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Simulating soil-plant-atmosphere interactions for sub-daily in situ observations of stable isotopes in soil and xylem water to assess two-pore domain model hypothesis

Fabian Bernhard[1], Stefan Seeger[2], Markus Weiler[2], Arthur Gessler[1,3], and Katrin Meusburger[1]
[1]Swiss Federal Research Institute WSL, Switzerland
[2]University of Freiburg, Freiburg, Germany
[3]ETH Zürich, Zurich, Switzerland

Recent advances in stable isotope measurements within the soil-plant-atmosphere continuum have paved the way to high-resolution sub-daily observations of plant water supply (Stumpp et al. 2018, Volkmann et al. 2016a, 2016b). It seems time is ripe for in-depth assessments of long-standing yet much-debated assumptions such as complete, homogenous mixing of water in the vadose zone (“one water world” versus "two water world") or absence of fractionation during root water uptake and vascular transport in plants.

Information on the nature of these processes contained in high-resolution data sets needs to be exploited. One way to test hypotheses and thereby advance our understanding of soil-plant water interactions is by analysing observations with numerical simulations of the system dynamics – a method also known as inverse modelling. By evaluating the model performance and parameter identifiability of different model structures, conclusions can be drawn regarding the relevance of the modelled processes for reproduction of the observations. Testing two different models allows thus to assess the impact of the difference.

We develop a framework for numerical simulation and model-based analysis of observations from soil-plant-atmosphere systems with a focus on isotopic fractionation. A central objective is to facilitate the evaluation of different model structures and thus test model hypotheses. This can assist development of models specifically tailored to the intended purpose and available data. The framework will first be tested with the "SWIS" model presented by Sprenger et al. (2018).

As an illustration of the framework, we will test the model performance on a dataset of continuous, in situ observations of stable isotopes in xylem water of beech trees and soil water in four depths combined with observations of soil water content. The model assumes one-dimensional soil water flow taking place in one or two separate flow domains for tightly and weakly bound pore water. These two water pools are separated by a matrix potential threshold and isotopic exchange is modelled only through the vapour phase. Root water uptake is parametrised using the Feddes-Jarvis model. First results allow to assess the relevance of the two-pore domain hypothesis for the different soil depths and xylem water.

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