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The spatial scale distribution of extreme precipitation synchronizations around the globe

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Extreme precipitation events (EPEs) on the earth's surface occur with varying degrees of synchronization, depending on spatial distances and the governing atmospheric processes. The spatial scales across which such EPEs synchronize around the globe, as well as the dependence of these interaction distances on the event magnitudes, have not yet been rigorously addressed in the literature.

Here, we address these questions on the basis of a globally gridded, high-resolution satellite dataset (TRMM 3B42) of 576 000 daily precipitation time series for the time period 1998—2014. EPE synchronizations around the globe are in our approach represented as spatially embedded functional networks, and the object we are interested in is the probability distribution of spatial link lengths in these networks. First, it is shown how Bayes' Theorem can be employed to derive a scheme to correct for spatial embedding effects in node-based network measures from this distribution. We then discuss the problem of multiple comparisons immanent to all functional network approaches as soon as the statistical significance of single links is addressed. A statistical method is proposed to distinguish physical network links from those occurring by chance due to multiple comparisons, which is generally applicable to spatially embedded functional networks. Finally, a combination of maximum likelihood estimation and Markov Chain Monte Carlo sampling is used to find the most likely functional form of the spatial length distributions of physical EPE synchronizations.

We find that the spatial distances of physical EPE synchronizations are distributed according to an exponentially truncated power law. Furthermore, it is shown that the distributions' tail becomes nonlinearly heavier the stronger the events are, providing statistical evidence for the importance of atmospheric teleconnections for the most extreme events. Since this implies that the most extreme events are typically part of particularly large weather patterns, our results thus suggest that there exists an enhanced degree of predictability for these events. Insights into these EPE characteristics are crucial for the fundamental understanding of the climate system, for evaluating the coupling structure of general circulation models, but also for the assessment of the predictability of EPEs.