EMRP Call 2013 – Energy and Environment

Selected Research Topic number: **SRT-v13**
Version: 1.0

Title: Aerosol metrology for air quality and climate change

Abstract

Consistent, accurate measurements of aerosol particles are needed in order to enforce regulations which protect human health, to determine their effects on climate change, and to understand relevant atmospheric processes. Recently regulated air quality metrics such as $PM_{2.5}$, PAHs, elemental carbon and organic carbon require robust metrological support. Emerging metrics, such as number concentration and black carbon, would greatly benefit from a metrological framework being in place. Standardised measurement and calibration procedures for Condensation Particle Counters and for Mobility Particle Size Spectrometers should be developed, as should more reproducible reference methods for PM_{10} and $PM_{2.5}$. Reproducible methods and traceability for particulate matter chemical analysis should be developed. A metrological framework for black carbon measurement and a traceability framework and validated methods for the regulated major components of particulate matter should also be provided.

Conformity with the Work Programme

This Call for JRPs conforms to the EMRP Outline 2008, section on "Grand Challenges" related to Energy and Environment on pages 8, 13, 24 and 40.

Keywords

Air quality, particulate matter, aerosol, fine particles, ultrafine particles, black carbon, particle number, particle composition, particle number size distribution

Background to the Metrological Challenges

Ambient aerosol particles represent a serious human health issue across Europe. They likely cause 500 000 premature deaths per year within the EU and the average loss of life expectancy in major EU cities is up to 22 months. They have been regulated by the mass concentration of the size fractions PM_{10} and $PM_{2.5}$ for example within the EU Air Quality Directive 2008/50/EC. These metrics are defined by flawed manual methods and compliance with PM legislation is a major EU problem. Consequently, this Directive is being revised. Lower limit values are likely to be introduced and this will increase the demands on the measurements [1].

The particles vary in composition and size therefore, mass concentration is too crude a metric to characterise ambient aerosol particles in order to understand their sources, health effects, and control. Ultrafine particles have a negligible mass in comparison to $PM_{2.5}$ and PM_{10}. Other requirements include monitoring certain chemical components of particles in Annex IV of 2008/50/EC, and metals and PAHs in 2004/107/EC. To meet these requirements metrological support and a full understanding of the measurement method is needed. New metrics e.g. black carbon and particle number concentration are being considered for the revised Directives.

Aerosol particles play a key role in atmospheric science, including climate change, for example through their direct effect on the optical properties of the atmosphere via scattering and absorption of radiation, their indirect optical effect via cloud formation, and their chemical interactions. Aerosols have significant radiative forcing effects, typically net cooling, but within this net cooling the black carbon has a significant warming effect. As the relevant metrics are largely common with those in air quality, there is an opportunity for metrology to bring a common basis to these different fields.

Measurement issues specific to ambient aerosol particles include the fact that their concentrations and composition in ambient air are highly variable both temporally and spatially. The range of particle sources is very diverse. There can be a high proportion of semi-volatile particles whose presence is a function of temperature. Many particles are hygroscopic, so their mass and size depends strongly on humidity. There can be significant sampling issues such as impaction and diffusive losses to walls. Collecting particles on filters can bring additional sampling issues relating to chemical interactions and to the effects of different filter materials.

EU regulatory measurements of parameters such as $PM_{2.5}$, anion and cation concentration, and elemental/organic carbon (EC/OC) have been addressed through CEN committees and in their mandated validation work. Other areas such as particle number concentration and size distribution, and black carbon, have been addressed through UNECE and EU projects such as EUSAAR and ACTRIS. The practical implementation of air quality monitoring systems to meet the Directive's uncertainty requirements is handled by the Network of European Air Quality Reference Laboratories. Automatic PM_{10} monitoring is proving problematic because of inconsistency in the instruments and because of ambiguity within the reference method, which is being revised within CEN TC 264 WG 15. Manual reference methods for anions and cations, and for EC/OC are being written in CEN TC 264 WGs 34 and 35 respectively. Further research will be needed for EC/OC before a well-characterised method is available. Standard methods currently exist for the measurement of PAHs but these are not fit for purpose. Particle number concentration and size distribution are being standardised within CEN WG 32, which is close to finalising a method for number concentration in ambient air. Standardisation on the calibration of CPCs is close to completion within ISO TC 24 SC4 WG 12. CEN's work is supported by the ACTRIS project and by the European Monitoring and Evaluation Programme, which has its own set of measurement protocols. The need for NMIs to provide an infrastructure for particle number concentration has been explicitly acknowledged within ISO 24, and work has been done on this in EURAMET comparison 1027. This will continue in EURAMET comparison 1244. Anions and cations are important metrics for understanding secondary inorganic aerosol formation, and also for measuring primary ionic PM. Accurate measurement of natural sources is important as legislation allows them to be subtracted from a Member State's PM concentrations. Standard methods are lacking and a better understanding of potential measurement biases is required before full SI traceability can be put in place. In both areas there is also an increasing emphasis on high time resolution measurement in order to understand human exposure more fully. Black carbon suffers as a metric from being operationally defined, with several related but distinct technologies producing data of variable comparability (i.e. measured concentrations can differ by up to 80 %). As an optical measurement, elemental carbon could be used as a reference or a reference aerosol could be developed. Calibration and standardisation procedures for these metrics would therefore be extremely timely.

