TROPOS
Leibniz Institute for
Tropospheric Research

ECAC
European Center for Aerosol Calibration

WCCAP
World Calibration Centre
for Aerosol Physics

Intercomparison of Absorption Photometers
Project No.: AP-2016-1-2

Basic Information:

Location of the quality assurance: TROPOS, lab 121

Date: 18 July, 2016

Principal Investigator	Home Institution	Participant	Instrument
Harald Flentje	Deutscher Wetterdienst, DWD	-	MAAP, SN 13

1. Instrument inter-comparison summary

Flow calibration: The flow of the instrument agreed to the flow measured with a reference flow meter (Gilibrator 'TROPOS-T'). The instrument flow was 1.7 % too high resulting in higher eBC concentrations. Correction of the flow error was included in the data evaluation.

Noise. The noise level of the instrument was little higher than expected form the MAAP specification sheet. The average noise (1σ) was 28.3 ng/m^3 for 1 minute averaging time.

Comparison to reference MAAP: BC concentrations are about 5.4% lower than BC concentrations from the 'reference' MAAP.

Comparison to reference absorption: Absorption coefficients derived from MAAP are 16 % higher than absorption coefficients from the Multiwavelength Absorption Reference setup. The uncertainty of the reference absorption for the present concentrations is about 10% to 15%.

Cell Inspection: Cell was dirty and needed to be cleaned.

Recommendations: None

Overall assessment: The instrument meets the requirements.

2. Details

Configuration parameters (Print format 8)
SIGMA BC: 6.6 m2/g LUFTDURCHSATZ l/h 480 MITTELWERTSPEICHER: 1 min KONZ. BEZOGEN AUF BETRIEBSBEDINGUNGEN NORMTEMPERATUR 0 _C DRUCKFORMAT: COM1 12 DRUCKZYCLUS: 1 min BAUDRATE: Bd COM1 9600 BAUDRATE: Bd COM2 9600 GERAETE-ADRESSE: 0 FILTERWECHSEL TRANSM. < % 50 ZYCLUS h 0 UHRZEIT UHR 0 SENSORKALIBRIERUNG P1,V P1,NP P2,V P2,NP P3,NP T1,NP T2,NP T3,NP -25 -9 -81 65 -86 -251 -180 LUFTDURCHSATZ 87.2 ANALOGAUSGAENGE AUSGABENULLPUNKT: 4mA CBC 0 10 MBC 0 2400 Q-OP 0 1000 T1 -20 40 T2 -20 40 P3 900 1100

Data Processing

Equivalent black carbon concentrations reported by instruments were corrected for flow deviations and adjusted to standard temperature and pressure conditions (T=0°C, P=1013.25 hPa) by

$$[BC] = [BC_{instr}]\times F_{flow}\times F_{STP}$$

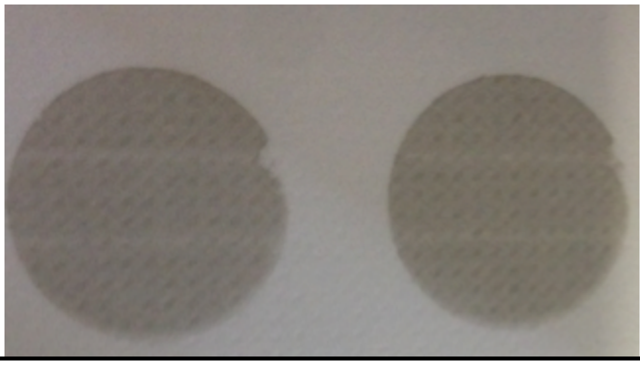
For details read Appendix A.

