

Session 1. Has the climate changed and why?

Chair: Prof Brian Hoskins FRS (Dept of Meteorology, University of Reading)

Biography: Brian Hoskins has mathematics degrees from Cambridge University. After post-doctoral positions in Princeton and the US National Center for Atmospheric Research he joined the Atmospheric Modelling Group at the Department of Meteorology in the University of Reading. He was later made Professor of Meteorology there. He was made a FRS in 1988 and was recently awarded a Royal Society Research Professorship. Amongst the prizes he has been given is the top prize of the American Meteorological Society. He is currently Vice-Chair of the Joint Scientific Committee for the World Climate Research Programme and on many national and international weather and climate related committees as well as being a member of the Royal Commission on Environmental Pollution.

Radiative forcing of climate

Speaker: Prof Joanna Haigh (Dept Physics, Imperial College)

Summary: Radiative forcing provides a convenient first-order measure of the contributions of different agents, produced by both human activities and natural causes, to climate change on a global annual mean. The definition of radiative forcing used by the IPCC will be explained and the strengths and limitations of the radiative forcing concept will be discussed in the context of agents with marked, geographical, vertical and temporal variations. Estimates of radiative forcing over the past 250 years, due to changes in well-mixed greenhouse gases, stratospheric and tropospheric ozone, aerosols, land-use and solar and volcanic activity, will be presented. Uncertainties in these estimates arise, to a greater or lesser extent in each case, from a lack of knowledge of the distributions (contemporary and historical) of the agents, their radiative properties or the physical and chemical processes by which they are produced.

Biography: Joanna Haigh gained a D.Phil. in Atmospheric Physics from Oxford University in 1980 and was appointed to a Lectureship in Remote Sensing at Imperial College, London in 1984. She has recently been awarded a Personal Chair in Atmospheric Physics at Imperial. Her research interests concern radiative transfer in the atmosphere, representation of radiative processes in climate models, measurement of cloud properties from satellite infrared spectral measurements, solar-climate links. She was a Lead Author on the IPCC Third Assessment Report, has been Vice-President of the Royal Meteorological Society (RMS) and served on numerous committees including the International Radiation Commission, the NASA Living With a Star panel and the NERC Atmospheric Sciences Board. She is currently Editor of the Quarterly Journal of the RMS, Co-ordinator of an EC project on solar-climate links and Principal Investigator on the UK Universities' Global Atmospheric Modelling Programme.

Discussant: Prof John Grace (IERM, University of Edinburgh)

Biography: John Grace has been working on the role of forests in the carbon cycle since 1990. He established eddy-covariance measurements of CO₂ flux over rain forest in Brazil, as a contribution to NERC's Terrestrial Initiative in Global Environmental Research and has been a member of the Steering Committee for the Large Scale Biosphere Atmosphere Experiment in Amazonia. Over several years, working with Brazilian and European collaborators, his group established that undisturbed rain forest is a sink for CO₂. More recently he and his colleagues have been working on the carbon balance of forest chronosequences in Europe, investigating the CO₂ fluxes over the entire life cycle of the forest. The project is one of a cluster of projects known as CARBOEUROPE, aiming to define and understand the carbon budget of Europe, using terrestrial-based methods, airborne approaches and modelling. John is the Head of the Institute of Ecology and Resource Management at Edinburgh University. He is the President-elect of the British Ecological Society.

Climate of the 20th Century

Speaker: Dr Myles Allen (Dept of Physics, Oxford University)

Summary: Dr Allen will review the evidence presented in the TAR for large-scale changes in the climate system over the past century and the increasingly strong evidence that a substantial fraction of these changes represent a response to external forcing, both natural and anthropogenic. The controversy surrounding different methods of monitoring temperature changes (surface and satellite-based), noted in the TAR, will be discussed. A number of outstanding problems will be highlighted, including the possibility that we still cannot account for the magnitude of the observed response to forcing by solar variability and the problem of understanding possible recent changes in atmospheric circulation. He will conclude by discussing the implications of recent observed changes for key underdetermined properties of the climate system, such as climate sensitivity.

Biography: After completing his first degree, Dr. Allen worked for the Energy Unit of the United Nations Environment Programme in Nairobi, Kenya, where he became interested in the problem of climate change. He returned to the Department of Physics in Oxford to complete a doctorate focussing on atmosphere-ocean interactions and internally-generated climate variability. He then joined the Space Science and Technology Department of the Rutherford Appleton Laboratory working on the use of remote sensing for monitoring climate variability and change. In the course of a year spent on a NOAA Global Change Fellowship working with Professor Richard Lindzen at MIT, he became interested in the problem of using climate observations to provide objective estimates of uncertainty in climate change forecasts, which has pre-occupied him ever since, working in close collaboration with the Hadley Centre for Climate Prediction and Research. He was one of the lead authors of Chapter 12, "Detection of Climate Change and Attribution of Causes" of the IPCC Third Assessment Report, WG1. In 2001 he again returned to Oxford to take over the Oceanography and Climate group as a University Lecturer. He is currently supported by a NERC Advanced Research Fellowship and is Principal Investigator of the climateprediction.com project, using distributed computing for global climate research.

Discussant: Prof Paul Valdes (Dept of Meteorology University of Reading)

Biography: After completing a D.Phil. at Oxford University about the Atmosphere of Venus in 1984, Prof Valdes moved to the Department of Meteorology, University of Reading, conducting research on various aspects of climate and climate change. For the past 10 years, the major focus of the work has been studying past natural climate variability, including modelling of the last ice-age and more distant time periods. Increasingly this has involved simulations of the whole Earth System, and his research group currently studies the interactions between the atmosphere, ocean, biosphere and cryosphere. He was appointed Professor of Earth System Science in 2000. He is currently a project scientist for the UK Universities Atmospheric Modelling Programme (UGAMP), and act as co-ordinator for subprojects of the PAGES/WCRP international programme called Palaeoclimate Modelling Intercomparison Project (PMIP).

Patterns of climate change

Speaker: Dr Tim Palmer (European Centre for Medium-Range Weather Forecasts, Reading)

Summary: The natural variability of the atmosphere can be characterised in many different ways. A number of dominant patterns associated with flow over Europe are shown, based on a hierarchical clustering method. Recent seasonal climate anomalies can be understood in terms of anomalously-high day-to-day recurrence of these patterns. From a dynamical point of view, since these are recurrent patterns, they are likely to be structurally stable (e.g. to weak external forcing). Hence in order to understand the extent to which recent climate trends might be associated with anthropogenic forcing, we need to be able to assess how the probability of occurrence of these patterns of variability is influenced by increasing greenhouse gases. This is even true on the hemispheric scale. This type of analysis strongly suggests a probabilistic approach to climate change prediction, and examples showing the impact of anthropogenic forcing on the probability of occurrence of extreme seasonal precipitation will be given. It will be concluded that ensemble-based probability forecasts of climate change are likely to have greater economic value than predictions from

some 'best-guess' deterministic forecast. There is a need to generate suitable ensembles to perform such probabilistic analysis.

