GSICS Quarterly

Global Space-based Inter-Calibration System

No. 1, Spring 2007

• CMA • CNES • EUMETSAT • JMA • KMA • NOAA • WMO •

Introducing GSICS

For most of the history of the earth sciences, weather and climate phenomena such as severe thunderstorms, blizzards, hurricanes, droughts, and monsoon floods have been studied as isolated regional-scale events using simplified theoretical or numerical models and limited observations. Furthermore, atmospheric, oceanographic, and geological scientists rarely crossed the boundaries of their own disciplines, and they scarcely thought of interacting with biological and social scientists. In the past decade or so, earth scientists have been summoned to mostly abandon this "pure research" mode of activity in favor of applying earth science principles to solve very complex environmentally-related societal problems. These problems, which are outlined within the Global Earth Observation System of Systems (GEOSS) concept, include:

- Reducing loss of life and property from disasters;
- Understanding environmental factors affecting human health;
- Improving management of energy resources;
- Understanding, assessing, predicting, mitigating and adapting to climate variability and change;
- Enhancing water resources management through better understanding the water cycle;
- Improving weather information, forecasting and warning;
- Improving the management and protection of terrestrial, coastal and marine ecosystems;
- Supporting sustainable agriculture and combating desertification; and
- Understanding, monitoring and conserving biodiversity.

In order to make tangible steps toward these goals, using space-based observations of the dynamic earth-ocean-atmosphere system is an essential part of the process.

The original concept of space-based observations was to provide snapshots of the state of our environment over large regions of the globe, especially in areas where conventional measurement systems are impractical. Highly accurate agreement between snapshots taken by different satellite instruments, or by the same instrument at different times, was not part of the concept. More recently, concerns about global climate change and the advent of more powerful methods of data assimilation and numerical weather prediction have forced satellite measurements to take on roles that they were not originally designed for. An example of this is the mid-tropospheric temperature time series created from several NOAA Polar-Orbiting Environmental Satellite (POES) Microwave Sounding Unit (MSU) instruments, which contain brightness temperature biases and bias drifts that must be removed to make a coherent climate data record. A perspective of the MSU time series over ocean, before and after bias correction, is given in Figure 1, which was taken from an analysis of Zou et al. (2006). This demonstrates that in order to make use of observations from the international constellation of satellite instruments to monitor and understand weather and climate phenomena that impact society, these instruments must be carefully inter-calibrated. This is the role of the Global Space-based Inter-Calibration System (GSICS), which has been established to foster collaboration and cooperation amongst the satellite data providers of the world.

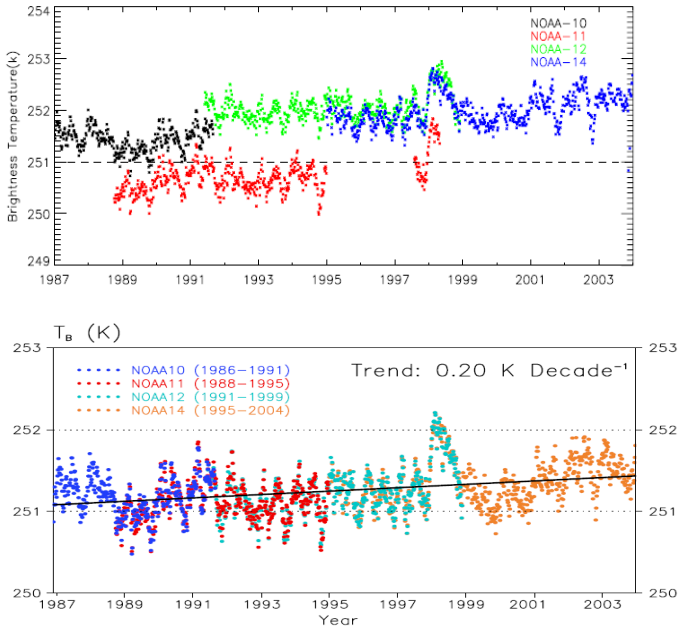


Figure 1. Global tropospheric temperature trends revealed by NOAA-10, -11, -12, and -14 Microwave Sounding Unit (MSU) data before (top) and after (bottom) intersatellite calibration bias correction.

