Source Apportionment of Carbonaceous Aerosols and Other Pollutants in Central Europe

Spatial and temporal variations of black carbon, carbonaceous aerosols and co-emitted pollutants depend on the sources – results of Central European campaigns

Duisburg, 5 March 2013

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MGRT(MVZT)/EUREKA Eurostars E!4825, FC Aeth

MGRT (MVZT) JR-KROP 3211-11-000519

Mestna občina Maribor, Nova Gorica, Celje, Klagenfurt, PMinter - SI-AT 2007-2013

CEA-ARRS, bilateral project BI-FR/CEA/10-12-006.

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Investing in your future
Operation Part Financed By The European Union
European Social Fund

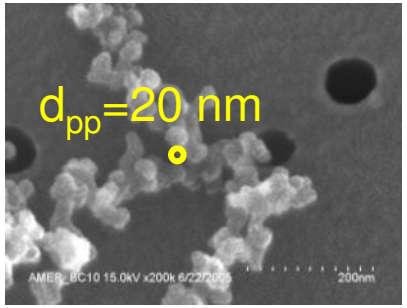
Aerosol Black Carbon

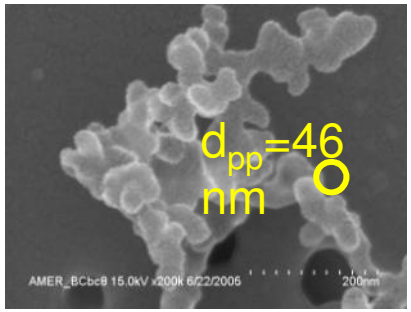
- BC is a **primary** product of incomplete **combustion**
- BC not automatically related to CO_2 emission
- BC emissions can not be predicted:

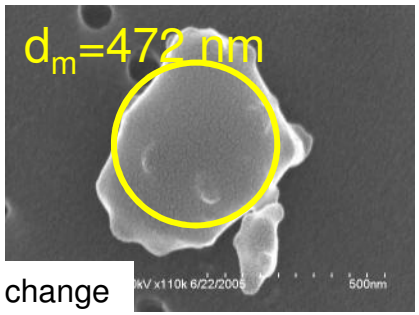
  must be measured

- BC particles from different sources can have different characteristics that produce different effects in the atmosphere:

  (Coal/Diesel/Biomass, USA/Asia/Europe)







Note change in scale

Advantages / Attributes of Optical Analysis

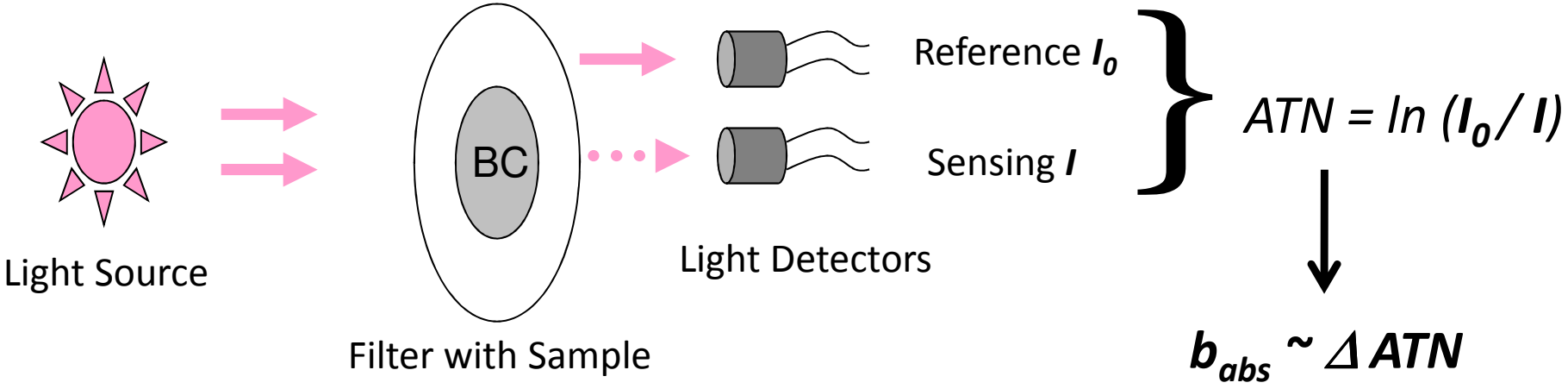
Typical **chemical speciation** time resolution – hours, **day**!

<u>Optical methods – minute!</u>

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

Aerosol

Analytical Instrument : Aethalometer™

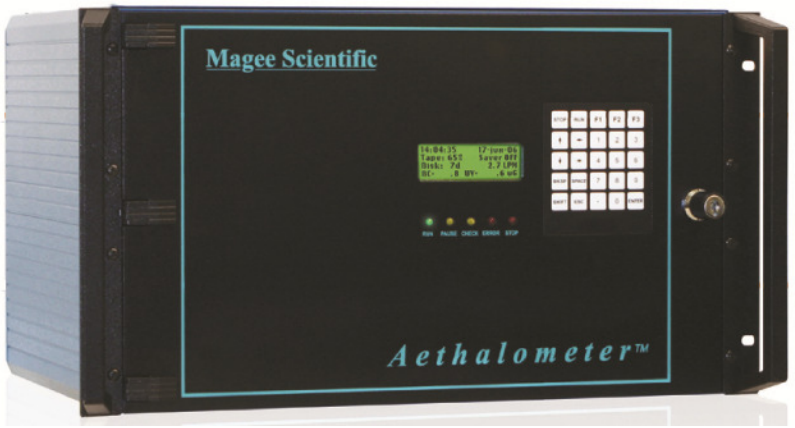


- Collect sample **<u>continuously</u>**.
- ***Optical absorption*** ~ change in ATN.
- Measure optical absorption <u>continuously</u> : λ = 370 to 950 nm.
- Convert ***optical absorption*** to ***concentration of BC:***

$$BC\ (t) = b(t) / \sigma$$

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

Aethalometer – Continuous rack mount instruments



AE31 Spectrum – Ambient Air Quality Monitoring

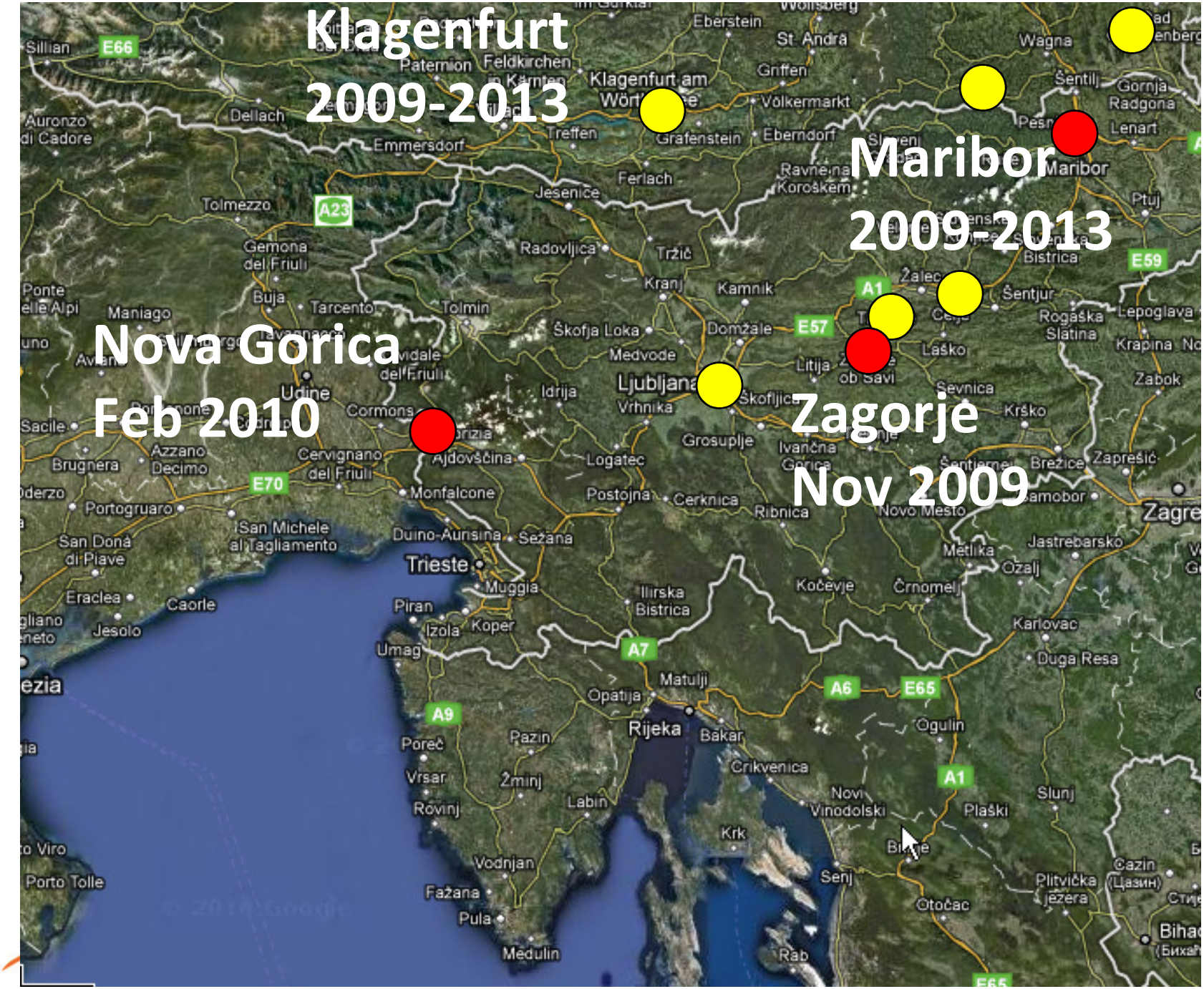
- ✓ ***Seven wavelength (370, 470, 520, 590, 660, 880, and 950 nm)***
- ✓ ***Local source identification***
- ✓ ***Regional, Continental, Global Atmospheric studies***
- ✓ ***Particle size distribution, radiative transfer***
- ✓ ***Climate change, albedo, cloud modification***

