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Impact of emissions from combustion sources, fossil fuel and biomass burning, on ambient concentrations of black carbon (BC) in the Milan metropolitan area

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Introduction

Motivation

Carbonaceous Matter (CM) composed of Organic Carbon (OC) and Black Carbon (BC), is a major constituent of atmospheric aerosols and one of the most important components that alter the chemical and radiative properties of atmospheric compounds.

In addition to its impact on climate change, BC has been associated with adverse health effects.

Earlier studies have used the Equivalent Black Carbon (EBC) model for source apportionment of BC to its major sources including BC_{bb} (biomass burning) and BC_{ff} (fossil fuel).

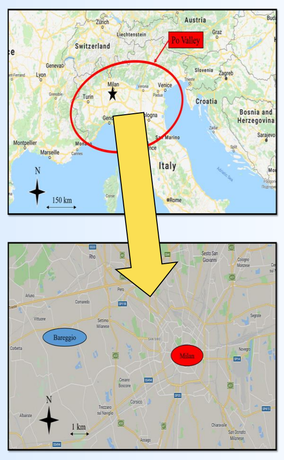
Objectives

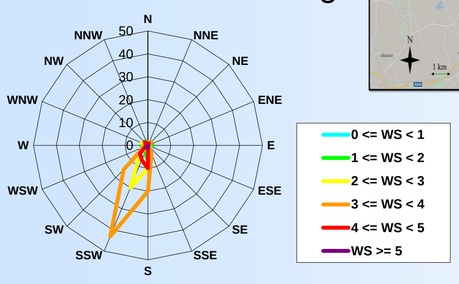
- To determine the **spatial** and **temporal** variability of **fossil-** and **non-fossil-**originated BC concentrations in the city center of **Milan** and **Bareggio** (sub-urban area to the west of the city).
- To investigate the effect of increased biomass burning in wintertime to total BC concentrations.

Methodology

Sampling Sites

- **Metropolitan Milan area:**
  - Urban traffic
  - Major source: Fossil fuel
- **Bareggio:**
  - Sub-urban city
  - Major sources: Fossil fuel and biomass burning





Prevailing wind direction

Sampling Period

- July - August 2017: warm phase
- September-October 2017: intermediate phase
- January-March 2018: winter phase

Instrumentation

- BC concentrations were measured in 7 wavelengths in Milan with Aethalometer (AE31), and 2 wavelengths in Bareggio with Aethalometer (AE51), both operating with a time resolution of 5 min.
- The PM2.5 samples were analyzed for elemental carbon (EC) concentrations by the thermal evolution/optical transmittance method, using the National Institute for Occupational Safety and Health (NIOSH) Thermal Optical Transmission (TOT) Protocol.

EBC model

$$\Delta ATN \equiv 100\ \mathrm{Ln}(I_0/I)$$

$$b_{ATN} \equiv \frac{A}{Q}\frac{\Delta ATN}{\Delta t}$$

$$b_{abs} \equiv \frac{b_{ATN}}{C\ R(ATN)}$$

$$MAC_{\lambda} = \frac{b_{abs,\lambda}}{EC}$$

$$b_{abs,\lambda} = b_{abs,ff,\lambda} + b_{abs,bb,\lambda}$$

$$\frac{b_{abs,ff,370}}{b_{abs,ff,880}} = \left(\frac{370}{880}\right)^{-\alpha_{ff}}$$

$$\frac{b_{abs,bb,370}}{b_{abs,bb,880}} = \left(\frac{370}{880}\right)^{-\alpha_{bb}}$$

$$BC_{ff} = \frac{b_{abs,ff,880}}{MAC_{880}}$$

$$BC = BC_{ff} + BC_{bb}$$

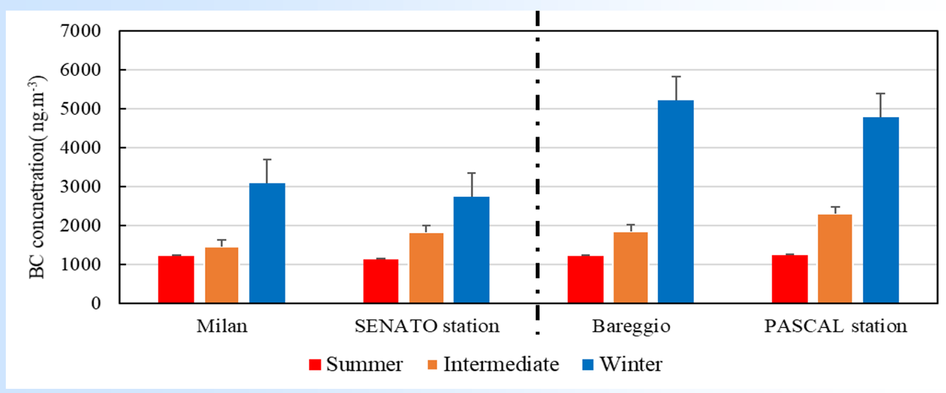
C^{14} istope analysis

$$\alpha_{bb} = \frac{-1}{\ln\left(\frac{370}{880}\right)} \times \ln\left(\frac{b_{abs(370)}}{b_{abs(880)}} + \frac{\frac{MACff(880)}{MACbb(880)} \times \left(\left(\frac{370}{880}\right)^{-\alpha ff} - \frac{b_{abs(370)}}{b_{abs}(880)}\right)}{1 - \frac{EC}{EC_{ff}}}\right)$$

