Wood-smoke in PMinter sites determined by the Aethalometer model

winter 2010 - 2011

PMinter

Klagenfurt, 18 October 2011

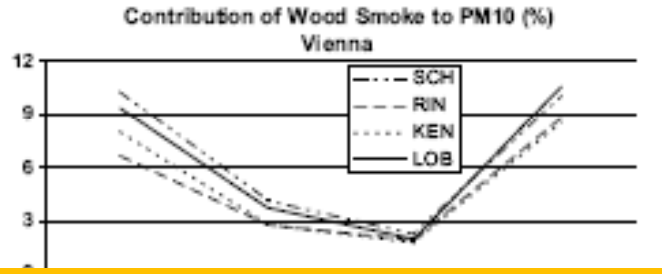
Griša Močnik

Aerosol d.o.o.

grisa.mocnik@aerosol.si

Wood-smoke – part of PM10

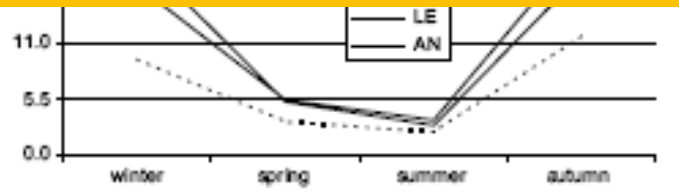
- **<u>rural areas</u>** (small villages in Lower Austria, Styria, Carinthia, Burgenland and Salzburg):



Up to 40% of all particulate matter is wood-smoke!

Woodsmoke is a local and regional air quality problem!

annual average	5 - 16%	9 - 20%
winter	8 - 22%	13 - 28%



Aerosol

Aquella, TUW; A. Caseiro et al. / Atmospheric Environment 43 (2009) 2186–2195

Advantages / Attributes of Optical Analysis

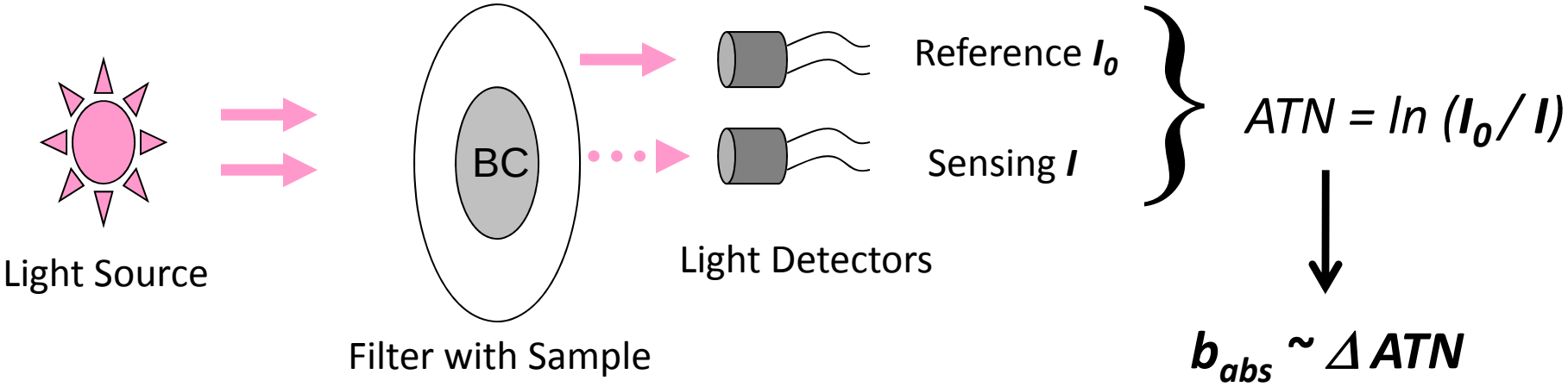
Typical **chemical speciation** time resolution – hours, **day**!

Optical methods – minute!

- Instantaneous
- Non-destructive
- Mobile / Portable
- Added dimension - *time*
- Added dimension – *wavelength*

Aerosol

Optical Analysis Method for Black Carbon



Analytical Instrument : Aethalometer™

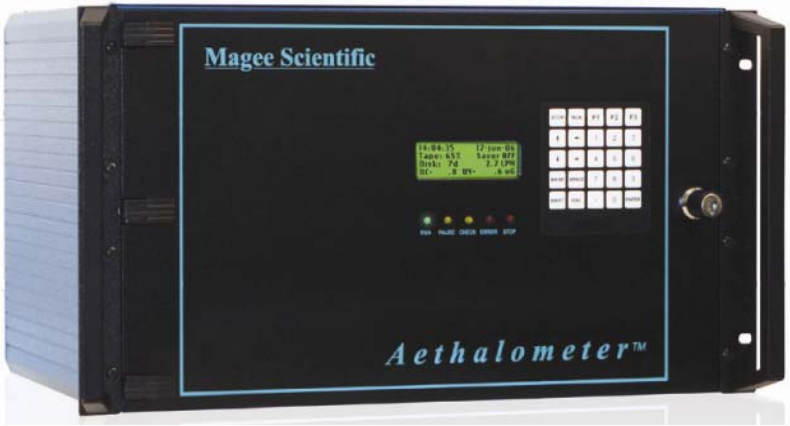
- Collect sample **<u>continuously</u>**.
- ***Optical absorption*** ~ change in ATN.
- Measure optical absorption <u>continuously</u> :
  optical wavelengths from 370 nm to 950 nm.
- Convert ***optical absorption*** to ***concentration of BC:***

$$BC\,(t) = b_{abs}\,(t) / \sigma$$

- Real-time data: 1 s / 1 min / **5 minutes**
  - *<u>Dynamical, real-time measurement, updated each period</u>*

Aerosol

Aethalometer – Continuous rack mount instruments

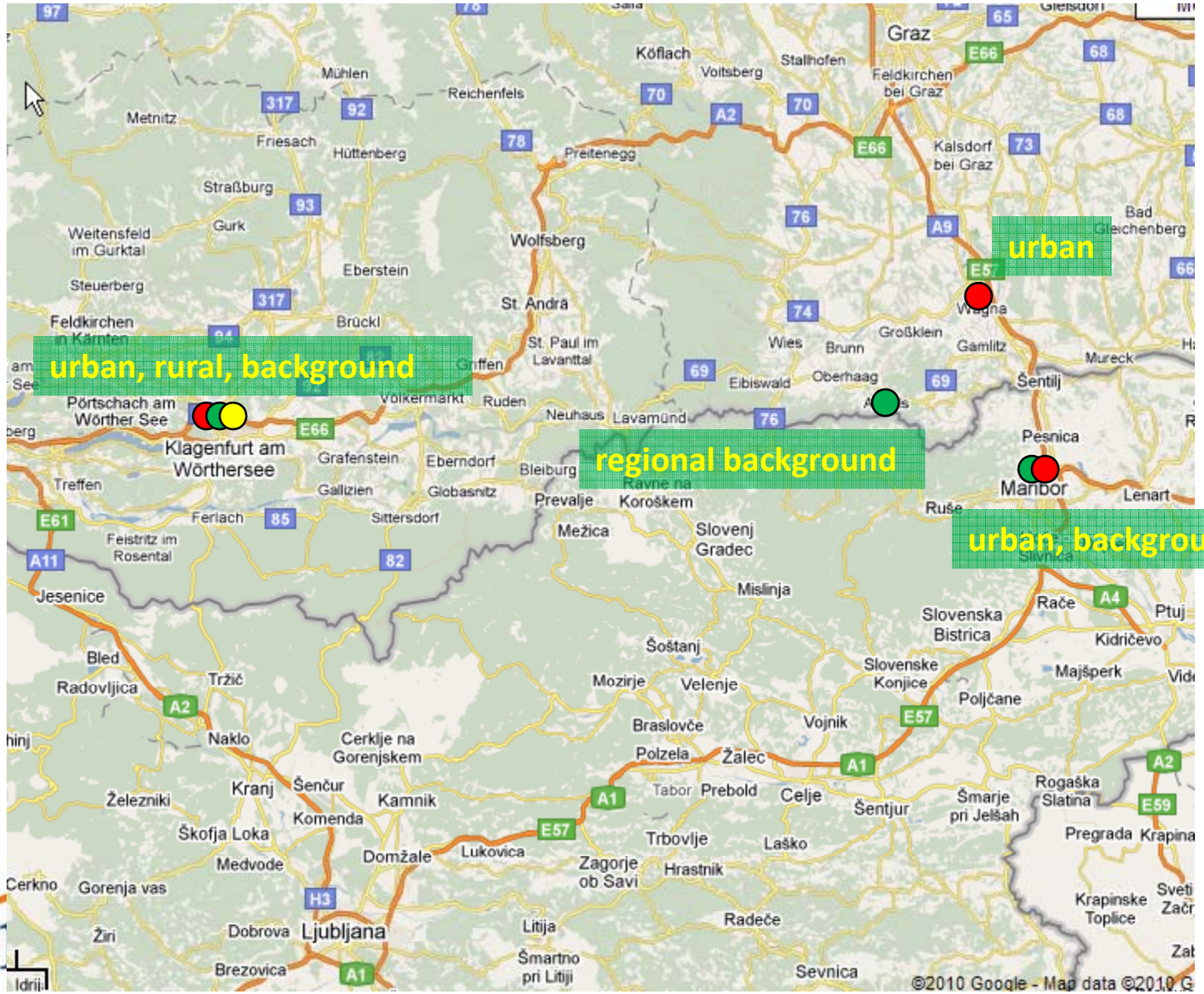


AE31 Spectrum – Ambient Air Quality Monitoring

- ✓ ***Seven wavelength (370, 470, 520, 590, 660, 880, and 950 nm)***
- ✓ ***Local source identification***
- ✓ ***Regional, Continental, Global Atmospheric studies***
- ✓ ***Particle size distribution, radiative transfer***
- ✓ ***Climate change, albedo, cloud modification***

Aerosol

PMinter *Aethalometer* Installations



Instrumentation

Aerosol light absorption:
Aethalometer AE31-ER

- 7 wavelengths: 370, 470, 520, 590, 660, 880, 950 nm
- flow 4 LPM
- absorption coefficient b_{abs} - compensation for loading and scattering
- Angstrom exponent α from $b_{abs}(\lambda)$

5 min time resolution

OC / EC filter analysis:
Sunset T-O Carbon Aerosol analyzer

- 24 h quartz filters, 16,7 LPM
- EUSAAR-2 protocol, others?

