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Spatial coherency of extreme weather events in Central Europe

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Correlation analysis has been widely used for characterizing the spatial variability of near-surface meteorological variables like temperature, precipitation and wind speed, which are typically measured at surface weather stations, i.e. at fixed locations in space. However, an intrinsic feature of classical correlation analysis is that two time series are compared to each other as a whole, making the correlation coefficient sensitive to the coherence of the bulk of the data, but not that much to the extremes, since these are relatively rare. Nevertheless, for many applications, e.g., in paleoclimatology, insurance issues or climate change research, it is important to know about the spatial coherence of extreme weather events.

In this study, a simple statistical approach is applied for analyzing the spatial representativeness of extreme events in daily meteorological surface observations from Central Europe. A percentile-based definition of extremes is employed, and the frequency of simultaneously occurring extreme events at different stations is used as a measure for their spatial coherence. The largest representativeness is diagnosed for daily temperature extremes, i.e. hot and cold days, which very often occur simultaneously at many stations. On the contrary, precipitation extremes usually are restricted to local or regional scales. The spatial coherence of wind gust maxima is intermediate between the other extremes and depends on station location and terrain complexity. For cold extremes, station altitude has a strong influence on the spatial coherence of the events. It is argued that the spatial representativeness of extreme weather events directly relates to the importance of a coherent large scale atmospheric forcing, compared to more local factors, for triggering these events. In particular, large scale advection is the most important driver of temperature extremes. Strong wind gusts in Central Europe are often caused by mid-latitude cyclones over the North Sea. The results from this study can also be used to assess the spatial representativeness of extreme weather reconstructions from proxy data in paleoclimate studies. More specifically, the reconstruction of temperature extremes from an archive in Central Europe would be representative for a large area in space. On the contrary, a set of spatially distributed proxy archives would be required for obtaining a complete picture of past heavy precipitation changes.