

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

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 32

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 1.5 % (average of two flow checks) too low resulting to lower eBC concentrations. Correction of the flow error was included in the data evaluation.

Noise. The noise level of the instrument was in the expected range. The average noise (1σ) was 40 ng/m³ for 1 minute averaging time. The average zero value of -18 ng/m³ indicated that the instrument was not leaky.

Comparison to reference MAAP: BC concentrations are about 3.9% lower than BC concentrations from the 'reference' MAAP.

Cell Inspection: The cell was clean and the sample spots were well defined with sharp edges. The sealing between detector head sample holder is old and should be replaced.

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 360
MITTELWERTSPEICHER: 1 min
KONZ. BEZOGEN AUF STANDARD BEDINGUNGEN
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 100
UHRZEIT UHR 0
SENSORKALIBRIERUNG
P1,V P1,NP P2,V P2,NP P3,NP T1,NP T2,NP T3,NP
-37 -1 -77 65 -33 -17 42
LUFTDURCHSATZ 84.6
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 m²/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 of 1.05 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 Fehler! Textmarke nicht definiert.	STP correction factor Fehler! Textmarke nicht definiert.
				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]		
Dec.8	6.0	NA	NA	5.99	20	1010	1.00	NA
Dec.9	6.0	NA	NA	5.84	20	2010	1.03	NA

Instrumental Noise

Noise in units of eBC concentration measured with filtered air.

Date	Avg. time	Wave-length [nm]	Num data points	Median [ng]	10 th percentile [ng]	90 th percentile [ng]	Mean [ng]	Standard deviation [ng]	Error of the mean [ng]
March 9	1 min	637	43	-1	-59	6	-18	40	7

Comparison to reference MAAP

Correlation of eBC from MAAP (SN 32) and reference MAAP (SN 504) at 637 nm.

Slope	0.961 ± 0.003
R ²	0.941

¹ For instrument intercomparison the MAAP was set to Standard flow with $T_0=0$ and $P_0=1013.25$ hPa.

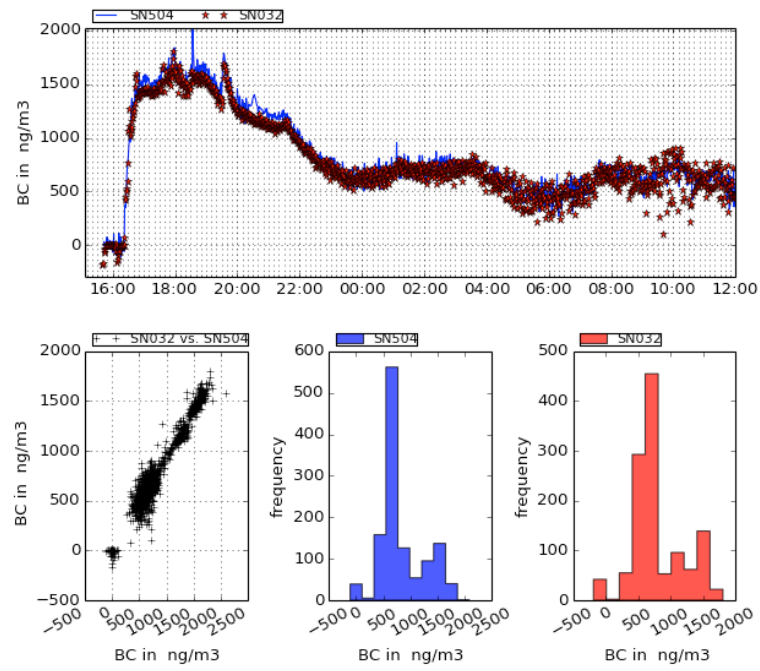


Figure 1: Comparison of eBC concentrations from MAAP SN-13 (red stars) and the reference MAAP SN-504 (blue line).

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 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 $T_0=0^\circ\text{C}$ 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.