



## A new mechanistic framework to predict OCS fluxes in soils

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A better description of the amplitude of photosynthetic and respiratory gross CO<sub>2</sub> fluxes at large scales is needed to improve our predictions of the current and future global CO<sub>2</sub> cycle. Carbonyl sulfide (COS) is the most abundant sulphur gas in the atmosphere and has been proposed as a new tracer of gross photosynthesis, as the uptake of COS from the atmosphere is dominated by the activity of carbonic anhydrase (CA), an enzyme abundant in leaves that also catalyses CO<sub>2</sub> hydration during photosynthesis. However, soils also exchange COS with the atmosphere and there is growing evidence that this flux must also be accounted for in atmospheric budgets. In this context a new mechanistic description of soil-atmosphere COS exchange is clearly needed. Soils can take up COS from the atmosphere as the soil biota also contain CA, and COS emissions from soils have also been reported in agricultural fields or anoxic soils. Previous studies have also shown that soil COS fluxes present an optimum soil water content and soil temperature. Here we propose a new mechanistic framework to predict the fluxes of COS between the soils and the atmosphere. We describe the COS soil budget by a first-order reaction-diffusion-production equation, assuming that the hydrolysis of COS by CA is total and irreversible. To describe COS diffusion through the soil matrix, we use different formulations of soil air-filled pore space and temperature, depending on the turbulence level above the soil surface. Using this model we are able to explain the observed presence of an optimum temperature for soil COS uptake and show how this optimum can shift to cooler temperatures in the presence of soil COS emissions. Our model can also explain the observed optimum with soil moisture content previously described in the literature (e.g. Van Diest & Kesselmeier, 2008) as a result of diffusional constraints on COS hydrolysis. These diffusional constraints are also responsible for the response of COS uptake to soil weight and depth observed by Kesselmeier et al. (1999). In order to simulate the exact COS uptake rates and patterns observed on several soils collected from a range of biomes (Van Diest & Kesselmeier, 2008) different CA activities had to be evoked in each soil type, coherent with the expected soil microbial population size and diversity. A better description of the drivers governing soil CA activity and COS emissions from soils is needed before incorporating our new mechanistic model of soil-atmosphere COS uptake in large-scale ecosystem models and COS atmospheric budgets.