Aethalometer
Black Carbon measurements, source apportionment model and its use in air pollution monitoring

Meeting on sensors, Utrecht, January 2017
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Aerosol

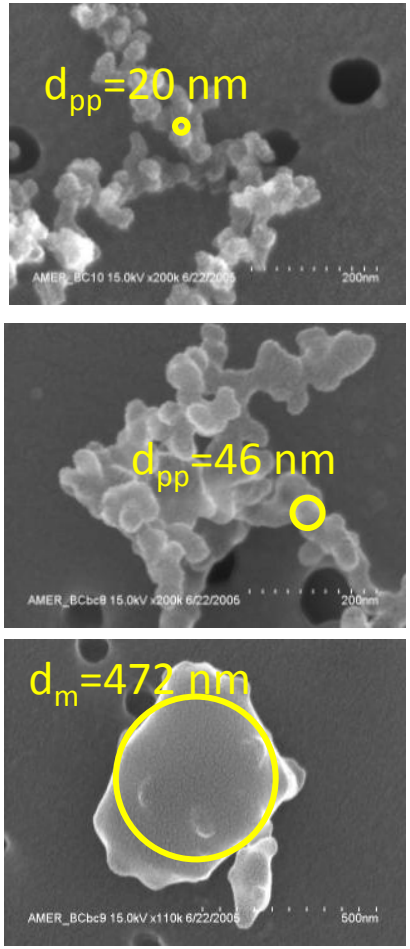
Aerosol Black Carbon (BC)

- Primary pollutant - product of incomplete combustion of carbonaceous fuels
- Inert - removed from the atmosphere by deposition
- Higher correlation to the adverse effects on public health and climate than PM.

(Janssen et al. 2012, Bond et al. 2013, Ramanathan et al., 2008)

Two **main sources** of BC in many urban areas: **traffic** and small **inefficient stoves** for domestic heating that mostly burn biomass.

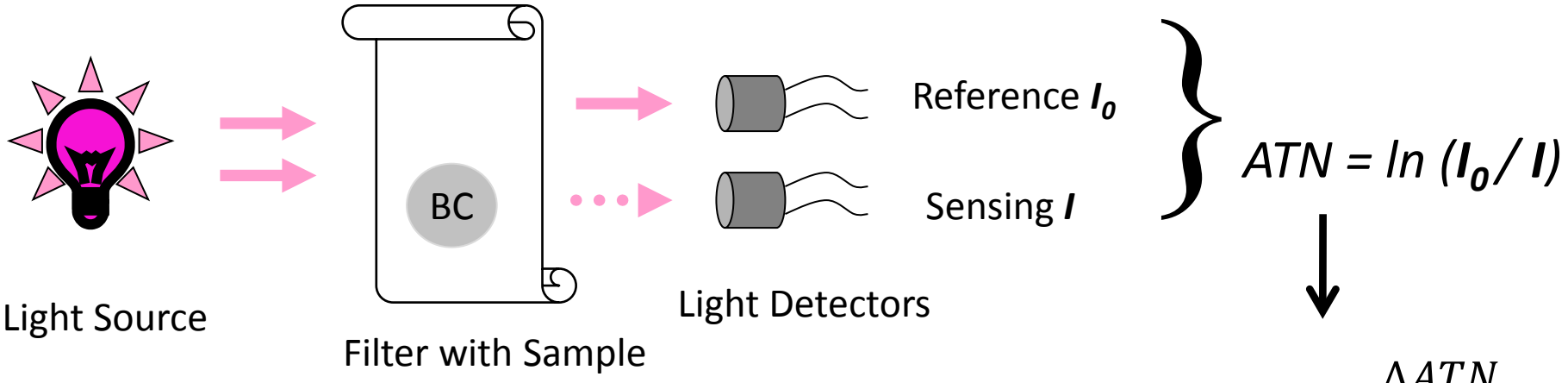
Separating sources contributions: implementation of **efficient abatements strategies** and **monitoring efficiency**.