Biography: Dr T.N.Palmer is Head of the Predictability, Diagnostics and Seasonal Prediction Section at the European Centre for Medium-Range Prediction. Much of his research has been on the predictability of climate. He was a lead author of Chapter 7 of the IPCC TAR, is a member of the CLIVAR Scientific Steering Group, and is co-ordinator of the EU project DEMETER, on the development of a European multi-model ensemble system for seasonal prediction.

Discussant: Prof Brian Hoskins (University of Reading)

Biography: as for Chair

Session 2. How will climate change this century?

Chair: Dr David Griggs (Hadley Centre, Met Office)

Biography: David Griggs has a BSc honours degree and a PhD from the University of Manchester Institute of Science and Technology (UMIST). After two years of atmospheric physics research at the University of Toronto, Canada and a further spell at UMIST he joined the UK Met Office in 1986. Posts he has held include Head of Sensor Development and International Manager. In 1996 he was appointed as Head of the Intergovernmental Panel on Climate Change (IPCC) Working Group I (WGI), Technical Support Unit. In that position he was the editor of several Technical Papers, the IPCC Special Report on Aviation and the Global Atmosphere and the IPCC WGI Third Assessment Report. He was appointed as Director of Climate Research in April 2001, with responsibilities that include directing and managing the Met Office's climate research and atmospheric dispersion activities. David was awarded the Vilho Vaisala award (World Meteorological Organization) in 1992.

Emission scenarios

Speaker: Dr Laurie Michaelis (OCEES, Mansfield College, Oxford)

Summary: Economic models are used to generate most emission outlooks. But modellers have to make assumptions about behaviour and technologies, often reducing them to price elasticities of energy demand and autonomous energy efficiency improvements. In the IPCC Special Report on Emission Scenarios, these assumptions were developed through creative "storylines". The research effort on climate change has tended to focus on aspects that can be quantified and modelled. Culture and values are acknowledged as important, but otherwise neglected or treated through exogenous assumptions made by scientists and economists with minimal reference to social theory and research. Social research is unlikely ever to lead to the accurate forecasts that policy-makers might like. Society is complex and reflexive: any attempt to predict human behaviour may change it. But a better understanding of culture would help us to recognise what path we are on, and how we might shift to a more sustainable one.

Biography: Laurie Michaelis is the Director of Research for the Oxford-based Commission on Sustainable Consumption, which is developing an Action Plan on sustainable consumption for the World Summit on Sustainable Development (2002). He has a PhD in energy studies, on wood use and the potential for alternative fuels in Kenya. He has worked as a volunteer in development organisations, as a school teacher and as an energy technology analyst. From 1992 to 1999 Laurie worked for the OECD, initially focusing on energy, transport and climate change but most recently leading programmes on eco-efficiency and resource efficiency. He has published several books including *Eco-efficiency* (1998), *Reforming Energy and Transport Subsidies* (1997), *Biofuels* (1994) and *Cars and Climate Change* (1993). He has been a Lead Author on several of the reports of the Intergovernmental Panel on Climate Change, including the Special Report on Emission Scenarios.

Discussant: Dr Frans Berkhout (SPRU, University of Sussex)

Biography: Dr Frans Berkhout is a Senior Fellow at SPRU – Science and Technology Policy Research - at the University of Sussex. He received his first degree in geography from the University of Leeds, and his doctorate in science and technology policy studies at SPRU. Between 1992 and 1994 he worked at the Center for Energy and Environmental Studies at Princeton University (US). In 1999 and 2000 he was Co-Director of the Global Environmental Change Programme of the UK Economic and Social Research Council (ESRC). From January 2002 he will be Director of the ESRC's Sustainable Technologies Programme. Dr Berkhout has extensive research and research management experience across a number of fields. His early research was concerned with the economic, political and security aspects of the nuclear fuel cycle and radioactive waste management, with special emphasis on the control of nuclear weapons materials (plutonium and highly enriched uranium). His more recent work has been on business, technology and the environment, with a focus on the relationship between innovation and environmental performance, measurement of environmental performance in firms, integrated product policy, socio-economic futures scenarios research and adaptation of business to climate impacts.

Projections of climate change

Speaker: Ms Catherine Senior (Hadley Centre, Met Office)

Summary: The IPCC TAR had available to it results from many more AOGCM projections of future climate change using a range of scenarios than was the case for any previous assessment. A simple model, calibrated to a number of the AOGCMs has been used to extend the global projections to cover the full range of 35 SRES scenarios. This gives a rise in global average surface temperature from 1990 to 2100 of 1.4 to 5.8°C. For the first time, we quantify a mean climate response from all models along with a range to give some estimate of model and scenario uncertainty. New results from such an analysis will be described as well as those that corroborate or challenge earlier findings. Projections of regional climate change and changes in climate variability and extreme events still have low confidence due to the inability of models to simulate these details in today's climate and limitations in our understanding of the physical mechanisms involved. The major sources of uncertainty in the projections arise from uncertainties in the external forcing and choice of scenario, a poor knowledge of natural climate variability, the large range of climate sensitivity amongst models and the possibility of rapid climate change.

Biography: Catherine Senior joined the Met office in 1986 after completing a first degree in mathematics at the University of Leeds. She has worked for 15 years on understanding and predicting climate change and joined the Hadley Centre on its opening in 1990. Her main research interests are climate feedback processes especially those related to clouds. She has been involved in the IPCC assessments in 1990, 1992 and 1996 and was a lead author in 2001 on the chapter on 'Projections of future Climate Change'

Discussant: Dr Rowan Sutton (CGAM, Department of Meteorology, University of Reading)

Biography: Dr Rowan Sutton came to atmospheric science during a year spent as a Henry Fellow at Harvard University. He has a D.Phil. in atmospheric physics from the University of Oxford and is currently a Royal Society Research Fellow based at the NERC Centre for Global Atmospheric Modelling (CGAM) in the Department of Meteorology at the University of Reading. Within CGAM he is head of the Atlantic-European Climate Group. His research interests focus on the role of the Atlantic Ocean in seasonal-to-decadal climate variability and prediction. He is co-ordinator of a European Framework 5 project, PREDICATE, which is addressing the problem of climate forecasting for time horizons of 1-20 years.

How reliable are global climate models?

