Reviewer 2

We would like to thank the Reviewer for his/her thorough report. Thanks to his/her constructive comments our submitted manuscript has been substantially improved. Below are given point-by-point replies (regular font) to the comments (bold font) raised by the Reviewer.

The authors perform an assessment of the SCA backscatter coefficient product from the Aeolus satellite by comparison to ground based lidar observations. They have split their work in two parts. First, an analysis of four dedicated, illustrative test cases is presented, including a creditable multitude of ancillary data that provides information on the aerosol origin and type. In a second part, all available collocation cases over the chosen lidar stations contribute to a statistical analysis of bias and RMSE, spanning the current mission lifetime. In lack of a cloud mask within Aeolus' data products, the authors efficiently filter the data themselves and can thereby show moderate to good performance of Aeolus backscatter coefficients. However, the findings suggest that particularly the retrieved backscatter coefficients closest to the ground are not reliable since they suffer from low SNR. The retrieved backscatter coefficient above the ground is biased due to surface reflectance. However, there are some substantial changes and clarifications necessary before publication of the work.

General (Major) Comments

I agree with referee 1 that the wording and sentence structure throughout the manuscript makes it often more difficult to grasp. That is particularly because of numerous insertions into the sentences, separated by commas or parentheses, and maybe a general trend for nouns over verbs. To provide only one example from L.468 "Under the prevalence of the Etesian winds (Tyrlis and Lelieveld, 2013), a typical pattern dominating over the broader Greek area during summer months, when winds blow mainly from NNE directions, anthropogenic aerosols from megacities (Kanakidou et al., 2011) and particles originating from biomass burning in the eastern Europe and in the surrounding area of the Black Sea (van der Werf et al., 2017) are transported southwards.". The main clause "Under the prevalence of winds [...] aerosols [...] are transported southwards." is stretched out too much.

We would like to thank the reviewer for his/her comment. We have revised the manuscript trying to "simplify" the text and reduce lengthy (or complicate) sentences.

Some parts of the manuscript seem not to contribute to or distract from the scope of the paper. Some sections or paragraphs could potentially be shortened or omitted, by asking who the audience of this work is. E.g. the second section with the Aeolus instrument description contains very general information that is mostly not used throughout the rest of the manuscript and can therefore be referenced (see suggestions in specific comments). Also, the conclusion can be made more compact by separating it into a conclusion and an outlook section, or can be condensed in other ways (also see suggestions in specific comments).

Please see our replies below in the relevant specific comments. As a short note, in most cases we have modified the manuscript as suggested by the reviewer.

It is good that the authors assess the aerosol climatology via the MODIS-Aqua AODs. However, the performed analysis of concentric circles seems not well suited for the assessment of the horizontal heterogeneity, see specific comments regarding L.351-366.

We have updated substantially this part of our work. Please see our detailed reply in the relevant specific comment.

Throughout most of the text, the authors do not differentiate between the performance of the Aeolus satellite itself and the performance of the retrieved SCA co-polar backscatter coefficient within the L2A product. This needs to be clarified, particularly since two significantly improved optical properties products are available as of March this year (see specific comments).

As it is explained below, we have modified the relevant parts as suggested by the reviewer.

The currently implemented collocation method appears to me to have an offset of about 45 km in flight direction, since only the start of a BRC but not its center location is used for the distance calculation to the lidar ground stations. If I did not miss something, this will need to be adjusted, making necessary to reanalyse the data and update the corresponding plots.

We agree with the reviewer that it would be better to use the coordinates of the BRC center instead of the beginning of the satellite scan. Nevertheless, this has an almost negligible impact in Thessaloniki and very small in Antikythera. On the contrary, in Athens, due to the "peculiarity" of the site such decision would exclude most of the matchups between Aeolus and ground-based profiles since ALADIN track resides near the edge of the defined circle. Therefore, we think that it is better to proceed with our initial approach trying not to reduce further the already limited number of cases and BRCs.

