

VIIRS reflective solar bands on-orbit calibration update

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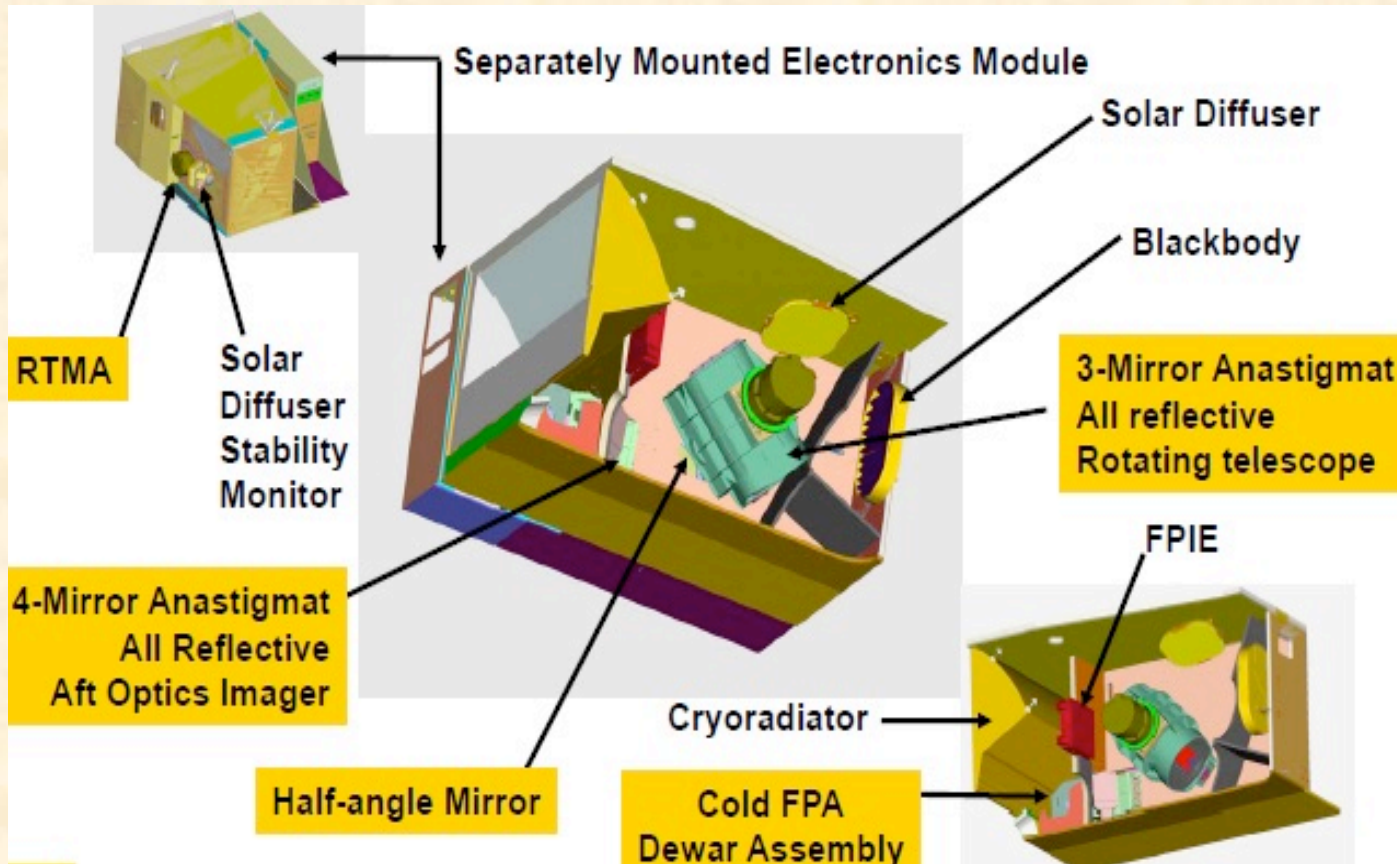


Outline



- Introduction
 - Brief information regarding the VIIRS RSB calibration
- SD/SDSM Calibration
 - SDSM calibration
 - SD calibration
- Lunar Corrected SD Calibration
 - Lunar calibration and comparison with SD calibration
 - Lunar corrected SD calibration
- L1B EV Image Destriping
- Summary

Instrument Background

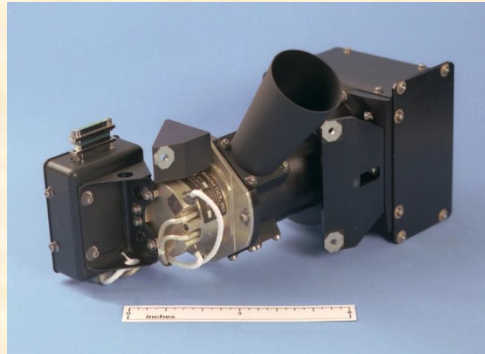


- 22 spectral bands with 412 nm to 12.013 μm spectral range
- 14 Reflective Solar Bands (RSB): 3 imaging bands, I1-I3, and 11 moderate bands, M1-M11
- The VIIRS RSB are calibrated on-orbit via SD/SDSM calibration
- Monthly lunar observations have been performed through its space view (SV) port since launch.
- For VIIRS, the angle of incidence (AOI) of the SV is the same as that of the SD. Lunar observations should provide identical on-orbit gain change as the SD/SDSM calibration for the VIIRS RSB.
- The most updated version of L1B is Collection 2 (C2) for both SNPP and NOAA-20 VIIRS instruments

