Atmos. Chem. Phys. Discuss.,
https://doi.org/10.5194/acp-2020-857-RC2, 2020

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Atmospheric Boundary Layer height estimation from aerosol lidar: a new approach based on morphological image processing techniques" *by* Gemine Vivone et al.

Anonymous Referee #2

Received and published: 10 November 2020

This paper aims to improve the knowledge about the atmospheric boundary layer (ABL) dynamics proposing a new method to retrieve the ABL height (ABLH). The technique used is based on image processing techniques, what is an innovative approach opening new research lines for this application. The manuscript is well structured, allowing for a clear comprehension of the research involved. However, I found some general issues to be addressed, together with some specific comments.

General comments:

Firstly, it is not clear to me what is the definition of ABL used by the authors. The residual layer seems to be part of the ABL sometimes through the manuscript (lines 15-19)

, but in other parts of the body text does not (for example when ECMWF retrievals are presented during nighttime). Therefore, this fact must be clarified and homogeneously used along the article.

Secondly (linked to my previous comment), most of the ABLH retrieving algorithms based on lidar data currently published in the literature suffer from a common drawback: a proper layer attribution. The proposed MIPAS algorithm allows for retrieving something that authors attribute to the ABLH. However, this ABLH is ambiguous because what they are retrieving essentially is a sharp decrease in the attenuated backscatter coefficient profile (or its uncalibrated version, i.e. the lidar range corrected signal). How this is attributed to a specific internal sublayer of the ABL is completely arbitrary without additional information such as turbulence or temperature. In my opinion, MIPA algorithm is a really nice new method with high potentiality but needs to be validated against different techniques involving co-located measurements of temperature (microwave radiometer) or turbulence (Doppler lidar).

Some discussions about these two general comments would hugely enrich this manuscript.

Specific comments:

Lines 15-16: This definition is biased to some extent. There are fundamental meteorological processes not occurring in the lowermost atmosphere, for example related to the hydrological cycle. I recommend removing this sentence.

Line 19: please, avoid to cite unpublished articles.

Lines 20-21: this is a generality. Not always stable layers appear during nighttime and not always mixed, mixing and convective layers appear in daytime. Please, remove the sentence after 'solar cycle'.

Lines 23-26: consider to briefly describe the role of snow as the underlying surface and also the topography as a key element to modify the ABL internal structure.

Lines 28-30: Please, cite some examples such as:

Lyamani, H., Fernández-Gálvez, J., Pérez-Ramírez, D., Valenzuela, A., Antón, M., Alados, I., Titos, G., Olmo, F.J., Alados-Arboledas, L. Aerosol properties over two urban sites in South Spain during an extended stagnation episode in winter season (2012) Atmospheric Environment, 62, pp. 424-432. DOI: 10.1016/j.atmosenv.2012.08.050.

Lines 42-44: The structure of this sentence is focusing because here the concepts of physical quantity and tracer are mixed up. For example, clouds and aerosols are not atmospheric properties to retrieve ABLH; attenuated backscatter coefficient is the physical quantity here.

Line 48: no, the tracer here is aerosol, backscatter profile is the observed quantity.

Lines 60-61: Please, add also:

Baars, H., A. Ansmann, R. Engelmann, and D. Althausen (2008), Continuous monitoring of the boundaryâĂŘlayer top with lidar, Atmos. Chem. Phys., 8, 7281– 7296, doi:10.5194/acpâĂŘ8âĂŘ7281âĂŘ2008.

Granados-Munoz, M.J., Navas-Guzmán, F., Bravo-Aranda, J.A., Guerrero-Rascado, J.L., Lyamani, H., Fernández-Gálvez, J., Alados-Arboledas, L. Automatic determination of the planetary boundary layer height using lidar: One-year analysis over southeastern Spain, (2012) Journal of Geophysical Research Atmospheres, 117 (17), art. no. D18208, DOI: 10.1029/2012JD017524.

Line 90: Consider to replace the term 'tracer'.

Line 101: regarding 'capping temperature inversion'. I guess you are referring to the entraiment zone (region leading to incorporate clean air from the troposphere into the ABL and, thus, to its growth). Capping temperature inversion mainly occurs during nighttime.

Lines 101-103: This sentence is rather pretentious and it is far from being truth in

general. From lidar signals is not possible to unambiguously determine neither the ABL or its internal structure. Essentially, lidar data allows for recognizing layer's edges but the attribution of them to specific internal ABL sublayers is not possible with standalone lidar data. To correctly perform this attribution, complementary information such as stability analysis or turbulence data are needed.

