Comment ID	From Page	From Line	To Page	To Line	Comment	Response
38331	0	0	0	0	Based on line 29-30 on page 141, ERFaci is the abbreviation of “Effective Radiative Forcing due to Aerosol-Cloud Interactions”, but in some places in the report, it refers to aerosol-cloud interactions (see lines 14 and 35 on page 40, among others); ERFari is the abbreviation of “Effective Radiative Forcing due to Aerosol-Radiation Interactions”, but in other places it refers to aerosol-radiative interactions (see line 21 on page 40, etc). It is suggested to harmonize the normative use of the two abbreviations in the report. [Yaming LIU, China]	Taken into account, text revised.
86775	0	0	0	0	We are generally concerned that the discussion on climate effects of mitigation of SLCFs in this chapter to a very high degree is steered by fact that SO2 abatement leads to warming. We welcome a more diffrenciated approach to be undertaken in which different abatement options and outcomes are described. [Oyvind Christophersen, Norway]	Taken into account, the chapter has been thoroughly reworked.
86523	0	0	0	0	The discussion on GHG emission metrics in this chapter will be expanded on in WGIII report and is only part of the story. Please make this clear in this chapter [Ala Taimar, Estonia]	Taken into account, this is explained in 6.1.
113935	0				Much - too much? - space allocated to desciption of trends. Useful but some compressing will make the chapter easier ro read [Jan Fuglestvedt, Norway]	Taken into account, section 6.3 has been thoroughly shortened.
103185	0				Chapter 6 title and framing This is an important chapter, relating feedbacks and climate impacts of multiple atmospheric constituents. Material collected is valuable and mostly very useful. However, there is a very basic problem with its conceptual framing. The chapter has been entitled “Short-Lived Climate Forcers”, yet the chapter includes many substances that are arguably not short-lived or not themselves forcers (SO2, NH3, NOx, CO, NMVOC). Given that the chapter title and scope have already been agreed by the panel, we propose to add a subtitle so that the scope of the chapter is clear to readers. For example: "Short-lived climate forcers: including their pre-cursors and health implications". [Philippe Tulkens, Belgium]	Rejected - Precursors are part of the SLCFs.
22037	0				Although somewhat better managed than in the FOD there is still an issue over splitting consideration of single SLCFs over multiple sections. Thus if I want to e.g. consider all aspects of SO2 I have to hunt out many individual subsections where individual aspects are considered and then try to mind map them together. In terms of accessability I'm not convinced that this is optimal. I guess it comes down to whether the author team believe most readers will be looking to look vertically (by species) or horizontally (by category) and there probably is no single optimal structure here. But I would just note the challenge currently for people looking for information on particular SLCFs who have to hop around the chapter often in an unintuitive manner to find all the relevant information. One issue with the chosen structure is that there is a degree of repetition arising from the need for each subsection to stand alone which means some things are reintroduced and there is an opportuunity therein for readers to play spot-the-difference. This gets particularly problematic toward the end of the chapter where I read whole sections really thinking you were just repeating text that you had already given to me. I'm not sure that the choice of structure for the future aspects can work without massively overt repetition of points often several times over. [Peter Thorne, Ireland]	Taken into account, redundancies have been reduced in FGD.
106519	0				A discussion on important compounds such as Hydrofluoroolefins (HFO’s) and Fluoroethers is missing in this chapter [ABDELWAHID MELLOUKI, France]	Rejected - too specific.
113951	0				Consistency and overlap with ch2 on observations of various SLCFs needs to be checked. [Jan Fuglestvedt, Norway]	Accepted - consistency with other chapters (2, 4, 7, 8, 12) checked.
113955	0				Some of the subsections in 6.2.2 are quite long and detailed. Please consider whether some of these could be shortened. Some of these also need more assessment and use of uncertainty language. [Jan Fuglestvedt, Norway]	Taken into account, the chapter has been thoroughly reworked as recommended.
113957	0				Glad to see the improvement in this chapter since FOD. Better focus and structure. The chapter contains a lot of useful information and will probably be very important reference for a comprehensive compilation of knowledge. But some parts are too much of a review and not enough assessment. [Jan Fuglestvedt, Norway]	Thanks, the chapter has been thoroughly reworked as recommended

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
22055	0				In several places (some of the more obvious have been commented individually) the chapter has a tendancy to discuss mitigation overtly which is presumably at conflict with WG3. In such instances it is likely that the content needs to be reexamined and if necessary realigned to the WG1 physical science basis. [Peter Thorne, Ireland]	Rejected - WG3 does not investigate air pollution control nor effect of climate mitigation on air quality. Chapter 6 is thus complementary to WG3.
113959	0				Unclear where the RF numbers in section 6.2.2. for the various species are coming from. And it is not clear whether these are RF or ERF. [Jan Fuglestvedt, Norway]	Taken into account, all the RF are discussed now in 6.4.
109609	0				Throughout this chapter, I am missing discussion on the importance of aerosol particle (number) size distribution instead of just focusing on PM mass. In the recent years it has become increasingly evident that PM and CCN numbers are not necessarily so well correlated, particularly in clean regions, while the latter are important particularly for the indirect climate impacts. Same goes for the air quality perspectives as well - there is increasing interest in looking into the health effects of ultrafine particles as a complement to PM mass. This is highly relevant when discussing the contribution of different chemical species to the aerosol particle loadings - for example, the contribution of ammonia in facilitating sulphate nucleation is mentioned, but this contribution to the PM mass is hardly significant as the impact comes through increasing CCN numbers. The same goes for many of the organic species. This is my most major comment on this chapter that I wish the authors would seriously consider. [Ilona Riipinen, Sweden]	Noted, size is evocated for climate effect (note that CCN is assessed in chapter 7). Impact of ultrafine particles on health is beyond the scope of chapter 6 (WG1 does not investigate health effect but the physics of the system).
22071	0				Chapter contains no limitations to the assessment section in contrast to almost all remaining chapters [Peter Thorne, Ireland]	A perspective section has been added.
104767	0				I have the feeling that the acronym SLCF and its plural form SLCFs is not used in a stringent form through the chapter. [Tobias Schad, Germany]	Editorial issues such as plural acronyms have been fixed for FGD.
79943	0				Comment on achieving an objective handling of the interlinkage between LLGHGs and SLCFs: The authors address the links between LLGHGs and SLCFs and the implications for the climate under different scenarios in chapter 6 and in other parts of the WG1 SOD. In general, the SOD addresses these links unilateraly from the perspective that SLCF mitigation is secondary or a co-benefit of strict CO2 measures. Within this frame SLCF-specific mitigation appears to be less important because it is assumed to be largely addressed through a focus on CO2. Conversely, and missing in the current analysis, are the linkages in the opposite direction, namely near-term mitigation of SLCFs resulting in reductions of CO2. A balanced and objective treatment of SLCFs and LLGHGs is requested. [Valentin Foltescu, India]	Taken into account a discussion has been added in 6.7.3 about that.
79945	0				Comment: GWP of the warming SLCFs should be mentioned consistently in this chapter. GWP is only provided as part of the discussions on HFCs. [Valentin Foltescu, India]	Rejected, GWP are treated in chapter 7.
67919	0				This chapter is comprehensive and covers a wide range of topics related to SLCFs; it is significantly improved from the previous version. The authors should be commended for their efforts. It is particularly helpful to compare what has been learned since AR5, especially the trends for several pollutants, which were not discussed in AR5; the remaining challenges, including uncertainties. [Luisa Molina, United States of America]	Thanks a lot.
67921	0				One suggestion to save space, as well as for consistency, is to use the acronyms once they have been defined. [Luisa Molina, United States of America]	Editorial issues such as acronyms have been fixed for FGD.
67923	0				In terms of regions, it seems a lot more information has been written about Asia, North America (mainly USA and Canada) and Europe, but relatively less about Latin America (Mexico, Central and South America), as reflected also in the number of citations. I would suggest to include a few studies conducted in Latin America in the appropriate sections. It is worth noting also that Mexico was one of the first countries that committed to reduce black carbon as part of the Intended Nationally Determined Contribution (INDC) to UNFCCCC, which subsequently became the NDC. [Luisa Molina, United States of America]	Noted.
16539	0				As far as I can see there is no explicit definition of "short-lived" in chapter 6. It be clearer if this could be defined, or if there are good reasons not to define it then say so. The discussion of the Kigali agreement states that some of the HFCs are not short-lived. But without a specified timescale it is not possible to work out which are being discussed in this chapter and which are excluded.. [William Collins, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account. SLCFs are defined in 6.1

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
21933	0				Figure 6.3 should be moved up to figure 6.1 and the introduction should be reordered accordingly for consistency with other chapters where the overview of structure is the first figure. [Peter Thorne, Ireland]	Rejected, the first figure(6.1) illustrates and thus introduces the main processes regarding SLCFs and the structure of the chapter and its outlinecomes more naturally after these explanations.
21937	0				SLCF is in many places seemingly randomly given as a plural or singular. Given that SLCFs are a collection of forcing agents it would potentially make sense to consistently pluralise and thus use SLCFs throughout unless a very specific reason for using the singular SLCF can be given. The current somewhat random SLCF / SLCFs usage makes reading more difficult than it arguably needs to be. [Peter Thorne, Ireland]	Editorial issues such as plural acronyms have been fixed for FGD.
21943	0				There are numerous small typos that point to the need for a more careful proofing in the final draft. I will not call them out individually but e.g. Sections is used and then only one section referred to so should be Section. More generally several passages require much more careful attention to language and proofing. [Peter Thorne, Ireland]	Editorial issues have been fixed for FGD.
21949	0				There is a lot of calling out in several places in the text of specifc countries, particularly China, individually. I wonder whether all such call-outs are necessary and whether they may arise issues with governments. Perhaps efforts should be made to minimise such occurence to reduce the risk of geopolitical sensitivities being triggered? [Peter Thorne, Ireland]	SLCF emissions and abundances are highly heterogeneous geographically, it would not make sense to discuss them without mentioning countries.
21957	0				There is a tendancy in many places to give numbers as if they are precisely quantified. While, occassionally this may be justified, most times the assessed number has an uncertainty which should be denoted accordingly using a range ideally corresponding to the very likely range (5-95%) [Peter Thorne, Ireland]	Taken into account -The chapter has been thoroughly rewritten and numbers are given in a more homogeneous way.
114119	0				Consistency shoudl be checked vs section 4.4.4 and chapter 20, as well as ch8. [Jan Fuglestvedt, Norway]	Accepted - consistency with other chapters (2, 4, 7, 8, 12) checked.
114121	0				section 6.6 is very useful and relevant. Please check consistency vs ch4 as well as WGIII, ch3. [Jan Fuglestvedt, Norway]	Accepted - consistency with other WG3 SOD has been checked through review of their chapter 3..
21963	0				The heterogeneity in whether each section closes with an assessment finding or not is not helpful to the reader. Personally I found the sections that ended with an assessment finding couched in uncertainty language more accessible and would suggest that approach be adopted throughout. This would also aid traceability between the ES and the main text. [Peter Thorne, Ireland]	Taken into account, the chapter has been thoroughly reworked as recommended.
114123	0				The chapter has a long list of acronyms. Please consider alternative formats for this; in consultations iwth TSU. [Jan Fuglestvedt, Norway]	Not applicable, this appendix does not exist anymore.
32207	0				Chapter 6 considers the impacts of PM according to their overall composition, but seems to only concentrate on PM2.5. The conclusions drawn would have more weight if the full granulometric spectra of PM were considered. As well, shape and not only diameter import for their interactions with the atmosphere. At the very least, a few words should be added as to why this focus has been chosen. [Eric Brun, France]	Not applicable - the effect of aerosol on climate is not restricted to PM2.5 but consider all sizes of aerosols.
55029	0				In general, the Executive Summary is good, covering all the aspects (emissios, abundances, their effects on radiative forcing and climate feedback). However, it seems that the entire chapter is made of many equal pieces without much coherence. Thus, the theme and the logic /structure built on it are not easy to follow. [Nancy Hamzawi, Canada]	Taken into account, the chapter has been thoroughly reworked.
112133	1	1	1	1	Chapter 6 on SLCFs is a great addition to this Assessment Report compared to AR5 and the authors have done a great job! I've only had time for a light reading through it, but I see nothing that I would make high level comments on - I find it really well done, and I'm sure the detailed comments will be dealt with well enough through others in this review and later in the technical review phase. [Mark Lawrence, Germany]	Thanks a lot.
81439	1	1	1	1	I congratulate the author team on the work they have carried out since the last draft, which has improved many parts of the chapter considerably. As a general comment, I find that more coordination is needed with other chapters to ensure a more consistent approach and message. Secondly, I am not sure why this chapter has an Appendix – is this material not meant to be in an Annex? [Johannes Laube, Germany]	Thank you - consistency with other chapters (2, 4, 7, 8, 12) checked. Appendix has been removed.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
35963	1	1	1	1	Congratulations to all for the great improvement since the FOD, and thank you for your efforts! [Nicolas Bellouin, United Kingdom (of Great Britain and Northern Ireland)]	Thank you.
86409	1	1	1	1	The entire Chapter is in much better shape and structure than the previous versions. The authors are to be commended for their discipline, hard work, and sharpened focus to the contents and arrangement. The authors have contended with: wealth of new material, multiple directions of SLCF research over the past decade, solidifying the bases initiated in earlier assessments. It is a tribute to the Author Team that they have wrestled with the challenges nicely, with the coverage and writing bearing this out. Overall, a splendid job. As tends to be usual in the aim towards a well-justified assessment of the science, there are a few shortcomings. Comments and suggestions have been made for the Author Team to consider, with a view towards strengthening the Chapter. Hope these are helpful. Best wishes as the Team drives into the final phase of the AR6. [venkatachalam ramaswamy, United States of America]	Thanks a lot.
44179	1	1	1	1	Interaction aerosols/urban climate scale is missing [Rafiq Hamdi, Belgium]	Rejected. Urban climate is not in the scope of this chapter.
44181	1	1	1	1	For some regions such as Arctic, south Asia, Mediterranean, Europe, there are some attribution statement on warming or cooling that are related in this chapter to the SLCF which should be checked with those in chapter10. [Rafiq Hamdi, Belgium]	Noted - consistency with chapter 10 has been checked.
44183	1	1	1	1	There is a link to section3 of chapter10 about the description of regional climate model dealing with aerosols effect but in our chapter10 we did not assess this type of regional climate/chemistry models. [Rafiq Hamdi, Belgium]	Accepted, the link has been removed.
44185	1	1	1	1	In this chapter it is mentioned with very likely that the northern hemisphere anthropogenic aerosols have weakened the Asian and West African monsoons with a reference to section10.6.3.3 this should be checked with LA of Chapter 10 responsible for each subsection. [Rafiq Hamdi, Belgium]	Noted - consistency with chapter 10 has been checked.
44187	1	1	1	1	Also it is mentioned in this report that black carbon deposition has contributed to snow cover decline in high mountain Asia (limited evidence, medium agreement), this should be checked with the cross-box on Himalaya. [Rafiq Hamdi, Belgium]	Noted - consistency with chapter 10 has been checked.
44189	1	1	1	1	Reduction of snow albedo due to dust/black carbon has been measured and characterized in the Arctic--- to be check with the cross-chapter box on the Arctic. [Rafiq Hamdi, Belgium]	Noted - consistency with chapter 10 has been checked.
44191	1	1	1	1	Deposition of black carbon aerosol in the Arctic have contributed to the strong warming in the region--- to be check with the cross-chapter box on the Arctic. [Rafiq Hamdi, Belgium]	Noted - consistency with chapter 10 has been checked.
44193	1	1	1	1	Precipitation change in the Mediterranean region is sensitive to black carbon change--- to be check with the Mediterranean case study in chapter 10 [Rafiq Hamdi, Belgium]	Noted - consistency with chapter 10 has been checked.
44195	1	1	1	1	SO2 emission lead to cooling of East Asia and a weakening of the East Asia summer monsoon to be check with case study in section4 chapter 10 [Rafiq Hamdi, Belgium]	Noted - consistency with chapter 10 has been checked.
44197	1	1	1	1	Page 49, line 12-34 a discussion about effect of SO2 emission on Sahel precipitation to be check with the case study on the Sahel in chapter 10 [Rafiq Hamdi, Belgium]	Noted - consistency with chapter 10 has been checked.
89789	1	1	1	1	The chapter is much improved over previous versions, nice work! [Trude Storelvmo, Norway]	Thank you.
77475	1	1	1	15	Include text here that frames SLCF in the context of the Earth energy balance and their contributions to warming and cooling separately. Eg use text similar to text in chapter 1 section 1.3.3 [Emer Griffin, Ireland]	Taken into account, text revised.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
72357	1	1	83	9	My major concern is the citation of material 'submitted'. Normally, journals will not accept such citations, although those accepted may be cited as such ('accepted' or 'in press'). Presumably there will be a check on whether or not these papers have been accepted. I have not flagged these instances in the text, bar one where I think the reliance on one submitted source is worrying. There are several other persistent editorial issues (mostly for consistency with other chapters I have looked at). 'Century' should be capitalised when it is used as a proper noun (e.g. '20th Century'). This is done inconsistently: I have not flagged all the instances of this in the text. Throughout the Chapter, by and large, British spellings are used. The exception to this is the use of 'paleo' as a single word or a suffix. This is incongruous in the context of other spellings, and ideally should be changed to 'palaeo'. Again, I have not flagged these instances, but a global search/replace could be applied. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	All the paper cited in FGD have been accepted before the 31st of January 2021. Editorial issues have been fixed for FGD.
77467	1	1	171	1	This is an important issue for climate actions. However, SLCFs have very diverse greater attention on how this diversity can be addressed and climate impacts quantified over a range of time scales could assist in quantifying the impacts of actions for climate and air quality. [Emer Griffin, Ireland]	Taken into account and made clear in the chapter and ES.
77469	1	1	171	1	Due to their short lived nature it is the flux/flow of these species to form the atmosphere that is important, this could be more clearly articulated. [Emer Griffin, Ireland]	Not applicable to this figure. See discussion about the time response of the climate effect for SLCFs discussed in 6.6.1.
77471	1	1	171	1	The impacts of short lived species on the Earth's energy balance are significant and in cases larger than that of long lived species. Greater attention to these issues is required and this chapter is welcome. [Emer Griffin, Ireland]	Thank you.
77473	1	1	171	1	Like other chapters the messages should be clear and linked as part of a narrative. From the title it is their impacts on the energy balance but this is not clearly flagged in the text. This can add clarity and should be included at the start e.g. use text from sections 3 of Chapter 1. [Emer Griffin, Ireland]	Noted. The intent of the chapter has been clarified in section 1 and the narrative follows the intent
77477	1	15	1	17	Some description of the types of PM/aerosols is warranted here e.g. primary such as soot/back carbon, secondary or formed from gases reacting in the atmosphere as providing a basis for this chapter [Emer Griffin, Ireland]	Taken into account, text revised.
77481	1	15	1	17	The fact that sources or many anthropogenic SLCFs are similar to those for key GHGs i.e. combustion, should be highlighted here. [Emer Griffin, Ireland]	Noted but this point is visible on figures 6.3 and 6.16.
38333	2	9	2	11	It is indicated in this part and Table 6.2 in line 25, page 12 of this chapter that the sources of SLCF fall into three categories: anthropogenic, natural, and biomass burning. Being subject to both anthropogenic emissions and the natural environment, biomass burning, if made an independent category, would easily lead to ambiguity. It is suggested the author team explain or modify it. [Yaming LIU, China]	Accepted - The case of perturbed natural systems has been clarified and emissions from biomass burning are now included there.
55031	2	14	3	2	the order of the species discussed in the sub-sections is confusing and no logical can be followed... Is this order (6.2.2.1 - 6.2.2.9) arranged according the total importance /contribution to climate forcing or life time or from aerosols to gases? It is suggested to arrange them by the importance of contribution to climate forcing first, then arranged by the life time if it is possible. [Nancy Hamzawi, Canada]	Accepted - the order has been changed and made more logical as recommended.
55033	2	33	2	36	Since the section 6.3.1. is titled as "Mechanisms of SLCFs", sections 6.3.1.1 and 6.3.1.2 should be combined as one section in which a simplified equation should be given to elucidate the relationship between emissions and concentrations as a mechanisim showing directive forcing. [Nancy Hamzawi, Canada]	Accepted - title has been changed and the order of section made more logical.
55035	2	37	3	2	Among those subtitles, no logics could be followed and several overlapping and repetitives across those subsections, e.g., section 6.3.1.4 (light-absorption particles effects on cryosphere) overlaps with section 6.3.2.1.3 (Carbonaceous aerosols and Light-Absorbing Particles on Snow and Ice). [Nancy Hamzawi, Canada]	Accepted - title has been changed and the order of section made more logical.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
32501	3	25	3	25	"Kigali Amendment" should be followed by "to the Montreal Protocol on Substances that Deplete the Ozone layer" [Sophia Mylona, Kenya]	Accepted: text revised
72359	5	1	5	1	Delete , from before 'and' (not required in this context) [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted. Done
44171	5	1	5	15	The spatial scale is not mentioned here if it goes until local, urban scale. [Rafiq Hamdi, Belgium]	Accepted
86777	5	1	7	23	The Excecutive summary seems quite complex to read and understand, and does not contain information easy to apply for policymakers. Please try to make the headline statements more relevant for potential inclusion in the SPM. We had e.g. expected to read about the role of SLCFs in attaining the Paris agreement temperature goal and net zero emissions by e.g. reduction in the rate of warming and less need for negative emissions in the last part of the century and lower risks for crossing tipping point in the ES. Further we think that the role of metane mitigation in the short term is undercommunicated. Figure 6.16 shows in fact that methane is the largest contributor to surface warming in a 10 years time frame for a 2014-puls. Further, the link between methane emissions, trop. ozone formation and the impact on food secturity and helath is not included in the executive summary and the SPM. We think that is is important for policy makers to understand that methane is a key pollutant to abate, and will provide benefits beond avoiding the direct climate change associated with it. Please consider to include some of the following from chapter 6 to the Excecutive summary: 1. There is a consensus in the literature that mitigation of SLCF emissions plays a central role in simultaneous mitigation of climate change, air quality, and other development goals including SDG targets (UNEP and WMO, 2011; Shindell et al., 2012, 2017a; Rogelj et al., 2014b, 2018b; e.g., AMAP, 2015a; Haines et al., 2017; Klimont et al., 2017b; McCollum et al., 2018; Rafaj et al., 2018; UNEP, 2019) {p. 66., l. 28}. The global sectoral attribution of temperature impacts on 10 and 100 year time scales for a pulse of 2014 emissions indicates substantial short-term impacts of SLCFs, especially CH4, BC and SO2 [Figure 6.16]. 2. CH4 mitigation will result in reduction of background ozone concentration and co-benefit for health and crop production (West et al., 2006; Fiore et al., 2008; Avnery et al., 2013) . Methane decrease can avoid crop loss due to decrease of ozone exposure (Feng and Kobayashi, 2009; Ainsworth et al., 2012; Emberson et al., 2018). Ozone-induced GPP losses ranges from 5-20 % regionally {Boks 6.2 and p. 50, l. 4-16, p. 67, l. 19}. 3. Neither ambitious climate change policy nor air quality abatement policy can automatically yield co-benefits without integrated policies aimed at co-beneficial solutions (Zusman et al., 2013; Schmale et al., 2014b; Melamed et al., 2016), particularly in the energy generation and transport sectors (Rao et al., 2013; Thompson et al., 2016; Shindell et al., 2018; Vandyck et al., 2018){p. 60, l. 16-19}. [Oyvind Christophersen, Norway]	Taken into account, the executive summary has been thoroughly reworked. . We now discuss the role of SLCFs in SSPs in the frame of the Paris goal attainment and underline this in the ES. Note that the effect of SLCF in the net zero emission and its consequence for carbon budget estimations is treated in chapter 5.
86321	5	1	7	24	Missed seeing points in the Executive Summary (ES) on past-to-present SLCF Radiative Forcing and Climate Impacts. The Future is given more weight in the ES, but developments in the understanding that have occurred since the last IPCC on SLCF ERFs and their effects on the climate of the past half-a-century are not explicit in the ES. There are many points in Section 6.3 that could be brought into the ES e.g., the increased confidence in the latitudinal movement of the tropical precipitation belt in response to aerosol forcing. [venkatachalam ramaswamy, United States of America]	Accepted and added to the ES.
111337	5	1	79	42	General comment: I appreciate the general organization of this chapter. It reviews several complex issues yet the flow is not too difficult for a reader to manage. Well done. [Tami Bond, United States of America]	Noted, thank you very much.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
111339	5	1	79	42	General comment: Throughout the chapter, there is inconsistency in how the components of particulate matter are treated. Sometimes they are discussed as all aerosols, sometimes as BC, POA, sulfate. The separation of the effects of "aerosols" and "BC on snow" is particularly odd. As decision-makers can change only emissions, it would seem that an emission-based representation would be most helpful, rather than mixing up the effects caused by different activities. The emission sources of sulfate, for example, aren't the same as those of BC or POA. I realize that it's probably too late to change this representation, but values and figures that are attributed to a large number of different activities probably aren't very helpful in assessing what to do in the future or how to improve knowledge. [Tami Bond, United States of America]	Accepted, a figure has been added to better highlight the sources/sectors (e.g. Figure 6.3) and effect on temperature and ERF are now shown per emitted compounds (figure 6. 12).
111341	5	1	79	42	General comment: The issue of "pre-industrial" radiative effect is addressed for most of the SLCFs, but its emphasis in the chapter is lower than its importance. The pre-industrial estimate is key in determining present-day forcing that will later be represented in ch7. I hope that confidence in each value, and the influence on forcing estimates could be presented consistently across species. This discussion is also needed for cloud effects [Tami Bond, United States of America]	Noted, the difference in evolution of aerosols since preindustrial is shown in Figure 6.8. and discussed in 6.3.5.
111343	5	1	79	42	General comment: The use of multi-model or ensemble averages to represent radiative forcing has limitations that need to be discussed throughout the chapter. I realize that it is politically expedient to give each model or entrant one "vote" and doing something better may go beyond the scope of a volunteer endeavor. But without a thorough assessment of why models differ and whether each model represents reality, their average or median is not a true best scientific estimate. For example, direct radiative forcing of many species is approximately proportional to atmospheric burden. Knowledge of burdens is discussed; model estimates of forcing are discussed; yet there is no discussion of whether each model that estimated forcing was able to reproduce the burden, or whether the estimated burden alone could contribute some intermodel variability. So, radiative forcing does not have to be estimated by models ONLY. The forcing should be an observationally-constrained estimate, to the extent possible. Limitations in this ability should be called out so that the next assessment does not suffer from lack of progress. This type of discussion is improved in ch7, but it should be supported by material presented in ch6. [Tami Bond, United States of America]	Taken into account, the ability of models to reproduce abundance and their evolution is now discussed more fully in 6.3. However, with the delay in CMIP6, the literature discussing in depth the intermodel variability was too scarce to enter into such details.
8581	5	1	82	45	I've read this chapter on behalf of Chapter 2. There are no strong inconsistencies between Ch.2 and 6. I noticed strong differences in structure and conciseness of the sections. Especially the emission scenario sections, and co-benefit discussions, while rich in content, and up-to-date, are in some sections somewhat repetitive. A number of sections are often quite descriptive, and do not seem to lead to a conclusion. A summary statement at each section (or cluster of section) would be appropriate, as done in some sections of this chapter, and elsewhere in the WG1 AR6. [Frank Dentener, Italy]	Taken into account, the chapter has been revised to provide more concise and homogeneous sections and avoid redundancies. Attention has been paid to come to clear conclusions at the end of each subsection.
103187	5	1			This executive summary needs revision once the topic of the chapter is fully clear. Also, sorting by priorities would be helpful, e.g. (i) chemistry links between different compounds (i.e., oxidation and particle formation), (ii) spatial and temporal behaviour of compounds in the past, e.g. as a function of emission sources, (iii) future development and climate impact, and climate dependency, (iv) feedbacks between compounds, feedback to biosphere, human health etc. Already the introdcution should mention which compounds are included (HFC's!) [Philippe Tulkens, Belgium]	Taken into account, the executive summary has been thoroughly reworked.
51223	5	2	5	4	The separation between SLCFs and GHGs is due to their impact, not whether they are pollutants are not; suggest this is rephrased for clarity: 'Short Lived Climate Forcers (SLCFs) affect climate (by cooling or warming) and often have other socio economic consequences e.g. for human health, ecosystems or materials. They are typically co-emitted with long lived GHGs (LLGHGs) as a result of fuel use in combustion however other substantial sources exist' [Jolene Cook, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text is revised
103189	5	2			"aerosol" is a mixture of a gas with particles. Suggest to delete this term and fully focus on particulate matter. [Philippe Tulkens, Belgium]	Not applicable, aerosols don't need to be defined.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
35965	5	3	5	3	"(by cooling or warming)" is an understatement, because SLCF also affect the hydrological cycle etc. Probably not needed anyway. [Nicolas Bellouin, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text is revised
127893	5	3	5	3	Put "SLCFs" in parentheses for consistency with definition of other acronyms. [Trigg Talley, United States of America]	Accepted. Done
80625	5	3	5	3	I suggest making it clear from the start that SLCFs have a number of climate interactions, not just through surface temperature. E.g. "Short-lived Climate Forcers or SLCFs affect the climate (by cooling or warming the surface, and by affecting precipitation and other weather components) and ..." [Bjorn Samset, Norway]	Accepted
51219	5	3	7	23	The executive summary reads more like a technical summary and can be quite difficult to understand for a non-expert. From a personal perspective, section 6.1 is easier to understand than the than the Exec summary page 5, lines 3 - 15. [Jolene Cook, United Kingdom (of Great Britain and Northern Ireland)]	Noted, the headline has been rewritten.
26145	5	4	5	4	Both LLGHG and WMGHG are used. The terms should be unified or clearly distinguished. [Toshihiko Takemura, Japan]	We now clearly mention which GHG we are talking about.
109611	5	4	5	4	Can we say "typically" here? Later in the chapter, also natural aerosols are referred to as short-lived climate forcers, but many of these are not co-emitted with LLGHGs. [Ilona Riipinen, Sweden]	Accepted
109613	5	4	5	4	I would suggest replacing "aerosols" with "aerosol particles" [Ilona Riipinen, Sweden]	Rejected, it's not the wording commonly used by the community.
103191	5	4	5	5	Defining aerosol solely by their chemical composition is hardly scientificly appropriate, as size and shape are equally important for climate and health. The list of components is moreover not complete. Suggested phrasing: They include aerosols, also called particulate matter, with mixed chemical composition (e.g. sulphate, nitrate, ammonium, carbonaceous aerosols, mineral dust, and sea salt) and size between a few nm and 10 um. [Philippe Tulkens, Belgium]	see comment 8225
8225	5	4	5	5	Defining aerosol solely by their chemical composition is hardly scientificly appropriate, as size and shape are equally important for climate and health. The list of components is moreover not complete. Suggested phrasing: They include aerosols, also called particulate matter, with mixed chemical composition (e.g. sulphate, nitrate, ammonium, carbonaceous aerosols, mineral dust, and sea salt) and size between a few nm and 10 um. [Frank Dentener, Italy]	The size is discussed in 6.1. The introduction of the Executive statement can not explain all the fundamental knowledge about aerosols. It is a compromise between the notions necessary to understand the frame of the chapter 6 assessment and the length of such introduction.
109857	5	5	5	5	It is recommended to add the abbrevation (PM) after the word (particulate matter). [Rehab El-Maghraby, Egypt]	Accepted
26147	5	5	5	5	"carbonaceous aerosols" shold be replaced with "organic matter, black carbon". [Toshihiko Takemura, Japan]	Rejected as "carbonaceous aerosols" is used in the litterature.
45357	5	5	5	5	particulate matter, (sulphate) --> particulate matter (sulphate) [Hitoshi Matsui, Japan]	Accepted. Done
109615	5	5	5	5	I would suggest replacing the contents of the parenthesis with "(comprising of e.g. sulphate, nitrate, ammonium, carbonaceous species, mineral dust and sea spray)" [Ilona Riipinen, Sweden]	Rejected, the list of species included in SLCFs is explained in 6.1 and repeated here.
45359	5	5	5	5	sea salt) and --> sea salt), and [Hitoshi Matsui, Japan]	Accepted. Done
127895	5	5	5	5	List of aerosol species "(sulphate, nitrate, ...)" is placed incorrectly in the sentence. [Trigg Talley, United States of America]	Accepted. Done
86317	5	6	5	6	Methane is discussed under SLCFs. However, GWPs are discussed in Chapter 7. Is there adequate cross-referencing to link methane characteristics discussed here to potential GWP discussions in Chapter 7? [venkatachalam ramaswamy, United States of America]	Chapter 7 discussed GWP for all compounds including SLCFs. Consistency between chapters for subjects or species treated in several chapter have been checked thoroughly for the FGD.
103193	5	6	5	7	It is formally not correct to call components like Nox, SO2, CO, NMVOC SLCFs, they are of course important as precursors to SLCFs. Suggest to include the word precursor where appropriate. Consistency with Table 2.1 is needed. [Philippe Tulkens, Belgium]	Rejected, precursors indirectly affect climate and thus are climate forcers. It is defined in 6.1
8227	5	6	5	7	I think it is formally not correct to call components like Nox, SO2, CO, NMVOC SLCFs, they are of course important as precursors to SLCFs. Suggest to include the word precursor where appropriate. Consistency with Table 2.1 is needed. [Frank Dentener, Italy]	Rejected, precursors indirectly affect climate and thus are climate forcers. It is defined in 6.1

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103195	5	6			the special role of CH4 (described in detail in Chapter 5) should be acknowledged very early [Philippe Tulkens, Belgium]	Rejected, here it is a brief introduction, the role of methane is rather a conclusion and is thus discussed in the statements themselves.
104727	5	7	5	7	Not clear if abundance is referring only to reactive gases or aerosols or both. [Tobias Schad, Germany]	Accepted, clarified in the text.
103197	5	7	5	7	Except Methane. This is not correct all SLCF with a lifetime larger than ca. 1 year (e.g. HFCs, some HCFCs) would also qualify. [Philippe Tulkens, Belgium]	see answer to #8229
109617	5	7	5	7	Can we say that ammonium is "chemically reactive"? [Ilona Riipinen, Sweden]	Not applicable, part of the sentence removed.
127897	5	7	5	7	Add parenthetical after methane: "Except methane (which is both an SLCF and an LLGHG), ..." (and in general, it would be worthwhile to make it clear that methane and HFCs are included in climate treaties, unlike the other SLCFs). [Trigg Talley, United States of America]	Accepted text revised
72361	5	7	5	7	Delete , from before 'and' (not required in this context) [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted. Done
104729	5	7	5	8	Temporal heterogeneity should be mentioned explicitly, something like: […] their abundances are highly spatially and temporal heterogeneous […]. [Tobias Schad, Germany]	Taken into account heterogeneity of lifetime better highlighted now.
112005	5	7	5	8	Qualify to show methane lifetime: “Except methane, which has a lifetime of about a decade, their abundances are …” [Cynthia Randles, United States of America]	Accepted. Done
81345	5	7	5	8	The transition between SLCFs and LLGHGs seems to be very blurred. For this statement it is worth noting that neither most HCFCs, nor most HFCs, halons or methyl bromide “persist in the atmosphere from a few hours to a couple of months”, so their abundances are not “highly spatially heterogenous”. More generally, some coordination of the terminology with Chapters 2 and 7 would be advisable as various, partly overlapping terms are used (including WMGHGs, LLGHGs, synthetic GHGs, halocarbons, halogenated species, and even “halogens”). [Johannes Laube, Germany]	Accepted - text is revised
8229	5	7	7	7	Except Methane. This is not correct all SLCF with a lifetime larger than ca. 1 year (e.g. HFCs, some HCFCs) would also qualify. [Frank Dentener, Italy]	Accepted - text is revised
76631	5	8			There are many compounds with shorter lifetimes than hours, e.g. the sesquiterpene beta-caryophyllene reacts with ozone within ~2 minutes (Atkinson and Arey 2003); Tale 6.1 also shows lifetimes of minutes in Table 6.1 [Felix Havermann (né Wiß), Germany]	Rejected, here it's a mean lifetime over the whole troposphere.
113893	5	9	5	11	Not sure you need to mention SR1.5 here. And that report did not have much material on SLCF. [Jan Fuglestvedt, Norway]	Accepted text revised
51225	5	11	5	12	Suggest this is rephrased to reflect the fact that the chapter doesn't explore all possible future scenarios: 'This chapter assesses our understanding of past and a selection of possible future changes…' [Jolene Cook, United Kingdom (of Great Britain and Northern Ireland)]	Accepted
104731	5	13	5	13	not very fluent to read. And not very clear what kind of feedbacks. Climate feedbacks? [Tobias Schad, Germany]	Accepted text revised
86313	5	13	5	13	The Chapter discusses SLCF-related radiative forcing and climate response, but not feedbacks. [venkatachalam ramaswamy, United States of America]	The chapter discusses the feedbacks in section 6.4.5.
77485	5	13	5	13	It is their effect on the Earth's energy balance through radiative forcing, rather than their effect on radiative forcing. The rest follows. [Emer Griffin, Ireland]	accepted
127899	5	13	5	14	Awkward phrasing: "the role of the sectoral emissions in SLCF effects." Rephrase. [Trigg Talley, United States of America]	Accepted text revised
8231	5	14	4	14	effects on climate, air pollution, or both? [Frank Dentener, Italy]	Accepted text revised
103199	5	14	5	15	effects on climate, air pollution, or both? [Philippe Tulkens, Belgium]	see answer to 8231
80627	5	19	5	19	Please specify the years for the last decade. Also, can a pattern be "strong shifting"? I propose "rapidly shifting". ("Over the last decade (2010-2019), rapidly shifting patterns of…") [Bjorn Samset, Norway]	Taken into account. Revised to "strong shifts in the geographical distribution of emissions…"

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64993	5	19	5	22	Is this the headline, first key finding, or not rather trivial given the very definition of SLCF? Why not bring out a clear and quantitative message that makes use e.g. of the “decline” statements in sentences 3 onwards? The main interest, in my opinion, would be in scattering and absorbing aerosols. Also I’d think it would be good to put the last decade into the longer context. [Johannes Quaas, Germany]	Noted but we consider that the heterogeneity of regional trends and between compounds is the most important point to convey, otherwise all the sentences should in bold in this paragraph.
28505	5	19	5	28	Although the title of this paragraph contains "emissions", all statements are on abundances. I would propose adding "Uncertainties in the SLCFs emission rates are larger than CO2, limiting confidence in the source/sink analysis" at the end of this paragraph, with a vision of SLCF inventory activities in the AR7 cycle led by TFI. [Hiroshi Tanimoto, Japan]	Rejected, the first statement is about emissions. Assessment of emission rates is not assessed compared with CO2 in the chapter. Inventory activities led by TFI have been added to chapter 1.
26985	5	19	5	28	This statement could be better supported by a table or a paragraph at the end of the section 6.2 synthetising the trends over the last decade for each type of species and the type of information it is based on. [Eric Brun, France]	Taken into account - The table has not been added but the section has been shortened and a strong attention has been paid to conclusions at the end of each subsection.
127901	5	19	5	28	Methane is noticeably absent here and in this first section overall; given importance placed on methane later in summary, why not lead with a point on methane? [Trigg Talley, United States of America]	Rejected - since the evolution of methane abundances is covered in Chapter 2 and 5, we do not include a point here to avoid overlap
127903	5	19	5	28	Should OH be considered a SLCF in opening paragarph above? [Trigg Talley, United States of America]	Noted - OH modulates the abundances of SLCFs
127905	5	19	5	28	Text block first says OH has increased since 1980 but then ends with noting small variability over this period; which is it? [Trigg Talley, United States of America]	Noted - we recognize that there is confusion in the understand of trends and variability in OH. Variability measures the range of the variance in OH over the 1980-2014 period and can still be low despite an increasing trend. We have removed the point about variability from this statement and keep the focus on the trend which is relevant for methane trends (discussed in Chapter 5)
98607	5	19	5	39	In general: it would be useful to make a statement on the global (not only regional) trend of anthropogenic aerosol loads (or AODs). Its hard to figure out from the text whether the regional trends compensate, add up, or are dominated by one region. Modelled trends consistent with regional model data comparisons of trends should be helpful to include. Recent work to possibly cite: Bellouin ESSD 2020, Mortier ACPD 2020 but surely other papers as well can inform here. [Michael Schulz, Norway]	Rejected. Statement on the evolution of global AOD is included in chapter 2.
127907	5	20	5	20	"abundances of SLCFs which are highly variable" --> "abundances of SLCFs, which are highly variable" (add a comma) [Trigg Talley, United States of America]	Accepted. Done
51227	5	21	5	21	Suggested addition to the end of the paragraph: the quote from 6.5 'Achieving Paris Agreement goals, including limiting warming to 1.5°C, requires simultaneous and ambitious reductions of SLCFs and LLGHGs within the next decades.' [Jolene Cook, United Kingdom (of Great Britain and Northern Ireland)]	Noted, a reference to the Paris agreement has been added in the Exec Summ on page 7
103201	5	22	5	22	NO2 and SO2 are SLCF precursors, not SLCFs. Suggest to include in line 21: "SLCFs and precursors." [Philippe Tulkens, Belgium]	see answer to #8233
8233	5	22	5	22	NO2 and SO2 are SLCF precursors, not SLCFs. Suggest to include in l. 21: "SLCFs and precursors." [Frank Dentener, Italy]	Rejected, as defined in 6.1, precursors are part of the SLCFs
98605	5	22	5	31	first paragaph: Tropospheric columns of NO2 declined - second paragraph: anthropogenic NOx as increased since 1980 .. Thta is not particularly consistent. Can one make a more statement on global Nox trends? [Michael Schulz, Norway]	Taken into account - the second paragraph explains global OH trends based on global NOx while the first paragraph talks about trends in regional NO2 columns. This nuance is now clarified
44173	5	23	5	23	is there a reason why only for east asia a year of decrease is mentioned and not for the other mentioned regions? [Rafiq Hamdi, Belgium]	Taken into account - this is better clarified now. The decline in NO2 and SO2 columns over East Asia began in 2011, up until then they were increasing
45829	5	23	5	24	Since a decline in tropospheric NO2 over East Asia has been observed from satellites, why would there be only medium confidence in this statement? [Twan van Noije, Netherlands]	Accepted - we have assigned high confidence to changes in trop NO2 over East Asia based on satellite observations

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
111347	5	23	13	2	BC and OC should be listed from fossil-fuel combustion as they are emitted by vehicles and other transportation [Tami Bond, United States of America]	No possibility to know what the comment refers to.
127909	5	26	5	28	"Global carbonaceous aerosol budgets and trends remain poorly characterised due to limited observations but black carbon (BC) is declining in several regions of the world (low confidence)." All aerosols (Nitrates, ammonia, dust ,seasalts...), with the exception of SO2, are poorly characterized. Suggest editing: "Global aerosol budgets and trends remain poorly characterized..." [Trigg Talley, United States of America]	Rejected. This statement provides assessment of trends for compounds for which there is relatively more robust evidence rather than an assessment of the number of observations. Chapter 6, and in particular Figure 6.7, provides more insights on observation availability.
103203	5	26			please check: are HFCs increasing, or are they increasing at an increasing rate? [Philippe Tulkens, Belgium]	Accepted, sentence modified.
98609	5	27	5	27	"BC trends are declining in several regions" - so what is the global trend? Are there also regions where BC is not declining and when? Would it be useful to eg look into ice core records? Alps, Greenland? [Michael Schulz, Norway]	Taken into account, see discussion in 6.3.5.3
35967	5	27	5	27	"black carbon (BC) is declining in several regions" needs to be made more concrete. Since when? In which regions is it still increasing? [Nicolas Bellouin, United Kingdom (of Great Britain and Northern Ireland)]	Noted. All the paragraph refers to the last decades but the statement about BC is now better explained.
77487	5	27	5	28	Does carbonous aerosols include both black carbon/soot and organic carbon? If so this should be clear. [Emer Griffin, Ireland]	yes, this is explained in the chapter (6.3.5.3)
103205	5	28	5	28	not clear what the 'low confidence' statement is referring to. The first part of the sentence is already stating that there is high uncertainty. If it refers to the second part of the sentence, it needs to be clarified what is meant with the low confidence. I suspect in most regions long-term trends are based on only a few observations, and therefore the representativity for larger regions is uncertain? Or is trends in other regions are uncertain because there are no observations? [Philippe Tulkens, Belgium]	see answer to #8235
8235	5	28	5	28	not clear what the 'low confidence' statement is referring to. The first part of the sentence is already stating that there is high uncertainty. If it refers to the second part of the sentence, it needs to be clarified what is meant with the low confidence. I suspect in most regions long-term trends are based on only a few observations, and therefore the representativity for larger regions is uncertain? Or is trends in other regions are uncertain because there are no observations? [Frank Dentener, Italy]	Noted. The statement about BC is now better explained.
51229	5	30	5	31	Please could you revisit this paragraph as its meaning is currently unclear; it currently appears internally contradictory. On the one hand stating the oxidising capacity of the troposphere has increased since 1980. On the other hand, having defined the oxidising capacity of the troposphere as 'global mean abundance of hydroxyl(OH) radical', the text goes on to say ' the interannual variation in OH has remained within 3% suggesting OH is not the primary driver of recent observed growth in atmospheric methane.' That is methane life time has not been substantially affected and hence the OH radical hasn't changed substantially. If what is meant is that while OH has increased by 3% the primary driver of the increase in methane concentration is increased emissions then the insertion of only into line 36 to make '..within only 3%' might help clarify the meaning. Or it might be possible to rephrase the paragraph to be clearer. [Jolene Cook, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account - this paragraph has been revised
127911	5	30	5	32	Has declining stratospheric ozone been ruled out as a key driver for an increase in tropospheric OH over this period (e.g., John et al., ACP, 2012)? [Trigg Talley, United States of America]	Noted - a more recent multi-model study (Stevenson et al 2020) finds declining stratospheric ozone and aerosols to have a small contribution compared with NOx and CO.
34899	5	30	5	33	Detailed Comments by SOD Chapter – Chapter 6: The SOD puts an upward revision of the short-wave forcing of Methane (CH4) since AR5. Please see rebuttal comment #4 above. [Jim O'Brien, Ireland]	Do not understand this comment
103207	5	30	5	39	Can something be said about the role of (declining) VOC emissions? Intuitively, the attribution of high confidence to variations <3 % could be challenged, as there are no direct observational constraints; and this statement relies on indirect model reconstructions. [Philippe Tulkens, Belgium]	see answer to #8237

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
8237	5	30	5	39	Can something be said about the role of (declining) VOC emissions? Intuitively I would challenge attribution high confidence to variations <3 %; as there are no direct observational constraints; and this statement relies on indirect model reconstructions. [Frank Dentener, Italy]	AerChemMIP model experiments did not separate the effects of different ozone precursors (NOx, CO and NMVOCs), but these have been explored in previous studies (Stevenson et al., 2013; Holmes et al., 2013), where increases in anthropogenic NOx emissions have been found to be the main driver of OH increases. We have removed the point about interannual variability and focus on the trends in OH and this is relevant from the perspective of methane lifetime changes
45361	5	30	5	39	Please clarify the relationship between the first sentence and the third sentence in this paragraph. The first sentence describes the oxidizing capacity has increased since 1980, while the third sentence describes OH change is limited during the same period. [Hitoshi Matsui, Japan]	Taken into account - text has been revised to remove confusion
12111	5	30	5	39	please be explicit, +/- 3%; just 3% would mean +/-1.5% to some readers; how do you separate the trends from variability? Or should they be separately reported?? I know this would call for more scrutiny on CH4 budget but you may try to give a fair assessment. Should the change during 1850 - 1980 have higher confidence; if you have low confidence in this period how can you have medium confidence for the period since 1980 ? [Prabir Patra, Japan]	Taken into account- due to the confusion about trends and variability, we have removed reference to variability and only focus on the trends in OH in this point.
112007	5	30	5	39	Would be good to comment on how, if at all, trends in oxidizing capacity (and hence methane lifetime) affect important metrics such as GWP [Cynthia Randles, United States of America]	Rejected - a comment on GWPs is outside the scope of this chapter
64995	5	30	5	39	I would expect a clear statement about methane and tropospheric ozone as the key message in this second statement. The oxidising capacity in itself is not an SLCF. Reading the entire ES statement, I see that CH4 was observed to increase, nothing on O3. But these are the key interests in SLCF. [Johannes Quaas, Germany]	A key message on ozone changes is in Chapter 2 and methane changes is in Chapter 5
35969	5	32	5	32	Is the medium confidence on the fact that oxidising capacity has increased, or on the identification of the drivers? The rest of the paragraph would suggests that oxidising capacity has in fact not changed significantly. [Nicolas Bellouin, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account - the medium confidence is for the identification of drivers. This is now clarified
99043	5	32	5	33	I'd suggest adding a phrase in the sentence so it says something like:' This implies a declining trend in the atmospheric lifetime of methane post 1980, which in turn implies that methane emissions have been going up at a rate greater than shown by its rising concentration." [Michael MacCracken, United States of America]	Noted. The trends in methane emissions are covered in Chapter 2.
45831	5	33	5	33	The sentence suggests that the oxidising capacity is defined as the global mean abundance of hydroxyl (OH) radical. However, global mean OH is not the only measure of the oxidising capacity. I suggest to remove the part between the parentheses. [Twan van Noije, Netherlands]	Accepted - text is revised
127913	5	33	5	33	The "oxidising capacity of the troposphere" is not equivalent to "global mean abundance of OH," even though the two are closely related. Should not use "i.e." here. [Trigg Talley, United States of America]	Taken into account - text has been simplified to describe OH as the primary sink of many SLCFs
127915	5	34	5	34	In the case of ozone and secondary aerosols, the influence of OH on (abundances and) radiative forcing is not primarily through affecting lifetime. Remove "therefore" from sentence. [Trigg Talley, United States of America]	Taken into account - text has been simplified to describe OH as the primary sink of many SLCFs
127917	5	36	5	36	Are there multiple lines of evidence to support high confidence in the 3% varaibility in OH? [Trigg Talley, United States of America]	Not applicable - we do not discuss variability anymore
45833	5	36	5	37	A stable global mean doesn't exclude the possibility of a spatial re-distribution of OH, which may have affected the CH4 growth rate. [Twan van Noije, Netherlands]	Noted - agreed but we keep the focus here on global mean OH relevant for methane lifetime
32033	5	36	5	37	High confidence? I'd agree but 'medium' might be a safer choice. There are a number of papers that would take different views. Also there is longitudinal variation. [Euan G. Nisbet, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable - we do not discuss variability anymore
28507	5	36	5	37	High confidence on OH IAV <3% might be too optimistic, given the possibility of missing/uncharacterized source/sink of OH. Medium confidence would be adequate, in a balance to other sentences with high/medium condidence. [Hiroshi Tanimoto, Japan]	Not applicable - we do not discuss variability anymore

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
44175	5	38	5	38	are there any differences spatially? [Rafiq Hamdi, Belgium]	Not applicable - we do not discuss variability anymore
51221	5	41	5	42	It would be helpful to expand the "SSP" and "RCP" acronyms i.e. Shared Socioeconomic Pathway (SSP), and Representative Concerntration Pathway (RCP) here, and refer the reader to their definitions elsewhere in the report. [Jolene Cook, United Kingdom (of Great Britain and Northern Ireland)]	Accepted
26149	5	41	5	46	If a difference in SLCFs between RCP and SSP is explained, specific explanation shold be included although here is an executive summary. This paragraph is too conceptual to understand what you want to say. [Toshihiko Takemura, Japan]	Taken into account - this paragraph has been revised
107511	5	41	5	46	This bullet is a description of the IAMs that produce the scenarios. It does not contain any assessment statement from the chapter. [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account - this paragraph has been revised
8239	5	43	5	43	It would be useful to provide some quantification what ranges you are talking about. Is this the place to directly quantify what that means for ERF? [Frank Dentener, Italy]	Taken into account - this paragraph has been revised
103209	5	43	5	44	It would be useful to provide some quantification what ranges we are talking about. Is this the place to directly quantify what that means for ERF? [Philippe Tulkens, Belgium]	see answer to #8239
106383	5	43	5	46	It is encouraging to see that a wider range of SLCF variation could be used based on the SSP. However, it would be valuable additional information for readers to know whether the range of SLCFs in the SSP-based scenarios is assessed to span a useful broad spectrum of high and low SLCF emissions future, or whether this range is still markedly narrower than what one could reasonably conceive. [Rogelj Joeri, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account - this paragraph has been revised
77489	5	43	5	46	Some mention of the UNECE CLTRTAP is warranted as it has been central to actions to address air pollution. Also development of analysis, observation and modelling systems. [Emer Griffin, Ireland]	Rejected - too detailed compared with the purpose of this statement which is just to highlight the wider range of scenario (compared with RCP) more able to cover the range of possible future trajectories for air pollutants.
127919	5	46	5	46	What are these discrepancies? Can a brief example be given? [Trigg Talley, United States of America]	Not applicable, sentence modified.
77491	5	46	5	46	Variability would be better than discrepancies. [Emer Griffin, Ireland]	Accepted. Done
44177	5	48	5	49	what do you mean by local scale? [Rafiq Hamdi, Belgium]	local scale ranges to a few hundreds of meters
127923	5	48	5	49	The role climate change plays in increasing wildfires and PM -- e.g., over western U.S. (e.g., McClure & Jaffe, 2018) -- is not mentioned here and yet seems like it could be a headline conclusion for this chapter? What about climate changing dust emissions? [Trigg Talley, United States of America]	Accepted. Ozone changes due wildfire emissions in a warmer climate are noted among the uncertainties in the revised version. We also note the uncertainties to emissions of land aerosols which include dust.
77493	5	48	5	50	Ground level ozone is a regional and to some extent hemispheric, these features should be mentioned as well as global and local. [Emer Griffin, Ireland]	We added "from global to local scale" to include within the hemispheric and the regional scale.
21145	5	48	6	9	It is also necessary to discuss the change of emissions in the Southern Hemisphere, espeically that the biomass burning in South America and Africa are highly dependent on climate. [Jing Li, China]	Rejected. We do not include in ES an explicit regional discussion in this chapter as regional aspects are covered in others chapters (Chapters 10, 11, 12 and ATLAS).
21917	5	48	6	9	This felt too long and convoluted a point packing too much information in. It may be cleaner and more accessible if it can be split into 2 or 3 more bite sized pieces. [Peter Thorne, Ireland]	Accepted
127921	5	48	7	49	As written, the finding can imply that climate has insignificant effects on surface ozone and PM. If authors flip the phrasing, it can avoid this implication: "Changes in precursor emissions will have much larger impacts relative to climate changes on future surface ozone and PM concentrations at global and local scales". [Trigg Talley, United States of America]	Accepted and revised accordingly.
127925	5	49	5	54	Clarify that this discussion pertains to mean concentrations, as distinct from final sentence of the paragraph on extremes. [Trigg Talley, United States of America]	Taken into account. Extremes are not discussed in this paragraph implying that mean concentrations are discussed here

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
98611	5	49	6	6	I wonder if one can say that emissions predominantly drive future ozone and PM with "high confidence" if there is "low to medium confidence in the response of ozone and PM due to uncertainty in natural processes"? All in one paragraph [Michael Schulz, Norway]	Accepted text modified. Note that in model simulations anthropogenic emission already dominate future surface ozone and PM changes despite the uncertainties in climate change induced in natural emissions and even without considering changes in natural emissions.
103211	5	50	5	50	what is meant by "small"? Please quantify, as done later for ozone. [Philippe Tulkens, Belgium]	Accepted. Text has been revised
8241	5	50	5	50	what is meant by small? Quantify. You do so later for ozone. [Frank Dentener, Italy]	see answer to #103211
127927	5	50	5	50	Avoid the use of the word "small": some models project that climate impacts on PM can contribute to thousands of excess deaths. In the next sentence, increases of "a few ppb" are specified: being able to put a number on the estimate would be an improvement. Also, specify "global". Particularly with climate-induced wildfires and dust storms, there could be some areas with larger PM effects. [Trigg Talley, United States of America]	Accepted. Text has been revised
45835	5	51	5	54	There are many uncertainties associated with model projections of surface ozone, one being the response to changing isoprene emissions. Does this statement properly account for these uncertainties? [Twan van Noije, Netherlands]	We refer to the low confidence level for quantifying the impact of climate change on surface ozone through BVOC emissions which includes also isoprene.
99045	5	51	5	54	What is critical for ozone formation is the ratio of volatile hydrocarbons to nitrogen oxides, and not just what the temperature is (and "warmer climate" is a strange way to say higher temperatures). Because of this, there is a dependence on what the local vegetation is and so it is not just whether regions are polluted or not. It is not clear from the statement here all that has gone into these conclusions (nor the ones further along in this paragraph) and I think it would be useful to give a bit better sense of what has been considered so air quality and other experts will be better informed on the mechanisms and processes included in the consideration. [Michael MacCracken, United States of America]	Accepted. It was added that ozone increase in polluted regions depends on the controlling role of NOx and VOCs for ozone formation. Furthermore the uncertainties of ozone changes in a warmer climate due to BVOC emissions and the biosphere interactions are also noted.
76633	5	51	5	55	It should be stressed more why surface ozone concentration will increase in future → due an emissions increase of precursor trace gases/pollutants [Felix Havermann (né Wiß), Germany]	Taken into account, text revised.
42993	5	53	5	54	It is not clear what conclusion to take from "regional discrepancies over South Asia for the monsoon season". Does it mean that surface ozone will not be decreased for unpolluted India (increased for polluted India) during the monsoon? Does it allude to the frequent monsoon rainfall washing out surface ozone and therefore the signal as witness in other regions would not be present? [Andrew Turner, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable. The part of the sentence "regional discrepancies over South Asia for the monsoon season" has been removed from ES and 6.4.1 as it is not a robust result.
18753	5		6		In the executive summary,a brief discussion of the cooling caused by major volcanic eruptions may be provided to provide context the climatic effect of short lived sulfate aerosols. [Govindasamy Bala, India]	Rejected, effect of volcanic eruptions on climate are not discussed in chapter 6 but in chapter 4. (Cross-Chapter Box 4.1).
130513	5		7		in Executive summary, the radiative forcing and climate responses of SLCFs covered in Section 6.3 have not been reflected. [Panmao Zhai, China]	Accepted and added to the ES.
32505	5		79		The use of the ranges 0.3–0.5 oC and 0.2 to 0.4 oC when referring to the impact of the implementation of the Kigali Amendment on the global temperature is somewhat confusing. You may wish to employ the following expression used in the WMO, 2018 report which shows the connection between the two ranges: "The Kigali Amendment is projected to reduce future global average warming in 2100 due to HFCs from a baseline of 0.3–0.5 oC to less than 0.1 oC. The magnitude of the avoided temperature increase due to the provisions of the Kigali Amendment (0.2 to 0.4 oC) is substantial in the context of the 2015 Paris Agreement, which aims to keep global temperature rise this century to well below 2 oC above pre-industrial levels." [Sophia Mylona, Kenya]	Taken into account - text revised in respective sections considering this and other comments related to the executive summary statement, (6.6.3.2 and 6.7.3 in FGD).
108227	6	1	6	1	Even though it is probably too late, I would like to state that “climate forcers” is not good wording, especially for a chapter heading. Replacing “forcers” by drivers would already be much better. The existant use of this type of inappropriate slang should not serve as a justification for further spreading this type of language. [Petra Seibert, Austria]	Rejected, the name of the chapter (which contain the name climate forcers) has been decided at the scoping meeting in 2017 and can not be modified.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
86025	6	1	79	42	The focus of this chapter is largely on Europe, the USA, and China with other regions given little attention. The Mediterranean region, for instance, appeared only once in the entire chapter. It is also not clear why the regional framing for this report provided by Chapter 1 was not used in this report. [Debra Roberts and the Durban WGII TSU, South Africa]	Not applicable. The explicit reference to Europe, USA and China within the statement has been removed.
37983	6	2	6	3	High methane levels …. measures … (measures => measure) [Junhee Lee, Republic of Korea]	It is "climate change mitigation measures".
103213	6	4	6	4	What is meant by low to medium confidence? Which part is low (PM?), which part is medium (O3?). As far as I know low-to-medium confidence is not a category in the uncertainty language definition. [Philippe Tulkens, Belgium]	Editorial, treated.
8243	6	4	6	4	What is meant by low to medium confidence? Which part is low (PM?), which part is medium (O3?). As far as I know low-to-medium confidence is not a category in the uncertainty language definition. [Frank Dentener, Italy]	Accepted and revised accordingly.
127929	6	4	6	7	This paragraph should include wildfires as an important component of natural emissions. The influence of climate change on wildfires and associated emissions is discussed in some detail in 6.2.1.3 but is omitted here. [Trigg Talley, United States of America]	Accepted. Ozone changes due wildfire emissions in a warmer climate are noted among the uncertainties in the revised version.
99047	6	4	6	7	This might be a good place to note that the ratios of species concentrations can matter--if the ratio stays the same, changes in emissions can have a very small effect. [Michael MacCracken, United States of America]	Rejected, too detailed for ES statement.
20357	6	4	6	9	The way this reader understands the IPCC calibrated language, "low confidence" does not mean "no confidence at all". Hence, one should not assign a "low confidence" statement to several conflicting opinions. From Box 1.1: a confidence statement should be attributed to "the validity of a finding, based on the type, amount, quality and consistency of evidence". It should spell out its object; this is still more necessary when assigning medium confidence. [philippe waldteufel, France]	Taken into consideration for the revision of the key statements.
21143	6	5	6	5	due -> due to [Jing Li, China]	Accepted. Done
72363	6	5	6	5	Capital 'S' for 'stratosphere' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial. The report will undergo professional copy-editing prior to publication. This type of issue will be fixed then.
86027	6	6	6	6	Write VOCs in full since this is the first usage. [Debra Roberts and the Durban WGII TSU, South Africa]	Accepted. Done
45363	6	6	6	6	VOCs --> volatile organic compounds (VOCs) [Hitoshi Matsui, Japan]	Accepted. Done
72365	6	6	6	6	Capital 'T' for 'troposphere [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial. The report will undergo professional copy-editing prior to publication. This type of issue will be fixed then.
20359	6	6	6	13	It will be necessary somewhere in this report to comment the statute of methane. In the present chapter CH4 is considered as belonging to the SLCF category; elsewhere (on figure SPM3 to begin with), it is listed as a well-mixed GHG. This hesitation can be explained. According to figure 6.1, methane is "rather" well mixed…similarly, its lifetime (table 6.1) is by far the largest among SLC [philippe waldteufel, France]	Accepted - this is explained in 6.1.1.
109619	6	7	6	7	I think it would be good to explain the reason for the warming trend briefly. [Ilona Riipinen, Sweden]	The comment does not correspond to the line and generally we cannot place in the paragraph.
127931	6	8	6	8	"atmospheric blockings" --> "atmospheric blocking events" [Trigg Talley, United States of America]	Not applicable - term removed.
104733	6	13	6	13	[…] largest sectors contributing to warming are energy […] [Tobias Schad, Germany]	Accepted. Done
18751	6	13	6	13	"transport" sector also is one of reason for warming. [Govindasamy Bala, India]	Rejected, here we refer to the assessment of the 10yr impact of pulse emission discussed in 6.4
78683	6	13	6	13	Suggestion to change "warming sectors" to "sectors contribution the most to global warming" [Heike Wex, Germany]	Accepted. Done
127935	6	13	6	13	Change "largest warming sectors" to, e.g., "sectors responsible for the most climate warming". [Trigg Talley, United States of America]	Accepted - text revised.
107513	6	13	6	13	"largest warming sectors": please improve wording I presume you mean the largest contributors to global surface warming trends? What about the SLCFs that cause surface cooling? [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised. Fixed. Improved wording as suggested.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
77495	6	13	6	17	Can some numbers be provided for sectoral emissions of sclf: e.g. % of total for different sources? [Emer Griffin, Ireland]	Rejected. Thank you for the comment. This bullet describes the GSAT responses of pulse emissions of current source sectors. Changes in source emissions themselves are summarized earlier in this section. The important role of CH4 emissions on short time scales is now emphasized in this bullet.
103215	6	13	6	21	Including CO2 in this analysis is off-topic [Philippe Tulkens, Belgium]	Rejected. Thank you for the comment. It is important to understand the role of SLCFs in GSAT change within the context of CO2 (the most important climate agent). In many cases, SLCFs and CO2 are co-emitted from the same sector activities.
103217	6	13	6	21	It is a bit awkward to compare CO2/SLCF, but ignore e.g. N2O, especially since a judgement on agriculture is given. Where are the CFCs/HFCFs related to industry? It is not immediately apparent why such a comparison of SCLFs with only one LLGHG is valuable. Is Ch 6 is the correct place for evaluation the impact of CO2? [Philippe Tulkens, Belgium]	Accepted - text revised. The GSAT analysis of source sectors in Section 6.5.2. and Fig 6.16 includes CO2, N2O and SLCFs (but not CFCs/HFCFs). The text now makes clear the exact climate agents included in the analysis. Ch 6 is the correct place to evaluate the GSAT effects of SLCFs within the context of CO2, the dominant climate forcing agent.
8245	6	13	6	21	It is a bit awkward to compare CO2/SLCF, but ignore e.g. N2O, especially since a judgement on agriculture is given. Where are the CFCs/HFCFs related to industry? It is not immediately apparent why such a comparison of SCLFs with only one LLGHG is valuable. I am also not certain if Ch 6 is the correct place for evaluation the impact of CO2. [Frank Dentener, Italy]	see answer to #103217
127933	6	13	6	21	This first bullet seems out of place in the SLCF chapter. It's mostly about CO2. It's good to open by making the long-term vs short-term point, which comes in on lines 19-20. The bullet should be re-written so that is the focus of this bullet; right now it is not. [Trigg Talley, United States of America]	Accepted - text revised. The bullet begins by describing the important role of SLCFs in affecting GSAT on short time scales ad emphasizes individual SLCFs.
113895	6	13	6	21	The focus on 10 and 100 years is a bit odd, since there is quite a gap between 10 and 100. A horizon of 20-30 could be more relevant for PA goals. [Jan Fuglestvedt, Norway]	Noted. The GSAT analysis included in AR6 Section 6.5.2 and Fig 6.16 focuses on 10 and 100 year time scales. 10 year time scales are important for GSAT changes for SLCF and CO2 climate agents, clearly shown in Fig. 6.16. The 10-year time scale is arguably important for PA. We have additionally assessed the 20-year time scale GSAT effects that do not change the major conclusions here.
127937	6	15	6	17	"Current emissions of CO2 and SLCFs from East Asia and North America are the largest regional contributions to global warming on both short and long-term scales." [Trigg Talley, United States of America]	Accepted - text revised. Removed bracketed (10-100) years that was confusing and in error.
21919	6	16	6	16	Given that many of the SLCFs act to cool the climate or their mitigation may act to cool the planet it would surely be better to use climate changes rather than global warming here? [Peter Thorne, Ireland]	Rejected, this statement provides assessment of the largest contributors to global warming (i.e. elevation of GSAT) in terms of sectors and regions.
107515	6	16	6	21	L16-17 implies short timescale is <10 years given long definition of (10-100 years) but L21 says short is (10-20 years). Please make consistent [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised. Removed bracketed (10-100) years that was confusing and in error.
77497	6	17	6	21	CO2 is addressed elswhere. This material is unclear, what is the message? [Emer Griffin, Ireland]	Noted. The fact that CO2 emissions also cause an important contribution to warming on short 10-20-year time scales (and therefore all time scales) is newly directly acknowledged in AR6 and not featured anywhere else in this report.
127939	6	19	6	20	This sentence is not correct. The lifetime of SLCFs does not determine the predominance of CO2; rather it is the relative magnitude as a function of time. [Trigg Talley, United States of America]	Noted. The sentence is correct as it refers to pulse emissions of current source sectors. Text now makes clear that results refer to "one-year pulse emissions of current sources of SLCFs, CO2 and N2O".

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
127941	6	19	6	21	But the peak warming depends on the RATE of SLCF emissions at the time of CO2-determined peak warming. Is it worth noting that the SLCF have potential to alter decadal warming rates? And also that when one considers scenarios, the SLCF reductions can still have long-term impacts when considered relative to a scenario in which they are continuing to be emitted? [Trigg Talley, United States of America]	Noted. Subsequent bullets summarizing the role of SLCFs in SSPs discuss peak warming and future scenarios. This bullet summarizes the GSAT effects of pulse emissions from current source sectors on 10 and 100 year time horizons. This bullet does not discuss future scenarios.
104735	6	20	6	20	Shorter: […] long-term temperature effect is dominated by CO2. [Tobias Schad, Germany]	Rejected. Thank you for the comment. The justification of the statement is clearly provided in Figure 6.16 and the updated analysis presented in Section 6.5.2 (and recently published in Lund et al, 2020). The fact that CO2 emissions also cause an important contribution to warming on short 10-20-year time scales (and therefore all time scales) is newly directly acknowledged in AR6 and not featured anywhere else in this report. It is now emphasized that these results refer to "pulse emissions of current sources of SLCFs, CO2 and N2O".
99049	6	20	6	21	I don't understand the justification for this statement. While the increased CO2 concentration resulting from earlier emissions causes a significant warming influence, the actual emissions over the next 10-20 year do not really increase the CO2 concentration by enough for that increase to have a comparatively important influence to either the already increased CO2 concentration or the concentrations of short-lived species. This is not to say that CO2 emissions should not be reduced, something critical to be doing to reduce long-term warming, but calculations I did with the MAGICC model suggest that the biggest increment on the few decade scale comes from emissions of the short-lived species that are contributing to warming and that reducing their emissions could rapidly slow the pace of warming. If the justification for the statement is that there is an offsetting influence from cutting of SO2 emissions and that is the basis for this statement, then I would suggest making it clear that reductions in SO2 emissions will exert a counter-vailing warming influence (and this is why I personally favor the tropspheric injection of SO2 as a SRM climate intervention, but doing so spread widely over remote oceanic areas both to be away from people and because whitening over a dark surface would create a comparatively large impact. I guess I just think more explanation is needed than this sentence provides. [Michael MacCracken, United States of America]	Rejected. Thank you for the comment. The justification of the statement is clearly provided in Figure 6.16 and the updated analysis presented in Section 6.5.2 (and recently published in Lund et al, 2020). The fact that CO2 emissions also cause an important contribution to warming on short 10-20-year time scales (and therefore all time scales) is newly directly acknowledged in AR6 and not featured anywhere else in this report. It is now emphasized that these results refer to "one-year pulse emissions of current sources of SLCFs, CO2 and N2O".
103219	6	23	6	23	Can this sentence be phrased quantitatively, now it reads that it highly certain that SLCFs have an effect, but it remains vague whether the effect is small, large or whatever. [Philippe Tulkens, Belgium]	see answer to comment #8249
103221	6	23	6	23	There is high confidence in the effects of reduced emissions of SLCFs on air quality=>most SLCFs (not all). [Philippe Tulkens, Belgium]	see answer to #8247
8247	6	23	6	23	There is high confidence in the effects of reduced emissions of SLCFs on air quality=>most SLCFs (not all). [Frank Dentener, Italy]	Taken into account. The first part of the sentence (referring to AQ impacts of SLCFs) is deleted. There are several paragraphs above in the ES about AQ impacts that covers this point.
8249	6	23	6	23	Can this sentence be phrased quantitatively, now it reads that it highly certain that SLCFs have an effect, but it remains vague whether the effect is small, large or whatever. [Frank Dentener, Italy]	The sentence has been rephrased.
64997	6	23	6	23	Why only “high confidence”? I’d say it is a fact that reduction in pollution emissions improves air quality. [Johannes Quaas, Germany]	Accepted. See response to comment 8247
98613	6	23	6	24	"There is high confidence in the effects of reduced emissions of SLCFs on air quality, but medium confidence in the magnitude of the climate effects of these emission reductions." => seems to me a bit confusing and unclear "confidence in effect" vs "medium confidence in magnitude" [Michael Schulz, Norway]	The sentence has been rephrased.
103223	6	23	6	28	Is it possible to quantify contribution of compounds to warming for the current situation, quantitatively? If there is temperature increase near where emissions happen, what is elsewhere? [Philippe Tulkens, Belgium]	Accepted, this is addressed in Figure 6.12 and text in 6.4.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
127943	6	23	6	28	Can anything be concluded with confidence about the role of aerosols on precipitation patterns? [Trigg Talley, United States of America]	Rejected - role of aerosols on precipitation is assessed by chapter 8 (and summarised in their ES).
77499	6	23	6	30	For clarity reduction in emissions would improve air quality. Some messages on synergies with Climate action could be included [Emer Griffin, Ireland]	It's not possible to disentangle in SSPs the effect of air pollution control vs climate mitigation. However this is discussed in 6.7.3 for one category of scenario (SSP3) but not elevated to the ES.
64999	6	24	6	24	If there is medium confidence in the magnitude of climate effects of SLCF emission reductions – can one at least say something about the overall sign? And perhaps provide a number for the magnitude? [Johannes Quaas, Germany]	Noted. Quantification of the magnitude and sign of effect on GSAT is discussed in the paragraphs further down in the ES.
45837	6	25	6	26	"All SO2 emission reductions (...) lead to stronger and more robust global climate responses than BC and OC emission reductions." This cannot be generally true. [Twan van Noije, Netherlands]	Taken into account. We removed this comparison of global climate response due to individual aerosol species.
127945	6	25	6	26	"Total projected" would be better than "all" here. [Trigg Talley, United States of America]	Accepted
51235	6	25	6	28	It would be helpful for the text here to clarify to what extent reducing BC and CH4 reduces SO2 warming. [Jolene Cook, United Kingdom (of Great Britain and Northern Ireland)]	Noted. The degree to which BC and methane counteract warming by SO2 reductions depends on the scenario and the time-horizon. This first paragraph discuss the general effects, and then quantifications are given in the paragraphs below.
52191	6	26	6	26	BC and OC emissions were mentioned. However, the OC pollutant has not been previously defined. [Maritza Jadrijevic Girardi, Chile]	See response to #45837
5135	6	26	6	28	"increase in surface air temperature in the northern hemisphere at mid and high latitudes where the emissions take place" is poorly phrased. The sentence sounds as if the temperature effect is local: the temperature change at high latitudes is caused by emissions at high latitudes, etc. As noted later in the summary and in Chapter 7, high latitude amplification occurs even in the absence of emissions at high latitudes. It is true that there is some hemispheric effect, emissions in of aerosols in the Northern Hemisphere affect Northern Hemisphere temperature more than Southern Hemisphere temperature, but even that is modulated by heat transport between Hemispheres. I suggest ending simply with "… an increase in surface air temperature, especially in the Northern Hemisphere." [Daniel Murphy, United States of America]	Taken into account. We agree that the sentence was poorly phrased. The modelling studies indicate that the temperature change is most pronounced in a mid-latitude zonal belt, so we keep an emphasis on NH mid- and high latitudes.
127947	6	26	6	28	"...with an increase in surface air temperature in the northern hemisphere at mid and high latitudes in the hemisphere where the emissions take place". This is really awkward wording. [Trigg Talley, United States of America]	Accepted. Done
35839	6	26	6	28	This is difficult to understand, consider re-phrasing. [Johannes Kaiser, Germany]	Text revised
104737	6	27	6	27	delete second mention of hemisphere. [Tobias Schad, Germany]	Text revised
18749	6	27	6	27	Delete "in the hemisphere"? [Govindasamy Bala, India]	Text revised
78685	6	27	6	27	The text is: "increase in surface air temperature in the northern hemisphere at mid and high latitudes in the hemisphere where the emissions take place" - one seems to need to be deleted, either "in the northern hemisphere" or "in the hemisphere where the emissions take place" [Heike Wex, Germany]	Text revised
21921	6	27	6	27	Double use of hemisphere could be confusing, especially to non-native speakers. I am assuming you mean eastern / western hemisphere with the second use. But that is an assumption and the phrasing here could be very confusing / twisted by vested interests. Is there a way to say the same thing without such a double use of hemisphere in quite such quick succession? [Peter Thorne, Ireland]	Accepted text revised
72367	6	27	6	27	Change 'northern hemisphere' to 'Northern Hemisphere' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Text revised
127949	6	27	6	28	Awkward phrasing: "in the northern hemisphere at mid and high latitudes in the hemisphere where the emissions take place." Rephrase. [Trigg Talley, United States of America]	Text revised

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51233	6	30	6	30	Paris Agreement targets are not expressed relative to temperatures in 2020. It would be useful to compare the future warming /cooling with pre-industrial levels here. [Jolene Cook, United Kingdom (of Great Britain and Northern Ireland)]	It is true that the Paris agreement is relative to pre-industrial. Also, the contribution to current warming by different forcing agents relative to pre-industrial is assessed in chapter 7. (section 7.3.5.4, figure 7.11). To inform policy-makers we believe that giving numbers relative to present day is most relevant also for the Paris agreement. This is because we have observational based assessments of the change in GSAT since pre-industrial, so it the future contribution from the SLCFs that is most relevant also in light of the Paris agreement.
86315	6	30	6	30	Is this the net effect of all the SLCFs considered in the Chapter? [venkatachalam ramaswamy, United States of America]	Yes. No changes to text.
98615	6	30	6	30	"the SLCFs will cause a warming" => a bit short, isnt it "the trends in SLCFs will cause a warming" [Michael Schulz, Norway]	revised to "SLCF emission changes.."
127955	6	30	6	30	Change to: "changes in SLCF emissions will cause ...." [Trigg Talley, United States of America]	Accepted. Done
103225	6	30	6	31	The use of near-term (20 years) is somewhat ambigious in view of the earlier use of short (10 years) and long-term (10-100 years). Can this be harmonized? Assuming that the range of 0.05-0.3 is mostly caused by the choice of scenario, it is not obvious why this is qualified as 'quite insensitive'. I suspect that the insensitive refers to studies that focus on single components, sectors, and show larger effects? Some context is needed. [Philippe Tulkens, Belgium]	see answer to #8251
8251	6	30	6	31	The use of near-term (20 years) is somewhat ambigious in view of the earlier use of short (10 years) and long-term (10-100 years). Can this be harmonized? Assuming that the range of 0.05-0.3 is mostly caused by the choice of scenario, it is not obvious why this is qualified as 'quite insensitive'. I suspect that the insensitive refers to studies that focus on single components, sectors, and show larger effects? Some context is needed. [Frank Dentener, Italy]	The wording "Near Term" means in IPCC language 2040, so we will keep that for consistency. The 10 and 100 year time scale used in the ES paragraph above is very closely linked to the underlying literature, so as long at is clearly stated in the ES bullet we keep it like that. The range of 0.05 to 0.3 is actually less scenario dependant than actual uncertainty in forcings and response. The word insensitive does not refer to single component studies, but is based on the results from emulators (as shown in figure 6.19) including the full range of SLCF emissions as given in the different SSPs.
15521	6	30	6	31	Re: a warming of 0.05-0.3°C relative to 2020.The range shown in the main text is 0.05-0.25°C (P.75, line 26) and the reference year is 2021 (P.75, line 21). Please consider harmonizing the use of reference year and the presentation with decimal places. [SAI MING LEE, China]	Accepted. The exact numbers have changed since the SOD due to updates in the emulator (see cross-chapter box in Ch7)
127951	6	30	6	31	This comment also applies to the underlying chapter: please be clear when discussing the effects of changes in SLCF emissions, rather than existing emissions. For example, "it is very likely that in the near term (2040) projected changes in SLCF emissions will cause a warming relative to 2020." [Trigg Talley, United States of America]	Accepted. It has been clarified throughout the chapter that the responses are due to changes in SLCF emissions rather than existing emissions.
127953	6	30	6	34	This bullet needs to be edited so that it's clear what time period is being referred to for each of the warming values given (0.05-0.3°C and 0.3-0.9°C). [Trigg Talley, United States of America]	Accepted. The ES has been reorganized to keep Near Term and end of century numbers in separate paragraphs.
107517	6	30	6	34	Giving temperature changes for a given year (2040 relative to a single year (2020) as opposed to a baseline period makes no account for internal variability which is comparable to the effects described here. This bullet should make clear this is forced temp changes which may be overwhelmed by internal variability. [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Rejected. The comment is of course correct, however, opening up a discussion about internal variability here (in the ES) is beyond the scope of the ES. This is important in a detection and attribution context, but the numbers given is anyway the expected outcome of emission change.
107519	6	30	6	34	Check consistency with Ch 4 section 4.4.4 where AerChemMIP results to 2055 are presented [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	AerChemMIP simulations can not be used to calculate the effect of SLCFs across the SSP scenarios (only for the difference between SSP3-7.0 and SSP3-7.0lowNTCF). This is discussed in a separate paragraph in ch. 6 ES (page 6 line 45-50 in the SOD).

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
35971	6	30	6	43	When writing the TS we found difficult to use those ES statements. It would be useful to rephrase in terms of potential for "warming avoided" from SLCF mitigation, perhaps across SSPs or SSP categories rather than individual SSPs. That statement in lines 45-50 was easier to use, so could be used as a template. It would also be useful to discuss trajectories that are realistic, yet not covered by the SSPs selected for CMIP6. [Nicolas Bellouin, United Kingdom (of Great Britain and Northern Ireland)]	Lines 45-50 is discussing one specific sensitivity experiment, while the statement above attempts to summarize across many scenarios. These ES statements have been reorganized to separate near-term impacts and long-term effects in separate statements to make this more clear.
35973	6	30	6	43	An aspect that is missing from this assessment is the fraction of SLCF mitigation that is already achieved from CO2 mitigation because of co-emissions. [Nicolas Bellouin, United Kingdom (of Great Britain and Northern Ireland)]	Rejected. It is not possible to disentangle purely climate action from air pollution control in SSPs (except by using extra scenario based on SSP3-7.0 as done in the chapter but which could be hard to explain in the ES).
104739	6	30	30	30	Do SLCFs cause warming or the change in their composition?! [Tobias Schad, Germany]	Changes in SLCF concentrations caused by changes in emissions give a warming. No changes to text.
109859	6	31	6	31	The abbrevation (GSAT) is not defined neither in the text nor in the (Acronyms for chapter 6) that extends from page 138 till page 150 [Rehab El-Maghraby, Egypt]	Accepted
26151	6	31	6	31	"GSAT" is the first appearance in this chapter. [Toshihiko Takemura, Japan]	Accepted. Done
35881	6	31	6	31	GSAT is missing from the list of acronyms [Jasper Kok, United States of America]	Accepted. Done
45365	6	31	6	31	GSAT --> global surface air temperature (GSAT) [Hitoshi Matsui, Japan]	Accepted. Done
127957	6	31	6	32	Use "near-term" when used as an adjective. [Trigg Talley, United States of America]	Accepted. Done
106385	6	32	6	32	It would be useful for readers to clarify that SSP scenarios span a range from very high to very low internally consistent future emission evolutions, highlighting that this findings is thus very robust. [Rogelj Joeri, United Kingdom (of Great Britain and Northern Ireland)]	Accepted
15523	6	33	6	34	Re: a warming relative to 2020 of 0.3-0.9oC. Figure 6.19 shows that the lower bound of warming range under high emission scenarios is more than 0.4oC and the reference year is 2021. Please check and revise as appropriate. [SAI MING LEE, China]	Accepted. Numbers have been revised.
98617	6	34	6	34	What is meant with "high emission scenario can cause a warming"? High aerosol emissions ? They would lead to cooling. Probably meant is specifically methane, or? [Michael Schulz, Norway]	Accepted
106387	6	36	6	36	"SSP1" is not a mitigation scenario per se. It describes a generally more sustainability focussed future world. Only in combination with the target radiative forcing levels (SSP1-1.9 or SSP1-2.6) does this become effectively a "mitigation scenario". [Rogelj Joeri, United Kingdom (of Great Britain and Northern Ireland)]	Accepted
113897	6	36	6	36	I suggest you also write the RF levels in the scenario label; ie. SSP1-1.9 and SSP1-2.6 [Jan Fuglestvedt, Norway]	Accepted
127959	6	36	6	37	It should be stated explicitly that this is a warming from 2020 to 2040. [Trigg Talley, United States of America]	Accepted
127961	6	36	6	37	The term SSP1 will be foreign to readers of this summary. Suggest defining the nature of this scenario along with others in 36-50. [Trigg Talley, United States of America]	Accepted
98619	6	39	6	39	"and at the end of century the temperature change due to SLCFs is close to zero." => relative to what? Not clear [Michael Schulz, Norway]	Sentence has been modified to make it clearer.
103227	6	39	6	39	What is the likely range for SPP3-7.0 and SSP5-8.5? Report similar to SSP1 [Philippe Tulkens, Belgium]	see answer to #8253
8253	6	39	6	39	What is the likely range for SPP3-7.0 and SSP5-85? Report similar to SSP1 [Frank Dentener, Italy]	Accepted.
55037	6	39	6	39	SSP3-7 and SSP5-8.5 should be consistently referred to. In Ch 1 these are described as "no mitigation" scenarios, not low mitigation scenarios. [Nancy Hamzawi, Canada]	Accepted
55039	6	39	6	39	SSP3-7 and SSP5-8.5 are described in the SPM as 'umitigated baseline scenarios (no climate mitigation) and not 'low climate mitigation scenarios". [Nancy Hamzawi, Canada]	Accepted
16537	6	40	6	40	"Aerosols are less important" It might be better to say are decreasing more slowly. Since the aerosol burdens are higher in these scenarios it could e argued that they are more important, not less. [William Collins, United Kingdom (of Great Britain and Northern Ireland)]	Accepted. Wording changed
104741	6	41	6	41	To which scenario is the steady warming referring? Is it the minimal warming seen in every scenario? [Tobias Schad, Germany]	Accepted. It is now clearly stated that everything is relative to 2019.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
103229	6	41	6	42	Which scenario(s) is the 0.08 C refering to? Not clear why SSP2-4.5 is lifted out, because it has the smallest effect (compared to 2020)? [Philippe Tulkens, Belgium]	see answer to #8255
8255	6	41	6	42	Which scenario(s) is the 0.08 C refering to? Not clear why SSP2-4.5 is lifted out, because it has the smallest effect (compared to 2020)? [Frank Dentener, Italy]	Clarified
127963	6	42	6	43	The SSP2-4.5 "warming in 2100" value needs to be referenced to a base year. (2020?) [Trigg Talley, United States of America]	Accepted. It is now clearly stated that everything is relative to 2019.
51237	6	45	6	45	Some further clarification of which aerosols this refers to would be useful at this point - presumably these are of anthropogenic origin? [Jolene Cook, United Kingdom (of Great Britain and Northern Ireland)]	Accepted, the word "anthropogenic is added.
103231	6	45	6	45	Clarify if this is a subset of the SSPs discussed in line 30. Can this somehow be combined with the statement in l 30; e.g the full SSP range 0.05-0.3 ; the contribution from aerosol/non methane emission reduction 0.1-0.2? The way it is phrased now is difficult to follow. [Philippe Tulkens, Belgium]	see answer to #8257
8257	6	45	6	45	Clarify if this is a subset of the SSPs discussed in line 30. Can this somehow be combined with the statement in l 30; e.g the full SSP range 0.05-0.3 ; the contribution from aerosol/non methane emission reduction 0.1-0.2? The way it is phrased now is difficult to follow. [Frank Dentener, Italy]	clarified
21923	6	45	6	46	Does this need to be explicit that the warming is a global change? Warming will vary from this regionally presumably? [Peter Thorne, Ireland]	Taken into account. Text has been revised
127965	6	45	6	46	Presumably this warming is due to aerosols decreasing rather than ozone increasing; could that be clarified here to emphasize that the aerosol changes are dominating the response? [Trigg Talley, United States of America]	Taken into account, text revised.
127967	6	47	6	47	"SSP3-7.0" and "SSP3-7.0-lowNTCF" [Trigg Talley, United States of America]	Accepted
21925	6	47	6	48	I'm not sure that bolded statements should be parenthetical. I have not seen this in any other chapters. [Peter Thorne, Ireland]	Text revised
51231	6	48	6	50	The key message of 6.6.4 seems to be in the last paragraph but does not come through in the executive summary. A reordering of the sentences could provide a more appropriate emphasis; 'Across the SSPs it is unlikely that methane mitigation alone can fully cancel out the near-term warming from reduction of non-methane cooling SLCFs(6.6.3. 6.6.4) . However methane mitigation stands out as an option that combines near and long-term gains on surface temperature (high agreement) (6.6.5) ' [Jolene Cook, United Kingdom (of Great Britain and Northern Ireland)]	Accepted, this sentence is now part of the ES.
107521	6	49	6	49	I don't think high agreement on its own is part of the formal IPCC uncertainty language. How much evidence is there? (limited, medium, robust) [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Accepted
98621	6	49	6	50	"that methane mitigation can fully cancel out the warming" not vey clear to me. [Michael Schulz, Norway]	Not applicable, Sentence has been removed.
127969	6	49	6	50	What about if HFCs are reduced along with CH4? [Trigg Talley, United States of America]	Accepted, the effect of reducing CH4/O3 and HFCs is now added to the ES.
127971	6	50	6	50	'cancel out' is not correct. Suggest 'offset'. [Trigg Talley, United States of America]	Accepted
32503	6	52	6	52	Since the Kigali Amendment is mentioned here for the first time, it would be clearer to say "Kigali Amendment to the Montreal Protocol on the phase-doen of HFCs". [Sophia Mylona, Kenya]	Accepted. Done
103233	6	52	6	56	It maybe useful to refer back to Chapter 2 (or 7), where the 2018 ERF of HFCs of 0.02 Wm-2 is reported. Kigali will initially still increase HFC emissions and ERF, and then turn down. This aspect is worth to highlight here. [Philippe Tulkens, Belgium]	see answer to #103233
8259	6	52	6	56	It maybe useful to refer back to Chapter 2 (or 7), where the 2018 ERF of HFCs of 0.02 Wm-2 is reported. Kigali will initially still increase HFC emissions and ERF, and then turn down. This aspect is worth to highlight here. [Frank Dentener, Italy]	Rejected, the time evolution of the effect of HFCs can be seen in the chapter (e.g. Figure 6.22),we considered it as too detailed for this ES statement.
106389	6	52	6	56	This is an incredibly clearly formulated and important finding. Please do keep it also for the Final Government Draft. [Rogelj Joeri, United Kingdom (of Great Britain and Northern Ireland)]	Accepted

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
68287	6	52	6	56	The avoided warming as stated here is that from the transition away from HFCs to low-GWP refrigerants. Further, the avoided warming does not consider HFC-23, which is primarily a by-product of producing HCFC-22, and not included in these calculations, although HFC-23 represents 17% of forcing from HFCs in 2016. Future emissions of HFC-23 are expected to be limited now that it is regulated by the Kigali Amendment. See World Meteorological Organization (WMO), United Nations Environment Programme (UNEP), National Oceanic and Atmospheric Administration (NOAA), National Aeronautics and Space Administration (NASA), and European Commission (2018). Scientific Assessment of Ozone Depletion: 2018, Global Ozone Research and Monitoring Project-Report No. 58. Geneva, Switzerland. ES.39 ("The 2016 Kigali Amendment to the Montreal Protocol, assuming global compliance, is expected to reduce future radiative forcing due to HFCs by about 50% in 2050 compared to the forcing from HFCs in the baseline scenario. Currently (in 2016), HFCs account for a forcing of 0.025 W m−2 not including 0.005 from HFC-23; forcing from these HFCs was projected to increase up to 0.25 W m−2 by 2050 (excluding a contribution from HFC-23) with projected increased use and emissions in the absence of controls. With the adoption of the Kigali Amendment, a phasedown schedule has been agreed for HFC production and consumption in developed and developing countries under the Montreal Protocol. With global adherence to this Amendment in combination with national and regional regulations that were already in place in, e.g., Europe, the USA, and Japan, along with additional recent controls in other countries, future radiative forcing from HFCs is projected to reach 0.13 W m−2 by 2050 (excluding HFC-23), or about half the forcing projected in the absence of these controls."); and Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer, Art. 2J, ¶¶ 1–4, 6–7, 15 Oct. 2016, C.N.872.2016.TREATIES-XXVII.2.f U.N.T.S. 2 ("Each country manufacturing HCFC-22 or HFCs shall ensure that starting in 2020 the emissions of HFC-23 generated in production facilities are destroyed to the extent practicable using technology approved by the Montreal Protocol"). Energy efficiency improvements to cooling equipment historically have been catalyzed by refrigerant transitions under the Montreal Protocol, and in the case of the Kigali Amendment, there are parallel decisions by the Parties promoting energy efficiency, as well as a fast-start fund. United States Environmental Protection Agency (EPA) (2002) Building owners save money, save the earth:	Taken into account - the text has been revised
66757	6	52	6	56	The avoided warming as stated here is that from the transition away from HFCs to low-GWP refrigerants. Energy efficiency improvements to cooling equipment, which could take places as part of this transition. Policies to improve efficiency of ACs and other cooling equipment can avoid significant emissions as demand for cooling grows. Shah, N., Wei, M., Letschert, V. and Phadke, A. (2019). Benefits of Energy Efficient and Low-Global Warming Potential Refrigerant Cooling Equipment. U.S.A: Lawrence Berkeley National Laboratory ("For best-available-technology (or "maximum" efficiency), total savings to 2050 are 373.0 and 257.6 GtCO2e for baseline (or static) electricity emission factors and decreasing emission factors, respectively (Fig. 1). Table S1 in the SI shows the GHG emissions for the reference case (no efficiency improvement and baseline HFC refrigerants) vs. the policy case of best-available technology (BAT) energy efficiency and low GWP refrigerants for 2030, 2040, and 2050 with static emission factors for both cases Reference case cumulative GHG emissions are 587.1 Gt CO2e while the policy case is 214.1 Gt for an overall cumulative savings of 373.0 Gt CO2e."); Dreyfus G., et al. (2020) ASSESSMENT OF CLIMATE AND DEVELOPMENT BENEFITS OF EFFICIENT AND CLIMATE-FRIENDLY COOLING, 1 ("However, robust policies that drive the use of best available technologies can cut cumulative emissions from the stationary air conditioning and refrigeration sectors by 38–60 GtCO2e by 2030, by 130–260 GtCO2e by 2050, and by 210–460 by 2060, depending on future rates of de- carbonization of electricity generation (Table 3.1). (For comparison, the global annual CO2 emissions from fossil fuel energy sources in 2018 totalled 33.1 GtCO2.8) A quarter of the mitigation is from phasing down HFC refrigerants and switching to alternatives with low-GWP, while three-quarters is from ensuring that cooling equipment uses the best available technology to improve energy efficiency and reduce the use of electricity (Table 3.1)."). [Kristin Campbell, United States of America]	Taken into account - the text has been revised

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
69871	6	52	6	56	The avoided warming as stated here is that from the transition away from HFCs to low-GWP refrigerants. Further, the avoided warming does not consider HFC-23, which is primarily a by-product of producing HCFC-22, andis not included in these calculations, although HFC-23 represents 17% of forcing from HFCs in 2016. Note that the enerrgy efficiency considered here is only associated with the chemical transition. It does not consider emissions reductions associated with improved the efficiency of the equipment. Energy efficiency improvements to cooling equipment historically have been catalyzed by refrigerant transitions under the Montreal Protocol, and in the case of the Kigali Amendment, there are parallel decisions by the Parties promoting energy efficiency, as well as a fast-start fund. Transitioning the best currently available efficiency and refrigerant technologies for stationary air conditioning and refrigeration would cut cumulative emissions by 38–60 GtCO2e by 2030, by 130–260 GtCO2e by 2050, and by 210–460 by 2060, depending on future rates of decarbonization of electricity generation. Shah, N., Wei, M., Letschert, V. and Phadke, A. (2019). Benefits of Energy Efficient and Low-Global Warming Potential Refrigerant Cooling Equipment. U.S.A: Lawrence Berkeley National Laboratory ("For best-available-technology (or "maximum" efficiency), total savings to 2050 are 373.0 and 257.6 GtCO2e for baseline (or static) electricity emission factors and decreasing emission factors, respectively (Fig. 1). Table S1 in the SI shows the GHG emissions for the reference case (no efficiency improvement and baseline HFC refrigerants) vs. the policy case of best-available technology (BAT) energy efficiency and low GWP refrigerants for 2030, 2040, and 2050 with static emission factors for both cases Reference case cumulative GHG emissions are 587.1 Gt CO2e while the policy case is 214.1 Gt for an overall cumulative savings of 373.0 Gt CO2e."); Dreyfus G., et al. (2020) ASSESSMENT OF CLIMATE AND DEVELOPMENT BENEFITS OF EFFICIENT AND CLIMATE-FRIENDLY COOLING, 1 ("However, robust policies that drive the use of best available technologies can cut cumulative emissions from the stationary air conditioning and refrigeration sectors by 38–60 GtCO2e by 2030, by 130–260 GtCO2e by 2050, and by 210–460 by 2060, depending on future rates of de- carbonization of electricity generation (Table 3.1). (For comparison, the global annual CO2 emissions from fossil fuel energy sources in 2018 totalled 33.1 GtCO2.8) A quarter of the mitigation is from phasing down HFC refrigerants and switching to	Taken into account - the text has been revised
127973	6	53	6	54	"...the estimated reduction of global warming due to hydrofluorocarbons (HFCs) would be less than 0.07°C by 2050 and between 0.2-0.4°C by 2100, relative to scenarios without HFCs regulation. This results from both HFC substitution and CO2 reduction driven by energy efficiency improvements in refrigeration and air-conditioning equipment. " The first sentence is really difficult to parse and not quite correct. The second sentence is simply wrong; these numbers don't include energy efficiency improvements. See WMO (2018), Chapter 2. Suggested rewording of the first sentence: "Provided that the Kigali Amendment and national regulations are implemented and efficiently enforced, HFC contributions to global warming would be 0.07°C in 2050 and 0.06°C in 2100, versus 0.1°C in 2050 and 0.3-0.5°C in 2100 absent regulation." From WMO (2018): "Improvements in energy efficiency in refrigeration and air-conditioner equipment during the transition to low-GWP alternative refrigerants can potentially double the climate benefits of the HFC phase- down of the Kigali Amendment." [Trigg Talley, United States of America]	Taken into account - the text has been revised correctly reflecting the future potential associated with energy efficiency improvements. The temp change due to HFCs in the baseline scenario and mitigation ranges are updated including studies that were not part of the WMO assessment as well as model simulations using SSP trajectories.
26987	6	54	6	54	0.2-0.4 is mentioned in paragraph 6.6.4 Compensating effects and linkages in SLCFs under different mitigation scenarios (page 79, line 20). However, in paragraph 6.5.3.3 Kigali Amendment (page 66, line 55) "The Kigali Amendment, and national and regional regulations are projected to reduce global average warming in 2100 due to HFCs by 0.3–0.5°C in a baseline scenario based on Xu et al. (2013) and Velders et al. (2015) to less than 0.1°C (see Figure 2.20 of WMO, 2018)." Please ensure the consitency. [Eric Brun, France]	Taken into account - the text has been revised to assure consistency

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
26989	6	55	6	56	The sentence is not accurate as the results mentioned in this paragraph only come from the Kigali amendment. The climate benefits would be higher if energey efficiency is improved in parallel. See paragraph 6.5.3.3 Kigali amendment (page 66, line 17), it is written "Furthermore the energy efficiency improvements of cooling equipment alongside the transition to low global warming potential alternative refrigerants for refrigeration and air-conditioner equipment could potentially increase the climate benefits from the HFC phasedown under the Kigali Amendment (Shah et al., 2015; Höglund-Isaksson et al., 2017; Purohit and Höglund-Isaksson, 2017; WMO, 2018). One sentence could be added highlighting that the climate benefits from the HFC phasedown could be further increased with energy efficiency improvements. [Eric Brun, France]	Accepted - the statement revised
26991	6	56	6	56	The reference is 6.6.4 instead of 6.6.3. [Eric Brun, France]	Accepted. Done
116513	6		6		I have a question about the estimate of temperature reduction through HFC regulation and energy efficiency improvements in cooling equipments; how does this include the growing demand for cooling due to increased heat stress? [Valerie Masson-Delmotte, France]	The number of "cooling degree days" and its evolution in the future is accounted for in the emission estimates (see for example Purohit 2020 (section 2.1).
32035	7	1	7	4	the COVID pandemic has shown that rapid decarbonisation really does bring air quality to within guidelines in many locations [Euan G. Nisbet, United Kingdom (of Great Britain and Northern Ireland)]	COVID did not bring about sustained decarbonization that is assumed in the scenarios analysed here. The COVID 19 is discussed in a cross chapter box in the chapter and led to a specific statement in the executive summary of chapter 6 in the FGD.
127975	7	2	7	5	References to policies to achieve goals are made here in addition to references to highly polluted regions. Recommend striking "highly polluted regions" and replacing with specific geographic regions. Also, should the IPCC not be associated with policies then references to certain policies should be removed. [Trigg Talley, United States of America]	Taken into account - text revised mentioning Asia. The policy relevance of WGI report is part of the AR6 mandate; that is different from previous assessments
103235	7	3	7	7	Which air quality quidelines are discussed here? I think mostly ozone, but perhaps also ozone and other components? It is a bit odd to come back to the climate effects, that were already discussed in previous statements? [Philippe Tulkens, Belgium]	see answer to #8261
8261	7	3	7	7	Which air quality quidelines are discussed here? I think mostly ozone, but perhaps also ozone and other components? It is a bit odd to come back to the climate effects, that were already discussed in previous statements? [Frank Dentener, Italy]	Taken into account - text revised to be more specific. It refers to guideline for fine particulate matter, the 10ug/m3 target. There is actually no WHO guideline for ozone
81539	7	4	7	4	Agricultural practices may be added to the list [Cathrine Lund Myhre, Norway]	Rejected, only a few examples are cited here for conciseness.
96669	7	5	7	5	Please write "Sustainable Development Goals" (or "SDGs") instead of "SDG goals". [Nicole Wilke, Germany]	Accepted. Done
127977	7	5	7	5	"SDG goals" redundant? [Trigg Talley, United States of America]	Accepted. Done
127979	7	6	7	6	"reduction" --> "reductions" [Trigg Talley, United States of America]	Accepted. Done
8267	7	8	7	8	I would agree with this cutoff of 20 years or longer to separate SLCF and LLGHGs, however chapter 7 should ensure that this is consistent with earlier reports, and make sure that it ends up correctly in the Glossary (which is still vague). It is important because there is contineous confusion on what is short and long lived. [Frank Dentener, Italy]	Agree - Definition of SLCF has been updated in the glossary (with mention of this cut-off).
8269	7	8	7	10	To clarify it even further suggest: much greater than the time scales of tropospheric mixing across the two hemispheres on the order of a year. As a result, all LLGHGs and some SLFCs (e.g. CH4) are also defined as well-mixed greenhouse gases (exhibiting relatively homogeneous distributions) in the troposphere [Frank Dentener, Italy]	Accepted, clarified in the text.
127981	7	9	7	11	The first sentence of this bullet needs rewording. Perhaps break into two sentences? [Trigg Talley, United States of America]	Accepted, sentence revised
86319	7	9	7	12	Is this feature similar to or different than for the model simulation of responses to the longer-lived species (LLGHGs)? It would be of interest to note whether the different models differ more for the SLCFs than they do for LLGHGs, or whether the degree of inter-model range is more for SLCFs? [venkatachalam ramaswamy, United States of America]	Taken into account. Details are discussed in the chapter.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
127983	7	9	7	12	This perhaps misses an opportunity to provide an assessment statement of a growing body of work examining precipitation responses as well as circulation patterns - PDRMIP studies; Westervelt et al. ACP 2018; work by Robert Allen at UC Riverside, and perhpas to comment on role of aerosols in hydrologic cycle? [Trigg Talley, United States of America]	Rejected, aerosols/precipitation interactions are discussed in chapter 8 and in its ES.
103237	7	14	7	14	limitations? [Philippe Tulkens, Belgium]	see answer to #8263
8263	7	14	7	14	limitations? [Frank Dentener, Italy]	Accepted. Done
103239	7	14	7	23	it is suggested that an important limitation of the assessment is that climate forcing and impacts rely mostly on models for larger regions, and not on direct observations. However, continuous progress is made in the (ESM) modelling, and advanced use of satellite observations help constrainign the models. Regarding the feedbacks of natural emissions, it should be explained how important it is- a second order effect, or possibly a game-changer. And how likely? [Philippe Tulkens, Belgium]	see answer to #8265
8265	7	14	7	23	I suggest that an important limitation of the assessment is that climate forcing and impacts rely mostly on models for larger regions, and not on direct observations. However, contineous progress is made in the (ESM) modelling, and advanced use of satellite observations help constrainign the models. Regarding the feedbacks of natural emissions, it should be explained how important it is- a second order effect, or possibly a game-changer. And how likely? [Frank Dentener, Italy]	Progress in ESM and possible feedback of natural emissions are given in the perspectives of the chapter (6.8).
130521	7	14	7	23	The section on "progress in understanding and limits to this assessment" needs to be discussed if we should have this section in Excutive Summery. [Panmao Zhai, China]	Noted, we removed this section in this form from our ES.
127985	7	16	7	18	Add wildfires explicitly to this list of natural SLCF emissions. [Trigg Talley, United States of America]	Noted. Wildfires are mentioned explicitly in the ES statement on future air quality projections. The statement referred here has been revised for conciseness.
109621	7	17	7	17	I would suggest replacing "sea salt" with "sea spray" as sea spray is not only salt as discussed later in the chapter. [Ilona Riipinen, Sweden]	Not applicable. This ES has been revised for conciseness
127987	7	18	7	21	The single sentence running from line 18-21 is run-on. Break into two sentences. [Trigg Talley, United States of America]	Not applicable - text has been edited
8271	7	19	7	19	predominantly occur in the first two decades'. It is true for CH4 and HFCs, but insufficiently reflect that other components have almost immediate impacts, or multiple timescale (e.g. short-term ozone, and 'long-term' ozone that follows the impacts from methane. Suggest; the climatic effects of SLCFs are largest at local and regional scales and occur on multiple timescales from days to about two decades. [Frank Dentener, Italy]	Accepted and revised accordingly.
127989	7	22	7	23	"While models have advanced, uncertainties in the understanding of processes that influence natural SLCF emissions remain high, resulting in low confidence in the magnitude and sign of most of these feedbacks." Should rephrase the sentence saying that because preindustial state is poorly characterized natural and early anthropogenic emissions represent a large source of uncertainty in estimates of anthropogenic forcing. Suggest: "While models have advanced, uncertainties in the understanding of processes that influence natural SLCF emissions and preindustrial emissions remain high, resulting in low confidence in the magnitude and sign of most of SLCF feedbacks and anthropogenic forcing." [Trigg Talley, United States of America]	Partially accepted - this paragraph has been edited.
8273	7	28	7	28	mixtures=>, and at sizes ranging from a few nanometer to more than 10 micrometer. These are the major components- other aerosol components would include other sulfate components (e.g. MSA); other nitrogen containing components; metals are missing (which is less relevant for climate but more for health and ecosystems) [Frank Dentener, Italy]	Accepted - text on size added.
8275	7	28	7	28	CO, SO2, etc are SLCFs precursors, but not formally forcers. See also the table 2.1 [Frank Dentener, Italy]	Precursors are part of the SLCFs.
77501	8	1	8	14	The opening section could be clearer and stronger, it should link to material on the energy balance in Chapter 7 as well as framing material in Chapter 1, and provide a basis for the material in this chapter. [Emer Griffin, Ireland]	Taken into account, see in particular 6.1.3.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
77503	8	1	8	14	Linking the text tho the earth energy balance and the importance of the flux of short lived species via their influence the energy balance by both positive and negative forcing would be useful here. [Emer Griffin, Ireland]	Noted. Priority given to definition of SLCFs. Further impact of SLCFs on the Earth's energy balance is discussed in section 6.1.1.
77509	8	1	8	14	Is there any complex molecule or particle that does not have direct or indirect radiative properties? [Emer Griffin, Ireland]	Not applicable - text changed
86779	8	1	11	34	We expect to see a reference to the IPCC exper meeting on SLCFs (https://www.ipcc.ch/site/assets/uploads/2019/02/1805_Expert_Meeting_on_SLCF_Report.pdf) and the susequent decision from the IPCC panel on development of methodology for estimating SLCFs (https://www.ipcc.ch/site/assets/uploads/2019/05/IPCC-49_decisions_adopted.pdf) in chapter 6.1 or at another appropriate place in ch 6. [Oyvind Christophersen, Norway]	Accepted but finally added to chapter 1.
103241	8	1			Please make clear that while most substances considered here are effective only for weeks, still there is potential of a long term impact as they are intrinsically connected with the global economic system, which relies on continuous emissions. This is a property shared by all compounds, even methane. And this makes it also possible to have effective abatement on a relatively short time scale. [Philippe Tulkens, Belgium]	Taken into account, text revised.
77505	8	3	8	3	"can act as climate forcers" can a more definitive statement be made? [Emer Griffin, Ireland]	Accepted, clarified.
77479	8	3	8	12	Some description of the types of PN/aerosols/SLCFs is warranted here e.g. primary such as soot/back carbon, secondary or formed from gases reacting in the atmosphere as providing a basis for this chapter. This can be short but should be accessible [Emer Griffin, Ireland]	Taken into account - table 6.1 makes distinction for each SLCF discussed in chapter 6
103243	8	3	8	13	Please make clear that most of the substances dealt with are not "SLCF's". Only O3, BC, particulate matter are. [Philippe Tulkens, Belgium]	Rejected - the definition of SLCFs includes substances that influence the abundance of SLCFs; glossary and text changed to enhance clarity
16541	8	3	8	13	This introduction needs to clarify that some SLCFs (such as methane and many of the HCFCs and HFCs) are well-mixed. [William Collins, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account - text reading: . "The atmospheric lifetime also determines the spatial and temporal variability, with most SLCFs showing high variability and CH4 and many HCFCs and HFCs that are also well mixed."
45839	8	4	8	4	Change "abundance" to "abundance and properties". [Twan van Noije, Netherlands]	Not applicable - sentence removed
127991	8	4	8	4	Change "climate forcers" here to "radiatively active species" (or to "other, radiatively active climate forcers"). [Trigg Talley, United States of America]	Not applicable - sentence removed
77507	8	4	8	5	" interact through atmospheric chemistry" not very clear. Atmospheric physics is also part of this atmospheric processing. [Emer Griffin, Ireland]	Not applicable - sentence removed
21929	8	5	8	6	Later in the same paragraph you note a combination of physical and chemical processes lead to loss so 'interact through atmospheric chemistry' raises a potential perceived conflict with later passage in the same paragraph. Should this be edited accordingly? [Peter Thorne, Ireland]	Accepted, clarified.
127993	8	6	8	6	Change "for" to ":" (colon). [Trigg Talley, United States of America]	Not applicable, sentence written differently.
104745	8	6	8	7	Rewrite: […] classified into two categories: long-lived […] [Tobias Schad, Germany]	Accepted, rewritten.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
40917	8	6	8	13	The current glossary definition states that SLCFs are "A set of compounds that are primarily composed of those with short lifetimes in the atmosphere compared to well-mixed greenhouse gases (GHGs), and are also referred to as near-term climate forcers." -> This definition is confusing. I guess 'primarily composed' refers to only the SLCFs that are not well-mixed (i.e, not methane). It would be better to say 'that are composed of those with shorter lifetimes than those of long-lived greenhouse gases (LLGHGs)'. While methane is a WMGHG, it is not an LLCF (i.e., while its lieftime is long enough for it to be well-mixed, it's not long enough to be considered 'long lived'). The definition could just say this, e.g. 'Most SLCFs are not well-mixed in the atmosphere. While methane has a sufficiently long lifetime to be considered a well-mixed, its lifetime it shorter than those of the long-lived greenhouse gases'. [TSU WGI, France]	Noted - text for definition has been changed in the glossary
40951	8	6	8	13	The glossary defines the term 'Long-lived climate forcers' rather than 'Long-lived greenhouse gases'. Do you want to change the name in the glossary to LLGHGs? [TSU WGI, France]	Accepted. We updated the glossary.
81347	8	7	8	8	If “LLGHGs are greenhouse gases with atmospheric lifetimes of more than two decades to centuries”, then HFC-143a (51 years, SAOD 2018) is not an SCLF either. On the other hand, CH3Cl and CH3CCl3 (both currently listed in Chapters 2 and 7) are SLCFs. [Johannes Laube, Germany]	HFC and halogenated compounds with atmospheric lifetimes shorter than two decades are part of the SLCFs. However for some analysis we have also considered HFCs with lifetimes up to 50years but it is specified in the text and caption of figure.
103245	8	8	8	8	Agree with this cutoff of 20 years or longer to separate SLCF and LLGHGs, however chapter 7 should ensure that this is consistent with earlier reports, and make sure that it ends up correctly in the Glossary (which is still vague). It is important because there is continuous confusion on what is short and long lived. [Philippe Tulkens, Belgium]	Noted - text for definition has been changed in the glossary
103247	8	8	8	10	To clarify it even further suggest: much greater than the time scales of tropospheric mixing across the two hemispheres on the order of a year. As a result, all LLGHGs and some SLFCs (e.g. CH4) are also defined as well-mixed greenhouse gases (exhibiting relatively homogeneous distributions) in the troposphere [Philippe Tulkens, Belgium]	Taken into account, LLGHG no longer in this introduction but clarified in 6.1.1
40473	8	9	8	10	It should be made clear that methane is also a well-mixed GHG. The text currently implies than all SLCFs aren't well-mixed. [TSU WGI, France]	Taken into account - text reading: . "The atmospheric lifetime also determines the spatial and temporal variability, with most SLCFs showing high variability and CH4 and many HCFCs and HFCs that are also well mixed."
16543	8	9	8	10	This sentences needs to take care not to imply that LLGHG and WMGHG are synonymous. While it is true that all LLGHGs are WMGHGs, it is not true that all WMGHGs are LLGHGs. [William Collins, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable - sentence removed
21927	8	10	8	10	in the troposphere twice in such quick succession is a bit jarring. Is this necessary or can the second be dropped or altered? [Peter Thorne, Ireland]	Not applicable - LLGHG removed from introduction
72369	8	10	8	10	Capital 'T' for 'troposphere [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable - LLGHG removed from introduction
127995	8	11	8	11	Add "(less than ~10 year lifetime)" after "short-lived." [Trigg Talley, United States of America]	Taken into account: sentence now reads "Short lived climate forcers (SLCF) are a set of chemically reactive compounds of primary or secondary origin with atmospheric lifetimes typically shorter than two decades."
77511	8	11	8	14	SLCFS are short lived and do not add much substance, perhaps discuss the flux rates and where these are largests and how SLFCs are removed from the atmosphere and hence their lifetimes. [Emer Griffin, Ireland]	Not applicable - sentence removed
127997	8	12	8	12	Rephrase as "the atmospheric abundances of most SLFCs exhibit ...." [Trigg Talley, United States of America]	Not applicable - sentence removed