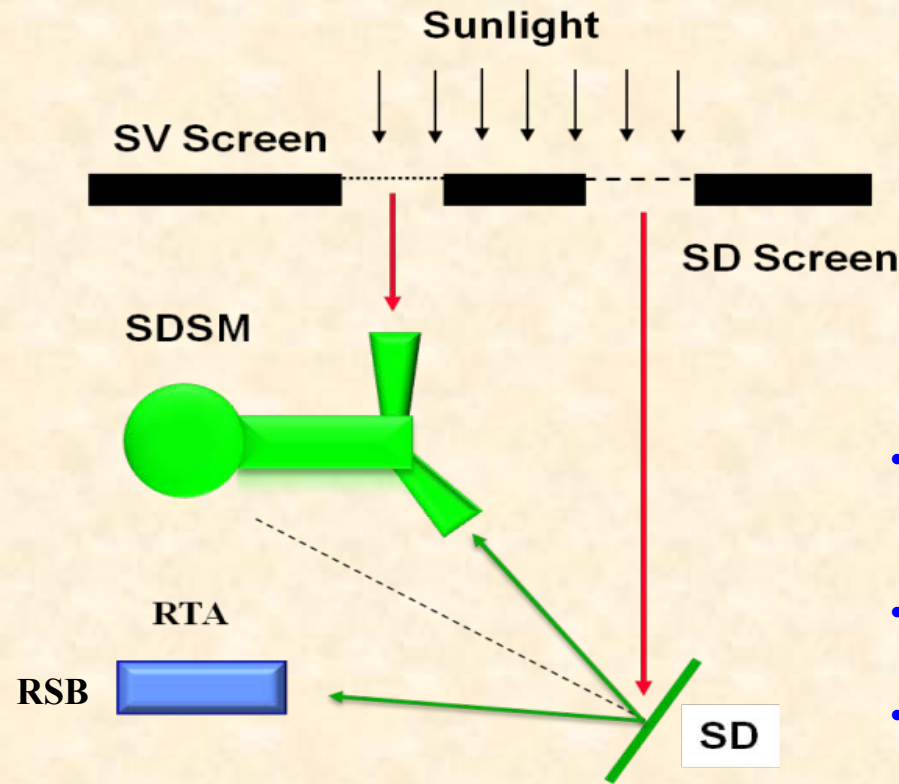
VIIRS RSB uncertainty specification is 2%. However, ocean color EDRs (those using bands M1-M7 (NIR); M8, M10, and M11 (NIR-SWIR); and, recently, I1) require a long-term stability of $\sim 0.2\%$.

VIIRS RSB on Orbit Calibration Overview

SDSM



SD

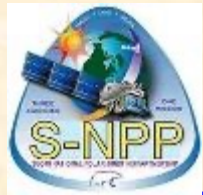


Moon



- SDSM tracks the SD on-orbit degradation, H-factors. Initially run every orbit, then the frequency reduced gradually.
- SD calibration tracks RSB gain changes on an orbit basis
- The SD degradation is view direction dependent and the RSBs view the SD from different direction compared to that of the SDSM view direction

• The lunar calibration has no degradation issue and is used to provide long-term basis for the calibration coefficients



SDSM Calibration

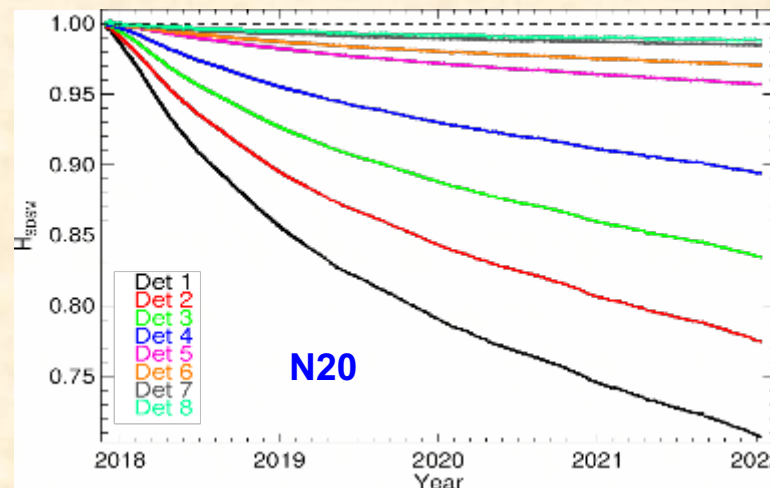
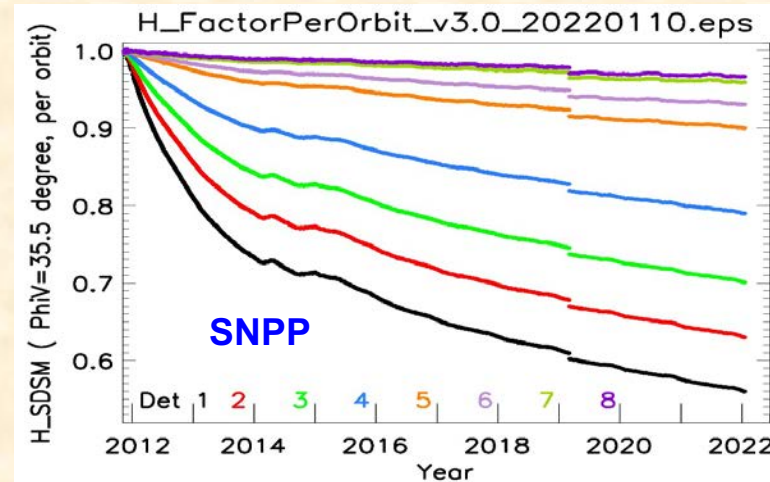


