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Prediction of extreme floods in the Central Andes by means of Complex Networks

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Based on a non-linear synchronisation measure and complex network theory, we present a novel framework for the prediction of extreme events of spatially embedded, interrelated time series. This method is general in the sense that it can be applied to any type of spatially sampled time series with significant interrelations, ranging from climate observables to biological or stock market data.

In this presentation, we apply our method to extreme rainfall in South America and show how this leads to the prediction of more than 60% (90% during El Niño conditions) of extreme rainfall events in the eastern Central Andes of Bolivia and northern Argentina, with only 1% false alarms. From paleoclimatic to decadal time scales, the Central Andes continue to be subject to pronounced changes in climatic conditions. In particular, our and past work shows that frequency as well as magnitudes of extreme rainfall events have increased significantly during past decades, calling for a better understanding of the involved climatic mechanisms. Due to their large spatial extend and occurrence at high elevations, these extreme events often lead to severe floods and landslides with disastrous socioeconomic impacts. They regularly affect tens of thousands of people and produce estimated costs of the order of several hundred million USD.

Alongside with the societal value of predicting natural hazards, our study provides insights into the responsible climatic features and suggests interactions between Rossby waves in polar regions and large scale (sub-)tropical moisture transport as a driver of subseasonal variability of the South American monsoon system. Predictable extreme events result from the propagation of extreme rainfall from the region of Buenos Aires towards the Central Andes given characteristic atmospheric conditions. Our results indicate that the role of frontal systems originating from Rossby waves in polar latitudes is much more dominant for controlling extreme rainfall in subtropical South America than has been assumed so far: These cold fronts cause abundant rainfall in southeastern South America, but they also dictate the direction of low-level flow from the Amazon to the subtropics. The low-level flow provides moisture for extreme rainfall which subsequently propagates from the La Plata Basin towards the eastern slopes of the Central Andes. These events become particularly interesting in view of the important role of tropical to extra-tropical couplings for assessing impacts of global warming to regional climate systems.