**Ensemble Seasonal Forecasting Initialized from Multiple Ocean Analyses with CFSv2**

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A seasonal ensemble prediction from a given initial time is usually generated by a set of perturbed atmospheric states (AIC) paired with one oceanic state (OIC) from a single data assimilation system. Given the relatively large uncertainty of current ocean analyses, however, an ensemble of perturbed OICs should also be introduced to cover its range of uncertainty and sample the potential error sources adequately. In this study, the impact of OIC uncertainty on seasonal forecast is examined through a set of hindcast experiments using the Climate Forecast System, version 2 (CFSv2), the current operational climate prediction model at the National Centers for Environmental Predictions (NCEP). Specifically, four sets of OICs, chosen from different state-of-the-art oceanic analyses, are used to initialize the 12-month hindcasts starting from April for 1979 to 2007. These oceanic analyses include the GODAS and CFSR by the NCEP and the ORA-S3 and COMBINE-NV by the European Center for Medium Range Weather Forecasts (ECMWF). To reduce the climate drift from various oceanic analyses, an anomaly initialization strategy is used for all hindcasts. For each OIC, four ensemble members are generated with slightly different atmosphere and land initial states derived from the CFSR. This multi-ocean initialization approach takes into account uncertainties in the ocean analysis arising from different models, data assimilation schemes, surface fluxes and oceanic observations.

The predictive skill in the tropical Pacific Ocean (i.e., ENSO) is assessed based on the ensemble mean hindcasts from each individual as well as multiple oceanic analyses. The results indicate that there exists a substantial spread in the sea surface temperature (SST) prediction skill with different ocean analyses. Specifically, the ENSO prediction skill in terms of the anomaly correlation of Niño-3.4 index can differ by as much as 0.1-0.2 at lead times longer than 2 months. The ensemble mean of the predictions initialized from all four ocean analyses gives prediction skill equivalent to the best one derived from the individual ocean analysis. Furthermore, compared to forecasts perturbed by AIC only, perterbing OIC gives a better ensemble spread. It is suggested that more accurate OIC can improve the ENSO prediction skill and an ensemble ocean initialization can provide a more reliable prediction.

The prediction skill of the summer precipitation in contiguous US is further analyzed. Both the CFS Reanalysis and Reforecast Project (CFSRR) and multi-ocean initialization runs show relatively high prediction skills over northwestern US. The source of predictability is diagnosed from the hindcast datasets and observations.