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Adapting FAO-56 Spreadsheet Program to estimate olive orchard transpiration fluxes under soil water stress condition

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In the Mediterranean environment, where the period of crops growth does not coincide with the rainy season, the crop is subject to water stress periods that may be amplified with improper irrigation management.
Agro-hydrological models can be considered an economic and simple tool to optimize irrigation water use, mainly when water represents a limiting factor for crop production. In the last two decades, agro-hydrological physically based models have been developed to simulate mass and energy exchange processes in the soil-plant-atmosphere system (Feddes et al., 1978; Bastiaanssen et al., 2007). Unfortunately these models, although very reliable, as a consequence of the high number of required variables and the complex computational analysis, cannot often be used. Therefore, simplified agro-hydrological models may represent an useful and simple tool for practical irrigation scheduling.
The main objective of the work is to assess, for an olive orchard, the suitability of FAO-56 spreadsheet agro-hydrological model to estimate a long time series of field transpiration, soil water content and crop water stress dynamic.
A modification of the spreadsheet is suggested in order to adapt the simulations to a crop tolerant to water stress. In particular, by implementing a new crop water stress function, actual transpiration fluxes and an ecophysiological stress indicator, i. e. the relative transpiration, are computed in order to evaluate a plant-based irrigation scheduling parameter.
Validation of the proposed amendment is carried out by means of measured sap fluxes, measured on different plants and up-scaled to plot level.
Spatial and temporal variability of soil water contents in the plot was measured, at several depths, using the Diviner 2000 capacitance probe (Sentek Environmental Technologies, 2000) and TDR-100 (Campbell scientific, Inc.) system. The detailed measurements of soil water content, allowed to explore the high spatial variability of soil water content due to the combined effect of the punctual irrigation and the non-uniform root density distribution.
A further validation of the plant-based irrigation-timing indicator will be carried out by considering another ecophysiological stress variable like the predawn leaf water potential.
Accuracy of the model output was assessed using the Mean Absolute Difference, the Root Mean Square Difference and the efficiency index of Nash and Sutcliffe.
Experimental data, recorded during three years of field observation, allowed, with a great level of detail, to investigate on the dynamic of water fluxes from the soil to atmosphere as well as to validate the proposed amendment of the FAO-56 spreadsheet.
The modified model simulated with a satisfactory approximation the measured values of average soil water content in the root zone, with error of estimation equal to about 2.0%. These differences can be considered acceptable for practical applications taking into account the intrinsic variability of the data especially in the soil moisture point measurements. An error less than 1 mm was calculated in the daily transpiration estimation. A good performance was observed in the estimation of the cumulate transpiration fluxes.