Note change in scale!

BC particles

Optical detection of BC: Aethalometer™



- Collect sample **continuously** : real-time data in **minutes, seconds**
- **Optical absorption coefficient** ~ change in ATN.
- Convert optical absorption to **concentration of BC** using mass absorption cross section σ:

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

- Measure optical absorption continuously: λ = 370 to 950 nm.

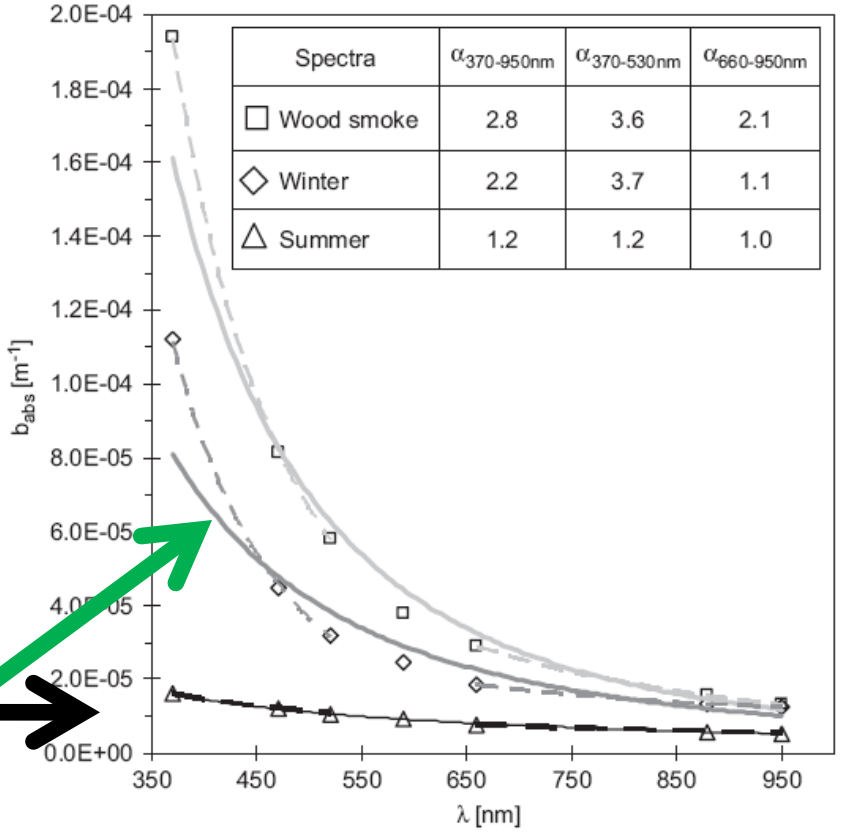
