AIII

Annex III: Glossary

Editor:
Serge Planton (France)

This annex should be cited as:
IPCC, 2013: Annex III: Glossary [Planton, S. (ed.)]. In: *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

This glossary defines some specific terms as the Lead Authors intend them to be interpreted in the context of this report. Red, italicized words indicate that the term is defined in the Glossary.

Abrupt climate change A large-scale 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 disruptions in human and natural systems.

Active layer The layer of ground that is subject to annual thawing and freezing in areas underlain by *permafrost*.

Adjustment time See *Lifetime*. See also *Response 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 a typical size between a few nanometres and 10 µm that reside in the *atmosphere* for at least several hours. For convenience 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. Aerosols may influence *climate* in several ways: directly through scattering and absorbing radiation (see *Aerosol–radiation interaction*) and indirectly by acting as *cloud condensation nuclei* or *ice nuclei*, modifying the optical properties and *lifetime* of clouds (see *Aerosol–cloud interaction*).

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:

Radiative forcing (or effect) due to aerosol–cloud interactions (RFaci) 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 rapidity and ubiquity of *rapid adjustments*.

Effective radiative forcing (or effect) due to aerosol–cloud interactions (ERFaci) The final radiative forcing (or effect) from the aerosol perturbation including the rapid 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.

The total effective radiative forcing due to both aerosol–cloud and aerosol–radiation interactions is denoted *aerosol effective radiative forcing (ERFari+aci).* See also *Aerosol–radiation interaction*.

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:

Radiative forcing (or effect) due to aerosol–radiation interactions (RFari) 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)*.

Effective radiative forcing (or effect) due to aerosol-radiation interactions (ERFari) The final radiative forcing (or effect) from the aerosol perturbation including the *rapid 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)*.

The total effective radiative forcing due to both aerosol–cloud and aerosol–radiation interactions is denoted *aerosol effective radiative forcing (ERFari+aci).* See also *Aerosol–cloud interaction*.

Afforestation Planting of new *forests* on lands that historically have not contained forests. For a discussion of the term *forest* and related terms such as *afforestation*, *reforestation* and *deforestation*, see the IPCC Special Report on Land Use, Land-Use Change and Forestry (IPCC, 2000). See also the report on Definitions and Methodological Options to Inventory Emissions from Direct Human-induced Degradation of Forests and Devegetation of Other Vegetation Types (IPCC, 2003).

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

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, 2000).

Albedo The fraction of *solar radiation* reflected by a surface or object, often expressed as a percentage. Snow-covered surfaces have a high albedo, the albedo of soils ranges from high to low, and vegetation-covered surfaces and oceans have a low albedo. The Earth's planetary albedo varies mainly through varying cloudiness, snow, ice, leaf area and and cover changes.

Alkalinity A measure of the capacity of an aqueous solution to neutralize acids.

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 See *Northern Annular Mode (NAM)* and *Southern Annular Mode (SAM)*.

Anthropogenic Resulting from or produced by human activities.

Atlantic Multi-decadal Oscillation/Variability (AMO/AMV) A multi-decadal (65- to 75-year) fluctuation in the North Atlantic, in which *sea surface temperatures* showed warm phases during roughly 1860 to 1880 and 1930 to 1960 and cool phases during 1905 to 1925 and 1970 to 1990 with a range of approximately 0.4°C. See AMO Index, Box 2.5.

Atmosphere The gaseous envelope surrounding the Earth. 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* such as *carbon dioxide* (0.035%

volume mixing ratio) and *ozone*. In addition, the atmosphere contains the greenhouse gas water vapour, whose amounts are highly variable but typically around 1% volume mixing ratio. The atmosphere also contains clouds and *aerosols*.

Atmosphere–Ocean General Circulation Model (AOGCM) See *Climate model*.

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, 2000). 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*.

Attribution See *Detection and attribution*.

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

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. A *baseline period* is the period relative to which anomalies are computed. The baseline concentration of a trace gas is that measured at a location not influenced by local *anthropogenic* emissions.

Bayesian method/approach A Bayesian method is a method by which a statistical analysis of an unknown or uncertain quantity(ies) is carried out in two steps. First, a prior probability distribution for the uncertain quantity(ies) is formulated on the basis of existing knowledge (either by eliciting expert opinion or by using existing data and studies). At this first stage, an element of subjectivity may influence the choice, but in many cases, the prior probability distribution can be chosen as neutrally as possible, in order not to influence the final outcome of the analysis. In the second step, newly acquired data are used to update the prior distribution into a posterior distribution. The update is carried out either through an analytic computation or though numeric approximation, using a theorem formulated by and named after the British mathematician Thomas Bayes (1702–1761).

Biological pump The process of transporting carbon from the ocean's surface layers to the deep ocean by the primary production of marine phytoplankton, which converts dissolved inorganic carbon (DIC) and nutrients into organic matter through *photosynthesis*. This natural cycle is limited primarily by the availability of light and nutrients such as phosphate, nitrate and silicic acid, and micronutrients, such as iron. See also *Solubility pump*.

Biomass The total mass of living organisms in a given area or volume; dead plant material can be included as dead biomass. *Biomass burning* is the burning of living and dead vegetation.

Biome A biome is a major and distinct regional element of the *biosphere*, typically consisting of several *ecosystems* (e.g., *forests*, rivers, ponds, swamps within a *region*). Biomes are characterized by typical communities of plants and animals.

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.

Black carbon (BC) Operationally defined *aerosol* species based on measurement of light absorption and chemical reactivity and/or thermal stability. It is sometimes referred to as *soot*.

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*.

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 gaseous substance of concern in the *atmosphere*.

^{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*).

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

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

Carbon cycle The term used to describe the flow of carbon (in various forms, e.g., as *carbon dioxide*) through the *atmosphere*, ocean, terrestrial and marine *biosphere* and *lithosphere*. In this report, the reference unit for the global carbon cycle is GtC or equivalently PgC (10^{15}g).

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

Carbon dioxide (CO_2) fertilization The enhancement of the growth of plants as a result of increased atmospheric *carbon dioxide (CO_2)* concentration.

Carbon Dioxide Removal (CDR) Carbon Dioxide Removal methods refer to a set of techniques that aim to remove CO_2 directly from the *atmosphere* by either (1) increasing natural *sinks* for carbon or (2) using chemical engineering to remove the CO_2, with the intent of reducing the atmospheric CO_2 concentration. CDR methods involve the ocean, land and technical systems, including such methods as *iron fertilization*, large-scale *afforestation* and direct capture of CO_2 from the atmosphere using engineered chemical means. Some CDR methods fall under the category of *geoengineering*, though this may not be the case for others, with the distinction being based on the magnitude, scale, and impact of the particular CDR activities. The boundary between CDR and *mitigation* is not clear and

there could be some overlap between the two given current definitions (IPCC, 2012, p. 2). See also *Solar Radiation Management (SRM)*.

CFC See *Halocarbons*.

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.

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

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

Clausius–Clapeyron equation/relationship The thermodynamic relationship between small changes in temperature and vapour pressure in an equilibrium system with condensed phases present. For trace gases such as water vapour, this relation gives the increase in equilibrium (or saturation) water 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. 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–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*.

Climate change Climate change refers to 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 *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 change commitment*, *Detection and Attribution*.

