Calibration and Validation of EWS-G*

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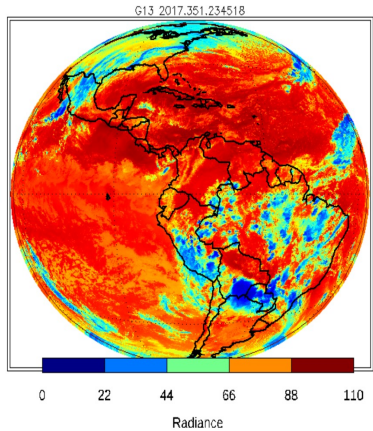* Paper 8B.1, Session 8B – Algorithm Development, Verification, and Cal/Val Part II

18th Annual Symposium on Operational Environmental Satellite Systems

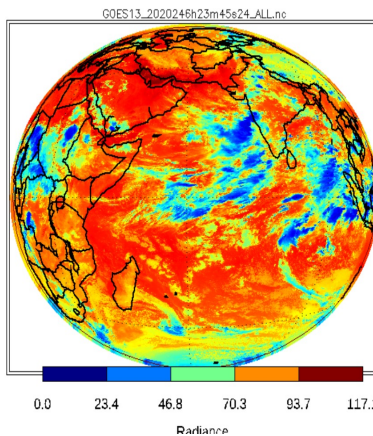102nd American Meteorological Society Annual Meeting

4:45 p.m. 25 January 2022

Introduction

GOES-13 Ch 4 at 2345 UTC on 2017-12-17 (above) and EWS-G at 2345 UTC on 2020-09-02 (below)

- In 2019, NOAA's GOES-13 was transferred to USSF as EWS-G1 over the Indian Ocean.
  - NOAA: National Oceanic and Atmospheric Administration
  - GOES-13: The 13th Geostationary Operational Environmental Satellite
  - USSF: United States Space Force
  - EWS-G: Electro-Optical Infrared (EO/IR) Weather System – Geostationary

- NOAA assisted the transition and operation of EWS-G1, including its operational calibration.

- For the Initial Operational Capability (IOC, achieved in September 2020), the focus was on Imager.
  - Calibration priority was its visible channel, which does not have onboard calibration.

Outline

- Vicarious calibration of GOES Imager visible channel using MODIS.
- Application to EWS-G1
  - Correct for spectral response functions
  - Update for reference radiometer
  - Account for degradation when the instrument is stowed.
- Calibration issues for IR channels
  - Verification of stray light correction
  - Near real time monitoring of instrument calibration and product validation
- Summary
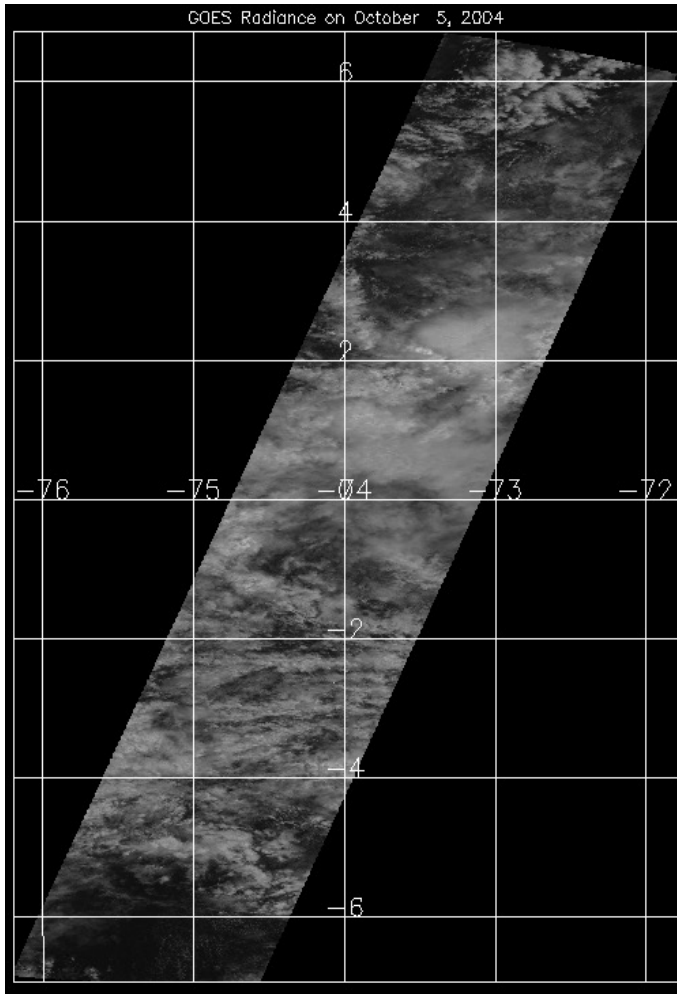
GOES VISIBLE CHANNEL CALIBRATION

Vicarious Calibration of Imager Visible Channel

- Explored several options:
  - Pseudo Invariant Targets/Features/Cal Sites/…: Desert (Sonora), DCC.
  - Celestial bodies: Star, Moon (later).

- Selected inter-calibration with MODIS.

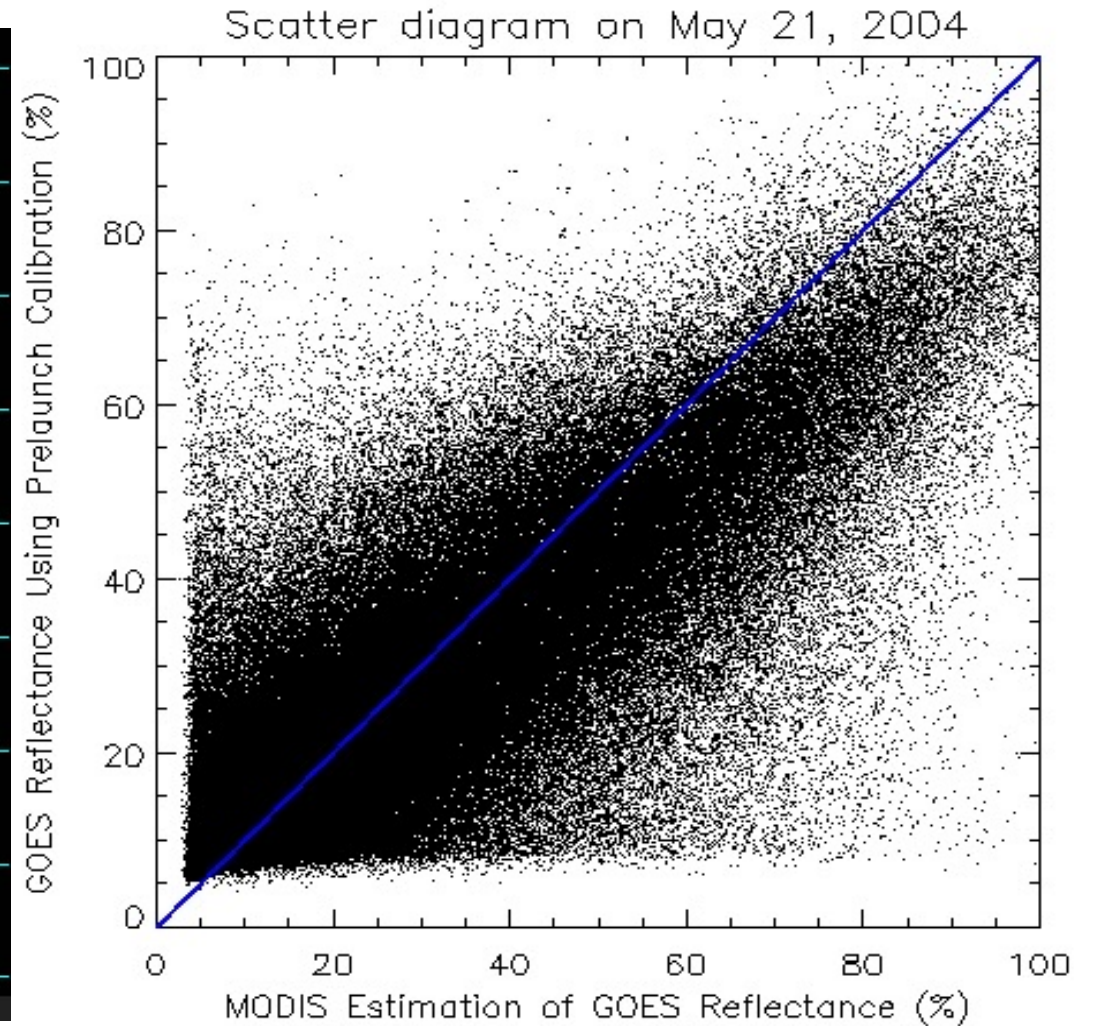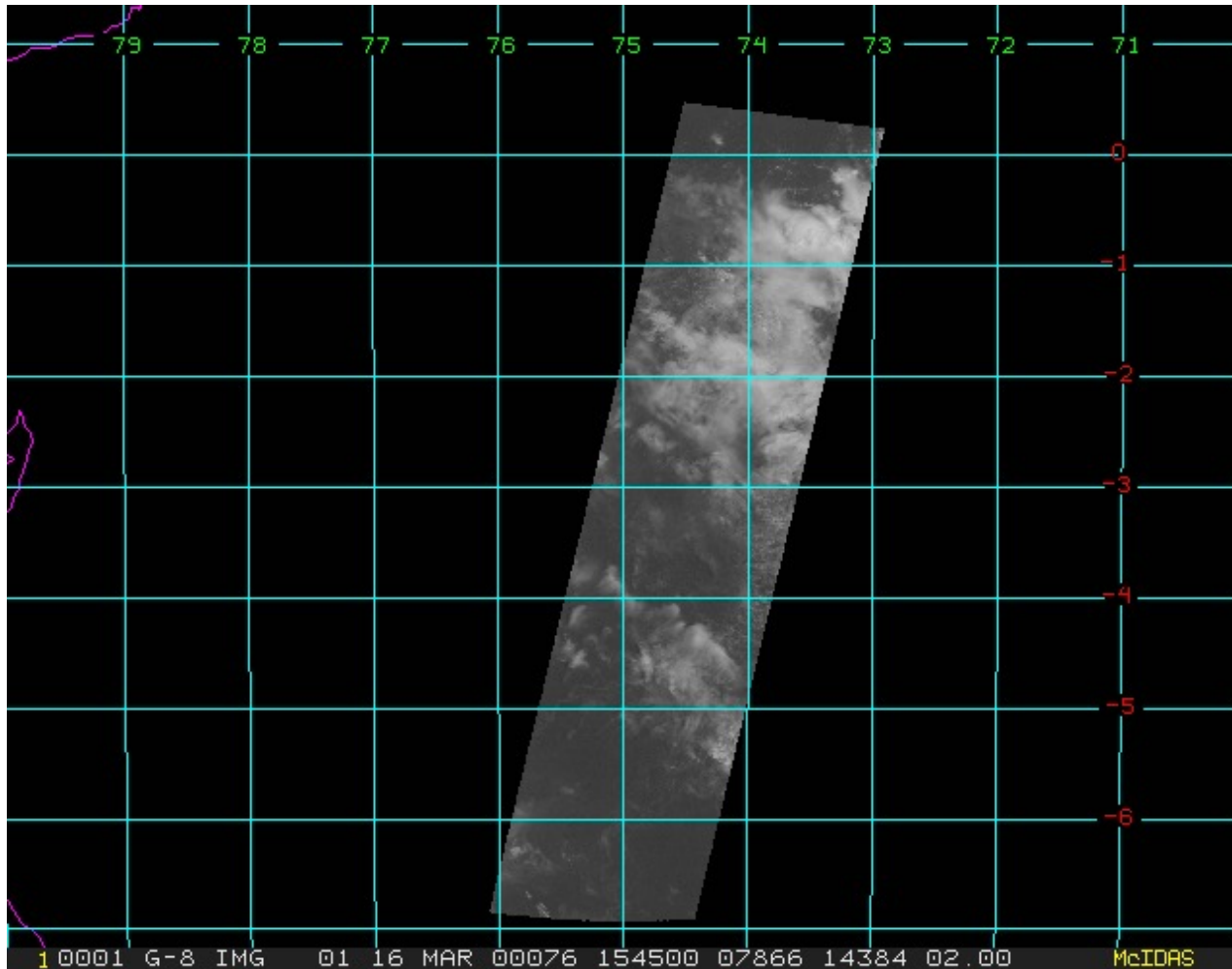| Requirement	Purpose
MODIS Channel 1 @ 1KM	Matching Spectral Response and Spatial Resolution
Within ~10 minutes	Concurrent in Time
Navigate MODIS to GOES	Co-located in Space
Within ~8° from Both Nadirs Cos(VZA) > 0.99	Similar Viewing Geometry & Minimal Rayleigh Scattering