- SDSM is a ratio radiometer that views the SD, Sun, and an internal dark scene successively in three-scan cycles.
- SD BRF for SDSM view direction:

$$BRF_{SD,SDSM}(\lambda, t) = \rho_{SD,SDSM}(\lambda)H(\lambda, t)$$
 - $\rho_{SD,SDSM}(\lambda)$: Pre-launch BRF for SDSM view direction
 - $H(\lambda)$ is the solar diffuser degradation since launch
- SD degradation and H-factors at the SDSM view direction and wavelength of SDSM detector D

$$H(\lambda_D) = \left\langle \frac{dc_{SD,D}}{\rho_{SD,SDSM}(\lambda_D)\tau_{SDS} \cos(\theta_{SD})} \right\rangle_{Scan} \left/ \left\langle \frac{dc_{SV,D}}{\tau_{SVS}} \right\rangle_{Scan} \right.$$

H-Factor



- High frequency early in mission and then gradually reduced.
- SNPP anomaly on 24/2/2019, which has impact on SD degradation and induces sudden jumps in the H-factors
- SNPP safe mode anomaly on 3/8/2021, which has no impact on SD degradation but has impact on RSB F-factors, especially SWIR bands
- NOAA-20 has some anomalies but has no impact on RSB calibration and performance



SD Calibration



- SD is made of Spectralon®; near Lambertian property

- Solar radiance reflected by the SD:

$$L_{SD}(\lambda) = I_{Sun}(\lambda) \cdot \tau_{SDS} \cdot \cos(\theta_{SD}) \cdot \rho_{SD,RTA}(\lambda) \cdot h(\lambda) / d_{VS}^2$$

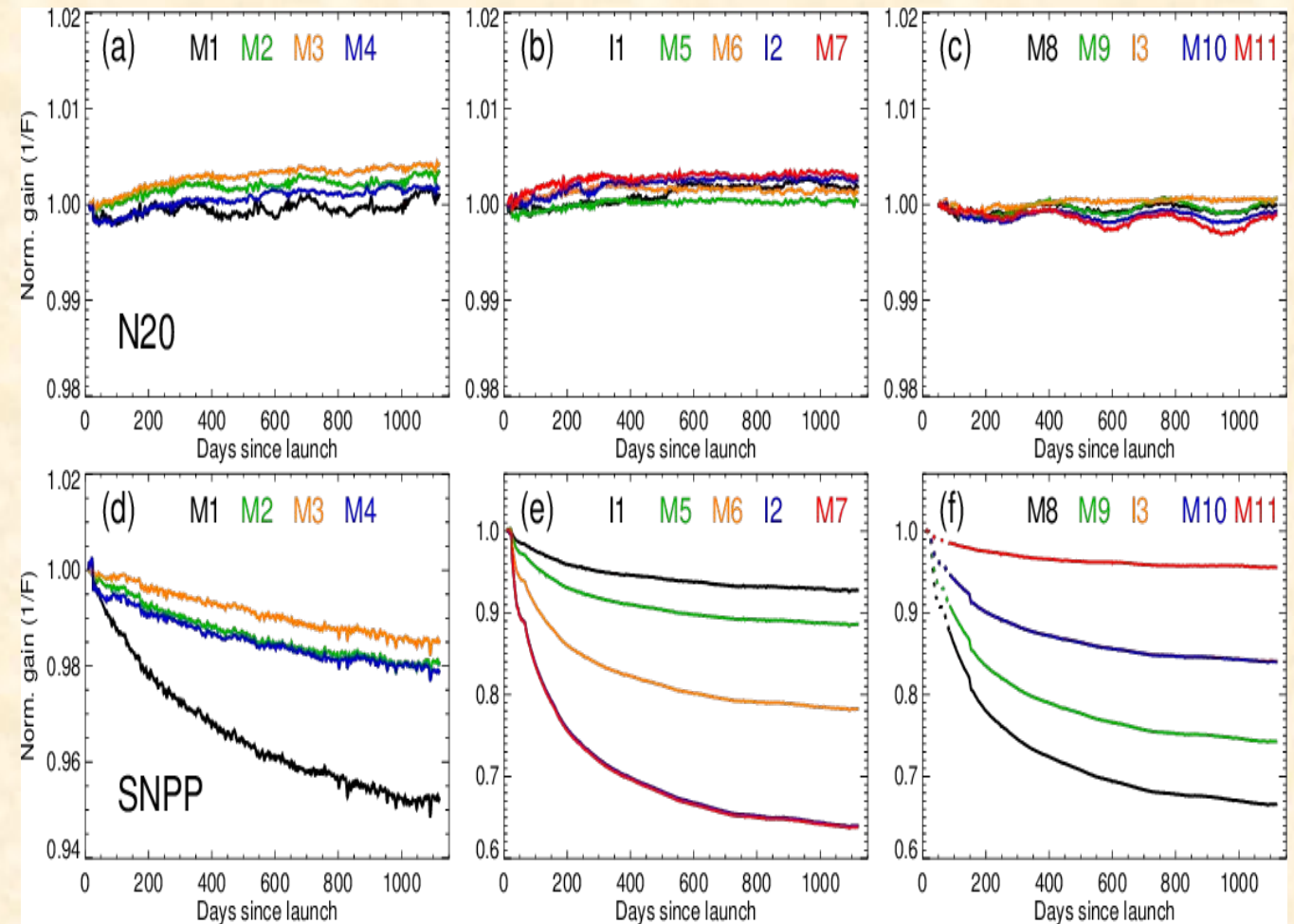
- I_{Sun} is solar irradiance at Sun-Earth distance of one astronomical unit (AU)
- $\rho_{RSD,RTA}(\lambda)$: Pre-launch BRDF at RTA view direction
- $h(\lambda)$: SD degradation measured by the SDSM