Speaker: Dr John Mitchell (Hadley Centre, Met Office)

Summary: The reliability of numerical weather prediction models can be evaluated through verification of past forecasts, this cannot be easily done for models used to predict future climate. The spread of predictions for the same scenario for current climate models indicates uncertainty in both magnitude and the patterns of

predictions. Traditionally, models have been assessed through simulations of present climate. However, the ability of a model to produce a good simulation of present climate and its variability does not necessarily guarantee it will produce reliable predictions of climate change. I will describe other ways of validating climate models, and outline developments that may improve our ability to quantify and reduce uncertainty in predictions of climate change.

Biography: Dr Mitchell OBE is currently Head of Climate Prediction at the Hadley Centre for Climate Prediction and Research, Meteorological Office, England, leading a group of about 25 scientists. He gained a BSc (Applied Mathematics) and a PhD (Theoretical Physics) from the Queen's University. In 1973 he joined the Met Office, since when he has written many papers on modelling climate, and on detecting, understanding and predicting climate change. He took part in US Department of Energy (co-lead author, 1984) and IPCC (lead author, 1990,1992,1995, 2001) reviews of greenhouse gas-induced climate change. He has twice been a winner the WMO Norbert-Gerbier-Mumm prize (1997,8). He is a member of the Academia Europaea and the IGBP GAIM Task Force, and is currently Chairman of World Climate Research Programme Working Group on Coupled Models.

Discussant: Prof Julia Slingo (CGAM, Department of Meteorology, University of Reading)

Biography: Julia Slingo is currently Professor of Meteorology and Deputy Director of the NERC Centre for Global Atmospheric Modelling at the University of Reading. She has had a long-term career in climate modelling, working at the Met Office, ECMWF and the US National Center for Atmospheric Research (NCAR) in Boulder. Her particular research interests are in tropical climate variability and predictability. She leads an active research group in various aspects of tropical variability and its influence on the global climate. These include the diurnal cycle, tropical cyclones, the Madden Julian/Intraseasonal Oscillation, El Nino and Monsoons (see <http://ugamp.nerc.ac.uk/cgam-trop/>). Increasingly her work involves considering the coupling between the atmosphere and the ocean and how that influences tropical variability on all timescales. She is currently co-ordinator of the EU FP5 project on 'Predictability and Variability of Monsoons and the Agricultural and Hydrological Impacts of Climate Change (PROMISE)'.

Session 3. Impacts and adaptation

Chair: Dr Tom Downing (Environmental Change Institute, University of Oxford)

Biography: Dr Thomas E Downing is currently Reader in Climate Policy in the Environmental Change Institute of the University of Oxford and Senior Research Fellow at Linacre College. He has been the science advisor to the UK Climate Impacts Programme, and research fellow in the University of Birmingham and National Centre for Atmospheric Research, since receiving his PhD (Geography) at Clark University (USA). From February 2002, he will be director of the Oxford office of the Stockholm Environment Institute. His major interests are vulnerability and adaptation to climate change and climatic hazards, with an emphasis on development methods in participatory integrated assessment (primarily using agent-based social simulation). He currently is chair of the International Geographical Union's Task Force on Vulnerability. He spent four years in Kenya advising the government on environmental assessment. He has been principal investigator or lead researcher on over £5 million in research grants and contracts while at the University of Oxford. He has published over 100 papers, books, reports and book reviews. Current projects include the UK national assessment of climate change and demand for water, agent-based simulation modelling in support of integrated water management in Europe, seasonal climate forecasting in southern African and potential implications for sustainable livelihoods, frameworks for vulnerability and adaptation to climatic hazards and climate change, and institutional adaptation to changing drought and flood hazards.

What are the key impacts at the global scale?

Speaker: Prof Martin Parry OBE (Jackson Environment Institute, University of East Anglia)

Summary: A number of global studies of climate change impacts have now been completed, much of it funded by the UK. These include effects on ecosystems, water supply, food production, malaria and coastal flooding. Some key conclusions include: a) there are major differences between regions, particularly Africa and southern Asia, which are broadly negatively affected by climate change, and those where the effects are broadly positive; b) but, globally, the net effect is clearly negative, with substantial increases in the millions of people at risk from water and food shortage, malaria and coastal flooding; c) the poorest regions are the most vulnerable; d) adaptation efforts are essential because even the most strenuous mitigation efforts will not avoid important effects; e) however, we have not yet researched the impacts under different socio-economic world futures nor of the effects of mitigation on these, and this remains an urgent next step.

Biography: Professor Parry is Director of the Jackson Environment Institute (JEI), and Professor of Environmental Science at the University of East Anglia. Formerly he was foundation Director of the Environmental Change Institute at Oxford (1992-95), and Director of the JEI at University College London (1996-99). He has published about 130 scientific papers, mainly in the field of climate impact assessment, including 5 books. His specific research interests are in climate change impacts and adaptation on agriculture, land use and landscape. He has been a convening lead author in all three assessments of the IPCC (on chapters on climate change impacts on agriculture (FAR), on the IPCC Technical Guidelines on Climate Impacts and Adaptation Assessment (SAR), and on impacts in Europe (TAR). He is Chair of the IPCC Task Group on Scenarios for Climate Impact Assessment. He is a recipient of the Peek Award (1991) from the Royal Geographical Society, and the Gerbier-Mumm International Award (1993) from the World Meteorological Organisation, both for contributions to research on climate change. He was awarded the OBE in 1998 for services to the environment and to climate change.

Discussant: Prof Nigel Arnell (Professor of Geography, University of Southampton)

Biography: Prof Arnell's research focuses on the implications of climate change for hydrology and water management. This research has been undertaken at the UK, European and global scales. He was one of the co-ordinating lead authors for the water chapter in the recent IPCC Third Assessment Report, and is the co-coordinator of the Adaptation Theme in the Tyndall Centre for Climate Research.

Key areas of vulnerability

Speaker: Dr Saleemul Huq (International Institute for Environment and Development, London)

Summary: The recently published Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) has highlighted the vulnerability of large parts of the developing world (especially in the tropics) to the adverse impacts of human induced climate change. It also highlights the need for adaptation and in particular to building adaptive capacity for the developing countries. The recently concluded seventh Conference of the Parties (COP7) of the United Nations Framework Convention on Climate Change (UNFCCC) held in Marrakech, Morocco has re-affirmed the need for support to the most vulnerable countries in the developing world. This points to the need to develop clear indices and understanding of vulnerabilities (and hence identify needs for building adaptive capacity) at a number of levels. These include between countries, sectors within regions and countries as well as different populations within countries. The progress on defining indicators of vulnerability to climate change at different scales, their relative usefulness and deficiencies, possible areas for strengthening capacity for analysis as well as adaptation in developing countries will be presented and discussed.

