Status of S-NPP VIIRS Solar and Lunar Calibration

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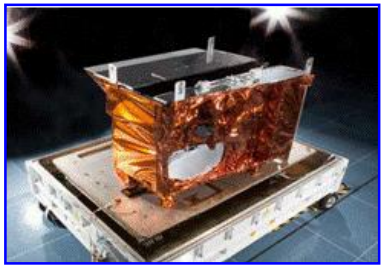

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Outline

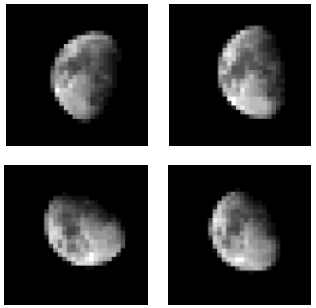
- **VIIRS Solar and Lunar Calibration**
  - Strategies and Activities
  - Methodologies
- **Performance and Discussion**
  - Changes and Updates (Improvements)
  - Comparison of Solar and Lunar Calibration
- **Future Efforts**

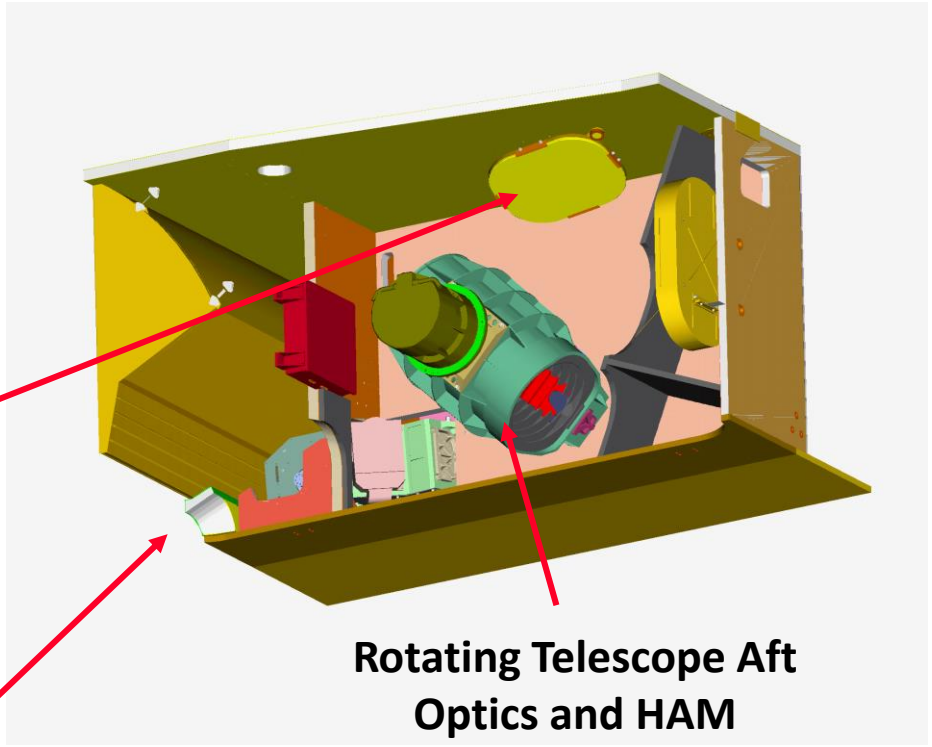
Solar and Lunar Calibration Strategies and Activities

Solar Diffuser Stability Monitor

Solar Diffuser

Extended SV Port





Rotating Telescope Aft Optics and HAM

SD:
each orbit

SDSM:
1 per orbit to 3 per week

Moon:
8-9/year;
through SV port;
sector rotation;
fixed phase angle;
fixed high gain

- **15 reflective solar bands (RSB) including a DNB: 0.4-2.3 μm**
- 7 thermal emissive bands (TEB): 3.7-12.1 μm
- Moderate/Imaging bands: 750/375 m nadir spatial resolution
- Dual gain bands: M1-M5, M7, and M13

Solar and Lunar Calibration Methodologies

VIIRS Radiance (L) Retrieval: $L = F \cdot L_{PL} = F \cdot \left(c_0 + c_1 \cdot dn + c_2 \cdot dn^2\right) / RVS$

