doi:10.7289/V5862DC9

GSICS Quarterly

Global Space-based Inter-Calibration System

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

Vol. 1, No. 2, 2007

www.orbit.nesdis.noaa.gov/smcd/spb/calibration/icvs/GSICS/index.html

Robert A. Iacovazzi, Jr. and Jerry T. Sullivan, Co-Editors

Message from the Chair of the GSICS Executive Panel

I am pleased to announce that the GSICS Program currently includes participation from China (CMA), Europe (CNES/France, EUMETSAT), Japan (JMA), Korea (KMA) and the United States (NOAA, NASA, and NIST). These agencies have agreed to take steps to ensure better comparability of satellite measurements made by different instruments and to tie these measurements to absolute standards. The direct benefit of improved satellite observations will be more reliable weather and climate assessments and predictions. Satellite inter-calibration is vital for reducing measurement uncertainty and optimally integrating data from different observing systems to help achieve the nine societal benefits of GEOSS.

At its inaugural meeting in October 2006, the Executive Panel established important priorities and activities for 2007 and 2008. GSICS activities are currently focused on the inter-calibration of operational satellites from China, Europe, Japan, Korea and the United States. Korea will launch its first operational satellite next year. The major milestone of GSICS for 2007 is the routine inter-calibration of operational instruments in low earth orbit (LEO). In 2008, GSICS will commission routine inter-calibration between LEO and geostationary earth orbit (GEO) satellites at CMA, EUMETSAT, JMA, KMA and NOAA. Important scientific contributions to this activity are being provided by CNES and NASA. The GEO imagers will be inter-calibrated using the EUMETSAT Infrared Atmospheric Sounding Interferometer (IASI) and NASA Atmospheric InfraRed Sounder (AIRS). Also, GSICS will routinely intercompare AIRS and IASI to ensure that both instruments continue to have excellent stability.

Our collaboration continues to be strong and there is continued growing interest in GSICS. We are making excellent progress. The GSICS web site has been established at NOAA and now includes routine LEO to LEO inter-calibration of NOAA and EUMETSAT infrared sounders and imagers and microwave sounders. The GSICS Research Working Group is currently focusing on establishing consensus algorithms for LEO to GEO inter-calibration. I also had the privilege to report on the GSICS activities at the CEOS Working Group on Cal/Val (WGCV) meeting in June held at the National Physical Laboratory near London. GSICS will be working very closely with the WGCV to implement best practices for calibration and validation developed by the WGCV.

Best Regards, Mitch Goldberg

GSICS Coordination Centre (GCC)

The GSICS Coordination Centre (GCC) is the GSICS data and information storage and distribution facility. The GCC is also responsible for coordinating several GSICS activities:

- Inter-comparison studies between satellite instruments;
- Development of GSICS data set formats;
- Definition of inter-comparison technical specifications;
- Development of common software tools to be shared by GSICS members; and
- Integration of partner calibration activities that support GSICS initiatives.

The GCC is located at the NOAA World Weather Building facility in Camp Springs, MD, USA and is directed by Dr. Fuzhong Weng of NESDIS. GCC operations are performed under the guidance of the GSICS Executive Panel, GSICS Research Working Group (GRWG), and GSICS Data Working Group (GDWG).

As a coordination center, the GCC is responsible for maintaining pathways of information communication and data transfer. The GCC hosts of GSICS web site and is responsible for developing and disseminating the GSICS Quarterly. It also facilitates meetings of the Executive Panel, GRWG and/or GDWG. These current GCC pathways are illustrated in Figure A1, on Page 2.

Future plans of the GCC are to expand the storage and dissemination of GSICS data and information by establishing a GSICS Virtual Library. The proposed virtual library is envisioned to have many services similar to the National Physical Laboratory's implementation of *Second Life* and the Virtual Center for Decadal Climate Variability Studies developed by Mehta *et al.* (2006):

- Fully interactive group seminar, private discussion, and bulletin board facilities;
- Collaborative work area where members can create and edit documents, software, and project plans;
- Data archive portal;

doi:10.7289/V5862DC9

- Program archive of official documents, presentations, meeting minutes, and newsletters;
- List of program-relevant journal articles and web links;
- E-mail addresses and paging facilities to contact other members; and
- Access limited according to membership level.

