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Net exchange of carbonyl sulfide, carbon monoxide, and carbon dioxide in a highly oligotrophic basaltic soil: a mesocosm study

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Soils can act as sink or source of carbonyl sulfide (COS/OCS; COS hereafter), carbon monoxide (CO), and carbon dioxide (CO_2) due to biotic and abiotic processes. Basaltic soils, despite their small area coverage in terrestrial ecosystems, play an important role in the carbon cycle, especially in the carbonate system. Abiotic processes can dominate CO_2 exchange in basaltic soils due to the bi-directional reaction of carbonate weathering. The co-variation of the exchange of COS, CO, and CO_2 has not been extensively investigated in this kind of soil, and could reveal how different biotic and abiotic processes interact. Here, we aim to explore the rates of exchange of COS, CO and CO_2 in a mesocosm experiment. The Biosphere 2 – Landscape Evolution Observatory (LEO) is a large-scale experimental facility used to investigate the interrelations between biogeochemistry, hydrology, and ecology in evolving soils. Here we used the scaled-down model of LEO (miniLEO; $2 \times 0.5 \times 1$ m, 10° slope), filled uniformly with the same (as LEO) ground basaltic tephra with loamy sand texture, and free of vegetation. We used a 2 m3 transparent chamber built of plexiglass and aluminium, divided in three sections (upslope, mid-slope, and downslope), connected to a quantum cascade laser spectrometer to measure the COS, CO, and CO_2 gas exchange between the surface of miniLEO and the atmosphere. In general, our results suggest that the soil in our mesocosm acted mostly as a sink of CO (-0.27 $\pm$ 0.71 nmol m^{-2} s^{-1}), and CO_2 (-0.19 $\pm$ 0.66 μmol $m^{-}2$ s^{-1}), with differences between the upslope and downslope sections, as well as being inversely correlated. For COS exchange, the soil in our mesocosms remained close to neutral (-0.06 $\pm$ 0.83 pmol m^{-2} s^{-1}). The constant uptake of CO in this highly oligotrophic system could be related to microbial consumption as a source of energy. On the other hand, the net uptake of CO_2 could be due to the uptake of abiotic processes (i.e., carbonate weathering), as well as biotic processes (i.e., microbial and non-vascular plant growth). The neutral COS exchange present in the basaltic soil of our experiment could be a result of competing consumption/production processes, such as abiotic degradation, or microbial consumption. In the next stages of our experiment, when we introduce vegetation to miniLEO, we expect that the exchanges rates COS, CO, and CO_2 change (i.e., higher uptake of COS and CO_2 due to photosynthesis). Our results from the miniLEO experiment will give insights on the potential outcomes for the unique and highly instrumented hillslopes of LEO, and will guide new experimentation at Biosphere 2 to study different trace gases. Further understanding on the mechanisms that drive the potential source or sink strength of COS, CO, and CO_2 is needed since, for example, COS can be used as an independent proxy of gross primary productivity, and global CO budgets remain highly uncertain.