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Atmospheric
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Discussions

Interactive comment on "Characterization and intercomparison of aerosol absorption photometers: result of two intercomparison workshops" *by* T. Müller et al.

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Answer to anonymous Referee #1

The authors thank the Referee for valuable comments.

Comment:

One of the major conclusions that I drew from this paper was that the experiments present precision and 'accuracy' (based on the MAAP) that appears to increase the uncertainty of filter based techniques. Is the variability between the same instrument

types shown here currently included in the uncertainty of reported data? It has been common to report filter-based absorption uncertainty between ~10 – 30% but what is it from these experiments? Could you estimate from this new data what that uncertainty should reasonable be reported as?

Reply:

It is inadequate to determine the 'accuracy' using MAAP as reference, although in Petzold et al. (2005) it was shown that MAAP agrees well to other reference methods (extinction minus scattering and photoacoustic spectroscopy). During both workshops no reference methods were available. The intention of the manuscript was not to present calibration experiments and to determine the 'accuracy' but to give an instrument intercomparison. Thus we would like to avoid the term 'accuracy' and use instead 'relative response to MAAP'. The variability between instruments of the same type are not included in the relative response to MAAP, since the relative response was determined from the average of all instruments of the same type. We will clarify this in the revised manuscript and add a sentence to the conclusion, page1549 line 17: "Unit to unit uncertainties of instruments (up to 27% for PSAP, 20% for Aethalometer, 3% for MAAP after recalibration of all sensors) are not included in the relative response to MAAP. Therefore the uncertainty of individual instruments can be larger than the relative response to MAAP. Since no reference method for measuring absorption was available we can not state absolute accuracies for filter based absorption measurements.

Comment:

Taking a step or two back it seems as though these inter-comparisons need to be simplified. The morphology and size distributions of kerosene soot can be characterized but the community would be better served by developing a simpler absorbing standard. (Lack et al., 2009) successfully used absorbing monodisperse polystyrene spheres for both photoacoustic and filter-based absorption experiments. These absorbing PSLs may not be atmospherically realistic but they can be very accurately characterized optically and physically and surely must constrain the scattering and filter loading issues.

Reply:

We agree that PSL spheres could serve as absorption standard. To get confidence in experiments using PSL spheres a comparison of absorption measured with a reliable reference measured and Mie calculated absorption would we desirable. During both workshops neither experiments with absorbing PSL were conducted nor absorption measured by a reference instrument was available. We will add a comment concerning absorption standards for calibration experiments to the conclusions: "Future calibration oder intercomparison experiments would benefit from experiments with physically well characterized absorption standards. In Lack et al. (2009) it was shown that absorption standards, e.g. polystyrene spheres, could serve as absorption standards."

Comment:

One interesting result from that study was a significant sensitivity of the PSAP to the size of the absorbing PSL.

Reply:

A size dependence of the response of PSAP to the particle size also was shown in a recent publication. We will add following comment in the discussion: "A dependence of the response of PSAP to particle size was shown by Lack et al. (2009) and Nakayama et al. (2010) using polystyrene spheres and nigrosin, respectively. This magnitude of the size dependence can be different for PSAP, MAAP, and Aethalometer, what complicates comparison of the relative responses to MAAP."

Specific Comments:

P1517 L28: Explain why photoacoustic / cavity ring down instruments might be preferable.

Reply:

We will change the sentence, since the detection limit of most reference methods is much higher compared to filter based absorption photometer. "An advantage of filter based instruments is that the detection limit is much smaller compared to other techniques, e.g. photoacoustic or extinction minus scattering. The detection limit is an important instrument characteristic for ambient air monitoring especially at remote places with low particle absorption.

Comment:

P1518 L10: "20 high quality" is a little subjective. I am not doubting the ability of the network, however I pause at statements like this without some form of validation.

Reply:

We follow the argumentation of the reviewer and delete the term "high quality".

Comment:

P1522 L3: Does carbon black contain any non-carbon dyes? This could affect the wavelength response.

Comment:

Reply:

To our knowledge Printex75 does not contain any dyes or volatile compounds (less than 1% at 950°C). This information will be added in the revised manuscript.

Comment:

Section 3.3.1: (Massoli et al., 2009) and (Bond et al., 2009) have recently identified uncertainties in scattering measurements by the nephelometer. Can you discuss these in this section and how/if these uncertainties might affect things?