Biography: Dr Saleemul Huq completed his BSc (with Honours) in 1975 from Imperial College, London, United Kingdom and his PhD in plant sciences also from Imperial College in 1978. He then taught at the University of Dhaka until 1984 when he set up (and became the first executive director) of the Bangladesh Centre for Advanced Studies (BCAS) in Dhaka, Bangladesh. When he left BCAS in 2000 it was the leading scientific research and policy institute in the country in the field of environment and development. In 2000 he

became an Academic Visitor at the Huxley School of Environment at Imperial College in London where he taught a course on Global Environmental policies. In February 2001 he joined the International Institute for Environment and Development (IIED) in London where he heads the climate change programme. His interests are in the inter-linkages between climate change (both mitigation as well adaptation) and sustainable development from the perspective of the least developed countries. He has published numerous articles in scientific and popular journals and was the lead author of the chapter on adaptation in the third assessment report of the Intergovernmental Panel on Climate Change (IPCC).

Discussant: Dr Tom Downing (Environmental Change Institute, University of Oxford)

Biography: as for Chair

Session 4. Mitigation and stabilisation

Chair: Sir Eric Ash (Treasurer and Vice-President of the Royal Society)

Biography: Sir Eric Ash is an electrical engineer whose work has been largely in the field of physical electronics. After almost a decade in industry he served in the Electrical Engineering Department at UCL and then moved to Imperial College as Rector. His current interests have centred on nuclear and renewable energies and the application of economic instruments to reduce greenhouse gas emissions.

Mitigating climate change: an overview of the potential for technologies and policies

Speaker: Prof Michael Grubb (Imperial College Centre for Environmental Technology)

Summary: The IPCC Third Assessment Report was notably optimistic in its assessment of the potential for low-carbon technologies to reduce emissions at acceptable cost, noting rapid progress in diverse options. This conclusion refers not just to short term goals, but also the potential for longer term atmospheric stabilisation. However there are still many discrepancies between technological and macro-economic assessments, and various obstacles that inhibit large-scale take up of low carbon technologies.

Biography: Michael Grubb is Professor of Climate Change and Energy Policy at Imperial College in London, and Senior Research Associate at the Department of Applied Economics in Cambridge University. Professor Grubb is a leading international researcher on the policy responses to climate change, and energy policy issues including renewable energy sources. He is editor-in-chief of the journal *Climate Policy*, and his book *The Kyoto Protocol: a Guide and Assessment* is the principal published analysis of the Protocol, and has been translated into Japanese and Russian. He has been a Lead Author for several reports of the Intergovernmental Panel on Climate Change (IPCC) addressing the economic, technological and social aspects of limiting greenhouse gas emissions, and has advised the UK government and European Commission on aspects of climate change and related policy.

Costs of emission limitations - a macroeconomic view

Speaker: Dr Terry Barker (Department of Applied Economics, Cambridge University)

Summary: What we know and what is new in the TAR:

- Model projections indicate that long-term growth paths are not significantly affected by mitigation actions towards stabilisation. This appears to be the case for all stabilisation levels (including 450ppm), all development pathways and all models considered in the post-SRES scenarios.
- However, costs and benefits of mitigation vary widely across sectors, countries and development paths; and for some sectors and countries (e.g. the coal and oil sectors and the oil-exporting economies) the costs may be significant (e.g. costs of Kyoto as high as 25% of oil-exporters' oil revenues).
- There are substantial opportunities for reducing the mitigation costs with a portfolio of actions:
 - Technological options suggest that global emissions may be reduced by 2020 to their 2000 level at costs below \$100 per tonne carbon-equivalent, with half the reduction at no cost or benefit
 - Ancillary benefits are sometimes of comparable size to the costs of mitigation policies

- With double-dividend policies there may be net short-term economic benefits from mitigation
- Modelling suggests that international emission-permit trading schemes will reduce the costs of mitigation by about half.

What we still do not know, given its importance in assessing costs of mitigation:

- Costs and availability of low-emissions technology
- How to remove barriers to implementation of such technology and the costs of removal
- Quantified cost estimates
 - reconciling and adopting different approaches (e.g. top-down, bottom-up)
 - with ancillary benefits included
 - allowing for policy-induced technological change
 - at comprehensive and consistent sectoral and global-regional levels.

Biography: Dr Terry Barker is Chairman of Cambridge Econometrics and Senior Research Associate at the Department of Applied Economics, University of Cambridge. He was a Co-ordinating Lead Author for Chapter 9 of Working Group III, Third Assessment Report of the IPCC, concerned with the sectoral effects of GHG mitigation (e.g. effects on the global oil industry). He was in the Core Team preparing the TAR Synthesis Report. His research interests are centred on energy-environment-economy modelling at the UK, European and global levels, designed to assess effective, efficient and equitable GHG mitigation policies. He has published extensively in this area. During 1984-1991 he led an in-house team re-constructing OPEC's World Energy Model. He has led the team constructing a UK model used to assess the effects of the Climate Change Levy on UK industry. He is currently working with a large-scale European model E3ME to assess CO₂ emission trading schemes in Europe.

Discussant: Mr Tom Burke (Visiting Professor, Imperial College)

Biography: Tom Burke CBE is currently Environmental Policy Adviser to Rio Tinto plc and to BP plc and a Visiting Professor at Imperial College. He is a member of the Council of English Nature. He was Special Adviser to three Secretaries of State for the Environment from 1991-97 after serving as Director of the Green Alliance from 1982-91. He is the co-chairman of the Anglo-German Environment Forum. He has been a professional environmentalist for more than 25 years and was formerly Executive Director of Friends of the Earth and a member of the Executive Committee of the European Environmental Bureau 1988-91. He was the Secretary-General of the Bergen 1990 Environment NGO Conference 1988-90. In 1993 he was appointed to United Nations Environment Programme's 'Global 500' roll of honour. In 1997, he was appointed CBE for services to the environment. He has written and broadcast extensively on environmental matters and is the co-author of a number of books including 'Green Pages' (Routledge, 1988), 'The Green Capitalists' (Gollancz, 1987) and 'Ethics, Environment and the Company' (IBE, 1990).

Cutting edge technologies

Renewable energy and energy efficiency technologies

Speaker: Prof Dr Frans Saris (Energy Research Centre, The Netherlands: ECN)

Summary: Numerous technical and economic opportunities exist for energy efficiency improvements, particularly in the final conversion step from useful energy to energy services. Combined effects made up by efficiency improvements and structural changes, could lead to decreases in the world energy intensity of 2.5% a year. Altogether, new renewable energy sources contributed 2% of the world energy sources in 1998, including 7 exajoules from modern biomass and 2 exajoules for all other renewables (geothermal, wind, solar, and marine energy, small-scale hydropower). Solar photovoltaics and grid-connected wind installed capacities are growing at a rate of 30% a year. The successful development of fuel cells would facilitate the introduction of H₂ as an energy carrier. Fuel cells are getting intense attention, especially for transportation, because they offer high efficiency and near-zero air pollutant emission. My presentation on these renewable and energy efficient technologies is based largely on the World Energy Assessment published recently by the UNDP.

