

### ***Response to Referee 1***

My comment on the statement that “ALADIN is more susceptible to signal attenuation from CALIOP” is not appropriately addressed. This statement is not proven in the manuscript and the author's reply is not convincing. The statement cannot be made without support.

We thank the referee once again for their careful review of our manuscript and for the additional comments.

Following your suggestion, we have removed this sentence from the abstract.

### ***Response to Referee 2***

The authors have addressed all my concerns and the manuscript has been improved. The labels and legends of Figure 3, 6, 7 and 8 are still hard to be read. Please make them larger.

We thank the referee once again for their careful review of our manuscript and for the additional comments.

We have increased the font size in Fig. 3, 6, 7, 8. For the curtain plots in Fig 6 - 8, we implemented a cutoff for the specific latitude range of the plume, and display the VFM data only up to a ceiling altitude of 10km.

### ***Response to Referee 3***

Thank you for addressing my comments.

I suggest to crop the CALIPSO curtains in Figs. 6 to 8 to cover only those latitudes that are shown in the other panels of the respective figures and to reduce the altitude range to 10 km.

We thank the referee once again for their careful review of our manuscript and for the additional comments.

For the curtain plots in Fig 6 - 8, we implemented a cutoff for the specific latitude range of the plume, and display the VFM data only up to a ceiling altitude of 10km.

### ***Response to Referee 4***

The authors have done a huge effort and tackled many aspects of the 4 reviewers.

The manuscript is now much clearer and better understandable and has significantly improved. However, it has not yet its full potential. Therefore, I have still some open, minor comments mostly related to responses to my previous concerns.

We thank the referee once again for their careful review of our manuscript and for the additional comments.

- Linear vs. logarithmic plotting

Thanks for making this approach and providing the linear plots to this response.

However, I still believe, as well as reviewer 3, that the linear scale would fit much better to your manuscript especially as you do not focus on the very small backscatter coefficients! Furthermore, it is anyhow questionable how trustable these values in regions with such low aerosol content are as they are beyond the detection threshold anyhow. Thus, please really consider again, which scale you prefer and if it is representative with respect to your argumentation and research focus ( e.g. signal attenuation in strong dust plumes)!

IF you stay with log scale, you should at least plot CALIOP and ALADIN mean profiles in the same plot for comparison, e.g. as Subfigure c.

Yes, we added a direct comparison in linear scale for Figure 5(c).

- Me: In Section 6, important information is missing, e.g., on how the columnar AOD is calculated from Calipso profiles which obviously are not available down to the ground. Currently, the section is really misleading.

Authors: The CALIPSO column AOD is derived by integrating the 532 nm aerosol extinction profile from the 5 km Aerosol Profile Products. Importantly, we have excluded profiles containing fully attenuated bins. This detail has now been added to the last sentence in the first paragraph of Section 4 (updated Section number).

Me again: This is okay, but please state again that you exclude fully attenuated profiles and that in most time the marine boundary layer is not captured and thus the comparison to MODIS is per se biased to underestimation.

We rephrased the two sentences you pointed out in the new comments, to mention the marine boundary layer.

- Me: 297 „A noteworthy observation is that ALADIN persistently records an extinction coefficient higher by ~2 compared to CALIOP“ I do not see that in you plots.

Authors: Thank you for your comment. This is illustrated in Fig.7(e), specifically within the latitude ranges of 8° N to 14° N, and 20° N to 22° N.

Me again: That's the problem of the log scales - it is hardly seen...

Nevertheless, I think the wording "persistently" is not valid in this context, as you also show underestimation ins the same figure. Please rephrase !

We changed “persistently” to “frequently”.

- Me: Figure 9. Why do you not provide the Aeolus AOD as well?

Authors: In this case of an extreme dust event, a significant number of Aeolus profiles contain bins with missing extinction retrievals. Given Aeolus's 1 km vertical resolution within the dust plume, attempting to integrate the extinction to compute columnar AOD would introduce a substantial bias. Consequently, our focus in this analysis was on utilising Aeolus's lidar ratio to correct CALIOP's extinction and AOD retrievals, rather than on the direct use of Aeolus AOD.

Me again: This is logical. Correct. But still, It would have be interesting to see the AOD profiles even though comparison results might not be well.

We acknowledge the potential interest in Aeolus AOD values. However, due to QA flags on extinction retrievals and its coarse vertical resolution, in this case study the Aeolus data basically gives the layer-AOD rather than total column AOD. To avoid potential confusion in comparing with CALIPSO AOD, we have opted not to include these misleading Aeolus AODs in our analysis.

- Me: Line 343ff According to Figure 11, there are no extinction profiles below ca. 1.8 km. Thus, I was wondering how you did calculate the total AOD from Calipso? Did you interpolate? Did you just skip the lowermost altitudes? Please clearly describe.

Authors: The extinction is not zero below 1.8 km; merely  $< 1e-2$  as shown in Fig.11. The integration of extinction coefficients to obtain AOD has considered all altitudes down to the surface.

Me again: Nevertheless, it is in contradiction with reality as there is a marine BL below. Thus, please make a statement in text. It is still a bit unclear, what conclusion one can draw out of it with these biased extinction profiles.

Yes, we understand neglecting even low extinction values in the MBL (compared with the dust layer above), can result in underestimation of AODs. So as suggested in the new comment, we rephrased the following relevant sentence "It is this latter set of profiles that tends to yield AOD values consistent with those derived from MODIS observations, even though the marine boundary layer is excluded."

- Me: Line 34 „Space-borne lidars have the advantage of minimal aerosol loading between the instrument and the calibration region. “ .. I know what you mean with that, but a non-expert user will not understand what is meant there. Please rephrase.

Authors: This sentence has been rephrased as "Space-borne lidars often self-calibrate by assuming some section of the atmosphere lacks aerosol contamination, typically the stratosphere."

Me again: well, this sentence is confusing again and has now a different meaning, what about "Space-borne lidars are often calibrated in atmospheric regions for which a very low aerosol content is assumed, i.e., typically the stratosphere. One further advantage is, that in contrast to ground-based lidars, no significant aerosol contribution is expected between the space-borne lidar and this calibration region."

We have incorporated the suggested revisions for this sentence.

Line 197 of the tracked-changed-highlighted manuscript:

Please state here also the Aeolus Data Version (i.e., 2A11) when mentioning the CALIPSO version.

“(baseline 2A11)” is added.

Figure 5 ff: As a compromise, could you plot the mean of both instruments in linear scale as Sub-Figure c?

We added a direct comparison of two mean profiles in linear scale to Figure 5(c).

Line 378 Please add „...AOD underestimation cannot be attributed to lost retrievals from the dust’s bottom layer AND MARINE BOUNDARY LAYER“. In general, a bit more discussion on the

underestimation of CALIOP could be made. E.g. not only focussing on lidar ratio improvements but also discuss maybe on missing aerosol layers (marine BL etc.).

We added the potential of losing retrievals for MBL into the sentence.

Line 397 of the tracked-changed-highlighted manuscript: The lidar ratio is actually not derived from CALIOP, maybe „ read out from each individual CALIOP profile“ is better?

Agree. We replaced with a word similar to “read” – ‘extracted’.

Line 424 of the tracked-changed-highlighted manuscript:

You may add „...It is this latter set of profiles that tends to yield AOD values consistent with those derived from MODIS observations EVEN THOUGH THE MARINE BL IS EXCLUDED“

We added this into the original sentence.