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

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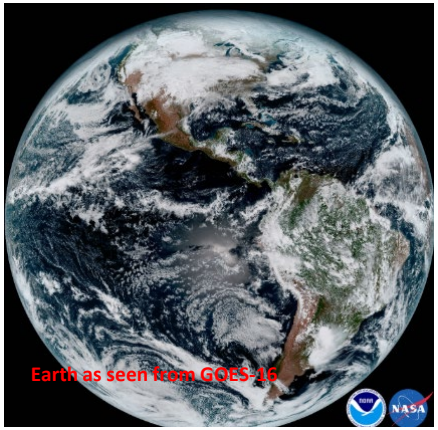
***: NOAA/NESDIS/STAR**

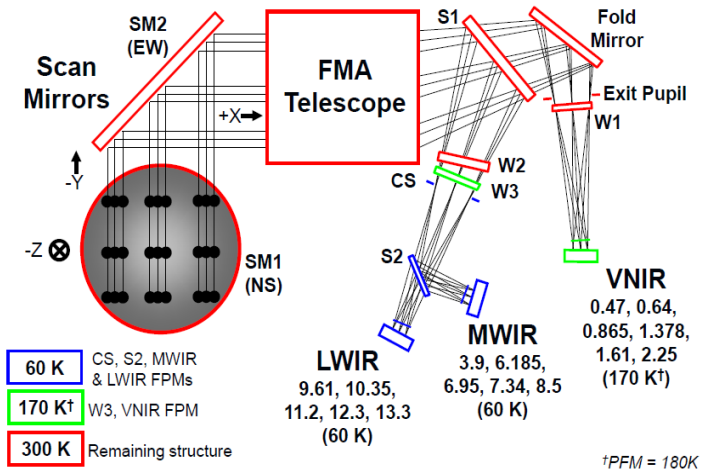
GOES-16/17

- **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**

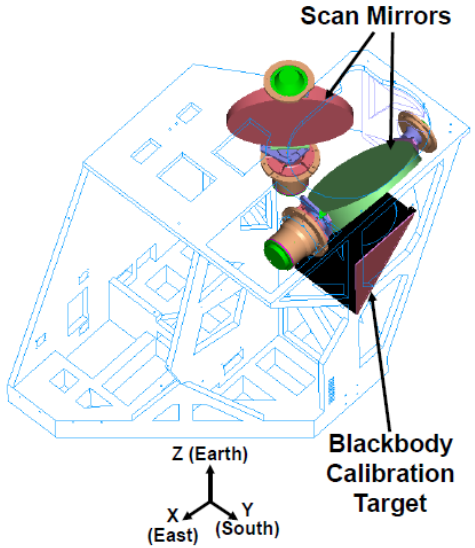


ABI Instrument

- **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

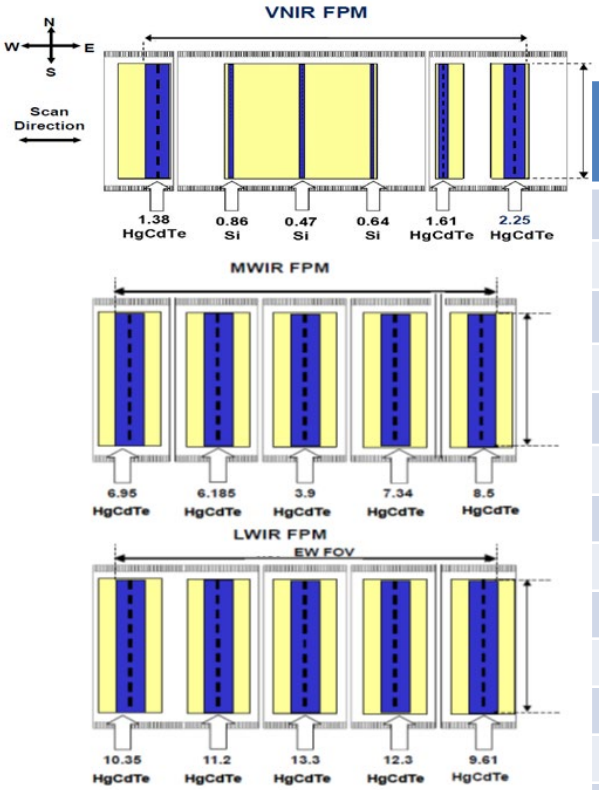


GOES-16 ABI Optical Architecture



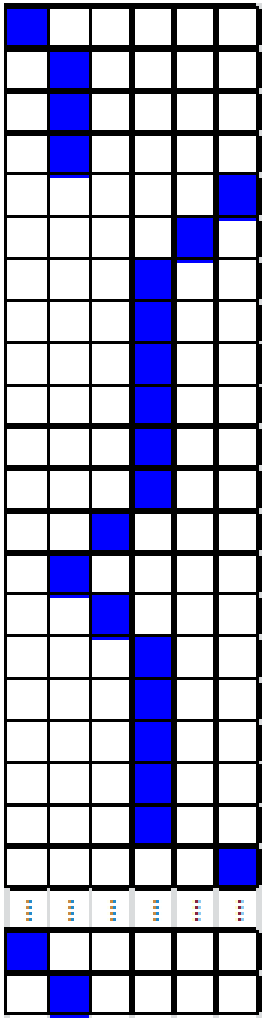
Figures are courtesy of L3Harris

Detector Focal Plane Modules and BDS



Band	FMP	Central Wvlen (µm)	IFOV EW (urad)	IFOV NS (urad)	Columns	Rows
1	VNIR	0.47	22.9	22.9	3	676
2		0.64	12.4	10.5	3	1460
3		0.87	22.9	22.9	3	676
4		1.38	51.5	42.0	6	372
5		1.61	22.9	22.9	6	676
6		2.25	51.5	42.0	6	372
7	MWIR	3.9	51.5	47.7	6	332
8		6.2	51.5	47.7	6	332
9		6.9	51.5	47.7	6	332
10		7.3	51.5	47.7	6	332
11		8.5	51.5	47.7	6	332
12	LWIR	9.6	51.5	47.7	6	332
13		10.4	34.3	38.1	6	408
14		11.2	34.3	38.1	6	408
15		12.3	34.3	38.1	6	408
16		13.3	34.3	38.1	6	408

Best Detector Selected (BDS) in each row



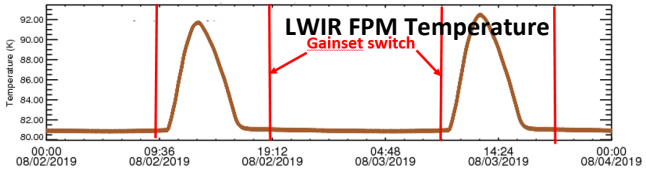
Each band has hundreds to thousands of detector rows. Each row has 3 or 6 detector columns.

