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EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

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CA16109 Chemical On-Line cOmpoSition and Source Apportionment of fine aerosoL

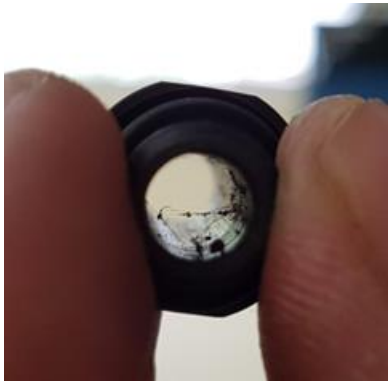
Jožef Stefan Institute
Ljubljana, Slovenia

Aethalometer AE33 training and quality control/assurance

Training School on Black and Brown Carbon, 15-17 January 2018, Ljubljana

Overview

- Uncertainties in BC measurements
- Uncertainties in BC source apportionment
- Training on AE33 operation and maintenance
- Data evaluation
- Instrument intercomparison
- Workshop: data quality assessment



Calculation of BC

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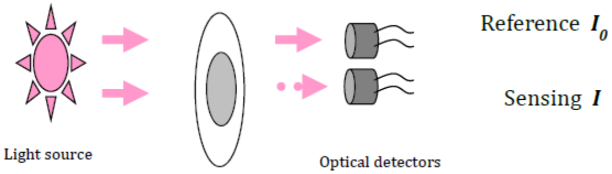

Optical attenuation: $ATN = -100 * \ln(I/I_0)$ (*) I_0 = reference signal; I = spot signal

*to get correct ATN, ATN0 must be subtracted from calculated ATN value

Flow: $F_{in} = F_{out} * (1 - \zeta)$ F_{out} = measured flow; ζ = leakage factor

Attenuation coefficient: $b_{atn} = \frac{S*(\Delta ATN/100)}{F_{in}\Delta t}$ S = spot area; t = time

Absorption coefficient: $b_{abs} = \frac{b_{atn}}{C}$ C = multiple scattering parameter (Weingartner et al. 2003)

Black carbon concentration: $BC = \frac{b_{abs}}{\sigma_{air}}$ σ_{air} = mass absorption cross-section

Loading effect compensation: $BC = BC_{measured}/(1 - k * ATN)$ k = compensation parameter

Final equation: $$BC = \frac{S*(\Delta ATN_1/100)}{F_1(1-\zeta)*\sigma_{air}*C*(1-k*ATN_1)*\Delta t}$$

Uncertainties in BC measurements

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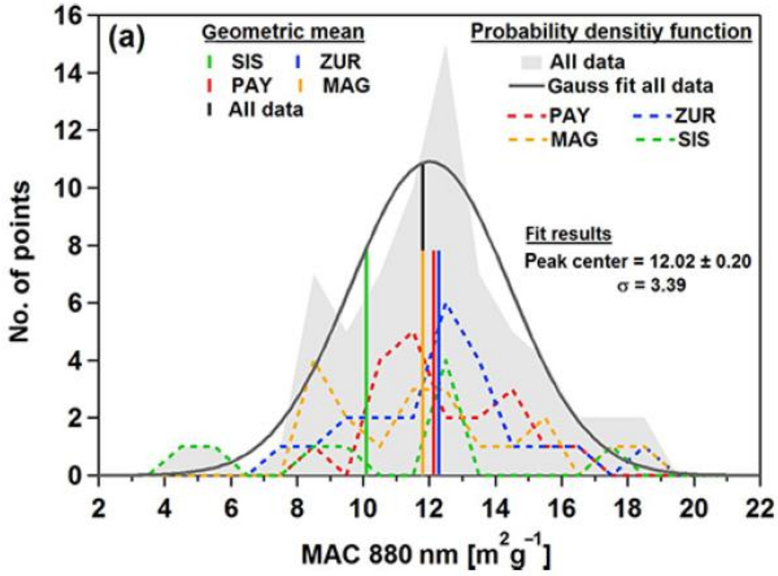
$$b_{abs} = \frac{b_{atn}}{C}$$

