Response to Anonymous Referee #1

We thank the referee for their helpful comments, suggestions, and for pointing out typos. They have helped improve the manuscript substantially. Referee comments and original text are shown below in black font. Responses and modifications to text are show in red font.

This paper outlines the methodology behind the CALIPSO Level 3 data product. A simple average is used to aggregate Level 2 profiles, with clear skies assigned zero extinction (rather than being omitted from the average). The quality control system is described at some length, identifying unreliable data by geometrical, statistical, and algorithmic means (e.g. aerosols found in unexpected locations, a maximal uncertainty on extinction, and QC flags, respectively). The spatial and temporal impacts of each filter are presented, demonstrating that these choices alter the final result but in a manner that is expected to be more representative of reality.

The paper is suitable for publishing with only typographical corrections. The many years that went into its development are evident from the depth and extent of the discussions. Every detail is rationalised (and I eagerly await their justification in the
upcoming validation paper). Some familiarity with lidar is required to completely understand some of their choices (e.g. the fact that negative extinctions should be retained is less well known that it should be but neither cited nor discussed here), but that seems fair given the paper's length and audience. The language and presentation are exemplary throughout.

I include only a few very minor comments and corrections. P1L2 means line 2 of page 1.

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§4.3 Considering aerosol properties tend to be log-normally distributed, have you explored averaging ln σ?

We felt a simple average would be appeal to a broad range of applications so we never explored averaging ln σ. We also believe it is important to retain the negative extinctions reported by CALIOP and "clear-air" extinction values of 0.0 /km in the average, which cannot be accomplished by taking the logarithm of extinction.

P11L8 This recommendation seems sufficiently novel and important to be worth mentioning in the paper's abstract.

Great suggestion. The abstract has been revised as follows, with new text in red.

> *The impact of quality screening on monthly mean aerosol extinction is investigated globally and regionally. After applying quality filters, the level 3 algorithm calculates monthly mean AOD by vertically integrating the monthly mean quality-screened aerosol extinction profile. Calculating monthly mean AOD by integrating the monthly mean extinction profile prevents a low bias that would result from alternately integrating the set of extinction profiles first and then averaging the resultant AOD values together. Ultimately, the quality filters reduce level 3 mean AOD by −24 and −31 % for global ocean and global land, respectively, indicating the importance of quality screening.*

Figs. 6,7 Larger tick lengths in these colourbars could be beneficial.

Done

P15L5 Add ‘the’ after ‘During’.

Done

P18L2 The peak of Fig. 13 looks nearer to 7 km than 6 to my eye.

Agreed. The text has been changed from 6 km to 7 km.

P19L3 Delete the first ‘the’ and ‘is’.

Done

P19L3 What motivated the choice of 4 km as a floor for this filter rather than, say, 5 km?

The following text was added to the manuscript to provide a rationale for the 4 km threshold. Within 4 ± 1 km, the choice is somewhat arbitrary. The intention was to choose an altitude which encompassed the bulk of aerosol retrievals and where we know that ice clouds also exist.

> *The 4 km altitude threshold limits the magnitude of error that would be made by rejecting legitimate aerosol in the lower troposphere where aerosol and clouds are more likely to coexist. For example, 95 % of all aerosol layers detected in 2010 are below 4 km (global). Meanwhile, 11 % of all ice clouds are also detected below this altitude. Ice clouds below 4 km are even more frequent at high latitudes: comprising ~22 % of all ice clouds at latitudes higher than 50° N/S in 2010. The global 4 km threshold thereby protects the majority of legitimate aerosols from being incorrectly rejected, albeit with the possibility of some remaining cirrus fringes at high latitudes.*

P21L15 There should be commas before and after ‘on the other hand’.

Done

P21L30 Add ‘the’ before ‘Antartic’.

Done

Fig. 15 Any idea why (b) is stripy when all the other fields shown have been fairly smooth?

The stripes in this figure occur at high altitudes, primarily over the Antarctic. This is because the number of aerosol samples is very low in these regions by several orders of magnitude relative to elsewhere (Fig. R1) which causes noisiness in the frequency calculation.

