IPCC Expert Meeting on Assessing Climate Information for Regions

Meeting Report

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This meeting report was prepared jointly by the scientific steering committee (SSC) for the meeting (Valérie Masson-Delmotte, Hans-Otto Pörtner, Debra Roberts, Panmao Zhai, Edvin Aldrian, Andreas Fischlin, Gregory Flato, Mark Howden, Ramon Pichs Madruga, Elvira Poloczanska, Melinda Tignor, Carolina Vera) as well as the Technical Support Unit (TSU) of the WGI (Anna Pirani, Wilfran Moufouma-Okia, Sarah Connors, Robin Matthews, and Chen Yang), and subjected to review by the meeting participants.

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Foreword

We are pleased to present the report of the Expert Meeting on Assessing Climate Information for Regions which was held on 16-18 May 2018 in Trieste, Italy.

Based on a joint proposal from the Co-Chairs of Working Group I and II, the Intergovernmental Panel on Climate Change (IPCC) agreed at its 46th Session (Montréal, Canada, 6-10 September 2017) to hold an expert meeting on Assessing Climate Information for Regions. The Expert Meeting proposal aimed to address the inter-linkage between regional climate information needs of the WGI and WGII IPCC Sixth Assessment Reports (AR6). The meeting also seek to improve coordination, relevance and coherency in the assessment of regional aspects across WGI and WGII, and to facilitate the synthesis.

To truly inform regional risk assessment and decision making, the IPCC is of the view that it is important to evolve from the WGI traditional one-direction approach of providing "climate information" to WGII and WGIII, to a more integrated or "handshake" approach in which the regional climate information and the associated uncertainty are considered altogether; building on observations, reanalyses, detection and attribution, as well as projections and hazards, exposure, vulnerability, impacts and risks. In this context, a continuous dialogue between IPCC working group (WGs) communities is essential for common understanding to be found on what relevant "regional climate information" means and how to represent it within the AR6.

The Expert Meeting was hosted by the International Centre for Theoretical Physics (ICTP). It brought together 110 experts from 43 countries to discuss challenges raised by the use of regional information in the assessment of climate processes and responses to drivers, analysis of impacts for decision making and risk management (including adaptation options). The meeting included WGI and WGII authors of the AR6 regional chapters, including experts on global and regional climate modelling, regional observations and reanalyses, climate extremes, and risks and impacts analysis. The Expert Meeting was scheduled one month prior to the first Lead Author Meeting (LAM1) of WGI, and thus its outcomes were carefully considered during LAM1 for shaping the AR6 internal draft of WGI.

This report summarises the conduct of the Expert Meeting and its recommendations for three audiences: AR6 authors of WGI and WGII reports; IPCC leadership; and the scientific communities upon which the IPCC relies upon. It contains summaries of discussions in the plenary sessions and the breakout groups, as well as abstracts of the presentations.

We gratefully acknowledge the expertise, rigour and dedication of all participants to the meeting – which contributed to a constructive, stimulating and fruitful dialogue. These exchange of views across disciplines resulted in more clarity in the issues discussed and pragmatic recommendations for considerations in the preparation of the AR6. The meeting could not have succeeded without the assistance, guidance, and wisdom of members of the Scientific Steering Committee.

We would like to thank sincerely the International Centre for Theoretical Physics and its Director Fernando Quevedo, for hosting the meeting in Trieste and providing excellent arrangements. We would also like to thank the members of the IPCC WGI, WGII and WGIII Bureaus for their assistance and guidance throughout the meeting deliberations: Edvin Aldrian, Fatima Driouech, Andreas Fischlin, Jan Fuglestvedt, Greg Flato, Mark Howden, Ramon Pisch Madruga, Joy Pereira, Muhammad I. Tariq, Carolina Vera, and Noureddine Yassa. We thankfully acknowledged the support provided by governments and institutions, through contributions to the IPCC Trust Fund, as it enabled the participation of the experts.

Our heartfelt appreciations go to the Working Group Technical Support Units whose tireless dedication, professionalism and enthusiasm were pivotal in all aspects of the preparation and execution of this Expert Meeting: Yang Chen, Sarah Connors, Elisabeth Lonnoy, Robin Matthews, Wilfran-Moufouma-Okia, Clotilde Péan, Roz Pidcock, Anna Pirani, and Tim Waterfield. Our warmest thanks go to the collegial and collaborative support provided by Elvira Poloczanska, Melinda Tignor and Nora Weyer from the WGII Technical Support Unit.

We are convinced that this Expert Meeting will be of key importance to strengthen coordination, relevance and coherency in the assessment of regional climate change aspects across the WGI and WGII contributions to the IPCC AR6, through the implementation of innovative coordination and integration approaches. This will facilitate the synthesis report. We also stress the need for timely publication of new interdisciplinary research to underpin the "handshake" between WGs.

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Co-Chair
IPCC Working Group I

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Executive Summary

The Intergovernmental Panel on Climate Change (IPCC) held a three-day Expert Meeting on Assessing Climate Information for Regions. The meeting aimed to explore the needs of regional information for the risk assessment framework and the current knowledge gaps in developing regional climate information, as well as the inter-linkage between regional climate information needs of the Working Group I (WGI) and Working Group II (WGII) IPCC Sixth Assessment Reports (AR6).

The deliberations first focused on assessing climate information, from global to regional changes, and provided participants with a broad perspective on the IPCC Sixth assessment cycle including its timescale, products, objectives, and dimensions central to the Expert meeting on Assessing Climate Information for Regions. IPCC Co-Chairs of WGI and WGII outlined the meeting objectives and the rationale for developing a joint WGI and WGII regional Atlas. The regional perspective of the WGIII assessment was also discussed, including the regional specificities associated with mitigation response options, the perspective of WGIII on the risk assessment concept, as well as the mitigation-adaptation-Sustainable Development linkages.

The regional emphasis of past IPCC reports has been rich, but highly heterogeneous and varied across WGs, often leading to regional statements with low confidence. This is due partly to the heterogeneous nature of climate observations across regions worldwide and the limitations of historical records. Therefore, it is essential to distinguish climate information from climate data, and place climate information into a relevant context in order to construct "useful" climate information. Recent climate modelling advances and research initiatives offer a wide range of opportunities to integrate across multiple regional climate information sources, enhance the recognition of context in constructing and constraining regional climate messages, and to foster co-assessment within and between IPCC Working Groups. However, there is a need to assess methods used for climate downscaling and the associated uncertainty, and to provide clear recommendations for the AR6 Authors – more specifically on the issues of regional scale use of IPCC guidelines for detection and attribution, multi-models assessment and treatment of uncertainties.

The meeting's discussions also focused on the regional climate information needs for the assessment of sectoral and climate change impacts and risk. Specific consideration was devoted to the Fifth Assessment Report (AR5) climate risk analysis and management framework, highly differentiate impacts, and the decision-making under uncertainty, with particular attention to near-term and long-term regional climate information and communication challenges. Discussions further expanded on the regional requirements for the impact modelling community and the development of a unified concept of risk, including both hazards associated with climate change and risk - reduction from the climate change response (adaptation and mitigation strategies). It was noted that the demand for regional climate information may be stimulated through research advances and needs, legislation, improved understanding of climate services and disaster risk reduction.

More details on the meeting's key recommendations are provided in the Sections below. The meeting's outcomes are expected to feed into the WGI and WGII AR6 report, in particular on the issues of linking global to regional climate change, extending the overall narrative of the WGI report to explicitly assess the foundations for information about regional climate change and regional phenomena (Chapter 10); treating weather and climate extreme events in a changing climate, within the context of regional relevance for WGII and accounting for both driving mechanisms, observed changes, models ability and fitness-for-purpose, and projected changes of extreme events, as well as the role of natural variability and the interplay between dynamic and thermodynamic processes (Chapter 11); providing end-to-end assessment of climate change information for regional impact and risk assessment, contributing to regions specific assessment of the present and future climate risks (Chapter 12); and developing a regional Atlas.

1. Principle Recommendations from the Expert Meeting

The recommendations arise from presentations and breakout group discussions, and are presented on behalf of the WGI and WGII Bureaus, as well as the Scientific Steering Committee. These recommendations may have immediate implications for early stages of the AR6 assessment process. Further details on the meeting's deliberations are available in the subsequent sections of the Report, most importantly in form of summaries for both plenary and the breakout group discussions. Here, we focus on recommendations that can be implemented by author teams with an active facilitator role by the IPCC WGI and WGII vice-chairs and co-chairs.

1.1 Scoping the IPCC AR6 Regional Atlas:

The meeting's constructive discussions stressed the need for the AR6 regional Atlas to go beyond the AR5 experience in facilitating the "handshake" between WGI and WGII, with respect to regional climate information needs and ensuring consistency. Key Atlas features should thus include maps, narrative and assessment support tools, as well as capability and methodologies to combine multiple sources data from the coordinated global climate modelling inter-comparison initiatives (CMIP5 and / or CMIP6) and the coordinated regional climate downscaling experiment (CORDEX), as well as observations, reanalyses, theory, statistical analyses, expert judgement, in close relationship with WGI chapter on linking global to regional climate change of AR6 (Chapter 10). The regional Atlas should also provide information on uncertainties, options for an electronic/online/dynamic version, and information across timescales (past, present and future). Above all, the AR6 Atlas should enable the traceability of underlying data.

Indicative Bullet Points for the Regional Atlas Outline:

- Framing: purpose, scope, limitations, and introduction; beyond AR5, from past to future and an interactive product.
- Regions, time slices; data selection, observations; scenarios, levels of warming; attribution, models, and other tools.
- Treatment of biases, inhomogeneity and data gaps; combining information from multiple sources e.g. CMIPs, CORDEX and observations; communication of confidence and uncertainty.
- Key variables, indices and metrics linked to WGI chapters.
- WGII-relevant variables/sector-specific indices/hazard information.
- Spatially resolvable phenomena (e.g. monsoons, storm tracks).
- Presentation and communication approaches: Guidance, Maps, figures, tables, animations, narrative, uncertainty.
- Traceability to WGI chapters, processing and curated datasets; IPCC stamp.
- Regional summaries and case studies.
- Detection and attribution

1.2. Guidance on Detection and Attribution, its Application across Working Groups and across Regions

- Update the 2010 IPCC Good Practice Guidance document on detection and attribution related to anthropogenic climate change (Hegerl et al, 2010[1]). The goal is to develop a process that provides some brief update on the guidance to be used consistently throughout the AR6, for instance in relationship with regional information and the attribution of single events.

- Establish a volunteer drafting author team for briefly updating the guidance document on detection and attribution related to anthropogenic climate change. The document will be refined for discussion at WG1 LAM1 and beyond.

- Make an improved and consistent use of the risk assessment framework across WGI and WGII, and regions.

- Explore the extent to which event attribution methodologies and language developed by WGI can be applied consistently to the WGII concepts of impacts and attribution of changing risk.

1.3. Guidance on the Definition of Regional and Sub-Regional Focus Areas

- Foster the definition of regions and sub-regions in the context of risk and sectoral assessment. This will ensure consistency between WGI and WGII definitions of regions, taking into account cross-regional information on hazards like compound events. It is recommended to start off with the regional definitions proposed by AR5 (including SREX), SR1.5, and SROCC reports.

- Develop guidance for how Chapters should define regions considering the information's robustness, quality, quantity, policy relevance, and methodological requirements.

- Encourage WGI and WGII authors to work closely together in identifying trade-off and balance between the regional climate information needs, as well as confidence/uncertainty and scales at which regional climate information is assessed. This will foster consistent regional treatment across the WGs contributions to the AR6.

- Identify cross-WGs issues that need a coupled implementation process in order to ensure efficient oversight and foster the coordination.

- Account for region specific methodologies and to ensure consistency across the report.

- Identify key contact persons for small islands to bridge WGI and WGII.

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1 http://www.ipcc-wg2.awi.de/guidancepaper/IPCC_D&A_GoodPracticeGuidancePaper.pdf

1.4. Guidance on Alternative Approaches to Providing Regional Information

• Consider various approaches to pull together multi-sources of information and obtain an improved regional perspective.

• Move beyond the use of simple maps and examine other types of figures and aggregations methods (e.g. time-series, bar charts), as well as impact-relevant and risk relevant thresholds.

• Assess narratives and storylines that factor in risk exposure must be considered.

• Evaluate timescales of interest and natural variability in systems.

• Consider case studies in regions with incomplete data coverage.

• Define impact-relevant and risk-relevant thresholds.

1.5. Guidance on regional information needs for various impact sectors

• Encourage IPCC WGI and WGII authors to engage in a dialogue to scope the sectoral regional information needs and metrics. Ideally, WGII authors would provide key sectoral variables, while WGI authors focus on assessing the methodological issues. The IPCC special reports SREX (Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation) and SR1.5 (Global Warming of 1.5°C) are good illustrations of WGI and WGII working closely together, and will serve as the starting point for identification of impact metrics and variables of interest.

• Prepare a guidance document on assessing, portraying, and distilling multiple sources of regional climate information.

1.6. Guidance on climate information quality/ uncertainty/availability in different regions and at different scales

• Assess models' performance (trends and key features affecting response), convey models' range in and beyond projections, communicate confidence and assess observational uncertainties, as well as the value added of combining multiple sources of climate information at regional scales (e.g. GCMs, RCMs, observations, theory, and expert judgement). This should be grounded in the well-established IPCC calibrated language for uncertainty.