BC = b_{abs}/MAC

- Multiple scattering parameter C and MAC
  - Particle size
  - Coating -> lensing effect
- Cross-sensitivity to scattering – important for high SSA
- Filter loading effect
  - Online and offline compensation methods
  - Assessing quality of compensation
- Instrument variability
  - SOP
  - intercomparisons

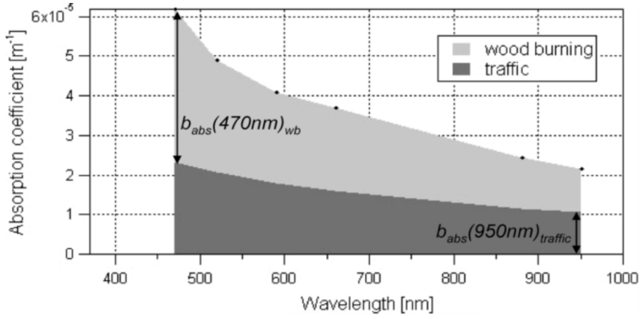
Zotter et al, 2017

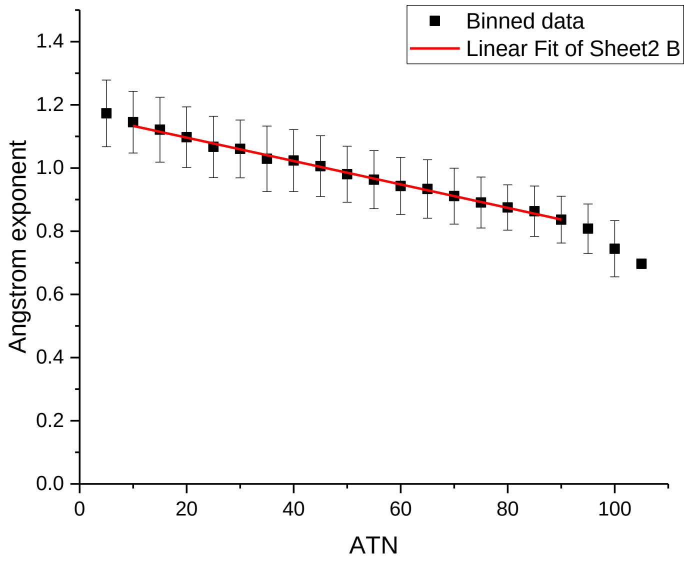


Uncertainties in BC source apportionment

Sandradewi source apportionment model is sensitive to:

- Sub-optimal filter loading compensation
- Selection of α_{ff} and α_{bb} values
    - C14 method – Zotter et al, 2017





Station	α_{WB} range	α_{WB} mean ± standard deviation
SIS	1.23–1.84	1.55 ± 0.21 ($n = 9$)
ZUR (winter)	1.47–1.80	1.67 ± 0.11 ($n = 14$)
ZUR (summer)	1.34–1.90	1.60 ± 0.14 ($n = 8$)
MAG	1.53–1.85	1.69 ± 0.09 ($n = 19$)
PAY	1.42–1.80	1.63 ± 0.10 ($n = 19$)
MOL	1.85–2.17	1.93 ± 0.16 ($n = 4$)
ROV	1.43–1.85	1.68 ± 0.11 ($n = 13$)
REI	1.70–1.86	1.81 ± 0.06 ($n = 5$)
MAS	1.46–1.65	1.56 ± 0.06 ($n = 8$)

Training on AE33 operation and maintenance

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1. Introduction to BC
2. Basic calculations
   - Loading effect compensation
   - Sigma & multiple scattering parameter
   - Leakage
3. Loading effect compensation
   - Introduction to loading effect
   - Algorithm sensitivity
4. User interface
   - Home
   - Operation
   - Data
   - Setup file
   - Flow reporting standard
5. Quality control
   - Stability & Clean air test
   - Flow verification
   - Leakage test
   - ND test
6. Service & Maintenance
   - Startup procedure
   - Software compatibility
   - Troubleshooting
   - Mechanics
7. Installation
   - Tubing
   - Inlet
   - Air conditioning

Data evaluation

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Filter data: remove BC data for status containing the following sub-statuses:

1 (tape advance),
2 (1st measurement, obtaining the initial attenuation ATN0),
3 (instrument stopped),
1024 (stability test),
2048 (clean air test,),
3072 (tape change procedure),
4096 (optical test with the Neutral Density filters).

