Climate Change 2014
Impacts, Adaptation, and Vulnerability
Part B: Regional Aspects

Working Group II Contribution to the
Fifth Assessment Report of the
Intergovernmental Panel on Climate Change

Edited by

Vicente R. Barros
Working Group II Co-Chair
Centro de Investigaciones del Mar y la Atmósfera
Universidad de Buenos Aires

Christopher B. Field
Working Group II Co-Chair
Department of Global Ecology
Carnegie Institution for Science

David Jon Dokken
Executive Director

Michael D. Mastrandrea
Co-Director of Science

Katharine J. Mach
Co-Director of Science

T. Eren Bilir **Monalisa Chatterjee** **Kristie L. Ebi** **Yuka Otsuki Estrada** **Robert C. Genova** **Betelhem Girma**
Eric S. Kissel **Andrew N. Levy** **Sandy MacCracken** **Patricia R. Mastrandrea** **Leslie L. White**

CAMBRIDGE
UNIVERSITY PRESS

CAMBRIDGE
UNIVERSITY PRESS

32 Avenue of the Americas, New York, NY 10013-2473, USA

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
Information on this title: www.cambridge.org/9781107683860

First published 2014

Printed in the United States of America

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

ISBN 978-1-107-05816-3 Hardback
ISBN 978-1-107-68386-0 Paperback

Use the following reference to cite Part B:

IPCC, 2014: *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Barros, V.R., C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 688.

Cover Photo:

Maeslant storm surge barrier in Rotterdam, Netherlands. © Asahi Shimbun / Getty Images

Contents

Regional Context

Coordinating Lead Authors:
Bruce Hewitson (South Africa), Anthony C. Janetos (USA)

Lead Authors:
Timothy R. Carter (Finland), Filippo Giorgi (Italy), Richard G. Jones (UK), Won-Tae Kwon (Republic of Korea), Linda O. Mearns (USA), E. Lisa F. Schipper (Sweden), Maarten K. van Aalst (Netherlands)

Contributing Authors:
Eren Bilir (USA), Monalisa Chatterjee (USA/India), Katharine J. Mach (USA), Carol McSweeney (UK), Grace Redmond (UK), Vanessa Schweizer (USA), Luke Wirth (USA), Claire van Wyk (South Africa)

Review Editors:
Thomas Downing (USA), Phil Duffy (USA)

Volunteer Chapter Scientist:
Kristin Kuntz-Duriseti (USA)

This chapter should be cited as:
Hewitson, B., A.C. Janetos, T.R. Carter, F. Giorgi, R.G. Jones, W.-T. Kwon, L.O. Mearns, E.L.F. Schipper, and M. van Aalst, 2014: Regional context. In: *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Barros, V.R., C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1133-1197.

Table of Contents

Executive Summary

There has been an evolution in the treatment of regional aspects of climate change in IPCC reports from a patchwork of case examples in early assessments toward recent attempts at a more systematic coverage of regional issues at continental and sub-continental scales. {21.2.2} Key topics requiring a regional treatment include changes in the climate itself and in other aspects of the climate system (such as the cryosphere, oceans, sea level, and atmospheric composition), climate change impacts on natural resource sectors and on human activities and infrastructure, factors determining adaptive capacity for adjusting to these impacts, emissions of greenhouse gases and aerosols and their cycling through the Earth system, and human responses to climate change through mitigation and adaptation.

A good understanding of decision-making contexts is essential to define the type and scale of information on climate change-related risks required from physical climate science and impacts, adaptation, and vulnerability (IAV) assessments (*high confidence*). {21.2.1} This is a general issue for all IAV assessments, but is especially important in the context of regional issues. Many studies still rely on global data sets, models, and assessment methods to inform regional decisions. However, tailored regional approaches are often more effective in accounting for variations in transnational, national, and local decision-making contexts, as well as across different groups of stakeholders and sectors. There is a growing body of literature offering guidance on how to provide the most relevant climate risk information to suit specific decision-making scales and processes.

