

Mixing relationships of young-water fractions and solute concentrations in Swiss rivers – a novel approach to describe catchment hydrological behavior

Jana von Freyberg (1) and James Kirchner (1,2)

(1) Institute of Terrestrial Ecosystems, Environmental Systems Science, ETH Zurich, Switzerland
(jana.vonfreyberg@usys.ethz.ch), (2) Swiss Federal Research Institute WSL, Birmensdorf, Switzerland

Fundamental catchment properties, such as storage, mixing and water flow pathways are often described through mean transit times (MTT's) or transit time distributions (TTD's). TTD's are usually inferred from concentrations of conservative tracers in precipitation and streamwater using lumped parameter models. Because of the simplifying assumptions of these models, the meaning of a MTT as a descriptor for spatially heterogeneous catchments is, however, highly uncertain. Instead the young water fraction (F_{yw}) – i.e., the fraction of water that is younger than a specified threshold age – has recently been proposed as a more reliable measure of water age in heterogeneous catchments (Kirchner, 2016a,b). This raises the question of whether the linkages previously found between watersheds' landscape characteristics (e.g., geomorphology, climate, soils, vegetation) and their MTT's or TTD's still hold when F_{yw} is used instead to characterize water age.

Using Kirchner's (2016a,b) approach, we have calculated young-water fractions for a series of Swiss catchments that represent a wide range of landscape characteristics and hydro-climatic conditions. We then analyzed mixing relationships between F_{yw} and solute concentrations in stream water for different flow regimes. For particular sites with wide ranges of F_{yw} , we estimated the concentrations of solutes corresponding to idealized young water ($F_{yw} = 1$) and old water ($F_{yw} = 0$) end-members, which we related to possible source areas. This catchment comparison study tests the utility of water threshold ages for quantifying catchment hydrological behavior and its linkages to site-specific landscape characteristics.

References:

Kirchner, J.W. (2016a) Aggregation in environmental systems – Part 1: Seasonal tracer cycles quantify young water fractions, but not mean transit times, in spatially heterogeneous catchments, *Hydrol. Earth Syst. Sci.*, in press.

Kirchner, J.W. (2016b) Aggregation in environmental systems – Part 2: Catchment mean transit times and young water fractions under hydrologic nonstationarity, *Hydrol. Earth Syst. Sci.*, in press.