Response to Referee Comment (RC1) on

Five years of Aeolus wind profiling: global coverage and data quality

*(*https://doi.org/10.5194/egusphere-2025-4596*)*

We sincerely appreciate the referee's insightful and detailed comments on our manuscript. Below, we provide responses to each comment along with the corresponding changes made to the manuscript.

General comment:

Is a similar in-depth analysis on the L2A dataset (aerosols) forthcoming? I think such a study would be an important complement to this one.

Response to General Comment:

Thank you for this comment. We fully agree that a similar study on the Aeolus L2A aerosol product would be useful and relevant for the wider scientific community using these data. Currently, no preparations are ongoing for such an analysis. However, several publications address the Aeolus L2A product and the algorithms applied in the L2A processor, for example:

> *Wang, P., Donovan, D. P., van Zadelhoff, G.-J., de Kloe, J., Huber, D., and Reissig, K.: Evaluation of Aeolus feature mask and particle extinction coefficient profile products using CALIPSO data, Atmos. Meas. Tech., 17, 5935–5955, https://doi.org/10.5194/amt-17-5935-2024*
>
> *Ehlers, F., Flament, T., Dabas, A., Trapon, D., Lacour, A., Baars, H., and Straume-Lindner, A. G.: Optimization of Aeolus' aerosol optical properties by maximum-likelihood estimation, Atmos. Meas. Tech., 15, 185–203, https://doi.org/10.5194/amt-15-185-2022*
>
> *Flament, T., Trapon, D., Lacour, A., Dabas, A., Ehlers, F., and Huber, D.: Aeolus L2A aerosol optical properties product: standard correct algorithm and Mie correct algorithm, Atmos. Meas. Tech., 14, 7851–7871, https://doi.org/10.5194/amt-14-7851-2021.*

The co-authors of the present work are primarily focused on the L2B product and do not currently intend to publish a similar study on the L2A product. Nevertheless, we will pass this suggestion on to the L2A experts within the Aeolus Data Innovation and Science Cluster (DISC) to help promote a forthcoming publication on the aerosol product.

Specific comment #1:

Line 55: "averaged L1B data onto the L2B grid": Were the L1B data in fact averaged or were they interpolated to the L2B grid? The abstract states they were interpolated; if so, what scheme did you use? If they were instead averaged, how was this done? Were only valid obs used? Was any quality control applied to the L1B data beforehand?

Response to Specific comment #1:

The L1B data, primarily the Rayleigh and Mie (refined) SNR analysed in this study, were indeed averaged, not interpolated. Specifically, the RMS value was calculated over all L1B measurements that contribute to a single L2B wind result within the grouping algorithm. The procedure and the rationale for using the RMS rather than an arithmetic mean are explained in Sect. 2.2.3, while details of the grouping algorithm are provided in Appendices A1 and A2.

A large number of validity flags within the L2B processor determine whether a wind result composed of L1B measurements is flagged as valid or invalid and thus serve as quality control. For example, configurable thresholds are applied to the Mie fringe fit parameters to prevent gross errors in the Mie-cloudy wind product arising from noisy Mie signals. For brevity, we do not describe the full concept of these validity flags in the main text. However, we have added the following sentence at the end of Appendix A2:

> *"Quality control is performed using numerous validity flags that determine whether a wind result derived from L1B measurements is valid or invalid. For example, configurable thresholds on the Mie fringe fit parameters prevent gross errors in the Mie-cloudy wind product caused by noisy Mie signals."*

To avoid confusion regarding the procedure, we have corrected the term in the abstract to read:

> *"[…] L1B instrument parameters are averaged onto the L2B wind grid […]"*

Specific comment #2:

Lines 245-248: Can you provide more detail about how exactly the "Mie-cloudy random error is more strongly affected by data processing algorithms and configuration changes than by the signal trend," instead of just stating that it is? Is the Oct-Nov 2019 example referencing Fig. 2, or something else? How does this example support your claim here?

