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-2016-1-6

Basic Information:

Location of the quality assurance: TROPOS, lab 121

Date: 25 July, 2016

Principal Investigator	Home Institution	Participant	Instrument
Angela Marinoni	Institute for Atmospheric Science and Climate, ISAC	Angela Marinoni	MAAP, SN 80

1. Intercomparison summary

Flow calibration: The instrument flow was 8 % too low. Reasons could be the calibration for 16.6 lpm at lower pressure at Monte Cimone. The flow should be recalibrated when operating the instrument at a different pressures height. For the workshops the instrument was set to10 l/min and recalibrated.

Noise. The noise level of the instrument was higher than specified in the MAAP manual. The average noise (1σ) was 79 ng/m^3 for 1 minute averaging time. The higher noise was observed the first time during an instrument intercomparison workshop in 2013. It was found, that the noise does not affect the average values of BC concentration.

Comparison to reference MAAP: BC concentrations are about 2% higher than BC concentrations from the reference MAAP SN-504.

Comparison to reference absorption: Absorption coefficients derived from MAAP are 24 % 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 clean.

Recommendations: Recalibrate flow for pressure conditions at Monte Cimone.

Overall assessment: The instrument meets the requirements.

Configuration parameters (Print format 8)
SIGMA BC: 6.6 m2/g AIR FLOW: 1000 changed to 600 STORE AVERAGES: 1 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. <   %   50 CYCLE   h   100 HOUR: 0 CALIBRATION OF SENS.   T1   T2   T3   T4   P1   P2   P3 -22   0 -42   78 -156 348 -182 AIR FLOW   88.3 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	16.66	Amb.	Amb.	15.43	20	1005	1.079	NA
Recalibration for Leipzig pressure height								
Mar 8	STP flow 10 lpm	0	1013.25	10.93	23	1005	1	1

Sample spot		
Date	**Spot appearance**	**Spot size correction factor**
March 9	Spot was round with sharp edges. Spot size was not measured.	1.0[2]

Instrumental Noise

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[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.

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	90	0	-88	85	-0.3	79.5	8.4

Comparison to reference MAAP Correlation of eBC from MAAP (SN 80) and reference MAAP (SN 504) at 637 nm.	
Slope	1.018 ± 0.006
R^2	0.797
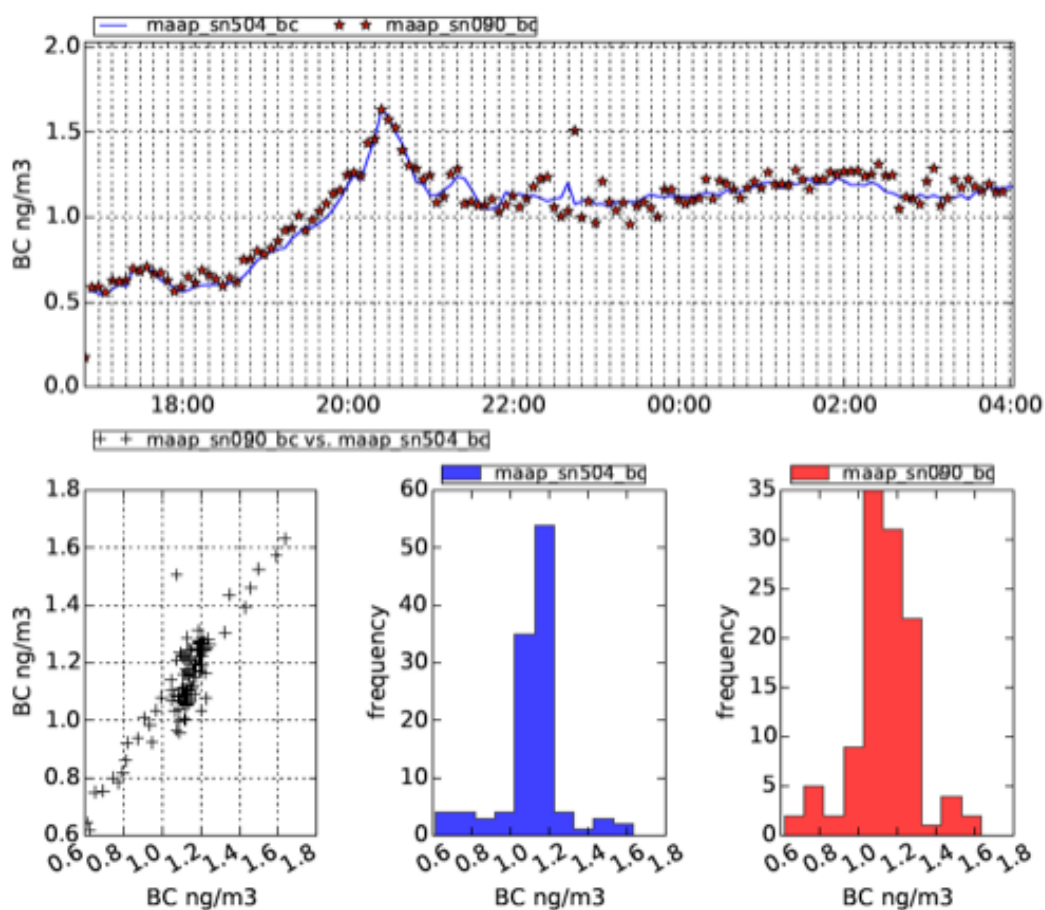
Figure 1: Comparison of eBC concentrations from MAAP SN-80 (red stars) and MAAP SN-504 (blue line).

