Title: Traceable Radiometry for Remote Measurement of Climate Parameters

Abstract

Remote sensing of the Earth from space, utilising the full electromagnetic spectrum, is the only means of obtaining the global data needed to underpin climate change research and provide the knowledge to enable policy makers to adopt appropriate mitigation and adaptation strategies. In some cases changes of a few tenths of a percent per decade are required relying on measurands currently only realisable in laboratories of NMIs at similar levels of uncertainty. A "virtual" centre for EO traceability is needed to lead international efforts to develop calibration and validation standards and techniques, pre & post launch, for land, ocean & atmosphere to extend the capabilities of the SI to meet the needs of climate measurement.

Conformity with the Work Programme

This Call for JRPs conforms to the EMRP 2008, section on "*Grand Challenges"* related to *Environment* on page 24.

Keywords

Remote-sensing, Climate, Calibration, Validation, Radiometry, Satellites, Traceability, Earth Observation, Test-site, Optical

Background to the Metrological Challenges

Remote monitoring of the Earth system is crucial to enable better stewardship of the environment and most importantly to provide the necessary information to aid policy makers in the development of appropriate mitigation strategies to respond to climate change. This must be tackled through global observations which can only be made from space. Although such observations have and are being made, the harsh and challenging environment of space limits the uncertainty currently attainable. In the specific case of climate this is often a factor 10 larger than required by the community [1,2]. This drive for reduced uncertainty together with the need to synergistically combine data from a variety of sources (space and in-situ) has placed "traceability" and its reliable quantification at the top of the agenda of space agencies and wider GEO community [3,4,5,6]. In the case of satellites, improvements are needed throughout all stages of data production: pre-flight and post-launch calibration and validation and all the intermediate processing steps. The technical scope spans the full electro-magnetic spectrum and entails the evolution of laboratory-based metrology into field (and space) situations whilst maintaining and in some cases improving the uncertainty available from nominally primary standards and facilities.

There are many examples demonstrating inconsistencies and biases between in-flight sensors and where normalisation has been used to enable long-term records to be established. The most commonly used example is that of Total Solar Irradiance [7], others exist e.g. the NOAA series of satellites show an apparent "greening" of the deserts as the sensors drift with time, for air temperature - observations between sondes and microwave sounders have led to significant debate on the nature of global warming. The work-plans of the international coordinating bodies on Earth Observation Satellites [5,6] are focussed on the development of improved traceability strategies and comparisons to evaluate biases. Such activities are particularly prevalent in the optical domain, where efforts are underway to establish networks of SI traceable post-launch reference standards in preparation to underpin the needs of virtual constellations of sensors. Significant research is needed to ensure that these can maintain SI traceablity in the long-term in a cost effective manner.

The long-term goal for the metrology community is to establish the capability to make SI traceable measurements from space at uncertainties commensurate with those obtained in the laboratory through direct use of a primary standard, in effect transferring an "NMI into orbit". This challenge has been placed on the community to meet the exacting needs of climate and in particular to constrain and improve the accuracy of forecast models to decadal rather than multi-decadal timescales. The US has initiated studies on a mission called CLARREO [8] to address this topic, which in part follows on from a European Mission concept called TRUTHS [9], the latter is currently the subject of a proposal to ESA and irrespective of this decision should be viewed as part of the long term vision for Europe.

The CGPM has highlighted the importance of this topic in resolution 11 of its 23rd meeting in 2007 and it is also was a key driver of the joint BIPM/WMO workshop (March 2010) [10].

Scientific and Technological 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 JRP-protocol.

The following objectives exceed the budgetary scope and time frame of a typical JRP. The proposers shall prioritise accordingly, considering opportunities in later EMRP calls. The proposers shall describe how, and on the basis of what stakeholder input, they prioritise the work.

1. A review of the metrological requirements of European Earth Observation missions during the period 2010 - 2025
2. The development of methods, tools and standards for traceability of air- and space-borne spectroradiometers in the spectral range from UV to microwave, with emphasis on standards specifically tailored for on-ground and/or on-board calibration
3. The characterisation and subsequent development of natural and artificial on-ground calibration reference sites for in-flight calibration of imaging-based spectroradiometers
4. prototype techniques to establish SI primary traceability in orbit with uncertainties comparable to those achieved at the NMIs and now demanded by the climate community.

These objectives need to be achieved in close interaction with the climate remote sensing community.

Proposers shall give priority to work that meets documented stakeholder needs and may include measures to facilitate the development of European standards and Directives.

Proposers should establish the current state of the art, and explain how their proposed project goes beyond this.

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the "end user" community. This may be through the inclusion of unfunded JRP partners or collaborators, or by including links to industrial/policy advisory committees, standards committees or other bodies. Evidence of support from the "end user" community (eg letters of support) is encouraged.

Where a European Directive is referenced in the proposal, the relevant paragraphs of the Directive identifying the need for the project should be quoted and referenced. It is not sufficient to quote the entire Directive per se as the rationale for the metrology need. Proposals must also clearly link the identified need in the Directive with the expected outputs from the project.

You should also detail other Impacts of your proposed JRP as detailed in the document "Guidance for writing a JRP"

You should detail how your JRP results are going to:

- feed into the development of urgent standards through appropriate standards bodies
- transfer knowledge to the Earth observation community.

You should also detail how your approach to realising the objectives will further the aim of the EMRP to develop a coherent approach at the European level in the field of metrology. 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 Member States and countries associated with the Seventh Framework Programme whose metrology programmes are at an early stage of development to be increased
- outside researchers & research organisations other than NMIs and DIs to be involved in the work

Time-scale

The project should be of 3 years duration.

Additional information

The references were provided by PRT submitters; proposers should therefore establish the relevance of any references.

1. http://www.orbit.nesdis.noaa.gov/star/documents/ASIC3-071218-webversfinal.pdf.
2. **http://gcos**.wmo.int
3. http://earthobservations.org/geoss_cl.shtml
4. http://www.wmo.int/pages/index_en.html
5. http://gsics.wmo.int/
6. http://ceos.org/ and http://wgcv.ceos.org/
7. http://www.pmodwrc.ch/pmod.php?topic=tsi/composite/SolarConstant
8. http://nasascience.nasa.gov/missions/clarreo
9. http://www.npl.co.uk/optical-radiation-photonics/environment-climate-change/research/truths
10. http://www.bipm.org/en/CGPM/db/23/11/