CGMS

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GLOBAL SPACE-BASED INTER-CALIBRATION SYSTEM (GSICS) PROGRESS REPORT

WMO-WP-03 reports on the progress of the Global Space-based Inter-Calibration System (GSICS), including:

- The completion and implementation of algorithms for intercalibration, including routine generation of correction coefficients, of the geostationary infrared imagers from EUMETSAT, JMA, NOAA, and shortly CMA and KMA, against EUMETSAT IASI and NASA AIRS hyperspectral infrared sounders as references;
- The development and implementation of the GSICS Procedure for Product Acceptance (GPPA) to review and document the GSICS intercalibration and correction algorithms;
- Establishment of the GSICS data servers, wiki pages, and individual operators' web sites for communication and data access;
- The addition of IMD, JAXA, USGS as full members;
- Major activities of the GCC, GRWG and GRDG;
- Feedback from the 3rd GSICS Users' Workshop.

Proposed Actions or Recommendations:

CGMS Satellite Operators to provide regular information on satellite/instrument events affecting calibration and establish corresponding web sites.

CGMS Satellite Operators to provide Instrument Performance Monitoring information routinely on their respective web sites.

CGMS members participating in GSICS to provide a representative in the GDWG.

CGMS to support the development of guidelines by WMO for the design of future instruments with a view of harmonizing some spectral characteristics (e.g. central λ) of at least some core geostationary imager channels.

CGMS members that are not currently participating to consider an active role in the future progress of GSICS.

GLOBAL SPACE-BASED INTERCALIBRATION SYSTEM

1. Introduction

The mission objectives of GSICS are: (i) To provide sustained calibration and validation of satellite observations; (ii) More specifically to intercalibrate critical components of the global observing system to climate quality benchmark observations and/or reference sites; and (iii) to provide corrected observations and/or correction algorithms to the user community for current and historical data. This implies that calibration discrepancies must be quantified (magnitude and uncertainty), diagnosed (root cause) and corrected (empirical removal based on physical interpretation).

Capacity building is an important aspect of GSICS: defining and sharing best practices and community algorithms helps each instrument operator to raise its expertise on satellite instrument calibration and intercalibration. Quality of data provided by any agency in the framework of GSICS should then meet GSICS standards and thereby facilitate the use of such data by the international community.

Accurate and consistent calibration is a prerequisite to evaluate decadal trends of climate variables. Feedback from NWP centres shows that intercalibration and subsequent bias analysis and correction are also of great benefit to NWP. GSICS held three users' workshops in September 2009, 2010, and 2011 collocated with the annual EUMETSAT Meteorological Satellite Conference with many participants from the climate and NWP communities. Both communities have expressed a need for intercalibration corrections to existing datasets to support the generation of climate data records, for real-time NWP data assimilation and for reanalyses.

2. GSICS components

GSICS membership continues to grow, with IMD, ISRO, JAXA and USGS as new members. Members now include CMA, CNES, EUMETSAT, IMD, ISRO, JAXA, JMA, KMA, NASA, NIST, NOAA, ROSHYDROMET, USGS and WMO, with ESA as an observer.

The major components of GSICS are the: GSICS Executive Panel, GSICS Coordination Center (GCC), GSICS Processing and Research Centers (GPRCs), GSICS Research Working Group (GRWG), GSICS Data Working Group (GDWG), and Calibration Support Segments (CSS). More information on GSICS can be accessed via the GSICS portal: http://gsics.wmo.int.

The GSICS Executive Panel is appointed by the WMO and consists of representatives from participating agencies. It sets strategic priorities, monitors and evaluates the evolution and operations of the GSICS. The GSICS Executive Panel has held its ninth session on 12 November 2010 in New Delhi upon closure of CGMS-38, and its tenth session from 6 to 8 June 2011 in Geneva. The GSICS Research Working Group and GSICS Data Working Group have held collocated meetings from 22 to 25 March 2011 in Daejeon, Republic of Korea, upon invitation by KMA. Reports of these meetings are available from the GSICS web site (http://gsics.wmo.int). The GSICS working groups also hold frequent web meetings over the year.

