natural climate change (medium confidence) "knowing that such circulation changes are not projected by CMIP5 models (Hanna et al., 2018)." Ref: Hanna, E., Fettweis, X., and Hall, R. J.: Brief communication: Recent changes in summer Greenland blocking captured by none of the CMIP5 models, The Cryosphere, 12, 3287-3292, https://doi.org/10.5194/tc-12-3287-2018 , 2018. [Xavier Fettweis, Belgium]	Useful though more for chapter 4 projections as the focus here is on understanding observed change.
29055	3	51	2	51	2	There appears to be no section on "Projections" for the ice sheets and to tie this to RCP emission pathways or to paleo studies, consistent with other sections in this chapter. Such an additional section, even if brief would be extremely helpful for consistency with other sections, as well as completeness. [Pam Pearson, Sweden]	See chapter 4.
16591	3	51	4	53	4	This new section has become very good! I recommend to check the uncertainty terms used. Often grades of likelihood are used ("likely, very likely" etc.) where I am not so sure that defined quantitative error bars exist for the statement. In that cases, rather grades of confidence should be used (or evidence/agreement; qualitative uncertainty statement). [Andreas Käab, Norway]	Taken into account - Uncertainty language was checked and updated in this section

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
3225	3	51	6	0		Section 3.3.2.1 - Recent papers that should be considered that examine changes in Arctic glaciers : Box et al. 2018. Global sea-level contribution from Arctic land ice: 1971–2017. Environ. Res. Let. 13(12) 125012 https://doi.org/10.1088/1748-9326/aaf2ed White & Copland 2018. Area change of glaciers across Northern Ellesmere Island, Nunavut, between ~1999 and ~2015. J of Glaciology Volume 64(246): 609-623 [Sharon Smith, Canada]	Taken into account - Box et al. 2018 is now part of the assessment.
23999	3	51	8	53	4	Alaska is never mentioned in Section 3.3.2, if it is implicitly included in Canadian Arctic, I think that it should be mentioned [Patricia Martinerie, France]	Rejected - Alaska is covered in Ch2. We now make this even more clear by stating 'Glaciers in all other regions including Alaska, Scandinavia and Iceland, are assessed in Chapter 2.'
19153	3	51	11	51	12	The attribution of a "very likely" statement to a paper still in submission raises skepticism (at least in my eyes) about the validity of the statement, since this paper (Zemp et al. Submitted) has yet to be passed and the results be validated by the expert review process. This skepticism is heightened by the following sentence which furthermore also includes another paper not yet fully passed the review process (Ciraci et al. In Review). I suggest either adding a second reference, or rewriting the sentence altogether using a different reference and adjusting the time frame accordingly. [APECS Group Review, Germany]	Accepted - Mass change estimates have been comprehensively overhauled and are now based on at least three studies or more where available. Uncertainty language has also been updated.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
328	3	51	11	51	54	<p>based on the accepted article:</p> <p>Box, J.E., W.T. Colgan, B. Wouters, D.O. Burgess, S. O'Neel, L.I. Thomson, S.H. Mernild 2018. Global sea-level contribution from Arctic land ice: 1971–2017, Environmental Research Letters, ERL-105795, https://doi.org/10.1088/1748-9326/aaf2ed</p> <p>and references therein, please consider incorporating elements from the following text that add missing detail about physical processes responsible for regional land ice mass balance change. Relevant text from the article is pasted in the following...</p> <p>"Cumulative mass balance from each region (figure 4) indicates relative stability (or land ice growth) from 1971 until the mid-1980s. The Greenland ice mass gain until 1977 is attributable to increasing snowfall (Burgess et al 2010) associated with persistent atmospheric circulation (Björk et al 2017) and relatively low surface melt rates (Box 2013). The Greenland variability shown here is consistent with the Rignot et al (2008) reconstruction. Increased Greenland ice loss starting in 1998 is attributed to increasing surface melting (Box 2013) and through surface albedo feedback amplifying melt from a larger and increased duration of darker bare ice area (Tedesco et al 2011, 2013a, Box et al 2012). Increased rain fraction of total precipitation also amplifies Greenland ice mass loss (Doyle et al 2015). The bare ice albedo feedback that involves mineral and micro-biological impurities (Stibal et al 2017, Ryan et al 2018) operates elsewhere in the Arctic than Greenland (Lutz et al 2016).</p> <p>Alaska having a roughly constant ice loss rate starting in 1988 is consistent with Larsen et al (2015) who estimate an equivalent Alaska ice loss rate of $75 \pm 11 \text{ Gt yr}^{-1}$ while for 2003–2015 satellite gravity data after Wouters et al (2018) average of $70 \pm 17 \text{ Gt yr}^{-1}$ (table 1). Alaska land ice mass variability is less attributed to precipitation variability than surface melting (Larsen et al 2015).</p> <p>Arctic Canada ice mass loss is characterized by an acceleration beginning in ~1986, increasing sharply 2006–2012 (Sharp et al 2011) until 2013 which had positive mass balance (Sharp et al 2015) while Alaska had lower loss ice rates. The increase in Canadian Arctic land ice loss is mainly due to increased surface melting and from warmer summers (Gardner et al 2011) as precipitation rates have remained relatively stable (Gardner et al 2012). Atmospheric heat advection into Baffin Bay from a region of anomalously high sea surface temperatures in the northwestern Atlantic appears to have been responsible for the warming that contributed to the increase in ice loss from Arctic Canada (Sharp and Walker 2011, Deksen et al 2012). Since in primary to review comment, the following accepted article confirms Zemp et al (submitted) by including Alaska (not in the Zemp reconstruction?) and supplies a further "Updated ice mass changes"</p>	<p>Accepted. Box et al. 2018 is now part of the assessment</p>
326	3	51	12	51	16	<p>Box, J.E., W.T. Colgan, B. Wouters, D.O. Burgess, S. O'Neel, L.I. Thomson, S.H. Mernild 2018. Global sea-level contribution from Arctic land ice: 1971–2017, Environmental Research Letters, ERL-105795, https://doi.org/10.1088/1748-9326/aaf2ed</p> <p>The request is to incorporate findings from this study which, again, was carefully designed to feed results from AMAP into the IPCC SROCC. [Jason Box, Denmark]</p>	<p>Accepted - Box et al. is now cited although we use the more recent Wouters et al. GRACE estimate (https://doi.org/10.3389/feart.2019.00096) in Figure 3.8 and Appendix 2.A.4 to make the overall mass change estimates.</p>

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
26027	3	51	12	51	16	Here only the Ciraci numbers are given, but there are 3 global assessments (Wouters, Zemp, Ciraci) which should all be used and perhaps combined to consensus numbers (best in consistent way with how this is done in chapter 2 for the remaining regions). [Regine Hock, United States of America]	Accepted: Wouters, Zemp and all other regional estimates are now included. Ciraci was removed as wasn't published in time.
26029	3	51	17	51	18	Zemp et al. 2015 is an interesting paper but it needs to critically evaluated in the context here. In fact it is controversial. Line 17f is a conclusion in Zemp et al., 2015, however, the paper is based only on direct glaciological observations covering only a tiny fraction of all glaciers, mostly after the 1950s, and mostly outside the polar regions. It should not be accompanied by a IPCC confidence language (since only ONE study and not result of multiple line of evidence), and played down. Given the extreme scarcity of data in the polar regions covered in this chapter I don't think this statement holds. Chapter 2 makes a similar cautiously formulated statement but there the statement is based on far more data (although still controversial). [Regine Hock, United States of America]	Accepted: Zemp et al. 2015 is no longer cited and we cite new studies specifically from the Arctic (see below).
9225	3	51	18	51	19	"Pre-historic glacial deposits show that Arctic glaciers may have been smaller than present or may have disappeared altogether in the mid Holocene (Solomina et al., 2015)": this is also supported by numerical modelling evidence, which suggests that world's northernmost ice cap largely disappeared during the mid Holocene and was much smaller than the present-day ice cap (Zekollari et al., 2017, Quaternary Science Reviews). [Harry Zekollari, Switzerland]	Accepted - citation added.
9965	3	51	18	51	23	Consider citation to the following paper for additional evidence to place Arctic ice-cap mass loss in context (study of Barnes ice cap, Baffin Island): Gilbert, A., G. E. Flowers, G. H. Miller, K. A. Refsnider, N. E. Young, and V. Radić (2017), The projected demise of Barnes Ice Cap: Evidence of an unusually warm 21st century Arctic, Geophys. Res. Lett., 44, 2810–2816, doi:10.1002/2016GL072394. [Gwenn Flowers, Canada]	Accepted - citation added.
9227	3	51	21	51	23	This is also addressed in the publication by Lecavalier et al. (2017, Proceedings of the National Academy of Sciences), who show that present-day temperatures and melt-rates for Agassiz ice cap are at their highest since the past 7-8 ka. [Harry Zekollari, Switzerland]	Accepted - citation added.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
324	3	51	23	51	24	<p>The following text is copied from the 22 Nov 2018 accepted (10 Aug 2018 submitted) article generated as an Arctic Monitoring and Assessment Programme (AMAP) activity designed to resonate with SROCC by providing land ice mass balance and sea level numbers for specific SROCC periods and downloadable data currently at https://www.dropbox.com/sh/j9v1q378i37kbtu/AAAa9bnhQVtR33PWn4DLStaga?dl=0 and later to be permanently posted at AMAP.no:</p> <p>Box, J.E., W.T. Colgan, B. Wouters, D.O. Burgess, S. O'Neel, L.I. Thomson, S.H. Mernild 2018. Global sea-level contribution from Arctic land ice: 1971–2017, Environmental Research Letters, ERL-105795, https://doi.org/10.1088/1748-9326/aaf2ed</p> <p>"The IPCC Fifth Assessment report identified constraining the pre-satellite era sea-level budget as a topic of low scientific understanding that we address and specify sea-level contributions coinciding with IPCC Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC) 'present day' (2005–2015) and 'recent past' (1986–2005) reference periods. We assess an Arctic land ice loss of 8.3 mm SLE during the recent past and 12.4 mm SLE during the present day.</p> <p>The request is to incorporate findings from this study which, again, was carefully designed to feed results from AMAP into the IPCC SROCC. [Jason Box, Denmark]</p>	Accepted - findings incorporated
26031	3	51	25	51	25	<p>I assume you mean 'Change in' or 'Increased glacier mass loss ...'. If so, is there really enough evidence to attribute this to changes in subaqueous melt? For both Alaska and the Canadian Arctic the contribution of frontal ablation (calving and subaqueous melt) is a tiny component of total ablation (4% in Alaska, less so in Canada). [Regine Hock, United States of America]</p>	Accepted - the role of subaqueous melt is clarified in revised version
2757	3	51	25	51	26	<p>"mechanisms exhibit spatiotemporal variability" I would note here that this variability is observed both within regions and between regions (i.e. for specific glaciers basins in Canada SMB is the primary mechanism for mass loss, while for others dynamics is more likely to be the primary driver of mass loss. [Wesley Van Wychen, Canada]</p>	Taken into account - spatio-temporal variability sentence was removed as it was too vague, and the text now focusses on specific examples
12195	3	51	26	51	26	<p>One could add references to "...exhibit spatiotemporal variability" such as (Hooke et al., 1989; Hubbard et al. 1995; Vieli et al., 2004) with:</p> <ul style="list-style-type: none"> - Hooke, R. L., Calla, P., Holmlund, P., Nilsson, M., and Stroeven, A.: A 3 year record of seasonal variations in surface velocity, Storglaciären, Sweden, Journal of Glaciology, 35, 235–247, doi:10.1017/S0022143000004561, 1989. - Hubbard, B., Sharp, M., Willis, I., Nielsen, M. t., and Smart, C.: Borehole water-level variations and the structure of the subglacial hydrological system of Haut Glacier d'Arolla, Valais, Switzerland, Journal of Glaciology, 41, 572–583, doi:10.3198/1995JoG41-139-572-583, 1995. - Vieli, A., Jania, J., Blatter, H., and Funk, M.: Short-term velocity variations on Hansbreen, a tidewater glacier in Spitsbergen, Journal of Glaciology, 50, 389–398, doi: 10.3189/172756504781829963, 2004. [Dorothee Vallot, Sweden] 	Rejected - no space for this level of detail and many of the suggested references are not for the polar regions covered in Ch3 or are too old for this assessment.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
2759	3	51	33	51	33	"most tidewater glaciers in Arctic Canada have decelerated", I would also encourage you to look at Van Wychen et al., 2016 JGR and Van Wychen et al., 2017 Journal of Glaciology which illustrates the fluctuations in glacier speed since ~2000. In many of these cases it seems that the deceleration is likely due the ceassation of surge events. However, some key glaciers have still sped up which has increased mass loss (e.g. the Trinity-Wykeham basin of Prince of Wales Icefield. [Wesley Van Wychen, Canada]	Accepted - new references added.
19157	3	51	33	51	38	Since the section refers also to peripheral Greenland Glaciers as well, I think this paragraph should include also retreat rates of Greenland Glaciers as this information is not provided in the previous sections [APECS Group Review, Germany]	Rejected - not enough space to consider retreat rates of glaciers on a regional scale, though this information is captured to some degree in regional mass loss estimates
2753	3	51	38	51	38	Van Wychen et al., 2013 reference here is incorrect - it should instead be: Van Wychen et al., 2014 Geophysical Research Letters [Wesley Van Wychen, Canada]	Accepted - reference updated
2755	3	51	38	51	38	I would recommend also adding Van Wychen et al., 2016 Journal of Geophysical Research as a reference here as well - it discusses this concept as well, but uses a larger timeperiod to discuss the key glaciers that loss mass over time. [Wesley Van Wychen, Canada]	Accepted - reference added
9229	3	51	40	51	47	In this paragraph a reference could be made to the recent work by Noël et al. (2018, JGR), who modelled the SMB of glaciers in the Canadian Arctic Archipelago at a very high spatial resolution (1 km) by downscaling output from the regional climate model RACMO. [Harry Zekollari, Switzerland]	Accepted - reference added
19155	3	51	40	51	47	It could be nice to refer the reader back to section 3.3.1.6.1 for Greenland outlet glaciers in additon to the info provided for other Arctic glaciers [APECS Group Review, Germany]	Rejected - a good idea but couldn't find specific text to link.
12197	3	51	41	51	41	add Vallot et al., 2018 to Luckman study. It uses modelling results (offline couline between ocean and ice) on the same glacier to assess the impact of undercutting on calving rates. "There is limited evidence that calving rates in Svalbard are linked to ocean temperatures which control rates of submarine melt (Luckman et al., 2015). Warm ocean waters are mixed with the subglacial discharge influencing melt rates and frontal undercutting (Vallot et al., 2018)" with: Vallot, D., Åström, J., Zwinger, T., Pettersson, R., Everett, A., Benn, D. I., Luckman, A., van Pelt, W. J. J., Nick, F., and Kohler, J.: Effects of undercutting and sliding on calving: a global approach applied to Kronebreen, Svalbard, The Cryosphere, 12, 609-625, https://doi.org/10.5194/tc-12-609-2018 , 2018. [Dorothee Vallot, Sweden]	Accepted - reference added
12199	3	51	41	51	45	Are we only talking about surging glaciers here? Otherwise one could add references to non-surging type glaciers. Also, what is meant by oceanic forcing? Is it the temperature referred above? [Dorothee Vallot, Sweden]	Taken into account - we now refer to ocean temperature specifically.
19159	3	51	49	51	50	I think the phrase is too vague. It is seemingly contradictory to other conclusions from sections 3.3.1.6.1 but vague enough to leave doubt... is this referring to land-terminating glaciers only then? Because there was significant discussion of ocean heating as a driver for change... [APECS Group Review, Germany]	Taken into account - forcing discussion has been revised
17523	3	51	49	51	54	Potential other citations: Tedesco M., et al. (2016) Arctic cut-off high drives the poleward shift of a new Greenland melting record, NATURE COMMUNICATIONS 7(11723):1–6; Hofer S., et al. (2017) Decreasing cloud cover drives the recent mass loss on the Greenland Ice Sheet, SCIENCE ADVANCES 3(e1700584):1–8. [Kristin Campbell, United States of America]	Rejected - suggested referneces are for the Greenland Ice Sheet not polar glaciers

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
17631	3	51	49	51	54	Potential other citations: Tedesco M., et al. (2016) Arctic cut-off high drives the poleward shift of a new Greenland melting record, NATURE COMMUNICATIONS 7(11723):1–6, 1 (“Here, using reanalysis data and the outputs of a regional climate model, we show that the persistence of an exceptional atmospheric ridge, centred over the Arctic Ocean, was responsible for a poleward shift of runoff, albedo and surface temperature records over the Greenland during the summer of 2015. New records of monthly mean zonal winds at 500hPa and of the maximum latitude of ridge peaks of the 5,700±50m isohypse over the Arctic were associated with the formation and persistency of a cutoff high. The unprecedented (1948–2015) and sustained atmospheric conditions promoted enhanced runoff, increased the surface temperatures and decreased the albedo in northern Greenland, while inhibiting melting in the south, where new melting records were set over the past decade.”); Hofer S., et al. (2017) Decreasing cloud cover drives the recent mass loss on the Greenland Ice Sheet, SCIENCE ADVANCES 3(e1700584):1–8, 4 (“Therefore, the exceptional melt of the GrIS since the mid-1990s has appeared to be a result of increases in both of the “external” drivers of the surface energy balance, LWD and SWD. Whereas previous studies have focused on the role of rising temperatures as the main cause of the current melt increase and albedo decline over the GrIS [for example, (15, 16)], our results strongly indicate that it is rather a combination of increased SWD due to reduced cloud cover in summer combined with an increase in LWD due to higher free-atmosphere temperatures causing melt and surface darkening. Therefore, the decrease in surface albedo due to the melt-albedo feedback (8), which increases surface melt by increasing the ratio of absorbed solar radiation, has also been partly driven by a recent decrease in summer cloud cover enhancing the melt-albedo feedback (see also fig. S4) and not only by temperature anomalies.”). [Durwood Zaelke, United States of America]	Rejected - suggested refernces are for the Greenland Ice Sheet not polar glaciers
26035	3	51	52	51	52	I guess you mean 'air temperature' and not 'surface temperature'. Esp over melting ice surfaces this is not even close. [Regine Hock, United States of America]	Accepted - text modified to specify air temperature
33363	3	51	53	51	54	Certainly there is more than one paper that highlights the uncertainty in the role of atmospheric circulation variability in glacier mass loss. [Government of United States of America, United States of America]	Taken into account. Box et al. 2018 which is a review and discusses atmospheric controls in depth is now cited.
26037	3	51	54	51	54	remove 'medium confidence'. Seems odd here. Are you saying that you only have medium confidence that the role of ... is unclear, i.e. it may not be unclear? [Regine Hock, United States of America]	Accepted - medium confidence removed.
26033	3	51	56	51	56	independent glacier' is an odd term not used in the literature [Regine Hock, United States of America]	Accepted - language changed
26039	3	51	56	52	16	This part about AP seems to be (almost) entirely about the main land AP, but this is already covered earlier in the chapter, and should be eliminated here. Instead information should be given about the >130,000 km ² ice that is found in the periphery of the ice sheet, which in RGI6.0 (which is shown in Figure 3.8) includes glaciers only on the islands surrounding the Antarctic continent. The recent counterintuitive results from mass chages on Livingston Island should perhaps be included (Francesco Navarro's group). [Regine Hock, United States of America]	Accepted - SOD material on mainland Antarctic peninsula was moved to ice sheet section, focus was shifted to the areas not covered previously, including citations to Navarro group papers.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
25651	3	51	56	52	6	While the whole discussion was focussed on Arctic till this line, use of acronym AP should be expanded once in the section. It is confusing whether AP is mentioned in the context of Arctic or it is about Antarctic Peninsula. Also it is confusing because of the usage of the term "glacier" retreat throughout in the context of Antarctic peninsula as some of them are basically ice shelf collapse or mass loss. [Government of India, India]	Accepted - AP removed
905	3	52	10	52	10	This figure is WIDE underestimate. It states 'selected' locations but the looks do not imply it. Needs to be stated very clearly instead [Falk Huettmann, United States of America]	Rejected - unclear exactly what this comment is referring to.
31629	3	52	17	0		Figure 3.8. If possible, use the same projection (Robinson) as other global map figures within SROCC. [Hans-Otto Poertner and WGII TSU, Germany]	Rejected - projection was chosen on purpose to highlight glaciers in polar regions.
31631	3	52	17	0		Figure 3.8. It might be better to enlarge the map slightly to allow for a better appreciation of the dark blue regions. For this, it will also be better if you move the large text down to the caption. [Hans-Otto Poertner and WGII TSU, Germany]	Accepted - map size increased
29177	3	52	17	52	18	Layout for time series plots is a bit of strange. Recommend switching Region 7 with Region 5. [Ge Peng, United States of America]	Accepted
19163	3	52	17	52	21	Figure 3.8; all of the subplots except for the top left (Arctic region 3,4,7,9) have SLE ranges no greater than -0.8 to +0.8. The top left subplot has an approximate range of -1.5 to +1.3, although much of the variability in the time series visually appears to be loosely between -0.7 and +0.5. This scale could be modified to better highlight the variability in this combined region over time. [APECS Group Review, Germany]	Accepted - common scale used
19165	3	52	17	52	21	Figure 3.8; the right y-axes on all of the subplots are consistent, but the left y-axes are highly variable, making a comparison between these subplots less intuitive [APECS Group Review, Germany]	Accepted - common scale used
19161	3	52	17	52	22	Shouldn't one of the y axes be positive if the other is negative, as mass loss is leading to sea-level rise, and the other way round? This is not clear to me. [APECS Group Review, Germany]	Accepted - figure modified
33365	3	52	18	52	19	In the panels showing mass budget and sea-level equivalent, would it make more sense to flip the sign for the sea-level equivalent axis, since as mass balance decreases sea level increases? [Government of United States of America, United States of America]	Accepted - figure modified
224	3	52	18	52	20	It's not immediately obvious if these glaciers are distinct from those in the similar figure in Chapter 2. The captions of these two figures should clarify if they are mutually exclusive and also note the existence of the other similar figure for cross-referencing. [Baylor Fox-Kemper, United States of America]	Accepted - cross referencing to Chapter 2 is now more obvious via our shared Appendix 2.A., and we also cross ref to Figure 2.5.
330	3	52	20	52	21	propose a table else text listing Zemp et al. (Submitted), Box et al. (2018), (possibly also Marzeion et al. (2015)) sea level totals for *SROCC reference periods*. See Table 2 in Box et al. (2018). Box et al. (2018) carefully met the SROCC deadlines for submission, acceptance Box, J.E., W.T. Colgan, B. Wouters, D.O. Burgess, S. O'Neel, L.I. Thomson, S.H. Mernild 2018. Global sea-level contribution from Arctic land ice: 1971–2017, Environmental Research Letters, ERL-105795, https://doi.org/10.1088/1748-9326/aaf2ed [Jason Box, Denmark]	Accepted - the new Appendix 2.A.4 contains a table with all available mass change estimates

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
17715	3	52	20	52	21	Consider incorporating measurements of new Box et al (2018) paper into figure. This paper attributes SLR to Arctic land ice losses since 1971 and is more up-to-date than referenced work in caption --> Box, J.E., W.T. Colgan, B. Wouters, D.O. Burgess, S. O'Neel, L.I. Thomson, S.H. Mernild 2018. Global sea-level contribution from Arctic land ice: 1971–2017, Environmental Research Letters. [Thomas Ballinger, United States of America]	Rejected - the Box et al. paper contains GRACE estimates from Bert Wouters. We show Wouters et al. 2019 which is (slightly) updated.
30359	3	52	20	52	21	Caption to Fig. 3.8: I assume that the plots for sea level equivalents and mass budgets contain the curves for regional average values and their error envelope. But I am not sure. So please expand the description of Fig. 3.8 to explain whether the curve (solid line) represents an average or median value along with the confidence interval for the error envelope. [Paul Glaser, United States of America]	Accepted - we now state that annual and time-averaged mass-budget estimates include the errors reported in each study
19169	3	52	24	52	24	Unless it is covered in another chapter, I find it weird that there is a section for projections concerning glacier changes but not ice sheet changes...If it is covered (Chapt 4?), maybe a sentence directing readers to that in the Ice Sheet section (3.3.1) is a good idea. [APECS Group Review, Germany]	Accepted - addressed by creating a new Cross Chapter Box (Ch's 2&3) on glacier projections
26043	3	52	26	52	27	I don't think this is correct. There is overlap in the spread of the end-of-century relative mass loss between the RCPs, but this is largely due to large differences between glacier models and choice of GCM but for the same glacier model and GCM RCP8.5 generates consistently more mass loss than RCP2.6 (as expected). Note that the problem in Hock et al., submitted is that the projections for the two RCPs are not based on the same ensemble of glacier models and the same ensemble of GCMs. [Regine Hock, United States of America]	Accepted - this text has been replaced by a new Cross Chapter Box (Ch's 2&3) on glacier projections
26041	3	52	26	53	4	Change in writing style: Very different from the rest of the report, here active voice ("We") is used. This should probably be avoided to emphasize that the report is 'person-independent', and content not associated with a group of people. [Regine Hock, United States of America]	Accepted - this text has been replaced by a new Cross Chapter Box (Ch's 2&3) on glacier projections
19167	3	52	28	52	31	Are the larger contributions from Antarctica and the Canadian Arctic because of their spatial extent or larger glacier thicknesses? [APECS Group Review, Germany]	Accepted - this text has been replaced by a new Cross Chapter Box (Ch's 2&3) on glacier projections. Note that glacier area and glacier thickness are related so it is because glaciers in these areas are more extensive.
9231	3	52	36	52	37	Not sure whether the reference to Lenaerts et al. (2013) is correct here: according to the reference list this is a paper on snowfall anomalies in Antarctica. That paper is the reference belonging to p.46, l.22. The paper which should be referred to here is probably another publication by Lenaerts et al. from 2013: "Irreversible mass loss of Canadian Arctic Archipelago glaciers" (Geophysical Research Letters). It should be study focuses on a region and not an individual polar glacier (as is written now on l. 36). [Harry Zekollari, Switzerland]	Taken into account - this text has been replaced by a new Cross Chapter Box (Ch's 2&3) on glacier projections.
9233	3	52	36	52	37	A reference could also be made to the work of Lang et al. (2015, The Cryosphere), who utilize a relatively similar setup as Lenaerts et al. (2013, GRL; cf. see previous comment) in which a regional SMB model is used for future projections (but without accounting for ice dynamic geometry changes), but then applied to Svalbard. [Harry Zekollari, Switzerland]	Rejected - only papers that make projections for at least one RGI glacier region are included
30247	3	53	1	53	1	Confidence in ice sheet models will also improve when they include subglacial hydrology. [Christine Dow, Canada]	Rejected - this section is about glacier models

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
2593	3	53	8	53	11	Important new study on sea-level contribution from Arctic land ice by Box et al. (2018), doi: 10.1088/1748-9326/aaf2ed [Charalampos Charalampidis, Germany]	Rejected here but Box et al. cited in earlier section on present-day mass changes where it is relevant
12201	3	53	13	0		Here only Antarctica is referred to. What about Greenland? [Dorothee Vallot, Sweden]	Taken into account. We now specify when we are referring to Greenland, Antarctica or if we are generalising
19185	3	53	13	53	13	There is a missing link between this section and the next two 3.3.3.3 and 3.3.3.4. whereby retreating marine terminating glaciers will change circulation patterns with in fjord affecting biogeochemistry and ecosystem. Also land terminating glacier fjords are subject to reduced mixing via enhanced stratification which has consequences from primary production (see Bendtsen, Jørgen, John Mortensen, and Søren Rysgaard. "Seasonal surface layer dynamics and sensitivity to runoff in a high Arctic fjord (Young Sound/Tyrolerfjord, 74 N)." Journal of Geophysical Research: Oceans 119.9 (2014): 6461-6478.) [APECS Group Review, Germany]	Accepted - Fjord circulation is now part of the assesment.
19171	3	53	15	53	18	While I agree that the major impact of GIS melting and consequent freshening around Greenland related to the AMOC. I believe that impacts of culation within fjords could be at least mentioned, though it is of less global importance, esp. since Greeland fjords are of such importance to fisheries (both commercial and sustanance), and considering small scale fjord dynamics are given such attention in the sections 3.3.3.3 and 3.3.3.4. The literature I know best is related to my own group, though I am sure of literature out of Fiamma Straneo's group (Scripps) as well. The four rows below include references to some literature. [APECS Group Review, Germany]	Accepted - Fjord circulation is now part of the assesment.
19173	3	53	15	53	18	Sejr, Mikael K., et al. "Evidence of local and regional freshening of Northeast Greenland coastal waters." Scientific reports 7.1 (2017): 13183. [APECS Group Review, Germany]	Accepted - Fjord circulation is now part of the assesment.
19175	3	53	15	53	18	Bendtsen, Jørgen, John Mortensen, and Søren Rysgaard. "Seasonal surface layer dynamics and sensitivity to runoff in a high Arctic fjord (Young Sound/Tyrolerfjord, 74 N)." Journal of Geophysical Research: Oceans 119.9 (2014): 6461-6478. [APECS Group Review, Germany]	Accepted - Fjord circulation is now part of the assesment.
19177	3	53	15	53	18	Straneo, Fiammetta, et al. "Impact of fjord dynamics and glacial runoff on the circulation near Helheim Glacier." Nature Geoscience 4.5 (2011): 322-327. [APECS Group Review, Germany]	Accepted - Fjord circulation is now part of the assesment.
19179	3	53	15	53	18	Mortensen, J., et al. "Heat sources for glacial melt in a sub-Arctic fjord (Godthåbsfjord) in contact with the Greenland Ice Sheet." Journal of Geophysical Research: Oceans 116.C1 (2011). [APECS Group Review, Germany]	Accepted - Fjord circulation is now part of the assesment.
5671	3	53	23	0		Replace "on" with "in" [Nina Hunter, South Africa]	Accepted - change made
3091	3	53	25	53	34	This paragraph appears to repeat text included earlier-resolve to reduce text? [Helene Hewitt, United Kingdom (of Great Britain and Northern Ireland)]	Rejected - we checked for redundancy and didn't find what the reviewer is referring to.
27221	3	53	28	0		Check format of citation [Christian Bock, Germany]	Editorial - copyedit to be completed prior to publication
3417	3	53	36	53	37	Needs reference [Patrick Orenstein, United States of America]	Accepted -reference added

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
3093	3	53	36	53	45	Is the conclusion from this paragraph that there is low confidence in the potential mechanisms? If so, this could be said explicitly and the level of discussion reduced [Helene Hewitt, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - now explicit
30361	3	53	36	53	45	The arguments for and against the role of glacial meltwater strengthening or weakening stratification in the Southern Ocean are dense and not very clear in my opinion. [Paul Glaser, United States of America]	Rejected - the arguments seem clear to us
22199	3	53	39	53	39	The Purich et al. (2018) paper that I suggested be removed as a citation from Chapter 1 (page 9, lines 47 to 48) would be appropriately placed here, after the Bintanja et al., 2013 reference. There is also a recent paper, Bronsalear et al. (2018) that could be cited here. Suggest that the citation therefore be changed to read "(Bintanja et al., 2013; Purich et al., 2018; Bronsalear et al., 2018)" Reference added: Bronselaer, B., Winton, M., Griffies, S.M., Hurlin, W.J., Rodgers, K.B., Sergienko, O.V., Stouffer, R.J., Russell, J.L. 2018. Change in future climate due to Antarctic meltwater. Nature, doi: 10.1038/s41586-018-0712-z. [Inga Smith, New Zealand]	Accepted - citations added
19183	3	53	47	53	47	I think this section is missing discussion of the very significant sediment input from glacial run-off that has a potential to affect primary production. See Murray, Ciarán, et al. "The influence of glacial melt water on bio-optical properties in two contrasting Greenlandic fjords." Estuarine, Coastal and Shelf Science 163 (2015): 72-83. [APECS Group Review, Germany]	Accepted - We have now included explicit mention of the sediments.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
2737	3	53	47	53	54	<p>may stimulate primary production....'. These references speculate that this may be the case around Greenland. Yet they are all primary freshwater studies. Meire 2017 (Global Change Biology, 2017) show that there is no evidence at all of freshwater discharge driving increased productivity around Greenland except in the specific case of marine-terminating glaciers where upwelling occurs throughout summer i.e. freshwater alone has no positive effect on primary production. For land-terminating systems there is no relationship between marine productivity and discharge volume in west Greenland and no evidence that meltwater-derived macronutrients can drive increased carbon drawdown from the atmosphere (Meire 2017). It is therefore not clear on what basis this point is supported by 'medium evidence'. Outside the Southern Ocean, where most freshwater discharge is associated with almost an immediate increase in primary production during the growth season due to relief of Fe limitation, there is little evidence to support a direct fertilizing effect of other glacially-derived nutrients on primary production. In fact, there are several studies showing the opposite- a negative relationship between increasing discharge and primary production because the stratification induced by freshwater discharge more than offsets any small benefit from direct nutrient addition (e.g. beyond Meire 2016/7, see extensive work in Patagonia Iriarte 2018 AAA). This point concerning 'primary production' may also need clarification as several of the references cited refer to DOC and not macronutrients. New DOM could stimulate an increase in total primary production, but DOC could also drive competition between diatoms and bacteria for nutrients and therefore it is not clear that it would have a positive effect on total primary production, or that it would increase CO2 drawdown (see, for example, Larsen et al, Limnology and Oceanography 2015 or Tsagaraki ISME 2018 which concern C addition experiments in Kongsfjorden-Svalbard). [Mark Hopwood, Germany]</p>	<p>Accepted - We clarified that the references cited refer to the polar ice sheets in general and not just Greenland (the ice sheets are discussed separately in the sections that follow). We also now include a number of more recent references which were not in the literature when this section was first drafted - these include references to the upwelling of marine water in the vicinity of glacial melt plumes.</p>
2739	3	53	47	53	54	<p>Care should also be used with the term 'flux' here. Where fluxes are derived exclusively from freshwater (most of the references cited above are), what constitutes a 'positive flux' of a low concentration nutrient e.g. N/P out of a 'glacial system' into the ocean, can actually cause a negative change in nutrient availability in a stratified marine environment- if the freshwater nutrient concentrations are very low compared to ambient concentrations flowing into a fjord system (which they invariably are for N and P in glacial discharge)- see Meire (GRL 2016) for this dilution argument around Greenland. [Mark Hopwood, Germany]</p>	<p>Rejected - This comment refers to lines 47-54 in which we do not use the term "Flux".</p>

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
19181	3	53	49	53	54	I find that this whole paragraph is very misleading. In the first sentence I disagree that the inputs of nutrients are "significant." at least in the literature from Greenland. While silica, phosphorus and possibly iron inputs may be more "significant", these are not a limiting nutrient in Greenland fjords. Inorganic Nitrogen inputs (which is the limiting nutrient around Greenland) are much lower than what can be found below the mixed layer in the fjords. (e.g. 1-2 µM max in this literature cited) while below mixed layer can reach 12- 13µM in west Greenland fjords (this can be found in some of the papers already cited regarding Gothabsfjord in Greenland.. otherwise Juul-Pedersen et al. 2015 MEPS). To an oceanographer, this is not a significant amount of nitrate to be delivered to the fjords that "may stimulate primary production." I would also say that the literature cited does not give "medium confidence" to that statement... that literature is written by glaciologists studying the biogeochemistry of the glacier run-off, not oceanographers studying the downstream effect that the glacier run-off has on primary production in the fjords. I am not aware of any literature that confirms that statement written, experimental or otherwise. Furthermore, in the literature cited, samples are taken far upstream of the fjord, and it is likely that most of that nitrate will be used up in the lake and stream communities along the way before it reaches the fjord. The literature cited does state that those nutrient inputs are significant and may stimulate primary productivity in the coast, but again it is written by people studying biogeochemist of the glaciers without putting it into context of the fjords. If you survey the oceanography community studying around Greenland fjords, you would have a hard time finding someone to agree with that statement. All that being said, I am not familiar with the literature in Antarctic fjords and coast, so maybe there is some more convincing evidence there, but I do not see any cited. As for carbon, also in many cases carbon content in run-off water is actually diluting fjord water so I would also not consider these inputs "significant" (see Paulsen et al. 2017- Frontiers in Marine Science). [APECS Group Review, Germany]	Rejected - In the first paragraph of the section (to which we think the comment refers), we are referring to ice sheets in general. The later paragraphs clarify which nutrients are important and where. It is absolutely the case that labile fractions of N and P are unlikely to be significantly sourced from either ice sheets. Silicon and iron are likely to be significant as fluxes terms. Please see Lines 14 onwards.
30363	3	53	51	53	51	What is the source of these nutrients on the AIS? Penguin colonies? [Paul Glaser, United States of America]	Taken into account - For the AIS, export of iron from the ice sheet is likely to have the most significant ocean fertilisation effect, since Southern Ocean waters are Fe limited. This Fe largely derives from the chemical weathering of iron minerals in rock material at the ice sheet bed (with some also contributed from the ice sheet surface where melting occurs). This gives rise to dissolved/colloidal and nanoparticulate forms of Fe. The dominant Fe flux term is thought to be associated with iceberg rafted debris (as ironoxyhydroxides such as ferrihydrite).
28251	3	53	52	0		Glaciers impact nutrient availability not just through direct discharge of nutrients but also by driving upwelling of deep nutrients into the upper ocean layers - where it can be utilized. In Greenland this may be the dominant effect by large marine terminating glaciers (see Cape et al. 2019, Nature Geoscience, 12, 34-39, and Hopwood et al. 2018, Nature Comm. article 3256). This is mentioned effectively in the next page in the paragraph starting with line 17 but not in this introductory paragraph. [Straneo Fiamma, United States of America]	Taken into account - We have amended the discussion in line with comments from the reviewer. Please see Lines 3-11
30365	3	53	52	53	57	Please clarify the intended antecedent for "this" by adding the appropriate word or words. [Paul Glaser, United States of America]	Taken into account - amended

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
5673	3	53	57	0		Insert "the" before "collapse" [Nina Hunter, South Africa]	Taken into account - amended
907	3	54	1	54	40	Lacks the concept of contaminations being re-released after frozen in ice and now melting off [Falk Huettmann, United States of America]	Taken into account - We note that there is no data on the release of contaminants in runoff or ice discharge from the Greenland Ice Sheet, although some compounds have been found in ice and snow and there is evidence of accumulation in downstream marine biota (but linking this to ice sheet processes is more problematic). A sentence is added indicating that this could be important but more data are needed. Please see Line 9-11.
2741	3	54	7	54	15	meltwater is a significant source of Si and P...!Not in the context of these fjord systems. The Meire reference cited includes a nutrient budget, similar budgets can be derived for Bowdoin glacier (Kanna JGR 2018), also now Sermilik (Cape Ngeoscience 2018) and with slightly larger uncertainties from the model work in Hopwood et al., (2018 NCommunications). These budgets all show 90% or more of the nutrients (N/P) driving summertime blooms around Greenland's glaciated fjords associated with freshwater discharge are derived from upwelling. Si is more mixed with a fraction arising from ice melt and runoff, but upwelling is still the major source. The P references cited make the liberal argument that meltwater is a significant P source because the P in glacially derived particles is assumed to be of comparable 'bioavailability' to dissolved PO4. This is challenging to reconcile with the observation that freshwater systems (which are full of glacially derived particles) tend towards P-limitation, and that meltwater drives localised P-limitation in the marine environment which directly contradicts the above assumptions (see Prado-Fiedler Rev. Biol. Mar. Oceanogr 2009). [Mark Hopwood, Germany]	Taken into account - We do not entirely agree with these statements. We refer to the budget calculations the reviewer kindly points out: Meire et al (2017) show from their budget calculations that glacial runoff is the primary Silicon source to Godthaabsfjord (subglacial upwelling is the primary source of nitrate, as the reviewer notes). The latter is also noted at Bowdoin Glacier (Kanna et al, 2018), and while (Cape et al, 2018) show very large fluxes of N, P and Si via upwelling, they still refer to subglacial meltwater as important for Silica and Iron. In the case of both, the flux is significantly influenced by particulate forms of these nutrient species. Further, offshore in Greenland, Arrigo et al (2017) suggested that the timing of blooms relate to Fe supply via meltwater from the ice sheet. In all cases (indirect or indirect nutrient supply from the ice sheet), the subglacial discharge itself is the key driver which is important to remember within the context of this section. We have revised this section to include the more recent references and to reflect these points. Please see Lines 14-1
19187	3	54	7	54	9	This phrase is misleading here. In this study it is not the meltwater discharge itself that stimulates the productivity, but rather the upwelling of nutrient rich deep water that stimulates the production (this is discussed in the following paragraphs, so stating it here is misleading and repetitive) [APECS Group Review, Germany]	Accepted - text amended
19189	3	54	17	54	19	I would remove "in addition to direct supply of nutrients contained in meltwater" from this statement for the reasons stated above, and also because the literature cited in this phrase does not discuss that. [APECS Group Review, Germany]	Accepted - text amended
19191	3	54	17	54	25	While I agree that, upwelling plumes are likely an important mechanism for supplying nutrients to fjords, I would argue that this is all "limited evidence" as these studies cited are based on only 1 fjord in Greenland. Also "high agreement" is a little misleading considering that both studies come from the same research group.... I say this as a person studying this very subject matter and collaborating with some of these same researchers, I am just trying to be realistic about what we know. And so far we only have good evidence of this from one fjord. [APECS Group Review, Germany]	Rejected- The studies cited are based around data collected in Godthaabsfjord, SW Greenland and Young Sound, NE Greenland (Meire et al, 2017), Bowdoin Fjord in NW Greenland (Kanna et al, 2018) and Sermilik Fjord, SE Greenland (Cape et al, 2019). Thus we consider that the studies have a reasonable geographical spread. There is a high level of agreement between these studies, and we would judge that there is sufficient data to suggest "medium evidence". Please see Section beginning Line 21.
28253	3	54	19	0		See comment above. Not sure if the Cape et al. 2019 paper is too late to reference - but now there is evidence of glacier mediated upwelling of nutrients. [Straneo Fiamma, United States of America]	Accepted - reference added

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
25265	3	54	19	54	21	Yet subglacial drainage associated with ice-dammed lakes have been detected by a moraine 47 km down fjord of the glacier terminus as cooling of the surface water followed by an increase in salinity, thus, underlining the spatial extent subglacial discharge may have. (Kjeldsen et al, 2014, doi: 10.1002/2013JF003034) [Kristian K. Kjeldsen, Denmark]	Taken into account - The impact 47 km downstream seems consistent with the statement in this section which indicates that runoffs from glaciers may indeed impact the fjord up to 100 km along flow path. Thus, we note this point but do not make further changes to the text.
2743	3	54	37	54	39	(Concerning the use of satellite data to derive iceberg-fertilization). But note also a lot of uncertainty here. Duprat argues that iceberg-fertilization has been vastly under-estimated to date due to a lack of consideration of potent fertilization from large icebergs, but Wu and Hou (The Cryosphere, 2017)-using a very similar satellite chl a technique and much more extensive statistics- suggest the exact opposite (that larger icebergs have less fertilizing effect) concluding that the effect is much more modest which supports other more extensive studies showing positive effects of icebergs on primary production during the mid-growth season and possible slight negative effects earlier/later in the year (Schwarz and Schodlok 2009). [Mark Hopwood, Germany]	Accepted - Thank you for pointing out this additional reference we now include. We also note the variable results of different studies with respect to iceberg enhancement of Southern Ocean primary productivity. Please see Line 38-40.
5023	3	55	0	0		It is very difficult to read the texts in Figure 3.9 [Debra Roberts and Durban Team, South Africa]	Taken into account - Figure has been revised. It is now sharp and has also been stylistically improved
21669	3	55	0	0		Not a good resolution for Figure 3.9 [Government of Republic of Korea, Republic of Korea]	Taken into account - Figure has been revised. It is now sharp and has also been stylistically improved
8611	3	55	0	55		Figure 3.9: The resolution of the figure is insufficient, making the text inside the figure unreadable. [Deborah Verfaillie, Spain]	Taken into account - Figure has been revised. It is now sharp and has also been stylistically improved
31633	3	55	1	0		Figure 3.9. Image needs better resolution. [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account - Figure has been revised. It is now sharp and has also been stylistically improved
31635	3	55	1	0		Figure 3.9. For space efficiency, panels may be redistributed into two columns, or, the image could be enlarged. [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account - Figure has been revised. It is now sharp and has also been stylistically improved
716	3	55	1	55	1	The quality of this figure is too low to be readable. [Mengxi Wu, United States of America]	Taken into account - Figure has been revised. It is now sharp and has also been stylistically improved
15019	3	55	1	55	1	Fig. 3.9 has poor quality and has blurred texts, please consider redrawing. [Government of Germany, Germany]	Taken into account - Figure has been revised. It is now sharp and has also been stylistically improved
19193	3	55	1	55	1	It is difficult for me to see this figure due to the poor quality, but from what I can tell it is very glaciology centered, I would suggest collaborating with an oceanographer to include fjord circulation dynamics in the figure as well. [APECS Group Review, Germany]	Taken into account - Figure has been revised. It is now sharp and has also been stylistically improved
33367	3	55	1	55	2	Text within figure is illegible. [Government of United States of America, United States of America]	Taken into account - Figure has been revised. It is now sharp and has also been stylistically improved
9539	3	55	3	0		The figure is too small and impossible to read. [Government of France, France]	Taken into account - Figure has been revised. It is now sharp and has also been stylistically improved
16305	3	55	3	55	3	Would suggest to align panels a,b,c horizontally. [Alexander Nauels, Germany]	Taken into account - Figure has been revised. It is now sharp and has also been stylistically improved
2385	3	55	10	55	19	There is also evidence that the upwelling of water at the face of sea-terminating glaciers is an important foraging area for seabirds. Contrasting communities of seabirds in subglacial meltwater plume and oceanic water in Bowdoin Fjord in northwestern Greenland. ICES J. Mar. Sci. [George Hunt, United States of America]	Accepted. The reference suggested was not found, but we now cite other literature on the importance for seabirds and mammals

