Author's Response to Referee #1

In this response, the referee comments (in black) are listed together with our replies (in blue) and the changes to the original manuscript (in red).

In this study, the Aeolus L2B wind product quality is verified by ERA5 and L-band radiosonde (RS) data. The accuracy of the Aeolus Rayleigh-clear data and Mie-cloudy data in four regions and different seasons in China and the reasons for the errors are explored by accounting for various potential factors. The evaluation method is generally sound and the results of error analyses are highly valuable for using new satellite product for various applications in the region. However, the paper needs significant improvements before it can be considered for publication.

Responds: Thanks a lot for your reviews on our manuscript entitled "Study on the seasonal variation of Aeolus detection performance over China using ERA5 and radiosonde data". The comments are valuable and very helpful for revising and improving our paper. We have revised the manuscript according to the comments and the details are shown as follows.

1. As the main objective of the study is to assess the validity and uncertainty of the Aeolus retrieval using the ERA5 and RS data, the quality and uncertainty of the latter two products must be well documented. While ERA5 data have widely used, its accuracy varies considerably, pending on the availability and usage of observation data used in the data assimilation system. Were ERA5 data accurate everywhere, there would be no need to launch the Aeolus.

Responds: Suggestions accepted. We have supplemented the quality verification of ERA5 data and RS data used in the manuscript (see Section 3.1). Although the uncertainty of ERA5 data varies pending on the availability and usage of observation data, the verification results show that the ERA5 data of the four regions used have high data quality. Therefore, this study uses ERA5 data as a reference to verify that the seasonal variation of wind and cloud detection efficiency is reasonable. The validity statement about RS data is added in Section 2.2, L78:

L78:

Added, "The L-band RS wind data used in this study are all the valid data detected by the four L-band RS stations."

More information about the quality of ERA5 wind data and RS wind data used is supplemented at the end of Section 3.1, L167.

L167:

Added, "The data qualities of the ERA5 wind data and L-band RS wind data are further verified as they are reference data. Studies have shown that ERA5 wind data and RS wind data are relatively reliable in various wind field models and detection methods (Molina et al., 2021; Piasecki et al., 2019; Ramon et al., 2019; Ingleby, 2017). The ERA5 data (matching the RS data) used in this study was compared and verified with the RS data in the vertical direction, and the results are shown in Figure 6. Except for the vertical height range of 14–19 km, the average error between RS wind data and ERA5 wind field data is basically within the range of -0.5–0.5m/s. However, it can be seen from Fig. 6b that the increase in the error within the range of 14–19 km is caused by the increase in the wind speed value, and the relative error between the RS wind data and the ERA5 wind data is mostly within 0.3. The good consistency of the two data in the vertical direction can indirectly verify the

quality of the ERA5 wind field data and the RS wind field data in this study."

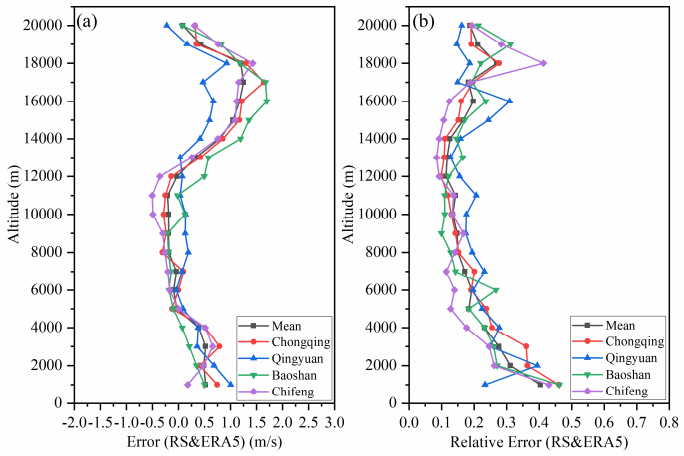


Figure 6. Vertical comparison of ERA5 wind data and RS wind data for four regions. (a) Error, (b) Relative Error.

2. The method needs to be described more clearly in terms of logical expression and working principles.

Responds: Suggestions accepted. More information in terms of logical expression and working principles has been added in the Section 2, L59:

L59:

Added, "The main processing procedures is showed in Fig. 2 and more details will be introduced below."