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
87535	8	16	6	44	Importance of SLCFs for climate and AQ There is an urgent need to predict more accurately how Global Climate is likely to react to increased emissions of Green House Gases (GHG) as a result of human activities. In order to predict the future, it is necessary to determine how Global Climate has responded during the past to natural variations in stratospheric sudden warming (SSW) and forcing factors such as changes in solar input and in the earth's orbital parameters during climatic periods similar to the present. Climate Change is altering our environment affecting agriculture, water availability, and sea-levels. It is increasing the intensity of natural disasters, rate of species extinction& diseases. Climate change kills about 3,15,000 people a year through hunger sickness and weather disasters, and the annual death toll is expected to rise to half a million by 2030.Enomics losses due to Global Warming amount to over $125 billion annually and are expected to rise to $340 billion each year by 2030 with projected population of the World 8.6 billion (the U.N-Report 2019). The increase of temperatures of earth surface has got direct relation with the rise of concentration of various Green House Gases (GHG) viz. Carbon-dioxide and Methane, Nitrous oxide, CFC (Chloro-Fluro Carbons), resulting major changes in the various climate parameter. GHG emissions & CO2 emissions in particular are responsible for Global Warming vis-à-vis Climate change. The meteorological and resource survey satellites have led that potential Global Warming would result the rise in Sea level and important environmental change in the coastal and low- lying regions of the earth. It has been reported that most of the World's Glaciers may disappear in the next Century if, the Environmental Pollution is not checked by detoxification of toxic gases, particularly GHG. This is based on recalculation of the dates at which boulders were uncovered by melting Glaciers at the end of the last Ice Age. It has been observed by Prof. Peter Clark, OSU College of earth, Ocean & Atmospheric Sciences that the Glacier retreat was due to rising levels of Carbon Dioxide and other GHG, as opposed to other types of forces. Due to Industrial Revolution other Human activities. Atmospheric processes & SLCF abundances HOW TO MITIGATE CLIMATE CHANGE:	Rejected - this comment is not relevant to chapter 6. IPCC is not supposed to be policy prescriptive
14871	8	16	8	16	please define AQ [Marie-France Loutre, Switzerland]	Taken into account, text revised.
104743	8	16	8	16	First mention of AQ. Should be declared first Air Quality (AQ) [Tobias Schad, Germany]	Taken into account, text revised.
78769	8	16	8	16	It should be shown what AQ stands for, as this is its first use in this chapter [Yasemin Aktas, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account, text revised.
96671	8	16			AQ (Air quality) is not given as the full word, neither in the heading, nor in the following paragraph. It also does not appear in the abbreviation list. Please add information accordingly. [Nicole Wilke, Germany]	Taken into account, text revised.
5137	8	18	8	19	"the climatic effects of SCLFs are largest at local and regional scales". This statement is incorrect. The radiative forcing from SCLFs are largest at local and regional scales. The climate impacts can be global. Sulfate aerosols have led to less sea level rise. That is global, not regional. The warming from black carbon is not largest at local scales. [Daniel Murphy, United States of America]	Accepted, the sentence now clearly refer to radiative forcing effects.
77483	8	18	22	17	Policy addressing sources is key, and options to establish synergies with actions to address all emissions to the atmosphere should be mentioned. [Emer Griffin, Ireland]	Noted but not added in the introduction. This point is discussed in FAQ 6.2 and discussed in section 6.6 (in particular 6.6.3) and in Box 6.2.
103249	8	19	8	19	predominantly occur in the first two decades'. It is true for CH4 and HFCs, but insufficiently reflect that other components have almost immediate impacts, or multiple timescale (e.g. short-term ozone, and 'long-term' ozone that follows the impacts from methane. Suggest; the climatic effects of SLCFs are largest at local and regional scales and occur on multiple timescales from days to about two decades. [Philippe Tulkens, Belgium]	Taken into account, text revised.
127999	8	19	8	21	The spatial patterns of climate responses don't necessarily mirror forcing or abundance changes (e.g., Levy et al., JGR, 2013 and many others more recently including newly published Westervelt et al. ACP 2020 for temperature). [Trigg Talley, United States of America]	Taken into account, text revised.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
113899	8	20	8	20	This is correct for pulses of emissions. But not for constant or increasing emissions. You may add "single year emisiosn" or "one-off emission". I also find local indicate e a bit too small scale [Jan Fuglestvedt, Norway]	Taken into account, text revised.
45841	8	20	8	21	Please clarify that this statement does not apply to the climate response, which is delayed compared to the emissions. [Twan van Noije, Netherlands]	Taken into account, text revised.
104747	8	20	8	21	It is a bit odd to speak prior to this sentence that the effect of SLCF is predominantly in the first two decades after emission and then suggesting if emissions decline to zero that effects decline to zero. Of course the effect is quite immediately but still within 10 to 20 years. [Tobias Schad, Germany]	Taken into account, text revised.
128003	8	21	8	21	Perturbations in OH or NOx have climate impacts via CH4 or HCFCs that last far beyond the NOx or OH lifetimes (e.g., Prather, GRL 1996; Wild et al., JGR 2001). This statement thus seems misleading. Is it rather the ability of these species to alter near-term climate that is the important property? [Trigg Talley, United States of America]	Taken into account, text revised.
113901	8	21	8	21	I would rather say "towards zero" [Jan Fuglestvedt, Norway]	Accepted
128001	8	21	8	22	AR5 used "near-term climate forcers" whereas AR6 uses "short-lived climate forcers". Recommend providing an explanation for the change in terms used. [Trigg Talley, United States of America]	Accepted and text revised.
80281	8	24	8	28	stratospheric ozone is also a short-lived climate forcer according to the definition. For HFC, it depends on their lifetime. For example HFC23 and HFC143a have a lifetime of 228 and 51 years respectively (see table 2-2 of chapter 2 of last WMO Assessment on the state of the ozone layer (WMO, 2018). The statement should thus be more precise. [Sophie Godin-Beekmann, France]	Accepted, stratospheric ozone is also an SLCF and HFC and halogenated compounds with atmospheric lifetimes shorter than two decades are part of the SLCFs as well. However for some analysis we have also considered HFCs with lifetimes up to 50years but it is specified in the text and caption of figure.
55041	8	24	8	30	When the species of SLCFs are mentioned, the order should be consistent with these in Table 6.1 which is listed first as primary emission type, then secondary emission type. Within the same emission type, it should be arranged according to the life time from longer ones to the shorter ones. [Nancy Hamzawi, Canada]	Taken into account - species mentioned in same order as in Table 6.1 and as discussed in section 6.2
128005	8	28	8	28	Change to "Emissions of some non-radiatively active SLCF affect the abundances ..., e.g., nitrogen oxides (NOx), ..." [Trigg Talley, United States of America]	Taken into account, text revised.
45843	8	28	8	28	Change "which's" to "of which". [Twan van Noije, Netherlands]	Editorial. The report will undergo professional copy-editing prior to publication. This type of issue will be fixed then.
51241	8	28	8	28	Suggested change to start of sentence from "SLCFs which's emissions…" to "Emissions of SLCFs which affect..." [Jolene Cook, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account, text revised.
103251	8	28	8	28	Insert after "mixtures": "and at sizes ranging from a few nanometer to more than 10 micrometer". These are the major components- other aerosol components would include other sulfate components (e.g. MSA); other nitrogen containing components; metals are missing (which is less relevant for climate but more for health and ecosystems) [Philippe Tulkens, Belgium]	Accepted
21147	8	28	8	28	which's -> whose [Jing Li, China]	Taken into account, text revised.
72371	8	28	8	28	Change to 'SLCF emissions'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account, text revised.
104749	8	28	8	30	Not very clear sentence. Should be reordered like: Emissions of SLCFs like nitrogen oxides [...enumeration of SLCFs...] affect the abundance of other radiatively active species. [Tobias Schad, Germany]	Taken into account (sentence now in the introduction section 6.1).
103253	8	28	8	30	CO, SO2, etc are SLCFs precursors, but not formally forcers. See also the table 2.1 [Philippe Tulkens, Belgium]	Rejected, precursors are part of SLCFs.
104751	8	30	8	32	What about changing of composition and properties of species, which may results in different effects on radiation? [Tobias Schad, Germany]	not applicable -The sentence no longer exists
128007	8	30	8	38	Be consistent in use of "SLCFs" or "SLCF" to refer to multiple forcers. [Trigg Talley, United States of America]	Editorial. The report will undergo professional copy-editing prior to publication. This type of issue will be fixed then.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
51243	8	31	8	31	Typo, the term 'perturbating' should be 'perturbing'. [Jolene Cook, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account, text revised.
103255	8	32			Add here, and also later in the chapter, info on CCN and/or IN, one other important implication some of these compounds may have on climate (occurs only implicitely here) [Philippe Tulkens, Belgium]	Taken into account, text revised.
128009	8	34	8	34	Change "both" to "either." [Trigg Talley, United States of America]	Taken into account, text revised.
72373	8	34	8	34	Change 'SLCF' to 'SLCFs' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted, revised.
5139	8	34	8	35	I don't know at all what is meant by "warming SLCFs…introduced for policy purpose." It sounds as if people deliberately added pollutants in order to warm the climate. I'm not sure the acronym "SLCF" needs to be introduced at all, as it is never used in the Chapter except to define it here and on page 80. [Daniel Murphy, United States of America]	The sentence has been rephrased and is now in the section 6.5.
45845	8	34	8	35	Change "SLCF" to "SLCFs" and "SLCP" to "SLCPs". [Twan van Noije, Netherlands]	Editorial. The report will undergo professional copy-editing prior to publication. This kind of issues will be fixed then.
128011	8	35	8	35	What does "introduced for policy purpose" mean here? [Trigg Talley, United States of America]	The sentence has been rephrased and is now in the section 6.5.
104753	8	37	8	37	instead of „[…] regulated as air pollutants [...]", I would shorten this to „air quality" or „air quality policies" [Tobias Schad, Germany]	rejected, the wording of this sentence is correct as it is.
72375	8	37	8	37	Change 'SLCF' to 'SLCFs' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted, revised.
128013	8	38	8	38	Typo: should be "deleterious influence on stratospheric ozone". [Trigg Talley, United States of America]	Editorial. The report will undergo professional copy-editing prior to publication. This type of issue will be fixed then.
128015	8	38	8	38	Typo: "influencec" --> "influence on" [Trigg Talley, United States of America]	Editorial. The report will undergo professional copy-editing prior to publication. This type of issue will be fixed then.
45847	8	38	8	38	Change "influenec" to "influence on". [Twan van Noije, Netherlands]	Editorial. The report will undergo professional copy-editing prior to publication. This type of issue will be fixed then.
51239	8	38	8	38	typo: ' deleterious influence on stratospheric ozone…' [Jolene Cook, United Kingdom (of Great Britain and Northern Ireland)]	Editorial. The report will undergo professional copy-editing prior to publication. This type of issue will be fixed then.
20023	8	38	8	38	typo on "influence" [philippe waldteufel, France]	Editorial. The report will undergo professional copy-editing prior to publication. This type of issue will be fixed then.
45367	8	38	8	38	Please correct "influenec". [Hitoshi Matsui, Japan]	Editorial. The report will undergo professional copy-editing prior to publication. This type of issue will be fixed then.
106391	8	38	8	38	Influence rather than influenec [Hamza Merabet, Algeria]	Editorial. The report will undergo professional copy-editing prior to publication. This type of issue will be fixed then.
21149	8	38	8	38	influence -> influence on [Jing Li, China]	Editorial. The report will undergo professional copy-editing prior to publication. This type of issue will be fixed then.
72377	8	38	8	38	Change to 'SLCFs assessed' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted, revised.
74035	8	38	8	39	The NO2 emissions addressed in table 6.1 and referred here in the text passage are surface sources, I presume. It would be good to mention this. Aviation emissions might have a different characteristics. [Volker Grewe, Germany]	not applicable, table changed to cover NOx

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
78687	8	44	8	44	Figure 6.1 - this figure, showing "(a) Column-averaged CH4 concentrations (XCH4) based …" seems unnecessary, and it is not mentioned in the text. It could be removed. [Heike Wex, Germany]	Not applicable - figure removed
32037	8	44			Fig 6.1 uses a very elderly SCIAMACHY total column map that has huge problems. It would be much much better to use a very much newer figure, from a newer satellite. [Euan G. Nisbet, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable - figure removed
104755	8	49	8	49	unit is missing. 2°x2° grid boxes. [Tobias Schad, Germany]	Not applicable - figure removed
116517	8		8		I suggest to write explicitely air quality instead of AQ [Valerie Masson-Delmotte, France]	Taken into account, text revised.
12113	8		8		Fig. 6.1 and discussion : it is better to use a more accurate product here, GOSAT should be fine or if something european is needed, go for TROPOMI; Best would be to show “representative” annual mean maps of SCIA, GOSAT and TROPOMI. A 4-panel figure; 2 where SCIA & GOSAT overlap & 2 where GOSAT & TropOMI overlaps [Prabir Patra, Japan]	Not applicable - figure removed
74037	9	1	9	17	The effects refer to surface emissions, I presume. NOx emitted by aviation has atmospheric residence times in the order of weeks to perhpas 2 months and aviation ozone in the order of months (see e.g. Fig 9 in Grewe et al. 2014). I suggest to either explicitely state that these refer to emissions at ground or mention with a foot note that high altitude emissions (e.g. subsonic aviation) these values are significantly larger, or even give estimates. Note also that for supersonic transport these values are in the order of years (see e.g. Fig. 6; for H2O emissions which are the same for NOy to a first order; Grewe and Stenke 2008). This is important to avoid confusion in the aviation community. Grewe, V., Frömming, C., Matthes, S., Brinkop, S., Ponater, M., Dietmüller, S., Jöckel, P., Garny, H., Dahlmann, K., Tsati, E., Søvde, O. A., Fuglestvedt, J., Berntsen, T. K., Shine, K. P., Irvine, E. A., Champougny, T., and Hullah, P.: Aircraft routing with minimal climate impact: The REACT4C climate cost function modelling approach (V1.0), Geosci. Model Dev. 7, 175-201, doi:10.5194/gmd-7-175-2014, 2014. Grewe, V. and A. Stenke, AirClim: an efficient climate impact assessment tool, Atmospheric Chemistry and Physics, 8, 4621 - 4639, 2008. [Volker Grewe, Germany]	Taken into account - since Grewe et al (2014) find the lifetime of NOx emissions from aviation to be 20 ± 11 days. Therefore, "hour to days" covers the range of NOx lifetime throughout the atmosphere.
112009	9	1	9	17	This table is very confusing with all of the “acronyms”. For example, nowhere do you explain what W/C means. I would suggest adding something like color coding or anything besides just all these letters that one has to either continuously look down at the footnotes or commit to memory. [Cynthia Randles, United States of America]	Taken into account, text revised.
32039	9	2			CH4 lifetime 9-12 years - is there a note saying these are differently defined lifetimes, not error margins? [Euan G. Nisbet, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account, a note has been added to explain that the second lifetime is the perturbation time.
76635	9	4	9	16	Table 6.1 defines NO2 as primary emitted only, however, it can also be formed within the atmosphere by the reaction of NO + O3 → NO2 + O2; Thus, please indicate the source type as P + S [Felix Havermann (né Wiß), Germany]	Not applicable - changed to NOx
113903	9	4	9	16	Table 6.1 is useful. One remark: While you indicate Warming and Cooling in the "Climate Effect" column, you also give I for indirect - withouth any sign to this. Can you consider indicating cooling or warming effects here? As it is now it looks "neutral" [Jan Fuglestvedt, Norway]	Taken into account, text revised.
107523	9	6	9	6	make clear that the climate effects listed inTable 6.1 correspond to an increase in the SLCF. This will help clarify later when you talk about effects of mitigation, i.e. in the opposite sense [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account, text revised.
26993	9	6	9	6	NO is missing in the table [Eric Brun, France]	Not applicable - NO2 changes to NOx
18295	9	6	9	6	Secondary aerosol is not formed exclusively through oxidative processes. For example, oligomerization, hydration, and other dark chemistry reactions can contribute to secondary organic aerosol formation, as well as acid-base reactions contribute to secondary inorganic aerosol. I would suggest to modify the sentence as "through atmospheric chemical processes". [Stefania Gilardoni, Italy]	Taken into account. Text revised

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
8277	9	6	9	10	Recommend to include under category : "SLCF precursor" for SO2, No2 etc. Define POA. A not unimportant part of SO4 is primary emission, especially in uncontrolled equipment. [Frank Dentener, Italy]	Taken into account, text revised.
103257	9	6	9	10	Recommend to include under category : "SLCF precursor" for SO2, No2 etc. Define POA. A not unimportant part of SO4 is primary emission, especially in uncontrolled equipment. [Philippe Tulkens, Belgium]	Taken into account, text revised.
81349	9	6	9	10	Some of the halocarbons included under “HFCs” also have quite high GWPs, so they do not just affect LLGH through “Strat. chem.”. [Johannes Laube, Germany]	not applicable - table changed
51245	9	6	9	11	Table 6.1: It would be useful to include BVOCs in this table [Jolene Cook, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable - BVOC included in NMVOCs
104757	9	6	9	16	Concerning the lifetime of the species: Either name dependency of the lifetime of all species or none and not only of aerosols. I would prefer not naming the processes which influence lifetime, because it is too much information. This should be covered in the chapters later. [Tobias Schad, Germany]	Taken into account, text revised.
104759	9	6	9	16	Concerning WHO guideline values: In case of PM there are not only annual mean values in case of PM2.5 and PM10, there exist also values for 24-hour means. PM2.5: 25µg/m3, PM10: 50µg/m3. [Tobias Schad, Germany]	Accepted
35975	9	6	9	16	Sulphate, nitrate, and SOA affect planetary albedo through clouds, so there should be a "CI" in the second-to-last column. [Nicolas Bellouin, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account, text revised.
45849	9	6			Table 6.1: What does "LLGH" stand for? [Twan van Noije, Netherlands]	Not applicable - column removed
45851	9	6			Table 6.1: Change "NO2" to "NOx". [Twan van Noije, Netherlands]	Accepted
45853	9	6			Table 6.1: Please clarify that numbers given for the lifetime of CH4 are the best estimates for the atmospheric lifetime (~9 years) and the for perturbation lifetime (~12 years), and not the likely range for the atmospheric lifetime. [Twan van Noije, Netherlands]	Taken into account, a note has been added to explain that the second lifetime is the perturbation time.
45855	9	6			Table 6.1: In the column listing the main radiatively active agents, I would suggest to change "OC" to "OA". Also, CO2 should be added for O3, as O3 affects the uptake of CO2 by plants, and consider adding Na2SO4 for Sulphate. [Twan van Noije, Netherlands]	Taken into account, text revised.
45857	9	6			Table 6.1: In the column listing the climate effects, consider adding "W" for mineral dust, to account for absorption of SW and LW radiation. Please explain what is meant with "I" or "Indirect Climate Effect". It seems only aerosol indirect effects are included, but it could have a more general meaning. If so, please add "I" for NO2 (NOx), NH3, NMVOC, CO and O3, to account for their indirect climate effects via chemical reactions. [Twan van Noije, Netherlands]	Taken into account, text revised.
45859	9	6			Table 6.1: As for POA, please add "CI" for "SOA". [Twan van Noije, Netherlands]	Not applicable - grouped as carbonaceous aerosol
128017	9	7	9	7	"LLGH" --> "LLGHG" [Trigg Talley, United States of America]	Not applicable - column removed
26153	9	7	9	7	"LLGH" is probably "LLGHG". [Toshihiko Takemura, Japan]	Not applicable - column removed
35883	9	7	9	7	LLGH is missing from the list of acronyms. Should this be LLGHGs? [Jasper Kok, United States of America]	Not applicable - column removed
72379	9	7	9	7	Change 'SLCF' to 'SLCFs' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted, revised.
106393	9	9	9	9	Organization rather than organisation [Hamza Merabet, Algeria]	Accepted, revised.
128019	9	10	9	10	Sulphate aerosol is not exclusively present as neutralized ammonium nitrate. Could also be ammonium bisulfate, pure sulfuric acid, or intermediate compositions. [Trigg Talley, United States of America]	Taken into account, the Table has been simplified to avoid this level of complexity.
35885	9	10	9	10	Mineral dust is listed here as a cooling agent, but this is actually a matter of substantial debate. See Kok et al. (Nature Geoscience, 2017), Di Biagio et al. (GRL, 2020), and Adebiyi and Kok (Science Advances, 2020) [Jasper Kok, United States of America]	Accepted and modified in the table.
45369	9	10	9	10	Table 1 is hard to understand unless we see the footnote carefully. I suggest to change W, C, D, I, AC, and Cl in the table to warming, cooling, direct, indirect, atmos chem, and cloud, respectively. [Hitoshi Matsui, Japan]	Taken into account, table simplified.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
45371	9	10	9	10	Table 1: Effect on LLGH via --> Effect on LLGHG via [Hitoshi Matsui, Japan]	Not applicable - column removed
45373	9	10	9	10	Table 1: what is "CCN active" for sea salt? [Hitoshi Matsui, Japan]	Not applicable - column removed
45375	9	10	9	10	Table 1: Org. Carbon/POA and SOA can be combined. [Hitoshi Matsui, Japan]	Taken into account, text revised.
45377	9	10	9	10	Table 1: Sulfate, Nitrate, and SOA: "Minutes - weeks" should be "Hours - weeks", add "SOA" in the Main Radiatively Active Agent column, and add "Cl" in the Effect on albedo column. [Hitoshi Matsui, Japan]	Taken into account, text revised.
28509	9	10	9	10	"NOx" would be better than "NO2". [Hiroshi Tanimoto, Japan]	Accepted
28511	9	10	9	10	Where is ammonium? Sulphate (and SO2), nitrate (and NO2 or NOx) are present but only NH3 is present. [Hiroshi Tanimoto, Japan]	Taken into account and added to the Table.
21931	9	10	9	11	Table would likely be more accessible if top row and first column were bolded? [Peter Thorne, Ireland]	Accepted, revised.
103259	9	10			Table 6.1: According to Table 7.15, lifetime of CH4 is 12.4 years [Philippe Tulkens, Belgium]	Accepted. Estimates were revised and made consistent across Chapters 5, 6 and 7. The perturbation lifetime of CH4 is 11.8 years.
103261	9	10			Table 6.1: Species do not exert an "Effect on LLGH via", they rather exert a "Radiative effect via" [Philippe Tulkens, Belgium]	Not applicable - column removed
103263	9	10			Table 6.1: Please check "main radiatively active agent". CH4 as a result of NO2? Or of CO? [Philippe Tulkens, Belgium]	CH4 lifetime is affected through NOx. The term "main radiatively active agent" is no longer in the Table.
18313	9	11	9	11	OC can have a warming effect, if we consider brown carbon. I wonder if W should be added to the OC line in table 6.1 [Stefania Gilardoni, Italy]	Taken into account, text revised.
128023	9	12	9	12	"secondary SLCF formed through atmospheric oxidation mechanisms": for NH3 (and perhaps some SOA)s, condensation can be the relevant process. Suggest: "secondary SLCF formed through atmospheric mechanisms". [Trigg Talley, United States of America]	Accepted
128021	9	12	9	13	Clarify the usage of "direct" and "indirect" here. In particular, note that this usage is disctinct from "direct" or "indirect" aerosol effects. [Trigg Talley, United States of America]	Taken into account, text revised.
8279	9	19	9	19	Figure 6.2 is OK, but perhaps a little bit 'text book'. Is it needed? [Frank Dentener, Italy]	Noted - figure retained
116519	9		9		What is the chapter doing the assessment of the lifetime of CH4 (it is mentioned in ch 2, 5, 6), please coordinate [Valerie Masson-Delmotte, France]	Not applicable - figure removed
72381	10	4	10	4	Change 'SLCF' to 'SLCFs' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted, revised.
104761	10	4	10	5	Rephrase: […] Figure 6.2, emissions of SLCFs are governed by anthropogenic activities and natural sources (see Section 6.2 for details). [Tobias Schad, Germany]	Accepted, revised.
128025	10	6	10	7	"secondary aerosols are exclusively formed through atmospheric oxidation processes". For NH3 (and perhaps some SOAs), condensation can be the relevant process. Suggest: "secondary SLCF formed through atmospheric mechanisms". [Trigg Talley, United States of America]	Accepted
104763	10	7	10	9	Keep it shorter: […] also reacts with SLCF, presenting a reactive sink for SLCFs and thereby influencing their lifetime […]. [Tobias Schad, Germany]	Accepted, revised.
72383	10	8	10	8	Change 'SLCF' to 'SLCFs' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted, revised.
104765	10	10	10	12	Rephrase: […] of LLGHG and influences the source strength of mainly natural SLCFs and perturbs the processes of other Earth System components which induces feedbacks in the climate system […] [Tobias Schad, Germany]	Taken into account. Text change to: These influence the source strength of mainly natural sources of SLCFs inducing feedbacks in the climate system (Section 6.3)
21935	10	10	10	12	I could not make sense of this sentence. Suggest to redraft for clarity as it feels like some necessary context is missing [Peter Thorne, Ireland]	Taken into account. Text change to: These influence the source strength of mainly natural sources of SLCFs inducing feedbacks in the climate system (Section 6.3)
72385	10	13	10	13	Change 'SLCF' to 'SLCFs' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted, revised.
104769	10	17			Very short and informative figure but is there a reason why AIR is in capital letters and Pollution not? Since all other descriptions are in capital letters. [Tobias Schad, Germany]	Accepted, revised.
103265	10	19	10	19	Figure 6.2 is OK, but perhaps a little bit 'text book'. Is it needed? [Philippe Tulkens, Belgium]	Rejected. We consider that this figure is necessary to illustrate the relations between SLCF, climate and air quality

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
113905	10	19	10	32	Useful figure. [Jan Fuglestvedt, Norway]	Thanks
128027	10	23	10	23	[PRECISION] "Wildfires" are listed as both natural and anthropogenic sources. Maybe reserve this name for natural sources, and change to "biomass burning" (or another term) for the anthropogenic source. Explain what is meant by natural versus anthropogenic sources in this context. The classification used in Table 6.2 differs, with "Open biomass burning" separated out, listed under neither anthropogenic nor natural. Elsewhere, biomass burning is used to refer to the sum of open biomass burning and biofuel burning. Be consistent throughout chapter. [Trigg Talley, United States of America]	Accepted, changed in the caption.
128029	10	25	10	27	In the case of BC, for instance, even the shortwave radiative effect is positive. This way of looking at individual components of forcing (referred to here as "net" forcing) is not useful. [Trigg Talley, United States of America]	Taken into account - text changed to read: . Radiative forcing by SLCFs can be net positive or net negative through interactions with outgoing or incoming radiation, respectively, and net positive through decreases of the surface albedo e.g. by black carbon deposition on snow.
103267	10	26			radiative forcing is positive when compounds interact with long wave radiatin - that is clear. But the opposite when tehy interact with short-wave radiation? Isn't it rather incoming radiation vs. outgoing radiation? [Philippe Tulkens, Belgium]	Accepted, revised.
104771	10	28	10	29	Not clear what is the meaning of this sentence. [Tobias Schad, Germany]	Taken into account - text changed to read: air pollutants such as ozone induce changes to biogenic VOC emissions.
107525	10	41	10	41	NTCF defined on page 8 L22 [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Accepted, revised.
113907	10	41	10	43	Here you focus on treatment in WGI of AR5. Thus you shoudl not write ony AR5 but "AR5 WGI". You may also add what AR5 WGII and WGIII did on SLCF. [Jan Fuglestvedt, Norway]	Accepted
8281	10	42	10	42	In my perception the way AR5 was considering SLCF was scattered across a number of chapter, and was rather lackign a quantitative and detailed analysis. Iwould rather tell which 'previous' chapters are combined here. [Frank Dentener, Italy]	Rejected. The aim of this subsection is to provide some key results from previous IPCC reports showing the importance of SLCFs not to provide a roadmap of these reports in term of SLCFs. Note that the results from previous reports are systematically recalled in the following sections of the chapter.
103269	10	42	10	42	In my perception the way AR5 was considering SLCF was scattered across a number of chapter, and was rather lackign a quantitative and detailed analysis. It maz be better to say which 'previous' chapters are combined here. [Philippe Tulkens, Belgium]	Rejected. The aim of this subsection is to provide some key results from previous IPCC reports showing the importance of SLCFs not to provide a roadmap of these reports in term of SLCFs. Note that the results from previous reports are systematically recalled in the following sections of the chapter.
26155	10	45	10	45	"ERF" is the first appearance in this chapter. [Toshihiko Takemura, Japan]	Accepted. Text revised
128031	10	46	10	46	"were" --> "was" [Trigg Talley, United States of America]	Accepted, revised.
113909	10	49	10	49	Add WGI after AR5 [Jan Fuglestvedt, Norway]	Accepted, revised.
45861	10	49	10	51	This statement is about the regional scale. At the local scale, e.g. close to point sources, the forcing by SLCFs can be even stronger. Please consider including a statement about the forcing by SLCFs at the local scale in comparison to the forcing by CO2. [Twan van Noije, Netherlands]	Not Applicable, the sentence has been removed.
113911	10	53	10	53	Add WGI after AR5 [Jan Fuglestvedt, Norway]	Accepted, revised.
113913	11	3	11	10	you refer explictely to ch1 in SR1.5, but you could make it clear taht you also refer to ch2 in SR1.5 later in the para. [Jan Fuglestvedt, Norway]	Accepted. The references are now clearer.
104773	11	9	11	9	Name the SLCFs in brackets for clarity [Tobias Schad, Germany]	Rejected. Specification not useful in the interest of length of the paragraph.
8283	11	9	11	9	Co-emitted (emitted at the same place and time of two of more components) is not always adequately describing the siutation. E.g. CH4 and CO2 emissions are correlated, but mostly not co-emitted. CH4 released at fossil fuel production location, whereas CO2 is emitted where the fuel is burnt. [Frank Dentener, Italy]	Rejected. The issue of co-emission is described in general, no particular case is made. The text says. "some" SLCFs.

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103271	11	9	11	9	Co-emitted (emitted at the same place and time of two of more components) is not always adequately describing the siutation. E.g. CH4 and CO2 emissions are correlated, but mostly not co-emitted. CH4 released at fossil fuel production location, whereas CO2 is emitted where the fuel is burnt. [Philippe Tulkens, Belgium]	Rejected. The issue of co-emission is described in general, no particular case is made. The text says. "some" SLCFs.
16545	11	9	11	9	"There is evidence that" sounds better that "It is also evidenced that" [William Collins, United Kingdom (of Great Britain and Northern Ireland)]	Accepted
104775	11	12	11	16	Could be shorter: Reductions of warming SLCFs (CH4 and BC) contribute significantly to limit warming to 1.5°C on the short term and as a substantial co-benefit imporve air quality, which limits effects on human health and agricultural yields. [Tobias Schad, Germany]	Rejected as it makes the sentence less precise.
68289	11	12	11	16	Speed is a key metric, and climate solutions must be measured along this dimension as well as along the conventional metrics. It is important how quickly a climate solution can deliver avoided warming. Molina M., et al. (2009) Reducing abrupt climate change risk using the Montreal Protocol and other regulatory actions to complement cuts in CO2 emissions, PROC. NAT'L. ACAD. SCI. 106(49):20616–20621. Because of their short lifetimes (days to a decade and a half), SLCPs can provide fast mitigation, avoiding warming at 2050 of up to 0.6 ºC, while cutting CO2 can avoid between 0.1–0.3 ºC; at 2100, SLCPs avoid 1.2 ºC warming and CO2 avoids 1.6–1.9 ºC. SLCP reductions are critical for vulnerable areas like the Arctic and because they can slow progression of tipping points and self-reinforcing feedbacks. See Xu and Ramanathan (2017) Well below 2 °C: Mitigation strategies for avoiding dangerous to catastrophic climate changes, Proc. Natl. Acad. Sci. 114(39):10315–10323; Ramanathan and Xu (2010) The Copenhagen Accord for limiting global warming: Criteria, constraints, and available avenues, Proc. Natl. Acad. Sci. 107(18):8055–8062; Ramanathan and Feng (2008) On avoiding dangerous anthropogenic interference with the climate system: Formidable challenges ahead, Proc. Natl. Acad. Sci. 105(38):14245–14250; Report of the Committee to Prevent Extreme Climate Change (Co-Chairs: Ramanathan V., Molina M. L., and Zaelke D.; Authors: Alex K., Auffhammer M., Bledsoe P., Borgford-Parnell N., Collins W., Croes B., Forman F., Gustafsson Ö., Haines A., Harnish R. Jacobson M. Z., King S., Lawrence M., Leloup D., Lenton T., Morehouse T., Munk W., Picolotti R., Prather K. Raga G. B., Rignot E., Shindell D., Singh A. K., Steiner A., Thiemens M., Titley D. W., Tucker M. E., Tripathi S., Victor D., & Xu Y.) (2017) Well Under 2 Degrees Celsius: Fast Action Policies to Protect People and the Planet from Extreme Climate Change. [Durwood Zaelke, United States of America]	Rejected: this subsection summarizes some key finding from previous IPCC assessments reports.
68291	11	12	11	16	It is critical to slow feedbacks in the coming decade, including by cutting the SLCPs, as well as by protecting sinks, enhancing urban albedo, and other fast mitigation strategies. Molina M., et al. (2009) Reducing abrupt climate change risk using the Montreal Protocol and other regulatory actions to complement cuts in CO2 emissions, PROC. NAT'L. ACAD. SCI. 106(49):20616–20621; Lenton T. M., et al. (2019) Climate tipping points—too risky to bet against, NATURE, Comment, 575:592–595 ("In our view, the consideration of tipping points helps to define that we are in a climate emergency and strengthens this year's chorus of calls for urgent climate action — from schoolchildren to scientists, cities and countries."); and Steffen W., et al. (2018) Trajectories of the Earth System in the Anthropocene, PROC. NAT'L. ACAD. SCI. 115(33):8252–8259, 8254. [Durwood Zaelke, United States of America]	Rejected: this subsection summarizes some key finding from previous IPCC assessments reports.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
68293	11	12	11	16	Any overshoot will cause some irreversible impacts, including SLR and glacial and ice sheet melt that will not be reversed when the overshoot is corrected. Tokarska K. B., et al. (2019) Path Independence of Carbon Budgets When Meeting a Stringent Global Mean Temperature Target After an Overshoot, EARTH'S FUTURE 7:1283–1295, 1283 ("Emission pathways that are consistent with meeting the Paris Agreement goal of holding global mean temperature rise well below 2 °C often assume a temperature overshoot. In such overshoot scenarios, a given temperature limit is first exceeded and later returned to, under the assumption of large-scale deliberate carbon dioxide removal from the atmosphere. Here we show that although such strategy might result in a reversal of global mean temperature, the carbon cycle exhibits path dependence. After an overshoot, more carbon is stored in the ocean and less on land compared to a scenario with the same cumulative CO2 emissions but no overshoot. The near-path independence of surface air temperature arises despite the path dependence in the carbon cycle, as it is offset by path dependence in the thermal response of the ocean. Such behavior has important implications for carbon budgets (i.e. the total amount of CO2 emissions consistent with holding warming to a given level), which do not differ much among scenarios that entail different levels of overshoot. Therefore, the concept of a carbon budget remains robust for scenarios with low levels of overshoot (up to 300 Pg C overshoot considered here) but should be used with caution for higher levels of overshoot, particularly for limiting the environmental change in dimensions other than global mean temperature rise."); Solomon S., et al. (2010) Persistence of climate changes due to a range of greenhouse gases, PROC. NAT'L. ACAD. SCI. 107(43):18354–18359, 18356 ("The transfer of heat from the atmosphere to the ocean's mixed layer (top 100 m or so) is thought to occur on timescales on the order of a decade or less (30), whereas multiple centuries are required to warm or cool the deep ocean (31), and changes in the great ice sheets and vegetation coverage may occur over many thousands of years (4)."). [Durwood Zaelke, United States of America]	Rejected: this subsection summarizes some key finding from previous IPCC assessments reports.
66759	11	12	11	16	Speed is a key metric, and climate solutions must be measured along this dimension as well as along the conventional metrics. The question that needs to be answered is how quickly a climate solution can deliver avoided warming. Molina M., et al. (2009) Reducing abrupt climate change risk using the Montreal Protocol and other regulatory actions to complement cuts in CO2 emissions, PROC. NAT'L. ACAD. SCI. 106(49):20616–20621. It is important to note that SLCPs are a critical part of that solution, and that cutting them can avoid warming at 2050 of up to 0.6 ºC, while cutting CO2 can avoid between 0.1–0.3 ºC; at 2100, SLCPs avoid 1.2 ºC warming and CO2 avoids 1.6–1.9 ºC. SLCP reductions are critical for vulnerable areas like the Arctic and because they can slow progression of tipping points and self-reinforcing feedbacks. See Xu and Ramanathan (2017) Well below 2 °C: Mitigation strategies for avoiding dangerous to catastrophic climate changes, Proc. Natl. Acad. Sci. 114(39):10315–10323; Ramanathan and Xu (2010) The Copenhagen Accord for limiting global warming: Criteria, constraints, and available avenues, Proc. Natl. Acad. Sci. 107(18):8055–8062; Ramanathan and Feng (2008) On avoiding dangerous anthropogenic interference with the climate system: Formidable challenges ahead, Proc. Natl. Acad. Sci. 105(38):14245–14250. [Kristin Campbell, United States of America]	Rejected: this subsection summarizes some key finding from previous IPCC assessments reports.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
66761	11	12	11	16	Any overshoot will cause some irreversible impacts, including SLR and glacial and ice sheet melt that will not be corrected when the overshoot is corrected. Tokarska K. B., et al. (2019) Path Independence of Carbon Budgets When Meeting a Stringent Global Mean Temperature Target After an Overshoot, EARTH'S FUTURE 7:1283–1295, 1283 ("Emission pathways that are consistent with meeting the Paris Agreement goal of holding global mean temperature rise well below 2 °C often assume a temperature overshoot. In such overshoot scenarios, a given temperature limit is first exceeded and later returned to, under the assumption of large-scale deliberate carbon dioxide removal from the atmosphere. Here we show that although such strategy might result in a reversal of global mean temperature, the carbon cycle exhibits path dependence. After an overshoot, more carbon is stored in the ocean and less on land compared to a scenario with the same cumulative CO2 emissions but no overshoot. The near-path independence of surface air temperature arises despite the path dependence in the carbon cycle, as it is offset by path dependence in the thermal response of the ocean. Such behavior has important implications for carbon budgets (i.e. the total amount of CO2 emissions consistent with holding warming to a given level), which do not differ much among scenarios that entail different levels of overshoot. Therefore, the concept of a carbon budget remains robust for scenarios with low levels of overshoot (up to 300 Pg C overshoot considered here) but should be used with caution for higher levels of overshoot, particularly for limiting the environmental change in dimensions other than global mean temperature rise."); Solomon S., et al. (2010) Persistence of climate changes due to a range of greenhouse gases, PROC. NAT'L. ACAD. SCI. 107(43):18354–18359, 18356 ("The transfer of heat from the atmosphere to the ocean's mixed layer (top 100 m or so) is thought to occur on timescales on the order of a decade or less (30), whereas multiple centuries are required to warm or cool the deep ocean (31), and changes in the great ice sheets and vegetation coverage may occur over many thousands of years (4)."). [Kristin Campbell, United States of America]	Rejected: this subsection summarizes some key finding from previous IPCC assessments reports.
69873	11	12	11	16	Note also importance of limiting warming in near term to reducing climate extremes, as discussed in Chapter 4 (4-76) and Chapter 11. [Gabrielle Dreyfus, United States of America]	Rejected. This paragraph refers to previous IPCC reports.
113915	11	12	11	16	make it clear that this still referesr yo SR1.5 [Jan Fuglestvedt, Norway]	Rejected: the reference is there.
128033	11	13	11	15	"Reductions of BC and CH4 would have substantial co-benefits improving air quality and therefore limit effects to human health and agricultural yields." This is true but too simple a statement. Lost is that BC is always co-emitted with climate-cooling aerosol components and that one needs to account for the total climate effect of any mitigation action. [Trigg Talley, United States of America]	Rejected: the aim of this subsection is to provide only a general summary of the key findings about SLCFs in previous report. Such aspect of mitigation is discussed more thoroughly in section 6.6.3.
76637	11	18	12	20	How are NMVOCs and BVOCs in the whole chapter distinguished? I also found occurences of „VOC" but no clear definition (VOC = AVOC + BVOC??) [Felix Havermann (né Wiß), Germany]	Taken into account, text revised.
45863	11	19	11	19	For clarity and consistency, please consider changing "OC" to "OA". [Twan van Noije, Netherlands]	Accepted, revised.
128035	11	20	11	22	Clarify what is meant by "there is no agreement ... (..., high agreement)." [Trigg Talley, United States of America]	Accepted, the sentence has been changed.
45865	11	22	11	28	I have the impression that the BVOC-SOA changes mentioned under point iii) are already partly included in ii). If this is not the case, please clarify the distinction between the BVOC-SOA changes mentioned under ii) and iii). [Twan van Noije, Netherlands]	Rejected: This is taken from the referred report.
8285	11	30	11	34	No discussion on seasalt, NH3 or DMS emissions from oceans? [Frank Dentener, Italy]	Rejected: This is taken from the referred report.
103273	11	30	11	34	No discussion on seasalt, NH3 or DMS emissions from oceans? [Philippe Tulkens, Belgium]	Rejected: This is taken from the referred report.
21151	11	30	11	34	Deposition of dust on snow also has a warming effect (e.g., Krinner et al., Climate Dynamics, 2006; Kaspari et al., ACP, 2014) [Jing Li, China]	Rejected: This is taken from the referred report.
107527	11	33	11	33	Arctic typo [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Accepted, revised.
45379	11	33	11	33	Artic --> Arctic [Hitoshi Matsui, Japan]	Accepted, revised.
72387	11	33	11	33	Change 'Artic' to 'Arctic'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted, revised.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
8287	11	36	11	47	Text and Figure seem to duplicate. Is figure 6.3 needed? [Frank Dentener, Italy]	Accepted, redundant text has been removed.
103275	11	36	12	47	Text and Figure 6.3 seem to duplicate. Is figure 6.3 needed? [Philippe Tulkens, Belgium]	Accepted, redundant text has been removed.
33035	11	37	12	5	in chapter "road map" current position and favourable objectives should be clearly describe and needs to be more understandable. [Sahar Tajbakhsh Mosalman, Iran]	Taken into account, text revised.
32705	11	37	12	5	in chapter "road map" current position and favourable objectives should be clearly describe and needs to be more understandable. [sadegh zeyaeyan, Iran]	Taken into account, text revised.
17407	11	37	12	5	In "Chapter Roadmap" current position and favorable objectives should be clearly describe and needs to be more understandable. [Mostafa Jafari, Iran]	Taken into account, text revised.
103277	11	37			Chapter Roadmap is valuable, but Figure 6.3 is not needed or helpful [Philippe Tulkens, Belgium]	Such a figure is included in each chapter but the text was too similar and has been removed.
113917	11	39	11	47	Useful para. Figure 6.3 as well [Jan Fuglestvedt, Norway]	Thanks
115563	11	39	11	55	One aspect not treated in this paper is the Aersosl layer in the South Asian monsoon region in summer (also referred to as ATAL) Not everything is known about this layer but it seems to be largely driven by anthropogenic emissions (Verneir et al., BAMS, 2918) . It has a significant impact on regional climate and may impact precipitation in the monsoon regions (e.g. Fadnavis et al, Sci. Reports, 9:10268, 2019) [Rolf Müller, Germany]	Rejected: seems to refer to different place/chapter
128037	11	46	11	46	Figure 6.3, not 6.1? [Trigg Talley, United States of America]	Accepted, revised.
128039	11	46	11	46	"Section 6.6.4" --> "Section 6.6.3". [Trigg Talley, United States of America]	Accepted, revised.
45381	11	46	11	46	Figure 6.1 --> Figure 6.3 [Hitoshi Matsui, Japan]	Accepted, revised.
104777	11	46	11	46	Correction: Figure 6.3 is the roadmap of the chapter [Tobias Schad, Germany]	Accepted and corrected
78689	11	46	11	46	The current Fig. 6.1 is NOT related to any roadmap. Do you mean Figure 6.3 here? - And (as said in the comment above), the current Fig. 6.1 is a figure which might not be needed. [Heike Wex, Germany]	Accepted, revised.
68823	11	46	11	46	Chapter 6 roadmap is summarized in Figure 6.3, not Figure 6.1. [Qing Ye, United States of America]	Accepted, revised.
107531	11	49	11	49	this should also point to section 4.4.4 which addresses near-term climate projections and SLCFs [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	accepted
107529	11	50	11	50	HFC typo [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Accepted, revised.
81351	11	50	11	50	Presumably either HCFCs or HFCs are meant here. [Johannes Laube, Germany]	Accepted, revised.
113919	11	55	11	55	If you need help in identifying authors in WGII and WGIII for help here, contact TSU or bureau [Jan Fuglestvedt, Norway]	Taken into account, text revised.
20361	12	1	12	5	The WG1 outline for chapter 4 includes, following the summary, 6 topics. The last one mentions air quality as follows "Connections to air quality and atmospheric composition". Comparing this to figure 6.3 where air quality figures in 4 sections out of 6 gives the feeling that the actual equilibrium has moved somewhat away from what was sketched in the outline. [philippe waldteufel, France]	Noted

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
16455	12	8	17	51	The observational studies on the source apportionment of BC and OC were not reviewed in the section 6.2.1 of this draft. The radiocarbon analyses for atmospheric aerosols have provided the observational constraints on the fuel use of the emission sources of BC and OC and the important insights into the validations of the model simulations. Here I summarized, in the following, several important publications on the source apportionment of BC and OC based on the radiocarbon analyses in the different regions of the world. Arctic/Sub-Arctic: Barrett, T., E. Robinson, S. Usenko, R. Sheesley (2015), Source contributions to wintertime elemental and organic carbon in the western arctic based on radiocarbon and tracer apportionment, Environ. Sci. Technol., 49, 11631-11639. Winiger, P., A. Andersson, S. Eckhardt, A. Stohl, I. P. Semiletov, O. V. Dudarev, A. Charkin, N. Shakhova, Z. Klimont, C. Heyes, Ö. Gustafsson (2017), Siberian Arctic black carbon sources constrained by model and observation, Proc. Natl. Acad. Sci, 114, E1054-E1061 US: Mouteva, G. O., J. T. Randerson, S. M. Fahrni, S. E. Bush, J. R. Ehleringer, X. Xu, G. M. Santos, R. Kuprov, B. A. Schichtel, C. I. Czimczik (2017), Using radiocarbon to constrain black and organic carbon aerosol sources in Salt Lake City, J. Geophys. Res., 122, 9843-9857, https://doi.org/10.1002/2017JD026519. Yoon, S., D. Fairly, T. E. Barrett, R. J. Sheesley (2018), Biomass and fossil fuel combustion contributions to elemental carbon across the San Francisco Bay Area, Atmos. Environ., 195, 229-242. Zotter, P., I. El-Haddad, Y. Zhang, P. L. Hayes, X. Zhang, Y. H. Lin, L. Wacker, J. Schnelle-Kreis, G. Abbaszade, R. Zimmermann (2014), Diurnal cycle of fossil and nonfossil carbon using radiocarbon analyses during CalNex, J. Geophys. Res., 119, 6818-6835, https://doi.org/10.1002/2013JD021114 EU:	Taken into account. While we do not cover the full list of publications provided in the interest of space, the key points related to trends in carbonaceous aerosol emissions as represented in emission inventories (used by global models) are covered in the revised text.
86781	12	8	37	48	We propose to add a table to ch 6.2 with emissions, trends, lifetimes, level of uncertainty and other relevant quantitative information on individual SLCFs. In this way, we think that the text could be shortened, more to the point and less a list of numbers to let new information since AR5 get more attention. [Oyvind Christophersen, Norway]	Accepted. A new graph is added showing sectoral and regional shares of emissions and a new table is added in section 6.1 including lifetimes, level of uncertainty, etc.
45867	12	8			Section 6.2: I am missing information about DMS, and an explanation of the distinction between non-sea salt sulfate and sea-salt sulfate. [Twan van Noije, Netherlands]	Taken into account. A separate section was marine aerosol and precursor emissions is added in section 6.2.2
45869	12	8			Section 6.2: As radiative forcing is addressed in Chapter 7, this section should not give (E)RF estimates not discuss radiative properties of aerosols beyond what is needed to categorize them (e.g. BC). [Twan van Noije, Netherlands]	Accepted
15019	12	10	12	20	Example of 'reference clutter'. Because there are so many, it would help if literature references were presented 'Nature' style, i.e. 'Currently, global models underestimate observed CO concentration globally1,2,3' rather than 'Currently, global models underestimate observed CO concentration globally (Shindell et al., 2006; Luo et al., 2015; Monks et al., 2015b)'. [Fredric Taylor, United Kingdom (of Great Britain and Northern Ireland)]	The reference style is decided at the IPCC bureau level for all the WG. This request has been transferred up.
72389	12	12	12	13	Change 'The last decades (since 1990s)' to The decades since the 1990s have' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised
113921	12	12	12	17	Here you list papers and then add "high confidence". I think you need to discuss and assess a bit more what these papers are saying [Jan Fuglestvedt, Norway]	Accepted - text revised; This paragraph has an introductory character; confidence level removed and assessment is provided in further sections.
8289	12	13	12	13	dramatic is normative language. [Frank Dentener, Italy]	Accepted - text revised; 'dramatic' changed to 'large'
103279	12	13	12	13	dramatic is normative language. [Philippe Tulkens, Belgium]	Accepted - text revised; 'dramatic' changed to 'large'

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
16549	12	15	12	15	Does this 50% include methane - presumably that is the biggest component by mass and would dominate this calculation. [William Collins, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised to clarify that the 50% refers to each species, including CH4 and NH3 which are highlighted as they are not strongly regulated yet but the change is driven by increasing activity in Asia.
72391	12	16	12	17	References should be in chronological order. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial. The report will undergo professional copy-editing prior to publication. This type of issue will be fixed then.
72393	12	17	12	17	insert space between)(. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised
76639	12	23	12	28	Besides dust, CO, and NOx, soil can also be a source for NMVOCs [Felix Havermann (né Wiß), Germany]	Noted - the table in this form has been removed but comments considered in the 6.2.x sections addressing particular species and in the revised table 6.1
103281	12	23	12	28	Table header: SLCFs and precursors (key-species). Direct SO4 emission and other PM needs to be included as a fossil fuel source (esp. in the past). H2S is quite important volcanic source. DMS oceans. [Philippe Tulkens, Belgium]	Noted - the table in this form has been removed but comments considered in the 6.2.x sections addressing particular species and in the revised table 6.1
103283	12	23	12	28	Table 6.2: Energy (commercial) use of biomass is missing. Solid biomass is often and increasingly used for electric power generation, heat and industrial applications, which result in SLCF emissions. [Philippe Tulkens, Belgium]	Noted - the table has been however removed
103285	12	23	12	28	Regarding footnote 1: This applies not only to cooking, but to other uses as well. Some biomass is harvested in a non-sustainable way in all regions, and no region has only unsustainable harvest. [Philippe Tulkens, Belgium]	Noted - the table has been however removed
103287	12	23	12	28	Table 6.2: Open biomass burning can include anthropogeninc and non-anthropogenic sources. An effort to separate the two should be made and documented. Even if the two cannot be separated for the purpose of this table, it should be recognised that biomass burning is mostly anthropogenic (which is very clear from, e.g., Figure 6.4), and that some of these sources (like agricultural residue burning) are entirely anthropogenic. It would be more reasonable to include biomass burning under "anthropogenic" emissions, with a footnote recognising that it may include some natural sources that could not be separated. [Philippe Tulkens, Belgium]	Accepted - Table 6.2 is removed but the comment is considered in section 6.2.1.3 (biomass burning)
33033	12	23	12	50	in table 6.2: Energy (fossil fuel combustion) In Natural Gas cumbustion the only SLCF key species is NOx) [Sahar Tajbakhsh Mosalman, Iran]	Rejected - While this Table has been revised and the comment became 'not applicable', the combustion of natural gas does produce also other SLCF species, including for example CO, NMVOC, as well as typically small amounts of BC and OC. This table in SOD listed however key species for a given category without intention to go into the details of differences between the fuels.
32703	12	23	12	50	in table 6.2: Energy (fossil fuel combustion) In Natural Gas cumbustion the only SLCF key species is NOx) [sadegh zeyaeyan, Iran]	Rejected - While this Table has been revised and the comment became 'not applicable', the combustion of natural gas does produce also other SLCF species, including for example CO, NMVOC, as well as typically small amounts of BC and OC. This table in SOD listed however key species for a given category without intention to go into the details of differences between the fuels.
69203	12	25	12	28	Considering the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, "N2O" can be added to LLGHGs of "Open biomass burning" and "Soil" in Table 6.2. [Kaoru Magosaki, Japan]	Noted - the table has been however removed; comments are considered to the possible extent in the new revised Table 6.1 and /or further sections addressing particular species

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
107377	12	25	12	28	Table 6.2 "Waste and Open fines" are also source of NH3 (see for example: https://doi.org/10.1016/j.atmosenv.2015.03.015 and Wentworth et al. Ammonia in the summertime Arctic marine boundary layer: sources, sinks and implications. Atmospheric Chemistry and Physics, 2016, 16 (4), pp.1937-1953. ⟨10.5194/acp-16-1937-2016⟩) [ABDELWAHID MELLOUKI, France]	Noted - the table has been however removed; comments are considered to the possible extent in the new revised Table 6.1 and /or further sections addressing particular species
81353	12	25	12	28	This table highlights again a general problem: Many HFCs are actually LLGHGs. Also, the column on LLGHGs almost exclusively lists CO2, when there are plenty long-lived halocarbons (such as CFCs, halons, PFCs, HFCs, SF6) emitted from the sources shown here. [Johannes Laube, Germany]	Noted - the table has been however removed; comments are considered to the possible extent in the new revised Table 6.1 and /or further sections addressing particular species
45871	12	25			Table 6.2: Please consider adding the dominant LLGHGs from "Leaking refrigeration and air conditioning". Please add DMS for the ocean source and H2S for the volcanic source. [Twan van Noije, Netherlands]	Noted - the table has been however removed; comments are considered to the possible extent in the new revised Table 6.1 and /or further sections addressing particular species
128041	12	28	12	28	Residential - cooking and heating (fossil fuels) can also emit methane. [Trigg Talley, United States of America]	Noted - the table has been however removed; comments are considered to the possible extent in the new revised Table 6.1 and /or further sections addressing particular species
128043	12	28	12	28	In Table 6.2, add the soil source of N2O to natural sources of LLGHG. [Trigg Talley, United States of America]	Noted - the table has been however removed; comments are considered to the possible extent in the new revised Table 6.1 and /or further sections addressing particular species
74039	12	28	12	28	Please add N2O to natural sources wetlands and NOy to stratosphere. [Volker Grewe, Germany]	Noted - the table has been however removed; comments are considered to the possible extent in the new revised Table 6.1 and /or further sections addressing particular species
74041	12	28	12	28	Please clarify whether aviation is included in transport. [Volker Grewe, Germany]	Noted - the table has been however removed; comments are considered to the possible extent in the new revised Table 6.1 and /or further sections addressing particular species
8291	12	28	12	28	Table header: SLCFs and precursors (key-species).Direct SO4 emission and other PM needs to be included as afossil fuel source (esp. in the past). H2S is quite important volcanic source. DMS oceans. [Frank Dentener, Italy]	Noted - the table has been however removed; comments are considered to the possible extent in the new revised Table 6.1 and /or further sections addressing particular species
32041	12	28			Table - CH4 is released by residential heating. Every time a gas heater comes on it releases a slug of unburned methane. This is a major source in northern countries. CH4 is also significantly released by biofuel combustion and by industrial combustion. Natural vegetation releases CH4 from trees, which channel CH4 from anaerobic soil archea in their sap - see all the Gauci/Pangala work. Pangala, S. R., Moore, S., Hornibrook, E. R., & Gauci, V. (2013). Trees are major conduits for methane egress from tropical forested wetlands. New Phytologist, 197(2), 524-531.Also: Covey, Kristofer R., and J. Patrick Megonigal. "Methane production and emissions in trees and forests." New Phytologist 222.1 (2019): 35-51. Wet soils also can release CH4. CH4 also has an open ocean plankton phosphonate source - see Karl, David M., et al. "Aerobic production of methane in the sea." Nature Geoscience 1.7 (2008): 473-478. [Euan G. Nisbet, United Kingdom (of Great Britain and Northern Ireland)]	Noted - the table has been however removed; comments are considered to the possible extent in the new revised Table 6.1 and /or further sections addressing particular species
103289	12	28			Table 6.2: lightning (not: lighting) [Philippe Tulkens, Belgium]	Editorial. The report will undergo professional copy-editing prior to publication. This kind of issues will be fixed then.
103291	12	28			Table 6.2: missing natural sources: sea salt, volcanoes [Philippe Tulkens, Belgium]	Noted - the table has been however removed; comments are considered to the possible extent in the new revised Table 6.1 and /or further sections addressing particular species
12115	12		12		Table 6.2: not sure of the use of this Table. Looks like a book chapter [Prabir Patra, Japan]	not applicable table removed

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
113927	13	5	17	51	section 6.2.1. woudl benefit from a short statement in the end (one for antro and one for natural) saying what the assessment says in general about the quality of the emission data. [Jan Fuglestvedt, Norway]	Accepted - text revised
128045	13	7	13	7	"*a* variety of sources" [Trigg Talley, United States of America]	Accepted - text revised
72395	13	7	13	7	Insert 'a' after 'from' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised
8293	13	7	13	25	The section reads as a somewhat uncritical description of the CEDS. What is need is an assessment of how the latest CEDS effort has improved the magnitude, location and time profiles of the variety of emissions. Did the uncertainties go down,and by how much. What role do (remaining) emisison uncertainties play in determining climate impacts? How good are the 2015 emissions as a baseline for future scenarios? While using the same/consistent activity data is certainly an asset of CEDS, I think the widely used GAINS and EDGAR data would qualify equally, and doesnot necessarily preclude large systematic uncertainties, as they often use similar proxy datasets. Some attempts are made in the following subparagraphs- but the effort could be brought out more prominently. [Frank Dentener, Italy]	Accepted - text revised, including adding an assessment statement at the end of the section
113923	13	7	15	27	Useful overview of data, but it some more assessment of the quality of the data is needed. [Jan Fuglestvedt, Norway]	Accepted - text revised
128049	13	11	13	12	Mention that this previous emissions inventory was used in CMIP5 (as referred to later). [Trigg Talley, United States of America]	Accepted - text amended
128047	13	11	13	25	This jumps from referencing RCPs to referencing CMIP5/CMIP6. Need to explain connection between these to the reader. Also, how do the new CMIP6 emissions inventories connect to SSPs? [Trigg Talley, United States of America]	Accepted - text revised
8295	13	11	13	25	think it is opportune in this paragraph to summarize the findings of HTAP (and similar efforts) that compile official emission inventories and compare them to scientific inventories. An assessment of the usefullness or not of reported emissions to assess SLCF impacts on climate, seems a highly policy relevant message. [Frank Dentener, Italy]	Noted - More inventories added in the discussion, owing to the length limitations no extensive discussion possible but several of these studies have been included in creating CMIP6 set (which is mentioned in the text) or included in other review papers.
103293	13	11	13	25	The section reads as a somewhat uncritical description of the CEDS. What is need is an assessment of how the latest CEDS effort has improved the magnitude, location and time profiles of the variety of emissions. Did the uncertainties go down,and by how much. What role do (remaining) emisison uncertainties play in determining climate impacts? How good are the 2015 emissions as a baseline for future scenarios? While using the same/consistent activity data is certainly an asset of CEDS, I think the widely used GAINS and EDGAR data would qualify equally, and doesnot necessarily preclude large systematic uncertainties, as they often use similar proxy datasets. Some attempts are made in the following subparagraphs- but the effort could be brought out more prominently. [Philippe Tulkens, Belgium]	see answer to #8293
103295	13	11	13	25	It would be opportune in this paragraph to summarize the findings of HTAP (and similar efforts) that compile official emission inventories and compare them to scientific inventories. An assessment of the usefullness or not of reported emissions to assess SLCF impacts on climate, seems a highly policy relevant message. [Philippe Tulkens, Belgium]	Taken into account - More inventories added in the discussion, owing to the length limitations no extensive discussion possible but several of these studies have been included in creating CMIP6 set (which is mentioned in the text) or included in other review papers.
8297	13	11	13	34	This material can be better integrated in the sub-paragraphs, avoiding duplication and reducing text. [Frank Dentener, Italy]	Accepted - text revised to avoid repetition
8299	13	11	13	34	This material can be better integrated in the sub-paragraphs, avoiding duplication. [Frank Dentener, Italy]	see answer to #8297
45873	13	11	13	43	The anthropogenic emissions from CEDS and the CMIP6 biomass burning emissions not only provide the emissions of SLCFs but also the emissions of LLGHGs underlying the LLGHG concentration pathways. In my view it would therefore make more sense to introduce and describe these datasets outside of this chapter. [Twan van Noije, Netherlands]	Noted - Chapter 1 (Box 1.4) has an overview; here a focus on SLCFs is warranted
128051	13	13	13	13	"*the* impact of environmental ...." [Trigg Talley, United States of America]	Accepted - text revised
78691	13	17	13	17	Should "than CMIP5" be "than those used in CMIP5"? [Heike Wex, Germany]	Rejected - This refers to the trend of several species rather than to estimates of species in CMIP5

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
29575	13	23	13	23	This " The CEDS will be published as" can be changed to " has been published as" as of December 2019. Ref (if data references are being used): Hoesly, Rachel; O'Rourke, Patrick; Braun, Caleb; Feng, Leyang; Smith, Steven J.; Pitkanen, Tyler; Seibert, Jonathan J.; Vu, Linh; Muwan, Presley; Bolt, Ryan; Goldstein, Ben; Kholod, Nazar (2019, December 23). Community Emissions Data System (Version Dec-23-2019). Zenodo. http://doi.org/10.5281/zenodo.3592073 [Steven Smith, United States of America]	Accepted - text revised
72397	13	23	13	23	delete 'time'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised
103297	13	23			"CEDS will be published": this can only be a Placeholder to the data source [Philippe Tulkens, Belgium]	Taken into account - see response to 29575
128053	13	25	13	25	"have" --> "has" [Trigg Talley, United States of America]	Accepted - text revised
21939	13	27	13	34	It feels odd to have a substantive assessment paragraph with absolutely no references. Are there really no apposite literature since AR5 which should be cited here? [Peter Thorne, Ireland]	Not applicable - section shortened; elements moved to 6.2.2 where natural emissions discussed, providing also references
104779	13	33	13	33	Would prefer “source functions” over “production mechanisms” [Tobias Schad, Germany]	Not applicable - section shortened; elements moved to 6.2.]2 where natural emissions discussed
128055	13	36	13	36	"Emissions from open biomass burning". Need to clarify if this is anthropogenic only or if it includes wildfires. [Trigg Talley, United States of America]	Not applicable - This text has been edited and integrated in 6.2.2.6 where open biomass burning is discussed
104781	13	36	13	38	There is the impression that the global carbon emissions stay high also after 2000, although the dataset of van Marle et al. 2017b show a decrease after the peak in mid 1990s (for example in figure 5). [Tobias Schad, Germany]	Not applicable - This text has been edited and integrated in 6.2.2.6 where open biomass burning is discussed; the declining trend in the last two decades is mentioned there
44153	13	42	13	43	Using bottom up estimates of biomass burning emissions in atmospheric models usually leads to a strong underestimation of atmospheric aerosol concentration (e.g. aerosol optical depth) when used as inputs to atmospheric models necessitating the application of large scaling factors to regional or global emissions within the models. Lasslop, G., Coppola, A.I., Voulgarakis, A., Yue, C., Veraverbeke, S., 2019. Influence of Fire on the Carbon Cycle and Climate. Curr. Clim. Chang. Reports 5, 112–123. https://doi.org/10.1007/s40641-019-00128-9 [Gitta Lasslop, Germany]	Not applicable - This text has been edited and integrated in 6.2.2.6 where open biomass burning is discussed
85997	13	46	13	46	The fossil fuel industry does not receive sufficient emphasis here? [Debra Roberts and the Durban WGII TSU, South Africa]	Taken into account - New Figure (6.3) has been added showing contribution of sectors in present day emission, obviously making power plants, transport, fossil fuel production, etc, more visible. Text added in reference to this Figure highlights in few instances the role of coal or fossil fuel sectors in some regions or particular species.
2749	13	46	15	27	Section 6.2.1.1 Has a heavy emphasis on emissions in Asia (China and India) when this is a global problem and development is rapidly growing all over the world. It may be useful to consider the provision of statistics and descriptive information on global emissions by region. This section should provide the data to support the global contribution to emissions. The section in its current state is bettwr suited for a study on Asian emissions versus a review of global emissions. There is little mention of Africa and no mention of the Americas (Central and South) and Middle East. [Carianne Johnson, Belize]	Taken into account - Within the limited space available, the discussion focuses and highlights regions and sources that have either contributed major emissions or to important changes over time. However, now a new figure (6.3) has been added showing regional shares for all continents. Furthermore, the evolution of emissions by region has been visualised in the Figure 6.19.
103299	13	46			Much more logical (and actually, also the separation anthropogenic/natural/biomass implies that) is a separation by source and then accounting for the gases that are released in a certain process. If describing the emission by process this automatically explains why the very different gases are actually to be dealt with together (as also measures can be better focussed). Moreover, the section could become more complete, when CH4 not only derives from fossil fuel production, when the process of NH3 release is made a bit more clear (it is not the industrial production of NH3, but fertilizer application that is responsivble for the major part of emissions - and urea decomposition in animal manure), and CO or the halogenated gases are at least mentioned here [Philippe Tulkens, Belgium]	Rejected - The logic of discussing species (and highlighting specific sources when needed) is consistent with the rest of the section 6.2, and with the presentation of emission trajectories, studies evaluating concentrations of species both ground based as well as remote sensing.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
103301	13	46			any info on spatial distribution in this section would be appreciated - note that the spatial element is distinctive for the class of compounds treated here! [Philippe Tulkens, Belgium]	Taken into account - explicit reference added to CMIP6 gridding and improvements made compared to the past. However, more extensive discussion is not possible owing to space limitation and the readers will be directed to original literature
128057	13	48	13	49	"For most of the SLCF species, the global and regional anthropogenic emission trends developed for CMIP6 for the period 1850 to 2000 are not substantially different from those used in CMIP5." The text in lines 15-18 implies that CMIP5 and CMIP6 historical emissions/trends are quite different. Maybe need to modify the text on lines 15-18 to be clear that the differences are not large. [Trigg Talley, United States of America]	Taken into account - the lines 15-18 have been removed to avoid confusion, although that sentence was referring to last two decades only while the beginning of this section refers to the period before 2000.
8301	13	48	14	4	This section describes differences but doesn't assess what is more accurate and why. [Frank Dentener, Italy]	Taken into account - Text revised and merged with elements of the next paragraph that bring in new evidence.
21941	13	49	13	52	The mixed use / non-use of parentheses and the virtual complete overlap of species is a bit jarring here. Might it be easier to say the 3 common species are all lower early / higher late and then document the two that are not common and do so consistently vis-a-vis the (non-use) of parentheses? [Peter Thorne, Ireland]	Not Applicable - Text in this section has been revised and shortened, this particular sentence has been removed.
72399	13	51	13	51	Please clarify the context of the 'last few decades'. Do you mean since the 1950s? [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account - Text revised to clarify; the last two to three decades
72401	14	2	14	2	Insert 'the' before 'CMIP6' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised
128059	14	4	14	4	"Sections" --> "Section" [Trigg Talley, United States of America]	Accepted - text revised
38335	14	6	14	7	The sentence reads “shortly before rapid economic development of large Asian countries (namely China and India) started.” Individual countries should not be listed in IPCC reports. In order to avoid unnecessary disputes, it is suggested to delete the words “namely China and India” in the sentence. [Yaming LIU, China]	Accepted - the whole sentence has been removed
8303	14	6	14	21	The point of this section should be made clearer. The RCP scenarios previously used for AR5, used as a baseline 2000, and missed strong changes between that year and 2015. T The evidence that the SSP baseline of 2015 has included more correctly the emissions of 2015 and before is xxx. The consequences for ERF and climate impacts are yyy? [Frank Dentener, Italy]	Taken into account - Text modified
103303	14	6	14	21	The point of this section should be made clearer. The RCP scenarios previously used for AR5, used as a baseline 2000, and missed strong changes between that year and 2015. The evidence that the SSP baseline of 2015 has included more correctly the emissions of 2015 and before is xxx. The consequences for ERF and climate impacts are yyy? [Philippe Tulkens, Belgium]	see answer to #8303
104783	14	8	13	9	would prefer “experienced” over “lived through” [Tobias Schad, Germany]	Not applicable - sentence removed
32043	14	9	14	16	Cite Saunois et al 2019 https://doi.org/10.5194/essd-2019-128. Also, the TD vs BU discrepancy is serious and shouldn't be passed over as lightly as here. [Euan G. Nisbet, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account. Saunois et al (2020) is cited on page 15.
103305	14	11			the "national standards" are irrelevant here. Instead, air pollution (and measures against it) as driving forces can be mentioned before the next sentence. [Philippe Tulkens, Belgium]	Taken into account - this particular part of the sentence has been removed
128061	14	12	14	18	Punctuation makes it difficult to parse this sentence. Modify. [Trigg Talley, United States of America]	Taken into account - Text revised, partly moved to pollutant specific paragraphs
104787	14	12	14	18	This part needs a rephrase since it is difficult to catch the content. It should be shorter and clearer. Suggestion: “Despite the success of environmental legislations introduced in several countries which affects the emission trends in specific regions (count all regions and literature) emissions of most species show no sign of stabilization or decline. Only SO2 and CO (high confidence) show a decline and emissions of NOx stabilize since 2011 […]” [Tobias Schad, Germany]	Taken into account - Text revised, partly moved to pollutant specific paragraphs
72403	14	15	14	15	References should be in chronological order with the submitted one at the end of the list. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial. The report will undergo professional copy-editing prior to publication. This type of issue will be fixed then.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
35723	14	15	14	16	Use published sources and bibliographic citations in chronological order [Carlos Antonio Poot Delgado, Mexico]	Editorial. The report will undergo professional copy-editing prior to publication. This type of issue will be fixed then.
45875	14	16	14	16	Does this statement apply to global emissions? Please clarify. [Twan van Noije, Netherlands]	Not applicable - text in this section has been revised and shortened, this particular sentence has been removed. However, the same information is provided in one of the earlier paragraphs with a clear statement it is referring to global trend
128063	14	17	14	17	"Figure 6.4" should be moved inside parentheses. [Trigg Talley, United States of America]	Not applicable - text revised as well as Figures that appear now in section 6.6. This particular sentence has been deleted
45383	14	17	14	17	It is probably better to delete "(Hoesly et al., 2018) and Figure 6.4" here. [Hitoshi Matsui, Japan]	Not applicable - text revised has been revised.
13461	14	17	14	17	Put "Figure 6.4" in parenthesis. Eliminate the word "and" before this parenthesis. [Maria Amparo Martinez Arroyo, Mexico]	Not applicable - text revised has been revised.
21945	14	17	14	17	What is 'and Figure 6.4' referring to? Text as written makes no logical sense to me. [Peter Thorne, Ireland]	Not applicable - text no longer in this section.
103307	14	19	14	21	"both anthropogenic and open biomass burning emissions": Open biomass burning is mostly anthropogenic. All agricultural biomass burning, all peat fires and many forest fires are anthropogenic, and the former are mostly intentional. [Philippe Tulkens, Belgium]	Not applicable - this paragraph has been removed. A separate section deals with Open Biomass Burning with indication of the anthropogenic and natural component.
85999	14	23	14	23	Has the rise in Asian emissions been completely offset by reductions in America and Europe? [Debra Roberts and the Durban WGII TSU, South Africa]	Taken into account - this depends on the time period; to simplify 'offset' was changed to 'countered'
128065	14	23	14	24	"For SO2, the strong growth of Asian emissions has been offset by reduction in North America and Europe and, since about 2006, also Chinese emissions continue to decline; reaching nearly 70% reduction by 2017." What does this 70% reduction refer to? 2017 vs 2006? Global? N America and Europe only? China only? N America + Europe + China emissions? [Trigg Talley, United States of America]	Taken into account - Text revised to clarify the statement
8307	14	23	14	26	As climate impacts of SLCF have a regional character, somewhere upfront the limitations of presenting global emission numbers for the components with lifetimes < few years should be clarified. It should be clarified to what extent Asian emissions can be offset by N. American/European; if the climate impacts are probably quite different. [Frank Dentener, Italy]	Noted - the 'offset' refers only to emissions without discussing consequences for regional/global forcing that is addressed in section 6.4 and 6.7
103309	14	23	14	26	Mention what evidence ithere is for these declines. Only inventories, or also atmospheric concentration observations? [Philippe Tulkens, Belgium]	Taken into account - a statement and also additional reference with observational evidence added
128067	14	24	14	24	"continue to decline" --> "have begun to decline" [Trigg Talley, United States of America]	Taken into account - Text revised
21947	14	24	14	24	Presumably Chinese emissions started to decline? But equally may calling out individual countries lead to issues? [Peter Thorne, Ireland]	Taken into account - Text revised
72405	14	25	14	25	References should be in chronological order with the submitted one at the end of the list. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial. The report will undergo professional copy-editing prior to publication. This type of issue will be fixed then.
35977	14	26	14	26	"counteracts" is true on a global average, but air quality and many climate impacts are felt regionally, where there is no such counteraction. [Nicolas Bellouin, United Kingdom (of Great Britain and Northern Ireland)]	Noted - agree, however, the section and this statement refers exclusively to trend in global emissions and how regional developments affect it
103311	14	26	14	26	Rather than 'counteracting' suggest to use the word 'contrast'. What is the evidence for increase in India? [Philippe Tulkens, Belgium]	Taken into account - text changed and this para includes now also references to observational evidence
86029	14	28	14	28	What does 'growing very fast' mean? Please consider quantifying the growth. [Debra Roberts and the Durban WGII TSU, South Africa]	Taken into account - text revised
8309	14	28	14	29	Which period is referred to when discussing 'growing fast'. [Frank Dentener, Italy]	Taken into account - the phrase has been removed
103313	14	28	14	29	Which period is referred to when discussing 'growing fast'. [Philippe Tulkens, Belgium]	see answer to #8309

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
74043	14	28	14	39	Please also include a statement on the growing aviation sector and the related NOx emissions. Although, the number is small compared to surface sources, the contribution to the radiation budget is important (Grewe et al. 2019). Grewe, V., Matthes, S., Dahlmann, K., The contribution of aviation NOx emissions to climate change: Are we ignoring methodological flaws?, Env. Res. Lett., DOI: 10.1088/1748-9326/ab5dd7, 2019. [Volker Grewe, Germany]	Taken into account - text revised
45877	14	28	28	39	A paper that is very relevant in this context is Liu et al., 2016: Recent reduction in NOx emissions over China: synthesis of satellite observations and emission inventories, Environ. Res. Lett., 11, 114002, doi:10.1088/1748-9326/11/11/114002. It would be appropriate to include a reference to this paper, and briefly mention its main findings. [Twan van Noije, Netherlands]	Taken into account - text revised
41169	14	29	14	29	what is OECD Asia? [TSU WGI, France]	Taken into account - Japan and Korea spelled out
2751	14	30	14	33	Is the idea here is that even though there are reductions those reductions are being offset by further emissions? If so, "offsetting these reductions" in line 33 should be reworded [Carianne Johnson, Belize]	Taken into account - offsetting has been used as counteracting and not as you suggest. Reworded for clarity
35979	14	31	14	32	Why is "(as well as non-compliance with emission standards)" between brackets? It sounds as important as the other causes. [Nicolas Bellouin, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account - text revised
128069	14	35	14	35	Subject-verb agreement problem. [Trigg Talley, United States of America]	Editorial. The report will undergo professional copy-editing prior to publication. This type of issue will be fixed then.
8311	14	36	14	39	Are there other satellite data (or other constraints from concentration or deposition observations) for regional Nox emission trends? What is the consistency of the satellite data derived trends in NO2 columns and reported emission trends? What is our overall confidence in regional (and global) NOx emissions trends combining this information [Frank Dentener, Italy]	Taken into account - additional reference added to Miyazaki et al (2017). The consistency of trends is addressed in general terms without quantification for each region; that is discussed in specific papers. Further discussion in section 6.3.3.1
103315	14	36	14	39	Are there other satellite data (or other constraints from concentration or deposition observations) for regional Nox emission trends? What is the consistency of the satellite data derived trends in NO2 columns and reported emission trends? What is our overall confidence in regional (and global) NOx emissions trends combining this information [Philippe Tulkens, Belgium]	see answer to #8311
72407	14	38	14	38	Insert 'a' after 'indicate'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised
72409	14	39	14	39	Insert 'does' after 'sensing' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised
78693	14	41	14	41	Pretty abrupt change in topic - the whole text so far seems to consist of paragraphs that were written by separate people and then just lined up. - Here, please, at least start the paragraph with: "At the beginning of the industrial revolution, ..." [Heike Wex, Germany]	Taken into account - The paragraph about NMVOC has been rewritten and extended
8313	14	41	14	41	Please use and contrast the information in 6.2.2.3, to provide uncertainty statements for the reported emisison trends. It is difficult to read from Figure 2.4 whether indeed NMVOC reported emissions continue to grow, or already turning over. [Frank Dentener, Italy]	Taken into account - parts of 6.2.2.3 (now 6.3.3.3) moved and uncertainty statements added
5177	14	41	14	46	Except for the last sentence, this paragraph could be deleted for brevity. The last sentence could be combined with the following paragraph. [Daniel Murphy, United States of America]	Taken into account - The paragraph about NMVOC has been rewritten and extended
51247	14	46	14	46	While discussing VOC emissions it would be helpful to reference increases in VOCs like ethane and propane from the coal-tar/sands oil and gas extraction in N. America [Jolene Cook, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account - mentioned and respective references added
8315	14	48	14	49	concentration doubled. Everywhere? I suspect this statement only applies to regions where observations where available. [Frank Dentener, Italy]	Taken into account - 'emissions' rather than 'concentrations' were meant; corrected
103317	14	48	14	49	concentration doubled. Everywhere? I suspect this statement only applies to regions where observations where available. [Philippe Tulkens, Belgium]	Taken into account - 'emissions' rather than 'concentrations' were meant; corrected

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
8317	14	48	15	7	It would be useful to quantify what is meant with estimates of emissions remain very uncertain. Does this only apply to current (2015?) global emissions, or are also to trends, what about regional trends? It would be useful to try to express this using the confidence language, or use probabilistic information. State more exactly if the evidence since AR5 has improved the emission information or not? [Frank Dentener, Italy]	Taken into account - text revised, uncertainty statements added
103319	14	48	15	7	It would be useful to quantify what is meant by "estimates of emissions of carbonaceous aerosols remain [...] very uncertain". Does this only apply to current (2015?) global emissions, or are also to trends, what about regional trends? It would be useful to try to express this using the confidence language, or use probabilistic information. State more exactly if the evidence since AR5 has improved the emission information or not? [Philippe Tulkens, Belgium]	see answer to #8317
78695	14	53	14	53	This is not my field, but I wondered about one of the continents that has not been mentioned here at all: How about South America and all the biomass burning in the Amazon - should that not contribute, too? It needs to be checked if this is simply not mentioned because emissions are not high enough or because not much research exists! - In general, overall in this chapter, besides for South America also Australia/Newseeland is not mentioned. Again, is that because not much is emitted from there, or because not much research is done!? Maybe this could be mentioned somewhere? [Heike Wex, Germany]	Noted - The open biomass burning emissions (and South America in that context) have a dedicated section 6.2.2.6. Some of the other regions that have indeed small emissions not impacting global trends are not mentioned but are shown in a new Figure 6.3 and also included in the now Figure 6.19
81355	14	53	14	54	The combination of “Currently” and references from 2007 to 2013 is questionable. [Johannes Laube, Germany]	Taken into account - additional references added
72411	15	3	15	3	Insert ;the' after 'of'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial. The report will undergo professional copy-editing prior to publication. This type of issue will be fixed then.
55043	15	4	15	6	It was suggested to put the citation to the end of the sentence, i.e., after ".... from east coast of China." [Nancy Hamzawi, Canada]	Editorial. The report will undergo professional copy-editing prior to publication. This type of issue will be fixed then.
45879	15	6	15	7	Besides the noted uncertainties in the estimates of the emitted amounts of carbonaceous aerosols, the size distributions of the emitted particles are also uncertain, and CEDS does not provide any information about this. Please mention this in the text. [Twan van Noije, Netherlands]	Taken into account - A sentence added stating the status.
8321	15	9	15	16	Would it possible to provide more quantitative summary of how well we know CH4 emissions and trends (possibly taken from chapter 5). [Frank Dentener, Italy]	Noted - Explicit, reference is made to Chapter 5. Due to space constraints repetition avoided
103321	15	9	15	16	Would it possible to provide more quantitative summary of how well we know CH4 emissions and trends (possibly taken from chapter 5). [Philippe Tulkens, Belgium]	see answer to #8321
86001	15	9	15	16	Are the sources of methane discussed in enough detail in this report somewhere? There seems to have been some confusion in this area which should be assessed clearly. This has major implications for mitigation. Please see https://www.nature.com/articles/nature19797; https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2016GL067987 for example. Also a critical evaluation of methane emissions from industrial sources (fossil fuels, mining etc) versus ‘natural’ emissions from plants and animals (including livestock) or swamps and peatlands, versus ‘unnatural’, human-induced emissions from nature (feedlots, rice paddies, waste), versus climate-change feedback (melting permafrost, additional wildfire). A clear assessment of this information is very important in terms of mitigation and adaptation. It is not enough simply to find that x% of methane comes from ruminant guts and rice paddies. This represents food for billions (not talking about excessive overconsumption, but basic nutrition) so for mitigation decisions to be made, one needs to know in more detail where the emissions related to agriculture come from, both in terms of process and regionally. How accurate are national GHG inventories in this instance? [Debra Roberts and the Durban WGII TSU, South Africa]	Noted - a reference to Chapter 5 added where more in depth discussion is carried out
8319	15	11	15	11	Steady growth pertains to emission in which period? [Frank Dentener, Italy]	Noted - It refers to the last 2 decades but now "steady" replaced with "continued"
81357	15	11	15	11	I find it hard to believe that there should only be one publication that carried out a top down assessment for global CH4 emissions. Perhaps a look at Chapter 5 might help. [Johannes Laube, Germany]	Noted - a reference to Chapter 5 added where more in depth discussion is carried out

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
128071	15	13	15	13	Hoglund-Isaksson et al. (2017) address HFCs and thus not relevant to oil and gas. [Trigg Talley, United States of America]	Accepted
128073	15	14	15	14	Dalsoren et al. (2018) compare top down and bottom up ethane and propane data and not methane. It does go on to infer that methane is underestimated based on their assessment of the other gases, but it may make sense to use a different example or provide some clarification. [Trigg Talley, United States of America]	Taken into account - Another reference added (Franco et al 2016). Strong increases in ethane observed over oil and gas production areas are not reflected in methane trends in these regions and such ethane increase cannot be explained by other sources but gas production
128075	15	14	15	14	The results of the Alvarez et al. (2018) study are not specific to unconventional production. It attempts to quantify emissions from all production in the U.S., a mix of conventional and unconventional. For the actual stage of hydraulic fracturing that typically defines unconventional production, Alvarez et al. use the same emission factors that are used by USEPA and do not therefore include a comparison of that process [Trigg Talley, United States of America]	Taken into account - all studies referring to different aspects of higher potential emissions from oil and gas sector are referred jointly and the specific reference to different to US EPA estimate removed
72413	15	15	15	15	Delete , from before 'and' (not required in this context) [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial. The report will undergo professional copy-editing prior to publication. This type of issue will be fixed then.
89637	15	16	15	16	Section 5.2.3 should be section 5.2.2 [Xiang Li, United States of America]	Editorial, treated
64547	15	18	15	19	“Industrial production of ammonia by the Haber-Bosch process, invented over a hundred years ago, has led to a strong increase in NH3 emissions (Erisman et al., 2008) increase in ammonia emissions over last 100 years”. It is not clear to me the article by Erisman is the best for the ammonia emission increase. For emission changes it references a paper by Galloway. You might use : Riddick et al (2016) (Riddick, S., Ward, D., Hess, P., Mahowald, N., Massad, R., & Holland, E. Estimate of changes in agricultural terrestrial nitrogen pathways and ammonia emissions from 1850 to present in the Community Earth System Model. Biogeosciences, 13(11). https://doi.org/10.5194/bg-13-3397-2016) which simulates the changes in emissions from synthetic fertilizer and manure from 1850-2000. [Peter Hess, United States of America]	Taken into account - Text revised and additional references considered
64551	15	18	15	27	It is worth mentioning there is an non-trivial climate component to ammonia emissions. Sutton et al (2013) (Toward a climate-dependent paradigm of ammonia emission & deposition. Phil. Trans. Roy. Soc. B 368 (1621) doi:10.1098/rstb.2013.0166) estimates a 42% (28-67%) increase for a 5 C global temperature increase. In a global simulation Riddick et al (2016) suggests the increase should be 4 % per degree of warming for manure and 3 % per degree of warming for synthetic fertilizers. In a more precise simulation accounting better for the impact of agricultural management and soil water Vira et al (2019) (Vira, J., Hess, P., Melkonian, J., and Wieder, W. R.: An improved mechanistic model for ammonia volatilization in Earth system models: Flow of Agricultural Nitrogen, version 2 (FANv2), Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2019-233, in review, 2019) find an increase of 3% increase per degree K. (or maybe talk about in the next section as changes in ammonia emissions are very much associated with LULCC emissions for cropland and pastureland with a component due to climate change). [Peter Hess, United States of America]	Taken into account - Text revised and additional references considered, except a reference to the impact of increasing temperature as this is better placed elsewhere
8323	15	18	15	27	What is the basis for the high confidence in growing NH3 emissions? [Frank Dentener, Italy]	Taken into account - sentence revised and references added; principally reliable statistical data shows growth in production and application of fertilizers while at the same time no control/abatement of emissions.
103323	15	18	15	27	What is the basis for the high confidence in growing NH3 emissions? [Philippe Tulkens, Belgium]	see answer to #8323
113925	15	20	15	20	How can high confidnce be stated here just based on one paper? [Jan Fuglestvedt, Norway]	Taken into account - more references added
64549	15	20	15	20	6-15, l20 Please check the reference to Couzin, 2019 which appears to be a religious text as referenced [Peter Hess, United States of America]	Reference removed and replaced with several other papers
45881	15	21	15	21	Change "the same" to "similar". [Twan van Noije, Netherlands]	Accepted
13463	15	37	15	37	The period (.) is duplicated. [Maria Amparo Martinez Arroyo, Mexico]	Editorial, done.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
68833	15	42	15	42	In this section, dimethyl sulfide emitted from oceans shoud be included as an imporant natural source for sulfate aerosols. [Qing Ye, United States of America]	Accepted. Text on DMS has been added
72415	15	44	15	44	Change 'phenomena' to 'phenomenon' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted.
35391	15	46	15	46	Medici et al. (2017) does not address amount of LNOx production per flash. Please remove this reference. [Kenneth Pickering, United States of America]	Accepted. It was not meant to refer to amount per flash but to the vertical allocation, which is the meaning of the previous phrase. The text is revised, separating what refers to vertical allocation and amount per flash.
35393	15	46	15	47	Please add additional references concerning uncertainty in LNOx production per flash and vertical allocation: Ott et al. (2010, JGR); Koshak et al. (2014, Atmos. Res.); Marais et al. (2018, ACP); Allen et al., (2019, JGR); Bucsela et al. (2019, JGR) Ott, L. E., K. E. Pickering, G. L. Stenchikov, D. J. Allen, A. J. DeCaria, B. Ridley, R.-F. Lin, S. Lang, W.-K. Tao, Production of lightning NOx and its vertical distribution calculated from 3-D cloud-scale chemical transport model simulations, J. Geophys. Res., 115, D04301, doi:10.1029/2009JD011880, 2010. Liaskos, C., D. J. Allen, and K. E. Pickering, Sensitivity of tropical tropospheric composition to lightning NOx production as determined by replay simulations with GEOS-5, J. Geophys. Res., 120, doi:10.1002/2014JD022987, 2015. Allen, D. J., K. E. Pickering, E. Bucsela, N. Krotkov, and R. Holzworth, Lightning NOx production in the tropics as determined using OMI NO2 retrievals and WWLLN stroke data, J. Geophys. Res. Atmos., 124, 13,498-13,518, https://doi.org/10.1029/2018JD029824, 2019. Bucsela, E. J., K. E. Pickering, D. J. Allen, R. Holzworth, and N. Krotkov, Mid-latitude lightning NOx production efficiency inferred from OMI and WWLLN data, J. Geophys. Res. Atmos., 124, 13,475-13497, https://doi.org/10.1029/2019JD030561, 2019. Marais, E. A., Jacob, D. J., Choi, S., Joiner, J., Belmonte-Rivas, M., Cohen, R. C., Beirle, S., Murray, L. T., Schiferl, L., Shah, V., & Jaeglé, L. (2018), Nitrogen oxides in the global upper troposphere: interpreting cloud-sliced NO2 observations from the OMI satellite instrument, Atmospheric Chemistry and Physics, 18, 17017–17027, https://doi.org/10.5194/acp-18-17017-2018. Koshak, W., Peterson, H., Biazar, A., Khan, M., & Wang, L. (2014). The NASA Lightning Nitrogen Oxides Model (LNOM): application to air quality modeling. Atmospheric Research, 135, 363-369. [Kenneth Pickering, United States of America]	Taken in account. Where applicable, references from this exhaustive list are added to the text. All the references could not be added due to space constraints
35395	15	54	15	54	An additional sentence is needed immediately before the sentence that begins "In sum….". Here is suggested text: Sensitivity studies increasing LNOx source strength from 2.5 to 10 TgNyr-1 showed that in the tropical upper troposphere OH increased by >100% and O3 increased by up to 60% (Liaskos et al., 2015, JGR). [Kenneth Pickering, United States of America]	Rejected. Not relevant to this section assessing the changes in LNOx due to climate change
103325	15	54	15	55	Recommend to use uncertainty language.E.g. "there is low confidence in LNOx responses to climate change, indicated by a range of negative and positive estimates stemming from different parameterisations. [Philippe Tulkens, Belgium]	Accepted. Text revised
8325	15	55	15	55	Recommend to use uncertainty language.E.g. "there is low confidence in LNOx responses to climate change, indicated by a range of negative and positive estimates stemming from different parameterisations. [Frank Dentener, Italy]	Accepted. Text revised
116523	15		15		There is some overlap with chapter 5 on the discussion of methane emission estimates. [Valerie Masson-Delmotte, France]	Noted - section kept short with an explicit reference to more discussion in chapter 5
4087	16	1	16	2	Other than the model study by Guenther et al. (2012) as was shown, a recent field study showed that the formation of biogenic secondary organic aerosols in a pristine forest is enhenced by the input of sulfate, implying that anthropogenic emissions could promote secondary organic aerosol formation. Reference: Zhu et al. Atmos Chem Phys, 2016 (doi:10.5194/acp-16-7497-2016). [Chunmao Zhu, Japan]	Considered but not applicable, as paragraph was reorganised

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
82979	16	1	16	24	In my opinion, among environmental factors that influence BVOC emissions, it would be important to include water availability that appears among abiotic factors in both Guenther et al. (2012) and Loreto et al. (2014) and whose effect is implemented directly or indirectly (via the linkage to photosynthesis) in BVOC emission models. Since warm temperatures and high-light conditions often match with water stress for plants, it is difficult to disentangle the effect of water stress on BVOC emissions. Moreover, observational studies show gaps in the taxonomic and geographical distribution of the sampled plants (Feng et al., 2019) and often follow different experimental protocol (e.g., pot/in-field trees vs. greenhouse/field campaigns; different definition of water stress, observed compound and of plant species) that make the comparison not easy. A recent meta-analytic review of observational studies concluded that reduced water availability (55% against 100% in the control experiments) decreases isoprene emission by 23%, whereas monoterpenes are not significantly affected (Feng et al., 2019). This conclusion is in contrast with previous review studies that distinguish the effect of severe/long-term water stress, which reduce emissions, from mild/short-term water stress, which seem to temporarily amplify or maintain BVOC emissions to protect plants against on-going stress (Penuelas and Staudt, 2010). The analysis of multi-year seasonal linear correlations between observed gross primary productivity (GPP) and tropospheric formaldehyde column variability (HCHOv) revealed that in some regions (the Amazon and the southeast US) soil moisture is an important factor to account for to reproduce the observed interannual seasonal GPP–HCHOv correlations (Zheng et al., 2015) New parameterizations have been recently proposed to better account for this link between BVOC emissions and water availability (Jiang et al., 2018; Bonn et al., 2019). In Jiang et al. (2018), the effect of soil moisture on isoprene and lastly on surface ozone levels is explored via six-month global simulations with an Earth System Model (the global Community Land Model of the Community Earth System Model, CLM4.5/CESM1.2) that implement an empirical biogenic emission model (Model of Emissions of Gases and Aerosols from Nature, MEGAN). Although this exercise is just shows that reduction in isoprene emissions due to drought alter surface ozone and OH levels, with effects that depend on the chemical background (NOx- vs. VOC-limited regions).	Accepted - text revised
17053	16	1	16	24	Maybe it would be worth mentioning that direct measurement of the OH loss rate in biogenic environments revealed that NMVOC observations often miss part of the OH sink, i.e. of total VOCs (review: Yang 2016, doi: 10.1016/j.atmosenv.2016.03.010). This implies that actual total BVOC emissions are larger than what is usually observed by measuring individual compounds, probably due to multiple unmeasured BVOCs of lower concentration. A recent modelling study (Ferracci 2018, doi:10.5194/acp-18-7109-2018) included this "unattributed" or "missing" OH reactivity into a global model, and found that this additional OH sink from unmeasured VOCs implicates atmospheric residence times of methane and pollutants. [Eva Y. Pfannerstill, Germany]	Accepted - text revised
20363	16	1	16	41	In spite of the title, anthropogenic sources are actively at work here. [philippe waldteufel, France]	Accepted - text revised. Title changed to Natural Systems. Included discussion of anthropogenic influence on natural emissions.
106395	16	2	16	2	aldehydes rather than aldehdyes [Hamza Merabet, Algeria]	Accepted - text revised
72417	16	2	16	2	Delete , from before 'and' (not required in this context) [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised
76641	16	7	16	8	There are more recent and more explicit studies with estimates about global yearly BVOC emissions than the MEGAN model description from Alex Guenther et. al. 2012 , e.g. from Sindelarova et. Al 2014: Global data set of biogenic VOC emissions calculated by the MEGAN model over the last 30 years [Felix Havermann (né Wiß), Germany]	Accepted - text revised
106521	16	7	16	11	the data on isoprene emission taken from Guenther et al. 2012 are quite old, may be updated [ABDELWAHID MELLOUKI, France]	Accepted - text revised

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
76643	16	8	16	9	There are more explicit studies on factors controlling BVOC emissions: Niinemets et al., 2014: Bidirectional exchange of biogenic volatiles with vegetation: emission sources, reactions, breakdown and deposition; Hantson et al., 2017: Global isoprene and monoterpene emissions under changing climate, vegetation, CO2 and land use; Szogs et al., 2017: Impact of LULCC on the emission of BVOCs during the 21st century; [Felix Havermann (né Wiß), Germany]	Accepted - text revised
26995	16	9	16	9	We suggest to mention also change in soil moisture. See Genard-Zielinski et al. (2018), (10.5194/bg-15-4711-2018) for isoprene emissions under drought stress [Eric Brun, France]	Accepted - text revised
8327	16	9	16	9	Given the influence of light (brightening/dimming), ambient CO2 (changing since preindustrial), and temperature(changing) what is the assessment on how this has changed in the past and may change in the future. I think there are studies in the literature (e.g. Ozone-vegetation feedback through dry deposition and isoprene emissions, Gong et al. ACP 2019; and probably other publications as well). If there is no evaluation available it should also be mentioned. [Frank Dentener, Italy]	Accepted - text revised. Made clearer assessment of historical and potential future changes based on existing literature. Gong et al. is a very interesting study but not covering all aspects of past and future changes.
103327	16	9	16	9	Given the influence of light (brightening/dimming), ambient CO2 (changing since preindustrial), and temperature (changing) what is the assessment on how this has changed in the past and may change in the future? There are studies in the literature (e.g. Ozone-vegetation feedback through dry deposition and isoprene emissions, Gong et al. ACP 2019; and probably other publications as well). If there is no evaluation available it should also be mentioned. [Philippe Tulkens, Belgium]	Accepted - text revised
76645	16	10	16	11	isoprene is emitted directly after synthesis (de novo emissions), thus its emission increase is directly linked to an increase in temperature AND radiation [Felix Havermann (né Wiß), Germany]	Accepted - text revised
13465	16	16	16	16	Add comma before the word "however", because the sentence is very long. [Maria Amparo Martinez Arroyo, Mexico]	Accepted - text revised
109623	16	20	16	21	It would be good to back up the sentence about the monoterpenes with a couple of references. One possible reference could be e.g. Acosta Navarro et al. J Geophys Res Atmos. 2014 Jun 16; 119(11): 6867–6885. Published online 2014 Jun 9. doi: 10.1002/2013JD021238 [Ilona Riipinen, Sweden]	Accepted - text revised
217	16	20	16	21	Monoterpene and sesquiterpene emissions have possibly slightly increased or remained fairly constant in the past ~200 years due to competing changes in environmental drivers according to Acosta Navarro et al. (2014), estimated using two independent BVOC emission models. Literature 1. Acosta Navarro, J.C., et al. "Global emissions of terpenoid VOCs from terrestrial vegetation in the last millennium." Journal of Geophysical Research: Atmospheres 119.11 (2014): 6867-6885. [Juan Camilo Acosta Navarro, Spain]	Accepted - text revised
17057	16	22	16	23	The study mentioned in this sentence (Jardine et al 2016) showed that the chemical composition of monoterpenes changed towards more reactive (shorter-lived) monoterpene species. Maybe worth including this detail in the sentence [Eva Y. Pfannerstill, Germany]	Accepted - text revised
26997	16	23	16	24	We suggest to add a reference to Hantson et al., 2017 (10.1016/j.atmosenv.2017.02.010) and Bauwens et al. (2018),10.5194/bg-15-3673-2018 [Eric Brun, France]	Accepted - text revised
51249	16	24	16	24	Request for coverage in WGIII - it would be useful to distinguish between emission changes of BVOCs due to a changing climate and changes due to policies such as tree planting - how will the latter affect isoprene emissions and other BVOCs? If it is not possible to detemine values, a statement on whether or not many countries plan to increase tree planting would provide some clarity. [Jolene Cook, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised
5145	16	26	16	28	I suggest deleting this sentence. You don't need the detail of describing saltation. The next sentence is a better topic sentence for this paragraph. [Daniel Murphy, United States of America]	Rejected. The natural processes of dust emission are poorly known, and it helps to better understand them to facilitate the distinction with dust emitted from hum activities.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
35887	16	26	16	41	I've suggested some corrections and additions to this paragraph: The emission of dust particles into the atmosphere results from a natural process, namely saltation bombardment of the soil by large wind-blown particles such as sand grains and from disintegration of saltating aggregates (Kok et al., 2012). The occurrence and intensity of dust emissions are controlled by soil properties, vegetation, and the near-surface wind, making dust emissions sensitive to changes in climate, land-use, and land cover (Jia et al., 2019). In addition, dust can be directly emitted through human activities such as agriculture, off-road vehicles, building construction, mining, and indirectly emitted through hydrological changes due to human actions such as irrigation (e.g., Ginoux et al., 2012). However, estimates of the anthropogenic fraction of global dust vary from less than 10% to over 60%, such that the human contribution to the global dust budget is quite uncertain (Ginoux et al., 2012; Stanelle et al., 2014; Xi and Sokolik, 2016). Wildfires may also be a source of airborne dust (Wagner et al., 2018). An extremely limited number of studies have explored the historical evolution of global dust sources (Mahowald et al., 2010; Stanelle et al., 2014). A recent modeling study estimated a 25% increase in global dust emissions between the late nighteenth century to present due to agricultural land expansion and climate change (Stanelle et al., 2014). CMIP5 models were unable to capture the observed variability of annual and longer timescales in North African dust emissions (Evan et al., 2014), however newer Earth System Models with more physically-based dust emission schemes that account for changes in vegetation and climate in a more consistent manner better match the observations (Kok et al., 2014; Evans et al., 2016). Overall, there is low confidence in the magnitude of past changes in atmospheric dust loading due to climate and land use changes. [Jasper Kok, United States of America]	Accepted: text revised
128077	16	26	16	41	Consider citing statistical approaches to projecting changes in dust -- e.g., Achakulwisut et al. 2019 (https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2019GH000187) [Trigg Talley, United States of America]	Rejected. While this is an interesting study and solid science, we do not include it here as we assess process-based, global scale studies of the sensitivity of dust emissions to climate change
8329	16	26	16	41	I am not sure that this section is fully up-to-date wrg to the literature. E.g. Kok et al Nature communication 2018, discussing the range of climate sensitivities due to dust; there may be other recent papers as well. [Frank Dentener, Italy]	Accepted: text revised. Reference of Kok et al. (2018) added.
103329	16	26	16	41	This section may not be fully up-to-date with regard to to the literature. E.g. Kok et al Nature communication 2018, discussing the range of climate sensitivities due to dust; there may be other recent papers as well. [Philippe Tulkens, Belgium]	Accepted: text revised. Reference of Kok et al. (2017) added.
104789	16	26			Although highly uncertain the anthropogenic dust burden could be moved into the anthropogenic section 6.2.1.1. Because anthropogenic fraction could be quite high and changes in land-use may also be anthropogenic driven, which also affects dust emissions. [Tobias Schad, Germany]	Taken into account - this section belongs in the revised section titled "Natural Systems" to indicate that many natural emissions are influenced by human activities including land-use change.
128079	16	27	16	34	There is no mention here of natural sources of N20 and methane, and how they are modulated by climate and land use. Add a sentence at the end of this paragraph pointing to the discussion in Chapter 5. "Detailed descriptions of the natural and anthrogenic sources and sinks of methane and N2O are described elsewhere (5.2.3; 5.2.4)." [Trigg Talley, United States of America]	Accepted
128081	16	29	16	29	Use "land use" as noun form. [Trigg Talley, United States of America]	Accepted: text revised
103331	16	30			under the section "natural": agriculture, off-road vehicles, building construction [Philippe Tulkens, Belgium]	Unfortunately, we cannot understand the comment so we are unable to provide a satisfactory response.
5179	16	33	16	33	I could not find Wagner et al. 2018 in the references [Daniel Murphy, United States of America]	Taken into account. Sentence was removed in an effort to provide robust assessment of dust sources.
45883	16	38	16	38	It would be fair to also mention that climate models still fall short in accurately representing the size distribution of atmospheric dust, and miss most of the coarse dust particles (e.g. Adebiyi and Kok, 2020: Climate models miss most of the coarse dust in the atmosphere, Science Adv., 6, eaaz9507, doi:10.1126/sciadv.aaz9507). [Twan van Noije, Netherlands]	Rejected: We have instead mentioned the initial work by Kok et al., Nature communication, 2017, from which the study of Adebiyi and Kok (2020) is based. This section is about dust sources, while the paper by Adebiyi and Kok (2020) is addressing the possible causes of misrepresentation of dust size distribution by models.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
128083	16	38	16	38	Run on sentence. Add semi-colon. [Trigg Talley, United States of America]	Accepted - text revised
26999	16	43	16	45	We suggest to mention DMS [Eric Brun, France]	Accepted - text revised to include an assessment of DMS emissions
112011	16	46	16	46	Suggest not using SSA for “sea spray aerosol” as it is also the most commonly used acronyms for single scattering albedo [Cynthia Randles, United States of America]	Accepted - text revised
27001	16	50	16	51	Sea-salt emissions may also enhance the formation of nitrate and/or biogenic organic aerosols in regions close to areas where NOx and/or biogenic emissions are high (Chrit M, Sartelet, K., Sciare, J., Pey, J., Nicolas, J. B., Marchand, N., Freney, E., Sellegri, K., Beekmann, M., and Dulac, F., Aerosol sources in the western Mediterranean during summertime: A model-based approach. Atmos. Chem. Phys., 18, 9631-9659, doi:10.5194/acp-18-9631-2018.) [Eric Brun, France]	Rejected. Here the sensitivity of sea-spray emissions to environmental factors are discussed as opposed to the influence of sea-spray on aerosol formation.
45885	16	53	16	55	"critical SSA contribution to cloud formation in regions": This part of the sentence seems incomplete. [Twan van Noije, Netherlands]	Taken into account - see response to #78697
78697	16	53	16	55	This sentence seems to have undergone some copy-paste error and also gives a wrong impression, concerning its content, as the Hamilton and the McCoy-papers only deal with cloud condensation nuclei (which may come from SSA), while for ice nuclei (which in the literature are now rather called ice nucleating particles, a term also used further down in this chapter), other studies exist. I suggest to replace this sentence by: "Studies suggest that SSA contributes important fractions of cloud condensation nuclei (CCN) for cloud formation in regions where anthropogenic aerosols are scarce (Hamilton et al., 2014; McCoy et al., 2015, Quinn et al., 2017), while marine POA may be an important source for primary ice nucleating particles (INP) in remote marine regions (Uetake et al., 2020), albeit not in regions closer to continental dust sources (Gong et al., 2020)." - When this is included, three additional citations need to be added, too: 1) Gong, X., Wex, H., van Pinxteren, M. , Triesch, N., Fomba, K. W., Lubitz, J., Stolle, C., Robinson, B., Müller, T., Herrmann, H., and Stratmann, F. (2020). Characterization of aerosol particles at Cape Verde close to sea and cloud level heights - Part 2: ice nucleating particles in air, cloud and seawater, Atmos. Chem. Phys., 20, 1451-1468, doi:10.5194/acp-20-1451-2020. 2) Quinn, P. K., Coffman, D. J., Johnson, J. E. , Upchurch, L. M., and Bates, T. S. (2017). Small fraction of marine cloud condensation nuclei made up of sea spray aerosol, Nat. Geosci., 10(9), 674-679, doi:10.1038/ngeo3003. 3) Uetake, J., Hill, T. C. J. , Moore, K. A. , DeMott, P. J. , Protat, A., and Kreidenweis, S. M. (2020). Airborne bacteria confirm the pristine nature of the Southern Ocean boundary layer, Proc. Natl. Acad. Sci., 202000134, doi:10.1073/pnas.2000134117. [Heike Wex, Germany]	Considered but not applicable, as paragraph was reorganised
128085	16	54	16	54	Awkward phrasing. Perhapcs rephrase to "..., allowing SSA to provide a critical contribution to ...." [Trigg Talley, United States of America]	Taken into account - see response to #78697
103333	16	55			missing: volcanoes [Philippe Tulkens, Belgium]	Taken into account - volcanic emissions of SO2 have been covered in Chapter 2 section 2.2.2
113929	17	1	17	51	Section 6.2.1.3 gives a useful overview, but more assessment of quality and agreement of data is needed, using the uncertainty language [Jan Fuglestvedt, Norway]	The uncertainty language was revised for the whole section.
128087	17	1	17	51	This discussion covers emissions and the expected future impacts of climate change on open biomass burning, but does not connect the two. It would be very helpful to include discussion on what is known about the potential future impacts of climate change on emissions from biomass burning, or at least to note whether this is a gap in understanding. [Trigg Talley, United States of America]	Taken into account, this section has been revised and a discussion on what we know (or ignore) about future emission from biomass burning and the influence of climate change has been added.
8331	17	1	17	51	This is a good overview of biomass burning, however it misses an assessment on what we know on the role of biomass burning driving or responding to climate change. Further aspects missing 1) discussion on drivers (natural vs anthropogenic, how much change since pre-industrial, drivers of future biomass burning (e.g. Knorr e tal who discuss the nexus of climate change, CO2 and population pressure for a variety of scenarios 2) a discussion what this means for air pollution/health impacts. [Frank Dentener, Italy]	Taken into account. Text has been revised to cover point 1 but a discussion of the health impacts is out of scope of the chapter.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
103335	17	1	17	51	This is a good overview of biomass burning, however it misses an assessment on what we know on the role of biomass burning driving or responding to climate change. Further aspects missing 1) discussion on drivers (natural vs anthropogenic, how much change since pre-industrial, drivers of future biomass burning (e.g. Knorr e tal who discuss the nexus of climate change, CO2 and population pressure for a variety of scenarios 2) a discussion what this means for air pollution/health impacts. [Philippe Tulkens, Belgium]	Taken into account. Text has been revised to cover point 1 but a discussion of the health impacts is out of scope of the chapter.
108229	17	1	17	51	There is no statement about the emission (injection) height of any of the trace substances considered in Ch. 6. This is most relevant for biomass burning, as large fires can inject their emissions throughout the troposphere, and with pyro Cbs even into the lower stratosphere. Some assumptions must have been made for the modelling, and they should be documented and/or appropriate literature refrences be given. [Petra Seibert, Austria]	We added a phrase about emission injection heights using as references the work of Freitas et al., and Darbyshire et al. And Marenco et al.,
55047	17	4	17	5	While Canada does not include boreal forest fires in anthropogenic emissions estimates, we do not classify forest fires as "natural" by default, as we know that many fires results from direct human activity. It is estimated that approximately half of Canadian forest fires are caused by human activity. Suggest changing text to something more general - "forest fires are a natural part of the boreal forest ecosystem, although human activity and climate change are increasing the frequency and intensity of boreal forest fires. Most tropical fores fires are considered to be anthropogenic in nature, as fire is not a typical part of the tropical forest ecosystem". [Nancy Hamzawi, Canada]	Taken into account - text in this section has been revised and shortened, this particular sentence has been removed. An introduction explaining that we discuss emission from natural systems which are perturbed by human activities has been added.
128089	17	4	17	5	"Typically, fires in boreal forests can be classified as natural, while most tropical fires are anthropogenic in nature." This is true in present day. But if trying to calculate PI to PD forcing one needs to account for natural fires in the tropics in the PI. Might want to note here what is known about PI fires in the tropics. [Trigg Talley, United States of America]	Taken into account- text in this section has been revised and shortened, this particular sentence has been removed. The section is focused more on the emissions from biomass burning rather than on the distribution of fires to avoid overlap with Chapter 5
30691	17	4	17	6	In this conrext add reference to Earl, N. et al., 2015: Weekly cycles of global fires: Associations with religion, wealth and culture, and insights into anthropogenic influences on global climate. Geophysical Research Letters, 42, 9579-9589, doi: 10.1002/2015GL066383. [Ian Simmonds, Australia]	Not applicable - text in this section has been revised and shortened, this particular sentence has been removed. The section is focused more on the emissions from biomass burning rather than on the distribution of fires to avoid overlap with Chapter 5
35841	17	5	17	5	Tropical forest fires are indeed primarily anthropogenic but savannah fires occure naturally in the subtropics and tropics. The African savannah fires are the largest source of open biomass burning emissions. [Johannes Kaiser, Germany]	Taken into account - text in this section has been revised and shortened, this particular sentence has been removed. The section is focused more on the emissions from biomass burning rather than on the distribution of fires to avoid overlap with Chapter 5
55045	17	8	17	9	As stated, biomass burning is the primary global source accounting for 59% of BC emissions and 85% of POA emissions, i.e., biomass burning emissions overall is larger than that of anthropogenic emissions on the global scale. Why is it still meaningful to mitigate the athropogenic emissions? [Nancy Hamzawi, Canada]	Not applicable - text in this section has been revised and shortened, this particular sentence has been removed. Updated estimates of the contribution of biomass burning to emission estimates are provided
27003	17	11	17	12	We sugesst to add at the end of the sentence "as well as the production of secondary organic aerosols (Majdi M., Sartelet, K., Lanzafame, G. M., Couvidat, F., Kim, Y., Chrit, M., and Turquety, S. Precursors and formation of secondary organic aerosols from wildfires in the Euro-Mediterranean region. Atmos. Chem. Phys., 19, 5543-5569, doi:10.5194/acp-19-5543-2019.)" [Eric Brun, France]	Not applicable - text in this section has been revised and shortened to read like an assessment rather than a review
88477	17	13	17	13	Wind is very important for fire behaviour but it is not noted here, so suggest adding it prior to the word "temperature" here [Andrew Dowdy, Australia]	Not applicable - text in this section has been revised and shortened. Tis sentence has been removed to avoid overlaps with Ch5 and 12
45887	17	14	17	20	In this context, one could add that attribution studies for recent large fire events indicate that there is a relation with climate change (e.g. van Oldenborgh, et al., 2020: Attribution of the Australian bushfire risk to anthropogenic climate change, Nat. Hazards Earth Syst. Sci. Discuss., https://doi.org/10.5194/nhess-2020-69, in review). [Twan van Noije, Netherlands]	The original phrase covers the suggestion: "reveal high correlations between fire activity and global average temperature, suggesting a likely enhancement of area burned and the consequent fire emissions in a warming future."

