Appendix I

Glossary

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A → indicates that the following term is also contained in this Glossary.

Adjustment time
See: →Lifetime; see also: →Response time.

Aerosols
A collection of airborne solid or liquid particles, with a typical size between 0.01 and 10 µm and residing in the atmosphere for at least several hours. Aerosols may be of either natural or anthropogenic origin. Aerosols 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. See: →Indirect aerosol effect.

The term has also come to be associated, erroneously, with the propellant used in "aerosol sprays".

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 Report on Land Use, Land-Use Change and Forestry (IPCC, 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; vegetation covered surfaces and oceans have a low albedo. The Earth's albedo varies mainly through varying cloudiness, snow, ice, leaf area and land cover changes.

Altimetry
A technique for the measurement of the elevation of the sea, land or ice surface. For example, the height of the sea surface (with respect to the centre of the Earth or, more conventionally, with respect to a standard "ellipsoid of revolution") can be measured from space by current state-of-the-art radar altimetry with centrimetric precision. Altimetry has the advantage of being a measurement relative to a geocentric reference frame, rather than relative to land level as for a →tide gauge, and of affording quasi-global coverage.

Anthropogenic
Resulting from or produced by human beings.

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 water vapour, whose amount is highly variable but typically 1% volume mixing ratio. The atmosphere also contains clouds and →aerosols.

Attribution
See: →Detection and attribution.

Autotrophic respiration
→Respiration by photosynthetic organisms (plants).

Biomass
The total mass of living organisms in a given area or volume; recently dead plant material is often included as dead biomass.

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
Operationally defined species based on measurement of light absorption and chemical reactivity and/or thermal stability; consists of soot, charcoal, and/or possible light-absorbing refractory organic matter. (Source: Charlson and Heintzenberg, 1995, p. 401.)

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

Carbonaceous aerosol
Aerosol consisting predominantly of organic substances and various forms of →black carbon. (Source: Charlson and Heintzenberg, 1995, p. 401.)

Carbon cycle
The term used to describe the flow of carbon (in various forms, e.g. as carbon dioxide) through the atmosphere, ocean, terrestrial →biosphere and lithosphere.

Carbon dioxide (CO_2)
A naturally occurring gas, also a by-product of burning fossil fuels and →biomass, as well as →land-use changes and other industrial processes. 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) fertilisation
The enhancement of the growth of plants as a result of increased atmospheric CO_2 concentration. Depending on their mechanism of →photosynthesis, certain types of plants are more sensitive to changes in atmospheric CO_2 concentratioin. In particular, →C_3 plants generally show a larger response to CO_2 than →C_4 plants.

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. See: →Black carbon; Soot particles. (Source: Charlson and Heintzenberg, 1995, p. 402.)

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 is 30 years, as defined by the World Meteorological Organization (WMO). These 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
Climate change refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting 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), in its Article 1, defines "climate change" as: "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods". The UNFCCC thus makes a distinction between "climate change" attributable to human activities altering the atmospheric composition, and "climate variability" attributable to natural causes.
See also: →Climate variability.

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 (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, i.e. for any one component or combination of components a *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/sea-ice General Circulation Models (AOGCMs) provide a comprehensive representation of the climate system. There is an evolution towards more complex models with active chemistry and biology.

Climate models are applied, as a research tool, to study and simulate the climate, but also for operational purposes, including monthly, seasonal and interannual →climate predictions.

Climate prediction
A climate prediction or climate forecast is the result of an attempt to produce a most likely description or estimate of the actual evolution of the climate in the future, e.g. at seasonal, interannual or long-term time scales. See also: →Climate projection and →Climate (change) scenario.

Climate projection
A →projection of the response of the climate system to →emission or concentration scenarios of greenhouse gases and aerosols, or →radiative forcing scenarios, often based upon simulations by →climate models. Climate projections are distinguished from →climate predictions in order to emphasise that climate projections depend upon the emission/concentration/

radiative forcing scenario used, which are based on assumptions, concerning, e.g., future socio-economic and technological developments, that may or may not be realised, and are therefore subject to substantial uncertainty.

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 about the observed current climate. A *climate change scenario* is the difference between a climate scenario and the current climate.

Climate sensitivity
In IPCC Reports, *equilibrium climate sensitivity* refers to the equilibrium change in global mean surface temperature following a doubling of the atmospheric (→equivalent) CO_2 concentration. More generally, equilibrium climate sensitivity refers to the equilibrium change in surface air temperature following a unit change in →radiative forcing ($°C/Wm^{-2}$). In practice, the evaluation of the equilibrium climate sensitivity requires very long simulations with Coupled General Circulation Models (→Climate model).

The *effective climate sensitivity* is a related measure that circumvents this requirement. It is evaluated from model output for evolving non-equilibrium conditions. It is a measure of the strengths of the →feedbacks at a particular time and may vary with forcing history and climate state. Details are discussed in Section 9.2.1 of Chapter 9 in this Report.

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 human-induced 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 temporal and spatial 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
Airborne particles that serve as an initial site for the condensation of liquid water and which can lead to the formation of cloud droplets. See also: →Aerosols.

CO_2 fertilisation
See →Carbon dioxide (CO_2) fertilisation

Cooling degree days
The integral over a day of the temperature above 18°C (e.g. a day with an average temperature of 20°C counts as 2 cooling degree days). See also: →Heating degree days.

Cryosphere
The component of the →climate system consisting of all snow, ice and permafrost on and beneath the surface of the earth and ocean. See: →Glacier; →Ice sheet.

C_3 plants
Plants that produce a three-carbon compound during photosynthesis; including most trees and agricultural crops such as rice, wheat, soyabeans, potatoes and vegetables.

C_4 plants
Plants that produce a four-carbon compound during photosynthesis; mainly of tropical origin, including grasses and the agriculturally important crops maize, sugar cane, millet and sorghum.

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 Report on Land Use, Land-Use Change and Forestry (IPCC, 2000).

Desertification
Land degradation in arid, semi-arid, and dry sub-humid areas resulting from various factors, including climatic variations and human activities. Further, the UNCCD (The United Nations Convention to Combat Desertification) defines land degradation as a reduction or loss, in arid, semi-arid, and dry sub-humid areas, of the biological or economic productivity and complexity of rain-fed cropland, irrigated cropland, or range, pasture, forest, and woodlands resulting from land uses or from a process or combination of processes, including processes arising from human activities and habitation patterns, such as: (i) soil erosion caused by wind and/or water; (ii) deterioration of the physical, chemical and biological or economic properties of soil; and (iii) long-term loss of natural vegetation.

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.

Diurnal temperature range
The difference between the maximum and minimum temperature during a day.

Dobson Unit (DU)
A unit to measure the total amount of ozone in a vertical column above the Earth's surface. 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 meter. A typical value for the amount of ozone in a column of the Earth's atmosphere, although very variable, is 300 DU.

Ecosystem
A system of interacting living organisms together with their physical environment. The boundaries of what could be called an ecosystem are somewhat arbitrary, depending on the focus of interest or study. Thus the extent of an ecosystem may range from very small spatial scales to, ultimately, the entire Earth.

El Niño-Southern Oscillation (ENSO)
El Niño, in its original sense, is a warm water current which periodically flows along the coast of Ecuador and Peru, disrupting the local fishery. This oceanic event is associated with a fluctuation of the intertropical surface pressure pattern and circulation in the Indian and Pacific oceans, called the Southern Oscillation. This coupled atmosphere-ocean phenomenon is collectively known as El Niño-Southern Oscillation, or ENSO. During an El Niño event, the prevailing trade winds weaken and the equatorial countercurrent strengthens, causing warm surface waters in the Indonesian area to flow eastward to overlie the cold waters of the Peru current. This event has 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. The opposite of an El Niño event is called *La Niña.*

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 socio-economic development, technological change) and their key relationships.

Concentration scenarios, derived from emission scenarios, are used as input into 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 *et al*., 2000) new 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 Chapter 9 of this Report. For the meaning of some terms related to these scenarios, see →SRES scenarios.

Energy balance
Averaged over the globe and over longer time periods, the energy budget of the →climate system must be in balance. Because the climate system derives all its energy from the Sun, this balance implies that, globally, the amount of incoming →solar radiation must on average be equal to the sum of the outgoing reflected solar radiation and the outgoing →infrared radiation emitted by the climate system. A perturbation of this global radiation balance, be it human induced or natural, is called →radiative forcing.

Equilibrium and transient climate experiment
An *equilibrium climate experiment* is an experiment in which a →climate 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 experiment is called a *transient climate experiment.* See: →Climate projection.

Equivalent CO_2 (carbon dioxide)
The concentration of →CO_2 that would cause the same amount of →radiative forcing as a given mixture of CO_2 and other →greenhouse gases.

Eustatic sea-level change
A change in global average sea level brought about by an alteration to the volume of the world ocean. This may be caused by changes in water density or in the total mass of water. In discussions of changes on geological time-scales, this term sometimes also includes changes in global average sea level caused by an alteration to the shape of the ocean basins. In this Report the term is not used with that sense.

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

External forcing
See: →Climate system.

Extreme weather event
An extreme weather event is an event that is rare within its statistical reference distribution at a particular place. Definitions of "rare" vary, but an extreme weather event would normally be as rare as or rarer than the 10th or 90th percentile. By definition, the characteristics of what is called *extreme weather* may vary from place to place.

An *extreme climate event* is an average of a number of weather events over a certain period of time, an average which is itself extreme (e.g. 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.

Flux adjustment
To avoid the problem of coupled atmosphere-ocean general circulation models 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 precomputed and therefore independent of the coupled model integration, they are uncorrelated to the anomalies which develop during the integration. In Chapter 8 of this Report it is concluded that present models have a reduced need for flux adjustment.

Forest
A vegetation type dominated by trees. Many definitions of the term forest are in use throughout the world, reflecting wide differences in bio-geophysical 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).

Fossil CO_2 (carbon dioxide) emissions
Emissions of CO_2 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).

General Circulation
The large scale motions of the atmosphere and the ocean as a consequence of differential heating on a rotating Earth, aiming to restore the →energy balance of the system through transport of heat and momentum.

General Circulation Model (GCM)
See: →Climate model.

Geoid
The surface which an ocean of uniform density would assume if it were in steady state and at rest (i.e. no ocean circulation and no applied forces other than the gravity of the Earth). This implies that the geoid will be a surface of constant gravitational potential, which can serve as a reference surface to which all surfaces (e.g., the Mean Sea Surface) can be referred. The geoid (and surfaces parallel to the geoid) are what we refer to in common experience as "level surfaces".

Glacier
A mass of land ice flowing downhill (by internal deformation and sliding at the base) and constrained by the surrounding topography e.g. the sides of a valley or surrounding peaks; the bedrock topography is the major influence on the dynamics and surface slope of a glacier. A glacier is maintained by accumulation of snow at high altitudes, balanced by melting at low altitudes or discharge into the sea.

Global surface temperature
The global surface temperature is the area-weighted global average of (i) the sea-surface temperature over the oceans (i.e. the subsurface bulk temperature in the first few meters of the ocean), and (ii) the surface-air temperature over land at 1.5 m above the ground.

Global Warming Potential (GWP)
An index, describing the radiative characteristics of well mixed →greenhouse gases, that represents the combined effect of the differing times these gases remain in the atmosphere and their relative effectiveness in absorbing outgoing →infrared radiation. This index approximates the time-integrated warming effect of a unit mass of a given greenhouse gas in today's atmosphere, relative to that of →carbon dioxide.

Greenhouse effect
→Greenhouse gases effectively absorb →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 *natural greenhouse effect.*

Atmospheric radiation is strongly coupled to the temperature of the level 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, an imbalance that can only be compensated for by an increase of the temperature of the surface-troposphere system. This is the *enhanced greenhouse effect.*

Greenhouse gas
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 infrared radiation emitted by the Earth's surface, the atmosphere and 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).

Gross Primary Production (GPP)
The amount of carbon fixed from the atmosphere through →photosynthesis.

Grounding line/zone
The junction between →ice sheet and →ice shelf or the place where the ice starts to float.

Halocarbons
Compounds containing either chlorine, bromine or fluorine and carbon. Such compounds can act as powerful →greenhouse gases in the atmosphere. The chlorine and bromine containing halocarbons are also involved in the depletion of the →ozone layer.

Heating degree days
The integral over a day of the temperature below 18°C (e.g. a day with an average temperature of 16°C counts as 2 heating degree days). See also: →Cooling degree days.

Heterotrophic respiration
The conversion of organic matter to CO_2 by organisms other than plants.

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

Ice cap
A dome shaped ice mass covering a highland area that is considerably smaller in extent than an→ice sheet.

Ice sheet
A mass of land ice which is sufficiently deep to cover most of the underlying bedrock topography, so that its shape is mainly determined by its internal dynamics (the flow of the ice as it deforms internally and slides at its base). An ice sheet flows outwards from a high central plateau with a small average surface slope. The margins slope steeply, and the 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 large ice sheets in the modern world, on Greenland and Antarctica, the Antarctic ice sheet being divided into East and West by the Transantarctic Mountains; during glacial periods there were others.

Ice shelf
A floating →ice sheet of considerable thickness attached to a coast (usually of great horizontal extent with a level or gently undulating surface); often a seaward extension of ice sheets.

Indirect aerosol effect
→Aerosols may lead to an indirect →radiative forcing of the →climate system through acting as condensation nuclei or modifying the optical properties and lifetime of clouds. Two indirect effects are distinguished:
First indirect effect
A radiative forcing induced by an increase in anthropogenic aerosols which cause an initial increase in droplet concentration and a decrease in droplet size for fixed liquid water content, leading to an increase of cloud →albedo. This effect is also known as the *Twomey effect*. This is sometimes referred to as the *cloud albedo effect*. However this is highly misleading since the second indirect effect also alters cloud albedo.
Second indirect effect
A radiative forcing induced by an increase in anthropogenic aerosols which cause a decrease in droplet size, reducing the precipitation efficiency, thereby modifying the liquid water content, cloud thickness, and cloud life time. This effect is also known as the *cloud life time effect* or *Albrecht effect*.

Industrial revolution
A period of rapid industrial growth with far-reaching social and economic consequences, beginning in England during the second half of the eighteenth 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
Radiation emitted by the earth's surface, the atmosphere and the clouds. It is also known as terrestrial or long-wave radiation. Infrared radiation 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 infrared radiation is practically distinct from that of →solar or short-wave radiation because of the difference in temperature between the Sun and the Earth-atmosphere system.

Integrated assessment
A method of analysis that combines results and models from the physical, biological, economic and social sciences, and the interactions between these components, in a consistent framework, to evaluate the status and the consequences of environmental change and the policy responses to it.

Internal variability
See: →Climate variability.

Inverse modelling
A mathematical procedure by which the input to a model is estimated from the observed outcome, rather than *vice versa*. It is, for instance, used to estimate the location and strength of sources and sinks of CO_2 from measurements of the distribution of the CO_2 concentration in the atmosphere, given models of the global →carbon cycle and for computing atmospheric transport.

Isostatic land movements
Isostasy refers to the way in which the →lithosphere and mantle respond to changes in surface loads. When the loading of the lithosphere is changed by alterations in land ice mass, ocean mass, sedimentation, erosion or mountain building, vertical isostatic adjustment results, in order to balance the new load.

Kyoto Protocol

The Kyoto Protocol to the United Nations →Framework Convention on Climate Change (UNFCCC) was adopted at the Third Session of the Conference of the Parties (COP) to the United Nations →Framework Convention on Climate Change, in 1997 in Kyoto, Japan. It contains legally binding commitments, in addition to those included in the UNFCCC. Countries included in Annex B of the Protocol (most OECD countries and countries with economies in transition) agreed to reduce their anthropogenic →greenhouse gas emissions (CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6) by at least 5% below 1990 levels in the commitment period 2008 to 2012. The Kyoto Protocol has not yet entered into force (April 2001).

Land use

The total of arrangements, activities and inputs undertaken in a certain land cover type (a set of human actions). The social and economic purposes for which land is managed (e.g., grazing, timber extraction, and conservation).

Land-use change

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 →albedo, →evapotranspiration, →sources and →sinks of →greenhouse gases, or other properties of the →climate system and may thus have an impact on climate, locally or globally. See also: the IPCC Report on Land Use, Land-Use Change, and Forestry (IPCC, 2000).

La Niña

See: →El Niño-Southern Oscillation.

Lifetime

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

Turnover time (T) 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 (MRT)*.

Adjustment time or *response time* (T_a) is the time-scale characterising the decay of an instantaneous pulse input into the reservoir. The term *adjustment time* is also used to characterise 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 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 S is not proportional to its total mass M.

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: →Isostatic land movements.

LOSU (Level of Scientific Understanding)

This is an index on a 4-step scale (High, Medium, Low and Very Low) designed to characterise the degree of scientific understanding of the radiative forcing agents that affect climate change. For each agent, the index represents a subjective judgement about the reliability of the estimate of its forcing, involving such factors as the assumptions necessary to evaluate the forcing, the degree of knowledge of the physical/ chemical mechanisms determining the forcing and the uncertainties surrounding the quantitative estimate.

Mean Sea Level

See: →Relative Sea Level.

Mitigation

A human intervention to reduce the →sources or enhance the →sinks of →greenhouse gases.

Mixing ratio

See: →Mole fraction.

Model hierarchy

See: →Climate model.

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 long-lived →greenhouse gases are in the order of μmol/mol (parts per million: ppm), nmol/mol (parts per billion: ppb), and fmol/mol (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. (Source: Schwartz and Warneck, 1995).

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 CFCs, methyl chloroform, carbon tetrachloride, and many others.

Net Biome Production (NBP)
Net gain or loss of carbon from a region. NBP is equal to the →Net Ecosystem Production minus the carbon lost due to a disturbance, e.g. a forest fire or a forest harvest.

Net Ecosystem Production (NEP)
Net gain or loss of carbon from an →ecosystem. NEP is equal to the →Net Primary Production minus the carbon lost through →heterotrophic respiration.

Net Primary Production (NPP)
The increase in plant →biomass or carbon of a unit of a landscape. NPP is equal to the →Gross Primary Production minus carbon lost through →autotrophic respiration.

Nitrogen fertilisation
Enhancement of plant growth through the addition of nitrogen compounds. In IPCC Reports, this typically refers to fertilisation from anthropogenic sources of nitrogen such as human-made fertilisers and nitrogen oxides released from burning fossil fuels.

Non-linearity
A process is called "non-linear" when there is no simple proportional relation between cause and effect. The →climate system contains many such non-linear processes, resulting in a system with a potentially very complex behaviour. Such complexity may lead to →rapid climate change.

North Atlantic Oscillation (NAO)
The North Atlantic Oscillation consists of opposing variations of barometric pressure near Iceland and near the Azores. On average, a westerly current, between the Icelandic low pressure area and the Azores high pressure area, carries cyclones with their associated frontal systems towards Europe. However, the pressure difference between Iceland and the Azores fluctuates on time-scales of days to decades, and can be reversed at times.

