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Event indicator analysis using depth functions to explain the occurrence of large floods in Germany

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Large floods occur due to particular hydrometeorological conditions and could be characterized by different event indicators. By analyzing a large set of catchments and different events, the drivers of large flood peaks remain unclear. In addition to precipitation, also the prevailing situation in the catchment such as soil moisture conditions could control the occurrence of large floods.In this study, we analyzed a set of event indicators ranging from event precipitation via antecedent catchment state to catchment response for 169 gauges in Germany. For each gauge with a length of at least 50 years of daily observations, we derived the POT5 series. In order to test whether floods are characterized with unusual values of event indicators, we used the Tukey's depth function. In this multivariate data analysis technique, a point cloud of different event indicators is subdivided at each point with a line into two groups. The depth value is hereby the minimum value of points in these two groups. This multivariate statistical method allows to find points in the center of the set, and those on or close to the boundary. Hence, points in the cloud center have high depth and correspond to ordinary values of the event indicators. Points at the edges of the cloud have low depth and indicate unusual indicator values. In case of low depth, the related event indicators can potentially be seen as drivers of these flood events. We compared all combinations of the event indicators with 2, 3 and 4 variables and analyzed which event indicators might cause the occurrence of large flood peaks.Our results show that the depth is reduced with increasing flood magnitude. Large floods are thus more unusual in terms of event indicators compared to smaller floods. The most relevant event indicators are maximum event precipitation and event precipitation volume. At least one of these indicators is required to explain the flood peak magnitude, but in most of the cases these two indicators are not sufficient. Inclusion of antecedent catchment state or a catchment response indicator improves the explanation in several but not all cases.Overall, we conclude that flood peak magnitudes at a specific catchment in our study region are mainly driven by the individual event characteristics. In most of the cases they cannot not be explained by typical patterns of event indicators for all large events at a given gauge.