# Eddy Covariance measurements of stable $CO_2$ and $H_2O$ isotopologue fluxes

*Ensuring sufficient instrument performance*

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## Motivation

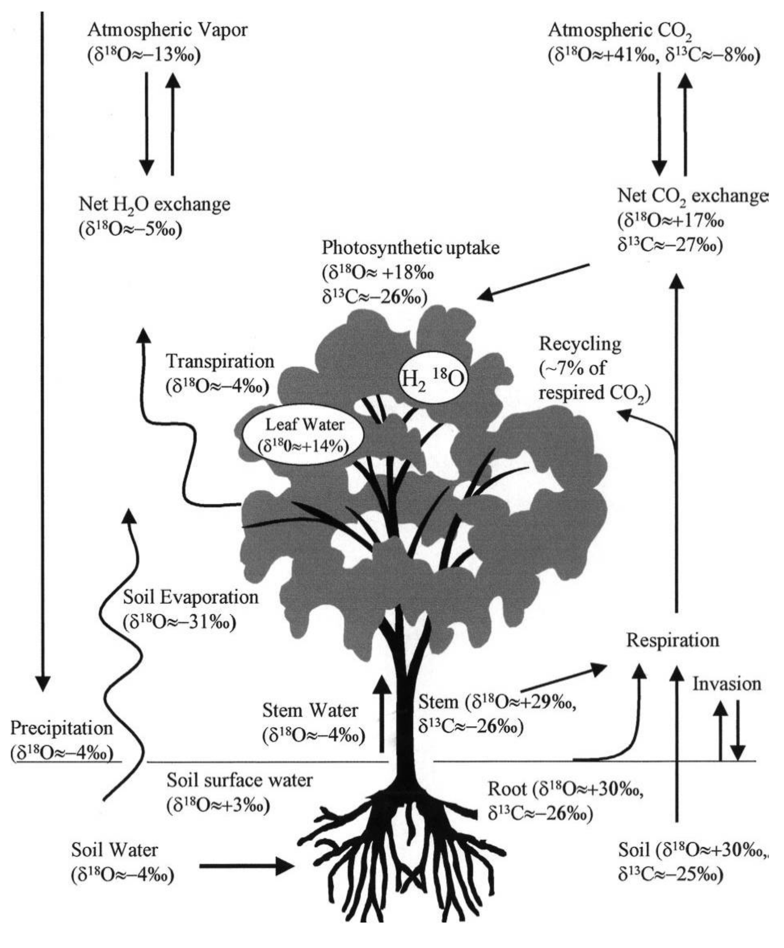

**Figure 1:** Isotopic Composition of $CO_2$ and $H_2O$ for different ecosystem components and fluxes [4]

Analyzing the stable isotope composition of $CO_2$ and $H_2O$ fluxes (such as $^{13}C$, $^{18}O$ and $^2H$ in $H_2O$ and $CO_2$) has provided valuable insights into ecosystem gas exchange (see e.g. Yakir & Sternberg, 2000 [4]), building on differences in the isotope signature of different ecosystem components.

In our measurement campaign planned for summer 2015, we want to use eddy covariance (EC) technique to measure net fluxes of different isotopologues in water vapor ($H_2O^{16}$; $H_2O^{18}$; $HDO^{16}$) and carbon dioxide ($C^{12}O^{16}O^{16}$; $C^{12}O^{18}O^{16}$; $C^{13}O^{16}O^{16}$) on ecosystem scale using laser based techniques and use this information to estimate exchange processes and to contribute to enhance the understanding of these processes on ecosystem scale.

## Planned Measurement campaign in 2015

During an eight month long measurement campaign in 2015, we plan to simultaneously measure $CO_2$ and $H_2Ov$ isotopologue fluxes with an EC-approach over a managed pure beech forest near Leinefelde, central Germany, with relatively homogeneous and even aged trees and a canopy height of app. 35 m. For this purpose we will add the following instruments to the EC-system (which is running at this site since 2002).

**Figure 2:** Field site

- **$CO_2$-isotope analyzer:** quantum cascade laser - based system with TE-cooled detectors (QCLAS, Aerodyne Research Inc.)
- **$H_2O_v$-isotope analyzer:** off axis integrated cavity output spectrometer (OA-ICOS, Los Gatos Research Inc.)

