Interactive comment on "Optical properties of a heated aerosol in an urban atmosphere: a case study" by J. Backman et al.

Anonymous Referee

Review of Backman et al. Optical properties of a heated aerosol in an urban atmosphere: a case study.

The manuscript presents the effect of varying temperatures on optical properties (single scattering albedo, absorption coefficients, and scattering coefficients) of the urban aerosol measured during 9-15 April 2009 at Helsinki. The volatility of the aerosols was studied by heating the aerosols from 50 ^{0}C to 280 ^{0}C. The absorption and scattering coefficients of the aerosol were measured by using PSAP, aethalometer, and nephelometer. The elemental carbon and organic carbon mass concentrations were measured with an OCEC analyzer. There is an attempt to describe that the light absorption measurements by using filter methods can be improved by heating the aerosol before it gets deposited on the filter media. This study showed that the single scattering albedo decreases considerably with the temperature of the aerosols.

General comments

After reading the Abstract and the Introduction, the title of the paper "Optical properties of a heated aerosol in an urban atmosphere: a case study" doesn't seem to carry the main message of the manuscript. For instance, the sentence of the abstract "Light absorption measurements most commonly rely on filter-based measurement tech…….. are disturbed by light scattering constituents in the aerosol deposited on the filters, and the description in the introduction "the aim was to show a proof-of –concept that the performance of the filter –based methods can be…" give the impression that you are trying to focus to improve the light absorption measurements by filter based techniques. It would be good to synchronize the main message in the Title, Abstract, Introduction, as well as in other parts of the paper.

If the main message of the manuscript was intended to improve the filter based measurements of aerosol light absorption, then more discussion and analysis pertaining to the interaction of the aerosol with the filter media would justify the scope of the manuscript. Sheridan et al. reported that at higher absorption (at lower single scattering albedo) the aerosol light absorption measurements by PSAP deviates more from the reference absorption due to the inadequate filter loading correction [*Sheridan et al.,* 2005]. This situation should be more pronounced in this work due to the evaporation of the volatile aerosols at the elevated temperatures, and so the reduced amount of the scattering aerosols on the filter matrix should also have an effect on both Bond and Virkkula algorithms used in this study. Discussion should have been focused on the appropriate temperature at which the aerosol should be heated to improve the light absorption measurements by using the filter method. This method is highly sensitive to how deeply the particles were deposited in the filter. For an example, see *Arnott et al.,* 2005.The hypothesis in both the Abstract and Introduction "the filter based measurements are

disturbed by light scattering constituents" doesn't seem to be supported by further example; the nature of the filter used in aethalometer, the PSAP and phenomenon of multiple scattering in the filter matrix, and the types of aerosol that would be mostly effected by the filter should be described to support the hypothesis.

The elevated temperature definitely effects the morphology and fractal state of the black carbon in comparison to its ambient state there by changing the optical properties. This should be included in the discussion of the manuscript. For more discussions pertaining to the surface modifications of hydrophobic and hydrophilic soot on optical coefficient see *Mikhailov et al.*, 2006. At the same time the heating of the aerosol might lose its coating and mixing state, so we also might lose this important information about the ambient aerosol.

The reported mass absorption coefficient (MAC) in this manuscript; 13.6 m^2g^{-1}, calculated by heating the aerosol using PSAP seems quite higher at 545 nm than the published value. For example Fuller et al. suggested MAC less than 7 m^2g^{-1} for diesel soot at 550 nm [*Fuller et al.*, 1999], and Bond and Bergstrom have proposed a value 7.5 m^2 g^{-1} for pure soot carbon particles [*Bond and Bergstrom*, 2006]. As mentioned in the paper at an elevated temperature of 280 ^{0}C the only aerosol remaining in the filter is dominantly of black carbon, so in this condition the calculated MAC shouldn't be so high because the residual aerosol is free of any kind of coating and internal and external mixing.

