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

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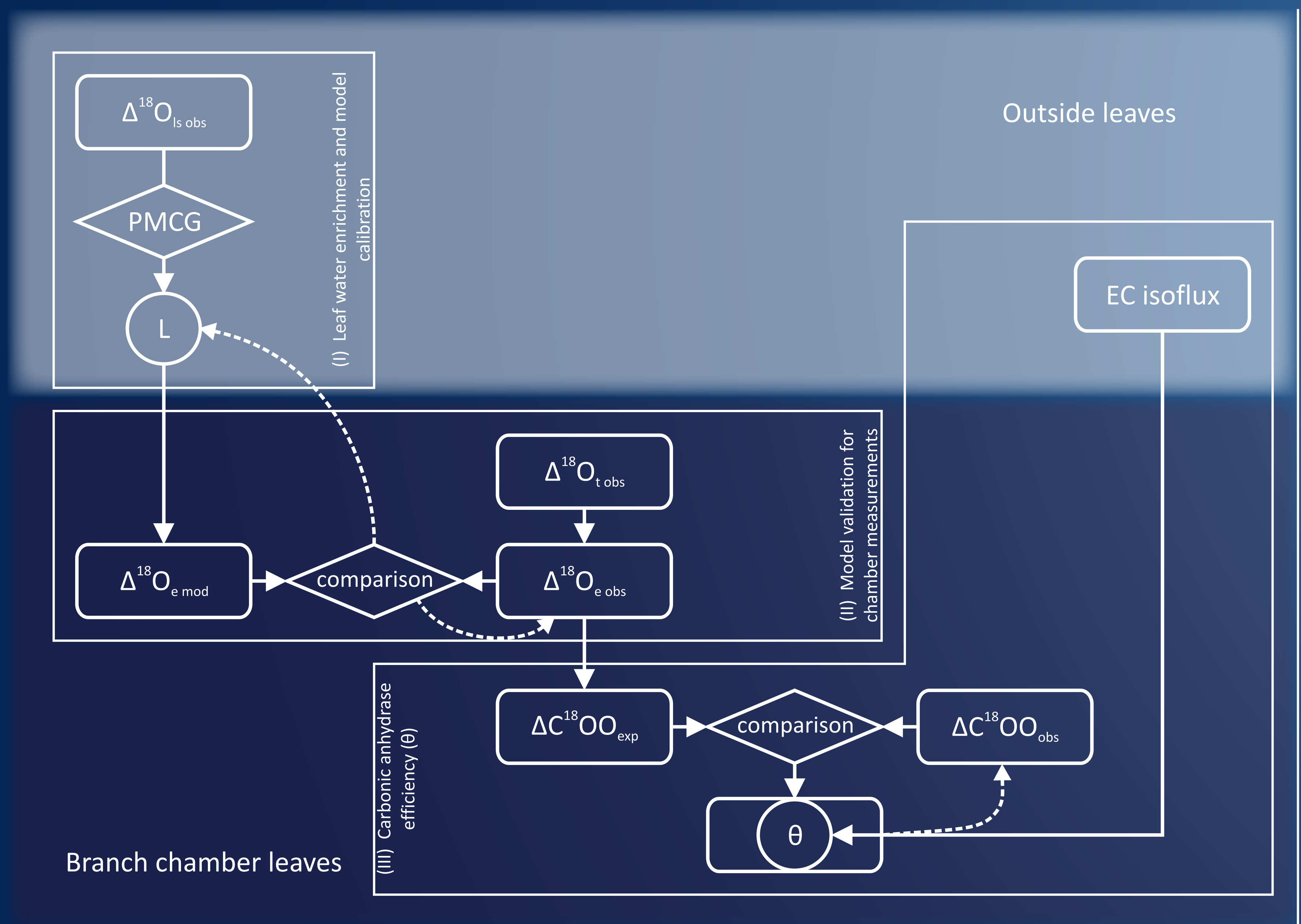
Background

