Stochastic parametrisations: reducing model error in the Community Earth System Model

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Stochastic parametrisations have been used for more than a decade in weather and seasonal forecasting models. They provide a way to represent model uncertainty through representing the variability of unresolved sub-grid processes, and have been shown to have a substantial beneficial effect on the spread and mean state of ensemble forecasts. Their beneficial impacts on weather and seasonal timescales turns our attention towards the impact of stochastic parametrisation schemes in climate models.

We present the first results which demonstrate the impact of a stochastic parametrisation developed by the weather forecasting community on the climate of an Earth system model. The Stochastically Perturbed Parametrisation Tendencies (SPPT) scheme is included the National Center for Atmospheric Research (NCAR) Community Earth System Model (CESM) run at 1° resolution in both the atmosphere and ocean. The control version of CESM exhibits systematic errors in the representation of the El Nino-Southern Oscillation (ENSO). SPPT significantly improves ENSO in CESM, improving the power spectrum, amplitude, and the inter- and intra-annual variability of tropical Pacific sea surface temperatures. We trace these improvements to improved variability in the zonal winds in CESM.

We compare the simulations with and without SPPT to a second CESM control simulation run at 0.25° resolution in the atmosphere and 0.1° in the ocean. This high-resolution simulation shows improvements to ENSO that are remarkably similar to those from including SPPT. Through mimicking sub-grid scale variability, stochastic schemes such as SPPT can go some way towards what is achieved by explicitly resolving that variability, at a fraction of the computational cost.

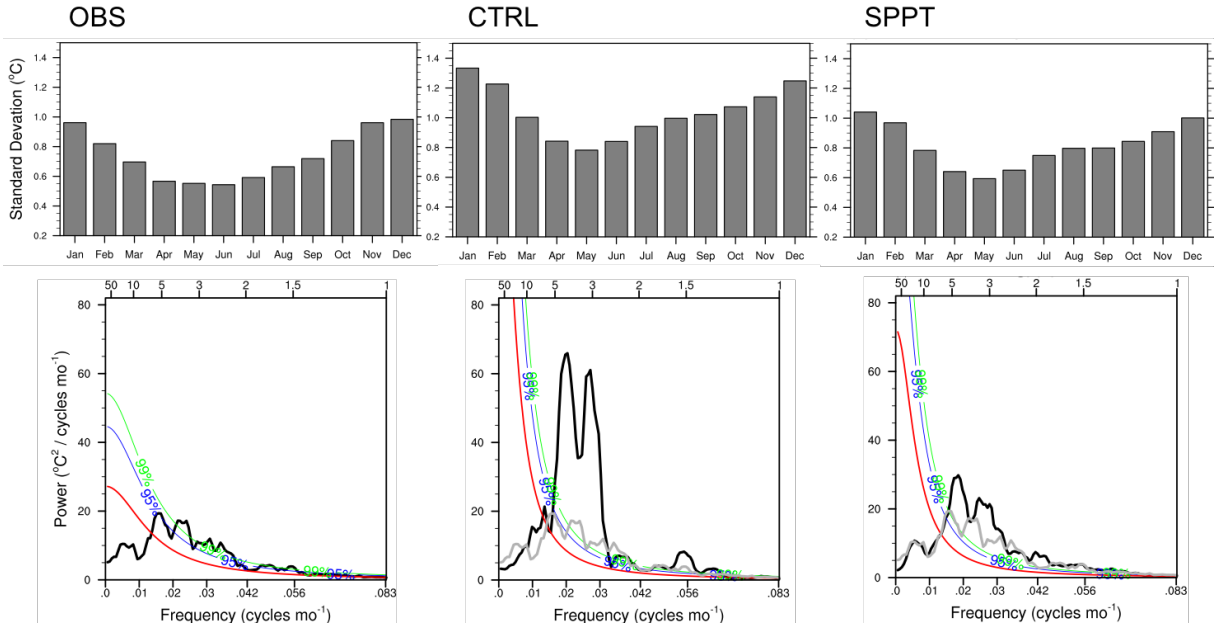

Figure (from Christensen et al, 2017): The impact of the SPPT scheme on the El Nino-Southern Oscillation in the Community Earth System Model. Top row: standard deviation of Nino 3.4 time-series as a function of month. Bottom row: power spectrum of Nino 3.4 time-series.

References: H.M. Christensen et al, 2017, J. Climate, 30(1),17–38.
J. Small et al, 2014, JAMES, 6,1065–1094.