Applying Conditional Nonlinear Optimal Perturbation (CNOP) in the ensemble ENSO forecast system

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Considering the effects of initial uncertainty on the ENSO forecast, ensemble forecasts method is applied in the latest version of ENSO forecast system in National Marine Environmental Forecasting Center (NMEFC, China). The currently operational ENSO forecasts system of NMEFC is established based on the CESM model, with initialization and data assimilation.

First, leading five Singular Vectors (SV) are obtained using the climatological SST empirical singular vector method, and a SV based ensemble forecasts system is . However, the SVs can only present the initial errors that have the fasted error growth rates in a linear assumption, while ENSO and its forecasting system both are nonlinear. So, Conditional Nonlinear Optimal Perturbations (CNOP), which is has the largest error growth at the prediction time in a nonlinear scenario, is used to replace the leading SV, while other 4 SVs are kept to construct a CNOP-SV based ensemble forecast system. The hindcasts of ENSO from 1982 to 2017 shows that, the ENSO prediction skills of both SV based and CNOP-SV based ENSO ensemble forecasts are improved when compared with the old forecasting system, moreover, the CNOP-SV based ensemble forecast system has a much larger spread, showing higher prediction skills.