Interactive comment on "The CALIPSO Version 4 Automated Aerosol Classification and Lidar Ratio Selection Algorithm" by Man-Hae Kim et al.

Anonymous Referee #1
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We thank the referee for their careful reading of our manuscript and their thoughtful comments. We have reproduced the referee's comments below (in black) and included our responses in-line (in blue).

Review: The CALIPSO Version 4 Automated Aerosol Classification and Lidar Ratio Selection Algorithm

Authors: Man-Hae Kim, Ali H. Omar, Jason L. Tackett, Mark A. Vaughan, David M. Winker, Charles R. Trepte, Yongxiang Hu, Zhaoyan Liu, Lamont R. Poole, Michael C. Pitts, Jayanta Kar, and Brian E. Magill

General comments:
The document clearly describes the steps taken in the algorithm and the changes made between the different versions, in that sense it is a very readable version of the ATBD and will be important for the users of the data to read. The paper is very lengthy but that is by no means a bad thing for this type of article which has to describe all the changes and the impacts of each.

I was very lucky to have a pro-active editor who made a large number of substantial comments resulting in a revised version before I had to go through the paper, making the task a lot easier. I will not add comments from my side which touches those discussions, knowing that some of the specific details have been looked at in detail. For the remainder the authors only need to look at some minor comments from my side.

I personally very much like the change in the concept in V4 of retrieving the subclasses for stratospheric aerosols and allowing the more general aerosols over polar regions. The main part which I am still wondering about is why the 1064nm channel provides you with no additional information in the troposphere. It is mentioned that within the PBL the color ratio does not help with the classification, however I did not notice a similar remark for the remainder of the troposphere. Please include a small discussion on why the color ratio has no impact on the classification in the troposphere since now only 2 of the three signals are used in this regime.
> The CALIPSO scene classification algorithm uses 1064 nm channel for cloud and stratospheric aerosols but not for tropospheric aerosol. It is mainly because low signal to noise ratio (SNR) for 1064 nm especially for aerosol layers during daytime. It might be available to use 1064 nm for some dense aerosol layer. But, the returned lidar signal is relatively weak for (faint) aerosols compared to cloud. In order to apply uniform criteria for all detected aerosol layers, the algorithm does not use 1064 nm for aerosol subtyping. We added some comments on this in the text (Sec. 2.1).

In a lot of places within the document the effects of the new Earth's Surface detection scheme (Vaughan 2018b) is discussed. Sadly enough I do not have a draft version available of this paper, making it impossible to understand the why's of any changes. There is enough information provided to 'trust' the results, so I will do without for this review.

Minor comments:
Page 2, Line 25: compare –> compared Line 26: Even though it is obvious please add V3 to CALIOP AOD
> It is corrected.

Page 6, Line 12: AOD differences
> It is corrected.

Page 10, Figure 5: would it be possible to overplot the Arctic PSC season (winter that year) to show that the -70 is consistent for both absolute high latitude regions.
> We updated figure 5 for the Arctic and Antarctic PSC seasons.

Page 14, Line 7: two releases. Also add a bit more information/origin on the 20 and 80km resolution
> It is corrected and simple explanation and reference are added.

Page 20, Line 4: demonstrates an
> It is corrected.

Page 21, Line 20: Can you explain the 31% quoted there. My guess is that it is the normalized values of 1.18 and 0.13 combined, but a bit more explanation here would make it a lot easier to comprehend
> We added 13% of newly introduced stratospheric aerosol in the text.

Page 22, Line 7: Add what the averaging boxes are 1 deg x 1deg ?
> We compared profile to profile for every Level 2 aerosol profile products which have 5 km x 60 m (5 km x 180 m for above 20.2 km) range bin. It is described in the second paragraph of Sec. 3.

Page 24, Line 2 : anan Line 13: give full name of AVD (maybe I missed it earlier) Line 18: WhileWhile
> They are corrected. The full name of AVD is introduced earlier in Sec. 3.

Page 24 Line19 & Page 30 line 15 : Remove correctly from 'correctly classified & correctly detected'. The word correct should not appear in this text as the absolute truth is not available. You can maybe use 'more realistically' or something like that if you would like to add an adverb. I agree that for surface detection one could consider it, however in the previous version the surface was also thought to be correct.
> They are changed from 'correctly' to 'realistically'.

