Atmos. Chem. Phys. Discuss.,
https://doi.org/10.5194/acp-2020-175-SC1, 2020

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Determination and climatology of diurnal cycle of atmospheric mixing layer height over Beijing 2013–2018: Lidar measurements and implication for airpollution" *by* Haofei Wang et al.

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Received and published: 12 May 2020

For the time being there is one reviewer's comment available. I agree with his/her general comments and suggestions so it is not necessary to repeat their remarks. Below please find a few additional comments focusing on selected technical or scientific details. As I am not an assigned reviewer I have only focused on the air quality aspect and the meaning of MLH'. Anyway, I hope that they can contribute to improve the paper.

- Title: Mentioning "implications for air pollution" in the manuscript's title is a little bit

misleading. The authors describe a methodology to derive the mixing layer height (convective, stable, residual layer (CBL, SL, RL)) from lidar measurements. They demonstrate that the agreement with radiosonde based retrievals is often quite limited. MLH is used as input for a numerical model (i.e. one equation) to estimate ground-based PM2.5 concentrations. The agreement with in-situ measurements is also limited. Consequently the whole procedure results in a rough estimate of PM2.5 only. Having this uncertainty and the heterogeneity of local sources of pollutants in mind (see also comments below), I feel that mentioning it in the title of the paper is somewhat exaggerated.

- L28: "...identification of pollutant emissions and sources": This statement seems to be misleading. The MLH (among others) has an influence of the dispersion of pollutants, but how sources can be identified from the MLH is not obvious and must be explained if the authors insist on that statement.
- L33: "contributes to the assessment of the pollutant concentration near the surface": I agree that MLH "contributes" to concentrations of pollutants but it must be kept in mind that the spatio-temporal distribution of sources plays a dominating role; see Geiß et al., (2017).
- L38: "MLH can be estimated by ... the concentration of PBL constituents". It is rather the other way around (having in mind the inherent problems already mentioned).
- L59: Here ceilometers should be explicitly mentioned. Lidars are comparably rare instruments, and only a few can be operated unattendedly and fully automatic (MPL is one of them, so often called a ceilometer or an "automated low power lidar, ALC"). Ceilometers are available as networks, e.g. in Europe. I don't know the situation in China but this option should be mentioned. It has been demonstrated that most ceilometers are capably to determine the MLH.

- L66: "only in the morning...". This statement is not true for all places in the world.
- L68: "the low vertical resolution": Most of the ceilometers (and lidars) provide a 15 m resolution that is fully sufficient to determine the CBL. In the framework of Ceilinex2015 we have compared instruments from Vaisala, Lufft, and Campbell. In particular for Lufft CHM15k and Vaisala CL51 no problems appeared (the corresponding AMT-paper was mainly on water vapor absorption corrections).
- L70: "low SBL height is not evaluated". I assume this is due to the overlap-problem. The reader is not aware of this at this point of the manuscript. So a short explanation should be added or the sentence should be moved to the next section.
- L85: Here the period of the measurements should be explicitly mentioned, and the time resolution, and the gaps in the measurement schedule if any. The coordinates of the location should be given with more decimal places.
- L89: "correction of overlap". As this is an essential point, it would be nice to read a few detail, at least the height of the lowest "useful" range bin should be given here (actually it is mentioned later, sometimes called "gate", sometimes "range").
- L94: To my knowledge Baars et al. (2008) were (one of) the first who applied the Haar-wavelet technique to continuous lidar measurements (de Haij et al. used the very old LD-40 with a limited vertical measurement range) including a detailed sensitivity analysis. This paper could be cited as well.
- L99: When mentioning "attenuated backscattering profile f(z)" here, this quantity should be defined previously. But in L89 only RCS and "then logarithm calculation" (ln(β'_{532})) are mentioned, but not $f(z)$.
- L103: The interpretation of the wavelet approach may have some pitfalls: to associate the largest maximum of W_f to the MLH (CBL) is obvious (though exceptions may occur), however, the interpretation of the first local maximum is critical (MLH'). Often the aerosols are structured and several internal layers appear making the allocation of a local maximum to an atmospheric feature very difficult. In the last years a lot of research has been devoted to estimate MLH resulting in a number of papers that should be mentioned here, e.g. Kotthaus et al., Geiß et al., Morille et al., de Bruine et al., Poltera et al. and many more.

