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WMO IOC ICSU International Council for Science

Report

A WCRP Workshop on Regional Climate: Facilitating the Production of Climate Information and its Use in Impact and Adaptation Work

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Introduction

The World Climate Research Programme (WCRP) is undergoing a process of defining its priorities and directions for the coming decades in consultation with the global scientific community. The workshop in Lille was convened to bring together scientists that generate regional climate information, such as global and regional climate modelers statistical downscalers, with the community of researchers engaged in climate impacts, vulnerability and adaptation research. This was done to encourage coordinated activities to feed into the IPCC 5th assessment process and to stimulate longer term scientific dialogue. The workshop focused on research priorities for facilitating the production and use of regional to local climate change information in support of impact assessment, adaptation and risk management.

The three main objectives of the workshop were:

1) To facilitate and promote a unifying vision and approach to regional climate research and the provision of regional climate information to facilitate increased interactions between IPCC WGI and WGII,

2) To find a common ground between the providers of regional climate information and the aforementioned users of such information,

3) To provide a unique opportunity for WCRP to advance the science and provision of regional climate research: methods and validation.

Presentations from the workshop are available at the meeting webpage:
http://wcrp.ipsl.jussieu.fr/Workshops/RegionalClimate/DocumentList.html and a list of participants is given at the end of this report. The presentations and discussions clearly indicate the manifold of research questions that require increased international coordination for significant progress to be made. The communities represented at the workshop plan to draft a White Paper that will be led by C. Jones and others that led the discussions at the Lille workshop, identifying the key science questions and associated research areas where coordination will deliver progress and in so doing, develop a potential coordination structure. This White Paper will be presented to the WCRP JSC at its next meeting in 2011 and will be submitted for publication in the peer-reviewed literature.

This report summarizes the issues raised on

- International Coordination for Regional Climate and Climate Change Science
- The Effective Generation and Use of Regional to Local scale Climate Information
- Improving, Evaluating and Standardizing Downscaling Techniques
- Uncertainties: Their Representation And Communication

International Coordination for Regional Climate and Climate Change Science

In recent years there has been a significant increase in societal and governmental demands for detailed regional climate information. Facilitating the production of such regional information and supporting its use in impact and adaptation work critically depends on understanding, quantifying and communicating the chain of uncertainties inherent in the production of this data.

Societal demands for climate information that is both relevant to their needs and useable to address specific tasks, was a key discussion point at the workshop. From the perspective of a user, scientific accuracy or excellence while important is not in itself enough to ensure that climate science results will actually be taken-up and used. The results must also be relevant to the problem being addressed by a given user. It is crucial to build up trust and respect for the capabilities between partners from different backgrounds guided by the best available science (e.g., international peer-reviewed Assessments). Credibility of the regional climate information for service needs will require traceability to the best available, if not rigorous, scientific basis. The generation of regional climate information would benefit from a climate risk management approach that starts with the problem to be solved rather than the science prediction, and involves interactive discussions between stakeholders and data generators, leading to a tailoring of climate information to a form that can be both understood and used by the stakeholder. Such a problem-driven approach is more likely to result in successful uptake of data. Local training in the best use of climate data is also a crucial component in any successful application of such data.

The regional climate research community has the expertise to provide guidance on how to best use regional climate information currently available. The WCRP Task Force on Regional Climate Downscaling (TFRCD) was appointed by WCRP, to respond to the demand for regional climate information and to coordinate the science needed to generate reliable information. The TFRCD has initiated CORDEX, a COordinated Regional Downscaling Experiment, in order to coordinate and standardize the generation of regional climate data internationally. CORDEX aims to develop a matrix of regional climate projections, for numerous land-regions of the globe that sample a range of emission scenarios, GCMs and RCMs. This matrix will facilitate a greater understanding and confidence in projections by exploring experimental design, sensitivity to domain size, physical consistency at GCM scales, evaluation against available observations, and how much ensemble divergence is scientifically important. CORDEX will also explore technical details of regional climate modeling, such as sensitivity of resolution, running models with and without spectral nudging, consistency across RCM boundary of different GCM and RCM physics packages, etc.