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
44155	17	15	17	17	add information from satellite data: burned area on global scale decreased by 25% over the last decade (Andela et al. 2017, Science) [Gitta Lasslop, Germany]	Not applicable - text in this section has been revised and shortened. Tis sentence has been removed to avoid overlaps with Ch5 and 12
3161	17	17	17	18	In Amazon basin, fires are not only sensitive to El Niño. Indeed, extreme droughts and intense fire activity have been reported during warm conditions in the tropical north Atlantic Ocean. See Marengo and Espinoza (2016. doi:10.1002/joc.4420.). [Jhan Carlo Espinoza, France]	Not applicable - text in this section has been revised and shortened. Tis sentence has been removed to avoid overlaps with Ch5 and 12
8959	17	17	17	18	ENSO is also very important for fire activity in Indonesia, causing extreme fire seasons in Sumatra and Kalimantan. [Chuvieco Emilio, Spain]	Not applicable - text in this section has been revised and shortened. Tis sentence has been removed to avoid overlaps with Ch5 and 12
3163	17	18	17	20	Increase in the dry season length is observed over central and southern Amazon related to warm condition in the north tropical Atlantic Ocean. Please use updated references about this topic (e.g Arias et al 2015 https:// doi.org/10.1007/s0038. 2-015-2533-1.; Espinoza et al., 2019. https://doi.org/10.1007/s00382-018-4462-2.) [Jhan Carlo Espinoza, France]	Not applicable - text in this section has been revised and shortened. Tis sentence has been removed to avoid overlaps with Ch5 and 12
35843	17	22	17	22	Fire emissions are also calculated with fire radiative power derived from remote sensing data (and no intermediate estimate of burnt area), e.g. Ichoku, C. and Kaufman, Y. J. (2005). A method to derive smoke emission rates from MODIS fire radiative energy measurements. IEEE TGRS, 43(11):2636–2649. Sofiev, M., Vankevich, R., Lotjonen, M., Prank, M., Petukhov, V., Ermakova, T., Kosk- inen, J., and Kukkonen, J. (2009). An operational system for the assimilation of the satellite information on wild-land fires for the needs of air quality modelling and forecasting. Atmospheric Chemistry and Physics, 9(18):6833–6847. Kaiser, J. W., Heil, A., Andreae, M. O., Benedetti, A., Chubarova, N., Jones, L., Morcrette, J.-J., Razinger, M., Schultz, M. G., Suttie, M., and van der Werf, G. R. (2012). Biomass burning emissions estimated with a global fire assimilation system based on observed fire radiative power. Biogeosciences, 9:527–554. [Johannes Kaiser, Germany]	Not applicable - text in this section has been revised and shortened. Tis sentence has been removed to avoid overlaps with Ch5 and 12
128091	17	22	17	22	Provide some information on how the emission factors are derived. Observationally based? [Trigg Talley, United States of America]	Not applicable - text in this section has been revised and shortened.
44159	17	22	17	22	emissions can also be estimated based on FRP. Kaiser JW, Heil A, Andreae MO, Benedetti A, Chubarova N, Jones L, et al. Biomass burning emissions estimated with a global fire assimilation system based on observed fire radiative power. Biogeosciences. 2012;9:527–54. [Gitta Lasslop, Germany]	Not applicable - text in this section has been revised and shortened and focusses more on CMIP6 emissions.
44161	17	22	17	22	if emissions are based on burned area they use burned area in combination with fuel loads, combustion completeness and emission factors [Gitta Lasslop, Germany]	Not applicable - text in this section has been revised and shortened and focusses more on CMIP6 emissions.
112013	17	22	17	23	This is not the ONLY way emissions are calculated. There are, for example, other databases based on remotely sensed Fire Radiative Power (e.g. QFED). Some argue that using burned area is not appropriate, and this should be acknowledged. [Cynthia Randles, United States of America]	Not applicable - text in this section has been revised and shortened and focusses more on CMIP6 emissions.
44157	17	23	17	25	missing reference for this sentence [Gitta Lasslop, Germany]	Not applicable - text in this section has been revised and shortened and focusses more on CMIP6 emissions.
4077	17	23	17	37	Biomass burned can be further affected by burned area and biomass amount in the area. A large source of uncertainty is burned area, which is based on remote sensing. For example, a recent study validating the MCD64A1 burned area (resolution 500 m) in the boreal Eurasia based on higher resolution satellite product (Landsat, RapidEye, WorldView-2 and GeoEye-1, resolution >5 m), which is the base of the GFED emission inventory, indicated that burned area is underestimated by 16%. In cropland, the understimation is as high as 87%. Reference: Zhu et al., Sci. Rep., 2017 (doi:10.1038/s41598-017-03739-0). [Chunmao Zhu, Japan]	Not applicable - text in this section has been revised and shortened and focusses more on CMIP6 emissions.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
128093	17	26	17	28	There needs to be a reference here to the uncertainties in the preindustrial wildfire emissions and their importance in causing uncertainties in the radiative forcing both diretly and through interactions with clouds. There is a lot of evidence that wildires could have been larger than the CMIP6 assumes in preindustrial times. This has to be mentioned. Recommend the following sentence at the end of this paragraph: "However, these reconstructions are highly uncertain, and different reconstructions result in substantially different radiative forcing estimates for preindustrial versus pesent day (Hamilton et al., 2018)." Citation: Hamilton, D. S., Hantson, S., Scott, C. E., Kaplan, J. O., Pringle, K. J., Nieradzik, L. P., et al. (2018). Reassessment of pre-industrial fire emissions strongly affects anthropogenic aerosol forcing. Nature Communications, 9(1). https://doi.org/10.1038/s41467-018-05592-9 [Trigg Talley, United States of America]	Not applicable - text in this section has been revised and shortened and focusses more on CMIP6 emissions.
86031	17	28	17	28	PI and PD are extremely unnecessary acronyms. Having acryonyms for nearly every concept makes the reading of this chapter difficult. There are several uncommon acronyms (e.g. DGVMs, GFED) some of which are only used once or twice in the chapter. It is important to bear in mind that not everyone that will read this chapter is an expert in the subject matter. The current level of usage of acronyms will require the reader to have to constantly revisit the list of acronyms. That will surely make reading the chapter very difficult for most policy makers. Even for experts in the field, the level of acronyms used in this chapter will certainly present difficulties. It is important to carefully review the chapter, eliminate unnecessary acronyms and only use those that are commonly understood. [Debra Roberts and the Durban WGII TSU, South Africa]	Agree totally. We spelled out PI and PD to Preindustrial and Present day.
72419	17	28	17	28	Define PI and PD. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted. Done
68831	17	30	17	42	In this paragraph on fire emissions from biomass burning, it is worth pointing out that there are large discrepencies in different fire emission inventories. Such uncertainties will significantly affect the estimation of the impacts from biomass burning on air quality and climate. For details, please see "Carter, Therese S., et al. "How emissions uncertainty influences the distribution and radiative impacts of smoke from fires in North America." Atmospheric Chemistry and Physics 20.4 (2020): 2073-2073." [Qing Ye, United States of America]	Noted, the section has been completely rewritten.
35845	17	33	17	33	Di Giuseppe et al. 2017 (or 2016) describe a potential, not implemented extension to GFAS, but not GFAS itself. It is not a correct reference for GFAS. Please cite instead: Kaiser, J. W., Heil, A., Andreae, M. O., Benedetti, A., Chubarova, N., Jones, L., Morcrette, J.-J., Razinger, M., Schultz, M. G., Suttie, M., and van der Werf, G. R. (2012). Biomass burning emissions estimated with a global fire assimilation system based on observed fire radiative power. Biogeosciences, 9:527–554. [Johannes Kaiser, Germany]	Not applicable, global initiatives are not listed anymore in FGD.
44169	17	33	17	33	Global fire atlas does not provide emissions [Gitta Lasslop, Germany]	Accepted. Citation to the global fire atlas removed.
13467	17	34	17	34	Modify the quote. Place the pharenthesis like following: Li et al. (2019a) [Maria Amparo Martinez Arroyo, Mexico]	Editorial. The report will undergo professional copy-editing prior to publication. This type of issue will be fixed then.
35847	17	36	17	36	The proper reference for the latest version of GFED is: van der Werf, G. R., Randerson, J. T., Giglio, L., van Leeuwen, T. T., Chen, Y., Rogers, B. M., Mu, M., van Marle, M. J. E., Morton, D. C., Collatz, G. J., Yokelson, R. J., and Kasibhatla, P. S. (2017). Global fire emissions estimates during 1997–2016. Earth System Science Data, 9(2):697–720. [Johannes Kaiser, Germany]	Not applicable, sentence about GFED removed.
45889	17	36	17	42	It would be instructive to link these remarks to the suggestion by Hamiton et al. that the pre-industrial fire emissions are underestimated in the CMIP6 data set (Hamilton et al.,, 2018: Reassessment of pre-industrial fire emissions strongly affects anthropogenic aerosol forcing, Nature Comm., 9, doi:10.1038/s41467-018-05592-9). [Twan van Noije, Netherlands]	Not applicable - text in this section has been revised and shortened.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
35849	17	37	17	37	Not only GFED but all fire emission databases that use field/lab-observed emission factors underestimate emissions of aerosols. Typcial factors are in the range 1.5 to 4. This strong effect is, however, a particular feature of aerosol emissions, in particular organic matter. It is not generally the case for the emission gases (CH4, CO, CO2,...). One reason for the the underestimatin may be the rapid ageing and growing of the emitted aerosols. [Johannes Kaiser, Germany]	Corrected.
44163	17	38	17	38	the dataset (van Marle) integrates remote sensing with fire proxies such as airport visibility and charcoal records with results from the fire model intercomparison project (Li et al. 2019a). [Gitta Lasslop, Germany]	yes, this issue is included in the discussion
128095	17	38	17	49	Since SLCFs have high spatial/temporal variability it would be good to at least briefly note that there are regional differences here -- e.g., BB is not decreasing uniformly everywhere (increasing in Africa). [Trigg Talley, United States of America]	Accepted. Done
21951	17	45	17	45	tough should be through I presume? [Peter Thorne, Ireland]	Corrected.
55049	17	45	17	46	Suggestion to include increasing intensity, as that is a great concern for boral forest fire management. Text would read "The boreal zone is experiencing larger, more frequent, and more intense fires, and this may increase under a warmer climate. [Nancy Hamzawi, Canada]	Rejected. Changes in the intensity of fire are covered in Chapter 5
44165	17	47	17	51	missing reference for this sentence [Gitta Lasslop, Germany]	Not applicable. Text has been revised and shortened.
72421	17	50	17	50	Replace 'warmer' with 'higher' (warmer temperatures is a physical inaccuracy). [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable. Text has been revised and shortened.
116527	17		17		Cross chapter coordination is needed for fire season / fire weather (ch 2 3?, 5, 11, 12) (also building on SRCCL fire box) to avoid inconsistencies. [Valerie Masson-Delmotte, France]	Accepted. Text was revised to avoid overlaps and inconsistencies
113933	18	1	19	39	Box 6.1 and its figure is useful since this stronger focus on SLCF is new in IPCC. [Jan Fuglestvedt, Norway]	Thank you
95851	18	3	19	37	After introduction of SLCFs beforehand, BOX6.1 promise to explain abundance from process level studies to global chemistry-climate models. However, SLCFs are not only gaseous and I was missing a balanced representation of both chemistry and aerosol processes in this box. This would be easy to do but has not been attempted. [Philip Philip Stier, United Kingdom (of Great Britain and Northern Ireland)]	See response to #45891
45891	18	3			Box 6.1: This box currently focuses strongly on the representation of gas-phase chemistry in models. As it is about the abundance of SLCFs, the representation of aerosols in models deserves more attention. [Twan van Noije, Netherlands]	Taken into account. Text has been added on the representation of aerosols in the models
28517	18	10	18	38	It seems that fundamental processes are described only for gases. Better to briefly mention fundamental processes of aerosols and how they are modeled, as the aerosols are SLCFs, too. [Hiroshi Tanimoto, Japan]	See response to #45891
8333	18	12	18	12	I suspect that rather than average it is common practice to use the median [Frank Dentener, Italy]	Not applicable. Text has been revised and shortened
113931	18	14	18	14	concentration --> concentrationS [Jan Fuglestvedt, Norway]	Accepted - text revised
20025	18	17	18	17	Rather than advancement, one should speak of improved knowledge, for example [philippe waldteufel, France]	Accepted - text revised
72423	18	18	18	18	References should be in chronological order. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial. The report will undergo professional copy-editing prior to publication. This type of issue will be fixed then.
128097	18	22	18	22	"artificial operators representing artificially" -- remove "artificially" [Trigg Talley, United States of America]	Accepted
35981	18	25	18	26	Perhaps more accurately, in-situ means direct contact between instrument and target, while remote sensing means that information about the target is carried by waves (generally electromagnetic waves), with no direct contact with the instrument. [Nicolas Bellouin, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account- text is revised as follows: A wide range of in situ (instrument is in direct contact with the target) and remotely sensed (instrument is not in direct contact with target rather measures information about the target carried by electromagnetic waves)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
21953	18	25	18	26	I'm not sure (instrument some distance away from the the subject of interest) is strictly speaking true as many remote sensing instruments start their measurement nearly instantaneously at the apeture. Rather remote sensing instruments sense a volume of air along some path through the atmosphere. [Peter Thorne, Ireland]	Taken into account - see response to #35981
38035	18	25	18	38	The advanced technique of satellite measurement should be more discussed. So far many satellite measurements for atmospheric chemicals are based on 'polar-orbit', usually once a day over the monitoring area. Although the spatial coverage becomes better, polar orbit satellite observation has a limitation for the temporal information. But nowadays, 'geostationary' satellite techniques are used, providing the hourly (sometimes even shorter) data for daytime. This definitely improve our knowledge because usually short-live chemicals have very large diurnal variations. In East Asia, where the air pollution is the highest in the world, have a several working geostationaly satellites to measure the aerosol turbidity (AOD),which is very useful parameter for the calculation of radiative forcing. These efforts need to be addressed. [Junhee Lee, Republic of Korea]	Rejected - while we acknowledge that the advances in satellite measurements have been tremendously useful for improving our understanding of the SLCF distributions, highlighting the satellite techniques is excessive detail for this Box
72425	18	28	18	28	Change 'programs' to 'programmes' (in keeping with British English used in the chapter and to avoid confusion with computing) [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted
28513	18	32	18	32	intensive [Hiroshi Tanimoto, Japan]	Accepted
28515	18	38	18	38	Data assiilation/reanalysis of chemical species is one of the key new steps after AR5. Besides the prospect paper (Bocquet et al. 2015), it is worth mentioning completed reanalysis products, e.g., Miyazaki et al. (ACP, 2015), Flemming et al. (ACP, 2017): References: Miyazaki, K., Eskes, H. J., and Sudo, K.: A tropospheric chemistry reanalysis for the years 2005–2012 based on an assimilation of OMI, MLS, TES, and MOPITT satellite data, Atmos. Chem. Phys., 15, 8315–8348, https://doi.org/10.5194/acp-15-8315-2015, 2015. Flemming, J., Benedetti, A., Inness, A., Engelen, R. J., Jones, L., Huijnen, V., Remy, S., Parrington, M., Suttie, M., Bozzo, A., Peuch, V.-H., Akritidis, D., and Katragkou, E.: The CAMS interim Reanalysis of Carbon Monoxide, Ozone and Aerosol for 2003–2015, Atmos. Chem. Phys., 17, 1945–1983, https://doi.org/10.5194/acp-17-1945-2017, 2017. [Hiroshi Tanimoto, Japan]	Accepted. Done
45893	18	40	18	41	Please explain that in practice models fall in different categories, depending on the processes that are represented (interactive aersosols and/or chemistry in troposphere and/or stratosphere). [Twan van Noije, Netherlands]	Accepted - we have revised the text as follows: "Global three-dimensional CCMs (Figure 1) represent the full coupling of chemistry with climate physics (e.g., Morgenstern et al. 2017) and fall in different categories depending on the level of complexity (e.g., interactive aerosols with or without tropospheric and/or stratospheric chemistry).
45895	18	41	18	44	It would be instructive to explain that in current CCMs CH4 concentrations are not calculated from emissions, but are either directly prescribed or strongly constrained. [Twan van Noije, Netherlands]	Accepted
74047	18	43	18	44	" to make future projections depending on emission scenarios and to understand global scale chemistry-climate interactions and feedbacks." Please clarify, I am not sure if I understand this part. Future projections are always depending on emission scenarios. What is exactly the meanng of this sentence? I think the authors wanted to state something, which I do not get. [Volker Grewe, Germany]	Taken into account - depending on emission scenarios is now deleted because of the redundancy

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
74045	18	44	18	44	I think here, between the description of the compelxity of CCMs and the use for interpretation of observations and downscaling, there is the possibility to emphasise the necessity of diagnostics to interpret the non-linear behaviour. One important part is the attribution of ozone to individual sectors. This is complex due to the highly non-linear behaviour, the competition between NOx and NHMCs for ozone production. There is quite some theory behind this (Grewe et al. 2010, Grewe, 2013, Clappier, et al. 2017) and worth mentioning that complex models alone, without diagnostics of similar complexity would not suffice. Proposed text (e.g.): This understanding often requires complex diagnostic tools, which enable disentagling, e.g. source-receptor relations (Grewe et al. 2017, Butler et al. 2020). Note that Butler et al. explicitely state in their recent manuscript: "We demonstrate the utility of ozone source attribution as a powerful model diagnostic tool, and recommend that similar source attribution techniques become a standard part of future model inter-comparison studies" Grewe, V., Tsati, E., Mertens, M., Frömming, C., and Jöckel, P., Contribution of emissions to concentrations: The TAGGING 1.0 submodel based on the Modular Earth Submodel System (MESSy 2.52), Geosci. Model Dev. 10, 2615-2633, doi:10.5194/gmd-2016-298, 2017. Butler, T., Lupascu, A., and Nalam, A.: Attribution of ground-level ozone to anthropogenic and natural sources of NOx and reactive carbon in a global chemical transport model, Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2020-436, in review, 2020. [Volker Grewe, Germany]	Rejected. While the reviewer makes a valid point, we have limited space. Therefore, we keep the discussion focused on the use of models and observations for the assessment of SLCF abundances
128099	18	46	18	48	Mention explicitly the (relatively) coarse spatial resolution of global CCMs. [Trigg Talley, United States of America]	Accepted - text revised
86003	19	0	35	0	In this general section with its many sub-sections, one would like to see more discussion on sources of these gases. Descriptions of trends could easily be replaced with charts, saving on word count. The sources are important for WGIII in terms of mitigation, and for WGII for other impacts (pollution, health etc) and discussions around co-benefits. [Debra Roberts and the Durban WGII TSU, South Africa]	Taken into account. Section 6.2 was split into 6.2 (emissions) and 6.3 (abundances) .
107533	19	4	19	4	Consider new literature showing nudged CCM simulations do not reproduce transport processes with much fidelity in the troposphere and stratosphere: https://www.atmos-chem-phys.net/18/7217/2018/ https://www.atmos-chem-phys.net/19/11559/2019/ [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account - text added: Although, caution is exercised as nudging can alter the model climate resulting in unintentional impacts on the simulated models atmospheric physics and/or chemistry (Orbe et al., 2018; Chrysanthou et al., 2019).
13469	19	4	19	4	Write the word "For" in lowercase [Maria Amparo Martinez Arroyo, Mexico]	Rejected - added period before for
128101	19	4	19	7	Note that nudging alters the mean model solution, e.g., by changing the representation of subgrid model physics. (Also, comma before this sentence should be a period.) [Trigg Talley, United States of America]	Taken into account - text added: Although, caution is exercised as nudging can alter the model climate resulting in unintentional impacts on the simulated models atmospheric physics and/or chemistry (Orbe et al., 2018; Chrysanthou et al., 2019). Comma is removed
45897	19	5	19	5	I would suggest changing "observed meteorology" to something like "observed or reanalysed meteorology". [Twan van Noije, Netherlands]	Accepted
72427	19	9	19	9	Insert 'The' before 'Multi-model' and change 'Multi' to 'multi' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account - in an effort to shorten the discussion, this sentences was deleted
72429	19	9	19	9	Change 'are' to 'is' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account - in an effort to shorten the discussion, this sentences was deleted
107535	19	9	19	10	This sentence has poor grammar [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account - in an effort to shorten the discussion, this sentences was deleted
20027	19	9	19	10	Please check grammar and punctuation [philippe waldteufel, France]	Taken into account - in an effort to shorten the discussion, this sentences was deleted

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
72431	19	10	19	10	Insert 'an' before 'ensemble' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account - in an effort to shorten the discussion, this sentences was deleted
107537	19	12	19	12	"The assumption is that"… Must this be an assumption, the skill of the MMM has been compared to the skill of individual models [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account - in an effort to shorten the discussion, this sentences was deleted
20029	19	13	19	17	This is addressed in detail in Box 4.1; does one need to repeat it? [philippe waldteufel, France]	Accepted - we now refer to Box 4.1 for more details
8335	19	19	19	27	Would this be the place for a statement on the fit-for-purposeness of CCMs to evaluate radiative forcing and climate impacts based on the collective information provided in the papers and section mentioned. The box is somewhat ending in a anti-climax, without an assessment statement. [Frank Dentener, Italy]	Accepted - the following statement has been added: Based on the collective information provided in this body of literature, the CMIP6 multimodel ensemble is largely fit-for-purpose of evaluating the influence of SLCFs on air quality, radiative forcing, climate and non-CO2 biogeochemical feedbacks.
103337	19	19	19	27	Would this be the place for a statement on the fit-for-purposeness of CCMs to evaluate radiative forcing and climate impacts based on the collective information provided in the papers and section mentioned. The box is somewhat ending in a anti-climax, without an assessment statement. [Philippe Tulkens, Belgium]	Accepted - see response to #8335
45899	19	20	19	20	Please remove "Atmospheric". [Twan van Noije, Netherlands]	Accepted
20031	19	23	19	27	There is a surplus of opening brackets here [philippe waldteufel, France]	Accepted - brackets are fixed
35725	19	24	19	27	Use published sources [Carlos Antonio Poot Delgado, Mexico]	This is required and has been checked for the FGD.
128103	19	27	19	27	"and characterise uncertainties" -- awkward phrasing. Depending on intended meaning, change to "and the characterization of uncertainties"? [Trigg Talley, United States of America]	Taken into account - deleted
45385	19	42	35	53	section 6.2.2: dust and sea salt are listed in Table 1, but they are not described in 6.2.2. I think they should be considered in this section. For example, recent studies have shown that anthropogenic dust (iron oxide) emitted from fossil fuel sources are ubiquitous (at least over East Asia and Europe) and could have positive radiative effects comparable to BrC regionally and globally (Moteki et al., 2017: Matsui et al., 2018: Ito et al., 2018; Yoshida et al. submitted). I think these studies should be considered somewhere in this section because this section describes the importance of BrC in detail. Moteki et al. (2017), Anthropogenic iron oxide aerosols enhance atmospheric heating, Nat. Commun., 8:15329, doi:10.1038/ncomms15329. Matsui et al. (2018), Anthropogenic combustion iron as a complex climate forcer, Nat. Commun., 9:1593, doi:10.1038/s41467-018-03997-0. Ito et al. (2018), Radiative forcing by light-absorbing aerosols of pyrogenetic iron oxides, Sci. Rep. 8:7347, doi:10.1038/s41598-018-25756-3. Yoshida et al., Abundances and microphysical properties of light-absorbing iron oxide and black carbon aerosols over East Asia and the Arctic, submitted to J. Geophys. Res. Atmos. [Hitoshi Matsui, Japan]	Rejected. Noted but this section (6.3 in the FGD) discusses the evolution of abundances in SLCFs. The internal mixing, coating and ageing of aerosols is of importance for their radiative properties but is discussed in Chapter 7.
103339	19	42			this section is entitled "atmospheric processes". This is central for the whole chapter and is essential. Unfortunately, very little is said about atmospheric processes. No details are needed (references to text books are good enough) but the basics, importance of OH as key oxidant of CH4, NMVOC, CO, HFCs; the sources of OH and its impact on e.g. CH4 need to find place to be able to understand the interference between the compounds covered here. This extends to SOA formation. Further statements on SIA and CCN/IN could be added [Philippe Tulkens, Belgium]	Taken into account. We have reframed this section to assess the historical evolution of SLCF abundances.
103341	19	42			When discussing SO2 oxidation and sulfate formation: are there any new conclusions on shipping and sulfate induced cooling along shipping lanes? [Philippe Tulkens, Belgium]	Taken into account. Climate influence of shipping emissions is considered in Section 6.6.2.3.2
103343	19	42			Measurements quoted here basically are satellite data. This is convenient for a global coverage. However, majority of air pollution data - and here especially in polluted regions, derives from monitoring data [Philippe Tulkens, Belgium]	Taken into account. Both satellite based and in-situ observations are considered in the assessment provided in section 6.3.
8337	19	44	19	44	better to refer to use the term residence time, given that it considers chemical and phyiscal processes. [Frank Dentener, Italy]	Rejected. Lifetime and residence time are used interchangeably.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
103345	19	44	19	44	better to use only the term "residence time", given that it considers chemical and phyiscal processes. [Philippe Tulkens, Belgium]	see answer to #8337
128105	19	48	19	48	Unclear: does "destruction" refer here to destruction of the primary emitted species, or of the secondary radiatively active species? Clarify. [Trigg Talley, United States of America]	Not applicable. Text was revised
82323	19	49	19	50	Stratoaphere-troposphere exchange is more appropriately described as "large-scale circulation" than as "long-range transport". [Guang Zeng, New Zealand]	Take into account. Text has been revised
128107	19	53	19	53	Should be "Nitrogen Oxides" [Trigg Talley, United States of America]	Accepted - text revised
86005	19	53	19	53	One expected to see a break-down of sources of NOx, including industry, agricultural fertilizer. With so much emphasis on agriculture when it comes to mitigation, one needs to know where this is a problem, and how big the problem is relative to other sources. – ok it comes up in section 6.2.2.7. It seems a bit strange, however, to have the N-compounds separated like this. Consider putting them together in the same section. A schematic showing which N-compounds are formed from which sources, and the relative abundance of each, would be informative. If sources are discussed elsewhere, please cross-reference. [Debra Roberts and the Durban WGII TSU, South Africa]	Taken into account - emissions of NOx are discussed in section 6.2.1 and shown in Figure 6.3 by sectors. We refer to this section in the following sentence: "Once emitted in the atmosphere from both anthropogenic (section 6.2.1.1) and natural sources (section 6.2.1.2), NOx undergoes chemical processing, including the formation of nitric acid (HNO3), nitrate (NO3-), organic nitrates (e.g., alkyl nitrate, peroxyacyl nitrate), atmospheric transport, and deposition resulting in a lifetime of hours to days. "
33031	20	8	20	8	Drop "and" after "the availability of" [Sahar Tajbakhsh Mosalman, Iran]	Accepted - "the availability of and" is deleted
19517	20	8	20	8	the availability of and refinements in satellite-derived…and must delete [Hamideh Dalaei, Iran]	Taken into account - see response to #33031
32701	20	8	20	8	Drop "and" after "the availability of" [sadegh zeyaeyan, Iran]	Taken into account - see response to #33031
18261	20	9	20	9	"facilitated improved understanding…": The removal of one of these two adjectives has been forgotten. [Yann Cohen, France]	Accepted - text revised
86007	20	13	20	13	Is it possible to add South Africa to the examples? [Debra Roberts and the Durban WGII TSU, South Africa]	Accepted - added South Africa in the examples of areas with high NO2 levels
72433	20	24	20	24	Change 'the 1996 to 2011 period based' to '1996 to 2011 based' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised
110845	20	35	20	35	attributed to *a* combination of factors [Claudia Steadman, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised
38037	20	37	20	37	(Georgoulias et al., 2019) . => (Georgoulias et al., 2019). [Junhee Lee, Republic of Korea]	Accepted - text revised
13471	20	37	20	37	Eliminate the extra space between pharenthesis and comma. [Maria Amparo Martinez Arroyo, Mexico]	Accepted - text revised
103347	20	40			air quality control in connection with the Syrian Civil War? [Philippe Tulkens, Belgium]	Taken into account - we have revised the sentence to note that the reasons for trend reversal in NO2 since 2011-2012 in individual areas of this regions were diverse, including warfare, imposed sanctions and air quality controls
104791	20	42			Increasing or decreasing trends!? If the sentence stills refers to Africa and Latin America: increasing trends according to Schneider et al. 2015. [Tobias Schad, Germany]	Taken into account - this sentence indeed refers to large agglomerations in Africa and Latin America which show both increasing and decreasing trends since early 2000s based on both Schneider et al(2015) and Duncan et al (2016). The sentence is revised to better clarify this.
103349	20	54	21	3	The summary statement could be complemented with an assessment to what extent satellite trends/distributions confirm reported bottom-up inventories (similar to the section on deposition). [Philippe Tulkens, Belgium]	Noted, such discussion is in the section discussing emission (6.2.1), here the discussion aims to discusses trends in abundance not inventories.
72435	20	55	20	55	Delete 'the'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised
128109	21	1	21	1	A space is needed between "there is" and "high confidence" [Trigg Talley, United States of America]	Accepted - text revised
38039	21	1	21	1	ishigh confidence => is high confidence [Junhee Lee, Republic of Korea]	Taken into account - see response to #128109

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106397	21	1	21	1	is high rather than ishigh [Hamza Merabet, Algeria]	Taken into account - see response to #128109
13473	21	1	21	1	Add a space between "there is" and "high confidence". [Maria Amparo Martinez Arroyo, Mexico]	Taken into account - see response to #128109
72437	21	1	21	1	Delete 'time period'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised
72439	21	1	21	1	Insert space between is and high [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account - see response to #128109
20033	21	6	21	12	The legend mentions 16 regions while the figure shows 10 curves. In any case, both dashed and continuous lines should be used in order to help to discriminate them [philippe waldteufel, France]	Accepted - revised caption to say 10 regions instead of 16. The use of dashed and continuous lines will be discussed with TSU.
103351	21	8	21	9	what is meant with self-consistent dataset? Harmonized, calibrated? [Philippe Tulkens, Belgium]	Taken into account - this dataset is created by merging data from three satellite retrievals. We have revised the caption to state that this is a merged GOME, SCIAMACHY, and GOME-2 dataset and thereby remove any ambiguity.
8341	21	9	21	9	what is meant with self-consistent dataset? Harmonized, calibrated? [Frank Dentener, Italy]	Taken into account - see response to #103351
11375	21	12	21	12	I would be nice for readers to see a list of biosphere sources in order to understand the confidence in emission numbers [Dan Bruhn, Denmark]	Rejected - this figure shows NO2 concentration trends, hence this comment is not applicable.
16551	21	15	22	29	There are a lot of numbers in section 6.2.2.2 which makes it difficult to pick out what the messages are (apart from the assessment that we have high confidence in them). Could the numbers be put in a table and the text used to make assessed statements? [William Collins, United Kingdom (of Great Britain and Northern Ireland)]	Accepted-a table summarizing CO trends has been added
82325	21	17	21	18	Changes in CO have a small effect on CO2 due to the very low emissions of CO compared to those of CO2. [Guang Zeng, New Zealand]	Taken into account. Text has been revised and shortened.
128111	21	21	21	21	"smaller contributions" --> "a smaller contribution" [Trigg Talley, United States of America]	Accepted-Text revised
8343	21	25	21	25	retrieval algoritms pertain to satellite retrievals? [Frank Dentener, Italy]	Accepted-Text revised
103353	21	25	21	25	retrieval algoritms pertain to satellite retrievals? [Philippe Tulkens, Belgium]	Accepted-Text revised
8345	21	26	21	29	These sentences miss some rationale as to why vertical information, and column amounts are need to understand CO's effect on climate. [Frank Dentener, Italy]	Taken into account. Text has been revised and shortened.
72441	21	27	21	27	Delete hyphen. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted-Text revised
128113	21	27	21	28	Higher vertical resolution? Or higher horizontal resolution? [Trigg Talley, United States of America]	Taken into account. Text has been revised and shortened.
103355	21	27	21	30	These sentences miss some rationale as to why vertical information, and column amounts are need to understand CO's effect on climate. [Philippe Tulkens, Belgium]	Taken into account. Text has been revised and shortened.
128115	21	29	21	29	"satelite" --> "satellite" [Trigg Talley, United States of America]	Accepted-Text revised
27005	21	29	21	29	Would not it be better to say column instead of columnar? [Eric Brun, France]	Not applicable. Text has been modified
128117	21	30	21	30	"declining global trends of about -1%/yr" is a double negative; either "trends of -1%/yr" or "decline of 1%/yr" [Trigg Talley, United States of America]	Accepted-Text revised
72443	21	30	21	31	Insert full stop after 2010 and change 'however' to 'However'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted-Text revised
55051	21	31	21	31	Is any of the ground surface data from GAW network used for verifying the trends? [Nancy Hamzawi, Canada]	Taken into account. This refers to the assessment in AR5.
113937	21	31	21	36	Here you list papers and then add "high confidence". I think you need to discuss and assess a bit more what these papers are saying [Jan Fuglestvedt, Norway]	Accepted-Text revised
20035	21	31	21	36	check punctuation [philippe waldteufel, France]	Accepted-Text revised

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
18263	21	34	21	34	There is a lack of precision about aircraft measurements: 1/ Petetin et al. (2018) is a study using commercial aircraft observations (IAGOS), but not aircraft campaigns. For instance, the study from Hoor et al. (2004) based on the SPURT campaign would be a better example. 2/ The same Petetin et al. (2018) only dealt with vertical profiles built from aircraft ascent and descent phases near 3 well-sampled airports. For a better example of CO geographical distribution, Cohen et al. (2018) showed notably climatological averages in the upper troposphere and in the lower stratosphere. [Yann Cohen, France]	Accepted-Text revised
8347	21	38	21	41	The CO reconstruction is presented as statements of fact, so it is not clear why there is a low confidence. How do these numbers corroborate or not the earlier reported 1 % decline. I presume that the statements mostly refer to NH changes, please clarify? [Frank Dentener, Italy]	Taken into account. Text has been revised. However, comparison of ice core data to decreasing trend with satellite is not possible due to time mismatch (In addition, isotope study focus before 1990s). Sentence revised to better reflect the time period.
103357	21	38	21	41	The CO reconstruction is presented as statements of fact, so it is not clear why there is a low confidence. How do these numbers corroborate or not the earlier reported 1 % decline? The statements presumably mostly refer to northern hemisphere changes, please clarify? [Philippe Tulkens, Belgium]	Taken into account. Text has been revised. However, comparison of ice core data to decreasing trend with satellite is not possible due to time mismatch (In addition, isotope study focus before 1990s). Sentence revised to better reflect the time period.
128119	21	39	21	39	Is the given range for present-day CO? If so, delete "with concentration." Otherwise, rephrase to clarify. [Trigg Talley, United States of America]	Accepted-Text revised
18265	21	43	22	4	There are also the commercial aircraft (IAGOS) measurements that showed a 95%-significant decrease in CO since 2002 until 2013 (included) over 7 well-sampled regions in northern midlatitudes, as shown in Cohen et al. (2018, ACP). In the upper troposphere, these significant trends spread from −0.82 [−2.10; −0.14] %/yr in the western Mediterranean basin to −1.89 [−2.87; −0.71] %/yr in Northeast Asia. [Yann Cohen, France]	Accepted-Text revised. Trend data added in Table and text.
32045	21	46			Should mention the NOAA record here? Petron, G., et al. "Atmospheric Carbon Monoxide Dry Air Mole Fractions from the NOAA ESRL Carbon Cycle Cooperative Global Air Sampling Network, 1988–2017." US Department of Commerce: Boulder, CO, USA (2018). Also the decline is not just emission control. Declining CO in the decade to 2010 was also significantly an accidental small bonus consequence of the unhappy dieselisation of the global vehicle fleet in the post 2000 decade - diesels emit much less CO. Lowry, David, et al. "Diurnal, seasonal, and annual trends in tropospheric CO in Southwest London during 2000â 2015: Wind sector analysis and comparisons with urban and remote sites." Atmospheric environment (2018). [Euan G. Nisbet, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account: NOAA record are mentioned in the table through peer reviewed published sources. Dieselisation aspect -rejected, too detailed, changes in emissions are discussed in section 6.2.
128121	21	47	21	47	"decrease in global CO burden of -0.86%/yr" is a double negative; either "decrease of 0.86%/yr" or "trend of -0.86%/yr" [Trigg Talley, United States of America]	Taken into account. Text has been revised and shortened. Table with a summary of trends has been added
72445	21	47	21	47	Delete 'of'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted-Text revised
21955	21	47	21	54	Shouldn't all these numbers come with ranges and would this information not be more accessible if presented in a table? Also, that the periods overlap but are non-identical greatly complicates reader interpretation. Could results for both over the common period of record be shown if tabulated to be clearer what component of differences arises from the different techniques and what component arises from the time period differences? [Peter Thorne, Ireland]	Accepted. Table with trends has been added
103359	21	48	21	48	Are the inversion studies also global? Clarify. [Philippe Tulkens, Belgium]	Accepted. These are global inversions. Text has been revised to clarify
8349	21	49	21	49	Are the inversion studies also global? Clarify. [Frank Dentener, Italy]	Accepted. These are global inversions. Text has been revised to clarify
35727	21	53	21	53	delete comma Buchholz et al., (2019) [Carlos Antonio Poot Delgado, Mexico]	Accepted-Text revised
72447	21	54	21	54	Delete the negative sign. A decrease of a negative quantity is an increase! [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account. Text has been revised and shortened. Table with a summary of trends has been added

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
8339	21	54	22	3	The summary statement could be complemented with an assessment to what extent satellite trends/distributions confirm reported bottom-up inventories (similar to the section on deposition). [Frank Dentener, Italy]	Accepted-Text revised
8351	21	55	21	55	This statement is not consistent with p 55 l. 36-41, which is another source of information [Frank Dentener, Italy]	Not Applicable, we could not find what the comment refers to.
103361	21	55	21	55	This statement is not consistent with p 55 l. 36-41, which is another source of information [Philippe Tulkens, Belgium]	Accepted-Text revised
128123	21	55	22	4	Do these models also show a decline in global CO post-2000? Are they consistent with the recent observations? [Trigg Talley, United States of America]	Taken into account. Text has been revised.
103363	22	1			here for CO and elsewhere: decisive about pollutants is that they are highly variable spatially and temporarily. So I wonder how relevant a "global burden" is - at least that needs an explanation [Philippe Tulkens, Belgium]	Taken into account - the spatial heterogeneity due to SLCF lifetime and limitation in considering SLCFs globally are caveat in section 6.1
72449	22	4	22	4	Delete 'the year'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial. The report will undergo professional copy-editing prior to publication. This type of issue will be fixed then.
35729	22	4	22	4	Use published sources [Carlos Antonio Poot Delgado, Mexico]	Accepted - referenced updated
128127	22	6	22	6	Use either "from emissions to concentrations" or "between emissions and concentrations." [Trigg Talley, United States of America]	Not applicable. Sentence has been deleted in an effort to shorten and make text concise
128125	22	6	22	7	"...despite their limitations to reproduce observations." So far nothing has been stated about model ability to reproduce observation so this assertion seems to come out of nowhere. The paragraph on lines 18-26 should precede this paragraph. [Trigg Talley, United States of America]	Accepted. Text in this section has been reorganized
72451	22	7	22	7	Insert 'the' after 'Despite'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable. Sentence has been deleted in an effort to shorten and make text concise
128129	22	7	22	7	Restate to: "Global models have produced estimates of CO2 burden for the years 2000-present ranging from ...". Limitations were already raised in the previous sentence and the next paragraph. [Trigg Talley, United States of America]	Accepted-text has been revised and shortened
8353	22	7	22	7	There is two time mentioning of model's limitation but it is not clear how that is connected to the reported range of 246-475. Is that range reflecting the model uncertainties, or could the range be even larger if model uncertainties were appropriately appreciated? Clarify. [Frank Dentener, Italy]	Not applicable. The section has been revised and shortened
128131	22	7	22	8	Is this range (246-475 Tg(CO)) from models only? Or is this constrained by observations? [Trigg Talley, United States of America]	Not applicable. The section has been revised and shortened
103365	22	7	22	8	Model's limitations are mentionned twice but it is not clear how that is connected to the reported range of 246-475. Is that range reflecting the model uncertainties, or could the range be even larger if model uncertainties were appropriately appreciated? Could this be clarified ? . [Philippe Tulkens, Belgium]	Not applicable. The section has been revised and shortened
45901	22	8	22	10	This is a rather arbitrary selection. I propose to include only the most relevant papers, in particular multi-model intercomparisons, and results from the most advanced models. [Twan van Noije, Netherlands]	Rejected- Estimates are based on available published model results. If multimodel criteria is used then there is extremely limited model estimates
128133	22	10	22	12	Compare the given chemical production rate for CO with the direct emissions of CO. [Trigg Talley, United States of America]	Taken into account. Text has been revised and shortened
72453	22	13	22	13	Capital 'T' for 'troposphere. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial. The report will undergo professional copy-editing prior to publication. This kind of issues will be fixed then.
128135	22	14	22	15	"dry deposition ... strength" is odd wording. Change to "..with models reporting a rate of..." [Trigg Talley, United States of America]	Not applicable. Text has been revised and shortened
21959	22	18	22	22	I couldn't make sense of this as written. Efforts should be made to clarify for the reader. [Peter Thorne, Ireland]	Accepted-Text revised
113941	22	18	22	26	Here you give statements about models over or underestimating levels. This is important, but you need to do your own assement and add confidence statements [Jan Fuglestvedt, Norway]	Accepted-Text revised

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
13475	22	19	22	19	Remove hyphen after "Europe". [Maria Amparo Martinez Arroyo, Mexico]	Accepted-Text revised
72455	22	24	22	24	Capital 'T' for 'tropics'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial. The report will undergo professional copy-editing prior to publication. This kind of issues will be fixed then.
20365	22	24	22	26	Nothing is said here about the vertical profile of CO concentrations, nor whether models describe it correctly. [philippe waldteufel, France]	Taken into account. Text has been revised and shortened
72457	22	25	22	25	Capital 'T' for 'troposphere. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial. The report will undergo professional copy-editing prior to publication. This kind of issues will be fixed then.
113939	22	28	22	28	"since AR5" is uncelar. Do you mean improved etsimates or changes in atmospehric levels of CO since the time of AR5? [Jan Fuglestvedt, Norway]	Accepted-Text revised
8355	22	28	22	28	In what part of the global CO distribution we have high confidence? The previous section reports underestimates of 60 ppb (or ca. 50 %), contradicting this. Perhaps the main features of importance for climate are: changes since pre-industrial are consistent with info from models and inventories, consistent changes also during the last two decades (medium confidence), but medium (or low) confidence in the absolute magnitude of model derived CO columns (which are used to calculate RF). [Frank Dentener, Italy]	Accepted-Text revised
103367	22	28	22	28	In what part of the global CO distribution we have high confidence? The previous section reports underestimates of 60 ppb (or ca. 50 %), contradicting this. Perhaps the main features of importance for climate are: changes since pre-industrial are consistent with info from models and inventories, consistent changes also during the last two decades (medium confidence), but medium (or low) confidence in the absolute magnitude of model derived CO columns (which are used to calculate RF). [Philippe Tulkens, Belgium]	Accepted-Text revised
20367	22	28	22	29	From IPCC outline: " Confidence is a qualitative measure of the validity of a finding, based on the type, amount, quality and consistency of evidence". Illustration: estimates of the WG1 authors on line 28 are not a finding, while " global CO burden is declining" on line 29 is one! [philippe waldteufel, France]	Accepted-Text revised
16553	22	28	22	29	This doesn't seem a very comprehensive assessment after all those numbers. Presumably if the models and measurements disagree then there must be something we aren't confident about. Do the models still get the trends even with the bias? [William Collins, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account. Text has been revised.
72459	22	29	22	29	Delete 'period'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable. Sentence has been revised.
128137	22	29	22	29	Delete either dash or "to" [Trigg Talley, United States of America]	Not applicable. Sentence has been revised.
128139	22	32	22	32	Section title is "Volatile Organic Compounds (VOCs)," but the section is actually on non-methane VOCs. Upate section name. [Trigg Talley, United States of America]	Taken into account, text revised.
8357	22	32	22	32	Section header is not formally correct- as the section is about non-methane VOCs [Frank Dentener, Italy]	Taken into account, text revised.
15015	22	32	22	32	Example of a ‘good’ heading - the reader should be able to glance up at headings to get a reminder of what the acronyms used in the body of the section stand for. [Fredric Taylor, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account, text revised.
103369	22	32	22	32	Section header is not formally correct- as the section is about non-methane VOCs [Philippe Tulkens, Belgium]	Taken into account, text revised.
68829	22	32	22	32	In this section, emissions of dimethyl sulfide and its important contribution to the global budget of non sea-salt sulfate aerosol should be included [Qing Ye, United States of America]	Taken into account, a discussion on DMS has been added
113943	22	32	23	47	The section on VOC need to assess and summarize the knowledge [Jan Fuglestvedt, Norway]	Accepted, a summary statement has been added
103371	22	32			this is "Non-methane volatile organic componds" [Philippe Tulkens, Belgium]	Taken into account, text revised.
45903	22	34	22	35	Please include "natural fires". [Twan van Noije, Netherlands]	Taken into account, text revised.
8359	22	35	22	35	Since this is the SLCF chapter, all components discussed are short lived. Probably you want to indicate something like hours-to days-to-months. [Frank Dentener, Italy]	Taken into account, text revised.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
103373	22	35	22	35	Since this is the SLCF chapter, all components discussed are short lived. Probably you want to indicate something like hours-to days-to-months. [Philippe Tulkens, Belgium]	Taken into account, text revised.
72461	22	38	22	38	Should it be OH-? [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Rejected for consistency with the section dealing with OH
72463	22	38	22	38	Delete , from before 'and' (not required in this context) [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial. Treated
19015	22	39	22	39	should mention biogenic source emissions [Mengze Li, Germany]	Rejected, it is already in the sentence.
128141	22	39	22	41	Note also that anthropogenic activities can modify the "natural" source of NMVOCs, e.g., through land use change, or indirectly through modification of radiation fluxes or climate. [Trigg Talley, United States of America]	Noted. The section presenting the natural emissions has been renamed "natural system" and its text explicitly argues that emissions by natural system are perturbed by humans notably through land use change .
19017	22	40	22	40	please give citations for the number of 150-160 Tg [Mengze Li, Germany]	The numbers have been removed since the sources are discussed in 6.2.1.
76647	22	40	22	41	Reference about AVOC emissions is missing; Maybe this very old one with 110 TgC per year: Piccot et al., 1992: A global inventory of volatile organic compound emissions from anthropogenic sources [Felix Havermann (né Wiß), Germany]	Noted. The numbers have been removed since emissions are discussed in 6.2.1
76649	22	40	22	41	By anthropogenic drivers as the main source of long-term trends do you mean e.g, land conversion? Maybe define that more explicit. [Felix Havermann (né Wiß), Germany]	Noted, anthropogenic activities here is related to anthropogenic source described in 6.2.1 (and not perturbed natural systems)
8361	22	43	22	43	longest lived is not clear, suggest with lifetimes of several days to months. In this report it is important to avoid confusion with Long-lived GHGs. [Frank Dentener, Italy]	Taken into account, text revised.
103375	22	43	22	43	longest lived is not clear, suggest with lifetimes of several days to months. In this report it is important to avoid confusion with Long-lived GHGs. [Philippe Tulkens, Belgium]	Taken into account, text revised.
72465	22	49	22	49	Insert space between 'since' and 'growing'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial. The report will undergo professional copy-editing prior to publication. This type of issue will be fixed then.
128143	22	49	22	49	Typo: "sincegrowing" should just be "growing". [Trigg Talley, United States of America]	Taken into account, text revised.
27007	23	11	23	11	It is true except for ethane and propane (see Waked et L; 2016, 10.1016/j.atmosenv.2016.06.059 and Derwent et al. 2017, 10.1016/j.atmosenv.2017.02.030) [Eric Brun, France]	Taken into account, the sentence citing AR5 now specifies "for a range of NMVOCs". The period analysed by Waked is too short compared to the scope of this paragraph.
41783	23	13	23	15	The situation in the US city of Chicago is mentioned. How is that representative of global conditions? Is that an example of especially high reductions, of the average, of X? Without a specific quantified context I suggest removal. The same goes for the east Asia example in the following sentence. [Jan Cermak, Germany]	Partially accepted. Very detailed studies at specific locations are made not because of extreme or unusual behaviour at those locations, but because it would be impractical to go to that level of detail at the global scale. This is necessary to analyse them to have at the end a more global picture. Anyway, the study of McDonald et al (which was cited already) showed that those emissions decreased in all major U.S. cities (a bit less, but that's because of the different time range). Therefore the explicit mention of Chicago has been removed and the sentence is more general for the U.S.
27009	23	20	23	20	Residential heating (fossil fuel and wood burning) can also be a major source in cities, up to 50% in Paris in winter (Baudic et al., 2016, 10.5194/acp-16-11961-2016; Languille et al., 2020, 10.1016/j.scitotenv.2019.135055). It has been shown significant in many cities, like Athens (Kaltsonoudis et al., 2016, 10.5194/acp-16-14825-2016; Panopoulou et al;, 2018, 10.5194/acp-18-16139-2018), Beijing (Liu et al., 2017, 10.5194/acp-17-10633-2017), neighborhood of Helsinski (Hellen et al., 2008, 10.1016/j.scitotenv.2008.01.019 [Eric Brun, France]	Taken into account. Discussion of anthropogenic NMVOC emissions is provided in section 6.2.1
128145	23	29	23	30	"... and negative trends over northeastern U.S. cities.": Over what time period? [Trigg Talley, United States of America]	Taken into account, the period has been specified.

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72467	23	34	23	34	Change reference to De Smedt et al. (2015) [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account, the way the bibliographical references appear in the FGD are thoroughly checked.
72469	23	37	23	37	Change reference to Wang et al. (2015) [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account, the way the bibliographical references appear in the FGD are thoroughly checked.
13477	23	40	23	40	The close parenthesis is duplicated. [Maria Amparo Martinez Arroyo, Mexico]	Editorial. The report will undergo professional copy-editing prior to publication. This type of issue will be fixed then.
128147	23	42	23	43	"e.g. the Houston area (-2.2% yr-1 according to Zhu et al., 2017) and the Alberta oil sands (-3.8% yr-1)". Over what time period? [Trigg Talley, United States of America]	Taken into account, the period has been specified.
8363	23	47	23	47	6.2.2.3 lacks a summary statement on the collective evidence of our understanding of levels, distributions and trends of NMVOCs and how this would effect ERF. [Frank Dentener, Italy]	Accepted, a summary statement has been added
21961	23	47	23	47	Remaining subsections of this section have closed with an assessment finding whereas this does not. Suggest to be consistent. [Peter Thorne, Ireland]	Accepted, a summary statement has been added
103377	23	47	23	47	6.2.2.3 lacks a summary statement on the collective evidence of our understanding of levels, distributions and trends of NMVOCs and how this would affect ERF. [Philippe Tulkens, Belgium]	Accepted, a summary statement has been added
45905	23	50			Section 6.2.2.4: Why not discuss CH4 first? [Twan van Noije, Netherlands]	Accepted. Former section 6.2.2 is reorganized to section 6.3. CH4 is discussed first in section 6.3.1
72471	23	52	23	52	Insert 'radiation' before ([Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account. The introduction to this section is shortened as the influence of methane on climate is already introduced in section 6.1
128149	23	52	23	52	Missing word "radiation" [Trigg Talley, United States of America]	Taken into account. The introduction to this section is shortened as the influence of methane on climate is already introduced in section 6.1
16555	23	52	23	52	And it absorbs the near-infrared too - the main point of the Etiminan paper. [William Collins, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account. The introduction to this section is shortened as the influence of methane on climate is already introduced in section 6.1
21965	23	52	23	52	This statement does not reflect the new since AR5 insights around a SW effect by one of the CLAs! This clearly needs rectifying. [Peter Thorne, Ireland]	Accepted - see response to #16555
113945	23	53	22	53	You may delete "of its emissions" [Jan Fuglestvedt, Norway]	Accepted - see response to #16555
32047	24	3			Can probably cite 2019 number by the time this is edited. [Euan G. Nisbet, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - 2019 number from Chapter 2 is cited
16557	24	4	24	4	Either give the AR4 to AR5 time period dates, or express in terms of ppb/year. [William Collins, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account. This detail is removed.
32049	24	5			largely driven by anthropogenic activities??? That is likely but not confidently certain, as the isotopic shift suggests it is biogenically-driven, and the tropical wetlands seem to be responding strongly to warming and rainfall. It is very hard to distinguish between methane from more tropical cows and intensification of tropical wetlands in the same region, with cows in the swamps anyway. And is the warming and wetting of wet tropical wetlands anthropogenic... [Euan G. Nisbet, United Kingdom (of Great Britain and Northern Ireland)]	Noted - this statement is based on the assessment in Chapter 5
21967	24	7	24	8	I think it important to note here that the eventual result of this oxidation is production of CO2 and H2O. It is a common misconception that methane removal is harmless whereas actually a lot of the removal is via the production of CO2. [Peter Thorne, Ireland]	Rejected - this is conveyed in the introduction in section 6.1
72473	24	8	24	8	Capital 'T' for 'troposphere'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Rejected, does not correspond to IPCC standards.
128151	24	9	24	10	More accurately, "the methane chemical lifetime due to tropospheric OH." [Trigg Talley, United States of America]	Accepted - text revised
72475	24	13	24	13	Capital 'S' for 'stratosphere' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Rejected, does not correspond to IPCC standards.
103379	24	18	24	18	recommend to use the word residence time as it considers also physical [Philippe Tulkens, Belgium]	Rejected. Lifetime and residence time are used interchangeably in the literature

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
32051	24	23			This discussion relies on fairly old citations and should cite Naus, Stijn, et al. "Constraints and biases in a tropospheric two-box model of OH." Atmospheric Chemistry and Physics 19.1 (2019): 407-424 and also Nicely, Julie M., et al. "Quantifying the causes of differences in tropospheric OH within global models." Journal of Geophysical Research: Atmospheres 122.3 (2017): 1983-2007. Maybe also Zhao, Yuanhong, et al. Inter-model comparison of global hydroxyl radical (OH) distributions and their impact on atmospheric methane over the 2000–2016 period Atmospheric Chemistry and Physics 19.21 (2019): 13701-13723 and Wild, Oliver, et al. "Global sensitivity analysis of chemistry-climate model budgets of tropospheric ozone and OH: Exploring model diversity." Atmospheric Chemistry and Physics (2020). The statement on page 5 said with high certainty that OH is not doing anything much, and I think that is perhaps largely the case as it is well buffered, but that would be much disputed by Turner et al in the Harvard group, who call for huge shifts in OH. Yes, I think they are seriously wrong, but these are highly cited papers and should not just be ignored. Turner, Alexander J., et al. "Ambiguity in the causes for decadal trends in atmospheric methane and hydroxyl." Proceedings of the National Academy of Sciences 114.21 (2017): 5367-5372. Also should probably cite Rigby, Matthew, et al. "Role of atmospheric oxidation in recent methane growth." Proceedings of the National Academy of Sciences 114.21 (2017): 5373-5377. [Euan G. Nisbet, United Kingdom (of Great Britain and Northern Ireland)]	Noted- these are discussed in Section 6.2.3
51251	24	24	24	24	The term “methane perturbation lifetime” is not an easily understand term. What does it mean? Suggest this is simplified. [Jolene Cook, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text is simplified
18267	24	25	24	26	Since the ratio s depends on time and mixing ratio units, it would be clearer if the units were given with the equations. It is also not clear whether [CH4] is a concentration or a mixing ratio. [Yann Cohen, France]	Taken into account - text is simplified
128153	24	27	24	27	"OH-lifetime sensitivity of 0.31+/-0.04". It's not clear what this value is. Is the "sensitivity" "s" in line 25? [Trigg Talley, United States of America]	Taken into account - text is simplified
128155	24	27	24	27	Define "OH-lifetime sensitivity" and relationship to quantities defined above. [Trigg Talley, United States of America]	Taken into account - text is simplified
21969	24	34	24	34	The repetition of the number and range isn't necessary. [Peter Thorne, Ireland]	Taken into account, text revised.
103381	24	36	24	36	I miss a summary statement on CH4. What are the important climate relevant aspects that need to be brought to ES (there are such statements only for Nox and CO, but not for NMVOC and CH4 [Philippe Tulkens, Belgium]	Noted - ES statement for methane is in Chapter 5.
104795	24	41	24	44	May be it is better to list the properties of ozone according to its height. Limiting UV, important greenhouse gas, OH, and surface pollutant. [Tobias Schad, Germany]	Not applicable. Text is revised and shortened for conciseness. Properties of ozone are already mentioned in section 6.1 hence not repeated here
72477	24	42	24	42	Capital 'T' for troposphere. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial. The report will undergo professional copy-editing prior to publication. This type of issue will be fixed then.
72479	24	44	24	44	Capital 'S' for 'stratosphere' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial. The report will undergo professional copy-editing prior to publication. This type of issue will be fixed then.
104793	24	44	24	48	Full stop after stratosphere and then listing concentrations within troposphere [Tobias Schad, Germany]	Editorial. The report will undergo professional copy-editing prior to publication. This type of issue will be fixed then.
72481	24	45	24	45	Capital 'T' for troposphere. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial. The report will undergo professional copy-editing prior to publication. This type of issue will be fixed then.
77513	24	45	24	48	Distinction should be made between stratospheric ozone and ground level ozone. What are the units used to underpin the statement about 90% of O2 being in the stratosphere? [Emer Griffin, Ireland]	Not applicable. Sentence was removed.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
77515	24	45	24	48	This section is not clear and could be useful split into two sections. [Emer Griffin, Ireland]	Take into account. This section has been split into tropospheric and stratospheric ozone
72483	24	46	24	46	Capital 'T' for 'troposphere'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial. The report will undergo professional copy-editing prior to publication. This type of issue will be fixed then.
72485	24	48	24	48	Capital 'T' for 'troposphere'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial. The report will undergo professional copy-editing prior to publication. This type of issue will be fixed then.
128157	24	48	24	50	It seems confusing that authors give a range of a few hours in the troposphere to "up to several" (read: 3) or 21 days in the UT - then say the global average lifetime is >23 days. [Trigg Talley, United States of America]	Taken into account. Text was revised to "The CMIP6 multimodel ensemble estimate of the global mean lifetime of ozone for present day conditions is 25.5 ± 2.2 days (Griffiths et al., 2020) which is within the range of previous multi-model estimates (Stevenson et al., 2006; Young et al., 2013), indicating a high level of confidence."
128159	24	48	24	50	This is really short-hand for talking about the lifetime of the odd-oxygen family, or the *effective* lifetime of ozone. [Trigg Talley, United States of America]	Taken into account. Text was revised to "The CMIP6 multimodel ensemble estimate of the global mean lifetime of ozone for present day 16 conditions is 25.5 ± 2.2 days (Griffiths et al., 2020) which is within the range of previous multi-model 17 estimates (Stevenson et al., 2006; Young et al., 2013), indicating a high level of confidence."
72487	24	49	24	49	Capital 'T' for 'troposphere'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial. The report will undergo professional copy-editing prior to publication. This type of issue will be fixed then.
74049	24	49	24	50	The very comprehensive paper Monks et al. (2015a) focusses on surface sources, though others are inlcuded as well. Anyway, upper tropospheric ozone is not so much in the focus. On the other hand we analysed the ozone lifetime for aviation produced ozone. Fig. 9 of Grewe et al (2014) more indiates a e-folding time of up to several month, instead of weeks. Grewe, V., Frömming, C., Matthes, S., Brinkop, S., Ponater, M., Dietmüller, S., Jöckel, P., Garny, H., Dahlmann, K., Tsati, E., Søvde, O. A., Fuglestvedt, J., Berntsen, T. K., Shine, K. P., Irvine, E. A., Champougny, T., and Hullah, P.: Aircraft routing with minimal climate impact: The REACT4C climate cost function modelling approach (V1.0), Geosci. Model Dev. 7, 175-201, doi:10.5194/gmd-7-175-2014, 2014. [Volker Grewe, Germany]	Taken into account. Text was revised to "The CMIP6 multimodel ensemble estimate of the global mean lifetime of ozone for present day 16 conditions is 25.5 ± 2.2 days (Griffiths et al., 2020) which is within the range of previous multi-model 17 estimates (Stevenson et al., 2006; Young et al., 2013), indicating a high level of confidence."
77517	24	50	24	52	Is stratospheric ozone being included as a SLCF? [Emer Griffin, Ireland]	Yes and we made it clearer in the FGD.
72489	24	51	24	51	Capital 'S' for 'stratosphere' x2 [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial. The report will undergo professional copy-editing prior to publication. This type of issue will be fixed then.
72491	24	52	24	52	Capital 'S' for 'stratosphere' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial. The report will undergo professional copy-editing prior to publication. This type of issue will be fixed then.
103383	24	55			" … where observed surface ozone concentrations …" [Philippe Tulkens, Belgium]	Accepted: text revised
72493	25	2	25	2	Capital 'S' for 'stratosphere' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial. The report will undergo professional copy-editing prior to publication. This type of issue will be fixed then.
72495	25	2	25	2	Capital 'T' for 'troposphere'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial. The report will undergo professional copy-editing prior to publication. This type of issue will be fixed then.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
106399	25	6	25	6	assessment rather than assessement [Hamza Merabet, Algeria]	Accepted and revised accordingly.
38041	25	6	25	23	Sometimes the acronym is in the parenthesis, sometimes the full name is in the parenthesis. It seems better to have the consistent usage. [Junhee Lee, Republic of Korea]	Taken into account. Acronyms are defined clearly
128161	25	8	25	12	Give CMIP6 year-2000 ozone burden (311 Tg, according to Table 6.3) in text here. Why so inconsistent with ACCMIP/ACCENT and TOAR? The ozone burden values in Table 6.3 are not consistent with those shown in Figure 6.6 (presumably because they are from 2 models versus 3 models?). [Trigg Talley, United States of America]	Taken into account. Table 6.3 was revised with more CMIP6 simulations. To avoid interannual variability from year to year a ten year window was used for the near present period (2005-2014) instead of the single year 2000.
82327	25	10	25	10	Tropospheric ozone burden in year 2000 from CMIP6 models should also be given here for comparison. [Guang Zeng, New Zealand]	Accepted and revised accordingly.
128163	25	11	25	11	"103+/-21" needs units [Trigg Talley, United States of America]	Taken into account, text revised.
27011	25	15	25	15	We suggest to reference Schultz et al;, 2017 10.1525/elementa.244 [Eric Brun, France]	Rejected. Not applicable. We have referenced appropriate TOAR papers where applicable
17933	25	16	25	19	Although the total 60N-60S tropospheric ozone burden in the models is similar to satellite products, there are regional biases in these models (i.e. models overestimate ozone in the Northern Hemisphere and underestimate it in the Southern Hemisphere). This is noted later on p.27 line 31-33, but I think it is an important point to discuss when initially comparing the global ozone burdens. [Laura Revell, New Zealand]	Taken into account, text revised.
8365	25	18	25	18	recommend to use the word residence time as it considers also physical [Frank Dentener, Italy]	Lifetime and residence times are used interchangeably in the literature
18269	25	18	25	19	I don't manage to understand precisely: why is the ozone budget derived from ACCMIP models different from what is indicated in Tab. 6.3? I don't find 299 Tg in this table. Maybe it is during a different period? It would be clearer with an explanation about it. [Yann Cohen, France]	Taken into account. Values are clarified in the table.
72497	25	21	25	21	Capital 'T' for 'troposphere'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial. The report will undergo professional copy-editing prior to publication. This type of issue will be fixed then.
27013	25	21	25	22	There is a clear agreement between model with one of IASI estimates (IASI-FORLI), but greater differences with respect to other observational data such as IASI-SOFRID and OMI-RAL. This comparison should be more critical and not only mention closer agreements. [Eric Brun, France]	The Table was revised with the observations considered altogether and not separately. If we consider all observations for 60N-60S we have a mean estimate of 302+-12 Tg. If we consider the available obs for 90N-90S we have an estimate of 335+-3 (TOST and IASI-FORLI). The individual measurements are discussed in the relevant reference of Gaudel et al., 2018.
45907	25	24	25	24	Correct "presend-day". [Twan van Noije, Netherlands]	Editorial. The report will undergo professional copy-editing prior to publication. This type of issue will be fixed then.
128165	25	24	25	24	"presend" --> "present" [Trigg Talley, United States of America]	Editorial. The report will undergo professional copy-editing prior to publication. This type of issue will be fixed then.
128167	25	27	25	27	Clarify years for which this ozone burden estimate is calculated. Is this just the TOAR estimate? Why give just a model-bvased estimate in this summary statement, rather than a combined model-obs estimate? [Trigg Talley, United States of America]	Accepted. The number of TOAR estimate of ozone burden for 2000 was removed from this sentence.
28523	25	28	25	29	Short discussion is recommended here about ozone loss rates arising from tropospheric halogen chemistry, which is always missing from conventional chemistry climate models, corresponding to a sentence claiming the notable impacts on tropospheric ozone in the end of section 6.2.2.9.4 VSLSs. [Hiroshi Tanimoto, Japan]	Accepted and revised accordingly. We added: However, studies with single models have shown that the halogen chemistry, which is typically neglected from model chemistry schemes in CCMs, may have a notable impact on the ozone budget, as halogens, particularly of marine origin, take part in efficient ozone loss catalytic cycles in the troposphere (Saiz-Lopez et al., 2012; Sarwar et al., 2015; Sherwen et al., 2016)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
16559	25	34	25	34	In table 6.3 and associated text it is difficult to compare global and 60N-60S numbers. Since ACCMIP has number for both, the observations could be scaled up to give pseudo-global burdens. There is also an argument that the "observations" section of the table isn't useful since they are shown graphically in figure 6.6. anyway. [William Collins, United Kingdom (of Great Britain and Northern Ireland)]	Accepted. Table 3 has been revised.
45909	25	34			Table 6.3: Please indicate if all model estimates are based on the same tropopause definition (WMO thermal tropopause versus 150 ppb O3 definition adopted in recent model intercomparisons). [Twan van Noije, Netherlands]	Taken into account (discussed in the text).
8367	25	36	25	36	I miss a summary statement on CH4. What are the important climate relevant aspects that need to be brought to ES (there are such statements only for Nox and CO, but not for NMVOC and CH4 [Frank Dentener, Italy]	This refers presumably to 6.2.2.1 and not Table 3.
28519	25	39	25	39	The range from ONLY two models from CMIP6 does not provide much information. [Hiroshi Tanimoto, Japan]	Table 6.3 was revised with more CMIP6 simulations. To avoid interannual variability from year to year, a ten year window was used for the near present period (2005-2014) instead of the single year 2000.
28521	25	39	25	39	It would be better to summarize observational results into one or two rows to show ranges of multiple satellite products. [Hiroshi Tanimoto, Japan]	Accepted and revised accordingly.
35731	25	39	25	39	Use published sources [Carlos Antonio Poot Delgado, Mexico]	Accepted.
82329	25	39	25	39	Table 6.3: tropospheric ozone burden of 311Tg for "CMIP6 year 2000" is not consistent with Figure 6.6 (~340Tg). Figure 6.6 shows 3 models but there are only 2 models indicated in the table. Please make it consistent. [Guang Zeng, New Zealand]	Table 6.3 was revised with more CMIP6 simulations. To avoid interannual variability from year to year a ten year window was used for the near present period (2005-2014) instead of the single year 2000.
82331	25	39	25	39	Table 6.3: ozone budget numbers for the period of 2010-2014 are not shown by Griffiths et al. There are 3 models used in that paper, which is inconsistent with the 2 models indicated in the table. Again, consistency is needed here. [Guang Zeng, New Zealand]	Table 6.3 was revised with more CMIP6 simulations. To avoid interannual variability from year to year a ten year window was used for the near present period (2005-2014) instead of the single year 2000.
20369	26	5	26	23	Figure 6.6: The text of section 6.2.2.5.1 should mention why simulations show the tropospheric ozone burden to stabilize throughout the 21th century. [philippe waldteufel, France]	The discussion of future changes in tropospheric ozone burden can be found in 6.6.1.1
128169	26	12	26	12	Subject-verb agreement problem. [Trigg Talley, United States of America]	Accepted and revised accordingly.
72499	26	26	26	26	Change 'is' to 'are' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted and revised accordingly.
128171	26	26	26	26	Subject-verb agreement problem. [Trigg Talley, United States of America]	Taken into account. Sentence has been revised.
77519	26	26	26	26	This was stated in a clear manner earlier. [Emer Griffin, Ireland]	Taken into account. Sentence has been revised.
24403	26	28	27	6	The text is essentially a copy of the summary statement on tropospheric ozone from Chapter 2, which I worked on. However, the text reported here is an older version and it does not reflect the revised summary statement of Section 2.2.5.3, which now reads: “In summary, limited available isotopic evidence constrains the global tropospheric ozone increase to less than 40% between 1850 and 2005 (low confidence). When compared to sparse historical surface/low altitude data representative of the mid-20th century, tropospheric ozone has increased by 30-70% across the Northern Hemisphere (medium confidence). Surface ozone trends since the mid-1990s are variable at northern mid-latitudes, but positive in the tropics (2-17 % per decade) (high confidence). Since the mid-1990s, free tropospheric ozone has increased by 2-7 % per decade in most regions of the northern mid-latitudes, and 2-12 % in the sampled regions of the northern and southern tropics (high confidence). Ozone increases in southern mid-latitudes were less than 5 % (medium confidence).” Please update accordingly. [Owen Cooper, United States of America]	Taken into account. Text has been revised to eliminate overlap
113947	27	1	27	9	Here you use confidence statements, but it is unclear what the use of these are building on [Jan Fuglestvedt, Norway]	Taken into account. See response to #24403

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72501	27	2	27	2	Change to 'Northern Hemisphere' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable. Text is revised and shortened for conciseness.
72503	27	2	27	2	Capital 'T' for 'tropics'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial, treated.
27015	27	8	27	8	This is not consistent with some of the observational estimates devired from satellite data by Gaudel et al. (2018). It is the case of IASI-derived estimates of tropospheric ozone trends in the troposphere (most sensitive in the free troposphere) which shows mostly negative trends in the last decade (Gaudel et al., 2018). However, other satellite derived trends of tropospheric ozone are positive (such as those OMI). Such indication of the current knowledge of recent trends should be provided. [Eric Brun, France]	Figure 6.7 depicts the same surface and lower free tropospheric ozone trends (based on situ observations) as shown in Figure 2.8(a), with the exception that the data in Figure 6.7 are shown in map view. The purpose of Figure 6.7 is to build on Figure 2.8 and show the regions of the surface/lower troposphere where long-term (1994-2016) ozone trends differ. The IASI satellite instrument cannot report ozone trends for the surface over the period 1994-2016. IASI quantifies tropospheric column ozone, weighted towards the mid-troposphere, and the instrument is not sensitive to surface ozone. The IASI time series reported by Gaudel et al. [2018] was limited to 2008-2016, and therefore cannot be compared to the in situ ozone observations that extend back to 1994. The IASI results reported by Gaudel et al. [2018] were from new products that had not yet been closely evaluated against other satellite products; as a result Gaudel et al. [2018] could not provide an explanation as to why the IASI products showed decreases over 2008-2018, while the OMI products and the global ozonesonde products showed increases. Subsequent analysis of the IASI-FORLI product indicates a significant negative drift in the product that affects the trend calculation [Boynard et al., 2018]. Current work by the Tropospheric Ozone Assessment Report is trying to understand the causes of this drift and to further evaluate its impact on global ozone trends. At present we assess that the uncertainty on the IASI-FORLI product is too high in order to have confidence in the IASI
21971	27	15	27	15	Would it not be clear to say are globally heterogeneous? The current phrasing is confusing to me. [Peter Thorne, Ireland]	Not applicable. Text has been revised and shortened
128173	27	17	27	17	"require" --> "requires" [Trigg Talley, United States of America]	Not applicable. Text has been revised and shortened
74051	27	20	27	20	Not only recent, but also older studies have quantified the impact of climate varability (stratosphere, lightning, etc) on tropospheric ozone. Grewe (2007) for exampe used a dedicated attribution technique to analyse the impact of natural variability patterns from stratospheric dynamics, lightning, etc. to tropospheric ozone (see e.g. Fig 6b in that paper). It would be a nice opportunity to also highlight that in addition to more and more complex modelling adequate diagnostics are required. (see my comment to the box above). Grewe, V., Impact of climate variability on tropospheric ozone, Science of The Total Environment, 374, 167-181, 2007. [Volker Grewe, Germany]	Not applicable. Text has been revised and shortened
106401	27	20	27	20	repetition of the word scale [Hamza Merabet, Algeria]	Not applicable. Text has been revised and shortened
21973	27	20	27	20	clearer to say both globally (refs) and regionally (refs) [Peter Thorne, Ireland]	Not applicable. Text has been revised and shortened

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93517	27	20	27	22	Williams et al. (2019) [Williams, R. S., M. I. Hegglin, B. J. Kerridge, P. Jöckel, B. J. Latter, and D. A. Plummer, Characterising the seasonal and geographical variability of tropospheric ozone, stratospheric influence and recent changes, Atmos. Chem. Phys., 19, 3589-3620, https://doi.org/10.5194/acp-19-3589-2019, 2019.], using two chemistry-climate models in specified dynamics mode show that STE contributes up to 25-30% of the overall observed trends in tropospheric ozone. Another study that should be highlighted in this context is in addition Lin et al. (2014) [Lin, M., Horowitz, L. W., Oltmans, S. J., Fiore, A. M., and Fan, S.: Tropospheric ozone trends at Mauna Loa Observatory tied to decadal climate variability, Nat. Geosci., 7, 136–143, https://doi.org/10.1038/NGEO2066, 2014.]. This paper shows that indeed North American trends in surface ozone cannot be explained without accounting for the changing contribution in STE. [Michaela Hegglin, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable. Text has been revised and shortened
28503	27	23	27	23	Okamoto et al. 2018 paper is cited, but missing in the Reference list, though it was in the previous version. [Hiroshi Tanimoto, Japan]	Not applicable. Text has been revised and shortened
72505	27	26	27	27	References should be in chronological order. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable. Text has been revised and shortened
27017	27	27	27	27	Please add to this list the following study on ozone trendsr: Dufour, G., Eremenko, M., Beekmann, M., Cuesta, J., Foret, G., Fortems-Cheiney, A., Lachatre, M., Lin, W., Liu, Y., Xu, X., Zhang, Y. (2018). Lower tropospheric ozone over the North China Plain: variability and trends revealed by IASI satellite observations for 2008–2016. Atmospheric Chemistry and Physics, 18(22), 16439-16459. [Eric Brun, France]	Not applicable. Text has been revised and shortened
72507	27	29	27	29	Clumsy English. I suggest 'The skill of models in simulating…' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable. Text has been revised and shortened
72509	27	32	27	32	Change to 'Northern Hemisphere' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	editorial - treated
72511	27	33	27	33	Change to 'Southern Hemisphere' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	editorial - treated
72513	27	33	27	33	Capital 'T' for 'troposphere'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Rejected, does not correspond to IPCC standards.
8369	27	37	27	47	This section contains most of the material for a summary statement on trop. Ozone, but could include some of the earlier trend info from obs and models in a synthetic way. The conclusions of the Yeung paper (<40 % increase) are challenged by a following (submitted) paper referenced in chapter 2. [Frank Dentener, Italy]	Rejected. Gromov paper was not accepted by January 31, 2021, hence not cited here.
103385	27	37	27	47	This section contains most of the material for a summary statement on trop. Ozone, but could include some of the earlier trend info from obs and models in a synthetic way. The conclusions of the Yeung paper (<40 % increase) are challenged by a following (submitted) paper referenced in chapter 2. [Philippe Tulkens, Belgium]	See response to #8369
45911	27	40	27	42	What are the implications of the underestimate of the pre-industrial fire emissions in this context? [Twan van Noije, Netherlands]	Not applicable. Text is revised and shortened for conciseness
113949	27	42	27	47	This attribution part is useful, and I hope you will have more studies to build on for this - and that you will do an assessment of the knowledge. [Jan Fuglestvedt, Norway]	taken into account. Attribution to emissions is considered in section 6.4.2
21975	27	44	27	45	I assume the percentages reported here come with uncertainties and those should be reported here to avoid undue certainty being implied. [Peter Thorne, Ireland]	Not applicable. Text is revised and shortened for conciseness
16561	27	44	27	46	Thornhill et al. (submitted) also attributes ozone RF to precursors. The Thornhill study is used in 6.3.1.1 [William Collins, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account in section 6.4.2
35397	27	45	27	45	An additional sentence is needed following the Stevenson et al., (2013) reference: However, the NOx contribution to tropospheric O3 RF has a significant uncertainty due to uncertainty in LNOx emissions. A factor of four LNOx uncertainty translates to a factor of nearly three in net radiative flux at the tropopause attributable to ozone (Liaskos et al., 2015, JGR). [Kenneth Pickering, United States of America]	Not applicable. Text is revised and shortened for conciseness
35733	27	45	27	45	delete comma Stevenson et al., (2013) [Carlos Antonio Poot Delgado, Mexico]	Not applicable. Text is revised and shortened for conciseness

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45913	27	52			Figure 6.7: Please indicate which are the surface sites. [Twan van Noije, Netherlands]	The caption provides references for the surface sites.
113953	28	8	28	43	The section 6.2.2.5.2 on strat O3 is a summary and is very descriptive. Please develop this into more assessment and use confidence language [Jan Fuglestvedt, Norway]	Taken into account. This section is revised and shortened for conciseness.
103387	28	9	28	11	This sentence implicitly expresses an expectation of ozone increase (recovery). However without context this is not clear. Suggest including sentences relating to ODS at the beginning of this paragraph, providing context to this and later text. [Philippe Tulkens, Belgium]	Taken into account. Text is revised and shortened.
8371	28	10	28	10	This sentence implicitly expresses an expectation of ozone increase (recovery). However without context this is not clear. I suggest to include a sentences relating to ODS at the beginning of this paragraph, providing context to this and later sentences [Frank Dentener, Italy]	Taken into account. Text is revised and shortened.
115551	28	13	28	13	how sure are we abeout this attribution due to the Antarctic ozone hole – could you add a citation? [Rolf Müller, Germany]	Not applicable. The sentence has been removed as it is repeated in Section 2.2.5.2.
115553	28	14	28	16	Note that the recovery is most notable in the September observations, not in the October observations (when the ozone hole is most pronounced) This statement here might be a bit too general [Rolf Müller, Germany]	Not applicable. Text has been revised and shortened
87663	28	17	28	17	The reference should be specifically to chapter 4 of WMO 2018, which is properly cited as Langematz & Tully et al. [Matthew Tully, Australia]	Not applicable. Text has been revised and shortened
87665	28	21	28	21	The reference should be specifically to chapter 3 of WMO 2018, which is properly cited as Braesicke & Neu et al. [Matthew Tully, Australia]	Not applicable. Text has been revised and shortened
87667	28	27	28	27	The reference should be specifically to chapter 3 of WMO 2018, which is properly cited as Braesicke & Neu et al [Matthew Tully, Australia]	Not applicable. Text has been revised and shortened
82981	28	27	28	29	Referring to the two cited studies, I think it would be worth mentioning that the reasons for the observed continue decline in lower-stratospheric ozone are still not clear and, as a consequence, models do not reproduce these trends (Ball et al., 2018). As well, as stated by Ball et al. (2019), it would be important to say that this decrease do not show an inefficacy of the Montreal Protocol, rather it highlights the interdependence of Earth system processes and, in particular, of atmospheric chemistry, suggesting that other mechanisms are at work ("mainly dynamical variability on long or short time scales") and offset the positive effects of the Montreal Protocol on stratospheric ozone recovery. [Susanna Strada, Italy]	Taken into account but final text has been revised and shortened.
87669	28	27	28	29	I would argue you are somewhat misrepresenting this. WMO 2018 did not find a significant negative trend. Only Ball's series of papers have found it. Szelag et al ACP 2019 find only a patchy negative trend at some latitudes, some seasons and in some datasets but not all. [Matthew Tully, Australia]	Taken into account but final text has been revised and shortened.
18273	28	28	28	28	"datastes" -> datasets [Yann Cohen, France]	Not applicable. Text has been revised and shortened
115555	28	28	28	28	If Ball et al. Is mentioned here there should also be a citation here to the corresponding study by Chipperfield et al 2018, GRL (as in Chap. 2) [Rolf Müller, Germany]	Taken into account but final text has been revised and shortened.
106403	28	28	28	28	datasets rather than datastes [Hamza Merabet, Algeria]	Not applicable. Text has been revised and shortened
72515	28	31	28	31	Insert 'of' after 'factor'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable. Text has been revised and shortened
87671	28	31	28	33	I found this a very strange comment. The negative trend in profile ozone 1979-1996 is quite well-established and defined - see the LOTUS report. I am not sure what latitude range you are talking about? I think I am misunderstanding what you mean but in the case you should rewrite for greater clarity. [Matthew Tully, Australia]	Not applicable. Text has been revised and shortened
80283	28	31	28	33	There has been a large effort of assessing the trends of vertically resolved ozone data sets at global scale, see SPARC/IO3C/GAW report on long-term ozone trends and unvertianties in the stratosphere (SPARC Report N°9, WCRP Report 17/2018), so the statement mentiioning a factor 3 between the trends is outdated and should be revised. [Sophie Godin-Beekmann, France]	Not Applicable, global ozone trends are assessed in chapter 2.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
16563	28	31	28	38	It would be useful if there could be an AR6 assessment here of the stratospheric ozone trends. For instance combining information from 2.2.5.2 with the studies listed here, and WMO 2018, to come up with an AR6 assessed trend that could be used in chapter 7. [William Collins, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account but final text has been revised and shortened.
83021	28	31	28	43	A distinction between the three observational ozone databases and the CMIP6 dataset should be made. The CMIP6 ozone dataset is a model result (Checa-Garcia et al. 2018). [Olaf Morgenstern, New Zealand]	Not applicable. Text has been revised and shortened
83023	28	31	28	43	Somewhere, perhaps here, the radiative forcing due to ozone-depleting substances should be discussed. This is different from the RF due to stratospheric ozone changes (which are also driven by other forcers such as CH4).. A new paper by Morgenstern et al., GRL, in review (https://www.essoar.org/doi/10.1002/essoar.10502742.1; an early version of the paper was uploaded to the AR6 literature collection in 2019) evaluates the RF due to ozone depletion by ODSs and finds it more substantial than the central estimate of AR5. [Olaf Morgenstern, New Zealand]	Taken into account but final text has been revised and shortened.
72517	28	33	28	33	Replace),(with ; [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted and revised accordingly.
128175	28	33	28	36	Clarify: Do the RF values cited here represent the *changes* in RF from strat ozone from 1979 to 1996 (consistent with the observational trends) or total strat O3 RF (versus PI)? [Trigg Talley, United States of America]	This is now clarified in the revised version. The modelled RF value is estimated from pre-industrial (1850-1860) to present-day (2000-2014)
80027	28	34	28	43	Generally, the stratospheric ozone forcing is calculated as the stratosphere-adjusted forcing via the FDH approximation (e.g. Checa-Garcia), whereas the ERF values quoted in the IPCC for other forcing agents is quantified using a different methodology (fixed SST I presume). Hence, how are the RF values of ozone translated into ERF? Otherwise, it should be specifically emphasized here that the RF from ozone isn't directly comparable with the ERF of other forcing agents. From what I see, values from papers using the RF rather than the ERF definition are cited here, so I am not sure that consistency is ensured here. If it isn't, this caveat should be mentioned. [Gabriel Chiodo, Switzerland]	Taken into account. Ozone forcing calculations are detailed in Chapter 7.
115557	28	36	28	36	unclear what is meant by overall here – idow you mean the mean of the three numbers? [Rolf Müller, Germany]	It is the mean and revised in the text.
128177	28	36	28	36	Remove the word "forcing." It is confusing in this context. [Trigg Talley, United States of America]	Not applicable. Text is revised and shortened. Forcing is not discussed in the abundance section
80029	28	36	28	40	The similarity in the DU change in Checa-Garcia and the Keeble studies are not surprising, given that they both used the same data source (CMIP6), so I frankly don't see the point in the comparison between the two. Hence, I'd remove the sentence "A similar decrease..." unless more details concerning the differences between the data used in these studies (i.e. did Checa-Garcia perhaps just use a limited portion of CMIP6 models to derive the ozone forcing…?) [Gabriel Chiodo, Switzerland]	Taken into account but final text has been revised and shortened.
128179	28	36	28	40	Not clear from context that the first sentence refers to the input data used by models not simualting (strat) ozone internally, while the second refers to the output of models simulating ozone. [Trigg Talley, United States of America]	Not applicable. Text is revised and shortened. Forcing is not discussed in the abundance section
72519	28	40	28	40	A negative decrease is an increase. Delete the negative sign. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable. Text is revised and shortened.
115559	28	40	28	40	check if the paper has been published [Rolf Müller, Germany]	Taken into account. Paper has been published.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
93519	28	41	28	43	While this conclusion seems reasonable, this should be phrased differently since it is not based on a finding/scientific result, but on the assumption the authors make that there were no changes in the vertical distribution of ozone. As shown by Shepherd et al. (2014) stratospheric ozone loss can be masked by tropospheric ozone increases even if total column ozone remains constant (which would have consequences for the calculated RFs of tropospheric and stratospheric ozone respectively) [Shepherd, T. G., D. Plummer, J. Scinocca, M. I. Hegglin, C. Reader, V. Fioletov, E. Remsberg, T. von Clarmann, H. J. Wang, Reconciliation of halogen-induced ozone loss with the total-column ozone record, Nature Geoscience, 7 (6), 443–449, doi: 10.1038/NGEO2155, 2014.] [Michaela Hegglin, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable. Text is revised and shortened. Forcing is not discussed in the abundance section
77521	28	41	28	45	Significant trends are apparent but forcing remains the same. Why is this? [Emer Griffin, Ireland]	Not applicable. Text is revised and shortened. Forcing is not discussed in the abundance section
8373	28	42	28	43	Chapters 2 and 7 report –0.05 ± 0.10 W m–2 unchanged from AR5. The phrasing 'remains in the range' is somewhat vague, as also the other numbers quoted before would qualify for this. Suggest: remains unchanged from AR5 [–0.05 ± 0.10 W m–2] [Frank Dentener, Italy]	Not applicable. Text is revised and shortened. Forcing is not discussed in the abundance section
103389	28	42	28	43	Chapters 2 and 7 report –0.05 ± 0.10 W m–2 unchanged from AR5. The phrasing 'remains in the range' is somewhat vague, as also the other numbers quoted before would qualify for this. Suggest: remains unchanged from AR5 [–0.05 ± 0.10 W m–2] [Philippe Tulkens, Belgium]	Not applicable. Text is revised and shortened. Forcing is not discussed in the abundance section
19027	28	46	28	46	suggest to add OCS and DMS, they are also important for climate feedback [Mengze Li, Germany]	Taken into account. Emissions of DMS are assessed in Section 6.2.1.2 and feedbacks are assessed in Section 6.3.6
98657	28	46	28	46	I would recommend in general to update estimates of current model simulated aerosol species loads, optical properties from AeroCom phase III and AerChemMIP model simulations. EG Gliss et al 2020 ACPD [Michael Schulz, Norway]	Taken into account - reference has been added.
80285	28	46	30	48	I am surprised that there is no mention at all of the stratospheric sulfate aerosols injected by volcanic aerosols, that can have a large ERF (see for example Pinatubo). It is well known that recent moderate eruptions have increased the stratospheric aerosol load, with a detectable ERF. The chapter addresses the SRM geoengineering scheme (section 6.3.7) that precisely corresponds to such effect of stratospheric aerosols. [Sophie Godin-Beekmann, France]	Rejected - ERF due to volcanic sulfate aerosols are asses in Chapter 7
5181	28	46			section 6.2.2.6 This section is missing an advance since AR5 that there may be a moderately significant (circa -0.05 W m-2) radiative forcing from anthropogenic sulphate aerosol that reaches the stratosphere. I would rate it as still low confidence, but it is an important concept. [Daniel Murphy, United States of America]	Accepted - we had added the following text to note the contribution of anthropogenic SO2 to stratospheric aerosol layer "Majority of sulfate particles are formed in the troposphere, however, SO2 and other longer-lived natural precursors, such as OCS, transported into the stratosphere contribute to the background stratospheric aerosol layer (Kremser et al., 2016). SO2 emissions from volcanic eruptions are a significant source of stratospheric sulfate loading (see Chapter 2 for reconstruction of stratospheric aerosol optical depth and Chapter 7 for radiative forcing of volcanic aerosols). Furthermore, studies suggest contributions from anthropogenic SO2 emissions transported into the stratosphere with a consequent impact on radiative forcing. (Myhre et al, 2004; Yu et al. 2016) , however there is significant uncertainty in the relative importance of this stratospheric sulfate source (Kremser et al., 2016)."

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
5183	28	46			A paper since AR5 is Yu et al. (2016) Radiative forcing from anthropogenic sulfur and organic emissions reaching the stratosphere (https://doi.org/10.1002/2016GL070153). A previously underappreciated paper is Myhre, G., et al. (2004), The radiative effect of the anthropogenic influence on the stratospheric sulfate aerosol layer, Tellus B, 56(3), doi:10.1111/j.1600-0889.2004.00106.x. I can tell you that very recent data (that you can't cite because it isn't yet peer-reviewed) provide strong support for the concept of anthropogenic influence on stratospheric sulphate aerosol but will probably yield a smaller (less negative) quantitative estimate of the radiative forcing. [Daniel Murphy, United States of America]	Taken into account -see comment 5181
67925	28	47	30	21	Figure 6.8 includes mass concentration of PM2.5 aerosol components for different regions or countries: (a) and (b) North America (but only USA); (c) Europe; (d) East Asia; (e) Canada, South America, Africa, Asia and Middle East; (f) Others (field measurements) - South America, Africa, Asia and Oceania. It seems Mexico is excluded in this figure, although there have been several intensive field measurement studies conducted in the Mexico City Metropolitan Area (MCMA), providing comprehensive information about the composition of PM2.5 (and PM1) and other pollutants (see reference a-c below). It is worth noting that the PM2.5 concentration and fractional composition have not changed much between 1997-2006. Suggest including also a panel in Figure 6.8 showing the average composition of PM2.5 for the MCMA. (see e.g., Figure 12 in Reference (c) MILAGRO Campaign). [Luisa Molina, United States of America]	Taken into account, figure revised.
67927	28	47	30	21	References: (a) Chow, J. C., Watson, J. G., Edgerton, S. A., and Vega, E.: Chemical composition of PM2.5 and PM10 in Mexico City during winter 1997, Sci. Total Environ., 287, 177-201, 2002. https://doi.org/10.1016/S0048-9697(01)00982-2. (b) Molina, L. T., Kolb, C. E., de Foy, B., Lamb, B. K., Bruce, W. H., Jimenez, J. L., Ramos-Villegas, R., Sarmiento, J., Paramo-Figueroa, V. H., Cardenas, B., Gutierrez-Avedoy, V., and Molina, M. J.: Air quality in North America's most populous city-overview of MCMA-2003 Campaign, Atmos. Chem. Phys., 7, 2447-2473, https://doi.org/10.5194/acp-7-2447-2007, 2007. (c) Molina, L. T., Madronich, S., Gaffney, J. S., Apel, E., de Foy, B., Fast, J., Ferrare, R., Herndon, S., Jimenez, J. L., Lamb, B., Osornio-Vargas, A. R., Russell, P., Schauer, J. J., Stevens, P. S., Volkamer, R., and Zavala, M.: An overview of the MILAGRO 2006 Campaign: Mexico City emissions and their transport and transformation, Atmos. Chem. Phys., 10, 8697–8760, https://doi.org/10.5194/acp-10-8697-2010, 2010. [Luisa Molina, United States of America]	Noted
128181	28	48	28	51	It would be good to *briefly* note the sources of SO2. [Trigg Talley, United States of America]	Accepted - introductory text has been revised to "Sulphate aerosols are emitted directly or formed in the atmosphere by gas and aqueous phase oxidation of precursor sulfur gases, including SO2, DMS, and carbonyl sulphide (OCS), emitted from anthropogenic and natural sources (Section 6.2.1). "

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
17935	28	48	29	42	Given that DMS is mentioned elsewhere as a SLCF, why aren't studies examining DMS and its influence on sulfate aerosol formation included in section 6.2.2.6? There are several recent studies of relevance, including: 1) Chen, Q., Sherwen, T., Evans, M., and Alexander, B.: DMS oxidation and sulfur aerosol formation in the marine troposphere: a focus on reactive halogen and multiphase chemistry, Atmos. Chem. Phys., 18, 13617–13637, https://doi.org/10.5194/acp-18-13617-2018, 2018. 2) Fiddes, S. L., Woodhouse, M. T., Nicholls, Z., Lane, T. P., and Schofield, R.: Cloud, precipitation and radiation responses to large perturbations in global dimethyl sulfide, Atmos. Chem. Phys., 18, 10177–10198, https://doi.org/10.5194/acp-18-10177-2018, 2018. 3) Advanced modeling of dimethyl sulfide chemistry Erik Hans Hoffmann, Andreas Tilgner, Roland Schrödner, Peter Bräuer, Ralf Wolke, Hartmut Herrmann Proceedings of the National Academy of Sciences Oct 2016, 113 (42) 11776-11781; DOI: 10.1073/pnas.1606320113. 4) Mahajan, A. S., Fadnavis, S., Thomas, M. A., Pozzoli, L., Gupta, S., Royer, S., Saiz-Lopez, A., and Simó, R. (2015), Quantifying the impacts of an updated global dimethyl sulfide climatology on cloud microphysics and aerosol radiative forcing. J. Geophys. Res. Atmos., 120, 2524– 2536. doi: 10.1002/2014JD022687. [Laura Revell, New Zealand]	Rejected. This section discusses the historical evolution of sulfate aerosols. While DMS contributes to sulfate aerosol formation, it is not the primary driver of trends in atmospheric sulfate aerosols. We thank the reviewer for these citations, but do not add to this section
128183	28	49	28	50	"... and indirectly by the formation of clouds and precipitation." This wording reads as if aerosols form clouds and precipitation. How about: "and indirectly by influencing cloud micro- and macrophysical properties and precipitation." [Trigg Talley, United States of America]	Accepted - text revised
8375	28	50	28	51	Suggest: Sulphate aerosols and sulphate wet and dry deposition have a large impact on air quality and ecosystems [Frank Dentener, Italy]	Accepted - text revised
103391	28	50	28	51	Suggest: Sulphate aerosols and sulphate wet and dry deposition have a large impact on air quality and ecosystems [Philippe Tulkens, Belgium]	Accepted - text revised
72521	29	1	29	1	Change 'in' to 'into' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted
45915	29	2	29	4	This is statement relevant for all aerosol species, not just sulphate. [Twan van Noije, Netherlands]	Taken into account - addressed in section 6.3.5
30623	29	2	29	4	Assumed effective emission height in models also strongly affects the simulated aerosol distribution and forcing estimates (Yang, Y., Smith, S. J., Wang, H., Lou, S., & Rasch, P. J. (2019a). Impact of anthropogenic emission injection height uncertainty on global sulfur dioxide and aerosol distribution. Journal of Geophysical Research: Atmospheres, 124, 4812–4826. https://doi.org/10.1029/2018JD030001.) [Hong Liao, China]	Taken into account. Reference added
8377	29	4	29	8	It would be good to clarify better what has changed and why this is important. Something like: Production pathways of sulphate included in models now consider interactions with other acidic and alkaline components (such as nitrate, ammonium and mineral dust), resulting in higher/lower calculated conversion efficiency of SO2 to SO4 by xx percent. [Frank Dentener, Italy]	Accepted - text revised
103393	29	4	29	8	It would be good to clarify better what has changed and why this is important. Something like: Production pathways of sulphate included in models now consider interactions with other acidic and alkaline components (such as nitrate, ammonium and mineral dust), resulting in higher/lower calculated conversion efficiency of SO2 to SO4 by xx percent. [Philippe Tulkens, Belgium]	Accepted - text revised
45917	29	6	29	6	Change "influence" to "influences". [Twan van Noije, Netherlands]	Accepted - text revised
128185	29	6	29	6	"influence" --> "influences" [Trigg Talley, United States of America]	Accepted - text revised
35983	29	6	29	8	Some studies suggest that the influence of pH can be quite large see for example Turnock et al. 2019 doi:10.1029/2019GL082067 [Nicolas Bellouin, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised: "Some studies show that changes in cloudwater pH may have a significant impact on the radiative forcing(Turnock et al., 2019). "
72523	29	8	29	8	References should be in chronological order. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	editorial - protocol will be followed
45387	29	8	29	8	I could not find Cheng et al. 2016 and He et al. 2014 in the reference list. [Hitoshi Matsui, Japan]	Accepted - reference list updated

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
45919	29	8	29	8	Include reference to study by Nenes et al., 2020.: Aerosol pH and liquid water content determine when particulate matter is sensitive to ammonia and nitrate availability, Atmos. Chem. Phys., 20, 3249–3258, https://doi.org/10.5194/acp-20-3249-2020. [Twan van Noije, Netherlands]	Accepted - text revised
35735	29	8	29	8	Bibliographic citations in chronological order [Carlos Antonio Poot Delgado, Mexico]	editorial - protocol will be followed
128187	29	10	29	16	Need to mention explicitly that large declines in regional SO2 emissions are the root cause of the large observed decrease of sulfate (and SO2). [Trigg Talley, United States of America]	Taken into account. The restructuring of this section into separate SO2 and SO4 section makes this clearer
29577	29	10	29	32	It may be worth mentioning here that model assumptions about the effective injection height of SO2 emissions, which is not well quantified, may have a significant impact on model/observational comparisons (Yang, et al.. https://doi.org/10.1029/2018JD030001). [Steven Smith, United States of America]	Accepted
16565	29	10	29	32	There are lots of numbers given in this paragraph on SO2 which makes it difficult to pick out what the messages are. Could the numbers be put in a table and the text used to make assessed statements? [William Collins, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account - this section has been split into SO2 (under precursor gases) and sulphate (under aerosols). A Table has been created.
8379	29	16	29	17	Higher oxidation/more deposition: I think most readers will need some background information to understand the linkage to the presence of oxidants and linkage to co-deposition with NH3 (dry deposition). [Frank Dentener, Italy]	Taken into account -included explanation in parentheses: higher oxidation rate (hence more SO2 converted to SO42-)
103395	29	16	29	17	Higher oxidation/more deposition: I think most readers will need some background information to understand the linkage to the presence of oxidants and linkage to co-deposition with NH3 (dry deposition). [Philippe Tulkens, Belgium]	Taken into account -see comment 8379
72525	29	22	29	22	Remove the line break between numbers and units. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted
45921	29	23	29	23	Change "was" to "were". [Twan van Noije, Netherlands]	Accepted
72527	29	24	29	24	Insert space after % [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted
45923	29	34	29	34	Change "World" to lower case. [Twan van Noije, Netherlands]	Accepted
8381	29	34	29	34	It is not clear what is uncertain about the observations elsewhere in the world. The observations themselves (e.g.technique, representativity of location), their coverage (representativity for a larger region), or the temporal extent to derive trends. [Frank Dentener, Italy]	Taken into account -added some more clarification that it is mainly the number of sites which is the problem
128189	29	34	29	34	"World" --> "world" [Trigg Talley, United States of America]	Accepted -see comment 45923
103397	29	34	29	34	It is not clear what is uncertain about the observations elsewhere in the world. The observations themselves (e.g.technique, representativity of location), their coverage (representativity for a larger region), or the temporal extent to derive trends. [Philippe Tulkens, Belgium]	Taken into account -see comment 8381
35985	29	45	29	45	Thank you for that figure! Perhaps use arrow to connect the panel to regions on the map? [Nicolas Bellouin, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account, text revised.
72201	29	47	30	21	Figure 6.8 shows box plots with major PM2.5 chemical components throughout the world. The vast majority of the studies are located in North America and Europe. A recent study shows novel results of OC and EC in high-time resolved PM2.5 in the rapidly growing Megacity of Istanbul (Turkey). If possible, this study (Flores et al., (2020) Atmos Environ, 223, 117241) and other studies throughout the world, particularly in developing countries, should be included. [Flores Rosa, Turkey]	Noted. But priority has been given to data available through network database even if a huge effort to collect data from campaign has been done
19019	30	1	30	13	recent study shows that human ammonia emissions can be very high under high temperature or more skin exposure, this human-induced emission (count for ~5% of total ammonia emission) will be higher with the increasing climate, and human ammonia emission is mostly missing in models: You can find this study here: Mengze Li, Charles J. Weschler, Gabriel Bekö, Pawel Wargocki, Gregor Lucic, and Jonathan Williams Environmental Science & Technology 2020 54 (9), 5419-5428 DOI: 10.1021/acs.est.0c00094 [Mengze Li, Germany]	Taken into account. The section is divided into two separate, SO2 and SO4
81359	30	4	30	46	Why is SO2 only mentioned in the last sentence of this section? [Johannes Laube, Germany]	Taken into account, section rewritten.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
35987	30	26	30	32	Could point to figure 2.9(a) [Nicolas Bellouin, United Kingdom (of Great Britain and Northern Ireland)]	Reference added
128191	30	26	30	48	Line 30-31 implies a significant decrease of SO2 emissions from 1980 to 2000. But line 36 indicates a peak at 1990, not 1980. And line 42-43 states that SO2 increased from1850-2005. Improved consistency would be helpful, as well as a discussion of global burden trends post-2005. [Trigg Talley, United States of America]	Taken into account - Revised text to "an updated historical evolution of sulphate from pre-industrial times to present.."
8383	30	34	30	34	Evaluation of the evolution? What was found? The assessment needs to mention the regional limitation of ice-cores information, so that in quite some regions historic emissions can not be evaluated. [Frank Dentener, Italy]	Accepted -see comment 8383
21977	30	34	30	34	PD is not an acronym used generally elsewhere in the report thus far. Maybe juust say present? [Peter Thorne, Ireland]	Taken into account -see comment 128191
103399	30	34	30	34	Evaluation of the evolution? What was found? The assessment needs to mention the regional limitation of ice-cores information, so that in quite some regions historic emissions can not be evaluated. [Philippe Tulkens, Belgium]	Accepted
45925	30	35	30	35	Change "done" to "produced". [Twan van Noije, Netherlands]	Taken into account -see comments 45925
28525	30	35	30	35	What is "done"? [Hiroshi Tanimoto, Japan]	Accepted
128193	30	35	30	36	Delete "(i.e. the strongest negative forcing)." This parenthetical is out of place grammatically, and is also incorrect. Radiative forcing does not stricly scale with global burden. [Trigg Talley, United States of America]	Taken into account, text revised.
72529	30	37	30	37	This should be 'flatter' but it is still poor English. I would suggest 'less significant' or similar. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account -included "global" and a reflection of the regional differences
8385	30	37	30	37	global forcing? What about regional ones, also more flat? [Frank Dentener, Italy]	Taken into account -see comment 8385
103401	30	37	30	37	global forcing? What about regional ones, also more flat? [Philippe Tulkens, Belgium]	Taken into account. The section is restructured
8387	30	38	30	38	Is this still about SO2 emissions. [Frank Dentener, Italy]	Taken into account -deleted sentence since redundant
28527	30	39	30	39	Rewrite "weakening trend is even stronger " [Hiroshi Tanimoto, Japan]	Rejected. Not clear what statement is not documented
35737	30	39	30	39	Use published sources [Carlos Antonio Poot Delgado, Mexico]	All the publications cited in the FGD have been published before the 31st of January 2021.
8389	30	42	30	42	It is probably useful to provide also numbers for 1980-2015; consider harmonizing analysis periods with other parts of this report. Are updates to 2018 available. Note Chapter 2, will try have all numbers updated to 2019 at time of publishing the report. [Frank Dentener, Italy]	Rejected - amount reduction is given in next sentence and difficult to harmonize the analysis period since the analysis depends on published literature
72533	30	43	30	48	These details are unhelpful in their current form. Please quantify the amounts. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted
72531	30	44	30	44	Insert space after 2015. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted -see comment 72531
106405	30	44	30	44	a pace between 2015 and with [Hamza Merabet, Algeria]	Accepted, a space has been added.
21979	30	45	30	45	I assume both these percentages are in reality ranges due to uncertainties? The ranges should be quantified and reported accordingly. [Peter Thorne, Ireland]	Accepted, added.
8395	30	51	19	51	This section should refer back to section 6.2.2.1 Nox; as part of the O3 precursors section. However, as it is also important as aerosol precursor, it would be opportune to summarize the observed trends also in the aerosol context. [Frank Dentener, Italy]	Taken into account: this section has been split with NH3 under precursor gases (section 6.2.2.3.4) and nitrate and ammonium under aerosols (section 6.2.2.5.2). These sections refer back to emissions (section 6.2.1) and other appropriate sections on precursors now.
103403	30	51	32	8	This section should refer back to section 6.2.2.1 Nox; as part of the O3 precursors section. However, as it is also important as aerosol precursor, it would be opportune to summarize the observed trends also in the aerosol context. [Philippe Tulkens, Belgium]	Taken into account: this section has been split with NH3 under precursor gases (section 6.2.2.3.4) and nitrate and ammonium under aerosols (section 6.2.2.5.2). These sections refer back to emissions (section 6.2.1) and other appropriate sections on precursors now.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
128195	30	53	30	57	It would be good to include in this opening paragraph a brief note on the source of ammonia (e.g., is all of it directly emitted or can it form in the atmosphere? And what are the main sources?). [Trigg Talley, United States of America]	Taken into account: We have added the following sentence - "Ammonia is the most abundant alkaline gas in the atmosphere. Its present-day source is dominated by livestock and crop production (see Section 6.2.1)
20037	30	56	30	56	typo on "deposition" [philippe waldteufel, France]	Accepted: text revised
8391	30	56	30	56	Important for climate: N-deposition influences the uptake of carbon in ecosystem, and it contributes to indirect N2O emissions. [Frank Dentener, Italy]	Accepted: we have revised the text as follows "with impacts on climate, ecosystem functioning, and biodiversity (Sheppard et al., 2011, Flechard et al. 2020).
103405	30	56	30	56	Important for climate: N-deposition influences the uptake and release of carbon in ecosystem, and it contributes to indirect N2O emissions. [Philippe Tulkens, Belgium]	Accepted: we have revised the text as follows "with impacts on climate, ecosystem functioning, and biodiversity (Sheppard et al., 2011, Flechard et al. 2020).
72535	30	57	30	57	Delete , from before 'and' (not required in this context) [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	editorial - treated
128197	30	57	30	57	"NH4" --> "NH4+", "NO3" --> "NO3-" [Trigg Talley, United States of America]	Accepted: text revised
110841	30		32		Nitrate and ammonium are ions and their charges should be included when written as NO3- or NH4+. Similarly, sulfate should be written as SO42-, not SO4. [Claudia Steadman, United Kingdom (of Great Britain and Northern Ireland)]	Accepted
8393	31	2	31	2	Mention these estimates are based on models, as it is still difficult to use satellite for this. I think the magnitued of increase can be qualified as *uncertain* [Frank Dentener, Italy]	Accepted: we have revised the text to - "Global model simulated present-day NH3 burden is estimated to range from 0.04 to 0.7 TgN (Bian et al., 2017)"
128201	31	2	31	2	Is there really this much more uncertainty in the (observable) PD burden (factor of ~20) compared to the PI-to-PD change (factor of 3.5 uncertainty)? [Trigg Talley, United States of America]	Noted: indeed the model diversity in simulated present day ammonia burden is greater than the uncertainty in PI to PD change based on the cited studies.
103407	31	2	31	2	Mention these estimates are based on models, as it is still difficult to use satellite for this. I think the magnitude of increase can be qualified as *uncertain* [Philippe Tulkens, Belgium]	Accepted: we have revised the text to - "Global model simulated present-day NH3 burden is estimated to range from 0.04 to 0.7 TgN (Bian et al., 2017)"
128199	31	2	31	4	The second sentence implies that this estimate is model-based. Is that correct? Or is it somehow constrained by observations? [Trigg Talley, United States of America]	Taken in account: this estimate is based on model simulations with models being evaluated against observations.
89799	31	4	31	4	spelling mistake - scavenging not scavening [Peter Croot, Ireland]	Not applicable - scavenging has been replaced with deposition
45927	31	4	31	6	To what extent is this issue related to the fact that the observations may not be representative at the global models' spatial resolutions? [Twan van Noije, Netherlands]	Taken into account: we have revised this sentence as follows: Furthermore, global models severely underestimate surface NH3 concentrations (Bian et al., 2017) reflecting deficiencies in the process-level representation of NH3 in current global models and highlighting limitations in comparing site-specific observations with relatively coarse-resolution global models.
72537	31	17	31	17	Capital 'T' for 'troposphere'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Rejected, does not correspond to IPCC standards.
72539	31	17	31	17	Capital 'S' for 'stratosphere' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Rejected, does not correspond to IPCC standards.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
110843	31	18	31	22	"Recent increases in ammonia concentrations inferred from ground-based and space-borne platforms ... have been attributed to a decrease in the NH4:NH3 ratio associated with declining SO2 emissions rather than changes in NH3 emissions." While declining SO2 emissions do mean that one of the major sinks for ammonia has decreased, the NH3 emissions are also believed to be increasing (Sutton et al., 2013; Fowler et al., 2015). The increase in NH3 concentrations is therefore likely due to both a decrease in SO2 emissions and an increase in NH3 emissions. In particular, over the Indo-Gangetic Plain, a region of high ammonia concentrations, the increase is thought to be due to an increase in NH3 emissions, not a decrease in SO2 emissions. Also note there is an inconsistency in that on page 6-15 the text states that the increase in NH3 concentrations is attributed to the simultaneous decline in emissions of SO2 and NOx, whereas here only SO2 is mentioned. Sutton, Mark A., Stefan Reis, Stuart N. Riddick, Ulrike Dragosits, Eiko Nemitz, Mark R. Theobald, Y. Sim Tang, et al. “Towards a Climate-Dependent Paradigm of Ammonia Emission and Deposition.” Philosophical Transactions of the Royal Society of London B: Biological Sciences 368, no. 1621 (July 5, 2013). https://doi.org/10.1098/rstb.2013.0166. Fowler, D., C. E. Steadman, D. Stevenson, M. Coyle, R. M. Rees, U. M. Skiba, M. A. Sutton, et al. “Effects of Global Change during the 21st Century on the Nitrogen Cycle.” Atmos. Chem. Phys. 15, no. 24 (December 16, 2015): 13849–93. https://doi.org/10.5194/acp-15-13849-2015. [Claudia Steadman, United Kingdom (of Great Britain and Northern Ireland)]	Accepted: we have revised the text as follows - "Ground-based and space-borne observations show that NH3 concentration has been increasing in recent decades in the USA (Butler et al., 2016; Warner et al., 2016; Yu et al., 2018), western Europe (van Zanten et al., 2017; Warner et al., 2017, Wichink Kruit et al., 2017; Tang et al., 2018b), and China (Warner et al., 2017b; Liu et al., 2018). This trend has been attributed to a combination of increasing ammonia emissions (Sutton et al., 2013; Fowler et al., 2015) and decreases in the chemical reaction of NH3 with nitric and sulfuric acids associated with reductions in SO2 and NOx emissions depending on the region (Warner et al., 2017b; Yao and Zhang, 2019). "
35739	31	19	31	20	Bibliographic citations in chronological order and delete semicolon [Carlos Antonio Poot Delgado, Mexico]	editorial -treated
8397	31	24	31	24	.. Driven mainly by the reaction of Nh3 with SO4. Without increasing NH3 emissions the NH4 burden would not increase too much. The range of uncertainty is very similar to the one of NH3 (and derived from models not directly observed) Suggest: driven by increasing NH3 emissions, and facilitated by co-occurance of SO4 aerosol availability due to SO2 emissions. [Frank Dentener, Italy]	Taken into account - the first part of the sentence already highlights the importance of increasing NH3 emissions. We have revised the text as follows: The concomitant increases of NH3, SO2, and NOx emissions (see Section 6.2.1) have led to a factor of 3 to 9 increase in the simulated NH4+ burden from 1850 to 2000 (Hauglustaine et al., 2014; Lund et al., 2018), driven primarily by ammonium sulfate (70-90%).
103409	31	24	31	26	"Driven mainly by the reaction of NH3 with SO4": Without increasing NH3 emissions the NH4 burden would not increase too much. The range of uncertainty is very similar to the one of NH3 (and derived from models not directly observed) Suggest: driven by increasing NH3 emissions, and facilitated by co-occurance of SO4 aerosol availability due to SO2 emissions. [Philippe Tulkens, Belgium]	Taken into account - the first part of the sentence already highlights the importance of increasing NH3 emissions. We have revised the text as follows: The concomitant increases of NH3, SO2, and NOx emissions (see Section 6.2.1) have led to a factor of 3 to 9 increase in the simulated NH4+ burden from 1850 to 2000 (Hauglustaine et al., 2014; Lund et al., 2018), driven primarily by ammonium sulfate (70-90%).e (70-90%).
13479	31	26	31	26	Eliminate the extra space between "the" and "NH2". [Maria Amparo Martinez Arroyo, Mexico]	Accepted: text revised
72541	31	27	31	28	References should be in chronological order, [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	editorial -treated
35741	31	27	31	28	Bibliographic citations in chronological order [Carlos Antonio Poot Delgado, Mexico]	editorial - treated
128203	31	30	31	30	"SO4" --> "SO4 2-" [Trigg Talley, United States of America]	Accepted: text revised

