

## Global Change and Future Earth

*Global Change and Future Earth* is derived from the work of several programs of the International Union of Geodesy and Geophysics (IUGG). It demonstrates how multi- and interdisciplinary research outputs from the geoscience community can be applied to tackle the physical and societal impacts of climate change and contribute to the Future Earth program of the International Council for Science (now known as the International Science Council following a merger with the International Social Science Council). The volume brings together an international team of eminent researchers to provide authoritative reviews on the wide-ranging ramifications of climate change spanning eight key themes: planetary issues; geodetic issues; the Earth's fluid environment; regions of the Earth; urban environments; food security; risk, safety, and security; and climate change and global change. Covering the challenges faced by urban and rural areas, in both developed and developing countries, this volume provides an important resource for a global audience of graduate students and researchers from a broad range of disciplines, as well as policy advisers and practitioners.

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*Special Publications of the International Union of Geodesy and Geophysics Series*

The International Union of Geodesy and Geophysics (IUGG) promotes and coordinates international scientific studies of Earth (physical, chemical, and mathematical) and its environment in space, aiming to apply this knowledge to societal needs such as mineral resources, mitigation of natural hazards, and environmental preservation. The series is copublished by the IUGG and Cambridge University Press, providing researchers and graduate students with authoritative insights into major scientific developments and state-of-the-art research.

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 T. Beer, J. Li, and K. Alverson, *Global Change and Future Earth: The Geoscience Perspective*

# Global Change and Future Earth: The Geoscience Perspective

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**CAMBRIDGE**  
UNIVERSITY PRESS

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UNIVERSITY PRESS

University Printing House, Cambridge CB2 8BS, United Kingdom  
One Liberty Plaza, 20th Floor, New York, NY 10006, USA  
477 Williamstown Road, Port Melbourne, VIC 3207, Australia  
314–321, 3rd Floor, Plot 3, Splendor Forum, Jasola District Centre, New Delhi – 110025, India  
79 Anson Road, #06–04/06, Singapore 079906

Cambridge University Press is part of the University of Cambridge.

It furthers the University's mission by disseminating knowledge in the pursuit of education, learning, and research at the highest international levels of excellence.

[www.cambridge.org](http://www.cambridge.org)

Information on this title: [www.cambridge.org/9781107171596](http://www.cambridge.org/9781107171596)

DOI: 10.1017/9781316761489

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First published 2018

Printed in the United Kingdom by TJ International Ltd. Padstow Cornwall

*A catalogue record for this publication is available from the British Library.*

*Library of Congress Cataloging-in-Publication Data*

Names: Beer, Tom, editor.

Title: Global change and future earth : the geoscience perspective / edited by Tom Beer, IUGG Commission on Climatic and Environmental Change (CCEC), Jianping Li, College of Global Change and Earth System Sciences (GCESS) and Keith Alverson, UN Environment International Environmental Technology Centre, Osaka, Japan.

Description: Cambridge, United Kingdom ; New York, NY : Cambridge University Press, 2018. |

Series: International union of geodesy and geophysics series | Includes bibliographical references and index.

Identifiers: LCCN 2018013796 | ISBN 9781107171596 (hardback)

Subjects: LCSH: Earth science—Research.

Classification: LCC QE40 .G56 2018 | DDC 550—dc23

LC record available at <https://lccn.loc.gov/2018013796>

ISBN 978-1-107-17159-6 Hardback

Cambridge University Press has no responsibility for the persistence or accuracy of URLs for external or third-party internet websites referred to in this publication and does not guarantee that any content on such websites is, or will remain, accurate or appropriate.

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## Preface

The Union Commission on Climatic and Environmental Change (CCEC) was established by the Executive Committee of the International Union of Geodesy and Geophysics (IUGG) in June 2012 in order to promote the advancement of scientific understanding of climatic and environmental change, to boost research in reducing uncertainties in climate and environmental models, to define criteria for collaborative transdisciplinary research on climate and environmental change, to fulfill the objectives of IUGG and its associations, to provide an all-Union perspective on climatic and environmental change, and to make available the knowledge and insights developed through scientific research to the benefit of society and planet Earth, including consideration of the science of global change, related vulnerability and impacts, and potential responses.