MODIS image in GOES projection …

MODIS Radiance on October 5, 2004
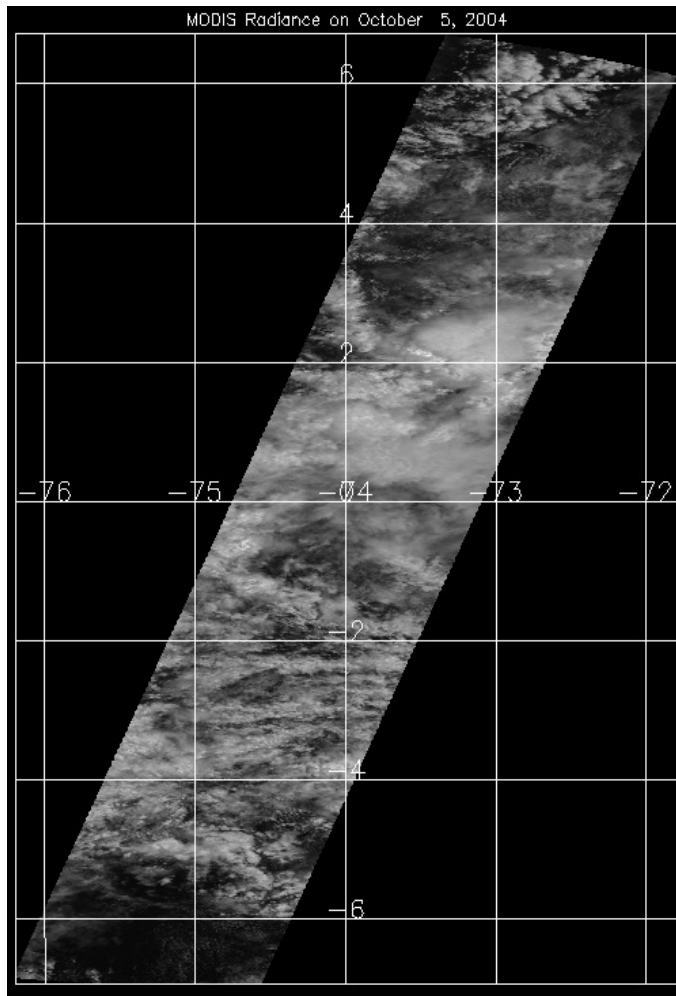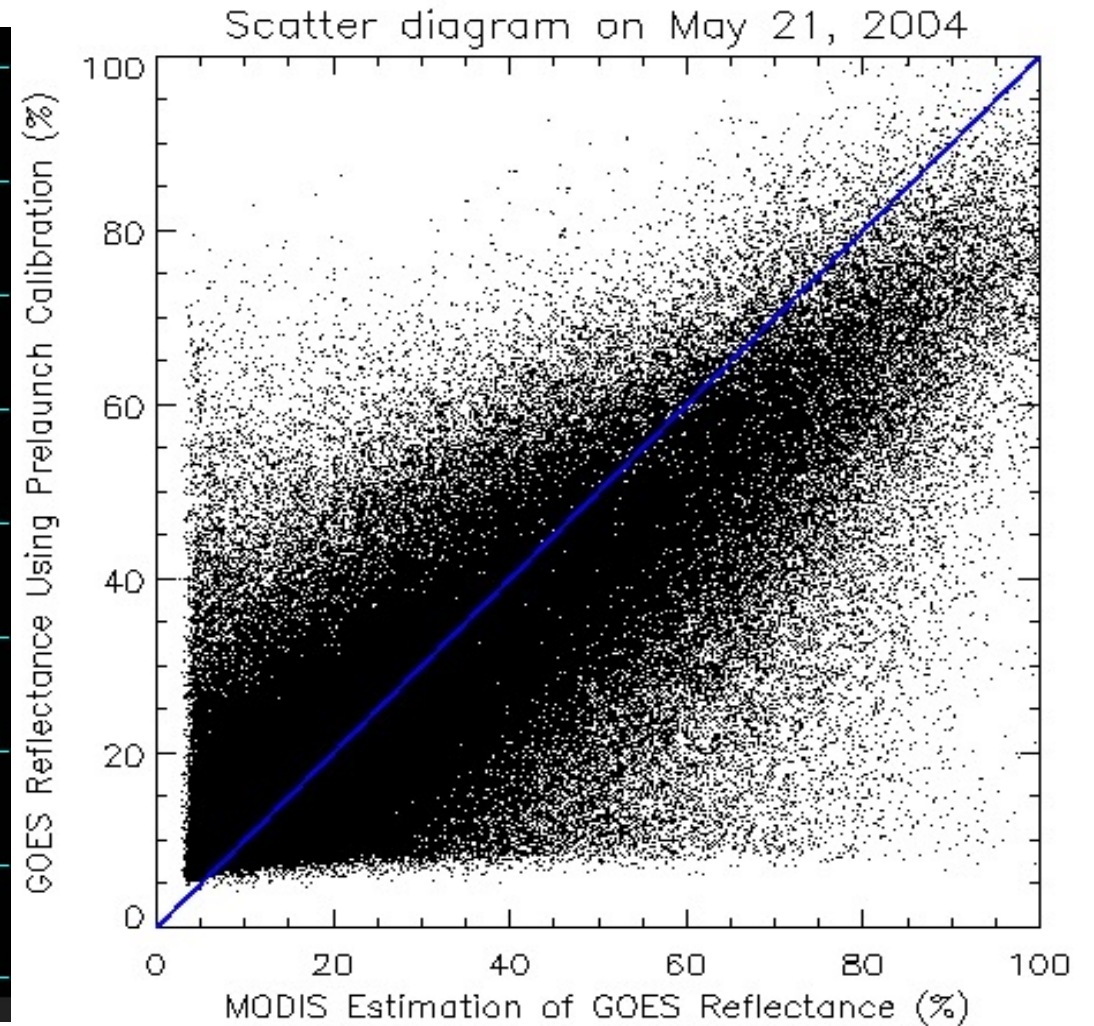
… and the corresponding GOES image

GOES Radiance on October 5, 2004

The slope of the regression line (white) would be a good indication of degradation.

