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Extreme meteorological droughts from paleo-climatic reconstructions analyzed through non-asymptotic extreme-value distributions

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Drought is a complex and multifaceted natural phenomenon whose effects may have serious environmental and socio-economic impacts on communities. Drought is a multi-year phenomenon and thus its probabilistic characterization needs long instrumental records. As a possible way to overcome the limitation posed by the paucity of long-term historical records of hydro-meteorological variables, in this work we aim at using paleo-climate reconstructions from tree-ring records, which are becoming increasingly available (International Tree-Ring Data Bank, ITRDB, accessible from the repositories of the NOAA's National Centers for Environmental Information). On the other side, we attempt to find the statistical link of paleo-climate data with drought characteristics identified on indices largely used in the literature, such as the self-calibrating Palmer Drought Severity Index (scPDSI). In particular, we determine drought events and their properties (severity, duration, and intensity) using threshold methods based on the statistical "theory of runs". We then explore the potentialities of using the recently-proposed Metastatistical Extreme Value Distribution (MEVD) to estimate the probability of occurrence of extreme drought events of different severity, duration, or intensity at several European sites. Unlike the statistical approaches based on the traditional Extreme Value Theory, the MEVD framework minimizes estimation uncertainty by leveraging the information content of all the ordinary values (i.e., those in the main body of the probability distribution).

More in detail, in this work we focus on: (1) tests of the reliability of these paleo-climatic reconstructions in reproducing meteorological droughts in long observational records, (2) the statistical analysis approach affording minimal uncertainty in the estimation of extreme drought events with an assigned probability of exceedance, and (3) how the severity and timing of impacts vary across and within drought-affected areas.