Response to Specific comment #2:

We have elaborated on this point in the text as follows:

> *"In contrast, the evolution of the Mie-cloudy random error varied very little during the mission, as it was largely independent of the signal trend under the nominal instrument configuration applied during most of the mission lifetime. However, changes in the data processing algorithms and instrument configurations were observed to influence the Mie random error. One notable example is the application of a dedicated range bin setting in October and November 2019, designed to investigate the correspondence between Aeolus*

observations and wind measurements derived from Atmospheric Motion Vectors (AMVs). For this purpose, the vertical thickness of the Mie wind bins was reduced to 250 m within the lowermost 2 km of the atmosphere, enabling higher vertical resolution in the planetary boundary layer, where most AMVs are typically found. The narrower range bins significantly decreased the SNR for most of the retrieved Mie-cloudy wind results, causing Poisson noise to become a noticeable contributor to the random error and increasing it from 3.2 to 3.6 m s^{-1}, as shown in Fig. 2. Another example is the change in the number of accumulated laser pulses implemented in December 2021, which slightly improved the Mie-cloudy random error due to the increased horizontal bin length, as discussed in the next section."

Specific comment #3:

Lines 249-251 (and Table 1): This seems out of place here, as the rest of this subsection seems to discuss the Aeolus mission in general and not the actual study presented in this article. I suggest starting a new subsection after line 248 and labeling it as "Dataset selection" or something similar. I further suggest the following:

a. *Delete the subsection title "2.4 Horizontal bin length of the L2B wind results" and instead incorporate its contents into the new "Dataset selection" subsection.*
b. *In line 249, add "in this study" after "selected for analysis" for clarity.*
c. *Similarly, in line 255, add "in this study" after "wind result" for clarity.*

Response to Specific comment #3:

We followed the referee's suggestion and introduced a new subsection titled "Dataset selection" after line 248, incorporating the content from the subsection "Horizontal bin length of the L2B wind results." The suggested additions "in this study" were also included in lines 249 and 255 for clarity. Furthermore, the description of the paper structure was updated as follows:

"[…] Section 2.3 presents an overview of instrument performance over the mission lifetime, while Sect. 2.4 introduces the datasets selected for this study and discusses the different horizontal integration lengths applied throughout the mission."

Specific comment #4:

Line 370: The phrase "increases throughout the troposphere" is confusing here as the next sentence also discusses the troposphere but presents a contradictory statement. I assume the next sentence discusses the free troposphere above the PBL? If so, I suggest changing the phrase to "increases throughout the PBL."

Response to Specific comment #4:

We agree that the original sentences were misleading, as they referred to the coverage increase when viewed from the top to the bottom of the plot in Fig. 6(a). This section has been revised to clarify this point and to explicitly state the two reasons for the decrease in coverage at low altitudes:

> *"For Mie-cloudy winds, coverage gradually increases from the lower stratosphere down through the troposphere, reaching a maximum between 1 and 2 km. The apparent decrease in coverage below 1 km is caused by signal attenuation from clouds and by the exclusion of ground returns, which are flagged as invalid wind data in the L2B product but are still included in the reference area used to calculate wind data coverage."*

Specific comment #5:

Figure 7: Do the statistics in this figure include winds from both the NH and SH, or just the NH? It is not clear in the text nor in the figure caption. I would explicitly state this, otherwise the results can be confusing. For example, the Tropics panel could be assumed to include all winds south of 20°N (including the entire SH), and the Poles panel could be assumed to only represent the Arctic. Further, if the panels include regions in both hemispheres, have you examined each hemisphere separately? Does the wind coverage differ based on season in the poles/storm track regions, and if so, how?

Response to Specific comment #5:

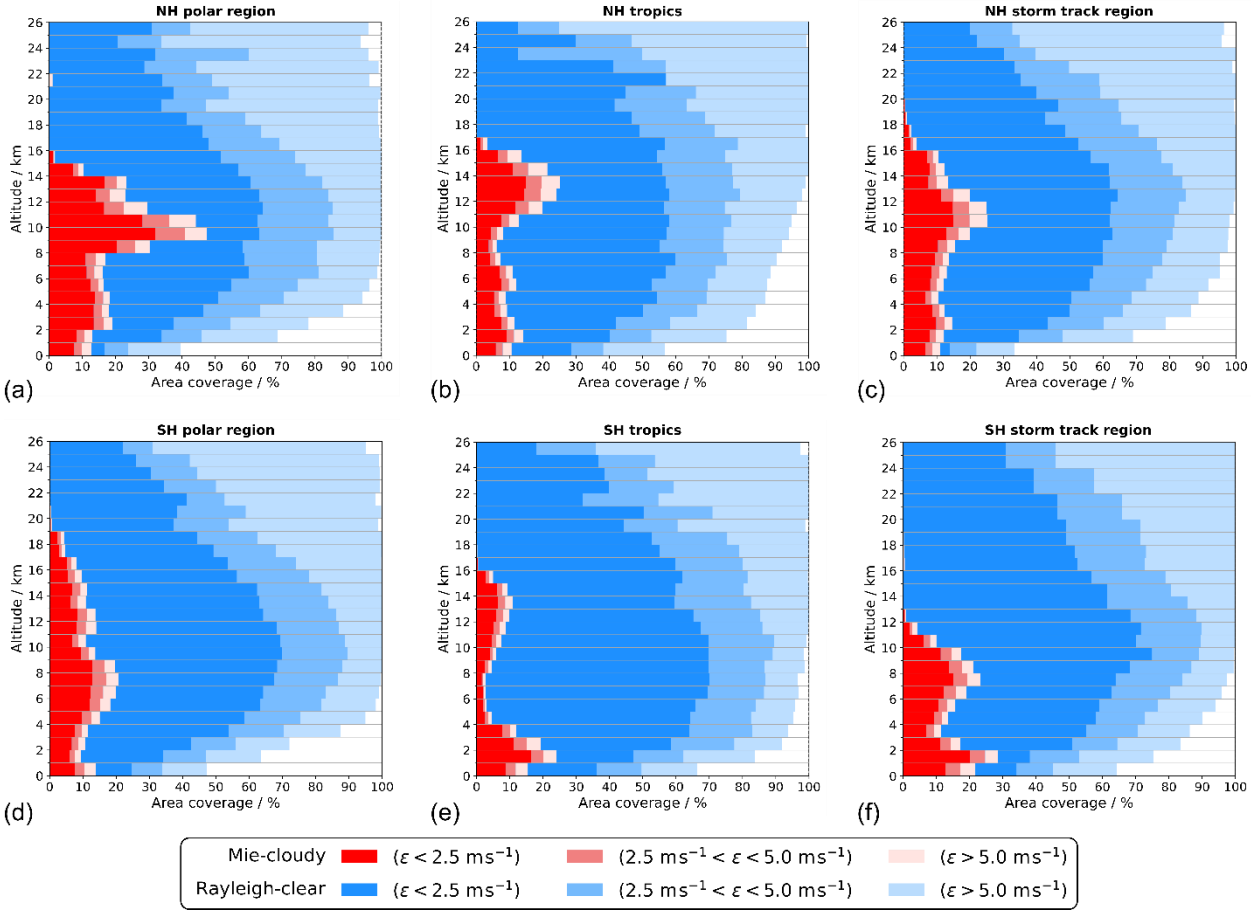
The statistics include winds from both hemispheres, i.e., from 20°N to 20°S for the tropics and combined winds from 60°N–90°N and 60°S–90°S for the poles. This has been clarified in both the main text and the caption of Fig. 7 as follows:

> *"The coverage of Rayleigh-clear and Mie-cloudy wind observations from the best-case scenario in July 2019 is analysed across three latitude bands (combined for both hemispheres) and depicted in Fig. 7: (a) the polar region (latitudes above 60°), (b) the tropics (latitudes below 20°), and (c) the storm-track region (latitudes between 40° and 60°)."*

and:

> *"Aeolus Mie-cloudy (reds) and Rayleigh-clear (blues) global wind data coverage on 20 July 2019 in different geographical regions: (a) poles (latitude > 60°N/S); (b) tropics (latitude < 20°N/S); storm track region (40°N/S < latitude < 60°N/S). […]"*

Following your suggestion, we also analysed the coverage in the three latitude bands separately for each hemisphere for the July 2019 case. The corresponding plots (shown below) reveal a larger coverage of high-quality Rayleigh-clear winds in the SH compared to the NH across all three regions, while the Mie-cloudy wind coverage is notably higher in the NH. The most pronounced differences occur in the polar regions above 8 km, attributable to the 2019 wildfires, and in the tropics above 10 km, which is linked to the monsoon region. These aspects are further discussed in Sect. 3.1.4, together with other factors influencing Mie-cloudy wind data coverage across different regions and altitudes, as illustrated in the maps in Fig. 9 (left column).