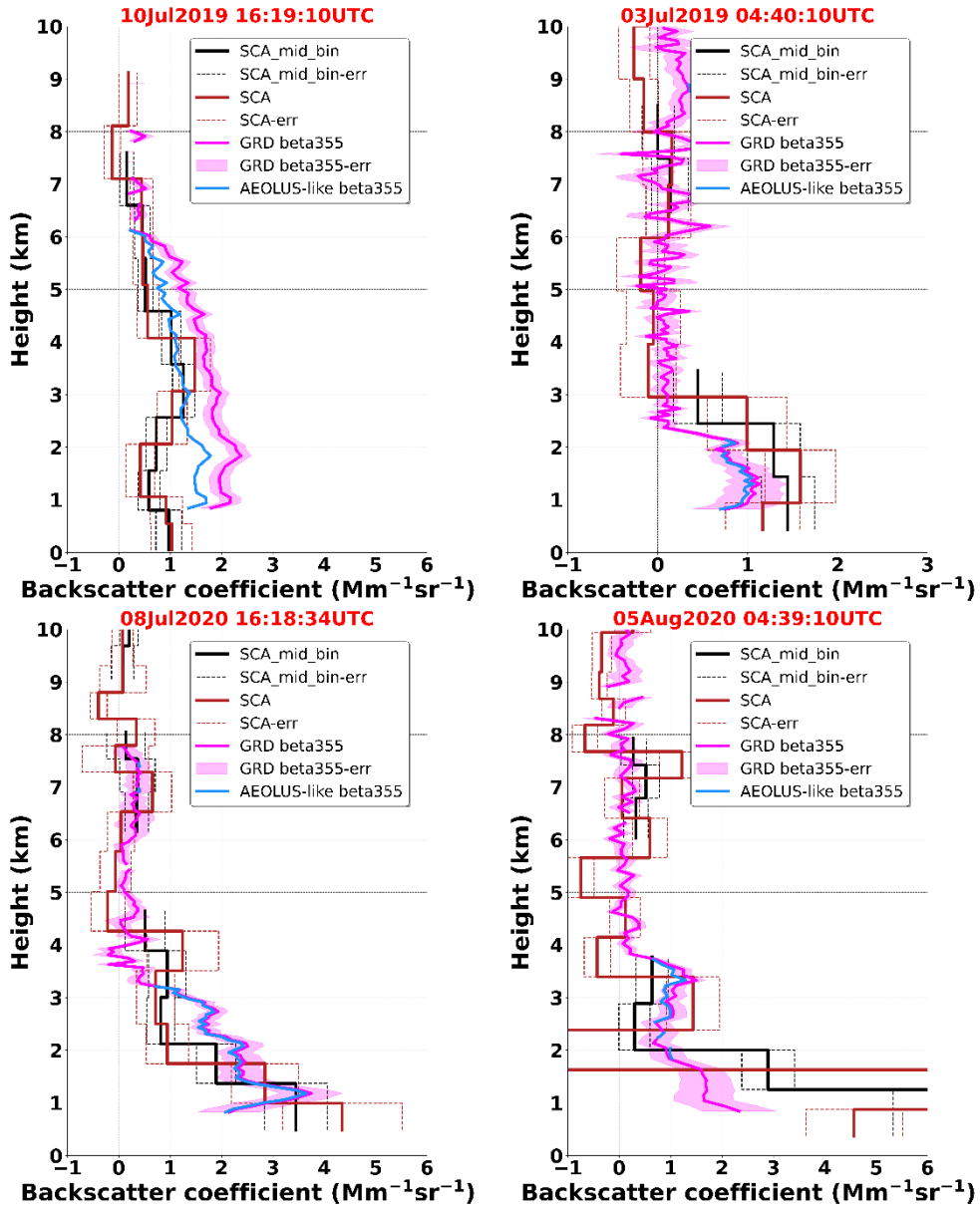
In order to illustrate how many BRCs are well spatially collocated with ground-based profiles, we are providing a table of all the considered cases denoting with green boxes the BRCs (either red or blue or magenta; see Fig. 2-iii) where at least half of its length resides within the circle whereas the opposite is displayed with red rectangles. The boxes with X symbol indicate that the corresponding BRCs do not satisfy the spatial collocation criterion. Overall, in 77% of the total number of BRCs (85) there is not any "impact" of which coordinates are used for the spatial collocation.

