Development of a new photometer for measuring the absorption coefficient at 5 different wavelength: Dual Beam Absorption Photometer 5 (DBAP5), description and first comparisons

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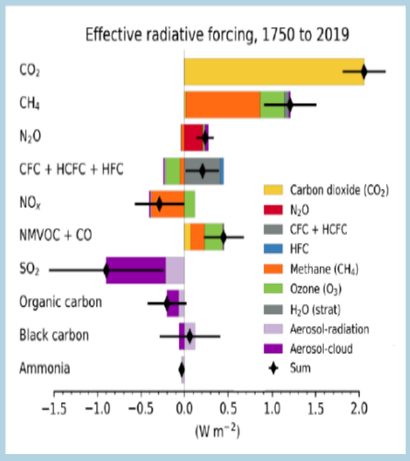
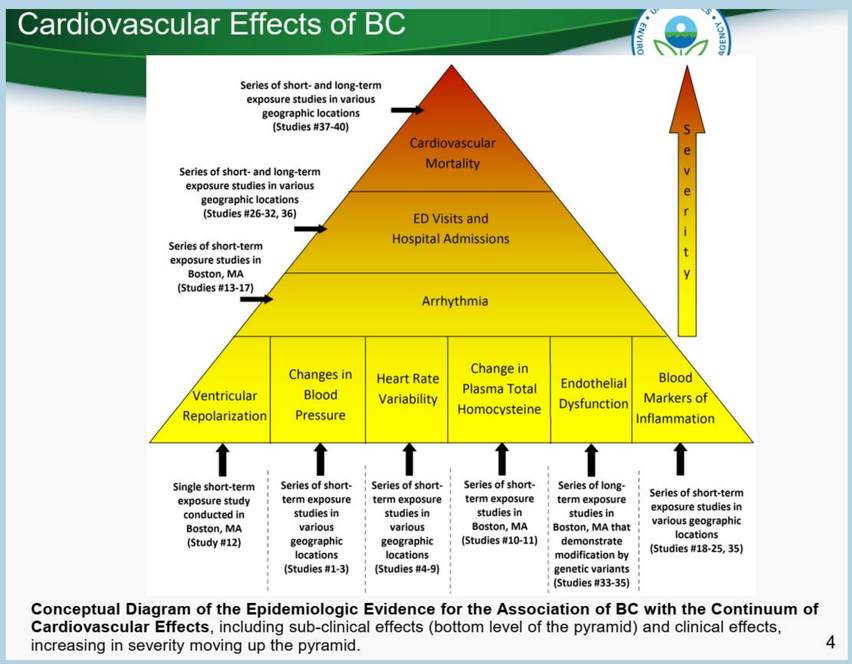
Motivation



Black Carbon (BC) is the main absorbing component of atmospheric aerosol. Generated by the incomplete combustion of fuels, biomass burning, internal combustion engines (especially diesel), and industrial processes, it has a lifetime in the atmosphere of days to weeks.

By strongly absorbing solar radiation and reducing albedo, when deposited on snow and ice, BC has a warming effect on climate [1], the quantification of which is still uncertain.

Moreover, epidemiological studies provide evidence of the association of cardiopulmonary morbidity and mortality with exposure to black carbon.

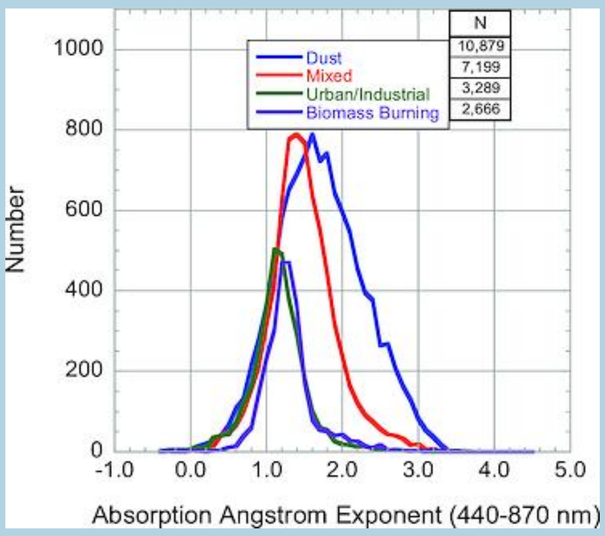


Conceptual Diagram of the Epidemiologic Evidence for the Association of BC with the Continuum of Cardiovascular Effects, including sub-clinical effects (bottom level of the pyramid) and clinical effects, increasing in severity moving up the pyramid. 4

These features have made BC an important pollutant to monitor, understand, and manage despite not currently having direct legal limits imposed in Europe and elsewhere (Reche et al., 2011; European Environment Agency, 2016).