Climate change commitment Due to the thermal inertia of the ocean and slow processes in the *cryosphere* and land surfaces, the *climate* would continue to change even if the atmospheric composition were held fixed at today's values. Past change in atmospheric composition leads to a *committed climate change*, which continues for as long as a radiative imbalance persists and until all components of the *climate system* have adjusted to a new state. The further change in temperature after the composition of the *atmosphere* is held constant is referred to as the *constant composition temperature commitment* or simply *committed warming* or *warming commitment*. Climate change commitment includes other future changes, for example, in the *hydrological cycle*, in *extreme weather events*, in *extreme climate events*, and in *sea level change*. The *constant emission commitment* is the committed climate change that would result from keeping *anthropogenic* emissions constant and the *zero emission commitment* is the climate change commitment when emissions are set to zero. See also *Climate change*.

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. In this Assessment Report, a somewhat narrower definition is often used in which the climate quantity that is perturbed is the *global mean surface temperature*, which in turn causes changes in the global radiation budget. In either case, the initial perturbation can either be externally forced or arise as part of *internal variability*. See also *Climate Feedback Parameter*.

Climate Feedback Parameter A way to quantify the radiative response of the *climate system* to a *global mean surface temperature* change induced by a *radiative forcing*. It varies as the inverse of the *effective climate sensitivity*. Formally, the Climate Feedback Parameter (α; units: W m^{-2} °C^{-1}) is defined as: $\alpha = (\Delta Q - \Delta F)/\Delta T$, where Q is the global mean radiative forcing, T is the global mean air surface temperature, F is the heat flux into the ocean and Δ represents a change with respect to an unperturbed *climate*.

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). See Box 2.5 for a summary of definitions for established observational indices. See also *Climate pattern*.

Climate model (spectrum or hierarchy) A numerical 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 *parametrizations* are involved. Coupled *Atmosphere–Ocean General Circulation Models (AOGCMs)* provide a representation of the climate system that is near or at the most comprehensive end of the spectrum currently available. 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 *Earth System Model*, *Earth-System Model of Intermediate Complexity*, *Energy Balance Model*, *Process-based Model, Regional Climate Model* and *Semi-empirical model*.

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, such predictions are usually probabilistic in nature. See also *Climate projection*, *Climate scenario*, *Model initialization* and *Predictability*.

Climate projection A climate *projection* is the simulated response of the *climate system* to a *scenario* of future emission or concentration of *greenhouse gases* and *aerosols*, 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 socioeconomic and technological developments that may or may not be realized. See also *Climate scenario*.

Climate regime A state of the *climate system* that occurs more frequently than nearby states due to either more persistence or more frequent recurrence. In other words, a cluster in climate state space associated with a local maximum in the *probability density function*.

Climate response See *Climate sensitivity*.

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. A *climate change scenario* is the difference between a climate scenario and the current climate. See also *Emission scenario*, *scenario*.

Climate sensitivity In IPCC reports, *equilibrium climate sensitivity* (units: °C) refers to the equilibrium (steady state) change in the annual *global mean surface temperature* following a doubling of the atmospheric *equivalent carbon dioxide concentration*. Owing to computational constraints, the equilibrium climate sensitivity in a *climate model* is sometimes estimated by running an atmospheric general circulation model coupled to a mixed-layer ocean model, because equilibrium climate sensitivity is largely determined by atmospheric processes. Efficient models can be run to equilibrium with a dynamic ocean. The *climate sensitivity parameter* (units: °C $(W\ m^{-2})^{-1}$) refers to the equilibrium change in the annual global mean surface temperature following a unit change in *radiative forcing*.

The *effective climate sensitivity* (units: °C) is an estimate of the global mean surface temperature response to doubled *carbon dioxide* concentration that is evaluated from model output or observations for evolving non-equilibrium conditions. It is a measure of the strengths of the *climate feedbacks* at a particular time and may vary with forcing history and *climate* state, and therefore may differ from equilibrium climate sensitivity.

The *transient climate response* (units: °C) is the change in the global mean surface temperature, averaged over a 20-year period, centred at the time of atmospheric carbon dioxide doubling, in a climate model simulation in which CO_2 increases at 1% yr^{-1}. It is a measure of the strength and rapidity of the surface temperature response to *greenhouse gas* forcing.

Climate sensitivity parameter See *climate sensitivity*.

Climate system The climate system is the highly complex 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 evolves in time under the influence of its own internal dynamics and because of *external forcings* such as volcanic eruptions, solar variations and *anthropogenic* forcings such as the changing composition of the atmosphere and *land use change*.

Climate variability Climate variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the *climate* on all *spatial and temporal scales* beyond that of individual weather events. Variability may be due to natural internal processes within the *climate system* (*internal variability*), or to variations in natural or *anthropogenic external forcing* (*external variability*). See also *Climate change*.

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. See also *Cloud radiative effect*.

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. See also *Cloud feedback*.

CO_2-equivalent See *Equivalent carbon dioxide*.

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.

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.

Confidence The validity 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. Confidence is expressed qualitatively (Mastrandrea et al., 2010). See Figure 1.11 for the levels of confidence and Table 1.1 for the list of *likelihood* qualifiers. See also *Uncertainty*.

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.

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*.

Cryosphere All regions on and beneath the surface of the Earth and ocean where water is in solid form, including *sea ice*, lake ice, river ice, snow cover, *glaciers* and *ice sheets*, and *frozen ground* (which includes *permafrost*).

Dansgaard–Oeschger events Abrupt events characterized in Greenland *ice cores* and in *palaeoclimate* records from the nearby North Atlantic by a cold glacial state, followed by a rapid transition to a warmer phase, and a slow cooling back to glacial conditions. Counterparts of Dansgaard–Oeschger events are observed in other regions as well.

Deforestation Conversion of *forest* to non-forest. For a discussion of the term *forest* and related terms such as *afforestation*, *reforestation*, and *deforestation* see the IPCC Special Report on Land Use, Land-Use Change and Forestry (IPCC, 2000). See also the report on Definitions and Methodological Options to Inventory Emissions from Direct Human-induced Degradation of Forests and Devegetation of Other Vegetation Types (IPCC, 2003).

Deglaciation/glacial termination Transitions from full glacial conditions (*ice age*) to warm *interglacials* characterized by global warming and sea level rise due to change in continental ice volume.

Detection and attribution *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%. *Attribution* is defined as the process of evaluating the relative contributions of multiple causal factors to a change or event with an assignment of statistical confidence (Hegerl et al., 2010).

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*.

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

Direct Air Capture Chemical process by which a pure CO_2 stream is produced by capturing CO_2 from the ambient air.

Diurnal temperature range 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 Downscaling is a method that derives local- to regional-scale (10 to 100 km) 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 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 the quality of the downscaled information.

Drought A period of abnormally dry weather long enough to cause a serious hydrological imbalance. Drought is a relative term; therefore any discussion in terms of precipitation deficit must refer to the particular precipitation-related activity that is under discussion. For example, shortage of precipitation during the growing season impinges on crop production or *ecosystem* function in general (due to *soil moisture* drought, also termed *agricultural drought*), and during the *runoff* and percolation season primarily affects water supplies (*hydrological drought*). Storage changes in soil moisture and groundwater are also affected by increases in actual *evapotranspiration* in addition to reductions in precipitation. A period with an abnormal precipitation deficit is defined as a *meteorological drought*. A *megadrought* is a very lengthy and pervasive drought, lasting much longer than normal, usually a decade or more. For the corresponding indices, see Box 2.4.

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. See also *Abrupt climate change*, *Chaotic*, *Nonlinearity* and *Predictability*.

Earth System Model (ESM) A coupled *atmosphere–ocean general circulation model* in which a representation of the *carbon cycle* is included, allowing for interactive calculation of atmospheric 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 *Climate model*.

