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Elbe floods: An interaction of hydrological and meteorological (pre-)conditions

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The genesis of a river flood is triggered by the interaction of various elements. Key factors are the hydrological pre-conditions (e.g. soil saturation, snow cover) and the meteorological situation (e.g. amount and spatial distribution of precipitation). For the analysis of those key factors, we propose to classify the hydrological and meteorological (pre-)conditions of the Elbe river catchment and to identify flood favouring patterns.

The meteorological classification is based on ERA 40 reanalysis data by Simulated Annealing clustering of mean sea level pressure, surface temperature and tropospheric humidity content. We find a good representation of typical winter and summer patterns, when using 40 classes. For each class its seasonality and probability to occur in connection with river flooding is determined. Two main types of patterns are found to be associated with Elbe river flooding: During summer, the most distinct pattern shows a cyclone over Southern Europe, which transports moist air from the Mediterranean towards central Europe, a situation also known as Vb. During winter, the patterns occurring prior to the floods mostly show a strong zonal flow, carrying moist air from the North East Atlantic.

The hydrological classification is based on soil moisture as a representative of the initial catchment state. Soil moisture is simulated using a semi-distributed conceptual rainfall-runoff model that is calibrated using a Monte Carlo scheme with an objective function emphasizing high flows. Principal component analysis and cluster analysis are applied successively to identify patterns explaining most of the variability of the soil moisture dynamics and to identify days of similar soil moisture patterns. Independently of the number of clusters finally chosen, flood prone soil moisture clusters are detected.

In a subsequent step, this pattern analysis will serve as the basis to estimate joint probabilities of the occurrence of hydro-meteorological pattern combinations that are flood prone. In addition, frequency changes of these pattern combinations under climate change will be examined.