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Xylem water isotopic variability in Fagus sylvatica L.: potential impacts for ecohydrology

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Understanding water dynamics in the Critical Zone is key for designing better water management strategies, particularly in the light of climate change. Of specific interest in this context is the large amount of water exchanged between regolith and trees in forest ecosystems. In the coming years and decades, the frequency of droughts is likely to increase during vegetative periods. The lack of understanding of how and where tree water uptake is taking place across different regolith layers becomes a critical economic and social issue – spanning from water resources to forest management, even in temperate ecosystems.

Stable isotopes of water have been largely used as tracers in ecohydrology, contributing enormously to the development of various hypotheses and interpretations on tree water uptake dynamics and evapo-transpiration fluxes. However, many issues remain when using O-H stable isotopes to trace the origin of the tree water uptake. The lack of standard protocols for tree water sampling and analysis, alongside the little attention given to the effect that tree physiology and biochemistry may have on the isotopic composition of xylem water, is a limitation to the use of these tracers in the regolith-tree continuum.

In this work, we present tree sap O and H isotopic data collected during three years with two different techniques: (i) an *in-situ* vacuum extraction of the sap flowing in the xylem vessel and (ii) the well-known cryogenic vacuum distillation applied on wood cores. Nine beech trees were sampled at different heights in the root-twigs continuum along a hillslope in the Weierbach Experimental Catchment in Luxembourg. The O-H isotopic signatures of the samples were then compared for observing differences proper to the techniques and/or to potential effects of internal tree processes controlled by either (1) the retention and mixing of water of different ages and/or (2) water exchange in xylem tissues. The isotopic signatures of the xylem water were also compared with the potentially available water sources in the regolith.

We observed a significant difference between the isotopic signatures in water collected with the two different techniques. The water sampling protocol from the root with the *in-situ* vacuum extraction appears to be more appropriate for the identification of the potentially absorbed water

source. We conjecture that roots are the first tree organ that interacts with the regolith water and in which a lesser impact from the internal tree processes can be expected. Our results also show a progressive ^{18}O and ^{2}H enrichment in the xylem water along the root-twig flow path for all studied trees. This enrichment seems to be closely related to the travel-distance inside the xylem: the longer the water is exposed to the internal tree processes, the stronger the modification of its isotopic signature. Finally, the range of the water isotopic signature obtained via cryogenic vacuum distillation is closely related to the tree compartment from which the water was collected from – questioning the contribution to internal tree process understanding from data obtained via this technique.