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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Assessment of vertically-resolved PM_{10} from mobile lidar observations" *by* J.-C. Raut and P. Chazette

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Response to reviewer2

The authors appreciated the comments of reviewer2 that help to improve our manuscript. Please find a point-by-point discussion and answer of the issues raised by the reviewer. To facilitate the work for the reviewers and readers, the reviewer s comments and suggestions are preceding each reply in bold face.

What are the variability and uncertainty in k parameters at these given locations?

The uncertainty on the retrievals of k1 and k2 coefficients has already been given in

Sect. 4.2 and in the conclusion. k1 and k2 are provided with a relative uncertainty of 12 % for urban and periurban aerosols and 26 % for rural aerosols. These uncertainties have been calculated according to Eq. 3 given in Sect. 3.1. k parameters have been derived from a statistical analysis (Sect. 3.1) and are proportional to the slopes of the linear regressions given in Fig. 2. As a consequence, no temporal variability is associated to these parameters.

The method seems to assume that the k1 or k2 value at a particular location is always used at this location to convert aerosol extinction into PM10: :is this correct? (Urban aerosol value for aerosol in boundary layer or nocturnal boundary layer, periurban value for aerosols in residual layer, etc.) This assumes they these specific aerosol types with these specific values are always at these locations and altitudes; what is the uncertainty in this assumption? Especially for aerosols above the surface, there is no way using the lidar data alone to be sure that the assumed aerosol type is what was actually present. Therefore, there must be some uncertainty in the retrieved PM10 concentration due to the uncertainty in the assumed aerosol type. What is the implication of this uncertainty on the derived PM10 concentrations?

At a given location, the ground-based instruments have recorded the same slope represented in Fig. 2 whatever the air masses origins have been. It is particularly true for periurban aerosols measured during ParisFog campaign over 6 months (Fig. 2c). This indicates that k parameters obtained from linear relationships are not statistically dependent on wind directions. The discrepancies observed among the different sites are more likely due to the proximity of particles sources and thus to the aerosol ageing.

Moreover, the coefficient obtained in the rural site (30 km far from Paris) has not been applied to lidar data because the lidar transects have been performed up to 15 km far from Paris (periurban location). Therefore, the uncertainty on the lidar-derived PM10 concentrations is due to the uncertainty on the retrieved aerosol extinction coefficient, the uncertainty on k1 in traffic (urban) or no traffic (periurban) situations and, as indi-

cated by Reviewer2, the uncertainty in the assumed aerosol type (urban or periurban). The latter is directly related to the difference between k1 in urban and periurban locations, which is of order of 20 % and can be considered as low since error bars on k1 (12 %) overlap. As a consequence, the choice of k parameter does not add an uncertainty larger than 5 % in the retrieved PM10 concentrations. This point has been precised. The uncertainty on the retrieved aerosol extinction coefficient depends on the lidar signal variability, the choice of the altitude of normalization and the BER assumption. It has been assessed to be of the order of 10 %. Finally, the global uncertainty on the lidar-derived PM10 is 25 %.

Figures 3-8 show PM10 concentrations as a function of location and altitude based on the lidar measurements. Does each of these figures use a specific k value throughout the image or do the k values vary as a function of location in each image? If the k values vary from the urban to periurban in each image, how do they vary? For example, at the surface, does the k value vary linearly from urban to periurban as a function of distance as the lidar traveled from the urban location to the periurban location? Does this variation vary with altitude?

As indicated in Sect. 5.2, k values do not vary as of function of distance as the lidar travelled from Paris to its southern suburb. In all case studies, a typical coefficient k for urban aerosols is applied in the boundary layer or nocturnal layer for pollutants emitted on the urban area or Paris Peripherique. Indeed, the pathway followed by the car when travelling from the urban to the periurban location is only highway. k values are principally governed by the traffic influence, which is a source of "urban" particles on our transects. However, the k value is different in each layer detected and a typical coefficient for periurban aerosols is applied in the residual layers (Sect. 5.2). This is suggested by the fact that those layers are mainly composed with aged aerosols trapped in altitude during the erosion of the boundary layer in the evening. Nevertheless, k coefficient does not linearly vary as a function of altitude since layer

structures are well disjoint.

Other comments:

1/ This standard deviation refers to an root-mean-square (rms) difference.

2/ The following sentence has been added: The anthropogenic aerosols currently account for about 10 percent of the total mass concentration of aerosols over the globe and this amount is associated with a high degree of regional variation (IPCC, 2007).

Intergovernmental Panel on Climate Control (IPCC): Climate Change 2007, the Fourth Assessment Report of the IPCC, Cambridge, United Kingdom and New York, NY, USA, 2007.

3/ The authors have never assumed that the aerosol properties and their horizontal distribution over this region were constant over this period (1999-2007). This section only presents the different experiments conducted in the Paris area over this period. The results described in the next sections show that, in fact, aerosol properties do not present significant variations over this period at a given location: results obtained in Paris during ESQUIF and LISAIR campaigns are very similar (Figs. 2a and 2b) and the same conclusion applies for periurban locations (Palaiseau during ParisFog and Saclay during ESQUIF, Figs. 2c and 2d). Moreover, the horizontal distribution of aerosols over Paris region is heterogeneous, as shown by our mobile measurements

4/ All the in situ measurements systems involved in this study (nephelometer, ELPI, TEOM) have recorded data every minute. Both LESAA and LAUV lidars worked at 20 Hz. Averaging thousand lidar shots every 50 seconds provided lidar profiles every minute.

