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Comparing the influence of catchment architecture on catchment residence times in different geomorphic provinces

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It is increasingly recognised that the geomorphic evolution of catchment landscapes explains much of the differences in hydrological behaviour observed in different geographical regions. This is particularly the case in montane catchments, where topography is one of the main drivers affecting runoff generation processes and the connectivity of hillslope and channel drainage networks. Combining advanced analyses of catchment topography based on DTMs, together with spatially distributed information on tracer behaviour, has allowed the development of topographic metrics which can predict scale-independent aspects of hydrological function on the basis of catchment architecture. However, differences in the landscape evolution mean that first order controls vary in different geographical settings and this has been a constraint on developing generalised theories and identifying macroscale laws in catchment hydrology. Here, we apply advanced topographic analyses to DTMs of 54 mesoscales catchments (varying in areas from 0.04 - 230 km2) located in six contrasting geomorphic provinces in Scotland (the Cairngorm mountains), Sweden (Northern Sweden) and the USA (the Western Cascades, Little Belt Mountains in Central Montana, Pennsylvania and Catskills in New York State). Topographic indices are related to catchment mean residence time (MRT) proxys derived from simple input - output relationships of oxygen isotopes. The results show that the controls on inter- and intra-site contrasts in MRTs can be very different. For example, in steep terrain, such as the Western Cascades, MRT proxys are inversely correlated with mean flow gradient in indicating strong topographic control. In contrast, in more subdued terrain such as Northern Sweden and parts of the Scottish Cairngorms, the gradient is positively correlated with MRT proxys as flatter areas are dominated by peats (Histosols) and steeper slopes have more freely draining soils. Thus, in such sites, topographic controls seem to be mediated through pedological factors. This contribution will emphasise the utility of inter-catchment comparison using advanced terrain analysis in terms of developing more generic macroscale relationships that link hydrological function to landscape evolution.