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Towards a framework for stochastic bifurcation analysis of atmospheric models

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We report on work aiming to develop a framework for stochastic mode reduction and subsequent stochastic bifurcation analysis of numerical models of the atmosphere.

Previous studies have demonstrated the effectiveness of various stochastic mode reduction techniques for simple models whose dynamics exhibit timescale separation, but little work has so far been done on applying these techniques to more realistic models of components of the climate system. We aim to compare the effectiveness of different mode reduction techniques applied to a relatively simple atmospheric general circulation model, examining both the techniques cited above as well as more "traditional" statistical methods such as principal interaction patterns (PIPs).

One of the primary aims of reducing the order of models is to perform bifurcation and other dynamical analyses on the reduced system. Of particular interest are questions about whether mathematical structures in the dynamics of the higher-order system (bifurcations, homoclinic orbits, heteroclinic connections, etc.) are preserved by the reduction to a lower-order system. We will focus on examining bifurcations in the reduced system, since these are of practical interest in considering transitions between different regimes of flow in the atmosphere.

Since the mode reduction techniques we will consider generally reduce a high-order deterministic system to a lower-order stochastic system, this will require the development of numerical techniques for analysis of bifurcations in stochastic systems.

In this poster, we outline the steps required in the development of this framework, and present, for a relatively trivial system, some early results from deterministic bifurcation analysis software created to serve as a basis for future development.