GLOSSARY

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Source: some definitions come from the Glossary of Terms used in the IPCC Fourth Assessment Report (http://www.ipcc.ch)

Active region: a localised, transient volume of the solar atmosphere in which various solar features, such as sunspots and flares may be observed. Active regions are the result of enhanced magnetic fields; they are bipolar and may be complex if the region contains two or more bipolar groups. The solar radiative output in the UV increases with the number of active regions, which is modulated by the solar cycle. The sunspot number is often used as a proxy for the number of active regions.

Aeronomy: field of physics and chemistry dealing with the specific study of the Earth's (and also planetary) middle and upper atmospheres.

Aerosols: collection of airborne solid or liquid particles, with a typical size between 10^{-9} and 10^{-2} m that reside in the atmosphere for at least several hours. Aerosols may be of either natural or anthropogenic origin. They may influence climate in two ways: directly through scattering and absorbing radiation, and indirectly through acting as condensation nuclei for cloud formation or modifying the optical properties and lifetime of clouds.

Albedo: fraction of the light and energy received that is reflected or diffused by a non-luminous body. The albedo is always comprised between 0 and 1. It varies according to the wavelength. An albedo equal to zero at a given wavelength characterises a body that absorbs all this radiation perfectly. A value of 1 characterises a perfect mirror for that wavelength.

ap: 3-hourly index of geomagnetic activity. The ap index is measured in nano-Tesla, and is derived from the Kp index. It quantifies the variation of the geomagnetic field at ground level compared to quiet day conditions. Ap stands for a daily average of the ap index. The ap index is frequently used as a proxy for the flux of energetic particles precipitating into the Earth's atmosphere. See also Radiation belts.

Astronomical unit (AU): the mean Earth-Sun distance, equal to $1.496 \cdot 10^6$ km.

Atmosphere: 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 are typically around 1% volume mixing ratio. The atmosphere also contains clouds and aerosols.

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Atmospheric tides: global-scale periodic oscillations of the atmosphere, by analogy with to ocean tides. They are typically excited by the alternation between day/night in the intense solar heating. Some are also driven by the pull of the gravitational field of the Moon.

Aurora: a visual phenomenon occurring during the night at high latitudes, called aurora borealis in the Northern hemisphere and aurora australis in the Southern hemisphere. Auroras are caused by the excitation of atmospheric species, followed by radiation of photons, due to collisions with ionised particles precipitating from the external magnetosphere along the geomagnetic field lines. Since the atmospheric composition changes with altitude, different colours originate from different heights. Yellow-green, for example, occurs from 90 to 250 km (atomic oxygen), while blue and red at lower heights (molecular nitrogen and molecular oxygen). Auroras are part of the complex phenomenon, known as magnetospheric substorm whose occurrence is generally related to solar activity. See Substorm.

Auroral oval: region where the auroras typically occur. The oval is an elliptical region around each geomagnetic pole, generally ranging in geomagnetic latitude from $\approx 65^\circ$ at midnight to $\approx 75^\circ$ at noon, but widens during magnetic storms and substorms. The oval is the region where reconnected magnetospheric field lines originate.

Chromosphere: region of the solar atmosphere, above the photosphere and below the corona, which is characterised by a sudden increase in temperature. During a total eclipse of the Sun, it shows up as a thin, bright pink layer, hence its name. The colour is due primarily to the emission of hydrogen at a wavelength of 656.3 nm. The chromospheres extends to about 10 000 km above the surface of the Sun.

Climate: in a narrow sense, it 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 Organisation. The relevant quantities are most often surface variables, such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the climate system.

Climate change: 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 which persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use. Note that the Framework Convention on Climate Change (UNFCCC) 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.

Climate feedback: an interaction mechanism between processes in the climate system is called a climate feedback when the result of an initial process triggers changes in a second process that in turn influences the initial one. A positive feedback intensifies the original process, and a negative feedback reduces it.

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 all or 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 parameterisations are involved. Coupled Atmosphere-Ocean General Circulation Models (AOGCMs) provide a representation of the climate system that is near 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.

Climate sensitivity: in IPCC reports, equilibrium climate sensitivity refers to the equilibrium change in the annual mean global surface temperature following a doubling of the atmospheric equivalent carbon dioxide concentration. Due to computational constraints, the equilibrium climate sensitivity in a climate model is usually 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.

Climate system: the climate system is the highly complex system consisting of five major components: the atmosphere, the hydrosphere, the cryosphere, the land surface 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.

