SOURCE-SPECIFIC EMISSION FACTORS OF BLACK CARBON AND ORGANIC CARBON CONSIDERING TWO MAJOR URBAN AEROSOLS SOURCES: TRAFFIC AND DOMESTIC HEATING

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Aerosol

CARBONACEOUS AEROSOL.

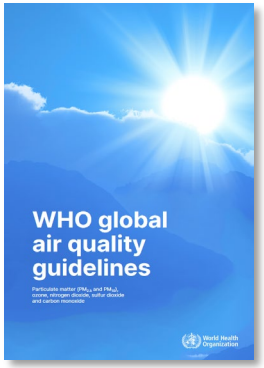
- Carbonaceous aerosols are highly diverse,
- They impact air quality, public health, visibility, cloud nucleation, the planetary radiation balance, and climate forcing,
- Carbonaceous aerosol are composed of BC/EC and organic aerosol (OA), which consists of different molecular structures:

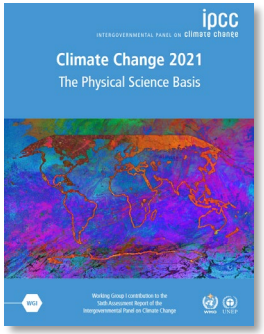
  carbon + hydrogen + oxygen + nitrogen + sulphur,

- The OA fraction is the largest and the least understood.

$$CA = BC + OA$$

$$TC = BC + OC$$





IPCC-Climate change 2021, The Physical Science Basis (2021)

World Health Organization. (2021)

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CARBONACEOUS AEROSOL

Primary CA

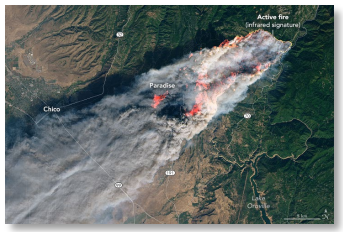
$SOA_a + SOA_b$
combustion SOA + non-comb SOA

$$CA = BC + POA + SOA$$

Combustion,
Human + Natural

Combustion,
Human + Natural

Secondary from precursors,
Combustion or biogenic
Human + Natural



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How can we measure them?

Component of OA

CARBONACEOUS AEROSOL SPECIATION SYSTEM

$OC = TC - BC$

Optical measurement of BC with Aethalometer AE-33

Thermal measurement of TC with newly developed TCA-08

Online

No gas, no glass

High time resolution

TCA08

16.7 LPM

Thermal determination

AE33

5 LPM

Optical determination

OC apportionment:

Primary – Secondary

BC source apportionment:

Fossil fuel (traffic)- Biomass Burning

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Rigler, M. *et al.*, AMT (2020) doi:10.5194/amt-2019-376.

Source apportionment

- Crucial information for air quality management and research,
- BC source apportionment is done by AE-33 based on the optical properties of different carbonaceous aerosols → Fossil Fuel combustion (BC^{FF}) vs. Biomass Burning (BC^{BB}),
- OC source apportionment?
- OC apportionment (primary vs. secondary)?

BC tracer approach

BC is widely used as a tracer for combustion emission (no other sources).

