European Metrology Programme for Innovation and Research

Delivering Impact

Providing confidence for measurement of atmospheric volatile organic compounds

Thousands of volatile organic compounds (VOCs) exist in the atmosphere. Produced by a diverse range of sources, from the burning of fossil fuels to natural ecosystems, VOCs can have an adverse effect on climate and human health. At the start of 2020, however, many were not covered by the European directive on air quality and monitoring networks struggled to assign metrological traceability and measurement uncertainty to many species.

Europe's National Measurement Institutes working together

The European Metrology Programme for Innovation and Research (EMPIR) has been developed as part of Horizon 2020, the EU Framework Programme for Research and Innovation. EMPIR funding is drawn from 28 participating EURAMET member states to support collaborative research between Measurement Institutes, academia and industry both within and outside Europe to address key metrology challenges and ensure that measurement science meets the future.

Challenge

A major contributor to air pollution is a diverse class of low-boiling point chemicals termed "Volatile Organic Compounds" (VOCs). Emitted from natural and anthropogenic sources, thousands of species have been observed in the atmosphere. These include non-methane hydrocarbons, such as terpenes from plants or benzene from fossil fuel, molecules containing oxygen groups (oxygenated VOCs; a.k.a. oxy-VOCs) such as acetone or methanol from solvents, or those containing halogens (halogenated VOCs) such as 1,2-dichloroethane from industry.

Many are short-lived or present in the environment at extremely low levels (pmol/mol - nmol/mol) but some can lead to the generation of secondary organic aerosols (SOA) and of ground-level ozone, which alone contributed to the premature deaths of 70,000 European citizens in 2022.

Although VOCs contribute indirectly to climate change and directly to poor air quality, at the start of 2020 only non-methane hydrocarbons and formaldehyde, were included in the EU's Air Quality Directive (ADQ) of 2008. Atmospheric monitoring networks, including the ***World Meteorological Organization's Global Atmosphere Watch*** (WMO-GAW) Programme and the ***Aerosols, Clouds, and Trace Gases Research Infrastructure*** (ACTRIS), highlighted the need to fill measurement gaps in this area. This included both identifying the species of most concern and developing harmonised ways to ascertain measurement uncertainty to improve the accuracy of data at monitoring networks.

Solution

Building on EURAMET projects KEY-VOCs and HIGHGAS, the EMPIR project MetClimVOC focused on filling the metrological gaps in atmospheric VOC measurements. The project's consortium, consisting of National Metrology Institutes (NMIs) and members of the ACTRIS Topical Centre for Reactive Trace Gases In Situ Measurements (CiGas), compiled an initial list of VOCs relevant to atmospheric monitoring. After consultation with stakeholders, which included atmospheric modelling and remote sensing communities, a priority list of 6 oxy-VOCs, 5 terpenes and 5 halogenated VOCs was finalised. This focused on those with the most importance in climate research but which currently lacked stable and SI-traceable reference gas mixtures.

The main sources of uncertainties of each analytical technique for each VOC were identified, described and quantified, covering sampling, calibration and analysis. Based on this, and guidelines described by ACTRIS and WMO-GAW, an on-line tool for the calculation of uncertainties was developed and made available to monitoring stations.

Impact

To support its production of high-quality data on short-lived atmospheric constituents, ACTRIS relies upon the work of CiGas. This is composed of experts in atmospheric measurements that includes laboratories from France, Germany, Switzerland and Finland.

IMT Nord Europe, a leading French engineering school and major Research and Innovation Center on Energy and Environment, represents one of the 6 units of CiGas, and also serves as the French National Reference Laboratory for Air Quality. At the end of the MetClimVOC project in 2023 they were instrumental in ensuring that the list of priority VOCs were incorporated into the 2024 revision of the AQD. This now includes, for the first time, terpenes and oxy-VOC species in addition to formaldehyde.

The Empa conducts cutting-edge research for air pollutants and greenhouse gases in the framework of the CiGas topical centre. Through its Group for Climate Gases it oversees 16 atmospheric monitoring stations in Switzerland. Empa, with the support of METAS, the NMI of Switzerland, led the development of the easy-to-use ***Tool for Uncertainty Calculation for Atmospheric VOC Measurements*** (TUCAVOC). This software, as well as providing a homogenised approach to uncertainty calculations for VOC monitoring sites, can also be used for greenhouse gases and other pollutants.

Through the work of MetClimVOC stronger links now exist between NMIs and atmospheric monitoring networks in Europe. It is vital, however, that measurements continue to improve in this area -- not only to protect human health but also to monitor the levels of those VOC species that have been linked to climate change.

Providing SI-tracebility for volatile organic species

The MetClimVOC project:

- Determined a priority list of oxygenated VOCs, terpenes and halogenated VOCs. Except for the latter, the listed VOCs were incorporated int the Air Quality Directive (EU) 2024/2881.
- Produced first SI-traceable refence gas mixtures for oxy-VOCs acetone, ethanol, butanone and methacrolein at low amount fractions (< 100 nmol/mol) with a temporal stability up to 18 months.
- Developed four protocols for generating SI-traceable working standards for oxy-VOCs, two for terpenes and one for halogenated VOCs.
- Developed an on-line tool to simplify uncertainty budget calculations for the atmospheric monitoring community.
- Investigated effects of line material, particle filters, water removal, ozone scrubbers and sorbent tubes on sampling.
- Developed a methanol analyser and contributed to the development of new SI-traceable reference material for Proton-Transfer-Reaction Mass Spectrometry.
- Obtained SI-traceable spectral parameters for tetrafluoromethane, sulfur hexafluoride and fluoroform to be provided to HITRAN, a database to predict and simulate the transmission and emission of light in the atmosphere.

The improved and harmonised data will allow better mitigation strategies aimed at decreasing the health and environmental burden related to air pollution and climate change.

EMPIR EURAMET

The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

www.euramet.org/project-19ENV06

Celine Pascale, Maitane Iturrate-Garcia

METAS, Switzerland
celine.pascale@metas.ch, maitane.iturrate@metas.ch

11326/08/25 - 19ENV06