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

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Introduction:

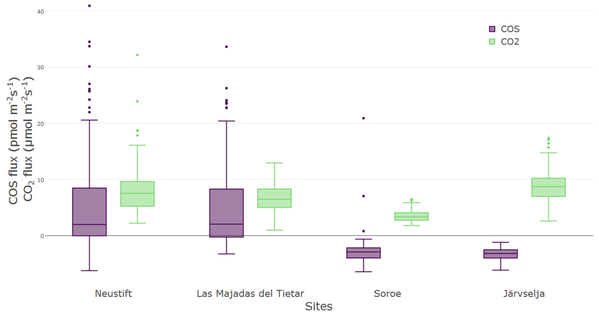
The measurement of carbonyl sulfide (COS) , a trace gas with a mean concentration of about 500 pptv in the troposphere, is a promising new approach to partition net ecosystem-scale CO_2 fluxes into photosynthesis and respiration. The utility of COS for flux partitioning on the ecosystem scale depends critically on the understanding of non-leaf sources and sinks of COS. Especially the role of soils, which have been shown to act both as sources and sinks for COS, needs to be clarified.

We conducted measurements

- **in the field:** in 4 different ecosystems, to asses the contribution of the soil to the net ecosystem COS flux
- **in the laboratory:** to asses the contribution of the soil, under different treatments, to the COS flux

Study sites:

Neustift: a temperate mountain grassland, in the Central Alps (47.11 N, 11.31 E) at an elevation of 990 m above sea level.
Järvselja : a hemiboreal forest, in Estonia (58.27 N, 27.30 E) at an elevation of 36 m above sea level.
Soroe: a deciduous broadleaf forest, in Denmark (55.48 N, 11.64 E) at an elevation of 40 m above sea level.
Las Majadas del Tietar: a savannah, in Spain (39.94 N, -5.77 E) at an elevation of 260 m above sea level.



(I) Comparison of the different sites in regard to COS and CO_2 soil fluxes, including the measurement campaign in Neustift from 2015. The grassland sites (Neustift and Majadas) – which experienced much higher radiation due to the experimental setup - showed much higher COS fluxes compared to the forest sites.

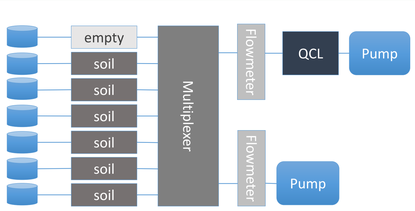
Methods:

In the field:

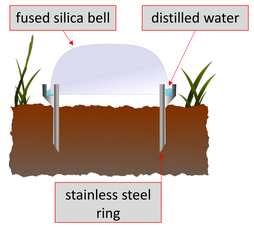
Transparent flow-through soil chambers (see sketch 3) were used together with a QCL (Aerodyne Research) to quantify soil COS and CO_2 fluxes .

In the lab:

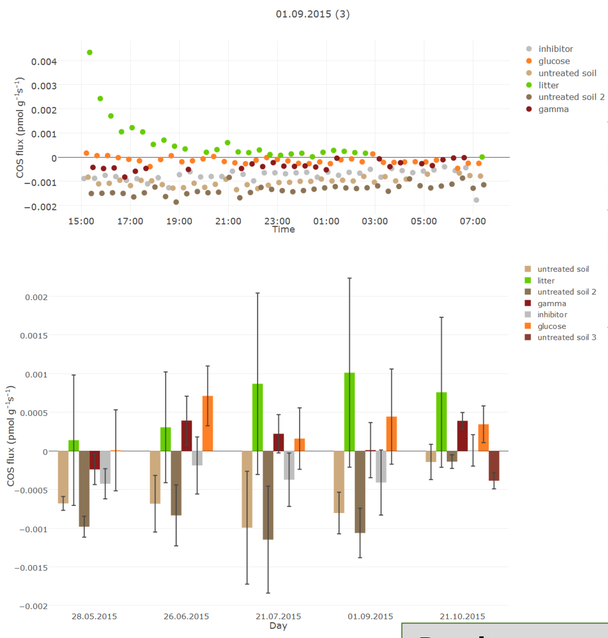
Transparent glass tubes (see sketch 2) were used together with a QCL (Aerodyne Research) to quantify soil COS and CO_2 fluxes. 5 different treatments were applied to sieved soil samples from Neustift, including the addition of an inhibitor of the enzym carbonic anhydrase (CA) , which is involved in the consumption of COS.