• Develop cross-Chapters case studies in the WGI contribution to AR6 (Chapters 10, 11, 12).

• Assess the availability, accessibility and quality of observations, and uncertainty across information streams (GCMs, RCMs, empirical and high resolution climate models).

1.7. Guidance on coordination and communication issues related to regional climate assessment

• Encourage WGI and WGII authors to engage in a dialogue to prepare a guidance note on regional and sectoral risks and appropriate hazard metrics. In this respect, liaison persons have been identified and the contact list may be expanded to include WGII relevant sectors' authors.

• Prepare Terms of Reference (ToR) to facilitate cross-WG communication on regional and sectoral risks and appropriate hazard metrics. It is suggested to invite all WGII authors to review the WGI internal draft, so as to foster early feedbacks on the AR6 chapters' development. Other suggested options include inviting the relevant authors from other WGs to joint lead author meetings (LAMs).

• AR6 authors of the WGI Chapter on Climate change information for regional impacts and risk assessment (Chapter 12) will include information relevant for climate services and connect to the WGII Chapter on Decision-making options for managing risk (Chapter 17).

2. Outline of the Expert Meeting

2.1. Background

From 16 to 18 May 2018, 110 experts from 43 countries gathered at the International Centre for Theoretical Physics (ICTP) in Trieste, Italy, to discuss the issue of assessing climate information for regions. This Expert Meeting was proposed by the IPCC Working Group I and II Co-chairs at the 46th Panel Session (Montréal, Canada, 6-10 September 2017) with the aim to provide guidance for the Sixth Assessment Report (AR6) on the issues of assessing regionally relevant climate information and the current knowledge gaps, exploring the needs of regional information for the risk assessment framework, and the translation of regional climate information for use by the vulnerability, impacts and adaptation, policy, and government communities. The 43rd Session of the IPCC (P-43) held in April 2016, decided on the AR6's focus, products, and timescale. P-43 also recommended that the AR6 cycle considers modalities to address and enhance the treatment of regional scale issues, a strong integration of the climate impact assessment on cities and their unique adaptation and mitigation opportunities, and make more robust the consideration of cities in the treatment of regional issues and in chapters that are focused on human settlements, urban areas and the like, allowing for detailed assessments of sectorally-relevant climate information. Meeting these assessment needs will require coordination, appropriate and coherent treatment of regional climate information across Working Groups (WGs) to ensure integrated assessment and consistency across AR6 products.

The AR6 cycle places an important weight on integrating the risk framework with solution-focused information and the growing demand for policy-relevant regional climate information, in support of international climate policies within the United Nations Framework Convention on Climate Change Convention (UNFCCC) and the Paris Agreement. It is also embedded within the broader global development agendas in order to fuse development needs with climate responsibility, impacts and emissions reduction pathways. These agendas include the Sendai Framework for Disaster Risk Reduction, 2030 Agenda for Sustainable Development (SDGs), Addis Ababa Action Agenda to support implementation of SDGs, and the New Urban Agenda. Strengthening the provision of the regional scientific information, including projections and Information that is spatially and temporally relevant to city level actors, is needed to inform actions at the national, regional and local levels, and to support government strategies in areas as broad as disaster risk management, economic and sustainable development policies, adaptation planning, mitigation policies, impacts of response measures and increasing resilience. Thus, enhancing the policy-relevant regional aspects in the AR6 will provide a robust scientific basis to inform the responses of the COP21 Paris meeting, primary the need for Parties to strengthen regional cooperation on adaptation.

The AR6 outlines of Working Groups (WGs) main contributions, approved by Government representatives at the IPCC's 46th Session (P-46) in September 2017 in Canada, promote enhanced interlinkages across WGs on several cross-cutting topics including the production of a Regional Atlas. Co-Chairs of the three Working Groups were invited to develop appropriate mechanisms to ensure the effective coordination and treatment of cross-cutting themes. For instance, the WG main report devotes three chapters to regional assessment of the science advances since the IPCC AR5 (Table 1). The regional chapters are designed to be holistic, drawing on multiple lines of evidence including observations, downscaling techniques, models, theory, projections and predictions, understanding of local and urban and regional and large-scale drivers (e.g., global modes of variability, tropical cyclones, monsoons, teleconnections, and atmospheric blocking) and feedbacks of region-specific processes (e.g. short lived climate forcers, land-atmosphere processes) within the climate risks assessment framework. The WGII AR6 contribution devotes seven chapters to the regional assessment of climate change impacts and risks, including coastal oceans. The WGII AR6 report also contains cross-chapter papers envisaged to update regional information produced in the special reports e.g. 'Polar Regions' and provide a synthetic view of regional impacts and risks in e.g. Biodiversity hotspots (land, coasts and oceans or the 'Mediterranean region'), mountains, tropical forests, deserts, semi-arid areas, and cities and settlements by the sea. Meeting these goals requires an active engagement from experts across WGs in joint activities and workshops that will strengthen the collaboration between the relevant sciences fields. Interdisciplinary research and associated publications need to be conducted to underpin the ´handshake´ between WGs.

For the IPCC AR6 Working Groups main contributions to comprehensively inform regional risk assessment and decision making, it is important to evolve from the traditional one-direction approach of WGI in providing ´regional climate information´ to WGII and WGIII, to a more integrated approach in which regional climate information, projections, vulnerabilities and impacts, and response options are considered altogether. In this approach, the three WGs each contribute from their perspective and the issue is how to integrate, distil and present such information in a readily accessible manner across the WGs. A continuous dialogue between authors of multiple chapters across Working Groups is thus essential throughout the AR6 cycle.

In this context, the IPCC proposed an Expert Meeting (EM) on assessing climate information for regions, to be held in the first trimester of 2018. This EM builds directly on the outcomes of the AR6 scoping meeting held in Ethiopia in May 2017, which followed a thorough and transparent process with leading scientists from around the globe, and highlighted the need for a WGI and WGII 'handshake' between the use of regional information in climate assessment of climate mechanisms and responses to drivers, with the use of regional information for application in decisions and impacts analysis. The former requires assessing through the underlying physical mechanisms, causes, and feedbacks of regional change, as well as associated uncertainty. The later requires instead assessing the mechanisms for provision and delivery of regional climate information. The AR6 scoping meeting also included cross-WG breakout group meetings on risk and regional aspects of climate change, which extended the outcomes of the IPCC Workshop on Regional Climate Projections and their Use in Impacts and Risk Analysis Studies, held in Brazil in 2015, and addressed directly the interface between regional climate projections; a topic that is traditionally assessed by WGI of the IPCC, and risk analyses which has been a focus of WGII.

Furthermore, the EM on assessing climate information for regions builds on the Future-Earth-PROVIA-IPCC workshop on integrated research on climate risk and sustainable solutions across IPCC Working Groups, held in Sweden in August 2016 – which included a dedicated task group on sharing information on risks and solution strategies across local to global scales, and concluded that the risk framework as outlined by WGII in AR5 proved as useful concept and should be continued to be used in AR6 with a strong recommendation to homogenize the risk framework and terminology across WGs and efforts from WGI and WGIII to feed into this framework. In addition, the WGIII Expert Meeting on Scenarios, held in Ethiopia in April 2017, indicates that substantial literature is accumulating on potential future societal vulnerability at the regional level based on the Shared Socioeconomic Pathway (SSP) scenario framework. Since climate risk is a function of both climate-related hazards and the exposure and vulnerability of society and ecosystems, SSPs can provide an exciting opportunity to integrate regional climate information with future changes in population, urbanization, economic growth, changes in land use and energy systems, and changes in other aspects of society to determine future risks. Thus, more discussions are needed to provide guidance on the visualization of climate risks and associated uncertainties in AR6 with emphasis on the diversity and heterogeneity of data (including quantitative and qualitative) describing the different components of risk (climate hazards, exposure and vulnerability).

Chapter Title (Working Group and Number)	Key Objectives and Focus Areas
Linking global to regional climate change **(WGI, Chapter 10)**	To assess the foundations for information about regional climate change and regional phenomena, including scale specific methodologies (e.g. urban, mountains, coastal, catchments, small islands) and approaches to synthesizing information from multiple lines of evidence
Weather and climate extreme events in a changing climate **(WGI, Chapter 11)**	To account for driving mechanisms, observed changes, models ability and fitness-for-purpose, and projected changes of extreme events, as well as the role of natural variability and the interplay between dynamic and thermodynamic processes
Climate change information for regional impact and for risk assessment **(WGI, Chapter 12)**	To provide end-to-end assessment of climate change information for regional impact and risk assessment, contributing to regions specific assessment of the present and future climate risks
Regional Atlas **(WGI)**	To be scoped
Africa **(WGII, Chapter 9)**	Africa
Asia **(WGII, Chapter 10)**	Asia
Australasia **(WGII, Chapter 11)**	Australasia
Central and South America **(WGII, Chapter 12)**	Central and South America
Europe **(WGII, Chapter 13)**	Europe
North America **(WGII, Chapter 14)**	North America
Small Islands **(WGII, Chapter 9)**	Small Islands
Cross-Chapter papers **(WGII)**	To update regional information produced in the special reports and provide a synthetic view of regional impacts and risks
Regional Atlas **(WGII)**	To be scoped

Table 1: List of regional chapters in the WGI and WGII contributions to the AR6.

2.2. Goals and Objectives

The IPCC Expert Meeting (EM) on assessing climate information for regions aims to explore the needs of regional information for the risk assessment framework and the current knowledge gaps in developing regional climate information, as well as to allow input at an early stage of the AR6 assessment report development and provide a platform for the participation of AR6 WGI, II and III authors, and facilitate cross-WG coordination. The EM also seeks to foster a coordinated way for the WGs to integrate/consolidate/communicate regional climate information that spans the domains of the three WGs, informing both the specific needs related to regional (climate) information and the ways in which it could be assessed in a more integrated manner and more effectively communicated in the AR6. This meeting builds on the 2015 Brazil workshop with the aim to provide more operational guidance for the AR6.

The EM is intended to address specifically the following objectives:

- To examine the contexts, expectations, priorities, and scales of regional climate information across Working Groups, and their implications for the formulation, interpretation, and assessment of climate information;
- To evaluate the use of the AR5 regional atlas and the degree to which it has met the needs of various stakeholders (e.g. for impacts research, resource managers);
- To evaluate ways / approaches / methodologies for consistently constructing and assessing regional climate change projections, including links to regional socioeconomic contexts and scenarios, in the AR6 and special reports;
- To quantify uncertainty and scale dependencies of regional climate projections, and how to achieve a scientific balance between overconfidence and conservatism in assessing evidence in relation to use and application;
- To discuss methods for assessing and integrating understanding of changes in climate processes and phenomena driving regional climate responses with region/local scale conditions and feedbacks;
- To evaluate frameworks for developing region-specific narratives of climate variability and change in an IPCC context and the cross-WG approaches – handshake – that will improve relevance for policy and decision-making communities;
- To explore approaches for a consistent assessment of outputs from Earth System models, regional climate models, empirical statistical downscaling, and other spatial disaggregation methods;
- To evaluate approaches for communicating regional climate change scenarios and regional

climate information including options for the development of a cross-Working Group regional climate information product, for example a regional Atlas;

• To consider challenges and solutions related to the integration of data of different nature and scales (e.g., hazard, exposure and vulnerability data) and what climate hazard information (e.g., type (indicator versus PDF), format, resolution) is specifically needed by WGI (and WGII), including differential needs in developed and developing countries, to comprehensively and coherently assess risk across regions and sector;

• To identify means to facilitate the documentation and traceability of data sets and versions used jointly by WGs, and bring consistency to the archiving of data during and beyond the assessment cycle;

• To produce a 2-page bullet points summary of principle recommendations for the AR6.

2.3. Structure and Outputs

The meeting was scheduled over 3 days and consisted of two elements: plenary sessions with invited scientific keynote speeches and perspective presentations, and nine breakout group (BOG) sessions to allow for extensive exchanges of ideas among participants. The full meeting agenda is described in Annex E.1 and abstracts of presentations are provided in Annex E.2.

As participants came from very diverse scientific backgrounds, the plenary sessions were followed by a Question and Answer (Q&A) and stocktaking sessions intended to bring everyone up to speed at the closing of every day. The plenary sessions discussed following themes:

Theme 1:
Assessing climate information, from global to regional changes.

Theme 2:
Climate information for the assessment of sectoral and regional climate change impacts.

Theme 3:
Scoping of the AR6 Regional Atlas.

Parallel breakout group sessions were designed to further expand plenary discussions, but placing a specific lens on the following issues:

• Detection and attribution, its application across Working Groups and across regions.

• Definition of regions and sub-regional areas for consistent treatment by regional chapters and Atlas.

• Alternative approaches to regional information, such as climatic zones, mountain areas, the use of case studies.

• Information needs for various impact sectors.

• Information quality/uncertainty/availability in different regions and at different scales.

• Presentation format and communication issues related to regional climate.

• Atlas list of indicative bullet points.

• Atlas variables/indices/scenario info.

• Atlas methodology.

