

Determination of Air Pollution Sources by Aethalometer measurements of aerosol light absorption

PM2014, Genova, May 2014

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Aerosol Black Carbon

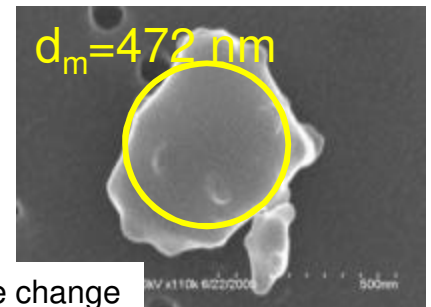
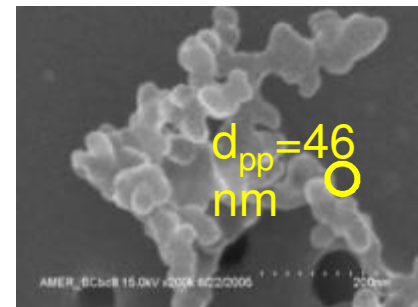
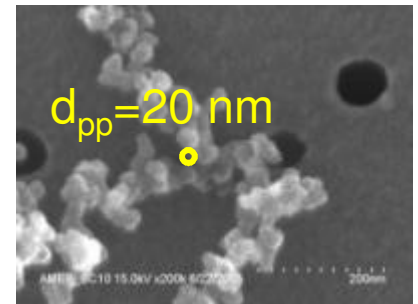
- BC is a **primary** product of incomplete **combustion**
- BC not automatically related to CO₂ emission
- BC emissions can not be predicted:

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)

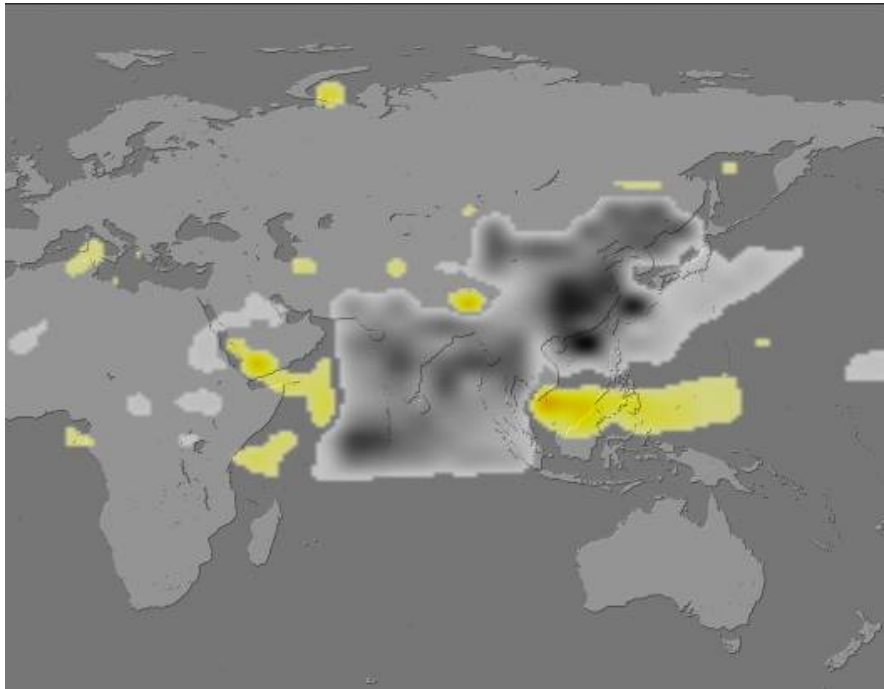
- **relevance:** climate change, health



Note change in scale

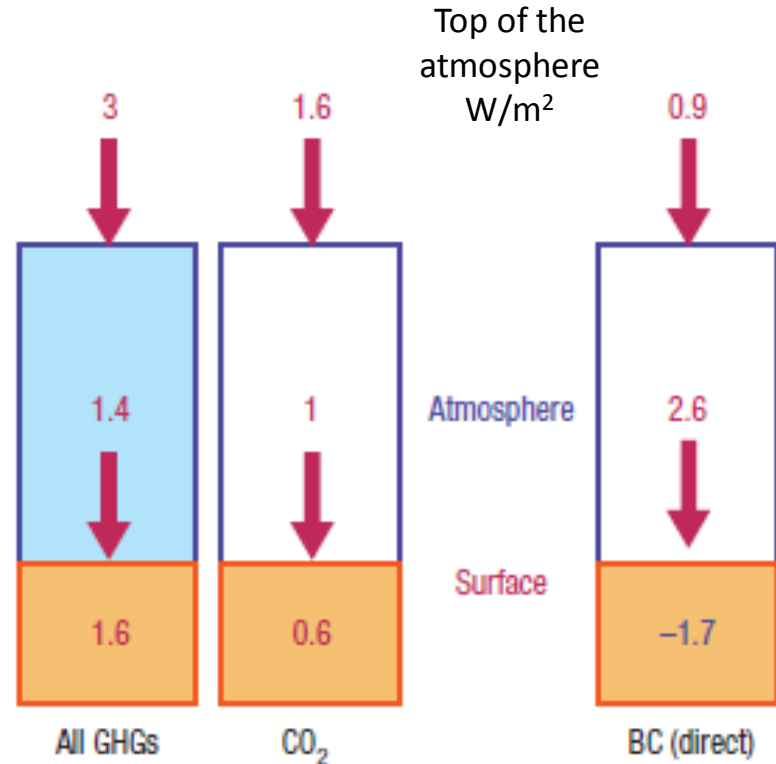
Climate Change Effects of Aerosols

Total BC forcing:
direct + indirect
1,1 W/m²
(Bond et al 2013)



S. Menon, J. Hansen et al. *Science* (2002) 2250

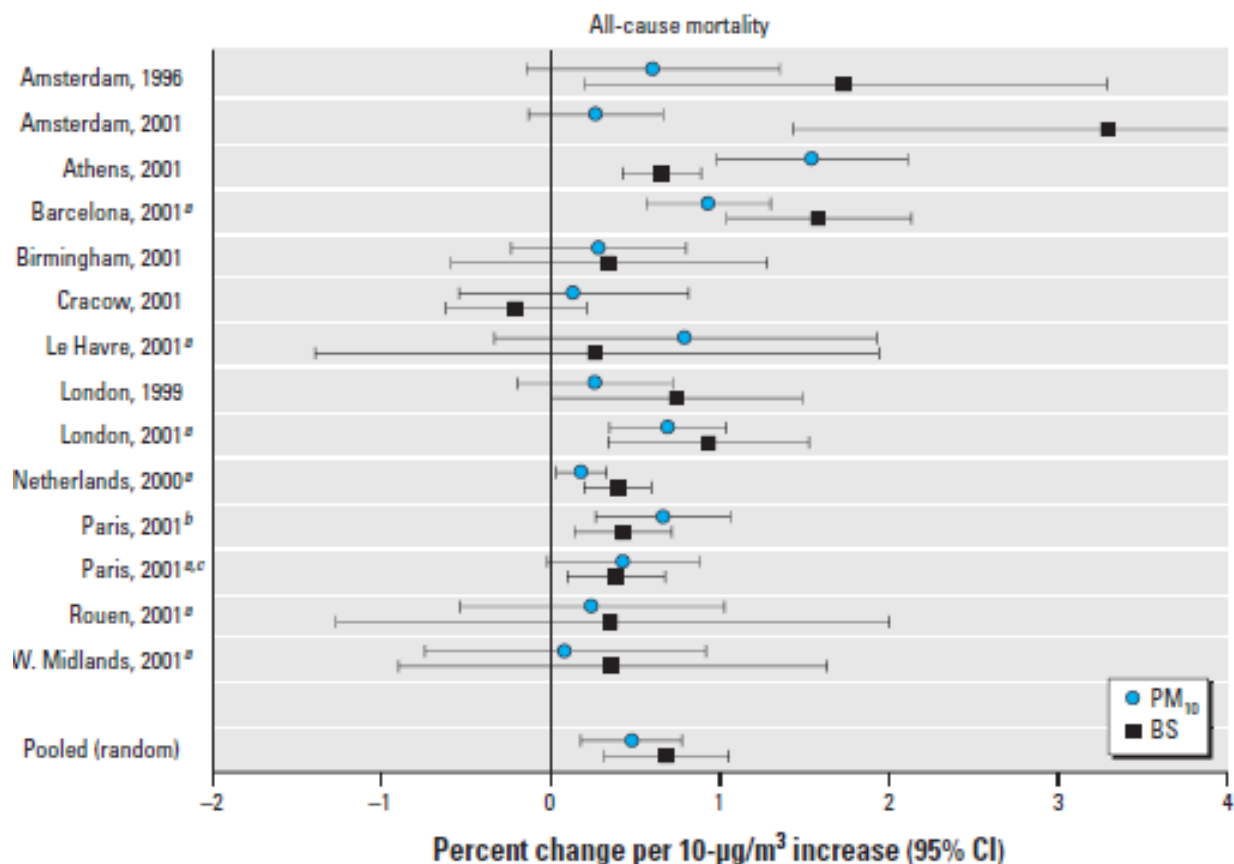
Haze over Asia: up to 40% of sunlight absorbed. Crop yields reduced ; local rainfall changed.



