ESTIMATION OF BLACK CARBON CONCENTRATION IN FINE PARTICULATE MATER IN URBAN AREA

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OUTLINE

- **Black carbon (BC) and Brown carbon (BrC) in PM2.5 -** *brief intro*
- ***Motivation and Goal***
- ***Sampling site, equipment and analysis***
- ***Results***
- ***Comparison with other studies***
- ***Conclusions***

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Introduction

- Fine particulate matter (PM2.5) is a key air pollutant in terms of adverse health effects
- Many sources may contribute to PM2.5 levels such as traffic, dust resuspension, biomass burning, industrial emissions, power plants, sea salt, ship emissions, etc.
- The main light-absorbing components of fine particulate matter are black carbon (BC) and brown carbon (BrC)

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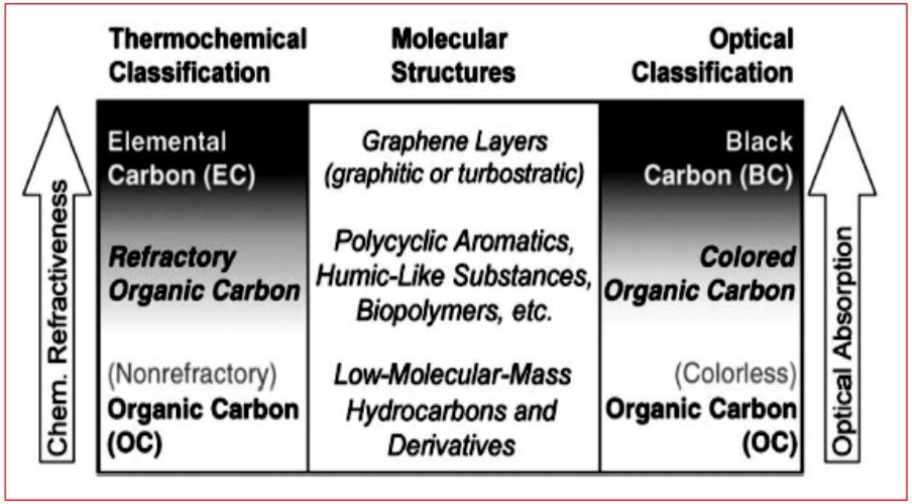
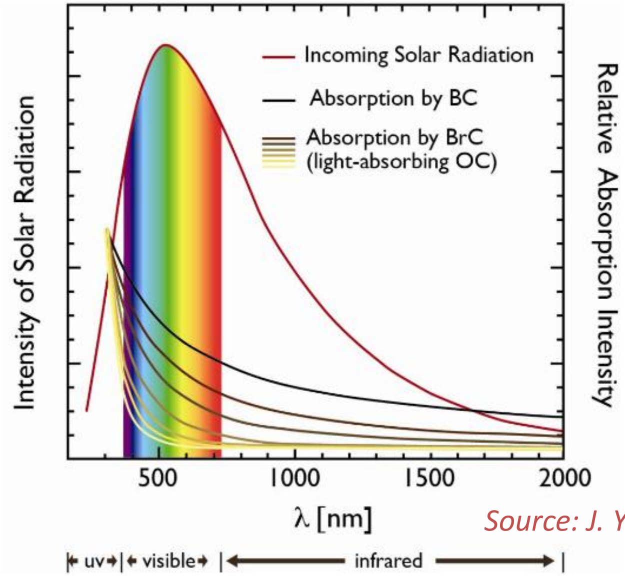
- Black carbon (BC) and brown carbon (BrC) are carbonaceous aerosol
- BC and BrC are mainly in fine particles (PM2.5)



Source: U. Poschl, AC, 2005



Source: J. Yuan, 2017

- **BC**
  - strong absorber in visible and near- IR light,
  - primarily released by high-temperature combustion of fossil fuels
- **BrC**
  - absorbs light primarily at the low visible wavelengths and the near ultraviolet range of the spectrum
  - emitted by biomass combustion

