WCRP REPORT

World Climate Research Programme

Workshop Report

Evaluating and Improving Regional Climate Projections

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Evaluating and Improving Regional Climate Projections

Held at the Météo-France International Conference Center
February 11-13, 2009

Scientific Committee

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Decisions and key actions

After extensive discussions, the following decisions have been reached:

1) We should define a general framework for the community to refer to (something along the lines of what AMIP and CMIP have been for GCMs) but we should start with a more limited effort to make sure achievable goals are set and achieved, specifically within the timeline of the AR5.
2) In terms of the evaluation and benchmarking experiments it was decided to use the ERA-Interim product (1989-2007) to produce lateral boundary conditions for Regional Climate Models (RCMs) and driving data for Statistical Downscaling (SD) (in the latter case recognizing that additional data might be used because of the short length of the ERA-Interim), until more extensive re-analysis products become available.
3) The initial standard resolution will be 50 km to enhance the feasibility of the experiments and the involvement of a wider community.
4) Although a comprehensive set of domains will be considered in the matrix of experiments, in particular covering all developing country regions, the initial focus will be on Africa and more specifically on a domain covering the entire African continent.
5) In terms of GCM-driven experiments, the first priority will be on the long term scenario simulations, and more specifically the periods
   1950-2005 - Historical run
   2005-2100 – RCP4.5 scenario run
   2005-2100 – RCP8.5 scenario run
6) Multiple GCMs should be used for driving the RCD in order to capture inter-model uncertainty

A number of issues remained unresolved, and it is the task of the Task Force on Regional Climate Downscaling (TFRCD) to follow up on them in the next few months leading to the Lund meeting (May 4-8, 2009), where the TFRCD will meet again. These key actions are the following:

1) We should find a name/acronym for the project to give it an identity. Ghassem will have the final word on this, but two suggestions to start with are
   1a) RCDIP: Regional Climate Downscaling Intercomparison Project – This would be the regional counterpart to the CMIP projects
   1b) CORDEX: Coordinated Regional (Climate) Downscaling Experiment – This would be more along the lines of calling this an experiment.
   Lead person : G. Asrar
2) Produce a workshop report along with a possible paper (BAMS or other option)
   Lead persons: F. Giorgi, S. Planton
3) Fine tune the general framework
   Lead persons: C. Jones, F. Giorgi
4) Finalize choice of regions/domains
   Lead persons: J. Christensen, K.K. Kanikicharla, W.T. Kwon, Gutowski, C. Jones (R. Jones also interested)
5) Identification of potential RCM participating groups
   Lead persons: Giorgi, Christensen, Gutowski
6) Identification and organization of the SD community:
   Lead person: Hewitson with C. Goodess
7) Data handling strategy, both for LBC and RCM/SD output
   Lead persons: Christensen, Gutowski, C. Jones
8) Identification of model-to-practice success stories (for eventual input into document above)
   Lead persons: Hewitson with Rob Wilby
9) Observation needs
   Lead persons: Hewitson with C. Goodess
10) Creation of regional “diagnostic” teams
   Lead persons: To be assigned
11) Sub-task force on RCM/SD intercomparison issues

Lead persons: Gutowski, Laprise, Murphy, Hewitson

12) Look for funding options
    Lead persons: Everyone
13) Finalize a plan for the decadal predictions. The suggestion so far is to have the periods 2005-2035 (forecast), 1980-2010 (hindcast), 1990-2000 (hindcast). This is an issue for the longer term, but it may be good to finalize at least a recommended plan.
    Lead person: Murphy
14) Contact Isabelle Nyang concerning her participation to the TFRCD and start thinking of an alternate
    Lead person: Hewitson
15) Meeting and side event at COP15
    Lead persons: Asrar, Giorgi, C. Jones

1. Context and main objectives

There is an increasing need for detailed, high-resolution regional information regarding future climate. Such information is needed by scientists in disciplines that require climate information (e.g. hydrologists), decision- and policy-makers, and by those assessing climate change impacts, adaptation and vulnerability. Although climate change projections must necessarily be undertaken with global models, such models will never have sufficient spatial detail for all applications. Constraints on available computing resources will always limit model resolution; therefore, various techniques have been developed for 'downscaling' global climate projections (and shorter-term climate predictions) and for producing fine-scale regional climate information. These include nested regional climate models, variable resolution global models, global uniform high-resolution time-slice simulations, statistical downscaling, and/or combinations of these methods.

