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Bringing light into the darkness of soil carbonyl sulfide fluxes

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Traditional approaches to quantify terrestrial photosynthesis and respiration, the two major components of the carbon cycle, at scales beyond the leaf level are plagued by several systematic uncertainties. A method which has gained momentum during the last decade is the use of carbonyl sulfide (COS) as a proxy for gross primary production (GPP). COS qualifies as a proxy because its pathway into the leaf is similar to CO_2 and both gases react with the enzyme carbonic anhydrase (CA) inside the leaf. The advantage of COS measurements compared to CO_2 measurements is the lack of COS emissions from vascular plants, opposed to the bidirectional CO_2 flux. The method has the underlying assumption that leaves contribute the major fraction of the net ecosystem COS flux and other COS sinks and sources are either small or easy to parameterize. Soils could be significant contributors to the ecosystem COS flux, since they harbor a large number of organisms producing CA or other COS-related enzymes. We investigated soils in Spain, Denmark and Estonia in situ and in the laboratory. For our field measurements we used self-built fused silica soil chambers to avoid COS emissions from built-in materials and to assess the impact of radiation. Soil samples taken at locations close to the chamber measurements were brought to Austria and analyzed in a lab experiment. The experiment compared the COS fluxes of the different soils to each other and their reaction to UV irradiation.

In situ the grassland site (Spain) was characterized by highly positive COS fluxes during daytime, with high levels of radiation on the soil surface, 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. The direct comparison of the different soils in the lab under dark conditions showed that the Spanish soil was still a net emitter of COS and the two forest soils exclusively exhibited COS uptake. UV radiation decreased soil COS uptake in the soils from Estonia and Denmark and increased soil COS emissions from the Spanish soil. This is further evidence for light induced COS production in soil. The observed difference in COS exchange between the grassland soil and the forest soils challenges the assumption of a small and uniform soil contribution to the net ecosystem COS flux.