Absorption coefficient Spectral Dependence (AAE)

Black carbon is not the only absorbing component of atmospheric aerosol, dust and organic compounds also absorb the radiation but with a different spectral dependence of the absorption coefficient, quantified by the Absorption Angstrom Exponent (AAE).

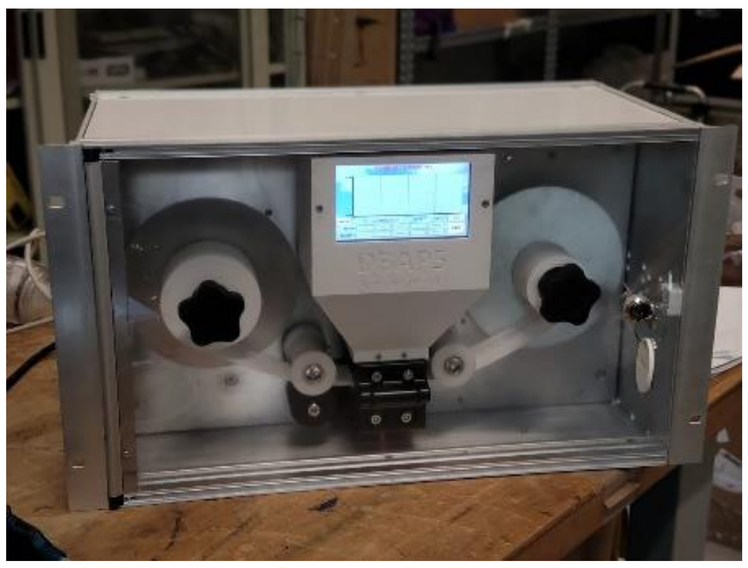


This is thus a key parameter to evaluate aerosol composition and sources.

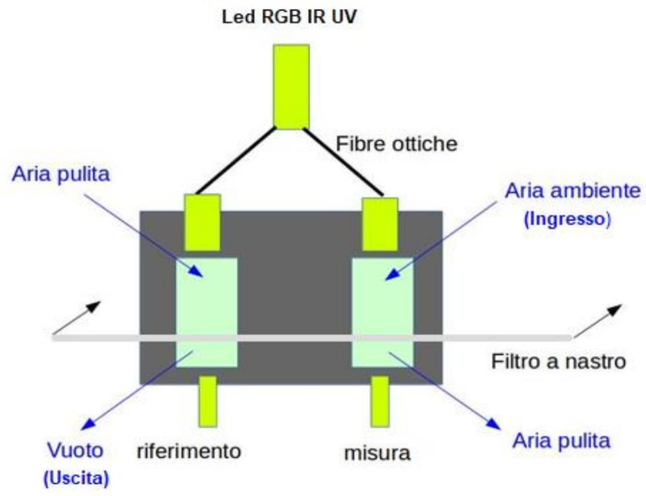
D. M. Gilles et al. 2012

DBAP5 description

The most popular method for measuring BC concentration and spectrally resolved aerosol absorption coefficient is the filter-based absorption photometer. Particles are collected on filter and as the particle load increase, the light passing though the filter decrease. DBAP5 is a 5 wavelength (from 420 to 870 nm, filter-based photometer based on the dual beam technology (Dual Beam Absorption Photometer).



Measuring the variation in filter light transmission at increasing particle load it evaluate the attenuation coefficients, then converted in the absorption coefficient by applying the appropriate filter correction equations.



Dual Beam chamber

Equivalent Black Carbon concentration can be then derived using the appropriate Mass Absorption Coefficients. The dual beam technology is a technique that simultaneously compare the absorption of the particulate matter with the absorption on the white filter, providing more precise measurement especially in low concentration site.