F: Calibration scaling factor derived from on-orbit calibration

c_i: Pre-launch calibration coefficients (quadratic algorithm)

RVS: Sensor response versus scan-angle

VIIRS Solar Calibration: $F_{SD} = \dfrac{L_{SUN}}{L_{SD,PL}}$

$$L_{SUN} \propto \cdot E_{SUN} \cdot BRDF(t) \cdot \tau_{SDS} \cdot \cos(\theta_{inc})$$

$$H(t) = \frac{dc_{SD} \cdot \tau_{SDSM}}{dc_{SUN} \cdot BRDF(t_0) \cdot \tau_{SDS} \cdot \cos\theta_{inc}}$$

L_{SUN}: Expected solar radiance reflected from SD panel

$L_{SD,PL}$: Retrieved solar radiance using pre-launch calibration coefficients

VIIRS Lunar Calibration: $F_{MOON} = \dfrac{I_{ROLO}}{I_{MOON,PL}} = \dfrac{I_{ROLO}}{\sum_{\det,sam,scan} L_{MOON,PL} \cdot \Omega_B \cdot g / N_{SCAN}}$

I_{ROLO}: Lunar irradiance (integrated) provided by ROLO model

$I_{MOON,PL}$: Lunar irradiance retrieved using pre-launch calibration coefficients

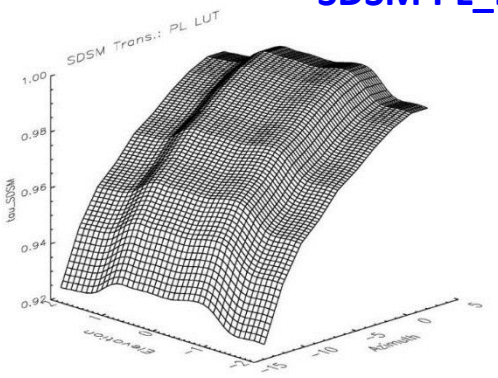
N_{SCAN}, Ω_B, g: number of scans, pixel solid angle, aggregation factor

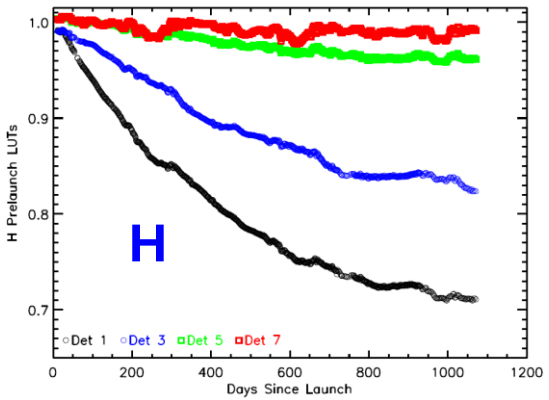
Changes and Updates (Improvements)

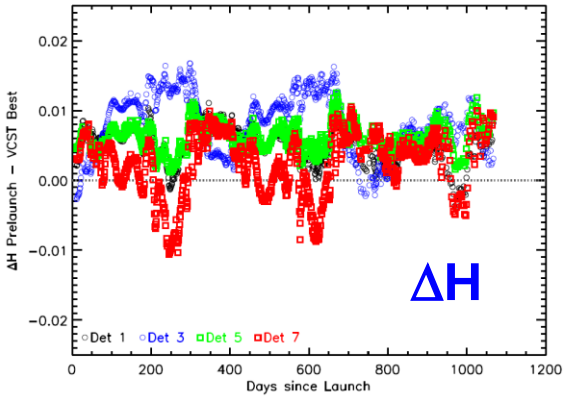
- **SD and SDSM Screen Transmission**
  - Pre-launch characterization
  - On-orbit yaw maneuvers
  - Yaw + regular on-orbit data
- **Correction for Solar Vector Error**
  - Consistently reprocessed SDR for NASA science research community
  - Different impact for VIS/NIR and SWIR
- **Modulated RSR (relative spectral response)**
  - Due to strong wavelength-dependent optics degradation
  - Different impact for solar and lunar calibration, and EV data
  - Large effect for DNB (broad bandwidth: 500-900 nm) calibration

