

Glossary ⁽³²⁾

Abrupt climate change — The nonlinearity of the climate system may lead to abrupt climate change, sometimes called rapid climate change, abrupt events or even surprises. The term abrupt often refers to time scales faster than the typical time scale of the responsible forcing. However, not all abrupt climate changes need be externally forced. Some possible abrupt events that have been proposed include a dramatic reorganisation of the thermohaline circulation, rapid deglaciation and massive melting of permafrost or increases in soil respiration leading to fast changes in the carbon cycle. Others may be truly unexpected, resulting from a strong, rapidly changing forcing of a nonlinear system.

Aerosols — A collection of airborne solid or liquid particles, with a typical size between 0.01 and 10 µm that reside in the atmosphere for at least several hours. Aerosols may be of either natural or anthropogenic origin. Aerosols may influence climate in several ways: directly through scattering and absorbing radiation, and indirectly by acting as cloud condensation nuclei or modifying the optical properties and lifetime of clouds.

Adaptation — Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory, autonomous and planned adaptation.

Adaptive capacity (in relation to climate change impacts) — The ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

Albedo — The fraction of solar radiation reflected by a surface or object, often expressed as a percentage.

Anthropogenic — Resulting from or produced by human beings.

Atmosphere — The gaseous envelope surrounding the Earth. The dry atmosphere consists almost entirely of nitrogen and oxygen, together with trace gases including carbon dioxide and ozone.

Baseline/reference — The baseline (or reference) is the state against which change is measured. It might be a 'current baseline', in which case it represents observable, present-day conditions. It might also be a 'future baseline', which is a projected future set of conditions excluding the driving factor of interest. Alternative interpretations of the reference conditions can give rise to multiple baselines.

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.

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

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. 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. The classical period of time is 30 years, as defined by the World Meteorological Organization (WMO).

Climate change — Climate change refers to any change in climate over time, whether due to natural

⁽³²⁾ This glossary was compiled by selecting the most relevant terms from various glossaries of the IPCC's 4th Assessment reports (IPCC, 2007) (See: <http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-annexes.pdf>; <http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-app.pdf>; <http://www.ipcc.ch/pdf/assessment-report/ar4/wg3/ar4-wg3-annex1.pdf>).

variability or as a result of human activity. This usage differs from that in the United Nations Framework Convention on Climate Change (UNFCCC), which 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'.

Climate (change) scenario — A plausible and often simplified representation of the future climate, based on an internally consistent set of climatological relationships and assumptions of radiative forcing, typically constructed for explicit use as input to climate change impact models. 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 the annual mean global surface temperature following a doubling of the atmospheric equivalent carbon dioxide concentration. Due to computational constraints, the equilibrium climate sensitivity in a climate model is usually estimated by running an atmospheric general circulation model coupled to a mixed-layer ocean model, because equilibrium climate sensitivity is largely determined by atmospheric processes. Efficient models can be run to equilibrium with a dynamic ocean. The effective climate sensitivity is a related measure that circumvents the requirement of equilibrium. It is evaluated from model output for evolving non-equilibrium conditions. It is a measure of the strengths of the climate feedbacks at a particular time and may vary with forcing history and climate state. The climate sensitivity parameter (units: $^{\circ}\text{C} (\text{W m}^{-2})^{-1}$) refers to the equilibrium change in the annual mean global surface temperature following a unit change in radiative forcing. The transient climate response is the change in the global surface temperature, averaged over a 20-year period, centred at the time of atmospheric carbon dioxide doubling, that is, at year 70 in a 1 % yr^{-1} compound carbon dioxide increase experiment with a global coupled climate model. It is a measure of the strength and rapidity of the surface temperature response to greenhouse gas forcing.

Climate system — The climate system is defined by the dynamics and interactions of five major components: atmosphere, hydrosphere, cryosphere, land surface, and biosphere. Climate system dynamics are driven by both internal and external forcing, such as volcanic eruptions, solar variations, or human-induced modifications to the planetary

radiative balance, for instance via anthropogenic emissions of greenhouse gases and/or land-use changes.

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

Control run — A model run carried out to provide a 'baseline' for comparison with climate-change experiments. The control run uses constant values for the radiative forcing due to greenhouse gases and anthropogenic aerosols appropriate to pre-industrial conditions.

Cost-benefit analysis — Monetary measurement of all negative and positive impacts associated with a given action. Costs and benefits are compared in terms of their difference and/or ratio as an indicator of how a given investment or other policy effort pays off seen from the society's point of view.

Cryosphere — The component of the climate system consisting of all snow, ice and frozen ground (including permafrost) on and beneath the surface of the Earth and ocean.

Desertification — Land degradation in arid, semi-arid, and dry sub-humid areas resulting from various factors, including climatic variations and human activities. Further, the United Nations Convention to Combat Desertification (UNCCD) 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 those 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.

Emission scenario — A plausible representation of the future development of emissions of substances that are potentially radiatively active (e.g. greenhouse gases, aerosols), based on a coherent and internally consistent set of assumptions about driving forces (such as demographic and

socioeconomic development, technological change) and their key relationships. Concentration scenarios, derived from emission scenarios, are used as input to a climate model to compute climate projections. In IPCC (1992) a set of emission scenarios was presented which were used as a basis for the climate projections in IPCC (1996). These emission scenarios are referred to as the IS92 scenarios. In the IPCC Special Report on Emission Scenarios (Nakićenović and Swart, 2000) 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 TAR-IPCC (2001) and 4AR-IPCC (2007).

Energy balance — The difference between the total incoming and total outgoing energy. If this balance is positive, warming occurs; if it is negative, cooling occurs. Averaged over the globe and over long time periods, this balance must be zero. Because the climate system derives virtually all its energy from the Sun, zero balance implies that, globally, the amount of incoming solar radiation on average must be equal to the sum of the outgoing reflected solar radiation and the outgoing thermal infrared radiation emitted by the climate system. A perturbation of this global radiation balance, be it anthropogenic or natural, is called radiative forcing.

Erosion — The process of removal and transport of soil and rock by weathering, mass wasting, and the action of streams, glaciers, waves, winds and underground water.

Extreme weather event — An extreme weather event is an event that is rare at a particular place and time of year. Definitions of rare vary, but an extreme weather event would normally be as rare as or rarer than the 10th or 90th percentile of the observed probability density function. By definition, the characteristics of what is called extreme weather may vary from place to place in an absolute sense. Single extreme events cannot be simply and directly attributed to anthropogenic climate change, as there is always a finite chance the event in question might have occurred naturally. When a pattern of extreme weather persists for some time, such as a season, it may be classed as an extreme climate event, especially if it yields an average or total that is itself extreme (e.g. drought or heavy rainfall over a season).

Feedback — An interaction mechanism between processes is called a feedback. When the result of an initial process triggers changes in a second process and that in turn influences the initial one. A positive

feedback intensifies the original process, and a negative feedback reduces it.

Forecast — Projected outcome from established physical, technological, economic, social, behavioral, etc. patterns.

Global warming — Global warming refers to the gradual increase, observed or projected, in global surface temperature, as one of the consequences of radiative forcing caused by anthropogenic emissions.

Greenhouse effect — Greenhouse gases effectively absorb thermal infrared radiation, emitted by the Earth's surface, by the atmosphere itself due to the same gases, and by clouds. Atmospheric radiation is emitted to all sides, including downward to the Earth's surface. Thus, greenhouse gases trap heat within the surface-troposphere system. This is called the greenhouse effect. Thermal infrared radiation in the troposphere is strongly coupled to the temperature of the atmosphere at the altitude at which it is emitted. In the troposphere, the temperature generally decreases with height. Effectively, infrared radiation emitted to space originates from an altitude with a temperature of, on average, $-19\text{ }^{\circ}\text{C}$, in balance with the net incoming solar radiation, whereas the Earth's surface is kept at a much higher temperature of, on average, $+14\text{ }^{\circ}\text{C}$. An increase in the concentration of greenhouse gases leads to an increased infrared opacity of the atmosphere, and therefore to an effective radiation into space from a higher altitude at a lower temperature. This causes a radiative forcing that leads to an enhancement of the greenhouse effect, the so-called enhanced greenhouse effect.

Greenhouse gas (GHG) — Greenhouse gases are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of thermal infrared radiation emitted by the Earth's surface, the atmosphere itself, and by clouds. This property causes the greenhouse effect. Water vapour (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4) and ozone (O_3) are the primary greenhouse gases in the Earth's atmosphere. Moreover, there are a number of entirely human-made greenhouse gases in the atmosphere, such as the halocarbons and other chlorine- and bromine-containing substances, dealt with under the Montreal Protocol. Beside CO_2 , N_2O and CH_4 , the Kyoto Protocol deals with the greenhouse gases sulphur hexafluoride (SF_6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs).

Gross domestic product — Gross domestic product (GDP) is the monetary value of all goods and services produced within a nation.

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

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 occurs when, e.g. forest is converted to agricultural land or to urban areas.

Likelihood — The likelihood of an occurrence, an outcome or a result, where this can be estimated probabilistically.

Macroeconomic costs — These costs are usually measured as changes in gross domestic product or changes in the growth of gross domestic product, or as loss of welfare or consumption.

Measures — Measures are technologies, processes, and practices that reduce GHG emissions or effects below anticipated future levels. Examples of measures are renewable energy technologies, waste minimization processes and public transport commuting practices, etc.

Mitigation — An anthropogenic intervention to reduce the anthropogenic forcing of the climate system; it includes strategies to reduce greenhouse gas sources and emissions and enhancing greenhouse gas sinks.

North Atlantic Oscillation (NAO) — The North Atlantic Oscillation (NAO) consists of opposing variations of barometric pressure near Iceland and near the Azores. It is the dominant mode of winter climate variability in the North Atlantic region.

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

Phenology — The study of natural phenomena that recur periodically (e.g. development stages, migration) and their relation to climate and seasonal changes.

Projection — The potential evolution of a quality 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, for example, future socio-economic and technological developments, that may or may not be realised — and are therefore subject to substantial uncertainty.

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 or external change in the forcing of the climate system, such as a change in the concentration of CO_2 or the output of the sun.

Reinsurance — The transfer of a portion of primary insurance risks to a secondary tier of insurers (reinsurers); essentially 'insurance for insurers'.

Resilience — The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organisation, and the capacity to adapt to stress and change.

River discharge/streamflow — Water flow within a river channel, for example expressed in m^3/s .

Runoff — That part of precipitation that does not evaporate and is not transpired.

Salinisation — The accumulation of salts in soils.

Scenario — 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.

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

Socio-economic scenarios — Scenarios concerning future conditions in terms of population, gross domestic product and other socio-economic factors relevant to understanding the implications of climate change.

Sustainable development — Development that meets the cultural, social, political and economic needs of the present generation without compromising the ability of future generations to meet their own needs.

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

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

Threshold — The level of magnitude of a system process at which sudden or rapid change occurs. A

point or level at which new properties emerge in an ecological, economic or other system, invalidating predictions based on mathematical relationships that apply at lower levels.

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, for example, a range of values calculated by various models, or by qualitative statements, for example, reflecting the judgement of a team of experts.

Vulnerability — Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity.

References

Summary

ACIA, 2004. *Impacts of a warming Arctic: Arctic Climate Impact assessment*, Cambridge University Press, Cambridge, UK.

Green Paper from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions – Adapting to climate change in Europe – options for EU action (SEC(2007) 849).

IPCC, 2007. *Climate Change 2007: Synthesis report Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, UK.

EC, 2004. *Communication from the Commission to the European Parliament and the Council: Global Monitoring for Environment and Security (GMES): Establishing a GMES capacity by 2008 – (Action Plan (2004–2008))* COM(2004)65 final <http://www.gmes.info/library/files/>.

EC, 2008. *Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions Towards a Shared Environmental Information System (SEIS)*, COM(2008)46 final, Brussels, 1.2.2008.

EC, 2007. Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE) <http://inspire.jrc.it/>.

EEA, 2004. *Impacts of Europe's changing climate, An indicator-based assessment*, EEA Report No 2/2004. EEA, Copenhagen.

UNEP, 2007. *Global Outlook for Ice and Snow*, (www.unep.org/geo/geo_ice).

Chapter 1 Introduction

ACIA, 2004. *Impacts of a warming Arctic: Arctic Climate Impact assessment*, Cambridge University Press, Cambridge, UK.

EEA, 2004. *Impacts of Europe's changing climate, An indicator-based assessment*, EEA Report No 2/2004. EEA, Copenhagen.

Human Development Report 2007/2008. *Fighting climate change: Human solidarity in a divided world*, Palgrave Macmillan, 2007, <http://hdr.undp.org/>.

IPCC, 2007. *Climate Change 2007: Synthesis report Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, UK.

UNEP, 2007. *Global Outlook for Ice and Snow*. www.unep.org/geo/geo_ice.

Chapter 2 The climate system and human activities

Crutzen P. J. and Stoemer, E. F., 2000. The 'Anthropocene' International Geosphere Biosphere Programme. *Newsletter* 41: 17–18.

Denman, K. L.; Brasseur, G.; Chidthaisong, A.; Ciais, P.; Cox, P. M.; Dickinson, R. E.; Hauglustaine, D.; Heinze, C.; Holland, E.; Jacob, D.; Lohmann, U.; Ramachandran, S.; da Silva Dias, P. L.; Wofsy, S.C. and Zhang, X., 2007. *Couplings Between Changes in the Climate System and Biogeochemistry*. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Solomon, S.; Qin, D.; Manning, M.; Chen, Z.; Marquis, M.; Averyt, K. B.; Tignor M. and Miller H. L., Eds., Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

IPCC, 2007. *Climate Change 2007: Synthesis report Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, UK.

Jansen, E.; Overpeck, J.; Briffa, K. R.; Duplessy, J.-C.; Joos, F.; Masson-Delmotte, V.; Olago, D.; Otto-Bliesner, B.; Peltier, W. R.; Rahmstorf, S.; Ramesh, R.; Raynaud, D.; Rind, D.; Solomina, O.; Villalba, R.; Zhang, D., 2007. *Palaeoclimate*. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth*

Assessment Report of the Intergovernmental Panel on Climate Change (Solomon, S.; Qin, D.; Manning, M.; Chen, Z.; Marquis, M.; Averyt, K. B.; Tignor, M. and Miller, H. L. (eds.)). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Lüthi, D.; Le Floch, M.; Bereiter, B.; Blunier, T.; Barnola, J.-M.; Siegenthaler, U.; Raynaud, D.; Jouzel, J.; Fischer, H.; Kawamura, K. and Stocker, T. F., 2008. High resolution carbon dioxide concentration record 650,000–800,000 years before present. *Nature* 453: 379–382.

Chapter 3 Observed climate changes impacts

Parry, M. L.; Canziani, O. F.; Palutikof, J. P. and co-authors, 2007. Technical Summary. *Climate Change 2007. Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Parry, M. L.; Canziani, O. F.; Palutikof, J. P.; van der Linden, P. J. and Hanson, C. E. (eds.), Cambridge University Press, Cambridge, UK, 23–78.

Rosenzweig, C.; Casassa, G.; Karoly, D. J.; Imeson, A.; Liu, C.; Menzel, A.; Rawlins, S.; Root, T. L.; Seguin, B.; Tryjanowski, P., 2007. Assessment of observed changes and responses in natural and managed systems. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Parry, M.L.; Canziani, O.F.; Palutikof, J. P.; van der Linden, P. J. and Hanson, C. E. (eds.), Cambridge University Press, Cambridge, UK, 79–131.

Rosenzweig, C.; Karoly, D.; Vicarelli, M.; Neofotis, P.; Wu, Q.; Casassa, G.; Menzel, A.; Root, T. L.; Estrella, N.; Seguin, B.; Tryjanowski, P.; Liu, C.; Rawlins, S.; and Imeson, A., 2008. Attributing physical and biological impacts to anthropogenic climate change. *Nature* 453: 353–357.

Chapter 4 Climate change impacts: what the future has in store

den Elzen, M. G. J.; Meinshausen, M. and van Vuuren, D. P., 2007. Multi-gas emission envelopes to meet greenhouse gas concentration targets: costs versus certainty of limiting temperature increase. *Global Environmental Change* 17 (2): 260–280.

EC, 2008. *20 20 by 2020: Europe's climate change opportunity*. Communication from the Commission COM(2008)13, 16, 17, 18, 19 final, Brussels.

EEA, 2007. *Climate change: the cost of inaction and the cost of adaptation*. EEA Technical report No 13/2007. EEA, Copenhagen.

IPCC, 2001. *Climate Change 2001: Mitigation*. Cambridge University Press, Cambridge, UK.

IPCC, 2007a. *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Solomon, S.; Qin, D.; Manning, M.; Chen, Z.; Marquis, M.; Averyt, K. B.; Tignor M. and Miller H. L., Eds., Cambridge University Press, Cambridge, UK.

IPCC, 2007b. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on climate Change*, Parry, M. L.; Canziani, O. F.; Palutikof, J. P.; van der Linden, P. J. and Hanson, C.E. (eds.), Cambridge University Press, Cambridge, UK.

IPCC, 2007c. *Climate Change 2007: Mitigation of Climate Change. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Metz, B.; Davidson, O. R.; Bosch, P. R.; Dave, R.; Meyer, L. A. (eds.), Cambridge University Press, Cambridge, UK.

IPCC, 2007d. *Climate Change 2007: Synthesis report Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge Univ Press, Cambridge, UK.

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

Parry, M. L.; Canziani, O. F.; Palutikof, J. P. and co-authors, 2007. Technical Summary. *Climate Change 2007. Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Parry, M.L.; Canziani, O. F.; Palutikof, J.P.; van der Linden, P. J. and C.E. Hanson (eds.), Cambridge University Press, Cambridge, UK, 23–78.

Scientific Expert Group on Climate Change (Bierbaum, R.M.; Holdren, J. P.; MacCracken, M. C.; Moss, R. H. and Raven, P. H. (eds.)), 2007. *Confronting Climate Change: Avoiding the Unmanageable and Managing the Unavoidable*. Report prepared for the United Nations Commission on Sustainable Development. Research Triangle Park, N.C., and Washington, D.C.: Sigma Xi and the United Nations Foundation.

UNFCCC, 2007. Decision -/CP.13, Bali Action Plan.

Van Vuuren, D.; Den Elzen, M.; Lucas, P.; Eickhout, B.; Strengers, B.; Van Ruijven, B.; Wonink, S. and Van den Houdt, R., 2007. Stabilizing greenhouse gas concentrations at low levels. An assessment of reduction strategies and costs. *Climatic Change* 81: 119–159.

Wigley, T. M. L. and Raper, S. C. B., 2001. Interpretation of high projections for global-mean warming. *Science* 293 (5529): 451–454.

Chapter 5 An indicator-based assessment

Section 5.2 Atmosphere and climate

ACIA, 2004. *Impacts of a warming Arctic: Arctic Climate Impact assessment*. Cambridge University Press, Cambridge, UK.

Andersson, C.; Langner, J. and Bergström, R., 2007. Interannual variation and trends in air pollution over Europe due to Climate variability during 1958–2001 simulated with a regional CTM coupled to the ERA40 reanalysis, *Tellus* 59B: 77–98.

Bengtsson, L.; Hodges, K. I. and Hagemann, S., 2004. Sensitivity of the ERA40 reanalysis to the observing system: determination of the global atmospheric circulation from reduced observations, *Tellus* 56A: 456–471.

Beniston, M., 2007. Linking extreme climate events and economic impacts: Examples from the Swiss Alps. *Energy Policy* 35: 5384–5392.

Beniston, M.; Stephenson, D. B.; Christensen, O. B.; Ferro, C. A. T.; Frei, C.; Goyette, S.; Halsnaes, K.; Holt, T.; Jylhä, K.; Koffi, B.; Palutikoff, J.; Schöll, R.; Semmler, T. and Woth, K., 2007. Future extreme events in European climate: An exploration of regional climate model projections. *Climatic Change* 81: 71–95.

Böhm R.; Auer, I.; Brunetti, M.; Maugeri, M.; Nanni, T.; Schöner, W., 2001. Regional temperature variability in the European Alps: 1760–1998 from homogenized instrumental time series. *International Journal of Climatology* 21: 1779–801.

Christensen, J. H.; Hewitson, B.; Busuioc, A.; Chen, A.; Gao, X.; Held, I.; Jones, R.; Kolli, R. K.; Kwon, W.-T.; Laprise, R.; Magaña Rueda, V.; Mearns, L.; Menéndez, C. G.; Räisänen, J.; Rinke, A.; Sarr, A. and Whetton, P., 2007. Regional Climate Projections. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Solomon, S.; Qin, D.; Manning, M.; Chen, Z.; Marquis, M.; Averyt, K. B.; Tignor, M. and Miller, H. L. (eds.), Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Dankers, R. and Hiederer, R., 2008. *Extreme Temperatures and Precipitation in Europe: Analysis of a High-Resolution Climate Change Scenario*. EUR 23291 EN. Office for Official Publications of the European Communities Luxembourg. 66 pp.

Della-Marta, P. M.; Haylock, M. R.; Luterbacher, J. and Wanner, H., 2007. Doubled length of western European summer heat waves since 1880. *Journal of Geophysical Research* 112, D15103, DOI:10.1029/2007JD008510.

Fiala, J.; Cernikovský, L.; de Leeuw, F.; Kurfuerst, P., 2003. Air pollution by ozone in Europe in summer 2003, *EEA Topic report* No. 3/2003.

Fischer-Bruns, I.; von Storch, H.; González-Rouco, F. and Zorita E., 2005. Modelling the variability of midlatitude storm activity on decadal and century time scales. *Climate Dynamic*, 25: 461–476.

Giorgi, F., Bi, X.Q., Pal, J., 2004. Mean, interannual variability and trends in a regional climate change experiment over Europe. II: climate change scenarios (2071–2100), *Climate Dynamic*, 23 (7–8): 839–858.

Halsnæs, K.; Köhl, J.; Olesen, J. E., 2007. Turning climate change information into economic and health impacts. *Climatic Change* 81: 145–162.

