Atmospheric Measurement Techniques Discussions

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Reply on RC1

Damao Zhang et al.

Author comment on "Comparison of planetary boundary layer height from ceilometer with ARM radiosonde data" by Damao Zhang et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2021-292-AC1, 2022

- *The author aimed to compare the ceilometer- and radiosonde-estimated PBLHTs under stale, unstable and RL, cloudy and cloud-free conditions. But what is the stability parameter used and how is the RL defined in this study? How the cloudy and cloud-free condition is defined? It should be explained.*

We pointed out in line 145 that 'The Liu-Liang method classifies the boundary layer regime as CBL, SBL, or NRL by comparing $q_5 - q_2$ with a stability threshold d_s'. We added another sentence at line 146 'For CBL, $q_5 - q_2 < -d_s$; for SBL, $q_5 - q_2 > +d_s$; and for NRL, $-d_s < q_5 - q_2 < +d_s$' to provide more details about how the stability regime is determined.

We pointed out in line 179 that 'The Vaisala CL31 ceilometer detects up to three cloud layers simultaneously and measures vertical visibility'. To make it more clear, we added a sentence in line 180 'Ceilometer cloud detections are used to distinguish cloudy and cloud-free conditions'.

- *The observation data used in this paper include both over land and ocean. However, what is the difference between the accuracy of PBLH estimation over land and ocean? It is suggested to be explained in the manuscript.*

We agree with the reviewer that when evaluating the retrieved variables, it is important to examine the retrieval bias, accuracy/differences between the retrievals and the ground truth. However, a great challenging for PBLHT estimations is that there is no ground truth to evaluate with. We pointed this out in the line 221. It is difficult to obtain the overall accuracy of the two ways of estimating PBLHTs. We believe that good comparisons between ceilometer- and radiosonde-estimated PBLHTs generally indicate more reliable PBLHT estimations.

- *In Figure 2, what is the reason for the great difference in PBLH retrieved by different methods at 18:00 LT? According to the attenuated backscatter coefficient, it is well mixed within the PBL, generally, the uncertainty of PBLH retrieving should be relatively small under this condition?*

We agree with the reviewer that for well mixed PBL, the uncertainty of PBLHT retrieving should be relatively small. The PBL structure at 18:00 LT is more

complicated. In lines 227-229 we pointed out that 'At 17:30 LT on February 10, there is a weak stable layer developed near the surface, where the low altitude atmosphere is still well-mixed. This is a typical structure of a residual layer overlaying a weak stable layer. PBLHT CEIL and PBLHT Heffter captured the top of the residual layer, while PBLHT Liu-Liang is underestimated. PBLHT bulk Richardson is quite low, because it takes the top of the weak stable layer as the PBLHT'.

- *In Figure 3, The profiles of backscatter and Richardson number is incomplete, which will lead us to doubt the rationality of the data. In addition, what are the reasons for the difference of PBLH retrieved by different methods? Because the defect of the method or the structures of the PBL? should be explained.*

The Vaisala CL31 ceilometer has a field-of-view of 0.83 *mrad* and receives considerable background signals when pointing vertically. Therefore, subtracting background signals during the post-processing procedure leads to noisy ceilometer backscatter profiles above PBL when the atmosphere is free of clouds or aerosol layers. Early studies show that CL31 ceilometer is capable of detecting aerosol layers and can be used to estimate PBLHT (Münkel et al., 2007).

The Bulk Richardson number increases dramatically above PBL and is out of the x-axis range in Figure 3. We pointed out in line 154 that 'The bulk Richardson number *Ri* represents the ratio of thermally produced turbulence to that generated by vertical wind shear. Since wind shear produced turbulence is greatly reduced above the top of atmospheric boundary layer, *Ri* increases dramatically at the top of SBL.'

As for the reasons of the difference of PBLHT retrieved by different methods, we believe that it is because of the limitation of the measurements, the defect of the methods, and the complicated structures of the PBL. (1) temperature, humidity, and aerosol intensity measurements only indirectly reflect PBL structures. Direct measurements of PBL turbulence structures with high temporal and vertical resolutions are not available; (2) the retrieval methods are often based on empirical relations, which might not be applicable to certain complicated PBL structures; (3) it is still challenging to obtain reliable PBLHT estimations under stable boundary layer conditions. In this study, we show that 'under unstable boundary layer conditions, ARM low- and mid-latitude land observatories have higher correlation coefficients and good comparisons between PBLHT CEIL and PBLHT SONDE. ARM observatories at the ocean surface and under stable boundary layer conditions have weak correlation coefficients between PBLHT CEIL and PBLHT SONDE.'

Reference:

Mu¨nkel, C., Roininen, R.: Automatic Monitoring of Boundary Layer Structures with Ceilometer. vol. 184 Vaisala News., 2010.