Radiometric Calibration Performance of GOES-16/17 Advanced Baseline Imager (ABI)

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GOES-16/17

- NOAA’s new generation operational weather satellites at the geostationary orbit
  - Advanced Baseline Imager (ABI) is the primary payload
- **GOES-16**: GOES-East at 75.2°W
  - Launched on 19 November 2016, became operational as GOES-East on 18 December 2017, operated as designed
- **GOES-17**: GOES-West at 137.2°W
  - Launched on 1 March 2018, became operational as GOES-West on 12 Feb 2019, operated at elevated/floating ICT/FPM temperature
• ABI Bands: 16 bands
  – 6 visible and near-infrared (VNIR) bands
  – 10 infrared (IR) bands

• Two independent scan mirrors
  – North-South (NS)
  – East-West (EW)

• On-orbit calibration for all the bands
  – On-orbit solar diffuser (SD) for VNIR bands
  – Blackbody for IR bands

Figures are courtesy of L3Harris
Detector Focal Plane Modules and BDS

<table>
<thead>
<tr>
<th>Band</th>
<th>FMP</th>
<th>Central Wvlen (µm)</th>
<th>IFOV EW (urad)</th>
<th>IFOV NS (urad)</th>
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</tbody>
</table>

Each band has hundreds to thousands of detector rows. Each row has 3 or 6 detector columns.

These figures and table values are courtesy of L3Harris.)
• Loop Heat Pipe (LHP) anomaly causes the malfunction of the cooling system
  – Detected in late April 2018
  – Degraded data quality at all IR channels

• Activities implemented to recover and optimize the ABI performance
  – Yaw-flip semi-annually
  – Changes of the focal plane module (FPM) operation temperature
    • Visible and Near-Infrared (VNIR) FPM: floating
    • Infrared (IR) FPMs: controlled at an elevated temperature (~81K) + floating when not controlled
  – Calibration gain-set switch for some IR bands
  – Adjustments of operational procedures
    • Timeline adjustment
    • More frequency of blackbody calibration
    • Cooling timeline implementation at the “hot” nights around the eclipse seasons
  – Algorithm changes
    • Predictive calibration algorithm (pCal) to improve the cal. accuracy during the unstable FPM period
    • Update RadCal LUTs to reduce striping
G17 ABI IR Performance

- Light to dark green: adequately to barely meet the original requirement
- Gray: failed the original requirement
- Red: data not usable

NEdT: 0–1 × Spec.
NEdT: 1–5 × Spec.
ICT Look Saturation
Space Look Saturation

Time in a day
Month in a year
00 03 06 09 12 15 18 21 24 UTC
G16/G17 VNIR bands are generally within 5% difference to SNPP/VIIRS

The updated solar diffuser BRDF look-up table, derived based on the prelaunch measurements, was implemented for G16 on 04/23/2019 and G17 on 04/27/2019 to mitigate the large bias for these two bands.

- The new difference to VIIRS are greatly reduced
G16/17 VNIR Rad. Cal. Monitoring

Monitoring for all the VNIR bands are available at:

https://www.star.nesdis.noaa.gov/GOESCal/G16_ABI_VNIR_InterCal_static.php
https://www.star.nesdis.noaa.gov/GOESCal/G17_ABI_VNIR_InterCal_static.php

B02 Solar Cal. LUT update
G16/17 IR Calibration Accuracy

G16/G17 vs. CrIS/IASI Inter-Calibration

- G17 data is assessed at the gainset I period
- The mean Tb difference to CrIS/IASI is less than 0.2K for all IR bands, except for B16 (~0.4K)
- G17 B16 IR radiometric calibration accuracy will be further improved once the new G17 IR SRF is implemented
  - New G17 IR SRF is derived at the 81K temperature, the controlled operational temperature.
  - New SRF available at: https://ncc.nesdis.noaa.gov/GOESR/ABI.php
G16 IR Rad. Cal. Monitoring

1: Metop-B update of non-linear responsivity in August 2017
2. G16 ABI update of the scan-mirror emissivity LUT in October 2017
3. G16 ABI update of ICT PRT LUT in June 2018

More detailed daily and long-term monitoring available at: https://www.star.nesdis.noaa.gov/GOESCal/G16_ABI_IR_InterCal_static.php
G17 IR Rad. Cal. Monitoring: Gainset I

G17 ABI update of the scan-mirror emissivity LUT in early August 2019

More detailed daily and long-term monitoring available at: https://www.star.nesdis.noaa.gov/GOESCal/G17_ABI_IR_InterCal_static.php
Predictive Calibration (pCal) algorithm was operationally implemented on 07/25/2019 to improve the radiometric calibration accuracy for B08-B16 when the IR FPM temperature is unstable.

**GEO-GEO Inter-comparison for pCal performance validation**

OE: without pCal algorithm  
ITE: with pCal algorithm turn-on  
FPM temperature

The pCal algorithm greatly reduces diurnal variation.
Time-series of G17 vs. G16 Tb Difference

2019 for G17ABI - G16ABI at Band14

2019 for G17ABI - G16ABI at Band16

pCal Implementation
Cooling Timeline to Recover Images

- Cooling timeline consists of cooling scenes and less earth scenes
- Implemented at 06:00-12:00z at “hot” nights in the eclipse seasons
- Recover 1-5 more FDs, 2-8 more CONUS, 30-100 more MESO images for most channels on most days
BDS update for Striping Reduction

Before BDS update

G17 B09 MESO1 2020/05/21T15:23:25UTC

After BDS update

G17 B09 MESO1 2020/05/21T15:24:25UTC
NOAA/STAR GOES Calibration Website

https://www.star.nesdis.noaa.gov/GOESCal/
Summary

- Calibration accuracy for the G16/17 VNIR bands is in general within 5%, after the calibration LUT updates in April 2019.
  - Using SNPP/VIIRS as the reference

- G16/17 ABI IR bands are well calibrated and stable
  - Bias to CrIS/IASI is less than 0.2K, except for G17 B16 at ~0.4-0.5K
  - New G17 IR SRFs will further improve the calibration accuracy, especially for B16

- Despite the LHP anomaly, G17 joins G16 to provide the high quality imagery for the weather and environmental studies
  - Detector noise meets the requirement at most IR channels at most time
  - G17 IR radiance is stable and well calibrated when the FPM temperature is controlled
  - The pCal algorithm greatly improves the radiometric calibration accuracy at the unstable FPM temperature time in a day
  - The cooling time helps to gain more valid earth images

- Efforts are still ongoing to further improve the ABI radiance quality
Acknowledgements

We would like to thank the ABI instrument engineers and calibration scientists from the Vendor, NASA Flight, MIT/LL and contractor companies for all the efforts to improve the ABI radiometric calibration performance, data users for the feedback, and the GOES-R Program Office for the coordination.