

Interactive comment on “Accuracy Assessment of MODIS Land Aerosol Optical Thickness Algorithms using AERONET Measurements” by Hiren Jethva et al.

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Dear Reviewer,

Thanks for offering your valuable comments on our manuscript # amt-2019-77. We have tried our best to incorporate all your suggestions, which have greatly improved the scientific merit of the paper. In the revision, two important and major changes have been applied according to the suggestions made by Reviewer # 3. These changes include,

- 1) use of the latest AERONET version 3 dataset (instead of version 2 used in the

original paper) 2) replacement of MAIAC BRF dataset with the MODIS standard BRF product (MOD09) in performing error characterization vs. BRF shown in Figure 6.

With these two changes, the entire analysis presented in the paper was reperformed to derive results tabulated in Table 3, 4, and Figure 1 through 6. While using AERONET version 3 dataset provided increased matchups and marginal change in the resultant statistics of the comparison (R, RMSE, bias, slope, intercept), the overall interpretation and conclusion of the MODIS-AERONET comparison for all three algorithms, i.e., DT, DB, and MAIAC, presented in the original paper haven't altered.

Following is the one-to-one response to each comment/suggestion made on the submitted manuscript.

RC: Referee's comment AR: Author's response

Minor comments:

RC: P1 L12: full name of GOES R/S AR: The full name of GOES, Geostationary Operational Environmental Satellites, is referred in the abstract

RC: P1 L15: change "spectral coverage" to "wavelengths" AR: The suggestion is considered.

RC: P1 L16: change "currently used" to "existing" AR: The suggestion is considered.

RC: P1 L17: change "existing" to "three" and change "that of derive" to "derived" AR: The sentence has been revised according to the suggestion.

RC: P1 L20: full name of "Aqua-MODIS" AR: MODIS is defined earlier in the abstract.

RC: P1 L20: change "carried out an independent evaluation of" to "evaluated" AR: Suggestion considered in the revision.

RC: P1 L21: change "the retrieved AOT" to "satellite retrieved AOT" AR: Changed.

RC: P1 L24: are they really "consistently"? later you mentioned different criteria of

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pixel selection were used? AR: We meant that the collocation procedure was applied to all three algorithms as identically as possible. Table 2 lists the configuration adopted for both satellite and ground datasets. For AERONET, the required minimum number of AOT measurements was set to 2 irrespective of the size of spatio-temporal window. The minimum number of satellite observations is selected depending on the size of spatial window. For DT-3km, DB, and MAIAC, the thresholds in min. number are set identical, whereas for the DT-10km product, the thresholds are relaxed to half to allow more matchups since a dark target algorithm uses limited number of 500m pixels in the retrieval after discarding 20% darkest and 50% brightest pixels in 10 km grid box.

RC: P1 L25: remove “while” and P1 L26: change the “MAIAC algorithm” to “and the MAIAC algorithm” AR: The sentence is now restricted according the suggestion.

RC: P1 L28: change “finer” to “higher” AR: The sentence is now rewritten as “The higher spatial resolution of MAIAC product (1 km) allows...”

RC: P2 L1: is it really “error” AR: The AERONET AOT due to its high accuracy (~ 0.01) is considered as ground-truth, and therefore, the difference between satellite and ground AOTs is treated as error in the satellite retrievals.

RC: P2 L2-3: refer to major comment

RC: P2 L2-3: these sentences are too general presented in abstract. AR: Here, we close the abstract by emphasizing the usefulness of derived results, which may provide a guidance in the development of the aerosol algorithms for the aerosol retrievals from ABI or other MODIS-like sensors.

RC: P3 L6: what suspended particle means here? PM concentration? If so, how the vertical profile can be derived from ABI? AR: One of the goals of TEMPO-GOES synergy is to retrieve the mean aerosol layer height and single-scattering albedo using information in the near-UV from TEMPO by constraining the observed AOD (interpolated to near-UV) from ABI.

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RC: P3 L14 – 16, this is not really accurate, the problem to get PM is to describe the vertical profile of aerosol and the humidity dependence of particle growth with respect to humidity. AR: We concur with the understanding here that neither TEMPO nor ABI can alone provide detailed vertical profiles of aerosols. However, the synergy between the two sensors can offer the mean aerosol layer height retrieved using information from the near-UV wavelengths with a constrain of AOT obtained from ABI using visible channels. The combined information of columnar AOT and aerosol layer height, therefore, help estimate the PM load when used as an input to the computation scheme equipped with other assumptions of meteorological variables including relative humidity. The sentences following to this claim in L14-L16 clearly states that the role of synergy between the two sensors.

RC: P3 L26 “over the globe” to “globally” AR: Changed.

RC:P3 L27 “land and oceans” to “land and ocean” AR: Changed.

RC: P4 L4, several sentence for the “similarities” and “differences” of those three algorithms have to be described. AR: Since detailed description of each algorithm (DT, DB, MAIAC) is given in papers published by the respective groups, we exercise brevity here and refer the readers to these paper for accessing details of each algorithm. However, we have tried to describe the major components of each algorithm, i.e., aerosol model and surface characterization, in the paper.

RC: P4 L5, refer to major comment 1, a quick search online, we can already find similar work over other regions, if we focus over NA, there are much more publication for either two or single product(s) of them.

Lyapustin, A., Wang, Y., Hsu, C., Torres, O., Leptoukh, G., Kalashnikova, O., Korkin, S., 2011b. Analysis of MAIAC dust aerosol retrievals from MODIS over North Africa. AAPP Phys. Math. Nat. Sci. 89. ELS XIII Conference, Vol. 89, Supplement No 1

Liu, N., Zou, B., Feng, H., Tang, Y., and Liang, Y.: Evaluation and comparison of

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how DT separate land and ocean? And there is no description of ocean algorithm in this section.