The GSICS Coordination Center (GCC) is located at the NOAA National Environmental Satellite Data and Information Service (NESDIS) facility in Maryland, United States. The GCC coordinates the development and implementation of methodologies, technical specifications and software tools, for satellite instrument inter-comparisons. For this purpose, GCC personnel work closely with scientists and data managers from the GRWG and GDWG. The GCC is also the main communication hub for GSICS. The GCC archives, distributes, and responds to requests for GSICS documentation, including all relevant data and results obtained by the program. The GCC also designs and hosts the GCC web site and a collaborative wiki, and is responsible for publishing

the GSICS Quarterly newsletter (http://www.star.nesdis.noaa.gov/smcd/GCC/newsletters.php), which has a growing audience and is a valuable vector of visibility on GSICS scientific and technical activities. A voluntary User Registration system has now been implemented to facilitate a two-way communication with the users.

The GSICS Processing and Research Centers, one at each operational satellite agency, are responsible for pre-launch calibration, inter-calibration of their own agency's sensors with reference sensors, and supporting research activities. They make their calibration results available through their web site and collaborative servers, as appropriate, in accordance with agreed specifications.

The GSICS Research Working Group coordinates, plans and implements GSICS research activities, developing methodologies and technical specifications for satellite instrument monitoring, inter-comparisons, intercalibration and assessment. The GSICS Data Working Group coordinates the definition of data exchange formats, metadata, archiving strategy, collaborative data server structure, for collocated data and inter-calibration results, and the harmonization of the GSICS web sites. The GRWG consists of scientists, and the GDWG of data management experts, representing the participating agencies.

GSICS Calibration Support Segments consist of activities that GSICS leverages to enhance its program. These calibration support activities are conducted at satellite agencies, national standards laboratories, major NWP centers, national research laboratories, and universities, and include:

Performing in-situ observations at Earth reference targets (e.g., stable desert and perpetual snow areas), long-term specially equipped ground sites, and special aircraft and field campaigns to monitor satellite instrument performance;
Observing stable extra-terrestrial calibration sources, such as the Sun, Moon, and stars, for on-orbit monitoring of instrument calibration;
Comparing radiances computed from NWP analyses of atmospheric conditions with those observed by satellite instruments;
Analyzing the results of GSICS inter-calibrations to diagnose why sensor calibrations change in-orbit;
Championing and supporting benchmark missions of the highest accuracy to serve as calibration standards in space for post-launch calibration of the operational sensors;
Developing calibration "best-practices" procedures; and
Supporting efforts to make satellite instruments SI-traceable.

3. GSICS Products

3.1 Product types

GSICS provides three main types of deliverables:

GSICS Correction Products, either in near-real time or in a re-analysis version
Instrument bias monitoring
Reports and guidelines.

3.2 GSICS Procedure for Product Acceptance (GPPA)

The GCC has coordinated the development and implementation of a GSICS Procedure for Product Acceptance (GPPA), which specifies all the documentation and test datasets to ensure that GSICS algorithms and products are documented, open, transparent and readily available to the user community.

The GPPA is the:

GSICS product developers pathway to obtain a "Stamp of Approval" for a potential product

GSICS data users window to GSICS product quality and "fitness for purpose"

GSICS governing body reference for judging GSICS product maturity.

The GPPA is composed of the four following phases:

Product Submission Phase: A GSICS Product Acceptance Form for a potential product has been satisfactorily completed and submitted to the GSICS Coordination Center

Demonstration Phase: The Product is determined to be within GSICS scope, its fundamental founding concepts are understood, and it meets GSICS data format/content guidelines. In this phase, the Product is released solely for the purpose of evaluation within GSICS and by potential product users

Pre-Operational Phase: The Product has been determined to be a valuable part of the GSICS product portfolio, and has developed and understood methodology, software, supporting models and measurements, uncertainty, quality indicator, and traceability to a community or SI standard

Operational Phase: In addition to its Pre-Operational Phase attributes, the Product has developed and understood generation, distribution, version control and archive strategies. It also has an available User's Guide. At this point, the Product is fully accepted and maintained within GSICS

3.3 Product status

Three GEO-LEO Infrared correction products are currently in demonstration, for MTSAT, METEOSAT METEOSAT and GOES imagers respectively, and further products are under development for GOES sounder, FY-2 and COMS. A GSICS monitoring product for these instruments is being developed. Two LEO-LEO products are in Demonstration Phase: the Patmos-X AVHRR solar reflective channel corrections based on MODIS, and the NOAA MSU/AMSU FCDRs time series (from1979 to present). The table below summarizes the status of the GEO-LEO Infrared products with respect to the GPPA.