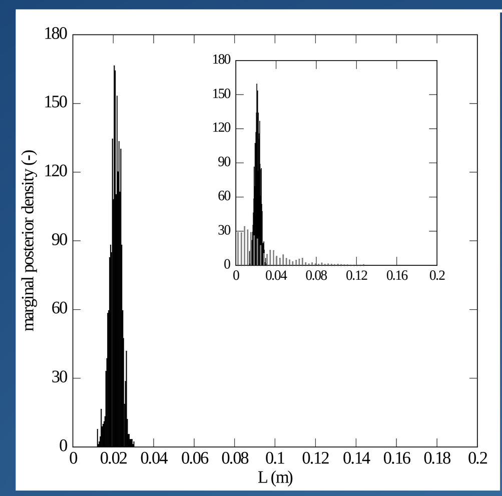
Here we present a unique data-set of ^{18}O of water vapor fluxes as well as carbon dioxide fluxes during leaf gas-exchange, measured simultaneously at high frequency by two laser spectrometers under field conditions, using steady-state through-flow branch chambers. The study was conducted on beech trees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

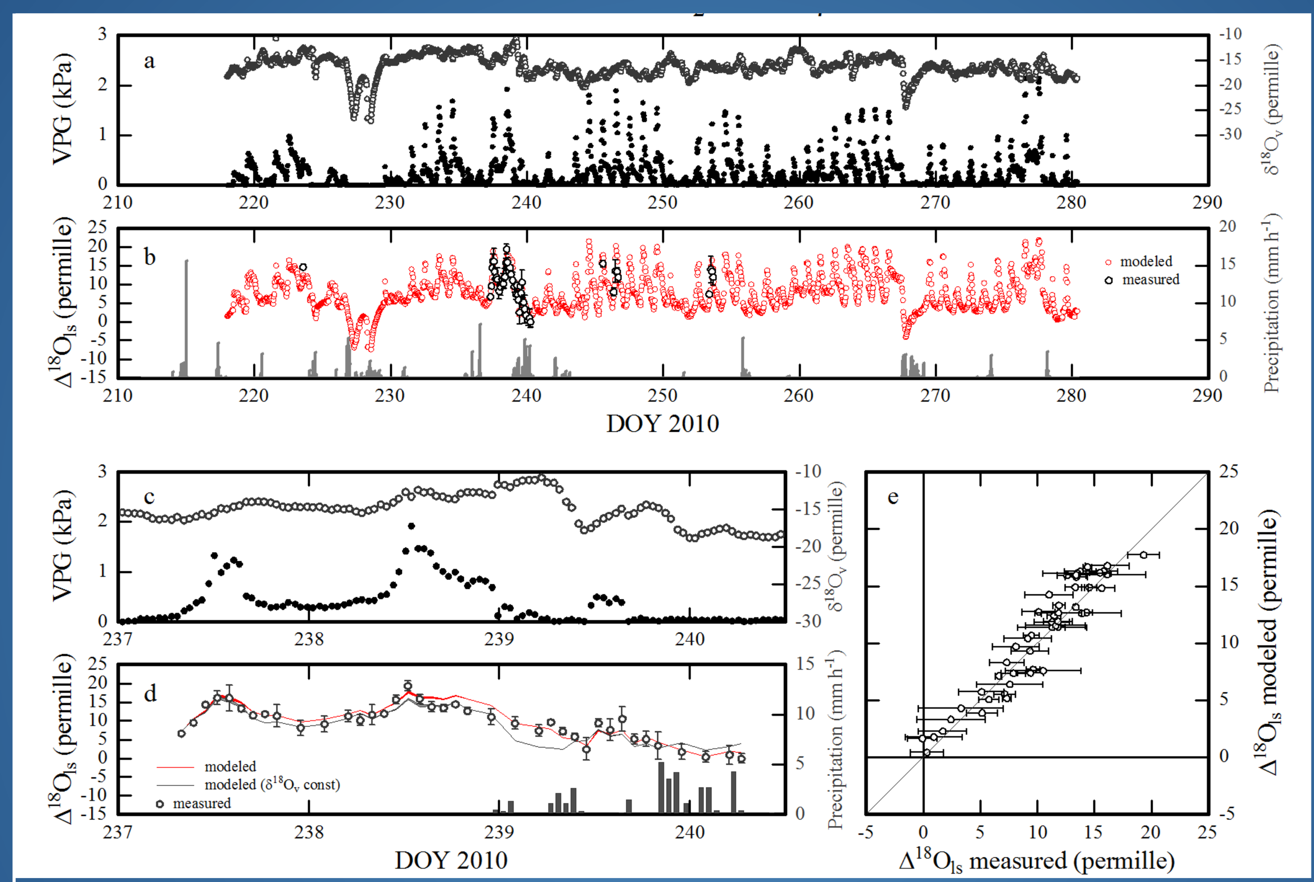
This study provides (i) a Bayesian inversion scheme to estimate L of beech leaves, (ii) a long data*set of parallel measurements of ^{18}O in water vapor and carbon dioxide gas exchange measured on branch level under field conditions and (iii) an estimate of the carbonic anhydrase efficiency of beech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