The concept and strategy for GSICS (GSICS-IP, 2006) were submitted by the World Meteorological Organization (WMO) and endorsed by the Coordination Group of Meteorological Satellites (CGMS) at its 33rd meeting (CGMS-XXXIII) held in Tokyo, Japan on 1-4 November 2005. The initial goal of GSICS is to achieve operational inter-calibration of satellite instruments within the space-based component of WMO's World Weather Watch/Global Observing System (WWW/GOS). The GSICS organizational chart given in Figure 2 also depicts how GSICS fits into the structure of WWW/GOS, whose purpose is to address climate, weather

forecasting and other environmental needs of WMO members. GSICS consists of a GSICS Executive Panel, GSICS Coordination Centre (GCC), GSICS Processing and Research Centers (GPRCs), and Calibration Support Segments (CSSs). It also consists of a GSICS Research Working Group (GRWG) and a GSICS Data Working Group (GDWG) that were formed by the WMO to assist in the coordination, planning, and implementation of research and data management activities of GSICS.

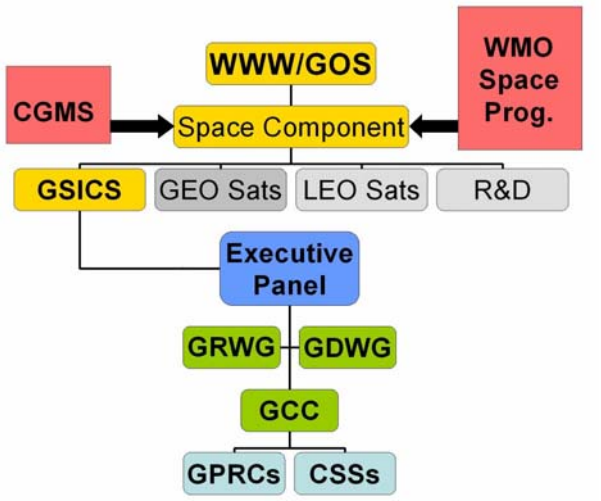


Figure 2. GSICS organizational chart within the WWW/GOS structure.

The GSICS Executive Panel, appointed by WMO, monitors and evaluates the evolution and operations of GSICS. The Panel also provides guidance and advice on the development and enhancement of GSICS. The Panel consists of representatives from WMO and each satellite agency, and conducts annual GSICS progress reviews.

The GSICS Coordination Centre (GCC), now located at the NOAA World Weather Building facility in Camp Springs, MD, USA, is also one of the participating GPRCs. With help from the GSICS Research and Data Working Groups, the GCC coordinates the development of specifications and requirements for data inter-comparisons between satellite instruments and with reference site measurements. In particular, GCC coordinates the definition of data collocation criteria and sampling frequencies; establishment of raw data availability and methods of data inter-comparison; and creation of data formats, reporting times, and archive space for inter-comparison results. The GCC also transmits satellite collocation times and locations to satellite operators, receives inter-calibration results and reports from satellite agencies and reference sites, and maintains a central archive for the inter-calibration collocations that is accessible by the GPRCs.

A GSICS Processing and Research Center (GPRC) is located at each operational satellite agency. Each GPRC supports data processing and research activities in the framework of the distributed data and research component of GSICS, which is facilitated by the GDWG, GRWG, and GCC. As GSICS develops, GPRCs are to perform inter-satellite calibration utilizing collocated satellite observations and overlapping satellite records to achieve comparability of sensors on different satellites. GPRCs also intend to collaborate with national standard laboratories of participating countries during pre-launch characterization and calibration activities to ensure that pre-launch calibrations are traceable to the accepted international standards.

