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Leaf oxygen isotope exchange in water vapor and carbon dioxide of *Fagus sylvatica* under field conditions

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The stable isotope ^{18}O in water and carbon dioxide is a powerful tracer to investigate ecological processes, such as the coupled carbon-water cycle and can provide a constraint on the contribution of terrestrial ecosystems to the global carbon and water cycles. Recently, laser spectroscopic techniques for isotope measurements have been developed which allow for field deployable, high accuracy and high frequency measurements of these isotopic gas-exchanges with the atmosphere.

Here we present a unique dataset of δ^{18}O of water vapor fluxes as well as carbon dioxide fluxes during leaf gas-exchange, measured simultaneously by two laser spectrometers under field conditions, using steady-state through-flow branch chambers. The study was conducted on beech trees (n=3) in a mixed-deciduous forest in Switzerland in 2010.

The effective path-length (L), an important parameter in respect to leaf water enrichment, was constrained by using a Bayesian inversion scheme in combination with the Péclet-modified Craig Gordon model and frequently taken leaf water samples. Using the determined value of L, modeled ^{18}O values of leaves inside the chambers were compared with values derived from the branch chamber transpiration measurements. The good agreement between these two approaches implies a very good performance of the chamber system in measuring isotopic gas-exchange of water. Given this validation of the measured leaf water enrichment values in ^{18}O, carbonic anhydrase efficiency was calculated from these leaf water enrichment values and the measured apparent "discrimination" of C^{18}OO. Our results support the few recent findings of other groups, that carbonic anhydrase efficiency measured under field conditions is lower compared to lab derived values.

In summary, this study provides (i) a Bayesian inversion scheme to estimate L of beech leaves, (ii) a long dataset of parallel measurements of ^{18}O in water vapor and carbon dioxide gas exchange measured on branch level under field conditions and (iii) an estimate of the carbonic anhydrase efficiency of beech trees.