Response to Reviewer #1's Comments

Aeolus is the satellite means for measurements of wind information for the first time, which is the milestone for wind observations for a global scale. In this paper, the authors evaluated the accuracy of wind products of Aeolus with ground-based wind observations from the RWP network in China. The results show that Rayleigh-clear wind products of categories 1 and 2 are better than category 3 with RWP winds, Mie-cloudy wind products are consistent with RWP winds in most of east China. This manuscript is of significance to understand the accuracy of the Aeolus product in China. Overall, this manuscript is clear and well written. However, the following major issues need to be improved:

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.

1. In the introduction part, the author proposes that the significance of this study is to systematically evaluate the accuracy of Aeolus products in the high aerosol background in China for the first time. However, the time of Aeolus products analyzed in this study is from May to September 2020. In this period, the concentration of aerosol in China is generally low. In addition, due to the influence of covid-19 this year, there is little air pollution from May to September, which does not match the hypothesis of "research significance: product accuracy evaluation under the background of high pollution in China". Therefore, is it more reasonable to choose a time with heavy pollution background to reevaluate Aeolus products? What is the author's consideration?

Response: Good questions! It is well recognized that the air quality in China has been significantly improved, largely thanks to the reduction of emission. Meanwhile, the aerosol concentration tends to be low in the summer due to the wet scavenging effect of summer monsoon rainfall. Nevertheless, the summertime PM2.5 in China varies between 30 and 60 μg/m3, depending on the region of interest (c.f. Fig. 3 in Zhai et al., 2019). This is approximately 3-5 times larger the global mean PM2.5, according to the global comparison analysis (van Donkelaar et al. 2016). Therefore, we think the evaluation of Aeolus wind products in China becomes more scientifically significant, given the high aerosol pollution background in China. In this sense, our study is unique and quite different from most of the validation study in the literature that is mainly limited to region or countries with relatively good air quality. On the other hand, limited availability of Aeolus satellite data prohibits us extending our study to longer time priod, since the Aeolus data went public on May 12, 2020.

As you indicated, the air quality became much better during our study period due to the emission-reduction measures taken by Chinese government in order to combat COVID-19. However, the concentration of pollutants in China is still at a high level during the COVID-19 period, due either to unfavorable meteorological factor, or to the secondary aerosol pollution. For instance, Le et al. (2020) pointed out that up to 90% reduction of certain emissions during the city-lockdown period can be identified from satellite and ground-based observations. Unexpectedly, extreme particulate matter levels simultaneously occurred in northern China. Huang et al., (2020) found that the haze during the COVID lockdown were driven by enhancements of secondary pollution. He et al. (2020) quantitatively studied the impact of the COVID-19 lockdown on China's air pollution. They found that AQI in the locked-down cities was brought down by 19.84 points (PM2.5 down by 14.07 μg m^{-3}) relative to the control group. Despite these improvements, PM2.5 concentrations during the lockdown periods remained four times higher than the World Health Organization recommendations. All of the above-mentioned studies confirmed that China remains plagued with frequent air pollution episodes.

Last but not least, aerosol pollution tends to become most severe in winter in China. The studies regarding how aerosol affects the accuracy of Aeolus wind products in winter merits further investigation in the future.

To clarify this point, we have added some descriptions in the introduction: "For instance, many studies have shown that China experienced several episodes of severe haze pollution during the COVID-19 lockdown period, despite the widespread emission reduction (Huang et al., 2020; He et al., 2020; Le et al., 2020; Su et al., 2020)."

References:

Le, T., Wang, Y., Liu, L., Yang, J., Yung, Y. L., Li, G., & Seinfeld, J. H.: Unexpected air pollution with marked emission reductions during the COVID-19 outbreak in China. Science, 369(6504), 702-706, 2020.

Huang, X., Ding, A., Gao, J., et al.: Enhanced secondary pollution offset reduction of primary emissions during COVID-19 lockdown in China. National Science Review, nwaa137, https://doi.org/10.1093/nsr/nwaa137, 2020.

He, G., Pan, Y., & Tanaka, T.: The short-term impacts of COVID-19 lockdown on urban air pollution in China. Nature Sustainability, 1-7, 2020.

Su, T., Li, Z., Zheng, Y., Luan, Q., and Guo, J.: Abnormally shallow boundary layer associated with severe air pollution during the COVID-19 lockdown in China. Geophys. Res. Lett., 47, e2020GL090041, 2020.

van Donkelaar, A. et al.: Global Estimates of Fine Particulate Matter using a Combined Geophysical-Statistical Method with Information from Satellites, Models, and Monitors. Environ. Sci. Technol. 50, 3762−3772, 2016.

Zhai, S., Jacob, D. J., Wang, X, et al.: Fine particulate matter (PM2.5) trends in China, 2013–2018: separating contributions from anthropogenic emissions and *meteorology, Atmos. Chem. Phys., 19, 11031–11041, https://doi.org/10.5194/acp-19-11031-2019, 2019.*

2. The paper mentioned the quality of satellite product and ground-based observations, is there any high levels of quality flag in the satellite products? Like low, middle and high? For the ground-based observations, how many 100% confident level data used?