Hogrefe, C.; Biswas, J.; Lynn, B.; Civerolo, K.; Ku, J. Y.; Rosenthal, J.; Rosenzweig, C.; Goldberg, R. and Kinney, P. L., 2004. Simulating regional-scale ozone climatology over the eastern United States: model evaluation results. *Atmospheric Environment* 38 (17): 2627–2638.

Holland, M.; Kinghorn, S.; Emberson, L.; Cinderby, S.; Ashmore, M.; Mills, G. and Harmens, H., 2006. Development of a framework for probabilistic assessment of the economic losses caused by ozone damage to crops in Europe, *CEH project No. C02309NEW*. Centre for Ecology and Hydrology, Natural Environment Research Council, Bangor, Wales, 49 pp.

Hurrell, J.W.; Kushnir, Y.; Ottensen, G. and Visbeck, M., 2003. An overview of the North Atlantic Oscillation. In: *The North Atlantic Oscillation: Climatic Significance and Environmental Impact* (Hurrell, J.W. et al. (eds.)). *Geophysical Monograph*, 134, Amer. Geophys. U., Washington, DC:1–35.

IPCC, 2001. *Climate Change 2001: The scientific basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change*. Houghton, J. T. et al. (eds), Cambridge University Press, UK.

IPCC, 2007a. *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Solomon, S.; Qin, D.; Manning, M.; Chen, Z.; Marquis, M.; Averyt, K. B.; Tignor M. and Miller H. L. (eds.), Cambridge University Press, Cambridge, UK.

IPCC, 2007b. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel*

- on *Climate Change*, Parry, M. L.; Canziani, O. F.; Palutikof, J. P.; van der Linden, P. J. and Hanson, C. E. (eds.), Cambridge University Press, Cambridge, UK.
- Kjellström, E., 2004. Recent and Future Signatures of Climate Change in Europe. *AMBIO: A Journal of the Human Environment* 33 (4): 193–198
- Kjellström, E.; Bärring, L.; Jacob, D.; Jones, R.; Lenderink, G. and Schär, C., 2007. Variability in daily maximum and minimum temperatures: recent and future changes over Europe. *Climatic Change* 81: 249–265.
- Klein Tank, A. M. G.; Wijngaard J. B. et al., 2002. Daily dataset of 20th-century surface air temperature and precipitation series for the European Climate Assessment. *International Journal of Climatology* 22: 1441–1453.
- Klein Tank, A. M. G. and Können G. P., 2003. Trends in indices of daily temperature and precipitation extremes in Europe, 1946–1999. *Journal of Climate* 16: 3665–3680.
- Klein Tank, A., 2004. Changing Temperature and Precipitation Extremes in Europe's Climate of the 20th Century. PhD-thesis. De Bilt, the Netherlands, 124 pp.
- Lambert, S. J. and Fyfe J. C., 2006. Changes in winter cyclone frequencies and strengths simulated in enhanced greenhouse warming experiments; results from the models participating in the IPCC diagnostic exercise. *Climate Dynamics* 26 (7–8): 713–728.
- Lionello, P., 2005. Extreme surges in the Gulf of Venice. Present and future climate Venice and its lagoon, State of Knowledge. Fletcher, C. and Spencer, T. (eds.), Cambridge University Press, Cambridge, UK, pp. 59–65.
- Lloyd-Hughes, B. and Saunders, M. A., 2002. A drought climatology for Europe. *International Journal of Climatology* 22: 1571–1592.
- Lowe, J. A. and Gregory, J. M., 2005. The effects of climate change on storm surges around the United Kingdom. *Proceedings of the Royal Society of London. Series A*: 363: 1313–1328.
- Luterbacher, J.; Dietrich, D.; Xoplaki, E.; Grosjean, M.; Wanner, H., 2004. European seasonal and annual temperature variability, trends, and extremes since 1500. *Science* 303: 1499–1503.
- Matulla, C.; Schöner, W.; Alexandersson, H.; von Storch, H. and Wang. X. L., 2007. European storminess: late nineteenth century to present. *Climate Dynamics*, DOI 10.1007/s00382-007-0333-y.
- Meleux, F.; Solmon, F. and Giorgi, F., 2007. Increase in summer European ozone amounts due to climate change. *Atmospheric Environment*, 41, 7577–7587: 10.1016/j.atmosenv.2007.05.048.
- Norrant, C. and Douguédroit, A., 2006. Monthly and daily precipitation trends in the Mediterranean (1950–2000). *Theoretical and Applied Climatology* 83:89–106, DOI 10.1007/s00704-005-0163-y.
- OECD, 2008. *Environmental outlook to 2030*. OECD Publishing, <http://213.253.134.43/oecd/pdfs/browseit/9708011E.PDF>.
- Pinto, J. G.; Fröhlich, E. L.; Leckebusch, G. C. and Ulbrich, U., 2007. Changing European storm loss potentials under modified climate conditions according to ensemble simulations of the ECHAM5/MPI-OM1 GCM. *Natural Hazards and Earth System Sciences* 7: 165–175.
- Räisänen J.; Hansson, U.; Ullerstig, A.; Döscher, R.; Graham, L. P.; Jones, C.; Meier, H. E. M.; Samuelsson, P. and Willén, U., 2004. European climate in the late 21st century: regional simulations with two driving global models and two forcing scenarios. *Climate Dynamics* 22: 13–31.
- Rao, S. T.; Ku, J. Y.; Berman, S.; Zhang, D. and Mao, H., 2003. Summertime characteristics of the atmospheric boundary layer and relationships to ozone levels over the eastern United States. *Pure and Applied Geophysics* 160: 21–55.
- Rijsberman, F. R. and Swart, R. J. (eds.), 1990. Targets and Indicators of Climatic Change. *Stockholm Environment Institute*, Stockholm, 1990.
- Robock, A.; Mu, M.; Vinnikov, K.; Trofimova, I. V. and Adamenko, T. I., 2005. Forty-five years of observed soil moisture in the Ukraine: No summer desiccation (yet). *Geophysical Research Letters* 32: 10.1029/2004GL021914.
- Schär, C.; Vidale, P. L.; Lüthi, D.; Frei, C.; Häberli, C.; Liniger, M. A. and Appenzeller, C., 2004. The role of increasing temperature variability in European summer heatwaves. *Nature* 427: 332–336.
- Schär, C. and Jendritzky, G., 2004. Hot news from summer 2003. *Nature* 432: 559–560.
- Schichtel, B. A. and Husar, R. B., 2001. Eastern North American transport climatology during high- and low-ozone days. *Atmospheric Environment* 35: 1029–1038.
- Sillmann, J. and Roeckner, E., 2008. Indices for extreme events in projections of anthropogenic climate change. *Climatic Change* 86 (1–2): 83–104.
- Simmons, A. J.; Jones, P. D.; da Costa Bechtold, V.; Beljaars, A. C. M.; Kållberg, P. W.; Saarinen, S.; Uppala, S. M.; Viterbo, P. and Wedi, N., 2004. Comparison of trends and low-frequency variability in CRU, ERA-40, and NCEP/NCAR analyses of surface air temperature. *Journal of Geophysical Research* 109, D24115, DOI:10.1029/2004JD005306.

- Smits, A.; Klein Tank, A. M. G. and Können G. P., 2005. Trends in storminess over the Netherlands, 1962–2002. *International Journal of Climatology* 25: 1331–1344.
- Sousounis P. J.; Scott, C. P. J. and Wilson. M. L., 2002. Possible climate change impacts on ozone in the Great Lakes region: Some implications for respiratory illness. *Journal Of Great Lakes Research* 28 (4): 626–642.
- Stevenson, D. S.; Dentener, F. J.; Schultz, M. G.; Ellingsen, K.; van Noije, T. C. P.; Wild, O.; Zeng, G.; Amann, A.; Atherton, C. A.; Bell, N.; Bergmann, D. J.; Bey, I.; Butler, T.; Cofala, J.; Collins, W. J.; Derwent, R. G.; Doherty, R. M.; Drevet, J.; Eskes, H. J.; Fiore, A. M.; Gauss, M.; Hauglustaine, D. A.; Horowitz, L. W.; Isaksen, I. S. A.; Krol, M. C.; Lamarque, J.-F.; Lawrence, M. G.; Montanaro, V.; Müller, J.-F.; Pitari, G.; Prather, M. J.; Pyle, J. A.; Rast, S.; Rodriguez, J. M.; Sanderson, M. G.; Savage, N. H.; Shindell, D. T.; Strahan, S. E.; Sudo, K. and Szopa, S., 2006. Multimodel ensemble simulations of present-day and near-future tropospheric ozone. *Journal of Geophysical Research* 111, D08301, DOI:10.1029/2005JD006338.
- Tebaldi, C.; Hayhoe, K.; Arblaster, J. M. and Meehl, G. A., 2006. Going to the extremes: an intercomparison of model-simulated historical and future changes in extreme events. *Climatic Change* 79: 185–211.
- Third WCRP International Conference on Reanalysis Conference Statement, 2008. <http://jra.kishou.go.jp/3rac/en.html>.
- Thompson, D. W. J.; Wallace, J. M. and Hegerl., G. C., 2000. Annular modes in the extratropical circulation. Part II: Trends. *Journal of Climate* 13: 1018–1036.
- van den Hurk, B.; Klein Tank, A.; Lenderink, G.; van Ulden, A.; van Oldenborgh, G. J.; Katsman, C.; van den Brink, H.; Keller, F.; Bessembinder, J.; Burgers, G.; Komen, G.; Hazeleger, W. and Sybren Drijfhout, S., 2006. KNMI Climate Change Scenarios 2006 for the Netherlands, *KNMI Scientific Report WR 2006-01*, 3730 AE De Bilt.
- van der Schrier, G.; Briffa, K. R.; Jones, P. D. and Osborn, T. J., 2006. Summer moisture variability across Europe. *Journal of Climate* 19: 2818–2834.
- Van Dingenen, R.; Raes, F.; Dentener, F.; Putaud, J. P. and Micale, F., 2008. The relation between temperature anomaly and ozone exceedance as an indication for the role of climate change on ozone exceedance in Europe (manuscript in preparation).
- van Lannen, H. A. J.; Tallaksen, L. M.; Rees, G., 2007. Drought and climate change (In: *Commission Staff Working Document Impact Assessment* (SEC(2007)993, (COM(2007)414), Commission of the European Communities, Brussels, Belgium).
- Vliet, A. J. H. van and Leemans, R., 2006. Ecological impacts of climate change in The Netherlands. In Harley, M.; Cordi, B.; Abreu, A. and Nijhoff, P. (eds.). *Climate change and biodiversity-meeting the challenge; people and nature: plan, adapt and survive: report of the 13th Annual Conference of the European Environment and Sustainable Development Advisory Councils EEAC, Oxford, 7–10 September 2005*, pp. 81–83. English Nature, London.
- von Storch, H.; Feser, F.; Pfizenmayer, A. and Weisse, R., 2002. Changig coastal weather and extremes. *Proceedings WCSE/UKC-2002, Weather Risk Management*, Seoul, 2002, 468–473.
- Wade, S. D., 2007. Contribution to EU Medin SSA on drought, 2007 (unpublished).
- WBGU, 2003. *Climate Protection Strategies for the 21st Century: Kyoto and Beyond*. Berlin.
- WMO, 2004. World Meteorological Organization statement on the status of global climate in 2003. *WMO publications*, Geneva, 12 pp.
- Woth, K., 2005. North Sea storm surge statistics based on projections in a warmer climate: How important are the driving GCM and the chosen emission scenario? *Geophysical Research Letters* 32, L22708, DOI:10.1029/2005GL023762.

Section 5.3 Cryosphere

ACIA, 2004. *Impacts of a warming Arctic: Arctic Climate Impact assessment*. Cambridge University Press, Cambridge, UK.

Andreassen, L.M.; Elvehøy, H.; Kjøllmoen, B.; Engeset, R.V. and Haakensen, N., 2005. Glacier mass balance and length variations in Norway. *Annals of Glaciology* 42, 317–325.

Bamber, J. L.; Krabill, W.; Raper, V. and Dowdeswell, J., 2004. Anomalous recent growth of part of a large Arctic ice cap: Austfonna, Svalbard. *Geophysical Research Letters* 31(12), L12402.

Beniston, M., 2003. Climatic change in mountain regions: a review of possible impacts. *Climatic Change* 59: 5-31.

Bevan, S.; Luckman, A.; Murray, T.; Sykes, H. and Kohler, J., 2007. Positive mass balance during the late 20th century on Austfonna, Svalbard, revealed using satellite radar interferometry. *Annals of Glaciology* 46: 117–122.

Brodzik, M. J.; Armstrong, R. I.; Weatherhead, E. C.; Savoie, M. H.; Knowles, W. K. and Robinson, D. A., 2006. Regional trend analysis of satellite derived snow extent and global temperature anomalies, *American Geophysical Union, Fall 2006*. San Francisco, USA.

Christensen, J. H. and Christensen, O. B., 2007. A summary of the PRUDENCE model projections of changes

- in European climate by the end of this century. *Climatic Change* 81: 7–30.
- Clark, M. P.; Serreze, M. C. and Robinson, D. A., 1999. Atmospheric controls on Eurasian snow extent. *International Journal of Climatology* 19: 27–40.
- Comiso, J. C.; Parkinson, C.; Gersten, R. and Stock, L., 2008. Accelerated decline in the Arctic sea ice cover. *Geophysical Research Letters* 35, L01703.
- Davies, M. C. R.; Hamza, O. and Harris, C., 2001. The effect of rise in mean annual temperature on the stability of rock slopes containing ice-filled discontinuities. *Permafrost and Periglacial Processes* 12 (1): 137–144.
- Dye, D. G., 2002. Variability and trends in the annual snow-cover cycle in Northern Hemisphere land areas, 1972–2000. *Hydrological Processes* 16: 3065–3077.
- Elsasser, H. and Bürki, R., 2002. Climate change as a threat to tourism in the Alps. *Climate Research* 20: 253–257.
- Falarz, M., 2002. Long-term variability in reconstructed and observed snow cover over the last 100 winter seasons in Cracow and Zakopane (southern Poland). *Climate Research* 19 (3): 247–256.
- Greene, A.M., 2005. A time constant for hemispheric glacier mass balance. *Journal of Glaciology* 51 (174): 353–362.
- Gruber, S. and Haeberli, W., 2007. Permafrost in steep bedrock slopes and its temperature-related destabilization following climate change. *Journal of Geophysical Research* 112, p. F02S18.
- Gruber, S.; King, L.; Kohl, T.; Herz, T.; Haeberli, W. and Hoelzle, M., 2004a. Interpretation of geothermal profiles perturbed by topography: the Alpine permafrost boreholes at Stockhorn Plateau, Switzerland. *Permafrost and Periglacial Processes* 15 (4): 349–357.
- Gruber, S.; Hoelzle, M. and Haeberli, W., 2004b. Permafrost thaw and destabilization of alpine rock walls in the hot summer of 2003. *Geophysical Research Letters* 31, L13504.
- Haas, C., 2004. Late-summer sea ice thickness variability in the Arctic Transpolar Drift 1991–2001 derived from ground-based electromagnetic sounding. *Geophysical Research Letters* 31, L09402, 5 pp., DOI:10.1029/2003GL019394.
- Haas, C.; Hendricks, S. and M. Doble., 2006. Comparison of the sea ice thickness distribution in the Lincoln Sea and adjacent Arctic Ocean in 2004 and 2005. *Annals of Glaciology* 44: 247–252.
- Haas, C.; Pfaffling, A.; Hendricks, S.; Rabenstein, L.; Etienne, J.-L. and Rigor, I., 2008. Reduced ice thickness in Arctic Transpolar Drift favors rapid ice retreat, *Geophysical Research Letters* (in press).
- Haeberli, W.; Noetzi, J.; Zemp, M.; Baumann, S.; Frauenfelder R. and Hoelzle, M., 2005. *Glacier Mass Balance Bulletin No. 8, 2002–2003*. IUGG(CCS)–UNEP–UNESCO–WMO, World Glacier Monitoring Service, Zurich.
- Haeberli, W.; Zemp, M. and Hoelzle, M., 2007. *Glacier Mass Balance Bulletin No.9, 2004–2005*. ISCU(FAGS)–IUGG(IACS)–UNEP–UNESCO–WMO, World Glacier Monitoring Service, Zurich.
- Hagen, J. O.; Melvold, K.; Kohler, J. and Winther, J.-G., 2003. Glaciers in Svalbard: mass balance, runoff and freshwater flux. *Polar Research* 22 (2): 145–159.
- Hanna, E.; Box, J. and Huybrechts, P., 2007. Greenland Ice Sheet mass balance. *Arctic Report Card* 2007. <http://www.arctic.noaa.gov/>.
- Hantel, M. and Hirtl-Wielke, L.-M., 2007. Sensitivity of Alpine snow cover to European temperature. *International Journal of Climatology* 27: 1265–1275.
- Harris, C.; Vonder Mühl, D.; Isaksen, K.; Haeberli, W.; Sollid, J. L.; King, L.; Holmlund, P.; Dramis, F.; Guglielmin, M. and Palacios, D., 2003. Warming permafrost in European mountains. *Global and Planetary Change* 39: 215–225.
- Holland, M.; Blitz, C. and Tremblay, B., 2006. Future abrupt reductions in the summer Arctic sea ice. *Geophysical Research Letters* 33. L23503, DOI:10.1029/2006GL028024.
- Hosaka, M.; Nohara, D. and Kitoh, A., 2005. Changes in snow coverage and snow water equivalent due to global warming simulated by a 20 km-mesh global atmospheric model. *Scientific Online Letters on the Atmosphere* 1: 93–96.
- Huggel, C.; Haeberli, W. and Käab, A., 2007. *Glacial hazards: changing threats, response and management in different high-mountain regions of the world*. In: B. Orlove, B. Luckman, E. Wiegandt (Eds.), *The Darkening Peaks: Glacial Retreat in Scientific and Social Context*, University of California Press.
- Hyvärinen, V., 2003. Trends and characteristics of hydrological time series in Finland. *Nordic Hydrology* 34 (1–2): 71–90.
- IPCC, 2007a. *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Solomon, S.; Qin, D.; Manning, M.; Chen, Z.; Marquis, M.; Averyt, K. B.; Tignor M. and Miller H. L. (eds.), Cambridge University Press, Cambridge, UK.
- IPCC, 2007b *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the*

- Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Parry, M. L.; Canziani, O. F.; Palutikof, J. P.; van der Linden, P. J. and Hanson, C. E. (eds.), Cambridge University Press, Cambridge, UK.
- Isaksen, K.; Sollid, J. L.; Holmlund, P. and Harris C., 2007. Recent warming of mountain permafrost in Svalbard and Scandinavia. *Journal of Geophysical Research* 112, F02S04.
- Jacob, D.; Göttel, H.; Lorenz, P., 2007. *Hochaufgelöste regionale Klimaszenarien für Deutschland, Österreich und die Schweiz*, DMG-Mitteilungen, 03/07, Berlin.
- Jylhä, K.; Fronzek, S.; Tuomenvirta, H.; Carter, T. R. and Ruosteenoja, K., 2007. Changes in frost and snow in Europe and Baltic sea ice by the end of the 21st century. *Climatic Change*, DOI 10.1007/s10584-007-9310-z.
- Kitajev, L.; Foerland, E.; Razuvaev, V.; Tveito, O. E. and Krueger, O., 2005. Distribution of snow cover over Northern Eurasia. *Nordic Hydrology* 36: 311–319.
- Kohler, J.; Brandt, O.; Johansson, M. and Callaghan, T., 2006. A long-term Arctic snow depth record from Abisko, northern Sweden, 1913–2004. *Polar Research* 25 (2): 91–113.
- Kohler, J.; James, T. D.; Murray, T.; Nuth, C.; Brandt, O.; Barrand, N. E.; Aas, H. F. and Luckman, A., 2007. Acceleration in thinning rate on western Svalbard glaciers. *Geophysical Research Letters* 34, L18502, DOI:10.1029/2007GL030681.
- Lawrence, D. M.; Slater, A. G.; Romanovsky, V. E. and Nicolsky, D. J., 2008. The sensitivity of a model projection of near-surface permafrost degradation to soil column depth and inclusion of soil organic matter, *In press J. Geophys. Res.*
- Meier, W. N.; Stroeve, J.; Fetterer, F.; 2007. Whither Arctic sea ice? A clear signal of decline regionally, seasonally and extending beyond the satellite record. *Annals of Glaciology* 46: 428–434.
- NSIDC (National Snow and Ice Data Center), 2007: *Arctic Sea Ice Shatters All Previous Record Lows*. http://www.nsidc.org/news/press/2007_seaiceminimum/20071001_pressrelease.html.
- Nesje, A.; Bakke, J.; Dahl, S. O.; Lie, O. and Matthews, J. A., 2008. Norwegian mountain glaciers in the past, present and future. *Global and Planetary Change* 60: 10–27.
- Nghiem, S. V.; Rigor, I. G.; Perovich, D. K.; Clemente-Colon, P.; Weatherly, J. W. and Neumann, G., 2007. Rapid reduction of Arctic perennial sea ice. *Geophysical Research Letters* 34, L19504.
- Noetzli, J.; Hoelzle, M. and Haeberli, W., 2003. Mountain permafrost and recent Alpine rock-fall events: a GIS-based approach to determine critical factors. In: Phillips, M., Springman, S.M. and L.U. Arenson (eds). *8th International Conference on Permafrost, 20–25 July 2003, Zurich, Lisse*. A. A. Balkema Publishers, the Netherlands.
- Nuth, C.; Kohler, J.; Aas, H. F.; Brandt, O. and Hagen, J. O., 2007. Glacier geometry and elevation changes on Svalbard (1936–90). *Annals of Glaciology* 46: 106–116.
- OECD, 2007. *Climate Change in the European Alps*, OECD publishing; Paris, France.
- Paul, F.; Kääb, A.; Maisch, M.; Kellenberger, T. and Haeberli, W., 2004. Rapid disintegration of Alpine glaciers observed with satellite data. *Geophysical Research Letters* 31: L21402.
- PERMOS, 2007. *Permafrost in Switzerland 2002/2003 and 2003/2004*. Glaciological Report (Permafrost) 4(5) of the Glaciological Commission of the Swiss Academy of Sciences (SAS) and Department of Geography, University of Zurich.
- Petkova, N.; Koleva, E. and Alexandrov, V., 2004. Snow cover variability and change in mountainous regions of Bulgaria, 1931–2000. *Meteorologische Zeitschrift* 13 (1): 19–23.
- Phillips, M.; Ladner, F.; Müller, M.; Sambeth, U.; Sorg, J. and Teyssere, P., 2007. Monitoring and reconstruction of a chairlift midway station in creeping permafrost terrain, Grächen, Swiss Alps. *Cold Regions Science and Technology* 47: 32–42.
- Pralong, A. and Funk, M., 2005. On the instability of hanging glaciers. *Journal of Glaciology* 52 (176): 31–48.
- Rignot, E. and Kanagaratnam, P., 2006. Changes in the Velocity Structure of the Greenland Ice Sheet. *Science* 17 (311): 986–990.
- Rodríguez J. M. M. et al., 2005. *Evaluación Preliminar de los Impactos en España por Efecto del Cambio Climático*, Edita: Centro de Publicaciones. Secretaría General Técnica. Ministerio de Medio Ambiente, Madrid; Spain; 2005.
- Scherrer, S. C.; Appenzeller C. and Laternser, M., 2004. Trends in Swiss alpine snow days — the role of local and large scale climate variability. *Geophysical Research Letters* 31, L13215.
- Serreze, M.; Holland, M. and Stroeve J., 2007. Perspectives on the Arctic's Shrinking Sea-Ice Cover. *Science* 315: 1533–1536.
- Steffen, K.; Nghiem, S. V.; Huff, R. and Neumann, G., 2004. The melt anomaly of 2002 on the Greenland Ice Sheet from active and passive microwave satellite observations. *Geophysical Research Letters* 31 (20): L2040210.1029/2004GL020444.
- Steffen, K., 2007. Presentation at AGU meeting December 2007, see <http://cires.colorado.edu/news/press/2007/07-12-10greenland.html>.

