Extreme meteorological droughts from paleo-climatic reconstructions analysed through the Metastatistical Extreme Value Distribution

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Recent major occurrences of weather and climate extremes (see, e.g., UNDRR, 2021) highlight increased risks of floods as well as of droughts in many areas. These natural hazards are expected to be exacerbated further by anthropogenic climate change and may cause irreparable ecological losses and significant economic impacts. Therefore, it is of interest for any water-dependent sector to accurately estimate and monitor the different components of the hydrological cycle (e.g., precipitation, evapotranspiration, runoff, groundwater, etc.).

This work is a contribution to the analysis of the probabilistic structure of droughts, notoriously a challenging problem due to the small drought sample size in the observational record. In fact, due to typical multi-year durations and to long interarrival times, droughts are poorly represented in historical records of hydro-meteorological variables in most areas of the world. In turn, this calls for the use of information sources other than direct observations of meteorological variables. Here, we use centuries-long reconstructions of climate based on tree-ring archives, which are becoming increasingly available through global open access archives, such as the International Tree-Ring Data Bank (ITRDB, accessible from the repositories of the NOAA's National Centers for Environmental Information). To gain a quantitative understanding of how well tree ring-based data capture drought occurrences, we compare dryness indicators, such as scPDSI (self-calibrating Palmer Drougth Severity Index; Wells et al., 2004) and SPEI (Standardized Precipitation-Evapotranspiration Index; Vicente-Serrano et al., 2010), computed with direct observations of precipitation and temperature, with those obtained from tree-ring proxies. Like other hazards, we characterize drought events and their properties (severity, duration, and timing) using threshold methods based on the statistical “theory of runs”. We then explore the potential of the Metastatistical Extreme Value Distribution (MEVD; Marani and Ignaccolo, 2015) to estimate the probability of occurrence of meteorological droughts relative to traditional approaches.

We find that scPDSI values computed from tree-ring data do track the time behaviour of the corresponding observation-based indices, and we characterize similarities and departures of the corresponding drought statistics.

References

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