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Tracing dynamics of soil – vegetation interactions in northern environments with stable isotopes

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Understanding the influence of vegetation on the water storage and flux in the upper soil is crucial in assessing the consequences of climate and land use changes.
We sampled the upper 20 cm of peaty podzols at 5 cm intervals in four sites differing in their vegetation (Scots Pine and heather (Calluna sp. and Erica Sp)) and aspect. The sites were located within the long-term experimental catchment Bruntland Burn in the Scottish Highlands, a low energy, wet environment. Sampling took place on 11 occasions between September 2015 and September 2016 to capture seasonal variability in isotope dynamics. The pore waters of the soil samples were analyzed for their isotopic composition (deuterium and oxygen-18) with the direct equilibration method. On 7 sampling days, vegetation samples were also taken (by clipping of heather branches and coring of trees) and their isotopic composition was determined by cryogenic extraction.
The soil water isotopes show that the water in the topsoil is, despite the low potential evaporation rates in such northern latitudes, kinetically fractionated compared to the precipitation input throughout the year. This fractionation signal decreases within the upper 15 cm resulting in the top 5 cm being isotopically differentiated to the soil at 15 – 20 cm soil depth. There are significant differences in the fractionation signal between soils beneath heather and soils beneath Scots pine, with the latter being more pronounced. But again, this difference diminishes within the upper 15 cm of soil.
The enrichment in heavy isotopes of the topsoil follows a seasonal hysteresis pattern, indicating a lag time between the fractionation signal in the soil and the increase/decrease of soil evaporation in spring/autumn. A similar hysteresis pattern is shown by the vegetation data, but the response in the fractionation signal of the plant water is even more lagged.
We used the data set for benchmarking a soil water isotope model that takes kinetic fractionation from soil evaporation into account. The model is then used to assess the differences between the study sites with regard to storage and mixing in the unsaturated zone, groundwater recharge, plant water uptake and evaporation of soil water.