- Stroeve, J.; Holland, M.; Meier, W.; Scambos, T. and Serreze, M., 2007. Arctic sea ice decline: Faster than forecast. *Geophysical Research Letters* 34, L09501, DOI:10.1029/2007GL029703.
- Sugiyama, S.; Bauder, A.; Zahno, C. and Funk, M., 2007. Evolution of Rhonegletscher, Switzerland, over the past 125 years and in the future: application of an improved flowline model. *Annals of Glaciology* 46: 268–274.
- Thies, H.-J.; M Nickus, U.; Mair, V.; Tessadri, R.; Tait, D.; Thaler, B. and Psenner, R., 2007. Unexpected Response of High alpine Lake Waters to Climate Warming. *Environmental Science & Technology* 41: 7424–7429.
- Thomas, R.; Davis, C.; Frederick, E.; Krabill, W.; Li, Y.; Manizade, S. and Martin, C., 2008. A comparison of Greenland ice-sheet volume changes derived from altimetry measurements. *Journal of glaciology* 54 (185): 203–212.
- Truffer, M. and Fahnestock, M., 2007. Rethinking Ice Sheet Time Scales. *Science* 315 (5818): 1508–1510.
- UNEP, 2007. *Global outlook for snow and ice*. UNEP Arendal/ Nairobi 2007.
- UNEP, 2008. *Meltdown in the Mountains*. UNEP Zürich/ Nairobi 2008.
- Vojtek, M.; Faško, P. and Štátný, P., 2003. Some selected snow climate trends in Slovakia with respect to altitude. *Acta Meteorologica Universitatis Comenianae* 32: 17–27.
- Vonder Mühll, D.; Noetzli, J.; Makowski, K. and Delaloye, R., 2007. Permafrost in Switzerland 2002/2003 and 2003/2004. *Glaciological Report (Permafrost)* No. 4/5 of the Cryospheric Commission (CC) of the Swiss Academy of Sciences (SCNAT) and Department of Geography, University of Zurich. 106 pp.
- Winton, M., 2006. Does the Arctic sea ice have a tipping point? *Geophysical Research Letters* 33.
- Witze, A., 2008. Losing Greenland. *Nature* 452: 798–802.
- Zemp, M.; Frauenfelder, R.; Haeberli, W. and Hoelzle, M., 2005. Worldwide glacier mass balance measurements: General trends and first results of the extraordinary year 2003 in Central Europe. In: Sciences R.A.o. (eds). *XIII Glaciological Symposium, Shrinkage of the Glacosphere: Facts and Analysis* 97. St. Petersburg, Russia.
- Zemp, M.; Haeberli, W.; Hoelzle, M. and Paul, F., 2006. Alpine glaciers to disappear within decades? *Geophysical Research Letters* 33: L13504.
- Zhang, T.; Barry, R. G.; Knowles, K.; Heginbottom, J.A. and Brown, J., 2000. Further statistics on the distribution of permafrost and ground ice in the Northern Hemisphere. *Polar Geography* 24: 126–131.
- Section 5.4 Marine biodiversity and ecosystems**
- ACIA, 2004. *Impacts of a warming Arctic: Arctic Climate Impact assessment*, Cambridge University Press, Cambridge, UK.
- Arnell, N. W., 2004. Climate change and global water resources: SRES emissions and socio-economic scenarios. *Global Environmental Change* 14: 31–52.
- Beare, D. J.; Burns, F.; Greig, A.; Jones, E. G.; Peach, K.; Kienzle, M.; McKenzie, E. and Reid, D. G., 2004. Long-term increases in prevalence of North Sea fishes having southern biogeographic affinities. *Marine Ecology Progress Series*, 284: 269–278.
- Beare, D.; Burns, F.; Jones, E.; Peach, K. and Reid, D., 2005. Red mullet migration into the northern North Sea during late winter. *Journal of Sea Research*, 53: 205–212.
- Beaugrand, G.; Reid, P. C.; Ibañez, F.; Lindley, J. A. and Edwards, M., 2002. Reorganization of North Atlantic marine copepod biodiversity and climate. *Science* 296: 1692–1694.
- Beugrand, G.; Brandner, K. M.; Lindley, J. A.; Souissi, S.; Reid, P. C., 2003. Plankton effect on cod recruitment in the North Sea. *Nature* 426: 661–664.
- Brander, K. M., 2007. Global Fish Production and Climate Change. Proceedings of the National Academy of Sciences of the United States of America, vol. 104, no 50: 19709–19714.
- Brander, K. M.; Blom, G.; Borges, M. F.; Erzini, K.; Henderson, G.; Mackenzie, B. R.; Mendes, H.; Ribeiro, J.; Santos, A. M. P. and Toresen, R., 2003. Changes in fish distribution in the eastern North Atlantic: Are we seeing a coherent response to changing temperature? *ICES Marine Science Symposia* 219: 261–270.
- Caldeira, K. and Wickett, M. E., 2003. Antropogenic carbon and ocean pH. *Nature* 425: 365–365.
- Caldeira, K. and Wickett, M. E., 2005. Ocean model predictions of chemistry changes from carbon dioxide emissions to the atmosphere and ocean, *Journal of Geophysical Research* 110, C09S04, DOI:10.1029/2004JC002671.
- Cazenave, A., 2006. How fast are the ice sheets melting? *Science* 314: 1250–1252.
- Chen, J. L.; Wilson, C. R. and Tapley, B. D., 2006. Satellite gravimetry measurements confirm accelerated melting of Greenland ice sheet. *Science* 313: 1958–60.
- Church, J. A. and White, N. J., 2006. A 20th century acceleration in global sea-level rise. In *Geophysical Research Letters* 33, L01602.

- Coetlogon, G. de; Frankignoul, C.; Bentsen, M.; Delon, C.; Haak, H.; Masina, S. and Pardaens, A., 2006. The gulf stream variability in five oceanic circulation models. *Journal of Physical Oceanography* 36 (11): 2119–2135.
- Coppini, G. and Pinardi, N., 2007. Compiled for EEA by the Istituto Nazionale di Geofisica e Vulcanologia (INGV) based on datasets made available by the Hadley Center HADISST1: <http://hadobs.metoffice.com/hadisst/data/download.html>.
- Coppini, G.; Pinardi, N.; Marullo, S. and Loewe, P., 2007. Compiled for EEA by the Istituto Nazionale di Geofisica e Vulcanologia (INGV) based on datasets made available by the Hadley Center. HADISST1: <http://hadobs.metoffice.com/hadisst/data/download.html>. ENEA within Mediterranean Operational Oceanography Network (MOON), and Bundesamt für Seeschifffahrt und Hydrographie (BSH) within the Baltic Operational Oceanography System (BOOS).
- Cunningham, S. A.; Kanzow, T.; Rayner, D.; Baringer, M. O.; Johns, W. E.; Marotzke, J.; Longworth, H. R.; Grant, E. M.; Hirschi, J. M. M.; Beal, L. M.; Meinen, C. S. and Bryden, H. L., 2007. Temporal variability of the Atlantic meridional overturning circulation at 26.5 degrees N. *Science* 317: 935–939.
- Curry, R. and Mauritzen, C., 2005. Dilution of the Northern North Atlantic Ocean in Recent Decades. *Science* 308: 1772–1774.
- Demirov E. and Pinardi N., 2002. Simulation of the Mediterranean Sea circulation from 1979 to 1993: *Part I. The inter-annual variability*. *Journal of Marine Systems* 33–34: 23–50.
- Devoy, R. J. N., 2008. Coastal vulnerability and the implications of sea-level rise for Ireland. *Journal of Coastal Research* 24 (2): 325–341.
- Edwards M. and Richardson A. J., 2004. Impact of climate change on marine pelagic phenology and trophic mismatch. *Nature* 430: 881–884.
- Edwards, M.; Reid P. C. and Planque, B., 2001. Long-term and regional variability of phytoplankton biomass in the Northeast Atlantic (1960–1995). *ICES Journal of Marine Science* 58: 39–49.
- Edwards, M.; Woo, J. and Richardson, A. J. (in preparation). Spatial variability in marine pelagic phenology.
- Frankignoul, C. and Kestenare, E., 2005. Observed Atlantic SST Anomaly Impact on the NAO: An update. *Journal of Climate* 18: 4089–4094.
- Frederiksen, M.; Edwards, M.; Richardson, A. J.; Halliday, N. C.; Wanless, S., 2006. From plankton to top predators: bottom-up control of a marine food web across four trophic levels. *Journal of Animal Ecology* 75: 1259–1268.
- Griffies S. M. and Bryan, K., 1997. Predictability of the North Atlantic Multidecadal Variability. *Science* 275: 181–184.
- Guinehut, S. and Larnicol, G., 2008. Produced for EEA by Collecte Localisation Satellites (CLS). <http://www.cls.fr/>.
- Halpern, B. S.; Walbridge, S.; Selkoe, K. A.; Kappel, C. V.; Micheli, F.; D'Agrosa, C.; Bruno, J. F.; Casey, K. S.; Ebert, C.; Fox, H. E.; Fujita, R.; Heinemann, D.; Lenihan, H. S.; Madin, E. M. P.; Perry, M. T.; Selig, E. R.; Spalding, M.; Steneck, R.; Watson, R., 2008: A Global Map of Human Impact on Marine Ecosystems. *Science* 319: 948–952.
- Hiddink, J. G. and Ter Hofstede, R., 2008. Climate Change induced increases in species richness of marine fishes. *Global Change Biology* 14: 453–460.
- Houghton, J. T.; Meira Filho, L. G.; Callander, B. A.; Harris, N.; Kattenberg, A. and Maskell, K. (eds.). 1995. *The science of climate change*. IPCC, Work. Group Rep. No. 1. Cambridge University Press, New York.
- Hulme, M.; Jenkins, G.; Lu, X.; Turnpenny, J. R.; Mitchell, T. D.; Jones, R. G.; Lowe, J.; Murphy, J. M.; Hassell, D.; Boorman, P.; McDonald, R. and Hill, S., 2002. *Climate Change Scenarios for the UK*. In: *The UKCIP02 Scientific Report*. Tyndall Centre for Climate Change Research, University of East Anglia, Norwich.
- IPCC, 2001. *Climate Change 2001: The scientific basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change*. Houghton, J. T. et al. (eds.), Cambridge University Press, UK.
- IPCC, 2007a. *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Solomon, S.; Qin, D.; Manning, M.; Chen, Z.; Marquis, M.; Averyt, K. B.; Tignor M. and Miller H. L. (eds.), Cambridge University Press, Cambridge, UK.
- IPCC, 2007b *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Parry, M. L.; Canziani, O. F.; Palutikof, J. P.; van der Linden, P.J. and Hanson, C.E. (eds.), Cambridge University Press, Cambridge, UK.
- Johansson, M. M.; Kahma, K. K. and Bowman H., 2004. Scenarios for sea level on the Finnish coast. *Boreal Environment Research* 9: 153–166.
- Katsman, C. A.; Hazeleger, W.; Drijfhout, S. S.; van Oldenborgh, G. J. and Burgers, G. J. H., 2007. Climate scenarios of sea level rise for the northeast Atlantic Ocean: *a study including the effects of ocean dynamics and gravity changes induced by ice melt*, Kluwer Academic publishers, the Netherlands.

- Keenlyside, N. S.; Latif, M.; Jungclauss, J.; Kornbluh, L. and Roeckner, E. 2008. Advancing decadal-scale climate prediction in the North Atlantic sector. *Nature* 453: 84–88.
- Key, R. M.; Kozyr, A.; Sabine, C. L.; Lee, K.; Wanninkhof, R.; Bullister, J. L.; Feely, R. A.; Millero, F. J.; Mordy, C. and Peng, T. H., 2004. A global ocean carbon climatology: Results from Global Data Analysis Project (GLODAP). *Global Biogeochemical Cycles* 18 (4): 1–23.
- Kundzewicz, Z. W.; Parry, M.; Cramer, W.; Holten, J. I.; Kaczmarek, Z.; Martens, P.; Nicholls, R. J.; Oquist, M.; Rounsevell, M. D. A. and Szolgay, J. 2001. Europe. Climate Change 2001: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, 641–692.
- Levitus, S.; Antonov, J. I.; Boyer, T. P.; Stephens, C., 2000. Warming of the world ocean. *Science* 287: 2225–2229.
- Lindley, J. A., 1987. Continuous Plankton Records: the geographical distributions and seasonal cycles of decapod crustacean larvae and pelagic post-larvae in the North-eastern Atlantic Ocean and the North Sea, 1981–83. *Journal of the Marine Biological Association of the United Kingdom* 67: 145–150.
- Liu, Z.; Vavrus, S.; He, F.; Wen, N. and Zhong, Y., 2005. Rethinking Tropical Ocean Response to Global Warming: The Enhanced Equatorial Warming. *Journal of Climate* 18: 4684–4700.
- MacKenzie, B. R., Gislason, H., Möllmann, C., and Köster, F. W. 2007. Impact of 21st century climate change on the Baltic Sea fish community and fisheries. *Global Change Biology*, 13: 1–20.
- Meehl, G. A.; Stocker, T. F.; Collins, W. D.; Friedlingstein, P.; Gaye, A. T.; Gregory, J. M.; Kitoh, A.; Knutti, R.; Murphy, J. M.; Noda, A.; Raper, S. C. B.; Watterson, I. G.; Weaver, A. J. and Zhao, Z.-C., 2007. Global Climate Projections. In: Solomon, S.; Qin, D.; Manning, M.; Chen, Z.; Marquis, M.; Averyt, K. B.; Tignor, M. and Miller, H. L. (eds). *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, UK and New York, USA.
- Meier, H. E. M.; Broman, B. and Kjellström, E., 2004. Simulated sea level in past and future climates of the Baltic Sea. *Climate Research* 27: 59–75.
- Meier H. E. M.; Kjellström E. and Graham L. P., 2006a. Estimating uncertainties of projected Baltic Sea salinity in the late 21st century. *Geophysical Research Letters* 33, L15705, DOI:10.1029/2006GL026488.
- Meier, H. E. M.; Broman, B.; Kallio, H. and Kjellström, E., 2006b. Projections of future surface winds, sea levels, and wind waves in the late 21st Century and their application for impact studies of flood prone areas in the Baltic Sea region. In: Schmidt-Thomé, P. (ed): *Sea level change affecting the spatial development of the Baltic Sea region, Geological Survey of Finland, Special Paper* 41: 23–43.
- Nerem, R. S.; Leuliette, E. and Cazenave, A., 2006. Present-day sea-level change: A review. *Comptes Rendus Geoscience* 338: 1077–1083.
- Nicholls, M.; Oquist, M. D.; Rounsevell, A. and Szolgay, J., 2001. *Climate Change 2001: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change*, University Press, Cambridge, pp. 641–692.
- Nicholls, R. J., 2004. Coastal flooding and wetland loss in the 21st century: changes under the SRES climate and socio-economic scenarios. *Global Environmental Change* 14: 69–86.
- Nicholls, R. J. and de la Vega-Leinert, A. C. (eds.), 2007. Implications of sea-level rise for Europe's coasts. *Journal of Coastal Research*. Special issue (in press).
- Nicholls, R. J. and Tol, R. S. J., 2006. Impacts and responses to sea-level rise: a global analysis of the SRES scenarios over the twenty-first century. *Philosophical Transactions of the Royal Society of London Series A* 364: 1073–1095.
- Novotny, K. and Groh, A., 2007. Untersuchung von Pegelreihen zur Bestimmung der Änderung des mittleren Meeresspiegels an den europäischen Küsten; Technical University of Dresden; *internal report prepared for the German Federal Environment Agency (UBA)*.
- Orr, J. C.; Fabry, V. J.; Aumont, O.; Bopp, L.; Doney, S. C.; Feely, R. A. et al., 2005. Anthropogenic ocean acidification over the twenty-first century and its impact on calcifying organisms. *Nature* 437: 681–686.
- Pearson, P. N. and Palmer, M. R., 1999. Middle Eocene Seawater pH and Atmospheric Carbon Dioxide Concentrations. *Science* 284: 1824–1826.
- Perry, A. L.; Low, P. J.; Ellis, J. R. and Reynolds, J. D., 2005. Climate Change and Distribution Shifts in Marine Fishes. *Science* 308: 1912–1915.
- Quero, J.-C.; Du Buit, M.-H. and Vayne, J.-J., 1998. Les observations de poissons tropicaux et le réchauffement des eaux dans l'Atlantique européen. *Oceanologica Acta* 21: 345–351.
- Rahmstorf, S., 2007. A semi-empirical approach to projecting future sea-level rise. *Science* 315: 367–370.
- Rahmstorf, S.; Cazenave, A.; Church, J. A.; Hansen, J. E.; Keeling, R.; Parker, D. E. and Somerville, R. C. J., 2007.

Recent climate observations compared to projections. *Science* 316: 709.

Rayner, N. A.; Brohan, P.; Parker, D. E.; Folland, C. K.; Kennedy, J. J.; Vanicek, M.; Ansell, T. J.; Tett, S. F. B., 2006. Improved analyses of changes and uncertainties in sea surface temperature measured in situ since the mid-nineteenth century: The HadSST2 dataset. *Journal of Climate* 19(3): 446–469.

Reid, P. C.; Edwards, M.; Hunt, H. G. and Warner, A. J., 1998. Phytoplankton change in the North Atlantic. *Nature* 391: 546.

Rignot, E. and Kanagaratnam, P. 2006. Changes in the velocity structure of the Greenland Ice Sheet. *Science* 311: 986–990.

Stebbing, A. R. D.; Turk, S. M. T.; Wheeler, A. and Clarke, K. R., 2002. Immigration of southern fish species to the southwest of England linked to warming of the North Atlantic (1960–2001). *Journal of the Marine Biological Association* 82: 177–180. UK.

Stouffer R. J., 2004. Time scales of climate response. *Journal of Climate* 17: 209–217.

Teal L.R.; de Leeuw J.J.; van der Veer H.W. *et al.*, 2008. Effects of climate change on growth of 0-group sole and plaice. *Marine Ecology-progress Series*, Volume 358: 219–230.

Tsimplis, M. N.; Woolf, D. K.; Osbourn, T. J.; Wakelin, S.; Wolf, J.; Flather, R.; Woodworth, P.; Shaw, A. G. P.; Challenor, P. and Yan, Z., 2004. Future changes of sea level and wave heights at the northern European coasts. *Geophysical Research Abstracts* 6: 00332.

UNEP, 2007. *Global Outlook for Ice & Snow*; UNEP/GRID-Arendal, 2007.

Watterson, I. G., 2003. Effects of a dynamic ocean on simulated climate sensitivity to greenhouse gases. *Climate Dynamics* 21: 197–209.

Woodworth, P. L.; Gregory, J. M. and Nicholls, R. J. 2005. *Long term sea level changes and their impacts*. In: Robinson A.R. and Brink, K.H. (eds). *The global coastal ocean: multiscale interdisciplinary processes*. Cambridge, Massachusetts, USA pp. 715–753.

Xu, Y.; Zhao, Z.-C.; Luo, Y. and Gao, X., 2005. Climate change projections for the 21st century by the NCC/IAP T63 with SRES scenarios. *Acta Meteorologica Sinica* 19: 407–417.

Section 5.5 Water quantity, river floods and droughts

Alcamo, J.; Döll, P.; Henrichs, T.; Kaspar, F.; Lehner, B.; Rösch, T. and Siebert, S., 2003. Global estimates of water withdrawals and availability under current and future business-as-usual conditions. *Hydrological Sciences Journal* 48: 339–348.

Alcamo, J.; Flörke, M. and Märker, M., 2007. Future long-term changes in global water resources driven by socio-economic and climatic change. *Hydrological Sciences Journal* 52: 247–275.

Andréasson, J.; Bergström, S.; Carlsson, B.; Graham, L.P. and Lindström, G., 2004. Hydrological change — climate change impact simulation for Sweden. *Ambio* 33: 228–234.

Arnell, N. W., 2004. Climate change and global water resources: SRES emissions and socio-economic scenarios. *Global Environmental Change* 14: 31–52.

