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Integrating transpiration and xylem water stable isotopes in a process-based model to determine transpiration and discharge age distributions

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Transpiration is an important component of the catchment water balance, and tree water uptake can significantly influence discharge dynamic and travel times. Tree usually use water of a different age than the water that generates discharge. Most hydrological models that track water age rely on discharge and stream water isotopes data for calibration. This calibrated age-tracking model enables to simulate time-variant discharge travel times. However, transpiration and related water isotopes data are rarely integrated. We currently lack understanding on the age distribution of transpiration and how discharge travel times relate to this age distribution. In this context, the objectives of this work are to 1) analyse spatio-temporal patterns of xylem water isotopes, 2) determine transpiration age distribution and investigate its temporal dynamic over two growing seasons and 3) evaluate how discharge travel times respond to changes in the transpiration age distribution. We determined the spatial controls on xylem water isotopes ($\delta^{18}O$ and $\delta^{2}H$) and simulated travel times in discharge and transpiration in a forested catchment in Luxembourg. We used a lumped, process-based catchment model for water fluxes and tracer transport based on storage-age selection functions. Using discharge, transpiration, stream and xylem water $\delta^{2}H$ measurements, the model was calibrated over a period of three years (October 2017-September 2020) by means of a Monte Carlo optimization and a multi-objectives approach. Preliminary results indicate that tree species and diameter are the main drivers of xylem water isotopes variation. Vegetation controls are especially dominant during a drier growing season while landscape variables (hillslope position, topographical position index, flow accumulation) appear to also control xylem water $\delta^{2}H$ in wetter conditions. Investigations of transpiration and discharge age distributions will help to better understand how tree water uptake influences discharge travel

times over the growing seasons. The spatial analysis of xylem water isotopes further provides a foundation for investigating the spatial variability of the transpiration age distribution. This study will also profit in assessing the value of transpiration and associated isotopes data for discharge travel times simulations and improving our current model representations of hydrological processes in forested catchments.