1 day time resolution

PM10:
TEOM (FDMS), beta gauges
Reference method
Intercomparison?

1 day, 1 hour time resolution

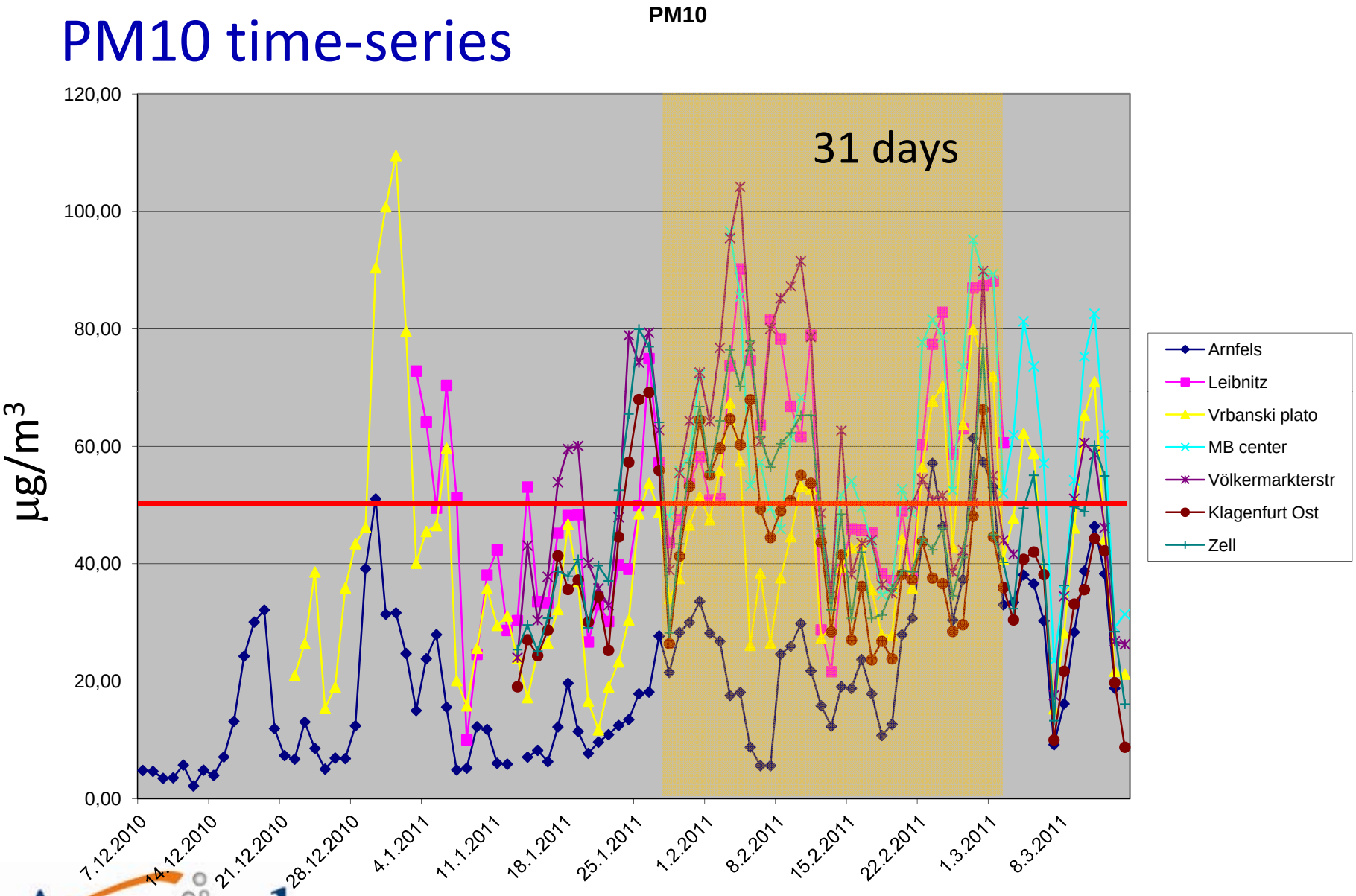
Aerosol

Installation dates

Klagenfurt	8 Nov 2010	ongoing
Hauptmann-Hermann Platz	17 Mar 2011	8 Apr 2011
Zell	8 Nov 2010	ongoing
Klagenfurt background	8 Nov 2010 8 Apr 2011	17 Mar 2011 9 May 2011
Leibnitz	4 Nov 2010	ongoing
Arnfels	4 Nov 2010	ongoing
Maribor center	21 Oct 2010	ongoing
Vrbanjski plato	14 Jan 2011	ongoing

