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Assessment of groundwater-surface water interaction using thermal infrared imagery, stable isotope composition and hydrochemical data

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Groundwater-stream water interaction has been drawn considerable attention recently as it has been recognized how vital such interaction is in runoff and flow path generation. To distinguish groundwater and surface water and to calculate mixing ratios, we are using thermal, isotopic and hydrochemical signatures. These signatures are well separable and stay comparably stable over time. Therefore, they can be employed as tracers to evaluate groundwater dynamics over the catchment boundary.

In this study, we assessed groundwater-surface water interaction in the Schwingbach Environmental Observatory (SEO) located in central Germany using a combination of ground-based thermal infrared (TIR) imagery, in-situ high-temporal resolution (<20 min) of stable water isotopes and hydrochemical (temperature, pH, EC) measurements. We sampled multiple sources including groundwater, surface water and rainfall and measured discharge at three RBC flumes as well as groundwater levels in twelve piezometers. We also sampled stream temperature and stream water EC as well as level of groundwater and surface water using weekly conventional surveys to crosscheck the measurements.

The preliminary observations suggest that the TIR imagery is a promising technique to visually assess high-resolution spatial patterns of discrete and diffusive groundwater seeps in-stream, hillslopes and riparian zones. However, the computed groundwater discharge fraction to the stream was overestimated, particularly in downstream reaches. The results indicated that the mean groundwater discharge fraction varied from 65% to 77% in meanders and seepage faces and ranged from 9% to 61% at the groundwater-fed tributary-stream junctions under baseflow conditions. Our high-frequency isotopic composition underlined the dynamic of runoff generation processes under different hydrological conditions. The results facilitated the quantification of event water fraction to streamflow based on a 2-component hydrograph separation model as well as the estimation of the short and long-term groundwater response to the storm events. In addition, the mapped temperature, EC and water level presented groundwater-stream exchange dynamics and inflow paths at the stream scale. The results represent the variable influent and effluent conditions due to the different hydrological conditions. The estimated groundwater response to storm events based on vertical head gradients is comparable with results we obtained with TIR imagery and isotope composition. The combination of methods reduces the uncertainty in the localization and evaluation of groundwater-surface water interaction in the SEO and leads to improved insight into the understanding of hydrological processes in the catchment.