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Probabilistic forecast of extreme heat waves and climate tipping points using neural networks and rare event simulations

Thursday, September 14, 2023 3:30 PM (1 hour)

Rare events are of primarily importance for understanding the impact of climate change. The first class are extreme events which have devastating impacts; the second are rare trajectories which lead to bifurcations and drastic changes of the climate system configurations and tipping points. However, because those events are too rare and realistic models are too complex, they cannot be computed directly. We must complement traditional approaches using direct numerical simulations with tools issued from statistical physics, stochastic processes, and applied mathematics, to enhance the sampling of these rare events.

Rare event simulation is a very efficient tool to oversample drastically the statistics of rare events. As a complementary tool, machine learning is a way to build statistical models of the probability to observe rare events, based on long datasets. We will demonstrate the efficiencies of both approaches for climate application and discuss their coupling to mutually enhance their efficiency, solving the lack of data issue on the one hand and the sampling difficulty on the other hand.

We will discuss applications to a few key problems related to the emergency related to the climate crisis and the needed transitions. First, we will study the probability of extreme heat waves, the deadliest phenomena related to climate change. Second, we will discuss apply those tools to climate tipping points. Finally, we will study the probability of rare periods of imbalance between renewable electricity production and demand, a key factor for the design of future electricity systems.

Presenter: BOUCHET, Freddy (ENS, LMD, IPSL)

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