Technical challenges of using high precision atmospheric O_2 measurements as a tracer for determining carbon fluxes in terrestrial ecosystems

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Atmospheric oxygen (O_2) measurements are a very useful tool for studying carbon cycle processes at the global scale, and have previously been used, for example, to separate the land and ocean sinks for carbon dioxide (CO_2) (e.g. Keeling and Manning, 2014). Until now, the potential of O_2 measurements at ecosystem level has not been exploited, largely owing to the significant technical challenges faced in measuring atmospheric O_2 to an accuracy and precision of a few ppm or less against a background mole fraction of 21%.

We introduce the “OXYFLUX” project (“Oxygen flux measurements as a new tracer for the carbon and nitrogen cycles in terrestrial ecosystems”), funded by the European Research Council and led by the University of Göttingen, Germany. OXYFLUX aims to develop high precision O_2 flux measurements as a new ecosystem-scale tool for understanding carbon and nitrogen cycle processes in the terrestrial biosphere. Using a network of soil and branch chambers in conjunction with a commercially available “Oxzilla” fuel cell O_2 analyser (Sable Systems Inc.) and a Li-820 CO_2 analyser (LiCor Biosciences), we will measure O_2 and CO_2 fluxes, and quantify oxidative ratios from different ecosystem components and processes at two sites in Germany: a beech forest site and an agricultural site. In addition, we will employ a state-of-the-art prototype laser-based O_2, CO_2 and H_2O instrument (Aerodyne Inc.) with a high flow-rate and fast measurement frequency to measure O_2 fluxes at the whole ecosystem level using the eddy covariance technique.

Our initial tests of several chamber system materials typically used by the CO_2 flux community reveal extremely large O_2 artefacts (biases ranging from 100 per meg to over 1000 per meg), and highlight the technical challenges that we face.

References:

Keeling, R. F. and Manning, A. C.: 5.15 - Studies of Recent Changes in Atmospheric O_2 Content. In: Treatise on Geochemistry (Second Edition), Holland, H. D. and Turekian, K. K. (Eds.), Elsevier, Oxford, 2014.