Flowchart representing the experimental concept. (I) The effective path length (L) was determined using a Bayesian inversion scheme in combination with the Peclet modified Craig-Gordon model (II) Given L, non-steady-state leaf water enrichment at the evaporative front ($\Delta^{18}O_e$) was modelled for the branches inside the branch bags and compared with the actually measured values, derived from transpiration measurements (III) Given $\Delta^{18}O_e$ the expected "discrimination" of $H_2^{18}O$ ($\Delta C^{18}OO_{exp}$) could be set in relation to measured discrimination rates resulting in an estimation of θ.

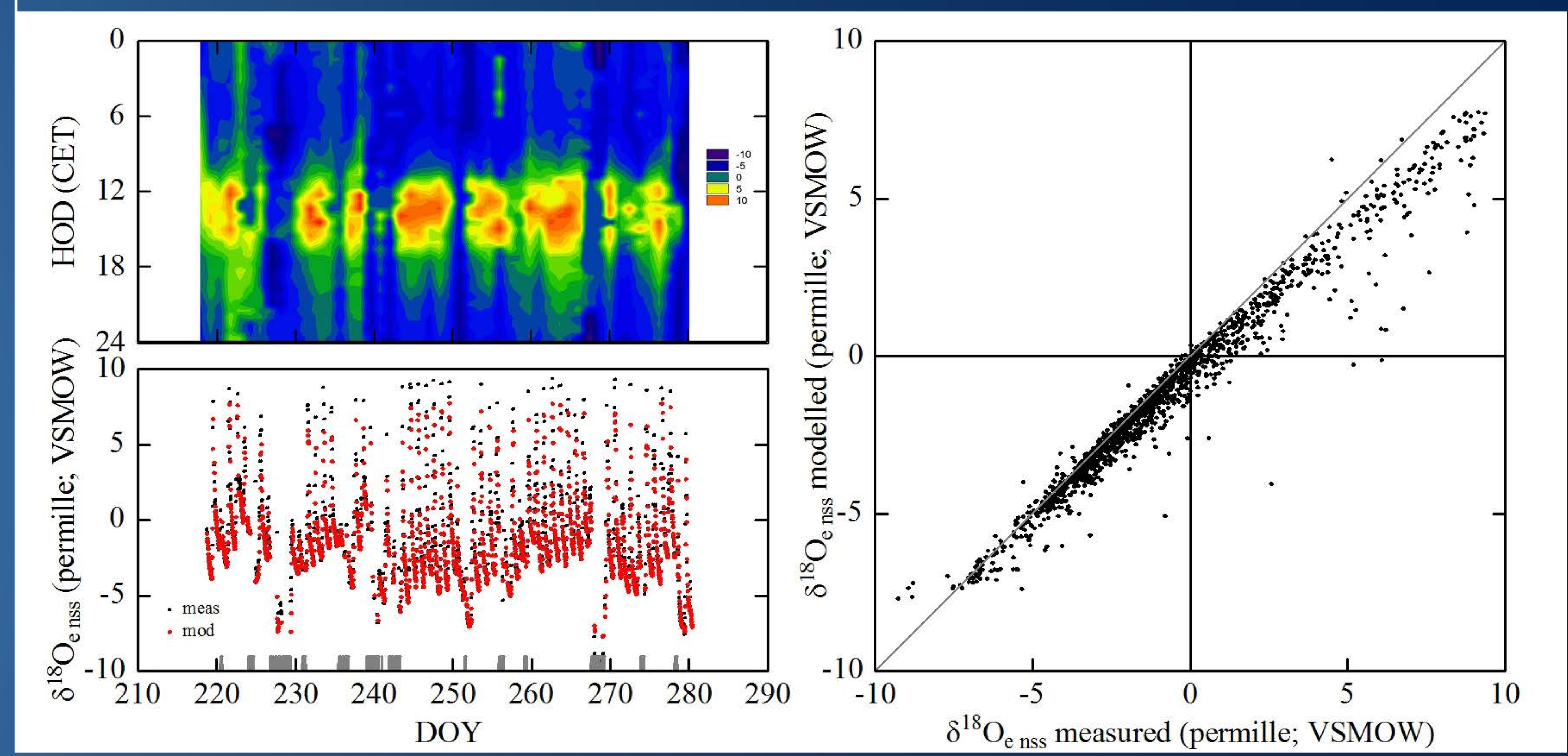
Marginal posterior densities of the Bayesian model inversion for the effective path length (L). X-axis scaling corresponds to the upper and lower bounds for the parameter estimation. The inset in panel a shows the marginal posterior densities for L using all measured mean lamina leaf enrichment in ^{18}O data lower than the median in the model inversion (grey vertical bars) and all values higher than the median (black vertical bars).