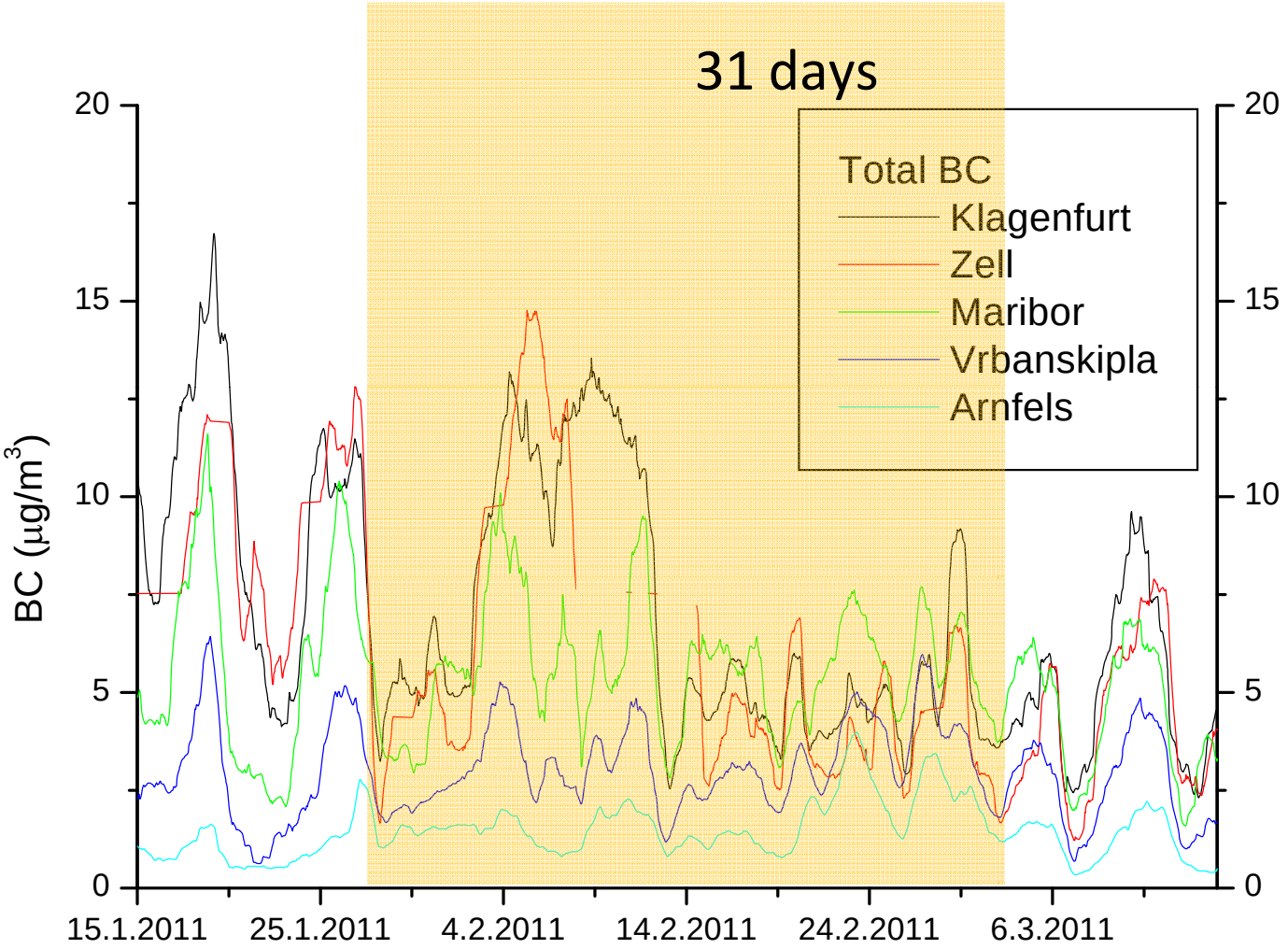
Aerosol

PM10 time-series

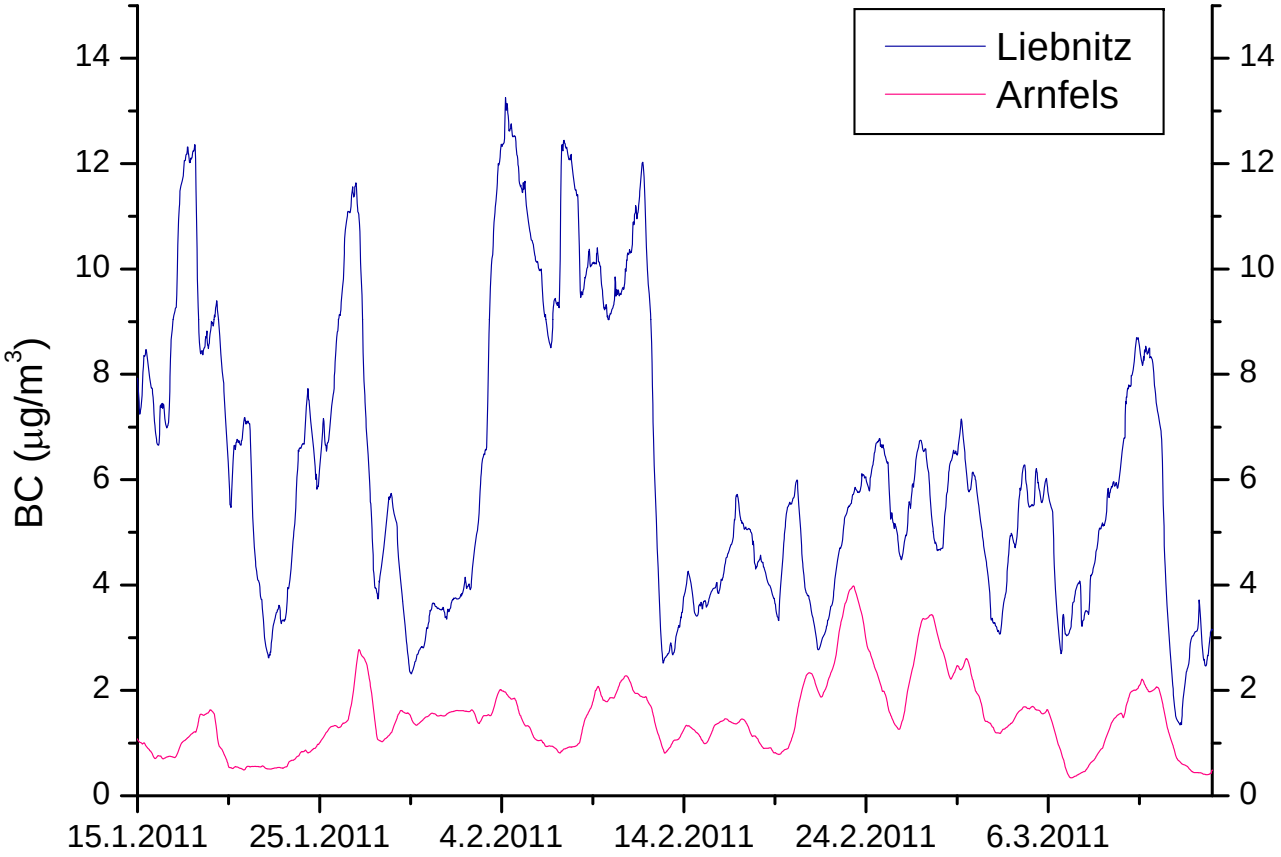


Source: PMinter partners, subcontractors

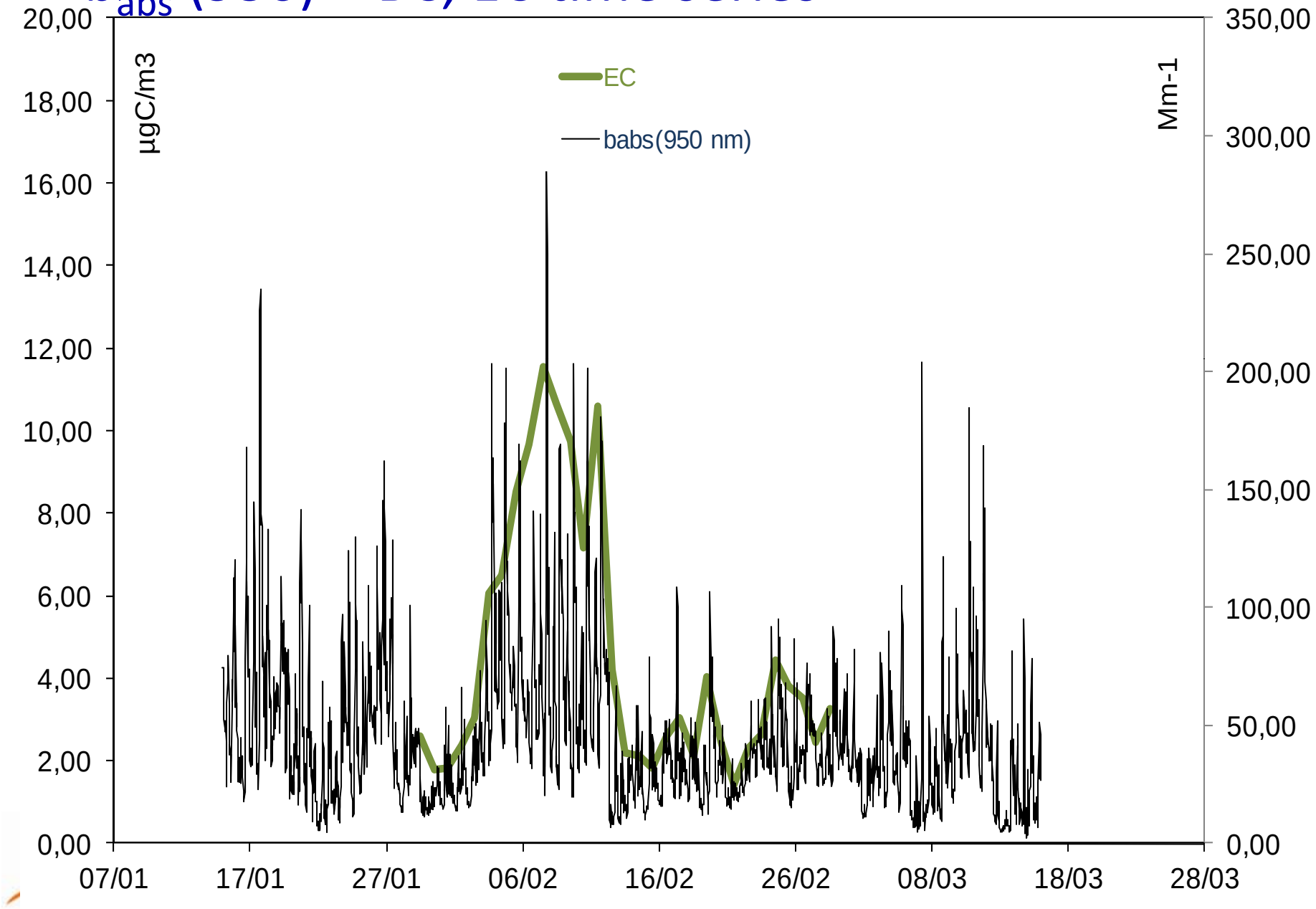
BC time-series (15 Jan – 15 Mar 2011)



