

CLIMATE CHANGE 2001: THE SCIENTIFIC BASIS

Climate Change 2001: The Scientific Basis is the most comprehensive and up-to-date scientific assessment of past, present and future climate change. The report:

- Analyses an enormous body of observations of all parts of the climate system.
- Catalogues increasing concentrations of atmospheric greenhouse gases.
- Assesses our understanding of the processes and feedbacks which govern the climate system.
- Projects scenarios of future climate change using a wide range of models of future emissions of greenhouse gases and aerosols.
- Makes a detailed study of whether a human influence on climate can be identified.
- Suggests gaps in information and understanding that remain in our knowledge of climate change and how these might be addressed.

Simply put, this latest assessment of the IPCC will again form the standard scientific reference for all those concerned with climate change and its consequences, including students and researchers in environmental science, meteorology, climatology, biology, ecology and atmospheric chemistry, and policymakers in governments and industry worldwide.

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Foreword

The Intergovernmental Panel on Climate Change (IPCC) was jointly established by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) in 1988. Its terms of reference include (i) to assess available scientific and socio-economic information on climate change and its impacts and on the options for mitigating climate change and adapting to it and (ii) to provide, on request, scientific/technical/socio-economic advice to the Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC). From 1990, the IPCC has produced a series of Assessment Reports, Special Reports, Technical Papers, methodologies and other products that have become standard works of reference, widely used by policy-makers, scientists and other experts.

This volume, which forms part of the Third Assessment Report (TAR), has been produced by Working Group I (WGI) of the IPCC and focuses on the science of climate change. It consists of 14 chapters covering the physical climate system, the factors that drive climate change, analyses of past climate and projections of future climate change, and detection and attribution of human influences on recent climate.

As is usual in the IPCC, success in producing this report has depended first and foremost on the knowledge, enthusiasm and co-operation of many hundreds of experts worldwide, in many related but different disciplines. We would like to express our gratitude to all the Co-ordinating Lead Authors, Lead Authors, Contributing Authors, Review Editors and Reviewers. These individuals have devoted enormous time and effort to produce this report and we are extremely grateful for their commitment to the IPCC process. We would like to thank the staff of the WGI Technical Support Unit and the IPCC Secretariat for their dedication in co-ordinating the production of another successful IPCC report. We are also grateful to the governments, who have supported their scientists' participation in the IPCC process and who have contributed to the IPCC Trust Fund to provide for the essential participation of experts from developing countries and countries with economies in transition. We would like to express our appreciation to the governments of France, Tanzania, New Zealand and Canada who hosted drafting sessions in their countries, to the government of China, who hosted the final session of Working Group I in Shanghai, and to the government of the United Kingdom, who funded the WGI Technical Support Unit.

We would particularly like to thank Dr Robert Watson, Chairman of the IPCC, for his sound direction and tireless and able guidance of the IPCC, and Sir John Houghton and Prof. Ding Yihui, the Co-Chairmen of Working Group I, for their skillful leadership of Working Group I through the production of this report.

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Preface

This report is the first complete assessment of the science of climate change since Working Group I (WGI) of the IPCC produced its second report *Climate Change 1995: The Science of Climate Change* in 1996. It enlarges upon and updates the information contained in that, and previous, reports, but primarily it assesses new information and research, produced in the last five years. The report analyses the enormous body of observations of all parts of the climate system, concluding that this body of observations now gives a collective picture of a warming world. The report catalogues the increasing concentrations of atmospheric greenhouse gases and assesses the effects of these gases and atmospheric aerosols in altering the radiation balance of the Earth-atmosphere system. The report assesses the understanding of the processes that govern the climate system and by studying how well the new generation of climate models represent these processes, assesses the suitability of the models for projecting climate change into the future. A detailed study is made of human influence on climate and whether it can be identified with any more confidence than in 1996, concluding that there is new and stronger evidence that most of the observed warming observed over the last 50 years is attributable to human activities. Projections of future climate change are presented using a wide range of scenarios of future emissions of greenhouse gases and aerosols. Both temperature and sea level are projected to continue to rise throughout the 21st century for all scenarios studied. Finally, the report looks at the gaps in information and understanding that remain and how these might be addressed.

This report on the scientific basis of climate change is the first part of *Climate Change 2001*, the Third Assessment Report (TAR) of the IPCC. Other companion assessment volumes have been produced by Working Group II (Impacts, Adaptation and Vulnerability) and by Working Group III (Mitigation). An important aim of the TAR is to provide objective information on which to base climate change policies that will meet the Objective of the FCCC, expressed in Article 2, of stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. To assist further in this aim, as part of the TAR a Synthesis Report is being produced that will draw from the Working Group Reports scientific and socio-economic information relevant to nine questions addressing particular policy issues raised by the FCCC objective.

This report was compiled between July 1998 and January 2001, by 122 Lead Authors. In addition, 515 Contributing Authors submitted draft text and information to the Lead Authors. The draft report was circulated for review by experts, with 420 reviewers submitting valuable suggestions for improvement. This was followed by review by governments and experts, through which several hundred more reviewers participated. All the comments received were carefully analysed and assimilated into a revised document for consideration at the session of Working Group I held in Shanghai, 17 to 20 January 2001. There the Summary for Policymakers was approved in detail and the underlying report accepted.

Strenuous efforts have also been made to maximise the ease of utility of the report. As in 1996 the report contains a Summary for Policymakers (SPM) and a Technical Summary (TS), in addition to the main chapters in the report. The SPM and the TS follow the same structure, so that more information on items of interest in the SPM can easily be found in the TS. In turn, each section of the SPM and TS has been referenced to the appropriate section of the relevant chapter by the use of Source Information, so that material in the SPM and TS can easily be followed up in further detail in the chapters. The report also contains an index at Appendix VIII, which although not comprehensive allows for a search of the report at relatively top-level broad categories. By the end of 2001 a more in-depth search will be possible on an electronic version of the report, which will be found on the web at <http://www.ipcc.ch>.

We wish to express our sincere appreciation to all the Co-ordinating Lead Authors, Lead Authors and Review Editors whose expertise, diligence and patience have underpinned the successful completion of this report, and to the many contributors and reviewers for their valuable and painstaking dedication and work. We are grateful to Jean Jouzel, Hervé Le Treut, Buruhani Nyenzi, Jim Salinger, John Stone and Francis Zwiers for helping to organise drafting meetings; and to Wang Caifang for helping to organise the session of Working Group I held in Shanghai, 17 to 20 January 2001.

We would also like to thank members of the Working Group I Bureau, Buruhani Nyenzi, Armando Ramirez-Rojas, John Stone, John Zillman and Fortunat Joos for their wise counsel and guidance throughout the preparation of the report.

We would particularly like to thank Dave Griggs, Maria Noguer, Paul van der Linden, Kathy Maskell, Xiaosu Dai, Cathy Johnson, Anne Murrill and David Hall in the Working Group I Technical Support Unit, with added assistance from Alison Renshaw, for their tireless and good humoured support throughout the preparation of the report. We would also like to thank Narasimhan Sundararaman, the Secretary of IPCC, Renate Christ, Deputy Secretary, and the staff of the IPCC Secretariat, Rudie Bourgeois, Chantal Etori and Annie Courtin who provided logistical support for government liaison and travel of experts from the developing and transitional economy countries.

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