Instrument Inter-Comparison Report

Instrument	
Type	Aethalometer AE31
Serial Number	408
Institution	JRC Atmosphere, Ispra
Contact	Sebastiao Martins dos Santos

Execution of instrument inter-comparison	
Organization	Leibniz Institute for Tropospheric Research (TROPOS) World Calibration Centre for Aerosol Physics (WCCAP)
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Workshop, etc.	WCCAP-2015-1, Absorption Photometer Workshop, 21-25 Sep. 2015

Report	
Status	final
Date	2015-10-13

1. Instrument inter-comparison summary

Flow calibration: The flow of the instrument was found to be 8% low resulting in lower eBC concentrations. Correction of the flow error was included in the 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 44 ng/m^3 for 3 minute averaging time. The maximum noise was 74.8 ng/m^3 at 590 nm.

Comparison to reference MAAP: BC concentrations are about 20% higher than BC concentrations from the reference MAAP (SN32). Higher values for Aethalometers are attributed to freshly emitted soot. Higher values for Aethalometers were many times observed for ambient air in Leipzig.

Comparison to reference Aethalometer AE33: The instrument AE31 (SN408) measures between 10% (370 nm) and 5% (950 nm) lower eBC concentrations than the reference Aethalometer of type AE33 (SN504).

Comparison to reference absorption: Absorption coefficients derived from Aethalometer using a conversion factors of C_0 =3.5 are higher by factors 1.19 (470nm), 1.10 (520 mn), and 1.24 (660) nm than absorption coefficients from the reference absorption setup.

Recommendations: Regular flow checks.

Overall assessment: The instrument meets the requirements.

2. Instrument configuration

Configuration parameters from AE-SETUP.TXT
Instrument serial number: 408 Software version: 985d4 Instrument type 7xLED (3X) Smoothing factor: 0 Maximum attenuation: 50 Spot size: Extended Range (Elongated 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).*

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 [m^2/g]	39.5	31.1	28.1	24.8	22.2	16.6	15.4

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 Flow			Reference flow			Flow correction factor[1]	STP correction factor[1]
				Reference flow meter: Gilibrator 'TROPOS-T'				
	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	2.5	20	1013	2.36	22	999	1.081	1.073

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, 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]	10th percentile [ng/m³]	90th percentile [ng/m³]	Mean [ng/m³]	Standard deviation [ng/m³]	Error of the mean [ng/m³]
Sep. 22	3 min	370	54	10.9	-3.0	29.4	12.2	12.9	1.8
		470	53	20.1	-11.5	50.6	17.7	23.0	20.1
		520	29	13.8	-23.2	50.6	14.5	28.8	5.4
		590	28	12.8	-86.9	107.1	10.7	74.8	14.1
		660	28	11.6	-12.7	48.7	14.5	27.9	5.2
		880	28	13.2	-68.7	61.0	9.4	62.8	13.2
		950	29	16.0	-86.5	104.6	11.7	73.6	13.7

5. Comparison to the TROPOS reference instruments

The original 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.

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

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 following table.

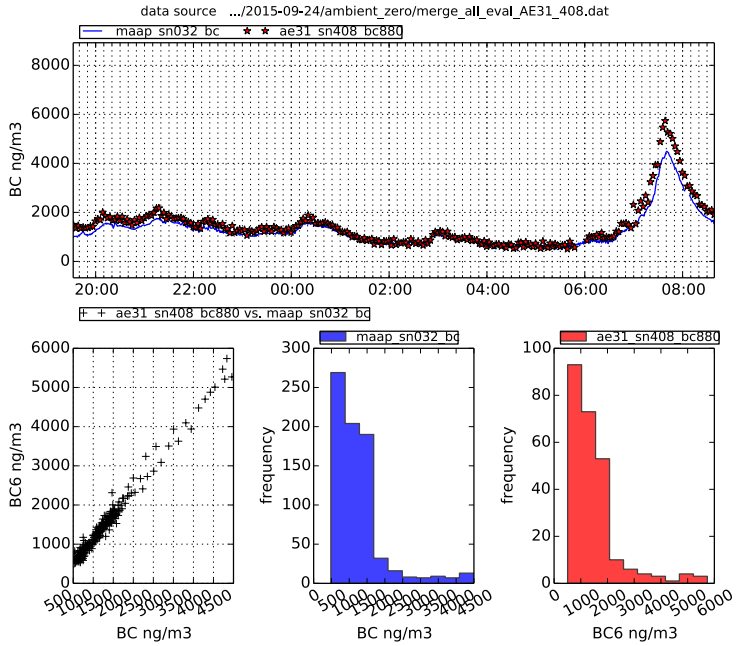

Figure: Comparison of eBC (660 nm) with MAAP SN32 (637 nm).