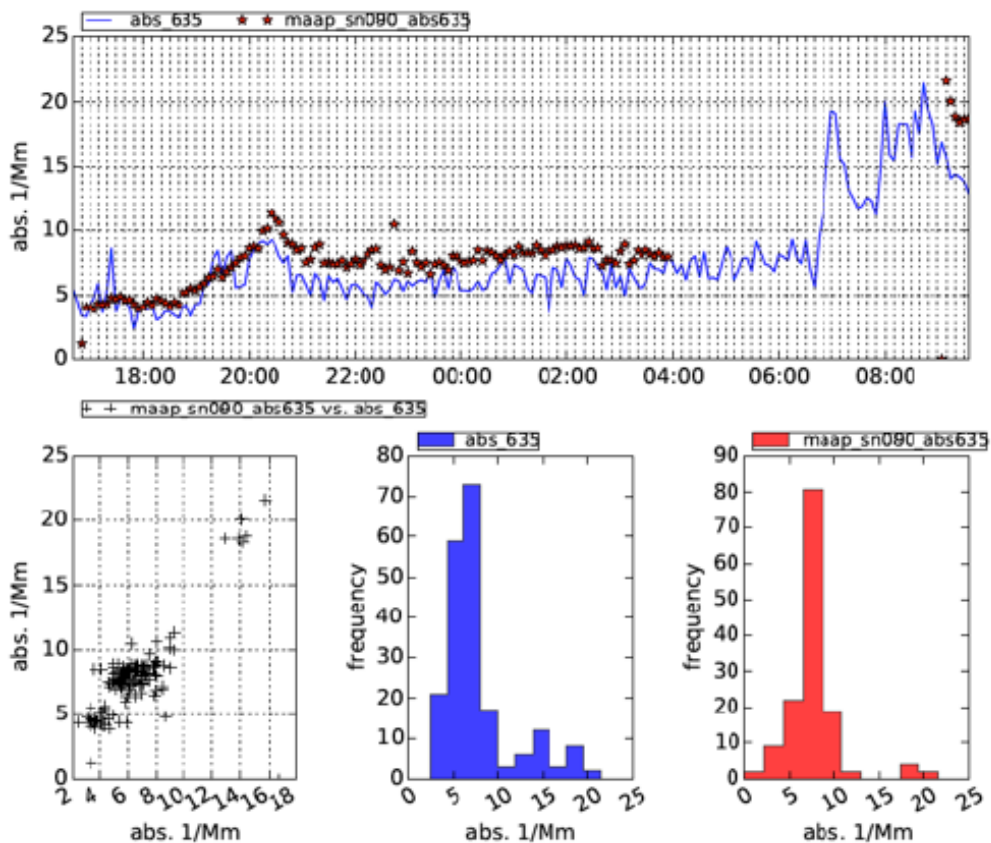| Correlation of absorption coefficients from MAAP (SN 13) and the Multi-wavelenght absorption reference (interpolated to wavelength 637 nm).	
Slope	1.236 ± 0.028
R^2	0.509

Figure 2: Comparison of absorption coefficients derived from MAAP SN-80 (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.