Referee #1

We would like to thank Reviewer 1 for his/her helpful comments which improved the quality of the manuscript. Our responses to the reviewer are listed below, the reviewer comments in italic and our response in regular font.

I have combined the scientific/major comments with some wording suggestions below. The work is certainly publishable after addressing some of the revisions, but I feel the method can be improved (see below) and wonder if improved results would follow.

L166: "h_n= the normalization tangent height = 40.5 km" -> "h_n, namely the normalization tangent height, set to a value of 40.5 km"

Done

L169: Similar -> Analogous

Done

L182-185: This is more constrained, not relaxed, on the low end (0.333 vs 0.2). Is "0.2" a typo?

The 1/3 value is an error, and has been corrected to 0.2 (same as the value used in the V1 algorithm).

L201: This is my first major criticism: stopping the retrieval based on convergence at one height is a mistake. This will mean poor low accuracy particularly below this tangent height but even at altitudes at/above this tangent height.

We understand the reviewer's concern and we are already planning on modifying the algorithm to check for convergence for all altitudes of the main aerosol layer, which will be released next year as Version 2.1. However, our analysis indicates that this change will have a limited impact on the retrieved aerosol profiles, mostly affecting the shorter wavelengths (675 nm or less), and only in the tropics in the aftermath of large aerosol enhancements such as volcanic eruptions, when it converges after 3 iterations. We have revised the sentence and it reads as "Iterations end when the retrieved aerosol extinction changes by < 2% at 20 km or when it reaches maximum number of iterations. The planned V2.1 release next year will use modified convergence criteria that checks for multiple altitudes."

L227: "it" is not defined

We replaced "it" with "the retrieval"

L235: "by" -> "caused by"

Done

L236: Sect 3.1 should state something more about SAGE III cloud detection if SAGE III data have been filtered for clouds in this paper. This becomes relevant with the statement at L395.

The cloud screening of all instruments is addressed in section 4. We have modified the text in L299 to add more details to the cloud clearing process. The text now reads "SAGE III is filtered for cloud contamination by using only data with extinction ratio at 510 nm / 1022 nm greater than 2 (Thomason and Vernier, 2013)"

L258: Regarding "retrieve extinction", CALIPSO does not really retrieve extinction.

We replaced "retrieve" with "obtain"

L261: retrieve -> obtain'

Done

L269: 30km -> 30 km (see also L344, L468)

Done

L281: Where -> where

Done

L288: What is a "cloud type flag" and how is this determined?

We have added the following text to explain the cloud types and how it is determined: "Cloud type classifies the identified cloud as cloud, enhanced aerosol, or PSC. The "enhanced aerosol" definition requires the cloud altitude to be at least 1.5 km above the tropopause. The "PSC" definition requires the cloud altitude to be at least 4 km above the tropopause, and the ancillary temperature at the cloud altitude to be less than 200 K."

L305: "negative 1%" -> "-1% per degree"

Done

L305: Why is "Junge" italicized?

"Junge" is changed to "Junge"

L306: "in the northern hemisphere high latitude"-> "at northern high latitudes"

Done

Figure 3: Why is there a wavelength dependence to this error? The wavelength dependence is obvious at 16.5 km. Are all months included here? Without doing any calculations, it seems that there should be some larger scattering angle differences when the sun is low (winter) for 60-70 degrees N. Why is the sign of the SSA dependence of the aerosol extinction difference changing (y-axis) between 25 and 16 km? I wonder if specifying the convergence criterion only at 20 km (see comment above) is partly responsible for the lack of SSA dependence at 20 km, while there is an obvious dependence at 25 and 16.5 km.

Wavelength dependence of this error is generally expected since the different wavelengths have different sensitivity to aerosol particle size (Reiger et al., 2014).
As we explained in the text (L304 – L306), because of the spacecraft orbit, these measurements only take place at high latitudes during the summer of both hemispheres. OMPS LP observations at high latitudes during the winter are mostly in the dark.
We are confident that the convergence criteria have no effect on the analysis shown in Figure 3, since these analyses were made in the NH for a period not affected by any volcanic perturbations (see our comment above). The aerosol differences seen at 16 and 25 km are largely driven the uncertainty in the assumed aerosol model. Lack of SSA dependence at 20 km means that the a-priori aerosol model used in the retrieval is more representative of the measured aerosol at 20 km. Similar pattern, albeit with larger difference, was found in V1.0 retrieval algorithm that used bimodal aerosol size model and different convergence criteria (see section 2.2.1). The retrieved aerosol extinction dependencies on the SSA were subsequently reduced in V1.5, which indicates that the gamma distribution ASD used in V1.5 is more accurate than the bi-modal ASD used in V1.0 (see figure 1 below). Similar pattern was also seen by Rieger et al. (2019).
We have also added the following text “The main assumption is that, if the retrieved aerosol values are different when the instrument is measuring the same air mass but with different scattering angle, then there is an error in the assumed phase function and ASD model. As shown by Rieger et al. (2019), the ASD errors can introduce seasonal variations that correlate well with the SSA.” We also added “Similar analyses made by Rieger et al. (2019) have shown that the OSIRS V7.0 aerosol extinction SSA dependence is 0.5% per degree.”