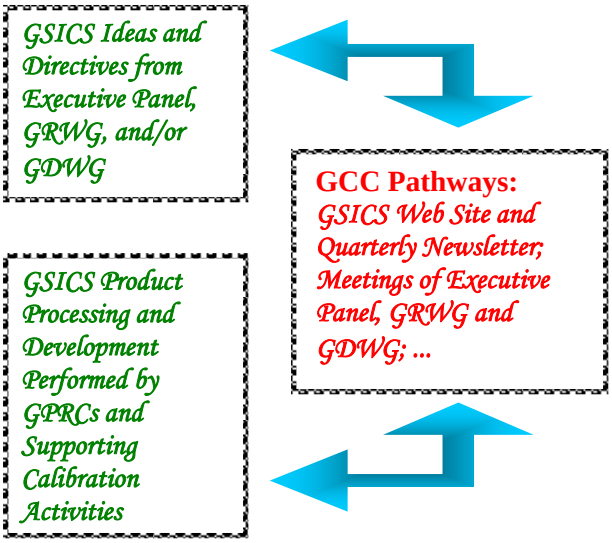

Figure A1: Depiction of the current GCC role within GSICS.

Other planned roles of the GCC are to help synergize activities between GSICS and independent validation programs, SI-traceable calibration initiatives, and satellite data assimilation offices.

REFERENCES

Mehta, V. M., E. J. Lindstrom, L. de Kort, and A. J. DeCandis, 2006: The Virtual Center For Decadal Climate Variability. *Bull. Amer. Met. Soc.* **87**, 421–424.

Second Life ® is a registered trademark of Linden Research, Inc.

(by Drs. R. Iacovazzi, Jr.; J. T. Sullivan; and F. Weng, [NOAA])

The GPM Inter-Satellite Calibration Study

The Global Precipitation Measurement (GPM) mission design includes a core satellite dedicated to making very precise cloud physics measurements with a dual-frequency precipitation radar and a constellation of satellites containing microwave radiometers that will observe precipitation over a given region at a time interval of three hours or less, as needed by many applications. The constellation of microwave radiometers and the parametric rainfall algorithms envisioned for GPM require that these radiometers be calibrated with an accuracy of approximately 1 K to the same uniform standard (Ohring *et al.*, 2005). To unambiguously detect global precipitation change forecasted by climate models, the GPM radiometers need to be able to detect a 0.003 $mmhr^{-1}$ decadal change in precipitation, which translates to a radiometer calibration drift of less than 0.03K per decade.

Experience has shown that pre-launch calibration of microwave radiometers is difficult at the sub-Kelvin level. Every instrument to date has required on orbit calibration adjustment, and residual calibration errors tend to behave differently from instrument to instrument. In GPM, considerable resources are being invested to ensure that the radiometer on the GPM core satellite, the GPM Microwave Imager (GMI), is as well calibrated as possible. In addition, the GPM project has started an activity aimed at bringing all constellation radiometers to a consistent calibration based upon on orbit data. In this activity, inter-comparisons among various instrument observations will be used to transform brightness temperatures of all instruments to a common virtual calibration standard based on a consensus of available instruments and information. These inter-calibrated brightness temperatures then will be used as input to existing rainfall algorithms to assess the residual uncertainty in the rainfall products. The objective is to estimate brightness temperature biases to the order of 1 K or less over the entire range of instrument brightness temperatures, which captures unresolved non-linearities in the data and makes bias removal more tractable. Figure B1 shows brightness temperatures observed by the TRMM Microwave Imager (TMI) on TRMM and the Special Sensor Microwave/Imager (SSM/I) on DMSP at a nearly simultaneous overpass.

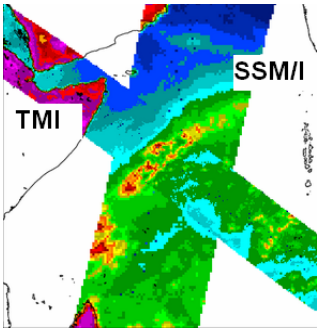

Figure B1: Microwave brightness temperatures observed by TRMM TMI and DMSP SSM/I within one minute of each other.

Comparisons between pairs of satellites in this GPM inter-calibration activity will not be straightforward, because there will be differences between the viewing geometries and channel center frequencies between any two satellite instruments. The first aim is thus to develop algorithms that convert one satellite's brightness temperatures to be equivalent to the other. These procedures will enable us to use coincident observations to derive transforms that adjust the calibration of one instrument to be equivalent to that of another or to the virtual instrument representing the consensus calibration. In

doi:10.7289/V5862DC9

order to initially develop these transforms, a common data period — July 2005 to June 2006 — and four sensors — TMI, Windsat, SSM/I-F13 and SSM/I-F14 — have been included in the comparison. Each participating team will generate transforms that make the calibration of Windsat and the two SSM/Is consistent with TMI. The results will be compared according to agreed upon metrics. The teams will use a common set of radiative transfer models so that the procedures used to generate the transforms can have an unambiguous comparison. The data sets and common radiative transfer models were in place in early May 2007. We hope to have results ready for comparison about six months later. Since inter-calibration between all of these instruments hasn't been done before, the time requirement is somewhat uncertain. At this point, five teams are participating in the study, and any group interested in participating or tracking progress in the study should contact Tom Wilheit (wilheit@tamu.edu). Also, to learn more about the GPM mission, please visit the GPM web site at http://gpm.gsfc.nasa.gov/.