CCEC provides a focus for IUGG scientific expertise in climate- and environment-related areas across the breadth of all IUGG disciplines and associations. CCEC enables the breadth of IUGG expertise to be brought to bear at the global level through collaborating with, and underpinning, the work of ICSU and other international organizations. It also enables the geographic spread of IUGG expertise to be applied at the local level through involvement with national bodies in the organization of meetings and other activities.



Figure 1 Speakers at the special session at the AGU Meeting of the Americas: Alik Ismail-Zadeh, Jaime Urrutia Fucugauchi, O. Brian Toon, Katya Kontar, Tom Beer, the late Mark Pagani.

### Objectives

- To build scientific capacity for responsibly addressing the broad, multidisciplinary issues involved in climatic and environmental change;
- to provide useful information, understanding, and support to the public and governmental organizations;
- to interact and cooperate with outside activities that would benefit from the capabilities and resources of the IUGG Associations; and
- to strengthen links across the Scientific Associations within IUGG, to build new external links to organizations outside IUGG, to strengthen existing links to external organizations, and to promote IUGG's contribution to global change research.

Information about CCEC is also available on the main IUGG web page at

[www.iugg.org/about/commissions/ccec.php](http://www.iugg.org/about/commissions/ccec.php).

IUGG has a long-established commission on climate (ICCL) that is one of the commissions of the International Association of Meteorology and Atmospheric Sciences (IAMAS) with an established membership that arranges activities and meetings that concentrate on the meteorological and atmospheric aspects of climate.



Figure 2 Albert McGill, IUFoST, addresses the IUNS symposium. Mark Wahlqvist, past President of IUNS, is on the left.

Table 1 *A List of Scientific Meetings That Dealt with the Topic of Weather, Climate, and Food Security*

Location	Theme	Linked to
Symposium Cancun, Mexico	Weather, Climate, and Food Security: American and Global Perspectives	AGU Meeting of the Americas
Workshop Nairobi, Kenya	Weather, Climate, and Food Security: African and Global Perspectives	First Africa Food Security Conference
Workshop Brisbane, Australia	Weather, Climate, and Food Security: Regional and Global Perspectives	AOGS Annual Meeting
Open Forum Granada, Spain	Weather, Climate, and Food Security: Global Perspectives	General Assembly of the International Union of Nutrition Science (IUNS)



Figure 3 Opening Session of the meeting of authors.  
 (Photo: Y. Kontar).

CCEC seeks to focus on relevant aspects of climate that correspond to the interests of the wider scientific community. CCEC focuses on both climate and environmental change within a transdisciplinary setting.

CCEC will “bring the Union’s research expertise to bear on some of the most challenging and important environmental and societal challenges of the 21st century.” Food security is obviously one of these challenges. Thus, CCEC was instrumental in persuading a consortium of international scientific unions to undertake an initiative on weather, climate, and food security. Specially targeted advanced research workshops and symposia (see Figure 1) listed in Table 1 drew together experts working on relevant issues.

When the International Council for Science (ICSU), as it was then known, initiated its new program called “Future Earth” by amalgamating a number of its interdisciplinary research efforts ([www.futureearth.org/](http://www.futureearth.org/)), CCEC sought to examine how activities could be included in Future Earth that had not hitherto been a part of the research efforts that were amalgamated. Selected distinguished scientists were approached, chosen on the basis that they had participated in the food security meetings listed in Table 1, or were involved in activities of international scientific unions

(see Figure 2). There was an enthusiastic response to the idea of preparing a volume showing the scope of the possible geoscience perspective to (a) Future Earth as a research program and (b) the future of the Earth as it undergoes global change.

A workshop of the authors of this volume (Figure 3) took place at the Université du Luxembourg in Belval, Luxembourg, 21–22 October 2016. They agreed that this volume should be a monograph that seeks to expound how the geoscience community can assist Future Earth so as to improve the future of the Earth and that it should comprise international and interdisciplinary contributions around the subject of climate change and its impacts on natural disasters and food security around the globe.