Case	Date	Station	Orbit	RED	BLUE	MAGENTA
1	06/11/2019	ATHENS	Dawn		**X**	**X**
2	18/12/2019	ATHENS	Dawn			**X**
3	15/01/2020	ATHENS	Dawn		**X**	**X**
4	22/01/2020	ATHENS	Dawn		**X**	**X**
5	13/05/2020	ATHENS	Dawn		**X**	**X**
6	20/05/2020	ATHENS	Dawn		**X**	**X**
7	01/07/2020	ATHENS	Dawn			**X**
8	15/07/2020	ATHENS	Dawn			**X**
9	22/07/2020	ATHENS	Dawn		**X**	**X**
10	29/07/2020	ATHENS	Dawn		**X**	**X**
11	09/09/2020	ATHENS	Dawn		**X**	**X**
12	30/09/2020	ATHENS	Dawn			**X**
13	03/07/2019	ANTIKYTHERA	Dawn			**X**
14	03/07/2019	ANTIKYTHERA	Dusk			**X**
15	10/07/2019	ANTIKYTHERA	Dawn			**X**
16	10/07/2019	ANTIKYTHERA	Dusk			
17	17/07/2019	ANTIKYTHERA	Dusk			**X**
18	24/07/2019	ANTIKYTHERA	Dusk			**X**
19	08/07/2020	ANTIKYTHERA	Dusk			**X**
20	29/07/2020	ANTIKYTHERA	Dawn		**X**	**X**
21	05/08/2020	ANTIKYTHERA	Dawn			
22	05/08/2020	ANTIKYTHERA	Dusk			**X**
23	12/08/2020	ANTIKYTHERA	Dawn			**X**

24	02/09/2020	ANTIKYTHERA	Dawn		**X**	**X**
25	16/09/2020	ANTIKYTHERA	Dusk			**X**
26	23/09/2020	ANTIKYTHERA	Dusk		**X**	**X**
27	24/02/2021	ANTIKYTHERA	Dusk			**X**
28	03/07/2019	THESSALONIKI	Dawn			
29	10/07/2019	THESSALONIKI	Dusk		**X**	**X**
30	24/07/2019	THESSALONIKI	Dawn			
31	07/08/2019	THESSALONIKI	Dawn			
32	04/09/2019	THESSALONIKI	Dawn			
33	18/09/2019	THESSALONIKI	Dusk		**X**	**X**
34	16/10/2019	THESSALONIKI	Dusk		**X**	**X**
35	23/10/2019	THESSALONIKI	Dawn			
36	08/01/2020	THESSALONIKI	Dawn			
37	15/01/2020	THESSALONIKI	Dawn			**X**
38	08/04/2020	THESSALONIKI	Dawn			**X**
39	06/05/2020	THESSALONIKI	Dawn			
40	13/05/2020	THESSALONIKI	Dawn			
41	10/06/2020	THESSALONIKI	Dawn			
42	01/07/2020	THESSALONIKI	Dawn			
43	22/07/2020	THESSALONIKI	Dawn			

Subsections 6.1.3 and 6.1.4: In my opinion, the descriptions and conclusions of the individual Aeolus lidar profiles in Fig. 3 may be much to detailed and flawed. I explain in my specific comment on L.502-503, that there is reason to believe that the discussed discrepancies are just noise induced and therefore the reached conclusions are not valuable or generalizable. I recommend the following procedure: As a first validation step, I encourage the authors to provide Figure 3 with all negative SCA backscatter values shown. This will provide an impression of the actual noise level encountered in the SCA backscatter in the different test cases. I expect to see values up to minus 0.5-1 Mm-1sr-1 in some cases in accordance with e.g. Fig. 8 in Ehlers et al. (2022, doi.org/10.5194/amt-15-185-2022). If that is indeed the case, then the discrepancies along the profiles may be mostly noise induced and the current, detailed conclusions must be reconsidered, i.e. the authors should test for the hypothesis and make accordingly changes to the text. In this case, especially the statement in the abstract L.41-43 "The level of agreement between spaceborne and ground-based retrievals varies with altitude when aerosol layers, composed of particles of different origin, are stratified (8th July 2020, 5th August 2020)." is contestable.

We have reproduced the plots of Figure 3 by decreasing the lower limit of x axis down to -1 $Mm^{-1}sr^{-1}$ thus visualizing negative backscatter coefficients. Following the reviewer's suggestion, we have modified accordingly the discussion in Sections 6.1.3 and 6.1.4 in the revised text.



Specific comments

L.38-43 This could be more compact, considering it is in the abstract. Particularly the discussion of the 4 test cases seems very specific and could be condensed into a shorter sentence.

We believe that this part is already short and compact. In the revised manuscript, we have slightly modified the text explaining that our results refer to specific cases. This is done in order to avoid any possible confusion that these findings can be "generalized" for the entire Aeolus L2A dataset.