Aerosol

The Aethalometer Model AE33

EUREKA/Eurostars FC Aeth E!4825

The Eurostars Programme is powered by
EUREKA and the European Community


Klagenfurt
2009-2013
Maribor
2009-2013
Nova Gorica
Feb 2010
Zagorje
Nov 2009
Ljubljana
Trieste
Rijeka
Udine
Klagenfurt am
Maribor
Celje
Kranj
Škofja Loka
Domžale
Postojna
Koper
Izola
Piran
Pula
Zagreb

Site and 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

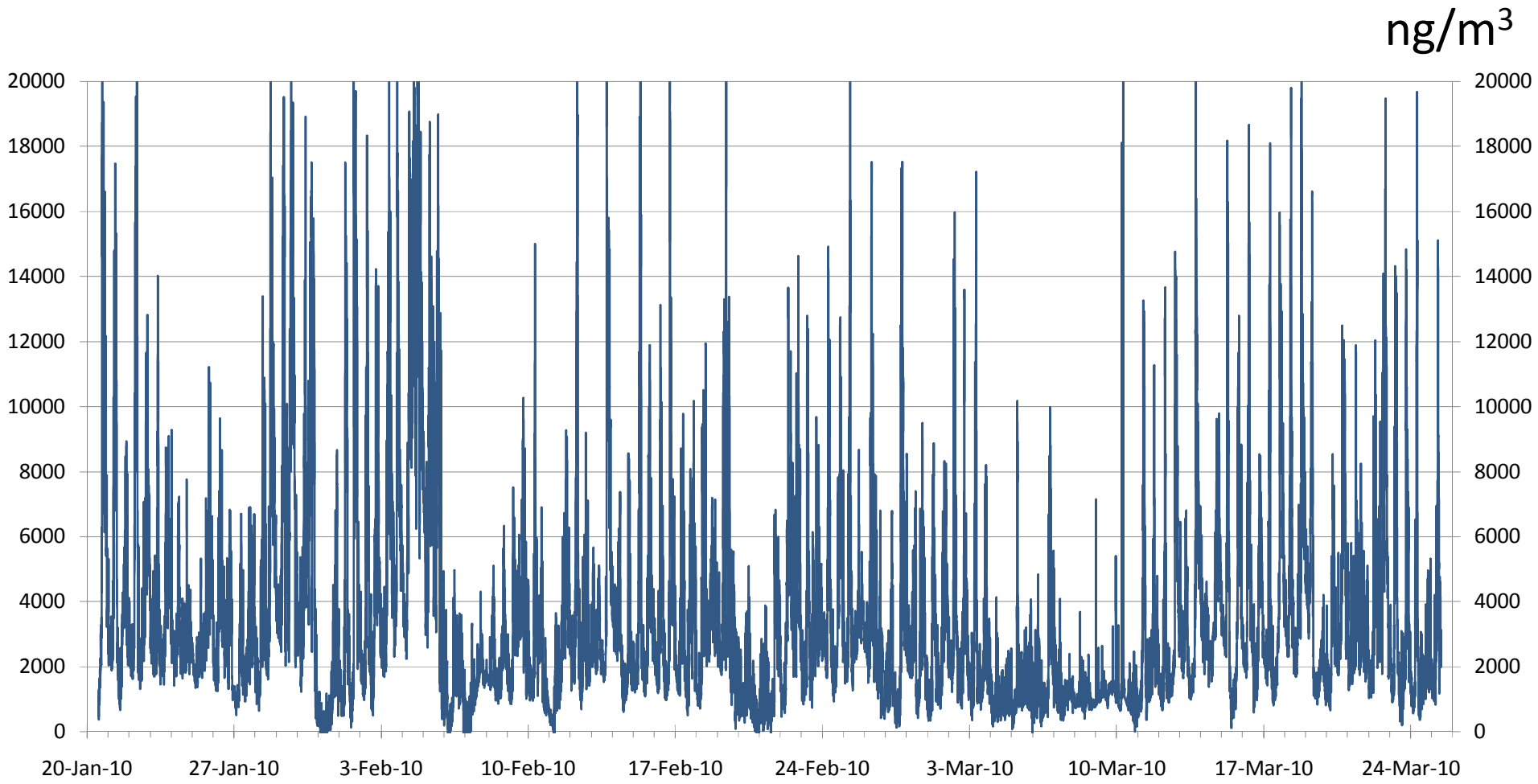
- 24 h quartz filters, 16,7 LPM
- EUSAAR-2 protocol

