Annex VII - Glossary

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This glossary defines some specific terms as the Lead Authors intend them to be interpreted in the context of this report. Italicized words in definitions indicate that the term is defined in the Glossary. Subterms appear in italics beneath main terms.

1.5°C pathway See *Pathways*.

Ablation (of glaciers, ice sheets, or snow cover) See *Mass balance / budget (of glaciers or ice sheets)*.

Abrupt change A change in the system that is substantially faster than the typical rate of the changes in its history.

Abrupt climate change A large-scale *abrupt change* in the *climate system* that takes place over a few decades or less, persists (or is anticipated to persist) for at least a few decades and causes substantial *impacts* in *human and/or natural systems*. See also *Tipping point* and *Abrupt change*.

Accumulation (of glaciers, ice sheets, or snow cover) See *Mass balance / budget (of glaciers or ice sheets)*.

Active layer Layer of ground above *permafrost* subject to annual thawing and freezing.

Adaptation In *human systems*, the process of adjustment to actual or expected *climate* and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate and its effects. See also *Adaptation options*, *Adaptive capacity* and *Maladaptive actions (Maladaptation)*.

Adaptation options The array of strategies and measures that are available and appropriate for addressing *adaptation*. They include a wide range of actions that can be categorised as structural, *institutional*, ecological or behavioural.

Adaptive capacity The ability of systems, *institutions*, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences (IPCC, 2014; MA, 2005).

Added value Improvement of the representation of some climatic aspects by one methodology compared to another methodology. For instance, downscaling a coarse resolution *global climate model (GCM)* may improve the representation of regional climate in complex terrain.

Adjustment time See *Response time or adjustment time*.

Advection Transport of water or air along with its properties (e.g., temperature, chemical tracers) by winds or currents. Regarding the general distinction between advection and *convection*, the former describes transport by large-scale motions of the *atmosphere* or ocean, while convection describes the predominantly vertical, locally induced motions.

Aerosol A suspension of airborne solid or liquid particles, with typical diameters between a few nanometres and a few micrometres and atmospheric lifetimes of up to several days in the *troposphere* and up to years in the *stratosphere*. The term aerosol, which includes both the particles and the suspending gas, is often used in this report in its plural form to mean 'aerosol particles'. Aerosols may be of either natural or *anthropogenic* origin in the troposphere; stratospheric aerosol mostly stems from volcanic eruptions. Aerosols can cause an *effective radiative forcing* directly through scattering and absorbing radiation (*aerosol-radiation interactions*), and indirectly by acting as *cloud condensation nuclei* or ice nucleating particles which affect the properties of clouds (*aerosol-cloud interactions*), and upon deposition on snow- or ice-covered surfaces. Atmospheric aerosols may be emitted as primary particulate matter (PM), and form within the atmosphere from gaseous *precursors* (secondary production). Main classes of aerosol chemical composition are sea salt, organic carbon, *black carbon (BC)*, mineral species (mainly desert dust), sulphate, nitrate, and ammonium. See also *Short-lived climate forcers (SLCFs)*.

Aerosol effective radiative forcing (ERFari+aci) See *Aerosol-radiation interaction*.

Aerosol optical depth (AOD) Wavelength-dependent aerosol optical depth is a measure of the *aerosol* contribution to extinction of top-of-the-atmosphere solar intensity measured at the ground. AOD is unitless.

Fine-mode aerosol optical depth Aerosol optical depth due to aerosol particles smaller than 1 μm in radius.

Aerosol-cloud interaction A process by which a perturbation to *aerosol* affects the microphysical properties and evolution of clouds through the aerosol role as *cloud condensation nuclei* or ice nuclei, particularly in ways that affect radiation or precipitation; such processes can also include the effect of clouds and precipitation on aerosol. The aerosol perturbation can be *anthropogenic* or come from some natural *source*. The *radiative forcing* from such interactions has traditionally been attributed to numerous indirect aerosol effects, but in this report, only two levels of radiative forcing (or effect) are distinguished: See also *Aerosol-radiation interaction*.

Effective radiative forcing (or effect) due to aerosol-cloud interactions (ERFaci) The final *radiative forcing* (or effect) from the *aerosol* perturbation including the adjustments to the initial change in droplet or crystal formation rate. These adjustments include changes in the strength of *convection*, precipitation efficiency, cloud fraction, *lifetime* or water content of clouds, and the formation or suppression of clouds in remote areas due to altered circulations. See also *Aerosol-radiation interaction*.

Instantaneous radiative forcing (or effect) due to aerosol-cloud interactions (IRFaci) The radiative forcing (or radiative effect, if the perturbation is internally generated) due to the change in number or size distribution of cloud droplets or ice crystals that is the proximate result of an aerosol perturbation, with other variables (in particular total cloud water content) remaining equal. In liquid clouds, an increase in cloud droplet concentration and surface area would increase the cloud albedo. This effect is also known as the cloud albedo effect, first indirect effect, or Twomey effect. It is a largely theoretical concept that cannot readily be isolated in observations or comprehensive process models due to the ubiquity of adjustments.

Aerosol-radiation interaction An interaction of *aerosol* directly with radiation produce *radiative effects*. In this report two levels of *radiative forcing* (or effect) are distinguished:

Aerosol effective radiative forcing (ERFari+aci) The total effective radiative forcing due to both aerosol-cloud and aerosol-radiation interactions is denoted aerosol effective radiative forcing (ERFari+aci).

Effective radiative forcing (or effect) due to aerosol-radiation interactions (ERFari) The final radiative forcing (or effect) from the aerosol perturbation including adjustments to the initial change in radiation. These adjustments include changes in cloud caused by the impact of the radiative heating on convective or larger-scale atmospheric circulations, traditionally known as semi-direct aerosol forcing (or effect). See also *Aerosol-cloud interaction*.

Instantaneous radiative forcing (or effect) due to aerosol-radiation interactions (IRFari) The radiative forcing (or radiative effect, if the perturbation is internally generated) of an aerosol perturbation due directly to aerosol-radiation interactions, with all environmental variables remaining unaffected. Traditionally known in the literature as the direct aerosol forcing (or effect).

Afforestation Conversion to *forest* of land that historically has not contained forests. [Note: For a discussion of the term forest and related terms such as afforestation, reforestation and deforestation, see the 2006 IPCC Guidelines for National Greenhouse Gas Inventories and their 2019 Refinement, and information provided by the United Nations Framework Convention on Climate Change (IPCC, 2006, 2019, UNFCCC, 2021a, 2021b).] See also *Deforestation*, *Reducing Emissions from Deforestation and Forest Degradation (REDD+)*, *Reforestation*, *Anthropogenic removals* and *Carbon dioxide removal (CDR)*.

Agreement In this report, the degree of agreement within the scientific body of knowledge on a particular finding is assessed based on multiple lines of *evidence* (e.g., mechanistic understanding, theory, data, models, expert judgement) and expressed qualitatively (Mastrandrea et al., 2010). See also *Confidence*, *Likelihood*, *Uncertainty* and *Evidence*.

Agricultural or ecological drought See *Drought*.

Air mass A widespread body of air, the approximately homogeneous properties of which (1) have been established while that air was situated over a particular *region* of the Earth's surface, and (2) undergo specific modifications while in transit away from the source region (AMS, 2021).

Air pollution Degradation of air quality with negative effects on human health or the natural or built environment due to the introduction, by natural processes or human activity, into the *atmosphere* of substances (gases, *aerosols*) which have a direct (primary pollutants) or indirect (secondary pollutants) harmful effect. See also *Short-lived climate forcers (SLCFs)*.

Airborne fraction The fraction of total *CO_2* emissions (from fossil fuel and land use change) remaining in the *atmosphere*.

Albedo The proportion of sunlight (*solar radiation*) reflected by a surface or object, often expressed as a percentage. Clouds, snow and ice usually have high albedo; soil surfaces cover the albedo range from high to low; vegetation in the dry season and/or in *arid zones* can have high albedo, whereas photosynthetically active vegetation and the *ocean* have low albedo. The Earth's planetary albedo changes mainly through changes in cloudiness and of snow, ice, leaf area and *land cover*.

Alkalinity See *Total alkalinity*.

Altimetry A technique for measuring the height of the Earth's surface with respect to the geocentre of the Earth within a defined terrestrial reference frame (geocentric sea level).

Annular modes Hemispheric scale patterns of atmospheric variability characterized by opposing and synchronous fluctuations in sea-level pressure between the polar caps and midlatitudes, with a structure exhibiting a high degree of zonal symmetry, and with no real preferred timescales ranging from days to decades. In each hemisphere, these fluctuations reflect changes in the latitudinal position and strength of the mid-latitude jets and associated storm tracks. Annular modes are defined as the leading mode of variability of extratropical sea-level pressure or geopotential heights and are known as the *Northern Annular Mode (NAM)* and *Southern Annular Mode (SAM)* in the two hemispheres, respectively.

Northern Annular Mode (NAM) A see-saw latitudinal fluctuation in Northern Hemisphere sea-level pressure or geopotential height between the Arctic and the mid-latitudes. The NAM has some links with the *stratospheric polar vortex* and is related to the fluctuation in strength and latitude of the mean westerlies. Its variance is maximum in winter and its pattern has a strong regional expression in the North Atlantic being strongly correlated with the *North Atlantic Oscillation* index. The NAM is also known as the Arctic Oscillation (AO). In its positive phase, the NAM is characterized by anomalously low pressure over the Arctic and high pressure over the mid-latitudes/subtropics, with a strengthening of the zonally averaged westerly winds on their polar flank that confines colder air across the Arctic. The negative NAM phase is characterized by a more distorted wind pattern and jet meanders which increases storminess in the midlatitude regions. See Section AIV.2.1 in Annex IV of the AR6 WGI report.

Southern Annular Mode (SAM) The leading mode of *climate variability* of Southern Hemisphere sea-level pressure and geopotential height, which is associated with the strength and latitudinal shifts in the mid- to high-latitudes westerly wind belt. The SAM is also known as the Antarctic Oscillation (AAO). A positive SAM phase is defined as lower-than-normal pressures over the polar regions and higher-than-normal pressures in the southern mid-latitudes, with a contraction towards Antarctica and strengthening of the westerly wind belt. The negative SAM phase exhibits positive high latitude pressure anomalies, negative mid-latitude pressure anomalies and a weaker westerly flow expanded towards the equator. See Section AIV.2.2 in Annex IV of the AR6 WGI report. See also *Annular modes*.

Anomaly The deviation of a variable from its value averaged over a *reference period*.

Antarctic amplification See *Polar amplification*.

Antarctic ice sheet (AIS) See *Ice sheet*.

Antarctic oscillation (AAO) See *Southern Annular Mode (SAM)* (under *Annular modes*).

Anthropocene A proposed new geological epoch resulting from significant human-driven changes to the structure and functioning of the Earth System, including the *climate system*. Originally proposed in the Earth System science community in 2000, the proposed new epoch is undergoing a formalization process within the geological community based on the stratigraphic *evidence* that human activities have changed the Earth System to the extent of forming geological deposits with a signature that is distinct from those of the *Holocene*, and which will remain in the geological record. Both the stratigraphic and Earth System approaches to defining the Anthropocene consider the mid-20th Century to be the most appropriate starting date (Steffen et al., 2016), although others have been proposed and continue to be discussed. The Anthropocene concept has already been informally adopted by diverse disciplines and the public to denote the substantive influence of humans on the Earth System.

Anthropogenic Resulting from or produced by human activities.

Anthropogenic emissions Emissions of *greenhouse gases (GHGs)*, precursors of GHGs and *aerosols* caused by human activities. These activities include the burning of *fossil fuels*, *deforestation*, *land use and land use changes (LULUC)*, livestock production, fertilisation, waste management, and industrial processes. See also *Anthropogenic* and *Anthropogenic removals*.

Anthropogenic removals The withdrawal of greenhouse gases (GHGs) from the atmosphere as a result of deliberate human activities. These include enhancing biological sinks of CO_2 and using chemical engineering to achieve long term removal and storage. Carbon capture and storage (CCS), which alone does not remove CO_2 from the atmosphere, can help reduce atmospheric CO_2 from industrial and energy-related sources if it is combined with bioenergy production (BECCS), or if CO_2 is captured from the air directly and stored (DACCS). [Note: In the 2006 IPCC Guidelines for national GHG Inventories (IPCC, 2006), which are used in reporting of emissions to the UNFCCC, 'anthropogenic' land-related GHG fluxes are defined as all those occurring on 'managed land', i.e. 'where human interventions and practices have been applied to perform production, ecological or social functions'. However, some removals (e.g. removals associated with CO_2 fertilisation and N deposition) are not considered as 'anthropogenic', or are referred to as 'indirect' anthropogenic effects, in some of the scientific literature assessed in this report. As a consequence, the land-related net GHG emission estimates from global models included in this report are not necessarily directly comparable with LULUCF estimates in national GHG Inventories.] See also *Carbon dioxide removal (CDR)*, *Afforestation*, *Biochar*, *Enhanced weathering*, *Ocean alkalinisation / Ocean alkalinity enhancement*, *Reforestation* and *Soil carbon sequestration (SCS)*.

Anthropogenic subsidence Downward motion of the land surface induced by anthropogenic drivers (e.g., loading, extraction of hydrocarbons and/or groundwater, drainage, mining activities) causing sediment compaction or subsidence/deformation of the sedimentary sequence, or oxidation of organic material, thereby leading to relative sea level rise.

Apparent hydrological sensitivity (η_a) The change in global mean precipitation per degree Celsius of global mean temperature change with units of % per °C although can also be calculated as W m^{-2} per °C. See also *Hydrological sensitivity (η)*.

Arctic amplification See *Polar amplification*.

Arid zone Areas where vegetation growth is severely constrained due to limited water availability. For the most part, the native vegetation of arid zones is sparse. There is high rainfall variability, with annual averages below 300 mm. Crop farming in arid zones requires irrigation.

Aridity The state of a long-term climatic feature characterised by low average precipitation or available water in a region. Aridity generally arises from widespread persistent *atmospheric* subsidence or anticyclonic conditions, and from more localised subsidence in the lee side of mountains (adapted from Gbeckor-Kove, 1989; Türkeş, 1999). See also *Drought*.

Artificial ocean upwelling (AOUpw) Artificial ocean upwelling (AOUpw) is a potential carbon dioxide removal method that aims to artificially pump up cooler, nutrient-rich waters from deep in the ocean to the surface. The aim is to stimulate phytoplankton activity and thereby increase ocean CO_2 uptake.

Assets Natural or human-made resources that provide current or future utility, benefit, economic or intrinsic value to natural or human systems.

Atlantic Equatorial Mode See *Atlantic Zonal Mode (AZM)* (under *Tropical Atlantic Variability (TAV)*).

Atlantic Meridional Mode (AMM) See *Tropical Atlantic Variability (TAV)*.

Atlantic Meridional Overturning Circulation (AMOC) See *Meridional overturning circulation (MOC)*.

Atlantic Multidecadal Oscillation (AMO) See *Atlantic Multidecadal Variability (AMV)*.

Atlantic Multidecadal Variability (AMV) Large-scale fluctuations observed from one decade to the next in a variety of instrumental records and *proxy* reconstructions over the entire North Atlantic ocean and surrounding continents. Fingerprints of Atlantic Multidecadal Variability (AMV) can be found at the surface ocean, which is characterized by swings in basin-scale *sea surface temperature* anomalies reflecting the interaction with the *atmosphere*. The positive phase of the AMV is characterized by anomalous warming over the entire North Atlantic, with the strongest amplitude in the subpolar gyre and along sea-ice margin zones in the Labrador Sea and Greenland/Barents Sea and in the subtropical North Atlantic basin to a lower extent. In the AR6 WGI report, the term AMV is preferred to Atlantic Multidecadal Oscillation (AMO) used in previous IPCC reports because there is no preferred timescale of decadal variability as the term oscillation would indirectly implied. See Section AIV.2.7 in Annex IV of the AR6 WGI report.

Atlantic Niño See *Atlantic Zonal Mode (AZM)* (under *Tropical Atlantic Variability (TAV)*).

Atlantic Zonal Mode (AZM) See *Tropical Atlantic Variability (TAV)*.

Atmosphere The gaseous envelope surrounding the Earth, divided into five layers – the *troposphere* which contains half of the Earth's atmosphere, the *stratosphere*, the mesosphere, the thermosphere, and the exosphere, which is the outer limit of the atmosphere. The dry atmosphere consists almost entirely of nitrogen (78.1% volume mixing ratio) and oxygen (20.9% volume mixing ratio), together with a number of trace gases, such as argon (0.93 % volume mixing ratio), helium and radiatively active *greenhouse gases (GHGs)* such as *carbon dioxide* (CO_2) (0.04% volume mixing ratio), *methane* (CH_4), *nitrous oxide* (N_2O) and *ozone* (O_3). In addition, the atmosphere contains the GHG water vapour (H_2O), whose concentrations are highly variable (0-5% volume mixing ratio) as the sources (*evapotranspiration*) and sinks (precipitation) of water vapour show large spato-temporal variations, and atmospheric temperature exerts a strong constraint on the amount of water vapour an air parcel can hold. The atmosphere also contains clouds and *aerosols*. See also *Hydrological cycle*, *Stratosphere* and *Troposphere*.

Atmosphere-ocean general circulation model (AOGCM) See *General circulation model (GCM)*.

Atmospheric boundary layer The atmospheric layer adjacent to the Earth's surface that is affected by friction against that boundary surface, and possibly by transport of heat and other variables across that surface (AMS, 2021). The lowest 100 m of the boundary layer (about 10% of the boundary layer thickness), where mechanical generation of turbulence is dominant, is called the surface boundary layer or surface layer.

Atmospheric lifetime See *Lifetime*.

Atmospheric rivers (ARs) Long, narrow (up to a few hundred km wide), shallow (up to a few km deep) and transient corridors of strong horizontal water vapour transport that are typically associated with a low-level jet stream ahead of the cold front of an *extratropical cyclone* (Ralph et al., 2018).

Attribution Attribution is defined as the process of evaluating the relative contributions of multiple causal factors to a change or event with an assessment of confidence.

Australian and Maritime Continent monsoon (AusMCM) See *Global monsoon*.

Autotrophic respiration Respiration by photosynthetic (see *photosynthesis*) organisms (e.g., plants and algae).

Avalanche A mass of snow, ice, earth or rocks, or a mixture of these, falling down a mountainside.

Barystatic See *Sea level change (sea level rise/sea level fall)*.

Basal lubrication Reduction of friction at the base of an *ice sheet* or *glacier* due to lubrication by meltwater. This can allow the glacier or ice sheet to slide over its base. Meltwater may be produced by pressure-induced melting, friction or geothermal heat, or surface melt may drain to the base through holes in the ice.

Baseline/reference The baseline (or reference) is the state against which change is measured.See *Baseline scenario* (under *Scenario*) and *Baseline/reference (period)*. See also *Baseline period* (under *Reference period*) and *Reference period*.

Baseline period See *Reference period*.

Baseline scenario See *Scenario*.

Bifurcation point See *Tipping point*.

Biodiversity Biodiversity or biological diversity means the variability among living organisms from all sources including, among other things, terrestrial, marine and other aquatic *ecosystems*, and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems (UN, 1992). See also *Ecosystem* and *Ecosystem services*.

Bioenergy with carbon dioxide capture and storage (BECCS) Carbon dioxide capture and storage (CCS) technology applied to a *bioenergy* facility. Note that depending on the total emissions of the BECCS supply chain, *carbon dioxide* (CO_2) can be removed from the *atmosphere*. See also *Bioenergy*, *Carbon dioxide capture and storage (CCS)*, *Anthropogenic removals* and *Carbon dioxide removal (CDR)*.

Biogenic volatile organic compounds (BVOCs) See *Volatile organic compounds (VOCs)*.

Biogeophysical potential See *Mitigation potential*.

Biological (carbon) pump A series of *ocean* processes through which inorganic carbon (as *carbon dioxide*, CO_2) is fixed as organic matter by photosynthesis in sunlit surface water and then transported to the ocean interior, and possibly the sediment, resulting in the storage of carbon.

Biomass Organic material excluding the material that is fossilised or embedded in geological formations. Biomass may refer to the mass of organic matter in a specific area (ISO, 2014). See also *Bioenergy* and *Biofuel*.

Biosphere (terrestrial and marine) The part of the Earth System comprising all *ecosystems* and living organisms, in the *atmosphere*, on land (terrestrial biosphere) or in the oceans (marine biosphere), including derived dead organic matter, such as litter, soil organic matter and oceanic detritus.

Bipolar seesaw (also interhemispheric seesaw, interhemispheric asymmetry, hemispheric asymmetry) A phenomenon in which temperature changes in the northern and southern hemispheres are related but out of phase, generally inferred to represent a change in the magnitude or sign of net heat transport across the equator. Originally called hemispheric asymmetry and linked to changes in thermohaline overturning circulation on multi-millennial scales (Mix et al., 1986), later named bipolar seesaw and applied to millennial scales (Broecker, 1998) with a similar thermohaline mechanism (Stocker and Johnsen, 2003). See also *Meridional overturning circulation (MOC)* and *Deglacial or deglaciation or glacial termination*.

Black carbon (BC) A relatively pure form of carbon, also known as soot, arising from the incomplete combustion of fossil fuels, biofuel, and biomass. It only stays in the atmosphere for days or weeks. BC is a climate forcing agent with strong warming effect, both in the atmosphere and when deposited on snow or ice. See also *Aerosol* and *Atmosphere*.

Blocking Associated with persistent, slow-moving high-pressure systems that obstruct the prevailing westerly winds in the middle and high latitudes and the normal eastward progress of extratropical transient storm systems. It is an important component of the intraseasonal *climate variability* in the extratropics and can cause long-lived weather conditions such as cold spells in winter and summer *heat waves*.

Blue carbon Biologically-driven carbon fluxes and storage in marine systems that are amenable to management. Coastal blue carbon focuses on rooted vegetation in the coastal zone, such as tidal marshes, mangroves and seagrasses. These *ecosystems* have high carbon burial rates on a per unit area basis and accumulate carbon in their soils and sediments. They provide many non-climatic benefits and can contribute to ecosystem-based adaptation. If degraded or lost, coastal blue carbon ecosystems are likely to release most of their carbon back to the *atmosphere*. There is current debate regarding the application of the blue carbon concept to other coastal and non-coastal processes and ecosystems, including the open *ocean*. See also *Ecosystem services* and *Sequestration*.

Brewer-Dobson circulation The meridional overturning circulation of the *stratosphere* transporting air upward in the tropics, poleward to the winter hemisphere, and downward at polar and subpolar latitudes. The Brewer-Dobson circulation is driven by the interaction between upward propagating planetary waves and the mean flow.

Burden The total mass of a substance of concern in the *atmosphere*.

Business as usual (BAU) The term business as usual scenario has been used to describe a scenario that assumes no additional policies beyond those currently in place and that patterns of socio-economic development are consistent with recent trends. The term is now used less frequently than in the past. See also *Reference scenario* (under *Scenario*).

^{13}C Stable *isotope* of carbon having an atomic weight of approximately 13. Measurements of the ratio of ^{13}C/^{12}C in *carbon dioxide* molecules are used to infer the importance of different *carbon cycle* and *climate* processes and the size of the terrestrial carbon *reservoir*.

^{14}C Unstable *isotope* of carbon having an atomic weight of approximately 14, and a half-life of about 5700 years. It is often used for dating purposes going back some 40 kyr. Its variation in time is affected by the magnetic fields of the Sun and Earth, which influence its production from cosmic rays (see *Cosmogenic radioisotopes*).

Calcification The process of biologically precipitating calcium carbonate minerals to create organism shells, skeletons, otoliths, or other body structures. The chemical equation describing calcification is Ca^{2+} (aq) + $2HCO_3^-$ (aq) → $CaCO_3$(s) + CO_2 + H_2O. Aragonite and calcite are two common crystalline forms of biologically precipitated calcium carbonate minerals that have different solubilities.

Calving (of glaciers or ice sheets) The breaking off of discrete pieces of ice from a *glacier, ice sheet* or an *ice shelf* into lake or seawater, producing *icebergs*. This is a form of mass loss from an ice body.

Canopy temperature The temperature within the canopy of a vegetation structure.

Carbon budget Refers to two concepts in the literature: (1) an assessment of carbon cycle *sources* and *sinks* on a global level, through the synthesis of evidence for *fossil-fuel* and cement emissions, emissions and removals associated with *land use* and *land use change*, ocean and natural land sources and sinks of *carbon dioxide* (CO_2), and the resulting change in atmospheric CO_2 concentration. This is referred to as the Global Carbon Budget; (2) the maximum amount of cumulative net global *anthropogenic* CO_2 emissions that would result in limiting *global warming* to a given level with a given probability, taking into account the effect of other anthropogenic climate *forcers*. This is referred to as the Total Carbon Budget when expressed starting from the *pre-industrial* period, and as the Remaining Carbon Budget when expressed from a recent specified date.

Note 1: Net anthropogenic CO_2 emissions are anthropogenic CO_2 emissions minus anthropogenic CO_2 removals. See also *Carbon Dioxide Removal (CDR)*.

Note 2: The maximum amount of cumulative net global anthropogenic CO_2 emissions is reached at the time that annual net anthropogenic CO_2 emissions reach zero.

Note 3: The degree to which anthropogenic climate forcers other than CO_2 affect the Total Carbon Budget and Remaining Carbon Budget depends on human choices about the extent to which these forcers are mitigated and their resulting *climate* effects.

