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High-resolution, ecosystem-level CO_2, H_2O and CH_4 fluxes with novel automatic light/dark chamber

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The eddy covariance measurement technique is broadly applied in terrestrial ecosystems for ecosystem-level measurements of CO_2, CH_4 and H_2O exchange between ecosystem and atmosphere. However, in ecological experiments with smaller plot sizes than typical footprints of eddy covariance towers, such as in field-scale climate change experiments, the eddy covariance technique cannot be applied. In these experiments, measurements of gas exchange with the atmosphere rely on chamber techniques. However, chambers large enough to measure at the ecosystem scale are currently not commercially available.

We built a novel automatic chamber for measurement of gas fluxes at the ecosystem scale in short-stature ecosystems. The chamber covers an area of 2827 cm^2 (60 cm diameter), is 80 cm tall (volume: 225 L). The unique feature of the chamber is that it is capable of switching automatically between light and darkened mode enabling separation of light-sensitive and light-indifferent processes. For CO_2 fluxes, net exchange (NEE) is measured in the light mode, while ecosystem respiration (RE) is measured in the darkened mode and Gross Primary Productivity (GPP) is estimated as NEE – RE. The chamber is controlled by a LI-COR 8100/8150 multiplexer system.

We measured hourly fluxes of CO_2, H_2O and CH_4 continuously for 3 years in Danish Calluna vulgaris (common heather) heathland thus generating more than 40,000 individual chamber measurements. We will present an analysis of the novel, high-frequency data set including new insights into the diel fluctuation in RE rates in response to diel, weekly and seasonal changes in GPP, temperature, soil water availability and rain events. Novel findings include the observation of increased RE at similar temperatures during daytime compared to nighttime, thus questioning if RE during daytime can be estimated based on temperature responses from nighttime NEE measurements. Over the study period the ecosystem was a net sink for both CO_2 and CH_4. Finally, we also estimated the evapotranspiration rates of the ecosystems by fitting non-linear models to the H_2O concentration development inside the chamber. The presentation will discuss the potential of using closed chambers for estimating evapotranspiration in experiments with plot sizes too small for application of the eddy-covariance technique. In summary, the ability of the chamber to be both transparent and darkened enables high-frequency, direct measurements of the processes of photosynthesis and ecosystem respiration during daytime. This is an advancement compared to transparent-only chambers as well as the eddy covariance technique which both rely on modelling daytime GPP and RE from the NEE measurements obtained.