Barnett, T. P.; Adam, J. C. and Lettenmaier, D. P., 2005. Potential impacts of a warming climate on water availability in snow-dominated regions. *Nature* 438: 303–309.

Barnolas, M. and Llasat, M. C., 2007. A flood geodatabase and its climatological implications: the case of Catalonia for the last century. *Natural Hazards and Earth System Sciences* 7: 271–281.

Becker, A. and Grunewald, U., 2003. Disaster management — flood risk in Central Europe. *Science* 300 (5622): 1099–1099.

Birsan, M. V.; Molnar, P.; Burlando, P. and Pfaundler, M., 2005. Streamflow trends in Switzerland. *Journal of Hydrology* 314: 312–329.

Brázdil, R.; Kotyza, O. and Dobrovolný, P. 2006. July 1432 and August 2002 — two millennial floods in Bohemia? *Hydrological Sciences Journal* 51 (5): 848–863.

Christensen O. B. and Christensen, J. H., 2003. Severe summertime flooding in Europe. *Nature* 421: 805–806.

Cyberski, J.; Grześ, M.; Gutry-Korycka, M.; Nachlik, E. and Kundzewicz, Z., 2006. History of floods on the River Vistula. *Hydrological Sciences Journal* 51 (5): 799–817.

Dankers, R.; Feyen, L., 2008a. Climate change impacts on river flow in Europe (manuscript in preparation).

Dankers, R.; Feyen, L., 2008b. Climate change impact on flood hazard in Europe: An assessment based on high resolution climate simulations. Manuscript submitted to *Journal of Geophysical Research Atmospheres*.

Dixon, H.; Lawler, D. M. and Shamseldin, A. Y., 2006. Streamflow trends in western Britain. *Geophysical Research Letters* 23: L19406, DOI:10.1029/2006GL027325.

References

- Douville, H.; Chauvin, F.; Planton, S.; Royer, J.F.; Salas-Melia, D. and S. Tyteca, S., 2002. Sensitivity of the hydrological cycle to increasing amounts of greenhouse gasses and aerosols. *Climate Dynamics* 20: 45–68.
- Döll, P., 2002. Impact of climate change and variability on irrigation requirements: a global perspective. *Climatic Change* 54: 269–293.
- EEA, 2007. *Europe's environment — The fourth assessment*. EEA Report No 1/2007, European Environment Agency, Copenhagen.
- Feyen, L. and Dankers, R., 2008. River flow drought in Europe in a future climate. Manuscript submitted to *Global Environmental Change*.
- Glaser, R. and Stangl, H., 2003. Historical floods in the Dutch Rhine Delta. *Natural Hazards and Earth System Sciences* 3: 605–613.
- Hanneford J. and Marsh, T., 2006. An assessment of trends in UK runoff and low flows using a network of undisturbed catchments. *International Journal of Climatology* 26: 1237–1253.
- Hisdal, H.; Stahl, K.; Tallaksen, L. M. and Demuth, S., 2001. Have droughts in Europe become more severe or frequent? *International Journal of Climatology* 21: 317–333.
- Hisdal, H.; Holmqvist, E.; Kuusisto, E.; Lindström, G. and Roald, L. A., 2007. Has streamflow changed in the Nordic countries? *Climate Research*, submitted.
- Jasper, K.; Calanca, P.; Gyalistras, D. and Fuhrer, J., 2004. Differential impacts of climate change on the hydrology of two alpine rivers. *Climate Research* 26: 113–125.
- Kay, A.; Reynard, N. S. and Jones, R. N., 2006. RCM rainfall for UK flood frequency estimation. II. Climate change results. *Journal of Hydrology* 318: 163–172.
- Kundzewicz, Z. W.; Radziejewski, M. and Pińskwar, I., 2006. Precipitation extremes in the changing climate of Europe. *Climate Research* 31: 51–58.
- Kundzewicz, Z. W.; Graczyk D.; Maurer T.; Pińskwar I.; Radziejewski M.; Svensson C.; Szwed M., 2005. Trend detection in river flow series: 1. Annual maximum flow. *Hydrological Sciences Journal* 50 (5): 797–810.
- Kundzewicz, Z. W.; Budhakooncharoen, S.; Bronstert, A.; Hoff, H.; Lettenmaier, D.; Menzel, L. and Schulze, R., 2002. Coping with variability and change: floods and droughts. *Natural Hazards Forum* 26: 263–274.
- Lang, M.; Renard, B.; Sauquet, E.; Bois, P.; Dupeyrat, A.; Laurent, C.; Mestre, O.; Niel, H.; Neppel, L. and Gailhard, J., 2006. *Climate Variability and Change — Hydrological Impacts*. IAHS Publ. 308.
- Lehner B.; Döll P.; Alcamo J.; Henrichs T. and Kaspar F., 2006. Estimating the impact of global change on flood and drought risks in Europe: a continental integrated analysis. *Climatic Change* 75: 273–299.
- Lindström, G. and Bergström, S., 2004. Runoff trends in Sweden 1807–2002. *Hydrological Sciences Journal* 49 (1): 69–83.
- Macklin, M. G. and Rumsby, B. T., 2007. Changing climate and extreme floods in the British Uplands. *Transactions of the Institute of British Geographers* 32 (2): 168–186.
- Milly, P. C. D.; Dunne, K. A. and Vecchia, A. V., 2005. Global pattern of trends in streamflow and water availability in a changing climate. *Nature* 438: 347–350.
- Milly, P. C. D.; Wetherald, R. T.; Dunne, K. A. and Delworth, T. L., 2002. Increasing risk of great floods in a changing climate. *Nature* 415: 514–517.
- Mudelsee, M.; Börngen, M.; Tetzlaff, G. and Grünewald, U., 2003. No upward trends in the occurrence of extreme floods in Central Europe. *Nature* 425: 166–169.
- Palmer, T. N. and Räisänen, J., 2002. Quantifying the risk of extreme seasonal precipitation events in a changing climate. *Nature* 415: 512–514.
- Pinter, N.; Ickes, B. S.; Wlosinski J. H. and van der Ploeg, R. R., 2006. Trends in flood stages: Contrasting results from the Mississippi and Rhine River systems. *Journal of Hydrology* 331: 554–566.
- Ramos, C. and Reis, E., 2002. Floods in Southern Portugal: their physical and human causes, impacts and human response. *Mitigation and Adaptation Strategies for Global Change* 7: 267–284.
- Robson, A., 2002. Evidence for trends in UK flooding. *Philosophical Transactions of the Royal Society A* 360: 1327–1343.
- Schröter, D.; Cramer, W.; Leemans, R.; Prentice, C.; Araújo, M. B.; Arnell, N. W.; Bondeau, A.; Bugmann, H.; Carter, T. R.; Gracia, C. A.; de la Vega-Leinert, A. C.; Erhard, M.; Ewert, F.; Glendinning, M.; House, J. I.; Kankaanpää, S.; Klein, R. J. T.; Lavorel, S.; Lindner, M.; Metzger, M. J.; Meyer, J.; Mitchell, T. D.; Reginster, I.; Rounsevell, M.; Sabaté, S.; Sitch, S.; Smith, B.; Smith, J.; Smith, P.; Sykes, M. T.; Thonicke, K.; Thuiller, W.; Tuck, G.; Zaehle, S. and Zierl, B., 2005. Ecosystem Service Supply and Vulnerability to Global Change in Europe. *Science* 310 (5752): 1333–1337.
- Stuyfzand P. J.; Ruediger, R. L. and Kristensen, P., 2007. *Impact of climate change on groundwater*. A background note for EEA produced by the EEA ETC/Water.

- Svensson, C.; Kundzewicz W. Z.; Maurer, T., 2005. Trend detection in river flow series: 2. Flood and low-flow index series. *Hydrological Sciences Journal*. 50: 811–824.
- UNEP, 2006. *Geo Year Book 2006*. An overview of our changing environment.
- Wade, S.; Vidal, J.-P.; Dabrowski, C.; Young, P. and Romanowicz, R., 2005. *Effect of climate change on river flows and groundwater recharge. A practical methodology. Trends in UK river flows: 1970–2002*. UKWIR Report 05/CL/04/5.
- van der Schrier, G.; Briffa, K. R.; Jones, P. D. and Osborn T. J., 2006. Summer moisture availability across Europe. *Journal of Climate* 19: 2818–2834.
- Wang, W.; Van Gelder, P. H. A. J. M. and Vrijling, J. K., 2005. Detection of changes in streamflow series in western Europe over 1901–2000. *Water Science and Technology: Water Supply* 5 (6): 289–299.
- Werritty, A., 2002. Living with uncertainty: climate change, river flows and water resource management in Scotland. *The Science of the Total Environment* 294: 29–40.
- Section 5.6 Freshwater quality and biodiversity**
- Adrian, R.; Wilhelm, S. and Gerten, D., 2006. Life-history traits of lake plankton species may govern their phenological response to climate warming. *Global Change Biology* 12: 652–661.
- Ambrosetti, W. and Barbanti, L., 1999. Deep water warming in lakes: an indicator of climate change. *Journal of Limnology* 58: 1–9.
- Anneville, O.; Gammeter, S. and Straile, D., 2005. Phosphorus decrease and climate variability: mediators of synchrony in phytoplankton changes among European peri-alpine lakes. *Freshwater Biology* 50: 1731–1746.
- Barica, J. and Mathias, J. A., 1979. Oxygen depletion and winterkill risk in small prairie lakes under extended ice cover. *Journal of the Fisheries Research Board of Canada* 36: 980–986.
- Battarbee, R.; Kernan, M.; Livingstone, D. M.; Nickus, U.; Verdonschot, P.; Hering, D.; Moss, B.; Wright, R. F.; Evans, C. D.; Grimalt, J. O.; Johnson, R.; Maltby, E.; Linstead, C. and Skeffington, R. A., 2008. Freshwater Ecosystem Responses to Climate Change: the Euro-limpacs project (in press).
- Benson, B. and Magnuson, J., 2000 (updated 2006). Global lake and river ice phenology database. In: Boulder, C.O., National Snow and Ice Data Center/World Data Center for Glaciology. Bauerfeind, E. and U.H. Humpesch 2001. Die Eintagsfliegen Zentraleuropas (Insecta: Ephemeroptera) Bestimmung und Ökologie. Verlag des Naturhistorischen Museums, Wien Austria.
- Biodiversity Indicators, 2006. Climate Change: Trend of Southern European dragonfly species. Research Institute for Nature and Forest, Brussels. www.natuurindicatoren.be (updated 08.05.2006). Available at www.natuurindicatoren.be/indicatorenportal.cgi?lang=en&detail=404&id_structuur=25.
- Burgmer, T.; Hillebrand, H. and Pfenninger, M., 2007. Effects of climate-driven temperature changes on the diversity of freshwater macroinvertebrates. *Oecologia* 151: 93–103.
- BUWAL, BWG, MeteoSchweiz, 2004. Auswirkungen des Hitzesommers 2003 auf die Gewässer. Schriftenreihe Umwelt Nr. 369. Bern-Ittigen: Bundesamt für Umwelt, Wald und Landschaft, 174 p.
- Dabrowski, M.; Marszelewski, W.; and Skowron, R., 2004. The trends and dependencies between air and water temperatures in lakes in northern Poland from 1961–2000. *Hydrology and Earth System Sciences* 8: 79–87.
- Daufresne, M.; Bady, P. and Fruget, J. F., 2007. Impacts of global changes and extreme hydroclimatic events on macroinvertebrate community structures in the French Rhone River. *Oecologia* 151: 544–559.
- Daufresne, M.; Roger, M. C.; Capra, H. and Lamouroux, N., 2004. Long-term changes within the invertebrate and fish communities of the Upper Rhone River: effects of climatic factors. *Global Change Biology* 10: 124–140.
- Dokulil, M. T.; Jagsch, A.; George, G. D.; Anneville, O.; Jankowski, T.; Wahl, B.; Lenhart, B.; Blenckner, T. and Teubner, K., 2006. Twenty years of spatially coherent deepwater warming in lakes across Europe related to the North Atlantic Oscillation. *Limnology and Oceanography* 51: 2787–2793.
- Dyble J.; Paerl, H. W. and Neilan, B. A., 2002. Genetic characterization of *Cylindrospermopsis raciborskii* (Cyanobacteria) isolates from diverse geographic origins based on nifH and cpcBA-IGS nucleotide sequence analysis. *Applied Environmental Microbiology* 68: 2567–2571.
- Estonian Meteorological and Hydrological Institute, water temperature measurements, Võrtsjärv period 1947–2006 (non published). See also Nöges and Järvet, 2005.
- Findlay, D. L.; Paterson, J. J.; Hendzel, L. L. and Kling, H. J., 2005. Factors influencing *Gonyostomum* semen blooms in a small boreal reservoir lake. *Hydrobiologia* 533: 243–252.
- Franssen H. J. Hendricks and Scherrer S. C., 2008. Freezing of lakes on the Swiss plateau in the period 1901–2006. *International Journal of Climatology* 28 (4): 421–433.
- George, G.; Hewitt, D; Jennings, E.; Allott, N. and McGinnity, P., 2005. The impact of changes in the weather on the surface temperatures of Windermere (UK) and Lough Feeagh (Ireland) In: Lobo Ferreira, J. P. and Vieira J. M. P.

- (eds). *Proceedings of the Fourth Inter-Celtic Colloquium on Hydrology and Management of Water Resources, Guimaraes, Portugal*. Lisbon. <http://www.aprh.pt/celtico/TEXT/papers.html>.
- George G.; Hurley M. and Hewitt D., 2007. The impact of climate change on the physical characteristics of the larger lakes in the English Lake District. *Freshwater Biology* 52: 1647–1666.
- George, D. G. and Hurley, M. A., 2004. The influence of sampling frequency on the detection of long-term change in three lakes in the English Lake District. *Aquatic Ecosystem Health and Management* 7: 1–14.
- Greenbank, J., 1945. Limnological conditions in ice-covered lakes, especially related to winterkill of fish. *Ecological Monographs* 15: 343–392.
- Grimalt, J. O.; Fernández, P.; Berdié, L.; Vilanova, R. M.; Catalan, J.; Psenner, R.; Hofer, R.; Appleby, P. G., Rosseland, B. O.; Lien L.; Massabuau J. C. and Battarbee, R. W., 2001. Selective trapping of organochlorine compounds in mountain lakes of temperate areas. *Environmental Science & Technology* 35: 2690–2697.
- Hari, R. E.; Livingstone, D. M.; Siber, R.; Burkhardt-Holm, P. and Guttinger, H., 2006. Consequences of climatic change for water temperature and brown trout populations in Alpine rivers and streams. *Global Change Biology* 12: 10–26.
- Hassall, C.; Thompson, D. J.; French, G. C. and Harvey, I. F., 2007. Historical changes in the phenology of British Odonata are related to climate. *Global Change Biology* 13: 933–941.
- Hering *et al.*, 2006. Evaluation of Trichoptera data in relation to climatic gradients. Deliverable No. 190 from the Eurolimpacs European Research Project. http://www.eurolimpacs.ucl.ac.uk/oldsite/docstore/Deliverable_190.pdf.
- Hickling, R.; Roy, D. B.; Hill, J. K. and Thomas, C. D., 2005. A northward shift of range margins in British Odonata. *Global Change Biology* 11 (3): 502–506.
- Hohensinner, S.; Haidvogel, G.; Jungwirth, M., 2006. Natural landscape dynamics and human interferences: the Danube river landscape in the Austrian Machland 1715–1991. Rivers Run Through Them. Landscapes in Environmental History. *Annual Meeting of the American Society for Environmental History*, 29.3.–1.4.2006, St. Paul, Minnesota, USA.
- IPCC, 2007: Summary for Policymakers. In: *Climate Change 2007: The Physical Science Basis*. Cambridge University Press, Cambridge, UK.
- IPCC, 2008. Technical paper on climate change and water. Available at www.ipcc.ch/meetings/session28/doc13.pdf.
- Jackson, L. J.; Lauridsen, T. L.; Søndergaard, M. and Jeppesen, E., 2007. A comparison of shallow Danish and Canadian lakes and implications of climate change. *Freshwater Biology* 52: 1782–1792.
- Järvinen, M.; Rask, M.; Ruuhijärvi, J. and Arvola, L., 2002. Temporal coherence in water temperature and chemistry under the ice of boreal lakes (Finland). *Water Research* 36: 3949–3956.
- Jöhnk, K. D.; Huisman, J.; Sharples, J.; Sommeijer, B.; Visser, P. M. and Stroom, J. M., 2008. Summer heatwaves promote blooms of harmful cyanobacteria. *Global Change Biology* 14: 495–512.
- Kerr, R. A., 1999. The Little Ice Age — only the latest big chill. *Science* 248: 2069. DOI: 10.1126/science.284.5423.2069.
- Kolar, C. S. and Lodge, D. M., 2000. Freshwater Nonindigenous Species: Interactions with Other Global Changes. In: Mooney, H.A. and Hobbs, R. (eds). *Invasive Species in a Changing World*. Island Press, Washington, 3–30.
- Korhonen, J., 2002. Water temperature conditions of lakes and rivers in Finland in the 20th century (in Finnish). *Suomen Ymparistö* 566: 1–115.
- Korhonen J., 2006. Long-term changes in lake ice cover in Finland. *Nordic Hydrology* 37: 347–363.
- Leppäranta, M.; Reinart, A.; Erm, A.; Arst, H.; Hussainov, M. and Sipelgas, L., 2003. Investigation of ice and water properties and under-ice light fields in fresh and brackish water bodies, *Nordic Hydrology* 34: 245–266.
- Livingstone, D. M., 1993. Lake oxygenation: Application of a one-box model with ice cover. *Internationale Revue der Gesamten Hydrobiologie* 78: 465–480.
- Livingstone, D. M., 1997. Break-up dates of Alpine lakes as proxy data for local and regional mean surface air temperatures. *Climatic Change* 37: 407–439.
- Livingstone, D. M., 2003. Impact of secular climate change on the thermal structure of a large temperate central European lake. *Climatic Change* 57: 205–225.
- Livingstone, D. M. and Adrian, R., 2007. Modeling the duration of intermittent ice cover on a lake for climate-change studies. *Limnology and Oceanography* (submitted).
- Magnuson, J. J.; Robertson, D. M.; Benson, B. J.; Wynne, R. H.; Livingstone, D. M.; Arai, T.; Assel, R. A.; Barry, R. G.; Card, V.; Kuusisto, E.; Granin, N. G.; Prowse, T. D.; Stewart K. M. and Vuglinski, V. S., 2000a. Historical trends in lake and river ice cover in the Northern Hemisphere. *Science* 289: 1743–1746.

- Malmaeus, J. M.; Blenckner, T.; Markensten, H. and Persson, I., 2006. Lake phosphorus dynamics and climate warming: A mechanistic model approach. *Ecological Modelling* 190: 1–14.
- Manca, M.; Portogallo, M.; Brown, M. E., 2007: Shifts in phenology of *Bythotrephes longimanus* and its modern success in Lake Maggiore as a result of changes in climate and trophy. *Journal of Plankton Research*, 29 (6): 515–525.
- MNP, 2006. The effects of climate change in the Netherlands. (Bresser *et al.* (eds) Report from MNP available at <http://www.mnp.nl/en/publications/2006/TheeffectsofclimatechangeintheNetherlands.html>.
- Mooij, W. M.; Hülsmann, S.; Domis, L. N. D.; Nolet, B. A.; Bodelier, P. L. E.; Boers, P. C. M.; Pires, L. M. D.; Gons, H. J.; Ibelings, B. W.; Noordhuis, R.; Portielje, R.; Wolfstein, K. and Lammens, E. H. R. R., 2005. The impact of climate change on lakes in The Netherlands: a review. *Aquatic Ecology* 39 (4): 381–400.
- Nöges *et al.* (in press). The impact of variations in the climate on seasonal dynamics of phytoplankton. Ch. 14 in: D. G. George (ed.) The impact of climate change on European lakes. Springer.
- Palecki, M. A. and Barry, R. G., 1986. Freeze-up and break-up of lakes as an index of temperature changes during the transition seasons: a case study for Finland. *Journal of Climate and Applied Meteorology* 25: 893–902.
- Pernaravičiūtė, B., 2004. The impact of climate change on thermal regime of Lithuanian lakes. *Ekologija* 2: 58–63.
- Phillips, K. A. and Fawley, M. W., 2002. Winter phytoplankton blooms under ice associated with elevated oxygen levels. *Journal of Phycology* 38: 1068–1073.
- Rijkswaterstaat, measurements Rhine River at Lobith period 1908–2006 (unpublished). See also MNP, 2006.
- Rodhe, W., 1955. Can phytoplankton production proceed during winter darkness in subarctic lakes? *Verhandlungen Internationale Vereinigung für theoretische und angewandte Limnologie* 12: 117–122.
- Schindler, D. W., 2001. The cumulative effects of climate warming and other human stresses on Canadian freshwaters in the new millennium. *Canadian Journal of Fisheries and Aquatic Sciences* 58: 18–29.
- Stewart, K. M., 1976. Oxygen deficits, clarity and eutrophication in some Madison lakes. *Internationale Revue der Gesamten Hydrobiologie* 61: 563–579.
- Svensson C.; Hannaford J.; Kundzewicz, Z. W. and Marsh, T., 2006: Trends in river floods: why is there no clear signal in observations? *Frontiers in Flood Research — IAHS Proceedings & Reports*.
- Walsh, C. L. and Kilsby, C. G., 2006. Potential impacts of climate change on Atlantic salmon: case study in the Eden catchment, Cumbria, UK. *Hydrology and Earth System Sciences*. In press (abstract).
- Weyhenmeyer, G. A.; Blenckner, T. and Pettersson, K., 1999. Changes of the plankton spring outburst related to the North Atlantic Oscillation. *Limnology and Oceanography* 44: 1788–1792.
- Weyhenmeyer, G. A., 2001. Warmer winters — are planktonic algal populations in Sweden's largest lakes affected? *Ambio* 30: 565–571.
- Weyhenmeyer, G. A.; Meili, M. and Livingstone, D. M., 2004. Nonlinear temperature response of lake ice breakup. *Geophysical Research Letters* 31 (7): L07203, DOI:10.1029/2004GL019530.
- Weyhenmeyer, G. A., 2007. Water chemical changes along a latitudinal gradient in relation to climate and atmospheric deposition. *Climate change* 88 (2): 199–208.
- Wilhelm, S. and Adrian, R., 2008. Impact of summer warming on the thermal characteristics of a polymictic lake and consequences for oxygen, nutrients and phytoplankton. *Freshwater Biology* 53 (2): 226–237.