Note 4: The notions of a Total Carbon Budget and Remaining Carbon Budget are also being applied in parts of the scientific literature and by some entities at regional, national, or sub-national level. The distribution of global budgets across individual different entities and emitters depends strongly on considerations of equity and other value judgements.

Carbon cycle The flow of carbon (in various forms, e.g., as *carbon dioxide* (CO_2), carbon in biomass, and carbon dissolved in the ocean as carbonate and bicarbonate) through the atmosphere, hydrosphere, terrestrial and marine biosphere and lithosphere. In this report, the reference unit for the global carbon cycle is $GtCO_2$ or GtC (one Gigatonne = 1 Gt = 10^{15} grams; 1GtC corresponds to 3.667 $GtCO_2$).

Carbon dioxide (CO_2) A naturally occurring gas, CO_2 is also a by-product of burning fossil fuels (such as oil, gas and coal), of burning *biomass*, of *land use* changes (LUC) and of industrial processes (e.g., cement production). It is the principal *anthropogenic* greenhouse gas (GHG) that affects the Earth's radiative balance. It is the reference gas against which other GHGs are measured and therefore has a Global Warming Potential (GWP) of 1. See also *Land use* and *Land-use change (LUC)*.

Carbon dioxide (CO_2) fertilisation The increase of plant photosynthesis and water-use efficiency in response to increased atmospheric *carbon dioxide* (CO_2) concentration. Whether this increased photosynthesis translates into increased plant growth and carbon storage on land depends on the interacting effects of temperature, moisture and nutrient availability.

Carbon dioxide capture and storage (CCS) A process in which a relatively pure stream of *carbon dioxide* (CO_2) from industrial and energy-related sources is separated (captured), conditioned, compressed and transported to a storage location for long-term isolation from the *atmosphere*. Sometimes referred to as Carbon Capture and Storage. See also *Bioenergy with carbon dioxide capture and storage (BECCS)*, *Carbon dioxide capture and utilisation (CCU)*, *Sequestration*, *Anthropogenic removals* and *Carbon dioxide removal (CDR)*.

Carbon dioxide removal (CDR) *Anthropogenic* activities removing *carbon dioxide* (CO_2) from the *atmosphere* and durably storing it in geological, terrestrial, or *ocean* reservoirs, or in products. It includes existing and potential anthropogenic enhancement of biological or geochemical CO_2 *sinks* and direct air capture and storage, but excludes natural CO_2 *uptake* not directly caused by human activities. See also *Anthropogenic removals, Afforestation, Biochar*, *Enhanced weathering, Ocean alkalinisation / Ocean alkalinity enhancement*, *Reforestation, Soil carbon sequestration (SCS)*, *Bioenergy with carbon dioxide capture and storage (BECCS)* and *Carbon dioxide capture and storage (CCS)*.

Carbon neutrality Condition in which anthropogenic CO_2 emissions associated with a subject are balanced by anthropogenic CO_2 removals. The subject can be an entity such as a country, an organisation, a district or a commodity, or an activity such as a service and an event. Carbon neutrality is often assessed over the life cycle including indirect ("scope 3") emissions, but can also be limited to the emissions and removals, over a specified period, for which the subject has direct control, as determined by the relevant scheme.

Note 1: Carbon neutrality and *net zero CO_2 emissions* are overlapping concepts. The concepts can be applied at global or sub-global scales (e.g., regional, national and sub-national). At a global scale, the terms carbon neutrality and net zero CO_2 emissions are equivalent. At sub-global scales, net zero CO_2 emissions is generally applied to emissions and removals under direct control or territorial responsibility of the reporting entity, while carbon neutrality generally includes emissions and removals within and beyond the direct control or territorial responsibility of the reporting entity. Accounting rules specified by GHG programmes or schemes can have a significant influence on the quantification of relevant CO_2 emissions and removals.

Note 2: In some cases achieving carbon neutrality may rely on the supplementary use of *offsets* to balance emissions that remain after actions by the reporting entity are taken into account.

See also *Greenhouse gas neutrality, Land use, land-use change and forestry (LULUCF)* and *Net zero CO_2 emissions*.

Carbon sequestration See *Sequestration*.

Carbon sink See *Sink*.

Carbon source See *Source*.

Carbon-climate feedback See *Climate-carbon cycle feedback*.

Carbonaceous aerosol Aerosol consisting predominantly of organic substances and *black carbon*.

Carbonate counter pump See *Carbonate pump*.

Carbonate pump Ocean carbon fixation through the biological formation of carbonates, primarily by plankton that generate bio-mineral particles that sink to the *ocean* interior, and possibly the sediment. It is also called carbonate counter-pump, since the formation of calcium carbonate ($CaCO_3$) is accompanied by the release of *carbon dioxide (CO_2)* to surrounding water and subsequently to the *atmosphere*.

Catchment An area that collects and drains precipitation.

Cenozoic Era The third and current geological Era, which began 66.0 Ma. It comprises the Paleogene, Neogene and Quaternary Periods.

Central Pacific El Niño See *El Niño-Southern Oscillation (ENSO)*.

Chaotic A *dynamical system* such as the *climate system*, governed by nonlinear deterministic equations (see *Nonlinearity*), may exhibit erratic or chaotic behaviour in the sense that very small changes in the initial state of the system in time lead to large and apparently unpredictable changes in its temporal evolution. Such chaotic behaviour limits the *predictability* of the state of a nonlinear dynamical system at specific future times, although changes in its statistics may still be predictable given changes in the system parameters or boundary conditions.

Charcoal Material resulting from charring of *biomass*, usually retaining some of the microscopic texture typical of plant tissues; chemically it consists mainly of carbon with a disturbed graphitic structure, with lesser amounts of oxygen and hydrogen.

Chlorofluorocarbons (CFCs) A chlorofluorocarbon is an organic compound that contains chlorine, carbon, hydrogen, and fluorine and is used for refrigeration, air conditioning, packaging, plastic foam, insulation, solvents, or aerosol propellants. Because they are not destroyed in the lower atmosphere, CFCs drift into the upper atmosphere where, given suitable conditions, they break down ozone (O_3). It is one of the greenhouse gases (GHGs) covered under the 1987 Montreal Protocol as a result of which manufacturing of these gases has been phased out and they are being replaced by other compounds, including hydrofluorocarbons (HFCs) which are GHGs covered under the Kyoto Protocol.

Chronology Arrangement of events according to dates or times of occurrence.

Cirrus cloud thinning (CCT) See *Solar radiation modification (SRM)*.

Clathrate (methane) A partly frozen slushy mix of *methane* gas and ice, usually found in sediments.

Clausius-Clapeyron equation/relationship The thermodynamic relationship between temperature and the vapour pressure of a substance in which two phases of the substance are in equilibrium (e.g., liquid water and *water vapour*). For gases such as water vapour, this relation gives the increase in equilibrium (or saturation) vapour pressure per unit change in air temperature.

Climate Climate in a narrow sense is usually defined as the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organization (WMO). The relevant quantities are most often surface variables such as temperature, precipitation and wind. Climate in a wider sense is the state, including a statistical description, of the *climate system*.

Climate change A change in the state of the *climate* that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external *forcings* such as modulations of the solar cycles, volcanic eruptions and persistent *anthropogenic* changes in the composition of the *atmosphere* or in *land use*. Note that the *United Nations Framework Convention on Climate Change (UNFCCC)*, in its Article 1, defines climate change as: 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods'. The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition and *climate variability* attributable to natural causes. See also *Climate variability*, *Detection and attribution*, *Global warming* and *Ocean acidification (OA)*.

Climate change commitment Climate change commitment is defined as the unavoidable future *climate change* resulting from inertia in the geophysical and socio-economic systems. Different types of climate change commitment are discussed in the literature (see subterms). Climate change commitment is usually quantified in terms of the further change in temperature, but it includes other future changes, for example in the *hydrological cycle*, in *extreme weather events*, in extreme climate events, and in sea level.

Constant composition commitment The constant composition commitment is the remaining *climate change* that would result if atmospheric composition, and hence *radiative forcing*, were held fixed at a given value. It results from the thermal inertia of the ocean and slow processes in the cryosphere and land surface.

Constant emissions commitment The constant emissions commitment is the committed *climate change* that would result from keeping *anthropogenic emissions* constant.

Zero emissions commitment The zero emissions commitment is an estimate of the subsequent *global warming* that would result after *anthropogenic emissions* are set to zero. It is determined by both inertia in physical *climate system* components (*ocean*, *cryosphere*, land surface) and *carbon cycle* inertia. In its widest sense it refers to emissions of each climate *forcer* including *greenhouses gases*, *aerosols* and their pre-cursors. The climate response to this can be complex due to the different timescale of response of each climate forcer. A specific sub-category of zero emissions commitment is the Zero CO_2 Emissions Commitment which refers to the climate system response to CO_2 emissions after setting these to net zero. The CO_2-only definition is of specific use in estimating *remaining carbon budgets*.

Climate extreme (extreme weather or climate event) The occurrence of a value of a weather or *climate* variable above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variable. By definition, the characteristics of what is called *extreme weather* may vary from place to place in an absolute sense. When a pattern of extreme weather persists for some time, such as a season, it may be classified as an extreme climate event, especially if it yields an average or total that is itself extreme (e.g., high temperature, *drought*, or heavy rainfall over a season). For simplicity, both extreme weather events and extreme climate events are referred to collectively as 'climate extremes'.

Climate feedback An interaction in which a perturbation in one *climate* quantity causes a change in a second and the change in the second quantity ultimately leads to an additional change in the first. A negative feedback is one in which the initial perturbation is weakened by the changes it causes; a positive feedback is one in which the initial perturbation is enhanced. The initial perturbation can either be externally forced or arise as part of internal variability. See also *Climate-carbon cycle feedback, Cloud feedback* and *Ice-albedo feedback*.

Climate feedback parameter A way to quantify the radiative response of the *climate system* to a global surface temperature change induced by a *radiative forcing*. It is quantified as the change in net energy flux at the top of atmosphere for a given change in annual global surface temperature. It has units of W m^{-2} $°C^{-1}$.

Climate forecast See *Climate prediction*.

Climate index A time series constructed from climate variables that provides an aggregate summary of the state of the *climate system*. For example, the difference between sea level pressure in Iceland and the Azores provides a simple yet useful historical *NAO* index. Because of their optimal properties, climate indices are often defined using *principal components* – linear combinations of climate variables at different locations that have maximum variance subject to certain normalisation constraints (e.g., the *NAM* and *SAM* indices which are principal components of Northern Hemisphere and Southern Hemisphere gridded pressure anomalies, respectively). Definitions of observational indices for Modes of variability can be found in the Annex VI.

Climate indicator Measures of the *climate system* including large-scale variables and climate *proxies*. See also *Global surface temperature indicators* and *Climate metrics*.

Key climate indicators Key indicators constitute a finite set of distinct variables that may collectively point to important overall changes in the *climate system* of broad societal relevance across the atmospheric, oceanic, cryospheric and biospheric domains, with land as an implicit cross-cutting theme. Taken together, these indicators would be expected to both have changed and continue to change in the future in a coherent and consistent manner. See Cross-Chapter Box 2.2, Table 1 in the AR6 WGI report.

Climate information Information about the past, current state, or future of the *climate system* that is relevant for *mitigation, adaptation* and *risk management*. It may be tailored or “co-produced” for specific contexts, taking into account users' needs and values.

Climate metrics Measures of aspects of the overall *climate system* response to *radiative forcing*, such as *equilibrium climate sensitivity (ECS)*, *transient climate response (TCR)*, *transient climate response to cumulative CO_2 emissions (TCRE)* and the airborne fraction of *anthropogenic* carbon dioxide. See also *Greenhouse gas emission metric*, *Climate indicator* and *Key climate indicators* (under *Climate indicator*).

Climate model A qualitative or quantitative representation of the climate system based on the physical, chemical and biological properties of its components, their interactions and feedback processes and accounting for some of its known properties. The climate system can be represented by models of varying complexity; that is, for any one component or combination of components a spectrum or hierarchy of models can be identified, differing in such aspects as the number of spatial dimensions, the extent to which physical, chemical or biological processes are explicitly represented, or the level at which empirical parametrisations are involved. There is an evolution towards more complex models with interactive chemistry and biology. Climate models are applied as a research tool to study and simulate the climate and for operational purposes, including monthly, seasonal and interannual climate predictions. See also *Chemistry-climate model*, *Earth system model (ESM)*, *Earth system model of intermediate complexity (EMIC)*, *Energy balance model (EBM)*, *Simple climate model (SCM)*, *Regional climate model (RCM)*, *Dynamic global vegetation model (DGVM)*, *General circulation model (GCM)* and *Emulators*.

Climate pattern A set of spatially varying coefficients obtained by "projection" (regression) of *climate* variables onto a *climate index* time series. When the climate index is a principal component, the climate pattern is an eigenvector of the covariance matrix, referred to as an Empirical Orthogonal Function (EOF) in climate science.

Climate prediction A climate prediction or climate forecast is the result of an attempt to produce (starting from a particular state of the *climate system*) an estimate of the actual evolution of the climate in the future, for example, at seasonal, interannual or decadal time scales. Because the future evolution of the climate system may be highly sensitive to initial conditions, has chaotic elements and is subject to *natural variability*, such predictions are usually probabilistic in nature.

Climate projection Simulated response of the *climate system* to a *scenario* of future emissions or concentrations of *greenhouse gases (GHGs)* and *aerosols* and changes in *land use*, generally derived using *climate models*. Climate projections are distinguished from *climate predictions* by their dependence on the emission/concentration/radiative forcing *scenario* used, which is in turn based on assumptions concerning, for example, future socio-economic and technological developments that may or may not be realised.

Climate response A general term for how the *climate system* responds to a *radiative forcing*.

Climate scenario A plausible and often simplified representation of the future *climate*, based on an internally consistent set of climatological relationships that has been constructed for explicit use in investigating the potential consequences of *anthropogenic* climate change, often serving as input to impact models. *Climate projections* often serve as the raw material for constructing climate scenarios, but climate scenarios usually require additional information such as the observed current climate. See also *Regional climate scenario*.

Climate sensitivity The change in the surface temperature in response to a change in the atmospheric carbon dioxide (CO_2) concentration or other radiative forcing. See also *Climate feedback parameter*.

Earth system sensitivity The equilibrium surface temperature response of the coupled *atmosphere*-ocean-*cryosphere*-vegetation-*carbon cycle* system to a doubling of the atmospheric carbon dioxide (*CO_2*) concentration is referred to as Earth System sensitivity. Because it allows ice sheets to adjust to the external perturbation, it may differ substantially from the *equilibrium climate sensitivity* derived from coupled atmosphere-ocean models.

Equilibrium climate sensitivity (ECS) The equilibrium (steady state) change in the surface temperature following a doubling of the atmospheric *carbon dioxide (CO_2)* concentration from *pre-industrial* conditions.

Transient climate response (TCR) The surface temperature response for the hypothetical scenario in which atmospheric *carbon dioxide (CO_2)* increases at 1% yr^{-1} from *pre-industrial* to the time of a doubling of atmospheric CO_2 concentration (year 70).

Transient climate response to cumulative CO_2 emissions (TCRE) The transient surface temperature change per unit cumulative *carbon dioxide (CO_2)* emissions, usually 1000 GtC. TCRE combines both information on the airborne fraction of cumulative CO_2 emissions (the fraction of the total CO_2 emitted that remains in the *atmosphere*, which is determined by *carbon cycle* processes) and on the *transient climate response (TCR)*.

Climate services Climate services involve the provision of climate information in such a way as to assist decision-making. The service includes appropriate engagement from users and providers, is based on scientifically credible information and expertise, has an effective access mechanism, and responds to user needs (Hewitt et al., 2012).

Climate simulation ensemble A group of parallel model simulations characterising historical *climate* conditions, *climate predictions*, or *climate projections*. Variation of the results across the ensemble members may give an estimate of modelling-based uncertainty. Ensembles made with the same model but different initial conditions characterise the uncertainty associated with internal *climate variability*, whereas multi-model ensembles including simulations by several models also include the effect of model differences. Perturbed parameter ensembles, in which model parameters are varied in a systematic manner, aim to assess the uncertainty resulting from internal model specifications within a single model. Remaining sources of uncertainty unaddressed with model ensembles are related to systematic model errors or biases, which may be assessed from systematic comparisons of model simulations with observations wherever available.

Climate system The global system consisting of five major components: the *atmosphere*, the *hydrosphere*, the *cryosphere*, the *lithosphere* and the *biosphere* and the interactions between them. The climate system changes in time under the influence of its own internal dynamics and because of *external forcings* such as volcanic eruptions, solar variations, orbital forcing, and *anthropogenic* forcings such as the changing composition of the atmosphere and *land-use change*.

Climate threshold A limit within the *climate system* (or its *forcing*) beyond which the behaviour of the system is qualitatively changed. See also *Abrupt climate change* and *Tipping point*.

Climate variability Deviations of climate variables from a given mean state (including the occurrence of extremes, etc.) at all spatial and temporal scales beyond that of individual weather events. Variability may be intrinsic, due to fluctuations of processes internal to the *climate system* (*internal variability*), or extrinsic, due to variations in natural or anthropogenic *external forcing* (forced variability). See also *Climate change* and *Modes of climate variability*.

Decadal variability Decadal variability refers to *climate variability* on decadal time scales. See also *Pacific Decadal Variability (PDV)*, *Atlantic Multi-decadal Oscillation/Variability (AMO/AMV)* and *Pacific Decadal Oscillation (PDO)* (under *Pacific Decadal Variability (PDV)*).

Internal variability Fluctuations of the climate dynamical system when subject to a constant or periodic external forcing (such as the annual cycle). See also *Climate variability*.

Natural variability Natural variability refers to climatic fluctuations that occur without any human influence, i.e. *internal variability* combined with the response to external natural factors such as volcanic eruptions, changes in *solar activity* and, on longer time-scales, orbital effects and plate tectonics. See also *Orbital forcing*.

Climate velocity The speed at which isolines of a specified climate variable travel across landscapes or seascapes due to changing climate. For example, climate velocity for temperature is the speed at which isotherms move due to changing climate (km yr^{-1}) and is calculated as the temporal change in temperature (°C yr^{-1}) divided by the current spatial gradient in temperature (°C km^{-1}). It can be calculated using additional climate variables such as precipitation or can be based on the climatic niche of organisms.

Climate-carbon cycle feedback A *climate feedback* involving changes in the properties of land and ocean *carbon cycle* in response to *climate change*. In the ocean, changes in oceanic temperature and circulation could affect the *atmosphere*-ocean CO_2 flux; on the continents, *climate change* could affect plant *photosynthesis* and soil microbial *respiration* and hence the flux of CO_2 between the *atmosphere* and the land *biosphere*.

Climatic impact-driver (CID) Climatic impact-drivers (CIDs) are physical *climate system* conditions (e.g., means, events, extremes) that affect an element of society or *ecosystems*. Depending on system tolerance, CIDs and their changes can be detrimental, beneficial, neutral, or a mixture of each across interacting system elements and regions. See also *Risk*, *Hazard* and *Impacts (consequences, outcomes)*.

Cloud condensation nuclei (CCN) The subset of *aerosol* particles that serve as an initial site for the condensation of liquid water, which can lead to the formation of cloud droplets, under typical cloud formation conditions. The main factor that determines which *aerosol* particles are CCN at a given supersaturation is their size.

Cloud feedback A climate feedback involving changes in any of the properties of clouds as a response to a change in the local or *global mean surface temperature*. Understanding cloud feedbacks and determining their magnitude and sign require an understanding of how a change in *climate* may affect the spectrum of cloud types, the cloud fraction and height, the radiative properties of clouds, and finally the Earth's radiation budget. At present, cloud feedbacks remain the largest source of *uncertainty* in *climate sensitivity* estimates.

Cloud radiative effect The *radiative effect* of clouds relative to the identical situation without clouds. In previous IPCC reports this was called cloud *radiative forcing*, but that terminology is inconsistent with other uses of the forcing term and is not maintained in this report.

Cloud-resolving models (CRMs) Numerical models that are that are of high enough resolution and have the necessary physics to represent the dynamical and physical processes of cloud formation.

CMIP6 See *Coupled Model Intercomparison Project (CMIP)*.

CO_2 equivalent (CO_2-eq) emission The amount of *carbon dioxide (CO_2)* emission that would have an equivalent effect on a specified key measure of *climate change*, over a specified time horizon, as an emitted amount of another *greenhouse gas (GHG)* or a mixture of other GHGs. For a mix of GHGs it is obtained by summing the CO_2-equivalent emissions of each gas. There are various ways and time horizons to compute such equivalent emissions (see *greenhouse gas emission metric*). CO_2-equivalent emissions are commonly used to compare emissions of different GHGs, but should not be taken to imply that these emissions have an equivalent effect across all key measures of climate change. [Note: Under the Paris Rulebook [Decision 18/CMA.1, annex, paragraph 37], parties have agreed to use GWP100 values from the IPCC AR5 or GWP100 values from a subsequent IPCC Assessment Report to report aggregate emissions and removals of GHGs. In addition, parties may use other metrics to report supplemental information on aggregate emissions and removals of GHGs.]

Coast The *land* near to the sea. The term ‘coastal’ can refer to that land (e.g., as in ‘coastal communities’), or to that part of the marine environment that is strongly influenced by land-based processes. Thus, coastal seas are generally shallow and near-shore. The landward and seaward limits of the coastal zone are not consistently defined, neither scientifically nor legally. Thus, coastal waters can either be considered as equivalent to territorial waters (extending 12 nautical miles / 22.2 km from mean low water), or to the full Exclusive Economic Zone, or to *shelf seas*, with less than 200 m water depth.

Cold days/cold nights Days where maximum temperature, or nights where minimum temperature, falls below the 10th *percentile*, where the respective temperature distributions are generally defined with respect to the 1961-1990 reference period. For the corresponding indices, see Box 2.4.

Common era (CE) CE (Common Era) and BCE (Before the Common Era) are alternative names for AD (Anno Domini) and BC (Before Christ) in the Gregorian international standard calendar-year system. CE/BCE are preferred in an international context because they are neutral with respect to religion. The numbering of calendar years is the same under both terminologies. The CE began in year AD 1 and extends to the present day.

Compatible emissions Earth System Models that simulate the land and ocean *carbon cycle* can calculate *CO_2* emissions that are compatible with a given atmospheric CO_2 concentration trajectory. The compatible emissions over a given period of time are equal to the increase of carbon over that same period of time in the sum of the three active *reservoirs*: the *atmosphere*, the land and the ocean.

Compound events See *Compound weather/climate events*.

Compound weather/climate events The combination of multiple *drivers* and/or *hazards* that contributes to societal and/or environmental *risk* (Zscheischler et al., 2018).

Concentrations scenario See *Scenario*.

Confidence The robustness of a finding based on the type, amount, quality and consistency of *evidence* (e.g., mechanistic understanding, theory, data, models, expert judgment) and on the degree of *agreement* across multiple lines of evidence. In this report, confidence is expressed qualitatively (Mastrandrea et al., 2010).

Constant composition commitment See *Climate change commitment*.

Constant emissions commitment See *Climate change commitment*.

Convection Vertical motion driven by buoyancy forces arising from static instability, usually caused by near-surface cooling or increases in salinity in the case of the ocean and near-surface warming or cloud-top radiative cooling in the case of the *atmosphere*. In the atmosphere, convection gives rise to cumulus clouds and precipitation and is effective at both scavenging and vertically transporting chemical species. In the ocean, convection can carry surface waters to deep within the ocean.

Convection-permitting models See *Cloud-resolving models (CRMs)*.

Coral bleaching Loss of coral pigmentation through the loss of intracellular symbiotic algae (known as zooxanthellae) and/or loss of their pigments.

Coral reef An underwater *ecosystem* characterised by structure-building stony corals. Warm-water coral reefs occur in shallow seas, mostly in the tropics, with the corals (animals) containing algae (plants) that depend on light and relatively stable temperature conditions. Cold-water coral reefs occur throughout the world, mostly at water depths of 50-500 m. In both kinds of reef, living corals frequently grow on older, dead material, predominantly made of calcium carbonate ($CaCO_3$). Both warm and cold-water coral reefs support high biodiversity of fish and other groups, and are considered to be especially vulnerable to *climate change*.

Cosmogenic radioisotopes Rare radioactive *isotopes* that are created by the interaction of a high-energy cosmic ray particles with atoms nuclei. They are often used as indicator of *solar activity* which modulates the cosmic rays intensity or as tracers of atmospheric transport processes, and are also called cosmogenic radionuclides.

Coupled Model Intercomparison Project (CMIP) A *climate* modelling activity from the World Climate

Research Programme (WCRP) which coordinates and archives *climate model* simulations based on shared model inputs by modelling groups from around the world. The CMIP3 multi-model data set includes projections using Special Report on Emissions Scenarios (SRES) scenarios. The CMIP5 data set includes projections using the *Representative Concentration Pathways (RCP)*. The CMIP6 phase involves a suite of common model experiments as well as an ensemble of CMIP-endorsed Model Intercomparison Projects (MIPs).

Cryosphere The components of the Earth System at and below the *land* and *ocean* surface that are frozen, including snow cover, *glaciers*, *ice sheets*, *ice shelves*, *icebergs*, *sea ice*, lake ice, river ice, *permafrost* and seasonally *frozen ground*.

