GSICS GEO-LEO Inter-Calibration at NOAA

X. Wu, 29 Jan 2009

Reporting work by L. Wang, F. Yu, R. Varma Raja, and S. Chung

- Algorithm
- Operation
- Performance Monitoring
- Anomaly Diagnosis
- Visible Calibration
Algorithm

- Version 0 (May 2007)
  - Test for GOES-AIRS, not operational.
- Version 1.0 (October 2007)
  - Separate subsetting (orbit prediction) from collocation.
- Version 1.1 (December 2007)
  - Improved selection
- Version 1.2 (January 2008)
  - Improved selection
- Version 1.3 (March 2008)
  - Output in NetCDF (instead of binary)
- **Version 2.0 (May 2008)**
  - JMA gap filling algorithm
  - Separate selection from collocation
- Version 2.0.1 (August 2008)
  - Adopted the code for GOES-IASI in IDL
- Version 2.1 (February 2009)
  - Modularization for GEO-AIRS/IASI
Algorithm

- No major change since May 2008
  - Data back-processed
- ATBD is incomplete
  - JMA gap filling algorithm to be finalized
- Hierarchical Structure for ATBD
  - Convenient to describe what it is
  - Extremely useful to compare with others
  - How much about “why” for certain steps or threshold values?
    - None – less than “Theoretical Basis”
    - Too much – no longer concise
Operation

- Version 2.0, GOES-AIRS, since January 2007
- Version 2.0.1, GOES-IASI, June 2007 to November 2008
- Version 2.1 will be tested for compatibility with 2.0 for GOES-AIRS and Version 2.0.1 for GOES-IASI
- Version 2.1 will be used to inter-calibrate MTSAT-1R, FY2C, METEOSAT-7/8/9 with AIRS/IASI since August 2008.
- Version 2.1 will replace 2.0 for GOES-AIRS/IASI.
- Version 2.0 or equivalent is used for
  - GOES-AIRS since Jan 2007
  - GOES-IASI since Jun 2007
  - GEO-AIRS/IASI since Aug 2008
Performance Monitoring

- Effects of METEOSAT-9 and GOES-12 decontamination
- Monitoring GOES-12 contamination
- Effects of IASI decontamination
- IASI recovery
GOES-12 13.3 UM

Days Since 20Oct07

(GOES Tb) - (AIRS Tb)

Bias -1.1°K

GOES-13 13.3 μm Channel

STAR: -1.8K

UW: -2.4K

21FEB07

Difference may be due to the methods used. Insufficient data in general.
Solution: Shift SRF by \( \sim 4.7 \text{ cm}^{-1} \)

Is it really the root cause?
Updated SRF with effective shift of ~-1 cm$^{-1}$
Satellite Instrument with incorrect SRF

Would the bias for warmer scenes be larger than that for colder scenes?

- No CO₂, No bias (almost)
- Add CO₂, Add bias
- Less CO₂, Less bias
- Colder

Warmer
Reversed correction

Inversion above tropopause

Adding a constant under-corrects warm scenes and over-corrects cold scenes
-2.6°K on 21FEB07

Now what about this outlier? It’s not, in fact it’s a clue to trace down a cause for SRF error
Time series of brightness temperature differences between MSG2-IASI for typical clear-sky radiances. Each MSG infrared channel is shown in a different color, with different symbols, following the legend. Error bars represent statistical uncertainty on each mean bias (may be very small).
Why did the 13.3μm and the 6.5 μm channels respond differently to the decontamination?
Spectral transmission of H₂O Ice with various thickness

Ice transmission function of the thickness of the film (in µm)

Remaining responsivity of 3 GOES-12 channels prior to the decontamination

Diagnosis for METEOSAT-9: ~1µm

From CNES, verified by IASI data
Effective shift of SRF assuming 2.1 μm ice
Performance Monitoring

- Effects of METEOSAT-9 and GOES-12 decontamination
- Monitoring contamination
- Effects of IASI decontamination
- IASI recovery
Performance Monitoring

- Effects of METEOSAT-9 and GOES-12 decontamination
- Monitoring contamination
- Effects of IASI decontamination
- IASI recovery
IASI Decontamination Effects: GOES12: 6.5 µm channel

GOES12 CH 3

(GOES-AIRS)-(GOES-IASI)  

-0.0008 ± 0.0628 K

-0.08 ± 0.069 K

IASI decontamination on 03/20/2008

Day since 2007

GRWG-IV/GDWG-III, Tokyo, Japan, 28-30 January 2009
Performance Monitoring

- Effects of METEOSAT-9 and GOES-12 decontamination
- Monitoring contamination
- Effects of IASI decontamination
- IASI recovery
  - Preliminary results, for discussion only
GOES-11 – AIRS in transition V2.0 to V2.1
MTSAT-1R

MTSAT-1R
GRWG-IV/GDWG-III, Tokyo, Japan, 28-30 January 2009

MTS01 vs. AIRS - Channel 3.8\,\mu m

MTS01 vs. AIRS - Channel 6.8\,\mu m

MTS01 vs. AIRS - Channel 10.8\,\mu m

MTS01 vs. AIRS - Channel 12.0\,\mu m

JMA
Anomaly Diagnosis

- GOES-11 patch change
- GOES-12/13 SRF error, pre-launch and post-launch
- GOES and MTSAT midnight blackbody calibration anomaly
Diurnal Variation of Bias

