Calibration of filter-based absorption photometers against two reference standards

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Soot particles in the atmosphere can be found in different forms: fresh soot with high elemental carbon content, aged soot (i.e. soot coated with secondary organic matter, SOM) and soot externally mixed with inorganic salt and/or dust particles. Depending on the composition, the single scattering albedo (SSA) of the aerosols can span the range from 0-1. Organic or inorganic admixtures to Black Carbon (BC) can cause interference with the BC measurements. Filter-based absorption photometers measure transmission of light through a sample laden filter. They make several assumptions to determine the aerosol light absorption coefficient (relevant for climate) and convert it to equivalent BC mass concentration (eBC) (relevant for air quality) with an assumed mass absorption cross-section (MAC) value. These instruments (e.g. aethalometers and MAAP) are often used by air quality monitoring networks and atmospheric scientists. They suffer from high measurement uncertainties due to the lack of suitable calibration procedures (Kalbermatter et al., 2022).

Kalbermatter et al. (2022) compared different filter-based and in-situ BC monitors with a photothermal interferometer (PTAAM-2λ, Haze Instruments, Slovenia; Drinovec et al., 2022) using well-characterised fresh and aged soot particles as test aerosols. This study builds upon the work by Kalbermatter et al. but extends the measurements to test aerosols with a single scattering albedo (SSA) of up to about 1 using well-defined synthetic PM_1 ambient aerosols generated in the laboratory with the PALMA facility (Horender et al., 2021).

The aerosols were prepared to mimic fresh and aged soot particles under different environmental conditions. Fresh soot with an SSA of 0.01 to 0.1 was simulated by generating combustion particles with a miniCAST generator and aged soot (SSA: 0.3-0.7) by coating the miniCAST particles with secondary organic and inorganic matter inorganic salt (ammonium sulphate). Ambient-like aerosols consisting of mixtures with known amounts of fresh soot, coated soot, secondary inorganic salts and mineral dust particles, with an SSA of 0.97-0.99 were generated with the PALMA facility. The aerosol properties other than absorption, especially mass, were characterised with MPSS, TEM, TEOM, EC/OC and IC analysis.

First, photometers, such as aethalometers (AE31, AE33, AE51), MAAP, and PAX were calibrated against the two reference methods for light absorption (Photothermal Interferometry, PTI, and Extinction Minus Scattering, EMS) using the setup depicted schematically in Fig. 1. This allowed us to obtain SSA-dependent (and therefore site-specific) calibration factors. Subsequently, SSA-dependent calibration factors and MAC values were used to calculate eBC mass concentrations from the measured light absorption coefficients.

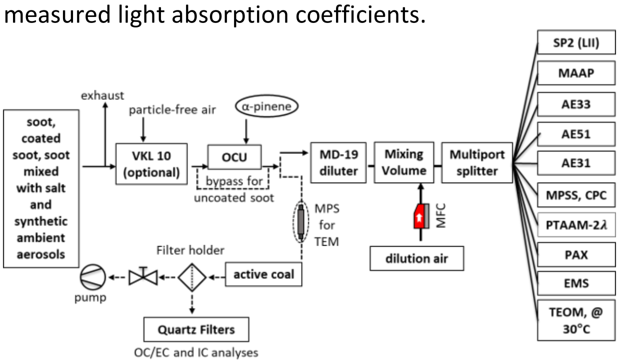

Figure 1. Experimental setup for the calibration of filter-based absorption photometers against the two reference methods for aerosol light absorption (PTI and EMS).

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