Added a figure below Fig.1:

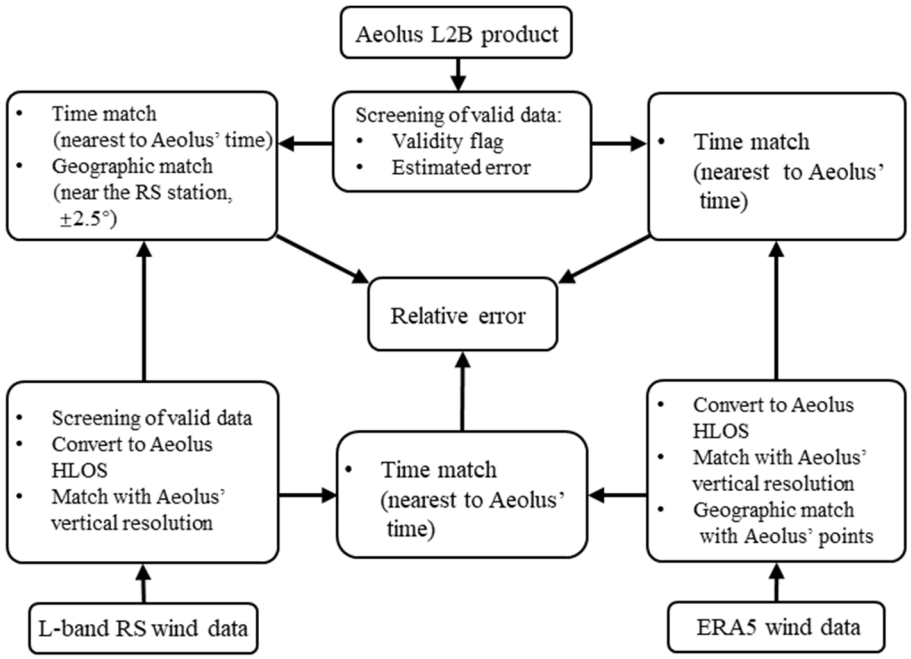
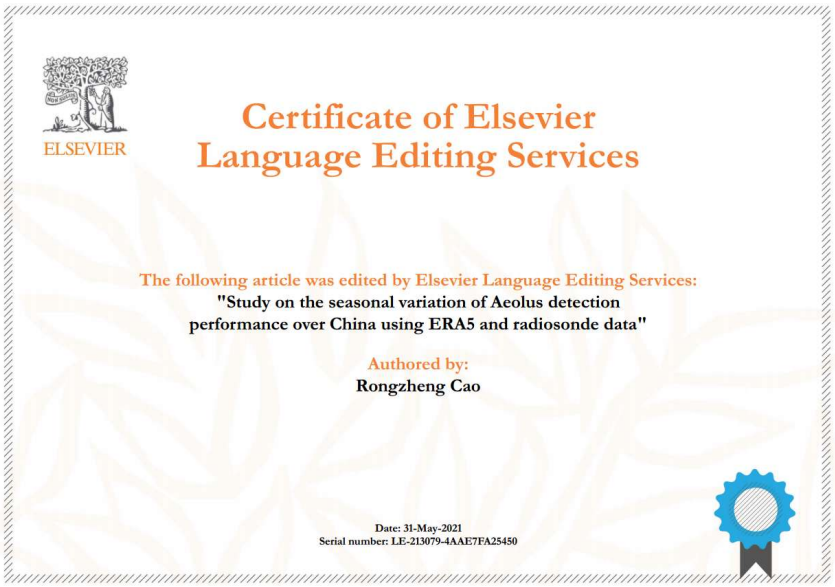


Figure 2. The main processing procedures of Aeolus, L-band RS and ERA5 wind data.

3. The paper needs to be edited extensively to correct many non-standard use of English such as "L34: relevant researchers...", "L42: deepened our understanding".

Responds: Suggestions accepted. The manuscript has been thoroughly revised by Elsevier language editing services. The certificate is displayed here.



ELSEVIER

Certificate of Elsevier
Language Editing Services

The following article was edited by Elsevier Language Editing Services:
"Study on the seasonal variation of Aeolus detection performance over China using ERA5 and radiosonde data"

Authored by:
Rongzheng Cao

Date: 31-May-2021
Serial number: LE-213079-4AAE7FA25450

4. In Figure 2, add the number of points within and outside the thresholds.

Responds: Suggestions accepted. The number of points within and outside the thresholds has been added in Figure 2.