## Main Objectives

The objectives of this study are to ensure that the two analyzers are suitable for EC-measurements in terms of:

1. Fast enough **data acquisition frequency**
2. Sufficient **precision**
3. Adequate **calibration strategy**

## Results

### Data acquisition frequency

Both instruments are capable of measurements at a sufficiently high frequency of 5 Hz. In figure 3, the actual frequency is plotted for a 30-minutes period.

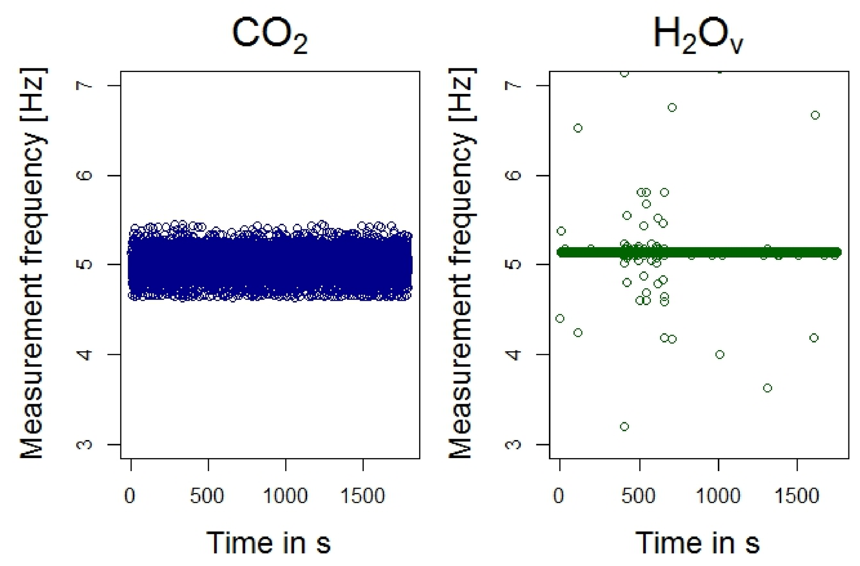


**Figure 3:** Frequency vs. time for the the $CO_2$ isotope analyzer (left) and for the $H_2O_v$ isotope analyzer (right)

### Precision

The Alan Variance plot for $CO_2$ (Figure 4,left) shows a generally comparable range to the measurements described in [2] and [3] who already successfully measured $CO_2$-isofluxes. The Alan variance plot of for $H_2O$ (Figure 4,right) follows the white noise line and the short-term noise for $\delta^{18}O$ is comparable to the 10 Hz noise of app. 1.6 measured in [1].

