GLOBAL SPACE-BASED INTER-CALIBRATION SYSTEM (GSI CS)

By
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Chair of GSI CS Executive Panel

Acknowledge to Dr. M. Goldberg, Dr. J. Lafeuille, Dr. L. E. Flynn, Dr. Manik Bali

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Outline

• GSICS Introduction
• 14th and 15th Exec Panel Highlights
• Vision for GSICS
• Outreach and Challenges
Global Space Based Inter-calibration System (GSICS) is an international collaborative effort initiated in 2005 by WMO and the CGMS to monitor, improve and harmonize the quality of observations from operational weather and environmental satellites of the Global Observing System (GOS). This is achieved through a comprehensive calibration strategy which involves:

- Monitoring instrument performances.
- Operational inter-calibration of satellite instruments.
- Tying the measurements to absolute references and standards and recalibration of archived data.
- GSICS delivers calibration products corrections needed for accurately integrating data from multiple observing systems into products, applications and services.

- Improve consistency between instruments.
- Reduce bias in Level 1 and 2 products.
- Provide traceability of measurements.
- Retrospectively re-calibrate archive data.
- Better specify future instruments.
14 Members Worldwide

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Gap analyses at both ends

Space-based Sensor Inventory

Potential for FCDRs in support of ECV product generation

GAPS?

ECV Product Inventory

Actual ECV product generation

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GSICS Products

- Near Real Time Correction Product
- Re-Analysis Correction Product

GSICS also identifies best practices and principals

Critical need to evaluate and assign maturity to the product
Executive Panel Highlights

• 14th Executive Panel, Tokyo, 15-16 July 2013
  – CMA, EUMETSAT, JAXA, JMA, NASA, NOAA, Roshydromet, WMO and GCOS (Observer)
  – Developed a Vision for GSICS

• 15th Executive Panel, Guangzhou, 16-17 May 2014
  – CMA, CNES, EUMETSAT, ISRO*, JAXA, JMA, KMA, NASA, NOAA, Roshydromet, USGS*, WMO, CNSA (Observer), CEOS/WGCV (Observer*)
  – Designated new Chair and Vice-Chair, with ToR
  – Discussed scope of GSICS Products and role of GSICS in the Architecture for Climate Monitoring

(*): remote participation

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GSICS leadership

- Executive Panel:
  - Mitch Goldberg (NOAA) chaired the EP for 8 years
  - Peng Zhang (CMA) elected Chair by EP-15 with Ken Holmlund (EUMETSAT) as Vice-Chair

- GRWG
  - Tim Hewison (EUMETSAT) current Chair until 2015
  - Fred Wu (NOAA) and Kim Dohyeong (KMA) Vice-Chairs
  - Masaya Takahashi (JMA) new Vice-Chair

- GDWG
  - Manik Bali (NOAA) interim Chair
  - More engagement of operational agencies is needed in GDWG

- GSICS Coordination Centre (GCC)
  - NOAA (Larry Flynn, Manik Bali)
  - The GDWG-GCC interaction needs to be further clarified
Introduction to GSICS/GCC
http://gsics.wmo.int

Introduction to GSICS/GCC
www.star.nesdis.noaa.gov/smcd/GCC/
gsics.nesdis.noaa.gov/wiki/GPRC/LeoLeo
gsics.nesdis.noaa.gov/wiki/Development/20140324

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GSICS Principals

• Systematic generation of inter-calibration products
  • for Level 1 data from satellite sensors
  • to compare, monitor and correct the calibration of monitored instruments to community references
  • by generating calibration corrections on a routine operational basis
  • with specified uncertainties
  • through well-documented, peer-reviewed procedures
  • based on various techniques to ensure consistent and robust results

• Delivery to users
  • Free and open access
  • Adopting community standards

• To promote
  • Greater understanding of instruments’ absolute calibration, by analysing the root causes of biases
  • More accurate and more globally consistent retrieved L2 products
  • Inter-operability for more accurate environmental, climate and weather forecasting products

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GSICS Procedure for Product Acceptance

- Based on QA4EO
- Products progress from
  - Demonstration Mode
- Through
  - Pre-Operational Mode
- To
  - Operational Mode
- By a series of reviews
- Over period of ~1.5yr
- Subject to meeting acceptance criteria

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A Vision for GSICS in 2020s:

Shaping GSICS for future challenges

GSICS is ...

