

Atmos. Meas. Tech. Discuss., referee comment RC2
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Comment on amt-2021-181

Anonymous Referee #2

Referee comment on "Aeolus L2A aerosol optical properties product: standard correct algorithm and Mie correct algorithm" by Thomas Flament et al., Atmos. Meas. Tech. Discuss., <https://doi.org/10.5194/amt-2021-181-RC2>, 2021

The paper describes in a short and concise way the algorithms for the retrievals of the aerosol and cloud product from Aeolus. It is thus very informative and valuable for the scientific community and therefore, in principle, well suited for publication in AMT.

However, I have some major concerns which need to be addressed before the paper can be published. The authors have done great work in developing the algorithms for Aeolus and updating calibration schemes, but the current presentation style of the paper needs to be clearly improved otherwise it is not understandable and thus publishable. Therefore, most of my comments are with respect to that topic.

General remarks:

The paper tries to make a compromise between extended algorithm description and concise information. This, however, was not successful all time. Especially, a lot of "Aeolus internal" language is used, which is not understandable for an external readers. Some examples are given below, but please check that everything is explained and clearly references so that a person with no access to the internal ESA pages can understand everything.

Furthermore, the main ESA documents which the authors reference on (e.g. the ATBD)

should be made available in a sustainable way. Currently they are published on an ESA webpage, but who knows if this is still the case in 1 or 2 years. Thus, please either put this important information on a repository where you can obtain a DOI (e.g. zendo) OR submit it as supplementary material.

Furthermore, while progressing with the reading the paper, the language style gets more and more sloppy and clearly needs to be improved (to be honest, one has the feeling it was submitted before it was really finalized, i.e. some sections are still in a draft-stage). E.g., the current conclusion is not sufficient and not appropriate for a journal like AMT. Also, the language itself is partly not scientific and still a lot of typos exist. Thus, this should be improved during the revision or language editing should be made by Copernicus.

In general section 4.1. and 4.2 has to be overworked. The explanations are partly insufficient and one has to guess many times what is meant....

References: The references given in the introduction and the paper are not up to date (one has the feeling the list is 2-3 years old). Meanwhile, some papers have been published, also dedicated to aerosol and cloud products, and should be mentioned. Some examples are given in the specific comments.

Figures: Please explain each Figure you use and what can be seen in this Figure. Currently, very often you draw conclusion from a Figure, but for an external reader it is not comprehensible/understandable because it is not sufficiently explained what is shown in the Figures. In principle, you need to explain each Figure in the text, and additional as a self-standing description in the caption. So that one could understand the Figure from reading the caption only, but also from reading the text only. Furthermore, please check which Figures you really need to make you message: "Illustrations should only be shown if they are necessary for the understanding of the paper, not because they have been created. "

Specific comments:

Line 26: "molecular photons" do not exist, I guess you mean photons backscatter by molecules.

Line 32: delete IN (after Calipso)

Introduction in general. Please review the current status of Aeolus (space lidar) related literature and add the important most recent references.

Line 35: Wrong naming in reference, it is OMAR et al and not Ali et al.

line 41: add "and" before nature

Line 52: Sustainable source for Flamant 2021 needed.

Line 66: Add "Fig." before 1 and 2. (do you need these figures?)

Line 79: "the top-most Rayleigh bin that must be above the top-most Mie bins" Please explain why and/or give reference.

84: "The shape of the optical filters is drawn in Fig. 3.". Language! What is shown in Figure 3 are the transmission curves for the different channels/filters.

86: " The figure shows that the Mie peak in the spectrum is significantly filtered out by the dual Fabry-Perot as it stands half-way between the peak transmissions of Fabry-Perot A and B, where the sum of the two transmissions reaches a local minimum." I assume that you reference now to the right panel of Figure 3. I took me quite some while to understand what you have written. You need to rewrite this paragraph adding more explanation. Please guide the reader to what is the "Mie peak". Explain all abbreviations in the Figures (e.g. what is TA and TB?) and use the line colour and style when referring to a specific curve to help the reader understanding.

