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Frequency analysis of hydro-meteorological extremes emerging from multiple nonstationary underlying processes

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A new formulation of the Metastatistical Extreme Value framework for the analyses of hydro-meteorological extremes emerging from multiple underlying processes is presented. The formulation allows to parsimoniously model changes in both intensity and probability of occurrence of the processes with application in sensitivity analyses, explanatory models, and climate projections.
The methodology is tested on daily precipitation data from 170 stations with at least 60-year record in the eastern Mediterranean, using Weibull distributions to model daily precipitation amounts generated by two classes of synoptic systems. Events generated by different synoptic classes are shown to both contribute to extremes and to be sampled from well distinguished distributions. The available sample of the upper tail commonly used for standard frequency analyses is insufficient to provide correct parametrizations, while the proposed formulation provides highly consistent estimates of extreme quantiles.
The sensitivity of extreme quantiles to changes in intensity and yearly occurrences of each synoptic class is examined by means of multi-dimensional plots. An application of the formulation to the analysis of nonstationary conditions is provided showing that combinations of simple trends in intensity and yearly occurrences may lead to complicated responses in the extreme quantiles: extrapolation from observed quantiles may lead to misleading conclusions.