Scatter diagram on October 5, 2004

GOES Reflectance Using Prelaunch Calibration (%)
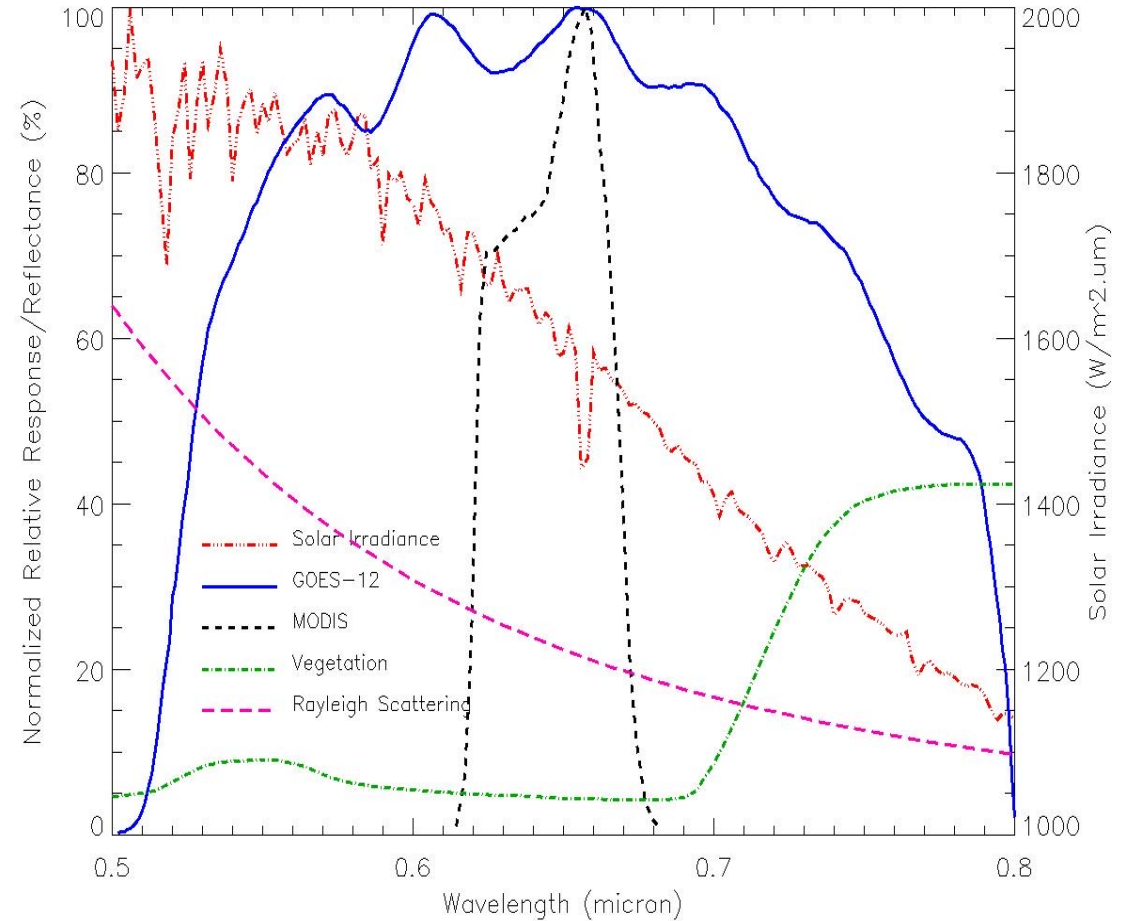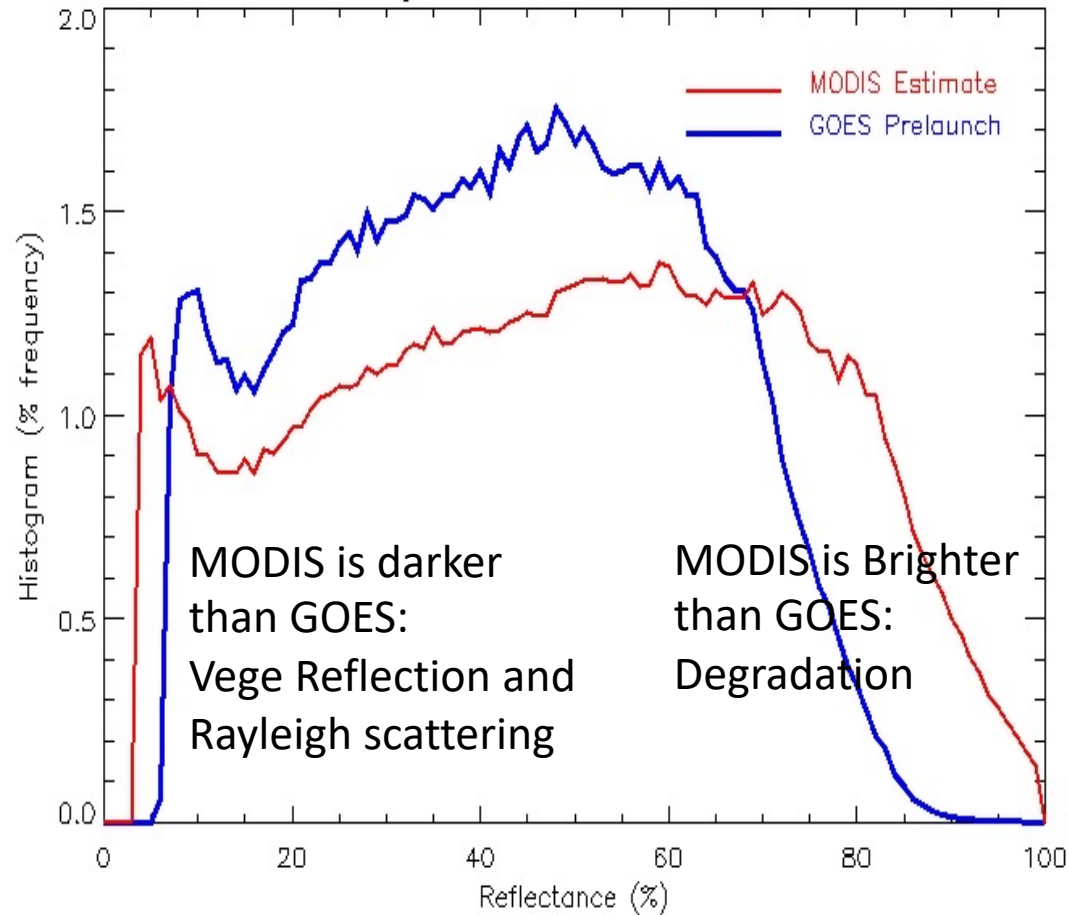
MODIS Estimation of GOES Reflectance (%)
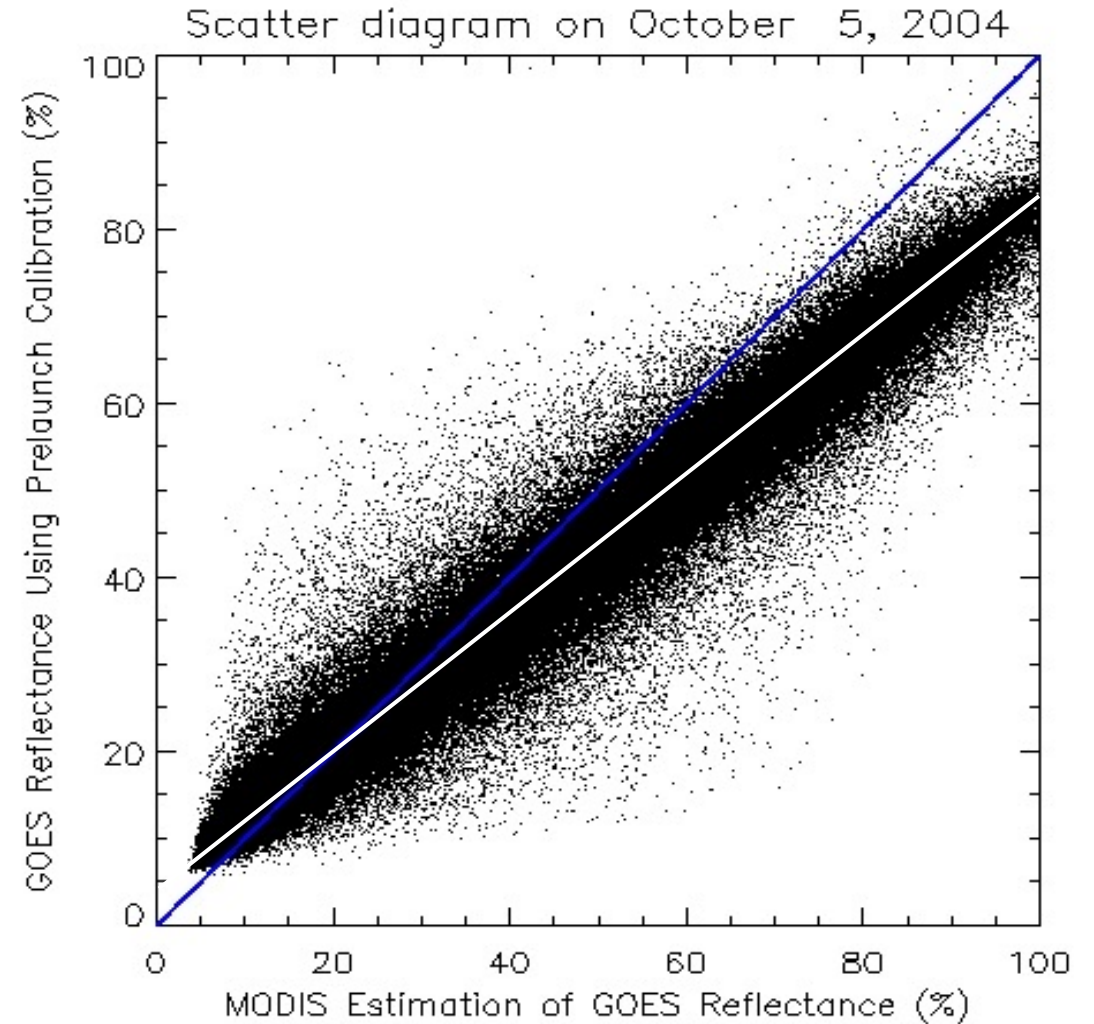
Often, the plot is more scattered …

… because of time gap between images
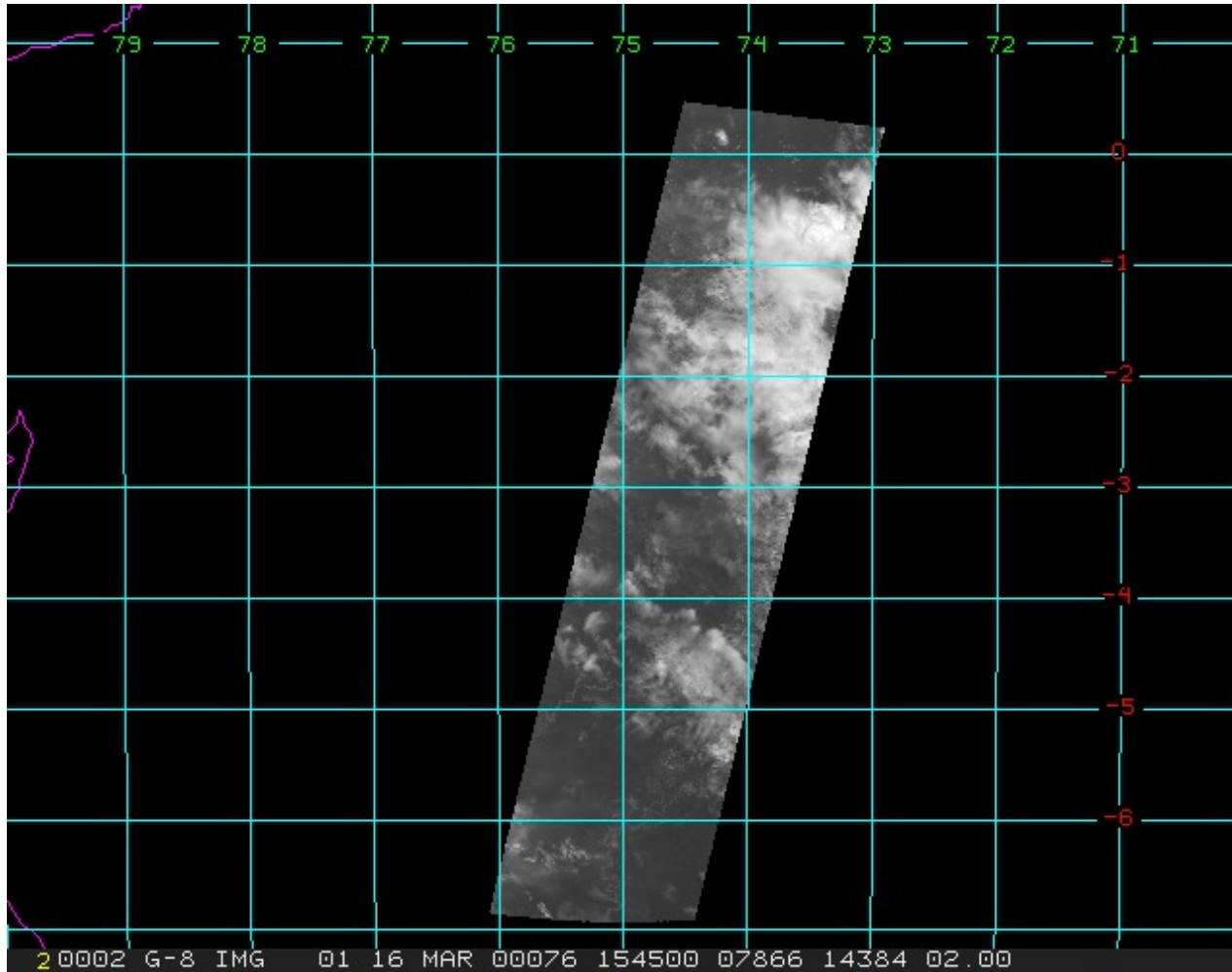
Scatter diagram on May 21, 2004

