Components C&D of the Decadal Climate Prediction Project

The Decadal Climate Prediction Project invites groups to participate in any or all of four DCPP multi-model Components dealing with decadal Hindcasts, Forecasts, Predictability and Mechanisms, and Case Studies. The overall project is described in Appendix 1 and preliminary statements concerning Components C&D, dealing with Predictability and Mechanisms and Case studies, are found in Appendices 2 and 3.

DCPP Component A, the Decadal Hindcast project, is an updated version of the CMIP5 core experiment that produced a multi-model collection of retrospective decadal forecasts (i.e hindcasts), initialized from observations, that have been and are being analyzed to ascertain available predictive skill on annual, multi-annual to decadal timescales. The results to date reveal skill mainly in temperature on these timescale with indications of skill for precipitation and other variables in some regions. The updated Component A will reflect improvements in all aspects of coupled modelling, initialization and analysis, and prediction systems affecting prediction at these timescales. The results will also offer indirect information on decadal variability, predictability, and prediction skill.

Although variability and predictability information can be an indirect outcome of the hindcast experiment, more direct investigations of decadal predictability and variability are proposed for DCPP Components C&D. The goal is to better understand the mechanisms providing predictive skill and to identify the gaps resulting from model deficiencies and imperfections in initialization and ensemble generation. The aim is to coordinate multi-model investigations of a restricted number of studies of predictability and of case studies focusing on particular climatic events (e.g. climate shift, hiatus, etc.) together with broader issues which arise.

The predictability/variability component of the DCPP is under development and the Panel has identified, as initial seed for discussion, a number of items for consideration:

- Predictability and predictive skill over land: Why is it so weak? Is it because of model deficiencies in simulating the teleconnections with the continents or because of a too large variability that masks a predictable signal?
- Regional differences in predictability and skill: Why is predictability and skill weaker in the Pacific than in the Atlantic? Is it due to the intrinsic nature of the climate system?
- What is the relationship between Atlantic Multidecadal Variability (AMV) and Interdecadal Pacific Variability (IPV) and what does it imply in terms of predictability and predictive skill?
- Role of ocean initial conditions in climate prediction and predictability: To what extent is it crucial to initialize the ocean subsurface and are there regions in which the correct initialization is particularly important? To what extent is initializing

the deep ocean important and what are the roles of initial salinity anomalies vs. temperature anomalies?

- Role of volcanic forcing in decadal predictability: To what extent do volcanic eruptions affect decadal predictability and skill? Can strong volcanic eruptions produce NAO-type atmospheric responses that temporarily offset the decadal modes or trigger specific phases of the modes?

To answer these questions, initial experiments will be conducted by interested groups and, if warranted, coordinated experiments will be proposed. The community will be surveyed to ascertain its willingness to undertake the proposed experiments and if there is interest, the experiments will be adopted, keeping in mind that the selected experiments need to be comparatively inexpensive in terms of resources should all benefit from a coordinated framework. The CMIP infrastructure consisting of NetCDF metadata (controlled vocabularies), file names, and data archiving via the ESGF will be used.

The pan-CLIVAR meeting in La Hague is an opportunity to discuss the complementarities between CLIVAR research focus teams and DCPP Components A and C&D.

Appendix 1. The Decadal Climate Prediction Project (DCPP)

The term "decadal prediction" encompasses predictions on annual, multi-annual to decadal timescales. The possibility of making skilful forecasts on these timescales and the ability to do so is investigated by means of predictability studies and retrospective predictions (hindcasts) made using the current generation of climate models as well as by means of statistical approaches. Skilful decadal prediction of relevant climate parameters is a Key Deliverable of the WCRP's Grand Challenge of providing Regional Climate Information (http://www.wcrp-climate.org/index.php/gc-regionalclimate).