The content and structure of the thirty chapters are built around eight key sections: Part I, Future Earth and Planetary Issues (Chapters 1 to 4); Part II, Future Earth and Geodetic Issues (Chapters 5 to 8); Part III, Future Earth and the Earth’s Fluid Environment (Chapters 9 to 12); Part IV, Future Earth and Regions (Chapters 13 and 14); Part V, Future Earth and Urban Environments (Chapters 15 to 17); Part VI, Future Earth and Food Security (Chapters 18 to 22); Part VII, Future Earth, Risk, Safety and Security (Chapter 23 to 27); Part VIII, Future Earth, Climate Change and Global Change (Chapters 28 to 30).

We expect the readers of this book to be research scientists who subscribe to the vision of Future Earth with an interdisciplinary, multidisciplinary, or pluridisciplinary outlook. This includes geoscientists in the broadest sense – namely, those dealing with solid earth science and fluid earth science – as well as bioscientists and other members of the international scientific research community involved in examining the impacts of global change.

The Future Earth Web site notes that Future Earth is committed to building and connecting global

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knowledge to intensify the impact of research and find new ways to accelerate sustainable development. The success of Future Earth will depend on active collaboration among nations, disciplines, programs, researchers, and stakeholders to ensure that know-

ledge is generated in partnership with society and users of science. This book is intended for all those who share this vision and for those who engage in such collaboration.

We hope that you enjoy reading this book.

## Acknowledgments

The editors wish to acknowledge the support of the International Union of Geodesy and Geophysics (IUGG), who provided funding to enable the authors to meet in Luxembourg. This volume has been a project of the IUGG Commission for Climatic and Environmental Change (CCEC), whose logo is shown in Figure 4.

Any project of this magnitude is reliant on the voluntary support of numerous people, many of whom rely on the implicit support of their home institution, the international scientific union to which they belong, and national and international funding agencies. We acknowledge them all.

In addition, the members of the IUGG Commission for Climatic and Environmental Change, under whose auspices this monograph has been prepared, have been helpful and supportive. Their names and photographs may be found at <http://ccec-iugg.org/node/13>.

In the preparatory phase of the monograph, the editors were assisted by an editorial advisory board consisting of

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We sincerely thank all authors of the book chapters for their hard work and their excellent contributions. The excellence of the final chapters was due, in part, to the peer review undergone by all the chapters and by the peer reviewers' willingness to undertake critical

reviews and provide constructive comments and by the authors' willingness to heed these comments and revise their work accordingly. The chapter reviewers, whom we acknowledge and thank, were Ian Allison, Keith Alverson, Tom Beer, Harry Bryden, Bruce M. Campbell, Anny Cazenave, Athena Coustenis, Ibrahim Elmadfa, Elaine M. Faustman, Eigil Friis-Christensen, Elizabeth A. Fulton, Alik Ismail-Zadeh, David Johnston, Fumiko Kasuga, Yekaterina Y. Kontar, Jianping Li, Trevor McDougall, Albert McGill, Michael E. Meadows, Richard Munang, Lawrence A. Mysak, Godwin D. Ndossi, Jane Rovins, Ladislaus Rybach, Serhat Sensoy, Michael G. Sideris, Ramesh Singh, R. B. Singh, Walter Spiess, Makoto Taniguchi, Brian Toon, Tonie van Dam, and Mark L. Wahlqvist.

Special thanks go to the staff of Cambridge University Press – Susan Francis, Sarah Lambert, Zoë Puce – for their guidance throughout the production of the book, and to Alik Ismail-Zadeh, the Editor-in-Chief of the IUGG Special Publication Series, for his guidance, contributions, and support.

