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Atmospheric Chemistry and Physics Discussions

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Interactive Comment

Interactive comment on "Towards understanding the variability in biospheric CO_2 fluxes: using FTIR spectrometry and a chemical transport model to investigate the sources and sinks of carbonyl sulfide and its link to CO_2" *by* Y. Wang et al.

Anonymous Referee #2

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General comments:

This paper aims at getting new insight into the sources and sinks of atmospheric OCS and better understanding of the vegetation sink of CO2 using the relationship between OCS and CO2. Multiyear measurements of OCS and CO2 from three (OCS) and two (CO2) sites by ground-based FTIR spectrometers are presented and compared with results from GEOS-Chem and SiB simulations. The model results are compared with latitudinal distributions of OCS and CO2 from the HIPPO campaigns made in five

periods during 2009-2011. Sources and sinks of OCS, particularly the plant uptake of OCS, and implications for CO2 fluxes (GPP and Re) are discussed based on the comparison results.

The budget of atmospheric OCS has been studied since decades. However, estimates of OCS sources and sinks, in particular the plant uptake, vary highly from study to study. Studies show that OCS uptake by plants is controlled by photosynthesis, similar to CO2 and is a one-way process. This makes it possible to use OCS as a tracer for canopy photosynthesis and a constraint of GPP (Campbell et al., 2008; Wohlfahrt et al., 2012). By using co-located OCS and CO2 measurements together with model results, the authors of this paper show a new approach to test current understanding of sources and sinks of OCS and CO2 and to differentiate photosynthesis and respiration of CO2 based on OCS measurements. They have gained some interesting results though many questions remain. This paper is within the scope of ACP and generally well written. I recommend publication of this paper in ACP after addressing following issues.

Specific comments:

1. Atmospheric OCS has several sources and sinks, as mentioned in the paper. Untill now, the sources and sinks as well as the budget of atmospheric OCS are highly uncertain. The plant uptake of OCS is probably the most important factor driving the seasonal variation of OCS and directly related with CO2. Some studies (Xu et al., 2002; Sandoval-Soto et al., 2005; Montzka et al., 2008) indicated that this sink of OCS was significantly underestimated in previous studies like Kettle et al. (2002). Increasing this sink did reduce the differences between observed and simulated OCS concentrations. However, I think this paper relies too much on the adjustment of the vegetation sink of OCS. Only plant sink and ocean source were changed in different GEOS-Chem simulations (K2002x2, K2002x3). Other possiblities were excluded without convincing explanations. Some related studies are not referenced and considered in the discussions. High concentration and anthropogenic source of OCS were ob-

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served in some regions (e.g., Guo et al., 2010; Cheng et al., 2015). Is it possible that the anthropogenic source is underestimated? Can the large discrepancies between the observed and modeled OCS over the North Hemisphere (Fig. 3) be explained by such underestimation? The in-situ measurements (Weiss et al., 1995; Xu et al., 2001) suggested that the open ocean may only be a very small source or even a sink of OCS, particularly in the tropics. However, ocean emission in the tropical regions is increased to balance the global budget of OCS after increasing the OCS uptake by plant. Soil uptake of OCS was increased in the SiB simulation though a multi-seasonal study in a forest suggested that the soil sink of OCS accounts for only less than 1% of the OCS flux into the ecosystem (Xu et al., 2002; Steinbacher et al., 2004). I do not mean that the authors should make an extensive review. However, the published studies relevant to this work should be considered appropriately. After robust analysis you would be able to obtain a more reliable vegetation sink of OCS, which can then be used to constrain the GPP.

2. A significant vertical gradient of OCS can be caused by seasonality of sinks and source (see Campbell et al., 2008). Is it possible to compare measured and modeled vertical profiles? If so, there might be some additional information to prove or disprove the changes in the sources and sinks.

3. P26036, L12, Whelan et al. (2013) is about emission of OCS from salt marsh vegetation. Salt marsh itself is also a source not a sink of OCS. Previous studies indicate that oxic soil is a sink of OCS. However, the strength of this sink is highly uncertain but may be very small (Xu et al., 2002; Steinbacher et al., 2004).

4. P26031, L9-14, it would be better if data from same other sites can be used in this study. For example, there are also FTIR measurements of OCS and CO2 at Lauder, New Zealand (Griffith et al., 1998; https://tccon-wiki.caltech.edu/Sites/Lauder).

5. P26030, L19-22, “When interpreted by models, total column measurements are much less sensitive to assumptions on the boundary layer mixing, because every

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molecule in the atmospheric column is detected, independent of whether it is at the surface or in the upper troposphere". I feel this is a little contradictory to "The FTIR OCS retrievals are sensitive at low altitude and can capture the variations due to the biospheric processes" (P26029, L24-25).

6. P26035, L24-28, some original studies should be cited here, e.g., Protoschill-Krebs and Kesselmeier (1992), Protoschill-Krebs et al. (1996), etc.

7. P26037, L14-15, the CO2 maximum seems not to be in spring but in later winter.

8. P26037, L24-25, such preference was also found in field experiments (Xu et al., 2002).

9. P26039, L14-23 and Table 3, factors other than plant and ocean? Ocean is probably not that large source of OCS (Weiss et al., 1995; Xu et al., 2001).

10. P26040, L7-10, evenif you had included the interannual variability in the simulations, you would not be able to judge the comparison between K2002x2 and K2002x3 for each year.

11. P26041, L6-8, were these values arbitrarily chosen?

12. P26041, L20-21, I think this statement is a little rash (see comments 1).

13. P26042, L10-11, can you prove this?

14. P26042, L18, "The plant uptake of K2002"? K2002x2 or K2002x3?

15. P26043, L16, "in Fig.6" or in Fig. 5?

16. P26045, L4-7, does this mean that we would not abtain a better estimate of GPP from OCS simulation than directly from the CO2 simulation?

17. P26045, L21, ". . .in SiB simulation". ". . .in SiB simulation of OCS"?

18. P26046, L 16, a missing source is possible, but I do not think an overestimate of a sink is excluded without critical review.

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