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
5147	31	31	31	32	The statement that most NO3- forms on dust and sea salt is true but misleading in the context of this chapter. Such NO3- may be a majority of the MASS but most of the both the radiative impact and PM2.5 health impact are from fine mode NO3- (mostly ammonium nitrate) rather than dust and sea salt. [Daniel Murphy, United States of America]	Accepted: We have revised the text to highlight the importance of coarse nitrate for the budget of nitrate as follows: "Ammonium sulphate and ammonium nitrate aerosols are formed when NH3 reacts with nitric acid (HNO3) and sulfuric acid (H2SO4) produced in the atmosphere by the oxidation of NOx and SO2, respectively. Ammonium nitrate is formed only after H2SO4 is fully neutralized. NH4+ and NO3- aerosols produced via these gas-to-particle reactions are a major fraction of fine-mode particles impacting air quality and climate. Coarse-mode nitrate, formed by the heterogeneous reaction of nitric acid with dust and sea salt, dominates the overall nitrate burden but has little radiative impact (Hauglustaine et al., 2014, Bian et al., 2017). "
128205	31	35	31	35	"the fine nitrate burden". Do authors mean "fine mode"? (Also, "fine mode" and "coarse mode" should probably be defined somewhere in this chapter.) [Trigg Talley, United States of America]	Taken into account- yes we do mean the fine-mode. We now define fine mode in the introduction to aerosols section (6.2.2.5)
27019	31	39	31	40	The value reported here is only based on one reference, which has several limitations: - filter sampling has been used to measure particulate ammonium nitrate, and due to its semi-volatility, negative artefacts may occur. - The SPARTAN study was based on several sampling locations, but for instance, there were no sampling in Europe, where there are many densely polluted areas. To this respect, this value should not be representative of the mean global concentration of ammonium nitrate. Instead, the report should emphasize on the geographical variability of ammonium nitrate occuring worldwide (Zhang et al. 2007; Putaud et al., 2010 for Europe). [Eric Brun, France]	Accepted: text is revised as follows - "Ammonium nitrate is semi volatile, which results in complex spatial and temporal patterns in its concentrations (Putaud, (2010), Hand (2012), Zhang (2012)) reflecting variations in its precursors, NH3 and HNO3, as well as H2SO4, non-volatile cations, temperature and relative humidity (Nenes et al., 2020). High relative humidity and low temperature as well as elevated fine particulate matter loading (Huang 2014, Petit, 2015, Li 2016, Sandrini et al., 2016) favour nitrate production. Measurements reveal high contribution of NO3- to surface PM2.5 (>30%) in regions with elevated regional NOx and NH3 emissions, such as the Paris area (Beekman, 2015; Zhang et al., 2019), northern Italy (Masiol et al., 2015; Ricciardelli et al., 2017), Salt Lake City (Kuprov et al., 2014; Franchin et al., 2018), the North China Plains (Guo et al., 2014; Chen et al., 2016), and New Delhi (Pant et al., 2015). "
8399	31	39	31	40	The Snider paper is based on a limited set of observations from the Spartan network, which can hardly be called representative for all the world's polluted regions composition. In Europe and North America there are some more observations from the regulatory networks, which can be asssesed. Also important to notice the marked dependency on temperature and RH of aerosol NH4NO3, with consequences for ERF. [Frank Dentener, Italy]	Accepted: text is revised as follows - "Ammonium nitrate is semi volatile, which results in complex spatial and temporal patterns in its concentrations (Putaud, (2010), Hand (2012), Zhang (2012)) reflecting variations in its precursors, NH3 and HNO3, as well as H2SO4, non-volatile cations, temperature and relative humidity (Nenes et al., 2020). High relative humidity and low temperature as well as elevated fine particulate matter loading (Huang 2014, Petit, 2015, Li 2016, Sandrini et al., 2016) favour nitrate production. Measurements reveal high contribution of NO3- to surface PM2.5 (>30%) in regions with elevated regional NOx and NH3 emissions, such as the Paris area (Beekman, 2015; Zhang et al., 2019), northern Italy (Masiol et al., 2015; Ricciardelli et al., 2017), Salt Lake City (Kuprov et al., 2014; Franchin et al., 2018), the North China Plains (Guo et al., 2014; Chen et al., 2016), and New Delhi (Pant et al., 2015). "

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
79583	31	39	31	40	The statement about a 5% fraction of fine PM accounted for nitrate on average is not supported by the study of Snider et al. (2016) which is based on only 8 measurement sites and for observations lasting one year or less. Moreover, the PTFE filters employed in SPARTAN are not safe from negative artifacts for particulate nitrate, especially in warm climates (nylon filters should be better used). I suggest that a global picture (in terms of range of variation) should be derived from the data reported in Figure 6.8 (page 159), integrating chemical composition data from several observation networks. [Decesari Stefano, Italy]	Accepted: text is revised as follows - "Present-day estimates of the global accumulation-mode NO3- burden range from 0.02 to 0.11 TgN (Bian et al., 2017). High contribution of NO3- to surface PM2.5 (>30%) have been reported in regions with elevated regional NOx and NH3 emissions, such as the Paris area (Beekman, 2015; Zhang et al., 2019), northern Italy (Masiol et al., 2015; Ricciardelli et al., 2017), Salt Lake City (Kuprov et al., 2014; Franchin et al., 2018), the North China Plains (Guo et al., 2014; Chen et al., 2016), and New Delhi (Pant et al., 2015). Ammonium nitrate is semi volatile, which results in complex spatial and temporal patterns (Putaud, (2010), Hand (2012), Zhang (2012)) that reflect variations in its precursors, ammonia and nitric acid, as well as sulfuric acid, non-volatile cations, temperature and relative humidity (Nenes, 2020). High relative humidity and low temperature as well as elevated fine particulate matter loading (Huan 2014, Petit, 2015, Li 2016, Sandrini et al., 2016) favour nitrate production. "
103411	31	39	31	40	The Snider paper is based on a limited set of observations from the Spartan network, which can hardly be called representative for all the world's polluted regions composition. In Europe and North America there are some more observations from the regulatory networks, which can be asssesed. Also important to notice the marked dependency on temperature and RH of aerosol NH4NO3, with consequences for ERF. [Philippe Tulkens, Belgium]	Accepted: text is revised as follows - "Present-day estimates of the global accumulation-mode NO3- burden range from 0.02 to 0.11 TgN (Bian et al., 2017). High contribution of NO3- to surface PM2.5 (>30%) have been reported in regions with elevated regional NOx and NH3 emissions, such as the Paris area (Beekman, 2015; Zhang et al., 2019), northern Italy (Masiol et al., 2015; Ricciardelli et al., 2017), Salt Lake City (Kuprov et al., 2014; Franchin et al., 2018), the North China Plains (Guo et al., 2014; Chen et al., 2016), and New Delhi (Pant et al., 2015). Ammonium nitrate is semi volatile, which results in complex spatial and temporal patterns (Putaud, (2010), Hand (2012), Zhang (2012)) that reflect variations in its precursors, ammonia and nitric acid, as well as sulfuric acid, non-volatile cations, temperature and relative humidity (Nenes, 2020). High relative humidity and low temperature as well as elevated fine particulate matter loading (Huan 2014, Petit, 2015, Li 2016, Sandrini et al., 2016) favour nitrate production. "

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
18297	31	40	31	42	One of the reason for the high ammonium nitrate concentration observed in the Po Valley is the high relative humidity, in addition to the high gas-phase precursor concentrations. I would suggest to add the following sentence: "Ground based observations suggest an important role of relative humidity in the formation of ammonium nitrate accumulation mode (Sandrini et al., 2016, ACP, 10879-10897)" [Stefania Gilardoni, Italy]	Accepted: text is revised as follows - "Ammonium nitrate is semi volatile, which results in complex spatial and temporal patterns in its concentrations (Putaud, (2010), Hand (2012), Zhang (2012)) reflecting variations in its precursors, NH3 and HNO3, as well as H2SO4, non-volatile cations, temperature and relative humidity (Nenes et al., 2020). High relative humidity and low temperature as well as elevated fine particulate matter loading (Huang 2014, Petit, 2015, Li 2016, Sandrini et al., 2016) favour nitrate production. Measurements reveal high contribution of NO3- to surface PM2.5 (>30%) in regions with elevated regional NOx and NH3 emissions, such as the Paris area (Beekman, 2015; Zhang et al., 2019), northern Italy (Masiol et al., 2015; Ricciardelli et al., 2017), Salt Lake City (Kuprov et al., 2014; Franchin et al., 2018), the North China Plains (Guo et al., 2014; Chen et al., 2016), and New Delhi (Pant et al., 2015). "
27021	31	40	31	42	One could also add for instance: - Paris, France: Zhang et al. (2019) Zhang, Y., Favez, O., Petit, J.-E., Canonaco, F., Truong, F., Bonnaire, N., Crenn, V., Amodeo, T., Prévôt, A. S. H., Sciare, J., Gros, V., and Albinet, A.: Six-year source apportionment of submicron organic aerosols from near-continuous highly time-resolved measurements at SIRTA (Paris area, France), Atmos. Chem. Phys., 19, 14755–14776, https://doi.org/10.5194/acp-19-14755-2019, 2019. [Eric Brun, France]	Example of Paris area has been added.
27023	31	42	31	42	Also, the report should also mention that the contribution of ammonium nitrate in PM varies along with PM loading. Indeed, many studies have emphasized the strong contribution of NH4NO3 during intense/extreme pollution events worldwide. - Paris: Petit et al. (2015); Beekmann et al. (2015) - China : Huang et al. (2014); Li et al. (2016) Petit, J.-E., Favez, O., Sciare, J., Crenn, V., Sarda-Estève, R., Bonnaire, N., Močnik, G., Dupont, J.-C., Haeffelin, M., and Leoz-Garziandia, E.: Two years of near real-time chemical composition of submicron aerosols in the region of Paris using an Aerosol Chemical Speciation Monitor (ACSM) and a multi-wavelength Aethalometer, Atmos. Chem. Phys., 15, 2985–3005, https://doi.org/10.5194/acp-15-2985-2015, 2015 Beekmann, M., Prévôt, A. S. H., Drewnick, F., Sciare, J., Pandis, S. N., Denier van der Gon, H. A. C., Crippa, M., Freutel, F., Poulain, L., Ghersi, V., Rodriguez, E., Beirle, S., Zotter, P., von der Weiden-Reinmüller, S.-L., Bressi, M., Fountoukis, C., Petetin, H., Szidat, S., Schneider, J., Rosso, A., El Haddad, I., Megaritis, A., Zhang, Q. J., Michoud, V., Slowik, J. G., Moukhtar, S., Kolmonen, P., Stohl, A., Eckhardt, S., Borbon, A., Gros, V., Marchand, N., Jaffrezo, J. L., Schwarzenboeck, A., Colomb, A., Wiedensohler, A., Borrmann, S., Lawrence, M., Baklanov, A., and Baltensperger, U.: In situ, satellite measurement and model evidence on the dominant regional contribution to fine particulate matter levels in the Paris megacity, Atmos. Chem. Phys., 15, 9577–9591, https://doi.org/10.5194/acp-15-9577-2015, 2015. R.-J. Huang, Y. Zhang, C. Bozzetti, K.-F. Ho, J.-J. Cao, Y. Han, K.R. Daellenbach, J.G. Slowik, S.M. Platt, F. Canonaco, P. Zotter, R. Wolf, S.M. Pieber, E.A. Bruns, M. Crippa, G. Ciarelli, A. Piazzalunga, M. Schwikowski, G. Abbaszade, J. Schnelle-Kreis, R. Zimmermann, Z. An, S. Szidat, U. Baltensperger, I.E. Haddad, A.S.H. Prévôt High secondary aerosol contribution to particulate pollution during haze events in China, Nature, 514 (2014) H. Li, F. Duan, K. He, Y. Ma, T. Kimoto, T. Huang Size-dependent characterization of atmospheric particles during winter in beijing, Atmosphere, 7 (3) (2016) [Eric Brun, France]	Taken into account: following text is added "High relative humidity and low temperature as well as elevated fine particulate matter loading (Huang 2014, Petit, 2015, Li 2016, Sandrini et al., 2016) favour nitrate production. "

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
72543	31	43	31	43	Capital 'T' for 'troposphere'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Rejected, does not correspond to IPCC standards.
5185	31	43	31	52	I suggest deleting this section for brevity as it is covers a number of very specific topics not required for assessing global nitrate. The new Hopfner paper is certainly interesting but only relevant to a small region over India. The Weber and Guo papers cover a rather specific range of conditions for NH3 and NO3. Even for the US, their conclusions for the Southeast US do not apply very well to the Midwest, which has seen increasing aerosol nitrate. [Daniel Murphy, United States of America]	Accepted: We have shortened the discussion of the work of Hopfner as follows - "Recent observations also show that ammonium nitrate contributes to the Asian Tropopause Aerosol Layer (Vernier et al., 2018, Höpfner et al., 2019). " Regarding the discussion of the Weber and Guo studies, we have emphasize the importance of the aerosol pH in determining the sensitivity of nitrate to ammonia, nitric acid, as follows: "The sensitivity of NO3- to changes in NH3, SO42-, and HNO3 is demined primarily by aerosol pH, temperature, and aerosol liquid water (Weber et al., 2016; Guo et al., 2016a ; Guo et al., 2018, Nenes et al. 2020). In regions, where aerosol pH is high, changes in NO3- follow changes in NOx emissions, consistent with the observed increase of ammonium nitrate in Northern China from 2000 to 2015 (Wen et al., 2018) and its decrease in the US Central Valley (Pusede et al., 2016). In contrast, there has been little change in NO3- in the US Southeast from 1998 to 2014 as aerosols have remained highly acidic in spite of declining SO2 emissions (Weber et al., 2016; Guo et al., 2018). "
5187	31	43	31	52	I very much disagree with stating an insensitivity to ammonia as a global conclusion. Over most of the globe there is extremely little fine mode nitrate, and that is because there is insufficient ammonia and other bases. The simplest thing to do is to delete lines 43 to 52 rather than put in all the caveats that would be necessary if they are left in. [Daniel Murphy, United States of America]	Accepted: This statement has been removed and the text has been revised to emphasize the importance of aerosol pH, which is applicable to both polluted and clean conditions, as follows - "The sensitivity of NO3- to changes in NH3, SO42-, and HNO3 is demined primarily by aerosol pH, temperature, and aerosol liquid water (Weber et al., 2016; Guo et al., 2016a ; Guo et al., 2018, Nenes et al. 2020). In regions, where aerosol pH is high, changes in NO3- follow changes in NOx emissions, consistent with the observed increase of ammonium nitrate in Northern China from 2000 to 2015 (Wen et al., 2018) and its decrease in the US Central Valley (Pusede et al., 2016). In contrast, the decrease in SO2 emissions in the US Southeast has caused little change in NO3- 1998 to 2014 as nitric acid largely remains in the gas phase due to highly acidic aerosols (Weber et al., 2016; Guo et al., 2018). "
115561	31	44	31	44	Höpfner et al 2019 is cited here for transport into the free troposphere and for cirrus nuclation. However, cirrus is not the focus of the Höpfner et al study. They argue that ammoniumnitrate should be found at great heights in the monsoon region reaching the lower stratosphere. This aerosol lyser in the mosnsoon region (ATAL) has a substantial impact ob regional climate when it is present (in summer) Thus some major points of the Höpfner at al study are nor properly represented here [Rolf Müller, Germany]	Accepted: text is revised as follows - "Recent observations also show that ammonium nitrate is found in the Asian Tropopause Aerosol Layer (Vernier et al. (2018), Höpfner et al., 2019)."
106407	31	44	31	44	particles rather than particules [Hamza Merabet, Algeria]	Accepted: text revised

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
45929	31	44	31	47	It seems this finding has implications for the validity of the assumption made in the simple-plume aerosol model MACv2-SP that the aerosol optical depth in the plumes scales are the sum of the regional SO2 plus NH3 emissions. Would it be worthwhile to discuss this somewhere in the report? [Twan van Noije, Netherlands]	Rejected, beyond the scope of the chapter (too technical)
72545	31	46	31	46	Change 'aircrafts' to 'aircradt'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted: text revised
8401	31	47	31	47	stronger sensitivity to HNO3 concentrations or rather Nox precursor emissions. The section could explain somewhat better that where there is an abundance of NH3 and relatively little precursor Nox/HNO3; formation of *additional* NH4NO3 is mostly dependent on NOx. [Frank Dentener, Italy]	Accepted: We have revised this section to emphasize the importance of aerosol pH, aerosol water, and temperature. A reference to the recent study of Nenes (2020) was also added. "The sensitivity of NO3- to changes in NH3, SO42-, and HNO3 is demined primarily by aerosol pH, temperature, and aerosol liquid water (Weber et al., 2016; Guo et al., 2016a ; Guo et al., 2018, Nenes et al. 2020)."
103413	31	47	31	47	stronger sensitivity to HNO3 concentrations or rather Nox precursor emissions. The section could explain somewhat better that where there is an abundance of NH3 and relatively little precursor Nox/HNO3; formation of *additional* NH4NO3 is mostly dependent on NOx. [Philippe Tulkens, Belgium]	Accepted: We have revised this section to emphasize the importance of aerosol pH, aerosol water, and temperature. A reference to the recent study of Nenes (2020) was also added. "The sensitivity of NO3- to changes in NH3, SO42-, and HNO3 is demined primarily by aerosol pH, temperature, and aerosol liquid water (Weber et al., 2016; Guo et al., 2016a ; Guo et al., 2018, Nenes et al. 2020)."
77523	31	51	31	51	"as aerosols have remained too acidic" can this statement be explained? [Emer Griffin, Ireland]	Accepted: We have revised the sentence as follows- "In contrast, the decrease in SO2 emissions in the US Southeast has caused little change in NO3- from 1998 to 2014 as nitric acid largely remains in the gas phase due to highly acidic aerosols (Weber et al., 2016; Guo et al., 2018)."
27025	31	54	31	55	Here the report should mention the semi-volatile property of ammonium nitrate leading to complex temporal variations, depending on the stoechiometric availability of its precursors (NH3 and HNO3) and H2SO4, and also on key atmospheric variables such as temperature, relative humidity and wind (i.e. long range transport). [Eric Brun, France]	Accepted: we have revised the text as follows: "This can be partly attributed to the semi-volatile nature of ammonium nitrate and biases in the simulation of its precursors (Heald et al., 2014; Paulot et al., 2016), including the subgrid scale heterogeneity in NOx and NH3 emissions (Zakoura and Pandis, 2018). "
3357	31		24	30	What can be the contribution to the sciences, from the correlation with the economy and current socioeconomic aspects, from an analysis that allows to extend ideas from relationships with other fundamental elements such as dialogue between disciplines [Eduardo Erazo Acosta, Colombia]	Unfortunately, we cannot understand the comment so we are unable to provide a satisfactory response.
27027	32	1	32	1	After "as well" we suggest to add "as well as uncertainties linked to missing interactions in models between HNO3 and sea-salt aerosols (Chrit, M., Sartelet, K., Sciare, J., Pey, J., Nicolas, J. B., Marchand, N., Freney, E., Sellegri, K., Beekmann, M., and Dulac, F. (2018), Aerosol sources in the western Mediterranean during summertime: A model-based approach. Atmos. Chem. Phys., 18, 9631-9659, doi:10.5194/acp-18-9631-2018.)" [Eric Brun, France]	Accepted: text revised as follows - "Ammonium nitrate is semi volatile, which results in complex spatial and temporal patterns (Putaud, (2010), Hand (2012), Zhang (2012)) that reflect variations in its precursors, ammonia and nitric acid, as well as sulfuric acid, non-volatile cations, temperature and relative humidity (Nenes, 2020)."
103415	32	4	32	5	have increased by how much? (factor 2-7)? [Philippe Tulkens, Belgium]	Taken into account, the fact we can not give a range is made clearer in the summary statement.
8403	32	4	32	8	have increased by how much? (factor 2-7)? [Frank Dentener, Italy]	Taken into account, the fact we can not give a range is made clearer in the summary statement.
128207	32	5	32	5	"NO3" --> "NO3-" [Trigg Talley, United States of America]	Accepted - text revised
128209	32	8	32	8	BC is a fairly minor component of PM2.5, but may have a disproportionate influence on health. [Trigg Talley, United States of America]	Accepted, it's health influence is mentioned.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
86009	32	11	32	11	Was expecting to see discussion on landscape fire as source? This is a big factor for health, for example, the Special Reports cite number of deaths attributed to landscape smoke. This information should ideally be anchored in this WGI report as this will certainly come up in the WGII report. It also is relevant for mitigation (e.g. reduced biomass burning for energy). Please cross-reference with other working groups. [Debra Roberts and the Durban WGII TSU, South Africa]	Rejected - Biomass burning discussed in section 6.2.1.3 (old) new section number 6.2.1.2.5
16453	32	11	33	52	In the subsection 6.2.2 “Atmospheric processes and SLCF abundances”, one of the most important aerosol classes, carbonaceous aerosols, is summarized in a section. As the role of carbonaceous aerosols in the climate forcing is complicated because of the diversity of the light scattering/absorbing capability among classes (OC vs BrC vs BC), this structure can confuse the potential readers. Especially, OC has complicated sources (primary emission and secondary formation) as compared to BC and the descriptions on OC seem to be scattered in this subsection. Moreover, carbonaceous aerosols actually include carbonate carbon and primary biological particles (PBAPs). The latter one, in recent researches, is recognized as one of the most important ice nucleating particles (INPs) to account for the formation of mixed phase clouds through freezing clouds. To enhance the readability, the reorganizing the structure of carbonaceous aerosols is recommended. For example, in terms of the radiative forcing, “carbonaceous aerosols” can be and should be separated into “Organic carbon (or Organic aerosols)” and “light absorbing carbon”. [Takuma Miyakawa, Japan]	taken into account - text revised for brevity and clarity with information relevant to climate and air quality and following SLCF speciation as discussed in section 6.1.
80287	32	11	33	52	The issue of biomass burning and its potential increase (see for example recent fire episodes in California, Canada, Australia as well as in Siberia) is poorly addressed in the chapter. Such event can be associated with pyrocumulonimbus that inject aerosols in the stratosphere, impacting for some time the aerosol load there with a measurable radiative forcing (see for example Brtitish Columbia fires in 2018, Khaykin et al., Geophysical Research Letter 2018). Such events are likely to be more frequent in the future due increased land temperature worldwide. [Sophie Godin-Beekmann, France]	Rejected - Biomass burning discussed in section 6.2.1.3 (old) new section number 6.2.1.2.5
5189	32	11			section 6.2.2.8 More than other parts of section 6.2, the carbonaceous aerosols section reads more like a review of recent literature than an assessment. I think the best remedy is to shorten the section. I will provide specific examples below. [Daniel Murphy, United States of America]	Accepted - Text Revised and shortened.
21981	32	11			This section requires considerable proofing. I kept having to re-read and add words that I assumed were intended for most of this text to make sense. It also in many places reads more review and less assessment. It would benefit from greater efforts at synthesis. [Peter Thorne, Ireland]	Accepted - Text Revised significantly and shortened.
55053	32	12	32	16	Need a little bit more room to explain, e.g., the relationship of elemental carbon with black carbon as well as organic carbon with brown carbon, via citing the references, i.e., Petzold et al, 2013 (see below) and Bond et al, 2013. [Nancy Hamzawi, Canada]	Taken into account - definition revised.
8405	32	13	32	14	I think carbonate e.g. CaCO3 in mineral dust is usually considered to be ogranic. [Frank Dentener, Italy]	Rejected- Inorganic Carbon, besides not relevant to the definition sentence
103417	32	13	32	14	Carbonate e.g. CaCO3 in mineral dust is usually considered to be organic. [Philippe Tulkens, Belgium]	Rejected- Inorganic Carbon, besides not relevant to the definition sentence
40485	32	13	32	16	It's unclear here if you mean that each carbonaceous aerosol contains both elemental carbon and organic carbon, or that within a 'cloud' of carbonaceous aerosols, there's a mix of particles that are entirely elemental carbon (would this be a black carbon aerosol?) and those that are entirely organic carbon. Or maybe it's all a continuum? Also, what's the difference between 'organic carbon' and 'organic aerosol', and between black carbon' and 'elemental carbon'? Altogether quite confusing! Finally, the current glossary definition for 'carbonaceous aerosols' is "Aerosol consisting predominantly of organic substances and black carbon." I think it could use extending (e.g., to mention brown carbon). [TSU WGI, France]	Taken into account - definition revised.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
128211	32	14	32	14	"Light absorbing fraction of carbonaceous aerosol is referred to as Black Carbon (BC)." This is not accurate. See, e.g., Bond et al. (2013) for a definition of black carbon/elemental carbon/refractory black carbon. The light-absorbing fraction of carbonaceous aerosol is a combination of BC and BrC. The sentence needs re-writing. [Trigg Talley, United States of America]	Taken into account - definition revised.
67929	32	14	32	15	Please rephrase the sentence "Light absorbing fraction of …… brown carbon (BrC)." Brown carbon aerosols are also light absorbing carbonaceous aerosols, not just black carbon. See reference: Andreae, M. O. and Gelencsér, A.: Black carbon or brown carbon? The nature of light-absorbing carbonaceous aerosols, Atmos. Chem. Phys., 6, 3131–3148, https://doi.org/10.5194/acp-6-3131-2006, 2006. [Luisa Molina, United States of America]	Taken into account - definition revised.
8407	32	17	32	17	greater than what? There are several publications that suggest substantially larger health impacts from EC, relative to SO4 or PM2.5 on a mass basis (E.g. Nicole Jansen 2011; WHO e96541.pdf; health effects of black carbon) . This is an additional reason to focus on EC. [Frank Dentener, Italy]	Taken into account - Text revised
103419	32	17	32	17	Greater than what? There are several publications that suggest substantially larger health impacts from EC, relative to SO4 or PM2.5 on a mass basis (E.g. Nicole Jansen 2011; WHO e96541.pdf; health effects of black carbon) . This is an additional reason to focus on EC. [Philippe Tulkens, Belgium]	Taken into account - Text revised
128213	32	17	32	18	BC is not a "stronger" climate forcer than other aerosol components. It does have a high mass absorption efficiency, but the key point to make here is that BC is a unique aerosol component, in that its direct effect is a positive radiative forcing, whereas for all other aerosols except some BrC in some locations their direct radiative effect is a negative radiative forcing. [Trigg Talley, United States of America]	Taken into account - text revised.
72547	32	20	32	20	Change 'pollutted' to 'polluted'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised
128215	32	20	32	20	"pollutted" --> "polluted" [Trigg Talley, United States of America]	Accepted -Text revised
27029	32	20	32	22	Add Zhang et al. (2007), since it provides a first glance of PM1 chemical composition worldwide from online measurements. Zhang, Q., Jimenez, J. L., Canagaratna, M. R., Allan, J. D., Coe, H., Ulbrich, I., Alfarra, M. R., Takami, A., Middlebrook, A. M., Sun, Y. L., Dzepina, K., Dunlea, E., Docherty, K., DeCarlo, P. F., Salcedo, D., Onasch, T., Jayne, J. T., Miyoshi, T., Shimono, A., Hatakeyama, S., Takegawa, N., Kondo, Y., Schneider, J., Drewnick, F., Borrmann, S., Weimer, S., Demerjian, K., Williams, P., Bower, K., Bahreini, R., Cottrell, L., Griffin, R. J., Rautiainen, J., Sun, J. Y., Zhang, Y. M. and Worsnop, D. R.: Ubiquity and dominance of oxygenated species in organic aerosols in anthropogenically-influenced Northern Hemisphere midlatitudes, Geophys. Res. Lett., 34(13), doi:10.1029/2007GL029979, 2007 [Eric Brun, France]	Accepted-References added
55055	32	24	32	25	The sentence is not a clear expression… One of important understandings for BC measurement since AR5 should be mentioned, i.e., recognizing the inconsistency between the different terminology and related measurement technologies for BC (Petzold et al, 2013). Using different measurements by different techniques to validate/constrain models could lead to large discrepancies. The following papers should be included: [1]. Petzold, A., J.A. Ogren et al., Recommendations for reporting "black carbon" measurements, Atmos. Chem. Phys., 13, 8365-8379, 2013, doi:10.5194/acp-13-8365-2013; [2]. Sangeeta Sharma, W. Richard Leaitch, L. Huang, D. Veber, F. Kolonjari, W. Zhang, S. J. Hanna, A. K. Bertram, and John A. Ogren: (2017), An evaluation of three methods for measuring black carbon in Alert, Canada, Atmos. Chem. Phys., 17, 15225–15243, 2017, doi.org/10.5194/acp-17-15225-2017. [Nancy Hamzawi, Canada]	Accepted- Text Revised and references added.
35989	32	24	32	39	Should mention ice core evidence by pointing to Figure 2.9b [Nicolas Bellouin, United Kingdom (of Great Britain and Northern Ireland)]	Accepted -Text Revised
21153	32	24	32	39	It it worthing mentioning trend analysis of aerosol absorption using the surface remote sensing network of AERONET, which revealed various changes in absorbing aeorosls worldwide such as decreases in Europe, East Asia and increases in India (e.g., Li et al., ACP, 2014) [Jing Li, China]	Rejected - AOD is discussed in chapter 2 and briefly in 6.2.2.5

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
67931	32	26			Please rephrase “total carbon (light absorbing carbon + organic carbon)”. Brown carbon is a subset of organic carbon that absorbs light (see L15-16). [Luisa Molina, United States of America]	Rejected- The term is used by AR5 and is reported here as used by AR5.
72549	32	27	32	27	Insert 'the' before 'Arctic'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted -Text revised
72551	32	28	32	28	Insert 'the' before 'Arctic'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted -Text revised
72553	32	30	32	30	Insert 'a' before 'growing'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted -Text revised
72555	32	30	32	30	Replace 'in-situ' with 'in situ'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted -Text revised
72203	32	30	32	32	"Despite growing number of observation sites worldwide of in-situ BC concentration, global/regional BC trends based on harmonized data among various sites and networks do not yet exist". This sentence may is not accurate. In Europe, EBAS (http://ebas.nilu.no/default.aspx) and ACTRIS (https://actris.nilu.no) are examples of very large databases of atmospheric chemical and physical properties of aerosols, including BC, eBC, and EC. An example of a current effort to establish a large nerwork in Europe and associated countries for harmonized measurements is provided by the COST Action CA-16109 (COLOSSAL, https://www.costcolossal.eu/) [Flores Rosa, Turkey]	Taken into Account - text revised and references added to back up the statement on lack of global (not only limited to Europe and North America) harmonized datasets.
27031	32	30	32	32	We suggest to add Maybe Laj et al. (2020) as well as Zanatta et al. (2016) for Europe Laj, P., Bigi, A., Rose, C., Andrews, E., Lund Myhre, C., Collaud Coen, M., Wiedensohler, A., Schultz, M., Ogren, J. A., Fiebig, M., Gliß, J., Mortier, A., Pandolfi, M., Petäjä, T., Kim, S.-W., Aas, W., Putaud, J.-P., Mayol-Bracero, O., Keywood, M., Labrador, L., Aalto, P., Ahlberg, E., Alados Arboledas, L., Alastuey, A., Andrade, M., Artíñano, B., Ausmeel, S., Arsov, T., Asmi, E., Backman, J., Baltensperger, U., Bastian, S., Bath, O., Beukes, J. P., Brem, B. T., Bukowiecki, N., Conil, S., Couret, C., Day, D., Dayantolis, W., Degorska, A., Dos Santos, S. M., Eleftheriadis, K., Fetfatzis, P., Favez, O., Flentje, H., Gini, M. I., Gregorič, A., Gysel-Beer, M., Hallar, G. A., Hand, J., Hoffer, A., Hueglin, C., Hooda, R. K., Hyvärinen, A., Kalapov, I., Kalivitis, N., Kasper-Giebl, A., Kim, J. E., Kouvarakis, G., Kranjc, I., Krejci, R., Kulmala, M., Labuschagne, C., Lee, H.-J., Lihavainen, H., Lin, N.-H., Löschau, G., Luoma, K., Marinoni, A., Meinhardt, F., Merkel, M., Metzger, J.-M., Mihalopoulos, N., Nguyen, N. A., Ondracek, J., Peréz, N., Perrone, M. R., Petit, J.-E., Picard, D., Pichon, J.-M., Pont, V., Prats, N., Prenni, A., Reisen, F., Romano, S., Sellegri, K., Sharma, S., Schauer, G., Sheridan, P., Sherman, J. P., Schütze, M., Schwerin, A., Sohmer, R., Sorribas, M., Steinbacher, M., Sun, J., Titos, G., Tokzko, B., Tuch, T., Tulet, P., Tunved, P., Vakkari, V., Velarde, F., Velasquez, P., Villani, P., Vratolis, S., Wang, S.-H., Weinhold, K., Weller, R., Yela, M., Yus-Diez, J., Zdimal, V., Zieger, P., and Zikova, N.: A global analysis of climate-relevant aerosol properties retrieved from the network of GAW near-surface observatories, Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2019-499, in review, 2020 zanatta et al. (2016) : https://doi.org/10.1016/j.atmosenv.2016.09.035 [Eric Brun, France]	Taken into account- Have added Laj et al paper which supports the current statement. This paper and several companion paper only report optical properties, size distribution and number concentration not carbonaceous aerosol mass concentration hence other references not added.
81535	32	30	32	33	The sentence "Despite growing number of observation sites worldwide of in-situ BC 30 concentration, global/regional BC trends based on harmonized data among various sites and networks do not 31 yet exist" shall be updated. Several studies based on harmonized data among various sites and networks (Laj et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2019-499, in review, 2020) are now available. Collaud Coen et al., (Atmos. Phys. Chem. https://doi.org/10.5194/acp-2019-1174.) provides a robust analysis of the long-term (>10 yr) trends of aerosol optical properties, including absorption coefficient directly related to BC concentrationswhich is shown to exhibit mainly decreasing trends where in-situ measurements are available. The aerosol loading (including BC) negative trends are confirmed in the study of Mortier et al., (Atmos. Phys. Chem., https://doi.org/10.5194/acp-2019-1203). [Cathrine Lund Myhre, Norway]	Rejected- the papers from SARGAN do not report carbonaceous aerosol concentration rather focus on the optical properties, number concentration and particle size distribution which is not the same as concentration referred in these sentences. In addition these studies use data from 52 stations world wide which are primarily over US and Europe and very limited global coverage being described. Laj et al actually support the statement in this assessment.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
28533	32	32	32	32	Pointing to new studies on BC source appotionment using 14C measuements (Winiger et al., Sci. Adv., 2019; Miyakawa et al., AE, 2019) might be useful. Ref: Winiger, P., Barrett, T. E., Sheesley, R. J., Huang, L., Sharma, S.,Barrie, L. A., Yttri, K. E., Evangeliou, N., Eckhardt, S., Stohl,A., Klimont, Z., Heyes, C., Semiletov, I. P., Dudarev, O. V.,Charkin, A., Shakhova, N., Holmstrand, H., Andersson, A., andGustafsson, Ö.: Source apportionment of circum-Arctic atmo-spheric black carbon from isotopes and modelling, Sci. Adv., 5,eaau8052, https://doi.org/10.1126/sciadv.aau8052, 2019. Miyakawa, T., Komazaki, Y., Zhu, C., Taketani, F., Pan, X., Wang, Z., and Kanaya, Y.: Characterization of carbonaceous aerosols in Asian outflow in the spring of 2015: Importance of non-fossil fuel sources, Atmos. Environ., 214, 116858, https://doi.org/10.1016/j.atmosenv.2019.116858, 2019. [Hiroshi Tanimoto, Japan]	Rejected- Beyond the scope of the assessment.
79585	32	32	32	33	Observations of organic aerosols is indeed scarce when considering the global scale, but quite comprehensive datasets do exist for organic carbon (OC) at regional scale (e.g. from the IMPROVE network). The note about the unavailability of long-term trend information for OA in the literature contrasts with the paragraph at Page 33 lines 12 - 14 quoting examples of such sort of studies. [Decesari Stefano, Italy]	Taken into account- Text revised to clarify the availability of OC data in US. Total carbonaceous aerosol referred to previous Page 33 lines 12 - 14 include EC and OA. The sentence here refers to OA only.
4079	32	32	32	33	A recent study based on long-term (2001-2012) observation in a remote island in the wesetern North Pacific indicated that OC is slightly increasing. Reference: Boreddy et al., Atmos Chem Phys, 2018 (doi:10.5194/acp-18-1291-2018). [Chunmao Zhu, Japan]	Rejected. The paper was examined but the trend values there were found questionable.
81537	32	33	32	36	It could be added that the relatively good agreement of the BC trends between models (Mortier et al.,) and observations (Collaud Coen et al.,), when co-locating them in time and space, give good confidence that global aerosol model trends for the last two decades, including those in poorly monitored regions, are likely correct. In fact, model-based estimates of aerosol trends at a global scale reveals a different picture from the one depicted by solely relying on ground based observations and rather a global increase of BC between 2000 and 2014. Despite significant improvements in coverage, and quality of ground-based observations, there is still significant uncertainty associated with some of the regional trends due to time and space sampling deficiencies in poorly sampled but highly populated regions where emissions are on the rise. [Cathrine Lund Myhre, Norway]	Rejected- Cohen et al and Mortier et al., discuss optical properties, absorption, number concentration and size distribution of aerosols and not mass concentration of carbonaceous aerosols which is discussed in this section. Optical properties and radiative forcing trends are discussed in section 6.3.
45389	32	36	32	38	Vertical measurements of carbonaceous aerosols are not so few. There are probably more than 10 campaigns. Cited papers, Worsy (2011) and Schwarz et al. (2013), are both from HIPPO. Both Hodgson et al. (2017) and Morgan et al. (2019) are from SAMBBA. Cited papers should be chosen in a more balanced way. Oshima et al. (2012) (A-FORCE) in East Asia and Matsui et al. (2011) (ARCTAS) and Schulz et al. (2019) (NETCARE) in the Arctic are some examples reporting vertical profiles. There may be some other papers on vertical profiles of carbonaceous aerosols in Europe (CONCERT, ACCESS) and U.S (SEAC4RS, SENEX) also. Oshima et al. (2012), Wet removal of black carbon in Asian outflow: Aerosol Radiative Forcing in East Asia (A-FORCE) aircraft campaign, J. Geophys. Res. 117, D03204, doi:10.1029/2011JD016552. Matsui et al. (2011), Seasonal variation of the transport of black carbon aerosol from the Asian continent to the Arctic during the ARCTAS aircraft campaign, J. Geophys. Res., 116, D05202, doi:10.1029/2010JD015067. Schulz et al. (2019), High Arctic aircraft measurements characterising black carbon vertical variability in spring and summer, Atmos. Chem. Phys., 19, 2361-2384, doi:10.5194/acp-19-2361-2019. [Hitoshi Matsui, Japan]	Taken into account -text revised, newer references cited. Vertical profile measurements are not continuous in space and time and are limited to airborne field campaigns.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
30627	32	36	32	38	There is a recent paper about vertical distribution of BC in China (Zhao, D., Huang, M., Tian, P., He, H., Lowe, D., Zhou, W., . . . Ding, D. (2019). Vertical characteristics of black carbon physical properties over Beijing region in warm and cold seasons. Atmospheric Environment) [Hong Liao, China]	Accepted - reference added
27033	32	37	32	37	We suggest to add a reference to Freney, E., Sellegri, K., Chrit, M., Adachi, K., Brito, J., Waked, A., Borbon, A., Colomb, A., Dupuy, R., Pichon, J.-M., Bouvier, L., Delon, C., Jambert, C., Durand, P., Bourianne, T., Gaimoz, C., Triquet, S., Féron, A., Beekmann, M., Dulac, F., and Sartelet, K. (2018), Aerosol composition and the contribution of SOA formation over Mediterranean forests. Atmos. Chem. Phys., 18, 7041-7056, doi:10.5194/acp-18-7041-2018. [Eric Brun, France]	Not applicable, too specific regarding the scope of the subsection.
72557	32	38	32	38	Capital 'T' for 'troposphere'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted -Text revised
72559	32	41	32	41	Replace 'on' with 'of'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted -Text revised
28531	32	41	32	42	Major advancement on SOA modeling since AR5 is on the implementation of new schemes including volatility-basis set scheme to the global chemistry models (e.g., Tilmes et al., JAMES, 2019) Ref: Tilmes, S., Hodzic, A., Emmons, L. K., Mills, M. J., Gettelman, A., Kinnison, D. E., et al. (2019). Climate forcing and trends of organic aerosols in the Community Earth System Model (CESM2). Journal of Advances in Modeling Earth Systems, 11, 4323– 4351. https://doi.org/10.1029/2019MS001827 [Hiroshi Tanimoto, Japan]	Taken into account - Tilmes et al paper cited for budget and burden. Also report on the different SOA production schemes used by models
45391	32	41	32	43	Global modeling studies considering particle-scale diversity of BC-containing particles have been made recently (Fierce et al., 2016; Matsui et al., 2018). These models are the most sophisticated global-scale models in terms of BC aging processes and should be cited here. Fierce et al. (2016), Black carbon absorption at the global scale is affected by particle-scale diversity in composition, Nat. Commun., 7:12361, doi:10.1038/ncomms12361. Matsui et al. (2018), Black carbon radiative effects highly sensitive to emitted particle size when resolving mixing-state diversity, Nat. Commun., 9:3446, doi:10.1038/s41467-018-05635-1. [Hitoshi Matsui, Japan]	Accepted - references added
81545	32	41	32	43	it seems fair to add also that observation studies in the natural atmosphere contributed to the knowledge of BC ageing. There are many studies published in that sense for various areas in the World including the Arctic [Cathrine Lund Myhre, Norway]	Accepted - see response to #18299
5191	32	41	32	52	This paragraph could be significantly shortened or deleted. It is really literature review with only very indirect connections to radiative forcing. [Daniel Murphy, United States of America]	Taken into account - paragraph shortened to assess specificcally our knowledge regarding burden, trends and lifetimes.
18299	32	43	32	43	In addition to laboratory and model studies, also field observations contributed to improve understanding of organic aerosol formation and ageing. For example, recent field experiments highlighted the role of aqueous phase chemistry, in addition to gas phase oxidation mechanisms, as a key formation pathway of secondary organic aerosol, as well as brown carbon (Ervens et al. , 2011, ACP, 11069-11102 - Gilardoni et al. 2016, PNAS, vol 113, no. 36, pag 10013-10018 - Kim et al., 2019, Atmospheric Environment, Vol. 200, pag. 158-166 - Herkes et al., 2013, 132-133, pag 434-449). [Stefania Gilardoni, Italy]	Taken into account - Text revised and new references added

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
45393	32	43	32	47	"Microphysics and chemical oxidation based carbonaceous aerosol aging": These processes are considered more mechanistically in some models considering particle-scale diversity and related microphysical and chemical processes of BC-containing particles (Fierce et al., 2016; Matsui et al., 2018) than the cited studies using parameterizations of BC aging processes. Fierce et al. (2016) and Matsui et al. (2018) clearly showed such particle-resolved aging processes are important for simulating global spatial distributions of carbonaceous aerosols, and they should be cited in this sentence. Fierce et al. (2016), Black carbon absorption at the global scale is affected by particle-scale diversity in composition, Nat. Commun., 7:12361, doi:10.1038/ncomms12361. Matsui et al. (2018), Black carbon radiative effects highly sensitive to emitted particle size when resolving mixing-state diversity, Nat. Commun., 9:3446, doi:10.1038/s41467-018-05635-1. [Hitoshi Matsui, Japan]	Rejected - the sentence here is referring to BC spatial and regional mass distribution including source regions both paper do not provide such results but only provide either direct radiative effect or absorption enhancement figures/results. However, the references are cited in an earlier sentence for advancement in modelling techniques see response #45391
72561	32	44	32	44	Replace 'show' with 'showing'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted -Text revised
128217	32	44	32	44	"although often assumed to have similar global lifetimes"? [Trigg Talley, United States of America]	Taken into account text revised
72563	32	45	32	45	Delete 'they'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted -Text revised
72565	32	46	32	46	Capital 'T' for 'troposphere'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted -Text revised
81541	32	49	32	49	The study of Lim et al., Atmos. Chem. Phys., 17, 3489–3505, https://doi.org/10.5194/acp-17-3489-2017, 2017, as it connect deposition of BC in European Ice Cores and its connection to emission inventories [Cathrine Lund Myhre, Norway]	Taken into account - ice core discussion is on Chapter 2 which also cites the suggested reference, text revised to point to the discussion and reference.
4081	32	50	32	51	Two studies on BC deposition at Rishiri Island, Japan in the northern range of the Asian outflow, indicated that transport events of both anthropgenic emissions and forest fires could foster elevation of BC deposition. References: Zhu et al., 2015, Geochem J, 2015 (10.2343/geochemj.2.0356); Kaneyasu et al., 2020, Sci Rep, 2020 (doi:10.1038/s41598-020-61067-2). [Chunmao Zhu, Japan]	Taken into account - Kaneyasu et al. reference added.
72567	32	51	32	51	Insert 'the' before 'literature'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Not Applicable - sentence revised
18301	32	51	32	51	Concerning wet removal analysis, although deposition observations are scarce, it might be worth it to mention the fog scavenging efficiency studies, such as Gilardoni et al. 2014 (ACP, 14, 6967 – 6981) and Herkes et al., 2013, (Atmospheric Research, 32-133, pag 434-449) [Stefania Gilardoni, Italy]	rejected - Fog beyond the scope of the current assessment in terms of wet removal process. For aging references have been added. See comment 18301

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
16457	32	51	32	52	At the last sentence of the third paragraph of section 6.2.2.8, only a few studies, based on the aircraft measurement, were referred to provide the insights into the size dependence of the wet removal of BC particles. To the best of my knowledge, more studies using a single particle soot photometer (SP2) have attacked this issue using the ground-based measurements as follows. Simultaneous measurements of BC particles in air and rain: Measurements of the size distributions of BC particles simultaneously in air and rain water provided the size-dependent removal of BC particles. Moteki, N., T. Mori, H. Matsui, and S. Ohata (2019), Observational constraint of in-cloud supersaturation for simulations of aerosol rainout in atmospheric models, npj Clim. Atmos. Sci., 2, 6. https://doi.org/10.1038/s41612-019-0063-y. Ohata, S., N. Moteki, T. Mori, M. Koike, Y. Kondo (2016), A key process controlling the wet removal of aerosols: new observational evidence, Sci. Rep. 6, 34113, https://doi.org/10.1038/srep34113. Mountainous observations of BC particles: A special inlet design using a counterflow virtual impactor allow us to investigate the total and interstitial aerosol particles. Based on this approach, the direct observations of BC particles in air and cloud droplets (or interstitial aerosol particles) have been conducted. Motos, G., J. Schmale, J. C. Corbin, Rob. L. Modini, N. Karlen, M. Berto, U. Baltensperger, and M. Gysel-Beer (2019), Cloud droplet activation properties and scavenged fraction of black carbon in liquid-phase clouds at the high-alpine research station Jungfraujoch (3580 m a.s.l.), Atmos. Chem. Phys., 19, 3833-3855, https://doi.org/10.5194/acp-19-3833-2019. Schroder, J. C., S. J. Hanna, R. L. Modini, A. L. Corrigan, S. M. Kreidenwies, A. M. Macdonald, K. J., Noone, L. M. Russell, W. R. Leaitch, and A. K. Bertram (2015), Size-resolved observations of refractory black carbon particles in cloud droplets at a marine boundary layer site, Atmos. Chem. Phys., 15, 1367-1383, https://doi.org/10.5194/acp-15-1367-2015.	Accepted - text revised, references added
30629	32	51	32	52	Here can add a new study (Ding, S., Zhao, D., He, C., Huang, M., He, H., Tian, P., . . . Liu, D. (2019). Observed Interactions Between Black Carbon and Hydrometeor During Wet Scavenging in Mixed-Phase Clouds. Geophysical Research Letters. doi:10.1029/2019gl083171) [Hong Liao, China]	Accepted - reference added
45395	32	52	32	52	Moteki et al. (2019) is a recent paper showing the particle-size dependent BC wet removal. Moteki et al. (2019), Observational constraint of in-cloud supersaturation for simulations of aerosol rainout in atmospheric models, npj Clim. Atmos. Sci., 2:6, doi:10.1038/s41612-019-0063-y. [Hitoshi Matsui, Japan]	Accepted - see response #16457
81543	32	54	32	54	Although the use and terminology of the different techniques are clarified by Petzold et al., (Atmos. Chem. Phys., 13, 8365–8379, https://doi.org/10.5194/acp-13-8365-2013, 2013) [Cathrine Lund Myhre, Norway]	Taken into account - Sentence revised. Petzold et al cited earlier in the opening paragraph
5193	32	54	32	55	Delete this sentence for brevity, because it isn't quite true, there have been some advances, and because the next sentence about global climate models is really the topic sentence for the paragraph. One significant advance I am involved with is Froyd et al. https://doi.org/10.5194/amt-12-6209-2019. But I don't so much suggest you cite this as not say there haven't been advances. [Daniel Murphy, United States of America]	Taken into account - Text revised for brevity and clarity
18303	32	54	32	55	This sentence might be misleading, since during the last decade, the spread use of mass spectrometry and isotopic measurements allowed a better description of carbonaceous aerosol abundance, time variability, and sources. [Stefania Gilardoni, Italy]	Taken in account: text revised for clarity

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
95853	32	54	33	10	The description of observational and model results on carbonaceous aerosol concentrations lacks additional constraints available. GCM evaluation with the available in-situ data (also more than just a few campaigns available, c.f. Reddington et al., BAMS, 2017, 10.1175/BAMS-D-15-00317.1 plus data available now from ATOM, ORACLES, CLARIFY) seems to robustly show that BC lifetime in GCMs is overestimated as concentrations remote areas are too high and often too low near source (Kipling et al., ACP, 2013; Lund et al., NPJ Climate and Atm Sci, 2019).). [Philip Philip Stier, United Kingdom (of Great Britain and Northern Ireland)]	taken into account - Reddington et al cited in explaining the lack of BC and OA observations. Additional constraints outside of mass concentrations are beyond the scope of this subsection. BC aerosol lifetimes text added.
4083	33	1	33	2	Recent version of atmospheric transport model Flexpart (v10) where wet depotion could be better treated for both in-cloud and below-cloud scavenging also showed underestimated BC in the Arctic. Reference: Zhu et al. Atmos Chem Phys, 2020 (doi:10.5194/acp-20-1641-2020). [Chunmao Zhu, Japan]	Rejected - the sentence refers to global climate model
16567	33	1	33	10	To understand the difference between models and observations the BC lifetimes need to be assessed here (there is discussion of this in 6.3.2.1.3). Presumably the fact 3 in burden is due to a factor of 3 in the lifetime. The total deposition isn't the issue since deposition=emission. Is the wet:dry ratio important, and if so why? In which case it would be useful to quote the range of ACCMIP wet:dry ratios rather than the mean. [William Collins, United Kingdom (of Great Britain and Northern Ireland)]	taken into account - Lifetime assessment text added
16583	33	1	33	10	Could also refer to Thornhill et al. (submitted) which is used in 6.3.1.1. They also found a factor of 3 difference in BC AODs (their table 5) from CMIP6 models. [William Collins, United Kingdom (of Great Britain and Northern Ireland)]	rejected- AODs are assessed in new section 6.4. Also AOD is a function of many variables not only mass which is assessed here.
16585	33	1	33	10	Presumably the information on observations and models in this paragraph could be used to constrain the BC burden. That would be a useful assessment. [William Collins, United Kingdom (of Great Britain and Northern Ireland)]	taken into account - life time and burden assessment text added.
45931	33	4	33	4	"Despite using same BC emissions": note that the emissions are only the same in terms of the emitted particle mass. Models have different representations of particle size distributions, and moreover make their own assumptions about the mean/median size, water solubility and mass density of the emitted particles. [Twan van Noije, Netherlands]	Taken into account - Sentence revised.
72569	33	4	33	4	Insert 'the' before 'same'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted -Text revised
5195	33	12	33	19	This paragraph is more relevant to the assessment – trends have a closer connection to climate assessment than some of the other paragraphs. [Daniel Murphy, United States of America]	Note. however, text revised in FGD draft and restructured
45933	33	18	33	18	Remove "have been measured and". [Twan van Noije, Netherlands]	Not Applicable - sentence revised
8409	33	18	33	19	Not clear if the number of 400±200 Tg C pertains only PAH; or to an POA estimated from PAH. If it is only a subset of POA, how can the numbers be compared? I am quite certain that there are many more available and published OA data in Europe from the EMEP network and related initiatives, beyond the Querol paper. [Frank Dentener, Italy]	Taken into account - Paragraph revised and shortened, relevant deposition numbers are in table describing the budget terms.
103421	33	18	33	19	Not clear if the number of 400±200 Tg C pertains only PAH; or to an POA estimated from PAH. If it is only a subset of POA, how can the numbers be compared? I am quite certain that there are many more available and published OA data in Europe from the EMEP network and related initiatives, beyond the Querol paper. [Philippe Tulkens, Belgium]	see answer to #8407
45935	33	19	33	19	This range is based on the model intercomparison study by Tsigaridis et al., 2014: The AeroCom evaluation and intercomparison of organic aerosol in global models, Atmos. Chem. Phys., 14, 10845–10895, https://doi.org/10.5194/acp-14-10845-2014. Please include a reference to that paper. The range is given in Tg OA/yr. It is then very confusing to refer to it as the "OC wet deposition". I'd rather call it "OA wet deposition". [Twan van Noije, Netherlands]	Taken into account - Text revised

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
27035	33	21	33	22	Numerous studies suggest missing organic precursors of intermediate volatility (Couvidat F., Debry E., Sartelet K.N., and Seigneur C. (2012), A hydrophilic/hydrophobic organic (H2O) aerosol model: Development, evaluation and sensitivity analysis. J. Geophys. Res., 117, D10304, doi:10.1029/2011JD017214.; Kim Y., Sartelet K., Seigneur C., Charron A., Besombes J.-L., Jaffrezo J.-L., Marchand N., Polo L. (2016), Effect of measurement protocol on organic aerosol measurements of exhaust emissions from gasoline and diesel vehicles Atmos. Environ., 140, 176-187; Chrit, M., Sartelet, K., Sciare, J., Majdi, M., Nicolas, J., Petit, J.-E., and Dulac, F. (2018), Modeling organic aerosol concentrations and properties during winter 2014 in the northwestern Mediterranean region. Atmos. Chem. Phys., 18, 18079-18100, doi:10.5194/acp-18-18079-2018; Sartelet K., Zhu S., Moukhtar S., André M., André J.M., Gros V., Favez O., Brasseur A., Redaelli M. (2018), Emission of intermediate, semi and low volatile organic compounds from traffic and their impact on secondary organic aerosol concentrations over Greater Paris. Atmos. Environ., 180, 126-137, doi:10.1016/j.atmosenv.2018.02.031. Paolo Giani, Alessandra Balzarini, Guido Pirovano, Stefania Gilardoni, Marco Paglione, Cristina Colombi, Vorne Luigi Gianelle, Claudio A. Belis, Vanes Poluzzi, Giovanni Lonati, Influence of semi- and intermediate-volatile organic compounds (S/IVOC) parameterizations, volatility distributions and aging schemes on organic aerosol modelling in winter conditions, (2019) Atmos Environ, 213, 11-24 doi: 10.1016/j.atmosenv.2019.05.061.) [Eric Brun, France]	rejected- too detailed, changes in emissions and precursors are discussed in section 6.2
72571	33	23	33	23	Insert 'the' before 'historical'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Not Applicable - sentence revised
72573	33	23	33	23	Delete 'time'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Not Applicable - sentence revised
128219	33	23	33	23	"Pre-Industrial" --> "pre-industrial" [Trigg Talley, United States of America]	Editorial -treated
128221	33	25	33	25	The cited upper bound for total OA is lower than that cited for POA! (What is meant by median burden here, since the range is across models?) [Trigg Talley, United States of America]	Taken into account - text revised numbers are now presented in Table
5197	33	28	33	39	I suggest putting the first sentence, part of the sentence on lines 34-35 about the global source, and the last sentence about sinks on the end of the previous paragraph and deleting the remainder of the paragraph. [Daniel Murphy, United States of America]	taken into account - text and paragraph revised
5199	33	28	33	39	The photolytic lifetime results are more controversial than you may realize – the recent model-measurement comparison of organic aerosol in the lower stratosphere by Yu et al. (https://doi.org/10.1002/2016GL070153) means that the photolytic organic aerosol lifetime must be fairly long in the lower stratosphere. And really, discussing recent controversies about the photolytic lifetime of SOA is straying pretty far from the climate assessment. I suggest deleting these sentences. [Daniel Murphy, United States of America]	Accepted - Text Revised and shortened.
5201	33	28	33	39	To summarize, I suggest deleting most of this paragraph and simply appending to the previous paragraph “The annual source of global SOA remains highly uncertain with recent model based estimates ranging from the AeroCom II mean of 35Tg yr-1 (Tsigaridis et al., 2014) to 132.2Tg yr-1 (Hodzic et al., 2016). Comparing results from more the 20 global aerosol models, the annual production rate of SOA varies between 13 and 119 Tg yr-1 (Tsigaridis et al., 2014). SOA deposition is consistently dominated by wet deposition (Hodzic et al., 2016).” [Daniel Murphy, United States of America]	Accepted text revised and shortened
79587	33	28	33	39	The use of the term "OVOC" here can be misleading because it is used by the authors to indicate aerosol precursors originating from VOC oxidation, but in atmospheric chemistry "OVOC" is normally used to indicate organic compounds which reside in the gas phase like methanol or acetone or that contribute to PM formation only in particular circumstances like formaldehyde. As a consequence, the sentence "Previously oxidized volatile organic compounds (OVOC) were primarely considered to contribute to aerosol mass" results most ambiguous. [Decesari Stefano, Italy]	Taken into account - Text revised to clarify
72575	33	29	33	29	Insert , after 'Previously'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted -Text revised

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
128223	33	29	33	30	This sentence is unclear. Were OVOC considered to contribute he majority of OC mass, or is the point that OVOC contributed to mass but not to number (cf. following sentence)? [Trigg Talley, United States of America]	Taken into account - Text revised to clarify
45937	33	30	33	30	Change "contribute to aerosol mass" to something like "contribute to aerosol mass, but not increase particle number". [Twan van Noije, Netherlands]	Taken into account - Text revised to clarify
72577	33	32	33	32	Change reference to Ehn et al. (2014) [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted -Text revised
35743	33	32	33	32	delete comma Ehn et al., (2014) [Carlos Antonio Poot Delgado, Mexico]	Accepted -Text revised
68827	33	32	33	33	In addition to citing Trostl et al. 2106 on the importance of highly oxidized organic molecules to atmospheric new-particle formation, I suggest also citing the review paper by Bianchi et al. "Highly oxygenated organic molecules (HOM) from gas-phase autoxidation involving peroxy radicals: A key contributor to atmospheric aerosol." Chemical reviews 119.6 (2019): 3472-3509." This paper provides a thorough review on our current knowledge of highly oxidized organic molecules and the impacts on new-particle formation. [Qing Ye, United States of America]	Taken into account - reference added
72579	33	33	33	34	Remove split of numbers and units across line. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial -treated
45939	33	34	33	34	Please avoid introducing acronyms that are not very helpful to the reader. I think "HULIS" is an example of an acronym that can be removed. [Twan van Noije, Netherlands]	Accepted - Text revised
128225	33	34	33	35	Comment also on the type of SOA production schemes used in these models. What processes/precursors are accounted for? [Trigg Talley, United States of America]	Accepted - Text added
72581	33	37	33	37	Capital 'T' for 'troposphere'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Not Applicable - sentence revised
16569	33	39	33	39	I'm confused how a source of 132.2 Tg/yr is balanced by losses of 8.9 and 73 Tg/yr? [William Collins, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable - Numbers now reported in table and text revised.
79589	33	41	33	43	The formation of brown carbon (BrC) from secondary and primary sources are here illustrated as equally possible. On the other hand, evidence of secondary BrC production is mostly supported by laboratory studies, while an association of BrC to biomass burning sources is also supported by several field studies. Observations of the seasonal cycles of BrC levels at mid-latitudes (Baduel et al, Atmos. Chem. Phys. 10, 4085 - 4095, 2010; Han et al., Atmos. Chem. Phys., 20, 2709 - 2718, 2020) and subtropical sites (Wu et al., Environ. Sci. Tech., 53, 3471 - 3479, 2019) indicate that the peak season is always characterized by intense biomass burning sources, while a minimum is found in the summer when SOA production is favoured. An effect of photobleaching of BrC in the summer is also possible. [Decesari Stefano, Italy]	rejected - too detailed, overall text revised for brevity and clarity
45397	33	41	33	49	The photochemical bleaching effect of BrC (Lee et al., 2014; Forrister et al., 2015) can be described in this paragraph. Lee et al. (2014), Effect of solar radiation on the optical properties and molecular composition of laboratory proxies of atmospheric brown carbon, Environ. Sci. Technol., 48, 10217-10226, doi:10.1021/es502515r. Forrister et al. (2015), Evolution of brown carbon in wildfire plumes, Geophys. Res. Lett., 42, 4623-4630, doi:10.1002/2015GL063897. [Hitoshi Matsui, Japan]	rejected - too detailed, overall text revised for brevity and clarity
128227	33	42	33	42	Delete "that can also generate BrC in the atmosphere." [Trigg Talley, United States of America]	Accepted - text revised
79591	33	46	33	49	It could be worth mentioning the study of Zhang et al (Atmos. Chem. Phys. 20, 1901-1920, 2020) based on a global model and showing that BrC particles - in reason of their hydrophobicity - can be transported in the tropical upper troposphere where their radiative effect can compete with (or even surpass) that of black carbon. [Decesari Stefano, Italy]	taken into account - Zhang's paper cited for uncertainties related to BrC.
77525	33	51	33	52	A statement on how this lack of information impacts on assessment of the ERF of BC would be useful. [Emer Griffin, Ireland]	taken into account summary statement revised
8411	33	51	33	52	The summary statement may be sharpened, by summarizing what we know about regional trends and how that could impact global trends. [Frank Dentener, Italy]	taken into account summary statement revised

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
103423	33	51	33	52	The summary statement may be sharpened, by summarizing what we know about regional trends and how that could impact global trends. [Philippe Tulkens, Belgium]	see answer to #8411
86783	33	55	35	53	Please include lastest findings and status of Carbon Tetrachloride (CCl4). It currently listed under "acronymes for Chapter 6" on page 139, but cannot find any information about this in the chapter text itself. At least one recent scientifical paper is available from https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2018GL079500, this and references therein could form a good basis for an assessment. Also information from https://www.pnas.org/content/pnas/113/11/2880.full.pdf could be of value. We are aware that CCl4 is not shortlived in itself. However, since it is such a vital component for production of many short-lived species we believe that an explicit description of CCl4 is warranted either in this chapter, or in Chapter 2 or 5. Please confer with authors from Chapter 2 and 5 to find the most suitable home for such an description. [Oyvind Christophersen, Norway]	CCl4 is not itself a SLCF. The discussion of CCl4 fits better in Chapter 2 (2.2.4).
27037	34	2	34	3	It could be mentioned that CFCs, HCFCs and HFCs are all synthetically produced (as it is written only for HFC. The three groups of fluorocarbons are synthetically produced) [Eric Brun, France]	Accepted and revised accordingly. It was added "… in the form of the synthetically produced …"
103425	34	2	34	6	Their global abundances *and trends* are discussed in Chapter 2. I think this chapter takes a treshold of 20 years for defining short-lived, so suggest to use 2 decades in line 6. [Philippe Tulkens, Belgium]	Accepted and revised accordingly. It was a added : " ...with their effect on climate being predominantly in the first two decades after their emission."
16571	34	2	34	6	It would be realyy useful if a timescale were specified here - say 20 years, to make it clear which species are SLCFs and which aren't. [William Collins, United Kingdom (of Great Britain and Northern Ireland)]	Accepted and revised accordingly. It was a added : " ...with their effect on climate being predominantly in the first two decades after their emission."
8413	34	2	34	6	Their global abundances *and trends* are discussed in Chapter 2. I think this chapter takes a treshold of 20 years for defining short-lived, so suggest to use 2 decades in line 6. [Frank Dentener, Italy]	Accepted and revised accordingly. It was a added : " ...with their effect on climate being predominantly in the first two decades after their emission."
128229	34	9	34	9	There needs to be some framing text here, noting that short-lived halogenated species affect climate both directly, by acting as greenhouse gases, and indirectly, by affecting column ozone amounts. The Kigali Amendment could be introduced here or in Section 6.2.2.9.2. It needs to be introduced somewhere. [Trigg Talley, United States of America]	Accepted and revised accordingly. We added " ...and affect climate both directly, by acting as greenhouse gases, and indirectly, by affecting column ozone amounts." We also make a link to the Kigali section 6.5.3.3.
86011	34	9	34	9	One expects to see some discussion of sources of these gases. If sources are discussed elsewhere, please cross-reference. [Debra Roberts and the Durban WGII TSU, South Africa]	Sources of these gases are covered in Section 2.2.4.2)
72583	34	10	34	10	Change 'are' to 'is'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Corrected.
8415	34	10	34	10	Please note that Chapter 2 reports numbers for 2018, and intends to update to 2019 in the final release. Advise to use the same in Chapter 6. Likewise Chapter 7 ERF is updated to 2018. [Frank Dentener, Italy]	Accepted and revised accordingly
40875	34	10	34	11	Suggest you add 'Hydrochlorofluorocarbons' to the glossary. [TSU WGI, France]	Taken into account. HCFCs are defined in the glossary within the definition of halocarbons.
100471	34	30	34	31	The table is Table 7.5 (not 7.3) and the updated value is 0.059 W m-2 (not 0.058) for 2018 (not 2016) [Øivind Hodnebrog, Norway]	Accepted and revised accordingly

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
68295	34	34	35	1	Add that energy efficiency has potential to avoid even more warming. Energy efficiency improvements to cooling equipment historically have been catalyzed by refrigerant transitions under the Montreal Protocol, and in the case of the Kigali Amendment, there are parallel decisions by the Parties promoting energy efficiency, as well as a fast-start fund. United States Environmental Protection Agency (EPA) (2002) Building owners save money, save the earth: replace your CFC air-conditioning chiller. 6–7 ("The most energy-efficient new chillers will reduce electric generation and associated greenhouse gas emissions by up to 50% or more compared to the CFC chillers they replace."); see also United Nations Environment Programme (UNEP) (2016) Report Of The Twenty-Eighth Meeting Of The Parties To The Montreal Protocol On Substances That Deplete The Ozone Layer. 15 November. UNEP/OzL.Pro.28/12; and U.S.A., White House Office of Press Secretary (2016) Leaders from 100+ Countries Call for Ambitious Amendment to the Montreal Protocol to Phase Down HFCs and Donors Announce Intent to Provide $80 Million of Support. The Kigali Cooling Efficiency Program was set up to administer the $53 million from private donors. Policies to improve efficiency of ACs and other cooling equipment can avoid significant emissions as demand for cooling grows. For instance, transitioning the best currently available efficiency and refrigerant technologies for stationary air conditioning and refrigeration would cut cumulative emissions by 38–60 GtCO2e by 2030, by 130–260 GtCO2e by 2050, and by 210–460 by 2060, depending on future rates of decarbonization of electricity generation. Shah, N., Wei, M., Letschert, V. and Phadke, A. (2019). Benefits of Energy Efficient and Low-Global Warming Potential Refrigerant Cooling Equipment. U.S.A: Lawrence Berkeley National Laboratory ("For best-available-technology (or "maximum" efficiency), total savings to 2050 are 373.0 and 257.6 GtCO2e for baseline (or static) electricity emission factors and decreasing emission factors, respectively (Fig. 1). Table S1 in the SI shows the GHG emissions for the reference case (no efficiency improvement and baseline HFC refrigerants) vs. the policy case of best-available technology (BAT) energy efficiency and low GWP refrigerants for 2030, 2040, and 2050 with static emission factors for both cases Reference case cumulative GHG emissions are 587.1 Gt CO2e while the policy case is 214.1 Gt for an overall cumulative savings of 373.0 Gt CO2e."); Dreyfus G., et al. (2020) ASSESSMENT OF CLIMATE AND DEVELOPMENT BENEFITS OF EFFICIENT AND CLIMATE-FRIENDLY	Not Applicable: This subsection is not about mitigation options.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
69875	34	34	35	1	Note that the enerrgy efficiency considered here is only associated with the chemical transition. It does not consider emissions reductions associated with improved the efficiency of the equipment. Energy efficiency improvements to cooling equipment historically have been catalyzed by refrigerant transitions under the Montreal Protocol, and in the case of the Kigali Amendment, there are parallel decisions by the Parties promoting energy efficiency, as well as a fast-start fund. Transitioning the best currently available efficiency and refrigerant technologies for stationary air conditioning and refrigeration would cut cumulative emissions by 38–60 GtCO2e by 2030, by 130–260 GtCO2e by 2050, and by 210–460 by 2060, depending on future rates of decarbonization of electricity generation. Shah, N., Wei, M., Letschert, V. and Phadke, A. (2019). Benefits of Energy Efficient and Low-Global Warming Potential Refrigerant Cooling Equipment. U.S.A: Lawrence Berkeley National Laboratory ("For best-available-technology (or "maximum" efficiency), total savings to 2050 are 373.0 and 257.6 GtCO2e for baseline (or static) electricity emission factors and decreasing emission factors, respectively (Fig. 1). Table S1 in the SI shows the GHG emissions for the reference case (no efficiency improvement and baseline HFC refrigerants) vs. the policy case of best-available technology (BAT) energy efficiency and low GWP refrigerants for 2030, 2040, and 2050 with static emission factors for both cases Reference case cumulative GHG emissions are 587.1 Gt CO2e while the policy case is 214.1 Gt for an overall cumulative savings of 373.0 Gt CO2e."); Dreyfus G., et al. (2020) ASSESSMENT OF CLIMATE AND DEVELOPMENT BENEFITS OF EFFICIENT AND CLIMATE-FRIENDLY COOLING, 1 ("However, robust policies that drive the use of best available technologies can cut cumulative emissions from the stationary air conditioning and refrigeration sectors by 38–60 GtCO2e by 2030, by 130–260 GtCO2e by 2050, and by 210–460 by 2060, depending on future rates of de- carbonization of electricity generation (Table 3.1). (For comparison, the global annual CO2 emissions from fossil fuel energy sources in 2018 totalled 33.1 GtCO2.8) A quarter of the mitigation is from phasing down HFC refrigerants and switching to alternatives with low-GWP, while three-quarters is from ensuring that cooling equipment uses the best available technology to improve energy efficiency and reduce the use of electricity (Table 3.1)."). [Gabrielle Dreyfus, United States of America]	Not Applicable: This subsection is not about mitigation options.
66763	34	34	36	1	Add that energy efficiency has potential to avoid even more warming. Energy efficiency improvements to cooling equipment, which could take places as part of this transition. Policies to improve efficiency of ACs and other cooling equipment can avoid significant emissions as demand for cooling grows. Shah, N., Wei, M., Letschert, V. and Phadke, A. (2019). Benefits of Energy Efficient and Low-Global Warming Potential Refrigerant Cooling Equipment. U.S.A: Lawrence Berkeley National Laboratory ("For best-available-technology (or "maximum" efficiency), total savings to 2050 are 373.0 and 257.6 GtCO2e for baseline (or static) electricity emission factors and decreasing emission factors, respectively (Fig. 1). Table S1 in the SI shows the GHG emissions for the reference case (no efficiency improvement and baseline HFC refrigerants) vs. the policy case of best-available technology (BAT) energy efficiency and low GWP refrigerants for 2030, 2040, and 2050 with static emission factors for both cases Reference case cumulative GHG emissions are 587.1 Gt CO2e while the policy case is 214.1 Gt for an overall cumulative savings of 373.0 Gt CO2e."); Dreyfus G., et al. (2020) ASSESSMENT OF CLIMATE AND DEVELOPMENT BENEFITS OF EFFICIENT AND CLIMATE-FRIENDLY COOLING, 1 ("However, robust policies that drive the use of best available technologies can cut cumulative emissions from the stationary air conditioning and refrigeration sectors by 38–60 GtCO2e by 2030, by 130–260 GtCO2e by 2050, and by 210–460 by 2060, depending on future rates of de- carbonization of electricity generation (Table 3.1). (For comparison, the global annual CO2 emissions from fossil fuel energy sources in 2018 totalled 33.1 GtCO2.8) A quarter of the mitigation is from phasing down HFC refrigerants and switching to alternatives with low-GWP, while three-quarters is from ensuring that cooling equipment uses the best available technology to improve energy efficiency and reduce the use of electricity (Table 3.1)."). [Kristin Campbell, United States of America]	Not Applicable: This subsection is not about mitigation options.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
27039	34	35	34	36	It could be also mentioned for CFC and HCFC [Eric Brun, France]	Accepted. It was added in the first paragraph that all these species are synthetically produced.
40631	34	35	34	36	Please check (and update as appropriate) the glossary definition for HFCs: "One of the six types of greenhouse gases (GHGs) or groups of GHGs to be mitigated under the Kyoto Protocol. They are produced commercially as a substitute for chlorofluorocarbons (CFCs). HFCs largely are used in refrigeration and semiconductor manufacturing." [TSU WGI, France]	Done!
103427	34	35	34	55	update to 2018 (and for final report to 2019). [Philippe Tulkens, Belgium]	The numbers have been updated for 2018 according to Table 2.3 and Table 7.5.
8417	34	35	34	55	update to 2018 (and for final report to 2019). [Frank Dentener, Italy]	The numbers have been updated for 2018 according to Table 2.3 and Table 7.5.
86785	34	39	34	39	There seems to be a typo in this sentence since 2016 is mentioned twice. [Oyvind Christophersen, Norway]	Corrected
96673	34	39	34	40	It is stated that "The radiative forcing from measured HFCs also continues to increase, accounting totally for 0.030 W m−2 in 2016 (from 0.020 W m−2 in 2016)[…]". It should read, "[…] accounting totally for 0,030 W m−2 in 2018 (from 0.020 W m−2 in 2011)[...]" with regard to table 7.5 (page 34) of chapter 7. Furthermore, HFCs account for an ERF of 0.035 W m−2 altogether, not 0.030 W m−2. [Nicole Wilke, Germany]	The numbers have been updated for 2018 according to Table 7.5.
72585	34	42	34	42	Insert , after 'increase. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	We inserted a comma after increase.
128231	34	43	34	43	Does 47% represent: the increase in forcing from HFC-134a compared to total HFC forcing, or the increase in forcing from HFC-134a compared to the increase in HFC forcing? And what are the date ranges for this increase? Starting date? Is the ending date 2016 or 2017? [Trigg Talley, United States of America]	The ERF due to HFC-134a accounts for 44% of the total HFCs ERF radiative forcing in 2018 (see Table 7.5 of Chapter 7).
13481	34	45	34	45	Add a space between comma and "but". [Maria Amparo Martinez Arroyo, Mexico]	Corrected
16573	34	45	34	45	How long are "long lifetimes"? What is the cut off? [William Collins, United Kingdom (of Great Britain and Northern Ireland)]	It was specified as longer than two decades.
128233	34	50	34	50	Typo: manyfold, not "manifold". A24 [Trigg Talley, United States of America]	Not applicable. This sentence is not in the text anymore
86787	34	52	35	1	Please also include references and a description of the other group of substitute chemicals, namely those that are not synthetic (man-made) e.g. CO2, Ammonia and Propane. [Oyvind Christophersen, Norway]	Not Applicable: This subsection is not about mitigation options.
81361	34	53	34	53	Should this be “in sub-ppt concentrations in ambient air”? [Johannes Laube, Germany]	Accepted and revised accordingly.
128235	34	54	34	55	It should be noted above this that HFCs are now controlled under the Kigali Amendment before stating (without context) what isn't included in Kigali. [Trigg Talley, United States of America]	Rejected. Aspects on mitigation are not covered here but rather in 6.6
81363	35	4	35	4	Why are no ERFs given in this section? [Johannes Laube, Germany]	Not Applicable. The discussion of ERF for the halogenated species has been removed from Section 6.2.
67933	35	5	35	8	Please fix the first two sentences; some of the words seem to be transposed. Also similar to the HCFCs and HFCs sections, suggest to add a sentence stating what are methyl bromide and halons, for example: Methyl bromide is a fumigant used against a wide variety of pests. Halons are used primarily as fire extinguishing agents. The most commonly used halons are halon-1211 (CBrClF2), halon-1301 (CBrF3), and halon-2402 (CBrF2CBrF2). [Luisa Molina, United States of America]	Taken into account. Text has been revised
103429	35	7	35	7	sentence broken, update [Philippe Tulkens, Belgium]	The sentence has been corrected.
72587	35	7	35	7	delete full stop after) and close space. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	The sentence has been corrected.
35745	35	7	35	7	correct paragraph [Carlos Antonio Poot Delgado, Mexico]	The sentence has been corrected.
13483	35	7	35	7	Erase period (.) between pharenthesis and "halon". [Maria Amparo Martinez Arroyo, Mexico]	The sentence has been corrected.
8419	35	7	35	7	sentence, update [Frank Dentener, Italy]	The sentence has been corrected.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
81365	35	10	35	10	I would be surprised if it was possible to quantify the decrease to two decimal places. [Johannes Laube, Germany]	Accepted and revised.
67935	35	11	35	12	Please provide the atmospheric lifetimes of methyl bromide and the halons mentioned. [Luisa Molina, United States of America]	Accepted and revised accordingly.
8425	35	14	35	25	First part of section is a bit textbook, second part could be more quantitative: what does it mean that (some) models include new low Nox recycling mechanisms. What does this the new knowledge on HONO mean for estimates of OH (specifically for climate) [Frank Dentener, Italy]	this is from 6.2.3 , page 36
67937	35	19	35	20	Suggest adding a sentence about VSLSs, i.e., they are halogenated substances with atmospheric lifetimes less than 0.5 year. [Luisa Molina, United States of America]	Accepted and revised accordingly.
72589	35	27	35	27	Capital 'S' for 'stratosphere'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	corrected.
72591	35	30	35	30	Capital 'T' for 'troposphere'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	corrected.
72593	35	31	35	31	Capital 'S' for 'stratosphere'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	corrected.
81367	35	32	35	33	This has been known since the 1990s, when VSLS bromocarbons were first detected in the stratosphere. A better formulation is needed. [Johannes Laube, Germany]	Not applicable. Text has been revised and shortened
72595	35	38	35	38	Replace 'at' with 'in the'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	corrected.
72597	35	38	35	38	Insert 'in the' after 'than'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	corrected.
33213	35	39	35	42	A short statement could be added addressing the potential link between naturally-emitted very short-lived bromocarbons and changes in the ozone layer resulting from volcanic eruptions. This approach is fully described in a 2017 paper published by Anderson Research Group from Harvard (https://www.arp.harvard.edu/) and Ross Salawitch Research Group from University of Maryland (https://www2.atmos.umd.edu/~rjs/). The proposal is motivated mainly by the potential climate implications of linking volcanic activity and biogenic VSLS. Proposed added text to lines 39-42. “Recent work suggests that stratospheric ozone depletion following volcanic eruptions would likely continue late into the 21st century due to the contribution of biogenic bromine VSLS regardless of the RCP scenario (Klobas et al, 2017).” Proposed added reference Klobas, J.E., Wilmouth, D.M., Weisenstein, D.K., Anderson, J.G. & Salawitch, R.J. 2017, "Ozone depletion following future volcanic eruptions", Geophysical Research Letters, vol. 44, no. 14, pp. 7490-7499. https://doi.org/10.1002/2017GL073972 [Fernando Serranía Alarcón, Spain]	Rejected. This recommended insertion was not made because this section deals with the evolution of short-lived halogenated species
81369	35	40	35	40	This is the wrong reference as the publication cited here exclusively focuses on CH2Cl2 (no bromocarbons). Perhaps another Leedham Elvidge et al. publication is meant here? [Johannes Laube, Germany]	Accepted. The reference was corrected.
8427	35	40	35	41	The notation < +/- doesn't make sense, perhaps something like <abs(+/- %) or just smaller than x %, as variations are always pos/neg around a mean. [Frank Dentener, Italy]	See response to 103439
33215	35	42	35	44	[1/5] Comment on tropospheric halogen chemistry (lines 42-44) separated in 5 parts. The confidence level could be adjusted in the statement considering the state-of-the art of the experimental research on tropospheric halogens. [Note: Radical halogen oxides XO (X= Cl, Br, I), formed through the combination of halogens with ozone, are commonly targeted species in this field and their retrievals are relevant to project present and future scenarios. (Simpson et al, 2015)] [Fernando Serranía Alarcón, Spain]	Noted. Due to space constraints, we cannot go into detailed assessment of tropospheric halogens and their effects of ozone.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
33217	35	42	35	44	[2/5] At present, assigning a medium confidence level to halogen oxides observations may be recommendable. This is due to experimental constraints (i.e. difficulties to reach the instrumental sensitivity needed to reach volume mixing ratios [vmr] in the pptv range) and uncertainties in retrieval algorithms. Variability between reported observations (at the same site and season) is challenging, as well as potentially large retrieval errors. For instance, in scientific literature published since AR5 it is found that maximum vmr for bromine monoxide (BrO) at Halley station (Antarctica) in springtime can vary from 13 pptv (Buys et al, 2013) to 25 pptv (Roscoe et al, 2014) Regarding iodine monoxide (IO), retrieval errors (for vmr typically smaller than BrO) may lead to significant uncertainties, as we found in observations in the global marine boundary layer (Prados-Román et al, 2015) where reported mixing ratios range from 0,4 to 1 pptv with 30% uncertainty. More specifically, in the Indian Ocean marine boundary layer (Mahajan et al, 2019) daily peaks such as 0.57 ± 0.27 pptv or 2.9 ± 1.0 pptv are reported. [Fernando Serranía Alarcón, Spain]	Discussion of halogen oxides is beyond the scope of this section taking into consideration space limitations for the chapter.
33219	35	42	35	44	[3/5] A high impact 2008 paper reporting pioneer measurements of halogen oxides in the tropical Atlantic Ocean was recently discussed on PubPeer due to plausible allegations of figure duplication (Read et al, 2008). It may have implications since, for instance, observations reported in the paper can be used to validate simulations with tropospheric halogen models (Sherwen et al, 2016) https://pubpeer.com/publications/24AE7B97E0A4F696C5BD03287808AC [Fernando Serranía Alarcón, Spain]	Discussion of halogen oxides is beyond the scope of this section taking into consideration space limitations for the chapter.
33221	35	42	35	44	[4/5] The proposal for refining the text about tropospheric halogens is motivated by their potential climate dimension. Given that these species destruct ozone, biogenic iodine and bromine species could potentially provide a natural pathway of destruction of a GHG with impact in warming potential estimations. At present, the likelihood of that natural cooling effect is still moderate. Fixing the uncertainty (and then limiting any potential overestimation of their role) may be useful for the community and policymakers. Proposed reformulated statement (lines 42 to 44) “The tropospheric halogen chemistry has been increasingly investigated since AR5 through global models combined with observations, suggesting a potential impact on tropospheric ozone depletion based on high agreement and medium evidence(Simpson et al, 2015; Saiz-López et al., 2016; Sarwar et al.,2015; Sherwen et al., 2016).” Proposed added reference for AR6 Simpson, W.R., Brown, S.S., Saiz-Lopez, A., Thornton, J.A. & von Glasow, R. 2015, "Tropospheric Halogen Chemistry: Sources, Cycling, and Impacts", Chemical reviews, vol. 115, no. 10, pp. 4035-4062 https://doi.org/10.1021/cr5006638 [Fernando Serranía Alarcón, Spain]	Noted. Due to space constraints, we cannot go into detailed assessment of tropospheric halogens and their effects of ozone.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
33223	35	42	35	44	[5/5] References cited in the comment (not proposed for AR6) Buys, Z., Brough, N., Huey, L.G., Tanner, D.J., von Glasow, R. & Jones, A.E. 2013, "High temporal resolution Br-2, BrCl and BrO observations in coastal Antarctica", Atmospheric Chemistry and Physics, vol. 13, no. 3, pp. 1329-1343. Mahajan, A.S., Tinel, L., Hulswar, S., Cuevas, C.A., Wang, S., Ghude, S., Naik, R.K., Mishra, R.K., Sabu, P., Sarkar, A., Anilkumar, N. & Lopez, A.S. 2019, "Observations of iodine oxide in the Indian Ocean marine boundary layer: A transect from the tropics to the high latitudes", Atmospheric Environment-X, vol. 1, pp. UNSP 100016. Prados-Roman, C., Cuevas, C.A., Hay, T., Fernandez, R.P., Mahajan, A.S., Royer, S.-., Gali, M., Simo, R., Dachs, J., Grossmann, K., Kinnison, D.E., Lamarque, J.-. & Saiz-Lopez, A. 2015, "Iodine oxide in the global marine boundary layer", Atmospheric Chemistry and Physics, vol. 15, no. 2, pp. 583-593. Read, K.A., Mahajan, A.S., Carpenter, L.J., Evans, M.J., Faria, B.V.E., Heard, D.E., Hopkins, J.R., Lee, J.D., Moller,S.J., Lewis, A.C., Mendes, L.M., McQuaid, J.B., Oetjen, H., Saiz-Lopez, A., Pilling, M.J., Plane, J.M.C., 2008. Extensive halogen-mediated ozone destruction over the tropical Atlantic Ocean. Nature 453, 1232–1235. https://doi.org/10.1038/nature07035 Roscoe, H.K., Brough, N., Jones, A.E., Wittrock, F., Richter, A., Van Roozendael, M. & Hendrick, F. 2014, "Characterisation of vertical BrO distribution during events of enhanced tropospheric BrO in Antarctica, from combined remote and in-situ measurements", Journal of Quantitative Spectroscopy & Radiative Transfer, vol. 138, pp. 70-81. [Fernando Serranía Alarcón, Spain]	Thanks for the proposed references.
81371	35	42	35	44	What are the radiative forcing implications for that impact? [Johannes Laube, Germany]	Noted. Forcing implications of halogenated compounds are discussed in Chapter 7
106409	35	43	35	43	tropospheric rather than troposphric [Hamza Merabet, Algeria]	The sentence was revised .
33225	35	44	35	44	First reference in line 44 is (Saiz-López et al, 2016) as it is listed at the end of chapter 6 (p.113) Saiz-Lopez, A., and Fernandez, R. P. (2016). On the formation of tropical rings of atomic halogens: Causes and implications. Geophys. Res. Lett. 43, 2928–2935. doi:10.1002/2015GL067608. [Fernando Serranía Alarcón, Spain]	Taken into consideration and revised accordingly.
83025	35	46	35	53	Here is another potential place to discuss the RF due to ozone depletion itself (or equivalently the effective RF of halocarbons). [Olaf Morgenstern, New Zealand]	Rejected. Forcings are given in Chapter 7
100473	35	50	35	53	The numbers in Table 7.5 (not 7.3) are different [Øivind Hodnebrog, Norway]	Accepted and revised accordingly.
103431	35	51	35	51	check consistency with Ch. 2 statement: Direct radiative forcing from CFCs, HCFCs, and HFCs and remaining predominantly synthetic components were 0.25, 0.06, 0.04, and 0.02 W m-2 totalling 0.38 ±0.07 W m-2 in 2018, respectively [Philippe Tulkens, Belgium]	Accepted and revised accordingly.
8421	35	51	35	51	check consistency with Ch. 2 statement: Direct radiative 10 forcing from CFCs, HCFCs, and HFCs and remaining predominantly synthetic components were 0.25, 0.06, 11 0.04, and 0.02 W m-2 totalling 0.38 ±0.07 W m-2 in 2018, respectively [Frank Dentener, Italy]	Accepted and revised accordingly.
72599	35	51	35	52	Remove split of numbers and units across line. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Corrected
81373	35	51	35	52	This should be 0.363 W m-2, 0.376 W m-2, and Table 7.5. Worth checking similar statements for HCFCs and HFCs. [Johannes Laube, Germany]	Taken into account. Forcings are given in Chapter 7
128237	35	51	35	53	If forcings are going to be given in this chapter it needs to be stated whether the values given are RFs or ERFs. [Trigg Talley, United States of America]	Accepted. Forcings are given in Chapter 7.

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128239	35	52	35	52	Typo: due to "a" compensating role. [Trigg Talley, United States of America]	Accepted.
17055	36	3	37	32	Maybe it would be worth mentioning that techniques for direct measurement of the OH loss rate (total OH reactivity) have been increasingly used in the past decade, and that they revealed that NMVOC observations often miss part of the OH sink , especially in forested environments (review: Yang 2016, doi: 10.1016/j.atmosenv.2016.03.010). This suggests that actual total NMVOC emissions are larger than what is usually observed by measuring individual compounds. A recent modelling study (Ferracci 2018, doi:10.5194/acp-18-7109-2018) included this "unattributed" or "missing" OH reactivity into a global model, and found that this additional OH sink implicates atmospheric residence times of methane and pollutants. [Eva Y. Pfannerstill, Germany]	Rejected - thank you for the suggestion, but this is too specific to be incorporated in this section on the implication of SLCF abundances on global OH
103433	36	5	36	5	section is missing a starting point on this topic from AR5 [Philippe Tulkens, Belgium]	Taken into account - AR5 is referenced beginning in the fourth paragraph of this section discussing trends in OH. Additionally, we have modified the following sentence: "Since AR5, some global models that incorporate these improved mechanistic OH-recycling pathways are better able to resolve measurements in low NOx environments (e.g., Bates and Jacob, 2019; Müller et al., 2019)."
8423	36	5	36	5	section is missing a starting point on this topic from AR5 [Frank Dentener, Italy]	See response to #103433
65463	36	5	36	7	Proposal: a short statement could be added to the introductory text in lines 5 to 7 specifying that hydroxyl (OH) radical is the main daytime oxidant , while another strong oxidant (nitrate radical [NO3]) is the dominant oxidant at night, with high agreement and robust evidence according to current scientific knowledge. It would be useful for the community if the difference between daytime and nocturnal atmospheric chemistry and the increasingly investigated impact of the latter in the oxidising capacity of the atmosphere were addressed in AR6 Proposed rephrased text for lines 5-7: “The atmospheric oxidising capacity is primary determined by tropospheric hydroxyl (OH) radical as the main daytime oxidant [while nitrate (NO3) radical likely plays a major role at night]. OH radical is the main sink for many SLCFs, including methane, halogenated compounds (HCFCs and HFCs), CO and NMVOCs, controlling their lifetimes and consequently their abundance and climate influence” Selected supporting reference (and proposed for citation in AR6) Gligorovski, S., Strekowski, R., Barbati, S. & Vione, D. 2015, "Environmental Implications of Hydroxyl Radicals (center dot OH)", Chemical reviews, vol. 115, no. 24, pp. 13051-13092. http://dx.doi.org/10.1021/cr500310b [Fernando Serranía Alarcón, Spain]	Taken into account - we have revised the first sentence of this section to: "The atmospheric oxidising capacity is primarily determined primarily by tropospheric hydroxyl (OH) radical (daytime) and to a smaller extent by NO3 radical (night-time), ozone, hydrogen peroxide (H2O2) and halogen radicals." Since this is text-bookish therefore we do not include the suggested reference
103435	36	14	36	25	First part of section is a bit textbook, second part could be more quantitative: what does it mean that (some) models include new low Nox recycling mechanisms? What does this the new knowledge on HONO mean for estimates of OH (specifically for climate)? [Philippe Tulkens, Belgium]	Taken into account. Text has been revised for conciseness
103437	36	14	36	25	OH is central - very important. Which formation mechanism (via NOx or via isoprene) is more important globally? Is it possible to provide more information here, also about spatial patterns? [Philippe Tulkens, Belgium]	Rejected. We appreciate the comment, but in this section we focus on the global mean OH which is relevant for methane lifetime
106411	36	16	36	16	recylcing rather than recyling [Hamza Merabet, Algeria]	Accepted

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
65465	36	17	36	19	[1/2] Proposal: a short statement could be added addressing the role of nitrous acid (HONO), a tropospheric pollutant (that can reach the ppbv range) likely formed by reactions involving NOx that are not clearly understood at present. Photolysis of HONO may be crucial in polluted environments as the major source of hydroxyl (OH) radicals in the early morning. Proposed rephrased text for lines 17-19: “In polluted air, NO2 emissions control the secondary OH production, through reactions leading to nitrous acid (HONO), whose photolysis is likely the main early morning source of hydroxyl (OH) radicals in polluted atmospheres [high agreement] (Lee et al., 2016; Spataro et al., 2014). In pristine air it occurs via other mechanisms involving, in particular, isoprene (Lelieveld et al., 2016; Wennberg et al., 2018)” Reference proposed for citation in AR6 Lee, J.D., Whalley, L.K., Heard, D.E., Stone, D., Dunmore, R.E., Hamilton, J.F., Young, D.E., Allan, J.D., Laufs, S. & Kleffmann, J. 2016, "Detailed budget analysis of HONO in central London reveals a missing daytime source", Atmospheric Chemistry and Physics, vol. 16, no. 5, pp. 2747-2764. Spataro, F. & Ianniello, A. 2014, "Sources of atmospheric nitrous acid: State of the science, current research needs, and future prospects", Journal of the Air & Waste Management Association, vol. 64, no. 11, pp. 1232-1250. [Fernando Serranía Alarcón, Spain]	Rejected - This recommended insertion was not made because, while it was interesting and solid science, it is not directly relevant to the global budgets of methane, CO and NMVOCs. Furthermore, the suggested reference (Li et al 2014) find that the impact of HONO on the abundance of OH in the troposphere is substantially overestimated. The impact of HONO may be relevant for local urban pollution but is not significant globally.
65467	36	17	36	19	[2/2] Supporting references published since AR5 (may be considered for citation) Czader, B.H., Choi, Y., Li, X., Alvarez, S. & Lefer, B. 2015, "Impact of updated traffic emissions on HONO mixing ratios simulated for urban site in Houston, Texas", Atmospheric Chemistry and Physics, vol. 15, no. 3, pp. 1253-1263. Li, X., Rohrer, F., Hofzumahaus, A., Brauers, T., Haeseler, R., Bohn, B., Broch, S., Fuchs, H., Gomm, S., Holland, F., Jaeger, J., Kaiser, J., Keutsch, F.N., Lohse, I., Lu, K., Tillmann, R., Wegener, R., Wolfe, G.M., Mentel, T.F., Kiendler-Scharr, A. & Wahner, A. 2014, "Missing Gas-Phase Source of HONO Inferred from Zeppelin Measurements in the Troposphere", Science, vol. 344, no. 6181, pp. 292-296. Zhang, L., Wang, T., Zhang, Q., Zheng, J., Xu, Z. & Lv, M. 2016, "Potential sources of nitrous acid (HONO) and their impacts on ozone: A WRF-Chem study in a polluted subtropical region", Journal of Geophysical Research-Atmospheres, vol. 121, no. 7, pp. 3645-3662. [Fernando Serranía Alarcón, Spain]	See response to# 65465
72601	36	29	36	29	Change 'vapor' to 'vapour'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted
32053	36	37		51	Aha! This is better than p24, and well put here. Fig 6.9. is good too. However, does it really chime with the 'high confidence' in OH stability on the next page, lines 23-24. I hope so, but do we know so with 'high' confidence? - or maybe better to say 'medium'? [Euan G. Nisbet, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account. Text has been revised
19021	36	38	36	39	not only possible with MCF measurement, but also CH3Cl,SF6,CH4 measurements, see: Li, M., Karu, E., Brenninkmeijer, C. et al. Tropospheric OH and stratospheric OH and Cl concentrations determined from CH4, CH3Cl, and SF6 measurements. npj Clim Atmos Sci 1, 29 (2018). https://doi.org/10.1038/s41612-018-0041-9 [Mengze Li, Germany]	Rejected. This recommended insertion was not made because, while it was interesting and solid science, we do not focus on the methodology for OH measurements but rather on the derived trends and variability
19023	36	38	36	39	need citations for "global chemistry models". A suggested citation: Lelieveld, J., Gromov, S., Pozzer, A., and Taraborrelli, D.: Global tropospheric hydroxyl distribution, budget and reactivity, Atmos. Chem. Phys., 16, 12477–12493, https://doi.org/10.5194/acp-16-12477-2016, 2016. [Mengze Li, Germany]	Accepted
103439	36	40	36	41	The notation < +/- doesn't make sense, perhaps something like <abs(+/- %) or just smaller than x %, as variations are always pos/neg around a mean. [Philippe Tulkens, Belgium]	Accepted. Text has been revised

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19025	36	42	36	43	consider to add the following two citations: 1. empirical estimation of stratopsheric OH over multiyears: Li, M., Karu, E., Brenninkmeijer, C. et al. Tropospheric OH and stratospheric OH and Cl concentrations determined from CH4, CH3Cl, and SF6 measurements. npj Clim Atmos Sci 1, 29 (2018). https://doi.org/10.1038/s41612-018-0041-9; 2. global model for OH variablity and trend analysis: Lelieveld, J., Gromov, S., Pozzer, A., and Taraborrelli, D.: Global tropospheric hydroxyl distribution, budget and reactivity, Atmos. Chem. Phys., 16, 12477–12493, https://doi.org/10.5194/acp-16-12477-2016, 2016. [Mengze Li, Germany]	Taken into account. Consideration to space and the relevance of a publication to the discussion is given for citations. The second reference is already cited.
72603	36	45	36	45	List submitted reference second in sequence. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	editorial - protocol will be followed
35747	36	45	36	45	Use published sources [Carlos Antonio Poot Delgado, Mexico]	editorial - protocol will be followed
72605	36	48	36	48	Delete negative sign (a negative decrease is an increase). [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted
72607	36	50	36	50	Change reference to Naus et al. (2019) [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted
103441	36	51	36	51	There are papers claiming that two box approaches are too simplistic to represent gradient, and therefore can lead to articificial results. What is your assessment? [Philippe Tulkens, Belgium]	Taken in to account. Problems with 2-box approaches have been highlighted.
8429	36	51	36	51	There are papers claiming that two box approaches are too simplistic to represent gradient, and therefore can lead to articificial results. What is your assessment? [Frank Dentener, Italy]	see answer to #103441
35749	36	54	36	54	Use published sources [Carlos Antonio Poot Delgado, Mexico]	editorial - protocol will be followed
13485	36	54	36	54	Add a space between the pharenthesis [Maria Amparo Martinez Arroyo, Mexico]	Accepted
45941	36	55	36	55	I don't see how a "lack of trend" would be "contrary" to "stabilized or increasing OH". [Twan van Noije, Netherlands]	Taken into account. Text revised
103443	37	23	37	23	Some explanation for this divergence of pre-1980 and after 1980 model derived changes would be useful here, as this is quite a large number. [Philippe Tulkens, Belgium]	Accepted. Text has been added
8431	37	23	37	23	Some explanation for this divergence of pre-1980 and after 1980 model derived changes would be useful here, as this is quite a large number. [Frank Dentener, Italy]	see answer to #103443
20371	37	26	27	32	In summary, would not the striking fact be that OH concentrations (and therefore the oxidising capacity of the Earth atmosphere) have managed during the historical period to remain approximately constant, in spite of global warming and every other perturbing factors due to human activity, deserve mentioning? [philippe waldteufel, France]	Taken into account. No significant change over the 1850 to 1980 is indicated in the text

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65469	37	26	37	32	[1/2] Proposal: a mention (tentatively after line 32) to the role of atmospheric chemistry involving nitrate (NO3) radical as the dominant nocturnal oxidant (high confidence). The impact of nocturnal radical chemistry has been increasingly investigated and has a potentially significant impact in the oxidising capacity of the troposphere at regional and global scales. Only a short statement is suggested (considering potential page length constraints) but further information could be added from the provided bibliography (for instance, the detailed review by Brown et al. (2012) Proposed added statement after line 32: “At night, when OH concentrations are typically smaller, the reaction between NO2 and O3 leads to nitrate (NO3) radical [robust evidence], which is likely the dominant nocturnal oxidant. NO3 radical occurs mainly at night due to its rapid photolysis and it is involved in various homogeneous and heterogeneous processes with impact in the oxidising capacity of the troposphere [medium to high agreement] (Brown et al., 2012; Ng et al., 2017)” Reference proposed for citation in AR6 Brown, S.S. & Stutz, J. 2012, "Nighttime radical observations and chemistry", Chemical Society Reviews, vol. 41, no. 19, pp. 6405-6447. Ng, N.L., Brown, S.S., Archibald, A.T., Atlas, E., Cohen, R.C., Crowley, J.N., Day, D.A., Donahue, N.M., Fry, J.L., Fuchs, H., Griffin, R.J., Guzman, M.I., Herrmann, H., Hodzic, A., Iinuma, Y., Jimenez, J.L., Kiendler-Scharr, A., Lee, B.H., Luecken, D.J., Mao, J., McLaren, R., Mutzel, A., Osthoff, H.D., Ouyang, B., Picquet-Varrault, B., Platt, U., Pye, H.O.T., Rudich, Y., Schwantes, R.H., Shiraiwa, M., Stutz, J., Thornton, J.A., Tilgner, A., Williams, B.J. & Zaveri, R.A. 2017, "Nitrate radicals and biogenic volatile organic compounds: oxidation, mechanisms, and organic aerosol", Atmospheric Chemistry and Physics, vol. 17, no. 3, pp. 2103-2162. [Fernando Serranía Alarcón, Spain]	Rejected - This recommended insertion was not made because, while it was interesting and solid science, it is not directly relevant to the budgets of methane, CO and NMVOCs, which are driven by OH and not NO3. We do not agree that NO3 is significant globally for the topic here. If we were addressing urban pollution, then it would be relevant, but we have limited space.
65471	37	26	37	32	[2/2] Supporting references published since AR5 (may be considered for citation) Kalalian, C., Roth, E. & Chakir, A. 2018, "Atmospheric reactivity of nitrate radicals: Reaction with peroxy radicals", Atmospheric Environment, vol. 190, pp. 308-316. Khan, M.A.H., Cooke, M.C., Utembe, S.R., Archibald, A.T., Derwent, R.G., Xiao, P., Percival, C.J., Jenkin, M.E., Morris, W.C. & Shallcross, D.E. 2015, "Global modeling of the nitrate radical (NO3) for present and pre-industrial scenarios", Atmospheric Research, vol. 164, pp. 347-357. Peleg, M., Tas, E., Obrist, D., Matveev, V., Moore, C., Gabay, M. & Luria, M. 2015, "Observational Evidence for Involvement of Nitrate Radicals in Nighttime Oxidation of Mercury", Environmental science & technology, vol. 49, no. 24, pp. 14008-14018. [Fernando Serranía Alarcón, Spain]	See response to #65469
28535	37	27	37	27	High confidence on OH IAV <3% might be too optimistic,given the possibilities of missing/uncharacterized OH sources/sinks. Medium confidence would be adequate, in a balance to other sentences with high/medium condidence. [Hiroshi Tanimoto, Japan]	Not applicable. Text has been revised, trends in OH are emphasized
103445	37	31	37	31	What is the consequence for CH4 (and other SLCFs) for RF and climate meterics? [Philippe Tulkens, Belgium]	Taken into account - covered in cross-chapter box 5.1
8433	37	31	37	31	What is the consequence for CH4 (and other SLCFs) for RF and climate meterics? [Frank Dentener, Italy]	Taken into account - covered in cross-chapter box 5.1
27041	37	48	37	48	A significant part of the results shown in the 6.6 section are derived from simple models or emulators. This subsection should describe how these emulators perform compared with ESM to simulate the effects of SLCF (for example over the historical period) or do a link toward relevant discussions elsewhere in the report. [Eric Brun, France]	Accepted - text revised as requested

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26157	37	48	54	20	Section 6.3: There are many contents that overlap with Chapter 7. Also, contents on radiative forcing and climate impacts by SLCFs are scattered between Chapters 6 and 7, so readers will not know which to read. I think this has already been discussed among lead authors, but further coordination is needed between Chapters. If they have been already sorted, it should be written at the beginning of the section what to write in Chapter 6 and what to write in Chapter 7, with a Table if possible. Chapter 7 is well-documented in terms of SLCF radiative forcing and climate impacts already at SOD. [Toshihiko Takemura, Japan]	Considered but not applicable, as paragraph was reorganised
69205	37	48	54	20	"The current Chapter 7 (SOD) dealing with radiative forcing of SLCF and its impacts on climate is well-documented. Thus, further coordination (avoiding overlapping and maintaining consistency) between the Lead Authors of Chapter 6 and Chapter 7 would be kindly requested. For instance, the contents in Section 6.3 coincide with that in Chapter 7. [Kaoru Magosaki, Japan]	Taken into account -- see response to comment 26157
113961	37	50	37	50	It is good that you stress the difference between SLCF and WMGHGs here. I think you could also mention "indirect effects" as a difference. "diversity of mechanisms" cover this, but I think you couldl say indirect effects explicitely [Jan Fuglestvedt, Norway]	Accepted -- with the agreement of chapter seven, we have moved section 7.3.5.3 on emissions-based forcing as well as figure 7.10 (SOD numbering) with the emissions-based forcing bar graph
82983	37	51	37	52	In my opinion, this short introduction of the section should also mention that all these factors ("the challenges of observing these mechanisms and inferring their global forcings from available data, the much larger uncertainties in the history of the short-lived climate forcing, and the historically larger but far more localized responses in the climate system") limit our abilities in parameterizing these mechanisms in numerical modelling. [Susanna Strada, Italy]	Accepted - text revised as requested
107539	37	53	37	53	short-lived climate forcing might be confused with the clearly defined SLCF. For clarity suggest changing to radiative forcing due to SLCFs [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised as requested
128241	37	53	37	54	What is meant by "the historically larger ... responses in the climate system"? That the SLFCs have historically caused larger climate effects than WMGHG? What is the evidence for this claim? [Trigg Talley, United States of America]	Accepted -- this assertion has been removed
86407	38	4	38	4	"atmospheric circulation" and "dynamics" are promised in the Section, but there is not much presented by way of the science contained in the problem. Since the confidence level of SLCFs particularly aerosols has increased, it necessitates reiterating or underscoring the validity of hypotheses/theories that are getting substantiated by the increasing number of model results and observations. [venkatachalam ramaswamy, United States of America]	Accepted - text revised as requested
128243	38	5	38	5	Somehwat confusing to use "indirect radiative forcing of SLCFs" in this sense. The term indirect RF is already used w.r.t. aerosol to denote Rfaci (aerosol-cloud interactions). [Trigg Talley, United States of America]	Accepted -- "direct and indirect" has been removed
103447	38	10	38	10	The title 'short lived climate forcing' is suggesting something else than was is inteded: "climate forcing of short-lived components' [Philippe Tulkens, Belgium]	Taken into account -- see response to comment 8435
8435	38	10	38	10	The title 'short lived climate forcing' is suggesting something else than was is inteded: "climate forcing of short live components' [Frank Dentener, Italy]	Accepted - text revised as requested
128245	38	13	38	15	"other compounds" -- are these other compounds also (all) considered to be SLCFs? The wording in these two sentences is awkward. [Trigg Talley, United States of America]	Accepted -- "other compounds" has been replaced by "precursor chemical species"
55057	38	15	38	17	Should an equation, linking the concentration to the emissions, be included here to better elucidate the content in 6.3.1.1 and 6.3.1.2. ? [Nancy Hamzawi, Canada]	Rejected -- IPCC does not employ equations in the main text
20373	38	15	38	17	Is not this alternative present also for WMGHG? [philippe waldteufel, France]	Not applicable, this introduction of section has been totally rewritten.
113963	38	16	38	19	You may make the difference clearer by inserting " (abundance or concentration based) " and " (emission based) " in the sentence [Jan Fuglestvedt, Norway]	Taken into account -- the sentences already mention the distinction
128247	38	17	38	17	"emissions of the precursor emissions" [Trigg Talley, United States of America]	Accepted - text revised as requested
21983	38	18	38	19	Given that you proceed directly to this section is this link text really required here? [Peter Thorne, Ireland]	Taken into account -- the emissions section no longer immediately proceeds this text