Key expectations from the expert meeting include improved understanding on:

• Ways to best quantify and integrate regional climate information and associated uncertainty.

• Ways best display regional climate information from multiple source of information (Including CMIP6 and other MIPs, CORDEX), and its reliability

To achieve its objectives, the EM sought participation of a range of experts including:

• Invited Experts from the international research community

• AR6 Experts representing the WGI authors teams on the following topics: Linking global to regional climate Change (Chapter 10), weather and climate extreme events in a changing climate (Chapter 11), climate change information for regional impacts and risk assessment (Chapter 12), and the regional Atlas;

• AR6 Experts representing the WGII authors teams on the following topics: Point of departure and key concepts (Chapter 1); ocean and coastal ecosystems and their services (Chapter 3); food, fibre, and other ecosystem products (Chapter 5); Africa (Chapter 9); Asia (Chapter 10); Australasia (Chapter 11); Central and South America (Chapter 12); Europe (Chapter 13); North America (Chapter 14); and key risks across sectors and regions (Chapter 16).

• AR6 Experts representing the WGIII authors teams on the following topics: Emissions trends and drivers (Chapter 2); Energy systems (Chapter 6); and Agriculture, Forestry, and Other Land Uses (Chapter 7).

The full participant list, including TSU and Bureau members, is shown in Annex E.3.

3. Summary of Plenary Discussions

3.1. Opening Plenary Session

The introductory presentations provided a broad perspective on the IPCC Sixth assessment cycle, its timescale, products, objectives, and dimensions central to the Expert meeting on Assessing Climate Information for Regions. IPCC Co-Chairs of WGI and WGII took this opportunity to outline the meeting objectives and provide the 'big picture' that will help guide further the discussions, including issues that underpin the appetite for the developing a joint WGI and WGII regional Atlas. It was noted that the regional perspective is also included in the WGIII assessment, including regional specificities with regard to mitigation responses and to the risk assessment concept, as well as mitigation- adaptation- sustainable development linkages.

The deliberations also highlighted the implication of the workshop on Regional climate projections and their use in impacts and risk analysis studies, held in 2015 in Brazil. This workshop addressed the interlinkages between provision of regional climate projections and risk analysis studies, and provided the following recommendations for the AR6:

• To enhance regionalization in the IPCC assessment report through rethink the approach of regional information, without adding more separate regional Chapters to WGs reports. This would be facilitated by early coordination between WG Co-Chairs and setup of joint discussion platforms with WGI and WGII authors' teams, as well as a dialogue with initiative such as the Global Programme of Research on Climate Change Vulnerability, Impacts and Adaptation (PROVIA), World Climate Research Programme (WCRP), Coordinated Model Intercomparison Project (CMIP), and Coordinated Regional Climate Downscaling Experiment (CORDEX) – with view to foster research on distilling across multi-model and multi-method ensemble data;

• To prepare a pair of AR6 WGI and WGII Atlases covering global and regional climate projections and climate impacts and risks: (i) based on coordinated, multi-model initiatives and (ii) complementary and closely coordinated across WG;

• To support cross-WG integration by dealing with topics of high regional relevance (e.g., water cycle, sea level, extremes) in a coordinated manner through, e.g., joint chapters, joint meetings of authors, dedicated contributing authors;

• To consider cross-WG IPCC Expert Meetings and Workshops as a mean to activate research communities for the regional assessment and to foster coordination across WGs.

The opening plenary deliberations also indicated that the regional focus of the AR6 has been growing from the scoping meeting to the approval outline session. There is clearly a need to assess the downscaling techniques and the large-scale drivers of regional changes, benchmark methods, and associated uncertainty. Thus, recommendations are required for AR6 Authors on the following issues: regional scale use of IPCC guidelines for detection and attribution (hereafter D&A), multi-models assessment and treatment of uncertainties.

3.2. Plenary Session 1

The first plenary session consisted of presentations and keynote talks devoted to the issue of assessing climate information, from global to regional changes – with view to understand the usefulness, shortcomings and opportunities of assessing regional climate information (see abstracts in Annex E.2). It was noted that past IPCC reports had a rich regional emphasis, but highly heterogeneous and varied across WGs – often leading to regional statements with low confidence. This is due partly to the heterogeneous nature of climate observations across regions worldwide and the limitations of historical records. Three main constraints affect the regional use of IPCC reports: (i) scale translation and disconnect between the decision making scale and availability of basic climate information, (ii) decoupling of the linear supply modelling chain from the information context, and (iii) contrasting messages emerging from multiple climate information sources. Historically, the first IPCC's response to the need for regional scale information is traced back to the 1997 special report on ´Regional Impacts of Climate Change: An Assessment of Vulnerability´ that followed the IPCC Second Assessment Report (SAR), though member States disputed the possibility for regional statements to be added to the SAR. There is a wide spectrum of IPCC stakeholders in need of regional climate assessment including local and national policymakers with a growing interest on adaptation needs and mitigation.

In order to construct ´useful´ climate information, there is a need to distinguish climate information from climate data, and to place climate information into a relevant context. Recent climate modelling advances and research initiatives (e.g. CORDEX, Future Climate for Africa) offer a wide range of opportunities to integrate across multiple regional climate information sources, enhance the recognition of context in constructing, constrain regional climate messages, and to foster co-assessment within and between IPCC WGs.

Due to difference between the WGI, WGII and WGIII perspectives on the issue of regional climate assessment, important consideration need to be given to: expectations from regional stakeholders, limits to the ´greenhouse gases-climate-impact-response´ paradigm, and opportunities entailed with the AR6. Traditionally, the ´greenhouse gases-climate-impact-response´ paradigm is used to connect observed or expected impacts to anthropogenic climate change, often leaving the impression that only well-detected and well-attributed climate impacts are ´real´. However, many more impacts are perceived by regional actors, despite lacking rigorous D&A studies, and regional changes need to understand the relative implications of climate change in the context of other drivers of regional environmental changes such as land use and air pollution. The recent scientific and methodological advances offer clear opportunities for the AR6 to leverage on high resolution climate and impact modelling, though the lack of monitoring of impact systems and the growing use of multiple sources of regional information remain important showstoppers. There is a need for improved multidisciplinary approaches, fully covering social and economic impacts. A potential solution proposed for the AR6 is to consider options for ´layered´ treatment of regional information involving climate hazard, vulnerability, exposure, and storyline.

Participants also discussed the different views across WGs on D&A and implications for the assessment. For the WGI, D&A mostly refer to the detection of change in the climate system (including trends and extremes) from statistical analyses, and the attribution of observed changes to a cause. The main challenge consists of identifying a coherent anthropogenic signal from the background noise of natural climate variability, including multi-annual variations caused by large-scale modes of variability (e.g. ENSO). A 2-step approach is thus needed: (i) detection of a change in climate beyond natural variability, and (ii) attribution of the most likely cause for that change, evaluating the contribution from natural forcing, anthropogenic forcing and internal system variability. By contrast, WGII D&A is focused on the influence of climate variability and change on natural and human systems exposed to multiple drivers of change, and in particular the attribution of observed impacts to climate change (i.e. ´impact attribution´). Post-AR5 research advances have strengthened the evidence basis for impact D&A and suggested a five steps approach: (i) hypothesis formulation: identification of a potential climate change impact; (ii) observation of a climate trend in the relevant spatial and temporal domain; (iii) identification of the baseline behaviour of the climate-sensitive systems in the absence of climate change; (iv) demonstration that the observed change is consistent with the expected response to the climate trend and inconsistent with plausible responses to non-climate drivers alone; and (v) assessment of the magnitude of the climate change contribution to overall change, relative to contributions from other drivers.

3.3. Plenary Session 2

The second plenary session consisted of seven presentations dealing with the regional climate information needs for the assessment of sectoral climate change impacts and risk. Regional climate information is important input to assessing both near term and longer term risks for different sectors. For the near term, which comprises the next 10 to 30 years, questions such as the type of regional climate information needed, the relative role of model, scenario, structural and internal uncertainty, the sectoral requirements or the communication challenges should be looked at from a specific perspective given the proximity in time and the short time available to adapt to the climate events. Anthropogenic climate change is taking place already, although the attribution of extreme events suggests that climate change should be considered in the context of an important internal, natural variability of the system and substantial regional differences. There is evidence that near-term adaptation is currently taking place in many sectors considering the complexity of climate change occurring in this background of natural variability. However, this means that the climate information needs to be regional and that it needs to take into account in a trustworthy way both internal and forced variability. At the same time, this complex view of climate variability and change leads to the question of when anthropogenic climate change can be unequivocally detected in a background of climate variability, which is also known as the ´time of emergence´ and is a well-known signal-to-noise problem with strong regional implications.

The deliberations also devoted specific considerations to the AR5 climate risk analysis and management framework, to highly differentiate impacts, and decision-making under uncertainty, as well as the near-term and long-term regional climate information and communication needs. It was indicated that emission scenarios are not particularly relevant in the near term, although some short-term forcings like volcanoes or anthropogenic aerosols, usually of a strong regional nature, will play an important role. Decadal prediction is one of the tools recently developed to address the formulation of near-term regional climate information. It bridges the well-established climate change projections, until recently the only source of near-term climate information, and the advantages that short-term climate prediction, which aims to constrain the internal variability. Recent efforts to develop decadal prediction systems show that there is added value for temperature and other variables of relevance to impact studies when considering information ten years into the future. In addition, Shared Socio-economic Pathways (SSPs) have been developed to depict alternative pathways of societal change in the coming decades, leading to different levels of vulnerability to climate hazards. These societal futures are being combined with projections of climate outcomes according to the Representative Concentration Pathways (RCPs). The SSP-RCP framework is already being widely used to evaluate risks across several sectors, and plays a key role for analysis of longer term risk. Overall, it was recommended to stimulate the demand for regional climate information through research advances and needs, legislation (e.g. UK climate change act in 2008[1]) and improved understanding of climate services and disaster risk reduction.

Discussions further expanded on the issue of tailoring regional climate information (including quality, value and availability) for assessing impact and risks of different sectors. Tailoring regional climate information is the process of extracting the most robust information available from climate sciences and making it specific enough for regional impact assessments and other applications such as climate risk assessments or informing climate policy. Providing specificity implies knowing who will use the information and for what. In an IPCC context the ´users´ internally will be chapter authors across the working groups and externally will be governments involved in forming climate policy both internationally and nationally and increasingly the wide range of actors dealing with climate risks through and beyond adaptation, mitigation and building resilience. The use of indicators is an important part of assessing climate risks. When choosing them consideration needs to be given to their social relevance, involving issues of scale, aggregation and accuracy, and technical aspects of data quality and availability to ensure they can be measured, monitored and validated. Also, qualitative information is often important but difficult to include. Issues that Chapter 12 and the Atlas thus need to consider are how much to focus on hazard versus risk indicators (i.e. which would imply including vulnerability and exposure aspects), should dynamic as well as just static information be included and how should uncertainties be treated and visualised.

1 https://www.theccc.org.uk/tackling-climate-change/the-legal-landscape/the-climate-change-act/

Participants also discussed the regional climate information needs for impact modelling highlighting lessons learnt from the ISIMIP (The Inter - Sectoral Impact Model Intercomparison Project) and the hydrology, AgMIP (The Agriculture and Model Intercomparison and Improvement Project), ecological studies, and risk assessment in hydrology and water resources. For instance, ISIMIP offers a framework for consistently projecting the impacts of climate change across affected sectors and spatial scales. The framework covers multiple sectors, and enable assessment of compound impacts of climate change and climate impacts hot-spots. AgMIP regroups an international community involving climate scientists, agronomists, economists and IT experts. AgMIP's activities operates at multi-scale (global, regional, local) and focus on multiple interaction processes (biophysical and economics).

3.4. Plenary Session 3

The third plenary session consisted of five presentations focusing on the Scoping of the AR6 Regional Atlas. Discussions spanned a wide number of critical dimensions to be accounted for in developing regional climate Atlases and presented some perspectives from ongoing experiences including the CORDEX based Atlas for Africa and the NARCCAP (North American Regional Climate Change Assessment Programme) based for North America, and the IPCC AR5 WGI Atlas. The deliberations indicate that regional climate scale and sector-relevant information, with indication of the timing of change as a result of increasing greenhouse gas concentrations, is crucial to inform adaptation and mitigation strategies. However, often policy decisions are made using global average information without an indication of the timing of change and which does not reflect the regional context nor speak to climate sensitive sectors and systems. The CORDEX based Atlas for Africa seeks to address, through a co-explorative approach, the timing of climate-sensitive threshold exceedances for range of sectors under global temperature targets of 1.5, 2, 3 and 4 degrees warming above pre-industrial levels.

The IPCC AR6 regional Atlas was suggested to be a key resource of information for the regional risk assessment framework. There are challenges and research opportunities tied up to the development of the AR6 regional Atlas including the distillation and consistency of regional climate information from multiple methods, which can lead to conflicting results and messages.