Pa);	Temperature(Â°C);	BB(%);	ContTemp;	SupplyTemp;	Status;	ContStatus;	DetectStatus;	LedStatus;	ValveStatus;	LedTemp;	BC11;	BC12;	BC1;	BC21;
325	21.11	0	26	41	3	0	20	10	0	25	0	0	0	0
325	21.11	0	26	40	3	0	20	10	0	25	0	0	0	0
325	21.11	0	26	40	3	0	20	10	0	25	0	0	0	0
325	21.11	0	26	38	3	0	20	10	0	25	0	0	0	0
325	21.11	0	26	41	3	0	20	10	0	25	0	0	0	0
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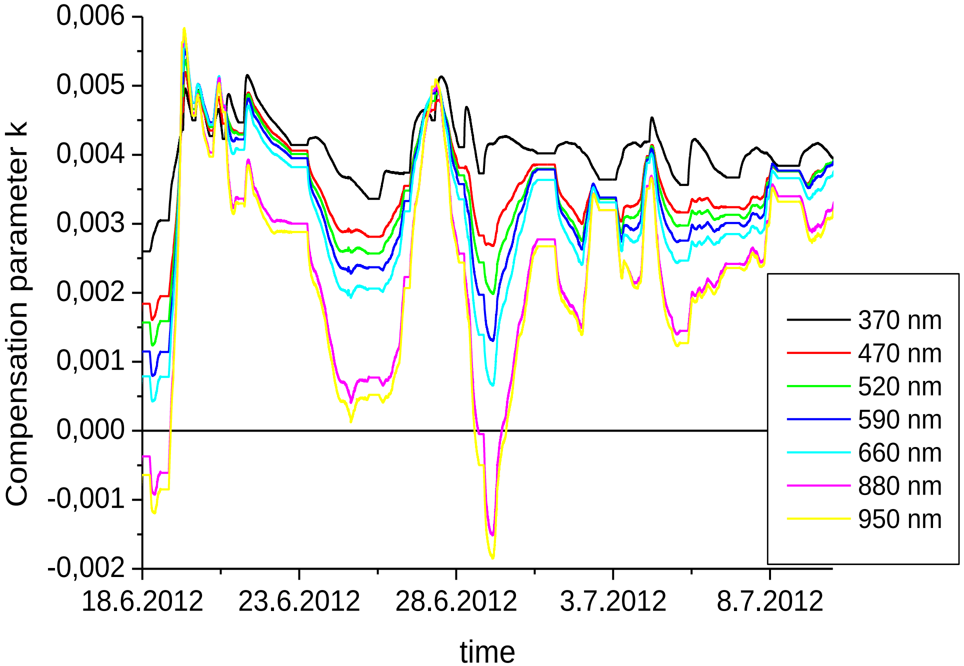
325	21.11	0	26	41	3	0	20	10	0	25	0	0	0	0
325	21.11	0	26	40	3	0	20	10	0	25	0	0	0	0
325	21.11	0	26	40	3	0	20	10	0	25	0	0	0	0
325	21.11	0	26	38	3	0	20	10	0	25	0	0	0	0
325	21.11	0	26	38	1	0	10	10	1100	25	0	0	0	0
325	21.11	0	26	40	1	0	10	10	1100	26	0	0	0	0
325	21.11	0	26	41	1	0	10	10	1100	27	0	0	0	0
325	21.11	0	26	41	1	0	10	10	100	27	0	0	0	0
325	21.11	0	26	41	1	0	10	10	0	27	0	0	0	0
325	21.11	0	26	40	2	0	10	10	0	28	0	0	0	0
325	21.11	0	26	39	0	0	10	10	0	28	259	344	259	4
325	21.11	0	26	39	0	0	10	10	0	28	196	271	196	0
325	21.11	0	27	40	0	0	10	10	0	28	99	37	99	14
325	21.11	0	26	41	0	0	10	10	0	28	126	94	126	19
325	21.11	0	26	41	0	0	10	10	0	28	67	29	67	-77
325	21.11	0	26	41	0	0	10	10	0	28	75	15	75	3
325	21.11	0	26	40	0	0	10	10	0	28	43	-58	43	-44
325	21.11	0	26	39	0	0	10	10	0	28	47	32	47	-32
325	21.11	36.9	26	39	0	0	10	10	0	28	23	-75	23	-78