V. Ramanathan, G. Charnichael, *Nature Geosci* (2008) 221

BC forcing is almost 1/3 of the total TOA GHG forcing!
Heat redistribution → weather

Health Effects



Dockery et al., *N. Engl. J. Med.* 329: 1753 (1993)

Mortality Ratio

Mortality

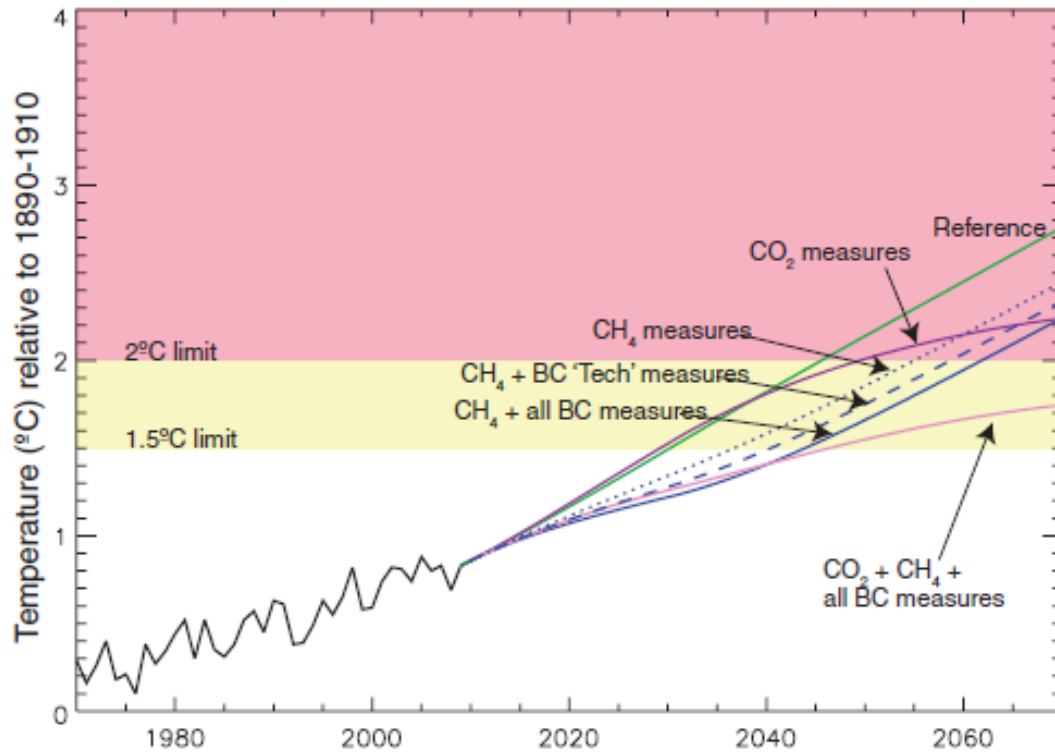
Highest vs. Lowest PM

All causes	1.26
Lung cancer	1.37
Other cardiopulmonary	1.37
Non-cardiopulmonary	1.01

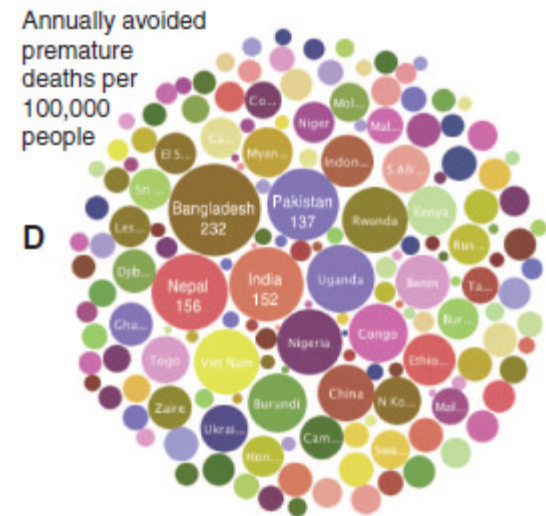
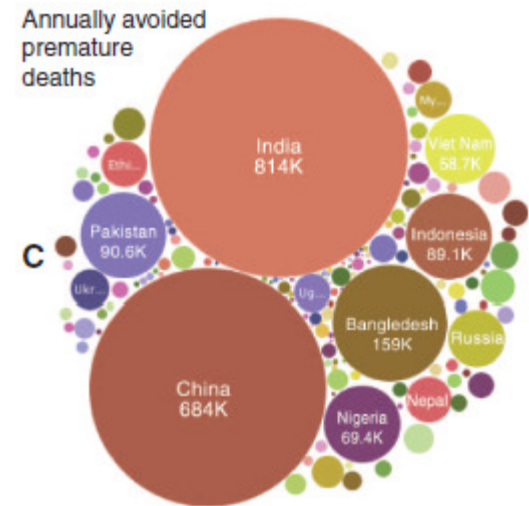
Two-pollutant models in time-series studies suggested that the effect of BCP was more robust than the effect of PM mass. The estimated increase in life expectancy associated with a hypothetical traffic abatement measure was four to nine times higher when expressed in BCP compared with an equivalent change in PM_{2.5} mass.