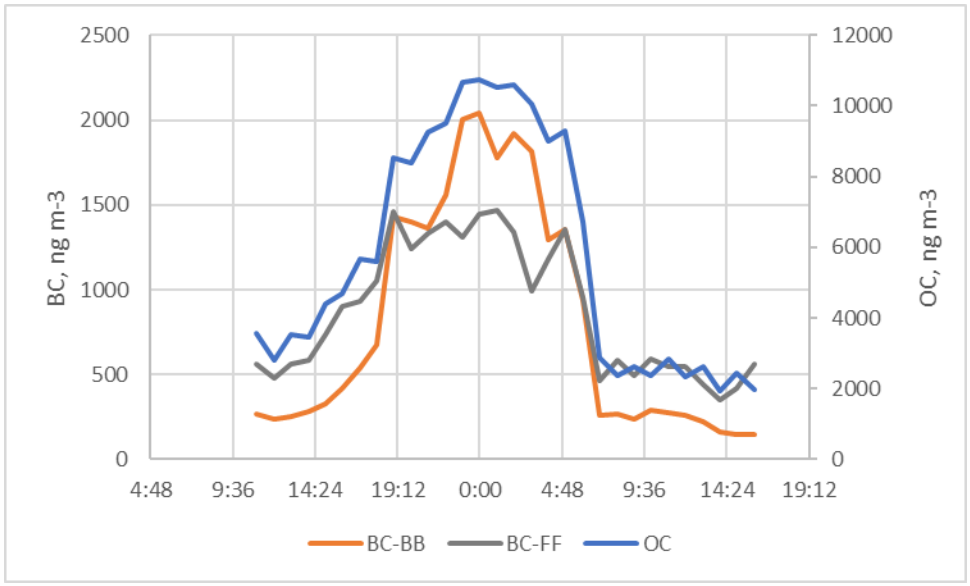
BC tracer method can be improved integrating the source apportionment:

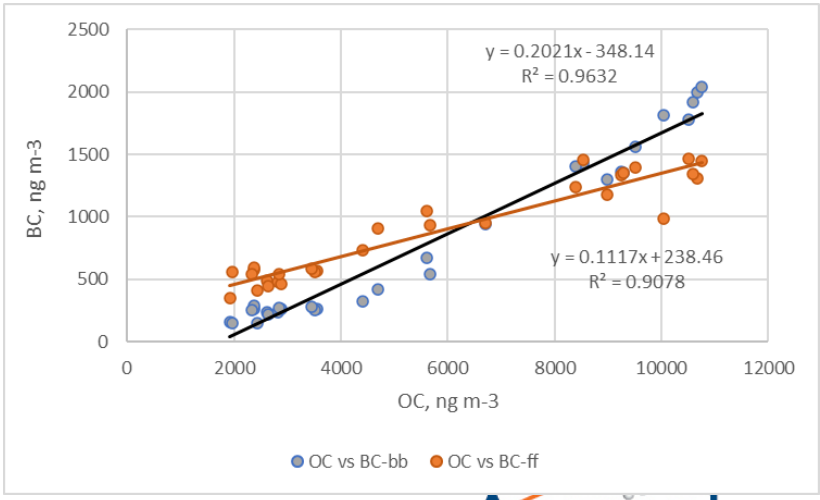
- Fossil fuel related BC: BC^{FF} – tracer for traffic emission,
- Biomass burning related BC: BC^{BB} – tracer for domestic combustion (heating).

Correlation analysis between the components indicates common sources.

BC tracer approach for OC

- Two source approach: fossil fuel & biomass burning related emission,
- Plus background (including secondary formation in case of OC),
- Pollutions emitted by the same source should be correlated,
- Separate the pollution time variation to two components that correlate with BC^{FF} and BC^{BB},
- Mathematical tool: Multi-linear regression analysis.





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BC tracer approach

$$OC' = ER^{ff} x BC^{ff} + ER^{bb} x BC^{bb} + SOC_b$$

$$ER^{ff} = OC^{ff} / BC^{ff}$$

$$ER^{bb} = OC^{bb} / BC^{bb}$$

- We are looking for the best correlation between the composed (OC') and measured OC choosing the suitable ER^{ff}, ER^{bb} and SOC_b parameter set,
- With the ER^{ff}, ER^{bb} parameters we can create the OC^{ff}, OC^{bb} components,
- While SOC_b gives the non-combustion SOC.

