Dear Editor,

Following the review process, we have produced an enhanced version of the paper that addresses the issues raised in the review process. The main additions to the paper are listed below

-The introduction section was expanded to provide a more complete description of the OMAERUV retrieval algorithm. The following text was added:

"The algorithm, based on TOMS (Total Ozone Mapping Spectrometer) heritage, takes advantage of the interaction of molecular scattering and particle absorption in the UV to detect and quantify absorption properties of UV-absorbing particulate such as carbonaceous, desert dust and volcanic ash aerosols [*Torres et al.,* 1998]. The retrieval algorithm relies on forward calculations of angle-dependent upwelling near UV radiances whose accuracy depend on the correct characterization of both molecular and particle scattering. Aerosol scattering depends on particle size, shape and composition. In the OMAERUV algorithm, the aerosol scattering phase function is calculated using Mie Theory, which applies only to spherical particles. Erroneous scattering phase function characterization may produce large errors in retrieved AOD and SSA values [*Gassó and Torres, 2016*]. OMAERUV uses external ancillary data from other A-train sensors for characterization of aerosol type and information on aerosol layer height [*Torres et al.,* 2013]."

-Section 4.2 was expanded to provide a more detailed description of the modelling aspects of scattering by non-spherical particles. This addition includes two additional figures.

"A known difficulty in the treatment of non-spherical particles is the need of prescribing the fraction of non-spherical elements in the polydispersion, as well as making assumptions on the prevailing aspect ratio values. To address those issues, we follow the statistically optimized approach of *Dubovik et al.* [2011] to account for mixtures of spherical and non-spherical particles, as well as mixtures of spheroids of varying Ɛ values as suggested earlier by *Mishchenko et al.,* [1997]. In *Dubovik et al.* [2006, 2011], the aerosol polydispersion is modelled as a mixture of randomly oriented spheroids. Each size bin consists of a size independent distribution of Ɛ ranging from 0.33 to 2.98 which includes flattened oblate spheroids (Ɛ<1), elongated prolate spheroids (Ɛ>1), in addition to spheres (Ɛ=1). The aspect ratio is distributed in 25 bins, with each Ɛ bin having a fixed weight such that the sum of all weights equals unity as shown in Figure 4. This modelling approach, that closely reproduces the laboratory measured single scattering matrices of mineral dust (Feldspar) reported by *Volten et al* [2001], is currently applied in the operational AERONET (AErosol RObotic NETwork) inversion of measured sky radiances [*Dubovik et al.,* 2006]. The resulting spheroid scattering phase function and it sphere-equivalent representation at 388 nm for single scattering albedo 0.9 are shown in Figure 5. Additional calculations (not shown) as a function of aerosol absorption, indicate that in the near UV, the observed sphere-spheroid phase function difference in the 80°-150° scattering angle range is largest for non-absorbing aerosols, and reduces significantly for SSA values 0.82 and lower. "

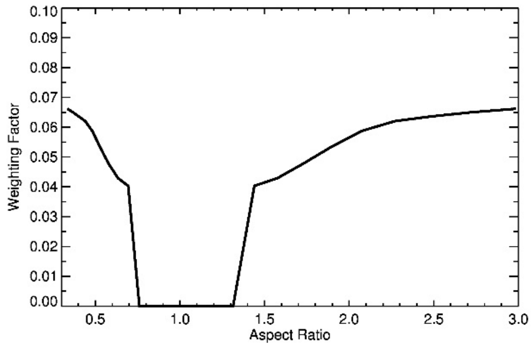


Figure 4. Spheroids aspect-ratio-weighted distribution

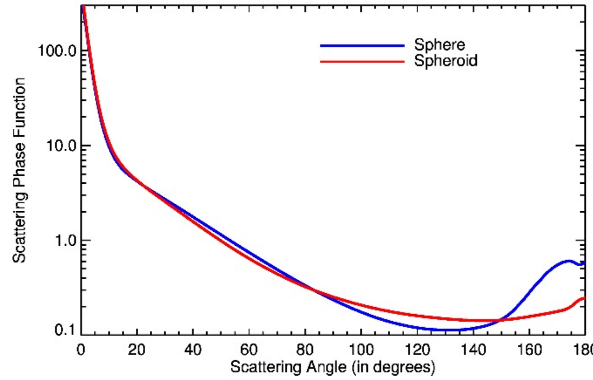


Figure 5. Sphere and Spheroid scattering phase functions

-A discussion section was added to the paper Section 6.0, including two more figures,

