

# Climate Change 2001: Synthesis Report

---

Edited by:

**Robert T. Watson**  
The World Bank

and the  
**Core Writing Team**

---

Based on a draft prepared by:

***Core Writing Team***

Daniel L. Albritton, Terry Barker, Igor A. Bashmakov, Osvaldo Canziani, Renate Christ, Ulrich Cubasch, Ogunlade Davidson, Habiba Gitay, David Griggs, Kirsten Halsnaes, John Houghton, Joanna House, Zbigniew Kundzewicz, Murari Lal, Neil Leary, Christopher Magadza, James J. McCarthy, John F.B. Mitchell, Jose Roberto Moreira, Mohan Munasinghe, Ian Noble, Rajendra Pachauri, Barrie Pittock, Michael Prather, Richard G. Richels, John B. Robinson, Jayant Sathaye, Stephen Schneider, Robert Scholes, Thomas Stocker, Narasimhan Sundararaman, Rob Swart, Tomihiro Taniguchi, and D. Zhou

***All IPCC Authors***

***Editorial Team***

David J. Dokken, Maria Noguera, Paul van der Linden, Cathy Johnson, Jiahua Pan, and the GRID-Arendal Design Studio

---

Contribution of Working Groups I, II, and III to the Third Assessment Report  
of the Intergovernmental Panel on Climate Change

*Published for the Intergovernmental Panel on Climate Change*



PUBLISHED BY THE PRESS SYNDICATE OF THE UNIVERSITY OF CAMBRIDGE  
The Pitt Building, Trumpington Street, Cambridge, United Kingdom

CAMBRIDGE UNIVERSITY PRESS  
The Edinburgh Building, Cambridge CB2 2RU, UK  
40 West 20th Street, New York, NY 10011-4211, USA  
477 Williamstown Road, Port Melbourne, VIC 3207, Australia  
Ruiz de Alarcón 13, 28014 Madrid, Spain  
Dock House, The Waterfront, Cape Town 8001, South Africa

<http://www.cambridge.org>

©IPCC 2001

This book is in copyright. Subject to statutory exception  
and to the provisions of relevant collective licensing agreements,  
no reproduction of any part may take place without  
the written permission of Cambridge University Press.

First published 2001

Printed in the United States of America

*Typeface* Times New Roman 10/12.5 pt. *System* Adobe PageMaker 6.5 [AU]

*A catalog record for this book is available from the British Library.*

*Library of Congress Cataloging in Publication Data available*

ISBN 0 521 80770 0 hardback  
ISBN 0 521 01507 3 paperback

### **Referencing the Volume**

**IPCC**, 2001: *Climate Change 2001: Synthesis Report. A Contribution of Working Groups I, II, and III to the Third Assessment Report of the Intergovernmental Panel on Climate Change* [Watson, R.T. and the Core Writing Team (eds.)]. Cambridge University Press, Cambridge, United Kingdom, and New York, NY, USA, 398 pp.

### **Cover Image Credits**

**Center:** Earth—shown for a projection centered on Asia—as seen by the Moderate-Resolution Imaging Spectroradiometer (MODIS) on board the National Aeronautics and Space Administration (NASA) EOS-Terra satellite. Land-surface data composited spatially at 1 km and temporally during May and June 2001; cloud layer derived from EOS-Terra, GOES 8/10, GMS-5, and Meteosat 5/7 sensor data; sea-ice composited over an 8-day period using MODIS data; and U.S. Geological Survey topography data overlain to visualize the terrain. Image by Reto Stöckli, Science Systems and Applications, Inc., and the Visualization and Analysis Laboratory at NASA Goddard Space Flight Center.

**Right:** The Lena Delta, Sakha Republic (Yakutia), Russia, as imaged from two Landsat-7 scenes taken at noon, 27 July 2000. Generated by the Norwegian Mapping Authority and GRID-Arendal, with palette derived from infrared channels to yield “natural colors” for the various landscape elements.