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
28255	3	55	12	0		While it is true that Greenland ice loss is presently dominated by SMB, dynamic processes still accounted for some 40% of ice loss over the last few decades. And while it may be true that over very long timescales the dynamic contribution may become negligible, I don't think it should be neglected for ice loss prediction over the next 100 years. Effectively, we currently have no real dynamic ice sheet models that can answer 'what will the future contribution from Greenland dynamic change be'. So I think the word 'dominated' here is a bit misleading and may be taken to mean that we can ignore future dynamic changes from Greenland. The statement, in turn, seems inconsistent with the discussion on this page starting on line 30. [Straneo Fiamma, United States of America]	This seems to refer to the Executive Summary. Statement on Greenland mass loss components now revised.
19195	3	55	13	55	15	I would think that in order for medium confidence there should be more evidence cited for this statement. [APECS Group Review, Germany]	Accepted - confidence language has been removed.
19197	3	55	17	55	18	This statement is vague and should refer to marine mammals and seabirds, as the citation is a study about that, rather than high "productivity" [APECS Group Review, Germany]	Rejected - Lydersen et al 2014 assess marine terminating glacial impacts on marine mammals, seabirds, as well as plankton and benthos in glacial fiord systems. Due to space limitations, 'productivity' is used to cover these diverse ecosystems.
33369	3	55	23	55	23	Authors should consider revising "high agreement" based on Ingels et al. (2018), Nature Climate Change volume 8, 848-851: To understand the complex responses of various ecosystems components, and to distinguish changes driven by ice-shelf disintegration from natural variability, the research community needs to increase its efforts to ascertain marine ecosystem conditions pre- and post-ice-shelf collapse. [Government of United States of America, United States of America]	Taken into account. Ingels et al. (2018) supports the statement that ice shelf collapse or retreat leads to new habitats and biological colonization. This paper calls for additional research effort to better understand the nature of this change. A reference to Ingels et al. has been included in the revised text.
29821	3	55	28	55	29	please specify what is meant by "enhanced carbon uptake" - is it increased benthic primary production? [Dorte Krause-Jensen, Denmark]	Taken into account. The existing text specifies that this is carbon uptake by marine ecosystems (primarily phytoplankton blooms and zoobenthos). In the revised text the second part of the sentence has been edited to clarify that estimates of biological carbon uptake are variable.
11001	3	55	33	55	35	This relates to Macro-organisms, I think it is important to state this. [Karen Cameron, United Kingdom (of Great Britain and Northern Ireland)]	Accepted. Stated as requested.
3095	3	56	0	58		I found that the text in the cross-chapter box jumped about a bit between mechanisms and poles. It would be good if it could be made more coherent [Helene Hewitt, United Kingdom (of Great Britain and Northern Ireland)]	Accepted. We have restructured the text.
22401	3	56	2	56	2	Semantics, but...the wording of the heading makes it sound like there are multiple ice sheets that are marine-based, rather than there being multiple regions of the Antarctic ice sheet that are marine based. [Abram Nerilie, Australia]	Accepted. We have modified the title
26049	3	56	2	56	2	The term 'marine' ice sheet may need an explanation [Regine Hock, United States of America]	Accepted. Done
30369	3	56	2	56	2	Cross-Chapter Box 6. This entire chapter and particularly this box uses too many abbreviations, which while critical for presenting complex concepts in a parsimonious manner will probably be overwhelming for the non-specialist. The best solution is to this problem is to include a table within this chapter of all abbreviations used along with their definitions. [Paul Glaser, United States of America]	Rejected. We have only 3 acronyms now in this CBox (AIS, MISI and MICI). Each is explained after the first use. we do not think there will be a problem for even a non-specialist to manage with only 3 acronyms

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
16307	3	56	2	58	41	Cross-Chapter Box 6 is very important. While the explanation of processes underlying MISI, MICI is comprehensive and very good to understand the SLR implications are not covered sufficiently. Indeed, the remaining 'deep uncertainties' do not allow for a precise quantification of the future AIS contribution. However, it would be very much appreciated if the authors could further describe potential long-term SLR implications. One of the most frequently cited studies in this context by DeConto & Pollard 2016 estimates a 2300 AIS GMSLR contribution of around 10 m under RCP8.5. Process understanding has improved and may render some of the underlying assumptions invalid, but it is not an option to simply stay silent about these estimates that had a profound impact on the overall SLR narrative. If these numbers are not to be considered anymore, it has to be explained why. Otherwise, these and related uncertain projections still have to be communicated as an existing risk as they are far to worrying to ignore. Please revise, extend and provide potential quantitative long-term SLR potentials resulting from MISI. [Alexander Nauels, Germany]	Rejected. All projections are in Chapter 4 - see the link in the end of the Box
23931	3	56	2	58	41	Regarding the description of MISI and MICI in the Cross-Chapter Box 6, if the reader reads through the box from the beginning to the end, that reader will most likely understand the relative uncertainty between MISI and MICI. However, the text for MICI uncertainty is concentrated in the latter part, and the relative weights of both processes seem to be equal at first glance. Thus, reformulation of the contents of the cross-chapter box, for example, to introduce MISI and MICI together with a brief summary in the beginning would seem beneficial to increase readability. [Government of Japan, Japan]	Accepted, done
26047	3	56	2	58	41	L40 refers to AR5 but this term and process has been introduced much earlier (Mercer 1978) [Regine Hock, United States of America]	Taken into account. We removed the ref to AR5, but we cannot add more references (the allowed number of references is limited)
29701	3	56	2	58	41	This Box is very well done, although I think that a bit more might be said about how the inclusion of treatment of marine ice sheet instability in model simulations seems to improve the ability of models to simulate the past history of the Antarctic ice sheets. A bit is said about particular basin simulations in the past—it seems to me a more general statement would also be helpful, to the effect that without it, as I understand it, simulations of Antarctic ice sheet mass are not in good accord with the geological record. [Michael MacCracken, United States of America]	Taken into account. We have in the Box text this statement: "Inclusion of MICI in one ice sheet model has improved its ability to match albeit uncertain geological sea level targets in the Pliocene (Pollard et al., 2015) and Last Interglacial (DeConto and Pollard, 2016), although the MICI solution may not be unique (Aitken et al., 2016)"
17135	3	56	2	59	37	This cross-chapter box is really nice – it's balanced, very clear and understandable with good appreciation of uncertainties. [Nick Golledge, New Zealand]	Noted. Thank you!
30055	3	56	2	59	37	Currently, MICI is explained and discussed in a number of different places throughout Chapter 4 (e.g. on page 37, line 45 - page 38, line 4; page 38, line 45 - page 39, line 2; page 39, line 31-39) as well as in Cross Chapter Box 6. You could dedicate Cross Chapter Box 6 only to the new processes (hydrofracturing together with MICI) introduced since AR5 and the debate around these. Assembling all information the scientific community has on these processes in one place with related agreement/evidence/confidence scales would improve stringency and help reduce redundancy. Since the basic MISI-mechanism was explained in AR5, newly gained understanding about this process could then be moved to Chapter 4. [Ronja Reese, Germany]	Rejected. The box is devoted to the overview of marine ice sheet instability processes, so we cannot omit the MISI here.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
31157	3	56	2	59	38	Rates of changes should be quantified at least b magnitude and with statement on confidence. [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account. The comment is not very clear to us. The rates of changes are quantified in the corresponding chapters - 3 (for observations) and 4 (for projections)
26045	3	56	4	56	13	Are these repeated cross-references to the other chapters really necessary? I don't understand the one to chapter 2. [Regine Hock, United States of America]	Accepted. Text modified
31057	3	56	7	56	10	Rather than citing chapters please add pointers to appropriate sections of chapters [Hans-Otto Poertner and WGII TSU, Germany]	Accepted. Text modified
30367	3	56	7	56	7	This statement directly contradicts one of the main conclusions of Chapter 13 of the IPCC AR5 report than states that the dominant process accounting for rising sea level is thermal expansion of the ocean from 1993 to 2010. Moreover, this process will continue unabated driven by warming of the deeper ocean. See comment #1 above with regard to the entire report. [Paul Glaser, United States of America]	Rejected: we am talking about increasing mass, not volume
28381	3	56	7	56	8	This statement is misleading and incorrect. The SMB of the GrIS responds ~instantaneously to changes in surface forcing and is the dominant source of recent delta in mass loss. Rephrase or remove. [Jonathan Bamber, United Kingdom (of Great Britain and Northern Ireland)]	Accepted. Text modified
28383	3	56	12	56	12	Another incorrect statement. The largest component of the mass balance of the GrIS is accumulation, followed by discharge, then runoff. Could replace "mass balance" by "increase in mass loss" and then it would be sort of correct [Jonathan Bamber, United Kingdom (of Great Britain and Northern Ireland)]	Accepted. Text modified
30029	3	56	12	56	12	"mass loss" instead of "mass balance"? [Ronja Reese, Germany]	Accepted. Text modified
26053	3	56	12	57	37	Greenland is dealt with in Lines 12-15 and then again on the next page L30-37. This interrupts the flow. It would read better if the processes MISI and MICI are explained in sequence. Can Greenland be dealt with in one paragraph e.g. at the very end instead of spread across the box? [Regine Hock, United States of America]	Accepted. We have restructured the text.
30035	3	56	24	56	25	That basal melting promotes icebergs calving is only discussed for Greenland outlet glaciers in chapter 3, not for the Antarctic ice sheet. [Ronja Reese, Germany]	Accepted. it was a mistake: section 3.3.1.3
30037	3	56	24	56	25	Section 3.3.2.3 does not exist. [Ronja Reese, Germany]	Accepted. it was a mistake: section 3.3.1.3
24483	3	56	25	0		Section 3.3.2.3 does not exist, probably this is supposed to be 3.3.1.3. [Eef van Dongen, Switzerland]	Accepted. it was a mistake: section 3.3.1.3
31059	3	56	29	56	29	Add a description of supraglacial in brackets eg supraglacial (on top of the glacier) [Hans-Otto Poertner and WGII TSU, Germany]	Accepted. Text modified
5675	3	56	34	0		Insert "the" before "future" [Nina Hunter, South Africa]	Accepted. Text modified
33371	3	56	34	56	34	Should it be made more explicit here that the "future response of AIS dynamics to warming will largely be determined by changes in ice shelves ..."? As written, it's implied that changes to SMB as a result of warming are not going to be significant. Furthermore, it skips over the importance of warming and changes in SMB in impacting the ice shelves (hence their ability to buttress flow from the grounded ice sheet). [Government of United States of America, United States of America]	Taken into account. we do not exclude the influence of warming on SMB, we just focus on ice shelves
30045	3	56	36	56	36	Konrad et al. 2018 assess rates of grounding line movement, they do not show that thinning initiates grounding line retreat. [Ronja Reese, Germany]	Rejected. See Figure 3 in Konrad et al., 2018

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
30049	3	56	36	56	44	Advances on the theory of ice-shelf buttressing and its relation to MISI have been made since AR5. A discussion about these is missing, including, e.g., Haseloff & Sergienko, Journal of Glaciology, 2018; Pegler, Journal of Fluid Mechanics, 2018a and 2018b. [Ronja Reese, Germany]	Taken into account. We had some of the mentioned references in the previous version, but had to delete due to the limit of the allowed number of references in the cross-chapter box
31061	3	56	40	56	40	I would include the term marine ice sheet instability in the title of the box as it appear in the SPM FOD [Hans-Otto Poertner and WGII TSU, Germany]	Accepted. Text modified
33373	3	56	40	56	44	The Gomez reference here only supports part of this sentence. Additional reference should be given to: Gudmundsson, G. H. (2013), Ice-shelf buttressing and the stability of marine ice sheets, Cryosph., 7(2012), 647--655, doi:10.5194/tc-7-647-2013 and/or Gudmundsson, G. H., J. Krug, G. Durand, L. Favier, and O. Gagliardini (2012), The stability of grounding lines on retrograde slopes, Cryosphere, 6(6), 1497--1505, doi:10.5194/tc-6-1497-2012. [Government of United States of America, United States of America]	Taken into account. We had the mentioned references in the previous version, but had to delete due to the limit of the allowed number of references in the cross-chapter box
28385	3	56	44	56	44	add citations to and comments related to Joughin 2014, doi:10.1126/science.1249055 and Rignot 2014 [Jonathan Bamber, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account. We cannot add more citations to the box
28573	3	56	44	56	44	The article by Konrad et al. (2015) should be cited in addition to that by Gomez et al. (2015) [Konrad, H., Sasgen, I., Pollard, D., Klemann, V. (2015). Potential of the solid-Earth response for limiting long-term West Antarctic Ice Sheet retreat in a warming climate. EPSL, 432, 254-264.] [Pippa Whitehouse, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account. We cannot add more citations to the box
28575	3	57	0	0		Relates to Figure CB6.1a: suggest including representation of the process of isostatic rebound in response to ice loss in the upper panel of this figure. This would reflect the text on lines 20-22 (page 57), which explains that such rebound may help to stabilize grounding line retreat. [Pippa Whitehouse, United Kingdom (of Great Britain and Northern Ireland)]	Accepted. Figure modified
23153	3	57	0	57		The level of scientific understanding could be reported in the figure (theory? Evidence? Agreement?) [Valerie Masson-Delmotte, France]	Taken into account. The level of scientific understanding is described in the Box text and partly reflected in the figure caption
3501	3	57	1	57	1	CB6.1 - Does (b) have zero flux at grounding line as implied? [Richard Allan, United Kingdom (of Great Britain and Northern Ireland)]	Accepted. Figure modified
26051	3	57	2	57	2	The box is well done, but the figure is a bit confusing and not self-explanatory: why is there 'Heat' in b but not a? Why is there a flux at the GL and 'retreating GL in plot a but not b. Cliff failure with a symbol is in the legend in b but where is it on in the cartoon? B also looks the same for the first steps but then not? It is not clear what happens and why in the third step? Can somehow time be included (e.g. label the 3 time steps somehow?) [Regine Hock, United States of America]	Accepted. Figure modified
26059	3	57	7	57	7	the numbers 800 and 100 sound like these are physically based numbers, but aren't they just derived from trying to get one model to match some data (thus derived from modeling), or is there any observational evidence since then. If not it should be made clearer where these numbers come from to avoid that these start propagating through the literature as sort of 'physical constants'. [Regine Hock, United States of America]	Accepted, text modified
15565	3	57	20	57	22	It should be noted that such rapid uplift is a consequence of very low viscosity, which is far from the usual Earth models used in global GIA calculations. [EUCE, Belgium]	Accepted, text modified
16895	3	57	20	57	22	It should be noted that such rapid upift is a consequence of very low viscosity, which is far from the usual Earth models used in global GIA calculations. [Louise Sandberg Soerensen, Denmark]	Accepted, text modified

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
33375	3	57	20	57	22	"... which could help stabilize groundline retreat". Note that there are multiple recent references for modeling work by Natalya Gomez and co-authors that could be used to further support this statement. [Government of United States of America, United States of America]	Taken into account. We cannot add more citations to the box
25871	3	57	21	57	21	Suggest '(41mm per year)' should read (up to 41mm per year) as per the cited source (Barletta et al. (2018). [Elizabeth Petrie, United Kingdom (of Great Britain and Northern Ireland)]	Accepted, text modified
17697	3	57	24	57	28	"has also been" is a little bit simplistic in that Roberts et al show that the speed of the system has changed a lot over the period and this nuance is missing (they also suggest along with Gwyther's work it is related to natural variability which is also missing). [Matt King, Australia]	first part: taken into account. We agree but no space to show all the nuances. Second part: rejected. We mention that the observed changes may be a linear response to increased ocean forcing
5677	3	57	30	0		Insert "the" before "Greenland" [Nina Hunter, South Africa]	Accepted, text modified
15567	3	57	30	57	30	This statement should remain without references, especially because it is not clear what is meant by less important. Is it that the dynamic mass loss will be less for GIS than AIS? Also the following sentences actually proves that is might be quite important. [EUCE, Belgium]	Accepted. This part of the text removed
16897	3	57	30	57	30	This statement should be not stand without references, especially because it is not clear what is meant by less important. Is it that the dynamic mass loss will be less for GIS than AIS? Also the following sentences actually proves that is might be quite important. [Louise Sandberg Soerensen, Denmark]	Accepted. This part of the text removed
25267	3	57	30	57	33	I encourage the authors to examine the newest version of BedMachine v3, Morlighem et al, 2017, published in the GRL, where potential exposure to Atlantic waters have been assessed. [Kristian K. Kjeldsen, Denmark]	Accepted, text modified
30249	3	57	31	57	31	I suggest you change 'subglacial channels' to 'subglacial troughs' as channels are usually associated with subglacial hydrology. [Christine Dow, Canada]	Accepted, text modified
24479	3	57	32	47	35	To me, it seems like there is no clear line in the report with respect to the dynamical contribution of Greenland to sea level rise, even though this is discussed at least three times in the report. In general it is mostly stressed that the SMB component will dominate for Greenland but suddenly here in CCBox 6 it is mentioned that "However, since AR5 it has been shown that several Greenland outlet glaciers (Petermann, Kangerdlugssuaq, Jakobshavn Isbræ, Helheim, Zachariæ Isstrøm) and North-East Greenland Ice Stream may contribute more than expected to future sea level rise (Mouginot et al., 2015). " This uncertainty should then also be mentioned in section 3.3.1.5 Mechanisms of Mass Change: Greenland and maybe in chapter 4, around p 4-33 21-22 "Greenland's potential for a rapid, dynamic contribution to sea level may be limited, as found in other ice-modelling studies (Goelzer et al., 2013; Lipscomb et al., 2013; Vizcaino et al., 2015)." [Eef van Dongen, Switzerland]	Rejected. First, this comment is not supported by other comments. Second, the statement "may contribute more than expected" does not contradict with "potential dynamic contribution may be limited". Here "more than expected" is a comparison with the previous reports, not with Chapter 4.
33377	3	57	32	57	33	"... since AR5 it has been shown that ... may contribute more than expected to future sea level rise". It has been "suggested" or "argued" but it has definitely not been "shown". [Government of United States of America, United States of America]	Accepted, text modified

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
5679	3	57	35	0		Insert "that" before "Greenland" [Nina Hunter, South Africa]	Accepted, text modified
30031	3	57	35	57	37	The findings by Biermann et al. (2016) are potentially incompatible with this, see section 4.2.2.1.2. [Ronja Reese, Germany]	Taken into account. In 4.2.2.1.2 it is written that "Data from 10Be and 26Al measurements of sediments below the ice suggest extensive, episodic ice-free conditions in Greenland's interior (Schaefer et al., 2016)" which is compatible to what we wrote here. However, we modified the text so that it is more close to that in Ch4
5681	3	58	1	0		Insert "the" before "formation" [Nina Hunter, South Africa]	Accepted, text modified
33379	3	58	1	58	1	"The disappearance of ice shelves allows formation of ice cliffs ...". Can this be stated as a fact or is it still somewhat speculative? Suggest weakening the language here a bit, e.g. "... may allow for the formation of ice cliffs ...". [Government of United States of America, United States of America]	Accepted, text modified
24485	3	58	3	0		The reference should probably be to Figure CB6.1. [Eef van Dongen, Switzerland]	Accepted, text modified
30065	3	58	7	58	15	I suggest moving the second paragraph ("Overall...") above the first paragraph ("Limited evidence"), to first introduce the overall state of knowledge and then specify this. [Ronja Reese, Germany]	Rejected. The "overall" section is not an introduction to the previous paragraph, but the conclusion of it.
25241	3	58	10	58	10	I don't think that the James et al. (2014) reference supports the claim that "MICI-style behavior is seen today at th termini of Jakobshavn and Helheim glaciers." That paper describes calving as the result of buoyant flexure and basal crevassing at Helheim glacier. It does not discuss the ice cliff instability nor does it discuss calving processes at Jakobshavn. A different reference should be used here. [Denis Felikson, United States of America]	Accepted. We replaced the reference by Parizek et al., 2019
26055	3	58	14	58	14	Wrong terminology: 'low evidence' should be 'limited evidence' (see footnote 3.3) [Regine Hock, United States of America]	Accepted, text modified
27937	3	58	17	58	20	It is still unclear whether the AIS experienced maximum deglacial grounded ice loss during Melt Water Pulse -1a and it is the grounded ice loss that is directly relevant for the given sealevel context. Weber et al provide clear evidence for more extensive ice-rafted debris loss in their core sites, but the inference that this implies maximum ice loss from the AIS (or more relevantly maximum grounded ice loss) has significant uncertainties. Geological inferences for timing of AIS ice margin retreat have poor chronological control (eg Anderson et al, 2013, Geological Society, London, Special Publications, doi 10.1144/SP381.13) and a major collaborative initiative among Antarctic glacial geologists found only a "relatively small Antarctic contribution to meltwater pulse 1a" (Bentley et al, 2014, QSR, A community-based geological reconstruction of Antarctic Ice Sheet deglaciation since the Last Glacial Maximum, RAISED consortium). The Golledge et al (2014) results of maximum ice loss during mwp1a have not been replicated by other models. It also relies on implicit and poorly constrained assumptions connecting inferred and modelled changes in Southern ocean temperatures to the marine temperatures on the ice shelves, associated local circulation, and resultant subshelf melt. [Lev Tarasov, Canada]	Accepted. We removed the paragraph about the MWP1a

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
30371	3	58	17	58	29	: I am not sure if this recent paper fits within the time-frame covered by this paragraph but a recent research report in Science based on a paper presented by Carelson et al. at AGU, reported a collapse of the WAIS during the last interglacial period at 125K BP (see Voosen, P. (2018). Antarctic ice melt 125,000 years ago offers warning. Science, 362: 6421-1339). [Paul Glaser, United States of America]	Taken into account. In this paragraph we focus on the time period since LGM, so this paper is not relevant
5683	3	58	18	0		Insert "the" before "Last" [Nina Hunter, South Africa]	Accepted, text modified
28577	3	58	19	58	21	The claim that the Antarctic Ice Sheet experienced rapid ice loss particularly during Melt Water Pulse 1a is not a robust result. Suggest ending the sentence on line 20, after "...ice loss between 20,000 and 9,000 years ago." If necessary, include references relating to in situ evidence for past rapid ice thinning (e.g. Small, D., Bentley, M.J., Jones, R.S., Pittard, M.L., Whitehouse, P.L., 2019. Antarctic ice sheet palaeo-thinning rates from vertical transects of cosmogenic exposure ages, Quat. Sci. Rev., 206, 65-80) and ice modelling (e.g. the Golledge et al., 2014 article already referenced). [Pippa Whitehouse, United Kingdom (of Great Britain and Northern Ireland)]	Accepted. We removed the paragraph about the MWP1a and added the proposed reference
15569	3	58	33	58	33	Please, specify what kind of observational data is needed to constrain the models [EUCE, Belgium]	Accepted, text modified
16899	3	58	33	58	33	Specify what kind of observational data is needed to constrain the models [Louise Sandberg Soerensen, Denmark]	Accepted, text modified
31063	3	58	38	58	41	Please include specifics for sea level eg potential range of SLR to reinforce message [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account. For the sake of saving the place, we have included the reference to the corresponding section of Chapter 4
31065	3	58	38	58	41	Reference cross chapter box 4 on deep uncertainty [Hans-Otto Poertner and WGII TSU, Germany]	Accepted, text modified
32041	3	58	38	58	41	Either the entire text in the box or the conclusions might require some re-writing: I cannot derive the same conclusions from the text, in other words, the rather significant statements in the conclusions do not appear to be well-supported right now. [Christian Reuten, Canada]	Accepted. We have re-worded the text
23155	3	58	39	58	39	what does "significant" mean here? Be more explicit (committed changes? Range?) [Valerie Masson-Delmotte, France]	Accepted. This part of the text removed.
26057	3	58	40	58	41	labeling sea level projections in general 'deeply uncertain is too negative. Perhaps better: 'on projections of the sea level contributions from the Antarctic ice sheet' [Regine Hock, United States of America]	Accepted, text modified
19199	3	59	1	67	35	Throughout the chapters 3.4.1 and 3.4.2 I found the titles of some sub-chapters not meaningful enough. More descriptive titles like e.g. in the subchapters within 3.4.3 could help the readers to orientate themselves more easily. If possible within the framework of the report, please consider renaming the following chapters: 3.4.1.1.1 Extent and duration (of snow cover), 3.4.1.1.3 Drivers (of seasonal snow cover), 3.4.1.2.1 Temperature (Permafrost temperature), 3.4.1.2.3 Carbon (Soil organic carbon content), 3.4.1.2.4 Drivers (of Frozen Ground), 3.4.1.3.3 Drivers (in Freshwater Systems). [APECS Group Review, Germany]	Reject; we followed IPCC protocols and guidance when constructing section/subsection titles, with brevity flagged to us as a priority.
19201	3	59	5	59	5	This citation is referenced in the text as 2015b (on the previous page, lines 23 and 28), but not in this reference list. These should be made consistent. [APECS Group Review, Germany]	Accepted, text modified
3097	3	59	28	0		Font issue [Helene Hewitt, United Kingdom (of Great Britain and Northern Ireland)]	Accepted, text modified

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
3519	3	59	28	0		Formatting error in Roberts et al. (2017) reference [Richard Allan, United Kingdom (of Great Britain and Northern Ireland)]	Accepted, text modified
32441	3	59	41	0		I am missing Arctic permafrost coasts and their rapid change in the Polar Regions chapter; I would expect them here in 3.4 Terrestrial Cryosphere: Changes, Consequences and Impacts. Particularly permafrost coasts with their sometimes extremely rapid erosion rates are undergoing major transformations with consequences for local settlements, historical sites, subsistence and modern economies, and terrestrial and marine ecosystems. There is substantial literature on this topic and many recent papers point out accelerating erosion rates. Coasts are particularly affected by terrestrial as well as oceanic and atmospheric drivers, and their consideration sometimes tends to fall between the cracks of thematic chapters as they are neither pure land areas nor pure marine areas. While some text exists on impacts on coastal communities, there is no content on the physical processes, drivers, and changes going on at Polar Coasts. Polar Coasts could be represented in a similar way as Polynyas (Box 3.2 in chapter 3) as a box. [Guido Grosse, Germany]	Noted-key citations referenced in cross chapter box and reference to ccb now in 3.5 text
26061	3	59	41	59	41	Should not be called 'Terrestrial cryosphere, since glaciers and much of the ice sheets covered elsewhere are also 'terrestrial cryosphere. Better: Snow, freshwater ice and permafrost: Changes, Consequences and Impacts. (This makes it also easier for a reader to identify just those topics in the table of content). [Regine Hock, United States of America]	Accepted: Section title changed
32383	3	59	41	59	41	Section 3.4 on the terrestrial polar systems could be substantially reduced. There is a lot of expansive text that is relatively detailed compared to the remainder of the chapter. In particular, space needs to be given to presenting the changes to terrestrial and freshwater systems occurring in the Antarctic. The changes in the Antarctic will have significant ecological and human effects. In the case of the latter, it will change the use of ice-free and permafrost areas and have important geopolitical implications. Thus, Antarctica needs to be given a reasonable space in this section. [Andrew Constable, Australia]	Taken into account: Given our page limit , and the need to focus on top-level policy-relevant messages, it is not possible to provide this level of detail. We have made the scope of Section 3.4 explicit by revising the section title.
30959	3	59	41	80	32	The entire section 3.4 is on the Arctic terrestrial cryosphere, the Antarctic is mentioned I think only twice under 3.4.1.2.1 (Temperature). I understand why the focus here is on the Arctic, but changes in the Antarctic terrestrial cryosphere shouldn't be completely ignored. What about, e.g., changes observed on the South Shetland Islands? Please include some more details on the Antarctic terrestrial cryosphere and clarify in introduction to this section why focus here is largely on the Arctic. [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account: Given our page limit , and the need to focus on top-level policy-relevant messages, it is not possible to provide this level of detail. We have made the scope of Section 3.4 explicit by revising the section title.
3503	3	59	50	59	50	suggest "almost always completely snow covered" if this means any land area north of 60N (e.g. Shetland isn't) but I guess Arctic excludes these although the schematic in 3.1 shows Iceland and Faero Islands included which presumably very occasionally melt in warm southerly flows. [Richard Allan, United Kingdom (of Great Britain and Northern Ireland)]	Accepted: text revised
17351	3	59	50	59	52	This is not the present case, and has never been, for the Northeast Atlantic coastal regions. [Svein Sundby, Norway]	Accepted: text revised

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
32509	3	59	50	59	52	always completely snow covered' - needs to be softened as it does not apply to 100% of areas north of 60N all the time in winter (e.g. North Atlantic islands, coastal Norway). [Blair Trewin, Australia]	Accepted: text revised
26235	3	59	55	60	26	It looks like everything here is only about the Arctic and nothing about the southern polar regions? This probably makes sense, but the domain should be made clear. [Regine Hock, United States of America]	Taken into account: Given our page limit , and the need to focus on top-level policy-relevant messages, it is not possible to provide this level of detail. We have made the scope of Section 3.4 explicit by revising the section title.
5685	3	59	56	0		Insert "respectively" before "per" [Nina Hunter, South Africa]	Accepted: text revised
24451	3	60	2	60	3	There are other long snow records that can be referenced. The Abisko data back dates to 1913 and is best referenced by Kohler et al (2006): http://www.aari.ru/docs/pub/061006/koh06.pdf . [veijo pohjola, Sweden]	Rejected: a more up to date citation is required
12117	3	60	3	60	3	The trend towards earlier spring melt onset for NH snow cover has been recently shown by Anttila et al. (2018) with an average magnitude of 6.1 days during 34 years of study. [Aku Riihelä, Finland]	Accepted: citation added
5687	3	60	7	0		Remove bracket before "Brown" [Nina Hunter, South Africa]	Accepted: text revised
3515	3	60	8	0		I assume SCE is defined elsewhere (may be more readable to write out in full) [Richard Allan, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account: we have removed the SCE acronym and spell out in full
19203	3	60	8	60	8	SCE has not been defined, nor is it used elsewhere. I suggest not using an abbreviation here. [APECS Group Review, Germany]	Taken into account: we have removed the SCE acronym and spell out in full
26063	3	60	14	60	14	delete 'before melt' (it's redundant) [Regine Hock, United States of America]	Accepted: text revised
26065	3	60	14	60	16	This looks like a misinterpretation of confidence language. The fact that spatial extrapolation is difficult and one should not have much confidence trend statement over large domain, should not make the observations themselves less confident. These are 2 very different things. The point measurements can be sound and show a trend which is robust against typical measurement errors, while any attempted spatial extrapolation and resulting large-scale computed trends will have lower confidence. This needs reformulation. [Regine Hock, United States of America]	Accepted: text revised
17091	3	60	44	60	44	In addition or replacement to Kochendorfer et al., it may be appropriate to refer to the full WMO-SPICE report like in Chapter 2 : Nitu, R., Y.-A. Roulet, M. Wolff, M. Earle, A. Reverdin, C. Smith, J. Kochendorfer, S. Morin, R. Rasmussen, K. Wong, J. Alastrué, L. Arnold, B. Baker, S. Buisán, J.L. Collado, M. Colli, B. Collins, A. Gaydos, H.-R. Hannula, J. Hoover, P. Joe, A. Kontu, T. Laine, L. Lanza, E. Lanzinger, GW Lee, Y. Lejeune, L. Leppänen, E. Mekis, J.-M. Panel, A. Poikonen, S. Ryu, F. Sabatini, J. Theriault, D. Yang, C. Genthon, F. van den Heuvel, N. Hirasawa, H. Konishi, K. Nishimura and A. Senese, WMO Solid Precipitation Intercomparison Experiment (SPICE) (2012 - 2015), Instruments and Observing Methods Report No. 131, World Meteorological Organization, Geneva, 2018. https://www.wmo.int/pages/prog/www/IMOP/publications-IOM-series.html [Samuel Morin, France]	Accepted: text revised

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
19205	3	60	53	60	55	It may be worth quickly indicating in how shrub cover influences soil temperature and snowmelt. Does more shrub lead to warmer or cooler soil temperatures, and why does this matter for snowpack mass budget. [APECS Group Review, Germany]	Taken into account: text no longer appears
19207	3	60	56	60	57	Spring snowmelt is discussed on lines 56-57, but autumn is ignored despite being mentioned as changing in previous sections (3.4.1.1.1). A more complete statement for these lines would include autumn, perhaps referencing Barrere et al. (2018). Barrere M, Domine F, Belke-Brea M, and Sarrazin D (2018) Snowmelt events in autumn can reduce or cancel the soil warming effect of snow-vegetation interactions in the Arctic. Journal of Climate 31: 9507-9518 [APECS Group Review, Germany]	Taken into account: text no longer appears
23157	3	61	0	61		In section 3.4 be more explicit on what is new since AR5. Again missing conclusions at the end of each subsection with use of calibrated uncertain language. [Valerie Masson-Delmotte, France]	Accepted: text revised throughout section
19211	3	61	1	0		caption, should indicate what time period the figure is the figure, June to August? Because for most of public the polar region is snow covered all year around [APECS Group Review, Germany]	Taken into account: figure was updated
19213	3	61	1	0		left column plots, observed river discharge, give a overall trend line to show the increasing trend [APECS Group Review, Germany]	Taken into account: figure was updated
19215	3	61	1	0		showing the groundwater table for a complete inland water cycle, show the ocean too if possible to make the global water cycle [APECS Group Review, Germany]	Taken into account: figure was updated

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
8665	3	61	1	61	3	<p>The confidence for impurities to enhance snow melt is high (agreed), but for larger dust deposition, an insulation effect can take place, preventing snow and ice from melting (medium confidence). In several independent literature references it has been detected that, e.g., for Icelandic dust (= various types of dust) melt versus insulation effects takes place when the dust layer thickness exceeds a certain (dust type specific) a critical layer thickness. In Iceland, dust layers on snow and glacier ice can be from millimeters up to meters. This means both melt and insulation effects. The best reference for these Icelandic and snow interaction studies is the paper by Boy et al. 2018 (in review for ACP, expected to be accepted early spring 2019, the citation is given in this excel-sheet in row 16, here below). The other literature references for dust and insulation can be found with the help of that paper. In my opinion, the paper by Boy et al. is worth citing, as it includes an overview and outcome of the Nordic Centre of Excellence CRAICC (CRyosphere-Atmosphere Interactions in a Changing Arctic Climate, funded by NordForsk in the years 2011–2016, as the largest joint Nordic research and innovation initiative to date), aiming to strengthen research and innovation regarding climate change issues in the Nordic Region. CRAICC gathered more than 100 scientists from all Nordic countries in a virtual Centre with the objectives to identify and quantify the major processes controlling Arctic warming and related feedback mechanisms, to outline strategies to mitigate Arctic warming and to develop Nordic Earth System modelling with a focus on the short-lived climate forcings (SLCF), including natural and anthropogenic aerosols. The outcome of CRAICC is reflected in more than 150 peer-reviewed scientific publications, most of which are in the CRAICC special-issue of the journal Atmospheric Chemistry and Physics. The manuscript by Boy et al. presents an overview on the main scientific topics investigated in the Centre and provides the reader a state-of-the-art comprehensive summary of what has been achieved in CRAICC with links to the particular publications for further detail. Facing the vast amount of outcomes we are not claiming to cover all results from CRAICC in this manuscript but concentrate here on the main results which are related to the feedback loops in the climate change-cryosphere interaction scheme affecting the Arctic amplification. [Outi Meinander, Finland]</p>	See #8667
8667	3	61	1	61	3	<p>Boy, M., Thomson, E. S., Acosta Navarro, J.-C., Arnalds, O., Batchvarova, E., Bäck, J., Berninger, F., Bilde, M., Dagsson-Waldhauserova, P., Castarède, D., Dalirian, M., de Leeuw, G., Dragosics, M., Duplissy, E.-M., Duplissy, J., Ekman, A. M. L., Fang, K., Gallet, J.-C., Glasius, M., Gryning, S.-E., Grythe, H., Hansson, H.-C., Hansson, M., Isaksson, E., Iversen, T., Jonsdottir, I., Kasurinen, V., Kirkevåg, A., Korhola, A., Krejci, R., Kristjansson, J. E., Lappalainen, H. K., Lauri, A., Leppäranta, M., Lihavainen, H., Makkonen, R., Massling, A., Meinander, O., Nilsson, E. D., Olafsson, H., Pettersson, J. B. C., Prisle, N. L., Riipinen, I., Roldin, P., Ruppel, M., Salter, M., Sand, M., Seland, Ø., Seppä, H., Skov, H., Soares, J., Stohl, A., Ström, J., Svensson, J., Swietlicki, E., Tabakova, K., Thorsteinsson, T., Virkkula, A., Weyhenmeyer, G. A., Wu, Y., Zieger, P., and Kulmala, M.: Interactions between the atmosphere, cryosphere and ecosystems at northern high latitudes, Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2018-733, in review, 2018. [Outi Meinander, Finland]</p>	Accepted: citation added

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
17525	3	61	2	61	13	Meltwater on the ice sheet can also provide an environment favorable for algae blooms, which can also reduce albedo and magnify warming. Lutz S., et al. (2016) The biogeography of red snow microbiomes and their role in melting arctic glaciers, NATURE COMMUNICATIONS 7(11968):1–9. [Kristin Campbell, United States of America]	Rejected: this section is focused on drivers of seasonal snow, not glaciers
17633	3	61	2	61	13	Meltwater on the ice sheet can also provide an environment favorable for algae blooms, which can also reduce albedo and magnify warming. Lutz S., et al. (2016) The biogeography of red snow microbiomes and their role in melting arctic glaciers, NATURE COMMUNICATIONS 7(11968):1–9. [Durwood Zaelke, United States of America]	Rejected: this section is focused on drivers of seasonal snow, not glaciers
19209	3	61	15	61	20	This paragraph is interesting, in the sense that sea ice conditions are rarely associated with terrestrial snow cover in the literature. However I think this is important, at least in coastal regions. The paragraph mostly mention changes in atmospheric moisture, but I am wondering if less Arctic sea ice near the coasts could also mean less available snow redistributed inland by winds (because sea ice can no longer serve as a temporary snow 'deposit'). Do we have data about this topic? Just curious... [APECS Group Review, Germany]	Taken into account: text no longer appears
19217	3	61	17	61	19	wetland/peatland soil is also an important example for excess ice, with >~90% ice volume [APECS Group Review, Germany]	Taken into account: text no longer appears
30089	3	61	18	61	18	"Temperature and snowfall responses" to reduced sea ice. The word "response" might be confusing. I assume primarily Increase is meant, which should be stated for clarification. Or "mostly increase". [Lena Rubensdotter, Norway]	Taken into account: text no longer appears
17077	3	61	22	0		what about permafrost and frozen ground in southern hemisphere and Antarctica? [Jorge Carrasco, Chile]	Accepted-key citations referenced in 3.4 and ES modified
19219	3	61	22	0		Section 3.4.1.2: I think it could help to restructure this section by first introducing the different ways that permafrost thaw manifests in the landscape because the drivers of this thaw can be very different. I suggest that the current "3.4.1.2.4 Drivers" section have its title changed to "Types of thaw", which I think better describes the content within it that discusses press, pulse, and abrupt thaw processes, and become the first sub-section of "3.4.1.2 Frozen Ground". Then the "3.4.1.2.1 Temperature" section title be changed to "Drivers of thaw". This section should then include notes on temperature, precipitation, and vegetation changes as it relates to drivers of thaw. [APECS Group Review, Germany]	Rejected-the order of observations matches the other sections of the chapters

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
19221	3	61	22	0		Section 3.4.1.2: The above suggestion to re-organize and re-name "3.4.1.2.1 Temperature" and "3.4.1.2.4 Drivers" within "3.4.1.2 Frozen Ground", stems from the fact that drivers of thaw (e.g. changes in temperature, precipitation, vegetation) can differ for different types of thaw. For some types of thaw (i.e. abrupt thaw processes; retrogressive thaw slumps) precipitation is a greater driver of the thaw process than temperature as shown in: (1) Kokelj, S. V., Tunnicliffe, J., Lacelle, D., Lantz, T. C., Chin, K. S., & Fraser, R. (2015). Increased precipitation drives mega slump development and destabilization of ice-rich permafrost terrain, northwestern Canada. <i>Global and Planetary Change</i> , 129, 56–68. https://doi.org/10.1016/j.gloplacha.2015.02.008 ; and (2) Segal, R. A., Lantz, T. C., & Kokelj, S. V. (2016). Acceleration of thaw slump activity in glaciated landscapes of the Western Canadian Arctic. <i>Environmental Research Letters</i> , 11(3), 034025. https://doi.org/10.1088/1748-9326/11/3/034025 . This is likely because of the accumulation of debris over thaw slump features where precipitation is needed to move off debris to expose massive ice bodies. As currently written, "3.4.1.2.1 Temperature" focuses on climate change links to active layer thaw, and there's a lack of coverage in how different factors (temperature, precipitation, vegetation change) that are changing impact different types of thaw processes. [APECS Group Review, Germany]	Rejected-the order of observations matches the other sections of the chapters
3227	3	61	22	61	22	Why not just say "Permafrost" since this is what is discussed. [Sharon Smith, Canada]	Accepted- text revised
21555	3	61	22	61	22	Replace with "Permafrost", the SROCC outline, in contrast to AR5, does not contain frozen ground. [Stephan Gruber, Canada]	Accepted- text revised
26071	3	61	22	61	22	This should be 'permafrost'. Frozen ground is not part of the annotated outline. Our mandate in this respect is permafrost (see annotated outline) [Regine Hock, United States of America]	Accepted- text revised
30123	3	61	24	0		Paper in press by Biskaborn et al in <i>Nature Communications</i> on "Permafrost is warming at a global scale" finds clear trends of global warming for all permafrost types (Arctic continuous: 0.39+/-0.15°C; Arctic discontinuous: 0.20+/- 0.10°C; Antarctic: 0.37+/-0.10°C, and Mountain permafrost: 0.19+/-0.05°C) based on analysis of 124 borehole records of the Global Terrestrial Network for Permafrost for the decade from 2007-2016. Globally, permafrost was warming by 0.29/-0.12°C during this decade. [Guido Grosse, Germany]	Accepted - this new paper was incorporated into the text
30091	3	61	24	61	32	The temperature changes in permafrost needs to be better references. Could be found in the Mountain chapter 2. [Lena Rubensdotter, Norway]	Accepted - new published papers incorporated into the text
3229	3	61	25	61	27	You need to say when record high temperatures occurred (2017?). Also AMAP 2017 would have only included data up to 2015 or 2016. The most recent State of Climate report (Romanovsky et al. 2018) would have the most recent information on trends and includes 2017 data. (note rates given may need to be revised based on most recent data). [Sharon Smith, Canada]	Accepted - this new paper was incorporated into the text

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
27473	3	61	25	61	27	This statement is vague ("most"): "Record high temperatures at ~10-20 m depth in the permafrost (below the depth affected by intra-annual fluctuation in temperature) have been documented at most long-term monitoring sites in the Northern Hemisphere circumpolar permafrost Zone (AMAP, 2017)". Please give a value for "most". It is unlikely that 10 m is below the depth affected by intra-annual fluctuations. There is newly published GTN-P survey of all permafrost temperature records. Please either replace the above (or append) with: "Ground temperature near the depth of zero annual amplitude increased by 0.39 ±0.15 °C (continuous permafrost), 0.20 ±0.10 °C (discontinuous permafrost) and 0.37 ±0.10 °C (Antarctica) between 2007 and 2016. The global permafrost temperature increase was 0.29 ±0.12 °C (Biskaborn et al., 2019)". CITATION: Biskaborn B.K., S. L. S., J. Noetzli, H. Matthes, G. Vieira, D. Streletskiy, P. Schoeneich, V.E. Romanovsky, A.G. Lewkowicz, A. Abramov, M. Allard, J. Boike, W.L. Cable, H.H. Christiansen, R. Delaloye, B. Diekmann, D. Drozdov, B. Etzelmüller, G. Grosse, M. Guglielmin, T. Ingeman-Nielsen, K. Isaksen, M. Ishikawa, M. Johansson, H. Johannsson, A. Joo, D. Kaverin, A. Kholodov, P. Konstantinov, T. Kröger, C. Lambiel, J.-P. Lanckman, D. Luo, G. Malkova, I. Meiklejohn, N. Moskalenko, M. Oliva, M. Phillips, M. Ramos, A. B.K. Sannel, D. Sergeev, C.Seybold, P. Skryabin, A. Vasiliev, Q. Wu, K. Yoshikawa, M. Zheleznyak, H. Lantuit. (accepted 2019). Permafrost is warming at a global scale. Nature Communications, doi:10.1038/s41467-018-08240-4. [Pier-Paul Overduin, Germany]	Accepted - this new paper was incorporated into the text
15571	3	61	28	61	33	Please, check if AMAP is the only the reference for all the statements given here. [EUCE, Belgium]	Accepted - a new paper was incorporated into the text
16901	3	61	28	61	33	Is AMAP the reference for all the statements given here? [Louise Sandberg Soerensen, Denmark]	Accepted - a new paper was incorporated into the text
27475	3	61	30	61	32	The sentence "Relatively smaller increases in permafrost temperature in warmer sites indicate that near-surface permafrost is thawing with additional heat absorbed by the ice-to-water phase change, and as a result, the active layer is increasing in thickness." - this is contradicted 3 lines later by mention of subsidence. This statement is ONLY true if there is no melting of excess ice occurring and needs correction. Is the point that warm permafrost is warming and/or thawing? If we do not know about changes to ice/water content or ground surface position, delete the sentence. [Pier-Paul Overduin, Germany]	Accepted - wording was changed to clarify
21557	3	61	31	61	31	omit "near-surface" and "additional" [Stephan Gruber, Canada]	Accepted - wording was changed to clarify
3231	3	61	31	61	32	What do you mean by "near-surface"? The temperature profile is isothermal at these warmer sites where phase change is occurring and this may be over depths of several metres. It might be more correct here to say summer thaw depths are increasing rather than active layer thickness is increasing given what is said below regarding thaw settlement. [Sharon Smith, Canada]	Accepted - wording was changed to clarify
21559	3	61	32	61	32	omit "and as a result, the active layer is increasing in thickness" as this is not necessarily true and the explanation does not add insight here [Stephan Gruber, Canada]	Accepted - wording was changed to clarify
26069	3	61	33	61	33	rephrase: 'layer thickness has increased' (the uncertainty is in the increase not the observation, right?) [Regine Hock, United States of America]	Accepted - wording was changed to clarify

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
30373	3	61	33	61	33	Please clarify the antecedent for the pronoun "This" which is otherwise unclear. [Paul Glaser, United States of America]	Accepted - wording was changed to clarify
3233	3	61	34	61	36	The key point here is that if changes in surface elevation are not considered then active layer thickness derived through probing may not give the full story with respect to permafrost degradation especially where permafrost is ice-rich. (Note you should indicate that this is particularly important where permafrost is ice-rich rather than saying "in some cases" - be more specific) [Sharon Smith, Canada]	Noted - this is the point of the statement
3235	3	61	37	61	40	An important point here is that the active layer is more responsive to shorter-term climate fluctuations compared to deeper permafrost temperatures and therefore exhibits greater interannual variability which can obscure longer term trend. [Sharon Smith, Canada]	Noted - this level of detail is beyond the length constraints of the text
29991	3	61	39	61	40	The sentence indicating "Permafrost in the Southern Hemisphere polar region occurs in ice-free exposed rock areas" is not correct, since there is permafrost in other types of terrain, such as Holocene deposits (moraines, beaches, rockglaciers and volcanic ashes and pyroclasts). Hence, the sentence should read "Permafrost in the Southern Hemisphere polar region occurs in ice-free exposed rock areas and sedimentary deposits". If you need to add a citation, refer to Bockheim J, Vieira G, Ramos M, Lopez-Martinez J, Serrano E, Guglielmin M, Wilhelm K, Nieuwendam A. 2013. Climate Warming and Permafrost Dynamics in the Antarctic Peninsula Region . Global and Planetary Change, 100: 215-223, Goyanes G, Vieira G, Caselli A, Cardoso M, Marmy A, Bernardo I, Hauck C. 2014. Geothermal anomalies, permafrost and geomorphological dynamics (Deception Island, Antarctica). Geomorphology. 225(15): 57-68. DOI: 10.1016/j.geomorph.2014.04.010 and Hauck, C.; Vieira, G.; Gruber, S.; Blanco, J.J.; Ramos, M., 2007. Geophysical identification of permafrost in Livingston Island, Maritime Antarctic. Journal of Geophysical Research, VOL. 112, F02S19, doi:10.1029/2006JF000544. [Gonçalo Vieira, Portugal]	Accepted - wording was changed to clarify
3237	3	61	39	61	44	This comment on area of Antarctic permafrost seems out of place especially since the area of the Arctic underlain by permafrost is not given in the discussion above. A more important point to make here is that there are limited observations compared to Arctic. The time period over which increase in temperature has been observed needs to be given as these records are generally shorter than those for the Arctic. (less confidence in magnitude of change?) [Sharon Smith, Canada]	Noted - the relative permafrost area is given for Antarctica and for the Northern Hemisphere in this paragraph
21561	3	61	40	61	40	omit "rock" [Stephan Gruber, Canada]	Accepted - wording was changed to clarify
27477	3	61	40	61	44	Subsea permafrost comprises an additional 2.5 x 106 km2 of frozen ground, more than 97% of which is warming (Overduin et al., in review) and poor in ice (Nicolosky et al., 2012). CITATION: Nicolosky, D. J., Romanovsky, V. E., Romanovskii, N. N., Kholodov, A. L., Shakhova, N. E., & Semiletov, I. P. (2012). Modeling sub-sea permafrost in the east Siberian Arctic shelf: The Laptev Sea region. J. Geophys. Res.: Earth Surface, 117(F3), F03028. doi: 10.1029/2012JF002358. CITATION: Overduin, P. P., Schneider von Deimling, T., Miesner, F., Grigoriev, M. N., Ruppel, C., Vasiliev, A., Lantuit, H., Juhls, B. & Westermann, S. (in review). Submarine Permafrost Map in the Arctic Modelled Using 1D Transient Heat Flux (SuPerMAP). J. Geophys. Res.: Oceans. [Pier-Paul Overduin, Germany]	Noted - the wording was changed to specify land to land comparisons across hemispheres
21563	3	61	42	61	42	omit "permafrost zone" [Stephan Gruber, Canada]	Accepted - wording was changed to clarify

