Instrument Inter-Comparison Report

Instrument	
Type	Aethalometer AE22
Serial Number	1083
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	2015-12-28

1. Instrument inter-comparison summary

Flow calibration: The flow of the instrument was found to be 3.6% too high. 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 both wavelengths was low with values of 6 ng/m^3 for 3 minute averaging time.

Leak check: Measurements with a zero filter revealed that there is a small (no serious) leak. The eBC values with zero filter attached were on average about 9 ng/m^3. The value can change depending on the level of pollution of the surrounding air.

Comparison to reference MAAP and reference AE33: eBC concentrations from the AE21 (SN1083) at 880 compare well to eBC concentrations from MAAP (SN32). Deviations were found to be smaller then 1%. Compared to a reference AE33(SN163) the eBC concentrations are smaller by up to 26%. It has to be considered, that the scaling factor 'mean ratio' of 0.85 was set by the manufacturer.
Absorption coefficients at 635 nm derived from AE21 are 10% lower then absorption coefficients from MAAP.

Recommendations: Frequently check flows and do zero measurements to observe possible leakage.

Overall assessment: The instrument meets the requirements.

2. Instrument configuration

Configuration parameters from AE-SETUP.TXT
Instrument type and serial number: AE21, SN 1083 Flow Set Point: 4 slpm Volume reference: T=20 °C, P=1013 hPa Spot for extended range Mean ration: 0.85 *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

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

Details can found in the Appendix A.

Conversion 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 **Fehler! Verweisquelle konnte nicht gefunden werden.**. For individual instruments the Sigma-values can be found in the setup file.

Conversion factors Conversion factors (*Sigma*) for *eBC* concentrations to absorption coefficients		
Wavelength [nm]	370	880
Sigma [m²/g]	39.5	16.6

4. 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}).

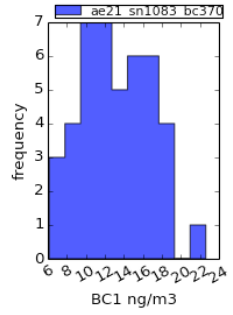
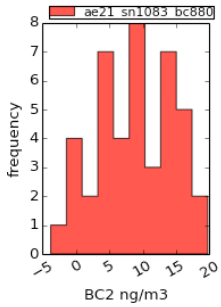
Date	System Flow			Reference flow Reference flow meter: Gilibrator 'TROPOS-T'			Flow correction factor[1]	STP correction factor[1]
	Mass flow	Volume reference		Volume flow	Ambient *T* and *P*			
	Q_{AE31} [slpm]	$T_{0,AE21}$ [°C]	$P_{0,AE21}$ [hPa]	*Q* [lpm]	*T* [°C]	*P* [hPa]	F_{flow}	F_{STP}
21. Sep	3.9	20	1013	3.82	21	1001	1.036	1.074

Spot size Correction factor for spot sizes F_{spot}.			
Date	Nominal spot size [mm²]	Measured spot size [mm²]	F_{spot}[1]
21. Sep	Elongated spot for extended range	Well defined spot. Size not measured	1.0

Instrument noise Noise in units of eBC concentrations measured with filtered air.									
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	3 min	880	46	9.5	1.4	16.5	9.4	5.9	0.87
		370	46	13.2	8.1	18.3	13.2	3.7	0.55

The noise distribution is not centred at zero, probably because of a leak. Multiple zero measurements gave the same result. The cell was opened and found to be clean and all connectors were tightly attached. The reason for the leak wasn't found.

An offset of 9 ng/m³ is not critical, except for measurements at very low concentrations. The noise of the instruments with values less than 6 ng/m³ relatively low.

Frequency distribution of eBC concentrations in ng/m³	
370 nm	880 nm
	

5. Comparison to TROPOS reference instruments

Comparison of eBC from AE21 and MAAP Correlation of eBC from AE21 (SN 1038) and eBC from the reference MAAP (SN 32)		
Wavelength [nm]	370	880
Slope	0.889 ±0.008	1.007 ±0.010

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

R^2	0.948	0.939

Comparison of absorption coefficients Correlation of absorption coefficients from AE21 (SN 1038) and from the reference MAAP (SN 32). Absorption coefficients for the AE21 were interpolated to 637 nm.	
Wavelength [nm]	637
Slope	0.90 ±0.01
R^2	0.94

Comparison of AE21 and AE33 Correlation of eBC from AE21 (SN 1038) and eBC from the reference Aethalometer AE33 (SN 163)		
Wavelength [nm]	370	880
Slope	0.688 ±0.003	0.734 ±0.002
R^2	0.996	0.993

eBC concentrations of AE21 (SN1083) at 880 nm compare well to eBC concentrations from MAAP. Compared to the reference AE33 (SN163) the eBC concentrations are lower by up to 26%. It has to be considered, that the scaling factor 'mean ratio' of 0.85 was set by the manufacturer to fit the eBC concentrations to a reference Aethalometer of the manufacturer.

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:

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

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.