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Reconstructing Root Water Uptake from isotopic data and physically-based models: looking at recent effort and proposing a path forward

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In the past decade, plant root water uptake (RWU) has been a major focus of ecohydrological studies employing water stable isotopes. The interest of the isotopic community for RWU rose concomitantly to the development of open-access multi-source mixing models based on Bayesian inference. Another more general reason was certainly the decrease in analytical cost with the advent of isotope-specific laser absorption spectrometry. The isotopic methodology used to determine relative profiles of RWU works on the premises that (i) RWU does not fractionate stable isotopes in water and (ii) the isotopic composition of water inside the xylem vessel of the last non-evaporating part of the plant (typically the stem) is that of RWU. Following a simple mass balance approach, the isotopic composition of RWU can be linked back by inversion to contributions to RWU (i.e., relative RWU) of a set of potential water sources (of known isotopic compositions) originating from the soil profile.

In recent research, the preferred tool for inverting water isotope data was Bayesian models and the literature shows that only a handful of studies complemented isotope analysis with observation of plant water status and flow. Consequently, most of the gathered information on RWU cannot be used to test hypotheses on which are built physically-based soil-root water flow models. The authors have on the other hand initiated an effort within the framework of dual experimental-modeling approaches, where tightly-controlled experiments are thought and prepared in order to validate, parameterize models, or test hypotheses. The present contribution gives an overview of the different attempts at integrating both water and isotope observations types and confronting them to model simulations explicitly accounting for root system architecture and hydraulic properties. It addresses the meaningfulness and limitations of isotope data, especially in the context of labeling experiments when treated with statistical (e.g. Bayesian) models. We finally propose a way forward and present improvements to be achieved on both experimental and modeling sides to increase the reliability and precision of isotope-derived

estimates of RWU.