Cumulative emissions The total amount of emissions released over a specified period of time. See also *Carbon budget* and *Transient climate response to cumulative CO_2 emissions (TCRE)* (under *Climate sensitivity*).

Dansgaard-Oeschger events (D-O events) Millennial-scale events first characterized in Greenland *ice cores* as abrupt warming from a cold *stadial* state to a warmer interstadial state, followed by a return to a cold stadial state (Dansgaard et al., 1993), and traced in the ocean via deposits of ice-rafted sand grains (Bond and Lotti, 1995). Named after Willi Dansgaard and Hans Oeschger by Bond and Lotti (1995). An example of a D-O event during the most recent *deglacial* transition is the Bølling-Allerød interstadial. Warm D-O events in Greenland are associated with cooling events in Antarctica (Blunier and Brook, 2001) through ocean *thermohaline circulation* (Stocker and Johnsen, 2003). See also *Bipolar seesaw (also interhemispheric seesaw, interhemispheric asymmetry, hemispheric asymmetry)*.

Data assimilation Mathematical method used to combine different sources of information in order to produce the best possible estimate of the state of a system. This information usually consists of observations of the system and a numerical model of the system evolution. Data assimilation techniques are used to create initial conditions for weather forecast models, and to construct *reanalyses* describing the trajectory of the *climate system* over the time period covered by the observations.

Dead zones Extremely *hypoxic* (i.e., low-oxygen) areas in oceans and lakes, caused by excessive nutrient input from human activities coupled with other factors that deplete the oxygen required to support many marine organisms in bottom and near-bottom water.

Decadal predictability Decadal predictability refers to the notion of predictability of the climate system on a decadal time scale. See also *Climate prediction*, *Predictability* and *Decadal prediction*.

Decadal prediction A decadal prediction is a climate prediction on decadal time scales.

Decadal variability See *Climate variability*.

Deep uncertainty See *Uncertainty*.

Deforestation Conversion of forest to non-forest. [Note: For a discussion of the term forest and related terms such as afforestation, reforestation and deforestation, see the 2006 IPCC Guidelines for National Greenhouse Gas Inventories and their 2019 Refinement, and information provided by the United Nations Framework Convention on Climate Change (IPCC, 2006, 2019, UNFCCC, 2021a, 2021b).]

See also *Reducing Emissions from Deforestation and Forest Degradation (REDD+)*, *Afforestation* and *Reforestation*.

Deglacial or deglaciation or glacial termination The period of transition from *glacial* conditions at the end of a glacial period to interglacial conditions characterized by a reduction in land ice volume. Gradual changes can be punctuated by *abrupt changes* linked to *stadial* / interstadial events and *bipolar seesaw* aspect. The last deglacial transition occurred between about 18,000 and 11,000 years ago. It encompasses rapid events such as *Meltwater Pulse 1A (MWP-1A)* and millennial-scale fluctuations such as the *Younger Dryas*. See also *Glacial-interglacial cycles* and *Ice age*.

Detection Detection of change is defined as the process of demonstrating that climate or a system affected by climate has changed in some defined statistical sense, without providing a reason for that change. An identified change is detected in observations if its likelihood of occurrence by chance due to internal variability alone is determined to be small, for example, <10%.

Detection and attribution See *Detection* and *Attribution*.

Diatoms Silt-sized algae that live in surface waters of lakes, rivers and oceans and form shells of opal. Their species distribution in ocean cores is often related to past *sea surface temperatures*.

Dimensions of integration In IPCC AR6, concepts used to synthesize the knowledge of *climate change* across not just the physical sciences, but also across *impact* and *adaptation*, and *mitigation* research. The concept of 'dimensions of integration' includes (i) emission and c*oncentration scenarios* underlying the climate change *projections* assessed in this report, (ii) levels of projected global mean temperature change and (iii) total amounts of cumulative carbon emissions for projections.

Direct (aerosol) effect See *Aerosol-radiation interaction*.

Direct air capture (DAC) Chemical process by which a pure carbon dioxide (CO_2) stream is produced by capturing CO_2 from the ambient air. See also *Direct air carbon dioxide capture and storage (DACCS)*, *Anthropogenic removals* and *Carbon dioxide removal (CDR)*.

Direct emissions Emissions that physically arise from activities within well-defined boundaries of, for instance, a region, an economic sector, a company, or a process. See also *Indirect emissions*.

Disaster A 'serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability and capacity, leading to one or more of the following: human, material, economic and environmental losses and impacts' (UNGA, 2016). See also *Exposure*, *Hazard*, *Risk* and *Vulnerability*.

Discharge (of ice) See *Mass balance / budget (of glaciers or ice sheets)*.

Dissolved inorganic carbon The combined total of different types of non-organic carbon in (seawater) solution, comprising carbonate (CO_3^{2-}), bicarbonate (HCO_3^-), carbonic acid (H_2CO_3) and *carbon dioxide (CO_2)*.

Diurnal temperature range (DTR) The difference between the maximum and minimum temperature during a 24-hour period.

Dobson unit (DU) A unit to measure the total amount of *ozone* in a vertical column above the Earth's surface (total column ozone). The number of Dobson Units is the thickness in units of 10^{-5} m that the *ozone* column would occupy if compressed into a layer of uniform density at a pressure of 1013 hPa and a temperature of 0°C. One DU corresponds to a column of ozone containing 2.69×10^{20} molecules per square metre. A typical value for the amount of ozone in a column of the Earth's *atmosphere*, although very variable, is 300 DU.

Downscaling A method that derives local- to regional-scale information from larger-scale models or data analyses. Two main methods exist: dynamical downscaling and empirical/statistical downscaling. The dynamical method uses the output of regional climate models, global models with variable spatial resolution, or high-resolution global models. The empirical/statistical methods are based on observations and develop statistical relationships that link the large-scale atmospheric variables with local/regional climate variables. In all cases, the quality of the driving model remains an important limitation on quality of the downscaled information. The two methods can be combined, e.g., applying empirical/statistical downscaling to the output of a regional climate model, consisting of a dynamical downscaling of a global climate model.

Drought An exceptional period of water shortage for existing *ecosystems* and the human population (due to low rainfall, high temperature, and/or wind). See also *Plant evaporative stress*.

Agricultural or ecological drought Agricultural or ecological drought (depending on the affected *biome*): a period with abnormal *soil moisture* deficit, which results from combined shortage of precipitation and excess *evapotranspiration*, and during the growing season impinges on crop production or *ecosystem* function in general.

Hydrological drought A period with large *runoff* and water deficits in rivers, lakes and reservoirs.

Meteorological drought A period with an abnormal precipitation deficit.

Dynamic global vegetation model (DGVM) A model that simulates vegetation development and dynamics through space and time, as driven by climate and other environmental changes.

Dynamical downscaling See *Downscaling*.

Dynamical system A process or set of processes whose evolution in time is governed by a set of deterministic physical laws. The *climate system* is a dynamical system.

Early Eocene Climatic Optimum (EECO) The EECO is a period of geological time that occurred about 53 to 49 million years ago, during the Eocene Epoch. Continental positions at this time were somewhat different to present due to tectonic plate movements. Geological data indicate that the EECO was a period of relatively high atmospheric CO_2 concentrations (about 1150-2500 ppmv) and relative warmth (*global mean surface temperature* was about 10-18 °C above the 1850-1900 reference), and polar *ice sheets* were absent.

Earth system model (ESM) A coupled *atmosphere*–ocean general circulation model (AOGCM) in which a representation of the *carbon cycle* is included, allowing for interactive calculation of atmospheric *carbon dioxide* (CO_2) or compatible emissions. Additional components (e.g., atmospheric chemistry, *ice sheets*, dynamic vegetation, nitrogen cycle, but also urban or crop models) may be included. See also *Earth system model of intermediate complexity (EMIC)*.

Earth system model of intermediate complexity (EMIC) Earth system models of intermediate complexity (EMIC) represent *climate* processes at a lower *resolution* or in a simpler, more idealised fashion than an *Earth system model (ESM)*.

Earth's energy budget For a given time period, Earth's energy budget expresses the balance between *total earth system heating*, the time-integrated *effective radiative forcing* and time-integrated *Earth's radiative response*. Units: Joules. See also *Earth's top of atmosphere energy budget*, *Earth's energy imbalance*, *Earth's surface energy budget*, *Earth's radiative response*, *Earth's energy flows* and *Earth system heating*.

Earth's energy flows The time-mean (or representative) energy exchanges within the *climate system* (including energy energy exchanges at the surface and top-of-atmosphere). This also includes horizontal ocean and atmospheric heat transports. See also *Earth's energy budget*, *Earth's top of atmosphere energy budget*, *Earth's energy imbalance*, *Earth's surface energy budget*, *Earth system heating* and *Earth's radiative response*.

Earth's energy imbalance The persistent and positive (downward) net top of atmosphere energy flux associated with greenhouse gas *forcing* of the *climate system*. See also *Earth's energy budget*, *Earth's top of atmosphere energy budget*, *Earth's surface energy budget*, *Earth system heating*, *Earth's radiative response* and *Earth's energy flows*.

Earth's radiative response The product of *global mean surface air temperature (GSAT)* change and the net feedback parameter (i.e. sum of all feedbacks), which determines the net top-of-atmosphere radiative flux that opposes a change in *radiative forcing*. Units: W m^{-2}. See also *Earth's energy budget*, *Earth's top of atmosphere energy budget*, *Earth's energy imbalance*, *Earth's surface energy budget*, *Earth system heating* and *Earth's energy flows*.

Earth's surface energy budget Earth's surface energy budget comprises the exchanges of heat at the surface of the Earth associated with both radiative and non-radiative processes. See also *Earth's energy budget*, *Earth's top of atmosphere energy budget*, *Earth's energy imbalance*, *Earth system heating*, *Earth's radiative response* and *Earth's energy flows*.

Earth system sensitivity See *Climate sensitivity*.

Earth's top of atmosphere energy budget Earth's top of atmosphere energy budget comprises the energy fluxes associated with incoming solar radiation, reflected solar radiation and emitted thermal radiation. See also *Earth's energy budget*, *Earth's energy imbalance*, *Earth's surface energy budget*, *Earth system heating*, *Earth's radiative response* and *Earth's energy flows*.

East Antarctic ice sheet (EAIS) See *Ice sheet*.

East Asian monsoon (EAsiaM) See *Global monsoon*.

Eastern boundary upwelling systems (EBUS) Eastern boundary upwelling system (EBUS) are located at the eastern (landward) edges of major ocean basins in both hemispheres, where equatorward winds drive upwelling currents that bring cool, nutrient-rich (and often oxygen-poor) waters from the deep ocean to the surface near the coast.

Eastern Pacific El Niño See *El Niño-Southern Oscillation (ENSO)*.

Economic potential See *Mitigation potential*.

Ecosystem A functional unit consisting of living organisms, their non-living environment and the interactions within and between them. The components included in a given ecosystem and its spatial boundaries depend on the purpose for which the ecosystem is defined: in some cases they are relatively sharp, while in others they are diffuse. Ecosystem boundaries can change over time. Ecosystems are nested within other ecosystems and their scale can range from very small to the entire biosphere. In the current era, most ecosystems either contain people as key organisms, or are influenced by the effects of human activities in their environment. See also *Ecosystem services*.

Effective radiative forcing (ERF) See *Radiative forcing*, *Aerosol effective radiative forcing (ERFari+aci)* (under *Aerosol-radiation interaction*), *Effective radiative forcing (or effect) due to aerosol-cloud interactions (ERFaci)* (under *Aerosol-cloud interaction*) and *Effective radiative forcing (or effect) due to aerosol-radiation interactions (ERFari)* (under *Aerosol-radiation interaction*).

Ekman transport The total transport resulting from a balance between the Coriolis force and the frictional stress due to the action of the wind on the ocean surface.

El Niño See *El Niño-Southern Oscillation (ENSO)*.

El Niño-Southern Oscillation (ENSO) The term El Niño was initially used to describe a warm-water current that periodically flows along the coast of Ecuador and Peru, disrupting the local fishery. It has since become identified with warming of the tropical Pacific Ocean east of the dateline. This oceanic event is associated with a fluctuation of a global-scale tropical and subtropical surface pressure pattern called the Southern Oscillation. This coupled atmosphere–ocean phenomenon, with preferred time scales of two to about seven years, is known as the El Niño-Southern Oscillation (ENSO). The warm and cold phases of

ENSO are called El Niño and La Niña, respectively. ENSO is often measured by the surface pressure anomaly difference between Tahiti and Darwin and/or the sea surface temperatures in the central and eastern equatorial Pacific. This phenomenon has a great impact on the wind, sea surface temperature and precipitation patterns in the tropical Pacific. It has climatic effects throughout the Pacific region and in many other parts of the world through global *teleconnections*. See Section AIV.2.3 in Annex IV of the AR6 WGI report.

Central Pacific El Niño An El Niño event in which *sea surface temperature* anomalies are stronger in the central equatorial Pacific than in the east. Also known as a Modoki El Niño event.

Eastern Pacific El Niño An El Niño event in which *sea surface temperature* anomalies are largest in the eastern tropical Pacific.

Electromagnetic spectrum Wavelength, frequency or energy range of all electromagnetic radiation. In terms of *solar radiation,* the spectral irradiance is the power arriving at the Earth per unit area, per unit wavelength.

Elevation-dependent warming (EDW) Characteristic of many regions where mountains are located, in which past and/or future surface air temperature changes vary neither uniformly nor linearly with elevation. In many cases, warming is enhanced within or above a certain elevation range.

Emergence (of the climate signal) Emergence of a *climate change* signal or trend refers to when a change in *climate* (the 'signal') becomes larger than the amplitude of natural or internal variations (defining the 'noise'), This concept is often expressed as a 'signal-to-noise' ratio and emergence occurs at a defined threshold of this ratio (e.g., S/N > 1 or 2). Emergence can refer to changes relative to a historical or modern baseline (usually at least 20 years long) and can also be expressed in terms of time (*time of emergence*) or in terms of a global warming level. Emergence is also used to refer to a time when we can expect to see a response of reducing *greenhouse gas (GHG)* emissions (emergence with respect to *mitigation*). Emergence can be estimated using observations and/or model simulations. See also *Time of emergence (ToE)*.

Emergent constraint An attempt to reduce the uncertainty in climate projections, using an ensemble of ESMs to relate a specific feedback or future change to an observation of the past or current climate (typically some trend, variability or change in variability).

Emission factor/Emissions intensity A coefficient that quantifies the emissions or removals of a gas per unit activity. Emission factors are often based on a sample of measurement data, averaged to develop a representative rate of emission for a given activity level under a given set of operating conditions.

Emissions See *Indirect emissions*, *Negative CO_2 emissions*, *Production-based emissions, Scope 1, Scope 2, and Scope 3 emissions*, *Territorial emissions*, *Agricultural emissions*, *Cumulative emissions*, *Direct emissions*, *Embodied (embedded) [emissions, water, land]*, *Anthropogenic emissions*, *Fossil fuel emissions*, *Non-CO_2 emissions and radiative forcing* and *Negative greenhouse gas emissions*. See also *Emissions scenario* (under *Scenario*), *Emission pathways* and *Emission trajectories*.

Emulation Reproducing the behaviour of complex, process-based models (namely, *Earth System Models, ESMs*) via simpler approaches, using either *emulators* or *simple climate models (SCMs)*. The computational efficiency of emulating approaches opens new analytical possibilities given that ESMs take a lot of computational resources for each simulation. See also *Emulators* and *Simple climate model (SCM)*.

Emulators A broad class of heavily parametrized models ('one-or-few-line climate models'), statistical methods like neural networks, genetic algorithms or other artificial intelligence approaches, designed to reproduce the responses of more complex, process-based Earth System Models (ESMs). The main application of emulators is to extrapolate insights from ESMs and observational constraints to a larger set of emission scenarios. See also *Emulation* and *Simple climate model (SCM)*.

Energy balance The difference between the total incoming and total outgoing energy. If this balance is positive, warming occurs; if it is negative, cooling occurs. Averaged over the globe and over long time periods, this balance must be zero. Because the *climate system* derives virtually all its energy from the Sun, zero balance implies that, globally, the absorbed *solar radiation*, that is, *incoming solar radiation* minus reflected *solar radiation* at the top of the *atmosphere* and *outgoing longwave radiation* emitted by the *climate system* are equal.

Energy balance model (EBM) An energy balance model is a simplified model that analyses the energy budget of the Earth to compute changes in the *climate*. In its simplest form, there is no explicit spatial dimension and the model then provides an estimate of the changes in globally averaged temperature computed from the changes in radiation. This zero-dimensional energy balance model can be extended to a one-dimensional or two-dimensional model if changes to the energy budget with respect to latitude, or both latitude and longitude, are explicitly considered.

Energy budget (of the Earth) The Earth is a physical system with an energy budget that includes all gains of incoming energy and all losses of outgoing energy. The Earth's energy budget is determined by measuring how much energy comes into the Earth System from the Sun, how much energy is lost to space, and accounting for the remainder on Earth and its *atmosphere*. *Solar radiation* is the dominant source of energy into the Earth System. Incoming solar energy may be scattered and reflected by clouds and *aerosols* or absorbed in the atmosphere. The transmitted radiation is then either absorbed or reflected at the Earth's surface. The average *albedo* of the Earth is about 0.3, which means that 30% of the incident solar energy is reflected into space, while 70% is absorbed by the Earth. Radiant solar or shortwave energy is transformed into sensible heat, latent energy (involving different water states), potential energy, and kinetic energy before being emitted as *infrared radiation*. With the average *surface temperature* of the Earth of about 15°C (288 K), the main outgoing energy flux is in the infrared part of the spectrum.

Enhanced weathering A proposed method to increase the natural rate of removal of *carbon dioxide (CO_2)* from the *atmosphere* using silicate and carbonate rocks. The active surface area of these minerals is increased by grinding, before they are actively added to soil, beaches or the open ocean. See also *Carbon dioxide removal (CDR)* and *Anthropogenic removals*.

Ensemble A collection of comparable datasets that reflect variations within the bounds of one or more sources of *uncertainty*, and that when averaged can provide a more robust estimate of underlying behaviour. Ensemble techniques are used by the observational, *reanalysis* and modelling communities. See also *Climate simulation ensemble*.

Equilibrium and transient climate experiment An equilibrium climate experiment is a *climate model* experiment in which the model is allowed to fully adjust to a change in *radiative forcing*. Such experiments provide information on the difference between the initial and final states of the model, but not on the time-dependent response. If the forcing is allowed to evolve gradually according to a prescribed *emission scenario*, the time-dependent response of a climate model may be analysed. Such an experiment is called a transient climate experiment.

Equilibrium climate sensitivity (ECS) See *Climate sensitivity*.

Equilibrium line The spatially averaged boundary at a given moment, usually chosen as the seasonal *mass budget* minimum at the end of summer, between the region on a *glacier* where there is a net annual loss of ice mass (ablation area) and that where there is a net annual gain (*accumulation* area). The altitude of this boundary is referred to as *equilibrium line* altitude (ELA).

Equivalent carbon dioxide (CO_2) emission See *CO_2 equivalent (CO_2-eq) emission*.

Eutrophication Over-enrichment of water by nutrients such as nitrogen and phosphorus. It is one of the leading causes of water quality impairment. The two most acute symptoms of eutrophication are *hypoxia* (or oxygen depletion) and harmful algal blooms.

Evaporation The physical process by which a liquid (e.g., water) becomes a gas (e.g., water vapour).

Evapotranspiration The combined processes through which water is transferred to the *atmosphere* from open water and ice surfaces, bare soil, and vegetation that make up the Earth's surface.

Potential evapotranspiration The potential rate of water loss from wet soils and from plant surfaces, without any limits imposed by the water supply.

Evidence Data and information used in the scientific process to establish findings. In this report, the degree of evidence reflects the amount, quality and consistency of scientific/technical information on which the Lead Authors are basing their findings. See also *Agreement*, *Confidence*, *Likelihood* and *Uncertainty*.

Exposure The presence of people; *livelihoods*; species or *ecosystems*; environmental functions, services, and resources; infrastructure; or economic, social, or cultural assets in places and settings that could be adversely affected.

Extended concentration pathways (ECPs) See *Representative concentration pathways (RCPs)* (under *Pathways*).

External forcing External forcing refers to a *forcing* agent outside the *climate system* causing a change in the climate system. Volcanic eruptions, solar variations and changes in Earth's orbit, as well as *anthropogenic* changes in the composition of the *atmosphere* or in *land use* are external forcings. See also *Orbital forcing*.

Extratropical cyclone (ETC) Any cyclonic-scale storm that is not a *tropical cyclone*. Usually refers to a middle- or high-latitude migratory storm system formed in regions of large horizontal temperature variations. Sometimes called extratropical storm or extratropical low.

Extratropical jets Extratropical jets are wind maxima in the upper *troposphere* marking zones of baroclinic instability. Anomalies in the position of these jets are often associated with storms, *blocking*, and weather extremes.

Extreme climate event See *Climate extreme (extreme weather or climate event)*.

Extreme coastal water level (ECWL) See *Extreme sea level (ESL)*.

Extreme sea level (ESL) The occurrence of an exceptionally low or high local sea-surface height, arising from (a combination of) short term phenomena (e.g. *storm surges*, tides and waves). *Relative sea-level changes* affect extreme sea levels directly by shifting the mean water levels and indirectly by modulating the propagation of tides, waves and/or surges due to increased water depth. In addition, extreme sea levels can be influenced by changes in the frequency, tracks, or strength of weather systems and storms, or due to anthropogenically induced changes such as the modification of coastlines or dredging. In turn, changes in any or all of the contributions to extreme sea levels may lead to long term relative sea-level changes. Alternate expressions for ESL may be used depending on the processes resolved.

Extreme Still Water Level (ESWL) refers to the combined contribution of relative sea-level change, tides and storm-surges. Wind-waves also contribute to coastal sea level via three processes: infragravity waves (lower frequency gravity waves generated by the wind waves); wave setup (time-mean sea-level elevation due to wave energy dissipation); and swash (vertical displacement up the shore-face induced by individual waves). Extreme Total Water Level (ETWL) is the ESWL plus wave setup. When considering coastal impacts, swash is also important, and Extreme Coastal Water Level (ECWL) is used. See also *Storm surge* and *Sea level change (sea level rise/sea level fall)*.

Extreme still water level (ESWL) See *Extreme sea level (ESL)*.

Extreme total water level (ETWL) See *Extreme sea level (ESL)*.

Extreme weather event An event that is rare at a particular place and time of year. Definitions of 'rare' vary, but an extreme weather event would normally be as rare as or rarer than the 10th or 90th percentile of a probability density function estimated from observations. By definition, the characteristics of what is called extreme weather may vary from place to place in an absolute sense. See also *Heatwave* and *Climate extreme (extreme weather or climate event)*.

Extreme/heavy precipitation event An extreme/heavy precipitation event is an event that is of very high magnitude with a very rare occurrence at a particular place. Types of extreme precipitation may vary depending on its duration, hourly, daily or multi-days (e.g., 5 days), though all of them qualitatively represent high magnitude. The intensity of such events may be defined with block maxima approach such as annual maxima or with peak over threshold approach, such as rainfall above 95th or 99th percentile at a particular space.

Faculae Bright patches on the Sun. The area covered by faculae is greater during periods of high *solar activity*.

Feedback See *Climate feedback*.

Fine-mode aerosol optical depth See *Aerosol optical depth (AOD)*.

Fingerprint The *climate* response pattern in space and/or time to a specific *forcing* is commonly referred to as a fingerprint. The spatial patterns of sea level response to melting of *glaciers* or *ice sheet*s (or other changes in surface loading) are also referred to as fingerprints. Fingerprints are used to detect the presence of this response in observations and are typically estimated using forced *climate model* simulations. See also *Detection and attribution*.

Fire weather Weather conditions conducive to triggering and sustaining wildfires, usually based on a set of indicators and combinations of indicators including temperature, soil moisture, humidity, and wind. Fire weather does not include the presence or absence of fuel load.

Firn Snow that has survived at least one *ablation* season but has not been transformed to *glacier* ice. Its pore space is at least partially interconnected, allowing air and water to circulate. Firn densities typically are 400–830 kg m^{-3}.

Fitness-for-purpose The suitability of a model (or other resource, such as a dataset or method) for a particular task, such as quantifying the contribution of increased *greenhouse gas* concentrations to recent changes in *global mean surface temperature* or projecting changes in *drought* frequency in a region under a given *scenario*. Assessment of a model's fitness-for-purpose can be informed both by how the model represents relevant physical processes and by how it scores on relevant performance metrics.

Flaring Open air burning of waste gases and volatile liquids, through a chimney, at oil wells or rigs, in refineries or chemical plants, and at landfills.

Flood The overflowing of the normal confines of a stream or other water body, or the accumulation of water over areas that are not normally submerged. Floods can be caused by unusually heavy rain, for example during storms and cyclones. Floods include river (fluvial) floods, flash floods, urban floods, rain (pluvial) floods, sewer floods, *coastal* floods, and *glacial lake outburst floods (GLOFs)*.

Flux A movement (a flow) of matter (e.g., water vapor, particles), heat or energy from one place to another, or from one medium (e.g., land surface) to another (e.g., atmosphere).

