Instrument Inter-Comparison Report

Instrument	
Type	Aethalometer AE33
Serial Number	152
Institution	University Granada, Granada
Contact	Gloria Titos

Instrument inter-comparison	
Organization	Leibniz Institute for Tropospheric Research (TROPOS) World Calibration Centre for Aerosol Physics (WCCAP)
Contact	Thomas Müller, thomas.mueller@tropos.de Alfred Wiedensohler, ali@tropos.de
Workshop, etc.	WCCAP-2015-1, Absorption Photometer Workshop, 21-25 Sep. 2015

Report	
Status	final
Date	2015-10-01

1. Instrument inter-comparison summary

Flow calibration: The flow of the instrument was found to be 2% too high resulting in higher eBC concentrations. Correction of the flow error was considered for data evaluation.

Noise. The noise level of the instrument was is in the expected range. The average noise (1σ) for all seven wavelengths was below 20.7 ng/m^3 for 1 minute averaging time. The maximum noise was 20.7 ng/m^3 at 660 nm.

Comparison to reference MAAP: BC concentrations at 660 and 880 nm are about 35% higher than BC concentrations from the 'reference' MAAP. Higher values for Aethalometers have been many times observed for ambient air in Leipzig.

Comparison to Aethalometer AE33: The instrument AE33 (SN152) measures on average 8% higher eBC concentrations than the TROPOS reference Aethalometer of type AE33 (SN 163). Reasons for this behaviour were not be found.

Comparison to Multi-wavelength reference absorption: Absorption coefficients derived from Aethalometer using C_0 =1.63 (equals to C_0=3.5 for AE31 aethalometers) are higher by factors 1.08 (470nm), 1.14 (520 mn), and 1.14 (660) nm than absorption coefficients from the reference absorption setup. Note, that ACTRIS recommends a values of C_0=3.5 for AE31.

Recommendations: None

Overall assessment: The instrument meets the requirements.

2. Instrument configuration

Configuration parameters
Instrument type and serial number: AE33-S02-00152 Flow Set Point: 4 slpm Volume Reference settings: "Iso", T=20 °C, P=1013.25 hPa Multiple scattering correction factor: C=1.57 Max. Attenuation: 120 Spot size: 0.785 cm^2 *More configuration parameters can be found in the setup file:* *AE-SETUP_AE33-S02-00152.xml*

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

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

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

4. Technical checks

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 Set Flow			Reference flow Reference flow meter: Gilibrator 'TROPOS-T'			Flow correction factor	STP correction factor
	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	4.0	20	1013.25	3.968	20	1001	1.020	1.073
23. Sep	4.0	21	1013.25	3.985	20	995	1.022	1.073

Table: Spot size correction factors

Date	Nominal spot size [mm²]	Measured spot size [mm²]	F_{spot}
21. Sep	0.785	Well defined spot. Spot size not measured	1.0

Instrument noise

Noise in units of eBC concentrations

Date	Avg. time	Wave-length [nm]	Num data points	Median [ng/m³]	10th percentile [ng/m³]	90th percentile [ng/m³]	Mean [ng/m³]	Standard deviation [ng/m³]	Error of the mean [ng/m³]
Sep. 22	1 min	370	83(1)	7.6	-2.1	18.6	7.3	8.8	1.0
		470	172	1.0	-10.9	14.2	1.3	10.4	0.8
		520	171	2.1	-13.1	15.3	1.7	11.9	0.9
		590	171	4.3	-16.4	18.6	2.3	14.3	1.1
		660	170	1.1	-22.1	29.7	2.5	20.7	1.6
		880	171	6.5	-18.6	32.8	6.7	18.8	1.4
		950	171	7.6	-15.3	31.7	7.9	18.2	1.4

(1): For the first hour values were continuously decreasing. All Aethalometers showed this behaviour. Reason could be adsorbed gases.

5. Comparison to reference instruments

The reference MAAP (SN504) was not available due to an instrumental error and was replaced by another MAAP (SN32). MAAP-SN32 was inter-compared before the workshop to two other MAAPs. The three instruments agreed within 5% and the noise level of MAAP-SN32 was in agreement with the instrumental specifications.

Inter-comparison of eBC concentrations from MAAP and BC_{aeth} at the wavelengths 660 for ambient air is shown in the below. Results for all wavelengths are summarised in the subsequent table.

