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High-Time-Resolution Measurements of Equivalent Black Carbon in an Urban Background Site of Lecce, Italy

D. Cesari, E. Bloise, M. Conte, A. Dinoi, G. Deluca,
A. Pennetta, P. Semeraro, E. Merico, D Contini

Istituto di Scienze dell'Atmosfera e del Clima, ISAC-CNR

Napoli, 26 – 29 Maggio 2026

NAPOLI PM 2026

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Aim of the study

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Providing a comprehensive characterization of carbonaceous aerosol at an urban background site in South Italy.

How?

- evaluating OC and EC concentrations in PM samples (PM_{10}, $PM_{2.5}$)
- analysing eBC with high time resolution
- estimating the in-situ Mass Absorption Cross-section (MAC)
- comparing different measurement techniques
- determining the contribution of different sources (i.e. fossil fuel and biomass burning), and assessing the role of BrC

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Materials and Methods

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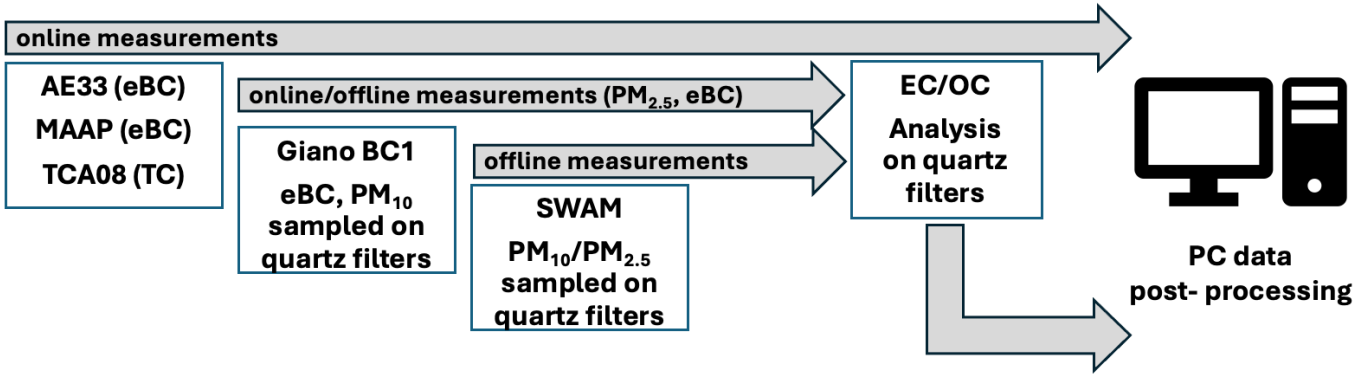


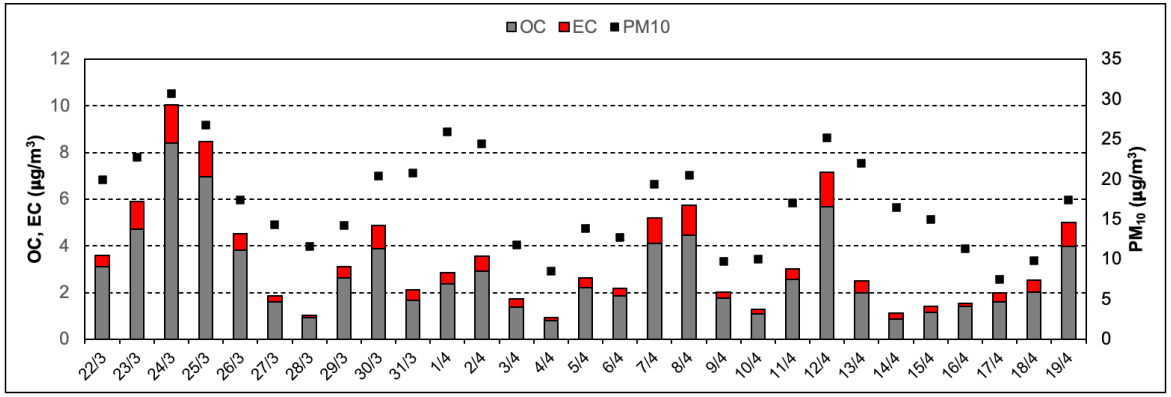
eBC online measurements: a Multiangle Absorption Photometer (MAAP, Thermoscientific, mod. 5012); an aethalometer (AE33); a black carbon analyser Giano BC1 (Dadolab Srl)