Section 5.7 Terrestrial ecosystems and biodiversity

- Araújo, M. B. and Luoto, M., 2007. The importance of biotic interactions for modelling species distributions under climate change. *Global ecology and biogeography* 16: 743–753.
- Araújo, M. B.; Thuiller, W. and Pearson, R. G., 2006. Climate warming and the decline of amphibians and reptiles in Europe. *Journal of Biogeography* 33: 1712–1728.
- Bakkenes, M.; Eickhout, B. and Alkemade, R., 2006. Impacts of different climate stabilisation scenarios on plants species in Europe. *Global Environmental Change* 16: 19–28.
- Bakkenes, M., 2007. Produced for the EEA by Netherlands Environmental Assessment Agency (PBL), based on data of the ALARM project (<http://www.alarmproject.net.ufz.de>).
- Bale, J. S. Masters; G. J., Hodkinson, I. D. *et al.*, 2002. Herbivory in global climate change research: direct effects of rising temperatures on insect herbivores. *Global Change Biology* 8: 1–16.
- Biesmeijer, J. C.; Roberts, S. P. M.; Reemer, M.; Ohlemüller, R.; Edwards, M.; Peeters, T.; Schaffers, A. P.; Potts, S. G.; Kleukers, R.; Thomas, C. D.; Settele, J. and Kunin, W. E., 2006. Parallel declines in pollinators and insect-pollinated plants in Britain and the Netherlands. *Science* 313: 351–354.

References

- Both, C. and Marvelde, L., 2007. Climate change and timing of avian breeding and migration throughout Europe. *Climate Research* 35: 93–105.
- Both, C., Bouwhuis, S., Lessells, C. M., and Visser, M. E., 2006. Climate change and population declines in a long-distance migratory bird. *Nature* 441: 81–83.
- Cannon, R. J. C., 1998. The implications of predicted climate change for insect pests in the UK, with emphasis on non-indigenous species. *Global Change Biology* 4: 785–796.
- CEH, Morton Frederiksen, 2005. Cited in 'A warm unwelcome', by Audrey Schulman. <http://www.grist.org/news/maindish/2005/01/25/schulman-seabirds/>.
- Crick, H. Q. P. and Sparks T. H., 1999. Climate change related to egg-laying trends. *Nature* 399: 423–424.
- DEFRA, 2007. Conserving biodiversity in a changing climate: guidance on building capacity to adapt. DEFRA, UK.
- Díaz, S.; Fargione, J.; Stuart Chapin III, F. and Tilman, D., 2006. Biodiversity loss threatens human well-being. *PLoS Biology* 4 (8): e277. DOI: 10.1371/journal.pbio.0040277.
- Fitter, A. H. and Fitter, R. S. R., 2002. Rapid Changes in Flowering Time in British Plants. *Science* 296: 1689–1691.
- Gitay, H.; Suarez, A.; Watson, R. T. and Dokken, D. J., 2002. *Climate change and biodiversity*; IPCC Technical paper 5, April 2002, 77pp.
- Gregory, R. D.; Willis, S. G.; Jiguet, F.; Voříšek, P.; Klvaňová, A.; van Strien, A.; Huntley, B.; Collingham, Y. C.; Couvet, D. and Green, R. E., 2008. An indicator of the impact of climatic change on European bird populations (in press).
- Hickling, R.; Roy, D. B.; Hill, J. K.; Fox, R. and Thomas, C. D., 2006. The distributions of a wide range of taxonomic groups are expanding polewards. *Global Change Biology* 12: 450–455.
- Høye, T. T.; Post, E.; Meltofte, H.; Schmidt, N. M. and Forchhammer, M. C., 2007. Rapid advancement of spring in the high Arctic. *Current Biology* 17 (12): 449–451.
- Huntley, B., 2007. *Climatic change and the conservation of European biodiversity: Towards the development of adaptation strategies*. Bern Convention Standing Committee on Climate Change. Council of Europe, Strasbourg.
- Huntley, B. et al., 2008. *A Climatic Atlas of European Breeding Birds*. Barcelona: Lynx Edicions.
- IPCC, 2007. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Parry, M. L.; Canziani, O. F.; Palutikof, J. P.; van der Linden, P. J. and Hanson, C. E. (eds.), Cambridge University Press, Cambridge, UK.
- Kullman, L., 2006. Long-term geobotanical observations of climate change impacts in the Scandes of West-Central Sweden. *Nordic Journal of Botany* 24: 445–467. Copenhagen.
- Kullman, L., 2007. Tree line population monitoring of *Pinus sylvestris* in the Swedish Scandes, 1973–2005: implications for tree line theory and climate change ecology. *Journal of Ecology* 95: 41–52.
- Lemoine N.; Schaefer, H. C. and Böhning-Gaese, K., 2007. Species richness of migratory birds is influenced by global climate change. *Global Ecology and Biogeography*, 16 (1): 55–64.
- Levinsky, I.; Skov, F.; Svenning, J. and Rahbek, C., 2007. Potential impacts of climate change on the distributions and diversity patterns of European mammals. *Biodiversity and Conservation* 16 (13): 3803–3816.
- Lovejoy, T. and Hannah, L., 2005. *Climate change and biodiversity*. Yale University Press. London, UK.
- McKinney, M. L. and Lockwood, J. L., 1999. Biotic homogenization: a few winners replacing many losers in the next mass extinction. *Trends in Ecology and Evolution* 14: 450–453.
- Menzel, A.; Sparks, T. H.; Estrella, N.; Koch, E.; Aasa, A.; Ahas, R.; Alm-Kübler, K.; Bissolli, P.; Braslavská, O.; Briede, A.; Chmielewski, F. M.; Crepinsek, Z.; Curnel, Y.; Dahl, Å.; Defila, C.; Donnelly, A.; Filella, I.; Jatczak, K.; Måge, F.; Mestre, A.; Nordli, Ø.; Peñuela, J.; Pirinen, P.; Remišová, V.; Scheinfinger, H.; Stříž, M.; Susnik, A.; Van Vliet, A. J. H.; Wiegolaski, F.-E.; Zach, S.; Züst, A., 2006. European phenological response to climate change matches the warming pattern. *Global Change Biology* 12: 1969–1976.
- Millennium Ecosystem Assessment. 2005. www.millenniumassessment.org.
- Nature's Calendar, UK. www.naturescalendar.org.uk/climate+change/past.htm.
- Nordic Council, 2005. Conservation of Nordic Nature in a Changing Climate. Nordic Council of Ministers, Copenhagen.
- Ott, J., 2007. The expansion of *Crocothemis erythraea* (Brullé, 1832) in Germany — an indicator of climatic changes. Odonata: Biology of Dragonflies. Tyagi, B.K. (ed.) *Scientific Publishers* (India) pp. 201–222.
- Parmesan, C. and Yohe, G., 2003. A globally coherent fingerprint of climate change impacts across natural systems. *Nature* 421: 37–42.

- Parmesan, C.; Ryrholm, N.; Stefanescu, C.; Hill, J. K.; Thomas, C. D.; Descimon, H.; Huntley, B.; Kaila, L.; Kullberg, J.; Tammaru, T.; Tennent, W. J.; Thomas, J. A. and Warren, M., 1999. Poleward shifts in geographical ranges of butterfly species associated with regional warming. *Nature* 399: 579–83.
- Pauli, H.; Gottfried, M.; Reiter, K.; Klettner, C. and Grabherr, G., 2007. Signals of range expansions and contractions of vascular plants in the high Alps: observations (1994–2004) at the GLORIA master site Schrankogel, Tyrol, Austria. *Global Change Biology* 13, 147–156.
- Reading, C. J., 2007. Linking global warming to amphibian declines through its effects on female body condition and survivorship. *Oecologia*, 151: 125–131.
- Reid, W. V. *et al.*, 2005. Ecosystems and human well-being: Synthesis, and Policy Responses. Island Press, Washington, DC.
- Root, T. L.; Price, J. T.; Hall, K. R., Schneider, S. H.; Rosenzweig, C.; Pounds, J. A., 2003. Fingerprints of global warming on wild animals and plants. *Nature* 421: 57–60.
- Schweiger, O.; Settele, J.; Kudrna, O.; Klotz, S. and Kühn, I., 2008. Climate change can cause spatial mismatch of trophically interacting species. *Ecology* (in press).
- Settele, J.; Hammen, V. C.; Hulme, P. E.; Karlson, U.; Klotz, S.; Kotarac, M.; Kunin, W. E.; Marion, G.; O'Connor, M.; Petanidou, T.; Peterson, K.; Potts, S. G.; Pritchard, H.; Pysek, P.; Rounsevell, M.; Spangenberg, J.; Steffan-Dewenter, I.; Sykes, M. T.; Vighi, M.; Zobel, M. and Kuhn, I., 2005. ALARM: Assessing large scale risks for biodiversity with tested methods. *GAIA — Ecological Perspectives in Science, Humanities and Economics* 14: 96–72.
- Sobrino Vesperinas, E.; González Moreno, A.; Sanz Elorza, M.; Dana Sánchez, E.; Sánchez Mata, D. and Gavilán, R., 2001. The expansion of thermophilic plants in the Iberian Peninsula as a sign of climatic change. 'Fingerprints' of climate change — adapted behaviour and shifting species ranges (ed. by Walther, G.-R.; Burga, C. A. and Edwards, P. J.), pp. 163–184. Kluwer Academic/Plenum Publishers, New York.
- Spangenberg, J. H., 2007. Integrated scenarios for assessing biodiversity risks. *Sustainable Development* 15 (6): 343–356.
- Sparks, T. H.; Dennis, R. L. H.; Croxton, P. J.; Cade, M.; 2007 Increased migration of Lepidoptera linked to climate change. *European Journal of Entomology* 104: 139–143.
- Thuiller, W.; Lavorel, S.; Araújo, M. B.; Sykesand, M. T. and Prentice, I. C., 2005. Climate change threatens plant diversity in Europe. *The Proceedings of the National Academy of Sciences US* 102: 8245–8250.
- UKCIP, 2005. UK Climate Impacts Programme. <http://www.ukcip.org.uk>.
- van Vliet, A., 2008. *Monitoring, analysing, forecasting and communicating phenological changes*. PhD thesis. University of Wageningen, the Netherlands.
- Walther, G.-R.; Beissner, S. and Burga, C. A., 2005. Trends in the uphill shift of alpine plants. *Journal of vegetation science* 16: 541–548.
- Walther, G.-R.; Berger, S. and Sykes, M. T., 2005. An ecological 'footprint' of climate change. *Proceedings of the Royal Society of London Series B — Biological Sciences* 272: 1427–1432.
- Warren, M. S.; Hill, J. K.; Thomas, J. A.; Asher, J.; Fox, R.; Huntley, B.; Roy, D. B.; Telfer, M. G.; Jeffcoate, S.; Harding, P.; Jeffcoate, G.; Willis, S. G.; Greatorex-Davies, J. N.; Moss, D. and Thomas, C. D., 2001. Rapid response of British butterflies to opposing forces of climate and habitat change. *Nature* 414: 65–69.
- Wilson, R. J.; Gutierrez, D.; Gutierrez, J.; Martinez, D.; Agudo, R. and Monserrat, V. J., 2005. Changes to the elevational limits and extent of species ranges associated with climate change. *Ecology Letters* 8: 1138–1146.
- Yamamura, K. and Kiritani, K., 1998. A simple method to estimate the potential increase in the number of generations under global warming in temperate zones. *Applied Entomology and Zoology* 33: 289–298.

Section 5.8 Soil

- Ayres, E.; Wall, D. H.; Simmons, B. L.; Field, C. B.; Milchunas, D. G.; Morgan J. A. and Roy, J., 2008. Belowground nematode herbivores are resistant to elevated atmospheric CO₂ concentrations in grassland ecosystems. *Soil Biology and Biochemistry* 40: 978–985.
- Barrett, J. E.; Virginia, R. A.; Wall, D. H. and Adams B. J., 2008. A decline in dominant invertebrate species contributes to altered carbon cycling in low diversity soil ecosystem. *Global Change Biology* 14: 1–11.
- Behan-Pelletier, V. and Newton, G., 1999. Linking soil biodiversity and ecosystem function: the taxonomic dilemma. *Bioscience* 49: 149–152.
- Bellamy, P. H.; Loveland, P. J.; Bradley, R. I.; Lark, R. M. and Kirk, G. J. D., 2005. Carbon losses from all soils across England and Wales 1978–2003. *Nature* 437: 245–248.
- Binkley, D. and Christian, G., 1998. Why do tree species affect soils? The warp and woof of tree-soil interactions. *Biogeochemistry* 42: 89–106.
- Brussaard, L.; Behan-Pelletier, W. M.; Bignell, D. E.; Brown, V. K.; Didden, W.; Folgarait, P.; Fragoso, C.; Wall

References

- Freckman, D.; Gupta, V. V. S. R.; Hattori, T.; Hawksworth, D. L.; Klopatek, C.; Lavelle, P.; Malloch, D. W.; Rusek, J.; Soderstrom, B.; Tiedje, J. M. and Virginia, R. A., 1997. Biodiversity and ecosystem functioning in soil. *Ambio* 26: 563–570.
- Brussaard, L.; de Ruiter, P. C.; Brown, G. G., 2007. Soil biodiversity for agricultural sustainability. *Agriculture Ecosystem and Environment* 121: 233–244.
- Byrne, K. A.; Chojnicki, B.; Christensen, T. R.; Drösler, M.; Freibauer, A.; Friborg, T.; Frohling, S.; Lindroth, A.; Mailhammer, J.; Malmer, N.; Selin, P.; Turunen, J.; Valentini, R. and Zetterberg, L., 2004. *EU peatlands; Current carbon stocks and trace gas fluxes*. Carbo-Europe report 4.
- Calanca, P.; Roesch, A.; Jasper, K.; Wild, M., 2006. Global warming and the summertime evapotranspiration regime of the Alpine region. *Climatic Change* 79: 65–78.
- González, G. and Seastedt, T. R., 2001. Soil fauna and plant litter decomposition in tropical and subalpine forests. *Ecology* 82 (4): 955–964.
- Convey, P.; Pugh, P. J. A.; Jackson, C.; Murray, A. W.; Ruhland, C. T.; Xiong, F. S.; Day, T. A., 2002. Response of Antarctic terrestrial microarthropods to long-term climate manipulations. *Ecology* 83: 3130–3140.
- Dersch, G. and Boehm, K., 1997. *Bodenschutz in Österreich*, edited by Blum, W. E. H.; Klaghofer, E.; Loechl, A. and Ruckebauer, P. Bundesamt und Forschungszentrum für Landwirtschaft, Österreich. pp. 411–432.
- EC, 2004. *Reports of the Technical Working Groups Established under the Thematic Strategy for Soil Protection*. Editors: Lieve Van-Camp, Benilde Bujarrabal, Anna Rita Gentile, Robert J A Jones, Luca Montanarella, Claudia Olazabal, Senthil-Kumar Selvaradjou. EUR 21319 EN/2, 872 pp. Office for Official Publications of the European Communities, Luxembourg.
- EC, 2006. COM(2006)231, Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions on a Thematic Strategy for Soil Protection.
- ECCE project — final report, 2005. 'Preliminary Assessment of the Impacts in Spain due to the Effect of Climate Change' Carried out under the Agreement between the Ministry of the Environment of Spain and the University of Castilla La Mancha.
- EEA, 2004a. *Environmental signals 2004*. European Environment Agency, Copenhagen.
- EEA, 2004b. *Impacts of Europe's changing climate: an indicator-based assessment*. EEA Report No 2/2004, European Environment Agency, Copenhagen.
- EEA, 2005a. *The European environment — State and outlook 2005*. European Environment Agency, Copenhagen.
- EEA, 2005b. *Vulnerability and adaptation to climate change in Europe*. EEA Technical report No 7/2005. European Environment Agency, Copenhagen.
- EEA, 2007. *Europe's environment — The fourth assessment*. European Environment Agency, Copenhagen.
- Favis-Mortlock, D. T. and Boardman, J., 1995. Nonlinear responses of soil erosion to climate change: a modelling study on the UK South Downs. *Catena* 25: 365–387.
- Gao, X. J.; Pal, J. S.; Giorgi, F., 2006. Projected changes in mean and extreme precipitation over the Mediterranean region from a high resolution double nested RCM simulation. *Geophysical Research Letters* 33, L03706.
- Hooper, D. U.; Bignell, D. E.; Brown, W. K.; Brussaard, L.; Dangerfield, J. M.; Wall, D. H.; Wardle, D. A.; Coleman, D. C.; Giller, K. E.; Lavelle, P. van der Putten, W. H.; de Ruiter, P. C.; Rusek, J.; Silver, W.; Tiedje, J. M. and Wolters, V., 2000. Interactions between above- and belowground biodiversity in terrestrial ecosystems: Patterns, mechanisms, and feedbacks. *BioScience* 50: 1049–1061.
- IPCC, 2007a. Summary for Policymakers. In: *Climate Change 2007: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Parry, M.L.; Canziani, O. F.; Palutikof, J. P.; van der Linden, P.J. and Hanson, C. E. (eds.), Cambridge University Press, Cambridge, UK, 7–22.
- IPCC, 2007b. Chapter 12, Europe. In: *Climate Change 2007: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Parry, M. L.; Canziani, O. F.; Palutikof, J. P.; van der Linden, P. J. and Hanson, C. E. (eds.), Cambridge University Press, Cambridge, UK, 541–580.
- Janssens I. A.; Freibaur, A.; Schlamadinger, B.; Ceulemans, R.; Ciais, P.; Dolman, A.; Heimann, M.; Nabuurs, G.-J.; Smith, P.; Valentini, R. and Schulze, E.-D., 2004. *The carbon budget of terrestrial ecosystems at the country-scale — a European case study*. Biogeosciences Discussions, www.biogeosciences.net/bgd/1/167/SRef-ID: 1810-6285/bgd/2004-1-167.
- Kirkby, M. J.; Jones, R. J. A.; Irvine, B.; Gobin, A.; Govers, G.; Cerdan, O.; Van Rompaey, A. J. J.; Le Bissonnais, Y.; Daroussin, J.; King, D.; Montanarella, L.; Grimm, M.; Vieillefont, V.; Puigdefabregas, J.; Boer, M.; Kosmas, C.; Yassoglou, N.; Tsara, M.; Mantel, S.; Van Lynden, G. J. and Huting, J., 2004. Pan-European Soil Erosion Risk Assessment: The PESERA Map, Version 1 October 2003. Explanation of Special Publication Ispra 2004 No. 73 (S.P.I.04.73). European Soil Bureau Research Report

- No. 16, EUR 21176, 18 pp. and 1 map in ISO B1 format. Office for Official Publications of the European Communities, Luxembourg.
- Lappalainen, E., 1996. Global Peat Resources (International Peat Society, Jyskä), Finland.
- Liski, J.; Perruchoud, D. and Karjalainen, T., 2002. Increasing carbon stocks in the forest soils of western Europe, *Forest Ecology and Management* 169: 159–175.
- Paustian, K.; Six, J.; Elliott, E. T. and Hunt, H. W., 2000. Management options for reducing CO₂ emissions from agricultural soils. *Biogeochemistry* 48: 147–163.
- Poage, M. A.; Barrett, J. E.; Virginia, R. A. and Wall, R.A., 2008. The influence of soil geochemistry on nematode distribution, McMurdo Dry Valleys, Antarctica. *Arctic, Antarctic, and Alpine Research* 40: 119–128.
- Rawls, W. J.; Pachepsky, Y. A.; Ritchie, J. C.; Sobecki, T. M.; Bloodworth, H., 2003. Effect of soil organic carbon on soil water retention, *Geoderma*, 2003. Elsevier.
- Ruess, L.; Michelsen, A.; Schmidt, I. K.; Jonasson, S., 1999. Simulated climate change affecting microorganisms, nematode density and biodiversity in subarctic soils. *Plant and soil* 212: 63–73.
- Sleutel, S.; De Neve, S. and Hofman, G., 2003. Estimates of carbon stock changes in Belgian cropland, *Soil Use & Manage* 19: 166–171.
- Smith J.; Smith P.; Wattenbach, M.; Zaehle, S., Hiederer, R., Jones, R. J. A.; Montanarella, L.; Rounsevell, M. D. A.; Reginster, I.; Ewert, F., 2005. Projected changes in mineral soil carbon of European croplands and grasslands, 1990–2080. *Global Change Biology* 11 (12): 2141.
- Smith, P.; Smith, J.; Wattenbach, M.; Meyer, J.; Lindner, M.; Zaehle, S.; Hiederer, R.; Jones, R. J. A.; Montanarella, L.; Rounsevell, M.; Reginster, I. and Kankaanpää, S., 2006. Projected changes in mineral soil carbon of European forests, 1990–2100. *Canadian Journal of Soil Science* 86: 159–169.
- Swift, M. J.; Andren, O.; Brussard, L.; Briones, M.; Couteaux, M. M.; Ekschmitt, K.; Kjoller, A.; Loiseau, P.; Smith, P., 1998. Global change, soil biodiversity, and nitrogen cycling in terrestrial ecosystems: three case studies. *Global Change Biology* 4: 729–743.
- UNCCD, 1997. United Nation Convention to Combat Desertification in those countries experiencing serious drought and/ or desertification, particularly in Africa. Text with Annexes. Geneva, Switzerland.
- UNCCD, 2008. United Nation Convention to combat desertification. Regional profiles (Northern Mediterranean; Central-Eastern Europe). <http://www.unccd.int>.
- Vleeshouwers, L. M. and Verhagen, A., 2002. Carbon emissions and sequestration by agricultural land use: a model study for Europe, *Global Change Biology* 8: 519–530.
- Wall, D. H.; Adams, G.; Parson, A. N., 2001. Soil Biodiversity. In: Chapin III, F. S.; Sala, E. O.; Huber-Sannwald E. (eds.). *Global Biodiversity in a Changing Environment: Scenarios for the XXI century*. Springer Verlag, pp. 47–82.
- Wall, D. H. and Virginia, R. A., 2000. The world beneath our feet: soil biodiversity and ecosystem functioning. Pages 225–241 in P.R. Raven and T. Williams, editors. *Nature and human society: the quest for a sustainable world*. National Academy of Sciences and National Research Council, Washington, DC.
- Williams J. R.; Sharpley, A. N., 1989. Productivity Impact Calculator.
- Wolters, V.; Silver, W. L.; Bignell, D. E.; Coleman, D. C.; Lavelle, P.; van der Putten, W. H.; de Ruiter, P.; Rusek, J.; Wall, D. H.; Wardle, D. A.; Brussaard, L.; Dangerfield, J. M.; Brown, W. K.; Giller, K.; Hooper, D. U.; Sala, O.; Tiedje; van Veen J. J. A., 2000. Effects of global changes on above- and below ground biodiversity in terrestrial ecosystems: implications for ecosystem functioning. *BioScience* 50: 1089–1098.
- WWF, 2007. *Ecological assessment of the wildfires of August 2007 in the Peloponnese, Greece*. WWF Greece, Athens, September 2007.