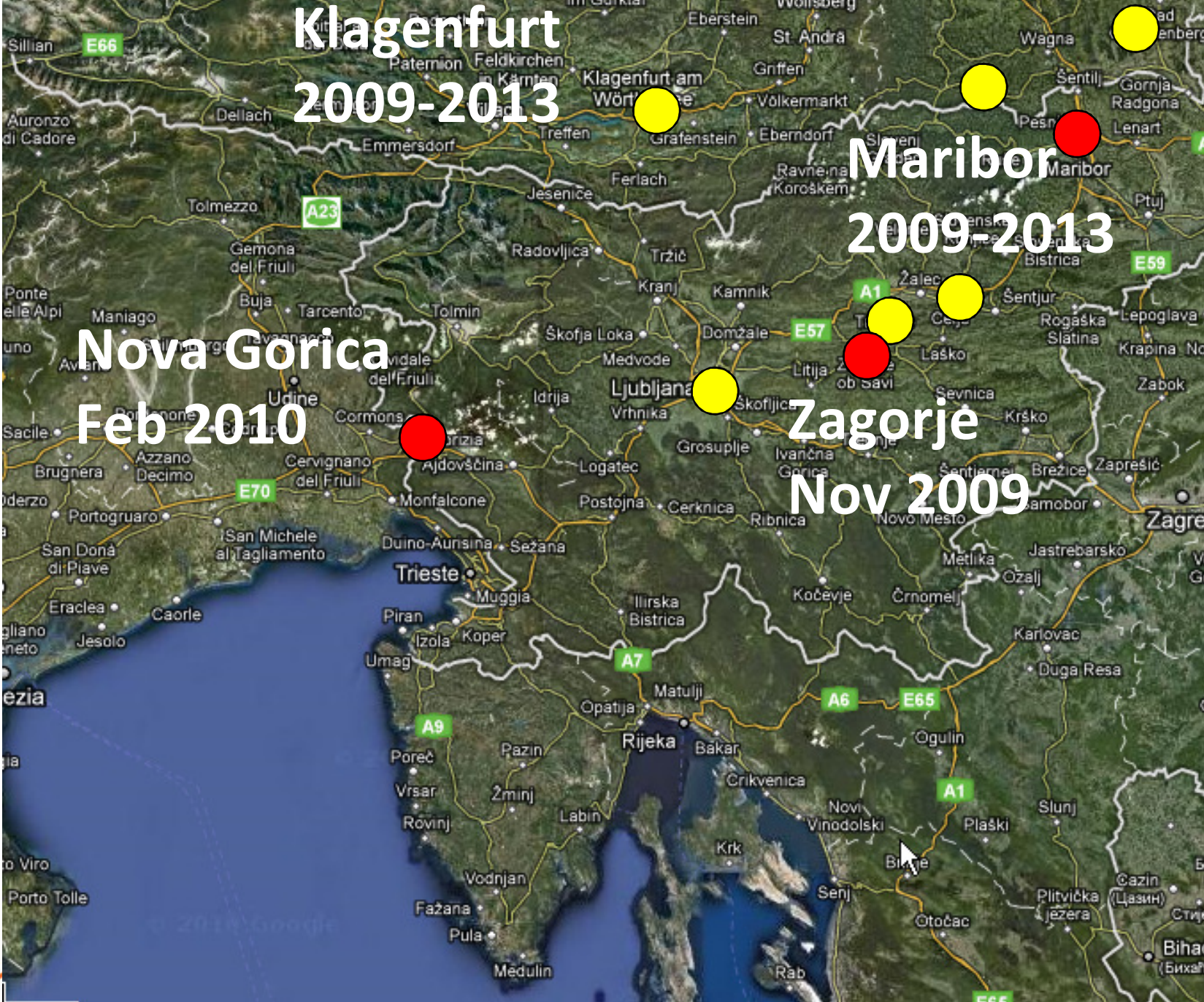
Jansen et al, 2011 EHP

Climate & health!



Drew Shindell, *et al.*
Simultaneously Mitigating Near-Term Climate Change and Improving Human Health and Food Security
Science 335, 183 (2012);





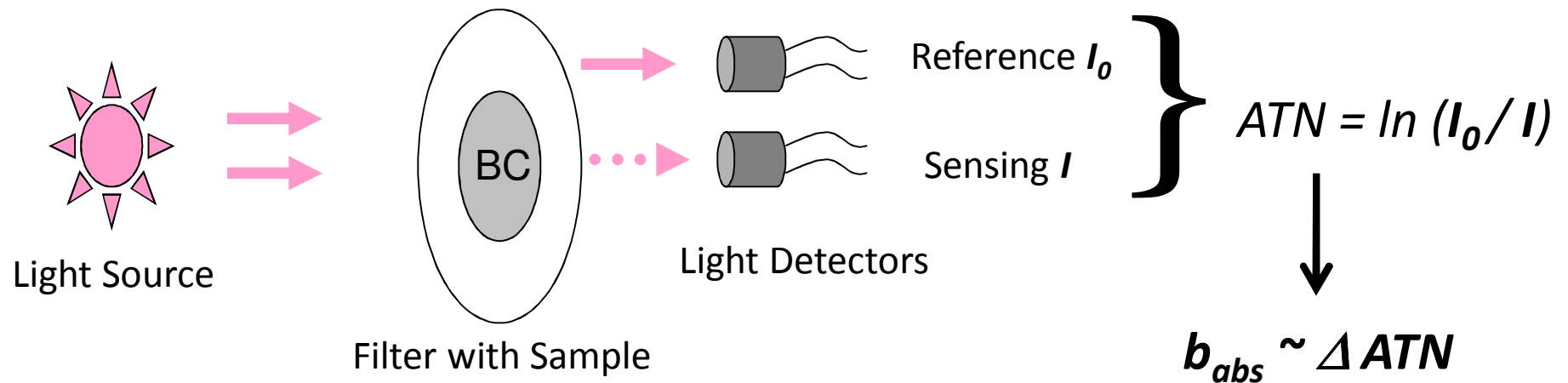
Klagenfurt
2009-2013

Maribor
2009-2013

Nova Gorica
Feb 2010

Zagorje
Nov 2009

Optical detection of BC: Aethalometer™

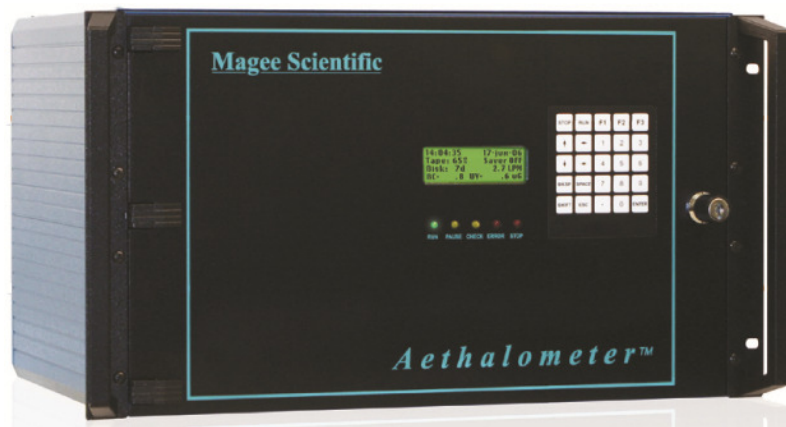


- Collect sample **continuously**.
- ***Optical absorption*** \sim change in ATN.
- Measure optical absorption **continuously**: $\lambda = 370$ to 950 nm.
- Convert ***optical absorption*** to ***concentration of BC***:

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

- Real-time data: **minutes**
 - *Dynamical, real-time measurement, updated each period*