Data evaluation

- Check instrument status for warnings -> Remove suspect data
- Check data for noise, spikes
- Check compensation
  - k1 range 0.004 - 0.005
  - k7 range -0.002 - 0.012
  - BC vs. ATN slope
  - Angstrom exponent slope
  - BC and Angstrom exponent jumps at tape advance



BC vs. ATN method

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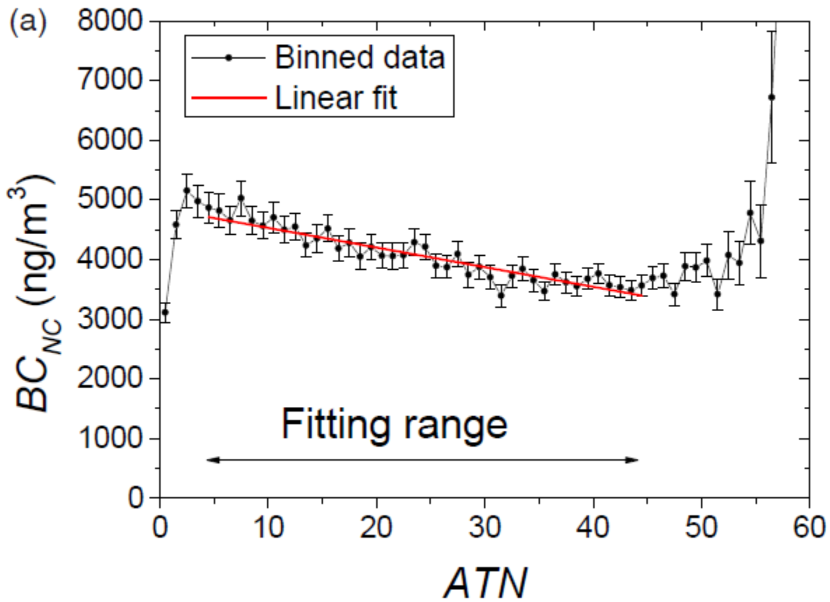
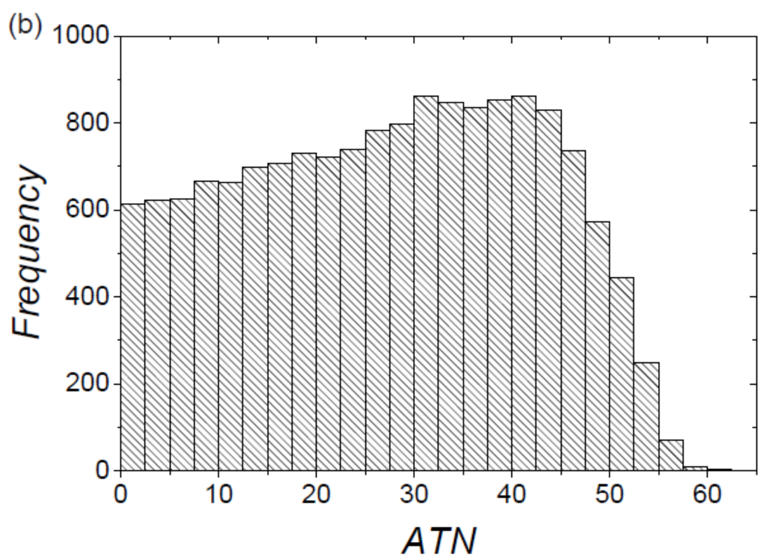
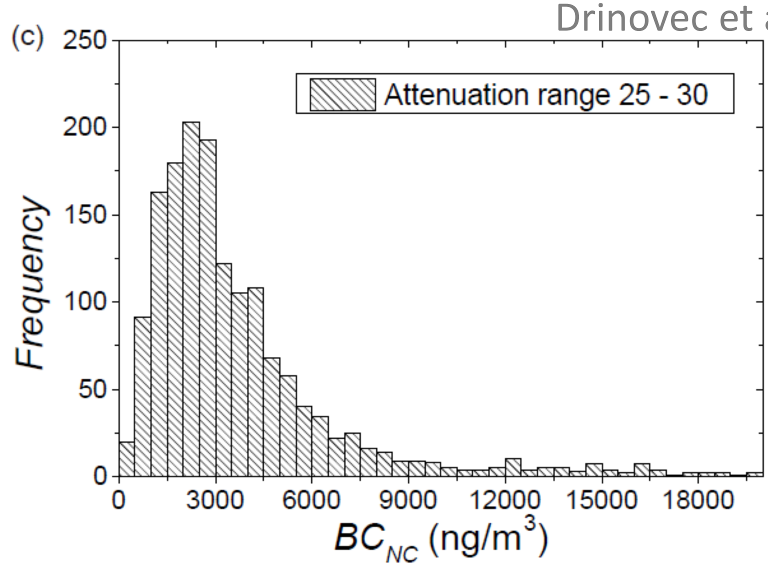


