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-2016-1-5

Basic Information:

Location of the quality assurance: TROPOS, lab 121

Date: 25 July, 2016

Principal Investigator	Home Institution	Participant	Instrument
Angela Marinoni	Institute for Atmospheric Science and Climate, ISAC	Angela Marinoni	AE31, SN 393-0301

1. Intercomparison summary

Flow calibration: The flow of the instrument was found to be 2.2% too high, resulting in higher eBC concentrations. Correction of the flow error was included in the data evaluation.
Note: The set flow of 4.1 l/min was not reached because of a weak pump. The flow was just 3.7 l/min.

Noise. The noise level of the instrument was ok. The average noise (1σ) for all seven wavelengths was 27.3 ng/m^3 for 5 minute averaging time. The maximum noise was 33.1 ng/m^3 at 370 nm.

Inspection: Cell was almost clean.

Comparison to reference MAAP: BC concentrations at wavelength 660 nm are 2% higher than BC concentrations from the reference MAAP (SN 504).

Comparison to reference Aethalometer AE33 (SN 163): The instrument 0301) measured at all wavelengths lower concentrations than the reference Aethalometer AE33 (SN163). The slope of the correlation is between 0.74 and 0.85 for wavelengths from 450 to 950 nm. The best agreement is at wavelength 880 nm with a slope of 0.85. At 370 the slope is lowest with 0.69.
Note: The reference AE33 measures shigher values 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 1.11___ (470nm), 1.06 (520 mn), and 1.08 (660) nm than absorption coefficients from the reference absorption setup.

Recommendations: Replace pump or use external pump.

Overall assessment: The instrument meets the requirements.

2. Details

Configuration parameters from AE-SETUP.TXT
Instrument serial number: 393 Software version: 985d7 Instrument type 7xLED (3X) Smoothing factor: 0 Maximum attenuation: 125 Spot size: Standard Range (Round Spot) Mean ratio: 1.00 BC Unit: 0 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 *More configuration parameters can be found in the setup file (AE-SETUP.txt).*

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	3.7	20	1013	3.905	22	989	0.977	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	50	Well defined spot, spot size not measured	1.0[1]

Instrumental Noise
Noise in units of eBC concentration measured with filtered air.

Date	Avg. time	Wave-length [nm]	Num data points	Median [ng]	Mean [ng/m³]	Standard deviation [ng/m³]	Error of the mean [ng/m³]
March 10	5 min	370	30	5.8	12.2	33.1	2.2
		450	30	8.6	13.8	28.3	2.5
		520	30	8.2	11.2	21.6	2
		590	30	6.7	11.6	23.9	2.1
		660	30	5.7	10.4	26.6	1.9
		880	30	6.6	11.3	28.8	2.1
		950	30	7.1	13.1	28.6	2.4

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

Comparison of AE31 and reference MAAP (SN 504) Correlation of eBC from AE31 (SN 393:0301) at 880 nm and eBC from the MAAP (SN 32) at 637 nm	
Wavelength [nm]	AE31: 660 nm MAAP: 637 nm
Slope	1.019±0.007
R^2	0.901

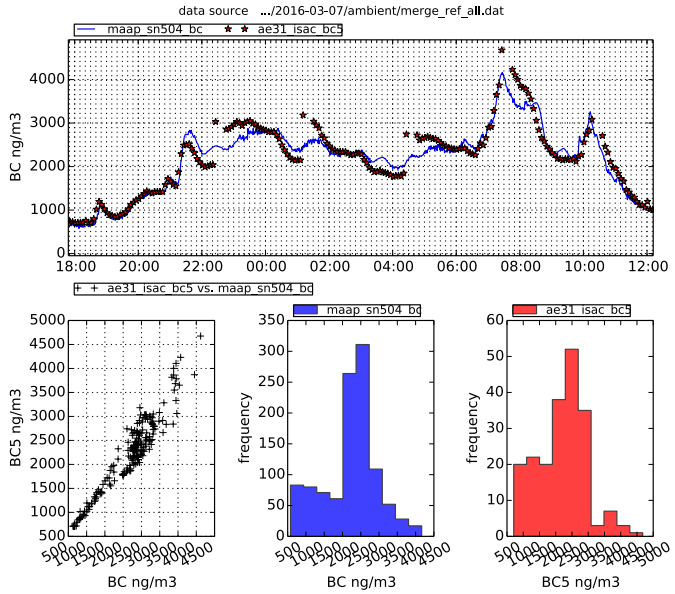

Figure 1: Comparison of eBC (660 nm) with MAAP SN504 (637 nm).

