Authors' response to comments are highlighted in **red.**

Review of paper:

A new MISR research aerosol retrieval algorithm: a multi-angle, multispectral, bounded-variable least square retrieval of particles properties over both land and water validation by J. Limbacher et al.

Highlights

- very detailed MISR retrieval approach of the research algorithm (RA)
- evaluations not just limited to AOD
- nice illustrations of strength and weaknesses

Concerns

- comparisons of results to the older RA and also to the standard (SA) algorithm
- likely incorrect assumptions about dust bias solutions
- regional (Sahara, off-Sahara) testbed cases are missing to examine the dust problem

General comments

MISR comprises a set of multi-spectral sensors oriented into different directions. Data combination in developed retrievals are quite powerful to determine multiple aerosol properties (at cloud-free conditions) with accuracies usually not matched by other satellite sensors. In addition, the long-term data record (in operation since 2000) makes this data-set highly attractive.

While a new retrieval is suggested, the 'research' aspect makes me frown, as new efforts for retrievals will only count for data-users, if retrievals are applied to the entire data-record (e.g. for climate studies) and not to a limited number of cases. In any case, statistical comparisons of retrievals (newRA vs oldRA vs stdR) for a limited period could be a nice addition to demonstrate newRA capabilities - in the discussion section.

The paper is rather technical and introduces a new (less complex) aerosol model with the number of permitted aerosol types – compared to the standard algorithm - reduced to 17. This is a step in the right direction (also for unique answers). Still I suggest further changes. I question the necessity of 'very small' (reff ~0.06um) sizes, which are hardly contributing to optics – unless they are very absorbing. However, 'very small' BC is quickly increased in size to 'small' and even to 'median' sizes as (absorbing OC and scattering SU) condensate attaches. Hereby for OC a weak absorption in the mid-vis but a strong absorption towards the UV should be assumed so that a BC(core, reff~0.06um))/OC(shell) type can mimic 'brown carbon'. Thus, there is high potential to reduce the number fine-mode choices. On the other hand, the coarse-mode choices are far too simple as also larger mineral dust sizes (with lower mid-vid SSA for the same Rfimag) should be considered. I am almost certain, that this will reduce FMF, non-sph and ANG biases of this new MISR retrieval.

Otherwise, this is a very informative paper.

The authors thank Stefan Kinne for his thorough comments. A couple broad comments are addressed below

1. **The algorithm described here represents the first version of the algorithm to be used to generate a global MISR Research *Product* which we are working toward producing for all 22+ years of MISR data. (We just recently received funding for the first time to produce a Research *Product,* largely based on the work presented in this and other recent MISR RA papers.)**
2. **This algorithm represents the first RA over-land results that the lead author has published (so no previous RA version to compare to).**
3. **We agree with your comments about the 0.06 micron aerosol models and have removed them. We have also added a spherical non-absorbing 0.57 micron effective radius particle as additional coarse mode aerosol mode. This change has been on our list to do since Kahn et al. (2010). We have also replaced the 1.28 micron effective radius analog with a 2.8 micron effective radius analog, as the algorithm has less sensitivity to size differences in the "coarse" range, but will be much more likely to distinguish between the 0.57 and 2.8 micron analogs.**

4. **We have added new non-spherical models with the same size distributions as our spherical analogs. The non-spherical analogs use the same set of refractive indices (although different than for our spherical analogs), which results in much more absorption for the larger size distributions.**
5. **The RA is also a testbed for changes to the SA, so some of the advances presented here might appear in the SA before a full Research Product is completed.**

P.S. I have attached a summary of the top-down concepts of my MACv3 climatology, where is the coarse-mode AAOD information – along with the dust coarse-mode AOD is used to determine coarse dust AOD and coarse dust size. (note, fine-mode dust AOD and fine-mode SSA contributions are considered secondary and being considered conservative scatters, they are attributed to non-absorbing fine-mode 'SU' in the MAC climatology)

