Geophysical Research Abstracts
Vol. 18, EGU2016-4364-1, 2016
EGU General Assembly 2016

Soil emission and uptake of carbonyl sulfide at a temperate mountain grassland

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Flux partitioning, i.e. inferring gross primary productivity (GPP) and ecosystem respiration from the measured net ecosystem carbon dioxide (CO_2) exchange, is one uncertainty in modelling the carbon cycle and in times where robust models are needed to assess future global changes a persistent problem. A promising new approach is to derive GPP by measuring carbonyl sulfide (COS), the most abundant sulfur-containing trace gas in the atmosphere, with a mean concentration of about 500 pptv in the troposphere. This is possible because COS and CO_2 enter the leaf via a similar pathway and are processed by the same enzyme (carbonic anhydrase). A prerequisite to use COS as a proxy for canopy photosynthesis is a robust estimation of COS sources and sinks in an ecosystem. Past studies described soils either as a sink or source, depending on properties like soil temperature and soil water content.
The main aim of this study was to quantify the soil COS exchange and its drivers of a temperate mountain grassland in order to aid the use of COS as tracer for canopy CO_2 and water vapor exchange.
We conducted a field campaign with a Quantum cascade laser at a temperate mountain grassland to estimate the soil COS fluxes under ambient conditions and while simulating a drought. We used self-built fused silica (i.e. light-transparent) soil chambers to avoid COS emissions from built-in materials and to assess the impact of radiation. Vegetation was removed within the chambers, therefor more radiation reached the soil surface compared to natural conditions. This might be the reason for highly positive fluxes during daytime more similar to agricultural study sites. To further investigate this large soil COS source we conducted within canopy concentration measurements near the soil surface and still recorded fluxes confirming the soil as a COS source during daytime. Results from the drought experiment suggested a strong impact of incoming radiation on soil COS fluxes followed by soil temperature, whereas the influence of soil water content (SWC) seemed to be negligible, even though the SWC dropped significantly due to rain exclusion. These results were bolstered by soil nighttime fluxes around zero and measurements with non-transparent chambers exhibiting much smaller fluxes compared to transparent ones. In the case that other ecosystems react in a similar fashion and biotic processes are negligible when parameterizing soil COS fluxes, we are a step closer to using COS as a proxy for GPP.