PM10:
EN 12341
reference gravimetric method

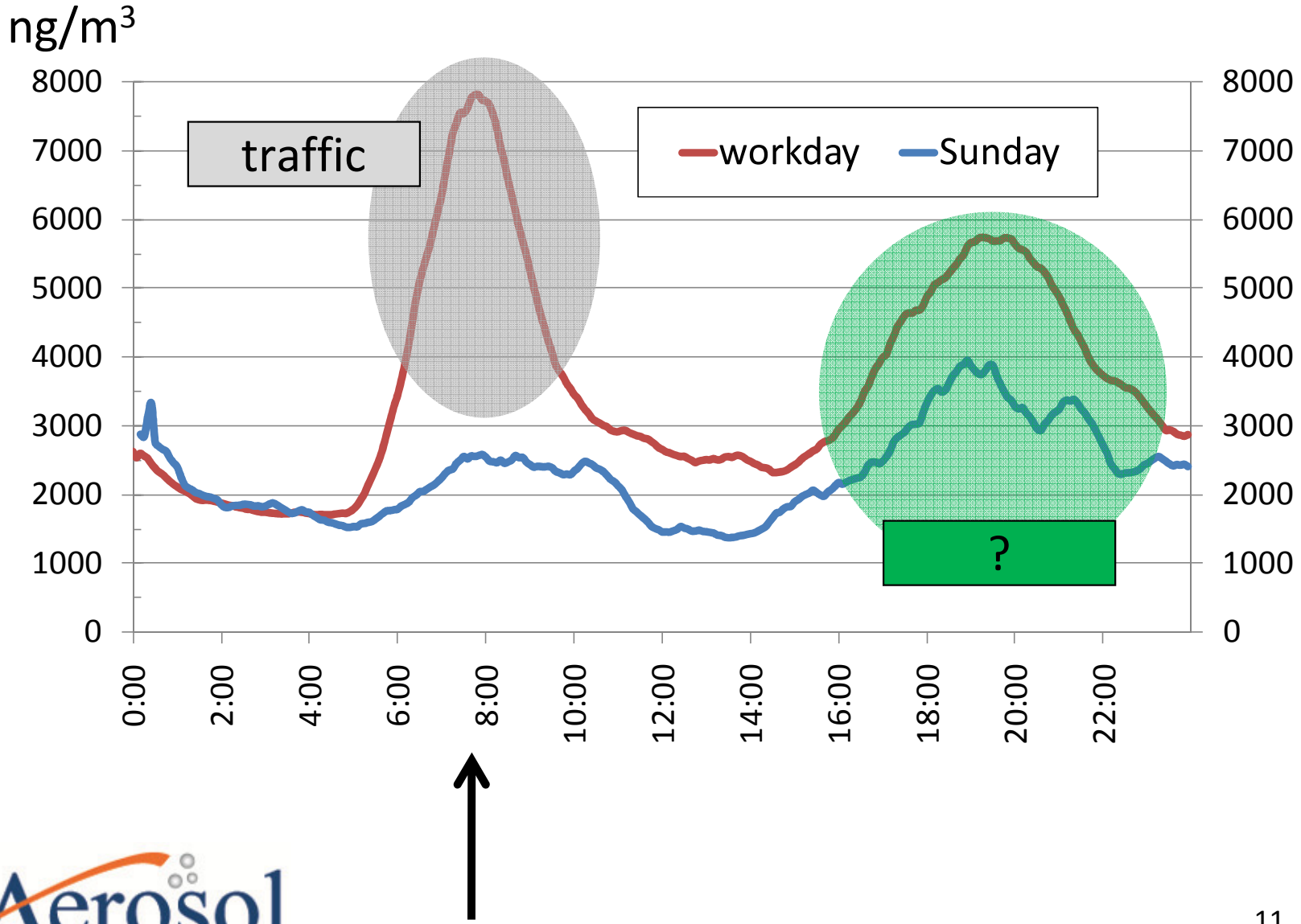
1 day time resolution

Aerosol

BC time-series, Nova Gorica



BC in Nova Gorica – diurnal variation



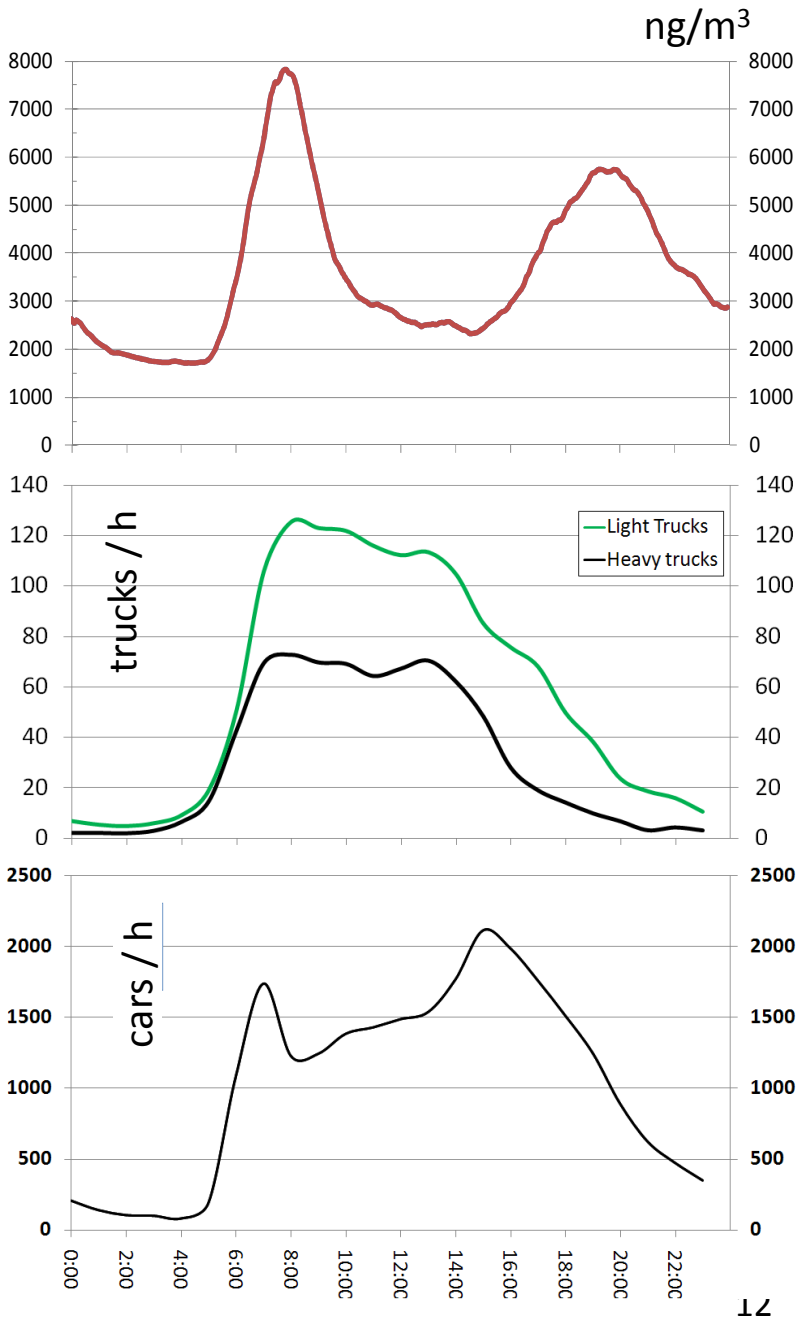
Traffic

Does traffic diurnal pattern match the BC pattern?

Trucks are all diesel and emit more than other vehicles.

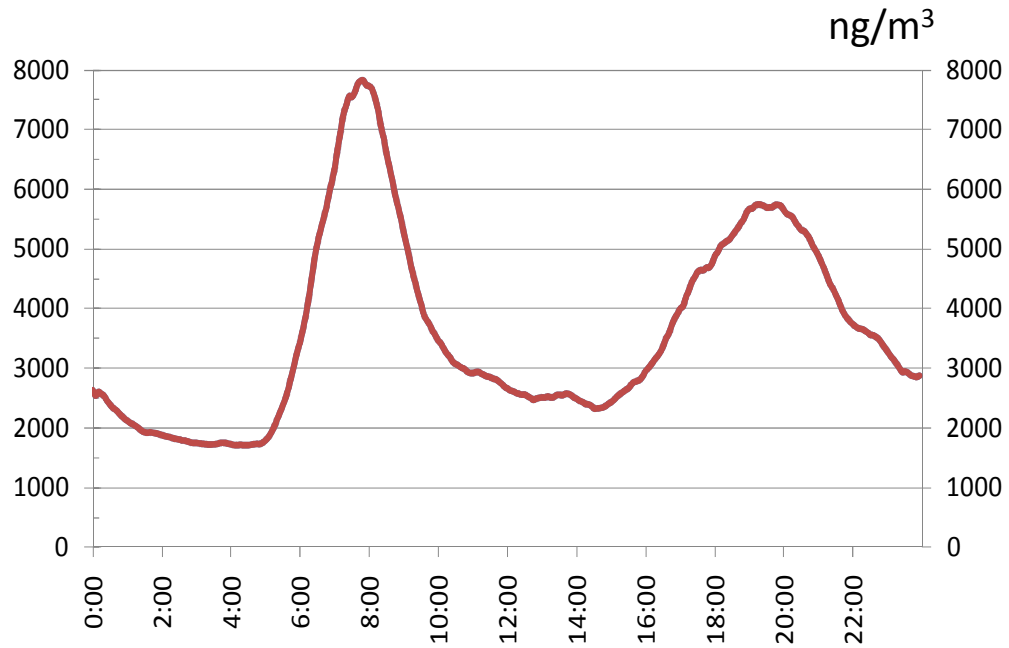
What about cars?

Note the change in scale!

