Atmospheric Chemistry and Physics Discussions

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Comment on acp-2021-294

Anonymous Referee #1

Referee comment on "A sulfur dioxide Covariance-Based Retrieval Algorithm (COBRA): application to TROPOMI reveals new emission sources" by Nicolas Theys et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-294-RC1, 2021

In this manuscript, the authors report on the first application of COBRA, a new algorithm to the retrieval of SO_2 columns from measurements of the TROPOMI instrument. The algorithm is briefly explained and results for a full year of data are compared to columns from existing algorithms for SO_2 retrievals (DOAS, PCA). The performance of the new algorithm is further demonstrated by a comparison to modelled SO_2 fields (CAMS regional) and MAX-DOAS measurements in two locations. Long-term averages of the new SO_2 product are shown together with existing SO_2 source lists and emission estimates based on the new data are compared to those based on the operational product. Finally, an example is shown for a multi-source emission estimate of a weak source.

The topic of the manuscript fits into the scope of ACP although, in my opinion, it would have been a better match for AMT. The article is clearly structured and well written, the algorithm described and the nice results shown a clear improvement over existing data and certainly worth reporting, and overall, I have only minor comments and suggestions. The only general point I would like to make is, that this being the first report of the method, a more detailed discussion of the implementation and the tests performed would be appropriate.

Page 3, line 21: Not sure, if TROPOMI is the first mission with a tropospheric focus – I guess instruments like OMI, MOPITT or TES could also be seen as having this focus.

Page 6, line 18: Maybe that is obvious, but can you please explain a bit more, what the difference is between the uncertainty in the SO_2 free spectrum and the measurement noise? Isn't in your method measurement noise one of the contributions to ε_{bg}?

Page 7, line 5: Can you please elaborate on how equation 6 follows from equation 5?

Page 7, line 25: How is wavelength calibration being dealt with in your method? Is there any analogue to shift and squeeze or are you assuming that wavelength calibration and stability of the spectra is so good that this is not needed?

Page 8, line 17: As this is the first report of an application of COBRA on UV/vis data, it would be good to add some discussion on the results of your tests and justification for the choice of parameters.

Page 9, line 1: The need for SO_2 free spectra in each orbit, row, and latitude segment can be an important limitation of this method in the case of volcanic SO_2 plumes reaching the stratosphere. Please add some discussion on this point here, including some numbers on how many measurements you had to skip in your data set because of this constraint.

Page 10, line 13: Was the background correction applied by row? If so, why do we see the low-frequency variations in the results? If not, why not?

Figure 2: To make this a bit more quantitative, it would be good to add scatter plots between the different existing products and the new COBRA data.

Page 15, line 16: is likely not reflecting => is likely reflecting

Figure 5: It would be interesting to add similar figures for the operational DOAS product, maybe in the supplement

Page 19, line 1: I could not find any link or other means to access this file

Figure 7: What does the size of the markers in the left panel stand for?

Figure 7: On which of the two emission estimates is the size of the marker in the right panel based on?

Page 28, line 14: "fairly consistent" – this is a vague formulation! Why not check if the values agree within their reported uncertainties? Why not add error bars to the left panel of Figure 7? It is an interesting piece of information for users of the existing emission values whether they are still valid (within their uncertainties) or if numbers will change with the new product. If the latter is the case, this would warrant some discussion.

Page 28, line 18: For some of the emission estimates, COBRA has smaller ratios. Have checked why?

Page 29, line 17: I agree that this indicates that COBRA is good in exploiting the gain in spatial resolution provided by TROPOMI; if it is optimal in doing so I wouldn’t know.