Multi-wavelength aerosol absorption coefficient measurements: instrument inter-comparison and implications for source and component apportionment

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Introduction

In this work, results obtained in the frame of a comprehensive COST COLOSSAL measuring campaign at an urban background station at the University of Milano-Bicocca (Italy) are presented. We investigate the performance of:

- different filter-based photometers for the determination of the aerosol absorption coefficient (b_{abs});
- different models based on multi-wavelength (multi-λ) b_{abs} measurements to identify light absorbing aerosol sources (fossil fuel, FF; biomass burning, BB) and/or components (Black Carbon, BC; Brown Carbon, BrC), i.e. the Aethalometer model (Sandradewi et al., 2008) and the Multi-Wavelength Absorption Analyzer (MWAA) model (Massabò et al., 2015).

Methods

Twelve-hour samples were collected on pre-fired (700°C, 1h) quartz fibre filters by a low volume sampler (flowrate 1 m^3/h). The samples were analysed by the multi-λ polar photometer PP_UniMI (Bernardoni et al., 2017, Vecchi et al., 2014) at the University of Milan for off-line b_{abs} determination. Thermal-Optical Transmittance analysis using the EUSAAR_2 protocol for OC/EC, and HPAEC_PAD for levoglucosan were performed at the University of Genoa. The sampling site was also equipped with on-line instrumentation - Aethalometers AE31 and AE33 (Magee Scientific), and a Multi-Angle Absorption Photometer MAAP (Thermo-Fischer) – determining equivalent black carbon.

Multi-λ b_{abs} data by AE33 were used as input to the Aethalometer model and to the MWAA model for source and source-component apportionment, respectively. In addition to BC and BrC, the MWAA model provided also information on α_{BrC}. Furthermore, following the MWAA model approach, a multi-λ fit of Aethalometer model equations was also attempted instead of the traditional approach based on the choice of two fixed wavelengths (λ).

Conclusions

The b_{abs} from PP_UniMI and MAAP (data averaged to 12-h filter sampling time) agreed very well. A high correlation (R=0.96) was found also between MAAP/PP_UniMI and Aethalometer data. The regression from AE31 and AE33 relative to the MAAP/PP_UniMI resulted in Aethalometer tape specific multiple scattering parameters C_{AE31}= 2.73 and C_{AE33}=2.53 for AE31 and AE33, respectively, with a limited variability of average values at different wavelengths (about 10%). These values are much higher than the ones used presently: C_{AE31}= 2.14 and C_{AE33}= 1.57. BC data from on-line instruments showed lower discrepancy, probably due to the different mass absorption cross-sections (also considering the different λs of operation) set in the instruments.

As far as the Aethalometer model is concerned, differences in the source apportionment depending on the range of the chosen λs were noticed both by choosing 2-λs and performing multi-λ fit, as well as between 2-λs and multi-λ fit considering the same λ range. Differently, the MWAA model results were independent of the choice of the range of λs both for the component apportionment and the α_{BrC} estimate (3.8±0.4) during the campaign.

An episode characterised by unusual BrC contribution (identified by high Ångström absorption exponent in AE31 and AE33 data) was identified and the performances of the models were investigated.

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