The Contribution of the Global Space-based InterCalibration System to US-International Partnerships

NOAA Satellite and Information Service

Dr. Mitch Goldberg, JPSS Program Scientist and first GSICS EP Chair

2016 September JPSS Science Seminar
The aim of GSICS

• To organize the production of satellite inter-calibration information to enable improved and consistent accuracy among space-based observations worldwide for climate monitoring, weather forecasting, and environmental applications.

• Why? Foundation for all applications are the fundamental measurements
Inter-Calibration is Critical for Climate Change Detection

Trend of global oceanic total precipitable water decreases from 0.54 mm/decade to 0.34 mm/decade after intercalibrations! Calibration uncertainties translate to uncertainties in climate change detection.
The 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.
GSICS Mission

- To provide sustained calibration and validation of satellite observations

- To intercalibrate critical components of the global observing system to climate quality benchmark observations and/or reference sites

- To provide corrected observations and/or correction algorithms to the user community for current and historical data
The Space Programme of WMO initiated a discussion and held several meeting in 2005 to develop the concept of a Global Space-based Inter-Calibration System (GSICS). The following experts participated:

- Mitch Goldberg – NOAA/NESDIS (Chair)
- Gerald Frazer – NIST
- Donald Hinsman – WMO (Space Program Director)
- John LeMarshall - JC Sat. Data Assimilation
- Paul Menzel – NOAA/NESDIS
- Toshi Kurino - JMA
- Tillmann Mohr – WMO
- Hank Revercomb – Univ. of Wisconsin
- Johannes Schmetz – Eumetsat
- Jörg Schulz – DWD, CM SAF
- William Smith – Hampton University
- Steve Ungar – CEOS, Chairman WG Cal/Val
Building Blocks for Satellite Intercalibration

• **Collocation**
  – Determination and distribution of locations for simultaneous observations by different sensors (space-based and in-situ)
  – Collocation with benchmark measurements

• **Data collection**
  – Archive, metadata - easily accessible

• **Coordinated operational data analyses**
  – Processing centers for assembling collocated data
  – Expert teams

• **Assessments**
  – Communication including recommendations
  – Vicarious coefficient updates for “drifting” sensors
Critical building blocks for accurate measurements and intercalibration

- Extensive pre-launch characterization of all instruments traceable to SI standards

- Benchmark instruments in space with appropriate accuracy, spectral coverage and resolution to act as a standard for inter-calibration

- Independent observations
  - Calibration/validation sites, ground based, aircraft
• Fully characterized sensor components
  – Traceability standard
    • Full instrument cycle test to ensure every component is traceable to SI standard
  – Pre-launch tests
  – Sustained post-launch characterization
    • Satellite to Satellite comparisons
    • Collocated in-situ observations
    • Radiative transfer models
    • Data assimilation models
GSICS Structure & Partnerships

GSICS Coordination Center

GSICS Research Working Group

GSICS Data Working Group

VIS/NIR Sub-Group

Microwave Sub-Group

UV Sub-Group

Future Sub-Groups...

WGCV IVOS

WGCV MWSG

GPM X-CAL

WGCV ACSG

CEOS ACC

EUMETSAT

CNES

JMA

NOAA

CMA

KMA

ISRO

NASA

WMO

USGS

NIST

ROSHYDROMET

IMD

ESA

Global Space-based Inter-Calibration System
Current GSICS leadership

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

• GRWG
  – Tim Hewison (EUMETSAT) current Chair until 2015
  – Fred Wu (NOAA) and Kim Dohyeong (KMA) Vice-Chairs
  – Masaya Takahashi (JMA) new Vice-Chair
  – Ralph Ferraro (NOAA) MWSG new Chair
  – Lawrence Flynn (NOAA) UVSG new Vice-Chair

• GDWG
  – Manik Bali (NOAA) interim Chair to 1/2015
  – New Co-chairs from JMA and EuMetSat 2/2015 on

• GSICS Coordination Centre (GCC)
  – Director Larry Flynn (NOAA), Deputy Director Manik Bali (NOAA)
Who we are