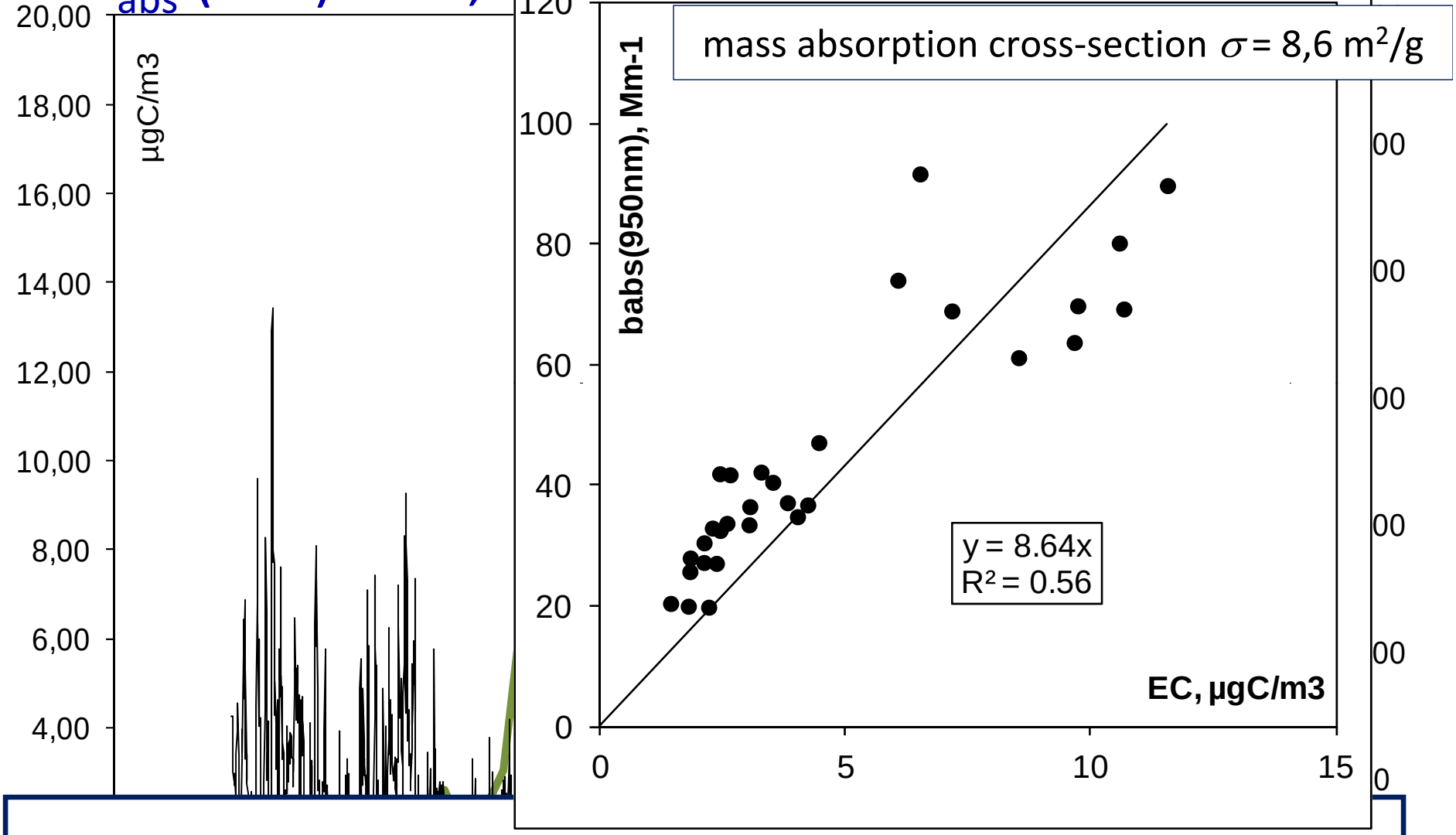
BC time-series. Leibnitz & Arnfels



b_{abs} (950) ~ BC, EC time series



b_{abs} (950) ~ BC, E



Good agreement between thermal EC and optical BC!

From Black&White to Color

Wood-smoke vs. diesel

- measure attenuation with the Aethalometer: UV-IR
- calculate absorption coefficient $b_{abs}(\lambda)$
- for completely **black sample**: $b_{abs} \sim 1/\lambda$
- woodsmoke contains aromatic substances – increased absorption: more at **lower wavelengths**!

Aerosol

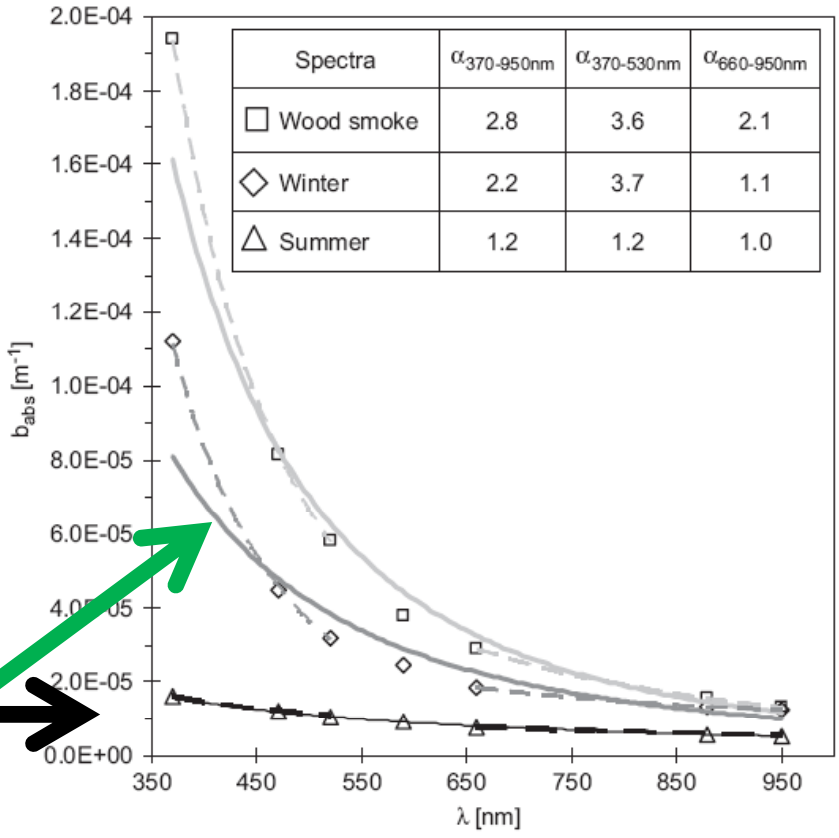
Wood-smoke vs. diesel - 7λ

- measure attenuation with the Aethalometer
- absorption coefficient - b_{abs}
- for pure black carbon: $b_{abs} \sim 1/\lambda$
- generalize **Angstrom exponent**:

$$b_{abs} \sim 1/\lambda^{\alpha}$$

diesel: $\alpha \approx 1$

wood-smoke: $\alpha \approx 2$ and higher



J. Sandradewi et al., A study of wood burning and traffic aerosols in an Alpine valley using a multi-wavelength Aethalometer, Atmospheric Environment (2008) 101–112

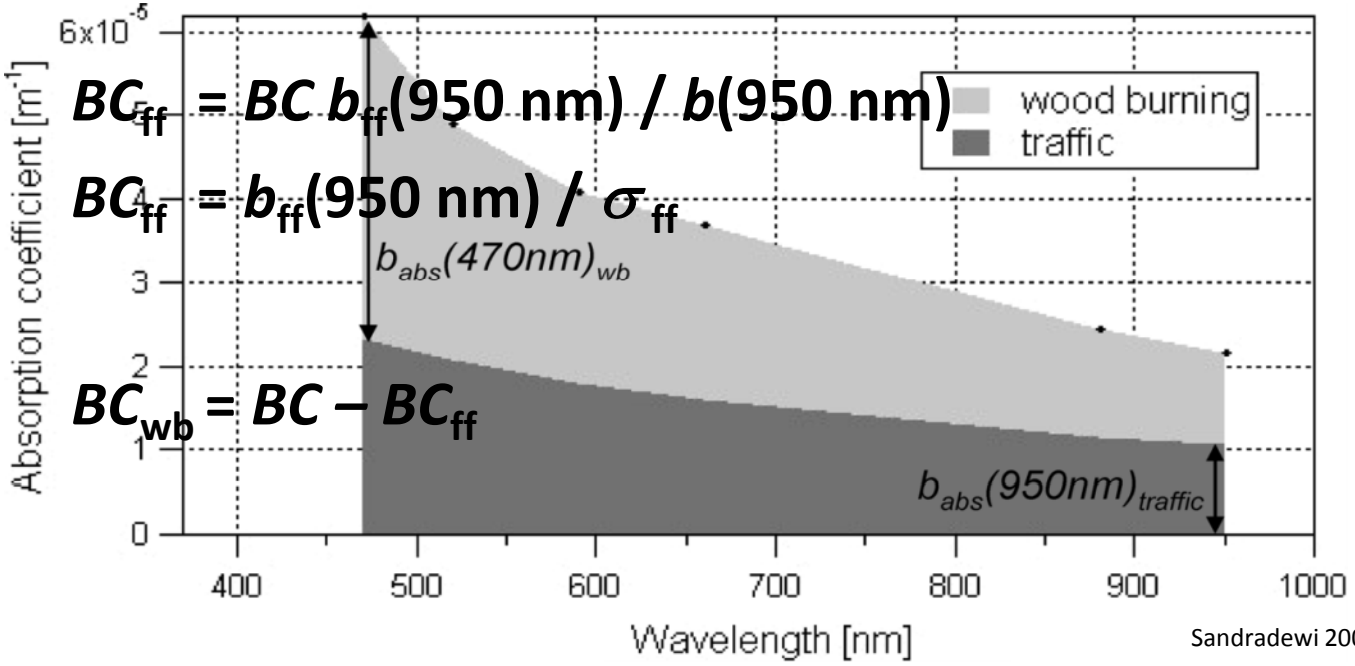
Quantification

$b(\lambda) = b(\lambda,\text{wood}) + b(\lambda,\text{fossil})$ λ = 470 nm, 950 nm

$b(470\text{ nm}) / b(950\text{ nm}) = (470\text{ nm} / 950\text{ nm})^{-\alpha}$