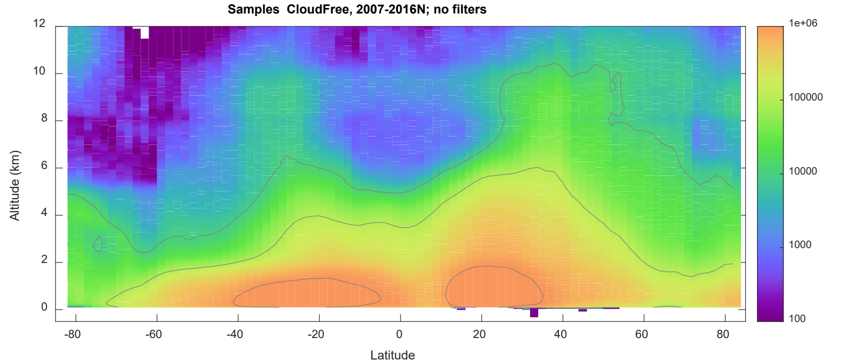

Figure R1. Number of aerosol samples for 2007-2016 at night, cloud-free with no filters applied.

P23L4 I'd word this, '. . . higher altitudes because there are more likely to be overlying layers.

Done. I like your recommendation.

P24L12 Delete the second 'or'.

Done

Fig. 19 If this image only showed the region in the red box, it'd be quite convincing. As it stands, my attention is drawn to the difference between the spatial patterns of the two panes outside of your box, especially near the equator, and how the filter slightly reduces AOD in regions where the NSA is uncommon.

These are good points. The difference in spatial patterns adds to the rationale for using the filter (it is hard to predict the influence of the NSA) while the reduction in AOD where the NSA is uncommon is worth emphasizing. We also want to note that the location of the NSA varies with season. The text has been revised in this section to reflect these issues (P24L9, P25L6 in original manuscript). The new text is shown in red below.

> *The NSA is intermittent, but tends to occur in sequences of adjacent profiles within latitude bands that vary seasonally.*
>
> …
>
> *An example of the impact of this NSA mitigation is shown in Fig. 19. AOD increases by roughly 5–10 % in level 3 profiles affected by the NSA (based on values > 1 within the red boxes) because strongly negative near-surface σ is rejected. Conversely, the NSA also is present in this example along the*

equator, and yet excluding these σ values does not increase AOD, illustrating the difficulty of predicting the influence of the NSA on retrieved extinction. AOD also decreases by roughly 5 % on average in unaffected regions, a consequence of this conservative strategy.

Fig. 22 Add ‘the’ before ‘extinction’.

Done

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§A.1 The aggressivness metric is new to me. Have you adapted it from somewhere or invented it? Also, does it ever happen that the filter both rejects many samples and sharply decreases the extinction, which could result in small Agr?

The aggressiveness metric was invented for this paper. Yes, this is possible, but in that case the filter was not particularly aggressive because it took rejecting many samples to decrease the extinction (even though it decreased by a lot). A small value of Agr would be appropriate based on this interpretation of “aggressiveness”.

P36L16 The page number for Koffi et al. 2012 is D10201.
P36L23 The page number for Koren et al. 2007 is L08805.
P38L20 The page number for Vernier et al. 2011 is L07804.

All three citations are now correct. Thank you.

• On three on my devices with different operating systems, equations at P15L19 and P33L1 are poorly rendered with overlapping symbols.

I will bring this comment to the attention of the AMT typesetting editor to ensure that these equations are rendered properly in the final publication. For your convenience, these lines are replicated below as screenshots.

The cloud-aerosol discrimination (CAD) algorithm evaluates five CALIOP observables to classify layers as aerosol or cloud: 532 nm layer-mean attenuated backscatter ($< \beta'_{532} >$), layer-mean attenuated color ratio ($\chi' = < \beta'_{1064} > / < \beta'_{532} >$), layer-integrated volume depolarization ratio (δ_v), latitude, and altitude. These five observables are evaluated against five

$$\int_0^{z_{63}} \overline{\sigma}(z)\,dz = 0.63AOD = 0.63\int_0^{12\,\mathrm{km}} \overline{\sigma}(z)\,dz \qquad \text{(A2)}$$

Here, $\overline{\sigma}$ is mean aerosol extinction and AOD is the total AOD integrated over the entire 12 km vertical extent.

• I believe the following should be hyphenated: P17L3 no-confidence; P18L11 and L13 high-confidence.

Agreed. The hyphens have been added.