ACTRIS-2 ECAC Workshop 5-9 December, 2016

Leibniz Institute for Tropospheric Research

European Center for Aerosol Calibration

World Calibration Centre for Aerosol Physics

Intercomparison of Absorption Photometers
Project No.: AP-2016-3-5

Basic Information:

Location of the quality assurance: TROPOS, lab 121

Date: 13 September, 2017

Principal Investigator	Home Institution	Participant	Instrument
A. Wiedensohler	TROPOS	-	MAAP, SN 171

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 1.6 % too low resulting to lower eBC concentrations. Correction of the flow error was included in the data evaluation.

Noise. The noise level (1σ) of the instrument was 80 ng/m^3 for 1 minute averaging time. The average value of 0.7 ng/m^3 indicates that the instrument is leak free.

Comparison to reference MAAP: BC concentrations are 4.5 % lower than BC concentrations from the 'reference' MAAP. The time series with ambient air was nosier than expected the noise level determined with zero air. The noise probably is induced by a non stable aerosol flow.

Cell Inspection: Insects were found in the cell. The sample spot was well defined.

Recommendations: Check pump and flow regulation.

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 NORMBEDINGUNGEN NORMTEMPERATUR 0 _C DRUCKZYCLUS: 1 min BAUDRATE: Bd COM1 9600 BAUDRATE: Bd COM2 9600 GERAETE-ADRESSE: 0 FILTERWECHSEL TRANSM. < % 50 ZYCLUS h 100 UHRZEIT UHR 24 SENSORKALIBRIERUNG P1,V P1,NP P2,V P2,NP P3,NP T1,NP T2,NP T3,NP -7 22 -25 57 276 122 -23 LUFTDURCHSATZ 96.5 ANALOGAUSGAENGE AUSGABENULLPUNKT: 4mA CBC 0 10 MBC 0 2400

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

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

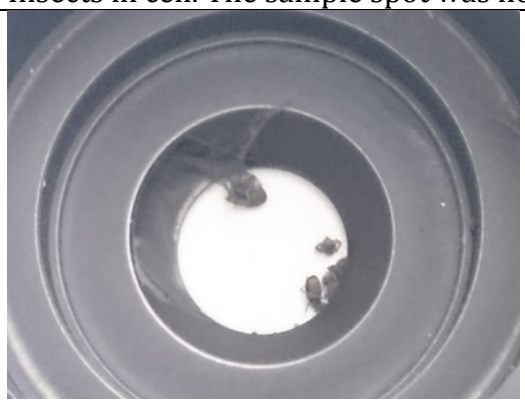
with the *mass absorption cross section* MAC=6.6 m^2/g. During the RAOS (Sheridan et al. 2005) experiment the MAAP was compared to a reference absorption at the wavelength 670 nm, but the true wavelength of MAAP is 637 nm. The factor compensates the resulting error in the absorption (Mueller et al. 2010).

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 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.7	8.0	NA	NA	7.87	20	1010	1.016	NA

Measurement cell

Date	Insects in cell. The sample spot was not obscured.
Dec. 8	

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. 6	1 min	637	37	1	-77	68	4	80	13

[1] For instrument intercomparison the MAAP was set to Standard flow with T_0=0 and P_0=1013.25 hPA.

Comparison to reference MAAP Correlation of eBC from MAAP (SN 171) and the reference MAAP (SN 504) at 637 nm.	
Slope	0.94568 ± 0.007
R^2	0.737

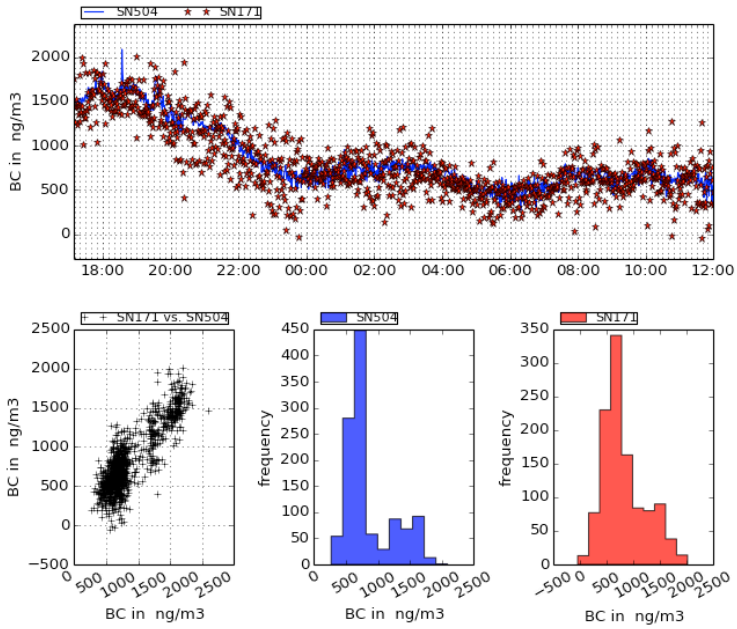


Figure 1: Comparison of eBC concentrations from MAAP SN-171 (red stars) and the reference MAAP SN-504 (blue line).

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.