These figures and table values are courtesy of L3Harris)

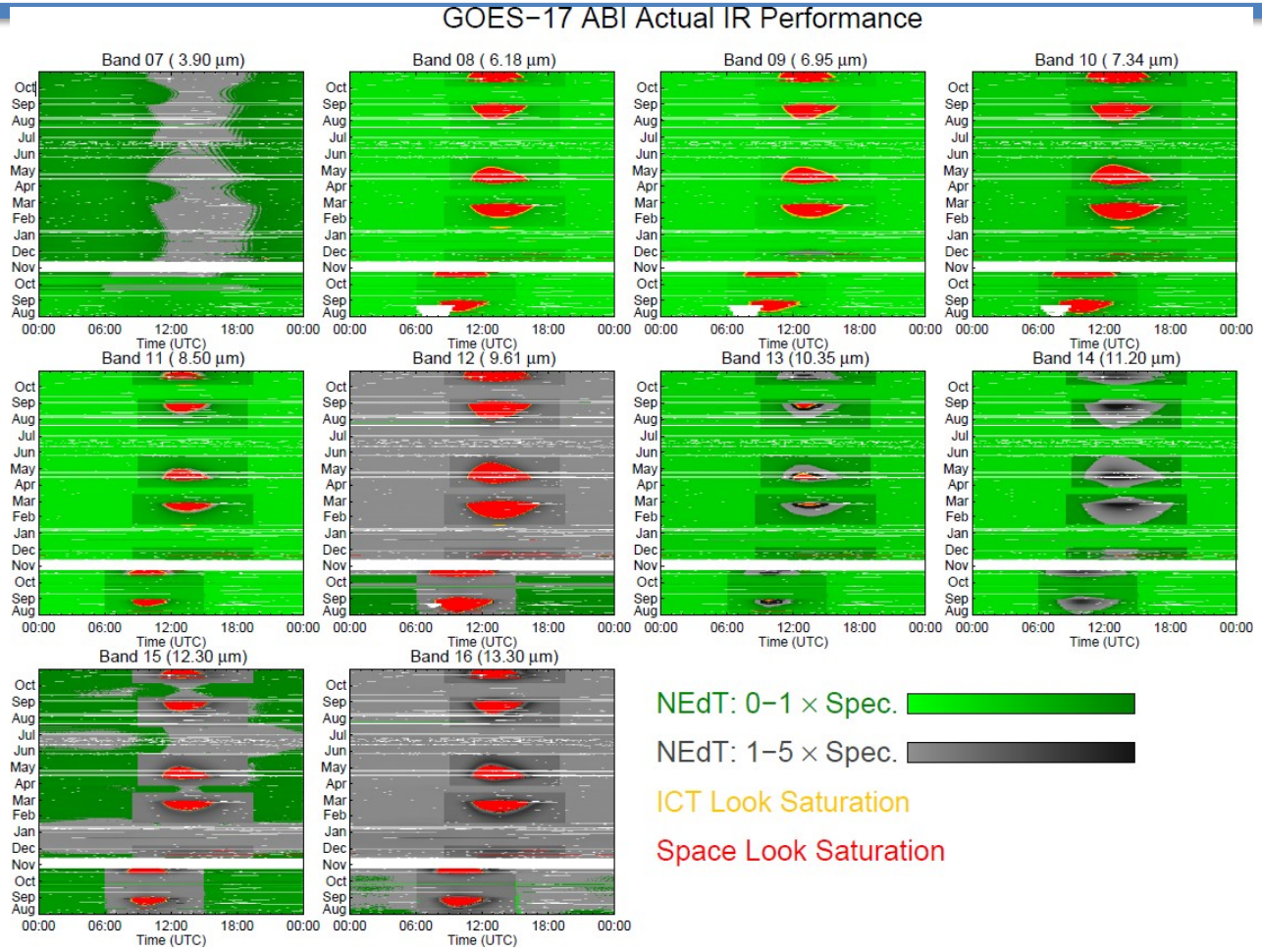
G17 ABI LHP Anomaly and Performance Recovery

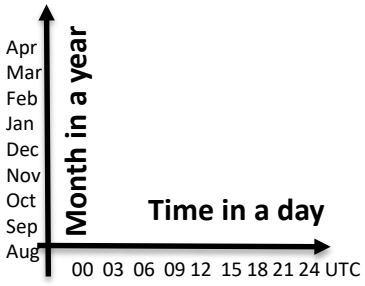
- **Loop Heat Pipe (LHP) anomaly causes the malfunction of the cooling system**
  - **Detected in late April 2018**
  - **Degraded data quality at all IR channels**

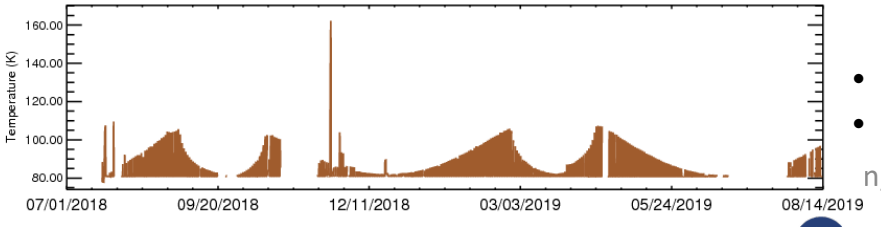
- **Activities implemented to recover and optimize the ABI performance**
  - **Yaw-flip semi-annually**
  - **Changes of the focal plane module (FPM) operation temperature**
    - Visible and Near-Infrared (VNIR) FPM: floating
    - Infrared (IR) FPMs: controlled at an elevated temperature (~81K) + floating 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

