

Title: Metrology to establish an SI traceable climate observing system

Abstract

Remote sensing of Earth from space is the major means of obtaining the trustable global data needed for climate change research and for providing knowledge to enable policy makers to adopt appropriate mitigation and adaptation strategies. Changes in the data of a few tenths of a percent per decade need to be detected which currently relies on measurands only realisable in NMI laboratories. Calibration and validation standards and methods, covering pre- and post- launch as well as complimentary in-situ networks, for land, ocean and atmosphere need to be developed. This will extend the capabilities of the SI to meet the needs of climate monitoring.

Keywords

Remote sensing, Climate, Calibration (Cal), Validation (Val), Radiometry, Satellites, Traceability, Earth Observation, Essential-Climatic-Variables (ECV)

Background to the Metrological Challenges

The Paris Agreement seeks to contain the rise in temperature of the Earth to < 2 °C above pre-industrial levels with a highly ambitious target of < 1.5 °C. Even if this higher-level goal is achieved, the world still faces significant consequences from climate change and there is an urgent need to establish a robust integrated global climate observing system to monitor all the essential climate variables (ECVs), to facilitate greater trust in climate forecasts and increased confidence for adaptation & mitigation policies. The harshness of the operational environment in space, as well as the launch and environmental conditions on aircraft and at extreme remote sites of earthbound observation all cause significant and unpredictable changes in the performance of remote-sensing instrumentation. Therefore, re-assessment of the accuracy of satellite instrumentation post-launch as well as the recalibration of airborne and ground based instrumentation at regular intervals is essential. The World Meteorological Organisation (WMO) and Group of Earth Observations (GEO) are currently trying to establish validation sites and networks of test-sites and/or other methods for the post-launch calibration and validation of sensors. However, traceability to the SI is required, including the development of new suitable standards and the incorporation of metrological best practise into sensor design.

Many pre-flight techniques have been developed and demonstrated in the laboratory. However, full uptake requires further adaption to provide cost effective solutions that meet the uncertainty demands of future missions. Internationally harmonised Cal/Val test-sites of CEOS have now become operational, although the concept needs to take into account other Fiducial Reference Measurement (FRM) quality networks. Exploitation of Artificial Intelligence and big data analysis in a metrological robust manner may provide new opportunities to help address global multi-sensor interoperability. Long-term data sets, as well as operational temporal continuity need scene and pixel dependent uncertainty characterisation. The retrieval algorithm, developed in EMPIR project 16ENV03, needs characterised bio-geophysical inputs to support performance testing in the virtual domain. The Paris Agreement details the need to monitor GHGs emissions and sinks from space in a trustable manner. At present evidence of the achieved uncertainties in these missions is lacking particularly for emissions but also for forests and oceans. Strategies and methods to establish traceability and evaluate associated uncertainties of the retrieved GHG inventories at power-station and even city scale is urgently needed. Similarly, work to quantify the uncertainty of Carbon stored in sinks such as biomass in forests and phytoplankton of the oceans as derived from remote observations from space is needed. EMPIR project 16ENV03 developed instruments for traceable climate measurements but further work to operationalise and remove associated uncertainty in the measurement is needed. Other instruments also need to be extended to allow spectral and spatially resolved measurements of thermal infrared sky radiance to be determined.

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 ECVs used for global climate observation systems.

The specific objectives are

1. To develop a robust metrological chain (infrastructure and methods) to trace to SI a new generation of highly accurate, cost-effective sensors, for a space-based climate observing system, suitable for pre- and in-flight measurements, prioritising the needs emerging from current mission studies.
2. To develop SI traceable measurement methods with associated uncertainties for bio-geophysical parameters at pixel level and accounting for scene specific characteristics including the means to optimally parameterise, validate and assess the uncertainties of retrieval algorithms
3. To develop satellite derived SI traceable measurement methods (including uncertainty assessment, associated validation and interoperability) for greenhouse gases emissions and natural carbon sinks, including robust monitoring of implemented policies to reduce the anthropogenic carbon emission (in accordance with the Paris Accord of 2015 and Vienna 2018).
4. To develop instrumentation and standards for traceable climate quality measurements, including temperature of the Mesopause and thermal infrared sky radiance, from surface-based networks such as those operated under the WMO.
5. To facilitate the take up of the technology and measurement infrastructure developed in the project by the measurement supply chain (accredited laboratories, instrument manufacturers), standards developing organisations and end users (environmental monitoring and regulation bodies such as the World Meteorological Organisation (WMO) and Group of Earth Observations (GEO)).

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.

In particular, proposers should outline the achievements of the EMRP projects ENV04 and ENV53 and EMPIR project 16ENV03 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 environmental, climate change and space agency sectors.

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.