Time series of vapour pressure deficit (VPD; closed black symbols) and $\delta^{18}O$ of atmospheric water vapour ($\delta^{18}Ov$; open grey symbols). (b) Time series of measured and modelled steady state leaf water enrichment in ^{18}O ($\Delta^{18}Ols$) as well as precipitation (vertical bars). Error bars refer to ±1 stdv of measured $\Delta^{18}O_{ls}$. Panels (c) and (d) depict the same information as (a) and (b) in detail for the intensive leaf water sampling campaign from DOY 237 to DOY 240. In addition modelling results assuming constant $\delta^{18}Ov$ (-16.25 ‰ VSMOW) are depicted in panel (d; grey line). (e) Regression of measured vs. modelled $\Delta^{18}O_{ls}$ including the 1:1 line (stdv-weighted robust regression results in y = 0.96x + 0.49; R^2 = 0.9 (not significantly different from 1:1)).

Modelled time series of non-steady-state leaf water enrichment at the evaporative front ($\Delta^{18}O_{e\ nss}$) (upper left panel). Comparison of measured and modelled $\Delta^{18}O_{e\ nss}$ values with grey horizontal bars indicating rain events (lower left panel). Regression of measured vs. modelled $\Delta^{18}O_{e\ nss}$ values (grey line represents 1:1; mod = 0.87 * meas - 0.57, R^2 = 0.963) (right panel).

