Answer to Referee #1

We highly value the insightful feedback given by Referee #1 during the second revision. The comments from the referee that have been addressed in the manuscript are indicated in green, and the responses from the authors to the referee are highlighted in red.

Thank the authors for well considering my comments and suggestions in the updated manuscript. Some final points that need to be addressed before publication are the following

Thank you for your additional comments and suggestions. They have significantly contributed to clarifying the overall scope of the study and enhancing its quality.

- Specific comments

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  - 1) I am happy with the stronger statement made in the abstract now, in answer to my earlier comment G2, although it is incorrect. The new sentence: "It is therefore concluded that Rayleigh-clear winds do not satisfy the random error requirement of the mission, whereas Mie-cloudy winds do so, when considering the standard error." mentions random error only while my statement for Mie winds was related to the bias. Please correct.
    I agree that there is overlap between the mission bias requirement of 0.7 m/s and the Mie-cloudy bias of -0.9 +/- 0.3 m/s. However, I would disagree with the conclusion that: "Mie-cloudy winds fulfill the wind bias requirement, when considering the standard error". With this statistic, the probability of being within the mission requirement is much below 50%. I therefore recommend (again): "based on the data used in this study Mie winds do most likely not meet the mission bias requirement".
    - Thank you for your feedback. We acknowledge that, strictly speaking, Mie-cloudy winds do not meet the mission bias requirement. We revised the abstract sentence you referred to on line 11: "It is therefore concluded that Rayleigh-clear winds do not meet the mission's random error requirement, while Mie winds do most likely not fulfill the mission bias requirement."
  - 2) The authors state in their reply that: "the ECMWF model equivalents perform less accurately in cloudy areas compared to clear-sky conditions." Can the authors please provide evidence for this general statement by adding a reference in line 284?
    - Unfortunately, we couldn't find a reference to support this statement. Therefore, we decided to remove the following sentence: "Please note that Mie-cloudy model equivalents, present in cloudy conditions, are anticipated to demonstrate lower performance compared to Rayleigh-clear model equivalents occurring in clear sky conditions."

Answer to Referee #2

We highly value the insightful feedback given by Referee #1 during the second revision. The comments from the referee that have been addressed in the manuscript are indicated in green, and the responses from the authors to the referee are highlighted in red.

Considering the rather large deviations of the Aeolus wind estimates from the radiosonde data, e.g. Figs 1a), 2, 8a), 9a), and the relative tighter agreement of the Aeolus model equivalents, Figs 1b), 2, 8a), 9a), an alternative test of the usefulness of the Aeolus wind data would be to compare ECMWF model runs with, and without, incorporating the Aeolus wind data. Considering the complexity and expense of incorporating/not incorporating data into the model, and running the model for both cases, this may not be possible. But if it were, it would be a nice straight forward demonstration of the usefulness of Aeolus winds.

Thank you for your comment. Various Observation System Experiments have already been conducted at different weather centers to assess the utility of Aeolus data, and numerous papers on this topic are available. Most experiments have consistently demonstrated the added value of assimilating Aeolus data, especially in the tropics and the upper tropospheric region. One notable example is the impact observed in the ECMWF IFS, discussed in Rennie et al. 2021 ("The impact of Aeolus wind retrievals on ECMWF global weather forecasts").

Given the maturity of this paper and the quantitative/complexity of the error descriptions and discussions, it is surprising the number of places where inconsistencies still occur. The authors are urged to double check that each figure reference in support of a statement, does in fact support the statement, thereby building trust in the reader. Presently that is not the case. As before comments follow here by line number. Text in the manuscript, or corrections to that text, are set off with ellipses.

Thank you for your valuable feedback. Your insights have greatly contributed to enhancing the clarity of this manuscript by addressing inconsistencies and omissions.

- Specific comments

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  - 14-15 This sentence needs some help. Try: …Gross outliers, defined as large deviations from the radiosonde data, but with low error estimates, account for less than 5% of the data…
    - Thank you for the suggested sentence. We have made the necessary adjustments.

