European Partnership on Metrology
Call 2022 – Digital Transformation, Health, Integrated European Metrology, Normative and Research Potential

Selected Research Topic number: **SRT-n02**
Version: 1.0

Title: Standardisation of Black Carbon aerosol metrics for air quality and climate modelling

Abstract

Black carbon (BC) plays a direct role in climate change and can have a significant impact on human health. This climate-forcing agent is emitted in the atmosphere due to incomplete combustion of fuels in motor vehicles and aircraft exhausts. Equivalent Black Carbon (EBC) data are obtained in real time with absorption photometers. However, standardised methods for the determination of EBC mass and related aerosol light absorption are lacking. Proposals addressing this SRT should establish a metrological framework and provide traceability for aerosol light absorption coefficient and its conversion to EBC mass concentration. This will enable consistent and comparable measurements across different air quality networks worldwide.

Keywords

aerosol, black carbon, aerosol light absorption, aerosol mass absorption cross section, mass concentration, photometers, equivalent black carbon

Background to the Metrological Challenges

Carbonaceous particles are nowadays receiving considerable attention from the scientific community and policy makers. Black carbon, in particular, is of high importance due to its direct role in climate change and as a specific constituent of combustion-generated aerosol for air quality purposes. Airborne (and ice-deposited) light-absorbing particles are significant contributors to global warming and BC has been identified as an important climate-forcing agent. Since BC has a much shorter atmospheric lifetime than other climate-forcing agents, such as CO_2, BC mitigation strategies could rapidly slow down the rate of climate change.

In 2019, more than 300,000 premature deaths in the EU were attributed to fine particulate matter. Currently, the only regulated metrics for airborne particles are $PM_{2.5}$ and PM_{10} (total mass concentration of particles with aerodynamic diameter smaller than 2.5 and 10 µm, respectively) and the mass concentration of a few selected metals. A significant fraction of ambient aerosols, however, consists of soot particles, which are identified as a serious risk to human health across Europe and worldwide. According to the World Health Organisation (WHO), health outcomes associated with $PM_{2.5}$ and PM_{10} are usually also associated with BC, and studies of short-term health effects even suggest that BC is a better indicator of harmful particulate substances from combustion sources than undifferentiated PM mass. The WHO Global Air Quality Guideline explicitly states the need for developing standards and target values for ambient BC concentrations. European National Emission Ceilings (NEC) Directive (2016/2284/EU) requires member states to prioritise measures that address black carbon in their National Air Pollution Control Programmes (NAPCPs) when taking action on fine particulate matter. Under the Convention on Long-Range Transboundary Air Pollution (CLRTAP), countries have also begun submitting black carbon emission inventories.

Despite the great variety of commercially available BC-monitoring instruments based on different measurement techniques, the quantification of aerosol light absorption remains a challenge, and its conversion to BC mass concentration is essentially impossible. Deviations up to 30 % among instruments of the same type and up to 60 % for instruments of different measurement principle have been reported. Up to date, standardised methods or guidelines on how to reliably calibrate these instruments and evaluate measurement uncertainties are lacking. Many aerosol measurement networks in Europe have integrated filter-based absorption photometers. These measure the optical absorption or attenuation coefficient b and convert it into a mass concentration M_{EBC} using a) a built-in correction factor which accounts for the optical properties of the filter and b) a built-in conversion factor known as MAC (mass absorption cross-section). Although the MAC value depends on both time- and site-specific aerosol properties, such as the particle mixing state, a single

MAC value is quasi arbitrarily set into the software by the instrument manufacturer, leading to M_{EBC} values that are systematically and significantly different from actual BC mass concentrations. Additionally, the determination of M_{EBC} is influenced by the instrument design and the assumptions made on the optical properties of the filter.

For a reliable calibration of filter-based absorption photometers it is important to: i) establish traceable measurements of light absorption *b* based on reference methods, ii) establish accurate measurements of EBC mass concentration M_{EBC}, and iii) determine a series of "mixing state-specific" EBC MAC values (MAC=b/M_{EBC}) in the laboratory based on the generation of well-defined reference aerosols. Candidates for reference measurement methods of aerosol light absorption and BC mass concentration exist, but they are not yet fully tested and adequately standardised.

