



Climate-system Historical Forecast Project (CHFP)

One of the overarching goals of the WCRP is determine the predictability of the complete climate system on time scales of weeks to decades. By complete climate system, we mean contributions from the atmosphere, oceans, land surface, cryosphere and atmospheric composition in producing regional and seasonal climate anomalies. Advances in climate research during the past decade has lead to the understanding that modeling and predicting a given seasonal climate anomaly over any region is incomplete without a proper treatment of the effects of SST, sea ice, snow, soil wetness, vegetation, stratospheric processes, and chemical composition (carbon dioxide, ozone, etc.). The observed current climate changes are a combination of anthropogenic influences and the natural variability. In addition to possible anthropogenic influence on climate due to changing the atmospheric composition, it is quite likely that land use in the tropics will undergo extensive changes, which will lead to significant changes in the biophysical properties of the land surface, which in turn will impact atmospheric variability on seasonal time scales. It is therefore essential that the past research by two somewhat non-interacting communities (i.e., climate change and seasonal prediction) be merged into a focused effort to understand the predictability of the complete climate system.

This problem of prediction and predictability of seasonal climate variability is necessarily multi-model and multi-institutional. We argue that the multi-model approach is necessary because there is compelling evidence that, with imperfect models, perturbing the physics of the models is superior to perturbing initial conditions of one model in terms of resolving the probability density function or quantifying the uncertainty. A multi-model approach is essentially a simple and consistent way of perturbing the physics. Moreover, by testing our hypotheses with multiple models it is possible to determine which results are model independent, and hence likely to be robust. This problem is also necessarily multi-institutional simply because the level of effort and computational resources required is just too large for any one institution. This multi-model multi-institutional aspect of the problem requires WCRP coordination.

In 2005, the WCRP formed the Task Force on Seasonal Prediction (TFSP) and commissioned it over two years to assess current seasonal prediction capability and skill considering a wide range of practical applications, and to enable the development and implementation of numerical experimentation specifically designed to enhance seasonal prediction skill and the use of seasonal forecast products for societal benefit. Since June 2007, the TFSP has ceased to exist and its mandate has been transferred to the CLIVAR Working Group on Seasonal to Interannual Prediction (WGSIP). WGSIP has now assumed the primary role of TFSP, that is to insure that these experiments are coordinated across all relevant WCRP activities, and that the seasonal prediction data is made readily available to both the applications and physical science communities. The various components of the WCRP will continue to lead assessment of the forecasts, developing strategies and experiments for improving the forecasts and component model, and observing system evaluations and process study and field campaign integration. The First WCRP Seasonal Prediction Workshop, held in June 2007, addressed how to improve seasonal prediction and how to assess our progress in improving forecasts and their utilization for societal benefit and, in early 2008, a WCRP position paper on seasonal prediction will be produced as the main deliverable of the Workshop.

A comprehensive seasonal prediction experiment is proposed that is designed to test the following hypothesis:

There is currently untapped coupled predictability due to interactions and memory associated with all the elements of the climate system (Atmosphere-Ocean-Land-Ice).

The results of these experiments provide a framework for future experiments, specifically these prediction results will:

- Provide a baseline assessment of our seasonal prediction capabilities using the best available models of the climate system and data for initialisation.

- Provide a framework for assessing of current and planned observing systems, and a test bed for integrating process studies and field campaigns into model improvements
- Provide an experimental framework for focused research on how various components of the climate system interact and affect one another
- Provide a test bed for evaluating IPCC class models in seasonal prediction mode

It is recognised that certain elements of the proposed experiment are already part of various WCRP activities. The intent here is to leverage these ongoing activities and to coordinate and synthesize these activities into a focused seasonal prediction experiment that incorporates all elements of the climate system. These experiments are the first necessary steps in developing seamless weekly-to-decadal prediction of the complete climate system.

2.1 Total Climate System Prediction Experiment Proposal

The core experiment is an ‘Interactive Atmosphere-Ocean-Land-Ice Prediction Experiment’ emphasizing the use of comprehensive coupled general circulation models, which includes realistic interactions among the component models. The experiment is to perform seven-month lead ensemble (10-members) predictions of the total climate system. If possible longer leads and larger ensembles are encouraged. The initialization strategy is to use the best available observations of all the components of the climate system.

While the emphasis is on comprehensive coupled general circulation models, uncoupled component, intermediate, simplified and statistical models are encouraged to participate where appropriate. The fundamental experimental design is to mimic real prediction in the sense that no “future” information can be used after the forecast is initialized. For example, the PROVOST or DSP experiments would be excluded because they use observed SST as the simulation evolves, whereas the SMIP/HFP experiment could be included as subset since no future information is used as the forecast evolves¹.

The component models should be interactive, but this is left open to accomplish a wider participation, e.g. for groups without sea-ice or vegetation model. The only requirement is that no “future” information is used once the prediction is initialized. This requirement necessarily includes any tuning or training either the component models or the development of statistical prediction schemes.

Thus, the component models are:

- Ocean – Open but interactive (e.g., slab mixed layer or GCM)
- Atmosphere – Open but interactive (most likely a GCM)
- Land – Open but interactive (e.g. SSiB, Mosaic, BATS, CLM, Bucket)
- Ice – Open but interactive (e.g., thermodynamic or dynamic)

The results of these experiments provide a framework for future experiments, specifically these prediction results will:

- (i) Provide a baseline assessment of our seasonal prediction capabilities using the best available models of the climate system and data for initialisation.
- (ii) Provide a framework for assessing of current and planned observing systems, and a test bed for integrating process studies and field campaigns into model improvements
- (iii) Provide an experimental framework for focused research on how various components of the climate system interact and affect one another
- (iv) Provide a test bed for evaluating IPCC class models in seasonal prediction mode

¹ The SMIP/HFP experiment is viewed as a subset of the experiments proposed here since they do not necessarily include feedbacks from land surface or sea ice processes or the initialization of these components of the climate system.

