DY 60: Poster - complex systems and data analysis

Time: Thursday 16:00–18:00 Location: Poster A

DY 60.1 Thu 16:00 Poster A

Modelling and prediction using symbolic regression by genetic programming — •Markus Quade, Markus Abel, and Ruggero Vasile — Ambrosys GmbH, Potsdam, Deutschland

Machine learning assisted modelling is used successfully in a broad variety of systems. However, the models are often not physically interpretable. Symbolic regression, in contrast, yields formulas as results, which can be analyzed by means of dynamical systems methods.

Specifically, we use evolutionary principles to explore possible models to forecast the production of green energy by genetic programming. In order to find suitable models in acceptable time, we extend the standard genetic programming method.

One advantage of this approach is that it is in principle not biased by human perception. Of course, prior knowledge about the system investigated should be used by providing building blocks and a goodness of fit measure. Finding a model means searching for a best fit in function and/or parameter space.

We illustrate our ideas in detail with real measurements and the corresponding prediction.

DY 60.2 Thu 16:00 Poster A

Complex Systems Approaches to Detecting Tipping Behavior in Paleoclimate Time Series — •Jasper G. Franke and Reik V. Donner — Potsdam Institute for Climate Impact Research, Potsdam, Germany

In the last years the existence of tipping elements in the Earth's climate system has gained increased attention. Here, tipping behavior refers to dynamical transitions of some subsystem leading to a qualitatively different state. In the light of the recent debate on possible regime shifts due to global climate change it is necessary to understand if, when and where such transitions have occurred in the past in order to assess possible future risks.

As tipping of climate elements should be accompanied by changes in the nonlinear dynamics (e.g., due to bifurcations or noise-induced transitions), methods from nonlinear time series analysis can lead to additional insights regarding the existence of past transitions. In this work, we study the capabilities of several recently developed methods like recurrence network analysis or visibility graphs as well as spatio-temporal methods to reveal complex signatures of past nonlinear regime shifts. The potentials and limitations of these novel approaches are systematically compared with those of classical early warning indicators like increasing autocorrelation, variance, etc. We illustrate the performance of the different methods for synthetic time series exhibiting tipping point behavior as well as different paleoclimate time series.

DY 60.3 Thu 16:00 Poster A

(How) Can we trust in Lyapunov exponents estimated from time series? — •Ulrich Parlitz — Max Planck Institute for Dynamics and Selforganization, Göttingen, Germany — Institute for Nonlinear Dynamics, Georg-August-Universität Göttingen, Germany

Lyapunov exponents are fundamental for quantifying sensitive dependence on initial conditions and chaos. While their computation using dynamical evolution equations is quite straight forward (even for high dimensions and extended systems) estimating Lyapunov exponents from time series remains a challenge. We shall discuss and illustrate problems and pitfalls using time series generated by different chaotic systems. In particular we shall consider a six dimensional Lorenz-96 model that possesses a chaotic attractor (Kaplan-Yorke dimension D=4.18) with a single positive Lyapunov exponent. For this example estimation of the (largest) Lyapunov exponent(s) turns to be quite difficult and requires very long time series indicating practical limits of purely data based estimation methods.

DY 60.4 Thu 16:00 Poster A

Inhomogeneous shear-induced alignment of anisotropic binary mixtures — •Henning Reinken, Rodrigo Lugo-Frias, and Sabine H. L. Klapp — Institut für Theoretische Physik, Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin, Germany

Due to their presence in a wide variety of biological contexts and technological applications, the study of homogenous [1] and inhomogeneous mixtures of anisotropic particles has increased considerably in recent years. One important question in that context is how their rheological properties change when they are driven out of equilibrium by means of a steady flow.

In the present work we develop an inhomogeneous equation for the shear-induced alignment of anisotropic binary mixtures in the scope of irreversible thermodynamics [2,3]. To this end, we calculate the entropy production that accounts for flow velocity, pressure and alignment. To guarantee a positive value, we establish the appropriate linear relations between the thermodynamic fluxes and forces.

[1] R. Lugo-Frias and S. H. L. Klapp, in preparation (2015).
[2] S. R. de Groot, P. Mazur, Non-Equilibrium Thermodynamics, Ed. Dover (1984).
[3] S. Hess, I. Pardowitz, Z.Naturforsch. A **36a**, 554 (1981).

DY 60.5 Thu 16:00 Poster A

Finding optimal solutions for the delacorte numbers problem by using a hybrid optimization approach — •Jan Jurczyk and Alexander Eckrot — University of Regensburg, Regensburg, Germany

The delacorte numbers problem was proposed by Al Zimmermann in his computational contests. The goal is to find the maximum and minimum groundstate, where an interaction was defined by the greatest denominator times the euclidean distance in a square matrix containing the numbers from 1 to n^2. Our approach is similar to the well known TSP-Problems, where finding backbones within the solution is critical in generating possible groundstates.