SD and SDSM Screen Transmission (look-up table)

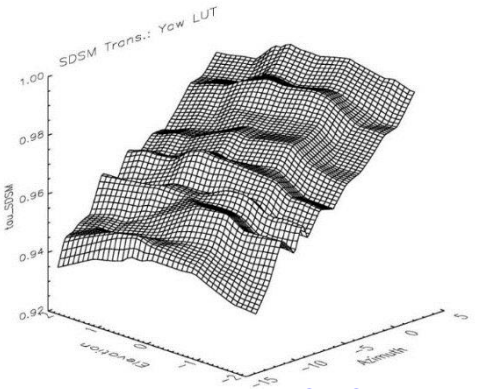
SDSM PL_LUT

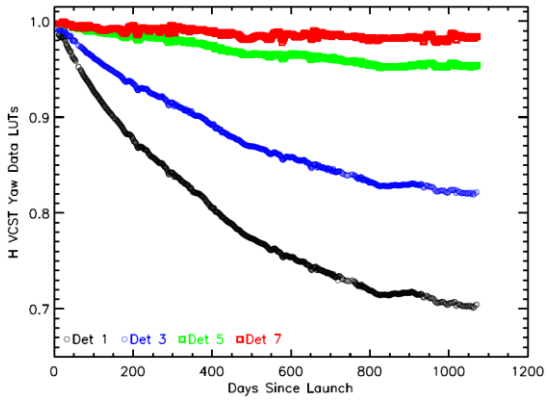


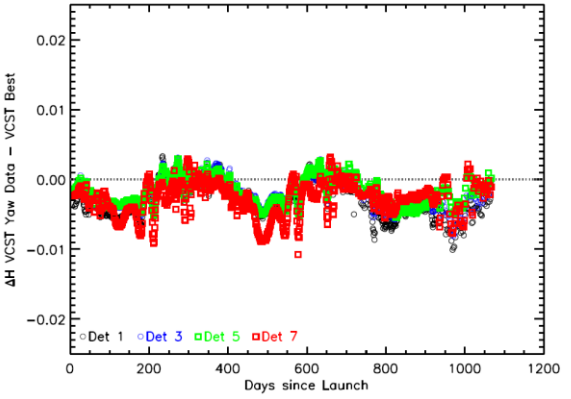




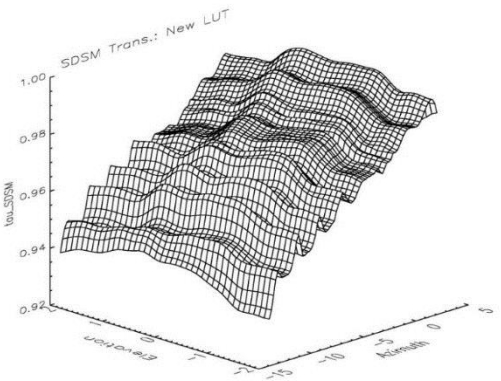
SDSM Yaw_LUT

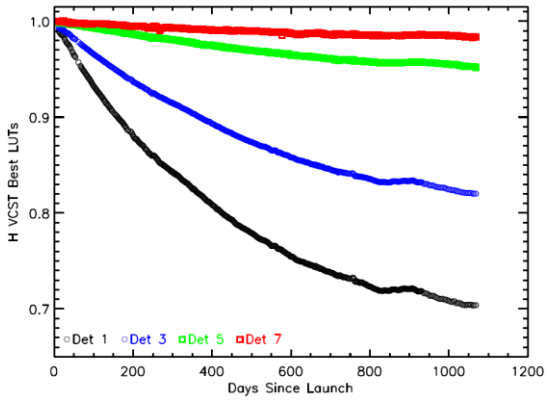






SDSM New_LUT





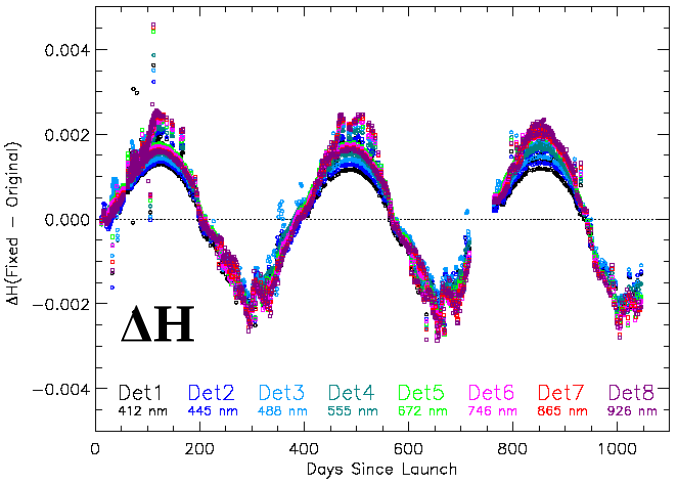
Improved H => better quality of F

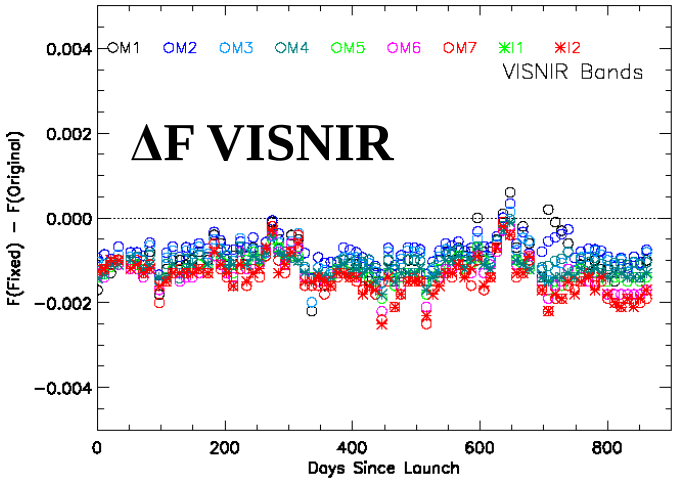