Foraminifera Single-celled, sand-sized marine organisms (protists) that possess a hard test mainly composed of agglutinated walls (detrital grains glued together with organic cement) or calcium carbonate (predominantly calcite). They are used to reconstruct a range of (paleo)environmental variables such as salinity, temperature, oxygenation, oxygen isotope composition, and organic and nutrient flux.

Forcing See *Radiative forcing*.

Forest A vegetation type dominated by trees. Many definitions of the term forest are in use throughout the world, reflecting wide differences in biogeophysical conditions, social structure and economics. [Note: For a discussion of the term forest in the context of National GHG inventories, see the 2006 IPCC Guidelines for National GHG Inventories and their 2019 Refinement, and information provided by the United Nations Framework Convention on Climate Change (IPCC, 2006, 2019, UNFCCC, 2021a, 2021b).] See also *Afforestation*, *Deforestation* and *Reforestation*.

Fossil fuel emissions Emissions of *greenhouse gases* (in particular *carbon dioxide*), other trace gases and *aerosols* resulting from the combustion of fuels from fossil carbon deposits such as oil, gas and coal.

Fossil fuels Carbon-based fuels from fossil hydrocarbon deposits, including coal, oil, and natural gas.

Free atmosphere The atmospheric layer that is negligibly affected by friction against the Earth's surface, and which is above the *atmospheric boundary layer*.

Frozen ground Soil or rock in which part or all of the pore water consists of ice. See also *Active layer* and *Permafrost*.

General circulation The large-scale motions of the *atmosphere* and the ocean as a consequence of differential heating on a rotating Earth. General circulation contributes to the *energy balance* of the system through transport of heat and momentum.

General circulation model (GCM) A numerical representation of the atmosphere-ocean-sea ice system based on the physical, chemical and biological properties of its components, their interactions and feedback processes. General circulation models are used for weather forecasts, seasonal to decadal prediction, and *climate projections*. They are the basis of the more complex *Earth system models (ESMs)*. See also *Climate model*.

Geocentric sea-level change See *Sea level change (sea level rise/sea level fall)*.

Geoid The equipotential surface having the same geopotential at each latitude and longitude around the world (geodesists denoting this potential W0) that best approximates the *mean sea level*. It is the surface of reference for measurement of altitude. In practice, several variations of definitions of the *geoid* exist depending on the way the permanent tide (the zero-frequency gravitational tide due to the Sun and Moon) is considered in geodetic studies.

Geostrophic winds or currents A wind or current that is in balance with the horizontal pressure gradient and the Coriolis force, and thus is outside of the influence of friction. Thus, the wind or current is directly parallel to isobars and its speed is proportional to the horizontal pressure gradient.

Glacial isostatic adjustment (GIA) The ongoing changes in *gravity, rotation and viscoelastic solid Earth deformation (GRD)* in response to past changes in the distribution of ice and water on Earth's surface. On a timescale of decades to tens of millennia following mass redistribution, Earth's mantle flows viscously as it evolves toward isostatic equilibrium, causing solid Earth movement and *geoid* changes, which can result in regional to local sea-level variations. See also *Sea level change (sea level rise/sea level fall)*.

Glacial lake outburst flood (GLOF) / Glacier lake outburst A sudden release of water from a glacier lake, including any of the following types – a glacier-dammed lake, a pro-glacial moraine-dammed lake or water that was stored within, under or on the glacier.

Glacial or glaciation A period characterized by the establishment of expanded ice sheets and glaciers, and associated with global mean sea level (GMSL) substantially lower than present. Generally coincides with even-numbered *marine isotope stages*. Glacial intervals were interrupted by interglacial intervals. The Last Glacial Maximum (LGM) is a specific interval within the most recent glaciation, when ice sheets were near their global maximum volume (Clark et al., 2009; Gowan et al., 2021) and GMSL was near its most recent lowest stand (Lambeck et al., 2014; Yokoyama et al., 2018). Local or regional glacial maxima may be diachronous, for example ranging from about 29,000 years ago and 16,000 years ago. For purposes of global synthesis, IPCC AR6 adopts a practical chronostratigraphic definition of LGM of 23,000-19,000 years BP (before 1950; chronozone level 1 of Mix et al., 2001). For modeling purposes, LGM is defined by the model time step nearest to the center of this interval, 21,000 years ago (Kageyama et al., 2017). See also *Deglacial or deglaciation or glacial termination*, *Glacial-interglacial cycles*, *Ice age* and *Interglacial or interglaciation*.

Glacial termination See *Deglacial or deglaciation or glacial termination*.

Glacial-interglacial cycles Phase of the Earth's history marked by large changes in continental ice volume and global sea level. See also *Glacial or glaciation*, *Deglacial or deglaciation or glacial termination*, *Interglacial or interglaciation* and *Ice age*.

Glaciated State of a surface that was covered by *glacier* ice in the past, but not at present. See also *Glacierised*.

Glacier A perennial mass of ice, and possibly firn and snow, originating on the land surface by accumulation and compaction of snow and showing evidence of past or present flow. A glacier typically gains mass by accumulation of snow, and loses mass by ablation. Land ice masses of continental size (>50,000 km^2) are referred to as ice sheets (Cogley et al., 2011).

Outlet glacier A *glacier*, usually between rock walls, that is part of, and drains an *ice sheet*. See also *Ice stream*.

Glacierised A surface that is currently covered by *glacier* ice. See also *Glaciated*.

Global carbon budget See *Carbon budget*.

Global dimming Global dimming refers to the observed widespread reduction in the amount of *solar radiation* received at the Earth's surface from the 1950s to the 1980s, with an increase in anthropogenic aerosol emissions appearing to have contributed. This was followed by a partial recovery since the 1990s ("brightening"), particularly in industrialized areas, coincident with a reduction in anthropogenic aerosol emissions.

Global mean sea-level (GMSL) change See *Sea level change (sea level rise/sea level fall)*.

Global mean surface air temperature (GSAT) Global average of near-surface air temperatures over land, oceans and sea ice. Changes in GSAT are often used as a measure of global temperature change in *climate models*. See also *Global mean surface temperature (GMST)*.

Global mean surface temperature (GMST) Estimated global average of near-surface air temperatures over land and sea ice, and *sea surface temperature (SST)* over ice-free ocean regions, with changes normally expressed as departures from a value over a specified *reference period*. See also *Global mean surface air temperature (GSAT)*.

Global monsoon The global monsoon (GM) is a global-scale solstitial mode that dominates the annual variation of tropical and sub-tropical precipitation and circulation. The GM domain is defined as the area where the annual range of precipitation (local summer minus winter mean precipitation rate) is greater than

2.5 mm/day, following on from the definition as in Kitoh et al. (2013). Further details on how the GM is defined, used and related to regional monsoons throughout the report is provided by AnnexV.

Australian and Maritime Continent monsoon (AusMCM) The Australian-Maritime Continent monsoon (AusMCM) occurs during December-January-February, with the large-scale shift of the Inter-Tropical Convergence Zone into the Southern Hemisphere and covering northern Australia and the Maritime Continent up to 10N. The AusMCM is characterized by the seasonal reversal of prevailing easterly winds to westerly winds and the onset of periods of active convection and heavy rainfall. Over northern Australia, the monsoon season generally lasts from December to March and is associated with west to northwesterly inflow of moist winds, producing convection and heavy precipitation. Over the Maritime Continent, the main rainy season south of the equator is centered on December to February with northwesterly monsoon flow at low levels. Further details on how AusMCM is defined and used throughout the report is provided in the Annex V.

East Asian monsoon (EAsiaM) The East Asian monsoon (EAsiaM) is the seasonal reversal in wind and precipitation occurring over East Asia, including eastern China, Japan and the Korean peninsula. Differently from the other monsoons it extends quite far north, out of the tropical belt, and it is largely influenced by subtropical systems and by disturbances from the mid-latitudes. The EAsiaM manifests during boreal summer with warm and wet southerly winds, but also during boreal winter with cold and dry northerly winds. In late April/early May rainfall onsets in central Indochina Peninsula, and in mid-June the rainy season arrives over East Asia with the formation of the Meiyu front along the Yangtze River valley, Changma in Korea and Baiu in Japan. Lately in July, the monsoon advances up to North China, the Korean peninsula and central Japan. During boreal winter, strong north-westerlies manifest over north, northeast China, Korea and Japan, while strong north easterlies arrive along the coast of East Asia. Further details on how EAsiaM is defined and used throughout the report is provided in the Annex V.

North American monsoon (NAmerM) The North American monsoon (NAmerM) is a regional-scale atmospheric circulation system with increase in summer precipitation over northwestern Mexico and southwest United States. The monsoonal characteristics of the region include a pronounced annual maximum of precipitation in boreal summer (June-July-August) accompanied by a surface low pressure system and an upper-level anticyclone, although seasonal reversal of the surface winds is primarily limited to the northern Gulf of California. Further details on how NAmerM is defined and used throughout the report is provided in the Annex V.

South American monsoon (SAmerM) The South American monsoon (SAmerM) is a regional circulation characterized by inflow of low-level winds from the Atlantic to South America, including Brazil, Peru', Bolivia and northern Argentina, associated with the development of surface pressure gradients (and intense precipitation) during austral summer (December-January-February). During September-October-November areas of intense convection migrate from northwestern South America to the south. Associated to this regime, an upper-tropospheric anticyclone (a.k.a the Bolivian High) forms over the Altiplano region during the monsoon onset. The SAmerM then retreats during March-April-May with a northeastward migration of the convection. Further details on how SAmerM is defined and used throughout the report is provided in the Annex V.

South and Southeast Asian monsoon (SAsiaM) The South and Southeast Asian monsoon (SAsiaM) is characterized by pronounced seasonal reversals of wind and precipitation. The SAsiaM region extends across vast geographical areas and several countries including India, Bangladesh, Nepal, Myanmar, Sri Lanka, Pakistan, Thailand, Laos, Cambodia, Vietnam and Philippine. The SAsiaM starts in late May/early June and progresses toward northeast, ending in late September/early October. During the core monsoon season, maxima of SAsiaM precipitation are located over the west coast, northeast and central north India, Myanmar and Bangladesh, whereas minima are located over northwest and southeastern India, western Pakistan, southeastern and northern Sri Lanka. Further details on how SAsiaM is defined and used throughout the report is provided in the Annex V.

West African monsoon (WAfriM) The West African monsoon (WAfriM) is a seasonal reversal in wind and precipitation whose domain includes Benin, Burkina-Faso, northern Cameroon, Cape Verde, northern Central African Republic, Chad, Gambia, Ghana, Guinea, Guinea Bissau, Ivory, Coast, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone and Togo. The WAfriM is characterized by the northward progression from May to September of moist low-level south-westerlies from the Gulf of Guinea. In May and June, rainfall essentially remains along the Guinean coast with a maximum occurring near 5°N, followed by a sudden decrease of rainfall, marking the "short dry season" in the Guinean coast and the monsoon onset in the Sahel. Then rainfall continues to progress northward up to about 18-20°N, with a maximum near 12°N in late August/September, until it retreats starting from October towards the Guinean coast for a second maximum. Further details on how WAfriM is defined and used throughout the report is provided in the Annex V.

Global surface temperature See *Global mean surface temperature (GMST)* and *Global mean surface air temperature (GSAT)*. See also *Global warming*.

Global warming Global warming refers to the increase in *global surface temperature* relative to a baseline *reference period*, averaging over a period sufficient to remove interannual variations (e.g., 20 or 30 years). A common choice for the baseline is 1850-1900 (the earliest period of reliable observations with sufficient geographic coverage), with more modern baselines used depending upon the application. See also *Climate change* and *Climate variability*.

Global warming potential (GWP) An index measuring the *radiative forcing* following an emission of a unit mass of a given substance, accumulated over a chosen time horizon, relative to that of the reference substance, *carbon dioxide* (CO_2). The GWP thus represents the combined effect of the differing times these substances remain in the atmosphere and their effectiveness in causing radiative forcing. See also *Lifetime* and *Greenhouse gas emission metric*.

Gravitational, rotational and deformational (GRD) effects See *Sea level change (sea level rise/sea level fall)*.

Gravity Recovery And Climate Experiment (GRACE) A pair of satellites to measure the Earth's gravity field anomalies from 2002 to 2017. These fields have been used, among other things, to study mass changes of the polar *ice sheets* and *glaciers*.

Greenhouse effect The infrared radiative effect of all infrared-absorbing constituents in the *atmosphere*. *Greenhouse gases (GHGs)*, clouds, and some *aerosols* absorb *terrestrial radiation* emitted by the Earth's surface and elsewhere in the atmosphere. These substances emit infrared radiation in all directions, but, everything else being equal, the net amount emitted to space is normally less than would have been emitted in the absence of these absorbers because of the decline of temperature with altitude in the *troposphere* and the consequent weakening of emission. An increase in the concentration of GHGs increases the magnitude of this effect; the difference is sometimes called the enhanced greenhouse effect. The change in a GHG concentration because of *anthropogenic* emissions contributes to an *instantaneous radiative forcing*. *Surface temperature* and *troposphere* warm in response to this forcing, gradually restoring the radiative balance at the top of the atmosphere.

Greenhouse gas emission metric A simplified relationship used to quantify the effect of emitting a unit mass of a given *greenhouse gas* on a specified key measure of *climate change*. A relative GHG emission metric expresses the effect from one gas relative to the effect of emitting a unit mass of a reference GHG on the same measure of climate change. There are multiple emission metrics and the most appropriate metric depends on the application. GHG emission metrics may differ with respect to (i) the key measure of climate change they consider, (ii) whether they consider climate outcomes for a specified point in time or integrated over a specified time horizon, (iii) the time horizon over which the metric is applied, (iv) whether they apply to a single emission pulse, emissions sustained over a period of time, or a combination of both, and (v) whether they consider the climate effect from an emission compared to the absence of that emission, or compared to a reference emissions level or climate state.

Notes: Most relative GHG emission metrics (such as the *Global Warming Potential (GWP)*, Global Temperature change Potential (GTP), Global Damage Potential, and GWP*), use carbon dioxide as the reference gas. Emissions of non-CO_2 gases, when expressed using such metrics, are often referred to as “carbon dioxide equivalent” emissions. A metric that establishes equivalence regarding one key measure of the *climate system* response to emissions does not imply equivalence regarding other key measures. The choice of a metric, including its time horizon, should reflect the policy objectives for which the metric is applied.

Greenhouse gas neutrality Condition in which metric-weighted anthropogenic greenhouse gas (GHG) emissions associated with a subject are balanced by metric-weighted anthropogenic GHG removals. The subject can be an entity such as a country, an organisation, a district or a commodity, or an activity such as a service and an event. GHG neutrality is often assessed over the life cycle including indirect (“scope 3”) emissions, but can also be limited to the emissions and removals, over a specified period, for which the subject has direct control, as determined by the relevant scheme. The quantification of GHG emissions and removals depends on the GHG emission metric chosen to compare emissions and removals of different gases, as well as the time horizon chosen for that metric.

Note 1: GHG neutrality and net zero GHG emissions are overlapping concepts. The concepts can be applied at global or sub-global scales (e.g., regional, national and sub-national). At a global scale, the terms greenhouse gas neutrality and net zero greenhouse gas emissions are equivalent. At sub-global scales, net zero greenhouse gas emissions is generally applied to emissions and removals under direct control or territorial responsibility of the reporting entity, while greenhouse gas neutrality generally includes emissions and removals within and beyond the direct control or territorial responsibility of the reporting entity. Accounting rules specified by GHG programmes or schemes can have a significant influence on the quantification of relevant emissions and removals.

Note 2. Under the Paris Rulebook [Decision 18/CMA.1, annex, paragraph 37], parties have agreed to use GWP100 values from the IPCC AR5 or GWP100 values from a subsequent IPCC Assessment Report to report aggregate emissions and removals of GHGs. In addition, parties may use other metrics to report supplemental information on aggregate emissions and removals of GHGs.

Note 3: In some cases, achieving greenhouse gas neutrality may rely on the supplementary use of *offsets* to balance emissions that remain after actions by the reporting entity are taken into account.] See also *Carbon neutrality*, *Greenhouse gas emission metric*, *Land use, land-use change and forestry (LULUCF)* and *Net zero greenhouse gas emissions*.

Greenhouse gases (GHGs) Gaseous constituents of the *atmosphere*, both natural and *anthropogenic*, that absorb and emit radiation at specific wavelengths within the spectrum of radiation emitted by the Earth's surface, by the atmosphere itself, and by clouds. This property causes the *greenhouse effect*. Water vapour (H_2O), *carbon dioxide (CO_2)*, *nitrous oxide (N_2O)*, *methane (CH_4)* and *ozone (O_3)* are the primary GHGs in the Earth's atmosphere. Human-made GHGs include *sulphur hexafluoride (SF_6)*, *hydrofluorocarbons (HFCs)*, *chlorofluorocarbons (CFCs)* and *perfluorocarbons (PFCs)*; several of these are also O_3-depleting (and are regulated under the *Montreal Protocol*). See also *Well-mixed greenhouse gas*.

Greenland ice sheet (GrIS) See *Ice sheet*.
Gross Primary Production (GPP) See *Primary production*.

Ground-level ozone Atmospheric *ozone (O_3)* formed naturally or from human-emitted precursors near Earth's surface, thus affecting human health, agriculture, and ecosystems. Ozone is a *greenhouse gas (GHG)*, but ground-level ozone, unlike stratospheric ozone, also directly affects organisms at the surface. Ground-level ozone is sometimes referred to as tropospheric ozone, although much of the troposphere is well above the surface and thus does not directly expose organisms at the surface.

Grounding line The junction between a *glacier* or *ice sheet* and an *ice shelf*; the place where ice starts to float. This junction normally occurs over a zone, rather than at a line.

Gyre Basin-scale ocean horizontal circulation pattern with slow flow circulating around the ocean basin, closed by a strong and narrow (100 to 200 km wide) boundary current on the western side. The subtropical gyres in each ocean are associated with high pressure in the centre of the gyres; the subpolar gyres are associated with low pressure.

Hadley cell See *Hadley circulation*.

Hadley circulation A direct, thermally driven overturning cell in the *atmosphere* consisting of poleward flow in the upper *troposphere*, subsiding air into the subtropical anticyclones, return flow as part of the trade winds near the surface, and with rising air near the equator in the so-called *Inter-Tropical Convergence Zone*.

Halocarbons A collective term for the group of partially halogenated organic species, which includes the *chlorofluorocarbons (CFCs)*, hydrochlorofluorocarbons (HCFCs), *hydrofluorocarbons (HFCs)*, halons, methyl chloride and methyl bromide. Many of the halocarbons have large *global warming potentials*. The chlorine and bromine-containing halocarbons are also involved in the depletion of the ozone layer.

Halocline A layer in the oceanic water column in which salinity changes rapidly with depth. Generally saltier water is denser and lies below less salty water. In some high latitude oceans the surface waters may be colder than the deep waters and the halocline is responsible for maintaining water column stability and isolating the surface waters from the deep waters.

Halosteric See *Sea level change (sea level rise/sea level fall)*.

Halosteric sea-level change See *Sea level change (sea level rise/sea level fall)*.

Hazard The potential occurrence of a natural or human-induced physical event or trend that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources. See also *Impacts (consequences, outcomes)* and *Risk*.

Heat index A measure of how hot the air feels to the human body. The index is mainly based on surface air temperature and relative humidity, thus it reflects the combined effect of high temperature and humidity on human physiology and provides a relative indication of potential health risks.

Heat stress A range of conditions in, e.g., terrestrial or aquatic organisms when the body absorbs excess heat during overexposure to high air or water temperatures or thermal radiation. In aquatic water breathing animals, hypoxia and acidification can exacerbate vulnerability to heat. Heat stress in mammals (including humans) and birds, both in air, is exacerbated by a detrimental combination of ambient heat, high humidity and low wind-speeds, causing regulation of body temperature to fail.

Heatwave A period of abnormally hot weather often defined with reference to a relative temperature threshold, lasting from two days to months. Heatwaves and warm spells have various and, in some cases, overlapping definitions. See also *Marine heatwave*, *Warm spell*, *Blocking*, *Heat index* and *Heat stress*.

Heavy precipitation event See *Extreme/heavy precipitation event*.

Heinrich event Distinct layers of coarse-grained sediments comprised of ice-rafted debris identified across marine sediment cores in the North Atlantic. These sedimentary layers are closely associated with millennial-scale cooling events in the North Atlantic and a distinct pattern of global temperature and hydrological changes that are largely consistent with evidence for a slowdown, or even near-collapse, of the *Atlantic meridional ocean circulation (AMOC)* during these times.

Heterotrophic respiration The conversion of organic matter to *carbon dioxide* by organisms other than autotrophs.

Hindcast or retrospective forecast A forecast made for a period in the past using only information available before the beginning of the forecast. A sequence of hindcasts can be used to calibrate the forecast system and/or provide a measure of the average skill that the forecast system has exhibited in the past as a guide to the skill that might be expected in the future.

Holocene The current *interglacial* geological epoch, the second of two epochs within the Quaternary Period, the preceding being the *Pleistocene*. The International Commission on Stratigraphy (ICS) defines the start of the Holocene Epoch at 11,700 years before 2000 (ICS, 2018). It encompasses the mid-Holocene (MH), the 1000-year-long interval centered at 6000 years before 1950; a period of long-standing focus for climate modelling, with enhanced seasonality in the Northern Hemisphere and decreased seasonality in the Southern Hemisphere. The early part of the Holocene is marked by the late stages of *deglaciation* of Pleistocene land ice, and sea level rise, and the occurrence of warm phases that affected different regions at different times, often referred to as the "Holocene thermal maximum". In addition, the epoch includes the post-glacial interval, which began approximately 7000 years ago when the fundamental features of the modern *climate system* were essentially in place, as the influence of remnant Pleistocene *ice sheets* waned. See also *Anthropocene*.

Holocene Thermal Maximum (HTM) See *Holocene*.

Human influence on the climate system Human-driven activities that lead to changes in the climate system due to perturbations of the Earth's energy budget (also called anthropogenic *forcing*). Human influence results from emissions of *greenhouse gases*, *aerosols*, *ozone-depleting substances (ODSs)*, and *land-use change*. See also *Anthropogenic, Anthropogenic emissions* and *Anthropogenic removals*.

Human system Any system in which human organisations and institutions play a major role. Often, but not always, the term is synonymous with society or social system. Systems such as agricultural systems, urban systems, political systems, technological systems, and economic systems are all human systems in the sense applied in this report.

Hurricane See *Tropical cyclone*.

Hydroclimate Part of the *climate* pertaining to the hydrology of a *region*.

Hydrofluorocarbons (HFCs) One of the seven 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.

Hydrological cycle The cycle in which water evaporates from the ocean and the land surface, is carried over the Earth in atmospheric circulation as water vapour, condenses to form clouds, precipitates over the ocean and land as rain or snow, which on land can be intercepted by trees and vegetation, potentially accumulating as snow or ice, provides runoff on the land surface, infiltrates into soils, recharges groundwater, discharges into streams, and ultimately, flows into the oceans as rivers, polar glaciers and ice sheets, from which it will eventually evaporate again. The various systems involved in the hydrological cycle are usually referred to as hydrological systems.

Hydrological drought See *Drought*.

Hydrological sensitivity (η) The change in global-mean precipitation per degree Celsius of global mean temperature change when precipitation changes related to fast atmospheric and land surface adjustments to radiative forcings are removed. Units are % per °C although can also be calculated as W m^{-2} per °C. See also *Apparent hydrological sensitivity (η_a)*.

Hydrosphere The component of the *climate system* comprising liquid surface and subterranean water, such as in oceans, seas, rivers, freshwater lakes, underground water, *wetlands*, etc.

Hypoxic Conditions of low dissolved oxygen in shallow water ocean and freshwater environments. There is no universal threshold for hypoxia. A value around 60 μmol kg^{-1} has commonly been used for some estuarine systems, although this does not necessarily directly translate into biological impacts. Anoxic conditions occur where there is no oxygen present at all. See also *Eutrophication*.

Hypsometry The distribution of land or ice surface as a function of altitude.

Ice age An informal term for a geological period characterised by a long-term reduction in the temperature of the Earth's *climate*, resulting in the presence or expansion of *ice sheets* and *glaciers*. Among the Earth's ice ages is the current Quaternary Period, characterized by alternating *glacial* and *interglacial* intervals. See also *Deglacial or deglaciation or glacial termination* and *Glacial-interglacial cycles*.

Ice core A cylinder of ice drilled out of a *glacier* or *ice sheet* to determine the physical properties of the ice body, and to gain information on past changes in *climate* and composition of the *atmosphere* that are preserved in the ice or in air trapped in the ice.

Ice sheet An ice body originating on land that covers an area of continental size, generally defined as covering >50,000 km^2, and that has formed over thousands of years through *accumulation* and compaction of snow. An ice sheet flows outward from a high central ice plateau with a small average surface slope. The margins usually slope more steeply, and most ice is *discharged* through fast-flowing ice streams or outlet *glaciers*, often into the sea or into *ice shelves* floating on the sea. There are only two ice sheets in the modern world, one on Greenland and one on Antarctica. The latter is divided into the East Antarctic Ice Sheet (EAIS), the West Antarctic Ice Sheet (WAIS) and the Antarctic Peninsula ice sheet. During glacial periods, there were other ice sheets.

Ice shelf A floating slab of ice originating from *land* of considerable thickness extending from the *coast* (usually of great horizontal extent with a very gently sloping surface), resulting from the flow of *ice sheets*, initially formed by the accumulation of snow, and often filling embayments in the coastline of an ice sheet. Nearly all ice shelves are in Antarctica, where most of the ice *discharged* into the *ocean* flows via ice shelves.

