Geophysical Research Abstracts
Vol. 17, EGU2015-13104, 2015
EGU General Assembly 2015

Characterization of agricultural drought risk by a two-dimensional copula

Lorenzo Vergni, Francesca Todisco, and Francesco Mannocchi

Department of Agricultural, Food and Environmental Sciences University of Perugia Borgo XX Giugno 74 06121 Perugia, Italy (lorenzo.vergni@unipg.it)

In this work, the joint probability distribution of two agricultural drought characteristics (Relative Severity, RS, and Onset, O) has been modeled by a two-dimensional copula. The application is illustrated with reference to a single-station case study (Perugia, Central Italy) and to the crop sunflower, widely grown in Central Italy, usually under rainfed conditions.

The 86-year time series of daily precipitation and maximum and minimum temperature from the Perugia station (Central Italy) were used to simulate the soil water dynamics in the root-zone of sunflower. For each year, single seasonal values of RS and O have been quantified by applying the theory of runs to the soil water volume dynamics, with a threshold equal to the crop critical point. RS derives from the summation of the severities (i.e. total water stress) of the drought runs occurred during the growing season. The attribute "relative" is here used because the severity value is corrected taking into account both the available water capacity of the soil and the growing season length. Thus, RS is a non-dimensional value ranging between 0 (no water stress) and 1 (maximum theoretical water stress for a given growing season length).

The characteristic O describes the water stress temporal position (with respect to the growing season length) and it derives from a weighted average of the times of occurrence of the different drought runs (run severities being the weights). O is a non-dimensional value that expresses the temporal position of water stress as percentage of residual growing season, and it ranges between 0 (drought location at harvest) and 1 (drought location at seeding). The information provided by this characteristic can be considered particularly useful in agricultural drought risk management, because, as it is known, the drought impact on crop yield (being equal the severity) can vary substantially with the sensitivity of the growth stages affected by water stress conditions.

The analysis showed that the best-fitting marginal distribution for both drought onset and relative severity is a truncated Gumbel distribution. The distribution parameters, estimated by a maximum log-likelihood algorithm are α=0.385 and β=0.091 for O and α=0.183 and β=0.076 for RS.

The dependence structure of O and RS was investigated by several graphical and analytical techniques. Among these, the Genest-Rémillard goodness-of-fit test based on the Cramer-Von Mises statistic, has been applied. It was found that a Student copula, (with parameter 0.924 and 18 degrees of freedom) is able to adequately reproduce both the overall dependence structure and the upper tail dependence among variables.

The Student copula has been finally used to obtain joint probabilities and bivariate return periods of drought onset and relative severity.

To check the reliability of the drought risk assessment provided by the identified copula model, the bivariate return period of each pair (RSi, Oi) was compared with the univariate return period of the corresponding yield value, estimated for each year by means of a crop growth model, specifically calibrated and validated for sunflower in Central Italy. This comparison, taking into account the uncertainty and the complexity of the phenomenon, led to satisfactory results and enabled to identify the combinations of O and RS values that can be considered critical for sunflower in Perugia.