- RSB calibration coefficients and F-factors

$$F(B, D, M, G) = \frac{RVS_{B,SD} \cdot \int RSR_B(\lambda) \cdot L_{SD}(\lambda) \cdot d\lambda}{\sum_i c_i(B, D, M, G) \cdot dn^i \cdot \int RSR_B(\lambda) \cdot d\lambda}$$

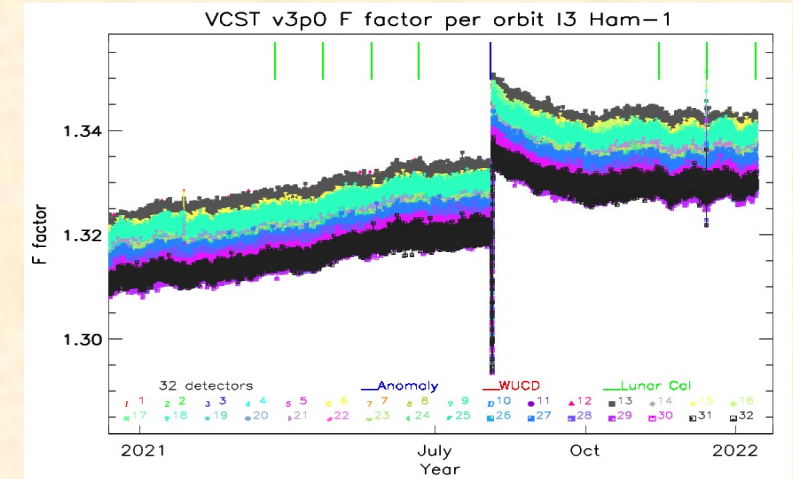
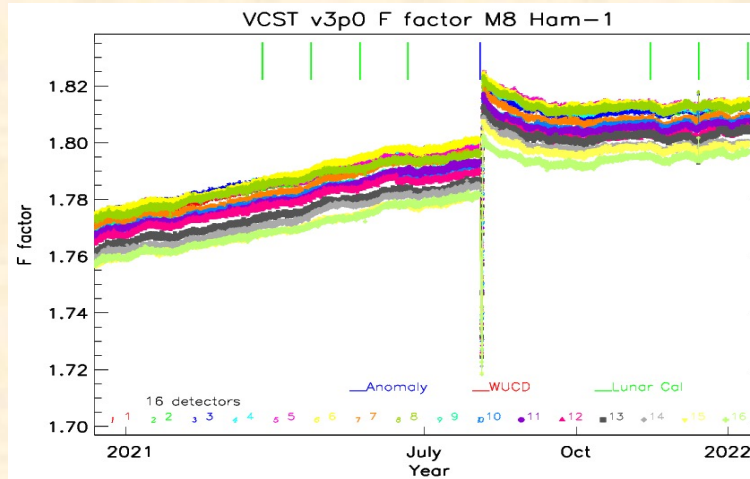
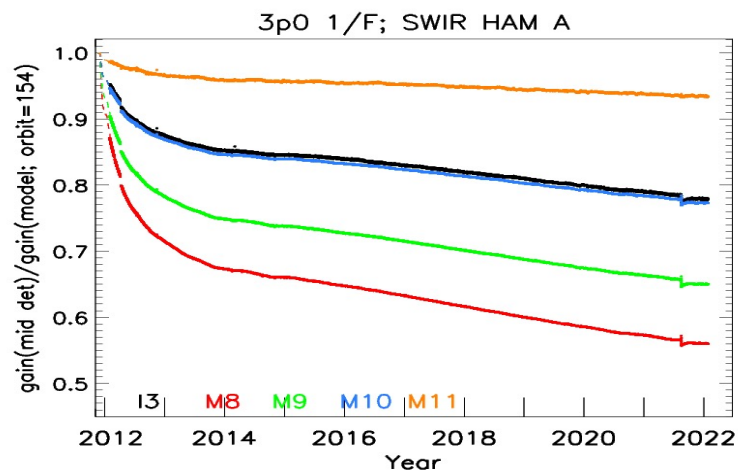
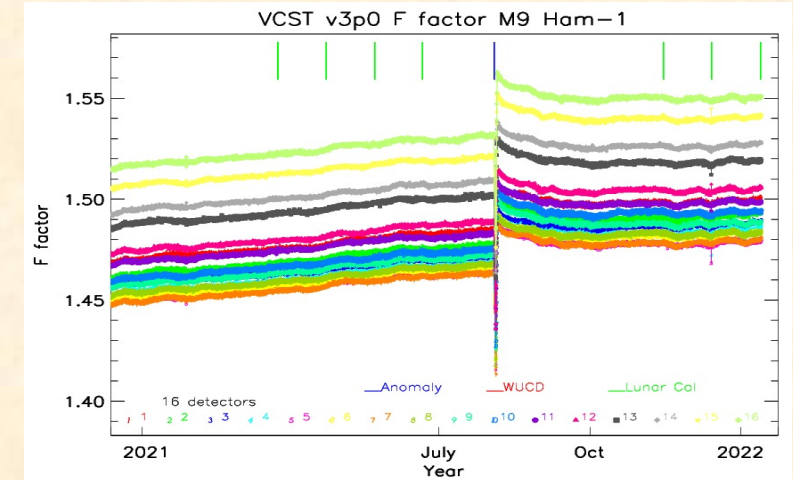
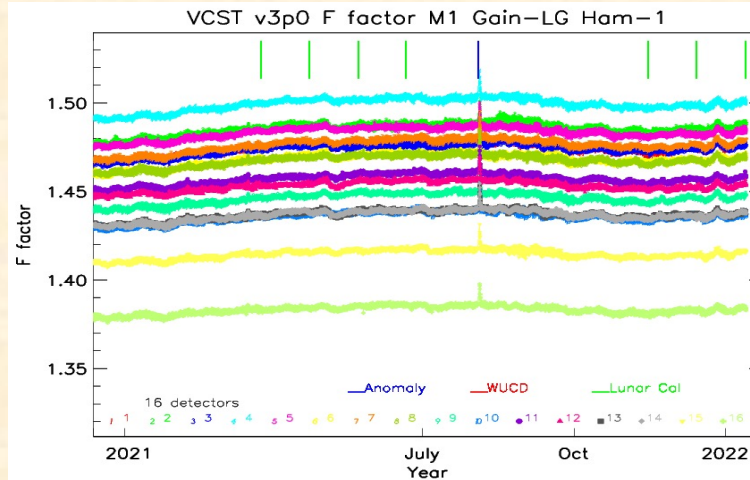
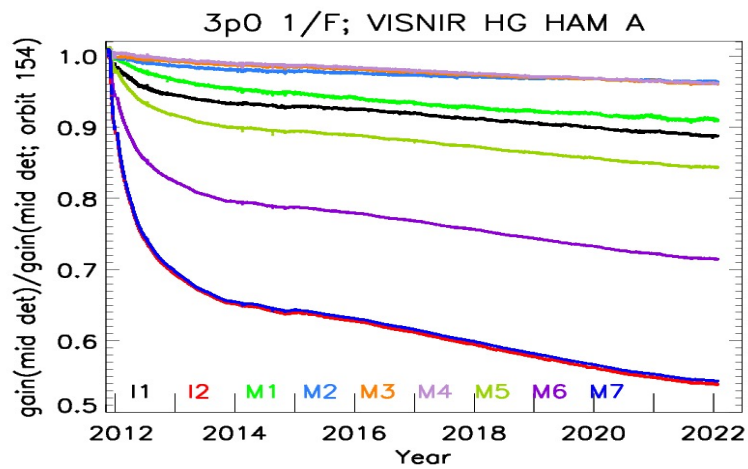
- B, D, M, G : Band, Detector, HAM-side, and gain status
- SD calibration on orbit basis

