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Dynamics of transit times and StorAge Selection functions in four forested catchments from stable isotope data

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Transit time distributions, residence time distributions and StorAge Selection functions are fundamental integrated descriptors of water storage, mixing, and release in catchments. In this contribution, we determined these time-variant functions in four neighboring forested catchments in H.J. Andrews Experimental Forest, Oregon, USA by employing a two year time series of 18O in precipitation and discharge. Previous studies in these catchments assumed stationary, exponentially distributed transit times, and complete mixing/random sampling to explore the influence of various catchment properties on the mean transit time. Here we relaxed such assumptions to relate transit time dynamics and the variability of StoreAge Selection functions to catchment characteristics, catchment storage, and meteorological forcing seasonality. Conceptual models of the catchments, consisting of two reservoirs combined in series-parallel, were calibrated to discharge and stable isotope tracer data. We assumed randomly sampled/fully mixed conditions for each reservoir, which resulted in an incompletely mixed system overall. Based on the results we solved the Master Equation, which describes the dynamics of water ages in storage and in catchment outflows Consistent between all catchments, we found that transit times were generally shorter during wet periods, indicating the contribution of shallow storage (soil, saprolite) to discharge. During extended dry periods, transit times increased significantly indicating the contribution of deeper storage (bedrock) to discharge. Our work indicated that the strong seasonality of precipitation impacted transit times by leading to a dynamic selection of stored water ages, whereas catchment size was not a control on transit times. In general this work showed the usefulness of using time-variant transit times with conceptual models and confirmed the existence of the catchment age mixing behaviors emerging from other similar studies.