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-2016-3-6

Basic Information:

Location of the quality assurance: TROPOS, lab 121

Date: 26 September, 2017

Principal Investigator	Home Institution	Participant	Instrument
Radovan Krejci	ACES	-	MAAP, SN 365

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 measured at the beginning and end of the workshop. It was found that the flow meter was well calibrated with deviations of 1.2% and 1.3%. In both cases the flow was too high resulting in little higher eBC concentrations. The flow error is within the typical uncertainty of the instrument flow regulation of about 3%. Correction of the flow error was included in the data evaluation.

Noise. The noise level of the instrument was relative. The average noise (1σ) was measured to be 16 ng/m^3 for 1 minute averaging for a period of 90 minutes.

Comparison to reference MAAP: eBC concentrations are about 1.3% lower than eBC concentrations from the 'reference' MAAP (SN CM504).

Cell Inspection: The instrument was in good conditions. The instrument showed no visual damages. The cell was found to be clean.

Recommendations: None

Overall assessment: The instrument meets the requirements.

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:       COM2    8
PRINTCYCLE:           1 min
BAUDRATE:       Bd COM1  9600
BAUDRATE:       Bd COM2  9600
DEVICE-ADDRESS:         1
FILTER CHANGE
TRANSM. <      %      20
CYCLE         h      100
HOUR:                 0
CALIBRATION OF SENS.
   T1    T2    T3    T4    P1    P2    P3
   -7    11   -53    85   348  -232  -282
AIR FLOW            97.8
HEATER PARAMETERS
Diff. T2-T1 nominal      0 _C
Max. Heating Temp.      45 _C
Min. Heating Power      10 %
```

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).
(1) For instrument intercomparison the MAAP was set to standard flow with T_0=0 and P_0=1013.25 hPA.

Date	System Flow			Reference flow Reference flow meter: Gilibrator 'TROPOS-T'			Flow correction factor**Fehler! Textmarke nicht definiert.**	STP correction factor**Fehler! Textmarke nicht definiert.**
	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}
Dec. 2	16.66	0	1013.25	16.86	22	1002	1.012	1.0
DEc. 6	16.66	0	1013.25	16.88	21	1015	1.013	1.0

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]
Dec. 06	1 min	637	90	27	3	49	-27	16.6	1.8

Comparison to reference MAAP
Correlation of eBC from MAAP (SN-365) and reference MAAP (SN-CM504) at 637 nm.

Slope	0.987 ± 0.001
R^2	0.944

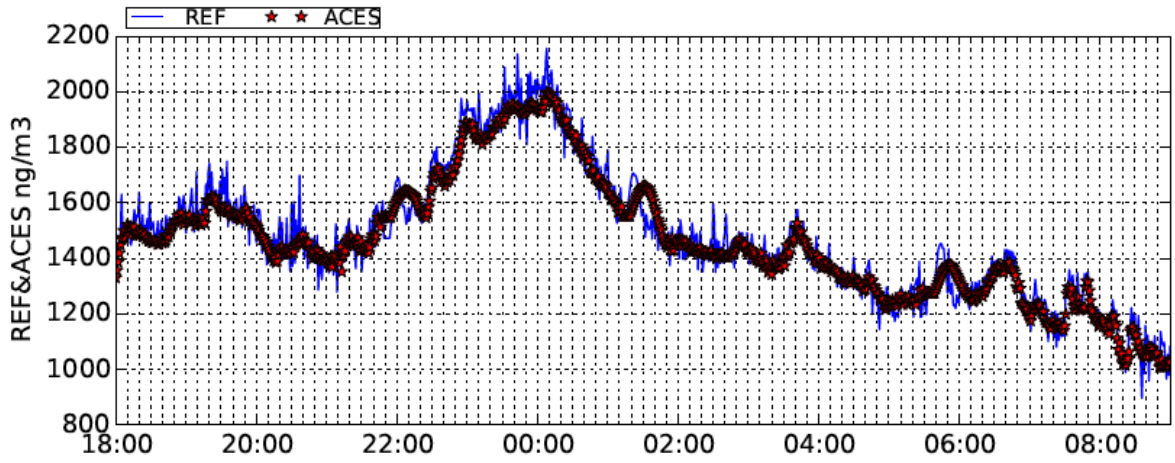

Figure 1: Comparison of eBC concentrations from MAAP SN-365 (red stars) and the reference MAAP SN-CM504 (blue line).

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.