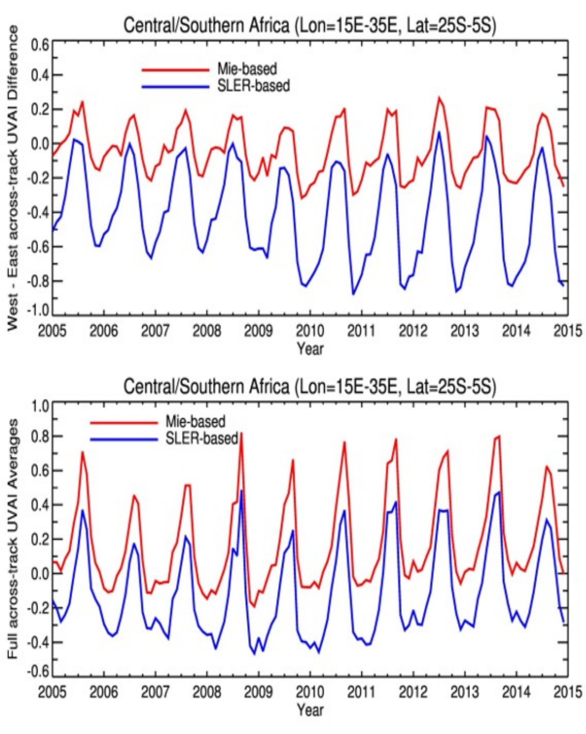
Section 6.0 Discussion

"The improved radiative transfer modelling in the presence of desert dust aerosols and water clouds, as discussed in this paper, was incorporated in a revised version of the OMAERUV algorithm. The effect of these upgrades on the global product, and the impact of the row anomaly on the long-term OMAERUV regional records are briefly discussed here. A more detailed discussion of the global long-term OMAERUV record will be given in a forthcoming publication.

A global comparison of resulting Mie and SLER based UVAI definitions under cloudy conditions are shown in Fig. 12 for August 20, 2007. The across-scan bias of the Mie-based UVAI map, shown on the middle panel, is significantly reduced in relation to the corresponding SLER-based UVAI map depicted in the top panel. To facilitate the comparison, the bottom panel of Fig 12 shows the associated reflectivity field. A clear reduction in across-scan Mie UVAI bias is observed over cloudy regions of reflectivity larger than about 20%.

Figure 13 (upper panel) shows the W-E differences between the monthly averages of UVAI obtained with the SLER (blue line) and Mie-based (red line) calculation approaches over the SAF region for the 2005-2014 period. Both results show repeatable seasonal cycles over the first four years of observations. The SLER UVAI across-track differences oscillate between about -0.6 in winter to about 0 in winter whereas the Mie UVAI W-E differences shows much less seasonal variability (-0.1 to 0.2). An overall drop of the W-E UVAI differences is apparent by the summer of 2009 when the row anomaly has fully developed. A decrease of about 0.2 is observed in the SLER UVAI data whereas a smaller change (~0.1) can be seen in the Mie-based UVAI definition. From then on, the winter W-E UVAI difference stabilizes at -0.8 for the SLER method, and at -0.2 for the Mie-based definition. The summer maxima, on the other hand, slowly increases with time after 2010 for both parameters but a more rapid increase is apparent for the SLER UVAI term. Overall, the effect of the row anomaly is larger and more noticeable in the SLER UVAI definition. Similar results (not shown) are also observed over the NEUS region. The eleven-year record of monthly average UVAI over the SAF region obtained by both definitions is shown in the lower panel of Figure 13. Overall, the Mie-based UVAI record is about 0.3 higher. This increase moves up the minima UVAI values associated with water clouds from negative (~ -0.3) in the SLER definition to nearly zero in the Mie-based calculation. The rapid decrease in the SLER UVAI annual minimum in early 2008, following the onset of the row anomaly, is not present in the Mie-based UVAI record. Both records show an increasing trend beginning in 2009. The SLER UVAI shows a 0.04/yr. increase, whereas the Mie-based UVAI is about half that value.

