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Thermal tracer tests for characterizing a shallow alluvial aquifer

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Using heat as an active tracer in different types of aquifers is a topic of increasing interest [e.g. Vandenbohede et al.; 2008, Wagner et al., 2013; Read et al., 2013]. In this study, we investigate the potential interest of coupling heat and solute tracer tests for characterization of a shallow alluvial aquifer. A thermal tracer test was conducted in the alluvial aquifer of the Meuse River, Belgium. The tracing experiment consisted in simultaneously injecting heated water and a dye tracer in a piezometer and monitoring the evolution of groundwater temperature and tracer concentration in the recovery well and in nine monitoring wells located according to three transects with regards to the main groundwater flow direction.

The breakthrough curves measured in the recovery well showed that heat transfer in the alluvial aquifer is slower and more dispersive than solute transport. Recovery is very low for heat while in the same time it is measured as relatively high for the solute tracer. This is due to the fact that heat diffusion is larger than molecular diffusion, implying that exchange between groundwater and the porous medium matrix is far more significant for heat than for solute tracers. Temperature and concentrations in the recovery well are then used for estimating the specific heat capacity with the energy balance approach and the estimated value is found to be consistent with those found in the literature.

Temperature breakthrough curves in other piezometers are contrasted with what would be expected in an ideal layered aquifer. They reveal strongly unequal lateral and vertical components of the transport mechanisms. By means of a numerical heat transport model, we provide a preliminary interpretation of these temperature breakthrough curves. Furthermore, these data could be included in the calibration of a complex heat transfer model for estimating the entire set of heat transfer parameters and their spatial distribution by inverse modeling.