L.41-43 The "level of agreement" is not strictly defined and, hence, seems subjective. In my opinion, this statement is presented too confident. In fact, this is concluded from two single BRC of Aeolus. The authors themselves stress the issues with collocation, so I am not convinced at this point that the remaining variations in the profiles are caused only by the stratification, but can originate from horizontal inhomogeneity of the atmosphere's aerosol load. The supplementary material helps only little, since the models provide AOD only.

We have changed this sentence in the revised text.

"*For the rest two cases (8th July 2020, 5th August 2020), due to noise issues, Aeolus performance downgrades in terms of depicting the stratification of aerosol layers composed of particles of different origin.*"

L.74-80 This sentence is too long and the last part seems not to fit in gramatically.

We have rephrased the sentence as follows:

"*Therefore, this deficiency hampers a reliable quantification of the suspended particles' load within the planetary boundary layer (PBL), related to health impacts. Moreover, it is not feasible to depict the three-dimensional structure of transported loads in the free troposphere, linked to aerosol-cloud-radiation interactions and associated impacts on atmospheric dynamics (Perez et al., 2006; Gkikas et al., 2018; Haywood et al., 2021). Likewise, passive aerosol observations are not suitable for monitoring stratospheric long-lived plumes that affect aerosol-chemistry interactions and perturb the radiation fields (Solomon et al., 2022).*"

L.82 "as well as the geometric features of the particle's layers" What are the "geometric features", if not the already-mentioned vertical structure? Please omit or specify.

The geometric features of the particle layers and the vertical (or three dimensional) structure of the aerosol layers have the same meaning. We think that we can use them in the text without confusing the reader.

L.94-115 This paragraph provides an overview of the L2B wind product development and application. Considering the paper's scope of aerosol backscatter assessment, I recommend to omit/condense it.

We have reduced the length of this paragraph.

"*On 22nd August 2018, the European Space Agency (ESA) launched its Earth Explorer wind mission, Aeolus. It is the first space-based Doppler Wind lidar worldwide, and was a major step forward for Earth Observations (EO) and atmospheric sciences. The key scientific objective of Aeolus is to improve numerical weather forecasts and to improve our understanding of atmospheric dynamics and their associated impacts on climate (Stoffelen et al., 2005; Isaksen and Rennie, 2019; Rennie and Isaksen, 2019). After about 1.5 years of instrument and algorithm improvements, the Aeolus L2B wind product was of such good quality that the European Centre for Medium Range Forecasts (ECMWF) could start operational assimilation (January 2020). In May 2020, three further European weather forecast institutes (DWD, Météo-France and the UK MetOffice) started the operational*

assimilation of Aeolus winds. All meteorological institutes reported that Aeolus winds had significant positive impact on the short and medium term forecasts, with the largest impact in remote areas less covered by other direct wind observations including the tropics, southern hemisphere and polar areas (e.g. ECMWF 2020; Rennie et al., 2021)."

L.116-128 This paragraph might be better placed in / merged with the second section about the ALADIN instrument.

We agree with the reviewer and we have modified the text as suggested.

L.169, Section 2; While reading this section I was reminded of other Aeolus related works. In fact, I was wondering whether the degree of detail is relevant for the audience of your manuscript, or if you could get away with a more high-level description of the Aeolus typical vocabulary only (as in the L2a user guide). Essentially, the information here can be looked up in the Aeolus Science Report or many other papers. But since your work focuses on validating the data rather than e.g. modifying the L2A processing chain or including so-far unknown instrumental effects, it may be a consideration to omit most parts for brevity.

We have reduced Section 2 in the revised manuscript.

L.192-194 It is unclear with which property the angle increases. Please make the formulation unambiguous by changing the statement to something like e.g. "The 35 degree off-nadir pointing corresponds to an angle of about 37.6 degree with the Earth surface, due to its curvature".

We have adjusted the manuscript according to the reviewer's suggestion.

L.205, Section 3; This description of the L2A data product is outdated at least with the start of the new baseline 2A14 from 29th March 2022. It has been decided to remove the ICA product completely and two new optical property products have been added, namely the SCA-MLE Optical Properties (Ehlers et al., 2021) and the AEL-PRO Optical Properties (from adjusted EARTHCARE algorithms). Both products are expected to bring considerable improvement over the SCA, since the inverse retrieval problem is solved not algebraically but via state-of-the-art methods (Maximum Likelihood Estimation, Optimal Estimation, respectively), see Ehlers et al. (2021) for the SCA-MLE product. These changes are tracked e.g. in the Aeolus Level 2a Processor Input/Output Data Definition available here: https://earth.esa.int/eogateway/documents/20142/37627/Aeolus-L2A-Input-Output-Data-Definitions-Interface-Control-Document Please give an adequate description of the data product, in order to put your analysis in the correct context. To my knowledge the Aeolus mission data has not yet been reprocessed with the new processors, which then offers potential for future studies.