GSICS Executive Panel 2015 Guangzhou

GRWG/GDWG 2009 Tokyo
GSICS Procedure for Product Acceptance

- 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

Figure 1: From top to bottom, the GSICS Procedure for Product Acceptance is described by four phases: Product Submission Phase, Demonstration Phase (DP), Pre-operational Phase (PP), and Operational Phase (OP) — and their review and revision cycles. The time markers at the far right, and their defined limits, are: date of submission (D₀); and the number of days from D₀ to fulfill requirements to enter DP (D₁DP ≤ D₀+90days), PP (D₁PP ≤ D₁DP+365days), and OP (D₁OP ≤ D₁PP+180days).
GSICS Product Acceptance Documentation

- Product Algorithm Theoretical Basis Documentation (ATBD)
  - Discussion of physical principles supporting the product
- Software Document
- Algorithm flowchart
  - including data I/O, logic and software module descriptions
- Software that meets GSICS standards
  - On coding, I/O, filename, and documentation (TBD)
- Software verification results
- Version Control Plan
  - Describes process of performing software/model/measurement updates and archive
GSICS Coordination Center Roles

NOAA continued in its role as the lead for the GCC providing the director and deputy director, guiding products through the GPPA, hosting the GSICS products and development websites, helping to organize the 2014 User’s Workshop (as a session at the AOMSUC in Shanghai) and the 2015 User’s Workshop (to be held with the EUMETSAT conference in Toulouse), and producing the GSICS Quarterlies.

GSICS Procedure for Product Acceptance (GPPA) Timeline

<table>
<thead>
<tr>
<th>Phase</th>
<th>Activities</th>
</tr>
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<tr>
<td>Submission Phase</td>
<td>Fill out GSICS Product Acceptance Form (GPAF)</td>
</tr>
<tr>
<td>Demonstration Phase</td>
<td>Founding concepts, Supporting models, ATBD, Peer-Publications, Traceability</td>
</tr>
<tr>
<td>Preoperational Phase</td>
<td>Product version Control, Operations and distribution plan</td>
</tr>
<tr>
<td>Operational Phase</td>
<td>Product is fully accepted by GSICS Executive Panel (EP) and maintained within GSICS and distributed to the public.</td>
</tr>
</tbody>
</table>

Some key GSICS/GCC/GPRC websites at NOAA

www.star.nesdis.noaa.gov/smcd/GCC/ProductCatalog.php
https://gsics.nesdis.noaa.gov/wiki/GPRC/
https://gsics.nesdis.noaa.gov/wiki/Development/WebHome
www.star.nesdis.noaa.gov/smcd/GCC/
Since Fall 2013, brand new format.

Since Winter 2014, the Newsletter has a doi.

Accepts articles on topics related to calibration (Pre and Post launch).

New Landing page on the GCC website.

Rate and Comment section: readers and authors can interact.

Articles are reviewed by subject experts.

Help available to non native English speaking contributors.

Since Fall 2014, new navigation features added to the Cover Letter.
GSICS Intercalibration Methodology

Simultaneous Nadir Overpass- Two in-orbit instruments observe ‘a’ target under similar viewing conditions.

Step 1. Identification of Collocated Pixels that satisfy GSICS selection criterion.

Step 2. Selection of pixels for inter-comparison

GSICS collocated pixel selection criterion
- Time difference of observations < 5 Min
- Atmospheric path diff $\Delta \text{sec}(\text{sat. zenith angle}) < 0.01$

Uniformity Constraint
- STD (GEO pixels within LEO FOV) < 0.01 K (yellow in figure below).
- STD (GEO pixels around the LEO pixel) < 1 K (Green in figure below). One reference (say IASI) instrument footprint is compared with the averaged value of the GOES pixels falling into that IASI footprint (see below).

Step 3. Convolution and Comparison

GSICS Product
Regression coefficients

$R$ is the Hyperspectral Radiance
$S$ is the spectral response function
$L$ is the IASI convolved radiance
$V$ is the wavenumber

$$L_i = \frac{\int_{v_1}^{v_2} R(v)S_i(v)dv}{\int_{v_1}^{v_2} S_i(v)dv}$$

Inter-comparison also done by using DCC as transfer target

Final Result
Correction Formula
To be applied on Monitored Instrument
First international coordinated GSICS project is the intercalibration of geostationary infrared channels with IASI and AIRS
GSICS Correction Algorithm for Geostationary Infrared Imagers

GSICS will provide correction coefficients for all GEOs from 2003 (beginning of AIRS record) to present

The first major deliverable to the user community is the GSICS correction algorithm for geostationary satellites.