Histograms on October 5, 2004

MODIS is darker than GOES: Vege Reflection and Rayleigh scattering

MODIS is Brighter than GOES: Degradation

1. Accumulate MODIS histogram (**red**) from 100% reflectance.

2. Repeat for GOES (**blue**).

3. Compute the total difference up to 25% reflectance (avoid clear).

4. Multiply GOES reflectance by a "correction", and go to Step 2.

5. After sufficient number of corrections have been tested, find the one that minimizes the difference in Step 3.

6. Repeat on all days with collocations. Log regression over time.

Histograms on October 5, 2004
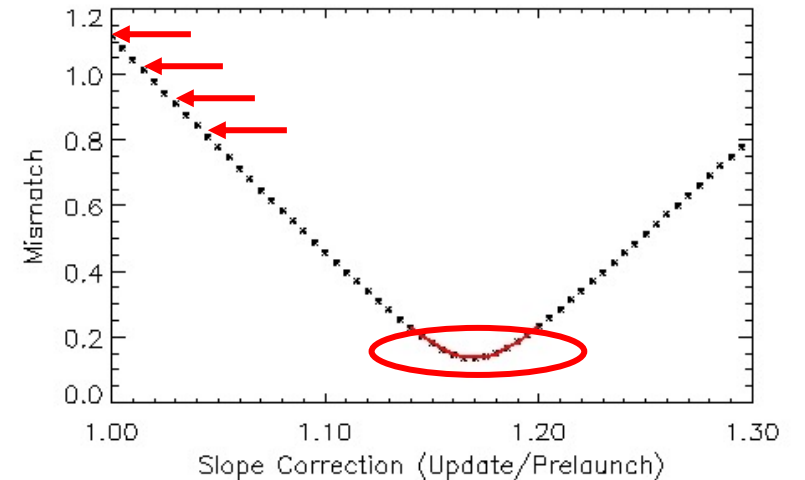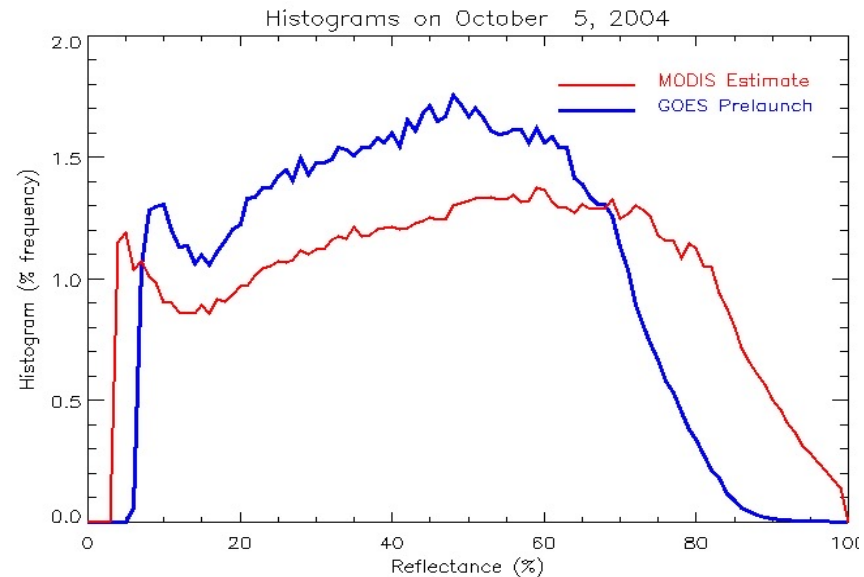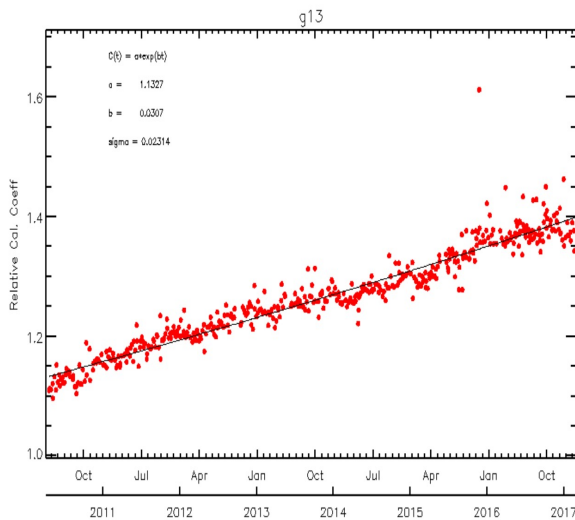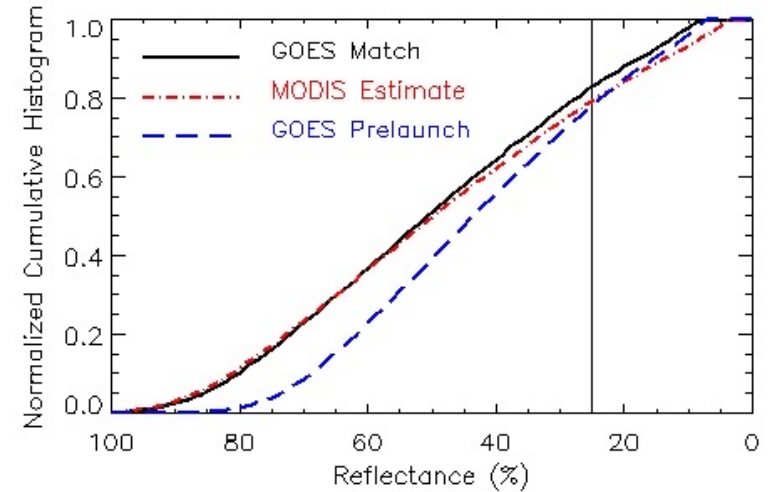
APPLICATION TO EWS-G

1. Adjust for Spectral Response

- The matching channels have similar but not identical Spectral Response Functions (SRF).

- MODIS radiance was adjusted for GOES SRF using a radiative transfer model "MODTRAN" (Wu 2003).

- The impact of SRF difference has since been characterized comprehensively as Spectral Band Adjustment Factor (SBAF, Doelling et al. 2011, Scarino et al. 2018).

- It is found that the difference between SBAF and the MODTRAN-based adjustment is negligible.
 - Switched to SBAF for Terra MODIS now.
  - And for NOAA-20 VIIRS in future.
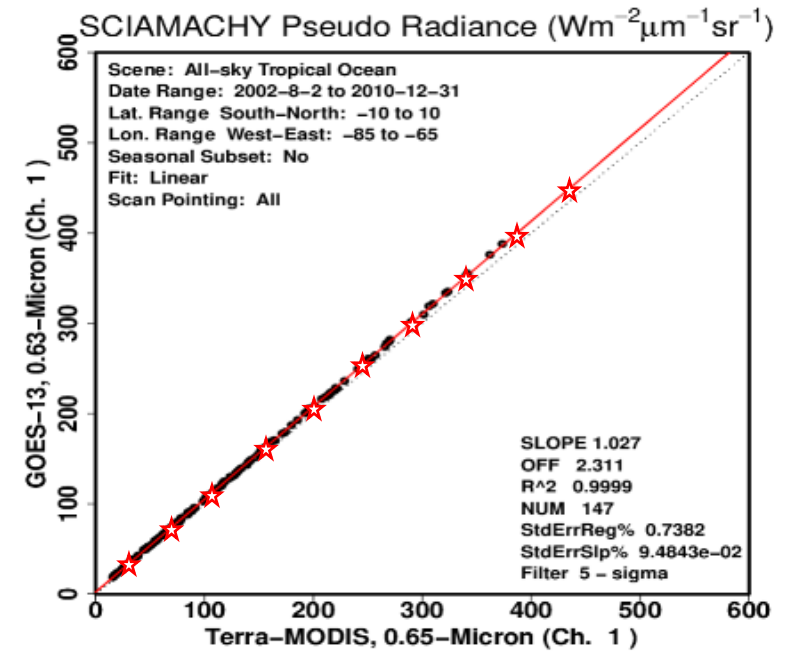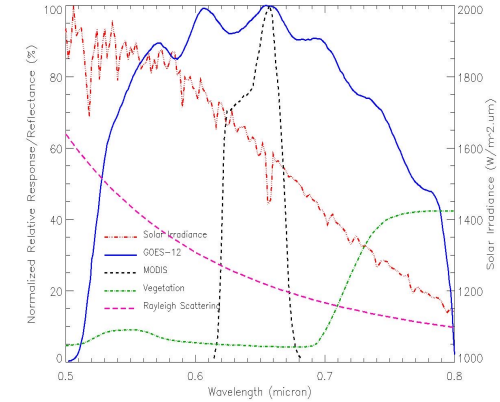
2. Adapt to New Reference

- Chose Terra MODIS since 2003.

