REPORT OF THE FIRST GSICS RESEARCH WORKING GROUP MEETING (GRWG-I)

NOAA Science Center, Camp Springs, Maryland, USA, 22-23 January 2007

SUMMARY: The GRWG-I was attended by representatives of WMO (the sponsoring organization of GSICS), the five GSICS members, and seven supporting organizations. The 31 participants were first briefed on the GSICS program including its mission, origin, structure, and relation with other programs and organizations. The GRWG-I then heard reports from members, reviewed the existing algorithm for GEO-LEO comparison in the VISNIR bands, decided upon the principles of the common algorithm to be used by all members, and drew plan for future activities.

INTRODUCTION

The first meeting of the Global Space-based Inter-Satellite Calibration System (GSICS) Research Working Group (GRWG) was held on 22-23 January 2007 at NOAA Science Center in Camp Springs, Maryland, USA. The main purpose of the meeting, as mandated by the first GSICS Executive Panel Meeting in October 2006, was to build consensus on the algorithm for inter-calibration between the geostationary (GEO) and low earth orbiting (LEO) satellites in the infrared (IR) spectrum. The meeting agenda is included as Appendix A.

Attending the GRWG-I were representative from the World Meteorological Organization (WMO), the sponsoring organization of the GSICS, and delegates from member organizations including 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), and the United States (US) National Oceanic and Atmospheric Administration (NOAA). Also invited to the meeting were external experts from the Goddard Space Flight Center (GSFC) and the Langley Research Center (LaRC) of the US 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 the Space Science and Engineering (SSEC) of the University of Wisconsin (UW). The list of meeting participants is included as Appendix B.

SESSION I: OVERVIEWS

After a brief welcome by Mr. Fred Wu, chair of the GRWG, Mr. Mitch Goldberg, chair of the GSICS Executive Panel, provided an overview of the GSICS program. He explained that GSICS is a WMO-sponsored collaboration among national and international agencies that manage operational environmental satellites. GSICS is largely motivated by the increasingly demanding users, due to both the sophistication of the traditional applications such as numerical weather prediction (NWP) and the expansion to the new applications such as climate monitoring. GSICS is also motivated by the rapidly growing global observing system in terms of the number and diversity of the sensors. The goal of the GSICS is to enhance satellite instrument calibration and satellite data validation, which are critical components of the global observing system. He then outlined the conception and evolution, components and organization, leadership and membership, near term and long term objectives, and the implementation plan of GSICS. In closing, he reminded the participants of the focus and expected outcome of the GRWG-I.

Mr. Greg Withee, NOAA's coordinator of Global Earth Observing System of Systems (GEOSS) and former NOAA Assistant Administrator of Satellite Service, offered a GEOSS perspective of GSICS. He praised the vision and enthusiasm of the GSICS program, endorsed that

what GSICS is inspired to accomplish are indeed critical to the success of GEOSS, but challenged the participants to come up with a mission statement that is concise and precise to the professionals, public, and administrators alike.

Mr. Jérôme Lafeuille, Chief of WMO Space-based Observing System Division, acting as secretary of the GSICS Executive Panel, highlighted activities carried out within the WMO Space Programme. He noted the key role the WMO Space Programme has played, with the support of the Coordination Group for Meteorological Satellites (CGMS) in coordinating member states' space activities to ensure and improve data dissemination and access, interoperability and interface standards, education and training. . He mentioned a new emphasis put on global mission planning in order to address climate requirements and to optimize the GEO, LEO and R&D constellations comprising the space-based Global Observing System. Optimization implies that CGMS Members rely on each other's satellites. In that context, it is a prerequisite for the WMO to promote the GSICS because shared data must be of comparable, consistent and high quality. He also reconfirmed the strong support to the GSICS by international bodies including CGMS, the Global Climate Observing System (GCOS), and the Committee on Earth Observation Satellites (CEOS).

Mr. Fuzhong Weng, Director of GSICS Coordination Center (GCC), presented the plan for GCC activities. He envisioned four components within the GCC, including Communication, LEO-LEO inter-calibration, GEO-LEO inter-calibration, and Data Acquisition and Product Dissemination. For resources, he enlisted the help from many of his staff, leveraged on the products or components of a number of past or concurrent projects, and linked GCC activities to a variety of programs for funding. As a precursor of the expected outcome of the GSICS, he demonstrated with examples the positive impact of NOAA's Integrated Calibration and Validation System (ICVS) on NOAA's operations.

