APO meeting 2020

Measuring oxygen fluxes in a European beech forest - results from the OXYFLUX project

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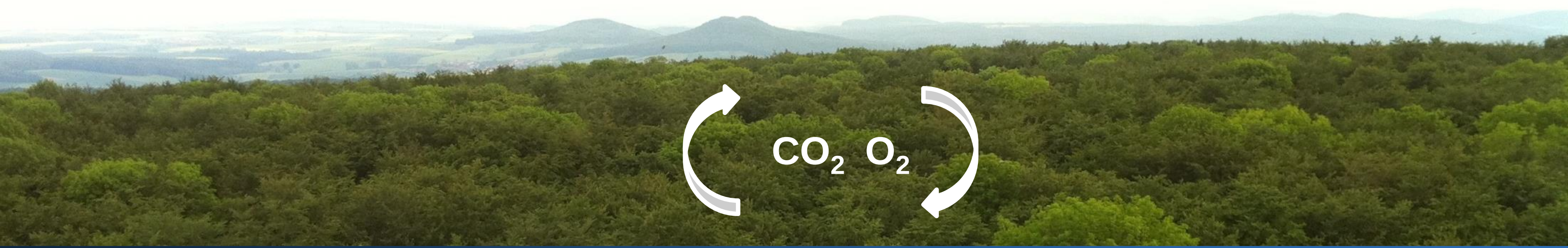


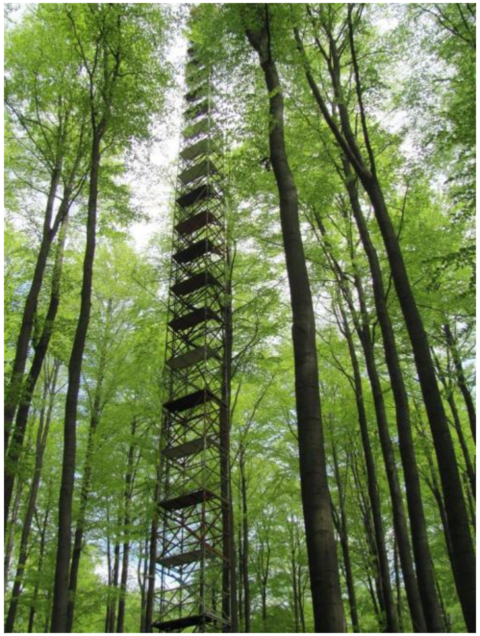
O_2 fluxes in a forest ecosystem

Overall objective

Understanding the O_2:CO_2 ratio of gas exchange of a forest ecosystem in Germany

Approaches

1. Custom-made fully automated chamber branches, stems and soils
2. Canopy air profile measurements and Inverse Lagrangian modelling
3. Oxidative ratios from organic material
4. Ecosystem modelling



1. Chambers for ecosystem component measurements

<u>Component fluxes</u>
- Branch
- Stem
- Soil

➔ 4 chambers each

<u>Non-measurement mode</u>
Chamber concentrations are kept at constant level close to <u>ambient concentration</u> in between measurements