AR: We concur with the reviewer that several papers before ours have validated MODIS DT and DB aerosol products, either together or alone, over different parts of the world, including North America. However, to our knowledge, our paper is the first attempt comparing all three existing aerosol products (DT, BD, MAIAC) simultaneously following a near-identical collocation approach against AERONET over North America region.

Since the main objective of the paper was to validate satellite retrievals of AOD over land, no emphasis was given to the over-ocean algorithm and its description in the manuscript.

RC:P4 L19-20, I suggest re-write this sentence, the assumption is the impact of fine mode aerosol to 2.1 μm is ignorable AR: The sentence has been re-written as,

“The over-land DT algorithm exploits the top-of-atmosphere (TOA) reflectance measurements in three MODIS bands, i.e., 470 nm, 670 nm, and 2130 nm to simultaneously derive AOT at all three channels with an underlying assumption that the impact of fine mode aerosol to 2130 nm signal is ignorable, and that the 2130 nm channel contains information about coarse mode aerosol as well as the surface reflectance”

RC: P4 L25, how “cloudy pixels” detected? A reference is needed. AR: A sentence mentioning the references and primary method to screen the cloudy pixels is added here. Since these references and ATBD describe cloud masking adequately, we don't include its details in this paper.

“The DT over-land algorithm screens cloudy pixels following a series of tests that rely on using absolute magnitude and spatial variability at 470 nm (500 m resolution) and 1380 nm (1 km resolution), the details of which are given in Martins et al., (2002) and

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Levy et al., (2013)."

RC: P4 L26-28, aerosol type in DT is a location-time dependent prescribed type. AR: The sentence is re-written to reflect location-time dependent aerosol type feature of DT algorithm as,

"DT is essentially a look-up table search algorithm which combines the pre-calculated spectral reflectance of the location-time dependent aerosol models comprised of dominant fine and coarse modes with a proper weighting to represent the ambient aerosol properties over the target."

RC: P5 L1, how "best match" is found? AR: The sentence is re-written as,

"The weighted-average spectral LUT reflectance values are compared against the TOA spectral measurements of MODIS to find the best match in AOT yielding least square difference between simulated and observed reflectances."

RC: P5L13, here the ocean algorithm suddenly appears AR: The sentences have been simplified as,

"The expected error associated with the 3-km aerosol retrievals over land globally is found to be 0.01 to 0.02 higher than that of 10-km product (Remer et al., 2013)."

RC: P5 L18, there is no" AOT over vegetated" in Hsu et al (2004) AR: The sentence is now corrected as,

"...where the surface reflectance over land is relatively lower than that at longer visible wavelengths, to retrieve the column AOT over bright surfaces (Hsu et al., 2004) as well as vegetated areas (Hsu et al., 2013)."

RC: P5, L24 – 26, the dust screening should be mentioned AR: Additional information on dust screening is added as,

"The enhanced second generation of DB algorithm identifies mineral dust aerosols based on the brightness temperature difference between infrared channels 8.6 μm

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and $11\text{ }\mu\text{m}$ as dust often produces stronger absorption at $8.6\text{ }\mu\text{m}$ than that at $11\text{ }\mu\text{m}$ providing a robust way to detect strongly absorbing dust such as the silicates (Hsu et al., 2013)."

RC: P6, L3, "Hsu et al., (2013)" to "Hsu et al. (2013)" AR: Corrected.

RC: P6 L21, " $iC\leq 0.05iC\geq 0.15^*\text{AOD}$ " to " $iC \leq (0.05+15\%)$ ", and harmonize AOT, AOD in the manuscript. AR: Corrected. Also, we adopt aerosol optical thickness (AOT) terminology throughout the manuscript.

RC: P7 L3, refer to major comment 2, why version 2? AR: At the time of performing the present analysis (2016-2018), AERONET version 3 dataset wasn't published to the general public, and therefore not used. However, since now a complete version 3 data is available for use, we have re-performed the entire validation analysis using the latest AERONET v3 dataset.

RC: P8 L10 – 13, please check what the DT and DB retrieve? No AOT at 550 nm? AR: None of the three algorithms retrieve AOT at 550 nm. The DT algorithm retrieves and reports AOT at 470, 660, and 2130 nm, DB retrievals are available at 412, 470, and 660 nm, and MAIAC retrieves AOT at 470 nm and reports it at 550 nm.

RC: P9 L3 -5, why? AR: We believe that the overestimation in AOT shown by DT algorithm could primarily be due to the following few reasons: 1) inadequate characterization of surface reflectance, 2) choice of aerosol model, 3) non-optimum selection of 500 m resolution pixels, and 4) some minimal cloud contamination in the aerosol pixels (although it can't explain the totality of the overestimation). The main objective of the paper is to report the validation results instead of diagnosing the errors in detail. It is up to the algorithm development teams to analyze these results and figure out the probable causes of errors.

RC: P9 L6, what is "better statistics" and why better? P9 L10 – 25, again, why? AR: We meant here that the measures of comparison, i.e., RMSE, bias, and slope-intercept of

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satellite vs. ground AOTs, are relatively better or improved. For instance, lower RMSE, bias, and intercept against little higher ones.

RC: P9 L10 – 25, again, why? The authors need more explanations rather than simply list the statistics. AR: Regarding why better comparison, please refer to the response given just above.

RC: Section 3.3, refer to major comment 3, I think the authors need to use an independent surface product. AR: We have replaced MAIAC surface BRF database with MODIS standard MOD09 product to reproduce revised Figure 6 showing error characterization as a function of surface BRF. The original Figure 6 using MAIAC BRF is now placed under supplementary material.

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