The regional climate community has two primary motivations: (i) with respect to climate science, to improve modelling capabilities and better understand processes at regional scales and (ii) to support stakeholders who aim to use climate information for regionally-specific impact assessment and adaptation planning. The community needs to develop a modus operandi that allows scientific progress while also meeting with user demands. New demands from the adaptation community raises scientific questions presently not addressed by existing WCRP working groups and panels, such as suitable methodologies to go beyond regional scales to even smaller, local scales, at which many adaption decisions must be made. Such demands, and associated scientific and research challenges are likely to increase greatly in the coming years, in parallel with the development of national and regional climate service centres.

The workshop participants widely endorsed the proposal for a permanent WCRP Working Group on Regional Climate Science. This would replace the current ad-hoc TFRCD, whose term ends in early 2011, and should go beyond just focusing on regional downscaling and CORDEX. The Working Group should widen its participation, sustaining a network and mandate that includes; identifying climate processes and challenges specific to different regions of the world, advancing climate science especially the understanding and modelling of mechanisms that act as connectors from the global- and continental-scales to the regional and local scales, developing region-specific process orientated metrics and promoting the use of best practices in generating and disseminating regional climate information. It should play a key role in providing and generating climate information for adaptation and impact studies, incorporating in its membership representatives from these sectors, strengthening education and communication between the different communities. Such a Working Group would bring a new WCRP cross cutting focus on understanding and simulating regional climate phenomena that will feed both into the global modeling and the impact and adaptation communities.

Effective Generation and Use of Regional to Local Scale Climate Information

A wealth of simulated climate data is being generated by global and regional climate modeling centers. Coordinated activities, like the Coupled Model Intercomparison Project (CMIP) and other model intercomparison projects, together with the IPCC process, have not just generated data; they have allowed the scientific community to address questions not before possible without such a level of coordination. For example, how does global and regional climate sensitivity depend on model complexity and resolution? Current and future capabilities for the provision of **credible** regional or local climate projections depend on the extent to which historical model simulations agree with observations, as well as the level of understanding of the main processes driving projected changes in various regions, not all of which can be attributed solely to greenhouse gas forcing. Process-based model evaluation is important in order to increase confidence in the ability of models to simulate both the observed climate and variability in regions, as well as potential changes in regional climate processes in response to external perturbations, such as increased greenhouse gas concentrations, changed land use etc.

Adaptation is a societal process, involving a range of decisions taken on spatial scales from highly-localized to international. Climate is only one of a number of factors that influence decisions on appropriate adaptation pathways. There are two dominant aspects to adaptation: building adaptive capacity and implementing adaptation decisions. Climate information is important in convincing policy makers that climate drivers should be part of the decision-making process, to find decisions that are insensitive to climate-related uncertainties and to develop flexible adaptation pathways. There is a clear distinction between usefulness and usability of climate information. Usefulness is defined by the climate science perception of user needs, while usability comes from the reverse perspective that of what the user perceives as necessary to address a given problem. Usable science is knowledge that meets its constituents' needs, recognising that there are multiple users and needs. Climate services are in the early stages of development and should target an increase in the **usability** of climate data, along with an increased understanding of the sensitivity of various sectors to climate variability. Presently, there is little knowledge of the sensitivity of societal systems, services and local ecosystems to weather and climate variability. An important aspect is to provide the user with clear, accessible and trusted sources of quality-assured climate information. In turn, the climate community must manage expectations, keeping them at a realizable level and, where possible, explain the level of regional climate predictability and the associated levels of certainty in a given product.

In spite of the growth of the number of initiatives intended to interact closely with stakeholders and policymakers, there is still very little meaningful, two-way, and continuous interaction between the climate science community and various user communities. Part of the reason for this may lie in the extreme heterogeneity of the user community. A "user" in relation to climate modelling, may be a decision maker acting individually or as part of a collective group, or a translator of climate information and it's associated impacts, supplying decision makers with this transformed information. Similarly, a "provider" may be the climate scientist running global and regional climate models or it may be the translator of forecast data who modifies the initial information into a more usable format for the policy or decision maker. As an example a "provider" of climate information may be an individual or institute that takes information from climate simulations and feeds it through a hydrology or crop model, with the subsequent information being a tailored form of climate impact data targeted for a specific sector.