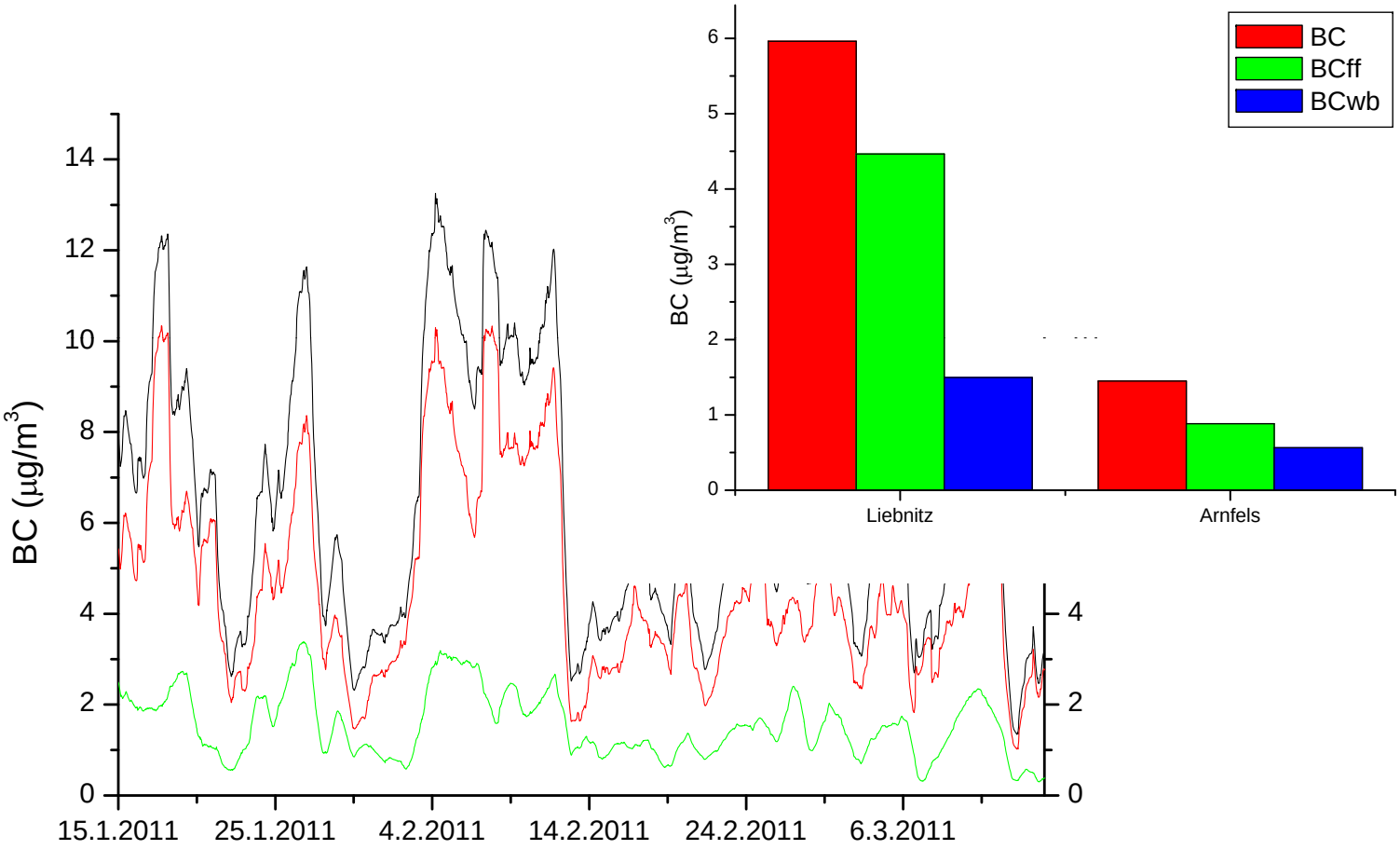
$\alpha = 1{,}0 \pm 0{,}1$ (fossil) Bond & Bergstrom 2004 .

