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Reliability of in-stream retention metrics

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The temporary solute retention within transient storage zones (TSZs) has been shown to have a large effect on the transport of solute. This retention can significantly increase the overall in-stream residence time and as consequence increase the contact time of solute with aquatic interfaces (biota, sediment) and living species. An important question that arises is whether the currently available metrics adequately represent retention mechanism. This work attempts to investigate the reliability of two existing measures, the hydrological retention factor (R_h) and the fraction of median travel time due to transient storage zone ($F_{med}200$). For this purpose, five conservative tracer tests were conducted in four European streams with distinct morphological, sediment composition, vegetation and hydraulic characteristics. The obtained breakthrough curves (BTCs) were used to derive storage zone parameters (storage zone area, storage zone exchange coefficient and mean residence time), which then were used for comparison and in the metric expressions. The storage zone parameters were computed using a single TSZ model OTIS-P and a multiple TSZ model STIR. The STIR model was applied to BTCs as an additional tool to separate TSZs into short timescale (ST) and long timescale (LT). The study results reveal correlation between $F_{med}200$ and LT residence time T_2 values, where the streams with the lowest $F_{med}200$ (0.01-0.96) have the smallest long timescale storage zones T_2 values, ranging from 912 s to 1402 s. The findings also demonstrate an influence of discharge rate on both retention metrics. The greatest $F_{med}200$ (6.19) and R_h (0.938) values are calculated for the streams with low discharge rates (0.08-0.10 m^3s^{-1}) and a relatively high ST storage zone residence times T_1 (159 s to 351 s). Results show that the $F_{med}200$ and R_h metrics are strongly affected by the short timescale transient storage zones, whereas the LT storage zones (hyporheic) effects are not taken into account.