Response to Reviewer #1:

General comments:

Based on one year of simultaneous wind measurements acquired from 17 Doppler wind lidars across China, this manuscript by Wu et al. conducted a comprehensive comparison study against Aeolus wind products. Overall, this topic fits well the AMT. The instruments and data are reliable, and the analysis methods are scientifically sound. In my opinion, the manuscript is well organized except for some typos and grammar errors. The comparison results are of great importance to better understand the performance of Aeolus wind products in China, even though the measurements are obtained from coherent Doppler lidar (with 1550 nm wavelength) over China. However, before the manuscript can be recommended for acceptance for publication, I have several suggestions and comments here that need to be addressed.

Specific comments:

1. Section 2.2.2: Line 128 says "The measurement heights selected for comparison are 50 m, 100m." Nevertheless, I only see the comparison results at 50 m in Figure 2. I am curious why not showing the results at 100 m AGL? 2 only compares the wind speed without considering the wind direction. I suggest the authors compare the u-component wind.

AR:

Sorry about the misleading. We actually compared both the heights at 50 m and 100 m for the wind speed and direction (as shown below). From the comparison, the slopes, offsets, correlation coefficients, standard deviations and BIAS all have same consistence. We think the comparison results at 50 m is enough to demonstrate the stability and the precision of Wind3D 6000 and WindMast PBL, thus we didn't plan to present the comparison results at 100 m in the manuscript, which might not make more sense. Besides, the manuscript will be tedious if we do that. We modified the sentences as "The measurement heights selected for comparison are 50 m, 100m. Figure 3 shows the comparison results at 50 m, which are wind speed and wind direction for Wind3D 6000 and WindMast PBL, respectively." in the revised manuscript.

Thank you for your suggestion. The wind direction comparison results at 50 m are shown in Fig. 3 in the revised manuscripts, which are presented as below as well:

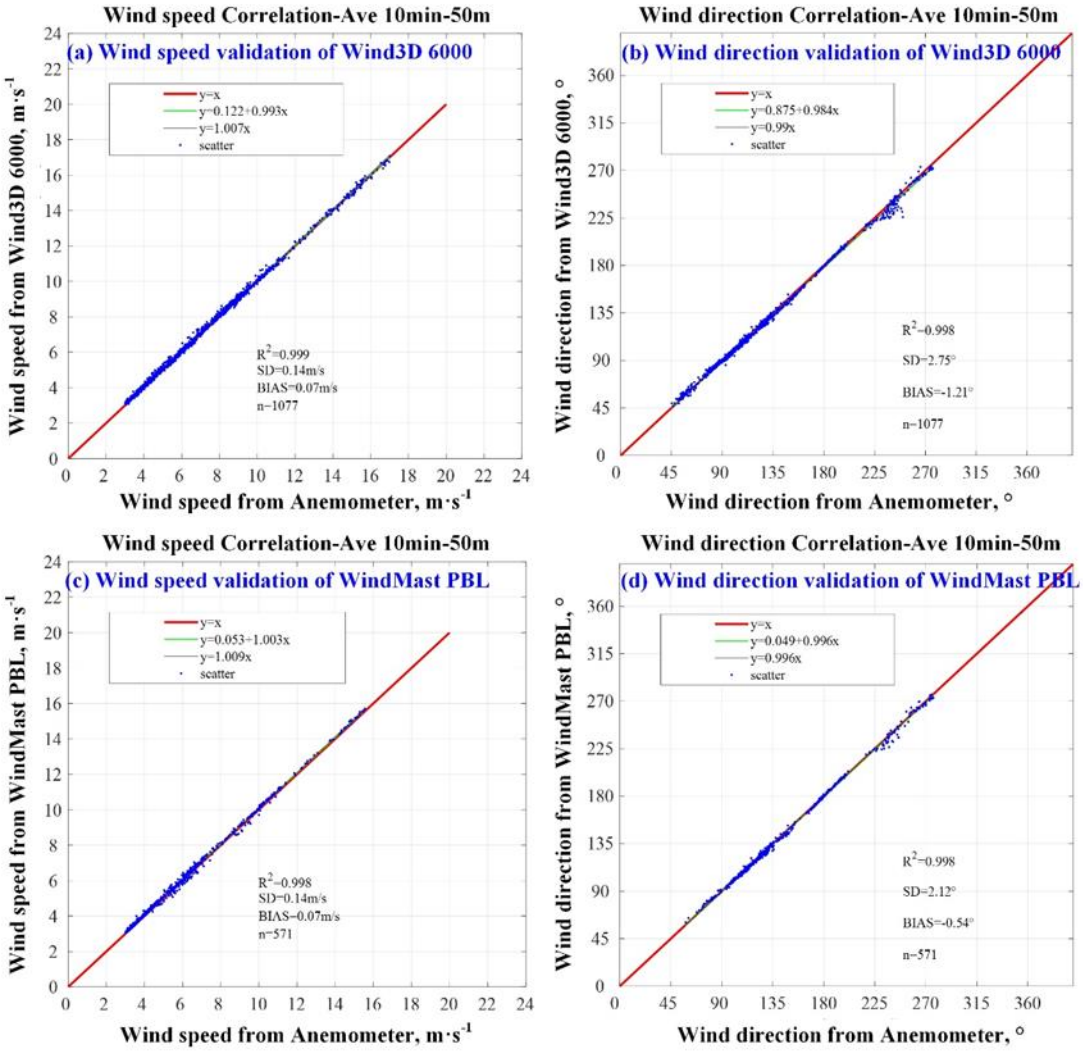
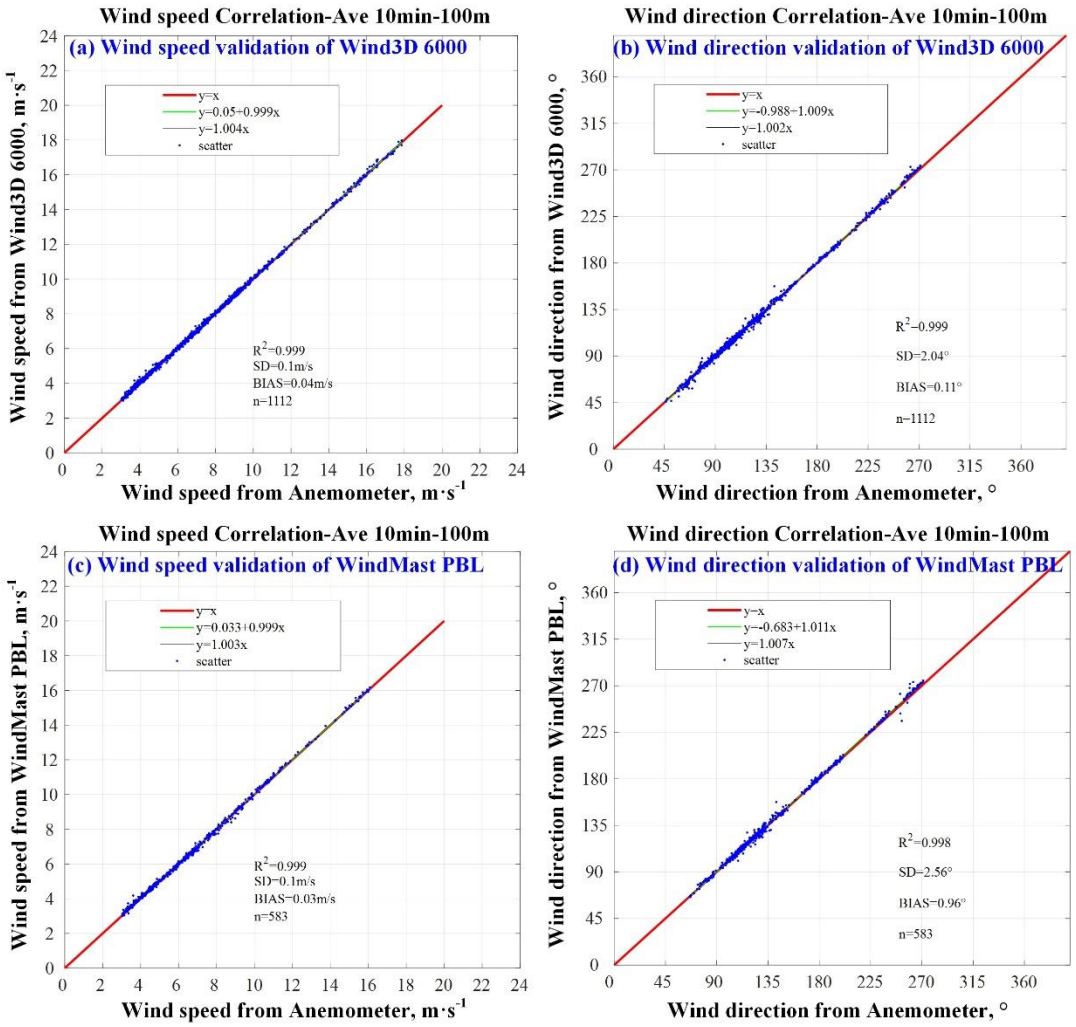


Figure 3. Evaluation tests of (a), (b) Wind3D 6000 and (c), (d) WindMast PBL performance by comparing their measurements against the conventional wind measurements with mast mounted cup anemometers and wind vanes.

Besides, the comparison results between Wind3D 6000/WindMast PBL and cup anemometers/wind vanes at 100 m AGL are shown below for the further knowledge.



It is considered that the since the CDLs of type Wind3D 6000 and WindMast PBL can measure wind speed and wind direction precisely, the u-component wind could also be calculated accurately.

Also, more details about the site Haiyang and the specification of the mast that is mounted cup anemometers and wind vanes at Haiyang needs to be added.