Earth System Model of Intermediate Complexity (EMIC) A *climate model* attempting to include all the most important earth system processes as in ESMs but at a lower *resolution* or in a simpler, more idealized fashion.

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

Ecosystem An ecosystem is 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.

Effective climate sensitivity See *Climate sensitivity*.

Effective radiative forcing See *Radiative forcing*.

Efficacy A measure of how effective a *radiative forcing* from a given *anthropogenic* or natural mechanism is at changing the equilibrium *global mean surface temperature* compared to an equivalent radiative forcing from *carbon dioxide*. A carbon dioxide increase by definition has an efficacy of 1.0. Variations in climate efficacy may result from *rapid adjustments* to the applied forcing, which differ with different forcings.

Ekman pumping Frictional stress at the surface between two fluids (*atmosphere* and ocean) or between a fluid and the adjacent solid surface (the Earth's surface) forces a circulation. When the resulting mass

transport is converging, mass conservation requires a vertical flow away from the surface. This is called Ekman pumping. The opposite effect, in case of divergence, is called *Ekman suction*. The effect is important in both the atmosphere and the ocean.

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. See also *Ekman pumping*.

Electromagnetic spectrum Wavelength 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.

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 a basin-wide 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). It is often measured by the surface pressure anomaly difference between Tahiti and Darwin or the *sea surface temperatures* in the central and eastern equatorial Pacific. During an ENSO event, the prevailing trade winds weaken, reducing upwelling and altering ocean currents such that the sea surface temperatures warm, further weakening the trade winds. This event 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*. The cold phase of ENSO is called *La Niña*. For the corresponding indices, see Box 2.5.

Emission scenario A plausible representation of the future development of emissions of substances that are potentially radiatively active (e.g., *greenhouse gases*, *aerosols*) based on a coherent and internally consistent set of assumptions about driving forces (such as demographic and socioeconomic development, technological change) and their key relationships. *Concentration scenarios*, derived from emission scenarios, are used as input to a *climate model* to compute *climate projections*. In IPCC (1992) a set of emission scenarios was presented which were used as a basis for the climate projections in IPCC (1996). These emission scenarios are referred to as the IS92 scenarios. In the IPCC Special Report on Emission Scenarios (Nakićenović and Swart, 2000) emission scenarios, the so-called *SRES scenarios*, were published, some of which were used, among others, as a basis for the climate projections presented in Chapters 9 to 11 of IPCC (2001) and Chapters 10 and 11 of IPCC (2007). New emission scenarios for *climate change*, the four *Representative Concentration Pathways*, were developed for, but independently of, the present IPCC assessment. See also *Climate scenario* and *Scenario*.

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. See also *Energy budget*.

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. See also *Climate model*.

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. See also *Energy balance*, *Latent heat flux*, *Sensible heat flux*.

Ensemble A collection of model simulations characterizing a *climate prediction* or *projection*. Differences in initial conditions and model formulation result in different evolutions of the modelled system and may give information on *uncertainty* associated with model error and error in initial conditions in the case of *climate forecasts* and on uncertainty associated with model error and with internally generated *climate variability* in the case of climate projections.

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*. See also *Climate projection*.

Equilibrium climate sensitivity 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) concentration The concentration of *carbon dioxide* that would cause the same *radiative forcing* as a given mixture of carbon dioxide and other forcing components. Those values may consider only *greenhouse gases*, or a combination of greenhouse gases and *aerosols*. Equivalent carbon dioxide concentration is a *metric* for comparing radiative forcing of a mix of different greenhouse gases at a particular time but does not imply equivalence of the corresponding *climate change* responses nor future forcing. There is generally no connection between *equivalent carbon dioxide emissions* and resulting equivalent carbon dioxide concentrations.

Equivalent carbon dioxide (CO_2) emission The amount of *carbon dioxide* emission that would cause the same integrated *radiative forcing*, over a given time horizon, as an emitted amount of a *greenhouse gas* or a mixture of greenhouse gases. The equivalent carbon dioxide emission is obtained by multiplying the emission of a greenhouse gas by its *Global Warming Potential* for the given time horizon. For a mix of greenhouse

gases it is obtained by summing the equivalent carbon dioxide emissions of each gas. Equivalent carbon dioxide emission is a common scale for comparing emissions of different greenhouse gases but does not imply equivalence of the corresponding *climate change* responses. See also *Equivalent carbon dioxide concentration*.

Evapotranspiration The combined process of evaporation from the Earth's surface and transpiration from vegetation.

Extended Concentration Pathways See *Representative Concentration 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 *anthropogenic* changes in the composition of the *atmosphere* and *land use change* are external forcings. Orbital forcing is also an external forcing as the *insolation* changes with orbital parameters eccentricity, tilt and precession of the equinox.

Extratropical cyclone A large-scale (of order 1000 km) storm in the middle or high latitudes having low central pressure and fronts with strong horizontal gradients in temperature and humidity. A major cause of extreme wind speeds and heavy precipitation especially in wintertime.

Extreme climate event See *Extreme weather event*.

Extreme sea level See *Storm surge*.

AIII

Extreme weather event An extreme weather event is 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. When a pattern of extreme weather persists for some time, such as a season, it may be classed as an *extreme climate event*, especially if it yields an average or total that is itself extreme (e.g., *drought* or heavy rainfall over a season).

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

Feedback See *Climate feedback*.

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 sheets* (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.

Flux adjustment To avoid the problem of coupled *Atmosphere–Ocean General Circulation Models (AOGCMs)* drifting into some unrealistic *climate* state, adjustment terms can be applied to the atmosphere-ocean fluxes of heat and moisture (and sometimes the surface stresses resulting from the effect of the wind on the ocean surface) before these fluxes are imposed on the model ocean and atmosphere. Because these adjustments are pre-computed and therefore independent of the coupled model integration, they are uncorrelated with the anomalies that develop during the integration.

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. For a discussion of the term *forest* and related terms such as *afforestation*, *reforestation* and *deforestation* see the IPCC Report on Land Use, Land-Use Change and Forestry (IPCC, 2000). See also the Report on Definitions and Methodological Options to Inventory Emissions from Direct Human-induced Degradation of Forests and Devegetation of Other Vegetation Types (IPCC, 2003).

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.

Framework Convention on Climate Change See *United Nations Framework Convention on Climate Change (UNFCCC)*.

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* is frozen. Frozen ground includes *permafrost.* Ground that freezes and thaws annually is called *seasonally frozen ground*.

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) See *Climate model*.

Geoengineering Geoengineering refers to a broad set of methods and technologies that aim to deliberately alter the *climate system* in order to alleviate the impacts of *climate change*. Most, but not all, methods seek to either (1) reduce the amount of absorbed solar energy in the climate system (*Solar Radiation Management*) or (2) increase net carbon sinks from the *atmosphere* at a scale sufficiently large to alter *climate* (*Carbon Dioxide Removal*). Scale and intent are of central importance. Two key characteristics of geoengineering methods of particular concern are that they use or affect the climate system (e.g., atmosphere, land or ocean) globally or regionally and/or could have substantive unintended effects that cross national boundaries. Geoengineering is different from weather modification and ecological engineering, but the boundary can be fuzzy (IPCC, 2012, p. 2).

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–interglacial cycles Phase of the Earth's history marked by large changes in continental ice volume and global sea level. See also *Ice age* and *Interglacials*.

