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Joint probability of hot and dry meteorological extremes

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Drought and heatwaves are major sources of risk to several socio-economic activities and their impacts are expected to increase under future global warming conditions. Regions recurrently affected by hot and dry climate Extremes, such as the Iberian Peninsula (IP), require enhanced climate risk analysis in order to mitigate climate changes impacts. However, the simultaneous or sequential occurrence of different climate extremes may lead to larger impacts. Although the major efforts in assessing hot and dry extremes and their interactions, the development of multivariate probabilistic models describing the joint behaviour of climate extremes is still a challenge. To contribute to the understanding of compound events of those extremes, here we estimate the joint probability distribution between heat waves and droughts, describing the amount of dependence between the different hazards. Our methodology is based on the copula theory, which is becoming quite popular among multivariate statistical analysis in hydrometeorological studies.
The drought hazard was characterized by the well-established multi-scalar Standardized Precipitation Evaporation Index (SPEI), during the summer month of July, computed based on the CRU TS4.01 database. The drought hazard was computed for the 6 months' timescale to incorporate the memory of the respective past months. The heatwaves were analysed based on the number of hot days per month (NHD) summed over the months of July and August, based on the E-OBS (version 17).
Here, we propose to assess if the summer extremely hot days in the IP are preceded by drought events in spring and early summer. This is assessed initially by computing the correlation coefficients between the number of hot days in the regions' hottest months with a drought indicator in the prior months, for the period 1980-2014. Probabilistic models based on copula functions were also established based on pairs of hot and dry events, and the best copulas were selected according to the Akaike's Information Criteria (AIC) to support correlation analysis. The established models were used for data generation preserving the dependence structure between the extreme episodes.
Most regions exhibit significantly negative correlations, i.e. high (low) NHD following negative (positive) SPEI values, and thus a potential for NHD early warning. The IP was identified as a hotspot of extreme hot temperatures preceded by drought events, suggesting how surface moisture deficits play an important role in the occurrence of hot extremes. The estimated joint probability distribution allows to provide estimates of their joint occurrence in order to mitigate the impacts magnified by the interactions between the different hazards.

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