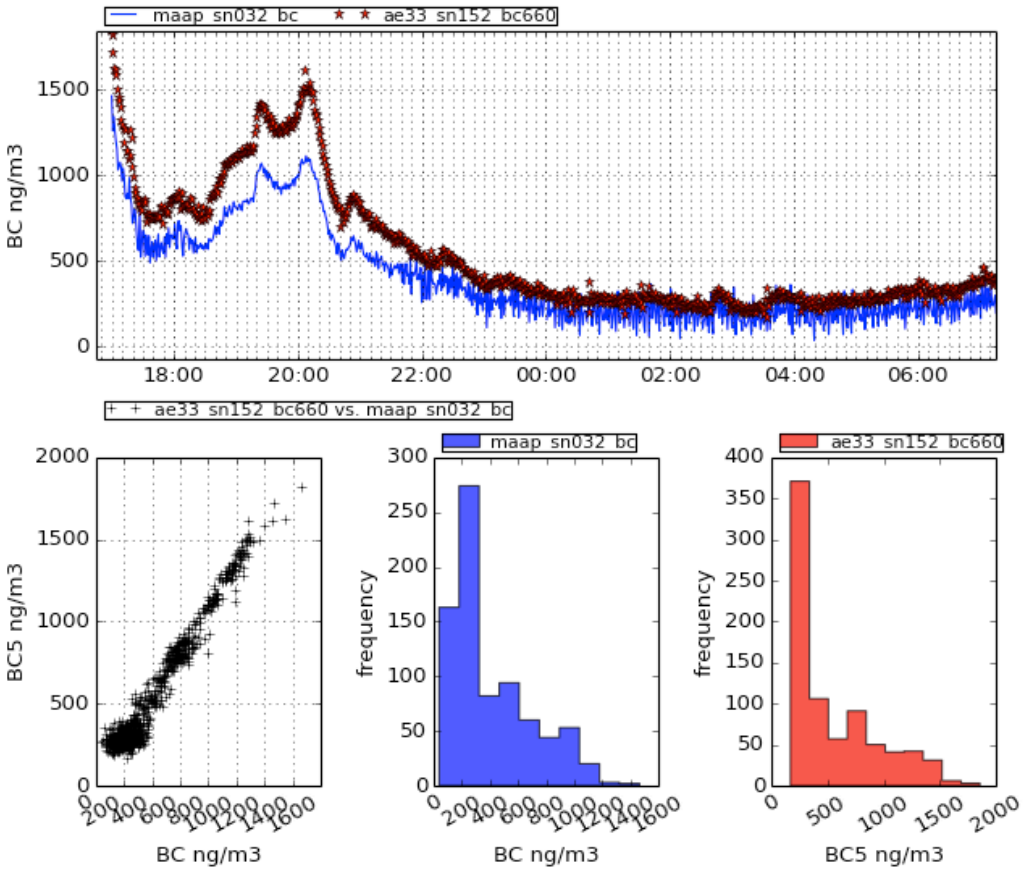


Figure: Comparison of eBC (660 nm) with MAAP SN32 (637 nm).

Table: Comparison of AE33 and MAAP
Correlation of eBC from AE33 (SN 152) and eBC from MAAP (SN 32)

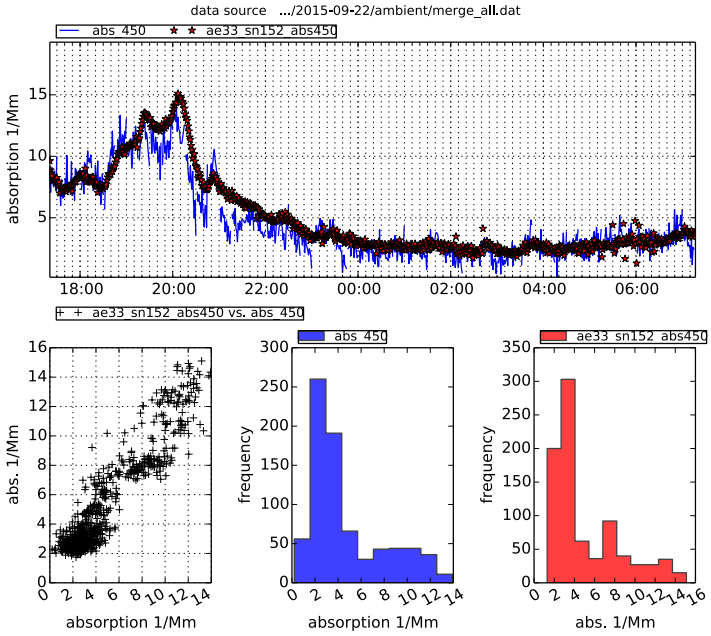
Wavelength [nm]	370	470	520	590	660	880	950
Slope	1.608 ± 0.007	1.512 ± 0.006	1.445 ± 0.006	1.412 ± 0.006	1.35 ± 0.006	1.344 ± 0.006	1.357 ± 0.006
R^2	0.952	0.946	0.955	0.956	0.959	0.952	0.951

