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Use of stable isotope tracers to identify flow paths, residence times and landscape controls in larger river basins

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δ^{18}O tracer measurements of precipitation, soil waters and stream waters were used to investigate hydrological flow paths and residence times at nested spatial scales in the larger catchment (233km^2) of the River Feugh in the northeast of Scotland. Precipitation δ^{18}O exhibited strong seasonal variation over the 2001-02 hydrological year, ranging from -5.1‰ in the summer, to -13.5‰ during winter snowfalls (mean δ^{18}O -8.96‰). Although significantly damped by catchment mixing processes, this seasonality was reflected in stream water outputs at six sampling sites, allowing δ^{18}O variations to be used to infer the influence of different hydrological sources; seasonally variable soil-derived storm flow mixing with groundwater of more constant isotopic composition. Periodic regression analysis allowed the differences in mixing processes between sub-catchments to be assessed more quantitatively, using an exponential flow model to provide preliminary estimates of mean stream water residence times; which varied between 0.4 – 2.9 yrs. This showed that the effects of increasing scale on estimated mean stream water residence time was minimal beyond the smallest (ca. 1km^2) headwater catchment scale. Instead, the interaction of catchment soil cover and topography acted as the dominant influence. Responsive hydrological pathways, associated with peat soils in the headwater sub-catchments, produced seasonally variable δ^{18}O signatures in runoff with short mean residence times (0.4 – 0.8 yrs). In contrast, areas dominated by more freely draining soils and larger groundwater storage in shallow aquifers appear to provide effective mixing and damping of variable precipitation inputs implying longer residence times (1.4 – 2.9 yrs). These insights from δ^{18}O measurements extend the hydrological understanding of the Feugh catchment gained from previous geochemical tracer studies, and demonstrate the utility of isotope tracers in

investigating the interaction of hydrological processes and landscape controls in larger catchments with practical management issues.