- 34 … which is directed perpendicular to the direction of satellite propagation… This direction could be downward or horizontal to the satellite propagation? Text on the next page suggests the latter. In any case it should be made clear for readers not intimately familiar with Aeolus.
    - Thank you for your feedback. We have revised the sentence for clarity as follows: "The instrument carries a direct detection Doppler wind lidar called ALADIN (Atmospheric LAser Doppler INstrument) that emits short ultraviolet (UV) pulses at 355 nm along the Line Of Sight (LOS) of the instrument, perpendicular to the satellite's ground track and oriented 35° off-nadir."
- 2.2 Radiosondes. Only about ¼ of the radiosondes flown during the campaign matched Aeolus overflights. Why so few and why were the other ¾ of radiosondes flown? Twenty comparisons is not that many for the length of the campaign. How does number compare to the number of Aeolus overflights of each station during the campaign
    - The JATAC campaign over Sal lasted approximately three weeks, during which only co-located radiosonde profiles were utilized—corresponding to only three Aeolus overpasses per week in Sal for comparison. In regions like Puerto Rico and Saint Croix, radiosondes were not consistently co-located with Aeolus in space and time, as it wasn't the primary focus of the CPEX-AW campaign, resulting in fewer available comparisons. The additional radiosondes launched in Cape Verde were added to the Global Observing System for operational assimilation in NWP centers. This dataset also contributes to various studies, including comparisons with GNSS data within the framework of the CADDIWA campaign.
- Figure 2. Even with the three value moving average it is difficult to reconcile the individual data, points, with the O-RS lines and their standard error. Presuming the line to represent the mean it is difficult to reconcile the ascending line in Fig. 2b) with the corresponding data points. Concentrating only on the first 3 levels. Level 1 all data are > than the mean at -5 m/s. Level 2 only one data point is below the mean at -3 m/s, whereas 4 data points are well above that. Finally at level 3 the mean and data make sense. It is not clear how a 3 value moving average will produce the line represented for these three levels.
    - Thank you for your input. To utilize the moving average function, the "Minimum number of observations in window required to have a value" is set to 2 at both ends of the profile. Although this may impact the expected outcome at these points, our code verification revealed no errors, and the average values align with the individual data points. However, for clarity and to prevent confusion, we have opted to exclude the data points and retain only the vertical average of the points in the figure.
- Figure 3, the d) label is not defined in the caption. At normal zoom levels it is very difficult to see the Rayleigh-cloudy data. Use a clearly distinguishable color, e.g. red, or cyan. The green is so dark it appears black.

    - Thank you for your comment. We have added the omitted (d) in the legend. Initially, our intention was to assign a specific color to each type of observation throughout the manuscript. We initially chose orange, but due to its close resemblance to the red used for Mie-cloudy, we switched to green as suggested by the referee. Subsequently, we now opted for the golden color, as cyan appears too clear and red is already used for Mie-cloudy. We made consistent updates to all figures (1, 2 and 8) and the text.
- 386 … outliers as values exceeding an absolute error of 6 m s–1 along with EEs inferior to 3 m s–1… According to the data in Fig. 4a) the outliers are at EEtot < 3.6 m/s, not < 3 m/s.
    - EEtot denotes the total error estimate, encompassing both radiosonde observation error and representativeness error. On the other hand, EE specifically pertains to the error estimate attributed to Aeolus alone. The distinction between 3 m/s and 3.6 m/s primarily stems from the conversion between EE and EEtot as presented in the figures.
- Table 4 caption …for dust mixing ratios above (Dust) and below (DustNO) 109 kgkg–1 along the track… For the readers sake, organize this sentence, here and in the text, to follow the columns in the table, as is done for cloudiness, not the reverse. Even better use this … for dust mixing ratios < (>) 10^9 kg kg^-1 DustNO (Dust) along the track.
    - Thank you for your feedback. Following your suggestion, we have revised the caption to enhance clarity. It now reads: "This comprises three categories of cloud cover (< 50%, > 50%, > 75%) and two dust mixing ratio sub-categories (> 10^8 (Dust), < 10^8 (noDust)) kg/kg along the track."
- 415 Why are the dust criteria different in the text and table caption. Perhaps the text is correct?
    - Thank you for bringing this to our attention. In the course of correcting the dust criteria from 10^9 to 10^8 kg/kg in the text during the first revision, we overlooked updating the caption. We have now rectified this oversight.
- 460 …quality as well, with an average MADI of 1.5 m s–1 (Fig. 4b)… Where does 1.5 come from? In Table 5 it is 1.6 at best, while Fig. 4b) shows it be more, primarily near 2.3.
    - Thank you for bringing this to our attention. The mention of 1.5 m/s corresponds to values above 12.5 km altitude, which unfortunately are not depicted in Figure 4b due to the limited size of the dataset. To prevent confusion, we have removed this sentence from the text.
- 467 …Surprisingly, observations sampled at the lower 1 km have the lowest normalized useful signals, mostly below 5e15 a.u. and are not discarded… Where are these observations? All accepted observations, except one, have a signal above 0.5 e 14 a.u., Fig. 6g).