- A collaborative framework among satellite operators and science teams to develop, implement and share community-agreed best practices and standards, procedures and tools
- ...to monitor, improve and harmonize the calibration of GOS environmental satellites
- Focus: systematic generation of in-orbit inter-calibration information to refine the individual calibration of Level 1 satellite data

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A Vision for GSICS in 2020s: *Shaping GSICS for future challenges*

**GSICS aims to enable satellite operators...**

- to assess uncertainties, and to assess calibration methods
- to deliver state-of-the-art NRT calibration
- to understand and mitigate the calibration differences
- to share knowledge, development effort, test data sets and references...

**GSICS benefits to users and WMO programmes**

- Time-consistency, comparability and traceability of climate data records for the Architecture for Climate Monitoring from Space
- Consistent multi-satellite data for composite products
- Error characterization for NWP
- Enable integration of observation systems (WIGOS)
A Vision for GSICS in 2020s: *Shaping GSICS for future challenges*

**Membership**
- All CGMS Members are encouraged to participate & benefit from GSICS.
- Other governmental agencies can attend as observers

**Partnerships**
- Increasing collaboration with CEOS/WGCV (IVOS)
- GCOS Reference Upper Air Network (GRUAN)
- WMO Workshop on GRUAN-GSICS-GNSS-RO collaboration
- Envisaged: with the metrology community BIPM, WMO/CIMO and Radiative Transfer Models (RTM) community (e.g. ITWG)
A Vision for GSICS in 2020s: *Shaping GSICS for future challenges*

**Core principles**

- Calibration of satellite instruments is monitored and assessed by comparing with community references, using common methodologies, international standards, *best practices*, & ultimately SI-traceable standards.

- Continuous chain of comparisons with stated uncertainties, to ensure *metrological traceability*.

- Calibration corrections are generated for both *Near-Real-Time use* and *retrospective analyses*, with specified uncertainties, through documented, *peer-reviewed procedures* to ensure consistent and robust results (...)

- Inter-calibration assessments, comparisons and corrections are delivered through *free and open access*, adopting community data standards.

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Outreach

• Quarterly newsletter (revamped)
• User Workshops
  – Spring 2013 – NOAA
  – October 2014 – CMA, Shanghai
• GRWG – promoting scientific partnerships
• IEEE-TGRS special issue on satellite calibration
  (collaboration with CEOS/WGCV)
• User messaging service
• Certificates of Appreciation for reviewers

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GSICS Products and Services

- GSICS Bias Monitoring
  - Routine comparisons of satellite radiances against reference

- GSICS Correction
  - Function to correct issued radiances
  - For consistent calibration with reference

- GSICS Reports & Guidelines
  - Recommendations to modify practices
  - Design and Operation of future satellite instruments

- For Operational Environmental Satellites
  - Intra-red recalibration (GEO and LEO)
    - (current operational satellites)
  - Visible and near-infrared recalibration (GEO and LEO)
  - Microwave – Conical & Cross-track Scanners (LEO)
  - Historical Instruments

Operational (IASI) or research instruments (MODIS, AIRS) are used for references.

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Product Use Case-1

IR Calibration Bias of FY-2 VISSR

FY-2 vs IASI+AIRS

Significant progresses were made in FY-2 operational calibration (Changed to GSICS in 2012)

Operational calibration of FY-2D/2E was upgraded using GSICS inter-calibration algorithm in 2012-04 and 2012-01 separately.

The calibration biases were sharply decreased, and reduced to about 0.5~1K @290K (@250K) without eclipse period.

Time series of TBB biases for IR1~3 channels vs AQUA/AIRS reference scenes (290 K for IR1 and IR2, 250 K for IR3).

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Product Use Case-2
GSICS Correction Algorithm for Geostationary Infrared Imagers

Before: 3K Bias

After: ~0K Bias

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Initial Projects for the GRWG UV Subgroup

1. Best practices for BUV on-ground and in-flight calibration and characterization. This project seeks to build on the lessons learned from past instruments to identify the key areas of calibration that will most benefit the mission goals.

2. Solar UV measurement project. This project’s goal is to create quantitative comparisons among the solar spectra measured by the different instruments.

3. Calibration of reflectivity and aerosol channels. This project’s goals are to develop vicarious calibration methods and provide comparisons for monitoring the BUV measurements for channels with little trace gas absorption, primarily from 340 nm to 405 nm.

4. Calibration comparisons for 240 nm to 300 nm. The fourth project seeks to develop comparisons of radiance / irradiance ratios from 240 nm to 300 nm.
The sensor response presents a linear varying trend with seasonal patterns.

