WCRP World Climate Research Programme

Decadal prediction cross cut Annual Progress Report 2007 for JSC-29

CLIVAR Climate Variability & Predictability World Climate Research Programme

SCIENTIFIC IMPACTS, BALANCE AND RELEVANCE OF WCRP OVERALL

1. INTRODUCTION

The two overarching objectives of WCRP are:

1. to determine the predictability of climate, and:
2. to determine the effect of human activities on climate

Both of WCRP's objectives are addressed by a study of decadal prediction.

The WCRP strategic framework (WCRP, 2005) aims to facilitate analysis and prediction of Earth system variability and change for use in an increasing range of practical applications of direct relevance, benefit and value to society. Clearly work in the area of decadal prediction well fits this aim. More specifically, however, a key focus of the WCRP strategic framework is towards seamless prediction, and there are many theoretical and practical reasons for the weather and climate community to adopt a seamless prediction methodology (Hurrell et al, 2007). Decadal prediction is a "meeting ground" for the weather and climate modeling communities. The climate-change community is typically focused on the problem of estimating anthropogenically-induced climate change on centennial timescales. For this community, the provision of accurate initial conditions is not a major concern, since the level of predictability of the first kind is believed to be small on century timescales. By contrast, the numerical weather prediction and seasonal forecast community have well-developed data assimilation schemes to determine initial conditions, however the models do not incorporate many of the cryospheric and biogeochemical processes believed to be important on timescales of centuries. A focus on decadal prediction by the two groups may help expedite the development of data assimilation schemes in Earth system models, and the use of Earth system models for shorter-range prediction, e.g., seasonal. For example, as has been discussed elsewhere (Palmer et al 2008), seasonal predictions can be used to calibrate probabilistic climate-change projections, in a seamless prediction system. Hence there is common ground over which to base a cooperation of the two communities in order to develop seamless prediction systems.

2. CURRENT STATUS OF WCRP DECADAL PREDICTION ACTIVITIES

At JSC-28, a proposal was made for a cross cutting activity to advance the science of decadal prediction based on internationally-coordinated multi-model experimentation to gauge the overall level of predictability arising from having both different initial conditions and different greenhouse gas forcings. This activity, which will cut across all of WCRP's core projects, now is being led by a joint WCRP/CLIVAR/WGCM/WGSIP sub group, the members of which are: Tim Stockdale, Gabi Hegerl, Jerry Meehl, James Murphy, Ron Stouffer, Marco Giorgetta, Masihide Kimoto, Tim Palmer, Wilco Hazeleger, Detlef Stammer, Ben Kirtman and George Boer.

A detailed proposal is being developed on numerical experimentation to assess the expected skill of decadal predictions. It is anticipated that the programme of experimentation initiated by this programme will contribute to any IPCC fifth assessment report. The present version of the proposal describes a framework for coordinating intended experimentation covering two different but related objectives:

Objective 1: Short-term prediction of climate for the next 30 years [to 2030 or 2035]
Objective 2: Developing the science of multi-decadal prediction in the context of a changing climate

Experimentation addressing Objective 1 was called for at the Aspen meeting of 2006 (WCRP/IGBP/ICPO, 2007) and is currently being planned by various groups, in many cases using high resolution models, and is expected by the wider international community. However, many questions remain about how best to initialize such forecasts, and how to assess the uncertainties in the resulting predictions. Thus, experiments to assess and develop the science of multi-decadal prediction are needed (Objective 2), and individual groups are already starting to work in this area. To address Objective 2, the current plan requests a coordinated set of low resolution experiments and a common framework in which individual groups explore ideas and sensitivities. By linking the framework of the scientific development (often at low resolution) with the requested "best guess" predictions to 2035 (often at high resolution), scientific return is expected to be maximized and comparisons between the various experiments facilitated.

A draft detailed paper outlining the experiments is currently under discussion. In particular, for the Objective 1 experiments:

The aims are:

- To provide model integrations to allow estimation of the evolution of expected climate for the period 2005-2035, relative to the climate of recent decades.
- To encourage use of higher resolution climate models, with the hope of better resolving synoptic processes associated with extremes, and assessing the benefits of higher resolution in general.

The final analysis of expected climate in 2005-2035 should:

- Aim to give guidance on the changing risk of extremes
- Aim to give guidance on the possibility of changes in the monsoons
- Assess likely errors in the prediction, based on the spread of results from different models and different initialization techniques, and the errors seen in the ability of initialized climate forecasts to reproduce the observed changes of the last few decades - results from Objective 2 experimentation will be needed for this.
- Be a step towards probabilistic forecasts of near-term future climate, using a variety of methods and sources, including multi-decadal model predictions, empirical predictions based on attribution of observed changes to date, and results of other modeling studies.

