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Quantification of water fluxes at the stream-groundwater interface using mapped streambed temperatures

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The quantification of water fluxes through the streambed with fine spatial resolution on a large scale can be crucial to understanding near-stream flow dynamics and accurately assessing the distribution of contaminant transport across the groundwater/surface-water interface.

Streambed temperature mapping takes advantage of the naturally occurring temperature gradient between the groundwater and the stream water to determine the spatial patterns and the magnitude of groundwater discharges. Shallow streambed temperatures can be easily and inexpensively measured at hundreds of locations along a stream reach in a short period of time and can be used for the delineation of spatial patterns of stream-groundwater interactions. The current study quantified water fluxes for each temperature observation profile by applying a simple steady-state analytical solution of the one-dimensional heat diffusion-advection equation. This method was successfully applied to two different streams in Germany on reaches that were between 220 and 750 m in length. A key underlying assumption for quantification using this method is that the streambed temperatures are measured at a depth where quasi-steady-state temperatures exist throughout the time required to map the temperatures (i.e., devoid of diurnal variations). The assumption appeared to be valid, but quasi-steady-state conditions occurred at greater depths for low-discharge zones than for high-discharge zones. The magnitudes and spatial patterns of water fluxes obtained from applying the analytical model to the mapped streambed temperatures agreed well with the fluxes obtained using piezometers and Darcy's law.

We believe that streambed temperature mapping can provide a useful basis for studies aiming at the characterization of groundwater-surface water interactions. The method is cost-effective, has minimal data and instrumentation requirements and is appropriate to resolve the spatial heterogeneity of stream-groundwater interactions on reaches up to 1 km in length.