Partnership systems are needed to provide "actionable climate knowledge" (Meinke *et al.*, Clim. Res., Vol. 33: 101–110, 2006) that have:

Saliency (the relevance of information to a given sectorial concern);
Credibility (the perceived scientific/technical quality of the information);
Legitimacy (the perceived objectivity of the process by which the information is shared)

Climate scientists need to better understand what users actually need, not just asking what users want, but also understanding what users do. Users, in turn, have to clearly define the information they require and become more familiar with the climate data they use, how it is generated, what the uncertainties are and the limitations inherent in climate projections. Such demands require a sustained, two-way dialogue. A few examples of this sustained dialogue do exist, the wider climate and user community should try to learn from and build on these successful examples. This dialogue should include better information on what the drivers of regional climate variability and change are and, in particular, strive to go beyond a single-value, deterministic approach to climate impact assessment, to a more probabilistic assessment of future climate change and risk. The communication of uncertainty should detail both the limits and usability of information, as well as describing overall uncertainty levels. One specific example of communication needs pertains to simulated climate data being a spatially averaged, grid-box, value while many users and impacts models are more familiar working with point observations. Dialogue of this nature needs to be continuous as, in the case of simulated climate data, grid-box average values systematically approach equivalency with point data as model resolution increases. Such updates to the quality and nature of climate data must be communicated to users on a regular basis.

Communication of climate science needs to be improved across the board, from communicating the consensus view of the IPCC 4th Assessment, to practical issues, such as the importance of analyzing long time series (i.e. delineating climate variability from climate change), problems in going from large to small scales in delivering climate data, to more clearly communicating the uncertainties and limitations of climate data. The source of information is important. Users prefer to source their information from local scientists. This has been an important motivation behind the CORDEX project. High-quality climate data needs to be available to scientists local to a given region, allowing them the opportunity to locally evaluate the data and lead the development of regionally-specific scenarios. This, combined with raising the expertise of local scientists, will lead to a greater uptake of climate data and a more successful use of such data in practical areas, with users being confident that they can turn to local resources for explaining details of the data in use.

Recommendations:

- A partnership system is needed with two-way interactions, combining science driven research with user driven requirements. This would best occur through a WCRP-sponsored activity to coordinate such transdisciplinary research activities focused on regional climate change and societal needs.
- Data distribution, with the same level of detailed documentation as CMIP5, is needed for regional models, with facilitated and supported access to data in regions worldwide.
- Communication of best practices is required to prevent the misuse of information, which not only leads to bad decisions but also has a detrimental impact on climate science. TGICA has the charge to provide some of this guidance on good practice (e.g. uncertainty analysis, sensitivity studies). Existing documents should be updated and new standards developed, for example in the light of new climate information web portals presently under development.
- Documents that clearly identify the most reliable sources of both observational and model data and articulate the uncertainties of these data sources would be of huge value for stakeholders.
- Transmission of expertise and interdisciplinary education to students in order to develop the future of climate science, impact assessment and climate services in regions worldwide.

Improving, Evaluating and Standardizing Downscaling Techniques

Downscaling techniques have been widely used to resolve fine scale features in regional climate data and reduce numerical truncation. Improvement and evaluation should be more strongly targeted to the identification of ‘added value’ provided by different downscaling techniques. A key challenge for the climate downscaling community is how to combine and make use of both dynamical and statistical downscaling techniques to generate maximum added value information for user communities. The regional downscaling community has to look in two directions: towards improving the ability to model and understand regional climate processes **and** towards its connection and support of the impacts, adaptation and vulnerability (IAV) communities, with process understanding spanning both ends of the spectrum.

The analysis of RCM simulations contributes to the identification of the physical origins of divergence between GCM simulations, as well as aiding in understanding critical aspects of the large-scale flow determining climate variability at the regional scale. Dynamical regional and global models should use the same evaluation framework with respect to regional climate variability and, at the other end of the problem, data from global and regional models should be used in a common framework to force and evaluate IAV models.