A Calibration Support Segment (CSS) represents a GRWG-coordinated research activity carried out by participating satellite agencies, national standards laboratories, numerical weather prediction (NWP) centers, and/or national research laboratories. As GSICS matures, planned CSS activities include:

- Performing highly-accurate, SI standards traceable tests on satellite instruments and their on-board calibration references using special satellite and ground-based instruments;
- Collecting high-quality in-situ data from earth-based reference sites — *e.g.*, stable desert areas, long-term specially-equipped ground sites, and intensive field campaigns — that are used to monitor satellite instrument performance;
- Independent monitoring of extra-terrestrial calibration sources, such as the sun, moon, and stars, which provide stable calibration targets for on-orbit monitoring of instrument calibration; and
- Simulations of satellite radiances, computed from NWP analyses of atmospheric conditions, which are compared with observations of satellite instruments.

Ultimately, each CSS activity is designed to standardize and improve the accuracy of satellite measurements.

Integrating satellite data from a diverse system of space-based platforms and instruments is critical in producing weather and climate products with levels of accuracy needed to achieve the societal benefits outlined in GEOSS. For example, advances in NWP have led to the need for more accurate radiometric data with finer space and time resolution. As the requirements for monitoring global climate become clearer – temperature changes as small as 0.2 K per decade, ozone trends as small as 1% per decade – developing long-term continuous time series of observations from the data of multiple satellite instruments becomes inevitable. In order for progress to be made in these activities, understanding and mitigating data discrepancies between satellite-observing platforms become very important. These relatively stringent data requirements present a challenge to the global science community, and this challenge is now beginning to be met by the satellite data providers of the world through the GSICS.

REFERENCES

GSICS-IP, 2006: Draft Implementation Plan for a Global Space-based Inter-Calibration System, World Meteorological Organization and Coordination Group of Meteorological Satellites, 22 pp.

Zou, C.-Z., M. D. Goldberg, Z. Cheng, N. C. Grody, J. T. Sullivan, C. Cao, and D. Tarpley, 2006: Recalibration of microwave sounding units for climate studies using simultaneous nadir overpasses, *J. Geophys. Res.*, **111**, D19114, doi: 10.1029/2005JD006798.

(by Drs. R. Iacovazzi, Jr. and J. T. Sullivan, NOAA)

News in This Quarter

GRWG-I Meeting Report

The first meeting of the Global Space-based Inter-Satellite Calibration System (GSICS) Research Working Group (GRWG) was held with a great deal of enthusiasm and optimism from an international group of about 30 participants. These participants represented several worldwide agencies: World Meteorological Organization (WMO), China Meteorological Administration (CMA), Centre National d'Etudes Spatiales (CNES), European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT), Korea Meteorological Administration (KMA), Japan Meteorological Agency (JMA), National Oceanic and Atmospheric Administration (NOAA), National Aeronautics and Space Administration (NASA), National Institute of Science and Technology (NIST), National Climate Data Center (NCDC), and the Cooperative Institute for Meteorological Satellite Studies (CIMSS) and Space Science and Engineering Center (SSEC) of the University of Wisconsin (UW). The main purpose of the meeting, hosted on 22-23 January 2007 at NOAA Science Center in Camp Springs, Maryland, USA, was to build consensus on the algorithm for inter-calibration between the geostationary (GEO) and low-earth-orbiting (LEO) satellite instruments in the infrared (IR) spectrum.

After a brief welcome by Dr. Fred Wu (GRWG Chair), the audience heard from Dr. Mitch Goldberg (GSICS Executive Panel Chair), Mr. Greg Withee (NOAA's Coordinator of the Global Earth Observing System of Systems (GEOSS)), Mr. Jérôme Lafeuille (GSICS Executive Panel Secretary), Dr. Fuzhong Weng (GSICS Coordination Center (GCC) Director), Dr. Fred Wu, and Dr. Johannes Schmetz (GSICS Executive Panel Member). These presentations provided an overview of the GSICS program, including its context within contemporary satellite radiometery, underlying concept, structure, current capabilities and future direction. They also stressed the importance of ensuring and improving data dissemination and access, format standardization, and documentation. The point most emphasized was that GSICS must be able to demonstrate how inter-calibration of the international constellation of satellite instruments leads to societal benefits as outlined by GEOSS.