We have updated Section 3 in the revised manuscript as suggested by the reviewer.

L.238 NITWT is not the name of the method, but the name of the variable that allows for simpler notation.

Thanks a lot for the correction.

L.243-250 This paragraph is a perfect introduction to then mention the SCA-MLE and AEL-PRO optical properties data products, which aim to mitigate such problems to a big part. A brief description could be added hereafter to update the section. It must be stressed that also the backscatter profits from the processing update!

We have followed the reviewer's recommendation.

L.250-252 This is not a primary reference for the zero-flooring. The primary reference is Flament et al. (2021) or the L2A Algorithm Theoretical Baseline Document, section 6.2.2.1, see here: https://earth.esa.int/eogateway/documents/20142/37627/Aeolus-L2A-Algorithm-Theoretical-Baseline-Document.

Thanks a lot for the correction

L. 351-366, Criterion for spatial homogeneity; The authors want a measure for spatial homogeneity of the atmosphere's aerosol load on an instantaneous base. However, the presented, concentric, climatological analysis is not suited for these needs for at least two reasons. Also, the description lacks some detail. The two main points below:

i) Figure 1 provides one AOD value per concentric circle and location. So the reader has to assume that in addition to the spatial average a temporal average over the 10 year period has been performed. This average is not mentioned in the text and the word "climatological" appears only in the figure caption. Therefore, the word "Annual" in Fig. 1i and 1ii is misleading.

In the revised manuscript we are clarifying better the averaging procedure both in spatial and temporal terms.

Now, averaging the AOD pattern over time will potentially smoothen out most of the horizontal heterogeneity of AOD that is present on a daily basis. However, the latter is the desired property in order to assess the quality of collocation. An (oversimplified) counter example goes as follows: Assume AOD pixels follow a chess board pattern (with changing locations over time due to wind). This would show a lot of heterogeneity, hampering collocation. But due to the two averages, one over the rings and one over time, the developed criterion would indicate perfect homogeneity.

We can understand the point raised by the reviewer. Nevertheless, the AOD pattern around a station cannot have a chess board structure. Depending on the station location and the prevailing meteorological/aerosol conditions the AOD in the vicinity of the station has "specific" spatial patterns, which can vary in temporal terms. Among the selected stations in the current study there is a clear contrast between Antikythera (background aerosol conditions) and Athens/Thessaloniki (urban aerosol conditions). This is quite evident in the urban sites where the AOD decreases rapidly for increasing radii. A critical point mentioned by the reviewer is the AOD variability in time and we admit that this aspect has not been appropriately treated in the submitted manuscript. In the revised text, we are presenting the coefficient of variation (CV) defined as the ratio of the standard deviation and the arithmetic mean (Anderson et al., 2003). CV expresses how much variable is the AOD, with respect to its mean value, in temporal terms. For completeness, we have also calculated the spatial autocorrelation (the correlation matrices are given in the revised supplement) among all the possible combinations of the defined circles. Since we are processing the MODIS swath data (they are not provided on a gridded structure) and we are selecting only AOD retrievals of best quality (QA=3) (many AODs have been discarded) we believe that it is better to work with the daily spatial AOD averages of each circle.

ii) Another shortcoming is the possibly very location specific outcome of this analysis: In my opinion, there is no reason to either favour Aeolus' frequent observation location or the ground-based lidar location as a center for the concentric circles. However, if the center was chosen e.g. 80 km away from pollution sources such as Athens or Thessaloniki, then their increased AOD pixels would be averaged with all pixels from a whole ring of unrelated locations, including ocean, meadows and villages 160 km away. This way, pollution sources will be hidden by averaging, if the circles' center is not coincident with them, making the presented analysis little robust.

Standard tools such as 2D autocorrelation functions of the AOD "images" would not suffer from such shortcomings.

