SPARC Short Course on

Networks, Causality and Statistics for Climate Sciences

Adway Mitra (IIT Kharagpur), Prof. Auroop Ganguly (Northeastern University)

Dates: 6-24 January 2025

Lectures: Every week day, 6-7 PM (Total 15 hours)

Location: Nalanda Complex, IIT Kharagpur

Audience: B.Tech, M.Tech, Ph.D. students of IIT Kharagpur

Course Plan:

The aim of this course is to explore the topics of Complex Networks and statistical models, including causality and extreme value statistics for Climate Sciences. With the threat of global climate change, there is renewed interest in climate sciences, especially for understanding the relations between different climatic processes. Data-driven methods, such as networks and causal models may help to uncover relations that were previously unknown. Moreover, as extreme weather events keep increasing under the changing climate, extreme value statistics provide a tool in understanding the nature and scale of such events, and quantifying their risks. Specifically, compound extreme events are of special concern. Attribution of such events to specific causes is also an important task, which requires specialized statistical tools. This course aims to not only provide in-depth technical understanding of these methods, but also demonstrate their uses in finding impactful answers to important questions in climate science. There will be guest lectures by leading researchers working in climate science and hydrology, who are proponents of these techniques. Student participants of this course are also welcome to present their research on relevant topics.

Week 1: (Prof. Auroop Ganguly)

L1: Climate Technology: From Science and Engineering to Finance and Policy

L2: Climate Data Science: Time Series, Spatial, and Spatiotemporal Data Analysis

L3: Climate Dynamics: Statistics of Extremes, Nonlinear Physics, and Machine Learning

L4: Climate Networks: A Network Lens from Science to Adaptation and Mitigation

L5: Climate Enterprise: Translational Solutions from Startups to Communities

Week 2: (Adway Mitra)

L6: Spatio-temporal data models: Bayesian models to Neural Networks (CNN and RNN/LSTM)

L7: Networks for complex systems: centrality measure, community structures, : correlation-based and MI-based networks, dynamic networks, robustness of networks, random network models

L8: Concept of Causality, causality in Geosciences, Granger causality, Conditional independence, PCMCI family of models

L9: Counterfactuals, Intervention-based causality, Bayesian Models for Attribution, Shapley-value based Analysis

L10: Extreme event analysis, Extreme value distributions (GEV and generalized Pareto)

Week 3: (Guest lectures)

L11: Guest Lecture on Teleconnection

L12: Guest Lecture on Compound Extremes

L13: Guest Lecture on Attributions

L14: Guest Lecture on Resilient Infrastructure Networks/Student Presentations

L15: Student presentations