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Role of unsteady flow conditions on the hyporheic exchange induced by bedforms

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Interactions between surface water and groundwater are widely recognized as a key process for the stream ecosystem, as they supply dissolved oxygen and nutrients to microorganisms living in stream sediments and buried fish eggs. The exchange of water and solutes between stream and hyporheic zone has a dynamic behaviour that is influenced by the fluctuations of the stream surface and of the groundwater table. However, our knowledge of the temporal behaviour of hyporheic exchange is still limited. This lack of knowledge is partly related to the costs and technical constraints that hinder on-site collection of exchange data over sufficiently long times.
In this work we apply a mathematical model to investigate the temporal dynamics of water exchange between a bedform-covered stream and its sediments. The model is based on a stochastic approach that generates long series of streamflow data, and it evaluates the exchange induced by bedforms that move and adapt their shape to the changing streamflow. The results of the numerical simulations show that temporal fluctuations of surface-subsurface exchange are relatively small compared to average streamflow conditions. Even though residence times and exchange depths vary in response to discharge variations, their distributions are similar to those that result from the average streamflow. This finding points out that steady-state flow models may be useful to assess stream-aquifer exchange even in unsteady conditions.