Complexity

Special Issue on
Dynamical Systems Extremes in Climate Science

CALL FOR PAPERS

Most human activities and infrastructure are affected by geophysical events and are, to varying degrees, designed to take into account extreme occurrences. For example, river bank heights are determined based on flood return times, breather switches in railway and bridge sections take into account high summer temperatures, and deicing facilities are stocked at airports where low temperatures are likely. This pragmatic approach, formalized by Pickands and Pareto, views extremes as large or small events with respect to a certain local observable.

We tend to forget that the local effects are produced by large-scale nonstatic complex phenomena. High-impact events such as heat-waves, cold spells, and extratropical storms are often associated with specific dynamic and thermodynamic patterns which might not be extreme themselves, unless they occur in combination or they persist for long times.

The classical approach to extreme events computes their return times for static fields. However, two similar atmospheric fields (weather analogues) might not share the same physical origin nor evolve in a similar way, thus introducing a bias in the return times. Moreover, the classical approach can only be used *a posteriori*, once the events have happened.

Recent developments in extreme value theory try to overcome this difficulty by using a dynamical systems framework. This approach considers the trajectory of atmospheric flows. Climate extremes can be diagnosed in terms of rarely recurring segments of such trajectories, or *dynamical* extremes. Mathematically, such extremes correspond to the unstable fixed points of the equations that generate the attractor—the geometrical object which hosts the states explored by the system.

Recent studies have developed dynamical system metrics to study climate extremes, such as the local dimension and persistence of the trajectory. However, it is important to note that the dynamical systems definition of climate extremes is not the same as the standard statistical definition of the maxima or minima of a given observable. Indeed, the two quantities are closely interlinked but reflect different interpretations of what an extreme is.

The ongoing challenge is to extend the definition of dynamical system metrics to vector fields and more generally to multivariate problems. The lack of such indicators has so far limited the application of dynamical systems techniques to complex set-ups such as realistic atmospheric flows. Tackling this challenge will require the development of new techniques at the interface between physics, statistical mechanics, and mathematics. In order to progress in this direction, we propose to group together people from the three disciplines to combine dynamical systems results with multivariate extreme value statistics and collect their contributions in Complexity.

Potential topics include but are not limited to the following:

- Advances in diagnosing local and mean properties of dynamical systems
- Extremes in dynamical systems
- Low-dimensional modelling of complex dynamical systems
- The atmosphere as a dynamical system: classification of large-scale atmospheric flows
- Linking dynamical systems extremes to weather and climate extremes
- Dynamical systems metrics as indicators of climate change
- Dynamical downscaling of weather and climate extremes
- Large deviations results for geophysical flows

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Lead Guest Editor
Davide Faranda, LSCE-CEA Saclay, Saclay, France
davide.faranda@lsce.ipsl.fr

Guest Editors
Gabriele Messori, Stockholm University, Stockholm, Sweden
gabriele.messori@misu.su.se

Nili Harnik, Tel Aviv University, Tel Aviv, Israel
harnik@post.tau.ac.il

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