Upper panel of Figure 14 depicts the eleven-year temporal record of the across-track AOD bias for both spherical and spheroidal model representations of desert dust aerosols. The W-E differences for the spheroidal model (red line) oscillate around 0.05 but are never larger than 0.1, with no clearly observable effect of the onset of the row anomaly. The spherical model (blue line), on the other hand, produces across-track differences as large as 0.25 during the first two years, and a decrease to 0.15 coincident with the initial loss of viewing capability associated with the row anomaly. Following the row anomaly onset, the spherical model yields seasonal and inter-annual variability of across-track AOD differences as high as 0.2 towards the end of the shown temporal record. The resulting multi-annual records of AOD over the SAH region as calculated by the spherical and spheroidal models are shown on the bottom panel of Figure 14. During the first four years of the record, the spherical model underestimates spring and summer monthly averages by about 0.05 with respect to the spheroidal model. Starting in 2009, after the full development of the row anomaly, the bias goes down, and the spherical model results are closer to those of the spheroidal model. The reason for this bias reduction is the exclusion of observations from most of the rows in the East across-track segment of the orbits (yielding larger errors associated with the erroneous phase function assumption) as they are affected by the row anomaly."



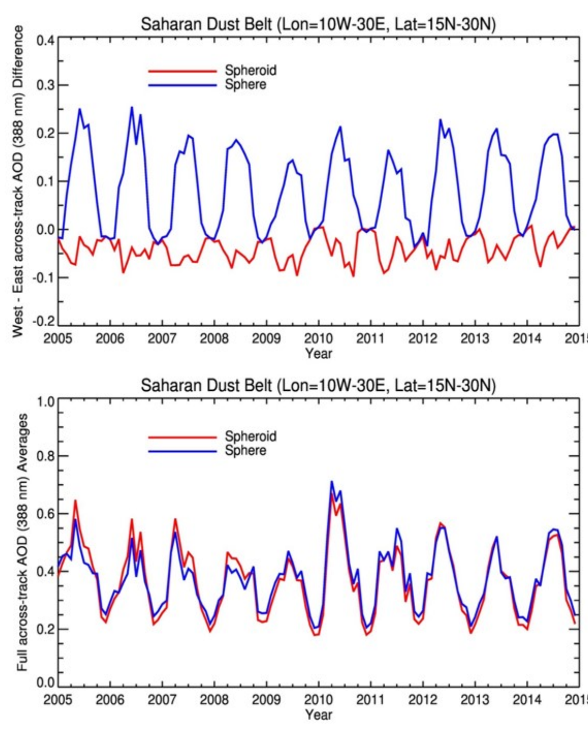


Figure 13. Figure 14

- The Summary and Conclusions section has been enhanced

“The OMI sensor is currently affected by a loss of spatial coverage commonly referred to as row-anomaly. Although an unequivocal explanation of the row anomaly does not exist, it is believed to be the result of an internal obstruction affecting the sensor’s across-track viewing capability. Prompted by the loss of angular coverage associated with OMI’s row anomaly, we carried out a detailed examination of the effect of the reduction of OMI’s angular sampling capability on the accuracy and statistical representativity of retrieved aerosol parameters, and the consequences of the row anomaly on the long-term record derived from OMI observations. “

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“The analysis discussed here has uncovered important algorithmic deficiencies associated with the model representation of the angular dependence of scattering effects of desert dust aerosols and cloud droplets. In addition to the documented east-west asymmetries in the magnitude of the retrieved aerosol parameters, the use of inaccurate scattering phase functions of desert dust aerosols and clouds introduces spurious features in the long-term record when a range of scattering angles is no longer available because of the row anomaly. The more accurate representation of the scattering patterns of water clouds, and the spheroidal particle shape assumption in the retrieval of desert dust properties eliminates the observed inconsistency of aerosol retrieval results associated with the separate use of east-of-nadir or west-of nadir observations. The recommended improvements in the modelling of scattering by cloud droplets and desert dust aerosols also reduces the magnitude of row-anomaly related discontinuities in the long-term record of the OMI aerosol products. “

Reply to Comments to review by Anonymous Referee #2

The manuscript of amt-2017-429 by Torres et al. presents an interesting topic in satellite aerosol retrievals: the representation of the angular distribution of scattered light by aerosols and its consequences for satellite retrieval algorithms. The paper is well structured. The ideas are not new, but they are explored straightforward with appropriate data and theoretical (model) considerations. The results are convincing and relevant. The results are important for the further development of aerosol retrieval algorithms, which are under constant development and have to be adapted to increasingly more sophisticated instrumental capabilities. The aerosol products which are treated in this paper are in dire need of improvement, having been developed for instruments that were designed decades ago. Once state-of-the-art products, delivering daily global aerosol characteristics, they now suffer from increasingly large inaccuracies as the instruments’ spatial resolution and measurement quality increase considerably. This paper presents an excellent example of the problems that are encountered when un-adjusted algorithms are applied to a new, more sophisticated instrument like OMI with much more detail in the across-track direction than previous instruments like TOMS, GOME and SCIAMACHY. The problems addressed here will be even more pronounced in the successors of OMI, and the manuscript presents a clear direction for improvement.