TC online measurement: Real Time Total Carbon Aerosol Analyzer (TCA08, Aerosol Magee Scientific). AE33 + TCA08 for deriving secondary and the primary organic carbon (SOC and POC)

Daily OC and EC: Sunset OC/EC Analyser (Sunset Laboratory Inc., TOR, EUSAAR2 protocol)

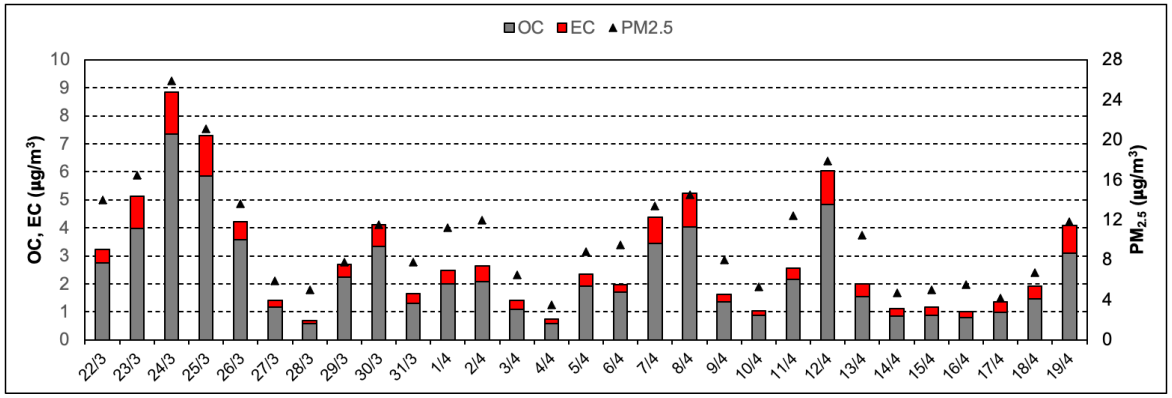
86 daily PM samples (57 PM_{10} and 29 $PM_{2.5}$) (SWAM 5A, FAI Instruments Srl)

OC, EC and MAC in situ



Average concentrations of PM:
17.1 (± 1.1) µgm^3 for PM_{10}
10.4 (± 1.0) µgm^3 for $PM_{2.5}$.

OC and EC represented **16.5%** and **3.6 %** of PM_{10} in mass, and **22.6%** and **5.5%** of $PM_{2.5}$. These values agree with those reported in a recent study [1].

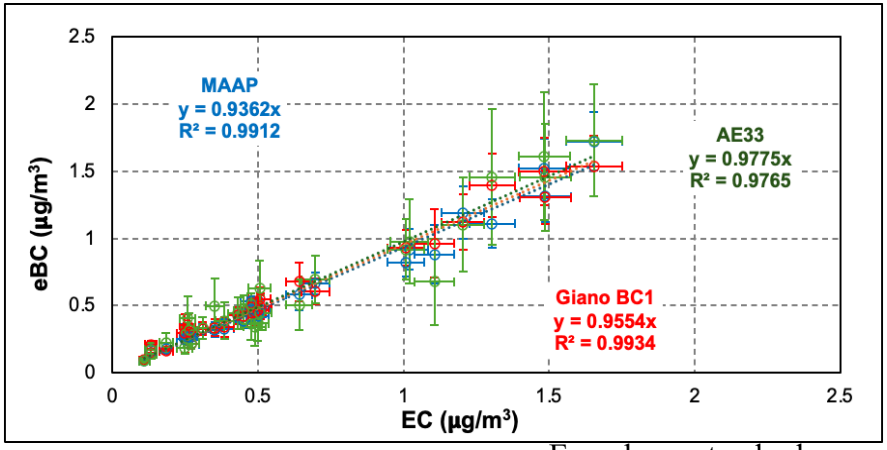


Instrument	Wavelength (λ)	MAC (m²/g)
MAAP	670 nm	12 (± 0.3)
AE33	880 nm	8.1 (± 0.3)
Giano BC1	635 nm	12.2 (± 0.5)

