DY 28: Extreme Events

Time: Thursday 9:30–12:15 Location: ZEU 146

DY 28.1 Thu 9:30 ZEU 146

Branching in Tsunami Waves — •Henri-Philippe Degueldre[1,2], Jakob J. Metzger[1,2], Ragnar Fleischmann[1], and Theo Geisel[1,2] — [1]MPIDS, am Fassberg 17, 37077 Goettingen, Germany — [2]Institute for Nonlinear Dynamics, Departement of Physics, University of Goettingen, Germany

Branched flow is a universal phenomenon occuring in particle or wave flows propagating through weakly scattering, correlated, random media. Even for very weak disorder in the medium it can lead to extremely strong fluctuations in the wave intensity. We show how tsunami waves are affected by branching. We model the tsunamis propagating over the ocean floor with its complex height fluctuations by the linearized shallow water wave equations with random bathymetries. We calculate the typical distance from the source at which the strongest wave fluctuations occur as a function of the statistical properties of the bathymetry.

DY 28.2 Thu 9:45 ZEU 146

Experimental Observation of a Fundamental Length Scale of Waves in Random Media — •Sonja Barkhofen[5,1], Jakob Metzger[2,3], Ragnar Fleischmann[2], Ulrich Kuhl[4,1], and Hans-Jürgen Stöckmann[1] — [1]Fachbereich Physik, Philipps-Universität Marburg, Renthof 5, 35032 Marburg, Germany — [2]Max-Planck-Institute for Dynamics and Self-Organization, Am Faßberg 17, 37077 Göttingen, Germany — [3]Institute for Nonlinear Dynamics, Department of Physics, University of Göttingen, 37077 Göttingen, Germany — [4]LPMC, CNRS UMR 7336, Université de Nice Sophia-Antipolis, F-06108 Nice, France — [5]Applied Physics, University of Paderborn, Warburger Straße 100, 33098 Paderborn, Germany

Waves propagating through a weakly scattering random medium show a pronounced branching of the flow accompanied by the formation of freak waves, i.e. extremely intense waves. Theory predicts that this strong fluctuation regime is accompanied by its own fundamental length scale of transport in random media, parametrically different from the mean free path or the localization length. We report the experimental observation of this scaling using microwave transport experiments in quasi-two dimensional resonators with randomly distributed weak scatterers. Remarkably, the scaling range extends much further than expected from random caustics statistics.

DY 28.3 Thu 10:00 ZEU 146

Statistics of Extreme Waves in Random Media — •Jakob Metzger[1,2], Ragnar Fleischmann[1], and Theo Geisel[1,2] — [1]Max-Planck-Institut für Dynamik und Selbstorganisation, Göttingen, Deutschland — [2]Institut für Nichtlineare Dynamik, Universität Göttingen, Deutschland

Waves traveling through random media exhibit random focusing that leads to extremely high wave intensities even in the absence of nonlinearities. Although such extreme events are present in a wide variety of physical systems and the statistics of the highest waves is important for their analysis and forecast, it remains poorly understood in particular in the regime where the waves are highest. We suggest a new approach that greatly simplifies the mathematical analysis and calculate the scaling and the distribution of the highest waves valid for a wide range of parameters [1].

[1] JJ Metzger, R Fleischmann, T Geisel, arXiv:1311.4578

DY 28.4 Thu 10:15 ZEU 146

Optimizing cluster analysis by stochastic methods — •Philip Rinn[1], Yuriy Stepanov[2], Thomas Guhr[2], Joachim Peinke[1], and Rudi Schäfer[2] — [1]ForWind – Center for Wind Energy Research, Institute of Physics, University of Oldenburg, Germany — [2]Faculty of Physics, University of Duisburg-Essen, Germany

A new method to analyze the the results of a clustering algorithm is presented. Using a similarity measure daily prices of S&P 500 stocks are clustered with a top-down clustering scheme to represent states in the financial market. Time series of the distance between each data point and the cluster centers are calculated which describe the evolution of the financial market seen from the respective cluster center.

With methods from stochastic data analysis we separate the stochastic part from the deterministic part of the given time series. From the deterministic part we calculate a potential and find the fixed points of the system. We link the stable fixed points of the deterministic potential to the centers of the aforementioned clusters. Fixed points of the system that do not match with cluster centers can be identified as artificial clusters and ideas for optimizing the clustering to match the systems fixed points can be derived.

DY 28.5 Thu 10:30 ZEU 146

Improving Predictions using the Crooks Fluctuation Theorem — •Julia Gundermann[1], Stefan Siegert[2], and Holger Kantz[1] — [1]Max Planck Institut für Physik komplexer Systeme, Dresden, Germany — [2]University of Exeter, United Kingdom

The Crooks fluctuation theorem is a relation from non-equilibrium thermodynamics, quantifying the amount of work produced in a process more exactly than the second law inequality by giving an exact equation for the work's distribution.

We take this equation as a constraint for the distribution of a random variable and ask the question: Given a finite data set drawn from such a distribution, how can we improve the estimate of this variable to exceed a certain threshold compared to the event frequency deduced from the data set? Using the knowledge about Crooks' relation we propose a forecast that will prove to be "better" than simple counting on the data set. We measure the notion of "better" in terms of the Brier score. Studies of parameters such as exceedance threshold and data set size are presented.