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
21671	3	62	0	0		Hard to read some index in Figure 3.10 [Government of Republic of Korea, Republic of Korea]	Taken into account: figure revised
19235	3	62	1	0		legends of bottom two subplots in the left column are too small to see [APECS Group Review, Germany]	Taken into account: figure revised
19237	3	62	1	0		a snow water equivalent subplot would help to decide if [APECS Group Review, Germany]	Rejected: cannot add an additional snow panel
698	3	62	1	62	1	Some information of this figure is described much later in the main text e.g., the projection. Therefore, I suggest separating it into two figures. And I think it is helpful to have a map to show changes in the spatial distribution in addition to the curves. [Mengxi Wu, United States of America]	Rejected: cannot add an additional figure due to space limitations
4123	3	62	1	62	1	I propose to show the interactions and influences related to snow, permafrost, and runoff, separately, with an illustration such as provided in the draft (the middle panel of Figure 3.10), by adding marks and arrows as in Figure 3.2. Moreover, placing each illustration next to the corresponding time series of the variable (snow area, permafrost temperature/area, or runoff) from past to future by merging (or connecting) one in the left column with the other in the right column. Please look at the attached picture in which an example of the placing of panels is shown. Figure 2 of Saito et al. (2013, Ecological Application, https://doi.org/10.1890/11-1062.1) can be a reference in adding marks and arrows to show the interactions and influences among the factors and processes in the Arctic terrestrial cryosphere. [Kumiko Takata, Japan]	Taken into account: figure revised
33381	3	62	1	62	1	Do each of these panels represent the entire Arctic? Also, will there be labels on the figure to call out specific components of the terrestrial cryosphere changes? [Government of United States of America, United States of America]	Taken into account: figure revised
3239	3	62	1	62	11	Fig 3.10 - This Figure is so small and difficult to read. Other cryospheric components (sea ice, glaciers, ice sheets) have multiple figures so why cram 3 cryospheric components into one figure to show observed changes and projections. The central figure could be smaller or perhaps presented separately earlier in the document to show key processes, linkages between components etc. Additional information also needs to be provided in the caption for permafrost figure, including baseline period and number of sites utilized for each region (especially since the sites included in Romanovsky et al. 2017b have varying record lengths). Most recent data source for permafrost should also be given - see State of Climate in 2017 report (Romanovsky et al. 2018). [Sharon Smith, Canada]	Taken into account: figure revised
12119	3	62	1	62	11	The center picture in Figure 3.10 is pretty, but it is currently completely disconnected from the graphs surrounding it. While revising the figure, please consider revising it so that the graphs would connect logically to (parts) of the center figure. [Aku Riihelä, Finland]	Taken into account: figure revised
19225	3	62	1	62	11	Figure 3.10. I am guessing that the final resolution of this figure will be better, right? Because for now we can not really read some text (e.g. "Observed permafrost temperature change" figure, left panel: what's written in the legend for color lines?). [APECS Group Review, Germany]	Taken into account: figure revised

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
19233	3	62	1	62	11	The schematic of the landscape is described in the caption as showing "important land surface processes influenced by the Arctic terrestrial cryosphere". I think it nicely illustrates the heterogeneity of the landscape. However, it might become confusing for the readers in several ways: 1) the only processes that are visible to me in this graphic are fire and runoff. 2) I can identify results of processes like thawslumps and possibly the thawing of permafrost is illustrated by the small inlet with the ice wedge. 3) These processes are not only influenced by the Arctic terrestrial cryosphere, but are also influencing it. For a more complete picture, I would suggest the following additions: i) consider making the schematic more complete by including soil organic carbon. ii) modify the inset figure with the ice wedge as the arrow is not really clear to me. iii) consider describing the figure in more detail in the caption. iv) refer to the central schematic in the text (as far as I could tell only the figures in the left and right panel are referred to in the text). [APECS Group Review, Germany]	Taken into account: figure revised
1019	3	62	1	62	12	In Figure 3.10, bottom left figure: the data source arcticgreativers.org doesn't sound like a reputable dataset. Are there national hydrographic records for these rivers? A good, but 11-year old citation for this would be: □[1] T. M. Pavelsky and L. C. Smith, "Intercomparison of four global precipitation data sets and their correlation with increased Eurasian river discharge to the Arctic Ocean," J. Geophys. Res., vol. 111, no. D21, p. D21112, Nov. 2006. [Ethan Kyzivat, United States of America]	Rejected: this is a reputable data source
30375	3	62	2	62	2	An outstanding visual graphic! I recognize the north face of the Alaska Range from Mt. Brooks (left) to the twin peaks of Mt. McKinley (center but of course the features in the foreground particularly the high- and low-centered polygons are only found much further north. But the graphic is superb and has great eye appeal [Paul Glaser, United States of America]	Taken into account: figure revised
1021	3	62	6	62	7	"northern flowing watersheds" is a vague term- do the rivers flow north, or are the watersheds located in northern regions? Also, how did you choose these particular rivers [Ethan Kyzivat, United States of America]	Rejected: these rivers flow north and discharge into the Arctic Ocean. That is why they were selected.
5689	3	62	8	0		Remove "to" [Nina Hunter, South Africa]	Accepted: text revised
3241	3	62	8	62	8	"near surface permafrost" needs to be defined in caption - more correct to say area where thaw depths are less than x metres. [Sharon Smith, Canada]	Taken into account: figure revised
1097	3	62	11	62	11	Referred to a submitted manuscript. Please update. [George Burba, United States of America]	Accepted
11833	3	62	14	62	28	Mention exploding pingos in Siberia. [William Lorenz, Australia]	Rejected - not relevant to this section
21565	3	62	15	62	15	start with "The loss of excess ground ice" as thaw can happen without subsidence and collapse when no excess ice is present [Stephan Gruber, Canada]	Rejected - thaw can happen without subsidence but it specifically says subsidence is linked to ice loss
4211	3	62	15	65	42	most of the results for the ground ice, carbon and fresh water system are referenced to the studies without any tables, diagrams or figures. It's suggested that relevant tables and diagrams maybe added to the report for better understanding. [Behzad Layeghi, Iran]	Noted - figure space was very limited but there is a figure in the carbon emission section and a figure on permafrost temperature
5483	3	62	15	65	42	most of the results for the ground ice, carbon and fresh water system are referenced to the studies without any tables, diagrams or figures. It's suggested that relevant tables and diagrams maybe added to the report for better understanding. [rashidian leila, Iran]	Noted - figure space was very limited but there is a figure in the carbon emission section and a figure on permafrost temperature

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
5537	3	62	15	65	42	most of the results for the ground ice, carbon and fresh water system are referenced to the studies without any tables, diagrams or figures. It's suggested that relevant tables and diagrams maybe added to the report for better understanding. [Government of Iran, Iran]	Noted - figure space was very limited but there is a figure in the carbon emission section and a figure on permafrost temperature
27479	3	62	17	62	17	change the word "ranging" to "reaching". The values given are maxima, not ranges. [Pier-Paul Overduin, Germany]	Accepted - wording was changed to clarify
3243	3	62	17	62	19	Are you sure you are referring to excess ice here which when melted the volume of water exceeds the pore space in the sediment. Sands and coarse grained sediments generally have low excess ice contents (low segregation potential) and 40% would appear to refer pore ice volume. However, there can be massive ice (e.g. buried glacier ice) in glacial fluvial sediments like sands etc. It isn't clear however this is what it is being referred to here. [Sharon Smith, Canada]	Noted-these numbers refer to total ice as stated and some of this is in the form of wedge ice even in the sands
5691	3	62	19	0		Change "includes" to "include" [Nina Hunter, South Africa]	Accepted - wording was changed to clarify
21567	3	62	19	62	19	the notion of impacts here is misleading as that term suggests and interplay of hazards, exposure, and vulnerability – whereas the argument presented appears to relate to hazard (much ice to lose, strong changes), only [Stephan Gruber, Canada]	Accepted - wording was changed to clarify
30093	3	62	19	62	21	The sentence should clarify that it is effects on permafrost thawing (!) which is discussed. The word "impact" in line 19 is confusing and implies some other process than thawing. If so it needs to be explained, but I assume it only means thawing. [Lena Rubensdotter, Norway]	Accepted - wording was changed to clarify
27481	3	62	20	62	20	what does the word "roughly" refer to? it can be deleted without losing meaning. [Pier-Paul Overduin, Germany]	Accepted - wording was changed to clarify
3245	3	62	21	52	28	There are large areas where segregated ice is present (usually in fine-grained soils, peat), i.e. present as ice lenses - is this what you mean by smaller ice features. Where segregated ice is present the ice content can be significant. Also this type of ice does not only occur in Yedoma deposits or with ice-wedges and can be important with respect to thermokarst potential and also for infrastructure stability. Areas where segregated ice is extensive are in lacustrine sediments for example. [Sharon Smith, Canada]	Noted - these points are captured within the text already and space constraints limit additional detail
19227	3	62	21	62	21	The Zimov et al. (2006) reference is not quite relevant in this sentence. This paragraph is about ground ice, including ice-rich Yedoma deposits. The Zimov reference would fit better in the next paragraph about carbon. [APECS Group Review, Germany]	Accepted - older reference deleted
30125	3	62	22	62	24	Add Canadian Archipelago as a region to this list: On many of these islands buried glacial ice has been found, such as on Bylot Island (suggested reference: Coloumbe et al., 2019: Origin, burial and preservation of late Pleistocene-age glacier ice in Arctic permafrost (Bylot Island, NU, Canada). The Cryosphere) [Guido Grosse, Germany]	Accepted - text changed and reference inserted
21569	3	62	27	62	28	this argument can be read to imply that the work of Minsley et al., 2012 can increase the resolution at the pan-arctic scale. This is unlikely at present. [Stephan Gruber, Canada]	Accepted - other reference included to broaden this statement
19229	3	62	28	62	28	I might be a little picky here, but re. the Minsley et al. (2012) reference: can we really still talk about 'new technologies' when the work was published 6-7 years ago, probably the result of methods developed almost 10 years ago? Isn't there a more recent reference showing that such 'new technologies' really work? [APECS Group Review, Germany]	Accepted - other reference included to broaden this statement

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
30127	3	62	28	62	28	Add studies combining remote sensing technologies and subsurface modeling to quantify ice wedge volume in the ground (Ulrich et al., 2014: Quantifying Wedge-Ice Volumes in Yedoma and Thermokarst Basin Deposits. Permafrost and Periglacial Processes) and combining remote sensing and machine learning approaches to map and quantify regional scale ice wedge distribution (Zhang et al., 2018: Deep Convolutional Neural Networks for Automated Characterization of Arctic Ice-Wedge Polygons in Very High Spatial Resolution Aerial Imagery. Remote Sensing) [Guido Grosse, Germany]	Accepted - other reference included
19239	3	62	30	0		Section 3.4.1.2.3: This section focuses on mechanisms related to organic carbon pools and I would suggest the inclusion of processes associated with inorganic carbon such as weathering of carbonate rocks via sulfuric acid due to permafrost thaw that can also result in increasing gaseous carbon release to the atmosphere as shown in: (1) Zolkos, S., Tank, S. E., & Kokelj, S. V. (2018). Mineral Weathering and the Permafrost Carbon-Climate Feedback. Geophysical Research Letters, 45. https://doi.org/10.1029/2018GL078748 . This study was also conducted in a mineral-rich region that contrasts the organic-rich yedoma regions that a lot of these decomposition studies have been conducted in and is an important representation of glacial margin landscapes experiencing abrupt thaw processes (i.e. retrogressive thaw slumps). Because of the lack of quantification of this process across the circumpolar arctic in relation to thawing permafrost, it is unclear how important this process is in comparison to exposure of permafrost organic carbon stocks to microbial decomposition following thaw. [APECS Group Review, Germany]	Rejected - this is beyond scope
19231	3	62	30	63	25	I see that carbon transfers from permafrost to the atmosphere - including via thermokarst (thaw) lakes - are treated in the next section about 'Consequences and Impacts' (3.4.3; p. 67 line 37). But it would be interesting to have at least an idea of carbon stocks and/or fluxes from northern permafrost aquatic ecosystems (lakes, wetlands). Several references exist (e.g., Walter Anthony et al. 2016 in Nature Geoscience, among others). [APECS Group Review, Germany]	Noted - this material is incorporated here to some degree already and then in subsequent sections as noted by reviewer
21571	3	62	31	62	31	"The permafrost region represents" – zones are the subsets of the permafrost region. Correct the use of "zone" to "region" in the rest of the chapter. [Stephan Gruber, Canada]	Accepted-text revised
1099	3	62	32	62	32	"transferred to the atmosphere" -- is this discussed anywhere elae in detail. This is important process with very serious consequences. [George Burba, United States of America]	Noted - this is covered in a later section
1101	3	62	32	62	32	carbon dioxide and methane [George Burba, United States of America]	Accepted-text revised
19223	3	62	34	62	34	What is meant by 'surface' vs. 'deep' soil? Usually, maps show 'surface' soil organic carbon as within the first 3 meters. Is that the limit used here? (ex. lines 38 and 42) Could it be mentioned? [APECS Group Review, Germany]	Noted-this is defined in the paragraph
21573	3	62	35	62	35	Clarify use of "permafrost zone". The use suggests you refer to the permafrost region (i.e. some of it underlain by permafrost) but the area quoted is more likely the permafrost area (only those areas actually underlain by permafrost). [Stephan Gruber, Canada]	Accepted-text revised

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
25405	3	62	35	62	35	This number of 1460 to 1600 Petagrams does not follow from the rest of the text. The 1035 ± 150 Pg C from Hugelius et al. (2014) for the top 3 m is mentioned, and also the 327 to 466 Pg C from Strauss et al. (2017) for yedoma but the 96 ± 55 Pg C for detailic alluvium deposits from Strauss et al. (2017) are missing from the text. Also, the errors on the 1035 Pg and 96 Pg C (±150 and ±55 Pg C respectively) should be carried over to the above-mentioned range of carbon present in the northern permafrost zone. This would widen the range beyond 1460-1600 Pg C. [Parmentier Frans-Jan, Norway]	Accepted-text revised for clarity
25407	3	62	38	62	38	I would not label the 1035 ± 150 Pg C estimate as a high confidence number. It's the best estimate we have but it's still based on a limited number of pedons that have been upscaled to the rest of the permafrost region. There is no data included from Southern Siberia or China, and very few measurements in Canada. Most data came from Alaska and West Siberia. Medium confidence seems more appropriate here. [Parmentier Frans-Jan, Norway]	Noted-confidence language checked against literature and with other experts
11885	3	62	39	62	39	Do we really have high confidence in these numbers? There is excellent work behind them, no doubt, but is our confidence really high that these estimates cannot change substantially? [Gerhard Krinner, France]	Noted-confidence language checked against literature and with other experts
1023	3	62	40	62	41	"of this amount" is unclear-- which amount are you talking about? The 1035 pG found in the top 3m of circumpolar permafrost soils? Or the subset in North America? [Ethan Kyzivat, United States of America]	Accepted-text revised for clarity
1025	3	62	40	63	2	"another 50%" is unclear- how can the northern circumpolar permafrost zone add to a global inventory? Perhaps the "excluding tundra and boreal biomes " qualifier should be taken out of the parenthical to make it more clear. A better way to say this might be: "The 15% of soils contained in the northern circumpolar permafrost zone down to 3m hold 50% of the amount of the rest of global soils to 3m depth." [Ethan Kyzivat, United States of America]	Accepted-text revised for clarity
3247	3	62	41	62	41	Seasonally thawed soils - Do you mean the active layer or areas with no permafrost? [Sharon Smith, Canada]	Noted - both are described by this statement
19241	3	63	4	63	11	OK, now it is explained here ('deep' permafrost carbon). See my comment just above; it would be usefull to define surface vs. deep permafrost carbon at the start of the sub-section (3.4.1.2.3). [APECS Group Review, Germany]	Noted
25777	3	63	13	63	25	This text could benefit from brief discussion of the mineral carbon pool in permafrost soils/sediments, which is likely to be substantial, can be reactive upon thaw, and amplify C cycling (please see comment for page 68 L7-29). [Scott Zolkos, United States of America]	Noted-this is likely small compared to changes in organic carbon and beyond the scope here
30129	3	63	16	63	18	Add reference here: Lindgren et al 2018 Nature (Extensive loss of past permafrost carbon but a net accumulation into present-day soils). This study features a reconstruction of permafrost soil carbon pools durign the LGM including on exposed shelves. [Guido Grosse, Germany]	Noted-this study is cited later in the text

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
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27483	3	63	20	63	20	Add a statement on an additional carbon pool, important due to the chance of sudden release: "An additional but poorly quantified pool of carbon is gas trapped by ice-rich, low gas diffusivity permafrost or thermally stabilized as gas hydrates below or within the permafrost (Riedel et al., 2017; Ruppel and Kessler, 2017)". CITATION: Ruppel, C. D., and J. D. Kessler (2017). The interaction of climate change and methane hydrates, Rev. Geophys., 55, doi:10.1002/2016RG000534. CITATION: Riedel, M., Brent, T. A., Taylor, G., Taylor, A. E., Honge, J.K., Jine, Y.-K., Dallimore, S. R. (2017). Evidence for gas hydrate occurrences in the Canadian Arctic Beaufort Sea within permafrost-associated shelf and deep-water marine environments. Marine and Petroleum Geology, 81: 66-78, doi:10.1016/j.marpetgeo.2016.12.027. [Pier-Paul Overduin, Germany]	Noted-this section leads by quantifying organic carbon pools; this discussion of inorganic methane returns in a later section on methane emissions
27485	3	63	23	63	23	"(<120 m sea level depth)" should be corrected to "(<120 m sea water depth)" [Pier-Paul Overduin, Germany]	Accepted-text revised for clarity
30131	3	63	23	63	24	This statement contradicts geophysical evidence of submarine permafrost in some shelf regions with deeper water depths, e.g. Rekant et al 2015 arktos (Evolution of subsea permafrost landscapes in Arctic Siberia since the Late Pleistocene: a synoptic insight from acoustic data of the Laptev Sea) or Portnov et al GRL (Offshore permafrost decay and massive seabed methane escape in water depths >20 m at the South Kara Sea shelf). [Guido Grosse, Germany]	Accepted-citations added and text changed to incorporate
27487	3	63	23	63	25	The statement "These observations are supported by modelling that suggests that submarine permafrost would already be thawed >10m depth or more under current submerged conditions (Anisimov et al., 2012; AMAP 2017)" is problematic. In line 21 the term "subsea permafrost" is used, rather than "submarine permafrost" - I suggest being consistent and using "subsea". Delete the word "already", which sets up an alarmist comparison to nothing (the difference between "would be thawed" and "would already be thawed" is tacit and subjective). ">10m depth or more" is the SAME as ">10m depth" - it also sounds like an attempt at drama. Delete "under current submerged conditions" - the statement is talking about "subsea permafrost" which is by definition submerged. AMAP 2017 does not introduce new modelling of subsea permafrost. The statement should more properly read: "Observations and modelling show that subsea permafrost thaws below the seafloor at metres per year following submergence to less than centimetres per year thousands of years after submergence (Angelopoulos et al., in review; Anisimov et al., 2012)." CITATION: Angelopoulos, M., Westermann, S., Overduin, P.P., Fague, A., Olenchenko, V., Grosse, G., and Grigoriev, M.N. (in revision). Heat and salt flow in subsea permafrost modelled with CryoGRID2. Journal of Geophysical Research: Earth Surface. [Pier-Paul Overduin, Germany]	Accepted - text changed; already was previously used in the sense of 'by the time in question'

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
25409	3	63	27	63	36	<p>In this section, it would make sense to include the role of sea ice decline as a driver. Changes in arctic temperature and precipitation are to a large degree driven by sea ice decline (as described in sections 3.A.1.2 and 3.4.2.3). The influence of sea ice decline on climate extends to the terrestrial domain and affects greenhouse gas release from permafrost. Respiration and methane emissions may increase considerably in autumn, when sea ice-induced warming is strongest (Parmentier et al. 2013; 2015). While a comparable link between sea ice decline and tundra greening is mentioned on page 70, line 40, the connection to terrestrial greenhouse gas exchange is missing. A description of potential connections between sea ice decline and carbon release from terrestrial permafrost would be at place in a report that describes the ocean and cryosphere, and linkages in between.</p> <p>Parmentier F J W, Christensen T R, Sørensen L L, Rysgaard S, McGuire A D, Miller P A and Walker D A 2013 The impact of lower sea-ice extent on Arctic greenhouse-gas exchange Nat. Clim. Chang. 3 195–202</p> <p>Parmentier F J W, Zhang W, Mi Y, Zhu X, Huissteden J, Hayes D J, Zhuang Q, Christensen T R and McGuire A D 2015 Rising methane emissions from northern wetlands associated with sea ice decline Geophys. Res. Lett. 42 7214–22 [Parmentier Frans-Jan, Norway]</p>	Noted-the mechanisms of Arctic temperature change, including changes in sea ice are beyond the scope of this section but is covered elsewhere
1027	3	63	28	63	30	"as discussed in 3.4.1.3.1." -- I think this section reference is incorrect and should read 3.4.1.2.1 [Ethan Kyzivat, United States of America]	Accepted-typo corrected
3249	3	63	29	63	30	Better references should be given here that provide detailed discussion of changes in the ground thermal regime (Romanovsky et al. 2010 Permafrost and Periglacial Processes; Romanovsky et al. 2017 SWIPA) because Biskaborn focusses more on a database not analysis or details of how thermal regime responds to changes in climate which are given in the suggested publications (you can probably delete the last part of the sentences after "thermal regime" as it does not really provide any useful information). [Sharon Smith, Canada]	Rejected-this is the correct citation for the sentence and the permafrost trends are cited earlier
5693	3	63	30	0		Insert "section" before "3,4,1,3,1"; Suggest "can" and "also" change positions [Nina Hunter, South Africa]	Accepted-text revised for clarity
3251	3	63	30	63	32	It is probably more correct to say climate changes modify the impact on permafrost of abrupt physical disturbances like fire. Soil (ground would be better word) subsidence, erosion etc. are consequences of thawing permafrost that may result from disturbances like fire. The actual thawing of permafrost may not be abrupt but the impact resulting may be. [Sharon Smith, Canada]	Rejected-the proposed wording is not in line with the sentence meaning
21575	3	63	31	63	31	how is fire resulting from thaw of ice-rich permafrost? Do you mean "resulting in"? [Stephan Gruber, Canada]	Rejected-the proposed wording is not in line with the sentence meaning
30377	3	63	38	63	53	Forest fires have always been frequent natural occurrences in Alaska and boreal Canada at least through last half of the 20th century. Could the authors provide the source of their data on increasing boreal fire frequency (e.g. satellite data)? [Paul Glaser, United States of America]	Noted-the citations that are listed provide this evidence

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
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3253	3	63	42	63	48	Information on trend over time in fire occurrence is not really presented here and the statement only refers to 2 extreme years. It is not clear from this text that there is a long-term trend in fire occurrence [Sharon Smith, Canada]	Rejected-there are statements and citations of this
2337	3	63	45	63	48	Soil organic layer combustion in the extreme fire years mentioned here offset half of the annual carbon taken up as net primary production of the Canadian boreal forest. Walker, X. J., Rogers, B. M., Baltzer, J. L., Cumming, S. G., Day, N. J., Goetz, S. J., Johnstone, J. F., Schuur, E. A., Turetsky, M. R., and Mack, M. C. Cross-scale controls on carbon emissions from boreal forest megafires. <i>Global Change Biology</i> , 24(9): 4251-4265, doi.org/10.1111/gcb.14287 [Scott Goetz, United States of America]	Noted-this section is about trends in fire but not specifically effects on carbon
23985	3	63	48	63	50	It would be beneficial to add a reference to the following statement: "These extreme North American fire years were balanced by lower-than-average area burned in Eurasian forests, resulting in a 5% overall increase in global boreal area burned." [Government of Japan, Japan]	Noted -The citations for this statement link to the previous statement on the same topic; space limitations prevent repetition
3255	3	63	50	63	53	Unclear how one can conclude with very high confidence given that only one paper is cited and it focusses on Alaska - representative of entire Arctic permafrost region? [Sharon Smith, Canada]	Accepted-confidence level changed and additional papers cited
30379	3	63	55	63	55	Change "warming" to "climatic warming." [Paul Glaser, United States of America]	Accepted-text revised for clarity
3257	3	63	55	63	57	Is it the thaw that is abrupt or the impact of thaw? Also slope movements such as thaw slumps or active layer detachments (geomorphic processes) that disturb vegetation mat (reduce insulation) can result in greater response of underlying frozen sediments to climate, i.e. exacerbate warming and further slumping [Sharon Smith, Canada]	Noted-this process is described in text
29057	3	63	55	64	12	This section should now add the results of Walter Anthony, KM et al (2018). 21st-century modeled permafrost carbon emissions accelerated by abrupt thaw beneath lakes. <i>Nature Comm</i> 9:3262 [Pam Pearson, Sweden]	Noted-this paper is now cited in projections section
30133	3	63	55	64	12	New findings by Nitze et al 2018 <i>Nature Communications</i> (Remote sensing quantifies widespread abundance of permafrost region disturbances across the Arctic and Subarctic) report the widespread abundance of a range of disturbances (lakes, lake change, fires, thaw slumps) across 4 large continental-scale permafrost-region study transects with a total area of 2.5 Mkm ² . The study used Landsat-based trend analysis for a recent 15-year period (1999-2014) and highlights the urgent need to consider these abundant disturbances in models projecting permafrost-carbon feedbacks. It should be clarified, whether these findings still allow the label "low confidence" on the importance of abrupt thaw for driving change in permafrost, or this should rather be at least "medium confidence". [Guido Grosse, Germany]	Accepted - citation was added; confidence level was changed
30135	3	63	55	64	12	It should be pointed out that several studies indicate a particularly high vulnerability of high Arctic permafrost sites to rapid thaw due to the presence of near-surface ground ice, thin protective layers, and strong air temperature warming trends due to sea ice loss. One example is Fraser et al 2018 <i>Remote Sensing (Climate Sensitivity of High Arctic Permafrost Terrain Demonstrated by Widespread Ice-Wedge Thermokarst on Banks Island)</i> [Guido Grosse, Germany]	Noted-the details of this comment are beyond the word length of this section
3259	3	64	1	64	1	How short of a time? [Sharon Smith, Canada]	Noted-the general description compares time frames in a relative sense between mechanisms of change

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
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30381	3	64	1	64	12	The older permafrost literature stresses the insulating effects of snow and vegetation in driving the aggradation and degradation of permafrost (e.g. summaries in Brown 1973; Williams & Smith 1989; French 1996). [Paul Glaser, United States of America]	Accepted-the driving factor was revised for clarity; older citations not added as per IPCC style
30383	3	64	1	64	12	Collectively they support the opinion of the authors that local factors limit confidence in regional estimates based on local data. [Paul Glaser, United States of America]	Noted
30385	3	64	2	64	2	Please clarify the antecedent of "this" by adding the appropriate word(s) after the pronoun. [Paul Glaser, United States of America]	Accepted-text revised for clarity
25779	3	64	5	64	8	Including citations and references to Segal et al. (2016) and Kokelj et al. (2017) could strengthen the assertions made here. Kokelj, S. V., Lantz, T. C., Tunnicliffe, J., Segal, R., & Lacle, R. (2017). Climate-driven thaw of permafrost preserved glacial landscapes, northwestern Canada. <i>Geology</i> , 45(4), 371–374. https://doi.org/10.1130/G38626.1 Segal, R. A., Lantz, T. C., & Kokelj, S. V. (2016). Acceleration of thaw slump activity in glaciated landscapes of the Western Canadian Arctic. <i>Environmental Research Letters</i> , 11(3), 034025. https://doi.org/10.1088/1748-9326/11/3/034025 [Scott Zolkos, United States of America]	Accepted-citations added
17527	3	64	8	64	12	Thawing permafrost is also an important self-reinforcing feedback that will amplify warming as the thawing permafrost releases carbon dioxide and methane into the atmosphere, which even a small amount of carbon from permafrost (1%) can double the current rate of warming; see World Bank & International Cryosphere Climate Initiative (ICCI) (2013) ON THIN ICE: HOW CUTTING POLLUTION CAN SLOW WARMING AND SAVE LIVES and Schuur E. A. G., et al. (2015) Climate Change and the Permafrost Carbon Feedback, <i>NATURE</i> 520:171–179. [Kristin Campbell, United States of America]	Noted-this citation is used in later sections
17635	3	64	8	64	12	Thawing permafrost is also an important self-reinforcing feedback that will amplify warming as the thawing permafrost releases carbon dioxide and methane into the atmosphere, which even a small amount of carbon from permafrost (1%) can double the current rate of warming; see World Bank & International Cryosphere Climate Initiative (ICCI) (2013) ON THIN ICE: HOW CUTTING POLLUTION CAN SLOW WARMING AND SAVE LIVES, 17 ("Permafrost scientists estimate that release of just one percent of stored carbon in the form of methane will double current rates of warming due to methane's more powerful near-term forcing effects.") and Schuur E. A. G., et al. (2015) Climate Change and the Permafrost Carbon Feedback, <i>NATURE</i> 520: 171–179, 171 ("At the proposed rates, the observed and projected emissions of CH4 and CO2 from thawing permafrost are unlikely to cause abrupt climate change over a period of a few years to a decade. Instead, permafrost carbon emissions are likely to be felt over decades to centuries as northern regions warm, making climate change happen faster than we would expect on the basis of projected emissions from human activities alone."). [Durwood Zaelke, United States of America]	Noted-this citation is used in later sections
3261	3	64	9	64	9	Isn't "thermokarst vulnerability" a better term for what this study considers rather than abrupt thaw? [Sharon Smith, Canada]	Noted-Thermokarst is a more specific term; abrupt thaw is used to describe a wider range of processes
30387	3	64	9	64	9	Please clarify the antecedent of "this" by adding the appropriate word(s) after the pronoun. [Paul Glaser, United States of America]	Noted-'suceptible area' already follows 'this'

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
15573	3	64	40	65	17	In the recent papers, how large a fraction of the drainage area do the river discharge data cover? Is it an issue with the limited number of river gauge data? [EUCE, Belgium]	Taken into account: we focus on rivers that drain into the Arctic ocean, which cover most of the land areas north of 60.
16917	3	64	40	65	17	In the recent papers, how large a fraction of the drainage area do the river discharge data cover? Is it an issue with the limited number of river gauge data? [Louise Sandberg Soerensen, Denmark]	Taken into account: we focus on rivers that drain into the Arctic ocean, which cover most of the land areas north of 60.
19245	3	64	40	65	17	In addition to the discharge rate, water temperature, the water chemicals (e.g., organic carbon) would be another important indicators of change in permafrost area [APECS Group Review, Germany]	Taken into account: see Section 3.4.3.2.3
31067	3	64	41	64	41	What does fraction mean? Add definition in brackets [Hans-Otto Poertner and WGII TSU, Germany]	Accepted: text revised
3263	3	64	41	64	49	Doesn't the type of underlying material and drainage characteristics influence the impact with respect to surface water impacts etc.? [Sharon Smith, Canada]	Taken into account: true, but we can't cover that level of detail here
21577	3	64	45	64	45	"landscapes with degrading ice-wedge polygons" may be less ambiguous [Stephan Gruber, Canada]	Accepted: text revised
4125	3	64	51	64	52	Ulrich et al. (2017, Water Resour. Res., doi:10.1002/2016WR019267) can be added as a reference, in which not only satellite data but also field work information and maps are used to deduce the increase in thermokarst lake in eastern Siberia. [Kumiko Takata, Japan]	Accepted: citation added
30251	3	64	51	64	57	There is no confidence level given for the likelihood of thermokarst lake expansion [Christine Dow, Canada]	Accepted: text revised
30137	3	64	51	65	2	It should be considered to cite Nitze et al 2018 Nature Communications (Remote sensing quantifies widespread abundance of permafrost region disturbances across the Arctic and Subarctic) who report on lake change for 2.5 Mkm ² of permafrost regions across 4 major study transects in West Siberia, East Siberia, Alaska, and East Canada. Findings suggest that lake change (expansion, loss) is a major process in these regions, but that drivers can be regionally diverse. Multiple regions with dominant lake loss or dominant lake gain are identified. [Guido Grosse, Germany]	Accepted: text revised and citation added
29993	3	64	53	64	53	Add explanation of the causes for the decrease in lake area in the discontinuous permafrost zone, such as drainage, sediment infill and subsequent terrestrialization processes. [Gonçalo Vieira, Portugal]	Rejected: additional material cannot be added to length limitations. Readers will need to check cited literature for additional details
19243	3	64	54	64	54	According to the references, this is rather WESTERN Canada (i.e. Yukon) than just Canada. Such precisions are given for Siberia and Alaska, why not do the same here. [APECS Group Review, Germany]	Accepted: text revised
26073	3	65	4	65	17	Lots and lots of old references here. Can older ones be removed or replaced by newer findings? [Regine Hock, United States of America]	Accepted: text revised and citations removed/updated
700	3	65	4	65	40	These paragraphs may not be important and relevant enough in this special report on the ocean and cryosphere. [Mengxi Wu, United States of America]	Taken into account: freshwater changes are important to Arctic landscapes and ecosystems. Text was revised and shortened.
1029	3	65	11	65	12	Not just heat flux- freshwater flux, which is also important for ocean processes. [Ethan Kyzivat, United States of America]	Accepted: text revised

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
3267	3	65	36	65	37	Are you referring to open taliks (thaw through entire body of permafrost) which would provided the connection between surface and sub-permafrost ground water, rather than closed taliks which would not. Note that creation of an open talik may require thawing of >100 m of permafrost and thawing of deeper permafrost is not considered in any of the modelling results presented in this chapter (a reason why modelling should consider more than near-surface permafrost). [Sharon Smith, Canada]	The Wellman et al citation refers to open taliks.
3265	3	65	38	65	40	Some additional explanation would be helpful here - what type of changes in vegetation and why it affects ground temperature (how they are affected). [Sharon Smith, Canada]	Rejected: due to length limitations additional details cannot be added
29703	3	65	46	65	51	I'd like to suggest that an additional factor may well be inaccuracies (or at least uncertainties) in the aerosol forcing term, both for airborne and deposited aerosols [Michael MacCracken, United States of America]	Rejected: citations needed
30389	3	65	46	65	51	A major source of error in estimating snow depths in the Arctic is wind transport which sweeps snow off of exposed surfaces into depressions or the concave flanks of lee slopes. Wind transport therefore leads to very uneven snow cover across the landscape presenting an important source of error for estimating regional snow cover [Paul Glaser, United States of America]	Taken into account: this is an important source of uncertainty in Arctic snow and climate models largely do not simulate blowing snow.
23159	3	66	0	66		what is "projected climate forcing"? Do you mean : "climate projections"? But what is the message from this paragraph and is it needed? [Valerie Masson-Delmotte, France]	Accepted: text revised
19247	3	66	3	66	4	The meaning of the sentence following the semicolon is unclear to me (possibly that is just due to a grammatical error). Please consider rephrasing it. [APECS Group Review, Germany]	Accepted: text revised
5695	3	66	4	0		Remove "to" before "unabated" [Nina Hunter, South Africa]	Accepted: text revised
5697	3	66	7	0		Add "RCP" before "8.5" [Nina Hunter, South Africa]	Accepted: text revised
12121	3	66	7	66	7	I somewhat question the high confidence assigned to the positive SWE changes stated here, given the large uncertainties in the magnitude and phase of future Arctic and subarctic precipitation as noted i 3.4.1.3.3. and 3.4.1.1.3. [Aku Riihelä, Finland]	Accepted: good point, and consistent with medium confidence in SWE observations. Confidence language revised.
4659	3	66	23	67	2	Two references related to the simulation and projection of the permafrost are suggested to be added: Guo, D., H. Wang, 2017: Simulated historical (1901-2010) changes in the permafrost extent and active layer thickness in the Northern Hemisphere. J. Geophys. Res.-Atmos, 122, 12285–12295. Guo, D., H. Wang, 2016: CMIP5 permafrost degradation projection: a comparison among different regions. J. Geophys. Res.-Atmos, 121, 4499–4517. [botao zhou, China]	Rejected-the 2016 paper reanalyzes same data as the papers already cited; due to limited space this was not included; the 2017 paper is a historical reconstruction, but this section is about future projections
30095	3	66	25	66	25	Starting the whole chapter with the word "Models" is unprecise and bad language. [Lena Rubensdotter, Norway]	Accepted-text revised for clarity
30391	3	66	25	66	26	Please include some comments on sources of error caused by local changes in winter snow cover, geomorphic processes, vegetation, and soil composition all of which have major effects on permafrost depths, aggradation, and degradation. These factors present serious limitations for modeling permafrost depth at the global or circumpolar scale. However, permafrost maps based on local field data have been in existence since the mid-20th century. Perhaps enhanced use of satellite imagery could constrain these models to produce more realistic global and circumpolar simulations of permafrost extent, thickness, and depth. [Paul Glaser, United States of America]	Noted-Discussions of processes are beyond the scope of this section due to limited length

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
29995	3	66	25	66	27	While this is clear to those involved in modelling, I think that the sentence should be rephrased clarifying that permafrost is not well modelled yet in most models, but rather only active layer thickening. I think the sentence is not very clear. [Gonçalo Vieira, Portugal]	Accepted-wording changed for clarity
3269	3	66	26	66	26	Thaw depth might be a better term here as effect of subsidence is not considered in these models (which is important for determining active layer thickness). Also, there appears to be recognition here that only increases in thaw depth are considered in these models but it is unclear why results from models are not presented in terms of thaw depth rather than near-surface permafrost extent (which doesn't really make sense and is ambiguous). [Sharon Smith, Canada]	Accepted-wording changed for clarity
2815	3	66	26	66	28	The CMIP5 models project with high confidence that active layers will increase and areal extent of near-surface permafrost will decrease substantially (Koven et al., 2013; Slater and Lawrence, 2013; Guo and Wang, 2016) [Suggestion to add a citation] Guo, D., and H. Wang (2016), CMIP5 permafrost degradation projection: A comparison among different regions, J. Geophys. Res. Atmos., 121, 4499–4517, doi:10.1002/2015JD024108. [Kazuyuki Saito, Japan]	Rejected-the new paper reanalyzes same data as the papers already cited; due to limited space this was not included
3271	3	66	33	66	34	See comment above. "Near-surface" is not defined and terminology is ambiguous [Sharon Smith, Canada]	Near-surface permafrost is defined in glossary and was used (and defined) in the modeling literature as well as AR5. Definition was updated for SROCC based on AR5, SR15, and literature definitions
1031	3	66	34	66	35	Also known as the Canadian archipelago [Ethan Kyzivat, United States of America]	Accepted-wording changed for clarity
30097	3	66	42	66	42	"Pulse disturbance" is a strange and confusing way of starting the section, Especially the work "pulse". I suggest use the work episodic rather than pulse. [Lena Rubensdotter, Norway]	Rejected-pulse disturbance was defined in an earlier section and used here in same context
30139	3	66	42	66	44	This statement with high confidence here ("...there is high confidence that fire and abrupt thaw will accelerate change in permafrost..."), which I believe is correct, contradicts with the statement on page 64 line 5 of this chapter 3 ("There is low confidence in the importance of abrupt thaw for driving change in permafrost at the circumpolar scale..."). [Guido Grosse, Germany]	Rejected-the wording is consistent; fire and abrupt thaw will make thaw proceed faster; the earlier statement says we have lower confidence quantifying how much faster.
3273	3	66	42	66	46	One thing that has not been mentioned in discussion regarding fire and permafrost is that the severity of the burn is important. Greater impacts on permafrost occur where organic layer destroyed (including severe burning of peat) - See for e.g. Smith et al. (2015). This is important influence on amount of thawing that may occur and whether permafrost recovers as vegetation recovers. Smith SL, et al. (2015) Eighteen year record of forest fire effects on ground thermal regimes and permafrost in the central Mackenzie Valley, NWT, Canada. Permafrost and Periglacial Processes 26 (4):289-303. doi:10.1002/ppp.1849 [Sharon Smith, Canada]	Noted-this comes up (in a citation) in the previous section on fire; this is beyond the scope of the discussion here
5699	3	66	44	0		Change "increased" to "increase" [Nina Hunter, South Africa]	Accepted-wording changed for clarity
5701	3	66	51	0		Change "increases" to "increase" [Nina Hunter, South Africa]	Accepted-wording changed for clarity

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
3275	3	66	54	66	56	Unclear how these results were arrived at given paper is only "submitted" and can't be consulted. Also models would need to consider geomorphic processes and lateral heat flow is important at these scales. [Sharon Smith, Canada]	Noted-however the reviewer is not correct; the paper was available for inspection/review as per IPCC standards
21579	3	67	1	67	1	"risk" is not the right term here [Stephan Gruber, Canada]	Accepted- wording changed for clarity
1033	3	67	4	67	36	Missing from this discussion is water quality, which was discussed in the context of consequences/impacts in section 3.4.3.2.3. For brevity, it is fine if you don't address water quality in this section, but it may be worth mentioning projected changes in DOM quality and quantity, nutrients, and turbidity. [Ethan Kyzivat, United States of America]	Taken into account: given length limitations we have retained water quality content only in Section 3.4.3.2.3
2841	3	67	6	67	35	For Freshwater Systems, there are evidences of seasonable discharge change due to climate change (Shrestha et al., 2017, Science of the Total Environment, 601–602: 425–440). This should be mentioned because seasonable change of freshwater could affect biodiversity, agricultural production and human well-being. [Junye Wang, Canada]	Taken into account: projections text on discharge in Section 3.4.2.3 was revised with some new citations added.
702	3	67	12	67	12	This paragraph may not be important and relavant enough in this special report on the ocean and cryosphere. [Mengxi Wu, United States of America]	Taken into account: paragraph revised
5703	3	67	22	0		Insert "the" before "Arctic Ocean" [Nina Hunter, South Africa]	Accepted: text revised
5705	3	67	23	0		Change "are" to "is" [Nina Hunter, South Africa]	Text no longer appears
11209	3	67	32	67	35	First, the sentence starting with "Complex..." is not perfectly clear. I assume the reference to Turcotte(2011) is only related to sediments? Is there a missing ")" after Turcotte (2011). I do not think there is anything in the paper by Turcotte that is related to climate projection confidence. Secondly, what related projections have reduced confidence? The earlier break-up of river ice? I think some clarifications are needed here. [Knut Alfredsen, Norway]	Accepted: text revised
31159	3	67	37	0		Prominent quantitative information should be reported in the Executive summary. [Hans-Otto Poertner and WGII TSU, Germany]	Accepted - ES revised with this in mind
2843	3	67	37	68	26	This section is on GHGs. It should be better to include N2O emissions in cold regions since N2O is one of main GHGs. Some recent studies have shown evidences of N2O emission change at cold region in Athabasca river basin in West Cabada (Shrestha et al., 2018, Environmental Pollution 239, 648-660). In a warmer future condition, early snowfreshet led to increased winter season emissions and decreased spring season emissions in some regions of the basin. [Junye Wang, Canada]	Noted-the chapter follows carbon in permafrost to emissions; not all greenhouse gases
4213	3	67	37	69	26	in the reprot, the situation and longterm prediction of carbon cycle in arctic region has been described. It is necessary that similar descriptionwill be done for carbon cycle in antarctic region (southern hemisphere). [Behzad Layeghi, Iran]	Noted-the carbon cycle has been described at the regional to global scale; in the Arctic this includes terrestrial systems (in this section); in the Antarctic it includes the oceans (earlier sections) but the land area is too small to have impact at those scales
5485	3	67	37	69	26	in the reprot, the situation and longterm prediction of carbon cycle in arctic region has been described. It is necessary that similar descriptionwill be done for carbon cycle in antarctic region (southern hemisphere). [rashidian leila, Iran]	Noted-the carbon cycle has been described at the regional to global scale; in the Arctic this includes terrestrial systems (in this section); in the Antarctic it includes the oceans (earlier sections) but the land area is too small to have impact at those scales

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
5539	3	67	37	69	26	in the reprot, the situation and longterm prediction of carbon cycle in arctic region has been described. It is necessary that similar descriptionwill be done for carbon cycle in antarctic region (southern hemisphere). [Government of Iran, Iran]	Noted-the carbon cycle has been described at the regional to global scale; in the Arctic this includes terrestrial systems (in this section); in the Antarctic it includes the oceans (earlier sections) but the land area is too small to have impact at those scales
27495	3	67	42	69	17	This section on the Carbon cycle mentions ist connection to hydrology, but makes no mention of the potential oxidation of methane. Surely, given the potential for methane to provide short-term feedbacks, the role of oxidation in wetlands, the activel ayer, the lacustrine and arine water columns and in marine sediments, this is a topic that requires treatment in one or two sentences? I do not have an overview, otherwise I would make a constructive attempt to provide some text. [Pier-Paul Overduin, Germany]	Accepted-net methane emissions are detailed, which is the sum of production and oxidation; due to space limitations there is not a focus on individual one way fluxes except as how they affect the net exchange
1103	3	67	43	67	43	carbon dioxide and methane [George Burba, United States of America]	Accepted - wording was changed to clarify
5707	3	67	44	0		Insert "a" before "net" [Nina Hunter, South Africa]	Accepted - wording was changed to clarify
704	3	67	44	67	45	This chapter mainly talks about the recent climate change. If focusing on the recent climate change alone is the target (I am not sure), then I think this sentence is not so important and a little distracting. [Mengxi Wu, United States of America]	Rejected-earlier feedback was to use paleo evidence to put recent changes into context
5709	3	67	46	0		Should "ecosystem" not be in the plural? [Nina Hunter, South Africa]	Accepted-typo corrected
16715	3	67	46	67	46	The expression "but divergent" where places is not clear. I suggest rephrasing to: "There is increasing evidence that changing climate ... into net carbon sources. However, findings are not consistent across studies (Low confidence)." [Carl Wepking, United States of America]	Rejected-the suggested wording is not accurate; the original statement is better.
1105	3	67	53	67	53	Referred to a submitted manusriect. Please update. [George Burba, United States of America]	Updated or replaced
16717	3	67	53	67	53	Suggest replacing summer season, with growing season. [Carl Wepking, United States of America]	The analysis uses season (MAM=spring, JJA=summer, SON=fall, DJF=winter) and the periods outside of JJA do have plant activity. It is therefore not correct to refer to those seasons as 'growing/non-growing'
5711	3	67	54	0		Should 'ecosystems" not be in the singular? [Nina Hunter, South Africa]	Accepted-typo corrected
16719	3	67	54	6	9	Citations are submitted or in review -- is this OK? I would imagine references should have already been approved by the peer review system, and at least be in press. [Carl Wepking, United States of America]	Updated or replaced
2817	3	67	54	67	55	...or the separation of upland and wetland ecosystems types that can differ in carbon sink/source strength with wetlands more often than not still acting as annual net carbon sinks (Lund et al., 2010). [The meaning of the sentence, as well as the relationship to the cited paper, is unclear. The paper discusses the CO2 relase from wetlands, thgouh.] [Kazuyuki Saito, Japan]	Accepted - wording was changed to clarify

