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Prepared by ESA
Agenda Item: II/2

Radiometric calibration of the Medium Resolution Imaging Spectrometer (MERIS) on board ENVISAT

CGMS is informed by ESA about the status of the MERIS instrument calibration.

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1- INTRODUCTION

The Medium Resolution Imaging Spectrometer has been launched successfully onboard Envisat on March 1st 2002. Following the Commissioning Phase and during the first validation period MERIS data have been collected pointing towards a large exploitation potential, which goes beyond the original mission objectives, providing a unique space-borne European remote sensing capability for observing oceanic biology and marine water quality through observations of water colour and the secondary objectives directed to the understanding of atmospheric parameters associated with clouds, water vapour and aerosols in addition to land surface parameters, in particular vegetation processes.

MERIS has a high spectral and radiometric resolution and a dual spatial resolution, (1200m and 300m). The global mission (1200m) extends from +80 to -80 degree solar illumination angle and the regional mission (300m) is dedicated to coastal zone waters and land surfaces.

MERIS is a programmable, medium-spectral resolution, imaging spectrometer operating in the reflective solar spectral range (390 nm to 1040 nm). Its fifteen spectral bands are programmable by ground command both in width and in position by steps of 1.25nm.

The instrument scans the Earth's surface using the 'push broom' method where the spectral signal is dispersed to illuminate a 2-D detector array for each scan line. The spectral bands are constructed by first binning spectral samples directly on the array into micro-bands, and further grouping them into bands digitally before transmission to ground (See fig.1).

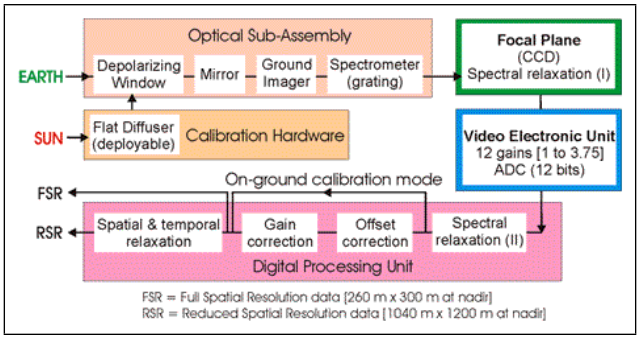

Fig. 1: Instrument concept

The instrument has a field of view of 68.5° and covers a swath width of 1150 km. The field of view is shared between five identical optical modules arranged in a fan shape configuration.

The earth is imaged at a spatial resolution of 300 m (at nadir). The reduced resolution data (1200 m) is computed by the on-board combination of four adjacent samples across track over four successive lines.

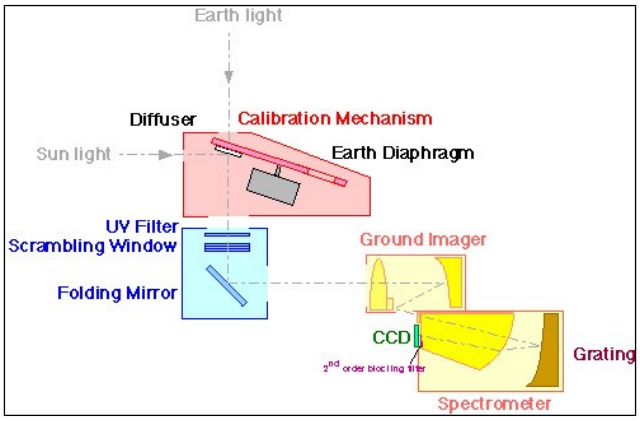

Fig. 2: Optical concept

2- CALIBRATION METHODOLOGY

Calibration of MERIS is performed at the orbital South Pole where diffuser plates are deployed by rotating a selection disk (See fig.2 and fig.3) into any of the five positions described below:

- Shutter: Will be used for dark calibration as well as for protecting the instrument from contaminants,
- Earth observation**:** A diaphragm is introduced in the field of view.
- Radiometric calibration**:** The sun illuminates a white diffuser plate inserted in the field of view
- Diffuser degradation monitoring**:** A normally shielded second white diffuser plate will be deployed every 3 months to monitor the degradation of the frequently used plate.
- Spectral calibration**:** An Erbium doped "Pink" diffuser will be deployed with MERIS configured to sample its absorption features.