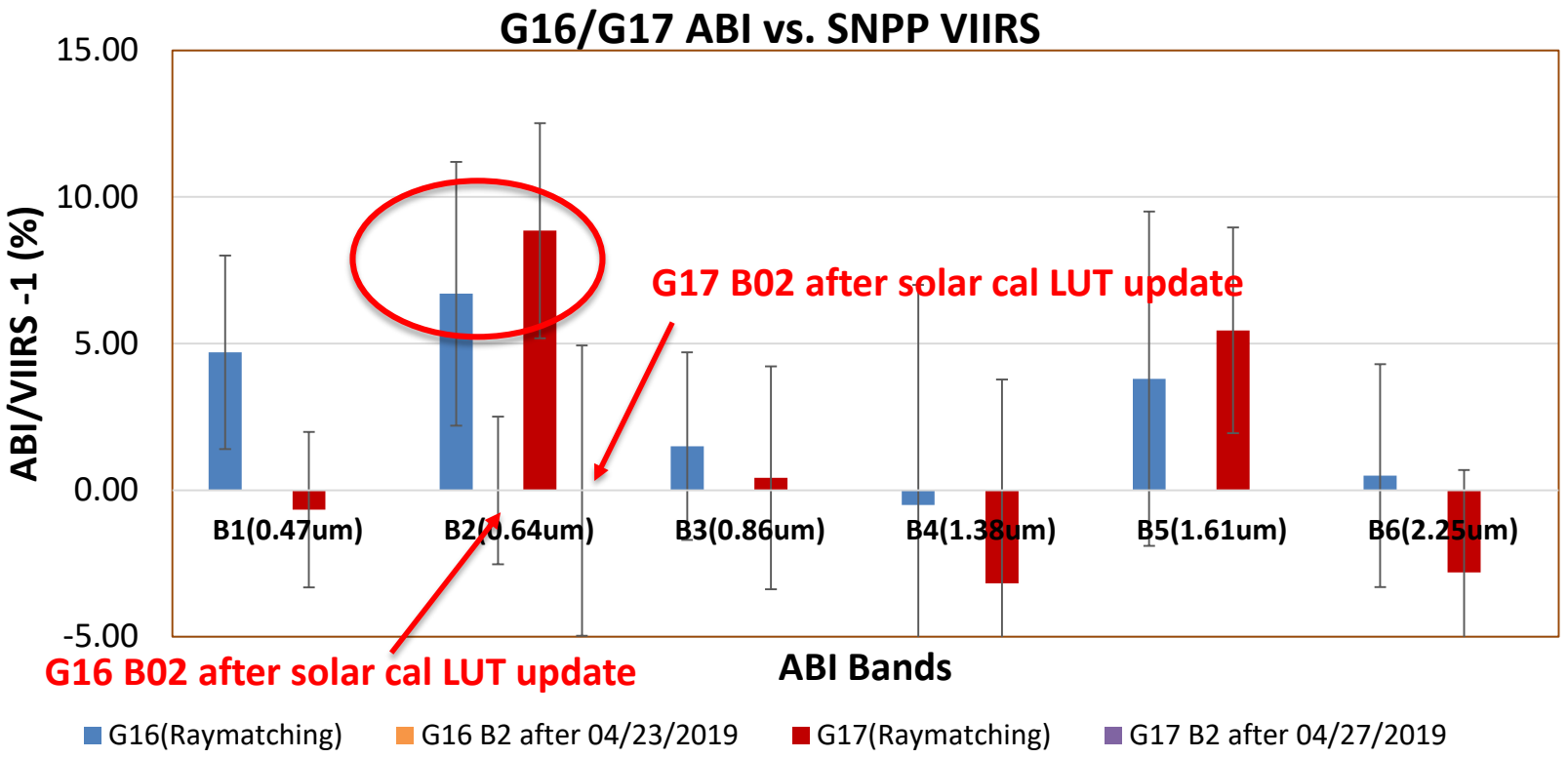




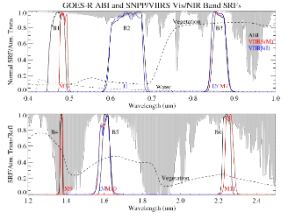


- **Light to dark green: adequately to barely meet the original requirement**
- **Gray: failed the original requirement**
- **Red: data not usable**