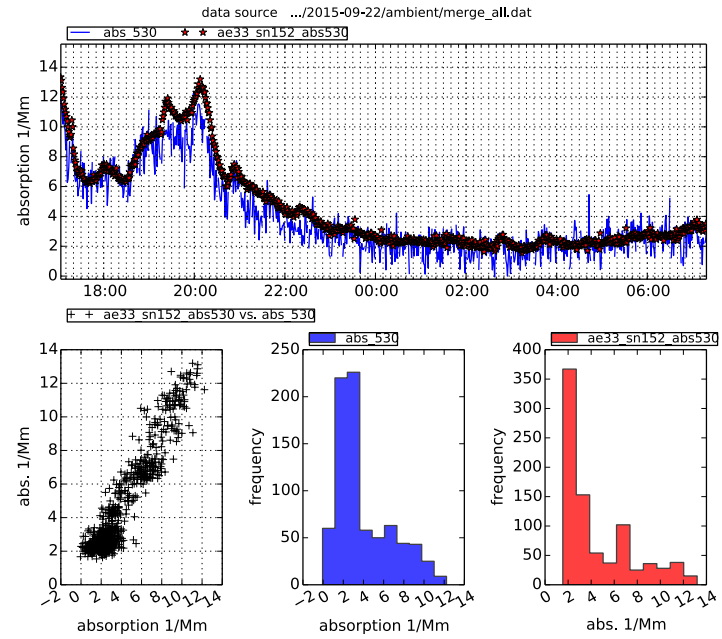
The higher eBC values in the UV indicates an influence of organics. The ratio of 1.35 for eBC concentrations for AE33 concentrations at 660 and MAAP is not within the uncertainty of ±25% of the C_0 value.

Table: Comparison to reference AE33 Correlation of eBC from AE33 (SN 152) and eBC from the TROPOS reference Aethalometer AE33 (SN 163)							
Wavelength [nm]	370	470	520	590	660	880	950
Slope	1.071 ± 0.002	1.081 ± 0.002	1.092 ± 0.002	1.086 ± 0.002	1.081 ± 0.002	1.081 ± 0.002	1.086 ± 0.002
R^2	0.995	0.990	0.994	0.991	0.990	0.991	0.989

The ratio of values shows, that AE33 (SN 152) measures on average 8% higher eBC concentrations compared to reference instrument. Reason for higher concentrations could not be found.

Comparison to the Multi-Wavelength absorption reference





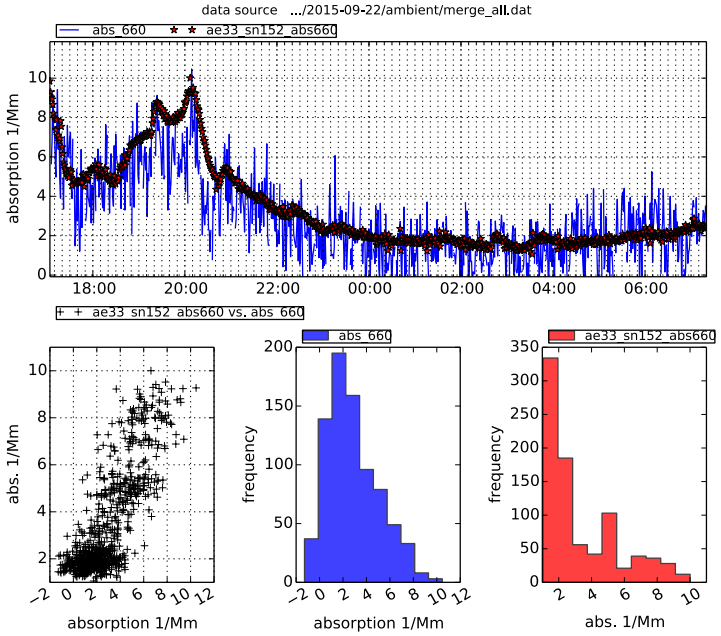


Table: Correlation of absorption coefficients from AE31 (SN 408) and the Multi-Wavelength absorption reference.			
Wavelength [nm]	450	530	660
Slope	1.083 ± 0.008	1.137 ± 0.008	1.139 ± 0.016
R^2	0.869	0.885	0.612

Appendix A: 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 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.