Ice stream A stream of ice with strongly enhanced flow that is part of an *ice sheet*. It is often separated from surrounding ice by strongly sheared, crevassed margins.

Ice-albedo feedback A *climate feedback* involving changes in the Earth's surface *albedo*. Snow and ice have an albedo much higher (up to ~0.8) than the average planetary albedo (~0.3). With increasing temperatures, it is anticipated that snow and ice extent will decrease, the Earth's overall albedo will decrease and more *solar radiation* will be absorbed, warming the Earth further.

Iceberg Large piece of freshwater ice broken off from a *glacier* or an *ice shelf* during *calving* and floating in open water (at least five metres height above sea level). Smaller pieces of floating ice known as 'bergy bits' (less than 5 metres above sea level) or 'growlers' (less than 2 metres above sea level) can originate from glaciers or ice shelves, or from the breaking up of a large iceberg. Icebergs can also be classified by shape, most commonly being either tabular (steep sides and a flat top) or non-tabular (varying shapes, with domes and spires) (NOAA, 2021). In lakes, icebergs can originate by breaking off shelf ice, which forms through freezing of a lake surface.

Impacts (consequences, outcomes) The consequences of realised risks on natural and human systems, where risks result from the interactions of climate-related hazards (including extreme weather / climate events), exposure, and vulnerability. Impacts generally refer to effects on lives, livelihoods, health and wellbeing, ecosystems and species, economic, social and cultural assets, services (including ecosystem services), and infrastructure. Impacts may be referred to as consequences or outcomes, and can be adverse or beneficial. See also *Adaptation*, *Exposure*, *Hazard*, *Loss and Damage, and losses and damages*, *Vulnerability* and *Risk*.

Incoming solar radiation See *Insolation*.

Indian Ocean Basin (IOB) mode A mode of interannual variability characterized by a temporal alternation of basin-wide warming and cooling of the Indian Ocean sea surface. It mostly develops in response to *El Niño-Southern Oscillation (ENSO)*, but often persists after ENSO's equatorial eastern Pacific signal has dissipated. The IOB affects atmospheric circulation, temperature, and precipitation in South, Southeast, and East Asia as well as Africa, and modulates *tropical cyclone* activity in the Northwestern Pacific. See Section AIV.2.4 in Annex IV of the AR6 WGI report. See also *Modes of climate variability* and *Indian Ocean Dipole (IOD)*.

Indian Ocean Dipole (IOD) A mode of interannual variability that features an east-west dipole of *sea surface temperature* anomalies in the tropical Indian Ocean. Its positive phase shows concurrent sea surface cooling off Sumatra and Java and warming off Somalia in the west, combined with anomalous surface easterlies along the equator, while the opposite anomalies are seen in the negative phase. The IOD typically develops in boreal summer and matures in boreal autumn and controls part of the rainfall interannual variability in Australia, South Eastern Asia and Eastern Africa. See Section AIV.2.4 in Annex IV of the AR6 WGI report. See also *Indian Ocean Basin (IOB) mode*.

Indirect aerosol effect See *Aerosol-cloud interaction*.

Indirect land-use change (iLUC) See *Land-use change (LUC)*.

Industrial revolution A period of rapid industrial growth with far-reaching social and economic consequences, beginning in Britain during the second half of the 18th century and spreading to Europe and later to other countries including the United States. The invention of the steam engine was an important trigger of this development. The industrial revolution marks the beginning of a strong increase in the use of *fossil fuels*, initially coal, and hence emission of *carbon dioxide* (CO_2).

Infrared radiation See *Terrestrial radiation*.

Initial condition ensemble (ICE) See *Model ensemble*.

Insolation The amount of *solar radiation* reaching the Earth by latitude and by season measured in W m^{-2}. Usually insolation refers to the radiation arriving at the top of the *atmosphere*. Sometimes it is specified as referring to the radiation arriving at the Earth's surface. See also *Orbital forcing* and *Total solar irradiance (TSI)*.

Instantaneous radiative forcing (or effect) due to aerosol-cloud interactions (IRFaci) See *Aerosol-cloud interaction*.

Instantaneous radiative forcing (or effect) due to aerosol-radiation interactions (IRFari) See *Aerosol-radiation interaction*.

Integrated assessment model (IAM) Models that integrate knowledge from two or more domains into a single framework. They are one of the main tools for undertaking integrated assessments. One class of IAM used in respect of climate change mitigation may include representations of: multiple sectors of the economy, such as energy, land use and land use change; interactions between sectors; the economy as a whole; associated greenhouse gas (GHG) emissions and sinks; and reduced representations of the climate system. This class of model is used to assess linkages between economic, social and technological development and the evolution of the climate system. Another class of IAM additionally includes representations of the costs associated with climate change impacts, but includes less detailed representations of economic systems. These can be used to assess impacts and mitigation in a cost-benefit framework and have been used to estimate the social cost of carbon.

Interdecadal Pacific Oscillation (IPO) See *Pacific Decadal Variability (PDV)*.

Inter-Tropical Convergence Zone (ITCZ) The Inter-Tropical Convergence Zone is an equatorial zonal belt of low pressure, strong *convection* and heavy precipitation near the equator where the northeast trade winds meet the southeast trade winds. This band moves seasonally. See also *South Pacific Convergence Zone (SPCZ)*.

Interglacial or interglaciation A globally warm period lasting thousands of years between *glacial* periods within an *ice age*. Generally coincides with odd-numbered *marine isotope stages (MIS)* when mean sea level was close to present. The Last Interglacial (LIG) occurred between about 129 and 116 ka (thousand years) before present (defined as 1950) although the warm period started in some areas a few thousand years earlier. In terms of marine isotope stages (MIS), *interglaciations* are defined as the interval between the midpoint of the preceding termination and the onset of the next glaciation. The LIG coincides with MIS 5e. The present interglaciation, the *Holocene*, started at 11,700 years before 2000 CE, although global mean sea level did not approach its present position until roughly 7000 years ago. See also *Deglacial or deglaciation or glacial termination*, *Glacial-interglacial cycles*, *Glacial or glaciation* and *Ice age*.

Internal climate variability See *Internal variability* (under *Climate variability*).

Irreversibility A perturbed state of a *dynamical system* is defined as irreversible on a given timescale, if the recovery from this state due to natural processes takes substantially longer than the timescale of interest. See also *Tipping point*.

Isostatic or Isostasy Isostasy refers to the response of the earth to changes in surface load. It includes the deformational and gravitational response. This response is elastic on short time scales, as in the earth-ocean response to recent changes in mountain glaciation, or viscoelastic on longer time scales, as in the response to the last *deglaciation* following the *Last Glacial Maximum*.

Isotopes Atoms of the same chemical element that have the same the number of protons but differ in the number of neutrons. Some proton-neutron configurations are stable (stable isotopes), others are unstable undergoing spontaneous radioactive decay (radioisotopes). Most elements have more than one stable isotope. Isotopes can be used to trace transport processes or to study processes that change the isotopic ratio. Radioisotopes provide in addition time information that can be used for radiometric dating. See also ^{13}C and ^{14}C.

Key climate indicators See *Climate indicator*.

Kriging Kriging is a method of interpolation (normally spatial interpolation when used with atmospheric or oceanographic data), in which the interpolated values are estimated using a Gaussian process governed by prior covariances.

La Niña See *El Niño-Southern Oscillation (ENSO)*.

Land The terrestrial portion of the biosphere that comprises the natural resources (soil, near-surface air, vegetation and other biota, and water), the ecological processes, topography, and human settlements and infrastructure that operate within that system (UNCCD, 1994; FAO, 2007).

Land cover The biophysical coverage of *land* (e.g., bare soil, rocks, forests, buildings and roads or lakes). Land cover is often categorised in broad land-cover classes (e.g., deciduous forest, coniferous forest, mixed forest, grassland, bare ground). [Note: In some literature, land cover and land use are used interchangeably, but the two represent distinct classification systems. For example, the land cover class woodland can be under various land uses such as livestock grazing, recreation, conservation, or wood harvest.]

Land cover change Change from one *land cover* class to another, due to change in *land use* or change in natural conditions (Pongratz et al., 2018). See also *Land management change* and *Land-use change (LUC)*.

Land surface air temperature (LSAT) The near-surface air temperature over land, typically measured at 1.25–2 m above the ground using standard meteorological equipment.

Land use The total of arrangements, activities and inputs applied to a parcel of land. The term land use is also used in the sense of the social and economic purposes for which land is managed (e.g., grazing, timber extraction, conservation and city dwelling). In national GHG inventories, land use is classified according to the IPCC land use categories of forest land, cropland, grassland, wetlands, settlements, other lands (see the 2006 IPCC Guidelines for National GHG Inventories and their 2019 Refinement for details (IPCC, 2006, 2019)).

Land water storage Land water storage (LWS) includes all surface water, soil moisture, groundwater storage and snow, but excludes water stored in *glaciers* and *ice sheets*. Changes in land water storage can be caused either by direct human intervention in the water cycle (e.g., storage of water in reservoirs by building dams in rivers, groundwater extraction from groundwater reservoirs for consumption and irrigation, or deforestation) or by *climate* variations (e.g., changes in the amount of water in endorheic lakes and wetlands, the canopy, the soil, the permafrost and the snowpack). Land water storage changes caused by climate variations may also be indirectly affected by *anthropogenic* influences. See also *Sea level change (sea level rise/sea level fall)*.

Land-use change (LUC) The change from one *land use* category to another. Note that in some scientific literature, land-use change encompasses changes in land-use categories as well as changes in land management. See also *Afforestation*, *Agriculture, Forestry and Other Land Use (AFOLU)*, *Deforestation*, *Land use, land-use change and forestry (LULUCF)* and *Reforestation*.

Indirect land-use change (iLUC) Land use change outside the area of focus, that occurs as a consequence of change in use or management of land within the area of focus, such as through market or policy drivers. For example, if agricultural land is diverted to biofuel production, forest clearance may occur elsewhere to replace the former agricultural production.See *Land-use change (LUC)*.

Lapse rate The rate of change of an atmospheric variable, usually temperature, with height. The lapse rate is considered positive when the variable decreases with height.

Large-scale The climate system involves process interactions from the micro- to the global-scale. Any threshold for defining “large-scale” is arbitrary. Understanding of large-scale climate variability and change requires knowledge of both the response to external forcings and the role of internal variability. Many external forcings have substantial hemispheric or continental scale variations. Modes of climate variability are driven by ocean basin scale processes. Thus we define large-scale to include ocean basin and continental scales as well as hemispheric and global scales.

Last deglacial transition See *Deglacial or deglaciation or glacial termination* and *Younger Dryas*.

Last Glacial Maximum (LGM) See *Glacial or glaciation*.

Last Interglacial (LIG) See *Interglacial or interglaciation*.

Last millennium The interval of the *Common Era (CE)* between 1001 and 2000 CE. Encompasses the Little Ice Age, a roughly defined period characterized by multiple expansions of mountain *glaciers* worldwide, the timing of which differs among regions, but generally occurred between 1400 CE and 1900 CE. The last millennium also mostly encompasses the Medieval Warm Period (also called the Medieval Climate Anomaly), a roughly defined period of relatively warm conditions or other *climate* excursions such as extensive *drought*, the timing and magnitude of which differ among regions, but generally occurred between 900 and 1400 CE. Transient *climate model* experiments by the Paleoclimate Modelling Intercomparison Project (PMIP) for the last millennium extend from 850-1849 CE.

Latent heat flux The turbulent flux of heat from the Earth's surface to the atmosphere that is associated with *evaporation* or condensation of water vapour at the surface; a component of the surface energy budget. See also *Atmosphere* and *Flux*.

Lifetime Lifetime is a general term used for various time scales characterizing the rate of processes affecting the concentration of trace gases. The following lifetimes may be distinguished:

Response time or adjustment time (Ta) Response time or adjustment time (T_a) is the time scale characterizing the decay of an instantaneous pulse input into the *reservoir*. The term adjustment time is also used to characterize the adjustment of the mass of a reservoir following a step change in the *source* strength. Half-life or decay constant is used to quantify a first-order exponential decay process. See *Response time or adjustment time* for a different definition pertinent to *climate* variations.

The term lifetime is sometimes used, for simplicity, as a surrogate for adjustment time.

In simple cases, where the global removal of the compound is directly proportional to the total mass of the reservoir, the adjustment time equals the *turnover time*: $T = T_a$. An example is CFC-11, which is removed from the *atmosphere* only by photochemical processes in the *stratosphere*. In more complicated cases, where several reservoirs are involved or where the removal is not proportional to the total mass, the equality $T = T_a$ no longer holds.

Carbon dioxide (CO_2) is an extreme example. Its turnover time is only about 4 years because of the rapid exchange between the atmosphere and the ocean and terrestrial biota. However, a large part of that CO_2 is returned to the atmosphere within a few years. The adjustment time of CO_2 in the atmosphere is determined from the rates of removal of carbon by a range of processes with timescales from months to hundreds of thousands of years. As a result, 15 to 40% of an emitted CO_2 pulse will remain in the atmosphere longer than 1,000 years, 10 to 25% will remain about ten thousand years, and the rest will be removed over several hundred thousand years.

In the case of *methane (CH_4)*, the adjustment time is different from the turnover time because the removal is mainly through a chemical reaction with the hydroxyl radical (OH), the concentration of which itself depends on the CH_4 concentration. Therefore, the CH_4 removal rate S is not proportional to its total mass M.

Turnover time (T) (also called global atmospheric lifetime) is the ratio of the mass M of a *reservoir* (e.g., a gaseous compound in the *atmosphere*) and the total rate of removal S from the *reservoir*: T = M/S. For each removal process, separate turnover times can be defined. In soil carbon biology, this is referred to as Mean Residence Time.

Light-absorbing particles Light-absorbing particles (LAP), e.g., black carbon, brown carbon, dust, are particles that absorb solar radiation and convert it into internal energy, thus raising the particle's temperature and emitting thermal-infrared radiation that is selectively absorbed by the surrounding medium. LAP affect the energy balance of the atmosphere, clouds, and when deposited on snow and ice, they reduce snow/ice albedo, increasing heating and accelerating smelting. These particles have a warming effect on climate.

Likelihood The chance of a specific outcome occurring, where this might be estimated probabilistically. Likelihood is expressed in this report using a standard terminology (Mastrandrea et al., 2010). See also *Agreement*, *Confidence*, *Evidence* and *Uncertainty*.

Lithosphere The upper layer of the solid Earth, both continental and oceanic, which comprises all crustal rocks and the cold, mainly elastic part of the uppermost mantle. Volcanic activity, although part of the *lithosphere*, is not considered as part of the *climate system*, but acts as an *external forcing* factor.

Livelihood The resources used and the activities undertaken in order for people to live. Livelihoods are usually determined by the entitlements and assets to which people have access. Such assets can be categorised as human, social, natural, physical, or financial.

Local sea level change See *Sea level change (sea level rise/sea level fall)*.

Long-lived climate forcers (LLCFs) A set of well-mixed *greenhouse gases* with long atmospheric lifetimes. This set of compounds includes *carbon dioxide (CO_2)* and *nitrous oxide (N_2O)*, together with some fluorinated gases. They have a warming effect on *climate*. These compounds accumulate in the atmosphere at decadal to centennial timescales, and their effect on climate hence persists for decades to centuries after their emission. On timescales of decades to a century already emitted emissions of long-lived climate forcers can only be abated by *greenhouse gas removal (GGR)*.

Longwave radiation See *Terrestrial radiation*.

Low-likelihood, high impact events Events whose probability of occurrence is low or not well known (as in the context of deep uncertainty) but whose potential impacts on society and ecosystems could be high. To better inform risk assessment and decision-making, such low-likelihood outcomes are considered if they are associated with very large consequences and may therefore constitute material risks, even though those consequences do not necessarily represent the most likely outcome.

Madden-Julian Oscillation (MJO) The largest mode of tropical atmospheric intraseasonal variability with typical periods ranging from 20 to 90 days. The MJO corresponds to planetary-scale disturbances of pressure, wind and deep convection moving predominantly eastward along the equator. As it progresses, the MJO is associated with the temporal alternation of large-scale enhanced and suppressed rainfall, with maximum loading over the Indian and western Pacific oceans, although influences of the MJO can be tracked over the Atlantic/Africa in dynamical fields. See Section AIV.2.8 in Annex IV of the AR6 WGI report.

Maladaptive actions (Maladaptation) Actions that may lead to increased risk of adverse climate-related outcomes, including via increased greenhouse gas (GHG) emissions, increased vulnerability to climate change, or diminished welfare, now or in the future. Maladaptation is usually an unintended consequence.

Marine cloud brightening (MCB) See *Solar radiation modification (SRM)*.

Marine heatwave A period during which water temperature is abnormally warm for the time of the year relative to historical temperatures with that extreme warmth persisting for days to months. The phenomenon can manifest in any place in the ocean and at scales of up to thousands of kilometres. See also *Heatwave*.

Marine ice cliff instability (MICI) A hypothetic mechanism of an ice cliff failure. In case a marine-terminated *ice sheet* loses its buttressing *ice shelf*, an ice cliff can be exposed. If the exposed ice cliff is tall enough (about 800 m of the total height, or about 100 m of the above-water part), the stresses at the cliff face exceed the strength of the ice, and the cliff fails structurally in repeated *calving* events. See also *Marine ice sheet instability (MISI)*.

Marine ice sheet instability (MISI) A mechanism of irreversible (on the decadal to centennial time scale) retreat of a *grounding line* for the marine-terminating *glaciers*, in case the glacier bed slopes towards the *ice sheet* interior. See also *Marine ice cliff instability (MICI)*.

Marine isotope stage (MIS) Geological periods of alternating glacial and interglacial conditions, each typically lasting tens of thousands of years as inferred from the oxygen isotope composition of microfossils from deep sea sediment cores. MIS numbers increase back in time from the present, which is MIS 1. Even-number MISs coincide with glacial periods, and odd-numbered MISs are interglacials.

Marine-based ice sheet An *ice sheet* containing a substantial *region* that rests on a bed lying below sea level and whose perimeter is in contact with the ocean. The best known example is the West Antarctic ice sheet.

Mass balance / budget (of glaciers or ice sheets) Difference between the mass input (*accumulation*) and the mass loss (*ablation*) of an ice body (e.g., a glacier or ice sheet) over a stated time period, which is often a year or a season. Surface mass balance refers to the difference between surface accumulation and surface ablation.

Ablation (of glaciers, ice sheets, or snow cover) All processes that reduce the mass of a *glacier*, *ice sheet*, or snow cover. The main processes are melting, and for glaciers also *calving* (or, when the glacier nourishes an *ice shelf*, *discharge of ice* across the *grounding line*), but other processes such as sublimation and loss of wind-blown snow can also contribute to ablation. Ablation also refers to the mass lost by any of these processes.

Accumulation (of glaciers, ice sheets, or snow cover) All processes that add to the mass of a *glacier*, an *ice sheet*, or snow cover. The main process of accumulation is snowfall. Accumulation also includes deposition of hoar, freezing rain, other types of solid precipitation, gain of wind-blown snow, avalanching, and basal accumulation (often beneath floating ice).

Discharge (of ice) Rate of the flow of ice through a vertical section of a *glacier* perpendicular to the direction of the flow of ice. Often used to refer to the loss of mass at marine-terminating glacier fronts (mostly *calving* of *icebergs* and submarine melt), or to mass flowing across the *grounding line* of a floating ice shelf.

Mean sea level The surface level of the ocean at a particular point averaged over an extended period of time such as a month or year. Mean sea level is often used as a national datum to which heights on land are referred.

Medieval Climate Anomaly (MCA) See *Medieval Warm Period (MWP)*.

Megacity Urban agglomerations with 10 million inhabitants or more.

Meltwater Pulse 1A (MWP-1A) A particular interval of rapid global *sea level rise* between about 14,700 and 14,300 years ago, associated with the end of the last *ice age* and attributed to freshwater flux to the ocean from accelerated melting of *ice sheets* and *glaciers*. First defined based on oxygen *isotope* data (Duplessy et al., 1981), and later shown to be reflected by high rates of sea-level rise (Fairbanks, 1989). See also *Deglacial or deglaciation or glacial termination*.

Meridional overturning circulation (MOC) Meridional (north-south) overturning circulation in the *ocean* quantified by zonal (east-west) sums of mass transports in depth or density layers. In the North Atlantic, away from the subpolar regions, the MOC (which is in principle an observable quantity) is often identified with the thermohaline circulation (THC), which is a conceptual and incomplete interpretation. The MOC is also driven by wind, and can also include shallower overturning cells such as occur in the upper ocean in the tropics and subtropics, in which warm (light) waters moving poleward are transformed to slightly denser waters and subducted equatorward at deeper levels.

Atlantic Meridional Overturning Circulation (AMOC) The main current system in the South and North Atlantic Oceans. AMOC transports warm upper-ocean water northwards, and cold, deep water southwards, as part of the global ocean circulation system. Changes in the strength of AMOC can affect other components of the *climate system*.

Meteorological drought See *Drought*.

Methane (CH_4) One of the seven greenhouse gases (GHGs) to be mitigated under the Kyoto Protocol. Methane is the major component of natural gas and associated with all hydrocarbon fuels. Significant anthropogenic emissions also occur as a result of animal husbandry and paddy rice production. Methane is also produced naturally where organic matter decays under anaerobic conditions, such as in wetlands. Under future global warming, there is risk of increased methane emissions from thawing permafrost, coastal wetlands and sub-sea gas hydrates. See also *Short-lived climate forcers (SLCFs)*.

Microclimate Local climate at or near the Earth's surface.

Microwave sounding unit (MSU) A microwave sounder on National Oceanic and Atmospheric Administration (NOAA) polar orbiter satellites, that estimates the temperature of thick layers of the *atmosphere* by measuring the thermal emission of oxygen molecules from a complex of emission lines near 60 GHz. A series of nine MSUs began making this kind of measurement in late 1978. Beginning in mid-1998, a follow-on series of instruments, the Advanced Microwave Sounding Units (AMSUs), began operation.

Mid-Holocene (MH) See *Holocene*.

Mid-Pliocene Warm Period (MPWP) See *Pliocene*.

Mineralisation/Remineralisation The conversion of an element from its organic form to an inorganic form as a result of microbial decomposition. In nitrogen mineralisation, organic nitrogen from decaying plant and animal residues (proteins, nucleic acids, amino sugars and urea) is converted to ammonia (NH_3) and ammonium (NH_4^+) by biological activity.

Mitigation (of climate change) A human intervention to reduce emissions or enhance the sinks of greenhouse gases.

Mitigation potential The quantity of net greenhouse gas emission reductions that can be achieved by a given mitigation option relative to specified emission baselines. [Note: Net greenhouse gas emission reductions is the sum of reduced emissions and/or enhanced sinks.] See also *Sequestration potential*.

Biogeophysical potential The mitigation potential constrained by biological, geophysical and geochemical limits and thermodynamics, without taking into account technical, social, economic, and/or environmental considerations.

Economic potential The portion of the technical potential for which the social benefits exceed the social costs, taking into account a social discount rate and the value of externalities

Technical potential The mitigation potential constrained by biogeophysical limits as well as availability of technologies and practices. Quantification of technical potentials takes into account primarily technical considerations, but social, economic and/or environmental considerations are occasionally also included, if these represent strong barriers for the deployment of an option.

Mitigation scenario See *Scenario*.

Mixing ratio See *Mole fraction or mixing ratio*.

Model bias See *Biases*.

Model drift Since model *climate* differs to some extent from observed climate, *climate forecasts* will typically 'drift' from the initial observation-based state towards the model's climate. This drift occurs at different time scales for different variables, can obscure the initial-condition forecast information and is usually removed a posteriori by an empirical, usually linear, adjustment.

Model initialization A *climate prediction* typically proceeds by integrating a *climate model* forward in time from an initial state that is intended to reflect the actual state of the *climate system*. Available observations of the climate system are 'assimilated' into the model. Initialization is a complex process that is limited by available observations, observational errors and, depending on the procedure used, may be affected by *uncertainty* in the history of *climate* forcing. The initial conditions will contain errors that grow as the forecast progresses, thereby limiting the time for which the forecast will be useful.

Model spread The range or spread in results from *climate models*, such as those assembled for Coupled Model Intercomparison Project Phase 6 (CMIP6). Does not necessarily provide an exhaustive and formal estimate of the *uncertainty* in *feedbacks*, forcing or *projections* even when expressed numerically, for example, by computing a standard deviation of the models' responses. In order to quantify uncertainty, information from observations, physical constraints and expert judgement must be combined, using a statistical framework.

