NPL activities in Earth Observation 2003 report to CEOS WGCV 21

Primary scales

In May 2003 NPL changed its disseminated scale of spectral irradiance and radiance to a new detector based realisation directly linked to it primary standard cryogenic radiometer Fig 1. This new scale shown relative to our previous scale in Fig.2 results in a significant reduction in uncertainty and a small change in the UV region of the spectrum.

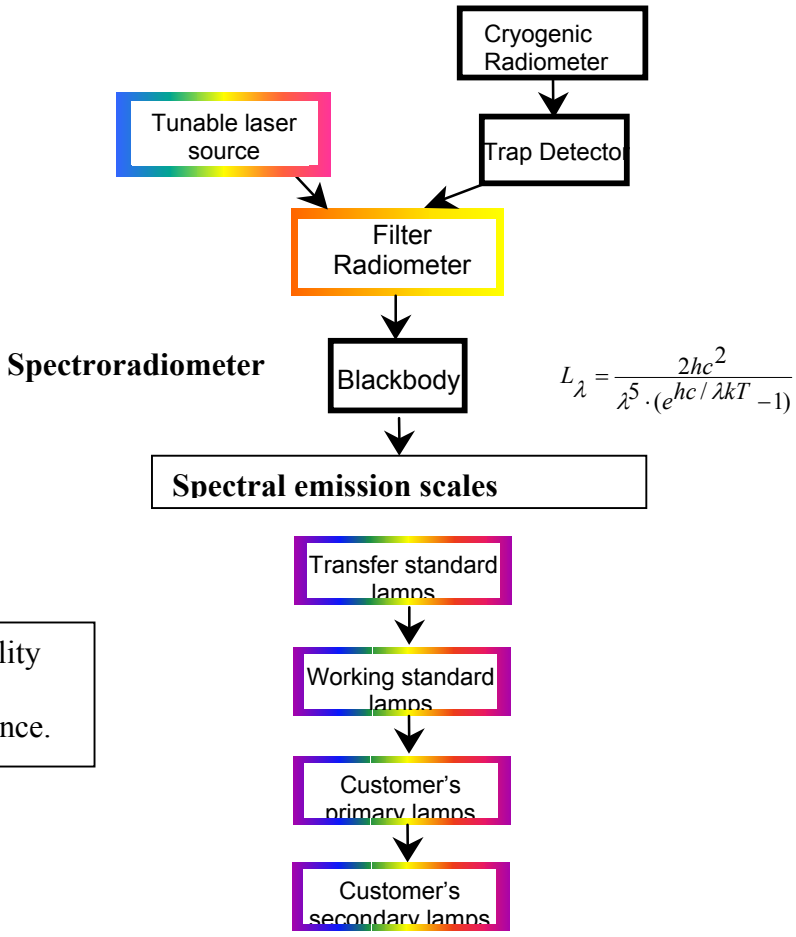


Figure 1: Traceability chain for spectral irradiance and radiance.

This scale is currently being compared as part of an international key comparison, for which NPL is the pilot. This key comparison is nearing completion and the results should be available in the spring of 2004.

