

Instrument Inter-Comparison Report

Instrument	
Type	Aethalometer AE33
Serial Number	169
Institution	Institut Scientifique de Service Public (ISSeP)
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Instrument inter-comparison	
Organization	Leibniz Institute for Tropospheric Research (TROPOS) World Calibration Centre for Aerosol Physics (WCCAP)
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Workshop, etc.	ACTRIS 2 Absorption Photometer Workshop, 21-25 Sep. 2015

Report	
Status	final
Date	2015-12-20

1. Instrument inter-comparison summary

Flow calibration: The flow of the instrument was found to be 5% too low. 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 21.3 ng/m^3 for 1 minute averaging time. The maximum noise was 21.3 ng/m^3 at 660 nm.

Comparison to reference MAAP: BC concentrations at wavelengths 660 and 880 nm are about 28% and 22% 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 ratio of values shows, that AE33 (SN169) measures on average 5.3% lower eBC concentrations compared to reference instrument AE33 (SN163). Reasons for lower concentrations could not be found.

Comparison to Multiwavelength 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 1.28 (470nm), 1.22 (520 nm), and 1.25 (660) nm than absorption coefficients from the reference absorption setup. Note, that ACTRIS recommends a C_0 values of 3.5 for AE31.

Recommendations: None

Overall assessment: The instrument meets the requirements.

1. Instrument configuration

Configuration parameters from AE-SETUP.TXT
Instrument serial number: AE33-S02-169 Flow set point: 5 slpm Volume reference settings: T=21.11°C, P=1013.25 hPa Multiple scattering correction factor: C=1.57 Maximum attenuation: 120 Spot size: 0.785 cm ² Sigma values: 18.47, 14.54, 13.14, 11.58, 10.35, 7.77, 7.19 <i>More configuration parameters can be found in the setup file: AE-SETUP_AE33-S02-00169.txt</i>

2. 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

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

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

3. Technical checks

Flow checks

Correction factors for inlet flow (F_{flow}) and for adjusting concentrations to STP (0°C, 1013.25 hPa) conditions (F_{STP}).

Date	System Flow			Reference flow			Flow correction factor	STP correction factor
				Reference flow meter: Gilibrator ‘TROPOS-T’				
	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]		
21. Sep	5.0	21.11	1013.25	4.8	20	1001	1.050	1.077
23. Sep	5.0	21.11	1013.25	4.89	22	995	1.044	1.077

Spot size correction

Date	Nominal spot size [cm ²]	Measured spot size [mm ²]	F_{spot}^1
21. Sep	0.785	Well defined spot, spot size not measured	1.0

Instrument noise

Noise in units of eBC concentration measured with filtered air

Date	Avg. time	Wave-length [nm]	Num data points	Median [ng]	10 th percentile [ng]	90 th percentile [ng]	Mean [ng]	Standard deviation [ng]	Error of the mean [ng]
Sep. 22	1 min	370	93 ⁽¹⁾	7.917	-2.262	21.263	8.148	9.55	0.99
		470	170	1.131	-11.31	14.703	1.184	10.699	0.821
		520	171	2.262	-13.572	15.834	1.713	12.33	0.943
		590	171	4.524	-16.965	19.227	2.566	14.663	1.121
		660	171	1.131	-22.62	30.537	2.619	21.305	1.629
		880	170	6.786	-19.227	33.93	6.819	19.415	1.489
		950	171	7.917	-15.834	32.799	8.182	18.847	1.441

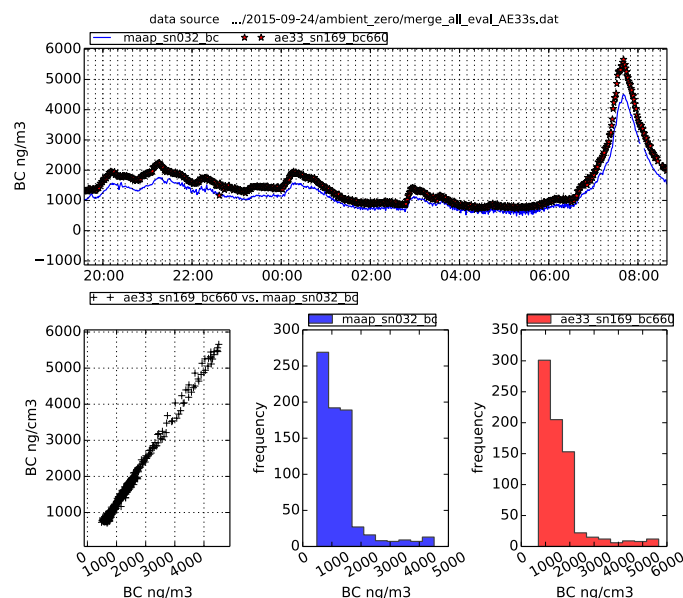
⁽¹⁾: First hour values was continuously decreasing. All Aethalometers showed this behaviour. Reason could be adsorbed gases.