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
17019	3	68	0	69		Again combined treatment of all sources terrestrial and marine permafrost etc is to be found in Christensen, TR, Rysgaard, S, Bendtsen, J, Glud, RN, Else, B, van Huissteden, K, Parmentier, F-JW, Sachs, T & Vonk, JE 2017, Arctic Carbon Cycling, in, AMAP, Snow, Water, Ice and Permafrost in the Arctic (SWIPA) 2017. AMAP, Oslo. Parts of this is also in: 73. Parmentier, F-JW, Christensen, TR, Rysgaard, S, Bendtsen, J, Glud, RN, Else, B, van Huissteden, J, Sachs, T, Vonk, JE & Sejr, MK. 2017, A synthesis of the arctic terrestrial and marine carbon cycles under pressure from a dwindling cryosphere. Ambio, 46: Suppl 1:53-69. DOI: 10.1007/s13280-016-0872-8 [Torben R. Christensen, Sweden]	Noted-these references were checked for suitability; in general Chapter 3 relied on primary literature in most places
23161	3	68	0	69		Very useful insights on evidence / uncertainty linked with permafrost thawing implications for GHG emissions. More to be conveyed in ES / SPM. Figure 3.11 could include level of scientific understanding and causes for range changes from year to year (why have estimated ranges changed). [Valerie Masson-Delmotte, France]	Accepted-text revised for clarity
31163	3	68	0	69		The findings on methane are poorly represented in the ES. [Hans-Otto Poertner and WGII TSU, Germany]	Accepted-text revised for clarity
29059	3	68	3	68	3	"...only a fraction of fossil fuel emissions (high confidence)." While technically accurate, this statement diminishes the relative importance and scale of these emissions in terms of their projected impact on global carbon budgets. Both Schuur et al (2015) and Chadburn et al (2017) estimate emissions on the order of 50-150Gt under RCP8.5. This is of course a "fraction" of the existing carbon budget, but one equal to a major emitter (China or U.S.), and thus highly relevant despite not being greater than projected fossil fuel emissions. Strongly suggest changing or contexting this statement, eg, "...a significant fraction of projected fossil fuel emissions (high confidence) that could have impacts on remaining carbon budgets. Work to decrease the uncertainty of current projected ranges under different emissions pathways is therefore of high importance, as the SR1.5 for example was unable to include these estimates in its mitigation pathways despite noting its importance." [Pam Pearson, Sweden]	Accepted-wording changed as suggested
21581	3	68	5	68	5	I assume you mean permafrost region and for this you should have a differing number for the area. See one of my earlier comments. Is 'soil area' addigin information or is just 'area' sufficient? [Stephan Gruber, Canada]	Accepted-wording changed for clarity; this is the soil area (versus permafrost area), which is more appropriate for scaling carbon flux
30393	3	68	5	68	5	But of course scaling-up carbon fluxes from one region to the other within the cirumboreal region raises serious sources of error. [Paul Glaser, United States of America]	Noted-the wording is very clear that this is just to put the numbers in a global context so they can be compared across the section
706	3	68	7	68	29	The widening of the range of cumulative emission is not so well described in this paragraph. Perhaps the sentence in Line 8-10 can be put between the "initial estimates" and the "recent studies" to clarify these ambiguous terms. [Mengxi Wu, United States of America]	Noted-wording has been altered in this paragraph for clarity
16721	3	68	7	68	29	In this paragraph, authors present soil C responses to warming. While they appear to present responses of both active soil layer and permafrost (I did not have the full references so could not check if the several studies cited refer to permafrost specifically or to all arctic soil), they generically refer to the soil of the arctic region as permafrost. If that is the case, it is inaccurate and confusing, and clarity should be made regarding the response from the higher activity of the already active layer and its expansion from towing permafrost. [Carl Wepking, United States of America]	Noted-the permafrost carbon pool was defined earlier as all soil carbon in the permfrost region; the effect on carbon fluxes does not depend on whether soil carbon is in permafrost, or the active layer, or non-permafrost soils of this region

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
25781	3	68	7	68	29	<p>The intensification of mineral weathering via deepening flowpaths (Walvoord and Striegl 2007) and thermokarst (Zolkos et al. 2018) is relevant to the Arctic and global C cycle, but is not discussed here. In addition to organic C, permafrost soils/sediments contain minerals and mineral carbon (e.g. carbonate) that can be highly reactive following thaw and exposure to chemical weathering. In some regions, the exposure and weathering of minerals can enable the loss of permafrost mineral C to the atmosphere (Zolkos et al. 2018), acting to counterbalance projections of accelerating atmospheric CO2 fixation by mineral weathering (Beaulieu et al. 2012). Further, this feedback depends on the mineral composition of permafrost, which is poorly quantified at a pan-Arctic scale. In some Arctic regions, thaw-enhanced mineral weathering acts as a CO2 sink (Tank et al. 2012). The climate-driven intensification of permafrost thaw, mineral weathering, and land-freshwater linkages can also increase riverine bicarbonate export to the Arctic Ocean, with important implications for the buffering capacity of the coastal Arctic ocean and ecosystems (Tank et al. 2012).</p> <p>Tank, S. E., Raymond, P. A., Striegl, R. G., McClelland, J. W., Holmes, R. M., Fiske, G. J., & Peterson, B. J. (2012). A land-to-ocean perspective on the magnitude, source and implication of DIC flux from major Arctic rivers to the Arctic Ocean. <i>Global Biogeochemical Cycles</i>, 26(4), 1–15. https://doi.org/10.1029/2011GB004192</p> <p>Walvoord, M. A., & Striegl, R. G. (2007). Increased groundwater to stream discharge from permafrost thawing in the Yukon River basin: Potential impacts on lateral export of carbon and nitrogen. <i>Geophysical Research Letters</i>, 34(12). https://doi.org/10.1029/2007GL030216</p> <p>Zolkos, S., Tank, S. E., & Kokelj, S. V. (2018). Mineral Weathering and the Permafrost Carbon-Climate Feedback. <i>Geophysical Research Letters</i>, 45(18), 9623–9632. https://doi.org/10.1029/2018GL078748 [Scott Zolkos, United States of America]</p>	Noted-in general changes in the inorganic carbon cycle due to weathering are much smaller than changes in organic pools, which is the subject of this paragraph. These citations are interesting but do not make the case for inorganic carbon at the regional/global scale that is the focus here.
21363	3	68	7	68	8	<p>Schuur et al in review is another unpublished work. This time contained within a report. It seems odd to cite this single unpublished work and then claim high confidence. [Steven Chown, Australia]</p>	Noted-this is citation that presents a synthesis with new calculations and so is included here. This is an update to very well known facts and so we have increased the confidence level.
16723	3	68	22	68	22	<p>Similar to what? A broad range from 57 to 102 PgC was given in the lines above, reference to the specific magnitude of the flux projected by these new models would be preferred. [Carl Wepking, United States of America]</p>	Accepted-wording was changed to clarify
5713	3	68	27	0		<p>Suggest inserting "this" before "will" [Nina Hunter, South Africa]</p>	Noted-wording was changed in this section in response to other comments
25411	3	68	28	68	28	<p>This statement is supported by Natali et al. (submitted) which you also cite elsewhere. [Parmentier Frans-Jan, Norway]</p>	Noted-this section refers mainly to the models cited
17013	3	68	28	68	29	<p>Cite: Christensen, T.R., Arora, V.K., Gauss, M., Höglund-Isaksson, L. and Parmentier, F.-J.P, 2019. Tracing the climate signal: mitigation of anthropogenic methane emissions can outweigh a large Arctic natural emission increase. <i>Nature Scientific Reports</i>, in press. Paper provided earlier to lead authors. [Torben R. Christensen, Sweden]</p>	Accepted-citation added
31069	3	68	28	68	29	<p>The main finding from this section and others with regards to climate feedbacks and potential acceleration of climate change and reduction at lower emission levels, should be captured in the executive summary [Hans-Otto Poertner and WGII TSU, Germany]</p>	Accepted-text revised for clarity

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
30141	3	68	31	68	53	Please add new findings by Walter Anthony et al 2018 Nature Communications (21st-century modeled permafrost carbon emissions accelerated by abrupt thaw beneath lakes): They use model data, supported by field observations, radiocarbon dating, and remote sensing, to show that methane and carbon dioxide emissions from abrupt thaw beneath thermokarst lakes will more than double radiative forcing from circumpolar permafrost-soil carbon fluxes in the 21st century. They reiterate the important finding by Schneider v. Deimling 2015 (Biogeosciences) that relative contributions to the permafrost carbon feedback from abrupt thaw lakes are larger under moderate warming scenarios versus strong warming scenarios. [Guido Grosse, Germany]	Accepted-citation incorporated into next section
27489	3	68	33	68	33	The use of "...is already contributing..." is begging the question. There is a tacit and subjective assertion embedded in the word "already". This is not serious analysis, but betrayal of an agenda - i.e. we expect a particular trajectory and it is only a matter of time until our presumptions are confirmed. Please delete the word. [Pier-Paul Overduin, Germany]	Noted-Already was used in the context of its definition: 'by the time in question'; this is an accurate representation of the meaning of the sentence. The word was changed to 'currently' to avoid misperception.
16725	3	68	37	68	37	Not clear what "responding in step" means [Carl Wepking, United States of America]	Accepted-wording changed for clarity
27491	3	68	39	68	53	Methane emissions from wetland ecosystems is pegged at 1.6-5 Tg CH4 per year in line 40, but the marine emissions are described as very high to very low for values of 17 and 3 Tg CH4 per year, respectively. Compared to terrestrial emissions, both are high. This section needs to be made internally consistent by someone with a global view and no vested interest in any of the bottom-up components. [Pier-Paul Overduin, Germany]	Accepted-wording changed for clarity
19249	3	68	41	68	53	This sentence is important; according to literature methane fluxes are indeed very heterogeneous in time and space, and real field data are scarce across the circum-Arctic. Among the reported new insights (e.g., cold-season emissions; Zona et al. 2016), I would also add the importance of local ground and lake conditions, such as energy input or surface sediment temperature (e.g., Wik et al. 2014), or the age (modern vs. millennia-old) of carbon released as methane (e.g., Negandhi et al. 2013; Bouchard et al. 2015). Full references: 1) Wik et al. 2014. Energy input is primary controller of methane bubbling in subarctic lakes. Geophysical Research Letters, 41, 555-560, doi: 10.1002/2013gl058510. 2) Negandhi et al. 2013. Small thaw ponds: An unaccounted source of methane in the Canadian High Arctic. Plos One, 8, e78204, doi: 10.1371/journal.pone.0078204. 3) Bouchard et al. 2015. Modern to millennium-old greenhouse gases emitted from ponds and lakes of the Eastern Canadian Arctic (Bylot Island, Nunavut). Biogeosciences, 12, 7279-7298, doi: 10.5194/bg-12-7279-2015. [APECS Group Review, Germany]	Noted-citations were reviewed for suitability within the length constraints of this paragraph
30395	3	68	43	68	43	The antecedent to "this" is not clear. Please clarify the intended meaning of "this" by adding the appropriate word or words after the pronoun. [Paul Glaser, United States of America]	Accepted-wording was changed to clarify
3277	3	68	45	68	46	The discussion on projected permafrost conditions only focusses on degradation in the upper few metres and does not consider that permafrost may be more than 100m thick (doesn't consider complete thaw) - It is therefore difficult to evaluate impact of warming on release of geological methane (assume this also includes hydrate) if degradation of deeper permafrost is not considered. [Sharon Smith, Canada]	Noted-this interpretation by the reviewer is not correct

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
25413	3	68	48	68	49	The statement "the range of estimates has increased" can be misinterpreted. An inattentive reader may draw the false conclusion that emission estimates have gone up in recent years while in fact they have gone down. This is explained in the rest of the sentence but it would be better to use the word 'widened' instead of 'increased' to avoid misunderstandings. [Parmentier Frans-Jan, Norway]	Accepted-wording changed for clarity
25415	3	68	49	68	49	Besides Thornton et al., you can mention Berchet et al. (2016) already here. They estimated a range of 0-4.5 Tg CH4 yr-1 [Parmentier Frans-Jan, Norway]	Noted-this citation is used in the next sentence
30397	3	68	49	68	49	There is a strong bias toward sampling "hot spots" at the expense of "dead zones" with regard to reporting methane fluxes. Regional to circumpolar estimates of methane fluxes can therefore incorporate serious sources of error because of local variability in landscapes with regard to carbon fluxes. [Paul Glaser, United States of America]	Noted-this has also been addressed in the literature and so is a part of this already.
17017	3	68	51	68	53	Here and elsewhere in the section more thorough treatment of the issue in recent assessment particularly on the topic like the AMAP methane report of 2015 ought to be cited [Torben R. Christensen, Sweden]	Noted-citations were reviewed for suitability within the length constraints of this paragraph
25783	3	68	55	69	17	Abrupt thaw lake emissions stand to significantly enhance permafrost C emissions in the coming century (Walter Anthony et al. 2018), but are not mentioned here. Considering this here could strengthen this discussion. Walter Anthony, K., Schneider von Deimling, T., Nitze, I., Frolking, S., Emond, A., Daanen, R., et al. (2018). 21st-century modeled permafrost carbon emissions accelerated by abrupt thaw beneath lakes. Nature Communications, 9(1). https://doi.org/10.1038/s41467-018-05738-9 [Scott Zolkos, United States of America]	Noted-citations was added
27493	3	69	1	69	1	Once again, an author has betryed an agenda with one small adverb: "already"! "Already" connotes "early than expected" - in this context the presumption that methane emissions must increase is neither explicitly declared nor is it supported in any way. Such use of language undermines the credibility of this report!! Delete the word "already". [Pier-Paul Overduin, Germany]	Noted-'already' also means: 'by the time in question' and so that meaning was intended here. Wording was changed to avoid misperception.
5715	3	69	5	0		Remove "the" before "2100" [Nina Hunter, South Africa]	Accepted-typo corrected
1107	3	69	9	69	9	Referred to a submitted manusriect. Please update here and throughout the text. If IPCC report will have referred to the manuscript that was found incorrect and rejected, it would weaken the reception by policymakers and public. [George Burba, United States of America]	Noted- the paper was available for inspection/review as per IPCC standards
17015	3	69	16	69	17	The citation above considers scenarios of all arctic natural emission sources changes [Torben R. Christensen, Sweden]	Noted-text changed for clarity
29061	3	69	17	69	17	Similar to the comment above, suggest this section be ended by noting the importance of narrowing this uncertainty in methane fraction due to its potential impact on potential mitigation pathways consistent with 1.5 or 2 degrees. [Pam Pearson, Sweden]	Noted
19251	3	69	19	69	26	Figure 3.11. What does 'MIP' mean, in 'Permafrost Carbon MIP' (right of the graph)? I assume it stands for 'Model Intercomparison Project'. For the non specialist, it might be helpful to include this on the graph or in the figure caption. [APECS Group Review, Germany]	Accepted-caption modified
708	3	69	20	69	20	Some bars start from 0 while others do not. I cannot understand what this difference means. [Mengxi Wu, United States of America]	Accepted-caption modified

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
32487	3	69	20	69	26	The models listed here under the figure heading "Earth System Models" under the superscript number 5 are really EMICS rather than ESMs, and should be labelled EMICS. Why is the ensemble mean for heading number 6 shown? Lastly, some of the scenarios used in the 2011-205 Model projections are from SRES scenarios rather than RCPs so aren't exactly the same. [Charles Koven, United States of America]	Accepted-caption modified
31637	3	69	21	0		Figure 3.11. It is not clear why only the data for source #4 is labeled with distinct Carbon compounds. [Hans-Otto Poertner and WGII TSU, Germany]	Accepted-caption modified
30399	3	69	21	69	26	Please explain the "ensemble mean" label at the far end of Bar graph in the caption for Figure 3.11. Does it cover the complete spectrum of data plotted in this figure? [Paul Glaser, United States of America]	Accepted-caption modified
5717	3	69	24	69	26	Referencing needs to be made consistent [Nina Hunter, South Africa]	Accepted-caption modified
4215	3	69	29	70	17	for the energy budget in polar region, only some hypothesis have been described and there is not any measurements or evidence for them. It's better to add some of the results of studies in related to radiation measurement (net, terrestrial,...) [Behzad Layeghi, Iran]	Taken into account: section revised
5487	3	69	29	70	17	for the energy budget in polar region, only some hypothesis have been described and there is not any measurements or evidence for them. It's better to add some of the results of studies in related to radiation measurement (net, terrestrial,...) [rashidian leila, Iran]	Taken into account: section revised
5541	3	69	29	70	17	for the energy budget in polar region, only some hypothesis have been described and there is not any measurements or evidence for them. It's better to add some of the results of studies in related to radiation measurement (net, terrestrial,...) [Government of Iran, Iran]	Taken into account: section revised
12123	3	69	32	69	32	"constitutes a positive feedback to global climate" is a rather ambiguous statement, which could be understood as a mechanism that somehow improves the climate (whatever that means). Perhaps a better alternative might be "constitutes a positive feedback to global temperatures" [Aku Riihelä, Finland]	Accepted: text revised
909	3	70	1	70	45	This section misses Nitrogen and Phosphate views and from air pollution [Falk Huettmann, United States of America]	Rejected: meaning of comment not clear
12125	3	70	1	70	6	The present text on surface energy budget omits any mention of cloudiness change/trend impacts, which can be significant over the Arctic, and whose representation in e.g. atmospheric reanalyses is lacking. Please consider some references on this topic, e.g. Sledd and L'Ecuyer (2018), Kay et al. (2016) and Sedlar (2018) [Aku Riihelä, Finland]	Accepted: text revised and citations added
921	3	70	1	81	40	The economy views are a wide disservice and based on outdated and unscientific approaches to economy; it's horrible to see and also a disservice [Falk Huettmann, United States of America]	Rejected: incorrect page reference? Meaning not clear.
3279	3	70	15	70	17	Unclear since it is change in temperature at the surface that drives the changes in ground temperature. [Sharon Smith, Canada]	Accepted: text revised
25785	3	70	19	0		It would be interesting and useful to clarify more explicitly where Indigenous Knowledge aligns with these findings/observations. This could help to strengthen the assertions early in the report that IK plays a critical role in understanding Arctic ecosystems. [Scott Zolkos, United States of America]	Noted-indigenous knowledge is cited in this chapter as described but no attempts are made to cross compare with other types of knowledge - whiel certainly interating and worthwhile doing as suggested is beyond teh scoep of eth chapter

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
4217	3	70	19	71	28	it is necessary to give more information about present and future situation of different vegetation type in polar region in table, map, satellite image and [Behzad Layeghi, Iran]	Accepted- text revised and citations added to strengthen future projections
5489	3	70	19	71	28	it is necessary to give more information about present and future situation of different vegetation type in polar region in table, map, satellite image and [rashidian leila, Iran]	Accepted- text revised and citations added to strengthen future projections
5543	3	70	19	71	28	it is necessary to give more information about present and future situation of different vegetation type in polar region in table, map, satellite image and [Government of Iran, Iran]	Accepted- text revised and citations added to strengthen future projections
2327	3	70	24	70	24	suggest adding Pearson et al. (2013) as a citation here. Pearson, R.G., Phillips, S.J., Loranty, M.M., Beck, P.S.A., Damoulas, T., Knight, S.J., & Goetz, S.J. (2013). Shifts in Arctic vegetation and associated feedbacks under climate change. Nature Climate Change, 3(7): 673-677, doi:10.1038/nclimate1858 [Scott Goetz, United States of America]	Accepted- text revised and citations added to strengthen future projections
5719	3	70	27	70	33	Is the equals sign (=) necessary in lines 27 and 33? Is there a reason why it is not applied consistently elsewhere? [Nina Hunter, South Africa]	Accepted-text revised
2329	3	70	28	70	30	The "satellite record" referred to here is specifically the 8km resolution AVHRR (GIMMS3g) data set (Pinzon and Tucker 2014). Bhatt et al. (2017) used 1982-2015 and Xu et al (2013) used 1982-2011, but Ju & Masek actually used Landsat (1984-2012). [Scott Goetz, United States of America]	Accepted-wording revised for clarity
2331	3	70	28	70	30	suggest editing the sentence to note a range of satellite data sets are available & used, but the momentum is towards Landsat Thematic Mapper data (30m resolution from 1984-present) to better resolve drivers - and we now have the capability to process these massive data sets. [Scott Goetz, United States of America]	Noted-the text was revised, but there is not room for all details due to space constraints
718	3	70	30	70	32	I am not sure of the confidence level because there is only one reference listed. [Mengxi Wu, United States of America]	Noted-confidence language checked against literature and with other experts; it is not based on number of citations
2333	3	70	31	70	31	While shrubs are increasing in height and density in many places, often riparian areas, they are not necessarily driving greening; evidence on this is mixed since greening is common in areas with low shrub cover. I suggest "medium confidence". [Scott Goetz, United States of America]	Accepted-text modified to better reflect confidence language
3597	3	70	31	70	31	1) change in parentheses to "grasses and grass-like plants" [Howard Epstein, United States of America]	Accepted-text modified with appropriate language
5721	3	70	34	0		Is "the" necessary in this line? [Nina Hunter, South Africa]	Accepted-text revised
3599	3	70	34	70	34	remove "the" before "northwestern" [Howard Epstein, United States of America]	Accepted-text revised
3601	3	70	36	70	36	1) change "special" to "spatial" [Howard Epstein, United States of America]	Accepted-text revised
23385	3	70	36	70	36	what are these "special" variations? [Valerie Masson-Delmotte, France]	Accepted-text revised

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
30143	3	70	36	70	51	Lara et al 2018 Scientific Reports (Reduced arctic tundra productivity linked with landform and climate change interactions) provide evidence linking decadal patterns in arctic greening and browning with regional climate change and local permafrost-driven landscape heterogeneity for the Alaska North Slope. They find that landscape heterogeneity and regional climate change are the most important factors controlling historical greenness trends, while browning was linked to increased temperature and precipitation. [Guido Grosse, Germany]	Accepted-citation added
3603	3	70	37	70	38	1) change to "suggesting that interactions between the changing environment and the biological components of the system control these trends." [Howard Epstein, United States of America]	Accepted - wording was changed as suggested
25417	3	70	38	70	38	Increasing winter temperatures are not necessarily linked to greening but rather browning. As explained later, winter warming is linked to extreme events (e.g. rain-on-snow, lack of snow) which can lead to freezing and dessication, and this damages vegetation. [Parmentier Frans-Jan, Norway]	Noted-both correlations have been observed and are described in text
5723	3	70	39	0		"increases growing season length" - should it not read "increases in season length"? [Nina Hunter, South Africa]	Accepted-text revised
3605	3	70	39	70	39	1) add "in" before "growing" [Howard Epstein, United States of America]	Accepted-text revised
3281	3	70	42	70	42	Changes in rooting depth due to active layer increases? Drainage changes also important? [Sharon Smith, Canada]	Accepted-text revised
2335	3	70	47	70	51	suggest noting "Research on tundra browning is more limited AND LOCALIZED.." as both citations are specific to northern Norway. Other locations not well documented wrt tundra browning. [Scott Goetz, United States of America]	Noted-there are other areas of browning outside of Norway; limited captures the lesser amount of study on this
29145	3	70	53	70	57	It should be noted that indigenous peoples of Eastern Siberia also unanimously notice this greening and browning (and shrubification) of the boreal forest, as well as other disruptions in the vegetation and identify these changes are linked to CC, and especially to CC impacts that raise the many disruptions in the snow cover and ices (Lavrillier, Gabyshev & Rojo, 2016, pp. 9, 119. More precisely, see in Lavrillier and Gabyshev 2017 (this book is already quoted in the report), p.30 : "Abnormal winter and summer analysis as well as analysis of events considered 'extreme' by the nomads (conducted with reference to both TEK and social anthropology). This demonstrated frequent anomalies in the evolution of the snow and ice covers and significant variations in different topographies. In addition, these anomalies seem to be causing significant changes in the vegetal cover. (cf. Evenki climatology, snow and ice typology, Part III)" [Alexandra LAVRILLIER, France]	Noted-this reference used elsewhere in chapter
3283	3	71	2	71	6	See also Smith et al (2015) - provide results for regions other than AK.(considers severity of burn, long-term effects on permafrost etc) Smith SL,et al. (2015) Eighteen year record of forest fire effects on ground thermal regimes and permafrost in the central Mackenzie Valley, NWT, Canada. Permafrost and Periglacial Processes 26 (4):289-303. doi:10.1002/ppp.1849 [Sharon Smith, Canada]	Noted-this paper has been evaluated previously
26075	3	71	4	71	5	Are 4 references (3 of them pre-AR5) needed for a textbook like statement? [Regine Hock, United States of America]	Accepted-older citations replace or deleted

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
29147	3	71	12	71	13	Could be good to integrate indigenous knowledge about it: "In eastern Siberia, from the point of view of indigenous communities, the increasing density of the larch forest and bushes is raised by CC which delays the installation of the snow cover and shorten the coldest part (= $<-50^{\circ}\text{C}$) of the winter (1-2 months). It creates perturbations in the evolution of snow cover (internal snow physical transformation); and it acts upon the formation of the vegetal cover (Lavrillier, Gabyshev, Rojo 2016, p. 116; Lavrillier and Gabyshev 2017, pp. 243-283; 300-445),and specifically on snow cover and ice anomalies (ibid - p. 400-445)" References: Lavrillier A. & S. Gabyshev, 2017 An Arctic Indigenous Knowledge System of Landscape, Climate, and Human interactions. Evenki Reindeer Herders and Hunters, Studies in Social and Cultural Anthropology, Kulturstiftung Sibirien, Fürstenberg/Havel, Germany 467p./ Lavrillier, A., Gabyshev, S and Rojo, M., 2016 The Sable for Evenk Reindeer Herders in Southeastern Siberia: Interplaying Drivers of Changes on Biodiversity and Ecosystem Services: Climate Change, Worldwide Market Economy and Extractive Industries, in M. Roué and Z. Molnar (eds.), Indigenous and Local Knowledge of Biodiversity and Ecosystems Services in Europe and Central Asia: Contributions to an IPBES regional assessment. Knowledge and Nature 9. UNESCO: Paris, p. 111-128. [Alexandra LAVRILLIER, France]	Noted-this reference used elsewhere in chapter
5725	3	71	13	0		Suggest inserting "the" before "shifting" [Nina Hunter, South Africa]	Rejected-text remains as written; meaning is the same
5727	3	71	16	0		Suggest inserting "a" before "cool" [Nina Hunter, South Africa]	Accepted - wording was changed to clarify
911	3	71	30	72	20	The wildlife section is VERY POOR. It misses many aspects and publications, including reviews and work by ourselves [Falk Huettmann, United States of America]	Taken into account: section revised
913	3	71	30	72	20	e.g. Huettmann 2017. For caribou, that is very one-sided as most herds are going down, in the south etc. (see Canada). There is much work by Josh Lawler on this things done too (see in Drew, Wiersma, Huettmann 2011) [Falk Huettmann, United States of America]	Rejected: text clearly states a strong decline in caribou numbers; not clear what citations are being suggested
915	3	71	30	72	20	Lacks small mammal work by A. Baltensperger et al [Falk Huettmann, United States of America]	Rejected: out of scope
4219	3	71	30	72	39	in the section 3.4.3.2.2, shifting the living area of polar animals to upper latitudes has not been considered. [Behzad Layeghi, Iran]	Taken into account: range shifts covered in Box 3.4
5407	3	71	30	72	39	I am extremely happy with the way the authors have incorporated other wildlife species into the terrestrial wildlife section, congratulations! This section is so much more holistic than it was for the FOD, and indicates understanding of and consideration for the effects of climate change on Arctic biota beyond humans, reindeer and fish. [Michelle North, South Africa]	Much appreciated
5491	3	71	30	72	39	in the section 3.4.3.2.2, shifting the living area of polar animals to upper latitudes has not been considered. [rashidian leila, Iran]	Taken into account: range shifts covered in Box 3.4
5545	3	71	30	72	39	in the section 3.4.3.2.2, shifting the living area of polar animals to upper latitudes has not been considered. [Government of Iran, Iran]	Taken into account: range shifts covered in Box 3.4
5729	3	71	36	0		Is this web reference meant to be in here? Seems inconsistent with referencing across the report [Nina Hunter, South Africa]	Accepted: citation removed

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
31071	3	71	36	71	37	Any indication of the drivers/mechnisms for this? [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account: see following sentence. Text revised to make clear there is low confidence in drivers of all rangifer changes
9541	3	71	39	71	39	Rangifer should be in italic because it is a name of genus. Rangifer tarandus is the name of the specie for vernacular named reindeer and caribou. Consequently, if Rangifer is relevant for caribou and reindeer, it is better to write R.tarandus in italic, for more clarity. [Government of France, France]	Accepted: text revised
3285	3	71	39	72	39	Discussion seems to go beyond impacts related to changing cryosphere. [Sharon Smith, Canada]	Taken into account: text extensively revised
5731	3	71	41	0		Suggest removing semi-colon after bracket for consistency [Nina Hunter, South Africa]	Accepted: text revised
5733	3	71	46	0		Suggest removing semi-colon before "Ovibos" and placing "Ovibos moschatus" in parentheses [Nina Hunter, South Africa]	Accepted: text revised
5285	3	71	57	71	57	I would add the publication of Grenfell and Putkonen (2008) here where they study a big Caribou die-off on Banks Island Canada in 2003 after a rain-on-snow event. Grenfell T. C. and Putkonen J. 2008. A method for the detection of severe rain-on-snow event on Banks Island, October 2003, using passive microwave remote sensing. Water Resources Research, vol. 44, W03425. [Benoit Montpetit, Canada]	Rejected: emphasis is on literature since AR5
5735	3	72	14	0		Suggest changing "degree" to "degrees" [Nina Hunter, South Africa]	Taken into account: paragraph revised
5737	3	72	25	0		Change "populations" to "population" [Nina Hunter, South Africa]	Taken into account: paragraph revised
5739	3	72	30	0		Change "reduces" to "reduce" [Nina Hunter, South Africa]	Taken into account: paragraph revised
5741	3	72	37	0		Insert "of" after "couple"; change "demonstrates" to "demonstrate" [Nina Hunter, South Africa]	Taken into account: paragraph revised

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
19253	3	72	41	0		<p>Section 3.4.3.2.3: Similar to my previous comment on Section "3.4.1.2.3 Carbon", I would suggest inclusion of the changes that can occur to the inorganic carbon cycle due to disturbances to inorganic carbon dynamics. Dissolved inorganic carbon can comprise the majority of dissolved carbon fluxes in arctic rivers and have been shown to be controlled by features that are changing with a changing climate (e.g. runoff, permafrost extent, glacial coverage; Tank et al. 2012, full refs. at end of this comment). Where thaw results in the exposure of carbon bearing rocks to weathering (Zolkos et al. 2018), deeper flow paths resulting in increased flow of water over rock, or the easement of obstruction of mineral-rich groundwater from reaching surface flowpaths (Walvoord and Striegl, 2007) dissolved inorganic export in arctic rivers can increase. How this dissolved inorganic carbon is created can influence whether these changes result in an increase or decrease of CO2 emissions to the atmosphere from freshwaters (Zolkos et al. 2018). REFS: (1) Tank, S. E., Raymond, P. A., Striegl, R. G., McClelland, J. W., Holmes, R. M., Fiske, G. J., & Peterson, B. J. (2012). A land-to-ocean perspective on the magnitude, source and implication of DIC flux from major Arctic rivers to the Arctic Ocean. <i>Global Biogeochemical Cycles</i>, 26(4). https://doi.org/10.1029/2011GB004192;(2) Zolkos, S., Tank, S. E., & Kokelj, S. V. (2018). Mineral Weathering and the Permafrost Carbon-Climate Feedback. <i>Geophysical Research Letters</i>, 45. https://doi.org/10.1029/2018GL078748.; (3) Walvoord, M. A., & Striegl, R. G. (2007). Increased groundwater to stream discharge from permafrost thawing in the Yukon River basin: Potential impacts on lateral export of carbon and nitrogen. <i>Geophysical Research Letters</i>, 34(12). https://doi.org/10.1029/2007GL030216 [APECS Group Review, Germany]</p>	Accepted: reference to Zolkos et al 2018 added to Section 3.4.3.2.3
2845	3	72	41	72	56	<p>For Freshwater Systems, it has not mentioned seasonable discharge change due to snow melt and glacier retreat under climate change (Shrestha et al., 2017. Assessing climate change impacts on fresh water resources of the Athabasca River Basin, <i>Science of the Total Environment</i>, 601–602: 425–440). Significant increases (16–54%) in annual streamflow held the potential to pose flooding problems across the basin. Increment in plant biomass was observed across the basin as a result of decreased temperature stress occurring during all seasons. The biomass increment, as well as a warmer and wetter future climatic condition, led to higher green water flow (9–22%) from the basin. Consequently, the greenwater storage was projected to decrease, especially during the summer and autumn seasons for the late-century period in the middle regions of the basin where agricultural activity levels were significant. Plants would be expected to experience increased water stress which might require a solution in the form of the artificial supply of water. There was ample evidence of temporal and spatial heterogeneity of the blue and green resources of the basin for the future. [Junye Wang, Canada]</p>	Taken into account: seasonal discharge change is covered in Section 3.4.3.1.2

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
5411	3	72	41	74	15	If this section is relating to "freshwater ecosystems and their services", I think the authors should take a step back from what they've written currently and consider what the gist of the section should be. The current arrangement of sentences and facts is haphazard and doesn't convey what the 'point' or meaning of these facts is. If the section were reorganised, the same facts could be arranged in a more cohesive manner. An introductory sentence saying that/why changes relating to climate are affecting Arctic freshwater ecosystems, from invertebrate scale to fish and riparian vegetation, changing food webs, causing toxicant dispersal and generally altering the system as a whole, could provide the link that holds all the subsequent facts together in the reader's mind. [Michelle North, South Africa]	Taken into account: section revised and reorganized
5743	3	72	42	0		Insert "and" before "alder" to make it more understandable [Nina Hunter, South Africa]	Accepted: text revised
5745	3	72	43	0		"enhances" should be "enhance" [Nina Hunter, South Africa]	Accepted: text revised
3287	3	73	1	73	14	Thaw slumps and other slope failures can completely block streams - affect ecosystems, water flow [Sharon Smith, Canada]	Accepted: text revised
2847	3	73	1	73	15	There are evidences that climate change induced effects in sediment yield from upland sub-basins were region specific and land-use type dependent indicating marked spatial and temporal heterogeneity. In cold climate regions, where annual sediment yield budget is dominated by spring season sediment yield, an earlier spring freshet due to projected increase in winter and spring temperature led to decreased sediment yield in Athabasca River basin, west Canada(Shrestha andWang, Science of the Total Environment 625, 1030–1045). However, at regions where summer sediment yield dominated the annual sediment yield budget such as in regions with steep topography, projected decrease in summer precipitation also led to decreased sediment yield. As expected, the sediment yield from the agriculture land was by far the highest (2.91 t/ha/yr) in the base period and would experience an average annual increases up to 0.94 t/ha/yr. These increments are, in general, greater than reported soil formation rates reported in the region. As with the sediment yield, changes in the sediment load transport through reaches also showed both temporal and spatial variability and have primarily followed the trend of future streamflows variability. Further, annual sediment estimates showed that channel erosion and deposition were the dominant processes over hill slope erosion in the ARB [Junye Wang, Canada]	Rejected: this comment draws on a study that falls outside our definition of polar regions
5747	3	73	6	0		It should read "confidence in" not "confidence on" [Nina Hunter, South Africa]	Accepted: text revised
5749	3	73	10	0		"residences" should be in the singular [Nina Hunter, South Africa]	Accepted: text revised
5409	3	73	12	73	27	This section is disjointed, with sentences on mercury pollution coming directly after dissolved organic carbon, then other pollutants in the next paragraph, mixed in with aquatic community structure, primary productivity, water balance and then back to chemical pollutants. Please reorganise this section to flow more cleanly, with paragraphs divided by logical topic. [Michelle North, South Africa]	Taken into account: section revised and reorganized

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

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25787	3	73	13	73	13	Mercury release from thawing permafrost can be striking- including a citation and reference to St. Pierre et al. (2018) could strengthen the points made here. Also, please see e.g. St. Pierre et al. (2018) text for additional references on mercury in Arctic/permafrost regions, if of interest. St. Pierre, K. A., Zolkos, S., Shakil, S., Tank, S. E., St. Louis, V. L., & Kokelj, S. V. (2018). Unprecedented Increases in Total and Methyl Mercury Concentrations Downstream of Retrogressive Thaw Slumps in the Western Canadian Arctic. Environmental Science & Technology, 52(24), 14099–14109. https://doi.org/10.1021/acs.est.8b05348 [Scott Zolkos, United States of America]	Accepted: citation added
3289	3	73	13	73	14	Other heavy metals and solutes can also be released when permafrost thaws and subsurface water becomes mobile. [Sharon Smith, Canada]	Accepted: text revised and citation added
5025	3	73	14	73	14	Will this not also have implications for dependent communities? [Debra Roberts and Durban Team, South Africa]	Accepted: we have added a point to this section in the community health and wellbeing section.
2849	3	73	16	73	27	Polycyclic Aromatic Hydrocarbons (PAHs) has been evaluated in Muskeg River Watershed in Athabasca oil sands region, Western Canada. The results indicate that the summer season is the hot moment for the PAHs transport mainly driving by the intense rainfall-runoff events in this season (Du et al., 2019, Environmental Modelling and Software 111, 432–443). [Junye Wang, Canada]	Rejected: this comment draws on a study that falls outside our definition of polar regions
5751	3	73	19	0		What is this extended growing season a result of? Perhaps state why the growing season is extended. Or would it help to put the sentence that comes after this one ("Shortened ... productivity") before it? [Nina Hunter, South Africa]	Taken into account: text no longer appears
3291	3	73	24	73	27	Some areas have more industrial development including mining and hydrocarbon development so some of these effects might be more important in some areas or increase as industrial development increases. These affects may be loss of containment where permafrost may have been used as a barrier in waste containment facilities. [Sharon Smith, Canada]	Rejected: not clear what is being suggested
5753	3	73	32	0		Insert "the" before "overwintering" [Nina Hunter, South Africa]	Accepted: text revised

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
2851	3	73	38	73	55	Impact of climate change on Athabasca river ecosystem in Rocky Maintains, west Canada, was assessed recently using three climate models under the Representative Concentration Pathways 4.6 and 8.5 scenarios (Du et al., 2019, Science of the Total Environment 650, 1872–1881). Results showed that warmer and wetter future condition would prevail in the basin. As a result, streamflow in the basin would increase despite the projected increases in evapotranspiration due to warmer condition. On the basin scale, annual stream temperatures are expected to increase by 0.8 to 1.1 °C in mid-century and by 1.6 to 3.1 °C in late century. Moreover, the stream temperature changes showed a marked temporal pattern with the highest increases (2.0 to 7.4 °C) in summer. The increasing stream temperatures would affect water quality dynamics in the basin by decreasing dissolved oxygen concentrations and increasing biochemical reaction rates in the streams. Furthermore, the magnitudes of temperature changes vary significantly among different months and seasons and the biggest temperature increases are found to be in summer season. Such spatial-temporal changes in stream temperature regimes in future period would also affect aquatic species. The marked increasing number of days exceeding the upper tolerance temperatures will pose a potential threat to the fish species, such as northern pike and walleye in the basin. [Junye Wang, Canada]	Rejected: this comment draws on a study that falls outside our definition of polar regions
25789	3	73	44	73	44	Increased sediment loads is an example of a specific driver that can be detrimental to aquatic invertebrates, but is not mentioned here. Including a citation and reference to Chin et al. 2016 could strengthen the points made here. Chin, K. S., Lento, J., Culp, J. M., Lacelle, D., & Kokelj, S. V. (2016). Permafrost thaw and intense thermokarst activity decreases abundance of stream benthic macroinvertebrates. <i>Global Change Biology</i> , 22(8), 2715–2728. https://doi.org/10.1111/gcb.13225 [Scott Zolkos, United States of America]	Accepted: text revised and citation added
5755	3	73	45	0		Insert "the" before "loss" [Nina Hunter, South Africa]	Accepted: text revised
5757	3	73	54	0		"increases" should be "increase" [Nina Hunter, South Africa]	Accepted: text revised
5759	3	73	55	0		"poses" should be "pose" [Nina Hunter, South Africa]	Accepted: text revised
9543	3	74	4	74	4	fungus should be in italic. [Government of France, France]	Accepted: text revised
1035	3	74	8	74	19	A more recent citation to add to Frey et al 2007 could be the review by Vonk et al (2015), which talks about the potential of thermokarst lakes for increased anoxia due to shallow depths, high bacterial metabolism, and prolonged ice cover. A second highly-cited study (Spencer et al. 2015) found that ancient carbon entering rivers from permafrost regions is rapidly metabolized and resembles newer carbon by the time it reaches the mouths of these rivers. □[1] J. E. Vonk et al., "Reviews and syntheses: Effects of permafrost thaw on Arctic aquatic ecosystems," <i>Biogeosciences</i> , vol. 12, pp. 7129–7167, 2015. □[2] R. G. M. Spencer et al., "Detecting the signature of permafrost thaw in Arctic rivers." [Ethan Kyzivat, United States of America]	Taken into account: section revised and reorganized; Vonk et al is cited.
5761	3	74	13	0		replace "are" with "is" [Nina Hunter, South Africa]	Rejected: data are
30967	3	74	18	77	9	This nice box on impacts and risks for polar biodiversity is very useful and provides a good overview. [Hans-Otto Poertner and WGII TSU, Germany]	Noted. Thank you for the positive feedback

