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Quantifying spatio-temporal stream-aquifer water exchanges along a multi-layer aquifer system using LOMOS and hydro-thermo modelling

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The aim of this work is to understand the spatial and temporal variability of stream-aquifer water exchanges along a 6 km-stream network in a multi-layer aquifer system using both LOcal MOnitoring Stations (LOMOSs) coupled with the optimization of a hydro-thermo model per LOMOS. With an area of 45 km2, the Orgeval experimental basin is located 70 km east from Paris. It drains a multi-layer aquifer system, which is composed of two main geological formations: the Oligocene (upper aquifer unit) and the Eocene (lower aquifer unit). These two aquifer units are separated by a clayey aquitard. The connectivity status between streams and aquifer units has been evaluated using near surface geophysical investigations as well as drill cores.

Five LOMOSs of the stream-aquifer exchanges have been deployed along the stream-network to monitor stream-aquifer exchanges over years, based on continuous pressure and temperature measurements (15 min-time step). Each LOMOS is composed of one or two shallow piezometers located 2 to 3 m away from the river edge; one surface water monitoring system; two hyporheic zone temperature profiles located close to each river bank. The five LOMOSs are distributed in two upstream, two intermediate, and one downstream site. The two upstream sites are connected to the upper aquifer unit, and the downstream one is connected to the lower aquifer unit. The 2012-April - 2013-december period of hydrological data are hereafter analyzed. We first focus on the spatial distribution of the stream-aquifer exchanges along the multi-layer aquifer system during the low flow period. Results display an upstream-downstream functional gradient, with upstream gaining stream and downstream losing stream. This spatial distribution is due to the multi-layer nature of the aquifer system, whose lower aquifer unit is depleted. Then it appears that the downstream losing streams temporally switch into gaining ones during extreme hydrological events, while the upstream streams remain gaining streams even during the flood peak when overflow drastically reduces the water exchanges. To illustrate the spatial distribution of the stream-aquifer exchanges temporal variability three extreme hydrological events of various intensity are analyzed.

Finally, temperature profiles in the HZ are interpreted with a coupled thermo-hydro finite element METIS code at each LOMOS. The coupled 2D vertical flow and heat transfer simulations are carried out to explain the discrete experimental data at the HZ scale and allow the instantaneous quantification of the water exchanged at each LOMOS.

Keyword: stream-aquifer interface, monitoring data, thermo-hydro modeling, hyporehic flux.