Modes of climate variability Recurrent space-time structures of *natural variability* of the *climate system* with intrinsic spatial patterns, seasonality and time scales. Modes can arise through the dynamical characteristics of the atmospheric circulation but also through coupling between the ocean and the *atmosphere*, with some interactions with land surfaces and *sea ice*. Many modes of variability are driven by internal climate processes and are a critical potential source of climate predictability on sub-seasonal to decadal time scales. See Annex IV of the AR6 WGI report. See also *Annular modes*, *Tropical Atlantic Variability (TAV)*, *Indian Ocean Dipole (IOD)*, *Indian Ocean Basin (IOB) mode*, *Pacific Decadal Variability (PDV)*, *Pacific Decadal Oscillation (PDO)* (under *Pacific Decadal Variability (PDV)*), *El Niño-Southern Oscillation (ENSO)*, *North Atlantic Oscillation (NAO)*, *Northern Annular Mode (NAM)* (under *Annular modes*), *Southern Annular Mode (SAM)* (under *Annular modes*), *Atlantic Meridional Mode (AMM)* (under *Tropical Atlantic Variability (TAV)*), *Atlantic Zonal Mode (AZM)* (under *Tropical Atlantic Variability (TAV)*), *Madden-Julian Oscillation (MJO)*, *Atlantic Multidecadal Variability (AMV)* and *Interdecadal Pacific Oscillation (IPO)* (under *Pacific Decadal Variability (PDV)*).

Mole fraction or mixing ratio Mole fraction, or mixing ratio, is the ratio of the number of moles of a constituent in a given volume to the total number of moles of all constituents in that volume. It is usually reported for dry air. Typical values for well-mixed greenhouse gases are in the order of $\mu mol\ mol^{-1}$ (parts per million: ppm), $nmol\ mol^{-1}$ (parts per billion: ppb), and $fmol\ mol^{-1}$ (parts per trillion: ppt). Mole fraction differs from volume mixing ratio, often expressed in ppmv etc., by the corrections for non-ideality of gases. This correction is significant relative to measurement precision for many greenhouse gases (Schwartz and Warneck, 1995).

Monsoon See *Global monsoon*.

Montreal Protocol 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 (O_3), such as chlorofluorocarbons (CFCs), methyl chloroform, carbon tetrachloride and many others.

Multi-model ensemble (MME) See *Climate simulation ensemble*. See also *Ensemble*.

Narrative See *Storyline*. See also *Pathways*.

Natural systems The dynamic physical and biological components of the environment that would operate in the absence of human impacts. Most, if not all, natural systems are also now affected by human activities to some degree.

Natural variability See *Climate variability*.

Near-surface permafrost See *Permafrost*.

Negative greenhouse gas emissions Removal of *greenhouse gases (GHGs)* from the *atmosphere* by deliberate human activities, i.e., in addition to the removal that would occur via natural carbon cycle or atmospheric chemistry processes. See also *Carbon dioxide removal (CDR)*, *Greenhouse gas removal (GGR)*, *Negative CO_2 emissions*, *Net negative greenhouse gas emissions*, *Net zero CO_2 emissions* and *Net zero greenhouse gas emissions*.

Net negative greenhouse gas emissions A situation of net negative greenhouse gas emissions is achieved when metric-weighted anthropogenic greenhouse gas (GHG) removals exceed metric-weighted anthropogenic GHG emissions. Where multiple GHG are involved, the quantification of net emissions depends on the metric chosen to compare emissions of different gases (such as *global warming potential*, global temperature change potential, and others, as well as the chosen time horizon). See also *Net zero CO_2 emissions*, *Net zero greenhouse gas emissions*, *Negative greenhouse gas emissions*, *Carbon dioxide removal (CDR)*, *Greenhouse gas removal (GGR)* and *Greenhouse gas emission metric*.

Net primary production (NPP) See *Primary production*.

Net zero CO_2 emissions Condition in which anthropogenic carbon dioxide (CO_2) emissions are balanced by anthropogenic CO_2 removals over a specified period. [Note: Carbon neutrality and net zero CO_2 emissions are overlapping concepts. The concepts can be applied at global or sub-global scales (e.g., regional, national and sub-national). At a global scale, the terms carbon neutrality and net zero CO_2 emissions are equivalent. At sub-global scales, net zero CO_2 emissions is generally applied to emissions and removals under direct control or territorial responsibility of the reporting entity, while carbon neutrality generally includes emissions and removals within and beyond the direct control or territorial responsibility of the reporting entity. Accounting rules specified by GHG programmes or schemes can have a significant influence on the quantification of relevant CO_2 emissions and removals.] See also *Net zero greenhouse gas emissions*, *Carbon neutrality* and *Land use, land-use change and forestry (LULUCF)*.

Net zero greenhouse gas emissions Condition in which metric-weighted anthropogenic greenhouse gas (GHG) emissions are balanced by metric-weighted anthropogenic GHG removals over a specified period. The quantification of net zero GHG emissions depends on the GHG emission metric chosen to compare emissions and removals of different gases, as well as the time horizon chosen for that metric.

[Note 1: GHG neutrality and net zero GHG emissions are overlapping concepts. The concept of net zero GHG emissions can be applied at global or sub-global scales (e.g., regional, national and sub-national). At a global scale, the terms GHG neutrality and net zero GHG emissions are equivalent. At sub-global scales, net zero GHG emissions is generally applied to emissions and removals under direct control or territorial responsibility of the reporting entity, while GHG neutrality generally includes anthropogenic emissions and anthropogenic removals within and beyond the direct control or territorial responsibility of the reporting entity. Accounting rules specified by GHG programmes or schemes can have a significant influence on the quantification of relevant emissions and removals.

Note 2. Under the Paris Rulebook [Decision 18/CMA.1, annex, paragraph 37], parties have agreed to use GWP100 values from the IPCC AR5 or GWP100 values from a subsequent IPCC Assessment Report to report aggregate emissions and removals of GHGs. In addition, parties may use other metrics to report supplemental information on aggregate emissions and removals of GHGs.]

See also *Net zero CO_2 emissions*, *Greenhouse gas emission metric*, *Greenhouse gas neutrality* and *Land use, land-use change and forestry (LULUCF)*.

Nitrogen deposition Nitrogen deposition is defined as the nitrogen transferred from the *atmosphere* to the Earth's surface by the processes of wet deposition and dry deposition.

Nitrous oxide (N_2O) One of the seven *greenhouse gases (GHGs)* to be mitigated under the Kyoto Protocol. The main anthropogenic source of N_2O is agriculture (soil and animal manure management), but important contributions also come from sewage treatment, *fossil fuel* combustion, and chemical industrial processes. N_2O is also produced naturally from a wide variety of biological sources in soil and water, particularly microbial action in wet tropical forests.

Non-CO_2 emissions and radiative forcing Non-CO_2 emissions included in this report are all *anthropogenic emissions* other than *CO_2* that result in *radiative forcing*. These include *short-lived climate forcers*, such as *methane (CH_4)*, some fluorinated gases, *ozone (O_3)* precursors, *aerosols* or aerosol *precursors*, such as *black carbon* and sulphur dioxide, respectively, as well as long-lived *greenhouse gases*, such as *nitrous oxide (N_2O)* or other fluorinated gases. The radiative forcing associated with non-CO_2 emissions and changes in surface *albedo* (e.g., resulting from land-use change) is referred to as non-CO_2 radiative forcing.

Non-methane volatile organic compounds (NMVOCs) See *Volatile organic compounds (VOCs)*.

Nonlinearity A process is called nonlinear when there is no simple proportional relation between cause and effect. The *climate system* contains many such nonlinear processes, resulting in a system with potentially very complex behaviour. Such complexity may lead to *abrupt climate change*.

North American monsoon (NAmerM) See *Global monsoon*.

Northern Annular Mode (NAM) See *Annular modes*.

North Atlantic Oscillation (NAO) The leading mode of large-scale atmospheric variability in the North Atlantic basin characterized by alternating (see-saw) variations in sea-level pressure or geopotential height between the Azores High in the subtropics and the Icelandic Low in the mid- to high latitudes, with some northward extension deep into the Arctic. It is associated with fluctuations in strength and latitudinal position of the main westerly winds across a vast North Atlantic-Europe domain, and thus with fluctuations in the embedded extratropical cyclones and associated frontal systems leading to strong *teleconnection* over the entire North Atlantic adjacent continents. The positive and negative phases of the NAO show similar characteristics described for the *Northern Annular Mode (NAM)*. See Section AIV.2.1 in Annex IV of the AR6 WGI report.

Northern polar vortex See *Stratospheric polar vortex*.

Ocean The interconnected body of saline water that covers 71% of the Earth's surface, contains 97% of the Earth's water and provides 99% of the Earth's biologically-habitable space. It includes the Arctic, Atlantic, Indian, Pacific and Southern Oceans, as well as their marginal seas and coastal waters.

Ocean acidification (OA) A reduction in the *pH* of the *ocean*, accompanied by other chemical changes (primarily in the levels of carbonate and bicarbonate ions), over an extended period, typically decades or longer, which is caused primarily by *uptake* of *carbon dioxide (CO_2)* from the *atmosphere*, but can also be caused by other chemical additions or subtractions from the ocean. *Anthropogenic* OA refers to the component of pH reduction that is caused by human activity (IPCC, 2011, p. 37).

Ocean alkalinisation / Ocean alkalinity enhancement A proposed carbon dioxide removal method that involves deposition of alkaline minerals or their dissociation products at the ocean surface. This increases surface total alkalinity, and may thus increase ocean CO_2 uptake and ameliorate surface ocean acidification. See also *Anthropogenic removals* and *Carbon dioxide removal (CDR)*.

Ocean carbon cycle The ocean *carbon cycle* is the set of processes that exchange carbon between various pools within the ocean, as well as between the *atmosphere*, Earth's interior, *cryosphere*, and the seafloor. See also *Carbon cycle*.

Ocean deoxygenation The loss of oxygen in the *ocean*. It results from ocean warming, which reduces oxygen solubility and increases oxygen consumption and *stratification*, thereby reducing the mixing of oxygen into the ocean interior. Deoxygenation can also be exacerbated by the addition of excess nutrients in the *coastal* zone.

Ocean dynamic sea level change See *Sea level change (sea level rise/sea level fall)*.

Ocean fertilisation A proposed carbon dioxide removal method that relies on the deliberate increase of nutrient supply to the near-surface ocean with the aim of sequestering additional CO_2 from the atmosphere through biological production. Methods include direct addition of micro-nutrients or macro-nutrients. To be successful, the additional carbon needs to reach the deep ocean where it has the potential to be sequestered on climatically-relevant timescales. See also *Anthropogenic removals* and *Carbon dioxide removal (CDR)*.

Ocean heat uptake efficiency This is a measure (W m^{-2} $°C^{-1}$) of the rate at which heat storage by the global ocean increases as global surface temperature rises. It is a useful parameter for *climate change* simulations in which the *radiative forcing* is changing monotonically, when it can be compared with the c*limate feedback parameter* to gauge the relative importance of radiative response and ocean heat *uptake* in determining the rate of *climate change*. It can be estimated from such an experiment as the ratio of the rate of increase of ocean heat content to the surface temperature change.

Ocean stratification See *Stratification*.

Orbital forcing Orbital *forcing* is the influence of slow, systematic and predictable changes in orbital parameters (eccentricity, obliquity and precession of the equinox) on incoming solar radiation (*insolation*), especially its latitudinal and seasonal distribution. It is an *external forcing* and a key driver of *glacial-interglacial cycles*.

Organic aerosol Component of the *aerosol* that consists of organic compounds, mainly carbon, hydrogen, oxygen and lesser amounts of other elements.

Outgoing longwave radiation Net outgoing radiation in the infrared part of the spectrum at the top of the *atmosphere.*

Outlet glacier See *Glacier*.

Oxygen minimum zone (OMZ) The midwater layer (200–1000 m) in the open ocean in which oxygen saturation is the lowest in the ocean. The degree of oxygen depletion depends on the largely bacterial consumption of organic matter and the distribution of the OMZs is influenced by large-scale ocean circulation. In coastal oceans, OMZs extend to the shelves and may also affect benthic ecosystems.

Ozone (O_3) The triatomic form of oxygen, and a gaseous *atmospheric* constituent. In the troposphere, O_3 is created both naturally and by photochemical reactions involving gases resulting from human activities (e.g., smog). Tropospheric O_3 acts as a *greenhouse gas (GHG)*. In the stratosphere, O_3 is created by the interaction between solar ultraviolet radiation and molecular oxygen (O_2). Stratospheric O_3 plays a dominant role in the stratospheric radiative balance. Its concentration is highest in the ozone layer. See also *Ground-level ozone*, *Ozone hole*, *Ozone layer*, *Ozone-depleting substances (ODSs)*, *Ozonesonde* and *Short-lived climate forcers (SLCFs)*.

Ozone layer The ozone layer is a layer of Earth's *stratosphere* that absorbs most of the Sun's ultraviolet radiation. It contains high concentrations of *ozone (O_3)* in relation to other parts of the *atmosphere*, although still small in relation to other gases in the stratosphere. The ozone layer contains less than 10 parts per million of ozone, while the average ozone concentration in Earth's atmosphere as a whole is about 0.3 parts per million. The ozone layer is mainly found in the lower portion of the stratosphere, from approximately 15 to 35 kilometres (9.3 to 21.7 miles) above Earth, although its thickness varies seasonally and geographically. See also *Ozone hole* and *Ozone-depleting substances (ODSs)*.

Ozone-depleting substances (ODSs) Ozone-depleting substances (ODSs) are man-made gases that destroy *ozone (O_3)* once they reach the *ozone layer* in the *stratosphere*. Ozone depleting substances include: *chlorofluorocarbons (CFCs)*, hydrochlorofluorocarbons (HCFCs), hydrobromofluorocarbons (HBFCs), halons, methyl bromide, carbon tetrachloride and methyl chloroform. They are used as refrigerants in commercial, home and vehicle air conditioners and refrigerators, foam blowing agents, components in electrical equipment, industrial solvents, solvents for cleaning (including dry cleaning), aerosol spray propellants and fumigants. See also *Ozone layer*, *Ozone (O_3)* and *Stratospheric ozone*.

Ozonesonde An ozonesonde is a radiosonde measuring *ozone (O_3)* concentrations. The radiosonde is usually carried on a weather balloon and transmits measured quantities by radio to a ground-based receiver.

Pacific Decadal Oscillation (PDO) See *Pacific Decadal Variability (PDV)*.

Pacific Decadal Variability (PDV) Coupled decadal-to-interdecadal variability of the atmospheric circulation and underlying ocean that is typically observed over the entire Pacific Basin beyond the *El Niño-Southern Oscillation (ENSO)* timescale. In the AR6 WGI report, PDV encapsulates the *Pacific Decadal Oscillation (PDO)*, the South Pacific Decadal Oscillation (SPDO), tropical Pacific decadal variability (also called decadal ENSO), and the Interdecadal Pacific Oscillation (IPO). Typically, the positive phase of the PDV is characterized by anomalously high *sea surface temperatures* in the central-eastern tropical Pacific that extend to the extratropical North and South Pacific along the American coasts, encircled to the west by cold sea surface anomalies in the mid-latitude North and South Pacific. The negative phase is accompanied by sea surface temperature anomalies in the opposite sign. Those sea surface temperature anomalies are linked to anomalies in atmospheric and oceanic circulation throughout the whole Pacific Basin. The PDV is associated with decadal modulations in the relative occurrence of El Niño and La Niña. See Section AIV.2.6 in Annex IV of the AR6 WGI report.

Interdecadal Pacific Oscillation (IPO) An equatorially symmetric pattern of *sea surface temperature* variability at decadal-to-interdecadal timescales. While the *Pacific Decadal Oscillation (PDO)* and its South Pacific counterpart, the South Pacific Decadal Oscillation (SPDO), are considered as physically distinct modes, the tropical Pacific decadal-interdecadal variability can drive both the PDO and SPDO, forming the IPO as a synchronized pan-Pacific variability. Its spatial pattern of sea surface temperature anomalies is similar to that of the *El Niño-Southern Oscillation (ENSO)*, but with a broader meridional extent in the tropical signal and more weights in the extratropics compared to the tropics. In the AR6 WGI report, it is encapsulated within the definition and description of the *Pacific Decadal Variability (PDV)*. See also Section AIV.2.6 in Annex IV of the AR6 WGI report.

Pacific Decadal Oscillation (PDO) The leading mode of variability obtained from decomposition in empirical orthogonal function of *sea surface temperature* over the North Pacific north of 20°N, and characterized by a strong decadal component. The positive phase of the PDO features a dipole of sea surface temperature anomalies in the North Pacific, with a cold lobe near the center of the basin and extending westward along the Kuroshio, encircled by warmer conditions along the coast of North America and in the subtropics. A positive PDO is accompanied by an intensified Aleutian Low and an associated cyclonic circulation enhancement leading to *teleconnections* over the continents adjacent to the North Pacific. In AR6 WGI report, the PDO is encapsulated within the definition and description of *Pacific Decadal Variability (PDV)*. See also Section AIV.2.6 in Annex IV of the AR6 WGI report.

Pacific-North American (PNA) pattern An atmospheric large-scale wave pattern featuring a sequence of tropospheric high and low pressure anomalies stretching from the subtropical west Pacific to the east coast of North America. See also *Pacific-South American (PSA) pattern*.

Palaeocene-Eocene Thermal Maximum (PETM) The PETM is a transient event that occurred between 55.9 and 55.7 million years ago. Continental positions at this time were somewhat different to present due to tectonic plate movements. Geological data indicate that the PETM was characterised by a warming (*global mean surface temperature* rose to about 4-7 °C warmer than the preceding mean state), and an increase in atmospheric CO_2 (from about 900 to about 2000 ppmv). In addition, ocean *pH* and oxygen content decreased; many deep-sea species went extinct and tropical *coral reefs* diminished.

Paleoclimate Climate during periods prior to the development of measuring instruments, including historic and geologic time, for which only *proxy* climate records are available.

Parameterisation In *climate models*, this term refers to the technique of representing processes that cannot be explicitly resolved at the spatial or temporal *resolution* of the model (sub-grid scale processes) by relationships between model-resolved larger-scale variables and the area- or time-averaged effect of such subgrid scale processes.

Pathways The temporal evolution of natural and/or human systems towards a future state. Pathway concepts range from sets of quantitative and qualitative *scenarios* or *narratives* of potential futures to solution-oriented decision-making processes to achieve desirable societal goals. Pathway approaches typically focus on biophysical, techno-economic, and/or socio-behavioural trajectories and involve various dynamics, goals, and actors across different scales. See also *Scenario storyline* (under *Storyline*), *Mitigation scenario* (under *Scenario*), *Baseline scenario* (under *Scenario*) and *Stabilisation (of GHG or CO_2-equivalent concentration)*.

1.5°C pathway A pathway of emissions of greenhouse gases and other climate forcers that provides an approximately one-in-two to two-in-three chance, given current knowledge of the climate response, of global warming either remaining below 1.5°C or returning to 1.5°C by around 2100 following an overshoot.

Representative concentration pathways (RCPs) *Scenarios* that include time series of *emissions* and concentrations of the full suite of *greenhouse gases (GHGs)* and *aerosols* and chemically active gases, as well as *land use*/*land cover* (Moss et al., 2010). The word representative signifies that each RCP provides only one of many possible scenarios that would lead to the specific *radiative forcing* characteristics. The term pathway emphasises that not only the long-term concentration levels are of interest, but also the trajectory taken over time to reach that outcome (Moss et al., 2010).

RCPs usually refer to the portion of the concentration pathway extending up to 2100, for which *Integrated assessment models* produced corresponding emission scenarios. Extended concentration pathways describe extensions of the RCPs from 2100 to 2300 that were calculated using simple rules generated by stakeholder consultations, and do not represent fully consistent scenarios. Four RCPs produced from Integrated assessment models were selected from the published literature and are used in the Fifth IPCC Assessment and also used in this Assessment for comparison, spanning the range from approximately below 2°C warming to high (>4°C) warming best-estimates by the end of the 21st century: RCP2.6, RCP4.5 and RCP6.0 and RCP8.5.

- RCP2.6: One pathway where radiative forcing peaks at approximately 3 W m^{-2} and then declines to be limited at 2.6 W m^{-2} in 2100 (the corresponding Extended Concentration Pathway, or ECP, has constant emissions after 2100).
- RCP4.5 and RCP6.0: Two intermediate stabilisation pathways in which radiative forcing is limited at approximately 4.5 W m^{-2} and 6.0 W m^{-2} in 2100 (the corresponding ECPs have constant concentrations after 2150).
- RCP8.5: One high pathway which leads to >8.5 W m^{-2} in 2100 (the corresponding ECP has constant emissions after 2100 until 2150 and constant concentrations after 2250).

See also *Coupled Model Intercomparison Project (CMIP)* and *Shared socio-economic pathways (SSPs)* (under *Pathways*).

Shared socio-economic pathways (SSPs) Shared socio-economic pathways (SSPs) have been developed to complement the *Representative concentration pathways (RCPs)*. By design, the RCP emission and concentration pathways were stripped of their association with a certain socio-economic development. Different levels of *emissions* and *climate change* along the dimension of the RCPs can hence be explored against the backdrop if different socio-economic development pathways (SSPs) on the other dimension in a matrix. This integrative SSP-RCP framework is now widely used in the climate *impact* and policy analysis literature, where *climate projections* obtained under the RCP scenarios are analysed against the backdrop of various SSPs. As several emission updates were due, a new set of emission scenarios was developed in conjunction with the SSPs. Hence, the abbreviation SSP is now used for two things: On the one hand SSP1, SSP2, …, SSP5 is used to denote the five socio-economic scenario families. On the other hand, the abbreviations SSP1-1.9, SSP1-2.6, …, SSP5-8.5 are used to denote the newly developed emission scenarios that are the result of an SSP implementation within an integrated assessment model. Those SSP scenarios are bare of climate policy assumption, but in combination with so-called shared policy assumptions (SPAs), various approximate *radiative forcing* levels of 1.9, 2.6, …, or 8.5 W m^{-2} are reached by the end of the century, respectively.

Pattern scaling Techniques used to represent the spatial variations in *climate* at a given increase in *global mean surface air temperature (GSAT)* are referred to as 'pattern scaling'.

Peat Soft, porous or compressed, sedimentary deposit of which a substantial portion is partly decomposed plant material with high water content in the natural state (up to about 90%).

Peatlands Peatland is a land where soils are dominated by *peat*.

Percentile A partition value in a population distribution that a given percentage of the data values are below or equal to. The 50th percentile corresponds to the median of the population. Percentiles are often used to estimate the extremes of a distribution. For example, the 90th (10th) percentile may be used to refer to the threshold for the upper (lower) extremes.

Permafrost Ground (soil or rock, and included ice and organic material) that remains at or below 0°C for at least two consecutive years (Harris et al., 1988). Note that permafrost is defined via temperature rather than ice content and, in some instances, may be ice-free.

Near-surface permafrost Permafrost within ~3-4 m of the ground surface. The depth is not precise, but describes what commonly is highly relevant for people and *ecosystems*. Deeper permafrost is often progressively less ice-rich and responds more slowly to warming than near-surface permafrost. Presence or absence of near-surface permafrost is not the only significant metric of permafrost change, and deeper permafrost may persist when near-surface permafrost is absent.

Permafrost degradation Decrease in the thickness and/or areal extent of permafrost.

Permafrost thaw Progressive loss of ground ice in permafrost, usually due to input of heat. Thaw can occur over decades to centuries over the entire depth of permafrost ground, with impacts occurring while thaw progresses. During thaw, temperature fluctuations are subdued because energy is transferred by phase change between ice and water. After the transition from permafrost to non-permafrost, ground can be described as thawed.

Perturbed parameter ensemble See *Model ensemble*.

pH A dimensionless measure of the acidity of a solution given by its concentration of hydrogen ions (H^+). pH is measured on a logarithmic scale where pH = $-\log_{10}(H^+)$. Thus, a pH decrease of 1 unit corresponds to a 10-fold increase in the concentration of H^+, or acidity.

Phenology The relationship between biological phenomena that recur periodically (e.g., development stages, migration) and *climate* and seasonal changes.

Photosynthesis The production of carbohydrates in plants, algae and some bacteria using the energy of light. Carbon dioxide (CO_2) is used as the carbon source.

Physical climate storyline See *Storyline*.

Piacenzian warm period See *Pliocene*.

Plankton Microorganisms living in the upper layers of aquatic systems. A distinction is made between phytoplankton, which depend on *photosynthesis* for their energy supply, and zooplankton, which feed on phytoplankton.

Plant evaporative stress Plant evaporative stress in both crops and natural vegetation can result from the combination of a high atmospheric evaporative demand and limited available water to supply this demand by means of evapotranspiration, further enhancing *agricultural or ecological drought*.

Pleistocene The Pleistocene Epoch is the earlier of two epochs in the *Quaternary* System, extending from 2.59 Ma to the beginning of the *Holocene* at 11.65 ka.

Pliocene The Pliocene Epoch is the more recent of two epochs of the Neogene Period within the *Cenozoic Era*. It extends from 5.33 Ma to the beginning of the *Pleistocene* Epoch at 2.59 Ma. The Neogene Period precedes the current geological period, the *Quaternary* Period, which is one of several ice ages that have occurred during Earth's geological history. It encompasses the mid-Pliocene warm period (MPWP), also known as the Piacenzian warm period, which occurred approximately 3.3 to 3.0 Ma. The MPWP, in turn, encompasses the interglacial episode, marine isotope stage (MIS) KM5c, which peaked at 3.205 Ma, when orbital forcing was similar to modern (Haywood et al., 2016).

Polar amplification Polar amplification describes the phenomenon where surface temperature change at high latitudes exceeds the global average surface temperature change. The terms Arctic Amplification or Antarctic Amplification are used when describing the phenomenon occurring at one of the poles.

Pollen analysis A technique of both relative dating and environmental *reconstruction*, consisting of the identification and counting of pollen types preserved in peat, lake sediments and other deposits.

Post-glacial period See *Holocene*.