A greater range of regional scale climate information is now available that provides a more coherent picture of past and future regional changes with associated uncertainties. {21.3.3} More targeted analyses of reference and projected climate information for impact assessment studies have been carried out. Leading messages include:

- Significant improvements have been made in the amount and quality of climate data that are available for establishing baseline reference states of climate-sensitive systems. {21.5.3.1} These include new and improved observational data sets, rescue and digitization of historical data sets, and a range of improved global reconstructions of weather sequences.
- A larger set of global and regional (both dynamical and statistical) model projections allow a better characterization of ranges of plausible climate futures than in the Fourth Assessment Report (AR4) {21.3.3}, and more methods are available to produce regional probabilistic projections of changes for use in IAV assessment work. {21.5.3}
- Better process understanding would strengthen the emerging messages on future climate change where there remains significant regional variation in their reliability. {21.3.3}
- Confidence in past climate trends has different regional variability, and in many regions there is higher confidence in future changes, often owing to a lack of evidence on observed changes. {21.3; Box 21-4}

In spite of improvements, the available information is limited by the lack of comprehensive observations of regional climate, or analyses of these, and different levels of confidence in projected climate change (*high confidence*). Some trends that are of particular significance for regional impacts and adaptation include: {21.3.3.1; WGI AR5 SPM}

- The globally averaged combined land and ocean surface temperature data show a warming of 0.85 (0.65 to 1.06) °C, over the period 1880–2012. There is regional variation in the global trend, but overall the entire globe has warmed during the period 1901–2012. {WGI AR5 SPM} Future warming is *very likely* to be larger over land areas than over oceans. {WGI AR5 SPM}
- Averaged over mid-latitude land areas, precipitation has increased since 1901 (*medium confidence* before and *high confidence* after 1951), but for other regions there is *low confidence* in the assessment of precipitation trends. {WGI AR5 SPM}
- There are *likely* more land regions where the number of heavy precipitation events has increased than where it has decreased. The frequency or intensity of heavy precipitation events has *likely* increased in North America and Europe. In other continents, confidence in changes in heavy precipitation events is at most *medium*. The frequency and intensity of drought has *likely* increased in the Mediterranean and West Africa and *likely* decreased in central North America and northwest Australia.
- The annual mean Arctic sea ice extent decreased over the period 1979–2012 with a rate that was *very likely* in the range 3.5 to 4.1% per decade. Climate models indicate a nearly ice-free Arctic Ocean in September before mid-century is *likely* under the high forcing scenario Representative Concentration Pathway 8.5 (RCP8.5) (*medium confidence*).
- The average rate of ice loss from glaciers worldwide, excluding those near the Greenland and Antarctic ice sheets, was *very likely* 275 (140 to 410) Gt yr^{-1} over the period 1993–2009. By the end of the 21st century, the volume of glaciers (excluding those near the Antarctic ice sheet) is projected to decrease by 15 to 55% for RCP2.6, and by 35 to 85% for RCP8.5, relative to 1986–2005 (*medium confidence*).

- The rate of global mean sea level rise during the 21st century is *very likely* to exceed the rate observed during 1971–2010, under all RCP scenarios. {21.3.3.5; WGI AR5 SPM} By the end of the 21st century it is *very likely* that sea level will rise in more than about 95% of the ocean area, with about 70% of the global coastlines projected to experience a sea level change within 20% of the global mean change. Sea level rise along coasts will also be a function of local and regional conditions, including land subsidence or uplift and patterns of development near the coast.

There is substantial regional variation in observations and projections of climate change impacts, both because the impacts themselves vary and because of unequal research attention. {21.3.1} Evidence linking observed impacts on biological, physical, and increasingly) human systems to recent and ongoing regional temperature and (in some cases) precipitation changes have become more compelling since the Fourth Assessment Report (AR4). This is due both to the greater availability of statistically robust, calibrated satellite records, and to improved reporting from monitoring sites in hitherto under-represented regions, though the disparity still remains large between data-rich and data-poor regions. Regional variations in physical impacts such as vegetation changes, sea level rise, and ocean acidification are increasingly well documented, though their consequences for ecosystems and humans are less well studied or understood. Projections of future impacts rely primarily on a diverse suite of biophysical, economic, and integrated models operating from global to site scales, though some physical experiments are also conducted to study processes in altered environments. New research initiatives are beginning to exploit the diversity of impact model projections, through cross-scale model intercomparison exercises.

