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Heat as a tracer for improving a transient 3D groundwater model at a bank filtration site with changing riverbed

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Bank filtration, by its effective improvement of water quality is widely used in many countries for water supply, and its major characteristics, the interaction between groundwater and surface water has been a hot topic for decades. As a key parameter, the travel time of the infiltrating river water to the wells is considered to be highly correlated with its water quality and has always been used as a main reference for estimating the filtering performance. As a periodic environmental tracer, heat has been used for estimating travel times by comparing the attenuation and the phase shift for temperature patterns in both the river and groundwater observation points. In most cases, the methods applied are analytical time series analysis, or 2D and 3D groundwater models with homogeneous attributes, in which many details of geological discontinuity and heterogeneity might be missed and further decrease the reliability of model result. However in our study, the transient heat transport model was set up based on a calibrated transient groundwater model with complex and discontinuous geological structures referenced by available geological information.

At the study area, a water work is placed hundreds of meters from a river. By the pumping induced hydraulic gradient, river water flows into pumping wells through the river bank and shallow aquifers. The unconsolidated impermeable glacial deposits of different glacial periods showed discontinuities in forms of geological windows and lenses. Referenced by 145 drillings and 7 geological cross-sections, a geological model was set up and further translated into a groundwater model in FEFLOW. The model was first calibrated by FEPEST in steady state referenced by 104 observation wells and then it was adapted into a transient model. Influenced by an excavation at the channel bottom, a substantial water head rise happened. And in the model this could be simulated well by introducing an increasing hydraulic conductivity at the excavated area following the schedule of the measures performed. Also heat was further added as a tracer into the model. After a manual calibration, some observation wells were matched reasonably while some observation wells close to the GW-SW interface still showed a clear mismatch for the temperature patterns in amplitude or phase shift. Therefore, a part of the geological structure was adjusted and the model was recalibrated aiming at a better match in both heat transport and water flow. Now this model is a good basis to also add more tracers such as stable isotope and electrical conductivity information. This will enable to calculate travel times from this model more reliably, which will enable the investigation and model interpretation of the water quality problems such as micropollutants.