The afternoon sessions on the first day of GRWG-I focused on current GEO to LEO instrument inter-calibration efforts by the GSICS members. Presenting during this session were Dr. Marianne König (EUMETSAT), Dr. Yoshihiko Tahara (JMA), Mr. Peng Zhang (CMA), Prof. Byung-Ju Sohn (KMA), Mr. Matt Gunshor (CIMSS), Dr. Dave Tobin (SSEC), Dr. Ken Knapp (NOAA), and Drs. Patrick Minnis, Louis Nguyen, and Dave Doelling (NASA). A brief summary of contemporary GEO-LEO IR instrument inter-calibration methods being considered by GSICS is presented in the next article of this newsletter.

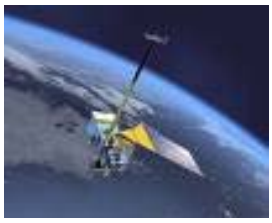
The second day of the GRWG-I was devoted to discussing the GSICS algorithm for GEO-LEO IR instrument inter-calibration. The dialogue began with Dr. Fred Wu reiterating the importance of envisioning the purpose and intended utility of the inter-calibration results before work is started. He also emphasized that the resultant GSICS inter-calibration algorithm should maximize use of existing expertise, and align as much as possible with common programmatic goals, of the member institutions. During this part of the workshop, participants chose working satellite data sets, and then the GEO-LEO instrument inter-calibration and data processing parameters, to limit the analysis. It was made clear that the main purpose of the initial GEO-LEO instrument inter-comparison exercise is to ensure that identical results can be obtained by all members using the same algorithm.

The workshop attendees quickly agreed that the Earth Observing System (EOS)-Aqua Atmospheric InfraRed Sounder (AIRS) data should be used initially to develop the GEO-LEO inter-calibration algorithm between imaging instruments. The primary reasons surrounding this choice are that AIRS is a well-calibrated and well-understood instrument, and its hyperspectral coverage of some GEO spectral bands reduces the uncertainties of GEO-LEO instrument inter-comparison due to spectral response function differences. The GRWG plans to expand this effort in the future to incorporate METOP-A Infrared Atmospheric Sounding Interferometer (IASI) data as soon as they are available and stable. Also, GEO-LEO instrument inter-calibration in visible and near IR spectral bands using measurements of other polar-orbiting sounding or imaging instruments is to follow. Furthermore, the group agreed that collocated data should be accumulated to the extent that the data volume is manageable, and then down-select the highest quality data during the analysis phase.

Dr. Goldberg gave the closing remarks of GRWG-I. He thanked participants for sharing their time and expertise for this important program. He also expressed confidence that members would return to their respective institutes, perform the work agreed upon, and reconvene in June with news of great progress. In the end, GRWG-I represents a historic step towards inter-calibration of the global constellation of space-based instruments, and the goals of GEOSS.

(by Drs. R. Iacovazzi, Jr. and X. Wu, NOAA)

Inter-Calibrating GEO-LEO IR Instruments: GRWG Perspective



The basic steps of geostationary (GEO) to low-earth-orbit (LEO) IR instrument inter-calibration methodologies deviate very little. GEO and LEO instrument data are gathered for events when the sensors are viewing the same earth scene at similar times (within about 15 minutes) and local zenith angles (within about 5 degrees). Calibration offsets are computed using this data, and in most methods spectral response function-related radiance differences between instruments are estimated. Some methods also have a threshold related to azimuth angle differences of the observations and earth-scene inhomogeneities.

Although methods to compute simple radiance offsets between satellite instruments do not vary substantially, the methods of spectral correction can deviate considerably. In the mid- to long-wave infrared region, popular spectral correction methods make use of the hyperspectral EOS-Aqua AIRS instrument. Methods outlined during the recent GRWG-I meeting include one technique based on constrained optimization and two methods that utilize spectral gap filling. Constrained optimization is appropriate for continuous spectral radiances, such as those from IASI, while spectral gap filling can be used when spectral radiances are not continuous. At present, the most pragmatic and theoretically sound method applicable to the AIRS data considered by GSICS is Dr. David Tobin's method to fill spectral gaps using radiative transfer model simulations.