Although the use of RCD techniques (RCMs, variable resolution and statistical downscaling tools) has tremendously increased in the last years, there is a need for more information in order that users are better able to evaluate the adequacy or applicability of these various methods for a particular problem. The need has also been expressed for a strong coordinated program aimed at evaluating and improving downscaling methods as well as improving the production of the next generation of regional climate change projections. Experience in the global climate modeling community has shown the immense value of internationally coordinated model experiments, and the value of the resulting multi-model ensembles in producing credible climate change information and associated measures of uncertainty. Ensemble results from global coupled models have been used extensively in the IPCC assessment reports, but similar ensemble results from regional models or other downscaling methods have not been widely available for most regions of the world. This has limited the use of downscaling products in climate change impact assessment and adaptation studies.

To address this problem, WCRP, through WGCM, has created in 2008 the Task Force on Regional Climate Downscaling (TFRCD), chaired by F. Giorgi and C. Jones, with the task of supervising the development of a plan to carry out the following three main tasks:

1) Develop a framework to evaluate and improve RCD techniques for use in downscaling global climate projections.
2) Design an international coordinated effort to produce a new generation of RCD-based high-resolution climate change projections over regions worldwide for input into the AR5 and use in impact/adaptation studies.
3) Promote greater interactions between climate modellers, downscalers and end-users to better support impact/adaptation activities, fostering in particular a greater involvement of developing country scientists

One main task of the TFRCD is thus to supervise the design of an international coordinated experiment framework, something along the lines of what AMIP and CMIP3 have been for the GCM community. In particular, one of the specific goals of this framework is to facilitate the provision of information that would provide a strong RCD-based input into the AR5, scheduled to be released in 2013. This gives us a very stringent deadline as in principle such RCD-based information needs to be produced within the next couple of years so that it can be used by WGII scientists.

In this context, the Toulouse workshop is the first step for the discussion of the details of this framework, with the hope of making long strides towards the definition of a plan. Its specific objectives are:

1) To summarize what is already known about the attributes of various downscaling methods.
2) To discuss the extent to which these methods address the needs of a broad and very inhomogeneous user community.
3) To begin discussion of a coordinated international activity, under the World Climate Research Programme (WCRP), that would develop a framework with the following twofold purpose:

i) provide a framework for the evaluation and intercomparison of regional downscaling models and methods as well as defining standards for the preparation and dissemination of model data (perhaps modelled along the lines of the successful series of Coupled Model Intercomparison Projects, and

ii) provide a framework for the production of a multi-model ensemble of regional climate downscaling simulations for regions worldwide, which would significantly enhance the contribution of regional dynamical and statistical downscaling tools to future IPCC assessments.

To reach the third objective, some key issues to discuss were identified a few weeks before the beginning of the workshop:

1) **Number of participating models and partners.** Of course the more the better, however it should be realized that at the moment there is no funding specifically available for this, so that the participation needs to be necessarily on a voluntary basis. On the other hand, we feel that a well-conceived and designed plan might elicit opportunities for funding.
2) **Experiments to be completed.** In the next round of IPCC there is a wide range of experiments planned, from decadal prediction to standard scenario runs (using specified GHG Reference Concentration Pathways), stabilization runs and a number of sensitivity experiments to isolate the effects of different forcings and processes. We cannot obviously do them all, so we need to prioritize the key ones to be carried out.
3) **Choice of domains, resolution and time slices.** WCRP is keen that as many regions of the globe as possible be treated. This may increase the number of domains by quite a lot. The model resolution should be state-of-the-art, and a value that has been floating around is 25 km grid point spacing. Should we do full 150-year simulations or time slices? We need to find an optimal compromise among these issues.
4) **Choice of GCMs for providing lateral boundary conditions or, more generally, forcing fields.** This is a key issue. In order to produce RCD runs, we need to have GCM data to downscale, and we need them in a timely fashion. At the last WGCM meeting, GCM groups generally expressed their support for this notion, as long as it does not add to much work for them. So we need to design an approach workable for them as well as for us.
5) **Databanks and data accessibility.** There will be a lot of data, both the GCM data to drive the RCDs and the output produced by the RCDs. CMIP3 has been incredibly successful because of the role of the PCMDI databank. How should we approach this? The idea has been floating around of regional databanks, since nobody might afford a comprehensive central one. And then, how to produce comprehensive but workable sets of model fields?
6) **End-user community involvement.** We need to involve the end-user community, represented in the Toulouse workshop by a number of impact experts, from the very beginning of the discussion, because they are the recipients of the RCD-information. How to optimize this process?
7) **Involvement of scientists from developing countries.** A final issue that WCRP is very keen on is to increase the involvement of scientists from developing countries, so we do need to discuss this issue as well.