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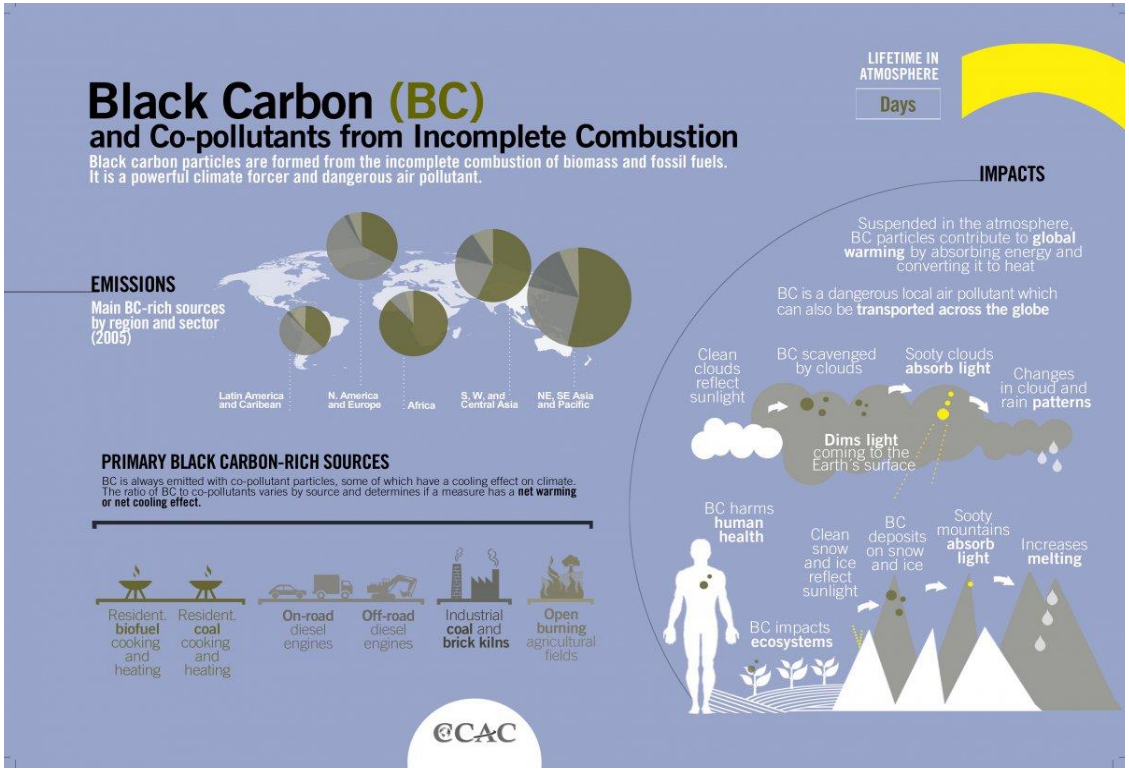
Impact

- Air quality and visibility
- Climate
- Polar climate
- Human health



https://www.ccacoalition.org/en/slcps/black-carbon

Motivation and Goal

Importance

- A significant proportion of fine particle aerosol composition is comprised of black carbon (BC)
- BC not only contribute to visual degradation and climate change caused by absorption and reflection of solar and terrestrial radiation, but also have significant implications for human health
- The assessment of the relative contributions of fossil fuel and biomass burning to the total BC mass is of high importance for managing the BC air pollution

Lack of observations of **BC in Bulgaria.**

The objective – estimation of BC and BrC concentration in urban fine particulate matter ($PM_{2.5}$), new knowledge of significant species in particulate matter in Bulgaria

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Sampling location

Central Meteorological Observatory (CMO) at NIMH
42.66 N, 23.38 E, 586 m a.s.l.

Sampling equipment

- PM2.5 sampling - **TECORA Echo PM low volume sampler** according to EN-12341 standard (one of each 3 days)
- Study period: **June 2018 – June 2019**
- Sampling duration - **24h**.
- Filters type: **Teflon - PTFE PP Ring Supported**
- Filters conditioned for 48h before and after sampling in a **temperature and humidity controlled room** (T= 20±2°C, RH=50±5%).
- Gravimetric analysis by analytical balance (Mettler Toledo, AG135).