General conclusions/recommendations

- Need to use a common language and coordination mechanisms across WG chapter teams to deal with the issues of regional climate information and risks;

- Since past regional assessments for adaptation have focused on the need of modelling tools to provide confidence in key quantitative variables; resulting in impossibility to implement the adaptation options – there is a need to first improve the modelling capability to provide credible regional climate information;

- To consider options for the cross-WG regional Atlas to be an online and/or interactive compendium of regional climate change observations and projections on multiple timescales, including extremes and end-to-end treatment of uncertainty;

- The AR6 regional assessment is likely to benefit from recent advances in climate and impacts modelling at higher resolution;

- To consider options for the cross-WG regional Atlas to be an online and/or interactive compendium of regional climate change observations and projections on multiple timescales, including extremes and end-to-end treatment of uncertainty;

- WGI needs to generate and compile maps for the regional Atlas with WGII relevant regional climate information and consistent with WGI regional Chapters of the AR6;

- To consider layered regional information combining vulnerability and exposure, and geophysical features, top-down bottom-up impacts, compound impacts;

- To develop rapidly a process that will provide update on the IPCC guidance on D&A in order to influence development of AR6 – which could be expanded further over time;

- To establish a Volunteer drafting team – which should be ready by LAM2 of WGII, to be held on 8–12 July 2019.

3.5. Synthesis Plenary

The synthesis plenary on day 3 afternoon provided an opportunity to recap the breakout groups' deliberations and to develop high-level recommendations. This session agreed on the following bullet points for the scoping of the AR6 regional climate Atlas for WGI:

- Framing: purpose, scope, limitations, and introduction; beyond AR5, from past to future and an interactive product.

- Regions, time slices; data selection, observations; scenarios, levels of warming; attribution, models, and other tools.

- Treatment of biases, inhomogeneity and data gaps; combining information from multiple sources e.g. CMIPs, CORDEX and observations; communication of confidence and uncertainty;

- Key variables, indices and metrics linked to WGI chapters.

- WGII-relevant variables/sector-specific indices/hazard information;

- Spatially resolvable phenomena (e.g. monsoons, storm tracks);

- Presentation and communication approaches: Guidance, Maps, figures, tables, animations, narrative, uncertainty;

- Traceability to WGI chapters, processing and curated datasets; IPCC stamp;

- Regional summaries and case studies;

- Detection and attribution.

4. Breakout Group Discussions

The parallel breakout groups (BOGs) sessions provided an opportunity for participants to discuss in small groups some of the key dimensions related to assessing climate information for regions. Each BOG was supported by members of the Scientific Steering Committee and led by a team consisting of two facilitators and a rapporteur selected from within the participants, and who reported back the discussion and conclusions to the plenary in form of a summary.

4.1. Breakout group 1.1: Detection and Attribution, its Application across Working Groups and across Regions

The BOG discussed best ways to apply the current IPCC guidance on detection and attribution (D&A) methodology across WGs in the framework of the AR6 regional assessment. The different perspectives provided by WGI and WGII on D&A raise a number of issues and challenges. On one hand, the definition of "attribution" varies substantially across WGs and may involve storyline or probabilistic analysis (attribution of impact, or attribution of change in climate), differentiation between forced response and natural variability, and strive for the use of multi-method approaches (affecting confidence statements). On the other hand, the definition of "detection" involves either the determination of observed change relative to natural climate variability (WG-I) or consider changes relative to other sources of variability (WG-II). Thus, there is a need to clarify what drivers are considered (baselines) in D&A.

The current IPCC guidance document only covers 'conventional' D&A methodology and is mostly appropriate for early chapters of the WG1 contribution to AR6. However, it does not cope with regional issues and event attribution as treated by WGI, or the impact attribution as dealt with by WGII. Of course, different approaches of D&A are inevitable across WGs, but the use of different definitions, terminologies, and assessment formalisms may have implications for the clarity, credibility, readability and consistency of reports.

Recommendations and Requirements Emerging from the Discussion:

- Need for consistent use of the IPCC 'risk' framework – to ensure everyone is clear on what it meant by how to apply such a framing. Note that WG-II already has definitions that should be propagated to or adjusted for WGI if necessary;
- The AR6 Glossary provides a tool to define terms consistently across WGs;
- To explore the extent to which event attribution methodologies/language could be applied to impacts;
- Since attribution is always 'conditional' and conditions need to be clearly stated;
- To develop rapidly a process that will provide some update on the IPCC guidance on D&A in order to influence development of AR6 – which could be expanded further over time;
- To establish a Volunteer drafting team.

4.2. Breakout Group 1.2: Defining Regional and Sub-Regional Areas for Consistent Treatment by Regional Chapters and Atlas (Models, Methods and Confidence)

The definition of regional and sub-regional scales of interest for the decision makers is of central relevance to assessing climate information for regions. This is also a serious challenge that can be only addressed through close collaboration across WGs, particularly in the AR6 context. The current BOG discussion bore both constructive and inclusive spirits and involved the contribution of most participants, which explore the trade-off and balance between scales at which information is useful and the various climatic regional definitions needs.

Recommendations and Requirements Emerging from the Discussion:

- While AR5 and SR1.5 reports provide a starting point for the climatic regions definition, the AR6 requires for the definition to be revisited in the context of WGII risk and sectoral assessments, considering cross-regional information on hazards like compound events;
- To distinguish IPCC assessments from national climate communications;
- To consider the consistency of region specific methodologies across the WGI regional Chapters of the AR6 (chapter 10,11,12), though this may be a challenging issue for the Atlas and for available information;
- WGI and WGII authors to work together in precisely defining region boundaries;
- WGII regional, sectoral and cross-chapter papers can serve as a tool to both feed in WGI report with climate zones information, or to pull information from WGI and WGIII;
- To consider political sensitivity of risk mapping;
- To identify issues across the WGs that will need a coordinated mechanism to ensure implementation and oversight.

4.3. Breakout Group 1.3: Alternative Approaches to Regional Information, such as Climatic Zones, Mountain Areas, the Use of Case Studies

There are important issues around the assessment of regional climate information that need to be addressed, particularly the development of guidance documents to define the regions and the approaches to pull together information from multiple sources and methods and obtain an improved perspective (e.g. similarities in adaptation measures across climatic zones). In the academic literature there are a wide range of methods and tools to generate climate information for regions. But, their robustness varies from geographical location according to the availability of information (e.g. observations and modelling for mountain

regions), methodological requirements for regions, and policy-relevance. This can potentially result in contradictory conclusions. Participants discussed in length the different intersections between WGs regional information needs. For instance WGII may seek the following parameters from WGI: Sub-regional hazard scenarios (e.g. metropolitan regions, mountains, and biodiversity), extremes events and time of emergence.

Participants discussed various alternative approaches to regional information and suggested to combine to combine different types of figures and aggregations with assessment narratives and storylines (based on the risk exposure), case studies where incomplete coverage, and impact-relevant and risk relevant thresholds. Such approaches may suit number of climate phenomena and geographical areas including monsoons, regional circulations, mountains, megacities, wetlands, coastal zones, semi-arid and arid regions, Mediterranean region, and land use categories. The discussions also briefly touched upon the scoping of the regional Atlas and highlighted some growing appetite for the development of a multi-layered online or dynamical Atlas, which is capable to cope with different timescales of interest and account for the natural variability in systems.

Recommendations and Requirements Emerging from the Discussion:

- Combine different types of figures and aggregations approaches with assessment narratives and storylines (based on the risk exposure);
- Make use of case studies where there is incomplete data coverage;
- Define impact-relevant and risk relevant thresholds. Such approaches may suit number of climate phenomena and geographical areas including monsoons, regional circulations, mountains, megacities, wetlands, coastal zones, semi-arid and arid regions, Mediterranean region, and land use categories;
- Consider the development of a multi-layered online or dynamical Atlas, which is capable to cope with different timescales of interest and account for the natural variability in systems.

4.4. Breakout Group 2.1: Information Needs for Various Impact Sectors

The overarching topic addressed by this BOG was the identification of regional climate information needs for impacts sectors, way to portray such information within the AR6 regional Atlas, and cross-WG mechanism for collaboration to ensure consistency of reports. From the WGI standpoint this is the first opportunity to interact with WGII participants on the assessment of changing hazards at regional scales and the risk assessment framework – two issues that will be discussed within the WGII sectoral and regional chapters of the AR6.

Recommendations and Requirements Emerging from the Discussion:

- To set up calls between WGI and WGII lead authors of regional and sectorial Chapters to scope the list of appropriate variables for the regional assessment;
- WGI authors to assess methodological by issues using the complete or incomplete list of appropriate variables, including the models and regions dependence;
- The IPCC special reports SREX (Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation) and SR1.5 (global warming of 1.5°C) are good illustrations of WGI and WGII successful collaboration, which can serve as the starting point for identification of regional information needs for various impact sectors, impact metrics and variables of interest.
- To consider portraying the WGI Atlas maps with climate change information, SSP (socioeconomic pathways) information, and other relevant information all together – depending on how much information and detail is needed and relevant for the hazard input to risk assessment (e.g. changing population density, urbanization). In addition, maps could encompass outliers and ranges, rather than just mean or medians. This will facilitate the communication of outliers with the associated uncertainty (growing interests in storylines);
- To provide better guidance on ways to ensure policy-relevance of the regional assessment. For instance, assessment using the RCP1.9 scenario should be emphasized in AR6 since it was not available for the SR1.5;
- To consider ways to produce a guidance document on how to deal with multiple sources of data that can be used in the regional Atlas, factoring in issues such as bias corrections and distillation.

4.5. Breakout Group 2.2: Information Quality/Uncertainty/Availability in Different Regions and at Different Scales

The quality and uncertainty of climate information are complex concepts used differently in the real and modelling world. Regional scales climate information can be obtained from global and regional multi-modelling ensemble (MME) techniques – which are used to explore the uncertainty in climate model simulation that arise from internal variability, boundary conditions, and parameter value for a given model structure i.e. the "structural uncertainty". The MME is often generated from existing climate simulations from several climate modelling centres. However, due to limited sample size and the role of structural uncertainty, it important to consider the following dimensions in assessing the quality of regional scales information produced by MME: model skill, model weighting, and communications of the confidence of results (models capability, areas with no change, and areas with lack of change).

The BOG deliberation also touched upon the issue of combining multiple sources of information (e.g. GCMs, RCMs, observations, theory, and expert judgement) pointing the need for AR6 to clarity the added value of climate downscaling techniques used to derive small scales climate information from GCMs, and observational uncertainties (missing information and different sources). It was also discussed the benefit of using the well-established IPCC guidance note on uncertainty and calibrated IPCC language to assess regional scales climate information. The uncertainty of regional climate information can originate from various sources including the availability, accessibility and quality of observations, climate model fidelity (trends and key features affecting response), and uncertainty across modelling streams (GCMs, RCMs, empirical and high res).

Specific Recommendations

- WGI to identify the uncertainty in key regional climate assessment metrics and make this information available for WGII;
- To engage in continuous cross-WGs dialogue to develop a useful regional Atlas which goes beyond a simple compilation of maps;
- To consider the involvement of WGII in assessing the quality/uncertainty/availability of some key variables;
- Transparent expert judgement is needed to convey credible regional assessment messages;
- Key regional climate assessment variable to include oceanic, coastal and cryosphere information

4.6. Breakout Group 2.3: Presentation Format and Communication Issues Related to Regional Climate Information

The overarching topic addressed by this BOG was the identification of approaches and mechanisms for improved communication of regional climate information. But, the discussion also touched upon topics key to the scoping of the regional Atlas, and the potential linkages with the IPCC TG Data (perhaps providing a continuity across the assessment cycle).

Recommendations and Requirements Emerging from the Discussion:

- To consider development of an early guidance documents by WGII and WGII authors on the regional and sectoral risks and appropriate hazard metrics;
- To identify WGII regional key contacts to liaise with WGI regional chapter teams – with possibility for this contact list to be extended to WGII authors;
- To develop Terms of Reference (TOR) to foster cross-WGs communication. A possible solution is for the relevant WGI Chapters authors to provide the Zero-order-draft (ZOD) to WGII authors, in order to facilitate early feedbacks on how chapters are evolving. Alternatively, key lead authors can be invited to attend lead author meetings of other Working Groups;
- The IPCC Bureau needs to clarify the acceptability of interactive graphics and web-based Atlas;
- To connect WGI chapter on Climate change information for regional impact and risk assessment, contributing to regions specific assessment of the present and future climate risks (Chapter 2) with WGII chapter on Decision-making options for managing risk (Chapter 17), and will include information relevant for climate services.

Specific Recommendations

- To consider expanding the regional Atlas with case studies that could illustrate climate risk narratives (co-production taking into account different methodologies between WGs);
- To provide background information on how maps/figures/illustrations in atlas were developed to be provided in chapters;
- To trace back the Atlas output to methodologies and assessment discussed in the chapters;
- To identify hotspots (showing geographical and sectoral differences) by WGI and WGII; Atlas cannot be exhaustive;
- To consider and evolutionary that can inform WGI assessment, WGII assessment (risks/impacts and adaptation), and the synthesis report (providing an overall picture and outward looking product for end user);
- To consider different stages of development which require different inputs and support (current Atlas resources may need to be reviewed).