One anticipated outcome of the workshop is to have a rough draft of a plan that can be presented at the following JSC/WCRP meeting at the beginning of 6-9 April 2009 in Maryland. The plan is then to eventually finalize the framework at the RCM workshop of May 4-8 in Lund, so that participating groups can gear up to start their simulations not too far thereafter and contribute through some of them to the AR5.

2. General framework

The session started with a presentation of Ghassem Asrar who at first transmitted a message from Michel Jarraud, communicating his greetings and best wishes to the participants, is keen interest for the outcome of the workshop and his commitment and support for the activity related to it. He then presented the role of WCRP insisting on the focus now made on regional climate for risk management and the need to tackle scientific issues. He also presented the agenda of climate issues including the World Climate Conference-3 (31 August – 4 September in Geneva) where the question of the mechanism to provide climate prediction and information for the climate adaptation issue will be discussed. He also presented a draft of the recent WCRP review that recommended in particular to "Enhance visibility and better uptake of WCRP outreach - not only at international but also regional, and national levels". In his conclusion he underlined that WCRP has a great opportunity with attendant challenges to build on its 30 years of *successful legacy* by staying focused on the forefront of climate system research for the rest of this century. He also concluded that WCRP must promote and enable the timely use of climate information and knowledge it generates for decision-making through its partnerships with providers and users of such information. The greatest challenge for WCRP is to demonstrate the value of its global and regional scientific coordination and integration efforts to its sponsors/donors, and the participant scientists and organizations that support its Projects and activities.

In his presentation, Greg Flato communicated information on the CMIP5 simulation plans provided by Karl Taylor (not present at the workshop the first day). He showed the organization of the modeling exercise divided in three suites of experiments ("Near-Term" with decadal prediction simulations, "Long-Term" with century and longer simulations and "Atmosphere-Only" corresponding to time-slice computationally demanding simulations). Each suite of experiments will comprise core simulations and two somewhat lower priority additional sets of simulations (grouped into Tiers 1 and 2) including more detailed simulations to explore multiple aspects of climate system response and projections. He then presented the current expressions of interest from groups planning to participate in CMIP5 and the estimated deadlines for a contribution to the IPCC AR5 WGI report. He noted that in contrast to the AR4, there would be a relatively long delay (about 18 months) between this report and WGII report. During the discussion following his presentation, the point was made that such an exercise has as its primary objective to do the science required for the future, not to directly serve the IPCC. The decadal prediction simulations are considered a step forward in this respect. Concerning the short delay between the availability of model output and the publication deadline for papers to be assessed by the IPCC, it was remarked that model output from projects of this kind are of considerable value even if they do not meet the IPCC deadline. Indeed subsequent to the AR4, additional contributions to the CMIP3 archive have been analyzed in many recent publications. The IPCC assessment has to be considered as a client of the CMIP simulation exercise for which a specific effort is made to satisfy the IPCC timeline.

Jens Christensen then presented some lessons that can be learned from the AR4 concerning the regional climate issue. He insisted on the fact that all the information included in the Summary for Policy Makers must be policy relevant. However, there was a lack of information at the regional scale in the AR4 with many figures on temperature change that were produced from GCM results when for instance small islands are not even represented by these models. The last report suffered from an absence of coordinated effort to produce regional downscaling over many regions like the one provided for Europe in the context of the PRUDENCE project. As the material building on AR4 or even TAR GCMs will be obsolete and as there is a need to cover all regions due to political reasons, he concluded on the need to establish liaison with the GCM community to define what is meant by regional. The discussion then raised the question of the priority that should be given to focus good analyses using all available information but also came back to the need of a coordinated exercise at the level of CMIP5. The point was also made to accelerate the process of providing boundary conditions for regional climate simulations. The place of the regional chapter in the next report was also discussed but putting emphasis on the need to first provide information at the regional scale extending in some respects what was included in the AR4 (link to validation,

probability distribution function for any area?…). One main point coming from the discussion was the importance to be more proactive on the agenda.