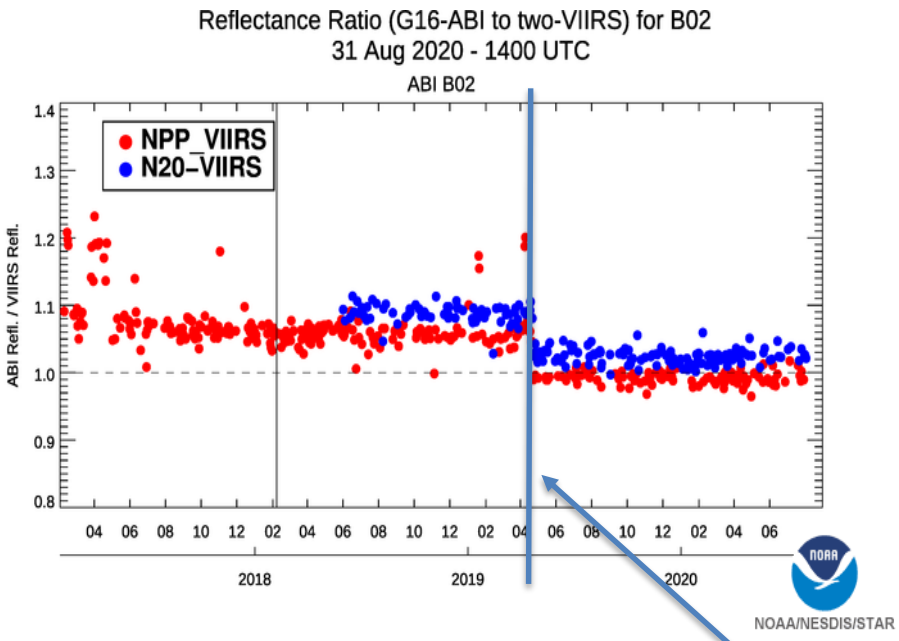
G16/G17 VNIR Calibration Accuracy

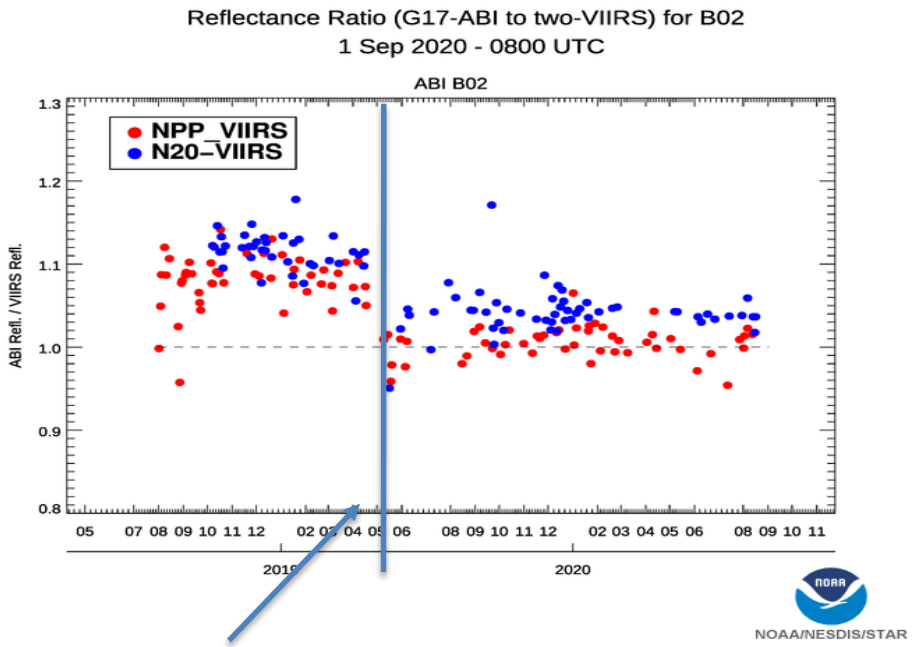


- **G16/G17 VNIR bands are generally within 5% difference to SNPP/VIIRS**
- **The updated solar diffuser BRDF look-up table, derived based on the prelaunch measurements, was implemented for G16 on 04/23/2019 and G17 on 04/27/2019 to mitigate the large bias for these two bands.**
  - **The new difference to VIIRS are greatly reduced**