$\alpha = 2{,}0\ -0{,}5/+1{,}0$ (wood) Kirchstetter 2004, Day 2006, Lewis 2008

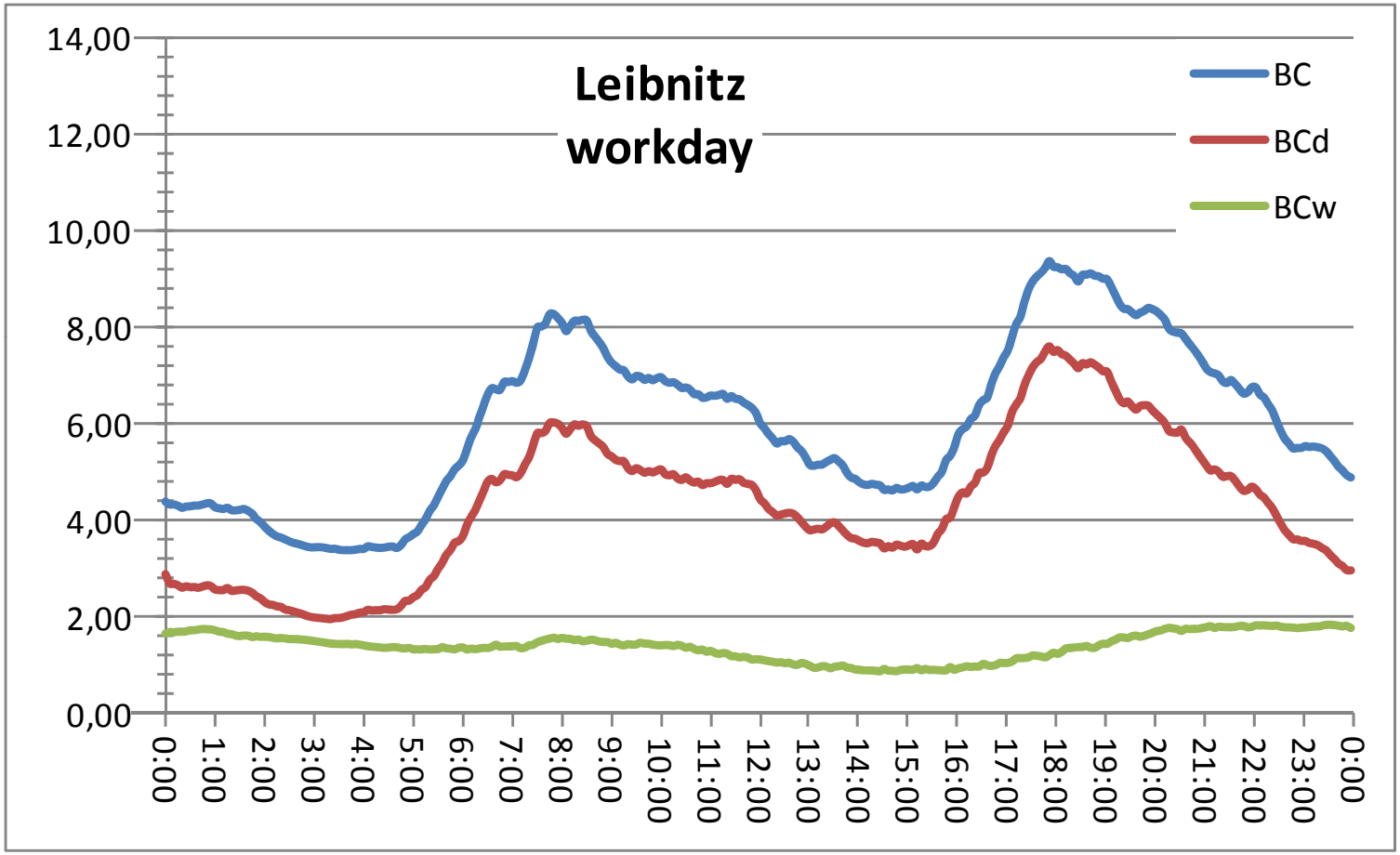


Sandradewi 2008

BC_{ff}, BC_{wb} time series

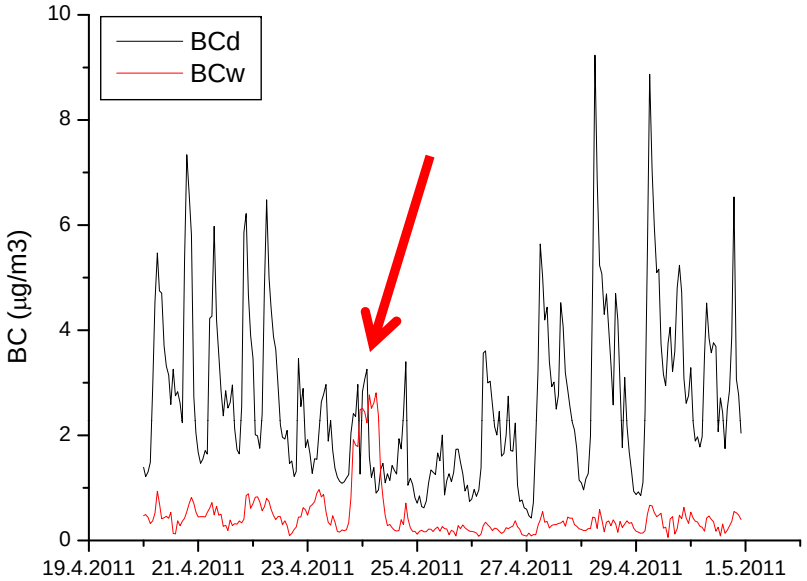


BC_{ff}, BC_{wb} – diurnal

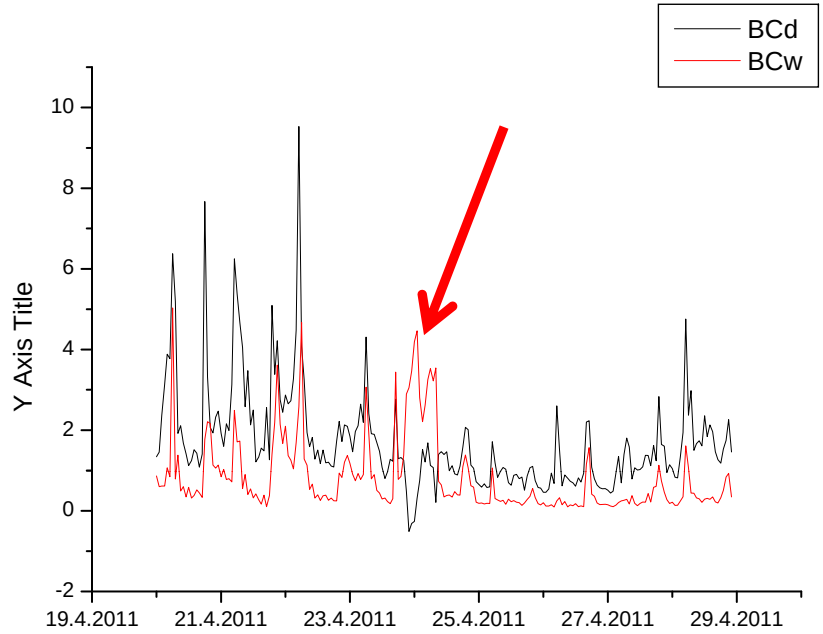


Aerosol

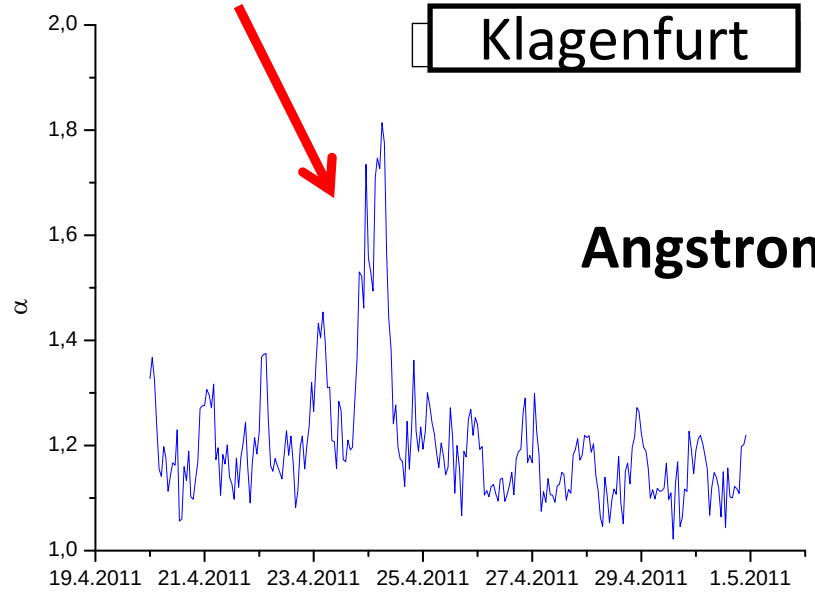
Easter bonefires!



BC

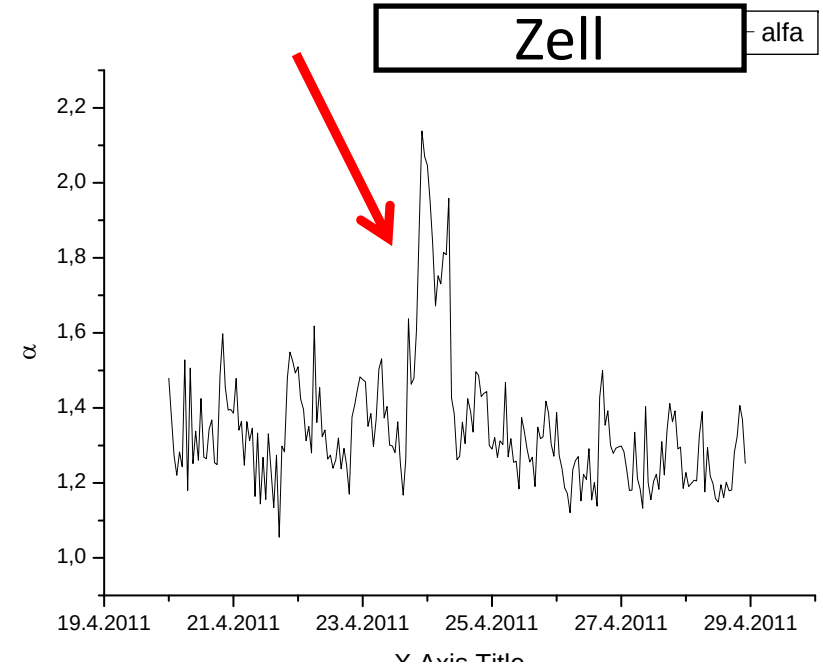


Klagenfurt



Angstrom exp

Zell



What about all CM?

- OC/EC with 24 h time resolution
- Carbonaceous matter (CM)
  - CM: sum of fossil fuel & wood-burning contributions
  - Determine contributions from Aethalometer & OC/EC data – 24 h resolution
  - Apply contributions to 30 min Aethalometer data
  - Time series, diurnal variation for **CM ff & wb** – 30 min resolution

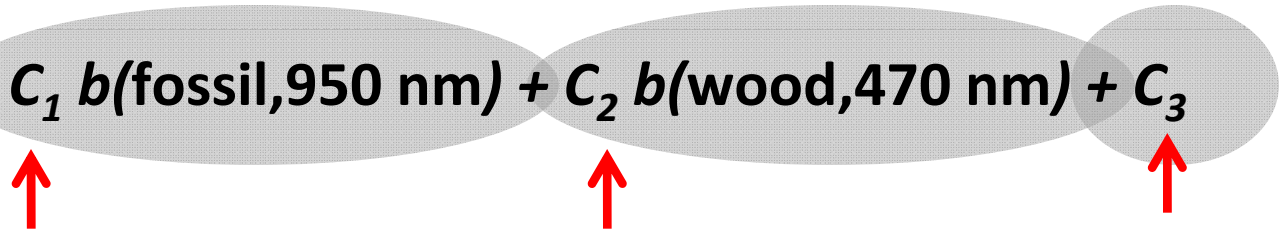
Aerosol

Carbonaceous matter – details and example

measure Total Carbon – 24 h resolution

CM = TC = OC + EC

$$CM = C_1\, b(\text{fossil}, 950\ \text{nm}) + C_2\, b(\text{wood}, 470\ \text{nm}) + C_3$$



fossil fuel combustion BrC containing – wood combustion non-combustion sources

CM = BC + OM

C_1, C_2, C_3 determination

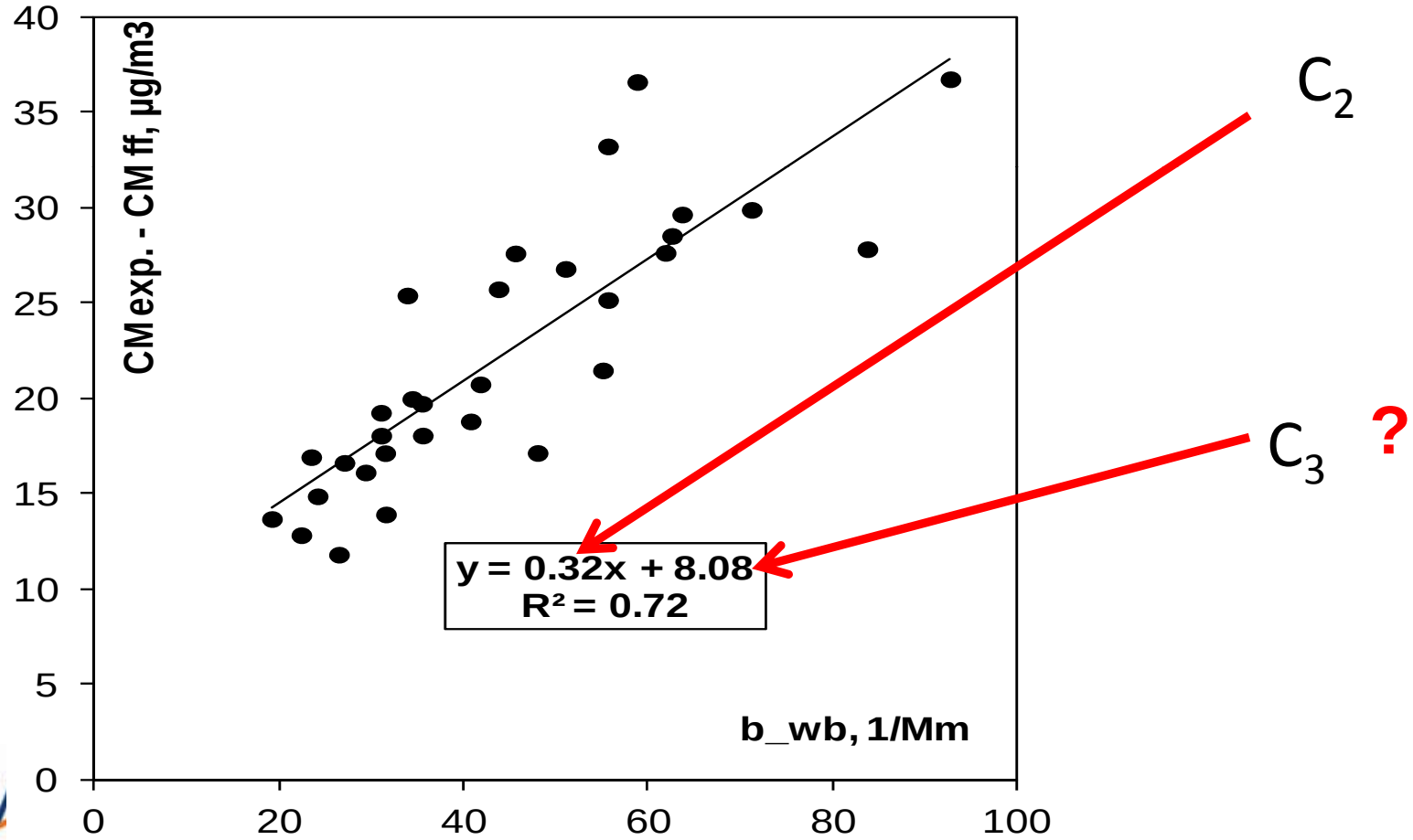
- C_1 is less variable than C_2 and C_3 and fixed to 290.000 (Sandradewi 2008, Favez 2009, Favez 2010)
- C_2 and C_3 determined from (CM-CM_{ff}) vs. CM
- determine CM_{ff} from

