Metrology for Earth Observation and Climate Newsletter

www.meteoc.org November 2016

What is MetEOC-2?

MetEOC-2 (Metrology for Earth Observation and Climate) is a joint research project (JRP) that brings together a coordinated network of National Metrology Institutes (NMIs) across Europe, in collaboration with other international experts, to progress towards establishing a European centre of excellence to provide metrology support to aid the improvement and assessment of Earth Observation (EO) datasets with a particular focus on climate applications. This is the second of a continuing series of projects and builds on previous expertise developed nationally. Within this current JRP, four themes of work (outlined below) address the development of the tools, methods, and infrastructure required to enable trustable confidence levels to be assigned to data derived from Earth Observation satellites that is used for climate change monitoring.

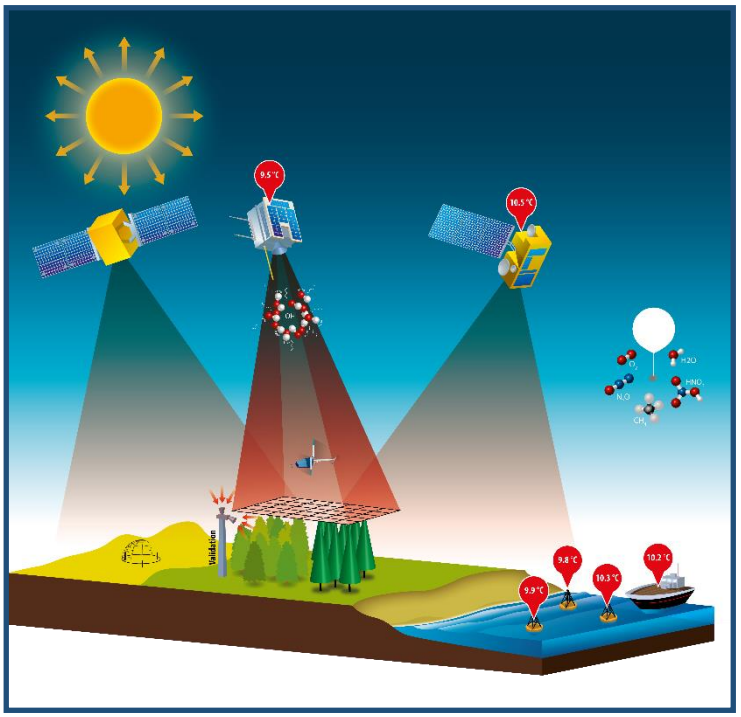
The European Metrology Research Programme (EMRP) MetEOC-2 project is jointly funded by the EMRP participating countries within the European Association of National Metrology Institutes (EURAMET) and the European Union.

Project start: *September 2014*
Project end: *August 2017*
For more information: *www.meteoc.org*

MetEOC-2 Activities

Remote sensing of the Earth from space is the major means of obtaining the global data needed to underpin climate change research. Climate Data Records (CDRs) are the long term time-series of Essential Climate Variables (ECVs). Approximately 50 ECVs have been identified internationally as the key geophysical parameters necessary to systematically monitor and understand the drivers and impact of climate change. The CDRs of ECVs are the cornerstone of long term monitoring of climate, derived from a combination of data from multiple sources and sensors. ECVs such as, incoming radiation from the Sun, Sea Surface Temperature (SST) or the fraction of Photosynthetically Active Radiation absorbed by vegetation (fAPAR), are monitored using space assets in order to characterise the Earth system and its response to natural or human-induced changes.

The effective production of CDRs relies on robust knowledge of the data sources and their uncertainties. Despite progress in recent years, trustable, SI-traceable evidence for the quality of the retrieved EO datasets is lacking. In most cases, detection of small changes are required to distinguish climate trends from data noise. Thus climate science relies on measurements with uncertainty levels currently only realisable in NMI's.

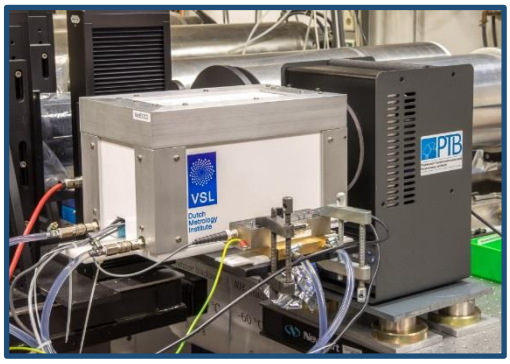


The four themes of work within MetEOC-2:

1) Underpinning requirements for Earth Observation **sensor traceability**:
   - Develop Level 1 satellite optical products to be consistent with each other and, in the long term, the goal is to make them SI-traceable;
   - Develop mathematical tools for propagating uncertainty and assess traceability through data processing chains.
2) Improve traceability to determine and reduce the measurement uncertainties of **atmospheric ECVs**.
3) Establishing traceability for satellite-derived **biophysical ECVs** through modelling, reference measurements and test-site characterisation.
4) SI-traceability and uncertainty analysis of **radiation balance ECVs**, and the creation of reliable multi-decadal CDRs.