The details of the modeling strategy are still under discussion; currently, Objective 1 requests 30 year model integrations with initial dates 1st November 1960, 1980 and 2005. Each start date should be run with a 3-member ensemble, optionally to be increased to O(10). Ocean initial conditions must represent in some measure the observed anomalies for the start date. A set of proposed experiments is also available for Objective 2.

A key issue for decadal prediction is the determination of the initial conditions for the state of the climate system. So far, this initialization discussion appears to have focused exclusively on the ocean, and a number of approaches to ocean data assimilation have been employed to provide ocean initial conditions. The activities of CLIVAR's Global Synthesis and observations Panel (GSOP) in promoting and evaluating ocean synthesis activities provide an essential input to the decadal prediction activity therefore. The Panel recently held a 2nd Synthesis Evaluation Workshop (MIT from 24-25 September 2007); among its goals was coming to quantitative conclusions about which of the existing synthesis products can provide inputs useful for decadal studies. The report of the meeting is in preparation. GSOP's input to initialization of model runs for IPCC AR5 will be on the agenda of the next GSOP meeting in Southampton, UK, in March 2008.

In addition to the above planning and evaluation activities, a number of other activities relevant to understanding of decadal variability and predictability are being carried out under CLIVAR. Decadal predictability is now a particular focus for CLIVAR's Atlantic Implementation Panel (AIP). The panel has promoted coordinated activities on this topic in the Atlantic, in particular RAPID/MOCHA, AMOC, German CLIVAR-related activities and new EU Framework 7 proposals on decadal predictability and observations in the subpolar gyre. The panel will contribute to EU and US efforts on MOC variability and predictability and is working with WGCM, GSOP and others on the planned WCRP cross cut decadal prediction studies (Wilco Hazeleger, the AIP co-chair, is a member of the planning group).

More specifically:

- The UK RAPID WATCH program, the successor of RAPID, will be funded by NERC to continue MOC monitoring at 26.5°N and further north at the western boundary, from 2008 until 2014. A focus added to RAPID WATCH, not present in RAPID, is the use of the MOC observations in decadal MOC and climate predictability.
- The EU FP7 project THOR, aimed at the stability of the THC and currently under negotiation, has as one focus decadal predictability of the MOC/THC.
- The EU FP7 project COMBINE, currently in planning for submission by 29 February 2008, has as one work package the ocean initialization of climate models for decadal prediction; another work package will be devoted to decadal predictions themselves. Details of the work packages are still under negotiation; the starting point are the recent papers on decadal predictability and prediction by European labs (Smith et al., 2007; Troccoli and Palmer, 2007; Keenlyside et al., 2008; Pohlmann et al., 2008).
- The German Ministry for Education and Research is funding a CLIVAR-related collaborative project "The North Atlantic as Part of the Earth System: From System Comprehension to Analysis of Regional Impacts", which has as one of its foci decadal predictability.
- NCAR, GFDL, and MIT are collaborating on the initialization of climate models for decadal-timescale predictability studies. A joint proposal is under review.

In addition the CLIVAR Atlantic Panel will:
- Convene a Decadal Predictability and MOC session at AGU Ocean Sciences, March 2008, Orlando, U.S;
- Organize a Workshop on Decadal Predictability, possibly in collaboration with a new EU FP7 programme.
- Meet with a US Atlantic Meridional Overturning Circulation (AMOC) investigators in late 2008/early 2009.

The CLIVAR Pacific Panel have been promoting a Pacific perspective on decadal prediction, emphasizing the effects of its changes on tropical and North Pacific climate and highlighting that decadal prediction is a prediction problem both of the first and second kind (anthropogenic boundary conditions vs. initial condition uncertainties). The Panel has now started an initiative to compute, from the CMIP3 database and the multi-parameter ensemble of the Hadley Center, the multi-model-multi-scenario ensemble mean and variance composites differences for the periods 2011-2020, 2021-2030 and 1980-2010. The analysis will focus on the Pacific and study the forced signal-to-noise ratio for the next 10 and 20 years. For this period the different emission scenarios are still quite similar, so the analysis will take them as members of one ensemble. Primary variables of interest are sea-level, thermocline depth, SST, T2M, P-E, winds. The assumption is that the decadal predictability of Pacific climate originates mostly from the boundary forcing (CO_2 and aerosols), rather than from internal climate modes (2nd kind versus 1st kind). Once the analysis is finished a BAMS article will be drafted.

The CLIVAR Indian Ocean Panel (IOP) have not overseen any research activities related to the decadal prediction and predictability so far. However, during the last IOP meeting in

Pretoria, South Africa, the IOP discussed future directions of its research activities, and all the members agree that the decadal variability and its predictability in the Indian Ocean would be important issue to be addressed in the near future. As the first step toward better understanding of the decadal variability, a possibility of studies on global climate model experiments and surface layer heat budgets using observations and reanalysis products were discussed. Tony Lee (JPL) and Gabe Vecchi (GFDL) were identified as leaders of the discussion on decadal variability and coupled GCM results, respectively.