- Ambient campaign data 1-4 weeks
- Average BC in ATN bins
- Perform linear regression:
  $BC=BC_0*(1-k*ATN)$
- Check frequency of BC in ATN bins
- Check frequency distribution in single ATN bin

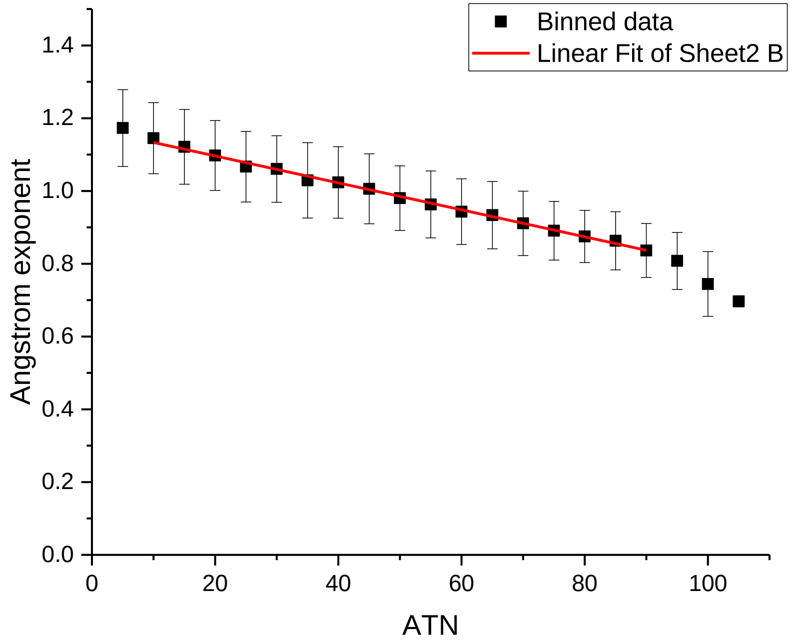
Drinovec et al., 2015

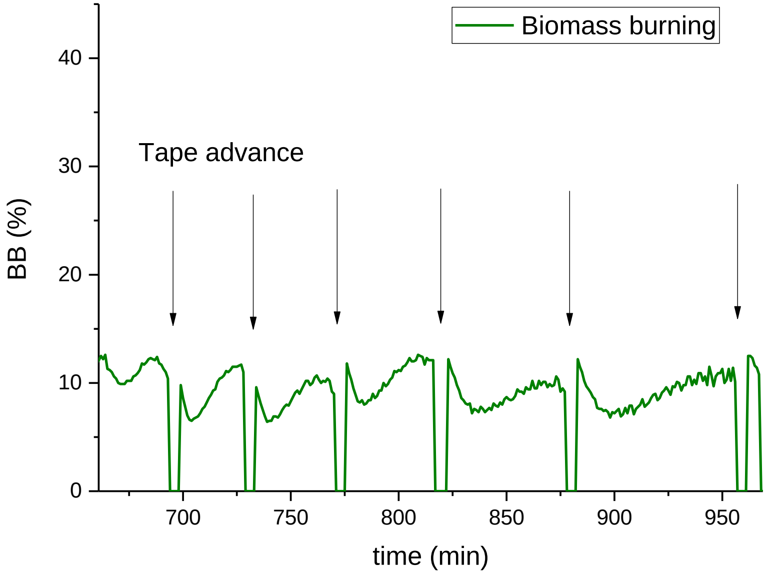




Angstrom exponent

- Angstrom exponent vs. ATN
- Jumps of Angstrom exponent at tape advance





Data evaluation – source apportionment

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Recalculation of biomass burning contribution

