# The European metrology network for climate and ocean observation: a review of Earth observation needs for metrology

Emma Woolliams[1], Nigel Fox[1], Paola Fisicaro[2], Céline Pascale[3] and Christian Monte[4]

*[1]National Physical Laboratory (NPL), Teddington, UK, [2]Laboratoire national de métrologie et d'essais (LNE), Paris, France. [3]Federal Institute of Metrology (METAS), Bern, Switzerland. [4]Physikalisch-Technische Bundesanstalt (PTB), Berlin, Germany.*

*Corresponding e-mail address: emma.woolliams@npl.co.uk*

**EURAMET established the European Metrology Network (EMN) for Climate and Ocean Observation to support the observation expert communities to engage with metrologists at national metrology institutes and to coordinate European metrological research in response to community needs. The EMN has carried out a survey of what its stakeholders need from metrology. We present the results of that survey for satellite and related radiometric observations.**

## METROLOGY IN CLIMATE MEASUREMENT

Observations of essential climate variables (ECVs) and related environmental quantities made by satellites and in situ observational networks are used for a wide range of societal applications. To identify a small climate trend from an observational record that is also sensitive to weather, seasons and geophysical processes, stable, multi-decadal observations are needed, that still allow for changes in the observation instrumentation and procedures. To achieve this, all aspects of data collection and handling must be underpinned by robust quality assurance. The resultant data should also be linked to a common (preferably SI) reference, with robust and transparent uncertainty assessment, so that observational results are interoperable and coherent; measurements by different organisations, different instruments and different techniques should be able to be meaningfully combined and compared.

Metrology can provide a critical role in enabling robust, interoperable and stable observational records and can thus aid users in judging the fitness-for-purpose of such records. Many national metrology institutes (NMIs) worldwide have active research programmes in collaboration with the communities making and using climate observations and provide calibration services to those communities.

The value of metrology in observational systems such as the Global Climate Observing System (GCOS), and the role of NMIs in supporting the quality assurance of such observations, has been recognised in initiatives such as the Quality Assurance Framework for Earth Observation (QA4EO) established by the Committee on Earth Observation Satellites (CEOS) and in the implementation plans of the World Meteorological Organization's (WMO's), Global Atmosphere Watch and the European Ocean Observing System.

## THE EUROPEAN METROLOGY NETWORK FOR CLIMATE AND OCEAN OBSERVATION

The European Association for National Metrology Institutes (EURAMET) has recently created the "European Metrology Network (EMN) for Climate and Ocean Observation" to support the expert communities to engage with and to guide and encourage Europe's metrologists to coordinate their research in response to community needs. The EMN has a scope that covers metrological support for in situ and remote sensing observations of atmosphere, land and ocean ECVs (and related parameters) for climate applications. It also covers the additional economic and ecological applications of Essential Ocean Variable (EOV) observations.

It is the European contribution to a global effort to further develop metrological best practice into such observations through targeted research efforts.

## SURVEY OF METROLOGY NEEDS FOR CLIMATE AND OCEAN OBSERVATIONS

The EMN for Climate and Ocean Observation has been carrying out a survey to identify the ways in which metrology can most valuably contribute to the climate and ocean observation communities. The survey has involved the following aspects: (a) a set of online questionnaires that was sent to expert communities and received more than 50 responses, (b) a review of the literature, the strategies of key coordinating organisations and reports of community workshops and (c) a set of webinars, held 12/13

February 2020, with observation experts and metrologists. Here, we present the results of the survey as regards satellite Earth Observation.

## METROLOGY IN SATELLITE AND GROUND-BASED EARTH OBSERVATION

The Newrad conference has, since its origin in 1985, "provided a platform for the discussion of developments in optical radiometry among scientists working in laboratory and space radiometry." (quote from [1], 1996). Arguably it is this joint platform that helped to create the collaborative discipline of Earth Observation Metrology.

In 2008 CEOS formally endorsed QA4EO as a framework [2] around the principle that "All data and derived products must have associated with them a Quality Indicator (QI) based on documented quantitative assessment of its traceability to community-agreed reference standards. This requires all steps in the data and product delivery chain (collection, archiving, processing and dissemination) to be documented with evidence of their traceability." The framework was introduced alongside practical guidelines for reporting, for assessing uncertainties and for performing comparisons. These guidelines were based on metrology guidelines for comparisons for the Mutual Recognition Arrangement, especially the Consultative Committee for Photometry and Radiometry's (CCPR) guidelines for comparisons.

This formal recognition of the importance of metrological processes to underpin the long-term stability and interoperability of satellite Earth observation has opened further collaboration between the space agencies and the NMIs, much of which has been presented at Newrad conferences.

Within Europe, the Metrology for Earth Observation and Climate (MetEOC) series of EU-funded projects have developed new metrological techniques and applied them not only to pre-flight and post-launch radiometric calibration, but also to the derivation of ECV products, and to ground-based solar observations for the world standard group and the baseline surface radiation network. Those projects have provided a firm foundation for other work, performed collaboratively with (and often commercially for) the European Space Agency (ESA) and academic partners across Europe.

There have been projects to develop guidelines for ECV records [3], to establish "fiducial reference measurements" (FRM) of SI-traceable ground truthing observations [4] and for applying metrology to fundamental climate data records [5]. Recently, there has been approval of funding to design, build and launch a satellite that puts NMI traceability (and a cryogenic radiometer) into orbit, implemented through the ESA Earth Watch Programme. The TRUTHS satellite [6] will provide a climate benchmark through highly accurate observations of incoming and reflected solar radiation, and will serve as an inflight calibrator, able to transfer its SI-traceability to other sensors in orbit. The MetEOC projects will also provide SI-traceability to the ESA infrared satellite mission FORUM.

## SURVEY RESULTS

At the time of writing the abstract, the survey has not been completed (completion due May 2020). However, preliminary results show that the satellite Earth observation community recognises the value that metrology plays in ensuring long term stability and interoperability of satellite sensor data, but that there are many barriers to the implementation of metrological methods. At present there is no clear framework for systematic provision of metrological traceability prelaunch or in postlaunch calibration through vicarious references. There is a desire for metrologists to support the development of calibration methods and uncertainty analysis determination for a wider variety of sensors – both passive radiometric sensors and active (radar) sensors.

There is also a common request for improved training material and improved coordination of vocabulary.

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