1st Milestone towards an end-to-end traceability chain for the NDMC

The Network for Detection of Mesospheric Change (NDMC) monitors the long term temperature trends in the upper atmosphere to answer a key question: Is the climate of the mesopause region (80 – 100km) changing? If so, how and why?



The planned traceability chain will enable an identification of trends with 1 K / decade. An important part of it, the Near Infrared Radiation Transfer Radiometer (NIRTR), was designed and built as part of the MetEOC-2 project (see picture). This non-imaging sensitive radiometer is adapted to the detection geometry of the NDMC instruments and is able to detect very low light levels at a wavelength of 1.5 µm. This has been shown to fulfil the requirements in term of signal-to-noise ratio, stray light suppression and stability.

For more information about the NDMC, see here

Instruments to support traceability and autonomous test-sites such as the CEOS WGCV RadCalNet initiative

Spatially uniform, bright and ideally stable land based targets typified by deserts are used to provide post-launch radiometric calibration/validation of Earth viewing satellite optical imagers. CEOS is now prototyping a network of sites called RadCalNet which have been instrumented with autonomous sensors to monitor surface reflectance change and associated atmospheric properties to allow satellites to compare their measurements against. NPL, in part supported by MetEOC 2, is helping to create a test site in Gobabeb, Namibia as a European contribution to RadCalNet in partnership with CNES and ESA. NPL is also helping to evaluate traceability and uncertainty of all the individual member test sites and their consistency with each other.

The Istituto Nazionale di Ricerca Metrologica (INRIM), Italy has designed, in collaboration with NPL, and built an autonomous sensor web composed of 5 self-calibrating radiometers with bandwidth selective LED detectors and an associated 'self-calibration' mechanism for potential deployment at existing or future test sites to help monitor stability of spatial uniformity of large area test sites.

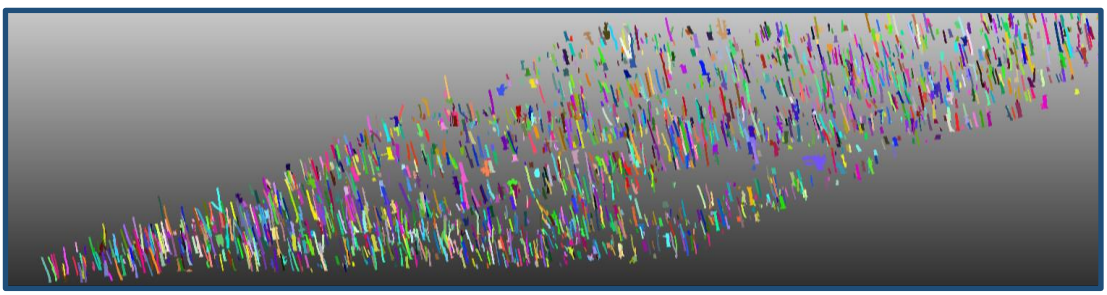
The Czech Metrology Institute (CMI) has additionally designed and built a hand held 'reference spectrometer' called MuSTR which, after calibration at NPL, will be used to compare measurements and ensure consistency and SI traceability between the current and future test sites of the CEOS WGCV RadCalNet which is now in beta test mode before becoming fully operational in 2017.

3,500 trees mapped in Oxford test-site to support vegetation monitoring

Covering about 30% of global land area, forests play a significant role in the delivery of ecosystem services including climate regulation, carbon storage, biodiversity, prevention of soil erosion and flood mitigation. Work within MetEOC2 aims to provide traceability for terrestrial and satellite measurements of key biophysical climate variables, including forest cover, to provide quality-assured data which decision-makers can act on with confidence.

Terrestrial Laser Scanner (bottom right picture) data has been used by NPL in collaboration with UCL to extract 3500 tree stems >10cm DBH in the 6ha field site at Wytham Woods, Oxford. A team at the University of Oxford have linked the stem map to the Smithsonian field inventory data for all 3500 trees (location, DBH, height, species and condition). The stems (pictured bottom right) will be modelled into trees producing a highly realistic virtual 3D representation of Wytham woods that can be used for vegetation monitoring and satellite product validation activities.

More information here



EURAMET European Association of National Metrology Institutes
EMRP European Metrology Research Programme Programme of EURAMET
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Novel SI traceable in-flight calibration system for the TRUTHS climate satellite ready for testing

A set of laser diode sources have been chosen and tested at LNE-Cnam, France and CSIC, Spain, to serve as representative sources for the vacuum breadboard testing of the on-board calibration system of the TRUTHS climate imager. TRUTHS is a proposed satellite mission, led by NPL that will put an 'NMI into space', providing measurements of incoming solar irradiance and Earth reflected spectral radiance at 10 times higher accuracy than existing sensors, enabling the establishment of a climate benchmark for decadal climate model testing and a means to upgrade the calibration of other sensors from orbit.

