Comparison of stream reach residence time distributions measured with tracer experiments of different time scales

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Abstract. In stream hydrology, water residence time distributions (RTD's) are often inferred from the dynamics of artificial tracer concentrations (breakthrough curves) after some distance (reach) of stream transport. Tracer applications upstream of the study reach are typically either instantaneous releases or constant-rate releases, where the breakthrough curves represent an impulse or step response to the tracer application, respectively. Though aimed at measuring the same residence time characteristics, instantaneous and constant-rate applications introduce tracer mass over different time scales and subsequently create different spatio-temporal distributions of tracer mass during the experiment. The objective of this work is to determine if, and how, tracer application technique influences the conclusions about stream water RTD. Tracer experiments were performed in two morphologically differing stream reaches where RTD's were expected to differ significantly. During the same day for each reach, an instantaneous release experiment was followed by a constant-rate release experiment. An RTD for each experiment is obtained by numerically de-convolving the applied upstream concentration curve, an impulse or step function, from the downstream breakthrough curve. The RTD's from the two different application techniques are compared within each reach to determine if, and how, the duration of the tracer study might affect conclusions about reach hydraulics. Furthermore, results from the two reaches are compared to determine if measured RTD's of different shape are uniquely sensitive to the time scale of the tracer experiment. This work will help indicate if there is bias in stream residence time measurements stemming from time-scale differences in the tracer source.