Reply:

The authors admit Chapter 3.3.1 is misleading. When introducing the term "truncation error" we referred to Anderson and Ogren 1998. Actually the truncation correction is based on Mie theory (e.g. Anderson et al., 1996). The authors will clarify this point and replace lines 6 to 10 by: "Corrections for this so called 'truncation error' were discussed in Literature. Anderson and Ogren (1998) presented a correction for the TSI 3565 nephelometer based on the wavelength dependence of the scattering coefficient, which is derived from the nephelometer itself. The Anderon and Ogren correction was obtained for less absorbing aerosols with real parts of refractive index between 1.40 and 1.52 and for imaginary parts below 0.01. In Massoli et al. (2009) it was shown, that the uncertainty using the Anderson and Ogren correction can be up to 30% for absorption particles with refractive index of 1.7-0.3i, what is mostly due to the high real part of refractive index. In Bond et al. (2009) it was suggested, that the correction should be calculated using Mie theory to minimize errors. We followed this approach and corrected the scattering coefficients using Mie theory (e.g. Anderson et al., 1996). For ambient or black particles the uncertainties in the truncation correction of nephelometer data do not significantly influence the filter based absorption measurements, since attenuation of light passing the filter is dominated by particle absorption. For highly scattering particles the uncertainty becomes important if the attenuation is dominated by particle scattering. This would be the case for single scattering albedos larger 0.95."

The following sentence "Sometimes, the uncorrected scattering coefficients are used, e.g. when applying the scattering correction for commercial PSAPs proposed by Bond et al. (1999)" will be deleted in the revised manuscript, since this an issue of PSAP correction and is described in detail in the chapter 4.1 (page 1526, lines 17-19).

Comment:

P1524 L12: What is the scattering correction for the non-532nm wavelengths?

Reply:

The scattering correction follows the method described in Ogren (2010). The scattering coefficients for the scattering corrections were calculated using the Ångström

exponents from the 3-wavelength TSI nephelometer. The authors will change the lines 11-13 to: "Absorption coefficients measured by PSAP were corrected using the Bond correction scheme. In Ogren (2010) a procedure to adjust the Bond correction to other wavelengths is given."

Comment:

P1545 L10 – 25: How does this variability in scattering correction affect an example set of monitoring stations? For example remote, rural, polluted will have different scattering components/magnitudes so will the scattering uncertainty measured here affect one site differently than another site (in terms of the overall uncertainty of measured absorption?

Reply:

The authors will add following discussion and example to the text in the revised manuscript: "Uncertainties in the absorption caused by particle scattering is an important matter. The bias in absorption coefficients due to particle scattering is about 1.6% of the scattering coefficient, where the uncertainty of this scattering correction is ±100%. This is in agreement with data shown in Figure 12. The uncertainty of absorption introduced by the uncertainty of the scattering correction depends on the single scattering albedo. For PSAP the uncertainty of absorption is 30% at single scattering albedos of 0.95 and 14% at single scattering albedos of about 0.90, when using the Bond et al. (1999) correction. "

Comment:

P1548 L8: Do the MAAP data need to be corrected or was it decided not to correct this data?

Reply:

The authors will correct a mistake, since MAAP data were corrected by a factor of 1.05 to account for the wavelength adjustments as shown in line 14.

Comment:

Figure 7. I don't see the benefit to this figure.

Reply:

The Authors agree that this figure does not contain information necessary for the understanding of the manuscript. The authors will delete this figure in the revised manuscript.

References not found in the discussion paper:

Bond, T. C., Covert, D. S., and Müller, T.: Truncation and Angular Scattering Corrections for Absorbing Aerosols in the TSI 3563 Nephelometer, Aerosol Science and Technology, 43, 866–871, 2009.

Lack, D. A., Cappa, C. D., Cross, E. S., Massoli, P., Ahern, A. T., Davidovits, P., and Onasch, T. B.: Absorption Enhancement of Coated Absorbing Aerosols: Validation of the Photo-Acoustic Technique for Measuring the Enhancement Aerosol Science and Technology, 43, 1006-1012, 2009.

Massoli, P., Baynard, T., Lack, D. A., Brock, C. A., Murphy, D. M., and Lovejoy, E. R.: Uncertainty in Light Scattering Measurements by Nephelomter: Resulsts from Laboratory Studies and Implications for Ambient Measurements, Aerosol Science and Technology, 43, DOI: 10.1080/02786820903156542 2009.

Nakayama, T., Kondo, Y., Moteki, N., Sahu, L. K., Kinase, T., Kita, K. and Matsumi, Y. (2010). Size-dependent correction factors for absorption measurements using filter-based photometers: PSAP and COSMOS. Journal of Aerosol Science 41:333-343.

Ogren, J. A. (2010). Comment on "Calibration and Intercomparison of Filter-Based Measurements of Visible Light Absorption by Aerosols". Aerosol Sci. Tech. 44:589-591.

Interactive comment on Atmos. Meas. Tech. Discuss., 3, 1511, 2010.