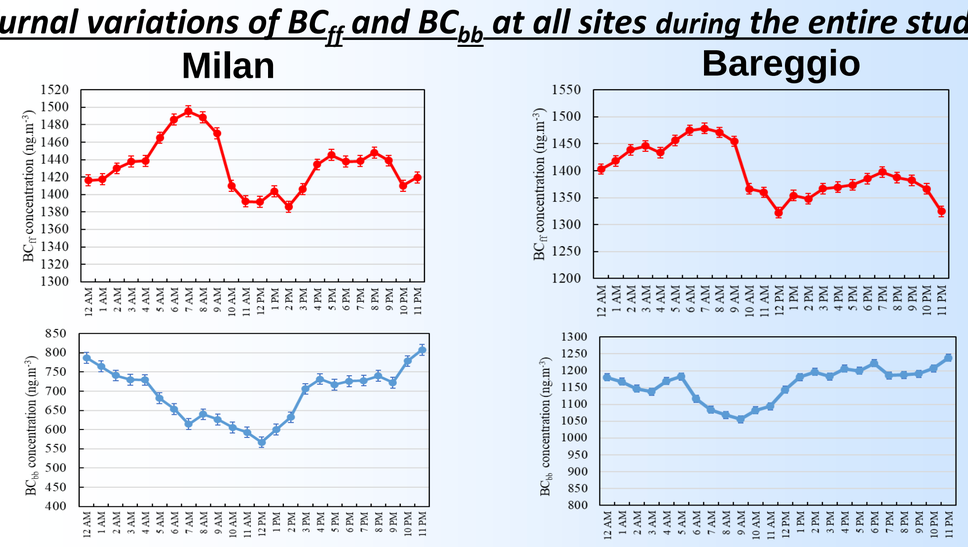
$EC_{ff}/EC = f_M = (C^{14}/C^{12})$ ratio

Results

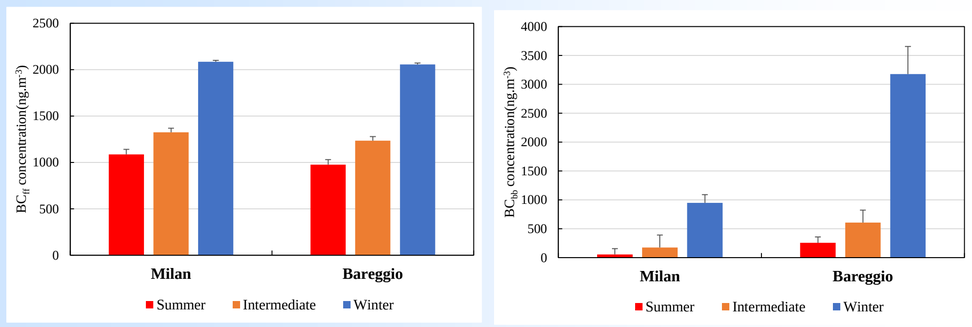
Seasonal variation of total BC concentrations at sampling sites



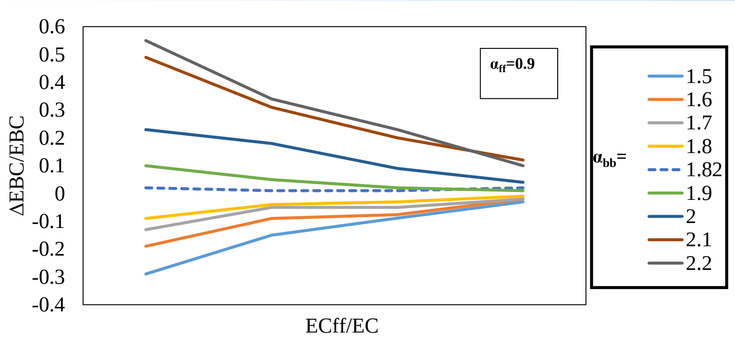
Diurnal variations of BC_{ff} and BC_{bb} at all sites during the entire study



Seasonal variation of BC_{ff} and BC_{bb} concentrations at sampling sites



Residuals of EBCff/EBC compared to ECff/EC (ΔEBCff = EBC) as a function of measured ECff/EC



Conclusions

- Our results revealed that the suburban site of Bareggio had a higher annual total BC concentration (2.76 µg.m-3) in comparison to the central Milan site.
- BC concentrations in the winter phase were approximately 3-5 times higher than the levels in the summer phase, which can be mostly attributed to biomass burning.
- EBC source apportionment results indicated that, while annually averaged fossil fuel combustion contributions to the total BC concentrations are dominant in both sites (84.6% for Milan and 61.9% for Bareggio), biomass burning contribution reaches 30.5% and 60.5% in winter phase for Milan and Bareggio, respectively.
- These results highlight the significant impact of wood burning for residential heating on the total BC concentrations, particularly in suburban areas of metropolitan Milan, and can be used as a guide in future regulatory efforts to decrease the concentrations of atmospheric BC and minimize the deleterious health impacts of this air pollutant in the area.

References

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