A Prospectus for a US-CLIVAR Working Group On Decadal Predictability

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I. Motivation and Background

Through the research efforts of numerous scientists and working groups, such as the CLIVAR AMOC WG, it has been increasingly clear that a global strategy is required to understand and predict decadal climate variability. This conclusion is based on findings that indicate that significant dynamical connections exist between the tropics/extratropics, Pacific/Atlantic basins, ocean/land etc. In addition, the results of previous studies and working groups have identified the importance of furthering our ability to distinguish between natural and forced decadal variability in order to identify climate impacts due to an increase in greenhouse gases. International and national efforts are currently underway to study decadal prediction in climate models (for example, the PREDICATE and the US-CLIVAR Atlantic Meridional Overturning Circulation Planning Team, though both of these efforts emphasize the Atlantic basin) and there is increasing interest among user communities for decadal climate information. A U.S. CLIVAR working group focused on these questions will further our understanding of the mechanisms that cause decadal variability, the decadal climate response to an increase in greenhouse gases, and potential impacts on user communities.

The purpose of this document is to outline objectives for a U.S. CLIVAR Working Group on Decadal Predictability (DPWG). This Working Group seeks to advance the science of decadal prediction through *(i)* augmenting existing efforts underway in the Atlantic basin by developing a global framework for understanding decadal variability that can be used as a strategy to validate and initialize climate models and to *(ii)* define a mechanistic framework to distinguish natural variability from anthropogenically forced variability on decadal timescales.

II. Objectives

Objective 1: The first objective of the working group will be *to develop a global framework for understanding decadal variability that can be used as a strategy to validate and initialize climate models*. This involves the following tasks:

1.1. Define frameworks for decadal prediction

The phrase "decadal prediction" conjures different ideas in different research communities. A part of the discrepancy between definitions of a decadal prediction stems from a lack of agreement about how the research community might proceed with decadal predictions, or possible *frameworks* for decadal prediction. Examples of prediction frameworks include: *a)* seamless initiated

prediction, in which weather forecast models are initialized with the observed state of the climate system and integrated forward for some period; *b)* a "phenomenon / mechanism" approach which identifies a well defined phenomenon (e.g. ENSO) that evolves via some physical mechanism with a long time scale, and predicts its evolution through some knowledge of its present state; or *c)* "forced predictability" in which the initial state of the system may not matter, and the trajectory of the system is determined by anthropogenic forcing. A completely different framework for decadal prediction includes a "bottom-up" framework, in which the effect of climate variability on a specific impact system is understood through better understanding of the impact system itself. A "decadal prediction" would then involve predicting the changing effect of climate variations (even if the variations are unpredictable) as the impact system evolves. This task will help to define the role of the user community in shaping the definition of "decadal prediction".

1.2. Identify metrics to assess the simulation of decadal variability in climate models

Discussions of decadal predictability are hindered by differing definitions of decadal prediction due to different choices of metrics. For example, the definition of a "skillful" forecast may differ depending on the metric with which the forecast is "verified". As an example, consider a near perfect forecast of some climate parameter that has no present relevance to society. The *quality* of the forecast may be quite good, but its *usefulness*, and as a consequence its *value*, will be low. Alternatively, a forecast with only moderate skill (quality) in a given region may be extremely valuable to a specific user group. Again, these discussions will clarify the role that user communities provide in helping to shape the definition of "decadal prediction". The DPWG will identify relevant metrics for evaluating forecast skill, with an emphasis on climate-related parameters. Additionally, the DPWG will identify metrics that will address the *usefulness* of decadal forecasts for broad impact systems[1] (e.g. continental drought, with input from the Drought Working Group).

The DPWG will initially focus on process-oriented metrics to assess the simulation of decadal variability in climate models. The goal of this task is to provide a framework that can be used to assess and compare coupled climate model simulations of decadal variability in order to advance model improvement and to serve as a standard for model performance in the upcoming IPCC AR5 report.

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[1] Due to the specificity required of a wide variety of different impact systems, a full assessment of specific needs of user communities is well beyond the scope of the DPWG. However, it would also be naïve to proceed in the absence of information required by specific impact systems. Hence, the DPWG will focus on a few broad impact systems, such as continental drought.

1.3. Identify what limits our ability to simulate and predict decadal variability in climate models

Using the frameworks and metrics identified in the two tasks above, we will synthesize the recent findings of the U.S. CLIVAR Drought Working Group, the WCRP / International CLIVAR Decadal Prediction Cross Cut, the AR5 modeling activities, and existing efforts at understanding decadal predictability in the Atlantic in order to develop an overarching global perspective on decadal predictability. The DPWG will focus on identifying what limits our ability to simulate and predict decadal variability. This will involve an assessment of observational and empirical statistical model studies of current and past climate variations, model simulations of decadal variability, and proposed mechanisms for decadal variability. The comparison will focus on limitations of attributing decadal variability to specific basins or large-scale processes, and implications for decadal prediction. The DPWG will potentially focus additional effort on the Pacific, in order to *(i)* compliment existing efforts in the Atlantic, and *(ii)* maintain a reasonable scope for the DPWG.

What is the role for U.S. CLIVAR in achieving this objective? Through outlining different frameworks and metrics for decadal prediction, this task will facilitate communication between very different efforts at decadal prediction now ongoing in the scientific community. The findings of the DPWG will contribute to the upcoming IPCC AR5 report by providing a global framework for assessing simulations of decadal variability in coupled climate models. The DPWG will potentially also focus additional effort on the Pacific, which would compliment existing efforts in the Atlantic.

Expected deliverables:
The tasks outlined above will be written up into a white paper entitled "Moving towards decadal prediction" to be submitted to *BAMS* and a workshop on "Defining Metrics to Assess Decadal Predictions in Climate Models" to be held concurrently with the Eighth Decadal Variability Workshop.

***Objective 2*:** The second objective of the working group will be *to define a mechanistic framework to distinguish natural variability from anthropogenically forced variability on decadal times.* This objective involves the following tasks:

2.1 Define a mechanistic framework to distinguish natural variability from anthropogenically forced variability on decadal times

Empirical statistical model studies suggest that natural and anthropogenically-forced decadal variability have distinct spatial structures and timescales. This finding indicates that different physical processes may be controlling these two types of variability. In this working group we seek to identify to what extent a mechanistic basis can be established to separate natural decadal variability from anthropogenically-forced decadal variability. In this objective we will use

observational studies of current and past climate together with empirical statistical model studies to suggest process-oriented strategies for separating anthropogenically-forced and naturally occurring decadal variability. Any progress in the area will greatly benefit the climate community's ability to predict decadal variability, as well as project the impact of an increase in greenhouse gases on future climate.

What is the role for U.S. CLIVAR in achieving this objective? Ongoing efforts at understanding decadal variability do not focus on implications for decadal prediction. Existing efforts at decadal prediction in the Pacific assume predictability emerges mainly from external forcing, rather than uncertainty in initial conditions (Marotzke and Cattle, 2008). The DPWG will help to quantify the role that natural variability plays in decadal prediction.

Expected Deliverables: Deliverables from this objective will include *(i)* a workshop on "Isolating Natural Decadal Variability in the Climate Record" to be held concurrently with the Ninth Decadal Variability Workshop and as existing efforts at short term (~30yr) climate projections evolve, the DPWG will *(ii)* recommend a call by funding agencies for numerous small projects (similar to DRICOMP) to investigate decadal predictability in the short-term AR5 model projections.