- Operational calibration for GOES-13 started on 14 April 2010.
  - Terra MODIS "Collection 5".

- C5 was terminated in Feb 2017, replaced by C6.

- Used C6 to reprocessed February data 2011-2017. The C6 – C5 difference is 0.0305.

- Adjusted the data prior to Feb 2017.
  - Used Terra MODIS C6 thereafter.
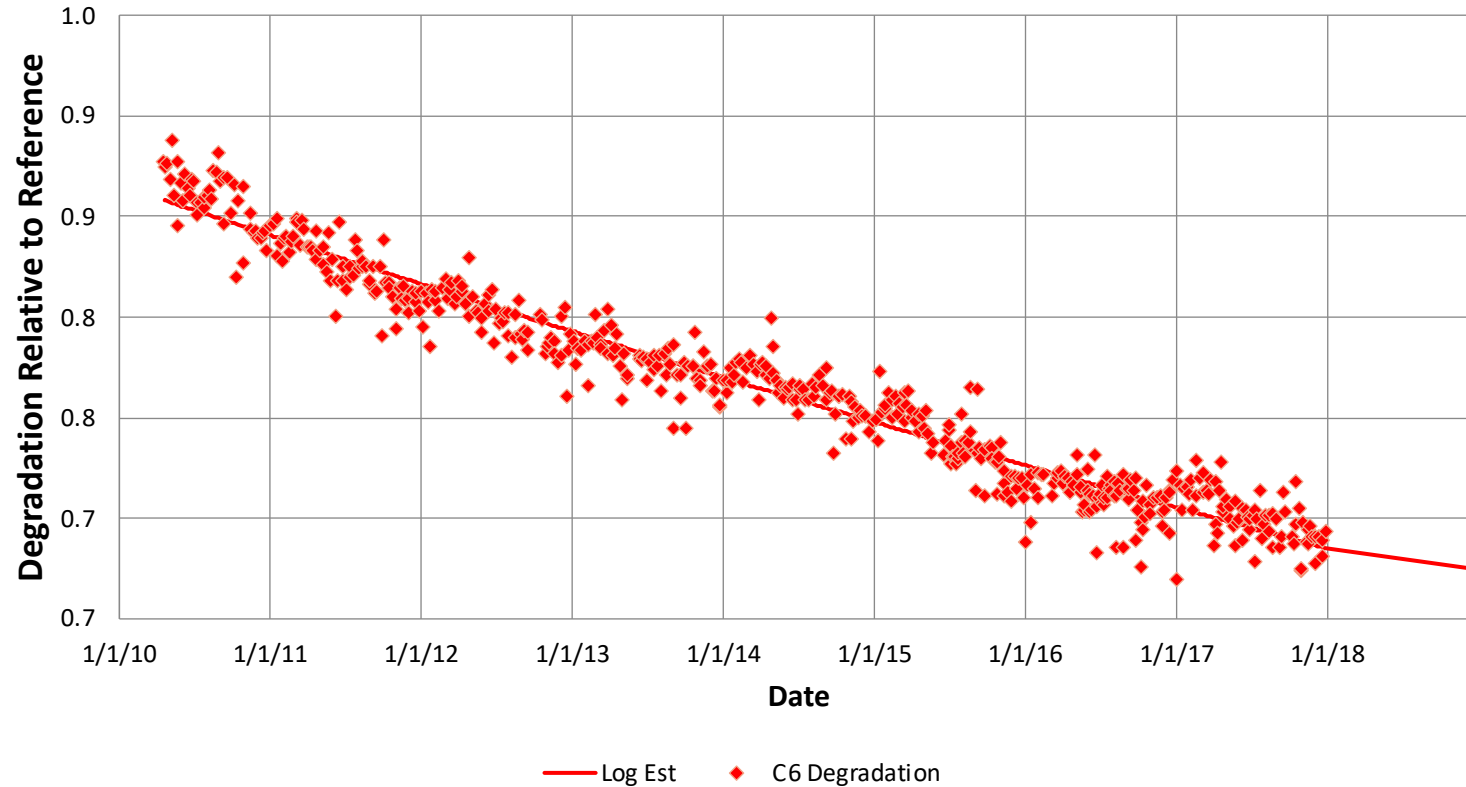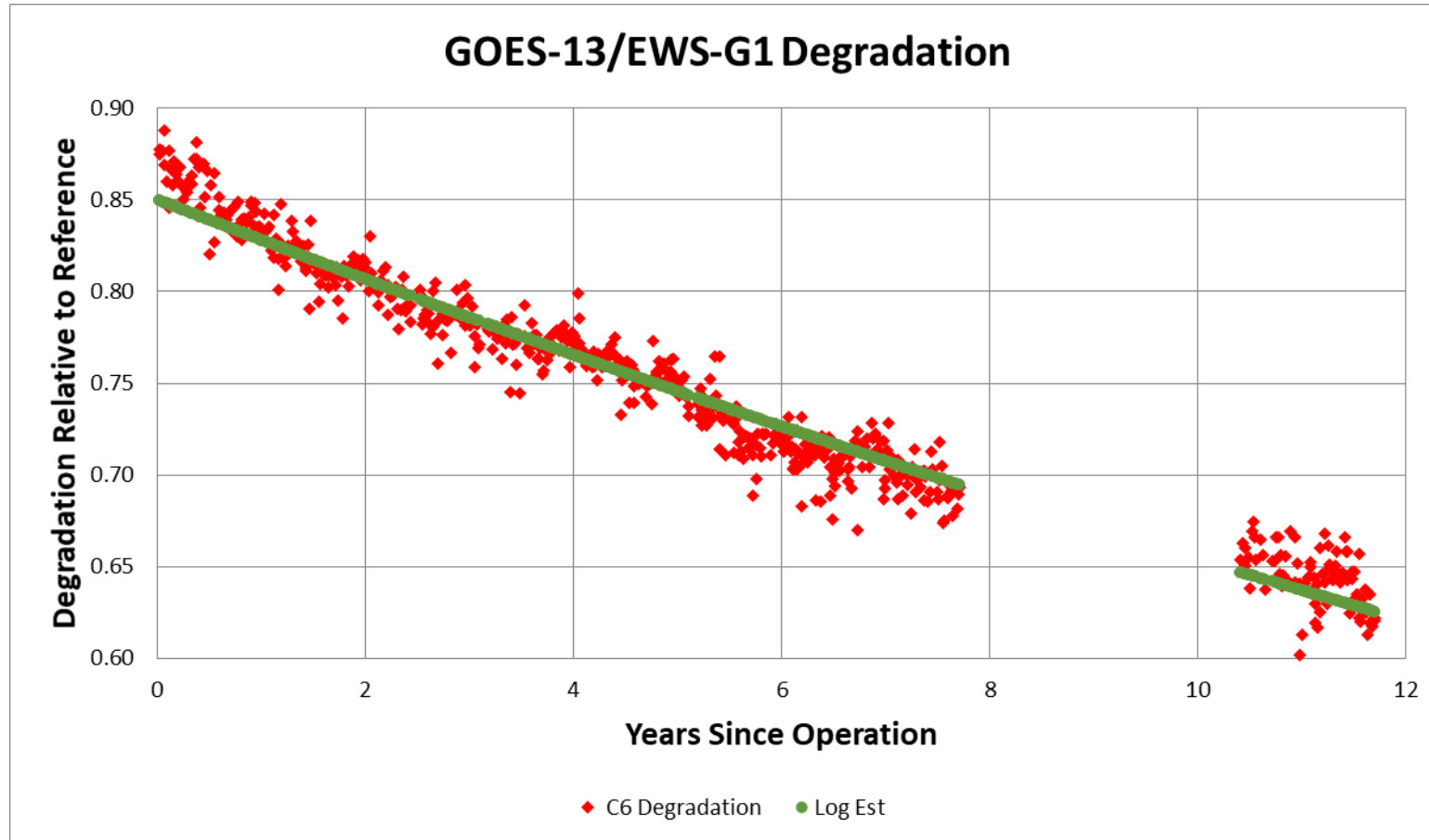 - Will shift to NOAA-20 VIIRS in future.
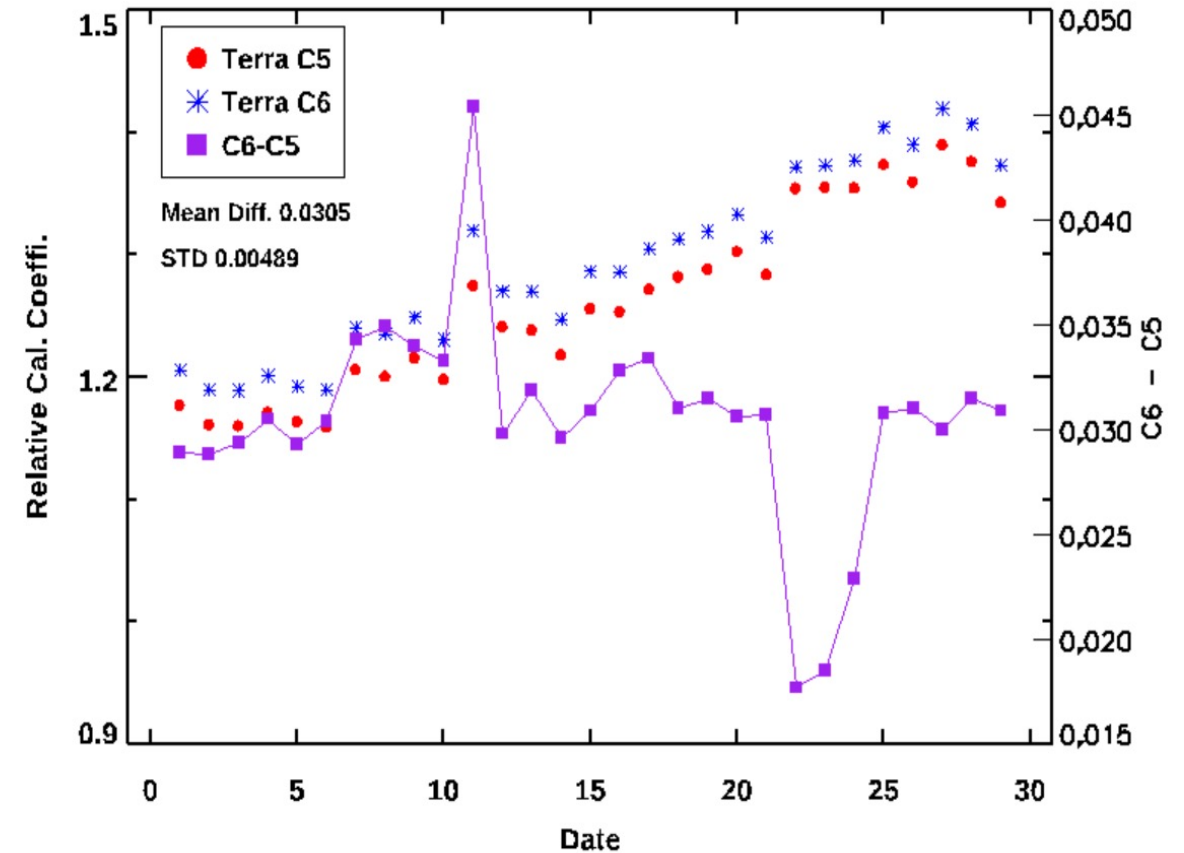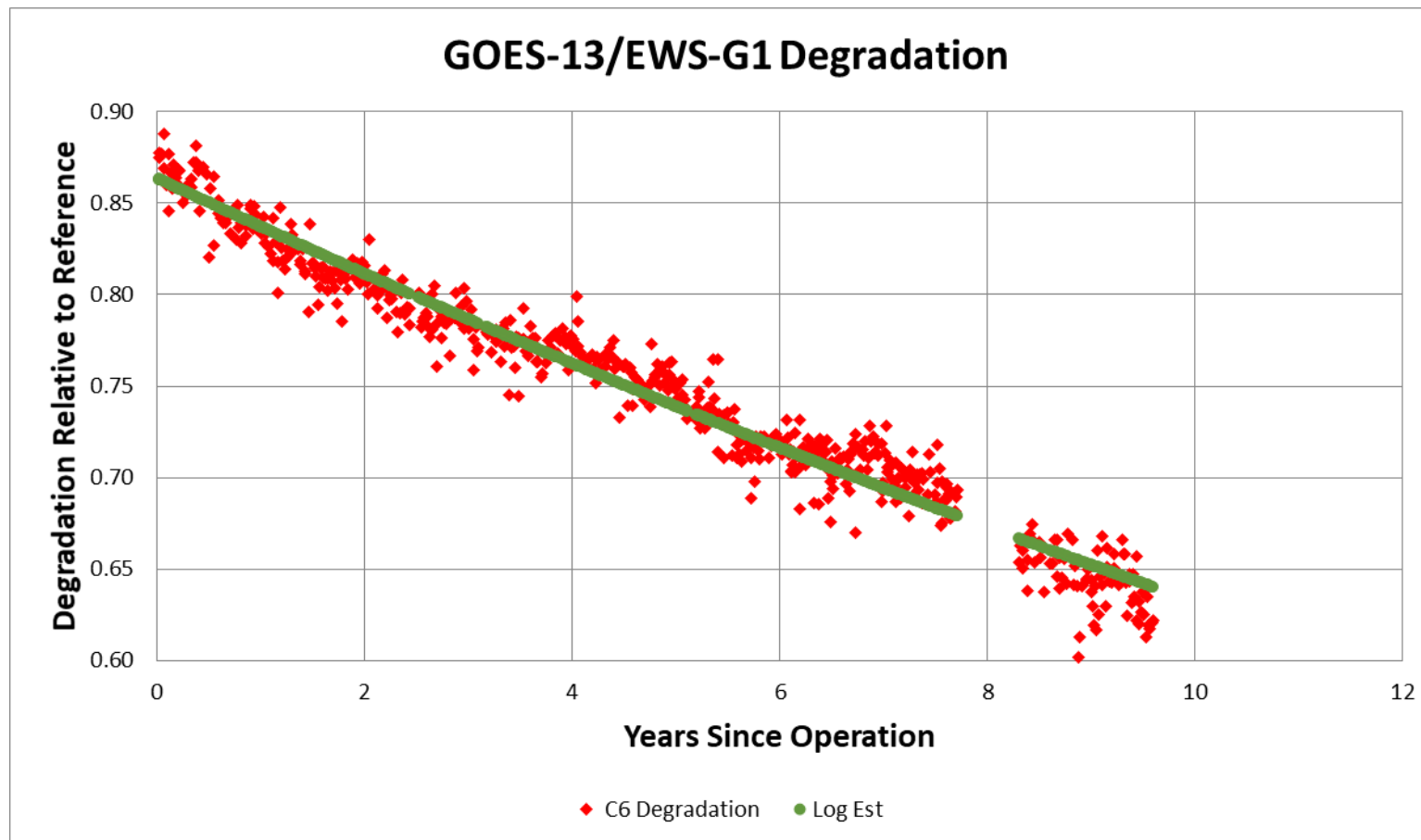
Reference Adjustment
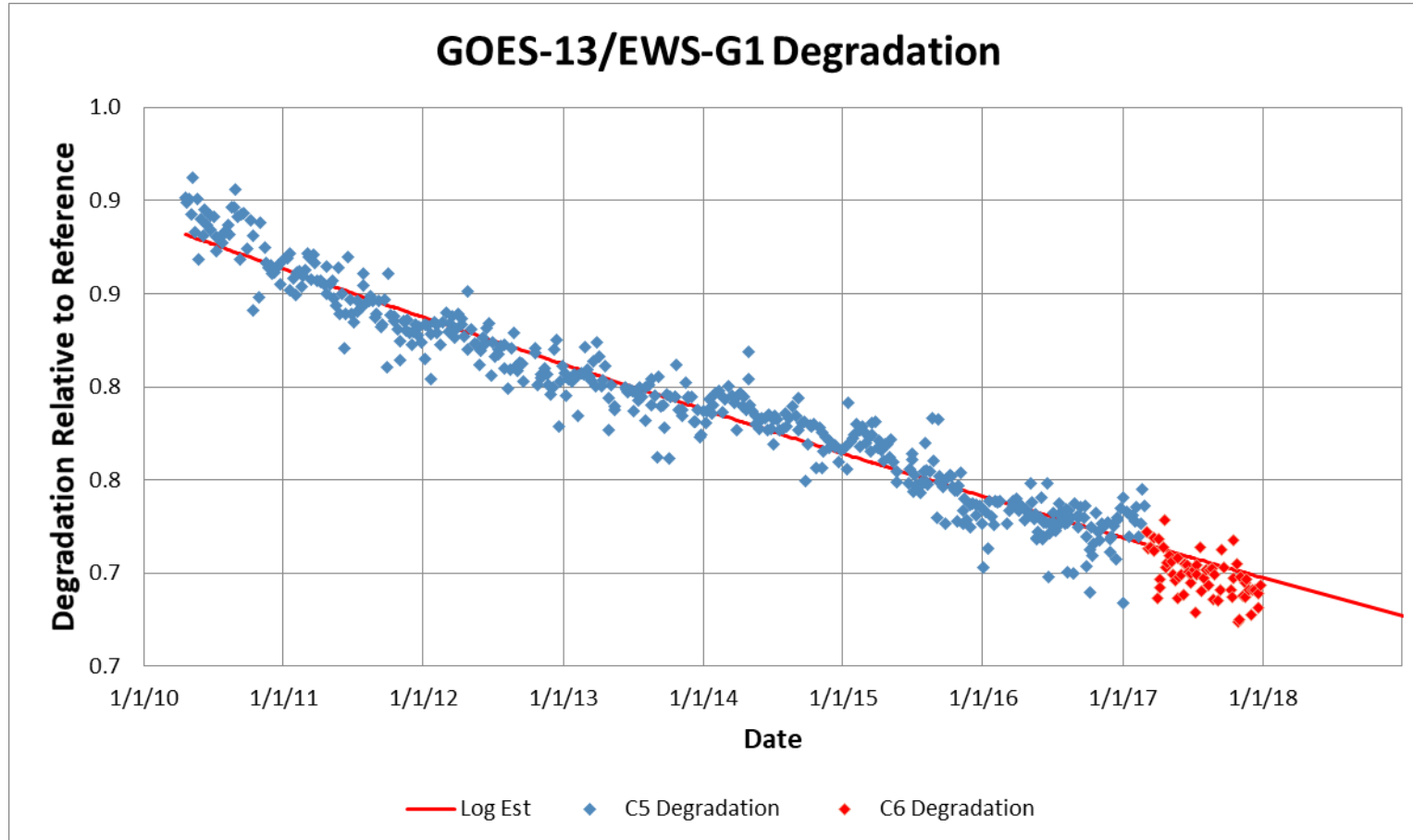
GOES-13/EWS-G1 Degradation