Similar improvements to SD screen transmission

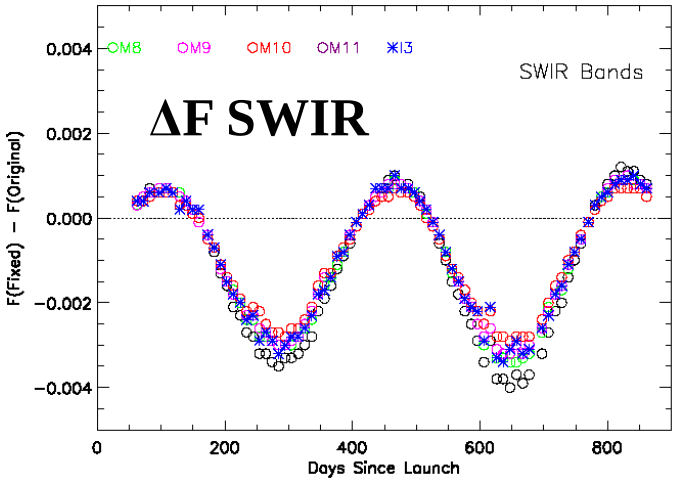
0.41, 0.48, 0.67, 0.86 μm

Correction for Solar Vector Error (in SDR Geo Library)

- **A mismatch of ECI (Earth-Centered Inertial) frames when computing the transformation to spacecraft frame library leads to ~0.2º error in the solar angles used in the RSB radiometric calibration.**
- **Different impact for VIS/NIR and SWIR bands**