There are large variations in the degree to which adaptation processes, practices, and policy have been studied and implemented in different regions (*high confidence*). {21.3.2} Europe and Australia have had extensive research programs on climate change adaptation, while research in Africa and Asia has been dominated by international partners and relies heavily on case studies of community-based adaptation. National adaptation strategies are common in Europe, and adaptation plans are in place in some cities in Europe, the Americas, and Australasia, with agriculture, water, and land use management the primary sectors of activity. However, it is still the case that implementation lags behind planning in most regions of the world.

Contested definitions and alternative approaches to describing regional vulnerability to climate change pose problems for interpreting vulnerability indicators. {21.3.1.2, 21.5.1.1} There are numerous studies that use indicators to define aspects of vulnerability, quantifying these across regional units (e.g., by country or municipality), often weighting and merging them into vulnerability indices and presenting them regionally as maps. However, methods of constructing indices are subjective, often lack transparency, and can be difficult to interpret. Moreover, indices commonly combine indicators reflecting current conditions (e.g., of socioeconomic capacity) with other indicators describing projected changes (e.g., of future climate or population), and have failed to reflect the dynamic nature of the different indicator variables.

Hotspots draw attention, from various perspectives and often controversially, to locations judged to be especially vulnerable to climate change. {21.5.1.2} Identifying hotspots is an approach that has been used to indicate locations that stand out in terms of IAV capacity (or combinations of these). The approach exists in many fields and the meaning and use of the term hotspots differs, though their purpose is generally to set priorities for policy action or for further research. Hotspots can be very effective as communication tools, but may also suffer from methodological weaknesses. They are often subjectively defined, relationships between indicator variables may be poorly understood, and they can be highly scale dependent. In part due to these ambiguities, there has been controversy surrounding the growing use of hotspots in decision making, particularly in relation to prioritizing regions for climate change funding.

Cross-regional phenomena can be crucial for understanding the ramifications of climate change at regional scales, and its impacts and policies of response (*high confidence*). {21.4} These include global trade and international financial transactions, which are linked to climate change as a direct or indirect cause of anthropogenic emissions; as a predisposing factor for regional vulnerability, through their sensitivity to climate trends and extreme climate events; and as an instrument for implementing mitigation and adaptation policies. Migration is also a cross-regional phenomenon, whether of people or of ecosystems, both requiring transboundary consideration of their causes, implications, and possible interventions to alleviate human suffering and promote biodiversity.

Downscaling of global climate reconstructions and models has advanced to bring the climate data to a closer match for the temporal and spatial resolution requirements for assessing many regional impacts, and the application of downscaled climate

data has expanded substantially since AR4. {21.3.3, 21.5.3} This information remains weakly coordinated, and current results indicate that high-resolution downscaled reconstructions of the current climate can have significant errors. The increase in downscaled data sets has not narrowed the uncertainty range. Integrating these data with historical change and process-based understanding remains an important challenge.

Characterization of uncertainty in climate change research on regional scales has advanced well beyond quantifying uncertainties in regional climate projections alone, to incorporating uncertainties in simulations of future impacts as well as considering uncertainties in projections of societal vulnerability. {21.3.3, 21.5} In particular, intercomparison studies are now examining the uncertainties in impacts models (e.g., Agricultural Model Intercomparison and Improvement Project (AgMIP) and Inter-Sectoral Impact Model Intercomparison Project (ISI-MIP)) and combining them with uncertainties in regional climate projections. Some results indicate that a larger portion of the uncertainty in estimates of future impacts can be attributed to the impact models applied rather than to the climate projections assumed. In addition, the deeper uncertainties associated with aspects of defining societal vulnerability to climate change related to the alternative approaches to defining vulnerability are becoming appreciated. As yet there has been little research actively to quantify these uncertainties or to combine them with physical impact and climate uncertainties.

Studies of multiple stressors and assessments of potential global and regional futures using scenarios with multiple, non-climate elements are becoming increasingly common. {21.5.3.2-3} Non-climatic factors relevant to assessing a system's vulnerability generally involve a complex mix of influences such as environmental changes (e.g., in air, water, and soil quality; sea level; resource depletion), land use and land cover changes, and socioeconomic changes (e.g., in population, income, technology, education, equity, governance). All of these non-climate factors have important regional variations. There is significant variation in vulnerability owing to variability in these factors.