



Comparative analysis of scalar upper tail indicators

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Heavy tail phenomena have been discussed in various branches of science reaching from finances, economics and environmental sciences to natural hazard research and hydrology. While several definitions of heavy tail behavior of distributions coexist, it can generally be characterized by a higher probability for the occurrence of extreme events compared to bounded- and light-tailed distributions. In hydrological studies, scalar measures of heavy-tail behavior are often applied to compare the upper tail behavior of different flood or heavy precipitation distributions. However, there is no comparative study of these indicators so far.

In our study, we aim to compare four scalar indicators of heavy-tail behavior and assess their immanent properties: The shape parameter of the GEV, the obesity index, the Gini index and the upper tail ratio. Our analyses with synthetic data include examining the impact of sample size and location shifts as well as testing for scale invariance. Further, we introduce the surprise factor which is defined as the probability that a known HQ_x event is strongly underestimated by observations to provide a benchmark for heavy-tail behavior. Our results show that all four indicators exhibit a monotonic relation to the surprise factor. These relations highly depend on the Lorenz asymmetry coefficient which is a measure for the arrangement of extremes in the upper tail. For distributions with symmetric Lorenz curves, the indicators are partially linear correlated. We further found that the indicators behave differently under change in location parameters and scaling. Taking into account the different properties of the indicators, the appropriate choice of an upper tail indicator depends on the specific research questions as well as the respective definition of heavy-tail behavior and is facilitated by results of this study.