Lines 117-120: This is only valid under scenarios of no decoupled layers. Under the presence of strong layering inside the ABL or decoupled aerosol layers in the free troposphere, the minimum in equation 3 might correspond to a layer or sublayer different from the ABL. See Morille et al (2007) or Granados-Muñoz et al. (2012).

Section 3: Congratulations for this detailed description of the methodology used. Really nice and informative.

Lines 211-212: why is this value of 20 m used?

Lines 248-249: What is the threshold to consider a variation as too fast? I mean, the temporal scale to consider an edge change as unrealistic. Is this threshold the same during the whole daily cycle? This must be taking into account that since faster changes are expected, in general, at sunrise and sunset than during nighttime.

Lines 270-273: It is advisable to transform this subsection into a flux diagram.

Lines 278-280: Thanks to the strict standardization from the instrumental and algorithm point of view, all lidar systems in EARLINET are comparable, therefore this statement makes no sense. For the scope of study, to include different datasets during this 72h-intensive exercise covering different ABL types would enrich this study: topography (mountain versus flat), inland/coastal, latitude dependence, etc. I encourage you to extend the analysis to other relevant stations participating in this intensive exercise to cover as much as possible a variety of atmospheric scenarios.

Lines 283-284: How does the depolarization ratio is performed? No need to provide a large explanation, perhaps you can provide some references on how this is carried

out.

Line 288: Similarly to MUSA, please provide a reference where to see more technical features of PAOLI.

LIne 290: replace ‘green’ by ‘visible channel’ or ‘532 nm’.

Line 293: Information about the full overlap height is crucial for all ABLH methods based on vertical changes of the lidar signals. It is mandatory to include such kind of information here.

Line 293-294: Again I consider that the authors focused incorrectly on the technical differences of the lidar systems used. Because of the standardization protocols in EARLINET, both systems should be equivalents. The focus should be moved to the different characteristics of the ABL over both stations.

Line 295: Is this attenuated backscatter coefficient already calibrated or uncalibrated (the latter, therefore, range corrected signal)?

LIne 317-321: Some details on the meaning of high resolution should be included here. For example, this resolution is 5 min? 1 min? less than 60 s?

Line 323: replace ‘PBL’ by ‘ABL’ (also in other parts of the manuscript).

Lines 325-328: this sentence is repetitive (already presented previously in some way) and, therefore, might be removed.

Lines 329-342: Due to ABL strongly depends on many factors, only co-located and simultaneous radiosoundings must be used for validation of ABLH algorithm comparisons. Because of the lack of such kind of usable radiosoundings, please remove all radiosounding information and data in this article, and focus your validation on NWP data. Another possibility is to compare with microwave radiometer derived profiles.

Lines 357-358: Is the GDAS accuracy the same as the ECWMF NWP? You should use an homogeneous dataset for all the stations involved in the study.

LInes 361-362: There are several publications reporting the atmospheric scenarios occurred during the 72-h exercise. Please, consider to cite them in case the readers wish additional details.

Lines 369: replace ‘convection’ by ‘convection’.

Lines 381-390: Please, combine figure 2 and 3 into one figure with two panels in order to better identify the agreements/disagreements. The same as the next pairs of figures. Also, there are huge discrepancies during nighttime and this is not appropriately discussed. In my opinion, the reason is that the model retrieved the top of the stable boundary layer whereas your lidar-based method retrieves the top of the residual layer. Is it possible to get information on the top of the residual layer from model by using the potential temperature or, even better, potential virtual temperature? Likely, the agreement will improve.

Lines 397-398: The information on the full overlap height should have been given when the MUSA technical features were presented.

Lines 400-401: Again, the references are chosen to be the ECMWF retrievals, what during nighttime do not ’see’ the same ABL structure than the lidar-based methods. This issue needs to be appropriately discussed in detail.

Lines 409-411: It doesn’t make sense to validate an ABL retrieving algorithm using radiosondes launched 110 km far away. To my knowledge Lisbon is a huge city, therefore affected by heat island related effects, whereas Évora is a small, non-industrialized city with very different atmospheric conditions.

Lines 415-417: The overlap is not the only effect, MIPA and EMCWF allow for retrieving different ABL sublayers!

Lines 464-466: Since the computational cost is really low, I encourage to apply the MIPA approach to the whole 72h exercise (all the participant stations) in order to get more robust conclusions.

Figures 2 and 4: Why does the ECMWF model systematically produce the same ABLH during nighttime (independently on the time along the night, and also the date)?

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