DY 52: Extreme events

Time: Thursday 11:30–12:45 Location: H47

DY 52.1 Thu 11:30 H47

Branched Flow in Anisotropic Media — Henri Degueldre[1], Jakob Metzger[2], and •Ragnar Fleischmann[1] — [1]Max-Planck-Institut für Dynamik und Selbstorganisation (MPIDS), 37077 Göttingen, Deutschland — [2]Rockefeller University, New York, NY 10065, USA

In many natural and technological systems, waves are weakly scattered by a complex medium that often is best described as random. Due to its internal structure, however, the randomness exhibits spatial correlations. If these correlations persist on scales longer or comparable to the wavelength, even tiny fluctuations in the medium will focus the waves into branches, leading to strong fluctuations in the wave intensity in a large variety of physical systems extending form the propagation of electrons in semiconductors to the focusing of tsunami waves. This phenomenon of *branched flow* generically leads to heavy tailed intensity distributions and extreme wave events. So far the theory of branched flows only described homogeneous, isotropic random media, however, many real systems show a pronounced anisotropy in their structure. For example, the geological processes that generate the ocean floor topography that scatters tsunami waves tend to be highly anisotropic. We present recent results on the theory of branched flows in anisotropic random media and especially show that the focusing has a strong, non-trivial angle dependence.

DY 52.2 Thu 11:45 H47

Study of large deviation probability for correlated Gaussian stochastic processes, motivated by a climate science issue — •Mozhdeh Massah and Holger Kantz — Max Planck Institute for Physics of Complex Systems, Dresden, Germany

As we have one and only one earth and no replicas, climate characteristics are usually computed as time averages from a single time series. For understanding climate variability, it is essential to understand how close a single time average will typically be to an ensemble average. To answer this question, we study large deviation probabilities (LDP) of stochastic processes and characterize them by their dependence on the time window. In contrast to iid variables for which there exists an analytic expression for the rate function, the correlated variables such as auto-regressive (short memory) and auto-regressive fractionally integrated moving average (long memory) processes, have not an analytic LDP. We study LDP for these processes, in order to see how correlation affects this probability in comparison to iid data. At last, we study the LDP for a series of standardized tree ring widths in Nevada (U.S) and compare it to the LDPs for stochastic processes that we have studied.

DY 52.3 Thu 12:00 H47

Event coincidence analysis for quantifying statistical interrelationships between event time series — Jonathan F. Donges[1,2], Carl-Friedrich Schleussner[1,3], Jonatan F. Siegmund[1,4], and •Reik V. Donner[1] — [1]Potsdam Institute for Climate Impact Research, Potsdam, Germany — [2]Stockholm Resilience Centre, Stockholm, Sweden — [3]Climate Analytics, Berlin, Germany — [4]University of Potsdam, Germany

Despite its relevance and wide applicability for interdisciplinary research, the statistical analysis of interrelations between event time series has received relatively little attention in the literature so far. Here, we introduce the concept of event coincidence analysis (ECA) as a novel framework for quantifying the strength, directionality and time lag of statistical interrelationships between event series. ECA allows to formulate and test null hypotheses on the origin of the observed interrelationships including tests based on Poisson processes or, more generally, stochastic point processes with a prescribed inter-event time distribution. As an illustrative example, we apply ECA to country-level observational data on flood events and epidemic outbreaks, providing robust statistical evidence for corresponding relationships since the 1950s.

DY 52.4 Thu 12:15 H47

Capturing rogue waves by multi-point statistics — Ali Hadjihosseini[1], Matthias Waechter[1], Norbert Hoffmann[2], and •Joachim Peinke[1,3] — [1]ForWind - Center for Wind Energy Research, Institute of Physics, University of Oldenburg, 26111 Oldenburg, Germany — [2]Hamburg University of Technology, 21073 Hamburg, Germany — [3]Fraunhofer Institute for Wind Energy and Energy System Technology, 26129 Oldenburg, Germany

As an example for complex systems with extreme events we investigate ocean wave states exhibiting rogue waves. Mapping the complexity of multi-point data onto the statistics of hierarchically ordered height increments for different time scales, we can show that the wave data can be described by a stochastic cascade process with Markov properties, which is given by a Fokker-Planck equation. Conditional probabilities as well as the Fokker-Planck equation itself can be estimated directly from the available observational data. With this stochastic description surrogate data sets can in turn be generated allowing to work out statistical features of the complex sea state in general and extreme rogue wave events in particular. The results also open up new perspectives for forecasting the occurrence probability of extreme rogue wave events, and even for forecasting the occurrence of individual rogue waves based on precursory dynamics.

DY 52.5 Thu 12:30 H47

Harmful algal blooms as extreme events: Connectivity patterns in a coastal ecosystem — •Stephan Bialonski — Max-Planck-Institute for the Physics of Complex Systems, Dresden, Germany

Harmful algal blooms (HABs) are extreme events that can cause large-scale marine mortality incidents and affect human health and economy. Since HABs are observed to become more frequent and intense due to climate change, a better understanding of the mechanisms leading to their occurrence is highly desirable and may inform the development of mitigation and prevention strategies. We study the occurrence of HABs in the Southern California Bight, an area for which such events are well documented. Our cross-correlation analyses of HAB monitoring data and our Lagrangian particle simulations support the hypothesis that transport pathways, in addition to local environmental conditions, decisively influence the spatiotemporal sequence of occurrences of such extreme events in the study area. The observed connectivity patterns can be interpreted as a temporal directed network in which different regions (nodes) are temporarily connected via ocean flows (links). We speculate that deeper insights into the complex interaction between hydrodynamics and population dynamics will pave the way for methods with increased power to predict harmful algal blooms.