Black carbon aerosol concentrations and mixing state in Pallas, Finland

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Black carbon (BC) aerosols have various climate effects. In addition to directly absorbing solar radiation, they have an effect on aerosol-cloud interactions and snow and ice albedo. Single Particle Soot Photometer (SP2) detects BC by using laser-induced incandescence and non-absorbing particles are identified from the scattered light (Stephens et al, 2003). Absorbing particles, with or without coating, are quickly heated to the incandescence temperature and the resulting peak signal, which is seen before evaporation, is proportional to the BC mass. Sizes of the purely scattering particles can be calculated from the peak intensity of the scattered light, which is seen when the particle is at the centre of the laser beam. However, particles containing both BC and scattering material heat up rapidly so that the scattering material evaporates before the centre of the laser beam. In this case, the initial scattering particle size can be extrapolated.

Two commonly used methods to extrapolate scattering sizes for evaporating particles are Leading Edge Optimization (LEO; Gao et al, 2008) and Normalized Derivative Method (NDM; Moteki and Kondo, 2008). The NDM is computationally demanding, and both methods can fail when, for example, the sample flow rate fluctuates. Significant flow rate fluctuations were observed in the SP2 measurements conducted at Pallas station in northern Finland during winter 2011-2012. To improve the coating thickness calculations, we have improved the NDM method so that the computationally heavy a priori estimate of the scattering signal is replaced by a linear fit to the normalized derivative and a fast posteriori likelihood test.

Figure 1 shows number concentrations of the different particle types. Concentrations are low in this pristine environment, but about 10 % of the observed (150-500 nm) particles contain BC. In addition, practically all BC particles are coated.

Figure 2 shows coating thickness distributions based on the original scattering sizes and those calculated with LEO, NDM and the new method. Due to the fluctuating flow rate, the NDM often fails to find a solution. The LEO method can find a solution, but it could overestimate coating thickness. The new method finds a reasonable solution for most particles (4715 of 5973) and the results show that most particles are thinly coated (68 % have less than 50 nm coating). This finding is in good agreement with the observation that 73 % of these particles experienced rapid coating evaporation determined from the lag time between scattering and incandescence peak signals. Further calibration experiments with mixed particles will be used to show that the new method finds the correct scattering size.

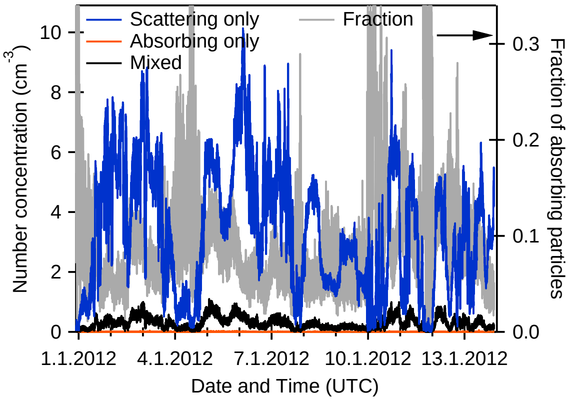

Figure 1. Total concentrations of scattering, absorbing and mixed particles from the 150-500 nm size range, and the fraction of absorbing particles.

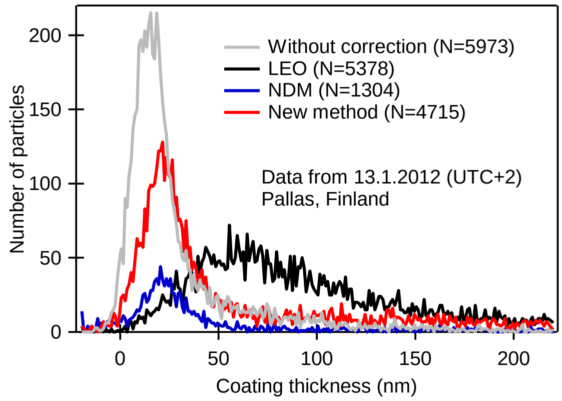

Figure 2. Coating thickness distributions for mixed particles which BC core diameter is 150-170 nm.

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Gao, R.S., et al. (2007) *Aerosol Sci. Technol.* **41**, 125-135.

Moteki, N. and Kondo, Y. (2008) *J. Aerosol. Sci*. **39**, 348-364.

Stephens, M., Turner, N. and Sandberg, J. (2003) *Appl. Opt.* **42**, 3726-3736.