Glacial isostatic adjustment (GIA) The deformation of the Earth and its gravity field due to the response of the earth–ocean system to changes in ice and associated water loads. It is sometimes referred to as *glacio-hydro isostasy*. It includes vertical and horizontal deformations of the Earth's surface and changes in *geoid* due to the redistribution of mass during the ice–ocean mass exchange.

Glacier A perennial mass of land ice that originates from compressed snow, shows evidence of past or present flow (through internal deformation and/or sliding at the base) and is constrained by internal stress and friction at the base and sides. A glacier is maintained by accumulation of snow at high altitudes, balanced by melting at low altitudes and/or discharge into the sea. An ice mass of the same origin as glaciers, but of continental size, is called an *ice sheet*. For the purpose of simplicity in this Assessment Report, all ice masses other than ice sheets are referred to as

glaciers. See also *Equilibrium line* and *Mass balance/budget (of glaciers or ice sheets)*.

Global dimming Global dimming refers to a widespread reduction of *solar radiation* received at the surface of the Earth from about the year 1961 to around 1990.

Global mean surface temperature An estimate of the global mean surface air temperature. However, for changes over time, only anomalies, as departures from a climatology, are used, most commonly based on the area-weighted global average of the *sea surface temperature* anomaly and *land surface air temperature* anomaly.

Global Warming Potential (GWP) An index, based on radiative properties of *greenhouse gases*, measuring the *radiative forcing* following a pulse emission of a unit mass of a given greenhouse gas in the present-day *atmosphere* integrated over a chosen time horizon, relative to that of *carbon dioxide*. The GWP represents the combined effect of the differing times these gases remain in the atmosphere and their relative effectiveness in causing radiative forcing. The *Kyoto Protocol* is based on GWPs from pulse emissions over a 100-year time frame.

Greenhouse effect The infrared *radiative effect* of all infrared-absorbing constituents in the *atmosphere*. *Greenhouse gases*, clouds, and (to a small extent) *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 greenhouse gases increases the magnitude of this effect; the difference is sometimes called the enhanced greenhouse effect. The change in a greenhouse gas 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 (GHG) Greenhouse gases are those gaseous constituents of the *atmosphere*, both natural and *anthropogenic*, that absorb and emit radiation at specific wavelengths within the spectrum of *terrestrial radiation* emitted by the Earth's surface, 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 greenhouse gases in the Earth's atmosphere. Moreover, there are a number of entirely human-made greenhouse gases in the atmosphere, such as the *halocarbons* and other chlorine- and bromine-containing substances, dealt with under the *Montreal Protocol.* Beside CO_2, N_2O and CH_4, the *Kyoto Protocol* deals with the greenhouse gases sulphur hexafluoride (SF_6), hydrofluorocarbons (*HFCs*) and perfluorocarbons (PFCs). For a list of *well-mixed greenhouse gases*, see Table 2.A.1.

Gross Primary Production (GPP) The amount of carbon fixed by the autotrophs (e.g. plants and algaes).

Grounding line The junction between a *glacier* or *ice sheet* and *ice shelf*; the place where ice starts to float. This junction normally occurs over a finite 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 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. See also *Thermocline.*

Halosteric See *Sea level change*.

HCFC See *Halocarbons*.

Heat wave A period of abnormally and uncomfortably hot weather. See also *Warm spell*.

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

HFC See *Halocarbons*.

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 Holocene Epoch is the latter of two epochs in the *Quaternary* System, extending from 11.65 ka (thousand years before 1950) to the present. It is also known as *Marine Isotopic Stage (MIS) 1* or *current interglacial*.

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

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

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

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

Ice age An ice age or *glacial period* is characterized by a long-term reduction in the temperature of the Earth's *climate*, resulting in growth of *ice sheets* and *glaciers*.

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.

Ice core A cylinder of ice drilled out of a *glacier* or *ice sheet*.

Ice sheet A mass of land ice of continental size that is sufficiently thick to cover most of the underlying bed, so that its shape is mainly determined by its dynamics (the flow of the ice as it deforms internally and/or slides at its base). 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*, in some cases 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. During glacial periods there were others.

Ice shelf A floating slab of ice of considerable thickness extending from the coast (usually of great horizontal extent with a very gently sloping surface), 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. See also *Outlet glacier.*

Incoming solar radiation See *Insolation*.

Indian Ocean Dipole (IOD) Large–scale mode of interannual variability of *sea surface temperature* in the Indian Ocean. This pattern manifests through a zonal gradient of tropical sea surface temperature, which in one extreme phase in boreal autumn shows cooling off Sumatra and warming off Somalia in the west, combined with anomalous easterlies along the equator.

Indirect aerosol effect See *Aerosol-cloud interaction*.

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 and emission of, in particular, fossil *carbon dioxide*. In this report the terms *pre-industrial* and *industrial* refer, somewhat arbitrarily, to the periods before and after 1750, respectively.

Infrared radiation See *Terrestrial radiation*.

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 *Total Solar Irradiance*.

Interglacials or interglaciations The warm periods between *ice age* glaciations. Often defined as the periods at which sea levels were close to present sea level. For the *Last Interglacial (LIG)* this 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 the oxygen *isotope* record interglaciations are defined as the interval between the midpoint of the preceding termination and the onset of the next glaciation. The present interglaciation, the *Holocene*, started at 11.65 ka before present although globally sea levels did not approach their present position until about 7 ka before present.

Internal variability See *Climate variability*.

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.

Iron fertilization Deliberate introduction of iron to the upper ocean intended to enhance biological productivity which can sequester additional atmospheric *carbon dioxide* into the oceans.

Irreversibility A perturbed state of a *dynamical system* is defined as irreversible on a given timescale, if the recovery timescale from this state due to natural processes is significantly longer than the time it takes for the system to reach this perturbed state. In the context of WGI, the time scale of interest is centennial to millennial. 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*. See also *Glacial Isostatic Adjustment (GIA)*.

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.

Kyoto Protocol The Kyoto Protocol to the *United Nations Framework Convention on Climate Change (UNFCCC)* was adopted in 1997 in Kyoto, Japan, at the Third Session of the Conference of the Parties (COP) to the UNFCCC. It contains legally binding commitments, in addition to those included in the UNFCCC. Countries included in Annex B of the Protocol (most Organisation for Economic Cooperation and Development countries and countries with economies in transition) agreed to reduce their *anthropogenic greenhouse gas* emissions (*carbon dioxide*, *methane*, *nitrous oxide*, hydrofluorocarbons, perfluorocarbons, and sulphur hexafluoride) by at least 5% below 1990 levels in the commitment period 2008–2012. The Kyoto Protocol entered into force on 16 February 2005.

Land surface air temperature The surface air temperature as measured in well-ventilated screens over land at 1.5 m above the ground.

Land use and Land use change *Land use* refers to the total of arrangements, activities and inputs undertaken in a certain land cover type (a set of human actions). 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 and conservation). *Land use change* refers to a change in the use or management of land by humans, which may lead to a change in land cover. Land cover and land use change may have an impact on the surface *albedo*, *evapotranspiration*, *sources* and *sinks* of *greenhouse gases*, or other properties of the *climate system* and may thus give rise to *radiative forcing* and/or other impacts on *climate*, locally or globally. See also the IPCC Report on Land Use, Land-Use Change, and Forestry (IPCC, 2000).

Land water storage Water stored on land other than in *glaciers* and *ice sheets* (that is water stored in rivers, lakes, wetlands, the vadose zone, aquifers, reservoirs, snow and *permafrost*). Changes in land water storage driven by *climate* and human activities contribute to *sea level change*.

La Niña See *El Niño-Southern Oscillation*.

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.