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Ohring, G., B. Leilicki, R. Spencer, B. Emery, and R. Datla, 2005: Satellite instrument calibration for measuring global climate change - Report of a workshop. *Bull. Amer. Met. Soc.*, **86**, 1303-1313.

(by Drs. C. Kummerow [Colorado State Univ.]; C. Ruf [Univ. of Michigan]; and T. Wilheit [Texas A&M Univ.])

A Glimpse from GSICS Labs

Compensation of AIRS Spectral Gaps for Inter-Calibration Between AIRS and a Broadband Sensor

Inter-calibration between broadband imagers on geostationary-earth-orbiting (GEO) satellites, and hyperspectral sounders such as AIRS and IASI aboard low-earth-orbiting (LEO) satellites, is planned in GSICS. In the comparison, a channel virtually imitating each broadband channel is generated by convolving hyperspectral channels to mitigate spectral response differences between the two sensors. In this method, accounting for all spectral gaps in the hyperspectral channels, as found in the AIRS instrument, is important. This study proposes a compensation method to fill the spectral gaps by using line-by-line radiative transfer model (RTM) simulations and hyperspectral observations.

The proposed method involves: 1) preparing line-by-line RTM simulated radiances with respect to a particular atmospheric model profile, and 2) adjusting the radiances to observed hyperspectral radiances. The adjustment is conducted by using an average ratio between observed hyperspectral radiances and corresponding simulated radiances computed from the line-by-line simulation. This is represented by

$$Ratio = \underset{i}{Ave}\left(\frac{R_{hyper,i}^{obs}}{R_{hyper,i}^{sim}}\right), \qquad (1)$$

where $R_{hyper,i}^{obs}$ and $R_{hyper,i}^{sim}$ are respectively observed and simulated radiances of the i'th hyperspectral channel. Figure C1 shows that the simulated AIRS spectrum adjusted by a factor of the average ratio (green curve) computed over the MTSAT-1R spectral region (orange curve) is closer to the measured AIRS spectrum (blue points) than the no-adjusted spectrum (purple curve).

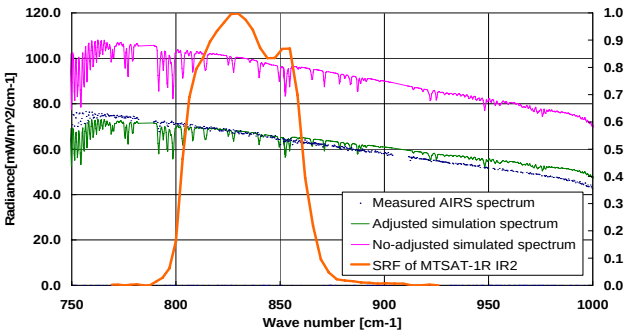

Figure C1: Observed and simulated AIRS spectra over the MTSAT-1R spectral region.

This approach is examined for comparison between the MTSAT-1R IR2 (12 μm) channel and AIRS. Over the channel IR2 spectral band, there is no significant AIRS gap. In this case, the SRF of the virtual channel (blue curve in Figure C2) fits well with the SRF of the channel IR2 (red curve). However, 59 AIRS channels are blacklisted over the IR2 range, and the quality of the SRF of the virtual channel degrades considerably (green curve). In actual AIRS observations, the number of useless channels is increased to about 70, and the SRF of the virtual channel become even more departed from that of IR2.

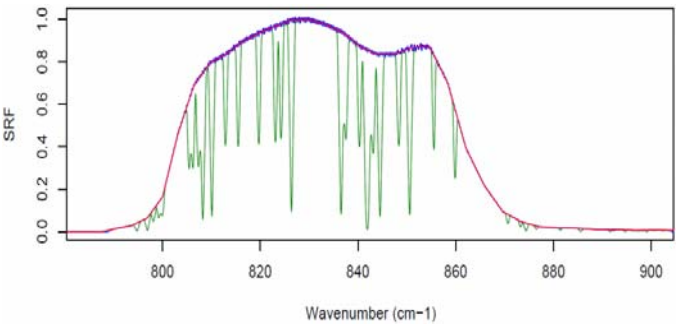

Figure C2: SRFs of MTSAT−1R IR2 (red) and its AIRS virtual channel using all AIRS channels (blue) and not using blacklisted channels (green).

