Calibration experiments for filter based absorption photometers during the EUSAAR-2009 photometer workshop

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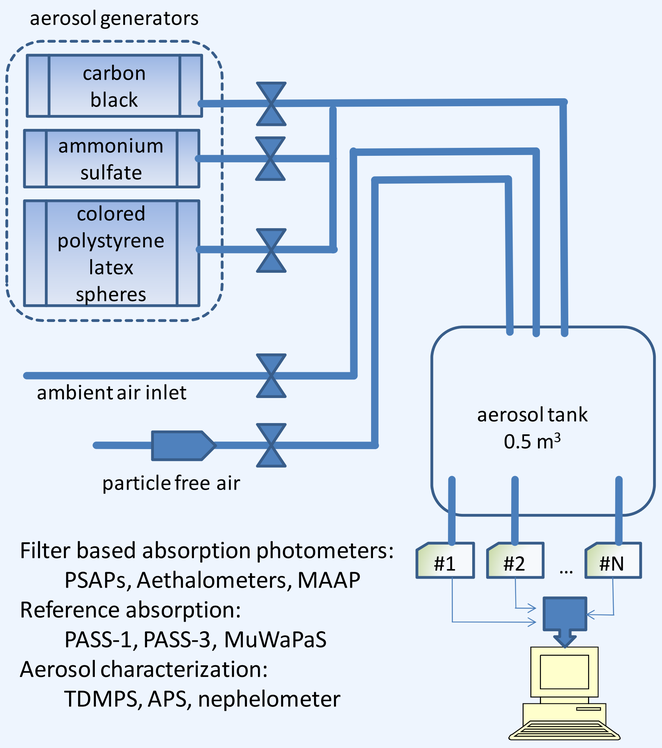
Introduction

Aerosol light absorption is an important parameter for the assessment of the radiation budget of the atmosphere. Filter based absorption photometers, e.g. the Aethalometer and the Particle Soot Absorption Photometer (PSAP) have been available for several years. Multiple scattering of light in the filter medium and the presence of scattering particles result in a measured attenuation coefficient, which is different from the absorption coefficient of airborne particles. Correction schemes have to be determined experimentally using reference methods (e.g. photoacoustic photometers or extinction minus scattering). Often used correction schemes are described in Bond et al. (1999) and Virkkula et al. (2005) for PSAP and in Weingartner et al. (2003) for Aethalometer. In the frameworks of EUSAAR a workshop for testing existing and developing new correction schemes has been conducted in 2009 at the Leibniz Institute for Tropospheric Research in Leipzig.

Experiments

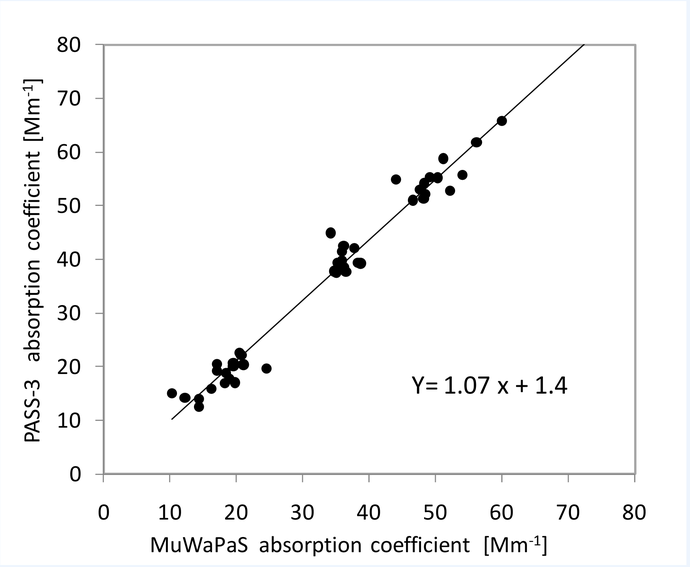


Filter based absorption photometers:
PSAPs, Aethalometers, MAAP
Reference absorption:
PASS-1, PASS-3, MuWaPaS
Aerosol characterization:
TDMPS, APS, nephelometer

Aerosol types and properties

Ångström exponents were derived from PASS-3 at wavelengths 405 and 532 nm and single scattering albedos were determined with PASS-3 and a nephelometer at 532 nm.

Aerosol type	Ångström exponent	Single scattering albedo
Black (Printex 75, P75)	0.89	0.32
White (ammonium sulfate, AS)	0.08 to 2.5	0.997-0.999
Gray (external mixture of P75 and AS)	1.22 to 1.41	0.59 to 0.96
Colored (colored PSL spheres)	-1.31 to 1.98	0.71 to 0.81
Ambient	1.97 to 2.3	0.78 to 0.83



Correlation of two reference instruments at wavelength 532 nm. Reference instruments are photoacoustic photometers of types PASS-3 (Droplet Measurement Technologies) and MUWaPaS (Hilase Ltd.).

