Title: Metrology for stable isotope reference standards

Abstract

Climate change is accepted as one of the greatest risks to society worldwide. The rise in temperature, due to increasing greenhouse gas concentrations in the atmosphere, is predominantly driven by human produced (i.e. anthropogenic) emissions; two thirds of which are CO_2 and N_2O. However, to distinguish between anthropogenic and natural emissions, a more robust metrological infrastructure, including stable isotope reference standards, is needed to underpin measurements of CO_2 and N_2O. Such an infrastructure would allow improved source apportionment of emissions, and validation of emission inventory data. It will also support the verification of nationally determined emission targets and allow pledges of emissions reductions made by governments to be demonstrated.

Keywords

Climate change, stable isotopes, reference standards, greenhouse gas, CO_2, N_2O, isotope ratio scale, gas metrology

Background to the Metrological Challenges

The Intergovernmental Panel on Climate Change (IPCC) in its latest report stated that there is a clear human influence on the climate and the longer we wait to reduce our emissions, the more expensive it will become. In addition, the programmes of the World Meteorological Organisation Global Atmosphere Watch (WMO-GAW) and the International Atomic Energy Agency (IAEA) require long term high-quality observations of the stable isotopic composition of high impact greenhouse gases (i.e. CO_2 and N_2O) and their isotopic content, in order to provide data for the analysis of trends, atmospheric burdens and the anthropogenic contribution.

Verifying emissions requires accurate measurement of both baseline concentrations and contributions resulting from emission events. Furthermore, the anthropogenic component of CO_2 and N_2O is very difficult to assess due to significant temporal and spatial variability of natural sinks and sources. Therefore, separating anthropogenic emission contributions from measured CO_2 and N_2O concentrations requires further information on their stable isotopic composition in order to provide important information on the biogeochemical cycles of CO_2 and N_2O.

Abundance ratios of CO_2 and N_2O isotopic components are regarded as important parameters for inferring their origin, production-consumption mechanisms and to estimate their global concentrations. Therefore, a more robust metrological infrastructure for isotopic component measurements of CO_2 and N_2O is needed. Such an infrastructure should include static and dynamic reference standards and new, more accurate methods for isotope measurements that meet the requirements for regionally focused monitoring studies and are also suitable for use in the field.

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 stable isotope reference standards for CO_2 and N_2O

The specific objectives are

1. To develop static and dynamic reference standards for pure CO_2 and at 400 µmol/mol in an air matrix with uncertainties of $\delta^{13}C\text{-}CO_2$ 0.1 ‰ and $\delta^{18}O\text{-}CO_2$ 0.5 ‰. To ensure traceability and consistency with the Vienna Pee Dee Belemnite (VPDB) primary standard and to work to meet the WMO compatibility goals ($\delta^{13}C\text{-}CO_2$ 0.01 ‰ and $\delta^{18}O\text{-}CO_2$ 0.05 ‰).
2. To re-measure the absolute CO_2 isotope-ratios of the reference materials (including the 47 mass peak), in order to provide the data necessary for SI traceability.
3. To develop static and dynamic reference standards for pure N_2O and at (300 – 1000) nmol/mol in an air matrix. The static and dynamic reference standards should meet the requirements for regionally focused monitoring studies and have target uncertainties of 1.0 ‰ ($\delta^{15}N^{\alpha}$ and $\delta^{15}N^{\beta}$) and 0.5 ‰ ($\delta^{18}O$).
4. To develop spectroscopic methods for isotope ratio measurements of CO_2 with a target uncertainty of 0.1 ‰ for $\delta^{13}C\text{-}CO_2$, $\delta^{18}O\text{-}CO_2$ and N_2O, including site specific delta values in real time with a target precision of 0.1 ‰ for $\delta^{15}N^{\alpha}$, $\delta^{15}N^{\beta}$ and $\delta^{18}O\text{-}N_2O$. The methods will be suitable for use in the field and include spectral line data measurements to improve isotope-specific line parameters. In addition, to study the stability and fractionation of CO_2 and N_2O static reference materials.
5. To facilitate the take up of the technology and measurement infrastructure developed in the project by industry, by standards developing organisations (such as ISO/TC158 and CENTC/264 and those associated with the Air Quality Directive 2008/50/EC) and by end users (the WMO-GAW, International Union of Pure and Applied Chemistry Commission on Isotopic Abundances and Atomic Weights (IUPAC CIAAW) and the IAEA).

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 and EMRP JRP ENV52 HIGHGAS.

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 climate change, air quality and environmental 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.