**Lower Left:** “One Way Water” (Thailand). Photograph provided by Topham/UNEP/Waranun Chutchawantipakorn.

**Upper Left:** “In Search of Water” (India). Photograph provided by Topham/UNEP/P.K. De.

# Climate Change 2001: Synthesis Report

---

## Contents

---

Foreword	vii
Preface	ix
<b>Summary for Policymakers</b>	<b>1</b>
<b>Synthesis Report</b>	<b>35</b>
Question 1	37
Question 2	43
Question 3	59
Question 4	79
Question 5	87
Question 6	97
Question 7	107
Question 8	123
Question 9	135
<b>Working Group Summaries</b>	<b>147</b>
Working Group I: The Scientific Basis	149
Working Group II: Impacts, Adaptation, and Vulnerability	219
Working Group III: Mitigation	291
<b>Annexes</b>	<b>355</b>
A. Authors and Expert Reviewers	356
B. Glossary of Terms	365
C. Acronyms, Abbreviations, and Units	390
D. Scientific, Technical, and Socio-Economic Questions Selected by the Panel	394
E. List of Major IPCC Reports	396

## Foreword

---

The Intergovernmental Panel on Climate Change (IPCC) was jointly established in 1988, by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP). Its present terms of reference are to:

- Assess available information on the science, the impacts, and the economics of—and the options for mitigating and/or adapting to—climate change.
- 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).

Since its establishment, the IPCC has produced a series of Assessment Reports (1990, 1995, and 2001), Special Reports, Technical Papers, and methodologies, such as the *Guidelines for National Greenhouse Gas Inventories*, which have become standard works of reference, widely used by policymakers, scientists, and other experts and students.

This Synthesis Report completes the four-volume Third Assessment Report (TAR). It addresses specifically the issues of concern to the policymaker, in the context of Article 2 of the UNFCCC—issues such as the extent to which human activities have influenced and will in the future influence the global climate, the impacts of a changed climate on ecological

and socio-economic systems, and existing and projected technical and policy capacity to address anthropogenic climate change. It explores briefly the linked nature of a number of multilateral environmental conventions. It draws on the work of hundreds of experts from all regions of the world who have in the past and at present participated in the IPCC process. As is customary in the IPCC, success in producing this report has depended first and foremost on the dedication, enthusiasm, and cooperation of these experts in many different but related disciplines.

We take this opportunity to express our heart-felt gratitude to the authors and reviewers of all the IPCC reports and Technical Papers, particularly the TAR. We thank likewise the IPCC Bureau; Dr. Sundararaman, Secretary of IPCC, and his Secretariat staff; and those staffing the Technical Support Units of the three Working Groups. We acknowledge with gratitude the governments and organizations that contribute to the IPCC Trust Fund, and provide support to the experts and in other ways. The IPCC has been especially successful in engaging in its work a large number of experts from the developing countries and countries with their economies in transition; the Trust Fund enables extending financial assistance for their travel to IPCC meetings.

We thank the Chairman of the IPCC, Dr. Robert T. Watson, for guiding the effort in completing the TAR.

---

**G.O.P. Obasi**  
Secretary General  
World Meteorological Organization

---

**K. Töpfer**  
Executive Director  
United Nations Environment Programme  
and Director-General  
United Nations Office in Nairobi

## Preface

---

This Synthesis Report with its Summary for Policymakers is the fourth and final part of the Third Assessment Report (TAR) of the Intergovernmental Panel on Climate Change (IPCC). It draws together and integrates for the benefit of policy makers, and others, and in response to questions identified by governments and subsequently agreed by the IPCC, information that has been approved and/or accepted by the IPCC.<sup>i</sup> It is intended to assist governments, individually and collectively, in formulating appropriate adaptation and mitigation responses to the threat of human-induced climate change.

The Synthesis Report is based mainly on the contributions of the three IPCC Working Groups to the TAR, but also uses information from earlier IPCC assessments, Special Reports, and Technical Papers. It follows the question and answer format, and is in two parts: a Summary for Policymakers and a longer document that contains expanded responses to each of the questions posed by governments. The Summary for Policymakers references the appropriate paragraphs in the longer report, while the longer report contains references to the source of the material on which the response is based—that is, the Summaries for Policymakers and chapters from previously approved and accepted Working Group contributions to the TAR and earlier IPCC reports and Technical Papers (see the accompanying box for cross-referencing nomenclature).

The procedures for approving the Summary for Policymakers and adopting the balance of the Synthesis Report were formalized by the IPCC at its Fifteenth Session (San Jose, Costa Rica, 15–18 April 1999). A draft of the Synthesis Report and its Summary for Policymakers was prepared by a team of lead authors, who were involved in preparation of the TAR, and submitted for simultaneous government/technical and expert review. The revised drafts were circulated to governments in a final distribution before approval/adoption at the IPCC's Eighteenth Session (Wembley, United Kingdom, 24–29 September 2001).