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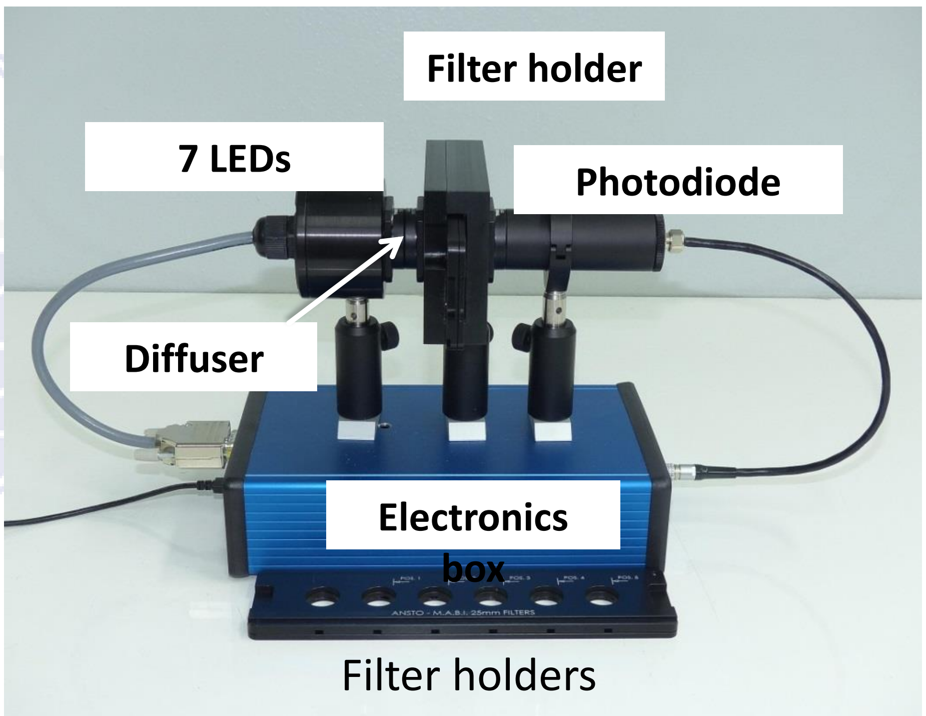
Estimation of BC in $PM_{2.5}$

- Multi-wavelength Absorption Black instrument (**MABI**) developed at Australian Nuclear Science and Technology Organisation
- This instrument measures light absorption (*I_o and I*) at seven different wavelengths, spanning ultraviolet to infrared (**405nm, 465nm, 525nm, 639nm, 870nm, 940nm and 1050nm**)
- Possibilities to differentiate the contributions from sources such as biomass burning (BC_{bb} /BrC) and motor vehicles-traffic (BC / BCtr).



Atanacio A. J., Cohen D. D., Button D., Paneras N., Garton D., Multi-wavelength Absorption Black Carbon Instrument (MABI) Manual, Australian Nuclear Science and Technology Organisation, Australia.

Calculations

- Determination of black carbon ***light absorption coefficient***:

$$b_{abs} = 10^2 \left[\frac{\mathrm{A}}{V}\right] ln \left[\frac{I_o}{I}\right]$$

A - filter collection area in cm^2
V - volume of air sampled through the filter in m^3
I_o - measured light transmission through blank (unexposed) filter
I - measured light transmission through exposed filter

- Determination of ***mass absorption coefficient*** :

Mass absorption coefficient (ε) equation is a function of wavelength *(λ)*:

$$\varepsilon = a * \lambda^b$$

- Determination of ***BC concentration***

$$BC\left(ngm^{-3}\right) = \frac{10^5\left[A\left(cm^2\right)\right]}{\left[\varepsilon\left(m^2 g^{-1}\right)\right]\left[V\left(m^3\right)\right]} ln \left[\frac{I_0}{I}\right]$$