Mr. Fred Wu, trying to keep the meeting on schedule, decided to summarize instrument characteristics at a later time. Instead, he reminded the participants to start focusing on the task on hand and pointed out a few things to ponder while reviewing the existing and constructing the consensus algorithm. It is imperative to be clear and to articulate clearly what each member is expected of the GSICS to do for them, and to make sure that the consensus algorithm meets most of the needs with minimal compromises. He also emphasized the importance of benchmark data, pseudo code, and results.

Mr. Johannes Schmetz, member of the GSICS Executive Panel, presented an overview of the EUMETSAT Polar System (EPS) and the early results from its first installment, the METOP-A. With a few minor exceptions, everything indicate that all instruments function well and excellent data and products can be expected for the decades to come. METOP-A exemplifies the beneficial and successful cooperation among the European Space Agency (ESA), CNES, NOAA, and EUMETSAT.

SESSION II: MEMBERS REPORT

Ms. Marianne König described the GEO-LEO inter-calibration at EUMETSAT, which has been most regular and persistent among members for nearly 10 years. One practical reason is that, for sensors onboard the spin-scan platform, and especially for those (METEOSAT-5/6) without functioning blackbody, inter-calibration is more valued in operational calibration. In the EUMETSAT algorithm, a collocation is defined as δt(difference in sampling time) < 15 minutes, $\delta\theta$ (difference in viewing zenith) < 5°, θ < 50°, and the GEO pixels interior to the LEO pixel are averaged to compare with LEO measurements. Difference in spectral response function (SRF) is accounted for by regression of the simulated channel radiances using TIGR profiles and RTTOV-

8.5. Results are used in operational calibration. In addition, EUMETSAT also perform GEO-GEO inter-calibration.

Mr. Yoshihiko Tahara described two types of GEO-LEO inter-calibration at JMA. One compares with the Advanced Very High Resolution Radiometer (AVHRR), whose spectral and spatial resolutions are comparable to that of Multi-functional Transport Satellite (MTSAT-1R). The other compares the MTSAT-1R with the Atmospheric InfraRed Sounder (AIRS), which has much higher spectral resolution but somehow coarse spatial resolution. A key component in the latter work is the constrained minimization that finds the optimal weights to spectrally convolve AIRS measurements to MTSAT-1R measurements. This approach works well for some channels but has large errors for the MTSAT-1R channels that contain spectral gap of AIRS measurements. A unique feature of both work is the separation of clear and cloudy scenes, a fine consideration in view that sensor performance (e.g., effect of nonlinearity) and scene characteristics (e.g., temporal stability and spatial homogeneity) could be rather different.

Mr. Peng Zhang could not come to the meeting in person but he called from Beijing in the middle of night to give a rather comprehensive overview of satellite instrument calibration at CMA. GEO-LEO inter-calibration was mentioned briefly. Judging from the results, the methodology seems similar to that adopted at JMA.

Mr. Byung-Ju Sohn came to the meeting but, due to family emergency, had to return home shortly before the meeting started. His presentation was displayed and distributed at the meeting. KMA is actively engaging in GSICS and will be represented in future GRWG meetings.

SESSION III: REVIEW OF ADDITIONAL ALGORITHMS

Mr. Mat Gunshor presented the GEO-LEO inter-calibration for the IR channels at the UW/CIMSS where, thanks to the vision of Mr. Paul Menzel, inter-calibration involving HIRS and AVHRR was pioneered and has been continuously carried out for more than ten years. In their recent work using AIRS, the comparison, as before, was based on average of large area near the nadirs of both LEO and GEO nadir. The comparisons were good for well covered GEO channels, but for channels with spectral gaps, such as the water vapor channel, the results were poor. After he filled the spectral gaps with computed spectral radiances, the differences were reduced dramatically, although it was not well understood why the simulated spectral radiances based on the US Standard Atmosphere led to better agreement than those based on the presumably more appropriate tropical atmosphere.

