We appreciate referee #1 for the comments and suggestions. We have answered all questions and revised the manuscript. We also modified figures 4, 14, 15, 16, so that the AEL-PRO figures come first, then the SCA-mid or CALIPSO figures. In this document, the answers are given in blue text.

The manuscript presents and discusses an algorithm that is used to analyze aerosol-related observations with ESA's spaceborne wind Doppler lidar AEOLUS. The unique methodology is originally designed to analyze EarthCARE space lidar observations (feature mask algorithm, aerosol profile algorithm).

The respective AEOLUS aerosol products are compared with observations performed with NASA's CALIPSO space lidar.

I clearly recommend publication.

I have only minor points

P5, L149: in Eq.3 we have … Ra … then in L150 we have … R_a …. please harmonize!

We have changed 'R_a' to 'Ra'.

P5, L156: In Eq.4 we have Ra_a,1 and so on. All this is a bit confusing!

Ra for effect area radius. '_a' refers to the a priori. Sorry for so many 'a' here.

P7, L197: To my opinion, a discussion of the findings in Figures 4 and 5 is missing! Please, explain the observed features, at least a bit! The paper should not only focus on technical and data analysis points.

For example, the feature in Figure 4 (0-12.5km, and 15-20.0km , -63.2N, 228.3E, winter, July 2019) is interesting, I mean this column-like red/yellow feature? What is it? Smoke? Volcanic aerosol at 15-17.5 km height? The lidar ratio seems to be around 50 sr at 355 nm. So that could have been smoke! The particles were probably spherical so that AEOLUS data can provide reliable lidar ratios.

The lidar ratios in Figure 4 are often in yellow (around 100sr). Is that always related to dust and cirrus features, and therefore related to the fact that the cross-polarized signal component is missing in the case of the AEOLUS observations?

In Figure 5, there is layer from 7.5-11 km height over North/Eastern Siberia on the way to Alaska. Is that a smoke layer? Please explain and discuss. In Figure 4 (on the right and left sides of panels), there are large areas with reasonable lidar ratios around 50 sr, all over Siberia (from the ground up to the tropopause, 40N-85N, 42E-210E). Is that related to the strong Siberian fires in the summer of 2019? The smoke particles were probably spherical and the cross-polarized signal component zero…, that may explain the reasonable lidar ratios (see the MOSAiC paper of Ohneiser, ACP, 2021).

We agree that we did not have discussions about Figs. 4, 5 and only used them to show the AEL-PRO retrieval algorithm. We have added some explanations about Figs. 4, 5 close to line 208.

"The lidar ratios in Fig. 4 are often in yellow (around 100 sr). This is mostly caused by dust and/or cirrus clouds, and related to the fact that the cross-polarized signal component is missing in the Aeolus observations. The orbit shown in Fig. 4 passed over east Siberia and north America at the beginning (0-9000 km) and the end (>42000 km) of the orbit. In these areas, the large extinction coefficients (yellow to red color) and lidar ratios of 50 – 60 sr indicate that the biomass burning smoke present from the ground surface up to the tropopause. In Fig. 5 the layer from 7.5-11 km height over eastern Siberia on the way to Alaska seems like a smoke layer. There were lots of wildfires in July 2019 in east and central Sibiera, consequently biomass burning smoke was transported to north America (Johnson et al., 2021). The lidar ratio values were reasonable, most probably because of the small depolarization ratio of these smoke particles as reported by Ohneiser et al. (2021). In the southern hemisphere close to -63.2 ◦N, 228.4 ◦E the high extinction coefficient features might be due to cirrus or PSCs."

P7, section 3.1: I would mention more often that the wavelength is 355 nm.

Be clear: The CALIPSO extinction profiles are computed (estimated) from the retrieved backscatter profiles. CALIPSO cannot measure extinction profiles.

Thank you for the explanation. We added the the following sentence in sect. 3.1.

'The CALIPSO extinction coefficient profiles are computed from the retrieved backscatter profiles, not measured directly. '

We added the wavelengths in the figure captions.

An Angstroem exponent of 0.55 is almost too high for dust, may be useful for marine aerosol, but is clearly too low for other aerosols (urban haze, smoke). However, you used 0.55 for all observations, right?

I am missing a bit a discussion on the uncertainty in the CALIPSO products caused by the Angstroem exponent assumption (0.55).

Yes, we used 0.55 for all observations. We added some discussions about the uncertainty in the CALIPSO products at the end of Sect. 3.1.

'We used one one Angstroem coefficient of 0.55 to convert the CALIPSO extinction coefficient from 532 nm to 355 nm, namely the CALIPSO extinction coefficient is multiplied 1.25. If we use Asngstroem coefficient of 0.1, 0.2, or 0.9, the CALIPSO extinction coefficient will be multiplied 1.04, 1.08 or 1.44, which could cause an uncertainty of < +/-20% compared to using the Angstroem coefficient of 0.55 . '

P10, Sect 4.1.2:

P10, L290: When comparing CALIPSO and AEOLUS observations please clearly state the wavelengths of comparison. It is always 355 nm, but the reader may not remember the content of section 3.1. One could provide such information in the figure captions.

Thank you for the suggestion. We have added the wavelengths in the figure captions.