BC source apportionment

- 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

BC source apportionment

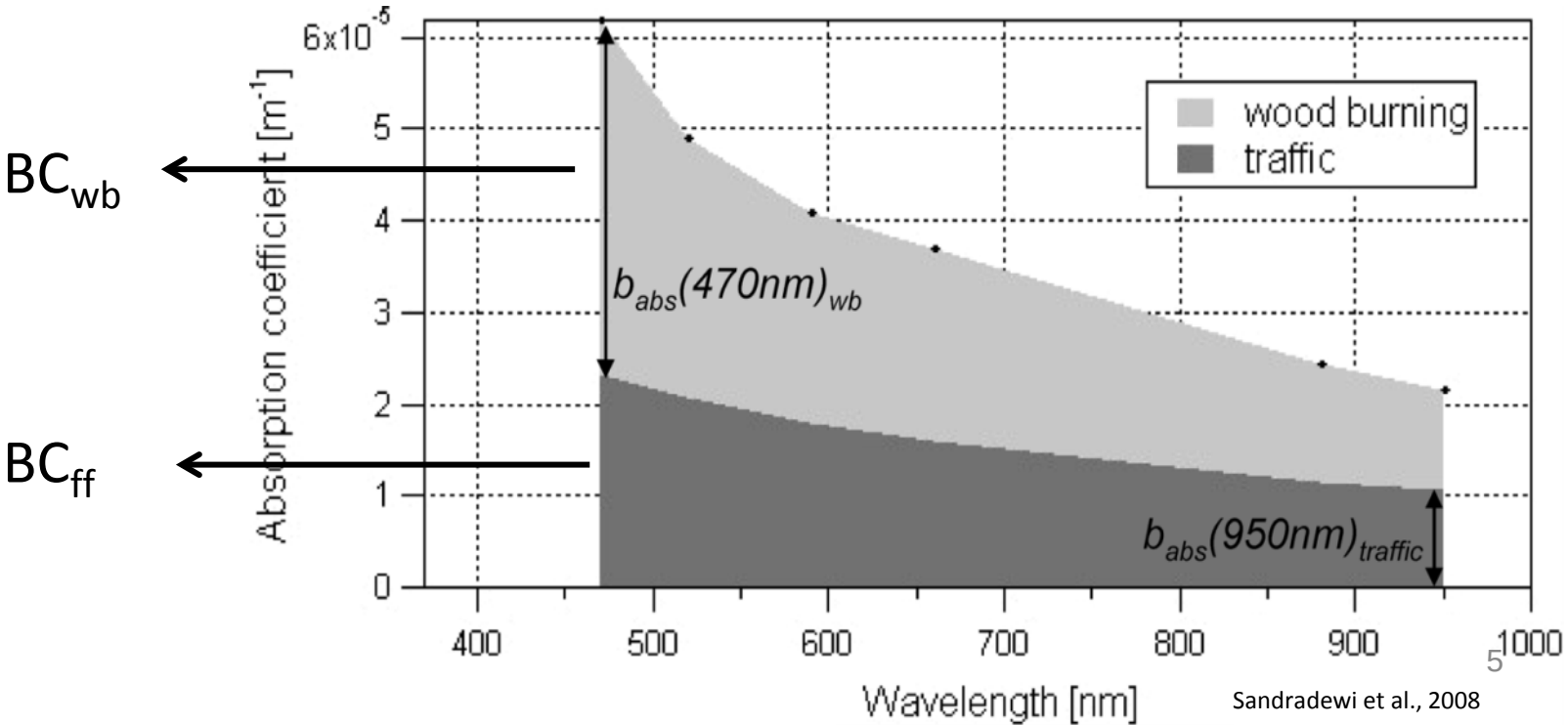
Sandradewi et al., 2008

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

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

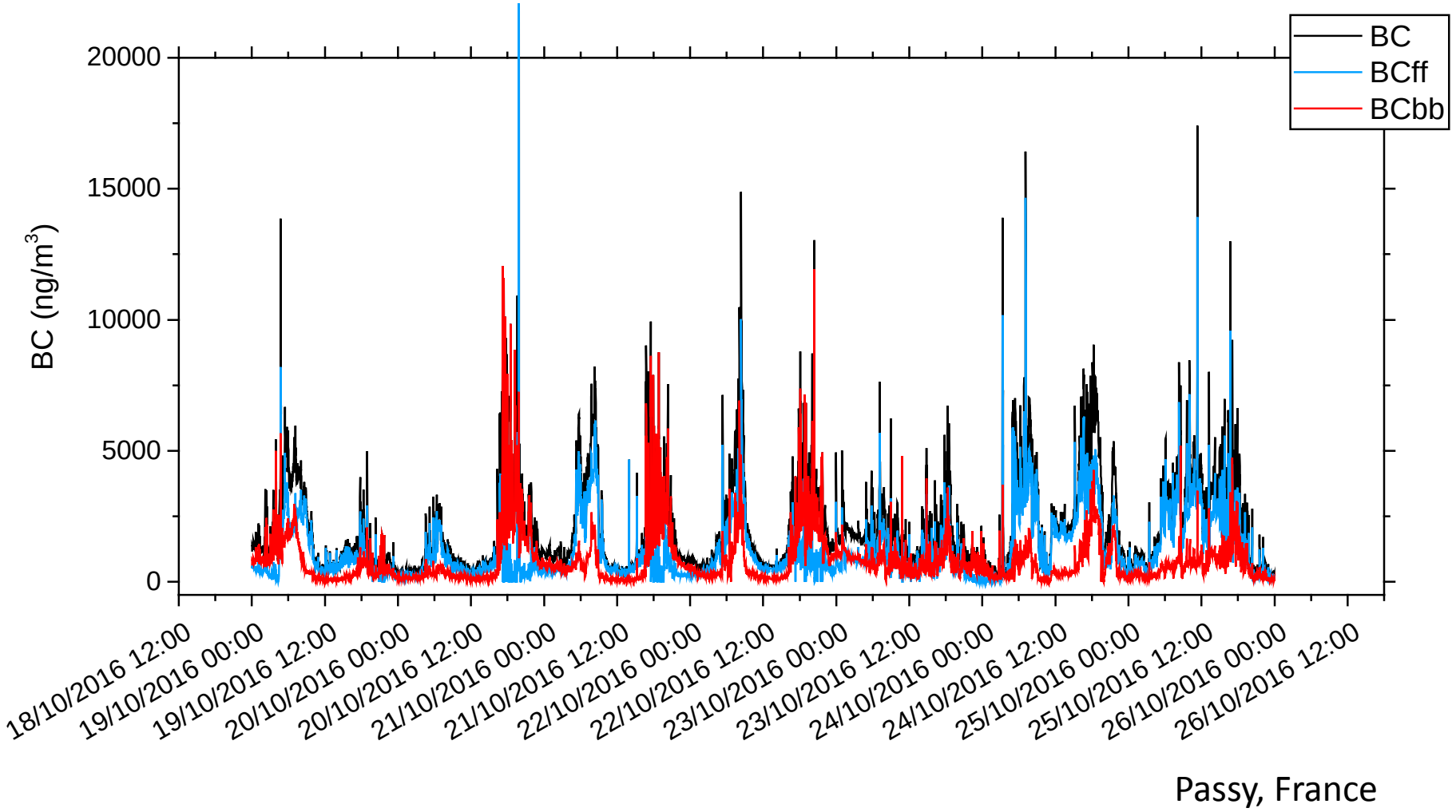
$\alpha = 1,0 \pm 0,1$ (fossil) Bond & Bergstrom 2004

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

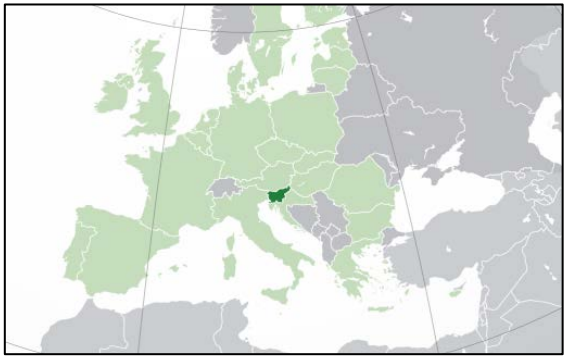


Sandradewi et al., 2008

Example of source apportionment data



Passy, France



Case example: Ljubljana

Population: $0.5*10^6$

Surrounded by hills 500-1700 m above basin floor

Air pollution: 44 exceedances of daily PM10 limit (50 $\mu g/m3$) in 2015

Study:

Influence of source specific black carbon production and meteorology on spatio-temporal distribution of black carbon concentration in Central-European basin

