Response to Interactive comments from Referee #3 on: “AerGOM, an improved algorithm for stratospheric aerosol retrieval from GOMOS observations. Part 2: Intercomparisons” by C. E. Robert

We would like to thank referee #3 for the useful comments made regarding the manuscript.

Text legend:

Referee comment
Author reply
Author addition to the original manuscript

1. Major comments

1.1 The paper title clearly states that the analysis presented are for data Intercomparisons not validation. I suggest that the authors provide a proper validation and discussions of the observed biases and data quality rather than just present data Intercomparisons. To do so, they need to use officially released and validated correlative measurements, and expand on the discussion, mainly in section 5. Furthermore, its not clear to the user what is the AerGOM end product, is it aerosol extinction at selected wavelengths or fitting parameters or both.

We used intercomparison because, as explained in the text, it is difficult to find data with which one can validate this dataset, although it is not impossible. There is the plan to write a manuscript in the near-future within the scope of the Aerosol_CCI project (that uses the current AerGOM dataset for the stratosphere) that will at least partly focus on the validation of the AerGOM/stratospheric Aerosol_CCI Level 3 dataset using lidar observations and balloon-borne measurements. This will be done with colleagues who are well versed in these techniques and can perform proper validations.

The closest to what we can find to a properly validated dataset derived from satellite instruments are SAGE II, SAGE III and OSIRIS datasets. The SAGE instruments have been used extensively, and OSIRIS agreement with SAGE III measurements at 750 nm is excellent and provides a better coverage. Therefore, we improved Section 5 of the manuscript by putting more emphasis on the known accuracy and precision of these measurements and discussed the results of the AerGOM intercomparisons with more reference to the literature available. We also provide more tentative explanation of the difference observed between the various datasets and AerGOM, and come up with possible ways to improve the dataset in the future.

Concerning the AerGOM end product, see 2.2 below.

2. Specific comments

2.1 Abstract: Abstract should include summary of key findings.

The abstract has been improved to include a summary of the important findings.

2.2 Section 2: The authors need to describe the new data product format and retrieved aerosol wavelengths, if any.

As there is not yet an official dataset available, the format is not yet fixed, although it will probably be netCDF. To clarify what is retrieved, I added a paragraph to section 2.2: *Given that the aerosol spectral law chosen for the AerGOM processing is of degree N, the AerGOM data product consists of extinction values at N + 1 wavelengths, but can be interpolated at other wavelengths using equations 2 and 3. The data used for the current work is based on a quadratic polynomial in inverse wavelength, with 350 nm, 550 nm, and 750 nm set as reference wavelengths.*

2.3 Section 2.3, p5: "These profiles are easy to identify and were discarded for the inter-comparisons of this paper", is it also valid for section 6?

Yes, no anomalous profiles have been included in the analysis of section 6. We also added more information on anomalous profiles in section 2.3 (at the request of another referee): *The reason for the retrieval of such profiles by AerGOM was due to a combination of low signal-to-noise ratio (SNR) of the transmittance at shorter wavelengths for dim and cold stars, and an inadequate a priori of gaseous and aerosol species. The operational retrieval sidestepped this issue by using first a DOAS method to retrieve NO2 and NO3, removing their contribution from the measured signal before carrying out ozone and aerosol retrieval. This problem has now been fixed by using full climatologies of gas and aerosol species as a priori for the spectral inversion.*

2.4 Section 3: Did you screen any of the correlative measurements for clouds? SAGE II and III provide separate cloud product which can be used for cloud screening, and OSIRIS v5.0x is already screened for clouds.

No we did not screen the correlative measurements for clouds, since we have yet to find a reliable way to flag cloud observations in the AerGOM data, although we are actively trying to find a good detection algorithm.

