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Global oscillatory modes in observations and high-end modeling

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Interannual oscillatory modes, atmospheric and oceanic, are present in many regions of the globe. We examine here low-frequency variability (LFV) over the entire globe in the NCEP-NCAR reanalysis and in the Community Earth System Model (CESM). To identify complex patterns of spatio-temporal behavior in both the reanalysis and the model datasets, we apply here multichannel singular spectrum analysis (M-SSA), which provides an efficient and robust tool to extract dynamics from short, noisy time series.

The reanalysis was used at its resolution of 2.5x2.5 degrees over the 68-yr interval from January 1949 to December 2016. Our global analysis was performed on the fields of sea level pressure and of 200-hPa geopotential. Oscillations with periods of 12 and 3.6 yr are found to be statistically significant in this dataset.

CESM1.1 is a fully coupled climate model with a resolution of 0.1x0.1 degrees in the ocean and 0.25x0.25 degrees in the atmosphere, set up here for year-2000 conditions. This resolution suffices to study the oceans' internal dynamics in western boundary currents, and the atmosphere's dynamics above narrow SST fronts, like the Gulf Stream. The duration of the simulation was 100 yr and the last 66 yr were used in the analysis. The fields analyzed were surface temperatures, sea level pressures and the 200-hPa geopotential.

In this IPCC-class model, the statistically significant periodicities are 11 and 3.4 yr. The spatio-temporal structure of the oscillations in the observational and the modeling dataset are quite similar, while the difference in periodicities is small enough to be due mostly to the short length of the datasets, rather than to fundamental differences in model vs. nature processes or to the different resolution in the two datasets.

The spatial pattern of these global oscillations over the North Pacific and North Atlantic resemble the Pacific Decadal Oscillation and the LFV found in the Gulf Stream region and Labrador Sea, respectively. We speculate that these regional oscillations are synchronized over the globe, thus yielding the global oscillatory modes found herein. The robustness of these two modes, with their 11-12 and 3.4-3.6 yr periodicities, also suggests potential contributions to predictability at 1–3-yr horizons.