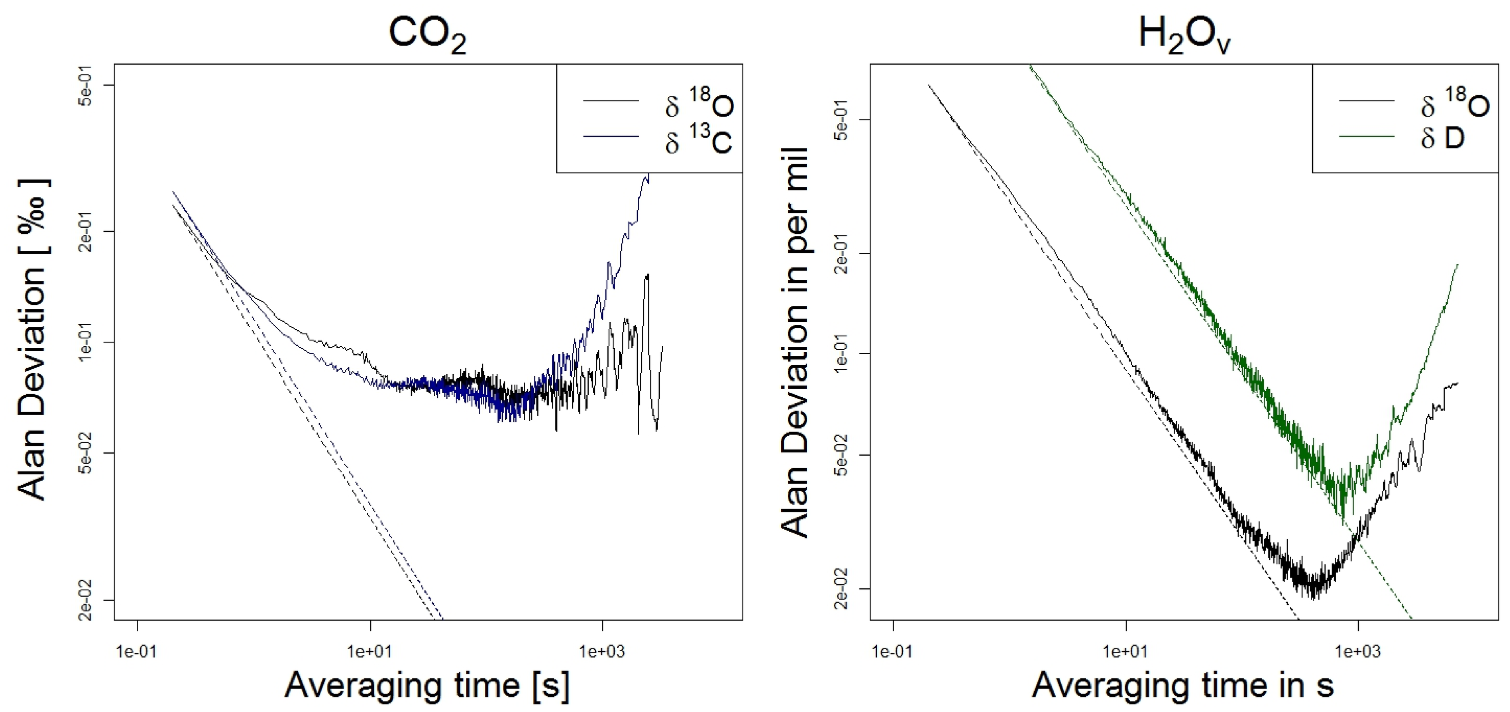


**Figure 4:** Alan Variance Plot for the $CO_2$ isotope analyzer (left) and for thre $H_2O$ isotope analyzer (right)

### Calibration Strategy

#### $CO_2$-isotope analyzer

Our calibration strategy for the $CO_2$ isotope analyzer is similar to the one described by [3] and includes hourly measurements (each for 2 minutes) of:

- **a high standard** (app. 450 ppm) and known isotopic composition
- **a low standard** (app. 300 ppm) and known isotopic composition
- **a zero gas**

Additionally will use 4 **target standards with different isotopic composition and concentration**. One of those is measured hourly and has to be exchanged after 2-3 month and the others are measured daily over the whole campaign.

#### $H_2O_v$-isotope analyzer

The calibration of the water vapor isotope analyzer was extensively tested in the lab and in the field, resulting in a 4 steps-calibration procedure:

1. **Concentration calibration** (c.f. Figure 5)
2. **Concentration dependency of delta values** (c.f. Figure 7)
3. **Offset-correction** (measured hourly to correct for variations of C-dependency)
4. **Absolute $\delta$ scale** (c.f. Figure 6)

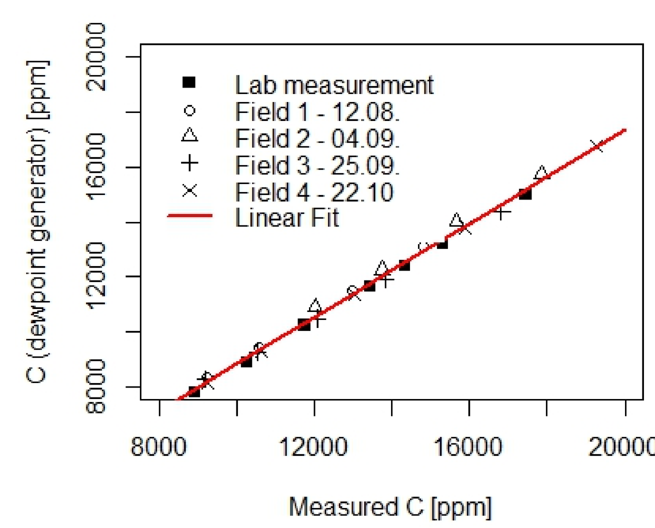


**Figure 5:** Concentration Calibration, measured with a dewpoint generator on different days in the lab and in the field, constant linear relationship

