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Modeling of drainage and hay production over the Crau aquifer for analyzing the impact of global change on aquifer recharge

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The recharge of the aquifer in the Crau plain (550 km^2, Southern Rhone Valley, France) depends on the irrigation of 15000 ha of meadow using water withdrawn from the River Durance through a dense network of channels. Traditional irrigation practice, since the XVIth century, has consisted in flooding the grassland fields with a large amount of water, the excess being infiltrated toward the water table. Today, the Crau aquifer holds the main resource in water in the area (300 000 inhabitants) but changes in the agricultural practices and progressive replacement of the irrigated meadows by urbanized area threaten the sustainability of groundwater.

The distributed modeling of irrigated meadows together with the modeling of groundwater has been undertaken for quantifying the contribution of the irrigation to the recharge of the aquifer and to investigate possible evolution of hay production, water drainage, evapotranspiration and water table under scenarios of climate and land-use changes. The model combines a crop model (STICS) that simulates hay production, evapotranspiration and water drainage, a multisimulation tool (MultiSimLib) that allows to run STICS over each agricultural field in the aquifer perimeter, a groundwater model MODFLOW to simulate the water table from recharge data (simulated drainage).

Specific models were developed for simulating the spatial distribution of climate, including scenario of changes for the 2025 – 2035 time period, soil properties (influenced by irrigation), and agricultural practices (calendar and amount), in particular irrigation and hay cutting. This step was crucial for correctly simulating hay production level and amount of water used for irrigation.

Model results were evaluated thanks to plot experiments and information from farmers (biomass production, downward water flow, quantity of irrigated water, cutting calendar...), a network of piezometers and remote sensing maps of evapotranspiration.

Main results included:

- the proportion of irrigation water that contributes to the recharge of aquifer was evaluated to 75 %, which represent 80% of the total recharge;

- increase in temperature in the future leads to an increase in hay production (+ 10% in 2030 compared to now)

- increase in potential evapotranspiration in the future leads to an increase of meadow evapotranspiration by 10% which has a significant impact on the amount of irrigation water required to sustain the level of aquifer recharge and the level of the water table

- decrease in irrigated surfaces (-10% forecasted for 2030) results in a significant decrease of aquifer recharge (-8%) that may affect water resources in the area (amount almost equivalent to water withdrawal for domestic use in the area)

- reduction in available water for irrigation directly affect the aquifer recharge: e.g. 30% reduction in irrigation level result in a 35% reduction in drainage at the aquifer scale; however, the production of hay would be just slightly affected.

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