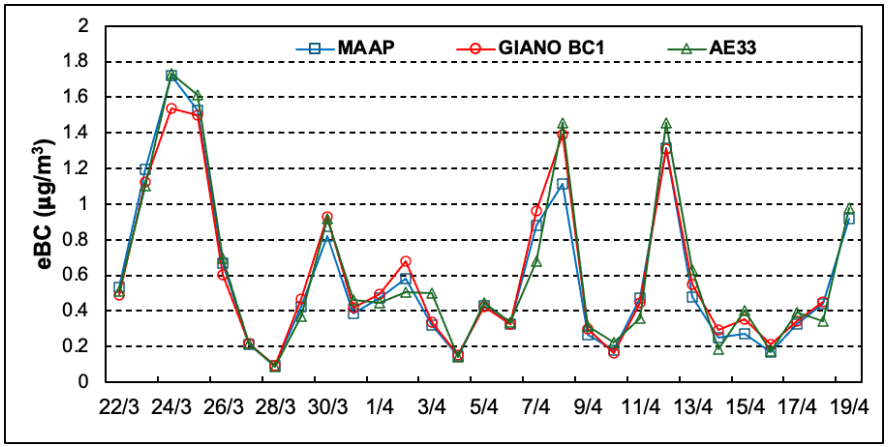
MAC values in agreement with those for several European sites [2].

[1] Merico et al., A.P.R., 16 (11), 102668, 2025.
[2] Zanatta et al., Atmos. Environ. 2016, 145.

eBC daily concentrations



Error bars: standard error



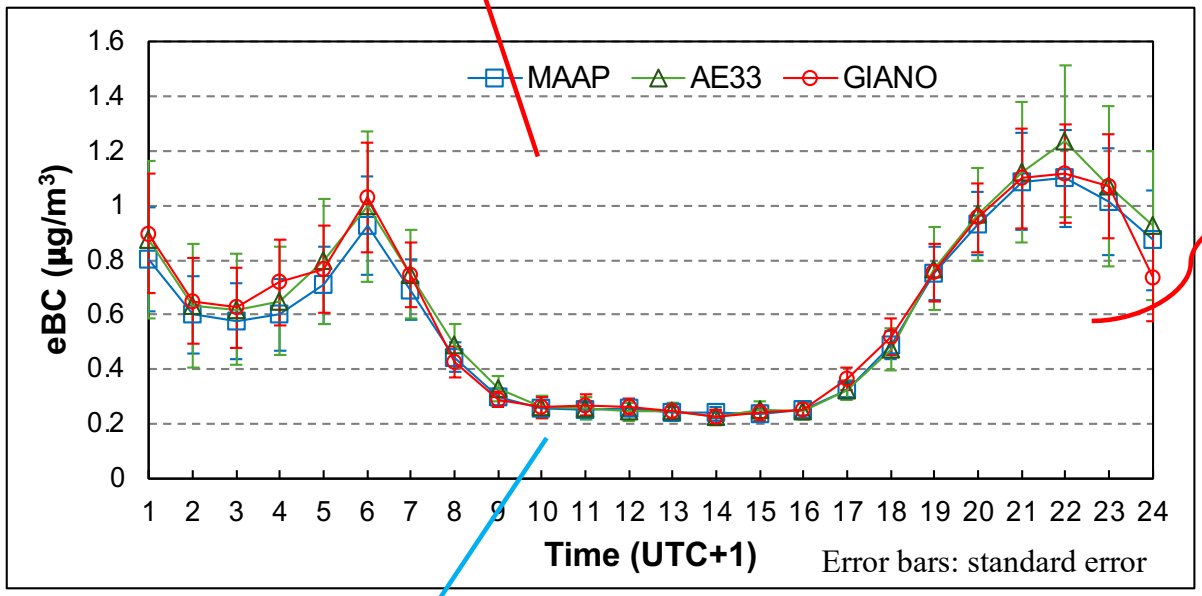
EC data concentrations resulted in good agreement ($R^2 > 0.97$ for all instruments).

Consistency of the data and the reliability of the measurements

(especially after correcting values with in-situ MAC).

