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Temporal dynamics of water age and transit time: What can flux tracking tell us about internal processes of contrasting catchments?

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In conceptual models it is important to represent temporal dynamics in the function of dominant catchment flow generation processes in a realistic way. A correct representation of these dynamics helps to increase the predictive power of a model. Tracer data can be used to gain crucial insights into these internal processes of catchments and thus help to reduce misrepresentations of process dynamics.

In this study we use long term – up to 16 years – data of conservative tracers collected at relatively high resolution (1 week) for three contrasting catchments (∼ 2 - 10 km2) in the Scottish Highlands. Tracer fluxes were tracked through the system by using parsimonious conceptual models and three mixing assumptions. This facilitated the determination of the temporal dynamics of flow generation processes. These process dynamics are represented by changes in the distribution of water age at the catchment outlet as well as by changes in water transit time distributions, which exhibit distinct patterns under non-steady state conditions and in different environments. The temporal dynamics of both, water age and transit time distributions, were linked to antecedent wetness conditions as well as to characteristics of storm events. In addition, it could be shown how, under changing wetness conditions, the age distribution of water varies between contrasting flow paths, such as base flow and evaporation. The distinct dynamics in the individual flow paths are caused by varying pools of water in the system sustaining these flow paths. On the other hand, tracking climate induced changes in transit time distributions allowed us to assess temporal dynamics of how water is routed through the system in three contrasting environments. This facilitated the development of a simple classification framework for hydrological response patterns.

Flux tracking and thus the concept of time-variable distributions of water age and transit times has not only the advantage of getting a conceptually better understanding of catchment processes. It also serves as an indication of which pools of water in a system are temporally immobile and which ones are dominant in sustaining the different flow paths present in a catchment at a given time. Furthermore, it helps to better identify the conditions under which flow paths are connected. Both issues are highly relevant not only for flow prediction but also for water quality issues for developing more sustainable prevention, protection and mitigation measures.