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Institute of Mechanical Systems: Prof. G. Haller (NDS)
Institute of Fluid Dynamics: Prof. P. Jenny, Prof. T. Rösgen (IFD)

05/11/2018

I N V I T A T I O N

to a talk as part of the

Colloquium Thermo- and Fluid Dynamics

Date: **Wednesday, November 28, 2018**

Time: **16:15h**

Place: Machine Laboratory ETH Zurich, **Lecture Hall ML H 44**

Speaker: **Prof. Themis Sapsis**
Department of Mechanical Engineering
Massachusetts Institute of Technology, USA

Title: **Extreme events in complex dynamical systems: prediction and statistical quantification**

For many natural and engineering systems, extreme events, corresponding to large excursions, have significant consequences and are important to predict. Examples include extreme environmental events: rogue waves in the ocean, flooding events, climate transitions, as well as extreme events in engineering systems: unsteady flow separation, large ship motions, and dangerous structural loads. Therefore, predicting and understanding extreme events is an essential task for reliability assessment and design, characterization of operational capabilities, control and suppression of extreme transitions, just to mention a few. Despite their importance, understanding of extreme events for chaotic systems with intrinsically high-dimensional attractors has been a formidable problem, due to the stochastic, nonlinear, and essentially transient character of the underlying dynamics. Here we discuss two themes in contemporary, equation-assisted, data-driven modeling of dynamical systems related to extreme events: the *prediction* problem and the *statistical quantification* problem. For the first theme, a major challenge is the computation of low-energy patterns or signals, which systematically precede the occurrence of these extreme transient responses. We develop a variational framework for probing conditions that trigger intermittent extreme events in high-dimensional nonlinear dynamical systems. The algorithms exploit in a combined manner some physical properties of the chaotic attractor, as well as, finite-time stability properties of the governing equations. In the second part of the talk we develop a method for the evaluation of extreme event statistics associated with nonlinear dynamical systems from a small number of samples. From an initial dataset of design points, we formulate a sequential strategy that provides the ‘next-best’ data point (set of parameters) that when evaluated results in improved estimates of the probability density function (pdf) for any scalar quantity of interest. The approach combines machine learning and optimization methods to determine the ‘next-best’ design point that maximally reduces uncertainty between the estimated bounds of the pdf prediction. We assess the performance of the derived schemes through direct numerical simulations on realistic problems and we discuss limitations of other methods such as Large Deviations Theory. Applications are presented for many different areas, including prediction of extreme events in turbulent fluid flows and ocean waves, and probabilistic quantification of extreme events in fluid-structure interactions and ship motions.

Host: Prof. G. Haller

Guests are welcome!

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