Daily pattern of eBC

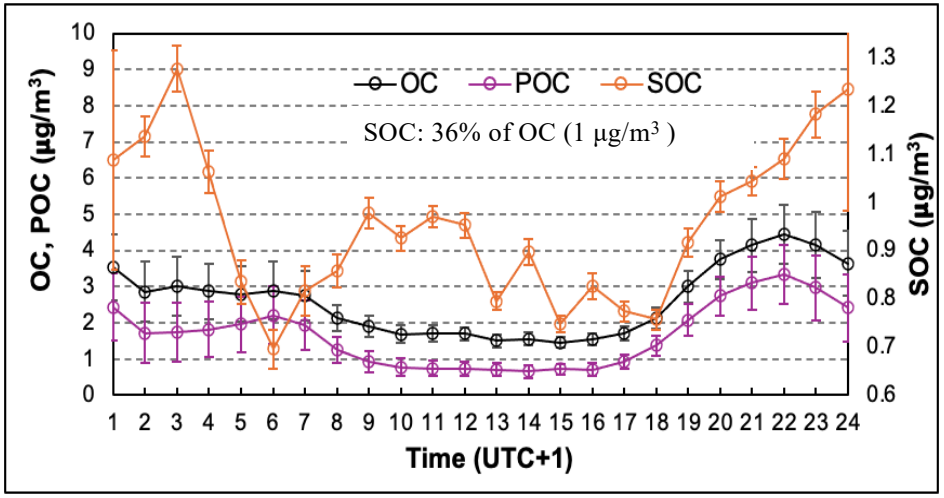
traffic emissions



effects of PBL behaviour
+
traffic & domestic heating emissions

min. concentrations around midday-early afternoon: influences from the daily growth of the planetary boundary layer (PBL).

Daily pattern of OC, SOC and POC

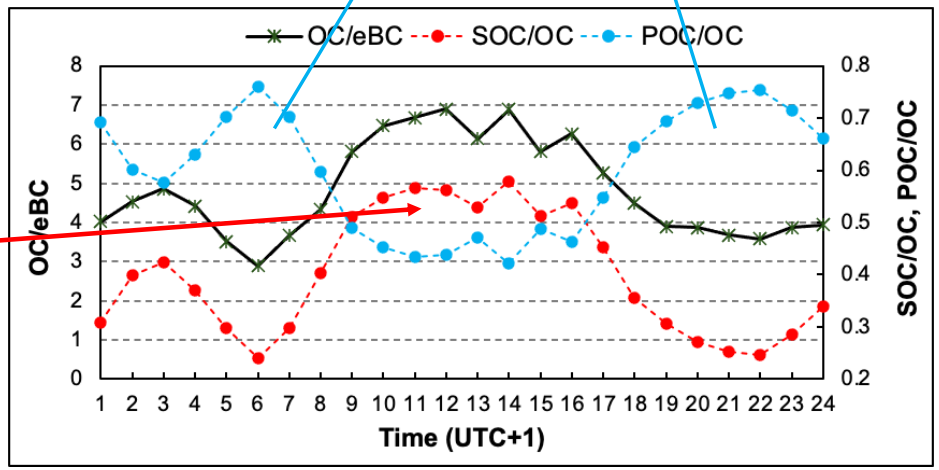


Error bars: standard error

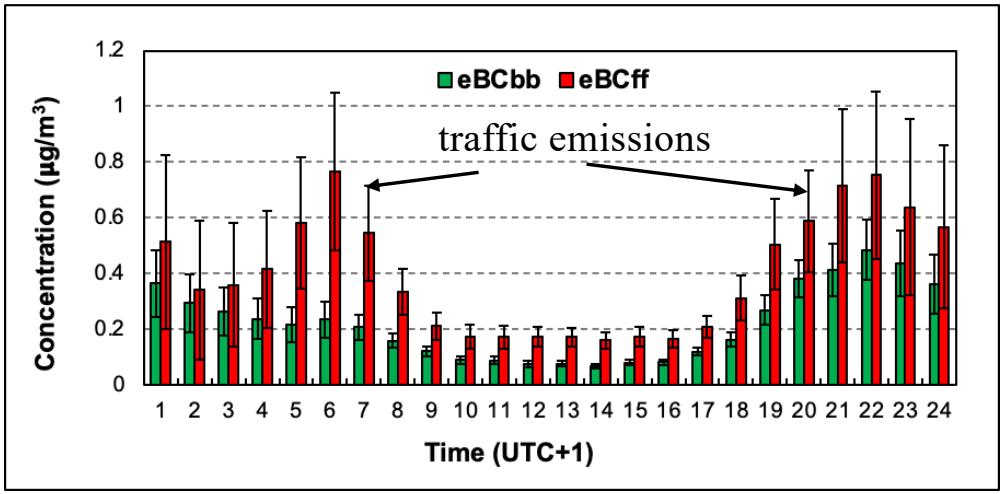
POC characterized by the same daily pattern observed for eBC (confirming the primary origin of the eBC).

primary combustion emissions

contributions from secondary organic aerosols (i.e., SOC)