Potential evapotranspiration See *Evapotranspiration*.

Pre-industrial (period) The multi-century period prior to the onset of large-scale industrial activity around 1750. The *reference period* 1850–1900 is used to approximate pre-industrial *global mean surface temperature (GMST)*. See also *Industrial revolution*.

Precipitable water The total amount of atmospheric water vapour in a vertical column of unit cross-sectional area. It is commonly expressed in terms of the height of the water if completely condensed and collected in a vessel of the same unit cross section.

Precursors Atmospheric compounds that are not *greenhouse gases (GHGs)* or *aerosols*, but that have an effect on GHG or aerosol concentrations by taking part in physical or chemical processes regulating their production or destruction rates.

Predictability The extent to which future states of a system may be predicted based on knowledge of current and past states of the system. Because knowledge of the climate system's past and current states is generally imperfect, as are the models that utilize this knowledge to produce a *climate prediction*, and because the *climate system* is inherently nonlinear and chaotic, predictability of the climate system is inherently limited. Even with arbitrarily accurate models and observations, there may still be limits to the predictability of such a nonlinear system (AMS, 2021).

Prediction quality/skill Measures of the success of a prediction against observationally based information. No single measure can summarize all aspects of forecast quality and a suite of *metrics* is considered. Metrics will differ for forecasts given in deterministic and probabilistic form.

Primary production The synthesis of organic compounds by plants and microbes, on land or in the ocean, primarily by photosynthesis using light and carbon dioxide (CO_2) as sources of energy and carbon respectively. It can also occur through chemosynthesis, using chemical energy, e.g., in deep sea vents.

Gross Primary Production (GPP) The total amount of carbon fixed by photosynthesis over a specified time period.

Net primary production (NPP) The amount of carbon fixed by photosynthesis minus the amount lost by respiration over a specified time period.

Probability density function (PDF) A probability density function is a function that indicates the relative chances of occurrence of different outcomes of a variable. The function integrates to unity over the domain for which it is defined and has the property that the integral over a sub-domain equals the probability that the outcome of the variable lies within that sub-domain. For example, the probability that a temperature anomaly defined in a particular way is greater than zero is obtained from its PDF by integrating the PDF over all possible temperature anomalies greater than zero. Probability density functions that describe two or more variables simultaneously are similarly defined.

Process-based model Theoretical concepts and computational methods that represent and simulate the behaviour of real-world systems derived from a set of functional components and their interactions with each other and the system environment, through physical and mechanistic processes occurring over time.

Projection A potential future evolution of a quantity or set of quantities, often computed with the aid of a model. Unlike predictions, projections are conditional on assumptions concerning, for example, future socio-economic and technological developments that may or may not be realised. See also *Climate projection*, *Pathways* and *Scenario*.

Proxy A proxy *climate indicator* is any biophysical property of materials formed during the past that is interpreted to represent some combination of climate-related variations back in time. Climate-related data derived in this way are referred to as proxy data and time series of proxy data are proxy records. Examples of proxy types include pollen assemblages, *tree ring* widths, speleothem and coral geochemistry, and various data derived from marine sediments and glacier ice. Proxy data can be calibrated to provide quantitative climate information.

Proxy records See *Proxy*.

Quasi-Biennial Oscillation (QBO) A near-periodic oscillation of the equatorial zonal wind between easterlies and westerlies in the tropical *stratosphere* with a mean period of around 28 months. The alternating wind maxima descend from the base of the mesosphere down to the *tropopause*, and are driven by wave energy that propagates up from the *troposphere*.

Quaternary The Quaternary Period is the last of three periods that make up the Cenozoic Era (66 Ma to present), extending from 2.58 Ma to the present, and includes the *Pleistocene* and *Holocene* Epochs.

Radiative effect The impact on a radiation flux or heating rate (most commonly, on the downward flux at the top of *atmosphere*) caused by the interaction of a particular constituent with either the *infrared* or *solar radiation* fields through absorption, scattering and emission, relative to an otherwise identical *atmosphere* free of that constituent. This quantifies the impact of the constituent on the *climate system*. Examples include the *aerosol-radiation interactions*, *cloud radiative effect*, and *greenhouse effect*. In this report, the portion of any top-of-atmosphere radiative effect that is due to *anthropogenic* or other external influences (e.g., volcanic eruptions or changes in the sun) is termed the instantaneous *radiative forcing*.

Radiative forcing The change in the net, downward minus upward, radiative flux (expressed in W m^{-2}) due to a change in an external *driver* of *climate change*, such as a change in the concentration of *carbon dioxide (CO_2)*, the concentration of volcanic *aerosols* or in the output of the Sun. The stratospherically adjusted radiative forcing is computed with all tropospheric properties held fixed at their unperturbed values, and after allowing for stratospheric temperatures, if perturbed, to readjust to radiative-dynamical equilibrium. Radiative forcing is called instantaneous if no change in stratospheric temperature is accounted for. The radiative forcing once both stratospheric and tropospheric adjustments are accounted for is termed the effective radiative forcing.

Rapid adjustment The response to an agent perturbing the *climate system* that is driven directly by the agent, independently of any change in the *global mean surface temperature*. For example, *carbon dioxide* and *aerosols*, by altering internal heating and cooling rates within the *atmosphere*, can each cause changes to cloud cover and other variables thereby producing a *radiative effect* even in the absence of any surface warming or cooling. Adjustments are rapid in the sense that they begin to occur right away, before *climate feedbacks* which are driven by warming (although some adjustments may still take significant time to proceed to completion, for example those involving vegetation or *ice sheets*). It is also called the rapid response or fast adjustment.

Rapid climate change See *Abrupt change / abrupt climate change*.

Rapid dynamical change (of glaciers or ice sheets) Changes in *glacier* or *ice sheet* mass controlled by changes in flow speed and discharge rather than by *accumulation* or ablation. This can result in a rate of mass change larger than that due to any imbalance between accumulation and ablation. Rapid dynamical change may be initiated by a climatic trigger, such as incursion of warm ocean water beneath an *ice shelf*, or thinning of a grounded tidewater terminus, which may lead to reactions within the glacier system, that may result in rapid ice loss.

Reanalysis Reanalyses are created by processing past meteorological or oceanographic data using fixed state-of-the-art weather forecasting or ocean circulation models with *data assimilation* techniques. They are used to provide estimates of variables such as historical atmospheric temperature and wind or oceanographic temperature and currents, and other quantities. Using fixed data assimilation avoids effects from the changing analysis system that occur in operational analyses. Although continuity is improved, global reanalyses still suffer from changing coverage and biases in the observing systems.

Reasons for concern (RFCs) Elements of a classification framework, first developed in the IPCC Third Assessment Report, which aims to facilitate judgments about what level of climate change may be dangerous (in the language of Article 2 of the UNFCCC) by aggregating risks from various sectors, considering hazards, exposures, vulnerabilities, capacities to adapt, and the resulting impacts.

Reconstruction (of climate variable) Approach to reconstructing the past temporal and spatial characteristics of a *climate* variable from predictors. The predictors can be instrumental data if the reconstruction is used to infill missing data or *proxy* data if it is used to develop *paleoclimate* reconstructions. Various techniques have been developed for this purpose: linear multivariate regression based methods and nonlinear *Bayesian* and analogue methods.

Reference period The period relative to which *anomalies* are computed. See also *Baseline/reference (period)*.

Baseline period The period relative to which *anomalies* are computed. See also *Baseline/reference (period)*.

Reference scenario See *Scenario*.

Reforestation Conversion to forest of land that has previously contained forests but that has been converted to some other use. [Note: For a discussion of the term forest and related terms such as afforestation, reforestation and deforestation, see the 2006 IPCC Guidelines for National Greenhouse Gas Inventories and their 2019 Refinement, and information provided by the United Nations Framework Convention on Climate Change (IPCC, 2006, 2019, UNFCCC, 2021a, 2021b).] See also *Afforestation*, *Deforestation*, *Reducing Emissions from Deforestation and Forest Degradation (REDD+)*, *Anthropogenic removals* and *Carbon dioxide removal (CDR)*.

Region *Land* and/or *ocean* area characterised by specific geographical and/or climatological features. The *climate* of a region emerges from a multiscale combination of its own features, remote influences from other regions, and global climate conditions.

Regional climate messages Regional climate messages translate *climate information* synthesized from different lines of *evidence* into the context of a user *vulnerable* to climate at regional scales taking into account the values of both the producer and user (WGI Section 10.5).

Regional climate model (RCM) A *climate model* at higher *resolution* over a limited area. Such models are used in *downscaling* global *climate* results over specific regional domains.

Regional climate scenario A narrative used to describe how the future might unfold for a region (IPCC-TGICA, 2007). These are often used to guide impact understanding and adaptation efforts. They can include quantitative information based on scaled historical data or derived from GCM-based internally consistent future climates. See also *Climate scenario*.

Regional sea level change See *Sea level change (sea level rise/sea level fall)*.

Relative humidity The relative humidity specifies the ratio of actual water vapour pressure to that at saturation with respect to liquid water or ice at the same temperature. See also *Specific humidity*.

Relative sea-level (RSL) change See *Sea level change (sea level rise/sea level fall)*.

Remaining carbon budget See *Carbon budget*.

Representative concentration pathways (RCPs) See *Pathways*.

Reservoir A component or components of the climate system where a *greenhouse gas (GHG)* or a *precursor* of a greenhouse gas is stored (UNFCCC Article 1.7 (UNFCCC, 1992)).

Resilience The capacity of interconnected social, economic and ecological systems to cope with a hazardous event, trend or disturbance, responding or reorganising in ways that maintain their essential function, identity and structure. Resilience is a positive attribute when it maintains capacity for adaptation, learning and/or transformation (Arctic Council, 2016). See also *Hazard*, *Risk* and *Vulnerability*.

Resolution In *climate models*, this term refers to the physical distance (metres or degrees) between each point on the grid used to compute the equations. Temporal resolution refers to the time step or time elapsed between each model computation of the equations.

Respiration The process whereby living organisms convert organic matter to *carbon dioxide* (CO_2), releasing energy and consuming molecular oxygen.

Response time or adjustment time In the context of climate variations, the response time or adjustment time is the time needed for the *climate system* or its components to re-equilibrate to a new state, following a forcing resulting from external processes. It is very different for various components of the climate system. The response time of the *troposphere* is relatively short, from days to weeks, whereas the *stratosphere* reaches equilibrium on a time scale of typically a few months. Due to their large heat capacity, the oceans have a much longer response time: typically decades, but up to centuries or millennia. The response time of the strongly coupled surface-troposphere system is, therefore, slow compared to that of the stratosphere, and mainly determined by the oceans. The *biosphere* may respond quickly (e.g., to *droughts*), but also very slowly to imposed changes.

In the context of *lifetimes*, response time or adjustment time (T_a) is the time scale characterizing the decay of an instantaneous pulse input into the *reservoir*. See *Response time or adjustment time (Ta)* under *Lifetime*.

Return period An estimate of the average time interval between occurrences of an event (e.g., flood or extreme rainfall) of (or below/above) a defined size or intensity.

Return value The highest (or, alternatively, lowest) value of a given variable, on average occurring once in a given period of time (e.g., in 10 years).

Risk The potential for adverse consequences for human or ecological systems, recognising the diversity of values and objectives associated with such systems. In the context of *climate change*, risks can arise from potential *impacts* of climate change as well as human responses to climate change. Relevant adverse consequences include those on lives, *livelihoods*, health and *well-being*, economic, social and cultural assets and investments, infrastructure, services (including *ecosystem services*), *ecosystems* and species.

In the context of climate change impacts, risks result from dynamic interactions between climate-related *hazards* with the *exposure* and *vulnerability* of the affected human or ecological system to the hazards. Hazards, exposure and vulnerability may each be subject to uncertainty in terms of magnitude and *likelihood* of occurrence, and each may change over time and space due to socio-economic changes and human decision-making (see also *risk management*, *adaptation* and *mitigation*).

In the context of climate change responses, risks result from the potential for such responses not achieving the intended objective(s), or from potential trade-offs with, or negative side-effects on, other societal objectives, such as the *Sustainable Development Goals (SDGs)* (see also *risk trade-off*). Risks can arise for example from uncertainty in implementation, effectiveness or outcomes of *climate policy*, climate-related investments, technology development or adoption, and system transitions. See also *Hazard* and *Impacts (consequences, outcomes)*.

Risk assessment The qualitative and/or quantitative scientific estimation of *risks*. See also *Risk management* and *Risk perception*.

Risk framework A common framework for describing and assessing risk across all three working groups is adopted to promote clear and consistent communication of risks and to better inform risk assessment and decision making related to climate change.

Risk management Plans, actions, strategies or policies to reduce the *likelihood* and/or magnitude of adverse potential consequences, based on assessed or perceived *risks*. See also *Risk assessment*, *Risk perception* and *Risk transfer*.

Risk perception The subjective judgment that people make about the characteristics and severity of a *risk*. See also *Risk assessment*, *Risk management* and *Risk transfer*.

Risk trade-off The change in the portfolio of *risks* that occurs when a countervailing risk is generated (knowingly or inadvertently) by an intervention to reduce the target risk (Wiener and Graham, 2009).

River discharge See *Streamflow*.

Rock glacier A debris landform (mass of rock fragments and finer material that contains either an ice core or an ice-cemented matrix) generated by a former or current gravity-driven creep of *permafrost* in mountain slopes (Harris et al., 1988; Giardino et al., 2011; IPA-RG, 2020). It is detectable in the landscape due to the occurrence of (i) a steep slope delimiting the terminal part; (2) generally well-defined lateral margins in a continuation of the front; (3) transversal or longitudinal ridges and furrows (ridge and furrow topography). These are geomorphological indicators of the occurrence of permafrost conditions. Although it is an ice storage feature, it is not a type of glacier since it is not originated over the surface by the recrystallization of snow.

Runoff The flow of water over the surface or through the subsurface, which typically originates from the part of liquid precipitation and/or snow/ice melt that does not evaporate, transpire or refreeze, and returns to water bodies.

Sampling uncertainty See *Uncertainty*.

Scenario A plausible description of how the future may develop based on a coherent and internally consistent set of assumptions about key driving forces (e.g., rate of technological change (TC), prices) and relationships. Note that scenarios are neither predictions nor forecasts, but are used to provide a view of the implications of developments and actions. See also *Climate scenario* and *Regional climate scenario*.

Baseline scenario See Reference ScenarioSee *Reference scenario* (under *Scenario*).

Concentrations scenario A plausible representation of the future development of atmospheric concentrations of substances that are radiatively active (e.g., *greenhouse gases (GHGs)*, *aerosols*, tropospheric *ozone*), plus human-induced *land cover changes* that can be radiatively active via *albedo* changes, and often used as input to a *climate model* to compute *climate projections.*

Emissions scenario A plausible representation of the future development of emissions of substances that are radiatively active (e.g., *greenhouse gases (GHGs)* or *aerosols*), plus human-induced land cover changes that can be radiatively active via albedo changes, based on a coherent and internally consistent set of assumptions about driving forces (such as demographic and socio-economic development, technological change, energy and *land use*) and their key relationships. *Concentration scenarios*, derived from emission scenarios, are often used as input to a *climate model* to compute *climate projections*. See also *Representative concentration pathways (RCPs)* (under *Pathways*) and *Shared socio-economic pathways (SSPs)* (under *Pathways*).

Mitigation scenario A plausible description of the future that describes how the (studied) system responds to the implementation of *mitigation* policies and measures. See also *Pathways*, *Socio-economic scenario* (under *Scenario*) and *Stabilisation (of GHG or CO_2-equivalent concentration)*.

Reference scenario Scenario used as starting or reference point for a comparison between two or more scenarios.

[Note 1: In many types of climate change research, reference scenarios reflect specific assumptions about patterns of socio-economic development and may represent futures that assume no climate policies or specified climate policies, for example those in place or planned at the time a study is carried out. Reference scenarios may also represent futures with limited or no climate impacts or adaptation, to serve as a point of comparison for futures with impacts and adaptation. These are also referred to as baseline scenarios in the literature.

Note 2: Reference scenarios can also be climate policy or impact scenarios, which in that case are taken as a point of comparison to explore the implications of other features, e.g., of delay, technological options, policy design and strategy or to explore the effects of additional impacts and adaptation beyond those represented in the reference scenario.

Note 3: The term business as usual scenario has been used to describe a scenario that assumes no additional policies beyond those currently in place and that patterns of socio-economic development are consistent with recent trends. The term is now used less frequently than in the past.

Note 4: In climate change attribution or impact attribution research reference scenarios may refer to counterfactual historical scenarios assuming no anthropogenic greenhouse gas emissions (climate change attribution) or no climate change (impact attribution).]

Socio-economic scenario A scenario that describes a plausible future in terms of population, *gross domestic product (GDP)*, and other socio-economic factors relevant to understanding the implications of *climate change*. See also *Baseline scenario* (under *Scenario*), *Mitigation scenario* (under *Scenario*) and *Pathways*.

Scenario storyline See *Storyline*.

Sea ice Ice found at the sea surface that has originated from the freezing of seawater. Sea ice may be discontinuous pieces (ice floes) moved on the *ocean* surface by wind and currents (pack ice), or a motionless sheet attached to the *coast* (land-fast ice). Sea ice concentration is the fraction of the ocean covered by ice. Sea ice less than one year old is called first-year ice. Perennial ice is sea ice that survives at least one summer. It may be subdivided into second-year ice and multi-year ice, where multiyear ice has survived at least two summers.

Sea ice area (SIA) Sea ice area is the area covered by sea ice. In contrast to *sea ice extent*, it is a linear measure of sea ice coverage that does not depend on grid resolution.

Sea ice concentration Sea ice concentration is the fraction of the ocean covered by ice.

Sea ice extent (SIE) Sea ice extent is calculated for gridded data products as the total area of all grid cells with *sea ice concentration* above a given threshold, usually 15 %. It hence is a grid-dependent, non-linear measure of sea ice coverage.

Sea level change (sea level rise/sea level fall) Change to the height of sea level, both globally and locally (*relative sea level* change) at seasonal, annual, or longer time scales due to (1) a change in *ocean* volume as a result of a change in the mass of water in the ocean (e.g., due to melt of *glaciers* and *ice sheets*), (2) changes in ocean volume as a result of changes in ocean water density (e.g., expansion under warmer conditions), (3) changes in the shape of the ocean basins and changes in the Earth's gravitational and rotational fields, and (4) local subsidence or uplift of the *land*. *Global mean sea level change* resulting from change in the mass of the ocean is called barystatic. The amount of barystatic sea level change due to the addition or removal of a mass of water is called its *sea level equivalent (SLE)*. Sea level changes, both globally and locally, resulting from changes in water density are called steric. Density changes induced by temperature changes only are called thermosteric, while density changes induced by salinity changes are called halosteric. Barystatic and steric sea level changes do not include the effect of changes in the shape of ocean basins induced by the change in the ocean mass and its distribution. See also *Vertical land motion (VLM)*, *Land water storage*, *Sea level commitment*, *Glacial isostatic adjustment (GIA)*, *Extreme sea level (ESL)* and *Storm surge*.

Geocentric sea-level change The change in local mean sea surface height with respect to the terrestrial reference frame, it is the sea-level change observed with instruments from space. See also *Altimetry*.

Global mean sea-level (GMSL) change The increase or decrease in the volume of the ocean divided by the ocean surface area. It is the sum of changes in ocean density through temperature changes (global mean *thermosteric sea-level change*) and changes in the ocean mass as a result of changes in the cryosphere or land water storage (barystatic sea-level change). See also *Terrestrial water storage (TWS)*.

Gravitational, rotational and deformational (GRD) effects Changes in Earth Gravity, Earth Rotation and viscoelastic solid Earth Deformation (GRD) result from the redistribution of mass between terrestrial ice and water reservoirs and the ocean. Contemporary terrestrial mass loss leads to elastic solid Earth uplift and a nearby relative sea-level fall (for a single source of terrestrial mass loss this is within ~2000 km, for multiple sources the distance depends on the interaction of the different relative sea-level patterns). Farther away (more than ~7000 km for a single source of terrestrial mass loss), relative sea level rises more than the global average, due, to first order, to gravitational effects. Earth deformation associated with adding water to the oceans and a shift of the Earth's rotation axis towards the source of terrestrial mass loss leads to second-order effects that increase spatial variability of the pattern globally. GRD effects due to the redistribution of ocean water within the ocean itself are referred to as self-attraction and loading effects.

Halosteric sea-level change Halosteric sea-level change occurs as a result of salinity variations: higher salinity leads to higher density and decreases the volume per unit of mass. Although both processes can be relevant on regional to local scales, only thermosteric changes impact the *global mean sea-level change*, whereas the global mean halosteric change is negligible (Gregory et al., 2019).

Local sea level change Change in sea level relative to a datum (such as present-day mean sea level) at spatial scales smaller than 10 km.

Ocean dynamic sea level change Change in mean sea level relative to the geoid associated with circulation and density-driven changes in the ocean. Ocean dynamic sea-level change is regionally varying but by definition has a zero global mean and conventionally is inverse-barometer corrected (i.e., the effect of the hydrostatic depression of the sea surface by atmospheric pressure changes is removed). Changes in ocean currents occur due to variations in heating and cooling, variability in winds and changes in seasonally- to annually-averaged air temperature and humidity.

Regional sea level change Change in sea level relative to a datum (such as present-day *mean sea level*) at spatial scales of about 100 km.

Relative sea-level (RSL) change The change in local mean *sea surface height (SSH)* relative to the local solid surface, i.e. the sea floor, as measured by instruments that are fixed to the Earth's surface, such as *tide gauges*. This reference frame is used when considering coastal *impacts*, *hazards* and *adaptation* needs.

Steric sea level change Steric sea-level change is caused by changes in the ocean density and is composed of *thermosteric sea-level change* and *halosteric sea-level change*.

Thermosteric sea-level change Thermosteric sea-level change (where thermosteric sea-level rise may also be referred to as thermal expansion) occurs as a result of changes in ocean temperature: increasing temperature reduces ocean density and increases the volume per unit of mass.

Sea level equivalent (SLE) The SLE of a mass of water, ice, or water vapour is that mass, converted to a volume using a density of 1000 kg m^{-3}, and divided by the present-day *ocean* surface area of 3.625 × 1000 m^2. Thus, 362.5 Gt of water mass added to the ocean correspond to 1 mm of global mean sea level rise. However, more accurate estimates of SLE must account for additional processes affecting mean sea level rise, such as shoreline migration, changes in ocean area, and for vertical land movements.

Sea level rise (SLR) See *Sea level change (sea level rise/sea level fall)*.

Sea surface temperature (SST) The subsurface bulk temperature in the top few metres of the ocean, measured by ships, buoys, and drifters. From ships, measurements of water samples in buckets were mostly switched in the 1940s to samples from engine intake water. Satellite measurements of skin temperature (uppermost layer; a fraction of a millimetre thick) in the infrared or the top centimetre or so in the microwave are also used, but must be adjusted to be compatible with the bulk temperature.

Semi-direct (aerosol) effect See *Aerosol-radiation interaction*.

Semi-empirical model Model in which calculations are based on a combination of observed associations between variables and theoretical considerations relating variables through fundamental principles (e.g., conservation of energy). For example, in sea level studies, semi-empirical models refer specifically to transfer functions formulated to project future *global mean sea level change*, or contributions to it, from future *global mean surface temperature* change or *radiative forcing*.

Sensible heat flux The turbulent or conductive flux of heat from the Earth's surface to the *atmosphere* that is not associated with phase changes of water; a component of the surface *energy budget*.

Sequestration The process of storing carbon in a carbon pool. See also *Uptake* and *Soil carbon sequestration (SCS)*.

Sequestration potential The quantity of greenhouse gases that can be removed from the atmosphere by anthropogenic enhancement of sinks and stored in a pool. See Mitigation potential for different subcategories of sequestration potential. See also *Pool, carbon and nitrogen*, *Sequestration* and *Sink*.

Shared policy assumptions (SPAs) See *Shared socio-economic pathways (SSPs)* (under *Pathways*).

Shared socio-economic pathways (SSPs) See *Pathways*.

Short-lived climate forcers (SLCFs) A set of chemically reactive compounds with short (relative to CO_2) atmospheric lifetimes (from hours to decades) but characterised by different physiochemical properties and environmental effects. Their emission or formation has a significant effect on radiative forcing over a period determined by their respective atmospheric *lifetimes*. Changes in their *emissions* can also induce long-term *climate* effects via, in particular, their interactions with some biogeochemical cycles. SLCFs are classified as direct or indirect, with direct SLCFs exerting climate effects through their *radiative forcing* and indirect SLCFs being the *precursors* of other direct climate forcers. Direct SLCFs include *methane* (*CH_4*), *ozone* (*O_3*), primary *aerosols* and some halogenated species. Indirect SLCFs are precursors of ozone or secondary aerosols. SLCFs can be cooling or warming through interactions with radiation and clouds. They are also referred to as near-term climate forcers (NTCFs). Many SLCFs are also air pollutants. A subset of exclusively warming SLCFs is also referred to as short-lived climate pollutants (SLCPs), including methane, ozone, and black carbon.

Short-lived climate pollutants (SLCP) See *Short-lived climate forcers (SLCFs)*.

Shortwave radiation See *Solar radiation*.

Significant wave height The average trough-to-crest height of the highest one-third of the wave heights (sea and swell) occurring in a particular time period.

