As a result of the review process, the manuscript has been modified significantly. Mayor changes are:

1) Section 2 of the paper has been extended to include a brief but detailed description of the TropOMAER algorithm. It includes a description of the UVAI calculation as well as a summary of the AOD/SSA retrieval process.
2) Section 3 on the validation of retrieval results using AERONET observations also changed considerably. The original validation analysis consisting of a direct validation of TROPOMI AOD results to AERONET observations at 12 sites was replaced with an approach that allows the separate evaluation of retrieved product improvement as a result of instrument enhancement and algorithmic improvement. AERONET observations 12 sites are used as an aggregate. A three way validation exercise is then carried out: 1) AERONET vs OMI, 2) AERONET vs TROPOMI using heritage (OMI) cloud mask, and 3) AERONET vs TROPOMI using VIIRS-based cloud mask. Inter-comparison for validations 1 and 2 highlights the effect of improved instrumental capabilities, whereas differences in validations 2 and 3 indicate retrieved product improvement due to algorithmic upgrades.
3) The revised paper (to be available soon after the submission of replies to reviewers' comments) contains 13 figures (five more than in the original version).

In the reply below the reviewer's comment is in black and our answer in blue.

Reply to Comments by Reviewer 1

Summary:

This manuscript introduces the TropOMAER aerosol retrieval algorithm. The algorithm is essentially the heritage OMAERUV algorithm from the OMI collection, now modified to be applied to TropOMI data instead. In this adaptation process, the ability to retrieve above cloud aerosol OMACA has been included. The introduction to the algorithm itself is quick. The authors point out two major differences from OMAERUV: (1) TropOMI's finer spatial resolution (2) still evolving radiometric calibration. There is a quick evaluation section showing TropOMAER retrievals against 12 selected individual AERONET stations for aerosol optical depth (AOD) and an aggregation of all 12 stations for single scattering albedo (SSA). Then the bulk of the manuscript demonstrates TropOMAER in three interesting and newsworthy biomass burning events.

We thank the reviewer for his/her comments that have contributed to an improved manuscript.

Assessment:

There is much merit in this manuscript. The three examples, especially the third example, are scientifically extremely interesting. However as currently written, it is missing too much detail for publication in AMT. AMT is where algorithm developers, such as these authors and myself "talk shop", and where we document the details of algorithms and validity of our products. While the heritage algorithms are well-documented in the literature, porting an algorithm to a new sensor introduces new challenges that are very interesting to other algorithm developers and should be included in a paper like this one. This manuscript could easily be adapted into a form that would be appropriate for AMT, if that is what the authors want to do. These are the points that would make the manuscript ready for publication in AMT:

(1) much more description of the algorithm itself, even if that description were partly reiterated from previous publications.

The section on algorithm description was extended to elaborate on key aspects of the inversion scheme.

(2) highlight differences between OMI and TropOMI instruments, between OMIAERUV and TropOMAER algorithms, most importantly between results from each sensor.

The purpose of the comparison to AERONET has changed from the narrowly focused AOD validation exercise in the original version of the paper, to an analysis of the instrumental and algorithmic differences throughout the use of independent ground-based observations. The combined AERONET data aggregate from observations the 12 sites, is compared to satellite observations as follows. An evaluation of instrument-related and algorithmic improvements is done by comparing AERONET measurements to three satellite-based data sets:1) OMAERUV, 2) TropOMAER with heritage (i.e., OMAERUV) cloud screening, and 3) TropOMAER with VIIRS cloud mask.

A comparative analysis of evaluations 1 and 2 shows the impact of enhanced instrumental capabilities, whereas the analysis of evaluations 2 and 3 highlights the effect of using the VIIRS cloud mask which is the only TropOMAER algorithmic modification.

