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Impact of Mediterranean crop rotation on long-term temporal dynamics of evapotranspiration

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Improved understanding of the surface water balance of Mediterranean cropland is required to accurately predict the impact of climate change on water resources and to adapt irrigation management practices. Evapotranspiration (ET) has been identified as one of the most uncertain term of the surface water balance. One source of uncertainties in ET estimation concerns its partitioning between the soil evaporation and the vegetation transpiration. Most studies on ET partitioning over cropland were done at seasonal scale. Crop rotation can lead to long periods with bare soil surface that strongly affects the dynamic of ET. Besides, the succession of irrigated and rainfed crops can lead to large inter-annual variability in ET dynamics.

In this study we analyze long-term temporal dynamics of ET partitioning simulated from a land surface model over a 13-yr crop succession. The main originality of this work consists in representing the succession of crop cycles and inter-crop bare soil periods and assessing its impact on the dynamic of ET. ET simulations are analyzed over the Avignon crop site where soil water content and energy surface fluxes have been continuously monitored over 15 arable crop cycles and 15 inter-crop periods since 2001. The approach consists in combining land surface modelling, observations and uncertainty analysis to monitor ET and the associated uncertainties. The ISBA land surface model is exploited in its A-gs version which includes a coupled stomatal conductance-photosynthesis scheme. The model is driven by local meteorological and vegetation observations. Key soil parameters, which drive the simulation of ET, are calibrated using the long time series of measured ET and soil moisture. An ensemble of simulation is generated to represent the impact of uncertainties in model parameters and measurements. The ISBA simulations are compared with simulations from the STICS crop model to investigate uncertainties related to the model structure.

This work shows that ET mainly results from soil evaporation when it is simulated over a succession of crop cycles and inter-crop periods for Mediterranean croplands. Crop transpiration generates high ET over short-time periods while soil evaporation represents more than 50% of ET for 80% of the days. The variability in ET partitioning dynamics is analyzed for distinct crop types and crop management practices. The uncertainty analysis highlights the impact of errors in the soil hydrodynamic properties on ET partitioning. We show the key role of i) the soil moisture at wilting point in the simulation of the crop transpiration during water stress period and ii) the soil moisture at saturation to simulate the soil evaporation during wet soil periods. The comparison of the ISBA simulations with the crop model simulations highlights the influence of the representation of crop phenology and agricultural practices on the simulation of ET partitioning. This paper shows that accounting for crop succession in land surface model is essential to accurately estimate ET amount and temporal dynamic which are both critical to properly represent land-surface atmosphere interactions.