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Exploring unforced climate variability uncertainty as it applies to climate change detection and model calibration statistics

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Climate change detection and climate model calibration provide two areas in multivariate statistics where the estimated unforced variability of the climate system is a critical input. In optimal climate change detection, the unforced variability is required both to estimate the noise component of the signal-to-noise ratio and also to optimize the multivariate signal pattern. In climate model calibration, the estimated unforced variability is a critical component in estimating the Bayesian likelihood function for the model parameter space given the observations. Thus, at the core of both statistical methods, we require estimates of the unforced variability in the spatio-temporal patterns of climate change. These are typically estimated from "long" control simulations of AOGCMs because the observational records are too short to provide adequate estimates.

We have recently developed a Bayesian hierarchical statistical model that includes uncertainty in the estimates of the unforced variability in addition to other components of the model calibration exercise. Specifically, we seek to separate the different sources of error by using three sources of information: observational records, control runs and forced runs to estimate the variability. The variability from each source is handled separately in the statistical model and estimates for each are provided. As a critical test, we will use data from seven AOGCMs of the CMIP3 archive to provide estimates of the unforced variability from multiple models. We will explore the sensitivity of the estimated probability distributions for the model parameters (effective climate sensitivity, rate of deep-ocean heat uptake, and the strength of the net aerosol forcing) to using individual AOGCM control runs and from combining the outputs from multiple AOGCMs. By separating the results from individual models, we will obtain an estimate of the effects of structural uncertainty in the AOGCMs on their estimates of the variability and how this influences the distributions of climate system properties. We have also adapted this statistical model to the climate change detection problem and initial results will be presented.