Comparison of calibration methods for in-situ aerosol absorption instruments

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There are several methods for in-situ aerosol absorption measurement, including photothermal interferometry, photo-acoustic spectroscopy and extinction-minus-scattering. In-situ absorption instruments utilize different calibration schemes based on the light absorption or scattering of particles and gases.

NO_2 is used for calibration in the visible range (Arnott et al., 2000; Schnaiter et al., 2023) and can be traceable to SI units (Drinovec et al., 2022). Particles, on the other hand, allow for calibration without wavelength range limitations. A candidate particle calibration material is water soluble nigrosin, which forms spherical particles when nebulized. Mie calculations based on the refractive index of nigrosin is then used to determine absorption coefficients. In general, the calibration with monodisperse aerosols provides lower uncertainties compared to polydisperse aerosols. Several approaches for calibration with size-selected aerosols have been developed (Symonds et al., 2013; Bluvstein et al., 2017; Sang-Nourpour and Olfert, 1019).

The aim of this work was to compare different calibration schemes with respect to their measurement uncertainty and ease of implementation, whether in the field or laboratory.

Aerosol absorption was measured using a photothermal interferometer PTAAM-2λ (Haze Instruments), a photo-acoustic extinctiometer PAX (Droplet Measurement Technologies) and an extinction-minus-scattering (EMS) method consisting of a cavity attenuated phase shift extinction instrument (CAPS PM_{EX}, Aerodyne Research) and a nephelometer (Aurora 4000, Acoem) nephelometer.

NO_2 calibration was performed using a SI-traceable mobile reference gas generator based on the permeation method (METAS), pre-prepared NO_2 mixtures in cylinders or ambient NO_2.

Monodisperse nigrosin was selected from the nebulized sample using either an electrostatic classifier (EC 3082, TSI), an aerodynamic aerosol classifier (AAC, Cambustion) or a centrifugal particle mass analyser (CPMA, Cambustion). Particle number concentration was quantified using a condensation particle counter (CPC 3750, TSI) or an aerosol electrometer (AE 3068B, TSI). The refractive index of nigrosin (CAS 8005-03-6) was determined by using an ellipsometer EP3SE (Acurion).

First, we compared the measured and calculated absorption of monodisperse nigrosin aerosols generated using EC, AAC and CPMA. The experimental results with the electrostatic classifier are shown in Figure 1. These measurements are affected by doubly-charged particles which increase the measured absorption by 6%, 4% and 2% for 100, 150 and 200 nm particles, respectively.

We also compared the response of in-situ absorption instruments PTAAM, PAX and EMS using monodisperse nigrosin and carbon black (CAB-O-JET200) aerosols.

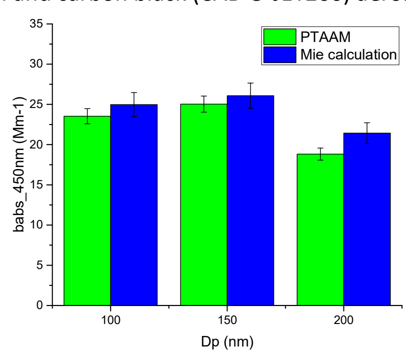

Figure 1. Comparison of measured and predicted absorption coefficient of monodisperse nigrosin. Mie calculation is based on measured particle number, their mobility diameter and nigrosin refractive index. Error bars represent method uncertainty.

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Arnott et al. 2000; doi.org/10.1063/1.1322585
Bluvstein et al., 2017; doi.org/10.5194/amt-10-1203-2017
Drinovec et al. 2022; doi.org/10.5194/amt-15-3805-2022
Sang-Nourpour and Olfert 1019; doi.org/10.1016/j.jaerosci.2019.105452
Schnaiter et al. 2023; doi.org/10.5194/amt-16-2753-2023
Symonds et al. 2013; doi.org/10.1080/02786826.2013.801547