Geophysical Research Abstracts
Vol. 20, EGU2018-10900-1, 2018
EGU General Assembly 2018

Sensitivity of simulated hyporheic exchange residence times to river bathymetry

Reynold Chow (1), Hao Wu (2), Jeremy Bennett (1), Jürnjakob Dugge (1), Thomas Wöhling (3), and Wolfgang Nowak (2)

(1) University of Tübingen, Center for Applied Geoscience, Integrated Hydrosystem Modelling, Tübingen, Germany (reynoldtor@hotmail.com), (2) Institute for Modelling Hydraulic and Environmental Systems (LS3)/SimTech, University of Stuttgart, Stuttgart, Germany, (3) Department of Hydrology, Technische Universität Dresden, Dresden, Germany

Hyporheic exchange is defined hydrologically as river water infiltrating into the subsurface, mixing with groundwater, and returning to the river. Hyporheic exchange is driven by hydrostatic and hydrodynamic pressure variations due to variable bedform structures or larger features, such as meanders, and is influenced by the structural heterogeneity of the hyporheic sediments. Understanding hyporheic exchange processes are important because the associated water is believed to undergo biogeochemical reactions that are attributed to the retention and degradation of pollutants within watersheds, ultimately impacting ecosystem health. The distribution of hyporheic residence times (the time taken for water to move through the subsurface) is an important factor when determining the magnitude of potential biogeochemical reactions.

Modelling hyporheic exchange processes at relevant scales is important in deepening our understanding of this complex phenomenon. One model aspect readily identified as contributing significantly to the predictive uncertainty of hyporheic exchange is the accurate representation of river bathymetry. Our study determined the aspects of river bathymetry that have the greatest influence on the predictive biases when simulating hyporheic exchange at the meander-scale. To investigate this, a highly parameterized HydroGeoSphere model (Aquanty Inc., 2015) of the Steinlach River Test Site in southwest Germany was built as a reference. This model was then modified with simpler bathymetries, evaluating the changes to hyporheic exchange fluxes and residence time distributions.

Results indicate that simulating hyporheic exchange with a 3D integrated surface water-groundwater model is sensitive to the representation of river bathymetry which affects the river stage, and consequently the underlying subsurface hydraulic head distributions. Simulating hyporheic exchange with a high-resolution detailed bathymetry leads to nested multi-scale hyporheic exchange systems. The presence of local-scale contrasts in bathymetry can lead to greater small-scale bedform-driven hyporheic exchange nested within large-scale meander-driven hyporheic exchange systems.

Conversely, simulations of hyporheic exchange at the meander-scale that lack detailed bathymetry data can lead to the underestimation of smaller bedform-scale hyporheic exchange. Biasing the simulated hyporheic exchange towards larger meander-scale exchange, thus leading to overestimates of hyporheic residence times. This can lead to gross biases of the catchment's capacity to act as a reactor to attenuate pollutants when extrapolated to account for all meanders along an entire river within a watershed.

The detailed river slope alone is not enough to accurately simulate the locations and magnitudes of losing and gaining river reaches. Thus, local bedforms in terms of bathymetric highs and lows within the river are required. Bathymetry surveying campaigns can be more effective by prioritizing bathymetry measurements along the thalweg and gegenweg of a meandering channel, which can be identified visually. We define the gegenweg as the line that connects the shallowest points in successive cross-sections along a river opposite the thalweg under average flow conditions. Incorporating local bedforms will likely capture the nested hierarchical nature of hyporheic exchange systems, leading to more accurate simulations of hyporheic exchange fluxes and residence times.