A Methodology for North American Decadal Climate Prediction

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Final Report

Results and accomplishments

a. Year 1

Our implemented strategy in the first year of the proposal involved assessing the overall effect of external radiative forcing on climate since 1980, in addition to exploring the impact of the externally forced changes in SSTs and sea ice alone. To assess the former, a large suite of 20^{th} Century climate simulations was completed with CCSM4. To assess the latter, we conducted atmospheric model simulations to assess the impact of long-term (1880-2012) changes in observed ocean boundary conditions on North American climate variability.

We also estimated the North American climate due to the SST trajectory associated with internal climate variability. Our strategy used two different atmospheric models to simulate the variability in climate since 1979 that resulted principally from internally generated mechanisms, including internal variability in SSTs and also atmospheric noise alone. We performed long (600-yr) integrations of CAM4 subjected to repeating annual cycle boundary forcings, the purpose of these runs being to determine North American decadal variability that may have originated from purely internal atmospheric dynamics. The effect of this mechanism represents the fraction of decadal variability unconstrained by either natural boundary forcing or external radiative forcing. This component is understood to be inherently unpredictable for the time scales under consideration, and thus not reducible by methods of data assimilation, initialization, or model improvement.

Several papers, listed in the year 1 progress report, were completed and published.

b. Year 2

During the second year our work continued to focus on complementary research themes: model simulations to quantify role of internal variability and role of changes in external forcings on climate; analysis of skill of decadal prediction and assessment of decadal predictability; role of internal variability and external forcings on climate extremes; and understanding of decadal variations in observed regional climate conditions, especially over the U.S. Details of our efforts were provide in the year 2 progress report. Briefly, it included:

- Model simulations: we continued to expand ensemble size of climate simulations, including both AMIP and fully coupled simulations.
- Analysis of prediction skill and assessment of predictability: we completed an analysis of skill of initialized decadal predictions with the CFSv2, focusing on skill in prediction of SSTs coupled modes of variability.
- Role of internal variability and external forcings on extremes: availability of large ensemble of seasonal hindcasts spanning last 30-years, and forced with observed changes in anthropogenic forcings, provided a unique opportunity to assess its influence on seasonal variability. The results of our analysis, for instance, indicated that the increasing global and U.S. temperatures over the last 30 years are predominantly the result of shifts in the mean temperature distribution and not due to an increase in temperature variability.

- Understanding of decadal variations in observed regional climate conditions, especially over the U.S: we examined how observed regional drying may be linked to decadal ocean variability, and also explored linkages to other emergent decadal conditions including an apparent rapid poleward expansion of the Hadley cell. In particular, we studied the factors associated with the development of a U.S. dry regime in the last decade, and found confirmation for a sensitivity to decadal ocean conditions as one of the driving mechanisms.

Several papers, listed in the year 2 progress report, were completed and published.

c. Year 3

In the final year our work focused on following research themes: model simulations to quantify role of various forcing on decadal climate variability; potential of extratropical sea surface temperature anomalies for improving climate predictions; and low-frequency variability in El Niño – Southern Oscillation that could be one of primary factors responsible for decadal variability over the U.S., e.g., droughts. Briefly, it included:

- Model simulations: the completion of five different sets of 20-member ensemble climate simulations in support of this project. Some of these data are now available to the broader community via a data repository and interactive web tool portal (http://www.esrl.noaa.gov/psd/repository/alias/facts/). All data sets are available upon request.
- Characterizing Decadal Variability/Predictability of U.S. Heavy Rainfall: we characterized decadal trends in heavy daily precipitation over the contiguous US. Our results revealed a large spread in 1979-2013 heavy precipitation trends among identically forced ensemble members of historical coupled simulations, indicating that particular traces of internal coupled ocean-atmosphere variability could be especially relevant for interpreting recent observed trends, and for predicting their evolution. By studying the regionality and seasonality of observed and model simulated heavy precipitation trends, we provided physical arguments that support a view that recent atmospheric trends have been strongly forced, though less by human induced climate change than by decadal ocean variability.
- Potential of extratropical sea surface temperature anomalies for improving climate predictions: we revisited an analysis approach based a simple model that replicates the essential characteristics of coupled ocean–atmosphere interaction in extratropical latitudes. We demonstrated that lack of additional skill in predicting atmospheric and terrestrial variability is more a consequence of fundamental characteristics of coupled evolution of ocean–atmosphere system.
- Understanding low-frequency variability in ENSO: a comparison between two 480-year model simulations with and without ENSO variability suggested that ENSO can alter the characteristics of precipitation, and thus droughts over the Southwest in terms of frequency and intensity. The modeling study we conducted also demonstrated a sensitivity of the Southwest precipitation-related teleconnection to both the phase and intensity of ENSO, which helps understand the observed decadal changes in the strength of the link between Southwest precipitation and ENSO.

Several papers, listed in the year 3 progress report, were completed and published.