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Evaluating the impact of land use changes on the behaviour of shallow aquifers, by quantifying the groundwater mean residence times distribution

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Residence time is one of the key factors of the groundwater resource management. The Crau aquifer (Mediterranean area, south of France) is a major resource for drinking water supply, threatened by climate change, changes in irrigation patterns, and urban expansion. Water residence time in the aquifer is expected to be highly dependent on these changes. We propose to determinate it using an isotopic approach, associated to numerical modelling.
The Crau aquifer is a palaeo-alluvial fan of the Durance river, made of alluviums lying on a Miocene substratum, and recharged by rainwater and gravity irrigation water, diverted from the Durance river. The irrigation water being more depleted in 18O than the rain water, the contribution of irrigation to the aquifer recharge can be quantified (up to 80 to 85% of the total recharge), but is variable in space and time.
The modelling approach uses two models, a lumped one and a discretised one. They are based on daily recharge data (rainfall, drainage rates under irrigated crops calculated from the STICS crop model, Olioso et al., 2013), and on monthly water sampling conducted from February 2012 to November 2016 for δ18O content in rainwater, surface water and groundwater. The lumped approach was carried out at a monthly time step, using a binary mixing model, including two exponentially draining reservoirs in parallel. It leads to a satisfying simulation of the δ18O variations in the monitored wells, and gives mean residence times between 3 and 20 months depending on the wells locations. The discretised model is a combination of MODFLOW and MODPATH, through the free user interface MODELMUSE, on a daily time-step. The permeability map used is the one calibrated by Baillieux et al. (2015). Recharge is applied with an increasing spatial complexity, in three successive steps:
- a homogeneous recharge, provided by the intermediate output of the lumped model, in order to compare the two models results;
- a recharge discretised in two zones, non irrigated/irrigated;
- a discretised recharge coming from the STICS crop model outputs.
Environmental parameters that greatly influence water residence time in the aquifer could be deduced from this approach by progressive increase of the model complexity.

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