Hydraulic boundary conditions as a controlling factor of water exchanges between a saturated karstic conduit and its surrounding rock

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Keywords: karst hydrology, isotopes, water exchanges, saturated conduit

The exchanges of water between the conduits and its surrounding rock in karstic aquifer are key parameters to understand the changes of water quality at the outlet of these aquifers.
The mechanisms controlling these exchanges under saturated conditions are explored using a 2D coupled continuum-conduit flow model (Feflow®). The flows in the conduits and in the surrounding rock are described by the Manning-Strickler equation and the Darcy law respectively. We choose fluid transfer conditions to describe the aquifer boundaries, which imply that the hydraulic heads at the boundaries of the conduit are not fixed. Thus the model can calculate freely the amounts of water exchanged between the two domains.
Isotopic ($\delta^{18}O$ and 2H) and discharge measurements were conducted on the Val d'Orléans karstic aquifer (France), during the 2008 hydrologic cycle. The aims were (1) to estimate the amounts of water exchanged between the two domains and (2) to validate the proposed model.
The modelled amounts of exchanged water between the two domains are consistent with those derived from the monitoring. The steady flow results show a spatial variability of the water exchanges from recharge to discharge areas that are controlled by the turbulent head loss in the conduit and by the boundary conditions. The transient calculation shows a zone where the water is mixed at the interface between the conduit and the rock. Only the point recharge in the conduit controls the observed transient changes of water exchanges between the two domains.