

Interactive comment on “Soil fluxes of carbonyl sulfide (COS), carbon monoxide, and carbon dioxide in a boreal forest in southern Finland” by Wu Sun et al.

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General comments:

Gas exchange processes at the atmosphere-soil interface play a key role in regulating both atmospheric chemistry and soil ecosystem. As in this paper, the exchange behaviors of three important gas species including COS, CO, and CO₂ at a representative boreal forest floor are investigated and, their potential implications are further discussed. Under the measured soil temperature and moisture ranges, soil more likely acts as a sink for COS

C1

and CO. The effects of biotic and abiotic factors on the uptake/exchange mechanism are usually closely combined under natural conditions and are difficult to be distinguished, unless the soil samples undergo specific pre-treatments (e.g., soil sterilization). The coexistence of both factors makes the analysis of uptake/exchange mechanism even more complicated. However, the results proposed in this paper, to some extent, emphasize one important point that, both the biotic processes and the abiotic processes can have crucial influences on gas uptake/exchange and their relative importance depends on the soil conditions. For clarity of the context of this paper, some more detailed elucidation and several minor corrections are further needed, as shown in the following specific comments and technical corrections.

We thank the referee for the constructive comments that helped to improve the manuscript. We have made clarifications and corrections to the issues raised here. Please see the detailed response below.

Specific comments:

Page 2, line 4: “Earth’s radiative balance”, how do the concentrations and distributions of COS and CO affect the Earth’s radiative balance? Please give an explanation for easier understanding.

We have provided examples to elaborate on this issue. COS is a precursor to the stratospheric sulfate aerosols and also a greenhouse gas (GHG), and its net radiative forcing is negative, while CO regulates concentrations of CH₄ and other GHGs through chemical reactions. See Line 5–10 on Page 2 in the revised version.

Page 2, line 14: “are geographically separated from the terrestrial sinks of

C2

COS” how do the terrestrial sinks of COS affect the COS emissions from the ocean? To what extent the plant and soil can be the sources of COS?

This statement was to emphasize that ocean emissions and terrestrial uptake are geographically separated, and merely that. Globally, leaf uptake is the dominant COS sink and there is no evidence of COS re-emission from leaves (see Line 16–17 on Page 2 in the revised version). Soil emissions of COS do exist and are treated in details in the paragraph that follows this one. But globally, the soil is still a major sink of COS second only to leaf uptake. We have made revisions in Line 21–27 on Page 2 to clarify this argument.

Page 3, line 14: “As the uptake of CO and COS is due to microbial activity” the uptake of CO and COS can also be related to physical or chemical processes (abiotic processes), it is better to add “possibly” or “partly” in front of “due to”.

We have added “mainly” before “due to”. We agree with the referee on the existence of abiotic uptake of COS and CO. However, abiotic uptake is unlikely to play a substantial role for soil COS or CO flux, as is repeatedly confirmed by sterilization and selective enzyme inhibition experiments. We have added references in Line 1–2 on Page 4 to support such claim.

Page 5, line 1: “air was sampled for 9-10 minutes” what is the gas residence time in the chamber? The sampling time period should be larger than the residence time. What is the chamber outlet position? Please provide more detailed information about the chamber configuration.

We have added these details on the chamber configuration as requested by the referee. The sampling period was indeed much larger than the residence time. See Line 12–13

C3

on Page 6 for the calculated residence time, and Line 5 on Page 6 for the chamber outlet position.

Page 5, line 15: “To prevent pressure-related flux biases, . . .” according to this sentence, a vent at the top of the chamber exists during the sampling time period, then how to keep the mass balance inside the chamber, please give a further explanation while interpreting the Eq. (1) (Page 5, line 24).

In Eq. (1) the flow rate is always the flow rate at the inlet (clarified on Line 29 on Page 6). The residual flow that is dissipated at the top vent carries the same concentration as the outlet flow, both equal to the mean headspace concentration within the chamber. Therefore, this residual flow does not affect the mass balance as long as the inlet flow rate is used in flux calculation. We have explained this on Line 19–20 on Page 6.

Page 24: For Figure 6, why the flux ratios come to a plateau at higher temperature bins? Does this ratio to some extent reflect the relative effects between biotic and abiotic processes in COS/CO fluxes? Please give explanations about the meanings/implications of the flux ratios.

The asymptote values of flux ratios may reflect the uptake to respiration sensitivity behavior of the microbial groups that are active at higher temperature. We have now devoted one paragraph to explain what this feature could mean and what its cause could be. In addition, we have acknowledge the possible influence from abiotic production. See Line 19–33 on Page 11.

Technical corrections:

Page 2, line 4: Please add “the” before “Earth’s radiative balance”.

C4

Corrected. (Line 9 on Page 2)

Page 2, line 17: Please change “over” to “from”.

This sentence has been completely rewritten to address an issue raised previously. (Line 25–27 on Page 2)

Page 2, line 30: It seems that the sentence “These phenomena have presented . . .” needs to be further edited as it reads awkwardly.

The sentence has been rewritten. (Line 4–6 on Page 3)

Page 3, line 15: Please re-edit this part of “as CO and COS are consumption processes” to make it more clear to be understood.

We have rewritten the whole sentence and the previous one to improve clarity. See Line 1–4 on Page 4.

Page 4, line 1: What does “(ibid)” mean?

It literally means “in the same reference (aforementioned)”. We have replaced it with the proper citation entry. See Line 21 on Page 4.

Page 6, line 15: Please change “in” to “of”.

Corrected. (Line 19 on Page 7)

C5

Page 7, line 7: Please add “, respectively.” after “SC2”.

Added. (Line 22 on Page 8)

Additional revisions

1. The study has received support from the NOAA contract NA13OAR4310082 (to H.C.). This funding source was accidentally missed out in the Acknowledgements in the previous version. It has now been added.
2. These parts have been improved for clarity and readability without changing the messages (unless otherwise noted in the response above):
 - Abstract
 - Introduction
 - Results
3. Due to a recent update of the plotting software `matplotlib`, the blue color on some figures may differ from the previous version. However, the figure contents remain the same unless otherwise noted in the response above.

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C6