Known carrier gas

Switching Unit

Branch chambers

Stem chambers

Soil chambers

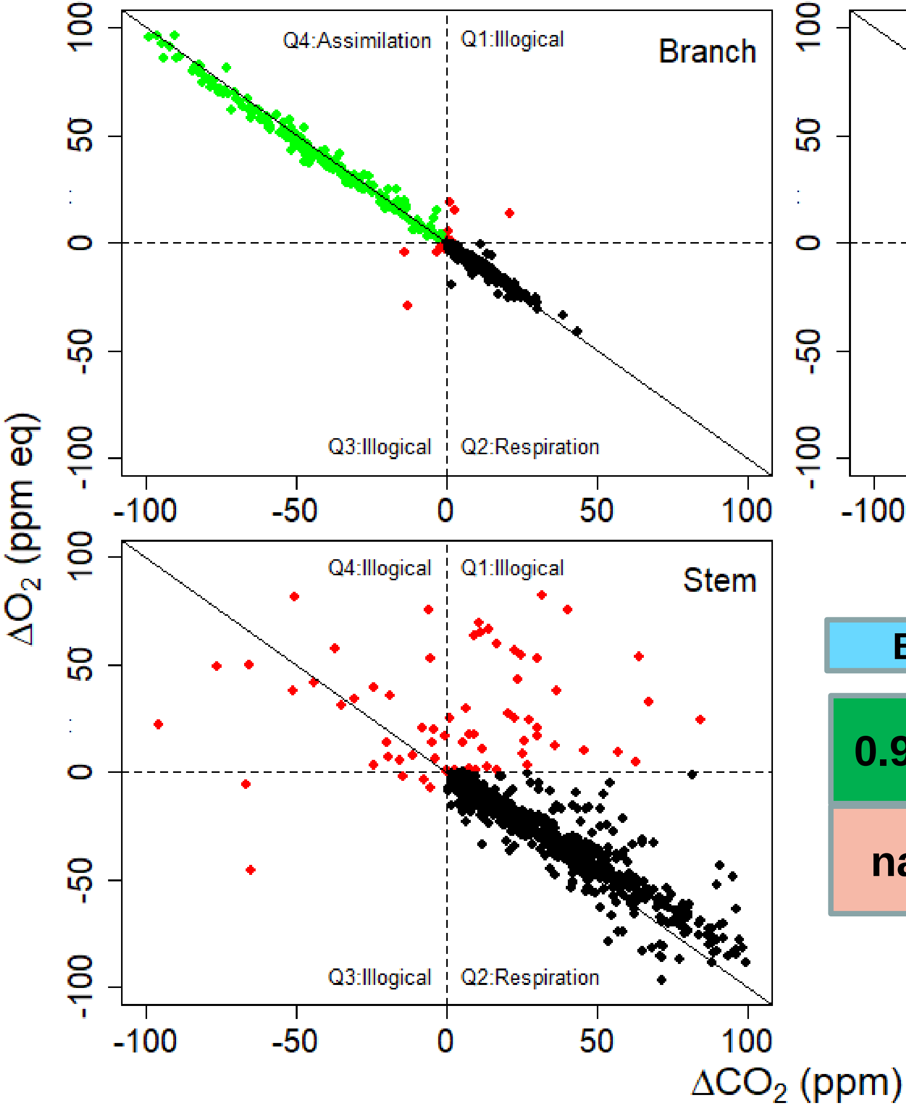
<u>Measurement mode</u>
Chambers are measured one-by-one
Gas of known concentration is pumped through the chamber and concentration changes (ΔO_2, ΔCO_2) are measured

