Review on Manuscript " Technical note: Evolution of convective boundary layer height estimated by Ka-band continuous millimeter wave radar at Wuhan in central China"

General comments:

The manuscript offers basically two estimations of Convective Boundary Layer Height (CBLH) for Wuhan, one based on the variance of the vertical velocity from Ka-band cloud radar (MMCR) and one based on the range corrected signal (RCS) from lidar. These two techniques are compared in study-cases and the variance of the vertical velocity from MMCR is also investigated seasonally and monthly. The investigation is relevant and results are interesting, my recommendation would be to eventually accept the present manuscript. However, before it is suitable for publication there are some major revisions that need to be carefully addressed.

1. The focus need to be more precisely explained by the authors since the beginning. Mainly the methodology of RCS and the one of variance of vertical velocity are employed to derive CBLH and compared to each other. Furthermore, the authors investigate some study-cases (during August, November and March 2020) and then the monthly and seasonal variability of CBLH during the year 2020. However, it is not clear why the dates of the study-cases were chosen, that should be clearly stated. Moreover, it is not clear if they want to disentangle the variations of the two methodologies through the seasonal variability or they want to focus on particular dynamics of the study-cases. The focus and novelty of the present research should be much more clear and precise in order to be suitable for publication.

2. There are many discussions that need to be further explained. The physical mechanisms that could be responsible for the difference between the two employed methodologies should be clear. Also, when attributing results to the "history of mixing" or to "seasonality "or "weather conditions", there is often a lot of analysis and specifications lacking. This needs to be better addressed. Specific comments on that are mentioned later in the present review.

3. The introduction includes a lot of basic concepts of boundary layer that need to be better summarized. In its current state, the introduction is quite repetitive and includes too much basic information that is not necessarily relevant for the particular investigation nor referred to in the results.

Specific comments:

In the next comments the text in the Manuscript is inside "these marks", while when it is necessary to delete it, it is ~~marked like this~~ and the red text is the suggested added words or phrases.

Line 31: "The seasonal mean CBLH reaches the peak heights of 1.29 km in summer, 1.14 km in spring, and 0.6 km in autumn and winter, with occurrence time between 13:30 and 15:00 LT." For being in the abstract, it would fit better to mention what do higher or lower CBLH mean or put it in terms of mean and standard deviation. What do the authors want to focus in here? Seasonal variability? Diurnal variability? That should be clear.

Line 40: " Atmosphere boundary layer is located in the lowermost layer of the troposphere, and directly impacts the air-land/sea interaction" It is not very precise, authors should better say something like: "The Atmospheric Boundary Layer (ABL) is located in the lower part of the troposphere, it is directly impacted by the surface forcings and thus it is in the ABL that the land-atmosphere (or land-sea) interaction takes place."

Lines 45 and 46: "Typically, the boundary layer top varies diurnally following the local surface temperature with a magnitude from a few tens of meters to several kilometers." This sentence is not clear, what do authors mean by "following the local surface temperature"? I assume they refer to the surface forcing because of the solar radiation that heats the ground, but that should be explained, because there is no such a thing like "local surface temperature". And then, it is also not clear what has a magnitude from a few tens of meters to several kilometers. I assume they are referring to the ABL height, but that should be explained, as well as the concept of ABL height.

From line 47 to line 54: The evolution of the ABL is explained, but that is very basic knowledge that needs to be better summarized and the focus of what part of this knowledge is useful for the present manuscript should be more clear.

From line 58 to line 66: The authors are again explaining the diurnal evolution of the ABL, so it becomes repetitive and very basic explanations are re-phrased. The whole introduction should be re-structured in order to concisely explain the evolution of the ABL and the different zones that develop within it, and then the observations and methods that are used to estimate CBLH and its variations (there are also very basic concepts about this from line 75 to 80 that need to be better summarized). And the focus on what part of this is relevant to the present manuscript should be clear. In general a much more accurate and concise introduction is required.

