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Using a numerical modelling approach to test the relationship between groundwater travel time estimates, catchment characteristics and stream water chemistry

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Groundwater travel times is an important factor for many hydrological questions, including water quality. In this study, modelled travel times for groundwater using the Mike SHE model contributing to stream discharge, were tested against chemical data of 14 boreal sub-catchments in northern Sweden. Particle tracking was used on a fully integrated surface and subsurface model over the Krycklan catchment to derive advective travel times for the nested long-term monitored sub-catchments, which ranged from 0.12 to 67.90 km2 in size. The studied sub-catchments have distinct differences in stream chemistry, for example ranging twofold in average magnesium concentration and from 4.4 to 6.5 in long-term annual average of pH. Since both the magnesium concentration and pH are weathering dependent they provide good proxies for groundwater/soil contact time. We found a strong correlation between average calculated travel times and long-term average pH as well as magnesium concentration. We also found that two catchment characteristics were important factors impacting the travel times. The occurrences of low hydrologically conductive soils increased the calculated travel time, whereas steeper catchments slopes decreased the travel time in the sub-catchments. Our results reaffirm that numerical models can be an important tool for groundwater travel time investigations. Models, such as Mike SHE, can hence be used to help predict groundwater travel times in ungauged catchments. Furthermore, they can be a good complement to field studies, since they can be used to estimate mean travel times over much longer time scale than most monitoring time series exists and because they can provide continuous water travel path information.