The evaluation of downscaling techniques should include a series of steps, beginning with an analysis of regional climatologies, variability and extremes, through to an impacts-based assessment, taking care of the cascade of uncertainties from the specification of external forcings, through physical climate simulation, to impact models. An important question is how to evaluate regional climate change signals and trends, whether there are specific regional climate sensitivities and whether these can be evaluated using downscaling techniques. A straight evaluation of simulated regional climate variability is not enough to determine the robustness of projected changes. A more process-orientated evaluation with process-orientated diagnostics is necessary. The RCM community should build stronger links to GCM model intercomparison studies (e.g. CFMIP, CCMval) that are developing such approaches and contribute local expertise to the evaluation of regionally-specific climate processes. Multi-variate approaches should be used to map current climate errors in order to quantify the robustness of future climate change simulations. Breaking down the response to different forcings, for example aerosols, GHGs and land-use, is necessary for the detection and attribution of climate signals.

Empirical statistical downscaling (ESD) continues to be the most widely used downscaling approach in the impacts and adaptation community, with many methodologies in use often with associated pitfalls. Different criteria were used for assessing statistical downscaling methods in the STARDEX project (www.cru.uea.ac.uk/projects/stardex/). These included performance criteria and robustness (stationarity), as well as applications-based (e.g. temporal or spatial consistency) criteria. The outcome of STARDEX was that there is no one best statistical method. How good any method is depends on the region, season, and variable and is related to the complexity of the application. Greater coordination should be encouraged, with CORDEX being an opportunity, to develop best practices, for example on the use of ensemble techniques, more thorough sensitivity analyses, assessment of calibration periods and the evaluation of stationarity of different methods. A TIGICA best practices document does exist and this will be updated as part of CORDEX.

The standardization of downscaling techniques has not been addressed in detail. While RCM methods are generally transferable to any region, most statistical methodologies are case specific. A good practice document would help by clarifying calibration and validation methods, including the quality of data used for calibration, and would recommend which downscaling methodologies are most appropriate depending on the specific questions and regions being addressed.

Recommendations:

- Initiate a concrete, problem-driven, intercomparison activity of different downscaling techniques, including ESD, formulated for a CORDEX control period, focused on Africa and forced by Era-interim. Driving this activity should be a number of practical climate impacts studies, with a full and coordinated analysis of each step in the chain, from downscaling to impact model to potential adaptation options. Such an activity would bring together climate scientists, impacts scientists and adaptation specialists around a few specific problem-based activities.
- Propose a 'working' workshop with IAV specialists to determine their requirements and guidance to build on what is planned as part of CORDEX, expanding this effort towards the user community. The IAV community in turn should seek guidance on what information sources are available, as well as a quantification of data quality and the associated uncertainties, from the regional downscaling community.
- Produce a guidance document on downscaling techniques that identifies the most appropriate tools for given questions and regions. This should also include information on the uncertainties associated with observational data. It is important that the necessary date storage and transfer

requirements be recognized and resourced for the analyses and policymaking inputs.

- CORDEX should interact with other WCRP projects and regional panels that are working on process-orientated evaluation and help expand the community that evaluates CORDEX simulations. The CORDEX Regional Analysis and Evaluation Teams should develop process-orientated metrics targeted for evaluating downscaling performance in their regions.

Uncertainties: Their Representation and Communication

Uncertainty is sometimes interpreted, particularly amongst policy makers, as mis-information. Communicating uncertainty needs to be clear to maintain standards for proper use and interpretation of climate model projections, particularly regional model products. Uncertainties need to be communicated to users without damaging their view of the credibility of the results. Robust results should be emphasized, with, where possible, likelihood-of-occurrences attached. Uncertainty analysis should quantify and communicate how much of the expected spread in possible future regional projections has been captured by various techniques.

There are various sources of uncertainty in regional climate data. Information must be distinguished from noise and the analysis has to be optimized to get credible estimates of uncertainty. The IPCC has developed language to convey confidence relative to uncertainty. Is this language appropriate to convey to the broader user communities and public who need information about risk? Keeping rigorously to a defined language, from how it is used in written reports to spoken explanations is difficult and yet necessary to avoid confusion and misrepresentation. Terms and language will always lead to different interpretations by users and the wider public so it should include context. This means that messages should be packaged with context information, instead of assuming everyone uses standardized terms, definitions and jargon. Communicating risk is in general outside the area of expertise of the climate modelling community, so there is a need for education in communication and an increasing role for social science. Climate uncertainty and information is not the primary issue for many sectors, that portion of the full information portfolio, of use to a given sector, must be carefully extracted in full consultation with the sector in question. In particular, the level of added value from climate information on top of all other relevant information utilized in planning and adaptation decision-making will vary from sector to sector.