Organic aerosol
→Aerosol particles consisting predominantly of organic compounds, mainly C, H, O, and lesser amounts of other elements. (Source: Charlson and Heintzenberg, 1995, p. 405.) See: →Carbonaceous aerosol.

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 decisive 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. 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, also caused by human-made chlorine and bromine compounds in combination with the specific meteorological conditions of that region. This phenomenon is called the ***ozone hole***.

Parametrization
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 the area or time averaged effect of such sub-grid scale processes and the larger scale flow.

Patterns of climate variability
Natural variability of the →climate system, in particular on seasonal and longer time-scales, predominantly occurs in preferred spatial patterns, through the dynamical non-linear characteristics of the atmospheric circulation and through interactions with the land and ocean surfaces. Such spatial patterns are also called "regimes" or "modes". Examples are the →North Atlantic Oscillation (NAO), the Pacific-North American pattern (PNA), the →El Niño-Southern Oscillation (ENSO), and the Antarctic Oscillation (AO).

Photosynthesis
The process by which plants take CO_2 from the air (or bicarbonate in water) to build carbohydrates, releasing O_2 in the process. There are several pathways of photosynthesis with different responses to atmospheric CO_2 concentrations. See: →Carbon dioxide fertilisation.

Pool
See: →Reservoir.

Post-glacial rebound
The vertical movement of the continents and sea floor following

the disappearance and shrinking of →ice sheets, e.g. since the Last Glacial Maximum (21 ky BP). The rebound is an →isostatic land movement.

Ppm, ppb, ppt
See: → Mole fraction.

Precursors
Atmospheric compounds which themselves are not →greenhouse gases or →aerosols, but which have an effect on greenhouse gas or aerosol concentrations by taking part in physical or chemical processes regulating their production or destruction rates.

Pre-industrial
See: →Industrial revolution.

Projection (generic)
A projection is a potential future evolution of a quantity or set of quantities, often computed with the aid of a model. Projections are distinguished from *predictions* in order to emphasise that projections involve assumptions concerning, e.g., future socio-economic and technological developments that may or may not be realised, and are therefore subject to substantial uncertainty. See also →Climate projection; →Climate prediction.

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. Examples of proxies are: tree ring records, characteristics of corals, and various data derived from ice cores.

Radiative forcing
Radiative forcing is the change in the net vertical irradiance (expressed in Watts per square metre: Wm^{-2}) at the →tropopause due to an internal change or a change in the external forcing of the →climate system, such as, for example, a change in the concentration of →carbon dioxide or the output of the Sun. Usually radiative forcing is computed after allowing for stratospheric temperatures to readjust to radiative equilibrium, but with all tropospheric properties held fixed at their unperturbed values. Radiative forcing is called *instantaneous* if no change in stratospheric temperature is accounted for. Practical problems with this definition, in particular with respect to radiative forcing associated with changes, by aerosols, of the precipitation formation by clouds, are discussed in Chapter 6 of this Report.

Radiative forcing scenario
A plausible representation of the future development of →radiative forcing associated, for example, with changes in atmospheric composition or land-use change, or with external factors such as variations in →solar activity. Radiative forcing scenarios can be used as input into simplified →climate models to compute →climate projections.

Radio-echosounding
The surface and bedrock, and hence the thickness, of a glacier can be mapped by radar; signals penetrating the ice are reflected at the lower boundary with rock (or water, for a floating glacier tongue).

Rapid climate change
The →non-linearity of the →climate system may lead to rapid climate change, sometimes called *abrupt events* or even *surprises*. Some such abrupt events may be imaginable, such as a dramatic reorganisation of the →thermohaline circulation, rapid deglaciation, or massive melting of permafrost leading to fast changes in the →carbon cycle. Others may be truly unexpected, as a consequence of a strong, rapidly changing, forcing of a non-linear system.

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).

Regimes
Preferred →patterns of climate variability.

Relative Sea Level
Sea level measured by a →tide gauge with respect to the land upon which it is situated. Mean Sea Level (MSL) is normally defined as the average Relative Sea Level over a period, such as a month or a year, long enough to average out transients such as waves.

(Relative) Sea Level Secular Change
Long term changes in relative sea level caused by either →eustatic changes, e.g. brought about by →thermal expansion, or changes in vertical land movements.

Reservoir
A component of the →climate system, other than the atmosphere, which has the capacity to store, accumulate or release a substance of concern, e.g. 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 substance of concerns, held within a reservoir at a specified time, is called the *stock*.

Respiration
The process whereby living organisms convert organic matter to CO_2, releasing energy and consuming O_2.

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 and internal processes or →feedbacks. 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 comes into 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 fast, 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.

Scenario (generic)
A plausible and often simplified description of how the future may develop, based on a coherent and internally consistent set of assumptions about driving forces and key relationships. Scenarios may be derived from →projections, but are often based on additional information from other sources, sometimes combined with a “narrative storyline”. See also: →SRES scenarios; →Climate scenario; →Emission scenarios.

Sea level rise
See: →Relative Sea Level Secular Change; →Thermal expansion.

Sequestration
See: →Uptake.

Significant wave height
The average height of the highest one-third of all sea waves occurring in a particular time period. This serves as an indicator of the characteristic size of the highest waves.

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

Soil moisture
Water stored in or at the land surface and available for evaporation.

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 (“11 year”) cycle
A quasi-regular modulation of →solar activity with varying amplitude and a period of between 9 and 13 years.

Solar radiation
Radiation emitted by the Sun. It is also referred to as short-wave radiation. Solar radiation has a distinctive range of wavelengths (spectrum) determined by the temperature of the Sun. See also: →Infrared radiation.

Soot particles
Particles formed during the quenching of gases at the outer edge of flames of organic vapours, consisting predominantly of carbon, with lesser amounts of oxygen and hydrogen present as carboxyl and phenolic groups and exhibiting an imperfect graphitic structure. See: →Black carbon; Charcoal. (Source: Charlson and Heintzenberg, 1995, p. 406.)

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

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).

SRES scenarios
SRES scenarios are →emission scenarios developed by Nakićenović *et al*. (2000) and used, among others, as a basis for the climate projections in Chapter 9 of this Report. 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.
(Scenario) Group
Scenarios within a family that reflect a consistent variation of the storyline. The A1 scenario family includes four groups designated as A1T, A1C, A1G and A1B that explore alternative structures of future energy systems. In the Summary for Policymakers of Nakićenović *et al*. (2000), the A1C and A1G groups have been combined into one ‘Fossil Intensive’ A1FI scenario group. The other three scenario families consist of one group each. The SRES scenario set reflected in the Summary for Policymakers of Nakićenović *et al*. (2000) thus consist of six distinct scenario groups, all of which are equally sound and together capture the range of uncertainties associated with driving forces and emissions.
Illustrative Scenario
A scenario that is illustrative for each of the six scenario groups reflected in the Summary for Policymakers of Nakićenović *et al*. (2000). They include four revised ‘scenario markers’ for the scenario groups A1B, A2, B1, B2, and two additional scenarios for the A1FI and A1T groups. All scenario groups are equally sound.
(Scenario) Marker
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 *et al*. (2000). These scenarios have received the closest scrutiny of the entire writing team and via the SRES open process. Scenarios have also been selected to illustrate the other two scenario groups (see also 'Scenario Group' and 'Illustrative Scenario').

(Scenario) Storyline

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

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.

Stratosphere

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

Sunspots

Small dark areas on the Sun. The number of sunspots is higher during periods of high →solar activity, and varies in particular with the →solar cycle.

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.

Thermohaline circulation

Large-scale density-driven circulation in the ocean, caused by differences in temperature and salinity. In the North Atlantic the thermohaline circulation consists of warm surface water flowing northward and cold deep water flowing southward, resulting in a net poleward transport of heat. The surface water sinks in highly restricted sinking regions located in high latitudes.

Tide gauge

A device at a coastal location (and some deep sea locations) which continuously measures the level of the sea with respect to the adjacent land. Time-averaging of the sea level so recorded gives the observed →Relative Sea Level Secular Changes.

Transient climate response

The globally averaged surface air temperature increase, averaged over a 20 year period, centred at the time of CO_2 doubling, i.e., at year 70 in a 1% per year compound CO_2 increase experiment with a global coupled →climate model.

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 in mid-latitudes (ranging from 9 km in high latitudes to 16 km in the tropics on average) where clouds and "weather" phenomena occur. In the troposphere temperatures generally decrease with height.

Turnover time

See: →Lifetime.

Uncertainty

An expression of the degree to which a value (e.g. the future state of the climate system) is unknown. Uncertainty can result from lack of information or from disagreement about what is known or even knowable. It may have many types of sources, from quantifiable errors 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 range of values calculated by various models) or by qualitative statements (e.g., reflecting the judgement of a team of experts). See Moss and Schneider (2000).

United Nations Framework Convention on Climate Change (UNFCC)

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 aim to return greenhouse gas emissions not controlled by the Montreal Protocol to 1990 levels by the year 2000. The convention entered into force in March 1994. See: →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*.

Volume mixing ratio

See: →Mole fraction.

Sources:

Charlson, R. J., and J. Heintzenberg (Eds.): *Aerosol Forcing of Climate*, pp. 91-108, copyright 1995 ©John Wiley and Sons Limited. Reproduced with permission.

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, UK, xi + 116 pp.

IPCC, 1994: *Climate Change 1994: Radiative Forcing of Climate Change and an Evaluation of the IPCC IS92 Emission Scenarios,* [J. T. Houghton, L. G. Meira Filho, J. Bruce, Hoesung Lee, B. A. Callander, E. Haites, N. Harris and K. Maskell (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, 339 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 Filho, B. A. Callander, N. Harris, A. Kattenberg, and K. Maskell (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 572 pp.

IPCC, 1997a: *IPCC Technical Paper 2: An introduction to simple climate models used in the IPCC Second Assessment Report,* [J. T. Houghton, L.G. Meira Filho, D. J. Griggs and K. Maskell (eds.)]. 51 pp.

IPCC, 1997b: *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* (3 volumes) [J. T. Houghton, L. G. Meira Filho, B. Lim, K. Tréanton, I. Mamaty, Y. Bonduki, D. J. Griggs and B. A. Callander (eds.)].

IPCC, 1997c*: IPCC technical Paper 4: Implications of proposed* CO_2 *emissions limitations.* [J. T. Houghton, L.G. Meira Filho, D. J. Griggs and M Noguer (eds.)]. 41 pp.

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

Maunder, W. John , 1992: *Dictionary of Global Climate Change,* UCL Press Ltd.

Moss, R. and S. Schneider, 2000: *IPCC Supporting Material, pp. 33-51:Uncertainties in the IPCC TAR: Recommendations to Lead Authors for more consistent Assessment and Reporting,* [R. Pachauri, T. Taniguchi and K. Tanaka (eds.)]

Nakićenović, N., J. Alcamo, G. Davis, B. de Vries, J. Fenhann, S. Gaffin, K. Gregory, A. Grübler, T. Y. Jung, T. Kram, E. L. La Rovere, L. Michaelis, S. Mori, T. Morita, W. Pepper, H. Pitcher, L. Price, K. Raihi, A. Roehrl, H-H. Rogner, A. Sankovski, M. Schlesinger, P. Shukla, S. Smith, R. Swart, S. van Rooijen, N. Victor, Z. Dadi, 2000: *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, pp. 1377-1406.

Appendix II

SRES Tables

Contents

Introduction

Appendix II gives, in tabulated form, the values for emissions, abundances and burdens, and, radiative forcing of major greenhouse gases and aerosols based on the SRES[1] scenarios (Nakićenović *et. al.*, 2000). The Appendix also presents global projections of changes in surface air temperature and sea level using these SRES emission scenarios.

The emission values are only anthropogenic emissions and are the ones published in Appendix VII of the SRES Report. Apart from the CO_2 emissions, for which deforestation and land use values are given in the SRES Report, the SRES scenarios for the rest of the gases define only the changes in direct anthropogenic emissions and do not specify the current magnitude of the natural emissions nor the concurrent changes in natural emissions due either to direct human activities such as land-use change or to the indirect impacts of climate change. Emissions for black carbon (BC) aerosols and organic matter carbonaceous (OC) aerosols species not covered in the SRES Report, are calculated by scaling to the SRES anthropogenic CO emissions.

The abundances and burdens for each of the species are calculated with the latest climate chemistry and climate carbon models (see Chapters 3, 4 and 5 for details).

The radiative forcings due to well-mixed greenhouse gases are computed using each of the simplified expressions given in Chapter 6, Table 6.2. The radiative forcings associated with future tropospheric O_3 increase are calculated on the basis of the O_3 changes presented in Chapter 4 for the various SRES scenarios. The mean forcing per DU estimated from the various models, and given in Chapter 6, Table 6.3 (i.e., 0.042 Wm^{-2}/DU), is used to derive these future forcings. For each aerosol species, the ratio of the column burdens for the particular scenario to that of the year 2000 is multiplied by the “best estimate” of the present day radiative forcing (see Chapter 6 for more details). The radiative forcings for all the species have been calculated since pre-industrial time.

The global mean surface air temperature and sea level projections, based on the SRES scenarios, have been calculated using Simple Climate models which have been “tuned” to get similar responses to the AOGCMs in the global mean (see Chapters 9 and 11 for details).

The results presented are global mean values, every ten years from 2000 to 2100, for a range of scenarios. These scenarios are the final approved Illustrative Marker Scenarios (A1B, A1T, A1FI, A2, B1, and B2); the preliminary marker scenarios (A1p, A2p, B1p, B2p, approved by the IPCC Bureau in June 1998) and, for comparison and for some species, results based on a previous scenario used by IPCC (IS92a) have also been added. For some gases, the values tabulated in the IPCC Second Assessment Report (IPCC, 1996; hereafter SAR), for that IS92a scenario using the previous generation of chemistry and climate models, are also given.

[1] IPCC Special Report on Emission Scenarios (Nakićenović *et. al.*, 2000), herafter SRES.

Main Chemical Symbols used in this Appendix:

CO_2	carbon dioxide
CH_4	methane
CFC	chlorofluorocarbon
CO	carbon monoxide
HFC	hydrofluorocarbon
N_2O	nitrous oxide
NO_x	the sum of NO (nitric oxide) and NO_2 (nitrogen dioxide)
O_3	ozone
OH	hydroxyl
PFC	perfluorocarbon
SO_2	sulphur dioxide
SO_4^{2-}	sulphate ion
SF_6	sulphur hexafluoride
VOC	volatile organic compound

II.1: Anthropogenic Emissions

II.1.1: CO_2 emissions (PgC/yr)

CO_2 emissions from fossil fuel and industrial processes (PgC/yr)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a
2000	6.90	6.90	6.90	6.90	6.90	6.90	6.8	6.8	6.8	6.8	7.1
2010	9.68	8.33	8.65	8.46	8.50	7.99	9.7	8.4	7.7	7.9	8.68
2020	12.12	10.00	11.19	11.01	10.00	9.02	12.2	10.9	8.3	8.9	10.26
2030	14.01	12.26	14.61	13.53	11.20	10.15	14.2	13.3	8.4	10.0	11.62
2040	14.95	12.60	18.66	15.01	12.20	10.93	15.2	14.7	9.1	10.8	12.66
2050	16.01	12.29	23.10	16.49	11.70	11.23	16.2	16.4	9.8	11.1	13.7
2060	15.70	11.41	25.14	18.49	10.20	11.74	15.9	18.2	10.4	11.6	14.68
2070	15.43	9.91	27.12	20.49	8.60	11.87	15.6	20.2	10.1	11.8	15.66
2080	14.83	8.05	29.04	22.97	7.30	12.46	15.0	22.7	8.7	12.4	17.0
2090	13.94	6.27	29.64	25.94	6.10	13.20	14.1	25.6	7.5	13.1	18.7
2100	13.10	4.31	30.32	28.91	5.20	13.82	13.2	28.8	6.5	13.7	20.4

CO_2 emissions from deforestation and land use (PgC/yr)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a
2000	1.07	1.07	1.07	1.07	1.07	1.07	1.6	1.6	1.6	1.6	1.3
2010	1.20	1.04	1.08	1.12	0.78	0.80	1.5	1.6	0.8	1.8	1.22
2020	0.52	0.26	1.55	1.25	0.63	0.03	1.6	1.7	1.3	1.6	1.14
2030	0.47	0.12	1.57	1.19	−0.09	−0.25	0.7	1.5	0.7	0.3	1.04
2040	0.40	0.05	1.31	1.06	−0.48	−0.24	0.3	1.3	0.6	0.0	0.92
2050	0.37	−0.02	0.80	0.93	−0.41	−0.23	−0.2	1.2	0.5	−0.3	0.8
2060	0.30	−0.03	0.55	0.67	−0.46	−0.24	−0.3	0.7	0.7	−0.2	0.54
2070	0.30	−0.03	0.16	0.40	−0.42	−0.25	−0.3	0.4	0.8	−0.2	0.28
2080	0.35	−0.03	−0.36	0.25	−0.60	−0.31	−0.4	0.3	1.0	−0.2	0.12
2090	0.36	−0.01	−1.22	0.21	−0.78	−0.41	−0.5	0.2	1.2	−0.2	0.06
2100	0.39	0.00	−2.08	0.18	−0.97	−0.50	−0.6	0.2	1.4	−0.2	−0.1

CO_2 emissions – total (PgC/yr)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a
2000	7.97	7.97	7.97	7.97	7.97	7.97	8.4	8.4	8.4	8.4	8.4
2010	10.88	9.38	9.73	9.58	9.28	8.78	11.2	10.0	8.5	9.7	9.9
2020	12.64	10.26	12.73	12.25	10.63	9.05	13.8	12.6	9.6	10.5	11.4
2030	14.48	12.38	16.19	14.72	11.11	9.90	14.9	14.8	9.1	10.3	12.66
2040	15.35	12.65	19.97	16.07	11.72	10.69	15.5	16.0	9.7	10.8	13.58
2050	16.38	12.26	23.90	17.43	11.29	11.01	16.0	17.6	10.3	10.8	14.5
2060	16.00	11.38	25.69	19.16	9.74	11.49	15.6	18.9	11.1	11.4	15.22
2070	15.73	9.87	27.28	20.89	8.18	11.62	15.3	20.6	10.9	11.6	15.94
2080	15.18	8.02	28.68	23.22	6.70	12.15	14.6	23.0	9.7	12.2	17.12
2090	14.30	6.26	28.42	26.15	5.32	12.79	13.6	25.8	8.7	12.9	18.76
2100	13.49	4.32	28.24	29.09	4.23	13.32	12.6	29.0	7.9	13.5	20.3