Aethalometer – Continuous rack mount instruments

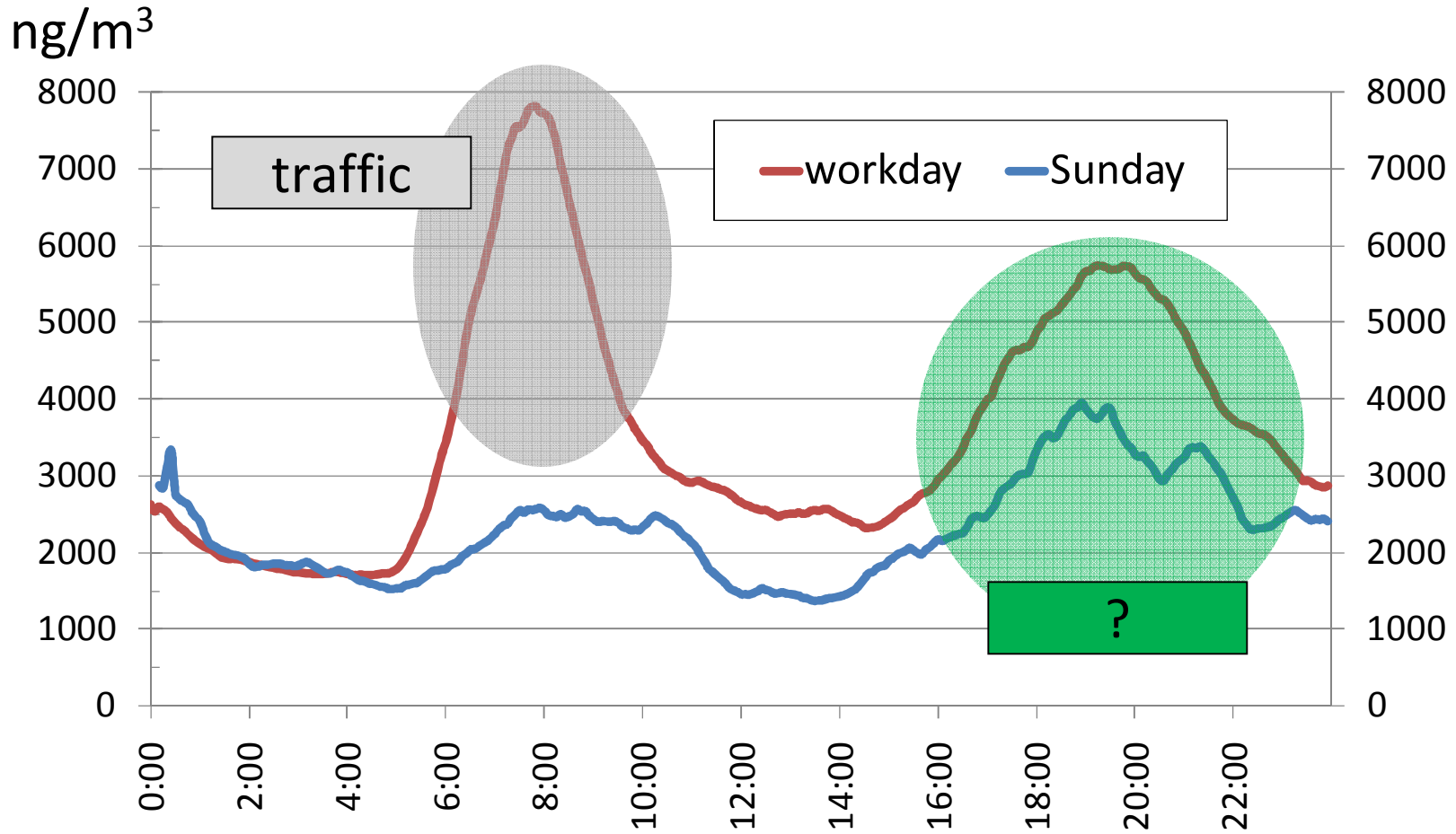


AE31 & AE33 – Ambient Air Quality Monitoring

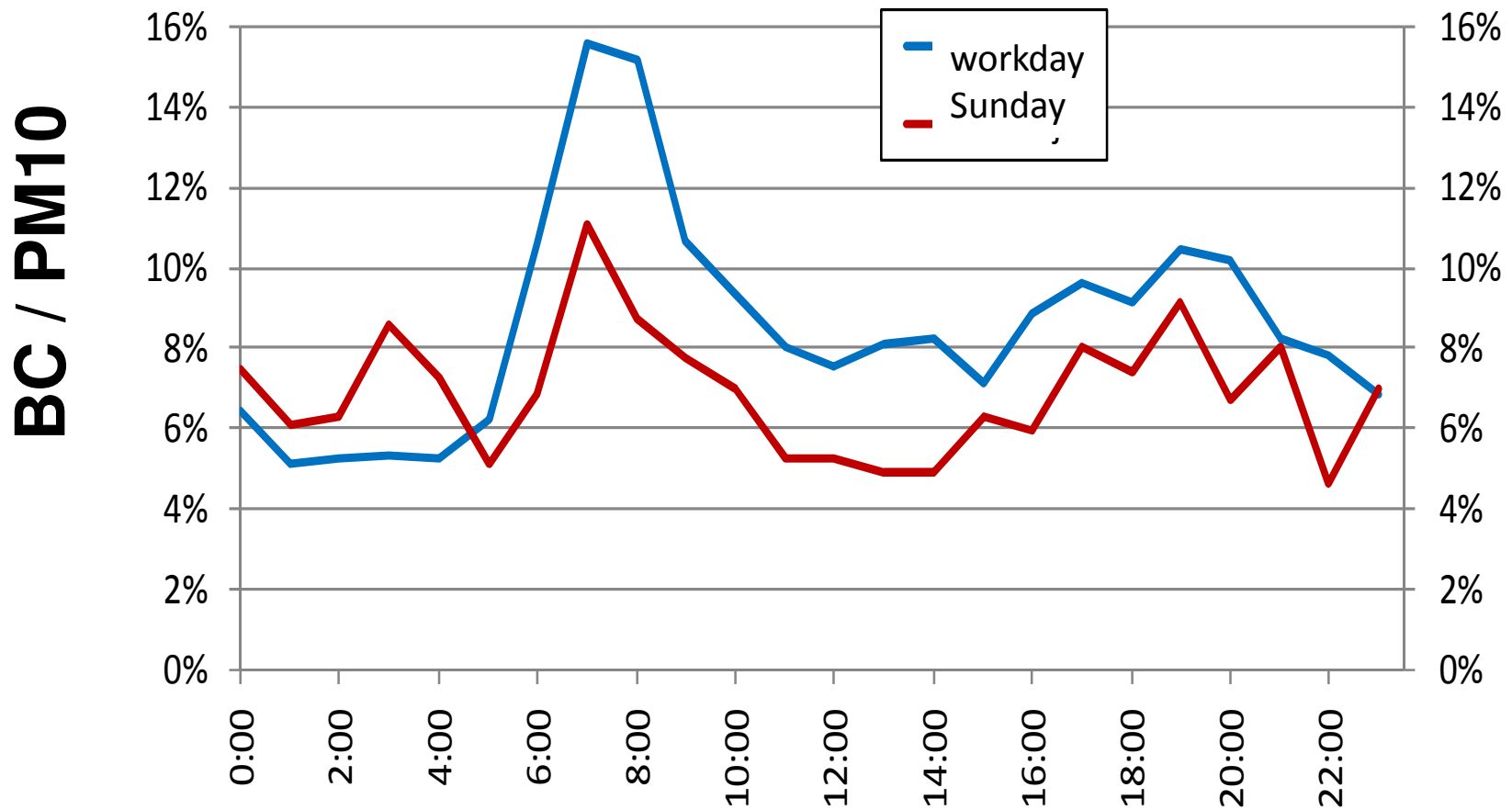
- ✓ *Seven wavelength (370, 470, 520, 590, 660, 880, and 950 nm)*
- ✓ *Local source identification*
- ✓ *Regional, Continental, Global Atmospheric studies*
- ✓ *Particle size distribution, radiative transfer*
- ✓ *Climate change, albedo, cloud modification*



BC in Nova Gorica – diurnal variation



Composition of PM10 changes during the day!



