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Ecohydrological modeling: the consideration of agricultural trees is essential in the Mediterranean area

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In the Mediterranean region, climate and land use change are expected to impact on natural and agricultural ecosystems by warming, reduced rainfall and direct degradation of ecosystems. Human population growth and socioeconomic changes, notably on the Eastern and Southern shores, will require increases in food production and put additional pressure on agro-ecosystems and water resources. Coping with these challenges requires informed decisions that, in turn, require assessments by means of a comprehensive ecohydrological model.

Here we present here the inclusion of 10 Mediterranean agricultural plants, mainly perennial crops, in an agro-ecosystem model (LPJmL, "Lund-Potsdam-Jena managed Land"): nut trees, date palms, citrus trees, orchards, olive trees, grapes, cotton, potatoes, vegetables and fodder grasses. The model was then successfully tested in three model outputs: agricultural yields, irrigation requirements and soil carbon density.

A first application of the model indicates that, currently, agricultural trees consume in average more irrigation water per hectare than annual crops. Also, different crops show different magnitude of changes in net irrigation requirements due to climate change, being the increases most pronounced in agricultural trees. This is very relevant since the Mediterranean area as a whole might face an increase in gross irrigation requirements between 4% and 74% from climate change and population growth if irrigation systems and conveyance are not improved. Additionally, future water scarcity might pose further challenges to the agricultural sector: Algeria, Libya, Israel, Jordan, Lebanon, Syria, Serbia, Morocco, Tunisia and Spain have a high risk of not being able to sustainably meet future irrigation water requirements in some scenarios by the end of the century (1).

The importance of including agricultural trees in the ecohydrological models is also shown in the results concerning soil organic carbon (SOC). Since in former model versions, areas with agricultural trees were simulated as perennial grasslands, implementing agricultural trees in LPJmL increased the carbon stock in soils in most of the Mediterranean area. We compared the SOC estimates before and after the implementation of agricultural trees, with the organic carbon density from the HWSD database (2). These data are produced by establishing functions between SOC and soil type, topography, climate variables and land use situation. The number of grid-cells with decreased differences to the HWSD estimates almost doubles the number of grid-cells with increased differences. This means that the development moved LPJmL's results for SOC closer to HWSD values (3).

With the model development presented here, LPJmL is now able to simulate in good detail and mechanistically the functioning of Mediterranean agriculture and its linkage with water use and resources.

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