Or how many data were dropped?

Response: To the best of our knowledge, currently there is no high levels of quality flag in the satellite products. At this stage, the Aeolus team only provide the validity flags (0=invalid and 1=valid) and estimated errors (theoretical) as the quality flag.

For the ground-based observations, the confident level is equivalent to valid flag (100%=valid, less than 100%=invalid). As long as it was matched with Aeolus and the confidence is 100%, it has been be used. According to our previous study regarding the introduction of the RWP network in China (Liu et al., 2020), the 100% confident level data accounts for more than 98% of RWP network observation data. Therefore, only about 2% of data were dropped, which has been clarified in section 2 of this revision.

Reference:

Liu, B., Guo, J., Gong, W., Shi, L., Zhang, Y., & Ma, Y.: Characteristics and performance of wind profiles as observed by the radar wind profiler network of China. Atmospheric Measurement Techniques, 13(8), 4589-4600, 2020.

3. What's the meanings of Rayleigh-clear and Mie-cloudy? How do these two algorithms calculate wind information?

Response: The wind observations are classified into Rayleigh-clear wind that refers to the wind in aerosol-poor atmosphere, and Mie-cloudy wind that refers to the wind acquired from Mie backscatter signals induced by aerosols and clouds.

Regarding the algorithms used to estimate wind, the wind speed is calculated based on the Doppler effect. When the laser encounters atmospheric particles (aerosols or molecular), it would produce a Doppler frequency shift. The wind speed can be calculated by detecting this frequency shift. ALADIN is equipped with two different frequency discriminators, namely a Fizeau interferometer that is used to analyze the frequency shift of the narrowband particulate backscatter signal (Mie) and two sequentially coupled Fabry–Pérot interferometers that are used to analyze the frequency shift of the broadband molecular return signal (Rayleigh). Figure R1 illustrates the Doppler effect.

We have added the following paragraph in Section 2.1, which shows as follows: "The wind speed is calculated based on the Doppler effect (Tan et al., 2008). Here,

we mainly discuss the performance of Rayleigh-clear winds and Mie-cloudy winds. Rayleigh-clear winds refer to the wind observations in aerosol-free atmosphere, whereas Mie-cloudy winds refer to the winds acquired from Mie backscatter signals induced by aerosols and clouds (Witschas et al., 2020).”

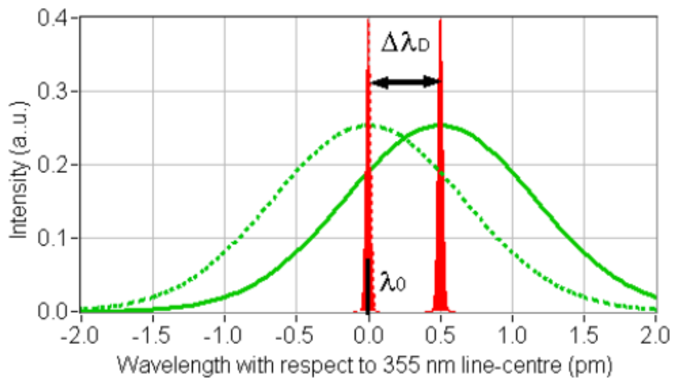

Figure R1. Wavelength spectra for the backscattered Mie (red) and Rayleigh (green) signal for a 355 nm source at λ_0 (dotted lines) and a Doppler shift $\Delta\lambda_D$ (bold lines); the indicated Doppler shift of 0.5 pm corresponds to a LOS wind speed of ~ 200 ms^{-1}

4. What’s the estimated errors (x-axis) in the Figure 4? How about all accuracy when using all quality’s data (not control the quality using estimated errors)?

Response: The estimated error is theoretical value, which is estimated based on the measured signal levels as well as the temperature and pressure sensitivity of the Rayleigh channel response. It was provided as a separate parameter in the L2B data product. We have added the following descriptions in section 2.1. “The estimated error is a theoretical value, which is estimated based on the measured signal levels as well as the temperature and pressure sensitivity of the Rayleigh channel response (Dabas et al., 2008). It was provided as an indispensable parameter in the L2B data product.”

Per your suggestion, we carried out comparison analysis using all quality’s data (not control the quality using estimated errors), and the results are shown in Figure R2. It can be found that the correlation is very poor. Therefore, the official documentation and references pointed out that the estimated errors need to be considered when performing data quality control. In addition, we added Figure R2 to the supplementary material. We have added the following sentence in section 2.3: “Figure S1 shows the scatter plots of Aeolus wind speed against RWP wind speed for all data without controlling the quality using estimated errors. It can be found that the correlation is very poor. Therefore, the official documentation and references pointed out that the estimated errors need to be considered when performing data quality control.”

