Rencontre distribution des événements extrêmes application à la climatologie

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Abstracts

Freddy Bouchet (ENS Lyon)

Predictions at the predictability margin and committor functions

Abstract: The attractor dimension is an important quantity in information theory, as it is related to the number of effective degrees of freedom of the underlying dynamical system. By using the link between extreme value theory and Poincar\'e recurrences, it is possible to compute this quantity from time series of high-dimensional systems without embedding the data. In general $d<n$, where n is the dimension of the full phase-space, as the dynamics freezes some of the available degrees of freedom. This is equivalent to constraining trajectories on a compact object in phase space, namely the attractor. Information theory shows that the equality $d=n$ holds for random systems. However, applying extreme value theory, we show that this result cannot be recovered and that $d<n$. We attribute this effect to the curse of dimensionality, and in particular to the phenomenon of concentration of the norm observed in high-dimensional systems. We derive a theoretical expression for $d(n)$ for Gaussian random vectors, and we show numerically that similar curse of dimensionality effects are found for random systems characterized by non-Gaussian distributions. Finally, we show that the effect of the curse of dimensionality can be quantified using the extreme value theory, thus enabling to retrieve the degree of non-randomness of a system. We provide examples issued from real-world climate and financial datasets.

Marc Bocquet (École des Ponts ParisTech)

Data-driven reconstruction of chaotic dynamics using data assimilation and machine learning

Theo Caby (CPT Marseille)

Extreme Value Theory for observations

Abstract: We investigate the recurrence properties of an observable defined on the phasespace of a chaotic dynamical systems, using the framework of Extreme Value Theory. We are able to give an asymptotic law for the statistics of reurrences, that depends on the local dimension of the image measure. We study in details the value of this parameter in different situations of physical interest.

Berengere Dubrulle (SPEC, CNRS, CEA Saclay)

Extreme events of inertial dissipation

Davide Faranda (LSCE, CNRS, CEA Saclay)

Boosting performance in machine learning of turbulent and geophysical flows via scale separation

Abstract: Recent advances in statistical learning have opened the possibility to forecast the behavior of chaotic systems using recurrent neural networks. In this letter we investigate the applicability of this framework to geophysical flows, known to be intermittent and turbulent. We show that both turbulence and intermittency introduce severe limitations on the applicability of recurrent neural networks, both for short term forecasts as well as for the reconstruction of the underlying attractor. We suggest that possible strategies to overcome such limitations should be based on separating the smooth large-scale dynamics, from the intermittent/turbulent features. We test these ideas on global sea-level pressure data for the past 40 years, a proxy of the atmospheric circulation dynamics.

Corentin Herbert (ENS, Lyon)

Abrupt transitions in geophysical flows: the case of superrotation

Even though they have a very low probability of occurrence, rare events play a crucial part in many systems because they can have a huge impact. In the climate system, examples range from heat waves and winter storms to the more dramatic possibility of a bifurcation of the general circulation of the atmosphere or the ocean. In all cases, a major obstacle to study the dynamics of such events is that they are difficult to sample, either from observations or from direct numerical simulations with GCMs. In particular, although it has been hypothesized that bistability of the oceanic circulation could explain some abrupt events observed in paleoclimatic proxies, the dynamics and statistics of such transitions remains poorly understood. In this talk, I will first present a conceptual framework to study these abrupt transitions, based on statistical physics, and numerical algorithms which have been developed to efficiently sample these events. Then, most of the talk will be devoted to a particular case of a mechanism potentially leading to abrupt transitions in the atmospheric circulation: equatorial superrotation. I will focus on the conditions for bistability and the nonlinear mechanisms leading to it: Rossby wave resonance and the Hadley cell.

Gabriele Messori (University of Upssala, Sweeden)

A spatial model for warm temperature extremes in the High Arctic

Abstract: Warm wintertime temperature extremes in the high Arctic, primarily associated with intrusions of moist airmasses from the mid-latitudes, have occurred with an ostensibly high frequency in recent years. Here, we compute the temperature anomaly return values associated with such events for long return times. Our approach, which we term space-time maxima--exposure (STM-E), improves on conventional extreme value estimates performed on a single-location basis by explicitly taking into account the spatial structure of the moisture intrusions driving the temperature extremes.

Philippe Naveau (LSCE, CNRS, CEA Saclay)

Multi-model error in Detection and Attribution analysis (joint work with Soulivan Thao)

Flavio Pons (LSCE, CEA Saclay)

Sampling hyperspheres via extreme value theory: implications for measuring attractor dimensions

Abstract**:** The attractor dimension is an important quantity in information theory, as it is related to the number of effective degrees of freedom of the underlying dynamical system. By using the link between extreme value theory and Poincar\'e recurrences, it is possible to compute this quantity from time series of high-dimensional systems without embedding the data. In general $d<n$, where n is the dimension of the full phase-space, as the dynamics freezes some of the available degrees of freedom. This is equivalent to constraining trajectories on a compact object in phase space, namely the attractor. Information theory shows that the equality $d=n$ holds for random systems. However, applying extreme value theory, we show that this result cannot be recovered and that $d<n$. We attribute this effect to the curse of dimensionality, and in particular to the phenomenon of concentration of the norm observed in high-dimensional systems. We derive a theoretical expression for $d(n)$ for Gaussian random vectors, and we show numerically that similar curse of dimensionality effects are found for random systems characterized by non-Gaussian distributions. Finally, we show that the effect of the curse of dimensionality can be quantified using the extreme value theory, thus enabling to retrieve the degree of non-randomness of a system. We provide examples issued from real-world climate and financial datasets.

Benoit Saussol (University of Brest, CNRS)

Recurrence in phase space

Abstract: We look at the distribution of rare events, recording the time of the event but also its position (or strength) in the phase space, and show how it gives rise to a spatio-temporal Poisson point process.

Sandro Vaienti

Targets and Holes

Abstract: We address the extreme value problem of a one-dimensional dynamical system approaching a fixed target while constrained to avoid a fixed set—which can be thought of as a small hole. The presence of the latter influences the extremal index which will now depend explicitly on the escape rate.