A Review of "Derivation and validation of a refined dust product from Aeolus (L2A+)" by Konstantinos Rizos et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/egusphere-2025-1175, 2025

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The paper is well structured and provides valuable insights into the potential of Aeolus aerosol data product Level-2A labelled Baseline 16 for the characterization of dust particles. Kindly consider the comments attached which may help clarifying some points.

General comments:

1) The study makes use of the extinction and backscatter coefficients for particles retrieved by the Aeolus Level-2A AEL_PRO algorithm which is initially provided at measurement level ~ 3 km horizontal, and averaged onto the coarser resolution BRC ~ 90 km to be compared with BRC-level retrievals from SCA and MLE algorithms. But the principle of AEL_PRO profiling using optimal estimation and features identification may induce deviation in their horizontal neighbooring (Wang et al., 2024). Therefore, any variability happening in the consecutive 30 measurements of AEL_PRO are not considered here right ? Did the authors take a look at some heteroegenity indicators per BRC ?.Are the statistics impacted when using 1st, 15th or last AEL_PRO measurement profile instead ? And what if a localized cloud is detected , e.g. by the 20th measurement : is the entire BRC flagged as cloud contaminated condition, or is the averaging still perfomed between 1st and 19th measurement ? Kindly clarify.

2) The study makes use of a cloud screening method derived from Aeolus Level-2A AEL_FM and CLAAS-3/SEVIRI. It is described as a complex method, which is not straightforward because of the measurement level ~ 3 km of AEL_FM compared to coarser horizontal BRC ~ 90 km for SCA and MLE. The L2A product labelled Baseline 16 includes a ready-to-use cloud mask for SCA and MLE (ATBD, Flamant et al., 2022), given at BRC level and based on ECMWF model, i.e. using cloud liquid water content and cloud ice water content and implemented by L2A processor version 3.13. Can the authors clarify why they have not selected it ? If some tests have been performed, a short paragraph describing the outcomes may be added to the text.

3) Aeolus only measure the co-polarized backattered light, therefore underestimating the total backscatter for highly depolarizing particles such as Saharan dust. In the text an underestimation factor of ~ 33 % is mentionned for pure dust (line 128). But when looking at Fig. 10 the L2A+ total backscatter do not seem significantly increased accordingly, even after removal of cloud contaminated bins and dust-free bins. Could the authors discuss further this point ? Is it because of a lower computed circular depolarization ratio than expected for pure dust ? Is the linear particle depolarization ratio value of 0.244 applied for Saharan dust with Eq. 3 in cause ? The selected continuous linear colormap may also play a role. Kindly consider adjustment of colormap to better highlight the increase, or adding difference map in appendix.

4) The study relies on both the circular depolarization ratio at 355 nm derived with Eq.3 from the data collection DeLiAn, and aerosol typing method based on CAMS reanalysis products. The depolarization information then appears crucial to derive the L2A+ total backscatter, and to confirm the occurrence of irregularly shaped particles such as Saharan dust. But no tables or values of both the circular and linear depolarization ratios at 355

nm can be found in the text. Can the authors share some estimations, at least for the pure dust case of 3rd September 2021 which is illustrated in Figs. 9 - 10 ? Moreover, showing any collocated measurement of volume circular an linear depolarization ratios with Aeolus direct overpasses would be valuable as ground-truth . Are such profiling available from the instruments Polly^{XT} and EVE lidar ? If yes, kindly consider discussing it, or possibly showing the profiles on 3rd September 2021. Highlighting which Aeolus profile is the direct overpass above the instruments, i.e. above Mindelo, Cabo Verde would also be a plus for Figs. 10-11.

5) The L2A products labelled Baseline 16 include Quality Checks (QC) flags for SCA, SCA-MB, and MLE (ATBD, Flamant et al., 2022, and User Guide, Trapon et al., 2022). These flags are of high relevance, especially for noisy signals derived with the SCA in low Signal-to-Noise regions and for MLE in low altitudes below 2 km. Could the authors clarify if these quality flags have been applied to the signals ? If not applied, is it because bins removal and the will to keep as many valid bins as possible before cloud screening ? A few lines discussing this point can be added to the text, at least saying that ready-to-use QC flags are included in the L2A product.