$$\boldsymbol{CM_{ff} = BC_{ff} + OM_{ff}}$$

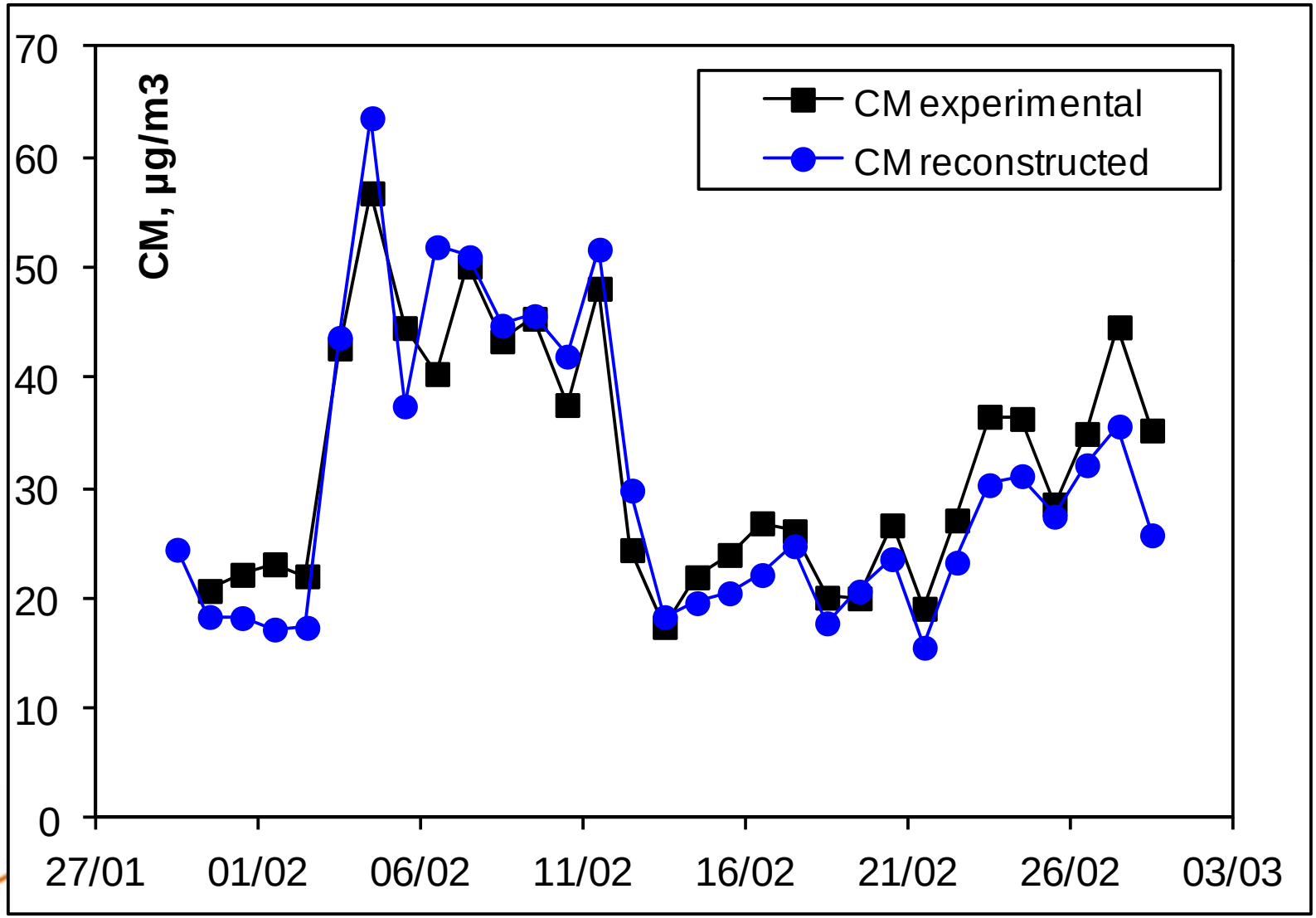
$$\left.\begin{array}{l} \boldsymbol{BC_{ff} / OC_{ff} = 1} \\ \boldsymbol{OM_{ff} = 1{,}8\ OC_{ff}} \end{array}\right\}$$ supported by ambient and emission studies

C_2, C_3 determination (2)

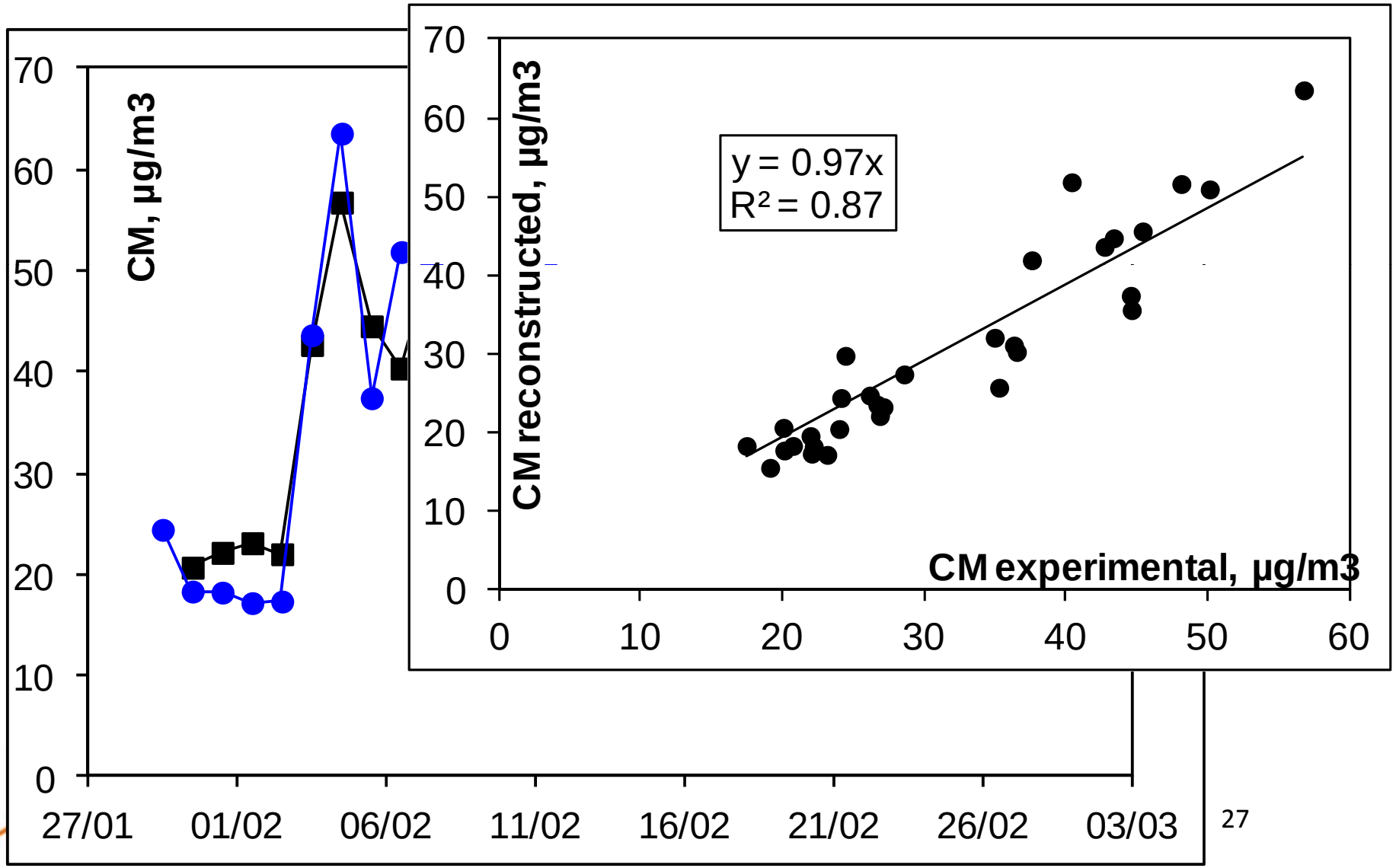
$$CM = C_1\, b(\text{fossil},950\text{ nm}) + C_2\, b(\text{wood},470\text{ nm}) + C_3$$