The user applies the correction to the original data using GSICS provided software and coefficients.

The correction adjusts the GOES data to be consistent with IASI and AIRS.

The figures to the left show the difference between observed and calculated brightness temperatures (from NCEP analysis) before and after correction.

The bias is reduced from 3 K to nearly zero.
GSICS Product Portfolio

• For Operational Meteorological Satellites
  – Geostationary – IR & Solar
  – LEO – IR, Solar, UV, and Microwave – Conical & Cross-track Scanners
  – Current Operational & Historic Instruments
  – In near real-time and re-analysis modes
• GSICS Bias Monitoring
  – Routine comparisons of satellite radiances against reference
• GSICS Correction
  – Function to correct issued radiances
  – For consistent calibration with reference
• GSICS Diagnosis
  – Recommendations to modify practices
  – Design and Operation of future satellite instruments
Achieving 0.1 K absolute calibration is important for verifying real climate trends

- Through detail validation we have demonstrated that both CrIS and IASI have achieved a high level climate monitoring performance capability.
- Climate monitoring performance allows you to minimize the time to detect a real climate trend from natural variability.
- In the figure to the right, we see that a trend of 0.1 K per decade would take 20 years to confirm with perfect observations.
- While a calibration accuracy of 0.1 would take about 25-27 years
- While a calibration accuracy of 0.3 would take about 50 years.
- This chart would imply that CrIS and IASI are not good for monitoring trends. The accuracy noted in the chart for IASI, AIRS, CRIS are from the specification
- Good news - CrIS and IASI are approaching 0.1 K - beating the specification by significant margins

March 2015 Greenland SNPP campaign

SNPP-2 Calibration Validation

- Mission Goals:
  - radiometric calibration validation over cold clear scenes
    - Resolve CrIS and IASI differences
  - assess satellite T/q profile retrievals for cold scenes
- Flights out of Keflavik from March 7-29, 2015
  - ~4.8 hours per flight lag time over Greenland Ice Sheet
- Primary Target – SNPP
- Secondary Targets – METOP A and B, Aqua, Terra

SNPP – 2 CalVal Payload

- S-HIS (Scanning High-resolution Interferometer Sounder)
  - cross-track scanning interferometer sounder which measures emitted thermal radiation at high spectral resolution between 3.3 and 18 microns
  - [https://shis.ssec.wisc.edu](https://shis.ssec.wisc.edu)
- NAST-I (NPOESS Airborne Sounding Testbed-Interferometer)
  - high spectral resolution (0.25 cm^-1) and high spatial resolution (0.13 km linear resolution per km of aircraft flight altitude, at nadir) scanning
- NAST-M (NPOESS Airborne Sounding Testbed-Microwave)
  - passive microwave spectrometers
- MASTER (MODIS Airborne Simulator)
  - visible, shortwave infrared, and thermal infrared channels
Assessment of the calibration accuracy for cold Earth scenes

Mean SNO differences for 910-930 cm\(^{-1}\)

- AIRS - IASI-A
- AIRS - IASI-B
- CrIS - IASI-A
- CrIS - IASI-B

Error-bars represent statistical matchup uncertainty, not sensor uncertainty

0.050 K Agreement

> 0.3 K relative differences

Decreasing Scene Temperature
Preliminary Analysis and Results:
SNPP Calibration Validation Campaign 2015

SNAP2015, 850–900 cm\(^{-1}\)

Credit: Tobin

**PRELIMINARY: Native spectral resolutions (no DOMC)**

- Red circles: CrIS
- Blue squares: IASI–A
- Green triangles: IASI–B
- Black triangles: AIRS

Error bars only represent spatial variation for footprints used in comparisons.
GSICS correction is negligible for AHI

MTSAT-2 Infrared Channel
- IRL (10.8 μm)
- IRL2 (12.0 μm)
- IRL3 (6.5 μm)
- IRL4 (3.8 μm)

LEO Data
- AIRS & IASI-A (asc & Des)
- AIRS (desc. 1.303μm)
- IASI-A (desc. 9.30μm)
- IASI-B (desc. 9.30μm)
- AIRS (asc. 1.303μm)
- IASI-A (asc. 9.30μm)
- IASI-B (asc. 9.30μm)

Time Sequence
- TB difference
- Regression coef.