3. Regional climate downscaling techniques

The session started with a presentation by Filippo Giorgi on the status and open issues regarding regional climate modeling, including a document prepared by R. Laprise at the last WGNE (Working Group on Numerical Experimentation) meeting (Montreal, 2008). The presentation stressed the weaknesses and strengths of limited area modeling in regional climate simulation. After a brief recall of the strategy of dynamical downscaling, of related projects and relevant publications, and of the state of the art, Filippo GIorgi introduced some basic issues with illustrated examples. These last concerned the added value of dynamical downscaling, the issues of lateral boundary conditions (LBC) technique, of internal variability and of physics consistency. The broad conclusions of his talk were that RCM nesting "works" as: they produce small scale features, realistic climate when driven by good quality LBC and added value; that good quality LBC are a prerequisite for good quality RCM simulations; that RCMs should be used and interpreted in view of a number of "technical issues"; and, that assessment and understanding of these issues strongly requires large coordinated projects. In the following discussion the impact of domain size and model resolution was stressed. Concerning the impact of physics consistency, exchange of experiences between the participants showed that it appears as model dependant.

Rob Wilby gave the second presentation of the session on the status and open issues regarding statistical downscaling. After introducing the main motivations for the downscaling process he raised the issue of the cascade of uncertainties in the chain of impact studies and the question of incorporating those linked to downscaling. Some of his main conclusions are that GCM boundary conditions are the main source of uncertainties and that statistical and dynamical downscaling have similar skill, at least for appropriate metrics and methods. He also pointed out a few practical considerations that limit the capabilities of statistical downscaling – in particular, the decaying observing network and poor data quality in some regions. To face the wide diversity of methods that are used in this field, he mentioned existing supporting documentation to summarize existing science but pointed out the lack of translation of this science for impact and adaptation applications. He also insisted to identify where downscaling is possible and where it is not due to large-scale uncertainties and on the need to put the users at the top of the list of priorities, The discussion raised the point of statistical downscaling from RCMs, considered as insufficiently used by some participants, but also considered as only useful when there is an added value from RCMs compared to GCMs.

Michel Déqué made the last presentation of the session on the use of variable resolution GCMs as an alternative to limited area models (LAMs). After a short evocation of the history of this technique, he discussed some validation work and the state of the art of the methods including the multi-pole approach, driving of stretched models and two-way nesting. In particular he pointed out the work done in the context of the Stretched Grid Model Intercomparison exercise (SGMIP) and presented results of climate change scenarios performed in the context of a multi-pole approach. His main conclusions are that a variable resolution GCM can replace a high resolution GCM and can replace a LAM under appropriate implementation but that there is a need to take care of physical parameterizations that are robust to climate change but hard to tune regionally. In the following discussion, the point of whether high resolution far from the area of interest contributes to regional climate features was raised and existing simulations show that this is indeed the case, at least for Europe and North America, and probably for mid-latitudes. It was also concluded that a contribution of multi-pole stretched simulations to the coordinated regional projection is a valuable option.

4. Specific applications

Tim Carter made the first presentation of the session on the topic of the use of climate information for impact and adaptation applications. He started by listing some needs of the users regarding

climate information and of what the scientific community has been able to deliver but also should deliver in the future. He then gave an overview of the activities of climate information delivery in a "bottom-up" approach including observational datasets, analytical tools for processing climate information or national web portals. Some of his main conclusions were that these initiatives need more scientific scrutiny and should in particular be evaluated by the IPCC. Another point he made was that to face the increasing volume of data this climate information generates, some creative approaches to data analysis and delivery need to be developed, this including probabilistic methods and a separate delivery of information for specialists and non-specialists. He also pleaded in favor of a program of systematic downscaling from global model outputs in different regions to provide information where it is now missing, specifically on extreme climate events and to give a regional focus of direct relevance to regional scientists and policy makers. In the following discussion, the point was also made that there is the need for a broad discussion among countries on the topic of the communication of climate information and that the end-users should be part of the coordinated exercise.

The presentation by Liqiang Sun focused on the use of RCM for seasonal prediction with the scope of drawing some recommendations for the use of RCM for climate change applications. He first gave some examples of results showing that, at least for some parameters and seasons, the skill of long-range forecast can be improved by using a nested RCM compared to the one of the driving GCM. He also pointed out some challenges in dynamical downscaling and raised the question of the way to manage climate variability knowing that there is some skill at intraseasonal scale. His main recommendation for dynamical downscaling was the use of a multi-model ensemble approach in the context of a coordinated exercise to estimate climate change signal and variability, to correct for GCM systematic biases before driving the nested RCMs, to improve the representation of soil hydrology in the RCMs, to use a spectral nudging approach to reduce RCM errors and to prioritise both relevant and predictable climate variables to address user needs.

