Response to Review #1

Review of amt-2022-290, "Assessment of Severe Aerosol Events from NASA MODIS and VIIRS Aerosol Products for Data Assimilation and Climate Continuity", by Amanda Gumber, Jeffery S. Reid, Robert E. Holz, Thomas F. Eck, N. Christina Hsu, Robert C. Levy, Jianglong Zhang, and Paolo Veglio

The paper provides an assessment of two MODIS AOD datasets (the combined Dark Target / Deep Blue and MAIAC) in comparison to the operational VIIRS dataset (and AERONET ground-based sun photometer measurements) with a focus on high AOD events.

The paper is of high relevance as it provides significant and detailed insights into the performance and deviations of MODIS vs. VIIRS which prepare the ground for the transition between those instruments in late 2023. Given the importance of MODIS for operational modeling systems through data assimilation, the assessment of the consistency of continuing observations (e.g. for air quality) and of long-term Climate Data records after this transition is of high importance.

I found one type of maps presented in a confusing way / not completely described (mean bias – absolute or relative) – this should be harmonized and its descriptions extended for better clarity.

I have a few minor suggestions on wording and graphics, symbols where I struggled to grasp the key messages (see detailed comments at the end).

I therefore recommend publication with minor revisions.

Response to review questions
1. Does the paper address relevant scientific questions within the scope of AMT?
Yes, a specific assessment of high AOD cases and of the consistency od datasets related to a sensor transition are of great value and importance.

2. Does the paper present novel concepts, ideas, tools, or data?
Yes, the paper is innovative with its specific focus on a comprehensive assessment of high AOD cases for different regions stratified by their different dominant aerosol types or mixtures of them.

3. Are substantial conclusions reached?
Yes, the paper does go into detailed regional / aerosol-type stratified analysis, and in its conclusions extracts major overall findings relevant for data assimilation and direct use of VIIRS AOD in sequence to MODIS AOD.

4. Are the scientific methods and assumptions valid and clearly outlined?
Yes, the paper applies an appropriate combination of methods to assess / compare the long tails of probability distributions with their specific complexity of low numbers. Applying different methodology for the bulk of the AOD range (< 0.8) and for the rare high AOD cases is fully appropriate. Furthermore, the limitations entailed in the methodology used as well as due to the

Aeronet reference data limited coverage are clearly described to put this part of the analysis into the right context.

5. Are the results sufficient to support the interpretations and conclusions?
Yes, the paper does provide a wealth of plots which justify in detail the conclusions drawn; in particular in the analysis of specific regions in section 4. The discussions do include some qualitative aspects of possible reasons for the differences (as proving each hypothesis would go far beyond the paper's scope). However, those discussionsare all well underpinned by plausible arguments based on the observations in the various plots.
I found one type of maps presented in a confusing way / not completely described (mean bias – absolute or relative) – this should be harmonized and its descriptions extended for better clarity.

6. Is the description of experiments and calculations sufficiently complete and precise to allow their reproduction by fellow scientists (traceability of results)?
Yes, the methodology is either described or referenced in their underlying publications.

7. Do the authors give proper credit to related work and clearly indicate their own new/original contribution?
Yes, I could not identify any major gap in the references quoted and there are clear (and valid) statements highlighting the unique elements of the paper).

8. Does the title clearly reflect the contents of the paper?
Yes, the title highlights the focus on high AOD cases as well as the intended applications of data assimilation and climate data record consistency.

9. Does the abstract provide a concise and complete summary?
Yes, the abstract summarizes the goal, methodology and overall conclusions.

10. Is the overall presentation well-structured and clear?
Yes, the presentation starts with a brief introduction of the datasets / their underlying algorithms, and then conducts the analysis first globally and then regionally, which provides a rich set of analysis details.

11. Is the language fluent and precise?
Yes, overall, the paper is well written. I have a few suggestions for small improvements.

12. Are mathematical formulae, symbols, abbreviations, and units correctly defined and used?
Yes, overall, I see clear definitions and consistent usage. I have a few minor suggestions for improvements (see below).

13. Should any parts of the paper (text, formulae, figures, tables) be clarified, reduced, combined, or eliminated?
No, as the authors have already taken care to split some further analysis into a supplement, so that the overall flow of the argumentation can be better followed.

14. Are the number and quality of references appropriate?

Yes, I see all relevant work cited.

15. Is the amount and quality of supplementary material appropriate?
I appreciate the provision of further interesting detail in the supplement.

My few small concerns
1) Maps of mean bias are presented in Fig. 5 (right column) and Fig. 6 (all) and only the caption of Fig. 5 calls it "mean relative bias". As there are no negative values and in Fig. 6 over ocean for the lowest AOD range the value 1.0 dominates, it cannot be absolute biases, but the captions / text on a fast reading made me expect absolute bias. Can you please add one or two sentences clearly defining what is shown in the maps and use consistent terminology to ease a reader's understanding?