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
113967	38	22	38	54	Section 6.3.1.1 Emission-based versus concentration-based radiative forcing could show the difference between emisisons based and concentration based more clearly [Jan Fuglestvedt, Norway]	Accepted -- material from 7.3.5.3 has been moved here in agreement with Chapter 7
111345	38	22	39	42	Discussion of ERF: Comment on limitations of multi-model or ensemble average applies here, especially for ERF of aerosols. As pointed out in the chapter, a large number of mechanisms influence radiative effect. But some of the models don't even include some of the mechanisms, or parameterize them crudely. This means that not all the results are of equivalent quality and this situation is not addressed clearly. Evidence is discussed in ch7, although without much detail on mechanisms. However in ch6 the range is presented without an underlying discussion. Perhaps ch6 and ch7 need to be harmonized. [Tami Bond, United States of America]	Accepted - Effort has been done to discuss the fit for purpose of models for AOD trends modelling and in term of mechanism (6.4 introduction and 6.3.5 introduction)
74053	38	30	38	30	Please clarify that is related to surface NOx sources and not aviation NOx, there the RF is estimated to be positive. This is really an important message, since it has implications on developments of e.g. engine technologies! Grewe, V., Matthes, S., Dahlmann, K., The contribution of aviation NOx emissions to climate change: Are we ignoring methodological flaws?, Env. Res. Lett., DOI: 10.1088/1748-9326/ab5dd7, 2019. [Volker Grewe, Germany]	Not applicable, sentence modified.
74055	38	30	38	30	The statement on negative RF for NOx seems to disagree with the numbers shown in Table 6.4 0.14+-0.09>0! I propose to clarify that table 6.4 only includes ozone, whereas the other also methane (strat H2O?). [Volker Grewe, Germany]	Not applicable -- Table 6.4 has been removed
74057	38	30	38	30	Is the statement of the negative NOx-RF in AR5 still true in light of the steady-state assumption in the methane lifetime change, which I guess was also applied in AR5? Calculating a transient lifetime change and transient methane concentration change alters probably the picture? PLease comment on this and revise the calculaiton and statement accordingly, if needed. Grewe, V., Matthes, S., Dahlmann, K., The contribution of aviation NOx emissions to climate change: Are we ignoring methodological flaws?, Env. Res. Lett., DOI: 10.1088/1748-9326/ab5dd7, 2019. [Volker Grewe, Germany]	Take into account -- see response to comment 74053. Latest results from CMIP6 AerChemMIP experiments still show net negative forcing
107541	38	39	38	39	ERF has already been used in the chapter [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised as requested
16575	38	39	38	54	It should be discussed in this paragraph that chemical responses are part of the "adjustments" included in the ERF when calculating emission-based ERFs. [William Collins, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised as requested
107545	38	41	38	41	specify this relates to present day ERF estimates [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised as requested
45943	38	41	38	42	The Radiative Forcing MIP (RFMIP) also includes experiments focused on SLCFs, including aerosols. Why are they not included in the assessment? [Twan van Noije, Netherlands]	Rejected -- the SW forcing component of RFMIP is devoted to uncertainties in the radiative transfer parameterizations in the instantaneous forcing -- computational constraints mean that RFMIP will not produce time-mean regional or global assessments of aerosol RF.
107543	38	44	38	44	The Checa-Garcia et al (2018) reference seems wrong here. Is it included as the citation for a radiative transfer model? That study uses the Met Office SOCRATES RTM - if that has been used here then include a primary reference for the model not Checa-Garcia et al. who simply use the model to calculate SARF (as have many other studies that are not cited here) [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable -- this paragraph has been removed from the FGD
100475	38	48	38	50	Given that the numbers in Table 6.4 are correct, the CFC/HCFC radiative forcing central estimate is outside the range of the AR5 radiative forcing [Øivind Hodnebrog, Norway]	Not applicable -- Table 6.4 has been removed
45945	38	49	38	49	N2O is a LLGHG and outside the scope of this chapter. [Twan van Noije, Netherlands]	Rejected -- the effects of N2O on other species is the focus here.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
107547	38	50	38	54	This does not read like an assessment of current knowledge. What is important is the overall assessment of N2O and Nox forcing not some detail of differences between model sets [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account -- see response to comment 107543
45947	38	52	38	52	"(cloud, ozone above tropopause)". Please clarify which processes are meant here. [Twan van Noije, Netherlands]	Taken into account -- see response to comment 107543
35751	38	53	38	54	Use published sources [Carlos Antonio Poot Delgado, Mexico]	Taken into account -- see response to comment 107543
128249	38	53	39	15	If different subsets of models are used for different AR6 RF entries in Table 6.4, this should be indicated somehow in table. [Trigg Talley, United States of America]	Not applicable -- Table 6.4 has been removed
103449	38	54	38	54	It would be good to have a clear statement with numbers summarizing the differences between emission-attributed forcing and concentration-based forcing, currently missing. [Philippe Tulkens, Belgium]	Taken into account -- see response to comment 8437
8437	38	54	38	54	It would be good to have a clear statement with numbers summarizing the differences between emission-attributed forcing and concentration-based forcing, currently missing. [Frank Dentener, Italy]	Taken into account -- see response to comment 107543
112015	39	1	39	15	Table 6.4: For methane, how many of these models include shortwave absorption by CH4 (i.e. is this forcing reflective of these new, known absorption bands)? For the last three lines, are these all referring to aerosol species (SO2, BC, OC)? SO2 could be construed as gas although I don't think that's what is meant here. [Cynthia Randles, United States of America]	Not applicable -- Table 6.4 has been removed
100477	39	3	39	17	The radiative forcing for CFC/HCFC of -0.02+/-0.24 W m-2 seems too low given that the cited paper (Thornhill et al., ACPD, doi: 10.5194/acp-2019-1205) presents an ERF value due to halocarbons of 0.15+/-0.27 W m-2, and this is compared to 0.18+/-0.15 W m-2 in IPCC AR5. [Øivind Hodnebrog, Norway]	Not applicable -- Table 6.4 has been removed
29579	39	5	39	5	Table 6.4 caption. Clarify if this is ERF or Stat adjusted RF. [Steven Smith, United States of America]	Not applicable -- Table 6.4 has been removed
8439	39	5	39	5	It would be good to have one column for the relevant components with the concentration based forcing. Is there somewhere the attribution of emission attributed forcing, split into components. [Frank Dentener, Italy]	Not applicable -- Table 6.4 has been removed
107549	39	5	39	12	Important in the discussion of Table 6.4 to cross-reference to chapter 7 and their assessment of total historical ERF and components, which is based on more information than just CMIP6 models. Make sure the overall assessments are consistent [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable -- Table 6.4 has been removed
113965	39	5	39	17	Table 6.4 shows ERF for methane from AR5 and AR6 as 0.79 and 0.69 Wm-2. The latter number is not discussed and appears only in the table. The reduced values compared to AR5 is not discussed either, as far as I can see. [Jan Fuglestvedt, Norway]	Not applicable -- Table 6.4 has been removed
113969	39	5	39	17	The ERFs in Table 6.4 should be more clearly relatedand compared to what is found in ch7. [Jan Fuglestvedt, Norway]	Not applicable -- Table 6.4 has been removed
45949	39	5			Table 6.4: Please indicate that the AR5 RF estimates are for the period 1750 to 2011. [Twan van Noije, Netherlands]	Not applicable -- Table 6.4 has been removed
45951	39	5			Table 6.4 The AR5 range given for CH4 is incorrect. It should be 0.97 +- 0.23 W/m2. [Twan van Noije, Netherlands]	Not applicable -- Table 6.4 has been removed
45953	39	5			Table 6.4: I assume the O3 precursors do not include CH4 and CFC/HCFC. Please clarify this. [Twan van Noije, Netherlands]	Not applicable -- Table 6.4 has been removed
45955	39	5			Table 6.4: The values for NOx should be negative. [Twan van Noije, Netherlands]	Not applicable -- Table 6.4 has been removed
45957	39	5			Table 6.4: In Chapter 7 ERF is defined as the radiative forcing with global surface temperature fixed over both ocean and land. I assume the ERF values given in this table are consistent with the AR5 definition of ERF, where only SSTs are kept fixed. Please clarify which definition has been used, and what this implies for consistency with Chapter 7. [Twan van Noije, Netherlands]	Not applicable -- Table 6.4 has been removed
35753	39	6	39	6	Use published sources [Carlos Antonio Poot Delgado, Mexico]	Not applicable -- Table 6.4 has been removed
128251	39	6	39	6	[PRECISION] Need to clarify terminology used in this chapter. Are "chemical precursors to SLCFs" considered SLCFs themselves, or are only radiatively-active species considered SLCFs? [Trigg Talley, United States of America]	Not applicable -- Table 6.4 has been removed

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
28537	39	13	39	13	Difference between "O3 precursors" and "VOC or NOx" in the other rows? Where is CO? [Hiroshi Tanimoto, Japan]	Not applicable -- Table 6.4 has been removed
96675	39	13	39	14	It does not seem to be plausible that an atmospheric concentration decrease of the most important CFCs, CFC-11 and CFC-12, of only 4 % (compared to 2011 values) in combination with an increase of HCFC-22 concentration results in a ERF below zero (-0.02 W m−2), compared to an ERF of 0.15 W m−2 in 2011. This also contradicts the findings of Polvani et. al, Nature Climate Change volume 10, pages 130–133 (2020), which provide that ERF of ODS was 0.30 W m−2 in 2005 with only small decrease since then. Please check. [Nicole Wilke, Germany]	Not applicable -- Table 6.4 has been removed
103451	39	13			Table 6-4: check AR5, radiative forcing for CH4: in AR5, Fig. SPM.5 this is 0.97 +/- 0.23 [Philippe Tulkens, Belgium]	Not applicable -- Table 6.4 has been removed
103453	39	13			Table 6-4: O3 precursors - which emitted compounds are meant? Only CO is still not in the list? [Philippe Tulkens, Belgium]	Not applicable -- Table 6.4 has been removed
103455	39	13			Table 6-4: for comparison, values of CO2 would be interesting (even if just in the figure caption) [Philippe Tulkens, Belgium]	Not applicable -- Table 6.4 has been removed
103457	39	13			Table 6-4: CFC/HCFC: this is now - with some uncertainty - negative. How should that be interpreted? That additional emissions would (under very high uncertainty) decrase radiative forcing, they would act cooling? Explanation in text form is needed, as that would imply that there is no climate reason to abate CFCs and HCFCs. [Philippe Tulkens, Belgium]	Not applicable -- Table 6.4 has been removed
32069	39	13			Further thought about Table 6.4. I'm a bit puzzled by this: CH4 AR5 0.79Wm-2, AR6 0.69Wm-2 despite Etminan et at 2016? Is the decline in methane ERF from the negative adjustment in 7.3.2.2 (–14% ± 15%, which is not exaclty a narrow error) or is it this saying AR5 was badly wrong? How do these numbers tally with 7-31 line 13? [Euan G. Nisbet, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable -- Table 6.4 has been removed
32055	39	14			Table 6.4 seems to suggest CFC/HCFC emission cools the air??? Is this table a bit premature as it depends on a submitted paper? Are the AR5 and AR6 methodologies really comparable? Also I'm a bit puzzled as there seem to be different values. In the online abstract of Thornhill et al the ERF methane number seems to be 0.69 ± 0.04 W m−2 for methane, while in the dowloaded Thornhill et al manuscript text the number seems to be 0.70 +/- 0.08 Wm-2 for methane, both values with much smaller errors than the value cited here in Table 6.4: or I'm presumably misreading something from a quick skim? Also I'm having trouble trying to reconcile this number with the text of Chapter 7.3.2.2 [Euan G. Nisbet, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable -- Table 6.4 has been removed
64815	39	20	39	20	This section should cover model evaluation. To what extent do we trust the radiative forcing of SLCF simulated by the models? That should include the ability to model aerosol-cloud interactions, but also volcanic forcing, since they are relevant to two possible SRM mechanisms. [Nicolas Bellouin, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable -- this section did not provide new assessments but instead pointers to other portions of this report or to prior reports. It has been removed for brevity
74059	39	22	39	23	From discussions on conferences, with policymakers and industry, the role of RF (either ERF or SARF) is often misinterpreted. To my understanding RF is a predictor for future near-surface temperature changes and the individual implementations (ERF or SARF) and concepts of climate sensitivity and efficacies are derived in a way to best match temperture changes. It would be good to recall this in the beginning or if the authors have a different view to state this discussion. [Volker Grewe, Germany]	Taken into account -- see response to 64815
86323	39	25	39	25	Although ERF used in AR6 is formally defined in Chapter 7, because this Chapter precedes Chapter 7, it might be useful to flag the fact that the ERF definition in AR6 does not partition in terms of fast and slow timescales of response but rather in terms of adjustments of the climate system. [venkatachalam ramaswamy, United States of America]	Taken into account -- see response to 64815
16577	39	27	39	34	It is not quite clear that the definitions of IRFari, ERFari, IRFaci, ERFaci are the same as in chapter7, 7.3.3. Ch 7 has the semi-direct effect included in the ERFari, the Twomey effect in the IRFaci, and the Albrect effect in the ERFaci. [William Collins, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account -- see response to 64815

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
5203	39	30	39	33	This sentence is technically OK but needs to be rewritten for clarity. I had a really hard time getting through “It distinguishes between the basic and quasi-immediate perturbation of the cloud particle number concentration in response to an aerosol perturbation, that implies the radiative forcing due to aerosol-cloud interactions (RFaci) on the one hand, and subsequent rapid adjustment processes in the atmosphere on the other hand.” [Daniel Murphy, United States of America]	Taken into account -- see response to 64815
89665	39	36	39	42	WHY are you comparing the aerosol ERF assessment from AR5 with a table of model output in ch. 7?!? We have an actual assessment of aerosol ERF in THIS report, which is based on multiple lines of evidence, and which can be found in 7.3.3. If anything should be compared to the aerosol ERF assessment of AR5, it needs to be the corresponding assessment for AR6. [Trude Storelvmo, Norway]	Taken into account -- see response to 64815
95855	39	36	39	42	I find this section slightly misleading. It compares the AR5 ERF estimates, which were an expert judgement ("assessed") based on models and observationally derived ERFs with multi-model average from CMIP6. There should be a clear comparison between model based estimates between AR5 and aR6, separately from an AR6 assessed forcing range. [Philip Philip Stier, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account -- see response to 64815
45959	39	39	39	42	Please give more information about the CMIP6 simulations that have been included in the assessment. Which kind of RFMIP simulations have been included? Are they only from RFMIP-ERF or also from RFMIP-SpAer? Have the aerosol ERF simulations from AerChemMIP been included? [Twan van Noije, Netherlands]	Taken into account -- see response to 64815
128253	39	39	39	42	Comment on the causes of the shift towards decreased magnitude of ERFari and (dramatically) increased magnitude of ERFaci in CMIP6 (or refer to somewhere in Chapter 7 where this is discussed?). [Trigg Talley, United States of America]	Taken into account -- see response to 64815
28539	39	41	39	41	Provide uncertainty ranges of ERFari and ERFari+aci. [Hiroshi Tanimoto, Japan]	Taken into account -- see response to 64815
107551	39	41	39	42	This states what the model range in ERF_ari and ERA_aci are but what are the assessed best estimate forcings? (which may be based on more than climate model information) [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account -- see response to 64815
103459	39	41	39	42	Please report the confidence intervals on the -0.24 and -1.17 W m-2, similar to AR5 [Philippe Tulkens, Belgium]	Taken into account -- see response to 64815
8441	39	41	39	42	Please report the error bars on the -0.24 and -1.17 W m-2, similar to AR5 [Frank Dentener, Italy]	Taken into account -- see response to 64815
116529	39		39		Has ch 6 contributed to the x chapter box in chapter 1 on pre industrial reference levels? (there is an assessment of SLCF RF for the period 1750-1850). Please check. [Valerie Masson-Delmotte, France]	Accepted - text revised as requested
95857	40	5	40	26	This section provides only a very high level information that is of limited substance. CCN and IN effects are discussed but none of the mechanisms or scales potential changes apply to. [Philip Philip Stier, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account -- see response to comment 107555
26159	40	7	45	34	Sections 6.3.2 and 6.3.3 especially overlap with Chapter 7, therefore further coordination is needed between Chapters. [Toshihiko Takemura, Japan]	Taken into account -- this coordination has occurred for the FGD
78699	40	8	40	8	The up-to-date term for ice nuclei is now ice nucleating particles (INP), which is used in other chapters - I make suggestions for replacements in all necessary locations. Also, CCN and INP were defined above -> change from "cloud-condensation nuclei (CCN) or ice nuclei (IN)" to "CCN and INP" [Heike Wex, Germany]	'The words 'ice nuclei' have been changed to 'ice nucleating particles'.
130515	40	14	40	14	“aeroslo cloud interactions（ERFaci）" shuld be “the effective radiative forcing due to aerosol-cloud interactions （ERFaci）” [Panmao Zhai, China]	The wording was revised.
86325	40	17	40	17	"in part due to absorbing aerosols": what is/are the other major factor/s? Further, is "convective inhibition" the only mechanism in play? [venkatachalam ramaswamy, United States of America]	Taken into account -- see response to comment 107555
107553	40	21	40	21	use consistent terminology "aerosol-radiation interactions" [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	The wording was revised.
42995	40	21	40	23	Some brief reference is needed to the time period, e.g. "since the 1950s". [Andrew Turner, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account -- see response to comment 107555

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
86327	40	23	40	23	Asian summer monsoon only, or both summer and winter monsoons? [venkatachalam ramaswamy, United States of America]	Taken into account -- see response to comment 107555
107555	40	24	40	24	"Large regional responses" this contains no useful information. Large regions where? Uninformative statement. [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable -- section 6.3.1.3 has been removed
89667	40	29	40	29	This title doesn't make sense as is - it needs to begin with "The impact of" or something along those lines (same with the title of 6.3.1.3) [Trude Storelvmo, Norway]	Taken into account -- see response to comment 128255
27043	40	29	40	29	This subsection could be merged with the subsection discussing LAP in 6.3.2 [Eric Brun, France]	Not applicable -- section 6.3.1.4 has been removed
128255	40	29	40	29	Section header is awkward. Change to "Effects of light-absorbing particles on cryosphere". [Trigg Talley, United States of America]	Not applicable -- section 6.3.1.4 has been removed
103461	40	31	41	4	Suggest to improve the sequence of the assessment finding- AR5/SROCC and AR6. l. 40-45 are somehwat repetive. When talking about snow/ice clearly define snow ice amount or snow fall/preciptation. [Philippe Tulkens, Belgium]	Taken into account -- see response to comment 103461
8443	40	31	41	4	Suggest to improve the sequence of the assessment finding- AR5/SROCC and AR6. l. 40-45 are somehwat repetive. When talking about snow/ice clearly define snow ice amount or snow fall/preciptation. [Frank Dentener, Italy]	Taken into account -- see response to comment 16579
91109	40	35	40	35	You may refer here to Section 7.2.2.3 Changes in Earth's surface energy budget, where the dimming is discussed in more depth. [Martin Wild, Switzerland]	Reference to Section 7.2.2.3 has been added for 'dimming'
128257	40	39	40	39	"darkened" --> "decreased" [Trigg Talley, United States of America]	Considered but not applicable, as paragraph was reorganised
104821	40	42	40	46	Whilst there are improvements in landfill practices to avoid surface and underground fires (UNEP 2019 - see: https://www.unenvironment.org/ietc/resources/publication/waste-management-outlook-west-asia), even with engineered sites in dry climate California (129 listed in Walker 2012 data base In: Spokas et al 2015) there are underground and surface fires. Landfill fires are largely controlled with 25 subsurface fires reported in the previous 15 years (from 2018), though many more surface fires (numbers not provided) are understood to occur Calrecycle 2018. Spokas K, Bogner J, Corcoran M, Walker S. (2015). From California dreaming to California data: Challenging historic models for landfill CH4 emissions.2015. Elem Sci Anth. 2015;3:51. DOI:http://doi.org/10.12952/journal.elementa.000051 Calrecycle (2018). Landfill Fires Guidance Document, updated: 17 August 2018. Accessed 11/6/19 at https://www.calrecycle.ca.gov/SWFacilities/Fires/LFFiresGuide/ [Paul Dumble, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable -- section 6.3.1.4 has been removed
128259	40	44	40	44	Delete the "however". [Trigg Talley, United States of America]	Taken into account -- this sentence has been removed
20375	40	44	40	44	Depending whether there is or not a comma following the second "forcing", the meaning of this sentence changes completely. This is somewhat irritating, considering that missing commas are not infrequent in this SOD. This might well be the case here. [philippe waldteufel, France]	Not applicable -- section 6.3.1.4 has been removed
16579	40	44	40	45	The factor of three increase in ERF needs a reference. If this is actually due to feedbacks as the sentence says, then this should be included in the efficacy, not the ERF. [William Collins, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable -- section 6.3.1.4 has been removed
128261	40	47	40	47	Grammar: "probably did not" is better than "did probably not". [Trigg Talley, United States of America]	Taken into account -- see response to comment 72609
107557	40	47	40	47	"did probabily not significantly contributed" !!! [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account -- see response to comment 72609
72609	40	47	40	47	Change 'did probably' to 'probably did' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised as requested
128263	40	47	40	48	Awkward. Change to "probably did not contribute significantly to ...." [Trigg Talley, United States of America]	Taken into account -- see response to comment 72609
86033	40	47	40	48	The point here is not clear. Also, is this a statistical probability? Please rephrase [Debra Roberts and the Durban WGII TSU, South Africa]	Not applicable -- section 6.3.1.4 has been removed
45961	40	47	40	48	Change "did (...) contributed" to "did (...) contribute". [Twan van Noije, Netherlands]	Taken into account -- see response to comment 72609
20039	40	48	40	48	Contribute does not need a final "d". [philippe waldteufel, France]	Accepted - text revised as requested

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
72611	40	49	40	49	Delete 'O' from reference. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised as requested
28541	40	52	40	52	Here it is mentioned that the RF from LAPs on snow and ice remained unchanged from AR5 but were estimated later in page 42 lines 31-45. [Hiroshi Tanimoto, Japan]	Not applicable -- section 6.3.1.4 has been removed
86035	40	55	40	55	Change 'confidence' to 'agreement' [Debra Roberts and the Durban WGII TSU, South Africa]	Accepted - text revised as requested
116531	40		40		On the attribution of changes to aerosol forcing, please also coordinate with chapter 3 (ch 3- ch 8) (for monsoon but also circulation changes). [Valerie Masson-Delmotte, France]	Taken into account -- see response to 64815
128265	41	3	41	4	Maybe "low agreement that LAPs have caused DETECTABLE long-term changes"? It seems unlikely that LAPs wouldn't have altered glacial mass in some way, but maybe it is small compared to other factors. [Trigg Talley, United States of America]	Not applicable -- section 6.3.1.4 has been removed
107559	41	7	41	7	Be aware of many COVID studies that are likely to appear before January 2021 and may be relevant to this section [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account -- a cross chapter box on COVID has been included in the FGD
103463	41	16	41	25	This introductory section can explain better what is done in the following subsections. It seems that the only direct observations of RF are derived for methane, with limited value. The other subsections seem to discuss mainly model derived forcings. However, also these have a relatively well known observational component- i.e. the spectroscopic properties measured in laboratories with high accuracy. This is probably the domain for Ch. 7, but it should be clearer what is the scope of the Ch. 6 sections [Philippe Tulkens, Belgium]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
8447	41	16	41	25	This introductory section can explain better what is done in the following subsections. It seems that the only direct observations of RF are for derived for methane, with limited value. The other subsections seem to discuss mainly model derived forcings. However, also these have a relatively well known observational component- i.e. the spectroscopic properties measured in laboratories with high accuracy. This is probably the domain for Ch. 7, but it should be clearer what is the scope of the Ch. 6 sections [Frank Dentener, Italy]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
103465	41	18	41	18	Sentence is confusing. Section 6.2.2. is only decribing changes in concentrations. Clarify. [Philippe Tulkens, Belgium]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
8445	41	18	41	18	Sentence is confusing. Section 6.2.2. is only decribing changes in concentrations. Clarify. [Frank Dentener, Italy]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
28543	41	19	41	19	Why special mentioning of short-lived halogenated species? [Hiroshi Tanimoto, Japan]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
34901	41	28	41	39	The SOD notes that methane concentrations were stable from 2002 to 2007; as in the comment above, the whole impact of Methane must now be reconsidered. Please see comment #4 above. [Jim O'Brien, Ireland]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
8449	41	29	41	39	If this section is about testing at one point whether fundamentally our knowledge on radiative properties and concentration changes are consistent, it seems quite incomplete. What is the point of comparing a local RF trend with a global methane trends? Despite the 10 years lifetime, there will be some local interannual variabiility in trends related to large scale weather pattern fluctuations.What is the importance of H2O trends here? How do you arrive at the high agreement asssement statement? [Frank Dentener, Italy]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
103467	41	29	41	39	If this section is about testing at one point whether fundamentally our knowledge on radiative properties and concentration changes are consistent, it seems quite incomplete. What is the point of comparing a local RF trend with a global methane trends? Despite the 10 years lifetime, there will be some local interannual variabiility in trends related to large scale weather pattern fluctuations.What is the importance of H2O trends here? How do you arrive at the high agreement asssement statement? [Philippe Tulkens, Belgium]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
20377	41	29	41	39	This paragraph is packed with difficulties which stimulate remarks. Surface measurements involve atmospheric CH4, rather than "the atmosphere"; rather than "infrared energy", they involve energy in a IR frequency band specific of CH4. The reason for mentioning "Oklahoma" is mysterious. Next the so-called trend of the CH4 radiated energy over 2002-2007 is essentially zero. Therefore, one does not understand why it is stated that this "trend" increases when moving to the 2007-2012 period: the "multiplicative factor" would be 0,026/(-0,003). Meanwhile the CH4 atmospheric concentration increase rate increases by a factor of about 2, as is well known from previous chapters (e.g. figure 2.5b). Adding information about atmospheric humidity loss (over which period? What about it?), we have 5 numerical values which do constitute information, without constituting evidence of anything. [philippe waldteufel, France]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
20379	41	31	41	35	This seems contradictory [philippe waldteufel, France]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
107561	41	32	41	32	Sentence needs at least one citation [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
72613	41	32	41	32	Change 'shows' to 'show' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
128267	41	32	41	34	Need some context for how a point measurement of methane forcing is related to global forcing values. For instance, how sensitivity is the forcing to vertical profiles of temperature and water vapor? [Trigg Talley, United States of America]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
128269	41	32	41	34	What is the point here? A trend of 3.3 +/- 4.9 (i.e., from -1.6 to +8.2) W/m2/yr hardly seems "nearly constant." [Trigg Talley, United States of America]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
72615	41	36	41	36	delete negative sign [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
16581	41	42	41	51	It would be good to link the obs and models here. Do they agree/disagree? [William Collins, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
72617	41	43	41	44	Please review this for English: I doubt Hosey et al. were emitting ozone precursors! [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
28547	41	43	41	51	It is recommended to start with observational quantities (i.e., remote sensing estimation of LWRE), and then comparisons with "model-derived" radiative forcing are presented, to make the logic clearer. For the latter, model-derived radiative forcings are only enumerated, and the comparisons with observations are not clearly discussed. The logic was clearer for methane (section 6.3.2.1.1). [Hiroshi Tanimoto, Japan]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
8451	41	43	42	4	In contrast to the previous section, this is about differences in global model estimates of O3 RF. If there are no direct observations it should be mentioned. The statement that RF is the change over time of the Radiative effect, is formally correct I guess, but most studies concern a fixed point in the past (e.g. e.g. preindustriial) for such calculation, while here you can read a first derivative. Avoid confusion. There is no discussion on ERF. [Frank Dentener, Italy]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
103469	41	43	42	4	In contrast to the previous section, this is about differences in global model estimates of O3 RF. If there are no direct observations it should be mentioned. The statement that RF is the change over time of the Radiative effect, is formally correct I guess, but most studies concern a fixed point in the past (e.g. e.g. preindustriial) for such calculation, while here you can read a first derivative. Avoid confusion. There is no discussion on ERF. [Philippe Tulkens, Belgium]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
128271	41	44	41	46	Clarify that the value given is the *change* in RF from *changes* in ozone over this time period (not an estimate of the mean RF versus 1850 over this time period). [Trigg Talley, United States of America]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
128273	41	44	41	46	What is meant by "multiplicative uncertainty range ... of the order of 50"? Presumably ± 50%. [Trigg Talley, United States of America]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
21985	41	45	41	46	It is unclear to me what this multiplicative factor means and whether the 50 is unitless or has units. It likely needs to be redrafted for clarity for a scientific lay audience. [Peter Thorne, Ireland]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
28545	41	46	41	46	What is meant wth the order of 50? [Hiroshi Tanimoto, Japan]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
128275	41	46	41	49	Is the value cited here the the *change* in ozone SARF from 1990 to 2014? [Trigg Talley, United States of America]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
72619	41	47	41	49	Please review this for English: I cannot untangle what is being said. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
107563	41	48	41	48	SARF has been introduced, use terminology consistently [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
72621	41	49	41	49	Insert 'the' after 'For' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
72623	41	50	41	50	Change reference to 'Checa-Garcia et al. ((2018)' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
107565	41	51	41	51	This is not the CMIP5 archive, rather is it the ozone forcing data created for CMIP5 models. This paragraph needs to explain there are limitations with producing these 3-D model forcing datasets to put context on this 80% difference. For example, Cionni et al (2011) - which should be cited here for the dataset - used a multi linear regression fitted to observations where as the CMIP6 ozone forcing dataset is based on two CCMs. [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
86329	41	51	41	51	An important aspect of ozone RF/ERF is the vertical profile of ozone change. In particular what is the change in the upper troposphere - lower stratosphere region and what is the contribution from this region to the RE? Has the picture changed from the previous Assessment? [venkatachalam ramaswamy, United States of America]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
107567	41	53	41	53	clarify that Rap et al (2015) use the remote sensing ozone data input to an offline radiative code to estimate LWRE. This reads as though the LWRE can be directly assessed from remote sensing data. [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
45963	41	54	41	54	Remove ", the TOA radiative imbalance caused by ozone in the troposphere". [Twan van Noije, Netherlands]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
72625	41	55	41	55	Change 'a' to 'an' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
128277	42	1	42	4	This framing text should open (not end) this sub-section. [Trigg Talley, United States of America]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
21155	42	7	42	29	The vertical distribuiton of absorbing aerosls is also very important but cannot be retrieved in space. There are a few attempts to derive aerosol layer height based on O-2 bands, but there is not global product with sufficient accuracy. [Jing Li, China]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
128279	42	7	43	15	The flow of this Section (6.3.2.1.3) is really odd and confusing. The paragraph on pg 43, lines 4-15, seems like it should frame/precede a statement of the best estimate of RF or ERF by LAP in the cryosphere. As written, it's not at all clear how these observations have been used to constrain the AR6 best estimate. [Trigg Talley, United States of America]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
28549	42	7	43	15	The logical flow is unclear; for this "observationally-derived" estimates section, it is not reader-friendly to start with somewhat lengthy description about the modeled RFs. It is also not very clear from which sentence the "observational" estimations are described. It is also recommended to have clear discussion comparing the observational and modeled quantities. The first paragraph about the radiative forcing from "airborne" BC particles may not fit well, as "observational" constraint was only on the albedo change, induced by "deposited" light-absorbing particles on the ice/snow surface. The logic here needs to be as clear as that for methane (section 6.3.2.1.1). [Hiroshi Tanimoto, Japan]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
128281	42	8	42	8	"increases radiative forcing" RF can be positive or negative so saying it "increases" RF is ambiguous. [Trigg Talley, United States of America]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
45965	42	10	42	10	Please explain what is meant with equivalent black carbon (EBC). [Twan van Noije, Netherlands]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
103471	42	14	42	16	mention which years the estimates pertain to. [Philippe Tulkens, Belgium]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
98439	42	14	42	16	The chapter states that as of the AR5, the expert estimate of RF by black carbon (BC) was +0.4 (+0.05 to 15 +0.8) W m-2. In the AR6, the central estimate for the RF by BC has decreased to approximately +0.32 W m-2. For black carbon, the maximum-minimum RF derives from the different treatment of transport, transformation, deposition, size representation, parameters (e.g., density, refractive index), and interactions with radiation and cloud between the models. Particle size and mixing state determine the solar absorption efficiency of BC and also strongly influence how effectively BC is removed, but they have large uncertainties. Studies that use a multiple-mixing-state global aerosol microphysics model show that the sensitivity (range) of present-day BC direct radiative effect, due to current uncertainties in emission size distributions, it could be amplified 5–7 times when the diversity in BC mixing state is sufficiently resolved. This amplification is caused by the lifetime, core absorption, and absorption enhancement effects of BC, whose variability is underestimated by 45–70% in a single-mixing-state model representation. Some of the statements made in this chapter require additional explanation and a citation. Chapter 6 should also demonstrate that reducing uncertainties in emission size distributions and how they change in the future, while also resolving modeled BC mixing state diversity, is now essential when evaluating BC radiative effects and the effectiveness of BC mitigation on future temperature changes. [nehzat Motallebi, United States of America]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
45967	42	15	42	15	Remove initial in "O Boucher et al." (appears also at other locations in the text). [Twan van Noije, Netherlands]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
8453	42	15	42	16	mention which years the estimates pertain to. [Frank Dentener, Italy]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
89669	42	15	42	16	There is no such estimate in Section 7.3.3.1.1 or Figure 7.9 [Trude Storelvmo, Norway]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
112017	42	15	42	16	Isn’t this reported RF for BC in conflict with what was printed for Table 6.4? [Cynthia Randles, United States of America]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
8459	42	16	42	16	does this number contain the black carbon on snow? [Frank Dentener, Italy]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
103473	42	16	42	16	does this number contain the black carbon on snow? [Philippe Tulkens, Belgium]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
79593	42	16			this central value for the RF of BC (0.32 W/m2) differs from the ERFari of 0.287 W/m2 reported in Table 6.4 at page 39. If the RF value reported here does not account for rapid adjustments, this shoud be clarified. [Decesari Stefano, Italy]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
89671	42	22	42	22	What is REari? [Trude Storelvmo, Norway]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
95859	42	26	42	27	The RF of BC additionally depends on emission strength, then on lifetime and absorptivity. Also, the mixing state dependency is not well captured in this section (affecting both lifetime and absorption c.f. Stier et al., JGR, 2006, 10.1029/2006jd007147) [Philip Philip Stier, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
68825	42	26	42	27	The morphology and mixing state determine the optical properties of black carbon and thus affect its DRE. This point should be briefly mentioned somewhere in this section. For more detailed quatification on the effects, please see Saleh, Rawad, et al. "The interplay between assumed morphology and the direct radiative effect of light-absorbing organic aerosol." Geophysical Research Letters 43.16 (2016): 8735-8743. [Qing Ye, United States of America]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
16587	42	26	42	29	This discussion on BC lifetime should be linked with that in 6.2.2.8. [William Collins, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
86037	42	28	42	28	Reduced from what to what? [Debra Roberts and the Durban WGII TSU, South Africa]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
8455	42	28	42	29	reduced from / to? Number valid where? Explain if these lifetime reductions directly scales with calculated RF? This section is very thin compared to the next section where the deposition on snow is discussed. Why? [Frank Dentener, Italy]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
103475	42	28	42	29	reduced from / to? Number valid where? Explain if these lifetime reductions directly scales with calculated RF? This section is very thin compared to the next section where the deposition on snow is discussed. Why? [Philippe Tulkens, Belgium]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
29581	42	31	41	33	It appears the first couple sentences of this paragraph on BC on snow are misplaced and should be in the next paragraph? [Steven Smith, United States of America]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
128285	42	31	42	35	This is quite confusing: It says AR5 estimate was +0.04 and that the AR6 estimate is *smaller* than this; but then it says that the central estimates range from 0.19 to 0.21. Is the latter referring to forcing by BC in the atmosphere? This whole paragraph lacks clarity in distinguishing forcing by BC/BrC in the cryosphere vs. in the atmosphere. [Trigg Talley, United States of America]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
8457	42	31	42	45	In this section it is not clear what kind of studies are referred to? Individual modelling studies, extensive reviews, community assessment reflecting best science? Is there a scientific reason why these numbers are better/more robust than individual studies, or should the final assessment range also take into account the wider body of pre-AR6 literature. Clarify if all numbers are global. [Frank Dentener, Italy]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
128283	42	31	42	45	Line 33 claims that forcing by BC on snow has decreased since AR5, but the previous sentence states that AR5 found forcing by BC on snow was 0.04 W/m2, and the next sentence suggests a central estiamte of 0.19 W/m2-0.21 W/m2, which is an INCREASE, not a decrease. Or is the subsequent sentence referring to atmospheric forcing? That should be made clear. Also, check consistency with 7.3.4.3 which concludes that the best estimate for ERF is 0.08 W/m2. Also surprised to see brown carbon's lower bound be estimated as -0.21 W/m2. That is a very large negative number for something that one would have thought would generally be a positive number. [Trigg Talley, United States of America]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
103477	42	31	42	45	In this section it is not clear what kind of studies are referred to? Individual modelling studies, extensive reviews, community assessment reflecting best science? Is there a scientific reason why these numbers are better/more robust than individual studies, or should the final assessment range also take into account the wider body of pre-AR6 literature. Clarify if all numbers are global. [Philippe Tulkens, Belgium]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
79595	42	31	42	45	The paragraph starts dealing with past estimation of BC snow albedo effect (Myhre et al. 2013), then turns into a review of BC direct radiative effects in the atmosphere (e.g. Wang et al 2014a). Not only the two processes are distinct but also the associated RFs differ of almost an order of magnitude. I suggest to restructure the entire paragraph. [Decesari Stefano, Italy]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
128287	42	33	42	33	Unclear. Has the magnitude of forcing by BC on snow *increased* or *decreased*? AR5 central estimate is given as 0.04 W/m2, with new estimates around 0.20 W/m2. Please clarify. [Trigg Talley, United States of America]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
45399	42	33	42	37	Forcing values in these sentences are very high. They are not consistent with the second sentence in this paragraph. Are they for regional estimates? Please clarify why these values are several times greater than the AR5 estimate. [Hitoshi Matsui, Japan]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
90249	42	33	42	39	Using a model and observations from the Central United States, Cusworth et al. (2017) found that the observed increase in downward surface solar radiation of ~13 Wm-2 from 2000 to 2014 could be explained by declines in aerosol optical depth as restrictions were tightened on aerosol sources. The study also found evidence of a response in surface temperature and soil moisture as solar insolation increased. Cusworth, D.H., L.J. Mickley, E.M. Leibensperger, and M.J. Iacono, Aerosol trends as a potential driver of regional climate in the central United States: Evidence from observations, Atmos. Chem. Phys., 17, 17, 13559-13572, 2017. [Loretta Mickley, United States of America]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
45969	42	35	42	36	The values given in the text are the model estimates of the SW and LW radiative effects of all organic aerosol, including a small contribution from brown carbon. According to this study the total (SW plus LW) radiative effect of BrC is +0.03 W/m2. [Twan van Noije, Netherlands]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
89673	42	37	42	37	What is DRF? [Trude Storelvmo, Norway]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
45971	42	38	42	38	"high variable" should be "highly variable". [Twan van Noije, Netherlands]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
106413	42	42	42	42	of -5.2 rather than of-5.2 [Hamza Merabet, Algeria]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
13487	42	42	42	42	Add a space between "of" and "-5.2" [Maria Amparo Martinez Arroyo, Mexico]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
72627	42	45	42	45	Delete 'ranges' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
89675	42	48	42	48	BC has already been defined and used etensively above [Trude Storelvmo, Norway]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
45973	42	48	42	50	In the RF or ERF framework (where surface temperatures are not allowed to respond), enhanced snow melt due to deposition of black carbon is not a forcing but a feedback, and is therefore not relevant for this section. Please clarify and/or move to the appropriate section. [Twan van Noije, Netherlands]	Not applicable -- section 6.3.2.1 through 6.3.2.1.3 page 42, line 47 removed from chapter
128289	42	54	42	54	Why give the 1-5% from Hansen and Nazarenko (2004)? This is an old study and the 1-5% was a ballpark range. Since then many field measurements have constrained the amount of BC in snow. [Trigg Talley, United States of America]	Accepted -- the reference to this paper has been removed to emphasize the most recent literature.
45975	42	54	42	54	Change "The reductions" to "Reductions". [Twan van Noije, Netherlands]	Accepted - text revised as requested
45401	43	4	43	4	Artic --> Arctic [Hitoshi Matsui, Japan]	Taken into account -- see response to comment 45401
106415	43	4	43	4	arctic rather than artic [Hamza Merabet, Algeria]	Accepted - text revised as requested
45403	43	10	43	10	delete "there" [Hitoshi Matsui, Japan]	Taken into account -- see response to comment 45403
45977	43	10	43	10	Remove "there". [Twan van Noije, Netherlands]	Taken into account -- see response to comment 45977
72629	43	10	43	10	Delete 'there' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised as requested
27045	43	18	43	18	Could the recent covid outbreak provide information about SLCF forcing? Could this subsection provide statement about spatial and temporal detectability of mitigation measures discussed in SPM D4.2? [Eric Brun, France]	Not applicable -- section 6.3.2.2 removed from chapter
114709	43	18	44	8	As far as I can see, this would fit beter in ch7. Please coordinate. [Jan Fuglestvedt, Norway]	Not applicable -- section 6.3.2.2 removed from chapter
35991	43	18	44	8	Section 6.3.2.2 overlaps quite a lot with Section 7.3.3.3. [Nicolas Bellouin, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable -- section 6.3.2.2 removed from chapter
89677	43	20	44	8	Given that it has been agreed that Ch. 7 assesses regional and per-specie aerosol ERF, why is there an entire section here on emergent constraints on global aerosol ERF?? [Trude Storelvmo, Norway]	Not applicable -- section 6.3.2.2 removed from chapter
8461	43	24	43	31	Are there observational updates of these brigtening/dimming studies? [Frank Dentener, Italy]	Not applicable -- section 6.3.2.2 removed from chapter
103479	43	24	43	31	Are there observational updates of these brigtening/dimming studies? [Philippe Tulkens, Belgium]	Not applicable -- section 6.3.2.2 removed from chapter
107569	43	24	43	39	these two paragraphs talk about the same topic (global dimming/brightening) but are totally disconnected and duplicate some information. They need reworking [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable -- section 6.3.2.2 removed from chapter
34903	43	24	43	48	The SOD notes solar dimming from the 1950s to the 1980s, but fails to connect it with the global cooling that took place over that period. Please see general comments #2 and #13 above. [Jim O'Brien, Ireland]	Not applicable -- section 6.3.2.2 removed from chapter
128291	43	27	43	37	Lines 27-28: "Many of the observational records show a decline from the 1950s to the 1980s (dimming) partially negated by subsequent incresases (brightening)." Lines 35-37: "The observed increase in surface shortwave radiation by 5% between 1960 to 2009 is known as global brightening". These two sentences seem to contradict each other. [Trigg Talley, United States of America]	Not applicable -- section 6.3.2.2 removed from chapter
91111	43	31	43	31	should be Section 7.2.2, not Section 7.2.1 (or specifically Section 7.2.2.3 Changes in Earth's surface energy budget) [Martin Wild, Switzerland]	Not applicable -- section 6.3.2.2 removed from chapter

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
86331	43	33	43	35	An example of a model-observation comparison of the dimming observed over East Asia is shown in: Persad, G., Y. Ming, and V Ramaswamy, 2014: The Role of Aerosol Absorption in Driving Clear-Sky Solar Dimming over East Asia. Journal of Geophysical Research: Atmospheres, 119(17), DOI:10.1002/2014JD021577. One key point from the paper is how disparate aerosol mechanisms and representation in models can lead to similarity of results when compared with observations. This creates some ambiguity in the precise characteristics of aerosols that gave rise to the observed dimming. [venkatachalam ramaswamy, United States of America]	Not applicable -- section 6.3.2.2 removed from chapter
86333	43	35	43	37	From 1960 to 2009, while overall there may have been a 'brightening', this period also underwent a 'dimming' for some portion. If so, it would be informative to state that the trend comprises a period of dimming first followed by a brightening. 'Global' is too much of a catch-all; could this be separated into effects across the different continents (say, NH?)? [venkatachalam ramaswamy, United States of America]	Not applicable -- section 6.3.2.2 removed from chapter
91113	43	35	43	37	This sentence is wrong, Widespread brightening did not already start in 1960 but only in the 1980s. Also the 5% are not stated in the related section in AR5. Sentence needs to be revised or removed. [Martin Wild, Switzerland]	Not applicable -- section 6.3.2.2 removed from chapter
45979	43	37	43	38	Please add estimates for a wider range of models, e.g. multi-model estimates from the ACCMIP and AerChemMIP historical simulations. [Twan van Noije, Netherlands]	Not applicable -- section 6.3.2.2 removed from chapter
128293	43	38	43	38	This should just be "brightening", not "increase of brightening". [Trigg Talley, United States of America]	Not applicable -- section 6.3.2.2 removed from chapter
8463	43	41	43	48	forcing number also for Europe or worldwide? What is the error bar for the Rotsteyn study? What is your asessment of the validity of the Storevlmo study, that leads you to a low agreement statement. [Frank Dentener, Italy]	Not applicable -- section 6.3.2.2 removed from chapter
103481	43	41	43	48	forcing number also for Europe or worldwide? What is the confidence interval for the Rotsteyn study? What is your asessment of the validity of the Storevlmo study, that leads you to a low agreement statement. [Philippe Tulkens, Belgium]	Not applicable -- section 6.3.2.2 removed from chapter
5205	43	41	43	48	I wonder if this paragraph could be folded into Chapter 7. [Daniel Murphy, United States of America]	Not applicable -- section 6.3.2.2 removed from chapter
45981	43	41	43	48	Please elaborate a bit on the differences between these studies. Are they all equally plausible? [Twan van Noije, Netherlands]	Not applicable -- section 6.3.2.2 removed from chapter
128295	43	42	43	44	"for the total-aerosol ERF, to infer a plausible value of -1.3+/-0.4Wm-2" Is this ERF over Europe only, or global? Similarly, on line 44: "ERF of -0.9Wm-2". Is this global? [Trigg Talley, United States of America]	Not applicable -- section 6.3.2.2 removed from chapter
107571	43	43	43	43	"the observed temperature change" - where - regional or global? Over what period? [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable -- section 6.3.2.2 removed from chapter
45405	43	43	43	43	Rotstayn et al. (2015): please clarify whether 2015a or 2015b in the reference list. [Hitoshi Matsui, Japan]	Not applicable -- section 6.3.2.2 removed from chapter
98633	43	44	43	45	Moseid et al ACPD 2020 have updated the Storelvmo comparison of downwelling surface radiation with CMIP6 model output. There is also in the current model generation a dimming and brigthning trend which is not easily reconcilable with surface observations. [Michael Schulz, Norway]	Not applicable -- section 6.3.2.2 removed from chapter
86335	43	46	43	48	The sentence implies that surface temperature change can act as an emergent constraint for changes in surface solar radiation. Maybe the intended message is that models should be satisfying the constraint of the observed fluxes in addition to the observed temperature change, but as worded this seems to reverse the normal flow of thinking where radiative flux drives the temperature change. The construct is awkward, or even incorrect. [venkatachalam ramaswamy, United States of America]	Not applicable -- section 6.3.2.2 removed from chapter
91115	43	47	43	48	"changes in surface in temperature can be used as an emergent constraint changes in surface solar radiation ..." multiple errors in wordings which make the statement unreadable [Martin Wild, Switzerland]	Not applicable -- section 6.3.2.2 removed from chapter
45983	43	48	43	48	Change to "constraint for". [Twan van Noije, Netherlands]	Not applicable -- section 6.3.2.2 removed from chapter
78701	43	51	43	51	Change IN to INP. [Heike Wex, Germany]	Not applicable -- section 6.3.2.2 removed from chapter

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
116533	43		43		It is striking that dimming / brigthening is addressed in ch 2, 7, here, but not in ch 3 (attribution). Please check with chapter 3. [Valerie Masson-Delmotte, France]	Taken into account -- chapter 3 has been contacted
45985	44	2	44	4	For tropospheric NO2, this was shown already by Beirle et al., 2003: Weekly cycle of NO2 by GOME measurements: a signature of anthropogenic sources, Atmos. Chem. Phys., 3, 2225–2232, https://doi.org/10.5194/acp-3-2225-2003. It would be fair to include a reference to that study. [Twan van Noije, Netherlands]	Not applicable -- section 6.3.2.2 removed from chapter
13489	44	4	44	4	Eliminate comma after "Quaas" [Maria Amparo Martinez Arroyo, Mexico]	Not applicable -- section 6.3.2.2 removed from chapter
113971	44	11	45	34	Section 6.3.3 gives interesting information about SW and LW ERF given by time, region and sector. But it would be useful to say more what these insights are used for and what the implications are. [Jan Fuglestvedt, Norway]	Accepted - text revised as requested
5207	44	11			section 6.3.3 I think there is a concept missing from this section, or perhaps it belongs in section 6.2. I think there has been an increased understanding since AR5 that historical estimates of aerosol radiative forcing are extremely sensitive to the pre-industrial natural aerosol level (e.g. Carslaw et al., Aerosols in the Pre-industrial Atmosphere, 2017). [Daniel Murphy, United States of America]	Taken into account. This is addressed in Section 6.2.2.6. and mentioned in the perspective.
5209	44	11			The historical evolution is also sensitive to how models treat aerosol-cloud interactions. When I've looked at model estimates of historical aerosol forcing, there are huge differences between models circa 1900 to 1940. I am pretty sure this is due to how models treat aerosol-cloud interactions. The GISS model (at least as of a few years ago) assumed that aerosol-cloud interactions are fairly linear in aerosol loading. It gets relatively low total aerosol-cloud forcing in the early 1900s. Models that have an initially strong aerosol effect on clouds that later saturates can have relatively large aerosol forcing then even if they don't have an especially large aerosol forcing today. [Daniel Murphy, United States of America]	Discussion on model fit for purpose has been added to the introduction in 6.4
8465	44	13	45	11	Would it be possible to also show and discuss the LW+SW together, perhaps even focus on it? [Frank Dentener, Italy]	Accepted -- the new version of the figure of the FGD displays shortwave and longwave together
89679	44	20	44	20	You have already define and used ERF extensively above [Trude Storelvmo, Norway]	Accepted - text revised as requested
45987	44	20	44	22	Again, RFMIP also provides information on ERF from SLCFs. [Twan van Noije, Netherlands]	Noted. Given the difference in simulation protocols between RFMIP and AerChemMIP, we chose to use one set of estimates for consistency
107577	44	20	44	24	The AerChemMip models are relied on heavily in the chapter for ERF estimates but little regard is given to evaluation of their performance. Do they verify against observations? We can extract these numbers from the models but how can a reader assess whether they are useful or not? [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Discussion on model fit for purpose has been added to the introduction in 6.4
128297	44	22	44	23	"by differencing" --> "as the difference between radiative fluxes in" (and "from" --> "and", line 23) [Trigg Talley, United States of America]	Accepted - text revised as requested
45989	44	22	44	24	Why not use the AerChemMIP time slice simulations to calculate the ERFs between 1850 and 2014? [Twan van Noije, Netherlands]	Accepted
45991	44	22	44	24	Please clarify that CH4 is treated separately from the other SLCFs in the AerChemMIP sensitivity simulations. The ERF estimates obtained by differencing the histSST and histSST-piNTCF simulations do not include the contribution from CH4. [Twan van Noije, Netherlands]	Not applicable. We no longer use histSST-piNTCF simulations recognizing that the contribution of methane is not included
45993	44	22	44	24	Please also note that the ERF estimates calculated from the AerChemMIP simulations are fixed-SST ERFs, and therefore not fully consistent with the definition adopted in Chapter 7. [Twan van Noije, Netherlands]	Accepted. We note the difference in methodologies between ERF estimates calculated from AerChemMIP simulations and that adopted in Chapter 7
45995	44	22	44	24	Another complicating factor to mention is that not all SLCFs are represented in all models. This will bias the model ensemble mean ERF estimates. [Twan van Noije, Netherlands]	Noted. This diversity across models provides an estimate of structural uncertainty
45997	44	26	44	26	Again, it should clarified that the estimates presented here are the ERFs from the combined SLCFs but excluding CH4. [Twan van Noije, Netherlands]	Not applicable, since we no longer use histSST-piNTCF simulations recognizing that the contribution of methane is not included
128299	44	26	44	27	Add "from SLCFs" after "ERFs" [Trigg Talley, United States of America]	Not applicable, section completely rewritten

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
28551	44	26	44	27	Better to discuss why shortwave (longwave) ERFs are negative (positive) briefly. [Hiroshi Tanimoto, Japan]	Noted -- in the absence of analysing the ERF runs from AerChemMIP, any such assignment of sign to forcing agent would be speculative
51253	44	26	44	29	The alternating brackets for shortwave and then (longwave) are slightly confusing here and might be clearer if separated into two distinct clauses rather than multiple ones. E.g. “shortwave- [shortwave explained] and longwave- [longwave explained]” rather than alternating back and forth. [Jolene Cook, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised as requested
128301	44	26	44	41	Move definition of years for modern period "(1995-2014)" from line 41 to line 26. [Trigg Talley, United States of America]	Not applicable, section completely rewritten
45407	44	27	44	27	over most the Earth's surface: "Earth's surface" is a bit confusing because Figure 6.10 shows TOA forcing. "over most areas" may be enough. [Hitoshi Matsui, Japan]	Accepted - text revised as requested
128303	44	30	44	30	The wording needs revision: ERFs fall below the 5th percentile could be read to mean the SMALLEST forcings, not the most negative forcings. [Trigg Talley, United States of America]	Not applicable, section completely rewritten
107573	44	30	44	30	spell out percentile [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account -- see response to comment 106417
106417	44	30	44	32	% ile rather than than %ile [Hamza Merabet, Algeria]	Accepted -- text revised to use percentile rather than %ile
72631	44	31	44	31	Delete , from before 'and' (not required in this context) [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised as requested
86337	44	34	44	34	Begs the question - what is special in the case of South America? [venkatachalam ramaswamy, United States of America]	Not applicable, section completely rewritten
21987	44	36	44	36	What is super regional? This seems ill defined and ripe for conflation with regional. Do you mean something like continental and would that be clearer here? [Peter Thorne, Ireland]	Accepted -- the adjective used here is "major", not "super", and refers to the two levels of hierarchy used by the Atlas. The figure captions make the reference to Atlas nomenclature -- this has been added here.
8467	44	37	4	56	The concept of slow and fast responses needs to be explained better and more upfront. [Frank Dentener, Italy]	Not applicable -- responses are not discussed until section 6.3.4.
107579	44	37	44	38	either delete band or replace with spectral region [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Accepted -- text revised to omit "band" after "shortwave" and "longwave"
107575	44	41	44	41	86.3% seems unbelievably precise given the uncertainties. [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable, section completely rewritten
128305	44	45	44	45	"two-decade-mean ... 20 year periods" -- redundant [Trigg Talley, United States of America]	Accepted -- text "on 20-year" revised to "during"
72633	44	45	44	45	Change 'centered' to 'centred' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised as requested
72635	44	47	44	47	Delete , from before 'and' (not required in this context) [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised as requested
128307	44	49	44	49	"whether" --> "when" [Trigg Talley, United States of America]	Accepted - text revised as requested
128309	44	51	44	51	Aren't "SLCF precursor compounds" also considered SLCFs under the definition used in this chapter? [Trigg Talley, United States of America]	Precursors are part of the SLCFs.
95863	45	1	45	11	Personally I find that lumping gaseous and aerosol SLCF into one ERF makes it very hard to assess or understand the underlying processes and mechanims. [Philip Philip Stier, United Kingdom (of Great Britain and Northern Ireland)]	Accepted, only ERF from aerosols in presented in FGD
45999	45	2	45	2	Change "SLCFs" to "SLCFs excluding CH4". [Twan van Noije, Netherlands]	Accepted - only ERF from aerosols is shown now
46001	45	16	45	16	Change to "(ERFs) from SLCFs excluding CH4". [Twan van Noije, Netherlands]	Accepted - only ERF from aerosols is shown now
46003	45	28	45	28	Change to "(ERFs) from SLCFs excluding CH4". [Twan van Noije, Netherlands]	Accepted - only ERF from aerosols is shown now

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
103483	45	37	46	46	The concept of slow and fast responses needs to be explained better and more upfront. [Philippe Tulkens, Belgium]	Accepted - text revised as requested. The following sentence was added "AR5 has clarified the importance of distinguishing instantaneous radiative forcing and fast responses (through rapid atmospheric adjustments which modify the radiative budget indirectly) from slow responses through feedbacks (affecting climate variables that are mediated by a change in surface temperature and involve the response of the oceans to the forcing) (Boucher et al., 2013). Rapid adjustments affect cloud cover and other components of the climate system and thereby alter the global radiation budget indirectly much faster than responses of the ocean to forcing (Myhre et al., 2013). Although adjustments generally occur on timescales of hours to several months, and feedbacks on timescales of a year or more, timescale is not used to separate the definitions (see BOX 7.1 in Chapter 7).The dual fast and slow response framework has been applied across a range of recent global model studies (Baker et al., 2015; Richardson et al., 2016; Samset et al., 2016, 2018a; Liu et al., 2018). A schematic representation of rapid and slow responses of the atmospheric energy balance and global precipitation to radiative forcing is presented in Figure 8.3 (Section 8.2.1). "
46005	45	37			Section 6.3.4: The climate response discussed in this section currently doesn't include the response to changes in CH4 concentrations. Wouldn't it be better to include these in the discussion? [Twan van Noije, Netherlands]	The discussion is focused on the climate responses from SLCFs but excluding the WMGHGs such as CH4 which induces a homogeneously distributed RF similarly to CO2. It is added that CH4 RF-driven changes are in parallel to CO2 due to the relatively homogeneous spatial influence from WMGHGs. The following sentence was added: "Consequently, climate influence from these SLCFs is more important on a regional scale (Collins et al., 2013; Aamaas et al., 2017), contrary to the relatively homogeneous spatial influence from WMGHGs (including methane). "
107581	45	39	45	39	replace "has been pointed out" with "discussed" [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised as requested
107583	45	41	45	45	It is not clear why increased model spread in temperature projections leads to improve modelling of regional climate change. Please elaborate [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	The large spread in aerosol + ozone forcing, stemming from uncertainties in several factors foremost among which are aerosol-cloud interactions, and potentially differences in regional land use forcing as well, appears to play an important role in the variability in regional temperature changes simulated in global models. The sentence has been revised.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
86339	45	45	45	45	An important distinction between scattering and absorbing aerosols is the opposing nature of their influences on circulation, clouds, and precipitation, besides of course surface temperature. Couple of examples of investigations that reveal the sensitivity particularly in the context of regional aerosols and regional climate changes: (a) Asia: Randles, C A., and V Ramaswamy, 2008: Absorbing aerosols over Asia: A Geophysical Fluid Dynamics Laboratory general circulation model sensitivity study of model response to aerosol optical depth and aerosol absorption. Journal of Geophysical Research, 113, D21203, DOI:10.1029/2008JD010140; and (b) Africa: Randles, C A., and V Ramaswamy, 2010: Direct and semi-direct impacts of absorbing biomass burning aerosol on the climate of southern Africa: a Geophysical Fluid Dynamics Laboratory GCM sensitivity study. Atmospheric Chemistry and Physics, 10(20), DOI:10.5194/acp-10-9819-2010 [venkatachalam ramaswamy, United States of America]	Accepted - text revised as requested. The following sentence was added "An important distinction between scattering and absorbing aerosols is the opposing nature of their influences on circulation, clouds, and precipitation, besides of course surface temperature as it is shown in previous studies that reveal the sensitivity particularly in the context of regional aerosols and regional climate changes (Randles and Ramaswamy, 2008, 2010). "
95865	45	47	45	47	I suggest to add Dagan et al., GRL, (2019), 10.1029/2019GL083479 , outlining a simple theoretical framework that helps to explain the contrasting precipitation response in low and mid-latitudes. [Philip Philip Stier, United Kingdom (of Great Britain and Northern Ireland)]	Accepted. The reference was added and discussed in 6.3.4.2.
72637	45	51	45	51	Replace 'like' with 'such as' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised as requested
86341	45	54	45	54	"local influence of aerosols": Note that, even in the case of the effects of aerosols on the Asian monsoon, there is a distinct influence brought about by the remote aerosols (i.e., aerosols present outside of Asia). See e.g., Bollasina, M., Y. Ming, V Ramaswamy, M. D. Schwarzkopf, and V. Naik, 2014: Contribution of Local and Remote Anthropogenic Aerosols to the 20th century Weakening of the South Asian Monsoon. Geophysical Research Letters, 41(2), DOI:10.1002/2013GL058183 [venkatachalam ramaswamy, United States of America]	The reference was considered.
86343	45	56	45	56	"fast and slow" responses": Note that Chapter 7 argues in the definition of ERF for a preference to view the feedback in terms of adjustment rather than timescale. [venkatachalam ramaswamy, United States of America]	A link to Box 7.1 (chapter 7) is made and the following sentence has been added: "Although adjustments generally occur on timescales of hours to several months, and feedbacks on timescales of a year or more, timescale is not used to separate the definitions (see BOX 7.1)."
35993	46	1	46	1	What is meant by "verified" here? The studies cited are model studies, which simply apply the fast/slow response framework so cannot be said to verify anything. [Nicolas Bellouin, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised as requested
86345	46	3	46	3	One key point is that atmosphere and land surface processes are capable of achieving substantial within-hemisphere homogenization in the climate response to disparate forcers (such as LLGHGs and aerosols) on fast, societally-relevant timescales. The surface energy flux response patterns achieve roughly two-thirds of the anti-correlation seen in the fully coupled response, being driven by Rossby waves excited by changes to the land–sea contrast. See (a) Persad, G., Y. Ming, Z. Shen, and V Ramaswamy, 2018: Spatially similar surface energy flux perturbations due to greenhouse gases and aerosols. Nature Communications, 9, 3247, DOI:10.1038/s41467-018-05735-y; (b) Ming, Y., and V Ramaswamy, 2012: Nonlocal component of radiative flux perturbation. Geophysical Research Letters, 39, L22706, DOI:10.1029/2012GL054050. [venkatachalam ramaswamy, United States of America]	Not applicable. The sentence has been removed.
107585	46	5	46	5	I think this result was first shown by Andrews et al (2010) not Samset et al (2016) [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable. The sentence has been removed.
86347	46	9	46	10	One can also argue that there is a flip side to this viz., remote aerosols can influence temperature and precipitation in the localized region under consideration (e.g., Bollasina et al., 2014, Geophysical Research Letters, 41(2), DOI:10.1002/2013GL058183) [venkatachalam ramaswamy, United States of America]	Yes indeed but the current sentence does not exclude this flip side. We added Bollasina et al. (2014) in the references cited in this sentence.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
51255	46	9	46	13	It would be useful to provide some information on the uncertainties in estimating local forcings compared with remote forcings & their interactions. [Jolene Cook, United Kingdom (of Great Britain and Northern Ireland)]	The impact of remote forcings are very much sensitive to the induced circulation and dynamical changes whereas local forcings have stronger local thermodynamical impacts. We have a paragraph discussing the model uncertainties in climate responses.
113973	46	15	46	15	simulation --> simulationS [Jan Fuglestvedt, Norway]	Accepted - text revised as requested
128311	46	15	46	30	[PRECISION] In addition to these model-based estimates of uncertainties, authors should mention the problem of not knowing the emissions in the preindustrial. Add a sentence such as the following to the end of this paragraph: "Estimates of radiative forcing from aerosols are very sensitive to poorly constrained emission estimates for the preindustrial time period, especially from wildfires (Hamilton et al., 2018)." [Trigg Talley, United States of America]	Accepted - text revised as requested by adding the proposed sentence.
5211	46	15	46	30	I was confused by this paragraph. The previous two paragraphs were very well-written about the distinction between local and distant responses as well as fast and slow responses. Then suddenly in this paragraph there is a general discussion of model uncertainties such as wet removal on line 20 and the ammonium nitrate-sulfate interaction on line 22. I can see the point you are trying to make but these sentences are distracting. [Daniel Murphy, United States of America]	Accepted. We reformulated the paragraph discussing the model uncertainties and we reduced the text by removing discussion of specific examples.
5213	46	15	46	30	I suggest deleting “These uncertainties… (Baker et al. 2015)” on lines 19-25 and replacing it with a much more direct statement such as “Different representations of aerosol processes such as wet removal and chemical interactions lead to an even greater intermodal spread at regional scales than at a global scale (Baker et al., 2015).” [Daniel Murphy, United States of America]	Accepted. We reformulated the paragraph discussing the model uncertainties taking into consideration the proposed sentence.
95867	46	15	46	46	The model description and framing misses an or "the" elephant in the room: neither GCMs nor RCMs represent aerosol effects on convection explicltly (or at all). Evidence on these effects exist, e.g. in the ACPC initiative, and may not fit here but this should be discussed somewhere. [Philip Philip Stier, United Kingdom (of Great Britain and Northern Ireland)]	This is an issue that the discussion fits in Chapter 8. It is mentioned in 8.5.1.
107587	46	18	46	18	replace undergo with "are affected by" [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable. The sentence has been removed.
21989	46	18	46	18	Undergo feels like a very odd phraseology here. I assume you mean something like suffer from or are affected / afflicted by? [Peter Thorne, Ireland]	Not applicable. The sentence has been removed.
86349	46	20	46	20	An uncertainty accompanying the factors mentioned is that the transformation processes affect the aerosol distributions and thus their radiative effects. [venkatachalam ramaswamy, United States of America]	This is implied but not explicitly mentioned in this sentence. Nevertheless earlier on we state that "The AR5 reported that models vary considerably in their representation of aerosols and their radiative properties, resulting in a large uncertainty in aerosol radiative forcing (Myhre et al., 2013)."
128313	46	22	46	24	"SO4" --> "SO4 2-" [Trigg Talley, United States of America]	Not applicable. The sentence has been removed.
128315	46	28	46	28	"added *to* those"? [Trigg Talley, United States of America]	Accepted - text revised as requested
20041	46	28	46	28	Missing "to" before "those"? [philippe waldteufel, France]	Accepted - text revised as requested
21991	46	28	46	30	This sentence made no sense to me as presently written. It feels like some necessary context has been dropped but I'm not sure what this might be so cannot make a constructive suggestion, sorry. [Peter Thorne, Ireland]	Accepted - text revised as follows: "The effects of changes in aerosols on local and remote changes in temperature, circulation and precipitation are sensitive to a number of model uncertainties and hence caution must be paid when interpreting regional climate effects in model studies. "
89221	46	31	46	31	Mineral dust is mentioned as a possible contributor to ERF from change in snow and ice. In the aerosol-radition interaction section it is not discussed any anthropogenic influence on mineral dust. In several of the earlier IPCC assesments, an estimate of dust IRFari has been provided so useful with a consistency. [Gunnar Myhre, Norway]	Noted. Multimodel estimates of dust IRF from RFMIP or AerChemMIP were not available in time to be included in the assessment.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
67939	46	32	46	41	This chapter covers extensively Aerosol-Radiation Interaction (ARI) and Aerosol-Cloud Interaction (ACI), but there was no mention of Aerosol-Photolysis Interaction (API). I would like to share a new study on the synergetic effect of ARI and API on PM2.5 pollution in North China Plain. Perhaps this could be included either in this sub-section (6.3.4) or in another sub-section (6.4.3). Reference: Wu, J., Bei, N., Hu, B., Liu, S., Wang, Y., Shen, Z., Li, X., Liu, L., Wang, R., Liu, Z., Cao, J., Tie, X., Molina, L. T., and Li, G.: Aerosol–photolysis interaction reduces particulate matter during wintertime haze events, Proc. Natl. Acad. Sci. U.S.A. 117, 9755-9761; https://doi.org/10.1073/pnas.1916775117 (2020). A summary of this study is pasted in the next row. [Luisa Molina, United States of America]	An explicit discussion of this issue does not fit in 6.3.4. However in the generic discussion of model uncertainties we also refer to aerosol-photolysis interactions and we cited the proposed reference.
67941	46	32	46	41	ARI plays a significant role in the accumulation of PM2.5 by stabilizing the planetary boundary layer and thus deteriorating air quality during haze events. However, modification of photolysis caused by aerosol absorbing and/or scattering solar radiation (i.e., aerosol–photolysis interaction or API) changes atmospheric oxidizing capacity, decreases the rate of secondary aerosol formation, and ultimately alleviates the ARI effect on PM2.5 pollution. A new study assesses the synergetic effect of API and ARI on PM pollution during a heavy haze episode in North China Plain by using a fully coupled WRF-Chem model. The modeling results reveal that API hinders secondary aerosol formation and substantially mitigates the PM pollution caused by ARI. Additionally, API increases the solar radiation reaching the surface and perturbs aerosol nucleation and activation to form cloud condensation nuclei, influencing ACI. The results suggest that API reduces PM2.5 pollution during haze events, but adds uncertainties in climate prediction. [Luisa Molina, United States of America]	An explicit discussion of this issue does not fit in 6.3.4. However in the generic discussion of model uncertainties we also refer to aerosol-photolysis interactions and we cited the proposed reference.
106419	46	33	46	33	assessment rather than assessement [Hamza Merabet, Algeria]	Accepted and corrected.
35755	46	34	46	37	Bibliographic citations in chronological order [Carlos Antonio Poot Delgado, Mexico]	Accepted and corrected.
72639	46	35	46	36	References should be in chronological order [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted and corrected.
8469	46	43	46	46	The key finding is currently only talking about RCMs, but misses other content of this section. [Frank Dentener, Italy]	Not applicable. The sentence has been removed.
21993	46	43	46	46	Is this intended as a summary? If so make this clear so that it is obvious this is a summation of the lines of evidence outlined above. Also, make clearer in that preceding text that it used RCMs? Otherwise this text is odd in that there are no references given and therefore no justification for the assessment being made here. [Peter Thorne, Ireland]	Not applicable. The sentence has been removed.
86351	46	45	46	46	From the studies available, can inferences be drawn on why the 'aci' influences on precipitation are problematic in the comparison between GCMs and regional models? Does the lack of an agreement handicap the use of GCMs in projecting future influences on climate due to 'aci' processes? [venkatachalam ramaswamy, United States of America]	Not applicable. The sentence has been removed.
46009	46	52	46	54	Since in reality methane is also an ozone precursor, it would be helpful to clarify that the term "ozone precursors" as used here does not include methane (consistent with the usage in AerChemMIP). [Twan van Noije, Netherlands]	Accepted - only ERF from aerosols is shown now
46007	46	54	47	7	A relevant paper in this context is MacIntosh et al., 2016: Contrasting fast precipitation responses to tropospheric and stratospheric ozone forcing, Geophys. Res. Lett., 43, 1263– 1271, doi:10.1002/2015GL067231. Please consider including this study in the discussion. [Twan van Noije, Netherlands]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
46011	47	3	47	7	In Chapter 4 unequal weighting of models is applied when making future projections based on multi-model ensembles. Shouldn't a similar weighting procedure be applied here? If not, please explain why this cannot be done. [Twan van Noije, Netherlands]	In chapter 4 this is done for GSAT. All other quantities are based on the raw CMIP6 ensemble because there is not enough evidence that would support a non-uniform weighting for anything but GSAT.
26161	47	12	48	12	Section 6.3.4.1 is much similar to section 7.3.5.4. [Toshihiko Takemura, Japan]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
86353	47	14	47	15	I think BC stabilizing the atmosphere need not be true in general once vertical and horizontal dynamical processes are taken into account. This is critically dependent on the amount and altitude distribution of BC. Vertical distribution of BC could well stabilize the atmosphere in some regions but the heating caused by the solar absorption can get dissipated instead of giving rise to a stabilization. This dissipation could arise from principally convective or large-scale dynamical processes, or some combination of both. A picture of how sensitivities could arise can be discerned from: (a) Erlick, C, V Ramaswamy, and L M Russell, 2006: Differing regional responses to a perturbation in solar cloud absorption in the SKYHI general circulation model. Journal of Geophysical Research, 111, D06204, DOI:10.1029/2005JD006491; and (b) Ming, Y., V Ramaswamy, and G. Persad, 2010: Two opposing effects of absorbing aerosols on global-mean precipitation. Geophysical Research Letters, 37, L13701, DOI:10.1029/2010GL042895. [venkatachalam ramaswamy, United States of America]	Not applicable, section has been completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
46013	47	14	47	24	It would be instructive to repeat here that the lack of nitrate chemistry in models tends to overestimate the climate response to SO2 emission reductions. [Twan van Noije, Netherlands]	Noted. Without a full exploration of responses in models with and without nitrate chemistry, such a statement would be speculative
64803	47	15	47	16	The remainder of the section suggests that uncertainties are also large for sulfate, not just BC. [Nicolas Bellouin, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable. section has been completely rewritten
64805	47	17	47	17	Suggest to say "would induce" rather than "induces" [Nicolas Bellouin, United Kingdom (of Great Britain and Northern Ireland)]	Accepted and corrected.
113975	47	17	47	21	This is presented as a fact, but is the result of one single study. Please do an assessment of this issue; using more studies. [Jan Fuglestvedt, Norway]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
46015	47	26	47	27	Please clarify that the climate response is calculated by differencing simulations in which methane concentrations are kept fixed. [Twan van Noije, Netherlands]	Accepted - only ERF from aerosols is shown now
8471	47	26	47	32	Why is ozone discussed here, but not in the previous section. Is it possible to separate O3 / aerosol [Frank Dentener, Italy]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
103485	47	26	47	32	Why is ozone discussed here, but not in the previous section. Is it possible to separate O3 / aerosol [Philippe Tulkens, Belgium]	Not applicable, section completely rewritten to only summarize the assessment from chapters 3,7, 8 and 10.
107589	47	28	47	29	clearer to replace 2014 with present day since the averaging period is actually 1995-2014 (the AR6 definition of present day) [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text and figure revised as requested
106421	47	30	47	30	a maximum rather than an maximum [Hamza Merabet, Algeria]	Accepted and corrected.
72641	47	36	47	36	Delete , from before 'and' (not required in this context) [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable. The sentence has been removed.
72643	47	37	47	37	Insert , after 'Arctic' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable. The sentence has been removed.
128317	47	42	47	42	No hyphen in "northern hemisphere" [Trigg Talley, United States of America]	Accepted and corrected.
72645	47	42	47	42	Replace 'northern-hemisphere;' with 'Northern Hemisphere' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted and corrected.
107591	47	44	47	46	Richardson et al (2019) is also relevant to the similar pattern of surface temperature response for different patterns of ERF (doi: https://doi.org/10.1029/2019JD030581) [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
107593	47	48	47	50	this sentence reads as though Arctic amplification is due to aerosol forcing. Please rephrase [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised as requested
109625	47	52	47	52	"Navarro et al." should be "Acosta Navarro et al." [Ilona Riipinen, Sweden]	Accepted

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
39009	47	55	47	56	It is important to state the large contribution of black carbon (BC) to the effective radiative forcing (ERF) in the Arctic based on the latest CMIP6 model results. For example, Oshima et al. (submitted) used the MRI-ESM2.0 model, one of the CMIP6 models, and found that BC provides the second largest contribution to the positive ERF after carbon dioxide in the Arctic, suggesting a possible important role of BC in Arctic surface warming. [Seiji Yukimoto, Japan]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
103487	48	1	48	3	"weak" is misspelled. [Philippe Tulkens, Belgium]	Not applicable. The word has been removed.
8473	48	3	48	3	0.07 is about 6 % of the 1.24 C, why is this 'weak', it is less than linear. [Frank Dentener, Italy]	Considered but not applicable, as paragraph was reorganised
103489	48	3	48	3	0.07 is about 6 % of the 1.24 C, why is this 'weak', it is less than linear. [Philippe Tulkens, Belgium]	Accepted and the words "weak" and "merely" have been deleted.
72647	48	3	48	3	Replace 'evidences' with 'evidence' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable. The sentence has been removed.
21995	48	3	48	3	weak (sic) warming of merely is editorialising value judgement and probably should be removed. [Peter Thorne, Ireland]	Accepted and the words "weak" and "merely" have been deleted.
128319	48	3	48	5	Section 6.3.1.5 doesn't say this. It says kind of the opposite -- that the forcing and effect on snow melt is probably small, i.e., "In AR5, it was assessed that the effects of light-absorbing particles (LAPs) did probably not significantly contributed to recent reductions in Arctic ice and snow (Vaughan et al., 2013 Section 4.5.4). The RF from LAPs on snow and ice was assessed to +0.04". It says nothing about BC deposition contributing to strong Arctic warming. [Trigg Talley, United States of America]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
18305	48	3	48	8	This sentence seems to contradict the sentence at page 40 line 47 ("In AR5, it was assessed that the effects of light-absorbing particles (LAPs) did probably not significantly contributed to recent reductions in Arctic ice and snow (Vaughan et al., 2013 Section 4.5.4). The RF from LAPs on snow and ice was assessed to +0.04 (+0.02 to +0.09) W m-2 (O Boucher et al., 2013 Chapter 7 Executive Summary), a range appreciably lower than the estimates given in AR4 (Myhre et al., 2013 Chapter 8.3.4.4). This effect was assessed to be low confidence (medium evidence, low agreement) (Myhre et al., 2013 Table 8.5). These estimates remain unchanged in AR6 (Section 7.3.4.3)." [Stefania Gilardoni, Italy]	Not applicable, section completely rewritten to only summarize the assessment from chapters 3,7, 8 and 10.
72649	48	4	48	4	Replace 'have' with 'has' x2 [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable. The sentence has been removed.
18307	48	5	48	5	Section 6.3.1.5 is actually 6.3.1.4 [Stefania Gilardoni, Italy]	Accepted and corrected.
28559	48	5	48	8	The results of Abbatt et al., 2019 could be augmented by citing recent modeling papers focusing on long-range transport of Asian BC emissions - Ikeda et al. (ACP 2017) and C. Zhu et al. (ACP 2020). Strongly suggest to cite these. References: Ikeda, K., Tanimoto, H., Sugita, T., Akiyoshi, H., Kanaya, Y., Zhu, C., and Taketani, F.: Tagged tracer simulations of black carbon in the Arctic: transport, source contributions, and budget, Atmos. Chem. Phys., 17, 10515–10533, https://doi.org/10.5194/acp-17-10515-2017, 2017. Zhu, C., Kanaya, Y., Takigawa, M., Ikeda, K., Tanimoto, H., Taketani, F., Miyakawa, T., Kobayashi, H., and Pisso, I.: FLEXPART v10.1 simulation of source contributions to Arctic black carbon, Atmos. Chem. Phys., 20, 1641–1656, https://doi.org/10.5194/acp-20-1641-2020, 2020. [Hiroshi Tanimoto, Japan]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
5215	48	10	48	10	I suggest moving “remote”: “In response to local aerosol forcings global climate model simulations show qualitatively similar remote temperature…” [Daniel Murphy, United States of America]	Accepted - text revised as requested
8475	48	10	48	12	In this summary statement, it would be useful to give some quantification of the regional temperature response. [Frank Dentener, Italy]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
8481	48	10	48	12	The summary finding only discusses aerosol responses, while the model experiments take O3 and aerosol together. Discussion + summary statement are needed on this. [Frank Dentener, Italy]	Taken into account. Figure changed to show only aerosol effect on GSAT.
103491	48	10	48	12	In this summary statement, it would be useful to give some quantification of the regional temperature response. [Philippe Tulkens, Belgium]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
103493	48	10	48	12	The summary finding only discusses aerosol responses, while the model experiments take O3 and aerosol together. Discussion + summary statement are needed on this. [Philippe Tulkens, Belgium]	Accepted, figure changed to show only aerosol effect on GSAT.
5217	48	10	48	12	There are well-written paragraphs on page 47. I think this summary statement needs to be strengthened to restate the obvious, something like “it is important to realize that studies consistently show that changes in aerosol have important distant temperature responses as well as local responses.” I still encounter a lot of people who think that local aerosol forcing only gives local response. [Daniel Murphy, United States of America]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
21997	48	10	48	12	Edit to make clear that this is a summary of the prior assessment text for avoidance of ambiguity? [Peter Thorne, Ireland]	The summary statement was revised.
113977	48	10	48	13	It would be good if you could expand this summary a bit and give some clearer messages. [Jan Fuglestvedt, Norway]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
86411	48	15	48	15	Section 6.3.4.2 presents very interesting material on the linkage between aerosol spatial forcing, circulation changes and other dynamical aspects, and precipitation. In particular, the hemispherically asymmetric forcing created by aerosols, the effect this has on the equatorial circulation and the cross-equator precipitation change that is totally in contrast to the pattern expected for LLGHGs, is virtually a new subject in the context of the IPCC assessment. Although casually mentioned in earlier assessments in the context of aerosol influences on cloud microphysics and convective motions (e.g., Section 7.6.4 and 8.6.2.2 in AR5), the linkage from the asymmetric forcing to shift of circulation and ITCZ due to anthropogenic aerosols, now becoming evident from a plethora of model investigations, is justifiably figuring more prominently in the context of this Chapter. The justification is that this is a distinctive, unique feature brought about by the spatial aspects of aerosol emissions and atmospheric concentrations, including the difference between scattering and absorbing aerosols. The authors have done a fine job in spotlighting this aerosol SLCF feature. [venkatachalam ramaswamy, United States of America]	Considered but Not applicable, section completely rewritten to briefly discuss the surface temperature response to SLCF (mainly aerosols) and summarize the assessment other climate responses from chapters 3,7, 8 and 10.
8477	48	16	38	16	Explain if this can be attributed to sfc temperature increase. [Frank Dentener, Italy]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
128321	48	17	48	18	This text framing how aerosols affect precipitation should come earlier in the chapter! [Trigg Talley, United States of America]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
86355	48	17	48	21	The first sentence speaks to both ari and aci. Does the discussion here regarding the range cover BC as externally or internally mixed with sulfate and other species? Does sulfate consider the totality of the aci effects in the range stated? What does "large" increases mean? Is this realistic when applied to the real-world aerosol distributions? [venkatachalam ramaswamy, United States of America]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
20381	48	18	46	21	Is this precipitation increase interpreted as the consequence of increased warming when removing the aerosol, or of other effects which occur independently of warming? In which proportions? [philippe waldteufel, France]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
28561	48	18	48	21	Are there any obserational evidences, about the precipitation increase with removal of aerosols? Confident level must be dependent on this. [Hiroshi Tanimoto, Japan]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
72651	48	20	48	20	Delete negative sign [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	The sentence has been deleted.
128323	48	20	48	21	"decrease by -3±1% and -6±4.5%". This is a double-negative. "'precipitation changes by -3±1% and -6±4.5%" or "precipitation decreases by 3±1% and 6±4.5%" [Trigg Talley, United States of America]	The sentence has been deleted.
72653	48	31	48	31	Change 'dominate' to 'dominates' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	The sentence has been deleted.
72655	48	39	48	39	Capital 'T' for 'tropics'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted and corrected.
86357	48	39	48	41	Why is precipitation change more sensitive to changes in BC than SO2 for the Mediterranean region? [venkatachalam ramaswamy, United States of America]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
86359	48	43	48	43	Why does the local carbonaceous aerosol emissions cause the decline in southern African dry season precipitation? I think there is earlier literature that could yield insights into how absorbing aerosols shape the recipitation (e.g., Randles, C A., and V Ramaswamy, 2010: Direct and semi-direct impacts of absorbing biomass burning aerosol on the climate of southern Africa: a Geophysical Fluid Dynamics Laboratory GCM sensitivity study. Atmospheric Chemistry and Physics, 10(20), DOI:10.5194/acp-10-9819-2010) [venkatachalam ramaswamy, United States of America]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
106423	48	43	48	44	delete the repeated word "also" [Hamza Merabet, Algeria]	Accepted and corrected.
72657	48	44	48	44	Delete 'also' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted and corrected.
113979	48	46	48	47	When you say that SO2 reductions lead to stronger responses than BC and OC, I thuink you should specify on what basis this comparison is done. Tonne vs tonne? Same percentage redcution… [Jan Fuglestvedt, Norway]	Not applicable. The sentence has been removed.
128325	48	46	48	47	"SO2 emission reductions will lead to stronger and more robust global climate responses than BC and OC emission reductions." Based on what? Reductions in equivalent masses of emisisons? Equivalent percentage reductions in emissions? [Trigg Talley, United States of America]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
8479	48	49	48	49	It would be useful to have numbers in the summary statement. [Frank Dentener, Italy]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
86361	48	51	48	51	Aerosols affect circulation and climate through radiative perturbations. Further, it is not regional aerosols alone that affect circulation and climate, instead the effects on circulation is in a complete sense due to the entire global aerosol distributions unless proven otherwise. Perhaps this can be worded as "Emissions of aerosols from around the globe cause perturbations to the radiation budget which can influence atmospheric dynamics. Regional emissions of aerosols can contribute very significantly to influencing atmospheric circulation and climate, and become essential factors in the understanding of regional precipitation changes." References, as examples: Ming, Y., and V Ramaswamy, 2011: A model investigation of aerosol-induced changes in tropical circulation. Journal of Climate, 24(19), DOI:10.1175/2011JCLI4108.1; Ming, Y., V Ramaswamy, and G Chen, 2011: A model investigation of aerosol-induced changes in boreal winter extratropical circulation. Journal of Climate, 24(23), DOI:10.1175/2011JCLI4111.1 [venkatachalam ramaswamy, United States of America]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
86363	48	51	48	51	Besides the effects of regional aerosols on regional circulation, an important distinction lies in what part of the season this dominance occurs. For instance, while model studies indicate a weakening of the summer monsoon over the Indo-Gangetic Plains, the month-by-month precipitation change does not suggest the weakening happening in all months. Early part of the monson season actually has a slight increase, to be overwhelmed by the decreases later in the summer (Bollasina, M., Y. Ming, and V Ramaswamy, 2013: Earlier onset of the Indian Monsoon in the late 20th century: The role of anthropogenic aerosols. Geophysical Research Letters, 40(14), DOI:10.1002/grl.50719). Observations tend to corroborate this behavior though there is considerable interannual variability. [venkatachalam ramaswamy, United States of America]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
28563	48	51	49	4	Are there any obserational evidences, about the ITCZ location change described in this section? Confident level must be dependent on this. [Hiroshi Tanimoto, Japan]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
107595	48	51	49	34	this is an extremely long paragraph. Consider breaking up [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Accepted and revised accordingly.
21999	48	51	49	34	It would be more accessible if this very long paragraph could be split into two or more smaller paragraphs. It would also be useful to reorder materials as this paragraph presently jumps around a lot between topics and climatological features as well as regions. Reconciling the text so it better flows and splitting out into several paragraphs would greatly improve this segment. [Peter Thorne, Ireland]	Text revised into FGD Section 6.4
42999	48	51	49	34	These paragraphs of text have made good cross references to other parts of the report, chiefly Chapters 8 and 10. [Andrew Turner, United Kingdom (of Great Britain and Northern Ireland)]	We would like to thank the reviewer.
72659	48	52	48	52	Insert 'out' after 'pointed' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted and corrected.
86367	48	52	49	4	This is a very nicely assessed scientific piece, underscoring the modeling studies dating back from a couple of decades ago to now confirming the processes and outcomes with greater confidence than in AR5, based on the advancements due to the increase in model investigations, multimodel assessments ,and better analysis of observations. [venkatachalam ramaswamy, United States of America]	We would like to thank the reviewer.
86365	48	53	48	53	Do you want to qualify by inserting "anthropogenic"? "increased anthropogenic aerosol loading" ? Aerosols from volcanic eruptions may have played a small role in the precipitation changes occurring in the latter half of the 20th C. [venkatachalam ramaswamy, United States of America]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
128327	48	54	48	54	"with a reversal to northward shift since then." Nortward of where it was pre-industrial, or is this just partly cancelling the southward shift? [Trigg Talley, United States of America]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
29583	49	1	49	34	This section focuses entirely on the impact of SO2 changes. There is also significant literature looking at the impact of BC changes on circulation and precipitation, which are substantively different in character to the impacts of SO2 due to heating in the atmosphere (much of this literature focusing on Asia). This should probably also be reviewed here. [Steven Smith, United States of America]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
86375	49	2	49	3	A significant aspect of the shifts in ITCZ due to anthropogenic aerosols is the contrast between different species of aerosols. Thus, while sulphate aerosols and their effects in the NH cause a southward shift of the ITCZ, the effects due to black carbon run in the opposite direction. While aerosols as a whole in models cause an hemispherically asymmetric forcing and response relative to the LLGHGs, absorbing and scattering aerosols between themselves pull the effects in opposite directions (e.g., Ocko, I B., V Ramaswamy, and Y. Ming, 2014: Contrasting Climate Responses to the Scattering and Absorbing Features of Anthropogenic Aerosol Forcings. Journal of Climate, 27(14), DOI:10.1175/JCLI-D-13-00401.1.). There are therefore two distinct contrasts offered by the anthropogenic forcings and which are important to consider in the cross-equatorial precipitation responses viz., LLGHG-total aerosol contrast and the absorbing-scattering aerosol contrast. [venkatachalam ramaswamy, United States of America]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
42997	49	2			Insert "the" before "ITCZ" [Andrew Turner, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable. Sentence was revised.
86369	49	4	49	4	One major point is that one cannot explain the southward ITCZ shift due to anthropogenic greenhouse gas emissions at all. In fact, greenhouse gas increases cause a precipitation distribution that is much more symmetric across the two hemispheres. It is the asymmetric nature of the albedo perturbation such as that arising due to the aerosols across the two hemispheres that gives rise to this effect (e.g., Chen, C-T, and V Ramaswamy, 1996: Sensitivity of simulated global climate to perturbations in low cloud microphysical properties. Part II: Spatially localized perturbations. Journal of Climate, 9(11), 2788-2801; Ming, Y., and V Ramaswamy, 2009: Nonlinear climate and hydrological responses to aerosol effects. Journal of Climate, 22(6), DOI:10.1175/2008JCLI2362.1). This happens in spite of the overall greater magnitude of the global-mean LLGHG forcing relative to aerosols. [venkatachalam ramaswamy, United States of America]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
86373	49	4	49	4	"sulphate aerosol" is mentioned in conjunction with anthropogenic aerosol cooling. Factually, the model investigations that purport to represent the real-world effects and then exercise a comparison with observations include other anthropogenic aerosol species too in the runs. However, several of the CMIP models likely have sulphate as the major anthropogenic aerosol forcer. Further, in these models, the 'aci' mechanism is likely the major factor behind the large asymmetry of the cooling tendency across the hemispheres which then yields the change in the mean meridional circulation and cross-equatorial precipitation. [venkatachalam ramaswamy, United States of America]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
86371	49	6	49	6	A significant aspect of the precipitation shift issue is how strongly this feature is controlled by the aerosols. It would be substantive to underscore the physical reasons and go beyond stating the result only. For instance, even if the NH aerosols and globally pervasive LLGHG effects combined to give a zero net global-mean radiative forcing, while global-mean temperature change would be zero as a result of the offset, the shift of ITCZ (southward for NH sulfate aerosol perturbation) will still occur. The explanation is the change in the diabatic heating and meridional structure that results in the cross-equatorial transport of energy and thus hydrologic changes north and south of the equator in the tropics (e.g., Ramaswamy, V, and C-T Chen, 1997: Linear additivity of climate response for combined albedo and greenhouse perturbations. Geophysical Research Letters, 24(5), 567-570. Subsequent studies substantiate and expand this point: Rotstayn and Lohmann, 2002; Penner et al. etc.). Later, there has been more elaboration e.g., in the context of moist static energy changes (Kang, S M., I M Held, D M W Frierson, and M Zhao, 2008: The response of the ITCZ to extratropical thermal forcing: Idealized slab-ocean experiments with a GCM. Journal of Climate, 21(14), DOI:10.1175/2007JCLI2146.1.; Hwang et al., 2013; Hill, S A., Y. Ming, and I. Held, 2015: Mechanisms of forced tropical meridional energy flux change. Journal of Climate, 28(5), DOI:10.1175/JCLI-D-14-00165.1; Allen et al., 2015; Soden and Chung, 2017). [venkatachalam ramaswamy, United States of America]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
38043	49	9	49	11	I would like to another paper is cited about aerosol cooling effect like this. "The response to Asian and European SO2 emissions lead to cooling of East Asia and a weakening of the East Asia summer monsoon with decrease of precipitation over East Asia (Song et al. 2014; Shim et al., 2019), and an increase to the south and over the Western North Pacific (Dong et al., 2016). - Responses of East Asian summer monsoon to natural and anthropogenic forcings in the 17 latest CMIP5 models (Song et al., 2014) - Effects of anthropongenic and natural forcings on the summer temperature variations in East Asia during the 20th century (Shim et al., 2019) [Junhee Lee, Republic of Korea]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
78765	49	9	49	11	For the attribution of the weakening of East Asia summer mosoon, please refer to Chapter 10 (10.4.1.2.2). "Among various contributing factors, inter-decadal changes of SSTs in different ocean basins play an important role in weakening tendency of the EASM since the late 1970s. …… Anthropogenic factors such as GHGs and aerosols may also have an influence on the EASM " [jian li, China]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
86377	49	9	49	13	For the effects in Asia, note that the differential heating of land and oceans and thus changes in land-sea contrast and resultant convective changes are also important factors, besides the diabatic heating changes in the atmosphere caused by aerosols. [venkatachalam ramaswamy, United States of America]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
86393	49	9	49	13	The effects are accentuated by the stronger aerosol-cloud interaction effect due to the sulfate aerosols (e.g., Levy II, H., L W Horowitz, M D Schwarzkopf, Y Ming, J-C Golaz, V Naik, and V Ramaswamy, 2013: The Roles of Aerosol Direct and Indirect Effects in Past and Future Climate Change. Journal of Geophysical Research: Atmospheres, 118, DOI:10.1002/jgrd.50192). [venkatachalam ramaswamy, United States of America]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
30625	49	9	49	17	In addition to sulphate, increase in BC also weakens the East Asian winter monsoon circulation (Lou, S., Yang, Y., Wang, H., Smith, S. J., Qian, Y., & Rasch, P. J., 2019. Black carbon amplifies haze over the North China Plain by weakening the East Asian winter monsoon. Geophysical Research Letters, 46, 452–460. https:// doi.org/10.1029/2018GL080941.) [Hong Liao, China]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
86379	49	13	49	16	The major issue is that LLGHG increases yield an increasing precipitation trend in model simulations which runs counter to that observed in the late 20th C. Whereas it is ony the dominance of the scattering aerosols (ari and aci effects) that yields a trend which is at least qualitatively consistent with observations (Bollasina et al., 2011). In this regard, it must also be noted that volcanic aerosol-induced changes (another sulfate-aerosol-induced cooling process) could have also contributed non-negligibly to the weakening of the Asian monsoon, although probably much less of an effect compared to the anthropogenic troposperic aerosol. [venkatachalam ramaswamy, United States of America]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
5219	49	13	49	24	This paragraph is too long and too detailed. It starts out well before about line 9 or 13 and then turns into a list of model results, some of which are single-model studies of regional effects which surely must fairly low confidence. I suggest collecting them into a single short sentence simply saying “many model studies have examined precipitation shifts from regional aerosol changes (Dong et al., Westervelt et al, Undorf et al, Bartlett et al., Li et al.)” [Daniel Murphy, United States of America]	The paragraph has been revised accordingly.
72661	49	19	49	19	Delete 'the' before 'West'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	corrected
86381	49	19	49	22	In the context of aerosols and Africa, one other effect is the impact of biomass burning aerosols affecting clouds, hydrologic cycle, and precipitation in southern Africa. E.g., Randles, C A., and V Ramaswamy, 2010: Direct and semi-direct impacts of absorbing biomass burning aerosol on the climate of southern Africa: a Geophysical Fluid Dynamics Laboratory GCM sensitivity study. Atmospheric Chemistry and Physics, 10(20), DOI:10.5194/acp-10-9819-2010. [venkatachalam ramaswamy, United States of America]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
43003	49	19	49	22	For this passage I suggest considering the work of Giannini and Kaplan (2018) (https://doi.org/10.1007/s10584-018-2341-9) which considers the increase and subsequent decrease of aerosol loading over the North Atlantic since the 1950s. It supports your argument here. [Andrew Turner, United Kingdom (of Great Britain and Northern Ireland)]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
43001	49	19			Remove "the" before "West Africa" [Andrew Turner, United Kingdom (of Great Britain and Northern Ireland)]	corrected
51257	49	22	49	23	The sentence is not clear in its meaning. It could helpfully be modified to ' However for South Asia, changes in observed monsoon precipitation and the weakening of the East Asian summer monsoon cannot be explained with accounting for local emissions'. [Jolene Cook, United Kingdom (of Great Britain and Northern Ireland)]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
86383	49	22	49	23	That local aerosol emissions are important is shown in Bollasina, M., Y. Ming, V Ramaswamy, M. D. Schwarzkopf, and V. Naik, 2014: Contribution of Local and Remote Anthropogenic Aerosols to the 20th century Weakening of the South Asian Monsoon. Geophysical Research Letters, 41(2), DOI:10.1002/2013GL058183. Also, from this study, the effect of remote aerosols needs to be also considered in the context of the weakening of the Asian monsoon. [venkatachalam ramaswamy, United States of America]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
46017	49	23	49	23	Remove "should". [Twan van Noije, Netherlands]	The sentence was revised.
43005	49	23			The important contributions of local and remote emissions to the South Asian monsoon were also suggested by Guo et al. (2016) J Clim. (http://dx.doi.org/10.1175/JCLI-D-15-0728.1), which may be of interest. [Andrew Turner, United Kingdom (of Great Britain and Northern Ireland)]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
43007	49	24	49	26	The reader might be interested to know the relative magnitudes of these changes. Is the southward movement of the ITCZ in response to methane (etc.) mitigation as large as the northward shift when SO2 is reduced? [Andrew Turner, United Kingdom (of Great Britain and Northern Ireland)]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
72663	49	25	49	25	Delete , from before 'and' (not required in this context) [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	corrected
43009	49	26	49	28	This sentence is extremely confusing to read due to the use of the alternative bracketing structure (you are using "/" but the same principal - see discussion in https://eos.org/opinions/parentheses-are-are-not-for-references-and-clarification-saving-space). Why not just say, "Multimodel studies show that the respective ITCZ shifts in experiments changing only sulphate or BC emissions are a robust feature among many models (REFs)." [Andrew Turner, United Kingdom (of Great Britain and Northern Ireland)]	Accepted and corrected as suggested
86385	49	26	49	28	The opposite nature of the ITCZ shifts due to whether the asymmetric NH forcing is a negative (cooling) or positive (warming) is demonstrated in model investigations which have considered separately, and jointly, the direct sulfate, BC, and 'indirect' aerosol effects. E.g., Ocko, I B., V Ramaswamy, and Y. Ming, 2014: Contrasting Climate Responses to the Scattering and Absorbing Features of Anthropogenic Aerosol Forcings. Journal of Climate, 27(14), DOI:10.1175/JCLI-D-13-00401.1. The model experiments also contrast the aerosol effects with that due to the LLGHGs. [venkatachalam ramaswamy, United States of America]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
86387	49	28	49	32	One of the big advance in aerosol-LLGHG-climate-contrast is the assessment here in Section 6.3.5. Previously, the aerosol-precipitation responses have not been discussed in the context of forced large-scale circulation changes. Now, with the numerous investigations in recent years, the evidence and confidence of the aerosol effects on the cross-equatorial hydrologic cycle change has increased significantly. It woud be therefore substantive to go beyond merely stating results from the studies and underscore how reliable the physics in the problem has become. The history and physics in the problem actually goes back to before 2000. A concise review of the asymmetry of NH-SH forcings and resultant response in the cross-equatorial precipitation as emanating from investigations over the past two decades can be found in the following reference: Ramaswamy, V, W D Collins, J M Haywood, J Lean, N Mahowald, G Myhre, and V Naik, K. P. Shine, B. J. Soden, G. Stenchikov, T. Storelvmo, 2019: Radiative Forcing of Climate: The Historical Evolution of the Radiative Forcing Concept, the Forcing Agents and their Quantification, and Applications In A Century of Progress in Atmospheric and Related Sciences: Celebrating the American Meteorological Society Centennial, Boston, MA, Meteorological Monographs, American Meteorological Society, 59, DOI:10.1175/AMSMONOGRAPHS-D-19-0001.114.1-14.100 (see section 12). [venkatachalam ramaswamy, United States of America]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
72665	49	30	49	30	Replace 'leading' with 'causing' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted and corrected as suggested
43011	49	33	49	34	Being more specific here might be useful to the reader. Does it refer to historical experiments, or future RCPs/SSPs, or more idealised projections? Perhaps also insert "biased to the northern hemisphere" after "from aerosols". [Andrew Turner, United Kingdom (of Great Britain and Northern Ireland)]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
86389	49	34	49	34	The same sequence of physics that leads to the aerosol-induced changes in the meridional circulation and cross-equatorial precipitation also leads to influence on other variables such as humidity, circulation, vertical velocity, and poleward heat transport in the atmosphere and ocean (see e.g., Ocko, I B., V Ramaswamy, and Y. Ming, 2014: Contrasting Climate Responses to the Scattering and Absorbing Features of Anthropogenic Aerosol Forcings. Journal of Climate, 27(14), DOI:10.1175/JCLI-D-13-00401.1.). [venkatachalam ramaswamy, United States of America]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
43013	49	36	49	38	This is true, but should you add the nuance of its northward return after the 1980s, as suggested in lines 52-54 of the previous page? [Andrew Turner, United Kingdom (of Great Britain and Northern Ireland)]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
8483	49	36	49	38	The summary statement only discusses a shift of the ITCZ, whereas the text also discusses (medium confidence?) changes in large-basin scale circulations. Suggest to include this as important. [Frank Dentener, Italy]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
103495	49	36	49	38	The summary statement only discusses a shift of the ITCZ, whereas the text also discusses (medium confidence?) changes in large-basin scale circulations. Suggest to include this as important. [Philippe Tulkens, Belgium]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
86391	49	36	49	38	One caveat here should be that this stems from models which have a dominant NH forcing due to scattering (ari and aci), which is why the ITCZ shifts southward. If absorbing aerosol was the dominant type, the ITCZ change would be in the opposite (northward) direction. The Ocko et al. (2014) study demonstrates this point. [venkatachalam ramaswamy, United States of America]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
22001	49	36	49	38	This seems at odds with the prior text that implies a more subtle story of initial southward displacement followed by a shift back toward a more northerly position. It should probably be updated to reflect this. [Peter Thorne, Ireland]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
64807	49	37	49	38	Why the medium confidence? Because of a lack of observational support? [Nicolas Bellouin, United Kingdom (of Great Britain and Northern Ireland)]	Considered but Not applicable, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
64809	49	41	49	41	This section should also mention aerosol fertilisation of vegetation through diffuse fraction changes. There have been some progress since AR5, for example: Malavelle et al. 2019 https://doi.org/10.5194/acp-19-1301-2019, who revise down the strength of the impact on the carbon cycle. [Nicolas Bellouin, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised
16589	49	41	49	41	Section 6.3.5 should mention the effect of reactive-N depostion on the carbon cycle, even if it can't be quantified. [William Collins, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised
219	49	41	50	23	A recent publication by Rap et al. (2018) shows an enhancement of global primary production by biogenic aerosol via diffuse radiation fertilization. This potentially important BVOC-NPP feedback in turn results in a negative climate feedback through terrestrial carbon uptake and in my opinion should be mentioned in some detail in section 6.3.5. Currently is omitted. Literature 1. Rap, A., et al. "Enhanced global primary production by biogenic aerosol via diffuse radiation fertilization." Nature Geoscience 11.9 (2018): 640-644. [Juan Camilo Acosta Navarro, Spain]	Not applicable. Although an important study, Rap et al discuss a ecosystem feedback between BVOC and productivity while here we assess the climate change induced feedbacks from BVOC emissions (via SOA or ozone)
8485	49	43	49	47	A source of carbon=>a smaller sink for carbon?. Where is a similar discussion on the role of N-deposition? Interactions with O3 are mentioned later, but not the overall effect. If discussed (e.g. in Ch. 5) it should be mentioned here. [Frank Dentener, Italy]	Accepted - text revised
103497	49	43	49	47	Where is a similar discussion on the role of N-deposition? Interactions with O3 are mentioned later, but not the overall effect. If discussed (e.g. in Ch. 5) it should be mentioned here. [Philippe Tulkens, Belgium]	Accepted - text revised
128329	49	44	49	45	Are the effects of ozone damage to plants included in any CMIP6 Earth System Models? If so, can these models quantify the magnitude of this effect? [Trigg Talley, United States of America]	Noted. Process not included in any of the CMIP6 runs.
128331	49	51	49	51	Hyphenate "ozone-vegetation" here. [Trigg Talley, United States of America]	Accepted - text revised
35757	49	53	49	54	Bibliographic citations in chronological order [Carlos Antonio Poot Delgado, Mexico]	Accepted - text revised
72667	49	53	49	54	References should be in chronological order. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised
116541	49		49		Coordination is needed with ch 3 (attribution) and chapter 8 on the role of aerosol forcing for large scale changes in circulation, and monsoon precipitation. There are duplications of efforts, and consistency needs to be ensured. [Valerie Masson-Delmotte, France]	Considered, section completely rewritten to briefly discuss the climate response to SLCF (mainly aerosols) and summarize the assessment from chapters 3,7, 8 and 10.
80493	50	1	50	1	Your discussion is "during the 20th century" but Lea et al., 2014b is titled "Greenland tidewater glacier during the early 19th century". [Heiko Goelzer, Belgium]	Not applicable, sentence and citation not found in the SOD.
115565	50	4	50	13	Even if the mean precipitation does not change in the monsoon people living in the area could be afected severely by floods and droughts. There is also a discussion of the impact of the Aerosol layer at high altitudes in the South east asian monsoon on precipitation and droughts (e.g. Fadnavis, Sci. Reports, 10268, 2019, and references therin). [Rolf Müller, Germany]	Not applicable, sentence and citation not found in the SOD.
51259	50	4	50	23	The key point 'Since AR5, there has been an increase in evidence to support the influence of ozone on the land carbon cycle' is an important policy relevant point and would therefore be good to highlight in the Executive Summary. [Jolene Cook, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised. Agreed.
113981	50	12	50	12	I suggest you change "pessimistic future emisisons scenario" to "high emission scenario" or somthing similar. The word "pessimistic" is too imprecise. [Jan Fuglestvedt, Norway]	Accepted - text revised
128333	50	18	50	19	Also mention modification of direct/diffuse radiation fluxes. [Trigg Talley, United States of America]	Accepted - text revised
8487	50	18	50	23	This summary statement needs refinement, as it is not clear how something can be extremely important, without being able to give any numbers. [Frank Dentener, Italy]	Accepted - text revised

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
82985	50	18	50	23	Although there is limited evidence and low confidence, I think it might be worth mentioning that, by influencing the land ecosystem productivity, atmospheric aerosols modify BVOC emissions (Strada and Unger, 2016; Unger et al., 2017). Suggested reference: Strada, S. and Unger, N.: Potential sensitivity of photosynthesis and isoprene emission to direct radiative effects of atmospheric aerosol pollution, Atmos. Chem. Phys., 16, 4213–4234, https://doi.org/10.5194/acp-16-4213-2016, 2016. [Susanna Strada, Italy]	Accepted - text revised
103499	50	18	50	23	This summary statement needs refinement, as it is not clear how something can be extremely important, without being able to give any numbers. [Philippe Tulkens, Belgium]	Accepted - text revised
78577	50	18	50	24	also need to consider aerosol impact on diffuse light which can affect vegetation productivity. Check for consistency with chapter 7. (section 7.6.2.3) [Chris Jones, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised
113983	50	21	50	23	I find this sentence a bit probelmatic. The basis for saying "extremely" seems weak given the high uncertainty. Thus I suggest changing "extremely important" to "potentially very important". [Jan Fuglestvedt, Norway]	Accepted - text revised
5221	50	21	50	23	A good assessment statement, I like it. Personally I would say “may be extremely important” rather than “are extremely important”. [Daniel Murphy, United States of America]	Accepted - text revised
45409	50	26	50	26	section 6.3.6: climate-fire feedback (e.g., Scott et al. 2018a) can be added to this section. [Hitoshi Matsui, Japan]	Accepted. A new climate-fire feedback section has been added
8489	50	26	52	31	It would be good to have a summary statement on this section mentioning: a) there a number of feedback processes each single one of them slightly negative. The overall non-CO2 biogeochemical feedback is evaluated to be -0.22+/-0.123 C per degree C. Section could possibly also discuss whether this feedback is likely to change differenty under high CC scenarios- mention this as an additional uncertainty. [Frank Dentener, Italy]	Accepted - text revised. A summary statement has been added at the end of the section
28571	50	26	52	31	Climate-Fire feedback is also worth mentioning here. [Hiroshi Tanimoto, Japan]	See response to #45409
46019	50	26			Section 6.3.6: A potentially important feedback involving natural fires is missing in this section (also in Table 6.2). [Twan van Noije, Netherlands]	See response to #45409
20383	50	29	50	29	Probably "due" ought to be understood as "directly due" [philippe waldteufel, France]	Not applicable - text has been edited
128335	50	30	50	30	Add dash: "climate change--induced changes" [Trigg Talley, United States of America]	Accepted
72669	50	30	50	30	Delete , from before 'and' (not required in this context) [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable - text has been edited
72671	50	33	50	33	Don't italicise biogeochemical feedbacks, italics are reserved for statistical statements [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted
22003	50	37	50	39	Given the decision in Box 2.3 to use GSAT as the primary metric in balance of the report this should reference GSAT instead of GMST. Also, it’s a bit confusing to refer to GMST twice. [Peter Thorne, Ireland]	Not applicable - text has been edited
20043	50	41	50	45	This passage, as it is, has not meaning. Will the reader be right in assuming that "5.4.7. While…" on line 43 should read "5.4.7, while…"? [philippe waldteufel, France]	Taken into account - text has been edited
128337	50	43	50	43	Either change period to comma before "while," or delete "while." [Trigg Talley, United States of America]	Taken into account - text has been edited
28565	50	43	50	43	"Meanwhile" is better than "While"? [Hiroshi Tanimoto, Japan]	Taken into account - text has been edited
78297	50	43	50	45	Typo. “. While” should be “, while” [Leonie Lee, Singapore]	Taken into account - text has been edited
18309	50	52	50	52	Emission of sea-salt from ocean surfaces are also sensitive to sea ice extent [Stefania Gilardoni, Italy]	Taken into account - text revised
28567	50	52	50	52	"Sea-spray" would be better for "Sea-salt", as organics in the particles are discussed. [Hiroshi Tanimoto, Japan]	Accepted - all instances of sea salt have been replaced with sea spray except where we state that the feedback factor is calculated explicitly for sea-salt
23447	50	52	50	54	To be a feedback, there also needs to be an impact of sea salt on climate. In this case this is mediated by cloud changes due to seasalt being a CCN, but this needs to be spelled out more clearly here. [Daniel Lunt, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised
46021	50	52	51	6	Better to change sea salt to sea spray, which also includes an organic component. [Twan van Noije, Netherlands]	See response to #28567