AR:

Thanks for the suggestion. The details about the site Haiyang and the specification of the mast that is mounted cup anemometers and wind vanes at Haiyang are added in the revised manuscript, which are also presented as below:

"The photos of the CDLs and the mast that mounted cup anemometers and wind vanes at site Haiyang are shown in Fig. 2. The horizontal distance between the Wind3D 6000, the WindMast PBL and the mast are around 6 m. The met mast configuration is compliant with IEC 61400-12-1 Edition 2 (IEC, 2011).

All cup anemometers installed on the reference mast are class 0.9A instruments and have undergone individual rotor specific MEASNET calibration at a MEASNET certified wind tunnel. Data acquisition systems sample all input ports and connected sensors continuously with a sampling rate of 1 Hz and compress the values to 10-minute-average-values. The specifications of the cup anemometers and wind vanes are listed in Table 3.

Figure 2. Photos of the CDLs and the mast that mounted cup anemometers and wind vanes at site Haiyang.

Table 3. Overview of the specifications of cup anemometers and wind vanes used for CDLs validation

Name of instrument	Type	Accuracy	Sampling frequency	Height
WS_50m_E	First Class Advanced 4.3351.00.000	0.2m/s	1Hz	50m
WS_50m_F	First Class Advanced 4.3351.00.000	0.2m/s	1Hz	50m
WD_48m	First Class Vane 4.3151.00.173	1°	1Hz	48m

”

Reference:

IEC: IEC 61400-12-1, Edition 2 Committee Draft, Wind turbines - Part 12-1: Power performance measurements of electricity producing wind turbines, 2011.

2. My biggest concern is on section 3.2. In this section, the authors proposed an important result that the vertical velocity could impact the HLOS wind velocity retrieval from Aeolus. But there are neither references nor experimental demonstrations here, only theoretical derivation. I suggest authors add a result about the deviation of Aeolus and CDL HLOS wind varies with vertical velocity.

AR: Yes, this section indeed only presents the theoretical derivation of vertical velocity correction. Actually, because Aeolus doesn't provide vertical velocity data products, vertical velocity correction is only conducted for ground based CDL. **Section 3.2 presents the correction method for the ground based lidar. Section 4.1 provides the Aeolus HLOS profiles, the CDL HLOS profiles and the vertical velocity corrected HLOS profiles of 5 cases, as well as the detailed analysis of CDL HLOS wind varies.** To make it clearer, the sentence "In Fig. 7 and Fig. 8, the CDL V_w Correction (30 mins) profiles (yellow lines) are the corrected results by the vertical velocity correction." is added in the revised Section 3.2. **Besides, it should be emphasized that, because of the horizontal distances between the Aeolus scanning tracks and the ground based CDL sites, and the heterogeneous atmospheric boundary layer, the vertical velocity correction is only used in the case studies but not used for the statistical comparison.**

3. The number of Mie-cloudy comparison pairs and 387 Rayleigh-clear comparison pairs were 52 and 387, respectively. In my opinion, the sample size is too small. Therefore, the significance test must be performed in Fig.10-12.

AR:

Thanks for the suggestion. According to significance test theory, if the probability value (p) of two data arrays is larger than 0.05, it is considered that there is no significant different between the data arrays. The significance test of Fig.10-12 is performed below:

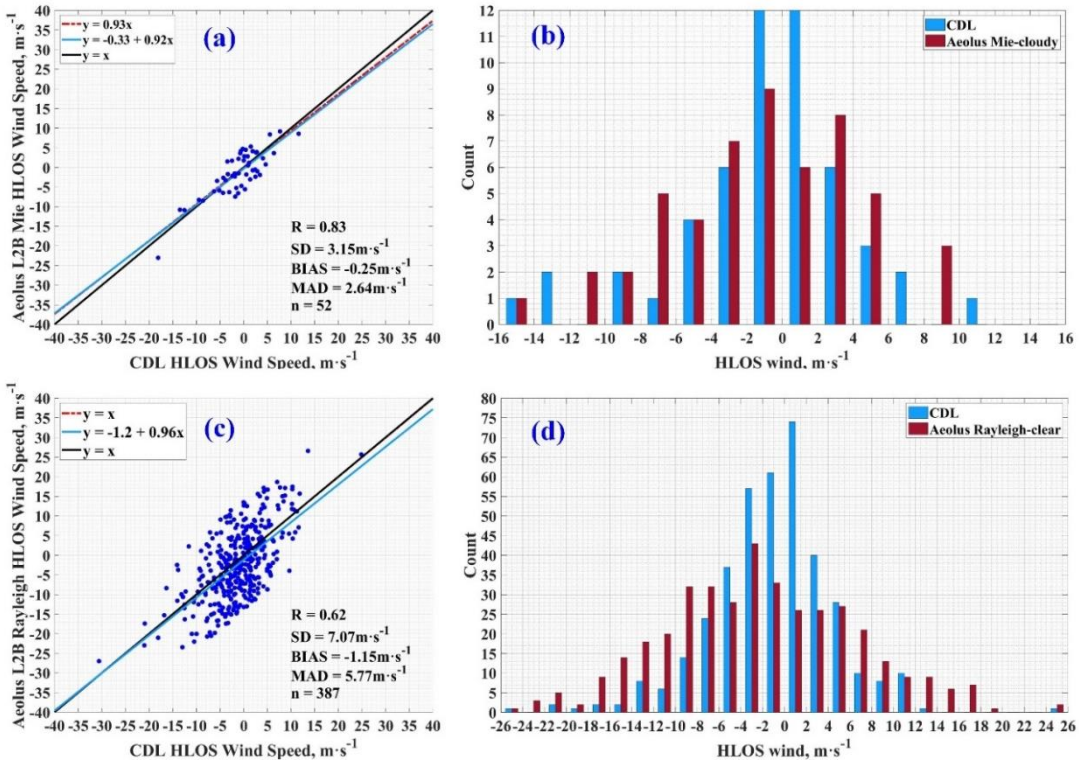


Figure 10. Comparisons of Aeolus L2B Rayleigh-clear HLOS wind velocities and Mie-cloudy HLOS wind velocities against that from CDL. In Fig. 10 (a) and (c), the red dotted lines represent the "y=ax" fitting lines; the blue lines represent the "y=ax+b" fitting lines; the black lines represent the "y=x" reference line. Figure 10 (b) and (d) show the histogram of counts of HLOS wind velocities, where the blue columns represent the count of CDL HLOS wind velocities and the red columns represent the count of Aeolus HLOS wind velocities.

Table. 1 The results of the significance test of Fig. 10 in the manuscript

Classification	Mie	Rayleigh
p	0.9084	0.0322

Table. 1 shows the results (p values) of the significance tests of the Mie-cloudy dataset and the Rayleigh-clear dataset respectively. The Mie-cloudy dataset's $p = 0.9084 > \alpha = 0.05$, thus it is considered that there is no significant difference between Aeolus Mie-cloudy HLOS data and the corresponding CDL HLOS data. That the Rayleigh-clear dataset's $p = 0.0322 < \alpha = 0.05$ is because the exist of the BIAS (-1.15 $m \cdot s^{-1}$) between Aeolus Mie-cloudy HLOS data and the corresponding CDL HLOS data.

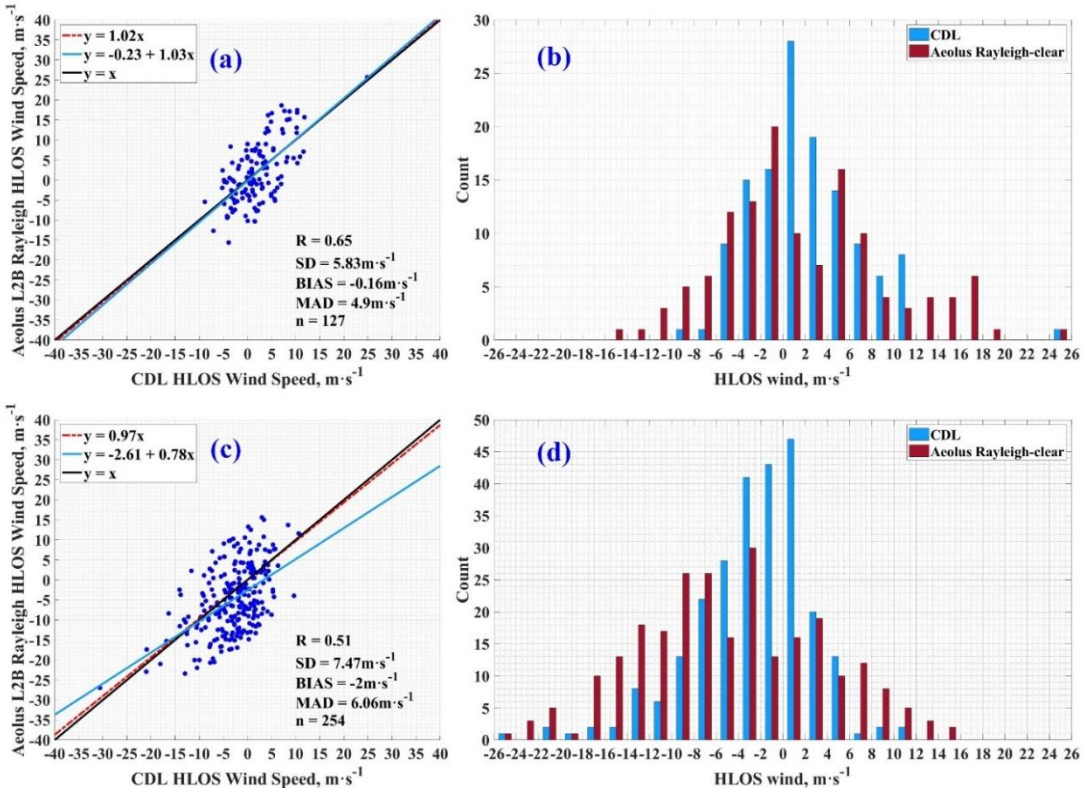


Figure 11. Comparisons of Aeolus Rayleigh-clear HLOS against the CDL-retrieved HLOS according to the measurements made on (a)(b) ascending and (c)(d) descending tracks. The lines and the histograms represent the same as those of Fig. 10.

