Joint probability analysis of drought and hot extremes in Australia

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The simultaneous or sequential occurrence of extreme climate events, often designated as compound events, has recently received further attention, due to the higher impacts they cause, when compared to individual extreme events, and also due to the expected increase in their frequency within a warming climate context. The occurrence of compound dry and hot extremes has been observed in several regions throughout the world. The recent extreme bushfire season of 2019-2020 in Australia was probably driven by the sequential occurrence of spring drought and severe summer heatwaves.

Previous works have used correlation analysis to study these extreme dry and hot compound events, but it has been shown that, although necessary, antecedent drought is not a sufficient condition for the occurrence of hot extremes. For this reason, in this work we used copula functions to study the joint probability of occurrence of these extremes. This method, already applied for this type of compound events in other regions of the globe, allows to study dependences between variables, even if they are non-linear.

The drought conditions were assessed using the Standardized Precipitation Evaporation Index (SPEI) at time scales of 1, 3, and 6 months, using data from the CRU TS 4.04 dataset. The Number of Hot Days (NHD) and Number of Hot Nights (NHN) were used to quantify the hot extremes in the summer months in Australia and were computed with temperature data from the ERA5 dataset. The probability of occurrence of hot extremes given drought/non-drought conditions were estimated over the different regions of Australia. Differences in these probabilities further suggest the effect on hot summer extremes by droughts occurring on the concurrent and on previous months.

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