- Yes, there is just one outlier below this threshold. After thoughtful consideration, we have chosen to omit the description below 1 km, as we believe discussing it is not crucial within the context of this paper.

- General comment on the color scales and text. Why use scales from 0 – 1.0 in the figure axes and color scales, and then refer to them in the text in the realm of 1 – 10, forcing the reader to do the conversion from text to figure? Make it simple for the reader, use the same scale in the figure as the one discussed in the text, or in the text discuss in the same units as in the figure.
  - We assume you are addressing the dust concentration colorbar. We chose a 1-10 colorbar for better visibility of gradients, having found it to be the most suitable after trying different options. In the text, our focus is on whether values are above or below a specific threshold, so there's no need to investigate into individual categories within the 1-10 range.
- 469 …They also correspond to the largest MADI scaling up to 4 m s–1 on average (i.e. Fig. 4d)… This statement is not consistent with Fig. 4d) where only 3 out of many observations are > 4 m s-1. The majority are well less than that.
  - Indeed, you've identified errors that resulted from corrections omitted during the first revision. As mentioned in the previous comment, we have now removed this part from the manuscript.
- Figs 7-9. The source of the 20 profiles mentioned in the caption to Fig. 7, …together with the EEtot of all 20 profiles (grey solid lines)…, is not explained and is not clear to this reader. Does Aeolus make 20 profiles within the coincidence criteria, or? What determines the blue one that is used?
  - The 20 profiles refer to those meeting the co-location criteria outlined in section 3.1 and specified in Table 1. To prevent confusion, we have included "described in Table 1" in the caption of Fig. 7. The blue line in figures 7, 8, and 9 corresponds, respectively, to three selected case studies, each characterized by distinct clear-sky, cloudy, and dusty conditions. The first sentence in section 4.2.3 is highlighting this.
- 498 … which corresponds to SAFNWC CT at 07:30 UTC, Aeolus overpasses a variety of high clouds, mainly high semitransparent clouds… According to the color scale explanation in Fig 8e) Aeolus passes through "High semitransparent meanly thick clouds". First, the statement in the text is not consistent with the figure scale. Second, what is a "meanly thick cloud"? Third, isn't "semitransparent … thick" clouds an oxymoron
  - Firstly, in the text, our focus is on the vertical location of clouds, which is why we specifically mention "high clouds." The exact cloud types is referenced in the figure using the NWSAF nomenclature, but it is not crucial for the discussion and, therefore, omitted. Secondly, detailed descriptions of cloud types as per the NWSAF classification can be found at https://www.nwcsaf.org/ct_description. This classification distinguishes between meanly thick and high semitransparent thick clouds, which is "based

on the use of CMA and spectral & textural features computed from the multispectral satellite images and compared with a set of thresholds.".Thirdly, we acknowledge that it may seem like an oxymoron, but we are just adhering to the nomenclature provided by the NWSAF product.

- Why are the spatial scales used for Figs 7e), 8e), and 9e) so vastly different?
    - The spatial scales differ due to the application of different co-location radii for the three cases, as detailed in Table 1 and in section 3.1.