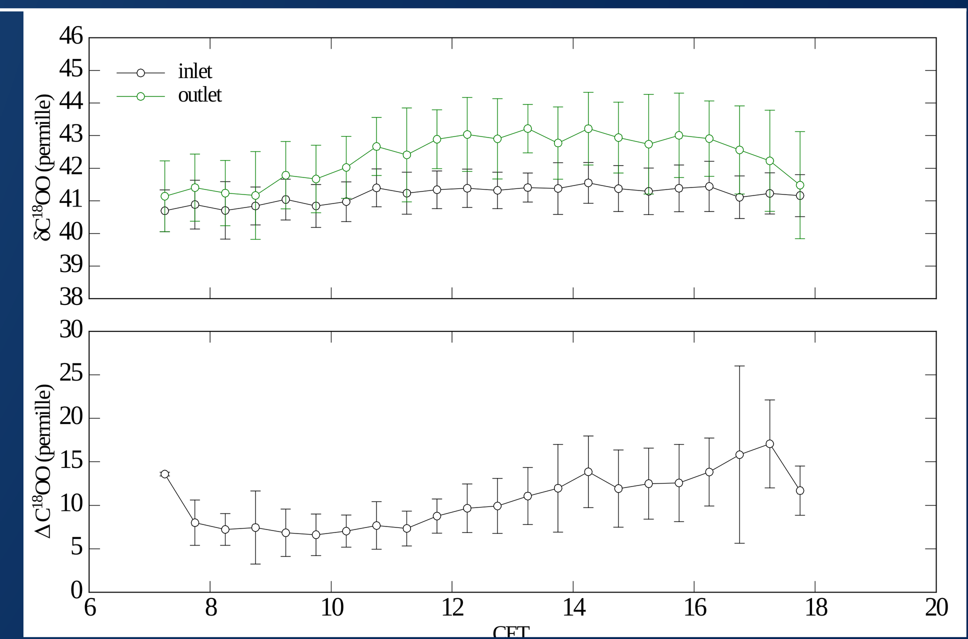


Findings

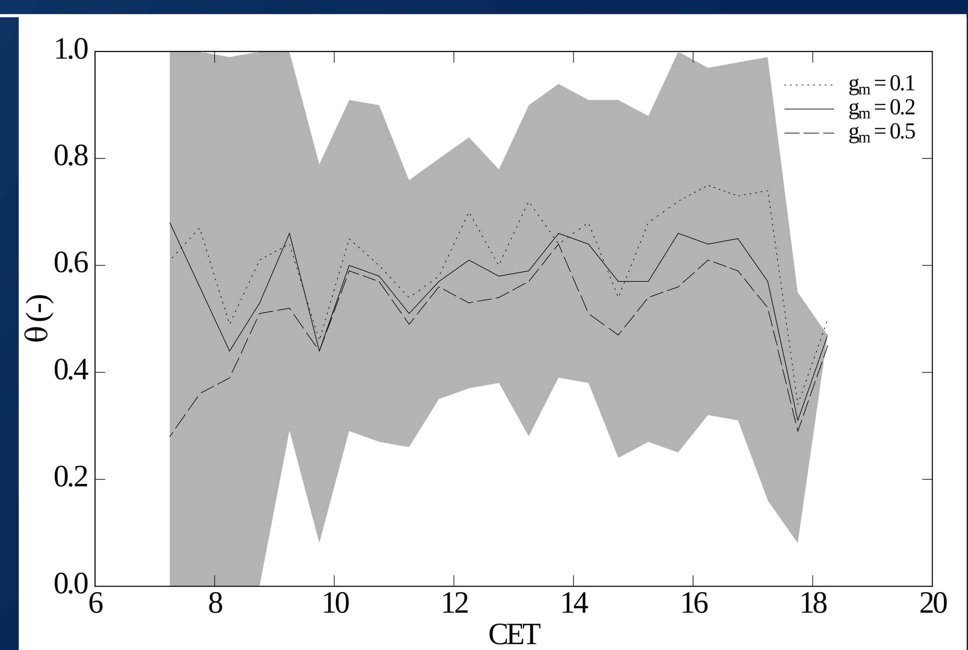
The effective path-length for *Fagus sylvatica* was found to be 0.02 m (0.015 - 0.026 m). Using this value modelled non steady state leaf water enrichment at the evaporative front agreed well with measured values determined from transpiration measurements. This fact implies a very good performance of 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, that carbonic anhydrase efficiency measured under field conditions is lower compared to lab derived values.

MDV of the $\delta C^{18}OO$ signal at the branch bag inlets and outlets (upper panel) and the resulting apparent discrimination of $C^{18}OO$ (lower panel)



MDV of the carbonic anhydrase efficiency (θ) depicted for different mesophyll conductances. The shaded area represents ± 1 stdv.



MARIE CURIE ACTIONS

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