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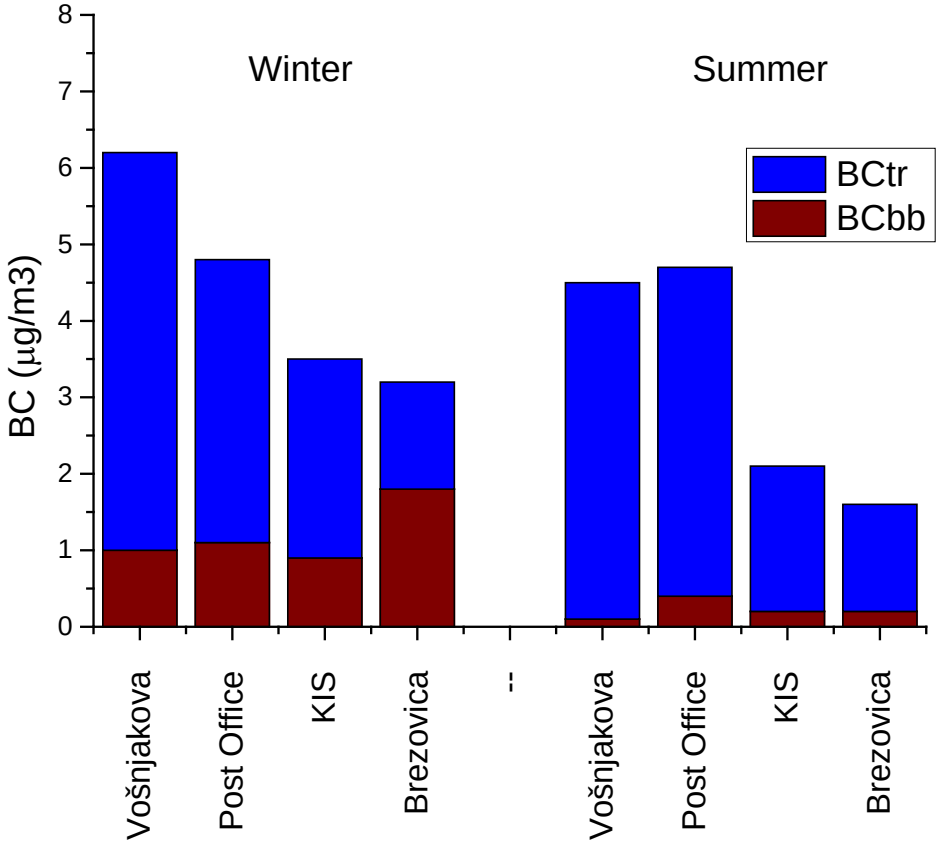
Aerosol

Average BC: Different stations



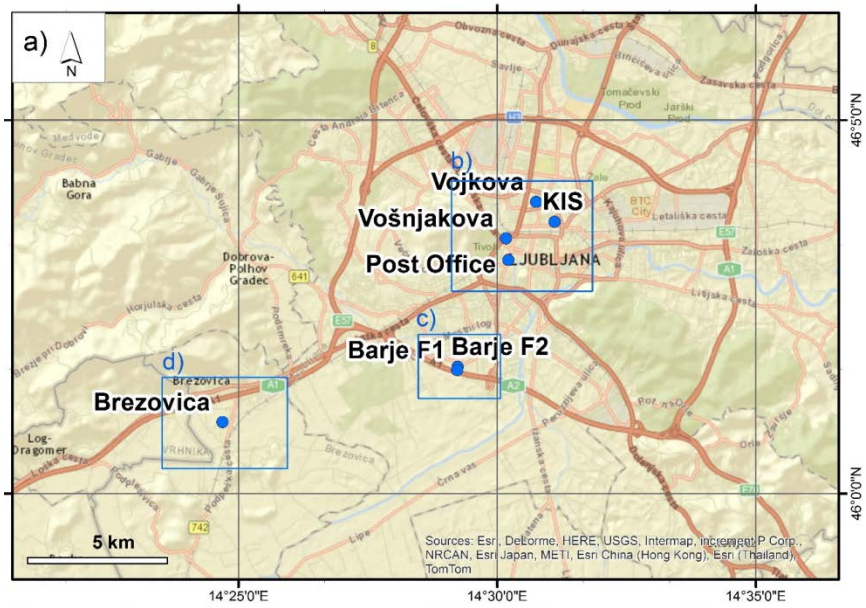
Vošnjakova	Roadside
Post office	Street canyon
KIS	Urban background
Brezovica	Suburban background