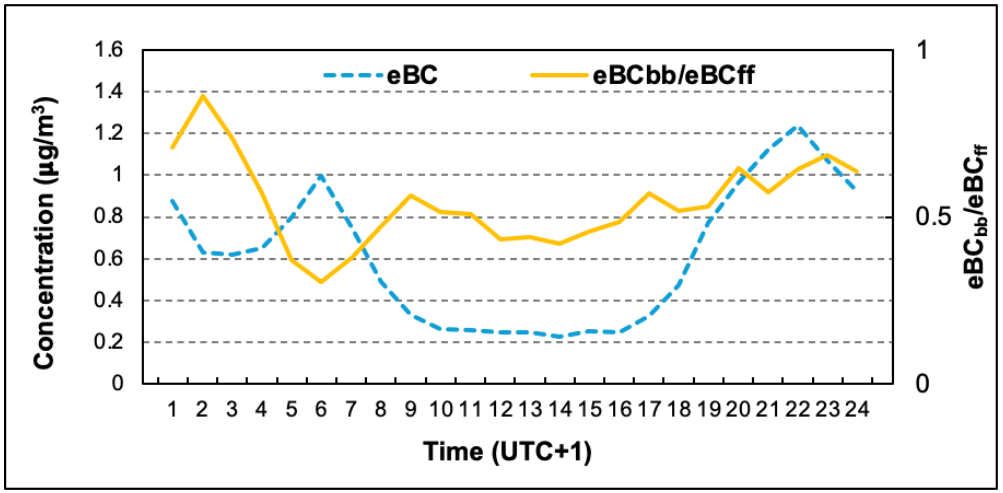
Daily pattern of eBC_{ff} and eBC_{bb}



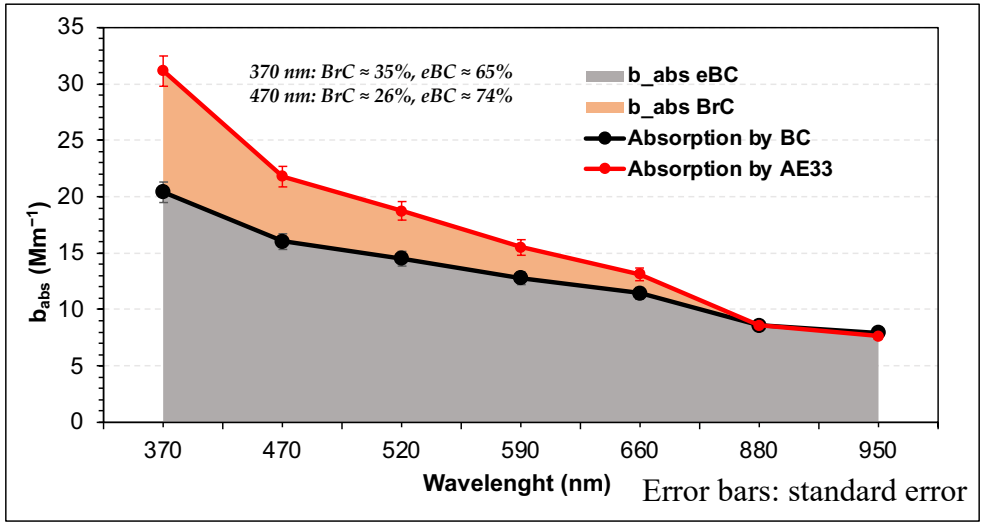
Error bars: standard error

eBCff about 64% (0.71 µg/m³) of eBC, while eBCbb was 36% (0.39 µg/m³): the ECO site is more influenced by fossil fuel combustion. Two pronounced eBCff peaks clearly associated with human activity.

The ratio eBCbb/eBCff also highlights the role of biomass-burning emissions (domestic heating), especially during the early hours of the day and in the late afternoon/night, also combined with PBL height effect.

