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Comment on amt-2021-181

Anonymous Referee #1

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-RC1, 2021

General comments
The manuscript under review describes the standard correct and Mie correct retrieval algorithms as part of the Aeolus L2A data products. It is a high-level summary of those algorithms, meant to introduce the most important aspects and to point readers to the more technical algorithm theoretical basis document. The text meets this objective successfully. The different algorithms are described with adequate detail to get a good picture of their inner workings. Ample evidence is given to justify algorithm decisions and retrieval behavior is characterized using simulated data and case studies using data measured in orbit. The manuscript is organized in a logical manner. There are some minor areas where the text could be clarified, and arguments made stronger. These are noted in the specific comments below.
The topic of the paper is relevant and important for the scientific community to understand the Aeolus L2A data products. It is accessible to a broad audience. The title is appropriate, and the amount of information presented is appropriate for the intentions of the manuscript. The abstract also contains sufficient detail, with only a minor amount of clarification requested. The conclusion section seems a bit too concise without much detail, but all relevant details already exist in the main text. Altogether, this manuscript is well within the scope of AMT and will be welcome asset to the scientific community. My specific comments below are to encourage more clarity in some areas, to make the language more precise, and to bolster a few arguments. These comments could easily be addressed with a minor revision.

Specific comments
Abstract: (optional recommendation) It would be helpful it the abstract mention that the standard correct algorithm and Mie correct algorithm are described in detail. That would help researchers know that this information is included based on the abstract alone.

We added the name of the SCA and MCA to the abstract.

Abstract, line 5: “the theoretical basis is the same as Flamant et al. (2008)”. Elsewhere the manuscript says that the processor has “substantially evolved” since Flamant et al. (2008) which seems at odds with this statement.

We reformulated the later text to say that the software evolved while keeping the same “core principles”

Line 94 suggests that “most of the theoretical basis is consistent with Flamant et al. (2008). Could these statements be made consistent?On a related note, the paper mentions “the processor” numerous times. Could some description of what this processor is be given in the main text? Is it meant to describe the code for the entire collection of L2A algorithms? Or just the algorithms

themselves? It seems like the terms “theoretical basis”, “algorithms”, and “processor” are used synonymously. Should they be?

We acknowledge that we sometimes mix up the term in our daily use and that was reflected in this paper. We trier to clarify the use:
the algorithm is used for the actual equations as described in the theoretical basis document, the processor is the software implementing the algorithms.

Abstract, line 5: The abstract is the only place in the manuscript where the version number (3.12) and baseline number are mentioned. This should probably be described in the main text as well. In fact, it would be helpful to describe what is meant by baseline in terms of the data production strategy for the mission.

We added the following paragraph at the beginning of section 2.2 “L2A product overview”.

As the processor evolves, its version number is incremented. This paper describes the processor version 3.12. The processor are then picked up by ESA and integrated to the processing facility. The configurations of this facility are labelled as baselines: each change of processor or major change in processors configurations would trigger an increment in the baseline number. This paper uses the L2A configuration for Baseline 12, which came into Near Real Time production at the beginning of 2021 and was released to the public on 12 May 2021.

Lines 124-125: What are the units of calibration constants K and C? Is this something that should be added to the text?
The C coefficients are unit-less.

The K coefficients are used to scale numerical signals, in “Least Significant Bit” or unit-less to the attenuated backscatters and the laser energy. According to equations 1 and 2, the K coefficients would have units of $m.sr.J^{-1}$.

Line 212: The phrase “full observation file” is a bit confusing, because an there are multiple “observations” (as defined by lines 70-71) in the file. Does omitting the word “file” and just using the phrase “full observation” make the statement accurate?

We replaced “full observation file” by “orbit file”, and added the following paragraph to explain what is meant:
“Data is downlinked from the satellite at two ground stations, in Svalbard and at Troll, Antarctica. This is reflected in the product files that are cut at the downlink time. Most of the files are full orbits, e.g. from Svalbard to Svalbard, but some file only cover half orbits, e.g. from Svalbard to Troll while others files cover more than one orbit. These are indiscriminately and improperly called "orbit" files within the Aeolus DISC consortium.”

Line 228: How does Figure 6 hint that the extinction is underestimated? If the fixed lidar ratio is supposedly too low and the lidar ratio in Fig 12 is biased high, then how do we know the extinction is underestimated? With figure 6 alone it is difficult to make the argument that the dust extinction is underestimated. Some more detail or a stronger argument should be given here.
The underestimation only comes from the fixed lidar ratio. We added: “(see Fig. 15 for comparison with the SCA lidar ratio)”

Figure 6: It would be helpful to draw a box or otherwise point out the dust plume. It is hard to see otherwise without some sort of annotation.
We wrote “The dust plume is located around BRC #100 at altitudes below 5 km” in the legend.

Line 253: “We will see that the original algorithm...” What is meant by the original algorithm? It is unclear what is being discussed here.
We replaced “original algorithm” with “SCA”.

