Instrument Inter-Comparison Report

Instrument	
Type	MAAP model 5012
Serial Number	43
Institution	University of Granada
Contact	Gloria Titos

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	2016-01-04

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 0.6 % too low resulting in lower eBC concentrations. A correction factor for eBC concentrations of 1.006 was included for the data evaluation.

External temperature sensor: One wire of the external temperature sensors was damaged when the instruments arrived in Leipzig. Calculations between volumetric and standard flow were not affected.

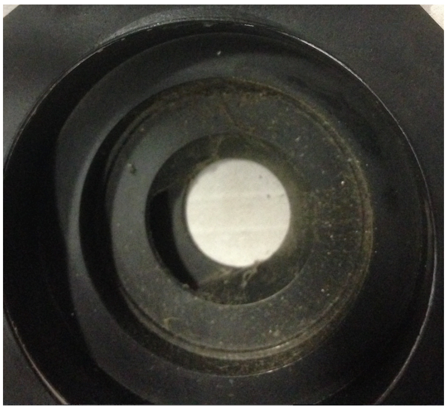
Noise. The noise level of the instrument was little higher than expected form the MAAP specification sheet. The average noise (1σ) was 59 ng/m^3 for 1 minute averaging time.

Comparison to reference MAAP: BC concentrations are about 2.4% higher than BC concentrations from the reference MAAP (SN32).

Comparison to reference absorption: Absorption coefficients derived from MAAP are about 6.1 % higher than absorption coefficients from the Multi-Wavelength Absorption Reference setup (extinction minus scattering).

Inlet fitting: Inlet threading is damaged. Teflon tape was needed to tightly attached inlet adapter.

Filter spot and Cell: The sample spot shoed that soot was deposited evenly on the tape with sharp edges. Some fibrous material and black sports were deposited at the edges of the spots. Therefore the cell was opened and cleaned. Fibrous material was found in cell. Diodes were found to be clean and no degradation of the system performance, e.g. increased noise level, is expected.



Recommendations: External sensor cable should be replaced. The whole inlet system of the measurement station should be check for dirt inside aerosol lines.

Overall assessment: The instrument meets the requirements.

2. Instrument configuration

Configuration parameters (Print format 8)

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Thermo ELECTRON     CARUSSO v1.28    SERIAL NUMBER  43    15-09-21
-------------------------------------------------------------------------------
SIGMA BC:           6.6 m2/g
AIR FLOW:           1000
STORE AVERAGES:         0 min

VOLUME REFERENCE    STANDARD TEMPERATURE
STANDARD TEMPERATURE     0 _C

PRINTFORMAT:       COM2     5
PRINTCYCLE:            0 s
BAUDRATE:       Bd COM1  9600
BAUDRATE:       Bd COM2  9600
DEVICE-ADDRESS:         0
FILTER CHANGE
TRANSM. <       %      30
CYCLE          h      100
HOUR:                  0
CALIBRATION OF SENS.
 P1,SP  P1,Z P2,SP  P2,Z  P3,Z  T1,Z  T2,Z  T3,Z  T4,Z
  -32   24   -48   65   147   88   -60
AIR FLOW            94.7
ANALOG OUTPUTS
OUTPUT ZERO:        4mA
CBC     0    10
MBC     0  2400
Q-OP    0  1000
T1    -20    40
T2    -20    40
```

