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Estimating parameters for reduced stochastic climate models

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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 parametrised by a Gaussian process and eliminated using the theory of homogenization to give a reduced stochastic differential equation for the climate variable.

The resulting equations have cubic interactions in the deterministic term and a state dependent noise. With increasing dimension there is a rapid increase in the number of unknown parameters in the system. We present a scheme for estimating these parameters from data while ensuring that solutions of the resulting system are non-explosive. The inferred parameter distributions are sampled to produce an ensemble of simulations approximating the dynamics of the climate variable.

We assess our approach using a three layer quasi-geostrophic model of the atmosphere on the sphere. We fit one, two and three dimensional models to EOFs of 500mb height and analyse predictive statistics.