Response to Reviewer #1's Comments

Response: We thank the anonymous reviewer for his/her comprehensive evaluation and thoughtful comments, which greatly improve the quality of our manuscript. We have made efforts to adequately address the reviewers' concern one by one. For clarity purpose, here we have listed the reviewer' comments in plain font, followed by our response in bold italics.

Significant: The difference Aeolus-ERA mean zonal wind differences for ascending and descending show a significant negative bias on ascending (toward NW) passes and positive zonal wind bias on descending (toward SW) passes. Is there any corroboration of these results from any other studies? This is a critical result. As is discussed below regarding Fig. 8, it appears that the RS data may have their own bias, which would undercut the conclusions of this paper. I have a hard time concluding that the ECMWF data has such a zonal wind bias.

Response: We appreciate your insightful comments. As you said, we made a mistake in the vertical height assignment of RS data. The reason is that we converted the height of RS data to the altitude above ground level. However, the height of Aeolus and ERA5 data are the altitude above sea level. This led to a series of wrong conclusions. We have corrected this error and provided new results, please see below.

Fig.8 is potentially the most important result of the paper. Since ECMWF includes the Aeolus winds, but ERA5 does not, could one conclude that there is a bias with the RS winds? It appears that this is the case. How do the authors explain this issue? On p.13, L14-15, they suggest a possible ECMWF wind bias, but there is no other evidence that that is the case.

Response: Good questions! Due to we made a mistake in the vertical height assignment of RS data, the previous results in Fig. 8 were wrong. We re-do the vertical height matching processing and provide new results. In addition, per your suggestion, we checked the number of matching samples at each height. To ensure the validity of the statistics, the comparison results with less than 20 matching samples were removed. The new Fig. 8 was show below. It found that the deviation in the vertical direction is significantly reduced. It is also worth mentioning that we

mistakenly believed that the large near-surface deviations were caused by aerosols. In fact, it is caused by too few matching sample points.

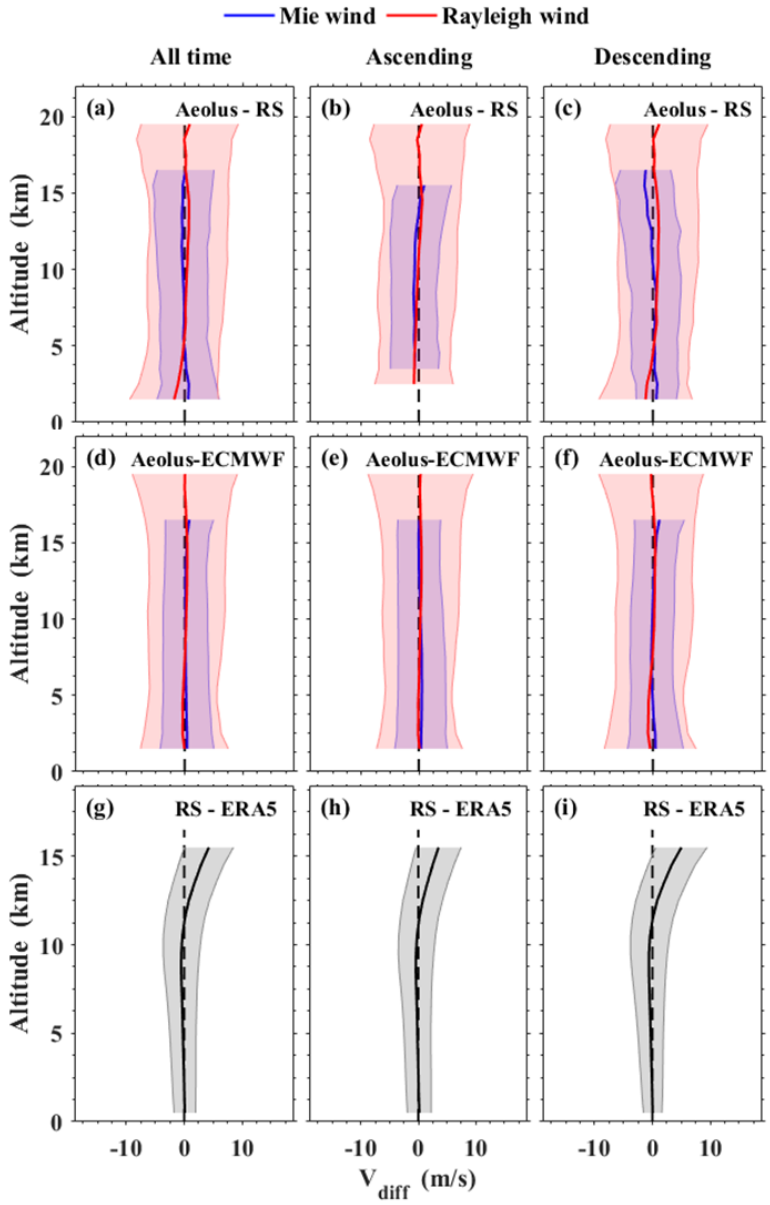

Fig. 8

- I assume that Chinese RS data are used in both ECMWF and ERA5 analyses. Is this the case? The text should specify this clearly.

