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Using ISBA model for partitioning evapotranspiration into soil evaporation and plant transpiration of irrigated crops under semi-arid climate

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The Haouz region, typical of southern Mediterranean basins, is characterized by a semi-arid climate, with average annual rainfall of 250, whilst evaporative demand is about 1600 mm per year. Under these conditions, crop irrigation is inevitable for growth and development. Irrigated agriculture currently consumes the majority of total available water (up to 85%), making it critical for more efficient water use. Flood irrigation is widely practiced by the majority of the farmers (more than 85 %) with an efficiency which does not exceed 50%. In this context, a good knowledge of the partitioning of evapotranspiration (ET) into soil evaporation and plant transpiration is of crucial need for improving the irrigation scheduling and thus water use efficiency.

In this study, the ISBA (Interactions Soil-Biosphere-Atmosphere) model was used for estimating ET and its partition over an olive orchard and a wheat field located near to the Marrakech City (Centre of Morocco). Two versions were evaluated: standard version which simulates a single energy balance for the soil and vegetation and the recently developed multiple energy balance (MEB) version which solves a separate energy balance for each of the two sources. Eddy covariance system, which provides the sensible and latent heat fluxes and meteorological instruments were operated during years 2003-2004 for the Olive Orchard and during years 2013 for wheat. The transpiration component was measured using a Sap flow system during summer over the wheat crop and stable isotope samples were gathered over wheat.

The comparison between ET estimated by ISBA model and that measured by the Eddy covariance system showed that MEB version yielded a remarkable improvement compared to the standard version. The root mean square error (RMSE) and the correlation coefficient (R^2) were about 45wm-2 and 0.8 for MEB version. By contrast, for the standard version, the RMSE and R^2 were about 60wm-2 and 0.7, respectively. The result also showed that MEB version simulates more accurately the crop transpiration compared to the standard version. The RMSE and R^2 were about 0.79 mm and 0.67 for MEB and 1.37mm and 0.65 for standard version. An in-depth analysis of the results points out : (1) a deficiency of the standard version in simulating soil evaporation, in particular after an irrigation event, that directly impact the latent heat fluxes prediction because of two much energy reaching the soil and (2) a significant improvement of the surface temperature predictions with the double energy balance version; an interesting feature in the context of data assimilation; (3) a poor parameterization of the stomatal conductance in the A-gs photosynthetic module that is corrected thanks to a stochastic parameter identification approach. Results have direct implication for the prediction of evapotranspiration and its partition over irrigated crops in semi-arid areas of the South Mediterranean region.