Leibniz Institute for Tropospheric Research

European Center for Aerosol Calibration

World Calibration Centre for Aerosol Physics

# Intercomparison of Absorption Photometers
# Project No.: AP-2016-3-1

**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 137 |

## 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 % too high resulting in higher eBC concentrations. Correction of the flow error was included in the data evaluation.

**Noise**. The noise level of the instrument was meets the requirements with single standard deviation (1σ) of 43 ng/m$^3$ for 1 minute averaging time. The average value of 42 ng/m$^3$ indicates that the instrument is leak free.

**Comparison to reference MAAP**: BC concentrations are about 1.2 % lower than BC concentrations from the 'reference' MAAP.

**Cell Inspection:** Cell was cleaned because of little dirt.

**Recommendations:** None

**Overall assessment:** The instrument meets the requirements.

## 2. Details

| Configuration parameters (Print format 8) |
|---|
| SIGMA BC: 6.6 m2/g<br>LUFTDURCHSATZ l/h 480<br>MITTELWERTSPEICHER: 1 min<br>KONZ. BEZOGEN AUF BETRIEBSBEDINGUNGEN<br>NORMTEMPERATUR 0 _C<br>DRUCKFORMAT: COM1 12<br>DRUCKZYCLUS: 1 min<br>BAUDRATE: Bd COM1 9600<br>BAUDRATE: Bd COM2 9600<br>GERAETE-ADRESSE: 0<br>FILTERWECHSEL<br>TRANSM. < % 50<br>ZYCLUS h 100<br>UHRZEIT UHR 24<br>SENSORKALIBRIERUNG<br>UNIT of BC ug/m3 ( changed to ng/m3)<br>P1,V P1,NP P2,V P2,NP P3,NP T1,NP T2,NP T3,NP<br>-20 -36 -83 64 49 137 -271<br>LUFTDURCHSATZ 97.3<br>ANALOGAUSGAENGE<br>AUSGABENULLPUNKT: 4mA<br>CBC 0 10<br>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 1.05 compensates the resulting error in the absorption (Mueller et al. 2010).

| **Flow check**<br>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<br>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.2 | 9 | NA | NA | 9.14 | 22 | 1005 | 0.985 | NA |
| | | | | | | | | |

| **Instrumental Noise**<br>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. 2 | 1 min | 637 | 81 | 31 | -4 | 104 | 42 | 43 | 5 |

| **Comparison to reference MAAP**<br>Correlation of eBC from MAAP (SN 137) and reference instrument MAAP (SN 504) at 637 nm. | |
|---|---|
| Slope | 0.988 ± 0.002 |
| $R^2$ | 0.966 |

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

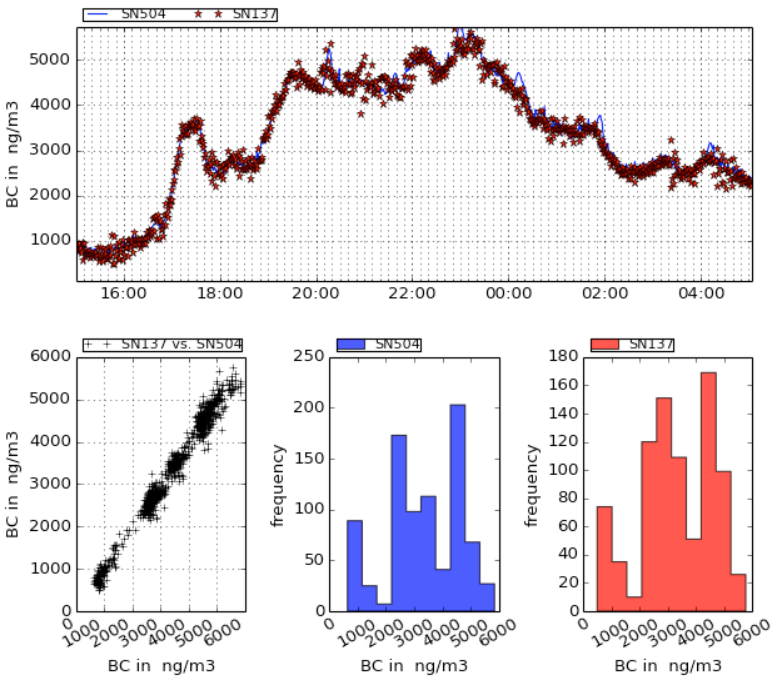


Figure 1: Comparison of eBC concentrations from MAAP SN-137 (red stars) and MAAP SN-504 (blue line).

## 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.