II.1.2: CH_4 emissions ($Tg(CH_4)$/yr)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a
2000	323	323	323	323	323	323	347	347	347	347	390
2010	373	362	359	370	349	349	417	394	367	389	433
2020	421	415	416	424	377	384	484	448	396	448	477
2030	466	483	489	486	385	426	547	506	403	501	529
2040	458	495	567	542	381	466	531	560	423	528	580
2050	452	500	630	598	359	504	514	621	444	538	630
2060	410	459	655	654	342	522	464	674	445	544	654
2070	373	404	677	711	324	544	413	732	446	542	678
2080	341	359	695	770	293	566	370	790	447	529	704
2090	314	317	715	829	266	579	336	848	413	508	733
2100	289	274	735	889	236	597	301	913	379	508	762

II.1.3: N_2O emissions (TgN/yr)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a
2000	7.0	7.0	7.0	7.0	7.0	7.0	6.9	6.9	6.9	6.9	5.5
2010	7.0	6.1	8.0	8.1	7.5	6.2	7.3	7.9	7.4	7.1	6.2
2020	7.2	6.1	9.3	9.6	8.1	6.1	7.7	9.4	8.1	7.1	7.1
2030	7.3	6.2	10.9	10.7	8.2	6.1	7.5	10.5	8.3	6.7	7.7
2040	7.4	6.2	12.8	11.3	8.3	6.2	7.1	11.1	8.6	6.4	8.0
2050	7.4	6.1	14.5	12.0	8.3	6.3	6.8	11.8	8.9	6.0	8.3
2060	7.3	6.0	15.0	12.9	7.7	6.4	6.3	12.7	8.8	5.8	8.3
2070	7.2	5.7	15.4	13.9	7.4	6.6	5.9	13.7	8.7	5.5	8.4
2080	7.1	5.6	15.7	14.8	7.0	6.7	5.5	14.6	8.6	5.4	8.5
2090	7.1	5.5	16.1	15.7	6.4	6.8	5.2	15.5	8.3	5.2	8.6
2100	7.0	5.4	16.6	16.5	5.7	6.9	4.9	16.4	8.0	5.1	8.7

II.1.4: PFCs, SF_6 and HFCs emissions (Gg/yr)

CF_4 emissions (Gg/yr)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p
2000	12.6	12.6	12.6	12.6	12.6	12.6	26.7	26.7	26.7	26.7
2010	15.3	15.3	15.3	20.3	14.5	21.0	28.4	28.9	27.0	29.9
2020	21.1	21.1	21.1	25.2	15.7	27.1	41.0	35.2	29.6	37.7
2030	30.1	30.1	30.1	31.4	16.6	34.6	59.4	43.0	31.4	47.4
2040	38.2	38.2	38.2	37.9	18.5	43.6	71.7	50.9	33.1	58.9
2050	43.8	43.8	43.8	45.6	20.9	52.7	77.3	60.0	35.5	70.5
2060	48.1	48.1	48.1	56.0	23.1	59.2	76.7	72.6	36.1	78.5
2070	52.1	52.1	52.1	63.6	22.5	63.1	64.2	84.7	29.6	85.1
2080	56.1	56.1	56.1	73.2	21.3	64.2	40.6	97.9	19.7	86.6
2090	58.9	58.9	58.9	82.8	22.5	62.9	46.8	110.9	20.8	84.7
2100	57.0	57.0	57.0	88.2	22.2	59.9	53.0	117.9	20.5	80.6

C_2F_6 emissions (Gg/yr)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p
2000	1.3	1.3	1.3	1.3	1.3	1.3	2.7	2.7	2.7	2.7
2010	1.5	1.5	1.5	2.0	1.5	2.1	2.8	2.9	2.7	3.0
2020	2.1	2.1	2.1	2.5	1.6	2.7	4.1	3.5	3.0	3.8
2030	3.0	3.0	3.0	3.1	1.7	3.5	5.9	4.3	3.1	4.7
2040	3.8	3.8	3.8	3.8	1.8	4.4	7.2	5.1	3.3	5.9
2050	4.4	4.4	4.4	4.6	2.1	5.3	7.7	6.0	3.6	7.1
2060	4.8	4.8	4.8	5.6	2.3	5.9	7.7	7.3	3.6	7.9
2070	5.2	5.2	5.2	6.4	2.2	6.3	6.4	8.5	3.0	8.5
2080	5.6	5.6	5.6	7.3	2.1	6.4	4.1	9.8	2.0	8.7
2090	5.9	5.9	5.9	8.3	2.2	6.3	4.7	11.1	2.1	8.5
2100	5.7	5.7	5.7	8.8	2.2	6.0	5.3	11.8	2.1	8.1

SF_6 emissions (Gg/yr)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p
2000	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2
2010	6.7	6.7	6.7	7.6	5.6	7.4	7.2	8.0	6.4	7.7
2020	7.3	7.3	7.3	9.7	5.7	8.4	7.9	10.2	6.5	9.9
2030	10.2	10.2	10.2	11.6	7.2	9.2	10.7	12.0	8.0	12.5
2040	15.2	15.2	15.2	13.7	8.9	11.7	15.8	14.0	9.7	15.8
2050	18.3	18.3	18.3	16.0	10.4	12.1	18.8	16.8	11.2	18.6
2060	19.5	19.5	19.5	18.8	10.9	12.2	20.0	18.7	11.6	20.4
2070	17.3	17.3	17.3	19.8	9.5	11.4	17.8	19.7	10.2	22.0
2080	13.5	13.5	13.5	20.7	7.1	9.6	12.0	20.6	6.8	22.8
2090	13.0	13.0	13.0	23.4	6.5	10.0	13.5	23.3	7.2	23.9
2100	14.5	14.5	14.5	25.2	6.5	10.6	15.0	25.1	7.2	24.4

HFC–23 emissions (Gg/yr)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p
2000	13	13	13	13	13	13	13	13	13	13
2010	15	15	15	15	15	15	15	15	15	15
2020	5	5	5	5	5	5	5	5	5	5
2030	2	2	2	2	2	2	2	2	2	2
2040	2	2	2	2	2	2	2	2	2	2
2050	1	1	1	1	1	1	0	0	0	0
2060	1	1	1	1	1	1	0	0	0	0
2070	1	1	1	1	1	1	0	0	0	0
2080	1	1	1	1	1	1	0	0	0	0
2090	1	1	1	1	1	1	0	0	0	0
2100	1	1	1	1	1	1	0	0	0	0

HFC–32 emissions (Gg/yr)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p
2000	0	0	0	0	0	0	2	2	2	2
2010	4	4	4	4	3	3	3	3	3	3
2020	8	8	8	6	6	6	8	6	6	7
2030	14	14	14	9	8	9	14	9	8	10
2040	19	19	19	11	10	11	19	10	10	12
2050	24	24	24	14	14	14	24	13	14	16
2060	28	28	28	17	14	17	26	16	14	19
2070	29	29	29	20	14	20	27	19	14	21
2080	30	30	30	24	14	22	28	23	14	23
2090	30	30	30	29	14	24	28	28	13	24
2100	30	30	30	33	13	26	28	33	13	25

HFC–125 emissions (Gg/yr)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a
2000	0	0	0	0	0	0	7	7	7	7	0
2010	12	12	12	11	11	11	11	10	10	10	1
2020	27	27	27	21	21	22	26	19	20	22	9
2030	45	45	45	29	29	30	44	27	28	32	46
2040	62	62	62	35	36	38	62	33	35	40	111
2050	80	80	80	46	48	49	78	43	47	52	175
2060	94	94	94	56	48	58	84	53	48	62	185
2070	98	98	98	66	48	67	88	62	47	70	194
2080	100	100	100	79	48	76	91	74	46	75	199
2090	101	101	101	94	46	83	92	89	45	79	199
2100	101	101	101	106	44	89	93	104	43	83	199

HFC–134a emissions (Gg/yr)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a
2000	80	80	80	80	80	80	147	147	147	147	148
2010	176	176	176	166	163	166	220	204	206	216	290
2020	326	326	326	252	249	262	427	315	319	359	396
2030	515	515	515	330	326	352	693	412	422	496	557
2040	725	725	725	405	414	443	997	508	545	638	738
2050	931	931	931	506	547	561	1215	635	734	816	918
2060	1076	1076	1076	633	550	679	1264	800	732	991	969
2070	1078	1078	1078	758	544	799	1272	962	718	1133	1020
2080	1061	1061	1061	915	533	910	1247	1169	698	1202	1047
2090	1029	1029	1029	1107	513	1002	1204	1422	667	1261	1051
2100	980	980	980	1260	486	1079	1142	1671	627	1317	1055

HFC–143a emissions (Gg/yr)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p
2000	0	0	0	0	0	0	6	6	6	6
2010	9	9	9	9	8	8	8	8	8	8
2020	21	21	21	16	15	16	20	15	15	17
2030	34	34	34	22	21	22	34	21	21	24
2040	47	47	47	27	26	27	48	26	26	30
2050	61	61	61	35	35	35	60	33	35	39
2060	70	70	70	43	35	42	64	41	35	47
2070	74	74	74	51	35	49	67	48	35	53
2080	75	75	75	61	35	55	69	58	35	57
2090	76	76	76	73	34	60	70	70	33	60
2100	76	76	76	82	32	65	70	81	32	63

HFC–152a emissions (Gg/yr)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a
2000	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0	0	0
2020	0	0	0	0	0	0	0	0	0	0	18
2030	0	0	0	0	0	0	0	0	0	0	114
2040	0	0	0	0	0	0	0	0	0	0	281
2050	0	0	0	0	0	0	0	0	0	0	448
2060	0	0	0	0	0	0	0	0	0	0	495
2070	0	0	0	0	0	0	0	0	0	0	542
2080	0	0	0	0	0	0	0	0	0	0	567
2090	0	0	0	0	0	0	0	0	0	0	568
2100	0	0	0	0	0	0	0	0	0	0	570

HFC–227ea emissions (Gg/yr)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p
2000	0	0	0	0	0	0	8	8	8	8
2010	13	13	13	12	13	14	12	11	11	12
2020	22	22	22	17	18	20	21	16	17	18
2030	34	34	34	21	24	26	33	19	22	25
2040	48	48	48	26	30	33	48	24	28	32
2050	62	62	62	32	39	41	57	29	38	41
2060	72	72	72	40	40	50	60	37	37	49
2070	71	71	71	48	39	59	60	44	37	57
2080	68	68	68	58	38	67	59	53	36	60
2090	65	65	65	70	36	74	56	64	34	63
2100	61	61	61	80	34	80	53	76	32	66

HFC−245ca emissions (Gg/yr)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p
2000	0	0	0	0	0	0	38	38	38	38
2010	62	62	62	59	60	61	56	52	53	55
2020	100	100	100	79	80	85	98	73	75	84
2030	158	158	158	98	102	112	159	92	97	114
2040	222	222	222	121	131	144	229	113	128	149
2050	292	292	292	149	173	178	281	140	173	188
2060	350	350	350	190	173	216	298	179	172	229
2070	343	343	343	228	170	255	299	216	168	266
2080	330	330	330	276	166	290	287	262	163	280
2090	312	312	312	334	159	323	271	319	155	291
2100	288	288	288	388	150	353	251	376	145	302

HFC43−10mee emissions (Gg/yr)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p
2000	0	0	0	0	0	0	5	5	5	5
2010	7	7	7	7	6	6	6	6	6	6
2020	9	9	9	8	7	7	8	7	7	7
2030	12	12	12	8	8	8	10	7	7	8
2040	15	15	15	9	9	10	13	8	9	9
2050	18	18	18	11	11	11	15	9	10	11
2060	22	22	22	12	11	12	17	11	10	12
2070	24	24	24	14	11	14	20	12	10	13
2080	27	27	27	16	11	15	22	14	10	14
2090	29	29	29	19	11	17	24	17	10	15
2100	30	30	30	22	10	18	26	19	10	15

Note: Table II.1.4 contains supplementary data to the SRES Report (Nakićenović *et. al*., 2000): The data contained in the SRES Report was insufficient to break down the individual contributions to HFCs, PFCs and SF_6, these emissions were supplied by Lead Authors of the SRES Report and are also available at the CIESIN (Center for International Earth Science Information Network) Website (http://sres.ciesin.org).
The sample scenario IS92a is only included for HFC−125, HFC−134a, and HFC−152a.
All PFCs, SF_6 and HFCs emissions are the same for family A1 (A1B, A1T and A1FI).

II.1.5: NO_x emissions (TgN/yr)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a
2000	32.0	32.0	32.0	32.0	32.0	32.0	32.5	32.5	32.5	32.5	37.0
2010	39.3	38.8	39.7	39.2	36.1	36.7	41.0	39.6	34.8	37.6	43.4
2020	46.1	46.4	50.4	50.3	39.9	42.7	48.9	50.7	39.3	43.4	49.8
2030	50.2	55.9	62.8	60.7	42.0	48.9	52.5	60.8	40.7	48.4	55.2
2040	48.9	59.7	77.1	65.9	42.6	53.4	50.9	65.8	44.8	52.8	59.6
2050	47.9	61.0	94.9	71.1	38.8	54.5	49.3	71.5	48.9	53.7	64.0
2060	46.0	59.6	102.1	75.5	34.3	56.1	47.2	75.6	48.9	55.4	67.8
2070	44.2	51.7	108.5	79.8	29.6	56.3	45.1	80.1	48.9	55.6	71.6
2080	42.7	42.8	115.4	87.5	25.7	59.2	43.3	87.3	48.9	58.5	75.4
2090	41.4	34.8	111.5	98.3	22.2	60.9	41.8	97.9	41.2	60.1	79.2
2100	40.2	28.1	109.6	109.2	18.7	61.2	40.3	109.7	33.6	60.4	83.0

Note: NO_x is the sum of NO and NO_2

II.1.6: CO emissions (Tg(CO)/yr)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a
2000	877	877	877	877	877	877	1036	1036	1036	1036	1048
2010	1002	1003	1020	977	789	935	1273	1136	849	1138	1096
2020	1032	1147	1204	1075	751	1022	1531	1234	985	1211	1145
2030	1109	1362	1436	1259	603	1111	1641	1413	864	1175	1207
2040	1160	1555	1726	1344	531	1220	1815	1494	903	1268	1282
2050	1214	1770	2159	1428	471	1319	1990	1586	942	1351	1358
2060	1245	1944	2270	1545	459	1423	2174	1696	984	1466	1431
2070	1276	2078	2483	1662	456	1570	2359	1816	1026	1625	1504
2080	1357	2164	2776	1842	426	1742	2455	1985	1068	1803	1576
2090	1499	2156	2685	2084	399	1886	2463	2218	1009	1948	1649
2100	1663	2077	2570	2326	363	2002	2471	2484	950	2067	1722

II.1.7: Total VOC emissions (Tg/yr)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a
2000	141	141	141	141	141	141	151	151	151	151	126
2010	178	164	166	155	141	159	178	164	143	172	142
2020	222	190	192	179	140	180	207	188	151	192	158
2030	266	212	214	202	131	199	229	210	144	202	173
2040	272	229	256	214	123	214	255	221	147	215	188
2050	279	241	322	225	116	217	285	235	150	217	202
2060	284	242	361	238	111	214	324	246	155	214	218
2070	289	229	405	251	103	202	301	260	160	202	234
2080	269	199	449	275	99	192	263	282	165	192	251
2090	228	167	435	309	96	178	223	315	159	178	267
2100	193	128	420	342	87	170	174	352	154	170	283

Note: Volatile Organic Compounds (VOC) include non−methane hydrocarbons (NMHC) and oxygenated NMHC (e.g., alcohols, aldehydes and organic acids).

II.1.8: SO_2 emissions (TgS/yr)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a
2000	69.0	69.0	69.0	69.0	69.0	69.0	69.0	69.0	69.0	69.0	79.0
2010	87.1	64.7	80.8	74.7	73.9	65.9	87.4	74.7	59.8	68.2	95.0
2020	100.2	59.9	86.9	99.5	74.6	61.3	100.8	99.5	56.2	65.0	111.0
2030	91.0	59.6	96.1	112.5	78.2	60.3	91.4	111.9	53.5	59.9	125.8
2040	68.9	45.9	94.0	109.0	78.5	59.0	77.9	108.1	53.3	58.8	139.4
2050	64.1	40.2	80.5	105.4	68.9	55.7	64.3	105.4	51.4	57.2	153.0
2060	46.9	34.4	56.3	89.6	55.8	53.8	51.2	86.3	51.2	53.7	151.8
2070	35.7	30.1	42.6	73.7	44.3	50.9	44.9	71.7	49.2	51.9	150.6
2080	30.7	25.2	39.4	64.7	36.1	50.0	30.7	64.2	42.2	49.1	149.4
2090	29.1	23.3	39.8	62.5	29.8	49.0	29.1	61.9	33.9	48.0	148.2
2100	27.6	20.2	40.1	60.3	24.9	47.9	27.4	60.3	28.6	47.3	147.0

Note: The SRES emissions for SO_2 are used with a linear offset in all scenarios to 69.0 TgS/yr in year 2000.

II.1.9: BC aerosol emissions (Tg/yr)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a
2000	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4
2010	13.9	13.9	14.1	13.6	11.3	13.1	15.2	13.6	10.2	13.6	13.0
2020	14.3	15.6	16.3	14.8	10.9	14.1	18.3	14.8	11.8	14.5	13.6
2030	15.2	18.2	19.1	17.0	9.1	15.2	19.6	16.9	10.3	14.1	14.3
2040	15.8	20.5	22.6	18.0	8.3	16.5	21.7	17.9	10.8	15.2	15.2
2050	16.4	23.1	27.7	19.0	7.5	17.7	23.8	19.0	11.3	16.2	16.1
2060	16.8	25.2	29.1	20.4	7.4	18.9	26.0	20.3	11.8	17.5	17.0
2070	17.2	26.8	31.6	21.8	7.4	20.7	28.2	21.7	12.3	19.4	17.9
2080	18.1	27.8	35.1	24.0	7.0	22.8	29.4	23.8	12.8	21.6	18.7
2090	19.8	27.7	34.0	26.8	6.7	24.5	29.5	26.5	12.1	23.3	19.6
2100	21.8	26.8	32.7	29.7	6.2	25.9	29.6	29.7	11.4	24.7	20.5

Note: Emissions for BC are scaled to SRES anthropogenic CO emissions offset to year 2000.

II.1.10: OC aerosol emissions (Tg/yr)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a
2000	81.4	81.4	81.4	81.4	81.4	81.4	81.4	81.4	81.4	81.4	81.4
2010	91.2	91.3	92.6	89.3	74.5	86.0	100.0	89.3	66.7	89.4	85.2
2020	93.6	102.6	107.1	97.0	71.5	92.8	120.3	97.0	77.4	95.2	89.0
2030	99.6	119.5	125.3	111.4	59.9	99.8	128.9	111.0	67.9	92.3	93.9
2040	103.6	134.7	148.1	118.1	54.2	108.3	142.6	117.4	71.0	99.6	99.8
2050	107.9	151.6	182.1	124.7	49.5	116.1	156.4	124.6	74.0	106.2	105.8
2060	110.3	165.2	190.9	133.9	48.6	124.3	170.8	133.3	77.3	115.2	111.5
2070	112.8	175.8	207.6	143.1	48.3	135.9	185.4	142.7	80.6	127.7	117.2
2080	119.1	182.5	230.6	157.2	46.0	149.4	192.9	156.0	83.9	141.7	122.9
2090	130.3	181.9	223.5	176.2	43.8	160.7	193.5	174.3	79.3	153.1	128.6
2100	143.2	175.7	214.4	195.2	41.0	169.8	194.2	195.2	74.6	162.4	134.4

Note: Emissions for OC are scaled to SRES anthropogenic CO emissions offset to year 2000.