Biography: Prof Dr Frans W. Saris (1942) is CEO of the Energy Research Centre in the Netherlands (ECN). He holds a PhD in atomic physics from Leiden University. For 25 years, while guiding 45 PhD students, he developed materials modification and analysis using nuclear techniques especially in silicon surfaces for micro-electronics and solar cell applications. For 15 years he has been a professor of physics in Utrecht and for 10 years the director of the FOM Institute AMOLF, a graduate school in Amsterdam. He is (co)author of 250 publications in refereed journals on atomic physics, surface science and materials science. He has been awarded the Rontgenpreis, Rontgenplakette and the Jacob Kistemaker prize for Physics.

CO₂ storage technologies

Speaker: Dr Sam Holloway (British Geological Survey)

Summary: Anthropogenic carbon can be removed to other domains of the planet rather than the atmosphere. It can be stored in the terrestrial biosphere, the oceans or the geosphere. Underground storage in porous and permeable reservoir rocks is a technically feasible way to dispose of industrial quantities of carbon dioxide such as are produced by fossil fuel fired power plant. All the necessary technological steps are commercially proven and in use today. Large naturally occurring CO₂ accumulations indicate that under favourable conditions CO₂ can be retained in underground reservoirs for millions of years. Large scale commercial underground CO₂ sequestration has begun at the Sleipner West gas field in the North Sea. It is possible that underground storage could be used as a bridging technology to ease the transition from fossil energy to low- or no-carbon fuels. Some of the major issues that must be addressed if this technology is to make an impact on CO₂ emissions to the atmosphere are cost of CO₂ capture, safety and security of storage and public acceptability.

Biography: Dr Sam Holloway is a geologist at the British Geological Survey based at Keyworth near Nottingham. He has worked on the underground storage of carbon dioxide for more than ten years. Originally he became involved via a small contract for the former British Coal, looking at the technical feasibility of underground CO₂ sequestration. Between 1992 and 1996 he was co-ordinator of a large multinational EU-supported project 'The underground disposal of carbon dioxide'. Subsequently he has been heavily involved in EU-supported research and demonstration projects on this topic at the Sleipner West gas field - the Saline Aquifer CO₂ Storage (SACS) projects. He is also technical manager of the GESTCO project. This involves 8 European Geological Surveys and industrial partners investigating the practicality and economics of spreading this technology to major industrial point sources of carbon dioxide such as power plant, iron and steel works, cement works, fertiliser plant and refineries.

Session 5. The Intergovernmental Panel on Climate Change

Chair: Sir John Houghton FRS (Co-chair, IPCC Working Group 1)

Biography: Sir John Houghton CBE FRS is co-chairman of the Science Assessment Working Group of the Intergovernmental Panel on Climate Change. He was Professor of Atmospheric Physics at the University of Oxford from 1976-1983, Chief Executive of the Meteorological Office from 1983 to his retirement in 1991, Chairman of the Royal Commission on Environmental Pollution from 1992-1998 and a member of the British Government's Panel on Sustainable Development from 1994-2000. He has received Gold medals from the Royal Meteorological Society and the Royal Astronomical Society and the prestigious International Meteorological Organisation Prize. He is author of 'Global Warming: the complete Briefing' which was runner up for the Sir Peter Kent Conservation Book Prize in 1994.

Overview of the IPCC Process

Speaker: Sir John Houghton FRS (Co-chair, IPCC Working Group 1)

Summary: The Intergovernmental Panel on Climate Change (IPCC) was founded in 1988 to provide authoritative assessments of anthropogenic climate change. It has produced three comprehensive reports, the latest being in 2001. By involving as many of the world's scientists as possible in the work of writing and reviewing its reports and by involving governments in the actual presentation of the reports, wide ownership of the reports has been achieved both by the world scientific community and by governments. IPCC reports have therefore had considerable influence on the formulation and work of the international Framework Convention on Climate Change (FCCC).

Biography: As for Chair.

Summary of IPCC Synthesis Report

Speaker: Dr Robert T Watson (Chair of IPCC; Chief Scientist & Director of ESSD at the World Bank)

Summary: The Intergovernmental Panel on Climate Change (IPCC) was set up in 1988 jointly by the World Meteorological Organization and the United Nations Environment Programme to provide authoritative international statements of scientific opinion on climate change. The IPCC's periodic assessments of the causes and impacts of, and possible adaptation and mitigation response strategies to climate change represent the most comprehensive and up-to-date reports on the subject available. The Synthesis Report provides a policy-relevant, but not policy-prescriptive, synthesis and integration of information contained within the Third Assessment Report (Climate Change 2001: The Scientific Basis (WG I); Impacts, Adaptation, and Vulnerability (WG II); and Mitigation (WG III)) and all previously approved and accepted IPCC reports relevant to nine key policy-relevant questions developed in consultation with governments. The presentation will address the IPCC response to each of these nine questions.

Biography: Dr Robert T. Watson is the Chairman of the Intergovernmental Panel on Climate Change (IPCC), co-chair of the Board of Directors of the Millennium Ecosystem Assessment and co-chair of the international assessment of Stratospheric Ozone Depletion. He is also currently the Chief Scientist and Director of Environmentally and Socially Sustainable Development at the World Bank. Before joining the World Bank, he was Associate Director for Environment in the Office of Science and Technology Policy, Executive Office of the President of the USA. He previously held the positions of Director of the Science Division and Chief Scientist for the Office of Mission to Planet Earth at NASA. He served as Chair of the Science and Technical Advisory Panel to the Global Environmental Facility. Dr. Watson has testified in the U.S. Congress on numerous occasions regarding global environmental issues, and has been awarded numerous national and international scientific awards.

Update on the UNFCCC process

Speaker: Ms Claire Parker (Secretariat, UNFCCC)

Summary: Building on the political momentum achieved in Bonn, Parties in Marrakech approved the rules and institutions for the implementation of the Kyoto Protocol. They confirmed their intention to see this landmark treaty in force by the end of 2002. The outcome of COP6 (The Hague and Bonn) was two-fold. First, a high-level political consensus on critical issues that had been the subject of negotiations since 1998. Second, a set of draft decisions –some at a more advanced stage of elaboration than others - to be referred to COP7 for completion and adoption as a package. The finalisation of the legal text of those decisions and their adoption are the main accomplishments of COP7. The Marrakech accords consist of 24 decisions spanning the various areas of negotiation. The presentation will review the major achievements of COP6 and COP7, and their significance for the climate change regime that has been established. It will attempt to show where the inputs from the IPCC have been most significant.