G16/17 VNIR Rad. Cal. Monitoring



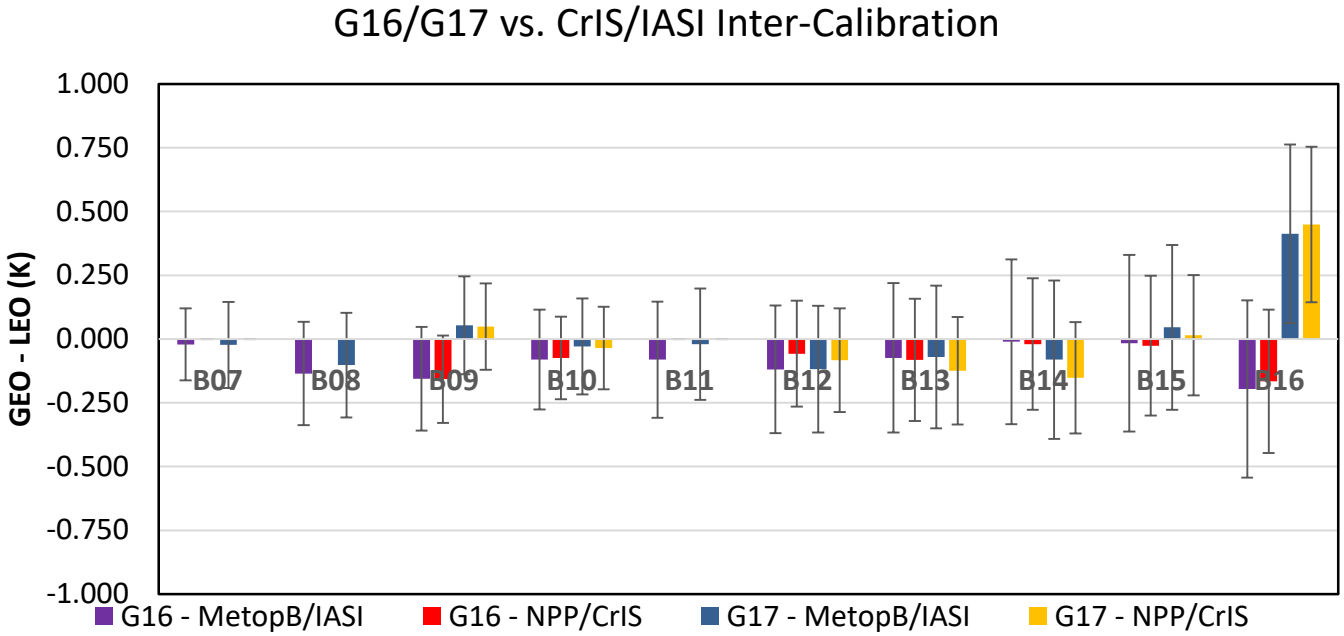


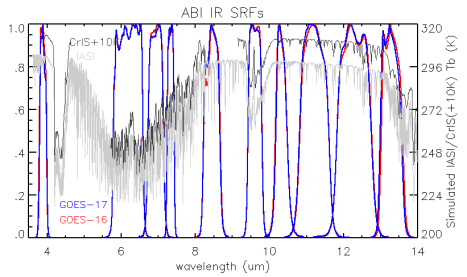
B02 Solar Cal. LUT update

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

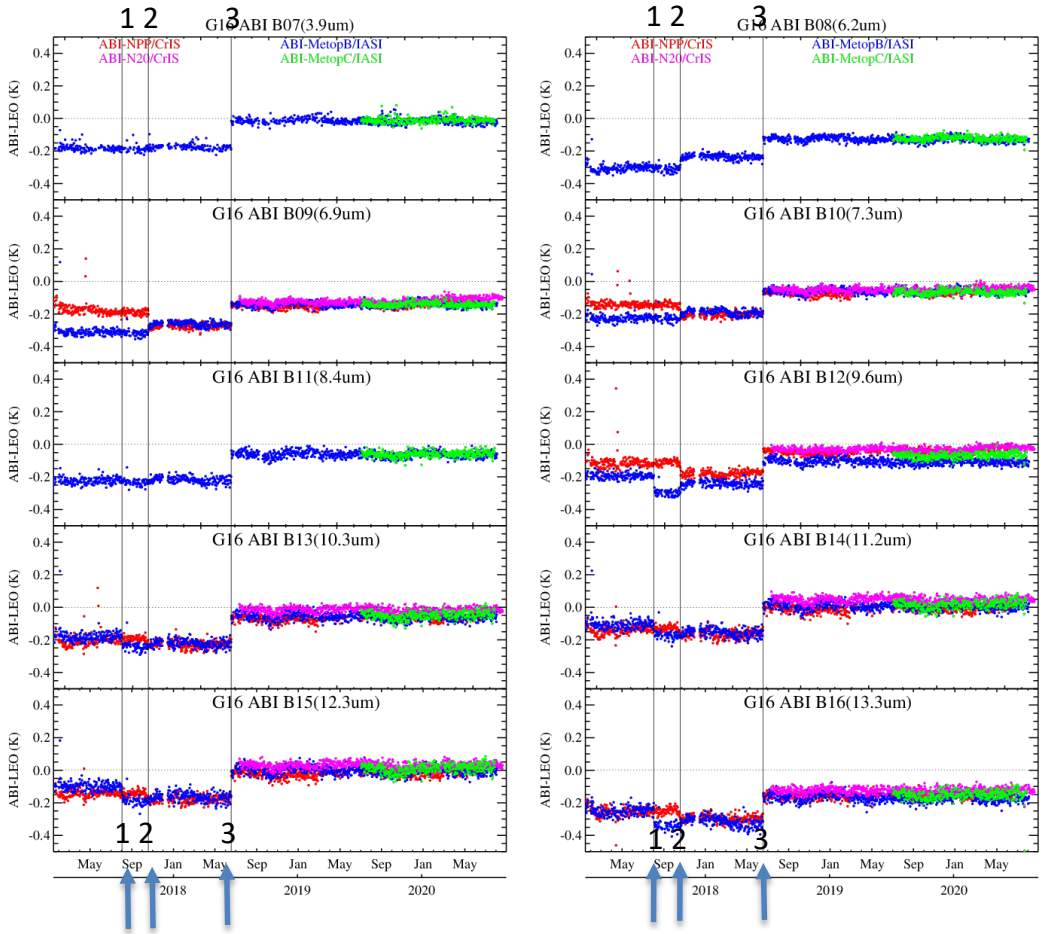
G16/17 IR Calibration Accuracy





- **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

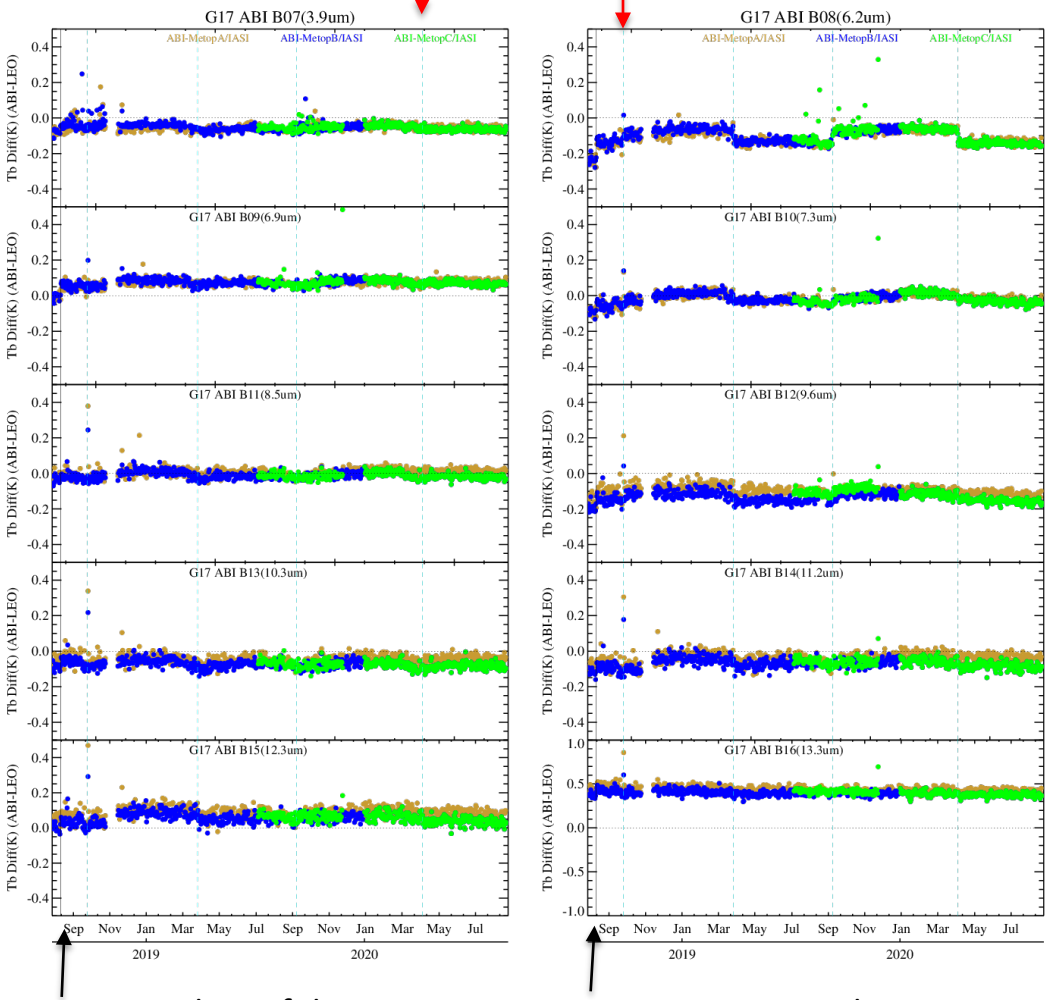
2. G16 ABI update of the scan-mirror emissivity LUT in October 2017

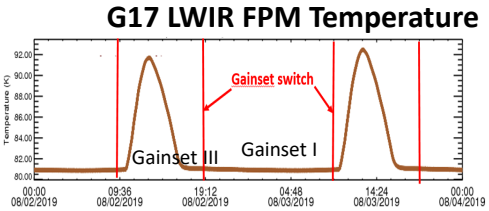
3. G16 ABI update of ICT PRT LUT in June 2018

