Climate Meets Complex Systems: Exploring Predictability of Extreme Climate Events via a Complex Network Approach

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The Earth system is a very complex and dynamical one basing on various feedbacks. This makes predictions and risk analysis even of very strong (sometime extreme) events as floods, landslides, heatwaves, and earthquakes etc. a challenging task. After introducing physical models for weather forecast already in 1922 by L.F. Richardson, a fundamental open problem has been the understanding of basic physical mechanisms and exploring anthropogenic influences on climate. In 2021 Hasselmann and Manabe got the Physics Nobel Price for their pioneering works on this. I will shortly review their main seminal contributions.
Next, I will introduce a recently developed approach via complex networks mainly to analyze strong climate events. This leads to an inverse problem: Is there a backbone-like structure underlying the climate system? To treat this problem, we have proposed a method to reconstruct and analyze a complex network from spatio-temporal data. This approach enables us to uncover relations to global and regional circulation patterns in oceans and atmosphere, which leads to construct substantially better predictions, in particular for the onset of the Indian Summer Monsoon, extreme rainfall in South America, the Indian Ocean Dipole and tropical cyclones but also to understand phase transition in the past climate.

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