From line 120 to line 132: Better write: " At the initial stage of CBL formation in the morning and the rapid decline stage of CBL in the afternoon, aerosol particles in the residual layer may cause the CBLH to be overestimated by about several hundred meters. This discrepancy is due to often reflects the historyical effect of aerosol mixing rather than the current situation of convectively driven turbulence (Burgos-Cuevas et al., 2023; Schween et al., 2014; Pearson et al., 2010). In the When utilizing Doppler lidar data Doppler lidar observation, a specified threshold of vertical velocity variance is used to define the height of CBL top. This method has been validated as reliable by comparison with the measurements from other equipment, and the sensitivity of threshold has been discussed across different sites (de Arruda et al., 2018; Manninen et al., 2018; Schween et al., 2014; Barlow et al., 2011; Pearson et al., 2010). In contrast to lidar with A disadvantage of lidar is that it has a large blind range and limited penetrating cloud capability, because of that it is valuable to utilize microwave cloud radar that offers good low altitude coverage and superior performance in cloud penetration. In the cloud observation, there always exist a weak echo layer near the surface, from which the vertical velocity can be retrieved. However, there are few reports utilizing on the use of vertical velocity obtained from Doppler cloud radar for the CBL investigations. "

Line 126: Which other equipment are the authors referring to? Radiosondes?

Line 142: "In this study, the CBLH derived from the MMCR measurements observation is compared..."

Lines 146 to 151: " The climate of the city is humid, dominated by the subtropical monsoon ~~humid climate~~, which is characterized ~~with~~ by abundant precipitation and four distinct seasons (Guo et al., 2023). Due to heavy traffic and industrial activities, large amounts of aerosols are emitted from the industrialized metropolis. ~~Meanwhile,~~ sandstorms from the northwest often pass through Wuhan, especially in spring. These sandstorms cause the remarkable variation in the spatial distribution and concentration of aerosols."

Line 155: Important technical information about the MMCR is missing. What brand is it? What retrieval does it utilize? Is the mode utilized the only possible? What other modes are there and why is this one chosen?

Line 171: What do authors refer to by "plankton"?

Line 174: Remove "and so on" This kind of expressions are not accurate and therefore not suitable for a scientific paper.

Lines 179-200: All section "2.2 Polarization Lidar" needs to be re-structured, information about the location of the lidar and its technical characteristics are merged together. Then authors also talk about how the data is transmitted and retrieved. However, ideas should be more clearly addressed in a more ordered way. Perhaps first talk about location of the lidar, then about the most important lidar measurements characteristics (resolution, brand, configuration...) And finally about how the lidar measures and how it retrieves relevant information. The final paragraph (lines 198-200) is completely out of context, but that information should be mentioned in a more ordered manner.

Lines 203 and 204: "~~In view of the CBLH derived from the vertical velocity (VV) in the MMCR observation but from the RCS in the lidar measurement, we use different algorithms to determine the CBLH, respectively~~." Not clear, it needs to be completely rewritten in something like: " Given that the CBLH is estimated from instruments that retrieve different variables, the algorithms that are utilized to make such estimations are also based on different principles that are explained in the following subsections.

Line 209: A sentence should be added before start talking about "The wavelet covariance..." This added sentence should brefly explain the physical mechanism because of which aerosol concentration is utilized as a proxy of ABL height. (Because it is assumed that the aerosols are able to mix below the ABL height).

Line 215: Authors need to specify variance of which variable are they referring to.

Line 216: what do authors mean by "temporal domain", they should explain this more precisely.

Lines 216-218: "The frequent exchange of matter and energy between the boundary layer and the free atmosphere causes the dramatical variation of aerosol concentration on small time scales around the CBL top." This sentence needs a reference.

Lines 220 and 221: "We estimate the CBLH from the lidar RCS every 30 min by using the three methods, and then the obtained height is marked at the central time of 30 min." What do authors mean by "marked at central time"? Please explain and re-write.

Line 223: Authors use VV for vertical velocity, it is more usual to utilize letter w for this and the greek letter sigma for the variance.

Line 230: Please add how many measurements does that lapse include.

Line 232: Why is 15th of August 2020 chosen? Any particular interest on this day study case? Are there any statistics to address how the three algorithms compare with each other?

Line 243: "demonstrates that the MMCR VV variance is a fine proxy in the estimation of CBLH" How is this demonstrated if authors are simply comparing particular heights from the three methodologies in a particular study-case? Which one is more reliable? What processes are responsible for the matching or differences of these values? What are the synoptic conditions in the study-case? Is there any sensitivity study regarding that? Is there any idea of how seasonality affects the CBLH retrievals and how to relate this with your study-case?