Table: Comparison of AE31 and MAAP Correlation of eBC from AE31 (SN 408) and eBC from the MAAP (SN 32)							
Wavelength [nm]	370	470	520	590	660	880	950
Slope	1.248 ± 0.007	1.252 ± 0.005	1.190 ± 0.005	1.191 ± 0.005	1.230 ± 0.005	1.191 ± 0.006	1.190 ± 0.006
R^2	0.966	0.984	0.989	0.988	0.990	0.981	0.982

Table: Comparion of AE31 (SN408) to the reference AE33 (SN163)							
Wavelength [nm]	370	470	520	590	660	880	950
Slope	0.898 ± 0.016	0.906 ± 0.003	0.914 ± 0.003	0.923 ± 0.003	0.986 ± 0.003	0.970 ± 0.005	0.955 ± 0.004
R^2	0.749	0.990	0.992	0.993	0.994	0.985	0.987

Comparison to TROPOS Multiwavelength Absorption Reference

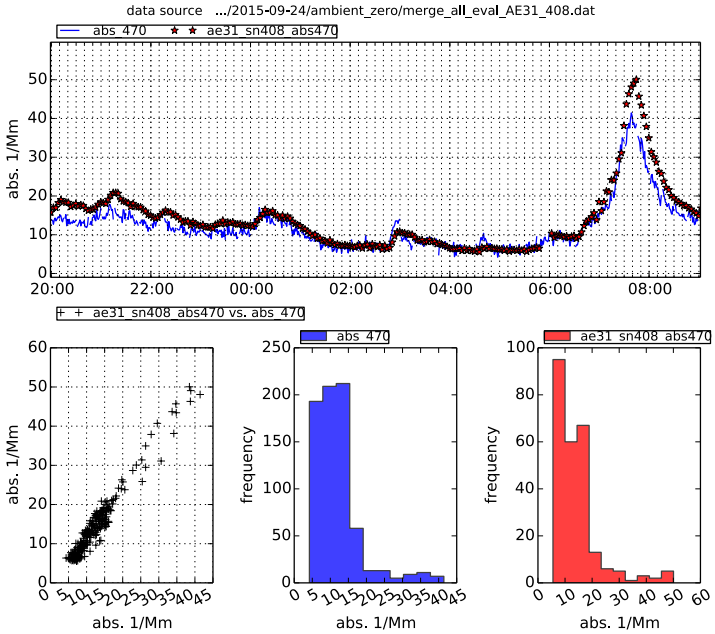

Figure: Comparison at 470 nm.

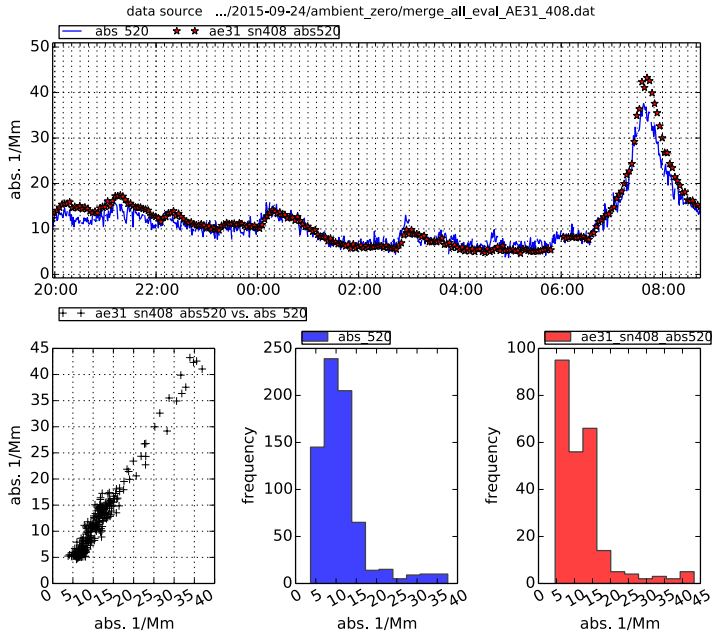

Figure: Comparison at 520 nm.

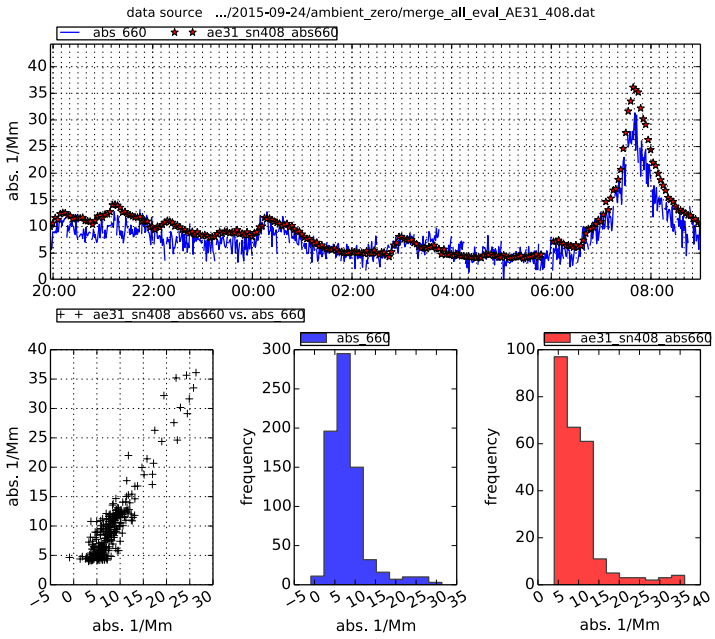

Figure: Comparison for 660 nm.

Table: Correlation of absorption coefficients from AE31 (SN 408) and the Multi-wavelength reference absorption.			
Wavelength [nm]	470	520	660
Slope	1.192 ± 0.018	1.10 ± 0.009	1.242 ± 0.016
R^2	0.948	0.955	0.846

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.