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

4. Comparison with the TROPOS WCCAP '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.



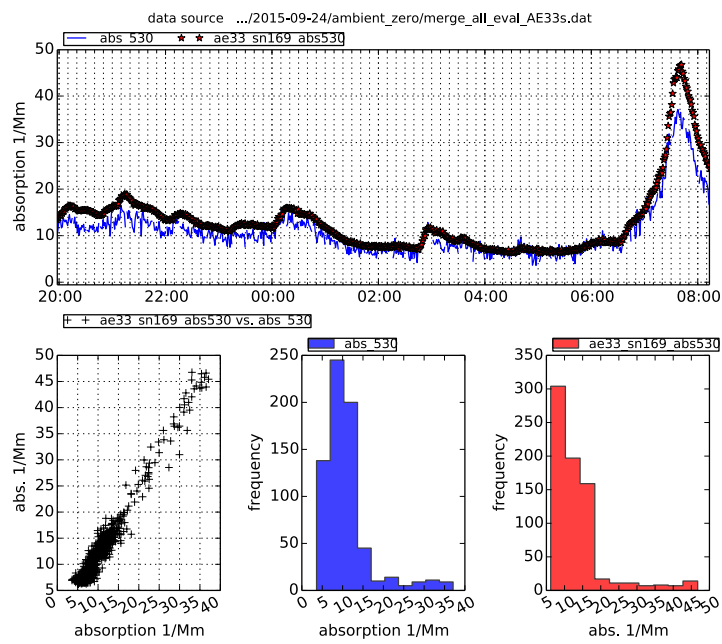
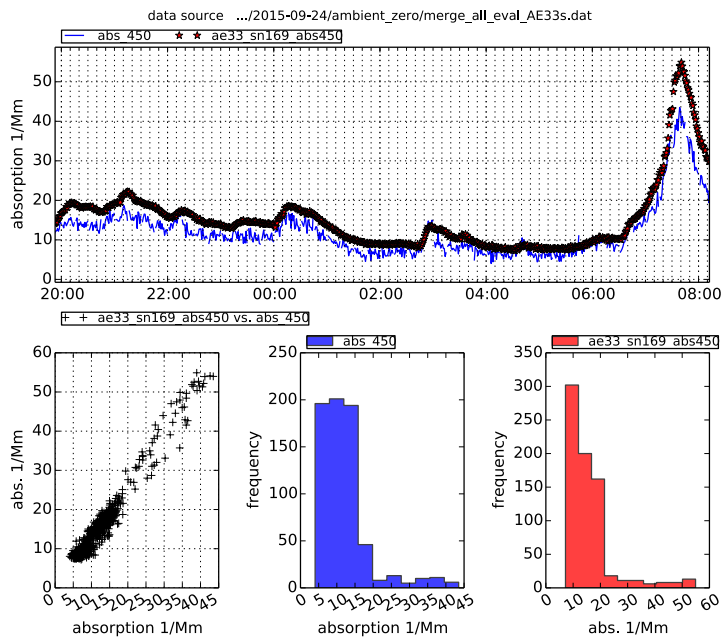
Correlation of eBC from AE31 (SN 408) and eBC from the Reference MAAP (SN 32)							
Wavelength [nm]	370	470	520	590	660	880	950
Slope	1.468 ± 0.003	1.373 ± 0.002	1.296 ± 0.002	1.280 ± 0.002	1.280 ± 0.002	1.223 ± 0.003	1.280 ± 0.002
R ²	0.988	0.991	0.991	0.991	0.990	0.983	0.982

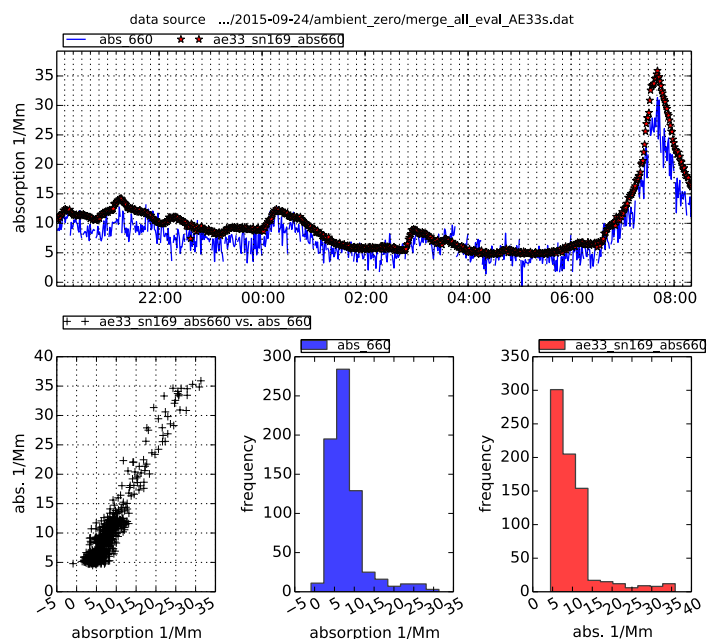
Comparison to reference AE33							
Correlation of eBC from AE33 (SN 169) and eBC from the TROPOS reference Aethalometer AE33 (SN 163)							
Wavelength [nm]	370	470	520	590	660	880	950
Slope	0.955 ± 0.001	0.940 ± 0.001	0.945 ± 0.001	(*)	0.918 ± 0.001	0.965 ± 0.001	0.961 ± 0.001
R ²	0.998	0.998	0.999		0.998	0.997	0.996

(*) error in K-factor of aethalometer AE33 SN504

The ratio of values shows, that AE33 SN 169 measures on average 5.3% lower eBC concentrations compared to reference instrument. Reasons for lower concentrations could not be found.

Comparison to Multi-wavelength absorption reference





Figures: Absorption from AE33 versus multiwavelength reference absorption.

Table: Correlation of absorption coefficients from AE33 (SN 169) and the Multi-Wavelength absorption reference.			
Wavelength [nm]	450	520	660
Slope	1.278 ± 0.005	1.218 ± 0.005	1.246 ± 0.008
R ²	0.954	0.954	0.868

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 $T_0=0^\circ\text{C}$ 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.

References

Weingartner, E., et al. (2003). "Absorption of light by soot particles: determination of the absorption coefficient by means of aethalometers." Journal of Aerosol Science **34**(10): 1445-1463.