PAUL SCHERRER INSTITUT

PSI

Full talk will be presented next week at the Melpitz Campaign Meeting at TROPOS next week!

Joel C. Corbin, M. Gysel, et al. :: Laboratory of Atmospheric Chemistry :: Paul Scherrer Institut

BC concentrations & light absorption at the Melpitz site (6. May — 17. July 2015)

JRA1 ACTRIS2 :: Leipzig TROPOS 2015-11-06

PAUL SCHERRER INSTITUT

Section 1: BC mass

BC / Abn. Instruments @ Melpitz

- **"BC" measurements**
  - SP2 (refractory incandescent BC)
    - total mass; size distr; approx. coating; Time res. < 10 min
  - OC/EC
    - EUSAAR2 *(Gerald Spindler);* Time res. 24h
- **Absorption measurements**
  - Aethalometer
    - Abn from filter attenuation at 7 wavelengths
  - MAAP
    - Direct, reliable, filter-based measurement at 637 nm
  - CAPS PM_{SSA}
    - 450, 630, 780 nm. Extinction minus scattering method
  - CAPS PMex and neph
    - 450, 550, 660 nm. Extinction minus scattering method

How to compare these instruments?

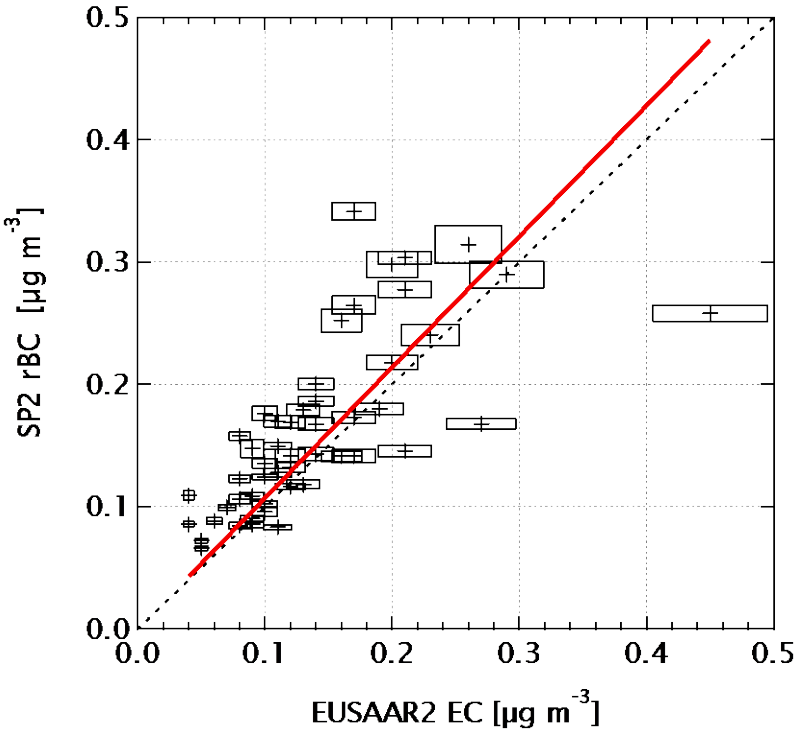
- We measure BC as
  1. How much carbon? (SP2 (rBC), EC, …) or
  2. How much absorption? (“eBC”)
- Effective BC (eBC) is the most common measurement, defined as [1] :

$$\mathrm{eBC} = \frac{b_{\mathrm{abs}}(\lambda)}{\mathrm{MAC}_{\mathrm{BC}}(\lambda, \mathrm{morphology})}$$

- …using:
  - $\mathrm{MAC}_{\mathrm{BC}}(637\ \mathrm{nm}, \mathrm{MAAP}) = 6.6\ \mathrm{g\ m^{-2}}$
  - $\mathrm{MAC}_{\mathrm{BC}}(880\ \mathrm{nm}, \mathrm{AE33}) = 7.77\ \mathrm{g\ m^{-2}}$
- So, next slides will compare:
  - BC measurements
    - How much carbon **or** how much eBC with standard MACs
  - BC absorption