Unrealistically precise information **-** *tell me exactly what will happen at this precise location***-** is generally not required by users. Policy decisions never convey a single value; instead they are always made in the context of a variety of scenarios that have some range of likelihood. In many instances decisions have to be made with or without this information. For those who have to act, there is not so much a fear of information that is not perfect, rather more a question of is there anything available that can help me make the decision, or should I just carry on as before. This leads to the question being reframed to ask first; what is it that has to be decided or thought about? And then determining what kind of information can be extracted, either from already available data or from special tailored simulations/analysis that is of use to the problem at hand. In other words, putting climate information into the context of the practical problem/question faced by the user.

From the perspective of management and decision-making communities, updates in climate information, such as going from the SRES to RCP scenarios, needs to be clearly explained. Users need to understand how new information relates to what is already known, how and where this information improves on what is already available and, as a result, how often adaptation decisions should be reconsidered, including all relevant political pathways.

In developing climate services, a few important steps and workshops can make an important initial difference in bridging the gap between climate information providers and users. But, for climate services to bring long-term benefits, a sustained investment in two-way dialogue and training is required. This will help build trust, mutual respect and understanding between communities. Such an effort will require an updated institutional structure, preferably building on present structures, where so-called boundary organizations will likely play an important role as facilitators and explainers of climate information. These organizations must be accountable for the quality of information they provide, with suitable traceability to the origin of data provided and the methodologies used in its generation. The climate research community should be protected from acting as this boundary organization, in order to allow the science and predictive capabilities to continue to develop.

Recommendations of relevance to climate services

- More emphasis is needed on communication of uncertainties. This needs to be simple and straightforward and supported by white papers or other appropriate documents.
- Climate services should include building the capacity to understand information and recognize standards and limitations of data.
- Communication should be interactive **-** a two way process with emphasis on knowledge transfer with transparency rather than data transfer.
- Information should be provided at different levels of depth, from full detail to more easily understandable levels.
- A workshop is proposed with a range of impacts modelers and sector level users to understand better what they actually do, how they presently source their information and how this can be improved in the future.
- Work with professional bodies, or institutional interfaces, is recommended so that information filters through to the various users they represent.
- There was clear agreement that, in addition to setting up climate services and improving communication between users and data providers, basic research must continue with an enhanced level of dedicated funding, in order to continuously improve the **quality and quantity** of information available to climate service sectors.

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Agenda

Day 1: Monday 14 June

8.30 - 9.00	Registration	
	Chair: H. Le Treut	
	Rapporteur: K. Taylor	
9.00 - 9.15	Various intros and setting the scene/aims of the workshop	***IPCC and WCRP representatives***

Session 1: Simulating regional climate variability and change: Present and future prospects for delivering information to support impact and adaptation work.

9.15 - 9.45	The present ability of coupled GCMs to simulate large-scale modes of variability influencing regional climates over tropical regions	***B.N. Goswami***
9.45-10.15	Interactions between climate and air pollution and aerosols, and its implications for environmental change	***S. Liu***
10.15 -10.45	From Global Climate Models to Earth System Models: Expected model improvements from AR4 to AR5	***V. Ramaswamy***
10.45 - 11.15	**Break**	

