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Spatial patterns in extreme events and dynamical complexity of precipitation over Germany

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Precipitation is commonly characterized by large spatial and temporal variability, which is often not sufficiently accounted for in regional climate models. Here, we present a reassessment of the distribution of extreme rainfall events over Germany in the time period 1951-2006. The resulting spatial patterns are compared with those obtained using measures of dynamical complexity for individual station records. For the latter case, we consider two conceptually different approaches: (a) The LVD dimension density computed for highly embedded time series quantifies the complex linear auto-correlation structure of observational records for a given maximum lag and sampling. (b) Several measures originally proposed in the framework of recurrence quantification analysis are adopted for the study of binary time series and applied to characterizing the distribution of the durations of individual rainfall periods.

All three types of characteristics show a pronounced spatial pattern reflecting the large-scale climatology of Central Europe and the local orographic influences on precipitation. In addition to the observational data, the same properties are additionally studied based on hindcast scenarios covering the same time period, which have been obtained using four regional climate models: the statistical models STAR and Wettreg as well as the dynamical models CCLM and REMO. Our analysis reveals distinct differences between observations and hindcast simulations that point to insufficiencies of present-day regional climate models to capture the behavior of extreme events as well as the nonlinear dynamics of climatic variables. The obtained results may contribute to a better understanding of these problems, which is of key importance for future improvements of the corresponding models with respect to their predictive skills.