SD F-Factor

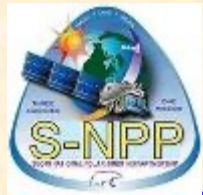




SNPP SD Calibration



Impact of the safe mode on August 3, 2021: Visible and near infrared bands quickly recovered while SWIR bands recovered slowly



Lunar Calibration



- Moon reflectance observations are quite stable

- RSB calibration coefficients, F-factors, from lunar observations

$$F(B, M) = \frac{g(B)N_{t,M}}{\sum_{D,S,N} L_{pl}(B, D, S, N)\delta(M, M_N)}$$

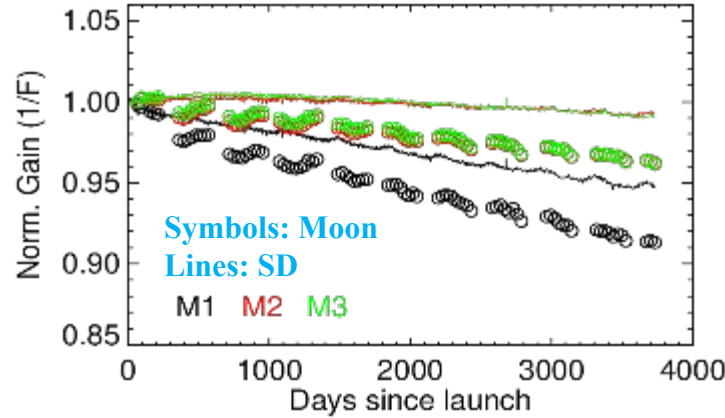
- $g(B)$: Geometric view effect correction (ROLO lunar model and extra correction)

S-NPP VIIRS is scheduled to view the Moon almost monthly (about nine months every year)

