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Hyporheic exchange induced by sinuosity of meandering rivers

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The hyporheic zone is a region of an unconfined aquifer that contains flowpaths that begin and return to the stream. The hyporheic exchange depends on the interaction between the stream and a number of geomorphological features, like bedforms, channel sinuosity, and land surface topography. Hyporheic flowpath length is conditioned by the geomorphological feature that induce the exchange and it varies from centimeters to hundreds of meters. However, many of these exchange processes are still poorly understood. In this work we try to improve the knowledge about the hyporheic exchange at the meander scale. This kind of exchange is characterized by long residence times of water and solutes in the aquifer. These long residence times allow to supply an elevated amount of nourishing to the microorganisms, and determine a long storage of the pollutants contained in the surface water.

A model for the evaluation of the intra-meander hyporheic exchange flow is used for this analysis. The method relies on a physically-based morphodynamic model to predict the characteristics of the flow field in a meandering river and the temporal evolution of its planimetry. Each planimetry of the river is used as a boundary condition in the study of hyporheic exchange. The hyporheic exchange is simulated for different kinds of meandering rivers and for different morphological conditions caused by the aging of the meander. For each case the model provides the trajectories of particles that are moving in the porous medium, the fraction of the river discharge that flows in the aquifer, and the distribution of the residence times of the water particles. In each simulated case the probability density function shows a power law behaviour ($p(t) = a \cdot t^b$, with b approximately equal to -1.3) for a wide range of timescales. These parameters are useful to quantify water and solute exchange in the intra-meander area.

The work has shown the fundamental role of the river planimetry on the hyporheic exchange pattern at the meander scale, and its influence on the long-term evolution of the hyporheic exchange. The main properties of the exchange process have been parametrized in terms of easily measurable quantities. These results are also useful for other sciences, for example they have remarkable implications on the biogeochemical reactions that occur in the intra-meander area.