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
5223	50	52	51	39	These are good paragraphs about climate salt, climate-DMS and climate dust [Daniel Murphy, United States of America]	Thank you!
46023	50	53	50	53	Change "feedback" to "feed back". [Twan van Noije, Netherlands]	Accepted
23445	50	60	52	33	In the intro to section 6.3.6 it would be worth telling the reader that the definition of feedback parameter is given in Chapter 7 (Section 7.4.1.1, and Section 7.4.2.5), and that the feedback paraemter for other biogeochemical processeses are assessed in Sections 5.4.7 and 7.4.2.5. [Daniel Lunt, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised to cross-reference appropriately
116543	50		50		The results of the assessment of the effect of ozone in ecosystem productivity and carbon cycle is not captured in the chapter ES and not reflected in chapter 5, despite its importance, and implications for differing SSP scenarios. Could there be an improved coordination on this? [Valerie Masson-Delmotte, France]	Accepted - text revised. ES statement. Discussion with Chapter 5 Las indicated that it belongs in Chapter 6.
46025	51	4	51	5	Please rephrase (or remove) "and potential interactions of surface tension with sea surface temperature to impact emissions". [Twan van Noije, Netherlands]	Accepted
128339	51	18	51	25	Lines 20-21 give positive values for the climate-DMS feedback; line 25 gives a negative value for the climate-DMS feedback. Is this correct? If so, why the sign change? [Trigg Talley, United States of America]	Taken into account - revised estimates of climate-DMS feedback factor by Thornhill et al are positive.
128341	51	20	51	21	The notion of feedback parameters for these climate-BGC feedbacks should be introduced at the top of Section 6.3.6. [Trigg Talley, United States of America]	See response to #23445
128343	51	20	51	25	Point out the discrepancy in sign for this feedback parameter. Also, need a more careful (rigorous) definition of this feedback parameter, especially if it is driven by pH changes. Is this a climate-DMS feedback parameter, or a CO2-DMS feedback parameter? (i.e., are the chemical effects of CO2 included, or just the physical effects of warming?) [Trigg Talley, United States of America]	Accepted - the text has been revised to note the diversity in the sign and magnitude of this feedback parameter.
32057	51	21			Climate methane lifetime feedback. Both cited papers are rather old. This just covers OH, not all the other factors, which could be mentioned here. As for sinks, the soil methanotrophy will likely increase, and marine Cl may change. Methane emission affects its own lifetime. Zhao, Yuanhong, et al. Inter-model comparison of global hydroxyl radical (OH) distributions and their impact on atmospheric methane over the 2000–2016 period Atmospheric Chemistry and Physics 19.21 (2019): 13701-13723. Dean, Joshua F., Jack J. Middelburg, Thomas Röckmann, Rien Aerts, Luke G. Blauw, Matthias Egger, Mike SM Jetten et al. "Methane feedbacks to the global climate system in a warmer world." Reviews of Geophysics 56, no. 1 (2018): 207-250. [Euan G. Nisbet, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account - methane feedbacks from changes in natural emissions are considered in Chapter 5. We mention climate driven changes in non-OH sinks, however the feedback parameter is based only on climate-induced changes in the chemical sinks because of lack of quantitative information on feedbacks from the soil sink
35759	51	25	51	25	Use published sources [Carlos Antonio Poot Delgado, Mexico]	All the publications cited have been published before the 31 January 2021
78703	51	27	51	27	Please, between "atmosphere and" insert "when considering aerosol mass" (otherwise this is not correct, and for aerosol-cloud processes often number concentrations are important). [Heike Wex, Germany]	Taken into account, text revised
35889	51	27	51	39	Dust is the most abundant aerosol type by mass (not number or AOD). "The consensus of the magnitude of radiative forcing due to mineral dust has been reduced since AR5 due to…" [Jasper Kok, United States of America]	Accepted - text has been revised to "Since AR5, an improved understanding of the shortwave absorption properties of dust as well as a consensus that dust particles are larger in size than previously thought has led to a revised understanding that the magnitude of radiative forcing due to mineral dust is small "
86395	51	27	51	39	In reading through this small sub-section, it is not clear as to how the feedback works in the various geographical regions that have significant dust emissions. Or, is this being spoken of in a globally-averaged context? Further, when dust loadings in the atmosphere are converted to radiative forcings, is this sensitive to the known optical property differences in the different geographical regions? [venkatachalam ramaswamy, United States of America]	Noted - the climate-dust feedback is discussed in terms of global mean.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
23455	51	27	51	39	It is worth highlighting in the text that dust interacts with both long and shortwave radiation, so acts as a greenhouse "gas" in addition to scattering and reflecting shortwave. [Daniel Lunt, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account - the first sentence of this section is revised to "Mineral dust is the most abundant aerosol type in the atmosphere, when considering aerosol mass, and affects the climate system by interacting with both longwave and shortwave radiation as well as contributing to the formation of CCN and INP"
78705	51	28	51	29	Replace "leading to CCN and ice nucleating particles" with "contributing CCN and INP to the atmospheric aerosol". [Heike Wex, Germany]	Taken into account - see response to #23455
20045	51	29	51	29	" The magnitude of radiative forcing due to mineral dust is small since AR5"? No, AR5 does not has the power to change any radiative forcing... [philippe waldteufel, France]	Taken into account - see response to #35889
128345	51	29	51	29	"The magnitude of radiative forcing due to mineral dust is small since AR5". Do authors mean the forcing estimate has gotten smaller? [Trigg Talley, United States of America]	Taken into account - see response to #35889
128347	51	29	51	29	What does "is small since AR5" mean? Have the RF estimates decreased *since* AR5? Or, were they small in AR5 and continue to be so? [Trigg Talley, United States of America]	Taken into account - see response to #35889
85041	51	30	51	31	The appropriate reference here should include the description of recent aircraft measurements of unexpectec high amounts of supermicron dust particles (Ryder, C. L., Marenco, F., Brooke, J. K., Estelles, V., Cotton, R., Formenti, P., McQuaid, J. B., Price, H. C., Liu, D., Ausset, P., Rosenberg, P. D., Taylor, J. W., Choularton, T., Bower, K., Coe, H., Gallagher, M., Crosier, J., Lloyd, G., Highwood, E. J. and Murray, B. J. (2018) Coarse mode mineral dust size distributions, composition and optical properties from AER-D aircraft measurements over the Tropical Eastern Atlantic. Atmospheric Chemistry and Physics, 18. pp. 17225-17257. ISSN 1680-7316). In addidion, the latest and best reference on the missing dust radiative effect of the supermcron particles in climate models is Adebiy, A.i and J. Kok, Climate models miss most of the coarse dust in the atmosphere, Science Advances 08 Apr 2020, Vol. 6, no. 15, eaaz9507, DOI: 10.1126/sciadv.aaz9507 [Ina Tegen, Germany]	Accepted - both the suggested references have been included.
108231	51	30	51	31	This paper might also be of interest in this context: Ryder, C. L., Highwood, E. J., Walser, A., Seibert, P., Philipp, A., Weinzierl, B., Coarse and giant particles are ubiquitous in Saharan dust export regions and are radiatively significant over the Sahara, Atmos. Chem. Phys.,19, 2019, DOI: 10.5194/acp-19-15353-2019 [Petra Seibert, Austria]	Rejected - we have cited the earlier paper by Ryder et al providing observational evidence for the presence of higher amounts of coarse dust particles
72673	51	30	51	31	Delete ''in size' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted
128349	51	33	51	33	What is a "retroaction loop"? [Trigg Talley, United States of America]	Taken into account - replaced retroaction with feedback
128351	51	33	51	33	"retroaction loop" --> "feedback loop"? [Trigg Talley, United States of America]	See response to #128349
23449	51	33	51	33	I have never heard of "retroaction loop" before - please rephrase. [Daniel Lunt, United Kingdom (of Great Britain and Northern Ireland)]	See response to #128349
85043	51	35	51	35	The reference Mahowald et al. (2004) is inappropriate here for the upper limita of positive dust emission shanges. Instead it should be Tegen et al, (2004) (Tegen, I., M. Werner, S. P. Harrison, and K. E. Kohfeld, 2004. Relative importance of cli-mate and land use in determining present and future global soil dust emission. Geophys. Res. Lett., 31, L05105, doi:10.1029/2003GL019216.) and Woodward et al, (2005).(Woodward, S. D. Roberts, R. Betts, A simulation of the effect of climate change–induced desertification on mineral dust aerosol, Geophys. Res. Lett., 32, 18, https://doi.org/10.1029/2005GL023482, doi:10.1029/2005GL023482, 2005)) [Ina Tegen, Germany]	Accepted - thank you! We have corrected this oversight and cited the appropriate papers
128353	51	38	51	39	Is this the "ensemble mean" feedback factor, or the full range across the participant models? [Trigg Talley, United States of America]	Taken into account - ensemble mean feedback parameter is provided
23451	51	38	51	39	"dust-climate feedback factor" should be "dust-climate feedback parameter" for consistency with Chapter 7 and elsewhere. [Daniel Lunt, United Kingdom (of Great Britain and Northern Ireland)]	Accepted-text revised
35761	51	39	51	39	Use published sources [Carlos Antonio Poot Delgado, Mexico]	All the publications cited have been published before the 31 January 2021

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
128355	51	45	51	45	Also due to advection of low-ozone (tropospheric) air upwards? (Maybe this phrasing is just the difference between Lagrangian and Eulerian frameworks.) [Trigg Talley, United States of America]	Taken into account - this section has been revised to clarify the response of stratospheric and tropospheric ozone to climate change
128357	51	49	51	50	Would be helpful to include this in Table 6.5, for completeness. [Trigg Talley, United States of America]	See response to #111973
80031	51	49	51	50	It is worth highlighting that the source of uncertainty in the climate-ozone feedback across models is unlikely to be the ozone itself, as shown in Chiodo and Polvani (2019 – DOI:10.1175/JCLI-D-19-0086.1). Also, despite the small global mean radiative feedback, ozone is likely to induce a substantial feedback on the atmospheric circulation, (Chiodo and Polvani, 2016 – DOI:10.1002/2016GL07101; Chiodo and Polvani, 2019 – DOI:10.1175/JCLI-D-19-0086.1). These aspects should be highlighted here. [Gabriel Chiodo, Switzerland]	Rejected - This recommended insertion was not made because, while it was interesting and solid science, it does not directly address the quantification of the climate feedback parameter. If we were discussing the ozone feedbacks on atmospheric circulation, we would have included this study; we have limited space.
23459	51	49	51	50	"The estimate of this climate-stratospheric ozone feedback is very model dependent ranging from –0.2 to 0 Wm–2 °C–1 and are therefore not included in Table 6.5.". I don't agree. If there is large uncertianty, it is even more important that it is included in the Table!! [Daniel Lunt, United Kingdom (of Great Britain and Northern Ireland)]	See response to #111973
72675	51	49	51	50	Remove split of numbers and units across line. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised
111973	51	49		50	Why not included into the Tab. 6.5. Actually, the range is in order of magnitude similar to the range of sea-salt and the estimate would significantly contribute to the overall feedback. After all, the confidence is low for all the estimates. [Tomas Halenka, Czech Republic]	Accepted - we now include the feedback parameter for climate-ozone feedback in Table 6.5
107597	51	50	51	50	the large model spread does not seem like a good reason to not include it in the table. Shouldn't it just be given low confidence like the others? [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	See response to #111973
128359	51	50	51	50	"are" --> "is" [Trigg Talley, United States of America]	Phrase has been removed from text.
128361	51	52	51	52	Does this also imply a reduced tropospheric ozone burden? [Trigg Talley, United States of America]	Noted, Text has been revised to provide more detailed assessment of climate feedbacks on tropospheric ozone
23453	51	53	51	54	"the climate-tropospheric ozone feedback is estimated to be" should be "the climate-tropospheric ozone feedback parameter is estimated to be" for conssitency with Chapter 7 and elsewhere. [Daniel Lunt, United Kingdom (of Great Britain and Northern Ireland)]	Accepted-text revised
35763	51	54	51	54	Use published sources [Carlos Antonio Poot Delgado, Mexico]	All the publications cited have been published before the 31 January 2021
78299	52	1	52	19	It would be good to include estimated feedback value for BVOC and lightning NOx [Leonie Lee, Singapore]	Noted - the feedback values are given in the table
76651	52	4	52	5	Here it should be made clear that CO2 increase leads to both, reduced BVOC (esp. Isoprene) emissions due to CO2 inhibition effect and increased BVOC emission due to CO2 fertilization and increased biomass density; Maybe that needs to be clarified especially as the CO2 inhibition effect was described on page 16 line 11 [Felix Havermann (né Wiß), Germany]	Accepted - thank you. In the revised text we refer to section 6.2.1.2 for the response of BVOC emissions to climate and CO2
128363	52	4	52	6	This sentence is conflating two different effects, a climate-BVOC feedback and a CO2-BVOC feedback. It is not correct to say that "increased atmospheric CO2 levels are expected to increase the emissions of BVOCs by the terrestrial biosphere." While higher temperatures and higher CO2 may occur together, it is important here to be clear about how each of these are driving BVOCs. Should also comment on the level of confidence regarding the increase in BVOCs. [Trigg Talley, United States of America]	Accepted - the response of BVOC emissions to climate and CO2 and the level of uncertainty are discussed in more detail in section 6.2.1.2, which we now refer to in this section.
38337	52	10	52	10	Based on the text in this paragraph, it is suggested to change "organic aerosols" to "secondary organic aerosols" to enhance the accuracy of the report. [Yaming LIU, China]	Accepted
35765	52	11	51	12	Use published sources [Carlos Antonio Poot Delgado, Mexico]	All the publications cited have been published before the 31 January 2021
16591	52	14	52	14	This should also mention that the Finney papers contradict the increased Nox. Refer also to 6.2.1.2. [William Collins, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - we have added the following sentence to connect with section 6.2.2
35399	52	15	52	16	Increased LNOx increases OH, leading to decreased CH4 lifetime, not increased lifetime as stated here. Reference should be Thornhill et al. (submitted, a). [Kenneth Pickering, United States of America]	Accepted - yes, of course. This typo has been corrected

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
74061	52	15	52	16	If lightning NOx emissions increase, then ozone increases, but the methane lifetime should decrease NOT BE ENHANCED. [Volker Grewe, Germany]	See response to #35399
74063	52	15	52	16	I am not sure if the relation between climate change and lightning NOx is settled. Lightning is parameterised based on the cloud scheme. There were some indications in the past that the way lightning is paramerised controls the sensitivity to future lightning occurrence. While Price and Rind 1992 kind of parameterisations tend to show increases in lightning, parameterisation, which are connected to the convective updraft tends to show a decrease (Grewe, 2009, Finney et al. 2018). The decrease is based on less but stronger individual events, giving in total a decrease (Grewe 2009). Please revise the discussion accordingly. Grewe, V., Impact of Lightning on Air Chemistry and Climate, In: Lightning: Principles, Instruments and Applications Review of Modern Lightning Research, Betz, Hans Dieter; Schumann, Ulrich; Laroche, Pierre (Eds.), 524-551, Springer Verlag, 2009. Finney, D.L., Doherty, R.M., Wild, O. et al. A projected decrease in lightning under climate change. Nature Clim Change 8, 210–213 (2018). https://doi.org/10.1038/s41558-018-0072-6. After having read it a couple of times I realised that 6.2.1.2. has a good discussion of this point - so it might be sufficient to bring these two parts more in line. [Volker Grewe, Germany]	Taken into account. Also see response to 16591
83131	52	15	52	16	Enhanced Nox from lightning should lead to enhanced ozone and OH, and thus a reduction in methane lifetime? [Terje Berntsen, Norway]	See response to #35399
128365	52	15	52	17	Increases in lightning NOx production would *decrease* methane lifetime. [Trigg Talley, United States of America]	See response to #35399
35767	52	18	51	19	Use published sources [Carlos Antonio Poot Delgado, Mexico]	All the publications cited have been published before the 31 January 2021
86039	52	20	52	20	Unless other references are added to the Thornhill et al in the fourth column, it is recommended that it be deleted and the source be added after the table. [Debra Roberts and the Durban WGII TSU, South Africa]	Accepted - we have deleted the column with Thornhill and added a column with feedback parameter estimates from other published literature
74065	52	21	52	22	Yes, I think this sentence is true and has been investigated prior to the mentioned papers. While the more recent work by Naik et al and Voulgarakis is highly important, I think it is equally important to show the consistency over time, which is strengthening the statement. E.g. Grewe et al (2001) showed that OH increases due to NOx emissions, it further increases due to chemical effects based on temperature and water vapour increases and third tropical OH increases due to changes in other climate relevant parameters such as precipitation and dynamics leading to a recuced NOy loss in the tropics and thereby an increased ozone and OH concentration. See also Toumi et al. 1996 or Johnson et al 1999. Grewe, V., M. Dameris, R. Hein, R. Sausen, B. Steil, Future changes of the atmospheric composition and the impact of climate change, Tellus, 53B, 103-121, 2001. [Volker Grewe, Germany]	Noted. We appreciate the comment, however we assess the advances since AR5 in this report. Therefore, we focus on papers since 2012
23457	52	24	52	24	"factor" should be "parameter" for consistency with Chapter 7 and elsewhere. Also throughout this section. [Daniel Lunt, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised
72677	52	24	52	25	Remove split of numbers and units across line. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised
35769	52	25	51	25	Use published sources [Carlos Antonio Poot Delgado, Mexico]	All the publications cited have been published before the 31 January 2021
113985	52	28	52	33	Table 6.5 is useful. But I hope this can be based on more studies than just one. And the confidence given in the table needs to be commented on and discussed in the text; rather than just assigning the confidence [Jan Fuglestvedt, Norway]	Taken into account - we have revised the table to include feedback parameter estimates from other published studies, however our assessed value relies on the multi-model analysis of Thornhill et al. The text discusses the reasons for assigning low confidence to these estimates
20047	52	28	53	33	One must wait chapter 7, box 7.1, equation 7.1, to learn the definition of the feedback parameter alpha. [philippe waldteufel, France]	Taken into account - we have included the definition of the feedback parameter in the Table 6.5 table caption

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
23461	52	30	52	30	More detail needed in the Table caption. For example, it appears that all the values in this table come directly from AerChemMIP, rather than being qualitatively assessed in AR6 from all the available literature. If this is the case, then make this clear in the caption. Also, some justification for the "Low" confidence should clearly be given in the caption, or in the underlying text. [Daniel Lunt, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - The table caption is modified to "Assessed estimates of the magnitude of non CO2 biogeochemical feedback parameter (α) on climate. As in Section 7.4.1.1, α (W m−2 °C−1) for a feedback variable x is defined as α_x=∂N/∂x dx/dT where ∂N/∂x is the change in TOA energy balance in response to a change in x induced by a change in surface temperature (T). Uncertainty is expressed as ± 1 standard deviation across α derived from AerChemMIP models for all processes. The level of confidence in these estimates is low given the large model spread."
72679	52	30	52	30	Subscript 2 required. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised
69207	52	30	52	32	The data of Table 6.5 comes from only one article and all confidence levels are "Low". Since the information in Tables appears as if it is an established fact, convincing reason or explanation would be needed if it is to remain. [Kaoru Magosaki, Japan]	Taken into account - we have revised the table to include feedback parameter estimates from other published studies, however our assessed value relies on the multi-model analysis of Thornhill et al. The text discusses the reasons for assigning low confidence to these estimates
72681	52	30	52	32	It is very dangerous relying on submitted material. All the data in this table are based on material submitted for publication. If it is not accepted for publication then presumably the table will be removed and subsequent ones renumbered. Also, I assume suitable adjustments will be made to the supporting text. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account - the Thornhill paper has been accepted
46027	52	30			Table 6.2: Are these multi-model estimates from AerChemMIP the best estimates we have for all of these feedbacks? [Twan van Noije, Netherlands]	Noted. Feedback parameters have been calculated in a consistent manner using the AerChemMIP ensemble. For comparison estimates from published literature are also provided
35771	52	31	51	51	Use published sources [Carlos Antonio Poot Delgado, Mexico]	All the publications cited have been published before the 31 January 2021
35891	52	31	52	31	The quoted value for the climate-dust feedback seems inconsistent with the values quoted in the corresponding paragraph. Should be more like +0.01 +/- 0.02 W/2/C. [Jasper Kok, United States of America]	Taken into account - text and table have been edited to be consistent
28569	52	31	52	31	Same as above - "Sea-spray" would be better for "Sea-salt", as organics in the particles are discussed. [Hiroshi Tanimoto, Japan]	Noted - here we prefer the title "sea-salt" since all AerChemMIP models include only the sea-salt part of sea-spray. This is clarified in the text
8491	53	1	54	20	This section could more systematically introduce the various SRM options (e.g. what is CCT), and describe the scenario assumptions leading to reported responses. A more systematic assessment (table?) would be helpful as well. The summary statement in its current form is not very informative. The abundant use of acronyms makes it hard to read. [Frank Dentener, Italy]	Taken into account - we have assured coherence with Chapter 4 and discussed with their authors. We are now cross-referencing between the chapter and checking for consistency of findings. Messages from ES are reflected in the section now.
103501	53	1	54	20	This section could more systematically introduce the aerosol SRM options (e.g. what is CCT), and describe the scenario assumptions leading to reported responses. A more systematic assessment (table?) would be helpful as well. The summary statement in its current form is not very informative. The abundant use of acronyms makes it hard to read. [Philippe Tulkens, Belgium]	Taken into account - the text has been revised and restructured with references to Chapter 4, Section 6 and their table which systematically compares the methods.
40789	53	3	53	3	should be solar radiation modification [TSU WGI, France]	Accepted - text revised.
130517	53	3	53	3	"Solar Radiation Management" should be "Solar Radiation Modification" [Panmao Zhai, China]	Accepted - text revised.
38339	53	3	53	6	For the sake of consistency of the report, it is suggested to change “Solar Radiation Management” in line 3 to “Solar Radiation Modification”, and “schemes” in lines 1 and 6 to “options” or “approaches”, to maintain consistency with those stated in Chapter 4. [Yaming LIU, China]	Accepted - text revised.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
89681	53	3	54	20	This section has an odd structure in which the forcings from different types of SRM are first discussed, and then at the very end you describe what SRM, MCB and CCT actually are. A more logical structure would be to first explain the different types of SRM, and thereafter discuss the resulting ERFs. [Trude Storelvmo, Norway]	Taken into account - combined with comment 8491
128367	53	8	53	8	Yes, SAI will provide a more spatially and temporally uniform ERF than MCB or CCT. But to state that it will actually *be* spatially and temporally uniform is not correct/realistic. In reality, if implemented, the aerosol will not be totlaly uniform but rather will likely vary with latitude, as does solar insolation. It is unlikely this will produce a uniform ERF over the whole global. (Also, "temporally" the ERF will still only act during daylight, so would not be "uniform" and instead would have a diural cycle, as would all SRM mechanisms.) [Trigg Talley, United States of America]	Accepted - the text has been reworded to more clearly distinguish between methods and aerosol distributions.
128369	53	8	53	8	The phrase "aerosol cloud" isn't ideal, especially given the later discussion of actual clouds in the context of SRM. Please reword. [Trigg Talley, United States of America]	Accepted - text revised.
128371	53	8	53	8	SAI would not necessarily need to produce a "spatially and temporally uniform ERF." This seems like a particularly specialized case of the general SAI method. [Trigg Talley, United States of America]	Accepted - the text has been reworded to more clearly distinguish between methods and aerosol distributions.
86397	53	8	53	8	"may form a spatially and temporally uniform ERF" - the canonical assumption is probably that it would not be spatially nor temporally uniform, or uniform? [venkatachalam ramaswamy, United States of America]	Accepted - the text has been reworded to more clearly distinguish between methods and aerosol distributions.
128373	53	9	53	9	"could be created" has no physical basis. The "global blanket" only exists in the model world. Suggest revising. [Trigg Talley, United States of America]	Accepted - the text has been revised.
72683	53	9	53	9	Capital 'S' for 'stratosphere' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Rejected - does not comply with IPCC edits
72685	53	12	53	12	Change 'Cirrus cloud thinning' to 'Cirrus Cloud Thinning'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted
128379	53	13	53	13	What is meant by 'time duration'. It is noted in the next sentence that SRM aerosol lifetime is 1-3 years which is the same for ERF. [Trigg Talley, United States of America]	Taken into account and combined with comment ID 128375, and 128377
128375	53	13	53	14	"The time duration of the ERF from a pulse of SRM aerosols would be up to 10-20 years, depending on the magnitude of the pulse emission." This statement applies to SAI only, not all SRM mechanisms. [Trigg Talley, United States of America]	Taken into account. The text has been revised to clarify the difference between the lifetime of the aerosols and the duration of the forcing from a pulse emission of aerosols.
128377	53	13	53	14	This sentence (mentioning up to 10-20 year lifetime of SRM aerosol effects) is misleading, especially given the following sentence, which talks about lifetimes as low as hours. Combine these two sentences to clarify. [Trigg Talley, United States of America]	Taken into account and combined with comment ID 128375
72687	53	14	53	15	Remove split of numbers and units across line. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted
13491	53	15	53	15	Erase "(e.2" after "CCT". [Maria Amparo Martinez Arroyo, Mexico]	Accepted
72689	53	15	53	15	Capital 'T' for 'troposphere' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Rejected - does not comply with IPCC edits
72691	53	15	53	15	Is there a bracket missing at the end of the line? Text seems odd. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted
72693	53	17	53	17	Delete hyphen. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted
80033	53	21	53	39	As pointed out in one of my previous comments on Chapter 4, it would be good to point out that SO2 is not the only injection species that has been studies. Promising results in terms of efficiency (TOA forcing per Mt of sulfur emitted) have been obtained for direct aerosol emissions of H2SO4 (see Vattioni et al., 2019). Even though research on these species is still at its infancy, it deserves to be mentioned somewhere here. [Gabriel Chiodo, Switzerland]	Taken into account - alternative aerosol species and the citation are included in the revised text.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
128381	53	23	53	23	What is meant by the "maximum achievable ERF"? Couldn't a stronger ERF be achieved by increasing the magnitude (and/or altitude) of the injection? Is there a limit imposed by side effects? From a radiative/energetic perspective alone, surely a global mean ERF stronger than -5 W/m2 is possible. [Trigg Talley, United States of America]	Taken into account - the text has been revised to address the comment by rewording the text and adding some more details on the high-end radiative forcing estimates found in the literature
72695	53	27	53	27	Change 'In specifc' to 'Specifically' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted
72697	53	27	53	27	replace ; with , [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted
128383	53	29	53	29	"have been found to". This is too definitive. Edit to "have been estimated" or "are expected to" or some such. [Trigg Talley, United States of America]	Accepted
72699	53	29	53	29	Delete , from before 'and' (not required in this context) [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - the text has been revised.
72701	53	36	53	36	Capital 'S' for 'stratosphere' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Rejected - does not comply with IPCC edits
128385	53	40	53	41	Section 6.3.1 does not give a description of ACI micro- and macro-physical cloud responses. It should, but it doesn't. [Trigg Talley, United States of America]	This is discussed in AR5 in detail and also in section 7.3.3.2
72703	53	42	53	42	Capital 'E' for 'effect' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Rejected - does not comply with IPCC edits
128387	53	42	53	43	"..but it has been found that ERFari may be of equal importance (Ahlm et al., 2017)." This conclusion was based on model studies where sea salt aerosol was added everywhere in the 30N to 30S latitude band -- i.e., even in regions with very low cloud fraction. This is not at all a realistic representation of how MCB would be implemented. As such, this is a very misleading statement. [Trigg Talley, United States of America]	Taken into account - the text has been revised to include the point that some studies aim to brighten clouds, whilst others are more focused on the direct effect of the aerosols.
72705	53	50	53	50	Change 'behavior' to 'behaviour' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted
128389	53	53	53	55	"Modelling literature indicates that the ERFari contribution to MCB could be of comparable magnitude to ERFaci (Jones and Haywood, 2012; Partanen et al., 2012; Alterskjaer et al., 2013; Ahlm et al., 2017)." In the Ahlm et al and Alterskjaer et al. studies sea salt aerosol was added everywhere in the 30N to 30S latitude band -- i.e., even in regions with very low cloud fraction. In the Partanen et al study sea salt was added over *all* ocean area. None of these are a realistic representation of how MCB would be implemented. The Jones and Haywood paper concluded that "The direct radiative effect of geoengineered sea-spray aerosol in clear skies is significant and should be taken into account, but its indirect effects on clouds are of greater importance." As such, this a very misleading statement. [Trigg Talley, United States of America]	Taken into account - combined with comment 128387
116545	53		53		Findings from this section need to be captured in the ES so that they can also be integrated with the corresponding assessment in chapter 4 to support the assessment of the state of knowledge related to SRM in the TS/SPM. I suggest to contribute to the cross WG coordination on SRM too. [Valerie Masson-Delmotte, France]	Noted, cross-chapter coordination has been done on SRM.
130519	54	1	54	1	increased? Or should be "decreased"? [Panmao Zhai, China]	Accepted - the text has been revised.
128391	54	2	54	2	"...be increased by making smaller cloud droplets..." "increased" should be "decreased" [Trigg Talley, United States of America]	Accepted - the text has been revised.
5225	54	5	54	5	I suggest adding a short paragraph “Because MCB concentrates radiative forcing in small regions, it has the potential to induce very large regional changes in atmospheric circulation. Such regional climate perturbations from MCB will last longer than the aerosol lifetime because any local sea surface temperature changes induced by MCB will persist for some time after the aerosol injection is stopped.” [Baughman (2012) Investigation of the Surface and Circulation Impacts of Cloud-Brightening Geoengineering and a more recent reference I can’t find]. [Daniel Murphy, United States of America]	Taken into account - the text has been revised to include your points. And Chapter 4.6.3.3 goes more into MCB. A cross-reference to this is added
78707	54	7	54	7	Replace "ice nuclei" with "INP". [Heike Wex, Germany]	Accepted - the text has been revised.
3519	54	10	54	14	Very small levels of cooling and in some cases heating occurs with a level of injection of 20 L^-1, when using an advanced/complete aerosol model (Penner et al., GRL 2015) [Joyce Penner, United States of America]	Accepted - reference included

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
72707	54	14	54	14	Change 'seed' to 'seeding' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - the text has been revised.
45411	54	17	54	17	MSB --> MCB [Hitoshi Matsui, Japan]	Accepted - the text has been revised.
128393	54	17	54	17	Typo: "MSB" --> "MCB" [Trigg Talley, United States of America]	Accepted - the text has been revised.
113987	54	17	54	20	This conclusion about the state of knowledge and challenegs related to modelleing is an important part of the assessment of SRM options and needs to be coupled to the treatment in ch4 as ell as in TS and SPM. [Jan Fuglestvedt, Norway]	Taken into account - we are ensuring coherency with chapter 4, TS, ES, and SPM on these issues.
27047	54	23	54	23	Would it be possible to discuss the effect of climate change on air quality as a function of warming levels? [Eric Brun, France]	A Figure and a paragraph have been added to illustrate this.
8493	54	23	54	60	If this section is about observational evidence of AQ/CC interactions, this could be reflected in the section title. The motivation would be a limited description of such interaction in current models. But I think the following subsections have a fair amount of modelling- so I am not sure if the introduction is completely correct [Frank Dentener, Italy]	This section is essentially based on models, text has been modified and shortened.
103503	54	23	55	3	If this section is about observational evidence of AQ/CC interactions, this could be reflected in the section title. The motivation would be a limited description of such interaction in current models. As the following subsections have a fair amount of modelling, not sure if the introduction is completely correct. [Philippe Tulkens, Belgium]	This section is essentially based on models, text has been modified and shortened.
28573	54	23	55	3	Considering that section 6.4 is focusing on climate impact on "surface concentrations" of pollutants, the introductory part (till page 54, line 48) describing mechanisms may be shortened, as there are substantial overlap with the preceding section 6.3.6 on non-CO2 feedback. [Hiroshi Tanimoto, Japan]	The text has been shortened and reference made to other sections of the chapter
22019	54	23			It seems that from a policy perspective a key question is how large the climate feedback effect is relative to the differences in SSP pathways. From a policy perspective if the climate feedback is > or == the SSP spread that is a huge deal. Whereas if the feedback effect is very minor in comparison then the message is that mitigation choices dominate. It seems that each section should compare the quantified feedback to the variation arising in the SSP scenarios and do so in a consistent manner to help the policymakers answer the 'so what' question here. [Peter Thorne, Ireland]	Actually the climate feedback is low compared to changes due to changes in emissions in the various SSP. Anyway, the new figure (6.14) representing the change as a function of warming level gives a more relevant insight for policymakers.
17059	54	27	54	29	Addition to biological changes: abiotic stress impacts on vegetation (e.g. Vickers 2009, Holopainen 2010 doi: 10.1016/j.tplants.2010.01.006, Niinemets 2010 - doi:10.1016/j.tplants.2009.11.008) [Eva Y. Pfannerstill, Germany]	Too specific, already contained in the text. Response of natural systems to climate change is discussed rather in section 6.2.
72709	54	33	54	33	Change 'stratosphere-troposphere' to 'Stratosphere-Troposphere' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted.
128395	54	34	54	37	Are these two sentences intended to make different points? Otherwise, they are a bit redundant (and "also" should be removed). [Trigg Talley, United States of America]	The first sentence is general while the second only refers to aerosols. Text changed as suggested.
112019	54	35	54	37	Specifically, this is linked to a reduction in large-scale precipitation (not convective precipitation), over aerosol source regions (i.e. land, especially in the northern Hemisphere). [Cynthia Randles, United States of America]	Accepted, text changed as suggested.
128397	54	39	54	39	"Climate change-driven" [Trigg Talley, United States of America]	Accepted.
128399	54	39	54	40	Sentence is unclear. First state the expected changes in NMVOC emissions with climate change, then the impacts on O3 and SOA. As written, it is unclear if the uncertainty is in the sign of the NMVOC emission response, or in the chemical response to these emissions. [Trigg Talley, United States of America]	Not applicable. The section has been changed and considerably shortened.
72711	54	41	54	41	Insert 'a' after 'in' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable. The section has been changed.
128401	54	42	54	42	"secondary aerosol precursors" --> "aerosol precursors"; also, there are primary aerosol emissions associated with fires. [Trigg Talley, United States of America]	Not applicable. The section has been changed.
109627	54	46	54	48	Temperature also affects the partitioning of low- to intermediate volatility species, shifting the equilibria (analogously to water), and hence impacting their effects on aerosol particle loadings and size distribution. [Ilona Riipinen, Sweden]	Noted, but too specific.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
128403	54	50	55	3	Another challenge is that, in contrast to photochemical model simulations performed to support air quality management planning, it's difficult to bias-adjust photochemical modeling in the climate context. As an example, the EPA "anchors" model predictions to observed monitor data, but this procedure is less useful when simulating late century air pollutant concentrations. [Trigg Talley, United States of America]	Noted, but too specific.
128405	54	53	54	53	"regional models" --> "atmospheric chemistry models" (?) -- not just regional [Trigg Talley, United States of America]	Accepted, text changed as suggested.
72713	54	53	54	54	Move 'properly' to after 'quality' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted, text changed as suggested.
128407	55	1	55	1	"numerical" --> "computational" [Trigg Talley, United States of America]	Accepted and corrected.
16597	55	6	58	1	I couldn't see discussion of dry deposition changes here, although it is in table 6.6. Meiyun Lin has a new paper in Nature Climate Change on the effect of stomatal closing on ozone levels. There were also papers on this after the August 2003 Europe heatwave and ozone episode. [William Collins, United Kingdom (of Great Britain and Northern Ireland)]	Rejected, the aim of this section is not to discuss the change in surface ozone due to each process but the net effect.
111975	55	6			One could expect similar section somewhere for stratospheric ozone separately, actually, it does not belong to the surface ozone and AQ section [Tomas Halenka, Czech Republic]	The analysis of climate change impact on stratospheric ozone is beyond the scope of this section. Response of natural systems to climate change is discussed rather in section 6.2. and in section 6.4.4.
20385	55	9	55	10	what is a "baseline surface ozone level"? [philippe waldteufel, France]	Accepted - We added a footnote with the definition.
128409	55	10	55	10	"pointed" --> "pointed out" (or "concluded") [Trigg Talley, United States of America]	Accepted and corrected.
128411	55	13	55	19	Can authors describe in greater detail the interaction between climate, air quality, and wildland fires? [Trigg Talley, United States of America]	Noted but the aim of this section is not to discuss the change in surface ozone due to each process but the net effect. The sensitivity of emissions due to wildfire changes caused by climate change is discussed in 6.2.2.6.
16593	55	17	55	23	It is misleading to discuss methane effects in this climate change section. Climate change doesn't necessarily imply increased methane, and vice-versa. This section should be reserved for studies where only climate changes. [William Collins, United Kingdom (of Great Britain and Northern Ireland)]	Accepted. This paragraph has been removed.
128413	55	18	55	18	Delete "warmer climate associated with a": it isn't the warming of the climate, it is the direct chemistry of methane that leads to the O3 increase. [Trigg Talley, United States of America]	Not applicable. The paragraph has been removed.
22005	55	19	55	19	Annihalating is a value-laden phrase and should be replaced with a more neutral term such as overwhelming. [Peter Thorne, Ireland]	Not applicable. The paragraph has been removed.
128415	55	20	55	20	Unclear, since CH4 is also an ozone precursor. Perhaps rephrase to: "reduced emissions of other ozone precursors (i.e., NOx, CO, NMVOC)." [Trigg Talley, United States of America]	Not applicable. The paragraph has been removed.
72715	55	25	55	25	Capital 'S' for 'stratosphere' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted and corrected.
72717	55	25	55	25	Capital 'T' for 'troposphere' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted and corrected.
128417	55	26	55	26	"the latter" --> "this" [Trigg Talley, United States of America]	Accepted and corrected.
72719	55	28	55	28	Capital 'S' for 'stratosphere' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted and corrected.
72721	55	30	55	30	Capital 'S' for 'stratosphere' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted and corrected.
128419	55	30	55	33	Unclear. Is "stratospheric ozone recovery" intended here to also represent changes in tropospheric actinitc fluxes (in contrast to physical transport changes, "stratospheric ozone influx")? [Trigg Talley, United States of America]	Noted but the aim of this section is not to discuss the change in surface ozone due to each process but the net effect. This discussion has been strongly shortened.
72723	55	31	55	31	Capital 'H' for 'hemisphere' x2 [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted and corrected.
72725	55	32	55	32	Capital 'T' for 'troposphere' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted and corrected.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
72727	55	34	55	34	Capital 'T' for 'troposphere' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted and corrected.
72729	55	34	55	34	Capital 'T' for 'tropopause' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted and corrected.
72731	55	35	55	35	Capital 'T' for 'troposphere' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted and corrected.
72733	55	36	55	36	Capital 'T' for 'tropopause' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted and corrected.
72735	55	41	55	41	Capital 'S' for 'stratosphere' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted and corrected.
72737	55	41	55	41	Capital 'T' for 'troposphere' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted and corrected.
8495	55	41	55	41	I would expect also due to different tropospheric mixing characteristics. [Frank Dentener, Italy]	Accepted and revised accordingly
103505	55	41	55	41	Probably also due to different tropospheric mixing characteristics. [Philippe Tulkens, Belgium]	Accepted and revised accordingly
72739	55	45	55	45	Change 'Non' to 'non' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted and corrected.
128421	55	45	55	45	"Non-methane" --> "non-methane" [Trigg Talley, United States of America]	Accepted and corrected.
128423	55	46	55	49	This argument about short- versus long-term impacts of lightning NOx increases on ozone doesn't seem entirely correct. Since most CH4 is lost in the troposphere via reaction with OH, the global rate of CH4+OH is set approximately by CH4 emissions (that is, CH4 abundance adjusts to make L~E). So, how does this result in a net *decrease* of ozone from increased lightning NOx? Is there direct modeling support for this conclusion? [Trigg Talley, United States of America]	Noted but the aim of this section is not to discuss the change in surface ozone due to each process but the net effect. This discussion has been strongly shortened. Effect of climate change on lightning NOx is now discussed in 6.2.2.1
128425	55	48	55	49	Murray (2016) says "In some places, the global methane-ozone decreases of a sustained lightning enhancement (e.g., due to climate change) could offset regional NO x -ozone increases", but doesn't offer modeling estimates. In the long term, a step increase in lightning-NOx-OH levels would still contribute to a net increase in background O3, just smaller than immediately after the increase. [Trigg Talley, United States of America]	Noted but the aim of this section is not to discuss the change in surface ozone due to each process but the net effect. This discussion has been strongly shortened. Effect of climate change on lightning NOx is now discussed in 6.2.2.1
128427	55	50	55	50	"activities" --> "activity" [Trigg Talley, United States of America]	Accepted and corrected.
72741	55	54	55	54	Change 'Non' to 'non' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted and corrected.
128429	55	54	55	54	"Non-methane" --> "non-methane" [Trigg Talley, United States of America]	Accepted and corrected.
3359	55		25	52	I consider the text very valuable, but I think it is important to expand ideas in this paragraph, in order to contribute more to the knowledge in the elements that are mentioned here, they are very valuable and I believe in these two paragraphs deserve to be deepened [Eduardo Erazo Acosta, Colombia]	Could not trace out the referred paragraphs. It is not clear if the reviewer refers to 6.4 or 6.4.1.
16595	56	1	56	4	There is at least high confidence in the sign of the wetland and permafrost feedbacks on ozone. Rough limits on the magnitude could be estimated from figure 5.28. [William Collins, United Kingdom (of Great Britain and Northern Ireland)]	Noted but the aim of this section is not to discuss the change in surface ozone due to each process but the net effect. This discussion has been strongly shortened.
32059	56	1			The ITCZ zone is expanding: Staten, P. W., Lu, J., Grise, K. M., Davis, S. M., & Birner, T. (2018). This seems to be causing major methane feedbacks. Re-examining tropical expansion. Nature Climate Change, 8(9), 768-775. These include increased wet tropical plant growth and increased ruminants, warmer wetlands (emission has an Arrhenius T dependence), wetter wetlands over wider areas in the moist tropics (Amazon, Congo, etc), more fuel for seasonal biomass burn. In boreal latitudes the T dependence of emission has impact. [Euan G. Nisbet, United Kingdom (of Great Britain and Northern Ireland)]	As it is pointed in Staten et al. (2018) it is too early to detect robust anthropogenically induced widening imprints due to large internal variability. A detailed discussion of the climate change impact on methane emissions through tropical expansion is beyond the scope of this sub-section since there is no specific study quantifying this effect on future surface ozone.
128431	56	6	56	7	Also, precipitation. [Trigg Talley, United States of America]	Accepted and revised accordingly.
8497	56	11	56	11	Here and several other spots there is reference to a paper by Fu and Tian. However, it would be better if IPCC would perform its own assessment, rather than relying on a rather short discussion paper as a basis for an assessment statement. [Frank Dentener, Italy]	Accepted and revised accordingly.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
103507	56	11	56	11	Here and several other spots there is reference to a paper by Fu and Tian. However, it would be better if IPCC would perform its own assessment, rather than relying on a rather short discussion paper as a basis for an assessment statement. [Philippe Tulkens, Belgium]	Accepted and revised accordingly.
72743	56	16	56	16	replace 'are' with 'is' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted and corrected.
72745	56	17	56	17	Delete , from before 'and' (not required in this context) [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted and corrected.
128433	56	21	56	21	"near-surface" [Trigg Talley, United States of America]	Accepted and corrected.
46029	56	23	56	25	Please include a reference to the section where this poleward shift of the storm tracks is described. The corresponding literature references should also be moved to that section. [Twan van Noije, Netherlands]	Not applicable. The sentence has been removed. (the aim of this section is not to discuss the change in surface ozone due to each process but the net effect.)
64555	56	23	56	26	“Over the mid-latitudes, there is a general consensus that the storm tracks will shift poleward in response to future increases in greenhouse gases, at least in the zonal mean (Barnes and Polvani, 2013; Shaw et al., 2016) and will lead to increased summertime surface ozone pollution episodes over the eastern USA and Europe (Forkel and Knoche, 2006; Leibensperger et al., 2008; Wu et al., 2008).” This sentence has a number of inaccuracies. 1) These papers tend to relate ozone to cyclone frequency and not directly to storm tracks. The paper by Forkel and Koch does not seem particularly relevant here. 2) More precisely, the CMIP5 models predict a poleward shift in the jet position in the North Atlantic (Barnes and Polvani, 2013) although the Pacific storm track shows little movement with climate change (Shaw et al., 2016) 3) The studies of Wu et al and Leibensperger et al. are during the summer months. During these months Lang and Waugh (2011) show “there are much smaller [future] changes in the frequency of summer cyclones and little consistency among the models. In particular, there is no consistency among the models as to whether the frequency of hemispheric-averaged summer cyclones will increase or decrease.” Any signal over the NE US does not seem particularly significant. 4) Turner et al (2013) states that: “The summertime ….cyclone frequency explains less than 10% of the variability in high-O3 events over the Northeastern US”. Sun et al. (2017) also only shows a small increases in ozone following cyclone passage. Sun et al. (2019) instead suggests that it is the position of the Atlantic anticyclone which is more important and its future changes. 5) Note that Wu et al only shows very circumstantial evidence between cyclone passages and ozone and its extremes. [Peter Hess, United States of America]	Not applicable. The sentence has been removed. (the aim of this section is not to discuss the change in surface ozone due to each process but the net effect.)
64553	56	26	56	26	While the reference Forkel and Knoche, 2006 relates ozone changes to meteorological conditions I do not see it explicitly relates it to changes in the position of the storm track or jet stream. [Peter Hess, United States of America]	Not applicable. The sentence has been removed. (the aim of this section is not to discuss the change in surface ozone due to each process but the net effect.)
64557	56	27	56	27	Regional changes in ozone due to future changes in zonally asymmetric circulations have been found to range between [-6,+6] ppb over the US (Sun et al., 2019; Sun, W., Hess, P., Chen, G., and Tilmes, S.: How waviness in the circulation changes surface ozone: a viewpoint using local finite-amplitude wave activity, Atmos. Chem. Phys., 19, 12917–12933, https://doi.org/10.5194/acp-19-12917-2019, 2019.). These changes are largely controlled by changes in the position of the Atlantic Anticyclone (which has been consistently shown to move west and intensify in the future (e.g., Li et al., 2012; Shaw and Voigt, 2015)) and by an intensification of anti-cyclonic wave activity in the western US. [Peter Hess, United States of America]	Not applicable. The sentence has been removed. (the aim of this section is not to discuss the change in surface ozone due to each process but the net effect.)
128435	56	29	56	32	"high-ozone" [Trigg Talley, United States of America]	Accepted.
82987	56	29	56	33	This sentence claims that "high ozone events are only weakly correlated against the ... number of stagnant days ....". Personally, I found this sentence a bit in contrast with the one that appears at page 59, lines 18-23 (see next comment). [Susanna Strada, Italy]	Accepted, all the discussion about stagnation is now in 6.5.3
22007	56	35	56	36	This single sentence paragraph feels odd. Why not include in the prior paragraph? [Peter Thorne, Ireland]	Not applicable. The sentence has been removed.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
46031	56	38	57	5	Please indicate that the RCPs do not span the plausible range of future air pollutant emissions, and how this biases the assessment. If possible, include results from the more recent AerChemMIP experiments. [Twan van Noije, Netherlands]	Accepted. Figure 6.14 has been substituted with a new one based on AerChemMIP experiments.
22011	56	38	57	5	This paragraph feels very disjointed and like the message could be articulated much more cleanly in fewer words if it attempted more to synthesise. There are several overlong sentences and some things are quasi-repeated. [Peter Thorne, Ireland]	The paragraph has been revised accordingly after the substitution of Figure 6.14 with a new one.
22009	56	39	56	42	This sentence is figure caption like material and should be moved there. [Peter Thorne, Ireland]	Not applicable. Sentence has been removed.
35773	56	44	56	44	Bibliographic citations in chronological order [Carlos Antonio Poot Delgado, Mexico]	The citations are in chronological order.
128437	56	48	56	49	It should be explained why climate change leads to lower ozone when averaged over the globe, when it leads to increased ozone over all of the regions shown in Figure 6.14. (because the effect is different in areas with initially low ozone concentrations -- e.g., over the world's oceans -- versus in areas with already-elevated ozone amounts?) [Trigg Talley, United States of America]	Accepted. Figure 6.14 has been substituted with a new one based on AerChemMIP experiments. The new Figure shows the spatial distribution of climate change impacts on surface ozone. Increasing temperatures show large decrease in surface O3 over remote regions in all models as a result of greater water vapor abundance accelerating ozone chemical loss .
87415	57	1	57	5	NMVOC-Limitation of ozone formation in polluted areas should be mentionned (e.g. Gretener, F. (2018)), because many models regard only NOx-Limitation leading to an underestimation of ozone increase due to temperature increase in summer. [Jürg Thudium, Switzerland]	The following sentence has been added: "High-resolution regional and urban-scale models over polluted regions may modify (amplify or deteriorate) the climate change penalty on ozone in comparison to course resolution global model as a number of controlling processes are resolution-dependent including e.g. local emissions, sensitivity to the chemical regime (VOC limited versus NOx limited) (Markakis et al., 2016; Lawvaet et al., 2014)."
72747	57	4	57	4	Insert 'a' after 'to' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Corrected.
8499	57	7	57	7	Statement is not clear. Low confidence in a response at al? Or in sign or magnitude? Or what is the final net effect of opposing/synergetic effects. Is it possible to give an upper limit for possible effects with more certainty? Check coherence with earlier section discussing biosphere ozone interactions (including confidence statements). [Frank Dentener, Italy]	The statement has been revised accordingly.
103509	57	7	57	7	Statement is not clear. Low confidence in a response at all? Or in sign or magnitude? Or what is the final net effect of opposing/synergetic effects. Is it possible to give an upper limit for possible effects with more certainty? Check coherence with earlier section discussing biosphere ozone interactions (including confidence statements). [Philippe Tulkens, Belgium]	The statement has been revised accordingly.
113989	57	7	57	12	can say more about what is leading up to the concluson on lines 7-12? [Jan Fuglestvedt, Norway]	The statement has been revised accordingly.
20387	57	7	57	25	These conclusions are far from clear, and table 6.6 is not of much help. In the table column 2, does the addressed increase is increase in O3 concentration? Or in what? But in column 3 one finds a minus sign where it is said "high" in column 2. All confusing [philippe waldteufel, France]	Not applicable. The Table has been removed.
72749	57	8	57	8	Capital 'S' for 'stratosphere' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Corrected.
72751	57	8	57	8	Capital 'T' for 'troposphere' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Corrected.
43015	57	12			As in the comment pertaining to the ES statement, the "discrepancies" here could be explained more clearly. [Andrew Turner, United Kingdom (of Great Britain and Northern Ireland)]	The statement has been revised accordingly.
72753	57	17	57	17	Change reference to Fu and Tian (2019) [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable. The Table has been removed.
128439	57	17	57	22	In Table 6.6, should "Stratospheric ozone transport" be "Stratosphere-to-troposphere ozone transport"? [Trigg Talley, United States of America]	Not applicable. The Table has been removed.
51261	57	17	57	24	Point of praise: Table 6.6 is a particulary useful table summarising a huge amount of information into an easily understood and digestable form. [Jolene Cook, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable. The Table has been removed.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
46033	57	17			Table 6.6: he confidence level that a warmer climate will lead to an increase in regional stagnation is assesses as 'medium'. This seems to be a higher level of confidence than given in Chapter 4 in relation to changes in atmospheric blocking. Please check consistency. [Twan van Noije, Netherlands]	Not applicable. The Table has been removed.
72755	57	23	57	24	BVOC should be defined in the table or the legned [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable. The Table has been removed.
22013	57	23	57	24	The table feels like in the final column it is trying to be too clever. What it ends up doing is speaking in codes. It is surely better to spell things out succinctly in the final column so that the table can be more easily understood. At the moment trying to flip back and forwards from the caption to table to understand each final column entry is really tough going. I'm not sure that the few saved lines are worth it for reader clarity here. [Peter Thorne, Ireland]	Not applicable. The Table has been removed.
27049	57	30	57	30	Please consider to compare the results to SSP projections rather than RCP. A better option would be to show climate change driven ozone for different levels of warming. [Eric Brun, France]	Accepted. Figure 6.14 has been substituted with a new one showing climate change driven ozone for different levels of warming based on AerChemMIP experiments.
72757	57	36	57	36	Delete , after al. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Corrected.
35775	57	36	57	36	delete comma Fiore et al., (2012) [Carlos Antonio Poot Delgado, Mexico]	Corrected.
35777	57	40	57	40	delete comma Pfister et al., (2013) [Carlos Antonio Poot Delgado, Mexico]	Corrected.
109629	58	8	58	13	I think it would be important to mention also the temperature effects on the volatility. [Ilona Riipinen, Sweden]	Rejected, too specific.
128441	58	8	58	50	What about windblown dust. See, for example, https://doi.org/10.1029/2019GH000187 [Trigg Talley, United States of America]	Sentence added
72759	58	15	58	15	Replace 'warmer' with 'higher' (warmer temperatures is a physical inaccuracy). [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted, text changed as suggested.
128443	58	15	58	24	This section should note that PM emissions from wildfire are also likely to change as the climate changes (e.g., 6.2.1.3). [Trigg Talley, United States of America]	Sentence added
27051	58	17	58	18	As noted in 6.4.1, higher temperatures may lead to an increase of O3, and hence to an increase of oxidants and to the formation of secondary condensables, i.e. compounds that may form particles. [Eric Brun, France]	Rejected, too specific.
72761	58	20	58	20	replace 'evidences' with 'evidence' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted, text changed as suggested.
8507	58	25	58	28	It is not clear why low agreement is attributed, as most studies refered to seems to be consistent. Medium? The statement could mention something on the relationship with circulation/precipation patterns that can lead to positive/negative impacts on air pollution. [Frank Dentener, Italy]	Not clear what is referring to.
46035	58	26	58	26	Please explain the opposite sign in the PM response in the two scenarios. [Twan van Noije, Netherlands]	Rejected, results are self explanatory.
128445	58	26	58	28	It would be very helpful to give a sense of what magnitude (percentage) changes these are, especially since authors contrast them to a percentage change in the next sentence. [Trigg Talley, United States of America]	Taken into account (the percentage is not given in the following)
8501	58	27	58	31	give uncertainty levels.How does the 3 % compare to the 0.21 ug/m3 mentioned earlier. Why 'on the other hand"? [Frank Dentener, Italy]	Taken into account, text made more general.
103511	58	27	58	31	give uncertainty levels.How does the 3 % compare to the 0.21 ug/m3 mentioned earlier. Why 'on the other hand"? [Philippe Tulkens, Belgium]	Taken into account, text made more general.
72763	58	28	58	28	Delete negative sugn [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Rejected, not confusing here.
13493	58	28	58	28	Homogenize the way of quoting. [Maria Amparo Martinez Arroyo, Mexico]	Accepted.
72765	58	28	58	29	Change reference to Xu and Lamarque (2018) [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
51263	58	28	58	33	It may be more understandable to integrate the values, currently shown in brackets in this paragraph, into the main body of the sentence to enable better consistency with text in the rest of this section. [Jolene Cook, United Kingdom (of Great Britain and Northern Ireland)]	Noted, no values integrated, but paragraph rewritten.
72767	58	29	58	29	Change reference to Xu and Lamarque (2018) [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted.
72769	58	30	58	30	Change reference to Xu and Lamarque (2018) [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted.
72771	58	30	58	30	Change reference to Allen et al. ((2016c, 2019b) [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted.
78301	58	31	58	31	Typo. Should be “This ‘is’ in spite of” [Leonie Lee, Singapore]	Accepted, sentence reworded.
22015	58	31	58	32	This reference is demonstrably to the wrong chapter as chapter 2 deals exclusively with historical observed changes. The reference should instead be to a specified section of chapter 4 or chapter 8 or likely both. [Peter Thorne, Ireland]	References removed.
128447	58	35	58	40	Some (many?) readers won't appreciate that the PM2.5 monitoring network is pretty limited. Some others might wonder why one couldn't expand the monitoring network by relying upon low-cost sensors. [Trigg Talley, United States of America]	Sorry, but this is the situation. Low cost sensors are not an issue here.
5227	58	42	58	45	Consider deleting this paragraph for brevity. It is not necessary – the points about sulfate, nitrate, and organics were made in the paragraphs above. [Daniel Murphy, United States of America]	It is an important issue. Text has been modified for better clarity.
72773	58	43	58	43	Insert 'the' after 'in' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted, text changed as suggested.
8509	58	47	58	47	clarify whether this is about co-benefits of *sectoral* mitigation efforts. [Frank Dentener, Italy]	Rejected, not pertinent.
128449	58	47	58	48	Edit to: "In conclusion, there is medium confidence of a small effect, positive or negative, on PM global burden due to climate change." (also, does this consider climate impacts on wildfires and dust?) [Trigg Talley, United States of America]	The take-home message is that climate change by itself would not do much in terms of future global aerosol burden and emissions should be controlled to limit PM. The text has been modified for better clarity.
128451	58	47	58	48	Sentence fragment. Either delete "while" or replace period with comma. [Trigg Talley, United States of America]	Accepted, text changed as suggested.
22017	58	47	58	50	It didn't feel to me like the preceding text naturally led to the conclusion given and I'm not sure what medium confidence in something that even the sign is unknown means practically to a policy maker. It is surely better to say there is low confidence in the sign or magnitude of any feedback between the climate changes and future particulate matter and perhaps worth noting more explicitly that any feedback is much smaller than the difference between SSP scenarios [Peter Thorne, Ireland]	The take-home message is that climate change by itself would not do much in terms of future global aerosol burden and emissions should be controlled to limit PM. The text has been modified for better clarity.
8503	58	47	58	50	While this probably correct, the contrast between natural and anthropogenic change has not been assessed in this section. So on the basis of what studies is this statement made? [Frank Dentener, Italy]	The text has been modified for better clarity.
78303	58	47	58	59	The sentences could be separated by a comma instead of a period. [Leonie Lee, Singapore]	Accepted, text changed as suggested.
103513	58	53	58	55	While most readers will understand the importance of extreme climate events, it may be necessary to explain why extreme pollution events are important (from epidemiology/health+regulatory point of view) [Philippe Tulkens, Belgium]	Rejected, this is an issue that will be dealt with by WGII
72775	59	4	59	4	The concept of exceedence is relevant here and should be mentioned. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Exceedance is a regulatory term, relevant for air quality planners but that is beyond the scope of such IPCC report (more focussed on climate).
22021	59	6	59	14	These paragraphs feel quasi-redundant and would probably be better if merged and reconciled. [Peter Thorne, Ireland]	Merged with previous paragraph.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
64559	59	12	59	12	Please see Phalitnonkiat et al, 2018 (Phalitnonkiat, P., Hess, P. G. M., Grigoriu, M. D., Samorodnitsky, G., Sun, W., Beaudry, E., Tilmes, S., Deushi, M., Josse, B., Plummer, D., and Sudo, K.: Extremal dependence between temperature and ozone over the continental US, Atmos. Chem. Phys., 18, 11927–11948, https://doi.org/10.5194/acp-18-11927-2018, 2018) who looked at the relationship between ozone and temperature extremes in the present and future climate. Maybe it is obvious, but it may be worthwhile pointing out that the connection between meteorological drivers and extreme ozone is geographically heterogeneous (Sun et al., 2017; Schnell and Prather, 2017; Zhang et al., 2017, Phalitnonkiat et al, 2018). Depending on the measure joint ozone and temperature extremes occur geographically up to approximately 30% of the time (Phalitnonkiat et al, 2018), 50% of the time (Schnell and Prather, 2017) and 30% of the time (Zhang et al., 2017). [Peter Hess, United States of America]	Taken into account, paragraph revised in depth
72777	59	13	59	13	Insert 'the' after 'with' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted, text changed as suggested.
90247	59	13	59	14	However, using a statistical model based on extreme value theory, Shen et al. (2016) captured the relationships between daily maximum temperature and maximum daily 8 h average (MDA8) ozone in May-September over much of the United States except the Southeast. Shen, L., L. J. Mickley and E. Gilleland, Impact of increasing heatwaves on U.S. ozone episodes in the 2050s: Results from a multi-model analysis using extreme value theory, Geophys. Res. Let., 43, 4017-4025, 2016. [Loretta Mickley, United States of America]	Rejected, too specific.
72779	59	16	59	16	Change 'wintertime' to 'winter' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted, text changed as suggested.
38341	59	16	59	19	The literatures, especially new research results, from developing countries are less cited in the report, resulting in factually inconsistent conclusions. This sentence points out that the frequency of severe PM pollution episodes in northern China increased significantly over the past decades. But thanks to the Chinese government's drastic measures to control air pollution since 2013, the PM concentration and pollution episodes in China have been decreasing. It is suggested to add "but the PM concentration and PM pollution episodes in China have been decreasing since 2013" after "The frequency of severe PM pollution……over the past decades". In addition, add references: Zhang, et al. (2019). Drivers of improved PM2.5 air quality in China from 2013 to 2017. PNAS, 116 (49), 24463-24469. [Yaming LIU, China]	Accepted, paragraph completely reworded.
72781	59	17	59	17	Quantify 'past decades'. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	The term is intentionally generic.
82989	59	18	59	23	This sentence states that " Amplification of ozone extremes is found to be correlated with number of successive days of stagnation rather than persistently high temperatures in past observations over the US (Sun et al., 2017)." However, on pag. 56 ll. 29-33, we can read that "high ozone events are only weakly correlated against the ... number of stagnant days ....". Personally, I found these two sentences a bit in contrast with each other. [Susanna Strada, Italy]	Accepted, all the discussion about stagnation is now in 6.5.3 and has been made consistent.
72783	59	19	59	19	Change reference to Cai et al. (2017) [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted, text changed as suggested.
72785	59	19	59	19	Change reference to Zou et al. (2017) [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted, text changed as suggested.
128453	59	19	59	19	Incorrect reference format (twice) [Trigg Talley, United States of America]	Accepted, text changed as suggested.
128455	59	23	59	23	"regionally" [Trigg Talley, United States of America]	Accepted, text changed as suggested.
72787	59	25	59	26	Change 'meteorology' to 'weather' and/or 'climate'. Meteorology is the science of weather rather than a state of atmospheric processes. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	The sentence has been changed.
22023	59	25	59	28	Again, I am not convinced that the finding here naturally follows from the precursor text. The text has highlighted a number of studies but not sufficiently detailed the findings to likely justify the present conclusions. The assessment finding should more logically follow from the text that precedes it. [Peter Thorne, Ireland]	Accepted, the sentence has been changed.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
103515	59	25	59	28	It is not clear why low agreement is attributed, as most studies refered to seems to be consistent. Medium? The statement could mention something on the relationship with circulation/precipation patterns that can lead to positive/negative impacts on air pollution. [Philippe Tulkens, Belgium]	Accepted, the sentence has been changed.
128457	59	25	59	28	Not considering climate-driven alteration in dust and wildfires? [Trigg Talley, United States of America]	Accepted, the sentence has been changed.
29585	59	31	59	55	The discussion in this section would benefit from being connected to the earlier discussion that indicates warming due to reduction of SLCFs in general. It is unclear if there actually are any comprehensive climate + air pollution policies that actually deliver a significant benefit in terms of climate forcing from SLCFs over and above the reductions from a climate policy alone (see other comment and Smith et al. 2019; in review). [Steven Smith, United States of America]	Accepted - text revised to include the suggested paper. We attempt to cover various aspects focusing on potential synergies and benefits of each species for climate mitigation that is assessed in section 6.6 in terms of climate reponses. We avoid discussion to what extent for example CH4 reduction could result from SLCF or climate policy as this is not within the WGI mandate.
29589	59	31	59	55	The EMF-30 multi-model study on SLCF mitigation seems relevant to this section. One particular aspects of those results are that, while we did find temperature reduction benefits from targeted SLCF (BC + CH4) reductions, we found that very small additional reductions when paired with comprehensive GHG reductions. (Smith et al. 2019. Climatic Change. Resubmitted May 2020 responding to reviewer comments.) [Steven Smith, United States of America]	Accepted - text revised; see also response to comment #29589
128459	59	33	59	33	Be consistent on whether to include an "s" at the end of LLGHG and SLCF when pluralized (here, and throughout chapter). [Trigg Talley, United States of America]	Editorial. The report will undergo professional copy-editing prior to publication. This kind of issues will be fixed then.
16599	59	37	59	39	It is not obvious from a climate point of view that SLCFs need to be reduced until nearer the time of peak warming (figure 6.15). Obviously from an AQ point of view they are better reduced earlier rather than later. Also figure 6.21 shows that SLCF mitigation is always a net warming, since the warming from aerosols dominates. [William Collins, United Kingdom (of Great Britain and Northern Ireland)]	Noted but this introduction is an attempt to gather all the arguments found in the literature, not our conclusion.
51265	59	38	59	38	"Achieving Paris Agreement goals, including limiting warming to 1.5°C, requires simultaneous and ambitious reductions of SLCFs and LLGHGs within the next decades (Rogelj et al., 2018a)" is a key statement in this chapter and should be included in the executive summary and SPM. [Jolene Cook, United Kingdom (of Great Britain and Northern Ireland)]	Noted. We now use here the exact wording of the ES from SR1.5 chapter 2 which is more focussing on CH4 that SLCFs. We will not repeat this statement but we make our own statement about the role of SLCF in the Paris agreement achievement in our ES.
28575	59	38	59	39	...reductions of SLCFs - better to limit SLCFs to "warming" SLCFs [Hiroshi Tanimoto, Japan]	Accepted - We now use here the exact wording of the ES from SR1.5 chapter 2 which is more focussing on CH4 that SLCFs
103517	59	47	59	47	clarify whether this is about co-benefits of *sectoral* mitigation efforts. [Philippe Tulkens, Belgium]	Accepted, sentence modified
5229	59	50	59	54	A well stated paragraph. [Daniel Murphy, United States of America]	Noted, thank you.
16601	59	50	59	54	This paragraph on policy and action could also point to the WG III report. [William Collins, United Kingdom (of Great Britain and Northern Ireland)]	Rejected, WG3 do not assess air pollution mitigation scenarios but only the climate change mitigation ones. In this section we try to compare the results from scenarios in the literature created to investigate various policy purposes related to SLCFs.
46037	59	52	59	53	It would be appropriate to also include the reference to Pierrehumbert et al. (2014) here. [Twan van Noije, Netherlands]	The reference is already here.
128461	59	53	59	53	Add comma before "to seeing it ..." [Trigg Talley, United States of America]	Accepted - text revised
113991	59	54	59	54	Another paper that is relevant here is Aakre et al., Nature Climate Change volume 8, pages85–90(2018) [Jan Fuglestvedt, Norway]	Accepted
116549	59		59		Please check the consistency of the assessment related to Arctic sea ice and implications for weather in mid latitudes, with other chapters exploring this feature (ch 2, 3, 4, 9, maybe 7 on polar amplification). To check very carefully. [Valerie Masson-Delmotte, France]	Accepted, sentence modified.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
72789	60	1	60	1	Replace 'to' with 'of' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised
29587	60	1	60	14	There is likely to be some confusion here because the section title says "SLCFs", however much of the co-benefit literature is focused on the co-benefits of comprehensive GHG reductions on air quality. [Steven Smith, United States of America]	Noted. The aim of this section is to compare and assess all the SLCF mitigation whatever the incentive. " The sentence "Whereas LLGHG emission reductions are typically motivated by climate mitigation policies, SLCF reductions result from air pollution control, climate policies (see FAQ6.2) as well as policies focusing on achieving UN Sustainable Development Goals (SDGs) (see Box 6.2) " has been added in the introduction.
72791	60	4	60	4	delete , before ([Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised
13495	60	8	60	8	Eliminate period (.) before pharenthesis. [Maria Amparo Martinez Arroyo, Mexico]	Accepted - text revised
51267	60	16	60	17	"Neither ambitious climate change policy nor air quality abatement policy can automatically yield co-benefits without integrated policies aimed at co-beneficial solutions , particularly in the energy generation and transport sectors." This is an important point and it would be beneficial to include in the Executive Summary of this chapter. [Jolene Cook, United Kingdom (of Great Britain and Northern Ireland)]	Noted - This paragraph has been moved at the end of the section, further edited, and is now elevated to the Executive Summary statement.
98441	60	16	60	18	The chapter states that neither ambitious climate change policy nor air quality abatement policy can automatically yield co-benefits without integrated policies aimed at co-beneficial solutions, particularly in the energy generation and transport sectors. It is a very important argument that decision makers should work on integrating climate and air quality policies which aim at co-beneficial solutions. It would be useful to extend this paragraph by adding further explanations that short-lived climate pollutants (SLCP or short-lived climate forcers SLCF) are crucial to link these policies, since reducing them can have both clean air and climate benefits. Mitigation measures which are likely to reduce global warming and at the same time provide clean air benefits by reducing air pollution. The challenges of improving air quality and mitigating climate change, as well as those of human development, are inextricably linked. Policy paths that integrate air quality, climate change and key development concerns bring mutual payoffs. Hence, reducing atmospheric concentrations of short-lived climate forcers (SLCFs), specifically black carbon, tropospheric ozone and methane, offers a real opportunity to improve public health, reduce crop-yield losses, and slow the rate of near-term climate change, thereby aiding sustainable development. However, because such reductions are likely to only make a modest contribution to longer-term climate goals, they must be viewed as a strategy that complements but does not replace carbon dioxide emission reductions. [nehzat Motallebi, United States of America]	Noted - This paragraph has been moved at the end of the section, further edited considered provided comments, and is now elevated to the Executive Summary statement.
76831	60	16	60	19	It is a very important argument that we should work on integrating climate and air quality policies which aim at co-beneficial solutions. It would be useful to extend this paragraph by adding further explanations that SLCPs/SLCFs are crucial to link these policies, since reducing them can have both clean air and climate benefits. It would be useful to cite UNEP (2019) (Tsinghua, CCAC and UNEP report) which explains that reducing short-lived climate pollutants can bring co-beneficial solutions in air quality, climate, health and other SDGs. (UNEP (2019): synergizing action on the environment and climate: good practice in China and around the globe. Available from: https://ccacoalition.org/en/resources/synergizing-action-environment-and-climate-good-practice-china-and-around-globe) [Nathan Borgford-Parnell, Switzerland]	Noted - This paragraph has been moved at the end of the section, further edited, and is now elevated to the Executive Summary statement. A more detailed discussion and assessment of the literature that is examined to arrive at a neutral and objective assessment is provided in section 6.5.3.4. That section considers already several studies providing and discussing evidence for this statement consistent with the report you refer to.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
113993	60	16	60	19	Is this just echoing (parts of) the literature or is this the assessment of the authors? This should be made more clear. [Jan Fuglestvedt, Norway]	Noted - The literature quoted here was selected to support the assessment that is drawing in fact on larger literature and discussion that is provided in the follow up sections. Considering this and other comments, this paragraph has been moved at the end of the section, further edited, and is now elevated to the Executive Summary statement.
67943	60	16	60	19	Suggest rephrasing this paragraph to make it a "positive" statement, such as the following: “Integrated policies linking climate change policy and air quality abatement are necessary to yield multi-benefits of mitigating climate change, improving air quality, protecting human health, and achieving some of the Sustainable Development Goals. Implementation of targeted SLCF policies, particularly in the energy generation, transport, residential, agriculture and waste sectors, are essential in bringing these benefits.” [Luisa Molina, United States of America]	Noted - This paragraph has been moved at the end of the section, further edited considering provided comments, and is now elevated to the Executive Summary statement.
27053	60	16	60	19	This paragraphs gives a rather bleak (half empty glass) view of the co-benefit of climate change or air quality policies. While it is true that policies targeting one of those two issues may not solve the other, there exist co-benefits in many cases as well, as detailed later in the chapter. Hence, a suggestion to modify and start the paragraph with "Climate change policies or air quality abatement policies can often generate co-benefits. However, this is not necessarily automatic and integrated polcies aimed at [...] could fare better [...]." [Eric Brun, France]	Noted - This paragraph has been moved at the end of the section, further edited considering provided comments, and is now elevated to the Executive Summary statement. The final statement is rewritten highlighting the conclusion that integration of policies is essential and it results in multiple benefits.
52193	60	16	60	19	"Neither the ambitious climate change policy nor the air quality reduction policy can automatically generate collateral benefits without integrated policies aimed at co-beneficial solutions." This is the moment to accentuate it in AR6. [Maritza Jadrijevic Girardi, Chile]	Noted - This paragraph has been moved at the end of the section, further edited considering provided comments, and is now elevated to the Executive Summary statement.
113995	60	24	60	28	And also for how long the reductions last; a single year, a period of x years, or sustained reductions. [Jan Fuglestvedt, Norway]	Accepted - text revised
29591	60	24	60	43	This section "6.5.1 Implications of SLCF lifetime on response time horizon" needs significant revision as it does not represent current knowledge. This illustration assumes that the IRF for well-mixed GHGs is applicable to other SLCFs. There is significant evidence that this is incorrect. Shindell (2014) concluded that the overall response to aerosols (+ some other forcings) was faster than the response to well-mixed GHGs, although this had to be done indirectly by comparing GHG to all forcing simulations. More directly, two studies have found that the temporal response to BC is very different in character (rapidly plateauing instead of having a long-term increase) than the response to CO2 increases (Sand et al. 2015 https://doi.org/10.1175/JCLI-D-14-00050.1; Note this is different than the Sand et al. 2015 paper already cited. Yang et al. 2019 https://doi.org/10.5194/acp-19-2405-2019). In those two models, therefore, the IRF for anthropogenic BC definitely is quite different than the well-mixed GHG IRF. See also the discussion in Schwarber et al. (2019 https://doi.org/10.5194/esd-10-729-2019). Figure 6.15, therefore, is mis-leading since, according to the studies above, it would not be accurate for BC, and perhaps not to other SLCFs. (It is likely ok for CH4 since it is well-mixed, although the background ozone changes induced by CH4 are not, so there may be some issue even for CH4). Some of the discussion in this section, therefore, would also not apply at least to BC. [Steven Smith, United States of America]	Taken into account. It is true that two of the papers referred to in the comment (Sand et al., and Yang et al) indicate that for BC forcing the full response in GSAT occurs after only a few years, and that there is little sign of a long term trend (as models generally find with LLGHGs). At least for BC there are some valid physical arguments to this, in that that the short-lived BC particles will mainly remain over the continents where they are emitted and the effect of absorbing particles over a dark ocean is anyway less important. This means that the longer time-scales of ocean heating is less affected. On the other hand both these two papers use similar models (CESM or NorESM, where the latter is based on CESM). Thus there is somewhat limited evidence to the robustness of this conclusion. For scattering aerosols there are not similar model results, and physical argument would indicate a stronger effect over oceans. Also, the impulse response function used here is equal to the once used in the emulator applied in chapter 7, so for consistency we keep to this in the simulations in 6.5.1. However, we have added a caveat in the text that there is some evidence that the response may be different for BC.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
27055	60	32	60	33	How pertinent is a linear approach, considering the non-linearities of the phenomena involved? [Eric Brun, France]	Rejected. It is true that there are non-linear processes in feedbacks and time scales of response that is neglected in this approach. However, it has been shown (cf cross-chapter box 7.1 on the use of Emulators) that simple linear models can be used for many purposes. Here in section 6.5.1 we only use the simulations to illustrate the point that even for very short-lived species there is likely to be some long-term changes due to the thermal inertia of the system. Going into discussion about non-linear effects would be beyond the scope of this section.
22025	60	32	60	34	x-chapter box 2.3 and then most subsequent chapters use GSAT and not GMST. Unless there is a very specific reason to use GMST here GSAT should be used. If the analysis is model based the diagnostic anyway is GSAT and not GMST. [Peter Thorne, Ireland]	Accepted - text revised
113997	60	32	60	34	I guess this should be GSAT not GMST; depending on the IRF [Jan Fuglestvedt, Norway]	Accepted - text revised
5231	60	33			Add at the end of the sentence “or temporal kernels (Larson and Portmann, 2016)” Reference is DOI: 10.1175/JCLI-D-15-0577. [Daniel Murphy, United States of America]	Rejected. This sentence is about temperature change, not ERF.
72793	60	37	60	37	Replace 'like' with 'such as' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised
113999	60	42	60	42	emissionsdrives --> emissions drives [Jan Fuglestvedt, Norway]	Accepted - text revised
106425	60	42	60	42	emissions drives rather than emissionsdrives [Hamza Merabet, Algeria]	Accepted - text revised
128463	60	42	60	42	"emissionsdrives" --> "emissions drives" [Trigg Talley, United States of America]	Accepted - text revised
16603	60	43	60	43	You could add a sentence such as: "Methods to compare rates of SLCF emission with cumulative CO2 emissions are discussed in chapter 7 section 7.6.2.4. Similarly section 7.6.2.4 should reference this chapter 6 discussion. [William Collins, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised
114001	60	48	60	48	I guess this should be GSAT not GMST; depending on the IRF [Jan Fuglestvedt, Norway]	Accepted - text revised
72795	60	49	60	50	Remove split of numbers and units across line. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial - done
114003	60	50	60	51	This sentence in unclear. A word seems also to be missing here. [Jan Fuglestvedt, Norway]	Accepted - text revised
128465	60	51	60	51	Caption text is garbled here. Should be, e.g., "will be reduced to a fixed lower value ...." Also, ">0" should be subscripted. [Trigg Talley, United States of America]	Editorial - done
128467	60	52	60	52	"*an* RF" [Trigg Talley, United States of America]	Editorial - done
16605	60	53	60	53	Note chapter 7 will update the impulse response function to CMIP6 models, and provide a best estimate of the climate feedback parameter alpha. It would be good if these could be used consistently across the report. [William Collins, United Kingdom (of Great Britain and Northern Ireland)]	Noted - updated IRF has been used for final version of the figure
116551	60		60		Please check that the findings of these sections is consistent with discussions in chapter 4. [Valerie Masson-Delmotte, France]	Accepted, done.
8511	61	3	61	3	atmospheric=>interhemispheric. Atmospheric mixing has a variety of timescales [Frank Dentener, Italy]	Accepted - text revised
103519	61	3	61	3	atmospheric=>interhemispheric. Atmospheric mixing has a variety of timescales [Philippe Tulkens, Belgium]	Accepted - text revised
128469	61	3	61	3	Remove comma [Trigg Talley, United States of America]	Editorial, done.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
68297	61	3	61	8	Black and brown carbon aerosols also are important climate forcers and often comes from some similar sources that should be considered part of this discussion. While organic carbon is reflective, the warming effect of black and brown carbon components overall amplify warming. Black carbon is a powerful climate-warming aerosol that directly warms the atmosphere by absorbing solar radiation and indirectly by darkening snow and ice surfaces. Nearly 90% of black carbon emissions come from residential solid fuels, diesel engines, and residential coal; the rest of the emissions come from aviation, shipping, and flaring. Reducing black carbon is especially beneficial for the Arctic because black carbon not only warms the atmosphere but also facilitates additional warming. Once black carbon is deposited on the snow and ice, it reduces the reflectivity (albedo) and absorbs extra solar radiation, which leads to further melting than pristine snow and ice. Since 1890, black carbon has contributed about 0.5–1.4 ºC of warming to the Arctic. Bond T. C., et al. (2013) Bounding the role of black carbon in the climate system: A scientific assessment, J. GEOPHYSICAL RESEARCH–ATMOSPHERES 118(11):5380–5552; Myhre G., et al. (2013) CHAPTER 8: ANTHROPOGENIC AND NATURAL RADIATIVE FORCING, in IPCC (2013) CLIMATE CHANGE 2013: THE PHYSICAL SCIENCE BASIS, Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Table 8.A.6; Qian Y., et al. (2014) Light-absorbing Particles in Snow and Ice: Measurement and Modeling of Climatic and Hydrological impact, ADVANCES IN ATMOSPHERIC SCIENCES 32:64–91; Arctic Monitoring and Assessment Programme (AMAP) (2017) ADAPTATION ACTIONS FOR A CHANGING ARCTIC: PERSPECTIVES FROM THE BARENTS AREA; International Energy Agency (IEA) (2016) WORLD ENERGY OUTLOOK SPECIAL REPORT: ENERGY AND AIR POLLUTION; World Bank & International Cryosphere Climate Initiative (2013) ON THIN ICE: HOW CUTTING POLLUTION CAN SLOW WARMING AND SAVE LIVES.; Shindell D. & Faluvegi G. (2009) Climate response to regional radiative forcing during the twentieth century, Nature Geoscience 2:294–300; Feng Y., et al. (2013) Brown carbon: a significant atmospheric absorber of solar radiation?, ATMOS. CHEM. PHYSICS 13:8607–8621. [Durwood Zaelke, United States of America]	Rejected. This short discussion is about the potential for regional effects of SLCFs due to their short lifetime vs LLGHGs such as e.g. CO2. No specific SLCF is mentioned here and BC and brown carbon is thus included in the SLCFs as a group in this discussion.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
66765	61	3	61	8	Black and brown carbon aerosols also are important climate forcers and often comes from some similar sources that should be considered part of this discussion. Also black carbon directly warms the atmosphere by absorbing solar radiation and indirectly by darkening snow and ice surfaces. The goal should be to ensure that reductions of black and brown carbon—in addition to mitigation of other SLCPs that may arise from similar sources—occur faster than reductions of the cooling sulfates. While organic carbon is reflective, the warming effect of black and brown carbon components overall amplify warming. Nearly 90% of black carbon emissions come from residential solid fuels, diesel engines, and residential coal; the rest of the emissions come from aviation, shipping, and flaring. Reducing black carbon is especially beneficial for the Arctic because black carbon not only warms the atmosphere but also facilitates additional warming. Once black carbon is deposited on the snow and ice, it reduces the reflectivity (albedo) and absorbs extra solar radiation, which leads to further melting than pristine snow and ice. Since 1890, black carbon has contributed about 0.5–1.4 ºC of warming to the Arctic. Bond T. C., et al. (2013) Bounding the role of black carbon in the climate system: A scientific assessment, J. GEOPHYSICAL RESEARCH–ATMOSPHERES 118(11):5380–5552; Qian Y., et al. (2014) Light-absorbing Particles in Snow and Ice: Measurement and Modeling of Climatic and Hydrological impact, ADVANCES IN ATMOSPHERIC SCIENCES 32:64–91; Arctic Monitoring and Assessment Programme (AMAP) (2017) ADAPTATION ACTIONS FOR A CHANGING ARCTIC: PERSPECTIVES FROM THE BARENTS AREA; International Energy Agency (IEA) (2016) WORLD ENERGY OUTLOOK SPECIAL REPORT: ENERGY AND AIR POLLUTION; World Bank & International Cryosphere Climate Initiative (2013) ON THIN ICE: HOW CUTTING POLLUTION CAN SLOW WARMING AND SAVE LIVES. Myhre G., et al. (2013) CHAPTER 8: ANTHROPOGENIC AND NATURAL RADIATIVE FORCING, in IPCC (2013) CLIMATE CHANGE 2013: THE PHYSICAL SCIENCE BASIS, Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Table 8.A.6; Shindell D. & Faluvegi G. (2009) Climate response to regional radiative forcing during the twentieth century, Nature Geoscience 2:294–300; Feng Y., et al. (2013) Brown carbon: a significant atmospheric absorber of solar radiation?, ATMOS. CHEM. PHYSICS 13:8607–8621. [Kristin Campbell, United States of America]	see answer to comment #68297
128471	61	5	61	5	Remove comma [Trigg Talley, United States of America]	Editorial, done.
128473	61	7	61	7	"causes" [Trigg Talley, United States of America]	Editorial, done.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
29595	61	8	61	11	This sentence "As such, the implementation of cleaner…" should probably be removed from a WG I chapter. There is too much subtly on this issue to be conveyed in a sentence. Some of the issues: 1) clean cookstove programs have largely failed to produce the promised benefits. The penetration of clean cookstoves is modest even in the best of circumstances in india, for example, ranging from 17% in Kerala to negligible in Rajasthan (refs below). 2) What could be argued to be a more successful program, the government of india has subsidized LPG hookups, with the use of LPG more than doubling from 2005 to 2017 (IEA Energy Statistics 2019). While LPG is still a fossil fuel, its particulate emissions are far lower resulting in a significant health benefit. 3) One of the significant issues with cookstove programs is "stacking", where both the new cookstove and the traditional stoves are both used, as there appears to be unmet cooking needs that having a more efficient new cookstove helps to fill. 4) In a related issue, use of Kerosene in residential sector is dropping fast (< 1/3 of its 1998 peak in 2017), as ~88% of India households now have access to electricity, which is preferred over Kerosene for lighting - illustrating that provision of modern fuels may be more effective than clean cookstove programs. The point being this is complex, and an overly simplified statement here is not useful in a scientific assessment. My suggest is to let other chapters address these complex issues and stick to the physical science component here. [Refs: Nielsen India Pvt. Ltd. (2016). Kerala Consumer Segmentation Study (Issue March). https://www.cleancookingalliance.org/resources/465.html; Nielsen India Pvt. Ltd. (2016). Rajasthan Consumer Segmentation Study (Issue March). https://www.cleancookingalliance.org/resources/467.html). [Steven Smith, United States of America]	Accepted - text revised
69209	61	11	62	11	In this section, the comparisons between the impact of SLCFs and LLGHGs are mentioned and only CO2 is focused as LLGHGs. It would be helpful if the information of N2O is added because N2O also has significant impact on global warming. [Kaoru Magosaki, Japan]	Taken into account - text revised
103521	61	11	64	15	The section should include maritime transport and commercial biomass burning (for heat or electricity). [Philippe Tulkens, Belgium]	Accepted - text revised. New sub-sections added for all sectors shown in Fig 6.16.
111349	61	11	64	15	I am surprised that transportation and power generation are not mentioned anywhere in sectoral analyses. If they are thought not to have any effect on SLCFs, that should be stated. [Tami Bond, United States of America]	Accepted-text revised. See response to #103521
22027	61	13	61	14	I can see the reason why location matters but that sector matters is sufficiently non-intuitive that it either requires one or more supporting references and / or further explanation here. If instead you mean that the contribution of each sector is differentiated then say so, but ultimately a molecule of CH4 emitted in a given location on a given date will have an identical impact irrespective of which sector the emission arises from and hence my confusion here. What is emitted where matters but the by what intuitively does not and yet that is implied here. [Peter Thorne, Ireland]	Taken into account - text revised. Included more detailed explanation and references to support that ozone and aerosol impacts do depend on sector via influences of co-emissions on chemical interactions and oxidation. Cited AR5 Tables.
114005	61	13	61	14	Re dependence on sector: Via location, time and co-emssions. A tonne of the component itelf has same effect [Jan Fuglestvedt, Norway]	Accepted - text revised. See response to comment #22027
114007	61	14	61	16	I think you could also mention the case where emisisons are reduced for a period. [Jan Fuglestvedt, Norway]	Accepted - text revised

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
74067	61	14	61	17	While it is true that the choice of the emission characterstics (pulse, sustained, scenario) controls the results, the implication that the emission characteristics can be freely choosen is in by view incorrect. I understand that this is not stated, but might be deduced from the text as it stnads now. There is a reation between "what am I interested in?" and the choice of emission characteristics. I understand that 6.5.2 asks what is the impact of a sector on temperture today and in future. From that I would deduce that historical emission scenarios should be used to quantify the today's impact and a historical+future emission scenario for the respective sector to quantify the future impacts. While pulse emissions have a great contribution in understanding principle mechanisms, I am not convinced that here it is the right choice. Apologies, if I misunderstood the section - might also be due to the very condensed way the information is presented. For the relation between message and choice of metrics see e.g. Grewe and Dahlmann (2015). Though the paper focusses on aviation applications, it can be in principle be generalised. Grewe, V., and Dahlmann, K.: How ambiguous are climate metrics? And are we prepared to assess and compare the climate impact of new air traffic technologies?, Atmos. Environm. 106, 373-374, doi:10.1016/j.atmosenv.2015.02.039, 2015. [Volker Grewe, Germany]	Noted. This section assesses the net effect of specific emission source/region on global surface temperature. It is not meant to attribute the historical temperature changes to specific emission sources/regions but provide and assessment of the response.
68299	61	14	61	23	Both warming and cooling SLCFs are emitted alongside CO2, and as CO2 is reduced through efficiency and clean energy, there will be warming in the near-term from reduction in sulfates (“global brightening”). Xu Y. & Ramanathan V. (2017) Well below 2 ºC: Mitigation strategies for avoiding dangerous to catastrophic climate changes, PROC. NAT’L. ACAD. SCI. 114(39):10315–10323 (“Another complexity of the coemission issue is that a major part of the cooling aerosols (mostly sulfates and nitrates) is also coemitted by CO2-dedicated measures. Hence, the CO2 measures implemented in 2020 will unmask some of the aerosol cooling (red lines in SI Ap- pendix, Fig. S5) and offset the warming reduction by CO2 and SLCP mitigation. In the baseline scenarios of this study, the cooling aerosols are regulated gradually between 2020 and 2100 (SI Appendix, Fig. S6), whereas in the mitigation scenario examined here, CO2 mitigation is implemented starting from 2020 and CO2 emission is brought to net zero in about three decades (SI Appendix, Fig. S2B). As a result, the unmasking of coemitted aerosol cooling (a net warming effect) is more rapid in the decreasing CO2 emissions beginning in 2020 (CN2020) mitigation scenario (SI Appendix, Fig. S5B vs. S7).”); Ramanathan V. & Feng Y. (2008) On avoiding dangerous anthropogenic interference with the climate system: Formidable challenges ahead, PROC. NAT’L. ACAD. SCI. 105(38):14245–14250, 14245 (“The observed increase in the concentration of greenhouse gases (GHGs) since the preindustrial era has most likely committed the world to a warming of 2.4ºC (1.4ºC to 4.3ºC) above the preindustrial surface temperatures. …The estimated warming of 2.4ºC is the equilibrium warming above preindustrial temperatures that the world will observe even if GHG concentrations are held fixed at their 2005 concentration levels but without any other anthropogenic forcing such as the cooling effect of aerosols. …IPCC models suggest that ≈25% (0.6ºC) of the committed warming has been realized as of now. About 90% or more of the rest of the committed warming of 1.6ºC will unfold during the 21st century, determined by the rate of the unmasking of the aerosol cooling effect by air pollution abatement laws and by the rate of release of the GHGs-forcing stored in the oceans. The accompanying sea-level rise can continue for more than several centuries.”); see also Ramanathan V. & Xu Y. (2010) The Copenhagen Accord for limiting global warming: criteria, constraints, and available avenues, PROC. NAT’L. ACAD. SCI. 107(18):8055–8062, 8056, Box 2 Figure (“CO2 (1.65 Wm−2) and the non-CO2 GHGs (1.35 Wm−2)	Noted. The point of this comment in not clear with respect to section 6.5.2

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
68301	61	14	61	23	However, targeting SLCPs and reducing them quickly can result in near-term avoided warming, which is critical to slowing feedbacks and avoiding tipping points. There are strategies that specifically target SLCPs that will provide further benefits than what comes from SLCPs that are co-emitted with CO2. See Shindell D., et al. (2012) Simultaneously Mitigating Near-Term Climate Change and Improving Human Health and Food Security, Science 335:183–189, 183–184 ("Tropospheric ozone and black carbon (BC) contribute to both degraded air quality and global warming. We considered ~400 emission control measures to reduce these pollutants by using current technology and experience. We identified 14 measures targeting methane and BC emissions that reduce projected global mean warming ~0.5°C by 2050. This strategy avoids 0.7 to 4.7 million annual premature deaths from outdoor air pollution and increases annual crop yields by 30 to 135 million metric tons due to ozone reductions in 2030 and beyond. Benefits of methane emissions reductions are valued at $700 to $5000 per metric ton, which is well above typical marginal abatement costs (less than $250). The selected controls target different sources and influence climate on shorter time scales than those of carbon dioxide–reduction measures. Implementing both substantially reduces the risks of crossing the 2°C threshold. …The short atmospheric lifetime of these species allows a rapid climate response to emissions reductions. In contrast, CO2 has a very long atmospheric lifetime (hence, growing CO2 emissions will affect climate for centuries), so that the CO2 emissions reductions analyzed here hardly affect temperatures before 2040. The combination of CH4 and BC measures along with substantial CO2 emissions reductions [a 450 parts per million (ppm) scenario] has a high probability of limiting global mean warming to <2°C during the next 60 years, something that neither set of emissions reductions achieves on its own [which is consistent with (19)]."); UNEP & WMO (2011) Integrated Assessment of Black Carbon and Tropospheric Ozone; Xu and Ramanathan (2017) Well below 2 °C: Mitigation strategies for avoiding dangerous to catastrophic climate changes, Proc. Natl. Acad. Sci. 114(39):10315–10323 ("The mitigation of the coemitted SLCPs and cooling aerosols by CO2-dedicated measures requires special consideration (33). SLCP emissions are not entirely independent of CO2 emissions, and emission rates of SLCPs can decrease due to CO2 mitigation, and likewise CO2 emissions can decrease due to mitigation of SLCPs. The role of coemitted SLCPs	Noted
66767	61	14	61	23	Given the short lifetimes of SLCFs, a shorter timescale than 50 or 100 years—like using a metric like GWP20—would provide a better understanding of the near-term warming from SLCPs. GWP* being used throughout the AR6 Report can be a useful metric, but does not completely negate the need and utility of a metric for a shorter timescales like GWP20. In the IPCC 1.5C Report, GWP* is noted for its ability to describe the impacts from SLCFs, even providing a Figure in Cross-Chapter Box 2 that shows the differences between GWP100, GTP100, and GWP*. This does not help for shorter timescale concerns. In the First Order Draft for WGIII for AR6, GWP* is explained in Chapter 2 as allowing the comparison of a sustained change in emissions for non-CO2 forcers in comparison with CO2, but the chapter also notes that there are limitations to using GWP* for policy applications, including those relevant for the Paris Agreement (see WGIII FOD 2-23–2-24). Further, Chapter 2 does suggest that GWP20 may be useful alongside metrics like GWP100 and GTP100 to compare changes in emissions (WGIII FOD 2-22). In Chapter 6 of WGIII FOD, the authors note that a chosen climate metric and the time horizon for which it covers affect assessing the timing of achieving climate targets like net-zero emissions (WGIII FOD 6-100). In discussing the balance of CO2 and non-CO2 emissions from aviation, Chapter 10 of WGIII's FOD suggests that time horizon is a subjective choice of the whomever is using the information, and that if longer time horizons are chosen, CO2 becomes more important (WGIII FOD 10-51: "Any GWP/GTP type emissions equivalency calculation always involves the user selection of a time horizon, over which the calculation is made, which is a subjective choice (Fuglestvedt et al., 2010). In general, the longer the time horizon, the more important CO2 becomes in comparison with a SCLF [sic]."). [Kristin Campbell, United States of America]	Noted - this section is not about metrics. It is about the net temperature effects of emission source sectors. Metrics are discussed in Chapter 7.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
68303	61	14	61	23	Even though SLCPs avoid warming quickly (days to about a decade and a half), SLCP mitigation can have lasting benefits in 2100 and even 2200, plus avoids irreversible harm from sea-level rise. Shoemaker J. K., et al. (2013) What Role for Short-Lived Climate Pollutants in Mitigation Policy?, SCIENCE 342:1323–1324, 1323–1324 ("Direct comparisons of the climate influence of SLCPs and CO2 require making a judgment about the relative importance of short and long time scales. SLCPs have a powerful impact on climate, but they persist in the atmosphere for only a short time—days to weeks for BC, a decade for CH4, and about 15 years for some HFCs. Thus, immediate reductions in SLCPs will result in relatively immediate climate benefits, as the effects on climate depend largely on the emission rate, or flow, of SLCPs to the atmosphere. …It is also important to recognize that CO2 and SLCP emissions are not independent. Some of the steps to reduce CO2 emissions will drive down emissions of SLCPs, as some of the largest sources of BC and methane are associated with fossil fuel production and combustion."); see also Shoemaker J. K., et al. (2013) What Role for Short-Lived Climate Pollutants in Mitigation Policy?, SCIENCE 342:1323–1324, Figure ("Climate temperature response to reductions in emissions of CO2, SLCPs, or both. Based on scenarios detailed in the supplemental material. Temperature change is shown relative to a pre-industrial baseline. In the Reference scenario, annual CO2 emissions peak in 2080, after which they decline rapidly, while SLCP (CH4, BC) emissions remain at or above current levels. In the "SLCP mitigation" scenario, deep cuts in BC (80%) and CH4 (40%) emissions, relative to 2010 levels, are implemented linearly from 2010 to 2050. In the "CO2 mitigation" scenario, CO2 emissions are reduced by 20% relative to the reference scenario by 2050, followed by slowly decreasing emissions that intercept the reference scenario emissions at 2150. In this scenario, emissions of both BC and CH4 are partially decreased relative to the reference scenario owing to those sources associated with fossil fuel consumption. The "HCM" scenario includes simultaneous mitigation of CO2, CH4, and BC, as described above. For simplicity we ignore HFCs as well as different sulfate aerosol trajectories. Including these would slightly change the shape of the curves, but not the relative time scales between them."); Hu A., et al. (2013) Mitigation of short-lived climate pollutants slows sea-level rise, NATURE CLIMATE CHANGE 3:730–734, 730 ("Our results show that SLCP mitigation can have significant effects on SLR. It can decrease the SLR rate by 24–50% and	Noted

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
68305	61	14	61	23	Given the short lifetimes of SLCFs, a shorter timescale than 50 or 100 years—specifically using a metric of GWP20—would provide a better understanding of the near-term warming from SLCPs. This is important because many feedbacks and tipping points are anticipated within the next 10 to 20 years, as the 1.5C guardrail is approached and likely breached. Masson-Delmotte V., et al. (eds.) (2018) SUMMARY FOR POLICYMAKERS, in IPCC (2018) GLOBAL WARMING OF 1.5 ºC; Lenton T. M., et al. (2019) Climate tipping points—too risky to bet against, NATURE, Comment, 575:592–595; Steffen W., et al. (2018) Trajectories of the Earth System in the Anthropocene, PROC. NAT'L. ACAD. SCI. 115(33):8252–8259, 8254; and Drijfhout S., et al. (2015) Catalogue of abrupt shifts in Intergovernmental Panel on Climate Change climate models, PROC. NAT'L. ACAD. SCI. 112(43):E5777–E5786, E5784. GWP* being used throughout the AR6 Report can be a useful metric, but does not completely negate the need and utility of a metric for a shorter timescale like GWP20. In the IPCC 1.5C Report, GWP* is noted for its ability to describe the impacts from SLCFs, even providing a Figure in Cross-Chapter Box 2 that shows the differences between GWP100, GTP100, and GWP*. This does not help for shorter timescale concerns. In the First Order Draft for WGIII for AR6, GWP* is explained in Chapter 2 as allowing the comparison of a sustained change in emissions for non-CO2 forcers in comparison with CO2, but the chapter also notes that there are limitations to using GWP* for policy applications, including those relevant for the Paris Agreement (see WGIII FOD 2-23–2-24). Further, Chapter 2 does suggest that GWP20 may be useful alongside metrics like GWP100 and GTP100 to compare changes in emissions (WGIII FOD 2-22). In Chapter 6 of WGIII FOD, the authors note that a chosen climate metric and the time horizon for which it covers affect assessing the timing of achieving climate targets like net-zero emissions (WGIII FOD 6-100). In discussing the balance of CO2 and non-CO2 emissions from aviation, Chapter 10 of WGIII's FOD suggests that time horizon is a subjective choice of the whomever is using the information, and that if longer time horizons are chosen, CO2 becomes more important (WGIII FOD 10-51: "Any GWP/GTP type emissions equivalency calculation always involves the user selection of a time horizon, over which the calculation is made, which is a subjective choice (Fuglestvedt et al., 2010). In general, the longer the time horizon, the more important CO2 becomes in comparison with a SCLF [sic]."). [Durwood Zaelke, United States of America]	Noted - this section is not about metrics. It is about the net temperature effects of emission source sectors. Metrics are discussed in Chapter 7. Duplicate of #66767
68307	61	14	61	23	For policymakers, changes in the near-term and creating policies that are in line with the lower emissions scenarios would benefit from the ability to emphasize the amount of avoided warming from the SLCPs and the near-immediate impact that they can have, which is aided by having the appropriate metric in GWP20. See Climate and Clean Air Coalition (CCAC) , Mexico , Molina Center for Energy and the Environment (MCE2), & United Nations Environment Programme (UNEP) (2018) Progress and Opportunities for Reducing SLCPs across Latin America and the Caribbean; UNEP & Climate and Clean Air Coalition (2018) Integrated Assessment of Short-lived Climate Pollutants in Latin America and the Caribbean: Improving air quality while contributing to climate change mitigation; Climate and Clean Air Coalition & UNEP (2019) Air Pollution in Asia and the Pacific: Science-based solutions; European Environment Agency (2018) Air quality in Europe — 2018 report, EEA Report No 12/2018. [Durwood Zaelke, United States of America]	Noted - this section is not about metrics. It is about the net temperature effects of emission source sectors. Metrics are discussed in Chapter 7. 10-year time scale is relevant for Paris Agreement.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
69877	61	14	61	23	Both warming and cooling SLCFs are emitted alongside CO2, and as CO2 is reduced through efficiency and clean energy, there will be warming in the near-term from reduction in sulfates ("global brightening"). Xu Y. & Ramanathan V. (2017) Well below 2 ºC: Mitigation strategies for avoiding dangerous to catastrophic climate changes, PROC. NAT'L. ACAD. SCI. 114(39):10315–10323 ("Another complexity of the coemission issue is that a major part of the cooling aerosols (mostly sulfates and nitrates) is also coemitted by CO2-dedicated measures. Hence, the CO2 measures implemented in 2020 will unmask some of the aerosol cooling (red lines in SI Ap- pendix, Fig. S5) and offset the warming reduction by CO2 and SLCP mitigation. In the baseline scenarios of this study, the cooling aerosols are regulated gradually between 2020 and 2100 (SI Appendix, Fig. S6), whereas in the mitigation scenario examined here, CO2 mitigation is implemented starting from 2020 and CO2 emission is brought to net zero in about three decades (SI Appendix, Fig. S2B). As a result, the unmasking of coemitted aerosol cooling (a net warming effect) is more rapid in the decreasing CO2 emissions beginning in 2020 (CN2020) mitigation scenario (SI Appendix, Fig. S5B vs. S7).") Even though SLCPs avoid warming quickly (days to about a decade and a half), SLCP mitigation can have lasting benefits in 2100 and even 2200, plus avoids irreversible harm from sea-level rise. Shoemaker J. K., et al. (2013) What Role for Short-Lived Climate Pollutants in Mitigation Policy?, SCIENCE 342:1323–1324, 1323–1324 Given the short lifetimes of SLCFs, a shorter timescale than 50 or 100 years—specifically using a metric of GWP20—would provide a better understanding of the near-term warming from SLCPs and the near-term opportunities to reduce warming. This is important because many feedbacks and tipping points are anticipated within the next 10 to 20 years, as the 1.5C guardrail is approached and likely breached. Masson-Delmotte V., et al. (eds.) (2018) SUMMARY FOR POLICYMAKERS, in IPCC (2018) GLOBAL WARMING OF 1.5 ºC; Lenton T. M., et al. (2019) Climate tipping points—too risky to bet against, NATURE, Comment, 575:592–595; Steffen W., et al. (2018) Trajectories of the Earth System in the Anthropocene, PROC. NAT'L. ACAD. SCI. 115(33):8252–8259, 8254; and Drijfhout S., et al. (2015) Catalogue of abrupt shifts in Intergovernmental Panel on Climate Change climate models, PROC. NAT'L. ACAD. SCI. 112(43):E5777–E5786, E5784. GWP*	Noted
128475	61	18	61	20	"AR5 found that the largest contributors to warming on 50-100 year time scales are the energy, industrial and on-road transportation sectors." Can authors clarify that this is contributions of SLCFs only to warming (not LLGHGs)? [Trigg Talley, United States of America]	Accepted - text revised
84019	61	20	61	21	For agriculture and waste/landfills, CH4 is indeed the largest SLCF to be considered. However, as per mentioned in table 5.2 (p.33, chap 5), the individual contribution to CH4 budget in the last period, informs that oil and gas contributes with 79, while landfills/waste, contributes with 65. If combined, CH4 originated for fossils, coal + oil and gas, will combined to a total of 121. Larger than solely 111 enteric fermentation and manure, that will add to agriculture, when combined with the 30 from rice, resulting in 141. The production of energy and fossil fuels is the second largest methane emitting sector (Janssens-Maenhout et al., 2019). From waste/landfill are much lower. Therefore, the example in brackets (agriculture and waste/landfills) as sectors that emit large amounts of CH4, should be reconsidered, as oil and gas is larger that waste/landfill, and combined with coal, as fossil fuels, even larger. No reduction in SLCF will be effective without a drastic reduction in fossil fuels CO2 emissions. It is important to leave this message very clear! Besides as it is mentioned in section 6.5.3 "Since climate change mitigation requires strong decrease of CO2 emissions, largely relying on fossil fuel use reduction, the co-emitted SLCFs from combustion and methane from production and distribution of fossil fuels will be reduced proportionally." [Marco Tulio Cabral, Brazil]	Taken into account - text revised. This section is about temperature effects of source sectors (groups of related emissions). We have extensive earlier section 6.2 on individual methane emission sources. Text reflects that CH4 is the dominant radiative component of AGR and WST. T effects of ENE are driven also by CO2 and sulfate. AGR T effects also driven by nitrate aerosol. In updated bar chart version we have separated out ENE into fossil fuel prod/dist and power generation/combustion that emphasizes CH4 role in ENE T effects much more clearly. In the real world actions that address source sectors affect all emissions from that source that in turn all influence the net T response.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
74069	61	20	61	23	The attribution of impacts (here temperature) to sectors in non-linear systems is non-trivial, since there are many significant feedbacks between the sectors (e.g. Grewe et al 2012; Figure 3; Grewe et al. 2017; Figure 11; both paper show that changes in Road traffic emissions feedback to other sectors). Without having read the Lund et al paper, it is difficult to understand how it is done. But I think a discussion on the chosen method their related uncertainties might be worth mentioning here. Grewe, V., Tsati, E., Mertens, M., Frömming, C., and Jöckel, P., Contribution of emissions to concentrations: The TAGGING 1.0 submodel based on the Modular Earth Submodel System (MESSy 2.52), Geosci. Model Dev. 10, 2615-2633, doi:10.5194/gmd-2016-298, 2017. Grewe, V., Dahlmann, K., Matthes, S., Steinbrecht, W., Attributing ozone to NOx emissions: Implications for climate mitigation measures, Atmos. Environm., 59, DOI: 10.1016/j.atmosenv.2012.05.002, 102-107, 2012. [Volker Grewe, Germany]	Taken into account - brief discussion of limitations of both methods for sector attribution
114009	61	22	61	23	Figure 6.16 is introduced very abruptly right after AR5 results. Delete? Since next para starts with this figure. [Jan Fuglestvedt, Norway]	Accepted - text revised
114011	61	25	61	25	I think it is a bit strong to call this the mitigation potential. The potential depends on opprtunties and costs etc. I think you simply can say the "temperature effect" [Jan Fuglestvedt, Norway]	Accepted - text revised. Changed to "temperature effects"
72797	61	25	61	25	Delete 'year' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised
128477	61	25	61	25	In Figure 6.16, the abbreviations along the left sides of the two panels (e.g. different sectors) need to be spelled out in the figure caption. [Trigg Talley, United States of America]	Accepted - text revised
114017	61	25	61	47	It woudl be useful with some reflections on the choice of 10 and 100 years as timehorions here [Jan Fuglestvedt, Norway]	Accepted - text revised
66769	61	25	61	47	Given the short lifetimes of SLCFs, a shorter timescale than 50 or 100 years—like using a metric like GWP20—would provide a better understanding of the near-term warming from SLCPs. GWP* being used throughout the AR6 Report can be a useful metric, but does not completely negate the need and utility of a metric for a shorter timescales like GWP20. In the IPCC 1.5C Report, GWP* is noted for its ability to describe the impacts from SLCFs, even providing a Figure in Cross-Chapter Box 2 that shows the differences between GWP100, GTP100, and GWP*. This does not help for shorter timescale concerns. In the First Order Draft for WGIII for AR6, GWP* is explained in Chapter 2 as allowing the comparison of a sustained change in emissions for non-CO2 forcers in comparison with CO2, but the chapter also notes that there are limitations to using GWP* for policy applications, including those relevant for the Paris Agreement (see WGIII FOD 2-23–2-24). Further, Chapter 2 does suggest that GWP20 may be useful alongside metrics like GWP100 and GTP100 to compare changes in emissions (WGIII FOD 2-22). In Chapter 6 of WGIII FOD, the authors note that a chosen climate metric and the time horizon for which it covers affect assessing the timing of achieving climate targets like net-zero emissions (WGIII FOD 6-100). In discussing the balance of CO2 and non-CO2 emissions from aviation, Chapter 10 of WGIII's FOD suggests that time horizon is a subjective choice of the whomever is using the information, and that if longer time horizons are chosen, CO2 becomes more important (WGIII FOD 10-51: "Any GWP/GTP type emissions equivalency calculation always involves the user selection of a time horizon, over which the calculation is made, which is a subjective choice (Fuglestvedt et al., 2010). In general, the longer the time horizon, the more important CO2 becomes in comparison with a SCLF [sic]."). [Kristin Campbell, United States of America]	See response to comment #68305

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
68309	61	25	61	47	Both warming and cooling SLCFs are emitted alongside CO2, and as CO2 is reduced through efficiency and clean energy, there will be warming in the near-term from reduction in sulfates ("global brightening"). Xu Y. & Ramanathan V. (2017) Well below 2 ºC: Mitigation strategies for avoiding dangerous to catastrophic climate changes, PROC. NAT'L. ACAD. SCI. 114(39):10315–10323 ("Another complexity of the coemission issue is that a major part of the cooling aerosols (mostly sulfates and nitrates) is also coemitted by CO2-dedicated measures. Hence, the CO2 measures implemented in 2020 will unmask some of the aerosol cooling (red lines in SI Ap- pendix, Fig. S5) and offset the warming reduction by CO2 and SLCP mitigation. In the baseline scenarios of this study, the cooling aerosols are regulated gradually between 2020 and 2100 (SI Appendix, Fig. S6), whereas in the mitigation scenario examined here, CO2 mitigation is implemented starting from 2020 and CO2 emission is brought to net zero in about three decades (SI Appendix, Fig. S2B). As a result, the unmasking of coemitted aerosol cooling (a net warming effect) is more rapid in the decreasing CO2 emissions beginning in 2020 (CN2020) mitigation scenario (SI Appendix, Fig. S5B vs. S7)."); Ramanathan V. & Feng Y. (2008) On avoiding dangerous anthropogenic interference with the climate system: Formidable challenges ahead, PROC. NAT'L. ACAD. SCI. 105(38):14245–14250, 14245 ("The observed increase in the concentration of greenhouse gases (GHGs) since the preindustrial era has most likely committed the world to a warming of 2.4ºC (1.4ºC to 4.3ºC) above the preindustrial surface temperatures. …The estimated warming of 2.4ºC is the equilibrium warming above preindustrial temperatures that the world will observe even if GHG concentrations are held fixed at their 2005 concentration levels but without any other anthropogenic forcing such as the cooling effect of aerosols. …IPCC models suggest that ≈25% (0.6ºC) of the committed warming has been realized as of now. About 90% or more of the rest of the committed warming of 1.6ºC will unfold during the 21st century, determined by the rate of the unmasking of the aerosol cooling effect by air pollution abatement laws and by the rate of release of the GHGs-forcing stored in the oceans. The accompanying sea-level rise can continue for more than several centuries."); see also Ramanathan V. & Xu Y. (2010) The Copenhagen Accord for limiting global warming: criteria, constraints, and available avenues, PROC. NAT'L. ACAD. SCI. 107(18):8055–8062, 8056, Box 2 Figure ("CO2 (1.65 Wm−2) and the non-CO2 GHGs (1.35 Wm−2)	See response to comment #68299

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
68311	61	25	61	47	However, targeting SLCPs and reducing them quickly can result in near-term avoided warming, which is critical to slowing feedbacks and avoiding tipping points. There are strategies that specifically target SLCPs that will provide further benefits than what comes from SLCPs that are co-emitted with CO2. See Shindell D., et al. (2012) Simultaneously Mitigating Near-Term Climate Change and Improving Human Health and Food Security, Science 335:183–189, 183–184 ("Tropospheric ozone and black carbon (BC) contribute to both degraded air quality and global warming. We considered ~400 emission control measures to reduce these pollutants by using current technology and experience. We identified 14 measures targeting methane and BC emissions that reduce projected global mean warming ~0.5°C by 2050. This strategy avoids 0.7 to 4.7 million annual premature deaths from outdoor air pollution and increases annual crop yields by 30 to 135 million metric tons due to ozone reductions in 2030 and beyond. Benefits of methane emissions reductions are valued at $700 to $5000 per metric ton, which is well above typical marginal abatement costs (less than $250). The selected controls target different sources and influence climate on shorter time scales than those of carbon dioxide–reduction measures. Implementing both substantially reduces the risks of crossing the 2°C threshold. …The short atmospheric lifetime of these species allows a rapid climate response to emissions reductions. In contrast, CO2 has a very long atmospheric lifetime (hence, growing CO2 emissions will affect climate for centuries), so that the CO2 emissions reductions analyzed here hardly affect temperatures before 2040. The combination of CH4 and BC measures along with substantial CO2 emissions reductions [a 450 parts per million (ppm) scenario] has a high probability of limiting global mean warming to <2°C during the next 60 years, something that neither set of emissions reductions achieves on its own [which is consistent with (19)]."); UNEP & WMO (2011) Integrated Assessment of Black Carbon and Tropospheric Ozone; Xu and Ramanathan (2017) Well below 2 °C: Mitigation strategies for avoiding dangerous to catastrophic climate changes, Proc. Natl. Acad. Sci. 114(39):10315–10323 ("The mitigation of the coemitted SLCPs and cooling aerosols by CO2-dedicated measures requires special consideration (33). SLCP emissions are not entirely independent of CO2 emissions, and emission rates of SLCPs can decrease due to CO2 mitigation, and likewise CO2 emissions can decrease due to mitigation of SLCPs. The role of coemitted SLCPs	See response to comment #68301

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
68313	61	25	61	47	Even though SLCPs avoid warming quickly (days to about a decade and a half), SLCP mitigation can have lasting benefits in 2100 and even 2200, plus avoids irreversible harm from sea-level rise. Shoemaker J. K., et al. (2013) What Role for Short-Lived Climate Pollutants in Mitigation Policy?, SCIENCE 342:1323–1324, 1323–1324 ("Direct comparisons of the climate influence of SLCPs and CO2 require making a judgment about the relative importance of short and long time scales. SLCPs have a powerful impact on climate, but they persist in the atmosphere for only a short time—days to weeks for BC, a decade for CH4, and about 15 years for some HFCs. Thus, immediate reductions in SLCPs will result in relatively immediate climate benefits, as the effects on climate depend largely on the emission rate, or flow, of SLCPs to the atmosphere. …It is also important to recognize that CO2 and SLCP emissions are not independent. Some of the steps to reduce CO2 emissions will drive down emissions of SLCPs, as some of the largest sources of BC and methane are associated with fossil fuel production and combustion."); see also Shoemaker J. K., et al. (2013) What Role for Short-Lived Climate Pollutants in Mitigation Policy?, SCIENCE 342:1323–1324, Figure ("Climate temperature response to reductions in emissions of CO2, SLCPs, or both. Based on scenarios detailed in the supplemental material. Temperature change is shown relative to a pre-industrial baseline. In the Reference scenario, annual CO2 emissions peak in 2080, after which they decline rapidly, while SLCP (CH4, BC) emissions remain at or above current levels. In the "SLCP mitigation" scenario, deep cuts in BC (80%) and CH4 (40%) emissions, relative to 2010 levels, are implemented linearly from 2010 to 2050. In the "CO2 mitigation" scenario, CO2 emissions are reduced by 20% relative to the reference scenario by 2050, followed by slowly decreasing emissions that intercept the reference scenario emissions at 2150. In this scenario, emissions of both BC and CH4 are partially decreased relative to the reference scenario owing to those sources associated with fossil fuel consumption. The "HCM" scenario includes simultaneous mitigation of CO2, CH4, and BC, as described above. For simplicity we ignore HFCs as well as different sulfate aerosol trajectories. Including these would slightly change the shape of the curves, but not the relative time scales between them."); Hu A., et al. (2013) Mitigation of short-lived climate pollutants slows sea-level rise, NATURE CLIMATE CHANGE 3:730–734, 730 ("Our results show that SLCP mitigation can have significant effects on SLR. It can decrease the SLR rate by 24–50% and	See response to comment #68303

