Nonlinear Sciences > Chaotic Dynamics

On finite-size Lyapunov exponents in multiscale systems

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We study the effect of regime switches on finite size Lyapunov exponents (FSLEs) in determining the error growth rates and predictability of multiscale systems. We consider a dynamical system involving slow and fast regimes and switches between them. The surprising result is that due to the presence of regimes the error growth rate can be a non-monotonic function of initial error amplitude. In particular, troughs in the large scales of FSLE spectra is shown to be a signature of slow regimes, whereas fast regimes are shown to cause large peaks in the spectra where error growth rates far exceed those estimated from the maximal Lyapunov exponent. We present analytical results explaining these signatures and corroborate them with numerical simulations. We show further that these peaks disappear in stochastic parametrizations of the fast chaotic processes, and the associated FSLE spectra reveal that large scale predictability properties of the full deterministic model are well approximated whereas small scale features are not properly resolved.

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