Last Glacial Maximum (LGM) The period during the last *ice age* when the *glaciers* and *ice sheets* reached their maximum extent, approximately

21 ka ago. This period has been widely studied because the *radiative forcings* and boundary conditions are relatively well known.

Last Interglacial (LIG) See *Interglacials*.

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*.

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:

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*.

Adjustment time or response 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* 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. Thus, the adjustment time of CO_2 in the atmosphere is actually determined by the rate of removal of carbon from the surface layer of the oceans into its deeper layers. Although an approximate value of 100 years may be given for the adjustment time of CO_2 in the atmosphere, the actual adjustment is faster initially and slower later on. 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.

Likelihood The chance of a specific outcome occurring, where this might be estimated probabilistically. This is expressed in this report using a standard terminology, defined in Table 1.1. See also *Confidence* 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. See also *Isostatic*.

Little Ice Age (LIA) An interval during the last millennium characterized by a number of extensive expansions of mountain *glaciers* and moderate retreats in between them, both in the Northern and Southern Hemispheres. The timing of glacial advances differs between *regions* and the LIA is, therefore, not clearly defined in time. Most definitions lie in the period 1400 CE and 1900 CE. Currently available *reconstructions* of average Northern Hemisphere temperature indicate that the coolest periods at the hemispheric scale may have occurred from 1450 to 1850 CE.

Longwave radiation See *Terrestrial radiation*.

Madden–Julian Oscillation (MJO) The largest single component of tropical atmospheric intraseasonal variability (periods from 30 to 90 days). The MJO propagates eastwards at around 5 m s^{-1} in the form of a large-scale coupling between atmospheric circulation and deep *convection*. As it progresses, it is associated with large regions of both enhanced and suppressed rainfall, mainly over the Indian and western Pacific Oceans. Each MJO event lasts approximately 30 to 60 days, hence the MJO is also known as the 30- to 60-day wave, or the intraseasonal oscillation.

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) The balance between the mass input to the ice body (*accumulation*) and the mass loss (*ablation* and iceberg *calving*) over a stated period of time, which is often a year or a season. Point mass balance refers to the mass balance at a particular location on the *glacier* or *ice sheet*. Surface mass balance is the difference between surface accumulation and surface ablation. The input and output terms for mass balance are:

Accumulation All processes that add to the mass of a glacier. The main contribution to accumulation is snowfall. Accumulation also includes deposition of hoar, freezing rain, other types of solid precipitation, gain of wind-blown snow, and avalanching.

Ablation Surface processes that reduce the mass of a glacier. The main contributor to ablation is melting with *runoff* but on some glaciers sublimation, loss of wind-blown snow and avalanching are also significant processes of ablation.

Discharge/outflow Mass loss by iceberg calving or ice discharge across the *grounding line* of a floating *ice shelf*. Although often treated as an ablation term, in this report iceberg calving and discharge is considered separately from surface ablation.

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*.

Medieval Warm Period (MWP) An interval of relatively warm conditions and other notable *climate* anomalies such as more extensive *drought* in some continental *regions*. The timing of this interval is not clearly defined, with different records showing onset and termination of the warmth at different times, and some showing intermittent warmth. Most definitions lie within the period 900 to 1400 CE. Currently available *reconstructions* of average Northern Hemisphere temperature indicate that the warmest period at the hemispheric scale may have occurred from 950 to 1250 CE. Currently available records and temperature reconstructions indicate that average temperatures during parts of the MWP were indeed warmer in the context of the last 2 kyr, though the warmth may not have been as ubiquitous across seasons and geographical regions as the 20th century warming. It is also called *Medieval Climate Anomaly*.

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. It must be borne in mind that 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.

Metadata Information about meteorological and climatological data concerning how and when they were measured, their quality, known problems and other characteristics.

Methane (CH_4) Methane is one of the six *greenhouse gases* to be mitigated under the *Kyoto Protocol* and is the major component of natural gas and associated with all hydrocarbon fuels, animal husbandry and agriculture.

Metric A consistent measurement of a characteristic of an object or activity that is otherwise difficult to quantify. Within the context of the evaluation of *climate models*, this is a quantitative measure of agreement between a simulated and observed quantity which can be used to assess the performance of individual models.

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.

Mineralization/Remineralization The conversion of an element from its organic form to an inorganic form as a result of microbial decomposition. In nitrogen mineralization, 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 A human intervention to reduce the *sources* or enhance the *sinks* of *greenhouse gases*.

Mixing ratio See *Mole fraction*.

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 hierarchy See *Climate model (spectrum or hierarchy)*.

Model initialization A *climate forecast* 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. See also *Climate prediction*.

Model spread The range or spread in results from *climate models*, such as those assembled for Coupled Model Intercomparison Project Phase 5 (CMIP5). 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.

Mode of climate variability Underlying space–time structure with preferred spatial pattern and temporal variation that helps account for the gross features in variance and for *teleconnections*. A mode of variability is often considered to be the product of a spatial *climate pattern* and an associated *climate index* time series.

Mole fraction 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 µmol 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 A monsoon is a tropical and subtropical seasonal reversal in both the surface winds and associated precipitation, caused by differential heating between a continental-scale land mass and the adjacent ocean. Monsoon rains occur mainly over land in summer.

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*, such as chlorofluorocarbons, methyl chloroform, carbon tetrachloride and many others.

Near-surface permafrost A term frequently used in *climate model* applications to refer to *permafrost* at depths close to the ground surface (typically down to 3.5 m). In modelling studies, near-surface permafrost is usually diagnosed from 20 or 30 year climate averages, which is different from the conventional definition of permafrost. Disappearance of near-surface permafrost in a location does not preclude the longer-term persistence of permafrost at greater depth. See also *Active layer*, *Frozen ground* and *Thermokarst*.

Near-term climate forcers (NTCF) Near-term climate forcers (NTCF) refer to those compounds whose impact on *climate* occurs primarily within the first decade after their emission. This set of compounds is primarily composed of those with short *lifetimes* in the atmosphere compared to *well-mixed greenhouse gases*, and has been sometimes referred to as short lived climate forcers or short-lived climate pollutants. However, the common property that is of greatest interest to a climate assessment is the timescale over which their impact on climate is felt. This set of compounds includes *methane*, which is also a well-mixed greenhouse gas, as well as *ozone* and *aerosols*, or their *precursors*, and some halogenated species that are not well-mixed greenhouse gases. These compounds do not accumulate in the atmosphere at decadal to centennial timescales, and so their effect on climate is predominantly in the near term following their emission.

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

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*. See also *Chaotic* and *Predictability*.

North Atlantic Oscillation (NAO) The North Atlantic Oscillation consists of opposing variations of surface pressure near Iceland and near the Azores. It therefore corresponds to fluctuations in the strength of the main westerly winds across the Atlantic into Europe, and thus to fluctuations in the embedded *extratropical cyclones* with their associated frontal systems. See NAO Index, Box 2.5.

Northern Annular Mode (NAM) A winter fluctuation in the amplitude of a pattern characterized by low surface pressure in the Arctic and strong mid-latitude westerlies. The NAM has links with the northern polar vortex into the *stratosphere*. Its pattern has a bias to the North Atlantic and its index has a large correlation with the *North Atlantic Oscillation* index. See NAM Index, Box 2.5.

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

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 mean surface temperature* rises. It is a useful parameter for *climate change* experiments in which the *radiative forcing* is changing monotonically, when it can be compared with the *Climate Feedback Parameter* to gauge the relative importance of *climate 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 global mean surface air temperature change.