Are the AEOLUS signals stronger than CALIPSO signals because the AEOLUS wavelength is 355 nm and the CALIPSO wavelength is 532 nm?

For molecular scattering, the wavelength difference leads to substantially more molecular backscattering and extinction at 355nm compared to 532 nm. For clouds not much difference is expected. For aerosol, the differences will depend on the size distribution and composition.

P12, L357: Monthly mean extinction coefficient… for the PBL? or for the entire troposphere?

Check and update the literature (preprint status may have changed).

The monthly mean extinction coefficient profiles are for the entire troposphere.

We have modified the sentence 'The monthly mean tropospheric extinction coefficient...' (close to line 389 in the revised manuscript). We have updated the references.

Figure 7 and 8, the text on top of the panels is too small. Mention wavelength in the caption.

The text on the top of panels are removed and the texts are moved in the caption. We did not add wavelength in the Feature mask figures because the features do not depend on wavelength. We added the wavelengths on the figures having extinction and/or lidar ratio.

Figure 9: Mention the wavelength in the figure caption.

We have added the wavelength in caption.

Figure 10: so many lidar ratios in yellow. Is the reason discussed in the main text body? Is that related to dust and cirrus?

The lidar ratio is an effective lidar ratio because there is only the co-polar channel. If the particles have a large depolarization ratio, the co-polar channel will have less signal than the total signal which includes both co-polar channel and cross-polar channel. So the effective S is typically larger than the real S. Cirrus and dust can have a linear depolarization ratio (depol) of 0.3, circular depolarization ratio depol_circ = 0.3*2/(1-0.3) = 0.86

beta_co = beta / (1+depol_circ)   beta_co is backscatter coefficient of co-polar channel

S_co = S * (1+depol_circ)

= S * 1.86

We explained the effective S in sect. 2.3 close to line 187

S in Figure 10 is explained in Sect. 4.1.2 line 327 - 333.

"Fig. 10(d) shows lots of large S values (in yellow color), which are mostly related to cirrus clouds and dust. We have analysed the distribution of S for dust at latitude 15–30 ◦N and height bins below 5 km, and for smoke at latitude 10–25 ◦S, height bins below 5 km. As shown in Fig. 11, the lidar ratios for the smoke and dust scenes have different distributions. The smoke lidar ratio has a peak close to 75 (72–78) sr but the distribution is rather broad from 25 to 120 sr. The dust lidar ratio has a large peak close to 54 (48-60) sr and a second peak close to 102 sr. In AEL-PRO the a priori of aerosol lidar ratio is 60 sr, depolarization 0.15. The retrievals are not sensitive to the a priori values. Floutsi et al. (2023) reported that the Saharan dust has the S of 53.5±7.7 sr and the depolarization ratio of 0.244±0.025, the effective S can be 1.646 times of the true S. The smoke has the S of 68.2±7.4 sr and the depolarization ratio of 0.027±0.013, the effective S can be 1.055 times of the true S. We think the lidar ratios in Fig. 11 are reasonable compared to the Sahara dust and smoke lidar ratios."

Figure 11: the lidar ratio distribution belongs to what height range? .

All altitude range below tropopause. We have replaced Fig. 11 because reviewer 1 found it confusing.

Figure 12: Mention the wavelength in the figure caption.

We have added the wavelength in the caption.

Figure 13: What is the message of the correlation? What is the impact of the assumed Angstroem exponent of 0.55?

A: The correction is small (presumably due to measurement error and real variability) but no large offset exists.

Based on DeLiAn paper, the Angström is 0.1+/0.2 for Sahara dust, 0.2+/- 0.1 for central Asian dust, 0.1+/- 0.1 for middle eastern dust, dust and marine 0.5+/- 0.5. Dust and pollution 0.7+/- 0.4.

The area we used in the analysis is main Sahara dust and dust and marine when dust over ocean.

So we used is close to dust and marine, if we use 0.1, 0.2, the CALIPSO ext at 355 nm would be smaller. The conversion factor is 1.25 to 1.08, 1.04.

We added the discussion in the revised manuscript in sect. 3.1

"We used one Angström coefficient of 0.55 to convert the CALIPSO extinction coefficient from 532 nm to 355 nm, namely the CALIPSO extinction coefficient is multiplied by 1.25. If we use an

Angström coefficient of 0.1, 0.2, or 0.9, the CALIPSO extinction coefficient will be multiplied by 1.04, 1.08 or 1.44, which could cause an uncertainty of <±20% compared to using the Angström coefficient of 0.55.”

Figure 14: The extinction values from 5-15 km are confusing. The tropopause for latitudes from 0-30N is probably around 15-17 km height. So, probably only tropospheric extinction profiles are shown? Why is the agreement of the different extinction profiles so bad for heights >5km? The background extinction coefficients in the clean upper troposphere (and lower stratosphere) should be around 0.75-1 Mm-1 at 355 nm and about 0.25-0.5 Mm-1 at 532 nm. Is again an Angstroem exponent of 0.55 used in the conversion of the CALIPSO data?

We only used the tropospheric extinction coefficients. Angström exponent is 0.55 for all conversions.

Figures 15 and 16. Do we need these figures?

We will keep the figures. They show the AOT map and the orbits and provide useful context