➔ **Open throughflow steady state**

Analyzer unit for O_2 and CO_2
Precision: 1 ppm O_2
0.5 ppm CO_2

built by UEA

$\Delta O_2 \sim \Delta CO_2$ by chamber location

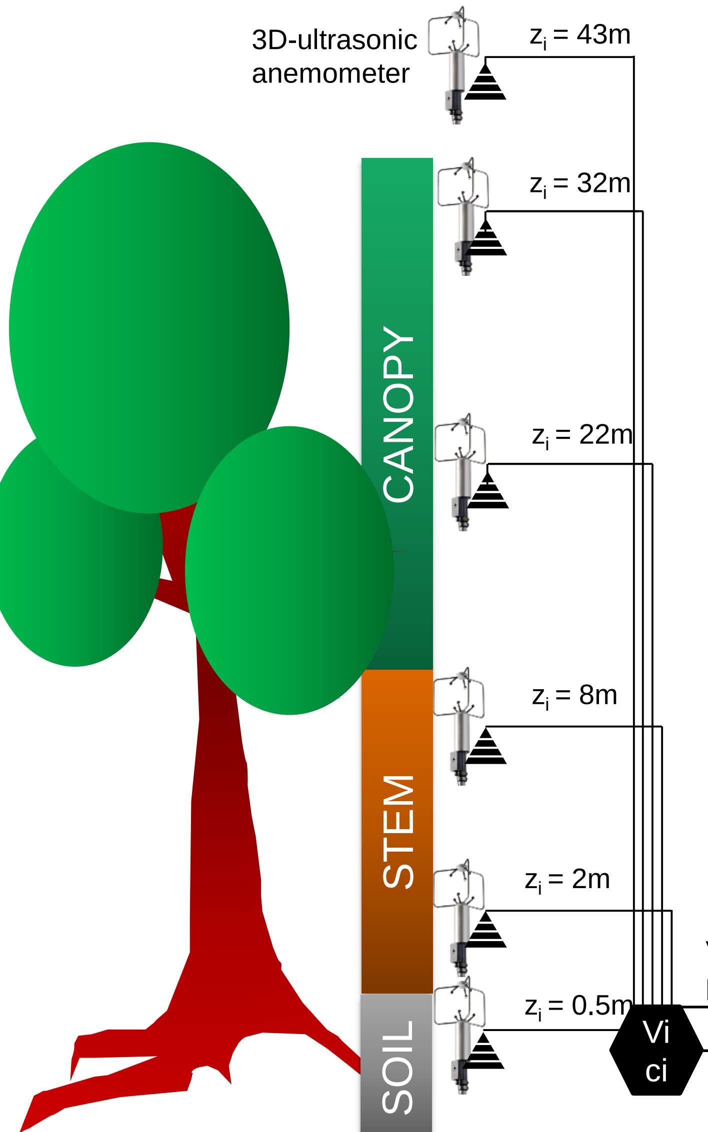


Branch		Soil		Stem	
0.95	na	na	na	na	na
na	1.00	na	0.95	na	0.94

$$\frac{-\Delta O_2}{\Delta CO_2}$$

Muhr et al, unpublished

2. Canopy profile



- high-frequency turbulence profile measurements with YOUNG 81000VRE
- all inlets aspirated Stevenson huts
- gas selection through constant flow VICI 8 port valve
  - each port is continuously sampled @ 1slpm by purge pump
  - selected port is sampled @ 1slpm by vacuum pump
  - switching increment 5 min
- O_2 signal stabilization in < 1 min
- coupled O_2, H_2O, CO_2 measurements @ 2Hz in Aerodyne QCL-TILDAS

Aerodyne O_2 instrument performance

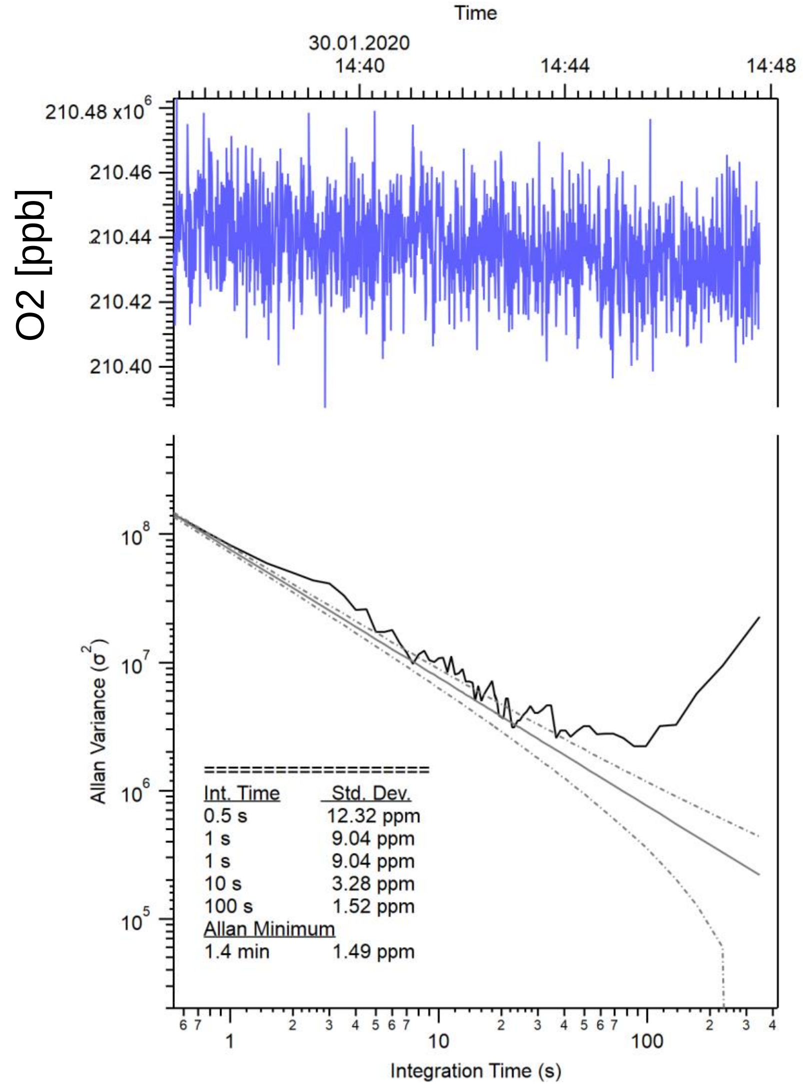
At 1 s integration:

- precision of 9 ppm O_2 (43 per meg)

At 100 s integration:

- precision of **1.5 ppm O_2 (7 per meg)**

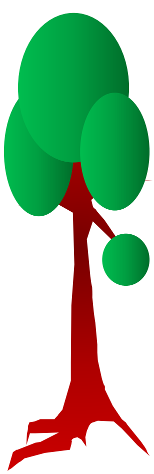
Calibration against O_2 tanks made at UEA



