Instrument Inter-Comparison Report

Instrument	
Type	MAAP model 5012
Serial Number	118
Institution	JRC Atmosphere, Ispra
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Instrument inter-comparison	
Organization	Leibniz Institute for Tropospheric Research (TROPOS) World Calibration Centre for Aerosol Physics (WCCAP)
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Workshop, etc.	WCCAP-2015-1, Absorption Photometer Workshop, 21-25 Sep. 2015

Report	
Status	final
Date	2015-10-20

1. Instrument inter-comparison summary

Flow calibration: The flow of the instrument agreed to the flow measured with a reference flow meter Gilibrator). The instrument flow was 0.25 % too low resulting in lower eBC concentrations. Correction of the flow error was included in the data evaluation.

Noise. The noise level of the instrument was little higher than expected form the MAAP specification sheet. The average noise (1σ) was 80.7 ng/m^3 for 1 minute averaging time. For unknown reasons the noise periodically increases by a factor of about 2. The noise does not influence long term averages.

Comparison to reference MAAP: BC concentrations are about 2.3% higher than BC concentrations from the 'reference' MAAP.

Comparison to reference absorption: Absorption coefficients derived from MAAP are about 6 % higher than absorption coefficients from the Multiwavelength Absorption Reference setup.

Flow regulation: The flow regulation of the instrument is unstable for flows below instrument shows problems with flows lower than 700 l/hour. The reason is unclear.

Recommendations: None
Overall assessment: The instrument meets the requirements.

2. Instrument configuration

Configuration parameters (Print format 8)

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THERMO SCIENTIFIC  MAAP v1.32       SERIAL NUMBER 118    15-09-21
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SIGMA BC:           6.6 m2/g
AIR FLOW:           800
STORE AVERAGES:       10 min
VOLUME REFERENCE    STANDARD TEMPERATURE
STANDARD TEMPERATURE    25 _C
PRINTFORMAT:       COM2    8
PRINTCYCLE:           1 min
BAUDRATE:       Bd COM1  9600
BAUDRATE:       Bd COM2  9600
DEVICE-ADDRESS:        0
FILTER CHANGE
TRANSM. <      %      50
CYCLE         h       0
HOUR:                 0
CALIBRATION OF SENS.
   T1   T2   T3   T4   P1   P2   P3
  -39  -24  -82   67  141 -245 -234
AIR FLOW           100.0
HEATER PARAMETERS
Diff. T2-T1 nominal     0 _C
Max. Heating Temp.     45 _C
Min. Heating Power     10 %
ANALOG OUTPUTS
OUTPUT ZERO:        0mA
CBC     0    10
MBC     0  2400
GESYTEC-PROTOKOL
STATUS VERSION     STANDARD
NUMBER OF VARIABLES     7
CBC REFLMBC Q-OPQ-N T1  P1
END
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3. 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).

4. Technical checks

Table: 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[1]	STP correction factor[1]
				Reference flow meter: Gilibrator 'TROPOS-T'				
	Mass flow	Volume reference		Volume flow	Ambient T and P			
	Q_{MAAP} [slpm]	$T_{0,MAAP}$ [°C]	$P_{0,MAAP}$ [hPa]	Q [lpm]	T [°C]	P [hPa]	F_{flow}	F_{STP}
21. Sep	13.33	25.0	1013	13.41	24	2001	1.0025	1.092

Table: Sample spot		
Date	Spot appearance	*Spot size correction factor*
21. Sep	Well defined spot, spot size not measured	1.0[1]

Table: 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]
Sep. 22	1 min	637	102	0.0	-58.0	72.0	2.7	80.7	8.0

5. Comparison to reference instruments

The reference MAAP (SN504) was not available due to an instrumental error and was replaced by another MAAP (SN32). MAAP-SN32 was inter-compared before the workshop to two other MAAPs. The three instruments agreed within 5% and the noise level of MAAP-SN32 was in agreement with the instrumental specifications.

[1] See appendix A for calculations of flow, STP and spot size corrections factors.