Aeolus Mie-cloudy (reds) and Rayleigh-clear (blues) global wind data coverage on 20 July 2019 in different geographical regions: (a) NH polar region (latitude > 60°N); (b) NH tropics (0° < latitude < 20°N); (c) NH storm track region (40°N < latitude < 60°N); (d) SH polar region (latitude > 60°S); (e) SH tropics (0° < latitude < 20°S); (f) SH storm track region (40°S < latitude < 60°S). The colour shading indicates the proportion of data within specific intervals of the absolute value of (O-B) wind speed difference ε. The Rayleigh-clear wind error is normalised to a vertical bin thickness of 1 km.

We have added this figure and its description to a new Appendix section (Appendix C).

Regarding seasonality:

Seasonal variations in data coverage are difficult to separate from other influencing factors such as the progressive signal loss during the mission and major events such as the 2019 wildfires and the 2022 Hunga Tonga eruption. Therefore, considering the already substantial length of the paper, we decided not to further elaborate on the seasonality of the coverage.

The following text has been added to the end of Sect. 3.1.1:

> *"It should be noted that seasonal variations in data coverage are difficult to disentangle from other influencing factors such as the progressive signal loss during the mission and special events like the 2019 wildfires and the 2022 Hunga Tonga eruption. Therefore, seasonality will not be further discussed in this study."*

Specific comment #6:

Figure 13: A note on discussion order of this figure in the text: Why is panel (b) discussed before panel (a)? Convention dictates that (a) should come first; I recommend matching the discussion in the text to the figure panels, where (a) is discussed first, to be consistent with all other figure discussions.

Response to Specific comment #6:

We have revised the discussion of Fig. 13 to match the figure panel order, discussing panel (a) first (Mie-cloudy winds), followed by panel (b) (Rayleigh-clear winds), as follows:

> *"Histograms of the EE per Mie-cloudy and Rayleigh-clear wind result for the six datasets are shown in Fig. 13. Mie-cloudy EE distributions (panel (a)) are narrower, typically extending only to about 10 m s^{-1}. Excluding the dataset from 15 September 2022, these distributions vary little across the mission, indicating the stable quality of Mie-cloudy winds despite the significant signal loss between 2019 and 2022. The September 2022 dataset stands out with a 2 m s^{-1} shift in Mie EE, linked to the P/N setting change to 114/5 in April 2022 (Rennie and Isaksen, 2024), where the fact that Mie-cloudy winds were formed from a single L1B measurement may have caused artifacts in the fit covariance matrix. Interestingly, Mie EE values in 2023 decreased again despite the same P/N settings and wind grouping, suggesting a processing issue still under investigation for resolution in Baseline 17.*

In contrast, as with the Rayleigh SNR, the Rayleigh EE (panel (b)) was normalised to a bin thickness of 1 km. Its distribution features a steep peak and a long tail. For high-SNR datasets (July 2019 and April 2023), the Rayleigh EE peaks around 3 m s^{-1} and extends up to 12 m s^{-1}. As expected from Eq. (3), the EE shifts to larger values for low-SNR datasets, well exceeding 12 m s^{-1}. Notably, a small fraction (<1 %) of Rayleigh-clear winds show unrealistically high EE values, up to several tens or even 100 m s^{-1} (not shown in the plot), which are addressed later in the text."

Specific comment #7:

Table 2: A note on discussion order of this table in the text: Why are the Rayleigh winds discussed before the Mie winds, when the Mie winds appear first in the table? Tables are typically read top-to-bottom; I recommend matching the discussion in the text to the table's top-to-bottom contents, where the top section (Mie) is discussed first, to be consistent with all other figure discussions.