- L113: It is stated that the temporal resolution of the MLH is one hour. In Figs. 1–4 the resolution seems to be better. Is this a inconsistency?
- L114: "eliminating ...false value and peak value": Please give a short hint, what is meant.
- L133: The description of the PMRS-model is quite relevant, so I suggest to move S2 to the main text. In particular the uncertainty of PM2.5 depending on the uncertainty of the MLH should be highlighted as the MLH and its (large) uncertainty is the main outcome of their study. Fig. 10 reveals extreme differences in case of the RS-retrieval.
- L139: What type of sunphotometer is used? Give a few comments on these measurements.
- Section 3.1: "case study" is mentioned in the caption, but it is not very clear, what this is. Four case studies each covering a period of 3 days corresponding to Figs. 1-4?
- Figs. 1–4: The triangles cover a vertical range of 300 m or so. What part of the symbol indicates the RS-retrieval? The top, the center, the bottom? In many cases the MLH seems to be zero.
- L151: "the aerosol layer height keep...": This sentence should be rephrased.

- L152: "MLH is always higher than MLH_RS,...": this seems to be in contradiction to the findings in L204. Please check all conclusions carefully.
- L175: "...RS is its very good precision". This should be explained. Why is the method conceptually superior to a ceilometer/lidar retrieval? The criteria involved for estimating the MLH from RS or lidars both have their "free parameters" (thresholds).
- L190: The histograms should be explained in much more detail to avoid confusion. The reader might expect that the columns (e.g. for winter) add up to 100 % (for the lidar and the RS retrieval). However, it seems that the total column is the annual relative frequency and the different colors indicate the contribution of each season to the total. If so, the seasonal distribution should be discussed as well. The overall agreement between the two data sets is actually low – neither the absolute values nor the shape of the distribution agree. Moreover, as stated by the authors, in 35 % of the cases no intercomparison is possible due to the overlap problem. This mainly occurs in spring – any idea why?
- Figs. 7 and 8: to compare these two figures (basically it is the same information, however, in Fig. 7 the annual mean and in Fig. 8 the seasonal means are shown?) relevant minimum/maximum values of the MLH should explicitly be given in the text. Then, it can be seen if the numbers are consistent. What is the "shaded area" in Fig. 7: from 550 m to 2000 m in case of MLH at 0000 hours? What are the consequences of such a large range for the significance of differences (in the course of the day, for inter-annual changes)?
- L228: According to the authors MLH' could be the residual layer or the stable layer (or any internal layer). So, the implications for the dispersion of pollutants are hard to infer. The benefit of MLH' should be clearly described in the paper (see comment above, and the conclusions of the manuscript).

- L236ff: The authors explain the "valley" in the diurnal cycle from the domination of the developing CBL over the RL (in terms of the signal gradient) after sunrise. In many publications the complete diurnal cycle is considered as the combination of the SL and the CBL. Then, a much smoother curve can be found. Moreover, the SL seems to be more relevant for the accumulation of pollutants close to the surface than the RL.
- L259: "...into near-surface air quality information". It has been shown by Geiß et al. (2017) that the near-surface air quality does not only depend on the MLH (see also comment L33, and manuscript L275).
- Fig. 9: Are the inter-annual differences of the annual cycles significant in view of the very large uncertainty ranges (see also comment above)?
- L262: A short description of the in-situ measurements should be added: where have they been made, what is their temporal resolution/coverage, and their accuracy. Is one site or an average over many sites considered? The differences between MLH_RS and the in-situ seem to be indeed too large for any air quality application.
- L297: Last sentence: the authors should be aware that many sophisticated methods to retrieve the diurnal cycle has been published recently. They should be cited (many references in the manuscript are quite old), see suggestions.

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