Biography: Claire N Parker is Co-ordinator of the Implementation Programme at the secretariat of the UNFCCC in Bonn, a post she has held since 1 January 1999. She is responsible for technical work and policy advice on all matters related to the implementation of the Convention, in particular the national communications from Parties. She also deals with funding for developing countries, the Global Environment Facility and capacity building. Claire Parker has a degree in Chemistry and Biochemistry from the Free University at Brussels, Belgium. She started off her career in environmental sciences as an Assistant Lecturer at Brussels University and moved to policy at the Belgian Ministry for the Environment. In 1984, Claire Parker joined the Oslo and Paris Commissions for the protection of the marine environment of the North-East Atlantic (as Deputy Secretary then as Executive Secretary in 1989). Claire Parker also spent 4 years as Museum Secretary at the British Museum in London.

Session 6. Sustainable climate change: challenges at the international level

Chair: Prof Michael Grubb (Imperial College Centre for Environmental Technology)

Biography: Michael Grubb is Professor of Climate Change and Energy Policy at Imperial College in London, and Senior Research Associate at the Department of Applied Economics in Cambridge University. Professor Grubb is a leading international researcher on the policy responses to climate change, and energy policy issues including renewable energy sources. He is editor-in-chief of the journal *Climate Policy*, and his book *The Kyoto Protocol: a Guide and Assessment* is the principal published analysis of the Protocol, and has been translated into Japanese and Russian. He has been a Lead Author for several reports of the Intergovernmental Panel on Climate Change (IPCC) addressing the economic, technological and social aspects of limiting greenhouse gas emissions, and has advised the UK government and European Commission on aspects of climate change and related policy.

What is a sustainable level of climate change?

Speaker: Prof Dr Hans-Joachim Schellnhuber (Tyndall Centre & Potsdam Institute for Climate Impact Research)

Summary: Anthropogenic climate change is on its way now and there are no means to suppress it altogether. Judicious climate-change management, however, may confine human-made deviations from pre-industrial atmospheric dynamics – and the impacts thereof - to a tolerable range. Science faces the crucial challenge of identifying potential climate excursions which transcend that range and are likely to cause enormous hardship for socio-economic and natural systems in spite of their respective adaptive capacities. All types of uncertainties render such an identification extremely difficult, yet a slim body of evidence is about to emerge. The talk will review the pertinent state of the art that is epitomised by the synthesis chapter of IPCC-TAR Working Group II, where qualitative “reasons for concern” were formulated for the first time ever. The formal underpinning of this reasoning is provided, in particular, by integrated assessment models operating in an inverse mode, i.e. starting from systemic and/or normative critical thresholds and calculating the emissions

corridors which respect those guard-rails. It will be argued that regional vulnerability analysis may revolutionise this entire field of inquiry.

Biography: Prof Dr Hans-Joachim Schellnhuber was born in 1950 in Ortenburg, Germany. Training in physics and mathematics with a scholarship for the highly gifted at the University of Regensburg. Doctorate in Theoretical Physics in 1980. Various periods of research abroad, in particular at several institutions of the University of California system (USA). Habilitation (German qualification for professorial status) in 1985, then Heisenberg Fellowship. Full Professor at the Interdisciplinary Centre for Marine and Environmental Sciences (ICBM) at the University of Oldenburg in 1989, later Director of the ICBM. Founding Director of the Potsdam Institute for Climate Impact Research (PIK) in 1991. Since 1993 Director of PIK and Professor for Theoretical Physics at the University of Potsdam. Since January 2001 also Visiting Research Director of the Tyndall Centre for Climate Change Research and Professor at the Environmental Sciences School of the University of East Anglia in Norwich, UK. Elected member of the Max Planck Society, Leibniz Society and Geological Society of London. Active participation on some dozen national and international panels for scientific strategies and policy advice on environment & development matters. Member of the German Advisory Council on Global Change (WBGU), Chairman of the GAIM Task Force of the International Geosphere-Biosphere Programme (IGBP), Co-ordinating Lead Author of the synthesis chapter of Working Group II in the Third IPCC Assessment Report. More than 150 articles and books on solid state physics, the theory of complex non-linear systems, coastal zone research, and regional and global environmental analysis.

How might global efforts be distributed?

Speaker: Dr Bert Metz (National Institute of Public Health and the Environment, The Netherlands)

Summary: The issue of "distribution of efforts" between countries will be discussed in the context of a global climate change regime towards fulfilling article 2 of UNFCCC. That means looking at the risks, looking at the potential "gap" between emission profiles for reference and stabilisation scenarios, discussing the main equity principles, showing how some of the existing practices and proposals fit into that picture and then elaborating some of the possible approaches, including per capita convergence and sustainable development approaches. Consequences for industrialised and developing countries will be illustrated.

Biography: Dr Bert Metz studied Chemical Engineering at the Delft University of Technology and received his doctorate in Biotechnology and bioengineering at the same university. He worked for about 15 years for the Dutch Ministry of Environment in the field of air pollution, external safety, noise pollution, chemical waste, enforcement of environmental laws and climate change. From 1980 to 1982 he was Senior Lecturer and Acting Head of Department of the Department of Chemical Engineering at the Ahmadu Bello University in Zaria, Nigeria. From 1987 until 1992 he was Counsellor for Health and Environment at the Royal Netherlands Embassy in Washington DC. In 1992 he became Deputy Director for Air and Energy of the Netherlands Ministry of Environment. In this function he was responsible for climate policy. He was leading the Netherlands delegation to the negotiations leading to the adoption of the Kyoto Protocol in December 1997. In 1997 he was elected as co-chairman of the Working Group on Climate Change Mitigation of the Intergovernmental Panel on Climate Change of the UN for the preparation of the Third Assessment Report. Since 1998 he is also heading the International Environmental Assessment Division of the National Institute of Public Health and the Environment in Bilthoven, The Netherlands.

The corporate contribution to sustainable climate change

Speaker: Sir Mark Moody-Stuart (former Chairman of the Royal Dutch/Shell Group)

Summary: Climate change is clearly a serious challenge, and some change is inevitable. How can we ensure that we stay at the lower end of the IPCC forecast range, which assumes significant – but entirely achievable – changes in energy patterns? So what can business and government do together with consumers? Consumers want instant economical and reliable energy, but worry about the environment; they want personal transportation, but worry about pollution and jams; they want economic development, but worry

about how can we bring others to acceptable levels without unacceptable consequences. Governments provide a regulatory framework; business works in commercial markets within that framework to satisfy the consumer. For Power, three levels of framework are required. First, a GHG reducing cap and trade system. Second, we need Portfolio standards for energy production: this is necessary to encourage new technologies. Finally building and lighting efficiency standards are required – specification of performance standards, not detailed regulation. For Transportation, there are two levels of framework required. First Average Fleet Efficiency standards, which should not mandate the type, just the level of efficiency and very possibly very simple emission controls. Secondly, taxation should be largely based on vehicle fuel consumption, not on fuel. In addition to power and transportation, a third effort needs to be made – to engage the consumer. We need to use the powers of social pressure and the attraction of beautiful engineering. The efficient alternative has to deliver the performance. The answer is the sort of performance being delivered by internal combustion electric hybrids – with identical comfort and performance – and in future by such vehicles as being developed by Hypercar.