II.2: Abundances and burdens

II.2.1: CO_2 abundances (ppm)

ISAM model (reference) – CO_2 abundances (ppm)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a	IS92a/ SAR
1970	325	325	325	325	325	325	325	325	325	325	325	326
1980	337	337	337	337	337	337	337	337	337	337	337	338
1990	353	353	353	353	353	353	353	353	353	353	353	354
2000	369	369	369	369	369	369	369	369	369	369	369	372
2010	391	389	389	390	388	388	393	391	388	390	390	393
2020	420	412	417	417	412	408	425	419	409	414	415	418
2030	454	440	455	451	437	429	461	453	429	438	444	446
2040	491	471	504	490	463	453	499	492	450	462	475	476
2050	532	501	567	532	488	478	538	535	472	486	508	509
2060	572	528	638	580	509	504	577	583	497	512	543	544
2070	611	550	716	635	525	531	615	637	522	539	582	580
2080	649	567	799	698	537	559	652	699	544	567	623	620
2090	685	577	885	771	545	589	685	771	563	597	670	664
2100	717	582	970	856	549	621	715	856	578	630	723	715

ISAM model (low) – CO_2 abundances (ppm)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a
2000	368	368	368	368	368	368	368	368	368	368	368
2010	383	381	381	382	380	380	385	383	380	382	382
2020	405	398	403	402	398	394	409	404	395	400	401
2030	432	419	433	429	416	410	438	431	410	417	423
2040	461	443	473	460	436	427	467	461	425	435	446
2050	493	466	525	493	455	446	498	495	442	454	472
2060	524	486	584	532	470	466	528	534	460	473	499
2070	554	501	647	576	480	486	557	577	479	492	529
2080	582	511	715	626	486	507	583	627	495	513	561
2090	607	516	783	686	490	530	607	686	507	536	598
2100	630	516	851	755	490	554	627	755	517	561	640

ISAM model (high) – CO_2 abundances (ppm)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a
2000	369	369	369	369	369	369	369	369	369	369	369
2010	397	394	394	395	394	393	398	396	393	396	396
2020	431	422	427	427	422	417	435	429	418	424	426
2030	470	455	471	466	452	443	477	469	444	453	460
2040	513	491	527	511	483	472	521	514	469	482	498
2050	560	527	597	561	514	502	568	564	496	512	539
2060	609	560	678	617	541	534	615	620	527	543	583
2070	656	590	767	681	563	567	661	682	558	577	631
2080	703	613	863	754	581	602	706	755	586	612	682
2090	748	631	962	838	594	640	749	838	611	650	739
2100	790	642	1062	936	603	680	789	936	634	691	804

Note: A "reference" case was defined with climate sensitivity 2.5°C, ocean uptake corresponding to the mean of the ocean model results in Chapter 3, Figure 3.10, and terrestrial uptake corresponding to the mean of the responses of mid–range models, LPJ, IBIS and SDGM (Chapter 3, Figure 3.10). A "low CO_2" parametrization was chosen with climate sensitivity 1.5°C and maximal CO_2 uptake by oceans and land. A "high CO_2" parametrization was defined with climate sensitivity 4.5°C and minimal CO_2 uptake by oceans and land. See Chapter 3, Box 3.7, and Jain *et al.* (1994) for more details on the ISAM model.
The IS92a column values are calculated using the ISAM parametrization noted above with IS92a emissions starting in the year 2000; whereas the IS92a/SAR column refers to values as reported in the SAR using IS92a emissions starting in 1990, using the SAR parametrization of ISAM.

Bern–CC model (reference) – CO_2 abundances (ppm)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a	IS92a/ SAR
1970	325	325	325	325	325	325	325	325	325	325	325	325
1980	337	337	337	337	337	337	337	337	337	337	337	337
1990	352	352	352	352	352	352	352	352	352	352	352	353
2000	367	367	367	367	367	367	367	367	367	367	367	370
2010	388	386	386	386	386	385	390	388	385	387	387	391
2020	418	410	415	414	410	406	421	416	407	412	413	416
2030	447	435	449	444	432	425	454	447	425	433	439	444
2040	483	466	495	481	457	448	490	484	445	457	468	475
2050	522	496	555	522	482	473	529	525	467	481	499	507
2060	563	523	625	568	503	499	569	571	492	506	533	541
2070	601	545	702	620	518	524	606	622	515	532	568	577
2080	639	563	786	682	530	552	642	683	537	559	607	616
2090	674	572	872	754	538	581	674	754	555	588	653	660
2100	703	575	958	836	540	611	702	836	569	618	703	709

Bern–CC model (low) – CO_2 abundances (ppm)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a
2000	367	367	367	367	367	367	367	367	367	367	367
2010	383	381	381	381	381	380	384	383	380	382	383
2020	407	400	405	404	400	396	411	406	397	402	403
2030	432	419	432	428	417	410	437	431	410	417	424
2040	460	442	472	459	436	427	466	461	425	434	448
2050	491	464	521	492	455	445	496	495	440	452	473
2060	522	483	577	529	470	464	524	531	458	470	500
2070	548	496	636	569	479	482	550	569	475	487	527
2080	575	505	700	617	485	502	575	616	490	507	559
2090	598	508	763	671	487	522	596	670	501	528	593
2100	617	506	824	735	486	544	613	734	509	550	632

Bern–CC model (high) – CO_2 abundances (ppm)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a
2000	367	367	367	367	367	367	367	367	367	367	367
2010	395	393	393	393	392	392	397	395	392	394	395
2020	436	427	433	431	426	422	441	434	424	430	431
2030	483	467	484	477	463	454	491	482	455	465	471
2040	538	514	552	533	503	491	548	538	488	504	517
2050	599	562	638	597	544	531	609	602	524	544	568
2060	666	610	743	670	584	575	675	675	566	588	624
2070	732	653	859	753	617	620	738	757	608	632	684
2080	797	689	985	848	645	668	802	851	648	680	750
2090	860	717	1118	957	666	718	863	959	682	730	822
2100	918	735	1248	1080	681	769	918	1082	713	782	902

Note: A "reference" case was defined with an average ocean uptake for the 1980s of 2.0 PgC/yr. A "low CO_2" parameterisation was obtained by combining a "fast ocean" (ocean uptake of 2.54 PgC/yr for the 1980s) and no response of heterotrophic respiration to temperature. A "high CO_2" parameterisation was obtained by combining a "slow ocean " (ocean uptake of 1.46 PgC/yr for the 1980s) and capping CO_2 fertilisation. Climate sensitivity was set to 2.5°C for a doubling of CO_2. See Chapter 3, Box 3.7 for more details on the Bern–CC model.
The IS92a/SAR column refers to values as reported in the SAR using IS92a emissions; whereas the IS92a column is calculated using IS92a emissions but with year 2000 starting values and the BERN-CC model as described in Chapter 3.
The Bern-CC model was initialised for observed atmospheric CO_2 which was prescribed for the period 1765 to 1999. The CO_2 data were smoothed by a spline. Scenario calculations started at the begining of the year 2000. This explains the difference in the values given for the years upto 2000. Values shown are for the beginning of each year. Annual-mean values are generally higher (up to 7ppm) depending on the scenario and the year.

II.2.2: CH_4 abundances (ppb)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a	IS92a/ SAR
1970	1420	1420	1420	1420	1420	1420	1420	1420	1420	1420	1420	1420
1980	1570	1570	1570	1570	1570	1570	1570	1570	1570	1570	1570	1570
1990	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700
2000	1760	1760	1760	1760	1760	1760	1760	1760	1760	1760	1760	1810
2010	1871	1856	1851	1861	1827	1839	1899	1861	1816	1862	1855	1964
2020	2026	1998	1986	1997	1891	1936	2126	1997	1878	2020	1979	2145
2030	2202	2194	2175	2163	1927	2058	2392	2159	1931	2201	2129	2343
2040	2337	2377	2413	2357	1919	2201	2598	2344	1963	2358	2306	2561
2050	2400	2503	2668	2562	1881	2363	2709	2549	2009	2473	2497	2793
2060	2386	2552	2875	2779	1836	2510	2736	2768	2049	2552	2663	3003
2070	2301	2507	3030	3011	1797	2639	2669	2998	2077	2606	2791	3175
2080	2191	2420	3175	3252	1741	2765	2533	3238	2100	2625	2905	3328
2090	2078	2310	3307	3493	1663	2872	2367	3475	2091	2597	3019	3474
2100	1974	2169	3413	3731	1574	2973	2187	3717	2039	2569	3136	3616

Note: The IS92a/SAR column refers to values as reported in the SAR using IS92a emissions; whereas the IS92a column is calculated using IS92a emissions but with year 2000 starting values and the new feedbacks on the lifetime. See Chapter 4 for details.

II.2.3: N_2O abundances (ppb)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a	IS92a/ SAR
1970	295	295	295	295	295	295	295	295	295	295	295	295
1980	301	301	301	301	301	301	301	301	301	301	301	301
1990	308	308	308	308	308	308	308	308	308	308	308	308
2000	316	316	316	316	316	316	316	316	316	316	316	319
2010	324	323	325	325	324	323	324	325	324	324	324	328
2020	331	328	335	335	333	328	332	335	333	331	333	339
2030	338	333	347	347	341	333	340	347	341	338	343	350
2040	344	338	361	360	349	338	346	360	350	343	353	361
2050	350	342	378	373	357	342	351	373	358	347	363	371
2060	356	345	396	387	363	346	355	386	366	350	372	382
2070	360	348	413	401	368	350	358	400	373	352	381	391
2080	365	350	429	416	371	354	360	415	380	354	389	400
2090	368	352	445	432	374	358	361	430	385	355	396	409
2100	372	354	460	447	375	362	361	446	389	356	403	417

Note: The IS92a/SAR column refers to values as reported in the SAR using IS92a emissions; whereas the IS92a column is calculated using IS92a emissions but with year 2000 starting values and the new feedbacks on the lifetime. See Chapter 4 for details.

II.2.4: PFCs, SF_6 and HFCs abundances (ppt)

CF_4 abundances (ppt)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p
1990	70	70	70	70	70	70	70	70	70	70
2000	82	82	82	82	82	82	82	82	82	82
2010	91	91	91	92	91	93	100	100	100	100
2020	103	103	103	107	101	108	122	121	118	122
2030	119	119	119	125	111	128	154	146	138	150
2040	141	141	141	148	122	153	197	176	159	184
2050	168	168	168	175	135	184	245	212	181	226
2060	198	198	198	208	150	221	296	255	204	274
2070	230	230	230	246	164	261	342	306	226	327
2080	265	265	265	291	179	302	377	365	242	383
2090	303	303	303	341	193	344	405	433	256	439
2100	341	341	341	397	208	384	437	508	269	493

C_2F_6 abundances (ppt)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p
1990	2	2	2	2	2	2	2	2	2	2
2000	3	3	3	3	3	3	3	3	3	3
2010	4	4	4	4	4	4	4	4	4	4
2020	5	5	5	5	4	5	6	6	6	6
2030	6	6	6	6	5	6	8	7	7	8
2040	7	7	7	7	6	8	11	9	8	10
2050	9	9	9	9	7	10	14	12	10	12
2060	11	11	11	11	8	12	17	14	11	16
2070	13	13	13	14	8	15	20	18	12	19
2080	15	15	15	17	9	17	22	21	13	22
2090	17	17	17	20	10	20	24	26	14	26
2100	20	20	20	23	11	22	26	30	15	30

SF_6 abundances (ppt)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p
1990	3	3	3	3	3	3	3	3	3	3
2000	5	5	5	5	5	5	5	5	5	5
2010	7	7	7	7	7	7	7	7	7	7
2020	10	10	10	11	9	10	10	11	10	11
2030	13	13	13	15	12	14	14	15	12	15
2040	18	18	18	20	15	18	19	20	16	21
2050	25	25	25	26	19	23	26	26	20	27
2060	32	32	32	32	23	27	33	33	24	35
2070	39	39	39	40	27	32	41	41	29	43
2080	45	45	45	48	30	36	46	48	32	52
2090	50	50	50	56	33	40	51	57	35	61
2100	56	56	56	65	35	44	57	66	37	70

HFC–23 abundances (ppt)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p
1990	8	8	8	8	8	8	8	8	8	8
2000	15	15	15	15	15	15	15	15	15	15
2010	26	26	26	26	26	26	26	26	26	26
2020	33	33	33	33	33	33	33	33	33	33
2030	35	35	35	35	35	35	35	35	35	35
2040	35	35	35	35	35	35	36	35	35	35
2050	35	35	35	35	35	35	35	35	35	35
2060	35	35	35	35	34	35	34	34	33	34
2070	35	35	34	34	34	34	33	32	32	33
2080	34	34	34	34	33	34	32	31	31	31
2090	34	34	34	34	33	34	31	30	30	30
2100	34	34	34	33	32	34	30	29	29	29

HFC–32 abundance (ppt)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p
1990	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	0	0
2010	1	1	1	1	1	1	1	1	1	1
2020	3	3	3	3	3	3	3	3	3	3
2030	7	7	6	4	4	4	7	4	4	5
2040	10	10	10	6	5	6	11	5	5	7
2050	14	14	13	7	7	8	15	7	7	9
2060	17	17	16	9	8	10	18	9	8	11
2070	19	19	18	11	8	12	20	11	8	13
2080	19	21	19	14	8	14	21	13	8	14
2090	20	22	20	17	8	15	21	16	8	15
2100	19	22	20	20	8	17	20	20	8	16

HFC–125 abundance (ppt)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a
1990	0	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	0	0	0
2010	2	2	2	2	2	2	4	3	3	3	0
2020	9	9	9	8	8	8	10	8	8	9	2
2030	21	21	21	16	16	16	22	15	16	17	12
2040	37	37	37	24	24	26	38	23	24	27	40
2050	57	56	55	34	33	36	57	32	33	38	87
2060	77	78	76	45	43	48	78	43	42	51	137
2070	97	98	95	58	49	61	96	54	49	65	177
2080	112	115	111	72	54	75	111	68	54	77	210
2090	124	129	124	89	57	88	123	83	57	89	236
2100	133	140	134	107	58	102	132	101	58	99	255

HFC–134a abundance (ppt)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a
1990	0	0	0	0	0	0	0	0	0	0	0
2000	12	12	12	12	12	12	12	12	12	12	12
2010	58	58	58	55	55	56	80	76	76	79	94
2020	130	130	129	111	108	113	172	141	142	155	183
2030	236	235	233	170	165	179	319	214	215	250	281
2040	375	373	366	231	223	250	522	290	294	356	401
2050	537	535	521	299	293	330	754	375	393	477	537
2060	698	701	675	382	352	424	954	480	476	615	657
2070	814	832	791	480	380	526	1092	606	515	756	743
2080	871	912	859	594	391	633	1167	753	530	878	807
2090	887	952	893	729	390	737	1185	930	531	968	850
2100	875	956	899	877	379	835	1157	1132	522	1041	878

HFC–143a abundance (ppt)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p
1990	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	0	0
2010	3	3	3	3	2	2	4	4	4	4
2020	11	11	11	10	9	9	12	11	11	11
2030	26	26	26	20	18	19	27	20	20	22
2040	47	47	47	32	29	31	48	31	31	35
2050	73	73	72	45	43	45	75	44	44	51
2060	103	103	101	62	57	62	104	60	58	69
2070	132	133	130	81	68	81	131	78	69	89
2080	158	161	157	103	77	101	156	98	79	110
2090	181	185	180	129	85	121	179	123	86	129
2100	200	207	201	157	90	142	197	151	92	147

HFC–152a abundance (ppt)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a
1990	0	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0	0	0
2020	0	0	0	0	0	0	0	0	0	0	2
2030	0	0	0	0	0	0	0	0	0	0	12
2040	0	0	0	0	0	0	0	0	0	0	33
2050	0	0	0	0	0	0	0	0	0	0	56
2060	0	0	0	0	0	0	0	0	0	0	67
2070	0	0	0	0	0	0	0	0	0	0	74
2080	0	0	0	0	0	0	0	0	0	0	79
2090	0	0	0	0	0	0	0	0	0	0	81
2100	0	0	0	0	0	0	0	0	0	0	82

HFC–227ea abundance (ppt)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p
1990	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	0	0
2010	2	2	2	2	2	2	3	3	3	3
2020	6	6	6	5	6	6	7	6	6	7
2030	13	13	13	10	10	11	13	9	10	11
2040	22	22	22	14	15	17	22	13	15	17
2050	33	33	32	19	21	24	33	18	20	23
2060	45	45	44	25	27	31	43	23	26	31
2070	56	56	55	32	31	40	52	29	30	39
2080	63	65	62	40	34	49	60	36	33	47
2090	68	71	68	49	35	59	64	45	34	54
2100	70	74	71	60	36	68	67	55	35	60

HFC–245ca abundance (ppt)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p
1990	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	0	0
2010	8	8	8	8	8	8	11	10	10	10
2020	20	20	20	17	17	18	20	16	16	18
2030	34	34	33	23	23	26	35	21	22	26
2040	52	51	50	29	29	34	55	27	28	35
2050	72	72	69	36	38	44	76	34	38	46
2060	92	93	88	46	43	55	92	43	44	58
2070	102	105	99	58	44	67	101	55	44	70
2080	101	108	101	72	43	80	101	68	44	79
2090	97	107	99	88	42	92	96	84	43	84
2100	90	101	94	105	40	103	88	101	41	88

HFC–43–10mee abundance (ppt)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p
1990	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	0	0
2010	1	1	1	1	1	1	1	1	1	1
2020	2	2	2	2	1	1	2	2	2	2
2030	3	3	3	2	2	2	3	2	2	2
2040	4	4	4	3	2	3	4	2	2	3
2050	5	5	5	3	3	3	5	3	3	3
2060	7	7	6	4	3	4	6	3	3	4
2070	8	8	8	4	4	5	7	4	3	4
2080	9	9	9	5	4	5	8	4	4	5
2090	10	11	10	6	4	6	9	5	4	5
2100	11	12	11	7	4	7	10	6	4	6

Note: Even though all PFCs, SF6 and HFCs emissions are the same for family A1 (A1B, A1T and A1FI), the OH changes due to CH_4, NO_x, CO and VOC (affecting only HFCs burdens). Hence the burden for HFCs can diverge for each of these scenarios within familiy A1. See Chapter 4 for details.

