EMPIR Call 2019 – Energy, Environment, Normative and Research Potential

Selected Research Topic number: **SRT-v10**
Version: 1.0

Title: Metrology for aerosol optical properties

Abstract

Aerosols are an important constituent part of the atmosphere and an Essential Climate Variable (ECV) contributing both to the climate change through their impact on the Earth's radiative balance and to the air quality. Passive remote sensing of atmospheric aerosols is the most widely used technique providing the total columnar aerosol optical properties for assessing the impact of radiative cooling or heating on Earth's climate. There is a need for a metrological approach to the remote sensing of atmospheric aerosols, thereby providing traceability to the SI and a systematic validation of this ECV of the Earth system.

Keywords

Remote sensing, atmosphere, essential climate variable, aerosols, traceability, radiometry, radiative forcing, climate

Background to the Metrological Challenges

Atmospheric aerosols are minor constituents of the atmosphere, but a critical component in terms of impact on climate change. Aerosols have been recognised as an essential climate variable (EVC) by the global climate observing system (GCOS). Aerosols influence the global radiation balance by directly scattering and absorbing solar radiation and indirectly through influencing cloud reflectivity, cloud cover and cloud lifetime. The main aerosol parameters relevant for Climate radiative forcing are the number of aerosols in the atmosphere, aerosol optical depth (AOD), and the single scatter albedo (SSA).

Current aerosol networks measuring AOD rely on a calibration hierarchy linking individual network instruments by direct comparisons to reference instruments, which are in turn calibrated at high mountain stations using subjective calibration procedures which are not traceable to the SI. Typical instruments calibration includes narrowband filter radiometers and spectroradiometers. The wavelength range between 310 nm to 1.7 µm covers the operational wavelength range of these instruments with standard technologies (Si and InGaAs detectors). To achieve full traceability for spectral irradiance responsivity, field of view, polarisation dependence, linearity, and stray-light rejection or out of band filter leakage instruments needs to be calibrated thus the need for developing calibrated methodologies and devices to allow full metrological traceability of the individual network instruments to the SI.

At present there are three different global surface-based networks such as the aerosol robotic network (AERONET), the Global Atmosphere Watch Precision Filter Radiometer network (GAW-PFR) the sky radiometer aerosol network (SKYNET) measuring aerosol optical properties. Each network has diverse calibration strategy relying on in-situ calibration of radiometer. AERONET and GAW-PFR operate reference radiometers to which network radiometers are directly compared to, SKYNET directly calibrates each radiometer at its measurement site rendering the quality assurance process dispute the well-defined calibration procedures implemented at each network calibrations are not traceable to SI. An essential requirement for such long-term monitoring instruments is their stability which needs to be verified at regular intervals using laboratory and field-based infrastructures.

Climate is changing and understanding its impact is vital and this can be achieved by providing more reliable data to policy makers and promoting human health and safety via greater access to key data on aerosols. Developing the metrological framework to provide traceability to the surface-based networks of remote sensing of aerosol optical properties. This will ensure homogeneous and consistent datasets of comparable quality with known uncertainties for current and future measurements. Outcome of previous EMPR projects can aid extend methodologies and devices to develop a full traceability chain for monitoring ECV. A traceable chain for monitoring ECV can also provide reliable and quality assessed datasets of aerosol optical properties for assuring the long-term monitoring of the impact of aerosols on climate.

A metrological approach to the remote sensing of atmospheric aerosols, thereby providing traceability to the SI and a systematic validation of this ECV of the Earth system can help collaboration between end-user's community and the NMIs and DI's leading to significant access and sharing of infrastructure. It will also aid in knowledge transfer in the field of radiometry as well as products, such as aerosol properties to provide traceable and high-quality climate-related measurement data to the wider user community.

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 the traceable measurement and characterisation of aerosol in the atmosphere.

The specific objectives are

1. To develop calibrated methods and traceable devices for SI-traceable laboratory and in-field calibrations for radiometers measuring direct solar spectral irradiance and sky radiance, in the spectral range 310 nm up to 1.7 µm with an expanded uncertainty of 1 %.
2. To validate the methods for zero airmass extrapolation by means of traceable ground-based solar spectral irradiance measurements and comparison to satellite-based solar extra-terrestrial spectra.
3. To develop a comprehensive uncertainty budget for aerosol optical properties, such as aerosol optical depth, aerosol size distribution, and aerosol single scatter albedo, retrieved from remote sensing-based measurements of direct and scattered solar radiation, enabling its inclusion in the corresponding data archives of the aerosol monitoring networks, with the relevant calibration and traceability information.
4. To facilitate the take-up of the developed technology and measurement infrastructure developed in the project by the measurement supply chain (NMIs, DIs, and calibration laboratories), standards developed organisations (WMO CIMO, WMO GAW SAG) and end users (e.g. ground-based and space-based remote sensing and atmospheric science communities). In addition, to support the European Metrology Network for Climate and Ocean.

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 research, the involvement of the appropriate user community such as industry, standardisation and regulatory bodies is strongly recommended, both prior to and during methodology development.

Proposers should establish the current state of the art, and explain how their proposed project goes beyond this. *(ENV03 SolarUV, ENV59 ATMOZ, and ENV04 METEOC)*

In particular, proposers should outline the achievements of the EMRP project(s) *ENV03, ENV59, ENV04* and how their proposal will build on those.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 2.0 M€, and has defined an upper limit of 2.3 M€ for this project.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 35 % of the total EU Contribution across all selected projects in this TP.

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 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 EMPIR 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.

Additional information

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

[1] M/503 Standardization mandate to CEN, CENELEC and ETSI in support of the implementation of the ambient air quality legislation