European Partnership on Metrology
Call 2024 –Digital Transformation, Green Deal, Normative and Research Potential

Selected Research Topic number: **SRT-v17**
Version: 1.0

Title: Metrology for harmonisation of field isotope ratio measurements

Abstract

Climate change is a major threat facing society. Greenhouse gases are continuously increasing in the atmosphere due to anthropogenic emissions, thereby causing global warming. Globally a call to reduce emissions of major greenhouse gases such as carbon dioxide, methane, and nitrous oxide has been made. Discriminating anthropogenic from natural contributions of these greenhouse gases by isotope ratio measurements could provide reliable data on the sources of these gases in the atmosphere. However, harmonised and standardised field calibration and measurements methods are required at the European and global level to support the work currently being done by measurements networks such as ICOS and NOAA.

Keywords

Greenhouse gases, harmonisation, isotope ratio, guidelines, field, traceability, uncertainty

Background to the Metrological Challenges

There are increasing concentrations of greenhouse gases (GHGs) in the atmosphere that are creating global warming. Atmospheric isotope ratio measurements provide the fingerprint for pinpointing greenhouse gas emission sources, as well as enabling the study of their biogeochemical and atmospheric cycles. The levels of methane (CH_4) and nitrous oxide (N_2O) increased in 2022 compared to 2021 with a growth rate higher than the mean over the past 10 years indicating that society is on the path of an increase in temperature well above the Paris Agreement targets by the end of the century. Therefore, there is an urgent global need to reduce the emissions of major causes of global warming – GHGs. To mitigate the current situation and implement reliable strategies to reduce GHG emissions relies on improvements in data harmonisation and greater standardisation of field (*in-situ*) isotope ratio measurement methods coupled with an expansion of the GHG assessed is required by monitoring networks such as ICOS. Field verification of GHGs emission sources relies on continuously making accurate and reliable atmospheric observations across large areas, countries, and continents that are interpreted using atmospheric transport models. It is essential to develop a European metrology infrastructure for field isotope ratio measurements of GHGs with a strong link to monitoring networks such as ICOS to supplement the current measurements carried out by these networks.

The metrology community has supported the network monitoring community who perform isotope ratio measurements for CO_2 and CH_4 by the development of field deployable spectroscopic methods as well as calibration approaches for CO_2 and CH_4 isotope ratio measurements with both past EMPIR and current Metrology Partnership projects contributing to improving isotope ratio CRMs for CO_2 and CH_4 with minimised associated uncertainties. Also, previous projects have worked to enable drone-based technologies to be introduced for the pinpointing of GHG pollution sources using atmospheric isotope ratio measurements. There is also a strong need to develop guidelines for field isotope ratio measurements of GHGs. Such guidelines elaborate the steps necessary to achieve comprehensive and transparent uncertainty evaluation and are needed to enable comparability of the results in measurement networks. The need for comprehensive and transparent uncertainty estimates was recently highlighted in the WMO/IAEA meeting in 2019.

Therefore, leveraging from the work that has been done in previous EMPIR and that is currently being performed in Metrology Partnership projects to enable the field implementation of the previously developed capabilities supported by guidelines is important. Hence, this SRT seeks to expand the existing knowledge and capabilities generated in these projects to increase greater uptake by field sites and monitoring networks.

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Metrological harmonised and standardised field measurement methods (including calibration) and guidelines for isotope ratio of the prominent GHGs (CO_2, N_2O and CH_4) are urgently needed as highlighted by the joint BIPM-WMO workshop [1] on Climate. The workshop identified the need for metadata to replicate and to identify potential biases to address harmonisation issues and recommended that ISO TC 158 should develop a standard calibration method for the determination of isotope ratios in GHGs. The development work must be carried out in collaboration with stakeholders including the new CCQM Task Group on Carbon Dioxide and Methane Stable Isotope Ratio Measurements (CCQM-GAWG-IRWG-TG-ISOTOP), instrument manufacturers and the GHGs monitoring communities for effective implementation.

