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Probabilistic agricultural drought risk using multiscalar and remote-sensing indices

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Agricultural ecosystems are critically affected by extreme weather events, such as droughts, and are expected to continue to be affected in the future due to climate change. Hence, regions dedicated to agricultural practices and recurrently affected by drought episodes, require an enhanced assessment of drought-related crop-failures, at various spatial and temporal scales. For this reason, in this work we propose a probabilistic agricultural drought risk model using remote sensing and multiscalar drought indices.
In this study the agricultural drought risk is defined as the conditional probability of occurrence of crop-loss when the drought conditions exceed specific thresholds, ranging between 0 (low agricultural drought risk) and 1 (high agricultural drought risk). Our methodology is based on the copula theory, which application is quite recent in agrometeorological studies. Copulas allow to model joint probability distributions with focus on the dependence between extreme values of different variables. Hence, we use copula functions to achieve two main objectives: (1) estimate joint probability distributions describing the amount of dependence between drought conditions and crop anomalies; (2) estimate conditional probability distributions of two major rainfed cereals in the Iberian Peninsula (IP) (wheat and barley) under different drought levels (no drought, mild or moderate drought and severe or extreme drought) according to the Standardized Precipitation Evapotranspiration Index (SPEI) and the satellite derived indices, the Vegetation Condition Index (VCI) and the Temperature Condition Index (TCI).
Bivariate copula models (Elliptical and Archimedean) were fitted on pairs of yield anomalies and drought indicators for the 1986-2016 period. The choice of the copula functions was made according to the Akaike's Information Criteria (AIC). The established models are used for data generation preserving the dependence structure between yield anomalies and drought conditions. The agricultural drought risk is finally determined based on the copula simulations.
The results indicate that, in comparison to wheat, barley shows a larger number of provinces characterized by greater probabilities of joint negative extremes (i.e. higher probability of observing a lower value of yield anomalies given drought conditions). In such cases, drought hazard is manly characterized by VCI and SPEI, while TCI is mainly used in copula models indicating greater probabilities of joint positive extremes of wheat and drought indicators. In addition, the estimated conditional probabilities suggest that barley is the crop with higher agricultural drought risk during mild or moderate droughts and severe or extreme droughts, in most of the provinces. From an operational point of view, the results aim to contribute to the decision-making process in agricultural practices.

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