Biogeosciences Discussions, 2, S95–S100, 2005
www.biogeosciences.net/bgd/2/S95/
European Geosciences Union

Biogeosciences Discussions

Interactive comment on "Global uptake of carbonyl sulfide (COS) by terrestrial vegetation: Estimates corrected by deposition velocities normalized to the uptake of carbon dioxide (CO_2)" *by* L. Sandoval-Soto et al.

L. Sandoval-Soto et al.

Received and published: 18 March 2005

We highly appreciate the comments of the referee #1. They will be very helpful in improving our manuscript. We try to answer all points listed in the interactive comment.

1. Inadequate literature overview

We tried to include all relevant literature, especially under the aspect of the close relation of COS and CO2 uptake. Unfortunately, we seem to have overlooked some papers. We will include the paper of Geng and Mu (2004) into our introduction as these authors presented a fundamental overview of the COS uptake by lawn and soil as investigated inside the city of Beijing. Furthermore, we include their estimations of the COS deposition velocity into table 2. Unfortunately they did not report about the ratios of deposition velocities of COS and CO_2. As far as the modelling study of Kjellstrom (1998) is concerned, we will include this global estimate for COS uptake by vegetation into table 4. The number (0.32 Tg/year) as well as the basic way of calculation is in close accordance with Chin and Davis (1993).

2. Missing discussion of a compensation point

This is a very interesting point raised by the referee. A compensation point as discussed by Geng and Mu (2004) can be expected as soon as there is a linear relationship between the exchange of a trace gas and its atmospheric concentration. Such behaviour has been reported in several cases in the past. Also in our recent study we clearly found such a linear relationship. As we fumigated our samples with purified air re-adjusted to ambient COS mixing ratios around 600 ppt we found fluctuations of the COS uptake related to fluctuations of COS mixing ratios (400 to 800 ppt over all experiments and years). We used the linear relationship to "normalize" our COS exchange rates to an atmospheric concentration of 600 ppt in order to be able to intercompare our data. However, the existence of a compensation point could not be proved within our experiments. Even under COS-free air we never found any emission of COS from the tree species investigated. Hence, a compensation point could only be discussed by extrapolation. Compensation points as estimated from such linearization (extrapolation) were always found to be lower than any natural COS mixing ratio. Thus, it can be stated that a compensation point will not interfere with our interpretations and estimates. Furthermore, by using the ratios of the deposition velocities of COS and CO_2 instead of their uptake ratios we already considered this effect. We will include a short discussion of the compensation point and its influence on global budget calculations in a revised manuscript.

3. One-directional uptake of COS and bidirectional exchange of CO_2

The referee is completely right in stating that we determine a net exchange of COS (as for CO_2) and that we can not prove that none of the COS molecules may leave the stomatal pore. We wanted to discuss the overall behaviour under normal atmospheric conditions with COS atmospheric mixing ratios high enough to balance any compensation point during day and night. Our remark was meant to point out that for CO_2 there is an emission by leaf, stem, root respiration and other heterotrophic respiration which is not found for COS. Even soils can mainly be regarded as sinks for COS. Hence, we can talk about net and gross productivity (see below) for CO_2 but not for COS. We will rewrite this chapter in order to avoid any misunderstanding.

4. Why do we introduce the gross primary productivity concept?

As mentioned under point 3, we have to consider that COS is taken up and consumed without being released by the vegetation. COS is irreversibly lost within the biochemical consumption. Furthermore, a production is not really known. In contrast, CO_2 is clearly produced by respiration processes and its release leads to a carbon loss. Hence, all data on net carbon uptake or net primary production do not consider the gross uptake rates of CO_2. However, as we used the net primary productivity data from Whittaker and Likens (1975) for global ecotype depending estimations, the loss by heterotrophic respiration has to be taken into account in order to relate the uptake of COS to the real uptake of CO_2. NPP does only reflect 50 % of the GPP. We tried to express this by introducing the term "one-directional uptake of COS" (see above). We will rewrite in order to better explain this point.