Reference Adjustment

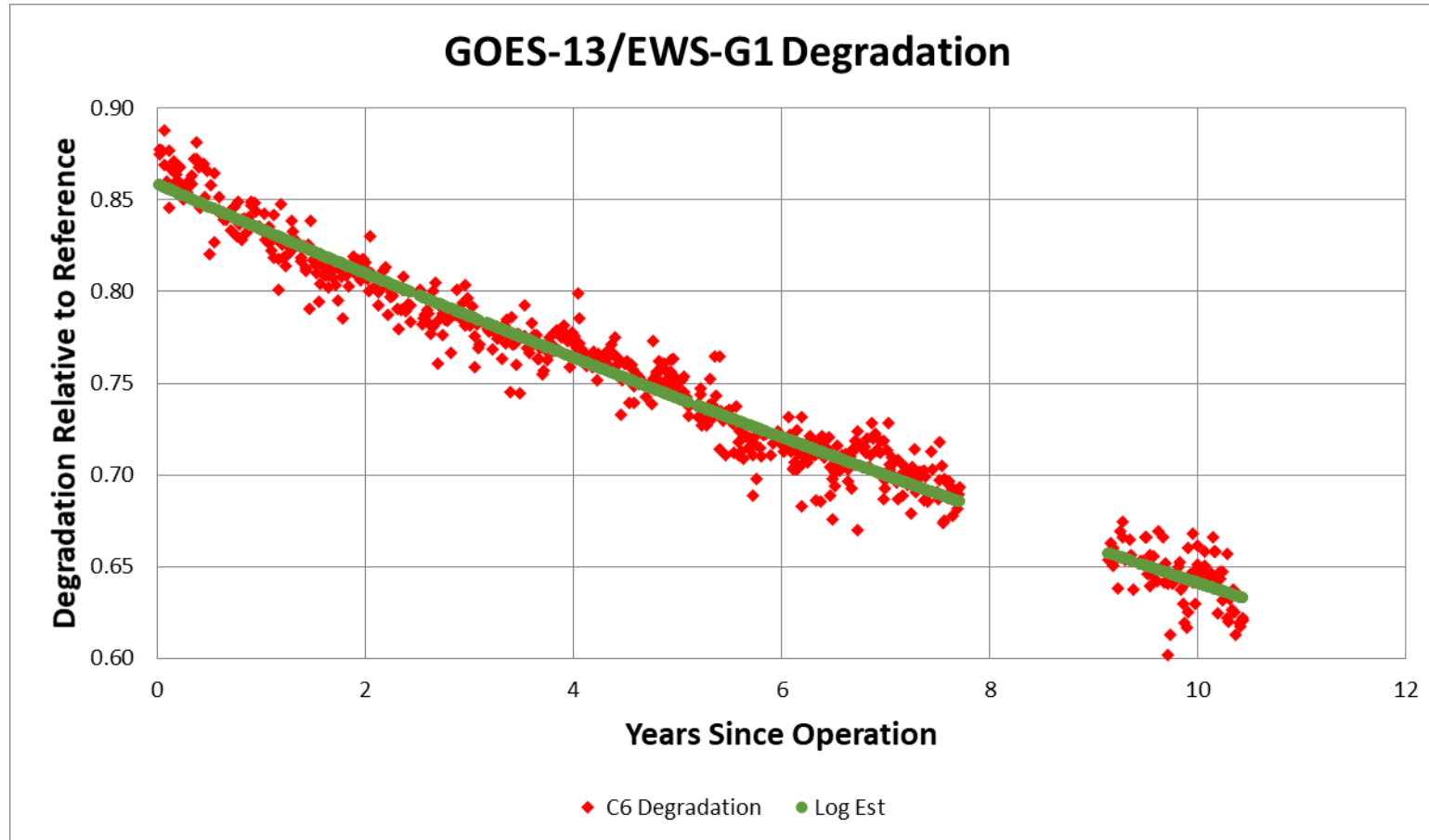## GOES-13/EWS-G1 Degradation

GOES-13/EWS-G1 Degradation

- Imager was not operated continuously during the 32 months between GOES-13 and EWS-G1.
- Overestimate if assuming degradation was as usual.

3. Account for Interrupted Operation


GOES-13/EWS-G1 Degradation

- Imager was not operated continuously during the 32 months between GOES-13 and EWS-G1.
- Underestimate if assuming degradation was stopped.

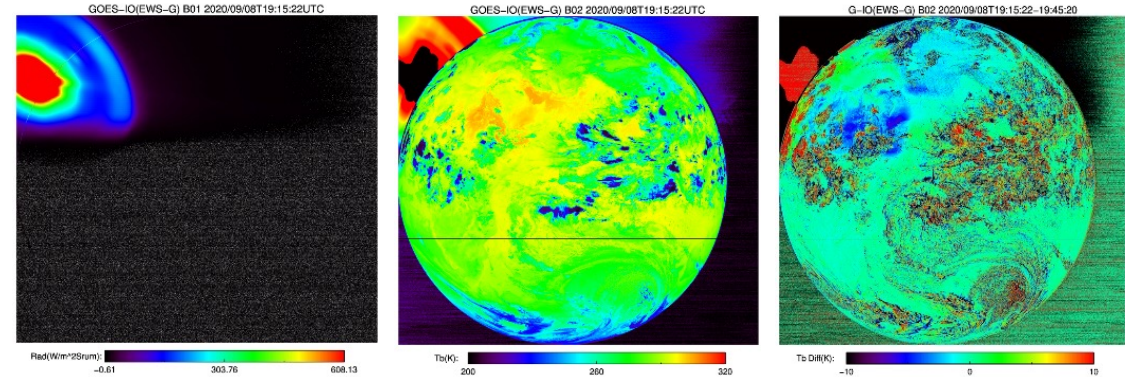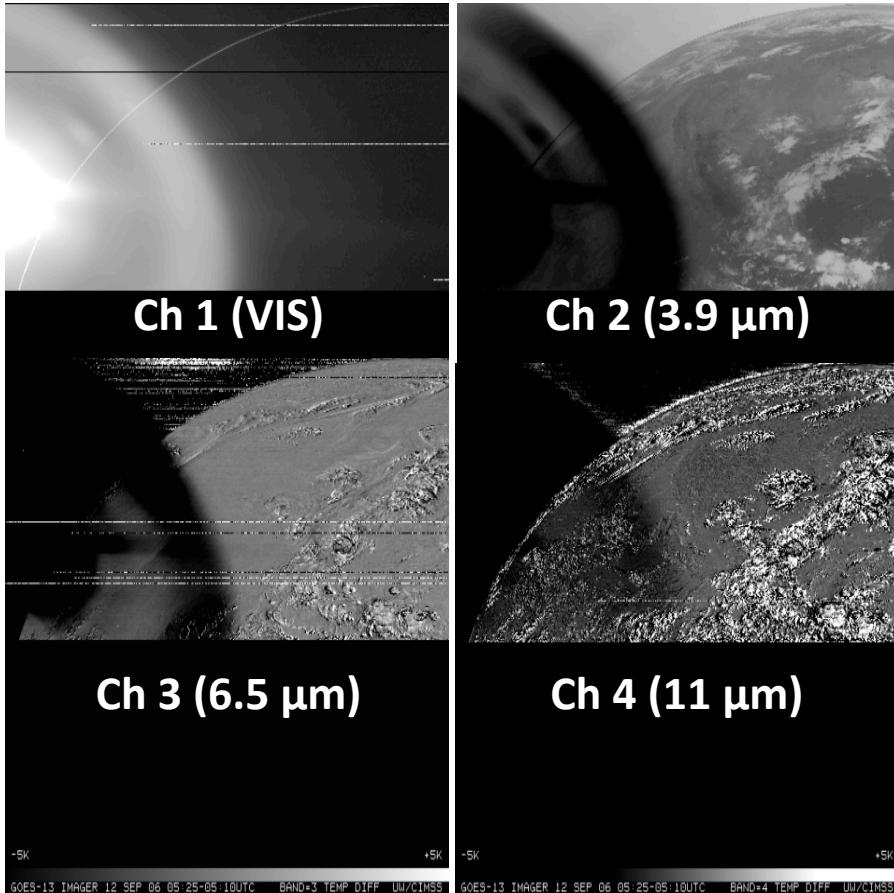# 3. Account for Interrupted Operation

GOES-13/EWS-G1 Degradation

- Imager was not operated continuously during the 32 months between GOES-13 and EWS-G1.
- Designed an algorithm to properly account for degradation during stow.
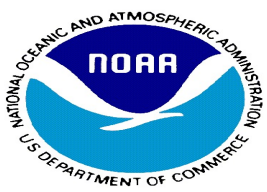
CALIBRATION FOR IR CHANNELS