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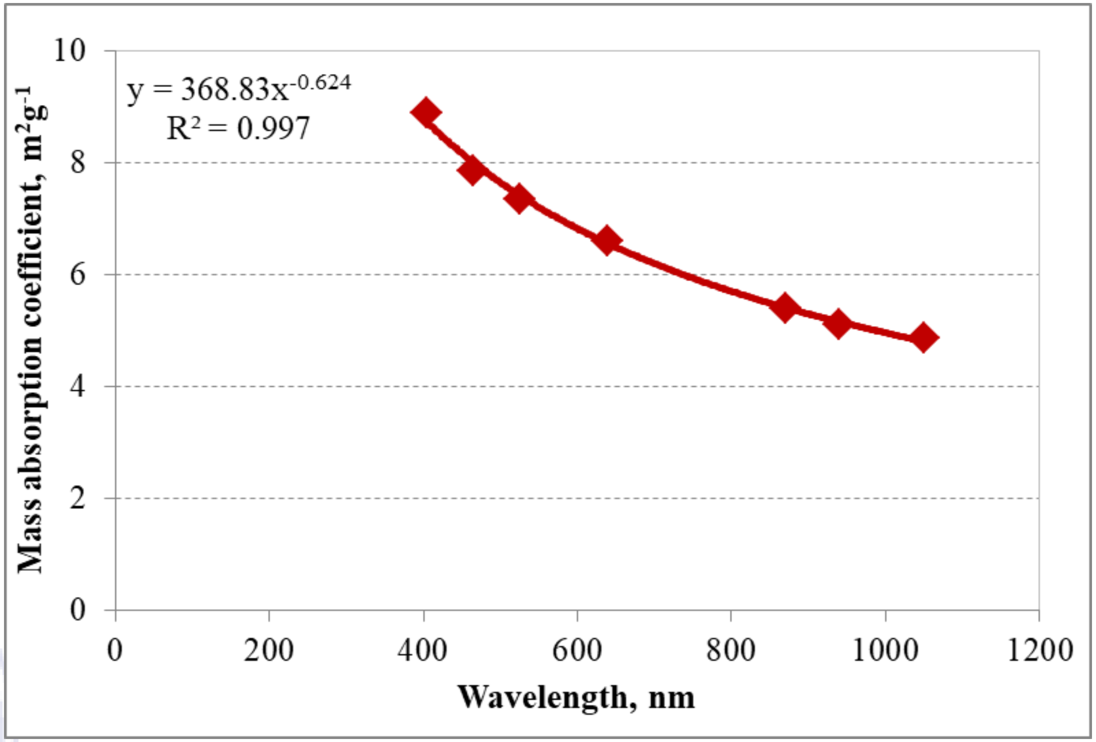
Mass absorption coefficient



λ (nm)	405	465	525	639	870	940	1050
ε (m^2/g)	8.88	7.86	7.34	**6.60**	5.40	5.11	4.86

The BrC concentration is derived from the differences between BC (405nm) and BC (1050nm) as suggested by Coenh et all. 2000

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Results

	BC [µgm^{-3}]	BrC [µgm^{-3}]	$PM_{2.5}$ [µgm^{-3}]
min	0.4	0.003	8.2
max	16.6	1.8	161.8
median	1.8	0.16	21.3
average	2.6	0.22	27.1
SD	2.4	0.27	21.5

10% of the $PM_{2.5}$ mass consists of BC and only **1.3 %** is BrC.