Replace Figure2:

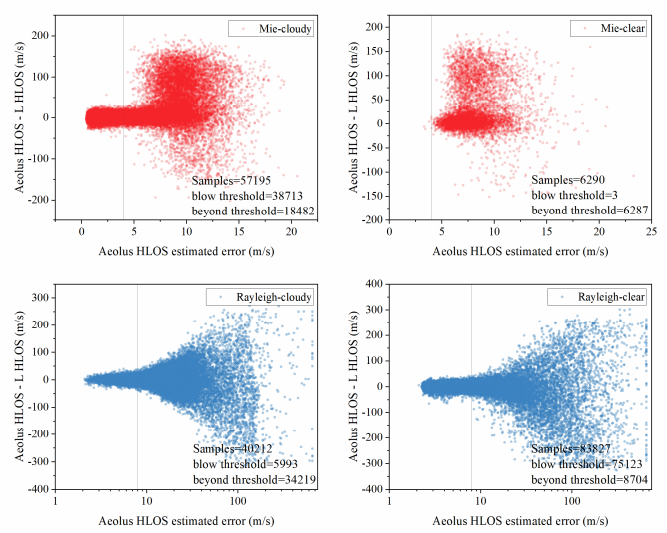


Figure 2. Difference between the Aeolus HLOS and L HLOS wind components as a function of estimated errors for (a) Mie-cloudy,(b) Mie-clear, (c) Rayleigh-cloudy and (d) Rayleigh-clear. Samples mean the number of data points and the samples blow or beyond the threshold are also listed. Reference lines are the screening threshold of estimated errors: 4 m/s (Mie) and 8 m/s (Rayleigh).

5. Add a table of all data used in the study.

Responds: Suggestions accepted. The table of all data used in the study is added after Figure 1. Meanwhile, a labeling error of Chifeng station has been modified in Figure 1 as follows.

Replace Figure 1:

Figure 1. The geographic location of the L-band RS site and the Aeolus measurement trajectory. In the partial enlarged view (http://aeolus-ds.eo.esa.int/socat/L1B_L2_Products), the red rectangles represent the range of ±2.5° around the L-band RS stations, and the gray-green lines represent Aeolus' overlapping trajectories of the 12 months.

Added a table,

Data	Aeolus	ERA5	L-band RS
Time	2019.07–2019.12 and 2020.05–2020.10 Around 10:00 UTC and 22:00UTC	2019.07–2019.12 and 2020.05–2020.10 Every hour	2019.07–2019.12 and 2020.05–2020.10 Around 0:00 UTC and 12:00 UTC
Geographical location	±2.5° (latitude and longitude) near the target RS station	±2.5° (latitude and longitude) near the target RS station	Chifeng(42.3°N,118.8°E) Baoshan(31.4°N,121.4°E) Shapingba(29.6°N,106.4°E) Qingyuan(23.7°N,113.1°E)
Vertical Resolution	0.25km to 2km	37 pressure levels for 1000hPa to 1hPa	< 10m
Max. Altitude	Around 20km for valid data	Around 45km	Around 32km

Table 1. Main characteristics of the data sets used in the comparison.

6. In section 2.4 (L105-110), add some related literature or a further explanation on the wind speed matching method of different data sets in the vertical direction.

Responds: Suggestions accepted. Further explanation on the wind speed matching method of different data sets in the vertical direction has been added and amended in Section 2.4, L106.

Section 2.4, L106:

"In the vertical direction, due to the difference in the vertical resolution of the three data, both L-band RS data and ERA5 data are matched with the Aeolus data through linear interpolation. For each Aeolus valid data point, L-band RS (ERA5) data points which are just higher and just lower than the Aeolus valid data point are found. We mark them as V(H^+) and V(H^-) and then do a

linear interpolation", changed to,

"In the vertical direction, due to the difference in the vertical resolution of the three data sets, both L-band RS data and ERA5 data need to be matched with the Aeolus data through linear interpolation. Linear interpolation is a method of curve fitting using linear polynomials to construct new data points within the range of a discrete set of known data points. The L-band RS (ERA5) data point which is just higher than one Aeolus data point in altitude is found and marked as $V(H^+)$. Then, $V(H^-)$ is also find which is just lower than the Aeolus data point. The L-band RS (ERA5) wind matched with the Aeolus data point is calculated by Eq. (2)."

We find that there is an error in equation (2), which may bring trouble to readers' understanding. We have corrected Eq. (2) in the manuscript.

Equation (2) changed to:

$$V_H = V(H^-) + \frac{H_{Aeolus} - H^-}{H^+ - H^-} \cdot \left(V(H^+) - V(H^-)\right), \quad (2)$$

7. In L116, how is the data represented by Vture corrected? Are there corrections for ERA5, Aeolus and RS data? The correction process needs further explanation. Does Vture on L125 refer to the same variable as that on line 116? If it is different, use a different expression.