Section 5.9 Agriculture and forestry

AEA Energy and Environment, 2007. Adaptation to climate change in the agricultural sector. AGRI-2006-G4-05 Report to European Commission Directorate-General for Agriculture and Rural Development ED05334.

Aerts, R.; Cornelissen, J. H. C. and Dorrepaal, E., 2006. Plant performance in a warmer world: general responses of plants from cold, northern biomes and the importance of winter and spring events. *Plant Ecology* 82 (1–2): 65–77.

Ainsworth, E. A. and Long, S. P., 2005. What have we learned from 15 years of freeair CO₂ enrichment (FACE)? A meta-analytic review of the responses of photosynthesis, canopy properties and plant production to rising CO₂. *New Phytol* 165: 351–371.

Alexander, L. V.; Zhang, X.; Peterson, T. C.; Caesar, J.; Gleason, B.; Klein Tank, A. M. G.; Haylock, M.; Collins, D.; Trewin, B.; Rahimzadeh, F.; Tagipour, A.; Rupa Kumar, K.; Revadekar, J.; Griffiths, G.; Vincent, I.; Stephenson, D. B.; Burn, J.; Aguilar, E.; Brunet, M.; Taylor, M.; New, M.; Zhai, P.; Rusticucci, M. and Vazquez-Aguirre, J. I., 2006. Global observed changes in daily climate extremes of temperature and precipitation. *Journal of Geophysical Research* 111(D5): D05109.

- Alpert, P.; Ben-gai, T.; Baharad, A.; Benjamini, Y.; Yekutieli, D.; Colacino, M.; Diodato, L.; Ramis, C.; Homar, V.; Romero, R.; Michaelides, S. and Manes, A., 2002. The paradoxical increase of Mediterranean extreme daily rainfall in spite of decrease in total values. *Geophysical Research Letters* 29 (11): 31-1–31-4.
- Bakkenes, M.; Alkemade, J. R. M.; Ihle, F.; Leemans, R. and Latour, J. B., 2002. Assessing effects of forecasted climate change on the diversity and distribution of European higher plants for 2050. *Global Change Biology* 8: 390–407.
- Bielza, M.; Conte, C.; Dittmann, C.; Gallego, J.; Stroblmair, J., 2008. *Agricultural Insurance Schemes*. EUR report (in press).
- Bongaarts, J., 1994. Can the growing human population feed itself?, *Scientific American* 270 (3): 18–24.
- Broadmeadow, M.; Ray, D.; Sing, L. and Poulson, E., 2003. Climate change and British woodland: what does the future hold? *Forest Research Annual Reports and Accounts 2002–2003*. HMSO, Edinburgh, pp. 70–83.
- Brunetti, M.; Maugeri, M.; Monti, F. and Nanni, T., 2004. Changes in daily precipitation frequency and distribution in Italy over the last 120 years. *Journal of Geophysical Research* 109 (D05): D05102.
- Camia, A.; Amatulli G.; San-Miguel-Ayanz, J., 2008. *Past and future trends of forest fire danger in Europe*. EUR Technical Report (EUR 23124).
- Cannell, M. G. R.; Thornley, J. H. M.; Mobbs, D. C. and Friend, A. D., 1998. UK conifer forests may be growing faster in response to increased N deposition, atmospheric CO₂ and temperature. *Forestry* 71: 277–296.
- Casalegno, S.; Amatulli, G.; Bastrup-Birk, A.; Houston, T., 2007. *Modelling Current and Future Distribution of European Forest Categories*. Proceedings of the 6th European Conference on Ecological Modelling: Challenges for ecological modelling in a changing world: Global Changes, Sustainability and Ecosystem Based Management. 27–30 November 2007. Trieste, Italy.
- Chmielewski, F.-M.; Müller, A. and Bruns, E., 2004. Climate changes and trends in phenology of fruit trees and field crops in Germany, 1961–2000. *Agricultural and Forest Meteorology* 121: 69–78.
- Chuine, I.; Yiou, P.; Viovy, N.; Seguin, B.; Daux, V. and Le Roy Ladurie, E., 2004. Grape ripening as a past climate indicator. *Nature* 432: 289–290.
- Dixon, R. K.; Brown, S.; Houghton, R. A.; Solomon, A. M.; Trexler, M. C. and Wisniewski, J., 1994. Carbon pools and flux of global forest ecosystems. *Science* 263: 185–190.
- Duchêne, E. and Schneider, C., 2005. Grapevine and climatic changes: a glance at the situation in Alsace. *Agronomy for Sustainable Development* 24: 93–99.
- Eastaugh, C., 2008. IUFRO Occasional Paper No. 21: Adaptations of Forests to Climate Change: A Multidisciplinary Review ISSN 1024-414X.
- Easterling, W. E.; Aggarwal, P. K.; Batima, P.; Brander, K. M.; Erda, L.; Howden, S. M.; Kirilenko, A.; Morton, J.; Soussana, J.-F.; Schmidhuber, J. and Tubiello, F. N., 2007. *Food, fibre and forest products. Climate Change 2007: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Parry, M. L.; Canziani, O.F.; Palutikof, J. P.; van der Linden, P. J. and Hanson, C. E. (eds.), Cambridge University Press, Cambridge, UK, 273–313.
- EC, MARS Bulletins, 2008. <http://mars.jrc.it/marsstat/Bulletins/2008.htm>.
- ECCE PROJECT — Final report, 2005. Preliminary Assessment of the Impacts in Spain due to the Effect of Climate Change. Carried out under the Agreement between the Ministry of the Environment of Spain and the University of Castilla La Mancha.
- EEA, 2006. *European forest types. Categories and types for sustainable forest management reporting and policy*. Technical report No 9/2006. Copenhagen.
- Flannigan, M. D.; Amiro, B. D.; Logan, K. A.; Stocks, B. J. and Wotton, B. M., 2005. Forest Fires and Climate Change in the 21st Century. Mitigation and Adaptation Strategies for Global Change. *Springer* 11: 847–859.
- Flannigan, M. D.; Stocks, B. J.; Wotton, B. M., 2000. Climate Change and Forest Fires. *The Science of the Total Environment* 262 (3): 221–229.
- Genovese, G. (ed.), 2004a. *Methodology of the MARS Crop Yield Forecasting System*. Vol. 1 to Vol. 4, EUR-report 21291 EN.
- Genovese, G., 2004b. *Methodology of the MARS Crop Yield Forecasting System*. EUR 21291 EN/1–4. http://mars.jrc.it/marsstat/Crop_Yield_Forecasting/METAMP/.
- Hafner, S., 2003. Trends in maize, rice and wheat yields for 188 nations over the past 40 years: a prevalence of linear growth. *Agriculture Ecosystems & Environment* 97: 275–283.
- Harrison, P. A.; Berry, P. M.; Butt, N.; New, M., 2006. Modelling climate change impacts on species' distributions at the European scale: implications for conservation policy. *Environmental Science & Policy* 9: 116–128.
- Heim, R. R., 2002. A review of twentieth-century drought indices used in the United States. *Bulletin of the American Meteorological Society* 83: 1149–1165.

- IPCC, 2007. *Climate Change 2007: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Parry, K. L.; Canziani, O. F.; Palutikof, J. P.; van der Linden, P. J. and Hanson, C. E. (eds.), Cambridge University Press, Cambridge, UK.
- Jablonski, L. M.; Wang, X. and Curtis, P. S., 2002. Plant reproduction under elevated CO₂ conditions: A meta-analysis of reports on 79 crop and wild species. *New Phytologist* 156: 9–26.
- Karnosky, D. F.; Pregitzer, K. S.; Zak, D. R.; Kubiske, M. E.; Hendrey, G. R.; Weinstein, D.; Nosal, M. and Percy, K. E., 2005. Scaling ozone responses of forest trees to the ecosystem level in a changing climate. *Plant, Cell & Environment* 28 (8): 965–981.
- Keeling, C. D.; Chin, F. J. S.; Whorf, T. P., 1996. Increased activity of northern vegetation inferred from atmospheric CO₂ measurements. *Nature* 382: 146–149.
- Kimball, B. A.; Kobayashi, K. and Bindi, M., 2002. Responses of agricultural crops to free-air CO₂ enrichment. *Advances in Agronomy* 70: 293–368.
- Kölling, C., 2008. Wälder im Klimawandel: Die Forstwirtschaft muss sich anpassen. In: Lozán, H. Graßl, H.; Jendritzky, G.; Karbe, L.; Reise, K. (Hrsg.) *Unter Mitwirkung von W. A.; Magnuson, J. J.; Robertson, D. M.; Benson, B. J.; Wynne, R. H.; Livingstone, D. M.; Arai, T.; Assel, R. A.; Barry, R. G.; Card, V.; Kuusisto, E.; Granin, N. G.; Prowse, T. D.; Stewart, K. M.; Vuglinski, V. S., 2000. Historical trends in lake and river ice cover in the Northern Hemisphere. *Science* 289: 1743–1746.*
- Maheras, P.; Tolika, K.; Anagnostopoulou, C.; Vafiadis, M.; Patrikas, I. and Flocas, H., 2004. On the relationships between circulation types and changes in rainfall variability in Greece. *International Journal of Climatology* 24: 1695–1712.
- Maracchi, G.; Sirotenko, O.; Bindi, M., 2005. Impacts of present and future Climate Variability on Agriculture and Forestry in the Temperate Regions: Europe. *Climatic Change* 70: 117–135.
- McCarthy, J. J.; Canziani, O. F.; Leary, N. A.; Dokken, D. J.; White, K. S. (eds). 2001. *Climate Change 2001: Impacts, Adaptation, and Vulnerability*. Contribution of the Working Group II to the Third Assessment Report of the Inter-governmental Panel on Climate Change. Cambridge University Press: Cambridge, UK; 1000 pp.
- Meleux, F.; Solmon, F.; Giorgi, F., 2007. Increase in summer European ozone amounts due to climate change. *Atmospheric Environment* 41 (35): 7577–7587.
- Menzel, A.; Estrella, N., 2001. Plant phenological changes. *Fingerprints of Climate Change — Adapted Behaviour and Shifting Species Ranges*, pp. 123–137. Walther, G. R.; Burga, C. A.; Edwards P. J. (eds). Kluwer Academic/Plenum, New York and London.
- Menzel, A.; Fabian, P., 1999. Growing season extended in Europe. *Nature* 397 (6721): 659.
- Menzel, A., 2000. Trends in phenological phases in Europe between 1951 and 1996. *International Journal of Biometeorology* 44 (2): 76–81.
- Menzel, A.; Jakobi, G.; Ahas, R.; Scheifinger, H. and Estrella, N., 2003. Variations of the climatological growing season (1951–2000) in Germany compared with other countries. *International Journal of Climatology* 23: 793–812.
- Myneni, R. B.; Keeling, C. D.; Tucker, C. J.; Asrar, G.; Nemani, R. R., 1997. Increased plant growth in the northern high latitudes from 1981 to 1991. *Nature* 386: 698–702.
- Norby, R. J.; Hartz-Rubin, J.; Verbrugge, M. J., 2003. Phenological responses in maple to experimental atmospheric warming and CO₂ enrichment. *Global Change Biology* 9: 1792–1801.
- Olesen, J. E. and Bindi, M., 2002. Consequences of climate change for European agricultural productivity, land use and policy. *European Journal of Agronomy* 16: 239–262.
- Parry, M. L. (ed.), 2000. *Assessment of the Potential Effects and Adaptations for Climate Change in Europe: The Europe ACACIA Project*. Jackson Environment Institute, University of East Anglia, Norwich, UK, 320 pp.
- Parry, M. L.; Rosenzweig, C.; Iglesias, A.; Livermore, M. and Fischer, G., 2004. Effects of climate change on global food production under SRES emissions and socio-economic scenarios. *Global Environmental Change* 14 (1): 53–67.
- Reilly, J.; Patsev, S.; Felzer, B.; Wang, X.; Dicklighter, D.; Melillo, J.; Prinn, R.; Sarofim, M.; Sokolov, A. and Wang, C., 2007. Global economic effects of changes in crops, pasture, and forests due to changing climate, carbon dioxide, and ozone. *Energy Policy* 35 (11): 5370–5383.
- Robeson, S.M., 2002. Increasing growing-season length in Illinois during the 20th century. *Climatic Change* 52 (1–2): 219–238.
- Root, T. L.; Price, J. T.; Hall, K. R.; Schneider, S. H.; Rosenzweig, C.; Pounds, A., 2003. Fingerprints of global warming on wild animals and plants. *Nature* 421: 57–60.
- San Miguel-Ayanz, J.; Carlson, J. D.; Alexander, M.; Tolhurst, K.; Morgan, G.; Sneeuwjagt, R. and Dudley, M., 2003. Current Methods to Assess Fire Danger Potential. In: *Wildland Fire Danger Estimation and Mapping. The Role of Remote Sensing Data* (E. Chuvieco, Ed.) *World Scientific Publishing*. Singapore, pp. 21–61.

- Scheifinger, H.; Menzel, A.; Koch, E.; Peter, C., 2003. Trends of spring time frost events and phenological dates in Central Europe. *Theoretical and Applied Climatology* 74 (1–2): 41–51.
- Sitch, S.; Cox, P. M.; Collins, W. J.; Huntingford, C., 2007. Indirect radiative forcing of climate change through ozone effects on the land-carbon sink. *Nature* 448: 791–795.
- Spiecker, H.; Mielikainen, K.; Kohl, M.; Skovsgaard, J. P.; 1996. *Growth Trends in European Forests: Studies from 12 Countries*. Springer-Verlag Berlin and Heidelberg GmbH & Co. pp. 372.
- Tait, A.; Zheng, X., 2003. Mapping frost occurrence using satellite data. *Journal of Applied Meteorology* 42 (2): 193–203.
- Tucker, C. J.; Slayback, D. A.; Pinzon, J. E.; Los, S. O.; Myneni, R. B.; Taylor, M. G., 2001. Higher northern latitude normalized difference vegetation index and growing season trends from 1982–1999. *International Journal of Biometeorology* 45: 184–190.
- Van Wagner, C. E., 1987. *Development and structure of the Canadian Forest Fire Weather Index System*. Canadian Forestry Service, Ottawa, Ontario. Forestry Technical Report 35. 37 pp.
- Walther, G. R.; Post, E.; Convey, P.; Menzel, A.; Parmesan, C.; Beebee, T. J. C.; Fromentin, J. M.; Hoegh-Guldberg, O.; Bairlein, F., 2002. Ecological responses to recent climate change. *Nature* 416: 389–395.
- Way, J.; Zimmermann, R.; Rignot, E.; McDonald, K.; Oren, R., 1997. Winter and spring thaw as observed with imaging radar at BOREAS. *Journal of Geophysical Research* 102 (24): 29673–29684.
- Winnett, S. M., 1998. Potential effects of climate change on U.S. forests: a review. *Climate Research* 11: 39–49.
- Yan, Z.; Jones, P. D.; Davies, T. D.; Moberg, A.; Bergström, H.; Camuffo, D.; Cocheo, C.; Maugeri, M.; Demarée, G.R.; Verhoeve, T.; Thoen, E.; Barriendos, M.; Rodríguez, R., Martín-Vide, J.; Yang, C., 2002. Trends of extreme temperatures in Europe and China based on daily observations. *Climatic Change* 53 (1–3): 355–392.
- Zhou, L.; Tucker, C. J.; Kaufmann, R. K.; Slayback, D.; Shabanov, N. V.; Myneni, R. B., 2001. Variations in northern vegetation activity inferred from satellite data of vegetation index during 1981 to 1999. *Journal of Geophysical Research* 106 (D17): 20069–20083.
- Section 5.10 Human health**
- Analitis, A.; Katsouyanni, K. (in press). Short-term effects of temperature and air pollution on health: the EuroHEAT analysis. In: Matthies F, Menne B. (eds.). Preparedness and response to heat-waves in Europe, from evidence to action. Public health response to extreme weather events. Copenhagen, WHO Regional Office for Europe.
- Baccini M.; Biggeri, A.; Accetta, G.; Kosatsky, T.; Katsouyanni, K.; Analitis, A.; Ross Anderson, H.; Bisanti, L.; D'Ippoliti, D.; Danova, J.; Forsberg, B.; Medina, S.; Paldy, A.; Rabczenko, D.; Schindler, C. and Michelozzi, P., 2008. Effects of apparent temperature on summer mortality in 15 European cities: results of the PHEWE project. *Epidemiology* 19 (5).
- Bouchama, A., 2007. *What should health professionals know?* EuroHEAT final meeting, Bonn, Germany, 22–23 March 2007.
- Carson, C.; Hajat, S.; Armstrong, B. *et al.*, 2006. Declining vulnerability to temperature-related mortality in London over the 20th century. *American Journal of Epidemiology* 164 (1): 77–84.
- Confalonieri, U.; Menne, B.; Akhtar, R. *et al.*, 2007. *Human Health*. In: Parry, M. L. *et al.*, eds. Impacts, Adaptation and Vulnerability. Working Group II contribution to the Intergovernmental Panel on Climate Change Fourth Assessment Report. Cambridge, United Kingdom and New York, NY, USA. Cambridge University Press.
- Daniel, M.; Danielová, V.; Kříž, B., 2006. Tick-borne Encephalitis. In: Menne B, Ebi KL, eds. *Climate Change and Adaptation Strategies for Human Health*. Darmstadt: WHO Regional Office for Europe, Steinkopff Verlag; p. 189–205.
- Dessai, S., 2003. Heat stress and mortality in Lisbon Part II. An assessment of the potential impacts of climate change. *International Journal of Biometeorology* 48 (1): 37–44.
- Donaldson, G.; Kovats, R. S.; Keatinge, W. R. *et al.*, 2001. Heat-and-cold-related mortality and morbidity and climate change. In: *Health effects of climate change in the UK*. London, Department of Health; p. 70–80.
- D'Souza, R.; Becker, N.; Hall, G. *et al.*, 2004. Does ambient temperature affect foodborne disease? *Epidemiology* 15: 86–92.
- Ebi, K. L., 2006. Floods and Human Health. In: Menne, B.; Ebi, K. L. (eds.). *Climate Change and Adaptation Strategies for Human Health*. Darmstadt: WHO Regional Office for Europe, Steinkopff Verlag; p. 99–121.
- Ebi, K. L.; Menne, B., 2006. Vector- and Rodent-borne Diseases. In: Menne, B.; Ebi, K. L. (eds.). *Climate Change and Adaptation Strategies for Human Health*. Darmstadt: WHO Regional Office for Europe, Steinkopff Verlag; pp. 129–265.
- ECDC, WHO, 2007. *Mission Report. Chikungunya in Italy. Joint ECDC/WHO visit for a European Risk Assessment*.

