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GSICS PROGRESS REPORT FROM EUMETSAT

In response to CGMS action 37.30 and recommendations 37.08 and 37.09

This paper reports EUMETSAT's progress in the Global Space-based Inter-Calibration System (GSICS) since CGMS-37.

During this period the definition of GSICS Products has been refined and a formal Procedure for Product Acceptance developed. EUMETSAT now routinely generates *GSICS Corrections* for Near Real-Time and Re-Analysis applications for the infrared channels of Meteosat-7, -8 and -9. The latter have been formally accepted as *demonstration* products and are available from EUMETSAT's GSICS Data and Products Server. Liaison with beta testers is continuing to improve the products, their format and distribution towards *pre-operational* status early in 2011.

During this period, EUMETSAT has also taken over the chair of the GSICS Research Working Group and defined a strategy to develop similar products for the channels in the solar-band. GSICS is also working together with other groups to develop similar products for microwave imagers and sounders on Low Earth Orbit satellites.

EUMETSAT is also developing mechanisms to provide public access to pre-launch characterisation, performance monitoring and logs of operating changes for its instruments on Metop and Meteosat satellites.

GSICS Progress Report from EUMETSAT

1 INTRODUCTION

During the period since CGMS-37, EUMETSAT has taken over the chair of the GSICS Research Working Group, while continuing extensive activities within the Data Working Group and representation on the GSICS Executive Panel. This has ensured EUMETSAT's activities are well aligned with those of GSICS. This paper reviews the developments of GSICS with EUMETSAT involvement, including strategic guidance.

EUMETSAT has also provided technical support, hosting a series of web meetings, which are held on a roughly monthly basis. These provide a valuable forum for GSICS developers to exchange ideas, focussing on a single topic each month to guide the development and distribution of new products.

2 GSICS PRODUCT DEVELOPMENT

2.1 GSICS Product Definitions

During this period the definition of GSICS Products has been refined and a formal Procedure for Product Acceptance developed and implemented. This certifies products as meeting increasingly demanding requirements for documentation, support and compliance with standards as they progress from *demonstration* through *pre-operational* to *operational* distribution modes over a development cycle. This period can last 18 months after the first demonstration products are made available to users for beta testing.

Different types of products have been identified for different applications, including the *GSICS Correction*, which is a function that users can apply to convert the calibration of issued datasets to be consistent with those of a reference instrument. Two versions of the *GSICS Correction* have been developed: one for Near Real-Time applications and another for Re-Analysis applications, such as re-processing of archive data.

The *GSICS Bias Monitoring* represents another type of product, allowing users to visualise in near real-time the calibration performance of an instrument relative to that of a reference. *GSICS Reports* and *Guidelines* complete the family of GSICS products.

2.2 GEO-LEO Infrared Channels

EUMETSAT has developed both Near Real-Time and Re-Analysis versions of the *GSICS Correction* for the infrared channels of Meteosat imagers, using IASI as an inter-calibration reference. These are available now in *demonstration* mode for Meteosat-9 and will soon be for Meteosat-7 and -8. EUMETSAT aims to include these in future reprocessing of archive datasets as optional calibration coefficients.

EUMETSAT has produced several reports, which shall be submitted for acceptance as GSICS products, including some currently published on the EUMETSAT GSICS webpage: http://www.eumetsat.int/Home/Main/AboutEUMETSAT/InternationalRelations/CGMS/SP_1226312587804.

To support the GSICS Correction for the infrared channels of Meteosat using IASI as an inter-calibration reference, EUMETSAT has conducted a thorough uncertainty analysis of the error budget for the complete algorithm. This concluded that the overall uncertainty was previously under-estimated by using only the spatial variances of the collocated radiances to estimate the uncertainty. However, it also showed that the requirement for the geometric alignment of pairs of observations could be significantly relaxed without degrading the overall accuracy of results. This will lead to revised collocation algorithms. Documentation of such error budgets will be required before the product can be accepted as *operational* as it provides users with confidence that the results are reliable within the stated level of accuracy.

2.3 GEO-LEO Solar-band Channels

A strategy has been developed to extend GSICS to cover the channels of GEO imagers in the solar band (visible and near-infrared). However, unlike the thermal infrared, there is no obvious choice of a reference sensor for solar channels (until the launch of CLARREO/ TRUTHS). So GSICS proposes adopting MODIS as an interim reference as well as a transfer standard because it is a well-characterised instrument with on-board solar diffusers and has channels similar to many of the operational instruments we want to monitor. Although MODIS has been operated since 2000, other inter-calibration references will be needed for older instruments. (In some cases, it may be possible to use radiative transfer models as references.)