The DCPP envisions four components and invites groups to participate in any and/or all of them. The four components deal with decadal:

- *Hindcasts*: the design and organization of a coordinated decadal prediction (hindcast) component of CMIP6 in conjunction with the seasonal prediction and climate modelling communities
- *Forecasts*: the ongoing production of experimental quasi-operational decadal climate predictions in support of multi-model annual to decadal forecasting and the application of the forecasts
- *Predictability and mechanisms*: the organization and coordination of decadal climate predictability studies including the study of the mechanisms that determine predictability
- *Case studies:* the organization and coordination of case studies to investigate the ability to predict particular climate shifts and variations that have occurred and to identify the processes determining these behaviours

Many scientific and practical questions are involved. The understanding of the physical processes that govern the long timescale predictability of the climate system is vital to improving decadal predictions and these are explored using observations, climate model studies and the results of decadal hindcasts. The analysis of available observations for initializing forecasts, the improvement of the models used in the production of the forecasts, post processing of forecasts including bias adjustment, calibration and multi-model combination, together with the production and application of probabilistic decadal forecasts of modest skill, are all involved in the research and development efforts contributing to the DCPP. As has been the case for weather forecasting, continued improvement in each of the components of a decadal forecasting system is expected to yield improvement in decadal prediction skill.

The Decadal Climate Prediction Panel with membership from the Working Group on Seasonal to Interannual Prediction (WGSIP) the Working Group on Coupled Modelling (WGCM), the Decadal Variability and Prediction Focus of CLIVAR, and the CMIP Panel is attempting to coordinate of the scientific and practical aspects of the DCPP. A survey will seek community input on the design of the components of the DCPP.

Appendix 2: DCPP Component C: Predictability and mechanisms

The predictability of the climate system on annual to decadal timescales may be studied using physically based and statistical models. Diagnostic predictability studies investigate climate system behaviour inferred indirectly from a long series of observations and/or model simulations. Prognostic predictability studies investigate the behaviour of models when initial conditions or model features such as physical parameterizations, numerics or forcings are perturbed. These diagnostic and prognostic studies are characterized as studies of "potential predictability" since they do not represent the actual ability to forecast the system but rather an estimate of the potential to do so under ideal circumstances.

Predictability studies based on perturbations to models may be referred to as "perfect model" studies in the sense that one has perfect knowledge of the modelled climate system in terms of the computer code. They represent "attainable predictability" only to the extent that the model is sufficiently similar to the real system. The usual assumption is that predictability is an upper bound on the practical skill that can be obtained in an actual forecast, although this may not always be the case. Nevertheless, predictability studies give some indication of the regions and timescales for which skilful forecasts may be possible and may also be used to study aspects of the physical mechanisms and processes involved.

In some cases, model-based predictability results may underestimate actual predictive skill, rather than providing an upper bound, if modelled behaviour deviates sufficiently from that of the real world. It is important to identify the climate statistics that signify these model deficiencies which are also expected to reduce skill when the models are

used to make actual forecasts. Modelling groups will be encouraged to calculate and make available a comparatively small subset of standard climate statistics which may be used to identify these deficiencies and from which estimates of predictability and other measures may be derived. These diagnostics will also serve as input to multi-model intercomparisons and analyses directed toward improving models, forecast systems, and predictability measures.

Predictability studies demand careful practical and statistical design. The predictability component of the DCPP is under development and a proposal will be circulated to potential participants shortly.

Appendix 3: DCPP Component D: Case Studies

Case studies are hindcasts which focus on a particular climatic event and the mechanisms and impacts involved. These are typically hindcast studies of an observed event although they can include particular kinds of events in model integrations (variations of AMOC and the associated variation of N Atlantic SSTs in models are an example). Studies of the skill with which a particular event (e.g. the hiatus, climate shift, extreme year, etc.) can be forecast and the mechanisms which support (or perhaps make difficult) a skilful prediction are of considerable interest.

The DCPP will attempt to coordinate a multi-model investigation of a very restricted number of case studies of general and sufficient interest. The community will be surveyed to ascertain its willingness to undertake the integrations and analyses necessary for a coordinated case study and the particular case or cases that merit community attention of this kind.