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Decadal Prediction in the Pacific using a High Resolution Climate Model

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In a near-term climate prediction covering the period up to 2030, we require knowledge of the future state of internal variations in the climate system as well as the global warming signal (i.e. response to external forcing). In particular, the Pacific Decadal Oscillation (PDO) is a dominant internal oscillation with phase shifts developing on decadal timescales. Recently, we performed ensemble decadal hindcast experiments with initialization, and explored predictability of the PDO (Mochizuki et al. 2010 in PNAS). Here, we build on our earlier experiences, by employing ensemble hindcast experiments using a higher-resolution climate model.
We perform 3-ensemble hindcast experiments w/o and w/ initialization (hereafter called as the NoAS and HCST runs, respectively), using a coupled atmosphere-ocean climate model (MIROC4 composed of T213L56 AGCM and 1/6-1/4deg. 48levs. OGCM). The boundary conditions are derived from historical data (up to 2000) and RCP4.5 scenario (after 2001). Our initialization for the HCST runs is based on data assimilation approach. Using MIROC4 and a gridded ocean temperature and salinity dataset upper 3000m depth, we perform an anomaly-assimilation run with the incremental analysis update method. The initial conditions in the HCST runs are defined using snapshots of this data assimilation run with the lagged average forecast method (time interval is 3months). We perform 10-sets of 10-year-long 3-ensemble hindcasts, every five years after 1961 (i.e. Jan1961-Dec1970, Jan1966-Dec1975, Jan1971-Dec1980,...).
When compared to the NoAS run, the root-mean-squared errors for 5-year hindcasts are slightly reduced in the HCST run, particularly over the central North Pacific where the PDO signals are simulated and observed strongest, and over the high-latitude of the North Atlantic. Anomaly correlation coefficient values also indicate large impacts of the initialization on the 5-year hindcasts over the mid- and high-latitudes of the North Pacific (e.g., downstream of the Kuroshio Oyashio Extension) and the high-latitude of the North Atlantic. In a statistical sense, the initialization reduces hindcast errors in initial 5-year-mean states of the PDO. In particular, in some cases of the HCST runs (e.g., during 1986-1995), the hindcasted PDO time series result in a favorable comparison with the observations. Changes in the strength of the Atlantic Meridional Overturning Circulation, defined here as the sea-surface-temperature differences between the equatorial Atlantic and high-latitude of the North Atlantic, also suggest good agreement with our objective analysis.
In terms of global-mean surface-air-temperature (SAT), the long-term variations (e.g., linear trends) are largely controlled by the external forcing and reasonably reproduced by the NoAS and HCST runs throughout virtually all of the hindcast periods, while the absence of an initialization in the NoAS run leads to a failure in simulating the late-1970s change in climate. The HCST run during 2006-2015 suggests that recent slowing down of the SAT rise (due to internal variability) will persist at least until early 2010s.
Overall, preliminary results for the HCST runs indicate, at least, a similar level of performance in decadal hindcasts, when compared to 10-ensemble hindcast experiments using a medium-resolution climate model. The HCST runs are capable of providing us with detailed regional information in addition to reproducing large-scale decadal climate variation (e.g., the PDO), while it may not be easy to hold fully significant discussions due to the small number of ensembles (i.e. three).