Response to Specific comment #7:

We have revised the discussion of Table 2 to match the top-to-bottom order of the table, discussing Mie winds first, followed by Rayleigh winds, as follows:

"Finally, Table 2 summarises key statistical parameters describing the Mie and Rayleigh channel performance for the six selected datasets. Mie wind coverage was less sensitive to the loss in atmospheric return signal and more influenced by cloud and aerosol variability, with notable enhancements following events such as the 2019 wildfires and the 2022 Hunga Tonga eruption. The increase in Mie-cloudy wind coverage in April 2023, despite no major aerosol event, suggests that improved signal transmission also benefits the Mie channel. The combination of longer horizontal accumulation (17 km at N = 5) and stronger backscatter allowed retrievals from weaker aerosol layers that previously fell below the detection threshold, particularly below 10 km, with a similar increase observed in both hemispheres (Fig. 6).

In contrast, the Rayleigh median SNR dropped from 13.5 in 2019 to 8.8 in 2022 due to the signal loss, resulting in a higher wind random error (from 4.5 to 7.0 m s^{-1}) and similarly increased EE. While overall Rayleigh-clear wind coverage decreased only slightly (from 96 % to 90 %), the share of high-quality winds (ε < 2.5 m s^{-1}) declined more noticeably from 74 % to 62 %."

Technical correction #1:

Line 40: Past tense should be used: Change "vary" to "varied".

Response to Technical correction #1:

The tense has been revised accordingly.

Technical correction #2:

Line 65: To be consistent with predefined acronyms, I suggest replacing "Level-2B" with "L2B".

Response to Technical correction #2:

The term has been replaced with "L2B" for consistency.

Technical correction #3:

Line 66: See previous comment (Line 65).

Response to Technical correction #3:

Same correction applied as in Line 65.

Technical correction #4:

Line 77: Define ALADIN here instead of in line 85.

Response to Technical correction #4:

The definition of ALADIN has been moved to line 77.

Technical correction #5:

Line 85: Don't define ALADIN here (rather, define it in line 77).

Response to Technical correction #5:

The redundant definition has been removed.

Technical correction #6:

Lines 317-319: This is one sentence and as such does not constitute a paragraph. Please move to the end of the previous paragraph.

Response to Technical correction #6:

Agreed. The sentence has been moved to the end of the previous paragraph.

Technical correction #7:

Line 350: Is the comma after "coverage" needed?

Response to Technical correction #7:

The comma after "coverage" has been removed. Thank you for noticing.

Technical correction #8:

Line 373: Replace the semicolon after "troposphere" with a comma.

Response to Technical correction #8:

We have removed the word "however", as it no longer fits with the preceding sentences, and consequently the semicolon was also removed.

Technical correction #9:

Lines 437-438: Tense mismatch: Either pluralize "thickness" in line 437 and replace "was" with "were" at the end of line 438, or replace "were" with "was" in the beginning of line 438.

Response to Technical correction #9:

Thank you for pointing out this mismatch. We have revised the sentence to:

> *"The thicknesses of the range bins were configured independently for both channels, typically set to 250 m, 500 m, 1000 m, or 2000 m, and were adjustable along the orbit."*

Technical correction #10:

Lines 490-491: This is one sentence and as such does not constitute a paragraph. Please move to the end of the previous paragraph.

Response to Technical correction #10:

Agreed. The sentence has been moved to the end of the previous paragraph.

Technical correction #11:

Lines 560-561: It looks like the July 2019 and April 2023 tails extend to 12 m/s. Therefore, I would either say "extends up to 12" or "exceeds 10" here.

Response to Technical correction #11:

We have revised the sentence to:

> *"For high-SNR datasets (July 2019 and April 2023), the Rayleigh EE peaks around 3 m s^{-1} and extends up to 12 m s^{-1}."*

Technical correction #12:

Line 561: The low-SNR datasets well exceed 12 m/s in Fig. 13b. Please update the stated range accordingly.

Response to Technical correction #12:

We have revised the sentence to:

> *"As expected from Eq. (3), the EE shifts to larger values for low-SNR datasets, well exceeding 12 m* s^{-1}*."*

Technical correction #13:

Line 648: Delete the extra space before "70 %".

Response to Technical correction #13:

Thank you for spotting this. The issue was caused by an incorrect LaTeX command. It has been corrected and now reads "≈70 %".

Technical correction #14:

Line 690: HLOS has already been defined in the main text. No need to redefine it here.

Response to Technical correction #14:

The redundant definition has been removed as suggested.

Technical correction #15:

Line 783: DCO has already been defined in the main text. No need to redefine it here.

Response to Technical correction #15:

The redundant definition has been removed as suggested.