II.2.5: Tropospheric O_3 burden (global mean column in DU)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a	IS92a/ SAR
1990	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0
2000	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.3
2010	35.8	35.6	35.8	35.7	34.8	35.2	36.2	35.6	34.3	35.4	35.5	34.8
2020	37.8	37.7	38.4	38.2	35.6	36.7	38.8	38.2	35.4	37.1	37.1	35.3
2030	39.3	40.3	41.5	40.8	35.9	38.4	40.5	40.7	35.7	38.5	38.7	35.8
2040	39.7	41.9	45.1	42.6	35.8	39.8	41.3	42.4	36.5	39.9	40.1	36.5
2050	39.8	42.9	49.6	44.2	35.0	40.7	41.6	44.1	37.5	40.6	41.6	37.1
2060	39.6	43.1	51.9	45.7	34.0	41.5	41.8	45.6	37.7	41.2	42.9	37.7
2070	39.1	41.9	53.8	47.2	33.1	42.1	41.4	47.1	37.9	41.6	44.0	38.2
2080	38.5	40.2	55.9	49.3	32.1	43.0	40.8	49.1	38.1	42.3	45.1	38.7
2090	38.0	38.4	55.6	52.0	31.2	43.7	39.9	51.8	36.8	42.6	46.1	39.1
2100	37.5	36.5	55.2	54.8	30.1	44.2	38.9	54.7	35.2	42.8	47.2	39.5

Note: IS92a/SAR column refers to IS92a emissions as reported in the SAR which estimated this O_3 change only as an indirect feedback effect from CH_4 increases; whereas IS92a column uses the latest models (see Chapter 4) which include also changes in emissions of NO_x, CO and VOC. A mean tropospheric O_3 content of 34 DU in 1990 is adopted; and 1 ppb of tropospheric O_3 = 0.65 DU.
These projected increases in troposheric O_3 are likely to be 25% too large, see note to Table 4.11 of Chapter 4 describing corrections made after government review.

II.2.6: Tropospheric OH (as a factor relative to year 2000)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a
2000	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2010	0.99	0.99	0.99	1.00	1.01	0.99	0.98	1.00	1.02	0.99	1.00
2020	0.97	0.98	0.99	1.00	1.02	0.99	0.94	1.00	1.01	0.97	0.99
2030	0.94	0.96	0.98	0.99	1.04	0.98	0.90	0.99	1.02	0.96	0.98
2040	0.91	0.93	0.96	0.98	1.06	0.96	0.85	0.98	1.03	0.95	0.96
2050	0.90	0.89	0.94	0.96	1.06	0.93	0.81	0.96	1.04	0.93	0.95
2060	0.89	0.87	0.92	0.94	1.05	0.91	0.78	0.94	1.03	0.92	0.93
2070	0.89	0.84	0.90	0.92	1.04	0.89	0.77	0.92	1.01	0.90	0.92
2080	0.89	0.81	0.88	0.90	1.04	0.87	0.77	0.90	1.01	0.89	0.91
2090	0.90	0.81	0.86	0.89	1.04	0.86	0.80	0.89	0.98	0.89	0.90
2100	0.90	0.82	0.86	0.88	1.05	0.84	0.82	0.88	0.97	0.89	0.89

II.2.7: SO_4^{2-} aerosol burden (TgS)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a
2000	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52
2010	0.66	0.49	0.61	0.56	0.56	0.50	0.66	0.56	0.45	0.51	0.64
2020	0.76	0.45	0.65	0.75	0.56	0.46	0.76	0.75	0.42	0.49	0.76
2030	0.69	0.45	0.72	0.85	0.59	0.45	0.69	0.84	0.40	0.45	0.87
2040	0.52	0.35	0.71	0.82	0.59	0.44	0.59	0.81	0.40	0.44	0.98
2050	0.48	0.30	0.61	0.79	0.52	0.42	0.48	0.79	0.39	0.43	1.08
2060	0.35	0.26	0.42	0.68	0.42	0.41	0.39	0.65	0.39	0.40	1.07
2070	0.27	0.23	0.32	0.56	0.33	0.38	0.34	0.54	0.37	0.39	1.06
2080	0.23	0.19	0.30	0.49	0.27	0.38	0.23	0.48	0.32	0.37	1.05
2090	0.22	0.18	0.30	0.47	0.22	0.37	0.22	0.47	0.26	0.36	1.04
2100	0.21	0.15	0.30	0.45	0.19	0.36	0.21	0.45	0.22	0.36	1.03

Note: Global burden is scaled to emissions: 0.52 Tg burden for 69.0 TgS/yr emissions.

II.2.8: BC aerosol burden (Tg)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a
2000	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26
2010	0.29	0.29	0.30	0.29	0.24	0.27	0.32	0.29	0.21	0.29	0.27
2020	0.30	0.33	0.34	0.31	0.23	0.30	0.38	0.31	0.25	0.30	0.28
2030	0.32	0.38	0.40	0.36	0.19	0.32	0.41	0.35	0.22	0.29	0.30
2040	0.33	0.43	0.47	0.38	0.17	0.35	0.46	0.37	0.23	0.32	0.32
2050	0.34	0.48	0.58	0.40	0.16	0.37	0.50	0.40	0.24	0.34	0.34
2060	0.35	0.53	0.61	0.43	0.16	0.40	0.55	0.43	0.25	0.37	0.36
2070	0.36	0.56	0.66	0.46	0.15	0.43	0.59	0.46	0.26	0.41	0.37
2080	0.38	0.58	0.74	0.50	0.15	0.48	0.62	0.50	0.27	0.45	0.39
2090	0.42	0.58	0.71	0.56	0.14	0.51	0.62	0.56	0.25	0.49	0.41
2100	0.46	0.56	0.68	0.62	0.13	0.54	0.62	0.62	0.24	0.52	0.43

Note: Global burden is scaled to emissions: 0.26 Tg burden for 12.4 Tg/yr emsissions.

II.2.9: OC aerosol burden (Tg)

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a
2000	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52
2010	1.70	1.70	1.73	1.67	1.39	1.61	1.87	1.67	1.25	1.67	1.59
2020	1.75	1.92	2.00	1.81	1.34	1.73	2.25	1.81	1.45	1.78	1.66
2030	1.86	2.23	2.34	2.08	1.12	1.86	2.41	2.07	1.27	1.72	1.75
2040	1.94	2.51	2.77	2.21	1.01	2.02	2.66	2.19	1.32	1.86	1.86
2050	2.01	2.83	3.40	2.33	0.92	2.17	2.92	2.33	1.38	1.98	1.97
2060	2.06	3.09	3.56	2.50	0.91	2.32	3.19	2.49	1.44	2.15	2.08
2070	2.11	3.28	3.88	2.67	0.90	2.54	3.46	2.66	1.51	2.38	2.19
2080	2.22	3.41	4.31	2.94	0.86	2.79	3.60	2.91	1.57	2.65	2.29
2090	2.43	3.40	4.17	3.29	0.82	3.00	3.61	3.25	1.48	2.86	2.40
2100	2.67	3.28	4.00	3.65	0.77	3.17	3.63	3.64	1.39	3.03	2.51

Note: Global burden is scaled to emissions: 1.52 Tg burden for 81.4 Tg/yr emissions.

II.2.10: CFCs and HFCs abundances from WMO98 Scenario A1(baseline) following the Montreal (1997) Amendments (ppt)

Year	CFC–11	CFC–12	CFC–113	CFC–114	CFC–115	CCl_4	CH_3CCl_3	HCFC–22	HCFC–141b	HCFC–142b	HCFC–123	CF_2BrCl	CF_3Br	EESCl
1970	50	109	4	6	0	56	13	13	0	0	0	0	0	1.25
1975	106	199	9	8	1	77	36	25	0	0	0	0	0	1.54
1980	164	290	18	10	1	92	75	41	0	0	0	1	0	1.99
1985	207	373	34	12	3	100	102	64	0	0	0	2	1	2.44
1990	258	467	67	15	5	102	125	90	0	1	0	3	2	2.87
1995	271	520	86	16	7	100	110	112	3	7	0	4	2	3.30
2000	267	535	85	16	9	92	44	145	13	15	0	4	3	3.28
2010	246	527	81	16	9	75	6	257	22	33	2	4	3	3.03
2020	214	486	72	15	9	59	1	229	16	32	3	3	3	2.74
2030	180	441	64	15	9	47	0	137	9	23	2	2	3	2.42
2040	149	400	57	14	9	37	0	88	6	17	2	1	3	2.16
2050	123	362	51	14	9	29	0	46	2	11	1	1	3	1.94
2060	101	328	45	13	9	23	0	20	1	6	1	0	2	1.76
2070	83	298	40	13	9	18	0	9	0	4	0	0	2	1.62
2080	68	270	36	12	8	14	0	4	0	2	0	0	2	1.51
2090	56	245	32	12	8	11	0	2	0	1	0	0	2	1.41
2100	45	222	28	12	8	9	0	1	0	1	0	0	1	1.33

Notes: Only significant greenhouse halocarbons shown (ppt).
EESCl = Equivalent Effective Stratospheric Chlorine in ppb (includes Br).
[Source: UNEP/WMO Scientific Assessment of Ozone Depletion: 1998 (Chapter 11), Version 5, June 3, 1998, Calculations by John Daniel and Guus Velders – guus.velders@rivm.nl & jdaniel@al.noaa.gov]

II.3: Radiative Forcing (Wm^{-2}) (relative to pre-industrial period, 1750)

The concentrations of CO_2 and CH_4 considered here correspond to the year 2000 and differ slightly from those considered in Chapter 6 which used the values corresponding to the year 1998 (as appropriate for the time frame when Chapter 6 began its preparation). The resulting difference in the computed present day forcings is about 3% in the case of CO_2 and about 2% in the case of CH_4. For N_2O, the difference in the computed forcings is negligible. In the case of tropospheric ozone, the forcing for the year 2000 given here and that in Chapter 6 are the results of slightly different scenarios employed which leads to about a 9% difference in the forcings. For the halogen containing compounds, the absolute differences in concentrations between here and Chapter 6 lead to a difference in present day forcing of less than 0.002 Wm^{-2} for any species.

II.3.1: CO_2 radiative forcing (Wm^{-2})

ISAM model (reference) – CO_2 radiative forcing (Wm^{-2})

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a	IS92a/ SAR
2000	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.56
2010	1.82	1.80	1.80	1.81	1.78	1.78	1.85	1.82	1.78	1.81	1.81	1.85
2020	2.21	2.10	2.17	2.17	2.10	2.05	2.27	2.19	2.07	2.13	2.14	2.18
2030	2.62	2.46	2.64	2.59	2.42	2.32	2.71	2.61	2.32	2.43	2.50	2.53
2040	3.04	2.82	3.18	3.03	2.73	2.61	3.13	3.05	2.58	2.72	2.87	2.88
2050	3.47	3.15	3.81	3.47	3.01	2.90	3.53	3.50	2.83	2.99	3.23	3.24
2060	3.86	3.43	4.44	3.93	3.24	3.18	3.91	3.96	3.11	3.27	3.58	3.59
2070	4.21	3.65	5.06	4.42	3.40	3.46	4.25	4.44	3.37	3.54	3.95	3.93
2080	4.54	3.81	5.65	4.93	3.52	3.74	4.56	4.93	3.59	3.81	4.32	4.29
2090	4.82	3.91	6.20	5.46	3.60	4.02	4.82	5.46	3.78	4.09	4.71	4.66
2100	5.07	3.95	6.69	6.02	3.64	4.30	5.05	6.02	3.92	4.38	5.11	5.05

ISAM model (low) – CO_2 radiative forcing (Wm^{-2})

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a
2000	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
2010	1.71	1.69	1.69	1.70	1.67	1.67	1.74	1.71	1.67	1.70	1.70
2020	2.01	1.92	1.99	1.97	1.92	1.87	2.07	2.00	1.88	1.95	1.96
2030	2.36	2.19	2.37	2.32	2.16	2.08	2.43	2.35	2.08	2.17	2.25
2040	2.71	2.49	2.84	2.69	2.41	2.30	2.78	2.71	2.27	2.40	2.53
2050	3.06	2.76	3.40	3.06	2.64	2.53	3.12	3.09	2.48	2.62	2.83
2060	3.39	2.99	3.97	3.47	2.81	2.76	3.43	3.49	2.69	2.84	3.13
2070	3.69	3.15	4.52	3.90	2.92	2.99	3.72	3.91	2.91	3.05	3.44
2080	3.95	3.26	5.05	4.34	2.99	3.21	3.96	4.35	3.09	3.28	3.76
2090	4.18	3.31	5.54	4.83	3.03	3.45	4.18	4.83	3.21	3.51	4.10
2100	4.38	3.31	5.99	5.35	3.03	3.69	4.35	5.35	3.32	3.76	4.46

ISAM model (high) – CO_2 radiative forcing (Wm^{-2})

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a
2000	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51
2010	1.91	1.87	1.87	1.88	1.87	1.85	1.92	1.89	1.85	1.89	1.89
2020	2.35	2.23	2.30	2.30	2.23	2.17	2.40	2.32	2.18	2.26	2.28
2030	2.81	2.64	2.82	2.76	2.60	2.49	2.89	2.80	2.50	2.61	2.69
2040	3.28	3.04	3.42	3.26	2.96	2.83	3.36	3.29	2.80	2.94	3.12
2050	3.75	3.42	4.09	3.76	3.29	3.16	3.82	3.78	3.10	3.27	3.54
2060	4.20	3.75	4.77	4.27	3.56	3.49	4.25	4.29	3.42	3.58	3.96
2070	4.59	4.03	5.43	4.79	3.78	3.81	4.63	4.80	3.73	3.91	4.39
2080	4.96	4.23	6.06	5.34	3.94	4.13	4.99	5.35	3.99	4.22	4.80
2090	5.30	4.39	6.64	5.90	4.06	4.46	5.30	5.90	4.21	4.54	5.23
2100	5.59	4.48	7.17	6.49	4.14	4.79	5.58	6.49	4.41	4.87	5.68

Bern–CC model (reference) – CO_2 radiative forcing (Wm^{-2})

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a	IS92a/ SAR
2000	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.53
2010	1.78	1.76	1.76	1.76	1.76	1.74	1.81	1.78	1.74	1.77	1.77	1.82
2020	2.18	2.08	2.14	2.13	2.08	2.03	2.22	2.16	2.04	2.10	2.12	2.16
2030	2.54	2.40	2.56	2.50	2.36	2.27	2.62	2.54	2.27	2.37	2.44	2.50
2040	2.96	2.76	3.09	2.93	2.66	2.55	3.03	2.97	2.52	2.66	2.79	2.87
2050	3.37	3.10	3.70	3.37	2.94	2.84	3.44	3.40	2.78	2.93	3.13	3.21
2060	3.78	3.38	4.33	3.82	3.17	3.13	3.83	3.85	3.05	3.20	3.48	3.56
2070	4.12	3.60	4.96	4.29	3.33	3.39	4.17	4.31	3.30	3.47	3.82	3.91
2080	4.45	3.78	5.56	4.80	3.45	3.67	4.48	4.81	3.52	3.74	4.18	4.26
2090	4.74	3.86	6.12	5.34	3.53	3.94	4.74	5.34	3.70	4.01	4.57	4.63
2100	4.96	3.89	6.62	5.89	3.55	4.21	4.96	5.89	3.83	4.27	4.96	5.01

Bern–CC model (low) – CO_2 radiative forcing (Wm^{-2})

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a
2000	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49
2010	1.71	1.69	1.69	1.69	1.69	1.67	1.73	1.71	1.67	1.70	1.71
2020	2.04	1.95	2.01	2.00	1.95	1.89	2.09	2.03	1.91	1.97	1.99
2030	2.36	2.19	2.36	2.31	2.17	2.08	2.42	2.35	2.08	2.17	2.26
2040	2.69	2.48	2.83	2.68	2.41	2.30	2.76	2.71	2.27	2.38	2.55
2050	3.04	2.74	3.36	3.05	2.64	2.52	3.10	3.09	2.46	2.60	2.84
2060	3.37	2.96	3.91	3.44	2.81	2.74	3.39	3.46	2.67	2.81	3.14
2070	3.63	3.10	4.43	3.83	2.91	2.94	3.65	3.83	2.87	3.00	3.42
2080	3.89	3.19	4.94	4.27	2.98	3.16	3.89	4.26	3.03	3.21	3.74
2090	4.10	3.23	5.40	4.71	3.00	3.37	4.08	4.71	3.15	3.43	4.05
2100	4.27	3.20	5.81	5.20	2.99	3.59	4.23	5.19	3.24	3.65	4.39

Bern–CC model (high) – CO_2 radiative forcing (Wm^{-2})

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a
2000	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49
2010	1.88	1.85	1.85	1.85	1.84	1.84	1.91	1.88	1.84	1.87	1.88
2020	2.41	2.30	2.37	2.35	2.28	2.23	2.47	2.38	2.26	2.33	2.35
2030	2.96	2.78	2.97	2.89	2.73	2.62	3.04	2.94	2.64	2.75	2.82
2040	3.53	3.29	3.67	3.48	3.17	3.04	3.63	3.53	3.01	3.18	3.32
2050	4.11	3.77	4.44	4.09	3.59	3.46	4.20	4.13	3.39	3.59	3.82
2060	4.67	4.20	5.26	4.71	3.97	3.89	4.75	4.75	3.80	4.01	4.33
2070	5.18	4.57	6.04	5.33	4.27	4.29	5.23	5.36	4.19	4.39	4.82
2080	5.63	4.86	6.77	5.97	4.50	4.69	5.67	5.99	4.53	4.79	5.31
2090	6.04	5.07	7.45	6.61	4.67	5.08	6.06	6.62	4.80	5.17	5.80
2100	6.39	5.20	8.03	7.26	4.79	5.44	6.39	7.27	5.04	5.53	6.30

II.3.2: CH_4 radiative forcing (Wm^{-2})

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a	IS92a/ SAR
2000	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.51
2010	0.53	0.52	0.52	0.53	0.51	0.52	0.54	0.53	0.51	0.53	0.52	0.56
2020	0.59	0.58	0.57	0.58	0.54	0.55	0.62	0.58	0.53	0.58	0.57	0.63
2030	0.65	0.64	0.64	0.63	0.55	0.60	0.71	0.63	0.55	0.64	0.62	0.69
2040	0.69	0.70	0.71	0.70	0.55	0.64	0.77	0.69	0.56	0.70	0.68	0.76
2050	0.71	0.74	0.79	0.76	0.53	0.70	0.80	0.76	0.58	0.73	0.74	0.83
2060	0.71	0.76	0.85	0.83	0.52	0.74	0.81	0.82	0.59	0.76	0.79	0.89
2070	0.68	0.74	0.90	0.89	0.50	0.78	0.79	0.89	0.60	0.77	0.83	0.94
2080	0.64	0.72	0.94	0.96	0.48	0.82	0.75	0.96	0.61	0.78	0.86	0.98
2090	0.60	0.68	0.97	1.02	0.45	0.85	0.70	1.02	0.61	0.77	0.90	1.02
2100	0.57	0.63	1.00	1.09	0.42	0.88	0.64	1.08	0.59	0.76	0.93	1.06