4.7. Breakout Group 3.1: Atlas list of indicative bullet points

The overarching topic addressed by this BOG was the scoping of the regional Atlas and indicative bullets. The discussion gravitated on the issues of framing, purpose, scope, limitations, and introduction, including explanation of scenarios. Participants emphasized on number methodological constraints including the choice of regions, time slices, data selection, scenarios, observations, modelling tools (GCMs, RCMs) and other tools for regional climate downscaling, the global warming levels (e.g.. 1.5°C, 2°C), and treatment of observational inhomogeneity and variable data coverage. A particular attention was devoted to the philosophy for combining information from multiple sources (linking to WGI Chapter 10) and for communication of confidence and uncertainty. An initial list of key WGI-type variables and metrics was discussed (e.g. temperature, precipitation, wind, snow cover, soil moisture, evaporation, ocean variables – sea surface temperature (SST), mixed layer depth etc.), median, mean and extremes). WGII-relevant variables will span natural and human systems (linked to WGI Chapter 12) including cloud cover and sunshine duration, relative humidity, insolation, sea ice cover, sea level rise (extremes, inundation), climate velocity, evapotranspiration, tropical cyclone-related, frost, hail. The regional Atlas should also target spatially resolvable phenomena (e.g. monsoons, storm tracks, coastal upwelling) and involve flexible sector-specific indices and extreme event indices (linked to WGI Chapter 11) – such as persistence and duration (e.g. heat stress, drought indices).

Overall the BOG discussion raised number of cross-WG coordination challenges to be addressed in developing the regional Atlas. These include the link between WGI and WGII information needs and co-authorship (with view to encourage contributing authors from WGII), best ways to coordinate with WGI chapters on the issue of detection and attribution and model evaluation, need for close coordination with Chapter 12 in linking with WGII, and the lack of consensus on including the scenario data (population, land use). Participants indicated some appetite for producing a regional Atlas with dynamic display options including for instance, the capability for overlays (e.g. for hot spots), aggregations, animations, dynamic selection, multiple panel plots (for GCMs, RCMs, empirical models and consistency), and coastal display options (e.g. 'thin blue line' type). The portraying format of the regional Atlas can be based on a survey of existing presentation styles.

Specific Recommendations

- Need to go beyond the AR5 regional Atlas experience and develop guidance to combine multiple sources of data, ensure data traceability, and facilitate the "handshake" between WGI and WGII.

Proposed scoping of the Atlas – indicative bullet points

- Framing: purpose, scope, limitations, and introduction; beyond AR5, from past to future and an interactive product;
- Regions, time slices; data selection, observations; scenarios, levels of warming; attribution, models, and other tools;
- Treatment of biases, inhomogeneity and data gaps: combining information from multiple sources e.g. CMIPs, CORDEX and observations; communication of confidence and uncertainty;
- Key variables, indices and metrics linked to WGI chapters;
- WGII-relevant variables/sector-specific indices/hazard information;
- Spatially resolvable phenomena (e.g. monsoons, storm tracks);
- Presentation and communication approaches: Guidance, Maps, figures, tables, animations, narrative, uncertainty;
- Traceability to WGI chapters, processing and curated datasets; IPCC stamp;
- Regional summaries and case studies;
- Detection and attribution;

4.8. Breakout Group 3.2: Atlas Variables/Indices/Scenario Info

The overarching topic addressed by this BOG was the brainstorming of key variables, indices, and scenario information to be included in the regional Atlas. Participants stressed that the Atlas content must have an assessment basis traced back in one of the report chapters. Chapter assessment will strongly constrain extent and type of climate information portrayed in the regional Atlas. There is a need for bias correction to be applied in view to sensibly define some indices that involve a threshold – we could focus on indices that do not depend on absolute values (need consistent reference periods). Data traceability is a key pre-requisite since source of model data used to create different regional indices will inevitably differ from regions and sectors. There is also a need to address uncertainty entailed to the methodology use for computing various indices involve (e.g. mixed-layer depth). From the policy-relevance perspective, it is envisaged to the regional Atlas outputs variables at different global temperature levels rather than for different emission scenarios. Scenario information options may include spatial patterns of emissions and land-use, population, GDP, urban land cover – maybe country level rather than gridded (or at least current distributions). However, the issue of timely availability of CMIP6 data is a key constraint to be factored in the selection of scenarios – we may prefer to focus (at least initially) on CMIP5 and CORDEX data.

Recommendations and Requirements Emerging from the Discussion:

- Input from WGII (needs to be pursued and coordinated), particularly to identify indices/thresholds that should/could be displayed in Atlas;
- Potential key indices for WGI Atlas may include sea-level rise, seasonality, extreme indices, growing season length, heat stress, E-P, SPEI and other drought indices, surface wind, salinity, pH, mixed-layer depth, oxygen, solar and cloud, soil moisture, humidity, runoff, frost, tropical cyclones, hail, 'fire', ice, snow, large-scale circulation indices and modes of variability;
- Potential for WGII Atlas (i.e. not WGI-related) may include crop yield and heat stress;
- To consider conveying confidence information in the figure itself, noting that some variables/indices are more relevant to some regions than other and some compound indices have significant uncertainties;
- To consider including detection and attribution information in the regional Atlas. For instance, one could look at 'changes' in indices even when absolute values are uncertain.

4.9. Breakout Group 3.3: Atlas Methodology

The overarching topic addressed by this BOG was the underlying methodology the regional Atlas to be grounded on. Participants converged on the need for all material presented on the Atlas to be traceable on the WGI assessment following an open data policy framework. The Atlas content should be informed by the needs of the other WGs, particularly WGII, and represents information across timescales (past, present and future). The discussion also stressed that regions of focus should be defined based on the AR5 WGI climatic zones and revisited through cross chapter interaction and in the context of WGII regions and sub-regions. A key attribute of this regional Atlas should be the capability to combine multiple sources of climate information (e.g. CORDEX, CMIPs, Observations, attribution, reanalysis). But, the regional assessment will be carried on in relevant chapters and not in the Atlas. With regard to the communication approaches of the Atlas outputs, it was suggested to facilitate downstream development of services or analyses, and include both examples of misuse of the information and an electronic version of the Atlas. More importantly, the Atlas should be consistent with the scenario and baselines used in the WGI chapters.

Specific Recommendations

- To consider assessing the underlying methodologies of the regional Atlas in WGI chapter 10;
- To consider assessing the CMIP5 vs CMIP6 in relevant WGI chapters, and expending the visualisation of the results in the Atlas;
- To develop a guidance document that explains the production and support the interpretation of the Atlas product (including narratives, recipe to reproduce the figures (link to the scripts)), and include caveats raised in previous chapters;
- The Atlas team will develop their vision of the WGI Regional Atlas during LAM1;
- To facilitate the exchange of information with WGII and the representation of regional information in the Synthesis Report;
- Need to go beyond the AR5 regional Atlas experience and develop guidance to combine multiple sources of data, ensure data traceability, and facilitate the "handshake" between WGI and WGII.

Annex 1: Proposal agreed at IPCC 57th Executive Committee 14 December 2017

Background

This meeting builds on the outcomes of the IPCC Workshop on Regional Climate Projections and their Use in Impacts and Risk Analysis Studies held in Brazil in 2015, and extend this to enable guidance for AR6 by focusing specifically on the approaches to constructing regionally relevant climate information, quantifying of quality and added value from integrated regional information, and translation to information products for the vulnerability, impacts and adaptation, policy, and government communities.

As discussed at the WGIII Expert Meeting on Scenarios in Addis Ababa in April, substantial literature is accumulating on potential future societal vulnerability at the regional level based on the Shared Socioeconomic Pathway (SSP) scenario framework. Since risk is a function of both climate-related hazards and the exposure and vulnerability of society and ecosystems, the growing experience with the SSPs provides an opportunity to integrate regional climate information with future changes in population, urbanization, economic growth, changes in land use and energy systems, and changes in other aspects of society to determine future risks.

The Future Earth-PROVIA-IPCC workshop on integrated research on climate risk and sustainable solutions across IPCC working groups: Lessons learnt from AR5 to support AR6 was held in Sweden in 2016 included a dedicated task group on sharing information on risks and solution strategies across local to global scales.

The IPCC Sixth Assessment cycle is aligned with the integration of a risk framework with solution-oriented information, in support the United Nations Framework Convention on Climate Change Convention (UNFCCC), as well as the global sustainable development agenda and priorities. The demand for policy-relevant information for regions requires the appropriate and consistent treatment of regional scale aspects. Strengthening the provision of scientific information and projections is needed to inform actions at the national, regional and local levels, and to support government strategies in areas as broad as disaster risk management, economic and sustainable development policies, adaptation planning, mitigation policies, impacts of response measures and increasing resilience. Enhancing regional aspects in the IPCC assessment will facilitate responses to the request, under paragraph 45 of Decision CP.21 of the COP21 Paris meeting, for Parties to strengthen regional cooperation on adaptation.

Proposal for Expert Meeting

Widespread interest in understanding past, present, and future climate change and variability and the impact, response and feedbacks of natural and managed ecosystems and many different socio-economic sectors, e.g. associated with energy, urban related activities, infrastructure, has motivated the development of a large spectrum of techniques and coordinated research efforts aimed at generating credible regional climate change scenarios for impact and vulnerability assessments. Regional climate change information provides the necessary foundations for a comprehensive assessment of projected climate change impacts and associated risks. Climate information based on robust climate science is essential to make better-informed decisions in the context of a changing climate.

An assessment of regional climate information needs to build on multiple sources of information, including an assessment of downscaling techniques, but also large scale drivers of regional responses, including global modes of variability, teleconnections, and critical process responses such as atmospheric blocking. The CMIP6 (Phase 6 of the Coupled Model Intercomparison Project) scenarios include the state-of-science earth system models and global climate models (GCM) with further increased spatial resolution and capable to provide useful information at regional scale detail to stakeholders. CMIP6 endorsed projects (e.g. HighResMIP, GMMIP and LUMIP) are expanding efforts and improving the provision of climate information at decision making scales. The Coordinated Regional climate and Downscaling Experiment (CORDEX) is another area rapid progress, with regional climate models (RCM) and empirical statistical downscaling (ESD) techniques configured to generate very high-resolution climate change data for many regions.

However, the scales at which climate model products have skill are often not reconciled with the space and time scales of decision-making processes. There are often contrasts between the regionally relevant messages emanating from the different approaches, and limited progress in understanding the translation of these and other climate data products for the integration of climate information with the other non-climate factors, or dimensions, involved in the risk framework in the context of decision making. In addition, the use of spatially detailed climate products in IPCC assessment has long been undermined by a weakness of both scientific understanding of the regional climate drivers under climate change, as well as incomplete observational bases in order to compare, integrate and reconcile contrasts and/or contradictions between methods for generating regional information, or even to assess the added-value and uncertainties around the products of each of these approaches.

This proposal builds directly on the outcomes of the AR6 scoping meeting in Addis, both the WG BOGs and the cross-WG BOGs on risk and regional aspects. The AR6 scoping highlighted the policy relevance of the integration and evaluation of climate information of different nature for decision-making scales. The last three chapters of the IPCC WGI report are designed to provide sound guidance on how climate information at national and subnational scales can be developed. Robust and consistent approaches to assessing the quality and applicability of regional climate information for near-term predictions and long-term projections, including how the quality and reliability of regional

climate information are quantified, integrated, and communicated. The main objective of the final chapter of the WGI report on climate change information for regional impact and risk assessment is to provide a comprehensive, region-specific assessment of the meteorological and climatological impacts of anthropogenic climate change. The products provided in this chapter will contribute to the hazard component of a quantitative assessment of present and future climate risks, resulting in a key 'handshake' point between WG I and II. This chapter and the information provided can therefore be framed in a risk context.

It is important to evolve from the traditional one-direction model of WGI providing "information" to WGII and WGIII, to the multi-direction model on how to reduce climate change risk at regional scales. In this context, the three WGs each contribute from their perspective and the urgent issue is how to integrate information/knowledge across all three WGs. Note that dialogue between working group communities is essential if common understanding is to be found on what relevant "regional information" means.

An Expert Meeting (EM) on constructing climate information for regions is proposed to explore the needs of regional information for the risk assessment framework and the current knowledge gaps in developing regional climate information.

The EM is proposed for the first trimester of 2018 to permit input at an early stage of the AR6 assessment report development and provide a platform for the participation of AR6 WGI, II and III authors and the development of tangible outcomes that will serve the AR6 assessment and facilitate cross-WG coordination.

Objectives of the expert meeting
Objectives of the expert meeting include:

- Examine the different contexts, expectations, priorities, and scales of climate information across Working Groups, and how this feeds into the formulation, interpretation, and assessment of information;

- Evaluate ways / approaches / methodologies for consistently constructing and assessing regional climate change projections, including links to regional socioeconomic contexts and scenarios, in the AR6 and special reports;

- Consider ways for quantifying uncertainty and scale dependencies of regional climate projections, and how to achieve a scientific balance between overconfidence and conservatism in assessing evidence in relation to use and application;

- Discuss methods for assessing and integrating an understanding of changes in climate processes and phenomena driving regional climate responses, alongside the location-specific projected changes of climate variables from models;

- Evaluate frameworks for how to develop region-specific narratives climate variability and change in an IPCC context and cross-Working Group handshake activity for policy and decision making communities;

- Explore approaches for the consistent assessment of outputs from regional climate models, global coupled models, empirical statistical downscaling, and other spatial disaggregation methods;

- Evaluate approaches to communicating regional climate change scenarios and regional climate information including options for the development of a cross-Working Group regional climate information product, for example a regional Atlas;

- Discuss ways and methods to integrate information from all three WGs to produce a unified concept of risk for policy makers.

