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Data assimilation for the construction of low dimensional stochastic models of the atmosphere

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The derivation of low dimensional stochastic models for a climate variable of interest relies upon the elimination of unresolved modes in the system. This can be done in a mathematically rigorous way if one assumes that the unresolved modes evolve on a much faster time scale than the resolved modes. The non-linear self interaction terms of the unresolved modes can be parametrized by a Gaussian process and eliminated using the theory of homogenization to give a reduced stochastic differential equation for the climate variable.
In practice the time scale separation in natural data is not perfect. This introduces memory into the system, which the reduced model can not reproduce. We tackle this problem by introducing extra variables to give a non-Markov system. The parameters associated with these variables, and those introduced originally, are estimated from data using recent methods for Bayesian inference for stochastic differential equations.
We present results of applying the method to a series of toy models including an ideal barotropic quasi-geostrophic model with zonal mean flow. We discuss future plans to apply the method to a realistic model climate.