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 proposal shall focus on developing an underpinning metrological infrastructure to harmonise field isotope ratio measurements of greenhouse gases.

The specific objectives are:

1. To develop improved metrological measurement approaches and guidelines for the harmonisation of in-situ field measurements of greenhouse gas isotope ratios by identifying current deficiencies in data accuracy and reliability based on gathering information from laboratories providing isotope Certified Reference Materials (CRMs) for N_2O, CO_2 and CH_4 and the requirements of networks making field-based isotope measurements.
2. To develop and validate improved metrological measurement methods (based on laser spectroscopy and mass spectrometry) for field isotope ratio measurements for N_2O, CO_2 and CH_4 targeting repeatability better than WMO compatibility goals ($\delta\ ^{13}C\text{-}CO_2$ 0.01 ‰, $\delta\ ^{18}O\text{-}CO_2$ 0.05 ‰, $\delta\ ^{3}C\text{-}CH_4$ 0.02 ‰, $\delta\ ^{2}H\text{-}CH_4$ 1 ‰) and 0.1 ‰, for $\delta^{15}N$ and $\delta^{18}O\text{-}N_2O$. CRMs identified in objective 1 will be used for calibration.
3. To develop metrological measurement methods to link site-specific isotopic composition ($\delta^{15}NSP$) in N_2O CRMs to international isotope ratio scales. CRMs identified in objective 1 will be used for calibration.
4. To implement metrological harmonised measurement approaches for GHGs isotope ratio measurements at field sites, employing the methods as well as the guidelines developed in objective 1. Measurements will be performed at existing field sites in e.g. the ICOS network to achieve improved compatibility of field site measurements with target uncertainties (to meet WMO extended compatibility goals) better than 0.2 ‰ for $\delta^{15}N$ and $\delta^{18}O\text{-}N_2O$, 1 ‰ for $\delta^{15}NSP$, 0.1 ‰ for $\delta^{13}C\text{-}CO_2$ and $\delta^{18}O\text{-}CO_2$, 0.2 ‰ for $\delta^{13}C\text{-}CH_4$ and 5 ‰ for $\delta^{2}H\text{-}CH_4$.
5. To facilitate the take up of the technology and measurement infrastructure developed in the project by the measurement supply chain (instrument manufacturers), standards developing organisations (CEN, ISO), and end users (e.g. ICOS, IAEA, WMO-GAW).

These objectives will require large-scale approaches that are beyond the capabilities of single National Metrology Institutes and Designated Institutes. Proposers shall give priority to work that meets documented needs, in particular those supporting the European Green Deal. 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 EMPIR projects 16ENV06 SIRS and 19ENV05 STELLAR, 19ENV01 traceRadon and Metrology Partnership 21 GRD04 isoMET project and how their proposal will build on those.

Proposers should note that the programme funds the activity of researchers to develop the capability, not the required infrastructure and capital equipment, which must be provided from other sources.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 2.8 M€ and has defined an upper limit of 3.5 M€ for this proposal.

EURAMET also expects the EU Contribution to the external funded beneficiaries to not exceed 35 % 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 proposal's 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,
- Facilitate improved industrial capability, or improved quality of life for European citizens in terms of personal health, protection of the environment and the climate, or energy security,
- Transfer knowledge to the environmental and climate monitoring 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 the Metrology 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.

Timescale

The project should be of up to 3 years duration.

Additional information

The links provided in this section are only correct at the time of publication up until the end of the Call year.

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

[1] *BIPM-WMO workshop on Metrology for climate action report:* https://www.bipm.org/documents/20126/27085544/RapportBIPM-2023-03.pdf/57b00234-2bd0-09e1-8d4f-4aaed2ae45fd?version=2.4&t=1687244959519&download=true

These references have been provided by EURAMET.

[2] *EMN Energy Gases Strategic Research Agenda* https://www.euramet.org/research-innovation/metrology-partnership/strategic-research-and-innovation-agendas