Table. 2 The results of the significance test of Fig. 11 in the manuscript

Classification	Rayleigh-ascending	Rayleigh-descending
p	0.6615	0.0069

Table. 2 shows the results (p values) of the significance tests of the Rayleigh-ascending dataset and the Rayleigh-descending dataset respectively. The Rayleigh-ascending dataset's $p = 0.6615 > \alpha = 0.05$, therefore it is thought that there is no significant difference between Aeolus Rayleigh-ascending HLOS data and the corresponding CDL HLOS data. That the Rayleigh-descending dataset's $p = 0.0069 < \alpha = 0.05$ is because the significant BIAS (-2 $m \cdot s^{-1}$) between the Rayleigh-descending HLOS data and the corresponding CDL HLOS data.

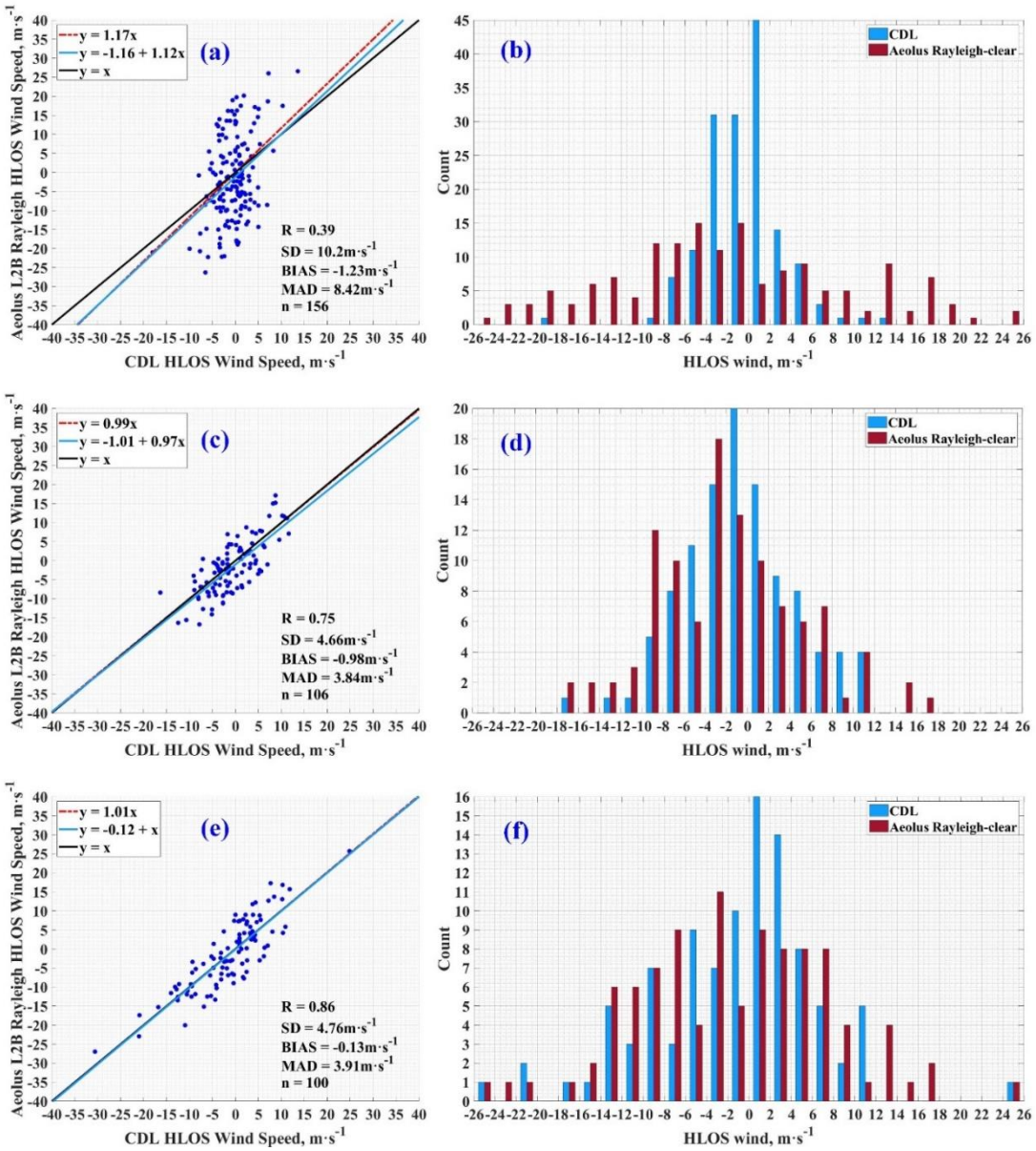


Figure 12. The comparison between the Aeolus L2B Rayleigh HLOS data from (a)(b) Baseline 07 and 08, (c)(d) Baseline 09 and 10, and (e)(f) Baseline 11 against the CDL-retrieved HLOS data. The lines and the histograms represent the same as those of Fig. 10.

