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Interactive comment on "Defining aerosol layer height for UVAI interpretation using aerosol vertical distributions characterized by MERRA-2" *by* Jiyunting Sun et al.

Anonymous Referee #1

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The main focus of this paper is to assess if the aerosol layer height derived from the MERRA-2 aerosol vertical distributions is representative to the observed ALH that could provide long-term ALH retrospectively before the satellite retrieval of ALH is available. It also evaluates several ALH retrievals from OMI, TROPOMI, and GOME2. The evaluation matrix is the OMI UVAI that is a function of aerosol layer height and absorbing aerosol amount; if the ALH increases with the increase of UVAI and the magnitude of such increase is stronger with higher AOD, then the ALH product from either satellite or MERRA-2 is deemed robust or reliable. At the end, with five satellite products and four different definition of ALH calculated from the MERRA-2 vertical profiles, it concludes that products from TROPOMI O2-A band and GOME2 retrievals and the

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Discussion paper

MERRA-2 aerosol layer top height are the most suitable products for ALH.

General comments

I find this paper is interesting to show the differences between the ALH products and appreciate the thoroughness of the comparisons. I am also happy to see the MERRA-2 vertical profiles, which is largely simulated by a CTM, is robust enough to be representative of the ALH. On the other hand, I do have several concerns listed below that should be clarified/addressed before the paper is accepted for publication.

1. Different ALH products should be put into a context of the physical/optical meaning. As indicated in the paper, different products have different definitions. To help the readers grasp what they actually retrieve, it would be very helpful to have a reference dataset to indicate the vertical locations of these ALH. I think the CALIOP data can be used as such reference, i.e., the altitude of various ALH can be plotted on the CALIOP vertical curtain to show if the products represent the aerosol top, or the peak height, or optically weighted height, or something else.

2. It has been emphasized several times in the paper that the purpose is “to find an ALH data set for interpreting aerosol absorption from UVAI”. I wonder how can that be achieved from a “robust” ALH? UVAI depends not only the ALH but also the amount of absorbing aerosol in the atmosphere. It will be helpful to add a few sentences how aerosol absorption (e.g., aerosol absorption optical depth) can be obtained from knowing the UVAI and ALH.

3. It is not clear to me if the feature of altitude-AOD dependence on UVAI or the actual altitude is more important for interpreting aerosol absorption from UVAI? For example, the study finds three products, TROPOMI O2-A, GOME2, and MERRA-2 Ht are the robust products judging from their features of altitude and AOD variation with UVAI. However, the actual altitudes are far apart among the three: taking from Figure 2 and 5 in the southern hemispheric biomass burning season, the altitudes are 2-2.5 km, >10 km, and ∼4 km for TROPOMI, GOME2 and MERRA-2 Ht over southern Africa (similar

discrepancy in South America as well). How will you use these remarkably different ALH in retrieving the aerosol absorption?

4. Using AERONET to “quality control” the ALH from OMAERUV over ocean: This is very unclear. The paper identified that OMAERUV ALH is extremely high (without approve) so additional quality control is necessary. However, 1) AERONET data is overwhelmingly over land and it has only a few sites on the islands, and 2) AERONET data does not have any ALH information to be used to “correct” OMAERUV ALH. In that regards, CALIOP would be more useful, but it is part of the climatology of ALH built in the OMAERUV already. Also, I found that dismissing the OMAERUV ALH data is unnecessary.

5. The slopes in some of the figures (e.g., Figure 7, 10) looks very strange – they don’t go through the data points. Please confirm.

Specific comments:

Page 1, line 32: I would delete “occasionally”. Tropospheric aerosols are being transported across the tropopause over the Asian summer monsoon region regularly every summer.

Page 2, line 51-52, lidar data: True, lidar data are limited in spatial or temporal coverages, but for this work the statistics is the most important, not event-by-event. I strongly encourage to use the lidar data such as CALIOP, since you already used them for MERRA-2 evaluation.

Page 2, line 65-66 to Page 3, line 67: The sentence is recursive: AAH has become an official product of the GOME-2. . .that retrieves the AAH. Revise.

Page 3, line 82: How good is "good"? e.g., within x meters? within y%? To what extend the error is acceptable?

Page 4, MERRA-2: Just keep that in mind that MERRA-2 aerosol vertical profile is NOT a reanalysis product. Only column AOD is.

Page 4, line 128: Again, please avoid the subjective adjectives such as “good”. Be more quantitative.

Page 7, line 181-182: 366 days in 2016 x 100 profiles/day = 36600 profiles. Where is 401800 coming from?

Page 7, line 183: How did you change the vertical grid size in MERRA-2?

Page 7, line 187: I think the vertical grid is also denser near the tropopause in MERRA-2.

Page 8, line 214-215, “...Ht is better associated with AOD”, and Figure 2: I wonder why anyone should expect ALH to be positively associated with AOD. The common knowledge is that the transported plumes are lifted higher (i.e., higher Ht) but AOD is lower than those near the source region. In that regards, Ht makes less sense. It would be informative if you could plot the profiles over the source regions as well as over the transported regions (e.g., North Pacific, North Atlantic) for comparison. Figure 4 only shows the vertical profiles over the source regions. Profiles over open ocean will be helpful.

Page 9, line 271: “extreme” high ALH in Figure 5a over oceans: it should be “extremely”. How high is extremely high? Over ocean the ALH from OMAERUV is about 4 km. How does it compare with independent data?

Page 9, line 273: How is the over-ocean ALH determined in OMAERUV? Is most of them from CALIOP or CTM, or assumed according to aerosol type (thus may have high bias if UVAI is high-biased)? Besides, Fig 5b shows much lower UVAI over ocean than over land; how does the lower UVAI produce higher ALH over ocean?

Page 10, line 275-276, using AERONET data: I already stated that in my general comments.

Page 10, line 300+, and Figure 5: Fig 5d and 5g shows "extremely" high values of ALH with a good fraction of points above 10 km! Also, it seems that OMI O2O2 (5d-f) and

TROPOMI O2A (5g-i) are almost identical? This is a bit puzzling given the differences in retrieving methods, pixel resolution, and spatial coverage (e.g., row anomaly of OMI).

General comment for Section 3: It would be helpful to indicate the nature of these different ALH products from satellite retrievals, for example, it is more representative of top of the aerosol layer, or median, or optical centroid, or effective (give definition), etc.

Page 12, line 366: What is CMT – typo?

Page 14, line 418: "...are less variable" – I would say "...have little variation".

Page 15, line 428-429: Why are the AOD thresholds different for different ALH products?

Page 15, paragraph starting at line 30: The AERONET quality screen is only applied to the OMAERUV data over the ocean, right?

Page 15, line 434-435: This needs to be quantified - if you use the original OMAERUV data without AERONET screening, how much difference does it make?

Page 15, line 449 and 457: the products and websites are not consistent, e.g., product is MYD08_D3 but the website is MOD08_M3 in line 449.

Page 16, line 479: I don't understand the argument that R > 0.6 for OMAERUV is unrealistic. The ALH in OMAERUV is mainly from CALIOP climatology, or a CTM; the UVAI is only used for selecting aerosol type. And it is not clear how much help the screening with AERONET data helps for a better correlation; if this is the reason to not exclude the OMAERUV data, then just don't apply the screening.

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