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Streamflow loss quantification for groundwater flow modeling using a wading-rod-mounted acoustic Doppler current profiler in a headwater stream

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Irrespective of the availability of various field measurement and modeling approaches, the quantification of interactions between surface water and groundwater systems remains associated with high uncertainty. Such uncertainties on stream-aquifer interaction have a high potential to misinterpret the local water budget and water quality significantly. Due to typically considerable temporal variation of stream discharge rates, it is desirable for the measurement of streamflow to reduce the measuring duration while reducing uncertainty.

Streamflow measurements, according to the velocity-area method, have been performed along reaches of a losing-disconnected, subalpine headwater stream using a 2-dimensional, wading-rod-mounted acoustic Doppler current profiler (ADCP). The method was chosen, with stream morphology not allowing for boat-mounted setups, to reduce uncertainty compared to conventional, single-point streamflow measurements of similar measurement duration. Reach-averaged stream loss rates were subsequently quantified between 12 cross sections. They enabled the delineation of strongly infiltrating stream reaches and their differentiation from insignificantly infiltrating reaches. Furthermore, a total of 10 near-stream observation wells were constructed and/or equipped with pressure and temperature loggers. The time series of near-stream groundwater temperature data were cross-correlated with stream temperature time series to yield supportive qualitative information on the delineation of infiltrating reaches.

Subsequently, as a reference parameterization, the hydraulic conductivity and specific yield of a numerical, steady-state model of groundwater flow, in the unconfined glaciofluvial aquifer adjacent to the stream, were inversely determined incorporating the inferred stream loss rates. Applying synthetic sets of infiltration rates, resembling increasing levels of uncertainty associated with single-point streamflow measurements of comparable duration, the same inversion procedure was run. The volume-weighted mean of the respective parameter distribution within 200 m of stream periphery deviated increasingly from the reference parameterization at increasing deviation of infiltration rates.