Biomass is globally a major energy source



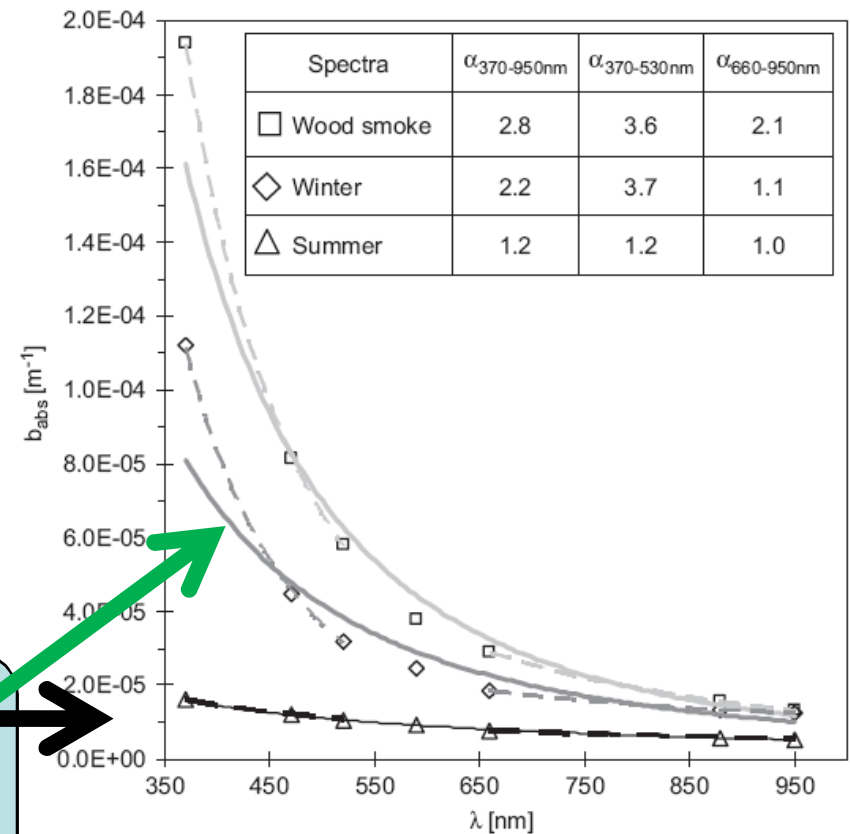
Biomass-smoke vs. diesel - 7λ

- 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: $\alpha \approx 1$

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



Quantification

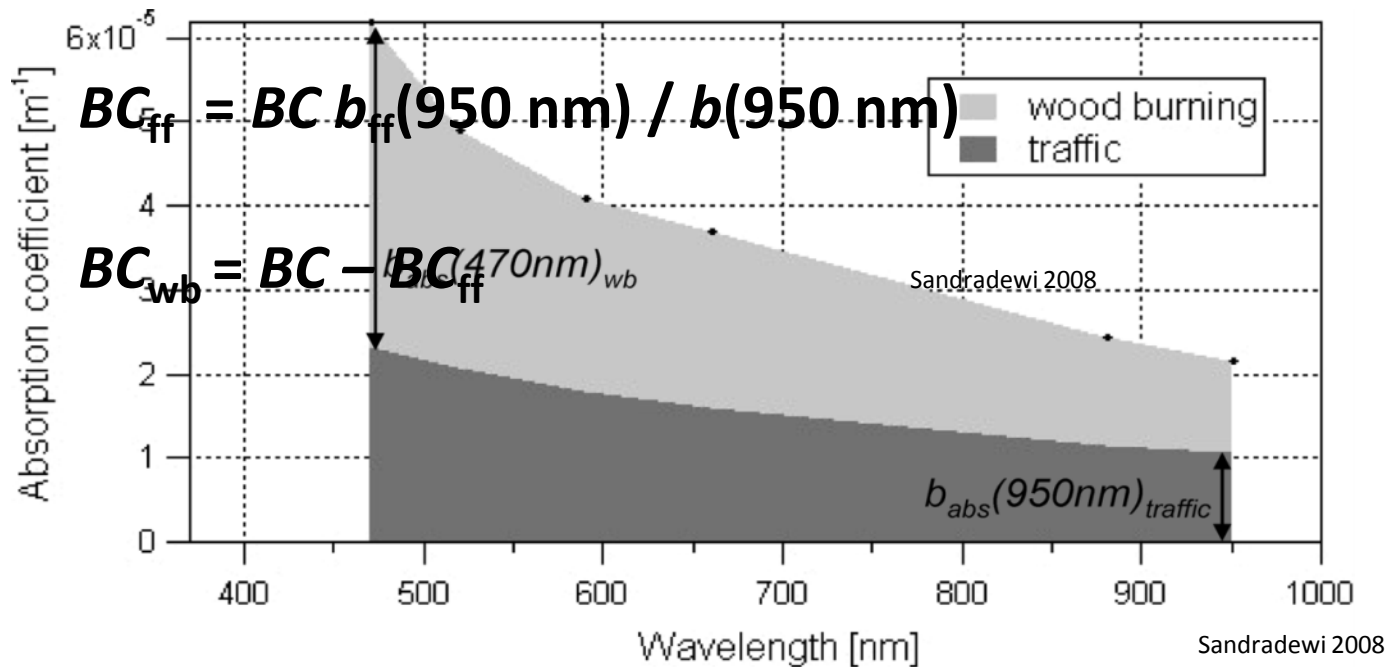
$$b(\lambda) = b_{wb}(\lambda, \text{wood}) + b_{ff}(\lambda, \text{fossil}) \quad \lambda = 470 \text{ nm}, 950 \text{ nm}$$

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

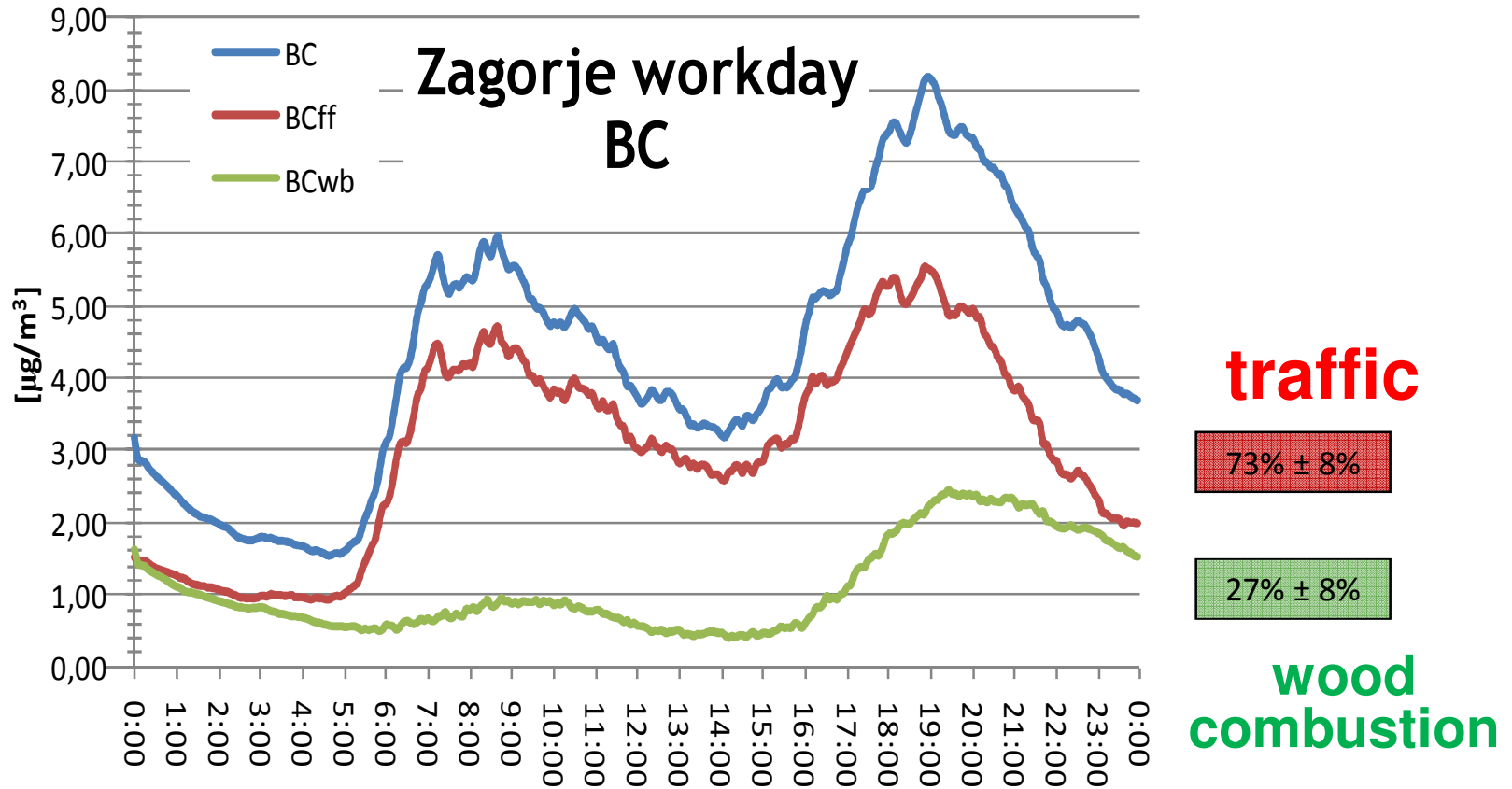
$$\alpha = 1,0 \pm 0,1 \text{ (fossil)} \quad \text{Bond \& Bergstrom 2004}$$