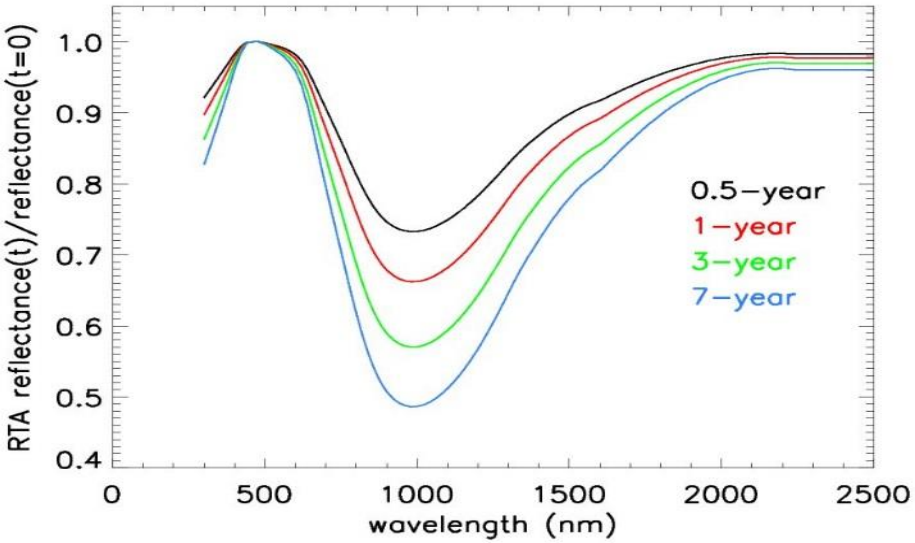




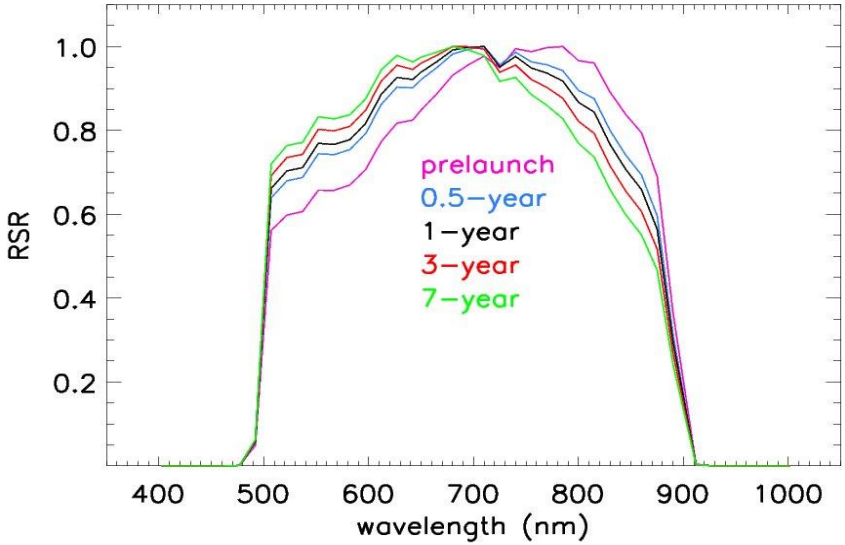
- **The cos θ_{SD} factor is used in both H- and F-factor calculations.**