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

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

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

Ozone Ozone, the triatomic form of oxygen (O_3), is a gaseous atmospheric constituent. In the *troposphere*, it is created both naturally and by photochemical reactions involving gases resulting from human activities (*smog*). Tropospheric ozone acts as a *greenhouse gas*. In the *stratosphere*, it is created by the interaction between solar ultraviolet radiation and molecular oxygen (O_2). Stratospheric ozone plays a dominant role in the stratospheric radiative balance. Its concentration is highest in the *ozone layer*.

Ozone hole See *Ozone layer*.

Ozone layer The *stratosphere* contains a layer in which the concentration of *ozone* is greatest, the so-called ozone layer. The layer extends from about 12 to 40 km above the Earth's surface. The ozone concentration reaches a maximum between about 20 and 25 km. This layer has been depleted by human emissions of chlorine and bromine compounds. Every year, during the Southern Hemisphere spring, a very strong depletion of the ozone layer takes place over the Antarctic, caused by *anthropogenic* chlorine and bromine compounds in combination with the specific meteorological conditions of that *region*. This phenomenon is called the *Ozone hole*. See also *Montreal Protocol*.

Pacific Decadal Oscillation (PDO) The pattern and time series of the first empirical orthogonal function of *sea surface temperature* over the North Pacific north of 20°N. The PDO broadened to cover the whole Pacific Basin is known as the Inter-decadal Pacific Oscillation. The PDO and IPO exhibit similar temporal evolution. See also *Pacific Decadal Variability*.

Pacific decadal variability Coupled decadal-to-inter-decadal variability of the atmospheric circulation and underlying ocean in the Pacific Basin. It is most prominent in the North Pacific, where fluctuations in the strength of the winter Aleutian Low pressure system co-vary with North Pacific *sea surface temperatures*, and are linked to decadal variations in atmospheric circulation, sea surface temperatures and ocean circulation throughout the whole Pacific Basin. Such fluctuations have the effect of modulating the *El Niño-Southern Oscillation* cycle. Key measures of Pacific decadal variability are the *North Pacific Index (NPI)*, the *Pacific Decadal Oscillation (PDO)* index and the *Inter-decadal Pacific Oscillation (IPO)* index, all defined in Box 2.5.

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 PNA pattern index, Box 2.5.

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

Parameterization 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.

Percentiles The set of partition values which divides the total population of a distribution into 100 equal parts, the 50th percentile corresponding to the *median* of the population.

Permafrost Ground (soil or rock and included ice and organic material) that remains at or below 0°C for at least two consecutive years. See also *Near-surface permafrost*.

pH pH is a dimensionless measure of the acidity of water (or any 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.

Photosynthesis The process by which plants take *carbon dioxide* from the air (or bicarbonate in water) to build carbohydrates, releasing oxygen in the process. There are several pathways of photosynthesis with different responses to atmospheric carbon dioxide concentrations. See also *Carbon dioxide fertilization*.

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.

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 Plionece Epoch is the last epoch of the *Neogene* System and extends from 5.33 Ma to the beginning of the *Pleistocene* at 2.59 Ma.

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. See also *Proxy*.

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* or *aerosols*, but that have an effect on greenhouse gas 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, 2000).

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. See also *Climate prediction*.

Pre-industrial See *Industrial Revolution*.

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. See also *Climate model*.

Projection A projection is 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 socioeconomic and technological developments that may or may not be realized. See also *Climate prediction* and *Climate projection*.

Proxy A proxy *climate* indicator is a record that is interpreted, using physical and biophysical principles, to represent some combination of climate-related variations back in time. Climate-related data derived in this way are referred to as proxy data. Examples of proxies include *pollen analysis*, *tree ring* records, speleothems, characteristics of corals and various data derived from marine sediments and *ice cores*. Proxy-data can be calibrated to provide quantitative climate information.

Quasi-Biennal 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 System is the latter of three systems that make up the *Cenozoic Era* (65 Ma to present), extending from 2.59 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 Radiative forcing is the change in the net, downward minus upward, radiative flux (expressed in W m^{-2}) at the *tropopause* or top of *atmosphere* due to a change in an external driver of *climate change*, such as, for example, a change in the concentration of *carbon dioxide* or the output of the Sun. Sometimes internal drivers are still treated as forcings even though they result from the alteration in *climate*, for example *aerosol* or *greenhouse gas* changes in *paleoclimates*. The traditional 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 *rapid adjustments* are accounted for is termed the *effective radiative forcing.* For the purposes of this report, radiative forcing is further defined as the change relative to the year 1750 and, unless otherwise noted, refers to a global and annual average value. Radiative forcing is not to be confused with *cloud radiative forcing*, which describes an unrelated measure of the impact of clouds on the radiative flux at the top of the atmosphere.

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*. For further explanation on the concept, see Sections 7.1 and 8.1.

Rapid climate change See *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. See also *Mass balance/budget (of glaciers or ice sheets)*.

Reanalysis Reanalyses are estimates of historical atmospheric temperature and wind or oceanographic temperature and current, and other quantities, created by processing past meteorological or oceanographic data using fixed state-of-the-art weather forecasting or ocean circulation models with data assimilation techniques. 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.

Rebound effect When CO_2 is removed from the *atmosphere*, the CO_2 concentration gradient between atmospheric and land/ocean carbon *reservoirs* is reduced. This leads to a reduction or reversal in subsequent inherent rate of removal of CO_2 from the atmosphere by natural *carbon cycle* processes on land and ocean.

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 analog methods.

Reforestation Planting of *forests* on lands that have previously contained forests but that have been converted to some other use. For a discussion of the term *forest* and related terms such as *afforestation*, *reforestation* and *deforestation*, see the IPCC Report on Land Use, Land-Use Change and Forestry (IPCC, 2000). See also the Report on Definitions and Methodological Options to Inventory Emissions from Direct Human-induced Degradation of Forests and Devegetation of Other Vegetation Types (IPCC, 2003).

Region A region is a territory characterized by specific geographical and climatological features. The *climate* of a region is affected by regional and local scale features like topography, *land use* characteristics and lakes, as well as remote influences from other regions. See also *Teleconnection*.

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.

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 Sea level measured by a *tide gauge* with respect to the land upon which it is situated. See also *Mean sea level* and *Sea level change*.

Representative Concentration Pathways (RCPs) *Scenarios* that include time series of emissions and concentrations of the full suite of *greenhouse gases* and *aerosols* and chemically active gases, as well as *land use*/land cover (Moss et al., 2008). 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* emphasizes 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 (ECPs)* describe extensions of the RCPs from 2100 to 2500 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 present IPCC Assessment as a basis for the *climate predictions* and *projections* presented in Chapters 11 to 14:

RCP2.6 One pathway where radiative forcing peaks at approximately 3 W m^{-2} before 2100 and then declines (the corresponding ECP assuming constant emissions after 2100)

RCP4.5 and RCP6.0 Two intermediate *stabilization pathways* in which radiative forcing is stabilized at approximately 4.5 W m^{-2} and 6.0 W m^{-2} after 2100 (the corresponding ECPs assuming constant concentrations after 2150)

RCP8.5 One high pathway for which radiative forcing reaches greater than 8.5 W m^{-2} by 2100 and continues to rise for some amount of time (the corresponding ECP assuming constant emissions after 2100 and constant concentrations after 2250)

For further description of future scenarios, see Box 1.1.