We believe that the updated analysis addresses all the necessary aspects regarding the horizontal AOD variability in the vicinity of the PANACEA sites. Our spatial collocation criterion is the common procedure applied in numerous studies related to the evaluation of satellite retrievals. The station must be the center of the circle (or square) area. For the 2D autocorrelation, we think that the reviewer assumes that the MODIS

AOD data are provided in a gridded structure. However, this is not the case for the MODIS L2 AOD covering the swath sampled area by the satellite (5-min segment).

L.374 You take the beginning of the scan as the location of an Aeolus BRC, however, its middle is more representative as centerpoint of the measurement but lies about 45 km further away. When considering Figure 2(i), imagine now that by random chance, Aeolus had started scanning each BRC 5 km earlier. Then the BRC that is now red would not be considered in the analysis at all, though still closest. This means, your collocation criterion is currently offset by about 45 km in flight direction, which is quite a lot! This must be fixed and can be done, e.g. approximately, by applying the running average filter ([0.5 0.5]) over the current latitude and longitude arrays, or by assuming the satellites' speed and direction. Otherwise, the location of the center measurement within the BRC can be extracted from elsewhere in the L2A product, to the best of my knowledge.

Please see our reply above in the general comments.

Fig.2 The tips of the orange arrows are barely visible, please enhance.

We have changed the color of the arrows.

L.380-383 The collocation criteria should be objective, so please quantify by up to how much time they have been relaxed, another hour? 2 hours?

We have revised this part of the manuscript providing more details. Below is given the modified text.

"For the ground-based observations, the aerosol backscatter profiles are derived considering a time window of ± 1 hour around the satellite overpass. Nevertheless, this temporal collocation criterion has been relaxed or shifted in few cases to improve the quality of the ground-based retrievals (i.e., by increasing the signal-to-noise ratio) as well as to increase the matched pairs with Aeolus L2A profiles. Both compromises are applied since the weather conditions favoring the development of persistent clouds may eliminate the number of simultaneous cases. It is noted, however, when the temporal window is shifted or relaxed we are taking into account the homogeneity of the atmospheric scene (probed by the ground lidar). For the Antikythera station we did not deviate from the pre-defined temporal criterion apart from one case study. In Thessaloniki and Athens, the time departure between Aeolus and ground-based profiles can vary from 1.5 to 2.5 hours. Overall, 43 cases are analyzed out of which 15 have been identified over Antikythera, 12 in Athens and the remaining 16 in Thessaloniki."

L.395-397 When reading the manuscript, my burning question was, how many of the above mentioned cases/BRCs remained after filtering. I only found this information much later in the text. Could the authors please consider moving this information up here?

Please note that we are discarding cloud contaminated BRCs and not cases (i.e., days). We think that it is better to discuss the reduction of the BRCs in Section 6.2 trying to avoid any confusion to the reader.

L.408-410 Can the authors motivate here why explicitly these cases where chosen? Also, I wonder which criterion was applied to choose a single BRC out of each case, presented in Fig. 3. The spatially closest? The visually most representative? I presume that at least for one of the cases there was more than one BRC to consider.

There is not any specific criterion. These were the most interesting cases, typical in the eastern Mediterranean, from our collocated sample. Regarding the BRC, we are selecting the nearest one to the station coordinates that falls entire within the circle area.

L.442-444 The word "ideal" is exaggerated.

We have replaced “ideal” with “appropriate”.

L. 484-486 As the authors report themselves earlier, the backscatter coefficient in SCA and SCA midbin is essentially identical, just averaged onto two different scales. Hence, I do not support this argument of overestimation/underestimation and find it misleading. Also, with a quick look it seems that both are overestimating. Do the authors mean that the layer reaches too far up in SCA midbin? Please specify.

We have kept the word “overestimates” and we have removed the second parenthesis which might cause a confusion.

“*Under these conditions, ALADIN is capable of reproducing satisfactorily the layer’s structure (SCA retrievals - brown curve) whereas slightly overestimates its intensity with respect to the ground-truth retrievals.*”

L.502-503 This sentence is stated with a suggestion, while in fact the information should just be that Aeolus and PollyXT do not agree over the entire profile, and where. As you are well aware this mismatch can have various reasons but a lack of performance of Aeolus.

Below we are providing the rephrased sentence.

“*For this specific case, Aeolus’ performance reveals an altitude dependency according to the comparison versus Polly^{XT} vertically resolved retrievals.*”

In the following sentences, we are describing in detail the Aeolus-Polly^{XT} comparison results throughout the profile.

