Measuring oxygen to unravel the forest carbon balance

Forest O_2/CO_2 gradient observations with Oxzilla and Picarro

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Abstract

Photosynthesis and respiration of CO_2 by forests are two major unknowns in the global carbon cycle. They are the two largest and most variable fluxes, and their difference currently acts as a global net sink. With this project (2017-2020) we aim to provide new insights in the forest carbon balance by separately quantifying photosynthesis and respiration using atmospheric measurements. The method is based on the inverse relationship between oxygen (O_2) and CO_2 which is different for photosynthesis and respiration (e.g. Ishidoya et al., 2015). Highly precise measurements of atmospheric O_2 and CO_2 concentrations will therefore allow to estimate both terms separately. In this poster we present the first results of our field test campaign in a forest in the Netherlands, where we also compared two instruments: Oxzilla and Picarro O_2 analyzers.

Conclusions and outlook

- → We present O_2 and CO_2 measurements from our field test campaign in Speulderbos forest in the Netherlands
- → We show measurements from 2 oxygen analyzers: Oxzilla and Picarro

Future plans:

- → Longer term campaign in Hyytiälä, Finland
- → Development of a numerical biosphere-atmosphere modeling framework for O_2 and CO_2 exchange in forests

Speulderbos, Netherlands

The Speulderbos site is located at: 52°15'08.1"N, 05°41'25.8"E, 52 m.a.s.l. and situated in a dense 2.5 ha Douglas fir forest, which is surrounded by Lark, Beech, Scotch Pine and Hemlock. At a distance of 1.5 km east from the tower the forest is bordered by a large heather area. The tree density at the site is 785 trees per hectare and the tree height is around 32 m. The tower is 45 meters high, and air inlets for our campaign were installed at 26 and 45 meters.

Speulderbos campaign (June-July 2017): O_2 and CO_2 in the forest

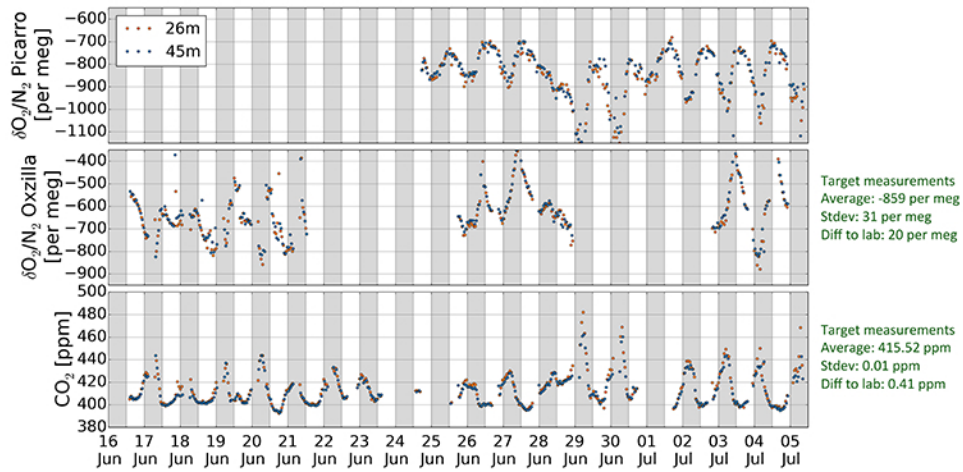
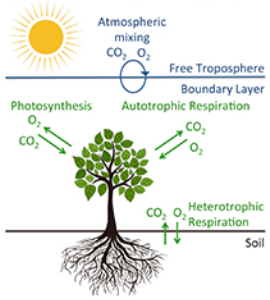


Figure 1: Preliminary O_2 and CO_2 observations from the Speulderbos test campaign measured by the Oxzilla/NDIR system and the Picarro analyzer. Note that the calibration is preliminary, and the O_2 scales are not yet calibrated for the 2 instruments. Observations are shown for the 2 heights: 26 and 45 meter.

Oxidative ratio

O_2 and CO_2 are inversely coupled in all processes in the global carbon cycle, except for oceanic uptake of CO_2. For example, the conversion of 1.0 mole of atmospheric CO_2 to carbohydrates by photosynthesis releases around 1.1 moles of O_2 into the atmosphere. This exchange ratio between O_2 and CO_2, or oxidative ratio (OR) is slightly different for photosynthesis and respiration. Accurate OR measurements therefore allow to unravel these main exchange processes in the forest carbon balance.

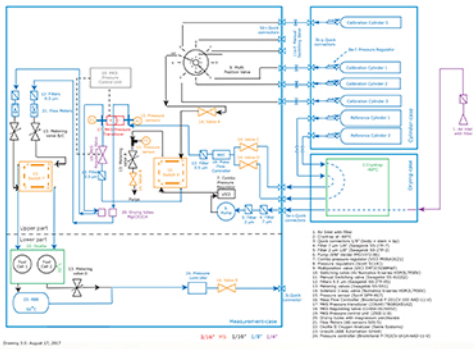


Measurement setup: Oxzilla and Picarro O_2 analyzers

The measurement setup consists of an Oxzilla oxygen analyzer, with a Uras26 NDIR CO_2 analyzer, and is an modified version of van Leeuwen and Meijer (2015). We sample air from 2 heights in the tower (26 and 45 meters) with aspirated inlets.

Parallel to the Oxzilla/Uras setup, we installed a prototype Picarro O_2 analyzer at the site, with parallel intake lines at both heights.

The air for both systems was dried cryogenically to around -50°C.



References

- Ishidoya, S. et al.: Ecol. Res. 30, 225–234 (2015).
- van Leeuwen & Meijer: Int. J. Greenh. Gas Con. 41, 194–209 (2015).

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