The laser diode sources (terrestrial demo pictured), cover the spectral range from 355 nm to 2300 nm at discrete wavelengths, and in space will allow an optical hyperspectral imager to be calibrated against a primary reference standard, a Cryogenic Solar Absolute Radiometer (CSAR) with an uncertainty of <0.3%. Laser radiation is used to illuminate a lambertian diffuser plate whose radiance can be measured by a transfer detector, itself, calibrated using the same laser radiation (before being reflected by the diffuser). The power of the laser beam having been previously calibrated in-flight against the CSAR.

The suite of lasers are connected through a conjoiner that enables only one laser to be used at a time and also distribute the radiation between the different components of the calibration system. The performance of the flight representative breadboard of the full calibration system is currently under test in an NPL vacuum chamber in collaboration with Airbus Defence and Space (UK) Ltd as part of a UKSA funded program to de-risk the TRUTHS mission and demonstrate its readiness for implementation. TRUTHS is currently under review by ESA as part of its Earth Explorer 9 competition.

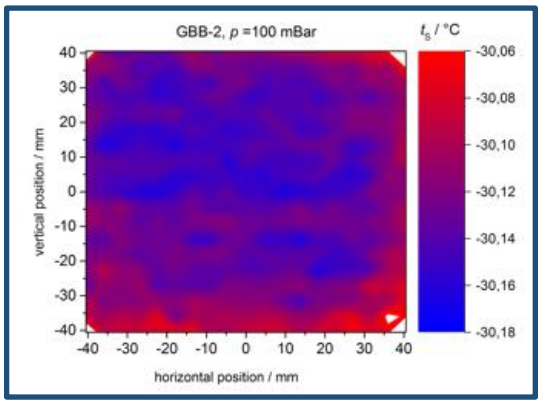
Find out more about the TRUTHS satellite mission here

GLORIA blackbodies show superior uniformity

The **G**imballed **L**imb **O**bserver for **R**adiance **I**maging of the **A**tmosphere (GLORIA) is a newly developed unique atmospheric remote sensing instrument that bridges the gap from scanning to imaging in the infrared spectral domain.

Within the MetEOC2 project, enhanced reference blackbodies for the GLORIA hyperspectral imager were characterized and calibrated under stratospheric conditions and show a remarkably good temperature uniformity. The achieved non-uniformity at -30 °C was 33 mK which is an improvement of about 10 times and now meets the requirement of the GLORIA mission.

For more information about GLORIA, see here



Showing science to the general public: recent exhibitions and events

MetEOC-2 strives to inform the general public about climate change and the importance of metrology. This summer, NPL exhibited an Earth observation exhibit at New Scientist Live, a major exhibition of science held in London's ExCeL Centre (see left photo).

NPL's stand featured a miniaturised 3D-printed satellite model that contains a spectrometer. Visitors could move the spectrometer between a range of materials that mimicked different types of landscapes, such as vegetation, bare soil, sand and inorganic material (plastic grass). By linking live measurements to a simple plot on a TV, visitors could see how each sample varied in its spectral response. Scaling it up to the real-world, this information is useful for monitoring environmental change such as urbanisation, desertification and deforestation over time.

Meanwhile, Scientists at PTB demonstrated at two public outreach events (right photo). The fascinating world of infrared thermography was illustrated by the exhibit 'Can you see temperatures?' It explained the long way from a thermographic image of gas escaping a spray bottle to traceability for remote sensing of the atmosphere to about 300 guests visiting the booth at both events.

More information about the NPL exhibit is here

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Get involved in MetEOC-2

Uncertainty for Earth Observation Training Courses

MetEOC-2 has delivered a training course on uncertainty analysis for earth observation measurements, with particular emphasis on the calibration and characterisation of remote sensing radiometric instruments: both pre-flight satellite instruments and for ground validation instrumentation. It was run in July 2014 and February 2015.

The course text book can be freely downloaded *here*

The course presentations are available for download *here*:

1. Introduction
2. Political Framework
3. Law of Propagation of Uncertainties
4. Steps to a Budget
5. The Measurement Equation
6. Validating Uncertainties
7. Example - The APEX imager
8. Pre-flight Calibration

Competition - Inspiring the next generation of climate scientists

Would you like to become a published author? Do you have an interest in climate change? Have your voice heard by writing a short article and you could be published in The Ecologist magazine.

The National Physical Laboratory (NPL) is welcoming 16 to 25 year olds to write about how you think climate change will impact your life and what you think should be done to combat it. This is a perfect opportunity for aspiring scientists or writers to have their voice heard by thousands of readers interested in environmental issues.

The winning article will be published under your name in the leading environmental magazine, The Ecologist, and on its website. Included with the article will be a short biography and links to your relevant blogs or social media, giving you the perfect opportunity to get recognised by thousands of readers in the industry.

For more information, click here

We are also running a survey to map how attitudes to climate change vary across demographics. Take the survey here

Funded partners:

Unfunded partners:

For more information visit: *www.meteoc.org*

Contact:

Matt Whitney
National Physical Laboratory, Hampton Road, Teddington, Middlesex, TW11 0LW, UK
T: +44 (0)20 8943 8746
E: outreach@meteoc.org

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