Convection zone: external region of the inside of the Sun (representing the last 30% of the radius), where the energy produced by the nuclear core is

transmitted by convection. This is the region where solar matter seethes. Active regions on the solar surface are generally considered to originate from a strong toroidal magnetic field generated at the base of the convection zone.

Corona: the outermost, most tenuous region of the solar atmosphere, characterised by very high temperatures ($> 10^6$ K) and very low density ($< 10^9$ cm^{-3}). The corona extends throughout the solar system, and transitions into the solar wind.

Coronal hole: extended region of the solar corona, which is characterised by low density and unipolar magnetic fields. In coronal holes, solar magnetic field lines open up into space, which allows a high speed solar wind to escape. These regions exhibit a deficit of EUV and XUV radiation.

Coronal mass ejection (CME): a sudden outflow of plasma from the solar corona, often associated with flares and eruptive prominences. CME that are directed earthwards usually reach the Earth in 1–2 days, and strongly perturb the geomagnetic field. This is known to impact the Global Electrical Circuit (GCE), and may be one of the mechanisms by which solar activity influences climate. See Global Electrical Circuit.

Corotating interaction regions: compression regions formed from the interaction of high and low speed solar wind streams. They are roughly aligned with the Archimedean spiral that characterises the large-scale structure of the solar wind, and appear to corotate with the Sun.

Corotation: joint rotation of a planet and its atmosphere.

Cosmic rays: see Galactic cosmic rays.

Cosmogenic isotope, or cosmogenic nuclide: isotopes created when a high-energy cosmic ray interacts with a nucleus, causing the break-up of the bombarded nucleus into several parts. Some of these isotopes, such as ^{10}Be and ^{14}C, are radioactive and are produced in the Earth's atmosphere. Their production rate is weakly modulated by the level of solar magnetic activity. Because of this, their concentration in natural archives, such as ice cores can be used as a tracer for past solar activity. Cosmogenic isotopes today provide access to solar activity up to several 10 000 years back.

Dalton minimum: a period of low solar activity, lasting from about 1790 to 1830, and named after the meteorologist John Dalton. As for the Maunder and Spörer minima, the Dalton minimum coincided with a period of relatively lower temperatures, especially in the Northern hemisphere.

Detection and attribution: climate varies continually on all time scales. Detection of climate change is the process of demonstrating that climate has changed in some defined statistical sense, without providing a reason for that change. Attribution of causes of climate change is the process of establishing the most likely causes for the detected change with some defined level of confidence.

Dst index: or disturbance storm time index, is the weighted average of the north-south component of the geomagnetic field, measured by four stations that are located near the geomagnetic equator. The Dst index gives information about the strength of the ring current around Earth, and is used in space weather for detecting geomagnetic storms. See Radiation belts.

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 Abrupt climate change; Chaos; Nonlinearity; Predictability.

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 Perú, 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 collectively known as the El Niño-Southern Oscillation (ENSO). It is often measured by the surface pressure anomaly difference between Darwin and Tahiti and 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. Together they constitute one of the major modes of internal climate variability on decadal time scales.

Ensemble: a group of parallel model simulations used for climate projections. Variation of the results across the ensemble members gives an estimate of uncertainty. Ensembles made with the same model but different initial conditions only characterise the uncertainty associated with internal climate variability, whereas multimodel ensembles including simulations by several models also include the impact of model differences. Perturbed-parameter ensembles, in which model parameters are varied in a systematic manner, aim to produce a more objective estimate of modelling uncertainty than is possible with traditional multi-model ensembles.

EUV or Extreme Ultraviolet: spectral band, which is part of the UV, with wavelengths ranging from 10 to 121 nm. Solar spectral irradiance emitted in the EUV is highly variable, and is the main source of ionisation in the Earth's upper atmosphere.

Exosphere: outermost layer of the Earth's atmosphere, defined as the region where collisions between particles are rare enough to be considered as negligible.

Atoms thus move freely, and some may even escape into space without undergoing collisions. The bottom of the exosphere (called exobase) is located between 350 and 800 km altitude, depending on its temperature, which is strongly modulated by the solar UV flux.

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.

F10.7 index: also called decimetric index, is the solar radio flux measured at a wavelength of 10.7 cm (expressed in 10^{22} $\mathrm{Wm^{-2}Hz^{-1}}$). This solar proxy closely matches the variability of the solar UV flux. Unlike the latter, however, it can be conveniently measured from the ground, hence its frequent use as a gauge of UV flux. The quiet Sun has an F10.7 index of approximately 70, whereas levels in excess of 300 are observed at solar maximum. This index does not include enhancements that are due to solar flares.