90: "Overall, the efficiency of the Rayleigh detection chain for the photons backscattered by particles is about 50% of what it is for molecular photons, while it is 130% through the Mie detection chain." The current phrasing is very, very hard to understand. Please try to rephrase to make it clearer for the reader.

Figure 3: y-Axes caption on the right column missing. X-axis caption: What is 0? This is never explained. I now it is the difference to the emission frequency but you need to state this. Thus, it is not the frequency but the frequency difference/shift.

Line 99: L1B never explained. What is this, any reference? I think all, the L1B and L2A

ATBD and product description documents need to be published with a DOI from the current versions.

106: L1B derived scattering ratio is defined by the physical quantities. But how can this be done at L1B level?

107: Which pre-defined lidar ratio is used? - please state this here.

112: Please explain SNR and also please explain what "high" means.

112: Is the group product really limited to one BRC? I thought features are grouped on the basis if "measurements" independent of the BRC.

122: $S_{rie} \rightarrow S_{Mie}$

130: add "and" after the formula

133ff: As C1 to C4 are fundamental coefficients, the short explanation is not sufficient to me (as the reference given is a zip file only and no peer-reviewed document). Especially the adhoc calibration procedure (line 137) needs a short and concise explanation here. Also the uncertainties related to that should be briefly discussed: E.g. how good are your C1 to C4 determined and what happens if the calibration fails.

144: I guess you invert not only Eq. 2. but also Eq. 1? At least id did not understand how to achieve 7 and 8 by using only Eq. 2. Please also write inverted "to".....

Eq. 7 and 8: C_3 subscript for "3" missing

155: maybe rephrase to "the assumption is made that within the first bin no particles exist".

159: Eq 12: β_m needs subscript sim as well?

Line 167: What is x – it's not explained. In general formula 14 is hard to understand. Do the brackets behind H^{-1} correspond to x ? That is unclear for me. Probably it would be better to explain this formula in two steps or you simply do not use " H ".

Figure 4 is never referenced. I think this should be done as it is very interesting.

169: For my own interest: Did you ever estimate to what extent possible extinction above the first bin could influence the SCA? Is the normalization procedure probably more prone to produce high errors than a possible extinction above the first bin?

180: Please explain " $M1$ ". E.g.: "...the primary mirror (called $M1$)". But probably this is not needed. Do you have by the way any reference for that statement? E.g. during last ILRC, a lot of Aeolus presentations were made:

<https://www.epj-conferences.org/articles/epjconf/abs/2020/13/contents/contents.html> or even that manuscript: <https://amt.copernicus.org/preprints/amt-2021-171/> ?

188: Does it impact the retrieval or the calibration?

Line 190: Do you have any reference how "clear sky" is defined? I.e. which measures do you apply?

Line 196/197: What is meant with step 2 in Figure 5? It is not clear for me. More explanation is needed here.

Fig. 5: I think Fig 5, left is not useful to understand the paper. If you want to keep it, it must be enlarged, colour scale must be changed and much more explained. But from my point of view, Fig. 4 and Fig 5. (right) are sufficient. Nevertheless, it is surprising to see a big difference in Fig 5. left for the orbit averaged k and the $M1$ fitted K , while in the distributions on the right side it is obviously not the case. Can you explain? Virtually you have much more values around or above 4 for the orbit averaged K but this is not seen in the distribution (right panels).

206: please explain what "distribution" you mean. I guess you refer to Fig. 5 right, but you need to explain what is shown there.

211: "The fit being made.....": which fit? It is unclear for externals what is meant with all this. Please explain more solid in scientific language.

216: "L1B derived scattering ratio": Never explained. What is this?

Eq. 16: What is $\rho_{L1B,I}$? Is this the scattering ratio. What is the difference between a real scattering ratio and the L1B derived one. Need to be explained.

224: $T_{m,sat,i-1}$ is not in Eq. 17. Please correct.

