



Parametrizing soil-vegetation-atmosphere transfer models with non-destructive and high resolution stable isotope data

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For nearly 50 years, stable isotopologues of water ($1\text{H}_2\text{H}^{16}\text{O}$ and $1\text{H}_2\text{H}^{18}\text{O}$) have been used in a wide range of water research disciplines to identify the origin and to quantify proportions of water pools involved in processes of the terrestrial water cycle. In soils between rain events, the combined action of convective capillary rise of water depleted in $1\text{H}_2\text{H}^{16}\text{O}$ and $1\text{H}_2\text{H}^{18}\text{O}$ with back-diffusion of water enriched in $1\text{H}_2\text{H}^{16}\text{O}$ and $1\text{H}_2\text{H}^{18}\text{O}$ from the evaporation site (i.e. soil surface or evaporation front) downwards leads to the formation of – typically exponential – soil water stable isotopologue profiles. The first steady state and isothermal analytical solutions of these isotopologues profiles were proposed in the late 60ies. They were later extended to unsteady state and non-isothermal conditions. These analytical formulations link the shape of the isotopologue profiles to soil evaporation flux and regime, and to the soil physical properties associated with both diffusive and convective water transport (such as tortuosity length and dispersivity). More recently, the movement of $1\text{H}_2\text{H}^{16}\text{O}$ and $1\text{H}_2\text{H}^{18}\text{O}$ was implemented in physically-based numerical soil-vegetation-atmosphere transfer (SVAT) models (e.g., TOUGHREACT, SiSPAT-Isotope, Soil-Litter iso, Hydrus 1D). In these fully coupled models, the output of the heat transfer module, i.e. the temperature profile, is fed into the isotope module. Isotope and water transport are therefore inter-dependent as opposed to analytical solutions. In addition to thermodynamic (equilibrium) isotope effects, which are only temperature-dependent, kinetic isotope effects during soil evaporation greatly affect the stable isotopic composition of soil water and evaporation and can be highly variable. Thus, a better understanding of the implications of these kinetic effects in addition to the well characterized equilibrium effects as well as their implementation in SVAT models are required for improving the use of $1\text{H}_2\text{H}^{16}\text{O}$ and $1\text{H}_2\text{H}^{18}\text{O}$ as tracers of soil water processes. An important challenge is to provide models with non-destructive and high resolution isotope data, both in space and time (e.g., using microporous tubing or membrane-based available setups). Moreover, parallel to field studies effort should be made to design specific experiments under controlled conditions, allowing for testing the underlying hypotheses of the above mentioned isotope-enabled SVAT models. Using isotope data obtained from these controlled experiments will improve the characterization of evaporation processes within the soil profile and ameliorate the parametrization of the respective isotope modules.