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Simultaneous O_2 and CO_2 Flux Measurements with Custom-made Branch Chambers for *Fagus sylvatica*

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The O_2:CO_2 exchange ratio of plants is an only recently explored new plant trait and provides novel insights into the carbon cycle. Measurements of O_2 fluxes at field sites are, however, scarce due to a number of technical challenges. This work presents unique field measurements of O_2 and CO_2 mole fractions and exchange fluxes of tree branches using a custom-made fully automated chamber system for quasi-continuous, high-precision measurements between *Fagus sylvatica* leaves and the atmosphere. Data from the vegetation period of 2021 in a temperate beech forest in Germany are shown.

Four steady-state, open-throughflow branch chambers were part of a larger chamber measurement set-up that also included four stem and eight soil chambers that were connected via a custom-built valve switching system to a modified FC-2 Differential Oxygen Analyzer (Oxzilla, Sable Systems International), and an LI-820 analyzer (LI-COR Biogeosciences GmbH). Precision was 1.3 ppm for O_2 and 0.3 ppm for CO_2. Both analyzers were located in an air-conditioned hut. O_2 and CO_2 mole fractions were measured continuously and logged in 10-sec intervals. Chambers were measured sequentially with typical observation times of 20-45 min per chamber, i.e. long enough for the mole fractions to reach steady state and allowing for at least two full measurement cycles of all sixteen chambers per day. For data processing, a quality check routine was developed for the branch chamber measurements, where spikes and non-steady-state conditions were excluded, and finally leaf exchange fluxes were quantified.

Diel, diurnal, and day-to-day variabilities were related to environmental and meteorological conditions. Further, the O_2:CO_2 exchange ratio on leaf-level was investigated for day- and nighttime. We could observe that the O_2:CO_2 exchange ratio varied stronger during nighttime than daytime and was affected mostly by the flux magnitude, the photosynthetically active radiation, and vapor pressure deficit. The exchange ratio was usually between 0.9 and 1.0 µmol µmol^{-1}.

Finally, we evaluated simulated photosynthetical O_2 and CO_2 fluxes of an extended version of the

one-dimensional, multi-layer atmosphere-biosphere gas exchange model CANVEG based on the obtained measurements.