Of prime interest to potential users of TropOMAER products who have been using OMI products is how do the products from the new sensor compare with the products from the old sensor. The only place I see a hint of that is the plotting of OMI retrievals with TropOMI retrievals on the time series in Fig. 5. However, that figure is not satisfying. Much more interesting than the 15-year time series would be a difference time series during the TropOMI era and a scatter plot of TropOMI against OMI, even on a monthly mean basis.

The parallel validation of OMI and TROPOMI described above addresses this issue.

As suggested, the consistency of the OMAERUV and TropOMAER records are evaluated by comparisons between the products at different time scales:

OMI-TROPOMI visual inspection comparisons of UVAI are shown on Figure 1 for the smoke plume over North America on August 18, 2018. This comparison also includes the KNMI TROPOMI UVAI.

Side-by-side maps of OMI and TROPOMI retrieved SSA and AOD for the same event are also shown on Figure 8.

A two-year time series of monthly-averaged OMI and TROPOMI AOD and AAOD over three regions are shown on Figure 4.

OMI and TROPOMI summer seasonal global maps are compared in Fig 6, and a scatter plot of OMI-TROPOMI monthly UVAI values is shown on Figure 7.

(3) evaluation of TropOMAER should be expanded. There should be an effort to trace the consequences of the finer spatial resolution and issues with calibration to the evaluation. Right now the authors skirt these issues without really proving anything. For example they mention subpixel cloud contamination being absent in most validation sites. However, when I look at the 12 panels in Figure 1, I see no qualitative difference between the 3 sites mentioned as having subpixel cloud contamination and the other 9 sites. If there was marked improvement from Ahn

et al., 2014, then that improvement should be demonstrated in this paper. I should not have to call up that paper and run my eyes between two different figures in two different papers to see the improvement.

The effect of the only implemented algorithm improvement (VIIRS cloud mask) has been addressed in our reply to comment (2) above.

Later they mention needing a finer resolution surface albedo map, and there is also mention of the calibration causing some of the offset in the validation plots. Each of these issues is very interesting to another algorithm developer, like myself, or to potential users of the products. AMT is the right journal to present an analysis of these issues, and prove their consequence on the retrievals. Currently that analysis is missing.

In principle, as discussed in the manuscript, the identified AERONET-TropOMAER positive AOD bias (~0.2) could be the result of remaining calibration offset and/or issues with the coarse resolution of the currently used surface albedo data base. A calibration error will affect all AOD retrievals (independently of AOD magnitude) whereas a surface-albedo related error will impact retrieved low AOD values (up to ~ 0.5). At larger AOD's surface-albedo-related effect become increasingly smaller. Specific conclusions regarding the magnitudes of these effects in TropOMAER are not yet available as we continue to investigate them. The discussion following the validation analysis includes these considerations.

(4) Slow down and present the details. I felt that there was a rush through the "boring" algorithm piece of the paper in order to get to the "exciting" demonstration with the big biomass burning events. There are many details left behind in the rush: There are many acronyms never properly introduced:

p.2 line 2 should put (SWIR) after shortwave infrared.

Done

P2 line 5. ESA and DLR?

Done

P2 line 28. Should put (ALH) after aerosol layer height

Done

P5 line 5. UVAI is never defined as an acronym, and worse, it is never defined as a product. Suddenly it is being shown in figures and being used as a fundamental part of the analysis.

This shortcoming has been addressed in the added algorithm description section.

P6 line 25 SAM?

Stratospheric Aerosol Mass

P6 line 33. What are total mappers?

Nadir looking full daily coverage sensors (no longer in the discussion)

The concepts of Level 1 and Level 2 data are not explained (p2 line 5).

Done

Exactly what AERONET data are we looking at? Version 2 or 3? Levels 1.5 or 2? There is no explanation that AERONET AOD has a documented uncertainty of 0.02 in the UV, but that the SSA retrieval is a retrieval with much broader error bars. There is no explanation of why or how these 12 stations are selected, nor what the time range we are looking at.

