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# Complex networks of climate extremes: Why Event Coincidence Analysis is preferable to Event Synchronization

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The combination of nonlinear time series analysis and complex network theory applied to climate datasets has been extensively used in recent research and offers novel insights into the intricate dynamics of the Earth climate. Spatio-temporal patterns of extreme events have been among the primary subjects of interest and have aroused several studies on monsoon systems, including efforts to predict onset times or strong floods.

In order to quantify the degree of statistical interdependence between event time series, many studies of precipitation extremes draw on Event Synchronization (ES) as a parameter-free method originally rooted in the EEG spike train analysis. Within climate network settings, ES automatically classifies two spatio-temporally distinct events as synchronized or not depending only on internal interevent distances, without the requirement of external time lag parameters. While such a dynamic parameter-free specification conveniently incorporates multiple time scales at once, it raises conceptual concerns if interevent distance distributions deviate from the narrow shape found in EEG data. Using a simple coupled autoregressive model process to simulate event time series, we show that ES has difficulties to detect interdependencies in the case of serial correlation, i.e. event clustering, as can be expected from climate time series with extreme events exceeding certain empirical percentiles. An alternative similarity measure for event time series that has been proposed recently is the Event Coincidence Analysis (ECA) that requires the manual setting of lag and coincidence interval parameters. We provide evidence that unlike ES, ECA is not negatively affected by event clustering in our simulations and additionally offers the possibility to isolate specific time scales which can be guided by or used to test climatological hypotheses.

Beyond mere simulations, we confirm the structural problems of ES by a climate network constructed from satellite-based TRMM precipitation data for the entire Asian monsoon domain, thereby reproducing previously published results. Specifically, we demonstrate that there is a strong undesired linkage between the fraction of events on subsequent days and the degree density at each grid point. This undermines the explanatory power of ES climate networks as trivial local properties of time series may predetermine the resulting synchronization to a large degree leading to spurious results. ECA, on the other hand, does not suffer from such drawbacks and exposes remarkably different degree density fields, opening up room for further analyses. Both our simulation and empirical results thus provide evidence that ECA is the preferable network construction tool for climate extremes, while ES results need to be interpreted with all due caution.