Development and Update of On-orbit Modulated RSR

λ dependent optics degradation



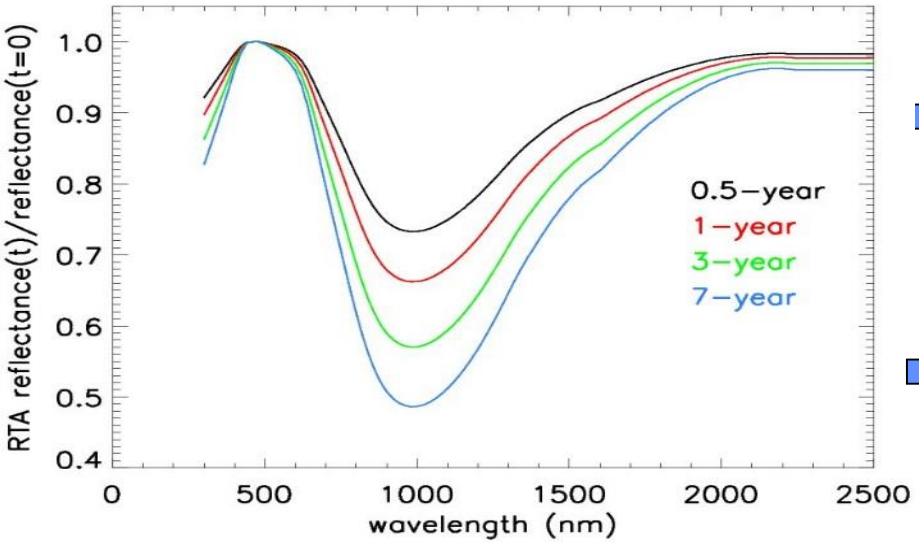
Modulated RSR

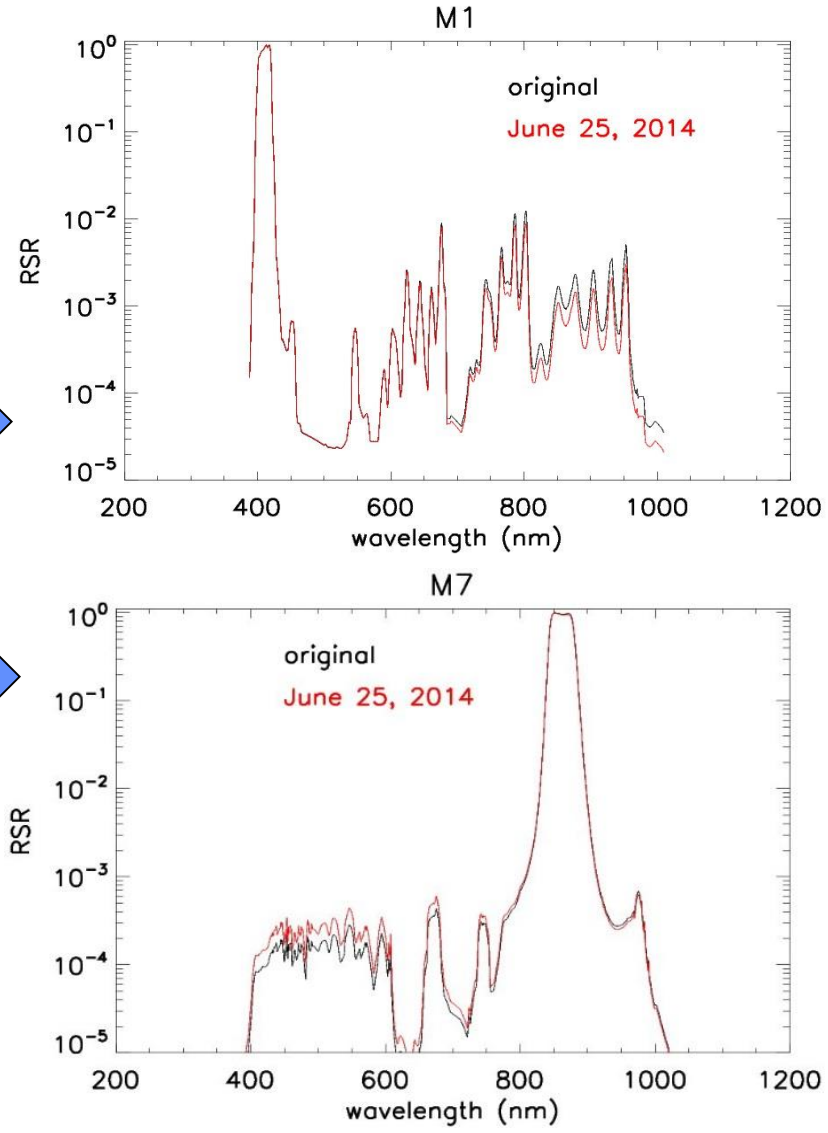


large impact on DNB (broad bandwidth)