Session 2: Defining regional climate change: Requirements & ability to deliver

	Chair: V. Ramaswamy	
	Rapporteur: J. Murphy	
11.15 - 11.45	Regional/local climate change, the WG1 perspective	***F. Zwiers***
11.45 - 12.15	Regional/local climate change needs and requirements, the WGII perspective	***K. Ebi***
12.15 - 12.45	Regional/local climate projections: present ability and future plans	***R. Jones***
12.45 - 13.45	**Lunch**	
	Chair: C. Jones	
	Rapporteur: M. Déqué	
13.45 - 14.15	Use of regional/local climate information in impact assessment and adaptation work: present knowledge and	***T. Carter***

	future needs	
14.15 -14.45	Time and spatial scale needs for adaptation and mitigation studies, from decadal prediction to long term stabilization	***R. Horton***
14.45 - 15.15		
15.15 - 15.45	**Break**	
	Chair: C. Vera	
	Rapporteur: M. Déqué	
15.45 - 16.15	Regional Climate Information needs for impact and adaptation work: Experiences from Asia	***G. Srinivasan***
16.15 - 16.45	Regional Climate Information needs for impact and adaptation work in South America	***S.C. Chou***
16.45 - 18.00	Discussion: Key focus: How do we best define and meet the regional climate information required. *Making the demands and the ability to deliver meet and evolve together*	***C. Vera***

Day 2: Tuesday 15 June

Session 3: Generating and using regional/local climate information

	Chair: S. Bony	
	Rapporteur: P. Drobinsky	
8.30 - 9.00	Techniques for dynamical downscaling	***M. Déqué***
9.00 - 9.30	Where and when should one hope to find added value from dynamical downscaling of GCM data	***R. Laprise***
9.30 - 10.00	Statistical downscaling	***B. Hewitson***
10.00 - 10.30	CMIP5	***K. Taylor***
	Chair: E. Lipiatou	
	Rapporteur: P. Drobinsky	
10.30 - 11.00	**Break**	
11.00 - 11.30	Overview of Regional Climate Model evaluation activities at JPL	***P. Lean***
11:30 - 12:45	Discussion: Key focus: How do we improve, evaluate and where possible standardize downscaling techniques for use in impact/ adaptation work	***D. Jacob***
12:45 - 13:45	**Lunch**	

Session 4: Representing and dealing with uncertainties in regional climate projections/predictions

Chair: S. Planton

Rapporteur: B. Hewitson

13:45 - 14:15	Deadling with uncertain climate information in adaptation to climate change	***S. Dessai***
14:15 - 14:45		
14:45 - 15:15	Probabilistic climate prediction/projection from the decadal to the centennial time scale	***J. Murphy***
15:15 - 15:45	Use of probabilistic climate change information for impact and adaptation work	***C. Goodess***
15:45 - 16:15	**Break**	
	Chair: J. Polcher	
	Rapporteur: B. Hewitson	
16.15 - 16.45	CORDEX	***C. Jones***
16:45 - 18:00	Discussion Key focus: Uncertainties: their representation and presentation in impact/adaptation work	***W. Gutowski***

Day 3: Wednesday 16 June

Session 4: Timescales of importance for climate information

	Chair: F. Zwiers	
	Rapporteur: C. Goodess	
8.30 - 9.00	Inter-annual to decadal climate prediction	***M. Latif***
9.00 - 9.30	Climate data and user demands, bridging the gap: Experience from seasonal forecasting	***S. Zebiak***
9.30 - 10.00	Detection and attribution on climate change at regional scales	***P. Stott***
10.00 - 10.30	**Break**	

Session 5: Key Information gaps and Research needs to close such gaps

	Chair: S. Zebiak	
	Rapporteur: C. Goodess	
10.30 - 11.00	Climate change and low lying states: Sea level, flooding and storms	***A. Rahman***
11.00 - 11:30	Extreme events	***C. Schar***
11.30 - 12.00	Monsoons and Climate Change	***K. Kumar***
12.00 - 12:30	The hydrological cycle in global or regional models : a challenge for climate physicists	***F. Hourdin***
12.30 - 13.30	**Lunch**	

	Chair: C. Jones	
	Rapporteur: R. Horton	
13.30 -14.00	AMMA: A European-African collaboration in understanding, observing and simulating the west African monsoon	***J. Polcher***
14.00 - 14.30	How to best make progress on closing the research gaps?	***R. Laprise***
14.30 - 15.30	**Rapporteur: R. Horton**	
	Final Discussion and Recommendations, proposal for a white paper	***C. Jones***
15.30 – 16.00	**Break**	
16.00	End of WCRP Regional Climate Workshop	