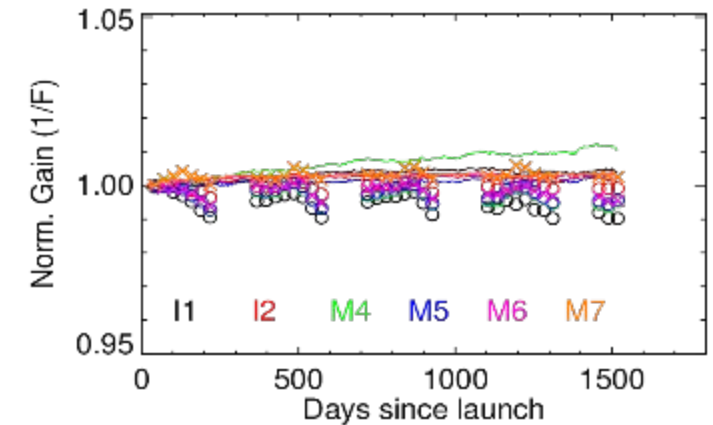
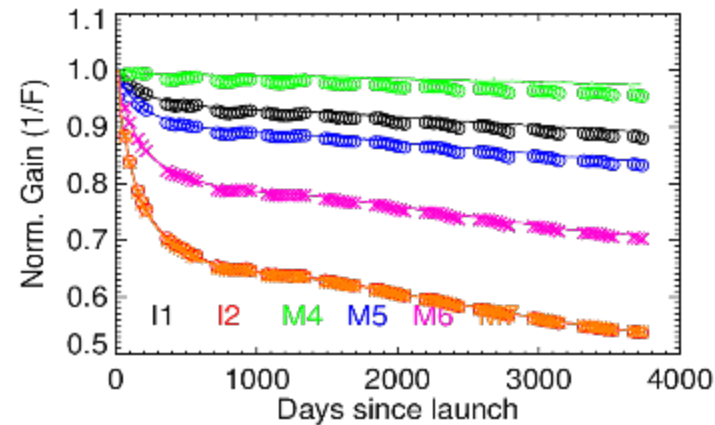
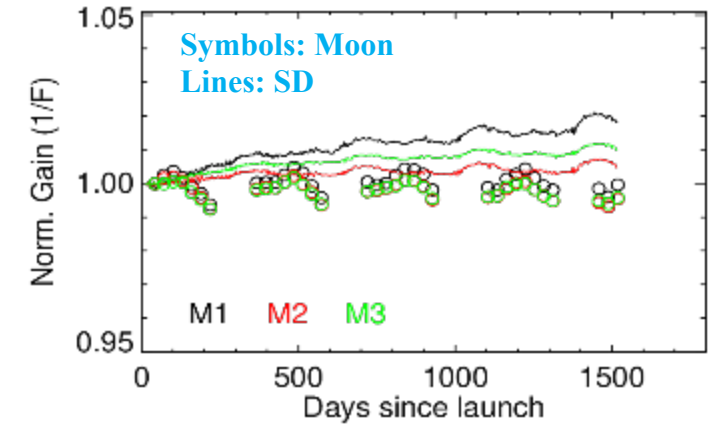
Lunar F-factors do not have long-term bias

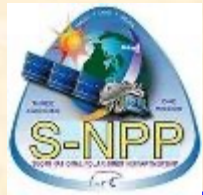
SD F-factors have long-term bias

SNPP



NOAA-20

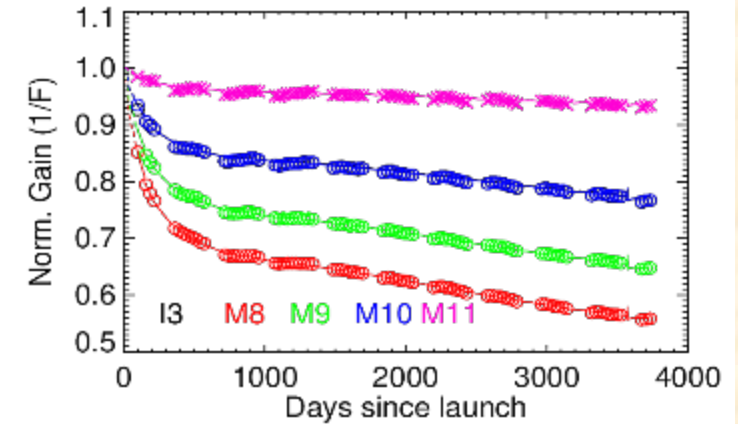
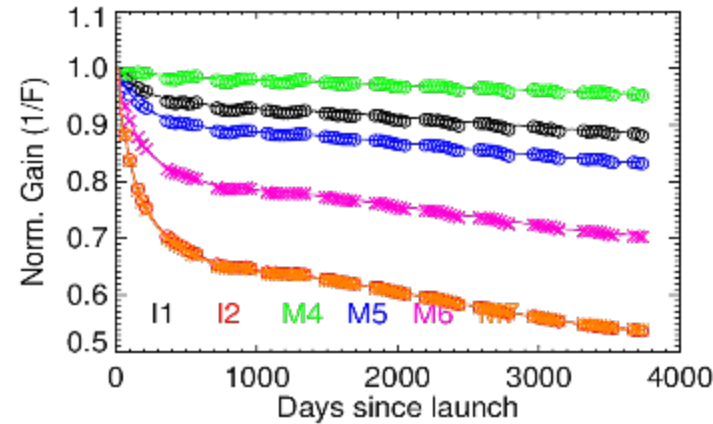
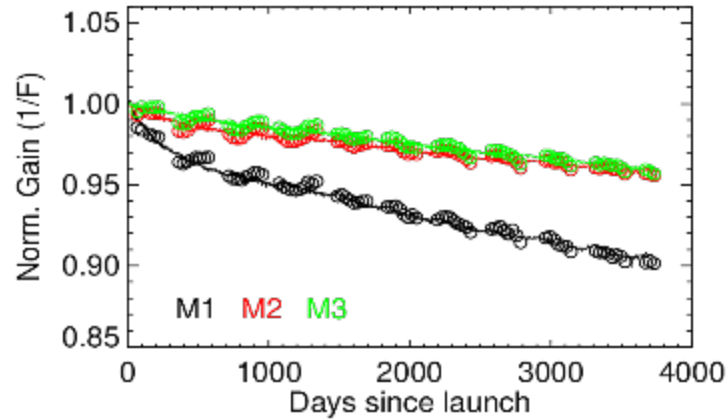




