Response to Reviewer #2's Comments

Response: We greatly appreciated the reviewer's positive comments on our manuscript, 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.

The authors compare ESA's satellite Aeolus wind data with radiosonde winds in China in a period 20 April - 31 May. They also compare Aeolus wind fields with ERA5 wind fields. They use a fourth data set - "ECMWF wind fields" (need to be clarified, see below) as part of the Aeolus L2C data set - in a second period (July -Sept). Unfortunately, comparing all 4 data sets in an overlapping period was not possible. Numbers for correlations and mean differences are provided. Aeolus Rayleigh-clear winds and Mie-cloudy winds are considered separately. Conclusions are drawn by interpreting the various comparisons. They find that Aeolus winds are biased, and the bias is strongly different for ascending and descending orbits. They also find ERA 5 is biased over China. They find that a time difference criterion and a distance criterion does not seem to matter when they select Aeolus overpasses closest to the radiosonde start time and start location. The figures 1, 3, 4, 5, 7, 8, 9, 10, 11 are illustrating their work and supporting their conclusions. Major revisions are necessary before the paper allows the reader to understand what was done with which data and what conclusions can be drawn, and how relevant they are compared to what was already known.

Response: Thanks for your 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.

In addition, 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.

Firstly, before publication, the authors need to describe exactly what the data are (versions), and who provided them. For instance, what is meant by "ECMWF data"? Were the background wind fields or the analysed wind fields used from the L2C product to compare to L2B? This makes a difference for the conclusion. Best support for their conclusion would be if they had used both background and analysis which would allow to illustrate how the change during data assimilation relates to Aeolus. Also, I assume L2C contains Aeolus obs error and data assimilation status flags, these would have been beneficial to consider in this paper. The L2B provided with the L2C data set contains Rayleigh winds only or also Mie, HLOS or components?

Response: Good suggestion! Here, the analysed wind data from the L2C product was used to compare with L2B wind data. The L2C wind product adds two assimilation data modules on the basis of the L2B wind product: "L2C Mie Assimilation Product Confidence Data" and "L2C Rayleigh Assimilation Product Confidence Data". These two data modules are generated by the ECMWF model that assimilated the Aeolus observation data. It contains reference information such as the observation error, background error and data assimilation quality flags etc. For the entire L2C data product, it contains all L2B data and these two assimilation data modules.

Per your suggestion, we have added some descriptions in the section 2.3.

Also, it would be important whether the Aeolus winds used in period 1 are comparable to period 2 - were they obtained with the same L2B processor? Are we comparing same Rayleigh / Mie winds?

Response: Good question! According to the Aeolus official instructions (https://earth.esa.int/eogateway/instruments/aladin/processor-releases, last access: 22-06-2021), there are three processor releases: Baseline 12 (26 May 2021 – present), Baseline 11 (8 Oct 2020 – 26 May 2021) and Baseline 10 (20 Apr – 8 Oct 2020). In this study, the L2B data were from 20 April 2020 to 30 September 2020. Therefore, the L2B processor release during this period should be "Baseline 10".

In addition, by consulting with Dr. Stoffelen, A., we learn that generation of AUX_TEL file needed to perform the telescope temperature bias correction has changed from once to twice per day (based on the previous 24 hours of data) at 10-Aug-2020. This should give a small quality improvement. Therefore, we think that the Aeolus winds used in period 1 are similar to period 2.

To dispel readers' doubts, we have added a description in the section 2.1.

Rayleigh and Mie winds cover different vertical ranges. Comparing both should take this into consideration. Where height dependency is considered (e.g. as done in Fig 7 and 8) conclusions can be drawn more easily.

Response: Good suggestion! 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. The height dependency is also considered. The new results indicate that the deviation in the vertical direction is significantly reduced.

Second issue before publication, the authors need to describe in a reproducible manner their data processing. Figure 2 is not useful. The two periods, and each data set should be described separately, Figure 2 is in contradiction to the text. They need to state for each comparison, which data were (automatically) excluded, as this determines their resulting means and correlation coefficients. Also, in section 2.5 the wind components are discussed. Most discussion in the paper refers to the horizontal line-of-sight (HLOS) wind. It is not clear, where Aeolus wind components are needed and which numbers refer to wind speed or wind components or HLOS winds.

Response: Per your suggestion, we described the data processing process in two periods. The first period is from 20 April to 30 September 2020 for the comparison between Aeolus and RS data. Another period is from 9 July to 30 September 2020 for the Aeolus-ECMWF and RS-ERA5 comparison. The new Fig. 2 was shown below.

In addition, for the Aeolus-ECMWF and RS-ERA5 comparison, the wind data were both converted to Aeolus horizontal line-of-sight (HLOS) wind. Only for the comparison of RS and ERA5 data, the wind data were converted to the zonal wind component. We have clarified it in section 2.5.