Comparison of AE31 (SN 393:0301) to the reference AE33 (SN163)							
Wavelength [nm]	370	470	520	590	660	880	950
Slope	0.691±0.008	0.736±0.008	0.770±0.007	0.803±0.008	0.809±0.008	0.846±0.006	0.814±0.007
R^2	0.770	0.809	0.839	0.844	0.762	0.881	0.875

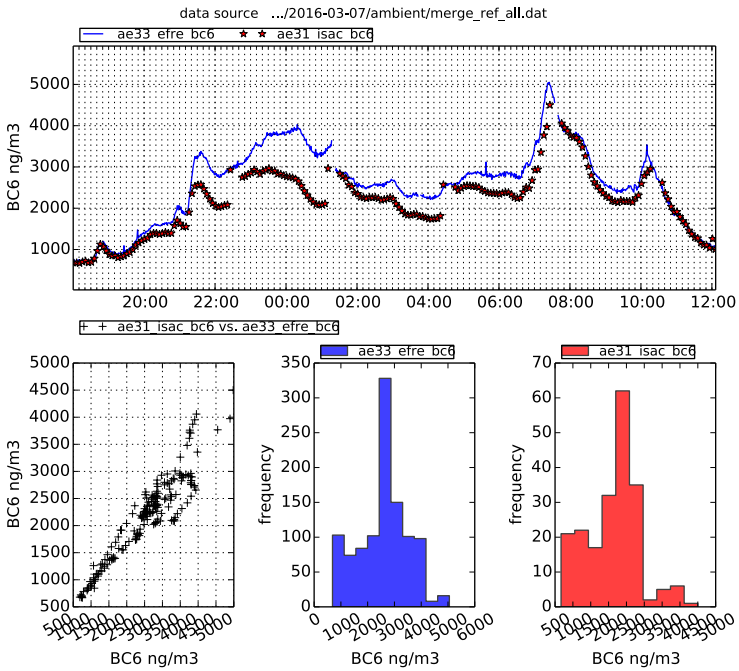

Figure 2: Comparison of AE31 (SN 393:0301) and AE33 (SN 163) at 880 nm.

Comparison of absorption coefficients from AE31 (393:0301) and the Multi-wavelength reference absorption (Extinction minus Scattering).			
Wavelength [nm]	470	520	660
Slope	1.109±0.16	1.064±0.016	1.077±0.023
R^2	0.782	0.767	0.618

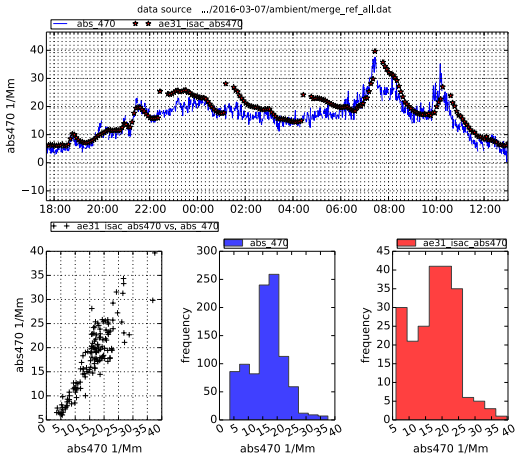

Figure 3: Comparison at 470 nm. Blue: reference absorption, Red: AE31 (SN-393:0301).

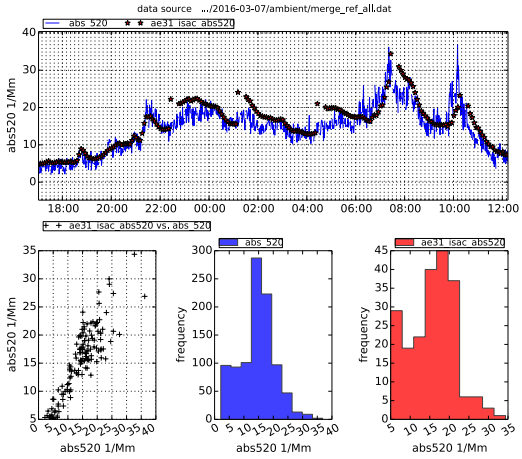

Figure 4: Comparison at 520 nm. Blue: reference absorption, Red: AE31 (SN-393:0301).

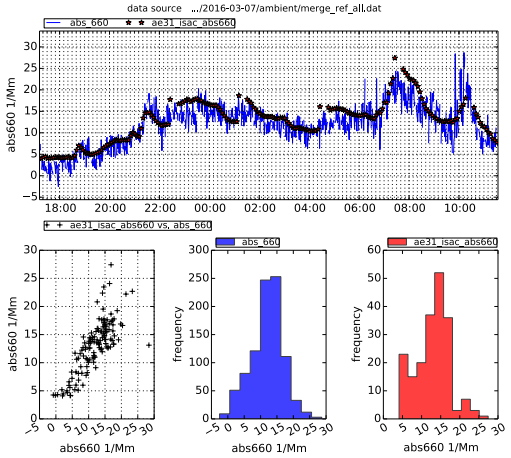

Figure 5: Comparison for 660 nm. Blue: reference absorption, Red: AE31 (SN-393:0301).

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 instruments. 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.