Using black carbon to measure the efficiency of air pollution abatement

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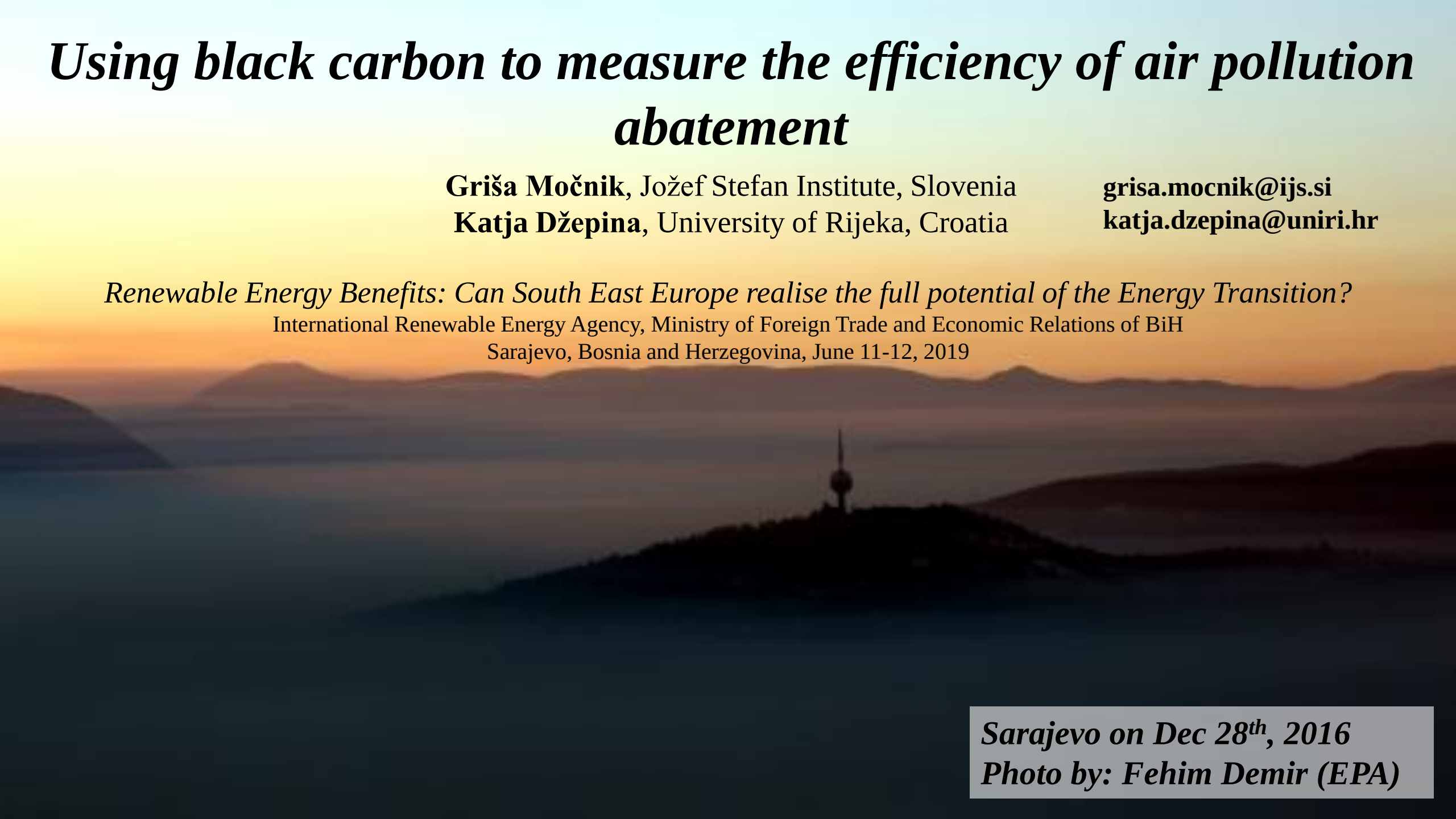
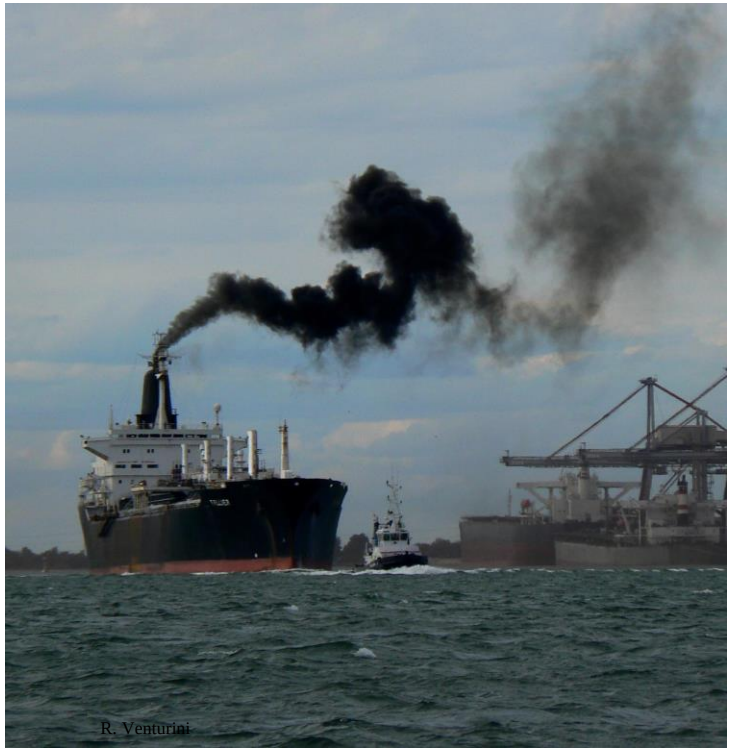
Renewable Energy Benefits: Can South East Europe realise the full potential of the Energy Transition?
International Renewable Energy Agency, Ministry of Foreign Trade and Economic Relations of BiH
Sarajevo, Bosnia and Herzegovina, June 11-12, 2019



Sarajevo on Dec 28th, 2016
Photo by: Fehim Demir (EPA)

Black Carbon *and* ***Particulate Matter***



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- BC – primary
- BC – direct to sources

- PM dominated by secondary
- well mixed

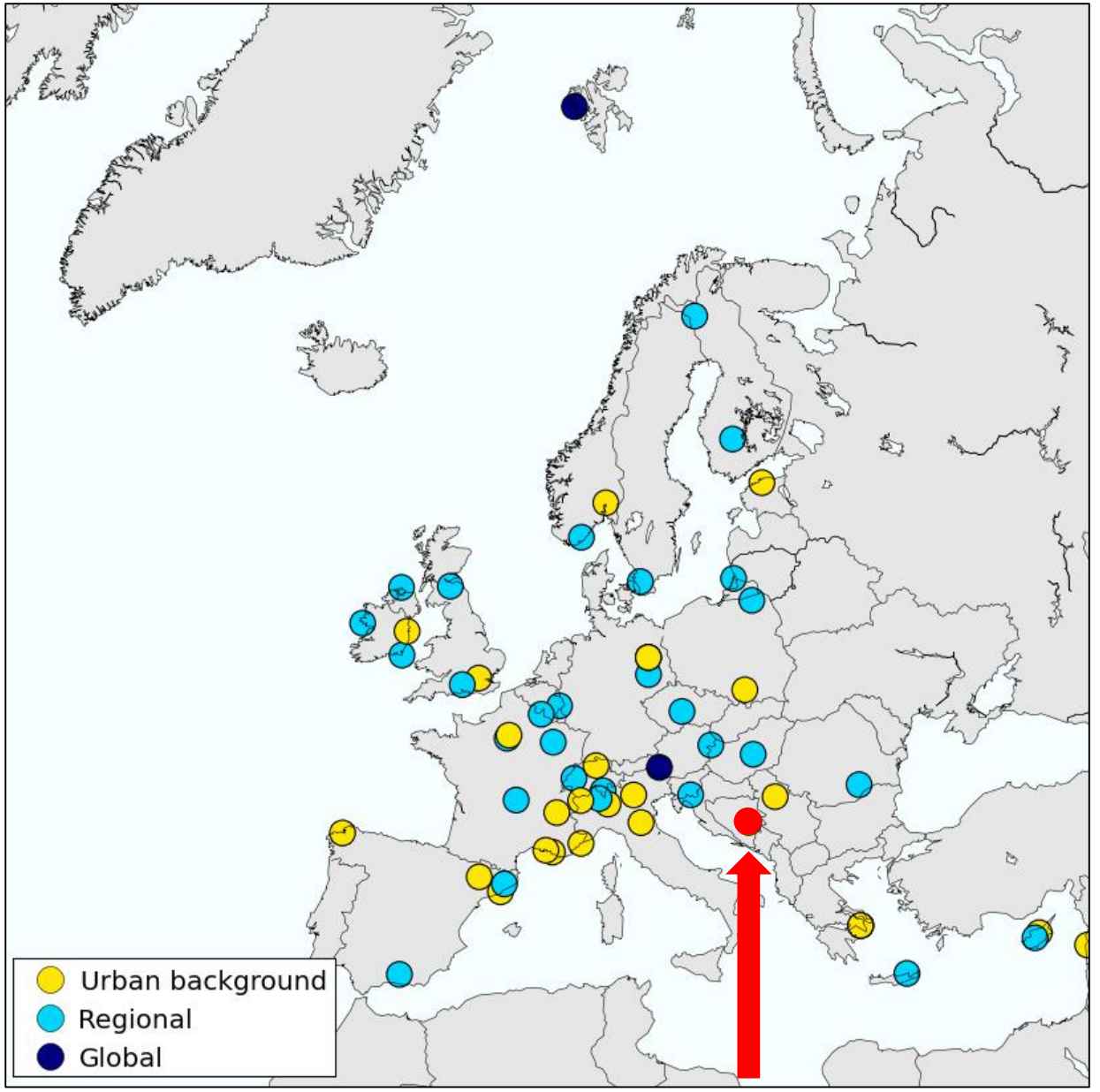
EMEP/ACTRIS/COLOSSAL intensive measurement period