5/ Calibration procedure is done by the constructor before each intensive experiment using two span gases and comparing the results between air (low span) and CO2 (high

span).

6/ Using the nephelometer measurements at 450 nm rather than at 700 nm to derive aerosol extinction at 355 nm at the surface does not reduce uncertainties. Indeed, in Eq. 2, the ratio $\alpha(\lambda)$* λ^a $isnotdependentonthewavelength\lambda$ used for the scattering coefficient.

7/ The authors indeed assumed that the Angstrom exponent between 355 and 450 nm was the same between 450 and 700 nm. The absolute uncertainty on the Angström exponent has been assessed to be 0.05. The relative uncertainty on PM10 due to k1 parameter is given by Eq. 3. The latter obviously takes into account the uncertainty due to the Angström exponent. As a consequence, the uncertainty on the Angström exponent leads to a relative error of 3% on PM10 concentrations retrieved thanks to k1 values.

8/ The effect of aerosol non-sphericity onto the aerosol scattering and extinction properties has been evaluated through a T-Matrix algorithm (Mishchenko et al., 1997). We considered a mixing of randomly oriented prolate and oblate particles with an aspect ratio between 1.7 and 2. We observed that the discrepancy between spherical and spheroidal particles on optical properties integrated over the whole size distribution was very weak (lower than 1% for the extinction coefficient and 2% for the scattering coefficient). This result is in agreement with the conclusions of Mishchenko et al. (1997) showing that the average of optical properties retrieved for various aspect ratios was close to the spherical case. The resulting uncertainty on the single-scattering albedo is lower than 1%.

9/ The authors have actually adjusted lidar measurements of aerosol extinction for hygroscopic growth when high relative humidity were measured in order to obtain the values of dry aerosol extinction to convert to PM10. The corresponding vertical profiles of relative humidity were derived from radiosounding measurements performed twice a day in Paris area (Trappes station, 48°46'39"N, 2°00'09"E).

10. As indicated in Sect. 3.4, the authors retrieved a humidification factor for each type of aerosols. Corrections of RH influence are consequently applied in each layer detected with the appropriate humidification factor.

11. Done. Correlation coefficients R have been given in Sect. 4.1 for all the cases represented in Fig. 2: LISAIR in Paris (R 0.67), ESQUIF in Paris (R 0.39), ParisFog in Palaiseau (R 0.73), ESQUIF in Saclay (R 0.37) and MEAUVE in Brétigny (R 0.62).

12. The experiment performed in the rural location (Brétigny) was done during winter 2001. Owing to rainy weather, only scarce measurements were available and the corresponding aerosol loading in the vertical column was very variable.

13. The discrepancy (5%) refers to a root-mean-square (rms) difference.

14. Done. The scattering growth factor has been assessed to be 0.69, which leads to a ratio of 0.73 between the wet and the dry aerosol scattering coefficients.

15. Elevated layers were observed on 26 and 27 May 2005. Their thicknesses were between 500 m and 1 km (Fig. 9).

16. The authors have given a possible explanation of higher residual layer on 24 May due to temperature on 23 May. But, the hypothesis of a weaker large scale subsidence could have also led to a higher residual layer on 24 May. This has been added in the revised version of the manuscript.

17. This discussion does not refer to Fig. 6 but is based on a comparison between Figs. 5 and 6 that were derived from consecutive lidar measurements.

18. The plume observed on Fig. 7b is located over A6 highway between 500 m and 900 m.

19. This is total depolarization ratio. Its value in the aerosol-free layer is 1.4%, corresponding to the molecular signature.

20. The simulations performed using the DREAM (Dust REgional Atmospheric Model)

model (http://www.bsc.es/projects/earthscience/DREAM/) have suggested that dust was actually over the Atlantic Ocean (page 13494, lines 26-28).

21. This is not an assumption. BER has been calculated in the dust layer. As indicated on Page 13495, lines 4-7, we have kept a constant BER value in the lowest layers (0.011 / sr, as previously determined) and we have sought the BER in the dust layer through an iterative method converging when the total optical thickness retrieved by the lidar was equal to that measured by the sunphotometer.

22. Right. Please refer to the discussion on Sect. 6 detailed in the comments to Reviewer1.

23. Table 1. Optical and microphysical parameters of different types of aerosols enabling the retrieval of specific extinction cross-sections (sext,355). k1 coefficient is determined from the knowledge of the slope C0 of optical to mass relationship and from the corresponding values of single scattering albedo (w0,355) and Angström exponent (a). k2 coefficient is determined from the knowledge of mean density rho, cubic radius r3 and extinction cross-section σext,355 of aerosols.

24. Done.

25. The white lines represent the results of the detection of lidar-derived vertical structures: top of the dust layer and top of the boundary layer. The method had been fully described in Sect. 5.1.

Interactive comment on Atmos. Chem. Phys. Discuss., 9, 13475, 2009.