```
P3    900  1100
GESYTEC-PROTOKOL
STATUS VERSION     STANDARD
NUMBER OF VARIABLES     1
CBC
END
```

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 (Müller et al. 2011).

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 Reference flow meter: Gilibrator 'TROPOS-T'			Flow correction factor[1]	STP correction factor[1]
	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	15.15	0	1013	16.36	20	1001	1.006	1.0

Table: Sample spot

Date	Spot appearance	*Spot size correction factor*

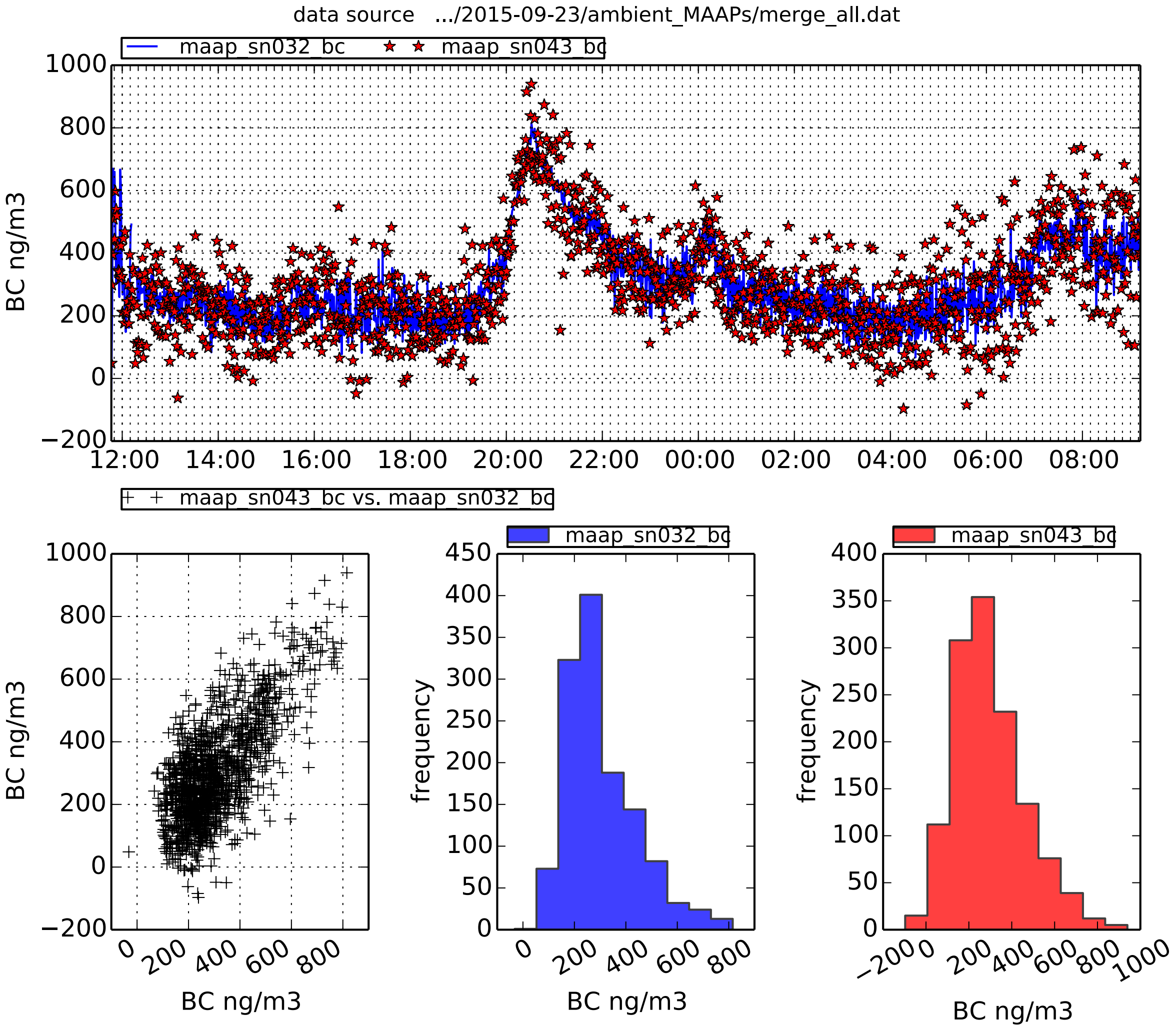
21. Sep	Sharp soot black carbon spot. Spot size not measured. Fibrous material deposited at the edges.	1.0[1]

Table: Instrumental Noise Noise in units of eBC concentration measured with filtered air.									
Date	Avg. time	Wave-length [nm]	Num data points	Median [ng]	10^{th} percentile [ng]	90^{th} percentile [ng]	Mean [ng]	Standard deviation [ng]	Error of the mean [ng]