- For low BC concentation (need to average 15min or 1h BC)
- For different values of α_{ff} and α_{bb}

$$BB(\%) = \frac{100}{1 - \frac{1 - \left(\frac{BC7 * 7.19}{BC2 * 14.54}\right)\left(\frac{950}{470}\right)^{\alpha_{bb}}}{1 - \left(\frac{BC7 * 7.19}{BC2 * 14.54}\right)\left(\frac{950}{470}\right)^{\alpha_{ff}}}}$$

BC_{bb} = BC6*BB/100

BC_{tr} = BC6*(100-BB)/100

Instrument intercomparison - goals

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- Determine the quality of instrument data – initial state
- Service instruments (cleaning, flow calibration, ...)
- Determine the quality of instrument data – after service
- Determine variability between instruments
- Provide SOP to improve future data quality

Results from Indian intercomparison 2017

- Initial state of the instruments
- Instrument malfunction is revealed by the results of clean air test and flow verification.

Instrument	Initial state	Problem description/Observations
Ref 1		
Ref 2		
Ref 3		
GKP	low signal, loud pump, CT failure, FV failure	Dirty optical chamber (completly bloked)
M&G	low signal, FV failure	Dirty optical chamber, faulty pump
VJD	ST failure	Faulty 24V- 100mA fuse
AGRA	Low signal, high BC peaks, CT failure, FV failure	Dirty optical chamber (including a spider)
BLR1 / IISc1		OK
BLR2 / IISc2		OK
CHK	not operational	Blocked inlet fitting
DEL	CT failure, FV failure	Dirty optical chamber
TVM1	FV failure	Damaged light guide o-ring
KLU2	FV failure	Dirty optical chamber

Results from Indian intercomparison 2017

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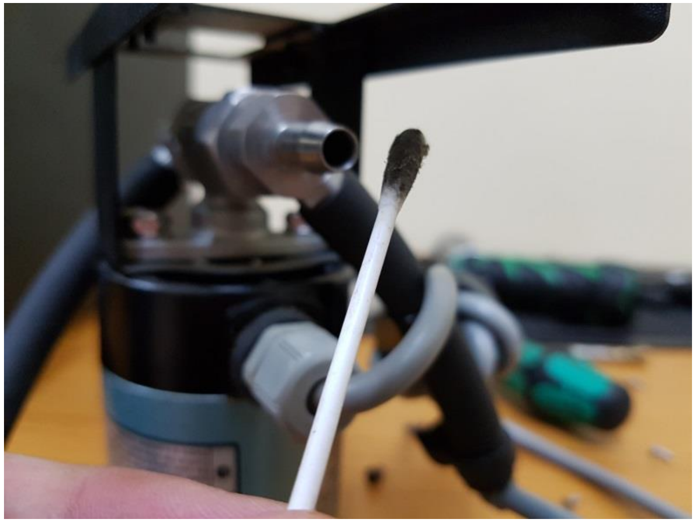
- Problems with contamination