- ***Carbonaceous aerosol source apportionment***

- Winter 2018
  - December 2017 – March 2018

- 24 countries

- 58 measurement sites
  - 27 urban
  - **Sarajevo urban background site**



Atmospheric aerosol measurements in Sarajevo Canton: Sarajevo Canton Field Campaign 2017-2018 (SAFICA)

SAFICA scientific goals:

- Chemical characterization of atmospheric pollutant species in the Sarajevo Canton
- Science-based recommendations for the improvement of the air quality in the Sarajevo Canton

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***On-line instrumentation (Bjelave** and Pofalići)*

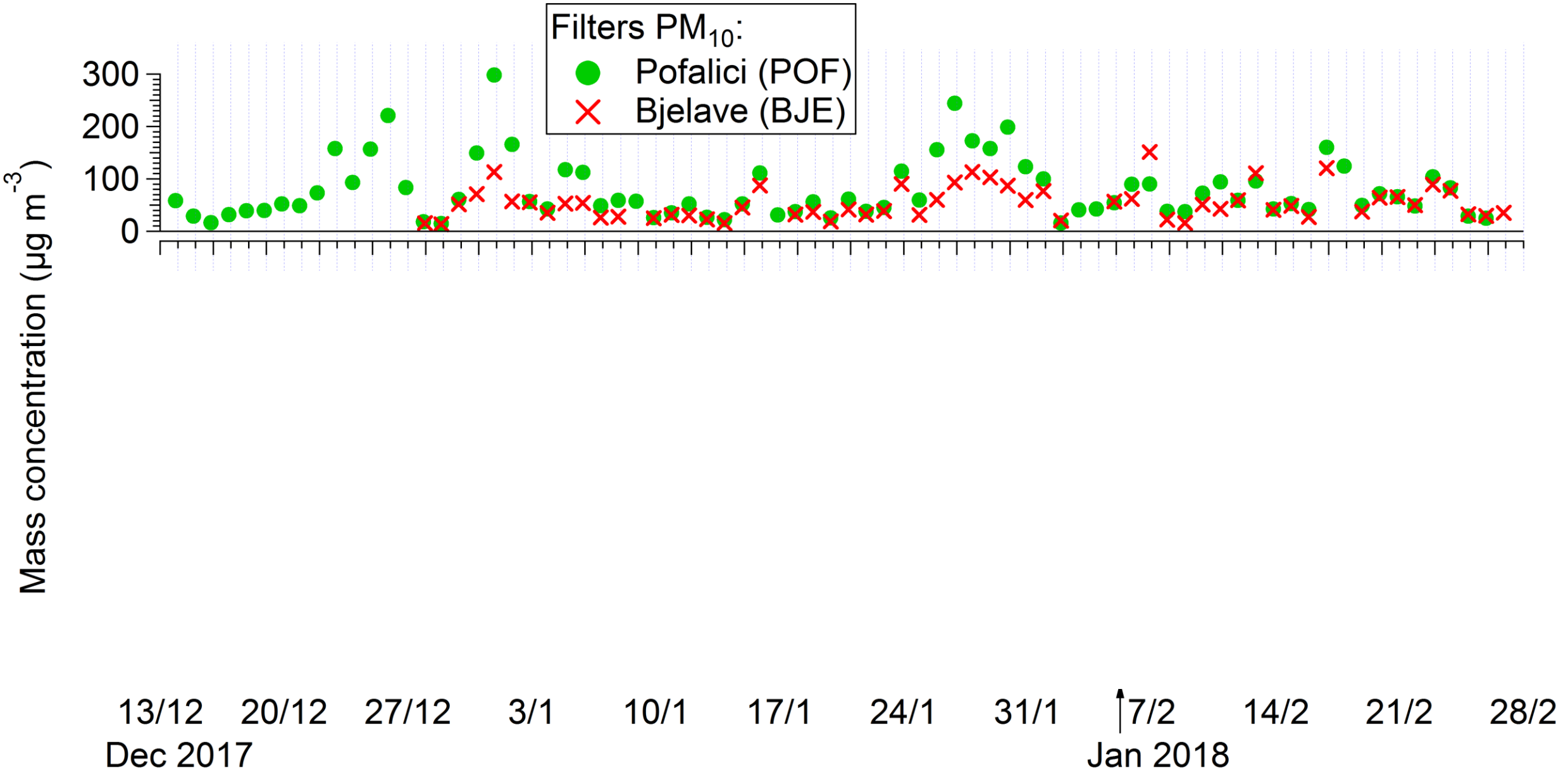
- Condensation Particle Counter
  - Particle number concentration: 4 nm–2.5 μm ($PM_{2.5}$)
- Optical Particle Sizer
  - Particle number concentration: 300 nm–10 μm, 16 size bins (PM_{10})
- Aethalometer AE33
  - Black carbon mass concentration in $PM_{2.5}$

***Off-line (Bjelave**, Pofalići*, Otoka, Ivan Sedlo*)*

- Daily (24 hrs) PM_{10} mass concentration

All data shown here are preliminary!!

Pofalići & Bjelave PM_{10} filter samples measured during SAFICA



Bjelave PM_{10} filter samples *vs.* black carbon (BC)

