CNR, Roma 07-08 aprile 2025

# TAVOLA ROTONDA
# Nuove variabili per la qualità dell'aria

# BLACK CARBON (BC)

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Finanziato dall'Unione europea NextGenerationEU

**Black Carbon (BC) is a product of incomplete combustion of carbon-based fuels (vehicles, wood and biomass burning, open burnings, industrial emissions, shipping, aviation,.....). Negative effects on HEALTH and CLIMATE!**

https://riurbans.eu/project/#service-tools

Proxy of combustion emissions

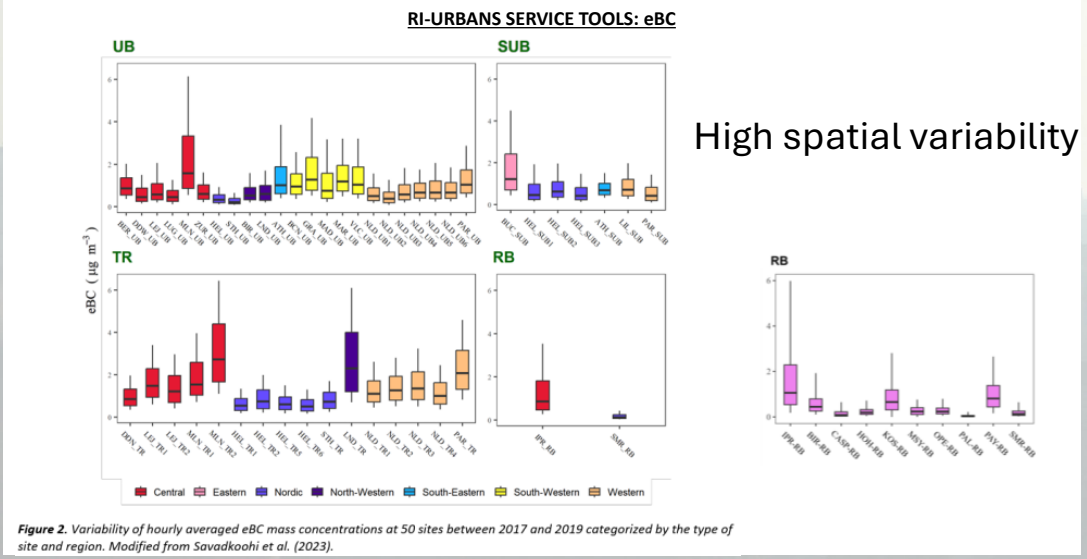


*Figure 2. Variability of hourly averaged eBC mass concentrations at 50 sites between 2017 and 2019 categorized by the type of site and region. Modified from Savadkoohi et al. (2023).*

High spatial variability

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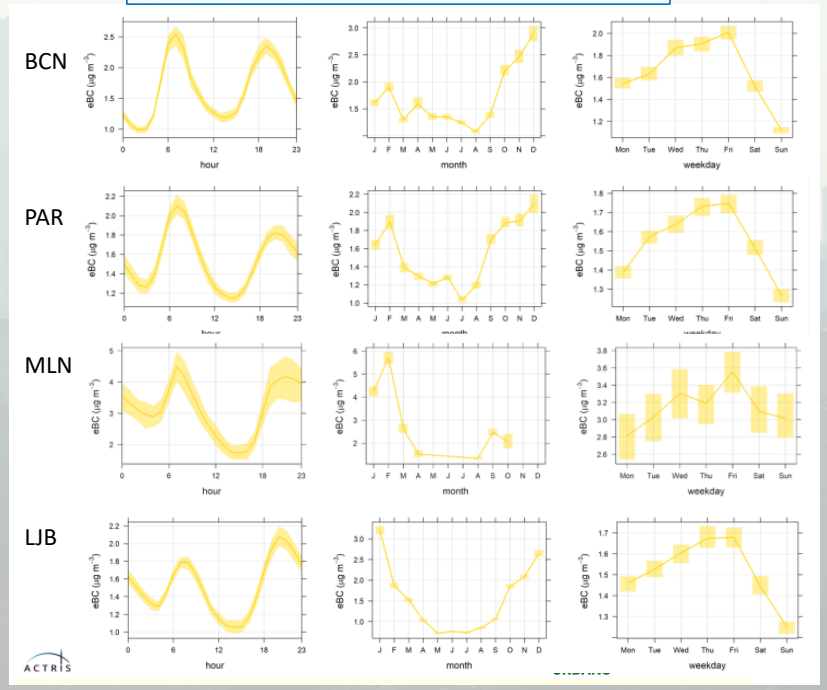

