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# Identification of the main factors affecting watershed-scale spatial patterns of river-aquifer exchange fluxes

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Interactions among surface water and groundwater can significantly affect ecosystem functioning since groundwater discharge has a strong effect on water quantity and quality, influencing the concentration of nutrients and pollutants in river water. For this reason, understanding the factors that control river-aquifer interactions at watershed scales is an essential issue in order to analyze the ecological effects of stream-aquifer connectivity. However, groundwater-surface interactions in streams are not easily measured in most locations, especially not with an extent and spatial resolution that allow for the characterization of groundwater discharge patterns at watershed scale. This entails that there is still a lack of easy and accurate methods to measure groundwater fluxes at the river-aquifer interface and, despite the significant advancements in recent years, obtaining high resolution field measurements remains difficult and not easily accessible. Therefore, it is important to develop refined techniques for modeling groundwater-river interactions, because a deeper understanding of the main factors that control the spatial patterns of groundwater discharge at large-catchment scale could improve the prediction of exchange fluxes.

The purpose of the present study is to investigate the dependence of exchange patterns on hydrogeological and topographic factors in order to improve the prediction of groundwater-river exchange fluxes. To this aim, we develop a numerical model to simulate river-aquifer interactions in a catchment well characterized relative to its hydrology and geology. Specifically, we analyze the spatial patterns of groundwater discharge and recharge over the river network under different hydrogeological approximations, predicting the intensity of groundwater fluxes along the river corridor and examining the factors that largely influence these patterns.
The results indicate that the heterogeneity of the aquifer and the spatial distribution of lithological units play the most important role in determining the spatial variability of groundwater inflow fluxes in a river network. Conversely, it seems that a detailed description of the spatial variability of recharge pattern and of other hydrological factors (e.g., parameters describing the stream channels) is less relevant to reproduce a plausible characterization of GW-SW interactions along the river corridor. The level of detail used to describe the topographic structure of the watershed also display a certain impact on determining the pattern of GW-SW flow interactions, highlighting the influence of land surface topography on the spatial patterns of groundwater inflow fluxes.