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Ergodicity of a stochastic Two Layer Quasi Geostrophic Model

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In the Climate Sciences, there is great interest in understanding the long term average behaviour of the climate system. In the context of climate models, this behaviour can be expressed intrinsically by concepts from the theory of dynamical systems such as attractors and invariant measures. In particular to ensure long term statistics of the model are well defined from a mathematical perspective, the model needs to admit a unique ergodic invariant probability measure.

In this work we consider a classic two layer quasi geostrophic model, with the upper layer perturbed by additive noise, white in time and coloured in space, in order to account for random forcing, for instance through wind shear. Existence and uniqueness of an ergodic invariant measure is established using a technique from stochastic analysis called asymptotic coupling as described in [1]. The main difficulty in the proof is to show that two copies of the system that are driven by the same noise realisation can be synchronised through a coupling. This coupling has to be finite dimensional and act only on the upper layer.

Our results will be a key step to allow rigorous investigation of the response theory for the system under concern.

[1] Glatt-Holtz, N., Mattingly, J.C. & Richards, G. J Stat Phys (2017) 166: 618.