Conversion between the eBC concentrations and the absorption coefficient is done by

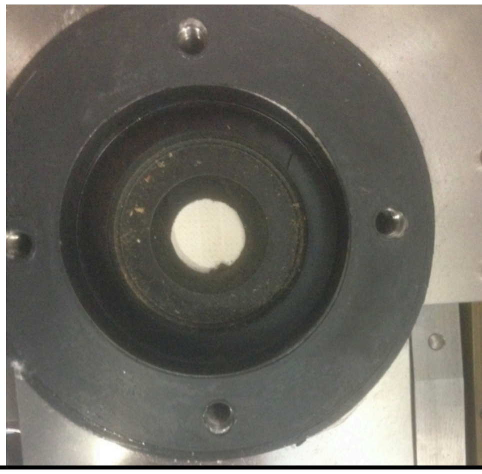
$$b_{abs}[1/Mm] = eBc[\mu g/cm] \times Sigma \times 1.05 \ ,$$

with the *mass absorption cross section* MAC=6.6 m^2/g. During the RAOS (Sheridan et al. 2005) experiment the MAAP was compared to a reference absorption at the wavelength 670 nm, but the true wavelength of MAAP is 637 nm. The factor compensates the resulting error in the absorption (Mueller et al. 2010).

Flow check Correction factors F_{flow} and F_{STP} for correcting eBC concentrations. F_{flow} corrects inlet flow errors. F_{STP} adjusting concentrations to STP conditions (0°C, 1013.25 hPa).								
Date	System Flow			Reference flow			Flow correction factor[2]	STP correction factor[2]
				Reference flow meter: Gilibrator 'TROPOS-T'				
	Volumetric flow [1]	Volume reference		Volume flow	Ambient *T* and *P*			
	Q_{MAAP} [lpm]	$T_{0,MAAP}$ [°C]	$P_{0,MAAP}$ [hPa]	Q [lpm]	T [°C]	P [hPa]	F_{flow}	F_{STP}
Mar.8	8.0	NA	NA	8.14	22	1000	0.982	NA

Sample spot		
Date	Spot appearance	*Spot size correction factor*
March 9	Small kerb in spot because of dirt. Error about 1%. 	1.0[2]

[1] For instrument intercomparison the MAAP was set to Standard flow with T_0=0 and P_0=1013.25 hPA.
[2] See appendix A for calculations of flow, STP and spot size corrections factors.

Measurement cell	
Cell was dirty. Fibrous material caused kerb in sample spot. Cell was cleaned.	

Instrumental Noise

Noise in units of eBC concentration measured with filtered air.

Date	Avg. time	Wave-length [nm]	Num data points	Median [ng]	10th percentile [ng]	90th percentile [ng]	Mean [ng]	Standard deviation [ng]	Error of the mean [ng]
March 9	1 min	637	308	-6	-50.0	7	-14.7	28.3	1.5

Comparison to reference MAAP

Correlation of eBC from MAAP (SN 13) and reference MAAP (SN 504) at 637 nm.

Slope	0.945 ± 0.002
R^2	0.982

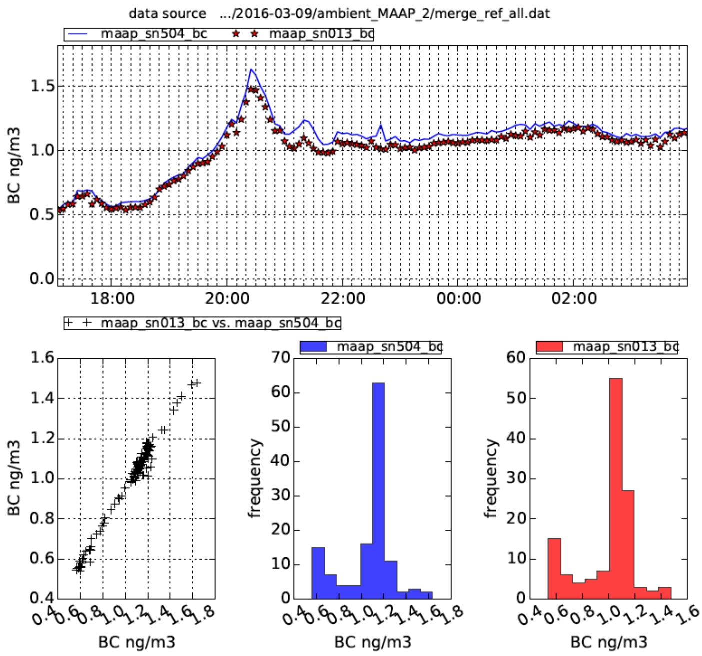


Figure 1: Comparison of eBC concentrations from MAAP SN-13 (red stars) and MAAP SN-504 (blue line).