Objectives

Proposers should address the objectives stated below, which are based on the PRT submissions. Proposers may identify amendments to the objectives or choose to address a subset of them in order to maximise the overall impact, or address budgetary or scientific / technical constraints, but the reasons for this should be clearly stated in the protocol.

The JRP shall focus on metrology research necessary to support standardisation in Equivalent Black Carbon (EBC) mass.

The specific objectives are

1. To develop standardised *in situ* reference methods for aerosol light absorption coefficient (extinction minus scattering and photo-thermal interferometry). To develop a robust uncertainty budget estimation as a function of the wavelength and ambient aerosol properties (e.g. single scattering albedo (SSA)) with target uncertainties of ≤10 % (95 % confidence level). To prepare a guide on the specifications, limitations and application range of each reference method.
2. To develop standardised measurement methods for aerosol mass absorption cross sections (MAC) at various wavelengths, based on traceable measurements of light absorption and EC mass. To determine the relationship between EBC mass and EC mass (EN 16909:2017) via inter-comparisons.
3. To develop methods for calibrating filter-based light absorption photometers and compare them with the reference methods that use a well-defined series of synthetic aerosols, generated in the laboratory. The SSA of the synthetic aerosols should span the range from <0.5 to almost 1, in order to obtain SSA-dependent calibration factors with a target uncertainty of <15 % for *k*=2.
4. To contribute to the development of a new CEN standard on i) traceable reference methods for determining aerosol light absorption coefficients (i.e. at multiple wavelengths) and ii) materials and methods for calibrating filter-based photometers against the reference method(s). This should include close collaboration with CEN/TC 264, CEN/TC 264/WG 35 and ISO/TC 146/SC 3.
5. To facilitate the take up of the technology and measurement infrastructure developed in the project by the measurement supply chain (e.g. accredited laboratories), standards developing organisations (e.g. CEN/TC 264, CEN/TC 264/WG 35 and ISO/TC 146/SC 3) and end users (e.g. air quality monitoring networks, instrument manufacturers).

The proposed research shall be justified by clear reference to the measurement needs within strategic documents published by the relevant Regulatory body or Standards Developing Organisation or by a letter signed by the convenor of the respective TC/WG. EURAMET encourages proposals that include representatives from industry, regulators and standardisation bodies actively participating in the projects. The proposal must name a "Chief Stakeholder", not a member of the consortium, but a representative of the user community that will benefit from the proposed work. The "Chief Stakeholder" should write a letter of support explaining how their organisation will make use of the outcomes from the research, be consulted regularly by the consortium during the project to ensure that the planned outcomes are still relevant, and be prepared to report to EURAMET on the benefits they have gained from the project.

Proposers should establish the current state of the art and explain how their proposed research goes beyond this. In particular, proposers should outline the achievements of EMPIR 16ENV02 Black Carbon and EMPIR 18HLT02 AeroTox and how their proposal will build on those.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 0.8 M€ and has defined an upper limit of 1.2 M€ for this project.

EURAMET also expects the EU Contribution to the external funded beneficiaries to not exceed 30 % of the total EU Contribution across all selected projects in this TP.

Any industrial beneficiaries that will receive significant benefit from the results of the proposed project are expected to be beneficiaries without receiving funding or associated partners.

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the ‘end user’ community, describing how the project partners will engage with relevant communities during the project to facilitate knowledge transfer and accelerate the uptake of project outputs. Evidence of support from the ‘end user’ community (e.g. letters of support) is also encouraged.

You should detail how your JRP results are going to:

- Address the SRT objectives and deliver solutions to the documented needs,
- Feed into the development of urgent documentary standards through appropriate standards bodies,
- Transfer knowledge to the environment – air quality sector.

You should detail other impacts of your proposed JRP as specified in the document “Guide 4: Writing Joint Research Projects (JRPs)”.

You should also detail how your approach to realising the objectives will further the aim of the Partnership to develop a coherent approach at the European level in the field of metrology and include the best available contributions from across the metrology community. Specifically, the opportunities for:

- improvement of the efficiency of use of available resources to better meet metrological needs and to assure the traceability of national standards
- the metrology capacity of EURAMET Member States whose metrology programmes are at an early stage of development to be increased
- organisations other than NMIs and DIs to be involved in the work.

Time-scale

The project should be of up to 3 years duration.