5. The importance of temperature

The referee is right in stating that temperature is of high importance for the uptake of COS. However, taking into account the carbon uptake data (Whittaker and Likens, 1975) such a temperature effect is automatically included. The COS uptake is related to ecotype-relevant data of carbon uptake. Thus, the temperature effects are considered already, except if we would expect diverging shifts of the deposition velocities of CO_2 and COS. I tend to exclude such a shift. But we will discuss it.

6. Calculation of deposition velocities and uptake numbers

Deposition velocities were calculated dividing exchange rate (nmol / m^2 s) by atmospheric concentration (nmol/m^3) resulting in the deposition velocity (Vd) given in m/s. For global uptake estimations formula 1 has been used. As we used the mixing ratio of the reference cuvette (=incoming air) for all calculations of the linear relationship between the COS uptake and the atmospheric concentration, we also took the mixing ratios of the reference cuvette to calculate Vd, as this number was more stable. As the plant cuvette air exhibited 20-40 % lower COS values due to the consumption, our actual result may underestimate Vd for COS. Hence, the final number of the global uptake might also be underestimated by roughly 20-40%. We will mention this point in a revised version in order to give the reader a better feeling of the uncertainty.

7. Clear plant effects and COS uptake scatter

We do not want to overinterpret the scatter of the COS uptake. It follows the uptake of CO2 quite well. Even the slow steady increase of the COS uptake can be also detected in the uptake of CO2. This seems to be an adaptation effect of the plant. The assimilation/respiration and the stomatal/leaf conductance exhibit a quite stable picture because of the very stable environmental conditions (light, temperature and CO2) as well as the highly sensitive measurements of CO2 and water which occurred at both, the plant and the reference cuvette simultaneously. In contrast, the COS mixing ratio was fluctuating a little bit more (for example 3-5% = 15-25 ppt in case of 500 ppt COS). Furthermore, the sampling occurred every 15 minutes and it has to be noted that for technical reasons samples from the empty reference cuvette and the plant cuvette had to be taken in succession. Hence, we regard the scatter of the COS uptake as caused by several factors, but mainly by the technical conditions of sampling which caused exchange rate calculations to be based on two successive samples to be subtracted from each other. This might be critical for a stable "base line" even under such controlled conditions. The scatter, which is visible in the standard deviations as shown in table 1, should be lower if we succeed to rearrange the automatic sampling to a simultaneous action on both cuvettes in future.

Minor points

1. Use of technical terms to be explained We apologize for any potential misunderstanding. We will explain all terms in the revised version. “Conductance” means the stomatal or leaf conductance and is a measure of the stomatal pore width. “Assimilation” is only one part of the CO2 exchange and is used to describe the uptake of CO2, whereas the term “CO2 exchange” comprises assimilation and respiration.

2. We agree and will exchange against “accordingly”.

3. We agree that the numbers might reflect a (un)certainty which is not supported by any data. We propose to leave these numbers in table 3 but shorten them to two digits in all other cases.

4. Other COS scientists in our research group. The referee seems to know our group quite well. Yes, there are other members who demonstrated their expertise on the exchange of COS. But the presented paper was part of the PhD-thesis of Lisseth Sandoval-Soto and we believe that the actual list of authors is justified.

References

Chin, M. and Davis, D. D.: Global sources and sinks of OCS and CS2 and their distribution. Global Biogeochem. Cycles. 7, 321-337, 1993.

Geng, C. M. and Mu Y. J.: Carbonyl sulfide and dimethyl sulfide exchange between lawn and the atmosphere. Journal of Geophysical Research-Atmospheres 109(D12), 2004.

Kjellstrom, E.: A three-dimensional global model study of carbonyl sulfide in the troposphere and the lower stratosphere." Journal of Atmospheric Chemistry 29(2), 151-177, 1998.

Whittaker, R.H. and Likens, G.E.: The biosphere and man. In: The Primary Productivity of the Biosphere (Helmut Lieth and Robert H. Whittaker, eds.), pp 305-328, Springer

Verlag, New York, 1975.

Interactive comment on Biogeosciences Discussions, 2, 183, 2005.