Results from Indian intercomparison 2017

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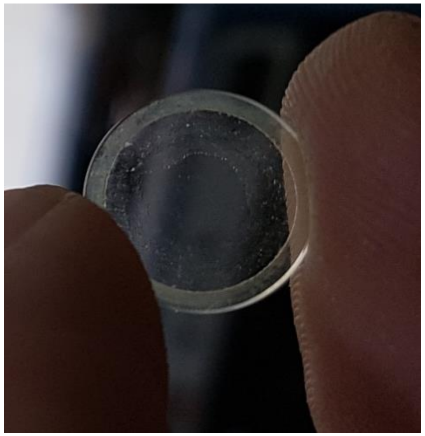
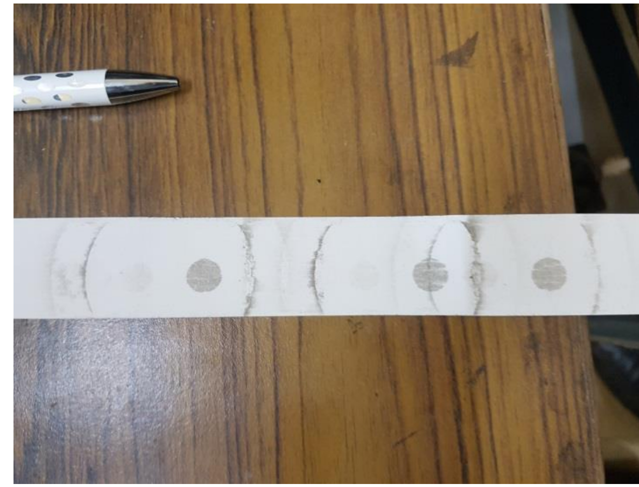
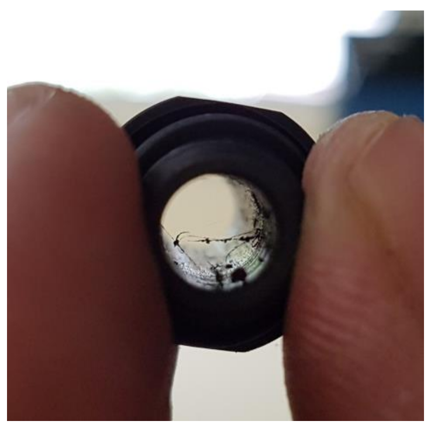
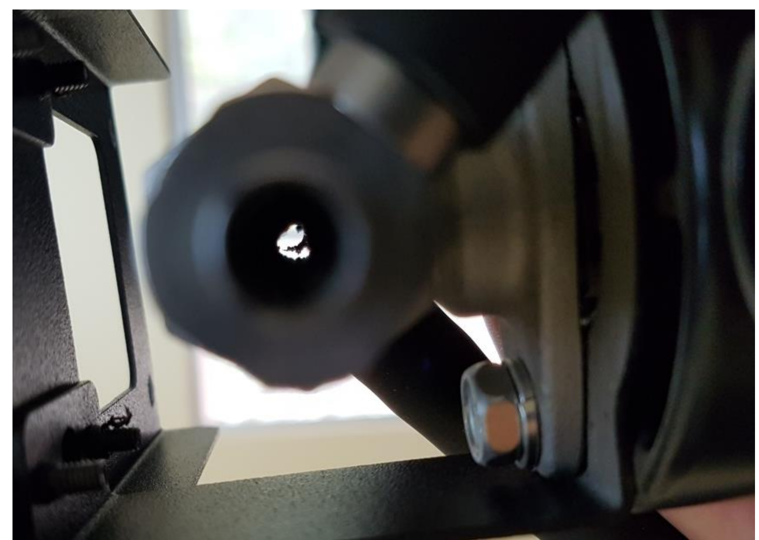
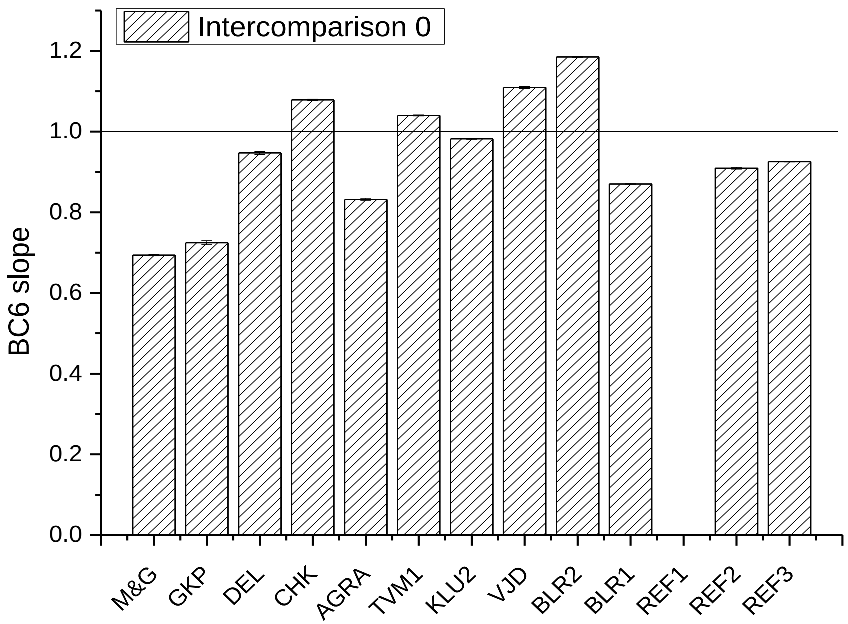