- 17–21 September 20: WHO Regional Office for Europe. Available under: http://ecdc.europa.eu/pdf/071030CHK_mission_ITA.pdf.
- EC, 2007. Commission Staff working document. Annex accompanying the Green paper from the commission to the council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions. *Adapting to climate change in Europe — options for EU action*. http://ec.europa.eu/environment/climat/pdf/ia_sec_8.pdf.
- Fleury, M.; Charron, D. F.; Holt, J. D. *et al.*, 2006. A time series analysis of the relationship of ambient temperature and common bacterial enteric infections in two Canadian provinces. *International Journal of Biometeorology* 50 (6): 385–391.
- Goulson, D.; Derwent, L. C.; Hanley, M. *et al.*, 2005. Predicting calyptate fly populations from the weather, and the likely consequences of climate change. *Journal of Applied Ecology and Society* 42: 795–804.
- Hales, S.; de Wet, N.; Maindonald, J. *et al.*, 2002. Potential effect of population and climate changes on global distribution of dengue fever: an empirical model. *Lancet* 360: 830–834.
- Hall, G. V.; D'Souza, R. M.; Kirk, M. D., 2002. Foodborne disease in the new millennium: out of the frying pan and into the fire. *Medical Journal of Australia* 177 (2/16 Dec): 614–618.
- Hassi, J.; Rytönen, M.; Kotaniemi, J. *et al.*, 2005. Impacts of cold climate on human heat balance, performance and health in circumpolar areas. *Int J Circumpolar Health* 64 (5): 459–467.
- Hubálek, Z.; Kříž, B.; Menne, B., 2006. West Nile Virus: Ecology, Epidemiology and Prevention. In: Menne, B.; Ebi, K. L. (eds.). *Climate Change and Adaptation Strategies for Human Health*. Darmstadt: WHO Regional Office for Europe, Steinkopff Verlag; p. 217–242.
- Hunter, P.R., 2003. Climate change and waterborne and vectorborne disease. *Journal of Applied Microbiology* 94: 37–46.
- IPCC, 2007a. *Summary for Policymakers*. In: Solomon S.; Qin, D.; Manning, M.; Chen, Z.; Marquis, M.; Averyt, K. B.; Tignor, M. and Miller, H. L. (eds.). *Climate Change 2007: The Physical Science Basis*. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom and New York, NY, USA. Cambridge University Press.
- IPCC, 2007b. *Summary for Policymakers*. In: Parry ML *et al.*, eds. *Climate Change 2007: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK: Cambridge University Press; pp. 7–22.
- Kistemann, T.; Classen, T.; Koch, C. *et al.*, 2002. Microbial Load of Drinking Water Reservoir Tributaries during Extreme Rainfall and Runoff. *Applied and Environmental Microbiology* 68 (5): 2188–2197.
- Koppe, C.; Jendritzky, G.; Pfaff, G., 2003. Die Auswirkungen der Hitzewelle 2003 auf die Gesundheit. In: DWD, editor. *Klimastatusbericht 2003*; pp. 152–162
- Korenberg, E., 2004. Environmental causes for possible relationship between climate change and changes of natural foci of diseases and their epidemiologic consequences. *Climate change and public health in Russia in the XXI Century. Proceeding of the international workshop, Moscow*.
- Kovats, R. S.; Edwards, S.; Hajat, S. *et al.*, 2004. The effect of temperature on food poisoning: time series analysis in 10 European countries. *Epidemiology and Infection* 132 (3): 443.
- Kovats, R. S.; Edwards, S. J.; Charron, D. *et al.*, 2005. Climate variability and campylobacter infection: an international study. *International Journal of Biometeorology* 49 (4): 207–214.
- Kovats, R. S. and Hajat, S., 2008. Heat stress and public health: a critical review. *Annual Review of Public Health* 29 (9): 11–55.
- Kovats, S., Jendritzky, G., *et al.*, 2006. Heat Waves and Human Health. In: Menne B, Ebi KL, eds. *Climate Change and Adaptation Strategies for Human Health*. Darmstadt: WHO Regional Office for Europe, Steinkopff Verlag; pp. 63–90.
- Kříž, B., Beneš, C., Částková, J. *et al.*, 1998. *Monitorování epidemiologické situace v zaplavených oblastech v České Republice v roce 1997*. (Monitoring the Epidemiological situation in flooded areas of the Czech Republic in 1997). In: Konference DDD '98; Kongresové Centrum Lázeňská Kolonáda Poděbrady, 11.–13. května 1998 (Proceedings of the Conference DDD'98, 11–12th May, 1998, Poděbrady, Czech Republic). Poděbrady, Czech Republic.
- Kunst, A. E., Looman, C. W., Mackenbach, J. P., 1991. The decline in winter excess mortality in The Netherlands. *International Journal of Epidemiology* 20 (4): 971–977.
- Lake, I. R.; Bentham, G.; Kovats, R. S. *et al.*, 2005. Effects of weather and river flow on cryptosporidiosis. *Journal of Water and Health* 3 (4): 469–474.
- Lehane, L. and Lewis, R. J., 2000. Ciguatera: recent advances but the risk remains. *International Journal of Food Microbiology* 61 (2–3): 91–125.

- Lerchl, A., 1998. Changes in the seasonality of mortality in Germany from 1946 to 1995: the role of temperature. *International Journal of Biometeorology* 42: 84–88.
- Lindgren, E.; Naucke, T., 2006. Leishmaniasis: influences of climate and climate change epidemiology, ecology and adaptation measures. In: Menne, B; Ebi, K. (eds.). *Climate change and adaptation strategies for human health*. Darmstadt: WHO Regional Office for Europe, Steinkopff; pp. 131–156.
- Louis, V. R.; Gillespie, I. A.; O'Brien, S. J. *et al.*, 2005. Temperature-driven *Campylobacter* seasonality in England and Wales. *Appl Environ Microbiol*, 71 (1): 85–92.
- Matthies, F.; Bickler, G.; Cardenosa Marin, N. *et al.* (eds.), 2008. *Heat-Health Action Plans. Guidance*. Copenhagen, WHO Regional Office for Europe.
- McMichael, A. J.; Woodruff, R. E.; Hales, S., 2006. Climate change and human health: present and future risks. *Lancet* 367 (9513): 859–869.
- Medlock, J.; Avenell, D.; Barrass, I. *et al.*, 2006. Analysis of the potential for survival and seasonal activity of *Aedes albopictus* (Diptera: Culicidae) in the United Kingdom. *J Vect Ecol*. 31 (2): 292–304.
- Menne, B.; Apfel, F.; Kovats, S. *et al.*, 2008. *Protecting health in Europe from climate change*. WHO Regional Office for Europe. Copenhagen.
- Miettinen, I.; Zacheus, O.; von Bonsdorff, C., 2001. Waterborne epidemics in Finland in 1998–1999. *Water Science and Technology* 43: 67–71.
- Ranhoff, A. H., 2000. Accidental hypothermia in the elderly. *Int J Circumpolar Health* 59 (3–4): 255–259.
- Reacher, M.; McKenzie, K.; Lane, C. *et al.*, 2004. Health impacts of flooding in Lewes: a comparison of reported gastrointestinal and other illness and mental health in flooded and non-flooded households. *Communicable disease and public health* 7 (1): 39–46.
- Roberts, J.; Cumberland, P.; Sockett, P. *et al.*, 2003. The study of infectious intestinal disease in England: socio-economic impact. *Epidemiology and Infection* 130: 1–11.
- Robine, J. M.; Cheung, S. L.; Le Roy, S. *et al.*, 2007. Report on excess mortality in Europe during summer 2003. EU Community Action Programme for Public Health, Grant Agreement 2005114. 2003 Heat wave project. Available under http://ec.europa.eu/health/ph_projects/2005/action1/docs/action1_2005_a2_15_en.pdf.
- Schaffner, F.; Hendrickx, G.; Scholte, E.J.; Medlock, J.; Angelini, P.; Ducheyne, E., 2008. Development of *Aedes albopictus* risk maps. TigerMaps project report. Stockholm: European Centre for Disease Prevention and Control. <http://ecdc.europa.eu/>.
- Scholte, E. and Schaffner, F., 2007. Chapter 14: Waiting for the tiger: establishment and spread of the *Aedes albopictus* mosquito in Europe. In: Takken, W.; BGJ, K. (eds.). *Emerging pests and vector-borne diseases in Europe. Ecology and control of vector-borne diseases*. Wageningen, The Netherlands: Wageningen Academic Publishers; p. 241–260.
- Semenza, J. and Menne, B., 2008. Infectious diseases and climate change in Europe. Submitted to *Lancet Infectious Diseases*, August 2008.
- Semenza, J. and Nichols, G., 2007. Cryptosporidiosis surveillance and water-borne outbreaks in Europe. *Euro surveill* 12 (5). <http://www.eurosurveillance.org/em/v12n05/1205-1227.asp>.
- Tam, C.; Rodrigues, L.; O'Brien, S. *et al.*, 2006. Temperature dependence of reported *Campylobacter* infection in England, 1989–1999. *Epidemiology and Infection* 134 (1): 119–125.
- van Pelt, W.; de Wit, M. A.; Wannet, W. J. *et al.*, 2003. Laboratory surveillance of bacterial gastroenteric pathogens in the Netherlands, 1991–2001. *Epidemiology and Infection* 130 (3): 431–441.

Chapter 6 Adaptation to climate change

EC, 2007. Adapting to climate change in Europe — options for EU action. SEC(2007) 849, European Commission, Brussels.

EEA, 2005. *Vulnerability and adaptation to climate change in Europe*. EEA Technical report No 7/2005. European Environment Agency, Copenhagen.

EEA, 2007. *Climate change: the cost of inaction and the cost of adaptation*. EEA Technical report No 13/2007. European Environment Agency, Copenhagen.

Füssel, H. M. and Klein, R. J. T., 2004. Conceptual Frameworks Of Adaptation To Climate Change And Their Applicability To Human Health, Potsdam Institute Climate Impact Research, PIK Report No 91, WHO-coordinated EC research project 'Climate Change and Adaptation Strategies for Human Health' (cCASHh).

Grothmann T. and Patt, A., 2005. Adaptive Capacity and Human Cognition: The Process of Individual Adaptation to Climate Change. *Global Environmental Change* 15 (3): 199–213.

- IPCC, 2007. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Parry, M. L.; Canziani, O. F.; Palutikof, J. P.; van der Linden, P. J. and Hanson, C. E. (eds.). Cambridge University Press, Cambridge, UK.
- Isoard, S.; Grothmann, T. and Zebisch, M., 2008. Climate Change Impacts, Vulnerability and Adaptation: Theory and Concepts', Workshop 'Climate Change Impacts and Adaptation in the European Alps: Focus Water', UBA Vienna.
- Massey, E., 2007. Framework for comparing adaptation initiatives within countries. Eionet workshop on impacts, vulnerability and adaptation, European Environment Agency, Copenhagen.
- OECD, 2008. *Economic aspects of adaptation to climate change — Costs, benefits and policy instruments*. Shardul Agrawala and Samuel Fankhauser (eds.).
- Oxfam International, 2007. *Adapting to Climate Change. What's Needed in Poor Countries, and Who Should Pay*. Oxfam Briefing Paper 104. Oxford.
- Swart, R. and Raes, F., 2007. Making integration of adaptation and mitigation work: mainstreaming into sustainable development policies? *Climate Policy* 7 (4): 288–303.
- Uhel, R. and Isoard, S., 2008. Regional adaptation to climate change: a European spatial planning challenge, InfoRegio Panorama, March 2008 No 25 'Regional policy, sustainable development and climate change', European Commission DG REGIO.
- UNDP, 2007. *Human Development Report 2007/2008 — Fighting climate change: Human solidarity in a divided world*, UNDP.
- UNDP, 2004. *Adaptation Policy Frameworks for Climate Change; Developing Strategies, Policies and Measures*, UNDP.
- UNFCCC, 2006. Five-year programme of work on impacts, vulnerability and adaptation to climate change, in: *Report of the Subsidiary Body for Scientific and Technological Advice* on its twenty-fifth session held at Nairobi from 6 to 14 November 2006.
- UNFCCC 2007a. *The analysis of existing and potential investment and financial flows relevant to the development of an effective and appropriate international response to climate change*, UNFCCC.
- UNFCCC 2007b. *Investment And Financial Flows To Address Climate Change*, United Nations Framework Convention on Climate Change.
- UNFCCC, 2007c. Decision 1/CP.13, Bali Action Plan.
- World Bank, 2007. World Development Indicators. CD-ROM. Washington, DC.

Chapter 7 Economic consequences of climate change

Abegg, B.; Agrawala S.; Crick F. and de Montfalcon, A., 2007. Climate change impacts and adaptation in winter tourism. In: *Climate change in the European Alps: adapting winter tourism and natural hazards management*. Paris: Organization for Economic Co-operation and Development: pp. 25–60.

ABI, 2005. *Financial risks of climate change — summary report*. http://www.abi.org.uk/Display/File/Child/552/Financial_Risks_of_Climate_Change.pdf.

ABI, 2006. *Coastal Flood Risk — Thinking for tomorrow, acting today*. http://www.abi.org.uk/DISPLAY/default.asp?Menu_ID=773&Menu_All=1,773,0&Child_ID=651.

ABI, 2007. *Adapting to our changing climate: A manifesto for business, government and the public*. http://www.abi.org.uk/BookShop/ResearchReports/Climate_Change_FINAL.pdf.

Ackerman, F. and Stanton, E., 2006. *Climate Change — the Costs of Inaction*. Report to Friends of the Earth England, Wales and Northern Ireland, October, 2006.

Alberini, A. and Chiabai, A., 2005. *Urban environmental health and sensitive populations: how much are the Italians willing to pay to reduce their risks?* SIEV — Sustainability Indicators and Environmental Valuation (NOTA DI LAVORO 105.2005), FEEM, Milano.

Alcamo, J.; Moreno, J. M.; Nováky, B.; Bindi, M.; Corobov, R.; Devoy, R. J. N.; Giannakopoulos, C.; Martin, E.; Olesen, J. E.; Shvidenko, A., 2007. Europe. Climate Change 2007: *Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Parry, M. L.; Canziani, O. F.; Palutikof, J. P.; van der Linden, P. J. and Hanson, C. E. (eds.). Cambridge University Press, Cambridge, UK, 541–580.

Andréasson, J.; Bergström, S.; Gardelin, M. and Hellström, S.-S., 2006. *Climate Change Effects on Dam Safety — A Sensitivity Analysis of the Swedish Hydrological Dam Safety Guidelines*. European Conference on Impacts of Climate Change on Renewable Energy Sources. Series Climate Change Effects on Dam Safety — A Sensitivity Analysis of the Swedish Hydrological Dam Safety Guidelines. http://verkefni.vatn.is/ce/files/Hydrological_models/johan_andreasson.pdf.

- Armstrong, B.; Mangtani, P.; Fletcher, A.; Kovats, R. S.; McMichael, A. J.; Pattenden, S. and Wilkinson, P., 2004. Effect of influenza vaccination on excess deaths occurring during periods of high circulation of influenza: cohort study in elderly people. *British Medical Journal* 329: 660–663.
- Barredo, J. I., 2007. Major flood disasters in Europe: 1950–2005. *Natural Hazards* 42: 125–148.
- Bresser *et al.*, 2006. *The effects of climate change in the Netherlands*. Report from Netherlands Environmental Assessment Agency. (eds.). www.mnp.nl/en/publications/2006/TheeffectsofclimatechangeintheNetherlands.html.
- Bergström, S.; Jóhannesson, T.; Aðalgeirsdóttir, G.; Ahlström, A.; Andreassen, L. M.; Andréasson, J.; Beldring, S.; Björnsson, H.; Carlsson, B.; Crochet, P.; de Woul, M.; Einarsson, B.; Elvehøy, H.; Flowers, G. E.; Graham, P.; Gröndal, G. O.; Guðmundsson, S.; Hellström, S.-S.; Hock, R.; Holmlund, P.; Jónsdóttir, J. F.; Pálsson, F.; Radoc, V.; Reeh, N.; Roald, L. A.; Rogozova, S.; Rosberg, J.; Sigurðsson, O.; Suomalainen, M.; Thorsteinsson, T.; Vehviläinen, B. and Veijalainen, N., 2007. *Impacts of climate change on river runoff, glaciers and hydropower in the Nordic area*. Joint final report from the CE Hydrological Models and Snow and Ice Groups. CE Report CE-6. 40 pp. Norden — Nordic Energy Research, Reykjavik. www.os.is/cefiles/hydro/final_report_high.pdf.
- BMU, 2007. Time to Adapt Symposium: Climate Change and the European Water Dimension. Discussion paper on Electricity. Series Time to Adapt Symposium: Climate Change and the European Water Dimension. Discussion paper on Electricity. Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit.
- Bouwer, L. M.; Crompton, R. P.; Faust, E.; Höpfe, P. and Pielke R. A. Jr., 2007. Disaster management: Confronting Disaster Losses. *Science* 318 (5851): 753.
- Cartalis, C.; Synodinou, A.; Proedrou, M.; Tsangrassoulis, A. and Santamouris, M., 2001. Modifications in energy demand in urban areas as a result of climate changes: an assessment for the southeast Mediterranean region. *Energy Conversion and Management* 42: 1647–1656.
- Cline, W., 2004. Meeting the challenge of global warming: reply to Manne and Mendelsohn. Copenhagen Consensus Challenge Paper, Opponents Notes Reply, 8 pp. http://www.copenhagenconsensus.com/Files/Filer/CC/Papers/Reply_-_Cline_-_Climate_Change_180504.pdf. (Global, adaptation).
- Confalonieri, U.; Menne, B.; Akhtar, R. *et al.*, 2007. Human Health. In: Parry, M. L. *et al.*, eds. *Impacts, Adaptation and Vulnerability. Working Group II contribution to the Intergovernmental Panel on Climate Change Fourth Assessment Report*. Cambridge, United Kingdom and New York, NY, USA. Cambridge University Press.
- Downing, T. E.; Butterfield, R. E.; Edmonds, B.; Knox, J. W.; Moss, S.; Piper, B. S. and Weatherhead, E. K. (and the CCDeW project team), 2003. *Climate Change and the Demand for Water*, Research Report, Stockholm Environment Institute Oxford Office, Oxford.
- EC, 2007. Adaptation to Climate Change in the Agricultural Sector, EC-DG AGRI, AEA-T and the Universidad de Politécnica de Madrid, Final report, December.
- EC, 2008a. Study on impacts of climate change on European forests and options for adaptation, EC-DG AGRI, European Forest Institute, 1st interim draft report of 31st March 2008.
- EC, 2008b. The economics of ecosystems and biodiversity, Interim Report.
- EEA, 2004. *Mapping the impacts of recent natural disasters and technological accidents in Europe*. Environmental issue report No 35, European Environment Agency, Copenhagen.
- EEA, 2006. Working paper. Climate Change: the Cost of Inaction — A review of assessment studies with a focus on the methodologies used. Specific Agreement No 3570/B2005.EEA.52247. Final working paper, January 2006. Barbara Buchner, Michela Catenacci, Alessandra Gorla (FEEM) Onno Kuik, Richard Tol (IVM).
- EEA, 2007a. *Climate change and water adaptation issues*. EEA Technical report No 2/2007. 114 pp. European Environment Agency, Copenhagen. http://reports.eea.europa.eu/technical_report_2007_2/en/eea_technical_report_2_2007.pdf.
- EEA, 2007b. *Climate change: the cost of inaction and the cost of adaptation*, EEA Technical report No 13/2007, European Environment Agency, Copenhagen.
- EU, 2006. A European Strategy for Sustainable, Competitive and Secure Energy. Green paper SEC (2006) 317. 20 pp. European Commission, Brussels. http://ec.europa.eu/energy/green-paper-energy/doc/2006_03_08_gp_document_en.pdf.
- Eurostat, 2007. Panorama of Energy. Energy statistics to support EU policies and solutions. 2007. http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-76-06-604/EN/KS-76-06-604-EN.PDF
- Fronzek, S. and Carter, T. R., 2007. Assessing uncertainties in climate change impacts on resource potential for Europe based on projections from RCMs and GCMs. *Climatic Change*, 81: 357–371.
- Giannakopoulos, C. and Psiloglou, B. E., 2006. Trends in energy load demand for Athens, Greece: weather and non-weather related factors. *Climate Research* 13: 97–108.
- Giannakopoulos, C., Bindi, M., Moriondo, M., LeSager, P. and Tin, T., 2005. *Climate Change Impacts in the Mediterranean*

- Resulting from a 20C Global Temperature Rise. WWF report, Gland Switzerland. Accessed 01.10.2006 at <http://assets.panda.org/downloads/medreportfinal8july05.pdf>.
- Hall, J. W., Sayers, P. B. and Dawson, R. J., 2005. National-scale Assessment of Current and Future Flood Risk in England and Wales. *Natural Hazards* 36: 147–164.
- Höppe, P. and Pielke Jr., R. A., 2006. Workshop Summary Report. In Workshop on Climate Change and Disaster Losses: Understanding and Attributing Trends and Projections, Höppe, P. and Pielke, Jr. R. A. (eds.). Hohenkammer, Germany, 4–12.
- Höppe, P.; Pielke Jr., R. A. (eds.), 2006. *Climate Change and Disaster Losses: Understanding and Attributing Trends and Projections*, Report of a workshop, Hohenkammer, Germany, 25 to 26 May 2006 (University of Colorado, Boulder and Munich Re, Munich, 2006); http://sciencepolicy.colorado.edu/sparc/research/projects/extreme_events/munich_workshop/.
- Huntington, T. G., 2006. Evidence for intensification of the global water cycle: Review and synthesis. *Journal of Hydrology* 319: 83–95.
- IPCC, 2007a. *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Solomon, S.; Qin, D.; Manning, M.; Chen, Z.; Marquis, M.; Averyt, K. B.; Tignor M. and Miller H. L. (eds.). Cambridge University Press, Cambridge, UK.
- IPCC, 2007b. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Parry, M. L.; Canziani, O. F.; Palutikof, J. P.; van der Linden, P. J. and Hanson, C. E. (eds.). Cambridge University Press, Cambridge, UK.
- Kirkinen, J.; Martikainen, A.; Holttinen, H.; Savolainen, I.; Auvinen, O. and Syri, S., 2005. Impacts on the energy sector and adaptation of the electricity network business under a changing climate in Finland. Mimeographs 340. 36 pp. Finnish Environment Institute, Helsinki. www.environment.fi/download.asp?contentid=45340&lan=en.
- Kovats, R.S. and Jendritzky, G., 2006. Heat waves and human health, in: *Climate Change and Adaptation Strategies for Humans Health* (eds. B. Menne and K.L. Ebi), Steinkopff, Darmstadt, Germany.
- Kundzewicz, Z. W., 2005. Intense precipitation and high river flows in Europe — Observations and projections. *Acta Geophysica Polonica* 53: 385–400.
- Kundzewicz, Z. W.; Ulbrich, U.; Brücher, T.; Graczyk, D.; Krüger, A.; Leckebusch, G. C.; Menzel, L.; Pińskwar, I.; Radziejewski, M. and Szwed, M., 2005. Summer Floods in Central Europe — Climate Change Track? *Natural Hazards* 36: 165–189.
- LCCP, 2002. *London's Warming. London Climate Change Partnership A Climate Change Impacts in London Evaluation Study*. Final Report November 2002. Greater London Authority, London.
- Lehner, B.; Czisch, G. and Vassolo, S., 2001. Europe's hydropower potential today and in the future. In: Lehner, B.; Henrichs, T.; Döll, P. and Alcamo, J. (eds.). *EuroWasser — Model-based assessment of European water resources and hydrology in the face of global change*. Kassel World Water Series. Center for Environmental Systems Research, University of Kassel. http://www.usf.uni-kassel.de/usf/archiv/dokumente/kwws/5/ew_8_hydropower.pdf.
- Lehner, B.; Czisch, G. and Vassolo, S., 2005. The impact of global change on the hydropower potential of Europe: a model-based analysis. *Energy Policy* 33: 839–855.
- López Zafra, J. M.; Sánchez de Tembleque, L. and Meneu, V., 2005: Impactos sobre el sector energético. *Evaluación Preliminar de los Impactos en España for Efecto del Cambio Climático*, J. M. Moreno, (ed.). Ministerio de Medio Ambiente, Madrid: 617–652.
- Marttila, V.; Granholm, H.; Laanikari, J.; Yrjölä, T.; Aalto, A.; Heikinheimo, P.; Honkatukia, J.; Järvinen, H.; Liski, J.; Merivirta, R. and Paunio, M., 2005. Finland's National Strategy for Adaptation to Climate Change. Publications series of the Ministry of Agriculture and Forestry of Finland, number 1a/2005. <http://www.mmm.fi/sopeutumisstrategia/>.
- Millennium Ecosystem Assessment, 2005. *Ecosystems and Human Well-being: Synthesis*. Island Press, Washington, DC.
- Mills, E., 2005. Insurance in a Climate of Change. *Science* 309: 1040–1044.
- Mo, B.; Doorman, G. and Grinden, B., 2006. Climate Change — Consequences for the electricity system. Analysis of the Nord Pool system. Climate and Energy Report CE-5. 159 pp. Norden — Nordic Energy Research, Reykjavik. http://www.os.is/cefiles/energy/Report_CE5.pdf.
- Mudelsee, M.; Borngen, M.; Tetzlaff, G. and Grunewald, U., 2003. No upward trends in the occurrence of extreme floods in central Europe. *Nature* 425: 166–169.
- Muir Wood, R.; Miller, S. and Boissonnade, A., 2006. *The search for trends in a global catalogue of normalized weather-related catastrophe losses*. In Workshop on Climate Change and Disaster Losses — Understanding and Attributing Trends and Projections, P. Höppe and R. A. Pielke, Jr. (eds.). Hohenkammer, Germany, 188–194.
- Munich Re, 2007. Naturkatastrophen in Europa, unpublished data.