Page 24 Line24: Rewrite sentence 'Similarly . . ..in V3'.
> The sentence is rewritten to make it clear.

Page 25,Table 5. Most of the work is a comparison between the two versions where we now have absolute values in this table. What is clearly noticeable is not only the change in mean value but also the larger standard deviations for the V4. Since we are looking at the 0, 1, 16 and 18 QC flags only, I would like to see the subdivision of the mean and std deviations for these four individual flagged pixels and see where the std deviation has increased most and a small discussion why. Please add the values for the four QC flags individually to the table.
> We note that the standard deviations (STDs) in table 5 are not related with their uncertainties. They show broadness (shape) of AOD distribution. Larger standard deviations (STDs) in V4 are strongly related to the AOD increase. If AODs increase with same amount for all data points, STD remains unchanged in V4 (only the mean will increase). However, if all AODs increase by 10%, for example, STD should also increase by 10%. (If σ is STD for x_i (i=0,1,2…n), STD for a x_i + b is aσ.) Below table shows % difference from V3 to V4 for both mean and STD. As shown in the table, the % differences for mean and STD are comparable. We thought it is expectable and there is no specific relation with QC flags for STD increase in V4. Thus, we didn't modify the text.

	Mean		Standard Deviation	
	Night	Day	Night	Day
V3	0.084	0.090	0.162	0.150
V4	0.128	0.126	0.242	0.202
Increased in %	52.4	40.0	49.4	34.7

Also, more detailed description about aerosol QC flags can be found in Young et al. (2018), another paper of our AMT special issue about the CALIPSO Version 4 updates. In Table 3(b) from Young et al. (2018), the majority of QC flags falls into QC=0 (95.32% for V3 and 92.97% for V4).
Young, S. A., Vaughan, M. A., Garnier, A., Tackett, J. L., Lambeth, J. B., and Powell, K. A.: Extinction and Optical Depth Retrievals for CALIPSO's Version 4 Data Release, Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2018-182, in review, 2018.

Page 30 Line 21: a decrease in the mean AOD
> It is corrected.

Page 32 Lines 27-29: The discussion is hard to follow, mostly due to the word smaller (I think). I guess you mean smaller in absolute value here or not. In any case please rephrase this sentence to make it crystal clear what you mean
> The sentence is modified to make it clear.

Page 34, Line 13: are now correctly classified as ! are more realistically classified as Line 19 : have been updated
> It is corrected.

Figure 17: By eye it looks like there are two distributions combined (heart shaped distribution) with one above and the other below the 1-1 line. Is there a reason for this, one day and the other night?
> The reviewer's comment is correct. The core (heart shaped distribution) is nearly parallel to 1:1 line, just above it. And minor branch is below (and right) the 1:1 line with the slope of <1. The former is mainly due to increase of the lidar ratio for clean marine and dust. As shown in Figure 13, (clean marine + dust) counts for ~60% of whole aerosol layers. Due to the lidar ratio increase for these two aerosols, CALIOP V4 AOD increases and the heart shaped distribution in Figure 17 located just above the 1:1 line. The latter corresponds mainly to dusty marine aerosol in V4. The most of dusty marine aerosols come from polluted dust in V3. Because the lidar ratios for polluted dust and dusty marine are 55 sr and 37 sr, respectively, V4 AOD decreases, shown as the minor branch in Figure 17.
This is a simple description, but in fact, it is much more complicated. We compared every single MODIS pixel with collocated CALIPSO data points, which means each collocated data pair is consist with one MODIS data pixel and 3~5 CALIPSO data points. Therefore, multiple aerosol layers with different types may coexist. Aerosol types may change from one to another or a new aerosol layers can be detected in V4. Because we averaged column AOD for collocated CALOPSO data points to compare with MODIS, it is difficult to separate those different contributions in Figure 17. Many figures and tables with additional analysis are needed for this discussion, and it is beyond the main topic of this paper.

Figures: The axes font-sizes of Figures 2, 3, 7, 8, 9, 11, 15 are extremely small, I think it would improve reading/glancing of the figures enormously if these would be increased.
> We adjusted figure sizes and font sizes.