Facula: a bright region on the solar photosphere, which is best seen in white light. Faculae correspond to regions with enhanced magnetic field, and can be a precursor of a sunspot. Their counterpart in the chromosphere is called facula. The modulation of plages and faculae by the solar cycle is one of the primary causes of the variations observed in the solar spectral irradiance.

Fingerprint: the climate response pattern in space and/or time to a specific forcing is commonly referred to as a fingerprint. Fingerprints are used to detect the presence of this response in observations and are typically estimated using forced climate model simulations.

Flare: an explosion on the Sun usually releasing large amounts of energy and particles, and generally occurring within an active region. Flares are more likely to occur at solar maximum. Flares last from minutes to hours.

FUV or Far Ultraviolet: spectral band, which is part of the UV, with wavelengths ranging from 121 to 200 nm. Solar spectral irradiance emitted in the FUV is mostly absorbed in the mesosphere and above.

Galactic Cosmic Rays (GCR) or Cosmic rays: high-energy particles, originating outside the Solar system. GCR are composed of protons ($\approx 90\%$) and atomic nuclei, with energies that can be of orders of magnitude larger than that of radiation belt particles, i.e. in the MeV–GeV range, and beyond. When penetrating the Earth's atmosphere, they generally produce showers of secondary particles, some of which reach the ground surface. High-energy particles produced by solar flares and/or by coronal mass ejections are called solar cosmic rays or Solar Energetic Particles. See also Solar Energetic Particle (SEP) event.

Geomagnetic field: the magnetic field observed in and around the Earth. The geomagnetic field can be approximated by a centered dipole field, with the axis of the dipole inclined to the Earth's rotational axis by about 11.5°. At the Earth's surface, its intensity is approximately 32 000 nT at the equator, and 62 000 nT at the north pole.

Geomagnetic storm: a temporary disturbance of the Earth's magnetosphere, which occurs when a solar wind perturbation interacts with the geomagnetic field. Geomagnetic storms cause an increase in movement of plasma through the magnetosphere (driven by increased electric fields inside the magnetosphere) and an increase in electric current in the magnetosphere and ionosphere. They last for several days and their main consequences are the injection of large quantities of ions in the radiation belts, which then partly precipitate into the upper atmosphere, where they release their energy and create NO_x. Storms are distinct from substorms in that the latter are much less energetic, and last for a few hours only.

Geostationary (orbit): satellite orbit that always flies over the same point of the terrestrial equator. Geostationary satellites are all located on the same circular orbit, which is located in the equatorial plane, at an altitude of 35 784 km.

GeV: unit of energy, which is frequently used for ionised particles: 1 GeV = 10^9 eV (electron-volts), which is equivalent to $1.6 \cdot 10^{-10}$ J (Joule). Particles with energies in the GeV range are relativistic because their speed is only a fraction of the speed of light. See also MeV.

Global Electrical Circuit (GEC): refers to the continuous electrical current that flows vertically between the ionosphere and the Earth's surface. This flow is powered by thunderstorms, which cause a build-up of positive charge in the ionosphere. During fair weather conditions, this positive charge slowly flows back to the Earth's surface. Cosmic rays are the principal source of atmospheric ions in the lower atmosphere; their intensity is modulated by solar activity, which may thus influence the GEC.

Gravity waves: generally occur in the atmosphere at interfaces between layers, and are primarily governed by the Earth's gravity. Gravity waves are well known to occur near the tropopause. They are generated from below by airflow over mountains. As they move upward and reach more rarefied air, their amplitude increases, until non-linear effects causes them to break, transferring their energy to the mean flow. See planetary waves.

Greenhouse effect: greenhouse gases effectively absorb thermal infrared radiation, emitted by the Earth's surface, by the atmosphere itself due to the same gases, and by clouds. Atmospheric radiation is emitted to all sides, including downward to the Earth's surface. Thus, greenhouse gases trap heat within the surface–troposphere system. This is called the greenhouse effect. Thermal infrared radiation in the troposphere is strongly coupled with the

temperature of the atmosphere at the altitude at which it is emitted. In the troposphere, the temperature generally decreases with height. Effectively, infrared radiation emitted to space originates from an altitude with a temperature of, on average, −19 °C, in balance with the net incoming solar radiation, whereas the Earth's surface is kept at a much higher temperature of, on average, 14 °C. An increase in the concentration of greenhouse gases leads to an increased infrared opacity of the atmosphere, and therefore to an effective radiation into space from a higher altitude at a lower temperature. This causes a radiative forcing that leads to an enhancement of the greenhouse effect, the so-called enhanced greenhouse effect.

