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Assessing irrigation sustainability in the Euro-Mediterranean region with an integrated agro-hydrologic model

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Irrigation accounts for between 40% and 90% of human freshwater abstractions in Mediterranean areas, where pressures on water resources are expected to increase further due to climate change and population growth. In this context, we apply the integrated crop growth and water resources model LISFLOOD-EPIC to assess the sustainability of irrigation water use in the Euro-Mediterranean region. Simulations explore the trade-off between irrigated crop production and freshwater availability at catchment scale.

The distributed water resources model LISFLOOD is coupled with the EPIC crop growth model and a newly developed irrigation module. The integrated model simulates the interactions between catchment hydrology, crop yield, irrigation and water resources management. The crop module simulates biophysical plant development processes accounting for weather conditions, atmospheric CO_2 concentration, and abiotic stress factors (including soil moisture deficit and over-saturation, heat and cold stresses, and frost damage). It is coupled with the hydrologic model through soil moisture, plant water uptake and freshwater availability for irrigation at the daily time scale. Three irrigation methods are represented: drip, sprinkler, and surface. Water abstractions of other sectors (household, industry, energy and livestock) are simulated based on spatially distributed requirement time series derived from national statistics. Water may be withdrawn from groundwater, rivers, lakes and reservoirs.

Simulated irrigation abstractions and crop yield are compared to historical records. Then we focus on how changes in irrigation intensity and efficiency affect crop production, the likelihood of water shortages and minimum environmental flow violations, and the storage levels of reservoirs and groundwater. As abstractions from reservoirs and groundwater are used to buffer the effects of hydrological and agricultural droughts, the depletion of these resources indicates potentially unsustainable water management. We design irrigation water abstraction rules to prevent the long term storage decline of groundwater and reservoirs. We evaluate the impacts on crop yield, water use, and the quantitative state of freshwater bodies.