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Interactive comment on "The flux of carbonyl sulfide and carbon disulfide between the atmosphere and a spruce forest" *by* X. Xu et al.

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We appreciate Dr. Heimann's comments on the paper and feel his criticism on our extrapolation method justified. Since the purpose of the extrapolation is to estimate the global vegetation uptake of COS, it would be strict to scale up the ratio of the local COS uptake and the local NPP using the global NPP. In our original paper, however, the slope of the correlation between the COS flux (F_{COS}) and the CO_2 flux (F_{CO_2}) is used for the extrapolation. This may introduce an error in the estimation.

Treating the measured COS flux as net exchange of COS between the atmosphere and the trees seems reasonable, because soil at the site was found to be a negligible sink of COS. The error may be caused by improperly using the data of the CO_2 flux. Micrometeorological flux measurements at an above-canopy height cannot distinguish between the contribution of air-plant exchange and that of heterotrophic respiration (mainly soil emission), one of the important sources of CO_2 in the forest ecosystem.

In addition, the storage of CO_2 in the layer between the ground and the measurement height (39 m in the case of this study) may also exert an influence on the observed flux. To obtain the local NPP, contributions of both heterotrophic respiration and storage should be subtracted from the measured CO_2 flux. We followed Dr. Heimann's suggestion and tried to find a correlation between the observed nighttime CO_2 flux and local temperature. We used mean values from half-hour measurements and from individual campaigns. In both cases, however, we found no correlation between the two quantities, a result consistent with an earlier study at the site (Ibrom et al., Phys. and Chem. Earth, 21, 409-414, 1998). In view of this fact, we present in the following some theoretical considerations to give an estimate of the error caused by neglecting the heterotrophic respiration and storage contributions.

Suppose there is a linear relationship between F_{COS} and the local NPP (NPP_l), i.e.,

$$F_{COS} = bNPP_l + a, \tag{1}$$

where a and b are the intercept and slope of the correlation line, respectively. The slope b is a quantity appropriate for the extrapolation. The CO_2 flux we measured at 39 m height can be expressed as

$$F_{CO_2} = NPP_l + R_h - S, \tag{2}$$

where R_h and S are heterotrophic respiration and storage, respectively. Combining (1) and (2) gives

$$F_{COS} = bF_{CO_2} - b(R_h - S) + a. \tag{3}$$

If the variation of F_{CO_2} is independent of that of $(R_h - S)$, the contribution of $(R_h - S)$ introduces only an intercept in the F_{COS}/F_{CO_2} correlation line, without changing its slope. However, it is possible that F_{CO_2} and $(R_h - S)$ are anti-correlated with each other, e.g., due to systematic diurnal or seasonal cycles in $(R_h - S)$. We can express such anti-correlation as

$$R_h - S = -kF_{CO_2} + c \tag{4}$$

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with k and c being constants. In this case, a linear regression of F_{COS} and F_{CO_2} data may lead to

$$F_{COS} = b(1+k)F_{CO_2} - bc + a. \quad (5)$$

with $b(1+k)$ and $-ba+a$ being the slope and intercept of the regression line, respectively.

If the slope $b(1+k)$ is used for upscaling, we will have a positive bias in our estimate of global vegetation sink of COS. Therefore, the key question is whether or not F_{CO_2} was anti-correlated with $(R_h - S)$ at the Solling site during our measurements. Although we cannot answer this question directly, due to the lack of daytime $(R_h - S)$ data, the data we have suggest that there was no anti-correlation between the two quantities. As already mentioned above, the observed nighttime CO_2 flux (containing respiration and storage contributions) and local temperature are not correlated with each other, implying that enhanced temperature during the daytime and warm seasons (when $|F_{CO_2}|$ was higher) did not cause an increase of $(R_h - S)$, i.e., no coincidence between F_{CO_2} and $(R_h - S)$. We also compared daytime averages of F_{CO_2} to nighttime averages of F_{CO_2}, and found no anti-correlation between them, suggesting that the night level of $(R_h - S)$ have no influence on the daytime F_{CO_2}. This also contradicts any $F_{CO_2}/(R_h - S)$ anti-correlation.

We conclude that the slope we used for the extrapolation is not significantly different from the slope that we would have obtained after subtracting heterotrophic respiration and storage from the observed CO_2 flux. This conclusion is not necessarily applicable to other similar studies. Oppositely, influences of heterotrophic respiration and storage should always be checked before extrapolation.

In the final revised paper we address the influences of heterotrophic respiration and storage. To avoid detailed discussion in the paper, we cite Dr. Heimann's comment and this response. We did not revise any number but state in the paper that the slope we obtained can represent the ratio of the COS- and CO_2-uptake.

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