ACTRIS-2 ECAC Workshop 7-11 March, 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-2016-1-3

Basic Information:

Location of the quality assurance: TROPOS, lab 121

Date: 25 July, 2016

Principal Investigator	Home Institution	Participant	Instrument
Jean Sciare	The Cyprus Institute	Michael Pikridis	AE31, SN 1050:1009

1. Intercomparison summary

Flow calibration: The flow of the instrument was found to be 2.8% too low. Correction of the flow error was included in the data evaluation.

Noise. The noise level of the instrument was ok. The average noise (1σ) for all seven wavelengths was 27.63 ng/m^3 for 5 minute averaging time. The maximum noise was 31.9 ng/m^3 at 950 nm.

Inspection: Measurement cell was clean. The spots edges are sharp, but spots are overlapping (not significant).

Note on mean Ratio: The instrument has a build in calibration factor, called mean ratio, of 0.85. This factor was determined on delivery by the manufacturer. For data processing this correction was undone. BC concentrations including this factor are lower by 17%.

Comparison to reference MAAP: BC concentrations at wavelength 660 nm are 6% lower than BC concentrations from the reference MAAP (SN 504).

Comparison to reference Aethalometer AE33: The AE31 (SN 1050:1009) measures at all wavelengths lower concentrations than the reference Aethalometer of type AE33 (SN 504). The slopes in the correlation plot are between 0.65 and 0.78 for all wavelengths.
Note: The reference AE33 measures significantly higher BC concentrations than the reference MAAP. Differences between AE31, AE33 and MAAP can occur due to physical properties of the test aerosol. These measurements were done with ambient air in Leipzig. It has many times been observes than AE33 measures higher BC concentrations than MAAP.

Comparison to reference absorption: Absorption coefficients derived from Aethalometer using a conversion factors of C_0 =3.5 are higher by factors 1.15 (470nm), 1.11 (520 mn), and 1.08 (660) nm than absorption coefficients from the reference absorption setup.

Recommendations: Spot advance should be increased.

Overall assessment: The instrument meets the requirements.

2. Details

Configuration parameters from AE-SETUP.TXT
Instrument serial number: 1050 Software version: 985d7 Instrument type 7xLED (3X) Smoothing factor: 0 Maximum attenuation: 125 Spot size: Extended range Mean ratio: 0.85 BC Unit: 0 (ng) Sigma values: 39.5, 31.1, 28.1, 24.8, 22.2, 16.6, 15.4 Volumetric reference: 'Standard' with P_0=1013 and hPa, T_0=20°C

3. Data processing

Equivalent black carbon concentrations reported by instruments were corrected for flow, spot size deviations and adjusted to standard temperature and pressure conditions (T=0°C, P=1013.25 hPa) by

$$[BC] = [BC_{instr}] \times F_{flow} \times F_{spot} \times F_{STP} \times mean\_ratio^{-1}$$

For details read Appendix A.

Conversions between eBC concentrations and absorption coefficients are done by

$$b_{abs}[1/Mm] = eBc[\mu g/cm] \times Sigma \; / \; C_0 \;\; ,$$

with the conversion factor C_0=3.5 and the *mass absorption cross sections* '*Sigma*' given in the table below. For individual instruments the Sigma-values can be found in the setup file.

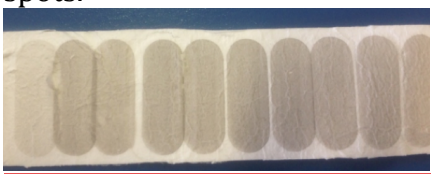
Table: Conversion factors
Conversion factors (*Sigma*) for *eBC* concentrations to absorption coefficients

Wavelength [nm]	370	450	530	590	660	880	950
Sigma [m²/g]	39.5	31.1	28.1	24.8	22.2	16.6	15.4

Flow check
Correction factors F_{flow} and F_{STP} for correcting eBC concentrations. F_{flow} corrects for inlet flow errors. F_{STP} is used to adjust 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_{AE31} [slpm]	$T_{0,AE31}$ [°C]	$P_{0,AE31}$ [hPa]	Q [lpm]	T [°C]	P [hPa]	F_{flow}	F_{STP}
21. Sep	5	20	1013	5.016	22	989	1.028	1.074

Spot size check
Correction factor for spot sizes F_{spot}.

Date	Nominal spot size [mm²]	Measured spot size [mm²]	F_{spot}
21. Sep	167	Well defined spot. Size not measured. Note overlapping spots. 	1.0[1]

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

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/m3]	90th percentile [ng/m3]	Mean [ng/ m3]	Standard deviation [ng/m3]	Error of the mean [ng/m3]
March 10	5 min	370	26	31	22.7	35.4	30.2	5.3	5.9
		450	26	3.1	-7.9	10.5	2.5	8.2	0.5
		520	26	-1.9	-10.3	11	0.8	9.5	0.2
		590	26	2.8	-4.5	16.7	4.7	9.9	0.9
		660	26	4.7	-8.1	13.4	4.7	9.9	0.9
		880	26	12.7	-14.4	42	13.9	20.4	2.7
		950	26	28.3	-8.1	76	29.2	31.9	5.7

Comparison of AE31 and MAAP Correlation of eBC from AE31 (SN 1050:1009) at 660 nm and from MAAP (SN 504) at 637 nm	
Wavelength [nm]	AE31: 660 nm MAAP: 637 nm
Slope	0.941±0.006
R^2	0.92