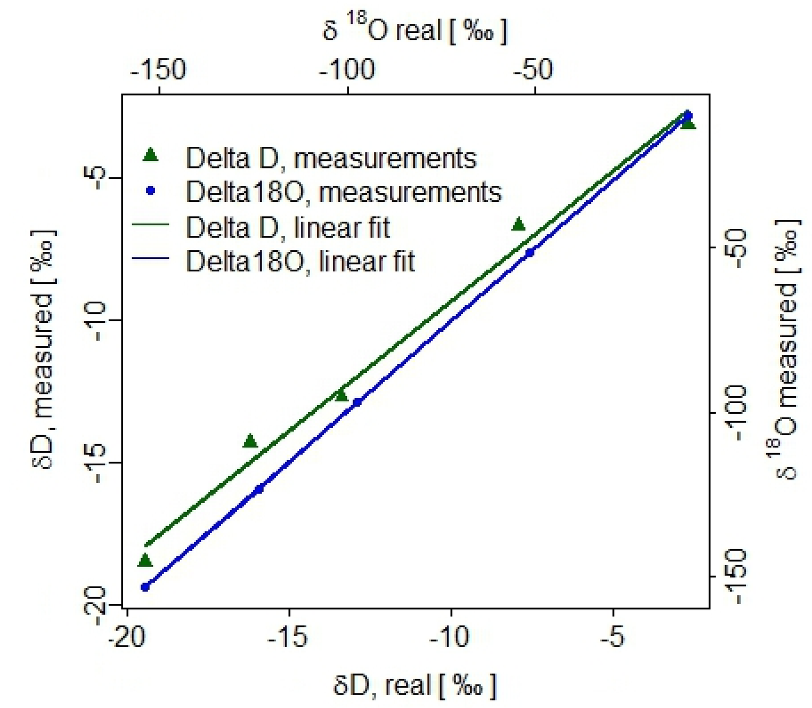


**Figure 6:** $\delta$ scale calibration, measured with samples of known $\delta$-values (VSMOW), linear relationship

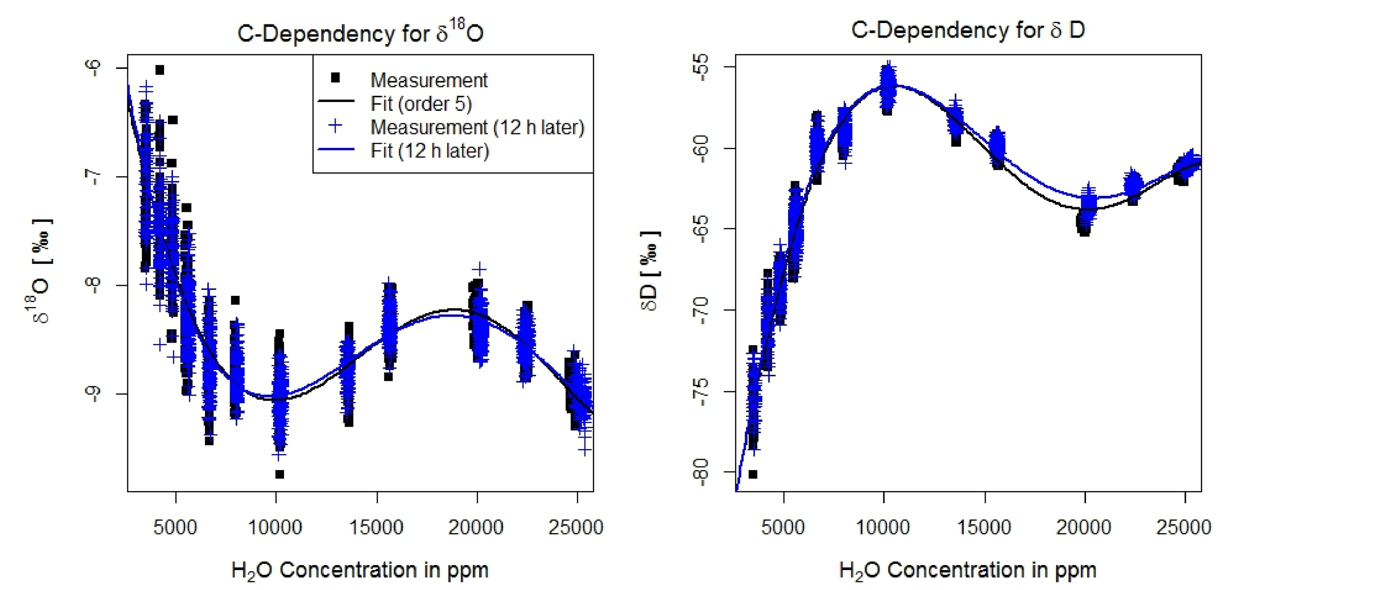


**Figure 7:** Dilution Calibration, measured daily with a water vapor isotope standard source (Los Gatos Research.)

## References

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