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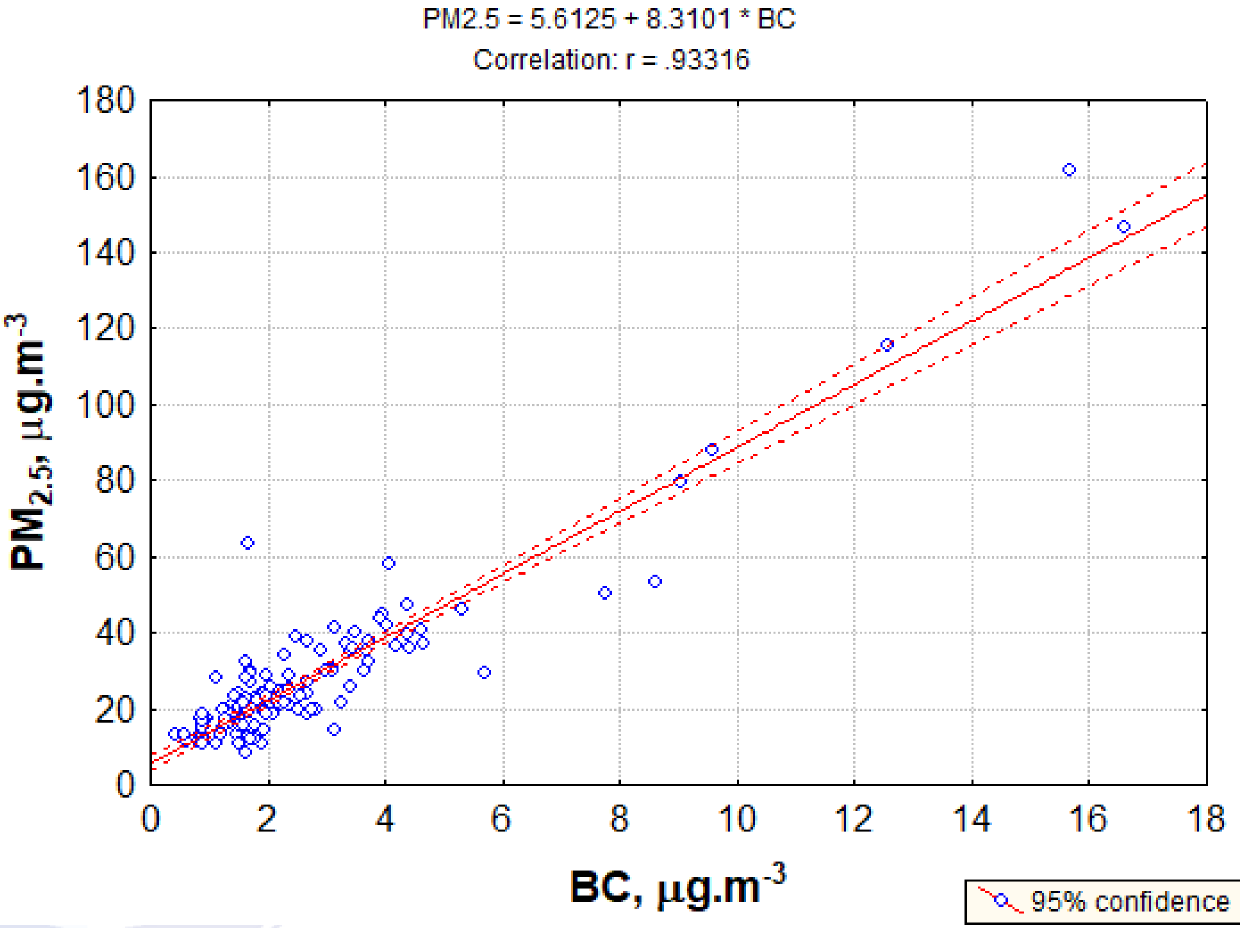
