

General Comments:

The manuscript summarizes the results from a global, long-term (12-15 yr) evaluation of the MODIS Collection 6 dark target 3km aerosol optical depth product, using Level 2 AOD from AERONET sites. A large number of MODIS-AERONET collocations (161,410) with highest quality flag (QA=3) from many regions are used to study overall MODIS 3km AOD performance on global and regional scales, time series of AOD performance, and factors influencing AOD performance. The result is a follow-up to previous studies of MODIS C6 10km AOD product (Levy et al., 2013) and 3km product (Remer, 2013), with this product providing a more thorough global evaluation of C6 3km product performance and some comparisons with C6 10km AOD product. The paper provides a thorough and well-documented source of information regarding MODIS C6 3km DT performance, including caveats for its usage. Methods are clearly explained and the analysis is thorough and pedagogically-sound. Scientific significance and scientific quality are very good and the paper meets the standards for publication in AMT but the authors should first clean up the document for persistent grammatical and sentence structure errors, which impact readability in many places. There is also redundancy in many places (a few of which I list below and recommend changes for) but I find some of the redundancies beneficial.

We thank the reviewer for the review. We have considered each one carefully. All our responses are in BOLD.

Specific Comments:

1. Section 2. Page 5. Lines 9-10. The authors state that “Therefore, for the 3 km² product, any fewer than 5 native 10 pixels automatically receives QAF=0. QAF values assigned as 1 or 2 are based on other criteria.”. Please either mention these criteria or reference a paper where the user can obtain such information.

Remer et al., 2013 Reference for further details is added. We have also revised the text with more explanation.

2. Page 10. Lines 19-21. Provide some reasoning as to why correlation breaks down at these sites. Grammar could also be improved upon in this sentence. You may wish to state that “Correlation is weaker” or something along these lines, instead of “Correlation breaks down..”.

Revision has been made in the text. Reasoning for the weaker correlations is given.

3. P. 19. Lines 4-6. The authors state that “Furthermore, the aerosol system itself has undergone significant changes since 2000, with the U.S. and Europe drastically reducing their urban/industrial emissions and substituting wildfire smoke as their primary source of aerosol.” This is likely true for the western U.S. but not likely to be true for the eastern U.S. Authors should either specify ‘western U.S.’ or provide the results from some

studies (which I have not seen) supporting their assertion. Regardless-they should cite some studies which substantiate this claim.

The point is that there has been a drastic reduction in traditional urban/industrial aerosol types throughout the U.S. and Europe. When there is a void, other types of aerosol become more important. Even in eastern U.S. there have been many intrusions of transported wildfire smoke from the west and from Canada, for example. However, we do see the reviewer's point here and have modified the statement and have added three references

Karnieli, A., Y. Derimian, R. Indoitu, N. Panov, R. C. Levy, L. A. Remer, W. Maenhaut, and B. N. Holben (2009), Temporal trend in anthropogenic sulfur aerosol transport from central and eastern Europe to Israel, *J. Geophys. Res.*, 114, D00D19, doi:10.1029/2009JD011870.

Toon, O.B., et al., Planning, implementation, and scientific goals of the Studies of Emissions and Atmospheric Composition, Clouds and Climate Coupling by Regional Surveys (SEAC4RS) field mission, *J. Geophys. Res. Atmos.*, 121, doi:10.1002/2015JD024297, 2016.

Hand, J.L., B.A. Schichtel, W.C. Malm, S. Copeland, J.V. Molenar, N. Frank, M. Pitchford, Widespread reductions in haze across the United States from the early 1990s through 2011., *Atmos. Environ.*, 94, 671-679, 2014.
<https://doi.org/10.1016/j.atmosenv.2014.05.062>

4. P.19, Lines 27-28: Please cite reference(s) to support this claim so that the interested reader can view these paper(s). Also state whether this systematic bias in MODIS C6 holds true for both DT and DB (as is implied by not stating which), DT only, or DB only.

Gupta et al., 2017 provides further details and proposed changes in the algorithm to correct biases over urban surface, which are now implemented in the Collection 6.1 data sets. Reference is added.

This is true for dark target only. The text has been revised to make this clear.

Technical Corrections:

There are many grammatical errors and incorrect sentence structure exists throughout the document. Readability and flow of the manuscript will be greatly improved upon once these are fixed. For brevity, I only list a few but encourage the authors to review the grammar and fix accordingly, or else ask an outsider to review the manuscript for grammar, sentence structure, and readability. There are examples of incorrect sentence structure (missing commas, commas placed where new sentences should begin, . . .). More efficient wording should also be utilized in many places, in place of long, rambling sentences.

