*ACTRIS-2 ECAC Workshop 5-9 December, 2016*

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-2016-3-4

**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 115 |

## 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 4 % 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 very high. The single standard deviation was determined to be 266 ng/m$^3$ for 1 minute averaging time. In the time series is can be seen, that there are periods with higher and periods with lower noise. The average zero value was 128 ng/m$^3$. It could not by figured out if the high zero and noise values are because of electronic problems.

**Comparison to reference MAAP**: BC concentrations are 6% higher than BC concentrations from the 'reference' MAAP.

**Cell Inspection:** Cell was clean and filter sport well defined with sharp edges.

**Recommendations:** The electronics should be checked.

**Overall assessment:** The instrument does not meet the requirements.

## 2. Details

**Configuration parameters (Print format 8)**

```
SIGMA BC:           6.6 m2/g
LUFTDURCHSATZ l/h     480
MITTELWERTSPEICHER:     30 min
KONZ. BEZOGEN AUF   NORMTEMPERATUR
NORMTEMPERATUR         0 °C
DRUCKFORMAT:       COM2   8
DRUCKZYCLUS:           1 min
BAUDRATE:       Bd COM1  9600
BAUDRATE:       Bd COM2  9600
GERAETE-ADRESSE:        0
FILTERWECHSEL
TRANSM. <      %      20     (changed to 50%)
ZYCLUS         h       100
UHRZEIT        UHR     0
SENSORKALIBRIERUNG
 P1,V P1,NP  P2,V P2,NP P3,NP T1,NP T2,NP T3,NP
  -6   17   -63    66   27  176  -196
LUFTDURCHSATZ        79.4
HEIZUNGSPARAMETER
Sollwert T2 UEBER T1     0 _C
Max. Heiztemperatur     45 _C
Min. Heizleistung       10 %

ANALOGAUSGAENGE
AUSGABENULLPUNKT:    4mA
CBC     0    10
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 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<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.7 | 8.0 | NA | NA | 8.29 | 22 | 1000 | 0.96 | NA |
| | | | | | | | | |

**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] |
|---|---|---|---|---|---|---|---|---|---|
| March 9 | 1 min | 637 | 553 | -122 | -214 | 465 | 128 | 266 | 11 |

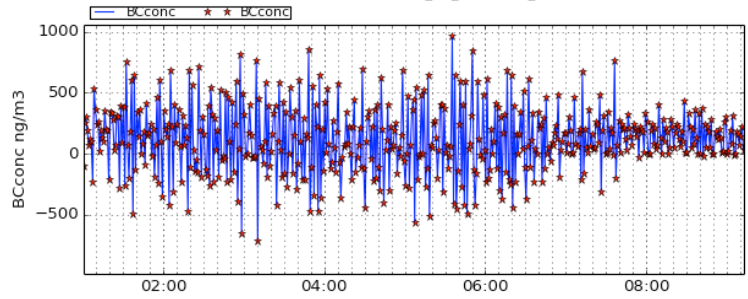


Figure: Time series of zero air / noise measurement.

**Comparison to reference MAAP**

Correlation of eBC from MAAP (SN 115) and the reference MAAP (SN 504) at 637 nm.

| | |
|---|---|
| Slope | 1.058<br>± 0.006 |

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

| | |
|---|---|
| $R^2$ | 0.859 |

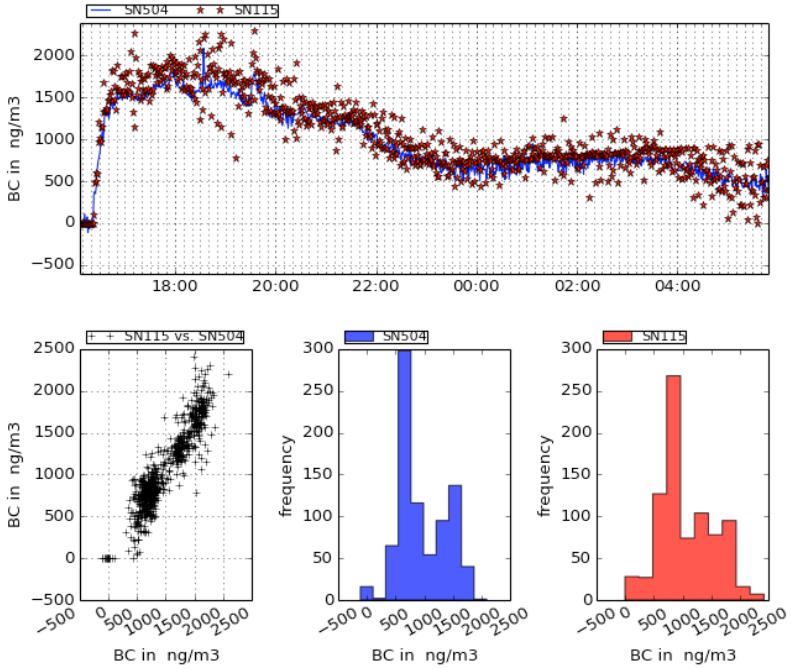


Figure 1: Comparison of eBC concentrations from MAAP SN-115 (red stars) and the reference MAAP SN-504 (blue line).

## 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 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.