II.3.3: N_2O radiative forcing (Wm^{-2})

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a	IS92a/ SAR
2000	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.16
2010	0.18	0.17	0.18	0.18	0.18	0.17	0.18	0.18	0.18	0.18	0.18	0.19
2020	0.20	0.19	0.21	0.21	0.21	0.19	0.20	0.21	0.21	0.20	0.21	0.22
2030	0.22	0.21	0.25	0.25	0.23	0.21	0.23	0.25	0.23	0.22	0.24	0.26
2040	0.24	0.22	0.29	0.29	0.25	0.22	0.25	0.29	0.26	0.24	0.27	0.29
2050	0.26	0.23	0.34	0.33	0.28	0.23	0.26	0.33	0.28	0.25	0.30	0.32
2060	0.28	0.24	0.39	0.37	0.30	0.25	0.27	0.36	0.31	0.26	0.32	0.35
2070	0.29	0.25	0.44	0.41	0.31	0.26	0.28	0.40	0.33	0.26	0.35	0.38
2080	0.30	0.26	0.48	0.45	0.32	0.27	0.29	0.45	0.35	0.27	0.37	0.40
2090	0.31	0.26	0.53	0.49	0.33	0.28	0.29	0.49	0.36	0.27	0.39	0.43
2100	0.32	0.27	0.57	0.53	0.33	0.29	0.29	0.53	0.37	0.28	0.41	0.45

II.3.4: PFCs, SF_6 and HFCs radiative forcing (Wm^{-2})

CF_4 radiative forcing (Wm^{-2})

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p
2000	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
2010	0.004	0.004	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005
2020	0.005	0.005	0.005	0.005	0.005	0.005	0.007	0.006	0.006	0.007
2030	0.006	0.006	0.006	0.007	0.006	0.007	0.009	0.008	0.008	0.009
2040	0.008	0.008	0.008	0.009	0.007	0.009	0.013	0.011	0.010	0.012
2050	0.010	0.010	0.010	0.011	0.008	0.012	0.016	0.014	0.011	0.015
2060	0.013	0.013	0.013	0.013	0.009	0.014	0.020	0.017	0.013	0.019
2070	0.015	0.015	0.015	0.016	0.010	0.018	0.024	0.021	0.015	0.023
2080	0.018	0.018	0.018	0.020	0.011	0.021	0.027	0.026	0.016	0.027
2090	0.021	0.021	0.021	0.024	0.012	0.024	0.029	0.031	0.017	0.032
2100	0.024	0.024	0.024	0.029	0.013	0.028	0.032	0.037	0.018	0.036

C_2F_6 radiative forcing (Wm^{-2})

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p
2000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
2010	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
2020	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002
2030	0.002	0.002	0.002	0.002	0.001	0.002	0.002	0.002	0.002	0.002
2040	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.002	0.002	0.003
2050	0.002	0.002	0.002	0.002	0.002	0.003	0.004	0.003	0.003	0.003
2060	0.003	0.003	0.003	0.003	0.002	0.003	0.004	0.004	0.003	0.004
2070	0.003	0.003	0.003	0.004	0.002	0.004	0.005	0.005	0.003	0.005
2080	0.004	0.004	0.004	0.004	0.002	0.004	0.006	0.005	0.003	0.006
2090	0.004	0.004	0.004	0.005	0.003	0.005	0.006	0.007	0.004	0.007
2100	0.005	0.005	0.005	0.006	0.003	0.006	0.007	0.008	0.004	0.008

SF_6 radiative forcing (Wm^{-2})

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p
2000	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
2010	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
2020	0.005	0.005	0.005	0.006	0.005	0.005	0.005	0.006	0.005	0.006
2030	0.007	0.007	0.007	0.008	0.006	0.007	0.007	0.008	0.006	0.008
2040	0.009	0.009	0.009	0.010	0.008	0.009	0.010	0.010	0.008	0.011
2050	0.013	0.013	0.013	0.014	0.010	0.012	0.014	0.014	0.010	0.014
2060	0.017	0.017	0.017	0.017	0.012	0.014	0.017	0.017	0.012	0.018
2070	0.020	0.020	0.020	0.021	0.014	0.017	0.021	0.021	0.015	0.022
2080	0.023	0.023	0.023	0.025	0.016	0.019	0.024	0.025	0.017	0.027
2090	0.026	0.026	0.026	0.029	0.017	0.021	0.027	0.030	0.018	0.032
2100	0.029	0.029	0.029	0.034	0.018	0.023	0.030	0.034	0.019	0.036

HFC–23 radiative forcing (Wm^{-2})

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p
2000	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
2010	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
2020	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
2030	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006
2040	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006
2050	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006
2060	0.006	0.006	0.006	0.006	0.005	0.006	0.005	0.005	0.005	0.005
2070	0.006	0.006	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
2080	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
2090	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
2100	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005

HFC–32 radiative forcing (Wm^{-2})

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p
2000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2020	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2030	0.001	0.001	0.001	0.000	0.000	0.000	0.001	0.000	0.000	0.000
2040	0.001	0.001	0.001	0.001	0.000	0.001	0.001	0.000	0.000	0.001
2050	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
2060	0.002	0.002	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001
2070	0.002	0.002	0.002	0.001	0.001	0.001	0.002	0.001	0.001	0.001
2080	0.002	0.002	0.002	0.001	0.001	0.001	0.002	0.001	0.001	0.001
2090	0.002	0.002	0.002	0.002	0.001	0.001	0.002	0.001	0.001	0.001
2100	0.002	0.002	0.002	0.002	0.001	0.002	0.002	0.002	0.001	0.001

HFC–125 radiative forcing (Wm^{-2})

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a
2000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2010	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.000
2020	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.000
2030	0.005	0.005	0.005	0.004	0.004	0.004	0.005	0.003	0.004	0.004	0.003
2040	0.009	0.009	0.009	0.006	0.006	0.006	0.009	0.005	0.006	0.006	0.009
2050	0.013	0.013	0.013	0.008	0.008	0.008	0.013	0.007	0.008	0.009	0.020
2060	0.018	0.018	0.017	0.010	0.010	0.011	0.018	0.010	0.010	0.012	0.032
2070	0.022	0.023	0.022	0.013	0.011	0.014	0.022	0.012	0.011	0.015	0.041
2080	0.026	0.026	0.026	0.017	0.012	0.017	0.026	0.016	0.012	0.018	0.048
2090	0.029	0.030	0.029	0.020	0.013	0.020	0.028	0.019	0.013	0.020	0.054
2100	0.031	0.032	0.031	0.025	0.013	0.023	0.030	0.023	0.013	0.023	0.059

HFC–134a radiative forcing (Wm^{-2})

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a
2000	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
2010	0.009	0.009	0.009	0.008	0.008	0.008	0.012	0.011	0.011	0.012	0.014
2020	0.020	0.020	0.019	0.017	0.016	0.017	0.026	0.021	0.021	0.023	0.027
2030	0.035	0.035	0.035	0.026	0.025	0.027	0.048	0.032	0.032	0.038	0.042
2040	0.056	0.056	0.055	0.035	0.033	0.038	0.078	0.043	0.044	0.053	0.060
2050	0.081	0.080	0.078	0.045	0.044	0.050	0.113	0.056	0.059	0.072	0.081
2060	0.105	0.105	0.101	0.057	0.053	0.064	0.143	0.072	0.071	0.092	0.099
2070	0.122	0.125	0.119	0.072	0.057	0.079	0.164	0.091	0.077	0.113	0.111
2080	0.131	0.137	0.129	0.089	0.059	0.095	0.175	0.113	0.079	0.132	0.121
2090	0.133	0.143	0.134	0.109	0.059	0.111	0.178	0.140	0.080	0.145	0.128
2100	0.131	0.143	0.135	0.132	0.057	0.125	0.174	0.170	0.078	0.156	0.132

HFC–143a radiative forcing (Wm^{-2})

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p
2000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2010	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001
2020	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001
2030	0.003	0.003	0.003	0.003	0.002	0.002	0.004	0.003	0.003	0.003
2040	0.006	0.006	0.006	0.004	0.004	0.004	0.006	0.004	0.004	0.005
2050	0.009	0.009	0.009	0.006	0.006	0.006	0.010	0.006	0.006	0.007
2060	0.013	0.013	0.013	0.008	0.007	0.008	0.014	0.008	0.008	0.009
2070	0.017	0.017	0.017	0.011	0.009	0.011	0.017	0.010	0.009	0.012
2080	0.021	0.021	0.020	0.013	0.010	0.013	0.020	0.013	0.010	0.014
2090	0.024	0.024	0.023	0.017	0.011	0.016	0.023	0.016	0.011	0.017
2100	0.026	0.027	0.026	0.020	0.012	0.018	0.026	0.020	0.012	0.019

HFC–152a radiative forcing (Wm^{-2})

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a
2000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2020	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2030	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
2040	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003
2050	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005
2060	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006
2070	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007
2080	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007
2090	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007
2100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007

HFC–227ea radiative forcing (Wm^{-2})

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p
2000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2010	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
2020	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
2030	0.004	0.004	0.004	0.003	0.003	0.003	0.004	0.003	0.003	0.003
2040	0.007	0.007	0.007	0.004	0.004	0.005	0.007	0.004	0.004	0.005
2050	0.010	0.010	0.010	0.006	0.006	0.007	0.010	0.005	0.006	0.007
2060	0.014	0.014	0.013	0.008	0.008	0.009	0.013	0.007	0.008	0.009
2070	0.017	0.017	0.016	0.010	0.009	0.012	0.016	0.009	0.009	0.012
2080	0.019	0.020	0.019	0.012	0.010	0.015	0.018	0.011	0.010	0.014
2090	0.020	0.021	0.020	0.015	0.010	0.018	0.019	0.014	0.010	0.016
2100	0.021	0.022	0.021	0.018	0.011	0.020	0.020	0.016	0.010	0.018

HFC–245ca radiative forcing (Wm^{-2})

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p
2000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2010	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.002	0.002	0.002
2020	0.005	0.005	0.005	0.004	0.004	0.004	0.005	0.004	0.004	0.004
2030	0.008	0.008	0.008	0.005	0.005	0.006	0.008	0.005	0.005	0.006
2040	0.012	0.012	0.012	0.007	0.007	0.008	0.013	0.006	0.006	0.008
2050	0.017	0.017	0.016	0.008	0.009	0.010	0.017	0.008	0.009	0.011
2060	0.021	0.021	0.020	0.011	0.010	0.013	0.021	0.010	0.010	0.013
2070	0.023	0.024	0.023	0.013	0.010	0.015	0.023	0.013	0.010	0.016
2080	0.023	0.025	0.023	0.017	0.010	0.018	0.023	0.016	0.010	0.018
2090	0.022	0.025	0.023	0.020	0.010	0.021	0.022	0.019	0.010	0.019
2100	0.021	0.023	0.022	0.024	0.009	0.024	0.020	0.023	0.009	0.020

HFC–43–10mee radiative forcing (Wm^{-2})

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p
2000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2020	0.001	0.001	0.001	0.001	0.000	0.000	0.001	0.001	0.001	0.001
2030	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
2040	0.002	0.002	0.002	0.001	0.001	0.001	0.002	0.001	0.001	0.001
2050	0.002	0.002	0.002	0.001	0.001	0.001	0.002	0.001	0.001	0.001
2060	0.003	0.003	0.002	0.002	0.001	0.002	0.002	0.001	0.001	0.002
2070	0.003	0.003	0.003	0.002	0.002	0.002	0.003	0.002	0.001	0.002
2080	0.004	0.004	0.004	0.002	0.002	0.002	0.003	0.002	0.002	0.002
2090	0.004	0.004	0.004	0.002	0.002	0.002	0.004	0.002	0.002	0.002
2100	0.004	0.005	0.004	0.003	0.002	0.003	0.004	0.002	0.002	0.002

II.3.5: Tropospheric O_3 radiative forcing (Wm^{-2})

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a	IS92a/ SAR
2000	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.39
2010	0.45	0.45	0.45	0.45	0.41	0.43	0.47	0.45	0.39	0.44	0.44	0.41
2020	0.54	0.53	0.56	0.55	0.45	0.49	0.58	0.55	0.44	0.51	0.51	0.43
2030	0.60	0.64	0.69	0.66	0.46	0.56	0.65	0.66	0.45	0.57	0.58	0.45
2040	0.62	0.71	0.84	0.74	0.45	0.62	0.68	0.73	0.48	0.63	0.63	0.48
2050	0.62	0.75	1.03	0.81	0.42	0.66	0.70	0.80	0.52	0.66	0.70	0.51
2060	0.61	0.76	1.13	0.87	0.38	0.69	0.71	0.87	0.53	0.68	0.75	0.53
2070	0.59	0.71	1.21	0.93	0.34	0.72	0.69	0.93	0.54	0.70	0.80	0.55
2080	0.57	0.64	1.30	1.02	0.30	0.76	0.66	1.01	0.55	0.73	0.84	0.58
2090	0.55	0.56	1.29	1.13	0.26	0.79	0.63	1.13	0.50	0.74	0.89	0.59
2100	0.52	0.48	1.27	1.25	0.21	0.81	0.58	1.25	0.43	0.75	0.93	0.61

II.3.6: SO_4^{2-} aerosols (direct effect) radiative forcing (Wm^{-2})

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a
2000	–0.40	–0.40	–0.40	–0.40	–0.40	–0.40	–0.40	–0.40	–0.40	–0.40	–0.40
2010	–0.51	–0.38	–0.47	–0.43	–0.43	–0.38	–0.51	–0.43	–0.35	–0.39	–0.49
2020	–0.58	–0.35	–0.50	–0.58	–0.43	–0.35	–0.58	–0.58	–0.32	–0.38	–0.58
2030	–0.53	–0.35	–0.55	–0.65	–0.45	–0.35	–0.53	–0.65	–0.31	–0.35	–0.67
2040	–0.40	–0.27	–0.55	–0.63	–0.45	–0.34	–0.45	–0.62	–0.31	–0.34	–0.75
2050	–0.37	–0.23	–0.47	–0.61	–0.40	–0.32	–0.37	–0.61	–0.30	–0.33	–0.83
2060	–0.27	–0.20	–0.32	–0.52	–0.32	–0.32	–0.30	–0.50	–0.30	–0.31	–0.82
2070	–0.21	–0.18	–0.25	–0.43	–0.25	–0.29	–0.26	–0.42	–0.28	–0.30	–0.82
2080	–0.18	–0.15	–0.23	–0.38	–0.21	–0.29	–0.18	–0.37	–0.25	–0.28	–0.81
2090	–0.17	–0.14	–0.23	–0.36	–0.17	–0.28	–0.17	–0.36	–0.20	–0.28	–0.80
2100	–0.16	–0.12	–0.23	–0.35	–0.15	–0.28	–0.16	–0.35	–0.17	–0.28	–0.79

II.3.7: BC aerosols radiative forcing (Wm^{-2})

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a
2000	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
2010	0.45	0.45	0.46	0.45	0.37	0.42	0.49	0.45	0.32	0.45	0.42
2020	0.46	0.51	0.52	0.48	0.35	0.46	0.58	0.48	0.38	0.46	0.43
2030	0.49	0.58	0.62	0.55	0.29	0.49	0.63	0.54	0.34	0.45	0.46
2040	0.51	0.66	0.72	0.58	0.26	0.54	0.71	0.57	0.35	0.49	0.49
2050	0.52	0.74	0.89	0.62	0.25	0.57	0.77	0.62	0.37	0.52	0.52
2060	0.54	0.82	0.94	0.66	0.25	0.62	0.85	0.66	0.38	0.57	0.55
2070	0.55	0.86	1.02	0.71	0.23	0.66	0.91	0.71	0.40	0.63	0.57
2080	0.58	0.89	1.14	0.77	0.23	0.74	0.95	0.77	0.42	0.69	0.60
2090	0.65	0.89	1.09	0.86	0.22	0.78	0.95	0.86	0.38	0.75	0.63
2100	0.71	0.86	1.05	0.95	0.20	0.83	0.95	0.95	0.37	0.80	0.66

II.3.8: OC aerosols radiative forcing (Wm^{-2})

Year	A1B	A1T	A1FI	A2	B1	B2	A1p	A2p	B1p	B2p	IS92a
2000	–0.50	–0.50	–0.50	–0.50	–0.50	–0.50	–0.50	–0.50	–0.50	–0.50	–0.50
2010	–0.56	–0.56	–0.57	–0.55	–0.46	–0.53	–0.62	–0.55	–0.41	–0.55	–0.52
2020	–0.58	–0.63	–0.66	–0.60	–0.44	–0.57	–0.74	–0.60	–0.48	–0.59	–0.55
2030	–0.61	–0.73	–0.77	–0.68	–0.37	–0.61	–0.79	–0.68	–0.42	–0.57	–0.58
2040	–0.64	–0.83	–0.91	–0.73	–0.33	–0.66	–0.88	–0.72	–0.43	–0.61	–0.61
2050	–0.66	–0.93	–1.12	–0.77	–0.30	–0.71	–0.96	–0.77	–0.45	–0.65	–0.65
2060	–0.68	–1.02	–1.17	–0.82	–0.30	–0.76	–1.05	–0.82	–0.47	–0.71	–0.68
2070	–0.69	–1.08	–1.28	–0.88	–0.30	–0.84	–1.14	–0.88	–0.50	–0.78	–0.72
2080	–0.73	–1.12	–1.42	–0.97	–0.28	–0.92	–1.18	–0.96	–0.52	–0.87	–0.75
2090	–0.80	–1.12	–1.37	–1.08	–0.27	–0.99	–1.19	–1.07	–0.49	–0.94	–0.79
2100	–0.88	–1.08	–1.32	–1.20	–0.25	–1.04	–1.19	–1.20	–0.46	–1.00	–0.83

II.3.9: Radiative forcing (Wm^{-2}) from CFCs and HCFCs following the Montreal (1997) Amendments