Lines 246 to 252: Authors discuss here figure 4 in which CBLH is estimated for the same day with different thresholds, so a comparison and analysis of how this height varies is presented. However this is poorly discussed because the threshold is seen to highly impact the estimated CBLH in the morning growing phase and in the afternoon decaying phase of the boundary layer. Authors only mention particular time in the day but a more comprehensive explanation of these phases and the boundary layer evolution and dependence on the thresholds is lacking. As said in lines 247 and 248 the CBLH does not abruptly changes with the thresholds from 9:30 to 17:30, however this corresponds to the developed phase where a fully convective boundary layer is expected. Further analysis on the growing and decaying phases is required, as well as a comparison with other boundary layer height estimation with other thresholds that could also help to argue why the threshold of $0.3\ m^2s^{-2}$ is chosen. Also, it would be helpful to include sunrise and sunset times.

Lines 259-261: " It is interesting that the CBLH from the lidar RCS variance drops at 07:30, and then shows a change similar to that from the MMCR VV variance." Authors should mention what physical mechanism could be responsible for that behavior that is coincident with the two techniques.

Lines 264-267: One can note from the reflectivity factor distribution in Figure 5b that cirrus clouds occur from 17:00, develop rapidly into the thick clouds at about 11-14.4 km at 17:30, and then dissipate quickly after 17:30. In the MMCR observation, the cirrus appearance makes a large contribution to a clear dip in the CBLH between 17:30 and 18:30,..." It is not clear what is the interest or the particular feature that the authors want to study with this. Please explain how this findings relate to the focus and in the context of your research.

Lines 269-270: "The influence of clouds on the CBLH is also reported in some earlier studies (Dewani et al., 2023; Bianco et al., 2022; Barlow et al., 2011)." Please explain more precisely how the clouds influence the CBLH.

Line 271: What do authors refer to here when they say "subsidence"? Because subsidence is usually understood as a large scale process that implies synoptic stable conditions and it is not clear what this has to do with the CBLH subsidence. Do authors want to talk about a contraction or a decayment? That is not the same as subsidence.

277: The authors mention the 3 days that were selected, however there is no explanation for making this selection, please include a reason that explains this and hopefully validates that the comparison of different methods for estimating CBLH during these days is relevant.

Line 279: "It is very cold in January at.." In this case "very cold" results rather subjective, so please say how cold or in comparison to what.

283: "Thereafter, the top of CBL ~~climbs~~ escalates quickly to.."

Lines 287- 289: "This implies that a moderately smaller threshold may be appropriate for the estimation of CBLH in winter with weak turbulence..." Following the discussion before, I don'e see the argument for this implication. Authors need to clarify this. Do they trust more on the RCS? And why? What ABL physical mechanisms are the different methodologies reflecting? I find a lack of discussion here that needs to be better addressed.

Lines 301-302: "In spring, sandstorms occur frequently in the northwest of China, and sand and dust with different intensities are often blown to Wuhan" Is there any particular interest in studying dust storms in spring? Is there any relationship for instance with the amount of dust and the resulting RCS or backscatter that the authors could analyze the impacts? Does that make any difference for the retrievals and their comparison during spring?

Line 316: " lidar measurement ~~but through~~ utilizing the VV change in the time domain"

Line 318: "of aerosol residual layer, the CBL tops from the MMCR and lidar ~~observations~~ CBLH retrievals are in good agreement with"

Line 321: "Hence, the MMCR VV observation can capture the CBLH evolution very well under a..." Why do authors state that CBLH evolution is "very well" captured? This term sounds subjective and there is a lack of explanation of what do they mean by that.

Line 323: What do authors refer to "seasonal characteristics of convection"? That needs to be clarified. Convection can be related to more larger-scale processes and stable or unstable tropospheric conditions that may or may not include humidity; which usually also implies a seasonality that is not mentioned here. Or it can be more related to radiative driven diurnal cycle convection and then it also can have a seasonality related to variations of radiation through the year, but that is also not explained. Furthermore on that same line, it is not clear why a "slightly smaller threshold may be more suitable". Please explain why.

Line 331: "~~Routinely, winter covers December, January, and February, and so on.~~ We consider that winter covers the months of December, January and February, while March, April and May are spring, June, July and August are summer and the rest is autumn"

Line 333: "As we expected,.."

Line 334: "As the spot of direct sunlight slowly moves northward, the mean variance gradually increases" While looking at the figure, it is clear that not only the intensity of the variance increases but also and more importantly, the height up to which these large values are reached also increases, as well as the time duration of them. These facts should be included in the current analysis.

Line 335: "... August, and then decreases ~~step by step~~ gradually..."