Statistics for GSICS Correction
- Scatter plot (DN)
- Scatter plot (Rad)

AHI Infrared Bands
- Band07 (3.9 μm)
- Band08 (6.2 μm)
- Band09 (6.9 μm)
- Band10 (7.3 μm)
- Band11 (8.6 μm)
- Band12 (9.6 μm)
- Band13 (10.4 μm)
- Band14 (11.2 μm)
- Band15 (12.4 μm)
- Band16 (13.3 μm)

LEO Data
- AIRS (all)
- IASI-A (all)
- IASI-B (all)
- GrIS (all)
- AIRS (asc. 1.303μm)
- IASI-A (asc. 9.30μm)
- IASI-B (asc. 9.30μm)
- GrIS asc. 9.30μm
- GrIS desc. 1.303μm

Time Series
- TB difference
- Regression coef.

Statistics for GSICS Correction
- Scatter plot (Month Day Year)
- Scatter plot (Rad)
Himawari-8/AHI IR Inter-calibration with AIRS, IASI-A/B and CrIS

AHI Infrared Bands
- Band07 (3.9 µm)
- Band08 (6.2 µm)
- Band09 (6.9 µm)
- Band10 (7.3 µm)
- Band11 (8.6 µm)
- Band12 (9.6 µm)
- Band13 (10.4 µm)
- Band14 (11.2 µm)
- Band15 (12.4 µm)
- Band16 (13.3 µm)

LEO Data
- AIRS (all)
- IASI-A (all)
- IASI-B (all)
- CrIS (all)
- AIRS (asc. 1:30pm)
- AIRS (des. 1:30pm)
- IASI-A (asc. 9:30am)
- IASI-A (des. 9:30am)
- IASI-B (asc. 9:30pm)
- IASI-B (des. 9:30pm)
- CrIS (asc. 1:30pm)
- CrIS (des. 1:30pm)

Time Series
- TB difference
- Regression coef

Statistics for GSICS Correction
- Scatter plot

Home Calibration Products Operations Supports
Current position: Home > GSICS Himawari-8 AHI Calibration Monitoring > Himawari-8 IR Inter-calibration with AIRS IASI CrIS
### GSICS Infrared Inter-calibration

**Himawari/SAHI IR Inter-calibration with AIRS, IASI-A/B and CrIS**

#### AHI Infrared Bands
- Band07 (3.9 µm)
- Band09 (5.2 µm)
- Band09 (5.9 µm)
- Band10 (7.3 µm)
- Band11 (8.6 µm)
- Band12 (9.6 µm)
- Band13 (10.4 µm)
- Band14 (11.2 µm)
- Band15 (12.4 µm)
- Band16 (13.3 µm)

#### LEO Data
- AIRS (all)
- IASI-A (all)
- IASI-B (all)
- CrIS (all)
- AIRS (asc, 1:30pm)
- AIRS (des, 1:30pm)
- IASI-A (asc, 9:30am)
- IASI-A (des, 9:30am)
- IASI-B (asc, 9:30am)
- IASI-B (des, 9:30am)
- CrIS (asc, 1:30pm)
- CrIS (des, 1:30pm)

#### Time Series
- TB difference
- Regression coeff.

#### Statistics for GSICS Correction
- Scatter plot

### Brightness Temperature Bias (HIMAWARI-8 BAND13 – IASI)

#### AIRS TB at Standard Radiance (288.16 K)

#### AIRS TB at 290 K

#### AIRS TB at 295 K

#### AIRS TB at 220 K

### Brightness Temperature Bias (HIMAWARI-8 BAND13 – CrIS)

#### CrIS TB at Standard Radiance (288.16 K)

#### CrIS TB at 290 K

#### CrIS TB at 295 K

#### CrIS TB at 220 K
**Inter-calibration between Himawari-8/AHI infrared bands and high-spectral-resolution sounders**

The Meteorological Satellite Center (MSC) examines ways of improving inter-calibration between Himawari-8/AHI (referred to here as AHI) infrared bands and high-spectral-resolution sounders (hypr sounders). Data from these three hypr sounders detailed below are used for this work:

- **Atmospheric Infrared Sounder (AIRS)** is a multi-aperture array grating spectrometer on board the Aqua satellite of the National Aeronautics and Space Administration (NASA, U.S.).
- **InfraRed Atmospheric Sounding Interferometers (IASIs)** are hosted by the Metop-A and -B satellites of the European Organization for the Exploration of Meteorological Satellites (EUMETSAT, EU).
- The **Cross-track Infrared Sounder (CIS)** is a Fourier transform spectrometer hosted by NASA’s Suomi NPP satellite.

Inter-calibration is conducted once a day. The hypr sounder data used in this work are collected via the Internet. Inter-calibration computation may be canceled if network conditions are poor.

As of July 2015, AHI GSICS Corrections are under development. The products will be reviewed within GSICS to enter Demonstration-phase.

**Outcome**

The results of this inter-calibration work have three statistical parameters. It should be noted that the results contain a certain level of uncertainty caused due to variations in instrument accuracy, differences in observation conditions and spectral compensation residuals.

**Coefficients of regression between the radiance of hypr sounders and AHI**

Linear regression coefficients ($C_0$ and $C_1$) and their standard uncertainties are computed to allow association of Himawari Standard Data (HSD) radiance with hypr sounder radiance. The radiance is in wavenumber space, and its unit is mW·m²·sr⁻¹·cm. Radiance (AHI) = $C_0 + C_1$ × Radiance (hypr sounder)

**GSICS Correction**

GSICS Correction is computed for every day. To reduce the random component of uncertainty, correction is derived from data over 25-15 day periods for Re-Analyzed Correction (RAC) and Near Real Time Correction (NRCT), respectively. The smoothing period for RAC is 7-14 days and for NRCT is 7-14 days to 7-0 days (where 0 is the date of validity).

**TB difference between hypr sounders and AHI**

The brightness temperature (TB) difference (AHI value minus hypr sounder value) and its standard uncertainty associated with AHI and hypr sounder radiances are computed at reference temperatures of standard radiances, 290 K, 250 K, and 220 K. A standard radiance from GSICS is defined to allow comparison and convenient expression of instrument inter-calibration bias in units that are understandable to users.

The standard radiance of AHI was calculated for each channel by RITTO-71.2 in a 1976 US Standard Atmosphere at nadir, at night, in clear sky, and over the sea with an SST of 280.19K and a wind speed of 7ms⁻¹.

<table>
<thead>
<tr>
<th>Hypr sounder</th>
<th>AHI band (µm)</th>
<th>Band7</th>
<th>Band8</th>
<th>Band9</th>
<th>Band10</th>
<th>Band11</th>
<th>Band12</th>
<th>Band13</th>
<th>Band14</th>
<th>Band15</th>
<th>Band16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard radiance (K)</td>
<td>283.79</td>
<td>234.81</td>
<td>242.81</td>
<td>254.98</td>
<td>283.82</td>
<td>259.45</td>
<td>286.15</td>
<td>266.10</td>
<td>323.78</td>
<td>268.73</td>
<td></td>
</tr>
</tbody>
</table>

**Conversion between brightness temperature and radiance**

The Planck function and sensor spectral response functions are used to compute brightness temperature (K) from radiance [mW·m²·sr⁻¹·cm⁻¹] and vice versa. In general, approximations called Fenton Planck functions, which are generated for AHI infrared bands, are used to facilitate computation.