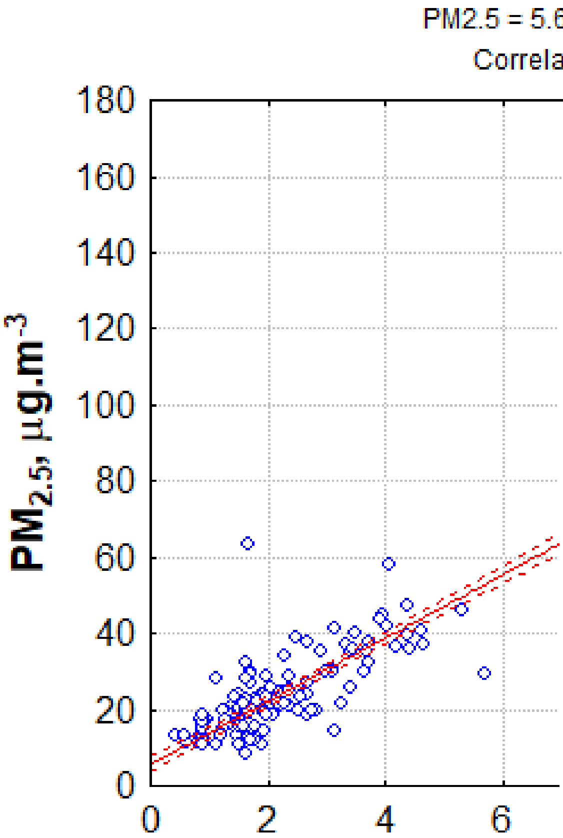
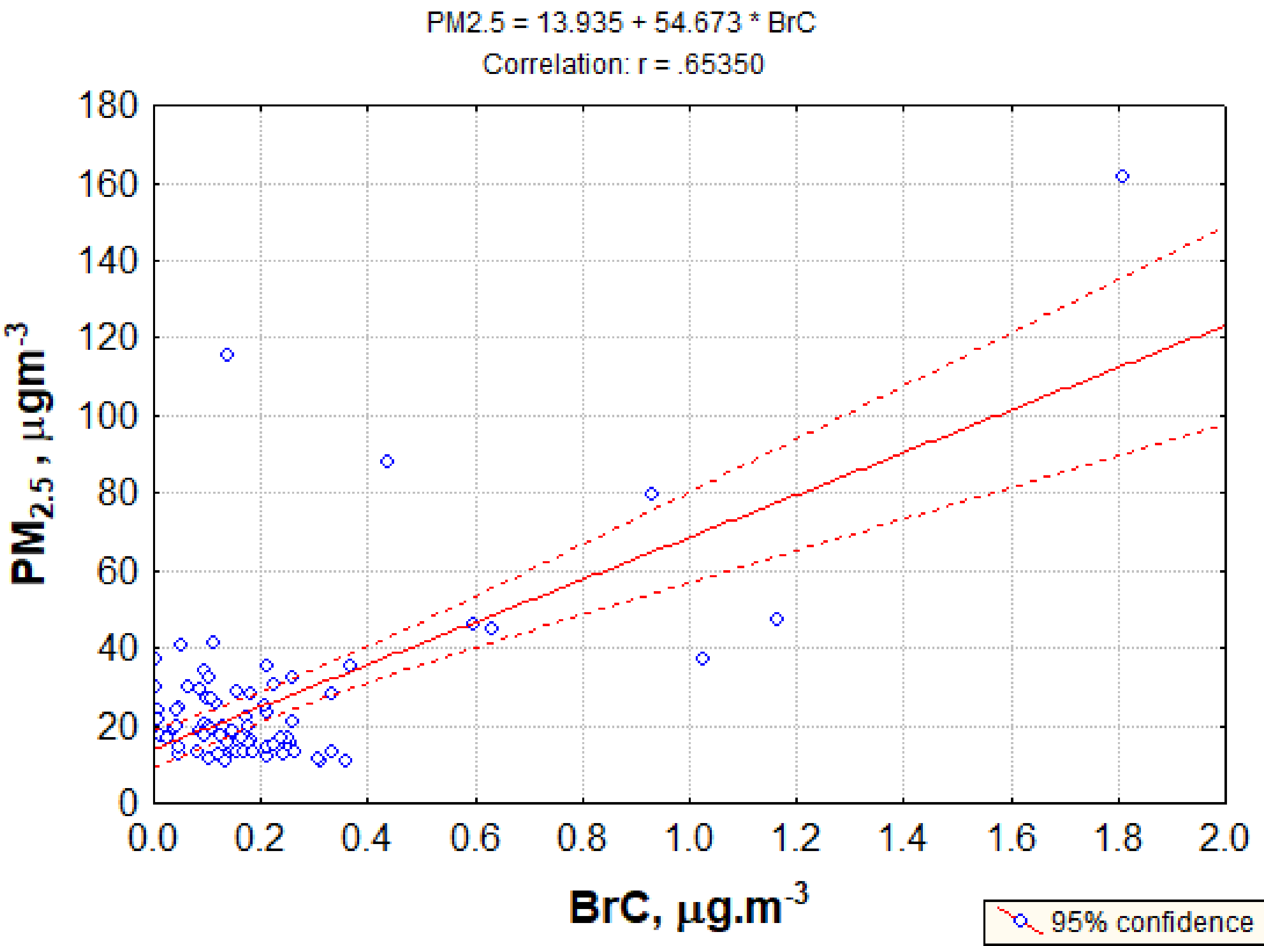
Correlation between BC, BrC and $PM_{2.5}$