Group sunspot number: index of solar activity that is similar to the sunspot number. The group sunspot number, however, is defined from the number of sunspot groups only, which makes it easier to infer from historic drawings.

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.

Heliosphere: region in space that undergoes the influence of the solar wind. It spreads from approximately 50 to 100 Astronomical Units (AU) from the Sun.

Heterosphere: layer of the atmosphere that is typically located above 80 km. In the heterosphere, each molecular constituent has its own scale height because for each of them, the pressure decreases differently with altitude. The layer below is called homosphere.

Holocene: the Holocene geological epoch is the latter of two Quaternary epochs, extending from about 11 600 years to and including the present.

Homosphere: designates the lower layers of the terrestrial atmosphere in which the scale height is the same for all constituents: for all, the pressure and the concentration decrease in the same way with altitude. The homosphere ends at an altitude of about 80 km, beyond which starts the heterosphere.

HO_x: a generic term used for hydrogen oxide radicals. These highly reactive, and consequently short-lived radicals are produced during UV-light dissociation of H_2O_2, typically above 50 km altitude. These radicals play a role in the middle stratosphere by depleting it from its ozone. See Radical and NO_x.

Hydrosphere: the component of the climate system composed of liquid surface and subterranean water, such as oceans, seas, rivers, freshwater lakes, underground water, etc.

Insolation: the amount of solar radiation reaching the Earth by latitude and by season. 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.

Interplanetary magnetic field (IMF): the solar magnetic field, carried by the solar wind into interplanetary space and twisted into an Archimedean spiral by the Sun's rotation.

Inter-Tropical Convergence Zone: area encircling the Earth near the equator where the northeast and southeast trade winds come together. Variation in its location zone drastically affects rainfall in many equatorial nations, accentuating the risk of having droughts and floods.

Ion: a charged molecule or an atom.

Ionisation: is a process by which an atom or a molecule acquires a negative or positive charge by gaining or losing electrons.

Ionosphere: region of the Earth's upper atmosphere consisting of charged particles (ions and electrons) that mingle with the thermosphere to form the upper atmosphere. The ionosphere is the ionised counterpart of the thermosphere and typically extends from 85 km to 500–1000 km. The ionosphere is often subdivided into 4 regions, called D-region (between 60 and 90 km), E-region (between 90 and 140 km), and F1 and F2-region (between 140 and 200 km).

Jet streams: meandering-shaped and fast flowing air currents that are located near the altitude of the tropopause. Each hemisphere has both a polar jet and a subtropical jet. The Northern hemisphere polar jet flows over the middle to northern latitudes of North America, Europe, and Asia. Jet streams are caused by a combination of the Earth's rotation, and atmospheric heating by solar radiation. There is growing evidence for their gradual weakening and equatorward drift with global warming.

keV: unit of energy, which is frequently used for ionised particles : 1 keV $= 10^3$ eV (electron-volts), which is equivalent to $1.6 \cdot 10^{-16}$ J (Joule). Most solar wind protons and electrons have energies between 0.1 and 10 eV. See also MeV and GeV.

Kp: index of geomagnetic activity, which measures disturbances of the horizontal component of the Earth's magnetic field at ground level. The Kp index is a weighted average of 13 stations that are located between 46 and 60° of southern and northern geomagnetic latitude. Its values are expressed on a semi-logarithmic scale from 0 to 9+, with 1 being calm and > 5 indicating a geomagnetic storm. The Kp index is delivered on a 3-hourly basis. See also ap and Dst indices.

Lagrange point: zone in space where the gravity and centrifugal force of two bodies balances out. The L1 point is on the Sun-Earth line (at about 1% of that distance from the Earth). Several Sun-observing spacecraft are located there because they rotate around the Sun in exactly one year.

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

Limb (solar limb): luminous edge of the solar disk, or of a heavenly body.

Longwave radiation: radiation emitted by the Earth's surface, the atmosphere and the clouds. See thermal infrared radiation.

Magnetic cloud: a region of the solar wind extending over about 0.15 AU, characterised by a strong magnetic field, a large and smooth rotation of the magnetic field direction and a low proton temperature. Magnetic clouds represent a subset of interplanetary coronal mass ejections.

Magnetic storm: a worldwide perturbation of the geomagnetic field due to an enhanced ring current. The intensity of the storm can be characterised by the minimum of the Dst (disturbance storm time) index, such that during intense storms the global field decreases at least by a hundred nanoTesla. A storm occurs when the interplanetary magnetic field turns southward for a prolonged period of time producing reconnection at the magnetopause. During the storm's main phase, which can last as long as two to two and a half days in the case of a severe storm, charged particles in the near-Earth plasma sheet are energised and injected deeper into the inner magnetosphere, producing the storm-time ring current

Magnetopause: boundary between the magnetosphere and the solar wind determined by the pressure balance between the solar wind on one side, and the magnetic pressure of the planetary field on the other. It is typically located at a geocentric distance of about 10 Earth radii on the upstream side.