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
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30961	3	74	23	74	25	Where are the references on which this assessment with high confidence is based? Please ensure traceability. [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account. Confidence statements have been revised throughout the box. In this case we now have a citation and "high confidence for detection, medium confidence for attribution".
720	3	74	23	74	33	I do not understand why human introduction of temperate species is also regarded as climate-induced impacts. More explanation is necessary. [Mengxi Wu, United States of America]	Accepted. We agree. We now make it clear, also in the title of the section, that our interest in introductions is only those related to climate change. Introduced species (particularly from warmer areas) may have a better chance of establishing themselves in polar regions with climate change. Also more human activity in the polar regions will increase the risk of unwanted introductions.
5763	3	74	28	73	29	Is it possible to rephrase "and in the sensitivity ... respectively" to make it more understandable? [Nina Hunter, South Africa]	Accepted. This has been rewritten.
31639	3	75	10	0		Box 3.3, Figure 1. A small global side-map showing the location of the Barents Sea would be helpful. Perhaps the same as in Appendix 3.A, Figure 7. Then you may even remove the coordinate axis, or leave only one N and one E. [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account. We have replaced the figure on cod with one showing changes at the community level - boreal "Atlantic" species expanding. Such a globe is used in the new figure.
31641	3	75	10	0		Box 3.3, Figure 1. Having the legend outside of the 2007 map would be better in order to have both maps equal, with only the data changing. [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account. We have replaced the figure on cod with one showing changes at the community level - boreal "Atlantic" species expanding.
5765	3	75	31	0		Is "decline" meant, instead of "cline"? [Nina Hunter, South Africa]	Rejected. "Cline" is correct.
5767	3	75	33	0		Is it possible to place the Latin names in brackets, instead of separating with commas, to make it read better? [Nina Hunter, South Africa]	Accepted. This has been changed.
5769	3	75	35	75	36	"govern" is used twice in the same sentence, is it possible to use a different word in one case? [Nina Hunter, South Africa]	Accepted. This has been changed. We thank this reviewer for many good suggestions to bettering the language.
21365	3	75	38	75	39	The Fraser et al. (2018) study did not investigate non-indigenous species, but rather a species that is indigenous to the Southern Ocean - the bull kelp <i>Durvillaea antarctica</i> . I could also not find a single reference to alien species in Beaugrand et al. 2015 or to the Antarctic (except in the reference list). These references are inappropriate. Perhaps the best general one for the expectation is Aronson et al. 2015 <i>J Biogeography</i> or Smith et al. 2017 <i>Ecosphere</i> . While not everyone agrees with these papers, they are at least about non-indigenous species. There's also the modelling work by Byrne et al. : Byrne M, Gall M, Wolfe K, Aguera A. 2016. From pole to pole: the potential for the Arctic seastar <i>Asterias amurensis</i> to invade a warming Southern Ocean. <i>Global Change Biology</i> 22:3874-87 [Steven Chown, Australia]	Taken into account. In the revised text we have deleted this statement and instead cite new evidence relating to the permeability of Southern Ocean fronts to biological dispersal (Fraser et al.). The Beaugrand study was cited because it presents future risk of invasive species at a global scale (including for the Southern Ocean) but this has been deleted in the revised text.
32379	3	75	40	75	41	The extent to which the ACC remains a biogeographic barrier has been questioned in recent publications with eddies contributing to cross-frontal transport of pelagic and floating species, with indications that species can travel from South America to the Antarctic continent through these processes. While this has only low confidence as an increasing pathway under climate change, it is worth flagging here. [Andrew Constable, Australia]	Accepted. Our revised text reflects this point, together with appropriate references.
31165	3	76	1	0	2	In the whole section distinguishing observations from projections is needed. Statement on invasion and expansion of crabs into the Antarctic cannot be restrained to the continental shelf. [Hans-Otto Poertner and WGII TSU, Germany]	Accepted. Edited to include the continental slope.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
30963	3	76	1	76	2	Maybe you wish to consider the following publication in this context (though it is pre-AR5): Smith, C.R., Grange, L.J., Honig, D.L., Naudts, L., Huber, B., Guidi, L., Domack, E.A., 2012. A large population of king crabs in Palmer Deep on the west Antarctic Peninsula shelf and potential invasive impacts. Proc. R. Soc. B 279, 1017–1026. [Hans-Otto Poertner and WGII TSU, Germany]	Accepted. Reference included in the revised text.
17353	3	76	17	76	29	The expansion of planktivorous species not adapted to the lack of primary production during winter will not survive at the highest latitudes (Sundby et al. 2016). See comment at page 32 above. [Svein Sundby, Norway]	Taken into account. A sentence making this clear is now included.
32381	3	76	17	76	48	These paragraphs could be simplified greatly without loss of information. [Andrew Constable, Australia]	Accepted. The whole of Box 3.3 has been edited for brevity, clarity and consistency.
30965	3	76	31	76	36	How can you assign «medium confidence» to both statements in this paragraph based on a single publication? Is this a meta-analysis? [Hans-Otto Poertner and WGII TSU, Germany]	Accepted. This has been changed, as has much of the text in the box.
5771	3	76	40	76	41	"e.g. ...Arctic" should be in parentheses as with the other example? [Nina Hunter, South Africa]	Taken into consideration. This has been rewritten.
26737	3	76	43	0		Deeply embedded in the range expansions is the threat from alien species brought in by man... Deeply embedded in the range expansions is the threat from alien species brought in by ("humans" or "anthropogenic means")... [Christopher Pereira, Canada]	Accepted. "Humans" is now used.
21367	3	76	43	76	44	Presumably the editors will also ensure that gender neutrality is given attention ('by man' is inappropriate). [Steven Chown, Australia]	Accepted. "Humans" is now used.
5773	3	76	48	0		"e.g. in Iceland" should be in parentheses? [Nina Hunter, South Africa]	Rejected. We think the phrasing is fine as it is.
21369	3	76	50	76	50	Change 'in Antarctica' to 'in the Antarctic region' otherwise the statement is inaccurate. Add to the citation list: Frenot Y, Chown SL, Whinam J, Selkirk PM, Convey P, et al. 2005. Biological invasions in the Antarctic: extent, impacts and implications. Biological Reviews 80:45-72 and McClelland GTW, Altwegg R, Van Aarde RJ, Ferreira S, Burger AE, Chown SL. 2018. Climate change leads to increasing population density and impacts of a key island invader. Ecological Applications 28:212-24. [Steven Chown, Australia]	Accepted. Changed as requested and references added.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
22483	3	76	50	77	2	<p>Suggest this paragraph clarify and more closely reflect the language of the Madrid Protocol to make it clear that there are situations where non-native species may be brought into an environment.</p> <p>Currently this section discusses the application of the Protocol on Environmental Protection to the Antarctic Treaty, otherwise known as the Madrid Protocol, in prohibiting the introduction of non-native species to Antarctica. The section currently states, "[t]he Protocol on Environmental Protection to the Antarctic Treaty prohibits the introduction of non-native species to Antarctica as do the management authorities of sub-Antarctic islands" (lines 50-52) and then goes on to provide examples of the introduction of alien species in sub-Antarctica.</p> <p>Article 4(1) of Annex II of the Madrid Protocol, however, actually states "[n]o species of living organisms not native to the Antarctic Treaty area shall be introduced onto land or ice shelves, or into water, in the Antarctic Treaty area except in accordance with a permit". This article then further explains how such permits may be provided. [Government of Australia, Australia]</p>	Taken into account. The word 'prohibits' has been replaced with 'restricts' so that the statement is consistent iwht the Madrid Protocol.
21371	3	76	53	76	54	<p>Unless there's a much more detailed explanation, the 'natural means' will cause much confusion. The point is subtle. Non-indigenous species introduced by humans to one place (e.g. starlings to New Zealand) which then move on their own to another (such as Macquarie Island) are still alien to the second place. But there's no space to explain this so I would suggst deleting 'via anthropogenic and natural means'. The citation (Houghton et al. 2016) actually does not cover introduction but just transport, which is different. Use: Hughes KA, Pertierra LR, Molina-Montenegro MA, Convey P. 2015. Biological invasions in terrestrial Antarctica: what is the current status and can we respond? Biodiversity and Conservation 24:1031-5 and McGeoch MA, Shaw JD, Terauds A, Lee JE, Chown SL. 2015. Monitoring biological invasion across the broader Antarctic: A baseline and indicator framework. Global Environmental Change 32:108-25. [Steven Chown, Australia]</p>	Accepted. Changed as suggested and references replaced.
21373	3	76	54	76	55	<p>The number is incorrect and the citation too downstream. According to Hughes et al. 2015 (see comment above for ref) 14 species have colonised the maritime Antarctic. In the case of the sub-Antarctic (strict) the number is much higher, well over the hundreds and the sub-Antarctic is well within the remit of polar. For the later one could cite: Frenot Y, Chown SL, Whinam J, Selkirk PM, Convey P, et al. 2005. Biological invasions in the Antarctic: extent, impacts and implications. Biological Reviews 80:45-72 [Steven Chown, Australia]</p>	Accepted. Edited as suggested.
5775	3	76	56	0		<p>Suggest inserting "the" before "establishment" [Nina Hunter, South Africa]</p>	Accepted. Inserted as suggested.
917	3	77	1	77	1	<p>Perhaps the authors have not understood that they deal here with a genocide ? This section reads absurd and is a wide insult to local people [Falk Huettmann, United States of America]</p>	Rejected. This comment seems to be missplaced. Does not relate to the text in Box 3.3.
21375	3	77	5	77	7	<p>This Chapters citation list includes Chown et al. 2012 PNAS and that work includes ome forecasting and so is an empirical reference to support the statement. [Steven Chown, Australia]</p>	Accepted. Reference included in the revised text.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
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24001	3	77	14	77	20	Relating a 'Connection with nature' to the whole Arctic population, without restriction to Indigenous communities (about 10% of the population as indicated p81 118) irrelevantly apply the nature connection to Arctic industry and non sustainable fossil fuel exploitation related populations and governance bodies. [Patricia Martinerie, France]	Accepted. Text revised to specify Indigenous
17331	3	77	28	78	18	This is a very important section and well done. However, it exemplifies an issue that extends across the entire chapter and the entire report. This is the issue of the blurred lines between local and Indigenous. For example, this section starts out by indicating that food insecurity risks are on the rise of Arctic peoples. This is true but specifically for Arctic Indigenous Peoples. There is a difference between 'Arctic peoples' and 'Arctic Indigenous Peoples' and this differentiation MUST be made clear. There are massive social and economic inequities facing Arctic Indigenous Peoples that are not felt by all people living in the Arctic. This is well communicated in Figure 2 of the National Inuit Strategy on Research (https://www.itk.ca/wp-content/uploads/2018/03/National-Inuit-Strategy-on-Research.pdf). In this figure, it shows that the median individual income for Inuit is almost 4 times lower than the median income for non-Indigenous people in Inuit Nunangat (Inuit homeland within Canada). These kinds of disparities are directly relevant and must be at the forefront in any discussions of climate change impacts in the Arctic, including food security. It must be made very clear that most of the content in this section is in relation to the Arctic INDIGENOUS population and not local populations, especially when social and economic factors are mentioned, when culture is brought in, and when things like hunting grounds are discussed. These aspects are specific to the Indigenous population. It may be understood by authors who have experience with communities in the Arctic where the local communities are often almost 100% Indigenous, but uninformed readers may not understand this important context and distinction. While this comment is being made here, it applies to the entire chapter, and indeed the entire report. [Joanna MacDonald, Canada]	Accepted. Text revised throughout the Section.
5777	3	77	36	0		"rain on snow events" - please briefly describe in parentheses (suggest "rain-on-snow" as in table 3.7) [Nina Hunter, South Africa]	Taken into account: text no longer appears
17721	3	77	44	77	47	Further explain that nutritional transition from country foods to store-bought foods can be problematic since most store-bought foods are non-nutrient dense and nonperishable such as junk foods [Crystal Gong, Canada]	Accepted: text was revised to include emphasis on a nutritious diet
2013	3	77	54	77	54	The line reads: "Ice break-up (Section 3.4.1.2) make overland travel more difficult." Comment: Could remove "overland" and just leave it as "...earlier ice break-up makes travel more difficult.". This way it will cover traveling by boat which is also more dangerous and difficult. [Laura Eerkes-Medrano, Canada]	Accepted: text revised
3293	3	78	1	78	1	Increases in landscape instability are also important consequence of permafrost thaw [Sharon Smith, Canada]	Accepted: text revised
32385	3	78	20	78	30	This paragraph has no information in it other than water supply is correlated to hydrology. What is the expected change? [Andrew Constable, Australia]	Accepted: text revised
5779	3	78	29	0		Should it not be "to" instead "of"? [Nina Hunter, South Africa]	Accepted: text revised

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
29705	3	78	33	78	44	During the first Arctic Assessment (ACIA, 2004), I was on the Synthesis team and we heard from the Indigenous groups that "Climate change is destroying our culture." We sort of came back wondering how it was not that riding on snowmobiles to jobs with the oil industry was not the major reason for losing their culture, but the response was again that it was climate change. It took a while until we (non-Indigenous members of the participants) came to understand that what was meant was that, to survive in the Arctic for thousands of years, the cultural approach that had survived was one of communal sharing of tasks and the rewards of sustainable harvesting on whales, walrus, and more. Were one a loner and a walrus was not harvested, the lack of food for the winter would lead to death--loners by chance will have a bad year and die off. Only by having a community that shares its harvesting of food, etc. were these people able to survive. So, working at an oil company would add money to the community and it could also keep its harvesting, but if one had climate change, in that it really takes sea ice to do the harvesting (like the polar bear, one does not chase a seal or a whale--one waits at an air hole for the seal or whale to come to you), the warming of the Arctic would so disrupt the ability to harvest from the sea and change the mobility on land as the surface thawed, etc., that the communal way of sharing resources would no longer be viable, and they would have to switch to a market economy, somehow having money to buy food from elsewhere. Now, their culture is more than just the food, but all the knowledge that it takes to be able to live there, know where to hunt, prepare the tools for doing this, harvesting the whale or walrus, etc.; sharing and preserving through the summer and winter, and much more. So, we came to understand what was being said about how climate change would destroy their culture--for everyone, the social safety net would have to be completely different, with assistance coming in, needing to earn money, etc. rather than having harvested food provided to the widow and her participation in repairing the nets, etc. I don't think the brief statement here really captures what needs to be said about how climate change will disrupt and then destroy the culture that has existed and helped everyone survive--all in the community were needed for the system to work, and now it will become much more based on individuals on their own. The other thing we heard was that the weather was becoming less predictable--well, for we modelers, that sounded very strange, as our models were getting better and better. Again, however, listening and listening again, what was being said was that all the empirical knowledge that had been accumulated over time and passed along from generation to generation was no longer proving useful in making few day forecasts, and so hunters were getting stranded as attached ice broke away, and hunters were as a result having to be	Not clear what this comment is suggesting/requesting
32387	3	78	33	78	44	Again, what is changing? [Andrew Constable, Australia]	Accepted: text revised
28091	3	78	34	78	44	Climate impacts in the Arctic are also degrading tangible cultural heritage, on which some aspects of Indigenous communities depend, and also the archaeological resources that provide connections to deep traditions and scientific information about long-term adaptations there. A relevant reference for a range of climate impacts being observed in Arctic heritage is Hollesen, Jørgen, Martin Callanan, Tom Dawson, Rasmus Fenger-Nielsen, T. Max Friesen, Anne Jensen, Adam Markham, Vibeke Vandrup Martens, Viktor Pitulko, and Marcy Rockman. (2018). Climate Change and the Deteriorating Archaeological and Environmental Archives of the Arctic. <i>Antiquity</i> 92(363): 573-586. [Marcy Rockman, United States of America]	Rejected: out of scope for this section

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
29149	3	78	43	78	44	The reference to Golovnev, 2017 does not fit with the sentence. The paper of Golovnev prove the contrary of this sentence. The sentence of the report does not represent the situation in Siberia (at least eastern part), where climate change is still faced only thanks to traditional knowledge and to its adaptability and creativity in face of new extreme events (Bogoslovskaja 2008; Lavrillier 2013, Lavrillier, Gabyshev, Rojo, 2016, Lavrillier and Gabyshev 2017, 2018, Golovnev 2018) (for detailed references, see 2nd part comment) [Alexandra LAVRILLIER, France]	Not clear what this comment is suggesting/requesting
29151	3	78	43	78	44	References of the comment for the same page & line - Bogoslovskaja, Liudmila Sergeevna, Vdovin, Boris Innokentevich, and V. V. Golbtseva 2008. Izmeneniia klimata v regione Beringova proliva. Traditsionnye i nauchnye znaniia [Climate Change in the Bering Strait Region: Integration of Scientific and Indigenous Knowledge], Ekologicheskoe planirovanie i upravlenie, 3-4(8-9):36-48./ Lavrillier, A. 2013 Climate change among nomadic and settled Tungus of Siberia: continuity and changes in economic and ritual relationships with the natural environment, Polar Record, Vol. 49, issue 03, pp. 260-271 / Lavrillier A. and S. Gabyshev 2018, An Emic Science of Climate: a Reindeer Evenki Environmental Knowledge and the Notion of an Extreme Process of Change, in A. Lavrillier, A. Dumont, D. Brandisauskas (eds) Human-environment relationships in Siberia and Northeast China: Skills, Rituals, Mobility and Politics among the Tungus Peoples, accepted, EMSCAT, 48; Golovnev, A. 2018 Challenges to Arctic Nomadism: Yamal Nenets Facing Climate Change Era Calamities, Arctic Anthropology, vol 54, 2, pp.40-51. [Alexandra LAVRILLIER, France]	Not clear what this comment is suggesting/requesting
32389	3	78	46	79	4	This paragraph has supposition but little information. It could be deleted without something firmer. [Andrew Constable, Australia]	Accepted: section revised
30969	3	78	46	80	32	Please provide confidence levels for statements where appropriate in these sections. [Hans-Otto Poertner and WGII TSU, Germany]	Accepted: confidence language added where appropriate
17723	3	78	47	79	4	Include the increased economic impacts of climate change on land-based hunting. Climate change impacts may affect access to hunting grounds and increase hunting costs [Crystal Gong, Canada]	Accepted: text revised
5781	3	78	50	0		Full stop missing after "2016)" [Nina Hunter, South Africa]	Accepted: text revised
29153	3	78	50	78	53	For Siberia, there is this detailed study of the impacts of climate change on the traditional economic activity of sable hunting in Eastern Siberia, please add "Lavrillier, Gabyshev, Rojo 2016" - (full reference already in the report: Lavrillier, A., Gabyshev, S and Rojo, M., 2016 The Sable for Evenk Reindeer Herders in Southeastern Siberia: Interplaying Drivers of Changes on Biodiversity and Ecosystem Services: Climate Change, Worldwide Market Economy and Extractive Industries, in M. Roué and Z. Molnar (eds.), Indigenous and Local Knowledge of Biodiversity and Ecosystems Services in Europe and Central Asia: Contributions to an IPBES regional assessment. Knowledge and Nature 9. UNESCO: Paris, p. 111-128.), Golovnev 2018 (Golovnev, A. 2018 Challenges to Arctic Nomadism: Yamal Nenets Facing Climate Change Era Calamities, Arctic Anthropology, vol 54, 2, pp.40-51.) [Alexandra LAVRILLIER, France]	Accepted: citation added
919	3	79	1	79	30	The disease sections are inappropriate and incomplete, a disservice. Suggest to cite more Susan Kutz in Huettmann 2012 and others [Falk Huettmann, United States of America]	Rejected: insufficient detail
3295	3	79	1	79	4	Also impacts on land based transportation [Sharon Smith, Canada]	Taken into account: text no longer appears

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
17333	3	79	7	79	7	Here, the distinction of Indigenous peoples from polar residents is clearly made, which is important as per comment above. This kind of distinction should be clear throughout the chapter. [Joanna MacDonald, Canada]	No response needed
3305	3	79	43	0		Section 3.4.3.3.4 - Changes in snow loads and impacts on infrastructure has not been discussed (note there is also a Canadian standard related to this - see comment above for link to NISI) [Sharon Smith, Canada]	Noted-not all climate related impacts on infrastructure are covered due to space constraints; this section relates mainly to permafrost
3297	3	79	44	79	46	You should mention that impacts related to climate will be combined with impacts resulting from construction and operation of infrastructure (which can also affect permafrost, snow distribution etc.). Also Romanovsky et al. (2010, 2017a) does not discuss infrastructure impacts but Romanovsky et al (2017b SWIPA) does consider infrastructure as well as discuss observed changes in ground thermal regime so probably only reference required here. [Sharon Smith, Canada]	Noted-human induced and climate induced impacts are mentioned; citations refer to permafrost temperatures as well as infrastructure
5417	3	79	44	79	54	This paragraph needs confidence language. It has been mentioned that there are "Extensive summaries of construction damages...", so this should provide a weight of evidence that is virtually certain. [Michelle North, South Africa]	Accepted-confidence language included
5783	3	79	45	0		Insert "the" before "ground" [Nina Hunter, South Africa]	Accepted - wording was changed to clarify
30145	3	79	45	79	46	Add reference Biskaborn et al 2019 in press Nature Communications (Permafrost is warming at a global scale) [Guido Grosse, Germany]	Accepted-citations updated
5413	3	79	47	79	48	"infrastructure (defined here as facilities with permanent foundations on ice-free land), in particular in ice-rich frozen ground" - the information included in parentheses seems at odds with the end of the sentence. [Michelle North, South Africa]	Accepted - parenthetical was removed due to confusion
3299	3	79	48	79	50	Instanes (2005) is not recent and Callaghan et al. 2011 has been superceded by Romanavsky et al. 2017b (SWIPA 2017) so these earlier referencnes can be removed and replaced with SWIPA 2017 and also the AMAP AACA regional reports or ArcticNet IRIS reports. Vincent al. 2017 is not detailed discussion of construction damages or mitigation measures. Key things that should be mentioned here that represent concrete actions in Canada with respect to impacts of climate change on infrastructure are CSA (2010) guidelines published in 2010 (currently being updated) and the set of Standards developed under Northern Infrastructure Standardization Initiative (NISI) - see https://www.scc.ca/en/nisi for more information and to download the various standards including those on moderating effects of permafrost thaw, geotechnical investigations etc. Reference for CSA guidelines: Canadian Standards Association (2010) Technical Guide - Infrastructure in permafrost: a guideline for climate change adaptation. CSA Special Publication Plus 4011-10. see also guidelines for transportation Transportation Association of Canada (2010) Guidelines for development and management of transportation infrastructure in permafrost regions. Ottawa [Sharon Smith, Canada]	Noted-citation list updated
5785	3	79	53	0		Replace "on" with "of" [Nina Hunter, South Africa]	Accepted - wording was changed to clarify
31073	3	79	57	79	57	Add number of settlements to Executive Summary [Hans-Otto Poertner and WGII TSU, Germany]	Noted-current KM formulation does not support this due to space limitations

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
23163	3	80	0	81		Several aspects of 3.5.1 read more like a text book than an assessment. Consider merging with aspects of chapter 1, the introduction of the chapter, and shortening here. [Valerie Masson-Delmotte, France]	Taken into account. Section shortened and merged. We have cooperated extensively with Ch 1 (CCB 2) to capture some of the concepts explained here (and applied in 3.5) there. This has only been partly successful because it challenges the comparatively narrow but well established risk framework IPCC is applying in general
3301	3	80	1	79	13	Equilibrium models are considered here so permafrost will not completely thaw in this area by 2050 (transient effects not considered). It is also important to note that not all infrastructure will be vulnerable to thaw because it depends on how it is designed and whether it is able to tolerate thaw and settlement that may occur - e.g. if built on piles anchored in bedrock then infrastructure stability will not be affected. This discussion also does not consider that much infrastructure such as buildings has a limited lifetime and will need to be replaced anyway and likely to be replaced with infrastructure built to higher standards and be less vulnerable to permafrost thaw (i.e. infrastructure there now likely not there anyway in 2050 as generally lifetime doesn't exceed 30 years). [Sharon Smith, Canada]	Noted-the text of this section is consistent with the citation
3111	3	80	1	80	1	A reference to Aalto et al (2018) could be added here. (Aalto, J., Karjalainen, O., Hjort, J. & M. Luoto (2018). Statistical forecasting of current and future circum-Arctic ground temperatures and active layer thickness. Geophysical Research Letters 45, 4889–4898.) [Jan Hjort, Finland]	Noted-citation downloaded and checked for relevance
3113	3	80	1	80	13	All "Hjort et al., submitted" must be changed to "Hjort et al., 2018" (Hjort, J., Karjalainen, O., Aalto, J., Westermann, S., Romanovsky, V.E., Nelson, F.E., Eitzelmüller, B. & M. Luoto (2018). Degrading permafrost puts Arctic infrastructure at risk by mid-century. Nature Communications 9: 5147. DOI:10.1038/s41467-018-07557-4.) [Jan Hjort, Finland]	Accepted-citation updated
5787	3	80	4	0		Insert "will" before "contain" [Nina Hunter, South Africa]	Accepted - wording was changed as suggested
5027	3	80	19	80	20	Would be useful to add the percentage reduction for RCP2.6. It will also be useful to separate the adaptation costs for the different scenarios. [Debra Roberts and Durban Team, South Africa]	Noted-RCP2.6 not addressed by citation; costs separated more clearly
3303	3	80	31	80	32	Reference should be made to report by Perrin et al (2015) as it provides better discussion of economic implications and considers key factors influencing ice-road operation such as ice thickness which is not really considered by Mullan et al which focus more on various climate scenarios. Perrin A, et al. (2015) Economic implications of climate change adaptations for mine access roads in northern Canada. Northern Climate Exchange, Yukon Research Centre, Yukon College, 93pp. Available at: https://www.yukoncollege.yk.ca/research/our-research/northern-climate-exchange/economic-implications-of-climate-change-adaptations-for-mine-access-roads-in-northern-canada [Sharon Smith, Canada]	Noted-grey literature; other citations considered
32391	3	80	35	80	35	This section as a whole is very difficult to read. Use plain English please. [Andrew Constable, Australia]	language modified

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
17637	3	80	37	80	41	This Report does not cover geoengineering, but maintaining Arctic sea ice is crucial for limiting warming and should be mentioned within this section (or elsewhere, as appropriate, in this Chapter or Report). Projects have been proposed to rebuild and maintain Arctic sea ice as a means for increasing global albedo and limiting the regional warming in the Arctic. One looks to pump ocean water onto the sea ice surface to increase thickness over time and another hopes to increase the natural reflectivity of the sea ice through application of an eco-safe, reflective sand. Desch S. J., et al. (2017) Arctic ice management, EARTH'S FUTURE 5:107–127, 107 (“As the Earth’s climate has changed, Arctic sea ice extent has decreased drastically. It is likely that the late-summer Arctic will be ice-free as soon as the 2030s. This loss of sea ice represents one of the most severe positive feedbacks in the climate system, as sunlight that would otherwise be reflected by sea ice is absorbed by open ocean. It is unlikely that CO2 levels and mean temperatures can be decreased in time to prevent this loss, so restoring sea ice artificially is an imperative. Here we investigate a means for enhancing Arctic sea ice production by using wind power during the Arctic winter to pump water to the surface, where it will freeze more rapidly. We show that where appropriate devices are employed, it is possible to increase ice thickness above natural levels, by about 1 m over the course of the winter. We examine the effects this has in the Arctic climate, concluding that deployment over 10% of the Arctic, especially where ice survival is marginal, could more than reverse current trends of ice loss in the Arctic, using existing industrial capacity. We propose that winter ice thickening by wind-powered pumps be considered and assessed as part of a multipronged strategy for restoring sea ice and arresting the strongest feedbacks in the climate system.”); and Field L., et al. (2018) Increasing Arctic Sea Ice Albedo Using Localized Reversible Geoengineering, EARTH'S FUTURE 6:882–901, 882 (“The rising costs of climate change merit serious evaluation of potential climate restoration solutions. The highest rate of change in climate is observed in the Arctic where the summer ice is diminishing at an accelerated rate. The loss of Arctic sea ice increases radiative forcing and contributes to global warming. Restoring reflectivity of Arctic ice could be a powerful lever to help in the effort to limit global warming to 1.5°C. Polar ice restoration should be considered in planning of 1.5°C pathways. In this paper, a novel localized surface albedo modification technique is presented that shows promise as a method to increase multiyear ice using reflective floating materials, chosen so as to have low subsidiary environmental impact. Detailed climate modeling studying the climate impact of such a method reveals more than 1.5°C cooler temperatures over a large part of the Arctic when simulating global sea ice albedo modification. In a region north of Barents and	Taken into account. SROCC doesn't have a mandate to assess solar radiation management. As we understand that the emerging literature on this topic can also be considered in term of ecosystem restoration, we include reference to the topic in our chapter. We don't elaborate further as we believe that the literature is at present too limited to allow assessing dimensions of feasibility, benefits and risks, and governance.
19255	3	80	49	80	51	Would it be an idea to add 'decreased food security' to this line? [APECS Group Review, Germany]	modified
19257	3	80	55	81	1	(C2/E2) These two sentences pose and list constraints on human choice, but are not cited, so appears as a generalization or surmised list rather than established constraints. [APECS Group Review, Germany]	not needed... basic statements of fact/section reduced in length
2015	3	80	56	80	56	..."remoteness from densely populated regions constrain human choice" could add : "and opportunities." it wold read: ..."human choice and opportunities" [Laura Eerkes-Medrano, Canada]	modified
19271	3	81	1	81	1	Could we add 'with increasing security issues' behind a complex geo-political environment? [APECS Group Review, Germany]	resolved

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
19259	3	81	2	81	2	□ C4 - should change to "including those of Indigenous People for which the Arctic is their ancestral homelands" instead of "who view the Arctic as" - there is a large difference in meaning. This means the sentence is consistent with sentence on line 10-11,page 81. [APECS Group Review, Germany]	resolved
19275	3	81	6	81	7	(E1a) Writing here is unclear as to how complexities discussed pertain to explaining past responses. It is clear that they have an effect on predictability of future responses, but it is not clear why explanation of past responses is similarly cloudy. Perhaps some clarifying language, or splitting this thought into two sentences, could clarify this point. [APECS Group Review, Germany]	language modified
32393	3	81	6	81	7	Delete the last sentence. It is a global truism. [Andrew Constable, Australia]	done
13861	3	81	9	81	9	instead of saying "Antarctic is no one's homeland" be clearer and say "Antarctica has no permanent human population" [Government of United Kingdom (of Great Britain and Northern Ireland), United Kingdom (of Great Britain and Northern Ireland)]	done
23991	3	81	9	81	9	"Antarctica is no one's homeland" several animal species can't live anywhere else, a less anthropo-centered point of view could be adopted [Patricia Martinerie, France]	done
5789	3	81	12	0		Suggest change "living urban" to "living in urban areas"; insert "of" after "68%" [Nina Hunter, South Africa]	done
5791	3	81	15	0		Suggest removing "And" and starting the sentence with "While" as previous sentence begins with "And". [Nina Hunter, South Africa]	done
32395	3	81	18	81	24	This paragraph could be deleted without loss. Is knowing the percentage of the population that is indigenous important? Indigenous values are important to consider irrespective of the percentage of people it effects. [Andrew Constable, Australia]	rejected - demographics are helpful to those who know nothing of the arctic
5793	3	81	19	0		Change "Canada" to "Canada's" and insert "people" after this word [Nina Hunter, South Africa]	done
5419	3	81	20	0		"Ethnicity and cultural orientation do in climate change responses" - do what in climate change responses? I think something has been left out [Michelle North, South Africa]	changed
19261	3	81	20	81	20	E1a - why is the word "Native" in quotation marks? [APECS Group Review, Germany]	changed
5795	3	81	20	81	21	Please clarify: "Ethnicity and cultural orientation do in climate change responses". [Nina Hunter, South Africa]	changed
3541	3	81	20	81	22	The beginning of this sentence "Ethnicity and cultural orientation do in climate change responses" does not make sense. I think there is a word missing (e.g. insert "matter" after "do", or replace "in" by "influence") [Sonya Legg, United States of America]	done
3985	3	81	20	81	22	I don't understand this sentence. [Stuart Chapin, United States of America]	resolved
19263	3	81	20	81	22	E1a - this sentence does not make sense. Suggest changing the term "cultural orientation" to "cultural identity" [APECS Group Review, Germany]	resolved
19277	3	81	20	81	22	(E1a) This particular sentence is missing a subject, as such it is unclear what ethnicity and cultural orientation have an effect on with respect to climate change. This point is important in terms of local responses in the changing Arctic, but it isn't made here. [APECS Group Review,]	resolved
5797	3	81	23	0		Insert "the" before "Antarctic" [Nina Hunter, South Africa]	resolved

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
19265	3	81	24	82	24	<input type="checkbox"/> E2 - Reference to section 3.5.5.2: This section (3.5.5.2 - linking knowledge systems with decision making) seems only tenuously related to the statement it follows about the human response to climate change in the Arctic. [APECS Group Review, Germany]	Taken into account. We improved section focus to make clearer the relevance of knowledge (systems) and decision making.
5421	3	81	27	0		Herding is listed twice, and "fish" should be "fishing" [Michelle North, South Africa]	resolved
5799	3	81	27	0		Change "fish" to "fishing"; remove second "herding" [Nina Hunter, South Africa]	done
2017	3	81	27	81	27	The line reads: "subsistence economies that are highly dependent on hunting, herding, fish, herding, and gathering" The word herding is repeated. [Laura Eerkes-Medrano, Canada]	done
19273	3	81	27	81	27	Herding is mentioned twice in the same line. [APECS Group Review, Germany]	done
19267	3	81	28	81	31	<input type="checkbox"/> E1a - the phrase structure of this sentence is confusing. Suggest rewording. [APECS Group Review, Germany]	done
5423	3	81	29	81	30	I do not understand how the dependence of Indigenous people on the environment for food makes them "sensitive to climate change in ways that inform understanding of..." the things listed. This sentence needs to be reworded for clarity [Michelle North, South Africa]	See the CCBox on indigneouns and local knowledge for explanation
5425	3	81	31	81	32	This sentence "And for Indigenous Peoples, human responses to climate change are considered a matter of cultural survival" needs to be reworded to clearly convey what the authors mean. What are human responses? Why are human responses to climate change more a matter of cultural survival than other cultural groups (like in the Pacific island states, or other groups)? If the point is to emphasize the risk of cultural extinction, then it should be phrased differently (e.g., "For Indigenous peoples of the Arctic, there is a risk that their responses to climate change may threaten the survival of their culture.") [Michelle North, South Africa]	the point is to tell the perspective of arctic indigenous peoples -- how they see it. This may or may not be related to "extinction"
5427	3	81	39	0		"Polar regions are also unique with respect to the novelty of their systems of governance" could be shortened and combined with the next, to read: "Polar regions have unique systems of governance, with the Antarctic Treaty...forming examples of a few of the organizational..." [Michelle North, South Africa]	modified
19279	3	81	39	81	44	(E1a) Listed here are different government types, but since the topic sentence references differences between the governance systems, perhaps it would be prudent to explain, briefly (or give examples of) how these government types are different from one another. For the unknowing eye, for example, it is hard to know what the systematic differences between the Inuit Circumpolar Council and the Arctic Council are. [APECS Group Review, Germany]	wish we could but not enough room for such in depth descriptions
923	3	81	42	81	42	The Arctic Council has 100% foreslept proactive management and action on Climate Change. What is stated in the text is pure propaganda instead; this is very poor and not based on facts [Falk Huettmann, United States of America]	Misplaced comment? this paragraph describes opportunities in poarl governance systems for responding to cliamte change

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
19269	3	81	44	81	44	E1a - I don't understand what statement requires a confidence indicator. I consider both sentences in this paragraph, prior to the confidence indicator, to be statements of fact. It is true that these organisations exist, and it is true that they provide opportunities to respond to climate change (what these opportunities are, are not discussed.) If the confidence indicator relates to whether or not these organisations provide opportunities to respond to climate change in a particular way, or if the opportunities are genuine, or some other clarifier, then this needs to be made clear. [APECS Group Review, Germany]	addressed later in the text
13863	3	81	46	82	22	The two paragraphs in section 3.5.2 Assessing Human Responses in the Polar Regions I believe are relevant in the Arctic and not the Antarctic - which does not have permanent human population - please clarify in the sub-heading if this is the case. [Government of United Kingdom (of Great Britain and Northern Ireland), United Kingdom (of Great Britain and Northern Ireland)]	Accepted and actioned
13865	3	81	46	82	22	Throughout section 3.5.2 Assessing human Responses in Polar Regions: Adaptation and resilience consider re-ordering the sub-sections by starting with issues that jointly impact for both poles, i.e. fisheries transportation/shipping, tourism, then those that are solely for the Arctic due to its permanent human population i.e. subsistence systems, reindeer herding, human health and well-being. [Government of United Kingdom (of Great Britain and Northern Ireland), United Kingdom (of Great Britain and Northern Ireland)]	have tried to reorganized in manner that is logical and also reflects importance
16309	3	81	46	83	22	Limits to adaptation should feature more prominently here, and in Section 3.5 more general. [Alexander Nauels, Germany]	addressed later in the text
5801	3	81	46	85	54	Was "adaptation" intended, instead of "adaption"? [Nina Hunter, South Africa]	done
5803	3	81	49	0		Suggest changing "examine" to "examining" [Nina Hunter, South Africa]	done
3709	3	81	49	81	49	add (SES) after "social-ecological system" so the reader has fresh acronym definition before using it at line 51. [Dee Williams, United States of America]	done
30971	3	81	51	81	51	What is "SES"? Use full term, please. [Hans-Otto Poertner and WGII TSU, Germany]	addressed
13867	3	81	57	81	57	Reference to "affect human livelihoods and well-being" is not relevant in Antarctica due to its lack of human population - please clarify this in the text. [Government of United Kingdom (of Great Britain and Northern Ireland), United Kingdom (of Great Britain and Northern Ireland)]	taken into account. we have specified relevance of issues to Arctic vs Antarctic across the section

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
13869	3	81	57	82	1	The report recognises that there are two polar regions, therefore it is inaccurate to ask "Are some individuals and groups of polar regions more able to adapt or transform to climate change than others?" [Government of United Kingdom (of Great Britain and Northern Ireland), United Kingdom (of Great Britain and Northern Ireland)]	Not really - some research groups may be more adaptable than others; adaptive capacity is relevant to both. But this section is modified
5805	3	82	5	0		Semi-colon after "problems" for consistency [Nina Hunter, South Africa]	prefer not to use semi colons
5807	3	82	7	0		Insert semi-colon after "feedbacks" and after "governance" [Nina Hunter, South Africa]	prefer not to sue semi coloms
19281	3	82	9	82	16	E1a - □suggest adding community adaptive capacity (as environmental knowledge and land skills). Pearce et al 2010. [APECS Group Review, Germany]	section modified
5429	3	82	10	0		How is "remoteness from required resources" an asset or tool? Would it not be better phrased "proximity to required resources"? [Michelle North, South Africa]	section modified
5431	3	82	17	0		"in response responding to" - either delete 'responding' or make it "when responding to" [Michelle North, South Africa]	modified
5809	3	82	17	82	20	Suggest parentheses for "e.g. ..events" and "e.g. ... stocks" for consistency across sections [Nina Hunter, South Africa]	modified
5811	3	82	20	0		Suggest replacing "As well" with "In addition" or similar [Nina Hunter, South Africa]	modified
33383	3	82	24	89	35	Should geo-political security be a subsection here? [Government of United States of America, United States of America]	Taken into account; editorial decision was made not to include this overtly
19283	3	82	26	82	29	E1a- This paragraph (lines 26-29), though does describe what is in Table 3.7, is densely worded (e.g. "...consequences...of climate change responses..." is misleading). Suggest rewording to describe more fully (and avoid condensing the sentence). E.g. Table 3.7 summarizes the consequences of climate change to select social-ecological systems (i.e., sectors) of Arctic and Antarctic regions, as well as their documented responses, and assets and strategies for continued adaptive and transformative response. Also noted are anticipated future impacts to the sectors (including a level of certainty) and other drivers of change that may interact with climate and affect outcomes. [APECS Group Review, Germany]	modified
19291	3	82	26	82	33	Line 32-33 there is mention of regional data gaps for Russia, however, the table does not capture any regional nuances (nor for that matter does it distinguish between Arctic and Antarctic). The table is so general (both in terms of covering the entire polar regions, and the issues highted) that notions of certainty seem inappropriate. [APECS Group Review, Germany]	The purpose of this table is to summarise, regional differences are made in the text, where possible. The differences between the polar regions is captured at the sector level - to make that clearer we have added Arctic and Antarctic in the line headers
33385	3	82	26	82	33	Suggest an additional citation: Metcalfe et al 2018 Patchy field sampling biases understanding of climate change impacts across the Arctic Nature Ecology & Evolution volume 2, pages 1443-1448 (2018) [Government of United States of America, United States of America]	Taken into account; other citations make equivalent points

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
29823	3	82	35	82	35	please consider adding a potential for exploitation of keps via sustainable harvest or seaweed aquaculture. In e.g. Norway & Canada there is high focus ion this possibility. [Dorte Krause-Jensen, Denmark]	Rejected. We agree that such a potential exists. However, we do not have space to explore furure potential for harvesting kelp or other ressources.
19293	3	82	37	82	37	Reference for changing abundance of fish resources (not sure if this term "fish resources" is appropriate) [APECS Group Review, Germany]	Taken into account. References are given here and in earlier sections. The focus and now title of this section is Commercial Fisheries. We thus find "fish ressources" appropriate.
5029	3	82	37	82	44	Source(s) of the information contained in this paragraph should be provided. [Debra Roberts and Durban Team, South Africa]	Taken into account. Has been rewritten.
19285	3	82	37	82	44	C1 - no references / evidence are provided for this paragraph or confidence attribution [APECS Group Review, Germany]	Taken into account. References are provided in the revised paragaraph.
19297	3	82	37	82	44	While fisheries are discussed in other subsections of the report, this section on adapation does not provide context or nuance regarding the different types of fisheries that exist in the Arctic - whether subsistence, comercial etc... large/small scale. The text of this section relates mostly to the context of commercial fisheries and neglects subsistence and co-management structures. If section "3.5.3.1 Fisheries" pertains exclusively to commercial fisheries, it should be titled as such; otherwise, more context regarding subsistence fishing should be provided. [APECS Group Review, Germany]	Accepted. This section has been retitled as 'Commercial Fisheries' and subsistence systems are now also discussed in a new subsection.
30973	3	82	37	82	44	On which literature is this assessment and confidence based on? Please ensure traceability of your assessments back to the literature. [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account. References are provided in the revised paragaraph.
19295	3	82	40	82	40	Tools should not merely alert managers, but also users (there can be an important distinction and tension) [APECS Group Review, Germany]	Rejected. We in principle agree with the statement. However, the focus of this paragraph is mainly adaptive management and we are not aware of tools directly targeting users (.i.e., fishers).
5433	3	82	47	0		What is EEZ in "200 nm EEZs"? It hasn't been mentioned previously in this chapter. [Michelle North, South Africa]	Accepted. This abbreviation is now articulated as Exclusive Economic Zone when first introduced.
925	3	82	54	82	54	Norways claims UNDERFISHING and TO EAT MORE WHALES. It's not serious, so I would not present that here as a role model, or citation worthwhile [Falk Huettmann, United States of America]	Rejected. Comment is not related to text, which says nothing about neither underfishing or whales.
19287	3	82	54	82	54	E1a - suggest reword for ease of reader: □ "In 2009, a new Marine Resources Act entered into force for Norway's EEZs." [APECS Group Review, Germany]	Rejected. The section has been rewritten so comment is no longer relevant.
19289	3	82	56	83	1	E2 - Is it best practice to use secondary references, when the Marine Resources Act could be referenced directly? [APECS Group Review, Germany]	Rejected. It is best practice to refer to peer reviewed articles.
5813	3	83	1	0		replace "are" with "is" [Nina Hunter, South Africa]	Rejected. The subject 'management strategies' is plural
30975	3	83	4	83	6	On which literature is this assessment/confidence level based on? Please ensure traceability. [Hans-Otto Poertner and WGII TSU, Germany]	Taken into account. Gullestad et al. (2017) is cited earlier in this section
927	3	83	8	83	10	The US is not a role model; most federal fisheries are not even assessed for impacts [Falk Huettmann, United States of America]	Rejected. We disagree. The US management is not perfect, but ahead of almost everywhere else. We have provided additional references
19299	3	83	12	83	14	E1a - This sentence needs clarification (limiting flexibility for what?). The Anderson et al. 2017b paper talks about regulatory frameworks limiting the ability for individual fishers to diversify, and therefore potentially reduce revenue variability/ financial vulnerability. This should be more clearly explained. [APECS Group Review, Germany]	Rejected. There was unfortunately not room to provide a detailed explanation.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
5815	3	83	14	83	19	Insert a space before "To" [Nina Hunter, South Africa]	Editorial. Has been fixed.
5825	3	83	16	0		Replace "have" with "has" [Nina Hunter, South Africa]	Accepted. Corrected.
19303	3	83	18	83	26	E1a - this paragraph could be re-drafted to read more smoothly. Suggest especially looking at phrasing of sentence on lines 21-22. [APECS Group Review, Germany]	Accepted. Corrected.
33387	3	83	19	83	19	Missing space before "In the Canadian..." [Government of United States of America, United States of America]	Editorial. Has been fixed.
5817	3	83	20	0		Suggest replacing "until now" with "currently" [Nina Hunter, South Africa]	Accepted. Corrected.
929	3	83	26	83	27	Most fish species here and elsewhere mention in the report LACK a relevant taxonomy agreement. Thus,its concluded wrongly [Falk Huettmann, United States of America]	Accepted but there is no space to insert Art. 10 of the Protocol
5819	3	83	28	0		Change "nations" to "nation's"; Replace "per" with "by" [Nina Hunter, South Africa]	Accepted. Corrected.
5827	3	83	28	0		Suggest changing "response" to "responses"? [Nina Hunter, South Africa]	Editorial. Comment appears to be misplaced as this word does not occur in the given line number or nearby.
1045	3	83	32	83	40	See the next. [Timo Koivurova, Finland]	Noted. Comment incomplete
1047	3	83	32	83	40	There are several errors here. The Oslo declaration and the 2018 signed central Arctic ocean fisheries agreement establish no moratoria since in both the parties commit themselves to abstain from unregulated fishing in the high seas portion (first the A5 agree politically this, and then A5 + 5 agree legally this. So there is no general moratorium, but parties only agree to ensure that their fishing fleets do not engage in unregulated fishing. Second, there is a misunderstanding on how this fishing agreement came about, so it was first the A5 that adopted the non-binding Oslo declaration, which was followed by the invitation from them to four nation states and the EU to negotiate a legally binding agreement, which was concluded in Nov. 2017 and signed in Oct. 2018. There is a general misunderstanding that the BBNJ global agreement on managing biodiversity in areas beyond national jurisdiction would have been already concluded, which is untrue - the negotiations are on-going, and the result is unclear at the moment. [Timo Koivurova, Finland]	Accepted. We thank the reviewer for important input. The text has been rewritten accordingly
13871	3	83	35	83	35	Suggest naming the "several other nations" as China, Iceland, Japan, South Korea and the EU [Government of United Kingdom (of Great Britain and Northern Ireland), United Kingdom (of Great Britain and Northern Ireland)]	Reject. With the extremely tight page limit, editorial decisions were made re where to save space; there was not room to provide a detailed list of countries.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
1041	3	83	36	83	40	There appears to be some confusion. The Central Arctic Ocean Fisheries Agreement (properly, the "Agreement to Prevent Unregulated High Seas Fisheries in the Central Arctic Ocean") is the instrument that imposes a 16-year moratorium on fishing in the international waters of the Arctic basin. BBNJ is a separate matter and does not (yet) have an Arctic component. The CAO Fisheries Agreement has ten signatories: the five Arctic coastal states (Canada, Denmark/Greenland, Norway, Russia, USA), plus the People's Republic of China, the Republic of Korea, Japan, Iceland, and the European Union. It might be worth mentioning all ten, rather than perpetuating the segregation of Arctic states and "others." [Henry Huntington, United States of America]	Accepted. We thank the reviewer for important input. The text has been rewritten accordingly
5821	3	83	38	0		Change "sustainable" to "Sustainable" [Nina Hunter, South Africa]	Noted. This text has been deleted in the revised draft
5435	3	83	42	0		This acronym "CCAMLR" needs to be written out in full at first mention [Michelle North, South Africa]	Accepted
21377	3	83	42	84	3	CCAMLR has not agreed to any climate change program and at its most recent meeting there was again no agreement to do so. The section is a little too positive about what is actually going on. Brooks et al. 2018 Nature or Brooks et al. Science make these points clearly. The CCAMLR reports and even its last external review do so too. [Steven Chown, Australia]	Taken into account. The fact that CCAMLR has not agreed to a climate change program is stated in section 3.5.3.2.
5437	3	83	50	0		The acronym CAMLR is now written with one fewer C, please check [Michelle North, South Africa]	Taken into account. This sentence has been deleted in the revised draft.
30977	3	83	50	83	53	On which literature is this assessment and confidence based on? Please ensure traceability of your assessments back to the literature. [Hans-Otto Poertner and WGII TSU, Germany]	Addressed. The sentence has been revised and references are provided.
19301	3	83	51	83	54	□E1a - this sentence is confusing. Is there a missing parenthesis before the word "although"? Even with this, the sentence should be edited, as sentence structure reads "such displacement could be attribute to both..or management techniques establishing marine protected areas..." [APECS Group Review, Germany]	Addressed. Has been rephrased in the revised draft.
19305	3	83	51	83	54	(E1a) This long sentence is unclear - it appears first to suggest two causes for the displacement of fisheries, but lists only one, then suggests "or" the other; this is unclear. There is also a hanging ")" that makes it unclear if the first cause was meant to be a parenthetical mention. Simple re-writing is required. [APECS Group Review, Germany]	Addressed. Has been rephrased in the revised draft.
30979	3	83	56	84	1	On which literature is this assessment and confidence based on? Please ensure traceability of your assessments back to the literature. [Hans-Otto Poertner and WGII TSU, Germany]	Addressed. Confidence statement has been deleted.
3307	3	84	5	0		Section 3.4.3.2. Another response in Canada for example has been to replace winter/ice roads with all season roads. Examples include recent construction of Inuvik-Tuktoyaktuk Highway to replace ice road and Ticho Road north of Yellowknife NWT that is currently being constructed. There are also proposals for all season roads to extend Mackenzie Highway north of Wrigley NWT and the Grays Bay Port and Road Nunavut to support mining development in the region. [Sharon Smith, Canada]	Taken into account. We added material on ice roads
19313	3	84	5	84	56	This section focuses primarily on marine shipping - air traffic is only mentioned in the last paragraph [APECS Group Review, Germany]	Taken into account: this aspect has so little literature coverage that it cannot be assessed properly and has been removed

