

Reviewer #1

We thank reviewer 1 for their suggestions and feedback.

Summary: The authors have upgraded their research algorithm (RA) in order to simultaneously derive aerosol optical depth (AOD), Ångström exponent (ANG) and remote sensing reflectance (Rrs) from MISR observations over water. AOD and ANG are validated (compared to AERONET) and retrievals of Rrs and gradients appear realistic. There are case studies over a variety of water types (ranging from clear to turbid - based on a new productivity/turbidity index scale (PTI)), and validation of AOD and ANG are from more than 2000 retrieved cases.

Overall: This paper is a suitable for AMT and provides a nice scientific analysis. Overall, I have no major objections to this paper being published, and have no compelling need for additional analyses. The results look good, and I would like to see (in a future study), the algorithm going “global”. The figures are informative, and almost works of art (they will make beautiful posters).

I am curious why there are no MODIS-OC or AERONET co-authors, (or MISR-SA authors for that matter), considering the heavy use of their products. Yes, the products are freely available, but I don’t believe acknowledgment-only is sufficient in this case.

Although we appreciate the reviewer’s perspective on this, the authors conceived the underlying ideas, developed the algorithm, wrote the text, and performed all the analysis. All products used here are freely available, except for the MISR RA, which is the authors’ algorithm.

One gripe is the appearance of too much self-referencing within the text. I believe the overall citation list is fair, but we don’t need to see so much “Limbacher and Kahn” and “Kahn et al.” within the text. I would rather see this space used to quickly describe the things that may be within these references. For example, I find lines 1-15 on Page 4 to be very confusing. I also don’t like the equations. Is there any way to write these things without so many subscripts and superscripts? Finally, there are places in the text where the authors are claiming that because it looks good, it must be good (page 9, line 16 for example).

This algorithm builds on prior work of the authors (this is also a “Part 2” paper), who have worked collaboratively for the last 8 years on this project. Many algorithm refinements that make the current advances possible are described in our previous papers, which is why there are many references to them. We have tried to consolidate citations, but are aware that others might question the justification for some steps if we didn’t provide adequate references. We have also added that f/Q represents essentially the BRDF of the ocean’s color and have tried to make the paragraph clearer in general.

I wonder about the PTI metric. It appears useful, but calling it “productivity” may need validation. I do not have a better suggestion for the name, but should be more descriptive of what it is, rather than what is the desired inference.

As water color relates to both productivity and turbidity, we think the calling it a productivity/turbidity index seems appropriate.

I tried something new, which is to annotate the PDF (with red text). Some of my comments are questions to answer; others are possible suggestions for text revision. Others are tiny issues of punctuation. I hope the uploaded supplement will solve the problem of trying to align line/page numbers when revising the text.

We have reviewed the annotated file, and made the indicated, minor edits to the text in many cases.

Overall, a good effort, and I think publishable with minor revisions.

Specific comments in the text:

P1 L10: Replace “the planet” with Earth

Done

P2 L2: What do you mean by biologically productive, and suggest a reference?

Chl-a maps from the MODIS OC website give an indication of biological productivity. We don’t think a reference is really necessary for such a generally accepted statement, but have added *Behrenfeld et al. (2005)* as a reference.

Behrenfeld, M. J., E. Boss, D. A. Siegel, and D. M. Shea (2005), Carbon-based ocean productivity and phytoplankton physiology from space, *Global Biogeochem. Cycles*, 19, GB1006, doi:10.1029/2004GB002299.

P2 L7: Suggest: One reason is that if attempting to use satellites to observe coastal waters, the atmospheric contribution to the measured top-of-atmosphere (TOA) radiance is large.

In this case, we prefer our wording, as it makes clear the specific algorithm limitations that we are overcoming with the new approach.

P2 L12: Originally intended as a 6-year mission,

Done

P2 L15: +/-

Done

P2 L16: optical path length

Done

P2 L17: Why only sometimes?

Removed sometimes.

P2 L22: Not sure how focal lengths and 15 years yields something sufficient for heterogeneous coastal waters.

