Plenary Talk
DOI 10.5162/SMSI2023/PT4

Metrology for Climate Observation: European Coordination

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Summary:
The European Metrology Network for Climate and Ocean Observation coordinates the European metrological community to become the European contribution to the global effort to bring metrological principles into the observations of the climate and broader observations of the ocean to support the quality assurance, stability and international consistency of the measurements that make up the global climate observing system. Here we describe activities of the network, and the requirements for metrology it has identified.

Keywords: climate change, observations, European Metrology Network, metrological framework,

Introduction

Measurements from space, air, ground, and sea provide comprehensive information on the state of the environment. Service providers, commercial and nonprofit organisations, local and national governments, and international organizations use information from observations to support social and economic development and address global and local challenges: natural hazards, climate change, biodiversity, and energy, water, and food security.

The Global Climate Observing System (GCOS) is a key component of the United Nations Framework Convention on Climate Change (UNFCCC). The 2022 GCOS implementation plan [1] describes observations as central to climate action: "At a fundamental level what we do not observe we cannot understand and what we cannot understand we cannot predict, adapt to and mitigate". That plan highlights how observation systems are critical to both the scientific analysis and to providing tailored climate information to decision makers and the public. It calls for more systematic observation of the water, carbon and Earth energy cycles, as well as a coordinated, high-quality, free, and open access to climate data.

There are references to metrological principles and techniques throughout the 2022 GCOS implementation plan. SI-traceability, robust uncertainty analysis and comparison approaches are explicitly mentioned.

In response to this increasing coordination of observation systems, and recognition of the value of metrology, it is timely for the metrology community to consider how it can also coordinate its efforts to provide systematic and sustainable metrological support for the climate observing system.

The European Metrology Network for Climate and Ocean Observation

In 2019, the European Association of National Metrology Institutes (EURAMET) established the European Metrology Network (EMN) for climate and ocean observation [2] as one of the first set of EMNs to provide coordination for metrology for societal benefit areas. The EMN has 24 member institutions from 19 European countries and its mission is to be the 'European contribution to a global effort to bring metrology into climate and ocean observations".

In its first three years, the EMN has performed a review of the needs of the climate and ocean observation communities and created a strategic research agenda in response. It has held several internal and stakeholder workshops and presented the metrological approach to key relevant conferences and organisations. The EMN also was key to organising the 2022 BIPM-WMO Metrology for Climate Action Workshop which is currently preparing recommendations for global collaboration between metrologists and the observation community.

Key common requirements

There are more than 50 ECVs, many of which can be measured in different ways, and there are many applications for climate observation data. While this broadens the scope of the EMN, its stakeholder needs reviews have identified some common requirements for metrological collaboration. These include:

- Providing guidelines, tailored to the observations community, for metrological terminology and how to apply the Guide to the Expression of Uncertainty in Measurement (GUM) to observational data
- Supporting the establishment of tiered networks with high-quality SI-traceable reference measurements, linked higher density operational observations and local information from low-cost sensors
- Supporting the development of methodologies to intercompare and combine local and satellite-based measurements and models, with different spatial and temporal scales
- Developing methods for metrological traceability and uncertainty analysis for data processing through neural network algorithms

Most generally, many observation communities welcome the participation of metrologists in their committees and research projects.

Example engagement with the satellite community

Collaboration between metrologists and the satellite observation community led to the Quality Assurance Framework for Earth Observation (QA4EO), which was endorsed by CEOS in 2008. QA4EO establishes the principle that Earth observations should have an associated quality indicator (e.g., uncertainty) and provide traceability to a community-agreed reference (ideally SI). Following the agreement of this principle, and particularly through research projects funded by the European space agencies ESA and EUMETSAT and the EU research programmes, collaboration has led to defined guidelines (on [3]) for applying uncertainties and traceability to satellite observations and the “fiducial reference measurement” suborbital observations that support them. It has also led to the first metrology satellite: TRUTHS, a satellite that will fly the primary optical radiometric standard into space, is in development for a ~2030 launch [4].

Example engagement in atmospheric chemistry

The metrology community is already involved with several atmospheric measurement communities, including the WMO-Global Atmosphere Watch (WMO-GAW) [5]. The WMO-GAW works towards a single coordinated global understanding of atmospheric composition and its changes, as well as improving understanding of how the atmosphere, oceans, and biosphere interact with one another. By coordinating high-quality atmospheric composition observations across global to local scales, GAW drives impactful science and produces the next generation of research-enabled products and services. Some components of the GAW observational network are recognized as comprehensive and baseline networks within GCOS. The GAW Implementation Plan 2016-2023 [6] embeds metrology in its data quality objectives on measurement and requires traceability to agreed references (ideally SI). Several metrology institutes already contribute actively by being assigned as a central calibration laboratory within WMO-GAW, and both communities participate in regular experts' meetings.

Example engagement with the marine science community

Collaboration between metrologists and the marine science community recently started via the MINKE [7] (Metrology for Integrated Marine Management and Knowledge-Transfer Network) initiative, under H2020. In addition to integrating key European marine metrology research infrastructures, it coordinates their use and development, and proposes a framework for monitoring and managing marine ecosystems based on high-quality oceanographic data. The MINKE consortium incorporates all key research infrastructures working on marine calibration, such as metrological and oceanographic institutions, and mature participatory networks around Europe, while targeted actions in the Networking Activities foresee the active involvement of technological partners, international institutions, including intergovernmental bodies, EU and International Networks and EU Research infrastructures.

Conclusions

This presentation will discuss the different needs and approaches to bring metrological principles into climate and ocean observation.

References

[1] 2022 GCOS Implementation Plan, https://gcos.wmo.int/en/publications/gcos-implementation-plan2022

[2] www.euramet.org/climate-ocean

[3] www.qa4eo.org

[4] https://doi.org/10.3390/rs12152400

[5] https://community.wmo.int/activity-areas/gaw

[6] https://public.wmo.int/en/resources/library/wmo-global-atmosphere-watch-gaw-implementation-plan-2016-2023

[7] https://minke.eu/