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Improving spatial estimations of groundwater-stream water exchange in heterogeneous stream-bed by combining point and distributed techniques and geophysical exploration of stream-bed properties.

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Reliable estimates of the groundwater-stream water interactions are the basis of water balances as well as chemical and biological investigation of processes taking place in the hyporheic zone (HZ). The complexity of field conditions requires coupling multiple techniques to minimize the uncertainty of flux estimates. Our study applies this concept with a special focus on the sediment properties to a study site at River Schlaube, Brandenburg, Germany. The multidimensional variability of factors governing groundwater-stream water interactions in the HZ has several consequences on estimating groundwater-surface water exchanges. The direct observation of sediment properties is challenging because dense sampling of the sediment is time-consuming and alters the hydraulics of the streambed. Thus, an alternative time-effective, non-invasive and high-resolution approach is required to identify the spatial and in-depth variability of hydraulic conductivity of the streambed. Geophysical techniques such as electromagnetic conductivity mapping methods (EM) have great potential to infer sediment properties such as hydraulic conductivity. We use capabilities of EM to explore the heterogeneity and patterns of hydraulic conductivity of the streambed of the River Schlaube. Additionally, the coarse measurement of sediment properties limits the applicability of upscaling methods for spatial estimation of the hyporheic exchanges flow (HEF). The current methods available for upscaling HEF estimates across the surface water-sediment interface only involve the use of a few point values of sediment properties. In consequence, the use of such a coarse input neglects the heterogeneity of the streambed with severe impact on the representativeness of the upscaled results. Our study suggests the integration of the spatial patterns of hydraulic conductivity inferred from EM techniques into the empirical function of upscaling methods to improve their accuracy. In conclusion, (1) the study highlights the capability of electromagnetic conductivity mapping to estimate the distribution of hydraulic conductivity in heterogeneous streambeds. (2) The study underlines the convenience of integrating distributed information from hydraulic conductivity in the methods for spatial upscaling of groundwater-surface water interactions. The combination of innovative experimental techniques and modelling contributes to the improvement of the reliability of HEF estimates.