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Predictions of Critical Transitions with Non-Stationary Reduced Order Models

Christian Franzke
British Antarctic Survey, Science Programmes, Cambridge, United Kingdom (chan1@bas.ac.uk)

Here we demonstrate the ability of stochastic reduced order models to predict the statistics of non-stationary systems undergoing critical transitions. First, we show that the reduced order models are able to accurately predict the autocorrelation function and probability density functions (PDF) of higher dimensional systems with time-dependent slow forcing of either the resolved or unresolved modes. Second, we demonstrate that the reduced order models are also able to predict the timing of critical transitions. Our results indicate that whether the system tips early or repeatedly jumps between the two equilibrium points depends on the strength of the coupling between the resolved and unresolved modes and the time scale separation. The skill of various proposed tipping indicators are discussed. We propose to use ensemble forecasts by reduced order models for the statistical prediction of tipping points. Our results suggest that ensemble forecasts are more robust for tipping point predictions. The used toy model is a generic non-linear model and can be generalized to be used in other areas; thus our approach should be applicable in many different areas.