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
21379	3	84	5	85	2	The section does not take into consideration the exceptional delay among Antarctic Treaty Parties in signing up to Annex VI on Liability to the Protocol on Environmental Protection to the Antarctic Treaty. Alan Hemmings has several papers dealing with this and the question is notable by its absence, meaning that Antarctica is insufficiently prepared for risks from marine accidents. These are expected to increase with increasing ice-berg prevalence and shipping. [Steven Chown, Australia]	Thank you, very unfortunately we have not been able to pursue this useful recommendation in a timely fashion.
1049	3	84	7	84	52	Several problems here. IMO is said to be the body responsible for Arctic international shipping, but it is better to say that it is body responsible for international shipping in general, including in the Arctic. It is not told that Polar Code has recommendatory and mandatory part, the latter of which consists in making revisions to the existing IMO conventions. It is said that Polar code is unlikely to meet future challenges, but no reason is given, even if polar code can be changed? There are also repetition of the polar code, suggesting that there have been several persons that have produced this text. It is said that there are "recent Arctic initiatives, such as joint search and rescue agreements and joint 28 oil pollution response", which likely refer to the legally binding agreements that have been negotiated under the auspices of the Arctic Council (search and rescue agreement, and marine preparedness and response agreement). There is no mention in the national level regulation of both Russian and Canadian special legislation for shipping in their arctic areas, basing them on Art. 234 of UNCLOS, which provides the possibility to make stricter shipping provisions in ice covered waters - and its relationship to the polar code. [Timo Koivurova, Finland]	Accepted. section revised and information added
17529	3	84	7	84	9	Increased shipping and other traffic within the Arctic will also increase local pollution, especially of particularly harmful short-lived climate pollutants like black carbon and methane. Stephenson S. R., et al. (2018) Climatic responses to future trans-Arctic shipping, GEOPHYSICAL RESEARCH LETTERS 45:9898–9908; Arctic Monitoring and Assessment Programme (AMAP) (2017) ADAPTATION ACTIONS FOR A CHANGING ARCTIC: PERSPECTIVES FROM THE BARENTS AREA; Arctic Council Secretariat (2017) EXPERT GROUP ON BLACK CARBON AND METHANE: SUMMARY OF PROGRESS AND RECOMMENDATIONS 2017. [Kristin Campbell, United States of America]	Taken into account. the issue of shipping melted BC on snow and ice is mentioend, but we refer to the ssctins on sea ice and snow for consideration of the importance of these emissions in the context of climate change

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
17639	3	84	7	84	9	Increased shipping and other traffic within the Arctic will also increase local pollution, especially of particularly harmful short-lived climate pollutants like black carbon and methane. Stephenson S. R., et al. (2018) Climatic responses to future trans-Arctic shipping, GEOPHYSICAL RESEARCH LETTERS 45:9898–9908, 9898 (“Because warming favors increased shipping traffic, previous studies have focused on the potential for ship emissions of black carbon (BC) and other particulates to enhance warming by lowering the otherwise high albedo of ice and snow (Browse et al., 2013; Corbett et al., 2010; Ødemark et al., 2012; Sand et al., 2016). The source of emissions is an important factor in determining the magnitude of this feedback and their ultimate climatic impact. Unlike BC transported to the Arctic from these midlatitude sources in Russia and Asia (Winiger et al., 2017; Wobus et al., 2016), strong surface inversions in the Arctic boundary layer make it more likely that BC emitted in the Arctic will be deposited on ice and snow, thereby maximizing its impact on surface temperature.”); Arctic Monitoring and Assessment Programme (AMAP) (2017) ADAPTATION ACTIONS FOR A CHANGING ARCTIC: PERSPECTIVES FROM THE BARENTS AREA, 1 (“Changes in climate will have direct impacts on snow and ice, as well as on terrestrial, freshwater and marine ecosystems. In addition to climate change, the region’s ecosystems are also influenced by several other impacts of human activities, such as chemical pollution, invasive species, and increased shipping and industrial developments. The end result is cumulative and cascading impacts on ecosystems and societies in the area.”); Arctic Council Secretariat (2017) EXPERT GROUP ON BLACK CARBON AND METHANE: SUMMARY OF PROGRESS AND RECOMMENDATIONS 2017, 17 (“Arctic shipping currently accounts for about 5 percent of black carbon emissions within the Arctic; absent emission controls, shipping emissions within the Arctic could double by 2030 under some projections of Arctic vessel traffic.”). Must emphasize that the risks and additional climate impacts far outweigh the benefits that may be gained from shipping, tourism, or other transit through the Arctic. [Durwood Zaelke, United States of America]	Taken into account. the issue of shipping melted BC on snow and ice is mentioned, but we refer to the sections on sea ice and snow for consideration of the importance of these emissions in the context of climate change
19311	3	84	8	84	8	Section does not address the development of new ground transportation infrastructure (examine: first road to the Arctic Ocean in Canada (linking Inuvik to Tuktoyaktuk) [APECS Group Review, Germany]	done
10143	3	84	9	0		Add "noise pollution," after "oil spills. Cavitation noise is a big deal for some sp [Lisa Speer, United States of America]	good point. But not directly related to CC, and no papers about it related to increased shipping
19315	3	84	9	84	9	"Accidents" is ambiguous [APECS Group Review, Germany]	reject; not sure what this comment means
5439	3	84	11	0		What is the point of providing examples of geographic areas ("NSR, AB and eventually NWP and maybe TPR") if the acronyms are not written out? [Michelle North, South Africa]	modified
5031	3	84	11	84	12	The acronyms need to be defined. [Debra Roberts and Durban Team, South Africa]	modified
30981	3	84	11	84	12	Provide full names for NSR, AB, NWP, TPR [Hans-Otto Poertner and WGII TSU, Germany]	modified
5441	3	84	13	0		"development of shipping design for travel in mixed ice environments" - do you mean ship design, rather than shipping? [Michelle North, South Africa]	yes; actioned
5823	3	84	13	0		Insert "the" before "development" [Nina Hunter, South Africa]	modified

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
5443	3	84	13	84	14	This sentence "Industry has responded by investing in development of shipping design for travel in mixed ice environments." does not fit with those before or following it. The current position and phrasing seems to indicate that industry has responded to increasing shipping activity in the Arctic by building better boats, which doesn't make sense. I recommend deleting it or moving it elsewhere, so that the paragraph describing the increasing ship traffic through the Arctic can flow more logically. [Michelle North, South Africa]	section modified
933	3	84	14	84	14	That is UNTRUE, only limited to land, not sea. Also, air exploitation and pollution is not resolved or enforced [Falk Huettmann, United States of America]	Section modified
5445	3	84	19	84	20	"The tools allow for qualification to assess Arctic oil-spill response capability..." - this doesn't make sense. Qualification to assess? Try "The tools facilitate the assessment of Arctic oil-spill response capability..." [Michelle North, South Africa]	change made
22865	3	84	23	84	23	This indicates misleading function of the international Maritime Organization (IMO). The IMO is a United Nations specialized agency with responsibility for the safety and security of shipping and the prevention of marine and atmospheric pollution by ships. [Government of Saudi Arabia, Saudi Arabia]	Accepted. Sentence revised
13873	3	84	23	84	52	To better frame section 3.5.3.2 Transportation an explanation of what the Polar Code is and what it does should come before the paragraphs on Arctic shipping. I'm no expert on the Polar Code but some of what has been written doesn't seem entirely accurate. The correct title for the Polar Code is "International Code for Ships Operating in Polar Waters", its related amendments made it mandatory under both the International Convention for the Safety of Life at Sea (SOLAS) and the International Convention for the Prevention of Pollution from Ships (MARPOL) in 2017. The regulations apply to both the Arctic and Antarctic, it does not cover fishing vessels, leisure yachts nor vessels on government service, therefore limits its effectiveness, which differs between the Arctic and Antarctic due to different volumes of shipping and types of ships that enter each region. [Government of United Kingdom (of Great Britain and Northern Ireland), United Kingdom (of Great Britain and Northern Ireland)]	Taken into account, Section refined
22867	3	84	28	84	28	Agreement at the IMO is through a simple majority, meaning there is a certain threshold to reach in order to adopt any new agreement, and some agreement come through tacit amendment. [Government of Saudi Arabia, Saudi Arabia]	accepted. Sentences rewritten
5447	3	84	28	84	32	"The agreement was consensus based, hence implemented at the lowest common denominator..." - is this necessary? Also, it doesn't match the second half of the sentence "...including a call to enhance enforcement capabilities and address emerging issues such as heavy fuel oil and black carbon, among other environmental protection provisions...". If you want to point out the weaknesses of the code then try to do so explicitly, without a) offending the stakeholders involved in reaching the consensus, and b) being ambiguous about which aspects are weak (are the things listed in the second half of the sentence the points that were lost while reaching consensus? If so, be explicit). [Michelle North, South Africa]	accepted. Sentences rewritten
22869	3	84	28	84	32	Calling for regulating other environmental emerging issues are redundant and invalid, because the IMO already regulated the use of heavy fuel oil, black carbon and the ballast water i.e. regulations are already in place and effective. [Government of Saudi Arabia, Saudi Arabia]	Taken into account. Sentence modified

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
19319	3	84	32	84	33	(C2) This last sentence of the paragraph is not supported by a citation or examples of such deficiencies. While surely they exist, this seems like an opinion rather than substantiated review. [APECS Group Review, Germany]	citations now included
5449	3	84	35	0		Please explain what "with flags of convenience" means [Michelle North, South Africa]	text has been modified - this aspect is not longer included
19317	3	84	36	82	37	Studies are only one component of a response (i.e. research, policy, programs and interventions) - this should be highlighted if the "national responses" presented are studies. [APECS Group Review, Germany]	yes that is true -- we address several types of responses
19307	3	84	42	84	45	E1a - paragraph should be deleted. Is a partial repeat of the following paragraph. Seemingly an error. Confidence indicator is redundant as it follows a statement of fact. [APECS Group Review, Germany]	This paragraph was deleted
33389	3	84	42	84	50	The line beginning "The IMO Polar Code, however, currently" is repeated in the paragraphs starting on lines 42 and 47. [Government of United States of America, United States of America]	This paragraph was deleted
5033	3	84	42	84	52	Check for repetition between the two paragraphs [Debra Roberts and Durban Team, South Africa]	This paragraph was deleted
5451	3	84	42	84	52	These paragraphs are duplicated, please delete the first one [Michelle North, South Africa]	This paragraph was deleted
15021	3	84	42	84	52	Please delete lines 43 to 45. Passage is duplicated in lns 48-50. [Government of Germany, Germany]	This paragraph was deleted
30985	3	84	42	84	52	There is some repetition/redundancy in these two paragraphs. [Hans-Otto Poertner and WGII TSU, Germany]	This paragraph was deleted
30983	3	84	43	84	45	This is a statement of fact and does not require a confidence statement. [Hans-Otto Poertner and WGII TSU, Germany]	This paragraph was deleted
2019	3	84	45	45	9	the text should read "...shipping activities in the "Arctic" and Antarctic regions (IMO 2017)." -- add word Arctic [Laura Eerkes-Medrano, Canada]	This paragraph was deleted
931	3	84	47	84	47	The Polar Code is poor and lacks enforcement [Falk Huettmann, United States of America]	reject; not clear what is being suggested
17531	3	84	47	84	52	It should be noted that the Polar Code bans use of heavy fuel oil in Antarctic waters, but there is not a similar provision in the Arctic. [Kristin Campbell, United States of America]	accepted and added
17641	3	84	47	84	52	It should be noted that the Polar Code bans use of heavy fuel oil in Antarctic waters, but there is not a similar provision in the Arctic and its essential to have this same ban in the Arctic. [Durwood Zaelke, United States of America]	accepted and added
19309	3	84	47	84	52	E1a - suggest rewording for clarity to read: The International Maritime Organization Polar Code of 2017 will set new standards for vessels travelling in polar areas to mitigate environmental damage and improve safety (IMO, 2017). The IMO Polar Code, however, currently excludes fishing vessels and vessels on government service, thereby excluding many shipping activities in the Antarctic region (IMO, 2017). Many ships travelling these waters will therefore continue to pose risks to the environment and to themselves, as they are not regulated under the Polar Code (high confidence). [APECS Group Review, Germany]	Accepted, thank you

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
22871	3	84	47	84	52	Fishing vessels and other small vessels are not included the SOLAS and Load Lines Conventions due to the differ the differences in the design and operation among these type vessels. Therefore, such vessels cannot be regulated and included in the Polar Code. It is worth mentioning that there are other international conventions and treaties regulate fishing vessels which the IMO urged its Parties to accept such as 1993 Torremolinos Protocol. [Government of Saudi Arabia, Saudi Arabia]	Reject. While certainly true we cannot go into these details here because of eht lack of space
2021	3	84	50	84	50	the text should read ..."shipping activities in the "Arctic" and Antarctic regions (IMO 2017)..". [Laura Eerkes-Medrano, Canada]	Taken into account. THis material was revised
5829	3	84	51	0		Suggest removing "as they ... Code" as it has already been stated in line 49 [Nina Hunter, South Africa]	Taken into account. THis material was revised
30253	3	84	56	85	2	Specify that it is the sea ice runways that are at risk. [Christine Dow, Canada]	this material has been removed
10145	3	85	4	85	34	This section is terrestrially focused. It needs some mention of Arctic offshore oil and gas development (oil spills, airgun arrays, noise and light pollution, air and water discharges etc. [Lisa Speer, United States of America]	text added
24003	3	85	4	85	34	Non-renewable extractive industries could also be considered in terms of climate change amplification sources (responsible for direct and indirect CO2 emissons etc.) [Patricia Martinerie, France]	yes - this is addressed elsewhere in the report
19327	3	85	6	85	34	An important driver for the oil and gas industry is the economy and politics (on the North Slope, Alaska - the protected land, and with government change, this could open the region to further oil and gas development). These important driving factors should be included, and their interaction with climate change and human responses. [APECS Group Review, Germany]	good point. this section was focused sqaurely on responses to climate change.
19323	3	85	6	85	6	"...forced, to a limited extent..." is not straightforward phrasing to follow with respect to certainty [APECS Group Review, Germany]	reject; not clear what is being suggested
15023	3	85	12	85	12	Please replace "Exploitation of natural resources in the Antarctic is prohibited by the Antarctic Treaty" with "Exploitation of natural resources in the Antarctic is prohibited by the Protocol on Environmental Protection to the Antarctic Treaty." [Government of Germany, Germany]	Accepeted as suggested
21381	3	85	12	85	12	The Antarctic Treaty does not prohibit exploitation of natural resources. Article 7 of the Protocol on Environmental Protection says this: 'Any activity relating to mineral resources, other than scientific research, shall be prohibited'. So other natural resources, such as fish, genetic material, invertebrates (like krill) may be exploited. Please revise 'natural' to 'mineral'. [Steven Chown, Australia]	Accepeted as suggested
32397	3	85	12	85	12	Given that the chapter has defined Antarctica to be the area south of the subantarctic front then it is not true that mineral resource extraction is prohibited from the whole of Antarctica. The statement is to be confined to the spatial extent of the Antarctic Treaty - south of 60oS. Currently there is no discussion about mineral extraction north of 60oS in the Southern Ocean, although this is possible under UNCLOS. [Andrew Constable, Australia]	Accepeted as suggested

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
13875	3	85	12	85	26	Please add a reference to UN resolution 1803 (XVII) that recognises that decisions on the development of natural resources are a matter for national governments. [Government of United Kingdom (of Great Britain and Northern Ireland), United Kingdom (of Great Britain and Northern Ireland)]	reject. We chose to rather make clear where and how mineral resource exploitation in the Antarctic is prohibited
30987	3	85	21	85	22	Can these financial losses be quantified to give it more relevance? [Hans-Otto Poertner and WGII TSU, Germany]	no data on that. In fact there is limited data on cost of CC on oil and gas industry
5831	3	85	22	0		Remove "that" [Nina Hunter, South Africa]	done
30255	3	85	23	85	23	What do you mean by 'implications of seismic studies?' The last sentence in this paragraph is also unclear. [Christine Dow, Canada]	seismic can potentially have great impacts on tundra with PF.
19341	3	85	23	85	24	(E1a) This sentence references implications of seismic studies for climate change, but only mentions that there are knowledge gaps. Possible to enumerate on the existing interpretations of the data between knowledge gaps? Right now this sentence doesn't support any conclusion aside from there being gaps in understanding; what can be deduced despite the gaps? [APECS Group Review, Germany]	most studies on impacts of seismic on PF were done decades ago.
5833	3	85	31	0		Change "ensure" to "ensuring"; suggest change remainder of sentence after "ensuring" to: "the continued protection of natural resources in oil field operations" [Nina Hunter, South Africa]	done
5835	3	85	32	0		Change "temps" to "temperatures" [Nina Hunter, South Africa]	did not change since most will know what it means
5837	3	85	33	0		Insert "give" before "industry" [Nina Hunter, South Africa]	no change made
19325	3	85	36	85	36	This section on subsistence systems would follow more coherently from Section 3.5.3.1 Fisheries - Section 5.3.3.2-3 interrupt a logical flow between commercial harvest and subsistence harvest. [APECS Group Review, Germany]	changed as suggested
1043	3	85	36	86	41	I commend this section: succinct, clear, authoritative, accurate. Well done! [Henry Huntington, United States of America]	thank you
19329	3	85	38	85	39	The statement "engaging in the climate policy process at multiple scales of governance" is ambiguous - what does this mean? [APECS Group Review, Germany]	what it means is that tribes/first nations and other groups are now having to interact at the regional, national, and international levels concurrently
19331	3	85	38	85	39	The statement "limitations of many formal institutions ..." is ambiguous - what limitations of formal governance are the authors referring to, and how does that relate, to achieving "greater resilience of subsistence systems" as the authors subsequently suggest? [APECS Group Review, Germany]	limitations are addressed in various parts of the chapter and elsewhere in the report
19333	3	85	41	85	41	Why only regional to national? Coordinated approaches from community, regional/territorial, national and international policies are often required in polar regions where species are transboundary and migratory etc... [APECS Group Review, Germany]	that is true, however it is at these level that most policies are made
19335	3	85	44	85	44	Would be helpful to summarize the different categories here - otherwise the statement that there are many categories is rather moot. [APECS Group Review, Germany]	good point

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
19337	3	85	44	85	46	A supporting reference would be appropriate here (See work by Ford J. or Wesche SD) [APECS Group Review, Germany]	sorry can't include more references
30257	3	85	44	85	48	Specify what you mean by 'harvesting'. Generally assumed to mean agriculture but I think in this case you're referring to fisheries? [Christine Dow, Canada]	harvesting - hunting, fishing, gathering -- but commonly referred to has harvesting... and is part of a greater wildfood production system
19321	3	85	46	85	49	E2 - the Brinkman paper doesn't reference river navigability and subsequent changes to types of boats, changes to vessels for whaling, or these changes making an increase in fuel cost. The study is about adaptations for subsistence hunters to rising fuel prices, which have resulted in adaptations to hunting practices that minimise fuel usage, such as using motors with better fuel efficiency (going from two-stroke to four-stroke engines), ATVs instead of boats etc, along with other measures (multipurpose trips, consuming less country food etc.). The statement is not supported by this particular paper. [APECS Group Review, Germany]	changed to use correct reference Brinkman, T. J., W. D. Hansen, F. S. Chapin, G. Kofinas, S. BurnSilver and T. S. Rupp (2016). "Arctic communities perceive climate impacts on access as a critical challenge to availability of subsistence resources." Climatic Change 139(3): 413-427.
5839	3	85	47	0		Remove "to" after "shifting" [Nina Hunter, South Africa]	done
30269	3	85	47	85	48	How can you switch from a propeller boat to an ATV? [Christine Dow, Canada]	one abandons the use of a boat and hunts overland. this is the case with moose hunting and caribou where river travel becomes too difficult and costly
2023	3	85	50	85	50	The line reads: Savoonga, Alaska whalers reported limitations in harvesting larger bowhead whales. Rosales and Chapman 2015 paper cited refers to residents now going after "smaller whales" and turning to reindeer to sell ...see paragraph from Rosales and Chapman:It is increasingly difficult, for example, for whalers in Savoonga to haul out large bowhead whales (Balaena mysticetus) that can weigh over 40 tons on thinner ice. As a result, they are now going after smaller whales. Some residents of Savoonga are also turning to reindeer (Rangifer tarandus) meat to sell wholesale and within the village, and adding Pacific halibut (Hippoglossus stenolepis) to their diet to supplement the decline in marine mammals. Less preferred seal meat (ringed, spotted, and ribbon seals), common murre (Uria aalge) meat, and fish like Dolly Varden trout (Salvelinus malma) are now supplementing their diet as well. [Laura Eerkes-Medrano, Canada]	Points well taken. Unfortunatly we have to summarize and could not add that level of detail, albeit good stuff!
5841	3	85	51	0		the words "in future" could be removed as they are already pointed to in "anticipate" [Nina Hunter, South Africa]	done
19339	3	85	54	85	55	How does this relate to declining consumption of traditional/country foods across the Arctic? Literature shows that communities (in Alaska) rarely substituted one species for another (Hansen, 2013) - a commonly mentioned "adapation" measure to maintain country food production. It is possible and anecdotal but unsure what the evidence suggests in terms of confidence. [APECS Group Review, Germany]	Yes - "species switching" is the adaptive response used by Winslow. There are mixed reports -- e.g., the AACA for Davis Strait noted that in spite of difficulties, many are meeting their needs. Of course there are still issues of food security - real and perceived
19351	3	86	1	86	1	The statement "adaptation to non-harvesting aspects of wildfood" is ambiguous [APECS Group Review, Germany]	no harvesting refers to the other aspects of food production, other than hunting.
19353	3	86	1	86	1	Is there evidence to support increased use of household and community freezers? There are dynamics between household and community freezers, and government policies and programs that shape these factors heavily [APECS Group Review, Germany]	yes - it is a general pattern, but not true in all places
935	3	86	1	86	20	Reindeer Herding: It has a HUGE devastation and destruction all over the Arctic. In Alaska, genetic leakage occurred. None of those works are cited. Another bias. [Falk Huettmann, United States of America]	Devestation? from what? Overgrazing? Genetic mixing? Citations please

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
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19373	3	86	1	86	41	(E1a) This paragraph contains many grammar and language mistakes that cloud its clarity significantly. While this is indeed a copy-editing comment, there are so many issues in this paragraph that correcting it will take a bit of effort to ensure clarity. [APECS Group Review, Germany]	corrected
5843	3	86	2	0		Remove "an" [Nina Hunter, South Africa]	done
5845	3	86	3	0		Replace "And" with "In" [Nina Hunter, South Africa]	done
19355	3	86	3	86	3	Wherefrom comes the notion of the "abaondonment" of drying practices? I have not seen any evidence to support this (anecdotaly or from the literature). I think there are more culturally-sensitive ways to stating that drying practices are less practiced (without saying abandonment) - moreover, the statement should be qualified with confidence or a supporting reference should be provided. [APECS Group Review, Germany]	as noted: "in some cases"
19349	3	86	3	86	5	E2 - I disagree that the Loring et al 2016 paper supports the statement about increased emphasis on community self-reliance, such as community gardens. The paper itself does not have any mention of specific climate-related adaptations (like food production), but speaks about community work and policy/planners/city employees being more fully engaged with immediate concerns, and that "climate change, while a component, is not a driver of local initiatives". [APECS Group Review, Germany]	it does, however, refer to great issues of food security. Also see Gerlach, Craig, Philip A. Loring, Gary Kofinas, and Henry Penn. (2017), Resilience to Rapid Chang in Bering, Beaufort, and Chukchi Sea communities, Chapter 6 of Adaptation Actions for a Changing Arctic (AACAA) Bering/Chukchi/Beaufort Region Report. AMAP. 155-176.
19357	3	86	3	86	6	These sentences discuss agricultural subsistence systems - whereas up to here, the chapter has referred to wild/harvest based subsistence. The different types of subsistence systems should be clearly distinguished or contextualized - in particular, since agricultural systems are discussed with respect to food self sufficiency and there are important nuances in how Indigenous food sovereignty is conceptualized by communities [APECS Group Review, Germany]	Rejected. The sentence simply states a potential future option for increased agriculture at the southern limit of the Arctic - there is no need and more importatnly no evidence to elaborate on different systems in this context.
19359	3	86	3	86	6	The notion that "Climate change may" should be qualified with certainty [APECS Group Review, Germany]	reject; it is not possible to add confidence statement to this
19361	3	86	11	86	12	The text is very unclear [APECS Group Review, Germany]	done
19343	3	86	15	86	15	C5 / E1b - Section 3.5.4.9 is missing [APECS Group Review, Germany]	comment is not clear
19363	3	86	17	86	17	I would not attribute this only to Indigenous leaders - it's more appropriately Indigenous communities, organizations, leaders etc...). Phrasing as leaders only excludes the fact that this is a collective process at multiple levels for Indigenous Peoples [APECS Group Review, Germany]	leadership is an important part of all colletive processes. Communties of all kinds are not purely consensus based, even the most traditional communities
19345	3	86	17	86	32	C5 / E1b - all references to sections 3.5.5.2.2, 3.5.5.2.3 (line 24), 3.5.5.1 (line 29) and 3.5.6.1 (line 32) do not exist. These sections are missing. [APECS Group Review, Germany]	accepted, section references updated
1051	3	86	18	86	24	The breakthrough in indigenous involvement in adaptation came only with the Paris agreement and its local communities and indigenous peoples platform. Second, it is said that "which sit as 'permanent participants' of the Arctic Council, are involved in many of the AC's working groups", which should be complemented by the fact that permanent participants are involved in both the working groups but also in the political level, in senior arctic affairs officials meetings + ministerial meetings (so also in the political level, with lots of power of influence). [Timo Koivurova, Finland]	accepeted, change made
5847	3	86	19	0		Change "People" to "People" [Nina Hunter, South Africa]	unclear comment

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
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17335	3	86	19	86	19	Indigenous People needs to be plural - add an S to People [Joanna MacDonald, Canada]	accepted, change made
17337	3	86	21	86	23	It would be helpful to have information about WHO Arctic Indigneous Peoples are at the very beginning of this chapter. As noted here, Arctic Indigenous Peoples include Inuit, Sami, Athabaskan, Gwich'in, Aleut and Russian Indigenous Peoples as represented at the Arctic Council. Within the UNFCCC, the Arctic Indigenous Peoples caucus is often made up primarily of representatives from Inuit and Sami. The Arctic has a unique context in that there are fewer distinct Indigenous groups in the Arctic than other regions in the world, and as such it may be possible to include this as important contrextual information at the beginning of the chapter without taking up too much space. [Joanna MacDonald, Canada]	This is a climate assessment and we make the point prominely that the Arctic is the homeland of Indigenous peoples. Mentioning the names of all arctic culture groups and political orgs or indigneous peoples is beyond the scope. the AC PPs are spelled out.
1053	3	86	24	86	27	Greater involvement - why is there no mentioning of the most important devolution process, that of, self-rule of inuit in Greenland? [Timo Koivurova, Finland]	accepted . aspect added
19365	3	86	26	86	26	The Nunavut Act (1993) is separate from the Nunavut Land Claims Agreement (also 1993) - the text referes to land claims, and the example act should reflect that [APECS Group Review, Germany]	taken into account. here, we restrict the discussion to land claim agreements
19367	3	86	26	86	26	What is intended by a boundary organization? [APECS Group Review, Germany]	a common term in literature on sustainability and resilience - org that works across organizaitons - many networks orgs like this in the north now
5849	3	86	27	0		Remove second full stop after "organizations" [Nina Hunter, South Africa]	done
19347	3	86	31	86	31	E1a - the term "suggested preferences" is ambiguous. Suggest changing "suggested preferences" to "needs" or merely "preferences". [APECS Group Review, Germany]	accepted and actioned
19369	3	86	31	86	31	This perspective is somewhat dated - there has been considerable achievement in co-management with respect to the meaningful inclusion of Indigenous knowledge. Avoid the term "legitimacy" please. Science or conventional management regimes cannot "give legitimacy" to Indigenous knowledge and should not be phrased as such - whether Indigenous knowledge is meaningfully included is another story (which implicitly embodies whether the management system has deemed the information credible but that's not their role in any case) [APECS Group Review, Germany]	Reject. While some progress may have been made we believe that in more cases the statement as written is still true.
19371	3	86	34	86	41	Some of the phrasing and implications are problematic. For example "...co-management can give communities greater voice..."; "...gives Indigenous leaders experience as agents of change..." This phrasing presumes that Indigenous communities and leaders do not already have voice and experience. The issue is equitable recognition and participation ... these are not "opportunities" that arise from "challenge" they must be recognized as affirmations of existing agency. [APECS Group Review, Germany]	reject; not the point being made here
5851	3	86	38	0		Replace "identify" with "identity" [Nina Hunter, South Africa]	done
5853	3	86	39	0		Insert "in" before "turn" [Nina Hunter, South Africa]	done

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
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13877	3	86	45	87	6	Section 3.5.3.5 Reindeer Herding, is an activity restricted to the Arctic as no human population in the Antarctic [Government of United Kingdom (of Great Britain and Northern Ireland), United Kingdom (of Great Britain and Northern Ireland)]	yes. that is true. Do we suggest there is herding in the south?
5855	3	86	46	0		Insert "have been" before "constrained" [Nina Hunter, South Africa]	done
5863	3	86	47	0		Insert full stop after "2017)" [Nina Hunter, South Africa]	done
5857	3	86	49	86	52	Please could the sentence from "In Alaska ... driven by climate" be made more understandable. [Nina Hunter, South Africa]	done
5861	3	86	53	0		Remove "on the Yamal" [Nina Hunter, South Africa]	retaining language for clarity
5859	3	86	54	0		Change "migrations" to "migration" [Nina Hunter, South Africa]	done
29157	3	86	54	86	56	after "...to take their deer to other pastures." It would be appropriate to add a ref also to Golovnev 2018 which describes in details these strategies of changing the roads of grazing in 2015 and 2016 far adapting to climate change extreme events. (reference: Golovnev, A. 2018 Challenges to Arctic Nomadism: Yamal Nenets Facing Climate Change Era Calamities, Arctic Anthropology, vol 54, 2, pp.40-51.) [Alexandra LAVRILLIER, France]	added
5865	3	86	55	86	56	Replace "of avoiding" with "to avoid" [Nina Hunter, South Africa]	not needed
29155	3	86	56	87	6	For better representing the reality of reindeer herding and its variety, should be added something like: 'In eastern Siberian mountain regions, herders and hunters are well aware that topography and the snow typology are interconnected. Herders use the various topographies of their nomadic lands to adapt to anomalies in the snow cover and ensure that they can find better pastures for the reindeer (Lavrillier and Gabyshev 2017, 245). (Full reference: Lavrillier A. & S. Gabyshev, 2017 An Arctic Indigenous Knowledge System of Landscape, Climate, and Human interactions. Evenki Reindeer Herders and Hunters, Studies in Social and Cultural Anthropology, Kulturstiftung Sibirien, Fürstenberg/Havel, Germany 467p.) [Alexandra LAVRILLIER, France]	interesting information on strategy for responding but could not include these details because of lack of space
30993	3	87	0	87	6	This figure is really important. This is exactly the information needed to get policy makers' attention! [Hans-Otto Poertner and WGII TSU, Germany]	thanks
5867	3	87	1	0		Replace "to have" with "for having" [Nina Hunter, South Africa]	actioned
19383	3	87	1	87	3	with respect to herd privatization - this statement should be more clearly qualified. In the Inuvialuit Settlement Region, the herd is privatized for commercial purposes (and not for local Indigenous communities) - this is not a matter of adaptive management. [APECS Group Review, Germany]	the herd in that region has always been private. the issues of privatization related to events in Russia.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
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19391	3	87	4	87	6	(E1a) Expanded explanation of how restriction of reindeer to pastures will negatively interact with climate effects is needed. While the first part (restriction to pastures) connects to the previous sentences in the paragraph, the interaction with effects of climate is not spelled out. For instance, an example of how pasturization interacts negatively with some aspect of the changing climate could serve as a supporting sentence. [APECS Group Review, Germany]	unfortunately not enough space for exxpanded explanation
19385	3	87	10	87	11	What does "last-chance opportunities" mean, with respect to tourism? To my knowledge, this is not a commonly understood term by the public. A quick internet search reveals a number of documents and common use I suspect a large part of the readership will be unfamiliar. Moreover, this notion of "last-chance" and "vanishing" Arctic is inappropriate when you are referring to people's homes, ancestral territories etc.. [APECS Group Review, Germany]	it means people are going to see the arctic and antarctic before it is changed by CC
937	3	87	10	87	40	IAATO must be mentioned, but lacks teeth either way. Tourism is not managed at all really, Wild West and a Growth Industry. Must be cited [Falk Huettmann, United States of America]	unclear what is being suggested. IAATO is discussed in this section and beyond
5869	3	87	12	0		Suggest removing "with the travel" [Nina Hunter, South Africa]	thank you for the suggestion
5871	3	87	13	0		Remove "adequate" [Nina Hunter, South Africa]	thank you for the suggestion
5873	3	87	14	0		Change "culture" to "cultural" [Nina Hunter, South Africa]	done
15025	3	87	14	87	15	Please replace the sentence by: More and more Polar-class expedition cruise vessels are built for recreational Polar sea travel. Expedition cruise vessels have been built for decades already, the market is heavily expanding right now. It affects Arctic and Antarctic as well. [Government of Germany, Germany]	section modified
5881	3	87	16	0		"may improve sovereignty claims" - what is meant by this? [Nina Hunter, South Africa]	section modified
5875	3	87	17	0		Insert "the" before "public" [Nina Hunter, South Africa]	section modified
5453	3	87	18	0		"grow" should be "growth" [Michelle North, South Africa]	section modified
5877	3	87	18	0		Change "grow" to "growth" [Nina Hunter, South Africa]	section modified
5879	3	87	21	0		Suggest replacing "As well" with "In addition" or similar [Nina Hunter, South Africa]	section modified
19393	3	87	23	87	25	(E1a) The last two sentences in this paragraph state that efforts have been initiated to lower risks, and then that the next step now is to further develop those strategies, but no mention of what those possible strategies are. What came out of the initial efforts to determine strategies? [APECS Group Review, Germany]	section modified
5883	3	87	25	0		Suggest replacing "those" with "these" [Nina Hunter, South Africa]	section modified

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
9545	3	87	27	87	28	A large majority but not all tourism operators are Members of IAATO. Tourism companies can be members of IAATO on a voluntary basis. IAATO is an NGO and not an intergovernmental regulatory body. Moreover, only the numerous regulations on tourism already been adopted by the Antarctic Treaty Consultative Meetings are considered as international legal framework. This context should be presented at the beginning of the paragraph before speaking about IAATO. [Government of France, France]	Accepted. The revised paragraph now explains that tourism activities in the Antarctic are conducted in accordance with the the Protocol on Environmental Protection to the Antarctic Treaty, and that this is supplemented by industry self-regulation, coordinated by IAATO.
21383	3	87	27	87	28	The industry association is known as the International Association of Antarctica Tour Operators. Change 'Antarctic' to 'Antarctica'. This is not a typo but a matter of importance to the association that they are named properly. [Steven Chown, Australia]	Accepted.
15027	3	87	27	87	29	Please replace the sentence as follows: "For years the Antarctic Treaty Consultative Parties have struggled to agree on proper management regulations for tourism in Antarctica. Meanwhile the touristic activities in the Antarctic are coordinated by the International Association of Antarctic Tour Operators (IAATO) that has set up straight rules for its members to mitigate the impact of tourism." Rationale: the previous sentence doesn't really reflect the reality. [Government of Germany, Germany]	Taken into account. The revised paragraph more clearly reflects that industry self-regulation, coordinated by IAATO, supplements management by the Antarctic Treaty Parties. It also reflects differing views amongst Treaty Parties on the regulation of tourism activities.
32399	3	87	27	87	36	It is worth reflecting that IAATO is self-regulated and that it is not compulsory to be a member of IAATO if, for example, you are a yacht-tour. Thus, tourism is largely unregulated in Antarctica, aside from the benefits of environmentally sensitive self-regulation achieves for the current operations. [Andrew Constable, Australia]	Taken into account. The revised paragraph states that the Antarctic tourism industry self-regulates (under the coordination of IAATO) and the point that private yachts are mostly unregulated is reflected in section 3.2.4.2.
5885	3	87	29	0		Remove "use of" [Nina Hunter, South Africa]	Accepted. This sentence has been deleted in the revised draft.
9547	3	87	31	87	32	This is correct that all Parties do not have the same vision of tourism in Antarctica and how to regulate it, but this sentence is not 100% exact as a number of decisions and recommendations on tourism have already been adopted in the ATCM. We could say that there is no general rules and principles to regulate tourism in Antarctica but sparse and multiple regulations, especially for some sites particularly targeted by tourism operators. [Government of France, France]	Taken into account. The revised paragraph provides a clearer description of the ATCM's approach to managing tourism impacts in Antarctica.
30989	3	87	32	87	33	Though this statement might be true, it rather reflects a personal opinion and not the current state of scientific knowledge. I suggest deleting this sentence. [Hans-Otto Poertner and WGII TSU, Germany]	Accepted. This sentence has been deleted in the revised draft.
1055	3	87	32	87	36	It is stated that: "Climate change is a challenge because it is often considered as an external factor that can be dealt with from a scientific perspective. Legal basis applying are the Madrid protocol (Art. 3) requiring a minimization of adverse environmental impacts vs.global environmental regimes (such as ATS) to a greater extent". I do not understand why after global environmental regimes, ATS is given as an example, since ATS includes Madrid Protocol? [Timo Koivurova, Finland]	Taken into account. These sentences have been revised to improve clarity.
3987	3	87	32	87	36	I don't understand the meaning or significance of these sentences. [Stuart Chapin, United States of America]	Taken into account. These sentences have been revised to improve clarity.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

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21385	3	87	32	87	36	I found the last sentence of this section barely understandable. Perhaps more importantly the text does not reflect the fact that the Antarctic Treaty Parties held a meeting of experts about climate change in 2010 (see www.ats.aq), on that basis developed a climate change response work program within its Committee for Environmental Protection, and then enhanced the status of this work by designating a Subsidiary Group on the Climate Change Response Work Program. The evidence is in the Treaty Reports available from the URL just given. The close relationship forged by the Treaty parties with the International Science Council's Scientific Committee on Antarctic Research (SCAR) and their request for annual reports about climate change from SCAR to the Antarctic Treaty Consultative Meetings, further reflects the situation. As written the statements are inaccurate, and reflected also by the dated references. The section needs revision to reflect better what is actually being done by the Antarctic Treaty Parties. The report from the Beijing meeting in 2017 will help to show this. [Steven Chown, Australia]	Accepted. These sentences have been revised and the paragraph has been updated to better reflect what is being done by the Antarctic Treaty Parties.
5887	3	87	33	87	34	Suggest replacing "Legal basis applying are the Madrid protocol" with "The Madrid Protocol is the legal basis applied" [Nina Hunter, South Africa]	Taken into account. This sentence has been revised to improve clarity.
15029	3	87	33	87	36	Please modify the sentence. The meaning of this sentence is unclear. [Government of Germany, Germany]	Accepted. This sentence has been revised to improve clarity.
19375	3	87	33	87	36	E1a - this sentence does not make sense. It seems some words have been missed out. [APECS Group Review, Germany]	Taken into account. This sentence has been revised to improve clarity.
22485	3	87	33	87	36	Suggest clarifying the meaning of the language on the legal regime that applies, referred to in the referenced lines, noting that the Madrid Protocol falls within the Antarctic Treaty System. [Government of Australia, Australia]	Taken into account. This sentence has been revised to improve clarity.
15031	3	87	34	87	34	For better clarity, please use official name for the Madrid Protocol: "Protocol on Environmental Protection to the Antarctic Treaty" [Government of Germany, Germany]	Accepted.
5889	3	87	35	0		Suggest taking out "to a greater extent" to make this sentence understandable [Nina Hunter, South Africa]	Taken into account. This sentence has been revised to improve clarity.
3311	3	87	38	88	18	As mentioned in earlier comment another response is development of standards and guidelines for infrastructure design under a changing climate - see comment above for references for NISI standards and CSA guidelines. [Sharon Smith, Canada]	Noted
19381	3	87	38	88	18	E1b - there is no reference to Canadian or Scandinavian infrastructure in this section, perhaps because there is little literature on these areas. A statement acknowledging this, or alternative comment, should be included. [APECS Group Review, Germany]	Noted-circumpolar infrastructure impacts considered in 3.4 with regional examples given also in 3.5. Space limitations prevent a complete regional review
30991	3	87	38	88	18	Please indicate confidence /likelihood of key statements in this section [Hans-Otto Poertner and WGII TSU, Germany]	Accepted-confidence statements checked and updated
19387	3	87	40	88	18	This subsection would follow more coherently from the subsection regarding transportation [APECS Group Review, Germany]	Noted-header order determined in part by coherence with chapter as a whole
19389	3	87	40	88	18	This statement "The analysis of Melvin et al. (2017)" is not clear and lacks content for readership - what is Melvin's analysis? What region? What does it look at? [APECS Group Review, Germany]	Accepted-text updated

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
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3309	3	87	45	87	50	As mentioned above - some Arctic infrastructure such as buildings have limited lifetime and designed for operating life of <30 years given harsh environment etc. The infrastructure existing now will not be the same infrastructure that will exist after the middle of the century and newer infrastructure will most likely be built to higher standards. This all needs to be considered when determining cost. As mentioned above, infrastructure design will also determine impact of climate change [Sharon Smith, Canada]	Noted
5455	3	87	46	87	50	This information on the costs has been included previously (page 80, lines 15 - 16), please check in which section this fits best and try not to duplicate. [Michelle North, South Africa]	Accepted-two sections have been more clearly separated into impacts (3.4) and responses (3.5)
5891	3	87	47	0		Suggest changing "costs damages" to "damage costs"; change "estimated" to "estimate" [Nina Hunter, South Africa]	Accepted-text updated
5893	3	87	49	0		Change "is" to "are"; suggest remove "Estimates of" and start sentence with "Proactive adaptation measures" [Nina Hunter, South Africa]	Accepted-text updated
19377	3	87	49	87	50	E2 - □A reduction of greenhouse gases is a mitigation, not adaptation, measure. As the mitigation measures are noted in the previous sentence (lines 46-49), it seems this sentence is intended to reference the proactive adaptation measures. Also unsure where the 1.4 billion comes from (reduction of greenhouse gases gives a reduction of damage costs by 1.3 billion, and reduction of damage costs due to proactive adaptation measures depends on which RCP is being assessed - for RCP8.5: 5.5 billion reduces to 2.9 and for RCP4.5: 4.2 billion reduces to 2.3.) Suggested replacement: "Proactive mitigation measures (e.g. upfront investment and modification of infrastructure) are estimated to reduce damage costs by approximately half" [APECS Group Review, Germany]	Accepted-text modified for clarity
19379	3	87	51	87	53	C1- There is no reference for this statement. With the words "may be", should a confidence indicator be used? [APECS Group Review, Germany]	Accepted-text updated
19395	3	88	1	88	6	E1a - In caption: - important to note that this is only for Alaska. - make clear in the caption what the start date of each era is. e.g. does the era 2030 represent 2030-2049 or 2020-2039? Position of tick marks and x-axis labels imply the latter, but this should be made explicit. For redrawing the figure: - remove the x-axis labels (Era) or make them clearly differentiated from the title fonts. Suggest have a single x-axis label below the 5 subplots - have a single y-axis label to the left of the subplots - reposition and declutter text - suggest RCP4.5 comes before RCP8.5 [APECS Group Review, Germany]	Accepted-caption updated
5895	3	88	5	0		Change "y" to "years" [Nina Hunter, South Africa]	Accepted-caption updated
5897	3	88	9	0		Begin the sentence with "Twelve" instead of "12" [Nina Hunter, South Africa]	Accepted-text updated

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

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939	3	88	9	88	18	Economic Growth and Infrastructure is addressed by Huettmann, F. (2014). Economic Growth and Wildlife Conservation in the North Pacific Rim. Chapter 4. In: E. Gates and D. Trauger (eds). Peak Oil, Economic Growth, and Wildlife Conservation. Island Press. P. 133-156. [Falk Huettmann, United States of America]	Noted
5899	3	88	11	0		Replace "of" with "in" before "Alaska" [Nina Hunter, South Africa]	Accepted-text revised for clarity
5901	3	88	15	0		Change "threatened" to "threatened" [Nina Hunter, South Africa]	Accepted-typo corrected
19397	3	88	20	89	35	Issues of health equity (disparities in health status within the Circumpolar regions) should be explicitly addressed; particularly as health equity is stated to be a major challenge to future health equity on a global scale [APECS Group Review, Germany]	good point - but not the focus of this report.
5903	3	88	24	0		Insert "the" before "health" [Nina Hunter, South Africa]	section modified
5905	3	88	30	0		Suggest removing "described" as it seems unnecessary [Nina Hunter, South Africa]	section modified
941	3	89	1	89	35	Rabies is missing, see for instance Huettmann et al. 2017 for Alaska and 2100 [Falk Huettmann, United States of America]	reject; unclear how is related to climate change
19405	3	89	4	89	4	E2 - the Pearce et al 2011 paper was actually published in 2010. Will need to be 2010a or b, as there is already another Pearce et al 2010 paper. [APECS Group Review, Germany]	corrected
5907	3	89	5	0		Change "publically" to "publicly" [Nina Hunter, South Africa]	done
5909	3	89	6	0		Insert "the" before "USA" [Nina Hunter, South Africa]	section modified
19407	3	89	6	89	7	E2 - the Ford et al reference should be 2014a, not 2014b. [APECS Group Review, Germany]	done
5911	3	89	9	0		Insert "on" after "focused" [Nina Hunter, South Africa]	section modified
5913	3	89	13	0		Change 'outlined' to 'outline' [Nina Hunter, South Africa]	done
1057	3	89	13	89	15	It is said that Finland's federal adaptation strategy, but Finland is not a federal state, so this is likely national strategy. [Timo Koivuova, Finland]	done
5915	3	89	18	0		Replace "an" with "a" [Nina Hunter, South Africa]	section modified
5917	3	89	21	0		Change "increase" to "increased" [Nina Hunter, South Africa]	done
19403	3	89	21	89	25	E2 - The Austin et al 2015 reference does not support this statement, which is particularly about the range of local-scale adaptation efforts. These are not mentioned in this study. [APECS Group Review, Germany]	cut
5919	3	89	23	0		Change "promote" to "promoting" [Nina Hunter, South Africa]	promote works better thank you
5921	3	89	27	0		Suggest changing "for" to "relating to" [Nina Hunter, South Africa]	thanks

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
19409	3	89	28	89	28	E2 - It is not clear to me how the Loring et al 2013 paper supports this statement. The paper concludes a link between locally-caught seafood and food security, but makes no claim about how this may change with climate change. It is true that changes to the fish stock may affect local fisheries and therefore local food security (on the Kenai Peninsula), but I feel like this is not the message that this statement is making (which is about current high levels of food insecurity prompting worries about vulnerability to climate change impacts) [APECS Group Review, Germany]	cut
5457	3	89	28	89	29	"At the international level, the Arctic Council launched the 'One Health' initiative, an effort to advance understanding of" - this sentence is unfinished, please check [Michelle North, South Africa]	modified
19399	3	89	28	89	29	E1a - unfinished sentence [APECS Group Review, Germany]	modified
30995	3	89	28	89	29	Sentence seems incomplete. [Hans-Otto Poertner and WGII TSU, Germany]	modified
5925	3	89	28	89	35	Where is the reference for this last section? [Nina Hunter, South Africa]	addressed
23165	3	89	28	89	35	These sentences look like a "promotion" of an initiative rather than the outcome of an assessment. [Valerie Masson-Delmotte, France]	modified
30997	3	89	28	89	35	Is there a reference for the One Health initiative that you could provide? [Hans-Otto Poertner and WGII TSU, Germany]	included
5923	3	89	29	0		Sentence incomplete. Suggest removing "understanding of ... One Health is a particularly well-matched tool" [Nina Hunter, South Africa]	modified
33391	3	89	29	89	29	This paragraph ends without finishing its sentence. [Government of United States of America, United States of America]	modified
19411	3	89	29	89	30	The text ends abruptly here [APECS Group Review, Germany]	modified
19415	3	89	29	89	35	(E1a) There is a missing sentence or two in line 29-30. As such the clarity of this paragraph is diminished. Furthermore, the way this paragraph is structured (every sentence starts with "One Health..."; as such it seems like an endorsement or advertisement for One Health, but does not include an explanation of One Health's strategies for achieving its goals that are listed here instead. It is good to know these goals, but with the idea that this is supposed to represent steps organizations are taking to address health issues, it would be best to list the strategies employed to actually achieve the goals already laid out. [APECS Group Review, Germany]	modified
30259	3	89	29	89	35	The end of the paragraph on line 29 is missing. The next few sentences then sound like a pitch for One Health rather than being an unbiased report. [Christine Dow, Canada]	modified
19401	3	89	31	89	35	E1a - paragraph could be rewritten for ease of reading and clarity. Should be placed at the end of the previous paragraph, with the sentence on lines 28-29 removed. Suggested rewording: At the international level, the Arctic Council launched the 'One Health' initiative, an effort to advance understanding of health threats from the direct and indirect impacts of climate change in the Arctic. As a multidisciplinary approach, One Health strengthens coordination between and among a wide range of scientific disciplines and stakeholders, and enhances participatory community-based approaches for identifying and responding to health issues in communities, by taking into account Indigenous Knowledge and local knowledge. [APECS Group Review, Germany]	modified