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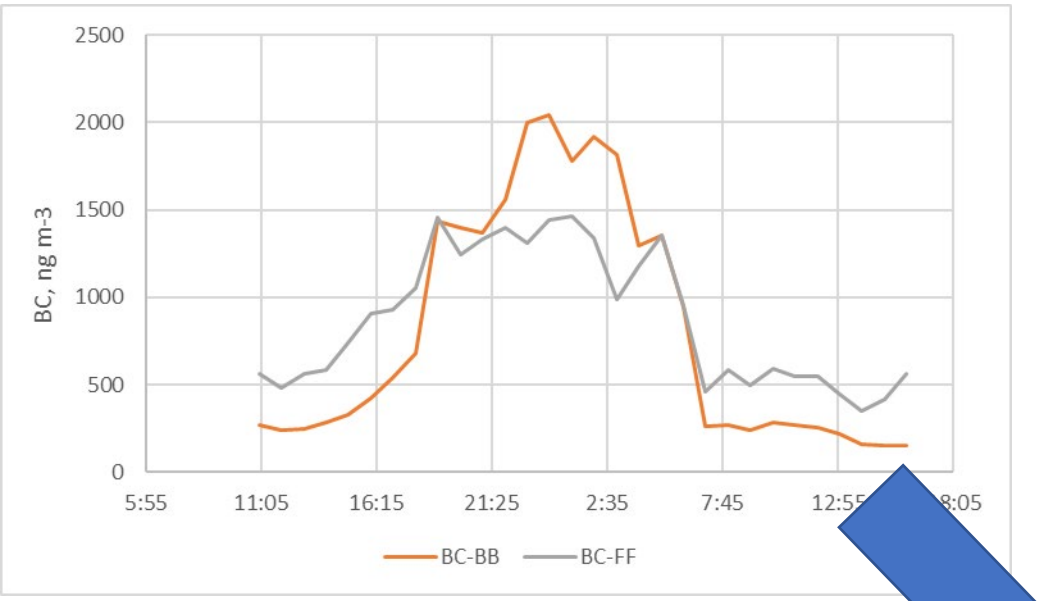
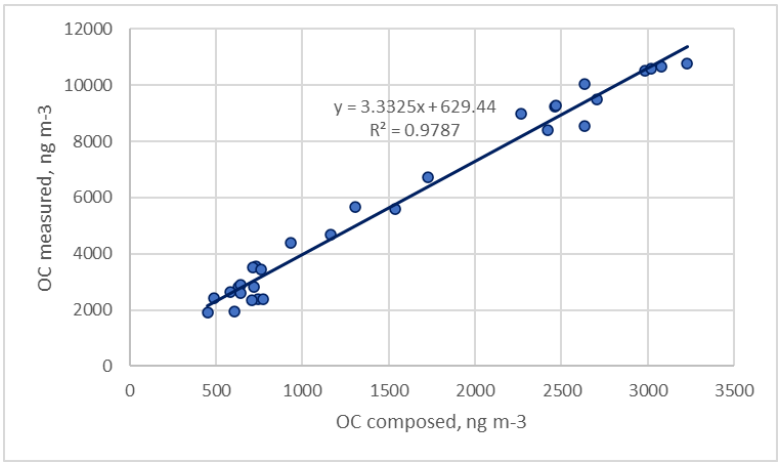
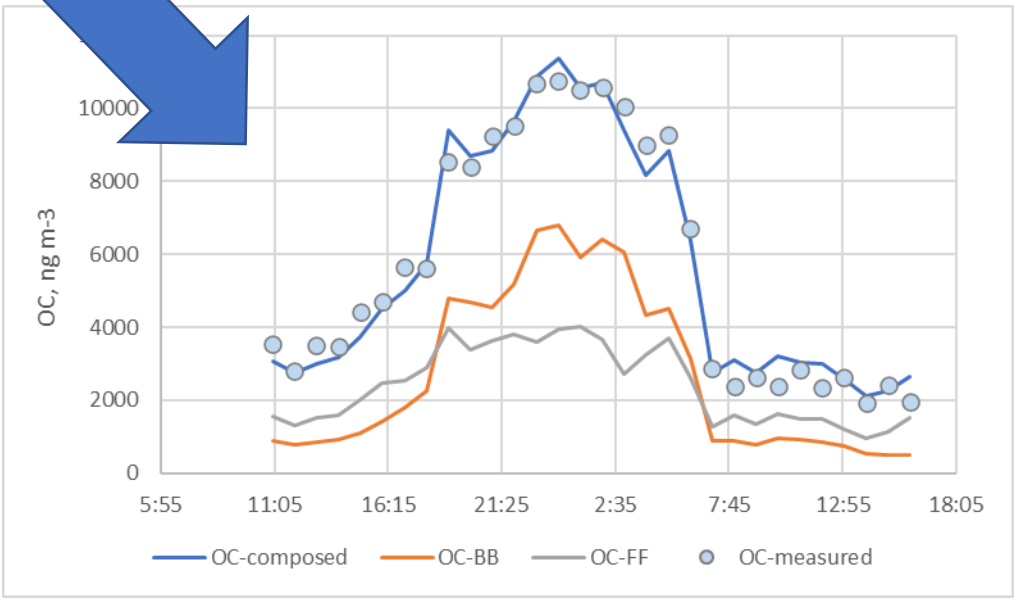