**Brightness temperature to radiance**

\[ B_i(T_i) = \frac{2h^4T_i^3}{c^2} \exp \left( \frac{hcT_i}{k(cT_i + a_iT_i)} - 1 \right) \]

where:
- $B_i$: sensor Planck function of band $i$
- $T_i$: brightness temperature
- $c_i$: central wavenumber of band $i$
- $a_i$: $b_i$: band correction coefficients of band $i$
- $h$: Planck constant
- $k$: Boltzmann constant
- $c$: speed of light

**Radiance to brightness temperature**

\[ T_i = \frac{T_i}{\ln \left( \frac{B_i(T_i)}{b_i} \right) + 1} \]

where:
- $T_i$: Planck temperature of band $i$
- $T_e$: effective temperature
- $B_i$: Planck temperature of band $i$
- $b_i$: spectral radiance
- $b_i$: $b_i$: band correction coefficients of band $i$

**AHI band**

<table>
<thead>
<tr>
<th>Wavenumber (µm)</th>
<th>$a_1$</th>
<th>$a_2$</th>
<th>$b_1$</th>
<th>$b_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Band 7 (3.9 µm)</td>
<td>2575.767</td>
<td>0.459467302</td>
<td>0.999901613</td>
<td>-0.0497597</td>
</tr>
<tr>
<td>Band 8 (6.2 µm)</td>
<td>1606.241</td>
<td>1.668446799</td>
<td>0.999640137</td>
<td>-1.605618</td>
</tr>
<tr>
<td>Band 9 (8.9 µm)</td>
<td>1442.079</td>
<td>0.108153557</td>
<td>0.999150883</td>
<td>-0.3357038</td>
</tr>
<tr>
<td>Band 10 (12.3 µm)</td>
<td>1361.387</td>
<td>0.057469486</td>
<td>0.999852482</td>
<td>-0.0626031</td>
</tr>
<tr>
<td>Band 11 (8.6 µm)</td>
<td>1164.443</td>
<td>0.135127754</td>
<td>0.999415660</td>
<td>-0.1051605</td>
</tr>
</tbody>
</table>
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).
EUMETSAT GSICS Website

GSICS Calibration Products Plotting Tool

Configuration and Plot
- GSICS Collaboration Server
- GSICS GPRC
- GSICS GICS

Correction Type
- Re-Analysis Corrections (RAC)
- Satellite/Instrument
- MSG-1 SEVIRI
- Reference Satellite/Instrument
- MetOp-A SAT

Mode
- Pre-Operational

Dataset Start Year
- 2015

Dataset Start Date-time (MM/dd hh:mm:ss)
- 06/01 00:00:00

Version
- 01

Channel
- All

Scene Brightness Temperature [K]

Bias Range (min - max) [K]

Date [UTC]

Save and Load
- Export
- Current Plots
- Help
Standard scene temperature for GOES-15 Imager is defined as [286K, 244K, 286K, 267K] 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.
Time-Series of GEO-LEO (GOES-15 - AIRS/CrIS/IASI Difference)

- **Figure:** Time-series of GEO-LEO inter-calibration between GOES and AIRS/CrIS/IASI trace each other very well, indicating the long-term radiometrical calibration stability of the three hyperspectral radiometers.
  - GOES-15 Imager displays slight seasonal variation at Ch4 and Ch6.
  - The mean Tb difference between AIRS/CrIS/IASI is very small <0.1-0.2K.
Multiple Vicarious Calibrations

Collection of Normalized Observations

- Comparable relative calibration accuracy.
- Similar degradation patterns over different reference targets indicate that the impact of spectral response function shift, if any, is very small and negligible on the reflectance.
GSICS Meetings and Conferences

This is a central place for information on our meetings and conferences. Each event must be in a separate topic with a link provided here. Any meeting material.