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
19413	3	89	31	89	35	One Health is only one of many integrative/multidisciplinary paradigms of environment - human health (e.g. EcoHealth). It is important to distinguish between One Health (as a general framework) and the IPCC operationalization of One Health. That is, recognizing many different paradigms and because this one has been operationalized by the IPCC, can be highlighted (don't want IPCC to be a venue to advocate for a particular orientation towards integrative/interdisciplinary health approaches). [APECS Group Review, Germany]	modified
2025	3	89	32	89	32	Suggest to ammend the line to read: "...As a multidisciplinary approach that recognizes the interconnectedness of human health to animal and ecosystem health." https://www.sdwg.org/wp-content/uploads/2017/04/One-Health-Report-for-May-2017_final-SAO-edit.pdf [Laura Erkes-Medrano, Canada]	can't reference websites
5927	3	89	33	0		Change "stakeholder" to plural [Nina Hunter, South Africa]	done
9549	3	90	0	0		Table 3.7 could be further developped about polar fisheries. Moreover, it needs to be consistant with the results exposed in Chapter 5. [Government of France, France]	its a summary table and if we create more catagories here we would have to do more in other places
5929	3	90	0	0		Second block across, second block down: change "to" to "on" [Nina Hunter, South Africa]	reject; unclear comment
5931	3	90	0	0		Second block across, third block down: insert space before first bracket [Nina Hunter, South Africa]	done
5933	3	90	0	0		Second block across, third block down: replace semi-colon after "storage" with comma [Nina Hunter, South Africa]	done
5935	3	90	0	0		Fifth block across, third block down: change "serious" to "seriously" [Nina Hunter, South Africa]	done
5937	3	90	0	0		Third block across, fourth block down: change "insure" to "ensure" [Nina Hunter, South Africa]	done
5941	3	90	0	0		Third block across, fifth block down: what does "coms" stand for? [Nina Hunter, South Africa]	test modified
10147	3	90	0	0		the "future conditions" column in the "commercial fisheries" row needs some text on Arctic fisheries [Lisa Speer, United States of America]	text added
10149	3	90	0	0		the "other changes" column in "commercial fisheries" row should include impacts from industrial development (offshore oil and gas, transportation etc. made possible by climate change. [Lisa Speer, United States of America]	done
5171	3	90	0	91		Despite the extensive range of impacts described in prior sections, this table does not give a sense of the costs of the impacts and related responses - is it possible to add in an additional column to provide some guidance of the costs likely to be incurred (both impact and response)? [Debra Roberts and Durban Team, South Africa]	yes - hard to do in a table
5939	3	90	0	91		In all blocks full-stops at close not consistently used. Please make consistent. [Nina Hunter, South Africa]	thank you
5945	3	90	0	91		In all blocks semi-colons and commas not used consistently. Please make consistent. [Nina Hunter, South Africa]	thank you
23167	3	90	0	91		What is the level of scientific understanding in Table 3.7? What are the links to evidecne (publications, sections of text)? Use of confidence language? What are the publications supporting these responses? [Valerie Masson-Delmotte, France]	supported in text

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
3313	3	90	1	90	2	Shouldn't this table cover response to impacts resulting from changes in cryosphere and oceanin response to climate change rather than all climate change impacts which is what the title implies. [Sharon Smith, Canada]	mention added int text, not table
16927	3	90	1	90	2	In the table - for transportation (and to some extent for tourism) it would be good to note the fact that receding ice because of climate change is actually leading to more hazardous navatatinoal situaitons - and not just to increased accessibility for ships. If this can fit, it is an importnat point. [Jackie Dawson, Canada]	citation would be helpful here
19417	3	90	1	91	2	E1a- table 3.7. -In Documented Responses of Reindeer Herding: suggest inclusion of "supplemental feeding" - In Anticipated future conditions / level of certainty: the level of certainty is missing for all rows from "non-renewable resource extraction" - In Consequences of CC - Transportation: suggest including thawing of ice runways - In Documented response - Transportation: Believe "Increased risk of....requiring search as rescue" is better fitted into the "Consequences of climate change" category. - in Key Assets - Infrastructure: suggest including upfront investment in infrastructure [APECS Group Review, Germany]	thanks - some addressed
9551	3	91	0	0		Isn't « Infrastructure-urban and rural human settlement, year round » an « Arctic only » case ? [Government of France, France]	section was modified in final edition
9553	3	91	0	0		On the issue of Tourism, the quarantine procedures could be precised as biosecurity procedures. [Government of France, France]	did not have references for this assertion
5943	3	91	0	0		Third block across, seventh block down: "Damage" not "damaged" [Nina Hunter, South Africa]	done
5947	3	91	0	0		Fourth block across, ninth block down: replace "insure" with "ensure" [Nina Hunter, South Africa]	done
15033	3	91	1	0		In Table 3.7, 8th row (Tourism), first column (Consequence of climate change), please add "increase of touristic activities in quantity and quality". [Government of Germany, Germany]	done
16311	3	92	1	96	18	Please cover in more detail the overarching topic of loss & damage in this crucial section. [Alexander Nauels, Germany]	this should have been covered in the "impacts section"
19419	3	92	7	92	9	In paragraph 3.5.4, Multilevel Governance is described as analytical tool, while it can have both a systemic approach (analytical) combined with a user-experience approach, known as 'Design Thinking' or participatory approach (mentioned on page 98, line 39). This combination is called Systemic Design, and it is a tool which can be used for multilevel governance and creating policies, strategies and for developing comprehensive solutions for complex systems. I would like to refer to Helsinki Design Lab and their publication 'Recipies for Systemic Change', which can be found on the following link: http://helsinkidesignlab.org/pages/publications.html In order for multilevel governments to be innovative and make positive change, it is important to include the systemic design approach as a tool. [APECS Group Review, Germany]	Noted. We have not been able to identify peer-reviewed publications from this initiative that refer to the polar regions
5949	3	92	10	0		Change "difference" to "different"; remove "are" before "polycentric" [Nina Hunter, South Africa]	This section has been revised
32401	3	92	16	92	16	Governance of Subantarctic islands in the Antarctic area is by nations. [Andrew Constable, Australia]	Rejected. Governance in Subantarctic islans in the Antarctic area is by nations operating in an internaitonal context of the law of the sea provisions

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
5951	3	92	24	0		Insert "undertook a" or similar before "comprehensive"; insert "and" after "initiatives" [Nina Hunter, South Africa]	Accepted
5953	3	92	27	0		Insert "need to be" after "experts" [Nina Hunter, South Africa]	Accepted
5955	3	92	29	0		Replace "is" with "are" [Nina Hunter, South Africa]	Accepted
5957	3	92	30	0		Insert "need to" before "used"; insert "The" before "success" [Nina Hunter, South Africa]	Accepted
5959	3	92	32	0		Change "also noted" to "notes" [Nina Hunter, South Africa]	Accepted
5961	3	92	37	0		Remove "as" before "studies" [Nina Hunter, South Africa]	Accepted
19421	3	92	41	92	43	Could this statement be explained and supported more? Why is this the case? [APECS Group Review, Germany]	Accepted. Statement will be explained and reformulated
5963	3	92	42	92	43	Insert apostrophe after "Wejs"; suggest remove "in their case studies" from end of sentence and insert after "found" [Nina Hunter, South Africa]	Accepted
3711	3	92	45	92	47	sentence needs correction as recent election results change the accuracy of the statement; perhaps add the word "momentarily" before "reconstituted" in line 45; no need to mention Governor Palin. [Dee Williams, United States of America]	Accepted. The report has to be updated as much as possible
5965	3	92	48	0		Remove "of" [Nina Hunter, South Africa]	Accepted
31001	3	92	53	93	9	Please provide references. [Hans-Otto Poertner and WGII TSU, Germany]	Accepted
5967	3	92	56	0		Replace "and" before "helps" with "it" [Nina Hunter, South Africa]	Accepted
30999	3	93	3	93	4	In suggest deleting the first part of the sentence and focussing on the assessment carried carried out by the US. [Hans-Otto Poertner and WGII TSU, Germany]	Accepted
1059	3	93	3	93	5	It is said that "In spite of the US government's withdrawal from the Paris Agreement, the US is now completing it second National Climate Change Assessment". This should be refined since US has indeed announced its withdrawal, but this can take effect only in 2020, so a better formulation would be "decision to withdraw". It is also important to remember that the US is a party to the UNFCCC! [Timo Koivurova, Finland]	Accepted
33393	3	93	3	93	5	This sentence contains multiple factual inaccuracies. Moreover, characterizing the domestic actions of specific countries is not in the scope of this report. The sentence should be deleted. [Government of United States of America, United States of America]	modified
2027	3	93	4	93	4	Ammend the line to reflect that US has just released its Fourth National Climate Assessment. https://www.globalchange.gov/nca4 [Laura Eerkes-Medrano, Canada]	Accepted but we cannot cite the website
33395	3	93	4	93	4	The Fourth National Climate Assesment has been released, so can update the wording. [Government of United States of America, United States of America]	Accepted
3315	3	93	6	93	9	In addition to contributing to International Assessment such as AACA, the Canadian government also conducts national climate change assessments (3rd assessment currently in progress) the latest of which can be accessed at: https://www.nrcan.gc.ca/environment/impacts-adaptation10761 There is also the recent Transportation Risk Assessment that is available at the same web site [Sharon Smith, Canada]	Rejected due to problems of space

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
21387	3	93	29	93	32	The Seals Convention is basically moribund as everyone knows. So this example is not especially useful. What is perhaps much more innovative is that the Antarctic Treaty Parties wrote SCAR into their Protocol on Environmental Protection to the Antarctic Treaty - the most significant regime for environmental governance in the region along with the CAMLR Convention). Here's Article 10.2 of the Protocol: Antarctic Treaty Consultative Meetings shall review the work of the Committee and shall draw fully upon its advice and recommendations in carrying out the tasks referred to in paragraph 1 above, as well as upon the advice of the Scientific Committee on Antarctic Research. I would strongly advise replacement of the current text which will strengthen the example. [Steven Chown, Australia]	Accepted, we included this point
31005	3	93	29	93	32	Provide reference for this statement. [Hans-Otto Poertner and WGII TSU, Germany]	Accepted.
1061	3	93	30	93	32	It should be remembered that the Seals convention is not a living treaty... [Timo Koivurova, Finland]	Accepted.
1063	3	93	32	93	34	It is stated that "In the Arctic, the status of Permanent Participants has enabled the effective participation of Indigenous Peoples in the work of the Council (Pincus 34 and Ali, 2016). Here I would suggest a closer study on what their actual influence power is in the Arctic Council: Timo Koivurova and Leena Heinämäki, "The Participation of Indigenous Peoples in International Norm-making in the Arctic" in Vol. 42, No. 221, April 2006, Polar Record (pp. 101-109). [Timo Koivurova, Finland]	Accepted.
1065	3	93	42	93	44	It is said with medium certainty that precautionary approach is not achieved in polar governance. This is not backed up by literature references or why this is so, even if we now have fisheries agreement and polar code adopted, even if there are no activities in most of the regions which these instruments aim to regulate, so clearly precautionary. The overall conclusion might also be this since the most difficult problems of the Arctic can only be tackled via the global level, in any case... [Timo Koivurova, Finland]	Rejected. It is backed up by 2 ref. (Jakobsen, Hossain) and when it is stated "several authors" and a confidence statements it is not necessary to add ref. It is not because we have fisheries agreements and the Pola Code that conclusions should be that there is a successful application of the precautionary approach. It is also too early to evaluate the success or effectiveness of these new instruments.
5969	3	93	44	0		What does "manage in a precautionary approach" mean? Perhaps it could be stated in a more understandable way. [Nina Hunter, South Africa]	Accepted. A more accurate formulation explaining the management of PP is needed
1067	3	93	44	93	48	Normally OSPAR is treated as a model regime so this conclusion here is a real surprise to me? [Timo Koivurova, Finland]	Rejected. This is an example of vertical implementation/interactions and synergies between level of governance. In addition, even if it is true that OSPAR is treated as a model convention and it is actually working in several situation, it only applies North East Atlantic and present several gaps as a regional instrument.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
1069	3	93	51	93	55	<p>It is said that "With ice retreating and thinning, leading to easy access to natural resources, coastal states are increasingly using Art. 76 of the UNCLOS (Art. 76 53 UNCLOS; Verschuren (2013)), which relates to the extension of territorial jurisdiction, which states would acquire once they can demonstrate with scientific data that their continental shelf is extended. In that case they can enjoy sovereign rights beyond the Exclusive Economic Zone (EEZ)". It is somewhat odd to say that coastal states are increasingly using art. 76, when they are required to do so on the basis of law of the sea, UNCLOS, so it is not something where they would enjoy choice, but they need to make submissions to the Commission on the Limits of Continental shelf within a set timeline. I would say that Art. 76 does not relate to extension of territorial jurisdiction but extension of their continental shelf entitlement beyond the EEZ. It is also not said why scientific data is needed to be shown, and the reason is that there are rules under UNCLOS (and under the CLCS) how continental shelf can be extended (and hence for what reasons scientific data is needed). [Timo Koivurova, Finland]</p>	<p>Rejected. The concept is backed up by very solid literature and narrative In addition, it is not "odd" to say that increasing use of art. 76 since this is what is happening, including the phenomena of "creeping jurisdiction". But of course, it is possible to choose another way to express this. There is a trend of some Nordic States to illustrate the Arctic as "free of any risks of conflict" and a peaceful zone open to investment. According to Art. 76, Arctic States can submit to the CLCs (Commission on the Limits of Continental Shelves) data and info on the borders of their own continental shelf. The Commission, on the basis of geographical matters, submits recommendations (on the external borders of the platform), which are final and binding. Since all five Arctic states claim sea portions, there will be overlapping sovereignty claims. The Commission is not a legal body; it is a technical body and has no competence in case of conflicts. Conflicts on sovereignty issues could be solved with agreements among states or with an arbitral tribunal. If states cannot reach agreements, Art. 83 of UNCLOS refers to and expressly makes the link to Art. 38 of the Statute of the International Court of Justice to reach an "equitable solution" and in "good faith". This could stimulate cooperation between states but denotes also the absence of binding mechanisms to solve conflicts. Even if such mechanisms did exist, they could have no effect at all, since not all the states are part of UNCLOS (i.e.: the US is not part of UNCLOS).</p>
5971	3	93	52	93	55	<p>Write "Art." in full in the text [Nina Hunter, South Africa]</p>	<p>Accepted</p>

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
22487	3	93	52	93	55	<p>Suggest clarifying how this sections describes the nature of the continental shelf. Currently, the section misdescribes the nature of the continental shelf which coastal States are inherently entitled to under Article 77(3) of UNCLOS (see also North Sea Continental Shelf (Federal Republic of Germany v Denmark; Federal Republic of Germany v The Netherlands) [1969] ICJ Rep 3, 23 [19]). Coastal States exercise sovereign rights over the continental shelf for the purpose of exploring it and exploiting its natural resources (Article 77(2)) rather than it being an 'extension of territorial jurisdiction'. Article 76 establishes a special regime for the setting of outer limits of a State's continental shelf. Article 76(1) of UNCLOS states that '[t]he continental shelf of a coastal State comprises the seabed and subsoil of the submarine areas that extend beyond its territorial sea throughout the natural prolongation of its land territory to the outer edge of the continental margin, or to a distance of 200 nautical miles from the baselines from which the breadth of the territorial sea is measured where the outer edge of the continental margin does not extend up to that distance'. While the regime in Article 76 is complex, where a coastal State's continental margin extends beyond 200 NM, the outer limit is determined by reference to the continental margin. Articles 76(3)-(6) describe what does and does not comprise the continental margin, sets out two alternative approaches to calculate the outer edge of the continental margin and also sets out 'limit lines' beyond which the outer limits of the maritime zone of the continental shelf may not exceed. Such lines are not to extend beyond 350 NM from a State's baseline or 100 NM from the 2,500 metre isobath. Where a coastal State seeks to establish the outer limits of its continental shelf beyond 200 NM, in accordance with Article 76(8), it must submit to the Commission on the Limits of the Continental Shelf (CLCS) information on the limits of the continental shelf beyond 200 NM from the baselines from which the breadth of the territorial sea is measured. The CLCS shall make recommendations to coastal States on matters related to the establishment of the outer limits of their continental shelf. The limits of the shelf established by a coastal State on the basis of these recommendations shall be 'final and binding'. Consistent with Article 76(10) of UNCLOS which provides that these provisions are without prejudice to the question of delimitation of the continental shelf between States with opposite or adjacent coasts, Annex I of the CLCS's Rules of Procedure address submissions made in the case of a dispute between States with opposite or adjacent coasts or other cases of unresolved land or maritime disputes. [Government of Australia, Australia]</p>	<p>Accepted. Nevertheless the response of this comment depend on how comment 1069 from Timo Koivurova will be resolved. This is a sensitive diplomatic topic that need to be bery carefully pondered in terms of formulation. This comment is accepted partly to the extent that it will also be linked to comment 1069 to make it clear that when states make submission, they can only do that respecting the regulatory frame of UNCLCLOS which include the definition of Continental Shelf. It is not possible to write the hole Definition of Continental Shelf since we have a limit of space but everybody can check that definition by reading UNCLOS. However, it is important to make clear that this is "regulated" by the the of the sea.</p>
1071	3	93	55	94	2	<p>This continental shelf development is said to cause small danger of military clashes, but to my mind the likelihood is close to zero, but obviously this can be discussed... [Timo Koivurova, Finland]</p>	<p>Rejected. According to the Document "Guidance Note Uncertainty Language", IPCC your assessemnt "close to 0" means "exceptionally unlikely" 0-1% probability". Therefore the formulation chosen for the paragrahraph is correct and corresponding to the assessment of the reviewer. See for that point Table 1, page 3 "Likelihood scale p. 3".</p>

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
19423	3	93	55	94	2	This statement has been denied according to the recent publication 'Security in Northern Europe - Deterrence, Defence and Dialogue' by John Andreas Olsen (2018). Recently I went to a lecture by Dr. Olsen and other first-class experts within the Security & Defense sector of the Arctic. The reference which you mention in this paragraph is from 2013, and the security issues in the Arctic environment are rapidly changing. There is need for new approaches and solutions regarding security policies and strategies, especially in regard to NATO and Norway. The possibility of future military conflict is high, especially with the recent activities of Russia on the radar. [APECS Group Review, Germany]	Accepted. However, this comment seems to contradict comment 1069 from Timo Koivurova and depends on the interpretation it is desired to give to Art.76. Changing the interpretation will change the conclusion. The conclusion should of course be "politically correct". There is no "wrong interpretation of a treaty". There is controversial interpretation. In any case I agree with this comment However it is not possible to base the assessment on one article. In addition, the rule of law and high level of institutionalization in the High North let presume that risk of conflicts are close to zero as outlined in comment 1071. Arguing the way you suggest would mean take a position and be policy prescriptive (even if I repeat I agree with you) which is not the purpose of this report. In addition, "lectures" cannot be included as part of the references. There is a need to evaluate the literature of the last 5 years. Therefore, for an 100% objective assessment, the formulation will be changed a little bit but not totally in accordance to your suggestion which was nevertheless a valid one. It is not possible to take a political position.
1073	3	94	4	94	10	I do not understand how the Antarctic co-operation is occurring via UNCLOS or how polar code deals only with tourism? [Timo Koivurova, Finland]	Accepted. International Cooperation is occurring also in Antarctic and especially when dealing with environmental issues. Environmental law applies when dealing with "global commons". Article 197 of UNCLOS states that States have the duty to cooperate. What we do not know is if there are agreements between Arctic and Antarctic on the "levels of Standard of Cooperation" this has not been yet established. However, there is consensus that states must exercise good faith when fulfilling the duty of cooperation. The Polar Code is not dealing only with tourism! But it is clear in the sentence that this is the case. However, to make it really clear and crystal the word "general" will be added after the word "cooperation" so it is clear it applies to all resources.
9555	3	94	5	94	9	Rejected. NGOs is an institution and an informal actor. This section is on international cooperation and considers formal and informal actors. IAATO is important in this context and it is written that IAATO is an "International Association" not an international governmental body. [Government of France, France]	Rejected. NGOs is an institution and an informal actor. IAATO is important and we do not see the reason why we should remove it from the report just because of "labelling issues". It is written that IAATO is an "International Association" not an international governmental body.
9557	3	94	7	94	7	It is worth to mention that the Polar Code does not apply to every tourism vessel. Only ships above a certain capacity are concerned. [Government of France, France]	Accepted. This is an important detail.
21389	3	94	8	94	8	The industry association is known as the International Association of Antarctica Tour Operators. Change 'Antarctic' to 'Antarctica'. This is not a typo but a matter of importance to the association that they are named properly. [Steven Chown, Australia]	Accepted
9559	3	94	10	94	10	Could we here introduce that CCAMLR is also one of the main actor involved in MPA creation in antarctic ? [Government of France, France]	Accepted

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
21391	3	94	10	94	11	CCAMLR has not agreed to any climate change program and at its most recent meeting there was again no agreement to do so. The section is a little too positive about what is actually going on. Brooks et al. 2018 Nature or Brooks et al. Science make these points clearly. The CCAMLR reports and even its last external review do so too. [Steven Chown, Australia]	Accepted
5973	3	94	15	0		Suggest "to alleviate" instead of "alleviating" [Nina Hunter, South Africa]	Accepted
5975	3	94	18	0		Please explain "for vertical implementation to the polar oceans" - meaning unclear [Nina Hunter, South Africa]	Accepted
21673	3	94	21	0		If possible, add as follow(refer to the IMO website) IMO has adopted the International Code for Ships Operating in Polar Waters (Polar Code) and related amendments to make it mandatory under both the International Convention for the Safety of Life at Sea (SOLAS) and the International Convention for the Prevention of Pollution from Ships (MARPOL). The Polar Code entered into force on 1 January 2017. This marks an historic milestone in the Organization's work to protect ships and people aboard them, both seafarers and passengers, in the harsh environment of the waters surrounding the two poles. The Polar Code and SOLAS amendments were adopted during the 94th session of IMO's Maritime Safety Committee (MSC), in November 2014; the environmental provisions and MARPOL amendments were adopted during the 68th session of the Marine Environment Protection Committee (MEPC) in May 2015. [Government of Republic of Korea, Republic of Korea]	Rejected. However, it will be discussed if this suggestion could be moved to another section nor related to international cooperation for reasons of space.
21675	3	94	21	0		Add 'In October 2018, the five Arctic States (Canada, Denmark, Norway, Russia, and the United States) together with China, the European Union, Iceland, Japan, and South Korea signed the Agreement to Prevent Unregulated High Seas Fisheries in the Central Arctic Ocean in Ilulissat, Greenland.' [Government of Republic of Korea, Republic of Korea]	Rejected. We have problems of space. In addition, this description is already inserted in another subsection
15035	3	94	22	94	30	Please add the member states of the Arctic council (permanent participants, observers states) in order to correct the meaning of the sentence. If you only name the latest additions among observer states (line 29 to 30), the statement remains unclear. [Government of Germany, Germany]	Rejected. We have problems of space. In addition, this description is already inserted in another subsection
5977	3	94	23	0		Change "occurs" to "occur" [Nina Hunter, South Africa]	Accepted.
1075	3	94	25	94	26	It is stated that "The Council is an example of cooperation through soft law, a middle-way and unique meta-judicial institutional body". What does meta-judicial institutional body means - i have never heard such a term, so it needs to be opened up. [Timo Koivurova, Finland]	term deleted
19425	3	94	29	94	30	In addition to the mentioned observers of the Arctic Council that were granted this position in 2013, would it be good to mention the other observers that were granted this position before, to give a more complete overview? https://arctic-council.org/index.php/en/about-us/arctic-council/observers France (2000), Germany (1998), The Netherlands (1998), Poland (1998), Spain (2006), Switzerland (2017) and the UK (1998). Besides that, will there be any changes in this list with Brexit in mind? [APECS Group Review, Germany]	Rejected. Too descriptive for an assesemnt and we do not have sufficient space.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
21677	3	94	30	0		Add 'And Switzerland was newly admitted as an observer to the Council in 2017.' [Government of Republic of Korea, Republic of Korea]	Accepted.
30261	3	94	32	94	32	Despite lacking the role to enact hard law' sounds very critical [Christine Dow, Canada]	Rejected. This is the objective reality and an assessment of the current state of the art from a regulatory analysis as it would be conducted for any institutions operating in the legal and policy context. Why should the AC be treated differently in that respect?
1077	3	94	32	94	35	It is implied here that the Council enacted these legally binding agreements, which is incorrect. These were negotiated under the auspices of the Council (in its task forces) but they are independent from the Arctic Council so it is normally said that these agreements were negotiated under the auspices of the Council. [Timo Koivurova, Finland]	Accepted. I do not see the problem in using the term "enactment" From where the law would be produced if not by the AC? Enactment is a correct legal term that is used to describe the production of law from International Organization, States, Institutions or "meta-judicial institutions (The AC is not and international organization and it is not a State) and it does not possess legal personality. However, despite this "unique" nature it is allowed to "enact" law.
5979	3	94	34	0		Insert "that" after "indication"; change "responding" to "respond" [Nina Hunter, South Africa]	Accepted. Terminology will be changed
1079	3	94	37	94	38	the framework program is implemented by an expert group chaired by the chair of the Arctic Council. I think it would be appropriate to also mention that several observers take part in implementing this! [Timo Koivurova, Finland]	Rejected. Too descriptive for a report and there is space limitation
29063	3	94	40	94	40	Add, "...with an agreed goal of reductions in black carbon emissions of 25-33% by 2025 adopted at the May 2017 Ministerial." [Pam Pearson, Sweden]	Rejected. Problems of space
5981	3	94	42	0		Change "require" to "requires" [Nina Hunter, South Africa]	Accepted.
5983	3	94	46	0		Suggest "that apply" to replace "applying" [Nina Hunter, South Africa]	Accepted.
10777	3	94	48	94	53	In this context, it would be advised to mention that Arctic Council has a potential to encourage or at least inspire non-Arctic observer to the AC to be more engaged in the international developments focused on the climate change, both in the Arctic and global context. There is a forum for such cooperation between the chairmanship of the AC and the observers - it is called the Warsaw Format Meetings - where such exchanges could take place. This forum has not been yet studied but it was noticed in a policy paper (on page 2) available here: https://www.pism.pl/files/?id_plik=19746 [Michał Łuszczuk, Poland]	Rejected. Too descriptive. This is an assessment. In addition there is not sufficient literature yet that can justify the inclusion of this statement in an assessment report and it is not possible to use a web-link for that
10151	3	94	50	0		"Unlikely" seems the more appropriate conclusion. The literature cited makes the case that major strengthening is required. [Lisa Speer, United States of America]	Rejected. Language guidance of the IPCC has been used. The terminology has been accurately chosen and to be 100% objective
5985	3	94	51	0		Change "going" to "it goes" [Nina Hunter, South Africa]	Accepted.
1081	3	94	55	94	57	It is stated: "The future of the governance of the changing Arctic Ocean, including the role of the Council will also depend on the implications of the recent new agreement on the Conservation and Sustainable use of Marine Biodiversity of Areas beyond National Jurisdictions (BBNJ), signed in December 2017". This should be corrected because it is incorrect - the negotiations are now on-going but there is NO such agreement yet! [Timo Koivurova, Finland]	Accepted. We will insert as suggested

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
9561	3	94	55	95	2	The BBNJ treaty is not adopted yet. The 24th of December, the UNGA voted a Resolution to officially convene an Intergovernmental Conference and open negotiations to develop a legally-binding agreement under UNCLOS on the conservation and rational use of BBNJ. We suggest to modify by "...depend on the implications of the development of a new agreement ...". It is not yet sure the agreement will be adopted and the negotiations can still last long. [Government of France, France]	Accepted. The change has been inserted
5987	3	94	57	0		Please check that acronym "BBNJ" is correct [Nina Hunter, South Africa]	Rejected. We are sure that this is the correct acronym
5989	3	95	7	0		Remove "is" [Nina Hunter, South Africa]	Accepted.
1083	3	95	7	95	8	It is said "...a non-governmental organization is representing about 8 160,000 Inuit living in four Arctic countries, is the most active...". This requires a literature reference, if one is identifies as most active. [Timo Koivurova, Finland]	Accepted. Deleted the "most active" and inserted "very active"
5991	3	95	10	0		Replace "on" with "relating to" [Nina Hunter, South Africa]	Accepted.
5993	3	95	13	0		Replace "of" with "for"; replace "assists" with "will assist" [Nina Hunter, South Africa]	Accepted. More precise
5997	3	95	14	0		Insert "The" before "Inuit" [Nina Hunter, South Africa]	Accepted.
1085	3	95	14	95	17	It is stated: "Inuit Circumpolar Council along with other Indigenous organizations, do not have the right to vote at the Council, which limits its influence affecting the Council's resolutions and policies addressing new risks and uncertainties". Check above the source reference. In the practise of the Council, if all the PP's are against a decision, in practise this will not even be taken to decision-making. [Timo Koivurova, Finland]	Accepted.
5995	3	95	15	0		"Council" at the end of the line - does it refer to "Arctic Council". If so please insert "Arctic" [Nina Hunter, South Africa]	Rejected. Council refers to the AC and there is no need to insert the suggested change. The reason why there is no need to insert this change it is because we have already identified this body. See for that point page , 94, between lines 23-24 were we wrote "The Arctic Council (herein " the Council")"
5999	3	95	16	0		Replace "limits its influence affecting" with "limits its ability to influence"; insert "that" before "addressing" [Nina Hunter, South Africa]	Accepted.
943	3	95	19	95	27	ATS very poor as a section and as a tool anyways (just a subpanel on climate change) [Falk Huettmann, United States of America]	Taken into account. We have included more detail into this section. However, the purpose is here nto to describe the ATS but to show the nature of international cooperation
9563	3	95	22	95	23	We suggest to add to the sentence : "...would adress these matters, and recognize the importance of climate change in this area of interests." [Government of France, France]	Rejected. Sentence is fine as is, and editorially there is pressure to condense.
9565	3	95	23	95	25	This is the ATCM which recognized that. SGCCR is only a sub-group of some Parties particularly in charge of the communication, better implementation and monitoring of the CCRWP, but have no power of decision or recognition : it delivers advise to the ATCM. We suggest to modify the sentence to add the role of the SGCCR described in this comment. [Government of France, France]	Rejected. Sentence is fine as is, and editorially there is pressure to condense.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
6001	3	95	25	0		"replace "in" with "as"; suggest deleting "which recognized...interest" as it is unnecessary (information in name in line 24) [Nina Hunter, South Africa]	Accepted
9567	3	95	25	95	27	This is not the Committee for environmental protection which does not have a CCRWP but CCAMLR. Australia and Norway submitted a CCRWP to CCAMLR which looks similar to the one adopted under the ATCM but for CCAMLR matters and mandate. But consensus was not reached at CCAMLR. It is then an other CCRWP. We suggest to modify by: "As its last meeting however, CCAMLR was unable to adopt its own Climate Change Response Work Plan..." [Government of France, France]	Accepted.
15037	3	95	25	95	27	Please check the source (CCAMLR, 2017a) to the sentence since it seems to be wrong. The CEP including their subsidiary groups usually have nothing to do with CCAMLR Fishery reports [Government of Germany, Germany]	Accepted. Sentence checked and revised
21393	3	95	25	95	27	The sentence confuses the Antarctic Treaty Meetings with the CCAMLR meetings. The Antarctic Treaty Parties have agreed on a climate change response work program and to a Subsidiary Group in the Committee for Environmental Protection on the climate change response work program. By contrast, CCAMLR has not yet agreed to do anything about climate change. Thus change the sentence to: 'By contrast, CCAMLR, at its last meeting, was unable to agree...' [Steven Chown, Australia]	Accepted. Sentence has been changed accordingly
32403	3	95	25	95	27	Does this sentence refer to CCAMLR rather than the CEP. If so, it should present what CCAMLR has done over time separately from the CEP/ATCM. [Andrew Constable, Australia]	Accepted
6003	3	95	26	0		Should it not read "the group" instead of "the committee" [Nina Hunter, South Africa]	Rejected. Suggested terminology not sufficiently precise compared to the current in use
9569	3	95	27	95	27	We suggest to add "consensus on a work program will be needed at CCAMLR to achieve ..." [Government of France, France]	Accepted
6005	3	95	30	0		Please explain how climate change is facilitating access to natural resources? [Nina Hunter, South Africa]	Rejected. Already explained at page 93, lines 50-51 and in the previous sections antecedent 3.5.4.2

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
19427	3	95	30	95	40	Stating that the increasing access to natural resources may generate financial capital even for Indigenous Peoples is in my experience not supported. Could you give one or more examples of how you see this? During the time I was living and working with indigenous communities in the Arctic (Kiruna area - Sweden and Taymyr peninsula - Siberia) and from the speeches and conversations with indigenous peoples during Arctic conferences, they are mostly interested in preserving natural resources and they are against mining and other forms of exploitation, especially in the areas where they herd their reindeers. Their believe is that everything you take from nature, you will have to give back. Even in cases where mining companies offer indigenous peoples jobs and 'better lives', they are often suppressing their communities and traditional lifestyle. [APECS Group Review, Germany]	Rejected. I think that this comment is lacking of objectivity and it is not applicable to the current situation in adaptive governance and law. It indirectly "labels" Indigeneity and Indigenous People" as "victims" while choosing an "identity" for them which is not valid anymore Now they are active players in the Arctic climate change policy-making and law. Indigenous People are relevant in this report, in terms of adaption, indigenous knowledge and are new, emerging, non-official actors but this should not be instrumentalized or overemphasized, as it could become a "tool" to undermine the importance of other aspects or other states. A delicate balance is required. The label as victim is unfortunate. The suggested change is contradicting the line of assessment present in other important paragraphs of the section and it does not correspond to the current situation especially from line 12 to line 15. Now the future of Arctic governance depends on the growth and transformation of the AC. This includes Inuit co-management regimes that have been in place in the Arctic since 1970s and are example of the role of indigenous people as active players not passive and not victim, which would include at local level the Nunavut Wildlife Management Board (NWMB), the Alaska Eskimo Whailing Commission (AEWC). In addition, operational aspects at regional resource governance are indicative of this new trend if we think to the Best Practices in Ecosystem Based Oceans Management (Bepomar) which is an example of project that seeks to develop a strategic plan for co-management process in the Arctic (but there are a lot of other examples). In sum, labeling or making indigenous peoples appearing as "victims" makes them tools for territorial defense in the name of adaptation and reliance practices, even if sometimes there is no adaptation and no resilience to undertake. Sometimes the impact and damage of climate change is irreversible, so innovation is necessary instead.
21679	3	95	33	95	37	Delete paragraph 'This protection..... (Young, 2016).' [Government of Republic of Korea, Republic of Korea]	Rejected. We do not see the need to delete.
1087	3	95	35	95	36	It is said "and are negotiated with powerful non-state actors, such as China National Petroleum Company". There should be some other term used to convey that the company in question is very heavily the arm of a state. [Timo Koivurova, Finland]	Rejected. The suggested statement might create a diplomatic issue as there is a risk that it might clearly show a possible abuse of power and corruption ffrom China (i.e.Greenland).
6007	3	95	36	0		Suggest comma instead of semi-colon after "Company" [Nina Hunter, South Africa]	Rejected
6009	3	95	39	0		Insert "Arctic" before "Council during" [Nina Hunter, South Africa]	Rejected for the same reason explaine in the comment n. 5995

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
9571	3	95	42	95	46	The Committee for the Environmental Protection is not a Subsidiary Group. It is a body created by the Madrid Protocol under the Antarctic Treaty which deliver advise to the ATCM. The Subsidiary group on CC is just a group created by the CEP of several Parties which have the lead to suggest actions to implement the CCRWP, but it is not an institutional body as the CEP. We suggest to modify by "through the CEP and its SGCCR". [Government of France, France]	Accepted. Good suggestion. Thank you
9573	3	95	44	95	45	It is a bit awkward to emphasise here the role of IAATO because it is an Observer to the ATS but so is for example ASOC which is doing a very important work for the protection of the Antarctic environment. Or WMO, IPCC (!) etc. We suggest to delete IAATO and to add "Observers to the Antarctic Treaty consultative meeting". [Government of France, France]	Rejected. We are emphasising the role of non-official actors not the quality of "observer"
6011	3	95	49	95	50	Change "progress has been done to understand" to "progress has been made in understanding" [Nina Hunter, South Africa]	Accepted.
31007	3	95	49	95	51	This second half of this sentence (" and progress has been done...") is very vague and would be much stronger with some more details. [Hans-Otto Poertner and WGII TSU, Germany]	Accepted. The sentence has been deleted
6013	3	95	54	0		Insert "Arctic" before "Council"; how are "informal actors" defined?; replace "of" with "in"; insert "the" before "decision-making" [Nina Hunter, South Africa]	Rejected. They are distinct informal actors. Like saying "other" in another way
6015	3	95	55	0		Who are "distinct actors"? [Nina Hunter, South Africa]	Accepted. Changed in "different"
21681	3	95	57	0		replace(CCI) to (CCU) [Government of Republic of Korea, Republic of Korea]	Accepted. Thank you; very useful
11225	3	96	6	96	10	Within the Antarctic Treaty System, several non-state actors play a major role in providing advice and influencing the governance of Antarctica and the Southern Ocean. Among the most prominent actors at the Antarctic Treaty Consultative Meetings are formal observers such as the Scientific Committee on Antarctic Research, and invited experts such as the International Association of Antarctica Tour Operators and the Antarctic and Southern Ocean Coalition. My suggestion is: Within the Antarctic Treaty System, several non-state actors play a major role in providing advice and influencing the governance of Antarctica and the Southern Ocean. Among the most prominent actors at the Antarctic Treaty Consultative Meetings are formal observers such as the Scientific Committee on Antarctic Research (SCAR), and invited experts such as the International Association of Antarctica Tour Operators (IAATO), the Antarctic and Southern Ocean Coalition (ASOC), Council of Managers of National Antarctic Programs (COMNAP) and Southern Ocean Observation System (SOOS). [Burcu Ozsoy, Turkey]	Rejected. The suggested paragraph is good but make the text longer and we have problems of space. We will need to reduce substantially this section
6017	3	96	11	0		Insert "the" before "Antarctic" [Nina Hunter, South Africa]	Accepted.
6019	3	96	12	0		Insert "the" before "International"; insert "the" before "Scientific" [Nina Hunter, South Africa]	Accepted

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
9575	3	96	18	96	18	We suggest to specify that SGCCR was "created under the CEP". [Government of France, France]	Taken into account. The requested information is included, but two paragraphs earlier
23169	3	96	20	0		Harmonize wording : climate resilient development pathways. Missing interplay with SD/SDs. [Valerie Masson-Delmotte, France]	thank you - modified- This section has been significantly revised
945	3	96	20	96	20	That section is plain silly, please delete. Nobody uses such things and its outdated, not science [Falk Huettmann, United States of America]	Reject; we respectfully disagree
31003	3	96	22	96	26	Please remove such specific references to glossary. [Hans-Otto Poertner and WGII TSU, Germany]	thank you - modified- This section has been significantly revised
6021	3	96	23	0		Insert "as" before "one" [Nina Hunter, South Africa]	thank you - modified- This section has been significantly revised
6023	3	96	25	0		Change "achieves" to "achieve" and change "goals" to "goal" [Nina Hunter, South Africa]	thank you - modified- This section has been significantly revised
6025	3	96	26	0		Change comma before "Resilience" to full stop [Nina Hunter, South Africa]	thank you - modified- This section has been significantly revised
6027	3	96	32	0		Remove "all" [Nina Hunter, South Africa]	thank you - modified- This section has been significantly revised
31009	3	96	36	96	36	On what is this conficende statement based? On this single publication? [Hans-Otto Poertner and WGII TSU, Germany]	thank you - modified- This section has been significantly revised
21395	3	96	38	97	23	The absence of any statements about the exceptional knowledge co-production and integration activities in the antarctic is a substantial failing here. The works by Kennicutt et al. 2014, 2015, 2016 have already been cited, but they demonstrate just how close the integration for the region is. So too does the work by: Hughes KA, Constable A, Frenot Y, López-Martínez J, Mclvor E, et al. 2018. Antarctic environmental protection: Strengthening the links between science and governance. Environmental Science & Policy 83:86-95. The fact that SCAR is written in to the Protocol on Environmental Protection to the Antarctic Treaty is a further example. At the Polar2018 meeting, many of those working in the Antarctic expressed their amazement at the close integration and knowledge co-production in the Antarctic. This report is remiss in not highlighting the situation. [Steven Chown, Australia]	thank you - modified- This section has been significantly revised
33397	3	96	44	96	46	"epistimological orientation of what is known and how it is known". What does sentence even say? Also, "Epistomology" is "how something is known" so that would be redundant. [Government of United States of America, United States of America]	thank you - modified- This section has been significantly revised
6029	3	96	45	0		Insert "of" before "actors" [Nina Hunter, South Africa]	thank you - modified- This section has been significantly revised
6031	3	96	49	0		Replace "/" with a comma; change "identification" to "identifying", remove "of", remove semi-colon and replace with comma [Nina Hunter, South Africa]	thank you - modified- This section has been significantly revised
6033	3	96	50	0		Insert "the" before "understanding and "of" before "causality" [Nina Hunter, South Africa]	thank you - modified- This section has been significantly revised
19429	3	96	53	96	55	There is in my experience also international cooperation of monitoring and research in the Arctic, such as the organisation INTER-ACT is doing. Is it possible to say 'and the international cooperation of Arctic and Antarctic monitoring and research' instead? [APECS Group Review, Germany]	was only able to include some examples
6035	3	96	54	0		Change "Antarctica monitoring and research" to "monitoring and research in Antarctica" [Nina Hunter, South Africa]	thank you - modified- This section has been significantly revised

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
6039	3	97	1	0		Remove "\" [Nina Hunter, South Africa]	removed
19431	3	97	4	97	5	The new technologies you mention are limited to camera-equipped GPS and 'the' phone apps. Which phone apps do you mean? Is it possible to include more background information? [APECS Group Review, Germany]	no - nnot enough room to elaborate - wee reference for examples
6037	3	97	5	0		Remove "the" [Nina Hunter, South Africa]	done
19433	3	97	12	97	14	It is stated that it is proven that executing community based monitoring is labour intensive and hard to sustain. Is there more background information about this available which can support this statement? There are new technologies available which make the issues that are stated much easier, such as from space agencies and their spin-offs. [APECS Group Review, Germany]	see references; labor intensive at the local and regional levels.
6041	3	97	15	0		Change "process" to "processes" [Nina Hunter, South Africa]	ok
19435	3	97	17	97	23	The possible outcomes that are stated are in my experience based on negative future scenarios only, which includes fear. Would it be good to include a possible positive outcome too, to increase the chances that those positive outcomes will happen? Integration of knowledge- and technology transfer practises on all levels for example and a cross-disciplinary systemic design approach can play an important role in developing innovative and positive outcomes, both locally and internationally. A good example of a Knowledge- and Technology transfer organisation on governmental level with positive outcomes is KTI (Knowledge Transfer Ireland) https://www.knowledgetransferireland.com/ [APECS Group Review, Germany]	yes - "backcasting" thank you - modified- This section has been significantly revised
31011	3	97	20	97	23	On which literature is this assessment with high confidence based? Please ensure traceability back to the literature. [Hans-Otto Poertner and WGII TSU, Germany]	thank you - modified- This section has been significantly revised
6043	3	97	23	0		Change "insure" to "ensure" [Nina Hunter, South Africa]	corrected
5173	3	97	25	0		This section carries a critical message that should be included in the ES. [Debra Roberts and Durban Team, South Africa]	KMs changed
32405	3	97	25	97	25	Constable et al 2017 (already included in references) shows the link between science and policy in a feedback system that will assist in considering how climate change risks can be actively considered in policy and how policy can frame science needs. [Andrew Constable, Australia]	thank you - modified- This section has been significantly revised - hard to include all great references
6045	3	97	27	0		Polling of which population? [Nina Hunter, South Africa]	see reference
19437	3	97	27	97	27	Was the double mention of post-truth correct, or did you mean something else? Would it be more clear to put 'or even post truth' in brackets? [APECS Group Review, Germany]	yes thank you - modified- This section has been significantly revised
9577	3	97	30	97	34	This is not so true for Antarctic as the main decision-making bodies (ATCM and CCAMLR) are supported by the CEP (ATCM) which is composed by scientists, policy-makers and representants of National antarctic program and by the Scientific Committee (CCAMLR) which is composed by scientists from all Parties, which can speak on their behalf and not for a country. [Government of France, France]	thank you - modified- This section has been significantly revised

