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Comment on amt-2021-261

Anonymous Referee #1

Referee comment on "Inter-comparison of ABL height estimates from different profiling sensors and models in the framework of HyMeX-SOP1" by Donato Summa et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2021-261-RC1, 2021

Review of « Inter-comparison of ABL height estimates from different sensors and models in the framework of HyMEX-SOP1" by Summa et al., AMT, 2021

The study compare the atmospheric boundary layer height determined by radio-sounding temperature profile, IGRA, wind profiler, ERA5 model, BASIL raman lidar backscattering profile. The description of the ABL structure is lacking detailed information, e.g. the term ABLH is use independently of the instrument and method used, even they are referring to different ABL sublayers. Strong methodological problems further invalidate the found results.

Main comments:

- The notion of ABL height is used in the whole introduction and attributed to several "heights" measured by various instruments and methods. The authors should really attribute the right ABL (sub)structure to the right layer height detection. For example, the temperature inversion (usually used for nocturnal boundary layer detection), the MLH detected by the bulk Richardson method and the LLJ cannot be assimilated to the same ABL substructure. A revision of all the concepts introduced in the introduction and of the use of these concepts through all the paper is necessary.
- First methodology problem: the ABL is subjected to a diurnal cycle that is clearly described in case of fair-weather day by Stüll (1989). The authors chose to use the mean ABLH over the entire daytime (from sunrise to sunset) to compare the instruments and methods. Moreover, this average is done without consideration of cloud cover, precipitation or different state of the atmospheric stability. This impeded the authors to identify potential artifacts of the measurements and of the modeled ABLH, e.g. too high or low ABLH maxima, attribution of ABLH to the cloud base, wrong timing of the ABL maxima.
- Second methodology problem: the authors chose to use the mean of all detection methods (including the measurements and the model) as a reference to estimate the bias of the individual ABLH estimation. This approach does not allow any clear assumptions about the accuracy of the ABLH estimations. Usually the parcel method or

the bulk Richardson method applied to the radio-sounding profiles are taken as a reference due to the accuracy of the in-situ measurements. Moreover, the first analysis shows that ERA5 has the worst results, so that it is removed out of the mean of all methods for the second part of the analysis. It is even not clear if EAR5 is removed for the whole month of October or only during the second half of the month when its results strongly differ from the measurements.

- The parcel and bulk Richardson methods could have been applied to the Raman Lidar data allowing a real comparison between the radio-sounding, the model and the lidar ABLH detection. This approach was however not applied by the author.
- Figure 5: ABLH corresponding to the maximal gradient of aerosol does not at all corresponds to the red points but is visible e.g. at about 3000 m between10:30 and 16:00. I then concluded that the used algorithm applied to the raman lidar is not valid.
- The paper is moreover not well written and structured. A lot of elements are not necessary and some descriptions does not allow the reading to understand the methodology (e.g. if the parcel or the bulk Richardson is used in ERA5).

Some minor comments are also given thereafter. There are not well written since I recommend the rejection of the paper due to the main comments:

- lines 44-45: "Specifically, potential temperature tends to keep nearly constant with height within the mixed layer." This is not true since the parcel method used the variation of the potential temperature to determine the convective boundary layer
- lines 45-48: " The level of maximum potential temperature vertical gradient identifies the transition from a convectively unstable region to a stable or more stable region": I've never seen such a definition.
- Line 54-56: to my knowledge, wind profilers are very often used to detect ABLH and their network is not the denser one.
- Wind profilers are impacted by birds migration but I never heard about artifacts due to insects' swarms
- Identification of fluctuation in wind: why is RS the only accurate method ?
- Line 84: The stable layer at the top of the mixed layer stops the turbulent eddies from further rising. Is it the right answer ?
- Line 87-88: "Additionally, radiosonding data can provide a long observational record, which is particularly suited for ABLH climatological studies (Madonna et al. 2021)." This does not matter for this paper since only one month of observation is used.
- Line 92-93: so called "bulk Richardson number for the entire ABL": the bulk Richardson number is well defined. I do not see why it is called here "bulk Richardson number for the entire ABL" ? Why to add " for the entire ABL"?
- Line 95-96 "Such gradients can be revealed in wind lidar, wind profiler, radiosonde and aircraft in- situ sensors' profile data (Sicard et al., 2006)." This sentence is not completely right. First, the bulk Richardson cannot really be considered as a gradient. Second the wind lidar and the wind profiler does not suit, alone, to the Rib calculation, that needs temperature and wind compounds. Radio-sounding does not need further wind measurement (wind profiler/lidar) since it usually also measures wind.
- Line 97-98: the low-level jet cannot be considered as an ABLH.
- In the introduction, it is not mentioned that the raman lidar BASIL also measured temperature profiles.
- Line 120: it would be nice to have detailed information on the applied vertical and temporal smoothing applied to the water vaoupe and temperature profiles.
- Line 127: the strongest echoes in the ABL are due to higher aerosol concentration. Aerosol is the real measured parameter, not the echoe.
- Line 138-140: the sentence at line 140 is completely right, but this does not correspond exactly to equation (3). The sentence line 138 is not precise enough, even it is

complete thereafter at line 140.

- 2.2 the ABL layers detected by the described gradient method correspond to CBLH in the mid-day and to RL during the night. This should be better described and explained. This comment complement the first main comment.
- Line 143-144: why the wind profiler impeded the detection of shallow ABLH and no the lidar overlap effects ? Please be more precise in your descriptions.
- Line 170-172: Is it possible to have an uncertainty estimation on the ABLH from the uncertainty in the temperature profile?
- Line 181 "agin"?
- Line 199-201: the reader does no more know, which method is used in EAR 5.
- Line 201-204: it the authors want to speak about the uncertainties of the algorithm used in ERA5 (the parcel method as given at line 198), the considered uncertainties have to be described. The examples given at lines 203-204 are, to my knowledge, never considered in the parcel method.
- Line 205: finally, the bR method is used ?? then what is the usefulness of lines 198-2004 ?
- Line 208-2010: it seems that the authors have not really understood the method. Rib is compute for all heights and not only for the ABLH. ABLH is given when Rib= the chosen threshold. This comment is another complement to the first main comment. It really seems that the authors have a too low knowledge of the ABL structure and the methods used to measure it.
- Line 208: please give a reference for the applied Rib equation.
- Equation 6 is not needed since it's the same as equation 5 at another level.
- Line 222: mothers ?
- Line 232: I really do not see the scientific meaning to average the SBLH from 09:00 to 21:00 UTC ? if you want to describe the ABL dynamic, you should describe the growth, the maximum and, if the method allows it, the decrease of the ABLH. To compare mean over the complete convective diurnal cycle does not bring any reliable information. Moreover, the gradient method applied to the Raman Lidar aerosol range corrected backscattering will monitor the residual layer during part of the morning and in the late afternoon, allowing no comparison with the other methods.
- Figure 2a: the y labeling should be ABLH and not only altitude
- Figure 2b and c, Fig. 3: why to choose the mean of all method as a reference ? usually the most reliable method (often the radio-sounding) is taken as the reference.
- Line 241: Up to now the authors claimed to analyze the month of October. Why August is now mentioned? There cannot be any influence of August weather conditions on the ABLH of October.
- Lines 252-254: is the EAR5 removed for the whole period or only for the second half of October ?
- Line 263: if ERA5 is the only method removed from the mean to make the correlation, it is obvious that it will obtained the lowest R^2.
- Lines 265-275: this is not the right way to present results in an attractive way.
- Line 306-307: All remote sensing observation figures are always constructed like that. There is no use to describe this in the text and in the figure caption.