- Munich Re, 2008. Geo Risks Research, NatCatSERVICE. Personal communication and submission by P. Löw and A. Wirtz.
- OECD, 2007. Authors: Nicholls, R.J.(1), Hanson, S., Herweijer, C., Patmore, N., Hallegatte, S., Corfee-Morlot, J., Chateau, J., and Muir-Wood, R. Screening Study: Ranking Port Cities With High Exposure And Vulnerability To Climate Extremes Interim Analysis: Exposure Estimates. ENV/EPOC/GSP(2007)11.
- OECD, 2008. Authors: Nicholls, R.J., Hanson, S., Herweijer, C., Patmore, N., Hallegatte, S., Corfee-Morlot, J., Chateau, J., and Muir-Wood, R., 'Screening Study: Ranking Port Cities With High Exposure And Vulnerability To Climate Extremes Interim Analysis: Exposure Estimates', ENV/EPOC/GSP(2007)11.
- Pielke Jr., R. A., 2007. Future economic damage from tropical cyclones: sensitivities to societal and climate changes. *Philosophical Transactions of the Royal Society* 365: 1–13.
- Pielke Jr., R. A. and Downton, M. W., 2000. Precipitation and Damaging Floods: Trends in the United States, 1932–97. *Journal of Climate* 13: 3625–3637.
- Robine, J. M.; Cheung, S. L.; Le Roy, S.; Van Oyen, H. and Herrmann, F. R., 2007. The CANICULE-project: The excess mortality in summer 2003; Presentation. Bonn, WHO-meeting on improving public health responses to extreme heat, 22.03.2007.
- Schär, C.; Vidale, P. L.; Lüthi, D.; Frei, C.; Häberli, C.; Liniger, M. A., and Appenzeller, C., 2004. The role of increasing temperature variability in European summer heatwaves. *Nature* 427: 332–336.
- Stern, N., 2006. The Economics of Climate Change. Cabinet Office — HM Treasury. Cambridge University Press.
- Tol, R., S., 2002a. Estimates of the damage costs of climate change. Part II. Dynamic estimates. *Environmental and Resource Economics* 21 (2): 135–160.
- Tol, R., S., 2002b. Estimates of the damage costs of climate change. Part I. Benchmark estimates. *Environmental and Resource Economics* 21 (1): 47–73.
- UCTE, 1999. *Langfristige Entwicklung von Abfließreihen im UCPT-E-Raum*. Bericht der UG Wasserwirtschaft. 9 pp. Union for the Coordination of Transmission of Electricity, Wien.
- UNEP FI, 2006. *Adaptation and vulnerability to climate change: the role of the finance sector*. United Nations Environment Programme Finance Initiative, Geneva, Switzerland. Also available at http://www.unepfi.org/fileadmin/documents/CEO_briefing_adaptation_vulnerability_2006.pdf.
- Vajda, A., Venäläinen, A., Tuomenvirta, H. and Jylhä, K., 2004. An estimate of the influence of climate change on heating energy demand on regions of Hungary, Romania and Finland. *Quarterly Journal of the Hungarian Meteorological Service* 108: 123–140.
- Veijalainen, N. and Vehviläinen, B., 2006. Climate change effects on dam safety in Finland. European Conference on Impacts of Climate Change on Renewable Energy Sources. Series Climate change effects on dam safety in Finland. http://verkefni.vatn.is/ce/files/Hydrological_models/noora_veijalainen.pdf.
- Watkiss, P., 2006. *The Social Costs of Carbon (SCC) Review — Methodological Approaches for Using SCC Estimates in Policy Assessment*, Final Report to Defra. Published January 2006. Paul Watkiss with contributions from David Anthoff, Tom Downing, Cameron Hepburn, Chris Hope, Alistair Hunt, and Richard Tol. <http://www.defra.gov.uk/environment/climatechange/carboncost/aeat-scc.htm>.
- WL Delft Hydraulics, 2007. *Overstromingsrisico's in Nederland in een veranderend klimaat* (Flood risks in the Netherlands under climate change). Report Q4290.00, WL Delft Hydraulics Delft, the Netherlands.

Chapter 8 Data gaps, uncertainties and future needs

Campbell-Lendrum, D. H.; Angulo, V. M.; Esteban, L.; Tarazona, Z.; Parra, G. J.; Restrepo, M.; Restrepo, B. N.; Guhl, F.; Pinto, N.; Aguilera, G.; Wilkinson, P. and Davies, C. R., 2007. House-level risk factors for triatomine infestation in Colombia. *International Journal of Epidemiology* 36(4): 866–872.

Carter, T. and Fronzek, S., 2008. Produced for EEA by Finnish Environment Institute (SYKE), based on data from the PRUDENCE project. <http://prudence.dmi.dk/index.html>.

Confalonieri, U.; Menne, B.; Akhtar, R. *et al.*, 2007. Human Health. In: Parry, M. L. *et al.* (eds.). *Impacts, Adaptation and Vulnerability. Working Group II contribution to the Intergovernmental Panel on Climate Change Fourth Assessment Report*. Cambridge, United Kingdom and New York, NY, USA. Cambridge University Press.

EC, 2004. *Communication from the Commission to the European Parliament and the Council: Global Monitoring for Environment and Security (GMES): Establishing a GMES capacity by 2008 — (Action Plan (2004–2008))* COM(2004)65 final <http://www.gmes.info/library/files/>.

EC, 2005. *European Research on Climate Change Catalogue of FP6 Projects Volume 1*, Environment Directorate, http://ec.europa.eu/research/environment/pdf/european_research_climate_change_en.pdf.

EC, 2006a. *Global Change and Ecosystems Catalogue of projects funded during the Sixth Framework Programme*, Environment Directorate. http://ec.europa.eu/research/environment/pdf/global_change_ecosystem.pdf.

EC, 2006b. *European Research on Climate Change Catalogue of FP5 and FP6 Projects on Carbon Cycle and Green House Gases*, Environment Directorate, http://ec.europa.eu/research/environment/pdf/catalogue_fp5fp6_carbon.pdf.

EC, 2006c. *International Symposium Climate Change Research Challenges*, Environment Directorate, http://ec.europa.eu/research/environment/pdf/climate_research_chall.pdf.

EC, 2007a. *European research on Polar Environment and Climate Results and information from FP5 and FP6 projects*, Environment Directorate, http://ec.europa.eu/research/environment/pdf/polar_catalogue_final.pdf.

EC, 2007b. *Polar Environment and Climate The challenges, International Symposium, European research in the context of the International Polar Year*, Environment Directorate, http://ec.europa.eu/research/environment/pdf/polar_env_and_climate_proceedings.pdf.

GCOS, 2003. *The second report on the adequacy of global observing systems for climate in support of the UNFCCC*. Report no. GCOS-82.

GEOSS, 2005. *The Global Earth Observation System of Systems (GEOSS) 10-Year Implementation Plan*. <http://www.earthobservations.org/docs/>.

IPCC, 2001. *Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change*, Houghton, J. T. et al. (eds.). Cambridge University Press, Cambridge, UK.

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

McMichael, A. J.; Campbell-Lendrum, D.; Kovats, S. et al., 2007. Climate Change. In: Ezzati, M.; Lopez, A.D.; Rodgers, A.; Mathers, C. (eds.). *Comparative quantification of health risks: global and regional burden of disease due to selected major risk factors*. Geneva: World Health Organization, 2004: 1543–649.

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

Ruosteenoja, K.; Carter, T. R.; Jylhä, K. and Tuomenvirta, H., 2003. Future climate in world regions: an intercomparison of model-based projections for the new IPCC emissions scenarios. *The Finnish Environment 644*, Finnish Environment Institute, Helsinki, 83 pp.

Glossary

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

IPCC, 1996. *Climate Change 1995: The Science of Climate Change. Contribution of Working Group I to the Second Assessment Report of the Intergovernmental Panel on Climate Change*, Houghton, J. T. et al. (eds.). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 572 pp.

IPCC, 2001. *Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change*, Houghton, J. T. et al. (eds.). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 881 pp.

Nakićenović, N., and R. Swart (eds.), 2000. *Special Report on Emissions Scenarios. A Special Report of Working Group III of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, UK.

List of tables, figures and maps

List of tables

Table S.1	Observed (obs) and projected (scen) trends in climate and impacts for northern (Arctic and boreal), temperate (maritime climate, central/eastern) and southern (Mediterranean) regions of Europe	17
Table 5.1	Average ocean surface pH values	77
Table 5.2	Contribution of different processes to global sea-level rise (1993–2006)	79
Table 5.3	Average sea-level rise in some European seas (satellite observations) October 1992–May 2007)	80
Table 5.4	Summary of sea surface temperature changes in the global ocean and the four European regional seas.....	82
Table 6.1	EU Member States progress towards National Adaptation Strategies (NAS) ..	165
Table 8.1	Major changes in indicators 2004–2008	196
Table 8.2	Emission scenarios and climate models used for impact studies.....	197
Table 8.3	Essential climate variables as required by UNFCCC for detecting and modelling climate change.....	203

List of figures

Figure 2.1	The 'greenhouse effect'	23
Figure 2.2	The global carbon cycle for the 1990s	24
Figure 2.3	Antarctic temperature change and atmospheric carbon dioxide concentration (CO ₂) over the past 800 000 years	25
Figure 2.4	Records of Northern Hemisphere temperature variation during the last 1 300 years	26
Figure 2.5	Observed changes in (a) global average surface temperature, (b) global average sea level and (c) northern hemispheric snow cover for March–April..	27
Figure 3.1	Selected relationships between climate change impacts included in this report	30
Figure 4.1	Examples of global impacts in various sectors projected for changes in climate associated with different amounts of increase in global average surface temperature in the 21st century	32
Figure 4.2	Examples of regional impacts projected for changes in climate associated with different amounts of increase in global average surface temperature in the 21st century	33
Figure 4.3	The probabilistic implications for global temperature increase up to year 2400.....	36
Figure 5.1	Mean winter (December–March) NAO index 1864–2007	39
Figure 5.2	Observed global and European annual average temperature deviations, 1850–2007	41

Figure 5.3	Percentage of Europe experiencing moderate drought conditions during the 20th century	51
Figure 5.4	Simulated land average maximum 5-day total precipitation for different European regions (1860–2100)	52
Figure 5.5	Simulated land average maximum number of consecutive dry days for different European regions (1860–2100)	52
Figure 5.6	Diagram of drought types	53
Figure 5.7	Storm index for various parts of Europe 1881–2005	54
Figure 5.8	Cumulative specific net mass balance of glaciers from all European glaciated regions 1946–2006.....	61
Figure 5.9	Shrinking of the Vernagtferner glacier, Austria	62
Figure 5.10	Modelled remains of the glacier cover in the European Alps for an increase in average summer air temperature of 1 to 5 °C	63
Figure 5.11	Northern hemisphere snow-cover extent variation 1966–2005	64
Figure 5.12	Estimated changes of the ice mass in Greenland 1992–2006	67
Figure 5.13	Area of Greenland ice sheet melting 1979–2007	69
Figure 5.14	Average extent of arctic sea ice in March and September 1979–2007.....	70
Figure 5.15	Area of multi-year Arctic sea ice in March 1957–2007	72
Figure 5.16	Observed and projected Arctic September sea-ice extent 1900–2100.....	73
Figure 5.17	Temperature distribution within a mountain range containing permafrost.....	74
Figure 5.18	Temperature measured in different boreholes in mountain permafrost in Switzerland 1987–2007	75
Figure 5.19	Changes in global sea level 1870–2006.....	79
Figure 5.20	Projected global average sea-level rise 1990–2100.....	81
Figure 5.21	Sea surface temperature anomaly for period 1870–2006.....	82
Figure 5.22	Decapod abundance in the central North Sea 1950–2005	85
Figure 5.23	Change in colour index in southern North Sea from the 1950s until 2000s.....	87
Figure 5.24	Recordings of two tropical fish 1963–1996	88
Figure 5.25	Relative abundance of warm-water to cold-water flatfish species	90
Figure 5.26	Projected change in daily average river flow between 2071–2100 and the reference period 1961–1990	95
Figure 5.27	Water temperatures in four selected European rivers and lakes in the 20th century.....	103
Figure 5.28	Ice break-up dates from selected European lakes and rivers (1835–2006) and the North Atlantic Oscillation (NAO) index for winter 1864–2006	105
Figure 5.29	Northward shift and changes in occurrence of selected freshwater species ...	107
Figure 5.30	Model simulation of hydrodynamics and phytoplankton dynamics during three contrasting summers in Lake Nieuwe Meer (the Netherlands)	108
Figure 5.31	Increase in species richness on Swiss Alpine mountain summits in 20th century	112
Figure 5.32	Phenological sensitivity to temperature changes.....	114
Figure 5.33	Oak (<i>Quercus</i> sp) leafing date in Surrey (United Kingdom) 1950–2008	115
Figure 5.34	Latitudinal shifts in northern range margins in the United Kingdom for selected groups of animal species over the past 40 years	116
Figure 5.35	Impact of climate change on populations of European birds, 1980–2005	117
Figure 5.36	Length of frost-free period in selected European areas 1975–2007	137
Figure 5.37	Potential alcohol level at harvest for Riesling in Alsace (France) 1972–2003	140

Figure 5.38	Agro-ecosystem processes and a changing climate	141
Figure 5.39	Sensitivity of cereal yields to climate change for maize and wheat	142
Figure 5.40	Meteorological water balance in selected parts of Europe 1975–2007	
Figure 5.41	Impacts of climate change on forest growth and forest conditions	146
Figure 5.42	Relationship between number of temperature-related daily deaths and daily temperature	150
Figure 5.43	Factors affecting human thermoregulation and the risk of heat illness	151
Figure 5.44	Daily mortality rates in 15 European cities by apparent temperature in summer time	152
Figure 5.45	Percentage change of weekly salmonella cases by 1 °C temperature increase	158
Figure 6.1	Conceptual model for climate change impacts, vulnerability and adaptation	162
Figure 7.1	Natural disasters in Europe 1980–2007	170
Figure 7.2	Natural disasters in Europe 1980–2007	170
Figure 7.3	Overall and insured losses from weather disasters in Europe 1980–2007	171
Figure 7.4	Example of the adjustment of loss distribution as a consequence of changing risk	171
Figure 7.5	Flood losses per thousand of GDP in the EU 1970–2005	173
Figure 7.6	Number of casualties caused by flood disasters in the EU 1970–2005	173
Figure 7.7	Heating degree days in Europe 1980–2005	185
Figure 7.8	Projected changes in hydropower production in Scandinavia	185
Figure 7.9	Number of days with water temperature higher than 23 °C in the river Rhine (Lobith, the Netherlands) 1909–2003	186
Figure 8.1	Comparison of scenarios of air temperature and precipitation applied in impact studies described in this report	199

List of maps

Map S.1	Key past and projected impacts and effects on sectors for the main biogeographic regions of Europe	19
Map 3.1	Locations of significant changes in physical and biological systems in Europe between 1970–2004	28
Map 3.2	Locations of significant changes in data series of physical and biological systems, shown together with surface air temperature changes over the period 1970–2004	29
Map 5.1	Observed temperature change over Europe 1976–2006	43
Map 5.2	Modelled change in mean temperature over Europe between 1980–1999 and 2080–2099	43
Map 5.3	The linear trend in surface temperature over Europe 1958–2001	44
Map 5.4	Observed changes in annual precipitation 1961–2006	45
Map 5.5	Modelled precipitation change between 1980–1999 and 2080–2099	46
Map 5.6	Observed changes in warm spells and frost days indices 1976–2006	47
Map 5.7	Modelled number of tropical nights over Europe during summer (June–August) 1961–1990 and 2071–2100	48
Map 5.8	Summer 2003 (June–August) daily maximum temperature anomaly	49
Map 5.9	Changes in the contribution of heavy rainfall to total precipitation 1961–2006	50

Map 5.10	Projected relative change of annual maximum daily mean wind speed between 1961–2000 and 2050 using different models	55
Map 5.11	Change in the height of a 50-year return period extreme water level event for the end of 21st century for different scenarios	56
Map 5.12	Modelled change in tropospheric ozone concentrations over Europe 1958–2001 and 1978–2001	57
Map 5.13	Change in number of ozone exceedance days between 1993–1996 and 2000–2004	58
Map 5.14	Contribution of temperature increase to the change in ozone exceedance days between 1993–1996 and 2000–2004	59
Map 5.15	Observed change in spring snow-cover duration 1970–2004	65
Map 5.16	Annual number of days with snow cover over European land areas 1961–1990 and projected change for 2071–2100.....	66
Map 5.17	The 2007 minimum sea-ice extent	71
Map 5.18	Sea-level change at different European tide-gauge stations 1896–2004	78
Map 5.19	Sea-level changes in Europe October 1992–May 2007.....	80
Map 5.20	Sea surface temperature changes for the European seas 1982–2006	83
Map 5.21	Northward movement of zooplankton between 1958–2005	89
Map 5.22	Modelled change in annual river flow between 1971–1998 and 1900–1970	93
Map 5.23	Projected change in mean seasonal and annual river flow between 2071–2100 and the reference period 1961–1990	94
Map 5.24	Occurrence of flood events in Europe 1998–2008	96
Map 5.25	Projected change in 100-year return level of river discharge between 2071–2100 and the reference period 1961–1990	98
Map 5.26	Change in the severity of river flow droughts in Europe 1962–1990	99
Map 5.27	Change in the severity of river flow droughts in France 1960–2000.....	100
Map 5.28	Projected change in mean annual and summer minimum 7-day river flow between 2071–2100 and the reference period 1961–1990	101
Map 5.29	The share of <i>Trichoptera taxa</i> sensitive to climate change in the European ecoregions	110
Map 5.30	Projected changes in number of plant species in 2050	113
Map 5.31	Projected impact of climate change on the potential distribution of reptiles and amphibians in 2050.....	118
Map 5.32	Changes in egg-laying dates (1980–2004) of the pied flycatcher (<i>Ficedula hypoleuca</i>)	119
Map 5.33	Current distribution range of the butterfly <i>Titania fritillaria</i> (<i>Boloria titania</i>) and its host plant American bistort (<i>Polygonum bistorta</i>)	121
Map 5.34	Relationship between projected distribution space of the butterfly <i>Titania fritillaria</i> (<i>Boloria titania</i>) and its host plant American bistort (<i>Polygonum bistorta</i>) for 2080.....	122
Map 5.35	Changes in soil organic carbon content across England and Wales between 1978 and 2003	127
Map 5.36	Projected changes in soil organic carbon for cropland 1990–2080.....	128
Map 5.37	Soil erosion risk assessment for Europe for the year 2000	130
Map 5.38	Modelled soil moisture in Europe.....	132
Map 5.39	Modelled summer soil moisture (1961–1990) and projected changes (2070–2080) over Europe	133
Map 5.40	Rate of change of crop growing season length 1975–2007	136
Map 5.41	Modelled change of flowering date for winter wheat 1975–2007	139
Map 5.42	Rate of change of the meteorological water balance 1975–2007	143

Map 5.43	Current (2000) and projected (2100) forest coverage in Europe	145
Map 5.44	Average annual changes in fire danger level 1958–2006	147
Map 5.45	Modelled three-monthly fire danger levels in Europe for 1961–1990 and 2071–2100 and change between these periods.....	148
Map 5.46	Presence of <i>Aedes albopictus</i> (the tiger mosquito) in Europe in January 2008	154
Map 5.47	Areas of possible establishment of <i>Aedes albopictus</i> (the tiger mosquito) in Europe for 2010 and 2030	155
Map 7.1	Examples of potential economic effects across Europe	168
Map 7.2	Projected change in damage of river floods with a 100-year return period between 2071–2100 and 1961–1990	175
Map 7.3	Modelled number of people flooded across Europe's coastal areas in 1961–1990 and in the 2080s	177
Map 7.4	Projected crop yield changes between the 2080s and the reference period 1961–1990 by two different models.....	180
Map 7.5	Projections of energy demand for several time horizons in Europe	184
Map 7.6	Modelled conditions for summer tourism in Europe for 1961–1990 and 2071–2100	188

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