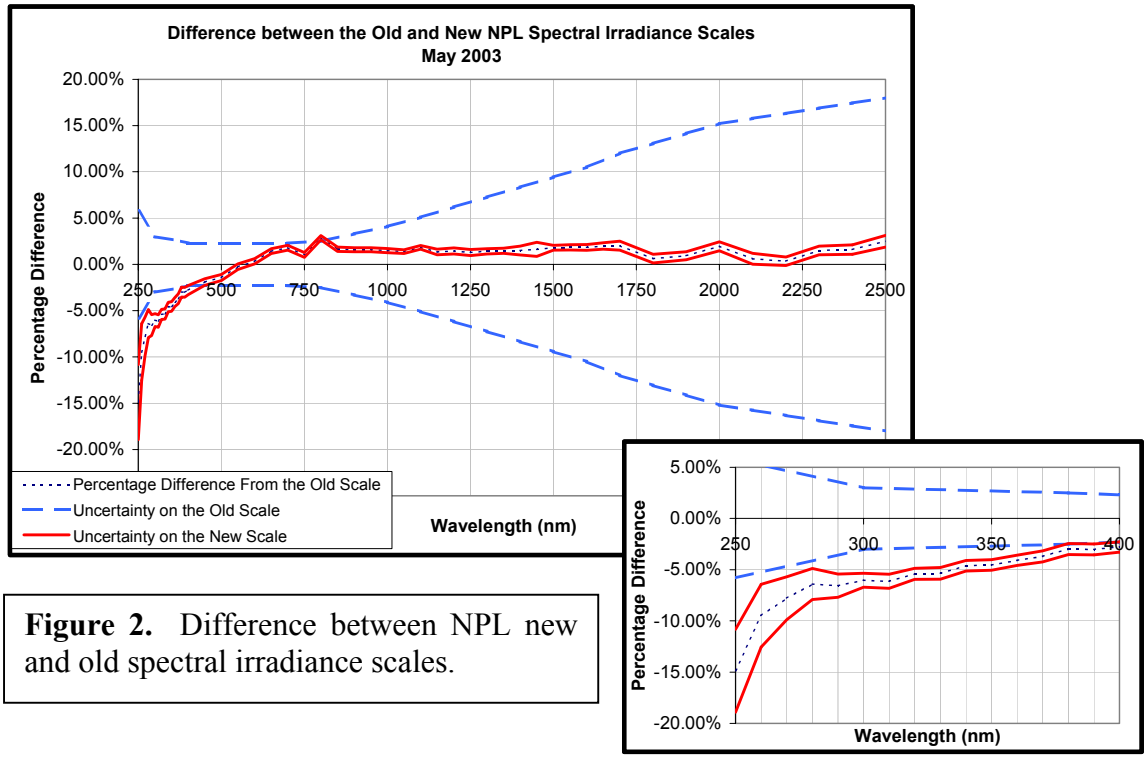


Figure 2. Difference between NPL new and old spectral irradiance scales.

Calibration activities:

GERB

NPL has been involved in two satellite instrument calibration since February 2003. The first a spectral radiance calibration of GERB (Geostationary Earth Radiation Budget) GERB 1 is operational and in flight on Meteosat Second Generation (MSG). The instrument only measures spatially resolved Earth radiance in two channels, Solar reflected and thermal emitted, and was calibrated at imperial college London using black bodies and Lamp illuminated spectral radiance standards (TSARS) from NPL. The detector is a spectrally non-selective (black) thermopile array which was also calibrated for spectral responsivity at NPL. However, in reviewing the data there are some concerns about how spectrally flat the detector is in the visible region of the spectrum and existing measured data is inconclusive.

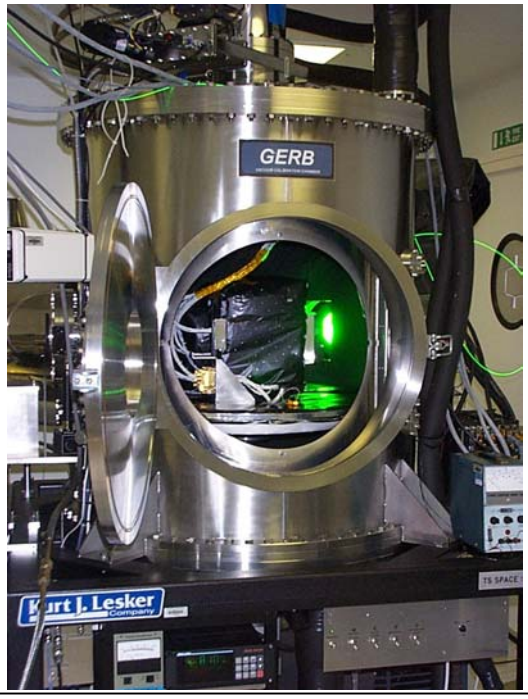


Figure 3: GERB inside vacuum tank being irradiated by spectral radiance from laser illuminated sphere.

