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Estimating the contribution of bryophytes to the atmospheric COS budget

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In the past decade, global biogeochemical modellers have embraced enthusiastically the potential of carbonyl sulphide (COS) as a tracer for gross primary productivity (GPP). COS is the most abundant sulphur-containing gas in the atmosphere, it is produced mainly in the ocean and it is consumed by the biosphere, with terrestrial vegetation being the most important contributor. Plant COS uptake is proportional to photosynthetic CO_2 withdraw and that is why measurements of the biosphere-atmosphere COS flux can serve a proxy for GPP. Plant COS uptake is mediated by the light-independent enzyme carbonic anhydrase that irreversibly hydrolyses COS into H_2S, which is quickly utilised as a sulphur source. Currently, there are no described plant-processes with COS as a by-product and hence the atmospheric-plant COS flux is assumed unidirectional. So far, we had focused on characterizing plant COS uptake dynamics on vascular plants and previous studies are consistent with the unidirectional flux assumption. However, although early works on sulphur metabolism suggested non-vascular plants might not abide to this assumption, we lack estimates of COS uptake dynamics for non-vascular communities.

Bryophytes are key constituents of biocrusts and non-vascular photoautrophic communities and in temperate and cold latitudes contribute significantly to ecosystem carbon and nutrient cycling. We expect that in these ecosystems the coupling between COS and CO_2 uptake will be influenced by specific environmental cues that control gas-exchange in bryophytes. We expect tissue hydration to be the most influential driver on COS uptake. In contrast, light would constrain CO_2 but not COS uptake and therefore we expect greater uncoupling of COS and CO_2 in the dark than in vascular plants. We characterized COS and CO_2 uptake dynamics in two broadly distributed bryophytes, with contrasting life forms and evolutionary origins: the liverwort Marchantia polymorpha and the feather moss Scleropodium purum. We measured CO_2 and COS uptake with varying hydration status, light and temperatures.

Our results showed that COS uptake is limited by either excess or low tissue water content, similar to photosynthetic CO_2 uptake. We found that COS uptake continued in the dark, despite impaired photosynthesis. We demonstrate that the COS flux in bryophytes is not unidirectional and that COS emissions are temperature and not light driven. Our results also suggest that both the uptake and the emission components are subject to seasonal regulation, with both uptakes limited in winter by low temperatures. Our results serve as a first approximation to model seasonal COS fluxes from air temperature and humidity in bryophyte-dominated ecosystems in high latitudes. We suggest that bryophytes might have an unexpected contribution to the ecosystem COS budget: during the day, when photosynthesis dominates the CO_2 flux, COS emission are enhanced by warmer temperatures, while COS uptake is limited by tissue hydration and bryophytes act a net COS source; at night when the temperatures are cool and humidity is high, COS uptake dominates and bryophytes would act a net COS sink, while continuing to emit CO_2 from respiration.