At this point I want to also mention, that the error bars on the L2A products are not found to be accurate, and hence suggest a wrong sense of precision, see the recent work of Adrien Lacour from Meteo France and e.g. Fig. 8 in Ehlers et al. (2022): In this test case, the MLE retrieval brings the optical properties much closer to the ground truth than SCA and SCA midbin. So the gaping disagreement between the SCA or SCA midbin and the ground truth is apparently due to noise in the cross-talk corrected particulate (Y) and molecular (X) signals (beta_p=Y/X*beta_m). The true magnitude of this noise can also be illustrated with the magnitude of the negative backscatter values in almost clear atmosphere, which unfortunately are not shown in Figure 3. However, Figure 6 gives a good idea of the spread of negative values in SCA, indicating a ballpark value of 0.5 up to 1 Mm-1sr-1 around the GROUND beta = 0.

We have reproduced the plots in Figure 3 showing the negative values as suggested by the reviewer and we have updated the relevant discussion in the manuscript.

Now, the discussion following in L.502 to 507 focuses entirely on the value of two Aeolus bins between 2 and 4 km altitude, the errors of which are most likely underestimated. However, the discrepancy with the ground truth is not much bigger than the approximate noise amplitude estimated from Figure 6 above. Therefore, it is very much possible that these discrepancies in just these 2 bins are indeed caused by noise! Therefore, it is not reasonable to generalize from these results an altitude dependent performance and to conclude a contradiction between the observations on such a weak fundament. This can only be done statistically.

The discussion between lines 502 and 507 focuses on the aerosol layers found between 6-8km and 2-4km. We have rephrased this part of the text. We think that in Section 6.1 it is clear that we are discussing each case individually and we are not “generalizing” our results. This is done in the statistical analysis presented in Section 6.2.

L.530-535 I see no to little reason to underline that SCA midbin is "better” in this particualar case. As you point out, SCA midbin has just worse resolution, which helps to reduce the mismatch here, because averaging consecutive bins also reduces the noise. This is no characteristic of this particular lidar profile

but follows from the math: In general, SCA midbin is worse at high SNR because of the resolution loss, but appears better in low SNR due to the additional smoothing that the average implies.

We have modified the text accordingly.

L.576-577 Can you specify how the ground profiles have been rescaled to match vertically the Aeolus bins? Were the ground-based observations averaged onto both different scales or simply sub-sampled? The latter is not preferred. Please provide an explanation or formula.

Thanks a lot for noticing our shortcoming. In the revised text we are clarifying how the rescaling is done.

L.579-585 The range bin index is a tricky reference to perform the analysis on, but I see the need for this implementation. However, it should be stressed in a separate sentence that, this way, one may mix up bins of e.g. 250 m size with bins of 1 km size, which have different noise properties. This is important for interpreting the reliability of RMSE and bias.

We agree with the reviewer but this is already mentioned in the submitted text (lines 579 – 581) as well as in Section 2.

L.586-596 Reading the text while looking at the figure, I cannot follow the choice of the authors to discuss the groups of bins 1-3, 4-12 and 12-23 separately. Can the motivation be explained? The bias and RMSE within the group 4-12 is anything but homogeneous.

The reason is that we are "defining" these groups based on the altitude (given into the parentheses) within the atmosphere. The first three bins reside within the PBL, from bin 4 to 12 we are in the free troposphere and the highest bins the upper/lower troposphere/stratosphere.

L.593 "the most important finding is that Aeolus is not capable to reproduce satisfactorily the backscatter profiles" I find this a bolt statement to make here. It is not Aeolus but specifically the current Aeulos SCA product in absence of cloud flagging. The cloud-flagged observations, presented some lines thereafter, let you draw a very different conclusion!

This is exactly what we want to show here and we believe that it is clearly stated in Section 6.2.1. In Figure 4, we are presenting the evaluation metrics for the Aeolus SCA raw (aerosols plus clouds) products and in Figure 5 the corresponding results for the SCA Aeolus cloud-filtered retrievals. Through this comparison it is highlighted the necessity of removing cloud-contaminated Aeolus profiles when compared with ground-based cloud-free retrievals. To summarize, we do not see which is the confusion here.

L.600-603, point ii); It is not motivated how increased noise causes bias in backscatter coefficients (I assume that "overestimation" is used synonymously to bias, if so, please use "bias" throughout the manuscript whenever appropriate). This is explained in Sec. 4.1 & 4.2 in Ehlers et al. (2022), so maybe reference here as well?

