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Partitioning groundwater recharge between rainfall infiltration and irrigation return flows using stable isotopes: the Crau aquifer.

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Traditional flood irrigation is used since the 16th century in the Crau plain (Southern France) for hay production. To supply this high consuming irrigation practice, water is diverted from the Durance River, originating from the Alps, and the large amount of irrigation return flows constitutes the main recharge of the Crau aquifer, which is in turn largely exploited for domestic, industrial and agricultural water use. A possible reduction of irrigation fluxes due to a need of water saving or to a future land-use change could endanger the groundwater resource. A robust quantification of the groundwater mass balance is thus required to assess a sustainable water management in the region. The high isotopic contrast between these exogenous irrigation waters and local precipitations allows the use of stable isotopes of water as conservative tracers to deduce their contributions to the surface recharge. An extensive groundwater sampling was performed to obtain δ18O and δ2H over the whole aquifer. Based on a new piezometric contour map, combined with a reestimate of the aquifer geometry, the isotopic data are implemented in a geostatistical approach to produce a conceptual equivalent-homogeneous reservoir, in order to apply a simple water and isotope mass balance mixing model. The isotopic composition of the two end-members is assessed, and the quantification of groundwater flows is then used to calculate the two recharge fluxes. Near to steady-state condition, the set of isotopic data treated by geostatistics leads to a recharge by irrigation of 5.20 $\pm$ 0.93 m3 s-1 i.e. 1173 $\pm$ 210 mm yr-1, and a natural recharge of 2.26 $\pm$ 0.91 m3 s-1 i.e. 132 $\pm$ 53 mm yr-1. Thus, 70 $\pm$ 9% of the effective surface recharge comes from the irrigation return flow, consistent with the literature (between 67% and 78%). This study constitutes a straightforward and independent approach to assess groundwater surface recharges with uncertainties and will help to constrain a future transient groundwater flow model of the Crau aquifer.