[1] Petzold et al., ACP 2013

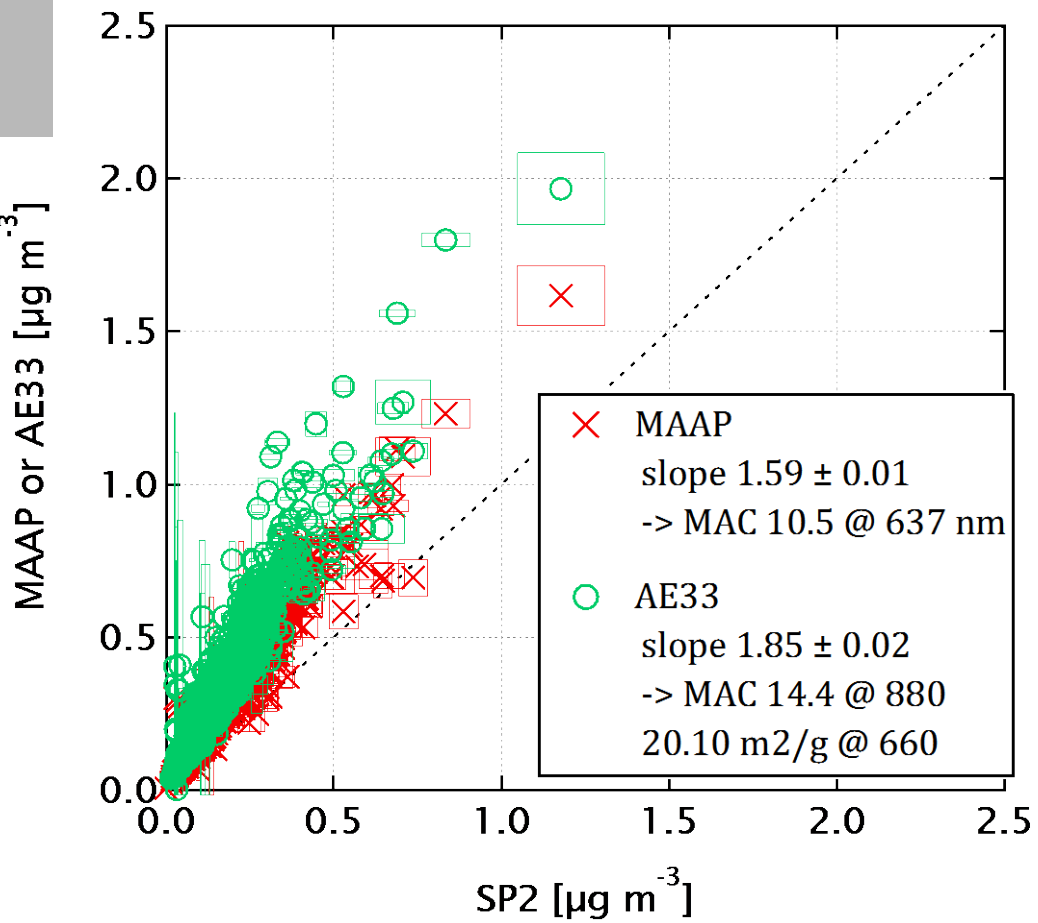
BC mass measurements at Melpitz



- Good agreement
  - Fit gives SP2 = 1.07*EC
- EC/OC = 5--10% *[2]*
  - BC mass fraction even less

1 day averages (EC) or 1 hour averages (size distribition)
Error bars == EC: 10%. SP2 + all others: S.D. of averaged data. [2] From Gerald Spindler

eBC mass concentrations at Melpitz



- eBC > rBC
  - ~1.7x more absorption than standard MAC values predict
  - Likely a coating effect
- MAAP MAC = 10.5 m2/g @ 637 nm
- AE33 MAC = 14.4 m2/g @ 880 nm
  - "Mass Attenuation Coeff.", not Mass Absorption Coeff

(1 hour means)

PAUL SCHERRER INSTITUT

PSI

Section 2: BC / PM absorption

PMssa Extinction Calibration

450 nm

– *PMssa = Extinction by CAPS, scattering by nephelom.*

➢ **CAPS extinction should not need calibration [1].** But comparing PSI's extinction ("PMssa") and TROPOS's ("PMex") CAPS-measured extinction:

- PMssa = 1.08*PMex at start
- PMssa = 1.16*PMex after some days
  - Changed suddenly: problem traced to pressure surge, mirror(s) dirtied
- PMssa = 1.05*PMex after mirror cleaning
  - Small particles were visible on mirrors
  - → All PMssa data were corrected so that PMssa = 1.05* Pmex

➢ **CAPS extinction is not calibration-free if mirrors contaminated.**

- What is the threshold for this effect?

[1] Kebabian et al., 2007; Massoli et al. AST 2008; Petzold et al., AST 2009

PMssa Neph. Calibration 450 nm

– *PMssa = Extinction by CAPS, scattering by nephelom.*

- Scattering (Sca) calibrated by scaling to extinction (Ext)
  - Scatterplot of particles with SSA=1 **or** gas-based ("zero / span", e.g. air / CO_2)
- *[450 nm]* Sca calib. **at Melpitz** with PSL
  gave 20% lower sca than Ecotech neph*, and zero absorption
- *[450 nm]* Sca calib. **at Melpitz** with CO_2 / air**
  gave 4% higher sca than Ecotech neph* and 'better' abn *(see next slide)*
- Is particle calibration fundamentally flawed?
  Sca calib. tests **at PSI** using CO_2 / N_2 **or** $(NH_4)_2SO_4$ particles suggest not.
  Relative to particle calib., gas calibs were lower by
  - 8% at 450 nm; 0.2% at 630 nm; 3% at 780 nm
- Inference: PSL calibrations at Melpitz were experimentally flawed.
  - Ambient air was used (NO_2 / gas abn.), PSL clusters cannot be ruled out.
  - Ext. bias due to gases & greater truncation at 450 nm*** are likely causes.

**Ecotech neph. data not yet truncation corrected / quality controlled!*

***At the time of calibration, [NO_2] ~ 2 ppb. Inferred interference is < 5%. No correction made.*

****Although a DMA was used, doublets / multiply charged particles are suspected [Ardon-Dryer, 2015]*

Summary

- **MAC(MAAP)** and **MAC(AE)** for **BC** at Melpitz were higher than manufacturer's values for those instruments.
  - As expected, for lensing by thick coatings (to be quantified)
  - Stable over time
- 450 nm CAPS PMssa
  - Extinction/scattering stable for a given mirror cleanliness
  - Mirror contamination may significantly bias extinction
  - Calibration 'challenged' by gas absorption (NO_2) and truncation
    - Same for measurement: local NO_2 sources (rapid changes in background) will cause issues.
  - 5% difference in extinction measurement between CAPS instruments
    - Gives 0.05 change in SSA
    - Gives 50% change in abn coefficient, for high-SSA aerosols
- 630 + 780 nm CAPS PMssa are likely easier reliable as gas absorption and truncation are less important. Work in progress.

More Questions?

- Joel Corbin will be happy to tell you more. (joel.corbin@psi.ch)
- On Wednesday, Marco Zanatta will present a MAC value climatology