The strategy combines observations from pairs of instruments viewing various invariant targets with direct comparisons of coincident, collocated, ray-matched observations. The former involves fitting observations from both instruments to a Bidirectional Reflectance Function (BRF) model, allowing comparisons over a range of viewing and solar geometries. Candidate invariant targets include Deep Convective Clouds (DCCs), deserts, low cloud banks, the moon and the pristine sea surface. Although there are different limitations associated with each of these, requiring additional data, together they cover the full range of observed radiances. This strategy allows direct comparisons of observations to be combined with those of several invariant targets by regression, as illustrated in Figure 1. Other methods will be reserved for use as validation of the results. However, all invariant targets and MODIS ray-matching can provide independent estimates of instrument stability.

Initially these methods will be used to monitor the relative calibration of the solar channels of operational geostationary imagers. GSICS Corrections will be developed to produce consistent calibration of these channels during 2011 and then extended to include other instruments.

Table 1 – Extract from minutes of CGMS-37

CGMS Members involved in CEOS WG CV and GSICS	Recommendation 37.08 WGII	Recommendation 37.08: CEOS WG CV and GSICS to study and report on intercomparisons of vicarious calibrations and trends in visible channels obtained from various land sites.

This recommendation is being addressed as part of the above activity, which is expected to report results during 2011.

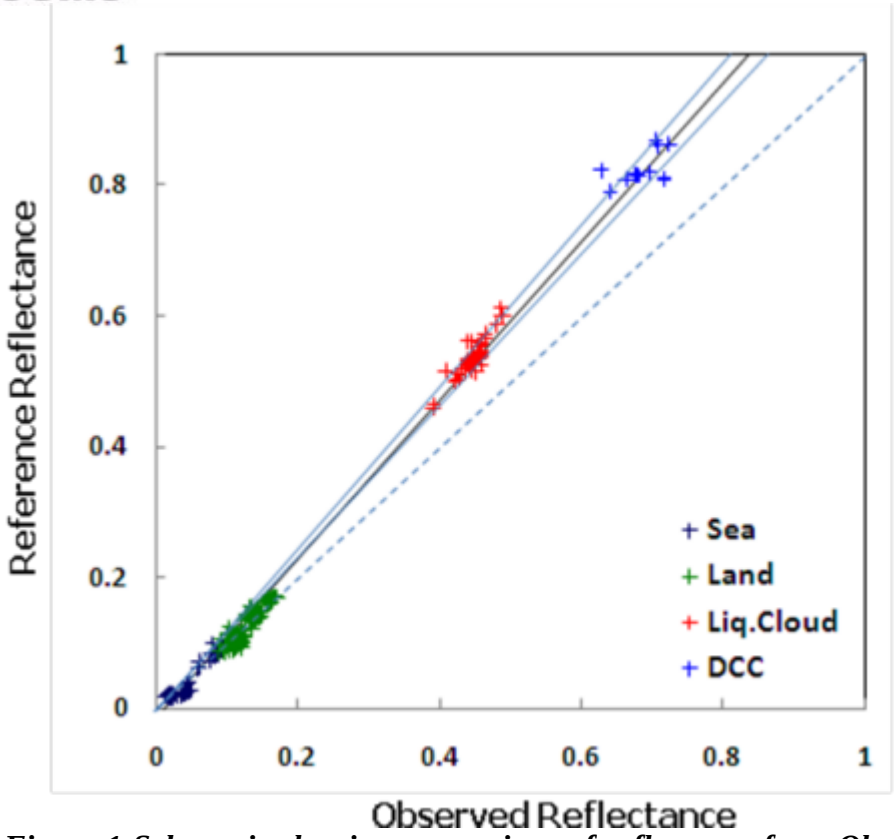

Figure 1 Schematic showing comparison of reflectance from Observations and Reference Instrument for 4 different invariant targets. Regression provides inter-calibration function.

2.4 LEO-LEO Microwave Instruments

GSICS is beginning to tackle the inter-calibration of pairs of instruments both operating on LEO satellites with the submission of NOAA's Patmos-X to the GSICS Procedure for Product Acceptance. At the same time, it is considering a general strategy for LEO-LEO inter-calibration, including microwave instruments.

Historically there has been a wealth of effort put into generating homogenised datasets from the constellations of both microwave imagers and sounders. However, there has not always been a clear distinction between the inter-calibration of level 1 radiances (which is the remit of GSICS) and level 2 products derived from them (e.g. layer-averaged temperatures, or Integrated Water Vapour).

The strategy adopted by GSICS is to identify existing activities in this area which could be certified as compliant with GSICS principles, while recognising that additional resources may be required to generate a GSICS-like product from an existing process. A *sub-group* of the GSICS Research Working Group is being formed of microwave specialists to represent these external activities, such as the X-Cal working group of the GPM project.

3 GSICS DATA ACCESS

3.1 EUMETSAT's GSICS Data And Products Server

EUMETSAT has already specified and set-up a dedicated server to enable the exchange of data between GSICS developers and supply of products to users. This is a THREDDS-based

system, where the data is stored in a logical directory structure divided between incoming level 1 satellite data, intermediate datasets of collocated radiances, and outgoing final products of GSICS Correction coefficients to allow users to inter-calibrate the monitored instruments.