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
3713	3	97	34	97	34	to enhance clarity, add the words "from officials" to end of sentence [Dee Williams, United States of America]	thank you - modified- This section has been significantly revised
6047	3	97	36	0		Is this a direct quotation? If so requires double quotation marks and page number in reference [Nina Hunter, South Africa]	thank you - modified- This section has been significantly revised
3715	3	97	44	97	44	to enhance clarity, add the word "solution" before visualization, add the words "scenario planning" before "and decision theaters". [Dee Williams, United States of America]	taken into account. added these elements
21397	3	97	48	97	56	The paragraph may be accurate for the Arctic, but it does not reflect the situation for the Antarctic. For example, SCAR scientists have been engaged actively in discussions which have substantially changed Antarctic policy, and indeed in many instances SCAR scientists have led the way. Perhaps the best example in the context of the SROCC is the Antarctic Climate Change and Environments Report by Turner et al, which then led to the Antarctic Treaty's meeting of experts on climate change, which included SCAR scientists. In turn this led to the Climate Change Response in the CEP and the subsidiary group and Antarctic scientists continue to participate in those. This paragraph as it stands reflects a situation that does not pertain to the Antarctic and needs revision to be more accurate and less a statement that one sees repeated everywhere with little critical appraisal. [Steven Chown, Australia]	Taken into account. This section has been revised
33399	3	97	48	97	56	Key Takeaway Message: The idea that scientists need to better understand stakeholder needs and provide decision support. But it's kind of buried here. It doesn't show up in the Executive Summary or SPM. This theme may warrant greater visibility. [Government of United States of America, United States of America]	thank you - modified- This section has been significantly revised
19439	3	98	3	98	5	We are always in conditions of uncertainty. Systemic design (big system thinking) can be a tool to create future scenarios for all levels, so adaption to unforeseen conditions will be easier and more accurate. [APECS Group Review, Germany]	good point - thank you - modified- This section has been significantly revised
6065	3	98	9	0		Remove "of" after "how" [Nina Hunter, South Africa]	thank you - modified- This section has been significantly revised
6067	3	98	10	0		Suggest insert "and" before "while" [Nina Hunter, South Africa]	thank you - modified- This section has been significantly revised
21399	3	98	15	98	17	The Liggett et al. (2017) work does sketch out a few scenarios, but what's missing here is the analysis by Rintoul et al. (2018 Nature) that does so specifically in a climate change context, considering both changes and governance responses. To characterize scenario planning as being in the early stages for the region takes a narrow view of strategic foresight approaches and is not in keeping with many developments (see e.g. Cook CN, Inayatullah S, Burgman MA, Sutherland WJ, Wintle BA. 2014. Strategic foresight: how planning for the unpredictable can improve environmental decision-making. Trends in Ecology and Evolution 29:531-41). In this regard the work by Chown SL, Lee JE, Hughes KA, Barnes J, Barrett PJ, et al. 2012. Challenges to the Future Conservation of the Antarctic. Science 337:158-9 is a useful early example, and so is the work referred to in the document by Kennicutt et al. 2014, 2015, 2016. The sentence requires revision to reflect the actual situation. [Steven Chown, Australia]	there are many great references - could not include them all as SROCC restricted total numbers
6049	3	98	23	0		Remove "it" [Nina Hunter, South Africa]	thank you - modified- This section has been significantly revised

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
6051	3	98	30	0		Remove "of" [Nina Hunter, South Africa]	thank you - modified- This section has been significantly revised
6053	3	98	33	0		Should it not rather be "Flynn et al's (2018) review"? [Nina Hunter, South Africa]	done
6055	3	98	34	0		Replace "scenarios" with "of scenario" [Nina Hunter, South Africa]	section modified
6057	3	98	39	0		Was "analysis" meant instead of "analytical"?; change "enhancing" to "enhance"; insert "the" before "potential" [Nina Hunter, South Africa]	thank you - modified- This section has been significantly revised
6059	3	98	40	0		Change "informing" to "inform" [Nina Hunter, South Africa]	thank you - modified- This section has been significantly revised
6061	3	98	54	0		"The first" what? [Nina Hunter, South Africa]	thank you - modified- This section has been significantly revised
6063	3	98	55	0		Insert "the" before "sustainable" [Nina Hunter, South Africa]	thank you - modified- This section has been significantly revised
23173	3	99	0	99		Link to climate change missing in Table 3.8. Why here, what is specific to SROCC? [Valerie Masson-Delmotte, France]	table deleted
1089	3	99	17	99	18	It is stated: "At national and international scales, two stewardship strategies have emerged in polar regions. One is to reduce global pressures that drive arctic climate change by reducing rates of greenhouse gas emissions". I do not think we can say that global strategy is polar region strategy... [Timo Koivurova, Finland]	thank you - modified- This section has been significantly revised
9579	3	99	17	99	18	This sentence can also apply to Antarctic. [Government of France, France]	thank you - modified- This section has been significantly revised
23171	3	99	17	99	25	Is this paragraph a conclusion or is it missing references supporting the assessment? Not clear. [Valerie Masson-Delmotte, France]	thank you - modified- This section has been significantly revised
21401	3	99	24	99	25	The sentence about the Antarctic is fair enough, but misses the point that the system is really not managing to keep up. The point is made by Liggett et al. 2017, by Hemmings in various papers, and demonstrated by the Chown et al. (2017 PLoS Biology) analysis which demonstrated that the situation in Antarctica and the Southern Ocean, as far as biodiversity conservation is concerned, is about the same as that for many regions globally. [Steven Chown, Australia]	thank you - modified- This section has been significantly revised
31013	3	99	24	99	25	Provide reference for this statement or provide link to the section where the information based on which this assessment has been made is provided. [Hans-Otto Poertner and WGII TSU, Germany]	Accepted. Section reference added
24005	3	99	32	100	7	Table 3.8 and the conclusions on resilient pathways could include the reduction of the main causes of climate change, and not refer to oil and gas industry only in terms of increased operational costs [Patricia Martinerie, France]	thank you - modified- This section has been significantly revised
6083	3	100	5	0		Change "represents" to "represent" [Nina Hunter, South Africa]	done
23175	3	100	5	100	16	I suggest rather to have key findings at the end of each section / subsection rather than this conclusion that lacks substance and confidence language. [Valerie Masson-Delmotte, France]	done
6069	3	100	8	0		Insert "to" before "harvesters" [Nina Hunter, South Africa]	thank you - modified- This section has been significantly revised
6071	3	100	9	0		Insert "and" before "in" [Nina Hunter, South Africa]	thank you - modified- This section has been significantly revised

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
6073	3	100	10	0		Insert "to" before "cases" and remove "of"; remove "support of" [Nina Hunter, South Africa]	thank you - modified- This section has been significantly revised
6075	3	100	11	0		Change "livelihood" to "livelihoods" [Nina Hunter, South Africa]	thank you - modified- This section has been significantly revised
31015	3	100	11	100	16	Please try to be less emotive and use neutral language. And please take care not being policy prescriptive. [Hans-Otto Poertner and WGII TSU, Germany]	section deleted - thank you
6077	3	100	16	0		Insert "and" after "experiment" [Nina Hunter, South Africa]	section deleted - thank you
31075	3	100	19	0		Please add knowledge gaps with regard to biodiversity [Hans-Otto Poertner and WGII TSU, Germany]	Accepted; now included
31077	3	100	19	0		You indicated in the earlier text knowledge gaps with regard to methane emissions from coastal and ocean permafrost, please add here [Hans-Otto Poertner and WGII TSU, Germany]	Accepted; now included
33401	3	100	19	100	19	Readers could benefit from a discussion of the knowledge gaps for each section of the chapter. This section could help inform research directions for governments and Arctic and Antarctic science teams. [Government of United States of America, United States of America]	Taken into account; with very limited space, we cannot provide detailed section-by-section discussion of knowledge gaps, however we have structured the paragraphs to mirror the section flow.
947	3	100	19	100	51	Lacks entirely the concept of moving away from Carbon and Fuel society, again [Falk Huettmann, United States of America]	Noted; the section relates to knowledge gaps.
33403	3	100	19	101	19	This section does well at identifying the key gaps, but it seems like it should have more on addressing those gaps. For example, snow depth on sea ice is essentially unmeasured, so then how should one get the measurements? Should there be more in situ observation platforms, could satellite data work (e.g., ICESat-2, CryoSat-2)? Same with land SWE. Yes there is a gap, but how could that gap be filled? Thoughts on how these gaps will be filled in the future would be useful. [Government of United States of America, United States of America]	Reject. We are precluded from being prescriptive - our role is to flag the gaps, and the consequences of those gaps, it is then up to policymakers/funding agencies/etc to make decisions concerning whether/how those gaps should be addressed.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
33405	3	100	21	101	19	Overall, the section on key knowledge gaps and uncertainties is quite thin. There are certainly more uncertainties such as the role of atmospheric variability on the cryosphere and ocean circulation that are not found here. It appears we know everything there is to know about Arctic sea ice evolution and how it may or may not influence the broader circulation. Knowledge of the polar surface energy budget is severely lacking with significant implications to the cryosphere. Moreover, one of the largest uncertainties in climate projections is the inter-model spread in Arctic Amplification. Climate models disagree more about how much the Arctic is going to warm than anywhere else. This is not mentioned. Recommend a more detailed and comprehensive discussion of the uncertainties than is currently given. This section has the potential to be the most useful and impactful section of the entire 174-page chapter. A synthesis of the results and a future direction can guide future research investment. A broader comment is that only uncertainties in single areas, such as Snow depth or glacial mass balance, are stated; it would be beneficial to examine the interactions between the atmosphere, ocean, sea ice, and land ice (the polar climate systems) as a key uncertainty. Researchers know much more about how these individual sub-systems operate than they know about how they interact. Lastly, there are statements about how "longer quantifications" of cryosphere changes are needed. Questions to consider...are the current observations accurate enough or are advancements in measurement science required to detect the important changes going forward? What specific observations are needed to address the outstanding science questions? How long do the records need to be? [Government of United States of America, United States of America]	With reference to the point on interactions: Taken into account. We have added the point on knowledge gaps pertaining to the interactions between cryosphere, ocean and atmosphere in the polar regions, noting also explicitly that our chapter does not have a mandate to assess atmospheric processes in detail. While we therefore cannot discuss associated knowledge gaps we mention that these are important for climate change assessments. With reference to the suggested adoption of additional details that inform disciplinary research programmes: reject. We cannot go into full detail concerning each, nor expand on how they could/should be addressed - this would veer toward being policy prescriptive, and this is not our remit. The combination of key gaps highlighted here plus varying levels of confidence ascribed to key messages in the Executive Summary denotes the extent to which we are able to address this"
2797	3	100	26	100	26	If the observed changes are driven by internal variability, we don't expect climate models to reproduce them. Changes in Antarctic sea-ice are generally within the spread of CMIP5 models, and hence not inconsistent with internal variability (e.g. Swart et al. 2013). [Neil Swart, Canada]	Noted. There are however, still marked knowledge gaps relating to processes that control the Antarctic sea ice evolution, how that will progress in future as external forcing increases, and the extent to which models will be able to reproduce this.
6079	3	100	32	0		Suggest insert "is" before "a" [Nina Hunter, South Africa]	Accepted and actioned
388	3	100	37	100	42	I would add to key uncertainties: fine-scale permafrost mapping, with implications for hydrologic cycle and ground stability for hard infrastructure. [Ethan Kyzivat, United States of America]	Noted; we have mentioned permafrost more overtly in the revised version.
27561	3	100	37	100	42	It would be highly beneficial to identify specific regions with the least amount of knowledge for both polar regions. Eg. southern Weddell Sea, CAO and regions dominated by Arctic MYI. [Benjamin A. Lange, Canada]	Reject; with finite space available, this is not possible.
6081	3	100	38	0		Change "is" to "are" [Nina Hunter, South Africa]	Taken into account; sentence revised
23179	3	101	0	102		Text to be more explicit on what is observed and what is projected. What are the consequences for fisheries (+ or -)? Check for prescriptive aspects (implementation... will lower impacts...). Irreversible loss could be highlighted. What about risks of abrupt ocean change? Irreversibility? the sentence on "cooling effect of polar regions on global climate" is not scientifically rigorous. [Valerie Masson-Delmotte, France]	Taken into account. We believe the reviewer is referring to the FAQ, not the Key Gaps, and has misquoted the line numbers and section reference. The FAQ has been revised and iterated extensively, in collaboration with IPCC Communications Experts, addressing some of the aspects mentioned
12203	3	101	2	101	8	The quantification of ocean forcing impacts on polar ice sheets and glacier requires better understanding also. [Dorothee Vallot, Sweden]	Taken into account; this is implicit in the statement concerning where mass losses are greatest

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
15575	3	101	3	101	3	'longer quantifications' should be 'longer and improved' quantifications. One example is that when using GRACE for mass change detection there is still (in some regions) a quite large uncertainty on the glacial isostatic adjustment signal, [EUCE, Belgium]	Accepted; change made
16903	3	101	3	101	3	'longer quantifications' should be 'longer and improved' quantifications. One example is that when using GRACE for mass change detection there is still (in some regions) a quite large uncertainty on the glacial isostatic adjustment signal, [Louise Sandberg Soerensen, Denmark]	Accepted; change made
25243	3	101	7	101	8	I may have missed something in a previous section but I don't see any mention of the uncertainty of the impact of subglacial hydrology on ice dynamics for Greenland. I do see it discussed in Section 3.3.1.3 for Antarctica but not for Greenland. Furthermore, in Chapter 4 (page 32, lines 53-54), it is stated that the "relationship between meltwater and ice dynamics" on "decadal time scales" seems "not important." If this link is not important, then it should be made clear here that the "potential feedbacks to ice dynamics and ice sheet mass balance" by the evolution of subglacial hydrologic systems is uncertain in Antarctica and may not be important in Greenland. [Denis Felikson, United States of America]	Reject; subglacial systems are covered at length in section 3.3.
16313	3	101	24	102	12	Would it make more sense to re-structure the FAQ by covering the implications of changes in the physical system before respective socio-economic aspects? [Alexander Nauels, Germany]	Taken into account: FAQ was revised
16797	3	101	24	102	12	FAQ 3.1 addresses a very valid question, and is well suited to the FAQ format. Overall, the language needs some refinement, and it may be helpful to add a figure. A few minor comments on content: For para starting p 101 ln 31, please check whether the use of the word impact here is consistent with the glossary, or the term "risk" or "hazard" should be used; on p 101 ln 37-39, please avoid prescriptive language; on p102 ln 9-12: this para describes an important process, however the FAQ addresses the effect of changes in Polar regions, so you'd have to add a statement on observed/projected change or take out this para. [Government of Germany, Germany]	Accepted: text revised to change 'impacts' to 'risks', policy prescriptive text revised, etc.
22405	3	101	24	102	16	There is potentially some overlap between FAQ 1.1 and FAQ 3.1. It would be good for the writing teams to work together to make sure that these are complementary and not duplicative. It may simply involve FAQ1.1 including a citation to FAQ3.1 to resolve this. [Abram Nerilie, Australia]	Accepted: pointer to FAQ 3.1 added to FAQ 1.1
33407	3	102	9	102	12	It might also be good to stress here that the S. Ocean is essentially a bottomless reservoir of heat that can be used to melt Antarctic ice shelves and grounding lines, that relatively small changes in ocean (or atmospheric) circulation can place that massive heat reservoir in direct contact with the ice sheet, and that right now scientists have very little understanding for how these conditions might change in the future. Thus, uncertainties in particular aspects of how the S. Ocean might change in the future severely limit the ability to project how future sea-level rise (from Antarctica) will change in the future. [Government of United States of America, United States of America]	Taken into account: this paragraph of the FAQ was heavily revised
19441	3	103	44	103	52	The AMAP references are not standardized, or they are incomplete. For example, there is 'AMAP 2017' and 2017a/2017b, both in the reference list and in the text. Also: there are several errors or missing parts in the reference list (e.g., missing bracket - line 44; two consecutive periods - line 45; incomplete reference - line 50). [APECS Group Review, Germany]	accepted. We fixed inconsistencies in the bibliography

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
3115	3	123	14	123	15	Please update reference: Hjort, J., Karjalainen, O., Aalto, J., Westermann, S., Romanovsky, V.E., Nelson, F.E., Eitzelmüller, B. & M. Luoto (2018). Degrading permafrost puts Arctic infrastructure at risk by mid-century. Nature Communications 9: 5147. DOI:10.1038/s41467-018-07557-4. [Jan Hjort, Finland]	accepted. We fixed inconsistencies in the bibliography
2109	3	126	15	126	16	This citation for Jahn 2018 is missing the volume and page numbers. Please add: Vol 8, pages 409–413 [Alexandra Jahn, United States of America]	accepted. We fixed inconsistencies in the bibliography
19443	3	127	23	127	28	Jones 2015a (B. M.; lines 23-24) is NOT the same person as Jones 2015b (R. S.; lines 27-28). I think that usually these should be separated, right? [APECS Group Review, Germany]	Editorial; chapter will be copyedited prior to publication
29143	3	132	15	132	16	Please be so kind to correct the reference by the right ref "Lavrillier, A. and S. Gabyshev, 2018: An emic science of climate. Reindeer Evenki environmental knowledge and the notion of an "extreme process", Études mongoles et sibériennes, centrasiatiques et tibétaines [Online], 49, Online, URL : http://journals.openedition.org/emscat/3280 ; DOI : 10.4000/emscat.3280" [Alexandra LAVRILLIER, France]	accepted. We fixed inconsistencies in the bibliography
19445	3	139	38	139	38	This reference does not appear complete. Is that a book chapter? If yes: what is the book title? Which pages? Editor(s)? [APECS Group Review, Germany]	accepted. We fixed inconsistencies in the bibliography
29179	3	140	46	140	51	M. Wang and M.Y. Wang are the same person. The author list for these papers should be consistent. [Ge Peng, United States of America]	accepted. We fixed inconsistencies in the bibliography
19447	3	143	34	143	35	There is a Prowse et al. 2011b, but NO Prowse et al. 2011a. Same thing in the text, as least for this chapter - I did not find any Prowse et al. 2011a. [APECS Group Review, Germany]	accepted. We fixed inconsistencies in the bibliography
3517	3	145	29	0		Formatting error in Roberts et al. (2017) reference [Richard Allan, United Kingdom (of Great Britain and Northern Ireland)]	accepted. We fixed inconsistencies in the bibliography
19449	3	145	36	145	43	Romanovsky et al. 2017b comes BEFORE Romanovsky et al. 2017a, both in the reference list AND in the text (p. 62, Fig. 3.10 caption, then p. 79). [APECS Group Review, Germany]	accepted. We fixed inconsistencies in the bibliography
19451	3	147	34	147	41	It is not clear if the Schuur et al. 2018 reference (lines 34-36) really differs from the Schuur et al. 'in review' reference (line 41). It seems that they are really similar, if not the exact same work. Please double-check and standardize. [APECS Group Review, Germany]	accepted. We have updated it with DOI in the bibliography
2111	3	149	3	149	4	This citation for Sigmond et al 2018 is missing the volume and page numbers. Please add Vol 8, pages 404–408 [Alexandra Jahn, United States of America]	accepted. We have updated the pages number in the bibliography
22489	3	150	23	150	24	Suggest a correction: Paper by Stammerjohn and Maksym should be 2016, not 2017. [Government of Australia, Australia]	accepted. We have updated the year in the bibliography
27541	3	151	30	151	30	author name should be D. Notz [Benjamin A. Lange, Canada]	accepted. We have updated the authors names in the bibliography

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
17393	3	154	16	154	16	There is Turner et al., 2017 b, but we do not have 2017a or 2017c which are mentioned in the appendix page 161, line 31-36. [Amna JRRAR, Jordan]	accepted. We have updated the year in the bibliography
23181	3	160	0	160		Some aspects of this suppl material are assessmnt outcomes, not supp technicall info; consider carefully where it best fits. Lots of material in this suppl. text, quality to be checked if not reviewed as intensively as the main text. [Valerie Masson-Delmotte, France]	Noted
3099	3	160	6	0		Why is this first appendix titled Polar regions, people and the planet? It seems to only describe modes of climate variability in polar regions? [Helene Hewitt, United Kingdom (of Great Britain and Northern Ireland)]	Noted. Box 3.1 is positioned inside section 3.1 (introduction), the chapter's first order headlines serve as structure for the appendix
11431	3	160	15	160	18	Citation needed: e.g. Thompson and Wallace 1998 -- Geophys. Res. Lett. [Anson Cheung, United States of America]	accepted, added reference
19453	3	160	21	160	21	for people outside of the scientific community the term "geopotential height" is not easy to understand. Please put other term or explain in a few words [APECS Group Review, Germany]	accepted, added clarification
6085	3	160	21	160	22	Should it be "Positive phase is associated with" instead of "are"? [Nina Hunter, South Africa]	accepted
6087	3	160	25	0		Change "Other" to "Another"? [Nina Hunter, South Africa]	accepted
19459	3	160	25	160	25	Multiple patterns have already been mentioned, it's unclear which of these are the first two hemispheric patterns. If this matters it should be stated. [APECS Group Review, Germany]	reject, sufficiently clear as is
19455	3	160	31	160	35	This part is not well connected with the beginning and the end of the paragraph. A good way to fix it ,it would be remove this part and add more explanations in why the modes are driven more by atmospheric stochastic variability rather than external forcing. [APECS Group Review, Germany]	Taken into account: Added a sentence to better connect parts of paragraph
11069	3	160	39	161	5	A thorough discussion of the various feedback contributions to the polar warming amplification is given by Taylor, P., Cai, M., Hu, A., Meehl, J., Washington, W. and Zhang, G.J. (2013). 'A Decomposition of Feedback Contributions to Polar Warming Amplification'. American Meteorological Society 26, 7023-7043. [Peter Lemke, Germany]	accepted, added reference
27613	3	160	39	161	5	Arctic feedbacks may become an obstacle to achieving a stabilized global climate, and there are new results indicating that this could be caused by GHG release from permafrost alone (see Gasser et al. https://doi.org/10.1038/s41561-018-0227-0). Relevant to add in here? [Government of Norway, Norway]	Noted. Emission from permafrost are discussed in the chapter itself.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
33409	3	160	41	161	5	Two recently published papers help clarify the inter-model spread and the relative roles of local vs. remote forcing. Also, Pithan and Mauritsen (2014) are not the first to demonstrate the role played by downwelling longwave radiation. References: Stuecker, M. et al. Nat. Clim. Change https://doi.org/10.1038/s41558-018-0339-y (2018) and Boeke, R. C. and P. C. Taylor, 2018: Seasonal energy exchange in sea ice retreat regions contributes to differences in projected Arctic warming. Nature Communications volume 9, Article number: 5017 (2018); Taylor, P. C., M. Cai, A. Hu, J. Meehl, W. Washington, G. J. Zhang, 2013: A Decomposition of Feedback Contributions to Polar Warming Amplification. J. Climate, 26, 7023-7043. doi: http://dx.doi.org/10.1175/JCLI-D-12-00696.1 [Government of United States of America, United States of America]	accepted. added Taylor 2013 and Boeke 2018
19457	3	160	50	161	5	This paragraph seems just a bunch of information put together but not well connected. I suggest to rewrite this paragraph. As far as I understood, the intention of this paragraph is to show what processes are related to the Arctic Amplification but is difficult to understand how the described processes are related to it. [APECS Group Review, Germany]	rejected. The objective of this paragraph is to briefly list and briefly explain the multiple processes involved.
10469	3	160	52	160	54	Add references, Maturilli and Kayser (2017, Theo. Apl. Climatol.), Rinke et al. (2017, Env. Res. Lett.), Woods et al. (2013, GRL) and Woods and Caballero (2016, J. Clim.) at the end of the sentence. [Takashi Yamanouchi, Japan]	reject. The sentence is referenced and references for processes referred to in its second part are to follow in subsequent sentences.
10471	3	160	57	161	2	Add reference, Yamanouchi (2018, Polar Science), at the end of the sentence. [Takashi Yamanouchi, Japan]	reject. The sentence is referenced with the prominent literature
19467	3	161	1	161	2	...increased down-welling longwave radiation from a warmer free troposphere as well as a change in optical depth from increased atmospheric moisture. = unclear to non-specialist audience [APECS Group Review, Germany]	taken into account: dropped optical depth
10473	3	161	2	161	3	Add reference, Yoshimori et al. (2017, Clim. Dynamics), at the end of the sentence. [Takashi Yamanouchi, Japan]	reject. The contribution of longwave radiation is adequately referenced.
17411	3	161	7	161	51	Subsection 3.A.1.3 Southern Hemispheric Climate Modes needs revision to include more references, make it easier to read and to link it to earlier sections in the chapter. [Amna JRRAR, Jordan]	Taken into account. We have added some of the citations suggested in other comments
19463	3	161	9	161	12	I didn't understand what the author means here. [APECS Group Review, Germany]	Not sure how to address this comment, more information on what is confusing is required

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
17395	3	161	9	161	16	<p>References for the SAM, PSA, ZW3, PDO & IPO were not included</p> <p>SAM: [Thompson & Wallace 2000]</p> <p>Thompson, D. W. J., and J. M. Wallace (2000), Annular modes in the extratropical circulation, part I, Month-to-month variability, J. Clim., 13, 1000 – 1016, doi:10.1175/1520-0442(2000)</p> <p>PSA: [Karoly, 1989; Mo and Higgins, 1998]</p> <p>Karoly, D. J. (1989), Southern Hemisphere circulation features associated with El Nino-Southern Oscillation events, J. Clim., 2, 1239–1252, doi:10.1175/1520-0442(1989)</p> <p>Mo, K. C., and R. W. Higgins (1998), The Pacific(South America modes and tropical convection during the Southern Hemisphere winter, Mon. Weather Rev., 126, 1581–1596, doi:10.1175/1520-0493(1998)</p> <p>ZW3: Raphael, 2004</p> <p>Raphael, M. N. (2004), A zonal wave 3 index for the Southern Hemisphere, Geophys. Res. Lett., 31, L23212, doi:10.1029/2004GL020365.</p> <p>PDO: Mantua et al., 1997,</p> <p>Mantua, N.J. and S.R. Hare, Y. Zhang, J.M. Wallace, and R.C. Francis 1997: A Pacific interdecadal climate oscillation with impacts on salmon production. Bulletin of the American Meteorological Society, 78, pp. 1069-1079.</p> <p>IPO: [Henley et al., 2015; Power et al, 1999]</p> <p>Power S et al (1999) Inter-decadal modulation of the impact of ENSO on Australia. Clim Dyn 15(5):319–324</p> <p>Henley, B. J., J. Gergis, D. J. Karoly, S. Power, J. Kennedy, and C. K. Folland, 2015: A tripole index for the interdecadal Pacific oscillation. Climate Dyn., 45. 3077-3090, doi:10.1007/ s00382-015-2525-l. [Amna JRRAR, Jordan]</p>	<p>Taken into account. We have added some of these citations. We are focusing on literature since AR5 so restrict our citations primarily to post-2012</p>
6089	3	161	16	161	50	<p>Is "40S" written in the same way in other parts of the report when referring to degrees north or south? [Nina Hunter, South Africa]</p>	<p>Corrected</p>
27201	3	161	20	161	20	<p>The text refers to 'the significant poleward shift ... of the SAM. ' However, the blue line for annual jet latitude on Appendix3.A Fig.1 doesn't appear to show a significant shift. So, can the authors quantify the trend in annual jet latitude over the period considered in the figure 1987-2017 and its level of significance? [Sion Josey, United Kingdom (of Great Britain and Northern Ireland)]</p>	<p>We have corrected this to indicate a significant summertime shift.</p>
22491	3	161	31	161	32	<p>Suggest ZW3 cite the original work by Raphael (GRL, 2004) and, due to the mention of sea ice connection with ZW3, Suggest also citing Raphael (JGR, 2007). [Government of Australia, Australia]</p>	<p>Citation added</p>
6091	3	161	32	0		<p>Remove comma after "blocking"? [Nina Hunter, South Africa]</p>	<p>The comma is necessary here</p>

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
17397	3	161	33	161	33	Earlier references on ZW3 [Raphael , 2007; Yuan & Li, 2008] Raphael, M.N., 2007. The influence of atmospheric zonal wave three on Antarctic sea ice variability. J. Geophys. Res.-Atmos. 112, Artn D12112. http://dx.doi.org/10.1029/2006jd007852 . Yuan, X.J., Li, C.H., 2008. Climate modes in southern high latitudes and their impacts on Antarctic sea ice. Journal of Geophysical Research-Oceans 113, Artn C06s91. http://dx.doi.org/10.1029/2006jc004067 . [Amna JRRAR, Jordan]	Citation to the original Raphael 2004 added
19469	3	161	39	0		What are 'SST's' - sea surface temps? Unclear and cannot find glossary or nearby reference to this acronym. NOTE: Not described as 'Sea Surface Temperature' until page 166 line 16 [APECS Group Review, Germany]	Accepted. used the full term
6093	3	161	40	0		Insert "the" before "Antarctic" [Nina Hunter, South Africa]	Accepted. used the full term
19461	3	161	40	161	46	This sentence is just too long and confusing. I didn't understand what was modifying what in the train. [APECS Group Review, Germany]	Accepted - a part of the sentence was inadvertently removed so thanks for catching this
12243	3	161	42	161	43	ENSO also impacts on sea ice in the Ross Sea, ie Pope et al., 2017 GRL "Impacts of EL Nino on observed sea ice budget of West Antarctica" [James Pope, United Kingdom (of Great Britain and Northern Ireland)]	accepted. Citation added
11433	3	161	48	161	50	Redundant: it's exactly the same as line 13-16 on the same page. [Anson Cheung, United States of America]	Accepted. Removed
19465	3	161	48	161	50	Exactly same tekst as in same section from 14 to 16 lines. I suggest to rephrase it or remove it. [APECS Group Review, Germany]	Accepted. Removed
3101	3	162	0	0		Can figure 3.A.2 list the CMIP5 models used? [Helene Hewitt, United Kingdom (of Great Britain and Northern Ireland)]	Accepted. Removed
8613	3	162	0	162		Appendix 3.A, Figure 1: the term "CCMP" in the caption is not defined. [Deborah Verfaillie, Spain]	Revised as suggested
8615	3	162	0	162		The hyperlink http://www.remss.com/measurements/ccmp.html in the figure caption does not seem to work. [Deborah Verfaillie, Spain]	Corrected
31643	3	162	1	0		Appendix 3.A, Figure 1. You could use a thinner line for either the blue or black, and keep the other as is - this will help distinguish the two more easily. [Hans-Otto Poertner and WGII TSU, Germany]	We prefer to keep the format similar to the original figure in Karpechko and Maycock 2018
19471	3	162	3	162	3	It would be helpful to have the correlation of the SAM and jet latitude for the overlapping times overlaid. That would help readers know which seasons have the best correspondence. [APECS Group Review, Germany]	Taken into account. We have revised the caption to indicate significance of the SAM trends, information which is included in the citation listed. Including the correlation between the two indices, while interesting, would be introducing new science at this late stage without an appropriate reference
19473	3	162	3	162	8	the blue line in the printed version is difficult to see, however the pdf is fine. The axes in the middle of the figure could be removed given that all figures have the same axes. Thus, the information is more evident. [APECS Group Review, Germany]	We prefer to keep the format similar to the original figure in Karpechko and Maycock 2018
6095	3	162	5	162	7	Try and get the two web link's to 'look' the same for the sake of consistency [Nina Hunter, South Africa]	Accepted. Corrected
19477	3	162	19	162	19	Appendix 3.A. Figure 2 is not cited anywhere in Chapter 3. Remove or cite. [APECS Group Review, Germany]	Reject. The figure is cited from within section 3.2.1.2

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
19621	3	162	20	162	21	Rephrase: 'between the mean over 1861-1880 and the mean over 1986-2005'. [APECS Group Review, Germany]	Reject. The formulation used aligns better with the source literature.
19475	3	162	21	162	21	why the underatinty for the total global ocean heat uptake is so large? What kind of model are they using? [APECS Group Review, Germany]	Noted. It would distort the text to include discussion of this point in the figure caption. Full details of the model are available in the paper cited.
17705	3	163	1	163	8	Figure 3 in appendix 3A: there is a black countour shown between 75oS and 60oS that seems to be an extra contour that is not explained or should not be there. This contour or black line starts from the coast at about 1.2km depth, then rise up to about 0.5km near 76oS and goes down again to the seafloor just north of 60oS. Please check if this black line/contour should actually be there or not. It does look to me that it is an extra line, but this should be shown on the figure, I'll suggest to add a mention of the contour in the caption, I doubt it is still the 34.7 psu contour. [Eva Cougnon, Australia]	Accepted. This figure has been redrafted accordingly.
19623	3	163	1	163	8	It is not clear what ZJ stands for in the Y axis of Fig. 3a of Appendix 3.A. [APECS Group Review, Germany]	Noted. Zettajoule is an SI unit.
19487	3	163	4	163	4	Appendix 3.A. Figure 3 is not cited anywhere in Chapter 3. Remove or cite. [APECS Group Review, Germany]	Reject: this figure is cited from within section 3.2.1.2
3103	3	163	4	163	8	Is this a single EN4 dataset? Is marking the residual-mean meridional overturning essential especially when the residul-mean hasn't been described [Helene Hewitt, United Kingdom (of Great Britain and Northern Ireland)]	Accepted. The figure has been amended to remove the residual mean overturning.
19483	3	163	11	164	30	Sections 3.A.2.3 & 3.A.2.4 difficult to understand for a non-specialist, less written to a general audience than the sections immediately before and after [APECS Group Review, Germany]	Noted. The supplementary material contains scientific and technical details that support the main assessment text, it need not always be standalone
19479	3	163	13	163	13	define sigma in the legend [APECS Group Review, Germany]	Accepted
19489	3	163	16	163	16	Appendix 3.A. Figure 4 is not cited anywhere in Chapter 3. Remove or cite. [APECS Group Review, Germany]	Rejected; it is cited twice from the main text
8617	3	163	28	163	28	The term "Revelle Factor" is not defined. [Deborah Verfaillie, Spain]	Accepted; clarification made
19481	3	163	28	163	28	define the revelle factor or just describe it in a few words for the reader knows how it is related to the pCO2 [APECS Group Review, Germany]	Accepted; clarification made
19485	3	163	28	163	28	Can a definition of Revelle factor be included? E.g. Wikipedia also calls it the 'buffer factor' so anyone not in the field could be quickly confused given the Revelle facor increses when buffer factor decreases here so they can't be the same thing. [APECS Group Review, Germany]	Accepted; clarification made
19491	3	164	18	164	20	it is not clear what is the biogeochemical and thermal forcings. How are they related to the trend? [APECS Group Review, Germany]	Accepted; explained further in the text

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3

Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
25293	3	164	20	164	23	This sentence (the last one in the paragraph) overemphasizes the importance of how changes in the seasonal cycle will affect the long-term trend of fluxes and storage of anthropogenic CO2 in the Southern Ocean. I do not believe that such a statement can be attributed to McNeil and Sasse (2016), the cited reference. Although asymmetries in seasonality and their trends from reduced buffering capacity will have some effect on long-term uptake of anthropogenic carbon, that will not be the "dominant" effect. The dominant effect will be the effect of reductions in buffer capacity on the mean state, not the seasonality. [James Orr, France]	Taken into account; the sentence actually says exactly that - the trends in buffer factor will drive the long term changes not specifically the seasonality, which as you say, is just a product of the changing gamma - with a smaller impact
6097	3	164	30	0		Remove second "(b)" [Nina Hunter, South Africa]	Accepted
19495	3	164	33	164	44	Is there a reference missing to Appendix 3.A Table 2 here? [APECS Group Review, Germany]	Accepted; reference included
19493	3	164	35	164	45	in the paragraph there is a comment saying that the CO2 is different from the anthropogenic CO2, what is the main difference? How this is related to the subduction of it by upper ocean overturning periods. This is a kind of information that would make the text clearer [APECS Group Review, Germany]	Taken into account; clarified explanation of natural carbon
8619	3	165	0	165		Appendix 3.A, Table 2: this table does not seem to be called anywhere in this document. [Deborah Verfaillie, Spain]	Accepted; reference included
19497	3	165	1	165	4	the third column of the table : the informations here are confuse, maybe using some commas or back slash would make clearer. [APECS Group Review, Germany]	Accepted; removed confusing colons
19499	3	165	6	165	10	I am surprised that the onset month-long undersaturation value is for RCP4.5 higher than the RCP8.6. what is the reason for this increase? Is the system reaching the maximum and for higher values the system will not keep increasing? [APECS Group Review, Germany]	Noted. The reason is because these are century scale averages for the areas affected by month-long onset of undersaturation. Month-long undersaturation in RCP2.6 covers a very small area 0.2% relative to RCP8.5 and all scenarios share the onset in those locations. However, as ATM CO2 increases for RCP4.5 and 8.5 the areas increase at a rate that depend on the pCO2 and the seasonal cycle. This explains why the onset of month-long undersaturation occurs latest in RCP4.5.
19501	3	165	6	165	6	Appendix 3.A. Table 2 is not cited anywhere in Chapter 3. Remove or cite. [APECS Group Review, Germany]	Accepted; reference included
4399	3	165	9	165	9	Why is the onset of month-long undersaturation earlier for RCP26 than RCP45 and RCP85? [The UBern Team Group Review, Switzerland]	see response to 19499
6099	3	165	26	0		Replace "will be" with "become"; replace "getting" with "becoming" [Nina Hunter, South Africa]	Accepted; sentence changed
3105	3	166	0	0		As a climate modeller I'm very dubious about drawing conclusions about Arctic shelf regions from climate models which have low horizontal resolution and do not include tidal or shelf processes. In general I would say that confidence in climate models doesn't extend to this level of detail. At very least, this needs to be explicitly stated and low confidence ascribed along with error bars for the range of models. [Helene Hewitt, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account. This subsection and associated figures have been deleted from the revised Appendix.
6101	3	166	15	0		Replace "to" with "for"? [Nina Hunter, South Africa]	As above.
19503	3	166	15	166	17	Figure 7 is cited before Figure 6. Reverse chronological order. [APECS Group Review, Germany]	As above.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
6103	3	166	34	0		Insert bracket after "Archipelago" [Nina Hunter, South Africa]	As above.
19505	3	166	34	166	34	End bracket is missing. [APECS Group Review, Germany]	As above.
6105	3	166	38	167	4	Insert "RCP" before "8.5" for consistency [Nina Hunter, South Africa]	As above.
3107	3	167	0	0		If this section is kept-figure 3.A.6 should show error bars on each projection. If I am reading it correctly, this figure demonstrates just how bad on average the climate models are in the shelf regions with error bars of up to 6 degrees on SST and 3 degrees on bottom temperatures. The models used need to be listed [Helene Hewitt, United Kingdom (of Great Britain and Northern Ireland)]	As above.
3109	3	168	0	0		Is the rotation in figure 3.A.7 consistent with the rest of the chapter? [Helene Hewitt, United Kingdom (of Great Britain and Northern Ireland)]	As above.
31645	3	168	1	0		Appendix 3.A, Figure 7. The dotted circle in the middle of the map has no label. You may want to standarize these polar type maps following the same layout as in Appendix 3.A, Figure 2, where the Lat and Lon are properly labeled for easy navigation of the reader. [Hans-Otto Poertner and WGII TSU, Germany]	As above.
19511	3	168	1	168	4	the figure 7 could be before the section 3.A.2.6, thus when you read the section you know where the regions are. [APECS Group Review, Germany]	As above.
19515	3	168	2	168	4	Appendix 3.A. Figure 7. Pink color legend is missing. The color in the center is not needed. What does broken circle represent? [APECS Group Review, Germany]	As above.
15577	3	168	7	169	42	Somewhere in sect. 3.A.3., it would be relevant to mention that since the AR5 there has been a huge improvement in our possibility to map high resolution (temporal and spatial) ice velocities. E.g. Reference Nagler, T.; Rott, H.; Hetzenecker, M.; Wuite, J.; Potin, P. The Sentinel-1 Mission: New Opportunities for Ice Sheet Observations. Remote Sens. 2015, 7, 9371-9389. [EUCE, Belgium]	Now added.
16911	3	168	7	169	42	Somewhere in sect. 3.A.3. I think it would be relevant to mention that since the AR5 there has been a huge improvement in our possibility to map high resolution (temporal and spatial) ice velocities. E.g. Reference Nagler, T.; Rott, H.; Hetzenecker, M.; Wuite, J.; Potin, P. The Sentinel-1 Mission: New Opportunities for Ice Sheet Observations. Remote Sens. 2015, 7, 9371-9389. [Louise Sandberg Soerensen, Denmark]	Now added.
19507	3	168	11	168	11	Add "Since the beginning of the satellite era in 1992" to "since the beginning of the satellite era" [APECS Group Review, Germany]	Changed to "Since the late-20th century beginning of the satellite era" (to include e.g., older Landsat etc).
28387	3	168	11	168	11	satellite era could mean since 1961 but suspect it means since 1992. Needs defining or add date in brackets [Jonathan Bamber, United Kingdom (of Great Britain and Northern Ireland)]	Changed to "Since the late-20th century beginning of the satellite era" (to include e.g., older Landsat etc).
19509	3	168	17	168	17	Same remark as in the section itself: what happened between pre-20th century and 1992? [APECS Group Review, Germany]	Changed to "pre-satellite mass changes"
25867	3	168	21	169	18	See also comment on p43-46 - I think the Shepherd et al. (2018) references are likely to be to IMBIE team (2018), which is not in the bibliography. E.g. lines 24-25, 27,p168 data are from IMBIE 2018 extended data Table 4), same for 17-18 on p169. [Elizabeth Petrie, United Kingdom (of Great Britain and Northern Ireland)]	Corrected.

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
19513	3	168	24	168	28	For both WAIS and AP, values of ice sheet change are given for the three individual methods, but only WAIS has a combined value given. Since magnitudes for both are listed as having "medium agreement" it seems there should be an overall combined gravimetry-altimetry value. [APECS Group Review, Germany]	The combined gravity-altimetry value available specifically for WAIS. Note that citation corrected to Mémin et al., 2014 doi: 10.1016/j.epsl.2014.08.008. Note also that the SROCC-assessed, combined mass changes are reported in Chapter 3, section 3.3, Table 3.3.
19517	3	168	32	168	32	Appendix 3.A. Table 3 is missing. [APECS Group Review, Germany]	This table now present.
6107	3	168	40	0		Insert space between "2014)" and "and"; Insert space between "2013)" and "(Velicogna" [Nina Hunter, South Africa]	Done.
8621	3	169	8	169	9	The sentence "On the AP, a multi-method assessment showing an increase in mass loss has from the 1990s to the last decade (Table 3.4) is supported by..." does not make sense. Please consider revising. [Deborah Verfaillie, Spain]	Corrected.
19523	3	169	17	169	32	There is ambiguity in results of the three methods, i.e. satellite gravity, altimetry, and input-output model-based budgeting. Which one is deemed to be the most reliable should be mentioned; otherwise it is confusing for the reader whether ice-sheet mass balance is positive or negative. Mention the level of confidence of East Antarctica Ice Sheet (EAIS) mass balance, i.e. low, medium, or high. [APECS Group Review, Germany]	No - ambiguities are real and described by the uncertainties given in the cited studies, and the statement that "estimates that agree within uncertainties but vary in sign around zero" stands. See Chapter 3, Table 3.3 for assessed total.
19519	3	169	23	169	23	Is this meant to be table 3.4? [APECS Group Review, Germany]	No, Table 3.3 now contains the assessed ice sheet mass balances.
6109	3	169	25	0		Insert space between "2016" and "(Rignot" [Nina Hunter, South Africa]	Done.
19521	3	169	29	169	29	It is unclear what "at the density of ice" means in relationship to dynamic thickening. [APECS Group Review, Germany]	Changed to "(i.e., at the density of ice as opposed to lower-density snow and firn)"
15579	3	169	34	169	40	It would be relevant to add some information on other changes than just mass changes. How e.g. The velocity/discharge have changed (King et al., 2018) and how the elevation changes have evolved (Sørensen et al, 2018). King, M. D., Howat, I. M., Jeong, S., Noh, M. J., Wouters, B., Noël, B., and van den Broeke, M. R.: Seasonal to decadal variability in ice discharge from the Greenland Ice Sheet, <i>The Cryosphere</i> , 12, 3813-3825, https://doi.org/10.5194/tc-12-3813-2018 , 2018. Sørensen, L. S., Simonsen, S. B., Forsberg, R., Khvorostovsky, K., Meister, R., & Engdahl, M. E. (2018). 25 years of elevation changes of the Greenland Ice Sheet from ERS, Envisat, and CryoSat-2 radar altimetry. <i>Earth and Planetary Science Letters</i> , 495, 234-241. DOI: 10.1016/j.epsl.2018.05.015 [EUCE, Belgium]	Agreed. King et al. already included in Chapter 3 section 3.3 and have now added Sørensen citation to that section to support the statement "The Greenland Ice Sheet (GIS) experienced a marked shift to strongly negative mass balance between the early 1990s and mid-2000s (very high confidence) {Shepherd, 2012 #1673;Schrama, 2014 #1674;Velicogna, 2014 #1675;Bamber, 2018 #637;WCRP, 2018 #1676;van den Broeke, 2016 #1677;King, 2018 #1678} Sørensen et al 2018 doi.org/10.1016/j.epsl.2018.05.015".

SROCC Second Order Draft Government and Expert Review Comments - Chapter 3							
Comment id	Chapter	From page	From line	To page	To line	Comment	Chapter Team Response
16913	3	169	34	169	40	<p>Would be relevant with some information on other changes than just mass changes. How e.g. The velocity/discharge have changed (King et al., 2018) and how the elevation changes have evolved (Sørensen et al. 2018).</p> <p>King, M. D., Howat, I. M., Jeong, S., Noh, M. J., Wouters, B., Noël, B., and van den Broeke, M. R.: Seasonal to decadal variability in ice discharge from the Greenland Ice Sheet, <i>The Cryosphere</i>, 12, 3813-3825, https://doi.org/10.5194/tc-12-3813-2018, 2018.</p> <p>Sørensen, L. S., Simonsen, S. B., Forsberg, R., Khvorostovsky, K., Meister, R., & Engdahl, M. E. (2018). 25 years of elevation changes of the Greenland Ice Sheet from ERS, Envisat, and CryoSat-2 radar altimetry. <i>Earth and Planetary Science Letters</i>, 495, 234-241. DOI: 10.1016/j.epsl.2018.05.015 [Louise Sandberg Soerensen, Denmark]</p>	<p>Agreed. King et al. already included in Chapter 3 section 3.3 and have now added Sørensen citation to that section to support the statement "The Greenland Ice Sheet (GIS) experienced a marked shift to strongly negative mass balance between the early 1990s and mid-2000s (very high confidence) {Shepherd, 2012 #1673;Schrama, 2014 #1674;Velicogna, 2014 #1675;Bamber, 2018 #637;WCRP, 2018 #1676;van den Broeke, 2016 #1677;King, 2018 #1678} Sørensen et al 2018 doi.org/10.1016/j.epsl.2018.05.015".</p>
8623	3	170	0	170		Appendix 3.A, Table 4: Table numbering problem. There is currently no Table 3 in this appendix. [Deborah Verfaillie, Spain]	Corrected.
19525	3	170	2	170	5	the quality of the figure is not good. [APECS Group Review, Germany]	Figure revised.
24487	3	170	8	0		Appendix 3.A, Table 4. The IMBIE team, 2018 is not included in the reference list. [Eef van Dongen, Switzerland]	Citation corrected.
19527	3	170	8	170	8	Martin-Espanol reference is missing in the reference section [APECS Group Review, Germany]	Corrected.
19529	3	170	8	170	8	I believe that it is missing a "b" after 2014 in the reference (McMillan et al., 2014b) [APECS Group Review, Germany]	Corrected.
19531	3	170	8	170	8	Appendix 3.A. Table 4. I cannot find source 'The IMBIE team, 2018' in the reference list. Unknown abbreviation 'IMBIE'. [APECS Group Review, Germany]	Corrected.
25869	3	170	8	170	8	Martin-Espanol et al. (2015) is not in the bibliography - this ref should be the (2016) paper. [Elizabeth Petrie, United Kingdom (of Great Britain and Northern Ireland)]	Corrected.
25859	3	170	8	170	9	This table (Appendix 3.A Table 4) contains a citation to the IMBIE team, 2018, which doesn't seem to be in the bibliography. The IMBIE Team, Shepherd, A., Ivins, E., Rignot, E., Smith, B., van den Broeke, M., et al. (2018). Mass balance of the Antarctic Ice Sheet from 1992 to 2017. <i>Nature</i> , 558, 219–222. [Elizabeth Petrie, United Kingdom (of Great Britain and Northern Ireland)]	Corrected.
19533	3	170	13	170	13	Appendix 3.A. Table 5 is not cited anywhere in Chapter 3. Remove or cite. [APECS Group Review, Germany]	Now cited in Chpater 3.