Magnetosphere: is the volume of space around an astronomical object that is controlled by that object's magnetic field. The Earth's magnetosphere is the cavity formed by the Earth's magnetic field in the flow of plasma from the Sun known as the solar wind.

Magnetospheric substorm: see Substorm.

Magnetosphere: is the volume of space around an astronomical object that is controlled by that object's magnetic field. The Earth's magnetosphere is the cavity formed by the Earth's magnetic field in the flow of plasma from the Sun, known as the solar wind. The terrestrial magnetosphere is highly dynamic, because of the continuously changing solar wind.

Maunder Minimum: a period of exceptionally low solar activity, named after the astronomer Edward Maunder, and which lasted from approximately 1645 to 1715. This period of low solar activity also coincides with one of the cold and wet climatic periods in the Northern Hemisphere, also called "Little Ice Age".

Mesopause: boundary between the mesosphere and the thermosphere. The mesopause is one of the coldest layers of the atmosphere, with temperatures as low as 130 K.

Mesosphere: region of the atmosphere situated above the stratosphere, at an altitude of approximately 50 to 90 km, where the temperature decreases with height. The upper boundary of the mesosphere is the mesopause, which can be the coldest naturally occurring place on Earth with temperatures below 130 K.

MeV: unit of energy, which is frequently used for ionised particles: 1 MeV = 10^6 eV (electron-volts), which is equivalent to $1.6 \cdot 10^{-13}$ J (Joule). Particles with energies in the MeV range are called high-energy particles. Most solar wind protons and electrons in contrast have energies between 0.1 and 10 eV. See also keV and GeV.

Middle atmosphere: name given to the stratosphere, mesosphere and lowest part of the thermosphere, which span heights from approximately 10 km to 100 km.

Modes of climate variability: natural variability of the climate system, in particular on seasonal and longer time scales, predominantly occurs with preferred spatial patterns and time scales, through the dynamical characteristics of the atmospheric circulation and through interactions with the land and ocean surfaces. Such patterns are often called regimes, modes or teleconnections. Examples are the North Atlantic Oscillation (NAO), the Pacific-North American pattern (PNA), the El Niño-Southern Oscillation (ENSO), the Northern Annular Mode (NAM; previously called Arctic Oscillation, AO) and the Southern Annular Mode (SAM; previously called the Antarctic Oscillation, AAO).

MUV or Medium Ultraviolet: spectral band, which is part of the UV, with wavelengths ranging from 200 to 300 nm. Solar spectral irradiance emitted in the FUV is predominantly absorbed in the stratosphere and in the mesosphere. In the stratosphere, MUV radiation is responsible for the generation of ozone, and as such represents an important connection between solar variability and climate.

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 a potentially very complex

behaviour. Such complexity may lead to abrupt climate change. See also Chaos; Predictability.

North Atlantic Oscillation (NAO): the North Atlantic Oscillation consists of opposing variations of barometric 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 cyclones with their associated frontal systems. The NAO is one of the main contributors to natural climate variability on the decadal time scale.

NO_x: a generic term used for mono-nitrogen oxides NO (nitric oxide) and NO_2 (nitrogen dioxide). Man-made NO_x is mainly produced by combustion processes. Natural sources of NO_x are lightning, but also energetic particles precipitating into the atmosphere. In atmospheric chemistry, the term means the total concentration of NO and NO_2. The term NO_y (reactive, odd nitrogen) refers to both NO_x and compounds that are produced from the oxidation of NO_x which include nitric acid.

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, ozone is created by the interaction between solar ultraviolet radiation and molecular oxygen (O_2). Stratospheric ozone, whose main source is solar UV radiation, plays a dominant role in the stratospheric radiative balance.

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 is being 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 region, caused by anthropogenic chlorine and bromine compounds in combination with the specific meteorological conditions of that region. This phenomenon is called the ozone hole.

Pacific decadal oscillation: 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.

Paleoclimate: climate during periods prior to the development of measuring instruments, including historic and geologic time, for which only indirect (i.e. proxy) climate records are available. See Proxy.

Photolysis: chemical process by which molecules are broken down into smaller units through the absorption of light. Atmospheric chemistry is heavily driven by photolysis.