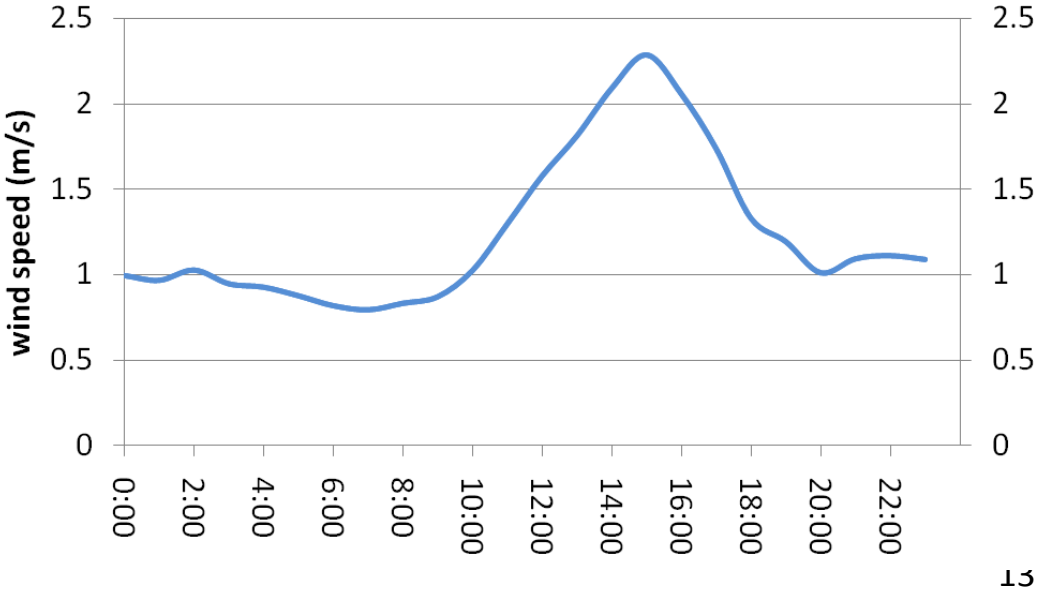


Wind

Does the wind diurnal pattern influence the BC pattern?

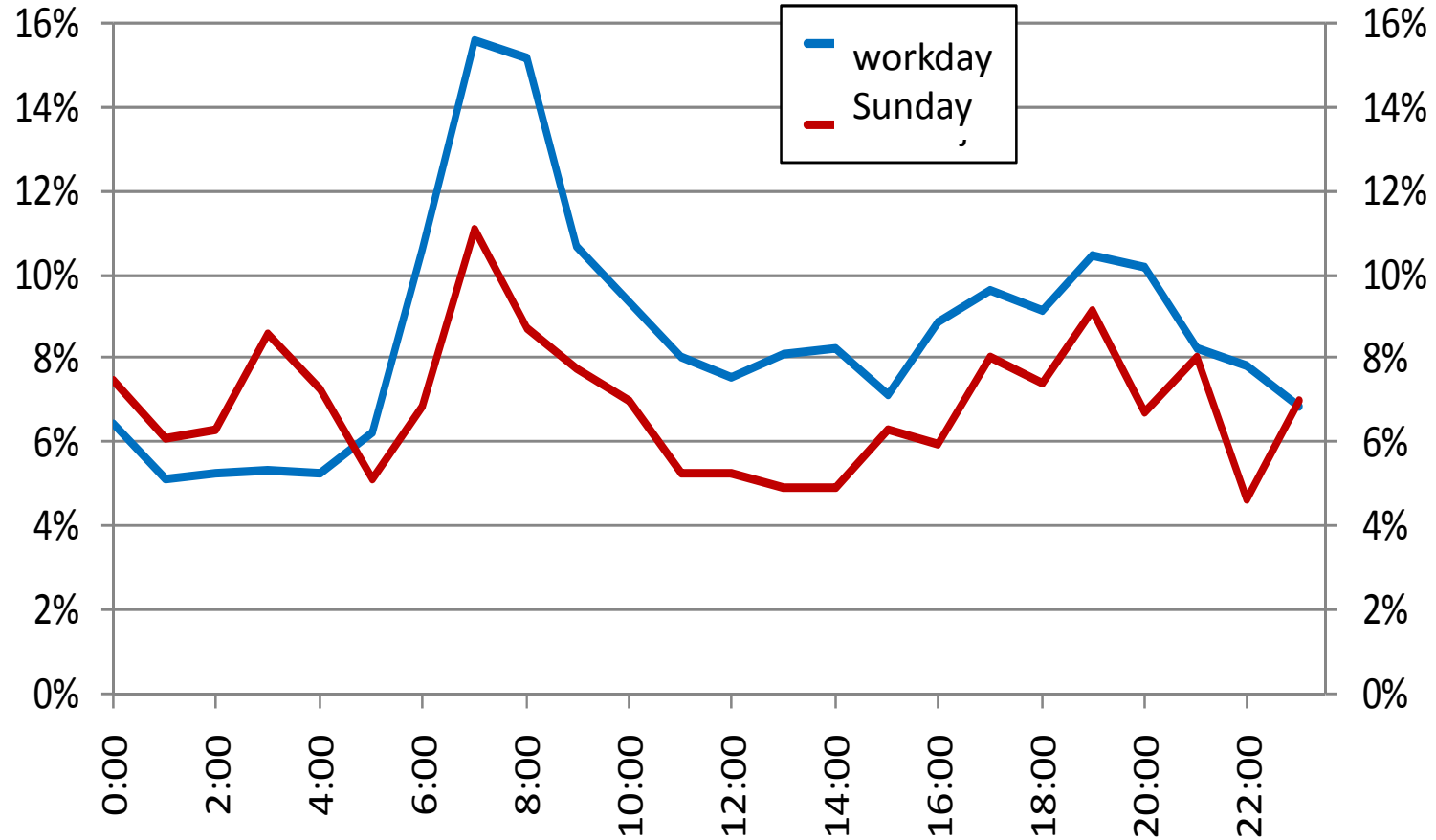


Wind does disperse the primary air pollution!



Aerosol

Composition of PM10 changes during the day!



Aerosol

Biomass is globally a major energy source

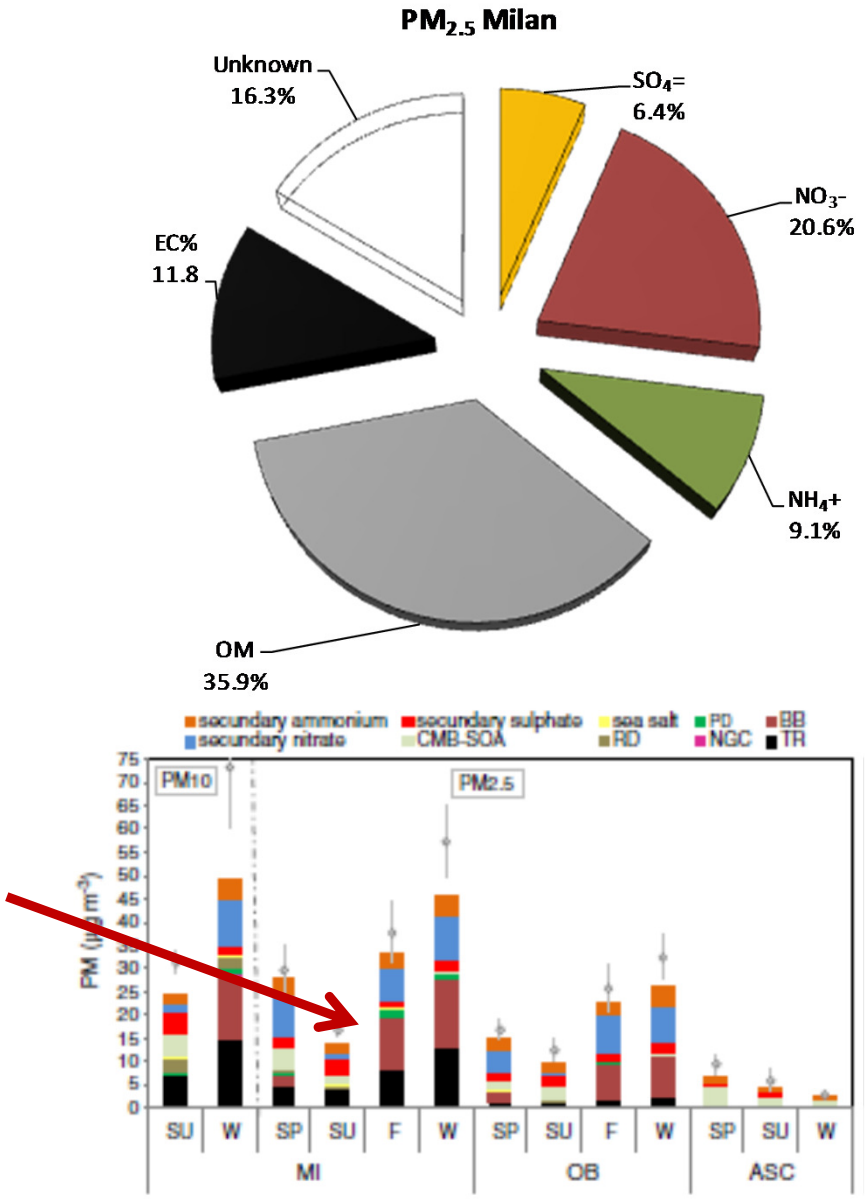
Woodsmoke in cities?!