24-h avg., Jan 9 – March 7, 2018

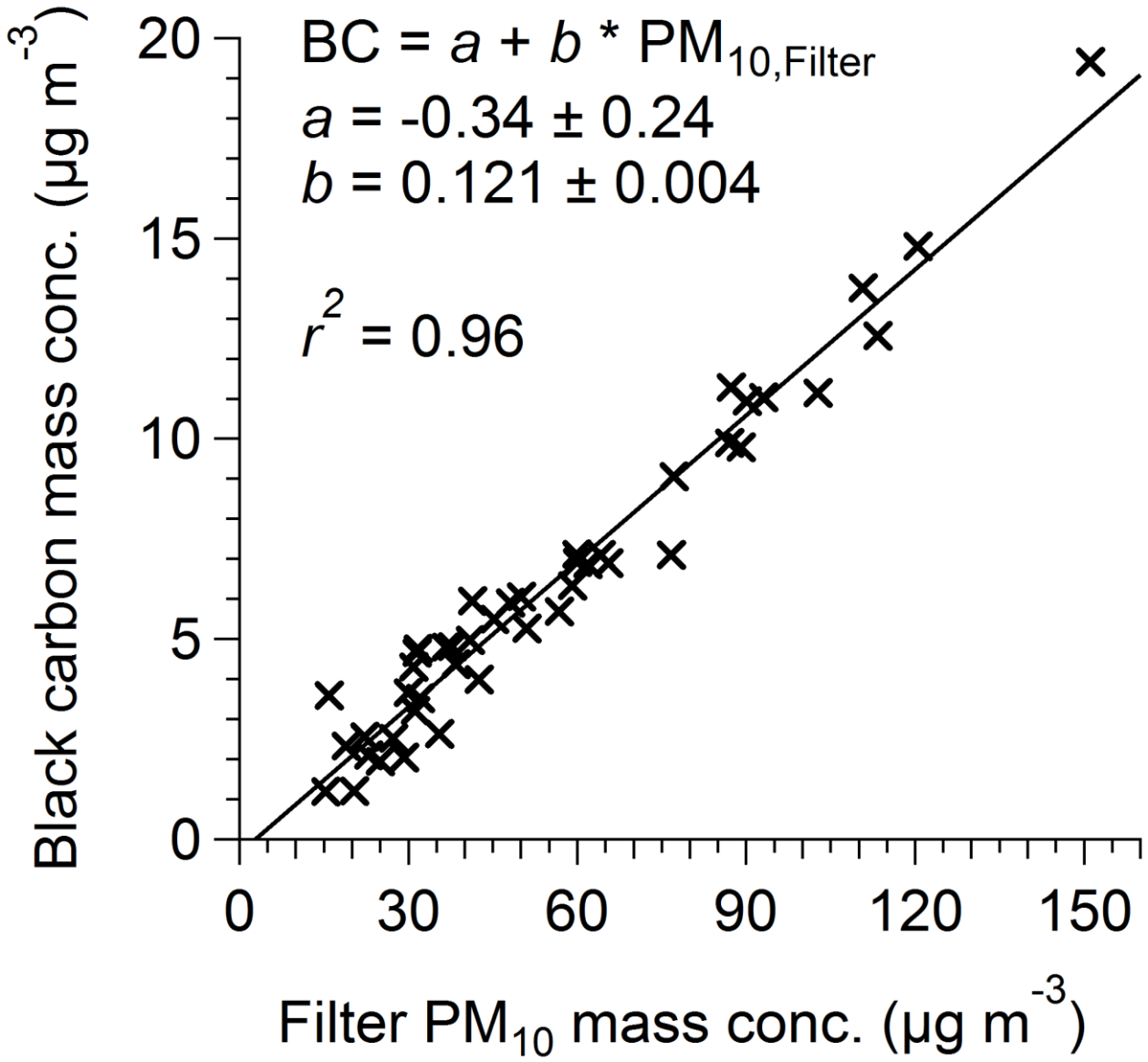
BC = (8.4 ± 9.9) µg m^{-3}

Sarajevo urban

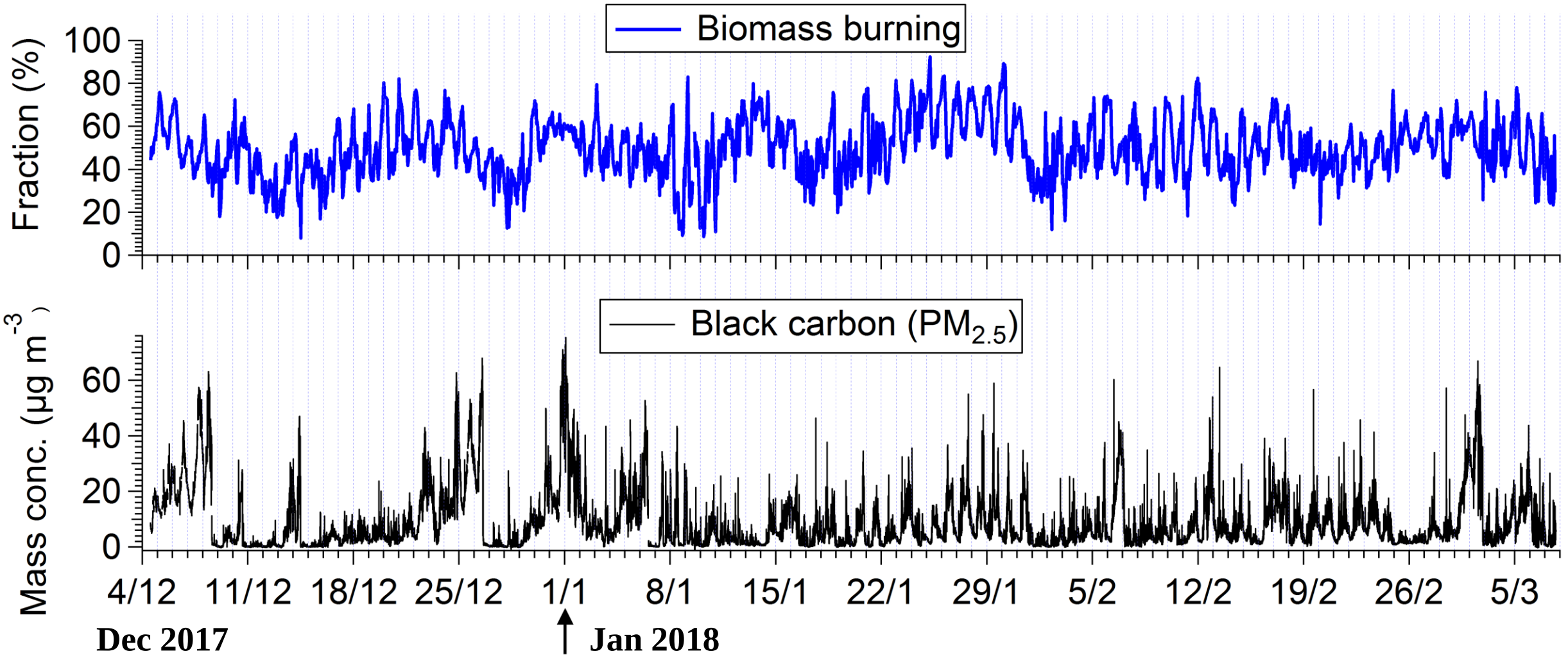
BC_{URB} = (10.9 ± 12.7) µg m^{-3}

Sarajevo urban background

$BC_{URB\ BG}$ = (6.4 ± 7.0) µg m^{-3}



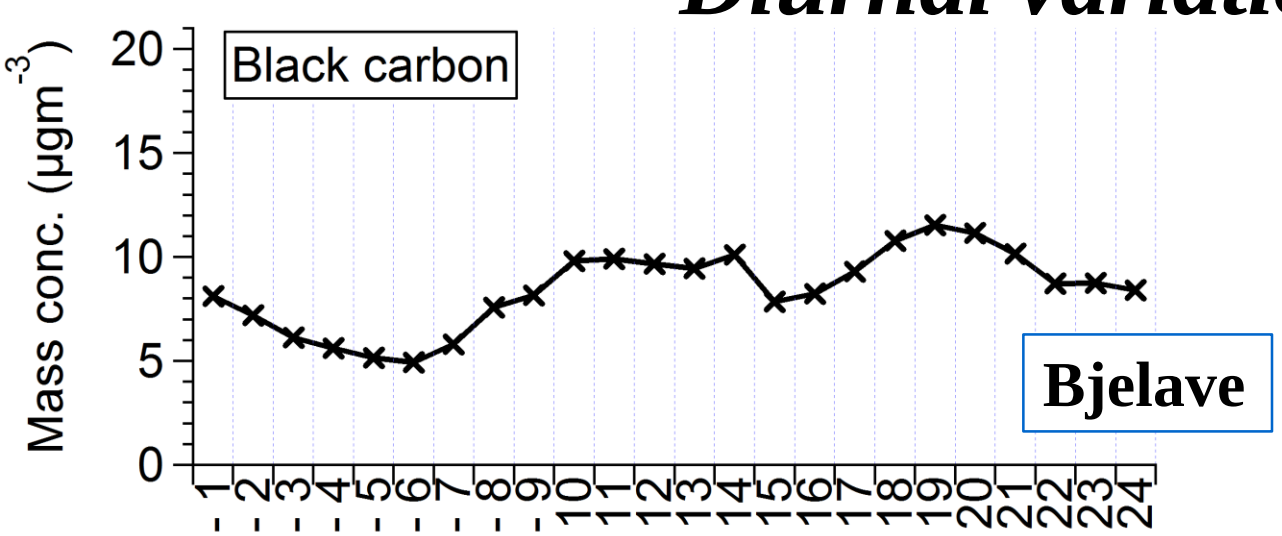
Ambient mass concentrations of measured black carbon