Photosphere: the lowest visible layer of the solar atmosphere that corresponds to the solar surface viewed in white light. The major part of solar radiation comes from the photosphere, and a very small part from the corona.

Plage: bright region of the solar chromosphere that exhibits enhanced emissions in the UV and in the visible bands of the spectrum. Plages are typically found near sunspots, and map closely to the faculae in the photosphere below. Their occurrence is modulated by the solar magnetic cycle, and is one of the main causes of the changing solar spectral irradiance.

Planetary waves (or Rossby waves): large-scale meanders in high-altitude winds that have a major influence on wind speeds, temperature, distribution of ozone, and other characteristics of the middle atmosphere structure. Planetary waves, together with gravity waves, are responsible for quasi-periodic oscillations in the stratosphere, such as the the Quasi-Biennial Oscillation (QBO). They are typically generated by orographic and adiabatic heating in the troposphere. See Gravity waves.

Plasma: gas in which charged particles (ions, electrons) are free. In geophysical plasmas, the charges are neutral, i.e. there are just about as many electrons as there are monovalent ions. A plasma is a good electrical conductor and is strongly affected by magnetic fields.

Plasmapause: external boundary of the plasmasphere.

Plasmasphere: a magnetospheric region of cool and dense plasma that may be considered an outer extension of the ionosphere with which it is coupled. Like the ionosphere, the plasmasphere tends to corotate with the Earth.

Polar vortex: a persistent, large-scale cyclone that circles the geographical north and south poles. Their bases are located in the middle and upper troposphere, and extend into the stratosphere. The rotation of these vortices is caused by the Coriolis effect. Polar vortices are weaker during summer and strongest during winter; when they are strong, the westerlies also increase in strength. Sudden stratospheric warming events, when temperatures within the stratosphere warm dramatically over a short time, are associated with weaker polar vortices. See also Sudden stratospheric warming, and Westerlies.

Predictability: the extent to which future states of a system may be predicted based on knowledge of current and past states of the system. Since knowledge of the climate system's past and current states is generally imperfect, as are the models that utilise this knowledge to produce a climate prediction, and since 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

Proxy: a proxy climate indicator is a local 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. The F10.7 index is a proxy for the solar UV flux.

Quasi-biennial oscillation (QBO): one of the most important modes of variability of the tropical stratosphere. This quasi-periodic oscillation of the equatorial zonal wind between easterlies and westerlies has a period of typically 28 to 29 months. The phase of the QBO is correlated with the solar cycle, which impacts the variability of the arctic stratosphere.

Radiation belts (van Allen radiation belts): annular shell in the magnetosphere surrounding the Earth at 1.2 to 6 Earth radii, in which highly energised particles are trapped by closed geomagnetic field lines. There are two belts. The inner one is part of the plasmasphere and corotates with the Earth; its maximum proton density lies near 5000 km. Inner belt protons have high energies (10–50 MeV range) and originate from the decay of secondary neutrons created during collisions between cosmic rays and upper atmospheric particles. The outer belt extends on to the magnetopause on the sunward side and to about 6 Earth radii on the nightside; it mostly consist of electrons. The altitude of maximum proton density is near 16 000–20 000 km. Outer belt protons have lower energies (about 200 eV to 1 MeV) and come from the solar wind and ionosphere. The population of radiation belt part particles gets enhanced by geomagnetic storms, and their precipitation into the upper atmosphere (at high latitudes) affects its chemistry.

Radiative forcing: the change in the net, downward minus upward, irradiance (expressed in Wm^{-2}) at the tropopause 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. 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. 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,

a similar terminology for describing an unrelated measure of the impact of clouds on the irradiance at the top of the atmosphere.

Radiative transfer: in the context of atmospheric physics, refers to the transfer of electromagnetic radiation through the atmosphere. Numerical models are needed to simulate the complex interaction of radiation with the atmosphere as it propagates.

Radiative zone: internal region of the Sun, between the nuclear oven and the convection zone, from 0.2 to 0.7 solar radii. Here, the energy produced by the nuclear core is transmitted by radiation.

Radical: in chemistry, radicals denote groups of atoms behaving as a single unit in a number of compounds. Hydroxyl (HO*) is an important radical for atmospheric chemistry.

Reanalysis: reanalyses are atmospheric and oceanic analyses of temperature, wind, current, and other meteorological and oceanographic quantities, created by processing past meteorological and oceanographic data using fixed state-of-the-art weather forecasting models and data assimilation techniques. Using fixed data assimilation avoids effects from the changing analysis system that occurs in operational analyses. Although continuity is improved, global reanalyses still suffer from changing coverage and biases in the observing systems.