Results

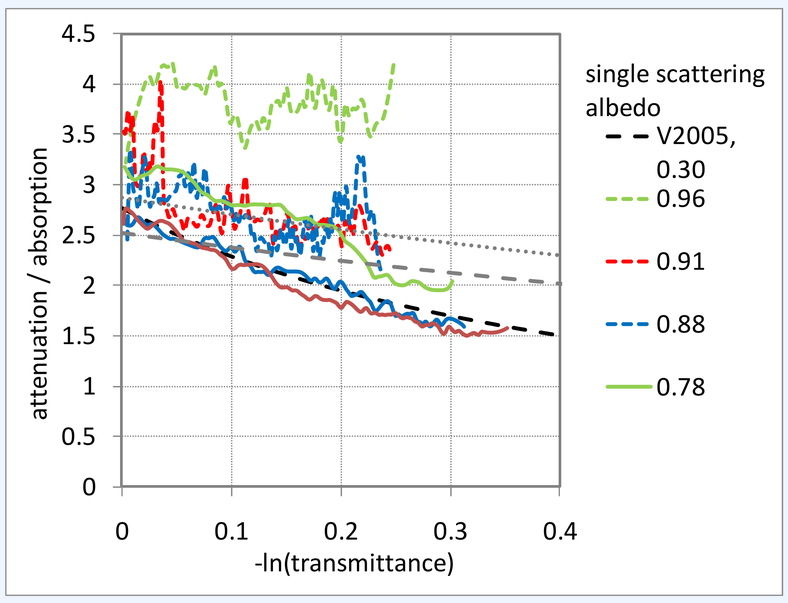
Filter based absorption photometers primarily measure the attenuation coefficent σ_{atn} defined by

$$\sigma_{atn}(t) = -\frac{1}{L}\ln\left(\frac{\tau(t)}{\tau(t-\Delta t)}\right) \quad ,$$

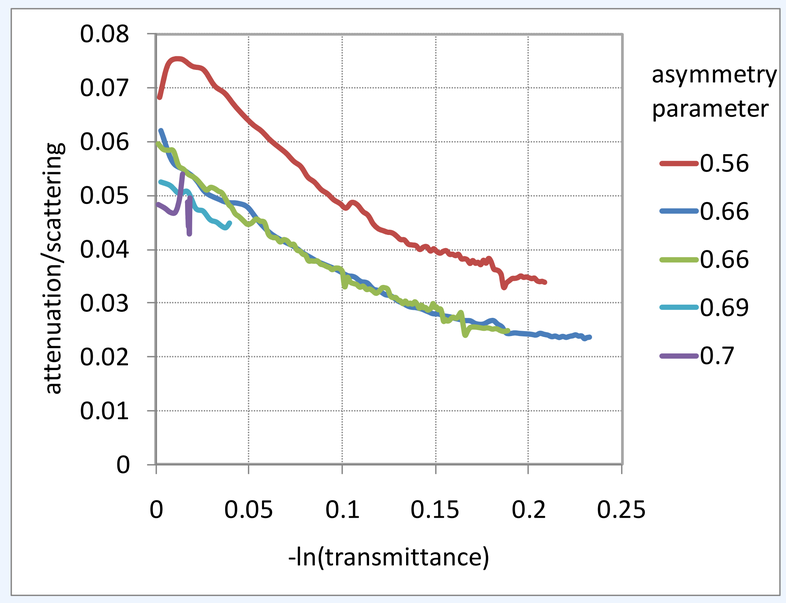
where L is the length of the colunm of air, which is drawn through the filter in the time interval Δt, and τ is the transmittance of light. The attenuation coefficient depends on several parameters, e.g. the type of aerosol and the mass of deposited particles.
Correction functions for relating the attenuation coefficient σ_{abs} measured with PSAP to the particle absorption coefficient are given by Bond et al. (1999) and Virkkula et al. (2005).

$$\sigma_{ap}(t) = B1999(\sigma_{atn}, \tau(t), \sigma_{sp}(t))$$
$$\sigma_{ap}(t) = V2005(\sigma_{atn}, \tau(t), \sigma_{sp}(t))$$

