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The global teleconnection pattern of extreme rainfall events

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Climatic variables can exhibit long-range dependencies between remote locations, which are typically caused by stable atmospheric circulation patterns or disturbances thereof. In particular, extreme events such as heat waves and floods are often related to such teleconnections.

Discovering such linkages from observations, as well as understanding the responsible atmospheric mechanisms, is of crucial relevance for increasing the predictive skill of weather and especially extreme event forecast. In view of the changes in extreme event characteristics that have been suggested under future global warming, the need for a better understanding of the mechanisms leading to extreme events and their teleconnections is further underlined.

In this talk, we introduce a methodological approach that is based on complex networks to reveal stable teleconnections between extreme rainfall events around the globe. This approach encompasses a technique to correct for potential biases caused by the multiple-comparison problem, which is present in all data-driven dependency analyses.

By applying our methodology to high-resolution, satellite-derived rainfall data, we reveal the global teleconnection pattern of extreme rainfall events. The distance distribution of significant synchronisations between extreme rainfall events around the globe decays like a power law for distances smaller than 2500 km. For longer distances, however, the probability of finding significant teleconnections is substantially higher than would be expected from the scaling of the shorter distances. We associate the shorter linkages with regional weather systems, while the longer, super-power law distributed linkages form the global pattern of extreme rainfall teleconnections. In addition, we show that these teleconnections are particularly important for dynamical couplings between the tropics and extra-tropics of both hemispheres.

An investigation of the atmospheric conditions that lead to the stable dependencies revealed here suggests that upper tropospheric Rossby waves are the main mechanism giving these global scale teleconnections. We exemplify our approach with a detailed analysis of the teleconnections related to extreme rainfall in South-Central Asia, including parts of eastern Pakistan, northern India, Nepal, and Tibet. Extreme events in this region are synchronised with events in central Europe and eastern Asia, in accordance with previous studies on the ‘Silk Road’ teleconnection pattern. In addition, we uncover concise linkages between South-Central Asia on the one hand, and the monsoon systems of South-Eastern Asia and Africa, but also the extra-tropics of both the northern and southern hemispheres, on the other hand.

These results offer new insights into the relationship between atmospheric Rossby waves and extreme rainfall and, consequently, into the predictability of associated natural hazards.