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Combining in situ and laboratory measurements of soil-atmosphere carbonyl sulfide fluxes from four different biomes across Europe

Florian Kitz (1), Maria Gomez-Brandon (2), Albin Hammerle (1), Felix M. Spielmann (1), Heribert Insam (2), Andreas Ibrom (3), Mirco Migliavacca (4), Gerardo Moreno (5), Steffen M. Noe (6), and Georg Wohlfahrt (1)

(1) Institute of Ecology, University of Innsbruck, Innsbruck, Austria, (2) Institute of Microbiology, University of Innsbruck, Innsbruck, Austria, (3) Department of Environmental Engineering, Technical University of Denmark, Kongens Lyngby, Denmark, (4) Department Biogeochemical Integration, Max Planck Institute for Biogeochemistry, Jena, Germany, (5) Forest Research Group, Universidad de Extremadura, Plasencia, Spain, (6) Institute of Agricultural and Environmental Sciences, Estonian University of Life Sciences, Tartu, Estonia

Flux partitioning, the quantification of photosynthesis and respiration, is a major uncertainty in modelling the carbon cycle and in times when robust models are needed to assess future global changes a persistent problem. A promising new approach is to derive gross primary production (GPP) from measurements of the carbonyl sulfide (COS) flux, 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 for using COS as a proxy for photosynthesis is a robust estimation of all non-leaf sources and sinks in an ecosystem. Past studies described soils either as a sink or source, depending on their properties like soil temperature and soil water content.

In 2016 we conducted field campaigns in Austria (managed temperate mountain grassland), Spain (savannah), Denmark (temperate beech forest) and Estonia (hemiboreal forest) to estimate the soil-atmosphere COS fluxes under ambient conditions in different biomes. We used self-built fused silica soil chambers to avoid COS emissions from built-in materials and to assess the impact of radiation. At the grassland sites (Austria, Spain) vegetation was removed below the chambers, therefor more radiation reached the soil surface compared to natural conditions.

The grassland sites were characterized by highly positive COS fluxes during daytime and COS fluxes around zero during nighttime. In contrast, the soils at the forest sites (Denmark, Estonia), characterized by less radiation on the soil surface, acted as a sink for COS. The impact of other abiotic factors, like soil water content and soil temperature, varied between the ecosystems.

In addition to the field measurements soil and litter samples were taken at the study sites and used to measure COS fluxes under controlled conditions in the lab. Results from the temperate mountain grassland in Austria suggest high initial but rapidly decreasing COS emission from soil mixed with litter, but uptake by soil alone. Those lab measurements were followed up by genetical analyses to link the fluxes to the soil microbial communities present in the samples.