ACP-2020-857, Atmospheric Boundary Layer height estimation from aerosol lidar: a new approach based on morphological image processing techniques

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We wish to thank the Associate Editor and all the Reviewers for the thoughtful comments. We appreciate the constructive comments and suggestions, which have helped us improving the quality of the paper. Corrections and updates have been made according to the Reviewers' indications and replies to each concern can be found below.

Reply to Reviewer 1

The paper entitled "Atmospheric Boundary Layer height estimation from aerosol lidar: a new approach based on morphological image processing techniques" approaches a new methodology to estimate the ABLH from the image/signal processing. The paper is innovative and presents an interesting solution to ABLH detection from elastic lidar/ceilometer data. In the clear sky and convective situations, the algorithm proposed has good results, however in complex or stable situations (e.g. presence of decoupled aerosol layers) the algorithm does not find the same performance.
We would like to thank the anonymous Reviewer for considering our paper innovative and the solution interesting.

1. Performing a separation between the different sublayers of ABLH (Convective Boundary Layer, Residual Layer, Stable Layer, etc.) and then compare how the method behaves when estimating each one can generate better results. Especially during the night.
   We agree with the reviewer that this section is not enough clear. Our methodology uses aerosols as proxy to retrieve the atmospheric boundary layer height, while classic methods, e.g. radiosoundes, use the atmosphere thermodynamics , i.e. retrieving the atmospheric boundary layer from the potential temperature profiles. While during convective boundary layers the two methods are equivalent, at night, they are not because from the aerosol point of view the boundary layer collapses into a stable layer and a residual layer. For this reason, during nighttime, it is difficult to perform an intercomparison because the methodologies are different. Because our algorithm detects edges, we set it up to detect the first edge at night because it is more close to the thermodynamic detection. Problems of course arise when the boundary layer height falls below the lidar overlap region.

2. If Canny's edge detector of other computational languages is applied, is it possible to find the same results? Thinking about the dissemination of this algorithm in other researches centers, an open-source library can be a better solution.
   We have already stated in the paper (see Sect. 3.4) that every edge detector can be exploited to extract a first estimation of the ABLH. Thus, the proposed approach is flexible and the edge detection block can be changed to possibly improve the results. Approaches as wavelet covariance transform or gradient-based could be adopted. However, the analysis of the performance varying these strategies in the proposed framework is out-of-the-scope of this paper. About the Reviewer's comment, all the above-mentioned edge detection approaches can be adopted to have a easier dissemination. Even other software platforms

have their own implementation of Canny's edge detector (see, e.g., Python), which can be exploited to have comparable results with the ones in the paper.

3. Considering the overlap values of the lidar systems, which is the layer detected by the algorithm during stable situations?
   As explained in the first comment, because the algorithm is setup to detect the first significant edge, the algorithm is sensed to detect the stable layer, unless it falls below the overlap region. In that case, the residual layer is detected.

4. Considering the edge detection, how the specific setup (e.g. energy of the laser beam) of the lidar system can affect the results?
   The detection is performed on the retrieved lidar attenuated backscattering, a variable depending just on the atmospheric variables, e.g., aerosol backscattering and extinction coefficients. The retrieval is not directly affected from the laser beam energy. Of course more energy is linked to a higher signal-to-noise ratio. In case of low power lidar systems, e.g., ceilometers, the boundary layer height detection in strong aerosol loading, e.g. during a haze event, could be difficult.

5. Line 398 - I recommend to add the information about the overlap close to the system description.
   Line 406 - I recommend to add the information about the overlap close to the system description.
   Done. Thanks.

6. It would be interesting to present a case with the presence of clouds close to ABLH.
   As our method is based on edge detection, clouds enhance the detection because, being optically thicker than aerosols, in a convective boundary layer, their base is coincident with boundary layer height. In case of clouds above the boundary layer height, the first edge is still detected. Clouds inside the boundary layer is instead a critical situation, but highly unlikely.

7. I recommend using the same pattern of font style and hour format in the figures.
   Fig.1 Time UTC Fig.6 Time UTC Fig.11 Time UTC
   Done. Thanks.

Sincerely,
The Authors