$$\alpha = 2,0 - 0,5 / +1,0 \text{ (wood)} \quad \text{Kirchstetter 2004,}$$

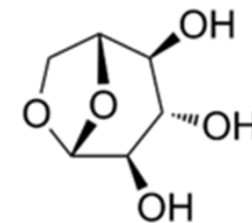
Day 2006,
Lewis 2008



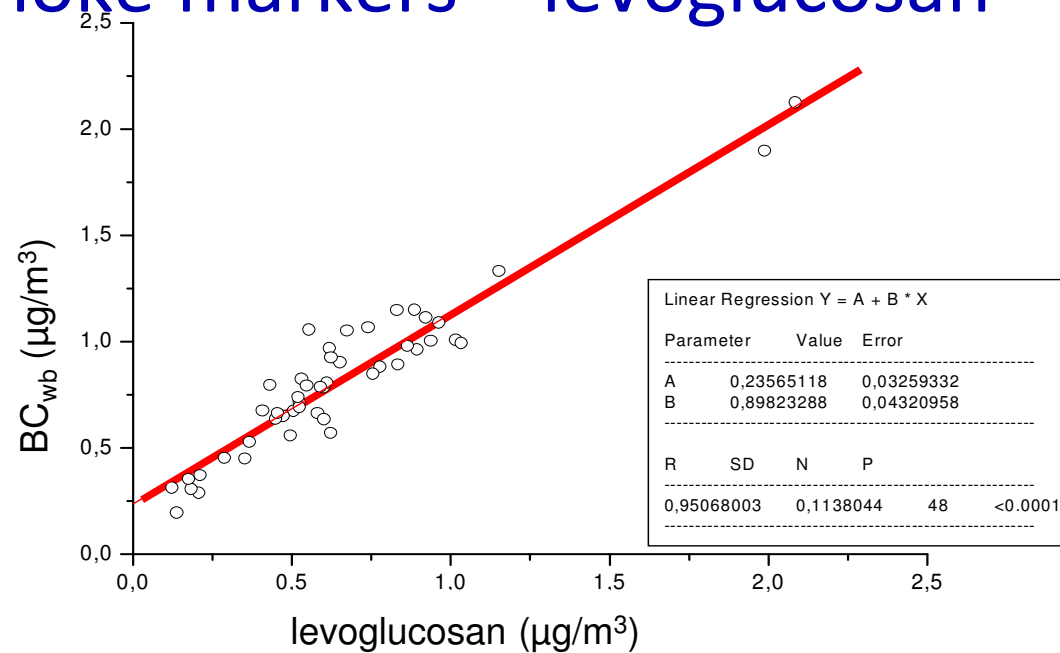
Source apportionment: which sources to regulate?



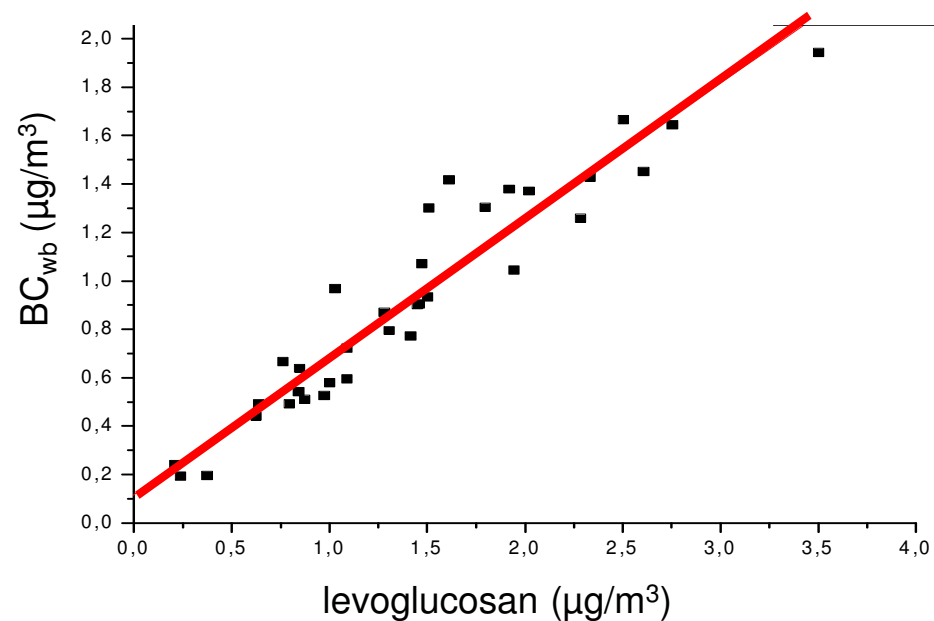
Wood-smoke markers – levoglucosan



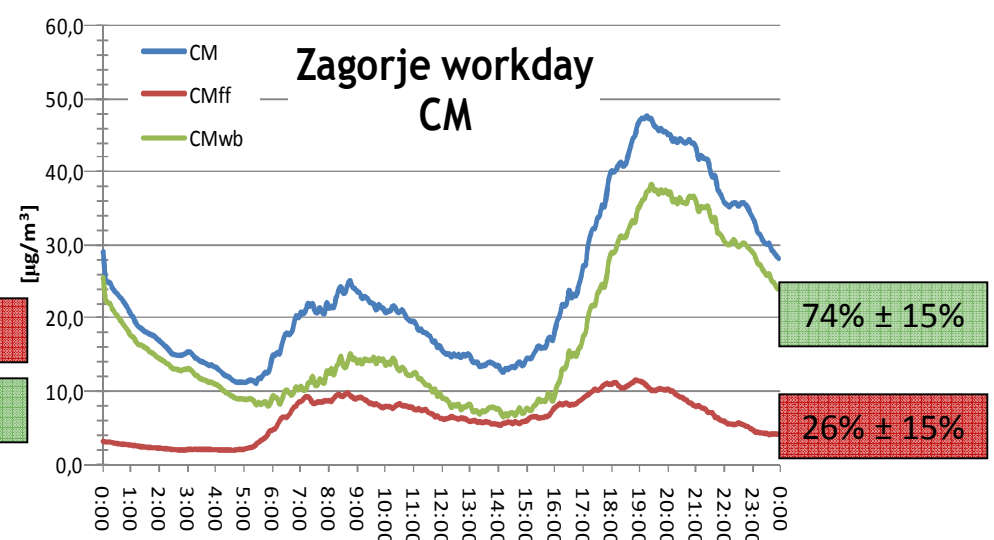
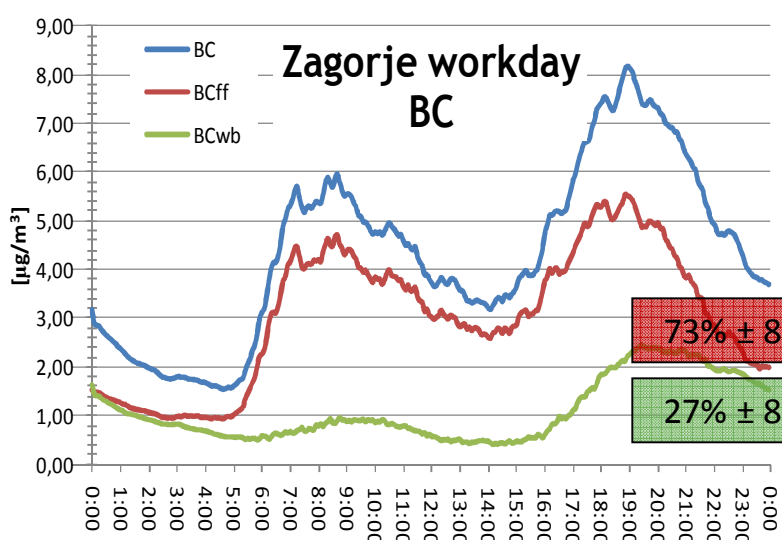
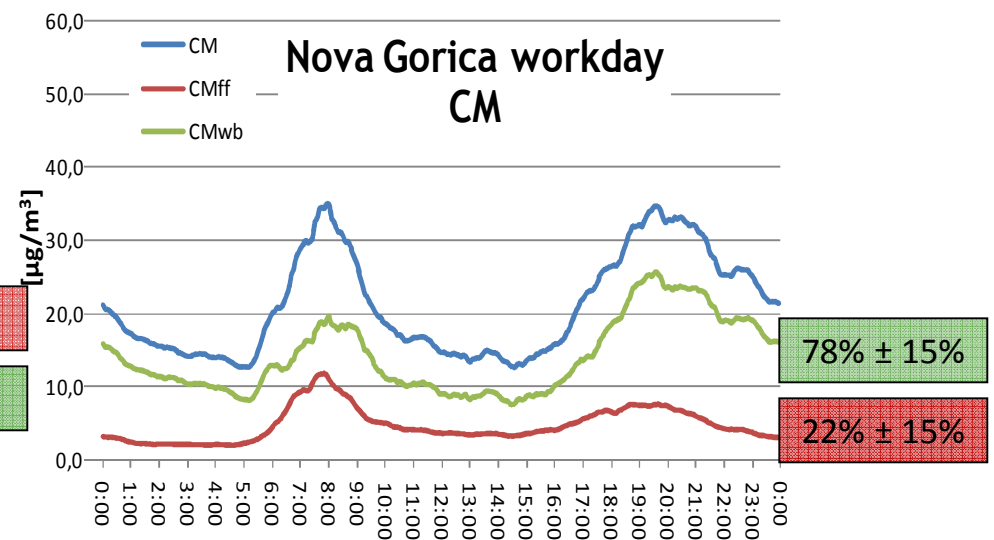
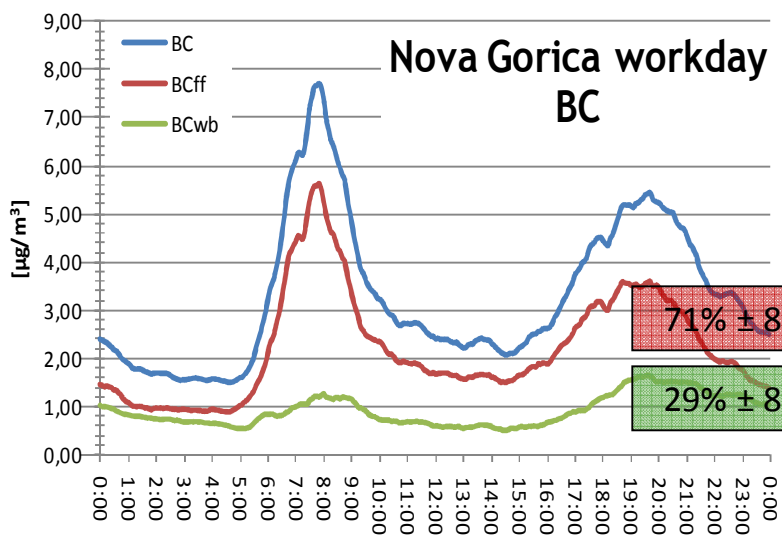
Nova Gorica



