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A new approach to determine time variant catchment transit times and their time distribution based on field data

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Mean transit times (MTT) and their transit time distributions (TTD) are a physical measure integrating all catchment processes, flow path variability, and the combined effects of water storage and water fluxes. The traditional approach for quantifying MTT and TTD of stream water is based on the convolution integral that relates the input and the output of a conservative tracer time series with a transfer function that determines the shape of the TTD. The main limitation with this standard approach is that convolution overlooks the temporal dynamics of water flow paths and their changing distributions through time. Despite recent progress, we still lack an approach for determining TT and TTD based on field data; one that accounts for the new theoretical developments and understanding, but also embraces the time series of isotope data that an experimentalist might have from an experimental watershed. Here we introduce a new, simple approach for calculating time-varying TT and TTD based on measured tracer input and output data and the hydrological fluxes from a catchment. Our approach is designed to account for time variance in the transit time and the transit time distribution and the irregular shape of the transit time distribution. The objectives for this presentation are to (1) demonstrate the conceptual background and the validation of the approach in a proof of concept with artificial data (2) and apply it to an actual dataset from the well-characterized WS10 in the HJA Experimental Forest, Oregon, USA. Applied to a virtual data set the model reproduces known isotope values and transit times with a Nash-Sutcliffe efficiency (NSE) of over 0.9, while it reproduces the observed 18Oxygen signatures in WS10 with a NSE of 0.86. Transit time in WS 10 varies between approximately 250 and 550 days. The transit time distributions are highly irregular in shape; these distributions do not follow a predetermined distribution such as the gamma or exponential distributions. After 329 days, 50% of the water had left WS10 the catchment. This is in contrast with the mean transit time of 415 days. After 1049 days 90% of the water had left the system, while 10% of water left the catchment within 28 days.