Status of GSICS GEO-LEO IR Correction and Monitoring Products
(September 2011)

GPRC	Monitored Instrument	Reference Instrument	GSICS NRT Correction	GSICS Re-Analysis Correction	GSICS Bias Monitoring
EUMETSAT	Meteosat-9 } Meteosat-8 }-- Meteosat-7 }	IASI	Demonstration	Demonstration	Prototype
JMA	MTSAT-1R } MTSAT-2 }	IASI (+ AIRS)	Demonstration	Demonstration	Prototype
NOAA	GOES-11 Imager GOES-12 Imager	IASI (+ AIRS)	Demonstration	Demonstration	Prototype
	GOES Sounder	IASI (+ AIRS)	In development	In development	In development

CMA	FY2C } FY2D } -- FY2E }	IASI (+ AIRS)	In development	In development	Prototype
KMA	COMS	IASI (+ AIRS)	In development	In development	In development

3.4 Instrument event log and performance monitoring

In response to earlier requests by CGMS, it is planned to set up a centralized instrument event logs in order to record the multitude of events such as sensor decontamination, satellite manoeuvre, eclipse, switching to back-up components, unplanned incidents, gain change, etc which should be known for a precise and meaningful exploitation of the data, but are currently not widely accessible. A centralized instrument event log that would record such events in a very brief but timely manner is expected to improve the accessibility of such information by the international community. It would require full collaboration of CGMS satellite operators to share this information and to feed it in a harmonized manner. In addition to the centralized event log, another important aspect of instrument monitoring is to provide time series of key housekeeping parameters (e.g. NeΔT, gain, black body temperature, local oscillator temperature) as provided by NOAA in the Integrated Calibration Validation System website. GSICS participating satellite operators are encouraged to provide equivalent information on a routine basis on their respective web sites and agreed the following action:

Action EP-10.10: Executive Panel Members to review the N OAA instrument performance monitoring provided on the STAR Integrated Calibration Validation System (ICVS): http://www.star.nesdis.noaa.gov/smcd/spb/icvs/satMonitoring_n19_amax.php, (also described in CGMS-38 NOAA-WP-21), to provide comments, and to indicate whether they would be ready to publish equivalent information for the instruments they are operating.

4. Research and Development

Research and Development activities are coordinated by the GRWG, which is chaired by Tim Hewison (EUMETSAT) with Kim Dohyeong (KMA) and Fred Wu (NOAA) are vice-chairs. Research and Development activities over the past year have focused on the GEO to LEO visible intercalibration and corrections. A strategy for this effort has been completed and approved by the Executive Panel. It involves the evaluation of a range of methods in parallel including Ray-matching, oceans, Deep Convective Clouds (DCC), sun-glint, liquid-water clouds, as well as moon, star and desert targets. It is envisaged to build a consensus method on the combined use of several methods, with particular emphasis on DCC which is the most universally applicable.

Whenever possible a baseline consensus algorithm for GSICS corrections for each agency is adopted. The GSICS priority for operational production is however to ensure consistency of products, rather than consistency of methods; this consistency is the most likely to be achieved if the product quality is optimized.

A traceability statement was prepared by GRWG members to demonstrate the suitability of the AIRS and IASI hyperspectral spectrometers as inter-calibration references. This discusses the various pre-flight and in-orbit tests that have been performed on these instruments. Particular attention is paid to their relative stability, as this is critical if they are to be used inter-changeably. Various methods are described which show that AIRS and IASI offer consistent radiometric calibration – each with uncertainties ~0.1K (k=1). The statement also discusses the traceability chain of AIRS and IASI to the SI international reference standards, which is needed to achieve the long-term goal of GSICS.

GSICS also discussed the combined use of multiple references, and agreed that one instrument only should be taken as the reference, while the others should be regarded as transfer standards, through which the calibration is transferred by defining delta correction functions. This approach avoids the ambiguity of dealing with diverging references, while securing the possibility of a smooth transition if the initial reference becomes unavailable. In the case of GEO-LEO IR products, Metop-A/IASI is currently defined as the reference and delta functions need to be developed based on comparisons of AIRS and IASI to allow AIRS comparisons to be included in the GSICS Corrections, as well as Metop-B/IASI in due time.