The varying focal length allows the instrument to make measurements at roughly the same spatial resolution for all nine cameras, allowing for retrievals in heterogeneous coastal waters (especially in the high-resolution mode). The 15 years is a reference to the local-mode dataset of high-resolution MISR data. We have emphasized these point in the revised text.

P2 L25: Don’t understand “in concert”. How about taken simultaneously, which offers a way to empirically go from optics to concentrations?

In concert with is a synonym for jointly (We have changed it to “jointly.”).

P3 L4: And the quality of the measurements of TOA radiance/reflectance

Right

P3 L6: Remove nicely

Done.

P3 L7: Define SeaWIFS please, and change NASA Goddard to NASA Goddard Space Flight Center.

Done

P3 L23: Let's combine 1st two sentences and make sound positive: "Unlike MISR standard aerosol (SA) product which provides aerosol information at 4.4 km globally, the research algorithm (RA) provides detailed aerosol parameters on a case-by-case basis at 1.1 km or 275 m resolution. These details include..."

We think it is important for the current paper to make clear the many differences between the SA and the RA. We have revised these sentences as follows:

The MISR standard aerosol product (SA; Diner et al., 2008; Martonchik et al., 2009) provides publicly accessible aerosol amount and type information globally (Kahn et al., 2010, Kahn and Gaitley, 2015; Garay et al., 2017). In contrast, the RA can only process MISR data for selected locations and times, on a case-by-case basis, but offers spatial resolution down to 1.1 km or 275 m pixel size, and advances in radiometric calibration critical for aerosol-type retrieval, improved surface representation, and the option of a greatly expanded aerosol optical model climatology (Limbacher and Kahn, 2014; 2015; 2017).

P3 L23: Note SA now provides at 4.4 km resolution, so newer references?

We mention that fact, and the appropriate reference Garay et al., 2017) is included.

P4 L3: AU → Astronomical Units?

Added, thanks

P4 L7: I am curious how much "correction" all of these things do?

This is in our previous work, which we reference extensively to address such questions.

P4 L11: What is f/Q correction?

We now explain that f/Q represents a non-Lambertian bi-directional surface modification.

P4 L12: Maybe if you aren't using it now, then don't even mention until maybe discussion/conclusions

f/Q corrections are fundamental to many ocean-color algorithms, so we feel it needs to be mentioned here..

P4 L13: Now, we are talking your algorithm, or the f/Q algorithm?

f/Q is a correction

P4 L14: normalized to what? Again, tell me what you are doing now, and not what you are doing later.

We removed this.

P4 L15-16: Don't understand "aggregate the resulting AOD... corresponding to best-fitting AOD"

We have revised the text to clarify this.

P4 L21: suggest using the form: "where w is, Unc is, and pmodel is.. "

We don't see any advantage to the suggested rewording.

P4 L25: Not sure "irradiant" is the correct word here, and symbol "E" usually refers to irradiance.

Our description is accurate, but we have added that it is analogous to the TOA reflectance normalization.

P4 L30: Why do you need all of these self citations? Using exponential weighting, rather than specific thresholds, avoids the possibility of arbitrarily excluding some mixtures.

We were pointing out what we had done in prior work, but we have now removed those references here at your request.

P5 L1-10: Somehow this text is really clunky. How about start by saying. To retrieve the Rrs signal from the TOA reflectance, we need to account for the roughened surface, the molecular scattering, and the geometry of observation. For roughened surface, we... For Rayleigh...

We prefer varying the sentence structure to minimize monotony. We did revise these sentences as follows:

To retrieve the remote-sensing reflectance, we prescribe the wind-driven effects of a roughened ocean surface (glint and whitecaps), using cross-calibrated multi-platform (CCMP; 0.25°, 6 hourly) version 2 data (Atlas et al., 2011; Wentz et al., 2015) 10-meter wind speed. The Rayleigh scattering contribution to TOA reflectance is prescribed with a 1013.25 mb surface pressure. This allows us to remove one dimension from our look-up-table (LUT) and has minimal impact over ocean, including coastal regions (though it might have an impact over elevated inland lakes).

