Global Space-based Inter-Calibration System (GSICS)

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GSICS Objectives

- To improve the use of space-based global observations for weather, climate and environmental applications through operational inter-calibration of satellite sensors.
  
  - Observations are well calibrated through operational analysis of instrument performance, satellite intercalibration, and validation over reference sites
  
  - Pre-launch testing is traceable to SI standards

- Provide ability to re-calibrate archived satellite data with consensus GSICS approach, leading to stable fundamental climate data records (FCDR)
Regional/Specialized Satellite Centres

- Address the requirements of GCOS in a cost-effective, coordinated manner, capitalising upon the existing expertise and infrastructures.
- Continuous and sustained provision of high-quality ECVs
- GSICS enables the generation of Fundamental Climate Data records and provides the basis for sustained climate monitoring and the generation of ECV satellite products.
GSICS Organization

GSICS Executive Panel

GRWG

GDWG

CSS

GCC

GPRC

Coordination Center

Regional Processing Research Centers at Satellite Agencies

Calibration Support Segments (reference sites, benchmark measurements, aircraft, model simulations)
Simultaneous Nadir Overpass (SNO) Method
-a core component in the Integrated Cal/Val System

POES intercalibration

- Has been applied to microwave, vis/nir, and infrared radiometers for on-orbit performance trending and climate calibration support
- Capabilities of 0.1 K for sounders and 1% for vis/nir have been demonstrated in pilot studies

• Useful for remote sensing scientists, climatologists, as well as calibration and instrument scientists
• Support new initiatives (GEOSS and GSICS)
• Significant progress are expected in GOES/POES intercal in the near future
Integrated Cal/Val System Architecture

Calibration Opportunity Prediction

Data Acquisition Scheduler

Calibration Opportunity Register (CORE)

Raw Data Acquisition for Calibration Analyses

Stored Raw Data for Calibration Analyses

SNO/SCO Rad. Bias and Spectral Analysis
Calibration Parameter Noise/ Stability Monitoring
RTM Model Rad. at Calibration Reference Sites
Inter-sensor Bias and Spectral Analysis
Earth & Lunar Calibration
Geolocation Assessment (Coastlines, etc.)

Assessment Reports and Calibration Updates
Progress

- Annual Operating Plan
- Three GRWG meetings (chair, Fred Wu)
  - Consensus algorithms for LEO to GEO intercalibration (IR)
  - Intercalibration of VIS/NIR channels
  - Intercalibration of microwave channels.
- Two GDWG (chair, Volker Gaertner)
  - Data management issues, metadata
- Commissioned GSICS Website and routine LEO to LEO intersatellite calibration
- Intercomparisons of AIRS and IASI
- Quarterly Newsletter
2008 Deliverables

- Commission intercalibration of MTSAT, MSG, GOES and FY2 Infrared Imagers with IASI and AIRS.
  - Routine intercomparisons between MSG (SEVIRI) and AIRS/IASI at EUMETSAT
  - Routine intercomparisons between GOES and AIRS/IASI at NESDIS
  - Routine intercomparisons between MTSAT and AIRS/IASI at JMA
  - Routine intercomparisons between FY2 and AIRS/IASI at CMA
Routine Intercalibration of AIRS and IASI

MODIS & AIRS ($\Delta \nu = 2400/\nu$) Channels

AVHRR, HIRS & IASI Channels ($\Delta \nu = 0.25 \text{ cm}^{-1}$)

Sampling of VIIRS & CrIS ($\Delta \nu = 0.625, 1.25, 2.50 \text{ cm}^{-1}$) Channels

- AIRS, 2378
- IASI, 8461
- CrIS, 1305
Radiometric calibration — IASI versus AIRS

Situation 16th of April

- IASI in External Cal.
  - Close to nadir
- Many comparison opportunities
  - 49 used
- Good uniformity
  - Cold scene

(Blumstein)
Radiometric calibration — IASI versus AIRS

Pseudo-channels
Summary results (case 16\textsuperscript{th} of April 2007)

- IASI External Calibration Mode. Very uniform situation
- 9 pseudo-channels / 49 soundings / 210 K in atmospheric window
- Differences scaled to 280 K reference temperature
1. FOV instead of large area
2. Not restricted to near nadir
Preliminary Results from Prototype Algorithm

Blue: time difference < 60 seconds
Baseline GEO to LEO Collocation Algorithm

• Key match-up conditions between GEO and LEO
  – Difference of observing times < 1800 (sec)
  – Difference of \(1/cos(\text{sat. zenith angles})\) < 0.05
  – Environment uniformity check
    • To choose only spatially uniform area to alleviate navigation error, MTF, observing time difference, optical path difference, etc.
    • Environment domain = 11x11 IR pixel box (MTSAT-1R vs. AIRS)
    • env_stdv_tb < (TBD)
  – Representation check of LEO-size GEO pixels in the environment
    • z-test
    • LEO FOV = 5x5 IR pixel box (MTSAT-1R vs. AIRS)
    • abs(fov_mean_tb – env_mean_tb) < Gaussian x env_stdv_tb / 5
Compensation vs. No Compensation

Radiance comparison of MTSAT1R 6.8-um and AIRS

- **w/o Compensation**
- **w/ Compensation**

MTSAT – AIRS

AIRS (mW/m$^2$.sr.cm$^{-1}$)