The meeting is expected to provide the basis, or foundations, for developing IPCC guidelines for authors and the research communities, expanding on the existing guidance document for assessing and Combining Multi Model Climate Projections (2010). It would lead to improved understanding, communication and consistency in the 6th Assessment Report of topics that are cross cutting across Working Groups.

Organising group (6-8 members)
The meeting will be organized by a scientific steering committee (SSC) of 6-8 members with representation across the Working Groups, supported by the Working Group I TSU. This committee will develop a more detailed meeting plan and agenda. Although a list of potential invitees will be developed in advance, finalization will await the outcome of Lead Author selection in early February, 2018, so that a representative group of Lead Authors can participate, thereby insuring direct translation of meeting outcomes to improved assessment and communication in the IPCC's AR6 reports.

Location
To be confirmed.

Date
To be held in the window between March 2018 and August 2018

Duration
3 days

Participants
This expert meeting would require participation of experts with the following background in order to achieve the objectives mentioned above:

- Representatives of WGI, WGII and WGIII from both developed and developing countries for the integration of cross-working group perspectives, communication and consistency;

- Global and regional climate modelling experts (e.g. CORDEX, IMPALA, CMIP6);

- Climate information/services research communities involved in the evaluation of regional climate information and risk assessment;

- Experts on the development and output of climate change scenarios;

- Experts on risk assessments of different socio-economic sectors (from some of the sectors that WGII report will assess);

- Policy makers and climate services developers and practitioners;

Meeting format
The proposal is for a 3-day expert meeting. Each day would involve a morning hour-long plenary session at which there would be invited presentations on topics related to surveying the different methods of developing regional climate change information, assessing their added value, describing the way in which regional information are applied in vulnerability, impact and adaptation studies and socio-economic-mitigation studies, and quantifying and communicating the confidence associated with providing projections of future climate at regional and national scales. The rest of the morning sessions will involve break out groups that frame, formulate and scope the critical questions. Breakouts will take place in the afternoon dedicated to tackling those questions. Each breakout group would be solicited to provide concrete recommendations for the AR6 on how to best present and assess regional climate information. An end-of-day wrap up plenary would identify key issues and knowledge gaps.

A meeting report summarizing the results will be produced towards the development of an IPCC Good Practice Guidance Paper for AR6 authors.

Annex 2: Programme

INTERGOVERNMENTAL PANEL ON climate change

Working Group I (WG I) – The Physical Science Basis

IPCC Expert Meeting on Assessing Climate Information for the Regions
ICTP, Trieste, Italy, 16-18 May 2018

Draft Programme (07 May 2018)

Tuesday, 15 May 2018	
10:00-17:00	WGI Bureau meeting
18:00	SSC Meeting / Dinner (tbc)
Wednesday, 16 May 2018	
08:00-09:00	**Meeting Registration (Conference Centre lobby)**
09:00-10:00	**Opening Plenary Session (Plenary room)**
09:00-09:10	Welcome, regional assessment in AR6 and introduction to the meeting WGI-WGII Co-Chairs
09:10-09:20	Welcome and introduction to ICTP and the Earth System Phyics Group *F. Giorgi (Italy)*
09:20-09:40	An overview, based on AR5, the AR6 scoping, the ongoing Special Reports - 'big picture' introduction that will help guide the ensuing scoping discussion, including issues that underpin the desire for a joint WG-I/WG-II Atlas, a reminder of how the two WG reports will be structured, and the desire to have a clear, traceable connection between the two reports. *WGI-WGII Co-Chairs / SSC*
09:40-09:55	Recommendations of Brazil Regional Expert Meeting: a high-level overview of the outcomes and guidance from the meeting *Kasper Plattner (Switzerland)*
09:55-10:00	photo
10:00-10:30	**Morning Break**

Day 1: From global to regional changes

10:30-12:30 **Plenary Session 1 (Plenary room)**

Chair: TBC, Rapporteur TBC

Key note presentations that discuss in general about evaluation of models and methods providing regional information, confidence of information at regional scale, uncertainty treatment, approaches to information synthesis, feeding into the risk assessment framework. Consideration of different WGs assessments, the use of regional information, and understanding the differences across WGs to establish a demand-driven element to the conversation

10:30-10:45 A synthesis past assessments of regional information characteristics to enhance usefulness: shortcomings and opportunities in assessing regional information
Bruce Hewitson (South Africa) and Gemma Narisma (Philippines)

10:45-11:00 WGI assessment of regional information and lessons learned
Jens Christensen (Denmark) and Sonia Seneviratne (Switzerland)

11:00-11:15 WGII assessment of regional information and lessons learned
Wolfgang Cramer (France)

11:15-11:30 WGIII assessment of regional information experience, linkages between CC responses strategies (A+M) and sustainable development at regional scale.
Ashina Shuichi (Japan) and Ramón Pichs Madruga (Cuba)

11:30-11:45 Detection and attribution and bridging the assessment across WGI and WGII
Robert Vautard (France) and Gerrit Hansen (Germany)

11:45-12:30 Discusssion, including organisation of afternoon BOGs
SSC

12:30-14:00 **Lunch**

14:00-17:00 **Break Out Group Session 1**

14:00-15:30 BOG1.1 - Detection and attribution, its application across Working Groups and across regions
Facilitator: SSC, Rappoteur TBC

14:00-15:30 BOG1.2 - Defining regional and sub-regional areas for consistent treatment by regional chapters and Atlas (models, methods and confidence)
Facilitator: SSC, Rappoteur TBC

14:00-15:30 "BOG1.3 - Alternative approaches to regional information, such as climatic zones, mountain areas, etc.
Including discussion about the pros and cons of strictly geographical boundaries versus more 'thematic' boundaries and whether this would be useful as a way of communicating regional climate information. Opportunity for exploring case studies at local level, including community perspectives, indigenous and local knowledge and practices."
Facilitator: SSC, Rappoteur TBC

15:30-16:00 **Afternoon Break**

16:00-17:30 **Break Out Group Session 1 continued**

16:00-17:30 BOG1.1
Facilitator: SSC, Rappoteur TBC

16:00-17:30 BOG1.2
Facilitator: SSC, Rappoteur TBC

16:00-17:30 BOG1.3
Facilitator: SSC, Rappoteur TBC

17:30-18:00 **Stocktaking Session 1 (Plenary room)**
Chair, Rapporteur TBC

17:30-18:30 Presentations of BOG outcomes (presentations + discussion)

18:30 **Adjourn**

18:30-19:00 SSC Meeting

19:30-22:30 Welcome Reception
Caffè degli Specchi, Piazza Unità, Trieste

Thursday, 17 May 2018

Day 2: Sectoral and Regional Climate Change Risks

09:00-10:30 **Plenary Session 2 (Plenary room)**

Chair: TBC, Rapporteur TBC

From the WGI point of view this is the day in which presentations/discussions related with CH12 should be made regarding the assessment of changing hazards at regional scales. What climate information is needed to assess impacts and risks associated with climate change in the context of WGII. Presentations from WGI, II, III participants towards a unified concept of risk, defined in general, including both risks associated to climate change and to climate change response (adaptation and mitigation strategies).

09:00-09:15 Regional climate information needs for assessing impacts and risk
Suraje Dessai (UK) and Marten van Aalst (The Netherlands)

09:15-09:30 Regional climate information needs related to climate prediction/projections for impact/risk assessment of different sectors (inc. SSPs)
Paco Doblas Reyes (Spain) and Brian O'Neill (USA)

09:30-09:45 Tailoring regional climate information (including quality, value and availability) for assessing impact and risks of different sectors
Richard Jones (UK) and Jana Sillman (Norway)

09:45-10:00 Regional climate information needs for impact modelling (e.g. lessons learned from ISIMIP (The Inter-Sectoral Impact Model Intercomparison Project) and AgMIP (The Agriculture and Model Intercomparison and Improvement Project)
Delphine Deryng

10:00-10:15 Regional climate information needs for risk assessment in hydrology and water resources
Jiang Tong (China)

10:15-10:30 Regional climate information needs related to ecological studies
David Schoeman (Australia) and Rebecca Harris (Australia)

10:30-10:45 Towards a unified concept of risk, defined in general, including both hazards associated with climate change and risk-reduction from the climate change response (adaptation and mitigation strategies)
Osvaldo L. L. Moraes (Brazil)

10:45-11:00 Discusssion, including organisation of afternoon BOGs
SSC

11:00-11:30 Morning Break

11:30-17:30 **Break Out Group Session 2**

11:30-13:00 BOG2.1- Exploring information needs for various impact sectors
Facilitator: SSC, Rappoteur TBC

11:30-13:00 BOG2.2 - Information quality/uncertainty/availability in different regions and at different scales
Facilitator: SSC, Rappoteur TBC

11:30-13:00 BOG2.3 - Presentation format and communication issues related to regional climate information Thinking broadly about the kind of information that should be conveyed, the needs of different audiences/readers, to what extent will it be in the individual chapters or cross-chapter papers, to what extent should it be consolidated in an Atlas, what are effective formats (tables, graphics), what are some examples of material that is already available and could be referenced rather than replicated, etc."
Facilitator: SSC, Rappoteur TBC

13:00-14:30 **Lunch**

14:30-17:30 **Break Out Group Session 2 continued**

14:30-16:00 BOG2.1 -
Facilitator: SSC, Rappoteur TBC

14:30-16:00 BOG2.2 -
Facilitator: SSC, Rappoteur TBC

14:30-16:00 BOG2.3 -
Facilitator: SSC, Rappoteur TBC

16:00-16:30 **Afternoon Break**

16:30-17:30 **Break Out Group Session 2 continued**

16:30-17:30 BOG2.1 -
Facilitator: SSC, Rappoteur TBC

16:30-17:30 BOG2.1 -
Facilitator: SSC, Rappoteur TBC

16:30-17:30 BOG2.3 -
Facilitator: SSC, Rappoteur TBC

17:30-18:00 Stocktaking Session 1 (Plenary room)
Chair, Rapporteur TBC

17:30-18:30	Presentations of BOG outcomes (presentations + discussion)
18:30	**Adjourn**
18:30-19:00	SSC Meeting

Friday, 18 May 2018

Day 3: Scoping the AR6 Regional Atlas

09:00-10:30 **Plenary Session 3 (Plenary room)**
Chair: TBC, Rapporteur TBC
What modeling, data, and products that would like to see in Atlas. The discussion should include communication approaches for the Atlas.

09:00-09:15 Introduction to scoping the regional Atlas (continued) and Day 3 objectivesWGI-WGII
Co-Chairs / SSC

09:15-09:30 Challenges and opportunities in preparing a regional Atlas: consistency in the provision of regional climate information from multiple methods
Jose Manuel Guttierez (Spain)

09:30-10:00 Experience in developing and delivering the AR5 IPCC regional Atlas
Geert Jan von Olenborgh (The Netherlands)

10:00-10:15 The provision of regional climate information: Building on experience from the US National Climate Assessment and the North American Regional Climate Change Assessment Program (NARCCAP)
Linda Mearns (USA)

10:15-10:30 The provision of regional climate information: Building on the development of an Africa climate atlas for sectors
Wilfran Moufouma Okia (France/Congo Brazzaville) and Chris Lennard (South Africa)

10:45-11:15 **Morning Break**

11:15-17:00 **Break Out Group Session 3**
Parallel BOGs with random allocation of participants for the morning session and asking each to come back with a proposed high-level sketch/outline of the Atlas.

11:15-13:00 BOG3.1
Facilitator: SSC, Rappoteur TBC

11:15-13:00 BOG3.2
Facilitator: SSC, Rappoteur TBC

11:15-13:00	BOG3.3 *Facilitator: SSC, Rappoteur TBC*
11:15-13:00	BOG3.4 *Facilitator: SSC, Rappoteur TBC*
13:00-14:30	**Lunch**
14:30-15:30	**Plenary Session 3: Scoping Stocktake (Plenary room)** Identify commonalities, propose a concrete structure and task the afternoon BOGs with fleshing out certain aspects of that. Receive, rename presentations
15:30-16:00	**Afternoon Break**
16:00-17:30	**Break Out Group Session 2 continued**
16:30-17:30	BOG3.1 - *Facilitator: SSC, Rappoteur TBC*
16:30-17:30	BOG3.2 - *Facilitator: SSC, Rappoteur TBC*
16:30-17:30	BOG3.3 - *Facilitator: SSC, Rappoteur TBC*
16:30-17:30	BOG3.4 - *Facilitator: SSC, Rappoteur TBC*
17:30-18:00	**Plenary Session 3** Scoping Stocktake continued (Plenary room) *Chair, Rapporteur TBC*
17:30-18:30	Discussion of final BOG outcomes
18:30	**Adjourn, close of meeting**
18:30-19:00	SSC Meeting

Annex 3: List of Participants

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Annex 4: Presentation Abstracts

Recommendations from the 2015 IPCC Workshop on 'Regional Climate Projections and their Use in Impacts and Risk Analysis Studies'

Gian-Kasper Plattner[1]

Regional climate change projections provide the quantitative basis for studies of projected impacts from climate change and associated risks, which are essential building blocks for the comprehensive assessment of climate change science by the IPCC. There exist a number of climate modelling initiatives aimed at producing regional climate change projections, but they overall had not reached the maturity necessary for their wide spread use by the impacts and risk assessment community and relevant stakeholders by the end of the IPCC Fifth Assessment Report (AR5). Working Group I (WGI) in its contribution to the AR5 did provide a comprehensive assessment of climate change projections from global to regional scales.