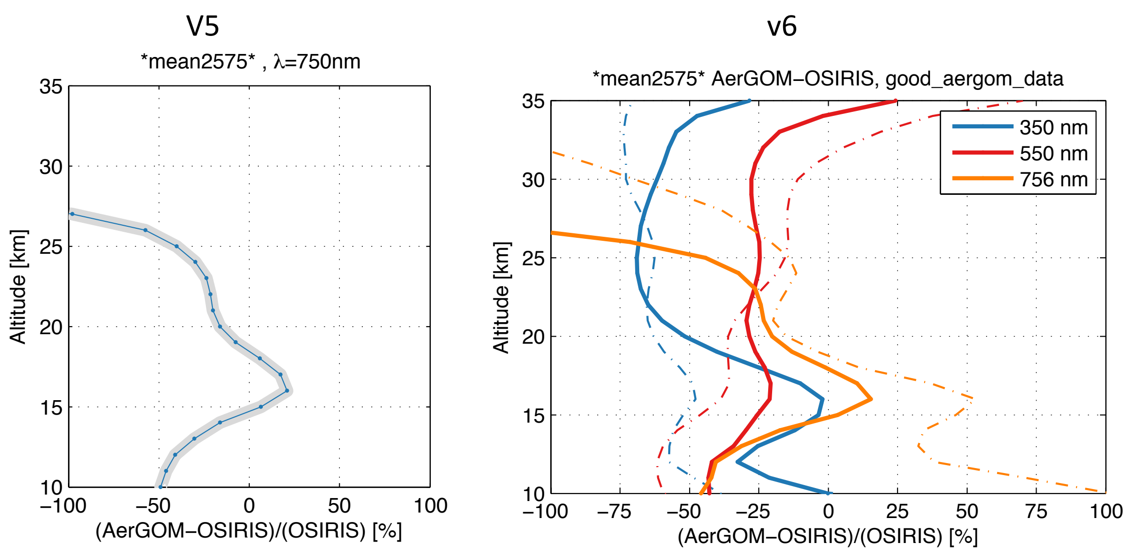
2.5 Section 3.4: Can you provide referenced uncertainty estimate for MAESTRO? The authors stated that MAESTRO have issues that affect its measurements. If these issues are significant and impacting the quality of the data, then the data is not suitable for validation studies.

Sadly, no information on the uncertainty of the data were provided. But as this is an intercomparison instead of a proper validation, I still think that it's worth looking into comparisons between MAESTRO and AerGOM, especially given the small and extremely constant variability between both datasets correlative measurements below approx. 25 km (see Figure 3).

2.6 Section 3.5: Is OSIRIS aerosol extinction profiles V6.0 a released or research product? Why not use V5.0x, which is the officially released and validated OSIRIS product? As noted by the authors, V6.0 is noisier and saturate at low altitudes. The comparison with OSIRIS V6.0 can also be affected by the angstrom coefficient used. The authors should be careful using an angstrom coefficient derived using long wavelengths to calculate the aerosol extinction at shorter wavelengths. OSIRIS uses a fixed aerosol model in version 5.0x which can be used to convert the aerosol profiles at different wavelengths.

A first version of this draft used data v5 but the OSIRIS team gave us the opportunity to look at this new dataset. OSIRIS aerosol extinction v6 is actually not an officially released dataset as far as I know, but it has been the object of a peer-reviewed publication as referenced in section 3.5 (Rieger et al., 2014). The main reason to look at OSIRIS aerosol data v6 was that we were curious to look at the spectral dependence derived from measurements and that was added to the dataset in the form of an Angstrom exponent, which is more realistic than the fix aerosol model of version 5. However, we also agree with the referee that we must be careful due to the way the Angstrom exponent was derived, hence the last paragraph of section 3.5.

I any case, comparison of both datasets against AerGOM give mostly the same results at 750 nm (with the largest difference of 10% around 17 km, see figure below), so we added the following text in section 3.5:
However, the comparison results presented in this paper can be generalized to OSIRIS aerosol extinction v5 dataset at 750 nm, as there are very little differences between both datasets when it comes to AerGOM comparisons.



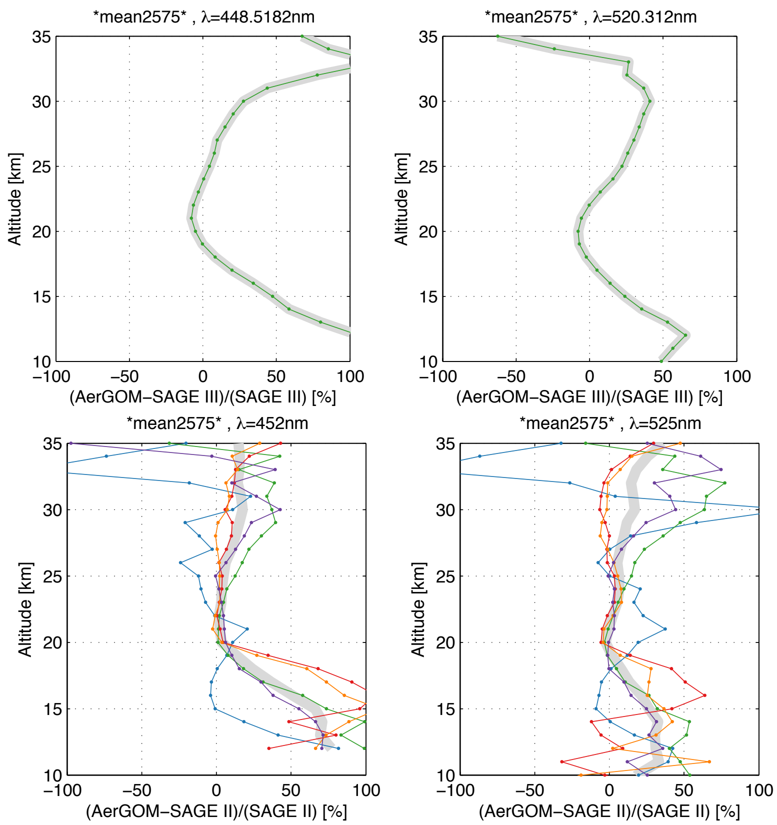
2.7 Section 5: To establish a baseline accuracy of the AerGOM aerosol profiles, the authors need to discuss the comparison with each instrument separately, and in more details, citing reported biases to explain the differences.