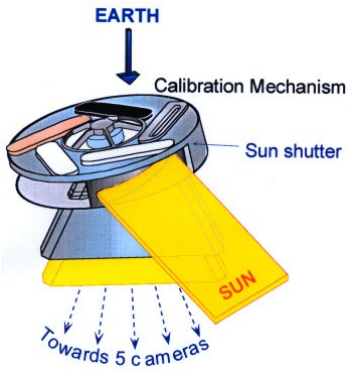

Fig.3: The calibration disk

3- RADIOMETRIC (SOLAR) CALIBRATION

The radiometric calibration of MERIS is performed with the use of the two on-board sun-lit radiometric (white) calibration diffuser plates described above. The diffuser plates, made of Spectralon™, provide a uniform illumination signal over the large field of view of the instrument.

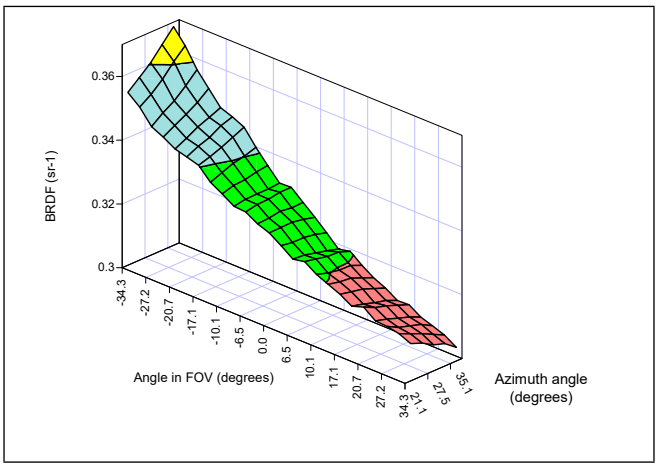

Fig. 4: Diffuser plate 1 BRDF at 410 nm for four illumination conditions corresponding to different times throughout the year.

The calibration plates have been extensively characterised prior to launch using a dedicated BDRF bench (See fig.3) to an absolute accuracy of better than 1%. This performance estimate was confirmed by a round-robin exercise performed with other laboratories (i.e. NIST, NASA, NPL).

The diffuser plates have been exposed to a post-production processing in order to reduce the degradation (browning) of its scattering characteristics to space environment. According to on-ground simulations, the degradation over the mission lifetime should be minimal**.** However, as a means of verification, MERIS will make use of both its on-board diffusers to monitor the degradation of the frequently used (every 15 days) diffuser-1 by comparing it with the results from diffuser-2 which is deployed only every 3 months. As a means of determining the degradation of the frequently used diffuser 1, measurements of diffuser 1 and diffuser 2 made for consecutive orbits are compared, hence with almost identical illumination conditions. On-ground characterization has shown that the two diffusers have almost identical BRDF. Comparing such measurements made at different times will allow one to determine the degradation of the frequently used diffuser with respect to the reference diffuser 2 through the mission lifetime.

It is worth mentioning that the extra terrestrial solar irradiance spectrum used in the MERIS calibration processing is given by Thuillier (2002).

4- FIRST IN FLIGHT CALIBRATION RESULTS

a) Diffuser Stability

On-ground characterization has shown that the two white diffusers have almost identical BRDF. The comparison of the in-flight calibration results using the two diffusers confirmed this nearly identical BRDF behaviour between diffusers, as expected. The observed residual differences lead to believe that a slight non-uniformity in BRDF across the extent of the diffuser plates is involved and that this pattern depends slightly on the scattering angle.

Comparing such measurement made at different times allows the degradation of the frequently used diffuser with respect to the reference diffuser to be determined.
The comparison using measurements from the 15th of July 2002 as a reference has revealed a slight degradation of less than 0.2 % of the frequently used diffuser 1 (browning effect) with respect to the reference diffuser (Fig. 5). Hereafter, the behaviour of all five MERIS cameras is shown and illustrate this degradation, in each band and at 3 different time intervals:

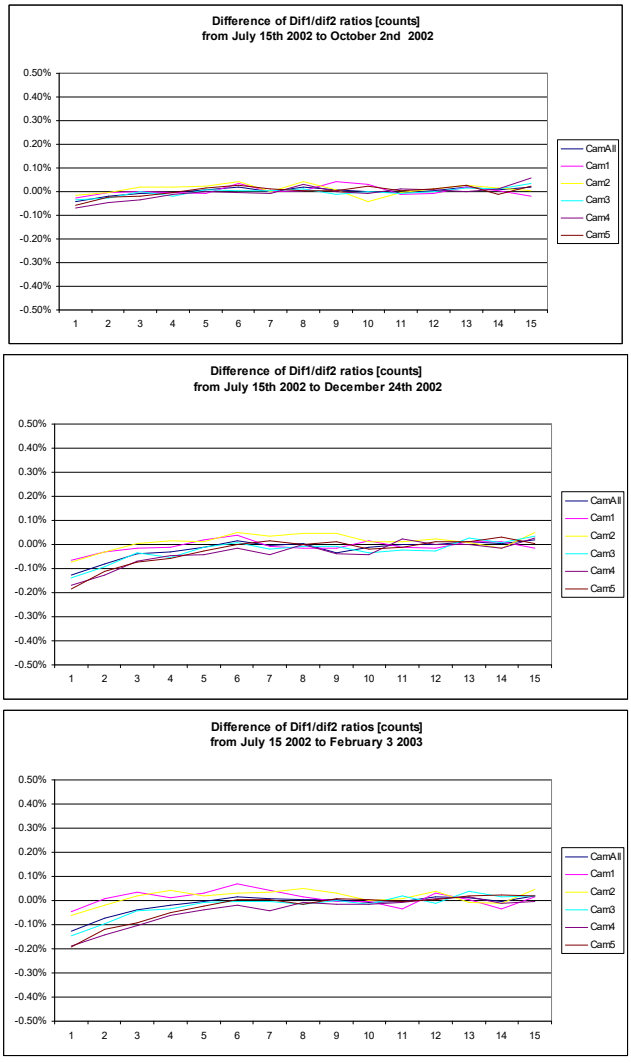

Fig. 5: Difference between the ratios of diffuser 1 / diffuser 2 [counts] for each MERIS band
(top: 15 July-3 October, middle:15 July – 24 December, bottom: 15 July – 2 February)

b) Radiometric calibration results

The first on-board calibration took place on orbit 308, March the 22nd. Raw counts are displayed in Fig. 6. Calibration data have been processed as soon as retrieved and corresponding auxiliary data files were ready the next day.

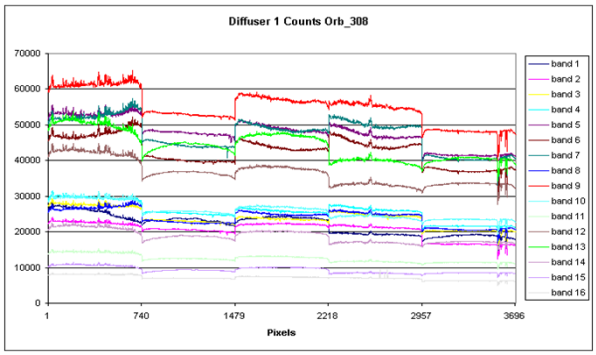

Fig. 6: First radiometric calibration results [counts]

5- CONCLUSION

The radiometric calibration of the instrument has yield results of very high accuracy with the Sun as reference and the using the Spectralon™ diffusers. The highly stable design of the instrument, coupled with the system described above, will guarantee users data of the highest quality for the complete lifetime of MERIS.

The CEOS working group Cal/Val (WGCV) subgroup on Infrared and Visible Optical System Calibration IVOS is under the chairmanship of ESA currently reviewing different solar radiometric calibration concepts and plans to hold a workshop in the 2005/2006 timeframe on the intercomparison of solar radiometric calibration of the large scale optical sensors.

References:

ENVISAT and MERIS: http://www.envisat.esa.int/
MERIS handbook: http://www.envisat.esa.int/dataproducts/meris/CNTR.htm

S. Delwart, L. Bourg, MERIS1st Year: Early Calibration Results, IGARSS proceeding 2003.

Thuillier, G., M. Hers, P. C. Simon, D. Labs, H. Mandel, D. Gillotay, and T. Foujols, The solar spectral irradiance from 200 to 2400 nm as measured by the SOLSPEC spectrometer from the ATLAS 1-2-3 and EURECA missions, Solar Physics, to be submitted, 2002