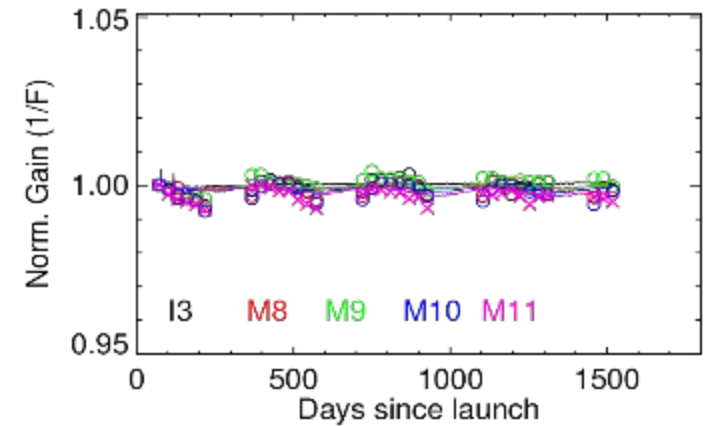
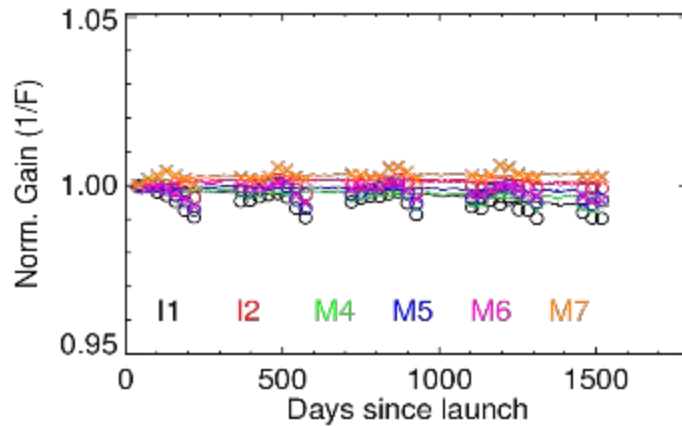
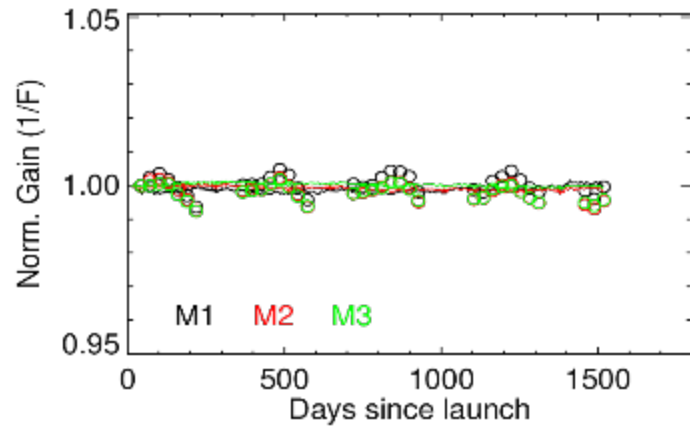
Lunar Corrected SD Calibration



