Characterizing mixing resulting from forcing of nonlinear systems, with an application to ENSO predictability

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Abstract

Transfer operators govern the decay of correlations, or mixing, and their eigenvalues are associated with resonances in the power spectrum, giving insights on the sensitivity of the system to perturbation. They are thus particularly well suited to the study of the intrinsic variability of chaotic or stochastic systems and their response to forcing.
Here, we present a geometric approach allowing one to characterize the mixing resulting from the interaction of the forcing (whether stochastic or deterministic) with the dynamics. An application to the response of nonlinear oscillators to noise reveals the role played by their isochrons in the phenomenon of phase diffusion. Small noise expansions are obtained for the mixing spectrum in terms of phase diffusion coefficient, which can be calculated from the Floquet analysis of the oscillator. In more general situations, the mixing spectrum may be approximated from reduced transfer operators.

This approach is used to study the response to stochastic forcing of a recharge oscillator and of the Zebiak-Cane models of ENSO. Changes in the phase diffusion coefficient with physical parameters are systematically studied and their implication for the predictability of the phase of ENSO events discussed.

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