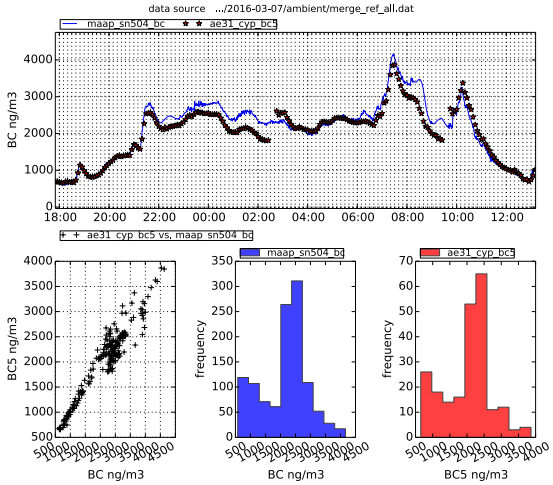


Figure1: eBC concentration from AE31 SN1050:1009 (660 nm) versus MAAP SN32 (637 nm).

Comparison of AE31 (SN 1050:1009) to the reference AE33 (SN163)							
Wavelength [nm]	370	470	520	590	660	880	950
Slope	0.657±0.009	0.703±0.008	0.731±0.008	0.736±0.007	0.743±0.007	0.783±0.019	0.740±0.007
R^2	0.651	0.782	0.782	0.806	0.81	0.853	0.848

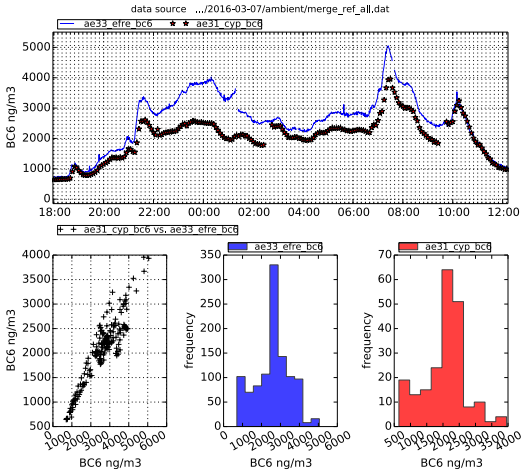


Figure 2: eBC concentrations from AE31 (SN 105:1009) versus eBC from AE33 (SN163) at 880 nm.

Comparioson of absorption coefficients from AE31 (SN 1050:1009) and the Multi-wavelength reference absorption (Extinction minus Scattering).			
Wavelength [nm]	470	520	660
Slope	1.154±0.015	1.107±0.016	1.078±0.018
R^2	0.793	0.768	0.692

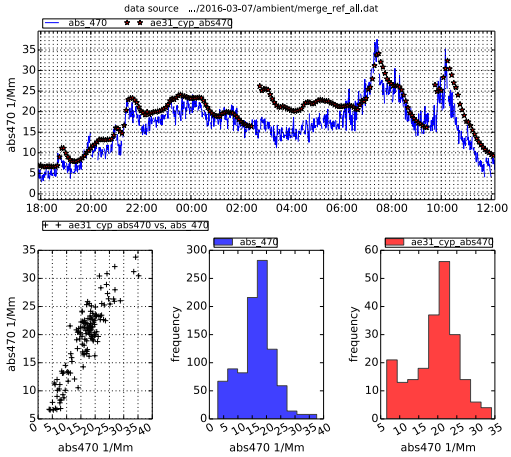


Figure 3: Comparison at 470 nm. Blue: reference absorption, Red: AE31 (SN-1050:1009).

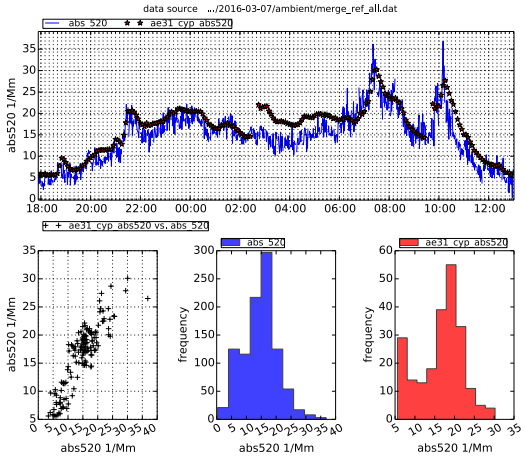


Figure 4: Comparison at 520 nm. Blue: reference absorption, Red: AE31 (SN-1050:1009).

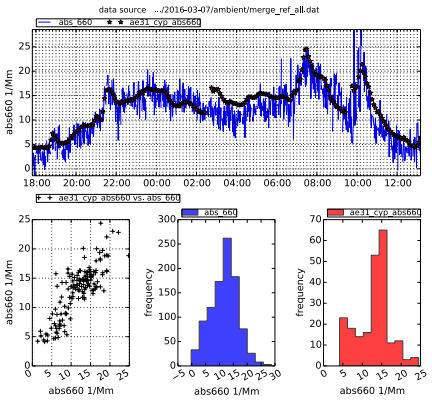


Figure 5: Comparison at 660 nm. Blue: reference absorption, Red: AE31 (SN-1050:1009).

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:

$$[BC] = [BC_{instr}] \times F_{flow} \times F_{spot} \times F_{STP} \times {}^{1}/_{mean\_ratio}$$

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.

e) The mean ration is a calibration parameter and can be found in the setup file of AE31 aethalometers. This factory calibration is undone for ACTRIS intercomparisons. If the mean ration deviates from unity, special care must be taken, since this calibration factor is always included in data from Aethalometers and can not be switched off.
This issue must be considered when discussion deviations to reference instruments.