Version 3 Level 2 data

(5) Provide more detail in the demonstration section. Figure 3 would benefit greatly by adding a swath just to the west of the swath shown. Right now there is a lot of description of fires and smoke in California, the Pacific Northwest and British Columbia, but none of those areas are shown in the figure. Only the areas downwind.

Added another orbit as suggested.

P6. Lines 1 to 6. Is this method here the manifestation of the ACA part of the TropOMI retrieval that is mentioned at the beginning? If so, then please make that clear. If it is a different method, then explain why the referenced ACA method is not used. If not, then is there any demonstration of the ACA TropOMI method? ACA is an important new addition to OMIAERUV, and should be highlighted or discussed if this is going to AMT.

It is the same. Stated in the manuscript.

P6 Line 10. The extinction-to-mass conversion is important. The appendix should be referenced here.

Done

P6 lines 13-16. Is there a physical basis for this? This is important, and how the UVAI AOD relationship relates to height, and especially to height in the stratosphere needs to be explained. Remember that UVAI jumps in suddenly with no introduction. It would be worthwhile to take the time to explain it, and some of the physics behind the whole interrelationship between height, AOD, UVAI and absorption. Maybe in Section 2?

For given values of ALH and AAE, UVAI increases rapidly with aerosol load up to AOD values in about the range 4-6 when it starts to saturate. At these large AOD's the aerosol absorption of Rayleigh scattered light peaks, and further UVAI enhancements are only possible for increased values of ALH and/or aerosol absorption exponent (AAE). Thus, for AOD values larger than about 6, and known or assumed AAE, the UVAI effectively becomes a measure of ALH. As suggested, this discussion has been included in section 2, where the UVAI concept is first introduced.

P6 line 25 to P7 line 2. A lot of numbers are given here and these are means with uncertainties surrounding them. The uncertainty is given at the end of±40%. It would be helpful to explain how the mean is derived (for what density) and what is the interplay between assumptions of density and uncertainty in height.

We meant uncertainty in AAE. ALH is given by CALIOP.
The uncertainty of the estimated stratospheric aerosol mass (SAM) is ±40% which represents the combined effect of uncertainties on assumed AAE (4.8±0.5) in the AOD retrieval, and the uncertainty in assumed aerosol density in the range 0.79 and 1.53 g-cm−3, which covers the range of values reported in the literature (Reid et al., 2005). For simplicity, we assume a midrange aerosol mass density value of 1.16 g-cm−3. These details are part of the discussion in the revised manuscript.

P7 lines 27-33. This is very interesting, but the figure doesn't really portray this information well. Figure 5 needs to become more informative.

(6) All the captions need to more descriptive. Be sure to give details on specific data, be sure to describe what is shown in each panel, what wavelength is being shown, what temporal resolution is being plotted (fig. 5), what do each of the colors in the color bars represent. But in general a LOT more information needs to be in the figure captions.

We assume the reviewer means fig 8.
Figure 13 (previously Fig 8) shows calculated daily values of aerosol mass (in kilotons) from December 31, 2019 thru January 7, 2020, resulting from aerosols above 12 km, altitude used as a proxy of the tropopause height. Separate aerosol mass retrievals were carried out for cloud free (blue bars) and cloudy scenes (green bars), with the daily total stratospheric aerosol mass given as the sum of these two components (orange bars).

Suggestion: It occurred to me that this manuscript might fit a "letters" journal much better. Right now it is not too long. The authors would need to triage their figures down to 4. Perhaps Figs. 1, 3, 5 (with a bottom panel showing the difference between TropOMI and OMI) and 8. Then the very short description of the algorithm, evaluation and methods would be appropriate, and the purpose of the paper is NOT to describe TropOMAER, but to illustrate these biomass burning events. The point of the paper shifts from an "atmospheric measurement technique" to a better understanding of the Earth's atmospheric phenomena. GRL would be a possibility, but also ERL.

Thanks for the suggestion. We decided to stay with AMT