Specific comments:

(1) In the statement on page 1583, line 5 "Most light scattering constituents in the sub-micron aerosol are volatile by their nature" do you mean they are volatile due to their size or due to their chemical composition? Further, this sentence would be more appropriate if you were selecting the size of aerosol in that range during your measurement periods.

(2) The mass absorption coefficient you reported in abstract is 13.5 m^2 g^{-1} at 545 nm (page 1583, line 14), but you also mentioned that you observed 9.6 m^2g^{-1} (page 1598, line 17) by using Bond et al. (1999) correction at the same wavelength and for the same instrument. Why is it so different for the same wavelength? I don't think these values are themselves consistent. Why do you choose the first one to report in the Abstract? The MAC 13.5 m^2 g^{-1} seems too high at this wavelength, so you must need to say something about why it is so high and why you are getting differing values by applying Virkkula and Bond et al algorithm.

(3) You should explain the abbreviation of SMEAR III (Page 1583, line 10), and OC1, OC2, OC3, OC4 (page 1595, line 9)

(4) All the notations used in equations (6), (7), and (8) should also be defined in the text.

(5) The sentence "suggesting that noisy …periods may have been due to near-by soot sources" on page 1594, line 21 is quite confusing. Were the "soot sources" presented for only one particular time of the measurements? If there were soot sources nearby, they should make the signal more robust rather than making it noise.

(6) The magnitude of observed single scattering albedo have been reported as 0.5 on page 1595,

line 30 and 0.4 on page 1598, line 25. Were both descriptions intended for maximum SSA observed after midnight on April 13? The explanation for this increased SSA (chemically different aerosol entering the oven in the first instance and organic carbon in the second instance) is not convincing. The mid visible wavelength should not be so much affected by organic carbon on the other hand to have organic aerosol there must be some noticeable different activity going on like bio-mass burning.

Comments on Figures:

Figure (2):

You should label upper panel and lower panel as Figure 2 (a), and 2(b). The error bars in upper panel are not consistent in length; the error bars are higher at the beginning and decreasing and increasing. Is there any particular reason for this, because in the lower panel it is decreasing continuously with the particle concentration?

Figure (3)

This figure seems much too busy; if you can split it into two parts it would be more readable. Make the size as well as the font bigger so that it would be easier to read. Also, it would be better if you used the symbol in the legend together with color. Label X-axis like days in 2009, or whatever you think appropriate

I don't see any point in including data of variable temperature (after April 14th) in this plot [you are saying it's the plot for fixed temperature of 280 ^{0}C, and also you have separate plot for variable temperature observation (Figure 5)]

Need to increase the font to readable size. Label the X-axis.

Figure (7)

Give some explanations how you calculate the error bar of single scattering albedo how does it propagate from both absorption and scattering measurements?

References

Arnott, W. P., K. Hamasha, H. Moosmüller, P. J. Sheridan, and J. A. Ogren (2005), Towards aerosol light absorption measurements with a 7-wavelength Aethalometer: Evaluation with a photoacoustic instrument and a 3 wavelength nephelometer, *Aerosol Science & Technology*, *39*, 17-29.

Bond, T. C., and R. W. Bergstrom (2006), Light absorption by carbonaceous particles: An investigative review., *Aerosol Science & Technology*, *40*, 27-67.

Fuller, K. A., W. C. Malm, and S. M. Kreidenweis (1999), Effects of mixing on extinction by carbonaceous particles, *Journal of geophysical research, 104*(D13), 15941-15954.

Mikhailov, E. F., S. S. Vlasenko, I. A. Podgorny, V. Ramanathan, and C. E. Corrigan (2006), Optical properties of soot–water drop agglomerates: An experimental study, *J. Geophys. Res, 111*.

Sheridan, P. J., W. P. Arnott, J. A. Ogren, B. E. Anderson, D. B. Atkinson, D. S. Covert, H. Moosmuller, A. Petzold, B. Schmid, A. W. Strawa, R. Varma, and A. Virkkula (2005), The Reno aerosol optics study: An Evaluation of Aerosol Absorption Measurement Methods, *Aerosol Science & Technology, 39*, 1-16.