Table. 3 The results of the significance test of Fig. 12 in the manuscript

Classification	Rayleigh-Baseline 07/08	Rayleigh- Baseline 09/10	Rayleigh- Baseline 11
p	0.1652	0.2471	0.9154

Table. 2 presents the p values of the significance tests of the Baseline 07/08 dataset, the Baseline 09/10 and the Baseline 11 dataset, respectively. As shown in Table. 3, the p values of these 3 datasets are all larger than $\alpha = 0.05$. Consequently, the Baseline 07/08 HLOS data its corresponding CDL HLOS data

have no significant different, so do the Baseline 09/10 HLOS data and the Baseline 11 HLOS data.

4. L144: "For Aeolus, only observations with the corresponding "validity flag" of TRUE are considered." Please clarify what is the "validity flag" of Aeolus. Similarly, why the estimated errors threshold of Mie-cloudy and Rayleigh-clear wind velocities were set to 4 and 8 m/s? There are neither references nor experimental demonstrations here.

AR:

The "validity flag" of Aeolus is the "validity_flag" data provided in the Aeolus L2B product. The "validity_flag" data bin corresponds to the Aeolus L2B HLOS wind data bin one by one, and 1 or TRUE of the "validity_flag" data represents valid while 0 or FALSE represents invalid. Hence, the Aeolus L2B HLOS wind data quality can be controlled preliminarily by using the "validity_flag". To clarify more clearer, the description in the manuscript has been revised as "For Aeolus, only observations with the corresponding "validity _flag" of TRUE, which is provided in the Aeolus L2B product, are considered."

We refer Witschas et al. (2020), "In this study, a threshold for the estimated error of 8 $\mathrm{m \cdot s^{-1}}$ is applied for the Rayleigh winds and 4 $\mathrm{m \cdot s^{-1}}$ for the Mie winds." Therefore, the estimated errors threshold of Mie-cloudy and Rayleigh-clear wind velocities were set to 4 $\mathrm{m \cdot s^{-1}}$ and 8 $\mathrm{m \cdot s^{-1}}$ respectively. The reference has been added in the revised manuscript and is listed below:

Witschas, B., Lemmerz, C., Geiß, A., Lux, O., Marksteiner, U., Rahm, S., Reitebuch, O., and Weiler, F.: First validation of Aeolus wind observations by airborne Doppler wind lidar measurements, Atmos. Meas. Tech., 13, 2381–2396, https://doi.org/10.5194/amt-13-2381-2020, 2020.

5. 3 needs to be modified. In the case studies, the HLOS wind and vertical correction HLOS wind from CDL are both used to compare with Aeolus HLOS wind. It needs to express the data matching process in a clearer way.

AR: Thanks for the suggestion. Fig. 3 has been modified in the revised manuscript to express the data matching, inter-comparison and statistical method in a clearer way, as shown below. From the revised Fig. 3, it can be seen that the HLOS wind and vertical correction HLOS wind from CDL are both used to compare with Aeolus HLOS wind, as you mention in the comment in the case studies. **However, in**

the statistical comparison of the Aeolus HLOS and the CDL HLOS, the corrected results over CDL HLOS are not used, because that due to the distances between the Aeolus scanning tracks and the CDL sites, the vertical velocity may be different in the heterogeneous atmospheric boundary layer, which could introduce error in statistical comparison. Consequently, the vertical velocity correction is only conducted in the profile comparisons for the case analysis and method discussion.

