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# Designing a multiscale experimental sampling system for quantifying stream-aquifer water exchanges in a multi-layer aquifer system

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This work aims at providing a methodological framework to build up a multi-scale sampling network of stream-aquifer water exchanges that integrates the idea of spatially telescoping measurements in a multi-layer aquifer system of the Orageval catchment (France). The multi-layer latter is composed of two main geological layeres: the Oligocene and the Eocene. These two aquifer units are separated by a clayey aquitard. Most of the basin is covered with table-land loess about 2-5 m in thickness. Studying stream-aquifer requires the coupling of multi-scale sampling and monitoring strategies, with spatio-temporal data analysis, interpretations and interpolations, as well as modelling techniques. Many sampling methods are available that aim at understanding the stream-aquifer interactions. Most of them are indirect methods, which permit the localization and identification of the exchanges. Almost all of these methods are site specific and do not solely allow for quantifying water exchanges along the stream network, which is the goal of this study.

First, geophysical (TDEM, ERT) and drilling investigations are performed to assess the regional structure of the aquifer system and the local connectivity between streams and aquifer units. This step permits the definition of sampling locations at the catchment and the local scales. At the catchment scale, the investigations validate the fact that loess are connected to Oligocene limestones composing the upper aquifer unit. Moreover, piezometric head maps representative of low and high flow regimes are interpolated using geostatistics, which provides distributions of piezometric heads and standard deviations of the estimation error. At the local scale, the connectivity status between streams and aquifer units is assessed using i) electrical resistivity tomography (ERT) with a 4 m electrode spacing (assessing the main connectivity between the stream network and the various aquifer units) ii) ERT section with a 0.25 m electrode spacing (defining the level of heterogeneity associated with the assumed hyporheic zone (HZ)).

These geophysical investigations are then used to select local monitoring stations (LMSs) along the stream network. The multi-scale LMSs network is composed of five river cross-sections distributed in two upstream, two intermediate and one downstream site. The two upstream sites are connected to the upper aquifer unit, the two intermediate sites are connected to the aquitard unit and the downstream one is connected to the lower aquifer unit. At each river cross section, hydraulic heads and temperature are recorded continuously within the river, the shallow aquifer, and the HZ. Altogether, the sampling system allows for monitoring water exchanges along 6 km of the stream network, with a finer hydro-geophysical sampling at each LMS. Finally, temperature profiles in the HZ are interpreted with a coupled thermo-hydro finite element code at the upstream station of the domain. Multiple simulations indicate first proof of evidence for a gaining stream in the upstream part of the sampling domain.

Keywords: stream-aquifer interface, multi-scale monitoring, hydro-geophysics, geostatistics, thermo-hydro modelling