For most bands from green to near-infrared, the responses tend to be lower from November to February than from May to August, especially for the red and near-infrared spectral region, e.g., band 3 (650 nm), 4 (865 nm), 13 (650 nm), 14 (685 nm), 15 (765 nm), and 16 (865 nm). However, the phenomenon tends to be different for blue bands, e.g., bands 1 (470 nm), 8 (412 nm), and 9 (443 nm).
Degradation monitoring using DCC method

DCC can be identified by MERSI infrared brightness temperature (< 205 K) within ± 20° N, and the response degradation of MERSI RSBs are derived by DCC monitoring on a monthly basis.
Product Monitoring at NOAA

Standard scene temperature for GOES-13 Imager is defined as [255.7K, 244.8K, 234.0K, 206.8K] for the four IR channels. In addition to the Tb bias at the standard scene temperature, the daily mean Tb bias at the homogeneous scenes are also monitored and plotted.

Bias Monitoring

Tb Corr validate C52 (3.9um)

GOES13 vs. IASI Tb Bias before/after GSICS Correction (night time)

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Product Monitoring at JMA

GSICS MTSAT Infrared Inter-calibration

**MTSAT-1R IR Inter-calibration with AIRS/AQUA and IASI/METOP A**

**Courtesy : JMA GPRC**

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Product Monitoring at KMA

Courtesy : KMA GPRC
GSICS Coordination Center, NOAA

Quarterly Newsletter

Articles of 700-800 word length with 2 Figures and 1 Table acceptable. Contact Manik Bali for more info.

- GSICS Quarterly Newsletter
  - Brand new format.
  - Newsletter has doi.
  - Accepts articles on topics related to calibration (Pre and Post launch).
  - Rate and Comment section readers and authors can interact.
  - Register at Messaging Service to get Newsletter
Challenges: Calibration references

- GSICS strives to ensure well characterized, on-orbit calibration reference standards, and to provide traceability to these references.

- IASI-A, MODIS are currently the primary references in IR and VIS. Additional references (AIRS, IASI-B, CrIS in the future) tied to the primary reference increase robustness. Excellent consistency between these instruments: the mean Tb difference between AIRS, IASI and CrIS is between 0.1 K to 0.2 K.

- Polar orbiting reference instrument in different orbital planes would reduce risk of undetected diurnal bias in GEO-LEO due to solar intrusion on current 3-axis stabilized geo imagers.

- GSICS should promote on-orbit SI-traceable references (e.g. CLARREO) which could leverage the traceability of the whole EO system.
Challenges: GSICS and Climate

- GSICS provides tools (best practices and references) enabling the production of **climate data records** by satellite operators and climate projects (SCOPE-CM, GEWEX, reanalysis)
- Contributes to the Architecture for Climate Monitoring from Space

**Fig. 2.** The role of GSICS in the end-to-end process of creating satellite-based climate data records operationally by the WMO’s SCOPE-CM program from observations of the satellite component of the GOS.
Summary

• GSICS is progressing in the right direction
• Science collaboration has never been so active!!
• Need to improve engagement in data working group.
• The GPPA procedure has the rigor needed to provide confidence in GSICS products
• GSICS is an integral part of the climate architecture
• GSICS Quarterly Newsletter attracts broad audience and contributions

• More engagement of operational agencies is needed in GDWG
• High appreciation of the attending GSICS session in this AOMSUC

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SESSiON 6 : Global Spaced-based Inter-Calibration System (GSI CS)
Chairs: Zhang Peng / Kenneth Holmlund

14:00     NOAA/ NESDIS, Fuzhong Weng
Characterization of ATMS on-orbit calibration accuracy for GSI CS Applications
14:15     ESSIC, University of Maryland, Likun Wang
Inter-Comparison of Suomi NPP CrIS Radiances with AI RS and IASI toward
Infrared Hyperspectral Benchmark Radiance Measurements
14:30     EUMETSAT, Tim Hewison
Update on GSICS Inter-Calibration Product Development
14:45     CMA/ NSMC, Hu Xiuqing, Xu Na
CMA GSICS product development and services
15:00     NOAA/ NESDIS, Lawrence E. Flynn, Manik Bali
Report on GSICS Coordination Center Activities and Plans

P13 Diurnal variation of Inter-calibration for COMS Infrared channels    KMA/NMSC, Tae-Hyeong Oh
P16 Solar Backscatter Ultraviolet Instruments (BUV) instruments on Satellites in GEO and L1 orbits.
NOAA/NESDIS, Lawrence E. Flynn
P17 In orbit determination and validation of Spectral Response Function using IASI Radiances and GSICS SNO
Comparisons    NOAA/NESDIS, Manik Bali

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