Title: Metrology for UV/Vis remote sensing of air quality

Abstract

Remote sensing of atmospheric trace gases such as O_3, NO_2 and SO_2 in the Ultraviolet and Visible Spectrum (UV/Vis) and knowledge of their distribution in the troposphere and stratosphere are key for air quality. Therefore, it is important to provide traceability and validation to remote sensing data for environmental monitoring. To address this issue, existing knowledge from two fields: i) radiometry, for the measurement of solar radiation, and ii) spectroscopy, for the determination of spectral absorption features of trace gases, needs to be combined. Then, from this knowledge improved methods for the measurement and characterisation of remote sensing data with lower uncertainty levels need to be developed, as well as reference transfer standard for field measurements

Keywords

Remote sensing, atmospheric trace gases, traceability, O_3, NO_2, SO_2, troposphere, stratosphere, air quality, UV/Vis

Background to the Metrological Challenges

The measurement of atmospheric trace gases such as O_3, NO_2, SO_2 and their partitioning into tropospheric and stratospheric column amounts is crucial for monitoring air quality and its effect on human health. NO_2 and O_3 are key atmospheric constituents and knowledge of their characteristics in terms of quantity as well as spatial and temporal distribution is key for modelling air quality for human health warnings. In addition, SO_2, as well as being an urban air pollutant, is directly connected to volcanic emissions into the atmosphere with significant consequences on air-traffic safety. These three gases, O_3, NO_2, SO_2, are considered by the Global Climate Observation System (GCOS), as essential climatic variables and knowledge of their distribution in the troposphere and stratosphere is essential for understanding and predicting changes in the composition of the atmosphere and for understanding the overall mechanisms of climate change.

Currently satellites provide near continuous spatial coverage, however their temporal coverage is limited by their polar orbits and their need to cover the whole globe with sufficient spatial resolution. In addition, due to the complexity of satellite based trace gas retrievals, (which are needed to derive tropospheric trace gas concentrations) surface based validation by well characterised instruments has not yet been achieved.

Passive spectrometric techniques that can retrieve total column measurements and vertical profiles of gases absorbed in the UV/Vis spectrum are widely used for monitoring and for input to atmospheric chemistry models. However, the determination of uncertainties related to the trace gas retrievals from such spectrometric techniques is a complex task as they are associated to atmospheric radiance measurements, the spectral fitting region, the absorption cross sections and their dependence with temperature, the processing steps needed to separate tropospheric from stratospheric contributions, and the radiative transfer calculations needed for the retrieval of air mass factors and the retrieval of column densities and vertical profiles. Therefore, there is a need to develop new methods with improved uncertainties for the measurement of atmospheric trace gases in the UV/VIS.

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 UV/Vis remote sensing data for the environmental monitoring of air quality.

The specific objectives are

1. To develop radiometric methods and devices for use with surface based networks for monitoring stratospheric and tropospheric trace gases in order to enable measurements of direct solar irradiance and radiance in the range 305 nm to 780 nm with a relative uncertainty of 2 % or better.
2. To determine the absorption cross-sections and reduce the associated uncertainty of specific wavelength regions for NO_2 (300 nm to 550 nm), SO_2 (290 nm to 330 nm) and O_3 (300 nm to 780 nm) for at least two different temperatures between 200 K and 293 K.
3. To develop a UV/VIS transfer standard instrument that can be used as a travelling standard for surface-based networks measuring column amounts of trace gases such as O_3, NO_2 and SO_2. To operate the transfer standard during a field campaign using UV/VIS instruments from surface-based networks.
4. To validate methods for total, tropospheric and stratospheric column measurements of atmospheric trace gases O_3, NO_2, SO_2, using characterised UV/VIS instruments, with uncertainties in the total column of 3 DU, 0.1 DU, and 0.1 DU for O_3, NO_2, and SO_2 respectively. The target uncertainty is below 30 % for partitioning the trace gases into tropospheric and stratospheric vertical columns in urban environments.
5. To facilitate the take up of the technologies and measurement infrastructure developed in the project by the measurement supply chain (NMIs, calibration laboratories), standards developing organisations (ISO, CEN) and end users (e.g. the ground- and satellite-based Earth observation communities, and atmospheric science communities).

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 research goes beyond this. In particular, proposers should outline the achievements of the EMRP projects: ENV03 “SolarUV”, ENV59 “atmoz” and ENV06 “EUMETRISPEC”, 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 to the project.

Any industrial partners that will receive significant benefit from the results of the proposed project are expected to be unfunded 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 Earth observation and atmospheric science communities, and environmental 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.