**SRF of super channel** not using blacklisted and gap channels
Compensation vs. No Compensation

Radiance comparison of MTSAT1R 6.8-um and AIRS

w/o Compensation

w/ Compensation

MTSAT – AIRS

AIRS (mW/m².sr.cm⁻¹)

MTSAT – AIRS

AIRS (mW/m².sr.cm⁻¹)

SRF of super channel not using blacklisted and gap channels
MTSAT-1R 6.8-um vs. AIRS/IASI August 2008

* Compensation applied to AIRS super channel computation
MTSAT-1R 6.8-um vs. AIRS/IASI
August 2008

- Daytime comparisons against AIRS & IASI show the same result
- Only midnight AIRS comparison shows different from others, that might indicate unknown solar effect on MTSAT
AIRS-GOES vs. IASI-GOES

• **Spectral Convolution**
  – Spectral Filling for AIRS measurements
  – Specially for water vapor channels

• **Pixel Size**
  – AIRS: 13.5 km
  – IASI: 12.0 km
  – GOES pixel: 4.0 km, 3 by 5 GOES pixels

• **Sampling Number**
  – AIRS: 6075 samples for 3 minutes
  – IASI: 2640 samples for 3 minutes

• **Diurnal Effects**
  – Aqua on afternoon orbit: 1:30pm
  – MetOp-A on morning orbit: 9:30am
Spectral Coverage

![Graph showing spectral coverage with wavelength (µm) on the x-axis and brightness temperature (K) on the y-axis. The graph includes lines for GOES11, GOES12, IASI, and AIRS, with specific channels labeled: Ch2, Ch3, Ch4, Ch6, and SRF. The wavenumber (cm⁻¹) is also indicated on the x-axis.]
Channel 6 (13.3 µm)

Decontamination
07/02/2008
Channel 4 (10.7 µm)

![Graph showing BT Diff (K) vs Day since 2007 for GOES12 and CH 4 channels. The graph includes data points for (GOES-AIRS)-(GOES-IASI), GOES-AIRS, and GOES-IASI, with a decontamination note dated 07/02/2008.]
Channel 3 (6.5 µm)

GOES12  CH 3

(GOES-AIRS)-(GOES-IASI)  GOES-AIRS  GOES-IASI

Decontamination
07/02/2008
CEOS Action: CL-06-02_2
“Operational Implementation of Geostationary to Low Earth Orbit intercalibration for all geostationary IR imagers

• This action is led by the WMO Global Space-based InterCalibration System (GSICS) program

• Routine intercalibration is now performed at NOAA, JMA and EUMETSAT.

• Intercalibration with accurate and stable high spectral resolution infrared sounders (AIRS and IASI) provides:
  • improved characterization of the geostationary infrared imagers and
  • generation of seamless radiance datasets for deriving products such as upper tropospheric water vapor

Significance: GSICS is an international coordinated effort to routinely provide instrument intercalibration and monitoring for the generation of fundamental climate data records.

Project Lead: Mitch Goldberg
IASI Spectrum – MSG Filter

(Koenig)
"Homogeneous" Targets (WV6.2)

Meteosat-8
and
Meteosat-9
# Results for 27 April 2007

<table>
<thead>
<tr>
<th>Channel</th>
<th>$\Delta T$ IASI – Meteosat-8 $^*$</th>
<th>$\Delta T$ IASI – Meteosat-9 $^*$</th>
</tr>
</thead>
<tbody>
<tr>
<td>IR3.9</td>
<td>-0.17</td>
<td>-0.20</td>
</tr>
<tr>
<td>WV6.2</td>
<td>-0.24</td>
<td>-0.40</td>
</tr>
<tr>
<td>WV7.3</td>
<td>-0.51</td>
<td>-0.14</td>
</tr>
<tr>
<td>IR8.7</td>
<td>0.15</td>
<td>0.15</td>
</tr>
<tr>
<td>IR9.7</td>
<td>0.17</td>
<td>0.20</td>
</tr>
<tr>
<td>IR10.8</td>
<td>0.16</td>
<td>0.07</td>
</tr>
<tr>
<td>IR12.0</td>
<td>0.19</td>
<td>0.08</td>
</tr>
<tr>
<td>IR13.4</td>
<td>0.44</td>
<td><strong>1.7</strong></td>
</tr>
</tbody>
</table>

$^*$Uncertainty 0.1 – 0.2 K
Time Series of MSG - IASI

M. König & T. Hewison

Decontamination
At Intersection: Time difference: <30 Sec
Distance: < 20 km

HIRS Image Channel 7
AIRS-convolved HIRS Image Channel 7

SNO event
AIRS Nadir
HIRS Nadir
SRF Shift for HIRS Channel 6

Since the HIRS sounding channels are located at the slope region of the atmospheric spectra, a small shift of the SRF can cause biases in observed radiances.

Details can be referred to Wang et al. (manuscript for JTECH, 2006)
GSICS Outcome

- Coordinated international intersatellite calibration program
- Exchange of critical datasets for cal/val
- Best practices/requirements for monitoring observing system performance (with CEOS WGCV)
- 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
- Close interaction with R/SSC-CM