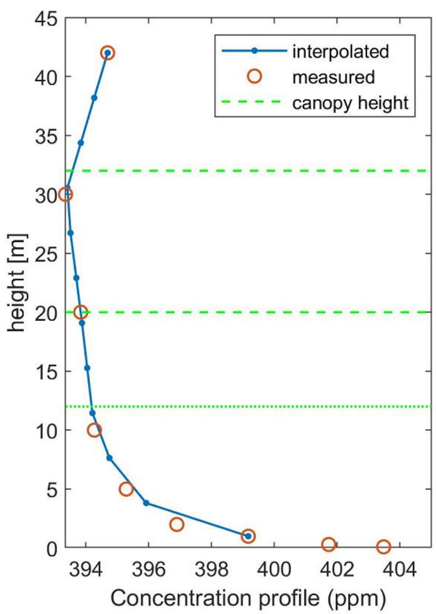
Braden-Behrens et al, unpublished

Inverse lagrangian modelling

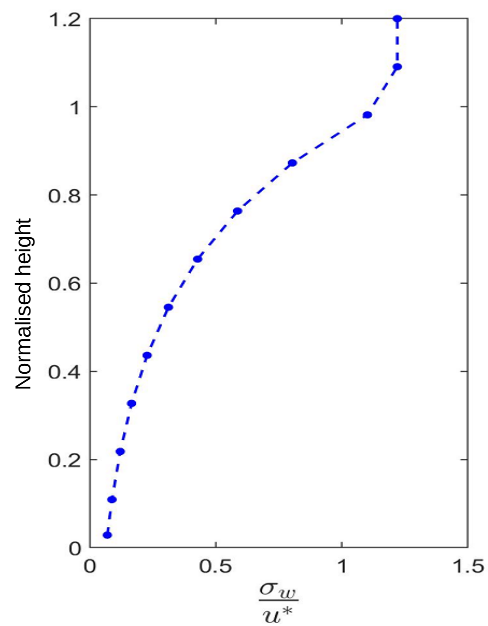
- Use measured O_2 and CO_2 concentration profile $C(z)$
- and turbulence $u_*(z)$ profile
- to infer vertical source /sink distribution profile $S(z)$ of O_2 and CO_2 inside canopy
- and integrated to get canopy net O_2 and CO_2 exchange.



