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Using continuous tracer data to infer runoff processes in nested experimental catchments - an underutilised resource in hydrological modelling?

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The potential value of tracer data to aid hydrological modelling - for example in terms of model calibration and validation - is well established, yet curiously under-utilised. In particular, in larger "mesoscale" basins (ca. $>$ 100km2), where scientific information is increasingly needed to support catchment management decisions, tracers have proven usefulness as tools that can provide insight into integrated functioning at a range of larger scales that is not possible from traditional hillslope studies. Tracers can be used to provide basic descriptors of catchment response - such as identification of runoff sources (e.g. % groundwater contribution to stream flow) and estimation of mean residence times (MRT) - that provide additional process-based objective functions to help underpin modelling investigations. Recent technological development means that continuous monitoring of conservative tracers is increasingly accurate, reliable and affordable. Thus, continuous tracer data can be collected at nested spatial scales and can - when analysed in conjunction with a GIS of controlling landscape characteristics - help understand catchment functioning at a range of spatial and temporal scales. This paper demonstrates the utility of high resolution (15 minutes) continuous environmental tracer data (pH, Gran alkalinity, conductivity) and GIS analysis in elucidating the hydrological functioning of the 233 km2 Feugh catchment in the Cairngorm Mountains of Scotland and two (40km2 and 1km2) of its nested sub-catchments. As catchment scale increased, groundwater contributions (with uncertainty) to annual runoff were estimated to increase from 19-30%, to 34-40% and 51-58%. Similarly, MRTs (estimated (with uncertainty) from weekly delta18O data) increased from 1.3-

4.7 months-1, 2.4-10.6 months-1 and 2.5-11.1months-1. GIS analysis of these 3 sites - and 3 other sites with weekly tracer data - indicated that these hydrological characteristics were strongly correlated with catchment characteristics: most notably soil cover as mapped by the UK's process-based Hydrology Of Soil Types (HOST) digital data base. It appears that increasing dominance of responsive peaty soils that generate saturation overland flow, increases the flashiness of runoff, reduces groundwater recharge and reduces MRTs. Conversely, increased coverage of more freely draining podzolic soils increases groundwater recharge and increases mean residence times. This provides an example of a nested mesoscale catchment where continuous tracer data are available and have been used to develop a conceptual model of catchment processes. This represents a hypothesis that can be tested by further hydrological modelling. At the same time, such tracer data represents a resource - and challenge - to modellers if models can be produced which use tracer data, as well as flow or other physical parameters, as an objective function in model evaluation.