PM2,5		
Paris, winter	20%	Favez 2009
Grenoble, winter	35%	Favez 2010

similar for Vienna, Graz, Salzburg (Caseiro 2009),
Zurich (Lanz 2008, Szidat 2006)...

and also:

Milano, fall	30%	Perrone 2012
Milano, winter	25%	Perrone 2012



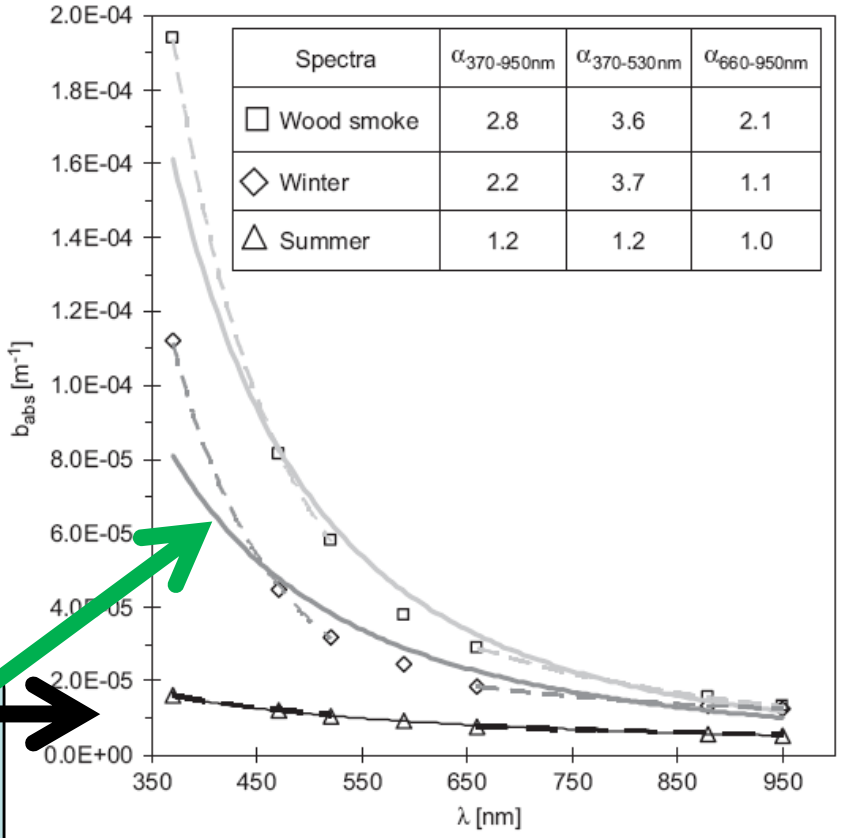
Biomass-smoke vs. diesel - 7λ

- measure attenuation with the Aethalometer
- absorption coefficient - b_{abs}
- for pure black carbon: b_{abs} *~1/λ*
- generalize **Angstrom exponent**:

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

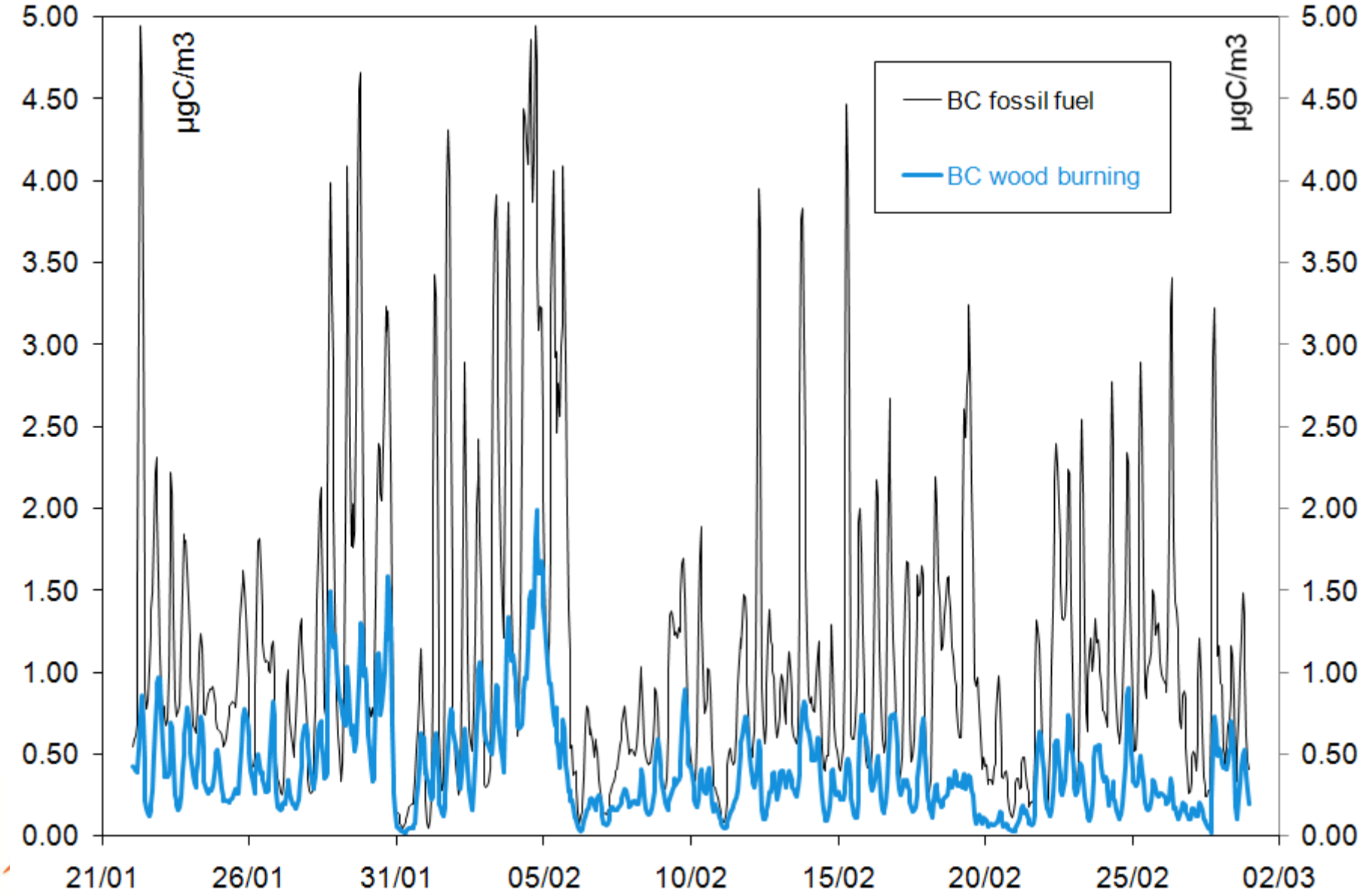
diesel: $\alpha \approx 1$

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

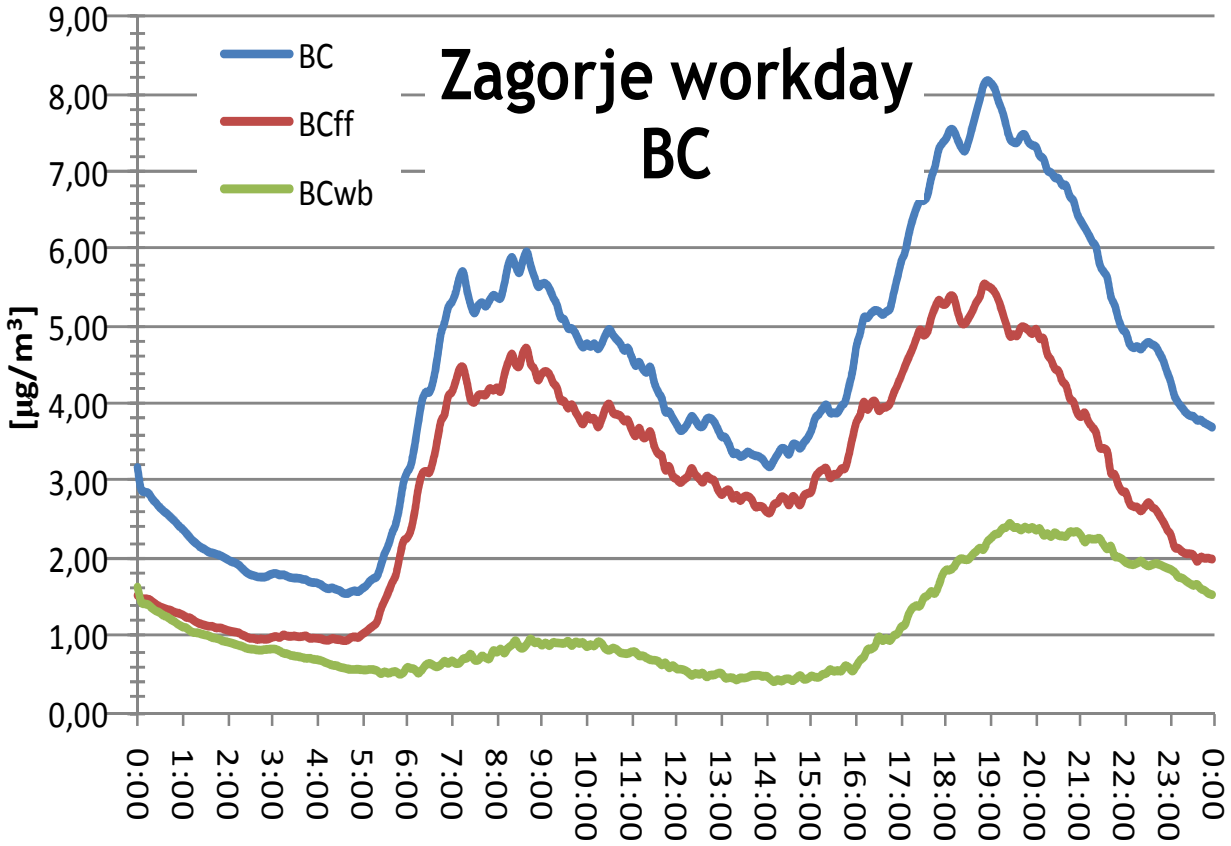


J. Sandradewi et al., A study of wood burning and traffic aerosols in an Alpine valley using a multi-wavelength Aethalometer, Atmospheric Environment (2008) 101–112

BC_{ff}, BC_{wb} time series, Nova Gorica



Source apportionment: which sources to regulate?