## Web Meetings, Joint Working Group Meeting & Users’ Workshops

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<th>Topics</th>
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<td>GRWG-Cheng-Zhi Zou</td>
<td>CEOS-GSICS Microwave Coordination Meeting</td>
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<tr>
<td>2016</td>
<td>GRWG</td>
<td>Joint web meeting with IVOS, ASCG on use of SBAF tool</td>
</tr>
<tr>
<td>2016</td>
<td>GRWG VIS/NIR - S.Wagner</td>
<td>Lunar Inter-Calibration Double-difference between MODIS/MIRS and GIRO</td>
</tr>
<tr>
<td>2016-02-29/03-04</td>
<td>GRWG/GDWG</td>
<td><strong>Annual GRWG+GDWG Meeting at Tsuchuba, Japan</strong></td>
</tr>
<tr>
<td>2016-01-06</td>
<td>GRWG</td>
<td>Scoping inter-calibration opportunities using NWP bias monitoring statistics</td>
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<tr>
<td>2015-12</td>
<td>GDWG</td>
<td>GSICS Working Groups' Actions Tracking Tool Requirements and Discussion</td>
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<tr>
<td>2015-10/08</td>
<td>GRWG</td>
<td>DCC - Plotting Tool Requirements, GPPA Review, Latest Ray-matching results</td>
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<td>2015-09-22</td>
<td>GRWG UVSG</td>
<td><strong>Joint Meeting of GRWG UV and WGCV Atmospheric Composition Sub-Groups</strong></td>
</tr>
<tr>
<td></td>
<td>Users</td>
<td>2015 GSICS Users Workshop</td>
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<tr>
<td>2015-09-16</td>
<td>GRWG</td>
<td>Update on microwave sensor calibrations and plans for 2015 GSICS Users Workshop</td>
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<td>2015-07-09</td>
<td>GRWG IR Sub-Group</td>
<td>Formation of Infrared Sub-Group of GRWG - and Reference Instruments' Requirements</td>
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<td>2015-05-13</td>
<td>GRWG-MWSG</td>
<td>Microwave Sub-Group Web Meeting</td>
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<td>2015-04-23</td>
<td>GRWG/GDWG</td>
<td>Review of Actions from 2015 Annual GRWG+GDWG Meeting</td>
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<td>2015-03-16/20</td>
<td>GRWG/GDWG</td>
<td><strong>Annual GRWG+GDWG Meeting at IMD, New Delhi, India</strong></td>
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<td>2015-02-03</td>
<td>GRWG+GDWG</td>
<td>Preparing for 2015 Meeting + DCC Seasonality</td>
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<td>2015-01-20</td>
<td>GDWG</td>
<td>Automation of GPPA &amp; timeliness</td>
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<td>2014-12-16</td>
<td>GRWG MicrowaveSubGroup</td>
<td>Microwave Sub-Group Web Meeting - Product Development Updates</td>
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<td>2014-12-01/04</td>
<td>GRWG/GDWG</td>
<td>Lunar Calibration Workshop at EUMETSAI</td>
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<td>GRWG VIS/NIR - S. Wagner</td>
<td>Lunar Calibration Workshop last-minute Preparation</td>
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<td>2014-11-21</td>
<td>Users</td>
<td><strong>Special GSICS Session at AGMUCG-5</strong></td>
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GSICS Outcome

- Coordinated international intersatellite calibration program
- Exchange of critical datasets for cal/val
- Best practices/requirements for monitoring observing system performance
- Best practices/requirements for prelaunch characterisation (with CEOS WGCV)
- Establish requirements for cal/val (with CEOS WGCV)
- Advocate for benchmark systems
- Quarterly reports of observing system performance and recommended solutions
- Improved sensor characterisation
- High quality radiances for NWP & Climate
Architecture for Climate Monitoring from Space


- The Strategy towards an Architecture for Climate Monitoring from Space is a first step defining a logical framework
Four Pillars of end-to-end Architecture

• The sensing level (Pillar 1) drives the **potential** to generate ECVs

• The **actual** use of this potential in climate records (Pillar 2) is reflected in the ECV inventory => helps to maximize the use of existing data

• Calibration activities must be addressed in both Pillars 1 and 2:
  – Space segment (pre-launch and on-board calibration, space/ground references)
  – Data processing
Wrap up

Where we are:
- GSICS has developed a cadre of calibration scientists throughout the world’s earth remote sensing satellite agencies
- Asia has embraced GSICS and we mutually benefit
- We continue to learn and benefit from our collaboration
- Observations that are well characterized for immediate use by the community
- Every satellite/instrument operator is now responsible for characterizing their own satellites with community consensus algorithms

Where we are going:
- GSICS will continue to promote capacity building
- Contribute significantly to the new Climate Architecture.
Learn more about GSICS

The Global Space-based Inter-Calibration System

An international project will tie observations from operational low-earth-orbiting and geostationary environmental satellites to those in-orbit sensors that serve as calibration standards.

Global Satellite Inter-Calibration System

VISION OF GSICS IN THE 2020s
Shaping GSICS to meet future challenges

Version 1.1
May 2015

BAMS April 2011
Questions?