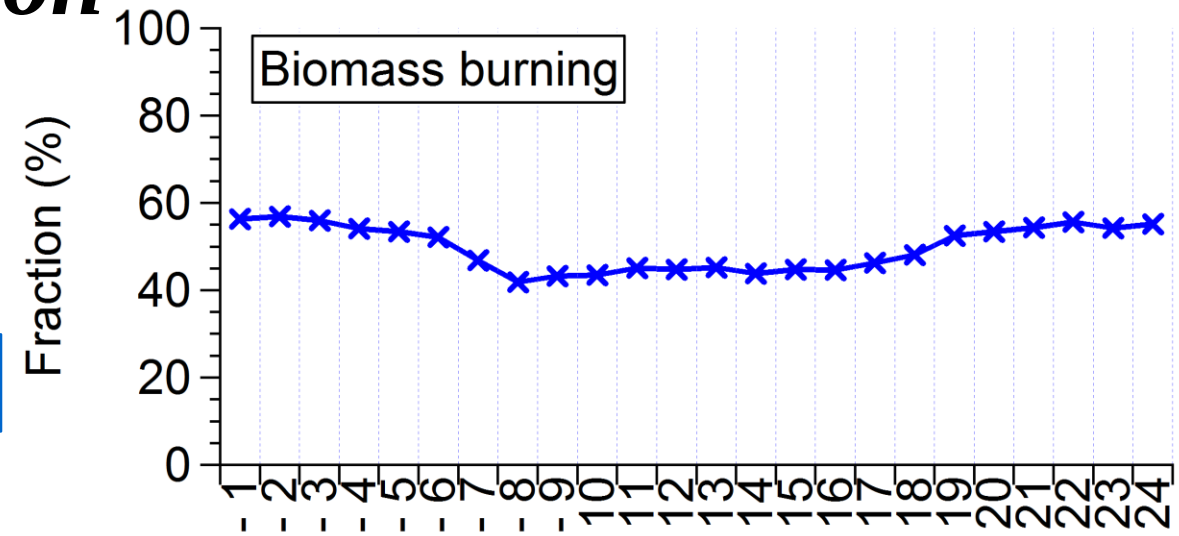


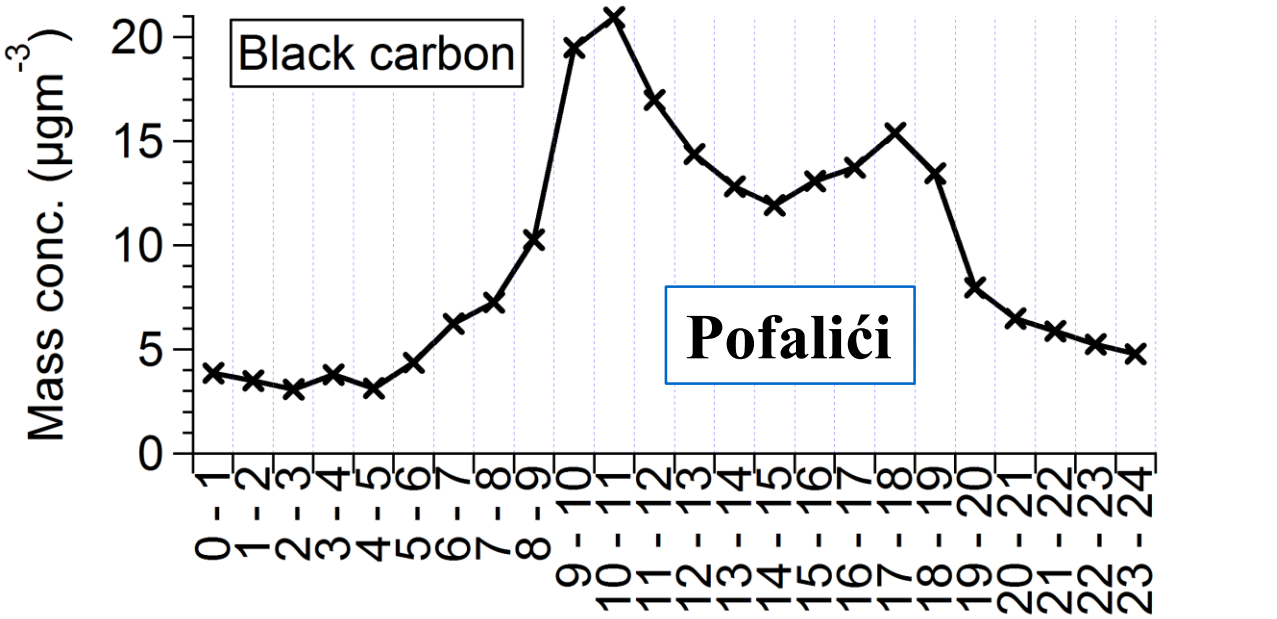
Biomass burning BC = (50 ± 13) %

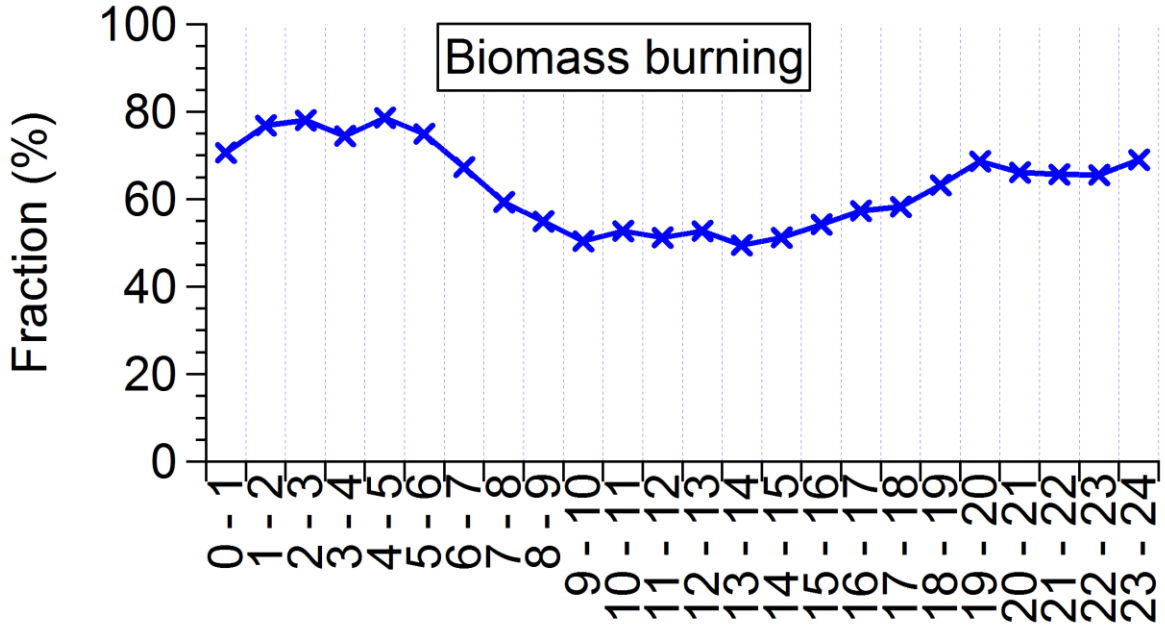
BC = (8.4 ± 9.9) μg m^{-3}

Diurnal variation









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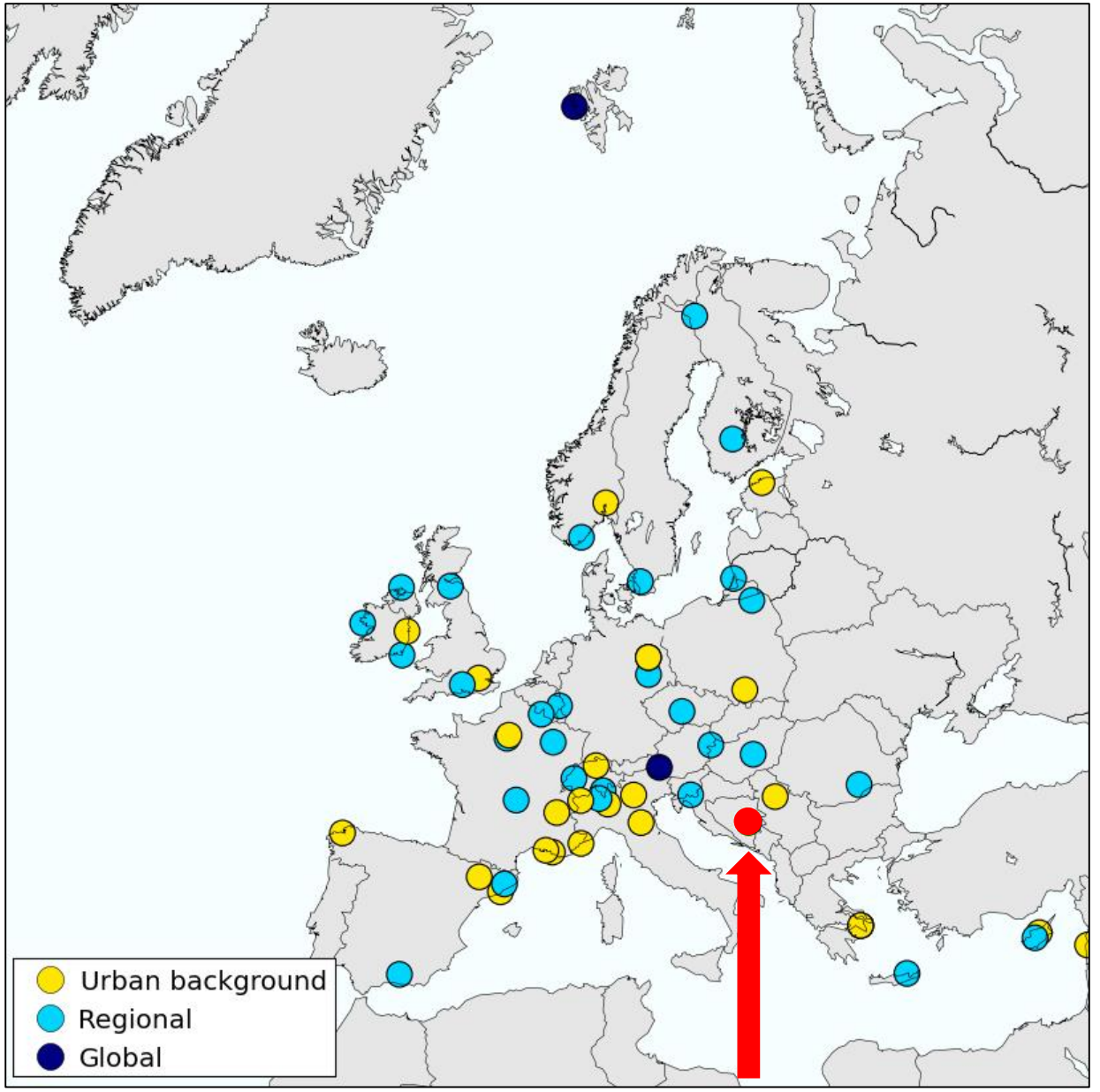
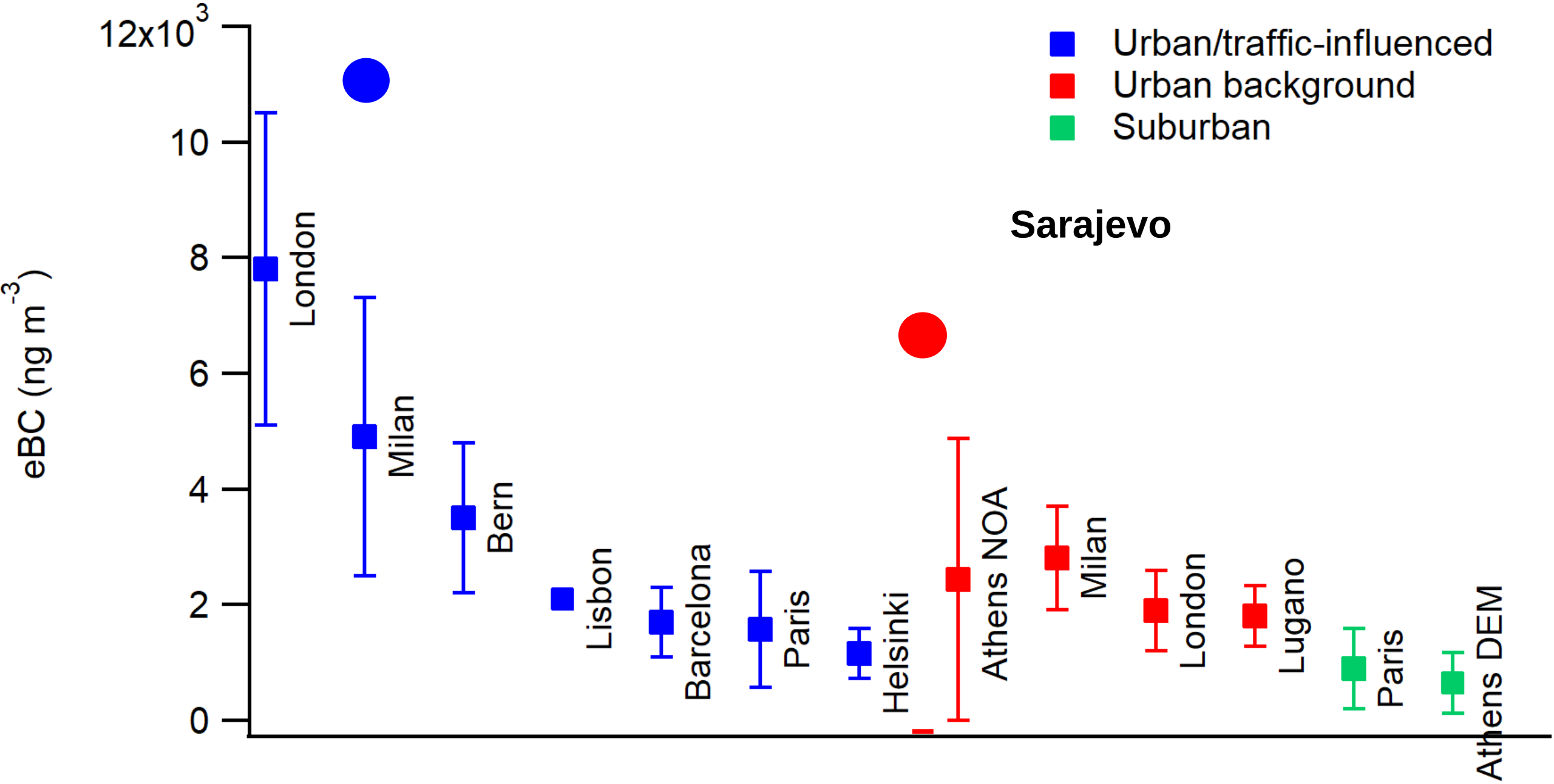




