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Atmospheric Chemistry and Physics Discussions

Interactive comment on "On the spatial variability of the regional aerosol distribution as determined from ceilometers" *by* Matthias Wiegner et al.

Anonymous Referee #4

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The paper investigates the spatial variability of the regional aerosol distribution using the so-called ALC (automated low power lidar and ceilometer) signals from two testbeds in Munich and Berlin, Germany. In particular, for each testbed measurements of 24 months from 6 ALCs of the same type (i.e. CHM15k) were analyzed to derive the mixing layer height (MLH) and the integrated backscatter (IB). The intercomparisons of these parameters show that: MLH mean differences are very similar between two sites (i.e. below 50 m) and the correlation coefficient slightly decreases with the distance between the corresponding sites; IB mean differences are of approximately 30 % when individual sites are compared whereas the correlation coefficient shows high and moderate correlation within the Berlin and Munich testbed, respectively.

The measurements coming from the ALCs constitute a remarkable dataset and the

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study is of interest. There some points that need to be discussed and/or clarified: - ALC measurement representativeness in characterizing the aerosol spatial variability. The ALC parameters (MLH and IB) are derived using measurements fulfilling specific requirements in terms of the testbed atmospheric conditions (e.g. cloud fraction, rain, βp value, etc..). Thus, the analyzed dataset refers only to a subset of aerosol spatial variability, affecting the sampling representativeness. In other terms: how much the results derived in this work are representative of the aerosol spatial variability in a regional domain? How could you extend these results to the atmospheric conditions not considered in this work? This aspect needs to be exhaustively discussed in the paper. - ALC instrumental terms affecting the ALC parameters. It could be of interest to evaluate the contribution of the ALC instrumental variability to the measured spatial variability. In particular, the effect of the overlap function on IB should be more detailed (e.g. how the assumption of a constant βp in the region of incomplete overlap can affect the variability? Is this assumption valid for different environments, urban and rural, and different season?). The effect of the calibration constant (CL) temporal variability is taken into account in the paper. However, more details should be provided regarding the CL uncertainty and its effect on IB variability.

The impression is that only partial information about the aerosol variability has been exploited from the potential information provided by the large number of ALCs used. The results obtained in terms of horizontal variability of MLH are similar to other works and the conclusion that MLH parameter is more homogenous than IB at a regional scale seems self-evident. In summary, the authors should well define the scientific context and the objectives of the work to better characterize the obtained results, highlighting their novelty and relevancy. Thus, I recommend the publication of the manuscript after major revisions, according to the following observations.

Major comments:

Introduction

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- The introduction should give an overview of the studies regarding the aerosol spatial variability using ground-based and satellite-borne passive sensor measurements as well as airborne and satellite-borne lidar measurements. Which are the limits and the benefits of using ALC datasets (e.g. temporal and spatial scales)? Please add some discussions and references.

- Page 2, Lines 12-13: recent works used ALC-derived backscatter also to derive aerosol optical depth and aerosol volume and mass (e.g. Dionisi et al., 2018 and Diemoz et al., 2019). Please add some references.

Section 2

- In this section, a characterization of the two testbeds (e.g. predominant local atmospheric circulation, topography, etc...) should be provided. This could be of help to interpret the obtained result and to establish the limit of using ALC measurements for aerosol variability studies. Figure 9 could be inserted in this section.

- Page 3, Lines 24-26: the work of Hervo et al., 2016 shows that the manufacturer overlap function cannot account for changes over time and that the derived correction is temperature-dependent. This could significantly affect the ALC profile in the first hundreds of meters. Did the authors take into account this problem?

- Page 6, Line 11: Is this only because B-PO is closer to Berlin in respect of B-LI? Please provide some references or a more detailed explanation.

- Page 6, Lines 14-17: I don't understand if the periods mentioned above are measurement gaps (if this is the case, these are not a few hours) or something else. Please explain or rephrase.

- Page 6, Line 18: the temporal resolution of MLH values (i.e. 2 min, 720 values per day) is defined on page 22 line 23 but it should be clearly defined in this section.

- Page 7, Lines 14-17: please add some details about this overlap correction. Is this correction applied also to compute the aerosol IB?

Section 3

This section should be re-organized to better highlight the results of the study. In particular, the authors could point out if this ALC set-up and the conducted analyses allow characterizing different environmental conditions (e.g. urban vs urban, urban vs rural, rural vs rural, day vs night) or not. This implies the description of the considered sample, the characterization of the impact of the considered selecting criteria, the identification and evaluation of all the potential factors contributing to the resulting variability. This information is scattered throughout the sub-sections but it is not easy to put it together.

Section 3.1

It is not clear to me if the cloud cover parameter is used with the ALC raw temporal resolution. Please clarify this point. Moreover, to better characterize the use and the representativeness of ALC measurements in this context (i.e. aerosol spatial variability), it could be of interest to add in this section a resuming table that shows the number of the available cases associated to the different filtering criteria considered to retrieve MLH and IB. Please also clarify why the reference configuration has been set as the 'reference.

Section 3.2

- Fig. 3 and 4. The relative frequency distribution plots provide potential information regarding urban vs rural conditions (asymmetric shape). This could be stressed in the text. Do the authors think that further analyses of the distribution shape could help in the characterization of the different sites in terms of variability? The scatter plots below the diagonal seem to be characterized by a large number of low MLH values concerning high MLH values. Is the linear regression weighted for MLH?

- Fig. 5, 6, and section 3.2.3: the correlation decreases with the distance up to 40-50 km then it seems to be constant. This could mean that at a certain distance from the

city, rural conditions are more homogeneous and less affected by urban conditions. Please clarify.

Section 3.3

- Fig 7 and 8. Please specify the bi-monthly number of points used to compute the diurnal cycle for each testbed.

- Fig. 9: I'm not sure that this figure is appropriate in this section.

Section 3.4

- Page 22, Eq.1: as already mentioned (see general comment), the assumption of a constant βp in the region of incomplete overlap, in particular in urban environments, could lead to biased values of IB. In the work of Barnaba et al. 2010, the lidar profiles in the incomplete overlap region were obtained by a linear fit of the first two valid lidar points. A sensitivity study considering also this approach could evaluate how the different assumptions affect IB values.

- Page 22, line 20: please explain the choice of LR=45 sr.

- Page 24, lines 25-29: strengthening the criteria (reducing the sample population) increase the correlation coefficient as more homogenous conditions are considered. The information on the impacts of the different selected criteria could help in characterizing the sample and the limit of the analysis. Please highlight this point in the text.

- Figure 11: please explain the large amount of high values of CL between 250 and 350 days.

- Page 26, lines 1-4: please explain why the authors decided to use the averaged CL over 24 months instead of the daily CL. How much this choice affects the IB variability?

- Page 26, lines 19-27: see the comment of Page 24, lines 25-29.

- Page 29, lines 10-11: these factors are crucial for the aerosol spatial variability. They

should be mentioned not only at the end of the paper but also at the beginning, to contextualize the objectives and limits of the considered approach.

Section 4

- Page 29, lines 19-20: the same type of instrument does not prevent the fact that each ALC has a different variability of instrumental parameters such as the CL term and the overlap function. This aspect should be pointed out in the text.

- Page 31, lines 0-3: the selection of arbitrary criteria to avoid 'fair-weather cases' deals with the problem of defining the sampling representativeness. This should be discussed in this section.

- Page 31, lines 8-11: the result of this study could suggest that a denser ALC network could be required in metropolitan areas, whereas a smaller number of ALCs could be representative of rural areas.

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