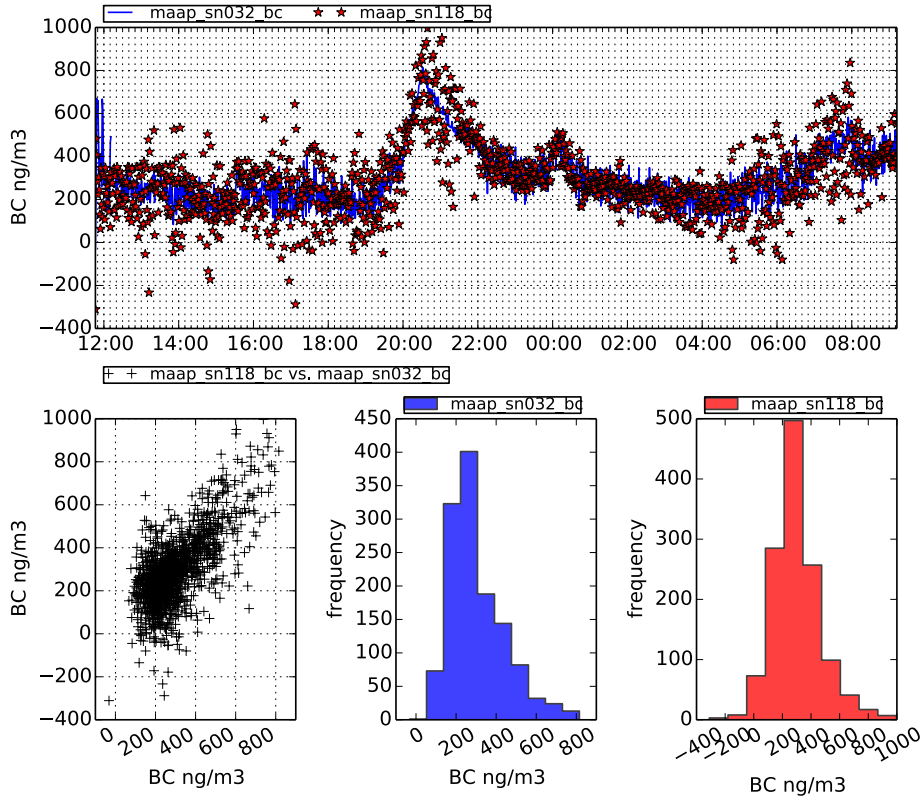

Table: Comparison of MAAPs Correlation of eBC from MAAP (SN118) and MAAP (SN032)	
Slope	1.023 ± 0.011
R^2	0.47

Comparison to the Multi-Wavelength absorption reference

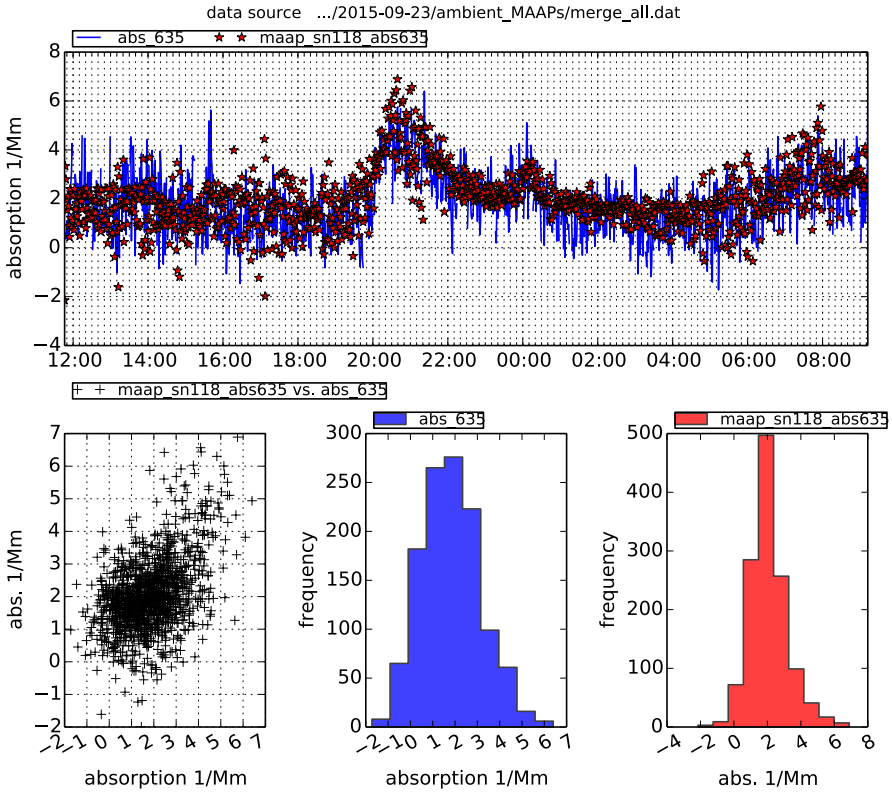

Table: Correlation of absorption coefficients from MAAP (SN118) and the Multi-wavelenght absorption reference (interpolated to 637 nm).	
Slope	1.061 ± 0.018
R^2	0.27

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.