Atmospheric Measurement Techniques Discussions

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

Anonymous Referee #1

Referee comment on "Improved retrieval of $SO_2$ 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

**Review of the manuscript "Improved retrieval of SO2 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 SO2 plume height from TROPOMI UV measurements even for low SO2 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 SO2 SCD from TROPOMI measurements and uses a method that was so far only used for IASI SO2 retrievals. It allows for the retrieval of SO2 LH even for SO2 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 SO2 cross-section for LIDORT. Have you considered using improved SO2 XS by Birk et al from the ESA IAS SEOM project?
- Since you apply an I0 correction to the SO2 cross-section, please mention which value you have used. Could you give numbers of how strong the effect is when (not) using the I0 correction? Does it have an effect for low SO2 VCDs?
- Since you are using LIDORT to calculate SO2 OD spectra, why do you also take into account O3 absorption? Maybe I am missing something here, but you are only interested in SO2 OD spectra itself, right?

Table 1:

- Is there a reason why you have chosen a coarser SO2 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 SO2 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 SO2-free spectra contain a huge number of cloudy pixels, whereas the retrieved SO2 pixels are cloud-free (or vice-versa), is the covariance matrix still well-posed? The same applies to ash clouds in the SO2-free pixels used to construct S. For these cases I would like to see some more discussion on the effect of the SO2 LH/VCD retrieval, if possible

Technical corrections:

Sect. 3.1, Acknowlegdements 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