6) The L2A products labelled Baseline 16 include newly implemented MLE processed at finer horizontal resolution sub-BRC (MLEsub) which was implemented in L2A processor version 3.16. Each sub profile corresponds to 6 accumulated measurements with September 2021 settings. A BRC is then filled with 5 MLEsub sub-profiles .If considering the comments 1), it would be interesting to reproduce the study looking at MLEsub versus AEL_PRO ; the averaging for AEL_PRO being then less prominent and possibly impacting the cloud screening. Kindly consider mentioning this open point into the *conclusion* section, or eventually within a *code and data availability* section.

Specific comments:

Line 104 *"...through the independent estimation of the the volume extinction and co-polarized volume backscatter coefficient..."*. This is because the ability to seperate the contributions from molecules and particles with the two channels. It can be mentionned here as well (it is mentionned later in the paper by section 2.1 line 188).

Line 106 *"…from two different spectral channels (Ehlers et al., 2022)…"*. Kindly consider (Flamant et al., 2008) instead.

Line 116 *"…reprocessed in Baseline 10 (B10)…"*. Kindly consider rephrasing, i.e. *L2A processor version 3.10, referred as Baseline 10 (B10)* .

Line 124 *"…underestimation of the order of 18% of the Aeolus-like backscatter…"*. What does *Aeolus-like backscatter* mean ? Do the authors refer to the underestimation of the total backscatter ? Kindly clarify.

Line 187 *"…cross-talk coefficients…"*. The principle of the *cross-talk* correction, i.e. seperation between lidar signal contributions from particles and molecules for vertical matching between Rayleigh an Mie channels, can be mentioned here.

Line 188 *"…and molecular and particulate contributions to the signals…"*. The reference papers (Flament et al., 2020 ; Flament et al., 2021) can be added.

Line 507 *"…To address this issue…"*. Would *limitation* be more suited than *issue* ?

Line 619 *"…L2A backscatter coefficients from the three retrieval algorithms exhibit unreasonably high values, primarily due to surface-related effects (Abril-Gago et al., 2022)"*. The statement can be complemented with *", and positive bias by optimal estimation based MLE in low altitude regions below 2 km."*. A possible reference for Level-2A product quality assessment from 4th reprocessing effort and labelled Baseline 16 is available at *https://earth.esa.int/eogateway/documents/d/earth-online/aeolus-summary-reprocessing-4-fm-b-disc-2024-04-30*.

Figures 9-10-11 If considering high dust fraction up to ~ 70 % between ~ 10 km altitude and ~ 16 km altitude between profiles [-21.87°E, 0.38°N] and [-25.28°E, 18.62°N] on case 3rd September 2021 in Fig. 9b, why do we see only white background for the corresponding regions in SCA and MLE retrievals in Figs 10-11 ? Does that mean fully cloud contaminated bins which were then removed, or invalid SCA and MLE ? But SCA and MLE products do not seem too much attenuated below this regions, then between ground and ~ 10 km...The flagging method including dust-free removal and cloudy contaminated bins is difficult to apprehend for such regions. Are there any other quality flagging applied here ? Is it because unrealistic dust fraction by CAMS ? Kindly clarify.

Figure 11 Kindly consider changing the colormap to be able to visualy compare the low dust mass concentration (i.e. below 150 $\mu g/m^3$) from the suroundings.

Figure 11 The DEM intersection is visible for pannels Fig. 11a-c-e-g but not for pannels Fig. 11b-d-f-h. This may be linked to a linewidth adjustment. Kindly consider re-generation of the figures.

Figures 12-13 The vertical profiles and errors in dashed lines are hardly dinstinguishable. Kindly consider 2x2 pannels with increased size instead, and possibly reducing the xaxis top limit of backscatter coefficient. Moreover, kindly consider other color combination than red-green to get colorblind-safe color scheme.

Figures 14-15 Kindly consider adjustment of yaxis and xaxis to lower values (e.g. 6 or 8 $Mm^{-1}sr^{-1}$) for better readability.