Standing orders deliver level 1 radiances from the monitored and reference instruments from the EUMETSAT Data Centre daily. These datasets use a netCDF format specifically designed for GSICS inter-calibrations. They are subsets of the full instrument dataset, where the time and area have been pre-selected the target areas where collocations are likely. In addition to Meteosat and IASI data for EUMETSAT's inter-calibration products, IASI data is also supplied to JMA through the server. These directories on the server are operated as a rolling archive with a 30 day period.

The inter-calibration software suite runs daily, downloading the relevant level 1 datasets and processing them into coefficients of the GSICS Correction. These are then written back to the server for archiving and dissemination in another GSICS-specific netCDF format.

3.2 GSICS Bias Monitoring Web Page

EUMETSAT originally developed web pages showing plots of the relative bias between Meteosat and IASI as a helpful diagnostic. However, it became apparent that these by-products of the inter-calibration process are useful for instrument monitoring purposes. It has since been decided that *GSICS Bias Monitoring* plots are to become official GSICS products. While the prototype web pages are still being updated (at http://www.eumetsat.int/Home/Main/DataProducts/Calibration/Inter-calibration/GSCISMeteosatIRInter-calibration/), effort is underway in liaison with JMA to define a common web interface for all the GSICS Bias Monitoring products. This will allow easy comparison of the relative biases of different instruments.

3.3 Instrument Performance Monitoring

Table 2 – Extract from minutes of CGMS-37

CGMS Members involved in GSICS	WGII 37.30	Action 37.30: GSICS agencies to implement web-accessible instrument performance monitoring capabilities using the guidelines provided from the GSICS Coordination Center. Deadline: CGMS-38
CGMS Members involved in GSICS	Recommendation 37.09 WGII	Recommendation 37.09: GSICS to establish a publicly accessible database to provide full history of operational changes that affect instrument performance and calibration. It should include the date and time of each operating changes that affect the performance and calibration of each instrument, a short summary of the change, and a quantitative assessment of the severity of the impact on the instrument's calibration.

EUMETSAT is responding to Action 37.30 by upgrading their current prototype web page showing the bias of the infrared channels of the Meteosat imagers relative to IASI, as described above. This is expected to be ready in early 2011.

Action 37.30 and Recommendation 37.09 are also being addressed by a new project, *ARGUS*, which aims to provide access to the full logs of satellite and instrumental changes for Metop. ARGUS includes an instrument monitoring component called CHART, which will hold – among other things – a log of all instrument related events. CHART intends to enable assessment of those events. This project is planned for implementation in 2011; it initially

addresses the current EUMETSAT Polar System and is expected to be extended to include the EUMETSAT Polar System – Second Generation and Meteosat Third Generation. EUMETSAT is also investigating an evolution of the User Notification Service (UNS) to provide an enhanced capability to access archives of operational announcements.

The operational history of EUMETSAT satellites is currently logged in a document entitled *EUMETSAT Satellite History* [EUM/OPS/DOC/08/4698], which is linked from the following webpage: http://www.eumetsat.int/Home/Main/DataAccess/EUMETSATDataCentre. The EUMETSAT Data Centre is also implementing a database to record ingestion problems. This will be used to query for all missing products to identify the reason for the outage (typically decontamination etc.), which effectively provides a way of recording the history of the satellite.

4 GSICS USER INTERACTION

EUMETSAT continues to liaise with beta testers to improve the contents, format and distribution of the GSICS Correction for the infrared channels of Meteosat-7, -8 and -9. EUMETSAT aims to submit these products for acceptance as *pre-operational* early in 2011.

Feedback from beta testers is presented at GSICS Users' Workshops, which have been hosted at the EUMETSAT Meteorological Satellite Conference in 2009 and 2010. These also provide potential users with updates on the latest GSICS developments and plans for future products. Further engagement with new users is also sought by encouraging them to beta test new GSICS products entering the demonstration mode.

5 CONCLUSIONS AND OUTLOOK

During the period since CGMS-37, the definition of GSICS Products has been refined and a formal Procedure for Product Acceptance developed. EUMETSAT now routinely generate GSICS Corrections for Near Real-Time and Re-Analysis applications for Meteosat-7, -8 and -9. The latter have been formally accepted as demonstration products and are available from EUMETSAT's GSICS Data and Products Server. Liaison with beta testers is continuing to improve the products, their format and distribution. EUMETSAT aims to progress these products towards *pre-operational* status early in 2011.

EUMETSAT plans to extend its range of GSICS products to include the Meteosat channels in the solar band and Bias Monitoring of all Meteosat channels during 2011. At the same time it will strive to ensure consistency between different inter-calibration products, which is essential if we are to develop products for other satellite instruments. One such example is the planned analysis of HIRS, both as a monitored instrument, using IASI as a reference, and as a reference instrument for reprocessing of archive Meteosat data.