Response: Yes! The Chinese RS data are used in both ECMWF and ERA5 analyses. We have clarified it in the text.

- The paper needs adding profiles for Aeolus winds (clear/cloudy/all) vs. ERA5. After all, Aeolus vs. ERA5 is shown in Fig. 9.

Response: Due to the problem of vertical height matching, we did not add the profile comparison of Aeolus and ERA5. The Aeolus wind profile was a vertical resolution of 0.25 to 2 km in 0-20 km. The wind speed on each bin is calculated from the integral of the signal on this bin. However, the ERA5 data is a layered data, which has a total of 28 layers in the height range of 0–20 km. It means that for each Aeolus bins, the height interval of the bin is hard to be covered by ERA5 data. Therefore, we think that it is not appropriate to use the value of a certain layer to match the corresponding Aeolus bin value.

As for the comparison between Aeolus and ERA5 in Figure 9, these are actually average wind speeds within 0-20 km. The purpose of Figure 9 is to see if the Aeolus and ERA5 data are consistent in spatial distribution.

As noted below, I suspect a misprocessing, possibly vertical height assignment, for either the RS or ERA5 data.

Response: This is a very insightful comments. As you said, we made a mistake in the vertical height assignment of RS data. The height of Aeolus and ERA5 data are the altitude above sea level. However, we converted the height of RS data to the altitude above ground level, which resulted in the wrong results. We have corrected this error and provided new results.

I understand that these statements will likely result in rejection of the manuscript. I urge the authors to either find the suspected error or more carefully support their logic and then, resubmit the manuscript. I thank the authors for their work in this intercomparison for the important Aeolus data even though I find these problems.

Response: Thanks for your critical but valuable comments on our manuscript, which helps great in improving the quality of our manuscript. Please see the following point-by-point response to your comments.

The higher accuracy of Mie/cloudy winds than Rayleigh/clear winds are as expected – good. Can the authors provide correlation coefficients in Fig. 5 for other observation types? It's hard to tell what these numbers mean. I can only tell that they are from the same atmosphere at the same time with R* ~0.9.

Response: Per your suggestion, we modified Fig. 5, and updated Fig. 5 is shown as below:

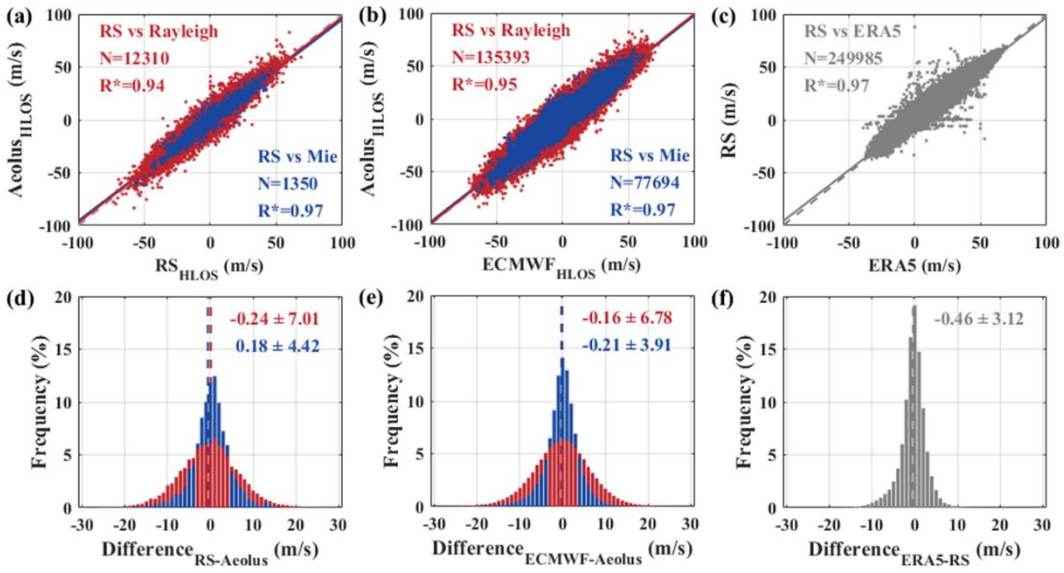

Fig.5

Fig. 9 should use the same color scale for all graphics. This is confusing. Similarly, Fig. 7 should use the same color scale at least for the same vertical levels (850, 500, 100 hPa), but they don't. The colors in these graphics are confusing and should be applied uniformly.

