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

This is a very good study describing research algorithm development for MISR. The standard MISR over-land retrieval has a long-standing problem of underestimating AOD at high AOD because the EOF algorithm fails when the surface contrast disappears at high AOD. This development uses prescribed MAIAC BRDF dataset over land (similar over ocean) to significantly improve the RA aerosol characterization at high AOD.

I recommend publication after the authors address my specific mostly editorial comments which I provide in the annotated manuscript. A minor re-structuring would also benefit this paper improving readability and understanding.

Alexei.

The authors thank Alexei Lyapustin for his comments and recommendation. We will add his comments with pages/line numbers (and our response) below.

Page 3, Line 2: The word "algorithm" makes it hard to understand - please remove.
Done.

Page 3, Line3: Excessive, please remove.
Done.

Page 3, Line 8: Please, replace "or" with dash.
Done.

Page 3, Line 18: Do you mean Lambertian water-leaving reflectance?
We have changed this to remote-sensing reflectance.

Page 3, Line 22: four to sixteen days, depending on latitude. MAIAC makes BRDF retrievals continuously, with every new orbit, but the BRDF is reported once in 8 days. In C6.1 it will be reported daily.
Clarified based on your comment.

Page 3, Line 27: I suggest to replace with "aerosol" for clarity.
Done

Page 4, Line 21: MAIAC BRDF retrieval already uses similar constraints on BRDF shape to avoid unphysical behaviour of surface albedo with SZA (see 113. Lyapustin, A. I., Y. Wang, I. Laszlo, T. Hilker, F. Hall, P. Sellers, J. Tucker, S. Korkin, 2012. "Multi-angle implementation of atmospheric

correction for MODIS (MAIAC): 3. Atmospheric correction." Rem. Sens. Env, 127: 385-393 [10.1016/j.rse.2012.09.002] , see sec. "3.2. Solution selection and update"
Added "(similar to constraints placed on MAIAC surface reflectances from *Lyapustin et al.*, 2012)."

Page 4, Line 26: You "consolidate the output ... to determine the surface type"? Please, re-write
We removed the redundancy from the end of the sentence.

Page 5, Line 12: Can you come up with some other name, say "full retrieval", because "retrieved surface aerosol retrieval" sounds very awkward and confusing, and in more than one place.
The authors have struggled with this as well. We used "retrieved surface aerosol retrieval" because it was the best description of what is done. We have instead opted for "Retrieved Surface Algorithm" (RSA), "Prescribed Surface Algorithm" (PSA), and "Combined Surface Algorithm" (CSA).

Page 5, Line 16: I suggest to call it either "water leaving reflectance" or reflectance of underlight" which is a more appropriate and clear terminology for water.
We changed this to remote-sensing reflectance.

Page 7, Line 14: I suggest that you say that this is a Lambert approximation of TOA (despite you are using the BRDF model, and use computed albedo, which, by the way, is also a function of AOD and SZA). But because your focus is high AOD retrievals, such approximation is reasonable and gives a good accuracy.
The authors admit this is an approximation and we add the following:
We recognize that this is only an approximation to account for multiple reflections of light off the surface.

Page 8, Line 21: I suggest to give this minimization equation first, prior to describing the specific set of equations (3) which follows from (4). This will make it more clear.
In this case, we prefer to keep the text as is.

Page 10, Line 3: You should mention that this is only an approximation. The water-leaving reflectance, theoretically, can be re-scattered by the water surface facets (we call glint) and the bulk of water after atmospheric backscattering, but the general formalism should be very different. In the ocean color community, the "ocean color" component does not bounce between the atmosphere and the ocean and propagates directly to TOA. That means there is no denominator for A*.
The authors agree, but have handled this in a previous comment with the following:
"We recognize that this is only an approximation to account for multiple reflections of light off the surface." The authors agree with your formalism, but in practical terms very little would change as both s and A (especially A) tend to be very small numbers. We have added that A* represents the remote-sensing reflectance over-water.

Page 11, Line 5: Please delete
Done.

Page 11, Line 6: of
Done.

Page 11, Line 19: Because you are using Lambertian formulation, you only retrieve a Lambert-equivalent reflectance. The "angular behavior" of the surface reflectance usually implies the BRDF model information. The most recent analysis "Lyapustin A, Zhao F and Wang Y (2021) A Comparison of Multi-Angle Implementation of Atmospheric Correction and MOD09 Daily Surface Reflectance Products From MODIS. Front. Remote Sens. 2:712093. doi: 10.3389/frsen.2021.712093"

clearly illustrates the differences between spectral BRF in MAIAC and Lambertian surface reflectance in standard MODIS surface reflectance MOD09.
The shape-similarity approximation (used over-land only) itself is a non-Lambertian surface reflectance model (whether accurate or not), although we are obviously using a Lambertian formalism for multiple reflections.

Page 11, Line 26: were
Done.

Page 13, Table 2, Row 1, Column 7: Personal comment, no action needed. You can reduce this dimension to 3-4 without change in accuracy.
Thanks for the comment, we will look into this in the future.

Page 14, Line 17: Do you mean 0.1-0.2?
Yes, changed.

Page 15, Line 2: where AERONET "sphericity" is given in %.
We have removed this, as we now retrieve total sphericity (instead of CM sphericity).

Page 16, Line 32: I thought the algorithm is generic. Did you apply it for the deserts? It should work the same way for the dust retrievals. If it does not, you should say it upfront in the Abstract and Introduction/Conclusions.
We have now set the NDVI limit to 0.0, which will allow good QA retrievals over desert regions.

Page 16, Line 22: How is it defined? According to "2*sigma, or 66% within EE"?
This prognostic error is taken as a line fitted to the 68th percentile absolute AOD errors (with respect to AERONET), binned at every 2% of MISR retrieved AOD (so 50 bins in total). This has been added

Page 17, Line 1: I don't quite get it: earlier you mentioned that you take "retrieved" when AOD<1, "prescribed" when AOD>2, and a superposition when AOD is in between. How ... No, it's possible, since you combine the best retrievals from each - no more questions.

Correct, we attempt to take the best pieces from each algorithm.

Page 30, Line 5: That's the 1st place you mention what dataset was used in this paper. Plus, I need to gread the other paper before making my conclusions. This is important for understanding - I strong recommend that you add a small paragraph at the beginning explaining what regions (or global? - probably not because you filtered deserts), which years of MISR measurements are used here.

We have added the following in the MISR RA General Description: "The MISR top-of-atmosphere (TOA) reflectances used for this study are identical to the set of MISR reflectances used in our 2019 turbid water aerosol retrieval paper (Limbacher and Kahn, 2019), and represent 4 years of MISR data interspersed between 2001 and 2016 (over select direct-sun aerosol validation sites)." It is unlikely that all deserts are now filtered out, as we have lowered the NDVI minimum to 0.0 and this should only filter out the most spectrally neutral (between the red and NIR) regions.