Insights into multi-year and multi-decadal predictability from ocean initial conditions in the CESM2 Large Ensemble

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The CESM2 Large Ensemble (CESM2-LE) includes 100 ensemble members of historical and SSP370 simulations over 1850-2100 with differing initial conditions, such that it samples different realizations of internal variability. Specifically, it uses two types of perturbations to the initial state: (1) differences in the ocean initial state (taken from a pre-industrial control run) and (2) random perturbations to the atmosphere. We explore the influence of ocean initial conditions on multi-year and multi-decadal predictability in CESM2 by examining four 20-member subsets of the CESM2-LE. The four sub-ensembles have different ocean initial conditions, which were chosen to sample different states of the Atlantic Meridional Overturning Circulation (AMOC), while differences within the sub-ensembles are only due to random perturbations to the atmosphere. This allows us to assess the fraction χ of variance originating from differences in ocean initial conditions. We use a χ-maximizing EOF analysis to identify the anomaly patterns that are most predictable from ocean initial conditions. We find AMOC, SST, and SLP anomaly patterns with statistically significant differences between ocean initial states that persist for more than 50-years after initialization. While processes in the North Atlantic and Southern Ocean dominate this multi-decadal predictability, several Pacific SST patterns give rise to predictability in the first 5-10 years of the simulations. We regress SLP, surface-air temperature, and precipitation anomalies onto these predictable SST patterns to diagnose their impact on the atmospheric circulation and regional climate.