Reconnection: magnetic reconnection refers to the breaking and reconnecting of oppositely directed magnetic field lines in plasma regions, which come in contact with each other. In the process, magnetic field energy is converted to plasma kinetic and thermal energy. It is the key mechanism in the solar wind-magnetosphere coupling and in the solar flare process.

Ring Current: in the magnetosphere, a toroidal electric current flowing westward around the Earth in a region near the geomagnetic equator, at geocentric distances between 2 and 9 Earth radii. It is generated by the drift of trapped charged particles with energies of 10–300 keV. This current is responsible of global decreases in the Earth's surface magnetic field during geomagnetic storms, when it is strongly enhanced by the injection of ions originated in the solar wind and the terrestrial ionosphere.

Schwabe cycle: see Solar cycle.

Shortwave radiation: radiation emitted by the Sun, in contrast to longwave radiation. See also Solar radiation, and Thermal infrared radiation.

Solar activity: the Sun exhibits periods of high activity observed in numbers of sunspots, as well as radiative output, magnetic activity and emission of high-energy particles. These variations take place on a range of time scales from millions of years to minutes. See Solar cycle.

Solar cycle (Schwabe cycle): a quasi-regular modulation of solar activity with varying amplitude, and a period of typically 10–11 years. One of the main manifestations of the solar cycle is the variation in the sunspot number. The true solar cycle (or Hale cycle) is actually a 20–22-year one, with two alternate periods of opposite magnetic polarity.

Solar corona: see Corona

Solar maximum: the time at which the Sun reaches its highest level of activity, as defined by the 12-month averaged sunspot number.

Solar minimum: the time at which the Sun reaches its lowest level of activity, as defined by the 12-month averaged sunspot number.

Solar energetic particle (SEP) event: is a burst of high-energy charged particles (dominated by protons) that are emitted by solar flares or accelerated in interplanetary space by a shock wave associated with a coronal mass ejection. These particles have energies in the MeV/nucleon and sometimes up to GeV/nucleon range. SEP events may occur anytime during a solar cycle, although avoiding minima, and typically last for hours to days. These particles penetrate deep into the atmosphere at high latitudes. They are often referred to as solar cosmic rays. See also Galactic cosmic rays.

Solar proton event (SPE): see Solar energetic particle (SEP) event.

Solar radiation: electromagnetic radiation emitted by the Sun. It is also referred to as shortwave radiation. Solar radiation has a distinctive range of wavelengths (spectrum) determined by the temperature of the Sun, peaking in visible wavelengths.

Solar spectral irradiance (SSI): the spectrally-resolved amount of solar radiation (or irradiance per unit wavelength) 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 the SSI can only be made from space, and the first full coverage of the solar spectrum (UV to infrared) extends back only to 2003 only. The variability of the SSI is highly-wavelength-dependent, and ranges from 0.1% in the visible to over 100% in the extreme ultraviolet. See also Total solar irradiance.

Solar storm: refers to various types of explosive events that occur at the surface of the Sun. Best known are solar flares, which are sudden flashes of brightness that can release up to 10^{26} J in just a few minutes. Flares also lead to the acceleration of mostly protons and electrons, which propagate away from the Sun at speeds close to that of light. Flares occur intermittently, but are more frequent when the Sun is active and has large, complex sunspots. They are frequently accompanied by the release of large amounts of plasma, called Coronal Mass Ejections (CME).

Solar wind: stream of charged particles (i.e., a plasma), which are ejected from the upper solar atmosphere. The solar wind consists mostly of high-energy electrons and protons (about 1 keV) that are able to escape the Sun's gravity in part because of the high temperature of the corona and the high kinetic energy particles gain through a process that is not well understood at this time. Several perturbations of the Earth's environment, such as geomagnetic storms, are driven by the solar wind. Fast solar winds mostly originate from solar coronal holes or from high latitude regions, with speeds in excess of about 700 km s^{-1}. Slow winds mostly originate from the quiet Sun, with speeds that are typically below 450 km s^{-1}. Alternating fast and slow solar winds disturb the Earth's magnetosphere, generate geomagnetic storms, and may lead, for example, to the precipitation of energetic particles from the radiation belts into the atmosphere. See Radiation belts.

Space climate: denotes the long-term variations in solar activity, as well as the related long-term changes in the heliosphere, the solar wind and the heliospheric magnetic field, and their effects in the near-Earth environment, including the magnetosphere and ionosphere, the upper and lower atmosphere, climate and other related systems.