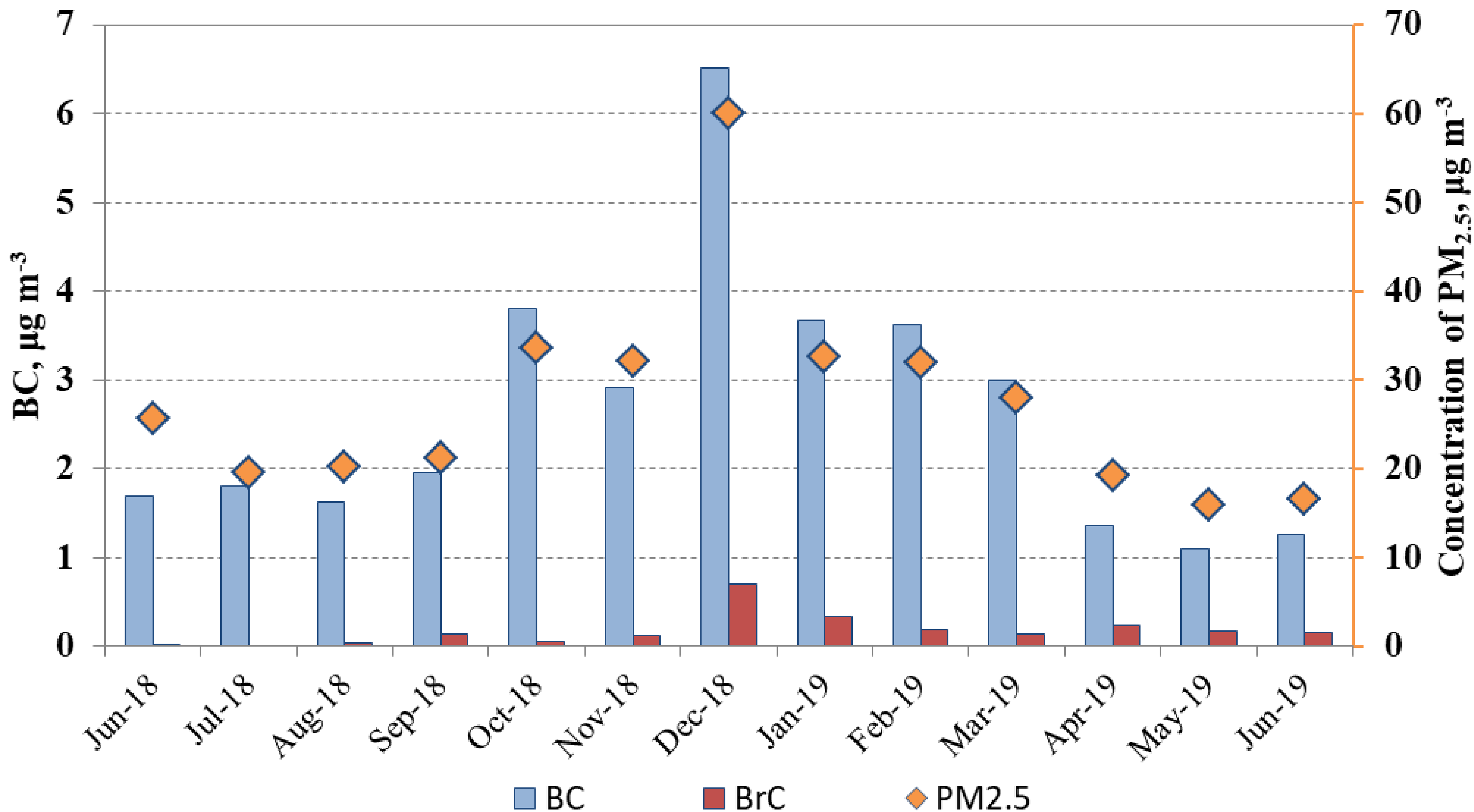


Correlation between BC, BrC and PM2.5





Monthly mean BC, BrC and $PM_{2.5}$ concentrations



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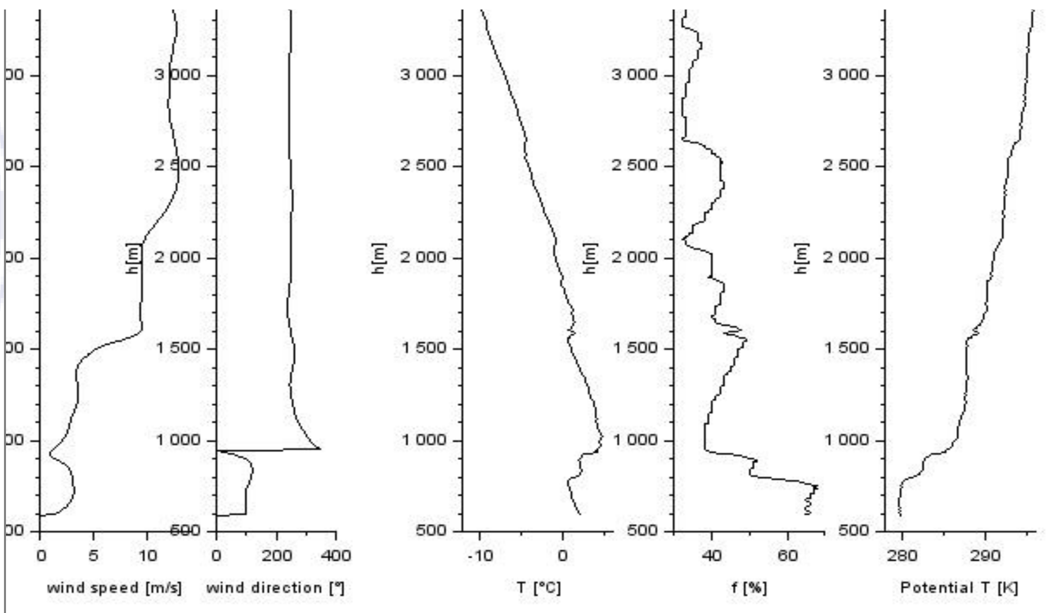
The highest average concentrations of BC , BrC and $PM_{2.5}$ are observed in the cold period (October 2018 – March 2019).

Case with high daily BC and $PM_{2.5}$ concentrations

18 Jan 2019

- The inversion level is less than 800m at noon time when usually the height of the mixing layer reaches maximum.
- The measured $PM_{2.5}$ mass concentration is 115 μgm^{-3} (4 times higher than a daily limit value (25 μgm^{-3}).
- The BC and BrC concentration are 12.6 μgm^{-3} and 0.14 μgm^{-3}, respectively.



Radio-sounding data from Central Meteorological Observatory

Comparison with other studies

	Mean BC [$\mu g m^{-3}$]	Mean BrC [$\mu g m^{-3}$]
This study (2018 – 2019)	2.6	0.2
Rijeka (2017-2018) [1]	5.2	4.2
Milan (2017-2018) [2]	0.6	1.1
Bareggio (2017-2018) [2]	1.4	3.3
Celje, Slovenia (2017) [3]	4.0	1.8
North Kensington , London (2015) [4]	1.2	-

[1] Kristina Glojek, M.A., Asta Gregorič, Matej Ogrin, 2019, BLACK CARBON AIR POLLUTION – CASE STUDY OF LOŠKI POTOK, Dela, 50, 25–43
[2] Mousavi, A., Sowlat, M.H., Lovett, C., Rauber, M., Szidat, S., Boffi, R., Borgini, A., De Marco, C., Ruprecht, A.A., Sioutas, C., Source apportionment of black carbon (BC) from fossil fuel and biomass burning in metropolitan Milan, Italy, *Atmospheric Environment*, https://doi.org/10.1016/j.atmosenv.2019.02.009.