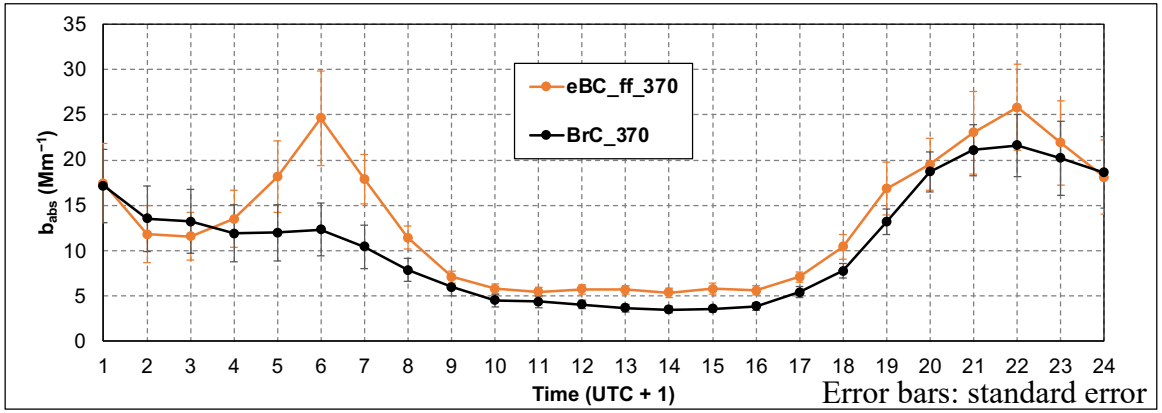


Absorption by BrC



The average AAE for aerosols collected at the ECO site was 1.46: presence of BrC.
BrC contribution especially significant at shorter wavelengths, especially for 370 nm (35%) and 470 nm wavelengths (26%). Observation in agreement with other studies [3, 4].

eBC and BrC patterns modulated by a combined effects: local micrometeorology and primary emissions.
In addition, secondary formation and atmospheric aging processes contribute to BrC levels.



[3] Fang et al., STOTEN, 838, 156431, 2022.
[4] Zang et al., STOTEN 743, 140752, 2020.

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Main results and conclusions

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- Comprehensive characterization of carbonaceous aerosol at the ECO urban background site through integrated online and offline measurements. Average PM concentrations: 17.1 µg/m³ for PM10 and 10.4 µg/m³ for PM2.5; OC and EC represented a significant fraction of PM mass.
- Excellent agreement between eBC and EC measurements ($R^2 > 0.97$), improved using site-specific in situ MAC values. In situ MAC values were consistent with those reported at other European urban background sites.
- eBC was mainly influenced by fossil fuel combustion (64%), with a significant contribution from biomass burning (36%).
- SOC represented about 36% of OC, with higher daytime concentrations linked to photochemical activity.
- BrC contributed significantly to aerosol absorption at short wavelengths, reaching ~35% at 370 nm.
- **Multi-instrument integration proved effective for improving carbonaceous aerosol characterization and supporting air-quality monitoring strategies under the new EU Directive 2024/2881/EU.**

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daniela.cesari@cnr.it

PM2026 Napoli, 26 – 29 Maggio 2026

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1

$$eBC_{raw}=\sigma_{abs,670\ nm}/6.6$$
$$MAC=\sigma_{abs,670\ nm}*(1/CF)/(EC*10^6)=\sigma_{abs,637\ nm}/(EC*10^6)$$
$$eBC=\sigma_{abs,637\ nm}/MAC*10^6$$

2

$$AAE=-\frac{\ln\left(\frac{b_{abs}(\lambda)}{b_{abs}(\lambda_{ref})}\right)}{\ln\left(\frac{\lambda}{\lambda_{ref}}\right)}$$

3

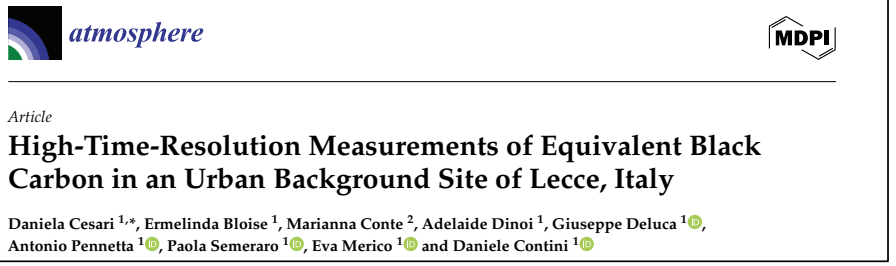
$$b_{BC,\lambda}=b_{tot,880nm}\times\left(\frac{880\ nm}{\lambda}\right)^{AAE}$$

4

$$b_{BrC,\lambda}=b_{tot,\lambda}-b_{BC,\lambda}$$

5

$$POC=(OC/eBC)_{prim}\times eBC$$
$$SOC=OC-POC$$



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