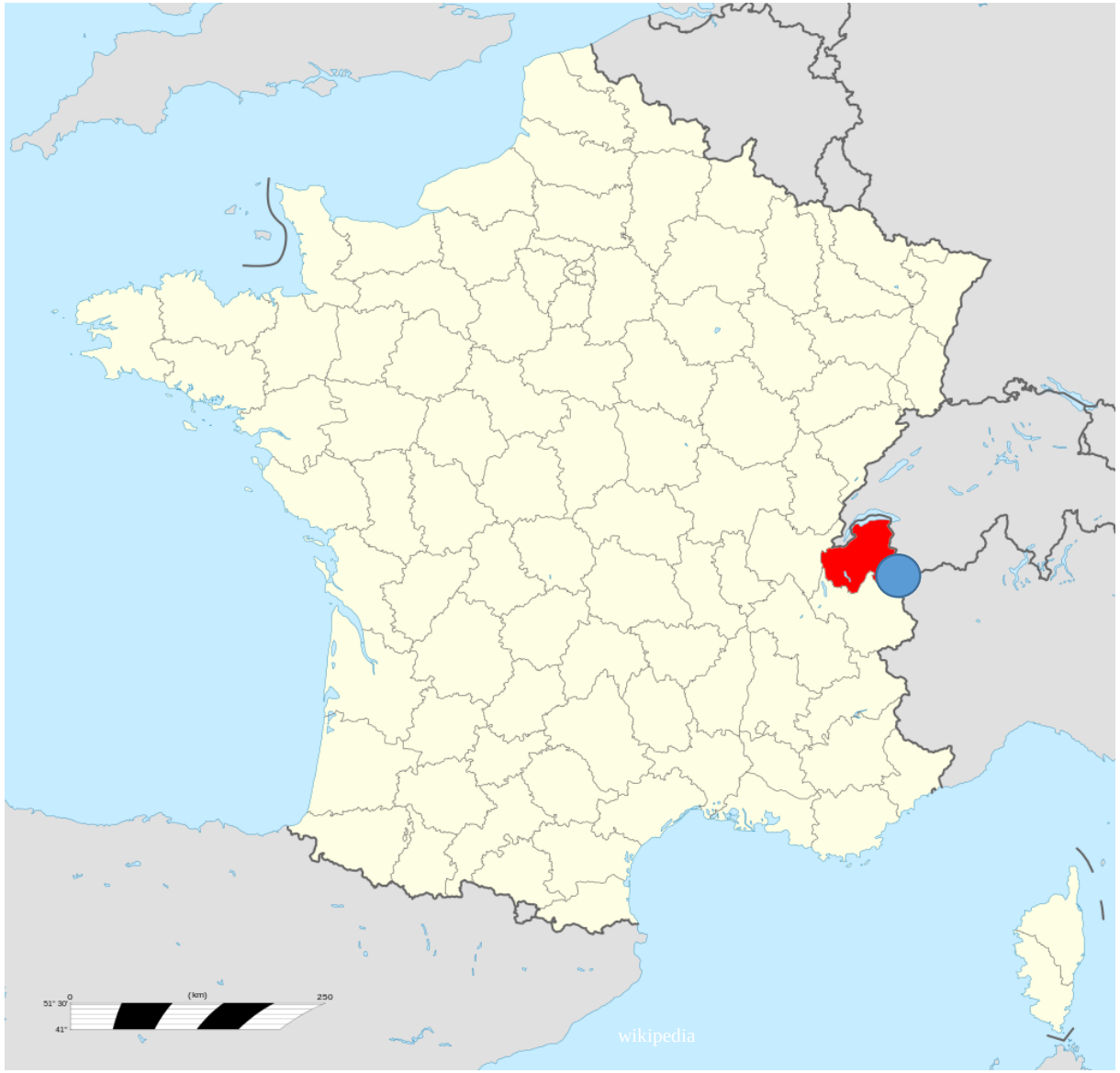
A.-C. Kalogridis et al., ACP, 18, 10219-10236, 2018.