In his presentation, Rupa Kumar Kolli made an overview of the downscaling activities in developing countries. He first underlined the efforts made by UNFCCC to enhance work on vulnerability and adaptation issues, through in particular the adoption of the Nairobi Work Program or the organization of a workshop on climate modeling, scenarios and downscaling. He also presented a few initiatives in developing countries for climate change downscaling and the WMO initiative to support climate change adaptation. One of his conclusions is that generally only few downscaled data exist for a limited number of GCMs and scenarios, limiting the risk assessment. He also mentioned the lack of understanding on how to use and interpret downscaled data. He mentioned that the Regional Climate Outlook Forum mainly focused on seasonal prediction could be used for adaptation issues as recognized by UNFCC. He insisted on the expectations for the next World Climate Conference (WCC-3) that will establish a framework for the provision and application of climate services in particular at the regional, national and local levels.

The last presentation of the session was made by Bruce Hewitson on the topic of the needs in developing countries in term of climate and impact information. He first insisted on the need for the scientific community to become better educated about the reality of user needs and on the fact that it is not possible to develop the unique product that satisfies all the end-users. He then extensively defined what kind of information is expected from the users and discussed the way to deliver it. One of his main conclusions is that in a multi-stressor environment, there is a need for a progressive assessment of robustness for delivered climate change products that must be credible, defensible and actionable. Another one is that there is a need for improved approaches to evaluating and communicating messages - this including the need to communicate envelopes of climate change and transforming data to user parameters. In the following discussion, the point was made on the communication between climatologists and users and one conclusion was that there is a need for interface scientists knowing language of the two and making the link.

5. Technical issues

This session started with a presentation by Karl Taylor of the lessons learned from CMIP3 as far as

data storage and distribution are concerned. He began with an overview of what was done for CMIP3 and more particularly the role of PCMDI for supporting the project. He then detailed what contributed to the success of CMIP3, what where the encountered problems and how to improve the process. He finally gave a first estimate of the amount of data that will be required by the RCM community from the GCM community. As a summary of lessons learned in previous model intercomparison project he pointed out the need to avoid an overly-elaborate set of experiments, to articulate it with the science objectives, to precisely define the experimental design and the output required, and to require some model documentation prior to accepting model output for distribution. The following discussion was mainly focused on the requirements of the RCMs modeling groups concerning the data that could be provided by the GCM modeling groups participating to the CMIP5 exercise. Some of the main points raised during this discussion were that the core simulations should at least include transient simulations over the period 1950-2100 with 2 different scenarios. It was recommended that some standard for data format will be defined and that all the data could be accessed in one centre, possibly PCMDI. It was also recommended that two lists of model outputs will be defined, one for the data located in the central archive and one for the data kept by each modeling center. It will be possible for RCM modelers to download only the data needed for driving their models. A first evaluation of the dimension of the core archive was made and appeared to be as feasible by comparison to the whole CMIP5 archive. A more detailed assessment is however to be done.

In his presentation, Ole Bøssing Christensen made an overview of the PRUDENCE and ENSEMBLES regional climate model output databases in term of creation, content, volume, and accessibility. One key message concerned the initial underestimate of the required size of the ENSEMBLES database due to voluntary contributions from RCM modellers. He also presented the budget and resources needed for software, hardware and management of the database. He underlined the progresses accomplished between the two projects and the current status of the ENSEMBLES database and of the associated statistical downscaling portal. He gave a first estimate of the volume needed for a complete database associated to a new project on regional projection experiment coordinated at the international level. He concluded that it represented an order of magnitude more than ENSEMBLES but considered it as not hard and relatively cheap.

6. Discussion on a coordinated international activity

The discussion was organized on specific topics after each session of presentation (see the agenda) and we report here on the main exchanges on these topics before presenting the decisions reached by the group at the end of the meeting.

6.1 Interfacing RCD techniques within the coordinated regional projection experiment framework

It was first stated that statistical and numerical downscaling are complementary rather than competing. The point was made that the consistency between RCM and SD is difficult due to the diversity of downscaling methods and the differences of application focus in different sectors involving diverse communities. It appeared that a minimum consistency could be to choose standard calibration/validation periods. The question of horizontal resolution for statistical downscaling makes little sense, because the target is typically station locations, not grid points. Some other questions remain open like the value of SD from RCM outputs. It was finally decided to form a contact group not to discuss the merits of each method but for planning a comparison for some cases and to address in some ways the RCM/SD issue.