Roadside: similar winter and summer

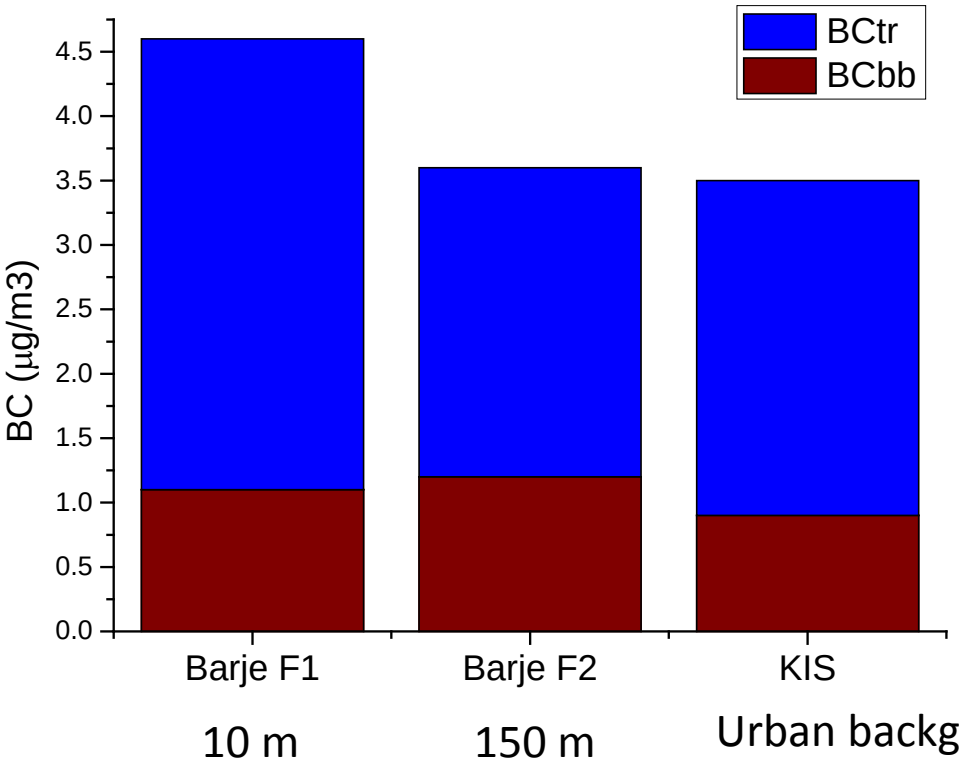
Background: Lower BC in summer

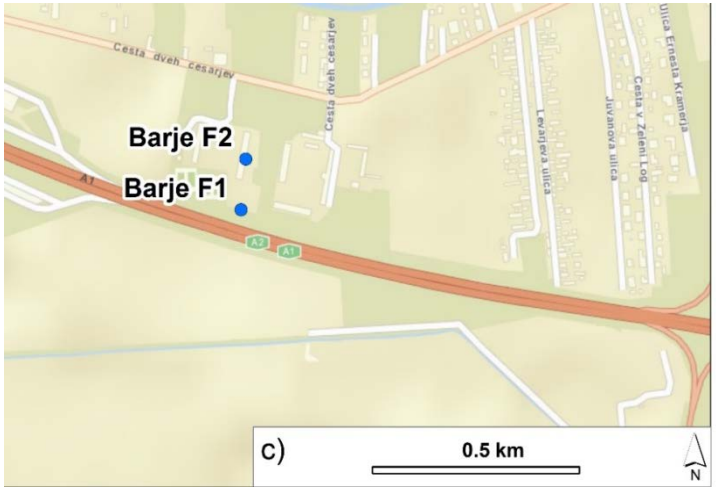
Traffic: **heterogeneous**

Biomass burning: **homogenous**



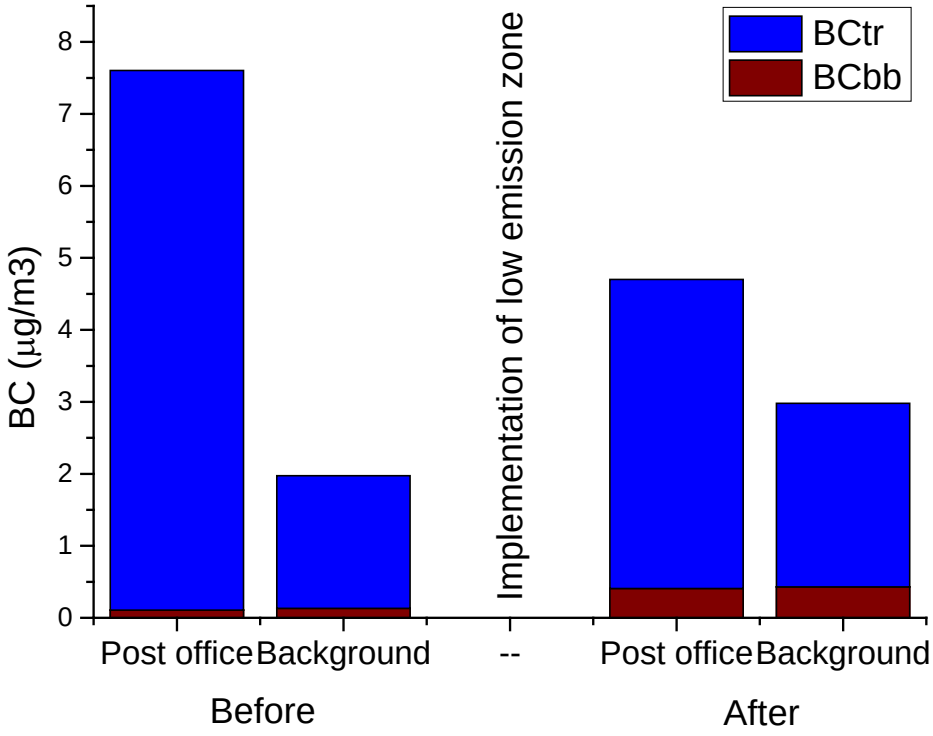
Heterogeneity: distance from highway





