Detailed performance assessment of the CAPS single scattering albedo monitor (CAPS PMssa) as a field-based instrument for measuring light absorption by aerosols

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Introduction

Light absorption by atmospheric aerosols is a key climatic process with important effects on the Earth's radiative balance. However, despite decades of active efforts, aerosol light absorption measurements are still too uncertain to adequately constrain these climate impacts (Samset et al., 2018). Recently, new in situ techniques have been developed that measure light absorption by aerosols in their natural, suspended state, thereby avoiding the measurement artefacts associated with traditional, filter-based absorption photometers. The CAPS PMssa (Aerodyne, Inc.) is one such new instrument that measures absorption at a single wavelength via the extinction-minus-scattering (EMS) method (Onasch et al., 2015). The accuracy of CAPS PMssa EMS measurements depends on aerosol properties (e.g. size distribution, single scattering albedo, SSA), as well as instrument specific parameters that can vary over time (e.g. the cross-calibration factors used to scale measured scattering coefficients). We performed field measurements to investigate how these factors influence the ability of the CAPS PMssa to function as a field-based instrument for measuring aerosol light absorption coefficients.

Methods

Two CAPS PMssa instruments (wavelengths 530 and 630 nm) were operated at the Cabauw Experimental Site for Atmospheric Reasearch (CESAR) in the Netherlands from 10 September to 20 October 2016 as part of the ACTRIS-2 JRA1 program. Particle size distributions were also measured (SMPS, APS) and used as inputs to models for calculating and correcting for scattered light truncation, one of which we developed to extend on the original CAPS PMssa truncation model (Onasch et al., 2015). Co-located absorption coefficient measurements were performed with a multi-angle absorption photometer (MAAP).

Conclusions

Measured scattering cross-calibration factors were stable over the full campaign. However, comprehensive follow-up laboratory measurements indicated that these constants can vary enough on a day-to-day basis to introduce considerable uncertainty in the EMS-derived absorption coefficients. Regarding scattered light truncation, regardless of the model used to correct for this effect, an SSA dependent bias was introduced in the CAPS PMssa absorption coefficients relative to those measured by the MAAP. We developed a method for correcting the scaled CAPS PMssa scattering coefficients that is based on minimizing this bias. Application of the method resulted in improved agreement between CAPS PMssa and MAAP absorption coefficients (Fig. 1).

Overall these results indicate that the CAPS PMssa is capable of operating stably over the length of a typical intensive field campaign. However, further work is required to reduce uncertainties in the underlying cross-calibration and truncation correction factors before the instrument can be used as a reliable, stand-alone instrument for measuring aerosol light absorption coefficients in the field.

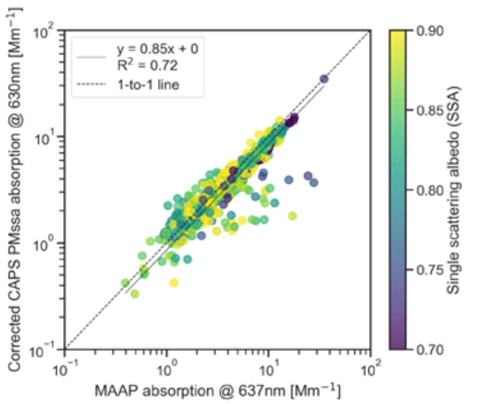

Figure 1. Absorption coefficients measured by the 630 nm CAPS PMssa and corrected by the SSA-dependent-bias minimization method versus those measured by MAAP

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