This contact group, chaired by Bruce Hewitson, met separately and reported during the final discussion. Three types of SD comparison/validation were identified. The first one consists in downscaling from reanalysis and then comparing to station data with distinction of different climate modes (dry or wet periods …). The second one consists in comparing the outputs from impact models, like crop or water resources models, driven by outputs from different downscaling methods. The third proposed comparison consists in using a high-resolution AMIP-like simulation,

a so-called “big brother experiment”, as a reference for a comparison of the different downscaling methods applied to a corresponding coarser resolution run. Other issues were also raised during the discussions of the group such as the exploration of the envelope of uncertainties with new methods and techniques, the physical consistency and the stationarity of either the statistics or the parameterizations.

It was finally concluded to later establish a sub-task force on validation.

6.2 Involving end users and developing country scientists within the regional climate projection experiment framework

The discussion first focused on the need to identify some actionable outcome of the exercise and the conclusion was made that one to three test cases should be identified. These practical examples, covering the whole process from the beginning to the end, in some regions and sectors, might show how science feeds in and helps at informing some decisions. The discussion also raised the issue of the funding support of the exercise, in particular in support of developing countries. It was argued that there is a value in participating in the exercise, like for CMIP, this will be compelling for people to participate in and will facilitate national support. It was proposed to have a document describing the organized framework to make it more visible and to show its own value. It was recognized that it will be necessary to demonstrate the added value for users compared to what is existing, the failure of the exercise if each group keeps only interest in its region, and the difficulty to go from the science to applications.

As a final decision, it was proposed to create a sub-task to look at test cases and past success stories for applications in a development decision-making context and make some recommendations. Bruce Hewitson will chair it, with Rob Wilby contributing.

6.3 Definition of the regions

The definition of the regions was considered as one of the first priorities in the definition of the design of the whole coordinated exercise. As it is linked to the choice of the regions and their extension, the issue of model resolution was first discussed. Some participants recommended choosing a 25 km resolution as this was for instance the case in the context of the ENSEMBLES European project. However other members of the group proposed a 50 km resolution for these simulations arguing that a 25 km resolution might be too constraining for developing countries and would be a constraint to enlarge the ensemble of simulations. In addition the issue of the added value of a 25 km resolution compared to a 50 km resolution was discussed and somewhere considering that, at least for Europe, the added value is more visible at a resolution of 10 km than at the resolution of 25 km. It was also argued that the difference between different models is generally higher than the difference between the two-targeted resolutions. No specific requirements could be identify from the impact community that commonly used statistical downscaling also directly from GCMs outputs. It was also noted that higher resolution required higher-resolution observations for validation. It was thus decided to start the exercise with a 50 km resolution and to make it mandatory to allow intercomparison on common domains. However, it was agreed that some groups could additionally make simulations at higher resolutions.

The discussion was then oriented on the choice of the domains and of their number. It was stated that, with a standard resolution of 50 km, the modeling groups could afford relatively large domains. A first guess of about 10 different regions was extensively discussed. It was proposed to account for existing projects on specific regions and also to try to cover all land regions but defining a few of them to concentrate on. Concerning these last, some agreement was on the fact that they should be chosen for scientific reasons (like tropical cyclone activity including an oceanic domain …) and that a priority should be given to regions that have received less attention and where it is important to provide information to end-users. Some participants insisted on the need to focus on a doable exercise in a short time, even if it cannot be completed before the AR5. Some other technical issues were also raised, like the relevance of using spectral nudging in the scenario simulations over large domains, the coupling of regional models in the Caribbean domain, or complementary use of statistical downscaling over some regions.

A contact group chaired by Filippo Giorgi met independently to make some proposal concerning the key 6 to 7 domains to select. The conclusion of this contact group given in the last session was that some agreement can be find for the selection of five key domains: Africa, South America, South East Asia and the domains directly related to the ENSEMBLES (Europe) and NARCCAP (North America) projects.

The last part of the discussion concerned the priorities given to the ensemble of simulations in the context of the calendar of AR5. It was proposed to first focus on Africa where there is a lack of regional scale information and due to its vulnerability to climate change, with the objective to contribute to AR5. It was also proposed to develop in parallel two other ensembles of simulations, one also for Africa but with another scenario (RCP 8.5 in addition to RCP 4.5) and an ensemble with the scenario RCP 4.5 applied to another region. A two-priority system was considered with a community of major centers concentrating first on Africa, but supporting activities on the other regions, and a community of other centers concentrating on their regions and Africa if they can.