Response: *Thank you for the suggestion. You are correct that it should be better defined. Rather than mean bias, it is the average of the ratios of the pairwise satellite products. In Fig. 6 over ocean where the value 1.0 dominates indicates that the products show small differences and have a relatively low bias. Both Figure 5 & 6 have been updated to read, "Ratio of AOD > 0.8" and "Pairwise Mean Ratio." We added a sentence to clarify this at line 492 in the revised manuscript: "The mean ratios calculated in Fig. 5 and Fig. 6 are defined as the averages of the ratios of the pairwise satellite products."*

2) In the abstract and the methodology you call your common consistent product used for the analysis "a Level3 product". I understand that you want to stress the consistent aggregation (which is important) and the fact, that you work with a gridded dataset. As there exist the operational Level3 products, can you please introduce a naming which makes it clear that you are using a specific gridded product which also included AERONET data and all satellite datasets under investigation which differs from (some of) the operational Level3 products?

Response*: Thanks for the recommendation. We have given the product a name, the SSEC/NRL L3 product and have added that product name throughout the revised manuscript. We have also added the sentence at line 255: "The creation of this SSEC/NRL L3 product differs from other operational L3 products because of the use of a consistent aggregation method and the options of filtering and masking which Yori provides."*

Minor / detailed comments which could help optimize the paper for reading
- In a few places I got lost whether analysis over ocean is part of the paper or not

Response: *For the global analysis (Section 4), we do include both land and ocean. For the regional analysis (Section 4), we chose to focus on land only for comparison with AERONET. We added a reference to this in the revised manuscript at line 507: "For better comparison to AERONET, this regional analysis will focus only on land data."*

- You have many "-" between parts of sentences without empty spaces, which confuse reading – please change them all to " – "
Response: *Noted and updated.*

- use “AERDB” instead of “DB” for VIIRS in all places to distinguish from the MODIS DB Product
Response: *Noted and updated.*

- There are a few cases, when your sentences are missing a verb (e. g. lines 35, 123, 575)
Response: *Noted and updated*

- Can you be consistent in “84th percentile ...” instead of sometimes using “84th% ...”?
Response: *Noted and updated*

- Please use “1° x 1°” consistently throughout the paper instead of “1 degree x 1 degree”
Response: *Noted and updated*

- Please use “biomass burning” consistently instead of sometimes only using “burning”
Response: *Noted and updated*

- Line 60 “conditions” should be moved before the bracket (then you keep together “lower boundary conditions”)
Response: *Noted and updated*

- Lines 93-96: split into two sentences
Response: *Noted and updated*

- Line 107: AERONET is not a sensor (CIMEL is)
Response: *Changed sensor to instrument*

- Line 115: I would add “comparison of the” before “product performance”
Response: *Noted and updated*

- Line 128: add “to” before “provide”
Response: *Noted and updated*

- Line 129: can you find a more appropriate word to replace “finalizing”
Response: *Changed finalized to resolved*

- Line 132: I do not understand what you want to say with “use the benchmark AOD values” / line 576
Response: We *deleted the word “benchmark,” it was intended to describe the most studied wavelength of AOD at 550nm.*

- Line 133: can you explain the principle behind “designed after commonly applied DA products”

Response: *It was intended to describe how many data assimilation products are set to a 1x1 degree grid. We changed the phase to "designed after commonly applied DA products" to "similar to commonly applied DA products"*

- Line 135: can you please say, which fraction of pixels is typically kept for each of the three dataset by applying the QA flags?
Response: *A sentence at line 138 has been added to address the fraction of pixels kept using the QA flags: "By using the highest quality retrievals, the amount of AOD pixels is reduced by approximately 55%, 52%, and 51% for VIIRS AERDB, MODIS DT/DB and MODIS MAIAC."*

- Line 143: please add "as level2" after "criterion"
Response: *Noted and updated*

- Line 145: why do you use Aeronet lv1.5?
Response: *When the dataset for this study was produced, some sites were still only AERONET Level 1.5 at the tail end of the study period. When a site elevates officially from 1.5 to 2, the 1.5 data is replaced by level 2 within the file.*

- Line 148: replace "isolate" by "separate"
Response: *Noted and updated*

- Line 163: which version of MYD04 do you analyse (collection 6.1 I guess) – please add.
Response: *Noted and updated*

- Line 163: what is the impact of comparing MCD19 which is a combined TERRA / AQUA product to the other afternoon only products?
Response: *There is a flag in the product to separate Aqua and Terra, so only Aqua is used in the study. For clarity, we added the sentence, "The product can be separated by satellite, so only Aqua is used in this study." at line 176.*

- Line 167: it would be very interesting to include VIIRS /DT, but I accept it was not yet available when the study was made – consider to delete the sentences on the new VIIRS version (here and later in the paper)
Response: *We think it is important to acknowledge why VIIRS DT is not in this study especially since it is a currently available dataset now.*

- Line 170: this sentence says that there is no fine mode AOD over land for any of the products – please reword
Response: *In revising the manuscript, this sentence has been removed to shorten the section and because fine mode fraction was not used in the results of this study.*

