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Concurrent COS and CO_2 exchange from an arid coniferous forest during the spring-summer transition

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Presently, land ecosystems fix around one third of the anthropogenic carbon dioxide (CO_2) emissions each year and thus slow down anthropogenic global warming. The proximate driver of this terrestrial carbon sink is the gross primary productivity (GPP) of land plants. GPP, however, cannot be measured directly beyond the leaf scale and thus is commonly inferred through a combination of proxy measurements and models, which is giving rise to an unknown uncertainty of global GPP estimates. During the past couple of years, carbonyl sulfide (COS), a trace gas present in the atmosphere at an average mole fraction of around 500 ppt, has received growing interest as a tracer for GPP. COS diffuses into leaves in a fashion very similar to CO_2, but in contrast to the latter is generally not emitted. Indeed it has been demonstrated that the leaf uptake of COS scales with the corresponding gross uptake of CO_2. The first few tests of the COS-GPP relationship at ecosystem scale have indicated that COS has potential for estimating GPP, but also highlighted a number of issues that need to be consolidated in order to routinely use COS for estimating GPP.

Here we present results from our continuing efforts for better understanding the ecosystem-scale COS exchange and its relationship to GPP. To this end we conducted a three-month measurement campaign at a coniferous forest in an arid climate in Israel. The measurements covered the phenological transition from productive spring to inactive summer conditions. We hypothesised that the ecosystem-scale COS exchange would reflect the seasonal dynamics of the two underlying component fluxes; (i) We expected the leaf COS uptake to decline with the reduction in leaf photosynthesis caused by the progressive decline in soil water availability and the associated reduction in stomatal conductance. (ii) In parallel we expected an increasing contribution of soil COS emissions, which have been shown to scale with temperature and radiation.

In order to test these hypothesis we conducted ecosystem-scale flux measurements of COS and CO_2 above the forest using the eddy covariance technique. Periodically, the understory and soil COS and CO_2 exchange was measured with an additional eddy covariance system and manual chambers, respectively.

The maximum of the diurnal mean of CO_2 decreased by the factor of 4 (from -12 in March to -3 in May) and the COS fluxes switched from mainly negative values (uptake - sink) in March and April to partially positive values (emission - source) in May. Understory as well as soil flux measurements of both gases showed only minor changes over the course of the measurement campaign.