Figure C3 shows the brightness temperature differences of the AIRS virtual channel computed with and without application of the proposed spectral gap filling method. Even though the

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observing region of the channel IR2 lies within the infrared window region, the impact of the AIRS failed channels yields -0.2 K to 0.1 K biases, which systematically vary with scene temperature. In the case of a comparison affected by AIRS failed channels and AIRS spectral gaps, the compensation is expected to be more effective.

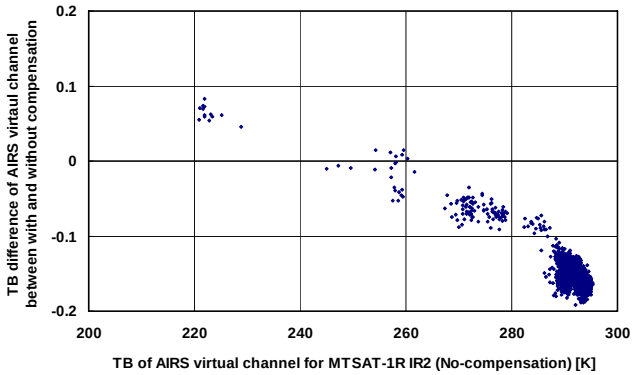

Figure C3: The brightness temperature differences of the AIRS virtual channel for MTSAT-1R IR2, TB(w/ compensate) - TB(w/o compensate).

The applicability of the proposed compensation method to water vapor and shortwave window channels that are affected by AIRS spectral gaps is still under study.

Acknowledgements: I am very grateful to Dr. Fred Wu for supervising this inter-calibration work in NESDIS.

(K. Kato and Dr. Y. Tahara [JMA])

Inter-Calibration of IASI with MSG-1/2 onboard METEOSAT-8/9

EUMETSAT successfully conducted inter-calibration of IASI with the SEVIRI instruments onboard Meteosat-8 and -9. For five consecutive days (27APR07 – 01MAY07), the differences between IASI and seven of the eight MSG thermal channels were stable and small. Results for 27APR07 (Table 1) show that the mean differences between IASI and MSG are less than 0.5 K; the maximum differences (not shown) are less than 1 K. In addition, the differences between the two Meteosats, using IASI as reference, were extremely small. The only exception is the 13.4 μm channel of Meteosat-9, which shows a large difference with respect to IASI (and thus also to Meteosat-8). This discrepancy, however, is in line with the ECMWF radiance monitoring, and is probably due to a change in the filter's spectral response function following sensor decontamination (M. König, EUMETSAT). This latter point is still under investigation at EUMETSAT, but the example here shows that the inter-calibration can help in both finding problems with the filter function and possibly also offering a solution.

Table 1: Mean difference (K) between IASI and the eight IR channels of MSG onboard METEOSAT-8/9 on April 27, 2007.

Channel	IASI – Meteosat-8	IASI – Meteosat-9
IR3.9	-0.17	-0.20
WV6.2	-0.24	-0.40
WV7.3	-0.51	-0.14
IR8.7	0.15	0.15
IR9.7	0.17	0.20
IR10.8	0.16	0.07
IR12.0	0.19	0.08
IR13.4	0.44	1.70

(Dr. M. Köenig [EUMETSAT])

News in this Quarter

GRWG-II and GDWG-I Meeting Report

The second GSICS Research Working Group (GRWG-II) and the first GSICS Data Working Group (GDWG-I) meetings were held in conjunction during 12-14 June 2007 at the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) in Darmstadt, Germany. Attending the meeting were delegates from China Meteorological Administration (CMA), Centre National d'Etudes Spatiales (CNES), EUMETSAT, Korea Meteorological Administration (KMA), Japan Meteorological Agency (JMA), NOAA, and World Meteorological Organization (WMO). Also participating were scientists from the Langley Research Center (LaRC) of National Aeronautics and Space Administration (NASA), NESDIS National Climatic Data Center (NCDC), and Laboratoire de Météorologie Dynamique (LMD), Ecole Polytechnique. The two working groups held joint presentations at the beginning, joint discussions at the end, and one-day parallel sessions in the middle of the meeting.

A major achievement of the GRWG-II is the refined core capability of inter-calibrating infrared instruments on geostationary (GEO) and low-earth orbiting (LEO) platforms. This capability serves the common interest of members, and the inter-calibration techniques are flexible enough that individual members can extend them. Another major achievement is that delegates present from CMA and KMA were committed to operational processing of, respectively, the Chinese Feng-Yun series (FY-2C/D) GEO satellite, and Japanese MTSAT as a precursor for the Korean Communication, Ocean, and Meteorological Satellite

doi:10.7289/V5862DC9

(COMS). Also discussed at the meeting were the strategy for inter-calibration in the visible and near infrared spectrum, collaboration with the GDWG, and tasks for IR inter-calibration to be reported at the next GRWG meeting.

