We appreciate Referee #2's positive comments and careful review, which improves the paper. Below, Referee's comments are in blue and our responses in black.

In this paper, the authors describe in a very comprehensive way the algorithm applied to DSCOVR observations to retrieve O3 and SO2 (for large volcanic eruptions) vertical columns using a direct-fitting approach.

The level of description of the algorithm is very high and unusual for publications, with the authors providing the basics of all involved processes in such a remote sensing application. Although this makes the paper quite long and perhaps not fully consistent with the editorial line, I find such papers useful for readers with less experience in the field.

The described algorithm itself is mature and provide high quality results and the derived retrievals are well characterized with solid error estimates. As the topic suits well AMT and I don't have major issues, I would recommend publication after the minor and technical corrections below have been considered.

Minor comments:

P. 9 lines 4-5: This statement is not clear to me. I understand that cloud/aerosol-free pixels have low LERs but why selecting such clean pixels only would remove the high VZA observations? Is the selection based on the LER values themselves or on independent cloud parameters?

Response:

From a polar-orbiting platform, a location on Earth may be observed with different VZAs (typically ranging from 0 to ~70 degrees) and a narrow range (~10 degrees) of SZAs during a calendar month. Since the reflectance of most natural surfaces increases with higher VZAs (e.g., see Coulson, 1966, Effects of Reflection Properties of Natural Surfaces in Aerial Reconnaissance, Appl. Opt. 5, 905-917, DOI: 10.1364/AO.5.000905) and furthermore IFOVs with higher VZAs (i.e., bigger footprint size) are more likely contaminated by clouds or aerosols, minimal LER selection tends to exclude observations with high VZAs.

Fig. 4b: How are those GLER values computed? Are they based on the Cox-Munk BRDF as well? The figure shows VZA dependences for low SZA but for EPIC, the SZA increases simultaneously with VZA. What's the influence of the SZA on GLER?

Response:

GLERs are inverted using Eq. (6) from simulated TOA radiances of a molecular atmosphere over a BRDF (Cox-Munk) surface.
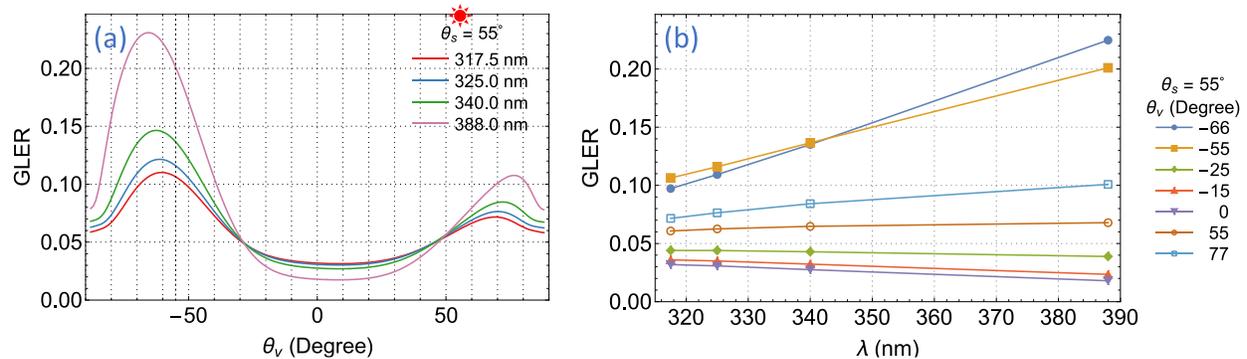
Figure AC2: Similar to figure Fig. 4 of the manuscript, except the Sun at a higher zenith angle

The effect of a high SZA on GLER is illustrated in Figure AC2, which displays the GLERs for a high SZA (θ_s=55°). From the L1 point, EPIC does not observe from the directions close to specular reflections for high SZAs, while near the backward scattering directions, the GLERs are slightly elevated for high SZAs. In short, significantly elevated GLERs over water surfaces are not observed for high SZAs from EPIC. Figure R1(b) shows that the linear extrapolation of GLER at longer wavelengths yields highly accurate GLER estimations at shorter wavelengths for high SZAs.

Fig. 7 and P. 11 line 24: please specify which data base is used.

Response:

As described in the manuscript, the ice GLERs are constructed from Aura OMI and SNPP OMPS. We created this ice GLER climatology for use as a reference to calibrate reflective UV bands of polar-orbiting instruments (like NOAA-20 OMPS and S5P TROPOMI) and monitor their performances over time. The sample results in the manuscript are intended to illustrate that ice reflectivity is significantly anisotropic. We have not published this database, but we would share this ice GLER climatology with a reader who contacts the authors directly.

Fig. 10: the use of % is confusing here. Does it mean that what's plotted here is (I_RRS-I_ELA)/I_ELA X 100? If yes, please clarify. Otherwise, don't use %

Response:

We put in the figure caption $\varrho = \frac{I_{RRS} - I_{ELA}}{I_{ELA}} \times 100$.

P. 21 line 7-8: please explicit the granularity of the climatology.

Response:

Description changed to: In short, M2TCO3 better captures the dynamical changes and spatiotemporal variations in O_3 profiles with higher resolutions in total O_3 column (25 DU), latitude (10°) and time (monthly).

