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The problem with simple lumped parameter models: Evidence from tritium mean transit times

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Simple lumped parameter models (LPMs) based on assuming homogeneity and stationarity in catchments and groundwater bodies are widely used to model and predict hydrological system outputs. However, most systems are not homogeneous or stationary, and errors resulting from disregard of the real heterogeneity and non-stationarity of such systems are not well understood and rarely quantified.
As an example, mean transit times (MTTs) of streamflow are usually estimated from tracer data using simple LPMs. The MTT or transit time distribution of water in a stream reveals basic catchment properties such as water flow paths, storage and mixing. Importantly however, Kirchner (2016a) has shown that there can be large (several hundred percent) aggregation errors in MTTs inferred from seasonal cycles in conservative tracers such as chloride or stable isotopes when they are interpreted using simple LPMs (i.e. a range of gamma models or GMs).
Here we show that MTTs estimated using tritium concentrations are similarly affected by aggregation errors due to heterogeneity and non-stationarity when interpreted using simple LPMs (e.g. GMs). The tritium aggregation error series from the strong nonlinearity between tritium concentrations and MTT, whereas for seasonal tracer cycles it is due to the nonlinearity between tracer cycle amplitudes and MTT. In effect, water from young subsystems in the catchment outweigh water from old subsystems. The main difference between the aggregation errors with the different tracers is that with tritium it applies at much greater ages than it does with seasonal tracer cycles.
We stress that the aggregation errors arise when simple LPMs are applied (with simple LPMs the hydrological system is assumed to be a homogeneous whole with parameters representing averages for the system). With well-chosen compound LPMs (which are combinations of simple LPMs) on the other hand, aggregation errors are very much smaller because young and old water flows are treated separately. “Well-chosen” means that the compound LPM is based on hydrologically- and geologically-validated information, and the choice can be assisted by matching simulations to time series of tritium measurements.

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. 20, 279-297.
Stewart, M.K., Morgenstern, U., Gusyev, M.A., Maloszewski, P. 2016: Aggregation effects on tritium-based mean transit times and young water fractions in spatially heterogeneous catchments and groundwater systems, and implications for past and future applications of tritium. Submitted to Hydrol. Earth Syst. Sci., 10 October 2016, doi:10.5194/hess-2016-532.