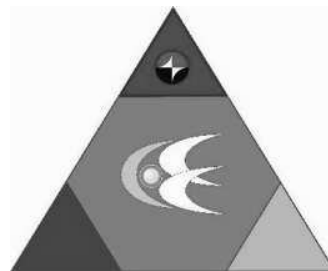


Figure 4 Logo of the IUGG Commission for Climatic and Environmental Change. For an explanation of the symbolism see <http://ccec-iugg.org/content/explanation-logo>.

## Abbreviations

AR5	Fifth Assessment Report of IPCC	IGBP	International Geosphere-Biosphere Programme
AR6	Sixth Assessment Report of IPCC	IHDP	International Human Dimensions Programme
ASTAAG	Asia Science, Technology and Academia Advisory Group	IMO	International Maritime Organization
CCEC	Commission on Climatic and Environmental Change (of IUGG)	IOC	Intergovernmental Oceanographic Commission
CCI	Commission for Climatology of WMO	IOM	International Organization for Migration
CFC	chlorofluorocarbon	IPBES	Intergovernmental Platform on Biodiversity and Ecosystem Services
CH <sub>4</sub>	methane	IPCC	Intergovernmental Panel on Climate Change
CLIVAR	CLimate VARIability and predictability (Core Project on Climate and Ocean)	IRDR	Integrated Research on Disaster Risk
CMIP5	Coupled Model Inter-Comparison Project Phase 5	ISA	International Seabed Authority
CO <sub>2</sub>	carbon dioxide	ISSC	International Social Science Council (now merged with ICSU to become ISC)
CO <sub>3</sub> <sup>2-</sup>	carbonate	IUFoST	International Union of Food Science and Technology
COBSEA	Coordinating Body on the Seas of East Asia	IUGG	International Union of Geodesy and Geophysics
COP	conference of parties	IUNS	International Union of Nutrition Sciences
DIVERSITAS	an international program of biodiversity science	KAN	Knowledge-Action Network
DRR	disaster risk reduction	LDC	least developed country
EEZ	Exclusive Economic Zone	MDG	Millennium Development Goal
FAO	Food and Agricultural Organization	MPA	marine protected area
GCM	Global Climate Model, and also General Circulation Model	MSP	marine spatial planning
GDP	gross domestic product	N <sub>2</sub> O	nitrous oxide
GHG	greenhouse gas	NAPA	National Adaptation Programme of Action
GOOS	Global Ocean Observing System	Ocean KAN	Ocean Knowledge-Action Network
H <sup>+</sup>	hydrogen ion	OSPAR	Oslo-Paris Convention
H <sub>2</sub> CO <sub>3</sub>	carbonic acid	OWG	open working group
H <sub>2</sub> S	hydrogen sulfide	ppm	part per million
HCO <sub>3</sub> <sup>-</sup>	bicarbonate	RCP	representative concentration pathway scenario
HELCOM	Helsinki Commission	ROPME	Regional Organisation for Protection of the Marine Environment
IAMAS	International Association of Meteorology and Atmospheric Sciences	RSP	Regional Seas Programme
IAG	International Association of Geodesy	SCOR	Scientific Committee on Ocean Research
ICSU	International Council for Science, now known as the International Science Council	SDG	sustainable development goal
IDMC	Internal Displacement Monitoring Centre	SDSN	Sustainable Development Solutions Network
IDP	Internally Displaced People		



SIDS	Small Island Developing State	UNESCO	United Nations Educational, Scientific and Cultural Organization
SLR	sea level rise	UNFCCC	United Nations Framework Convention on Climate Change
SO <sub>2</sub>	sulfur dioxide	UNHCR	United Nations High Commissioner for Refugees
SREX	Special Report on Managing the Risks of Extreme Events and Disaster Advance Climate Change Adaptation of IPCC	UNISDR	United Nations Office for Disaster Risk Reduction
SSP	Shared Socio-Economic Pathway Scenario	URL	Uniform Resource Locator
UN	United Nations	UV	ultraviolet radiation
UNCLOS	United Nations Convention of the Law of the Sea	WCRP	World Climate Research Programme
UNEP	United Nations Environmental Programme	WHO	World Health Organization
		WMO	World Meteorological Organization