Done. Thanks a lot! We think that there is not any confusion between overestimation and bias. Both have the same meaning.

L.615 It should be already explained here, that this low positive bias is due to omitted negative backscatter values (this can be seen in the scatterplots), as you do later in L.662-665. To my knowledge, the corresponding L2A processor parameter has been adjusted so that negative backscatter values in SCA midbin are not just omitted in the newer baselines!

Done.

L.622-625 It should be made clear that this statement regards only the bin closest to the surface. Also, "level" should be replaced by "bias".

In the revised text we are specifying that these bins are close to the surface. We think that it is not correct to use the word bias here since we are discussing the RMSE levels.

L.644-646 I would not use the word contradiction. I can simply not be said based on metric 1,2 and 3 which product is "better". However, it should also be mentioned that the SCA midbin scatterplot contains less data due to the inherent flagging of negative values, see scatterplots, and hence the analyses are not strictly comparable. Also, the discussion whether SCA backscatter or SCA mb backscatter is "better" depends simply on SNR, as has been addressed in my comment on L.530.

We have modified the text accordingly.

L.672 please use "bias" as in Table 1, instead of "overestimation", in order not to confuse the reader whether or not these are two different statistical properties.

We have replaced the word as suggested by the reviewer.

Table 1&2; provide units!

Done.

L.668-678 This paragraph describes the statistics of the unfiltered data in detail. At this point, it has already been made clear to the reader that the unfiltered data is not suited for statistical analysis. Hence, Table 1 may as well be moved into the Appendix and may be kept for the sake of completeness, including a hint in the text. Instead, a bit more detail about the metrics for the filtered backscatter profiles would be appropriate in L.678-681.

We prefer to keep the initial version of the text and the Table 1 as is. We believe that our description is well stated.

L.722 What does "they" refer to?

We have rephrased the sentence as follows:

"*Over areas with a complex terrain, vertical inconsistencies between ground-based and satellite profiles (reported above ground where its height is defined with respect to the WGS 84 ellipsoid), not physically explained, can be recorded.*"

L.748 It's rather "SCA backscatter coefficients" to be specific.

Done.

L.763 Please specify and write "Aeolus' SCA backscatter product" instead of "Aeolus".

Done.

L.781-790 Partly repeats the cross-polar misdetection mentioned above in L.757. Also, this paragraph does not contain a conclusion from your analysis seems detached. It resembles more of an Aeolus-2 future mission outlook? Maybe move into a separate section "outlook", if the information is crucial in your opinion?

We have removed the whole paragraph in the revised manuscript.

L. 793-797 The content of this text should be moved into Section 3, since these products have been released already at the end of March 2022. Specifically, it needs to be clarified that not only the extinction but also the quality of the backscatter coefficients (especially precision) is significantly increased with the Maximum-Likelihood Estimation (MLE), making new Cal-Val studies worthwhile once there processed data is available.

We agree with the reviewer and we have modified the manuscript according to his/her comments.

L.804-810 This also reads as a mission outlook rather than as a part of your conclusion and may be dropped or moved into a separate section "outlook".

We prefer to keep it as is since in the last paragraph we are discussing the ongoing and future Aeolus related activities.

Technical corrections

L.230 Refer to the "C coefficients" as cross-talk coefficients as above. In general, using words as "so-called" and setting words in quotation marks should be avoided. It suggests little reliability.

Done.

L.241 "downwards", same comment as in L.230.

Done.

L.343 The formulation seems odd. Just write "in Section 5" and omit the part in parentheses.

Done.

L.369-370 This sentence is wordy/bulky. Better: "The Aeolus L2A backscatter profiles are compared to the measurements of three PANACEA lidar stations."

We think that our version is better than those suggested by the reviewer.

L.384 replace "rest" by "remaining".

Thanks!

L.481-483 The information in the parentheses is different from the information in the text (SCA vs. Ground and Ground vs. Aeolus-like Ground observations).

We don't see any mistake in this sentence. Probably there is a misunderstanding with the order of the colors in the parenthesis. In the revised manuscript we are mentioning first the pink (total backscatter) and then the blue (Aeolus-like).

L.586 This should be Fig. 4 instead of 5.

Thanks for the correction!

L.653 replace "not any" with "no".

Done.

Ref list: Ehlers et al. (2022) is not included though cited in the text?

Thanks a lot for noticing our shortcoming.