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

S/C yaw flips

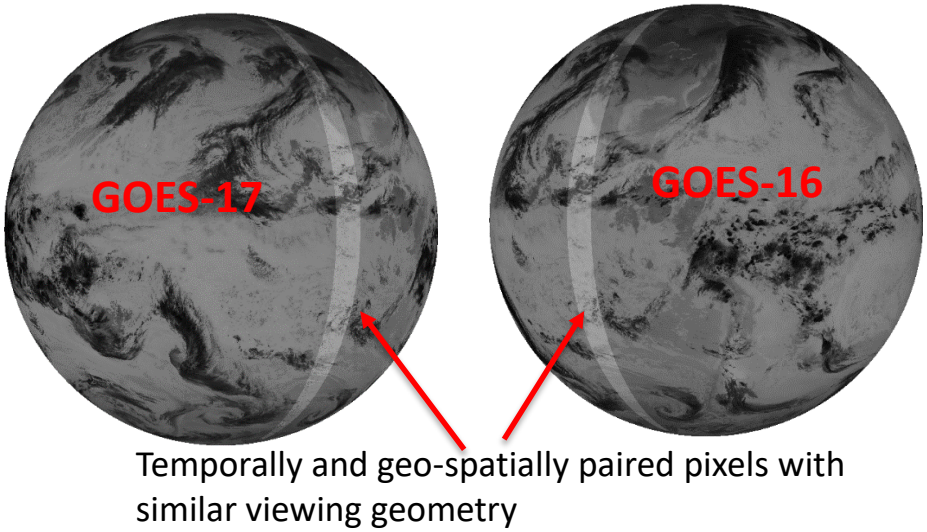




G17 ABI update of the scan-mirror emissivity LUT in early August 2019

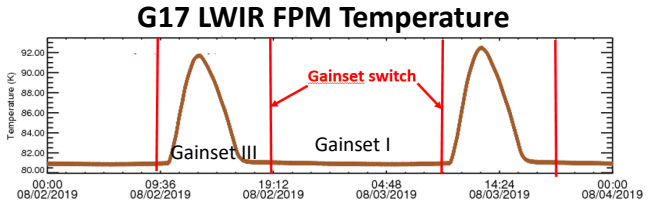
More detailed daily and long-term monitoring available at: https://www.star.nesdis.noaa.gov/GOESCal/G17_ABI_IR_InterCal_static.php

pCal Performance Validation



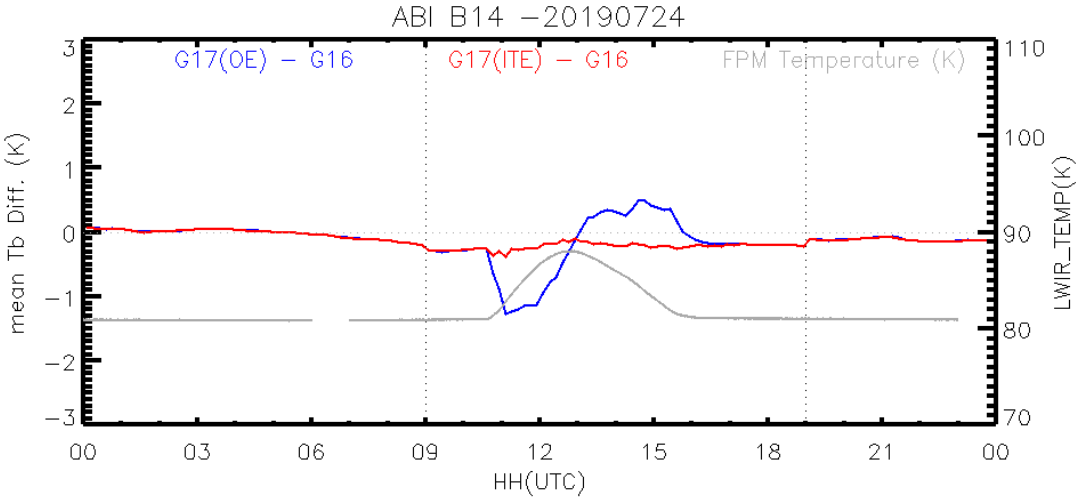
Temporally and geo-spatially paired pixels with similar viewing geometry

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



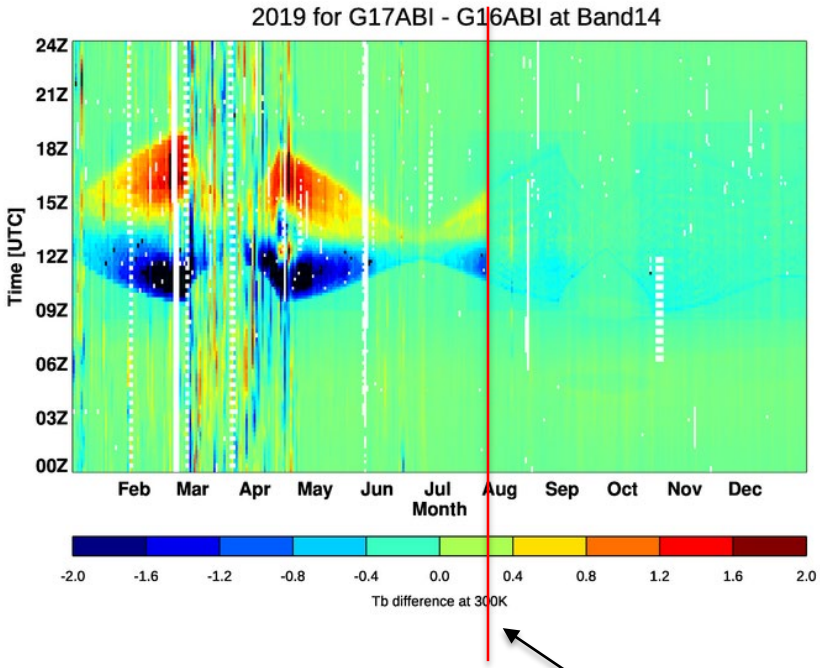
GEO-GEO Inter-comparison for pCal performance validation

