Global Optimal Estimation Retrievals of Atmospheric Carbonyl Sulfide Over Water from IASI Measurement Spectra for 2018

Response to Reviewers' Comments v2

We thank the editor and other reviewer for taking the time to evaluate our manuscript. Please find the comments reproduced below in *italics*, followed by '>>' and our responses.

Editor

1) *Fig. 4: The description of the curves in the figure caption is incomplete and confusing. As I understand, the averaging kernels labeled with 0.0 km (purple lines) belong to 0 to 4 km, the ones labeled with 5 km (blue lines) belong to 5 to 9 km, and so on. This must be explained in more detail. Further, what is the black line? tc_ak in the legend is not explained. Finally, the red line that does not seem to belong to the averaging kernel ensembles needs to be explained as well.*

>> Thank you for this comment. We have improved the readability and information content of the caption. In addition, some minor changes have been made to the plot to make it clearer; now the 50 km averaging kernel is identified in grey specifically. The total column averaging kernel (tc_ak) is described in the text, which has been edited, see lines highlighted throughout comments 2) and 3).

2) *line 320/21: "Additionally, a small amount of additional information is obtained in the upper troposphere and lower stratosphere between around 17 and 22 km." Do I understand correctly that these are the averaging kernels belonging to 30 km and above (red curves) that peak at around 20 km? This means the information is vertically displaced. That should be mentioned in the text.*

>> Thank you. That is correct. We have addressed this and re-written the text around lines 311-328, including clarification on the vertical displacement.

3) *line 321/22: the same comment refers to the averaging kernel of the 31 to 50 km layer, whatever this curve might be.*

>> Please see the two comments above. We believe this has been appropriately addressed, both in terms of clarity in the plot and caption, and then with suitable discussion in the text.

4) *line 338: "Fig. S3": I think you mean Fig. S1*

>> No. Updates have been made to the supplementary material, in response to Reviewer 2's second point: *"Lines 202-205: Rather than talking about the fact that the signal due to background OCS is above noise level, it would be more useful to say how big of an OCS variation would yield a detectable signal by IASI."*. We include two plots in the supplementary material to address this: Figures S1 and S2. As this discussion comes first in the text, it seemed appropriate to put them at the start of the supplement. Therefore, the figure being referenced here has moved to Figure S3.

5) *Fig.7: This figure would be much improved by including isolines or by a colour scales that allows to identify the numbers more clearly. This applies in particular to the percentage errors in the lower row.*

>> Thank you for this great suggestion, particularly the isolines. We have amended the range on the colourbar for both sets of plots, to improve visibility. As the % error is still quite homogeneous globally, we have included isolines for this set (bottom). We were reluctant to include isolines on the total column error (top) also, as it would not align with all other contour plots in the manuscript (and supplement) that do not include isolines.

6) *line 374/375: "OCS_OCE total column data were filtered to remove outliers, namely DOFS<0.6, normalised $\chi 2>7$, or a total column error > 4.0×10^{15} molecules cm^{-2} (~30-40 % error). " Please explain where these criteria come from and by which method they were defined.*

>> Thank you for the comment. Additional information regarding these filters has been added in the first paragraph of Section 3.2, now lines 380-388. Our goal was to remove the far edge of some of the data anomalies, both in terms of retrieval characteristics (DOFS and χ^2) and also in terms of unrealistic errors, for quality control purposes. As mentioned in the text, our goal is to present the data as a global climatology, rather than a means to specifically identify precise hotspots of OCS (or coldspots, so to speak) - though we do touch on some OCS enhancements in the manuscript. To retrieve a total of 159 million pixels overall. Cloudy scenes and swath edges are removed, leaving 134 million pixels. Then the filters highlighted here remove a further 2 million (~1.8%), to 132 million. As the data analysis presented in the manuscript utilises 132 million data points, these filters do not impact the data significantly and remove only outliers in terms of retrieval characterisation, OCS concentration/error.

7) *Fig. 8: Please could you comment if you consider the pronounced maxima around the Hudson Bay/Canada in Jan and Feb to be real features, or artefacts, or covered by the uncertainties of the data?*

>> Thank you for mentioning this feature. Around lines 470, there is a discussion about the rather 'noisy' standard deviation and retrieval error in this region. A new clarifying sentence has been added to the end of this paragraph, on lines 475-477: "This likely indicates that the elevated OCS_{OCE} values in the Hudson Bay area in Figure 8 (January-February) are retrieval artefacts, rather than real enhancements, driven by surface characteristics and retrieval limitations.". A study by Richards et al. (1994) looked at seasonality of biogenic sulfur species concentration in ponds and lakes in this area. But unlikely to account for such a large spike in OCS (both in concentration and spatial extent). For now we suspect it is likely a retrieval artefact.

References

Richards, S. R., J. W. M. Rudd, and C. A. Kelly. 1994. 'Organic Volatile Sulfur in Lakes Ranging in Sulfate and Dissolved Salt Concentration over Five Orders of Magnitude'. *Limnology and Oceanography* 39 (3): 562–72. https://doi.org/10.4319/lo.1994.39.3.0562.