Since then, however, important activities in the physical science community have evolved which will be crucial for an enhanced interaction between IPCC WGs in the area of assessing projections of climate change impacts at a regional scale. These concern, for example, the design and the start of Phase 6 of the Coupled Model Intercomparison Project (CMIP6) which includes the next generation of comprehensive climate models and the Coordinated Regional Climate and Downscaling Experiment (CORDEX) of the World Climate Research Programme (WCRP) with a rapidly growing data base of results from coordinated regional modelling initiatives.

In scoping the outline of the IPCC Sixth Assessment Report (AR6), regionalization was consistently highlighted as one of the most crucial areas for progress towards a more policy-relevant assessment of climate change by the IPCC. In particular, it was recognized that 'inter-linkage between the WGI and WGII reports depends on the implementation of a "handshake" between the use of regional information in climate assessment of climate mechanisms and responses to drivers with the use of regional information for application in decision making (risk management, including adaptation options) and impacts analysis´ (IPCC WGI AR6 scoping background document).

To support this `handshake´ early on in the AR6 cycle, IPCC WGI in 2015 organized the IPCC Workshop on `Regional Climate Projections and their Use in Impacts and Risk Analysis Studies´ in São José dos Campos, Brazil. The workshop brought together experts from the climate modelling community, the regional modelling and downscaling community, and the climate impacts and risk analysis communities. The workshop provided an opportunity to reflect on the past assessment and to explore ways to facilitate the collaboration and exchange between the different communities in advance of and during the AR6, with the goal to enhance the information IPCC can provide its users and stakeholders.

Key recommendations to the IPCC in general, for the IPCC AR6 cycle and for the IPCC AR6 scoping process were formulated by the participants. They were presented to the Panel ahead of the start of the AR6 cycle as part of the Workshop Report (IPCC, 2015) and a corresponding Information Paper (Stocker, 2015). Recommendations for example include suggestions to:

- enhance regionalization of the assessment throughout. Initiate close collaboration with WCRP, CMIP-6 and CORDEX, and PROVIA early on in AR6. Foster research on distilling across multi-model multi-method ensemble data;

- prepare a pair of AR6 WGI and WGII Atlases covering global and regional climate projections & climate impacts and risks: (i) based on coordinated, multi-model initiatives and (ii) complementary and closely coordinated across WG;

- support cross-WG integration by dealing with topics of high-regional relevance (e.g., water cycle, sea level, extremes) in a coordinated manner through, e.g., joint chapters, joint meetings of authors, dedicated contributing authors;

- make use of cross-WG IPCC Expert Meetings and Workshops to activate research communities for the assessment and to foster coordination across WGs.

In my keynote, I will present these key recommendations from the Brazil 2015 IPCC Workshop and discuss them in more detail in the context of the now approved AR6 WG outlines and the scope of the Expert Meeting.

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Keynote on Detection and Attribution – bridging the Assessment across WGI and WGII

Dr. Gerrit Hansen
and Dr. Robert Vautard

WGI and II provide different perspectives regarding detection and attribution (D&A). WGI is focused on examining human influence on the climate system in the observational record, and evaluates the contribution from natural forcing, natural variability and anthropogenic forcing to observed changes in climate. WGII, in contrast, starts from observed changes in systems sensitive to climate, such as forestry, marine ecosystems or agricultural production, and assesses the magnitude of the contribution of recent climate change compared to other drivers of change such as pollution, land use change or technological progress. Usually, the latter analysis does not include the consideration of the reasons for the observed change in climate, so to answer the question `whether and how much of the observed impact is due to human influence on the climate´, these two assessments have to be brought together.

For climate science, D&A has been a core discipline since as early as the 1970s, and there are elaborated methods, protocols and a dedicated research community. D&A work is less developed in a WGII context and tools and approaches differ. The IPCC held an Expert Meeting on D&A early in the 5th assessment cycle and developed a guidance document (Hegerl et al., 2010). Still, AR5 WGI and II used slightly different definitions and approaches to D&A and did not provide a joint assessment linking observed impacts of changes in climate (assessed in WGII Chapter 18, Cramer et al., 2014) to human influence on the climate (WGI Chapter 10, Bindoff et al., 2013). That missing link was delivered in a follow up publication that confirmed the discernable impact of anthropogenic climate change across regions and systems (Hansen and Stone, 2016). Since AR5, progress has also been made concerning event attribution, including first attempts to attribute impacts of extreme events.

To develop a joint or harmonized WGI – WGII D&A approach, the first question to address is why we do detection and attribution, what is or should be the goal of this exercise? Is the reference always necessarily the human influence on the climate? A related question is how attribution fits into the risk framework adopted by the IPCC: to what extent can current observations inform about future risk? Is there a difference between impacts and climate in this regard, and between long-term changes and single events?

One of the key concerns to address in this meeting is how improved regional information from climate models could help to better assess the current impacts of climate change and the role of anthropogenic forcing. Providing more accessible information to the impact community about the scale and resolution at which results from climate models can be used to determine local effects would be an important starting point. Going further, would it be possible to provide `on demand´ attribution information for specific regions and climate variables (similar to the approach used in Stone and Hansen)?

Other important issues that would need to be addressed in a common WG1-WGII framework for D&A include the integration of multiple lines of evidence, qualitative and quantitative, from multiple models and methods, the comparability of confidence assessments, and development of a joint protocol which would also help organize the workflow within WGI Chapters 10-11-12 and between WI and WGII.

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WGIII Assessment of Regional Information. Linkages between Climate Change Responses Strategies (Adaptation+Mitigation) and Sustainable Development at Regional Scale

Ramón Pichs-Madruga. IPCC WGIII

Key messages:

• In addition to WG1 and WG2, regional information is also relevant in the context of climate change mitigation (WG3). For instance, regional information on CC mitigation potential & capacities may be an important input for the policy-making process within regional integration initiatives.

• In contrast to other IPCC WGs, WG3 has not conceived specific chapters for regional information as part of the contribution of this WG to the IPCC Assessment Reports, including the outline for AR6.

• In WG3, regional information has been mainly assessed across the various chapters by using case studies (e.g. boxes) and trends, in relation to CC mitigation experiences (mitigation capacity, technologies, financing, risks).
Regional experiences in the context of WG3 also includes exploring linkages between mitigation, adaptation and sustainable development (risks & uncertainties, co-benefits, adverse side-effects, synergies, trade-offs).

• Widely used categories across sectoral chapters in IPCC AR5 WG3 include: Developed / Developing Countries, OECD, Economies in Transition (EIT), Latin America and the Caribbean (LAM), non-OECD Asia; and Middle East and Africa (MAF).
IPCC WG3 Assessment Reports have revealed very limited availability of sub-regional information, in relation to CC mitigation.

Regional information in IPCC AR6 WG3 will be assessed as a cross-cutting theme, as follows:

• Regional breakdown: local institutions, cultures, circumstances (Chapter 1)

• Past and present trends of emissions by regions (Chapter 2).

• Regional differences among mitigation pathways (Chapters 3 & 4).

• Regional specificities regarding the social aspects of mitigation (Chapter 5).

• Regional costs and potentials of mitigation / regional trends and drivers (Sectoral Chapters 6-11).

• International co-operation at the regional, sub-national and city level, as appropriate (Chapter 14)

• Investment and finance scenarios at regional scale (Chapter 15).

• Regional perspectives on climate change mitigation, including regional case studies on mitigation-adaptation interactions (Chapter 17).

Regional Climate Information Needs Related to Climate Prediction/Projections for Impact/Risk Assessment of Different Sectors

Francisco J. Doblas-Reyes
Brian O'Neill

Regional climate information is important input to assessing both near term and longer term risks for different sectors. For the near term, which comprises the next 10 to 30 years, questions such as the type of regional climate information needed, the relative role of model, scenario, structural and internal uncertainty, the sectoral requirements or the communication challenges should be looked at from a specific perspective given the proximity in time and the short time available to adapt to the climate events. Anthropogenic climate change is taking place already, although the attribution of extreme events suggests that climate change should be considered in the context of an important internal, natural variability of the system and substantial regional differences. There is evidence that near-term adaptation is currently taking place in many sectors considering the complexity of climate change occurring in this background of natural variability. However, this means that the climate information needs to be regional and that it needs to take into account in a trustworthy way both internal and forced variability. At the same time, this complex view of climate variability and change leads to the question of when anthropogenic climate change can be unequivocally detected in a background of climate variability, which is also known as the "time of emergence" and is a well-known signal-to-noise problem with strong regional implications.

The specific emission scenarios are not particularly relevant in the near term, although some short-term forcings like volcanoes or anthropogenic aerosols, usually of a strong regional nature, will necessarily play an important role. A number of studies trying to assess the impact of these forcings on both the energy balance and the circulation have been performed recently. Decadal prediction is one of the tools recently developed to address the formulation of near-term regional climate information. It bridges the well-established climate change projections, until recently the only source of near-term climate information, and the advantages that short-term climate prediction, which aims to constrain the internal variability. Recent efforts to develop decadal prediction systems show that there is added value for temperature and other variables of relevance to impact studies when considering information ten years into the future.

For analysis of longer term risk, climate information plays a key role in the SSP-RCP scenario framework. Shared Socio-economic Pathways (SSPs) have been developed to depict alternative pathways of societal change in the coming decades, leading to different levels of vulnerability to climate hazards. These societal futures are being combined with projections of climate outcomes according to the Representative Concentration Pathways (RCPs). The SSP-RCP framework is already being widely used to evaluate risks across several sectors. As of early 2018, more than 200 papers exist in the literature based on this framework, most addressing climate change impacts, and within the impacts area, most of these focus on agriculture and water-related sectors. Needs for specific climate variables at the regional or local level to support this type of anlaysis have been synthesized by the Vulnerability, Impacts, Adaptation, and Climate Services (VIACS) Advisory Board as part of CMIP6. Most of these variables were already part of the output request for CMIP5; for CMIP6, a small number of additional requests have been made, particularly for statistics of high frequency extremes at the monthly scale and for sub-grid cell level tile information.

In addition to climate information related to the scenario framework, projections of climate hazards also play a key role as input to risk judgements in the IPCC WG2 Reasons for Concern framework for community risks. This framework makes literature-based judgements of risks to society and ecosystems, but projected changes in climate hazards are important elements of those risks. In AR6, these judgements could be improved by having a much more systematic evaluation of changes in these hazards as a function of global mean temperature, the metric used in the Reasons for Concern framework. In particular, climate outcomes related to extreme heat and precipitation, Arctic sea ice extent, mountain glaciers, and climate velocity played a visible role in risk judgements made in AR5.

Tailoring Regional Climate Information (Including Quality, Value and Availability) for Assessing Impact and Risks of Different Sectors

Richard Jones
Jana Sillmann

In this talk we briefly introduce the concept of tailoring regional climate information and give some recent examples from IPCC. We then demonstrate how such information can be used, along with other contextual information, in the assessment of climate impacts and risks and raise issues related to the data required. Finally we note the wide range of categories of risk assessment and the implications for provision of tailored information and provide one sectoral and one regional example. During the talk we draw out implications for the IPCC AR6 WGI Chapter 12 and Atlas and close with some key messages and their implications.

Tailoring regional climate information is a process of extracting the most robust information available from climate sciences and making it specific enough for regional impact assessments and other applications such as climate risk assessments or informing climate policy. Providing specificity implies knowing who will use the information and for what. In an IPCC context the `users´ internally will be chapter authors across the working groups and externally will be governments involved in forming climate policy both internationally and nationally and increasingly the wide range of actors dealing with climate risks through and beyond adaptation, mitigation and building resilience.

Two examples of tailored information at continental scale are given by the IPCC AR5 WGII regional climate trends and change maps for continents and the maps with sub-continental summary figures of heavy rainfall change (WGII regional chapters and Chapter 21). The first clearly demonstrates the observed recent warming and average precipitation changes and indicates likely or plausible future changes in these variables under business as usual and aggressive mitigation emissions futures. The second demonstrates the clear signal across many regions for increased heavy precipitation in all global models assessed in AR5. Some implications for Chapter 12 and the Atlas are the importance of AR6 WGs I and II co-producing figures to ensure efficiency and consistent of information, ensuring there is balance between the robustness of regional changes and providing information that is specific enough in which the treatment and communication of ranges of plausible future outcomes will be key. Also, a possible role could be to generate guidance on how to provide regionally specific and robust climate (change) information (i.e. on hazard probability/intensity)

For the assessment of climate impacts and risks, information on vulnerability and exposure is required as well as on relevant climate hazards. There are various classes of the latter, e.g. climate extremes, slow onset events (sea-level rise, aridification etc) and variability-related events (for example driven by El Nino/La Nina, Indian Ocean Dipole). To understand the risks associated with these, some quantitative information is required, for example population density and human development indicators such as proportion of at risk age-groups vulnerable to disease. So in assessing effects of high temperatures, combining information on heat stress, population and vulnerable age-groups now and as they are projected to change in the future show those countries and their populations that are most at risk. Understanding the influence of modes of variability, many of which drive multiple hazards and can combine to generate compound risks, is also important for gaining a comprehensive understanding of the baseline risk as well as assessing multi-hazard resilience e.g. in insurance or food security.

