



## Ensemble generation in the MPI-ESM seasonal prediction system

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In the seasonal forecast system based on the global coupled climate model MPI-ESM as used for CMIP5 simulations, we describe the implementation of two ensemble generation techniques. The system is initialized in the atmospheric, oceanic, and sea ice component of the model from reanalysis/ observations with full field nudging in all three components. For the perturbation of the ensemble, we compare ensembles generated from lagged initialization and bred vectors, and demonstrate that the bred vector initialized ensemble can also yield reliable predictions.

Here, bred vectors are implemented with a vertically varying norm in the ocean component to generate initial perturbations of the full water column. Hindcast ensembles initialized with either ensemble generation method reproduce the observed surface temperature anomalies at 2-4 months lead time particularly in the tropics. Compared against the spread of surface temperature in the ERAinterim reanalysis, the resulting ensemble hindcasts are more reliable in the tropics than at higher latitudes, and more reliable over the ocean than over land.

However, Talagrand diagrams indicate that both the lagged initialized ensemble and the bred initialized ensemble are underdispersive at 2 to 4 months lead time, especially in the tropics. The direct comparison of the lagged and bred initialized ensembles shows distributions in the Talagrand diagram closer to 'flat' (quantified by  $\beta$ -scores) for more regions for the bred initialized ensemble than for the lagged ensemble. We also assess the reliability of the ensembles through the spread-error ratio. The bred initialized ensemble shows a small improvement over the lagged initialized ensemble, in particular at high latitudes. At mid-latitudes, the bred initialized ensemble shows smaller spread-error ratios than the lagged initialized ensemble in several coastal regions, particularly in the respective winter hemisphere.