Geophysical Research Abstracts
Vol. 15, EGU2013-7220, 2013
EGU General Assembly 2013

Novel insight into soil and ecosystem COS fluxes in an agricultural field

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A promising new approach to partition net ecosystem carbon and water fluxes is the use of carbonyl sulfide (COS) as a tracer of the canopy components. COS is taken up by leaves via the same pathway as CO_2 (stomatal diffusion followed by hydration by carbonic anhydrase), leading to a close coupling of vegetation COS and CO_2 fluxes during photosynthesis and the potential to estimate gross photosynthesis from concurrent measurements of COS and CO_2. A necessary requirement for this approach at ecosystem and continental scales is knowledge of soil COS fluxes. Considered small in magnitude relative to the vegetation fluxes, soil is also largely considered a sink for COS, but our knowledge of in situ soil COS fluxes remains very limited. We measured soil COS fluxes in a wheat field in Oklahoma from April to June 2012, using a novel combination of an automated soil chamber coupled to a COS laser analyzer, in parallel with some of the first eddy covariance measurements of ecosystem COS fluxes. We provide the first continuous record of soil COS fluxes under natural conditions, and report on some unique responses. In contrast to the majority of published results, we found that the agricultural soil was a source of COS under most conditions during the campaign. Mean COS flux over the study period was 1.9 pmol m-2 s-1 and highly correlated with soil temperature, shifting from a sink to a source at a soil temperature of around 15°C. Diel amplitudes of up to 15 pmol m-2 s-1 and fluxes of up to 25 pmol m-2 s-1 were observed. To locate the source of the COS production, we investigated different soil components. Wheat roots were found to be emitting COS under all conditions. Root-free soil was a COS sink up to a soil temperature of around 25°C, but turned into a COS source at higher soil temperatures. We also observed COS production from the roots of several other species, indicating that this may be a widespread phenomenon. The soil component was small relative to canopy uptake during the active growing period, when the ecosystem was a strong sink for COS, but the ecosystem transitioned to a source during plant senescence and after harvest. We discuss some possible mechanisms of the source and the influence of other biogeochemical cycles, namely nitrogen. This novel combination of soil, component and ecosystem flux measurements helps us understand the seasonal scale behavior of COS fluxes, and highlights potential considerations for using COS as a tracer of photosynthesis.