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Studying statistical dependency among short and persistent events – recent developments and application to mid-latitude circulation anomalies associated with heatwaves

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During the last years, the statistical analysis of compound extremes has gained increasing interest among the scientific community due to the multiple threats presented by such events to society, economy, and the environment. In many situations, the statistics of compound extremes is based on bivariate extreme value theory and measures provided by this framework. Such choice of statistical methodology may however not properly address two relevant aspects: the non-zero duration of such events (which can be rather persistent, e.g. in the case of droughts or heatwaves, which heavily violates the independence assumption of classical extreme value theory) and the fact that not all events of practical revelance can be described as cases falling into the tails of the distribution of some observable of interest.

A general framework addressing the non-extremeness aspect is provided by event coincidence analysis (ECA), which quantifies the empirical frequency of co-occurring events of arbitrary types and allows ist comparison with the values for certain random null models like independent Poisson processes with prescribed event rates. While classical ECA is based on temporal point processes and hence may be criticized for not capturing the statistical characteristics of persistent events very well, I will present a new methodological variant, interval coverage analysis (InCA), as an alternative for specifically addressing co-occurrences of persistent events. In the limit of vanishing event durations, the new interval coverage rates of InCA are identical to the event coincidence rates provided by ECA. By allowing for mutual time shifts between the different types of events under study as well as a temporal tolerance regarding their respective timing, fixed and even distributed time lags can be taken into consideration.

This presentation introduces and compares the basic methodological concepts behind both ECA and InCA (including their extension to studying multivariate and conditional dependency), and demonstrates an example of their respective application in geoscientific contexts. Specifically, the spatial patterns of dependency between the timing of heatwaves and large-scale circulation anomalies of the atmospheric jet stream in the Northern hemisphere is studied. The corresponding analysis reveals specific regions with elevated likelihood of heatwaves along with the emergence of a split (double-banded) jet stream, while the emergence of heatwaves is

suppressed at the same time in other regions. The obtained results may thus guide further targeted research regarding the specific mechanisms leading to this regional differentiation in heatwave frequency.