Correlation of absorption coefficients from MAAP (SN 13) and the Multi-wavelenght absorption reference (interpolated to wavelength 637 nm).	
Slope	1.163 ± 0.012
R^2	0.902

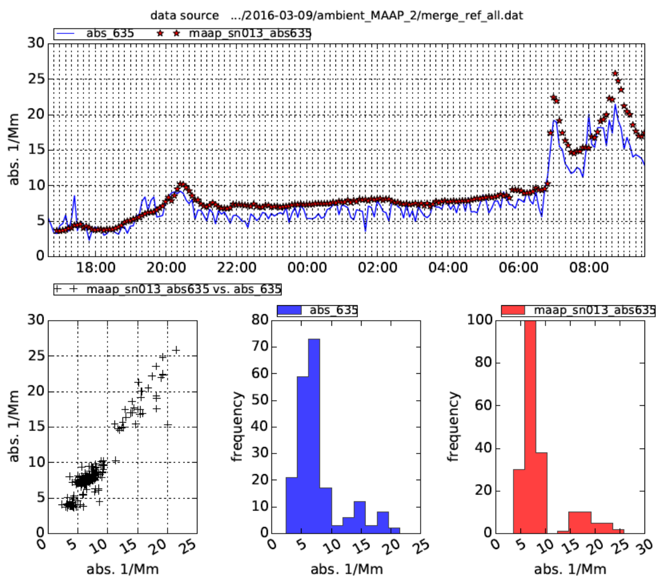


Figure 2: Comparison of absorption coefficients derived from MAAP SN-13 (red stars) and the Absorption Reference (blue line) at 637 nm.

Appendix: Instrument corrections

Necessary corrections to all instruments are flow and spot size correction and conversion of concentrations and absorption coefficients to STP conditions. BC concentrations from individual instruments [BC_{instr}] were by corrected by:

$$[BC] = [BC_{instr}] \times F_{flow} \times F_{spot} \times F_{STP}$$

a) The Flow correction factor for compensating calibration errors of the instrument flow meter and is defined by:

$$F_{flow} = \frac{Q_{instr}\,[slpm]}{Q_{ref}\,[lpm]} \times \frac{T_{ref}\,[K]}{T_{0,instr}\,[K]} \times \frac{P_{0,instr}\,[hPA]}{P_{ref}\,[hPa]}$$

where $Q_{instr.}$ and Q_{ref} are the flows measured with the instrument and determined with a reference volume flow meter, respectively. The flow of the volume flow meter is converted using the temperature T_{ref} and pressure P_{ref}, which are typically the ambient or room temperature or pressure near the reference flow meter. Also the standard temperature $T_{0,instr}$ and standard pressure $P_{0,instr}$ of the instrument have to be considered.

b) The adjustment of instrument flow to standard temperature and pressure (STP) is done by

$$F_{STP} = \frac{T_{0,instr.} + 273}{T_0 + 273} \times \frac{P_0}{P_{0,instr.}}$$

c) whereas $T_{0,instr}$ and $P_{0,instr.}$ are the standard temperature and pressure of individual instrument. For ACTRIS workshops STP is defined to be T_0=0°C and P_0=1013.25 hPa.

d) The spot size correction factor F_{spot} compensates for systematic deviations of sample spot sizes and is defined by

$$F_{spot} = \frac{A_{meas}}{A_{instr}}$$

where $A_{instr.}$ and A_{meas} are the instrument nominal and the measured spot area, respectively.

References

Sheridan, P. J., et al. (2005). "The Reno Aerosol Optics Study: An evaluation of aerosol absorption measurement methods." Aerosol Science and Technology **39**(1): 1-16.

Müller, T., et al. (2011). "Characterization and intercomparison of aerosol absorption photometers: result of two intercomparison workshops." Atmospheric Measurement Techniques **4**(2): 245-268.