228: Which lidar ratio did you use and why? This is an essential information.

228: How one can see a dust plume? Please indicate in Fig. 6 and maybe also put geophysical coordinates to Fig. 6 (as for the Calipso image or Fig.12).

Fig. 6: The size of this Figure is good as well as the color scale. Some more explanation is needed in the text: what are the white areas, why do the top of the profiles changes. Where has this curtain been made, etc.....

231-239: I am puzzled how I should deal with this information. So the ICA is kept in the data for historical reasons. But no development have been made. What does it mean? Shall I neglect the ICA? Same for the group product. A clear statement would be desirable. Or do not describe the ICA and group at all (maybe only in the introduction) as it is not used in your analysis. At least, in the current form it might be more confusing for the reader than providing valuable information.

245: As far as I know, ALADIN is not linearly but circular polarized....thus there is also no parallel direction....

245-247: Please put reference here. E.g. Ansmann et al., 2007; Flamant et al., 2008, or Baars et al. (2021).

255: Any reference for that statement that signals are weaker than expected as before launch? e.g.: Reitebuch,2020, ILRC or even directly in this special issue?

268: "See Fig. 7.": More explanation for Figure 7 needed. E.g. which plot in Fig. 7 is meant, what is shown there, etc. Just to refer to a Figure without any explanation what is shown there is not sufficient. Furthermore, many things shown in Fig. 7 are never discussed, e.g. backscatter *30sr...

274: Same as above but for Figure 8. E.g., Fig. 8, left is never referenced. And it is never explained what is seen there in general. Moreover, the panels should be enlarged to page width and been put over each other.

Eq. 18: most of the quantities shown in this equation are not explained, thus one cannot follow the argumentation and understand the formula.

Fig. 19: Same comment as for Eq. 18. Please discuss the equations or review if you really need to show them. I could not follow any of the argumentation from 277ff.

285: If you "lose" vertical resolution but also gain errors, why to use this method? I guess you mean lose resolution and decrease errors?

296: two times "presented", delete one of it.

299: E2S never explained, please do so when introducing the end-to-end simulation. Furthermore, what is the difference of the 20 simulation? It is not written here. If they are produced from the same input scene they should deliver the same results unless you alter some parameter. Which ones? what was simulated?

301: "Most of the time, the backscatter and extinction coefficients are correctly derived" how is this seen? What are you looking at?

Figure 10 and discussion: The current Figure is hard to read. It is 16 panels with 6 curves each. Do you really need all panels to make your statement? Maybe show only the most important. Please also explain all abbreviations and formula symbols. Why do you use log-scale for the backscatter and extinction values?

Maybe you could start introducing the reader to these kind of Figures by grapping one BRC and first explain in detail what is shown. Afterwards show the other BRC's and do your interpretations. But currently you ask too much from the reader to understand what you see in these plots.

302: "i.e. errors lie within the range of atmospheric heterogeneity" – how is this heterogeneity determined. It is currently a statement without proof.

303: "backscatter coefficients are also mostly correct" what does this mean, where it can be seen?

304: "The average of the 20 simulation overlap the expected values with a low dispersion meaning that one realization should be enough to characterize the atmospheric optical properties." I do not understand this sentence as I do not know to what you are referring to.

307: "In practice the vertical resolution of the bins is seldom below 500 m" has it ever be explained that the range-bin setting can be changed and is changed along one orbit? This is an important information....

299-309: The paragraph should be overworked in general. For me it was hard to understand to what the authors refer to when making a statement.

316: "The estimated errors are also too low and do not cover the expected values": How can I see that in the plot? Unclear for me.

319: "In this example," which one?

320: It has been never explained what a "useful" signal is.....

322: "bias is then propagated up to the calculation of the backscatter" what does it mean: propagated up to? Please check if you can find a proper peer-reviewed reference for CALIOP, e.g. Winker 2009

343: "determined by a threshold on the Mie SNR..." what is the threshold?

345: "reject low signal bins" please improve phrasing, what are low signal bins, bins with low signal?