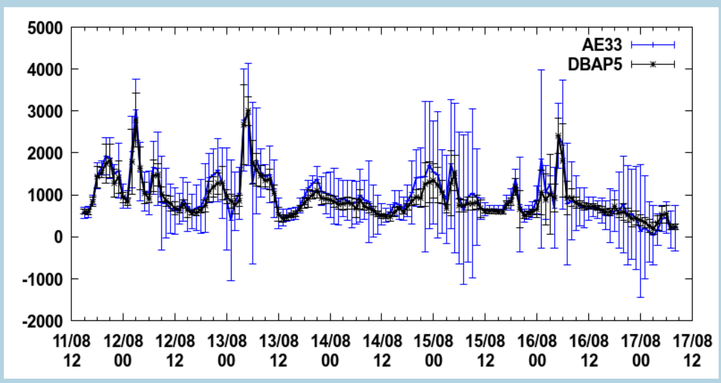
Technical Specification:

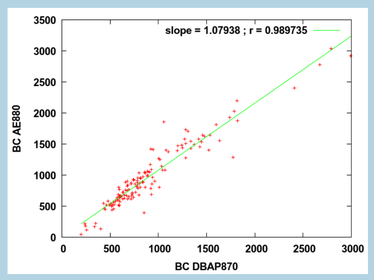
LED	870,634,522,465,420 nm
Air flow	1-5 l/m
Filter tape	Glass fiber GF-10 w=40mm
communication	RS232, telnet

Instrumental intercomparison

Urban site: Bologna with an AE33 (spring 2021)

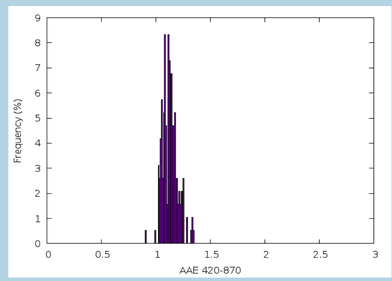
The BC [ng/cm3] DBAP5 has been evaluated from absorption coefficient at 870 nm





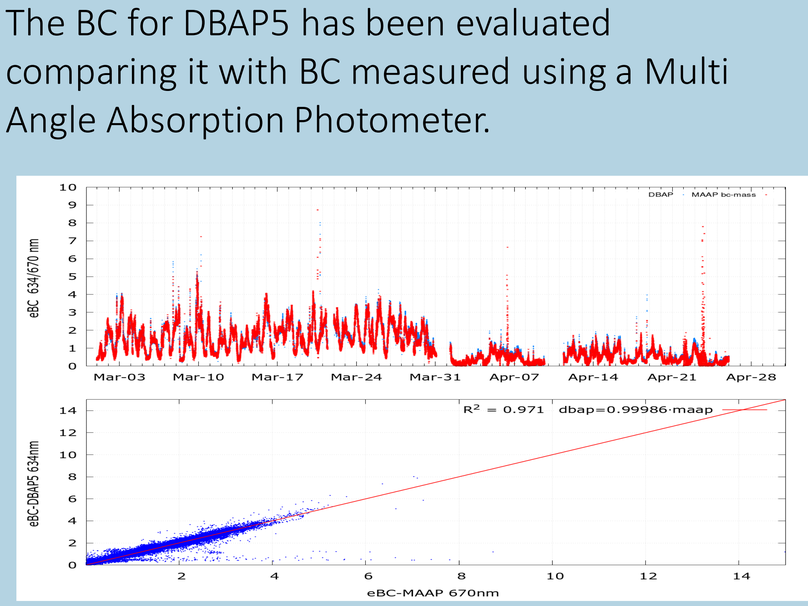
One hour averaged data has been used to compare DABP5 and AE33 measures. Correlation is very good, Comparing the SD, the DBAP5's SD is generally lower than AE33's, indicating less noise in the DBAP5 measurements in Urban areas.

During this period AAE has been evaluated from DBAP5 data, results agree with [3], showing typical values of urban sites



Rural site: San Pietro Capofiume, with a MAAP, Spring 2022

The BC for DBAP5 has been evaluated comparing it with BC measured using a Multi Angle Absorption Photometer.



One-minute data have been compared for two months. The results show a powerful agreement between two instrumental setup.

1) Reche. C. et al.: *New considerations for PM, Black Carbon and Atmos. Meas. Tech.*
2) *European Environment Agency: Black carbon: Better monitoring needed to assess health and climate change impacts*
3) *An analysis of AERONET aerosol absorption properties and classifications representative of aerosol source regions. D. M. Gilles et al. 2012 J. Geophys. Res.*
4) *S. K. Grange et al.: Evaluation of EBC source apportionment using observations from Switzerland 1885 particle number concentration for air quality monitoring across different European cities*