The Synthesis Report consists of nine policy-relevant questions:

- Question 1 addresses the ultimate objective of the United Nations Framework Convention on Climate Change, which

is found in Article 2 (i.e., what constitutes “dangerous anthropogenic interference in the climate system”) and provides a framework for placing the issue of climate change in the context of sustainable development.

- Question 2 assesses and, where possible, attributes observed changes in climate and ecological systems since the pre-industrial era.
- Questions 3 and 4 assess the impact of future emissions of greenhouse gases and sulfate aerosol precursors (without specific policies to mitigate climate change) on climate, including changes in variability and extreme events and in ecological and socio-economic systems.
- Question 5 discusses inertia in the climate, ecological systems, and socio-economic sectors, and implications for mitigation and adaptation.
- Question 6 assesses the near- and long-term implications of stabilizing atmospheric concentrations of greenhouse gases on climate, ecological systems, and socio-economic sectors.
- Question 7 assesses the technologies, policies, and costs of near- and long-term actions to mitigate greenhouse gas emissions.
- Question 8 identifies the interactions between climate change, other environmental issues, and development.
- Question 9 summarizes the most robust findings and key uncertainties.

We take this opportunity to thank:

- The Core Writing Team who drafted this report and, with their meticulous and painstaking attention to detail, finalized it
- Other members of the IPCC Bureau who acted as Review Editors
- The members of the Working Groups' teams of Coordinating Lead Authors and Lead Authors who helped with the initial drafting
- The Heads and the staff of the Technical Support Units of the three Working Groups, particularly David Dokken, Maria Noguer, and Paul van der Linden for logistical and editorial support
- The Head and the staff of the GRID office at Arendal, Norway—Philippe Rekacewicz in particular—for working with the author team on the graphics contained in the Synthesis Report
- The staff of the IPCC Secretariat for innumerable administrative tasks performed.

---

<sup>i</sup> See *Procedures for the Preparation, Review, Approval, Acceptance, Adoption, and Publication of the IPCC Reports* in <http://www.ipcc.ch> for descriptions of terms.

The Synthesis Report with its Summary for Policymakers is published here in a single volume together with the Summaries for Policymakers and Technical Summaries of the Working Group contributions to the TAR, as well as a comprehensive, consolidated glossary. The Synthesis Report is also available in Arabic, Chinese, French, Russian, and Spanish—the other official languages of the IPCC. The Synthesis Report is also available as a stand-alone publication, as are discrete brochures consisting of the Summaries for Policymakers, Technical Summaries, and glossaries of the respective Working Group reports. The full English text of all

four volumes comprising the Third Assessment Report has been published in both print and digital form, with searchable versions available on CD-ROM and at <http://www.ipcc.ch>.

**R.T. Watson**  
IPCC Chair

**N. Sundararaman**  
IPCC Secretary

→ **IPCC Assessments Cited in the Synthesis Report**

Qx.x	<i>Relevant paragraph in the underlying Synthesis Report</i>	SPM	Summary for Policymakers
WGI TAR	<i>Working Group I contribution to the Third Assessment Report</i>	TS	Technical Summary
WGII TAR	<i>Working Group II contribution to the Third Assessment Report</i>	ES	Executive Summary
WGIII TAR	<i>Working Group III contribution to the Third Assessment Report</i>	GP	Guidance Paper
SRES	<i>Special Report on Emissions Scenarios</i>	TP	Technical Paper
SRLULUCF	<i>Special Report on Land Use, Land-Use Change, and Forestry</i>		
SRTT	<i>Special Report on the Methodological and Technological Issues in Technology Transfer</i>		
SRAGA	<i>Special Report on Aviation and the Global Atmosphere</i>		
DES GP	<i>Guidance Paper on Development, Equity, and Sustainability</i>		
IPCC TP4	<i>Technical Paper on Implications of Proposed CO<sub>2</sub> Emissions Limitations</i>		
IPCC TP3	<i>Technical Paper on Stabilization of Atmospheric Greenhouse Gases: Physical, Biological, and Socio-Economic Implications</i>		
WGII SAR	<i>Working Group II contribution to the Second Assessment Report</i>		