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Transpirative Deficit Index (TDI) for the management of water scarcity in irrigated areas: development and application in northern Italy

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In Europe, the monitoring and assessment of drought is entrusted to the European Drought Observatory (EDO). EDO indicators are calculated considering rainfed agriculture and delivered on a 5 km grid. However, in southern Europe, irrigation may compensate for potentially severe agricultural droughts and specific water scarcity indicators that explicitly consider irrigation are needed.

In the Po River Plain, irrigated crops cover more than 70% of the agricultural land, massive amounts of water are diverted from rivers for irrigation, and surface irrigation methods are largely applied. Nowadays, the region is not a water scarce basin, but irrigation water shortages have occurred with increased frequency during the last two decades. Moreover, a recent EU report shows that the Po River Plain is included among areas in Europe that by 2030 shall be affected by water scarcity.

In this context, a study was started to select and develop indicators for the management and prevention of Water Scarcity and Drought (WS&D) based on the synergic use of hydrological modelling and Earth Observation data applied at a spatial scale of interest for end-users (250m grid). These indicators shall be better suited for the assessment of WS&D in Italy as well as in other southern European countries.

This work presents the development and the application of the TDI (Transpirative Deficit Index) to a study area, within the Po River Plain. TDI is an agricultural drought index based on the transpiration deficit (TDx, calculated as the difference between potential and actual transpiration), computed by the spatially distributed hydrological model IDRAGRA and cumulated over a period of x days. TDx for each day of a specific year is compared to the long-term TDx probability distribution (e.g., over 20-30 years), which is transformed into a standardized normal distribution. The non-exceedance probability of TDx is finally expressed in terms of unit of standard deviation (TDI), following the approach proposed for the well-known Standard Precipitation Index (SPI).

IDRAGRA is a distributed-parameters conceptual model, which allows the simulation of the water balance in the soil-plant-atmosphere system on a daily basis. It accounts for the spatial variability of soils, crops, meteorological and irrigation inputs by dividing study areas with a regular mesh. Modules for the simulation of crop development and irrigation water sources conveyance and distribution are moreover included. IDRAGRA was modified to allow the computation of TDI, both in absence and presence of irrigation.

The simulation system was applied to a pilot study area of about 230 km^2, located in the Po River Plain. TDI was computed considering a reference meteorological data series of 22 years (1993-2014). TDI patterns were analysed for two years, one (2003) with very scarce and the other (2014) with abundant precipitations. Results showed that the irrigation supply cannot compensate severe droughts in some districts of the pilot area, and were confirmed by yield data and by the staff of the Irrigation Consortium managing irrigation water in the area.