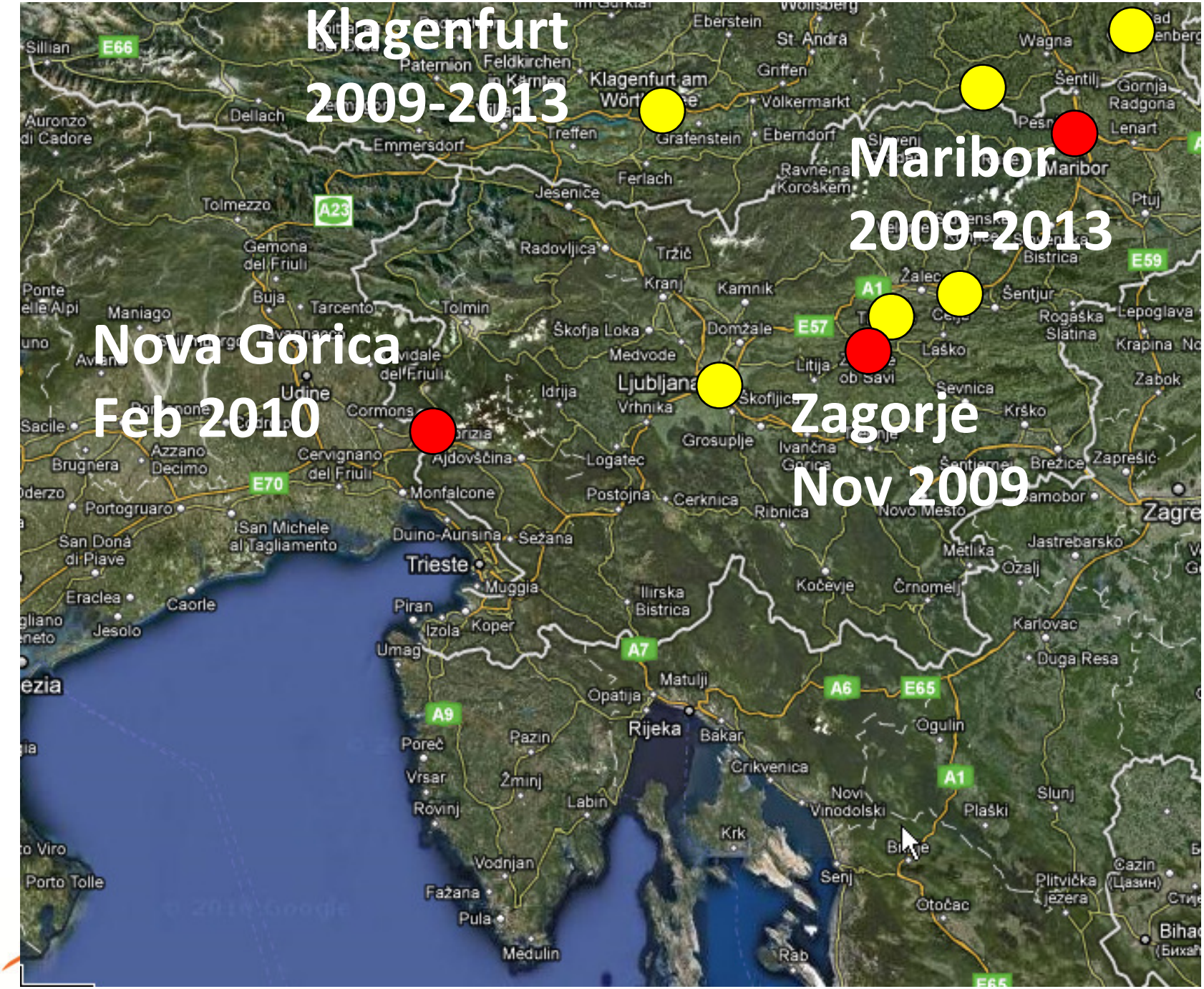
traffic

73% ± 8%

27% ± 8%

wood combustion

Aerosol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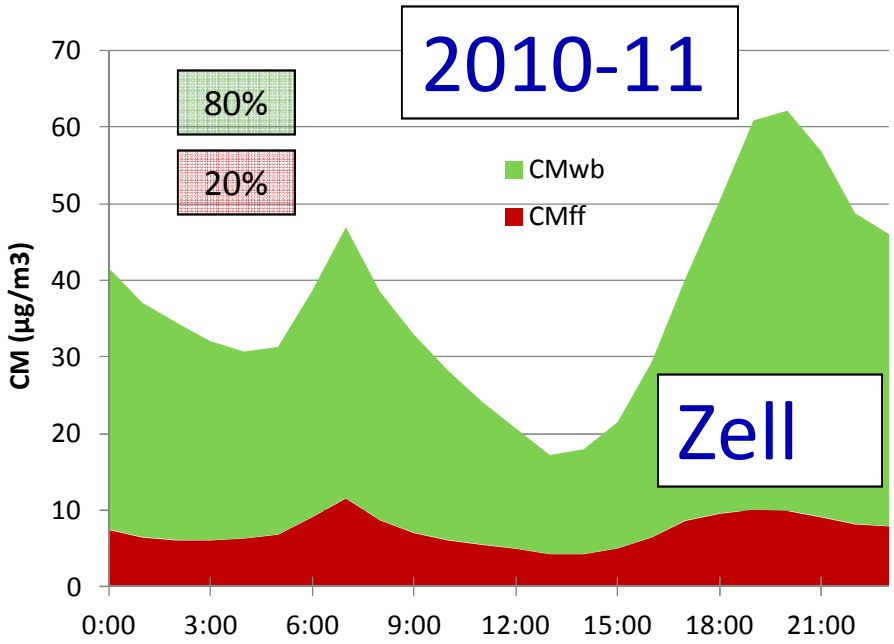
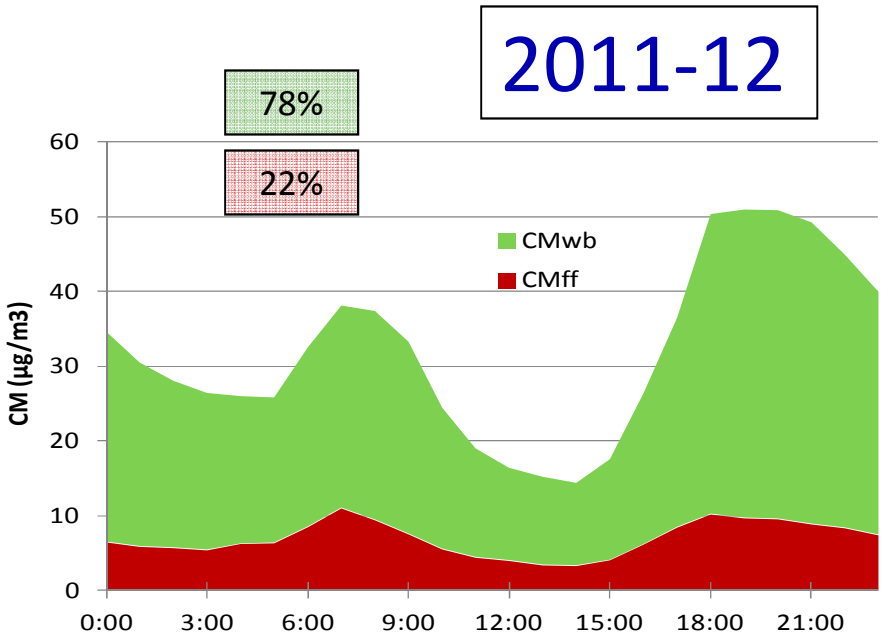
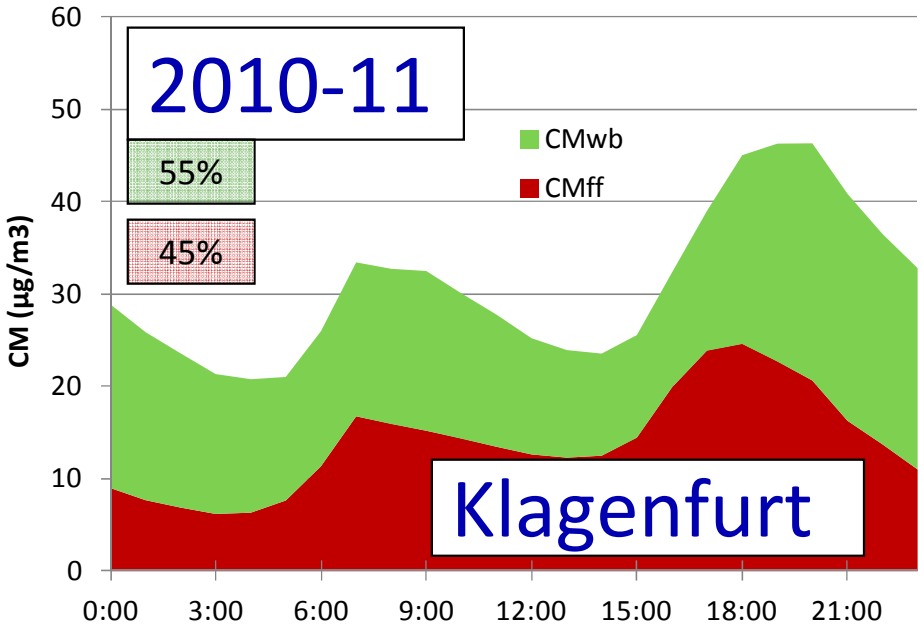
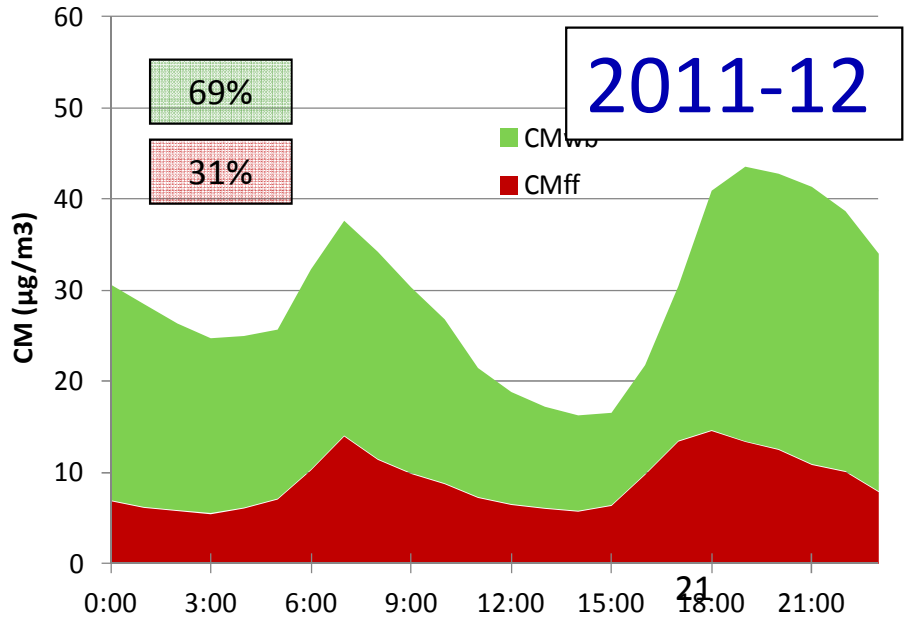
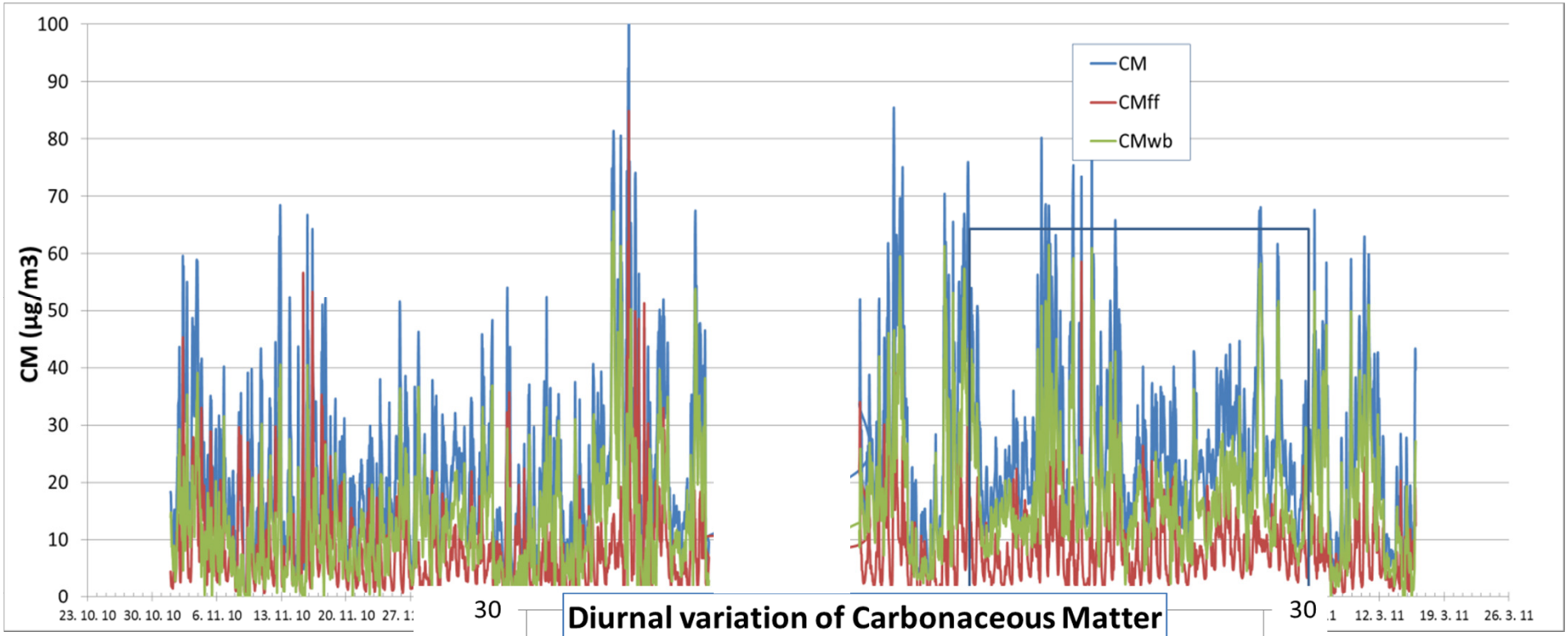
Domžale
Postojna
Koper
Izola
Piran
Pula
Zagreb