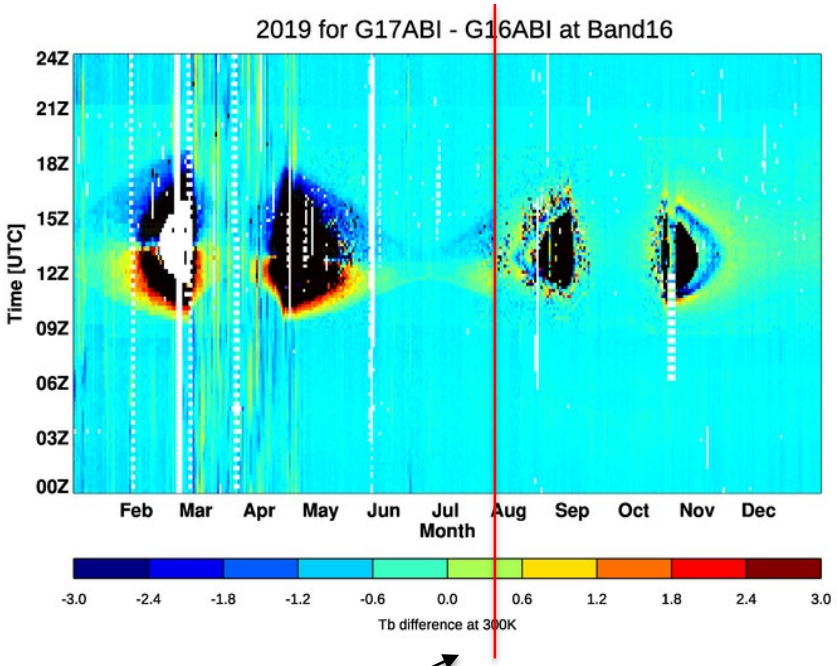
OE: without pCal algorithm
ITE: with pCal algorithm turn-on
FPM temperature



The pCal algorithm greatly reduces diurnal variation

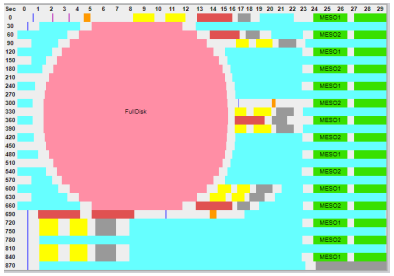
Time-series of G17 vs. G16 Tb Difference

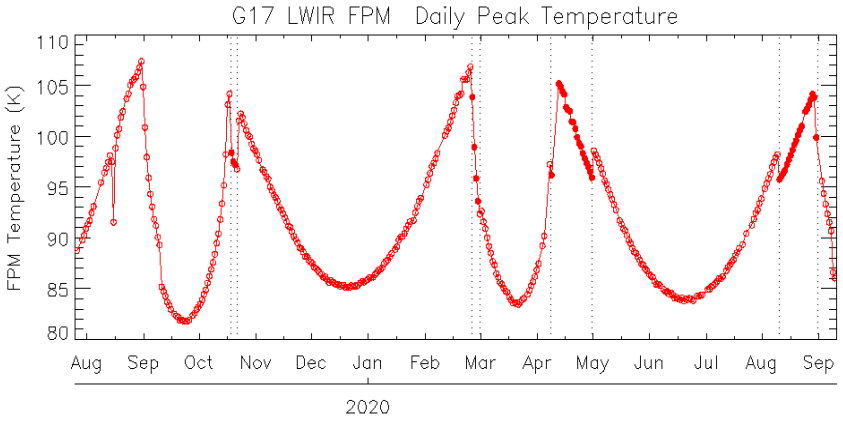




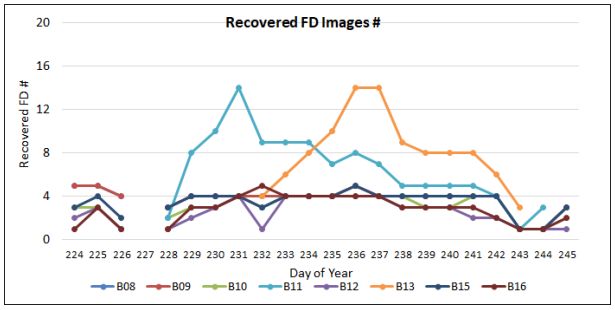
pCal Implementation

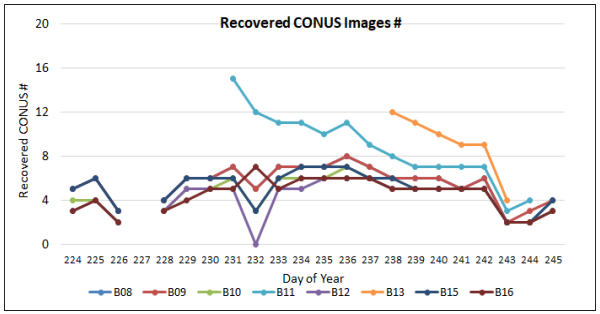
Cooling Timeline to Recover Images

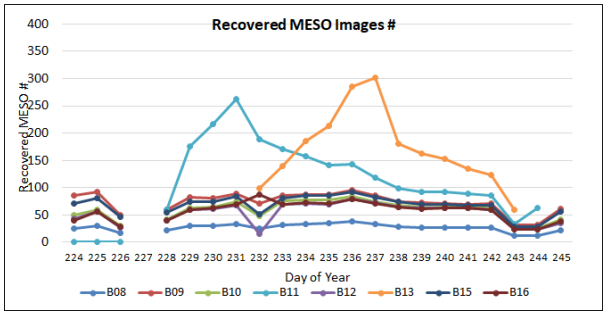




- Cooling timeline consists of cooling scenes and less earth scenes
- Implemented at 06:00-12:00z at “hot” nights in the eclipse seasons
- Recover 1-5 more FDs, 2-8 more CONUS, 30-100 more MESO images for most channels on most days