Technical correction #16:

Line 838: I believe you mean six selected mission days? Please revise.

Response to Technical correction #16:

You are absolutely right. The text has been revised accordingly.

Technical correction #17:

Figure 5 caption: Please pluralize "red" and "blue," as different shades of each are displayed.

Response to Technical correction #17:

Thank you for the suggestion. The figure caption has been revised to:

> *"Aeolus Mie-cloudy (reds) and Rayleigh-clear (blues) global wind data coverage for selected days throughout the mission period. […]"*

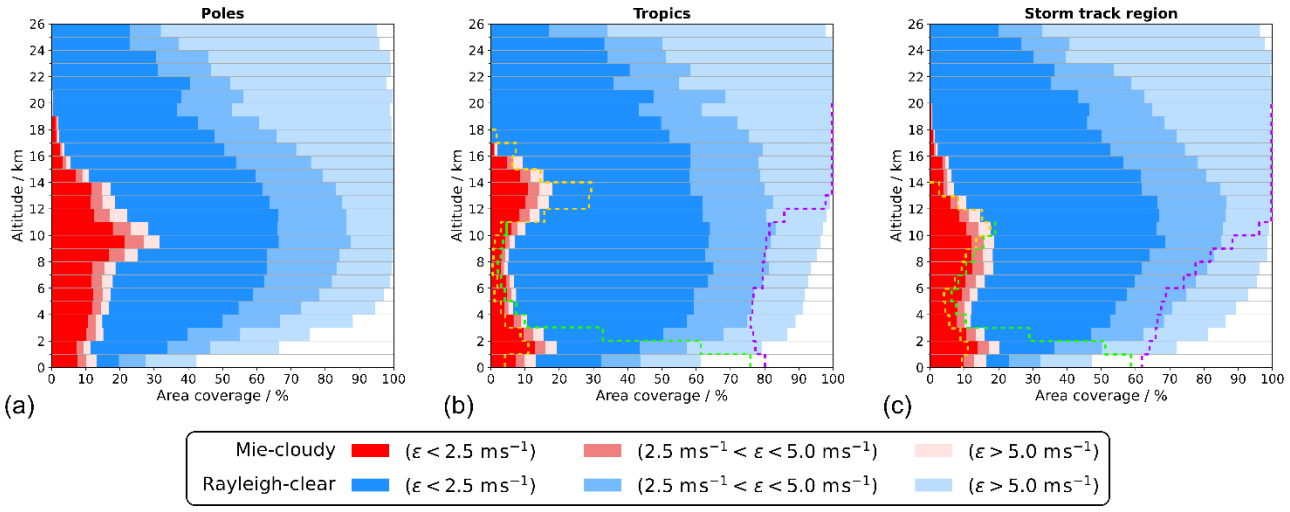
The same revisions have been applied to the caption of Fig. 7.

Technical correction #18:

Figure 7: The red and brown dashed lines are difficult to see in panels (b) and (c). And what I assume is the red line for clouds (that which somewhat outlines the Mie wind bars) is too close in color to the dark blue line representing molecules. Please replot with more distinct color choices for the dashed lines.

Response to Technical correction #18:

The colours of the dashed lines have been updated to improve visibility and distinction (see below).



The figure caption has been revised to:

> *"[…] The dashed lines in panels (b) and (c) represent pre-launch LIPAS simulations of the coverage from clouds (orange), aerosols (green) and molecules (purple), adapted from Marseille et al. (2001)."*

Technical correction #19:

Figure 15: In the caption, you state that the grey horizontal lines indicate Aeolus mission requirements for two regions in the vertical. However, the grey horizontal lines I see in this figure are those that correspond to the y-axis grid tick marks. Are you perhaps referring to the lines labeled 2.5 m/s and 1.0 m/s? If so, please explicitly state that they are labeled as such in the caption. If not, please add to the panels the Aeolus mission requirement lines in some color other than grey.

Response to Technical correction #19:

The horizontal lines indicating the Aeolus mission requirements have been changed to black to distinguish them from the gridlines. The figure caption has been revised to:

> *"[…] The black dashed horizontal lines indicate the Aeolus mission requirements for the free troposphere (2–16 km) and the PBL (0–2 km), respectively."*