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Chaotic Crisis and Climate Sensitivity: a Transfer Operator Approach

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Can abrupt climate changes occur and are GCMs able to resolve them? Climate stability has been studied from the linear stability of minimal models. Yet, for attractor crises occuring in large, chaotic GCMs, this is hardly applicable and it remains unclear whether the slowing down of the recovery to perturbations of small systems can be observed from the unperturbed dynamics of chaotic systems.

We focus on the evolution of densities rather than trajectories in phase space, as governed by the Liouville equation generating the semigroup of transfer operators. It is stressed that the correlation function can be directly calculated from the transfer operators and decomposed into slowly decaying components from their spectrum.

We give an example of chaotic system in which slowing down of the decay of
correlations of some observables does occur at the approach of a boundary crisis. The system considered is a high-dimensional, chaotic climate model of physical relevance, PlaSim. Moreover, coarsegrained approximations of the transfer operators on a reduced space, constructed from a long
time series of the system, give evidence that this behaviour is due to the approach of spectrum to the unit circle. This can be physically understood from the fact that the process responsible for the instability, the ice-albedo feedback, is also active on the attractor. Implications regarding response theory and the design of early-warning signals are finally discussed.