Finally a white paper on decadal prediction and predictability of African climate with links to Indian and Atlantic Oceans is being developed by CLIVAR's Variability of the African Climate System Panel, with a previous paper published in BAMS (Reason et al., 2006) as a starting point. CLIVAR's Indian Ocean and Atlantic Panels will provide inputs.

POLICY RELEVANCE OF WCRP

Decadal prediction is extremely policy-relevant for WCRP. Firstly, reliable decadal predictions have application in many sectors: health, agriculture, water management, tourism, forestry, fisheries, hurricane predictions, arctic navigation, permafrost and methane gas emission, electrical power generation, shipping and offshore construction to name a few (Crawford et al., 2006, www.clivar.org/organization/pacific/BenefitsDecadalPredictions.pdf).

These applications would all be relevant without the additional complication of anthropogenic climate change (ACC). However, in the light of ACC, many public and private sectors are now facing the problem of assessing what infrastructure investment is needed to adapt to climate change. Whilst mitigation policy is relevant for controlling carbon concentrations several decades and longer ahead, infrastructure investment decisions in climate-sensitive areas are most relevant on the decadal timescale. Hence developing a reliable decadal prediction system will be a key contribution WCRP can make to the problem of climate adaptation.

Because of the importance of short-range climate prediction for climate adaptation decisions, it is conceivable that multi-decadal climate prediction from observed initial states will play a prominent role in the next IPCC assessment report.

ORGANIZATION AND GOVERNANCE OF WCRP

The proposed prediction activities being coordinated by the WCRP/CLIVAR/WGCM/WGSIP sub group will provide opportunities to draw on the expertise of scientists across the whole range of WCRP for their diagnosis and build on overarching issues which lie under the scope of both WMP and WOAP. In particular they require attention to both state of the art analysis and assimilation systems for initialization of coupled models and carefully designed numerical experimentation. Both of these are key issues for CLIVAR which brings considerable wider expertise to this activity (decadal variability is a cross-cutting science topic within CLIVAR which also has the lead within WCRP on the role of the oceans in climate). Further, GEWEX can supply important expertise on the role of land surface processes and in particular experimentation on how initialization of the land surface may influence decadal predictions. In addition, expertise on the role of ice for decadal prediction through involvement of CliC scientists and of the potential influence of stratospheric processes on decadal prediction via SPARC will also be crucial. As yet experts from CliC, GEWEX and SPARC, have had little opportunity for input to the proposed design and will need to be consulted on the design, including needs for subsequent diagnostic studies.

VISIBILITY AND COMMUNICATION BY WCRP

Development of the basis for decadal timescale prediction is a key activity with potential for high visibility for WCRP, in particular providing a legacy similar to that which emerged from TOGA and ongoing efforts under CLIVAR for seasonal prediction. WCRP must communicate its understanding of, and the potential for, decadal prediction to its stakeholders and then build on this as key science achievements and capabilities emerge. The role of decadal prediction as a meeting ground for the weather and climate modeling communities and a vehicle for seamless prediction will also need to be widely communicated to ensure the buy-in from a wide range of the community and from a broad

spectrum of agencies world-wide. It is also essential to involve and communicate with those involved with the potential applications of decadal prediction both through publicity, but more importantly through their involvement in activities to assess the utility of the predictions themselves and advertisement of emerging capability.

INTERACTION WITH OTHER BODIES

There are potentially considerable opportunities to develop interactions with other bodies, including e.g. the WMO World Climate and Applications Services Programme (and in particular its Climate Information and Prediction Services (CLIPS) project) as well as a wide range of potential user communities, especially agencies seeking predictions for long-term planning. Decadal timescale predictions will also provide an interface with a range of other programmes and in particular with IGBP in terms of the impact of variability on biogeochemical systems, with IHDP in terms of impacts on society and its ability to plan and input to any future IPCC assessments (e.g., on short-range projections for climate adaptation), providing the perspective of the influence of long timescale climate variability.

CAPACITY BUILDING IN/BY WCRP

As a cross cutting topic of WCRP, decadal prediction will provide a focus for development of capacity in terms of seamless prediction and to help direct the activities and requirements (e.g., for observations and assimilation and prediction systems within WCRP overall as well as more widely. Decadal prediction has potential for a wide range of prediction services, building capacity for planning across both the developed and developing world. It will also impact on capacity building at intraseasonal-seasonal-interannual prediction timescales through increased understanding of the role of decadal timescale variability on seasonal predictions themselves.

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