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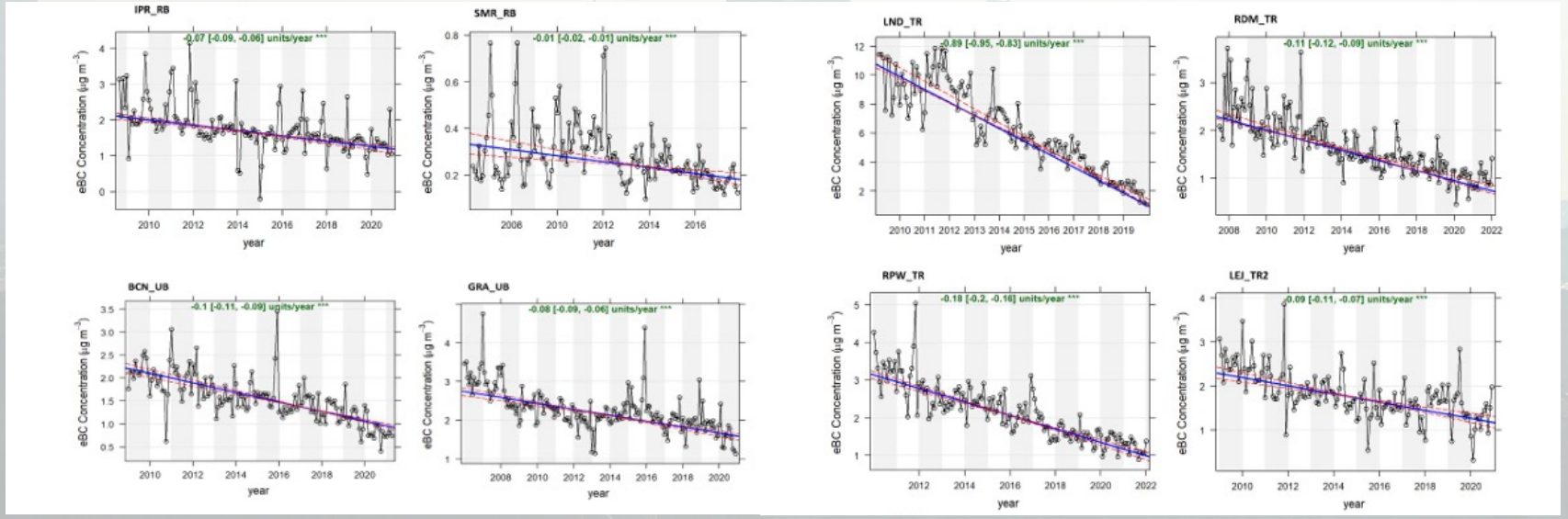


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## Physical characteristics:

- Refractory (vaporization temperature > 4000 $^{o}$K)
- Unsoluble in water and organic solvents
- Graphitic $SP^2$-bonded carbon atoms
- Strong absorption efficiency in the whole solar spectrum

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**The terms used to identify this product of incomplete combustión are primarily associated with the corresponding measurement methods**

| **elemental carbon (EC)** | **black carbon (BC)** |
|---|---|
| The EN 16909 standard method for determining EC | FAPs (filter absorption photometers; AE, MAAP) |
| - Thermal-optical technique<br>- EUSAAR_2 thermal protocol<br>- Charring correction based on transmittance | **BC is indirectly derived** through methods (FAPs) that measure the particle light absorption, assuming that BC is the unique absorbing species. |
| EC is determined by heating to high temperature the sample (PM) in presence of oxygen (for combustion) to determine the amount of pure carbon present. EC refers to carbon in its pure, elemental form. | There is no method for measuring “BC” mass concentration at all |

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$$BC = \frac{b_{Abs}}{MAC_{BC}} \qquad \left[\frac{\mu g}{m^3}\right] = \frac{[Mm^{-1}]}{\left[\frac{m^2}{g}\right]}$$

The softwares of FAPs apply a constant $\mathbf{MAC_{BC}}$ to derive BC.

$\mathbf{MAC_{BC}}$ obtained initially by comparing optical and thermal measurements of filters loaded with refractory carbonaceous material used as reference.

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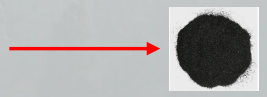

$M_{BC}$

$$MAC_{BC} = \frac{b_{Abs}}{M_{BC}}$$

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eBC is for particle light absorption the same as "$CO_2$-eq" is for Global Warming Potential. $CO_2$-eq is a metric measure that converts amounts of other gases to the equivalent amount of carbon dioxide with the same global warming potential as these other gases.

