Response to Referee 1

This manuscript presents the meaningful demonstration of the capabilities of ALADIN in retrieving aerosol optical properties, specifically the backscatter coefficient, extinction coefficient, and lidar ratio. The dust layers' lidar ratios used for CALIOP is also revised according the simultaneous measurements of ALADIN. The manuscript is well written and its contents are of high quality and scientific interest. The benefits of this study would be great for the accurate estimation of Aeolus and CALIOP aerosol data products. Hence, I recommend the acceptance of this manuscript after the necessary revisions.

We greatly appreciate the review and detailed comments provided by the referee. Our responses to the specific comments are as follows.

The specific comments are listed below:

- My main concern about the extinction coefficient/backscatter coefficient comparisons between CALIOP (at 532nm) and ALADIN (at 355nm) is their wavelength dependence. In this manuscript, the authors compare the aerosol products directly without any wavelength convert, even you mentioned it in line 244.

We recognise the limitation in comparing CALIOP (532 nm) and ALADIN (355 nm) due to their different wavelengths. Our study lacks simultaneous data for precise spectral conversion in the specific area and time. While using long-time averaged conversion factors from other experiments is an option, it carries the risk of introducing additional biases. However, as shown in Fig.4 to 7 there are discernible similarities in dust layer retrievals across both wavelengths. Importantly, in the Lidar Ratio and Extinction Retrievals Section, spectral conversion between 355 nm and 532 nm has been applied, allowing for more accurate comparisons of extinction coefficients and AODs at the same wavelength.

- Line 66: could you please give some more detailed comments on why the extinction coefficient is not affected by the misdetection of the cross-polar component?

The retrieval of the extinction coefficient is unaffected by the misdetection of the cross-polar component, as it depends solely on the transmission of light through the atmosphere regardless of polarization. In contrast, backscatter coefficient retrieval, which is dependent on the polarization of scattered light, is indeed influenced by any misdetection of the cross-polar component. For further detail and the relevant equations, please refer to Eq.6.44 for extinction and Eq.6.52 for backscatter in the L2A ATBD.

- Line 104-105: The authors should be aware that the horizontal resolution for Rayleigh channel and Mie channel is different.

Yes, we acknowledge the difference in horizontal resolution between the Rayleigh and Mie channels. To clarify this 87 km resolution is for L2A observation products, we added ".....which is defined as one basic repeat cycle BRC or 'observation'……".

- Line 120: Have the authors ever try to estimate the performance of the products from MLE? You mentioned the MLE method has positive effect on the products retrieve, however, why the Level-2 SCAmb products are applied in your study?

The enhancements of MLE largely arise from the imposition of positivity constraints on optical properties and the employment of a bounded lidar ratio. However, our study's primary objective is to compare the aerosol retrievals of the two lidars with different techniques. Therefore, we use the Aeolus SCAmb products for comparison. This allows us to directly compare the performance and outputs of these distinct lidar technologies. Specifically, the following sentence has been added to the manuscript:

"This approach allows a direct comparison of aerosol retrievals between two different lidar systems, focusing on the performance of the instruments themselves, rather than evaluating advancements in algorithms such as MLE.".

- Figure 1: why the temporal disparity of 9 hours and the maximum spatial difference of 200km are set as thresholds? Is there any physical basis for these selections? For example, wind direction? Air mass transport?

We have revised the collocation paragraph to better explain the selection of specific thresholds. This revision explains the original thresholds used in the collocation database, the narrower thresholds employed in Fig.1 for illustrating the global distribution, and the particular thresholds applied to filter data for the case study.

- The color bar in Figure 1 somehow misleads me. I suggest the authors may use the color bar oppositely, be like Figure 2.

We have now inverted the colourbar in Fig.1 to avoid any confusion and ensure consistency.

- Line 244: the spectral difference between 532 nm and 355 nm could be corrected somehow with the use of typical Angstrom exponent of dust. Have you ever tried to do this work?

We recognise the limitation in comparing CALIOP (532 nm) and ALADIN (355 nm) due to their different wavelengths. Our study lacks simultaneous measurements on Angstrom exponent for precise spectral conversion in the specific area and time. While using long-time averaged Angstrom exponent from other experiments is an option, it carries the risk of introducing additional biases. However, as shown in Fig.4 to 7 there are discernible similarities in dust layer retrievals across both wavelengths. Importantly, in the Lidar Ratio and Extinction Retrievals Section, spectral conversion between 355 nm and 532 nm has been applied, allowing for more accurate comparisons of extinction coefficients and AODs at the same wavelength.

- Line 312: what is the time difference between the measurements from MODIS and CALIOP?

Prior to September 2018, the time difference between MODIS and CALIPSO observations was typically just a few minutes. However, after September 2018 when CALIPSO adjusted its orbit within the A-Train (now referred as C-Train), this time difference increased. In the context of our

case study, the time difference is ~50 minutes. We have included this information in the caption of Fig.8

- The wavelength band that MODIS applied should be pointed out. Hence, we can figure it out whether the wavelength convert should be carried out. From this point of view, the underestimation may be solved.

We have revised the following section in include MODIS AOD wavelength (550 nm), along with the wavelength induced AOD difference at 532 and 550 nm:

"Figure 9 compares MODIS Aqua 550 nm and CALIOP 532 nm AODs for the scene depicted in Fig. 8(a). For this analysis, each CALIOP profile is paired with the nearest valid, cloud-free MODIS Aqua AOD observation. While the typical spectral difference in AODs at 532 nm and 550 nm is ∼3-6% (Kim et al., 2013), this difference is relatively small when compared to the larger discrepancies observed within the latitude range of 12◦ N to 20◦ N in Fig. 9. Given that CALIOP retrievals have already excluded vertical profiles containing fully attenuated bins, this AOD underestimation cannot be attributed to lost retrievals from the dust's bottom layer."

The technical corrections:

- Line 193: "the blue dots in (d) represent the footprint…" should be changed to "the blue dots in (d) represent the footprints…"

Corrected.

- Please provide the color bars' label for the green/blue gradients in Figure 4 and 5.

Colourbars have been added in Fig.4 (a) & (b), Fig.5 (a) and (b).

- Why there is only one red profile in Figure 4(a) and 5(a) between 12.5 km and 17.5 km? Is it because there is only one measurement case reach that height? Then I would suggest the authors provide the total numbers of measurements at different heights.

The red profile is the averaged value. Additionally, Fig.4(a) & (b), Fig.5(a) and (b) have been updated by adding the total number of measurements at the right margin of each subplot.

- It should be "Comparison of aerosol extinction coefficients…" instead of "Comparison of aerosol backscatter coefficients" in the caption of Figure 5. Please correct it.

Corrected.