Biography: Mark Moody-Stuart was Chairman of the Royal Dutch/Shell Group of companies from 1998-2001. He remains on the board of Shell and is a Director of HSBC Holdings plc and of Accenture, a Governor of Nuffield Hospitals and a Vice President of the Liverpool School of Tropical Medicine. He was co-Chair of the G8 Task Force on Renewable Energy in 2000 and 2001. He is currently chairing Business Action for Sustainable Development, a joint initiative of the International Chamber of Commerce and the World Business Council for Sustainable Development in preparation for business involvement in the UN World Summit on Sustainable Development in Johannesburg in September 2002. Following a doctorate in geology from Cambridge University, he has lived and worked in many different countries (Spain, The Netherlands, Oman, Brunei, Australia, Nigeria, Turkey, and Malaysia).

The international framework

Speaker: Mr Henry Derwent (Head of Global Atmosphere Division, Department for Food, Environment and Rural Affairs)

Discussant: Mr Andrew Bennett (Department for International Development)

Biography: Andrew Bennett is the Chief Natural Resources Adviser and Director of Rural Livelihoods and Environment at the (UK) Department for International Development, where he is responsible for the development of policy, provision of advisory services and research programmes in the fields of rural livelihoods, sustainable development, agriculture, forestry, fisheries, biodiversity, wildlife, and environment. He has served extensively overseas in development and research posts in Africa, the Caribbean, Asia and the Pacific. He was part of the UK negotiating teams for the Montreal Protocol, at Rio, the establishment of the GEF and on forestry issues.

Discussant: Ms Ute Collier (WWF UK)

Biography: Ute Collier has been the Head of WWF-UK's Climate Change Programme since April 1998. She has worked on climate change and energy issues since 1989. Her current work includes lobbying governments, working with progressive companies, as well as encouraging consumers take action on climate change. She has attended numerous UN climate meetings, including the Kyoto, Hague and Bonn climate summits. Before joining WWF, Ute was Senior Research Officer on Climate Change with Friends of the Earth (FoE) in London. Before moving to the NGO sector in 1997, she researched at a number of academic institutions, including the European University Institute in Florence, Sussex and Cambridge Universities. She also worked as a lecturer in environmental studies and European studies at the University of Hertfordshire, UK.

Session 7. Challenges for the UK

Chair: Mr Philip Wright (*Head of Air, Climate and Engineering Unit, Scottish Executive*)

Biography: A civil engineer by profession, Philip has held a range of posts in the Environment Group of the Scottish Executive and the former Scottish Office. He is currently Head of the Group's Air, Climate and Engineering Unit which, among other things, supports Scottish Ministers in the development and implementation of the Scottish Executive's policy on climate change. He is also Chairman of the Scotland and Northern Ireland Forum for Environmental Research (SNIFFER).

Reducing emissions

Speaker: Mr Tom Delay (The Carbon Trust)

Discussant: Mr Daniel Waller (*Association for the Conservation of Energy*)

Biography: Daniel Waller joined the Association for the Conservation of Energy (ACE) in November 2000. His primary role within ACE is that of supporting and representing the Association and its Director. Additionally, he co-ordinates Friends of ACE (FACE) disseminating information to the FACE members and developing new avenues for the programme. He currently sits on the Sustainability working group of the Local Government Task Force. He has given presentations at a variety of conferences including for IEA OECD in Paris, PIK in Potsdam and Energie-Cités in Vienna. Previously with the Housing Forum - part of the DETR's 'Rethinking Construction' initiative – Mr Waller was responsible for the development and management of the Demonstration project programme. He operated the Sustainability and the Prefabrication and Standardisation working groups. He also represented the housebuilding industry at the Movement for Innovation Sustainability working group. He has extensive practical experience within the construction industry, having worked for a contractor involved with delivery of Government energy efficiency programmes.

Discussant: Mr Adrian Ham (*British Nuclear Industry Forum*)

Biography: Adrian Ham is the newly-appointed Director-General of the British Nuclear Industry Forum. He has worked closely in an advisory role for Government Ministers, Chairmen and Chief Executives of major utilities. His career has ranged from preparing the first ever corporate plan for a major state industry to running a successful sales team in a UK Division of a major multinational company. He was appointed as Director-General on 1 January 2001 after directing a project to reform and restructure Ukraine's nuclear industry by establishing a new commercially focused power company out of state assets, in context of a new market. Now with BNIF, he seeks to advance the activity of the group and its members, and fortify their place in the market, both in the UK and globally. In this way, the BNIF will play a critical role in the modernisation of the industry and reinforce the potential of nuclear energy, driving it into the 21st Century.

Managing the dangers

Speaker: Mr Chris Newton (*Environment Agency*)

Summary: Climate change is the major environmental challenge facing society this century. The UK needs to start adapting now in a pragmatic and precautionary way, particularly for those projects that are long-term, infrastructural or sensitive to extreme events. Active adaptation is needed in many sectors: for water resources planning, flood protection (including development control) and biodiversity management. Simplified input-output models are needed for decision makers, covering both slowly altering "regular" impacts and for intermittent and extreme events. Distributive issues surrounding climate impacts should be made explicit. There are dangers in requiring ever more sophisticated climate information when decision choices are actually much blunter and cast within frameworks where other decision criteria may be dominant. Scrutiny of the UK's readiness to respond might be seen in overview by a Y2K type process.

Biography: Chris is the Head of Sustainable Development for the Environment Agency, this includes responsibility for Climate Policy. Prior to this he managed Environmental Protection in the North West. Chris has a degree in Zoology and is a Chartered Biologist and a Fellow of the Institute of Fisheries Management. He is a member of the Energy and Natural Environment Panel of the Government's Foresight Programme and a member of the Advisory Boards for Business in the Environment, the UK Climate Impacts Programme, and Wessex Water's Environment and Public Health Advisory Panel. The Environment Agency regulates processes that give rise to about half of the UK's emissions of greenhouse gases and controls several functions, such as flood defence and water resources, which are likely to be severely affected by a changing climate.