Influence of traffic diminishes quickly with distance from the highway

Heterogeneity: traffic restriction

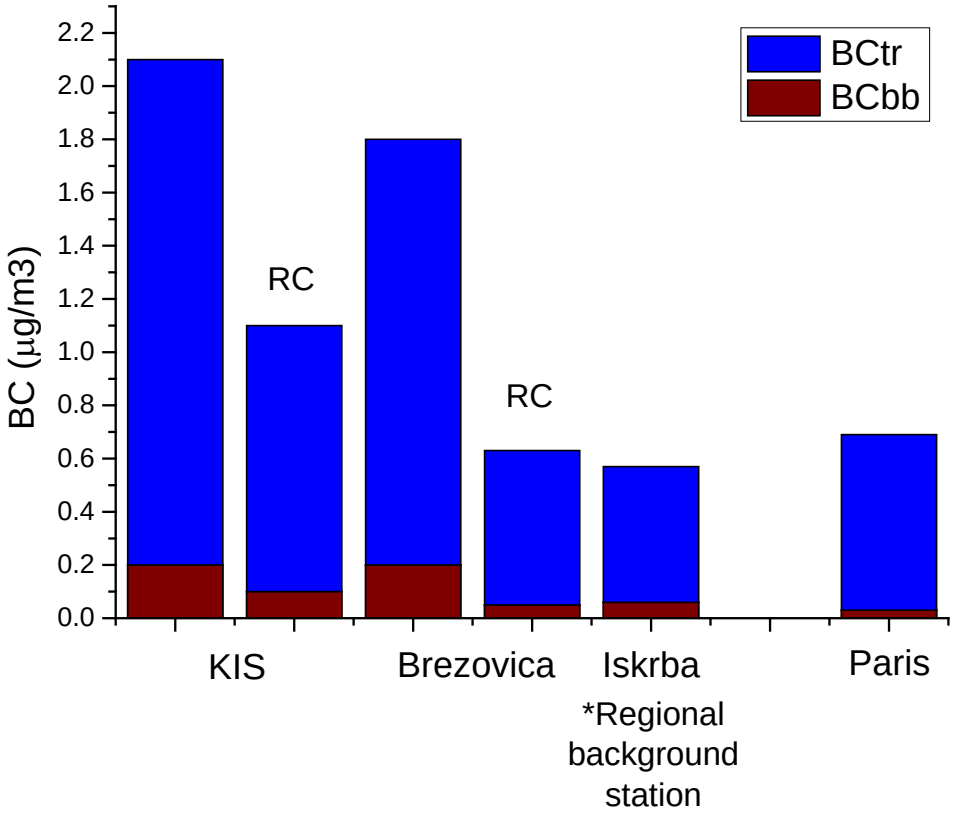


Only public transport is allowed in the low emission zone

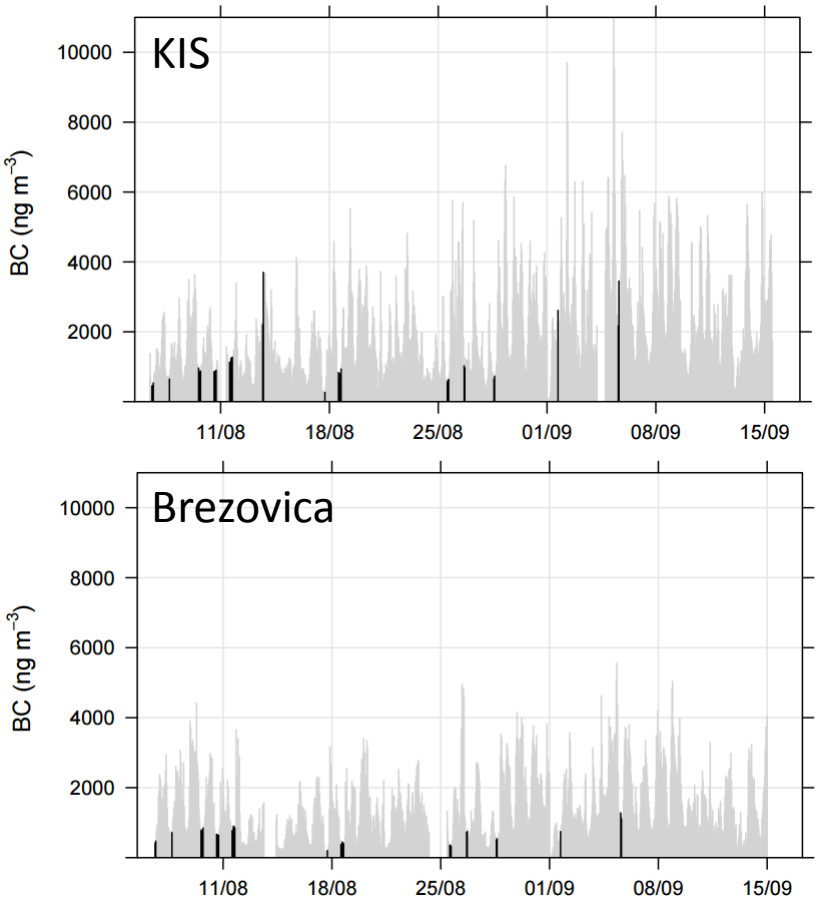
70% reduction of local emissions

Ref: Titos et al., 2015, Evaluation of the impact of transportation changes on air quality Atmospheric Environment, Volume 114

Background: Regional contribution



Regional contribution(**RC**) = average BC when planetary boundary layer > 1000 m



Meteorology is responsible for higher BC in Ljubljana!

Thank you for your attention!

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