Response: Amended as suggested. The same colour scale was used in Fig. 7 and 9.

Please remove national borders for areas of territorial disputes. The insert for the South China Sea area in the figures (1, 6, 7, 9, 10, 11) provide no scientific information whatsoever and should be removed.

Response: This suggestion has nothing to do with academic exchanges. Therefore, we don't think it is necessary to modify these pictures.

p.2, L3-5. How is it known that this behavior is due to aerosols?

Response: According to the new comparison results, we have deleted this wrong statement.

p.4, L1-2. The mean biases for A2D and Aeolus shown by Lux et al 2020 were against the ECMWF model – please correct.

Response: Amended as suggested.

The authors were not careful to ensure that the graphics all use similar scales. Instead, they simply used the range for each set of numbers rather than forcing a common range for the scales. Therefore, the colors mean different things for each plot. Fig. 5c does not use the same horizontal axis scale as 5a and 5b, please correct. Similarly, Fig. 5e does not use the same scale as Figs. 5d and 5f, again, please correct. Same problem for Fig.S1.

Response: Per your suggestion, we modified both Fig. 5 and Fig. S1.

For all difference fields (Figs. 3, 7, 9, 10, 11), please use a white or gray color for differences close to zero, +/- 0.5 m/s for instance.

Response: Per your suggestion, we modified the Fig. 10, 11 and S5. But for Fig. 3, 7 and 9, the color scale shows the wind speed value not the bias. Therefore, we did not modify the color scale of these three figures.

p.11, section 3. There is no need to repeat the statistics in this paragraph that are already obvious in the figures unless the authors want to draw some conclusion from those statistics. This paragraph can be shortened significantly.

Response: Good suggestion! We have rewritten this paragraph and deleted the redundant statistics

p.11, L18. What data assimilation settings? Observation and background error values? If so, please say so.

Response: The data assimilation settings mean the observation operator and expectations of 4D-var data assimilation, which is described in the TN (ECMWF TN 864, https://www.ecmwf.int/file/288329/download?token=y9cKewWP).

4D-var uses 3D spatial kernels for background (B) error representation, which spread the Aeolus observation (O) increments (O-B) in the ECMWF model domain. The kernels are based on the spread in an ensemble of forecasts and all observations in the temporal 4D-var window (12 hours) are considered to produce a ECMWF model trajectory that is consistent with all observations. The analysis weight of the Aeolus observations O depends on the local ratio of the estimated background and observation error covariances.

The Rayleigh winds have (variable) estimated errors associated with them, but these are inflated before data assimilation in accordance with the estimated Aeolus Rayleigh errors.

The Mie winds are on the 10-km scale and can be closely spaced horizontally. ECMWF follows arguments from Stoffelen et al. (2020) on observation density and spatial representativeness and found benefit in the forecasts by weight inflation of the Mie winds by a spatial representativeness error.

Per your suggestion, we clarified it the text.

Reference:

Stoffelen, A., Vogelzang, J., Marseille, G.-J.: High Resolution data assimilation guide. EUMETSAT NWP SAF Documentation, version 1.3, available: https://nwp-saf.eumetsat.int/site/download/documentation/scatterometer/reports/High_Resolution_Wind_Data_Assimilation_Guide_1.3.pdf, 2020.

Fig.7. What conclusions should the reader make from Fig. 7. There are some color differences the discussion on p.12-13 doesn't tell much except that the RS colors may very approximately match those from the other data sources.

Response: Figure 7 can be seen as a case study. Through comparison with ERA5 data, it shows the detection performance of Aeolus at different heights.

Fig.8 other issues.

- Side issue: I suggest that the authors add the vertical profile of the number of Aeolus observations for Fig. 8. That may help solve the unexplained results in Fig. 8. Are there far fewer Aeolus observations for the 0-5km layer? I will guess that is the case.

Response: Per your suggestion, we calculated the vertical profile of the number of Aeolus observations for Fig. 8, as shown in Fig. S4. It found that the number of Aeolus observations at near-surface is few. Therefore, the statistical results of the near surface are not credible. As you said, the large near-surface deviations were caused by too few matching sample points.