Year	CFC–11	CFC–12	CFC–113	CFC–114	CFC–115	CCl_4	CH_3CCl_3	HCFC–22	HCFC–141b	HCFC–142b	HCFC–123	CF_2BrCl	CF_3Br	SUM
2000	0.0668	0.1712	0.0255	0.0050	0.0016	0.0120	0.0026	0.0290	0.0018	0.0030	0.0000	0.0012	0.0010	0.3206
2010	0.0615	0.1686	0.0243	0.0050	0.0016	0.0098	0.0004	0.0514	0.0031	0.0066	0.0004	0.0012	0.0010	0.3348
2020	0.0535	0.1555	0.0216	0.0047	0.0016	0.0077	0.0001	0.0458	0.0022	0.0064	0.0006	0.0009	0.0010	0.3015
2030	0.0450	0.1411	0.0192	0.0047	0.0016	0.0061	0.0000	0.0274	0.0013	0.0046	0.0004	0.0006	0.0010	0.2529
2040	0.0373	0.1280	0.0171	0.0043	0.0016	0.0048	0.0000	0.0176	0.0008	0.0034	0.0004	0.0003	0.0010	0.2166
2050	0.0308	0.1158	0.0153	0.0043	0.0016	0.0038	0.0000	0.0092	0.0003	0.0022	0.0002	0.0003	0.0010	0.1848
2060	0.0253	0.1050	0.0135	0.0040	0.0016	0.0030	0.0000	0.0040	0.0001	0.0012	0.0002	0.0000	0.0006	0.1585
2070	0.0208	0.0954	0.0120	0.0040	0.0016	0.0023	0.0000	0.0018	0.0000	0.0008	0.0000	0.0000	0.0006	0.1393
2080	0.0170	0.0864	0.0108	0.0037	0.0014	0.0018	0.0000	0.0008	0.0000	0.0004	0.0000	0.0000	0.0006	0.1230
2090	0.0140	0.0784	0.0096	0.0037	0.0014	0.0014	0.0000	0.0004	0.0000	0.0002	0.0000	0.0000	0.0006	0.1098
2100	0.0113	0.0710	0.0084	0.0037	0.0014	0.0012	0.0000	0.0002	0.0000	0.0002	0.0000	0.0000	0.0003	0.0977

II.3.10: Radiative Forcing (Wm^{-2}) from fosil fuel plus biomass Organic and Black Carbon as used in the Chapter 9 Simple Model SRES Projections

Year	A1B	A1T	A1FI	A2	B1	B2	IS92a
1990	–0.0997	–0.0997	–0.0997	–0.0997	–0.0997	–0.0997	–0.0998
2000	–0.1361	–0.1361	–0.1361	–0.1361	–0.1361	–0.1361	–0.1586
2010	–0.1308	–0.1468	–0.1280	–0.1392	–0.1081	–0.1203	–0.1357
2020	–0.0524	–0.0799	–0.1714	–0.1248	–0.0926	–0.0516	–0.1103
2030	–0.0562	–0.0598	–0.1745	–0.1088	–0.0154	–0.0148	–0.0872
2040	–0.0780	–0.0644	–0.1614	–0.1064	0.0349	–0.0075	–0.0610
2050	–0.0804	–0.0603	–0.1351	–0.1029	0.0280	–0.0049	–0.0339
2060	–0.0948	–0.0615	–0.1417	–0.1002	0.0241	0.0015	–0.0190
2070	–0.1071	–0.0613	–0.1193	–0.0939	0.0147	0.0064	–0.0026
2080	–0.1161	–0.0629	–0.0644	–0.0871	0.0300	0.0180	0.0166
2090	–0.1178	–0.0619	0.0365	–0.0816	0.0421	0.0341	0.0390
2100	–0.1208	–0.0629	0.0565	–0.0762	0.0351	0.0510	0.0635

II.3.11: Total Radiative Forcing (Wm^{-2}) from GHG plus direct and indirect aerosol effects as used in the Chapter 9 Simple Model SRES Projections

Year	A1B	A1T	A1FI	A2	B1	B2	IS92a
1990	1.03	1.03	1.03	1.03	1.03	1.03	1.03
2000	1.33	1.33	1.33	1.33	1.33	1.33	1.31
2010	1.65	1.85	1.69	1.74	1.73	1.82	1.63
2020	2.16	2.48	2.17	2.04	2.15	2.36	2.00
2030	2.84	3.07	2.78	2.56	2.56	2.81	2.40
2040	3.61	3.76	3.67	3.22	2.93	3.26	2.82
2050	4.16	4.31	4.83	3.89	3.30	3.70	3.25
2060	4.79	4.73	5.99	4.71	3.65	4.11	3.76
2070	5.28	4.97	7.02	5.56	3.92	4.52	4.24
2080	5.62	5.11	7.89	6.40	4.09	4.92	4.74
2090	5.86	5.12	8.59	7.22	4.18	5.32	5.26
2100	6.05	5.07	9.14	8.07	4.19	5.71	5.79

II.4: Model Average Surface Air Temperature Change (°C)

Year	A1B	A1T	A1FI	A2	B1	B2	IS92a
1750 to 1990	0.33	0.33	0.33	0.33	0.33	0.33	0.34
1990	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.16	0.16	0.16	0.16	0.16	0.16	0.15
2010	0.30	0.40	0.32	0.35	0.34	0.39	0.27
2020	0.52	0.71	0.55	0.50	0.55	0.66	0.43
2030	0.85	1.03	0.85	0.73	0.77	0.93	0.61
2040	1.26	1.41	1.27	1.06	0.98	1.18	0.80
2050	1.59	1.75	1.86	1.42	1.21	1.44	1.00
2060	1.97	2.04	2.50	1.85	1.44	1.69	1.26
2070	2.30	2.25	3.10	2.33	1.63	1.94	1.52
2080	2.56	2.41	3.64	2.81	1.79	2.20	1.79
2090	2.77	2.49	4.09	3.29	1.91	2.44	2.08
2100	2.95	2.54	4.49	3.79	1.98	2.69	2.38

Note: See Chapter 9 for details.

II.5: Sea Level Change (mm)

Note: Values are for the middle of the year..

II.5.1: Total sea level change (mm)

Models average – Total sea level change (mm)

Year	A1B	A1T	A1FI	A2	B1	B2
1990	0	0	0	0	0	0
2000	17	17	17	17	17	17
2010	37	39	37	38	38	38
2020	61	66	61	61	62	64
2030	91	97	90	88	89	94
2040	127	134	126	120	118	126
2050	167	175	172	157	150	160
2060	210	217	228	201	183	197
2070	256	258	290	250	216	235
2080	301	298	356	304	249	275
2090	345	334	424	362	281	316
2100	387	367	491	424	310	358

Note: The sum of the components listed in Appendix II.5.2 to II.5.5 does not equal the values shown above owing to the addition of other terms. See Chapter 11, Section 11.5.1 for details.

Models minimum – Total sea level change (mm)

Year	A1B	A1T	A1FI	A2	B1	B2
1990	0	0	0	0	0	0
2000	6	6	6	6	6	6
2010	13	13	13	13	13	13
2020	22	22	24	21	22	23
2030	34	33	36	31	32	34
2040	48	47	49	44	42	45
2050	63	66	64	58	52	56
2060	78	89	77	75	63	68
2070	93	113	89	93	72	79
2080	107	137	99	113	80	91
2090	119	160	106	133	87	103
2100	129	182	111	155	92	114

Note: The final values of these timeseries correspond to the lower limit of the coloured bars on the right–hand side of Chapter 11, Figure 11.12.

Model maximum – Total sea level change (mm)

Year	A1B	A1T	A1FI	A2	B1	B2
1990	0	0	0	0	0	0
2000	29	29	29	29	29	29
2010	63	63	65	64	64	65
2020	103	104	110	104	105	109
2030	153	153	164	149	151	159
2040	214	214	228	204	203	216
2050	284	291	299	269	259	277
2060	360	386	375	343	319	344
2070	442	494	453	430	381	414
2080	527	612	529	526	444	488
2090	611	735	602	631	507	566
2100	694	859	671	743	567	646

Note: The final values of these timeseries correspond to the upper limit of the coloured bars on the right–hand side of Chapter 11, Figure 11.12.

II.5.2: Sea level change due to thermal expansion (mm)

Year	A1B	A1T	A1FI	A2	B1	B2
1990	0	0	0	0	0	0
2000	10	10	10	10	10	10
2010	23	24	23	23	23	24
2020	39	43	39	39	39	42
2030	60	66	60	57	58	62
2040	87	93	86	81	79	85
2050	117	123	122	109	101	110
2060	150	155	166	142	125	137
2070	185	186	217	180	149	165
2080	220	216	272	224	173	196
2090	255	243	329	272	195	227
2010	288	267	388	325	216	260

II.5.3: Sea level change due to glaciers and ice caps (mm)

Year	A1B	A1T	A1FI	A2	B1	B2
1990	0	0	0	0	0	0
2000	4	4	4	4	4	4
2010	9	10	9	10	10	10
2020	16	17	16	16	16	16
2030	23	25	23	23	23	24
2040	32	35	32	31	31	34
2050	43	46	44	41	41	44
2060	55	58	57	52	50	54
2070	67	71	72	65	61	66
2080	80	83	89	79	71	77
2090	93	95	105	93	82	89
2100	106	106	120	108	92	101

II.5.4: Sea level change due to Greenland (mm)

Year	A1B	A1T	A1FI	A2	B1	B2
1990	0	0	0	0	0	0
2000	0	0	0	0	0	0
2010	1	1	1	1	1	1
2020	2	2	2	2	2	2
2030	4	4	4	4	4	4
2040	5	6	5	5	5	6
2050	8	8	8	7	7	8
2060	10	11	11	10	9	10
2070	13	14	15	13	12	13
2080	17	17	19	16	14	16
2090	20	21	24	20	17	19
2100	24	24	29	25	20	22

II.5.5: Sea level change due to Antarctica (mm)

Year	A1B	A1T	A1FI	A2	B1	B2
1990	0	0	0	0	0	0
2000	–2	–2	–2	–2	–2	–2
2010	–5	–5	–5	–5	–5	–5
2020	–8	–9	–8	–8	–8	–9
2030	–12	–14	–13	–12	–13	–13
2040	–18	–20	–18	–17	–17	–19
2050	–25	–27	–25	–23	–23	–25
2060	–33	–35	–35	–31	–30	–32
2070	–42	–45	–46	–40	–37	–41
2080	–52	–54	–59	–50	–44	–49
2090	–63	–64	–74	–62	–53	–59
2100	–74	–75	–90	–76	–61	–70

References

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* [Houghton, J.T., L.G. Meira Filho, B.A. Callander, N. Harris, A. Kattenberg, and K. Maskell (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 572 pp.

Jain, A.K., H.S. Kheshgi, and D.J. Wuebbles, 1994: Integrated Science Model for Assessment of Climate Change. Lawrence Livermore National Laboratory, UCRL-JC-116526.

Nakićenović, N., J. Alcamo, G. Davis, B. de Vries, J. Fenhann, S. Gaffin, K. Gregory, A. Grübler, T. Y. Jung, T. Kram, E. L. La Rovere, L. Michaelis, S. Mori, T. Morita, W. Pepper, H. Pitcher, L. Price, K. Raihi, A. Roehrl, H-H. Rogner, A. Sankovski, M. Schlesinger, P. Shukla, S. Smith, R. Swart, S. van Rooijen, N. Victor, Z. Dadi, 2000: *IPCC Special Report on Emissions Scenarios*, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 599 pp.

WMO, 1999: Scientific Assessment of Ozone Depletion: 1998. Global Ozone Research and Monitoring Project - Report No. 44, World Meteorological Organization, Geneva, Switzerland, 732 pp.

Appendix III

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Appendix V

Acronyms and Abbreviations

AABW	Antarctic Bottom Water
AAO	Antarctic Oscillation
ABL	Atmospheric Boundary Layer
ACC	Antarctic Circumpolar Current
ACE	Aerosol Characterisation Experiment
ACRIM	Active Cavity Radiometer Irradiance Monitor
ACSYS	Arctic Climate System Study
ACW	Antarctic Circumpolar Wave
AEROCE	Atmosphere Ocean Chemistry Experiment
AGAGE	Advanced Global Atmospheric Gases Experiment
AGCM	Atmospheric General Circulation Model
AGWP	Absolute Global Warming Potential
AMIP	Atmospheric Model Intercomparison Project
ANN	Artificial Neural Networks
AO	Arctic Oscillation
AOGCM	Atmosphere-Ocean General Circulation Model
ARESE	Atmospheric Radiation Measurement Enhanced Shortwave Experiment
ARGO	Part of the Integrated Global Observation Strategy
ARM	Atmospheric Radiation Measurement
ARPEGE/OPA	Action de Recherche Petite Echelle Grande Echelle/Océan Parallélisé
ASHOE/MAESA	Airborne Southern Hemisphere Ozone Experiment/Measurement for Assessing the Effects of Stratospheric Aircraft
AVHRR	Advanced Very High Resolution Radiometer
AWI	Alfred Wegener Institute (Germany)
BAHC	Biospheric Aspects of the Hydrological Cycle
BC	Black Carbon
BERN2D	Two-dimensional Climate Model of University of Bern
BIOME 6000	Global Palaeo-vegetation Mapping Project
BMRC	Bureau of Meteorology Research Centre (Australia)
CART	Classification and Tree Analysis
CCA	Canonical Correlation Analysis
CCC(ma)	Canadian Centre for Climate (Modelling and Analysis) (Canada)
CCM	Community Climate Model
CCMLP	Carbon Cycle Model Linkage Project
CCN	Cloud Condensation Nuclei
CCSR	Centre for Climate System Research (Japan)
CERFACS	European Centre for Research and Advanced Training in Scientific Computation (France)
CIAP	Climate Impact Assessment Program

CLIMAP	Climate: Long-range Investigation, Mapping and Prediction
CLIMBER	Climate-Biosphere Model
CLIMPACTS	Integrated Model for Assessment of the Effects of Climate Change on the New Zealand Environment
CMAP	CPC Merged Analysis of Precipitation
CMDL	Climate Monitoring and Diagnostics Laboratory of NOAA (USA)
CMIP	Coupled Model Intercomparison Project
CNRM	Centre National de Recherches Météorologiques (France)
CNRS	Centre National de la Recherche Scientifique (France)
COADS	Comprehensive Ocean Atmosphere Data Set
COHMAP	Co-operative Holocene Mapping Project
COLA	Centre for Ocean-Land-Atmosphere Studies (USA)
COSAM	Comparison of Large-scale Atmospheric Sulphate Aerosol Model
COSMIC	Country Specific Model for Intertemporal Climate
COWL	Cold Ocean Warm Land
CPC	Climate Prediction Center of NOAA (USA)
CRF	Cloud Radiative Forcing
CRU	Climatic Research Unit of UEA (UK)
CRYOSat	Cryosphere Satellite
CSG	Climate Scenario Generator
CSIRO	Commonwealth Scientific and Industrial Research Organisation (Australia)
CSM	Climate System Model
CTM	Chemistry Transport Model
DARLAM	CSIRO Division of Atmospheric Research Limited Area Model
DDC	Data Distribution Centre of IPCC
DGVM	Dynamic Global Vegetation Model
DERF	Dynamical Extended Range Forecasting group of GFDL (USA)
DIC	Dissolved Inorganic Carbon
DJF	December, January, February
DKRZ	Deutsche KlimaRechenZentrum (Germany)
DMS	Dimethylsulfide
DMSP	Defense Meteorological Satellite Program
DNM	Department of Numerical Mathematics (Russia)
DOC	Dissolved Organic Carbon
DOE	Department of Energy (USA)
DORIS	Determination d'Orbite et Radiopositionnement Intégrés par Satellite
DRF	Direct Radiative Forcing
DTR	Diurnal Temperature Range
DYNAMO	Dynamics of North Atlantic Models
EBM	Energy Balance Model
ECHAM	ECMWF/MPI AGCM
ECMWF	European Centre for Medium-range Weather Forecasting
ECS	Effective Climate Sensitivity
EDGAR	Emission Database for Global Atmospheric Research
EISMINT	European Ice Sheet Modelling initiative
EMDI	Ecosystem Model/Data Intercomparison
EMIC	Earth system Models of Intermediate Complexity
ENSO	El Niño-Southern Oscillation
EOF	Empirical Orthogonal Function
EOS	Earth Observing System
ERA	ECMWF Reanalysis
ERB	Earth Radiation Budget
ERBE	Earth Radiation Budget Experiment
ERBS	Earth Radiation Budget Satellite
ESCAPE	Evaluation of Strategies to Address Climate Change by Adapting to and Preventing Emissions
ESMR	Electrically Scanning Microwave Radiometer
EURECA	European Retrievable Carrier
FACE	Free Air Carbon-dioxide Enrichment

FAO	Food and Agriculture Organisation (UN)
FCCC	Framework Convention on Climate Change
FDH	Fixed Dynamical Heating
FF	Fossil Fuel
FPAR	Plant-absorbed Fraction of Incoming Photosynthetically Active Radiation
FSU	Former Soviet Union
GASP	Global Assimilation and Prediction
GCIP	GEWEX Continental-scale International Program
GCM	General Circulation Model
GCOS	Global Climate Observing System
GCR	Galactic Cosmic Ray
GDP	Gross Domestic Product
GEBA	Global Energy Balance Archive
GEIA	Global Emissions Inventory Activity
GEISA	Gestion et Etude des Informations Spectroscopiques Atmosphériques
GEWEX	Global Energy and Water cycle Experiment
GFDL	Geophysical Fluid Dynamics Laboratory (USA)
GHCN	Global Historical Climate Network
GHG	Greenhouse Gas
GIM	Global Integration and Modelling
GISP	Greenland Ice Sheet Project
GISS	Goddard Institute for Space Studies (USA)
GISST	Global Sea Ice and Sea Surface Temperature
GLOSS	Global Sea Level Observing System
GOALS	Global Ocean-Atmosphere-Land System
GPCP	Global Precipitation Climatology Project
GPP	Gross Primary Production
GPS	Global Positioning System
GRACE	Gravity Recovery and Climate Experiment
GRIP	Greenland Ice Core Project
GSFC	Goddard Space Flight Centre (USA)
GSWP	Global Soil Wetness Project
GUAN	GCOS Upper Air Network
GWP	Global Warming Potential
HadCM	Hadley Centre Coupled Model
HIRETYCS	High Resolution Ten-Year Climate Simulations
HITRAN	High Resolution Transmission Molecular Absorption Database
HLM	High Latitude Mode
HNLC	High Nutrient-Low Chlorophyll
HRBM	High Resolution Biosphere Model
IAHS	International Association of Hydrological Science
IAP	Institute of Atmospheric Physics (China)
IASB	Institut d'Aéronomie Spatiale de Belgique (Belgium)
IBIS	Integrated Biosphere Simulator
ICESat	Ice, Cloud and Land Elevation Satellite
ICSI	International Commission on Snow and Ice
ICSU	International Council of Scientific Unions
IGAC	International Global Atmospheric Chemistry
IGBP	International Geosphere Biosphere Programme
IGCR	Institute for Global Change Research (Japan)
IHDP	International Human Dimensions Programme on Global Environmental Change
IMAGE	Integrated Model to Assess the Global Environment
IN	Ice Nuclei
INDOEX	Indian Ocean Experiment
IOC	Intergovernmental Oceanographic Commission
IPCC	Intergovernmental Panel on Climate Change
IPO	Interdecadal Pacific Oscillation

