SOE 24: Extreme Events (joint session DY / SOE)

Time: Thursday 15:00–17:00 Location: BH-N 243

Invited Talk SOE 24.1 Thu 15:00 BH-N 243

Branched Flows, Extreme Waves and the Random Focusing of Tsunami Waves — •Ragnar Fleischmann — Max Planck Institute for Dynamics and Self-Organization

Wave propagation in random media - this might sound abstract but is in fact very tangible and almost omnipresent in science and everyday life. Examples are surface water waves, but also light, sound, electrons, tsunamis and even earth quakes are waves that in a natural environment typically propagate through a complex medium. Due to its complexity, the medium is often best described as random, with examples including the turbulent atmosphere, complex patterns of ocean currents or a semiconductor crystal sprinkled with impurities. In recent years it has become clear that even very small fluctuations in the random medium, if they are correlated, lead to focussing of the waves in pronounced branch-like spatial structures and to extreme wave intensities. This branching has been reported for electron, micro, sound, and water waves.

I will give an overview over the progress we made in the last few years in the understanding of branched flows and the statistic of extreme waves. As an example, I will discuss the random focusing of tsunamis and its implications for the prediction of tsunami wave heights.

SOE 24.2 Thu 15:30 BH-N 243

Computing the probability of rare trajectories — •Jorge C. Leitão[1], João M. Viana Parente Lopes[2], and Eduardo G. Altmann[1] — [1]Max Planck Institute for the Physics of Complex Systems, 01187 Dresden, Germany — [2]Department of Physics and Center of Physics, University of Minho, P-4710-057, Braga, Portugal

Estimating the probability of extreme events often requires finding rare trajectories in (high-dimensional non-linear) dynamical systems. In this talk we show how such trajectories can be efficiently sampled using importance sampling Monte Carlo methods. We argue that the applicability and efficiency of these methods depend on the sensitivity of the observed quantity (in which the extreme event is measured) to perturbations of the initial conditions (in the phase space). We show analytical results and numerical simulations for different observables in (hyperbolic and non-hyperbolic) chaotic systems.

- J. C. Leitão, J. M. Viana Parente Lopes, E. G. Altmann "Efficiency of Monte Carlo Sampling in Chaotic Systems", Phys. Rev. E 90, 052916 (2014)

- J. C. Leitão, J. M. Viana Parente Lopes, E. G. Altmann "Monte Carlo Sampling in Fractal Landscapes", Phys. Rev. Lett. 110, 220601 (2013)

SOE 24.3 Thu 15:45 BH-N 243

Record statistics for complex random vector — •Shashi C. L. Srivastava — Max Planck Institute for the Physics of Complex Systems, Nöthnitzer Straße 38, 01187 Dresden Germany

In this talk, we present the analytical results for average record and average number of records in case of delta-correlated variables. These results are then compared with the numerical results for eigenfunctions of quantized standard map and found in good agreement [1]. Specifically, we will discuss the distribution of records which turns out to be a Gumbel distribution and the logarithmic dependence of average number of records on Planck's constant.

References:

[1] Srivastava, S. C. L., Lakshminarayan, A., and Jain, S. R. Record statistics in random vectors and quantum chaos, EPL 101, 10003 (2013).

SOE 24.4 Thu 16:00 BH-N 243

Statistical analysis of extreme weather events in a changing climate — •Philipp Müller and Holger Kantz — Max Planck Institute for the Physics of Complex Systems, Dresden, Germany

It is often claimed and from the perspective of atmospheric physics also plausible, that extreme weather conditions might occur more frequently in a warmer climate. We discuss statistical approaches to the characterization of the intensity and the frequency of extreme weather conditions on moving time windows. We present analysis results from the analysis of instrumental weather data from the past 100 years in central Europe. Temperature extremes, precipitation extremes, and wind speed extremes have different properties, whereas some very destructive extremes such as hailstorms have not been sufficiently recorded. Based on these data, we are unable to proof the existence of a systematic trend in extreme weather in Germany, although there are signatures which are consistent with a trend towards warming.

SOE 24.5 Thu 16:15 BH-N 243

A data-adaptive definition of extreme events in time series exhibiting seasonality — Eva K. Hauber[1,2,3] and •Reik V. Donner[1] — [1]Potsdam Intsitute for Climate Impact Research, Potsdam, Germany — [2]University of Copenhagen, Denmark — [3]University of Natural Resources and Life Sciences, Vienna, Austria

Environmental time series are often characterized by strong seasonal variations. In such a case, extreme events are traditionally defined by removing the underlying seasonal component in the mean and applying a threshold-based definition of an extreme to the residuals. However, this approach is only valid if the probability distribution function (PDF) shows a seasonal modulation exclusively of its mean. In turn, real-world climatological records exhibit heteroskedasticity, implying that their variance (but often also the shape of the PDF) changes over the year as well. Here, we present a data-adaptive method that allows defining extreme events under such conditions. Our approach is based on kernel estimates of the conditional PDF of the data taking the phase during the year as a covariate, which allow estimating any given quantile of the PDF as a function of this phase. We demonstrate the capabilities of this new approach for artificial time series as well as real-world observational data. Our results indicate that even for short time series covering only a few periods, the data-adaptive method leads to a systematic reduction of false identifications of extremes in comparison to standard techniques.

SOE 24.6 Thu 16:30 BH-N 243

Forecasting extreme events in high-dimensional excitable systems — •Stephan Bialonski[1], Gerrit Ansmann[2,3,4], and Holger Kantz[1] — [1]Max-Planck-Institute for the Physics of Complex Systems, Dresden, Germany — [2]Department of Epileptology, University of Bonn, Bonn, Germany — [3]Helmholtz Institute for Radiation and Nuclear Physics, University of Bonn, Bonn, Germany — [4]Interdisciplinary Center for Complex Systems, University of Bonn, Bonn, Germany

The dynamics of many high-dimensional systems, ranging from nature to technology and society, can exhibit extreme events, i.e. large deviations from the average behaviour. Since extreme events can pose severe threats and can have implications for economy, politics, or health, a successful and reliable prediction of such events is highly desirable. We investigate extreme events in a high-dimensional deterministic system: a network of FitzHugh-Nagumo units. Mimicking field studies, we assume that the temporal evolution of only some degrees of freedom of the system is observed and that the exact equations of motion are unknown. Addressing these challenges, we present a data-driven approach to predict extreme events which is only based on the time series of some observables and on the coupling topology of the network. By iterative predictions, we are able to forecast the onset of an extreme event as well as the propagation and extinction of excitation, i.e. the full life-cycle of an extreme event.

SOE 24.7 Thu 16:45 BH-N 243

The Role of Perturbation Growth in Critical Transitions and Extreme Events — •Nahal Sharafi[1], Sarah Hallerberg[1], and Marc Timme[1,2] — [1]Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany — [2]Göttingen University, Göttingen, Germany

Extreme events and critical transitions happen in a variety of dynamical systems. Marked by their high magnitude as well as their infrequent and irregular occurrence, they can lead to disasters.

Employing quantifiers of chaos, we work towards identifying changes in the dynamical structure of complex systems before an extreme event or a critical transition happens. Next we use these changes as precursors of the events. Apart from possible practical implementations, such as predictions, we use the relation between predictor and event in order to understand the dynamical origins of the events under study.

As candidate precursors, we consider changes in different features of covariant Lyapunov vectors such as growth rate, localization or direction.