(II) Experimental setup to measure differently treated soil samples.

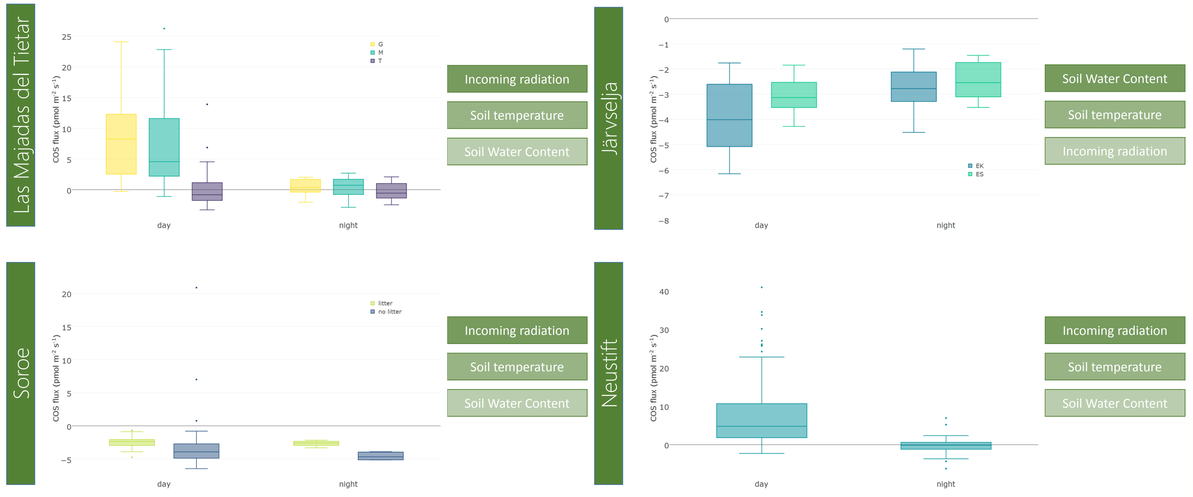


(III) Soil chamber to measure soil COS fluxes *in situ*.



(IV) COS fluxes from the different treatments; COS emission from the litter treatment started high and descreased fast over the course of the measurement. This pattern can be seen on all days (not shown). Untreated soil samples exhibited COS uptake, which decreased, when the CA inhibitor was added or the samples were sterilized (gamma).

(V) Summary of all COS fluxes (means ± sds across all soil samples – 3 replicates per day).



(IV) Boxplots summarizing the soil chamber measurements in Las Majadas, Soroe, Järvselja and Neustift. Night-(zenith above 90°) and daytime measurements are displayed separately. In Las Majadas (Spain) measurements were taken under Trees (T), in the open savannah (G) and inbetween (M). In Soroe (Denmark) some soil-rings were freed from litter (no litter), the rest kept their natural amount of litter (litter). In Järvselja (Estonia) some rings were placed on elevated spots (EK) and some in depressions (ES). Next to the boxplots a ranking of the predictors (random forest regression) for the COS soil flux – starting from most important to least important.

Results:

In the field:

- Radiation had the largest influence on soil COS fluxes in 3 of the 4 investigated sites.
- Forest soils acted as COS sink, grassland soils acted as COS source during the day and as sink during the night
- Soil water content was the least important predictor, with the exception of Estonia where it was the most important predictor
- The removal of litter within the chambers caused significant differences in Denmark

In the lab:

- Untreated soil samples were COS sinks, samples with added litter or glucose acted as sources.
- Both the CA inhibitor and sterilization lowered the uptake of COS in the samples.

Conclusion:

Soil COS exchange reflects a complex interplay between uptake and release processes controlled by a mix of biotic and abiotic drivers

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