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Using simple chaotic models to interpret climate under climate change: Implications for probabilistic climate prediction

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Exploring the reliability of model based projections is an important pre-cursor to evaluating their societal relevance. In order to better inform decisions concerning adaptation (and mitigation) to climate change, we must investigate whether or not our models are capable of replicating the dynamic nature of the climate system. Whilst uncertainty is inherent within climate prediction, establishing and communicating what is plausible as opposed to what is likely is the first step to ensuring that climate sensitive systems are robust to climate change.

Climate prediction centers are moving towards probabilistic projections of climate change at regional and local scales (Murphy et al., 2009). It is therefore important to understand what a probabilistic forecast means for a chaotic nonlinear dynamic system that is subject to changing forcings. It is in this context that we present the results of experiments using simple models that can be considered analogous to the more complex climate system, namely the Lorenz 1963 and Lorenz 1984 models (Lorenz, 1963; Lorenz, 1984).

Whilst the search for a low-dimensional climate attractor remains illusive (Fraedrich, 1986; Sahay and Sreenivasan, 1996) the characterization of the climate system in such terms can be useful for conceptual and computational simplicity. Recognising that a change in climate is manifest in a change in the distribution of a particular climate variable (Stainforth et al., 2007), we first establish the equilibrium distributions of the Lorenz systems for certain parameter settings. Allowing the parameters to vary in time, we investigate the dependency of such distributions to initial conditions and discuss the implications for climate prediction. We argue that the role of chaos and nonlinear dynamic behaviour ought to have more prominence in the discussion of the forecasting capabilities in climate prediction.

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