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
68315	61	25	61	47	Given the short lifetimes of SLCFs, a shorter timescale than 50 or 100 years—specifically using a metric of GWP20—would provide a better understanding of the near-term warming from SLCPs. This is important because many feedbacks and tipping points are anticipated within the next 10 to 20 years, as the 1.5C guardrail is approached and likely breached. Masson-Delmotte V., et al. (eds.) (2018) SUMMARY FOR POLICYMAKERS, in IPCC (2018) GLOBAL WARMING OF 1.5 ºC; Lenton T. M., et al. (2019) Climate tipping points—too risky to bet against, NATURE, Comment, 575:592–595; Steffen W., et al. (2018) Trajectories of the Earth System in the Anthropocene, PROC. NAT'L. ACAD. SCI. 115(33):8252–8259, 8254; and Drijfhout S., et al. (2015) Catalogue of abrupt shifts in Intergovernmental Panel on Climate Change climate models, PROC. NAT'L. ACAD. SCI. 112(43):E5777–E5786, E5784. GWP* being used throughout the AR6 Report can be a useful metric, but does not completely negate the need and utility of a metric for a shorter timescale like GWP20. In the IPCC 1.5C Report, GWP* is noted for its ability to describe the impacts from SLCFs, even providing a Figure in Cross-Chapter Box 2 that shows the differences between GWP100, GTP100, and GWP*. This does not help for shorter timescale concerns. In the First Order Draft for WGIII for AR6, GWP* is explained in Chapter 2 as allowing the comparison of a sustained change in emissions for non-CO2 forcers in comparison with CO2, but the chapter also notes that there are limitations to using GWP* for policy applications, including those relevant for the Paris Agreement (see WGIII FOD 2-23–2-24). Further, Chapter 2 does suggest that GWP20 may be useful alongside metrics like GWP100 and GTP100 to compare changes in emissions (WGIII FOD 2-22). In Chapter 6 of WGIII FOD, the authors note that a chosen climate metric and the time horizon for which it covers affect assessing the timing of achieving climate targets like net-zero emissions (WGIII FOD 6-100). In discussing the balance of CO2 and non-CO2 emissions from aviation, Chapter 10 of WGIII's FOD suggests that time horizon is a subjective choice of the whomever is using the information, and that if longer time horizons are chosen, CO2 becomes more important (WGIII FOD 10-51: "Any GWP/GTP type emissions equivalency calculation always involves the user selection of a time horizon, over which the calculation is made, which is a subjective choice (Fuglestvedt et al., 2010). In general, the longer the time horizon, the more important CO2 becomes in comparison with a SCLF [sic]."). [Durwood Zaelke, United States of America]	See response to comments #66767 and #68305
68317	61	25	61	47	For policymakers, changes in the near-term and creating policies that are in line with the lower emissions scenarios would benefit from the ability to emphasize the amount of avoided warming from the SLCPs and the near-immediate impact that they can have, which is aided by having the appropriate metric in GWP20. See Climate and Clean Air Coalition (CCAC) , Mexico , Molina Center for Energy and the Environment (MCE2), & United Nations Environment Programme (UNEP) (2018) Progress and Opportunities for Reducing SLCPs across Latin America and the Caribbean; UNEP & Climate and Clean Air Coalition (2018) Integrated Assessment of Short-lived Climate Pollutants in Latin America and the Caribbean: Improving air quality while contributing to climate change mitigation; Climate and Clean Air Coalition & UNEP (2019) Air Pollution in Asia and the Pacific: Science-based solutions; European Environment Agency (2018) Air quality in Europe — 2018 report, EEA Report No 12/2018. [Durwood Zaelke, United States of America]	See response to comment #68307
86013	61	25	61	47	Somehow the message of mitigation potential of reducing different GHGs does not yet come across clearly enough. Could this section spell out clearly which mitigation options will have the largest impacts, why and how? [Debra Roberts and the Durban WGII TSU, South Africa]	Noted. Removed "mitigation potential". This section quantifies net temperature effects of different human activities / source emission sectors. "Mitigation potential" not shown here.
114021	61	25	61	53	A reference to WGIII ch 10 can be given here [Jan Fuglestvedt, Norway]	Accepted - text revised
114013	61	26	61	26	Re "approximate balance" is not so easy to see. [Jan Fuglestvedt, Norway]	Accepted - text revised
72799	61	29	61	29	Replace 'horizons' with 'scales' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised
72801	61	31	61	31	Close up space between) and . [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
13497	61	31	61	31	Eliminate the extra space between pharenthesis and period [Maria Amparo Martinez Arroyo, Mexico]	Accepted - text revised
35779	61	31	61	31	Use published sources [Carlos Antonio Poot Delgado, Mexico]	Noted. IPCC acceptance due date is January 31 2021.
72803	61	33	61	33	Delete hyphen. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised
52195	61	33	61	33	The greatest impacts of global temperature over 10 years come from the energy, agriculture, waste / landfills and residential sectors (medium confidence). Clarify if the transport sector is part of the energy sector? [Maritza Jadrijevic Girardi, Chile]	Noted. Fig 6.16 reports transportation sectors separate from energy.
84021	61	34	61	35	The production of energy and fossil fuels is the second largest methane emitting sector (Janssens-Maenhout et al., 2019). From waste/landfill are much lower. Please adjust the sentence to reflect this reality. [Marco Tulio Cabral, Brazil]	Noted. There is no contradiction. See response to #84019. Sentence indicates that CH4 is main contributor to AGR and WST. Fig. 6.16 separates temperature effects of fossil fuel prod/dist and power generation for energy sector.
51269	61	37	61	37	Should the reference here be to "South Africa", the country, or to Southern Africa, the region? All previous areas in the preceding list are regions. [Jolene Cook, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised
114015	61	37	61	37	I suggest changing "importance" to "potenial related to" [Jan Fuglestvedt, Norway]	Accepted - text revised
84023	61	37	61	38	While considering the potential of CH4 reduction on different sectors, the exemplification, should carefully consider the impact of responses of essential aspects of human life, in particular the impacts on food securtiy and rural livelihoods. [Marco Tulio Cabral, Brazil]	Noted. Either cite WGII/WGIII, Box 6.2 if includes SDGs. No discussion appropriate in text for WG I
128479	61	41	61	43	Presumably, if AR6 results indicate a near-zero impact on 10-year timescale, they would agree with AR5 results concerning warming on 20-year timescale. [Trigg Talley, United States of America]	Rejected. Thank you for comment. Not true because emissions change between Assessment Reports.
128481	61	41	61	44	"10-year", "20-year" [Trigg Talley, United States of America]	Accepted - text revised
128483	61	45	61	46	This statement assumes that current residential biofuel cooking and heating would be replaced by something with net-negative or zero climate warming -- which would not be the case for all potential replacement options. (It's not realistic to assume these emissions could just be removed and not replaced by other emissions). More care needs to be taken in such statements. In genearal, what can be done in a model (e.g., remove all biofuel emissions) is not what would happen it the real world. [Trigg Talley, United States of America]	Accepted - text revised
27057	61	49	61	49	Population-weighted pollution fields are not commonly used in air quality policies. How are they pertinent here? [Eric Brun, France]	Accepted - text revised
114019	61	49	61	50	I would not use the term "climate impact" when you talk about radiative forcing here. [Jan Fuglestvedt, Norway]	Accepted - text revised
8513	61	49	61	55	The evidence and rationale for attribution of low or medium confidence is missing. [Frank Dentener, Italy]	Accepted - text revised
103523	61	49	61	55	The evidence and rationale for attribution of low or medium confidence is missing. [Philippe Tulkens, Belgium]	Accepted - text revised
72805	61	51	61	51	Replace)(with ; [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised
16607	61	52	61	54	Surely it is "unequivocal" that Lelieveld estimated agricultural sector emissions to have been to be the 2nd largest contributor since that estimate is there in black-and-white in the Lelieveld et al. paper. It would be better if this section could form an assessment then give a confidence on that assessment. [William Collins, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised
52197	61	54	61	55	The road transport sector is reported to be the largest contributor to global surface ozone concentrations. This due to the contribution of NOx and VOC emissions? [Maritza Jadrijevic Girardi, Chile]	Accepted - text revised. Now link to new bar chart figure of emissions by sector fractional contribution.
128485	61	55	61	55	"global scale" [Trigg Talley, United States of America]	Accepted - text revised
8515	62	2	62	3	Shipping is probably a far more important sector for health impacts than aviation. Why omitted? [Frank Dentener, Italy]	Accepted - text revised. All sectors in Fig. 6.16 now have sub-section. Included literature on shipping effects on human health.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
103525	62	2	62	3	Shipping is probably a far more important sector for health impacts than aviation. Why omitted? [Philippe Tulkens, Belgium]	See response to comment #8515
87417	62	14	62	22	7 major economic sectors and 13 source regions are not explained (also not in the acronyms) [Jürg Thudium, Switzerland]	Accepted - text revised
46039	62	16			Figure 6.16: Please indicate which indirect effects have been included in this study. [Twan van Noije, Netherlands]	Accepted - text revised
8517	62	25	62	53	Additional points that could be discussed in this section. Role of BC emissions in contrail formation and large scale Ci formation, option to reduce BC through improved fuel composition, other options to reduce SLCF emissions, but the need for carefull balancing with CO2 emissions. Advise to carefully word the uncertainty language, as most studies agree on a positive RF of aircraft emissions (medium confidence?), but less confidagreement on the absolute numbers. The way it is phrased can be interpreted as low confidence in climate impacts et al. [Frank Dentener, Italy]	Accepted - text revised
103527	62	25	62	53	Additional points that could be discussed in this section. Role of BC emissions in contrail formation and large scale Ci formation, option to reduce BC through improved fuel composition, other options to reduce SLCF emissions, but the need for carefull balancing with CO2 emissions. Advise to carefully word the uncertainty language, as most studies agree on a positive RF of aircraft emissions (medium confidence?), but less confidagreement on the absolute numbers. The way it is phrased can be interpreted as low confidence in climate impacts at all. [Philippe Tulkens, Belgium]	See response to comment #8517
110957	62	25	62	53	In this section, a table giving an overview of all the components of aviation climate impact should be included (with values and uncertainties). This could also be done in relation with section 7.3.4.2. There really is a need for this IPCC report to give as clear as possible an overview of the full climate impact of aviation (even if complex and with some uncertainties), because that is the information relevant for policy makers. Partial information (some climate impacts only, like CO2) is commonly taken as if it was full information (complete climate impact), which is misleading decision-makers, so an effort of clarity and pedagogy is really needed here. Most decision-makers don't even understand there are non-CO2 impacts for aviation and that these are as important as CO2 (or even more impacting). [Noé Lecocq, Belgium]	Taken into account - included an aviation bar in Fig. 6.16 and improved text discussion for aviation sub-section.
87097	62	27	62	53	There is a scientific consensus that the radiative forces of contrail is a minimum of five times that of carbon dioxide. The [Sarah Qureshi, Pakistan]	Rejected. Comment incomplete.
74071	62	29	62	29	Why only cirrus cloudiness? Low level clouds may also be affected. See Righi et al. (2015) Righi, M., Hendricks, J., and Sausen, R.: The global impact of the transport sectors on atmospheric aerosol in 2030 – Part 2: Aviation, Atmos. Chem. Phys., 16, 4481–4495, https://doi.org/10.5194/acp-16-4481-2016, 2016. [Volker Grewe, Germany]	Accepted - text revised
128487	62	30	62	30	"line-shaped" [Trigg Talley, United States of America]	Accepted - text revised
64811	62	32	62	32	contrail-cirrus -> contrail-induced cirrus [Nicolas Bellouin, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised
72807	62	34	62	34	Delete 'year' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised
128489	62	35	62	35	Change second 'estimate' to 'value'. [Trigg Talley, United States of America]	Accepted - text revised
72809	62	35	62	36	Delete 'the year' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised
22029	62	38	62	38	1940-2018 may be many things but the vast majority of it is not more recent than AR5 which was publisherd in 2013. [Peter Thorne, Ireland]	Accepted - text revised

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
74029	62	40	62	41	Grewe et al (2019) pointed out that the calculation of the contribution of aviation NOx emission to RF is much larger than reported in many previous studies, because of two major flaws, concerning assumptions in the methane lifetime and how parts of the ozone concentration is attributed to sectoral NOx emissions. They pointed out that RF-NOx is a factor of 6-7 higher than e.g. in Lee et al. (2009, 2010). I think this is an important question and should be reflected in this paragraph. Grewe, V., Matthes, S., Dahlmann, K., The contribution of aviation NOx emissions to climate change: Are we ignoring methodological flaws?, Env. Res. Lett., DOI: 10.1088/1748-9326/ab5dd7, 2019. [Volker Grewe, Germany]	Taken into account - Grewe et al., 2019 cited. However, Grewe et al., represents only minor updates most of which have already been published elsewhere e.g. Myhre e tal., 2011. The uncertainty range across multi-model estimates in Lee et al., in review, 2020 is larger than the changes with these relatively minor additions. Grewe et al. is a single model study and does not include any uncertainty due to interannual variability that also is likely important relative to these minor updates. Lee et al., in review 2020 and Brasseur et al., 2016 offer comprehensive multi-model assessments and span more realistic uncertainty ranges. See Fig 2 in Lee et al., 2020 on aviation NOx effects on ERFs.
96677	62	40	62	41	Recent results of Grewe (2019) should also be taken into account. According to that study the aviation RF of NOx is much higher than reported here and in previous studies. Grewe, V., Matthes, S., Dahlmann, K.: The contribution of aviation NOx emissions to climate change: are we ignoring methodological flaws? Environ. Res. Lett. 14 (2019) 121003, https://iopscience.iop.org/article/10.1088/1748-9326/ab5dd7/pdf. [Nicole Wilke, Germany]	Taken into account - see response to #74029 regarding Grewe et al., study.
74031	62	46	62	46	I do not think that the first sentence of this paragraph transports the correct message and reflects correctly the knowledge we have on the climate impact from aviation. As it stands the impression is given that the climate impact from aviation is fundamentally uncertain. I think we have a good understanding on many phyiscal and chemical mechanism leading to changes in the atmospheric composition. These are, e.g., on contribution to the CO2 concentration, the chemical reactions leading to ozone increase and methane decrease and the formation criterion for contrails. We even have a much better understanding on the different changes in ozone depending on cruise altitude (Köhler et al 2008; Grewe and Stenke, 2008; Frömming et al., 2012), the effects of soot number emissions on contrail properties (from measurements and modelling, see e.g. Moore et al. (2017) and Bier and Burkhardt (2019). I suggest to re-write the paragraph and start with some known aviation effects and then to concentrate on uncertainties. [Volker Grewe, Germany]	Accepted - text revised. Some previous confusion over mechanisms/processes versus quantifying values when discussing uncertainty.
74033	62	46	62	46	Please remove the wording "Fundamental". What is the difference between uncertainties and fundamental uncertainties? I think IPCC set up a terminology for how to address uncertainties and that does not include the wording fundamental uncertainties. [Volker Grewe, Germany]	Accepted - text revised
96679	62	46	62	46	We think there is already a better understanding of the climate impact of aviation than stated here. Especially the phrase "fundamental uncertain" gives the impression that there is almost no knowledge on aviation CO2 and non-CO2 effects. In our understanding, the contribution of aviation CO2 to climate change, physical and chemical processes resulting from NOx emissions and leading to an increase of ozone and a decrease of methane as well as processes leading to contrail and contrail-cirrus are better understood than reflected here. We strongly suggest that the paragraph should also focus on this and be re-written. [Nicole Wilke, Germany]	Accepted - text revised
16609	62	46	62	53	However ch 7 do assess a new ERF for contrails. Also the previous paragraph does provide values for Nox. [William Collins, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised. Included Chapter 7 contrail estimate.
87419	62	49	62	49	Furthermore it could be mentionned, that modelled contrail cirrus coverage tend to be overestimated compared with satellite observations (Duda et al. 2013), and that RF model assumptions for ice crystal sizes (minimum 10 µm) don't correspond to reality in contrail cirrus (Bock and Burkhardt, 2016). [Jürg Thudium, Switzerland]	Accepted - text revised

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
74073	62	50	62	51	There are several estimates on how aviation NOx contributes to ozone concentrations and changes in OH lifetime. Studies have looked into regional aspects and even showed that distinct weather situations lead to very distinct and consistent pattern of ozone contributions (e.g. Frömming et al. 2020 (submitted) and Rosanka et al. 2020 (submitted)). I think this statement is only true for aresol related effects. The amount of published paper on aviation chemistry effects is large and very consistent over the last years. Please delete the part 'the NOx-O3-CH4 system and other'. Christine Frömming, Volker Grewe, Sabine Brinkop, Patrick Jöckel, Amund S. Haslerud, Simon Rosanka, Jesper van Manen, and Sigrun Matthes, Influence of the actual weather situation on non-CO2 aviation climate effects: The REACT4C Climate Change Functions, Atmos. Chem. Phys., submitted, acp-2020-529, Submitted on 30 May 2020. Rosanka, S., Frömming, C., and Grewe, V.: The impact of weather pattern and related transport processes on aviation's contribution to ozone and methane concentrations from NOx emissions, Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2020-46, in review, 2020. [Volker Grewe, Germany]	Accepted - text revised
74075	62	50	62	51	The sentence "The net climate impacts of the NOx-O3-CH4 system remain too uncertain to be estimated here" contradicts with lines 40 to 41 on page 62, where an estmate is given. [Volker Grewe, Germany]	Accepted - text revised. It is not contradictory in terms of quantifying numerical values from individual sources e.g. Lee et al., 2020 report a factor of 3 uncertainty range in multi model estimates of aviation NOx impacts on short-term O3 (15-40 mWm-2) with models using identical emissions. Agreed that the mechanisms/processes are well understood.
74077	62	50	62	51	Is the uncertainty of the climate-ozone feedbacks on page 51 l 27ff, the Climate-lightning Nox feedback on pae 52 l14ff and the Climate-CH4 LIfetime so much lower than the respective uncertainty for the aviation effects? "The net climate impacts of the NOx-O3-CH4 system remain too uncertain to be estimated here". How can that be? Similar models, similar chemisty. I think the language should be harmonized here. [Volker Grewe, Germany]	Taken into account. The uncertainty range of climate-lightning NOx feedback is from 3 AerChemMIP models only. See response to #74075
74079	62	51	62	53	In the previous sentence the impression is given that ozone and aerosol effects are too uncertain, however here you conclude that both effects are small compared to other sectors. Please revise this part so that this seeming contradiction is resolved. [Volker Grewe, Germany]	Accepted - text revised
72811	62	52	62	52	Delete hyphen. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised
87099	62				events such as 9/11 and covid pandemic when all flying was stopped have proved that the impact of temprature were reduced because of the [Sarah Qureshi, Pakistan]	Rejected. Thank you for comment. Science does not support the 9/11 attribution of Travis et al., 2002.
87101	62				stoppage in flying (Travis, D., Carleton, A. & Lauritsen, R. Contrails reduce daily temperature range. Nature 418, 601 (2002)). A detail data is given in below in Qureshi.S. (2016). A new design for an add-on model of an aero-engine that can condense the contrail causing water vapor to liquid water and store it on aircraft is suggested in order to eliminate the source of contrail. A regulation fraework similar to that in automotive emmisions is needed for the aviation industry so as to compel the aircraft engine manufacturer to comply to regulation to reduce global warming in the atmosphere. Further details we can be avaialble on request. [Sarah Qureshi, Pakistan]	See response #87099

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
87103	62				ENVIRONMENTAL IMPACT OF AVIATION INTRODUCTION The earth's surface is transparent to incoming radiation and opaque to outgoing radiation, which keeps the earth warm. However, this atmospheric balance can be disturbed if the opacity is increased due to global warming. Global warming occurs as a result of the increase in the concentration of the greenhouse gases namely carbon dioxide ozone and water. Water is one of the most important greenhouse gases as it is very effective in trapping outgoing radiations. Incoming radiations for wavelengths less than 4 microns (μm) are absorbed by the atmosphere as well as the earth's surface whereas the outgoing radiation emitted by the earth's surface of greater than 4 microns (μm) are trapped by the greenhouse gases.(Wallace and Hobbs, 2006) The atmosphere on the other hand is transparent to the visible spectrum, opaque to the ultraviolet (UV) band and has variable opacity across the infra-red (IR) region. Among the other major atmospheric gases N2 does not figure in the absorption at all whereas O3 only absorbs little in the UV and IR region. Water (H2O) and carbon-di-oxide (CO2) are tri-atomic molecules which possess rotational and vibrational degrees of freedom that can be easily excited by Infra-red radiations. Mono atomic noble gases in the atmosphere are transparent to radiation. Gases with certain asymmetric molecular structures are highly effective in absorbing radiation, and are thus known as greenhouse gases, of which, the most important are H2O, CO2 and O3. These greenhouse gasses are generally transparent to white light (all wavelengths) and the sunlight penetrates to heat up the Earth during the day. At night, the Earth loses heat to outer space by emitting infra-red radiation, however, the greenhouse gasses reflect some of the IR heat back to Earth. This is the phenomenon behind global warming. Natural clouds filter out both ways, and their contribution is in equilibrium. THE GREENHOUSE EFFECT The total solar radiation reaching the Earth is 1373 Watts/meter2 when the Earth is at a mean distance from the Sun. This value is known as the Solar Constant. The solar radiation is reduced in the atmosphere due to absorption. According to the Wien's Law, the peak of the terrestrial	Noted. Thank you for comment.
103529	63	1	63	16	The impacts attributed to residential biomass burning apply also to commercial applications. [Philippe Tulkens, Belgium]	Accepted - text revised. Changed to "Residential and Commercial"
38489	63	3	63	3	Please change 'solar radiation management' to 'solar radiation modification' to be consistent with Chapter 4, 4.6.3 [LONG CAO, China]	This comment refers to p53 (section 6.3)
38491	63	3	63	3	Please change 'schemes' to 'options' or 'approaches' to be consistent with Chapter 4, 4.6.3 [LONG CAO, China]	This comment refers to p53 (section 6.3)
86041	63	3	63	16	This talks to many people particularly those in the developing world and underscores one of the core benefits of the energy transition. More focus should be given here beyond India. [Debra Roberts and the Durban WGII TSU, South Africa]	Accepted - text revised
87421	63	9	63	12	It should be mentioned that fine dust filters and particle separators result in a very large reduction in particle emissions. [Jürg Thudium, Switzerland]	Accepted - text revised
128491	63	11	63	12	Clarify that this statement pertains to outdoor air pollution. [Trigg Talley, United States of America]	Accepted - text revised
114025	63	12	63	12	Which quantitive impact are you referring to for which you assign low confidence? [Jan Fuglestvedt, Norway]	Accepted - text revised
13499	63	12	63	12	Erase comma before pharenthesis [Maria Amparo Martinez Arroyo, Mexico]	Accepted - text revised
22031	63	14	63	16	I'm not convinced that the text justifies a very likely assignment to the radiative impacts here given what was discussed in the prior sections. [Peter Thorne, Ireland]	Accepted - text revised
8519	63	14	63	16	If a best estimate is not possible, a range should be possible. Otherwise what is the basis for the 'very likely' effect on regional and global effects. [Frank Dentener, Italy]	Accepted - text revised
103531	63	14	63	16	If a best estimate is not possible, a range should be possible. Otherwise what is the basis for the 'very likely' effect on regional and global effects. [Philippe Tulkens, Belgium]	Accepted - text revised

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
4085	63	14	63	16	Influenced by the Asian monsoon, burning of biofuels in northern China and northeast China is affecting regional air quality in the outflow region in the western North Pacific. Reference: Zhu et al., Atmos Chem Phys, 2015 (10.5194/acp-15-1959-2015); Zhu et al., Environ Pollut, 2019 (10.1016/j.envpol.2019.01.003). [Chunmao Zhu, Japan]	Considered but not applicable, as paragraph was reorganised
8521	63	19	63	30	This section is very short and it unclear what aspects have been considered in the assessment of a 'net cooling' effect. Is this e.g. taking into account also the substantial emissions of CH4 by bb, O3 formation, albedo effects? If not a best estimate at least a range should be presented which is the basis of the medium confidence. [Frank Dentener, Italy]	Considered but not applicable, as paragraph was reorganised
114023	63	19	63	30	I think there more discussion of the basis for the confidence statements is needed here. [Jan Fuglestvedt, Norway]	Accepted - text revised
103533	63	19	63	30	This section is very short and it unclear what aspects have been considered in the assessment of a 'net cooling' effect. Is this e.g. taking into account also the substantial emissions of CH4 by bb, O3 formation, albedo effects? If not a best estimate at least a range should be presented which is the basis of the medium confidence. [Philippe Tulkens, Belgium]	Accepted - text revised
128493	63	23	63	23	Also mention possible absorption by brown carbon aerosols? Does this change the degree of certainty regarding the sign of the net forcing? [Trigg Talley, United States of America]	Accepted text revised
128495	63	29	63	29	"fire air pollution vegetation damage" [Trigg Talley, United States of America]	Accepted - text revised
5675	63	33	64	15	Please check and clarify in the text: does "land use change" here refer to the change OF land use, i.e. the conversion of forest to agricultural area as in GHG reporting, or does this also include changes IN land use, e.g. changes in cropland management? The latter should not be subsumed under "LUC", as this is a specififc term from GHG Inventory and Reporting. [Joachim Rock, Germany]	Taken into account, text revised.
82991	63	35	63	36	Human land use also includes wetland conversion-restoration that modifies CH4 emissions. Although Chapter 5 covers this topic (e.g., Sect. 5.6.2.2.1), I think it would be important to mention it here, to keep consistency among chapters. To date, the impact of wetland conversion on compound emissions other than CH4 and on atmospheric chemistry has been poorly investigated (Massad et al., 2019). Suggested reference: Massad, R. S., Lathière, J., Strada, S., Perrin, M., Personne, E., Stéfanon, M., Stella, P., Szopa, S., and de Noblet-Ducoudré, N.: Reviews and syntheses: influences of landscape structure and land uses on local to regional climate and air quality, Biogeosciences, 16, 2369–2408, https://doi.org/10.5194/bg-16-2369-2019, 2019. [Susanna Strada, Italy]	Accepted - text revised
51271	63	36	63	36	All land is under a form use even when its use is non-exploitation. Suggested edit for clarity: 'Nearly three quarters of the surface is under some form of direct human land use.' [Jolene Cook, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised
128497	63	36	63	36	"surface" --> "land surface" (or "land area") [Trigg Talley, United States of America]	Accepted - text revised
22033	63	37	63	37	The section is 2.2.7. [Peter Thorne, Ireland]	Accepted - text revised
70835	63	37	63	37	the qoute to Angelo & Du Plessis is a bit odd - rather qoute the SRCCL (would also be consistent with other chapters) [Karlheinz Erb, Austria]	Accepted - text revised
51273	63	39	63	39	Ammonia emissions are predominantly influenced by land use choices and management and so could be included in the list of relevant pollutants. [Jolene Cook, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised
35893	63	41	63	41	The quoted range of 20-25% for the fraction of dust that is anthropogenic seems much too narrow. See for instance page 16 in this chapter, which quotes a more realistic 10-60%. I'd suggest just repeating that range here with a reference to section 6.2.1.2. [Jasper Kok, United States of America]	Accepted - text revised
103535	63	41	63	42	There is some duplication. The same phenomenon is discussed in section 6.3.6 (p.51 l. 27-39). Discuss whether the sensitivity is inline with the 25 % mentioned here. [Philippe Tulkens, Belgium]	Accepted - text revised

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
5233	63	41	63	44	You could simply refer back to the appropriate sections on dust and ammonia rather than repeating the material here. For example, there is a more extensive discussion of anthropogenic dust on page 6-16 and a more extensive discussion of ammonia emissions on page 6-31 [Daniel Murphy, United States of America]	Accepted - text revised
8523	63	42	63	42	There is some duplication. The same phenomenon is discussed in section 6.3.6 (27-39). Discuss whether the sensitivity is inline with the 25 % mentioned here. [Frank Dentener, Italy]	Considered but not applicable, as paragraph was reorganised
51275	63	42	63	42	the 25% of mineral dust is estimated to be from anthropogenic sources - land use not land use change; please delete 'change' [Jolene Cook, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised
8525	63	43	63	43	This is very superficial. Landuse per se is not driving high ammonia emissions- but animal production (on fields and in stables) is most important. For earlier section: the feedback between temperature and NH3 emissions (Sutton; P Hess studies) should be discussed as feedbacks. [Frank Dentener, Italy]	Considered but not applicable, as paragraph was reorganised
103537	63	43	63	43	This is too superficial. Land use per se is not driving high ammonia emissions- but animal production (on fields and in stables) is most important. For earlier section: the feedback between temperature and NH3 emissions (Sutton; P Hess studies) should be discussed as feedbacks. [Philippe Tulkens, Belgium]	Accepted - text revised
76653	63	44	63	46	Total BVOC emissions may decrease due to LULCC from forest to croplands, however, emissions of specific highly reactive compounds may increase, esp. the group of monoterpenes, oxygenated monoterpenes, sesquiterpenes, etc (see e.g. Wiß et al.: Net ecosystem fluxes and composition of biogenic volatile organic compounds over a maize field -- interaction of meteorology and phenological stages) [Felix Havermann (né Wiß), Germany]	Accepted - text revised
76655	63	44	63	46	The enhanced use of woody bioenergy crops such as poplar can also lead to increased isoprene emissions compared to natural forests (see e.g. Szogs et al. 2017: Impact of LULCC on the emission of BVOCs during the 21st century) [Felix Havermann (né Wiß), Germany]	Accepted - text revised
45413	63	49	63	49	SLCFs) --> SLCFs [Hitoshi Matsui, Japan]	Considered but not applicable, as paragraph was reorganised
13501	63	49	63	49	Eliminate pharenthesis after "S1CFs". [Maria Amparo Martinez Arroyo, Mexico]	Accepted - text revised
128499	63	49	63	49	Delete ")" after SLFCs at the end of the sentence. [Trigg Talley, United States of America]	Considered but not applicable, as paragraph was reorganised
128501	63	49	63	49	"has" --> "have", also remove parenthesis at end of sentence [Trigg Talley, United States of America]	Considered but not applicable, as paragraph was reorganised
128503	63	53	63	55	[PROGRESS] How do results from the SRCCL affect these statements? Did the SRCCL also assess "only the changes to the land carbon storage and surface albedo" with respect to quantifying global climate impact of human land use change? Suggest incorporating how SRCCL has updated these statements or not. [Trigg Talley, United States of America]	Considered but not applicable, as paragraph was reorganised
16611	64	1	64	10	Thornhill et al. (submitted a) derive a CMIP6 model ERF for BVOCs. [William Collins, United Kingdom (of Great Britain and Northern Ireland)]	Considered but not applicable, as paragraph was reorganised
8527	64	18	64	18	further mitigation potential=>mitigation potential. [Frank Dentener, Italy]	Accepted - text revised
103539	64	18	64	18	further mitigation potential=>mitigation potential. [Philippe Tulkens, Belgium]	Accepted - text revised
27059	64	18	64	18	Would it be possible to compare the emissions trends in SSP to the ones in AQ studies? Consider to make use of a wider range of SSP scenario to assess the potential of AQ policies versus climate mitigation policies. [Eric Brun, France]	Accepted, Figure 6.18 presents several scenario discussed in the literature in addition to SSPs. Figure 6.25 and 6.26 (discussed in 6.7.3) make use of a wider range of SSPs to compare air pollution control policies and climate change mitigation policies.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
96681	64	18	68	55	Improved comprehensibility, gap, general comment on SDG integration in this chapter and in other AR6 WGI chapters: We strongly support the stressing of co-benefits of mitigation policies especially in regard to SLCFs and SDG related policies, especially regarding health issues and SDG 3 in chapter 6. In other thematic chapters of AR6 WGI no, or much less, reference to co-benefits and (co-challenges) of climate policies and reaching the SDGs is established. In our reception this is inconsistent. For the benefit of the reader, we suggest to use a more consistent approach and/or add further information. [Nicole Wilke, Germany]	Noted - this is true that climate policy and SDG aspects are only discussed in chapter 6. This is due to the peculiar nature of SLCFs which are involved in many environmental issues (CO2 is also involved in ocean acidification which is actually discussed in WG1 too). Air pollution was part of the key words identified for chapter 6 in the scoping meeting and this chapter tries to put together different ways of investigating SLCFs in the literature in a complementary manner to WG3. For long lived GHG, policy aspects are covered thoroughly by WG3.
22035	64	22	64	22	Modelling studies are suddenly introduced without any necessary context. The prior sentence was all about policy and not models. Edits are required here to more sensibly segway from policy to what I assume are a limited number of available modelling studies of the impacts of such policies - so why not say so? [Peter Thorne, Ireland]	Accepted - text revised
128505	64	22	64	22	Add "and" before "climate change" [Trigg Talley, United States of America]	Accepted - text revised
67945	64	24	64	25	Suggest to include also the following citation on SLCPs in Latin America and the Caribbean: (UNEP-CCAC, 2018). Reference: United Nations Environment Programme (UNEP) and Climate and Clean Air Coalition (CCAC): Integrated Assessment of Short-lived Climate Pollutants in Latin America and the Caribbean, 2018. Available at: https://www.ccacoalition.org/en/resources/integrated-assessment-short-lived-climate-pollutants-latin-america-and-caribbean. [Luisa Molina, United States of America]	Accepted - text revised
68319	64	24	64	25	Add citation to Shindell D., et al. (2012) Simultaneously Mitigating Near-Term Climate Change and Improving Human Health and Food Security, SCIENCE 335(6065):183–189 [Durwood Zaelke, United States of America]	Accepted - text revised
46041	64	29	64	33	Please mention that the RCPs do not span the plausible range of future air pollutant emissions, which limits their use in making air quality scenarios and assessing the potential of SLCF mitigation. [Twan van Noije, Netherlands]	Accepted - text revised
114027	64	35	64	35	Check to which extent scenarios are used for this in WGII. [Jan Fuglestvedt, Norway]	Accepted - mention to WGII removed.
128507	64	36	64	36	Add chapter-level citations to WGII and WGIII, if available and appropriate. [Trigg Talley, United States of America]	Accepted, mention to chapter added.
29597	64	38	64	42	This "the latter simulating impact of a very ambitious air quality policy where best available technology is implemented" needs to be modified. Complete removal of a pollution is NOT equivalent to best available technology (BAT). Even BAT cannot reduce pollutants to zero in many cases. There is abundant literature on this (particularly that by the GAINS group at IIASA). Complete removal is an idealized simulation of an aggressive air pollution policy. More appropriate wording, therefore, might be: "the latter an idealized simulation of a very ambitious air quality. " (and remove reference to BAT) [Steven Smith, United States of America]	Taken into account - text revised accordingly
29599	64	38	64	42	A second problem with this section is an incorrect description of the ssp370-lowNTCF scenario. That scenario simply replaces emissions factors from the SSP3 scenario with emission factors from an SSP15 scenario. Those are not BAT emission factors, although they do represent ambitious air pollutant emission reductions. [Steven Smith, United States of America]	Taken into account - text revised accordingly
8529	64	38	64	43	What is the abbreviation NTCF? Not clear what is fundamentally different from the first category. Is 'removal' in the first sentence referring to an attribution, or is rather referred to a 'strong emission reduction' study? [Frank Dentener, Italy]	Taken into account - NTCF stands for 'Near-term Climate Forcers' and was used for SLCFs in AR5, as well as selected for use in the scenario name for AR6. The term is included in the glossary. The 2nd category is different from first since it refers to a 'strategy/policy' that acts only on SLCFs ignoring likely changes to CO2 if such policies would be adopted and so it is more of a sensitivity study, similar to Samset et al (2018) for BC only. The latter ref also added in the text now.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
103541	64	38	64	43	What is the abbreviation NTCF? Not clear what is fundamentally different from the first category. Is 'removal' in the first sentence referring to an attribution, or is rather referred to a 'strong emission reduction' study? [Philippe Tulkens, Belgium]	Taken into account - NTCF stands for 'Near-term Climate Forcers' and was used for SLCFs in AR5, as well as selected for use in the scenario name for AR6. The term is included in the glossary. The 2nd category is different from first since it refers to a 'strategy/policy' that acts only on SLCFs ignoring likely changes to CO2 if such policies would be adopted and so it is more of a sensitivity study, similar to Samset et al (2018) for BC only. The latter ref also added in the text now.
128509	64	42	64	43	"although methane reductions have not historically been motivated by air pollution concerns" [Trigg Talley, United States of America]	Accepted - text revised
8531	64	52	64	52	The section title should reflect the limited scope of this section. Perhaps this section could in a light way contrast the GHG mitigation driven reductions with the air pollution policy driven SLCF reductions. [Frank Dentener, Italy]	Noted - the discussion of mitigation policies and opportunities goes beyond air quality as also Kigali is brought and so it is a broader SLCF focus.
103543	64	52	64	52	The section title should reflect the limited scope of this section. Perhaps this section could in a light way contrast the GHG mitigation driven reductions with the air pollution policy driven SLCF reductions. [Philippe Tulkens, Belgium]	Noted - see answer to comment #8531
8533	64	54	65	5	it is not very clear what is meant here. Section 6.5.3 seems to be an introduction to 6.5.3.1/2 but also to 6.6 which is confusing. [Frank Dentener, Italy]	Noted - the text has been revised (also in 6.7) to provide a clearer distinction making discussion in 6.7 focusing on SSP scenarios
103545	64	54	65	5	it is not very clear what is meant here. Section 6.5.3 seems to be an introduction to 6.5.3.1/2 but also to 6.6 which is confusing. [Philippe Tulkens, Belgium]	Noted - see answer to comment #8533
72813	65	12	65	12	Delete , before 'and' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial, done.
8535	65	15	65	30	In contrast to most other sections, here a statement what was known in AR5 was missing (e.g. Chapter 13 WG1). It is not clear why a regional number is quoted for China alone, whereas I think such info is available from more studies. Regional numbers will be quite dependent on the definition of the areal extent of the region (mention?). [Frank Dentener, Italy]	Noted - Respective statement about AR5 added. There are indeed several regional studies but they assess impact of hypothetical policies and changes or impact of past changes driven but not specifically addressing impact of particular policy.
103547	65	15	65	30	In contrast to most other sections, here a statement what was known in AR5 was missing (e.g. Chapter 13 WG1). It is not clear why a regional number is quoted for China alone, whereas I think such info is available from more studies. Regional numbers will be quite dependent on the definition of the areal extent of the region (mention?). [Philippe Tulkens, Belgium]	see answer to comment #8535
128511	65	20	65	20	"city" in Mexico City needs to be capitalized. [Trigg Talley, United States of America]	Editorial, done.
51279	65	24	65	30	The message from the text is not clear. Research is quoted which has estimated the extent of surface warming solely from measures to reduce harmful air pollutants. However this has happened over a time period of increasing CO2 and other LL GHG emissions. Have these been taken into account? How relevant are the results of this research? Is it suggested that air pollution emissions should not have been reduced to reduce harm to people and the environment? Or is the message that these measures were decoupled from tackling emissions of LL GHG overall, and policies need to tackle a greater range of emissions? [Jolene Cook, United Kingdom (of Great Britain and Northern Ireland)]	Noted - Indeed, GHG emissions have been changing and the authors have not considered this, although in this specific period CO2 emissions in China were stable, the impact of such changes would be much smaller than large shift in aerosol emissions (see revised text about Turnock et al study results). There is no suggestion about the fact that air pollution should not be abated, but the warming effect due to sulphate reduction is a fact. The choice between policies does not belong to IPCC but synergies and antagonisms have to be documented by science assessment.
114029	65	27	65	27	This is presented as a fact, but you could rather say that this is a finding in the study referred to. [Jan Fuglestvedt, Norway]	Accepted - text modified
64813	65	33	65	33	There are already observations that show that changes in shipping fuel sulfur content has decreased the occurrence of ship tracks, suggesting that aci from shipping has strongly decreased. See Gryspeerdt et al. 2019 10.1029/2019GL084700. Those observations support the modelled response. [Nicolas Bellouin, United Kingdom (of Great Britain and Northern Ireland)]	Noted. Here the net effect of shipping emissions is discused.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
8537	65	33	65	53	It is not clear what is the rationale to discuss shipping here in a 'policy' section, and road transport aviation in a different section on page 62 (6.5.2.1). It would be good to mention the AR5 conclusion and end with a summary statement. [Frank Dentener, Italy]	Noted - This section points specifically to the IMO legislation and its effect while section 6.5.2 now includes also discussion of the shipping sector and its impact, not necessarily reduction imposed by specific legislation
103549	65	33	65	53	It is not clear what is the rationale to discuss shipping here in a 'policy' section, and road transport aviation in a different section on page 62 (6.5.2.1). It would be good to mention the AR5 conclusion and end with a summary statement. [Philippe Tulkens, Belgium]	see answer to comment #2232
103551	65	33	65	53	Since 2012, the EU has taken firm action to reduce the sulphur content of marine fuels through the Sulphur Directive. In 2016, the International Maritime Organization (IMO) maintained 2020 as entry-into-force date of the global 0.5% sulphur cap. From 1 January 2020, the maximum sulphur content of marine fuels is reduced to 0.5% (down from 3.5%) globally – reducing air pollution and protecting health and the environment. Every organization in the shipping supply chain must find a way to reduce sulfur emissions through refitting existing ships, building compliant ships and building the alternative fuel infrastructure required to keep the global fleet operational. The EU has strived for an active role in tackling maritime emissions more generally, both at home and globally. In 2018, the IMO agreed to reduce greenhouse gas emissions from shipping by at least 50% by 2050. The EU and its Member States played an instrumental role in brokering and securing the deal for the sector, which currently represents 2-3% of global CO2 emissions. Discussions are already ongoing at the IMO to translate this deal into concrete measures. [Philippe Tulkens, Belgium]	Noted
128513	65	35	65	36	Was the new global standard to limit sulphur content in ship oil fuel approvedby IMO? Please confirm. [Trigg Talley, United States of America]	Noted - yes, it was. But the ship operators can also remove SO2 using scrubbers to achieve comparable emissions as when using low S fuel
128515	65	35	65	53	Is it appropraite to discuss open vs closed scrubbers on these ships and how some companies are reconfiguring scrubbers to inject sulpher into the ocean opposed to the atmosphere and the implications this pollution would have on the ocean ecosystem. [Trigg Talley, United States of America]	Noted and important but possible side effects of this legislation which are not related to SLCF in the atmosphere are beyond the scope of this chapter.
78295	65	35	65	53	It would be useful include the warming effect in the short term and the impact of this measure after 20 years. [Leonie Lee, Singapore]	Noted - this is shown and discussed in Section 6.5.2
72815	65	37	65	37	Move 'strongly' to after) [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial, done.
72817	65	38	65	38	Insert 'the' before 'Middle' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial, done.
128517	65	42	65	42	"Tg of SOx" should not be used as a unit for emissions. Either express as "Tg S" or "Tg SO2 equivalent". The molecular mass of "SOx" is not well defined. [Trigg Talley, United States of America]	Accepted - text revised to SO2
46043	65	42	65	42	Should it be "SOx" or "SO2"? [Twan van Noije, Netherlands]	Accepted - text revised to SO2
78709	65	44	65	45	Replace "as cloud condensation nuclei (CCNs)" with "CCN" (was already defined above). [Heike Wex, Germany]	Editorial, done.
128519	65	47	65	47	"content" --> "contain" [Trigg Talley, United States of America]	Editorial, done.
51277	65	47	65	47	Typo: 'content' to 'contain' [Jolene Cook, United Kingdom (of Great Britain and Northern Ireland)]	Editorial, done.
5235	65	47	65	49	First, replace “indirect effect” by “aerosol cloud interactions”. [Daniel Murphy, United States of America]	Accepted - text revised

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
5237	65	47	65	49	Second, of the three mechanisms, only the aerosol cloud interactions is important. The mixed particles is modestly important. The increase of nitrates by reducing sulphates may happen close to shore (e.g. emissions from the port of Los Angeles going over the city) but over the open ocean where most ship emissions take place the aerosol nitrate is controlled by sea salt nitrate, not the sulfate particles. For example, there are no significant concentrations of ammonium nitrate in the marine boundary layer, with or without sulphate from ships. The easiest edit is to delete (iii) to the end of the sentence. [Daniel Murphy, United States of America]	Noted - text revised
128521	65	48	65	48	"absorption" --> "absorbing" [Trigg Talley, United States of America]	Editorial, done.
128523	65	49	65	49	"mechanically" is not the right word here. Maybe "indirectly"? [Trigg Talley, United States of America]	Accepted - text revised
13503	65	51	65	51	Eliminate pharenthesis after "6.5.2". [Maria Amparo Martinez Arroyo, Mexico]	Editorial, done.
72819	65	52	65	52	Delete) after 2012 [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial, done.
116553	65		65		The climate response to AQ policy could be complemented by a box on the effect of temporary decreases in emissions due to reduced activities linked to the COVID19 pandemic in a specific box. A recent publication in GRL strenghtens the finding related to the increase of ozone (https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/2020GL088070). [Valerie Masson-Delmotte, France]	A cross-chapter box covering the effect of the COVI19 pandemic on air quality and climate is now hosted by this section.
114033	66	3	66	23	Section 6.5.3.3 just lists findings about effects of the Kigali Agreement. I would expect some synthesis and assessment of this knowledge. [Jan Fuglestvedt, Norway]	Taken into account - text revised to include ref to RCP and SSP analysis confirming earlier studies. New knowledge since AR5, but also lower than originally praised in KA documents impact as the high baseline less plausible.
40877	66	3	66	23	Suggest you update the glossary definition for the Montreal Protocol to include the Kigali Amendment. Current definition: "The Montreal Protocol on Substances that Deplete the Ozone Layer was adopted in Montreal in 1987, and subsequently adjusted and amended in London (1990), Copenhagen (1992), Vienna (1995), Montreal (1997) and Beijing (1999). It controls the consumption and production of chlorine- and bromine-containing chemicals that destroy stratospheric ozone (O3), such as chlorofluorocarbons (CFCs), methyl chloroform, carbon tetrachloride and many others." [TSU WGI, France]	Accepted.
16613	66	3	66	23	What is the assessment of this section? [William Collins, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account - text revised to include ref to RCP and SSP analysis confirming earlier studies. New knowledge since AR5, but also lower than originally praised in KA documents impact as the high baseline less plausible.
128525	66	7	66	10	"The Kigali Amendment, assuming global compliance, is expected to reduce future radiative forcing due to HFCs (excluding contribution from HFC-23) by about 50% (0.13 W m-2) in 2050 compared to the baseline scenario with projected increased use and emissions in the absence of controls (WMO, 2018)." This sentence is not accurate. It should read: "The Kigali Amendment, assuming global compliance, is expected to reduce future radiative forcing due to HFCs (excluding contribution from HFC-23) by about 50% (from 0.22-0.25Wm-2 to 0.13 W m-2) in 2050 compared to the baseline scenario with projected increased use and emissions in the absence of controls (WMO, 2018)." [Trigg Talley, United States of America]	Not applicable - text revised and the statement is not included
128527	66	8	66	8	Kigali does not reduce future RF; rather it 'reduces projections of RF' or 'limits RF'. [Trigg Talley, United States of America]	Not applicable - text revised and the statement is not included
128529	66	11	66	11	Cornwall (2016) is an opinion piece rather than a peer-reviewed journal article; suggest removing here and on page 70. [Trigg Talley, United States of America]	Accepted
8543	66	11	66	13	Can the characteristics of the baseline scenario be discussed in view of the widely used SSP-RCP frameworkk in this report. What is the range of forcing in the baseline projections for near term (20-30 years) and end of century. [Frank Dentener, Italy]	Taken into account - a reference to RCP range is made as well as results from SSP assessment are brought in

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
103553	66	11	66	13	Can the characteristics of the baseline scenario be discussed in view of the widely used SSP-RCP frameworkk in this report. What is the range of forcing in the baseline projections for near term (20-30 years) and end of century. [Philippe Tulkens, Belgium]	Taken into account - a reference to RCP range is made as well as results from SSP assessment are brought in
22039	66	12	66	13	This is meaningless without giving some sense of the spread by stating actual numbers. It is unreasonable to expect the reader to go to the literature to find this information so you need to give a quantitative sense here or delete this passage. [Peter Thorne, Ireland]	Not applicable - text revised and the statement is not included
114031	66	12	66	13	Uncelar / incomplete sentence [Jan Fuglestvedt, Norway]	Not applicable - text revised and the statement is not included
128531	66	13	66	16	"The Kigali Amendment, and national and regional regulations, are projected to reduce global average warming in 2100 due to HFCs by 0.3-0.5°C in a baseline scenario based on Xu et al. (2013) and Velders et al. (2015) to less than 0.1°C (see Figure 2.20 of WMO, 2018)." This sentence is not quite correct. It should read: "The Kigali Amendment and national and regional regulations are projected to reduce global average warming in 2100 due to HFCs *from* 0.3-0.5°C in baseline scenarios based on Xu et al. (2013) and Velders et al. (2015) to less than 0.1°C (see Figure 2.20 of WMO, 2018)." [Trigg Talley, United States of America]	Taken into account - text revised
128533	66	16	66	17	"The warming mitigation in the near term (2050) is estimated at about 0.05°C to 0.07°C (Klimont et al., 2017b; WMO, 2018)." WMO (2018) Figure 2-20 shows a reduction in warming in 2050 of ~0.04°C -- not 0.05-0.07°C. [Trigg Talley, United States of America]	Taken into account - text revised, the range is actually derived from Xu et al (2013) paper where for different Velders scenarios the baseline was resulting in about 0.1-0.12 oC and so mitigation impact of Kigali could be assessed at 0.03-0.05 while in the GISS model estimate used in the also quoted UNEP study gave a range of 0.05-0.07. Final text makes also a reference to assessment of SSP scenarios.
27061	66	19	66	19	In Scientic Assessment of Ozone Depletion (WMO, 2018), they mention "Improvements in energy efficiency in refrigeration and air-conditioner equipment during the transition to low-GWP alternative refrigerants can potentially double the climate benefits of the HFC phasedown of the Kigali Amendment." Could it be mentioned that it could double the benefits? [Eric Brun, France]	Taken into account - text revised
27063	66	20	66	20	The article Shah et al is not listed in the list of references [Eric Brun, France]	Taken into account - list of references corrected
8545	66	22	66	23	What would be the climate consequence of this relatively smal electricity saving. Can this section finish with a succint summary statement? [Frank Dentener, Italy]	Taken into account - text revised. New study added, the benefits are larger and explicitly stated
103555	66	22	66	23	What would be the climate consequence of this relatively smal electricity saving. Can this section finish with a succint summary statement? [Philippe Tulkens, Belgium]	Taken into account - text revised. New study added, the benefits are larger and explicitly stated
128535	66	23	66	23	"electricity savings" (no hyphen) [Trigg Talley, United States of America]	Accepted
22041	66	26	66	26	This section title made no sense to me. Is there a more intuitive and self describing title? SLCFs are agnostic and do not have strategies or opportunities so I assume that you are talking instead about strategies and opportutinities for / arising from SLCF abatement and / or mitigation? [Peter Thorne, Ireland]	Taken into account - title revised to: "Assessment of SLCF mitigation strategies and opportunities"
128537	66	26	68	14	The text in this section needs some proof reading. [Trigg Talley, United States of America]	Taken into account, this section has been thoroughly revised.
114037	66	26	68	14	section 6.5.3.4. could benefit from coorcination with WGIII, chapter 3 and 4. [Jan Fuglestvedt, Norway]	Noted
114045	66	26	68	14	section 6.5.3.4. given an interesting overview of mitigation studies, but would benefit from an assessment of what these studies tell us. What are the implications, what are the main findings and how robust is the knowledge about the mitigation strategies and opportunities discussed. [Jan Fuglestvedt, Norway]	Taken into account, this section has been rewritten with this aim.
103557	66	26	68	14	A table summarizing health benefits from a variety of scenarios could be useful; possibly normalized. A summary statement is missing. There is a lot of repetition in the description of later sections wrg to scenarios. Wouldn't it be better to have this section after the SSP scenarios descriptions.? [Philippe Tulkens, Belgium]	see answer to comment #8555

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
22043	66	26			This section felt like it might be over-reaching into WG3 space at various places? It should rigorously stick to the WG1 space and avoid mitigation policy discussions per se. [Peter Thorne, Ireland]	Noted - Given the mandate for AR6 WGI being more policy relevant the assessment naturally includes elements typically included in WGIII. Coordination with WGIII has been undertaken to achieve consistency. Policy aspects are discussed in chapter 6 due to the peculiar nature of SLCFs which are involved in many environmental issues. Air pollution was part of the key words identified for chapter 6 in the scoping meeting and this chapter tries to put together different ways of investigating SLCFs in the literature on a complementary manner to WG3.
66771	66	31	66	38	There is a distinction that could be made here to short-lived forcers that warm versus those that cool, and emphasis on the avoided warming possible by eliminating emissions of SLCPs (methane, tropospheric ozone, black carbon, and HFCs). [Kristin Campbell, United States of America]	Rejected - The climate impact of particular SLCFs have been assessed earlier in the chapter. Discussing strategies, we aim at an objective way to assess the effect of SLCF on climate and air pollution including all co-emitted species which is especially relevant for products of combustion like black carbon that cannot be removed alone. Section 6.6 offers further discussion of impacts of various strategies addressing SLCFs.
66773	66	31	66	38	Speed is the metric of concern because of our proximity to 1.5C and drastic mitigation efforts needed to meet that goal. As a result, policymakers that will rely on the IPCC's scientific expertise would greatly benefit from the access and analysis of climate metrics that consider the shorter timescales like GWP20, which was used in past assessments and throughout policy work. SLCFs are featured in Chapter 6 of this report, but their impact on the climate—especially in the crucial near-term—should not be relegated to only that chapter but instead considered as part of the whole, most importantly short-lived climate pollutants (black carbon, methane, tropospheric ozone, and HFCs). [Kristin Campbell, United States of America]	Rejected. Effect of SLCF on surface temperature at short term horizon is discussed in section 6.6. The choice of metrics is discussed in chapter 7.
66775	66	31	66	38	GWP* being used throughout the AR6 Report can be a useful metric, but does not completely negate the need and utility of a metric for a shorter timescales like GWP20. In the IPCC 1.5C Report, GWP* is noted for its ability to describe the impacts from SLCFs, even providing a Figure in Cross-Chapter Box 2 that shows the differences between GWP100, GTP100, and GWP*. This does not help for shorter timescale concerns. In the First Order Draft for WGIII for AR6, GWP* is explained in Chapter 2 as allowing the comparison of a sustained change in emissions for non-CO2 forcers in comparison with CO2, but the chapter also notes that there are limitations to using GWP* for policy applications, including those relevant for the Paris Agreement (see WGIII FOD 2-23–2-24). Further, Chapter 2 does suggest that GWP20 may be useful alongside metrics like GWP100 and GTP100 to compare changes in emissions (WGIII FOD 2-22). In Chapter 6 of WGIII FOD, the authors note that a chosen climate metric and the time horizon for which it covers affect assessing the timing of achieving climate targets like net-zero emissions (WGIII FOD 6-100). In discussing the balance of CO2 and non-CO2 emissions from aviation, Chapter 10 of WGIII's FOD suggests that time horizon is a subjective choice of the whomever is using the information, and that if longer time horizons are chosen, CO2 becomes more important (WGIII FOD 10-51: "Any GWP/GTP type emissions equivalency calculation always involves the user selection of a time horizon, over which the calculation is made, which is a subjective choice (Fuglestvedt et al., 2010). In general, the longer the time horizon, the more important CO2 becomes in comparison with a SCLF [sic]."). [Kristin Campbell, United States of America]	Rejected, choice of metrics is discussed in chapter 7

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
68321	66	31	66	38	Speed is the metric of concern because of our proximity to 1.5C and aggressive mitigation efforts needed to meet that goal. As a result, policymakers that will rely on the IPCC's scientific expertise would greatly benefit from the access and analysis of climate metrics that consider the shorter timescales like GWP20, which was used in past assessments and throughout policy work. SLCFs are featured in Chapter 6 of this report, but their impact on the climate—especially in the crucial near-term—should not be relegated to only that chapter but instead considered as part of the whole, most importantly short-lived climate pollutants (black carbon, methane, tropospheric ozone, and HFCs). Aggressive mitigation of SLCPs can cut the rate of warming in half, Arctic warming by two-thirds, and avoid up to 0.6C of warming by 2050. UNEP & WMO (2011) Integrated Assessment of Black Carbon and Tropospheric Ozone; Shindell D., et al. (2012) Simultaneously Mitigating Near-Term Climate Change and Improving Human Health and Food Security, Science 335(6065):183–189; Xu and Ramanathan (2017) Well below 2 °C: Mitigation strategies for avoiding dangerous to catastrophic climate changes, Proc. Natl. Acad. Sci. 114(39):10315–10323. [Durwood Zaelke, United States of America]	Rejected: Climate metrics is discussed in Chapter 7 of WGI. Chapter 6 aims to provide an objective assessment of studies addressing effect of SLCF mitigation (including both cooling and warming SLCFs). In fact, studies that are quoted in the comment are referred in the chapter and discussed in view of other, often more recent work, eventually providing a balanced assessment. Papers like Xu and Ramanathan present results excluding cooling aerosols effects (which can only be seen in supplementary material (Table S1 and Figure S5) and therefore present a somehow incomplete picture.
68323	66	31	66	38	GWP* being used throughout the AR6 Report can be a useful metric, but does not completely negate the need and utility of a metric for a shorter timescale like GWP20. In the IPCC 1.5C Report, GWP* is noted for its ability to describe the impacts from SLCFs, even providing a Figure in Cross-Chapter Box 2 that shows the differences between GWP100, GTP100, and GWP*. This does not help for shorter timescale concerns. In the First Order Draft for WGIII for AR6, GWP* is explained in Chapter 2 as allowing the comparison of a sustained change in emissions for non-CO2 forcers in comparison with CO2, but the chapter also notes that there are limitations to using GWP* for policy applications, including those relevant for the Paris Agreement (see WGIII FOD 2-23–2-24). Further, Chapter 2 does suggest that GWP20 may be useful alongside metrics like GWP100 and GTP100 to compare changes in emissions (WGIII FOD 2-22). In Chapter 6 of WGIII FOD, the authors note that a chosen climate metric and the time horizon for which it covers affect assessing the timing of achieving climate targets like net-zero emissions (WGIII FOD 6-100). In discussing the balance of CO2 and non-CO2 emissions from aviation, Chapter 10 of WGIII's FOD suggests that time horizon is a subjective choice of the whomever is using the information, and that if longer time horizons are chosen, CO2 becomes more important (WGIII FOD 10-51: "Any GWP/GTP type emissions equivalency calculation always involves the user selection of a time horizon, over which the calculation is made, which is a subjective choice (Fuglestvedt et al., 2010). In general, the longer the time horizon, the more important CO2 becomes in comparison with a SCLF [sic]."). [Durwood Zaelke, United States of America]	Rejected, choice of metrics is discussed in chapter 7
68325	66	31	66	38	SLCP mitigation has been underway for many years, including in California, which has reduced its BC emissions by 90% since the 1960s. Ramanathan V. (2013) Black Carbon and the Regional Climate of California, Report to the California Air Resources Board Contract 08-323. Additional SLCP mitigation efforts are ongoing under California's climate laws and policies (AB32 – The CA Global Warming Solutions Act, SB1083 – Short-lived climate pollutants, and SB1013 – Fluorinated gases). In other jurisdictions, efforts over the past half century or more have reduce BC and O3 through laws and policies promoting clean air. See Climate and Clean Air Coalition (CCAC) , Mexico , Molina Center for Energy and the Environment (MCE2), & United Nations Environment Programme (UNEP) (2018) Progress and Opportunities for Reducing SLCPs across Latin America and the Caribbean; UNEP & Climate and Clean Air Coalition (2018) Integrated Assessment of Short-lived Climate Pollutants in Latin America and the Caribbean: Improving air quality while contributing to climate change mitigation; Climate and Clean Air Coalition & UNEP (2019) Air Pollution in Asia and the Pacific: Science-based solutions; European Environment Agency (2018) Air quality in Europe — 2018 report, EEA Report No 12/2018. [Durwood Zaelke, United States of America]	Rejected, intention of the comment unclear.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
69879	66	31	66	38	"Avoided warming in near-term crucial for avoiding tipping points/feedbacks. Aggressive mitigation of SLCPs can cut the rate of warming in half, Arctic warming by two-thirds, and avoid up to 0.6C of warming by 2050. UNEP & WMO (2011) Integrated Assessment of Black Carbon and Tropospheric Ozone; Shindell D., et al. (2012) Simultaneously Mitigating Near-Term Climate Change and Improving Human Health and Food Security, Science 335(6065):183–189; Xu and Ramanathan (2017) Well below 2 °C: Mitigation strategies for avoiding dangerous to catastrophic climate changes, Proc. Natl. Acad. Sci. 114(39):10315–10323; Report of the Committee to Prevent Extreme Climate Change (Co-Chairs: Ramanathan V., Molina M. L., and Zaelke D.; Authors: Alex K., Auffhammer M., Bledsoe P., Borgford-Parnell N., Collins W., Croes B., Forman F., Gustafsson Ö., Haines A., Harnish R. Jacobson M. Z., King S., Lawrence M., Leloup D., Lenton T., Morehouse T., Munk W., Picolotti R., Prather K. Raga G. B., Rignot E., Shindell D., Singh A. K., Steiner A., Thiemens M., Titley D. W., Tucker M. E., Tripathi S., Victor D., & Xu Y.) (2017) Well Under 2 Degrees Celsius: Fast Action Policies to Protect People and the Planet from Extreme Climate Change. Given the short lifetimes of SLCFs, a shorter timescale than 50 or 100 years—specifically using a metric of GWP20—would provide a better understanding of the near-term warming from SLCPs. This is important because many feedbacks and tipping points are anticipated within the next 10 to 20 years, as the 1.5C guardrail is approached and likely breached. Masson-Delmotte V., et al. (eds.) (2018) SUMMARY FOR POLICYMAKERS, in IPCC (2018) GLOBAL WARMING OF 1.5 ºC; Lenton T. M., et al. (2019) Climate tipping points—too risky to bet against, NATURE, Comment, 575:592–595; Steffen W., et al. (2018) Trajectories of the Earth System in the Anthropocene, PROC. NAT'L. ACAD. SCI. 115(33):8252–8259, 8254; and Drijfhout S., et al. (2015) Catalogue of abrupt shifts in Intergovernmental Panel on Climate Change climate models, PROC. NAT'L. ACAD. SCI. 112(43):E5777–E5786, E5784. GWP* being used throughout the AR6 Report can be a useful metric, but does not completely negate the need and utility of a metric for a shorter timescales like GWP20. In the IPCC 1.5C Report, GWP* is noted for its ability to describe the impacts from SLCFs, even providing a Figure in Cross-Chapter Box 2 that shows the differences between GWP100, GTP100, and GWP*. This does not help for shorter timescale concerns. In the First Order Draft for WGIII for AR6, GWP* is explained in Chapter 2 as allowing the comparison of a sustained change in	Rejected, choice of metrics is discussed in chapter 7
8539	66	35	66	36	, hower… infancy. Not clear what is meant. [Frank Dentener, Italy]	Taken into account - Meant to say that this discussion is in early stages, not fully developed, not matured. The sentence has been revised.
103559	66	35	66	36	, hower… infancy. Not clear what is meant. [Philippe Tulkens, Belgium]	Taken into account - Meant to say that this discussion is in early stages, not fully developed, not matured. The sentence has been revised.
72821	66	36	66	36	Replace 'at' with 'in' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial, done.
72823	66	36	66	36	Move , from after 'policies' to after 'links' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial, done.
67947	66	36	66	52	Reducing air pollution is a high priority not only for Asian countries, but also for other regions around the world. It should be noted that in addition to the assessment for Asia, UNEP-CCAC also published an assessment for Latin America and the Caribbean, which was the first regional assessment conducted by CCAC. The assessment identifies a number of measures and estimates the emissions reduction potentials by 2050. I suggest to include this study also here. This is the same document mentioned in the previous comment. Reference: (UNEP-CCAC, 2018) United Nations Environment Programme (UNEP) and Climate and Clean Air Coalition (CCAC): Integrated Assessment of Short-lived Climate Pollutants in Latin America and the Caribbean, 2018. Available at: https://www.ccacoalition.org/en/resources/integrated-assessment-short-lived-climate-pollutants-latin-america-and-caribbean. [Luisa Molina, United States of America]	Taken into account - the reference to the Latin American assessment added in the beginning of the section. The objectives of the two assessments were however different since Latin American study was an extension of the global BC and ozone assessment showing co-benefits for air quality while the study for Asia had AQ focus and climate co-benefits were shown.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
8547	66	39	66	52	There is a lack of rigor in this discussion. What are the references for the statements, what are the confidence levels. I miss a discussion on the selective reduction of air pollution to reach air quality targets+climate targets simulataneously. I guess a major issue is still that overall SO2 emission reductions would lead to short-term warming. What are the newest studies telling us? [Frank Dentener, Italy]	Taken into account - whole para refers to one study (UNEP, 2019). The text does provide explicit steps in mitigation (aerosols with possible additional warming followed with CH4 and HFCs that bring also CO2 benefits and so offset the aerosol mitigation - but one study, one model - text reduced to one sentence
103561	66	39	66	52	There is a lack of rigor in this discussion. What are the references for the statements, what are the confidence levels? A discussion is missing on the selective reduction of air pollution to reach air quality targets+climate targets simulataneously. A major issue is still that overall SO2 emission reductions would lead to short-term warming. What are the newest studies telling us? [Philippe Tulkens, Belgium]	see answer to comment #8547
8541	66	41	66	41	regulatory standards. Mention 35 ug/m3 is a annual standard. [Frank Dentener, Italy]	Accepted - text revised to include 'regulatory' and refer to the 'annual average'
103563	66	41	66	41	regulatory standards. Mention 35 ug/m3 is a annual standard. [Philippe Tulkens, Belgium]	Accepted - text revised to include 'regulatory' and refer to the 'annual average'
28577	66	41	66	41	Is 35 ug/m3 a standard for annual average or daily average? [Hiroshi Tanimoto, Japan]	Accepted - text revised: annual average
128539	66	44	66	44	Remove parentheses (and add "from"). [Trigg Talley, United States of America]	Editorial, done.
72825	66	45	66	45	Insert 'a' before 'portfolio' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial, done.
32061	66	45			Maybe reference Nisbet, E. G., et al. "Methane mitigation: methods to reduce emissions, on the path to the Paris agreement." Reviews of Geophysics 58.1 (2020): e2019RG000675. 67 [Euan G. Nisbet, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - reference added
46045	66	46	66	48	Impact on crop yields shouldn't be discussed in the WG1 report. [Twan van Noije, Netherlands]	Not applicable, sentence removed. (But impact on crop yields is discussed in 6.4.4 as interaction between SLCF and the C cycle is in the scope of WG1.
72827	66	47	66	47	Replace hyphen with 'a' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial, done.
114035	66	50	66	50	It is a bit cryptic to just say "using AGTP". I suggest changing this to "based on a simple climate model" or "based on an emulator calculation". And is the comparison to the GISS model consistent? [Jan Fuglestvedt, Norway]	Accepted - changed. And the results are consistent with GISS
128541	66	51	66	51	"...with more significant reduction in the Himalayan and Tibetan Plateau". Edit to be clear that authors are referring to a more significant reduction in *temperature* in these regions -- not to more significant reductions in *emissions* from these regions. [Trigg Talley, United States of America]	Accepted - text revised but finally removed.
114039	67	2	67	2	When you say 0.2 deg C reduction, you need to make it clear compared to what? An earlier ref year, or a reference scenario for 2030. And also what kind of calculation that this is based on. [Jan Fuglestvedt, Norway]	Taken into account - text revised to make it clear
8549	67	2	67	3	50 % of anthropogenic emissions. Give range for 0.2 C. [Frank Dentener, Italy]	Taken into account - text revised and range added
103565	67	2	67	3	50 % of anthropogenic emissions. Give range for 0.2 C. [Philippe Tulkens, Belgium]	Taken into account - text revised and range added
8551	67	4	67	5	Confusing to discuss a 2030 goal with a 2050 temperature target. [Frank Dentener, Italy]	Taken into account - text revised and range added
103567	67	4	67	5	Confusing to discuss a 2030 goal with a 2050 temperature target. [Philippe Tulkens, Belgium]	Taken into account - text revised and range added
114041	67	5	67	5	When you say 0.3-0.6 deg C reductin, you need to make it clear compared to what? An earlier ref year, or a ref scenario for 2030. (As done on line 8) And also what kind of calculation that this is based on. [Jan Fuglestvedt, Norway]	Taken into account - text revised and range added
128543	67	9	67	9	Remove comma after "including". [Trigg Talley, United States of America]	Editorial, done.
128545	67	12	67	12	Change to "they found mixed results for BC-driven ...." [Trigg Talley, United States of America]	Editorial, done.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
84025	67	16	67	17	proposal: "There is wide agreement that strategies reducing CH4 in some sectors offer larger (and less uncertain) climate benefits than policies addressing BC. Just: it is important to consider the differences in feaseability and costs of actions in different sectors, such as informed in the continuation of the text. As well, it is crucial to consider the impacts of actions in areas essential for sustaining human society, such as the reproduction of livelihoods and food security. [Marco Tulio Cabral, Brazil]	Noted but the assessment of cost feasibility is beyond the scope of WG1 and the effects are essentially assessed in this chapter in term of climate which is the mandate of WG1. Chapter 6 slightly explore the effect on air pollution but can not go into such details.
84027	67	16	67	33	The text starts with potential reductions of methane, mentions differences, also according to sectors. However, agriculture, is the only sector mentioned. What are impacts, in long term, potential and feasibility of reduction of CH4 in other sectors, especially when understanding that this reduction as a cobenefit of CO2 reductions? A more balanced approach is reccommended. [Marco Tulio Cabral, Brazil]	Taken into account, this discussion (in 6.6.3.3) is organised differently in FGD.
8553	67	16	67	33	this section is quite descriptive and lacking quantification. A more systematic description of groups of scenarios would be helpful, e.g. the main assumptions tha lead to large CH4 emission reductions, and those that assume larger barrriers. [Frank Dentener, Italy]	Taken into account, this discussion (in 6.6.3.3) is organised differently in FGD.
103569	67	16	67	33	this section is quite descriptive and lacking quantification. A more systematic description of groups of scenarios would be helpful, e.g. the main assumptions tha lead to large CH4 emission reductions, and those that assume larger barrriers. [Philippe Tulkens, Belgium]	see answer to comment #2308
32063	67	18			ref Nisbet et al Rev Geo. 2020 ? [Euan G. Nisbet, United Kingdom (of Great Britain and Northern Ireland)]	Rejected - we refer to chapter 5 which assessed recent increase in CH4.
128547	67	22	67	22	Remove comma after "assumptions". [Trigg Talley, United States of America]	Editorial, done.
128549	67	23	67	33	Regarding the potential to reduce methane emissions by as much as 54% by 2050, the report states that, while literature estimates of potential methane mitigation ""include additional reductions due to fast decarbonization, they also include very rapid reduction of emissions in agriculture which can be realized by assuming fast shift to intensive livestock rearing in developing countries which has been debated (e.g., Udo et al., 2011)."" It is vital to emphasize that the most climate-mitigating approach to ""intensive livestock rearing"" is management-intensive rotational grazing (MIG). While cattle grazing on low-quality grass on poorly managed pasture do emit more enteric methane (up to 2X per unit production) than intensive confinement-raised cattle, this accounts for neither the methane and nitrous oxide emissions from liquid manure storage in confined animal feeding operations (CAFOs), nor the GHG emissions associated with grain production CAFO livestock. Furthermore, when unmanaged, overgrazed pasture is converted to MIG systems adapted to locale, per-animal enteric methane drops 30-50%, animal health and productivity improve, and grazing land managed under MIG typically sequesters >2 Mg C/ha-yr (7.3 Mg CO2/ha-yr). References: Ominski, K. H., D.A. Boadi, K. M. Wittenberg, D.L. Fulawka and J.A. Basarab. 2001. Estimates of Enteric Methane Emissions from Cattle in Canada Using the IPCC Tier-2 Methodology. Canadian Journal of Animal Science 87, 459-467. Machmuller et al., 2015 (cited in comments on Chapter 5, page 89) Stanley, P. L., J. E. Rowntree, D. K. Beede, M. S. DeLonge, and M. W. Hamm. 2018. Impacts of Soil Carbon Sequestration on Life Cycle Greenhouse Gas Emissions in Midwestern USA Beef Finishing Systems. Agricultural Systems, 162, 249-58. https://doi.org/10.1016/j.agsy.2018.02.003. Teague et al., 2016 (cited in comments on Chapter 5, page 89). Wang et al., 2015 (cited in comments on Chapter 5, page 89). [Trigg Talley, United States of America]	Noted but rejected, too detailed and beyond the scope of WG1.
128551	67	26	67	26	Add comma before "for example". [Trigg Talley, United States of America]	Editorial, done.
8555	67	26	68	14	A table summarizing health benefits from a variety of scenarios could be useful; possibly normalized. A summary statement is missing. There is a lot of repetition in the description of later sections wrg to scenarios. Wouldn't it be better to have this section after the SSP scenarios descriptions.? [Frank Dentener, Italy]	Taken into account, section reorganised (position before of after SSP has been discussed but this discussion is finally kept before). Health benefits are beyond the scope of WG1.
72829	67	31	67	31	Replace 'calls' with 'call' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial, done.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
128553	67	35	67	36	Should this be "key pillars of any ambitious climate mitigation strategy" (?) [Trigg Talley, United States of America]	Yes, thank you, the change has been done.
114043	67	35	67	36	This sentence is very long and heavy. In addition, I think decoarbonization… of our lives" is too imprecise. I suggest you consider reformualtions. [Jan Fuglestvedt, Norway]	Accepted - text modified
72831	67	39	67	39	Insert 'in' after 'resulting' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial, done.
72833	67	41	67	42	Remove split of numbers and units across line. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial, done.
86043	67	42	67	42	What is a 'significant reduction'? Perhaps consider providing the estimate of reduction in premature deaths. [Debra Roberts and the Durban WGII TSU, South Africa]	Rejected - methodology to assess health impact are not discussed and assessed in WG1, an isolated results quantifying that out of context would not be meaningful.
128555	67	42	67	44	This statement does not appear to be accurate. Lee et al. found the large reductions reported here to result from *air quality* regulations. The efforts to reduce CO2 by 50% produced modest PM2.5 benefits, but no benefit (or a slight disbenefit) for ozone. Rephrase this sentence to reflect accurately the results of this study. [Trigg Talley, United States of America]	Not applicable - text revised and this statement is not included anymore.
72835	67	47	67	47	Insert 'a' afer 'that' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial, done.
128557	67	48	67	48	Change to "24% lower annual ozone-related deaths". [Trigg Talley, United States of America]	Editorial, done.
72837	67	48	67	48	Replace 'like' with 'such as' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial, done.
28579	67	48	67	48	24% yr-1 might be a misleading phrase. "24% lower ozone-related annual deaths" would be correct, I guess. [Hiroshi Tanimoto, Japan]	Editorial, done.
13505	67	50	67	50	Add period (.) in the quote: et al. [Maria Amparo Martinez Arroyo, Mexico]	Editorial, done.
72839	67	52	67	52	Remove space between % and . [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial, done.
13507	68	1	68	1	Add period (.) in the quote: et al. [Maria Amparo Martinez Arroyo, Mexico]	Editorial, done.
72841	68	2	68	2	Remove split of numbers and units across line. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial, done.
22045	68	5	68	6	This makes no sense as written. Reducing what by 93+/-41 million worldwide? There is insufficient context here. [Peter Thorne, Ireland]	Editorial, done.
128559	68	5	68	6	Clarify that these numbers are the avoided premature mortalities. [Trigg Talley, United States of America]	Taken into account, the sentence has been rephrased.
28581	68	5	68	6	Are these numbers for premature mortality? [Hiroshi Tanimoto, Japan]	Taken into account, the sentence has been rephrased.
86045	68	6	68	6	million deaths? [Debra Roberts and the Durban WGII TSU, South Africa]	Taken into account, the sentence has been rephrased.
128561	68	6	68	6	"million deaths" [Trigg Talley, United States of America]	Editorial, done.
114051	68	15	68	19	I think you have to meake it more clear that you mean contribitions to warming , and not contributions in general; in which case some readers may think that the emisions will give that info. Thus, I sugest insert "to climate change" after "the contributions" on line 16. (YOu coudl alternatively write "to warming/cooling") [Jan Fuglestvedt, Norway]	Taken into account but the box has been thoroughly rewritten.
114053	68	17	68	17	You may also refer to the Box on emulators in ch7, [Jan Fuglestvedt, Norway]	Not applicable, this is not at all the purpose of this box.
20049	68	17	68	54	The title of box 6.2 is misleading. The links between SLCF mitigation and SDG are mentioned in a couple of lines, dodging both argumentation and quantitative analysis. As for the chain connecting emission to concentration, the reader learns nothing: the text says it is tricky and this is about it! The figure is hardly of any help. The conclusion given is that decision makers should take account of what the chemistry climate have to say, because they are mandatory to capture the complexity. Well everybody should agree with this, but the duty of the science community here is to get the decision makers to understand what matters most, in spite of the complexity. There is still a sizable way to go. [philippe waldteufel, France]	Taken into account, title modified, figure removed.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
27065	68	19	68	19	Could the effect of some technologies considered in mitigation strategies (e.g. BECCS, hydrogen, amines filtration to capture CO2) on atmospheric chemistry could be either assessed or at least mentionned as a knowledge gap if not enough literrature exists? [Eric Brun, France]	Taken into account, this is now mentioned in the perspectives of the chapter (6.8)
22049	68	19			I'm not sure what this box really added as it is so short and it is hard to differentiate from the main text in terms of content and context. The SDGs are mentioned in many other places and many of the references also. If the idea is to pull all this material together in one place (which I would support) then efforts need to be made to harvest the relative material from elsewhere in the chapter and integrate it in a somewhat expanded and more integrative box. The present box feels a half way house between having a comprehensive treatment or ceding in entirety the subject to the main text. As such it doesn't feel to me like it works. [Peter Thorne, Ireland]	Noted, Box deeply modified.
72843	68	27	68	27	Replace 'provides' with 'provide' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial, done.
20051	68	30	68	32	These lines are an accurate copy of lines 12-14 on the same page. This must absolutely be avoided. [philippe waldteufel, France]	Editorial, done.
114047	68	34	68	35	This sentence was first a bit unclear to me. But I think it will be clearer if you chnage "defintion" to "design" or "formulation" ? [Jan Fuglestvedt, Norway]	Accepted
22047	68	35	68	36	I'm not sure that the context is sufficient for the reader to not be confused between chemical species and biological species here and you may need to be explicit for the avoidance of doubt? [Peter Thorne, Ireland]	rejected, the term species for chemicals is widely used in the atmospheric chemistry field. We just avoided its use in the executive summary which is for a larger audience.
27067	68	37	68	42	Would it be possible to make use of the recent and abrupt decrease of emissions due to the covid outbreak to underline such complexity in the interlinkage between emissions and concentrations (and effects on Air Quality)? [Eric Brun, France]	A cross chapter box discussing the implications of COVID on air pollution and climate has been added to the chapter.
28583	68	38	68	42	Li et al. 2019b attributed the increase in surface ozone to reduced heterogeneous loss of HO2 on aerosol surfaces (Taketani et al., 2013), accelearting catalytic ozone production (not to changes in the NOx lifetime). This must be correctly mentioned here for a smoother connection to the next sentence. Ref: Taketani, F., Kanaya, Y., Pochanart, P., Liu, Y., Li, J., Okuzawa, K., Kawamura, K., Wang, Z., and Akimoto, H.: Measurement of overall uptake coefficients for HO2 radicals by aerosol particles sampled from ambient air at Mts. Tai and Mang (China), Atmos. Chem. Phys., 12, 11907–11916, https://doi.org/10.5194/acp-12-11907-2012, 2012. [Hiroshi Tanimoto, Japan]	Taken into account - text revised
51281	68	44	68	44	As mandatory tends to imply a regulatory rationale whereas the rationale here is scientific, please change 'mandatory' to 'required' [Jolene Cook, United Kingdom (of Great Britain and Northern Ireland)]	Editorial, done.
20053	68	48	68	48	Figure B6.2 1 is not of much help. Furthermore, on page 168 it is listed as Figure B6.2 2. [philippe waldteufel, France]	Not Applicable,the figure has been removed
22051	69	8	69	8	But chapter 2 says nothing about the future so you must mean to refer to another chapter here. [Peter Thorne, Ireland]	Accepted - this was a typo, we have revised the text to point to section 6.2
128563	69	14	69	15	Add some caveats to this sentence to indicate that ESMs include these BGC feedbacks to varying degrees -- not all feedbacks are represented in all models, and certainly not with the same strengths. [Trigg Talley, United States of America]	Accepted - text revised
128565	69	22	70	42	Clarify: Do these % changes in emissions refer only to *anthropogenic* emissions or to total emissions? [Trigg Talley, United States of America]	Taken into account - %changes for species refer to total anth+biomass burning as shown in Figure 6.20, 6.21; but sectoral changes refer to anthropogenic emissions - text revised
22063	69	22			Reading through much of 6.6.1 I got a distinct feeling of déjà vu in that much of what I was reading had effectively been said before in earlier sections. Such overt overlap should be minimised to the extent possible. [Peter Thorne, Ireland]	Taken into account - Text has been revised also in section 6.2 and 6.5 (now 6.6) to minimize repetition
114057	69	24	71	10	I found 6.6.1.1 very useful. Some readers/reviewers may find this long, but in my view this is a description that is needed and very useful since it gives information that is often not provided when SSPs are adressed. [Jan Fuglestvedt, Norway]	Thank you

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
103571	69	24	71	10	A lot of useful information, but difficult to understand what is the key message. [Philippe Tulkens, Belgium]	Noted - improved and better designed likely future development of SLCFs under different storylines; more specific statements about likelihood and plausibility are added
22053	69	24			This section relies so heavily on figure 6.4 which in the layout version will appear many pages earlier that there is a real question whether figure 6.4 should be pulled forward to here or whether this section should be moved up to there. I don't think it really works to have quite so much of the text rely so directly upon a figure that will be displaced from the text by a considerable distance. [Peter Thorne, Ireland]	Taken into account - Figure moved to this section
128567	69	26	69	27	"SSP scenarios starting from 2015 considered a wider range of outcomes for SLCFs than did the RCP scenarios used to inform AR5." [Trigg Talley, United States of America]	Accepted - text revised
8557	69	26	71	10	A lot of useful information, but difficult to understand what is the key message. [Frank Dentener, Italy]	Noted - improved and better designed likely future development of SLCFs under different storylines; more specific statements about likelihood and plausibility are added
46047	69	27	69	29	This is discussed in a paper by Chuwah et al. It would be appropriate to include a reference to that paper here: Chuwah, C., et al., 2013: Implications of alternative assumptions regarding future air pollution control in scenarios similar to the Representative Concentration Pathways, Atmos. Environ., 79, 787-801, https://doi.org/10.1016/j.atmosenv.2013.07.008. [Twan van Noije, Netherlands]	Accepted - text revised
128569	69	29	69	30	This statement is a bit too strong. Particularly for RCP6, there are significant differences from other RCPs (e.g., in East Asia). [Trigg Talley, United States of America]	Taken into account - text revised; 'most' instead of "all"
128571	69	30	69	30	"long term" (no hyphen) [Trigg Talley, United States of America]	Accepted - text revised
72845	69	32	69	32	Quantify 'last decades' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised; 'three'
128573	69	33	69	33	"difference in" --> "difference between" [Trigg Talley, United States of America]	Accepted - text revised
46049	69	36	69	36	It would be fair to add a reference to Chuwah et al., 2013: Implications of alternative assumptions regarding future air pollution control in scenarios similar to the Representative Concentration Pathways, Atmos. Environ., 79, 787-801, https://doi.org/10.1016/j.atmosenv.2013.07.008. [Twan van Noije, Netherlands]	Accepted - text revised
128575	69	37	69	37	Remove "also". [Trigg Talley, United States of America]	Accepted - text revised
107599	69	42	69	42	I thought the very high CH4 level reached in RCP8.5 was reduced in SSPs? [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised
114055	69	42	69	42	"similar range for CH4": Similar to what? There are many cases mentioned here. [Jan Fuglestvedt, Norway]	Accepted - text revised
51283	69	46	69	46	I believe there is a typo which is confusing to the less engaged reader; please replace 'SSP3-70' with' SSP3-7.0' [Jolene Cook, United Kingdom (of Great Britain and Northern Ireland)]	Accepted - text revised
128577	69	52	69	52	"near and long term" (no hyphens) [Trigg Talley, United States of America]	Accepted - text revised
72847	69	53	69	53	Submitted reference should come last in list. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial, fixed in final draft.
82993	70	6	70	6	In the chapter, I could not find the spelled-out form of the acronym OECD. I think it would be useful to add it. [Susanna Strada, Italy]	Editorial - ACRONYMS are fixed in final draft
128579	70	12	70	13	Either give a separate % decrease for each scenario (rather than a range), or remove "respectively". [Trigg Talley, United States of America]	Accepted - text revised
128581	70	21	70	21	Add "slightly below RCP8.5" after description of CH4 increase in SSP3-7.0. [Trigg Talley, United States of America]	Accepted - text revised
128583	70	24	70	24	"high-emission" (add hyphen) [Trigg Talley, United States of America]	Editorial, treated.
128585	70	39	70	40	Which RCP/SSP combinations are considered to be consistent with Paris? [Trigg Talley, United States of America]	Taken into account - a reference to Chapter 1 is made
72849	70	41	70	41	Insert 'a' afer 'by' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial, treated.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
128587	70	46	70	46	Unclear what the 30% refers to here. Should this be changed to "..., which accounts for over 30% of the BC emissions ..."? [Trigg Talley, United States of America]	Accepted- text revised
128589	70	53	70	54	"high-emission" (add hyphen) [Trigg Talley, United States of America]	Editorial, treated.
128591	71	5	71	5	Remove "of". [Trigg Talley, United States of America]	Editorial, treated.
107601	71	5	71	5	"the" impact and delete "of" before thereof [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Editorial, treated.
128593	71	6	71	6	"longer term" (no hyphen) [Trigg Talley, United States of America]	Editorial, treated.
114059	71	13	71	33	I find section 6.6.1.2. somewhat unclear, especially the last sentence. It would be good if you could try to say more clearly how well urbanziatoin and effects of SLCF are treated in IAMs and scenarios [Jan Fuglestvedt, Norway]	Taken into account, text revised.
16615	71	36	72	43	There are a lot of studies mentioned in section 6.6.1.3, but it is not clear what the AR6 assessment is of any of these quantities. [William Collins, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account. This section has been merged with 6.7.1.1 and shortened.
8559	71	38	71	38	Maybe useful to recall the 2019/2020 levels from chapter 2 for reference. [Frank Dentener, Italy]	Not applicable. See response to #16615
103573	71	38	71	40	Maybe useful to recall the 2019/2020 levels from chapter 2 for reference. [Philippe Tulkens, Belgium]	Not applicable. See response to #16615
22059	71	38	71	50	It makes no sense to give an approximate lower bound with implied precision of 100ppb and then in the next breath give an upper bound with precision of 1ppb. Both should be equivalent precision. The characterisation is then repeated in the final sentence of the paragraph giving a totally different set of numbers. The whole paragraph is confusingly written and has too many numbers such that a reader feels proverbially machine gunned by numbers. [Peter Thorne, Ireland]	See response to #16615
128595	71	43	71	44	This ~43% decerase in CH4 mixing ratio seems inconsistent with the claimed 75% reduction in emissions (page 70, line 21). Presumably, the former reference is to *anthropogenic* emissions changes. [Trigg Talley, United States of America]	Not applicable. See response to #16615
128597	71	46	71	47	This sentence is confusing. Perhaps rewrite as: "Under SSP3-7.0, the SSP scenario with the largest increase at 2100, the methane levels are 200 ppb lower than under RCP8.5 in AR5." [Trigg Talley, United States of America]	Not applicable. See response to #16615
22061	71	52	72	17	This paragraph was very confusing. It starts out saying only SSP3-7.0 can be assessed but then goes on to give numbers for a broad range of different SSPs in addition. [Peter Thorne, Ireland]	Not applicable. See response to #16615
8561	71	52	72	17	Clarify if ozone burden refers to *tropospheric* ozone bruden. [Frank Dentener, Italy]	Accepted
103575	71	52	72	17	Clarify if all ozone burden refer to *tropospheric* ozone bruden. [Philippe Tulkens, Belgium]	Accepted
72851	72	1	72	1	Inset space between s and ([Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial. The report will undergo professional copy-editing prior to publication. This kind of issues will be fixed then.
13509	72	1	72	1	Add a space between "2030s" and pharenthesis [Maria Amparo Martinez Arroyo, Mexico]	Editorial. The report will undergo professional copy-editing prior to publication. This kind of issues will be fixed then.
114061	72	4	72	4	Suddenly a confidence statement appears, which I find surprising wince you describe what is in the SSPs, and as far as I understnad , not doing an assessment here. [Jan Fuglestvedt, Norway]	Not applicable. See response to #16615
128599	72	15	72	16	Delete either "Although" or "however" for clarity. [Trigg Talley, United States of America]	Not applicable: section re-written
128601	72	17	72	17	"global increases" --> "a global increase" [Trigg Talley, United States of America]	Not applicable: section re-written
72853	72	19	72	19	Replace 'cooler' woth 'lower' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable. See response to #16615
72855	72	22	72	22	References should be in chronologcial order [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial. The report will undergo professional copy-editing prior to publication. This kind of issues will be fixed then.
72857	72	22	72	22	Insert 'the' before 'stratospheric' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable: section re-written

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
128603	72	27	72	28	Explain that lower stratospheric temperatures increase ozone by slowing chemical catalytic loss. [Trigg Talley, United States of America]	Not applicable. See response to #16615
72859	72	28	72	28	Capital 'S' for 'stratosphere' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable: section re-written
128605	72	30	72	30	Describe the type of models used in these two studies. (Also, Fiedler et al., 2019, is not included in references.) [Trigg Talley, United States of America]	Not applicable. See response to #16615
128607	72	31	72	31	"a" --> "an" [Trigg Talley, United States of America]	Editorial – copyedit to be completed prior to publication
72861	72	31	72	31	Change 'find a' to 'found an' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial – copyedit to be completed prior to publication
128609	72	32	72	32	"high-emission" (add hyphen) [Trigg Talley, United States of America]	Editorial – copyedit to be completed prior to publication
128611	72	33	72	33	Typo in AOD range. [Trigg Talley, United States of America]	Editorial – copyedit to be completed prior to publication
45415	72	33	72	33	0.0.28 --> 0.028 [Hitoshi Matsui, Japan]	Editorial – copyedit to be completed prior to publication
106427	72	33	72	33	0.28 rather than 0.0.28 [Hamza Merabet, Algeria]	Editorial – copyedit to be completed prior to publication
46051	72	34	72	36	To some extent, this disagreement might be related to the assumption made in the simple-plume model used by Fiedler et al. that the AOD in the plumes scales as the sum of the regional SO2 plus NH3 emissions, whereas in reality the nitrate contribution is more sensitive to HNO3 than to NH3 (see p. 31, line 47). Please discuss this in the text. [Twan van Noije, Netherlands]	Not applicable. See response to #16615
16459	72	35	72	35	There should be a reference for the Fiedler et al study to make the sentence consistent with the Lund et al study which has a reference. [Moa Sporre, Sweden]	Not applicable: section re-written
128613	72	35	72	35	"a continued strong decrease" [Trigg Talley, United States of America]	Editorial – copyedit to be completed prior to publication
72863	72	35	72	35	Change 'al' to 'al.' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial – copyedit to be completed prior to publication
128615	72	38	72	43	Given the large reported ranges in CH4 lifetime change, mention explicitly that models disagree even on the sign of the change. [Trigg Talley, United States of America]	Not applicable. See response to #16615
128617	72	39	72	39	"OH concentrations" (remove hyphen) [Trigg Talley, United States of America]	Editorial – copyedit to be completed prior to publication
128619	72	46	72	46	"land use" (no hyphen) [Trigg Talley, United States of America]	Editorial, treated.
114063	72	48	72	48	The SSPs as such do not contain climate policies. Please add more nuances and explanatoin here [Jan Fuglestvedt, Norway]	Clarified.
128621	72	53	72	55	Cite reference for emission-driven changes in surface ozone being large relative to climate-driven changes. [Trigg Talley, United States of America]	Not applicable, the sentence no longer exists.
128623	73	10	73	20	The figure caption references solid lines and shading around the line, but the figure only has solid lines (and one dashed line), no shading. [Trigg Talley, United States of America]	Accepted, figure modified.
114065	73	25	73	26	Some background for how you arrive at the various confidence levels here would be useful. [Jan Fuglestvedt, Norway]	Accepted- text revised
128625	73	25	73	27	Indicate years over which these increases occur. [Trigg Talley, United States of America]	Accepted- text revised
128627	73	28	73	29	Clarify how much of this increase is due to climate change versus CH4 increase (or at least mention the potential role of both factors). [Trigg Talley, United States of America]	Accepted- text revised
128629	73	34	73	36	For context, compare the ozone change in ssp370-lowNTCF with that in the base ssp370 scenario. [Trigg Talley, United States of America]	Accepted- text revised
128631	73	41	73	56	Same comment as for Figure 6.17: The caption references shading that is not shown in the figure. [Trigg Talley, United States of America]	Accepted, figure modified.
128633	73	45	73	45	Is ammonium mass included in the calculation of PM2.5 here? (Or is just the sulfate mass in, e.g., ammonium sulfate aerosols counted?) [Trigg Talley, United States of America]	Formulae used to compute PM2.5 is indicated in the caption.
116559	73		73		Some parts of section 6.6.2 are very descriptive, could they be placed in a table, with regional information linked to various SSPs (see previous comment on that)? [Valerie Masson-Delmotte, France]	Rejected, as explained in 6.1, we can only explore global air quality with the tools used here. There was no study on SSPs with regional models at the time of FGD writing.
87423	74	3	74	5	In the high emission scenario SSP5-8.5 there is a decrease in PM2.5 in Asia (I don't see that 'generally'). [Jürg Thudium, Switzerland]	Accepted- text revised
128635	74	4	74	4	"high-emission" (add hyphen) [Trigg Talley, United States of America]	Editorial – done
128637	74	8	74	8	"are" --> "is" [Trigg Talley, United States of America]	Editorial – done

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
128639	74	9	74	10	Are the feedbacks from climate change on natural emissions of aerosols and aerosol precursors quantified somewhere in the report (from AerChemMIP)? If so, a cross-reference would be useful here. [Trigg Talley, United States of America]	Taken into account. This is quantified (in terms of a feedback parameter) in section 6.3.6. A cross-ref is added.
114067	74	14	74	20	The para is a kind of summary, but it refers to two studies. It would be better if the section ends with the authors' own assessment of the potential and possibilties for reducing atmospheric abundances and improving AQ [Jan Fuglestvedt, Norway]	Accepted- text revised
107613	74	23	74	23	This section relies almost entirely on CMIP6 but there is other new literature assessing future radiative forcing due to ozone and attributing to specific drivers (ODSs, precursor emissions). This is relevant to the section: https://www.atmos-chem-phys.net/18/2899/2018/ https://www.atmos-chem-phys.net/18/6121/2018/ [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Rejected - outside the scope of the section. Section 6.6 is about the climate response to emissions as described in the SSP scenarios. The suggested references use the older RCP scenarios.
107607	74	25	74	25	ensure consistency with section 4.4.4 [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	accepted, done
15017	74	25	74	25	Example of a 'bad' heading, because it uses undefined acronyms. Acronyms not incorporated in the heading should be defined in each section where they are used, and their over-enthusiastic use should be minimised in the interest of readability. [Fredric Taylor, United Kingdom (of Great Britain and Northern Ireland)]	Rejected. SLCF and GSAT are defined at there first use (in the Executive summary).
27069	74	25	74	25	Would it be possible to analyse the pace of change due to SLCF change at a continental scale? [Eric Brun, France]	We agree that this is both scientifically interesting and could be of use for policymakers. A new section "Effects of SLCFs on regional ERF" has been added (new section 6.6.3.1). Regarding the CMIP6 simulations with the ESMs (using the SSP scenarios) there is only one experiment (multi-model) that can be used to quantify specifically the effect of the SLCFs on regional scale. That is the difference between the SSP3-7.0 and the SSP3-7.0lowNTCF scenarios (Allen et al., 2020). Allen et al. show that that warming rates are twice as high as the global mean on regional continental scale. This has been included in the text.
29601	74	27	74	39	The methodology and numerical assumptions used for Figure 6.19 should be further documented in a supplementary section so this work can be replicated. The simplifying assumptions should be discussed there as well. (For example, the use of a single IRF for all species.) [Steven Smith, United States of America]	Taken into account. Each figure is documented in detail in supplementary material.
114069	74	31	74	31	You may refer to the Box in ch7 on emulators [Jan Fuglestvedt, Norway]	Taken into account. A cross-reference has been added.
128641	74	33	74	33	"AerChemMip" --> "AerChemMIP" [Trigg Talley, United States of America]	Editorial , treated.
72865	74	33	74	33	replace '2017') with '2017;' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial , treated.
46053	74	33	74	33	Change "AerChemMip" to "AerChemMIP". [Twan van Noije, Netherlands]	Editorial , treated.
114071	74	36	74	36	I suggest changing "ERF" to "ERFs for the various components" [Jan Fuglestvedt, Norway]	Accepted - text revised
114073	74	36	74	39	It would be good if this is also consitent with what is used on Ch7 and Ch4 for scenarios [Jan Fuglestvedt, Norway]	Accepted, consistency checked.
107603	74	38	74	39	IRF is used for instantaneous radiative forcing (inc. in the caption for Fig. 6.19) and the description is confusing. Do you mean a two layer energy balance model is used with specified values of ECS and ocean heat uptake? Please make this clear and cross-reference to the X-chapter box on emulators. [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Accepted, clarified in Supplementary Material and in in the cross chapter box on emulators.
107619	74	38	74	39	there should be some more technical information (perhaps in an annex) about the energy balance modeling done in this section as the results are discussed quite extensively but it is not clear how they are derived. These are new results (rather than documenting existing literature) so must be carefully documented here [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Accepted, clarified in Supplementary Material and in in the cross chapter box on emulators.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
128643	74	45	74	52	What about differences in efficacies of various forcing agents? (Currently only discussed in section 6.3.7.) [Trigg Talley, United States of America]	Noted. Efficacy is the difference between climate response (GSAT) to equal global forcings by different forcing agents. This can be substantial when standard adjusted radiative forcing is used. However, most of the differences in efficacy is due to fast feedbacks included when Effective Radiative Forcings are used as in Figure 6.19.
128645	74	45	74	52	There are also uncertainties because of the poorly known state of the preindustrial or other errors in the emission assumed: Include these uncertainties in this list. [Trigg Talley, United States of America]	Rejected. This discussion relates to figure 6.19 that shows only the future GSAT change (relative to 2021) for given SSP scenarios. Thus the state of the pre-industrial emissions and the uncertainty in future emissions are irrelevant here.
114075	74	45	74	52	Useful explanation, but if you write explictely what the purpose of fig 6.19 is, then it will be come more clear why you keep ECS out of these calculations. Readers may find it strange that you leave out ECS uncertainty so this needs to be explainded and motivated clealy [Jan Fuglestvedt, Norway]	Not applicable, Sentence deleted
29603	74	48	74	51	These additional uncertainties cannot be dismissed so easily. It is only in the simplified approach used here that these additional physical uncertainties would not impact the differences between scenarios. In reality, for example, SLCFs have widely different forcings over land vs ocean (and N vs S hemisphere), which means that their IRF and response timescales will differ. Also, non-linearities are present (as discussed in sections above, e.g. concentration -> forcing nonlinearies that depend on background concentrations that change between these scenarios) that will also impact the differences between scenarios. The calculation is fine as an illustrative calculation, but it is important that the limitations be clearly referenced and the results presented with appropriate caveats. Because of these un-modeled issues, the probability statements in this section should be adjusted downward, as these findings are likely not nearly as definitive as indicated. [Steven Smith, United States of America]	Limitations clarified. Simplified method also explained in cross chapter box in chapter 7
114093	75	2	75	18	This is a very useful figure. It nicely illustrates the contributions to CC from the individual componets and the various spreads across scenario as well as the spread due to ERF ranges. I guess you have already considered using same scales on 2nd axis. That would put the contributions more clealy in perspective, but woudl also make the graphs harder to read for O3 and BC [Jan Fuglestvedt, Norway]	Taken into account. Contributions are easier to compare in Figure 6.24.
16617	75	4	75	17	Figure 6.19: It would be useful to include the ssp370_lowCH4 scenario in this figure as well. I suggest using the same scale for all the SLCFs to make it easier to compare their magnitudes. This would make it clearer that BC on snow is small. [William Collins, United Kingdom (of Great Britain and Northern Ireland)]	Accepted, figure modified.
128647	75	9	75	9	"response" --> "responses"? [Trigg Talley, United States of America]	Editorial , treated.
114095	75	15	75	16	The last sentence in fig caption: You may make it more clear to what extent this is taken into account [Jan Fuglestvedt, Norway]	Accepted. The figure caption has been modified to underline this without making it too technical.
107615	75	21	75	21	it would be more consistent with other parts of the assessment (e.g. projections in chapter 4) to use a present day 1995-2014 reference period [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Rejected. The SLCFs have changed significantly since 1995, so that that a "present-day" period starting in 1995 would be misleading in this context. In particular since there is a notion of a climate penalty related to cuts in emissions of cooling aerosols and their precursors. We made it clearer in the text that we are indeed using a different present-day definition here than in ch. 4.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
66777	75	21	75	27	This section—and much of this chapter as a whole—could include more detailed breakdown of the SLCFs represented in Figure 6.19 to emphasize the impact of avoided warming for the short-lived climate pollutants (SLCPs). There should be a distinction between the short-lived forcers that lead to warming and those that lead to cooling, as well as their relative contributions to short-lived forcing changes that have already happened and are projected to happen. [Kristin Campbell, United States of America]	Rejected. We agree that more detailed speciation could be useful to policymakers. However, this depends on the emulators ability to handle individual emissions. Adding quite a few extra lines in the figure (additional SSPs and more detailed speciation) would have reduced the readability of the figure. However, considering the current effect of individual compound (Figure 6.12) and changes in emissions (Figure 6.21), the dominant effect of changes in SO2 emissions and associated cooling aerosols is clear.
68327	75	21	75	27	This section could include more detailed breakdown of the SLCFs represented in Figure 6.19 to emphasize the impact of avoided warming for the short-lived climate pollutants (SLCPs). Providing only a lump sum of the SLCFs takes away from the individual contributions of each to warming. The current draft does specify the contributions of O3, CH4, and HFCs will have in the near future (until 2040), but the quantification of each of those is not provided and would be helpful for policymakers looking to make policies for mitigation in sector-specific emissions. Similarly, aerosols are lumped together, and this is another instance where distinction would be useful between the cooling versus warming aerosols (sulfates versus black carbon, for example). [Durwood Zaelke, United States of America]	Rejected. We agree that more detailed speciation could be useful to policymakers. However, this depends on the emulators ability to handle individual emissions. Adding quite a few extra lines in the figure (additional SSPs and more detailed speciation) would have reduced the readability of the figure. However, considering the current effect of individual compound (Figure 6.12) and changes in emissions (Figure 6.21), the dominant effect of changes in SO2 emissions and associated cooling aerosols is clear.
69881	75	21	75	27	Provide more detail on the specific SLCF emissions. How do these compare with the scenarios and key conclusions in IPCC SR 1.5 regarding need for deep cuts to methane and black carbon emissions? [Gabrielle Dreyfus, United States of America]	Taken into account, text revised.
107605	75	21	75	42	There is a Nature Communications paper in press (Samset et al., 2020) which is relevant to this section on SLCF mitigation. It talks about the magnitude of the SLCF signal compared to internal climate variability. It is cited in Chapter 4. [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable, this section is now focussed on the response to change in forcing agent as assessed by a common methodology to be comparable between regions.
114077	75	23	75	23	Not sure if "emphasize" is the right word here. "Take into account" …? [Jan Fuglestvedt, Norway]	Not applicable, Sentence deleted
128649	75	25	75	25	A "positive contribution" sounds like a good thing. Please re-word using clearer language. [Trigg Talley, United States of America]	Accepted. Sentence has been modified.
114079	75	26	75	26	The increase in range from 0.05-0.25 to 0-0.3 may seem small, and may need a brief explanation. [Jan Fuglestvedt, Norway]	Accepted. Clarified
13511	75	27	75	27	Erase pharenthesis in "0-0.3°C" [Maria Amparo Martinez Arroyo, Mexico]	Not applicable, the sentence no longer exists.
20055	75	29	75	29	"of" missing after "impact" [philippe waldteufel, France]	Not applicable, the sentence no longer exists.
114081	75	29	75	29	Would be useful if it could be more clear what this confidence statement is based on. [Jan Fuglestvedt, Norway]	Accepted. Clarified
72867	75	29	75	29	Insert 'of' after 'impact' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable, the sentence no longer exists.
128651	75	40	75	42	Run-on sentence. [Trigg Talley, United States of America]	Not applicable, the sentence no longer exists.
114083	75	44	75	44	Would be useful if it could be more clear what this confidence statement is based on. [Jan Fuglestvedt, Norway]	Accepted. Clarified
128653	75	44	75	45	A (forced) warming of up to 0.2°C over 6 years (2015 to 2021) from SLCFs seems implausible. Is some of this increase a result of an artifact in the CMIP6 emissions under which emissions in China remain too high during the late years of the historical period, and then decrease very rapidly in the first years of the SSPs? [Trigg Talley, United States of America]	Not applicable, Sentence deleted
72869	75	47	75	47	Change reference to 'Shindell and Smith (2019) [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial , treated.
128655	76	4	76	4	Add comma after "remains high". [Trigg Talley, United States of America]	Not applicable, the sentence no longer exists.
128657	76	10	76	12	In Figure 6.19, bottom panel, ssp370-LowNTCF shows an ~0.6°C warming in 2055 relative to 2015. Where does the 0.23°C come from? [Trigg Talley, United States of America]	This value comes from Allen's paper, clarified.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
114085	76	11	76	11	It is uncelar where this confidence statement is coming from.May sound as if Allen et al 2020 find this. [Jan Fuglestvedt, Norway]	uncertainties around numbers from Allen have been clarified.
107611	76	11	76	14	cross-check with section 4.4.4 which includes a figure on the AerChemMIP simulations discussed here [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	accepted, done
128659	76	12	76	13	Why give the increase in 2055 relative to 2015 here? The more relevant quantity (as motivated by the first half of this sentence) is the increase in 2055 relative to the base SSP3-7.0 simulation. (Same point regarding precipitation.) [Trigg Talley, United States of America]	The values reported come from Allen's paper in which they are expressed relative to 2015.
114087	76	16	76	16	Regarding "…policy (as embedded in SSPs) " coudl need some more nuances. Climate policies are not included in the unconstrained SSPs. Do you mean AQ policies? [Jan Fuglestvedt, Norway]	Accepted - text revised
114089	76	16	76	16	"low confidence" should be in italics [Jan Fuglestvedt, Norway]	Editorial , treated.
107609	76	16	76	21	there should be some discussion in this section about the magnitude of the SLCF forced signal compared to internal variability. The energy balance model in Fig 6.19 does not include internal variability which may mask these signals over decadal timescales [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	As the reviewer notes, the energy balance model does not include internal variability, therefore by construction emulators provide forced response in GSAT change and thus correspond to climatological mean of the change.
66779	76	16	76	21	Speed is the metric of concern because of our proximity to 1.5C and drastic mitigation efforts needed to meet that goal. As a result, policymakers that will rely on the IPCC's scientific expertise would greatly benefit from the access and analysis of climate metrics that consider the shorter timescales like GWP20, which was used in past assessments and throughout policy work. SLCFs are featured in Chapter 6 of this report, but their impact on the climate—especially in the crucial near-term—should not be relegated to only that chapter but instead considered as part of the whole, most importantly short-lived climate pollutants (black carbon, methane, tropospheric ozone, and HFCs). [Kristin Campbell, United States of America]	Rejected, metrics such as GWP are discussed in chapter 7
66781	76	16	76	21	GWP* being used throughout the AR6 Report can be a useful metric, but does not completely negate the need and utility of a metric for a shorter timescales like GWP20. In the IPCC 1.5C Report, GWP* is noted for its ability to describe the impacts from SLCFs, even providing a Figure in Cross-Chapter Box 2 that shows the differences between GWP100, GTP100, and GWP*. This does not help for shorter timescale concerns. In the First Order Draft for WGIII for AR6, GWP* is explained in Chapter 2 as allowing the comparison of a sustained change in emissions for non-CO2 forcers in comparison with CO2, but the chapter also notes that there are limitations to using GWP* for policy applications, including those relevant for the Paris Agreement (see WGIII FOD 2-23–2-24). Further, Chapter 2 does suggest that GWP20 may be useful alongside metrics like GWP100 and GTP100 to compare changes in emissions (WGIII FOD 2-22). In Chapter 6 of WGIII FOD, the authors note that a chosen climate metric and the time horizon for which it covers affect assessing the timing of achieving climate targets like net-zero emissions (WGIII FOD 6-100). In discussing the balance of CO2 and non-CO2 emissions from aviation, Chapter 10 of WGIII's FOD suggests that time horizon is a subjective choice of the whomever is using the information, and that if longer time horizons are chosen, CO2 becomes more important (WGIII FOD 10-51: "Any GWP/GTP type emissions equivalency calculation always involves the user selection of a time horizon, over which the calculation is made, which is a subjective choice (Fuglestvedt et al., 2010). In general, the longer the time horizon, the more important CO2 becomes in comparison with a SCLF [sic]."). [Kristin Campbell, United States of America]	Rejected, metrics such as GWP are discussed in chapter 7
68329	76	16	76	21	Providing only a lump sum of the SLCFs takes away from the individual contributions of each to warming. The current draft does specify the contributions of O3, CH4, and HFCs will have in the near future (until 2040), but the quantification of each of those is not provided and would be helpful for policymakers looking to make policies for mitigation in sector-specific emissions. Similarly, aerosols are lumped together, and this is another instance where distinction would be useful between the cooling versus warming aerosols (sulfates versus black carbon, for example). [Durwood Zaelke, United States of America]	Quantification of each (O3,CH4, HFC) is given separately in the figures 6.22 and 6.24. The respective influence of the various type of aerosols is given Figure 6.12 for past emission and concentration changes, showing the predominant role of sulfates.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
68331	76	16	76	21	Speed is the metric of concern because of our proximity to 1.5C and aggressive mitigation efforts needed to meet that goal. As a result, policymakers that will rely on the IPCC's scientific expertise would greatly benefit from the access and analysis of climate metrics that consider the shorter timescales like GWP20, which was used in past assessments and throughout policy work. SLCFs are featured in Chapter 6 of this report, but their impact on the climate—especially in the crucial near-term—should not be relegated to only that chapter but instead considered as part of the whole, most importantly short-lived climate pollutants (black carbon, methane, tropospheric ozone, and HFCs). Aggressive mitigation of SLCPs can cut the rate of warming in half, Arctic warming by two-thirds, and avoid up to 0.6C of warming by 2050. UNEP & WMO (2011) Integrated Assessment of Black Carbon and Tropospheric Ozone; Shindell D., et al. (2012) Simultaneously Mitigating Near-Term Climate Change and Improving Human Health and Food Security, Science 335(6065):183–189; Xu and Ramanathan (2017) Well below 2 °C: Mitigation strategies for avoiding dangerous to catastrophic climate changes, Proc. Natl. Acad. Sci. 114(39):10315–10323. [Durwood Zaelke, United States of America]	Rejected, metrics such as GWP are discussed in chapter 7
16619	76	16	76	21	This is interesting. I hadn't realised how closely the warming and cooling agents compensate in all the scenarios. [William Collins, United Kingdom (of Great Britain and Northern Ireland)]	Thanks.
68333	76	16	76	21	GWP* being used throughout the AR6 Report can be a useful metric, but does not completely negate the need and utility of a metric for a shorter timescale like GWP20. In the IPCC 1.5C Report, GWP* is noted for its ability to describe the impacts from SLCFs, even providing a Figure in Cross-Chapter Box 2 that shows the differences between GWP100, GTP100, and GWP*. This does not help for shorter timescale concerns. In the First Order Draft for WGIII for AR6, GWP* is explained in Chapter 2 as allowing the comparison of a sustained change in emissions for non-CO2 forcers in comparison with CO2, but the chapter also notes that there are limitations to using GWP* for policy applications, including those relevant for the Paris Agreement (see WGIII FOD 2-23–2-24). Further, Chapter 2 does suggest that GWP20 may be useful alongside metrics like GWP100 and GTP100 to compare changes in emissions (WGIII FOD 2-22). In Chapter 6 of WGIII FOD, the authors note that a chosen climate metric and the time horizon for which it covers affect assessing the timing of achieving climate targets like net-zero emissions (WGIII FOD 6-100). In discussing the balance of CO2 and non-CO2 emissions from aviation, Chapter 10 of WGIII's FOD suggests that time horizon is a subjective choice of the whomever is using the information, and that if longer time horizons are chosen, CO2 becomes more important (WGIII FOD 10-51: "Any GWP/GTP type emissions equivalency calculation always involves the user selection of a time horizon, over which the calculation is made, which is a subjective choice (Fuglestvedt et al., 2010). In general, the longer the time horizon, the more important CO2 becomes in comparison with a SCLF [sic]."). [Durwood Zaelke, United States of America]	Rejected, metrics such as GWP are discussed in chapter 7
68335	76	16	76	21	For policymakers, changes in the near-term and creating policies that are in line with the lower emissions scenarios would benefit from the ability to emphasize the amount of avoided warming from the SLCPs and the near-immediate impact that they can have, which is aided by having the appropriate metric in GWP20. See Climate and Clean Air Coalition (CCAC) , Mexico , Molina Center for Energy and the Environment (MCE2), & United Nations Environment Programme (UNEP) (2018) Progress and Opportunities for Reducing SLCPs across Latin America and the Caribbean; UNEP & Climate and Clean Air Coalition (2018) Integrated Assessment of Short-lived Climate Pollutants in Latin America and the Caribbean: Improving air quality while contributing to climate change mitigation; Climate and Clean Air Coalition & UNEP (2019) Air Pollution in Asia and the Pacific: Science-based solutions; European Environment Agency (2018) Air quality in Europe — 2018 report, EEA Report No 12/2018. [Durwood Zaelke, United States of America]	Rejected, choice and discussion of metrics is done in chapter 7.
128661	76	17	76	18	"net impact of *changes in* SLCFs on GSAT"? [Trigg Talley, United States of America]	Accepted - text revised

