Title: Traceability for surface spectral solar ultraviolet radiation

Abstract

Current measurements of spectral solar UV irradiance have uncertainties of around 5 % at or near the earth's surface. Uncertainties of 1 % to 2 % are required to unambiguously detect and quantify future changes in the solar UV from issues such as total column ozone, aerosols and variation in cloud cover. The spectra in the range 290 to 400 nm need to be obtained within less than 10 seconds with a repeat rate of 1 minute or less to accurately sample the surface UV under rapidly varying atmospheric conditions.

Conformity with the Work Programme

This Call for JRPs conforms to the EMRP 2008, section on "*Grand Challenges"* related to *Environment* on pages 8 and 24 and under *Photometry and Radiometry* on page 33-34.

Keywords

Climate change, Solar Ultraviolet Radiation, Aerosols, Spectroradiometry, Radiometry, Calibration

Background to the Metrological Challenges

Solar UV radiation causes photolysis in the atmosphere and affects the environment in many ways, therefore monitoring solar UV is highly important. The uncertainties of current measurements of spectral solar UV irradiance (around 5 % with typical discrepancies between instruments in the order of 10 - 15 % at the earths surface [4]), are too high to allow determination of long-term changes.

Uncertainties of 1 % to 2 % will enable unambiguously detection of solar UV; by quantifying the changes it may be possible to attribute the cause e.g. total column ozone, aerosols and variation in cloud cover. To achieve the target uncertainty solar UV irradiance spectra must be captured between 290 nm and 400 nm. However in order to monitor changes under rapidly varying atmospheric conditions, the data should be captured in under 10 seconds, with a repeat rate of 1 minute or less.

Insufficient global coverage: The current knowledge on spectral solar UV radiation is limited to very few places worldwide where spectral solar UV monitoring instruments are located. The instruments are large and bulky scanning spectroradiometers which are not or only barely moveable. Large-scale deployment of such instruments is limited by the required man-power and infrastructure to guarantee an adequate level of uncertainty. UV monitoring at additional locations is required to better understand the relationship between UV radiation and its influencing factors in view of improving meteorological UV forecasting models. More accurate UV radiation measurements with a denser spatial coverage will help to validate radiative transfer models and satellite-derived UV estimates.

Insufficient sampling rates: Current generation scanning instruments require several minutes to capture a solar spectrum. This limits the interpretation during rapidly fast varying atmospheric conditions. The slow scanning speed does not allow fast sampling rates, limiting the number of measurements available per day. Current national UV monitoring programs also use broadband filter radiometers that can make measurements with shorter intervals, but these instruments show physical degradation that renders them unsuitable for long-term monitoring. Furthermore they cannot attribute causes of the observed changes, since they lack any spectral data. Spectrographs potentially offer an alternative, but the results from current generation devices have large uncertainties caused by the significant stray light contamination, due to instrument design and compounded by the large dynamic range of the solar UV radiation between 300 and 330 nm.

Insufficient modelling of the radiance field: Global UV irradiance measurements need to capture accurately diffuse and direct solar irradiance with a suitable entrance optic (diffuser). This requires improved characterisation technologies for accurate determinations of the angular response and the reference plane of the entrance optics. Current state-of-the-art diffusers introduce systematic errors in the order of 2 - 3 % in the global irradiance due to deviations of the angular response from the nominal cosine response (cosine error). These deviations cannot be fully corrected because a complete description of the incoming solar radiance field is required, and this is not available. Model calculations of the radiance field are not precise enough because of the missing information of the influencing parameters (e.g. optical aerosol scattering and absorption characteristics, inhomogeneous cloud cover, effective surface reflectivity, vertical distribution of atmospheric components at high solar zenith angle) required for the radiative transfer calculations.

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 overall aim of the JRP is to develop traceable measurement capabilities for spectral solar UV irradiance (at or near the surface) to enable the unambiguous determination of long-term changes in solar UV radiation. The JRP should provide validated and reliable measurements/methods with traceability wherever it is practicable to do so.

The specific objectives are:

1. Development of methods for measurements of spectral solar UV direct irradiance, diffuse irradiance, global irradiance from 290 nm to 400 nm with an uncertainty of 1 % to 2 %.
2. Development of tools and methods for fast measurement of solar UV irradiance spectra (290 nm to 400 nm) to enable data capture under rapidly varying atmospheric conditions with sample time < 10 seconds and repeat rate < 1 min
3. Wavelength uncertainty and stability significantly better than ± 0.05 nm over the whole spectral range
4. Development and/or characterization of novel experimental approaches for solar UV measurement (e.g. CCD and diode-array based spectrographs, solar UV Fourier transform spectrometers, fast-scanning MEMS spectrometers, improved entrance optics, quality of optical components) as needed for the objectives 1 to 3.

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 (e.g. 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; including EN 14255 “Measurement and assessment of personal exposures to incoherent optical radiation” - Part 3: UV-Radiation emitted by the sun
- transfer knowledge to the Solar UV measurement sector, Global monitoring / climate change sector, meteorology / weather forecasting sector.

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] World Meteorological Organisation, Scientific Assessment of ozone depletion: 2006, chapter 7, " Surface Ultraviolet Radiation: Past, Present, and Future", ftp://ftp.nilu.no/pub/NILU/geir/assessment-2006/08%20Chapter%207.pdf

[2] Ultraviolet Spectroradiometry in the Network for the Detection of Atmospheric Composition Change (NDACC), http://www.ndsc.ncep.noaa.gov/organize/protocols/appendix6/

[3] G. Bernhard and G. Seckmeyer, “Uncertainty of measurements of spectral solar UV irradiance,” J. Geophys. Res. 104, 14,321–14,345 (1999).

[4] http://www.pmodwrc.ch/euvc/euvc.php?topic=qasume_audit