A calibration check has thus recently been carried out on GERB 2 due to fly on MSG2. This involved a few high accuracy monochromatic spectral radiance measurements across the visible region of the spectrum using a monochromatic spectral radiance source based on a Laser illuminated integrating sphere. The measurements were

completed October 7 and results are as yet unknown. Figure 3 shows GERB in the vacuum tank being irradiated by the laser radiance.

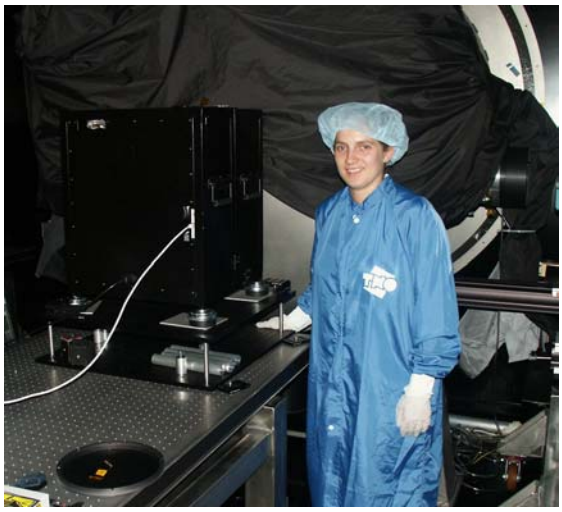


Figure 4: TSARS at TNO calibrating GOME 2.

GOME2

GOME2 built by Galileo Avionica is currently under calibration at TNO in Holland. As an opportunity to demonstrate the performance of the NPL TSARS (Transfer Standard Absolute Radiance Source) NPL established a collaboration to perform a calibration of GOME at TNO as part of a comparison activity which also included NASA. The comparison not only involved the TSARS radiance source but also an irradiance standard and was completed during the last week of September 2003. Figure 4 shows the TSARS at the TNO facility with the NPL calibration scientist. The results of the comparison are to be confirmed but appear in very close agreement NPL and TNO (which has traceability for these measurements from NIST). Unfortunately for these measurements the NPL TSARS that was available was only appropriate for measurements above 400 nm. However the uncertainty of the TSARS in this region was <0.5% as it was calibrated directly against the primary standard black body see Fig 5.

World Radiometric Reference

The World Radiometric Reference (WRR) is maintained by the World Radiation Centre in Davos Switzerland on behalf of WMO. It consists of a group of radiometers designed to measure total solar irradiance. Some years ago NPL performed a calibration to link the WRR to SI units through a calibration against its cryogenic radiometer. Earlier this year a further calibration was carried out, this time with the aim of providing a calibration in Vacuum, to represent the operational conditions of such radiometers in space, and in particular to provide a calibration for one radiometer due to fly on the ISS in a few years time. The results of the calibration are still under review.

Instrument development

TIFRI

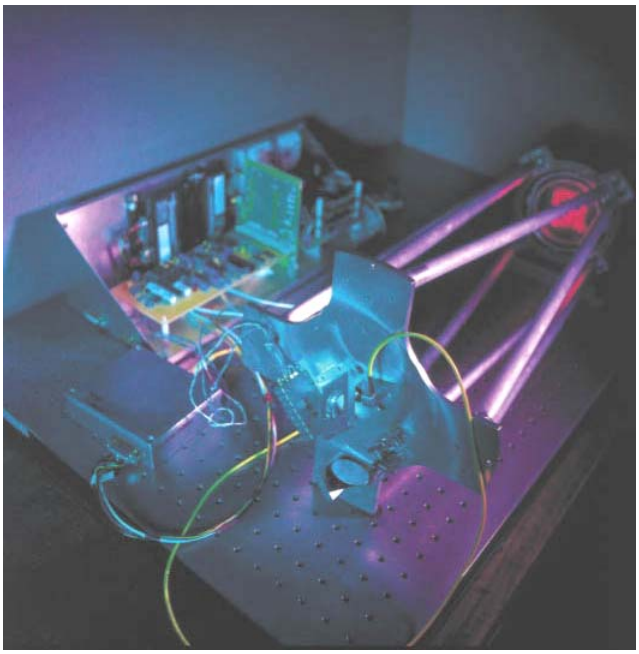
The new low mass/power high emissivity black body technology demonstration project is nearing completion. Novel reflective black body "mirror" has been constructed and is due for integration with the electronics in November. The demonstrator has taken the HIRDLS specification as a reference baseline for comparative purposes. The resultant black body with "flight electronics" would be < 0.5 mass of HIRDLS black body and with a similar reduction in power requirements yet also have an improved emissivity and flexibility.