SNPP



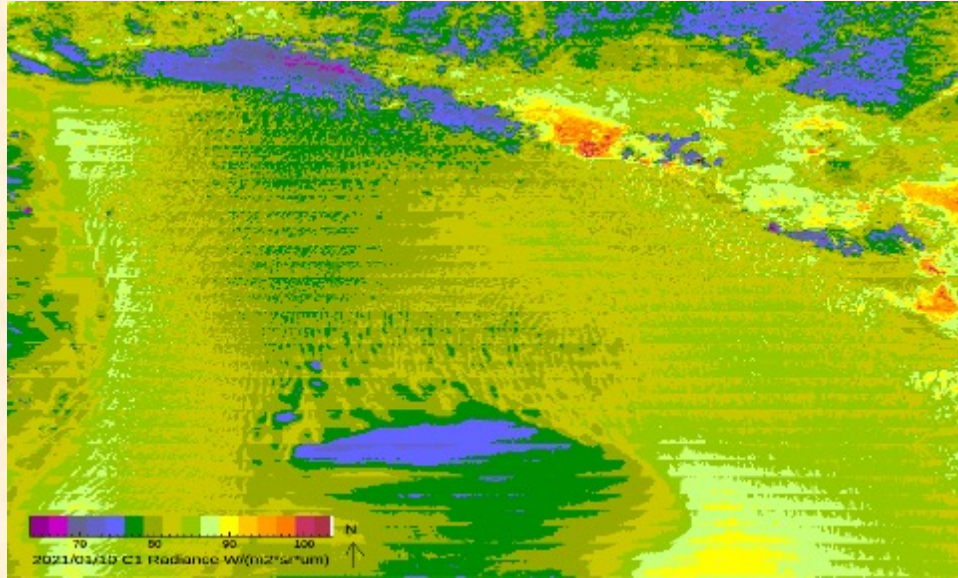
NOAA-20



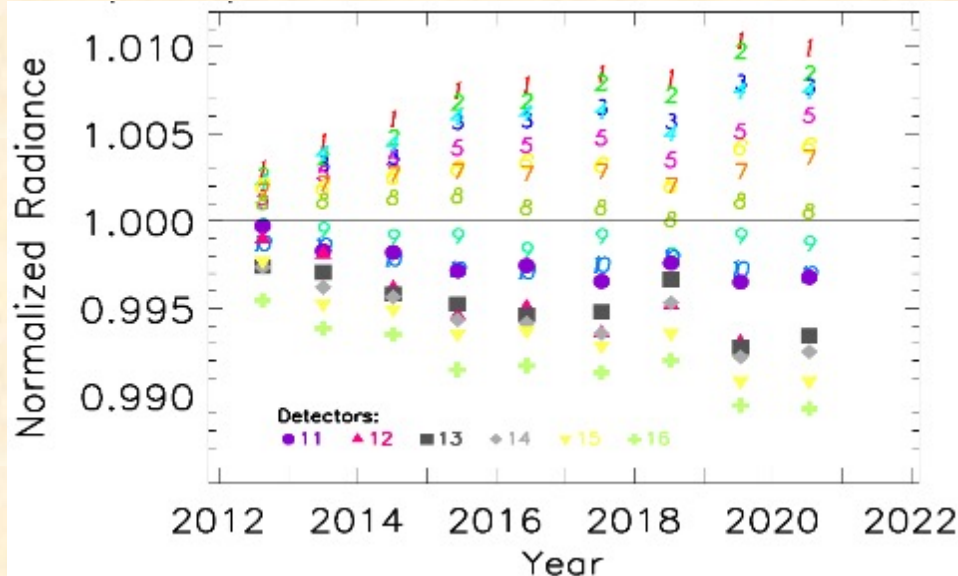
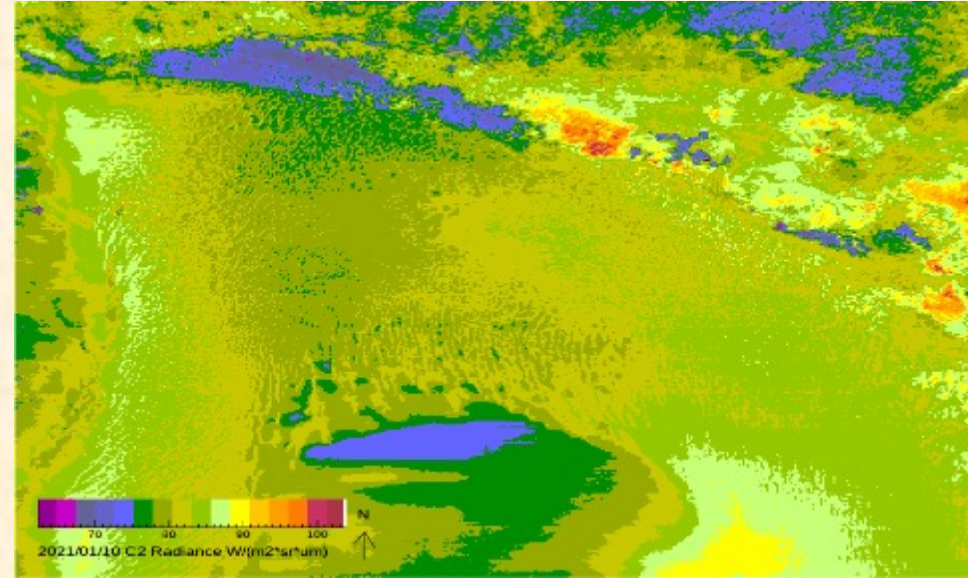
Lunar correction can be directly applied to SD F-factors (so called hybrid approach). Currently the lunar correction is applied to SD degradation, H-factors, which results in correction in SD F-factors.

L1B EV Images Destriping

Before Destriping



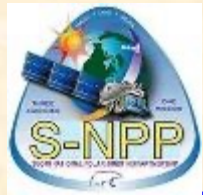
After Destriping



- The detector difference is described by

$$R_{str}(B, D, t) = \frac{\rho_{EV}(t, D) - \langle \rho_{EV}(t, D) \rangle_D}{\langle \rho_{EV}(t, d) \rangle_D} = -c_{B,0} (D - D_{B,mid}) - c_{B,1} (D - D_{B,mid}) \times (1 - H_{SDSM}(\lambda_B, t)).$$

- The destriping is applied to SNPP for most RSBs in C2.
- For N20, the analyzation of the striping is still undergoing.



Summary

- SNPP and NOAA-20 VIIRS have been successfully operated on-orbit for more than ten and four years since their launch on 28 October 2011 and 18 November 2017, respectively.
- The RSBs are calibrated by the SD/SDSM and Moon independently.
- SD calibration has long-term bias due to the SD view direction difference of the SDSM calibration and the RSBs.
- The lunar calibration has no degradation issue and is used to provide long-term basis while the SD/SDSM calibration provide the frequency and short-term accuracy of the calibration.
- Both VIIRS instruments have on-orbit anomalies, which have no impact on NOAA-20 RSB calibration while have impact on the SNPP RSB calibration. The impact has been successfully mitigated and removed.
- The L1B EV image striping induced by degradation nonuniformity of the SD surface has been successfully removed for SNPP VIIRS RSBs.
- The NASA VIIRS L1B RSB products in Collection 2 are accurate and reliable with high quality for both SNPP and NOAA-20 VIIRS instruments.