Additional chemical analyses for collected PM_{10} samples

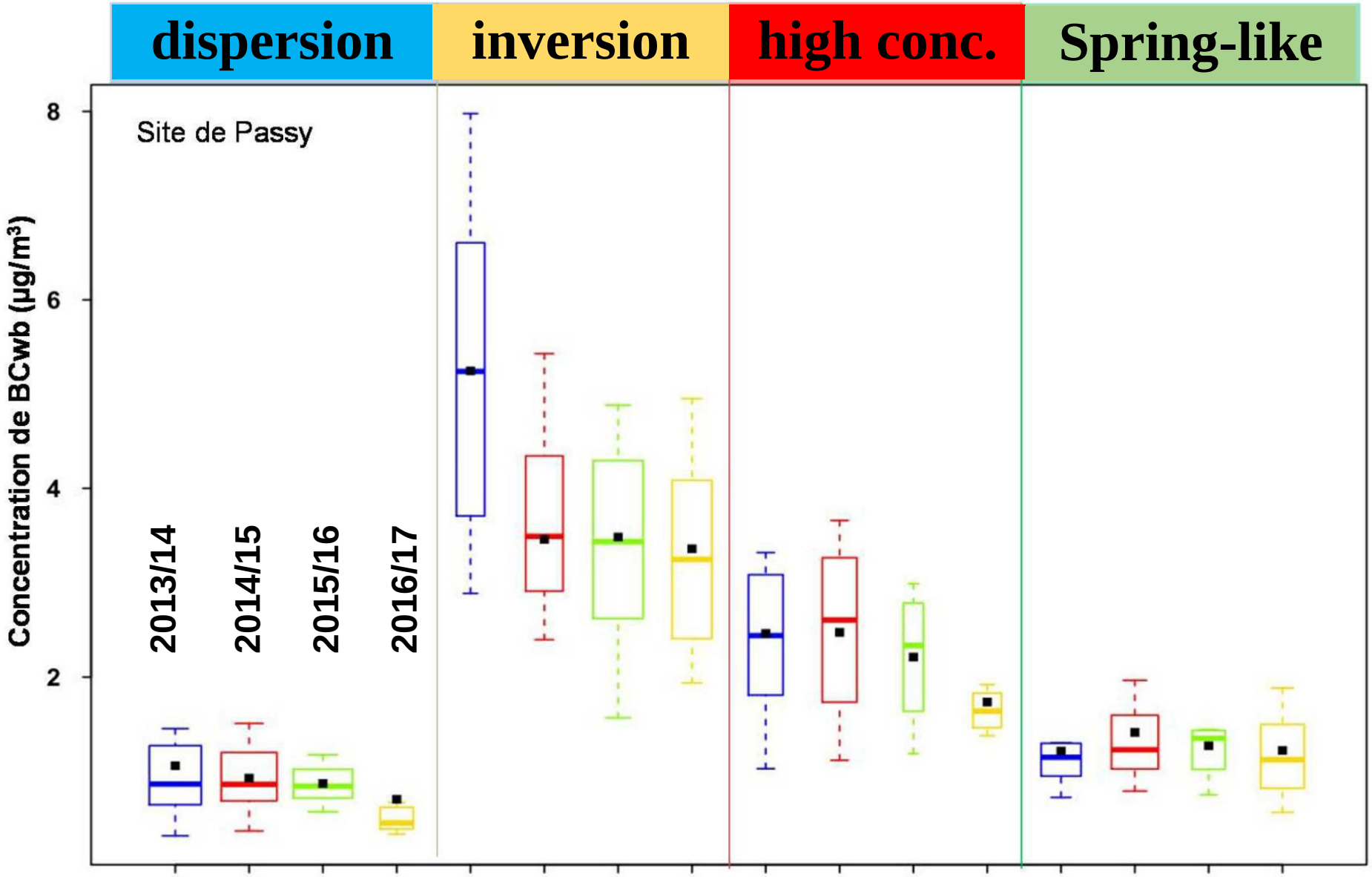
- ***Done PM_{10} filter samples chemical composition analyses:***
  - Organic and elemental carbon (OC / EC)
  - Polycyclic Aromatic Hydrocarbons (PAH)
  - Levoglucosan
  - Metals (different methods: AAS, ICP-MS)
  - Bulk chemical composition including organic aerosol species: Aerodyne High Resolution Aerosol Mass Spectrometer (Aerodyne AMS)
- ***Scientific goal: Chemical characterization and source apportionment of the Sarajevo Canton PM***
- ***SAFICA sponsoring institutions:***
  - TSI (Lucia Bustin) loan CPC and OPS for 5 weeks
  - Aerosol d.o.o. Aethalometer loan, 3 months
  - Jasminka Džepina
- ***SAFICA funding institutions:***
  - COST Action COLOSSAL Short Term Scientific Grant awards
  - SEE Change Net
- ***SAFICA Sarajevo Canton Team:***
  - Jasna Huremović and Sabina Žero (Department of Chemistry, Faculty of Natural Sciences and Mathematics, UniSa)
  - Almir Bijedić, Enis Omerčić i Enis Krečinić (Federal Hydrometeorological Institute of B&H)
  - Adnan Mašić, Boran Pikula, Dževad Bibić (Motors and Vehicles Dept., Mechanical Engineering Faculty, UniSa)
  - Sanela Salihagić (Institute for Public Health of Sarajevo Canton)

Measuring improvement

Vallée d‘Arve, France
7000 stoves!



Primary woodburning: BC_{wb} Nov – Mar



DECOMBIO, 2018

Conclusions

- **Biomass burning** – very large fraction of BC, major of PM.
- Most probably **individual stoves** – centralization!
- Long term monitoring to **measure improvement** is necessary.
- Challenge: disentangle meteorology and sources.

Thank you!

Questions?

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Back up slides

Atmospheric aerosol measurements in Sarajevo Canton: Sarajevo Canton Field Campaign 2017-2018 (SAFICA)

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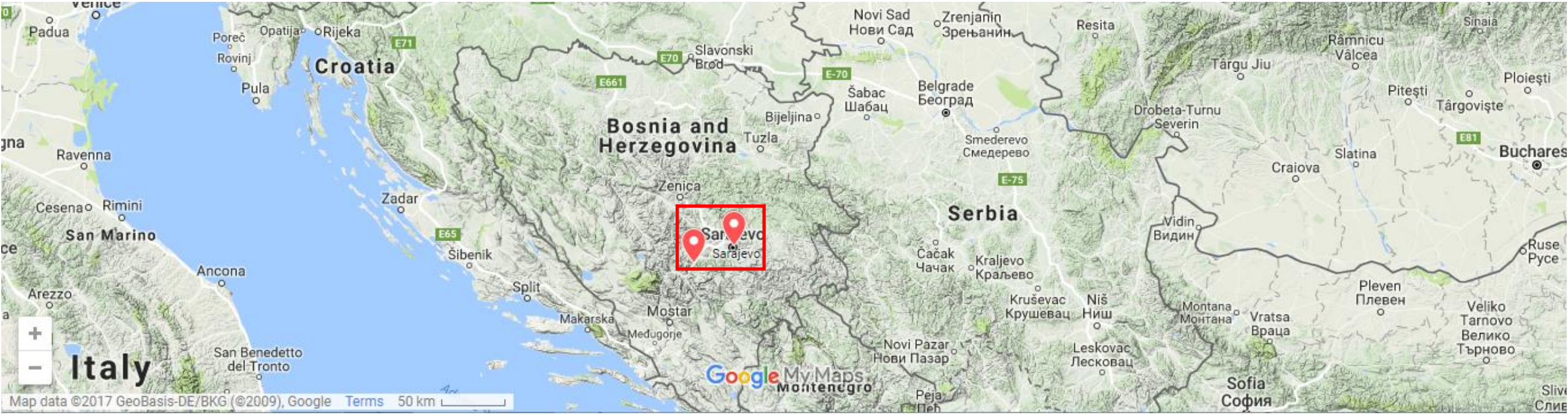