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Definitions:

14) "**black carbon**" or "**BC**" means carbonaceous aerosols measured by light absorption;

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In the absence of an EN standard method for sampling and measuring volatile organic compounds that are ozone precursor substances, methane, UFP, BC, size distribution of ultrafine particles, ammonia, particulate and gaseous divalent mercury, nitric acid, levoglucosan and oxidative potential of particulate matter, Member States may choose the sampling and measuring methods they use, in accordance with Annex V and taking into account the measurement objectives, including those set out in Section 3, Point A, and Section 4, Point A, of Annex VII, as applicable. Where international, EN or national standard reference measurement methods or CEN technical specifications are available, these may be used.

## eBC: Instruments

$$eBC = \frac{b_{Abs}}{MAC_{BC}}$$

**7λ-AE33 (Aerosol Magee Scientific)**

**7λ–AE36 (Aerosol Magee Scientific)**

**9λ–AE36s (Aerosol Magee Scientific)**

**1λ MAAP (Thermo Fisher Scientific)**

**7λ-AE43 (Aerosol Magee Scientific)**

**microAeth MA200/300/350 (AethLabs)**

**BC 1054 BC ANALYZER**

**BC 1060 & BC 1065**
**PORTABLE BC MONITOR**

**MET ONE INSTRUMENTS**

**C-12 PORTABLE BC MONITOR**

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## eBC mass concentration determination

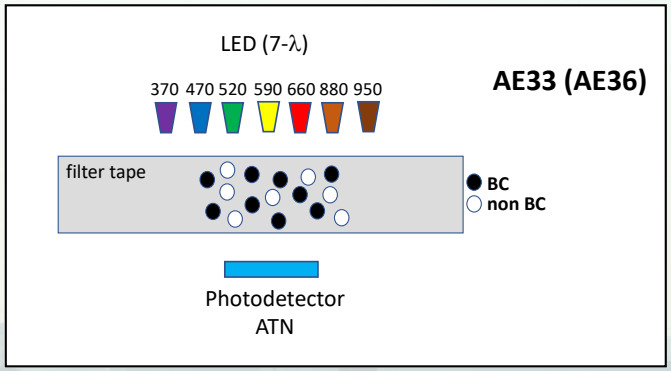
**AE33, AE36, AE36s**

$$BC6\ (880\ nm) = \frac{b_{ATN}}{C \cdot MAC_{BC}}$$

$b_{ATN}$: measured

$C$: multiple-scattering factor (C=1.39; M8060)

$MAC_{BC}$: Mass absorption cross section (7.77 $m^2/g$)




$$C^* = \frac{b_{ATN}}{b_{Abs}^{MAAP}} = 2.44$$

$$H^* = \frac{C^*}{C} = \frac{2.44}{1.39} = 1.76$$

$$eBC^* = \frac{BC6}{1.76}$$

$$b_{ABS}^*(880) = \frac{BC6 \times 7.77}{1.76}$$

Harmonization factor H* = 1.76 (M8060)
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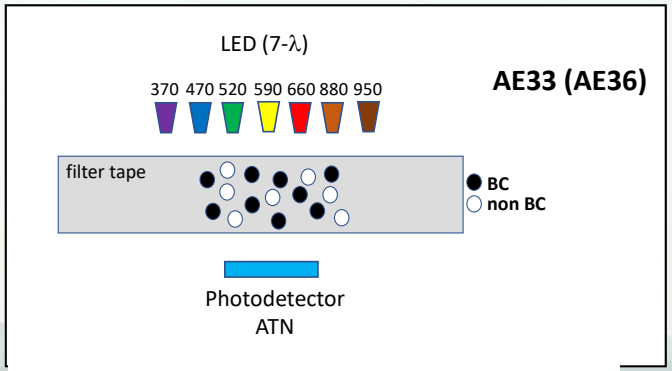
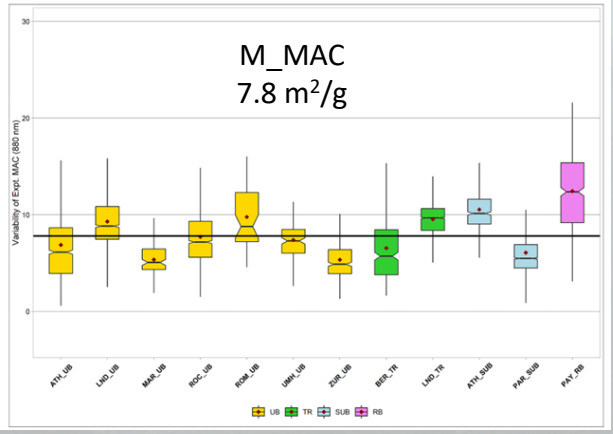
$$MAC^L_{BC}(880) = \frac{b^*_{Abs}(880)}{EC}$$