Discussant: Dr Paul Jefferiss (Royal Society for the Protection of Birds)

Biography: Dr Paul Jefferiss is Head of Environmental Policy at the RSPB. He has responsibility for policy on climate change, energy, transport, trade, economics, marine pollution, fisheries, planning and regional development. Previously, he was Director of Green Alliance in London and, before that, Director of the Energy Programme at the Union of Concerned Scientists in Washington, and Lecturer on Sustainable Development for UNEP at Tufts University, Massachusetts. He has a PhD from Harvard University and a Masters Degree in Environmental Policy from Tufts. His primary expertise is in sustainable energy systems and he has published extensively on energy and other policy areas. He is a member of numerous UK and US Government energy and climate policy committees and groups. He is a Board Member of the Carbon Trust, a Member of the DTI Energy Advisory Panel, an Advisory Board Member of the Tyndall Centre, and is currently a Member of the Advisory Group for the PIU Energy Review. In the US he was a Member of the President's Initiative on Climate Change Technology Strategies, and sat on the Board of the US Department of Energy's Renewable Energy Policy Project.

Discussant: Dr Peter Baxter (Dept of Community Medicine, University of Cambridge)

Communicating climate change science

Speaker: Mr Roger Harrabin (Environment Correspondent, BBC Today Programme)

Summary: Why climate change is very difficult to report as a news item: It has very long lead times, and is fraught with uncertainty. The issue are hugely complex and difficult for people to understand.

Journalists seem culturally sceptical and instinctively distrust experts. They also like to focus on the victims of any policies that emerge from the climate science. Also there has been a temptation for news editors to want to instil drama into the debate by highlighting the conflict between "climate sceptics" and the mainstream.

Biography: Roger Harrabin. Environment correspondent, BBC Radio 4 Today Programme. Has reported for the BBC on environmental issues for 14 years. Associate Press Fellow, Wolfson College Cambridge. Co-director, Cambridge Media and Environment Programme.

Discussant: Mr Steve Waller (Improvement and Development Agency)

Biography: On 1 November 2001 Steve joined the I&DeA as Climate Change Consultant to co-ordinate the Councils for Climate Protection project. This project is funded by DEFRA and is supporting 24 Councils through a programme piloting the use of Greenhouse Emissions software and preparing action plans to address the impacts of Climate Change. This role with the I&DeA is a part time secondment from Nottingham City Council where Steve also works leading a corporate team on sustainable development responsible for managing environmental partnerships, Local Agenda 21, environmental awareness, greening staff travel, Climate Change and the integration of sustainability into Council practice. Steve believes that Climate Change is fast becoming one of the key drivers of change within our communities and in addressing the impacts of Climate Change Councils must take the opportunity to tackle issues like Fuel Poverty which have affected disadvantaged communities for a long time. Steve assisted in the preparation of the joint guidance for local authorities Community leadership and climate change launched by Michael Meacher, Environment Minister in June this year and is the author of the Nottingham Declaration on Climate Change

which has now been signed by over 50 Councils in England. Steve has worked on Sustainable Development in local government since 1990.

Discussant: Mr Steve Sawyer (Greenpeace International)

Biography: Steve Sawyer has been active in all aspects of the environmental movement since he joined Greenpeace in Boston in 1978, with a special emphasis on strategic development of campaigns and the organisation as a whole. He was a member of founding Board of Directors of Greenpeace USA (1979 – 1980) and then served as crew aboard the Rainbow Warrior in Europe in 1980, taking over managerial responsibility for ships operations (1981-1982). In 1983, Steve was elected to represent the United States on Greenpeace's International Council, and subsequently elected to the first Greenpeace International Board of Directors (post held until 1995). He was Executive Director of Greenpeace USA (1986 to 1988) and Executive Director of Greenpeace International (1988-1993). Sawyer was responsible in large measure for the establishment of Greenpeace's political division, the lobbying arm of the organisation that was so successful in the 70's and 80's; and played a major role in the establishment and development of Greenpeace Communications, the press and publicity arm of the organisation. He played a major role in establishing and strategising the Greenpeace campaigns to protect Antarctica, to stop nuclear testing (France and US), to stop the international trade in toxic waste, and to ban ocean incineration of toxic waste, among others. Sawyer was one of the driving forces behind Greenpeace's expansion of its operations beyond the comfortable borders of Northwestern Europe and North America and as such he served on the Boards of Directors of Greenpeace organisations in the following countries/territories: Canada, Chile, China, Argentina, Brazil, Guatemala, Mexico, Sweden, Greece, Tunisia, Russia, and Ukraine. In early 1997, Sawyer returned the field, coordinating Greenpeace's Arctic campaign from Greenpeace's icebreaker the m/v Arctic Sunrise. In mid-2000 he became re-immersed in the policy/political process surrounding the Kyoto Protocol.

Session 8. Discussion: What do we still need to know?

Panel Chair: Prof David King FRS (Chief Scientific Adviser & Head of OST)

Biography: Prof David King has been Chief Scientific Adviser to HM Government and Head of the Office of Science and Technology (since 2000). He is also the 120 Professor of Physical Chemistry at Cambridge, a position that he has held since 1988. He has a degree and PhD in Chemistry from Witwatersrand University, Johannesburg. He has held various positions at Imperial College London, University of East Anglia, University of Liverpool and most recently at University of Cambridge where he was Master of Downing College from 1995-2000. He has published over 350 papers in scientific journals. He was Editor of Chemical Physics Letters (1989-01) and Chairman of the Leverhulme Trust Research Awards Advisory Committee (1995-01). Prof King has been a Fellow of the Royal Society since 1991 and is also a Fellow of both the Royal Society of Chemistry and the Institute of Physics. He has received a number of awards including the South African Institute of Chemistry Catalysis Award (1999) and the Schuit Prize and Lecture, Eindhoven, The Netherlands (2000).

Panel member: Dr Mike Hulme (Tyndall Centre for Climate Change Research)

Biography: Dr Hulme is Executive Director of the Tyndall Centre for Climate Change Research and is based in the School of Environmental Sciences at UEA where he has worked for the last 13 years. His general research interest is global climate change, but specialising in the construction and application of climate change scenarios for impact, adaptation and integrated assessment. He also works on the evaluation of climate models and on the development of global and national observational climate data sets. He has worked extensively on African climate. His work in the area of climate scenario construction and application has been recognised by being appointed to the IPCC Task Group on Climate Scenarios for Impact Assessment and by his subsequent appointment as Joint Manager of the Data Distribution Centre established in 1997 by the IPCC. Dr Hulme was a Co-ordinating Lead Author for the chapter on 'Climate scenario development' for the Third Assessment Report of the IPCC, as well as a contributing author for several other chapters. He is on the editorial board of the journals Progress in Physical Geography and Climate Policy. He has prepared climate

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scenarios for the UK government – including the UKCIP98 and UKCIP02 scenarios - the European Commission, UNEP, WWF-International and the IPCC. He writes a regular monthly climate column for The Guardian newspaper.

Other Panel Members: Prof Michael Grubb (*Biography*: see page 12), Sir John Houghton FRS (*Biography*: see page 11), Dr Bert Metz (*Biography*: see page 13) and Sir Mark Moody-Stuart (*Biography*: see page 13).