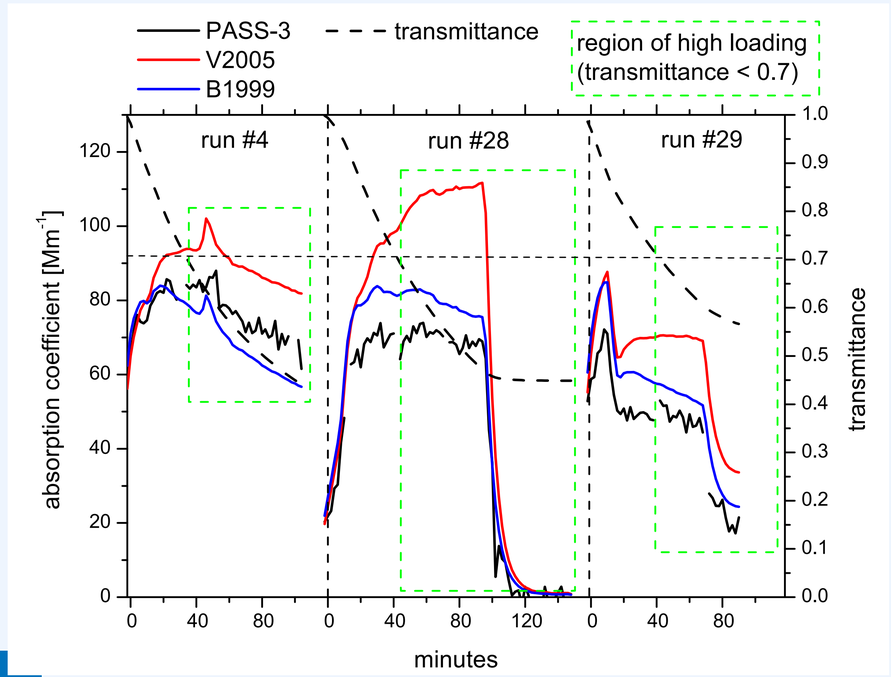
The dependence of the attenuation coefficient on filter transmittance τ and scattering coefficent σ_{sca} also was investigated during the EUSAAR workshop.



Ratios of attenuation and absorption coefficients for different single scattering albedos. Also shown are theoretical ratios according to the B1999 and V2005 correction functions.

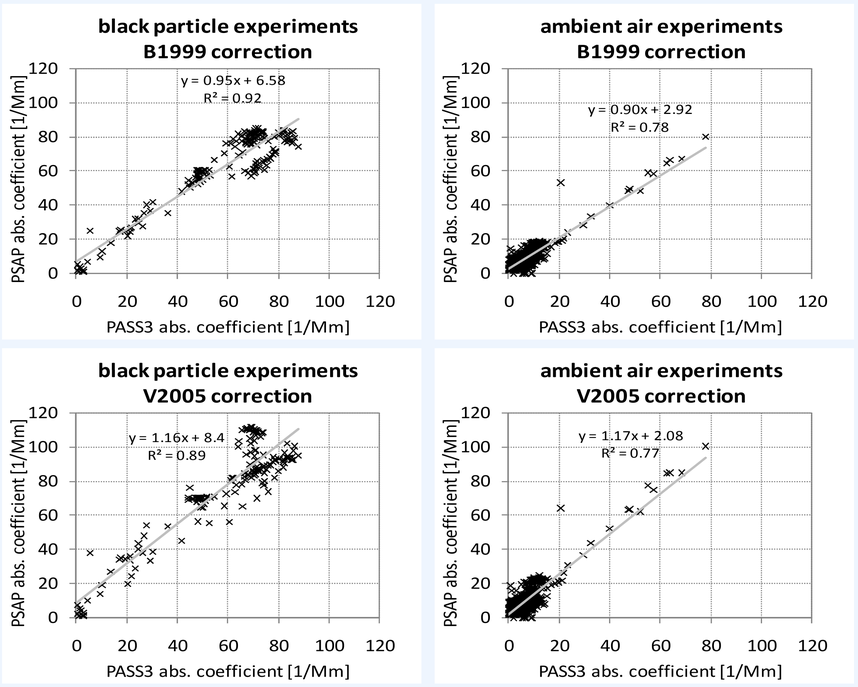


Ratios of attenuation and scattering coefficients for different particle asymmetry parameters.



Left figure: Results from runs with black particles. Absorption coefficients at the wavelength 532 nm were measured with PASS-3 and derived from PSAP using the B1999 and V2005 correction functions. Also shown is the filter transmittance.

Right figure: Scatter plot of absorption coefficients at wavelength 532 nm measured with PSAP versus the absorption coefficient measured with PASS-3. Shown are results from runs with black particles and ambient air.



References: Bond, T. C., et al. (1999). *Aerosol Sci. Technol.*, 30, 582-600.; Virkkula, A., et al. (2005). *Aerosol Sci. Tech.,* 39:68-83; Weingartner, E., et al. (2003). *Journal of Aerosol Science,* 34:1445-1463.