Section 5 has been improved in that respect. We tried to analyze the bias for each instrument separately and compared the results with values in the literature, with a particular emphasis on the SAGE instruments as those have been used in several studies. More tentative explanations for the discrepancies observed are also provided, with possible ways to improve the AerGOM dataset in the future.

2.8 I don't understand why SAGE II and III comparison show different biases, since both instruments agree well with each other. The difference might be related to AerGOM retrieval accuracy in southern hemisphere high latitudes measurements. Also, why SAGE III comparison only used above 15km.

SAGE II and SAGE III comparisons with AerGOM are in good agreement when seen from the point of view of latitude of observations. Collocations with SAGE III were only found in the southern hemisphere (-60° to -30°), but collocations with SAGE II were found in all latitude bands considered. I recopied the figures below, and if you look only at the green curves of SAGE II and compare those with the SAGE III comparisons, you'll see that both comparisons agree pretty well up to approx. 30 km. AerGOM is to blame, since comparisons between SAGE II and SAGE III for different latitude bands show a very good agreement. So indeed, there is some bias introduced when retrieving stratospheric aerosol extinction in the mid-latitudes with AerGOM. The reason for this discrepancy is however unclear.

This aspect has been added to the discussion in section 5.



Concerning the use of SAGE III data above 15km: as mentioned in section 3.2, it is recommended to only exploit the SAGE III aerosol extinction 385 nm measurements above 16 km hence the cut-off at that altitude, but due to a bug in our plotting routine, the cut-off was applied to all wavelengths. This has been fixed now.

2.10 Section 6: This section should be shortened to include comparison with SAGE II, SAGE III and OSIRIS only. The authors already shown that POAM III sunset and MAESTRO measurements have larger biases than SAGE and OSIRIS.

I understand the point of view of the referee, but the fact that some datasets are very biased is not an important aspect for this part of the work. I think that the more important criteria is that the data has a constant bias, whatever it is, as we try to see if this bias changes according to some parameters. It has been shown that the relative difference variability for AerGOM and MAESTRO is the smallest of all datasets (~25% from 10 to 25km and beyond, depending on the wavelength), therefore I would argue that this stability of the comparisons is good for such a study.

POAM III, on the other hand, suffers from very large variability at shorter wavelengths (< 500 nm) except between 18 and 20km. At longer wavelengths, the variability is still large but in the range of what we see in the other comparisons between 13 and 20km. Therefore, due to this large variability (probably linked to the limited number of collocations), POAM III data is not taken into account for Section 6 of this paper as we cannot rely on the reproducibility of the bias between AerGOM and POAM III. We added some text to clarify that point in Section 6, 2nd paragraph:
Due to the very large variability of the comparisons between POAM III and AerGOM observed in the last section, POAM III results are not included in this part of the work.

2.11 Figure 8 and section 6 is difficult to follow because of incorrect legend.

This has been corrected.

2.12 Conclusion: The authors should rewrite this section without bullets. Also, the authors need to provide recommendations of the wavelengths range useful for scientific studies.

Done.

2.13 Minor comments: Table1: Change measurements method “limb” to “limb scattering”.

Done

2.14 The authors need to provide better text and caption describing each figure.

We slightly improved the caption text for Figures.

2.15 Figures 3,5,6,7, and 8 x-axes range should be changed to [-100, 100]

Done.

2.16 Figure 8: The legend box shows wrong zones, please fix it.

Done.