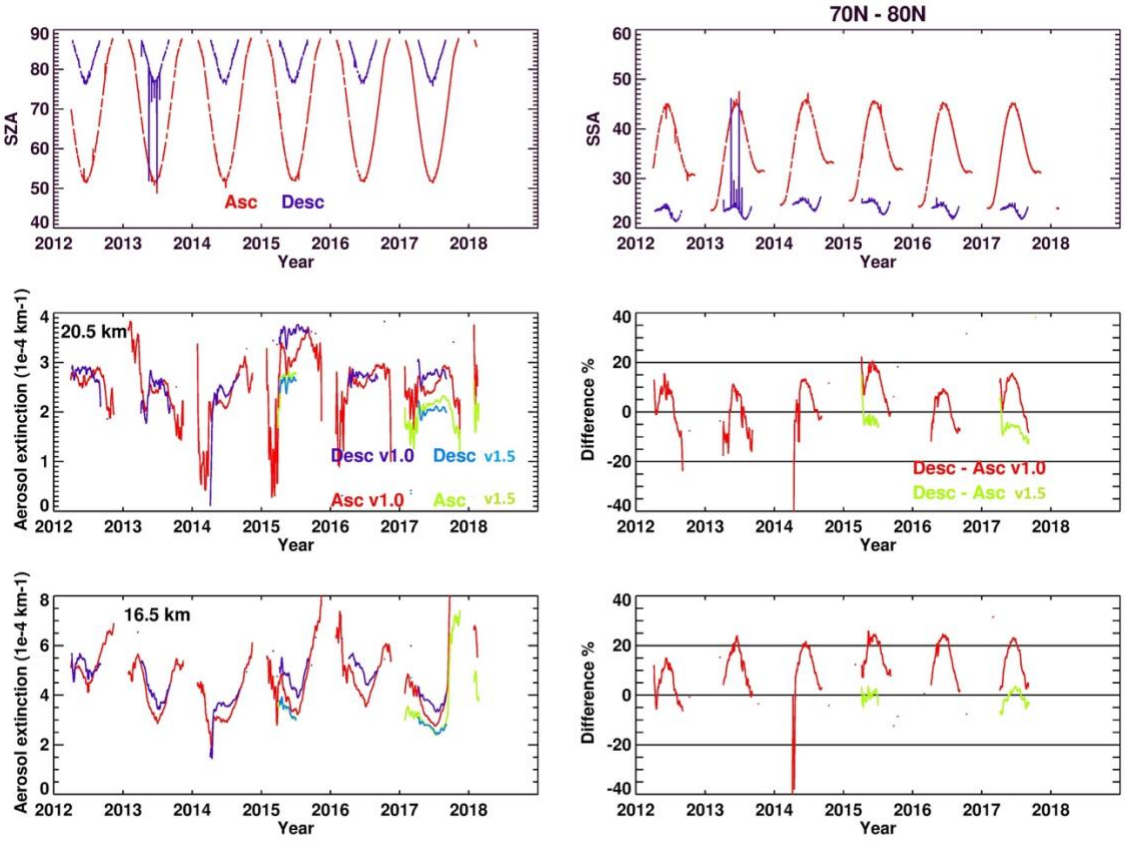

Figure 1: (left panel) top row shows daily average solar zenith angles (SZA) and SSA of the ascending and descending measurements from 70° N to 80° N. Red and green are for ascending v1.0, v1.5 respectively, while dark and light blue are for descending v1.0 and v1.5 respectively. The left side of the middle and bottom rows shows the retrieved aerosol extinction at 20.5 and 16.5 km, while the right side is the difference between the two measurements at the same altitudes. Red is v1.0 and green is v1.5.