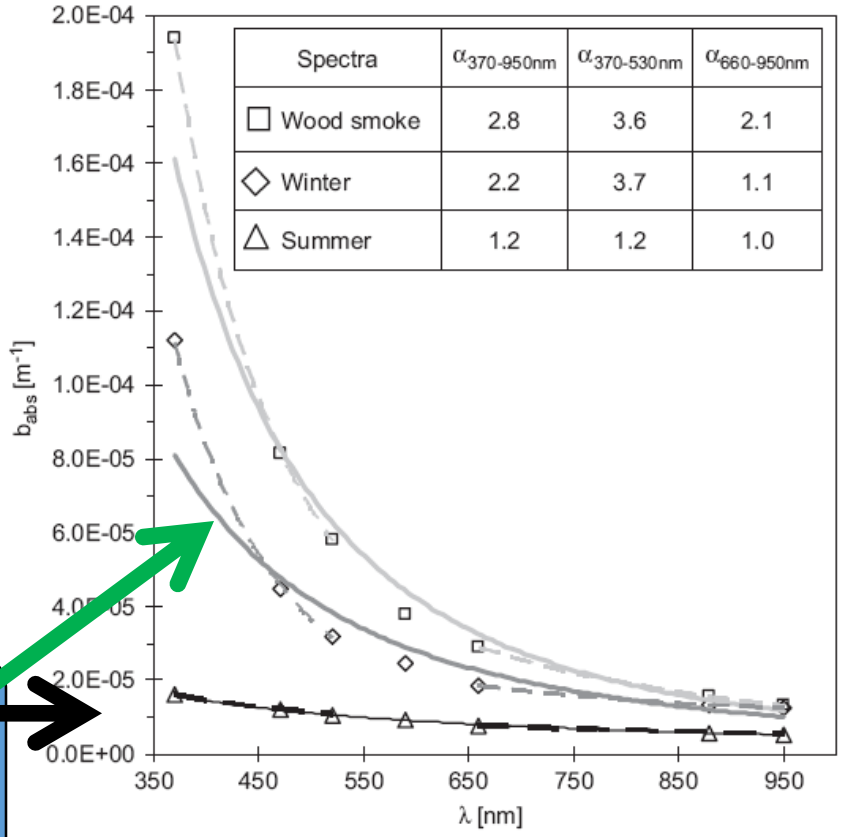
Biomass-smoke vs. diesel - 7λ

- 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



Sandradewi et al., 2008

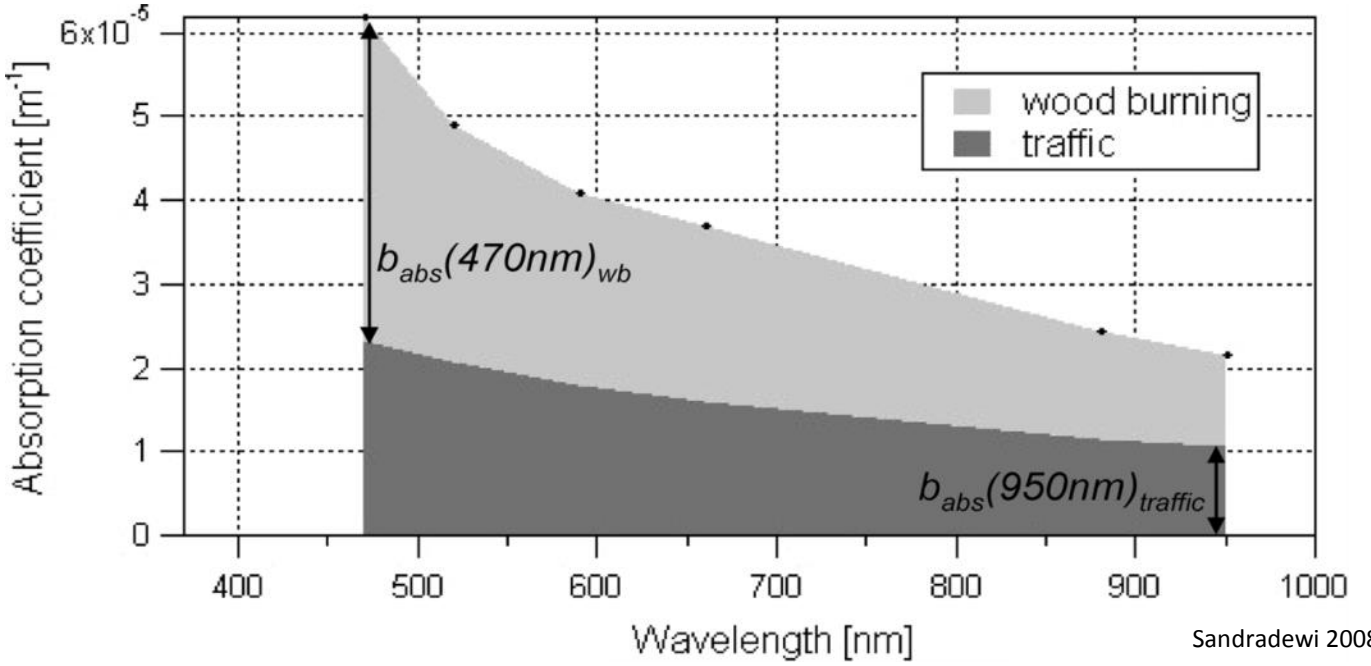
Quantification

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

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

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

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



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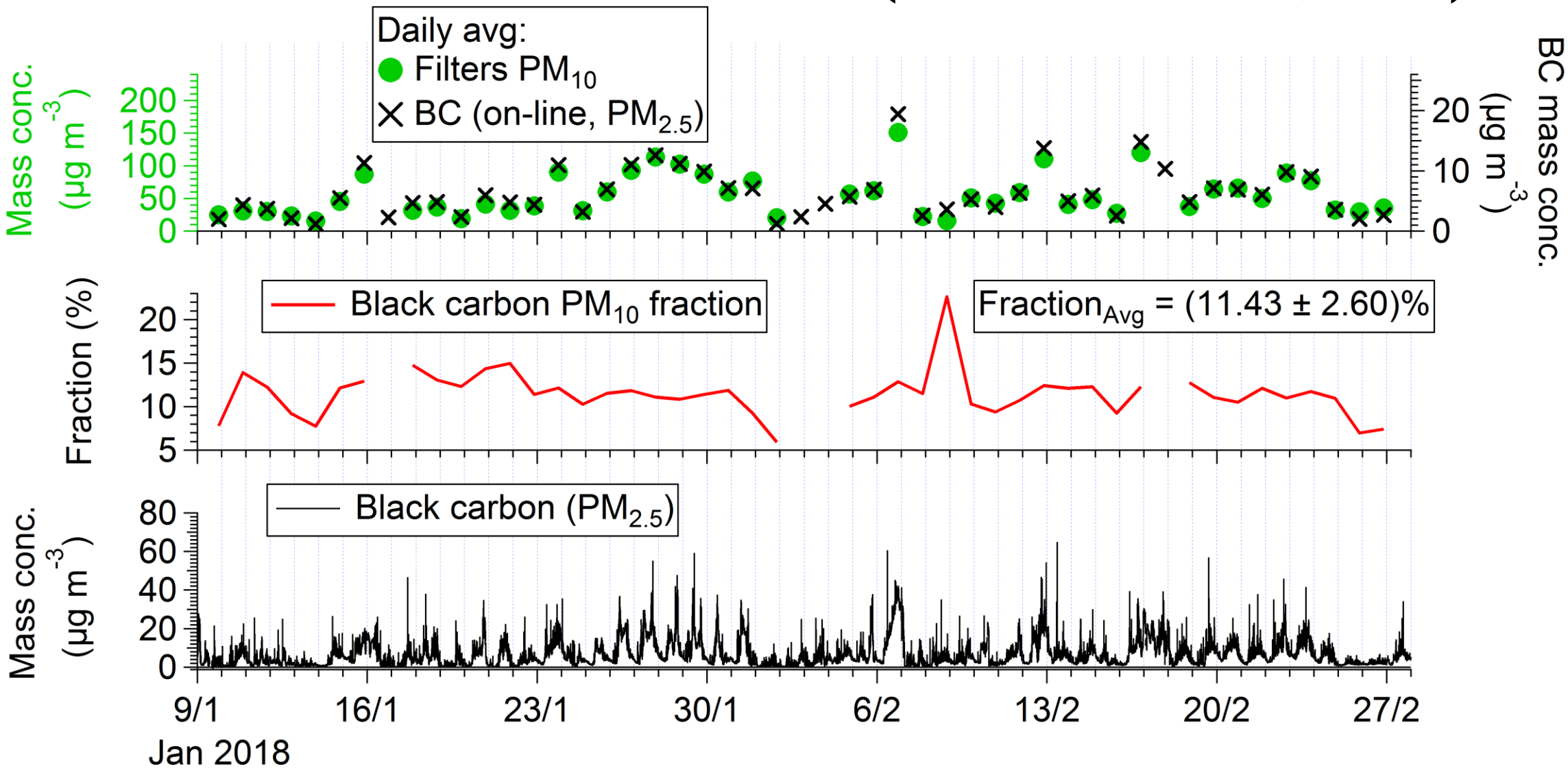
$BC_{ff} = BC\ b_{ff}(950\ nm) / b(950\ nm)$

$BC_{wb} = BC - BC_{ff}$ Sandradewi 2008

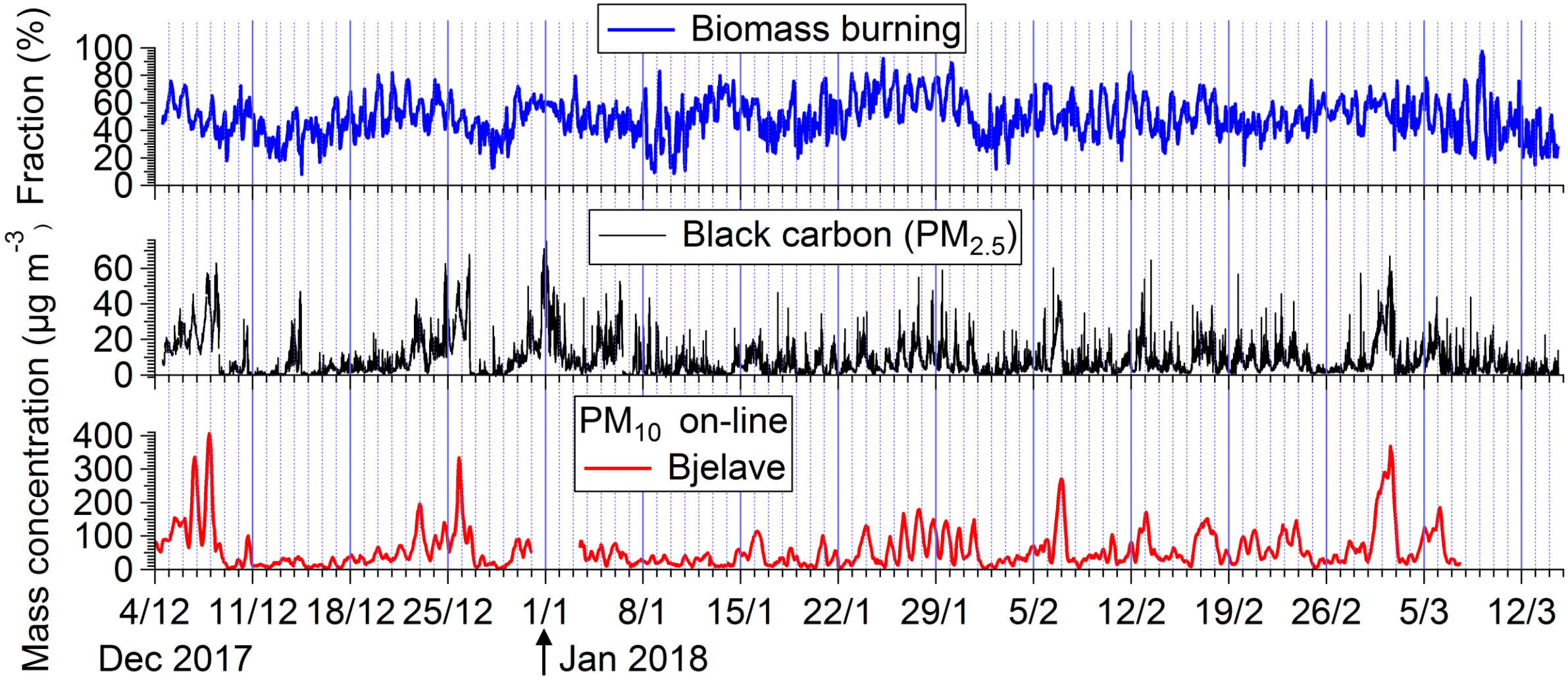
Assumption: MAC is not source dependent (Zotter, 2018)!

