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Leveraging oscillatory modes to improve forecasts of chaotic processes, with applications to the Indian monsoon

Singular spectrum analysis (SSA) is a powerful time-series analysis tool which can, among other things, isolate the oscillatory modes in a time-series from chaos and noise. These oscillatory modes, insofar as they are inaccurately predicted by existing models, represent low-hanging fruit for improving prediction, due to their regularity. Krishnamurthy and Sharma (2017) have shown that predictability of monsoon rainfall beyond that obtained from state-of-the-art models such as the NCEP Climate Forecast System can be achieved by making forecasts using the monsoon intraseasonal oscillation extracted from observations by SSA. However, this method was limited to improving forecasts of the oscillation itself, not of the full precipitation signal. Here, we develop a general method to correct oscillatory modes in ensemble forecasts using numerical models. This is done by a method we call ensemble oscillation correction, wherein the ensemble mean is computed with only the best ensemble members, as determined by their discrepancy from a data-driven forecast of the oscillatory modes. We test the method using chaotic toy models with significant oscillatory components, and show that it robustly reduces error compared to the uncorrected ensemble. We discuss the possibilities for this method to improve prediction of monsoons as well as other parts of the climate system.