Zagorje

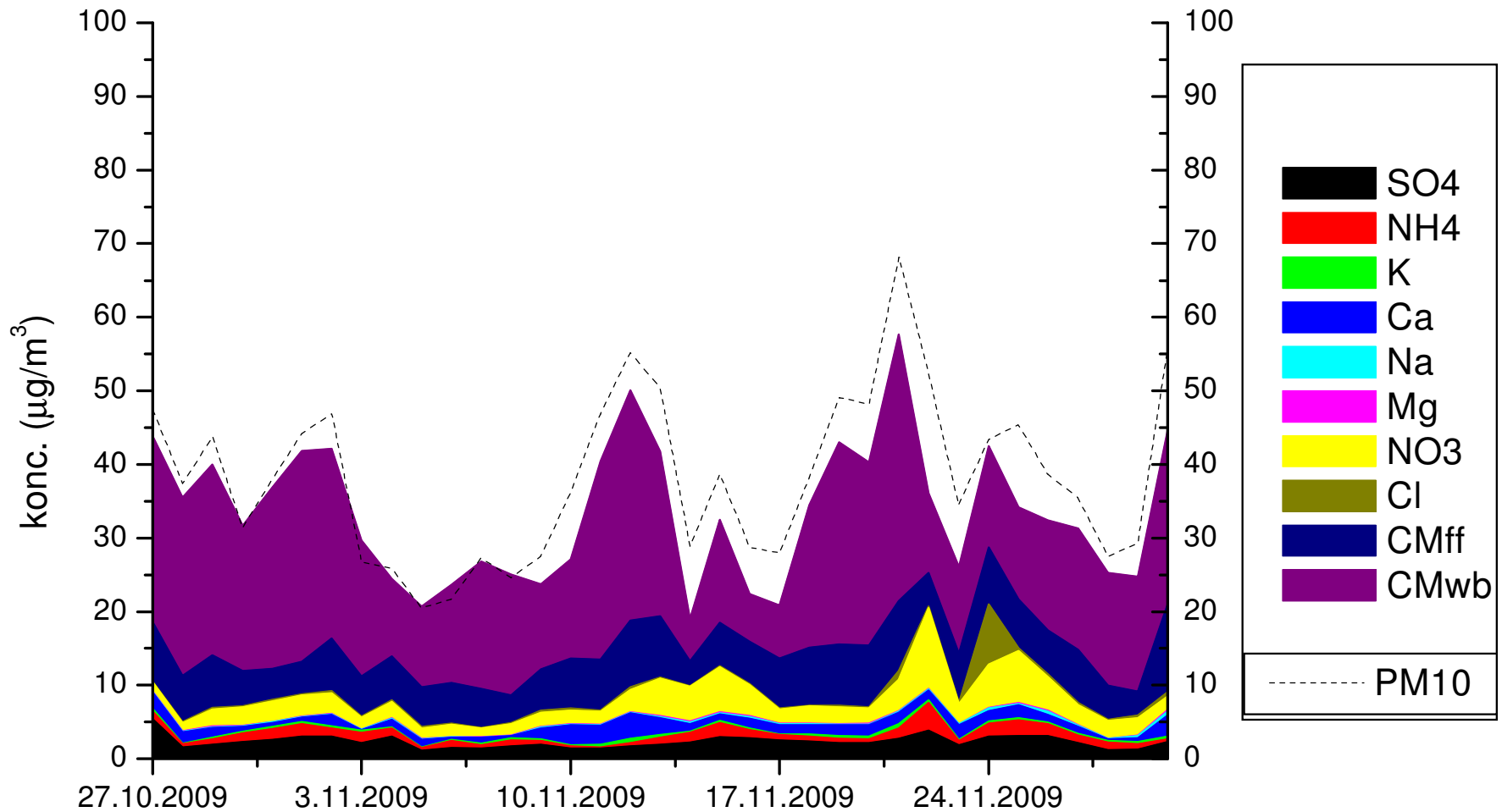


Levoglucosan - ion chromat. EARS

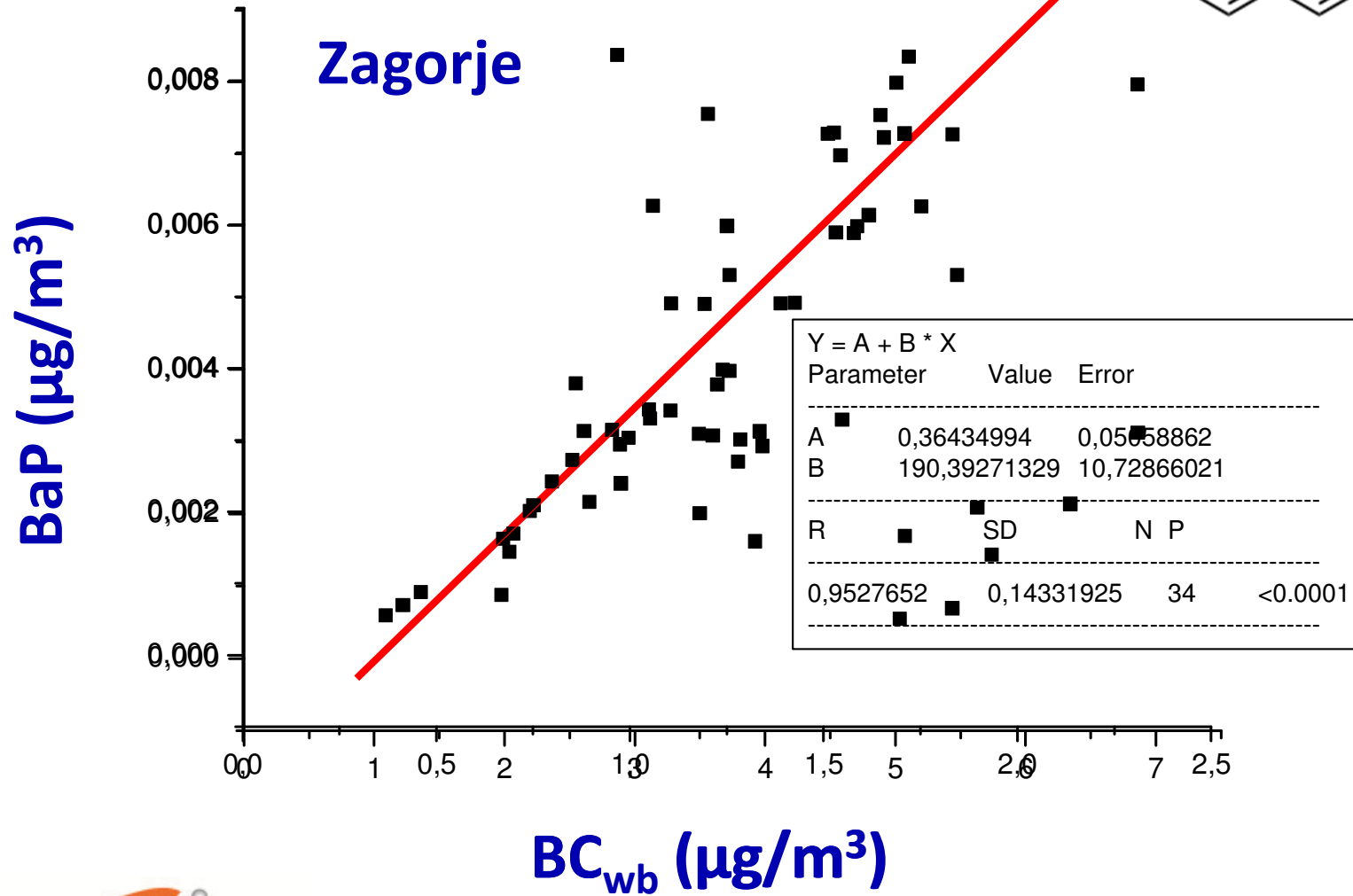
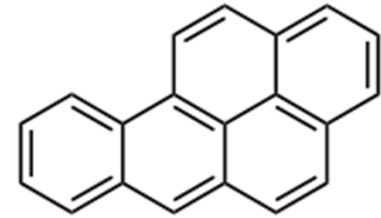


Mass closure - Zagorje

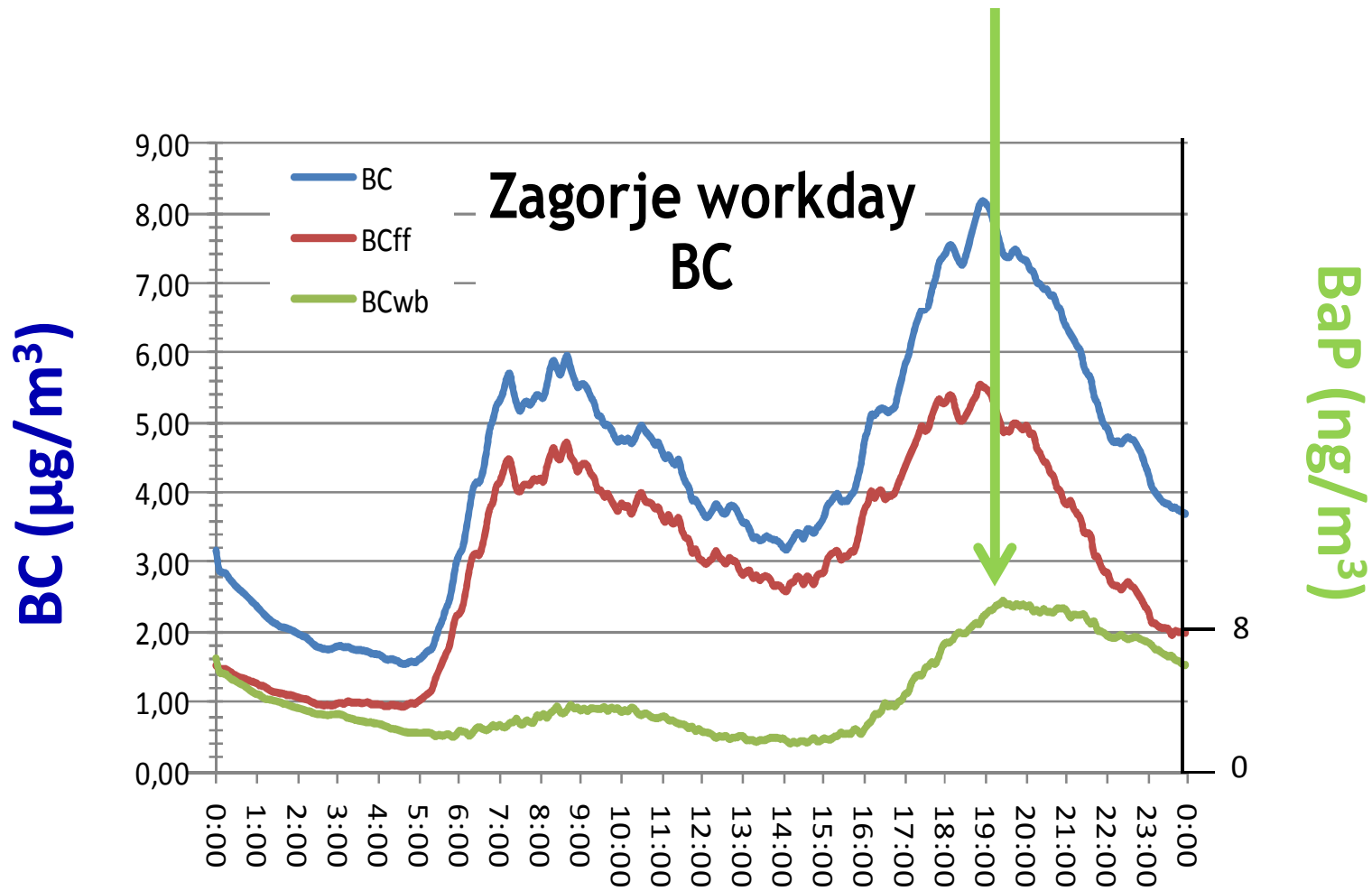
Filter chemical analysis- EARS



PAH – what is the source?



Diurnal variation of $BC_{wb} = BaP$



Science for Environment Policy

Wood burning in London undermines low traffic emissions' gains

Particulate matter (PM) emissions from domestic wood burning in London are higher than the PM reductions achieved through London's Low Emission Zone, finds a new study. The research suggests that increases in wood burning could risk undermining policies aimed at meeting EU PM₁₀ targets.

Conclusions

- source apportionment, “Aethalometer model“: **biomass vs. diesel**, excellent correlation with markers
- time resolution is **1 min**
- we can investigate **time evolution, spatial distribution**: BC, CM
- **correlation** between different pollutants: **PAH source**
- **quantitative Wood-Smoke determination** – “Aethalometer model“ CM time resolution: 15 min
- the new dual-spot Aethalometer AE33 with **real-time loading compensation** was developed, online source app.
- technical improvements facilitate **monitoring**



Thank you for your attention!

Questions?

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