Responds: Suggestions accepted. Equation (3) is used to calculate the difference between wind speeds of different data sets and the V_{ture} is not used. The V_{ture} in L125 refer to different variable as that on L116. We have modified the Eq. (3).

Equation (3) changed to,

$$D = V_a - V_b, \quad (3)$$

L116:

"where V represents the detection value, and V_{ture} represents the true value of the calibration", changed to, "where V_a and V_b represent the wind speeds of different data sets."

8. Figure 5 shows the statistical results of the Chifeng station. Are the statistical results at other stations similar to this one? It is recommended to add a description of the table.

Responds: Suggestions accepted. Yes. The statistical results at other stations is similar to this one. The statistical results of relative error at other stations is added in Section 3.2, L176.

L177:

Added, "The statistical results of relative error at four RS stations are summarized in Table 3. When we choose 3 (300%) as threshold of relative error, most of meaningful data points in four regions are within the threshold."

	P90	P95	P99
Chifeng	1.80	3.91	499.24
Baoshan	2.45	5.24	41.75
Shapingba	2.96	5.92	26.55
Qingyuan	3.33	6.29	30.42

Table 3. Percentiles of the relative error between Aeolus detection data and L-band RS data for 4 regions. P90 represents the boundary value of the range where 90% of the relative error falls. The mean of P95 and P99 is similar to P90.

9. In L195, specify the time interval of the data with low laser energy.

Responds: The time interval of the data with low laser energy can't be found in the literature. But it is reported that the ESA decided to switch to Aeolus' backup lasers in July 2019 due to a drop in laser energy. The Aeolus data used in this paper are from July to December 2019 as well as May to October 2020. Figure 7a showed that relative error in 2020 is apparently higher than 2019, so we suspect that the energy of the new laser is still declining.

10. In L256, the difference in r near the ground is caused by aerosols, but in eq 9 there are only clear and cloudy. Is the type of aerosol also classified into cloudy? Please clarify this.

Responds: Suggestions accepted. Yes. The type of scattering caused by aerosol is classified into cloudy group, which has been explained in Aeolus' data processing algorithm (Rennie et al., 2020). We are sorry for not fully clarified it, and now it is emphasized in Section 3.2.2, L246.

L246:

Added, "Scattering caused by clouds and aerosols are both classified into the cloudy group as they belong to Mie scattering."

11. L286, Daeolus represents the relative error value of the Aeolus data. There are many reasons for the error, SNR is one of them. Why can Daeolus represent SNR? The definitions of these two parameters are completely different.

Responds: Suggestions accepted. This statement is loosely, we have deleted it in the manuscript. However, the increase in D_{Aeolus} below 8km may be caused by the distribution of clouds. This provides a basis for explaining the insignificant seasonal variation of the detection accuracy of the Mie channel.

L286:

Delete this sentence, "When we use D_{Aeolus} to represent the value of SNR".

12. L304: increases with what?

Responds: Suggestions accepted. There may be a misunderstanding here because of the English expression. We have modified it in L304.

L304:

"the relative errors of the Rayleigh-clear data increase significantly for the four regions in the summer as the mean relative error parameter in July is 174% higher than that in December", changed to,

"the calculation results show that the relative error of summer Rayleigh-clear data in the four regions increases significantly, and the average relative error in July is 174% higher than that in December"

References:

Ingleby, B.: An assessment of different radiosonde types 2015/2016, European Centre for Medium Range Weather Forecasts, 2017.

Molina, M. O., Gutiérrez, C., and Sánchez, E.: Comparison of ERA5 surface wind speed climatologies over Europe with observations from the HADISD dataset, Int J Climatol, joc.7103, https://doi.org/10.1002/joc.7103, 2021.

Piasecki, A., Jurasz, J., and Kies, A.: Measurements and reanalysis data on wind speed and solar irradiation from energy generation perspectives at several locations in Poland, SN Appl. Sci., 1, 865, https://doi.org/10.1007/s42452-019-0897-2, 2019.

Ramon, J., Lledó, L., Torralba, V., Soret, A., and Doblas-Reyes, F. J.: What global reanalysis best represents near-surface winds?, 145, 3236–3251, https://doi.org/10.1002/qj.3616, 2019.

Rennie, M., Tan, D., Andersson, E., Poli, P., and Dabas, A.: (MATHEMATICAL DESCRIPTION OF THE AEOLUS LEVEL-2B PROCESSOR), 124, 2020.