346: "L2A valid lidar ratio" what does valid mean? I guess you mean that you applied the validity flags?

Figure 12: What you show is the co-polar lidar ratio, please indicate this in the Figure to avoid confusion. The blue and green frame is hardly seen. Can you use a different color?

347: "high lidar ratio values"...please indicate numbers – it is hard to see from the colors, e.g. 120 -140 sr. In my opinion you always should state that "only" the co-polar lidar ratio is measured, otherwise readers only looking at the plots may be really confused why the lidar ratio in dust is 2-3 times higher than normal. And you also should state what (co-polar) lidar ratio one would expect in mineral dust. Otherwise the reader is left alone in interpreting if Aeolus L2A data is useful...

350: You compare apples to peaches: Please state what lidar ratios (numbers) they have been measured (Mona and Nisanzi) and what you would expect for Aeolus taking into account the polar component. There was also a presentation by Wandinger showing that.

353: "A number of studies (Ansmann et al., 2003) have shown that light depolarization ratio of dust and marine particles mixture is significant." I do not understand this sentence.

358: In my opinion, you devalue Aeolus with no need. The lidar ratio is not overestimated taking into account the Aeolus capabilities. Even more, it is absolutely correct when considering the expectations, e.g., made in Wandinger et al. Thus, you might reconsider your statements here.

362ff and Figure 14: Is in my opinion not needed. First, it is "only" model data and therefore only an indicator, second it does not provide any additional valuable information. Thus, consider to omit this. If you consider it as very important, than much more explanation is needed.

As written before, the conclusion seem to be unfinished (i.e. still in draft stage) and are not sufficient in the current form. Please revise.

References:

Ansmann, A., Wandinger, U., Le Rille, O., Lajas, D., & Straume, A. G. (2007). Particle backscatter and extinction profiling with the spaceborne high-spectral-resolution Doppler lidar ALADIN: Methodology and simulations. *Applied Optics*, 46(26), 6606– 6622. <https://doi.org/10.1364/AO.46.006606>

Baars, H., Radenz, M., Floutsi, A. A., Engelmann, R., Althausen, D., Heese, B., et al. (2021). Californian wildfire smoke over Europe: A first example of the aerosol observing capabilities of Aeolus compared to ground-based lidar. *Geophysical Research Letters*, 48, e2020GL092194. <https://doi.org/10.1029/2020GL092194>

Flamant, P., Cuesta, J., Denneulin, M.-L., Dabas, A., & Huber, D. (2008). ADM-Aeolus retrieval algorithms for aerosol and cloud products. *Tellus A: Dynamic Meteorology and Oceanography*, 60(2), 273– 286. <https://doi.org/10.1111/j.1600-0870.2007.00287.x>

Reitebuch, O., Lemmerz, C., Lux, O., Marksteiner, U., Rahm, S., Weiler, F., et al. (2020). Initial assessment of the performance of the first Wind Lidar in space on Aeolus. *EPJ Web of Conferences*, 237, 01010. <https://doi.org/10.1051/epjconf/202023701010>

Wandinger et al., Validation of ADM-Aeolus L2 aerosol and cloud products employing advanced ground-based lidar Measurements (VADAM), ADM-Aeolus Science and CAL/VAL Workshop, 2015.

Weiler, F., Rennie, M., Kanitz, T., Isaksen, L., Checa, E., de Kloe, J., Okunde, N., and Reitebuch, O.: Correction of wind bias for the lidar on-board Aeolus using telescope temperatures, *Atmos. Meas. Tech. Discuss.* [preprint], <https://doi.org/10.5194/amt-2021-171>, in review, 2021

Winker, D. M., Vaughan, M. A., Omar, A., Hu, Y., Powell, K. A., Liu, Z., et al. (2009). Overview of the CALIPSO mission and CALIOP data processing algorithms. *Journal of Atmospheric and Oceanic Technology*, 26(11), 2310– 2323. <https://doi.org/10.1175/2009jtecha1281.1>