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Evaluating terrain-based predictions of groundwater discharge locations along a boreal stream using temperature and isotope tracers

Jason Leach, William Lidberg, Andres Peralta-Tapia, Anneli Ågren, and Hjalmar Laudon

Department of Forest Ecology and Management, Swedish University of Agricultural Sciences, Umeå, Sweden (jason.leach@slu.se)

Groundwater discharge along streams exerts an important influence on biogeochemistry and thermal regimes of aquatic ecosystems. A common approach for predicting locations of groundwater discharge is to use digital elevation models (DEMs) combined with flow accumulation algorithms. In this study, we evaluated these terrain-based predictions of groundwater discharge zones along a stream reach using temperature and isotope tracers. Our study was conducted on a 1300 m headwater stream reach in the boreal region of northern Sweden. Using flow accumulation algorithms and a 2 m LiDAR-derived DEM, we predicted locations of groundwater discharge along the stream reach. We deployed fibre-optic distributed temperature sensing (DTS) instrumentation to monitor stream temperature at 0.25 m intervals along the reach. We also conducted manual measurements of stream water isotope composition at 50 m intervals for four sampling periods representing distinct streamflow conditions before and during a major rain event. The combined tracer evaluation showed that terrain-based predictions of groundwater discharge were generally reasonable under baseflow conditions, although some prediction errors occurred. In addition, the tracers suggested that groundwater contributions were spatially dynamic during the rain event, which was not fully captured by the terrain-based predictions. Overall, this study highlights potential utility of predicting groundwater discharge zones using terrain-based approaches in boreal regions. In addition, we show advantages of using a combination of tracers to characterize spatiotemporal variability of groundwater discharge along streams.