SOC_b: Y intercept of the regression

ER^{ff}, ER^{bb}



Similar analysis for CO_2 source apportionment → emission factors for source specific BC and OC, Using carbon content of diesel fuel (86%) and wood (45%).

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APPLICATION ON THE URBAN ATMOSPHERE

- Where: Ljubljana, capital of Slovenia,
- Atmospheric Laboratory of Aerosol d.o.o. (urban background location),
- When: November 2021 – March 2022,
- Heating season with significant wood combustion,
- Data source: 1-hour average concentrations from CASS + CO_2 sensor,

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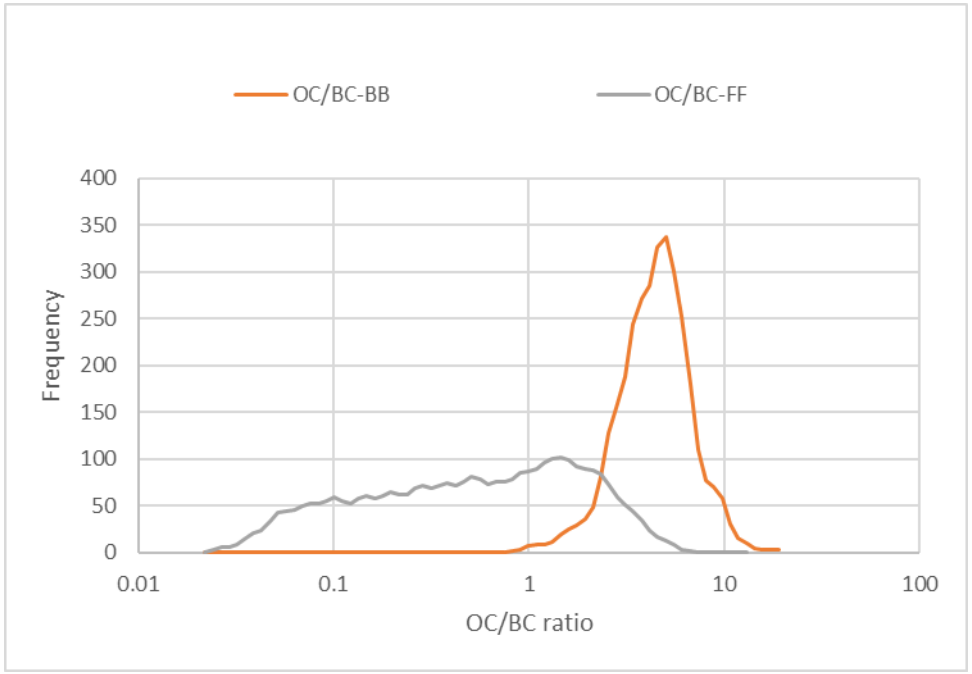
APPLICATION ON THE URBAN ATMOSPHERE



