Intercomparison of Absorption Photometers
Project No.: AP-2016-1-4

Basic Information:

Location of the quality assurance: TROPOS, lab 121

Delivery Date: -

Principal Investigator	Home Institution	Participant	Instrument
Radovan Krejci	Stockholm University, ACES	-	MAAP, SN 427

1. Intercomparison summary

Flow calibration: The instrument flow was 2.4 % too low.

Noise. The noise level of the instrument was higher than expected from the MAAP specification sheet. The average noise (1σ) was 79 ng/m^3 for 1 minute averaging time.

Comparison to reference MAAP: BC concentrations are 5% higher than BC concentrations from the reference MAAP SN-504. Reasons for this high but acceptable difference couldn't be found. The reference MAAP agreed to other MAAPs (SN-13 and SN-90) with differences of -5% and +2% respectively.

Comparison to reference absorption: Absorption coefficients derived from MAAP were higher by a factor of 1.33 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 clean.

Recommendations: None

Overall assessment: BC concentrations are 7% higher compared to a reference instrument (acceptable value 5%).

2. Details

Configuration parameters (Print format 8)

SIGMA BC: 6.6 m2/g
AIR FLOW: 1000
STORE AVERAGES: 30 min

VOLUME REFERENCE OPERATING CONDITIONS
STANDARD TEMPERATURE 0 _C

PRINTFORMAT: COM1 5
PRINTCYCLE: 1 min
BAUDRATE: Bd COM1 9600
BAUDRATE: Bd COM2 9600
DEVICE-ADDRESS: 0

FILTER CHANGE
TRANSM. < % 30
CYCLE h 100
HOUR: 0

CALIBRATION OF SENS.

T1	T2	T3	T4	P1	P2	P3
-32	0	-30	30	-1	79	-139

AIR FLOW 97.5

HEATER PARAMETERS
Diff. T2-T1 nominal 0 _C
Max. Heating Temp. 45 _C
Min. Heating Power 10 %

ANALOG OUTPUTS
OUTPUT ZERO: 4mA
CBC 0 10
MBC 0 2400

GESYTEC-PROTOKOL
STATUS VERSION STANDARD
NUMBER OF VARIABLES 1
CBC

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	16.6	NA	NA	16.2	NA	NA	1.024	NA

Sample spot

Date	**Spot appearance**	**Spot size correction factor**
March 9	Spot was round with sharp edges. Spot size not measured.	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.

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	189	10	-116	80	-26.2	79.6	5.8

Comparison to reference MAAP Correlation of eBC from MAAP (SN 427) and reference MAAP (SN 504) at 637 nm.	
Slope	1.052 ± 0.003
R^2	0.992

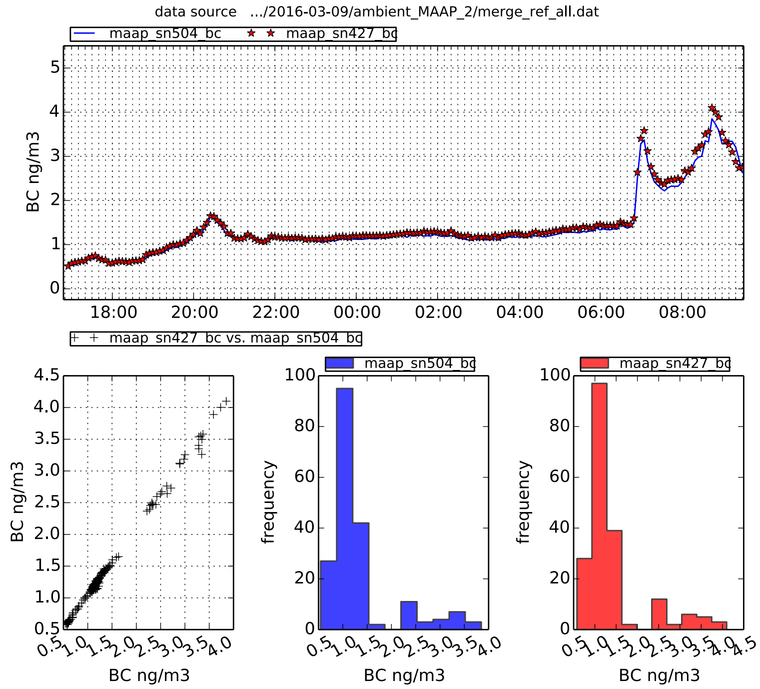

Figure 1: Comparison of eBC concentrations from MAAP SN-427 (red stars) and MAAP SN-504 (blue line).

Correlation of absorption coefficients from MAAP (SN 427) and the Multi-wavelenght absorption reference (interpolated to wavelength 637 nm).	
Slope	1.30 ± 0.014
R^2	0.897

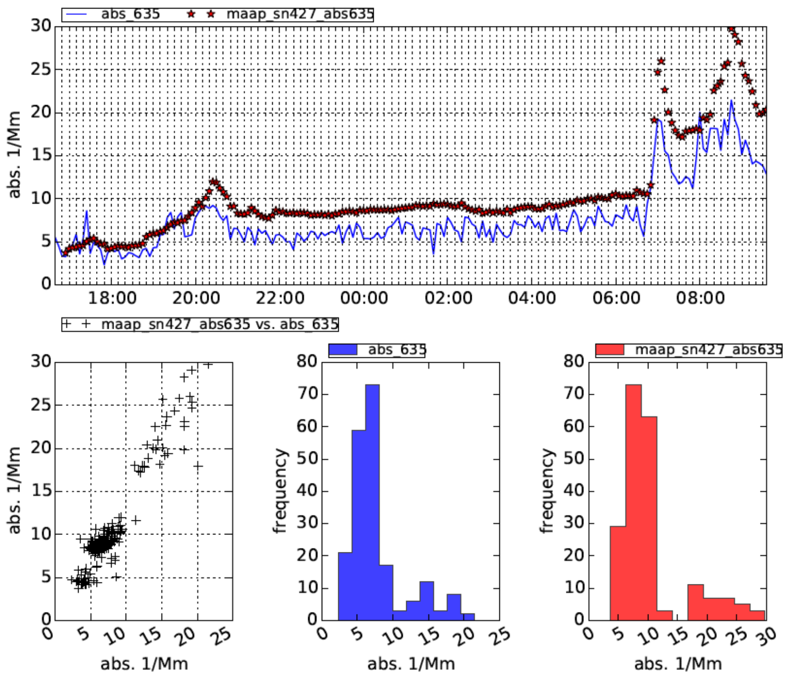

Figure 2: Comparison of absorption coefficients derived from MAAP SN-427 (red stars) and the Absorption Reference (blue line) at 637 nm.

Appendix A: 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.