In GDWG-I, it was identified that for inter-calibration purposes a set of FTP servers should be provided to host the collocated data sets of the GEO and LEO satellites. The basis for GEO/LEO inter-calibration would be the AIRS and IASI data provided by NOAA and EUMETSAT. In addition it was proposed to provide MODIS and AVHRR data as well. The information of software used, news and tools will be maintained on the GSICS web site. The GDWG-II meeting will be together with GRWG-III in early 2008 in the US.

(by Drs. X. Wu and V. Gartner [NOAA]; Photo courtesy of Z. Rong, [CMA])

GSICS EXP-II Meeting Report

The second GSICS Executive Panel Meeting (EXP-II) took place in Geneva, Switzerland on 24 April 2007. The primary focus of GSICS EXP-II was to review the draft GSICS Operations Plan for 2007 and 2008. The Plan looks to establish communications between GSICS members via the GSICS web site; GSICS Quarterly; meetings of the Executive Panel, GRWG, and GDWG; and GSICS Reports. The Plan also covers many aspects of geostationary (GEO) to low-earth orbit (LEO) satellite inter-calibration algorithm development and evaluation, and it covers LEO-LEO inter-comparisons. Special emphasis is placed in The Plan on expanding the use of hyperspectral sounders, such as IASI and AIRS in the process of data inter-calibration. The Panel reviewed the draft operations plan provided by the GCC and adopted the first version of the *GSICS Operations Plan*, covering 2007 and 2008 (GSICS_Operations-Plan_v1.xls). The remainder of GSICS EXP-II was invested in discussing and coordinating GSICS Research and Data Working Group (GRWG and GDWG) activities, including the GRWG-II and GDWG-I held at EUMETSAT in mid June.

(by J. LaFeuille [WMO])

WMO Congress

The WMO Congress is the plenary assembly of all 188 WMO Members (states or territories) convened every four years. The 15th Session was convened from 7 to 25 May 2007 in Geneva. When reviewing the activities of the WMO Space Programme, WMO Congress expressed strong support for the GSICS project, with the firm expectation that GSICS would ensure the stability and accuracy of satellite measurements from different instruments and programmes, relate these measurements to absolute references, and enable precise recalibration of archived data.

(by J. LaFeuille [WMO])

GSICS Representation at Meetings and Workshops

GSICS representation at meetings and workshops gives the GSICS initiative valuable exposure to the broader calibration/validation (cal/val) community. It also helps to establish potential collaborations between GSICS and other cal/val working groups. In this quarter, Mitch Goldberg, GSICS Executive Panel Chair, gave an invited presentation about GSICS to the GOES-R Cal/Val Working Group (CVWG) Workshop held at the National Conference Center in Leesburg, VA, USA during 15-16 May 2007. He also gave a presentation to the Committee on Earth Observation Satellites (CEOS) Working Group on Cal/Val (WGCV) at their 27th Plenary held at the National Physical Laboratory in London, UK during 12-15 June 2007.

(by Dr. R. Iacovazzi, Jr. [NOAA])

The GSICS initiative was the topic of a recent news article in Nature Photonics. The article can be found at:
Nature **447**, 358-359 (24 May 2007) |
doi:10.1038/447358b; Published online 23 May 2007.

Just Around the Bend …

GSICS-related Meetings

- **Photonics**, **26-30 August 2007, San Diego, CA, USA:** Session on atmospheric and environmental remote sensing data processing and utilization III: Readiness for GEOSS.
- **CALCON Technical Conference, 10-13 September 2007, Logan, UT, USA**

GSICS Classifieds

Are you looking to establish a GSICS-related collaboration, or do you have GSICS-related internships, exchange programs, and/or available data and services to offer? In future issues, *GSICS Quarterly* will include a classified advertisements section on an as-needed basis to enhance communication amongst GSICS members and partners. If you wish to place a classified advertisement in the newsletter, please send a two to four sentence advertisement that includes your contact information to Bob.Iacovazzi@noaa.gov.

The GSICS Quarterly press crew is looking for short articles (<1 page), especially related to cal/val capabilities and how they have used to positively impact weather and climate products. **Please submit contributions at least two weeks prior to the end of each quarter to Bob.Iacovazzi@noaa.gov, GSICS Quarterly Co-editor.**