However, since no definite conclusion could be given on the choice of complementary regions, it was decided to form a contact group to define some regions in the following couple of months in order to propose a list of domains as comprehensive as possible and to finalize at the Lund meeting (4-8 May 2009).

6.4 Selection of the emissions scenarios

Several emissions scenarios were considered of interest for the exercise. First, the RCP 4.5 is in the core of the CMIP5 GCM simulations and is the one chosen for the decadal simulation component. It is unfortunately not so close to the A1B scenario as initially considered in the discussion since it is between the B1 and A1T scenarios. However, some participants considered it as corresponding to a real world context and policy relevant. The RCP 8.5 was also considered as policy relevant in the context of the mitigation issue as it is associated to a high signal to noise ratio. It is also included in the core of the CMIP5 GCM simulations. On the contrary, RCP 2.6 and 2.9 are not included in this core, even if they were considered of interest for climate information as they are close to stabilization scenarios. The question of time slices for such scenarios was raised but not discussed further at this stage.

In conclusion to this discussion, it was decided that the RCP 4.5 and RCP 8.5 would be in the core of the regional simulation exercise. Concerning scenarios RCP 2.6 or 2.9 and time slice experiments, it was decided to expect to have some more feedback in Lund on the amount of data needed or whatever before coming to a definite conclusion.

6.5 Minimal set for experimental decadal prediction

As part of the general discussion on the design of the exercise, it was stated that projections for the next decades are very policy relevant. However some participants pointed out the requested ensembles of simulations needed to deal with internal variability could make the exercise too large to be on time for AR5 but moreover to keep it in reasonable limits in order to succeed. It was thus decided to create a contact group chaired by James Murphy that met separately and reported the last day of the meeting on the minimal set for the decadal prediction part of the regional modeling exercise.

The contact group first discussed the region of interest for this component of the modeling exercise and came to the conclusion that it is too early too choose because it remains unclear what kind of predictability can be expected. It was recommended to expect the assessment that will be done with the GCMs involved in CMIP5 before choosing a small ensemble of regions, but Africa might be one of them. Concerning the experimental design, the group made some specific suggestions. First, the RCMs should typically sample at least three different initial conditions per forcing GCM, as well for the forecasts and the hindcasts. Besides the forecast simulations over a 30-year period, it is proposed to perform two hindcast ensembles of simulations, the first one over the period 1980-2010 for verification and one over a wider period from 1990 to 2000 to test past predictability. The proposed decadal prediction exercise was considered as a post-AR5 activity

6.6 Design of the regional projection experiment framework

As a conclusion of the discussion of the above-mentioned specific issues, but also some other ones that are not reported here due to less extensive exchanges, the following decisions have finally been endorsed by the group:

1) We should define a general framework for the community to refer to (something along the lines of what AMIP and CMIP have been for GCMs) but we should start with a more limited effort to make sure achievable goals are set and achieved, specifically within the timeline of the AR5.
2) In terms of the evaluation and benchmarking experiments it was decided to use the ERA-Interim product (1989-2007) to produce lateral boundary conditions for Regional Climate Models (RCMs) and driving data for Statistical Downscaling (SD) (in the latter case recognizing that additional data might be used because of the short length of the ERA-Interim), until more extensive re-analysis products become available.
3) The initial standard resolution will be 50 km to enhance the feasibility of the experiments and the involvement of a wider community.
4) Although a comprehensive set of domains will be considered in the matrix of experiments, in particular covering all developing country regions, the initial focus will be on Africa and more specifically on a domain covering the entire African continent.
5) In terms of GCM-driven experiments, the first priority will be on the long term scenario simulations, and more specifically the periods
    a. - Historical run
    b. 2005-2100 – RCP4.5 scenario run
    c. 2005-2100 – RCP8.5 scenario run
6) Multiple GCMs should be used for driving the RCD in order to capture inter-model uncertainty

The consensus was evident in the room that the initial set up described above represented an optimal compromise and doable first step towards the definition of the broader framework.

A number of issues remained unresolved, and it is the task of the TFRCD to follow up on them in the next few months leading to the Lund meeting, where the TFRCD will meet again.

Unresolved issues leading to action items can be summarized in the following list. Lead TFRCD persons that agreed to take the lead for each action item are also listed, although it is obviously intended that a broader involvement of the community is necessary:

1) We should find a name/acronym for the project to give it an identity. Ghassem will have the final word on this, but two suggestions to start with are
    a. RCDIP: Regional Climate Downscaling Intercomparison Project – This would be the regional counterpart to the CMIP projects
    b. CORDEX: Coordinated Regional (Climate) Downscaling Experiment – This would be more along the lines of calling this an experiment.