Space weather: the physical and phenomenological state of natural space environments. The associated discipline aims, through observation, monitoring, analysis and modelling, at understanding and predicting the state of the Sun, the interplanetary and planetary environments, and the solar and non-solar driven perturbations that affect them; and also at forecasting and nowcasting the possible impacts on biological and technological systems.

Spörer minimum: a period of low solar activity, from approximately 1420 to 1570, named after the astronomer Friedrich Spörer. Like the Maunder and Dalton minima, this episode coincided with a period of lower-than-average global temperatures.

Sprite: brief optical flash of light that emanates from the upper atmosphere (mesosphere) of the Earth occurring above thunderstorm clouds.

Stratopause: atmospheric level, which separates the stratosphere and the mesosphere, and is located around 50–55 km altitude. The temperature, which gradually increases with height in the stratosphere, starts decreasing again above the stratopause.

Stratosphere: 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. The ozone layer is located in the upper stratosphere.

Substorm: a localised and brief disturbance in the Earth's magnetosphere by which energy is released from the tail of the magnetosphere, and injected into the

high latitude ionosphere. Its main manifestation is the brightening of auroras in polar regions. Substorms are distinct from geomagnetic storms in that the latter take place over a period of several days, are observable from anywhere on Earth, inject a large number of ions into the outer radiation belt. See also Magnetic storm.

Sudden stratospheric warming (SSW): event where the polar vortex of westerly winds in the winter hemisphere slows down or even reverses direction over the course of a few days. The change is accompanied by a rise of stratospheric temperature by several tens of kelvins. SSWs are mainly forced by planetary scale waves that propagate up from the lower atmosphere. The resulting reverse of high altitude winds weakens the jet stream, eventually resulting in dramatic reductions in temperature in the Eastern U.S. and in Europe.

Sunspot: dark zone of the solar photosphere, with a mean diameter approaching a few thousand kilometres. Sunspots are regions whose enhanced magnetic field block upwelling plasma motion, and thus causes their temperature to be somewhat lower than their surroundings. Their lifetime ranges from hours and months.

Sunspot Number: index of solar activity defined from the number of sunspots, and sunspot groups present on the Sun. The sunspot number is the most widely used gauge of solar activity; its recordings go back to 1610 but homogeneous data are available since the late 19th century only.

Synodic rotation: rotation of the Sun observed from the Earth, i.e. taking into account the Earth's own rotation (on its axis, and around the Sun).

Teleconnection: a connection between climate variations over widely separated parts of the world. In physical terms, teleconnections are often a consequence of large-scale wave motions, whereby energy is transferred from source regions along preferred paths in the atmosphere.

Thermal infrared radiation: radiation emitted by the Earth's surface, the atmosphere and the clouds. It is also known as terrestrial 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 colour in the visible part of the spectrum. The spectrum of thermal infrared radiation is practically distinct from that of shortwave or solar radiation because of the difference in temperature between the Sun and the Earth-atmosphere system.

Thermosphere: neutral component of the upper atmosphere. This layer is located between the mesosphere and the exosphere, and extends from about 85 km to 500–1000 km. Solar UV radiation causes the thermosphere to become electrically charged, thus producing its ionised counterpart, called ionosphere.

The dynamics of the thermosphere is dominated by atmospheric tides, which are driven by the intense diurnal heating.

Total solar irradiance (TSI): the amount of solar radiation 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 1361 W m^{-2}, with an accuracy of about 0.2%. 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%. The TSI is still occasionally (and incorrectly) called "solar constant".

Transition region: a very thin region that separates the solar chromosphere from the solar corona. The transition region is characterised by a sudden increase in temperature (from a few thousand to a few million degrees).

Tropopause: the interface between the troposphere and the stratosphere. The tropopause is located around 9 km altitude (at high latitude), and up to to 16 km (in tropical regions).

Troposphere: the lowermost part of the atmosphere, and also the most dynamic one, where clouds and weather phenomena occur. The troposphere is bounded by the tropopause. In the troposphere, temperatures generally decrease with height.

Upper atmosphere: often refers to that part of the atmosphere, which is above the troposphere. More generally, the upper atmosphere refers to the mesosphere, and above, and thus to altitudes beyond 50–55 km. See also middle and lower atmosphere.

Westerlies: prevailing winds from the west toward the east in the middle latitudes between 30 and 60° latitude.

XUV or Soft X-ray: spectral band with wavelengths ranging from 0.1 to 10 nm, i.e. with wavelengths smaller than in the UV band. Solar spectral irradiance emitted in the XUV is highly variable, and this energetic radiation is predominantly absorbed in the ionosphere, where it dissociates atoms and molecules.

Zonal: latitudinal, i.e. easterly or westerly, as opposed to meridional.