Figure 5. Electroformed TIFRI mirror providing high emissivity.

Refs.

Ray.Carvell, Eric.Usadi, Nigel.Fox, Richard.Rusby, Stephen.Bruce "Innovative black body for on-board calibration" Proc SPIE 5234 to be published (2004)

TDLAS (Tuneable Diode Laser Absorption Spectrometer)



This balloon borne spectrometer is a 100 m path length absorption spectrometer for trace gas species measurements including water (<0.1 ppb). It is next due to fly in Brazil in February 2004. NPL is also involved in using its ground based portable FTIR in conjunction with the NDSC network for monitoring tropospheric greenhouse gases as part of an EU project called UFTIR.

Figure 6. TDLAS complete with flight electronics.

TSARS (Transfer Standard Absolute Radiance Source

These sources have continued to be developed with the aim of producing low cost high accuracy robust transfers standards of spectral radiance for the calibration of satellite or airborne spectrometers as well as ground based field spectrometers. The current basic design can be seen below and consists of lamp illuminated detector stabilised and monitored sources. At present exit ports have ranged from 50 to 100 mm. Uniformities of <0.1 % have been achieved across 80 mm diameter of the exit port. Radiometric uncertainty of <0.5 % is also achieved when calibrated directly against primary scales.

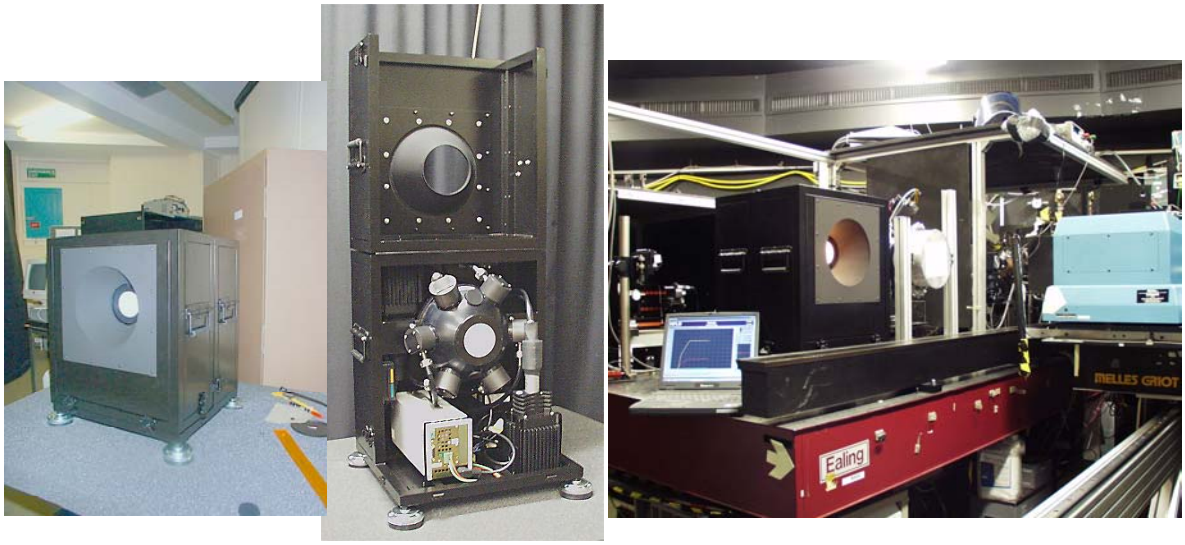


Figure 7. TSARS as used with GOME 2 and under calibration at NPL.

