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Assessing Surface Water and Groundwater Interactions Using Long-Term Hydrological and Time-Lapse Seismic Data in the Orgeval Critical Zone Observatory

Agnès Rivière[1], Marine Dangeard[3], Ludovic Bodet[2], Ramon Sanchez Gonzalez[2,1], and Alexandrine Gesret[1]

[1]Mines Paris PSL, Geoscience center, fontainebleau, France (agnes.riviere@minesparis.psl.eu)
[2]Sorbonne Université, CNRS, EPHE, UMR 7619 METIS, 4 place Jussieu, 75252 Paris 05, France
[3]SNCF Réseau, 6 avenue François Mitterrand, 7 93210 Saint-Denis, France

Quantifying the water and heat fluxes at the interface between surface water (SW) and groundwater (GW) is a key issue for hydrogeologists to consider for safe yield and good water quality. However, such quantification with field measurements is not straightforward because the SW-GW changes depend on the boundary conditions and the spatial description of the hydrofacies, which aren't well known and are usually guessed by calibrating models using standard data like hydraulic heads and river discharge. We provide a methodology to build stronger constraints to the numerical simulation and the hydrodynamic and thermal parameter calibration, both in space and time, by using a multi-method approach. Our method, applied to the Orgeval Critical Zone Observatory (France), estimates both water flow and heat fluxes through the SW-GW interface using long-term hydrological data, time-lapse seismic data, and modeling tools. We show how a thorough interpretation of high-resolution geophysical images, combined with geotechnical data, provides a detailed distribution of hydrofacies, valuable prior information about the associated hydrodynamic property distribution. The temporal dynamic of the WT table can be captured with high-resolution time-lapse seismic acquisitions. Each seismic snapshot is then thoroughly inverted to image spatial WT variations. The long-term hydrogeological data (such as hydraulic head and temperature) and this prior geophysical information are then used to set the parameters for the hydrogeological modeling domain. The use of the WT geometry and temperature data improves the estimation of transient stream-aquifer exchanges.