2010-11
80%
20%
CMwb
CMff
Zell
CM (µg/m3)
0
10
20
30
40
50
60
70
0:00
3:00
6:00
9:00
12:00
15:00
18:00
21:00


2011-12
78%
22%
CMwb
CMff
CM (µg/m3)
0
10
20
30
40
50
60
0:00
3:00
6:00
9:00
12:00
15:00
18:00
21:00


2010-11
55%
45%
CMwb
CMff
Klagenfurt
CM (µg/m3)
0
10
20
30
40
50
60
0:00
3:00
6:00
9:00
12:00
15:00
18:00
21:00


2011-12
69%
31%
CMwb
CMff
CM (µg/m3)
0
10
20
30
40
50
60
0:00
3:00
6:00
9:00
12:00
15:00
18:00
21:00

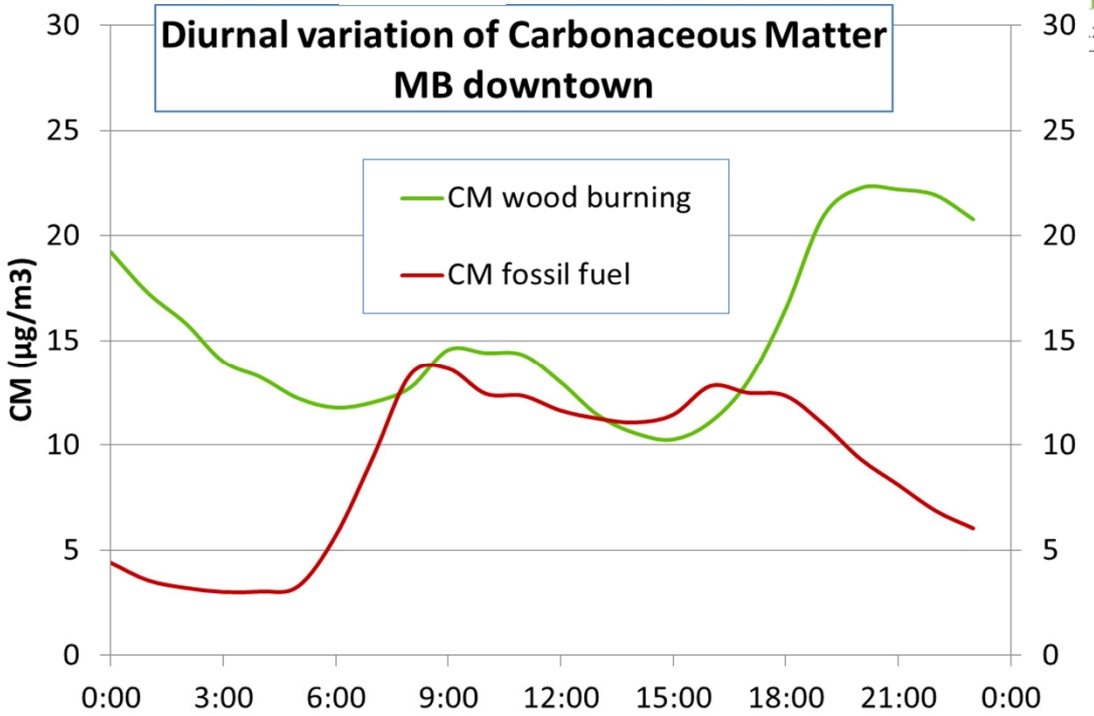


Maribor, SI

2010-2011

OC/EC TUW

Aerosol



63% ± 16%

37% ± 16%

Conclusions

- we can measure **Black Carbon** from **Fossil Fuel** and **Biomass** combustion with the Aethalometer
- time resolution is **1 min**
- we can investigate **time evolution** of BC and biomass smoke during the day, excellent correlation with markers, PAH source
- **quantitative biomass smoke determination** – 24 h TC, but Aethalometer high time resolution - minutes
- monitoring station pair: **regional and local behaviour**
- **woodsmoke is a regional pollutant**

Aerosol

Thank you for your attention!
Questions?

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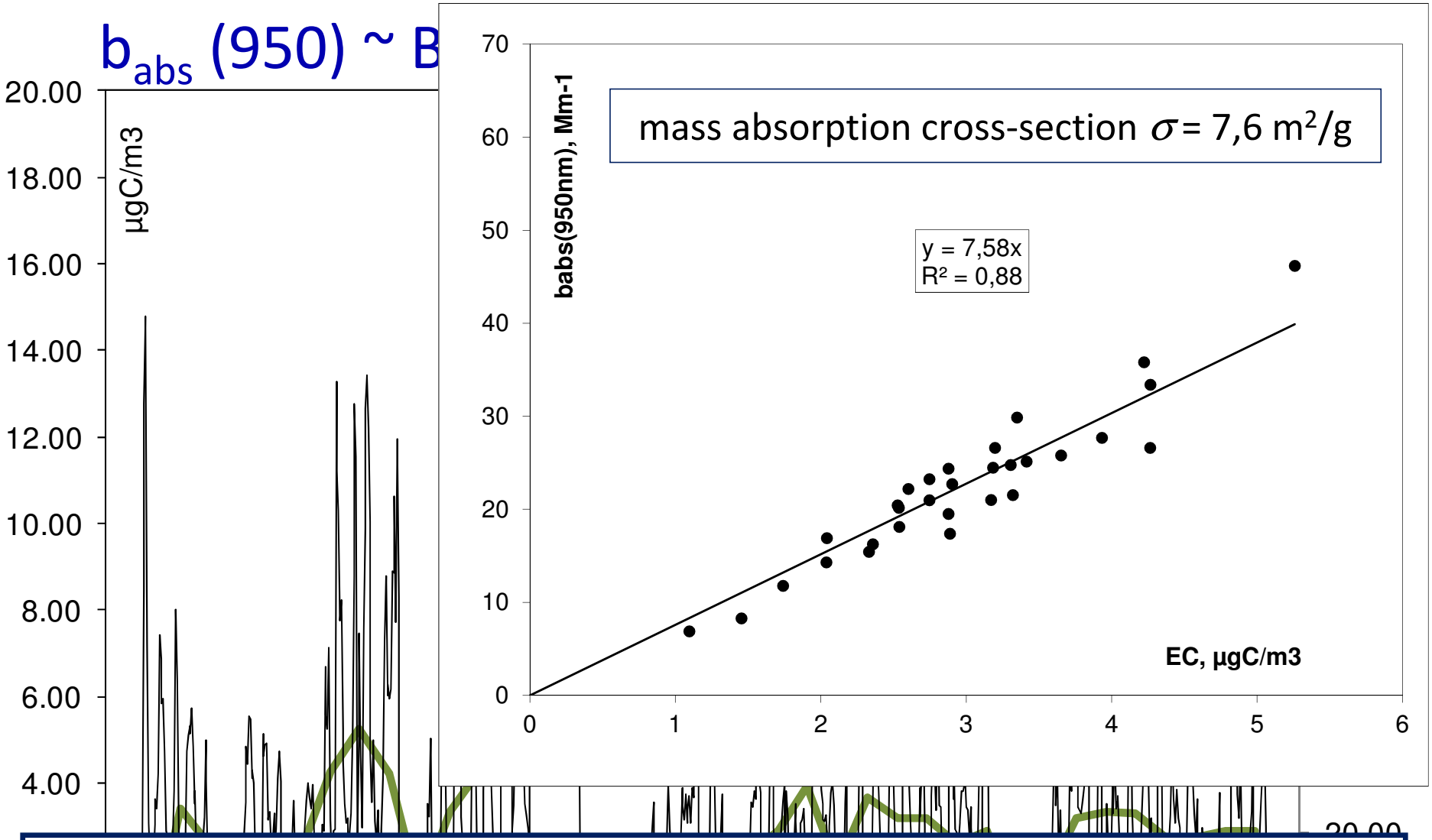
b_{abs} (950) ~ B



Good agreement between thermal EC and optical BC!