Reservoir A component of the *climate system*, other than the *atmosphere*, which has the capacity to store, accumulate or release a substance of concern, for example, carbon, a *greenhouse gas* or a *precursor*. Oceans, soils and *forests* are examples of reservoirs of carbon. *Pool* is an equivalent term (note that the definition of pool often includes the atmosphere). The absolute quantity of the substance of concern held within a reservoir at a specified time is called the *stock*.

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*, releasing energy and consuming molecular oxygen.

Response time 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. See *lifetime* for a different definition of response time pertinent to the rate of processes affecting the concentration of trace gases.

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. See also *Return value*.

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). See also *Return period*.

River discharge See *Streamflow*.

Runoff That part of precipitation that does not evaporate and is not transpired, but flows through the ground or over the ground surface and returns to bodies of water. See also *Hydrological cycle*.

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, prices) and relationships. Note that scenarios are neither predictions nor forecasts, but are useful to provide a view of the implications of developments and actions. See also *Climate scenario*, *Emission scenario*, *Representative Concentration Pathways* and *SRES scenarios*.

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 level change Sea level can change, both globally and locally due to (1) changes in the shape of the ocean basins, (2) a change in ocean volume as a result of a change in the mass of water in the ocean, and (3) changes in ocean volume as a result of changes in ocean water density. 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 *Relative Sea Level* and *Thermal expansion*.

Sea level equivalent (SLE) The sea level equivalent of a mass of water (ice, liquid or 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 3.625×10^{14} m^2. Thus, 362.5 Gt of water mass added to the ocean will cause 1 mm of global *mean sea level* rise. See also *Sea level change*.

Seasonally frozen ground See *Frozen ground*.

Sea surface temperature (SST) The sea surface temperature is 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 See *Uptake*.

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.

Sink Any process, activity or mechanism that removes a *greenhouse gas*, an *aerosol* or a *precursor* of a greenhouse gas or aerosol from the *atmosphere*.

Slab-ocean model A simplified representation in a *climate model* of the ocean as a motionless layer of water with a depth of 50 to 100 m. Climate models with a slab ocean can be used only for estimating the equilibrium response of *climate* to a given forcing, not the transient evolution of climate. See also *Equilibrium and transient climate experiment*.

Snow cover extent 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.

Soil moisture Water stored in the soil in liquid or frozen form.

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 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. See also *Solar cycle*.

Solar ('11-year') cycle 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 Management (SRM) Solar Radiation Management refers to the intentional modification of the Earth's shortwave radiative budget with the aim to reduce *climate change* according to a given *metric* (e.g., *surface temperature*, precipitation, regional impacts, etc). Artificial injection of stratospheric *aerosols* and cloud brightening are two examples of SRM techniques. Methods to modify some fast-responding elements of the longwave radiative budget (such as cirrus clouds), although not strictly speaking SRM, can be related to SRM. SRM techniques do not fall within the usual definitions of *mitigation* and adaptation (IPCC, 2012, p. 2). See also *Solar radiation*, *Carbon Dioxide Removal (CDR)* and *Geoengineering*.

Solubility pump Solubility pump is an important physicochemical process that transports dissolved inorganic carbon from the ocean's surface to its interior. This process controls the inventory of carbon in the ocean. The solubility of gaseous *carbon dioxide* can alter carbon dioxide concentrations in the oceans and the overlying *atmosphere*. See also *Biological pump*.

Source Any process, activity or mechanism that releases a *greenhouse gas*, an *aerosol* or a *precursor* of a greenhouse gas or aerosol into the *atmosphere*.

Southern Annular Mode (SAM) The leading mode of variability of Southern Hemisphere geopotential height, which is associated with shifts in the latitude of the midlatitude jet. See SAM Index, Box 2.5.

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

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 *ITCZ*, but is more extratropical in nature, especially east of the Dateline.

Spatial and temporal scales *Climate* may vary on a large range of spatial and temporal scales. Spatial scales may range from local (less than 100 000 km^2), through regional (100 000 to 10 million km^2) to continental (10 to 100 million km^2). Temporal scales may range from seasonal to geological (up to hundreds of millions of years).

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*.

SRES scenarios SRES scenarios are *emission scenarios* developed by Nakićenović and Swart (2000) and used, among others, as a basis for some of the *climate projections* shown in Chapters 9 to 11 of IPCC (2001) and Chapters 10 and 11 of IPCC (2007). The following terms are relevant for a better understanding of the structure and use of the set of SRES scenarios:

> **Scenario family** Scenarios that have a similar demographic, societal, economic and technical change storyline. Four scenario families comprise the SRES scenario set: A1, A2, B1 and B2.

Illustrative Scenario A scenario that is illustrative for each of the six scenario groups reflected in the Summary for Policymakers of Nakićenović and Swart (2000). They include four revised *marker scenarios* for the scenario groups A1B, A2, B1, B2 and two additional scenarios for the A1FI and A1T groups. All scenario groups are equally sound.

Marker Scenario A scenario that was originally posted in draft form on the SRES website to represent a given scenario family. The choice of markers was based on which of the initial quantifications best reflected the storyline, and the features of specific models. Markers are no more likely than other scenarios, but are considered by the SRES writing team as illustrative of a particular storyline. They are included in revised form in Nakićenović and Swart (2000). These scenarios received the closest scrutiny of the entire writing team and via the SRES open process. Scenarios were also selected to illustrate the other two scenario groups.

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.

Steric See *Sea level change*.

Stock See *Reservoir*.

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.

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.

Stratosphere The highly stratified region of the *atmosphere* above the *troposphere* extending from about 10 km (ranging from 9 km at high latitudes to 16 km in the tropics on average) to about 50 km altitude.

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.

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 layer See *Atmospheric boundary layer*.

Surface temperature See *Global mean surface temperature*, *Land surface air temperature* and *Sea surface temperature*.

Talik A layer of year-round unfrozen ground that lies in *permafrost* areas.

Teleconnection A statistical association between climate variables at widely separated, geographically-fixed spatial locations. Teleconnections are caused by large spatial structures such as basin-wide coupled modes of ocean–*atmosphere* variability, Rossby wave-trains, mid-latitude jets and *storm tracks*, etc. See also *Teleconnection pattern*.

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. See also *Teleconnection*.

Terrestrial radiation Radiation emitted by the Earth's surface, the *atmosphere* and the clouds. It is also known as *thermal infrared* or *longwave 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. See also *Outgoing longwave radiation*.

Thermal expansion In connection with sea level, this refers to the increase in volume (and decrease in density) that results from warming water. A warming of the ocean leads to an expansion of the ocean volume and hence an increase in sea level. See also *Sea level change*.

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) Large-scale circulation in the ocean that transforms low-density upper ocean waters to higher-density intermediate and deep waters and returns those waters back to the upper ocean. The circulation is asymmetric, with conversion to dense waters in restricted regions at high latitudes and the return to the surface involving slow upwelling and diffusive processes over much larger geographic regions. The THC is driven by high densities at or near the surface, caused by cold temperatures and/or high salinities, but despite its suggestive though common name, is also driven by mechanical forces such as wind and tides. Frequently, the name THC has been used synonymously with *Meridional Overturning Circulation*.

Thermokarst The process by which characteristic landforms result from the thawing of ice-rich *permafrost* or the melting of massive ground ice.

Thermosteric See *Sea level change*.

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*.

Tipping point In *climate*, a hypothesized critical threshold when global or regional *climate changes* from one stable state to another stable state. The tipping point event may be irreversible. See also *Irreversibility*.

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. The generally accepted value is 1368 W m^{-2} with an accuracy of about 0.2%. 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). Changes in the ultraviolet part of the spectrum during a solar cycle are comparatively larger (percent) than in TSI. See also *Insolation*.