15 min break

DY 28.6 Thu 11:00 ZEU 146

Extreme risks in financial markets - a random matrix approach — Thilo Schmitt, Desislava Chetalova, •Rudi Schäfer, and Thomas Guhr — Fakultät für Physik, Universität Duisburg-Essen

The instability of the financial system as experienced in recent years and in previous periods is often linked to credit defaults, i.e., to the failure of obligors to make promised payments. Given the large number of credit contracts, this problem is amenable to be treated with approaches developed in statistical physics. We introduce the idea of ensemble averaging and thereby uncover generic features of credit risk. We then show that the often advertised concept of diversification, i.e., reducing the risk by distributing it, is deeply flawed when it comes to credit risk. The risk of extreme losses remain due to the ever present correlations, implying a substantial and persistent intrinsic danger to the financial system.

DY 28.7 Thu 11:15 ZEU 146

Mapping the dynamics of quantiles in climate change relevant observables — •Sandra Chapman[1,2,3], David Stainforth[4,1,5], and Nicholas Watkins[2,4,1,6] — [1]CFSA, Physics, Univ. of Warwick, UK — [2]MPIPKS, Dresden, Germany — [3]Mathematics and Statistics, UIT, Norway — [4]LSE London, UK — [5]Environmental Change Institute, Univ. of Oxford, UK — [6]MCT, Open Univ., Milton Keynes, UK

Climate change poses challenges for decision makers across society, not just in preparing for the climate of the future but even when planning for the climate of the present day. When making climate sensitive decisions, policy makers and adaptation planners would benefit from information on local scales and for user-specific quantiles (e.g. the hottest/coldest 5% of days) and thresholds (e.g. days above 28 C), not just mean changes. Here, we translate observations of weather (daily records of temperature and precipitation) into observations of climate change, providing maps of the changing shape of climatic distributions. We have developed a simple deconstruction of how the difference between the cumulative density function of a weather observable from two different time periods can be assigned to the combination of natural statistical variability and/or the consequences of secular climate change; this also relates to the dynamics of return times. We will relate this to the dynamics of exceedence above a threshold.

DY 28.8 Thu 11:30 ZEU 146

Prediction of extreme temperatures: The issue of the performance measure — •Holger Kantz[1] and Stefan Siegert[2] — [1]MPI for the Physics of Complex System, Germany — [2]University of Exeter, UK

The perceived performance of every prediction scheme depends of the way how performance is measured. We compare different such performance measures on predictions of extreme temperature anomalies, using different forecast models. The embarrassing result is that not only quantitative details of performance but even the ranking of our four different models depends on the scoring scheme used, so that the notion of "the best forecast method" becomes very questionable.

DY 28.9 Thu 11:45 ZEU 146

Predictors and Prediction Mechanisms of Extreme Events in Spatio Temporal Chaotic systems — •Nahal Sharafi[1], Sarah Hallerberg[1], and Marc Timme[1,2,3] — [1]Network Dynamics, Max Planck Institute for Dynamics and Self-Organization (MPIDS), D-37077 Göttingen, Germany — [2]Faculty of Physics, University of Göttingen, D-37077 Göttingen, Germany — [3]Bernstein Center for Computational Neuroscience, D-37077 Göttingen, Germany

Extreme events 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, high-dimensional systems before an extreme event happens and use them as precursors of extreme events. As candiate precursors, we consider changes in different features of covariant Lyapunov vectors such as growth rate, localization, direction etc. before an extreme event happens in prototypes of chaotic systems. 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. For the Lorenz 1996 model, a paradigmatic model for high-dimensional chaotic systems, we computed covariant Lyapunov vectors and identified features of these vectors that indicate extreme events.

DY 28.10 Thu 12:00 ZEU 146

On the surprising robustness of the surplus run length ratio formula, and its application to extreme bursts in time series from natural complex systems — •Nicholas Watkins[1,2,3,4], Sandra Chapman[1,2,5], and Philip Hush[2] — [1]MPIPKS, Dresden, Germany — [2]CFSA, Physics, University of Warwick, Coventry, UK — [3]MCT, Open University, Milton Keynes, UK — [4]CATS, LSE, London, UK — [5]Maths and Statistics, UIT, Tromso, Norway

"Bursts", events that begin when a time series exceeds a threshold u, and end when it drops below it, have been widely studied in models of intermittent dynamical systems such as SOC and turbulence, and in natural datasets. Analytical approaches to bursts are needed which permit handling time dependence and heavy tailed amplitudes, and make contact with mature mathematics such as the theory of random fields and level crossings. We will discuss one such technique, which we call the surplus run length ratio [SRLR] formula, which states that the expectation value of the time T_u between successive up and downcrossings of a threshold u by values of stationary time series from a stochastic process $X(t)$ is the empirical survival function of X divided by the time rate of upcrossings at that level [Volkonskii, 1960; Cramér and Leadbetter,1967; Lawrance and Kottegoda, 1977]. We show that the SRLR formula applies surprisingly widely in highly skewed (lognormal), heavy tailed (α-stable) and long range dependent (fractional Gaussian) cases, among others. We demonstrate its utility on a non-Gaussian, correlated, natural example which has been previously studied using bursts, the auroral electrojet AE ionospheric index.