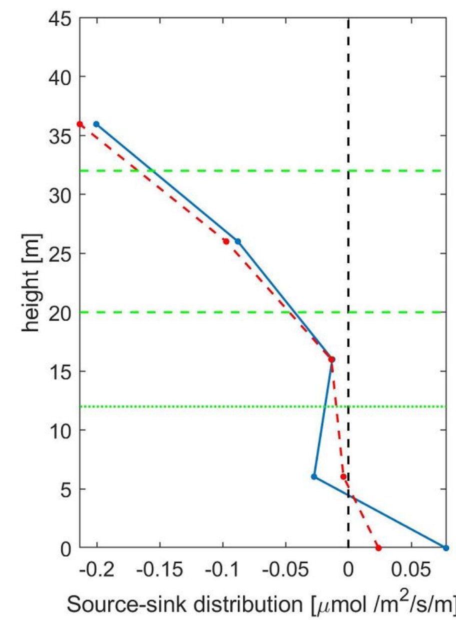
Concentration



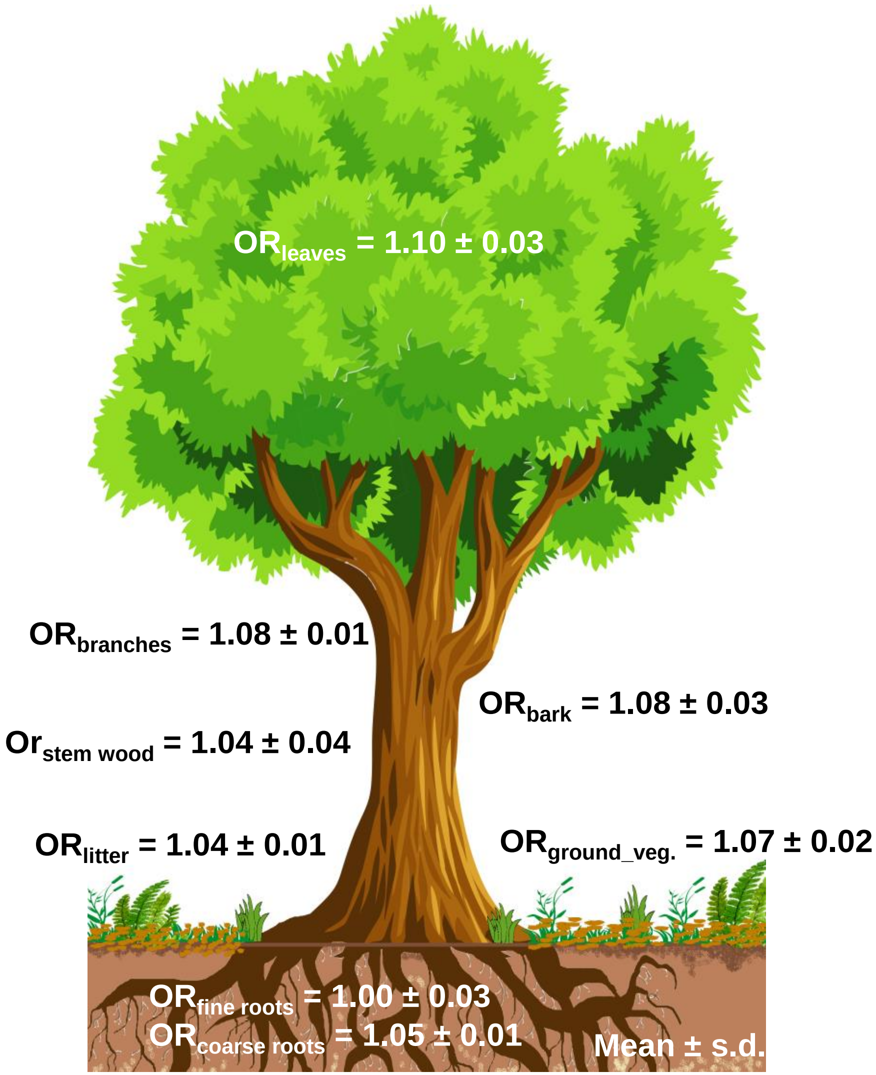
Turbulence



Source-sink distribution



3. Oxidative ratios of organic material



Oxidative ratio of organic material reflects the long-term O_2/CO_2 ratio based on the chemical composition of organic material

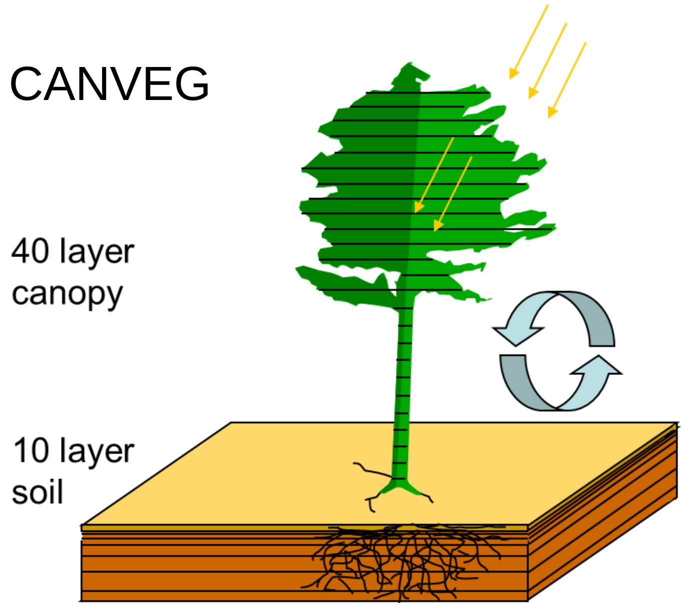
- Most oxidative ratios within this one forest are between 1 and 1.1
- Litter and fine & coarse roots are lower compared to fresh leaves and branches, or bark
- Temporal variation only in leaves
- No significant height effect on oxidative ratios in leaves

Jürgensen et al, unpublished

4. Ecosystem modelling

- Implementing O_2 fluxes in the multi-layer canopy model CANVEG
- Validating against chamber and profile measurements

CANVEG



Without N assimilation effects (Farquhar et al. 1980):

all electrons from water split are used to reduce CO_2 to glucose:

- $6CO_2 + 6H_2O = C_6H_{12}O_6 + 6O_2$
- $O_2 = CO_2 = min\{W_c, W_j\}\left(1 - \frac{\Gamma^*}{[C_i]}\right) - R_d$

➔ O_2:CO_2 = 1.0

With N assimilation effects (Busch et al. 2017):

Extra electron for NO_3^- reduction to NH_4^+ (e_{nit}^-) are provided by water split reaction:

- $$\begin{cases} NO_3^- + 2e_{nit}^- + 2H^+ = NO_2^- + H_2O \\ NO_2^- + 6e_{nit}^- + 8H^+ = NH_4^+ + 2H_2O \\ H_2O = 2e_{nit}^- + 2H^+ + 0.5O_{2_{nit}} \end{cases}$$
- $O_2 = CO_2 + O_{2_{nit}}$

➔ O_2:CO_2 > 1.0

Yuan et al, unpublished

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