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-2016-1-1

Basic Information:

Location of the quality assurance: TROPOS, lab 121

Date: 18 July, 2016

Principal Investigator	Home Institution	Participant	Instrument
Martin Gysel	Paul Scherrer Institute	-	AE33, SN AE33-S02-00248

1. Intercomparison summary

Flow calibration: The flow of the instrument was found to be 4% too low. This deviation is small and could be caused that the instrument calibration point at Jungfraujoch (650 hPA) and Leipzig (1000 hPa) are different. Corrections for the flow deviation and the temperature and pressure (STP correction) were considered in the data evaluation.

Noise. The noise level of the instrument is in the normal range. The average noise (1σ) for all seven wavelengths was 31 ng/m^3 for 1 minute averaging time. The maximum noise was 38.7 ng/m^3 at 370 nm.

Inspection: Measurement cell was clean. The spots edges are sharp.

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

Comparison to reference Aethalometer AE33 (SN S02-00163): The AE33 (SN 248) measures at all wavelengths lower concentrations than the reference Aethalometer of type AE33 (SN 163). The slopes in the correlation plot are between 0.921 (950 nm) and 0.947 (370 nm).

Comparison to reference absorption: Absorption coefficients derived from Aethalometer using a conversion factors of C_0 =1.63 are higher by factors 1.267 (470nm), 1.187 (520 mn), and 1.096 (660) nm than absorption coefficients from the reference absorption setup. Note, there is no agreement on a common conversion factor for Aethalometers of type AE33. Furthermore, the conversion factor can vary depending on aerosol type.

Recommendations: None.

Overall assessment: The instrument meets the requirements.

2. Details

Configuration parameters
Instrument serial number: S02-00248 BC Unit: 0 (ng) Sigma values: 18.47, 14.54, 13.13, 11.58, 10.35, 7.77, 7.19 Volumetric reference: 'Standard' with P_0=650 hPa and T_0=25°C

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

$$[BC] = [BC_{instr}] \times F_{flow} \times F_{spot} \times F_{STP}$$

For details read Appendix A.

Conversions between eBC concentrations and absorption coefficients are done by

$$b_{abs}[1/Mm] = eBc[\mu g/cm] \times \sigma_{air}/C_0 \quad ,$$

with C_0=1.63 *mass absorption cross sections* σ_{air} given in the table below. For individual instruments the Sigma-values can be found in the setup file.

Conversion factors (σ_{air}) for *eBC* concentrations to absorption coefficients							
Wavelength [nm]	370	450	530	590	660	880	950
σ_{air} [m^2/g]	18.47	14.54	13.13	11.58	10.35	7.77	7.19

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**Fehler! Textmarke nicht definiert.**	STP correction factor**Fehler! Textmarke nicht definiert.**
	Mass flow	Volume reference		Volume flow	Ambient T and P			
	Q_{AE33} [slpm]	$T_{0,AE33}$ [°C]	$P_{0,AE33}$ [hPa]	Q [lpm]	T [°C]	P [hPa]	F_{flow}	F_{STP}
21. Sep	5	25	650	3.37	22	997	0.957	1.701

Spot size check

Correction factor for spot sizes F_{spot}.

Date	Nominal spot size [cm²]	Measured spot size [mm²]	F_{spot}
2016-03-8	0.785	Well defined spot, spot size not measured	1.0

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	393	2	-9	13	3.9	38.7	2
		450	393	-1	-16	13	0.3	32.6	1.6
		520	393	-2	-18	15	-0.4	29	1.5
		590	393	-2	-21	19	-0.5	29.3	1.5
		660	393	-2	-18.7	15	-0.8	28.5	1.4
		880	393	-2	-21	19	-0.1	29.1	1.5
		950	393	-2	-21.7	17.7	-0.7	30.9	1.6

Comparison of AE33 and MAAP

Correlation of eBC from AE33 (SN 248) at 660 nm from the reference MAAP (SN 504) at 637 nm

Wavelength [nm]	AE33: 660 nm MAAP: 637 nm
Slope	1.021±0.002
R^2	0.932

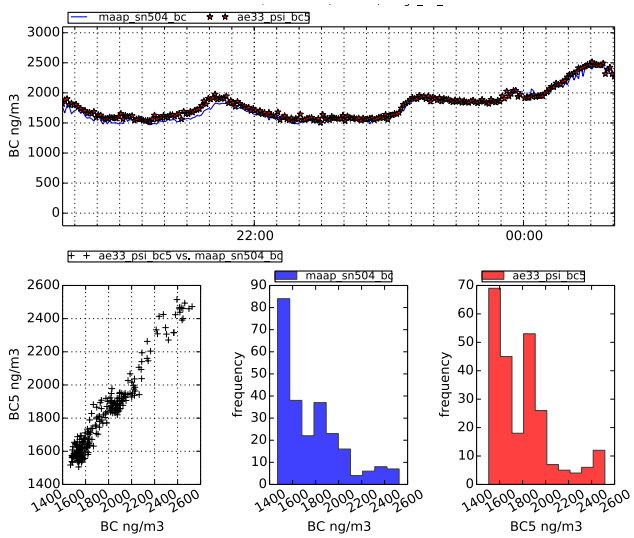

Figure 1: Comparison of eBC concentration for AE33 SN-248 (660 nm) and MAAP SN-504 (637 nm).