- Wide distribution of OC/BC-FF, more defined peak for OC/BC-BB

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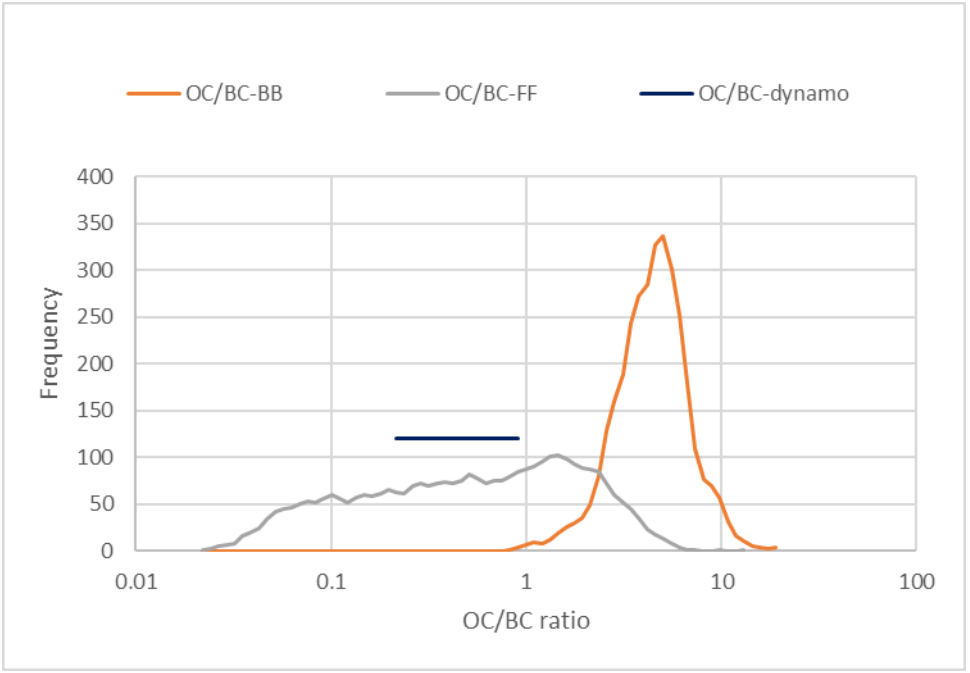
APPLICATION ON THE URBAN ATMOSPHERE



Pio et al., 2011. Atmos. Environ. 45, 6121–6132.

- Wide distribution of OC/BC-FF, more defined peak for OC/BC-BB
- Comparison with dynamometer emission measurements

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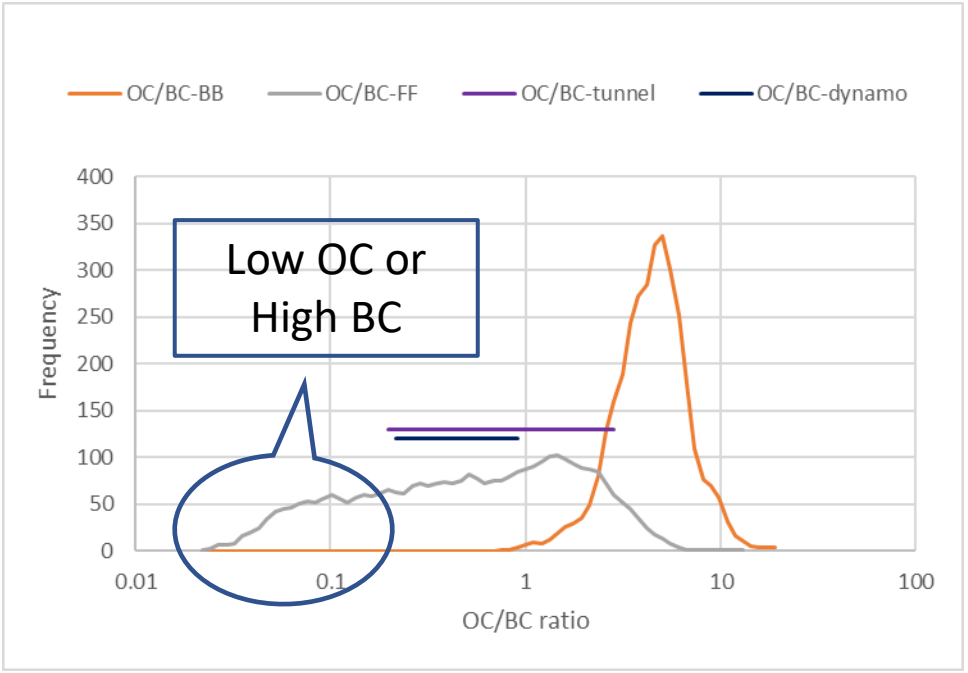