   Lead person : Asrar
2) Produce a workshop report along with a possible paper (BAMS or other option)
   Lead persons: Giorgi, Planton
3) Fine tune the general framework
   Lead persons: C. Jones, Giorgi
4) Finalize choice of regions/domains
   Lead persons: Christensen, Kumar, Kwon, Gutowski, C. Jones (R. Jones also interested)
5) Identification of potential RCM participating groups
   Lead persons: Giorgi, Christensen, Gutowski
6) Identification and organization of the SD community:
   Lead person: Hewitson with C. Goodess
7) Data handling strategy, both for LBC and RCM/SD output
   Lead persons: Christensen, Gutowski, C. Jones

8) Identification of model-to-practice success stories (for eventual input into document above)
   Lead persons: Hewitson with Rob Wilby
9) Observation needs
   Lead persons: Hewitson with C. Goodess
10) Creation of regional “diagnostic” teams
   Lead persons: To be assigned
11) Sub-task force on RCM/SD intercomparison issues
   Lead persons: Gutowski, Laprise, Murphy, Hewitson
12) Look for funding options
   Lead persons: Everyone
13) Finalize a plan for the decadal predictions. The suggestion so far is to have the periods 2005-2035 (forecast), 1980-2010 (hindcast), 1990-2000 (hindcast). This is an issue for the longer term, but it may be good to finalize at least a recommended plan.
   Lead person: Murphy
14) Contact Isabelle Nyang concerning her participation to the TFRCD and start thinking of an alternate
   Lead person: Hewitson
15) Meeting and side event at COP15
   Lead persons: Asrar, Giorgi, C. Jones

Appendix 1: AGENDA

Wednesday 11 February 2008

13:30 – 14:00 Registration

Session 1: General framework

14:00 – 14:05 E. Brun (Météo-France Research Director): Welcome address

14:05 – 14:20 S. Planton - G. Flato – F. Giorgi: logistics, Introduction and objectives of the workshop

14:20 – 14:40 G. Asrar – WCRP perspective

14:40 – 15:20 G. Flato – WCRP/WGCM plans for global projection experiments in support of the AR5 – From decadal prediction to climate projections

15:20 – 15:40 J. Christensen – Regional climate change projections: Lessons from the AR4

15:40 – 16:00 Coffee break

16:00 – 16:20 F. Giorgi – Current thinking on coordinated regional projection experiment framework

16:20 – 18:30 Preliminary discussion on the coordinated regional projection experiment framework (F. Giorgi facilitator)

Thursday 12 February 2008

Session II: Regional climate downscaling techniques

8:30 – 9:10 F. Giorgi - Regional climate modeling: Status and open issues

9:10 – 9:50 R. Wilby – Statistical downscaling: Status and open issues

9:50 – 10:30 M. Deque: Variable resolution and time slice AGCMs: Status and open issues

10:30 – 11:00 Coffee Break

11:00 – 12:30 Discussion: How to best interface RCD techniques within the coordinated regional projection experiment framework (C. Goodess facilitator)

12:30 – 14:00 Lunch

Session III: Specific applications

14:00 – 14:40 T. Carter - Bridging the gap between climate information and impact/adaptation application

14:40 – 15:10 L. Sun – Use of regional climate models for seasonal prediction – Lessons for climate change application

15:10 – 15:40 K. Kolli– A review of regional climate downscaling activities in developing countries

15:40 – 16:00 Coffee break

16:00 - 16:20 B. Hewitson – Climate/impact/information needs in developing countries

16:20 – 18:15 Discussion: How to best involve end users and developing country scientists within the regional climate projection experiment framework (B. Hewitson facilitator)

Friday 13 February 2008

Session IV: Technical issues

9:00 – 9:30 K. Taylor – Data storage and distribution: Lessons from the CMIP3

9:30 – 10:00 O. Christensen – Data storage and distribution: Lessons from PRUDENCE and ENSEMBLES

10:00 - 10:30 Coffee break

10:30 -12:45 Final discussion on plan and technical issues concerning the coordinated regional projection experiment framework (C. Jones facilitator)

12:45 – 13:00 Closing and next steps (F. Giorgi/C. Jones)

Appendix 2: LIST OF PARTICIPANTS

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