IPSL-CM	Institut Pierre Simon Laplace/Coupled Atmosphere-Ocean-Vegetation Model
ISAM	Integrated Science Assessment Model
ISCCP	International Satellite Cloud Climatology Project
ISLSCP	International Satellite Land Surface Climatology Project
ITCZ	Inter-Tropical Convergence Zone
IUPAC	International Union of Pure and Applied Chemistry
JGOFS	Joint Global Ocean Flux Study
JJA	June, July, August
JMA	Japan Meteorological Agency (Japan)
JPL	Jet Propulsion Laboratory of NASA (USA)
KNMI	Koninklijk Nederlands Meteorologisch Instituut (Netherlands)
LAI	Leaf Area Index
LASG	State Key Laboratory of Numerical Modelling for Atmospheric Sciences and Geophysical Fluid Dynamics (China)
LBA	Large-scale Biosphere-atmosphere Experiment in Amazonia
LGGE	Laboratoire de Glaciologie et Géophysique de l'Environnement (France)
LGM	Last Glacial Maximum
LLNL	Lawrence Livermore National Laboratory (USA)
LMD	Laboratoire de Météorologie Dynamique (France)
LOSU	Level of Scientific Understanding
LPJ	Land-Potsdam-Jena Terrestrial Carbon Model
LSAT	Land Surface Air Temperature
LSG	Large-Scale Geostrophic Ocean Model
LSP	Land Surface Parameterisation
LT	Lifetime
LWP	Liquid Water Path
MAGICC	Model for the Assessment of Greenhouse-gas Induced Climate Change
MAM	March, April, May
MARS	Multivariate Adaptive Regression Splines
MGO	Main Geophysical Observatory (Russia)
MJO	Madden-Julian Oscillation
ML	Mixed Layer
MLOPEX	Mauna Loa Observatory Photochemistry Experiment
MODIS	Moderate Resoluting Imaging Spectroradiometer
MOGUNTIA	Model of the General Universal Tracer Transport in the Atmosphere
MOM	Modular Ocean Model
MOZART	Model for Ozone and Related Chemical Tracers
MPI	Max-Plank Institute for Meteorology (Germany)
MRI	Meteorological Research Institute (Japan)
MSLP	Mean Sea Level Pressure
MSU	Microwave Sounding Unit
NADW	North Atlantic Deep Water
NAO	North Atlantic Oscillation
NARE	North Atlantic Regional Experiment
NASA	National Aeronautics and Space Administration (USA)
NBP	Net Biome Production
NCAR	National Center for Atmospheric Research (USA)
NCC	National Climate Centre (China)
NCDC	National Climatic Data Center of NOAA (USA)
NCEP	National Centers for Environmental Prediction of NOAA (USA)
NDVI	Normalised Difference Vegetation Index
NEP	Net Ecosystem Production
NESDIS	National Environmental Satellite, Data and Information Service of NOAA (USA)
NIC	National Ice Centre of NOAA (USA)
NIED	National Research Institute for Earth Science and Disaster Prevention (Japan)
NIES	National Institute for Environmental Studies (Japan)
NMAT	Night Marine Air Temperature

NMHC	Non-Methane Hydrocarbon
NOAA	National Oceanic and Atmospheric Administration (USA)
NPP	Net Primary Production
NPZD	Nutrients, Phytoplankton, Zooplankton and Detritus
NRC	National Research Council (USA)
NRL	Naval Research Laboratory (USA)
NWP	Numerical Weather Prediction
OC	Organic Carbon
OCMIP	Ocean Carbon-cycle Model Intercomparison Project
OCS	Organic Carbonyl Sulphide
OGCM	Ocean General Circulation Model
OLR	Outgoing Long-wave Radiation
OPYC	Ocean Isopycnal GCM
OxComp	Tropospheric Oxidant Model Comparison
PC	Principal Component
PCM	Parallel Climate Model
PDF	Probability Density Function
PDO	Pacific Decadal Oscillation
PEM	Pacific Exploratory Missions
PFT	Plant Functional Type
PGR	Post-Glacial Rebound
PhotoComp	Ozone Photochemistry Model Comparison
PICASSO	Pathfinder Instruments for Cloud and Aerosol Spaceborne Observations
PIK	Potsdam Institute for Climate Impact Research (Germany)
PILPS	Project for the Intercomparison of Land-surface Parameterisation Schemes
PIUB	Physics Institute University of Bern (Switzerland)
PMIP	Palaeoclimate Model Intercomparison Project
PNA	Pacific-North American
PNNL	Pacific Northwest National Laboratory (USA)
POC	Particulate Organic Carbon
POLDER	Polarisation and Directionality of the Earth's Reflectances
POPCORN	Photo-Oxidant Formation by Plant Emitted Compounds and OH Radicals in North-eastern Germany
PSMSL	Permanent Service for Mean Sea Level
PT	Perturbation Lifetime
QBO	Quasi-Biennial Oscillation
RAMS	Regional Atmospheric Modelling System
RCM	Regional Climate Model
RIHMI	Research Institute for Hydrometeorological Information
SAGE	Stratospheric Aerosol & Gas Experiment
SAR	IPCC Second Assessment Report
SAT	Surface Air Temperature
SBUV	Solar Backscatter Ultra Violet
SCAR-B	Smoke Cloud and Radiation-Brazil
SCE	Snow Cover Extent
SCENGEN	Scenario Generator
SCSWP	Small-scale Severe Weather Phenomena
SDD	Statistical-Dynamical Downscaling
SDGVM	Sheffield Dynamic Global Vegetation Model
SEFDH	Seasonally Evolving Fixed Dynamical Heating
SHEBA	Surface Heat Balance of the Arctic Ocean
SHI	State Hydrological Institute (Russia)
SIMIP	Sea Ice Model Intercomparison Project
SIO	Scripps Institution of Oceanography (USA)
SLP	Sea Level Pressure
SMMR	Scanning Multichannel Microwave Radiometer
SOA	Secondary Organic Aerosol
SOC	Southampton Oceanography Centre (UK)

SOHO	Solar Heliospheric Observatory
SOI	Southern Oscillation Index
SOLSTICE	Solar Stellar Irradiance Comparison Experiment
SON	September, October, November
SONEX	Subsonic Assessment Program Ozone and Nitrogen Oxide Experiment
SOS	Southern Oxidant Study
SPADE	Stratospheric Photochemistry, Aerosols, and Dynamics Expedition
SPARC	Stratospheric Processes and Their Role in Climate
SPCZ	South Pacific Convergence Zone
SRES	IPCC Special Report on Emission Scenarios
SSM/T-2	Special Sensor Microwave Water Vapour Sounder
SSM/I	Special Sensor Microwave/Imager
SST	Sea Surface Temperature
SSU	Stratospheric Sounding Unit
STRAT	Stratospheric Tracers of Atmospheric Transport
SUCCESS	Subsonic Aircraft Contrail and Cloud Effects Special Study
SUNGEN	State University of New York at Albany/NCAR Global Environmental and Ecological Simulation of Interactive Systems
SUSIM	Solar Ultraviolet Spectral Irradiance Monitor
TAR	IPCC Third Assessment Report
TARFOX	Tropospheric Aerosol Radiative Forcing Observational Experiment
TBFRA	Temperate and Boreal Forest Resource Assessment
TBO	Tropospheric Biennial Oscillation
TCR	Transient Climate Response
TEM	Terrestrial Ecosystem Model
TEMPUS	Sea Surface Temperature Evolution Mapping Project based on Alkenone Stratigraphy
THC	Thermohaline Circulation
TMR	TOPEX Microwave Radiometer
TOA	Top of the Atmosphere
TOMS	Total Ozone Mapping Spectrometer
TOPEX/POSEIDON	US/French Ocean Topography Satellite Altimeter Experiment
TOVS	Television Infrared Observation Satellite Operational Vertical Sounder
TPI	Trans Polar Index
TRIFFID	Top-down Representation of Interactive Foliage and Flora Including Dynamics
TSI	Total Solar Irradiance
UARS	Upper Atmosphere Research Satellite
UCAM	University of Cambridge (UK)
UCI	University of California at Irvine (USA)
UD/EB	Upwelling Diffusion-Energy Balance
UEA	University of East Anglia (UK)
UGAMP	University Global Atmospheric Modelling Project
UIO	Universitetet I Oslo (Norway)
UIUC	University of Illinois at Urbana-Champaign (USA)
UKHI	United Kingdom High-resolution climate model
UKMO	United Kingdom Met Office (UK)
UKTR	United Kingdom Transient climate experiment
ULAQ	Università degli studi dell'Aquila (Italy)
UM	Unified Model
UNEP	United Nations Environment Programme
UNESCO	United Nations Education, Scientific and Cultural Organisation
UNFCCC	United Nations Framework Convention on Climate Change
USSR	Union of Soviet Socialist Republics
UTH	Upper Tropospheric Humidity
UV	Ultraviolet radiation
UVic	University of Victoria (Canada)
VIRGO	Variability of Solar Irradiance and Gravity Oscillations
VLM	Vertical Land Movement

VOC	Volatile Organic Compounds
WAIS	West Antarctic Ice Sheet
WASA	Waves and Storms in the North Atlantic
WAVAS	Water Vapour Assessment
WBCs	Western Boundary Currents
WCRP	World Climate Research Programme
WMGGs	Well-Mixed Greenhouse Gases
WMO	World Meteorological Organization
WOCE	World Ocean Circulation Experiment
WP	Western Pacific
WRE	Wigley, Richels and Edmonds
YONU	Yonsei University (Korea)

Appendix VI

Units

SI (Systeme Internationale) Units:

Physical Quantity	Name of Unit	Symbol
length	metre	m
mass	kilogram	kg
time	second	s
thermodynamic temperature	kelvin	K
amount of substance	mole	mol

Fraction	Prefix	Symbol	Multiple	Prefix	Symbol
10^{-1}	deci	d	10	deca	da
10^{-2}	centi	c	10^{2}	hecto	h
10^{-3}	milli	m	10^{3}	kilo	k
10^{-6}	micro	μ	10^{6}	mega	M
10^{-9}	nano	n	10^{9}	giga	G
10^{-12}	pico	p	10^{12}	tera	T
10^{-15}	femto	f	10^{15}	peta	P

Special Names and Symbols for Certain SI-Derived Units:

Physical Quantity	Name of SI Unit	Symbol for SI Unit	Definition of Unit
force	newton	N	$kg\ m\ s^{-2}$
pressure	pascal	Pa	$kg\ m^{-1}\ s^{-2}$ (=$N\ m^{-2}$)
energy	joule	J	$kg\ m^{2}\ s^{-2}$
power	watt	W	$kg\ m^{2}\ s^{-3}$ (=$J\ s^{-1}$)
frequency	hertz	Hz	s^{-1} (cycles per second)

Decimal Fractions and Multiples of SI Units Having Special Names:

Physical Quantity	Name of Unit	Symbol for Unit	Definition of Unit
length	Ångstrom	Å	10^{-10} m = 10^{-8} cm
length	micron	µm	10^{-6} m
area	hectare	ha	10^{4} m^{2}
force	dyne	dyn	10^{-5} N
pressure	bar	bar	10^{5} N m^{-2} = 10^{5} Pa
pressure	millibar	mb	10^{2} N m^{-2} = 1 hPa
mass	tonne	t	10^{3} kg
mass	gram	g	10^{-3} kg
column density	Dobson units	DU	2.687×10^{16} molecules cm^{-2}
streamfunction	Sverdrup	Sv	10^{6} m^{3} s^{-1}

Non-SI Units:

°C	degree Celsius (0 °C = 273 K approximately) Temperature differences are also given in °C (=K) rather than the more correct form of "Celsius degrees".
ppmv	parts per million (10^{6}) by volume
ppbv	parts per billion (10^{9}) by volume
pptv	parts per trillion (10^{12}) by volume
yr	year
ky	thousands of years
bp	before present

The units of mass adopted in this report are generally those which have come into common usage and have deliberately not been harmonised, e.g.,

GtC	gigatonnes of carbon (1 GtC = 3.7 Gt carbon dioxide)
PgC	petagrams of carbon (1 PgC = 1 GtC)
MtN	megatonnes of nitrogen
TgC	teragrams of carbon (1 TgC = 1 MtC)
$Tg(CH_4)$	teragrams of methane
TgN	teragrams of nitrogen
TgS	teragrams of sulphur

Appendix VII

Some chemical symbols used in this report

C	carbon (there are three isotopes: ^{12}C, ^{13}C, ^{14}C)
Ca	calcium
$CaCO_3$	calcium carbonate
CCl_4	carbon tetrachloride
CF_4	perfluoromethane
C_2F_6	perfluoroethane
C_3F_8	perfluoropropane
C_4F_8	perfluorocyclobutane
C_4F_{10}	perfluorobutane
C_5F_{12}	perfluoropentane
C_6F_{14}	perfluorohexane
CFC	chlorofluorocarbon
CFC-11	$CFCl_3$ (trichlorofluoromethane)
CFC-12	CF_2Cl_2 (dichlorodifluoromethane)
CFC-13	CF_3Cl (chlorotrifluoromethane)
CFC-113	$CF_2ClCFCl_2$ (trichlorotrifluoroethane)
CFC-114	CF_2ClCF_2Cl (dichlorotetrafluoroethane)
CFC-115	CF_3CF_2Cl (chloropentafluoroethane)
CF_3I	trifluoroiodomethane
CH_4	methane
C_2H_6	ethane
C_5H_8	isoprene
C_6H_6	benzene
C_7H_8	toluene
$C_{10}H_{16}$	terpene
CH_3Br	methylbromide
CH_3CCl_3	methyl chloroform
$CHCl_3$	chloroform/trichloromethane
CH_2Cl_2	dichloromethane/methylene chloride
CH_3Cl	methylchloride
CH_3OCH_3	dimethyl ether
CO	carbon monoxide
CO_2	carbon dioxide
CO_3^{2-}	carbonate ion
DIC	dissolved inorganic carbon
DOC	dissolved organic carbon
H_2	hydrogen
halon-1211	CF_2ClBr
halon-1301	CF_3Br
halon-2402	CF_2BrCF_2Br
HCFC	hydrochlorofluorocarbon
HCFC-21	$CHCl_2F$
HCFC-22	CHF_2Cl
HCFC-123	$C_2F_3HCl_2$
HCFC-124	CF_3CHClF
HCFC-141b	CH_3CFCl_2
HCFC-142b	CH_3CF_2Cl
HCFC-225ca	$CF_3CF_2CHCl_2$
HCFC-225cb	$CClF_2CF_2CHClF$
HCFE-235da2	$CF_3CHClOCHF_2$
HCO_3^-	bicarbonate ion
HFC	hydrofluorocarbon
HFC-23	CHF_3
HFC-32	CH_2F_2
HFC-41	CH_3F
HFC-125	CHF_2CF_3
HFC-134	CHF_2CHF_2
HFC-134a	CF_3CH_2F
HFC-143	$CH_2F\ CHF_2$
HFC-143a	CH_3CF_3
HFC-152	CH_2FCH_2F
HFC-152a	CH_3CHF_2
HFC-161	CH_3CH_2F
HFC-227ea	CF_3CHFCF_3
HFC-236cb	$CF_3CF_2CH_2F$
HFC-236ea	$CF_3CHFCHF_2$
HFC-236fa	$CF_3CH_2CF_3$
HFC-245ca	$CH_2FCF_2CHF_2$
HFC-245ea	$CHF_2CHFCHF_2$
HFC-245eb	CF_3CHFCH_2F

HFC-245fa	$CHF_2CH_2CF_3$
HFC-263fb	$CF_3CH_2CH_3$
HFC-338pcc	$CHF_2CF_2CF_2CF_2H$
HFC-356mcf	$CF_3CF_2CH_2CH_2F$
HFC-356mff	$CF_3CH_2CH_2CF_3$
HFC-365mfc	$CF_3CH_2CF_2CH_3$
HFC-43-10mee	$CF_3CHFCHFCF_2CF_3$
HFC-458mfcf	$CF_3CH_2CF_2CH_2CF_3$
HFC-55-10mcff	$CF_3CF_2CH_2CH_2CF_2CF_3$
HFE-125	CF_3OCHF_2
HFE-134	CF_2HOCF_2H
HFE-143a	CF_3OCH_3
HFE-152a	CH_3OCHF_2
HFE-227ea	$CF_3CHFOCF_3$
HFE-236ea2	$CF_3CHFOCHF_2$
HFE-236fa	$CF_3CH_2OCF_3$
HFE-245cb2	$CF_3CF_2OCH_3$
HFE-245fa1	$CHF_2CH_2OCF_3$
HFE-245fa2	$CHF_2OCH_2CF_3$
HFE-254cb2	$CHF_2CF_2OCH_3$
HFE-263fb2	$CF_3CH_2OCH_3$
HFE-329mcc2	$CF_3CF_2OCF_2CHF_2$
HFE-338mcf2	$CF_3CF_2OCH_2CF_3$
HFE-347mcc3	$CF_3CF_2CF_2OCH_3$
HFE-347mcf2	$CF_3CF_2OCH_2CHF_2$
HFE-356mec3	$CF_3CHFCF_2OCH_3$
HFE-356mff2	$CF_3CH_2OCH_2CF_3$
HFE-356pcc3	$CHF_2CF_2CF_2OCH_3$
HFE-356pcf2	$CHF_2CF_2OCH_2CHF_2$
HFE-356pcf3	$CHF_2CF_2CH_2OCHF_2$
HFE-365mcf3	$CF_3CF_2CH_2OCH_3$
HFE-374pc2	$CHF_2CF_2OCH_2CH_3$
HFE-7100	$C_4F_9OCH_3$
HFE-7200	$C_4F_9OC_2H_5$
HFOC-125	CF_3OCHF_2
HFOC-134	CF_2HOCF_2H
HFOC-143a	CF_3OCH_3
HFOC-152a	CH_3OCHF_2
HFOC-245fa	$CHF_2OCH_2CF_3$
HFOC-356mmf	$CF_3CH_2OCH_2CF_3$
HG-01	$CHF_2OCF_2CF_2OCHF_2$
HG-10	$CHF_2OCF_2OCHF_2$
H-Galden 1040x	$CHF_2OCF_2OC_2F_4OCHF_2$
HNO_3	nitric acid
HO_2	hydroperoxyl
HO_x	the sum of OH and HO_2
H_2O	water vapour
H_2SO_4	sulphuric acid
N_2	molecular nitrogen
NF_3	nitrogen trifluoride
NH_3	ammonia
NH_4^+	ammonium ion
NMHC	non-methane hydrocarbon
NO	nitric oxide
NO_2	nitrogen dioxide
NO_x	nitrogen oxides (the sum of NO and NO_2)
NO_3	nitrate radical
NO_3^-	nitrate ion
N_2O	nitrous oxide
O_2	molecular oxygen
O_3	ozone
OCS	organic carbonyl sulphide
OH	hydroxyl radical
PAN	peroxyacetyl nitrate
PFC	perfluorocarbon
SF_6	sulphur hexafluoride
SF_5CF_3	trifluoromethyl sulphur pentafluoride
SO_2	sulphur dioxide
SO_4^{2-}	sulphate ion
VOC	volatile organic compounds

Appendix VIII

Index

† Term also appears in Appendix I: Glossary.
Numbers in italics indicate a reference to a table or diagram.
Numbers in bold indicate a reference to an entire chapter.