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Modelling spatial and temporal variability of surface water-groundwater fluxes and heat exchange along a lowland river reach

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In this study we used the deterministic, fully-integrated surface-subsurface flow and heat transport model (HydroGeoSphere) to investigate the spatial and temporal variability of surface water-groundwater (SFW-GW) interaction along a lowland river reach. The model incorporates the hydrological as well as the heat transport processes including (1) radiative fluxes warming and cooling the surface water; (2) seasonal groundwater temperature changes; (3) occasionally occurring heat inputs due to precipitation and (4) highly variable SFW-GW water advective heat exchange driven by the general relation between SFW and GW hydraulic heads and geomorphological structure of the riverbed.
The study area is a 100 m long lowland river reach of the Selke river, at the boundary of the Harz mountains characterized by distinctive gravel bars. Continuous time series of hydraulic heads and temperatures at different depth in the river bank, the hyporheic zone and within the river are used to define the boundary conditions, to calibrate and to validate the numerical model. The 3D modelling results show that the water and heat exchange at the SFW-GW interface is highly variable in space with zones of daily temperature oscillations penetrating deep into the sediment and spots of daily constant temperature following the average GW temperature. To increase the understanding of evolving pattern, the observed temperature variations in space and time will be linked to dominant stream flow conditions, streambed morphology, advective and conductive heat exchange between SFW and GW and subsurface solute residence times.
This study allows to analyse and quantify water and heat fluxes at the SFW-GW interface, to trace subsurface flow paths within the streambed sediments and thus improves the understanding of hyporheic zone exchange mechanisms. It is a sound basis for investigating quantitatively variations of sediment properties, boundary conditions and streambed morphology and also for subsequent generalization of SFW-GW exchange on reach scale river stretches and beyond.