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Early warning signals for topological tipping points

Gisela Daniela Charó[1,4], Michael Ghil[2,3], and Denisse Sciamarella[1,4]
[1]Centro de investigaciones del mar y la atmósfera, Universidad de Buenos Aires, Buenos Aires, Argentina (gcharo@fi.uba.ar)
[2]Geosciences Department and Laboratoire de Météorologie Dynamique, École Normale Supérieure and PSL University
[3]Department of Atmospheric and Oceanic Sciences, University of California
[4]Institut Franco-Argentin d'études sur le climat et ses impacts

The topology of the branched manifold associated with the Lorenz model's random attractor (LORA) evolves in time. LORA's time-evolving branched manifold robustly supports the point cloud associated with the system's invariant measure at each instant in time.

This manifold undergoes not only continuous deformations — with branches that bend, stretch or compress — but also discontinuous deformations, with branches that intersect at discrete times. These discontinuities in the system's invariant measure manifest themselves in the decrease or increase of the number of 1-holes, thus producing abrupt changes in the branched manifold's topology.

Topological tipping points (TTPs) are defined as abrupt changes in the topology of a random attractor's branched manifold. Branched Manifold Analysis through Homologies (BraMAH) is a robust method that allows one to detect these fundamental changes.
The existence of such TTPs is being confirmed by careful statistical analysis of LORA's time-evolving branched manifold, following up on Charó et al. (Chaos, 2021, doi:10.1063/5.0059461). Research is being pursued on early warning signals for these TTPs, concentrating on local fluctuations in the system's invariant measure.