[3] Borut Jereb , Tanja Batkovi, Luka Herman , Gregor Šipek , Špela Kovše ,Asta Gregori ˇ and Griša Mo ˇcnik , 2018, Exposure to Black Carbon during Bicycle Commuting–Alternative Route Selection , Atmosphere, 9, 2-21
[4] D Butterfield, S Beccaceci, P Quincey, B Sweeney, A Lilley ,C Bradshaw, G Fuller, D Green and A Font, 2015 ANNUAL REPORT FOR THE UK BLACK CARBON NETWORK, Queen's Printer and Controller of HMSO, year 2016, ISSN: 2059-6030

Conclusions

- One of the most significant components of atmospheric fine particle matter, Black Carbon (BC), is investigated
- The obtained results for BC concentration in urban fine particulate matter are first information for Sofia and Bulgaria.
- $PM_{2.5}$, BC and BrC showed clear seasonal variations with concentrations more than 10 times higher during the winter than during the summer, likely due to a combination of increased residential heating emissions and poor air pollution dispersion.
- 10% of the $PM_{2.5}$ mass has consisted from BC and only 1.3 % is BrC.
- Because of the important role of BC on the global climate, environment, urban air quality and human health more studies on source of BC are needed.

ACKNOWLEDGEMENTS

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CARBOAEROSOL

Study of black CARBOn and some important hydrocarbons in the atmospheric AEROSOL in an urban environment

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Thank you for your attention!

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