Sandradewi 2008

Bjelave PM_{10} filter samples *vs.* black carbon (BC) collocated measurements (Jan 9 – March 7, 2018)



Ambient mass concentrations of measured aerosol



- Very hign ambient black carbon concentrations
- Strong diurnal cycle of solid *vs.* liquid fraction

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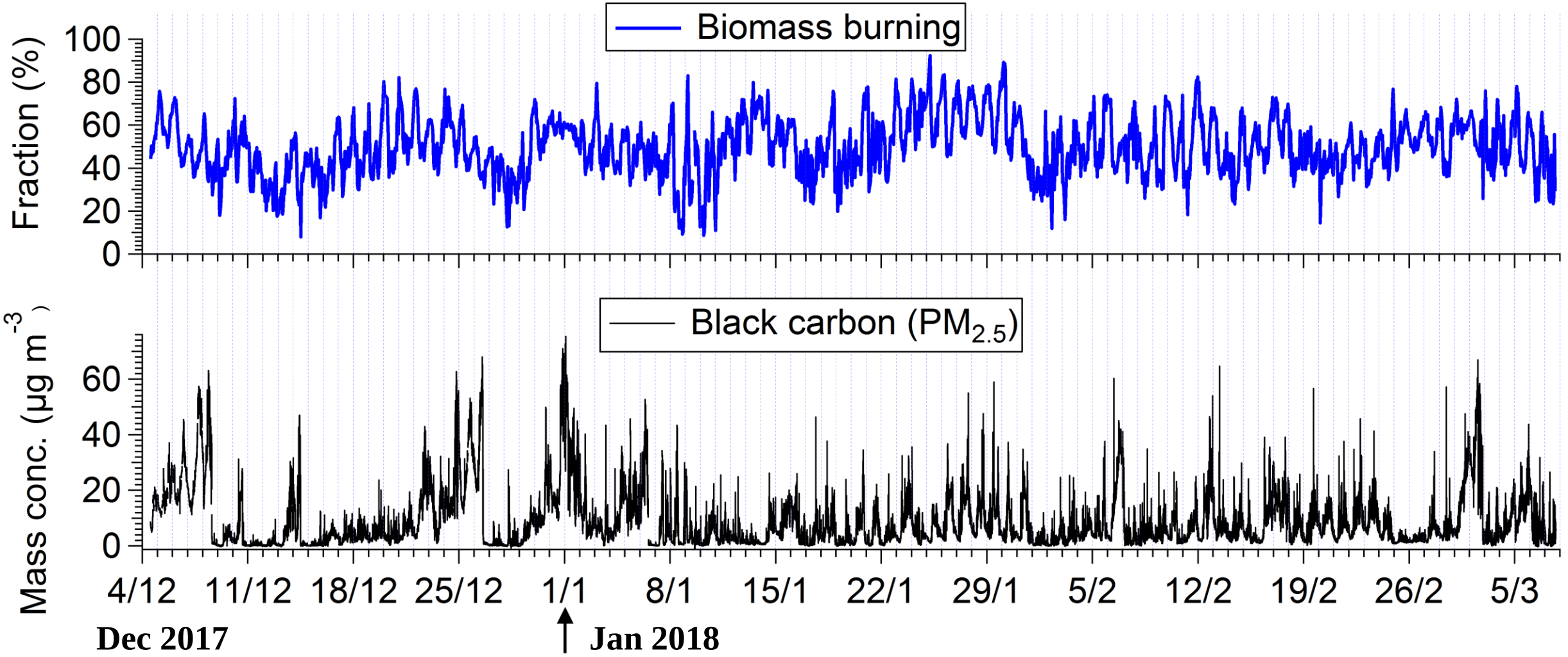
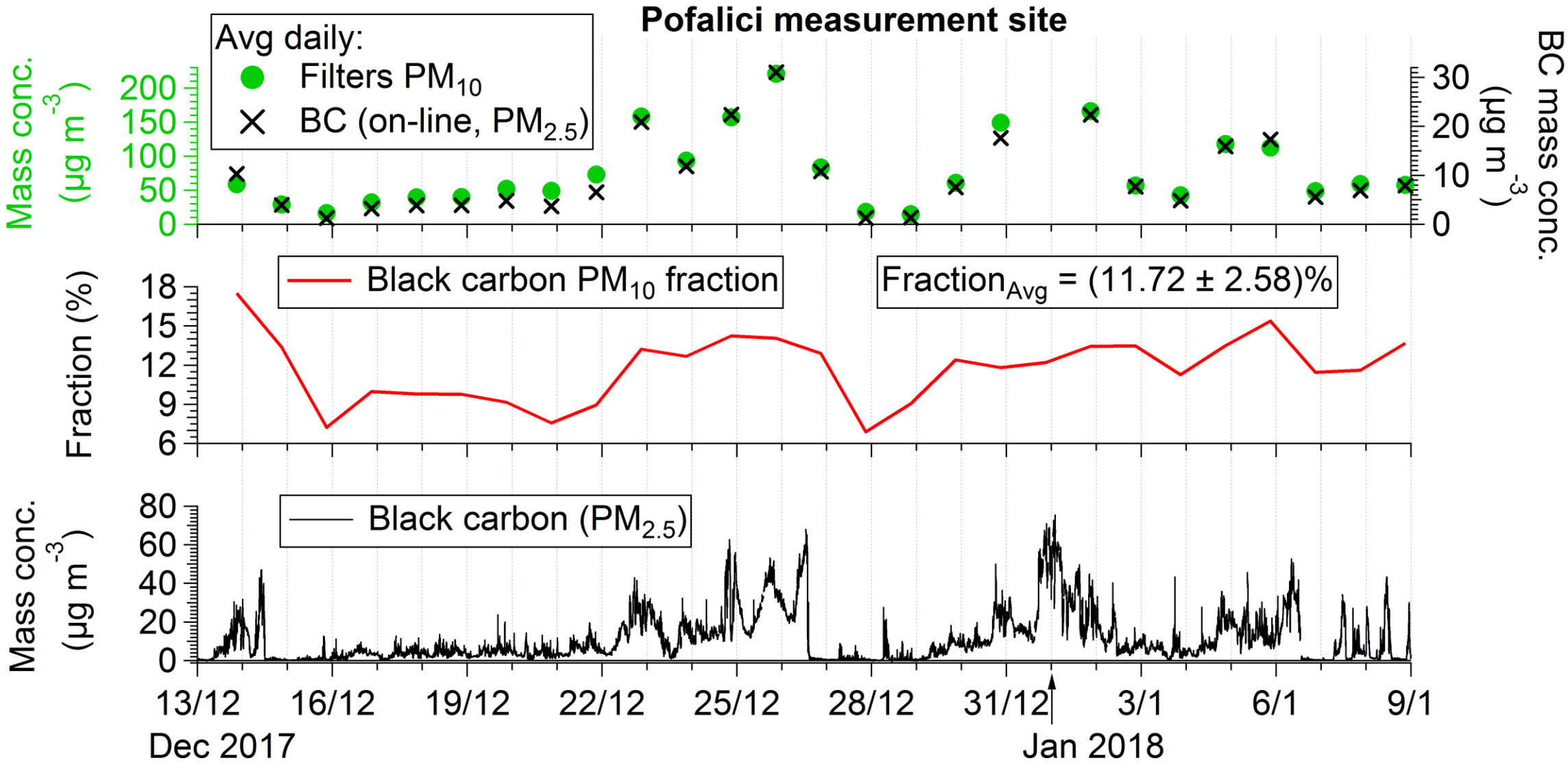


- Biomass burning BC = (49.8 ± 13.4) % (min 7.9%, max 92.3%)
- Black carbon mass conc. SAFICA avg = (8.4 ± 9.9) µg m^{-3} (min 0 µg m^{-3}, max 75.4 µg m^{-3})

Pofalići PM_{10} filter samples *vs.* black carbon (BC)
Only during collocated measurements (Dec 13, 2017 – Jan 9, 2018)



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