Line 336: "variance is significantly larger in spring than in autumn" Please be more specific, here you could add some numbers.

Lines 336 and 337: " These monthly and seasonal features of convectively driven turbulence dominate the evolution of monthly and seasonal mean CBLHs." This is a sentence with high repetitiveness and not really with any information, please re-write it or don't include it.

Lines 342-345: Authors analyze figure 10, where maximum value of CBLH is presented for the 12 months. However it is not clear why is this maximum value chosen and there is a lack of analysis on the seasonality that this data implies. Furthermore, figure 10 also shows the local

time when these maximum values were reached but this is not further analyzed nor explained, what does it imply? Then They start a sentence on line 344 saying " In weather forcast record there are 7,3,13,3 and 0 days with moderate to heavy rain..." But there is a lacking of a connecting sentence that connects this idea with the one in the previous sentence. Why are authors addressing heavy rain here? What do these numbers mean?

Lines 351-357: " As shown in Figure 9, the CBLH in July has the largest standard deviation (between 13:00 and 19:00) and the latest occurrence time of maximum value over the whole year, which is possibly attributable to the cloudy and rainy weather in addition to the strongest radiation. Similarly, the variability of weather conditions may be a major reason why the maximum height arises 1-2 hours earlier in April-June than in March. Nevertheless, with the gradual decline of solar radiation, the occurrence time of maximum height is steadily advanced from 17:30 in July to 13:00 in November and December." This explanation about figure 9 should be before in the Manuscript, before talking about figure 10, please move it and make it consistent.

Lines 363-368: " The occurrence time of averaged maximum CBLH is the earliest at about 12:40 in December and the latest at 15:45 in August, which is slightly distinguished from those in the maximum value of mean CBLH. The standard deviation of occurrence time is obviously large in January, July and September. These results imply that the maximum height and its occurrence time of daily CBL are significantly influenced by the weather conditions besides radiation since the VV variance as a proxy of convectively driven turbulence is sensitive to the weather changes." These lines first are purely descriptive but I don't see any elucidating analysis on how this maximum CBLH at different times during different months are showing any new information. Again there is a lack of discussion about the processes that can be responsible for those variations. And when the authors mention the "weather conditions" they should be more specific i which conditions are they referring to and how do they change seasonally. Please re-write this making a valuable physical analysis or maybe even don't use the plots on figure 10 if they don't have any conclusive fact about it.

Lines 371-373: " In this study, we investigate the diurnal evolution of monthly and seasonal mean CBLH at Wuhan by the VV variance method based on the Ka-band MMCR observation, and compare the CBLH evolution with that by the RCS gradient, variance and wavelet methods from the lidar measurement." You should add a sentence mentioning that also some study cases were investigated and why those particular study cases; how do they relate to your findings.

Line 374: Be more specific when saying "statistically analyze" what do authors refer to by that?

Lines 379-381: "The occurrence times is between 13:00 in November and December and 17:30 in July for the maximum value of monthly mean CBLH, but between about 12:40 in December and 15:45 in August for the monthly mean value of daily maximum CBLH, respectively." Authors should explain why are they investigating these times and specifically metioning them even in the summary. I don't see any clear elucidating analysis about these times.

Line 382: " ~~feature~~ behavior, the ~~seasonal~~ mean CBLH has the maximum heights of 1.29 km at 14:30 and 15:00 in summer, 1.14"

Lines 383-384: " These results are similar to those in earlier studies.." Similar in what sense? The variables, seasons, comparison between methodologies and its particular characteristics or

some more objective facts need to be specified in this sentence. Also maybe it is worth mentioning the influence of different terrain, latitudes, synoptic conditions. How is this comparable?

Lines 391-392: " ...the CBLH from the lidar RCS is higher than from the MMCR VV variance, due to the high blind range of lidar and the strong influence of aerosol residual layer on the lidar RCS." It is not clear why is this due to the high blind range of lidar. Please explain further.

Line 395: " Additionally, in comparison to the lidar RCS affected by the history of aerosol mixing processes, the CBLH" It is not clear how are the authors attributing this to the history of aerosol mixing processes. Please address it more specifically.

Line 407: Please specify what "weather conditions" in particular are the authors referring to. They should include maybe how was temperature, pressure, humidity, was there rain? How were the synoptic conditions on the investigated days. This implies that the authors may need to consider more information and make extra plots showing this or justifying it in a different manner.