P. 6 Lines 14-15. Grammar. It should read as “AERONET processes these spectral measurements to derive AOD at the wavelengths corresponding to the direct sun measurements.”

REVISED.

P. 7 Line 6: Please add the phrase “AOD at 550 nm” to the phrase “We have created a collocated data set (CDS) of both MODIS-Terra and MODIS-Aqua” to qualify the measurements being compared. It is obvious to most readers but still should be explicitly stated.

REVISED

P. 9. Lines 14-17: “Identified retrieval quality matters to product accuracy with QAF=3 showing stronger correlation, smaller RMSE and more retrievals falling within expected error than QAF=0, but the high quality data set loses about 20% of the retrievals.” Please fix grammar. One suggestion is to replace “matters to” with “influences”.

REVISED

P.10. Line 31. Change “can report” to “often report” or similar.

Changed to “sometimes report”

P. 10 Lines 6-10. The sentence is too long and difficult to follow. It should be broken down into two 2-3 sentences. An alternative is to enumerate the stated factors influencing regionally-specific retrieval performance. This alone would improve readability. Also change the word “will” in line 6 to “is”. There are several other places in the manuscript with similar long, rambling sentences that would be easier to follow if broken down into shorter, clear sentences.

The text has been revised for clarity and grammar.

P.11. Line 12: Change the word “fades” to “ranges from”.

‘fades’ replaced with ‘decreases’. We are comparing Terra and Aqua biases here. Words added to clarify this point.

P.11 Lines 13-14. Please reword the sentence “For many of the stations, positive mean biases decrease from Terra to Aqua.” to something along the lines of “At many of the stations, the positive mean AOD bias is larger for Terra than for Aqua.”

REVISED

P.11. Line 17. You mix present and future tense throughout the paper. Please pick a tense and stick with it. Present tense is typically used when describing the current study (yours)

and past tense is typically used to describe the referenced work of others. For this reason, I recommend using present tense throughout the paper.

REVISED

P.11. Line 24. Delete the sentence “Only QAF=3 retrievals are included.”. This has already been mentioned.

REVISED

P.11 Lines 17-24. Please combine the two short paragraphs with 2 sentences each into a single paragraph.

REVISED

P. 11 Line 26 through P.12 Line 17. These two paragraphs contain numerous redundancies and could easily be combined into a single paragraph. One example is on P.12. Lines 5-7. This sentence has already been stated above and should be eliminated. You could also include the good agreement for the sites in “north/central South America, equatorial and southern Africa, and Australia” in the last sentence of previous paragraph but re-stating that “Regions where MODIS 3 km² retrievals exhibit especially good agreement with AERONET 6 collocations include E. CONUS and Europe” is unnecessary. There are also redundant statements made throughout the paragraph, which could easily be consolidated with the previous paragraph.

We have removed an entire paragraph because of the redundancy between the discussion concerning the analysis at the local station level and that of the regional level. We do want to keep the statements about CONUS and Europe because we want to point out that the global statistics are heavily weighted by the collocations in this limited part of the globe. This can be implied by the circles plotted in Figure 5, but are not as apparent as when the number of collocations are tabulated by region in Table 1.

P.12 Line 19. Please either change the 3 km² to 3km or specify it as 3 x 3 km² throughout the document. You do so in the abstract but not in the other sections.

REVISED

P.12. Lines 22-27. Please fix several grammatical errors.

REVISED

P.14 Lines 9-13. This repeats what was already stated in

REVISED

P. 15. Lines 25-27: Another case of 2-sentence paragraph. Please combine with one of adjacent paragraphs

REVISED

P.17 Lines 11-12. The authors state that “There is significant degradation of validation accuracy if MODIS retrievals of Poor data quality ($QA < 3$) are included in the analysis”. This implies that QA values of 1 and 2 were used and that they gave “poor quality”. I thought that only $QA=3$ and $QA=0,3$ were used. If I am correct, please change $QA < 3$ to $QA=0$ to accurately describe the data used. Also please be consistent in the acronym for quality flag. You use QA in some places and QAF in others. Please pick one of them and use throughout the document.

REVISED for clarity and we are now consistently using QAF throughout the manuscript.

P. 17 Line 14. Please correct the dimensions of MODIS product. You state it as ‘3km²’. Please fix here and other instances in the paper.

REVISED

P 17 Line 23 – P. 18 Line 3: There are several grammatical errors in this paragraph (and similar errors in other sections of document), including missing commas and similar errors. Please fix throughout the document.

REVISED for the grammar.

P. 19. Lines 13-15. This is one of many sentences throughout the document which needs the grammar fixed. There are commas places where they should not be placed and missing from places where they should appear.

REVISED for the grammar.