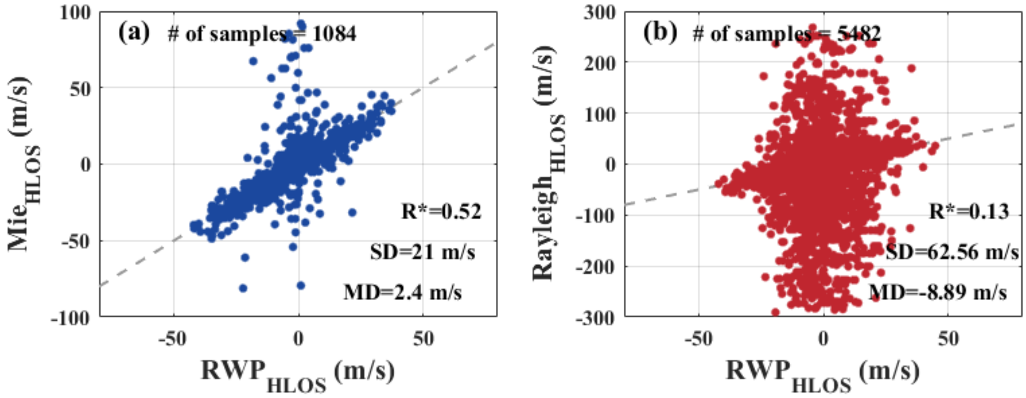

Figure R2. Aeolus against RWP HLOS winds for (a) Mie-cloudy winds and (d) Rayleigh-clear winds for all data.

5. Fig.6 shows a spatial distributions of correlation coefficients for each site. Why coastal areas have larger R values while inner of China has lower R values? Especially in the Sichuan basin.

Response: Good question! The RWP instruments have been updated in coastal provinces in China in recent years, and most of the RWP sites are concentrated along the coastal areas, where have relatively rapid economic development speed. Coincidently, the sites with high R values mostly lie at these regions. Therefore, the maintenance capability at these sites is likely to the major reason for the spatial variability of R values found in Fig. 6.

Another reason may be the small number of sample points of these inland sites (Figure R3), which affects the correlation results.

To clarify this issue, we have added the following sentence in section 3.1: "Therefore, the reason for the high R values observed here could be the sufficient maintenance of RWP instrument along the coastal region, resulting to more matched data points therein (Figure S2)."

6. Number of points of each site for validation of winds are important in calculating R, and SD, etc., some sites show a lower R values (e.g. Sichuan basin) in the Figure 6. So, what's the number of each site used in the validation? Give a spatial distribution of each site's number of paired data.

Response: Points taken! We added the Figure R3 to the supplementary material.

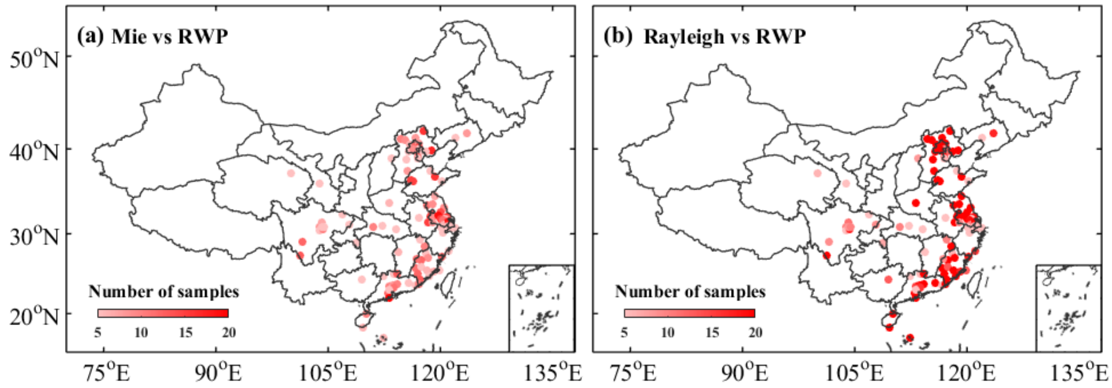

Figure R3. Spatial distribution of each site's number of paired data between Aeolus HLOS and RWP HLOS wind speeds. The wind measurements are separated in (a) Mie-cloudy winds and (b) Rayleigh-clear winds.

7. Why Rayleigh wind in the descending has a large error than ascending in the 0–2 km in the Figure 11 (b, c)?

Response: This may be caused by the diurnal variation of aerosols in the atmospheric boundary layer. At ascending time (06:00 LST), the boundary layer height is generally less than 0.5 km (Guo et al., 2016), and the atmosphere in the range of 0.5–2 km is dominated with molecule scattering. By comparison, at descending time (18:00 LST), the boundary layer height tends to be elevated to approximately 1–2 km, in which aerosol scattering dominates. It is noteworthy that the Rayleigh performance is largely limited by received power. Nevertheless, the strong aerosol scattering in the boundary layer would inevitably undermine the molecular scattering signal, thereby reducing the inversion accuracy of Rayleigh wind from Aeolus (Tian et al., 2017).

Related discussion has been added to this revision.