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Impact of climate, vegetation, soil and irrigation on multi-year ISBA-A-gs simulations of evapotranspiration over a Mediterranean crop site

Sebastien Garrigues (1,2), Albert Olioso (1,2), Dominique Carrer (3), Bertrand Decharme (3), Eric Martin (4), Jean-Christophe Calvet (3), Sophie Moulin (1,2), and Olivier Marloie (5)

(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-GAME, UMR3589, Météo-France, CNRS, Toulouse, France, (4) RECOVER/IRSTEA, Aix-en-Provence, France, (5) 5URFM, INRA, Avignon, France

Evapotranspiration (ET) has been recognized as one of the most uncertain terms in the surface water balance simulated by land surface models. Part of uncertainties arise from uncertainties in the climate and surface characteristic data sets used to drive the model and to integrate it spatially at large-scale. This paper aims at investigating the uncertainties in the climate, the irrigation, the vegetation dynamic and the soil property variables and analyzing their impacts on the evapotranspiration simulated over a 12-year Mediterranean crop succession. We use the Interactions between Soil, Biosphere, and Atmosphere (ISBA-A-gs) land surface model. We evaluate the forcing data sets used in the standard implementation of ISBA over France where the model is driven by the SAFRAN high spatial resolution atmospheric reanalysis, the ECOCLIMAP-II Leaf Area Index (LAI) climatology derived from MODIS satellite observations and the soil texture derived from the French soil database. For climate, we focus on the radiations and rainfall variables and we test additional datasets which include the ERA-Interim low spatial resolution reanalysis, the Global Precipitation Climatology Centre dataset (GPCC) and the MeteoSat Second Generation (MSG) satellite estimate of downwelling shortwave radiations.

The evaluation of the drivers indicates very low bias in daily downwelling shortwave radiation for ERA-I compared to the negative biases found for SAFRAN and the MSG satellite. Both SAFRAN and ERA-I underestimate downwelling longwave radiations. SAFRAN and ERA-I/GPCC rainfall are slightly biased at daily and longer timescales. The SAFRAN rainfall is more precise than the ERA-I/GPCC estimate which shows larger inter-annual variability in yearly rainfall error (up to 100 mm). The ECOCLIMAP-II LAI climatology does not properly resolve Mediterranean crop phenology and underestimates bare soil period which leads to an overall overestimation of LAI over the crop succession. The simulation of irrigation by the model provides accurate irrigation amounts over crop cycles but the timing of irrigation occurrences is frequently unrealistic.

Errors in the soil hydrodynamic parameters and the lack of irrigation in the simulation have the largest influence on ET compared to uncertainties in the climate reanalysis and the LAI climatology. Among climate variables, the errors in yearly ET are mainly related to the errors in yearly rainfall. The underestimation of the available water capacity and the soil hydraulic diffusivity induce a large underestimation of ET over 12 years. The underestimation of radiations by the climate reanalyses and the absence of irrigation in the simulation lead to the underestimation of ET while the overall overestimation of LAI by the ECOCLIMAP-II climatology induces an overestimation of ET over 12 years.

This work shows that the key challenges to monitor the water balance of cropland at regional scale concern the representation of the spatial distribution of the soil hydrodynamic parameters, the variability of the irrigation practices, the seasonal and interannual dynamics of vegetation and the spatiotemporal heterogeneity of rainfall. Approaches combining models and high spatial resolution ($\sim$10-20 m) and high temporal frequency (5-10 days) earth observations need to be developed to better resolve interactions between vegetation and hydrology.