The TFSP recognizes that certain elements of the proposed experiment are already part of various WCRP activities. The intent here is to leverage these ongoing activities and to coordinate and synthesize these activities into a focused seasonal prediction experiment that incorporates all elements of the climate system. These experiments are the first necessary steps in developing seamless weekly-to-decadal prediction of the complete climate system.

The parameters of the experiment are as follows:

- (i) Coupled models and resolution are left to the individual participants, but it is desirable that the models have a realistic simulation of the atmosphere, ocean, land and ice and the interactions among these components. Simplified component models (e.g., slab mixed layer or statistically predicted ice) are acceptable as long as the no future information is used in developing the simplified model.
- (ii) Atmospheric initial states to be taken from NCEP (or ECMWF) reanalysis each February, May, August and November of each year from 1979-present. Forecasts should be initialized on 00Z and 12Z on the last five days of each preceding month forming a 10-member ensemble. Other strategies for generating the ensemble members are acceptable as long as the basic principle of no future information as the forecast evolves is not violated. Each ensemble member should be run for at least six months. Additional ensemble members and longer leads are encouraged.
 - a. Addition retrospective forecasts using each month of each year from 1979-present are encouraged.
 - b. Additional retrospective forecast using initial conditions from each February, May, August, and November 1960-1978 are encouraged.
- (iii) Oceanic initial states: (if appropriate) to be taken from most appropriate ocean data assimilation system.
- (iv) Sea Ice initial states: (if appropriate) to be taken from best available observational data.
- (v) Land initial states: (if appropriate) to be taken from most appropriate land data assimilation system or consistent offline analyses driven by observed meteorology (i.e., GSWP; GLACE2).
- (vi) Atmospheric output:
 - a. Every 24 hours at 00 GMT-
 - i. Pressure levels (instantaneous): Geopotential Height, Temperature, Velocity and specific humidity for 850, 500, 200, (if available 100, 50, 10; these higher pressure levels are used for interactions with SPARC) hPa.
 - ii. Surface (instantaneous): 2m Tmax – daily, 2m Tmin – daily, Total soil moisture, Snow depth, Sea surface temperature and surface radiative temperature over land (if available), Mean sea level pressure, soil heat flux over land (if available).
 - iii. Surface (accumulated): Total precipitation, Downward surface solar radiation, Downward surface longwave radiation, Surface net solar radiation, Surface net longwave radiation, Top net solar radiation, Top net longwave radiation, Surface momentum flux, latent and sensible heat flux.
 - b. Every 6 hours at 00, 06, 12, 18 GMT-
 - i. Surface (instantaneous): Total cloud cover, 10m wind, 2m Temperature, 2m Dew Point, 2 m specific humidity.
- (vii) Oceanic output (where appropriate)
 - a. Every Month-
 - i. Accumulated temperature, salinity and currents in the (at least) upper 400 m, surface fluxes of heat, momentum and fresh water, sea level height, mixed layer depth.
 - b. Every 24 hours at 00 GMT-

- i. Temperature, salinity and currents in the (at least upper 400 m) at the equator, 2N and 2S (5N and 5S optional).
 - c. Every 6 hours at 00, 06, 12 18 GMT-
 - i. Surface fluxes of heat, momentum, and freshwater. Sea surface temperature and mixed layer depth
- (viii) Sea Ice output (where appropriate)
 - a. Every 24 hours at GMT –
 - i. Surface fluxes of heat and momentum. Snow cover, Sea ice concentration, thickness and temperature.
- (ix) Soil wetness and vegetation predicted.
- (x) Snow cover and depth predicted.
- (xi) Chemical Composition (carbon dioxide, ozone ...) prescribed and varying. This explicitly includes the transient changes in the chemical composition from 1979-present.
- (xii) Finally, it is noted that some forecast provides may no be able to provide the complete list noted here. Participation is strongly encouraged even if all the data requirements cannot be met.

2.2 Examples of Potential Diagnostic Sub-Projects

In order to maximize collaboration and duplication of effort, the proposed experiment will include a diagnostic sub-project approval process. The following is an abbreviated list of potential sub-projects. It is anticipated that a large number of addition sub-projects will be implemented as the experimental results become available.

- Limit of Predictability Estimates: One potential estimate for the limit of predictability is to determine when a particular forecast probability density function (pdf) is indistinguishable from climatological pdf of the forecasts.
- ENSO mechanism diagnostic: Recharge oscillator versus delayed oscillator, role of stochastic forcing, westerly wind events.
- Impact of the AO on seasonal predictability
- Regional predictability
 - Local land surface predictability
 - Extreme events
 - Monsoon predictability
 - Diurnal cycle in ocean
 - Diurnal cycle in the atmosphere
- Coupled Feedbacks
 - Intra-seasonal oscillations
- The diagnostic sub-projects will also include extensive interactions with the applications community and the regional panels within CLIVAR, GEWEX, SPARC and CliC. These interactions and collaborations are viewed as critical elements of the implementation plan and are strongly encouraged.