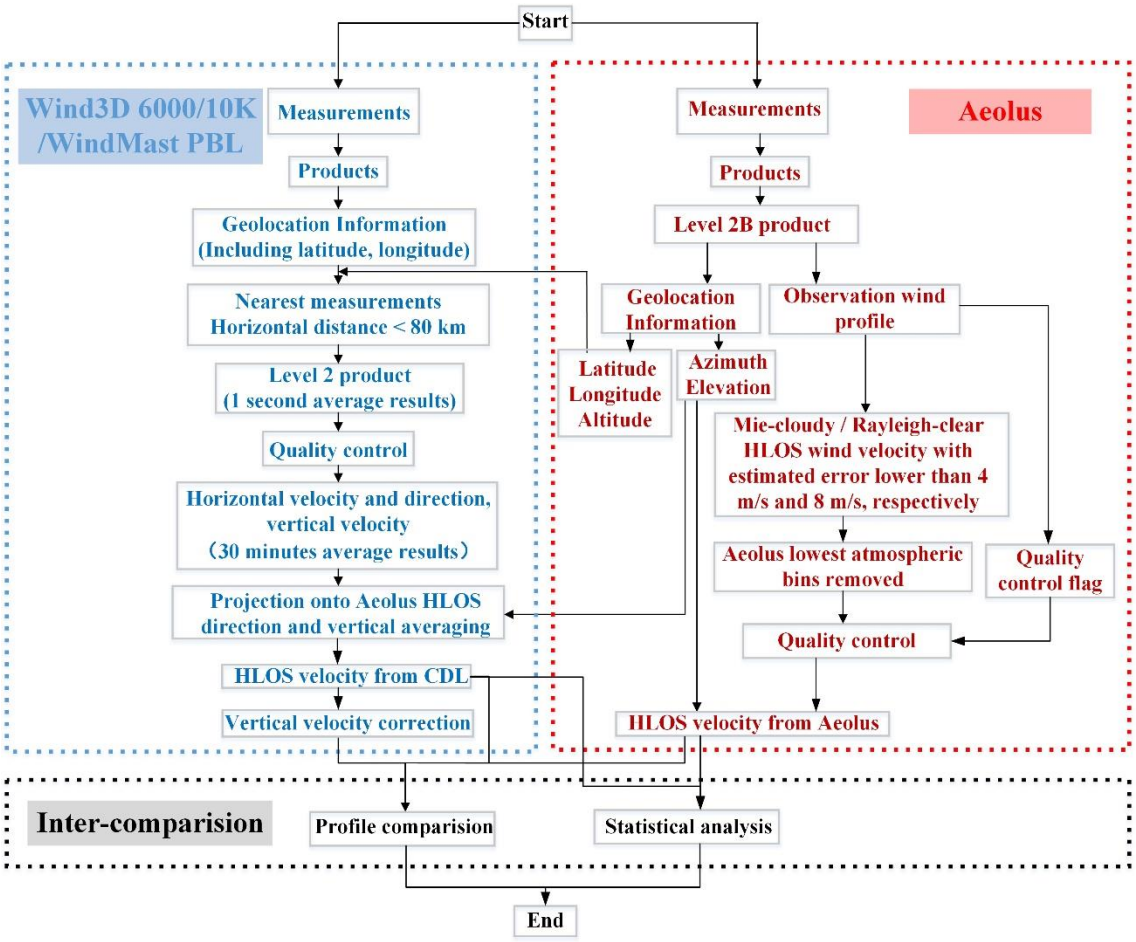


Figure 3. Sketch of the comparison between CDL and Aeolus in the atmospheric boundary layer.

6. What conclusions should the reader make from Fig. 6. It is just an observation case by Aeolus and CDL. I suggest that the author remove this picture, or draw the wind profiles that needs to be compared.

AR: Thanks for the suggestion. Figure. 6 has been removed in the revised manuscript.

7. If my understanding is correct, Figs. 7 and 8 should be the case comparison. What do the error bars

on the red and blue curves mean?

AR: The error bars on the red and blue curves mean the estimated errors of Aeolus L2B Mie-cloudy HLOS wind and Rayleigh-clear HLOS wind provided in the Aeolus L2B product.

Technical corrections:

L18: “atmospheric boundary layer” and “planetary boundary layer” appear several times in this MS, if both have the same meaning, just keeping one expressing is more appropriate.

AR: Thank you for your suggestion. “Atmospheric boundary layer” and “planetary boundary layer” do have the same meaning. The expressing has been unified as “atmospheric boundary layer” in the revised manuscript.

L27-28: It is not appropriate to say “better than” when describing MAD and bias.

AR: Thank you for your suggestion. The sentence in the revised manuscript has been revised as “It is found that the standard deviation, the scaled MAD and the bias on ascending tracks are lower than that on descending tracks.”

L41-42: the second and third “from” are redundant and can be dropped. Reference supports are needed for the statement “wind profiles from global radiosonde network and aircraft”. The authors may refer to Guo et al. 2021(https://doi.org/10.5194/acp-2021-257); and Zhang et al., 2020 (https://doi.org/10.1029/2020JD032803), respectively.

AR:

Thanks for the suggestion. The second and third “from” in the sentence has been dropped in the revised manuscript. The relevant references are added in the revised manuscript as well.

The sentence is modified as “Wind profiles are available from the global radiosonde network and aircraft ascents and descents and cruising altitudes for numerical weather prediction (Zhang et al., 2020;

Guo et al., 2021)."

The references are added as following:

Guo, J., Zhang, J., Yang, K., Liao, H., Zhang, S., Huang, K., Lv, Y., Shao, J., Yu, T., Tong, B., Li, J., Su, T., Yim, S. H. L., Stoffelen, A., Zhai, P., and Xu, X.: Investigation of near-global daytime boundary layer height using high-resolution radiosondes: First results and comparison with ERA-5, MERRA-2, JRA-55, and NCEP-2 reanalyses, Atmos. Chem. Phys. Discuss. [preprint], https://doi.org/10.5194/acp-2021-257, in review, 2021.