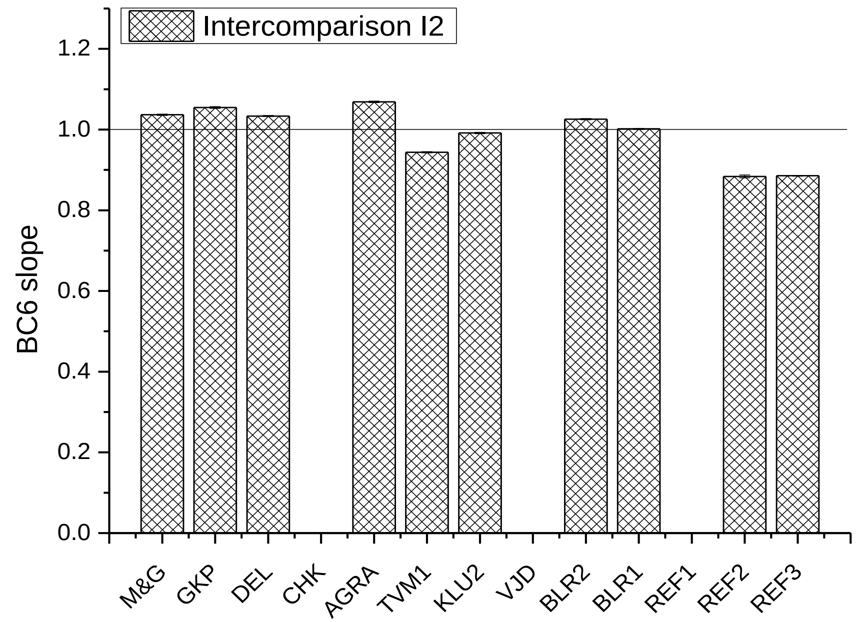



Results from Indian intercomparison 2017

Initial state



After service and calibration



Results from Indian intercomparison 2017

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Factors influencing quality of data

- Settings
- Installation
- Maintenance of Inlet & tubbing
- Maintenance of instruments
- Quality control tests
- Data evaluation

Recomended settings:

- Flow: 5 lpm; Can be decreased for highly polluted areas
- Flow rep. Std. The same for the whole network
- ATNmax: 120; Can be increased to 150 for highly polluted areas
- Timabase: 1 min
- DST: Off
- Time: IST or UTC
- Default values of the advanced settings

Maintenance of instruments

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Procedure	Frequency
Check the sample inlet flow	Once / month*
Verify time and date	Once / month
Inspect and clean the insect screen assembly	Once / month
Inspect and clean optical chamber	Once / month*
Change by-pass cartridge filter	When it is dark grey
Clean flow divider and ball valve (by expert only)	Once / year*
Verify flow (flow verification, flow calibration)	Once / 6 months
Clean Air Test	Once / 6 months
ND filter test	Once / year
Lubricate optical chamber sliders	Once / year

*Site dependent, use educated judgment!

Workshop: data quality assessment

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1. Instrument state

- Installation: inlet, insect screen, dryer
- Settings: ATNmax, flow rep. Standard, Timebase, C, ...
- Maintainance: Time and result of QA/QC tests, type of flow calibrator and the flow reporting standard

2. Data quality

- check for noise, spikes, etc.
- check compensation: BC vs. ATN, Angstrom exponent

3. Conclusions

- Is the data quality accaptable?
- Which procedures needs to be improved?

Thank you for your attention!

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