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
128663	76	20	76	20	"net warming of the SLCFs" --> "net warming induced by changes in SLCF emissions"? Not sure what this sentence means. The SSP3-7.0lowNTCF results cited above (lines 2-14) show that the change in NTCFs from high-emission scenario (SSP3-7.0) to a mitigation scenario (SSP1-1.9) results in a net *warming*. So, what is meant here by the statement than the "net warming [by] NTCFs will be *lower* in the mitigation scenarios than in the high emission scenarios"? [Trigg Talley, United States of America]	accepted, clarified by specifying 'scenario considering strong climate mitigation'.
114091	76	20	76	20	"high confidence" should be in italics [Jan Fuglestvedt, Norway]	Editorial , treated.
128665	76	21	76	21	"high-emission" (add hyphen) [Trigg Talley, United States of America]	Editorial , treated.
128667	76	30	76	31	Rephrase: "While the reduced complexity models in RCMIP either do not take the regional perspective into account, or do so only to a very limited extent, the set of..." [Trigg Talley, United States of America]	Accepted - text revised
66783	76	41	76	54	For policymakers, these changes in the near-term and creating policies that are in line with the lower emissions scenarios would benefit from the ability to emphasize the amount of avoided warming from the SLCPs and the near-immediate impact that they can have. Speed is the metric of concern because of our proximity to 1.5C and drastic mitigation efforts needed to meet that goal. As a result, policymakers that will rely on the IPCC's scientific expertise would greatly benefit from the access and analysis of climate metrics that consider the shorter timescales like GWP20, which was used in past assessments and throughout policy work. SLCFs are featured in Chapter 6 of this report, but their impact on the climate—especially in the crucial near-term—should not be relegated to only that chapter but instead considered as part of the whole, most importantly short-lived climate pollutants (black carbon, methane, tropospheric ozone, and HFCs). [Kristin Campbell, United States of America]	Rejected, metrics such as GWP are discussed in chapter 7
66785	76	41	76	54	GWP* being used throughout the AR6 Report can be a useful metric, but does not completely negate the need and utility of a metric for a shorter timescales like GWP20. In the IPCC 1.5C Report, GWP* is noted for its ability to describe the impacts from SLCFs, even providing a Figure in Cross-Chapter Box 2 that shows the differences between GWP100, GTP100, and GWP*. This does not help for shorter timescale concerns. In the First Order Draft for WGIII for AR6, GWP* is explained in Chapter 2 as allowing the comparison of a sustained change in emissions for non-CO2 forcers in comparison with CO2, but the chapter also notes that there are limitations to using GWP* for policy applications, including those relevant for the Paris Agreement (see WGIII FOD 2-23–2-24). Further, Chapter 2 does suggest that GWP20 may be useful alongside metrics like GWP100 and GTP100 to compare changes in emissions (WGIII FOD 2-22). In Chapter 6 of WGIII FOD, the authors note that a chosen climate metric and the time horizon for which it covers affect assessing the timing of achieving climate targets like net-zero emissions (WGIII FOD 6-100). In discussing the balance of CO2 and non-CO2 emissions from aviation, Chapter 10 of WGIII's FOD suggests that time horizon is a subjective choice of the whomever is using the information, and that if longer time horizons are chosen, CO2 becomes more important (WGIII FOD 10-51: "Any GWP/GTP type emissions equivalency calculation always involves the user selection of a time horizon, over which the calculation is made, which is a subjective choice (Fuglestvedt et al., 2010). In general, the longer the time horizon, the more important CO2 becomes in comparison with a SCLF [sic]."). [Kristin Campbell, United States of America]	Rejected, metrics such as GWP are discussed in chapter 7

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
68337	76	41	76	54	For policymakers, these changes in the near-term and creating policies that are in line with the lower emissions scenarios would benefit from the ability to emphasize the amount of avoided warming from the SLCPs and the near-immediate impact that they can have. See Climate and Clean Air Coalition (CCAC) , Mexico , Molina Center for Energy and the Environment (MCE2), & United Nations Environment Programme (UNEP) (2018) Progress and Opportunities for Reducing SLCPs across Latin America and the Caribbean; UNEP & Climate and Clean Air Coalition (2018) Integrated Assessment of Short-lived Climate Pollutants in Latin America and the Caribbean: Improving air quality while contributing to climate change mitigation; Climate and Clean Air Coalition & UNEP (2019) Air Pollution in Asia and the Pacific: Science-based solutions; European Environment Agency (2018) Air quality in Europe — 2018 report, EEA Report No 12/2018. Speed is the metric of concern because of our proximity to 1.5C and aggressive mitigation efforts needed to meet that goal. As a result, policymakers that will rely on the IPCC's scientific expertise would greatly benefit from the access and analysis of climate metrics that consider the shorter timescales like GWP20, which was used in past assessments and throughout policy work. SLCFs are featured in Chapter 6 of this report, but their impact on the climate—especially in the crucial near-term—should not be relegated to only that chapter but instead considered as part of the whole, most importantly short-lived climate pollutants (black carbon, methane, tropospheric ozone, and HFCs). Aggressive mitigation of SLCPs can cut the rate of warming in half, Arctic warming by two-thirds, and avoid up to 0.6C of warming by 2050. UNEP & WMO (2011) Integrated Assessment of Black Carbon and Tropospheric Ozone; Shindell D., et al. (2012) Simultaneously Mitigating Near-Term Climate Change and Improving Human Health and Food Security, Science 335(6065):183–189; Xu and Ramanathan (2017) Well below 2 °C: Mitigation strategies for avoiding dangerous to catastrophic climate changes, Proc. Natl. Acad. Sci. 114(39):10315–10323. [Durwood Zaelke, United States of America]	Rejected, metrics such as GWP are discussed in chapter 7
68339	76	41	76	54	GWP* being used throughout the AR6 Report can be a useful metric, but does not completely negate the need and utility of a metric for a shorter timescale like GWP20. In the IPCC 1.5C Report, GWP* is noted for its ability to describe the impacts from SLCFs, even providing a Figure in Cross-Chapter Box 2 that shows the differences between GWP100, GTP100, and GWP*. This does not help for shorter timescale concerns. In the First Order Draft for WGIII for AR6, GWP* is explained in Chapter 2 as allowing the comparison of a sustained change in emissions for non-CO2 forcers in comparison with CO2, but the chapter also notes that there are limitations to using GWP* for policy applications, including those relevant for the Paris Agreement (see WGIII FOD 2-23–2-24). Further, Chapter 2 does suggest that GWP20 may be useful alongside metrics like GWP100 and GTP100 to compare changes in emissions (WGIII FOD 2-22). In Chapter 6 of WGIII FOD, the authors note that a chosen climate metric and the time horizon for which it covers affect assessing the timing of achieving climate targets like net-zero emissions (WGIII FOD 6-100). In discussing the balance of CO2 and non-CO2 emissions from aviation, Chapter 10 of WGIII's FOD suggests that time horizon is a subjective choice of the whomever is using the information, and that if longer time horizons are chosen, CO2 becomes more important (WGIII FOD 10-51: "Any GWP/GTP type emissions equivalency calculation always involves the user selection of a time horizon, over which the calculation is made, which is a subjective choice (Fuglestvedt et al., 2010). In general, the longer the time horizon, the more important CO2 becomes in comparison with a SCLF [sic]."). [Durwood Zaelke, United States of America]	Rejected, metrics such as GWP are discussed in chapter 7
128669	76	42	76	42	Typo: dominated by emissions. [Trigg Talley, United States of America]	Editorial , treated.
128671	76	43	76	43	"net effect of *the changes (from 2020?) in* SLCFs" [Trigg Talley, United States of America]	Accepted - text revised
72871	76	45	76	45	Remove underbar from 'Figure 6.4) [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial , treated.
128673	76	47	76	47	"net effect of *the changes (from 2020?) in* SLCFs" [Trigg Talley, United States of America]	Accepted - text revised
128675	76	48	76	49	Clarify that this sentence still refers to SSP3-7.0. [Trigg Talley, United States of America]	Rejected, the scenario are clearly discussed one after the other.
35781	76	49	76	49	° C repeats [Carlos Antonio Poot Delgado, Mexico]	Editorial , treated.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
128677	76	51	76	51	"Europa" --> "Europe" [Trigg Talley, United States of America]	Editorial , treated.
106429	76	51	76	51	Europe raher than Europa [Hamza Merabet, Algeria]	Editorial , treated.
128679	76	53	76	53	"in 2100" --> "in 2100, versus 2020" [Trigg Talley, United States of America]	The reference year is indicated once for all in the paragraph before but not repeated to lighten the text.
128681	77	4	77	12	It would be very helpful to include the region numbers in the figure caption so it's easier for the reader to reference back and forth. [Trigg Talley, United States of America]	Accepted, Regions are now indicated n the figure.
128683	77	17	77	18	Unclear. Maybe change "varies between region in the different SSPs" --> "varies by region and by SSP" to clarify. [Trigg Talley, United States of America]	Not applicable, Sentence deleted
128685	77	18	77	18	"has" --> "have" [Trigg Talley, United States of America]	Not applicable, the sentence no longer exists.
32961	77	25	77	27	I find the term 'Compensating' here confusing. What is compensating for what? I think of 'compensate' as doing something to 'make up for' some other lack, but I don't really see how that fits here. There can be offsetting effects, but even that is not clear as they can be either additive or offsetting depending on which SLCFs were cut alongside CO2. Perhaps better to stick with 'inkagaes' as the term since both types of emissions affect climate and I think that's your main point. [Drew Shindell, United States of America]	Agreed, we removed the term compensating.
86789	77	25	79	31	It might be more useful if this section presented the linkages between long-lived and short-lived climate forcers in such a way that did not bias or presuppose the policy objectives of the climate mitigation community. Some countries come from the air pollution side of mitigation, and might see mitigation of CO2 as a co-benefit of their air quality policy. In other words it would benefit the chapter if win-win solutions for climate, health and environment was better articulated as well as drawbacks. [Oyvind Christophersen, Norway]	Noted, the full 6.6 section is now clearly focussed on SSP scenario and we use the SSP terminology regarding the policy purpose of the various level of mitigation applied in the scenario which is described in Rao et al. 2017. The layers of mitigation levels have been made clearer in the 6.6 1 section.
76835	77	25	79	31	This section - Compensating effects and linkages in SLCFs under different mitigation scenarios – appears to be predicated on an assumption that mitigating SLCF emissions is additional or a co-benefit of CO2 mitigation and (by implication) can never be the primary objective of a mitigation action or that reducing CO2 emission might instead be a co-benefit of SLCF action. If (as is stated in Rogelj 2014b) 'a large fraction of the warming SLCFs are co-emitted with CO2,' then by the same logic 'a large fraction of CO2 is co-emitted with warming SLCFs.' It might be more useful if this section presented the overwhelming linkages between long-lived and short-lived climate forcers in such a way that did not bias or presuppose the policy objectives of the climate mitigation community. [Nathan Borgford-Parnell, Switzerland]	Noted, the full 6.6 section is now clearly focussed on SSP scenario and we use the SSP terminology regarding the policy purpose of the various level of mitigation applied in the scenario which is described in Rao et al. 2017. The layers of mitigation levels have been made clearer in the 6.6 1 section. This question (how much CO2 is reduced with SLCF targeted policies) can not be addressed with the methodology used to build the SSP, it has been made clear in the FGD.
67949	77	25	79	31	Section 6.6.4 is an important sub-section addressing future climate response under various mitigation scenarios. Given that "a large fraction of the warming SLCFs are co-emitted with CO2" (L38-39, Page 6-77) and vice versa, it is important to emphasize that "SLCF mitigation measures are to be considered complementary rather than a substitute for early and stringent CO2 mitigation measures" (L53-54 on page 6-78) and that both should be implemented simultaneously, i.e., integrated climate and air quality policies linking SLCFs and CO2 mitigation measures. I would suggest reorganizing this sub-section, highlighting the key points, and making the sentences flow better and easier to follow. Also, while it is common practice in modeling studies to include "idealized simulations" (L33-35, page 6-77), it is questionable to include in this sub-section. As stated in L51-56, page 6-77, many idealized studies, including ceasing anthropogenic emissions abruptly, are "not a plausible scenario." Perhaps it would be better to provide more realistic case studies. [Luisa Molina, United States of America]	Noted, the section has been rewritten to focus on SSPs, discussion of idealized simulations have been removed .
22065	77	25			Again, in this section I get a feeling of déjà vu. So many of the points herein (almost all) have already been made at least once before if not several times in some cases within the chapter. Is this section required? And if retained can it be better differentiated from the several other chapter sections which currently obviously are overlapping with it? [Peter Thorne, Ireland]	Accepted, the section has been rewritten to focus on SSPs and the redundancies have been removed in the FGD.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
5239	77	25			section 6.6.4 This would be a good place to mention that various strategies to reduce BC have different impacts. Reducing diesel BC tends to reduce net positive radiative forcing. However, reducing biofuel BC can be neutral or even increase net radiative forcing because of the simultaneous reduction of scattering aerosol. However, the health benefits of reducing biofuel emissions are often compelling. I see that FAQ 6.2 goes part way to answering this, but a paragraph in the text would be helpful. [Daniel Murphy, United States of America]	Noted. The co-benefit// antagonism for specific measures or specific SLCF are too specific and is only discussed in the FAQ6.2. We only assess the role of sectoral emissions in the chapter (6.5).
98443	77	27	77	30	The section 6.6.4 states that the compensating effects of air quality policies that mitigate warming and cooling SLCFs and the linkages in the emissions among the different SLCFs and LLGHGs in climate mitigation policies induce a degree of complexity for mitigating SLCFs. These compensating effects become important when considering two related but somewhat different issues. It seems this is mainly based on an assumption that mitigating SLCF emissions is additional or a co-benefit of CO2 mitigation that can never be the primary objective of a mitigation action or that reducing CO2 emission might instead be a co-benefit of SLCF action. If a large fraction of the warming SLCFs are co- emitted with CO2, then by the same logic 'a large fraction of CO2 is co-emitted with warming SLCFs. There are a variety of factors that have gone into creating the current misconceptions. These include restriction of the analysis to an overly short time frame, failure to consider strategies involving delayed SLCF abatement, unrealistic assumptions about the amount of SLCF abatement that can be obtained without displacing CO2 abatement, and insufficient consideration of the amount of SLCF abatement one gets as an automatic co-benefit of CO2 abatement. Overall, it would be more useful if this section presented the overwhelming linkages between long-lived and short-lived climate forcers in such a way that did not bias or presuppose the policy objectives of the climate mitigation community. [nehzat Motallebi, United States of America]	Noted, the full 6.6 section is now clearly focussed on SSP scenario and we use the SSP terminology regarding the policy purpose of the various level of mitigation applied in the scenario which is described in Rao et al. 2017. The layers of mitigation levels have been made clearer in the 6.6 1 section. This question (how much CO2 is reduced with SLCF targeted policies) can not be addressed with the methodology used to build the SSP, it has been made clear in the FGD.
32963	77	27	77	39	There is another question, which is how much CO2 could be reduced by measures focused on either SLCFs or air quality? The first question here implies air quality improvement efforts will always interfere with climate change mitigation, but that's not necessarily the case and there are plenty of ways these two goals can be aligned (e.g. improved vehicle efficiency or a switch to EVs is beneficial for both air quality and CO2 emissions, as opposed to some 'end-of-pipe' emission controls). So I'd either add a third question or broaden the first one to look more broadly at how air quality policies can either cause warming or cooling depending on how they're put into place. [Drew Shindell, United States of America]	Noted. This question (how much CO2 is reduced with SLCF targeted policies) can not be addressed with the methodology used to build the SSP, it has been made clear in the FGD. The co-benefit// antagonism for very specific measures is too specific and is only discussed in the FAQ6.2. We only assess the role of sectoral emissions in the chapter (6.5).
128687	77	32	77	33	This sentence is confusing. Perhaps rewrite as: "Secondly, what is the potential for reducing warming through specific SLCF-targeted mitigation in the different SSP scenarios?" [Trigg Talley, United States of America]	Accepted. Sentence modified
76833	77	33	77	36	Citing idealized scenarios from Collins 2013 and Samset 2018a in a section about 'effects and linkages in SLCPs under different mitigation scenarios" is problematic. The cited simulations, which found that instantaneously removing all aerosols from the atmosphere would increase global warming by 0.5-1.1C is both unrealistic and inherently unlinked to any realistic mitigation scenario. The findings in Rogelj 2014b clearly show that "a large fraction of the warming from SLCPs are co-emitted with CO2." It would be better to replace these references with Shindell & Smith (2019) which modelled the co-emissions from fossil fuel sources and found no near-term aerosol 'temperature penalty' from a more realistic phasedown of fossil fuel sources (Shindell, D. & C.J. Smith (2019) Climate and Air-Quality Benefits of a Realistic Phase-Out of Fossil Fuels, Nature 573(7774):408-411) [Nathan Borgford-Parnell, Switzerland]	Accepted, the idealized simulations are not discussed in this section, dealing essentially with SSP, anymore.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
32959	77	33	77	36	Yes, instantaneously removing all aerosols from the atmosphere would increase global warming by 0.5-1.1C, but that is both implausible and unlinked to any realistic mitigation scenario. That's why we wrote our paper, Shindell & Smith (2019), which showed that under even a very ambitious but realistic phasedown of fossil fuel sources following the scenarios of SR1.5, the co-emissions from fossil fuel sources did not lead to a substantial near-term aerosol 'temperature penalty' since they do not occur instantaneously as it takes a while to make the clean economy transition (e.g. retiring coal plants). So these example are rather misleading given our current knowledge. (Ref: Shindell, D. & C.J. Smith (2019) Climate and Air-Quality Benefits of a Realistic Phase-Out of Fossil Fuels, Nature 573(7774):408-411) [Drew Shindell, United States of America]	Accepted, the idealized simulations are not discussed in the SSP section anymore.
128689	77	34	77	34	"instantanouesly" --> "instantaneously" [Trigg Talley, United States of America]	Editorial, treated.
106431	77	34	77	34	instantaneously ratherthan instantanouesly [Hamza Merabet, Algeria]	Editorial, treated.
114097	77	36	77	39	The study you refer to here is not recent, but from 2014. I suggest not writing "recent" [Jan Fuglestvedt, Norway]	Editorial, treated.
128691	77	37	77	37	"SLCF-specific" (add hypen) [Trigg Talley, United States of America]	Editorial, treated.
128693	77	38	77	38	Add "(e.g., BC, CO, CH4)"? [Trigg Talley, United States of America]	Editorial, treated.
8567	77	39	77	39	Mention which year this refers to. [Frank Dentener, Italy]	The sentence has been removed
128695	77	41	77	41	Delete "related" (after "CO2 and BC"). [Trigg Talley, United States of America]	Not applicable, Sentence deleted
8569	77	41	77	48	Repetition, has been discussed in earlier sections. [Frank Dentener, Italy]	Accepted, text deleted.
103577	77	41	77	48	Repetition, has been discussed in earlier sections. [Philippe Tulkens, Belgium]	Accepted, text deleted.
22067	77	41	78	1	These points have been made many times already in the chapter. Do they really need making again? There really is nothing new and novel compared to the sections that have come before here as far as I can tell. [Peter Thorne, Ireland]	Not applicable, Sentence deleted
128697	77	43	77	43	"black-carbon-rich" --> "black carbon-rich" [Trigg Talley, United States of America]	Not applicable, Sentence deleted
128699	77	49	77	49	"fossil fuels" (remove hypen) [Trigg Talley, United States of America]	Not applicable, Sentence deleted
128701	77	54	77	54	"fossil-fuel-related" --> "fossil fuel-related" [Trigg Talley, United States of America]	Not applicable, Sentence deleted
128703	77	55	77	55	"near-term" (add hypen) [Trigg Talley, United States of America]	Not applicable, Sentence deleted
114099	78	3	78	3	What does T1.5 indicate? I suggest either remove or explain [Jan Fuglestvedt, Norway]	Not applicable, Sentence deleted
128705	78	9	78	11	This sentence is unclear and poorly written. Focusing only on (global) total SO2 emissions obscures possible subtleties about sulfate (direct+indirect) forcing. [Trigg Talley, United States of America]	Not applicable, Sentence deleted
128707	78	10	78	10	"aerosols AOD" --> "aerosol AOD" [Trigg Talley, United States of America]	Not applicable, Sentence deleted
128709	78	11	78	11	"largely" --> "highly"? [Trigg Talley, United States of America]	Not applicable, Sentence deleted
114101	78	13	78	20	This para makes and important point. Could be highlighet more, with more assessment about what the studies and indicating. Reference and use of more studies would obviously also stengthen the assessment [Jan Fuglestvedt, Norway]	Not applicable, Sentence deleted
8571	78	15	78	15	presence=>acknowledgment, consideration? [Frank Dentener, Italy]	Accepted, sentence modified (and moved in 6.6.3.3)
103579	78	15	78	15	presence=>acknowledgment, consideration? [Philippe Tulkens, Belgium]	Accepted, sentence modified (and moved in 6.6.3.3)
8573	78	18	78	18	minimal change in absolute terms (i.e. stagnation of temperatures)? Or a change attributable to CO2/SO2 emissions? [Frank Dentener, Italy]	Accepted, precision has been added (now in 6.6.3.3)
103581	78	18	78	18	minimal change in absolute terms (i.e. stagnation of temperatures)? Or a change attributable to CO2/SO2 emissions? [Philippe Tulkens, Belgium]	Accepted, precision has been added (now in 6.6.3.3)
51285	78	18	78	20	This conclusion ('…there is not a strong conflict between climate and air-quality goals…') surely depends on the granularity of the modelling. At a local level there may well be antagonisms. Suggest that this is also made clear and highlight the need for further investigation at finer spatial resolutions of these issues. [Jolene Cook, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable, Sentence deleted

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
66787	78	22	78	40	For policymakers, these changes in the near-term and creating policies that are in line with the lower emissions scenarios would benefit from the ability to emphasize the amount of avoided warming from the SLCPs and the near-immediate impact that they can have. Speed is the metric of concern because of our proximity to 1.5C and drastic mitigation efforts needed to meet that goal. As a result, policymakers that will rely on the IPCC's scientific expertise would greatly benefit from the access and analysis of climate metrics that consider the shorter timescales like GWP20, which was used in past assessments and throughout policy work. SLCFs are featured in Chapter 6 of this report, but their impact on the climate—especially in the crucial near-term—should not be relegated to only that chapter but instead considered as part of the whole, most importantly short-lived climate pollutants (black carbon, methane, tropospheric ozone, and HFCs). [Kristin Campbell, United States of America]	Rejected, metrics such as GWP are discussed in chapter 7
66789	78	22	78	40	GWP* being used throughout the AR6 Report can be a useful metric, but does not completely negate the need and utility of a metric for a shorter timescales like GWP20. In the IPCC 1.5C Report, GWP* is noted for its ability to describe the impacts from SLCFs, even providing a Figure in Cross-Chapter Box 2 that shows the differences between GWP100, GTP100, and GWP*. This does not help for shorter timescale concerns. In the First Order Draft for WGIII for AR6, GWP* is explained in Chapter 2 as allowing the comparison of a sustained change in emissions for non-CO2 forcers in comparison with CO2, but the chapter also notes that there are limitations to using GWP* for policy applications, including those relevant for the Paris Agreement (see WGIII FOD 2-23–2-24). Further, Chapter 2 does suggest that GWP20 may be useful alongside metrics like GWP100 and GTP100 to compare changes in emissions (WGIII FOD 2-22). In Chapter 6 of WGIII FOD, the authors note that a chosen climate metric and the time horizon for which it covers affect assessing the timing of achieving climate targets like net-zero emissions (WGIII FOD 6-100). In discussing the balance of CO2 and non-CO2 emissions from aviation, Chapter 10 of WGIII's FOD suggests that time horizon is a subjective choice of the whomever is using the information, and that if longer time horizons are chosen, CO2 becomes more important (WGIII FOD 10-51: "Any GWP/GTP type emissions equivalency calculation always involves the user selection of a time horizon, over which the calculation is made, which is a subjective choice (Fuglestvedt et al., 2010). In general, the longer the time horizon, the more important CO2 becomes in comparison with a SCLF [sic]."). [Kristin Campbell, United States of America]	Rejected, metrics such as GWP are discussed in chapter 7

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
68341	78	22	78	40	For policymakers, these changes in the near-term and creating policies that are in line with the lower emissions scenarios would benefit from the ability to emphasize the amount of avoided warming from the SLCPs and the near-immediate impact that they can have. See Climate and Clean Air Coalition (CCAC) , Mexico , Molina Center for Energy and the Environment (MCE2), & United Nations Environment Programme (UNEP) (2018) Progress and Opportunities for Reducing SLCPs across Latin America and the Caribbean; UNEP & Climate and Clean Air Coalition (2018) Integrated Assessment of Short-lived Climate Pollutants in Latin America and the Caribbean: Improving air quality while contributing to climate change mitigation; Climate and Clean Air Coalition & UNEP (2019) Air Pollution in Asia and the Pacific: Science-based solutions; European Environment Agency (2018) Air quality in Europe — 2018 report, EEA Report No 12/2018. Speed is the metric of concern because of our proximity to 1.5C and aggressive mitigation efforts needed to meet that goal. As a result, policymakers that will rely on the IPCC's scientific expertise would greatly benefit from the access and analysis of climate metrics that consider the shorter timescales like GWP20, which was used in past assessments and throughout policy work. SLCFs are featured in Chapter 6 of this report, but their impact on the climate—especially in the crucial near-term—should not be relegated to only that chapter but instead considered as part of the whole, most importantly short-lived climate pollutants (black carbon, methane, tropospheric ozone, and HFCs). Aggressive mitigation of SLCPs can cut the rate of warming in half, Arctic warming by two-thirds, and avoid up to 0.6C of warming by 2050. UNEP & WMO (2011) Integrated Assessment of Black Carbon and Tropospheric Ozone; Shindell D., et al. (2012) Simultaneously Mitigating Near-Term Climate Change and Improving Human Health and Food Security, Science 335(6065):183–189; Xu and Ramanathan (2017) Well below 2 °C: Mitigation strategies for avoiding dangerous to catastrophic climate changes, Proc. Natl. Acad. Sci. 114(39):10315–10323. [Durwood Zaelke, United States of America]	Rejected, metrics such as GWP are discussed in chapter 7
68343	78	22	78	40	GWP* being used throughout the AR6 Report can be a useful metric, but does not completely negate the need and utility of a metric for a shorter timescale like GWP20. In the IPCC 1.5C Report, GWP* is noted for its ability to describe the impacts from SLCFs, even providing a Figure in Cross-Chapter Box 2 that shows the differences between GWP100, GTP100, and GWP*. This does not help for shorter timescale concerns. In the First Order Draft for WGIII for AR6, GWP* is explained in Chapter 2 as allowing the comparison of a sustained change in emissions for non-CO2 forcers in comparison with CO2, but the chapter also notes that there are limitations to using GWP* for policy applications, including those relevant for the Paris Agreement (see WGIII FOD 2-23–2-24). Further, Chapter 2 does suggest that GWP20 may be useful alongside metrics like GWP100 and GTP100 to compare changes in emissions (WGIII FOD 2-22). In Chapter 6 of WGIII FOD, the authors note that a chosen climate metric and the time horizon for which it covers affect assessing the timing of achieving climate targets like net-zero emissions (WGIII FOD 6-100). In discussing the balance of CO2 and non-CO2 emissions from aviation, Chapter 10 of WGIII's FOD suggests that time horizon is a subjective choice of the whomever is using the information, and that if longer time horizons are chosen, CO2 becomes more important (WGIII FOD 10-51: "Any GWP/GTP type emissions equivalency calculation always involves the user selection of a time horizon, over which the calculation is made, which is a subjective choice (Fuglestvedt et al., 2010). In general, the longer the time horizon, the more important CO2 becomes in comparison with a SCLF [sic]."). [Durwood Zaelke, United States of America]	Rejected, metrics such as GWP are discussed in chapter 7
107617	78	25	78	25	largerly? [Maycock Amanda, United Kingdom (of Great Britain and Northern Ireland)]	Editorial, done
72873	78	25	78	25	Replace 'largerly' with 'largely' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial, done
128711	78	25	78	25	"largerly" --> "largely" (or "widely"?) [Trigg Talley, United States of America]	Editorial, done
114103	78	25	78	26	Which 1.5 pathways by Shindell and Smith are you referring to? More info needed. [Jan Fuglestvedt, Norway]	Not applicable, Sentence deleted
128713	78	28	78	28	"rest" --> "remaining" [Trigg Talley, United States of America]	Not applicable, Sentence deleted

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
128715	78	30	78	30	"near-surface" (add hypen) [Trigg Talley, United States of America]	Editorial, done
72875	78	33	78	34	References should be in chronological order [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial, done
114105	78	34	78	34	Check the use of "Likely" here. [Jan Fuglestvedt, Norway]	Not applicable, Sentence deleted
128717	78	34	78	35	Add in results from ssp370-lowNTCFCH4 (AerChemMIP) simulations, if available. [Trigg Talley, United States of America]	A more systematic use of the lowNTCF scenario has been incorporated in the FGD version of the chapter.
128721	78	36	78	36	"make a substantial difference to the feasibility" --> "increase the feasibility" [Trigg Talley, United States of America]	Editorial, done
128719	78	36	78	37	Is this referring to emission targets or the long-term temperature goal? Clarify, as the Paris Agreement text does not contain the phrase "climate target". This phrasing is inconsistent with the next sentence that discusses "Paris Agreement goals". [Trigg Talley, United States of America]	Accepted - text revised
32065	78	37			Nisbet et al 2020 fig 22. [Euan G. Nisbet, United Kingdom (of Great Britain and Northern Ireland)]	Accepted, reference added
114107	78	38	78	40	This statement build on Nisbet et al., but the assessment by the authors is missing [Jan Fuglestvedt, Norway]	Not applicable, Sentence deleted
72877	78	42	78	42	Delete 'it is' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable, Sentence deleted
128723	78	42	78	45	Figure 6.19 is showing the impacts resulting from changes in SLCF emissions. The language needs to be clear that this isn't the total contribution of all SLCF loading, but rather a change compared to present. Second, looking at 2040, what is "relatively" insensitive. The central estimate for ssp126 is below the envelope for the higher SSPs in 2040. [Trigg Talley, United States of America]	Accepted, "change in SLCFs" is now systematically used to avoid confusion. In the near term and considering the very likely range, all the scenario are in the same envelope.
128725	78	42	78	45	Clarify: Are these the impacts of *changes* in SLCFs (versus 2014/2021?) under the SSPs? [Trigg Talley, United States of America]	Accepted - text revised
22069	78	42	79	32	Again, I'm feeling like I have been told all of this several times already. Can you differentiate this text from the rest of the chapter? [Peter Thorne, Ireland]	Noted, all this section has been rewritten trying to avoid redundancy with section 6.6.
128727	78	44	78	44	Delete "snow" (should include effects of both airborne and deposited BC). [Trigg Talley, United States of America]	Not applicable, Sentence deleted
46055	78	44	78	44	Change "relative insensitive" to "relatively insensitive". [Twan van Noije, Netherlands]	Not applicable, Sentence deleted
128729	78	46	78	46	"long term" (no hyphen) [Trigg Talley, United States of America]	Accepted, fixed in the whole chapter.
128731	78	49	78	50	"low-emission" and "high-emission" (add hyphens) [Trigg Talley, United States of America]	Not applicable, term deleted
13513	78	51	78	51	Check format. Change bold symbols (close pharenthesis and period). [Maria Amparo Martinez Arroyo, Mexico]	Editorial, checked
51287	78	53	78	55	….consensus in the literature that SLCF mitigation measures are to be considered complementary rather than a substitute for early and stringent CO2 mitigation measures..' This is an important, policy relevant point and suggest it would be beneficial to include in the SPM and Ch 6 Executive Summary. [Jolene Cook, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable, Sentence deleted
128735	79	5	79	6	"low-emission" and "high-emission" (add hyphens) [Trigg Talley, United States of America]	Not applicable, term deleted
128733	79	5	79	7	In line 5, add "changes in emissions of" before "all the SLCFs" and, in line 7, change to "emission controls act to reduce". [Trigg Talley, United States of America]	Not applicable, Sentence deleted
128737	79	5	79	7	This sentence is confusing without reference to the (sign of the) changes in each of these forcing agents. Also, odd here to separate the effects of atmospheric BC (lumped into aerosols) and deposited BC (separately listed as BC on snow). Be more explicit that these are the effects on climate from *changes* in SLCFs (versus 2021?). [Trigg Talley, United States of America]	Not applicable, Sentence deleted
114113	79	5	79	24	This para contains a lot of detailed but important information. It woud be good if the authors can try to improve the clarity in the findings here. [Jan Fuglestvedt, Norway]	Taken into account, text revised.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
66791	79	5	79	24	For policymakers, these changes in the near-term and creating policies that are in line with the lower emissions scenarios would benefit from the ability to emphasize the amount of avoided warming from the SLCPs and the near-immediate impact that they can have. Speed is the metric of concern because of our proximity to 1.5C and drastic mitigation efforts needed to meet that goal. As a result, policymakers that will rely on the IPCC's scientific expertise would greatly benefit from the access and analysis of climate metrics that consider the shorter timescales like GWP20, which was used in past assessments and throughout policy work. SLCFs are featured in Chapter 6 of this report, but their impact on the climate—especially in the crucial near-term—should not be relegated to only that chapter but instead considered as part of the whole, most importantly short-lived climate pollutants (black carbon, methane, tropospheric ozone, and HFCs). [Kristin Campbell, United States of America]	Rejected, metrics such as GWP are discussed in chapter 7
66793	79	5	79	24	GWP* being used throughout the AR6 Report can be a useful metric, but does not completely negate the need and utility of a metric for a shorter timescales like GWP20. In the IPCC 1.5C Report, GWP* is noted for its ability to describe the impacts from SLCFs, even providing a Figure in Cross-Chapter Box 2 that shows the differences between GWP100, GTP100, and GWP*. This does not help for shorter timescale concerns. In the First Order Draft for WGIII for AR6, GWP* is explained in Chapter 2 as allowing the comparison of a sustained change in emissions for non-CO2 forcers in comparison with CO2, but the chapter also notes that there are limitations to using GWP* for policy applications, including those relevant for the Paris Agreement (see WGIII FOD 2-23–2-24). Further, Chapter 2 does suggest that GWP20 may be useful alongside metrics like GWP100 and GTP100 to compare changes in emissions (WGIII FOD 2-22). In Chapter 6 of WGIII FOD, the authors note that a chosen climate metric and the time horizon for which it covers affect assessing the timing of achieving climate targets like net-zero emissions (WGIII FOD 6-100). In discussing the balance of CO2 and non-CO2 emissions from aviation, Chapter 10 of WGIII's FOD suggests that time horizon is a subjective choice of the whomever is using the information, and that if longer time horizons are chosen, CO2 becomes more important (WGIII FOD 10-51: "Any GWP/GTP type emissions equivalency calculation always involves the user selection of a time horizon, over which the calculation is made, which is a subjective choice (Fuglestvedt et al., 2010). In general, the longer the time horizon, the more important CO2 becomes in comparison with a SCLF [sic]."). [Kristin Campbell, United States of America]	Rejected, metrics such as GWP are discussed in chapter 7

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
68345	79	5	79	24	For policymakers, these changes in the near-term and creating policies that are in line with the lower emissions scenarios would benefit from the ability to emphasize the amount of avoided warming from the SLCPs and the near-immediate impact that they can have. See Climate and Clean Air Coalition (CCAC) , Mexico , Molina Center for Energy and the Environment (MCE2), & United Nations Environment Programme (UNEP) (2018) Progress and Opportunities for Reducing SLCPs across Latin America and the Caribbean; UNEP & Climate and Clean Air Coalition (2018) Integrated Assessment of Short-lived Climate Pollutants in Latin America and the Caribbean: Improving air quality while contributing to climate change mitigation; Climate and Clean Air Coalition & UNEP (2019) Air Pollution in Asia and the Pacific: Science-based solutions; European Environment Agency (2018) Air quality in Europe — 2018 report, EEA Report No 12/2018. Speed is the metric of concern because of our proximity to 1.5C and aggressive mitigation efforts needed to meet that goal. As a result, policymakers that will rely on the IPCC's scientific expertise would greatly benefit from the access and analysis of climate metrics that consider the shorter timescales like GWP20, which was used in past assessments and throughout policy work. SLCFs are featured in Chapter 6 of this report, but their impact on the climate—especially in the crucial near-term—should not be relegated to only that chapter but instead considered as part of the whole, most importantly short-lived climate pollutants (black carbon, methane, tropospheric ozone, and HFCs). Aggressive mitigation of SLCPs can cut the rate of warming in half, Arctic warming by two-thirds, and avoid up to 0.6C of warming by 2050. UNEP & WMO (2011) Integrated Assessment of Black Carbon and Tropospheric Ozone; Shindell D., et al. (2012) Simultaneously Mitigating Near-Term Climate Change and Improving Human Health and Food Security, Science 335(6065):183–189; Xu and Ramanathan (2017) Well below 2 °C: Mitigation strategies for avoiding dangerous to catastrophic climate changes, Proc. Natl. Acad. Sci. 114(39):10315–10323. [Durwood Zaelke, United States of America]	Rejected, metrics such as GWP are discussed in chapter 7
68347	79	5	79	24	GWP* being used throughout the AR6 Report can be a useful metric, but does not completely negate the need and utility of a metric for a shorter timescale like GWP20. In the IPCC 1.5C Report, GWP* is noted for its ability to describe the impacts from SLCFs, even providing a Figure in Cross-Chapter Box 2 that shows the differences between GWP100, GTP100, and GWP*. This does not help for shorter timescale concerns. In the First Order Draft for WGIII for AR6, GWP* is explained in Chapter 2 as allowing the comparison of a sustained change in emissions for non-CO2 forcers in comparison with CO2, but the chapter also notes that there are limitations to using GWP* for policy applications, including those relevant for the Paris Agreement (see WGIII FOD 2-23–2-24). Further, Chapter 2 does suggest that GWP20 may be useful alongside metrics like GWP100 and GTP100 to compare changes in emissions (WGIII FOD 2-22). In Chapter 6 of WGIII FOD, the authors note that a chosen climate metric and the time horizon for which it covers affect assessing the timing of achieving climate targets like net-zero emissions (WGIII FOD 6-100). In discussing the balance of CO2 and non-CO2 emissions from aviation, Chapter 10 of WGIII's FOD suggests that time horizon is a subjective choice of the whomever is using the information, and that if longer time horizons are chosen, CO2 becomes more important (WGIII FOD 10-51: "Any GWP/GTP type emissions equivalency calculation always involves the user selection of a time horizon, over which the calculation is made, which is a subjective choice (Fuglestvedt et al., 2010). In general, the longer the time horizon, the more important CO2 becomes in comparison with a SCLF [sic]."). [Durwood Zaelke, United States of America]	Rejected, metrics such as GWP are discussed in chapter 7

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
68349	79	5	79	24	The avoided warming does not consider HFC-23, which is primarily a by-product of producing HCFC-22, and not included in these calculations, although HFC-23 represents 17% of forcing from HFCs in 2016. Future emissions of HFC-23 are expected to be limited now that it is regulated by the Kigali Amendment. See World Meteorological Organization (WMO), United Nations Environment Programme (UNEP), National Oceanic and Atmospheric Administration (NOAA), National Aeronautics and Space Administration (NASA), and European Commission (2018). Scientific Assessment of Ozone Depletion: 2018, Global Ozone Research and Monitoring Project-Report No. 58. Geneva, Switzerland. ES.39 ("The 2016 Kigali Amendment to the Montreal Protocol, assuming global compliance, is expected to reduce future radiative forcing due to HFCs by about 50% in 2050 compared to the forcing from HFCs in the baseline scenario. Currently (in 2016), HFCs account for a forcing of 0.025 W m−2 not including 0.005 from HFC-23; forcing from these HFCs was projected to increase up to 0.25 W m−2 by 2050 (excluding a contribution from HFC-23) with projected increased use and emissions in the absence of controls. With the adoption of the Kigali Amendment, a phasedown schedule has been agreed for HFC production and consumption in developed and developing countries under the Montreal Protocol. With global adherence to this Amendment in combination with national and regional regulations that were already in place in, e.g., Europe, the USA, and Japan, along with additional recent controls in other countries, future radiative forcing from HFCs is projected to reach 0.13 W m−2 by 2050 (excluding HFC-23), or about half the forcing projected in the absence of these controls."); and Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer, Art. 2J, ¶¶ 1–4, 6–7, 15 Oct. 2016, C.N.872.2016.TREATIES-XXVII.2.f U.N.T.S. 2 ("Each country manufacturing HCFC-22 or HFCs shall ensure that starting in 2020 the emissions of HFC-23 generated in production facilities are destroyed to the extent practicable using technology approved by the Montreal Protocol"). Energy efficiency improvements to cooling equipment historically have been catalyzed by refrigerant transitions under the Montreal Protocol, and in the case of the Kigali Amendment, there are parallel decisions by the Parties promoting energy efficiency, as well as a fast-start fund. United States Environmental Protection Agency (EPA) (2002) Building owners save money, save the earth: replace your CFC air-conditioning chiller. 6–7 ("The most energy-efficient new chillers will reduce	Noted. The lifetime of HFC-23 is ~222 years (AR5), therefore it is not considered in this analysis.
128739	79	11	79	18	Confusing how the text flips back and forth between changes relative to 2021 and changes relative to a "baseline scenario" (SSP5-8.5). [Trigg Talley, United States of America]	Noted but the discussion comparing effect of HFC when regulated with HFC effect in baseline (in 2050 and 2100) is necessary to compare with results discussed in the literature.
128741	79	19	79	21	"...efficient implementation of the Kigali Amendment and national regulations is estimated to lead to cooling due to HFCs of less than 0.07°C by 2050 and between 0.2-0.4°C by 2100 relative to a baseline scenario with no regulations for HFCs (WMO, 2018)." "cooling due to HFCs" is incorrect! In fact, this whole statement is problematic. Reword to, e.g., "It is estimated that efficient implementation of the Kigali Amendment and national regulations would limit the contribution to global warming by HFCs to 0.07°C in 2050 and 0.06°C in 2100, versus 0.1°C in 2050 and 0.3-0.5°C in 2100 absent regulation." [Trigg Talley, United States of America]	Accepted - text revised
128743	79	21	79	24	This sentence is poorly worded. Perhaps rewrite as "It is very likely that emission controls on methane, ozone, HFCs and BC under a stringent mitigation scenario (SSP1-2.6) would lead to cooling towards the end of 21st century." [Trigg Talley, United States of America]	Not applicable, subsection completely rewritten.
72879	79	23	79	23	Insert 'the' after 'of' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial, done.
55059	79	26	79	29	Should the likely range here for warming due to reductions in aerosols and non-methane ozone precursors be 0.1C - 0.2C as in the Excutive Summary page 6 lines 45-46 (vs 0.1C to 0.3C)? [Nancy Hamzawi, Canada]	Not applicable, subsection deeply rewritten. Numbers in ES/chapter cross-checked.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
98445	79	26	79	29	The chapter states that there is robust evidence and high agreement that non-methane SLCFs mitigation measures through reductions in aerosols and non-methane ozone precursors to improve air quality but without stringent CO2 mitigation would lead to additional near-term warming with a likely range of 0.1-0.3°C. Some of the statements made in this chapter require additional explanation and a citation. For example, studies indicate that non-methane volatile organic compounds (NMVOCs) influence air quality and global climate change through their effects on secondary air pollutants and climate forcers. In fact, global and regional NMVOC reductions produce widespread negative net RFs (cooling) across both hemispheres from tropospheric ozone and methane decreases, and regional warming and cooling from changes in tropospheric ozone and sulfate (via several oxidation pathways). Accounting for a fuller set of RF contributions may change the relative magnitude of each region's impacts. The large variability in the RF and GWP of NMVOCs among regions suggest that regionally specific metrics may be necessary to include NMVOCs in multi-gas climate trading schemes. Furthermore, black carbon is a distinct type of carbonaceous material and strongly absorbs visible light. BC solar absorption became a central issue in climate change research when a synthesis of satellite, in situ, and ground observations concluded that the global solar absorption (i.e., direct radiative forcing, DRF) by atmospheric BC is as much as 0.9 W·m−2 (although much smaller level is reported in AR6, approximately +0.32 W m-2), second only to the CO2 DRF. When produced by burning biomass or fossil fuels, black carbon is accompanied by varying amounts of brown organic carbon. Both laboratory and field studies have shown organic carbon (OC) aerosols to absorb solar radiation (Brown Carbon or BrC for short), particularly in the shorter (<0.5 μ) wavelengths. When the BrC solar absorption is included in the treatment of OC aerosols, the net direct radiative forcing of these is close to zero because the heating resulting from BrC solar absorption nearly cancels the cooling effect of other OC. Hence, a convergence of the BC and BrC aerosol climate effect toward the upper end of the wide earlier range would make mitigation efforts even more rewarding. [nehzat Motallebi, United States of America]	Providing specific metrics for local planning is beyond the scope of this chapter. Carbonaceous aerosols is treated in 6.3.
114109	79	26	79	31	Useful sumamry and assessment in the end of this section. [Jan Fuglestvedt, Norway]	Thanks.
128745	79	26	79	31	Add in results from ssp370-lowNTCFCH4 (AerChemMIP) simulations, if available. [Trigg Talley, United States of America]	A more systematic use of the lowNTCF scenario has been incorporated in the FGD version of the chapter.
128747	79	29	79	31	"near- and long-term" (add hyphens) [Trigg Talley, United States of America]	Editorial, checked
128749	79	30	79	31	Clarify what is meant here. Reductions in SLCFs/CH4 in SSPs versus present day? Or, reductions in SLCFs/CH4 from a non-mitigation scenario to a mitigation scenario? For instance, the results from the AerChemMIP ssp370-lowNTCF/ssp370-lowNTCFCH4 simulations will show that methane mitigation cools the climate by MORE that the warming du to SLCF mitigation. [Trigg Talley, United States of America]	A more systematic use of the lowNTCF scenario has been incorporated in the FGD version of the chapter. Discussion about compensation by methane has been reworded.
16621	79	36	79	40	It would be useful to include the SSP370-lowCH4NTCF scenario in figure 6.21 (or what Nicholls et al. call SSP370-lowNTCF-gidden). This shows a clean comparison of mitigated vs non-mitigated SLCFs which results in an overall cooling compared to SSP370, suggesting that in fact it is possible to mitigate methane enough to compensate for aerosols. [William Collins, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable- figure removed.
114111	79	39	79	40	The sentence "The shaded…" may be found difficult. And I wonder if it would be useful to show the contributions from CO2? [Jan Fuglestvedt, Norway]	Not applicable- figure removed.
116563	79		79		Choices of baseline scenarios could be challenged, so it is good if you can be clear on choices, and make sure that choices are consistent with the approach implemented in WGIII too. [Valerie Masson-Delmotte, France]	Noted - Baseline is not used anymore for SSP discussion in chapter 6.
40791	80	0			Should the title change to "what are short-lived climate forcers and why do we care"? That way it doesn't assume everybody should know what it is? [TSU WGI, France]	Taken into account. The final title is "What are short-lived climate forcers and how do they affect the climate?"

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
40393	80	0			I wonder if it's not worth a short explanation about the 2 parameters to take into account to see the impact of a climate forcer: 1) lifetime 2) radiative power. I don't find it very clear at the moment that some forcers can be very powerful over very short period of time. [TSU WGI, France]	Accepted.
40397	80	0			I would avoid acronyms as much as possible, especially if the FAQ is only one page long, it's often not worth it and adds more confusion to the readers mind. In this case, I'd say the only acronym used enough is SLCF. [TSU WGI, France]	Accepted.
40151	80	0			FAQ6.1 is nice and interesting! [TSU WGI, France]	Thanks
86399	80	5	80	5	Sulfate aerosol - missing in the descriptor? [venkatachalam ramaswamy, United States of America]	Rejected. This is just two examples, the list is not meant to be complete. Figure FAQ-1 give the overview
114115	80	5	80	6	Re "affect Earth's climate over shorter times scales": Yes, for impact of individual emissions. But not when emisisons are stable or increasing. Woudl be useful if the chapter team can find a simple way of explaing this (here and in other places of the chpater) [Jan Fuglestvedt, Norway]	Rejected. This is a valid point, but adding this level of detail here would make the text too long. The point is implicitly addressed through "..., increases or decreases in emissions of SLCFs can have fairly rapid effects on the climate system." Thus implicitly, stable emissions don't have this rapid effects.
128751	80	5	80	7	Clarify here whether the term SLCFs refers only to radiativaly active species, or also to precursors. [Trigg Talley, United States of America]	Taken into account. Too detailed for the top summary, but included in the main text of the FAQ.
16623	80	6	80	6	It would be better to be more specific than "days to years". The adjustment time for methane is 12.2 years. A cut off at 20 years would cleanly separate long and short-lived. [William Collins, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account. Too detailed for the top summary, but included in the main text of the FAQ.
67951	80	6			Suggest changing to "....than long-lived greenhouse gases like....." [Luisa Molina, United States of America]	Accepted
16625	80	7	80	7	"nitrous dioxide"->"nitrous oxide" [William Collins, United Kingdom (of Great Britain and Northern Ireland)]	Accepted
128753	80	7	80	9	This is a common way to frame SLCF action, but it isn't quite correct: The implication of a short lifetime is that the atmospheric burden of SLCF can change quickly. The rapid effects are more directly related to the high radiative efficiency (e.g., if SF6 was suddenly emitted in gigaton quantities, it would have a very rapid effect on climate). [Trigg Talley, United States of America]	Noted. We have added a sentence on radiative efficiency of SLCFs, and that this needs to be relatively high in order for a compound with a short lifetime to have an impact on climate. We agree that theoretically this is true, but this FAQ is read in the context of the current emissions which are not driven by large pulse emissions. To elaborate on this would in our opinion probably lead to confusion.
67953	80	7			Please replace "nitrous dioxide" with "nitrous oxide" [Luisa Molina, United States of America]	Accepted
96683	80	7			Please add the fundamentally important information that CO2 remains in the atmosphere for thousands of years, since 15-40% is still there after 1000 years, see AR5 WG I FAQ 12.3. The authors seem to argue for a very high importance of SLCFs and even go so far as to conceal their much shorter lifetime in the atmosphere. Please try to be most objective when revising this FAQ. [Nicole Wilke, Germany]	Rejected. It is in principle there already "decades or more". In the summary statements for an FAQ, this becomes too detailed to elaborate.
39755	80	9		11	"human health ….over the last decades" this part is only mentioned in the summary, which shouldn't be the case. [TSU WGI, France]	Rejected. This is needed to put this FAQ in context with FAQ6.2 which discuss AQ and health issues.
8575	80	10	80	11	This statement is too general as it is written here, as it certainly doesn't hold for all types of emissions, and components. Many regions is essentially referring to Western Europe, North America and Japan=>some developed regions? [Frank Dentener, Italy]	Rejected/taken into account. Regionally, this also holds for China where remote sensing shows a steep decline in AOD over the last decade. The sentence has been modified since it does not hold for all SLCFs (cf reply to comment ID 108465).
103583	80	10	80	11	This statement is too general as it is written here, as it certainly doesn't hold for all types of emissions, and components. Many regions is essentially referring to Western Europe, North America and Japan=>some developed regions? [Philippe Tulkens, Belgium]	Rejected/taken into account. Regionally, this also holds for China where remote sensing shows a steep decline in AOD over the last decade. The sentence has been modified since it does not hold for all SLCFs (cf reply to comment ID 108465).

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
22073	80	11	80	11	over the last decades lacks specificity. Would it not be better to say the last 2-3 or 3-4 decades? [Peter Thorne, Ireland]	Rejected. There are differences between regions and species so we can not be more specific. For SO2 emissions in North America and Europa this started 4 decades ago, while for China we see the reduction over the last decade.
8577	80	13	80	14	Earlier in this chapter a treshold of 20 years to define SLCF was used. Probably this statement needs some refining to reflect the variety of lifetimes (aerosol- week; CH4 12 years) [Frank Dentener, Italy]	Accepted.
103585	80	13	80	14	Earlier in this chapter a treshold of 20 years to define SLCF was used. Probably this statement needs some refining to reflect the variety of lifetimes (aerosol- week; CH4 12 years) [Philippe Tulkens, Belgium]	Accepted.
28585	80	15	80	15	better to re-word "slowing down"? [Hiroshi Tanimoto, Japan]	Rejected. To avoid too technical wording we keep this. It is true that adding a GHG will slow down the loss of energy until a new equilibrium is reached.
128755	80	16	80	18	The reader doesn't get the message from reading this that aerosols significantly cool climate. A sentence is needed to give the reader a sense for the mechanism and magnitude of aerosol direct effects and impacts on clouds. [Trigg Talley, United States of America]	Taken into account. The text has been clarified. The quantitative difference between the cooling by the aerosols in general and the warming by black carbon is shown in the figure FAQ6.1
86401	80	18	80	19	Unclear whether the "increased reflection is mainly by sulfate aerosols" includes the effects via cloud modification, which is mentioned in the prior sentence. [venkatachalam ramaswamy, United States of America]	Taken into account. We now use the term "The main NET effect ...." to state that the cooling includes also the effects through clouds.
67955	80	20	80	21	Please clarify the last sentence. The sentence implies that SLCPs are a subgroup of SLCFs causing warming. SLCFs and SLCPs have been used interchangeably in many literature articles, although mitigation measures promoted by organizations such as CCAC have focused on removing warming agents. [Luisa Molina, United States of America]	Rejected. It may be that these terms have been used interchangeably, but the general use of these term now is as in the text. The text reflects just that, that it is sometimes referred to as SLCPs.
40415	80	20		21	I'm confused what is the difference between SLCF and SLCP? is pollutant is only warming? is it the same? [TSU WGI, France]	Noted. In the way this is used, yes.
104797	80	20			Could be more precise. Temperature and melting rates of what?! [Tobias Schad, Germany]	Taken into account. Sentence reformulated.
128757	80	37	80	37	"... significant reductions in the lifetime of snow due to the melting induced by soot." In most locations this is not the case, and evidence for it being the case in some locations is not terribly robust. Putting it on par with surface temperature changes doesn't seem right. [Trigg Talley, United States of America]	Taken into account. The sentence has been reformulated to focus on observed elevated BC concentrations that would lead to increased snow melt
86403	80	40	80	40	"might strongly influence regional weather systems" - there is evidence that regional emissions in Asia can strongly affect regional climate there. [venkatachalam ramaswamy, United States of America]	Accepted. The word "might" is deleted.
22077	80	52	80	55	This feels like it goes well beyond the remit of the FAQ and overlaps with a suite of other FAQs from other chapters. Is this passage really necessary? [Peter Thorne, Ireland]	Taken into account. The sentence has been simplified by omitting the comparison with the global effect of LLGHGs, and just stating the large regional forcing.
40971	80	52	81	4	The last paragraph is a bit confusing. is the link to climate sensitivity useful? mentioning it without explaining it might not be the clearest thing to do, especially if it is the last paragraph (which should be more a conclusion). [TSU WGI, France]	Taken into account. We have re-ordered the two last paragraphs, so that this is no longer the final paragraph.
128759	80	53	80	53	Clarify that "it constrains the remaining carbon budget" *to meet a given temperature target*. [Trigg Talley, United States of America]	Accepted
106433	80	55	80	55	SLCFs rather than SLFCs [Hamza Merabet, Algeria]	Accepted
128761	80	55	81	3	"SLFCs" --> "SLCFs" (three times) [Trigg Talley, United States of America]	Accepted
28587	81	1	81	3	SLCFs (twice) [Hiroshi Tanimoto, Japan]	Accepted
106435	81	1	81	3	SLCFs rather than SLFCs [Hamza Merabet, Algeria]	Accepted
114117	81	2	81	4	This is a good point. As far as I have seen, this has not been adressed very much in the chapetr. I think this deserves some attention. (Penner et al., Nat Geo, 2010 is one relevant ref on this issue). [Jan Fuglestvedt, Norway]	Noted. It is correct that ERF of aerosols including the fast feedbacks through cloud processes is not discussed much in chapter 6. However, this is covered in chapter 7.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
46057	81	9	81	9	Change "Short-lived climate forcers" to "short-lived climate pollutants". These include only the warming components, shown in the Figure. [Twan van Noije, Netherlands]	Rejected. Good point, but the figure has now been updated to also include scattering aerosols, thus SLCFs.
40375	82	0			I just find the use of the word "species" confusing for a lay audience, can't you use compound (as in FAQ6.1) or something else instead? [TSU WGI, France]	Accepted
40153	82	0			FAQ6.2: nice and interesting FAQ well explained with very clear summary and structure ! [TSU WGI, France]	Thanks
39671	82	0			should the conclusion be restated in the summary? i.e. that treating both issues together could favour the win-win situation? [TSU WGI, France]	Rejected. Would be a repetition
51289	82	1	82	45	This section needs a clearer message. For example, it would be useful to state here whether the writers agreed with the comments on p65 (lines 24 - 30). Perhaps a better approach would be to outline policies which have successfully reduced emissions to improve air quality and reduce climate change. [Jolene Cook, United Kingdom (of Great Britain and Northern Ireland)]	Rejected. FAQs are meant for a lay audience
15193	82	1	82	47	It is great to see a FAQ on the links between climate change and air quality. The FAQ though presents a far too overly balanced account of the impacts of climate mitigation in air quality. It seems divorced from the integrative research on the co-benefits. Yes, there are win-lose policies, but the mitigating climate change is a net benefit for air quality and human health. As presented, I worry this FAQ with just confuse people and run contrary to what WGIII produces. [Simon Donner, Canada]	Rejected. We do not share this concern
72881	82	6	82	6	Don't italicise vice versa if the rest of the text is in italics. [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted
51291	82	6	82	7	FAQ 6.2: Actions that aim to mitigate climate change can have negative impacts to air quality, it would be good to reflect this. Suggested edit: "However, some options for improving air quality can cause negative climate impacts, and vice versa." [Jolene Cook, United Kingdom (of Great Britain and Northern Ireland)]	Rejected. Sentence becomes awkward
104823	82	9	82	12	Food waste is a significant factor which is not picked up in this chapter 6. This is quote from the UNEP 2019 (DOI: 10.1017/9781108627146) p90 at https://www.unenvironment.org/resources/global-environment-outlook-6 “Food losses and waste result in unnecessary greenhouse gas emissions, estimated at 3.3 gigatons of CO2 equivalent in 2007, or around 9 per cent of total global GHG emissions that year (UNEP 2015). This estimate does not take into account GHG emissions as a result of land-use changes. Considering land-use changes, GHG emissions from food waste would be 25-40 per cent higher” UNEP (2015). Global Waste Management Outlook. Available at http:// wedocs.unep.org//handle/20.500.11822/9672 [Paul Dumble, United Kingdom (of Great Britain and Northern Ireland)]	Rejected. Not within the scope of WGI
72883	82	12	82	12	Delete , before 'and' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Editorial. The report will undergo professional copy-editing prior to publication. This type of issue will be fixed then.
7329	82	14	82	14	forestry' shouldbe cosidered under human activities. [SAN WIN, Myanmar]	Rejected. We do not see how.
128763	82	18	82	18	"both in" --> "in both" [Trigg Talley, United States of America]	Accepted
51293	82	21	82	24	This paragraph largely repeats what has already been said. I suggest it is deleted and the final sentence (line 24 - 25) is retained and added to the paragraph above. [Jolene Cook, United Kingdom (of Great Britain and Northern Ireland)]	Rejected. We do not think is a repetition.
72885	82	22	82	22	Move 'unambiguously' to after 'groups' [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted
72887	82	25	82	25	Although correctly italicised, no Latin text is italicised elsewhere in the Chapter (or the other chapters I have looked at). [Burt Peter, United Kingdom (of Great Britain and Northern Ireland)]	Accepted
67957	82	25			Suggest replacing “unintended benefits” with “co-benefits” [Luisa Molina, United States of America]	Rejected. We find the term unintended more appropriate in this context.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
104799	82	28			Zero-emission vehicles is imho misleading phrase because there may be no emission by combustion but there may still emission of particulate matter due to abrasion (tires, brakes) [Tobias Schad, Germany]	Rejected. Too specific.
128765	82	32	82	32	"offer" --> "offers" [Trigg Talley, United States of America]	Accepted
128767	82	34	82	34	Wood burning can potentially be carbon neutral, but it is complicated and requires sustainable practices and life cycle analysis to confirm. [Trigg Talley, United States of America]	Rejected. We do not want to complicate a text meant for a lay audience.
29605	82	34	82	35	This sentence "There are, however, also “win-lose” policies or activities. For example, wood burning is defined as carbon neutral because a tree accumulates the same amount of CO2 throughout its lifetime as is released when wood" should be modified, as it is only carbon neutral if there is no net LULUC associated with wood combustion. Suggest inserting "wood burning is often defined as", and then add at the end of the sentence, "although any impacts through LULUC also need to be considered." (The IAMs used to produce the SSP scenarios do consider such impacts through coupling energy system and land-use and land-use change models.") AR5 can be referenced regarding the LULUC issues. [Steven Smith, United States of America]	Rejected. The sentence seems correct as it is.
86791	82	39	82	39	Please consider to add the cooling effect of organic carbon (OC) here. [Oyvind Christophersen, Norway]	Rejected. It would complicate the text too much.
8579	82	40	82	40	Wrg to the unmasking, it may be worth summarizing the earlier paragraphs- a concurrent reduction of warming and cooling SLCF may limit the 'damage' (rapid T increase). [Frank Dentener, Italy]	Rejected. Too specific for a lay audience.
103587	82	40	82	40	Wrg to the unmasking, it may be worth summarizing the earlier paragraphs- a concurrent reduction of warming and cooling SLCF may limit the 'damage' (rapid T increase). [Philippe Tulkens, Belgium]	Rejected. Too specific for a lay audience.
51295	82	43	82	45	Air quality and climate change represent two sides of the same coin and addressing both issues together could lead to significant synergies and economic benefits while avoiding policy actions that mitigate one of the two issues but worsen the other.' This is an important, very policy-relevant, point and it would be beneficial to include in the Executive Summary of this chapter. [Jolene Cook, United Kingdom (of Great Britain and Northern Ireland)]	Taken into account, the message is present in the ES, although with a different wording.
128769	82	44	82	45	Delete the part of the sentence starting with "while avoiding policy actions". [Trigg Talley, United States of America]	Rejected. We believe that the sentence would be incomplete in the suggested way.
128771	83	6	83	7	Black carbon aerosols are included in "inorganic particulates". [Trigg Talley, United States of America]	Not applicable. Figure has been completely redesigned.
18311	84	35	84	35	Reis et al., 2018 is reported as Aleluia Reis in references. [Stefania Gilardoni, Italy]	Reference list has been checked for FGD.
128773	91	40	91	45	Fix references. [Trigg Talley, United States of America]	Reference list has been checked for FGD.
52069	92	42	92	42	Missing reference cited on page 72 (L. 30-36): Fiedler, S., Stevens, B., Gidden, M., Smith, S. J., Riahi, K., and van Vuuren, D.: First forcing estimates from the future CMIP6 scenarios of anthropogenic aerosol optical properties and an associated Twomey effect, Geosci. Model Dev., 12, 989–1007, https://doi.org/10.5194/gmd-12-989-2019, 2019. [Fiedler Stephanie, Germany]	Reference list has been checked for FGD.
43017	103	42			"east asia" needs capitals in the article title [Andrew Turner, United Kingdom (of Great Britain and Northern Ireland)]	Reference list has been checked for FGD.
93515	107	17	107	22	Morgenstern 2017a and 2017b is a duplicate [Michaela Hegglin, United Kingdom (of Great Britain and Northern Ireland)]	Reference list has been checked for FGD.
82995	123	60	123	61	The reference Yue and Unger (2018b) is exactly the same that Yue and Unger (2018a). [Susanna Strada, Italy]	Reference list has been checked for FGD.
22079	126	1	126	1	Are all these datasets in the observations annex and model annex? If so, why is this needed? If not, why not given that the intention of that annexes is to doocument all the observations and model datasets used throughout the report. Also I did not see this appendix or the tables mentioned in the main text (it may be mentioned in the figure captions) [Peter Thorne, Ireland]	Not applicable, this appendix does not exist anymore.
37985	127				GOME/OMI/GOME2 => GOME/OMI/GOME-2 [Junhee Lee, Republic of Korea]	editorial - treated

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
22081	138	1	138	1	Acronyms are not defined in this way for any other chapter. If done at all it would make sense to do for the report as a whole to avoid redundancy. [Peter Thorne, Ireland]	Not applicable, this appendix does not exist anymore.
86793	138	1	150	36	It does not seem appropriate to have a long list of acronymes for ch. 6 alone. We suggest that acronmyens for the whole report are placed upfront or in an annex. [Oyvind Christophersen, Norway]	Not applicable, this appendix does not exist anymore.
20059	138	1	150	36	When reading the TS, Page 168 Line 6, Table TS B1, one regrets that a table of acronyms (120 items) is built specifically for the TS. A similar remark holds here for the larger table (about 700 items) built specifically for chapter 6. An acronym table for the whole report should be built, and located in an annex of WG1, or still better added to the glossary file. Indicate in this table where in the report an acronym appears for the first time would be welcome. [philippe waldteufel, France]	Not applicable, this appendix does not exist anymore.
10691	138		150		Why is this list of acronyms included here? Many of the terms are not used in this chapter, some might not be used anywhere in the report. [Gareth S Jones, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable, this appendix does not exist anymore.
81375	139	22	139	22	C2Cl4 is listed here but appears nowhere in this chapter. Later on, many acronyms (e.g., “CF4”, “CFC”, “SPARC”,“TOA”, and “TSI”) appear twice. Perhaps a general check might be advisable to ensure that a) acronyms appear only once, and b) only the acronyms that are actually used are listed here. [Johannes Laube, Germany]	Not applicable, this appendix does not exist anymore.
78711	139	38	139	39	CCN is mentioned twice, delete one of the two entries. [Heike Wex, Germany]	Not applicable, this appendix does not exist anymore.
78713	139	48	139	49	The abbreviation CDR is used twice for two different things - this has to be sorted out! [Heike Wex, Germany]	Not applicable, this appendix does not exist anymore.
37987	140	5	140	7	Numbers of species name should be written in subscript (e.g., '3' of CFCl3) [Junhee Lee, Republic of Korea]	Not applicable, this appendix does not exist anymore.
78715	143	34	143	34	Include, above this line: INP Ice Nucleating Particles [Heike Wex, Germany]	Not applicable, this appendix does not exist anymore.
37989	147	4	147	5	Numbers of material name should be written in subscript (e.g., '10' of PM10) [Junhee Lee, Republic of Korea]	Not applicable, this appendix does not exist anymore.
20057	148	11	148	11	"SARF" is missing [philippe waldteufel, France]	Not applicable, this appendix does not exist anymore.
14797	148	30	148	30	SICOPOLIS' acronym is defined, but it apparently isn't used anywhere in Chapter 6. Suggest scanning this/other acronyms to ensure consistency and use in this chapter. E.g. SMIC ('Study of Mans' Impact on Climate') and SMOS (Soil Moisture and Ocean Salinity) are also defined but not used - and very odd and somewhat nonsensical acronyms! Is this acronym list actually for all of WG1? Or completely misplaced? [Jeremy Fyke, Canada]	Not applicable, this appendix does not exist anymore.
51297	149	22	149	22	please include STE in the abbreviation list which I believe stands for Stratospheric Tropospheric Exchange [Jolene Cook, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable, this appendix does not exist anymore.
86015	151	0	151	0	Figure 6.1: visually it is confusing that the darkest red is not the highest value. Instead of blending to pink and white consider blending into purple. [Debra Roberts and the Durban WGII TSU, South Africa]	Not applicable - figure removed
32067	151	0			Figure is extremely outdated, and there are lots of questions about Sciamachy retrievals. Use a more modern picture from a newer satellite. E.g. https://www.esa.int/Applications/Observing_the_Earth/Copernicus/Sentinel-5P/Methane_and_ozone_data_products_from_Copernicus_Sentinel-5P [Euan G. Nisbet, United Kingdom (of Great Britain and Northern Ireland)]	Not applicable - figure removed
28589	151	1	151	16	Figure 6.1. For (b), better to adjust color scales to avoid a wrong impression of "no NO2 data" over the oceans. For (a), a color scale starting with a lower value (e.g.. 1600 ppb) might help highlight a relatively uniform concentration distribution of methane. [Hiroshi Tanimoto, Japan]	Not applicable - figure removed
38343	151	1	151	16	The East Section and West Section of China-India Border are wrongly drawn and the Dotted Line of South China Sea, the Nanhai Zhudao, Diaoyu Dao and its affiliated islands of China are missing in Figure 6.1. In order to avoid unnecessary disputes, it is suggested to delete the boundary lines from the Figure. [Yaming LIU, China]	Not applicable - figure removed

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
22083	151	2	151	2	Figure panel b title why not spell out tropospheric for accessability. 2 should be a subscript in NO2. Text bottom right of panel A is not legible. Why use ppb in one and then molecules per cm3 in the other? Better surely to use the same at least measure type in each panel? Consider an overall figure title to better enable the figure to stand by itself? [Peter Thorne, Ireland]	Not applicable - figure removed
128775	151	5	151	5	Also (or instead) show TROPOMI CH4 results. [Trigg Talley, United States of America]	Not applicable - figure removed
37993	151	5	151	5	concentrations => mixing ratios [Junhee Lee, Republic of Korea]	Not applicable - figure removed
37991	151	5	151	13	Numbers of species name should be written in subscript (e.g., '4' of CH4, '2' of NO2) [Junhee Lee, Republic of Korea]	Not applicable - figure removed
37995	151	10	151	10	boxes => boxes. [Junhee Lee, Republic of Korea]	Not applicable - figure removed
128777	152	1	152	1	Figure 6.2 might consider including a link from climate to human emissions, e.g., via air conditioning / energy use. Also, why is the left-most column of boxes needed? How is it different from right hand side? [Trigg Talley, United States of America]	Taken into account, text revised.
22085	152	1	152	1	Adding a self describing figure title would greatly aid accessability here. [Peter Thorne, Ireland]	Accepted, revised.
95861	152	1	152	1	The figure lumps non-chemical processes, such as condensation and microphysical aerosol ageing (coagulation, condensation) all under Atmospheric Chemistry, which is confusing and not necessary. [Philip Philip Stier, United Kingdom (of Great Britain and Northern Ireland)]	Accepted, revised.
37997	152	4	152	4	Schematic => Schematic diagram [Junhee Lee, Republic of Korea]	Taken into account, text revised.
37999	152	5	152	5	the emission of precursors => emissions of precursors [Junhee Lee, Republic of Korea]	Not applicable - "precursors" removed
38001	152	12	152	13	e.g. by black carbon deposition on snow => (e.g. by black carbon deposition on snow) [Junhee Lee, Republic of Korea]	Taken into account, text revised.
116569	152		152		The figure would have pictograms about impacts of air pollution (for health and ecosystems?) [Valerie Masson-Delmotte, France]	Rejected, embedded in air pollution and here the figure is more focussed on SLCFs in the climate system.
5141	152				figure 6.2 I find the leftmost column of the figure useful – people may need to be reminded of the emissions -> burden -> forcing -> changes sequence. I don't find that anything in the right side of the figure adds to that message. [Daniel Murphy, United States of America]	Taken into account, text revised.
5143	152				I do not find this figure useful Figure 6.2 [Daniel Murphy, United States of America]	Taken into account, text revised.
116567	153		153		This visual may also include explicit links to other chapters to help the navigation on related aspects x whole report. [Valerie Masson-Delmotte, France]	The links to other chapters are made in the text (6.1.3) instead.
111977	153				This kind of roadmap use to be the first figure in many chapters, which makes a sense [Tomas Halenka, Czech Republic]	Rejected - schematic figure 6.1 maintained in chapter introduction
89687	154	1	154	1	Figure 6.4: Please split this figure up into either species or regions - the figure is not legible as it is. [Trude Storelvmo, Norway]	Taken into account, figure revised.
8305	154	1	154	13	Figure 6.4 is information rich, but also difficult to read (very small panels only readible enlarged in pdf) and to grasp differences. Authors to consider if it is useful to have some of the emission data tabulated in the Appendix 5, that tries to bring together climate system data (currently incomplete). The x-axis tick (century) doesn't allow to follow the decadal scale discussion in the text [Frank Dentener, Italy]	Taken into account, figure revised.
103589	154	1	154	13	Figure 6.4: The meaning of the two panels (A and B) presumably correspond to "anthropogenic" and "biomass burning", respectively. If so, the similarity of the patterns in both indicates strongly that what is labelled as "biomass burning" is predominantly anthropogenic (as they are indicated to be historically very low). The labelling can therefore be rather misleading by suggesting that "biomass burning" is somehow not anthropogenic. [Philippe Tulkens, Belgium]	Not applicable, the panels are now presented in 2 different figures (6.18 and 6.19)
103591	154	1	154	13	Figure 6.4 is information rich, but also difficult to read (very small panels only readible enlarged in pdf) and to grasp differences. Authors to consider if it is useful to have some of the emission data tabulated in the Appendix 5, that tries to bring together climate system data (currently incomplete). The x-axis tick (century) doesn't allow to follow the decadal scale discussion in the text [Philippe Tulkens, Belgium]	Taken into account, figure revised.
81377	154	1	154	15	Why are HFCs missing from this figure? [Johannes Laube, Germany]	Taken into account, HFCs added.
104785	154	1			Within the figure it would be very helpful to draw a vertical line on the time axis. So it may be better to distinguish between past emissions ans future projections. [Tobias Schad, Germany]	Noted.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
22087	154	3	153	6	Figure is inaccessible in present form. There are far too many panels and the font is eyewateringly tiny in the panels and in the keys. Panels need to be larger as does the font size. Why are parts A and B not split into separate figures? Where is a self-describing over-arching figure title? Why are some panels scaled? Can you not use background colouring to e.g. denote regions? Considerable thought is required on this figure. You cannot expect a reader to look at this under an (electronic) microscope to discern the details and this figure is used so broadly within the chapter that you really need it to be far more easily and readily accessible than is presently the case. For eample there could be a label region above the panels and a vertically aligned title SLCF up the left hand side. If this figure is so critical to the chapter it is key that the information be much more easily accessible and the figure stand far more effectively alone without recourse to the caption or text. [Peter Thorne, Ireland]	Taken into account, figure revised.
16461	154	3	154	8	What does the scale 1/2x in the figures mean. This is not explained in the figure captions. [Moa Sporre, Sweden]	Not applicable, the figure has been modified with different y-axis for different panels.
109861	154	3	154	13	Figure 6.4 contains two graph sets A) and B) and they are not defined in the figure caption. [Rehab El-Maghraby, Egypt]	Not applicable, the panels are now presented in 2 different figures (6.18 and 6.19)
22089	155	1	155	1	An over-arching self-describing figure caption would aid accessability here. Some of the text font is on the small side and there is plenty of white space which it could expand into. [Peter Thorne, Ireland]	Figure revised by graphic artists
109631	155	1	155	4	I am missing aerosol dynamics or at least something referring to multiphase chemistry here. Even with a very limited chemical reactivity, one can have significant time trends in variables relevant for the climate impacts of SLCFs. [Ilona Riipinen, Sweden]	Accepted. Microphysics Mechanisms has been added
109633	155	1	155	4	I think one should not focus only on quantum chemical theory. Quantum chemistry still cannot resolve phenomena happening in e.g. particles larger than a few nm, so development of the relevant thermodynamics and kinetic approaches bridging the gap to the bulk are still needed. [Ilona Riipinen, Sweden]	Noted. We have made efforts to only focus on the quantum chemical theory but also hihglight the value of thermodynamic and kinetic approaches both in the box text and the figure
28591	155	1	155	7	Box 6.1, Figure 1. In the "laboratory and Theoretical Reseach" box, only gas-phase processes are noted. Better to cover fundamental processes of aerosols (e.g., coagulation, internal mixing etc), considering a wide range of SLCFs discussed in this chapter. [Hiroshi Tanimoto, Japan]	Taken into account "microphysics processes" is now mentioned.
116571	155		155		Nice figure. Could information on major progress since AR5 be highlighted? [Valerie Masson-Delmotte, France]	Thanks! Progress since AR5 would be difficult to indicate on this figure
86017	156	0	156	0	Figure 6.5: this graph seems at odds with map in Fig 6.1, where South Africa has higher NO levels than South America, where Japan is also a hotspot, and where eastern US is near the highest and not the lowest. It does not make sense to normalize on the regional level in 1996. This misrepresents the issue. One needs to see the absolute levels. Regional trends would be equally visible on a graph that showed absolute levels. [Debra Roberts and the Durban WGII TSU, South Africa]	Taken into account. These individual NO2 figures have been combined to produce a panel plot Figure 6.6. The top panel shows climatological mean and the bottom panel shows the relative trends.
22091	156	1	156	6	The y-axis needs a label - presumably Vertical Column Density - and, critically the units are not given in either the y-axis (they should be) or the caption as it stands [Peter Thorne, Ireland]	Taken into account. Figure revised
12119	156		156		Fig. 6.5. What is the summary? Why NO2 increase only over China not elsewhere in the world. Now we have Indian economy increasing 5-8% per year, but no increase in NO2?? Is this because of short-lifetime of NO2 over India or the PBL is too high. In anycase the lifetime of NO2 is not longer than a day anywhere in the world, I suppose. [Prabir Patra, Japan]	Noted. Summary is given in section 6.3.3.1. Further details on regional trends are also provided there
128779	157	1	157	1	Will other SSPs be added here? Otherwise gives impression that tropospheric O3 will continue to increase the rest of this century. Maybe add old RCPs from ACCMIP? [Trigg Talley, United States of America]	Noted. Other SSPs could not be added because sufficient diagnostics for calculation of the tropospheric O3 burden were not available from ScenarioMIP simulations in time to be included in the FGD
81379	157	2	157	20	The only observation-based estimate available to constrain the multi-model mean is from 2010-2014? [Johannes Laube, Germany]	yes, it comes from an international assessment report. (TOAR)
38003	157	13	157	13	For UKESM1-LL-0 => For UKESM1-LL-0, [Junhee Lee, Republic of Korea]	Not applicable - caption rewritten
128781	157	17	157	17	"simulation1" --> "simulation" [Trigg Talley, United States of America]	Figure caption re-written
22093	158	1	158	1	Figure needs a self describing title to be added [Peter Thorne, Ireland]	Accepted and done.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
28593	158	2	158	2	Figure 6.7. Please double check if 28 sites are really "remote" [Hiroshi Tanimoto, Japan]	It has been checked with the contribution author and it is now called "remote and regionally representative surface sites"
128783	159	1	159	1	Very nice synthesis figure. Is it possible to provide the number of sites and mean values in panels or an accompanying table if there isn't one already somewhere else? [Trigg Talley, United States of America]	The location of sites is indicated on the map in the middle allowing to see the representativeness for each region. It has not been possible to add the numbers which would overload the figure.
22095	159	1	159	1	Another figure with illegible font at full size. The map of the world is taking up a disproportionate amount of the real estate for very little information content and the panels are commensurately tiny. Figure lacks an overarching title. None of the axis labels are legible making the figure completely unaccessible in hardcopy [Peter Thorne, Ireland]	Taken into account, figure revised.
28529	159	29	159	32	Figure 6.8 (f). Although the caption indicated that the data are from southern hemisphere, some data are not; i.e., data from Favez et al. are for Cairo and data from Wang et al. (2019) are for China. OC exceeding 20 ug m-3 from China may not represent whole "Asia". Some remark is necessary at least. [Hiroshi Tanimoto, Japan]	The location of sites is indicated on the map in the middle allowing to see the representativeness for each region.
55061	160	1	160	1	In the title of Figure 6.9, replace "Anomoly" with "Anomaly" [Nancy Hamzawi, Canada]	Accepted and done.
18271	160	1	160	2	In Fig. 6.9 title: "anomoly" is written instead of "anomaly". [Yann Cohen, France]	Accepted and done.
86405	160	1	161	1	Figs 6-9, 6-10, 6-13 display results from only 4 GCMs. It would be more substantive if additional model results were dispayed. [venkatachalam ramaswamy, United States of America]	More models have been added to Figures, except for Figure 6.9.
38005	160	5	160	5	Why is the period '1998-2017' selected for the calculation of OH anomaly? Justification looks required. [Junhee Lee, Republic of Korea]	Oh anomalies are calculated relative to mean over 1998-2007 as this is the period when global mean OH has been shown to be stable as derived from observations (Montzka et al., 2011)
89685	161	1	161	1	Figure 6.10: Include a third figure showing the net ERF [Trude Storelvmo, Norway]	Accepted - figure revised to display only Net ERF for map.
98623	161	1	161	10	I think it would be beneficial to include all CMIP6 models into the averaging, which are now available on ESGF [Michael Schulz, Norway]	The models are AerChemMIP experiments only. More models from AerChemMIP experiments added.
98625	161	1	161	10	What are the global mean values for SW and LW forcing from these figures, can this be included in the figure? [Michael Schulz, Norway]	Global weighted means are now reported in the lower right hand corner of the map. Only Net ERF is now presented in map.
98631	161	1	161	10	It would be useful to check whether the effective forcing values from the data and models used here are consistent with the recent AerChemMIP papers from Thornhill et al 2020 ACP a and b. EG the aerosol forcing from BCC posed problems and where not available in the submitted papers, so this model might not be fully consistent with the other models used. Possibly redo graph [Michael Schulz, Norway]	Accepted - figure has been redone.
28553	161	1	161	13	Figure 6.10. Better to include global average quantities. Also, clearly state if methane contribution is included as SLCFs or not here. [Hiroshi Tanimoto, Japan]	Taken into account - the figure now only shows aerosol ERF.
128785	161	1	162	1	Is there a disconnect between N America showing significance here in the longwave but not in Figure 6-10? [Trigg Talley, United States of America]	Accepted - figure revised. Method for deriving significance in bar charts and geomap ERF figures is now consistent.
38007	161	5	161	5	ERF' is already listed in acronyms. [Junhee Lee, Republic of Korea]	Rejected - Acronyms have to be explained in captions
22097	162	1	162	1	And again, a figure that has font sizes so small as to be indecipherable and this extends even to the titles but there is no hope of reading the axis labels or inline keys. If the y-axis labels are identical (I think they are) why do they need to be there twice? If they were there once they could be larger? Sinilarly are the keys identical so needed redundantly? Key could e.g. be bought outside to below the panels. Without addressing the font size issue so that the figure is understandable this figure is not usable. [Peter Thorne, Ireland]	Accepted - figure revised to display only 14 large Atlas regions
89683	162	1	162	1	Fig. 6.11: It would be great if you also showed the net ERF here in a third panel. It would be worth specifying that this is only SLCF forcing in the caption. [Trude Storelvmo, Norway]	"aerosol ERF" is denoted in the figure titles. Net ERFwould overload the figure.
28555	162	1	162	8	Figure 6.11. Clearly state if methane contribution is included or not. [Hiroshi Tanimoto, Japan]	Not applicable, the figure now only display results for aerosols.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
98627	162	1	162	10	Also in this figure 6.11 I am missing global area weighted means. [Michael Schulz, Norway]	The area weighted means for each region are denoted by the length of the bars in FGD Figure 6.10b
38009	162	3	162	3	ERF' is already listed in acronyms. [Junhee Lee, Republic of Korea]	Rejected - Acronyms have to be explained in captions
22099	163	1	163	1	Again, this figure is so small as to be indecipherable. The panels need to each be much larger than is presently the case as does the fiont size. Why not split into two figures rather than have as a and b which would help in terms of figure legibility. [Peter Thorne, Ireland]	Accepted - figure revised to display only 14 large Atlas regions
16463	163	1	163	2	These figures are very small and it is hard to read the labels on the axis [Moa Sporre, Sweden]	Accepted - figure revised
28557	163	1	163	8	Figure 6.12. Clearly state if methane contribution is included or not. [Hiroshi Tanimoto, Japan]	Not applicable, the figure now only display results for aerosols.
98629	163	1	163	10	Also in this figure 6.12 I am missing global area weighted means. [Michael Schulz, Norway]	"global area-weighted means' is added to the caption
38011	163	4	163	4	ERF' is already listed in acronyms. [Junhee Lee, Republic of Korea]	Rejected - Acronyms have to be explained in captions
22101	164	1	164	1	I know this is now sounding like a broken record but this figure is utterly indecipherable. The font is way too small as are the panels. It should be a 2x4 portrait set-up rather than 4x2 landscape and take up a whole page. All text must be legible and panels must be disernible at native resolution. The figure should have an overarching title that is self-describing. [Peter Thorne, Ireland]	Accepted - figure revised
16465	164	1	164	2	These figures are very small and it is hard to read the labels on the colorbar [Moa Sporre, Sweden]	Accepted - figure revised
38013	164	9	164	10	CMIP6' is already listed in acronyms. [Junhee Lee, Republic of Korea]	Noted, and long format removed.
22103	165	1	165	1	Figure would benefit from addition of a self-describing title so that it could be used in standalone mode [Peter Thorne, Ireland]	Not Applicable, Figure has changed.
38015	165	4	165	4	concentrations => mixing ratios [Junhee Lee, Republic of Korea]	Not Applicable, Figure has changed.
38017	165	6	165	6	RCP 6 => RCP 6.0 [Junhee Lee, Republic of Korea]	Not Applicable, Figure has changed.
111979	166	7			they will have/give …. [Tomas Halenka, Czech Republic]	Editorial - done
116575	166		166		The approach underlying this figure seems complementary, but different, from approaches to explore the effect of reduced CO2 emissions in Ch 4 and Ch 5. Could this be checked and coordinated? [Valerie Masson-Delmotte, France]	Taken into account, text revised.
86019	167	0	167	0	Figure 6.16 : this is very interesting but one thing that is confusing is that methane has higher impact than CO2. Perhaps that is because this shows only at 10 and 100 years. Perhaps include a short term measure, or cumulative, something that illustrates the fact that CO2 is still overall the most important GHG. Please spell out all abbreviations in the figure. [Debra Roberts and the Durban WGII TSU, South Africa]	Noted, abbreviations are now spelled out. The figure shows the effect of one-year pulse emissions that is why effect of CH4 is comparable to that of CO2., but the text in chapter 6 is clear on the predominant role of CO2.
22105	167	1	167	1	Figure would benefit from addition of a self-describing title so that it could be used in standalone mode [Peter Thorne, Ireland]	Accepted and done.
82997	167	4	167	8	If possible, I would suggest to add the spelled-out form of the geographical region or a map showing them. In the text some of them are spelled-out (pag. 61, ll. 25-47), but it seems to me that this is not the case for all of them. Same for sector acronyms. I could not find the spelled-out form in the final list of acronyms. In my opinion, this will ease the reading for those as me that are not used to these acronyms. [Susanna Strada, Italy]	Accepted and done.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
29593	167	4	167	8	This figure caption should be more carefully titled (along with the text that goes along with it). Suggest "Approximate global-mean surface temperature impact …", since this assumes that the same IRF can be applied for all species. Further, it has long been known that IRFs depend on the assumed background concentration trajectory. Which means one cannot specify an accurate temperature impact of current emissions without additional assumptions for the time evolution of background concentrations. This is due to non-linear relationships between emissions and concentrations, and concentrations and forcing. The figure is a useful illustration, but since this is a scientific assessment, it should be accurately described as being indicative only. [Steven Smith, United States of America]	Noted, however, we don't agree that the results from the analysis by Lund et al (2020) should be regarded as indicative only. It is true that the relation between emissions and global radiative forcing is influenced by non-linear processes and thus that the climate impact depends on background concentrations. However, this is taken into account by Lund et al in that the analysis is based on the HTAP2 simulations where the effect of regional emissions on concentration changes are simulated. The impact on radiative forcing is then estimated by a 4-D radiative kernel: From Lund et al (2020): "The regional radiative efficiencies (i.e., the global radiative forcing per unit of regional emissions) for BC, OC, sulfate, nitrate, and ozone (in response to NOx, CO and VOC) are derived using radiative kernels (Samset and Myhre, 2011) and atmospheric concentrations from simulations performed with the global chemistry transport model OsloCTM3 (Søvde et al., 2012) for the second phase of the Hemispheric Transport of Air Pollution (HTAP2) (Janssens-Maenhout et al., 2015). " In Lund et al., the IRF (same for all forcings) is then applied to the global radiative forcing to calculate the change in GSAT following the standard methods widely used in emulators (e.g. FaIR, Smith et al., 2018, https://gmd.copernicus.org/articles/11/2273/2018/) and for emission metrics (GTP). A title makes it clear now that it is relative to a one year pulse of emission.
27071	167	6	167	7	Maybe sector and region names need to be detailed/fully explained in the caption. Or a link to the text explaining them is missing. Sector names could be obvious for aware readers, but not all. Regions names are more difficult to figure out. (as in Fig 6.20) [Eric Brun, France]	Taken into account, abbreviations have been replaced.
114049	168	4	168	4	I guess this should be Box 6.2, figure 1 ? (And not 2) [Jan Fuglestvedt, Norway]	Accepted
38019	168	4	168	4	Schematic => Schematic diagram [Junhee Lee, Republic of Korea]	Not Applicable, figure removed
116577	168		168		The figure is very generic, but the chapter has more insights on effects of SLCF mitigation on climate and carbon cycle, could they be reported more explicitely (not just weather). [Valerie Masson-Delmotte, France]	Not Applicable, figure removed
22107	169	1	169	1	The global map is over-emphasised relative to the data. There is no over-arching figure title. The colours within the panels are not given in an inline key and should be. Use of colours for region titles is distracting and several colours are barely discernible from the white background. Better would to be use of black font and putting colour instead around the panels if you wish to persist with use of colour schema. But equally I'm not sure that buys much in terms of reader comprehension. Are these the regions defined by the later regional chapters? If not, why not? [Peter Thorne, Ireland]	Accepted - Global map removed. Regions used in chapter 6 are now explained in 6.1 and shown only once (figure 6.7) in FGD.
38345	169	1	169	14	The boundary lines of East Section of China-India Border are wrongly placed in Figure 6.17. In order to avoid unnecessary disputes, it is suggested to delete it from the Figure. [Yaming LIU, China]	Taken into account, figure revised
38021	169	4	169	4	annual mean surface ozone => annual mean surface ozone mixing ratios [Junhee Lee, Republic of Korea]	Rejected - True but rarely mentioned this way in literature.
38023	169	5	169	6	The terminology 'SSP' is not consistently used in this chapter. In other parts, just 'ssp370' is all description, but here SSP describtion is in detail. Inconsistent usage can induce the complex understanding of readers. [Junhee Lee, Republic of Korea]	Editorial, checked

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
22109	170	1	170	1	See my comments upon the prior figure which are equally applicable here. [Peter Thorne, Ireland]	Accepted - Global map removed. Regions used in chapter 6 are now explained in 6.1 and shown only once (figure 6.7) in FGD.
38347	170	1	170	19	The boundary lines of East Section of China-India Border are wrongly placed in Figure 6.18. In order to avoid unnecessary disputes, it is suggested to delete it from the Figure. [Yaming LIU, China]	Taken into account, figure revised
78767	170	1	170	20	The definition of regions are different with the regional Chapters while the region names are similar. This should be noted and clarified. [jian li, China]	Accepted - Global map removed. Regions used in chapter 6 are now explained in 6.1 and shown only once (figure 6.7) in FGD.
8563	170	4	170	10	As PM2.5 is a reguloratory quantity, it would make sense to show population-weighted concentrations- as area averages erroneously suggest that several continents are within the WHO recommended value of 10 ug/m3 already now. [Frank Dentener, Italy]	Rejected - population weighted is shown in Fig 6.25
103593	170	4	170	10	As PM2.5 is a reguloratory quantity, it would make sense to show population-weighted concentrations- as area averages erroneously suggest that several continents are within the WHO recommended value of 10 ug/m3 already now. [Philippe Tulkens, Belgium]	Rejected - population weighted is shown in Fig 6.25
38025	170	6	170	15	Again, the word SSP1-2.6, is not naturally matched to the ssp126 in the legend of figures. [Junhee Lee, Republic of Korea]	Editorial, checked
22111	171	1	171	1	y-axis labels should be GSAT impact (degrees C). Why not centre the second column? Major issue though is the varying y-axis ranges which are not immediately obvious. On a cursory glance a reader may assume comparability. Either use the same y-axis ranges or at least provide a yardstick measure of say 0.025C and place that scaled next to each panel to aid the reader here? [Peter Thorne, Ireland]	Rejected - Figure 6.24 allows to do such comparisons between forcers.
128787	171	3	171	3	Be clear that this figure shows the impact relative to the year 2021 of "changes in emissions" from five groups of SLCFs. [Trigg Talley, United States of America]	Accepted.
81381	171	4	171	4	HFCs is the abbreviation for Hydrofluorocarbons. It is also not clear, which HFCs are included here, since those with the strongest radiative effects are not actually defined as SLCFs. Exactly which compounds are included should be clarified, both here and in other parts of this chapter (e.g., Figure 6.21). [Johannes Laube, Germany]	Accepted - clarified in the caption.
38027	171	11	171	12	Unit looks weird. Is it right? [Junhee Lee, Republic of Korea]	Not applicable - caption rewritten
128789	171	15	171	16	Are the effects of the past changes in emissions included in this figure or not? [Trigg Talley, United States of America]	Yes, clarified in the text.
116579	171		172		There seems to be redundancy between these 2 figures, why? [Valerie Masson-Delmotte, France]	Not applicable - Maybe it's about 6.17 and 6.18 but maps have been removed and results are shown for ozone in one figure and for PM2.5 in the other.
22113	172	1	172	1	Figure needs a self-describing title. Text font is tiny but does not need to be. Why speak in codes in the key? You could bring the key below the figure and spell out region names in full. [Peter Thorne, Ireland]	Taken into account, text revised.
8565	172	3	172	11	It would be nice to see the net GSAT in Figure 6.20 as well. The difference of positive and negative. [Frank Dentener, Italy]	Rejected - figure already very dense.
103595	172	3	172	11	It would be nice to see the net GSAT in Figure 6.20 as well. The difference of positive and negative. [Philippe Tulkens, Belgium]	Rejected - figure already very dense.
38029	172	5	172	5	Again, maintain the consistent usage of SSP terminology (SSP is also listed in acronyms). [Junhee Lee, Republic of Korea]	Accepted, checked.
38031	173	7	173	7	Again, maintain the consistent usage of SSP terminology (SSP is also listed in acronyms). [Junhee Lee, Republic of Korea]	Accepted, checked.
86021	174	0	174	0	FAQ 6.1 Figure 1: although this is just a placeholder development of the final figure should consider that the icons of sources are useful, but words are needed because the icons on their own are not enough, you can't immediately see what they represent. Also, the sources should be ranked and listed in order of magnitude, or somehow show visually how much each source contributes. A sheep is not the best icon for livestock – should be a cow. [Debra Roberts and the Durban WGII TSU, South Africa]	Taken into account, the figure has been completely redesigned and now pictos are described explicitely with words.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
96685	174	1	174	1	FAQ 6.1 Figure 1: Suggestion: We would find it interesting to add some sort of quantification of the abundance of the different SLCPs in the schematic figure. We assume that the two figures will somehow be joined. In this case, please maintain the information about the lifetime of CO2 to clarify the relative importance of SLCF for the long term climate evolution. [Nicole Wilke, Germany]	Accepted. The impact on present day warming (since pre-industrial) of the different SLCFs are shown through different sizes of the globes in the last column.
111335	174	1	174	7	Figure 1 doesn't show any components of PM except for black carbon, but other components (like sulfate or organic matter) are much greater in mass and effects of sulfate are said in the text to have more confidence. [Tami Bond, United States of America]	Accepted. A new row including all other aerosols has been added.
38033	174	5	174	5	Schematic => Schematic diagram [Junhee Lee, Republic of Korea]	Editorial. The report will undergo professional copy-editing prior to publication. This kind of issues will be fixed then.
52071	174		174		Figure 1 for FAQ 6.1: I like the schematic, particularly the one on the left. I think a white background would further strengthen the readability. [Fiedler Stephanie, Germany]	Not Applicable, the figure has been completely redesigned.
86023	175	0	175	0	FAQ 6.2 Figure 1: although this is just a placeholder development of the final figure should consider that the climate effect should include a number (climate warming potential). H/E is not informative either, it should specify how and what. [Debra Roberts and the Durban WGII TSU, South Africa]	Taken into account. The revised figure does not include any number but is more informative, as it shows the relationship between the different compounds. The new figure also clarifies the climatic/environmental effect.
28595	175	1	175	9	FAQ 6.2, Figure 1. If possible, it may gain a better readability to show this in a "Venn diagram". [Hiroshi Tanimoto, Japan]	Taken into account - the figure has been completely redesigned and now shows more clearly and visually the climatic and environmental impacts of the various compounds.
76657	175	1	175	11	Climate effect of VOCs is indicated in the table as a positive impact („+“) on temperature change, however in the text about climate-bvoc feedback and the followiing table (both page 52) only negative radiative forcing is presented; to be consistent and with respect to modeled uncertainties the temperature effect on page 175 should be given as „+/-“ [Felix Havermann (né Wiß), Germany]	Taken into account, the relationship is highlighted with a dotted arrow.
81383	175	3	175	4	“Fluorinated gases” is yet another name (in addition to LLGHGs, synthetic GHGs, halocarbons, halogenated species, and even “halogens”) that is poorly defined and occurs nowhere else. Are e.g. the no-fluorine compounds CCl4, CH3CCl3 or CH2Cl2 included in “Fluorinated gases”? [Johannes Laube, Germany]	Taken into account - 'Fluorinated' no longer features on the figure
34407	175	4			faq 6.2 Figure 1 air quality impacts has 2 entries that appear to be negative but I expect that these should rather be "not appreciable". Suggest changing entry from "-" to "not appreciable". [Haroon Kheshgi, United States of America]	Take into account - the redesigned figure clarifies this.
8505			58	53	While most readers will understand the importance of extreme climate events, it may be necessary to explain why extreme pollution events are important (from epidemiology/health+regulatory point of view) [Frank Dentener, Italy]	Health is beyond the scope of WG1.
40973					The lifetime of CH4 is below 20 years but it is a well-mixed GHG, chapter 2 did not list CH4 in SLCF. Therefore, it is better to explain more clearly why methane is considered as a SLCF. And in the introduction, it could be mentioned that some SLCFs also could be well-mixed. [TSU WGI, France]	Taken into account - CH4 both WMGHG and SLCF are explained in 6.1.1
128791					[PRECISION] Overall, the chapter could do a better job of providing "synthesis" subsections. See Chapter 7 for an example of an approach that is more clear in terms of reviewing literature and then providing reasoning for coming up with synthesis numbers and conclusions. Also, given the overlap between Chapters 7 and 6 (e.g., in radiative forcing estimates of snow on ice or aviation, etc.), ensuring consistency is important. For the most part, Chapter 7 provided a clearer assessment in areas of overlap. [Trigg Talley, United States of America]	Taken into account, the chapter has been thoroughly reworked as recommended.
128793					Most of the chapter needs to be gone through and edited for improved wording and flow. There are still typos and non-sensical sentences in place that clearly need to be fixed. Section 6.1 is particularly problematic. More generally the writing through most of the chapter needs a scrub (an exception being Section 6.5 which needs a few corrections but overall reads very well). [Trigg Talley, United States of America]	Taken into account, the chapter has been thoroughly reworked as recommended.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
128795					The mechanisms by which different SLCFs affect climate is given in bits and pieces in different sub-sections. There should be one place where, in particular, a distinction is made between SL components that act through long-wave forcing (and whose trends mostly warm climate) and aerosols, which act through short-wave forcing (and whose trends cool climate). At least a brief explanation given of aerosol direct radiative and aerosol-cloud effects should be given. The significant difference bewteen RF and ERF for some SLCFs should also be noted. This is all framing information that should come somewhere near the beginning of the chapter. [Trigg Talley, United States of America]	Taken into account, the chapter has been thoroughly reworked as recommended.
116509					Congratulations for the maturation of the draft chapter, and also for coordination and complementarity with other chapters. Please consider carefully the use of ch 6 findings in the TS/SPM and make suggestions for improved integration of knowledge on SLCF and air quality. Chapter perspectives on labelling scenarios and on choice of scenarios to illustrate WGI findings are important (eg SSP7). [Valerie Masson-Delmotte, France]	Thank you, Taken into account, the chapter has been thoroughly reworked as recommended.
128797					The authors need to decide if they are going to use "SLCF" or "SLCFs" when referring to this group of species. Use SLCFs. Section 6.1 in particular goes back and forth, but the entire chapter should be checked. [Trigg Talley, United States of America]	Taken into account, plural acronyms are correctly edited in FGD.
116511					Please be explicit on what is new and what differs from findings in AR5 (also in the ES). [Valerie Masson-Delmotte, France]	Taken into account, the chapter has been thoroughly reworked as recommended.
128799					[PRECISION] Need to clarify the usage of the term "(climate) forcer" throughout the chapter. Does it refer only to radiatively active species, or also to precursors (e.g., NOx, SO2)? Currently, the usage is mixed (e.g., Introduction) and confusing. [Trigg Talley, United States of America]	Accepted and clarified in 6.1
128801					Heavy proofreading is needed. Lots of cases of missing or improperly used articles (the, a) , commas, and plurals. [Trigg Talley, United States of America]	Editorial issues have been fixed for FGD.
116515					Insights from ch 6 are relevant for the TS box on urban climate. [Valerie Masson-Delmotte, France]	Rejected - chapter 6 does not investigate this scale.
128803					This chapter would be more valuable if it included a table(s) that presented the relative contribution of SLCFs to global ERF and perhaps the past and future timeline of these contributions. Otherwise, the reader, after looking at Table 6.1, has to search to discover the importance of these terms. [Trigg Talley, United States of America]	Accepted, Figure 6.12 give this information (for ERF and GSAT change).
128805					[ACCESSIBILITY] This chapter reads much more as a tutorial than an assessement. The main text is extremely rich in detail and short on statements that reflect a true assessment of the information. It is difficult in reading the text to determine what the main points are regarding the role of SLCFs in forcing the climate system. The recommendation is to add clear summary/assessment statements in the text to mitigate this issue. [Trigg Talley, United States of America]	Taken into account, the chapter has been thoroughly reworked as recommended.
128807					[ACCESSIBILITY] This chapter would be improved if it was better coordinated with the other chapters that address similar topics. For example, there is no reference to Chapter 7 concerning the ERF values for SLCF climate forcing terms, or aviation, or BC on snow. The strong recommendation is to search the balance of the SOD to see where and how overlap occurs and first, point to this overlap, and second, to make sure there is consistency in detail and conclusions. [Trigg Talley, United States of America]	Accepted - consistency with other chapters (2, 4, 7, 8, 12) checked.
116521					Could it be possible to provide a brief summary description of the role of CH4 for air quality in the chapter ES, so that it can be reflected in the TS or SPM? When doing outreach, I have realized that this remains poorly known by most people, including decision makers. Also, the chapter provides assessments related to the aviation and shipping sectors. This could be relevant for the TS and be a point of coordination with the corresponding WGIII chapter (transport). [Valerie Masson-Delmotte, France]	Taken into account (and elevated up to the SPM).
128809					Some of the research emerging in early/mid 2020 because of COVID19 shutdowns should be worked into this chapter. [Trigg Talley, United States of America]	A cross chapter box as been added to discuss the effect of COVID 19 on climate and air quality as it occurred in 2020.
116525					SRCCL had a few limited statements on dust and dust storms. Could this be updated here (maybe in coordination with Ch 12)? [Valerie Masson-Delmotte, France]	Rejected - too specific.

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
116537					Coordination with chapter 3 is needed for the attribution of Arctic warming, and also possibly with chapter 7 (box on Arctic amplification). [Valerie Masson-Delmotte, France]	Not applicable - not discussed in chapter 6.
116539					For the synthesis of regional information across chapters, it could be relevant to develop a specific table showing past and projected trends of regional RF due to changes in emissions of aerosols / SLCF. This can be important for the approach used for instance in ch 12 where confidence in trends related to CID is linked to an observed trend, attribution, and continuation of this trend in projections. [Valerie Masson-Delmotte, France]	Taken into account, ERF from aerosol are presented in the interactive atlas.
116555					Findings related to aviation and shipping emissions could be captured in the ES. [Valerie Masson-Delmotte, France]	Rejected, too specific.
12109					My suspect is that the NH/SH OH bias (Patra et al., 2014) is probably linked with the OH trends we see in the CCMI models. One can test this hypothesis by plotting the OH increase rates by latitude bands (Stevenson et al., APCD, does a quite nice work). Then if we see bigger increase in OH in the NH latitudes (first in the high latitudes in the 1970s, and then in the midlatitudes in the 1980s, and now in the tropical latitudes), we can be sure about that internal feedback in OH biases, in the NH high and faster increase rate than the CH3CCl3 data? [Prabir Patra, Japan]	Noted - OH section has been reworked.
116557					Coordination with WGII and WGIII related to SLCF and air quality would enhance the relevance of the chapter and prepare integration across WG. Some chaoters are listed, for instance related to urbanisation, but it could be relevant tomake sure that WGI provides the expected handshake. [Valerie Masson-Delmotte, France]	Accepted - done through WG2 and WG3 SOD reviews.
116561					Chapter 4 has developed statements related to when would one be able to detect the effect of CO2 mitigation. There is also the issue of detection of ozone recovery. The chapter could be more explicit on the emergence of signals driven by stabilisations or reductions in aerosol forcing? [Valerie Masson-Delmotte, France]	Noted, there is a section discussing that in FGD.
12117					Too many schematic diagrams - may be no need for Fig 6.3. You can save space for new materials [Prabir Patra, Japan]	Roadmap figures are provided in each chapter.
116565					I would suggest to develop a cross chapter [Valerie Masson-Delmotte, France]	Not applicable. Comment uncomplete, we do not understand what the point of the reviewer is.
40025					Concerning ERF of Aerosols and Aerosol-cloud interactions on hydrological cycle, be cautious to avoid overlap with ch7 and ch8 Box 8.1 [TSU WGI, France]	Accepted - consistency with other chapters (7, 8,) checked.
116573					There are arguments from Chapter 6 to consider SSP7 as a reference high emission scenario allowing to explore the effect of SLCF mitigation. To discuss about the choice of high end emission scenarios for report projection figures. [Valerie Masson-Delmotte, France]	Not Applicable, not clear what is the purpose of the comment.
116581					Note, the term "impact" has a specific meaning in the IPCC context (see glossary), I think that it is used here in the sense of "effects, consequences", please check. [Valerie Masson-Delmotte, France]	Taken into account - Impact is kept only when there is no confusion with climate impact.
116589					Please note that Chapter 6 is too long by around 5%, so attention to length is needed when revising the text, figures etc. I think that the last sections could be made shorter and sharper. [Valerie Masson-Delmotte, France]	Taken into account, the chapter has been thoroughly reworked as recommended.
114287					figure 6.21: this is a figure important for conveying info about the role of SLCF in future scenarios. It may be somewhat difficult to understand since reuslts are presented ina way that may seem different from what many readers are used to; i.e. the contributions above and below the net line relative to 2020. I hope the authors can work on various ways to help the reader. One thing to consider is to show the contributions from the WMGHGs so one can see taht the controbutions are stacked. This will however be difficult for the lower scenario. Perhpas colums with timeslices for 2100 could help showing the full set of contributions? [Jan Fuglestvedt, Norway]	Not applicable - figure removed

Comment ID	From Page	From Line	To Page	To Line	Comment	Response
29319					I refer both to FAQ 6.2 (chapter 6, page 82) and to paragraph 12.3.7.1 (chapter 12, page 28). Regarding the link between air quality and climate change (See page 82, chapter 6 and page 28 of chapter 12), in Italy we are studying the correlation between air quality/pollution and the COVID-19 pandemic, because since the end of February 2020 we noticed that the new coronavirus SARS-CoV-2 has spread with greater virulence in the regions of Northern Italy such as Lombardy, which are the most polluted, as in China and in the USA. We have also a methodological question concerning the modeling of the new coronavirus as a thermodynamic object. I realized that the current biological models of SARS-CoV-2 present therefore a methodological defect that is expressed in a bad definition (sometimes omission) of the thermodynamics of the system. I therefore redefined the viral particle system in its micro-environment. Studying the coronavirus + environment system, I therefore had to take into account the possible presence of nano-particles and I have drawn up a comformal theory of the energy landscape of the SARS-CoV-2 complex with particulate matter. This complex represents a compact and stabilized structure of minimal entropy, through which the virus greatly enhances its lethal force, from which the reason why the most polluted areas are those most affected by the pandemic. My research merged into a report for the Accademia Nazionale dei Lincei about the Pandemic COVID-19 and the environment . The title of my report is "Energy landscape theory of SARS-CoV-2 complexes with Particulate Matter". The abstract is: "The pandemic COVID-19 caused by the new coronavirus SARS-CoV-2 has rightly mobilized world scientific research, looking for a cure or a way to stop this terrible catastrophe, which is causing thousands of deaths. Italy was the second country hit by the pandemic, after China.However, the virus has not been correctly characterized as a physical system that obeys the laws of thermodynamics and much is still unknown. In particular, SARS-CoV-2 models lack the characterization of the virus system within its environment. This is a serious systematic error. In the present work, we thus consider the system SARS-CoV-2 with its environment, through analysis and simulations, from air transport to cell entry through respiration. In the study of the aerosol environment, we must obviously take into account the presence of nano-particles or dust inside the environment. Therefore, analyzing and comparing the air environments in China and in Italy, we note that the Chinese and Italian regions most affected by the pandemic are also the most	A box on COVID has been added.
115901					FAQ6.1 The text does not refer to dust (only human emitted SLCF?). It is focused on some SLCF aspects but not all (they matter for many aspects eg aerosol cloud precipitation interplays or regional forcing. I suggest to build more across chapters 6-7-8-9 for this FAQ. The logical flow of information could be improved. Could an original figure be designed in line with the content of this report? [Valerie Masson-Delmotte, France]	Taken into account - FAQ has been thoroughly rewritten.
115903					FAQ6.2 I would suggest to highlight not just mortality but also the chronic disease burden linked to air quality. Please consider petrol car (not car, if using electricity from a zero carbon source). The FAQ is focused on emissions, but not on how a changing climate can affect air quality, or on how there can be compound effects of health (eg heat wave + poor air quality). The table is a good idea, it would be relevant to flag other aspects (eg albedo effects) and highlight the relative importance for climate vs health if possible. [Valerie Masson-Delmotte, France]	Taken into account - FAQ has been thoroughly rewritten.
116675					There is a need to improve the development of the assessment. In several parts of the chapter, there is a review of the literature, or descriptions of findings from cited papers, followed by a use of the calibrated language (confidence levels) difficult to relate to the assessment of evidence and agreement. Please consider carefully how the assessment is reported, and make the best use of the calibrated language in the final chapter draft. [Valerie Masson-Delmotte, France]	Taken into account -The chapter has been thoroughly rewritten in particular to better support the conclusions and their confidence level.