GOES12 CH 3

6.5 µm

21:30 (IASI)  9:30 (IASI)  1:30 (AIRS)  13:30 (AIRS)

GOES-12 Decontamination

BT Diff (K)

Day since 2007
Constraints used here:
GEO-LEO Azi. Within 25 degrees of each other, this constrain during day time only
Relative path difference <= 0.01. In addition during day time zenith angle difference restricted to 0.3 deg.
Env stdv/Env mean <= 0.01
FOV stdv/FOV mean <= 0.01
This Study

IASI

AIRS

SEVIRI

IASI

AIRS

SNOs

SNOs

IASI

AIRS

SNOs

SNOs
Visible Calibration

- Many methods
- Emphasize DCC
EDF

Statistical distribution of brightness is stable over time
HISTOGRAM OF VISIBLE CHANNEL VALUES INTENSITIES
GOES-10 FOR JANUARY 3, 2000

79% OF INTENSITIES ARE LESS THAN 200

SPACE VIEW INTENSITIES

EARTH VIEW INTENSITIES

EDF
GOES-10 Full-Disk Histograms and their Empirical Distribution Functions

Space View Region

Earth View Region
At least 75% of Intensities are less than 200

Visible-Channel Intensities (Counts)

Day 164, 1999
Day 164, 2001
Day 164, 2003

Top 5 million pixels are above the intensity level 413

Begin Earth View Region

Normalized Cumulative Frequency

Visible-Channel Intensities (Counts)
UPPER EDF OF VISIBLE CHANNEL INTENSITIES
GOES-10 FOR JANUARY 3, 2000

469 = INTENSITY VALUE WITH 5 MILLION COUNTS ABOVE
EDF = .978
PLOT OF INTENSITIES WITH 5 MILLION COUNTS ABOVE FOR GOES-10

$Y(t) = \text{INTENSITY WITH 5 MILLION COUNTS ABOVE}$

FIT WITH ANNUAL AND SEMI-ANNUAL TERMS
FIT WITH SOLAR CORRECTION
Desert

- Desert reflectance is stable
- No good target with favorable viewing geometry
- Useful for redundancy
Desert

GOES-08 Measurements over Grand Desert (Sonora, Mexico)
Star

Radiation from stars is stable
Trajectory of Star Image and OATS Computation of Star Signal SNR

Star

GOES-8 Star Delta-Eri
Detector 7
2/3/2003

GOES-8 Star Delta-Eri
12/16/2002

GOES-8 Star Delta-Eri
11/4/2004
Detector 3

GOES-8 Star Delta-Eri
11/4/2004
Detector 4

V1
V2
V3
V4
V5
V6
V7
V8

Signal in DFU

Time in DTU

Signal in DFU

Time in DTU

Signal in DFU

Time in DTU

Signal in DFU

Time in DTU

V1
V2
V3
V4
V5
V6
V7
V8

GRWG-IV/GDWG-III, Tokyo, Japan, 28-30 January 2009
Star

Star-Signal Time Series of Star Beta-Cnc (Method 1 and Method2)

GOES-8

GOES-10

GOES-12

GRWG-IV/GDWG-III, Tokyo, Japan, 28-30 January 2009
Star

Difficulties:

• Interruption of observations

• Intra-annual variation in addition to inter-annual degradation
MODIS is perfectly calibrated

Match data are available that are:

- Co-located in space  
  Operational Navigation

- Concurrent in time  
  Within 10 minutes

- Identical spatial and spectral coverage  
  MODIS Ch. 1 @ 1KM

- Identical view geometry  
  Within ~8° from nadir
MODIS

Histograms on October 5, 2004

- MODIS Estimate
- GOES Pre-launch
MODIS

![Graph showing normalized response/reflectance against solar irradiance for different wavelengths.](graph.png)
**Monthly Mean DCC Reflectances (June 1995 - March 2003)**

\[ Y = 69.315 - 0.3878X + 1.6992 \times 10^{-3}X^2 \]

\[ R^2 = 0.88 \]

**Monthly Median DCC Reflectances (June 1995 - March 2003)**

\[ Y = 70.453 - 0.3864X + 1.6366 \times 10^{-3}X^2 \]

\[ R^2 = 0.89 \]

- Tb4 < 205 K
- STD(Tb4) < 1 K
- STD(VIS) < 2%

No ADM

GRWG-IV/GDWG-III, Tokyo, Japan, 28-30 January 2009
Monthly Mean DCC Reflectances (June 1995 - March 2003)

\[ Y = 81.550 - 0.4607X + 1.9464 \times 10^{-3}X^2 \]

\[ R^2 = 0.96 \]

- Tb4 < 205 K
- STD(Tb4) < 1 K
- STD(VIS) < 2%

ADM

Monthly Median DCC Reflectances (June 1995 - March 2003)

\[ Y = 81.536 - 0.4564X + 1.8966 \times 10^{-3}X^2 \]

\[ R^2 = 0.96 \]

Number of DCC (June 1995 - March 2003)
Summary

- Algorithm – stable
- Operation – started
- Performance Monitoring – GSICS is a
- Anomaly Diagnosis – good tool
- Visible Calibration