The use of indicators, though often obscuring important details, is an important part of assessing climate risks. When choosing them consideration needs to be given to their social relevance, involving issues of scale, aggregation and accuracy, and technical aspects of data quality and availability to ensure they can be measured, monitored and validated. Also, qualitative information is often important but difficult to include. Issues that Chapter 12 and the Atlas thus need to consider are how much to focus on hazard versus risk indicators (i.e. which would imply including vulnerability and exposure aspects), should dynamic as well as just static information be included and how should uncertainties be treated and visualised.

There are many contrasting categories for risk assessments, for example in urban and rural situations or developed and developing countries and regions there will be significant differences in important aspects such as in the drivers of risks, data availability and quality or options for reducing exposure or vulnerability. The attributes of the systems involved can also be very different, e.g. infrastructure compared to social systems and the requirements for the risk assessment can range from involving all sectors within a region to focusing on a specific sector across regions.

In one example at the global-continental scale, a study on categorizing climate risk for investors assessed how urgent it was for them to consider climate change impacts resulting from a range of climate hazards. At a smaller scale, concern over potential changes in typhoon characteristics relevant to the Philippines and implications for vulnerable communities, businesses and infrastructure motivated a targeted modelling study to generate scale-relevant information. The most relevant evidence available was for likely increases in typhoon intensity and rainfall, but only applicable at basin-wide scale, i.e. the western north Pacific in this case. Thus a targeted refinement of these findings was required, through a carefully designed set of downscaled projections focused on the Philippines itself, which demonstrated that they were also applicable to the country itself.

This last example demonstrates clearly one of the key messages which is that tailoring is context-specific; information relevant to protecting communities in a specific developing country from changes in intense storm characteristics is very different from that for assessing risks associate with increasing heat stress globally. This implies that providing "generic" tailored products will only have relevance to certain categories of risk assessment. It is also clear that good examples exist of tailored regional

climate information and suggests that we may be able to use these as guidance on generating tailored information. Finally, it is obviously important for impacts and risk assessments that hazard, vulnerability and exposure information is shown combined. However, this raises many questions, specifically relevant to Chapter 12 and the Atlas, such as: How relevant are dynamic/ interactive graphics? How to deal with plausible ranges, missing data, variability, baselines, etc.?

Where should these graphics and other relevant figures and tables to be shown: in the Atlas; in WGII (and its Atlas)? In conclusion, assessing progress in tailoring regional climate information should be a key role for the IPCC AR6 with relevance across the working groups and will provide significant opportunities (with associated challenges) to enhance the relevance and usefulness of IPCC products.

Regional Climate Information Needs for Impact Modelling, Lessons Learned from ISIMIP and AgMIP

Delphine Deryng

Two international modelling intercomparison initiatives (ISIMIP & AgMIP) were presented. The types of climate information that have been used, the limitation with the approach and suggestion for improvements were discussed.

ISIMIP offers a framework for consistently projecting the impacts of climate change across affected sectors and spatial scales. The framework covers multiple sectors, and enable assessment of compound impacts of climate change and climate impacts hot-spots. ISIMIP started during the preparation of AR5 WGII volume, and covered six sectors (water, agriculture, biomes, forestry, and health). Additional sectors (i.e. fisheries, permafrost, biodiversity, forests, lakes, tropical storms) have joined the subsequent phases, which focused on historical validation and also low-emissions impacts to provide information to the preparation of the 1.5° SR. AgMIP was created in 2010 to provide a community for systematic improvement and application of multi-disciplinary, multi-model, multi-scale frameworks for agricultural development and food security. AgMIP regroups an international community involving climate scientists, agronomists, economists & IT experts. AgMIP's activities operates at multi-scale (global, regional, local) and focus on multiple interaction processes (biophysical and economics). The AgMIP global gridded crop modelling intercomparison initiative is also involved in ISIMIP (agriculture sector).

Climate information needs depend on the objective/focus of the modelling intercomparison activity: e.g. calibration, validation, projection, adaptation. For historical evaluation and validation, good historical forcing dataset are required, with high temporal and spatial resolution. The climate records need to be continuous and consistent. Surface variables that capture key drivers of sectorial impacts (e.g. water deficit, droughts) are needed. The ISIMIP method is designed to be trend-preserving, in absolute for temperature and relative terms for non-negative variables, so that it does not alter global mean temperature change. For agricultural impacts assessment, improved climate data products have been developed (e.g. AgMERRA dataset, which corrects monthly precipitation). Crop model validation have been shown to vary in some regions across the globe depending on the reanalysis products, highlighting the importance of accurate climate dataset that reflect local observed climate. For future projection, the choice of climate model also matters, especially in a large climate model ensemble: some models are wetter and/or hotter than others, which affects the response of impacts models. It's also important that the selection of models cover well the range of extreme. One approach followed by AgMIP is to select 5 models with one in each of the four quadrant and one middle of the road. Note in the case of the ISIMIP fast-track phase, the selection of models was made very practically by selecting the GCMs that were available and didn't represent well the full ensemble, in particular for precipitation patterns in South-East Asia, West Africa and Western Europe.

Areas of improvements includes: the use of improved tools such as dynamical and empirical downscaling to enhance our understanding of extreme events and variation across space; information on model regional skill (e.g. monsoon representation…etc.); better bias-correction method, such as bias-correction at multiple time scales.

Regional Climate-Information Needs for Ecological Studies and Assessment

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David Schoeman[2]

Climate-change ecologists aim to identify potential climate hazards, quantify the vulnerability and exposure of natural systems to these hazards, detect and attribute the responses of species and communities, and project future climate risks. These tasks often use a generic suite of climate data, but ecological and regional contexts impose some additional demands.

The most common goal in climate change ecology is to quantify relationships between long-term trends in physiologically or ecologically important environmental variables and corresponding ecological data. For land, these variables generally include temperature and rainfall, but relative humidity, evaporation and snow cover are also often required. For the ocean, important variables include temperature and pH (or carbonate saturation states), but oxygen concentration, salinity and ice cover are increasingly important, especially at regional scales. For transition zones such as coasts, sea-level rise and storm frequency/intensity are also vital. The most basic climate information needs therefore include summary maps of these variables. Maps of extreme event indices would be a valuable addition.

Beyond these simple summaries, however, many ecologists now routinely access data products that quantify the long and short-term climate variability that many organisms have adapted to cope with, as well as information describing the climate-change trend and the magnitude and frequency of extreme events. These data products usually comprise gridded data allowing not only assessment of temporal trends in "average" conditions, but also of variability around these averages. This is important, because many recent ecological responses to climate change have emerged in response to extreme events. In some cases, ecological responses occur when a single environmental variable exceeds some absolute physiological limit, but more commonly the response emerges when a small number of environmental variables together exceed some combination of relative deviations from historical conditions (often measured in percentiles). Alternatively, temporal shifts in ecologically important seasonal features (often temperature, precipitation, wind, or some combination of these) can have profound impacts at scales from individual species to entire ecosystems. The complexity of this suite of requirements emphasizes the importance of reliable gridded (generally interpolated) data products at relatively fine spatial and temporal scale. These products are needed not only for the `current´ period, but also for historical reference periods and potential futures.

Guidance on the appropriate usage of climate data is also still needed, because the implications of downscaling method, the range in climate models and emissions scenarios are still not widely understood. In particular, maps describing global climate model (GCM) performance in different regions are useful to help researchers choose the most skilful models for particular applications in different regions. Finally, a summary of where each model sits in relation to the archive mean (ie., the annual mean temperature and precipitation response) for the different regions of the world, as was provided in previous assessments, can inform the selections of GCMs to investigate the range of plausible futures.

A regional atlas cannot be expected to provide all of the climate information needs for ecological studies and assessments. For example, fine-scaled projections will often be needed for regional studies, because ecological studies aim to represent the world at scales relevant to animals and plants. Similarly, bias-adjusted data are often required for direct use in ecological models. Nevertheless, by providing summary maps and best practice guidelines, the regional atlas can be a powerful tool to support understanding of general climate trends and improve the uptake of climate data provided by the modelling community.

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The CORDEX-Africa Impacts Atlas

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Motivation

Thresholds exist in most biophysical and socioeconomic systems which if crossed impact the functioning of the system negatively. Inherent in many of these thresholds are climate sensitivities. For example, crops have temperature-sensitive thresholds which if exceeded for a specific number of days means the crop fails; crossing heat stress thresholds in animals and humans lead to ill health or mortality; crossing an energy demand threshold may lead to rolling blackouts in a country. Furthermore, these complex systems operate at the regional and local scale. Therefore information about change at relevant time and space scales for each system is critically important to assess the impacts of anthropogenic warming on these systems into the future.

Worryingly, several studies have demonstrated that most regions in Africa are likely to experience much higher rates of regional warming in space and time than the global average. This poses a notable threat to sustainable development on the continent where there is a high-risk exposure to climate stressors as these changes may exceed the coping capacities (thresholds) of particularly vulnerable sectors/communities.

Climate information at the regional scale that is sector relevant and has some indication of the timing of change as a result of increasing greenhouse gas concentrations is crucial to inform adaptation and mitigation strategies across Africa. However, many policy decisions are made using global average information without an indication of the timing of change. This information does not reflect the regional context nor speak to climate sensitive sectors and systems.

In this project we address this urgent need to provide regional scale climate (change) information that includes an indication of the timing and magnitude of change to inform adaptation and mitigation activities across a variety of sectors.

Objective

We will assess the timing of climate-sensitive threshold exceedances for range of sectors under global temperature targets of 1.5, 2 and 4 degrees warming above pre-industrial levels. We will investigate the impact of regional climate change once these global average warming levels are reached in key sectors identified by the Global Framework for Climate Service, namely health, disaster risk reduction, water, agriculture and energy across the African continent.

Approach

Through a co-explorative investigation with sector-specific experts, a series of indices will be derived using both climate and sector-specific information. Combining this information with the timing of reaching 1.5, 2 and 4 degrees of global warming an assessment will be made of when critical thresholds within these regional systems might be crossed that would have deleterious impacts on the system.

The timing, magnitude and robustness of projected regional change will be presented as indices in an Atlas of regional change for use by the scientific, impacts and policy-making communities. A quantification of the timing of threshold exceedences in affected systems will also facilitate and assessment of the cost delayed mitigation could have in regional socio-economic systems.

Three main activities are proposed.

- The development of a proof of concept atlas based on climate and agricultural indices/metrics. We would benefit from experiences learned in similar activities e.g. atlases of the IMPACT2C, CLIP-C and Healthy Futures programmes. The atlas would provide information useful to the climate, agriculture and policy development communities. This would take one year to develop and serve as a launching platform for a more extensive atlas.

- The development of a more extensive atlas with information pertaining to other GFCS sectors (e.g. health, energy, water). This development of this atlas would require a co-exploratory approach to co-develop (complex) indices based on data from climate, impacts and other application models (e.g. hydrology, agriculture, energy, economic etc.). Furthermore, the atlas will include tools for downloadable data, fact sheets on regional change and examples of best practice in using information. The timeline for completion of the work and delivery of this enhanced atlas is four years.

- Ongoing CORDEX-Africa research activities to understand the physical climate reasons for what we see in the atlas. This is a critical component of the project as a good understanding of the driving climate dynamics of change means the derived information presented in the atlas is credible and defensible.

All of these activities take place in the context of developing human capacity in cross- and trans-disciplinary networks to co-explore and co-develop solutions in the face of a warming climate. The product, an impacts atlas, would attract large interest from the impact modelling and policy making community and also contribute to existing climate information platforms. We therefore believe that this project is of great strategic importance in both a national and Pan-African framework, contributing actionable change information that has been inclusively co-produced by a multi- and trans-disciplinary community.

Annex 5: List of Acronyms and Abbreviations

AR5	Fifth Assessment Report
AR6	Sixth Assessment Report
CMIP5	Coupled Model Intercomparison Project Phase 5
CMIP6	Coupled Model Intercomparison Project Phase 6
CORDEX	Coordinated Regional Climate downscaling experiment
D&A	Detection and Attribution
GCM	General Circulation Model
ICTP	International Centre for Theoretical Physics
IPCC	Intergovernmental Panel on Climate Change
LAM	Lead author meeting
MME	Multi-Models Ensemble approach
NARCCAP	North American Regional Climate Change Assessment Programme
RCP	Representative Concentration Pathway
RCM	Regional Climate Model
SR1.5	IPCC special report on the impacts of global warming of 1.5 °C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty
SRCCL	IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems
SREX	IPCC special report Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation
SROCC	IPCC Special Report on the Ocean and Cryosphere in a Changing Climate
TSU	Technical Support Unit
UNFCCC	United Nations Framework Convention on Climate Change
WG	IPCC Working Group
WMO	World Meteorological Organisation