Mr. Dave Tobin demonstrated the depth of expertise in hyper-spectral remote sensing at the UW/SSEC with an overview of inter-calibration activities involving air-borne Scanning High-resolution Interferometer Sounder (S-HIS) and AIRS, plus a status report of the Geostationary Imaging Fourier Transfer Spectrometer (GIFTS). He also has a technique to fill the spectral gaps in AIRS measurements. In one example, he compared AIRS with GOES-10 Imager Channel 4 using near nadir clear pixels.

Mr. Ken Knapp reviewed the inter-calibration algorithm for the International Satellite Cloud Climatology Program (ISCCP). Based on the lessons learned there, he started a research at NCDC to independently evaluate the GEO calibration. He started with the algorithm by Wu et al but found that the targets selected by that algorithm have rather limited geographic distribution and dynamic range in scene temperature. Accordingly, he invented the proportionate noise filter to address these shortcomings.

Messrs. Pat Minnis, Louis Nguyen, and Dave Doelling have also been working on inter-satellite calibration for long time at NASA/LaRC. Their primary objective is to generate consistent product from measurements by various sensors, which requires timely standardization of these measurements using a common reference on earth (e.g., deep convective clouds, DCC) or in space (e.g., MODIS or CERES). Their GEO-LEO inter-calibration uses averages of large areas near nadirs. An impressive feature of their work is the infrastructure that automates the inter-calibrations among large number of satellites, the results of which are archived and are available on web in near real time. In addition, they are also working on GEO-GEO, LEO-LEO, and DCC inter-calibrations.

SESSION IV: CONSTRUCTION OF CONSENSUS ALGORITHM

The second day of the GRWG-I was devoted to the discussion of the common algorithm for GEO-LEO IR inter-calibration. After summarizing the accomplishments of Day 1, Fred Wu reiterated the importance of envisioning the purposes and intended utilities of the inter-calibration results before the work is started. Each member may have different priority on these purposes and utilities, as well as unique opportunities to realize them. Ideally, the resultant algorithm should maximize the existing expertise and opportunities to optimally reflect the common purposes and utilities among the members.

It was quickly agreed upon that we should initially focus on inter-calibration between AIRS and GEO imaging instrument. The primary reasons are: (1) AIRS is a well calibrated and well understood instrument; and (2) Inter-calibration using AIRS has the least uncertainty due to spectral difference among GEOs, especially for channels absent of spectral gaps in AIRS measurements. We will expand to IASI as soon as the data are available and stable, but we will not delay the program for that. Inter-calibration in visible and near IR and with measurements by other sounding (HIRS) or imaging (MODIS, AVHRR) instruments will follow.

It was also agreed that, in principle, we should collect as much data as possible and down select later during analysis phase, to the extent that the data volume is manageable. However, this principle needs to be further quantified.

Six aspects of the algorithm were elaborated, including difference in time; spatial error due to navigation or point spread function (PSF) or, equivalently, uniformity requirement; scene type; viewing geometry; spectral correction; and aerial coverage. For each of these categories, what were used in existing algorithms and what is proposed for the common algorithm are summarized, with additional consideration when relevant.

It was recognized that the GRWG can decide on algorithm in principle, which GCC will convert to pseudo code, but each GPRC must implement the algorithm individually. To be sure that the common algorithm is properly implemented everywhere, it is important to prepare a common data set and the results together with the pseudo code. For this purpose, we plan to collect one day data for November 2, 2006. NASA/LaRC will provide the GOES-10/12, METEOSAT-8/7, and FY-2C data; JMA will provide the re-navigated MTSAT-1R data; and GCC will provide the AIRS data.

Three spectral correction algorithms were considered. Tahara's constrained optimization is more appropriate for continuous spectral radiances such as those from IASI. Gunshor's gap filling is simple and seems to work well but, presently, is weaker in theoretical basis. The GRWG chose the algorithm by Tobin, who agreed to provide the pseudo code and test data in two weeks.

All data, code, and document provided to the GCC will be available to all GSICS members and, through members, other participants.

The selected algorithm is meant to serve as a baseline. The main purpose of this initial exercise is to ensure that identical results can be obtained by all members using the same algorithm and data. Improvement upon the initial algorithm is expected, in fact inevitable. Existence of parallel algorithms is also possible, as long as each member maintains and executes the common algorithm as required by the GCC.