L316: Since at L290, the authors inform us that clouds are being removed, any differences in aerosol extinction between low and high R are therefore not expected differences in extinction due to cirrus, but rather point to cirrus being missed by the cloud flagging. I suppose this is difficult to avoid in the tropical tropopause region.

That is correct. It is either cloud being missed or incomplete cloud clearing.

L322: Do the authors believe that the larger R (effective scene reflectivity) at higher latitudes is real or an artifact of the retrieval? If it is real, R should have a seasonal dependence, being higher in winter when there is snow covering the land at northern high latitudes.

That is correct, we do see seasonal dependence of *R* being higher in the winter, and lower during the summer, although it is nowhere as low in the tropics. We have revised the sentence and it now reads “Outside the tropics, *R* mean value is generally greater

than 0.3, with strong seasonal dependence that peaks in the winter. Therefore, any observed differences outside the tropics are uncorrelated with cloud presence."

Figure 4: This figure can be improved since the contours also look like dashed lines in certain spots.

Done

L337: wavelength 869 -> 869

Done

L343: Delete "wavelengths"

Done

L344: Lack of sensitivity does not necessarily result in bias, in should result in larger noise. Can the authors say anything insightful about the bias (e.g. the sign of the bias)?

We agree with the reviewer that this sentence is not accurate. The accuracy of the 510 nm is discussed in more details in section 5.2, figure 12, which shows OMPS 510 nm exhibiting periodic jumps in the aerosol extinction value. This is caused by the algorithm's reduced accuracy when the measurement vector is very small. We have now replaced this sentence with "This is an artifact in OMPS retrieval algorithm, which often results in noisy and large extinction values when the measurement vector is too small (see Figure 12)."

Figure 6: It seems a bit odd that the aerosol extinction bias relative to SAGE is higher at 600 nm than 510 nm for low latitudes at/below 18 km?

This is most likely caused by the ozone contamination for both OMPS and SAGE retrievals at this wavelength. We have added the following text "This is due to the ozone interreference in both OMPS and SAGE III 600 nm aerosol retrievals."

Figure 6: The retrieval clearly has a systematic error in the southern hemisphere. The behavior in the northern mid-latitudes is what one would expect and hope for....

We disagree with the reviewer. While this is true for the shorter wavelengths (675 or less), the longer wavelengths have strong sensitivity to aerosol, even in the SH (see section 2.2.2). Figures 5, 7, and 9, also show the longer wavelengths agreement with SAGE III is mostly within 10% for most altitudes.

L359: of -> to

Done

L369: 10% is a bit optimistic, particularly at 30 km. Could "~10%" be written instead?

Done

L374: instruments -> instruments'

Done

L388: This sentence is unclear. The authors imply that the difference would be even less than 20% if the ASD model varied in space/time. This seems a bit speculative (i.e. unsupported).

We deleted the sentence.

Figure 9: This figure is very convincing of the high quality of the OMPS aerosol extinction profile product.

We are glad that the reviewer shares our assessment of the high quality of the V2.0 OMPS LP aerosol. Figure 9 clearly support the argument made above, that the V2.0 longer wavelengths are of good quality in the SH.

L405: Regarding "corrections", does this need to be plural?

We changed it to correction.

L411: "Angstrom" -> "an Angstrom"

Done

L434: "measurement" -> "magnitude of the measurement"

Done

L439: "in general" -> ", in general,"

Done

L439: is -> are

Done

L441: "rather" -> "a rather"

Done

L445: "different" -> "a different"

Done

L455: shown -> show

Done

L470: rage -> range

Done

L482: Add “in the stratosphere”

Done

L490: Remove “multiple”

Done

References

Rieger, L. A., Bourassa, A. E., and Degenstein, D. A.: Stratospheric aerosol particle size information in Odin-OSIRIS limb scatter spectra, Atmos. Meas. Tech., 7, 507–522, https://doi.org/10.5194/amt-7-507-2014, 2014.

Rieger, L. A., Zawada, D. J., Bourassa, A. E., and Degenstein, D. A.: A multi-wavelength retrieval approach for improved OSIRIS aerosol extinction retrievals, J. Geophys. Res.-Atmos., 124, https://doi.org/10.1029/2018JD029897, 2019.

Thomason, L. W. and Vernier, J.-P.: Improved SAGE II cloud/aerosol categorization and observations of the Asian tropopause aerosol layer: 1989–2005, Atmos. Chem. Phys., 13, 4605–4616, https://doi.org/10.5194/acp-13-4605-2013, 2013.