Specific comments

5/4 to table 1: I missed a couple of (at least one) larger dust sizes (as with larger dust AOD usually also the mineral dust sizes are larger ... which strongly adds [coarse mode] absorption). I also would get rid of the very small aerosol types and would start with 'small'. Here I would add a mixture (a 'very small' BC core size with an organic OC shell to yield a 'small' mix type) as mostly (or only) scattering usually quickly condenses on BC. Hereby I would also define organic ('OC') with a strong increasing absorption increase towards the UV and a pure scattering fine-mode ('SU') component for both 'small' and 'medium'). Hereby the BC(core)/OC(shell) type covers the artifical 'brown carbon' component. This reduces the minimum number of types to be considered to eight: small: BC/OC, SU, OC / medium: OC, SU / large: SS and DU / very large: DU
We are adding 2 non-spherical fine-mode non-spherical models (0.12, 0.26 micron effective radius), 3 coarse mode dust models (0.57, 1.28, and 2.8 micron effective radius) and 1 more spherical non-absorbing analog (2.8 micron effective radius). This allows us to retrieve total sphericity (rather than only coarse-mode sphericity) and coarse-mode size. As we pointed out above, we are removing the smallest aerosol models (0.06) and adding a 0.57 micron effective radius "coarse" mode spherical analog. This gives us a total of 17 discrete aerosol models, but only adds one more retrieved parameter. These choices are motivated by our growing experience with the particle-property distinctions we can make with MISR under good retrieval conditions.

For the content in the table I would like to see next to the eff. radius also assumed distribution width information (std.dev or variance) rather than r,min and r,max. In addition, for the Angstrom parameter, the defining wavelengths need to be listed in the captions and SSA data should be shown that actually relate to the type assumption for size and composition (and not just made up by an arbitrary value, like 0.8). This will also help later to improve to relate types to those used in global modeling. Finally for AAE (as fro Angstrom) the defining wavelengths are needed or simply add an SSA value at another relevant wavelength (e.g. 440nm) – based on RFimag spectral data for the particular size of that type.
We added the log-normal characteristic width, and the radius as well. We apologize for not including wavelengths for our Angstrom exponent. We use all four MISR bands for determining this value. Although the 0.8 and 0.9 green-band SSA are rather arbitrary, rather than trying to match a few specific aerosol types that might have been observed in a few circumstances, we are taking the approach of covering a broad range of values that are seen in nature. This is also consistent with limited MISR sensitivity to SSA. As the prescribed surface algorithm will interpolate between the different bins, it shouldn't really matter what the bins themselves are (as long as they are densely spaced). The same wavelengths (all 4 MISR bands) are used for AANG as well, we added this).

6/6 one large non-spherical model is not sufficient - especially over the Sahara and for Saharan outflow - where extra large dust-sizes, if ignored, likely cause AODc underestimates and also possibly absorbing fine-mode overestimates
We are adding a second model at 2.8 microns, which will also result in significantly lower blue-band SSA (constant ni for all dust models are used), and we are replacing the 1.28 micron effective radius analog with a 0.57 micron effective radius analog. As the longest MISR wavelength is 0.87 microns, we have limited sensitivity to particle size for particles larger than 2-3 microns.

7/10 why not using initial values from a climatology or data from the most recent retrieval at that location?
The algorithm is set up to run from a static value globally, in part so our results are not unnecessarily skewed toward our pre-conceived biases (i.e., "confirmation bias," as per *Schutgens et al.*). Of course, we could do this in the future, but the current approach seems to yield reasonable results without introducing this bias.

9/7 actually it would be great if this mixture information could be saved – at least for a couple of test-cases. In this way I could be explored to what degree each of the now 17 types contributes also in efforts to reduce the number of required types.
This information will absolutely be saved for our research product, but for our current manuscript we will continue saving data this way, as this is just an initial validation study.

9/25 if you remove the smallest (re=0.06um) sizes (then you are down from 9 to 7) and when you add a larger non-sph dust (e.g. re ~ 5um) then you are up from seven to 8) 11/12 I assume that in the combined surface/aerosol retrieval constraints are built in, which do not allow for negative albedos or negative AOD.
We are removing the 0.06 micron effective radius set of analogs (5) and adding a 0.57 micron effective radius non-absorbing (and non-spherical analog) as well as a 2.8 micron effective radius non-absorbing (and non-spherical) analog, while removing the 1.28 micron non-spherical analog (which gives us 17 components still). You are correct that we have limits on the retrieved (and prescribed) surface albedos (and Lc as well). These were added in the updated manuscript.