$$eBC^{*,L} = \frac{b^*_{Abs}(880)}{MAC^L_{BC}(880)}$$

$$eBC^{*,L} \approx EC$$

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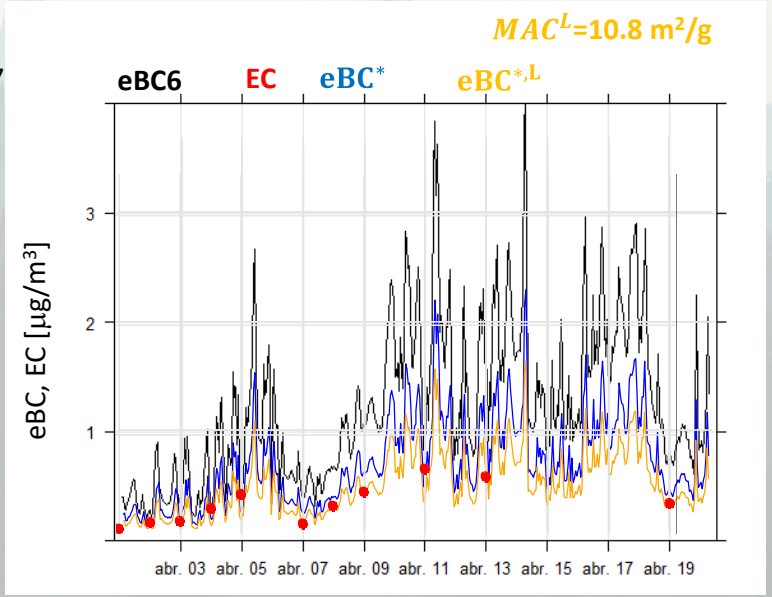


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## STEPS TO GO FURTHER WHAT FAPs ARE PROVIDING AS RAW DATA (eBC)

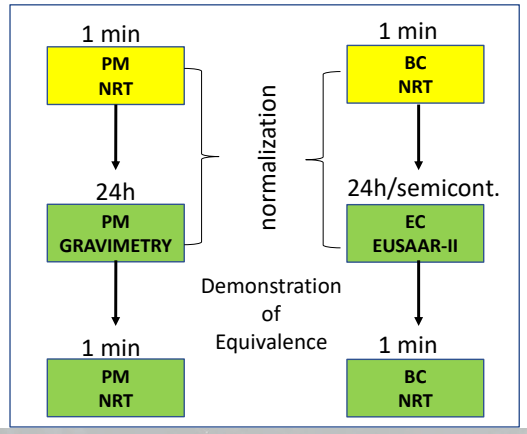
- For demonstrating the equivalence of a candidate method (e.g. the Beta-gauge technique) with the reference (gravimetric) method, it is allowed to establish first a site and time dependent calibration factor.
- Using site and time dependent MAC values would very probably make it possible to demonstrate the equivalence between FAP techniques and the CEN standard method (EN16909) for determining EC.

The EN 16909 standard method for determining EC → EC

GRAVIMETRY Protocol for Europe (Reference technique) → PM

BC ← FAPs (filter absorption photometers; MAAP, AE33, AE36)

PM ← NRT techniques for PM mass concentration (GRIMM;…)

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**MAAP**

nominal MAC

$$eBC = \frac{eBC^{maap} \cdot 1.05 \cdot 6.6}{10}$$

esperimental MAC

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## PUNTI DI DISCUSSIONE

- Quali strumenti sono utilizzati presso la tua Agenzia per le misure di eBC?
- Qualora non siano disponibili etalometro o MAAP, cosa è possibile fare (ACTRIS white list)?
- Qual è il sistema di inlet da utilizzare? Qual è il sistema di drying da utilizzare? (RI-URBANS ST)
- Quanto ritieni utile un supporto tecnico, metodologico o scientifico dall'infrastruttura di ricerca?
- Quanto ritieni utile un approfondimento specifico sul concetto di "equivalent BC"?
- Quanto ritieni utile un approfondimento specifico sull'"armonizzazione" delle concentrazioni di eBC?
- Quanto ritieni utile un approfondimento relativo alla determinazione della MAC locale usando misure di assorbimento e