Transient climate response See *Climate sensitivity*.

Transient climate response to cumulative CO_2 emissions (TCRE) The transient global average *surface temperature* change per unit cumulated *CO_2* emissions, usually 1000 PgC. TCRE combines both information on the *airborne fraction* of cumulated CO_2 emissions (the fraction of the total CO_2 emitted that remains in the *atmosphere*), and on the *transient climate response* (TCR).

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. See also *Proxy*.

Trend In this report, the word *trend* designates a change, generally monotonic in time, in the value of a variable.

Tropopause The boundary between the *troposphere* and the *stratosphere*.

Troposphere The lowest part of the *atmosphere*, from the surface to about 10 km in altitude at mid-latitudes (ranging from 9 km at high latitudes to 16 km in the tropics on average), where clouds and weather phenomena occur. In the troposphere, temperatures generally decrease with height. See also *Stratosphere*.

Turnover time See *Lifetime*.

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, 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; Manning et al., 2004; Mastrandrea et al., 2010). See also *Confidence* and *Likelihood*.

United Nations Framework Convention on Climate Change (UNFCCC) The Convention was adopted on 9 May 1992 in New York and signed at the 1992 Earth Summit in Rio de Janeiro by more than 150 countries and the European Community. Its 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*'. It contains commitments for all Parties. Under the Convention, Parties included in Annex I (all OECD countries and countries with economies in transition) aim to return greenhouse gas emissions not controlled by the *Montreal Protocol* to 1990 levels by the year 2000. The convention entered in force in March 1994. In 1997, the UNFCCC adopted the *Kyoto Protocol*.

Uptake The addition of a substance of concern to a *reservoir*. The uptake of carbon containing substances, in particular *carbon dioxide*, is often called (carbon) *sequestration*.

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, 2000), and the processes that propagate these properties into the ocean interior.

Volatile Organic Compounds (VOC) 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 NO_x and CO) to the formation of photochemical oxidants such as *ozone*.

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. For the corresponding indices, see Box 2.4.

Warm spell A period of abnormally hot weather. For the corresponding indices, see Box 2.4. See also *Heat wave*.

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.

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 See *Greenhouse gas*.

Younger Dryas A period 12.85 to 11.65 ka (thousand years before 1950), during the *deglaciation*, characterized by a temporary return to colder conditions in many locations, especially around the North Atlantic.

References

AMS, 2000: *AMS Glossary of Meteorology*, 2nd ed. American Meteorological Society, Boston, MA, http://amsglossary.allenpress.com/glossary/browse.

Hegerl, G. C., O. Hoegh-Guldberg, G. Casassa, M. P. Hoerling, R. S. Kovats, C. Parmesan, D. W. Pierce, and P. A. Stott, 2010: Good practice guidance paper on detection and attribution related to anthropogenic climate change. In: *Meeting Report of the Intergovernmental Panel on Climate Change Expert Meeting on Detection and Attribution of Anthropogenic Climate Change* [T. F. Stocker, C. B. Field, D. Qin, V. Barros, G.-K. Plattner, M. Tignor, P. M. Midgley and K. L. Ebi (eds.)]. IPCC Working Group I Technical Support Unit, University of Bern, Bern, Switzerland.

IPCC, 1992: *Climate Change 1992: The Supplementary Report to the IPCC Scientific Assessment* [J. T. Houghton, B. A. Callander and S. K. Varney (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 116 pp.

IPCC, 1996: *Climate Change 1995: The Science of Climate Change. Contribution of Working Group I to the Second Assessment Report of the Intergovernmental Panel on Climate Change* [J. T. Houghton., L. G. Meira . A. Callander, N. Harris, A. Kattenberg and K. Maskell (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 572 pp.

IPCC, 2000: *Land Use, Land-Use Change, and Forestry. Special Report of the Intergovernmental Panel on Climate Change* [R. T. Watson, I. R. Noble, B. Bolin, N. H. Ravindranath, D. J. Verardo, and D. J. Dokken (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 377 pp.

IPCC, 2001: *Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change* [T. Houghton, Y. Ding, D. J. Griggs, M. Noquer, P. J. van der Linden, X. Dai, K. Maskell and C. A. Johnson (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 881 pp.

IPCC, 2003: Definitions and Methodological Options to Inventory Emissions from Direct Human-Induced Degradation of Forests and Devegetation of Other Vegetation Types [Penman, J., M. Gytarsky, T. Hiraishi, T. Krug, D. Kruger, R. Pipatti, L. Buendia, K. Miwa, T. Ngara, K. Tanabe and F. Wagner (eds.)]. The Institute for Global Environmental Strategies (IGES), Japan, 32 pp.

IPCC, 2007: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor and H. L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 996 pp.

IPCC, 2011: *Workshop Report of the Intergovernmental Panel on Climate Change Workshop on Impacts of Ocean Acidification on Marine Biology and Ecosystems* [C. B. Field, V. Barros, T. F. Stocker, D. Qin, K.J. Mach, G.-K. Plattner, M. D. Mastrandrea, M. Tignor and K. L. Ebi (eds.)]. IPCC Working Group II Technical Support Unit, Carnegie Institution, Stanford, CA, USA, 164 pp.

IPCC, 2012: *Meeting Report of the Intergovernmental Panel on Climate Change Expert Meeting on Geoengineering* [O. Edenhofer, R. Pichs-Madruga, Y. Sokona, C. Field, V. Barros, T. F. Stocker, Q. Dahe, J. Minx, K. Mach, G.-K. Plattner, S. Schlömer, G. Hansen and M. Mastrandrea (eds.)]. IPCC Working Group III Technical Support Unit, Potsdam Institute for Climate Impact Research, Potsdam, Germany, 99 pp.

Manning, M., et al., 2004: *IPCC Workshop on Describing Scientific Uncertainties in Climate Change to Support Analysis of Risk of Options*. Workshop Report. IPCC Working Group I Technical Support Unit, Boulder, CO, USA, 138 pp.

Mastrandrea, M. D., C. B. Field, T. F. Stocker, O. Edenhofer, K. L. Ebi, D. J. Frame, H. Held, E. Kriegler, K. J. Mach, P. R. Matschoss, G.-K. Plattner, G. W. Yohe, and F. W. Zwiers, 2010: *Guidance Note for Lead Authors of the IPCC Fifth Assessment Report on Consistent Treatment of Uncertainties*. Intergovernmental Panel on Climate Change (IPCC). http://www.ipcc.ch.

Moss, R., and S. Schneider, 2000: *Uncertainties in the IPCC TAR: Recommendations to Lead Authors for More Consistent Assessment and Reporting*. In: IPCC Supporting Material: Guidance Papers on Cross Cutting Issues in the Third Assessment Report of the IPCC. [Pachauri, R., T. Taniguchi, and K. Tanaka (eds.)]. Intergovernmental Panel on Climate Change, Geneva, pp. 33–51.

Moss, R., et al., 2008: *Towards new scenarios for analysis of emissions, climate change, impacts and response strategies*. Intergovernmental Panel on Climate Change, Geneva, 132 pp.

Moss, R. et al., 2010: The next generation of scenarios for climate change research and assessment. *Nature*, **463**, 747–756.

Nakićenović, N., and R. Swart (eds.), 2000: *Special Report on Emissions Scenarios*. *A Special Report of Working Group III of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 599 pp.

Schwartz, S.E., and P. Warneck, 1995: Units for use in atmospheric chemistry. *Pure Appl. Chem.*, **67**, 1377–1406.