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- Wide distribution of OC/BC-FF, more defined peak for OC/BC-BB
- Comparison with dynamometer emission measurements
- And tunnel measurements (including gasoline vehicles)

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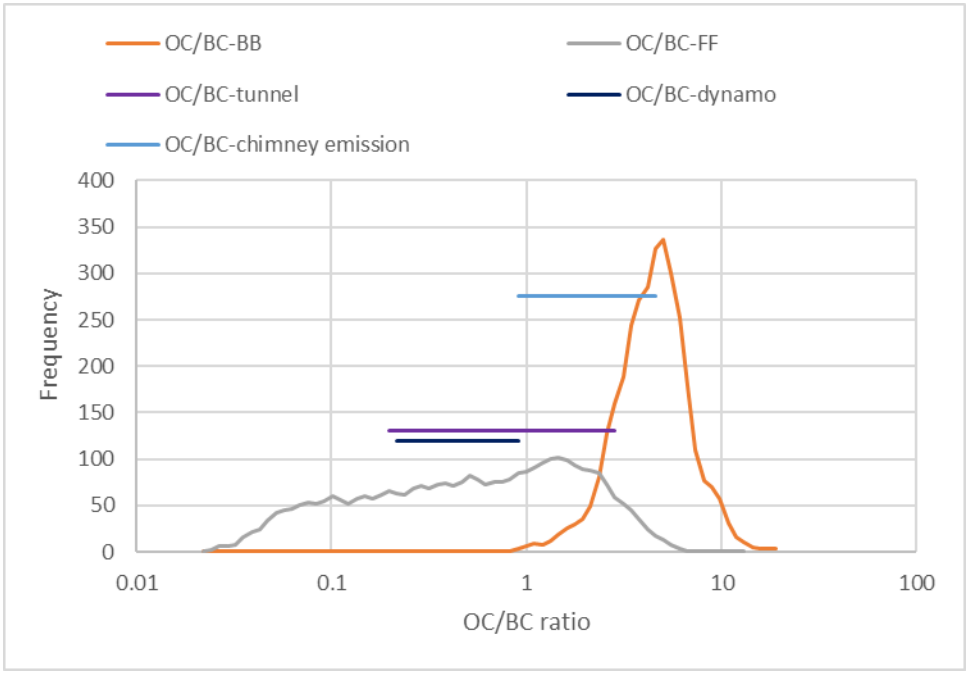

Gonçalves et al., 2010, Atmos. Environ. 44, 4474–4480.

Pio et al., 2011. Atmos. Environ. 45, 6121–6132.

- Wide distribution of OC/BC-FF, more defined peak for OC/BC-BB
- Comparison with dynamometer emission measurements
- And tunnel measurements (including gasoline vehicles)
- We measured higher OC/BC than direct chimney emission (atmospheric processes?)