Figure 15: Please comment on the large differences at high SZAs (edge of the disc)

Response:

Several versions of EPIC L1B data have been released since the launch of DSCOVR EPIC. The O_3 differences exhibited systematic changes in the interior of the disc between different L1B versions. However, near the disk edge, O_3 differences displayed large changes and even had sign reversion with calibration changes. Hence, the large differences near the edge of the disc are likely due to large discrepancies between measured and modeled radiances, given that higher calibration uncertainties of the edge pixels (see Cede et al., 2021, Raw EPIC Data Calibration, https://doi.org/10.3389/frsen.2021.702275) and large modeling errors at high zenith angles. Furthermore, retrievals from observations with large zenith angles (VZAs and/or SZAs) have considerably higher uncertainties due to enhanced sensitivities to other error sources (see the error analysis section), contributing to the large O_3 differences near the disc edge shown in Figure 15.

Algorithm 1/2 tables: Those tables are very useful. I think having flowcharts would be even nicer (keeping all references to Equations). Please consider doing this. Add also references to used data bases (minimum LER, cloud and snow parameters, O3/T° profiles).

Response:

We create flowcharts for O_3 and SO_2 retrievals, including references to L1, L2, ancillary, and climatological data used in making the L2 O3SO3AI product.

SO2 flagging: P. 33 line 33 and P. 341: it is not clear to me how "the vicinity outside the Delta_omega contour" and "adjacent areas" are defined. Please be more specific. Also I don't understand what is the reference value to draw the omega_1 contour, which is said to be taken between omega_min and omega_max. What does it mean? Do you take the mean of the two values or any other value?

Response:

We thank reviewer #2 for pointing out this unclear description.

After finding the $\Delta\Omega$ contour, we define an imaging region that covers the $\Delta\Omega$ contour. This rectangle region is formed by extending +/- 150 pixels from the contour, sufficiently large to cover volcanic plumes completely. Next, contour mapping of Ω_1 is performed to find the area of SO_2 enhancements within the rectangle region, accomplished by stepping through the contour values from Ω_{max} to Ω_{min} to find the Ω value that yields the longest closed contour.

We have rewritten this part to describe the flagging procedure concisely and accurately.

P. 34 line 6: what is the justification to take as initial SO2 value the difference between two O3 columns (omega_1 and omega_2)

Response:

Based on the values of O_3 and SO_2 absorption cross-sections, one DU of SO_2 would cause 2 DU Ω_1 and 0.7 DU Ω_2 enhancements. Thus $\Delta\Omega=\Omega_1-\Omega_2$ is about 1.3 Ξ (i.e., $\Xi = \Delta\Omega/1.3$). This estimate is accurate when the measurement sensitivities are the same for total O_3 and SO_2. But in general, they are different, with SO_2 sensitivity usually being lower than that of total O_3. In other words, one DU of Ξ causes $\Delta\Omega$ that is less than 1.3 Ξ. For simplicity, $\Xi= \Delta\Omega$ is used as initial estimate, since the retrieved Ξ is minimally affected by this initial estimate, as a loose constraint (i.e., SO_2 variance = Ξ^2) is imposed. The retrieved Ξ is primarily determined by the radiance measurements.

P. 40 line 30: I don't think this is true that profile errors systematically increase for bright surfaces. In case of bright surfaces at ground level, the AK will be closer to 1 instead of having a strong decrease in sensitivity. So AKs will be much less altitude-dependent and errors due to the profile shape may be reduced.

Response:

We thank the reviewer for pointing the incorrect statement. We have added AKs in Figure 18 for a high reflectivity surface, showing AKs moving closer to 1 for high zenith angles and exceeding 1 in the troposphere for low zenith angles. These results imply that errors due to the profile shape decrease for high zenith angles and can change signs at low angles. In general, retrieval errors are reduced for high reflectivity surfaces. We have revised the manuscript to correct the incorrect description.

Error estimates: It would be beneficial to add up all error terms to have an estimate of the typical total errors. Of course, respective contributions vary significantly depending on the observation and geophysical conditions but I would suggest attempting to provide such total error estimates for (1) favourable (e.g. no cloud/aerosol, low angles (2) difficult conditions (high angles, aerosols).

Response:

We have added as a subsection to summarize the error estimates.

Technical corrections :

P. 1 line 18 : remove 'the' in 'located the between'

Done

P. 2 line 21 : add Metop-C

Metop-C added.

P. 2 line 29 : 'an LEO' --> 'a LEO'

Corrected.

P. 5 line 22 : define μ

In the manuscript, it was defined using $\theta_v = \cos^{-1}(\mu)$. Revised to $\mu=\cos(\theta_v)$

P. 14 line 2 : 'is a smooth' --> 'in a smooth' ?

The statement is rewritten as follows:

The change in I_{TOA} due to the addition of aerosols and hence the cloud fraction (f_c) are smooth in wavelength.

P. 21 line 19 : should 'n' be 'p' instead for the number of e_k according Eq. 12 ?

'n' is replaced with 'p'.

P. 21 line 33 : O3 'climatology' instead of 'climatolgoy'

Corrected

P. 22 line 27 : suppress repetition of 'the'

Done

P. 24 line 16 : suppress repetition of 'the'

Done

P. 24 line 23: remove 'for as applicable'

Done

P. 24 line 25 : add Lerot et al., 2014

Reference added

P. 27 line 26 : close bracket after 'section 2.3'

Done

P. 36 line 12 : 'represent' instead of 'represents'

Corrected

Fig 23 : Expand the Y scale for the O3 differences to increase the readibility (+/- 15% instead of 30%)

Figure re-plotted with updated range ((+/- 15%).

P. 50 line 5 : rephrase the 'in this ATBD' in 'in this paper'

Done

P. 50 line 21 : 'laodings' --> 'loadings'

 Corrected