Work was done to evaluate the uncertainty of Meteosat-IASI corrections and similar evaluations were recommended to all GPRCs for their GEO-LEO infrared products. It was noted that the evaluation would be different for other product types. The Panel recalled the on-going action of NIST to develop a terminology and a guide on uncertainty evaluation for GSICS along the lines of the BIPM Guide on Uncertainty of Measurement (GUM).

5. Data Management

The GDWG chair is Aleksandar Jelenak (NOAA); Yuki Kosaka (JMA) was appointed vice-chair to replace Hiromi Owada (JMA). The effort towards unifying bias monitoring web pages content and disposition among GPRCs resulted in a recommendation to create a centralized, interactive web page where plots for all GPRCs will be dynamically generated based on user request. For now, only the time series of brightness temperature biases for standard scenes are to be available for plotting from this new web page. The development of such a web page requires very specific development skills so currently the effort is undergoing to scope the requirements and identify who among the GPRCs may be able to carry out this work. In the meantime, GPRCs will be asked to standardize the format of their plots on their current web pages.

The GDWG has developed a netCDF template for the current GEO-LEO IR products which will further standardize the content of these files. It is a requirement for the GEO-LEO IR products in the Demonstration phase to adopt the template in order to transition to the Preoperational phase.

Update on the GSICS data servers mentioned that the two currently functional servers, at EUMETSAT and NOAA, are receiving regular file uploads. The work has just began on standardizing configuration of the THREDDS software which provides access to the data.

The two most important current issues for the Working Group are availability of resources to carry out agreed tasks and the need to identify GSICS data users and determine their needs. The main goals for the period till the 2012 Joint Working Groups meeting are: supporting GSICS products in the product acceptance procedure, completing common THREDDS configuration, continuing the work on the bias monitoring web page design, and interfacing with the WMO Information System (WIS).

6. GSICS partnerships

6.1 Coordination with CEOS WGCV IVOS subgroup

The CEOS Working Group on Calibration and Validation (WGCV) has subgroups for Microwave, for Quality Assurance for Earth Observations (QA4EO), and for Infrared and Visible Optical Sensors (IVOS). Since IVOS is dealing with inter-calibration methodologies, metrology and standards, which is of relevance to GSICS, interaction among the two groups is encouraged, and overlap be avoided. The participation of the WGCV Chair in the GSICS Executive Panel, and the GSICS EP Chair in WGCV, should help to ensure that WGCV and GSICS have complementary focus and build on each other's. The core activity of GSICS is operational intercalibration, which is and should remain its area of strength; WGCV has a strong experience in other areas such as pre-flight calibration, cal/val sites and field campaigns, as well as producing best practice guidelines. If an intercalibration activity is going to be developed by IVOS, IVOS should be encouraged to do it in collaboration with GSICS. It would be helpful to share information on our respective practices (e.g.

ATBD templates) with a view to adopt them if relevant, or adapt them as appropriate. Finally, it is noted that cross-participation of several experts in both GRWG and WGCV/IVOS is contributing to the synergy of the two groups. Action was given to the GSICS EP Chair to communicate this understanding with the WGCV Chair and the proposed topics for cooperation.

6.2 Cooperation with GRUAN

The Panel confirmed the relevance of the GCOS Reference Upper-Air Network (GRUAN) for GSICS, with the primary benefit to support the evaluation of the use of GSICS corrections for Level 2 products. This would be mainly in the framework of downstream communities like SCOPE-CM and in the framework of cal-val activities for new systems. This would require a 3-way interaction with those groups. GSICS also sees the benefit of GRUAN to provide critical datasets to improve radiative transfer model development. Furthermore, GSICS could benefit to GRUAN as a provider of "traveling references".

GSICS acknowledges the potential benefit of coordinating radiosonde and satellite observations in the framework of post-launch cal/val campaigns of new satellite instruments. This should be discussed on a case-by-case basis by agencies bilaterally with GRUAN.

7. Outcome of the third GSICS Users' Workshop

Interaction with the user community through three workshops, hosted by EUMETSAT during EUMETSAT Meteorological Satellite Conferences, has been instrumental in providing the necessary feedback.