Zhang, Y., Sun, K., Gao, Z., Pan, Z., Shook, M. A., and Li, D.: Diurnal climatology of planetary boundary layer height over the contiguous United States derived from AMDAR and reanalysis data, Journal of Geophysical Research: Atmospheres, 125, e2020JD032803, https://doi.org/10.1029/2020JD032803, 2020.

L61-62: what is missing is the predicate in the sentence begin with "An example of early validation"

AR: Sorry about the mistake. This sentence has been modified as "An example of early validation of Aeolus with a direct-detection Rayleigh-Mie Doppler lidar was performed at Observatoire de Haute-Provence (OHP) in southern France (Khaykin et al., 2020)." in the revised manuscript.

L83: "During 14 January and 14" -> "During the period from 14 January to 14"

AR: Thanks for the suggestion. The sentence has been modified as "During the period from 14 January to 14 February 2019, Aeolus was in standby-mode and switched-on with FM-A." in the revised manuscript.

L85: delete ")"

AR: Thanks. The ")" has been delete in this sentence in the revised manuscript.

L174 and 177: Typos in Eqs. 2 and 3: “cot” should be revised to “cos”

AR: As the figure shown below, according to the projection relationship, the LOS component of vertical velocity is $V_1 = V_{vertical} \cdot \cos 37°$. Result from the definition of Aeolus HLOS wind ($V_{HLOS} = V_{LOS}/\sin 37°$), the influence of V_1 on V_{HLOS} is $V_2 = V_1/\sin 37°$. Consequently, the influence of $V_{vertical}$ on V_{HLOS} is $V_2 = V_{vertical} \cdot \cos 37°/\sin 37°$, i.e. $V_2 = V_{vertical} \cdot \cot 37°$. Thus, “cot” is correct in Eqs. 2 and 3.

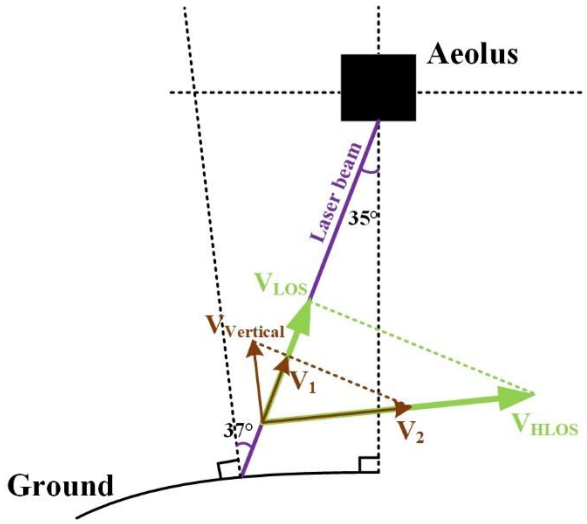


Figure 6a,b: “DEM altitude”s -> “DEM”

AR: Thanks. Figure. 6 has been removed in the revised manuscript.

Table 7a and 7b: error in the citation for “RS over China (Guo et al. 2021),” which should be revised to “Liu et al. 2021”. Also, The ACPD by Guo et al. 2020 in the reference list has been finally published as ACP in 2021, and is suggested to be corrected as well.

AR: Sorry about the mistake. “RS over China (Guo et al. 2021)” in Table 7a and 7b has been revised to “RS over China (Liu et al. 2021)”. Besides, the ACPD by Guo et al. (2020) in the reference list has been corrected as following:

Guo, J., Liu, B., Gong, W., Shi, L., Zhang, Y., Ma, Y., Zhang, J., Chen, T., Bai, K., Stoffelen, A., de Leeuw, G., and Xu, X.: Technical note: First comparison of wind observations from ESA's satellite mission

Aeolus and ground-based radar wind profiler network of China, Atmos. Chem. Phys., 21, 2945–2958, https://doi.org/10.5194/acp-21-2945-2021, 2021b.

L332: grammar errors in “by used with” and needs to be corrected.

AR: Sorry about the mistake. The sentence has been revised as “Mie-cloudy and Rayleigh-clear wind velocities from the Aeolus L2B are selected with the corresponding “validity_flag” of TRUE with the estimated errors lower than 4 m/s and 8 m/s, respectively.”

L341: “By” -> “Using”

AR: Thanks. This sentence has been rephrased as “Using the simultaneous wind measurements with CDLs and Aeolus, the Rayleigh-clear HLOS wind velocities and Mie-cloudy HLOS wind velocities from Aeolus are compared with that from CDL, respectively.” in the revised manuscript.

L364: the article “the” is missing before “planetary boundary layer”

AR: Thanks. The error has been corrected in the revised manuscript.

L364-365: The two sentence can be rephrased as “In the planetary boundary layer, the vertical velocity from convection and turbulence could influence the comparison, due to the impact of vertical velocity on the HLOS wind velocity retrieval from Aeolus.”

AR: Thanks. These two sentences have been rephrased in the revised manuscript.