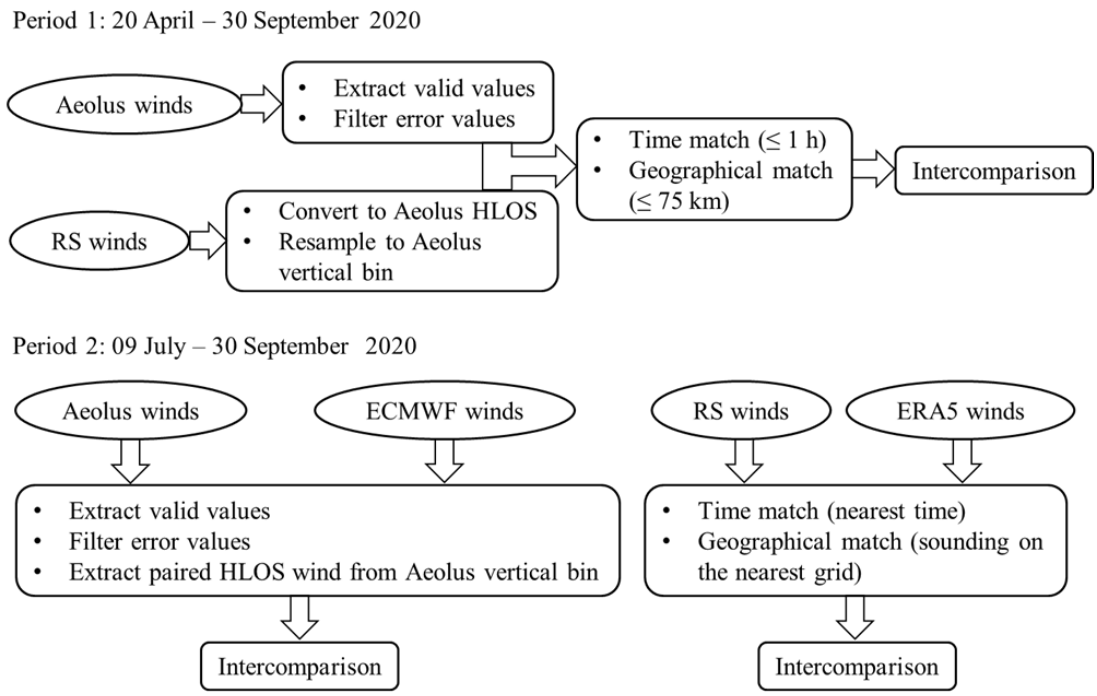

Fig. 2

Third issue, conclusions from the various comparisons have to be discussed in a scientifically rigorous manner. What can and what cannot be concluded from the 2 periods? Actually ERA5 should be available in both periods. However, known seasonal dependency of Aeolus biases might limit the option of drawing conclusions from the spring and autumn period ignoring their different season. Also, the known dependency on topography is ignored here but might matter (compare Fig. 7, 850 hPa)

Response: Good questions! Due to we made a mistake in the vertical height assignment of RS data, most of the previous results were wrong. We re-do the vertical height matching processing and provide new results.

Fourth major recommendation concerns bringing the findings of the paper into perspective with what is known from other literature, e.g., bias of Aeolus (ascending/descending) was known before (simple google search brought me to https://doi.org/10.5194/amt-2020-404), and so are ERA5 biases over complex topography. In the abstract it is concluded that the findings give sufficient information to apply Aeolus wind products in numerical weather prediction in China. This surely might be a valid point, but needs a criterion what is meant by "sufficient information". Are both Rayleigh and Mie winds considered useful, or one more than the other, useful always or under certain circumstances? How does the size of differences between data sets compare to other literature? Discussing known literature will help to illustrate the added value of this paper, which is studying the region of China in detail.

Response: Per your suggestion, we add some discussion in the text.

"Khaykin et al. (2020) also analyzed one wind profile of Aeolus with the Doppler lidar and found a good agreement between the two measurements, but below 5 km above ground level, a stronger deviation was observed, which was likely caused by horizontal heterogeneity of the atmosphere."

"Previous study also indicates that there are differences in bias between the ascending and descending orbit phase, which mainly occur for the Rayleigh channel in late summer and autumn (Martin et al., 2021)"

"The comparison results obtained in this study, by and large, agree well with most of validation work against Aeolus wind products, although the data sources and regions of interest vary a lot. For instance, Baars et al. (2020) revealed that the random errors were about 4 and 2.2 m/s for Rayleigh-clear and Mie-cloudy wind, respectively, by utilizing the RV Polarstern cruise from Bremerhaven to Cape Town. Lux et al. (2020) compared the Aeolus Rayleigh-clear wind observations to winds measured with the airborne demonstrator and the ECMWF model in central Europe. They reported a bias of 1.6 (2.53) m/s with random errors of 2.5 (3.57) m/s for the comparison against the ECMWF model (airborne demonstrator). In a recent comparison analysis based on a combination of Aeolus, RS and numerical weather prediction model on a global scale, the mean absolute bias is found to be approximately 1.8–2.3 m/s for the Rayleigh winds and 1.3–1.9 m/s for the Mie winds (Martin et al., 2021)."

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Several of the experienced co-authors should be able to rewrite this paper in a more scientifically stringent manner.

Response: Per your suggestion, we rephrased most of section in this revision in a more scientifically stringent manner.