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A kinetic model relating the leaf uptake of carbonyl sulfide (COS) to water and CO_2 fluxes and ^{13}C fractionation

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Carbonyl sulfide (COS) is an atmospheric trace gas that holds great promise for studies of terrestrial carbon and water exchange. During photosynthesis, COS and CO_2 follow the same pathway and are both taken up in enzyme reactions in leaves. We have developed a simple model of leaf COS uptake, analogous to the equations for CO_2 and water fluxes. Leaf COS uptake predicted from the new equation was in good agreement with data from field and laboratory chambers, although with large uncertainties. We also obtained first estimates for the ratio of conductances of COS and water vapour. Empirically derived estimates were 2.0 $\pm$ 0.3 for laboratory data on *Fagus sylvatica* and 2.2 $\pm$ 0.8 for field data on *Quercus agrifolia*, both close to the theoretical estimate of 2.0 $\pm$ 0.2. As a consequence of the close coupling of leaf COS and CO_2 uptake, the normalized uptake ratio of COS and CO_2 can be used to provide estimates of C_i/C_a, the ratio of intercellular to atmospheric CO_2, an important plant gas exchange parameter that cannot be measured directly. Published normalized COS to CO_2 uptake ratios for leaf studies on a variety of species fall in the range of 1.5 to 4, corresponding to C_i/C_a ratios of 0.5 to 0.8. In addition, we utilize the coupling of C_i/C_a and photosynthetic ^{13}C discrimination to derive an estimate of 2.8 $\pm$ 0.3 for the global mean normalized uptake ratio. This corresponds to a global vegetation sink of COS in the order of 900 $\pm$ 100 Gg S yr^{-1}. Similarly, COS and ^{13}C discrimination can be combined to obtain independent estimates of photosynthesis (GPP). The new process-oriented description provides a framework for understanding COS fluxes that should improve the usefulness of atmospheric COS data to obtain estimates of gross photosynthesis and stomatal conductance at regional to global scales.