Near the conclusion of GRWG-I, it became clear that the main purpose of the initial GEO-LEO instrument inter-comparison exercise is to ensure that identical results can be obtained by all members using the same algorithm and one-day data. After that, the plan is to further tune the algorithm parameters and to perform a test run with data for the month of April. This analysis is to be carried out using AIRS and IASI data, if available. The algorithm is planned for normal operations starting in Fall 2007.

(by Drs. R. Iacovazzi, Jr. and X. Wu, NOAA)

Just Around the Bend . . .

GSICS Meetings

GRWG-II and GDWG-I: 12-14 June 2007, EUMETSAT, Darmstadt, Germany.

Anticipated Accomplishments:

GRWG

- Pseudo code for inter-calibration, including co-location;
- Characteristics of the satellite instruments used in inter-calibration; and
- One-month data (April, with or without IASI) for further development of GSICS algorithm.

Appendix

GSICS Members & Representatives

GSICS Executive Panel

Affiliation	Last Name	First Name
CMA	Lu	Naimeng
CNES	Renaut	Didier
EUMETSAT	Schmetz	Johannes
JMA	Kurino	Toshiyuki
KMA	Ou	Mi-Lim
NOAA	Goldberg	Mitch (Chair)
WMO	Lafeuille	Jérôme

GSICS Coordination Center

Affiliation	Last Name	First Name
NOAA	Iacovazzi, Jr.	Bob (Deputy Director, GQ Co-Editor)
NOAA	Li	Yaping
NOAA	Sullivan	Jerry T. (GQ Co-Editor)
NOAA	Weng	Fuzhong (Director)

GSICS Data Working Group

Affiliation	Last Name	First Name
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JMA	Matsumoto	Takanori
NOAA	Barkstrom	Bruce
NOAA	Jelenak	Aleksandar
WMO	Lafeuille	Jerome

GSICS Research Working Group

Affiliation	Last Name	First Name
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CMA	Zhang	Peng
CNES	Blumstein	Denis
CNES	Henry	Patrice
EUMETSAT	König	Marianne
EUMETSAT	Van de Berg	Leo
JMA	Tahara	Yoshihiko
KMA	Ahn	Myoung-Hwan
KMA	Chung	Sung-Rae
KMA	Sohn	Byung-Ju
NASA	Doelling	David
NASA	Minnis	Patrick
NASA	Nguyen	Louis
NASA	Xiong	Jack
NIST	Datla	Raju
NIST	Johnson	Carol
NOAA	Beck	Trevor
NOAA	Cao	Changyong
NOAA	Flynn	Larry
NOAA	Knapp	Ken
NOAA	Privette	Jeff
NOAA	Wang	Likun
NOAA	Wu	Fred (Chair)
NOAA	Yan	Banghua
NOAA	Yu	Fangfang
NOAA	Zou	Cheng-Zhi
SSEC	Tobin	David
WMO	Lafeuille	Jerome

GSICS Quarterly Contributions

The press crew is looking for contributions from all GSICS participants to the GSICS Quarterly (GQ) newsletter. We are especially looking for short articles (< 1 page) from our partnering institutions related to their cal/val capabilities, and how they have used these capabilities to positively impact weather and climate products. Showcasing the links between inter-satellite cal/val activities and weather and climate product improvement is an important role of the GQ. Please keep in mind that this newsletter is not a technical journal, and is designed to reach an audience with wide interests including satellite remote sensing, weather prediction, climate change, and satellite product retrieval.

Please submit newsletter contributions at least two weeks prior to the end of each quarter to Bob.Iacovazzi@noaa.gov, GQ Co-Editor.

More GSICS Information

For more information about GSICS, please go to our web site: www.orbit.nesdis.noaa.gov/smcd/spb/calibration/icvs/GSICS/

With Help From Our Friends:

The GSICS Quarterly Co-Editors would like to thank Dr. Yaping Li and Ms. Regina Bellina for their help in compiling and proofreading this publication.