The one-day data will be used primarily to discover and remove possible discrepancy in data processing and algorithm implementation among members. After that, and with modification as necessary, we will perform a test run for the month of April, using IASI data as well if available. We will then allow some time for members to evaluate how well the results serve their needs, modify the algorithm as necessary, and start the normal operation in fall 2007.

The next meeting, GRWG-II, is scheduled for June in Europe, in conjunction with the first GSICS Data Working Group (GDWG-I). We will review the progress of the GEO-LEO IR inter-calibration and work with GDWG on data issues. Additional topics may include the expansion to VISNIR spectrum and LEO-LEO inter-calibration.

Mr. Fred Wu summarized the discussions and actions to be taken:

- Tobin: Provide spectral correction algorithm.
- Nguyen: Provide GOES-11/12, METEOSAT-7/8, and FY-2C data for Nov. 2, 2006
- Tahara: Provide MTSAT-1R data for Nov. 2, 2006
- Wu:
    - Make meeting material available on web (done – see http://www.orbit.nesdis.noaa.gov/smcd/spb/calibration/icvs/GSICS/
    - Write a meeting report to GSICS Executive Panel/WMO
    - Provide pseudo code of the inter-calibration algorithm
    - Provide AIRS data for Nov. 2, 2006
    - Make all data and code available to all members

Mr. Mitch Goldberg delivered the closing remarks. He thanked the participants for sharing their time and expertise for this important program, and he expressed his confidence that members would return to their respective institute, perform what have been agreed upon, and reconvene in June with great progress.

The meeting was then adjourned.

Appendix A: GRWG-I MEETING AGENDA

GLOBAL SPACE-BASED INTER-CALIBRATION SYSTEM (GSICS)
1st Meeting of GSICS Research Working Group (GRWG-I)

22-23 January 2007
Rm. 707 NOAA Science Building, 5200 Auth Road, Camp Springs, Maryland, USA

DAY 1

Morning:	**Overview of the GSICS Program and GRWG-I**	
09:00 – 09:15	Welcome / Introduction	Mitch Goldberg
09:15 – 09:45	Overview of GSICS Program and Goals for GRWG-I	Mitch Goldberg
09:45 – 10:15	GEOSS Coordination	Greg Withee
10:15 – 10:30	WMO Space Program Update	Jerome Lafeuille
Coffee Break		
11:00 – 11:30	GSICS Coordination Centre	Fuzhong Weng
11:30 – 12:00	Overview of Instruments Characteristics	Fred Wu
12:00 – 12:30	Early Result of METOP-A	Johannes Schmetz
Lunch		
Afternoon:	**Presentation of Existing GEO-LEO Inter-Calibration Algorithms**	
13:30 – 14:00	EUMETSAT	Marianne Koenig
14:00 – 14:30	JMA	Yoshihiko Tahara
14:30 – 15:00	CMA	Peng Zhang
15:00 – 15:30	KMA	B. J. Sohn
Coffee Break		
16:00 – 16:30	UW/CIMSS	Gunshor / Tobin
16:30 – 17:00	NASA/LaRC	Doelling / Minnis
17:00 – 17:30	ISCCP	Ken Knapp

DAY 2

Morning: Development of the GSICS GEO-LEO IR algorithm

09:00 – 10:30	Topics include Instrument selection: Which GEO and LEO and which instruments Match: time/space window, nav error, whether/how to correct View geometry: Tolerance threshold Spectral: Available methods for broadband and AIRS/IASI Test Data: Four weeks/months in each season Benchmark Result: For future S/W & H/W update etc. Uniform procedure and data/product format, yet flexible to different GEO	Fred Wu / All
Coffee Break		
11:00 –- 12:30	Adoption of the GSICS GEO-LEO Inter-Calibration Algorithm	Fred Wu / All
Lunch		

Afternoon: Plan for the Next Step

13:30 – 14:30	Tasks for all GPRCs before the Next GRWG	Fred Wu / All
14:30 – 15:00	Date, Venue, and Focus of the Next GRWG	Fred Wu / All
Coffee Break		
15:30 – 16:30	Summary of the GRWG-I Outcomes	Fred Wu
16:30 – 16:45	Closing Remarks	Mitch Goldberg
16:45	Meeting Adjourned	

Appendix B: GRWG-I MEETING PARTICIPANTS

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