Sep. 22	1 min	637	422	3	45	55	8	59	3

5. Comparison to Reference instruments

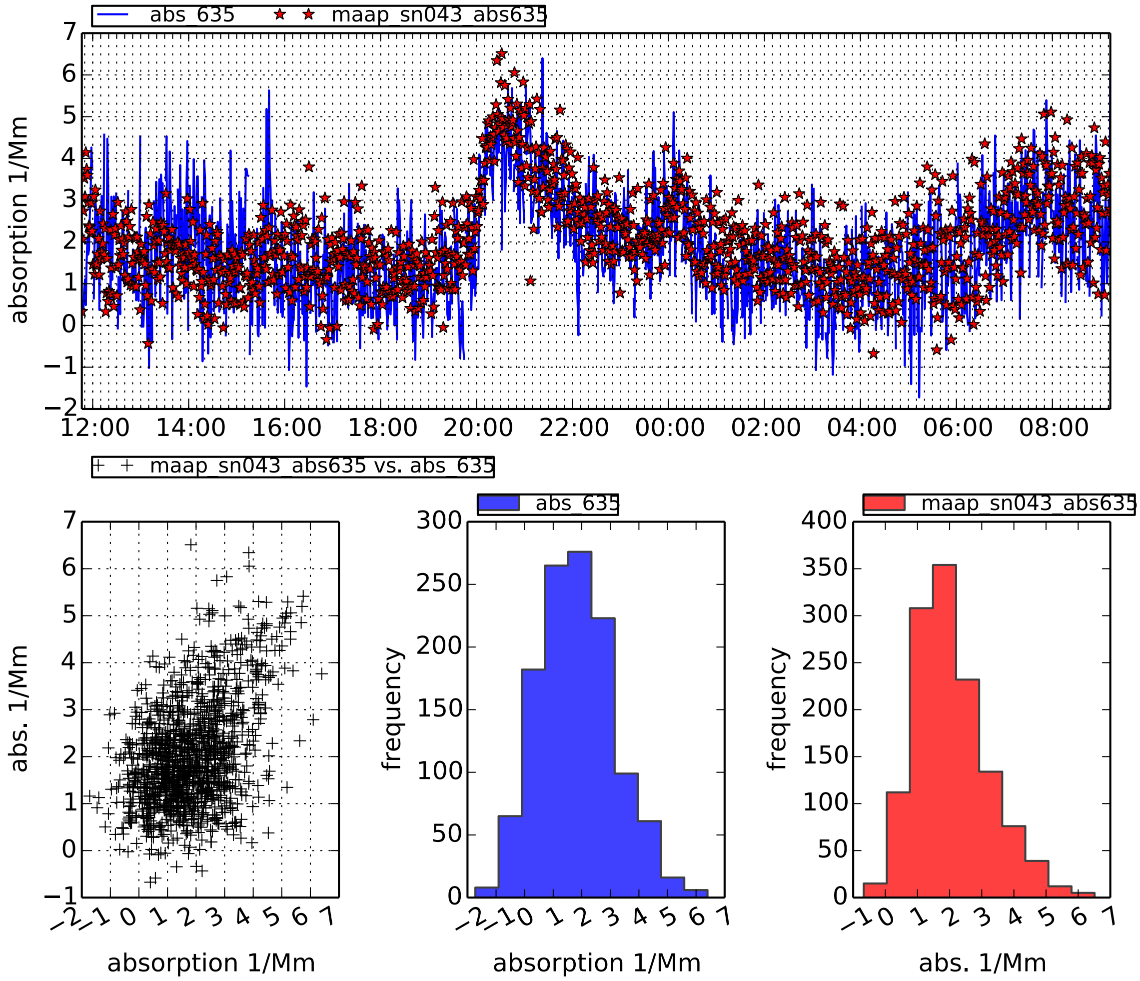
The reference MAAP (SN504) was not available due to an instrumental error and was replaced by another MAAP (SN32). MAAP-SN32 was inter-compared before the workshop to two other MAAPs. The three instruments agreed within 5% and the noise level of MAAP-SN32 was in agreement with the instrumental specifications.

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



Comparison of MAAPs Correlation of eBC from MAAP (SN043) and the reference MAAP (SN032)	
Slope	1.024 ± 0.010
R^2	0.493

6. Comparison to TROPOS Multiwavelength Absorption Reference



Correlation of absorption coefficients from MAAP (SN043) and the Multi-Wavelength absorption reference (interpolated to 637 nm).	
Slope	1.061 ± 0.018
R^2	0.19

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.