Comparion of AE33 (SN 248) to the reference AE33 (SN163)							
Wavelength [nm]	370	470	520	590	660	880	950
Slope	0.997±0.002	0.992±0.002	0.986±0.002	0.977±0.015	0.943±0.002	0.954±0.002	0.937±0.002
R^2	0.947	0.946	0.946	0.946	0.933	0.924	0.921

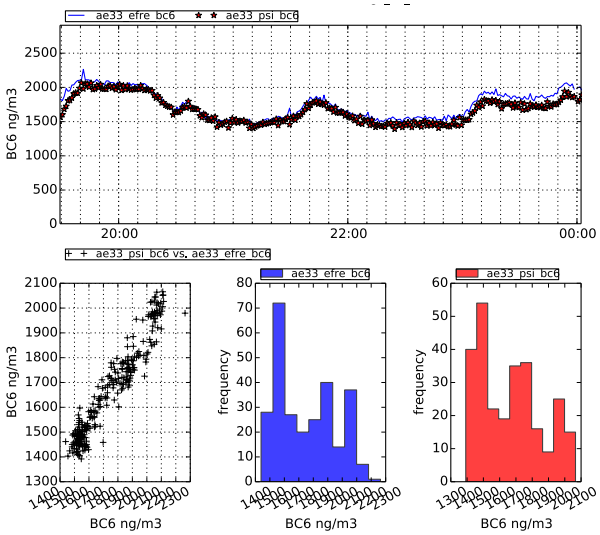

Figure 2: Comparions of AE33 (SN-248) to the reference instrument AE33 (SN163) at 880 nm.

Comparison of absorption coefficients from AE33 (SN 408) and the Multi-wavelength reference absorption (Extinction minus Scattering).			
Wavelength [nm]	470	520	660
Slope	1.267±0.013	1.187±0.010	1.096±0.018
R^2	0.464	0.464	0.162

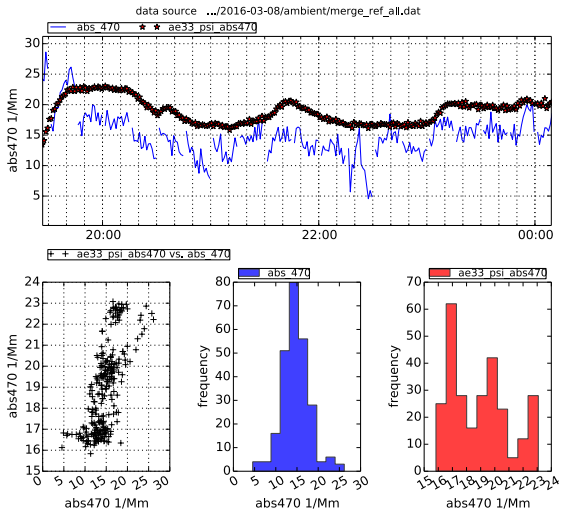

Figure 3: Comparison for 470 nm. Blue: reference absorption, Red: AE33 (SN-248).

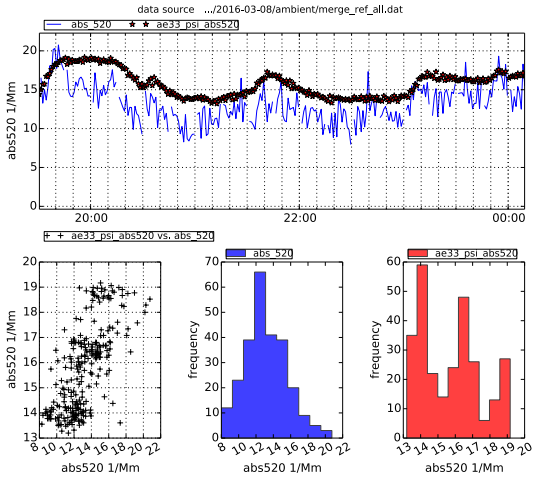

Figure 4: Comparison for 520 nm. Blue: reference absorption, Red: AE33 (SN-248).

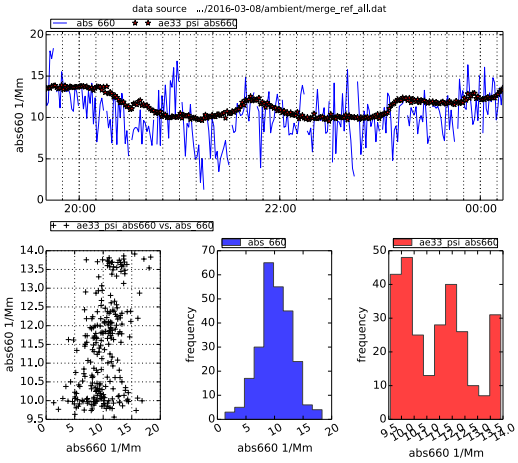

Figure 5: Comparison for 660 nm. Blue: reference absorption, Red: AE33 (SN-248).

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.