- Sections 2.2.1 – 2.2.3: the MDOIS part is much longer than the other two – maybe consider to harmonize

Response: *Thanks for the recommendation, we did try to shorten the MODIS Combined DT/DB section in the revised manuscript. We think it does end up needing to be a little longer than the others given that it is a combination of multiple algorithms.*

- Line 179: add "pre-defined" before "fine and coarse"
Response: *Noted and updated*

- Line 190: add "in visible bands" after "signal"
Response: *Noted and updated*

- Line 225: please explain "M band channels"
Response*:The M stands for moderate resolution. We added in "moderate resolution" for in front of M band in line 234*

- Line 228/229: so VIIRs AERDB has fine mode over bright land?
Response: *Thank you for pointing this out. It does not have fine mode over land, and we altered sentence to say, "their properties" instead of "fine mode fraction" in the revised manuscript.*

- Line 245: what do you mean by "aggregated to longer time domains"
Response*: The phrase "aggregated to longer time domains" was supposed to mean they were created into daily files. This sentence has since been removed from the revised manuscript.*

- Line 264: replace "this subsection" by "section 3"
Response: *Noted and updated*

- Caption to fig. 2: filtering of ratios for 84th percentile of AOD<0.1 (for one of the datasets or for all?
Response*: Yes, the ratios are filtered for the 84th percentile of AOD<0.1 for all datasets. We chose to do this filtering to enhance regions of interest for severe aerosol events.*

- Fig. 2: To simplify reading, I suggest a shorter legend title for the top right maps (σg) – better to define "σg = AOD 84th percentile / median AOD" in the text as equation
Response: *Noted and updated*

- Fig. 3: is the same filtering applied for rations as in fig. 2?
Response: *No, the same filtering was not applied to the ratios in fig 3. The filter was used in Fig 2. to remove areas that don't experience high aerosol loading. In fig. 3, the filter was not used to look at 95th and 98th percentile events.*

- Table 1 / caption: I would add "AOD550: " at the caption start
Response: *Noted and updated*

- Line 316: what does "good" mean here?
Response: *"AOD 550 signal is good" refer to the signal being good at revealing areas of seasonal aerosol loading. Added the text, "in revealing areas of seasonal aerosol loading" after the word good.*

- Lines 365ff: I suggest to avoid the word "capture" as it indicates that an algorithm detects something as compared to a truth, which you explicitly say cannot be assessed. Better use "observe" or "detect" or similar.
Response: *Changed "capture" to "observes"*

- Lines 370 – 372: I find this a very complicated sentence to understand.
Response: *Sentence has been re-worded to be hopefully more understandable at line 405*

- Fig. 4 / caption: duplication "detection" – "detected"
Response: *Noted and updated*

- Line 406: better say "pre-defined" instead of "programmed
Response: *Noted and updated*

- Line 437: I would replace "excellent" by "outstanding"
Response: *Noted and updated*

- Line 437: what do you mean by "model comparisons"?
Response: *Thank you for pointing that out. By model comparisons, we mean to reference the article Reid et al. (2022) where the ICAP consensus models are compared to MODIS. These models do not have the sharp boundaries for significant land plume ejections like the MODIS product does. This provides evidence that there are differences between the land and ocean retrievals resulting in coastal changes in AOD even when compared pairwise. We have added this description to line 474.*

- Line 443: add "truly" before "different"
Response: *Noted and updated*

- Figure 7: the lines are for which dataset? Aeronet, I guess – please add
Response*: The lines are a combination of all the datasets defined in the figure caption.*

- Line 487: add "which" before "have"
Response: *Noted and updated*

- Line 514: replace "less different" by "smaller"
Response: *Noted and updated*

- Line 538: add "showed that they" before "were"
Response: *Noted and updated*

- Line 545: what do you mean by "observed integer factors"?
Response: "*Observed integer factors" is intended to describe the large amount of bias between products.*

- Line 560: "constancy ???

Response: *Constancy changed to consistency*

- Line 562: replace "concerning" by "of concern"
Response: *Noted and updated*

- Line 573f: "Notable are differences include" is not a proper sentence.
Response*: We removed the word "are" to make it a proper sentence. Thank you for catching that error.*

- Line 629: replace "lower still" by "even lower"
Response: *Noted and updated*

- Line 725: replace "particulate" by "particular"
Response: *Noted and updated*

- Line 746: delete "when"
Response*: Noted and updated*

- Line 771: sometimes you use past tense, mostly you use present tense.
Response: *Noted and updated*

- Line 780: "under-sampling"
Response: *Noted and updated*

- Line 788: delete "The last aerosol regions studied" by combining the first two sentences "Regions with mixed pollution and dust within Asia include southwest Asia ..."
Response: *Noted and updated*

- Line 794: is "dark target types of algorithms" the correct summarizing of all algorithms here?
Response: *Yes, we would say it is correct. The Dark Target algorithm is one of the longer studied algorithms and has been expanded upon and incorporated into both MODIS and VIIRS products.*