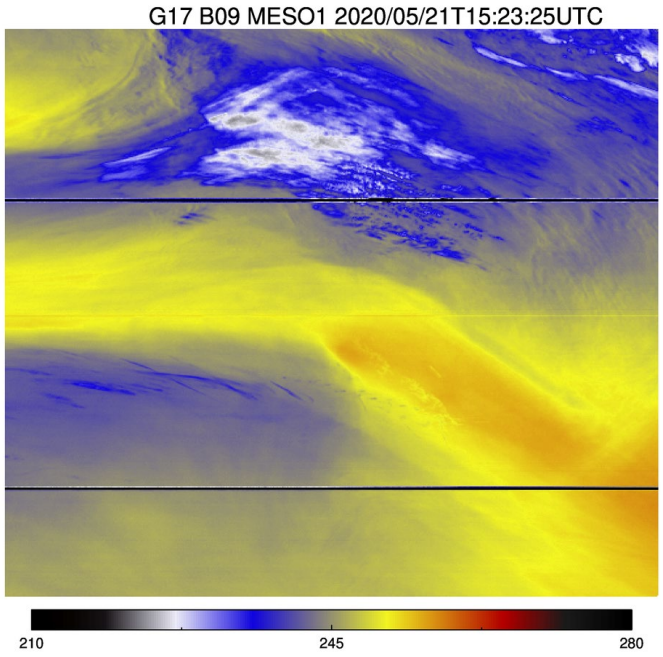




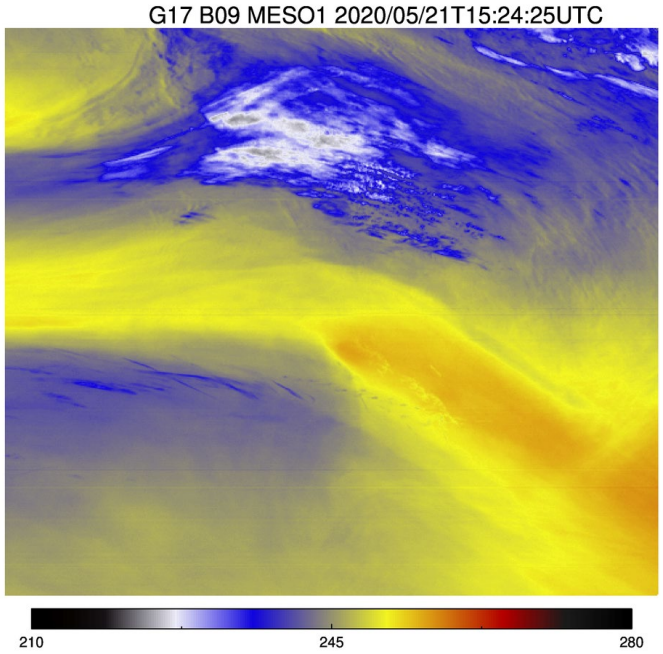


BDS update for Striping Reduction

Before BDS update

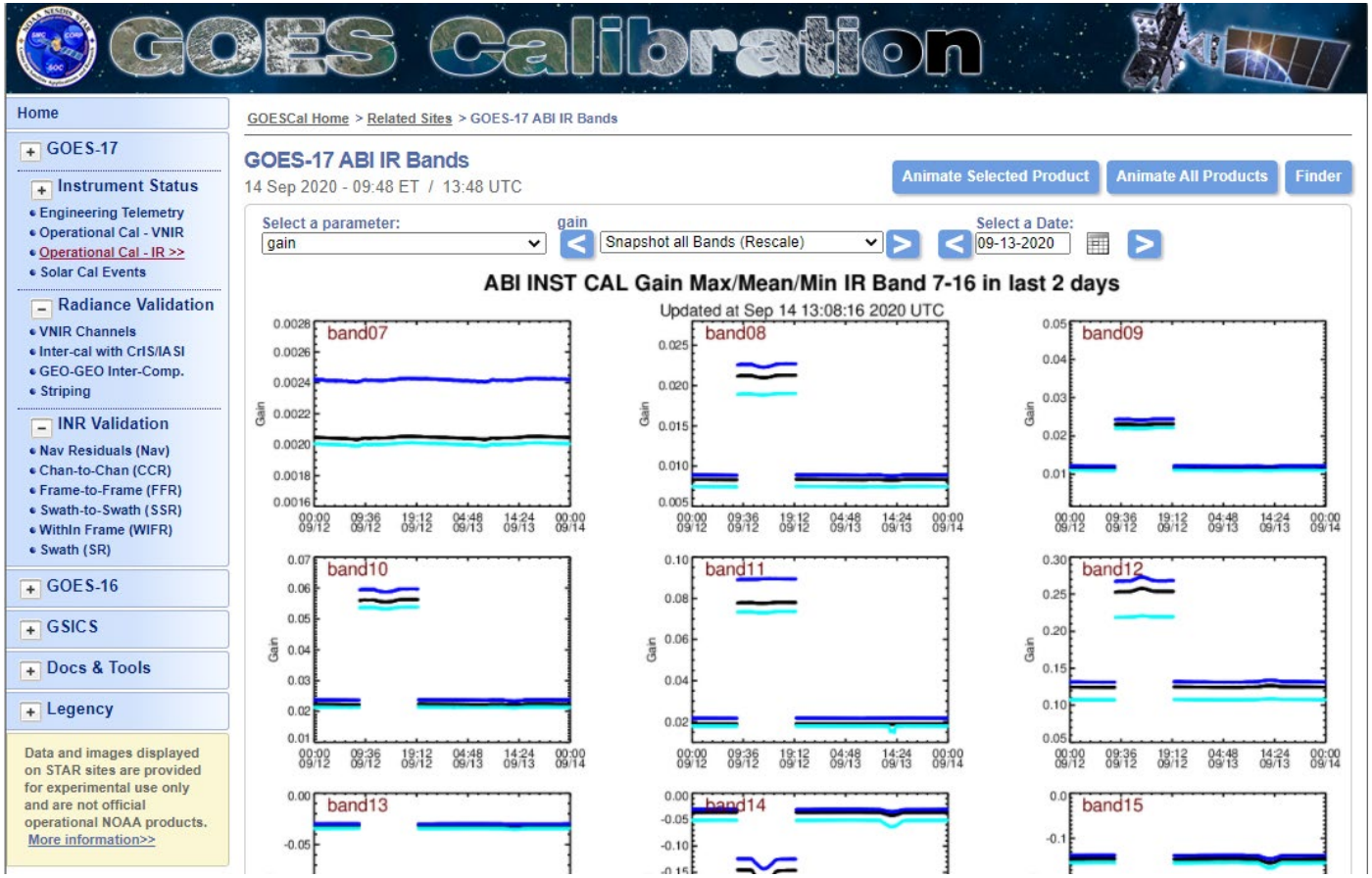


After BDS update



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.