

Interactive comment on “Minimum Aerosol Layer Detection Sensitivities and their Subsequent Impacts on Aerosol Optical Thickness Retrievals in CALIPSO Level 2 Data Products” by Travis D. Toth et al.

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Comment: The CALIPSO aerosol optical depth (AOD) for a particular profile is the sum of the extinction of various features identified as aerosol layers within it. Optically thin or diffuse layers may be missed due to detection limitations, leading to an underestimate of the total aerosol loading. The data product contains retrieval fill values (RFVs) when no aerosol layer is detected. Whether these are counted as zeroes or not when creating aerosol climatologies affects the results. This study builds on previous work to quantify the occurrence of RFVs and estimate, via comparison to MODIS and AERONET, what

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the missing optical depth in (daytime over-water) CALIPSO data as a result of this is.

This work is within scope for AMT and since CALIPSO is one of only two spaceborne lidar providing aerosol data (the other being CATS, which likely has similar issues for the same reasons), so understanding and correcting for biases, which some users may be unaware of, is unimportant. The authors do a thorough job and have a fairly rigorous approach. I recommend publication following minor revisions. I would be happy to review the next version, although a re-review may not be necessary.

Response: We thank the reviewer for his/her comments and encouragement.

Comment: A general comment is that the authors have done this analysis with data versions which are all becoming out of date around now (and this is something they acknowledge). For example CALIOP version 4 products are partially or fully released already (and are examined briefly in the paper in section 3.7); MODIS Collection 6.1 and AERONET version 3 are both available within the coming weeks or months. I agree with the authors' statements that this paper is a quantification of the problem and not the final word on the issue, but as some aspects of the data relevant to the analysis change in the latest data versions (e.g. CALIOP version 4 has improved a few detection and calibration issues, AERONET version 3 does a better job of screening out cirrus and not screening out smoke), rerunning the analysis with the latest data versions before final publication then that would be good to keep everything up to date. This is particularly relevant because AERONET, CALIOP, and MODIS all have fairly infrequent update schedules so these new versions are likely to be the latest for several years. Otherwise in the coming few years it may not be clear to readers how quantitatively transferable the results of this analysis are to the data products available at that time.

Response: We thank the reviewer for this suggestion. The reason for using Collection 6 MODIS, Version 3 (V3) CALIOP and Level 2.0 AERONET data is because these were the data sources available when we conducted the study. When the manuscript was in preparation for journal submission to JGR (where it was under

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review for over 4 months), the Version 4 (V4) CALIPSO products were in the process of being released. In anticipation of these new products, we added a section describing a two-month case study to check the frequency of occurrence of all-RFV profiles in V4 CALIPSO L2 aerosol data. We found only minor differences between V3 and V4, and therefore did not rerun the analysis with the new data. At the time of this writing, the Collection 6.1 MODIS data have just begun release. Still, checking the change log for over water Dark Target MODIS products (https://modis-atmosphere.gsfc.nasa.gov/sites/default/files/ModAtmo/C061_Aerosol_Dark_Target_v2.pdf), the only major change is the modification of the sedimentation mask, which is unlikely to make a significant change to the conclusions of the study. In addition, the MODIS Collection 6.1 data have been only partially released a month ago, and thus are not used in this study (<https://modis-atmos.gsfc.nasa.gov/>). Lastly, as we recently checked, the V3 Level 2.0 AERONET products are still not available for downloading (as of November 28th, 2017).

All of that aside, the point of the paper is not necessarily a quantitative evaluation of the current products on offer. Instead, our primary goal is a conceptualization of the problem, both for future missions and for science inquiries at high latitudes that rely on three-dimensional aerosol information (i.e., radiative forcing inquiries). Within that context, we consider our approach, the consideration of Version 3 and approximation of the effect within Version 4, wholly reasonable.

Comment: A second general comment is that the map projection used in mapped figures (e.g. Figure 3, but all of the maps) is a strange one. It distorts to give a disproportionately high weight to high-latitude areas, which is not only a comparatively small fraction of the Earth but the portion with fewest interesting aerosol features. For example the data gap resulting from Antarctica covers about the same amount of page space as the whole African/Asian dust outflow region. I suggest a better map projection is used. Even the regular equal-angle projection would be better, if not an equal-area projection. Otherwise the eye is naturally drawn away from these areas of most interest.

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Response: We agree with the reviewer that the current map projection distorts the high-latitude areas of the globe. We have created new Figs. 3, 5, and 7 with a new map projection (i.e., Robinson), and added them to the manuscript.

Comment: Line 186: For MODIS, I think it makes sense to use the data set Effective_Optical_Depth_Average_Ocean rather than Effective_Optical_Depth_Best_Ocean, as the 'average' solution is the one which is used to generate level 3 aerosol products (which are perhaps more heavily used than the level 2 products). There has not to my knowledge been much evaluation of the best vs. average MODIS ocean AODs, but Table 5 in Sayer et al (AMT 2012, doi:10.5194/acp-12-8889-2012), in comparison with limited ship-based data, suggests that the 'average' solution may have smaller bias and RMSE than the 'best' solution. That is relevant given the present study's attempt to use MODIS AODs to quantify the missing aerosol from CALIOP RFVs.