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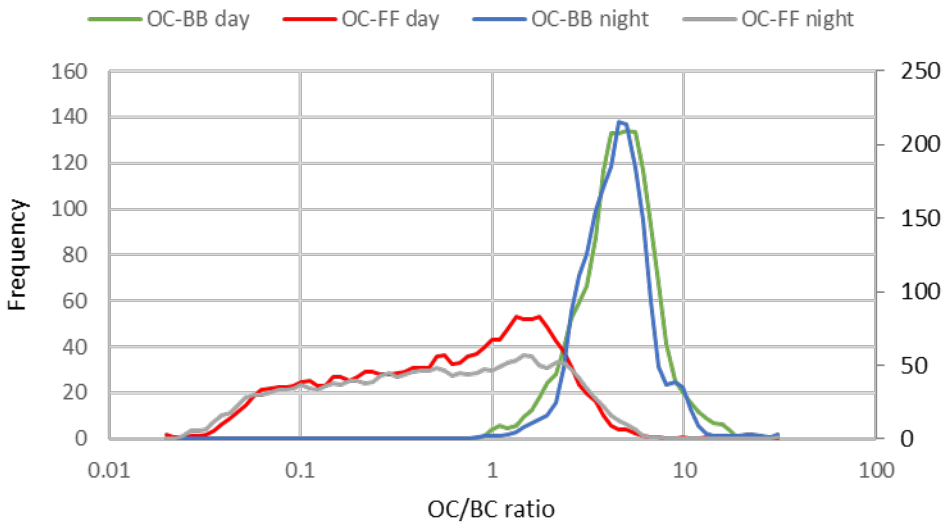
APPLICATION ON THE URBAN ATMOSPHERE



- Separated OC/BC distributions for day and night periods,
- Higher OC/BC ratios are more frequent during daylight period for FF component,
- Secondary formation (SOC_a)?

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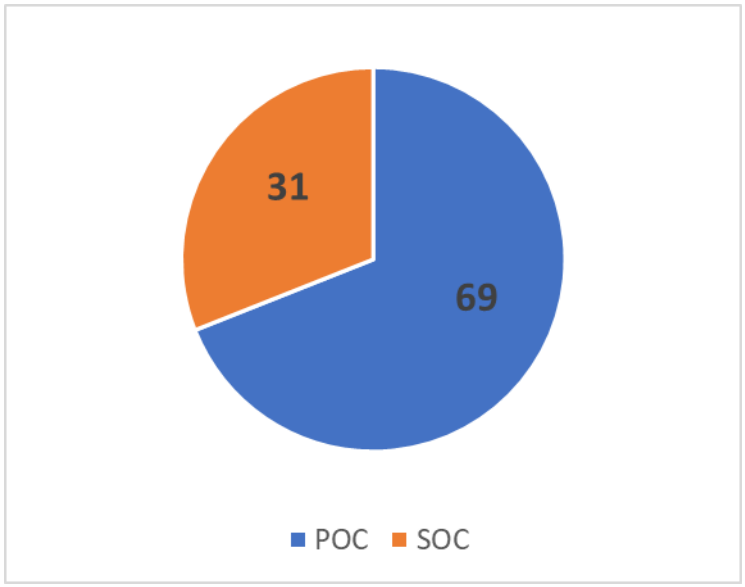
AVERAGE OC/BC RATIOS AND EMISSION FACTORS

	OC/BC	EF (g/kg) OC	EF (g/kg) BC
BB	5.45	0.65	0.12
FF	0.99	0.39	0.39



Average share of primary & secondary OC

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CONCLUSIONS

- Source specific BC tracer method was successfully applied for source apportionment of OC and CO_2,
- Traffic related OC has a wide distribution with a possible contribution of secondary OC formed from traffic emitted precursors,
- BB-related OC has more defined distribution but higher range than from direct chimney emission measurement (aging + atmospheric processes),
- Using the source specific CO_2 the emission factors were calculated,
- Non-combustion SOC (SOC_b) was estimated as 31% of total OC,
- More details: Alfoldy et al. (2022), AMT Discussions, DOI: 10.5194/amt-2022-53.

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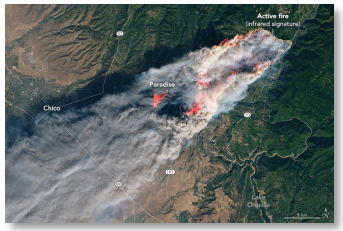
THANK YOU FOR YOUR KIND ATTENTION!



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