Scientific and Technological 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 JRP-Protocol.

The JRP shall focus on the SI traceable measurement and characterisation of aerosols in the fields of air quality and climate change.

The specific objectives are

1. To develop standardised measurement and calibration procedures for Condensation Particle Counters (CPCs) and for Mobility Particle Size Spectrometers (SMPSs). These should allow robust comparisons and uncertainty estimates to be made for ambient measurements in the size range up to 1000 nm. Appropriate test aerosols should be generated. The particle sizing issues that are needed to underpin SMPSs will also be addressed and the cut-off size for CPCs for ambient measurements is expected to be 7 nm.
2. To develop more reproducible metrological methods for PM_{10} and $PM_{2.5}$. A demonstration chamber system for calibrating PM_{10} and $PM_{2.5}$ instruments using a representative generated aerosol should be designed and built. Expanded uncertainties, which are typically 25 %, should be reduced to below 20 %.
3. To provide a metrological framework for black carbon measurement. The aerosol optical absorption metric is currently of limited use as several distinct measurement methods are being used. Calibration and standardisation procedures should be developed to allow valid comparisons to be made between the different techniques, and uncertainties to be calculated reliably.

4. To provide the SI traceability system for the regulated major components of particulate matter (elemental and organic carbon, anions and cations) to meet the required data quality objectives (DQOs).

5. To develop reproducible methods and the SI traceability for particulate matter chemical analysis such as PAHs using TD-GC/MS and other techniques. Methods should also be developed to mitigate oxidative loss of components such as PAHs during sampling and analysis, to meet DQOs and to support scientific needs for speciation of particulate matter, especially for real time analysis.

These objectives will require large-scale approaches that are beyond the capabilities of single National Metrology Institutes and Designated Institutes. To enhance the impact of the R&D work, the involvement of the user community such as industry, and standardisation and regulatory bodies, as appropriate, is strongly recommended.

Proposers should establish the current state of the art, and explain how their proposed project goes beyond this and EMRP JRP ENV02 (PartEmission) 'Emerging requirements for measuring pollutants from automotive exhaust emissions'.

EURAMET expects the average size of JRPs in this call to be between 3.0 to 3.5 M€, and has defined an upper limit of 5 M€ for any project. The available budget for integral Research Excellence Grants is 30 months of effort.

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the "end user" community. This may be through the inclusion of unfunded JRP partners or collaborators, or by including links to industrial/policy advisory committees, standards committees or other bodies. Evidence of support from the "end user" community (eg letters of support) is encouraged.

You should detail how your JRP results are going to:

- feed into the development of urgent documentary standards through appropriate standards bodies
- transfer knowledge on the traceable measurement and characterisation of aerosols in the fields of air quality and climate change

You should detail other impacts of your proposed JRP as detailed in the document "Guide 4: Writing a Joint Research Project"

You should also detail how your approach to realising the objectives will further the aim of the EMRP to develop a coherent approach at the European level in the field of metrology and includes 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 Member States and countries associated with the Seventh Framework Programme whose metrology programmes are at an early stage of development to be increased
- outside researchers & research organisations other than NMIs and DIs to be involved in the work

Time-scale

The project should be of up to 3 years duration.

Additional information

The references were provided by PRT submitters; proposers should therefore establish the relevance of any references.

[1] Review of evidence on health aspects of air pollution – REVIHAAP - First results (WHO, 2013)

[2] Integrated Assessment of Black Carbon and Tropospheric Ozone, Summary for Decision Makers (UNEP/WMO 2011)

[3] Health effects of black carbon (WHO 2012)