Uncertainties in simulated evapotranspiration from land surface models over a 15-year Mediterranean crop succession

S. Garrigues.[1,,4,], A. Verhoef[4], P-L Vidale[5], B.Sarojini[4], A. Olioso[1,2,], A.Boone[3], C. Albergel[3], B. Decharme[3], J-C. Calvet[3], D. Carrer[3], S. Moulin[1,2,]

[1] INRA, UMR1114 EMMAH, F-84914 Avignon Cedex 9, France
[2] Université d'Avignon et des Pays de Vaucluse, UMR1114 EMMAH, F-84000 Avignon, France

[3] CNRM, UMR3589, Météo-France, CNRS, Toulouse, France

[4] University of Reading, Department of Geography and Environmental Science, Reading, UK

[5] University of Reading, Department of Meteorology, Reading, UK

Corresponding author: Sébastien Garrigues, sebastien.garrigues@inra.fr

Evapotranspiration (ET) has been recognized as one of the most uncertain terms in the surface energy budget and the surface water balance simulated by Land Surface Models (LSM), particularly for Mediterranean regions. This study aims at assessing multi-year simulations of ET over a Mediterranean crop succession and identifying the main sources of uncertainties affecting ET simulations. We use the $C0_2$-responsive version of the 'Interactions between Soil, Biosphere, and Atmosphere' (ISBA-A-gs) and the 'Joint UK Land Environment Simulator' (JULES) models. The simulations are conducted for a typical Mediterranean crop site (Avignon, France) which provides 15-year of continuous measurements of soil moisture and surface fluxes. We evaluate the uncertainties related to:

- Climate, vegetation and crop management drivers: we test various climate datasets which include the SAFRAN atmospheric reanalysis, the ERA-Interim reanalysis, the Global Precipitation Climatology Centre dataset and the MeteoSat Second Generation satellite estimate of downwelling shortwave radiations. For vegetation, we assess the uncertainties resulting from the use of a Leaf Area Index (LAI) climatology. Finally, we test the impact of having no irrigation in ET simulations.

- Soil hydraulic parameters: we assess the impact of errors in the soil hydraulic parameters when they are estimated from the pedotransfer functions embedded in the model.

- Soil water transfer representation: we compare the performance skills of the force-restore reservoir model versus the multi-layer soil diffusion scheme.

- LSM: we compare ET simulated from ISBA-A-gs with ET obtained from the JULES using the same local forcing variables.

The main outcomes are:

- Errors in the soil hydraulic parameters and the lack of irrigation in the simulation have the largest influence on ET compared to uncertainties in climate data sets and LAI climatology. Among climate variables, the errors in yearly ET are mainly related to the errors in yearly rainfall.
- Errors in the soil parameters derived from the pedotransfer functions lead to underestimation of the water content available for the crop and the soil hydraulic diffusivity which results in a large underestimation of ET (1300 mm over 15 years).
- Soil evaporation represents 70 % of cumulative evapotranspiration over 15 years of crop succession which explains the high sensitivity of simulated evapotranspiration to uncertainties in the soil evaporation parameters.
- The spatiotemporal uncertainties in the soil parameters generate smaller uncertainties in ET when it is simulated with the multi-layer soil diffusion scheme (374 mm over 12 years) than when it is simulated using the force-restore scheme (962 mm over 12 years).
- The departure between the ISBA and JULES simulations highlight other sources of uncertainties related to the representation of the plant water stress, for example.

The main challenges for LSM over Mediterranean cropland concern the representation of :

- the spatial distribution of the soil hydraulic parameters, particularly those related to soil evaporation which is frequently the prevailing component of ET over Mediterranean crop succession,
- the variability of irrigation practices,
- the spatiotemporal variability of rainfall which can be particularly important for Mediterranean climate.

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