Response: Thank you for the suggestion. We have conducted a one-month (January 2008) case study comparing the 'best' and 'average' solutions for C6 MODIS AOTs, and found little difference between the two. For example, the mean MODIS AOTs for all collocated MODIS/CALIOP points are 0.118 and 0.122 for the 'best' and 'average' solutions, respectively. For only those MODIS points collocated with CALIOP all-RFV profiles, the mean MODIS AOTs are 0.088 and 0.092 for the 'best' and 'average' solutions, respectively. Thus, due to only minor differences between the datasets, we would like to leave the analysis as currently presented in the paper.

Comment: Line 196 (and also 425): It is true that AERONET data can suffer from cirrus contamination, but this is also true for the satellite products; perhaps an explicit mention of that is warranted. Related to my general comment, the AERONET team's presentations suggest this screening is better in AERONET version 3 than the version 2 the authors are using.

Response: We agree with the reviewer that mentioning this possibility should be stated

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in the paper. While CALIOP has the capability of detecting optically thin clouds, thin cirrus cloud contamination may exist in MODIS products. We have made the following changes to the text:

Modified a sentence in Section 2.2: “Also, thin cirrus contamination may exist in the MODIS aerosol products (e.g., Toth et al., 2013).”

Comment: Line 201: I believe the AERONET team like people to cite Smirnov et al (RSE 2000, doi:10.1016/S0034-4257(00)00109-7) when discussing the AERONET cloud screening and quality assurance procedures.

Response: We have added this citation to the paper.

Comment: Section 3.3: I wonder if this information about how collocation is achieved could be moved earlier in the manuscript. It is cumbersome to have results in Section 3.1 refer forward in the paper to a method in Section 3.3. Method description should come before results so the reader can understand what is done without having to flip forwards and then backwards again.

Response: We agree, and have moved the collocation description to Section 3.1.

Comment: Line 379: I am not sure why Ichoku et al (2003), which is about MODIS aerosol retrievals in Africa, is being cited in the context of limited over-ocean sampling at high ocean latitudes due to sea ice? This reference should be updated to a more appropriate reference, or removed (since almost all readers will know MODIS does not provide AOD retrievals over sea ice, and that sea ice is common near the poles).

Response: We have removed the reference.

Comment: Line 474: From the earlier discussion of MODIS, shouldn't this be 0.02-0.04, not 0.02- 0.03? Given the MODIS ocean uncertainty estimate for near-zero AOD ranges from -0.02 to +0.04.

Response: Yes. We have made the correction to the text.

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Comment: Lines 475-478: This sentence (known biases in V3 CALIOP calibration which have been addressed in V4) is another example why it would be better to update the study to use V4 CALIOP products instead. As the authors note V4 was released last year, and the authors include some CALIOP team members, so I don't understand why the study was performed and submitted using an outdated CALIOP data version.

Response: Thank you for the comment. When the study was originally designed and conducted, V3 was the current version of the CALIOP data. The V4.1 data were released in November 2016, and the initial version of this manuscript was submitted to JGR in February 2017 (where it was in review for over 4 months). We have checked a few months of V4 data, and found no major differences in our results between V3 and V4. Thus, we have left the analysis in the paper using V3 data, as the fundamental conclusions of our study remain unchanged.

Comment: Figure 6: It would be clearer to present this as one panel with three different colored lines (one per region). That would aid the reader in making the comparison between the different latitude ranges.

Response: We have made the suggested changes and inserted the new figure into the manuscript. The text and figure captions have been edited accordingly.

Comment: Table 3: The left column is quite awkward, especially as the descriptions require two additional subscripts in the caption to differentiate certain rows. Perhaps this can be redrawn as a set of check-boxes, i.e. check a box if non-all-RFVs are corrected, check another box if all-RFVs are set to zero, another box if all-RFVs are ignored, etc. That would more clearly and directly show the permutations. Also, the right column is somewhat redundant given it is just column 2 subtracted from column 3. Perhaps some additional statistics could be presented here.

Response: Thank you for this suggestion. We have made the recommended changes to the table (i.e., check boxes and included the standard deviations of each dataset).

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Paper cited:

Toth, T. D. and coauthors: Investigating enhanced Aqua MODIS aerosol optical depth retrievals over the mid to high latitude Southern Oceans through intercomparison with co-located CALIOP, MAN, and AERONET data sets, *Journal of Geophysical Research: Atmospheres*, 118(10), 4700-4714, 2013.

Interactive comment on *Atmos. Meas. Tech. Discuss.*, doi:10.5194/amt-2017-340, 2017.