18/24 Nice, that the comparison are shown for both the largest and (via ln/ln) the smaller AODs
Thanks, we know some people prefer log/log and some people prefer linear scales.

20 I think, that the missing coarse mode (e.g. MISR Angstrom overestimates at smaller AERONET Angstrom) has much to do with the missing larger coarse-mode sizes. This would have been also apparent, if the deviations of the scatter plot would have been places as a function of location. (This behavior is similar to SLSTR biases, which also only consider one dust size in their model and then attribute absorption to the fine mode (AODf overestimates), while this absorption should have gone to dust size (increases))
Some of this is surely a lack of information content, but we have added: 2 fine-mode dust models, 1 more coarse mode dust model, 1 more coarse-mode spherical model, and removed the 5 0.06 micron effective radius models. The changes made have definitely reduced the bias, although it is still present.

22/10 For me the fine-mode non-spherical dust is not the issue. If absorption is allowed not only to be associated with fine mode (BC, OC) and relative small DU, but also with larger DU size, then most of the MISR biases now will go away (better non-sphere, better fine-mode, better SSA) in comparisons to DUST cases (on the other hand at the largest AODs AERONET actually gives size-distributions, although size with re>10um are likely missed by these inversions). In the scatter plot presentation the 0.5-1.0 AOD already relates to the largest AOD events, so I consider only the first row in figures 5 and 9 relevant. (rows 2 and 3 in Figure 5 and row 3 in Figure 9 are interesting but less meaningful because of much lower statistics are less meaningful). Why not showing in Figure 5 the same range statistics as in Figure 9?
Respectfully, AERONET seems to indicate that this is at least partly due to fine-mode dust. We have added fine-mode dust models, but have also taken your suggestion and added another coarse-mode dust model as well (2.8 micron effective radius). MISR RA results are clearly improving with AOD (and this is an important point), so we will keep these other AOD ranges as well. Unfortunately, we don't have the numbers of high-AOD cases over-water to plot the results with the same AOD ranges. This is to be expected.

29/4 AOD >0.4 is already a large AOD and AOD>1 are very rare, so I suggest to focus on the 0.3 to 1.0 range for coarse mode AOD. And the scatter plots for FMF, non-sph and SSA do not indicate co-locations ... so I would look at dust outflow off Africa (ocean) and dust over the Sahara (land) to investigate the dust retrieval problem. Attached, below is the description of the top-down approach of the MAC aerosol climatology. In the top-down approach also the dust size is retrieved (from the coarse-mode AAOD). In the third column for Figure A3 the extracted dust effective radius (divided by 10) is illustrated. Especially over the Sahara and for dust outflow ontoe Atlantic – especially during JJA

AOD from smoke and dust plumes can easily exceed 1 (whether AERONET is well-suited to typically capture such events is a different matter). Considering that aggregate particle property results appear to be worsening while mean retrieved non-spherical fraction is increasing (plus the lack of multiple dust models) seems to indicate a definite problem with our dust retrieval. As we have added another coarse-mode dust model (and several fine mode dust models), we think this should be sufficient for now. We are now retrieving fine-mode size (+ ssa and black-smoke Fr), coarse-mode size, FMF, and total non-sphericity, so we should also be able to retrieve dust effective radius as well.

CORRECTION to REVIEW

in my review I also provided the MACv3 aerosol top down aerosol type approach. Unfortunately there is an error in table 1 as the (midvis) SSA for large mineral dust is (not constant) but a function of size (the table lists the same values 0.962 value).

Table 1 correction: for re= 1,5, 2.5, 4.0, 6.5 and 10 the mid-visible dust SSA values are 0.962, 0.931, 0.918, .882 and .840 for the same imaginary part (here 0.0011) ... that is very important to understand my comments of the review.

The authors understood what you were trying to convey and believe you will be satisfied with the revised manuscript (with new particle models).