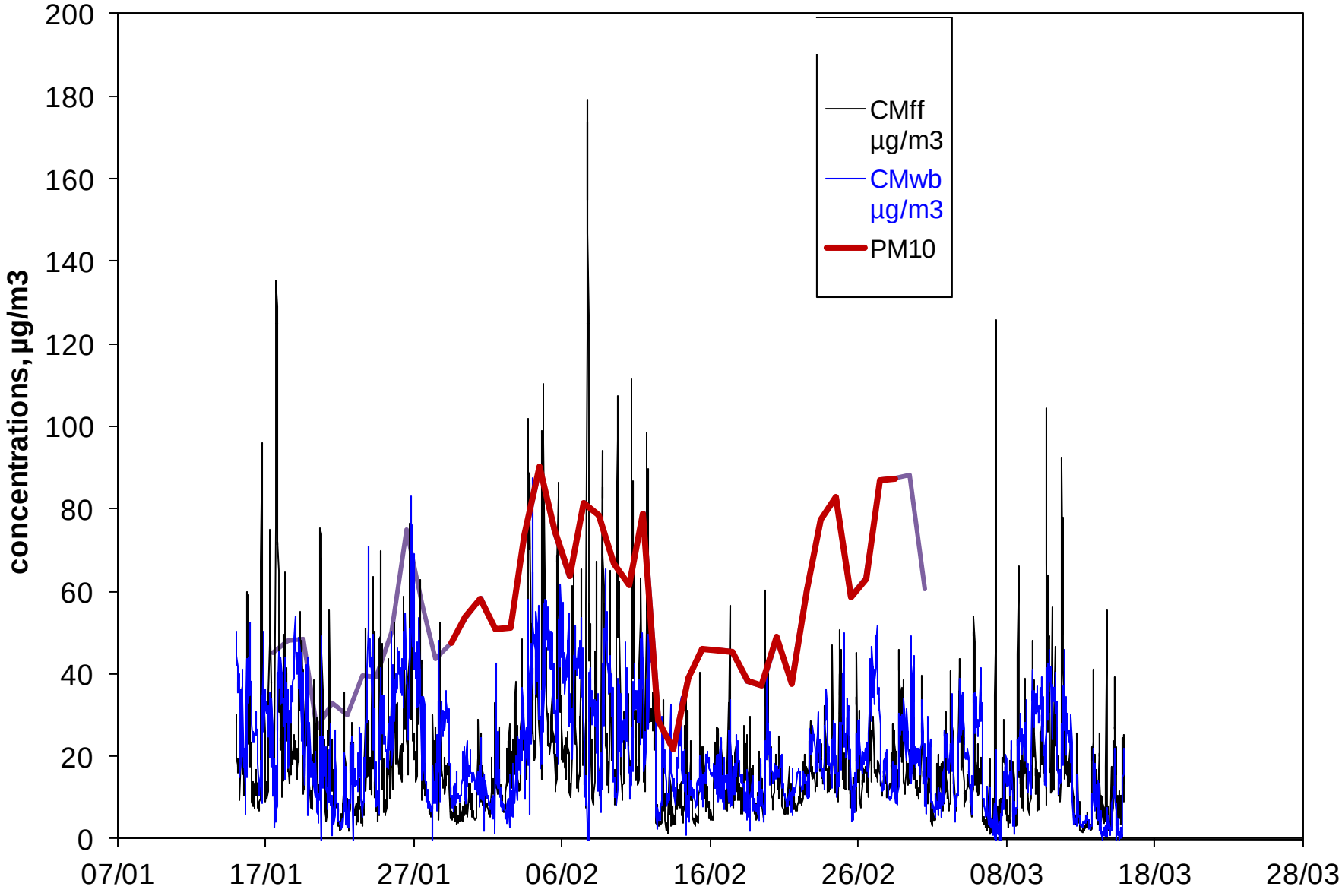
CM reconstruction using C_i



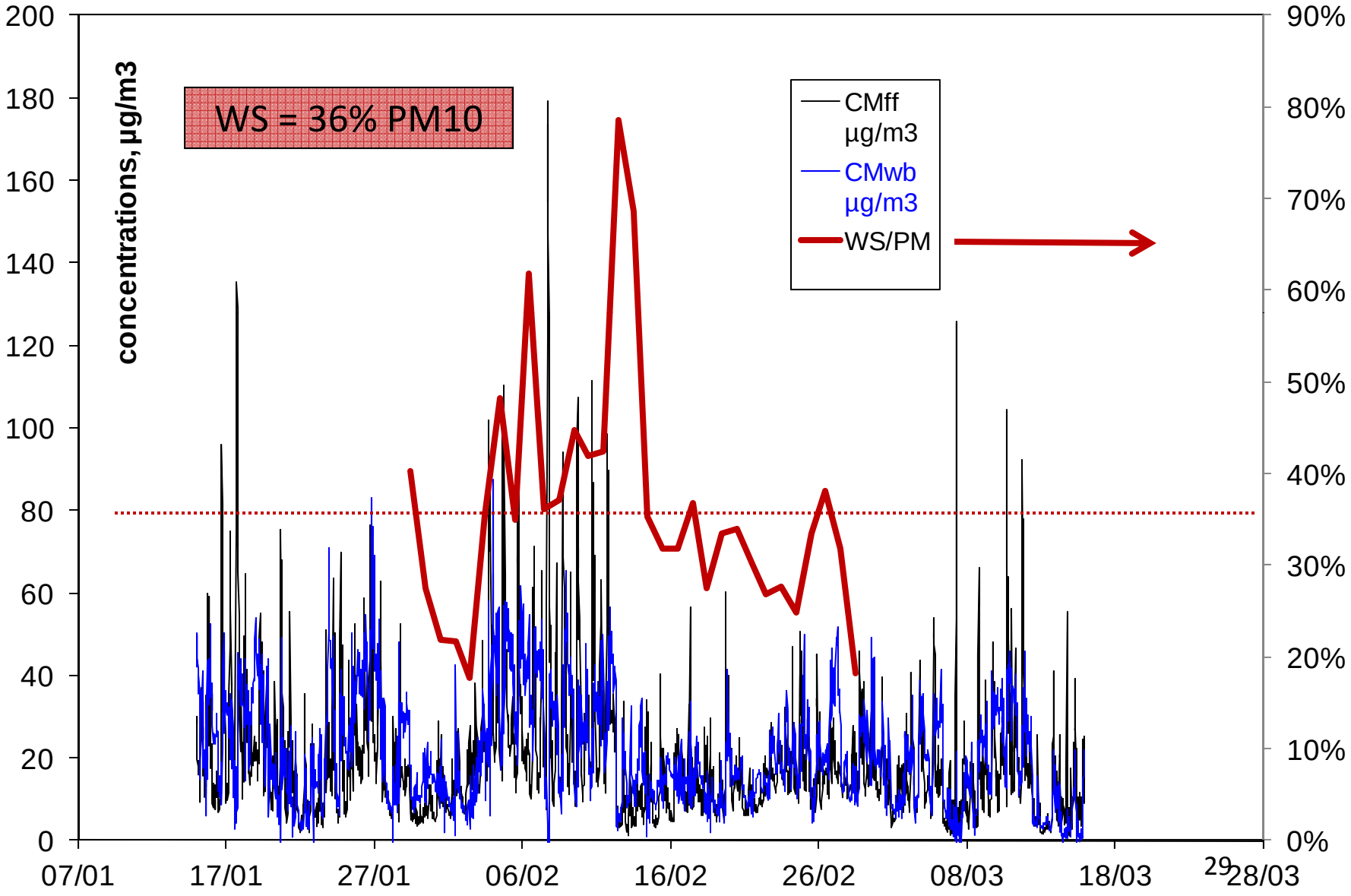
CM reconstruction using C_i



CMff, CMwb – **preliminary results** in Leibnitz



WS/PM10 – **preliminary results** in Leibnitz



Conclusions

- we can measure **fossil fuel** and **wood-smoke Black Carbon** with the Aethalometer: less BC from wb than ff
- time resolution is **5 min for BC and 30 min for CM**
- we can investigate **time evolution** of WS during the day: example Leibnitz – about the same CMff and CMwb
- Quantitative wood-smoke and diesel exhaust determination – use 24 h TC calibration, Aethalometer -> high time resolution
- All this for all PMinter sites

Aerosol

How do we verify / validate the determination of C_i?

- examine the influence of Angstrom exponents, assumptions, sensitivity analysis
- thermal protocol?
- measurements of woodsmoke specific markers: levoglucosan, K^+
- measurements of C14 – new vs. old carbon
- all PMinter stations: Klagenfurt basin (3), Leibnitz, Arnfels, Maribor, Vrbanjski plato

Aerosol

Data request and campaign planning

- PM10 data (+any chemistry: ions...) for Jan, Feb 2010 for all sites: 24h and hourly
- Winter 2011/2012 campaign: installation of new Aethalometers AE33

Thank you for your attention!

Questions?

Aerosol d.o.o.
Kamniška 41
SI-1000 Ljubljana
Slovenia

tel: +386 59 191 220
fax: +386 59 191 221

grisa.mocnik@aerosol.si