The main problem of the paper is the lack of detail and thoroughness. As said above, the paper is well structured in the sense that the ideas are explored clearly, but the text is sometimes careless to the point of being sloppy, and the analysis lacks the detail that is necessary to check the results should this be desired. The scientific significance warrants prompt publication of the manuscript, after a careful revision of the text. I will give an overview of the problems I encountered, but this is by no means a comprehensive list, and I encourage the authors to critically revise the manuscript and to provide more details about the analyses.

Following the referee's suggestions, the text has been critically revised. As a result, the revised manuscript includes a more detailed discussion of the radiative transfer modelling of non-spherical particles, as well as an extended and discussion of results.

Specific problems:
The analysis was probably prompted by OMI's reduced viewing capabilities, known as the row anomaly. No unequivocal explanation for this problem is known, and the manuscript's title suggests an analysis of at least its consequences. However, a detailed analysis of the angular distribution of aerosol scattering is presented, but not the consequences of the row anomaly. These topics are clearly connected, but the row anomaly is not treated in the manuscript at all, therefore a more suitable title should be provided.

The title of the paper has not been changed. We have instead added an extended discussion section that includes the row anomaly effects in the context of the identified scattering modelling issues.

A large part of the introduction is dedicated to the row anomaly, but this is not further treated, except for the statement that only data before 2007 is used because of this. In the conclusion section, at least a general discussion of the row anomaly's consequences in view of the angular distribution of aerosols scattering should be given.

The added discussion section addresses these issues.

In the introduction, section 3, and a few more times in the main text, the measurements of OMI are referred to as 'scanning'. Although this has no consequences for the results and conclusion of the analysis, I suggest that the authors, who are principle investigators in the OMI project, describe the instrument and its capabilities correctly and accurately.

The text has been revised accordingly.

The introduction lacks details. The reader is expected to know everything about the AOD and SSA retrieval in the OMAERUV algorithm. A reference is given, but I think a brief recap of the angular dependence on aerosol scattering and its consequences for the AOD and SSA is in order here. E.g. in the same way as the treatment of the UVAI product, which is more clear and detailed.
The description of the retrieval algorithm in the introduction has been expanded emphasizing the angular dependence of particle scattering, and the need to characterize accurately particle size, shape, and composition to avoid errors in retrieved AOD and SSA.

Also the difference between phase functions of spherical particles and spheroids are important to understand, in order to interpret the results.

A detailed discussion of the Radiative Transfer aspects of non-spherical particles have been added in section 4.2. Two new figures have been included in this section: Figure 4 describing the distribution of aspect ratio used in the calculation of the scattering phase function of spheroids, and, Figure 5 depicting the resulting spheroid phase function, as well as the originally assumed sphere phase function.

Abstract:
thru -> through
scattering-angle-dependent -> scattering-angle dependent (multiple times, and inconsistently)
main text: row-anomaly -> row anomaly (multiple times, and inconsistently)
two-days -> two days
worldwide-coverage -> world wide coverage
etc.
p3 slow -> slowed
p4 representative -> is representative
p4 separately -> separate
p6 Retrieval errors transition from overestimations to underestimations at about 155 scattering angle. -> Rephrase
AOD and AOT are both used, please be consistent.

The above technical corrections have been implemented.

The level of details of the plot is rather low, leaving questions that seem irrelevant but nag because it hampers a thorough check of the results: the monthly mean pictures seem at close inspection to consist of 4 points per month. Is it a running mean? Or a weekly mean?

We are assuming the above comment refers to the figure showing regional monthly averages of the analyzed parameters as a function of time for the initial OMI three-year period.

We are puzzled about the referee's estimate of 4 as the number of points per month. Each monthly mean value is the result of the averaging of 1 orbit per day (at least) X 30 rows per across-track segment X 60 across-track segments per orbit X 30 days per month = 54,000 points per month. This would be the number of points per month used in the UVAI analysis, which requires no cloud screening. For the retrieved parameters (AOD and SSA), the number of points per monthly mean value reduces to about 10,000.

The analysis in Fig. 4 was done for 'A non-spherical polydispersion'. Which one? What fraction? Was it a specific set that improves the data so well as shown in Fig. 5, or is it robust?

Details of the non-spherical poly-dispersion are given in section 4.3 of the revised manuscript.