Contemplating coincidences – Statistical relationships between geoscientific event series

J.F. Donges (1,2), R.V. Donner (1), J. Heitzig (1), J. Kurths (1,2)

(1) Potsdam Institute for Climate Impact Research, Transdisciplinary concepts and methods, Potsdam, Germany
(donges@pik-potsdam.de), (2) Department of Physics, Humboldt University, Berlin, Germany

In the geosciences, researchers are often interested in studying event series or temporal point processes like the timings t_i of extreme weather events, climate transitions, volcanic eruptions, earthquakes or the appearance and disappearance of species from the fossil record. In contrast to classical time series, the considered events either do not have a well-defined associated magnitude x_i, e.g., as for qualitative transitions in climate dynamics, or a measurable magnitude is discarded for simplifying the analysis. When series of distinct types of events are available in a common time frame, assessing their statistical interrelationships can be valuable for testing theories proposing specific causal relationships as well as for explorative data analysis. We introduce a technique called coincidence analysis for computing the probability p that the observed number of coincident events between two event series is due to chance given a fixed temporal tolerance window. Hence, a small p points to a significant statistical relationship. Furthermore, we illustrate coincidence analysis in several examples and point out formal links to other techniques like Ripley's cross-K function from spatial statistics, or event synchronization and cross-recurrence rate from nonlinear time series analysis.