Aerosol absorption and single-scattering albedo measurements at a remote European site: evaluation of the CAPS-PMssa monitor

J. C. Corbin[1], Th. Müller[2], B. Wehner[2], Th. Tuch[2], N. Bukowiecki[1], U. Baltensperger[1], and M. Gysel[1]

[1] Laboratory of Atmospheric Chemistry, PSI, Villigen, Switzerland
[2] Leibniz Institute for Tropospheric Research (TROPOS), Leipzig, Germany

Keywords: absorption, SSA, CAPS, nephelometer, monitoring
Presenting author email: Joel.Corbin@psi.ch

Reliable long-term measurements of aerosol optical properties require accurate, reliable, and affordable instrumentation. Nephelometers such as the Ecotech Aurora 4000 typically provide aerosol scattering measurements, while aethalometers are widely used to measure wavelength-dependent absorption. However, the uncertainty of the filter response in the aethalometer, resulting in the empirical "C value" correction, can impart significant uncertainty to the reported aerosol absorption σ_{ap} and SSA (Collaud-Coen et al., 2010). The Multi-Angle Absorption Photometer (MAAP, Petzold and Schönlinner 2004) does not require this empirical correction but measures absorption at only one wavelength. Photoacoustic methods also measure absorption, but are costly and are not considered here. A final approach, extinction-minus-scattering, is particularly sensitive to measurement error as the difference of two large numbers is taken.

The Aerodyne CAPS-PMssa monitor has recently been developed with the goal of providing accurate in-situ SSA measurements. The instrument measures the reduced path length of light in an optical cavity by monitoring the phase shift of a modulated LED signal (the "CAPS" technique, Kebabian et al., 2007). In the CAPS-PMssa, an integrating-sphere nephelometer simultaneously measures scattered light exiting the same optical cavity (Onasch et al., 2015). Thus scattering σ_{sp} and extinction σ_{ep} coefficients are measured on the same volume; scattering is calibrated against extinction to reduce measurement bias.

Here, we evaluate the CAPS-PMssa against standard optical measurements – MAAP and nephelometer, with aethalometer-derived wavelength dependence – based on a field campaign at a remote European site (Melpitz, eastern Germany, operated by Tropos). Three CAPS PMex (450 nm, 530 nm, and 630 nm) were available as references. The site was characterized by a high SSA, negligible brown carbon absorption, and relatively low aerosol loadings.

For three CAPS-PMssa instruments, scattering measurements were found to be highly stable when correctly calibrated. Extinction measurements were sensitive to mirror contamination. The best-obtained accuracy of three separate CAPS-PMssa instruments (450 nm, 630 nm, and 780 nm) was insufficient for an accurate determination of the wavelength-dependence of absorption. We conclude that the CAPS-PMssa approach provides sufficiently accurate measurements of SSA, even when SSA is ~0.9 and σ_{ep} is below 50 /Mm at 630 nm. However, its extinction measurements must be validated, and wavelength dependence is better measured by a single multi-wavelength instrument.

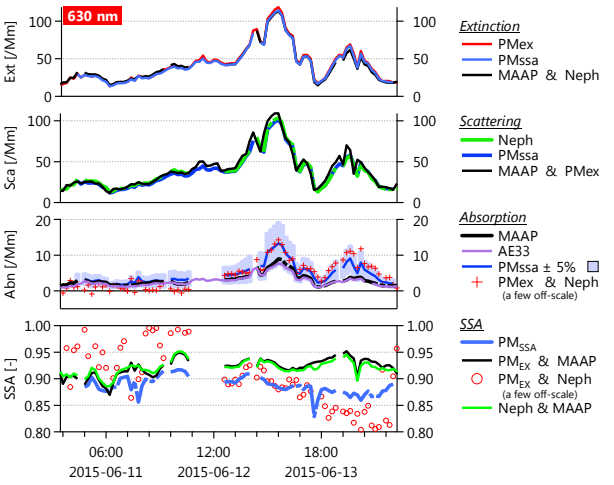

Figure 1: Time-series extract from the Melpitz campaign, for measurements at 630 nm only. Blue shading represents the estimated calibration uncertainty of the CAPS-PMssa σ_{sp}. The break in the data at ~12:00 is due to a nephelometer calibration.

Acknowledgements: This work was financially supported by an European Research Council grant (ERC-CoG 615922-BLACARAT) and from the European Union's Horizon 2020 research and innovation programme, under grant agreement No. 654109. Achim Grüner and other TROPOS colleagues are thanked for their support at the measurement site.

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