Line 258: “The ATBD describes in detail how we can access the extinction...” Doesn’t this manuscript describe how extinction is retrieved? This sentence makes it unclear if the extinction being discussed in this section is from the retrievals already introduced in the paper or if there is some other extinction retrieval described in the ATBD that needs to be understood before reading this section. Clarification is requested.

We extended the sentence:
“The ATBD describes in detail how we can access the extinction within bin i from the available observations. The following section intends to give a physical understanding of the SCA extinction retrieval and its limitations.“

Lines 272-273: “This choice of thresholding has been largely discussed.” It is not clear how this sentence adds to the justification for using the threshold. Does this just mean to say that the choice was considered carefully?
We meant that there was still a debate whether it is the right approach. We removed the sentence not to confuse the reader.

Lines 275-276: “...that the SCA extinction...lacks sensitivity”. What is meant by sensitivity here? Is it the ability to observe weak features? Some more details on the statement would better help understand the limitations of the retrieval.
We rephrased this sentence. We changed “…. lacks sensitivty” by “is unable to detect extinction in bins with an optical depth lower than the cumulated optical depth above.”

Equation 18. Some details about this equation should be added, for instance, what are the definitions of the variables?
We better described what is discussed in Eq. 18 and 19.
“where $\sigma_{Lp,i}$ is the standard deviation on particles optical depth in bin i, and e_{Xi} is the error added by the observation X_i on top of the actual value X_i, modelled as $X_i = X_i * (1 + e_{Xi})$”

Line 285: “The loss of vertical resolution is compensated by a substantial gain in errors” Does a “substantial gain in errors” mean that there is a substantial improvement in errors? The word “gain” is ambiguous because it could mean that there is an increase in errors, in which case both vertical resolution and accuracy are lost. “Improvement” is clearer.
We replaced gain by improvement.

Figure 8 and line 288. The text argues that the SCA mid-bin retrieval is the best choice for extinction because it would eliminate the stripes in the right-hand panel of figure 8. It would be useful to show the same example for Figure 8, but with the mid-bin retrieval to demonstrate how it improves the striping.
The mid-bin retrieval doesn’t apply the threshold to keep extinction positive, there are not stripes.
We added the mid-bin retrieval to figure 8.

Line 342: What quality flags have been applied? Is it just the SNR thresholds discussed in the paragraph? If there are more quality flags applied then it would be helpful, especially for data users, to state which flags are used.
We rephrased as follows:
“The SCA lidar ratio in Fig. 15 is read from the mid-bin product and quality flags have been applied. According to these flags, the backscatter coefficient retrieval is considered as valid in a

specific bin if the Mie SNR is larger than 40 and the extinction coefficient is valid if the Rayleigh SNR in this bin is larger than 90. This allows for the rejection of the bins with low signal, for which background noise is large."

Lines 352-353: The text states that the lidar ratio appears higher than other lidar measurements due to because only the co-polar channel is measured by Aeolus. How much higher is it reasonable to expect the lidar ratio to be due to this? Is it meaningful to estimate the depolarization of the dust plume and the subsequent expected overestimation of lidar ratio? Is that outside the scope of this manuscript? It would instill more confidence in the retrieval to know that the overestimation of lidar ratio in this example is consistent with what is expected due to the missing cross-polar channel rather than some other retrieval artifact or calibration bias.
The explanation on the depolarization and its impact on backscatter measurement has been reworked and expanded. We also provided values for the conversion of the co-polar lidar ratio derived from Wandinger et al. (2015).

Line 366: What is the "basic cloud classifier"? Is that part of the L2A data products? The remainder of this paragraph relies on determinations of the cloud classifier and cloud mask, but sparse details are given on how it works. Adding a reference to more information about this classifier would help readers understand its limitations in this analysis.
This paragraph was removed along with the last figure presenting the AUX_MET data.

Section 5. The conclusions section is missing a summary of the algorithms discussed in the paper. Maybe this section is meant to be concise, but it seems incomplete. It would be more informative if it restated the main algorithms discussed and quantities retrieved. Even better, it would be helpful to state which of these retrievals are recommended for users. All this is in the main body of the text, so my comment here is an optional suggestion for the authors.
We added a short summary at the beginning of the conclusion and added references to future algorithms, assimilation work and a validation study.

Technical corrections
Line 32: Remove unnecessary word, "In", ..."CALIPSO In is an older lidar mission…" Done
Line 35: Reference should be Omar et al., 2009 instead of Ali H. et al, 2009 Corrected
Line 65: Should say, "depicted in Figs. 1 and 2." Corrected
Equation 2: Subscripts for S and K should be mie instead of rie. Corrected
Line 139: Extra parentheses at beginning of Dabas reference. Removed
Equations 7 and 8: Is the subscript "i" missing or was it intentionally ommitted? It appeared in equation 2. It was ommited to lighten the equation, the subscript was added for clarity.
Line 221: The subscript for molecular extinction in the equation for molecular attenuation is incorrectly given as "p" instead of "m". Corrected
Line 226: Should be "This yields..." rather than "This yield…" Corrected
Line 270: The word "is" is unnecessary..."the SCA extinction is only yields…" Removed
Line 276: Unnecessary parentheses at the end of this sentence. Removed