Probing system dynamics using nonlinear time series analysis

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Being able to forecast into future is one of the ultimate goals of science. If so, conversely, forecast capability may be used effectively to examine system dynamics. Based on out-of-sample forecast skill, we employ nonlinear time series techniques to investigate system dynamics. These methods are rooted in the theory of state-space reconstruction of the system attractor. These techniques have ability to distinguish low-dimensional nonlinear dynamics from high-dimensional linear noise in natural time series. This exercise is fundamental to understanding and modeling systems. For example, if it can be shown that a system is governed by a dominant low-dimensional nonlinear mode, then it should be possible in principle to construct a reasonable (low dimensional) mechanistic model that captures this behavior. By contrast, this will not be possible if it is found that the underlying system is predominantly high-dimensional or linear-stochastic (involving the additive action of many variables). Using these nonlinear methods, we investigate potential catastrophes of ecosystems, examine how organisms' biological generation time determines their responses to environmental variations, and forecast episodic larval supply of reef fish.