DY 60.6 Thu 16:00 Poster A

Markovian approximation and perturbation theory of transport processes in geophysical flows — Naoya Fujiwara[1], Kathrin Kirchen[2,3], Jonathan F. Donges[3,4], •Reik V. Donner[3], Jürgen Kurths[3,5], and Kazuyuki Aihara[1] — [1]University of Tokyo, Japan — [2]University of Bonn, Germany — [3]Potsdam Institute for Climate Impact Research, Germany — [4]Stockholm Resilience Centre, Sweden — [5]Humboldt University, Berlin, Germany

We propose a Markov chain-based framework for analyzing passive transport in geophysical flows. For this purpose, the available space is coarse-grained, and transition probabilities between different boxes are estimated. The stochastic transition matrix becomes time-dependent if the underlying flow exhibits changes with time. In order to analytically treat this case, we introduce a first-order perturbation theory that allows evaluating the corresponding changes in terms of the largest eigenvalue and associated eigenvector of the perturbed transition matrix. Specifically, three different problem classes are studied that are potentially relevant for geophysical applications: point-wise absorption of particles, absorption in the presence of a constant input of particles, and changes in the steady state in the case of mass conservation. For some simple 2D flow model exhibiting Lagrangian turbulence, we demonstrate numerically that the absorption rates provided by first-order perturbation theory describe the actual dynamics of the system very well.

DY 60.7 Thu 16:00 Poster A

Non-global coupling in two- and three-state systems — •Simon Christ, Bernard Sonnenschein, and Lutz Schimansky-Geier — Humboldt-Universität zu Berlin, Institut für Physik, Deutschland

Two- and three-state renewal models with non-exponential waiting time densities have been used to mimic noisy excitable and oscillatory systems to decribe various processes like chemical reactions or neural networks. In this work effects of non-global coupling on steady and oscillatory states in random binary networks with exhibitory coupling or with indirect coupling as an active medium are investigated. In order to study global oscillations and bistable behaviour with respect to noise intensity and coupling strength or delayed feedback, direct numerical simulations are performed are performed as well as an approximate mean field model is proposed for complex networks. It allows solution for the steady states supplemented with their stability analysis. Transition states and multistability were observed if varying the network structure.

DY 60.8 Thu 16:00 Poster A

Long-range response in AC and DC electricity grids —

•Daniel Jung and Stefan Kettemann — School of Engineering and Science, Jacobs University Bremen gGmbH, Campus Ring 1, 28759 Bremen, Germany

Local changes in the topology of electricity grids can cause overloads far away from the disturbance [1], making the prediction of the robustness against power outages a challenging task. The impact of single-line additions on the long-range response of DC electricity grids has recently been studied [2]. With this work, we extend the investigation to the case of alternating currents. Therefore, we study electricity grids with a random distribution of complex impedances on the edges of a regular 2D grid. By determining the resonance frequencies of the circuit, we are able to forecast consequences for the conditions for stable grid operation. Further, we analyse the spatial distribution of the voltage amplitudes.

[1] D Witthaut, M Timme, Eur. Phys. J. B 86, 377 (2013).

[2] D Labavic, R Suciu, H Meyer-Ortmanns, S Kettemann, Eur. Phys. J. Spec. Top. (2014).

DY 60.9 Thu 16:00 Poster A

The Coincidence Skill Score - a new approach to quantify event simultaneity in climate applications — •Jonatan F. Siegmund and Reik V. Donner — Potsdam Institut für Klimafolgenforschung, Postfach 601203, 14412 Potsdam

Besides gradual changes of the mean behaviour of climate variables, global climate change results in higher frequencies and intensities of extreme events like heat waves, droughts or intense rain events. The impacts of these events on terrestrial ecosystems are hardly known.

In this study, we develope an extention of the Coincidence Analysis, a method to detect non-random simultaneous appearences of extreme events in two time series. For this purpose, we consider a Non-Reaction-Rate, complementing the formerly studied Coincidence Rate, to define a Coincidence Skill Score, related to the Peirce Skill Score which is widely used in meteorological applications. The new method has the advantage of distinguishing between different cases of simultaneous and non-simultaneous events and therefore provides an alternative for the comparison of time series with different numbers of extreme events.

We apply this approach to investigate the influence of climatic extreme events on wildlife plant flowering phenology for Germany. Our results underline formerly found relationships and additionally highlight long-term-dependencies between extremely high temperatures and very early plant flowering with a time-lag of almost one year. These results support hypotheses, that more and stronger climate extreme events might sustainably disturb domestic ecosystems.