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Spatial-temporal assessment of climate model drifts

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Decadal climate forecasts with full-field initialized coupled climate models are affected by a growing error signal that develops due to the adjustment of the simulations from the assimilated state consistent with observations to the state consistent with the biased model's climatology. Sea-surface temperature (SST) drifts and biases are a major concern due to the central role of SST properties for the dynamical coupling between the atmosphere and the ocean, and for the associated variability. Therefore, strong SST drifts complicate the initialization and assessment of decadal climate prediction experiments, and can be detrimental for their overall quality.

We propose a dynamic linear model based on a state-space approach and developed within a Bayesian hierarchical framework for probabilistic assessment of spatial and temporal characteristics of SST drifts in ensemble climate simulations. The state-space approach uses unobservable state variables to directly model the processes generating the observed variability. The statistical model is based on a sequential definition of the process having a conditional dependency only on the previous time step, which therefore corresponds to the Kalman filter formulas. In our formulation, the statistical model distinguishes between seasonal and longer-term drift components, and between large-scale and local drifts. We apply the Bayesian method to make inferences on the variance components of the Gaussian errors in both the observation and system equations of the state-space model. To this purpose, we draw samples from their posterior distributions using a Monte Carlo Markov Chain simulation technique with a Gibbs sampler.

In this contribution we illustrate a first application of the model using the MiKlip prototype system for decadal climate predictions. We focus on the tropical Atlantic Ocean – a region where climate models are typically affected by a severe warm SST bias - to demonstrate how our approach allows for a more reliable estimation of model drifts, and for a more efficient identification of associated sources of heterogeneity, non-stationarities and propagation pathways.