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Multi-scale hydropedological controls on water storage, mixing and release in upland catchments

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Water storage, mixing and flux processes regulate the generation of stream flow and the time scales for the transport of solutes and contaminants. Understanding the space and time variant dominant mechanisms on these processes in different landscapes and climates remains a key challenge in water resource research. The scope of this presentation is to provide an overview of new insights into the multiscale and integrated spatio-temporal controls of hydropedology on water storage, mixing and release in low energy, humid headwater catchments.

We provide some examples from the Bruntland Burn experimental catchment (3.2 km2) in the Scottish Highlands. This area is characterised by high precipitation inputs, low evapotranspiration rates and storage reservoirs which are typically close to the threshold of saturation for most of the time. We explored water storage, mixing, and flow processes in the soil matrix, at different soil-vegetation plots, and along a hillslope transect. Sites included two common soil types (Histosols in the riparian zone and Podzols on hillslopes) and both forested (with Scots Pine (Pinus sylvestris)) and non-forested areas. We also explored the integrated effects of the spatio-temporal dynamics in these processes at the catchment scale, using high resolution hydrometric and stable water isotope analyses.

By comparing stable water isotopes of soil water held at different soil water tensions, we found that water held at high tensions (i.e. in the smaller pores) had a longer residence time than that held at lower tensions. However, these variations were small in the context of the differences observed in soil water storage and flow dynamics between soil types and their integrated control at the catchment scale. Storage dynamics in the different hydropedological units controlled hydrological connectivity between hillslopes and the stream network, runoff generation, and the evolution of catchment transit time distributions. It was found that vegetation cover played a minor role and only locally during unusually dry conditions. We briefly reflect on the ecohydrological and management implications of these results at multiple scales and provide insights into future directions.