

Atmos. Meas. Tech. Discuss., referee comment RC1  
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## Comment on amt-2022-148

Anonymous Referee #1

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Referee comment on "Improved retrieval of SO<sub>2</sub> plume height from TROPOMI using an iterative Covariance-Based Retrieval Algorithm" by Nicolas Theys et al., Atmos. Meas. Tech. Discuss., <https://doi.org/10.5194/amt-2022-148-RC1>, 2022

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### **Review of the manuscript "Improved retrieval of SO<sub>2</sub> plume height from TROPOMI using an iterative Covariance-Based Retrieval Algorithm" by They et al.**

The manuscript presents a new and appealing method to retrieve the SO<sub>2</sub> plume height from TROPOMI UV measurements even for low SO<sub>2</sub> VCDs. The paper is very well written and I suggest publication after minor revision.

The suggested covariance-based method is an extension of the existing COBRA algorithm that has been developed by the authors to retrieve the SO<sub>2</sub> SCD from TROPOMI measurements and uses a method that was so far only used for IASI SO<sub>2</sub> retrievals. It allows for the retrieval of SO<sub>2</sub> LH even for SO<sub>2</sub> VCDs as low as 5DU with a precision better than 2km.

I have only a few minor points, which I would like the authors to address in a revision of the manuscript:

Sect. 2.1:

- You are using the Bogumil et al 2003 SO<sub>2</sub> cross-section for LIDORT. Have you considered using improved SO<sub>2</sub> XS by Birk et al from the ESA IAS SEOM project?
- Since you apply an I<sub>0</sub> correction to the SO<sub>2</sub> cross-section, please mention which value you have used. Could you give numbers of how strong the effect is when (not) using the I<sub>0</sub> correction? Does it have an effect for low SO<sub>2</sub> VCDs?
- Since you are using LIDORT to calculate SO<sub>2</sub> OD spectra, why do you also take into account O<sub>3</sub> absorption? Maybe I am missing something here, but you are only interested in SO<sub>2</sub> OD spectra itself, right?

Table 1:

- Is there a reason why you have chosen a coarser SO<sub>2</sub> LH grid at high altitude for generating your LUT? What is the effect when using a finer grid?
- Is there a reason why you only extend the LH grid until 25km and not higher, e.g. up to 30km?
- At the nadir point of the TROPOMI swath, the RAA shows a strong jump by up to 90° from one pixel to the neighboring pixel along the scanline. Does this cause problems/jumps in the retrieved SO<sub>2</sub> LH/VCD between pixels in the center of the swath since the OD is interpolated at strongly different RAAs?

Sect 2.2: When you construct the covariance matrix  $S$ , how is the whole retrieval affected by clouds? In detail, when the SO<sub>2</sub>-free spectra contain a huge number of cloudy pixels, whereas the retrieved SO<sub>2</sub> pixels are cloud-free (or vice-versa), is the covariance matrix still well-posed? The same applies to ash clouds in the SO<sub>2</sub>-free pixels used to construct  $S$ . For these cases I would like to see some more discussion on the effect of the SO<sub>2</sub> LH/VCD retrieval, if possible

Technical corrections:

Sect. 3.1, Acknowledgements and Reference sections show some strange bold uppercase 'K' letters (at least in my pdf viewer). Please correct

Reference to Koukouli et al 2021 is officially published: Atmos. Chem. Phys., 22, 5665–5683, 2022, <https://doi.org/10.5194/acp-22-5665-2022>. Please update the reference