P5 L2: Change prescribe to must account for
We do prescribe it.

P5 L2: Are whitecaps a function of surface windspeed?
Yes, as described in our previous papers. This is clarified in the above revision.

P5 L3: What is CCMP?
As stated, CCMP stands for cross-calibrated multi-platform, but we have added that this is 6 hourly wind data fused from multiple satellite instruments and model data.

P5 L4: Why 10 m wind and not surface (2 m) wind?
The widely used roughened surface model we adopted is designed for 10 m wind input.

P5 L5: The error of assuming a constant 1013 is minimal, except for over elevated inland lakes. Or is it? +/- 10 mb or 1% of atmosphere leads to 0.002 error at 446 wavelength.
Even a deviation of 50 mb is still only 0.01 in AOD in the blue (and is less in other channels). We suspect that actual surface pressure will be biased slightly higher than 1013, as we don't do retrievals over clouds.

P5 L11: Do you have a reference to suggest the normal "range" of surface?
We do not, but from our own experience, it can vary from nearly black to > 30% in shallow waters with bright sand, as illustrated in the case studies in Section 3.

P5 L13: What is that dimension? M becomes only a function of AOD, right?
Correct

P6 L3: I have never seen so many subscripts on a term!
We tried to be clear about the variable dependencies. The subscripts just refer to geometry and wind speed variables, with perturbations.

P7 L22: Need accents on Angstrom Exponent: Check other instances too.
Thanks! Changed this throughout the paper.

P8 L8: What is the raw product?
For clarity, we changed this to "...raw' data product, which provides AOD with minimal cloud screening"

P8 L17: Why not something else? Reference needed?

One can actually see the sun-glint with the MISR An (nadir-viewing) camera, indicating that it would be a problem for MODIS as well.

P8 L23: Do you mean “albedo” - why do you retrieve albedo?
This should be R_{rs} , thanks.

P8 L24-25: Just because the RA retrieves here doesn’t mean it should...
This is why we validate in all types of water

P8 L30-31: Again, not be snarky, but just because the algorithm separated surface and atmosphere, does not mean it did it correctly. Instead say that the algorithm attempts to separate surface and atmosphere even under high aerosol loadings ($AOD=0.5$). Qualitatively, it seems reasonable because...
We validate where we can, both statistically and for specific cases, and suggest that the errors will tend to be similar in locations where validation is lacking. We don’t claim the results are perfect.

P9 L1: aerosol → aerosol radius
We don’t think that is necessary here.

P9 L16: skill? Means it must be validated
The human eye can give a qualitative indication of skill, but we have removed “a great deal of”.

P9 L29-30: “quite a bit”, “appear”, “probably”, “might be”. Remove these qualifiers to improve the sentence.
Done

P10 L8-10: This sentence reads as if the L&K 2017 paper also compared against V23 4.4. I think you mean to say that here, MISR RA at 1.1 km is compared with 17.6 SA (V22) as well as new 4.4 SA (V23)
We agree that this was not worded well and have made changes.

P10 L13: Over what time interval?
Moved the bullet talking about temporal averaging up so it is first.

P11 L 4-7: Why use arrows? (→)
Changed to dashes.

P11 L13: I don’t understand this equation. How does one add MISR(Green + Red + NIR). And what is “Spectral Sum”? Finally, are you sure it is “productivity”?
These are MISR R_{rs} sums. Spectral sum would be Blue + Green + Red + NIR. We have added words to the text to make this clear. Figure 7 illustrates how this index reflects water surface productivity/turbidity. In future work, the index can be further verified with in-situ (or retrieved) Chl observations (or retrievals).

P11 L15: How do you know this is a cloud?
Its texture, shape, and color in the visible imagery all look like cloud.

P11 L21-22: This is a very good result!!
Thank you.

P11 L28-29: I think you mean “more turbid”. Saying water is “productive” is something to validate.
We are just putting results in perspective. We say here only that we *expect* coastal waters to be productive for a couple of reasons, one being that nutrient run-off can lead to near coastal blooms.

P13 L10-11: This is a great next step!
Thanks.