Stray Light Correction During Eclipse

- GOES-13 was the first GOES that enabled operation through eclipse.
- Because it was unprecedented, elaborate scan schedule to avoid the Sun was not implemented until ten year later with ABI on GOES-16.
- Stray light was a serious issue when launched in 2006. It was mitigated before GOES-13 became operational in 2010.
- Satisfactory performance for EWS-G1 was verified.
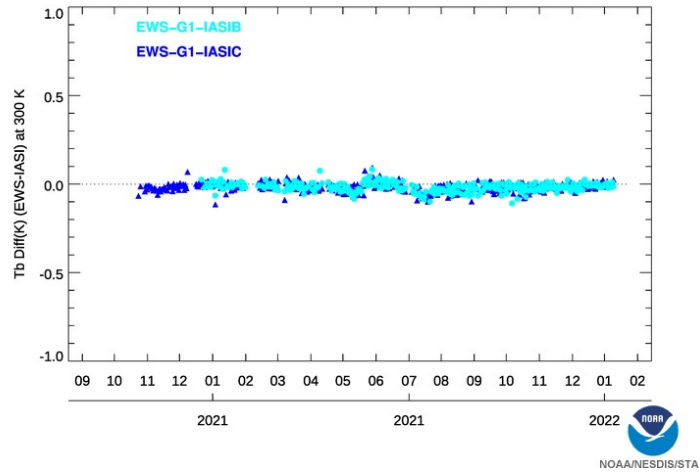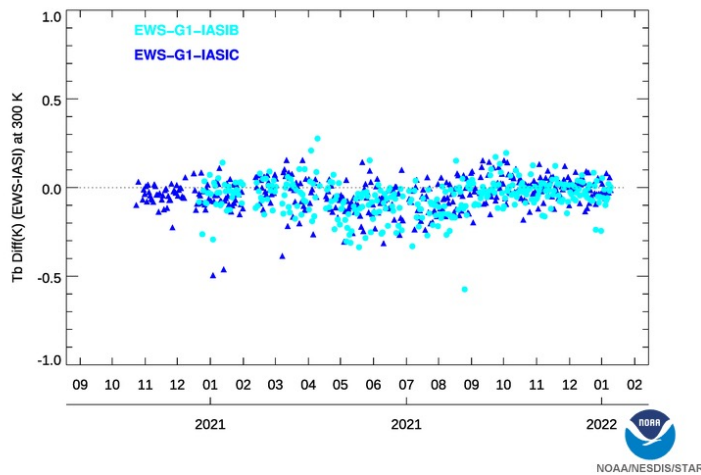
Near-Real-Time Monitoring
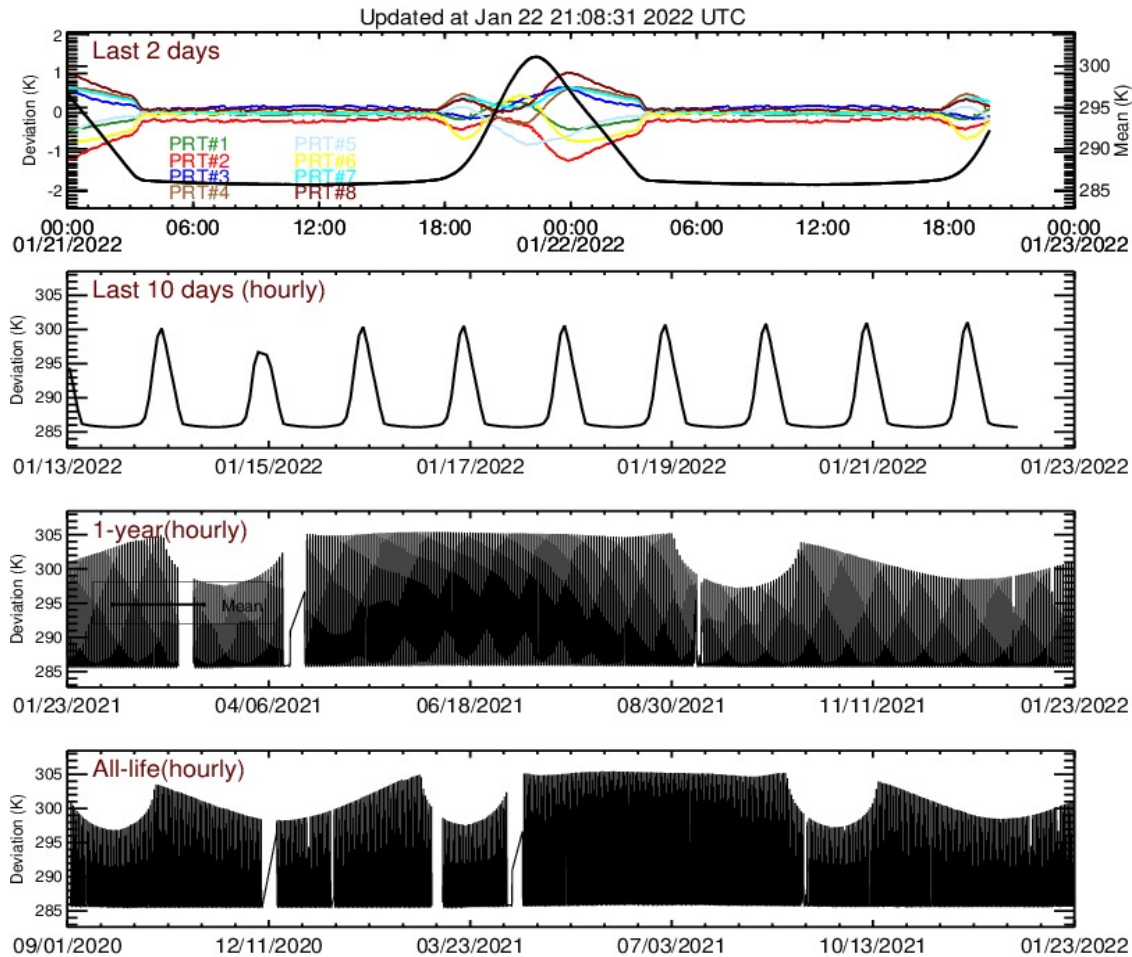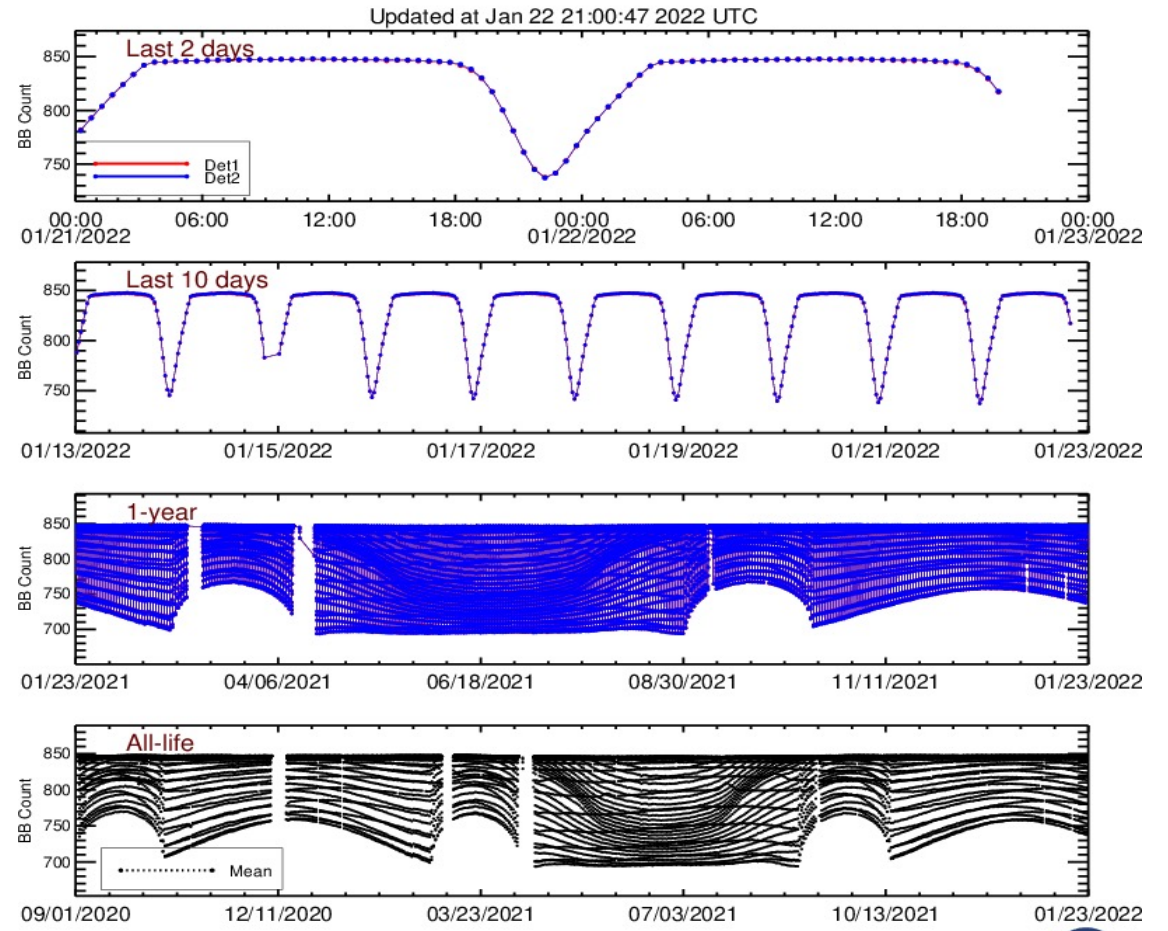
Validation

EWS-G1 vs IASI-B&C B02(3.8um)-Nighttime
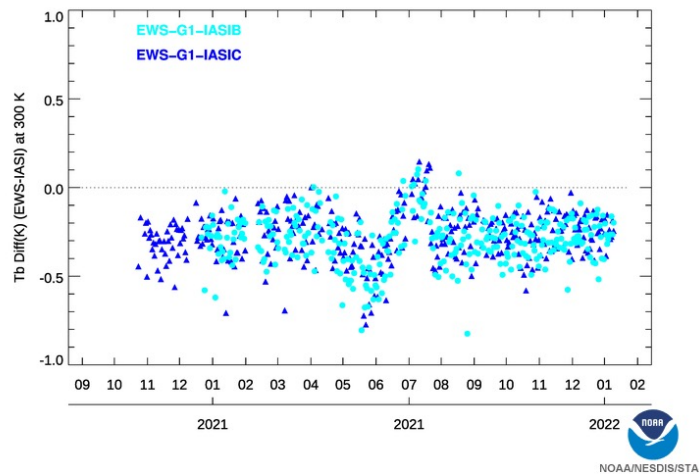23 Jan 2022 - 0800 UTC
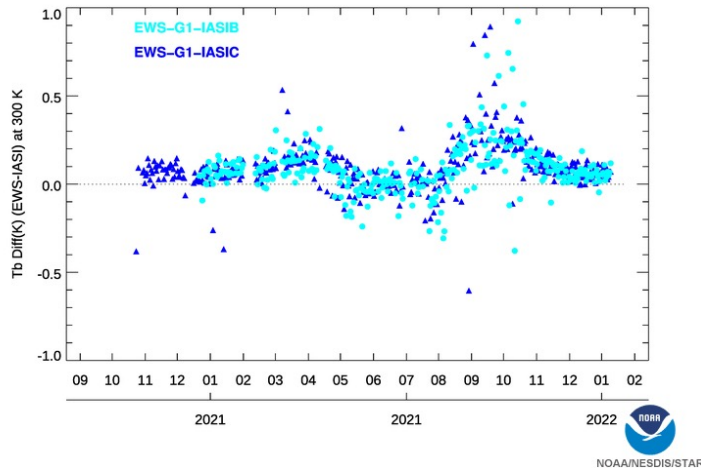
EWS-G1 vs IASI-B&C B03(6.5um)-Nighttime
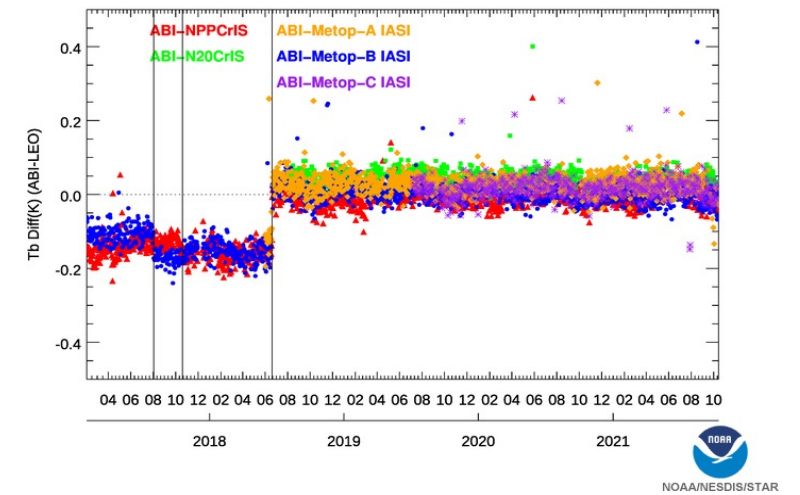23 Jan 2022 - 0800 UTC

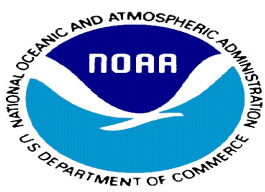EWS-G1 vs IASI-B&C B04(10.7um)-Nighttime
23 Jan 2022 - 0800 UTC

EWS-G1 vs IASI-B&C B06(13.3um)-Nighttime
23 Jan 2022 - 0800 UTC

GOES-16 ABI B14(11.2um) - Nighttime
15 Oct 2021 - 0600 UTC

EWS-G Cal Val, AMS 102, Virtual

Summary

- EWS-G1 has been transferred from NOAA to USSF and reached IOC in September 2020.

- NOAA assisted the transition and operation of EWS-G1, including its operational calibration.

- Calibration coefficients for its visible channel have been updated monthly since October 2020.

- Near-real-time monitoring of calibration of all channels and validation of their radiance products has started recently.

- NOAA is communicating with users to deliver customized calibration products and services.