Research projects

NPL at present has relatively little access to research funds for Earth observation activities, however it is hopeful that in recognition of the growing importance of Earth observation and climate change studies the UK Department of Trade and Industry (responsible for the UK National Measurement System) will fund a small project at NPL from next April to help develop improved transfer standards, establishment of "best practise" and traceability for the EO community. At present NPL supports some small research efforts from its own resources:

GRASS (Gonio RAdiometric Spectrometer System)
NPL In collaboration with NERC are looking at the prospect of building a new multi-angle field spectrometer system. The planned GRASS would be highly portable and have 36 moveable cameras to describe a half-hemisphere and make spectral radiance or reflectance measurements of a 1 m^2 surface over the spectral range 380 to 2400 nm in < 5 minutes (depending on the spectrometer integration time). In addition to GRASS itself NPL will also develop appropriate protocols and transfer standards to allow it to make high accuracy traceable measurements.

Missing Sunlight
It is reasonably well known that atmospheric radiative transfer codes currently underestimate the absorption of incoming solar radiation by up to 20 % as compared to that observed by measurements. This anomaly, which has a heating effect equivalent to 10x that of the sum of all greenhouse gases makes it difficult to use these models to predict the effects of global warming. It is thought that the anomaly is probably due to a number of missing spectral absorption features of water in the NIR region which have not been identified catalogued and included in the atmosphere codes. NPL in conjunction with University of Reading is making high radiometric accuracy and spectral resolution measurements of atmospheric transmission using FTIR to correlate with models being developed by University of Reading.

Accuracy requirements for Land processes
Following peer reviews of TRUTHS proposal, which offered to provide high accuracy measurements of Earths spectral radiance, doubt was cast as to the benefit and need for any improvement in accuracy over current instrumentation. To better understand the issue NPL is sponsoring a PhD studentship under the direction of Professor Mike Barnsley and Peter North of University of Swansea to develop a model with full sensitivity analysis of the complete radiative transfer process, from surface to Satellite in order to determine the influence of accuracy, resolution (spatial, spectral) etc on a number of key climate change parameters (to be selected). A student has been selected and the project about to commence.

TRUTHS
NPL continues to promote the concept of TRUTHS, as a mission but also as an "in-flight" calibration concept which can be adopted by existing planned missions. In particular, recognising that the full accuracy capability of TRUTHS as yet is not considered necessary, a simpler system can be envisaged based on the same philosophy but lower accuracy but still < 1% at end of life for spectral radiance.

Refs.
N. Fox, J. Aiken, J. J. Barnett, X. Briottet, R. Carvell, C. Frohlich, S. B. Groom, O. Hagolle, J. D. Haigh, H. H. Kieffer, J. Lean, D. B. Pollock, T. Quinn, M.C.W. Sandford, M. Schaepman, K. P. Shine, W. K. Schmutz, P. M. Teillet, K. J. Thome, M. M. Verstraete, E. Zalewski "Traceable Radiometry Underpinning Terrestrial- and Helio- Studies" Proc SPIE 4881 p395-406 (2003)

Also same authors and title(not text) to be published in Advances in Space Research (2003)

Traceability

NPL continues to promote the concept of "traceability" and the virtues of some form of more formal QualityAssurance (QA). As part of this process it recently undertook an internet based survey of the perceptions and requirements of the EO community. The survey required a positive action by a respondent in response to an email describing the survey aims and objectives. The email being distributed by asking recipients to forward to colleagues they felt might be interested. This resulted in more than 7500 hits on the E-survey web page, which indicated the interest from the community in QA issues. Of those more than 150 completed the survey, and results will shortly be published on the NPL web site, www.npl.co.uk. However, as a brief summary more than 70 % of respondents (which included both data providers and users) wished for a more formal system of QA.

Nigel Fox of NPL has also recently been nominated as an "expert" representative of the international metrology community on to WMO CIMO expert team on "meteorological radiation and atmospheric composition measurements". This follows a recent MOU of collaboration between the two international organisations, i.e. the CIPM (Commite International Poids et Mesures) and WMO.

Nigel Fox

Nigel.Fox@npl.co.uk
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