The third GSICS Users Workshop resulted in excellent interactions between GSICS and the user community represented by over 50 attendees. At the meeting we found that external users have expressed very positive feedbacks on the GSICS Algorithm Theoretical Basis Documents (ATBDs) used for describing the GSICS correction products currently in the demonstration phase, and on the accessibility and usability of these GSICS correction products. Positive impacts using the GSICS corrections for geostationary infrared imagers were reported on derived products. Examples included improved cloud detection and cloud top temperatures, sea surface temperatures and clear sky radiances. Small, but statistically significant, improvements were found in the data assimilation of clear sky MSG imager radiances by NCEP. A discussion on "common reference imager channels" has led to an action to suggest to CGMS the development of guidelines for the design of future instruments, with a view of harmonizing key specifications of at least a set of core imager channels, for a better interoperability. The Global Precipitation Mission Intersatellite Calibration Group (GPM X-Cal) project scientist attended the workshop, which led to an agreement to continue to discuss how best to enhance collaboration. The X-Cal and GSICS working groups agreed to share data, models and documentation. GSICS is willing to assist to evaluate X-Cal intercalibration algorithms using the GSICS Product Acceptance Procedures (GPPA). The SCOPE-CM and GEWEX communities expressed needs to improve interactions with GSICS, especially understanding the role of GSICS in intercalibration of historical satellite datasets going back to 1979. An earlier suggestion to establish a User Board might be a way to strengthen interactions with SCOPE-CM at a proper strategic level. It is still the desire of GSICS for the GEWEX International Satellite Cloud Climatology Project (ISCCP) to validate the GSICS corrections and provide feedback.

From a broader perspective, the discussion also pointed out the need to put more emphasis on explaining the scope of GSICS, its operating principles and planned deliverables, and on the development of some independent assessment of GSICS calibration results.

8. High-level priorities

Current activities are articulated along the following lines:

	GSICS Correction for Current Infrared Channels Complete the validation and acceptance of the GEO-to-LEO correction product, in accordance with the GSICS Product Acceptance Procedure Review the methodology for LEO-to-LEO GSICS correction
	GSICS corrections for heritage instruments Review the methodology for LEO-to-LEO heritage instruments (AVHRR, MSU, HIRS)
	GSICS Correction for Visible Channels Focus collaborative scientific activities on refining Visible channel correction methodology
	Microwave activities Continue collaboration with GPM Intersatellite Calibration team, adding current techniques for MSU, AMSU and SSMI intercalibration to the GSICS portfolio through the GSICS Process for Product Acceptance (GPPA)
	Consolidation of Infrastructure and General Methodology Commissioning the export functionality of the CNES database of reference sites (SADE) IASI/AIRS traceability reports Guide for Estimation of Uncertainty in GSICS intercomparisons Unified web monitoring system for GSICS GEO-to-LEO Infrared Correction
	Enhancing Interaction with Users Continue to seek feedback from beta users Convene the annual GSICS Users' Workshops. Engage ISCCP to evaluate GSICS corrections
	Expanding Membership and Partnerships Seek greater involvement of Roshydromet, ISRO and ESA Continue collaboration with CEOS WGCV Continue and formalize collaboration with SCOPE-CM

9. Conclusion

GSICS has made significant accomplishments and continues to grow both internally and externally. CGMS members are invited to take note of the progress that has been made since CGMS38. This progress has largely been the result of concerted actions between active members of GSICS.

CGMS Members are invited to note in particular the following:

The planned establishment of a centralized instrument event log that would briefly record events in a timely manner, which would require full collaboration of CGMS satellite operators to share this information and to feed it in a timely a harmonized manner.

The invitation made to GSICS participating satellite operators to provide key instrument house-keeping information on a routine basis on their respective web sites.

The need for a stronger representation of GSICS members in the GDWG, which is essential to carry out agreed data management tasks.

The suggestion to develop guidelines for the design of future instruments, with a view of harmonizing key features (such as central λ and Spectral Response Function) of at least a set of core geostationary imager channels, for enhanced interoperability.

The need stressed by the third GSICS Users' Workshop to better explain the scope of GSICS, its operating principles, and planned deliverables, and to develop some independent assessment of GSICS calibration results.

CGMS members that are not currently members of GSICS or do not yet actively participate in GSICS are kindly encouraged to consider an active role in its future progress.

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