Simple climate model (SCM) A broad class of lower-dimensional models of the *energy balance*, radiative transfer, *carbon cycle*, or a combination of such physical components. SCMs are also suitable for performing *emulations* of climate-mean variables of *Earth system models (ESMs)*, given that their structural flexibility can capture both the parametric and structural uncertainties across process-oriented ESM responses. They can also be used to test consistency across multiple lines of evidence with regard to *climate sensitivity* ranges, *transient climate responses (TCRs)*, *transient climate response to cumulative emissions (TCREs)* and carbon cycle *feedbacks*. See also *Emulators* and *Earth system model of intermediate complexity (EMIC)*.

Sink Any process, activity or mechanism which removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas from the atmosphere (UNFCCC Article 1.8 (UNFCCC, 1992)). See also *Source* and *Uptake*.

Small Island Developing States (SIDS) Small Island Developing States (SIDS), as recognised by the United Nations OHRLLS (Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States), are a distinct group of developing countries facing specific social, economic and environmental vulnerabilities (UN-OHRLLS, 2011). They were recognized as a special case both for their environment and development at the Rio Earth Summit in Brazil in 1992. Fifty-eight countries and territories are presently classified as SIDS by the UN OHRLLS, with 38 being UN member states and 20 being Non-UN Members or Associate Members of the Regional Commissions (UN-OHRLLS, 2018).

Snow cover Snow cover refers to all the snow that has accumulated on the ground at a given time (UNESCO/IASH/WMO, 1970).

Snow cover duration (SCD) How long snow continuously remains on the land surface, or the period between snow-on and snow-off dates.

Snow cover extent (SCE) The areal extent of snow covered ground.

Snow water equivalent (SWE) The depth of liquid water that would result if a mass of snow melted completely.

Socio-economic scenario See *Scenario*.

Soil moisture Water stored in the soil in liquid or frozen form. Root-zone soil moisture is of most relevance for plant activity.

Soil temperature The temperature of the soil. This can be measured or modelled at multiple levels within the depth of the soil.

Solar activity General term collectively describing a variety of magnetic phenomena on the Sun such as *sunspots*, *faculae* (bright areas), and flares (emission of high-energy particles). It varies on time scales from minutes to millions of years. The *solar cycle*, with an average duration of 11 years, is an example of a quasi-regular change in solar activity.

Solar cycle (11-year) A quasi-regular modulation of *solar activity* with varying amplitude and a period of between 8 and 14 years.

Solar radiation Electromagnetic radiation emitted by the Sun with a spectrum close to the one of a black body with a temperature of 5770 K. The radiation peaks in visible wavelengths. When compared to the *terrestrial radiation* it is often referred to as shortwave radiation. See also *Insolation* and *Total solar irradiance (TSI)*.

Solar radiation modification (SRM) Solar radiation modification (SRM) refers to a range of radiation modification measures not related to greenhouse gas (GHG) mitigation that seek to limit global warming. Most methods involve reducing the amount of incoming solar radiation reaching the surface, but others also act on the longwave radiation budget by reducing optical thickness and cloud lifetime.

Cirrus cloud thinning (CCT) Cirrus cloud thinning is one of several radiation modification approaches to counter the warming caused by greenhouse gases. In the approach, it is proposed to reduce the amount of cirrus clouds by injecting ice nucleating substances in the upper troposphere. The reduction in cirrus clouds is expected to increase the amount of longwave cooling to space resulting in a planetary cooling. Although cirrus cloud thinning primarily affects the longwave radiation budget of our planet, it is often identified as one of the *solar radiation modification (SRM)* approaches in the literature.

Marine cloud brightening (MCB) Marine cloud brightening is one of several solar radiation modification (SRM) approaches to increase the planetary albedo. In the approach, it is proposed to inject sea salt aerosols into the persistent marine lows clouds. This is expected to increase the cloud droplet concentration of these clouds and their reflectivity.

Stratospheric aerosol injection (SAI) Stratospheric aerosol injection is one of several solar radiation modification (SRM) approaches to increase the planetary albedo. In the approach, it is proposed to inject highly reflective aerosols such as sulphates into the lower stratosphere. This is expected to increase the fraction of solar radiation deflected to space resulting in a planetary cooling.

Solubility pump A physicochemical process that transports dissolved inorganic carbon from the *ocean*'s surface to its interior. The solubility pump is primarily driven by the solubility of *carbon dioxide (CO_2)* (with more CO_2 dissolving in colder water) and the large-scale, thermohaline patterns of ocean circulation.

Source Any process or activity which releases a greenhouse gas, an aerosol or a precursor of a greenhouse gas into the atmosphere (UNFCCC Article 1.9 (UNFCCC, 1992)). See also *Sink*.

South American monsoon (SAmerM) See *Global monsoon*.

South and Southeast Asian monsoon (SAsiaM) See *Global monsoon*.

Southern Annular Mode (SAM) See *Annular modes*.

South Pacific Convergence Zone (SPCZ) A band of low-level convergence, cloudiness and precipitation ranging from the west Pacific warm pool south-eastwards towards French Polynesia, which is one of the most significant features of subtropical Southern Hemisphere *climate*. It shares some characteristics with the *Inter-Tropical Convergence Zone (ITCZ)*, but is more extratropical in nature, especially east of the Dateline.

Southern Oscillation See *El Niño-Southern Oscillation (ENSO)*.

Specific humidity The specific humidity specifies the ratio of the mass of water vapour to the total mass of moist air. See also *Relative humidity*.

Stadial A period of North Atlantic cooling during the last glacial period, lasting anywhere from several centuries to millennia, as inferred from oxygen *isotopes* in Greenland *ice cores*. These episodes are often referred to as examples of "abrupt climate change events", as they are often terminated by abrupt warming. They occur repeatedly during the last glacial period, and are associated with a distinct pattern of global temperature and hydrological variations recorded in *paleoclimate* records from this interval. See also *Younger Dryas*.

Statistical downscaling See *Downscaling*.

Steric sea level change See *Sea level change (sea level rise/sea level fall)*.

Storm surge The temporary increase, at a particular locality, in the height of the sea due to extreme meteorological conditions (low atmospheric pressure and/or strong winds). The storm surge is defined as being the excess above the level expected from the tidal variation alone at that time and place. See also *Sea level change (sea level rise/sea level fall)* and *Extreme sea level (ESL)*.

Storm tracks Originally, a term referring to the tracks of individual cyclonic weather systems, but now often generalized to refer to the main *regions* where the tracks of extratropical disturbances occur as sequences of low (cyclonic) and high (anticyclonic) pressure systems.

Storyline A way of making sense of a situation or a series of events through the construction of a set of explanatory elements. Usually it is built on logical or causal reasoning. In *climate* research, the term storyline is used both in connection to *scenarios* as related to a future trajectory of the climate and human systems or to a weather or climate event. In this context, storylines can be used to describe plural, conditional possible futures or explanations of a current situation, in contrast to single, definitive futures or explanations.

Physical climate storyline A self-consistent and plausible unfolding of a physical trajectory of the *climate system*, or a weather or climate event, on timescales from hours to multiple decades (Shepherd et al., 2018). Through this, storylines explore, illustrate and communicate uncertainties in the *climate system* response to *forcing* and in *internal variability*.

Scenario storyline A narrative description of a *scenario* (or family of scenarios), highlighting the main scenario characteristics, relationships between key driving forces and the dynamics of their evolution.

Stratification Process of forming of layers of (*ocean*) water with different properties such as salinity, density and temperature that act as barrier for water mixing. The strengthening of near-surface stratification generally results in warmer surface waters, decreased oxygen levels in deeper water, and intensification of *ocean acidification (OA)* in the upper ocean.

Stratosphere The highly stratified region of the atmosphere above the *tropopause*, extending to about 50 km altitude. See also *Troposphere*.

Stratospheric aerosol injection (SAI) See *Solar radiation modification (SRM)*.

Stratosphere-troposphere exchange (STE) Stratosphere-troposphere exchange (STE) is understood as the flux of air or trace constituents across the tropopause, including both directions: the stratosphere to troposphere transport (STT) and troposphere to stratosphere transport (TST). STE is one of the key factors controlling the budgets of ozone, water vapour and other substances in both the *troposphere* and the lower *stratosphere*.

Stratospheric ozone Stratospheric ozone describes the *ozone* (O_3) that resides in the *stratosphere*, the region of the *atmosphere* which exists between 10 and 50 kilometres above the surface of the earth. Ninety percent of total-column ozone resides in the stratosphere.See *Ozone layer* and *Ozone* (O_3). See also *Ozone-depleting substances (ODSs)*.

Stratospheric polar vortex A large-scale region of cold air poleward of approximately 60 degrees that is contained by a strong westerly jet from the tropopause (8-10km) to the stratopause (50-60km) and that forms in each hemisphere during the winter half-year. Planetary waves can temporarily disrupt the vortex, producing easterly winds and rapid warming over polar regions in the stratosphere, and leading to substantial weakening or breakdown of the vortex.

Stratospheric sounding unit (SSU) A three-channel infrared sounder on operational NOAA polar-orbiting satellites. The three channels are used to determine profiles of temperature in the *stratosphere* (AMS, 2020).

Streamflow Water flow within a river channel, for example, expressed in $m^3 s^{-1}$. A synonym for river discharge.

Subduction Ocean process in which surface waters enter the ocean interior from the surface mixed layer through *Ekman pumping* and lateral *advection*. The latter occurs when surface waters are advected to a *region* where the local *surface layer* is less dense and therefore must slide below the surface layer, usually with no change in density.

Sudden stratospheric warming (SSW) A phenomena of rapid warming in the *stratosphere* at high latitudes (sometimes more than 50°C in 1-2 days) that can cause breakdown of *stratospheric polar vortices*.

Sulphur hexafluoride (SF_6) One of the seven types of *greenhouse gases (GHGs)* to be mitigated under the Kyoto Protocol. SF_6 is largely used in heavy industry to insulate high-voltage equipment and to assist in the manufacturing of cable-cooling systems and semi-conductors.

Sunspots Dark areas on the Sun where strong magnetic fields reduce the convection causing a temperature reduction of about 1500 K compared to the surrounding regions. The number of sunspots is higher during periods of higher *solar activity*, and varies in particular with the *solar cycle*.

Surface air temperature See *Land surface air temperature (LSAT)* and *Global mean surface air temperature (GSAT)*.

Surface mass balance (SMB) See *Mass balance / budget (of glaciers or ice sheets)*.

Surface temperature See *Global mean surface air temperature (GSAT)*, *Global mean surface temperature (GMST)*, *Land surface air temperature (LSAT)* and *Sea surface temperature (SST)*.

Surprises A class of risk that can be defined as low-likelihood but well-understood events, and events that cannot be predicted with current understanding (see 1.4.4.3 in AR6 WGI Chapter 1). See also *Unknown unknowns*.

Swash See *Extreme sea level (ESL)*.

Talik A layer or body of unfrozen ground in a *permafrost* area due to a local anomaly in thermal, hydrological, hydrogeological or hydrochemical conditions (IPA, 2005).

Technical potential See *Mitigation potential*.

Teleconnection Association between *climate* variables at widely separated, geographically fixed locations related to each other through physical processes and oceanic and/or atmospheric dynamical pathways. Teleconnections can be caused by several climate phenomena, such as Rossby wave-trains, mid-latitude jet and storm track displacements, fluctuations of the *Atlantic Meridional Overturning Circulation*, fluctuations of the Walker circulation, etc. They can be initiated by *modes of climate variability* thus providing the development of remote climate *anomalies* at various temporal lags.

Teleconnection pattern A correlation map obtained by calculating the correlation between variables at different spatial locations and a *climate index*. It is the special case of a *climate pattern* obtained for standardized variables and a standardized climate index, that is, the variables and index are each centred and scaled to have zero mean and unit variance. One-point *teleconnection* maps are made by choosing a variable at one of the locations to be the climate index.

Temperature overshoot Exceedance of a specified global warming level, followed by a decline to or below that level during a specified period of time (e.g., before 2100). Sometimes the magnitude and likelihood of the overshoot is also characterized. The overshoot duration can vary from one *pathway* to the next but in most *overshoot pathways* in the literature and referred to as overshoot pathways in the AR6, the overshoot occurs over a period of at least one and up to several decades. See also *Pathways*.

Terrestrial radiation Radiation emitted by the Earth's surface, the *atmosphere* and the clouds. It is also known as thermal infrared or long-wave radiation, and is to be distinguished from the near-infrared radiation that is part of the solar spectrum. Infrared radiation, in general, has a distinctive range of wavelengths (spectrum) longer than the wavelength of the red light in the visible part of the spectrum. The spectrum of terrestrial radiation is almost entirely distinct from that of shortwave or *solar radiation* because of the difference in temperature between the Sun and the Earth-atmosphere system.

Thermal expansion See *Steric sea level change* (under *Sea level change (sea level rise/sea level fall)*).

Thermocline The layer of maximum vertical temperature gradient in the ocean, lying between the surface ocean and the abyssal ocean. In subtropical regions, its source waters are typically surface waters at higher latitudes that have subducted (see *Subduction*) and moved equatorward. At high latitudes, it is sometimes absent, replaced by a *halocline*, which is a layer of maximum vertical salinity gradient.

Thermohaline circulation (THC) See *Meridional overturning circulation (MOC)*.

Thermokarst Process by which characteristic landforms result from thawing of ice-rich *permafrost* or melting of massive ice (IPA, 2005).

Thermosteric See *Sea level change (sea level rise/sea level fall)*.

Tide gauge A device at a coastal or deep-sea location that continuously measures the level of the sea with respect to the adjacent land. Time averaging of the sea level so recorded gives the observed secular changes of the *relative sea level*.

Time of emergence (ToE) Time when a specific *anthropogenic* signal related to *climate change* is statistically detected to emerge from the background noise of natural *climate variability* in a *reference period*, for a specific *region* (Hawkins and Sutton, 2012). See also *Emergence (of the climate signal)*.

Tipping element A component of the Earth System that is susceptible to a *tipping point*.

Tipping point A critical threshold beyond which a system reorganizes, often abruptly and/or irreversibly. See also *Tipping element*, *Irreversibility* and *Abrupt change*.

Total alkalinity Total Alkalinity (A_T) is a measurable parameter of the seawater acid-base system which, when expressed in micromoles per kilogram of seawater, is a conservative variable both on mixing, and for changes in temperature and/or pressure. Changes in total alkalinity in the oceans can result from a variety of biogeochemical processes that affect the acid-base composition of the seawater itself. However, its value is not affected by the exchange of carbon dioxide gas between seawater and the atmosphere. Measurements of total alkalinity can thus be used to help study these biogeochemical processes, and can also be used to help calculate the state of the seawater acid-base system. Total alkalinity is most commonly measured using an acidimetric titration technique, that determines how much acid is required to titrate a seawater sample to a specified equivalence point.

Total carbon budget See *Carbon budget*.

Total solar irradiance (TSI) The total amount of *solar radiation* in watts per square metre received outside the Earth's *atmosphere* on a surface normal to the incident radiation, and at the Earth's mean distance from the Sun. Reliable measurements of solar radiation can only be made from space and the precise record extends back only to 1978. It has recently been estimated to 1360.8 ± 0.5 W m^{-2} for the solar minimum of 2008. Variations of a few tenths of a percent are common, usually associated with the passage of *sunspots* across the solar disk. The *solar cycle* variation of TSI is of the order of 0.1% (AMS, 2000). See also *Insolation*.

Total water level See *Extreme sea level (ESL)*.

Trace gas A minor constituent of the *atmosphere*, next to nitrogen and oxygen that together make up 99 % of all volume. The most important trace gases contributing to the *greenhouse effect* are *carbon dioxide (CO_2)*, *ozone (O_3)*, *methane (CH_4)*, *nitrous oxide (N_2O)*, perfluorocarbons (PFCs), *chlorofluorocarbons (CFCs)*, hydrofluorocarbons (HFCs), *sulphur hexafluoride (SF_6)* and water vapour (H_2O).

Transient climate response (TCR) See *Climate sensitivity*.

Transient climate response to cumulative CO2 emissions (TCRE) See *Climate sensitivity*.

Tree rings Concentric rings of secondary wood evident in a cross section of the stem of a woody plant. The difference between the dense, small-celled late wood of one season and the wide-celled early wood of the following spring enables the age of a tree to be estimated, and the ring widths or density can be related to *climate* parameters such as temperature and precipitation.

Tropical Atlantic modes See *Tropical Atlantic Variability (TAV)*.

Tropical Atlantic Variability (TAV) A generic term to describe the *climate variability* of the tropical Atlantic which is dominated at interannual to decadal timescale by two main climate modes: the *Atlantic Zonal Mode (AZM)* and the *Atlantic Meridional Mode (AMM)*. The Atlantic Zonal Mode, also commonly referred to as the Atlantic Niño or Atlantic equatorial mode, is associated with *sea surface temperature* anomalies near the equator, peaking in the eastern basin, while the Atlantic meridional mode is characterized by an inter-hemispheric gradient of sea surface temperature and wind anomalies. Both modes are associated with significant *teleconnections* over Africa and South America.

Atlantic Meridional Mode (AMM) The Atlantic Meridional Mode (AMM) refers to the interannual to *decadal variability* of the cross-equatorial *sea surface temperature* gradients and surface wind anomalies in the tropical Atlantic. It modulates the strength and latitudinal shifts of the *Inter-tropical Convergence Zone (ITCZ)*, which impacts regional rainfall over Northeast Brazil and Atlantic hurricane activity. See Section

AIV.2.5 in Annex IV of the AR6 WGI report.

Atlantic Zonal Mode (AZM) An equatorial coupled mode in the Atlantic similar to *El Niño-Southern Oscillation (ENSO)* in the Pacific, and therefore sometimes referred to as "Atlantic Niño". The AZM is associated with *sea surface temperature* anomalies near the equatorial Atlantic and rainfall disturbances over the African monsoon domain. Its variations are mostly observed in the interannual scale. It is called also Atlantic equatorial mode. See Section AIV.2.5 in Annex IV of the AR6 WGI report.

Tropical cyclone The general term for a strong, cyclonic-scale disturbance that originates over tropical oceans. Distinguished from weaker systems (often named tropical disturbances or depressions) by exceeding a threshold wind speed. A tropical storm is a tropical cyclone with one-minute average surface winds between 18 and 32 m s^{-1}. Beyond 32 m s^{-1}, a tropical cyclone is called a hurricane, typhoon, or cyclone, depending on geographic location.

Tropopause The boundary between the *troposphere* and the *stratosphere*. It ranges from 8-9 km at high latitudes to 15-16 km in the tropics.

Troposphere The lowest part of the atmosphere, below the *tropopause*, where clouds and weather phenomena occur. In the troposphere, temperatures generally decrease with height. See also *Stratosphere*.

Tropospheric ozone See *Ozone (O_3)* and *Ground-level ozone*.

Tundra A treeless biome characteristic of polar and alpine regions.

Turnover time (T) See *Lifetime*.

Typhoon See *Tropical cyclone*.

Typological domains See *Typological regions*.

Typological regions Regions of the Earth that share one or more specific features (known as 'typologies'), such as geographic location (e.g., coastal), physical processes (e.g., *monsoons*), and biological (e.g., coral reefs, tropical *forests*), geological (e.g., mountains) or *anthropogenic* (e.g., megacities) formation, and for which it is useful to consider the common *climate* features. Typological regions are smaller than climatic zones (e.g., a mountain region) and can be discontinuous (e.g., a group of megacities affected by the *urban heat island* effect, or monsoon regions).

Uncertainty A state of incomplete knowledge that can result from a lack of information or from disagreement about what is known or even knowable. It may have many types of sources, from imprecision in the data to ambiguously defined concepts or terminology, incomplete understanding of critical processes, or uncertain projections of *human behaviour*. Uncertainty can therefore be represented by quantitative measures (e.g., a probability density function) or by qualitative statements (e.g., reflecting the judgment of a team of experts) (see Moss and Schneider, 2000; IPCC, 2004; Mastrandrea et al., 2010). See also *Confidence* and *Likelihood*.

Deep uncertainty A situation of deep uncertainty exists when experts or stakeholders do not know or cannot agree on: (1) appropriate conceptual models that describe relationships among key driving forces in a system; (2) the probability distributions used to represent uncertainty about key variables and parameters; and/or (3) how to weigh and value desirable alternative outcomes (Lempert et al., 2003).

Sampling uncertainty Uncertainty arising from incomplete or uneven availability of measurements in either space or time or both.

United Nations Framework Convention on Climate Change (UNFCCC) The UNFCCC was adopted in May 1992 and opened for signature at the 1992 Earth Summit in Rio de Janeiro. It entered into force in

March 1994 and as of September 2020 had 197 Parties (196 States and the European Union). The Convention's ultimate objective is the 'stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system'. The provisions of the Convention are pursued and implemented by two further treaties: the Kyoto Protocol and the Paris Agreement.

Uptake The transfer of substances (such as carbon) or energy (e.g., heat) from one compartment of a system to another; for example, in the Earth System from the atmosphere to the ocean or to the land. See also *Sequestration*.

Upwelling region A region of an ocean where cold, typically nutrient-rich waters well up from the deep ocean.

Urban heat island (UHI) The relative warmth of a city compared with surrounding rural areas, associated with changes in *runoff*, effects on heat retention, and changes in surface albedo.

Ventilation The exchange of ocean properties with the atmospheric *surface layer* such that property concentrations are brought closer to equilibrium values with the *atmosphere* (AMS, 2021), and the processes that propagate these properties into the ocean interior.

Vertical land motion (VLM) Vertical land motion (VLM) is the change in height of the land surface or the sea floor and can have several causes in addition to elastic deformation associated with contemporary changes in *gravity, rotation and viscoelastic solid Earth deformation (GRD)* and viscoelastic deformation associated with *glacial isostatic adjustment (GIA)*. Subsidence (sinking of the land surface or sea floor) can, for instance, occur through compaction of alluvial sediments in deltaic regions, removal of fluids such as gas, oil, and water, or drainage of peatlands. Tectonic deformation of the Earth's crust can occur as a result of earthquakes and volcanic eruptions. See also *Sea level change (sea level rise/sea level fall)*.

Very short-lived halogenated substances (VSLSs) Very short-lived halogenated substances (VSLSs) are considered to include source gases (very short-lived halogenated substances present in the *atmosphere* in the form they were emitted from natural and *anthropogenic* sources), halogenated product gases arising from source gas degradation, and other sources of *tropospheric* inorganic halogens. VSLSs have tropospheric *lifetimes* of around 0.5 years or less.

Volatile organic compounds (VOCs) Important class of organic chemical air pollutants that are volatile at ambient air conditions. Other terms used to represent VOCs are hydrocarbons (HCs), reactive organic gases (ROGs) and non-methane volatile organic compounds (NMVOCs). NMVOCs are major contributors – together with nitrogen oxides (NOx), and carbon monoxide (CO) – to the formation of photochemical oxidants such as ozone (O_3).

Biogenic volatile organic compounds (BVOCs) Organic gas-phase compounds emitted from terrestrial and aquatic ecosystems that are critical in ecology and plant physiology, from abiotic and biotic stress functions to integrated components of metabolism. BVOCs are important in atmospheric chemistry as precursors for ozone and secondary organic aerosol formation. Other terms used to represent BVOCs are hydrocarbons (HCs), reactive organic gases (ROGs) and non-methane volatile organic compounds (NMVOCs).

Vulnerability The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt. See also *Exposure*, *Hazard* and *Risk*.

Walker circulation Direct thermally driven zonal overturning circulation in the *atmosphere* over the tropical Pacific Ocean, with rising air in the western and sinking air in the eastern Pacific.

Warm days/warm nights Days where maximum temperature, or nights where minimum temperature, exceeds the 90th percentile, where the respective temperature distributions are generally defined with respect to the 1961-1990 reference period.

Warm spell A period of abnormally warm weather. *Heatwaves* and warm spells have various and, in some cases, overlapping definitions.

Water cycle See *Hydrological cycle*.

Water mass A body of ocean water with identifiable properties (temperature, salinity, density, chemical tracers) resulting from its unique formation process. Water masses are often identified through a vertical or horizontal extremum of a property such as salinity. North Pacific Intermediate Water (NPIW) and Antarctic Intermediate Water (AAIW) are examples of water masses.

Water security 'The capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability' (UN-Water, 2013).

Wave run-up See *Extreme sea level (ESL)*.

Wave setup See *Extreme sea level (ESL)*.

Weathering The gradual removal of atmospheric CO_2 through dissolution of silicate and carbonate rocks. Weathering may involve physical processes (mechanical weathering) or chemical activity (chemical weathering).

Well-mixed greenhouse gas A *greenhouse gas* that has an atmospheric *lifetime* long enough (> several years) to be homogeneously mixed in the *troposphere*, and as such the global average mixing ratio can be determined from a network of surface observations. For many well-mixed greenhouse gases, measurements made in remote regions differ from the global mean by < 15%.

West African monsoon (WAfriM) See *Global monsoon*.

West Antarctic ice sheet (WAIS) See *Ice sheet*.

Wetland Land that is covered or saturated by water for all or part of the year (e.g., *peatland*).

Younger Dryas A period 12.85 to 11.65 ka (thousand years before 1950), during the *last deglacial transition*, characterized by a temporary return to colder conditions in many locations, especially around the North Atlantic. See also *Stadial* and *Last deglacial transition*.

Zero emissions commitment See *Climate change commitment*.

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