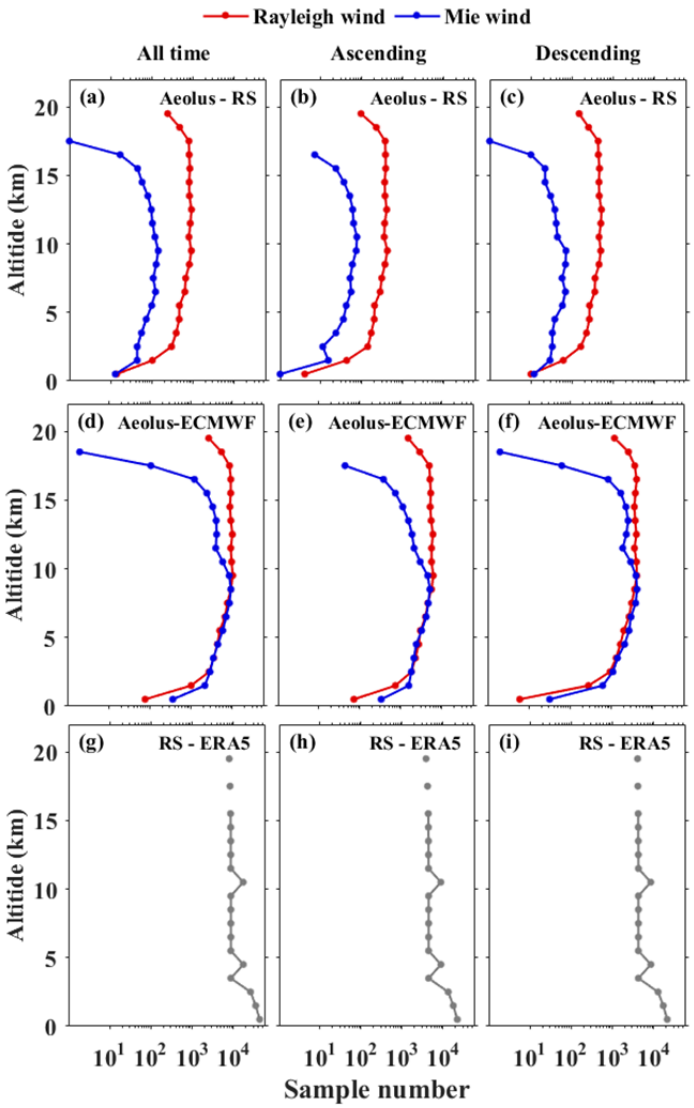

Fig. S4

- Is the altitude above sea level or above ground level? This should be added to the caption.

Response: The altitude is above sea level. We have added it to the caption.

- What is the evidence that behavior in the 0-5km layer is affected by aerosols? This statement appears to be speculative.

Response: According to the new comparison results, we have deleted this wrong statement.

- The paper needs adding profiles for Aeolus winds (clear/cloudy/all) vs. ERA5. After all, Aeolus vs. ERA5 is shown in Fig. 9.

Response: Due to the problem of vertical height matching, we did not add the profile comparison of Aeolus and ERA5. The Aeolus wind profile was a vertical resolution of 0.25 to 2 km in 0-20 km. The wind speed on each bin is calculated from the integral of the signal on this bin. However, the ERA5 data is a layered data, which has a total of 28 layers in the height range of 0–20 km. It means that for each Aeolus bins, the height interval of the bin is hard to be covered by ERA5 data. Therefore, we think that it is not appropriate to use the value of a certain layer to match the corresponding Aeolus bin value.

As for the comparison between Aeolus and ERA5 in Figure 9, these are actually average wind speeds within 0-20 km. The purpose of Figure 9 is to see if the Aeolus and ERA5 data are consistent in spatial distribution.

Fig.9.

- The stronger winds in RS than in ERA5 (Fig. 9e,f) possibly evident (very hard to visually average this) at least matches the vertical profile in Fig. 8e,f. Why is it not possible that the RS values are in error? Another possibility is an error in the vertical elevation matching using higher elevation in ERA5 or lower elevation in RS. This would result in the ERA5 having stronger winds up to ~12km and lower winds above.

Response: Good questions! As you said, we made a mistake in the vertical height assignment of RS data. It led to a series of wrong conclusions. We have corrected this error and provided new results. The new results show that the deviation between RS and ERA5 is very small.

Fig.10. - Please use the white or gray color for +/- 0.5 m/s. Then revise the number of sites for which difference is negative, i.e., less than -0.5 m/s.

Response: Amended as suggested.

- Fig. 10e and its geographical pattern suggests the possibility of a misprocessing since the RS sites with larger differences are to the west, perhaps with higher elevation.

Response: We have corrected this error and provided new results.

p.1, L27. It would be more accurate to say that the Aeolus winds observations were assimilated “into the ECMWF analysis”, not “into the ECMWF winds” since the data assimilation is multivariate.

Response: Good suggestion! Amended as suggested.

p.3, L18. Aeolus misspelled.

Response: Amended as suggested.

p.6. ERA5 misspelled.

Response: Amended as suggested.

The references are considerably out of alphabetical order – this is a problem for reviewers.

Response: Amended as suggested.

Fig. 9. ‘orbits’, not ‘obits’. Same in p.13, L8. Please spell-check the entire article and remove any ‘obits’.

Response: Amended as suggested.