Development and Update of On-orbit Modulated RSR

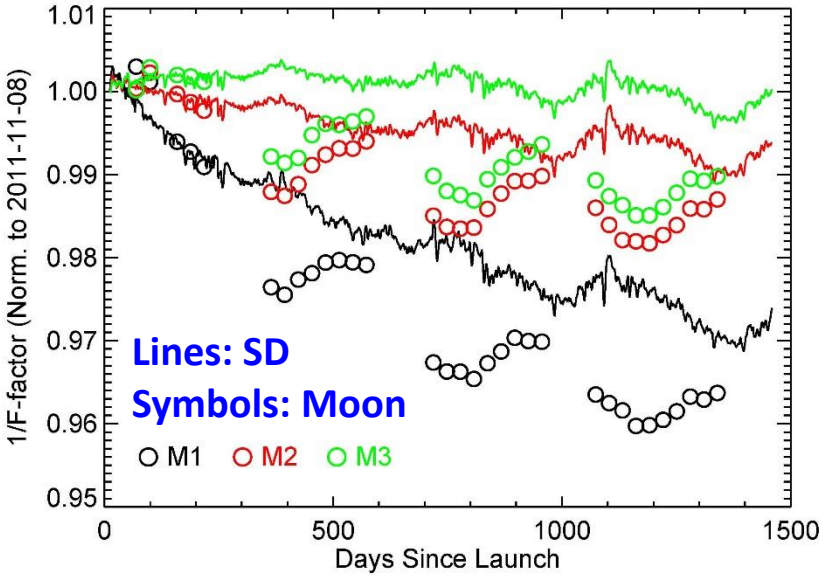
λ dependent optics degradation

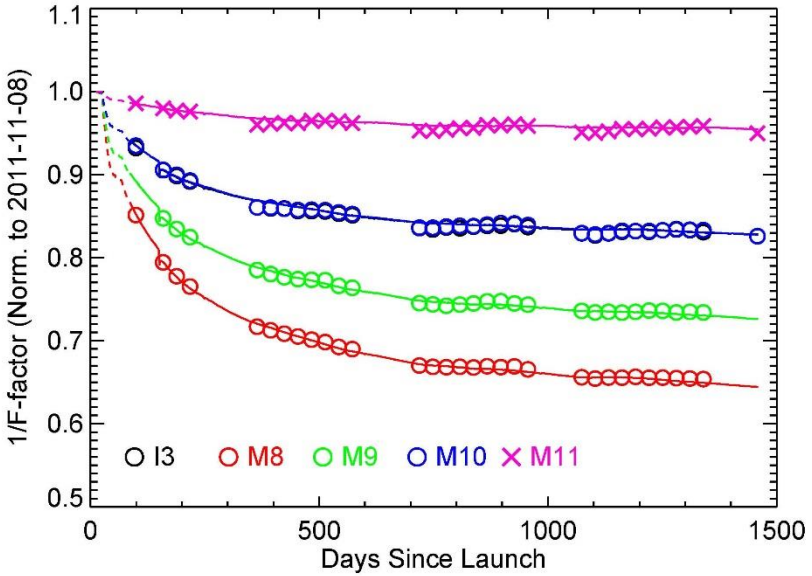


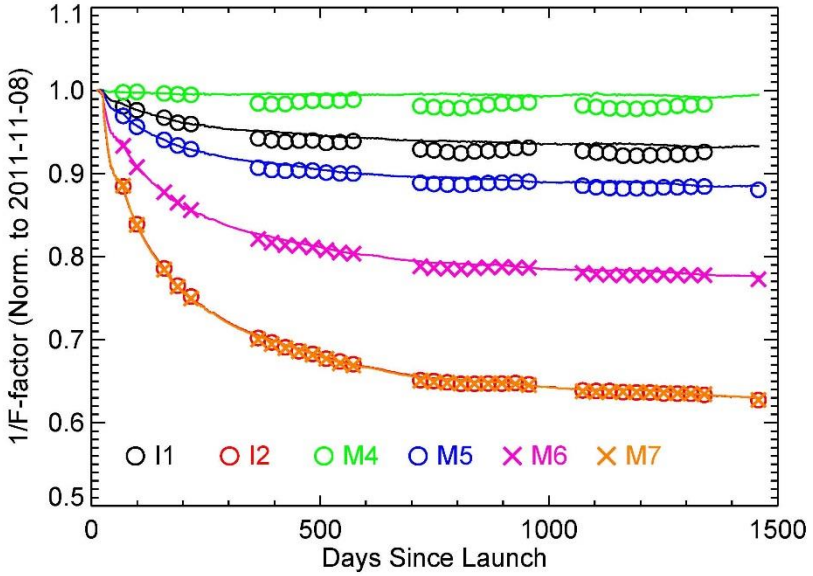


Small impact on bands with narrow bandwidths and small OOB responses

Comparison of Solar and Lunar Calibration







SD and lunar calibration made at the "same" angle of incidence (AOI)

Large changes in NIR/SWIR response due to telescope mirror degradation

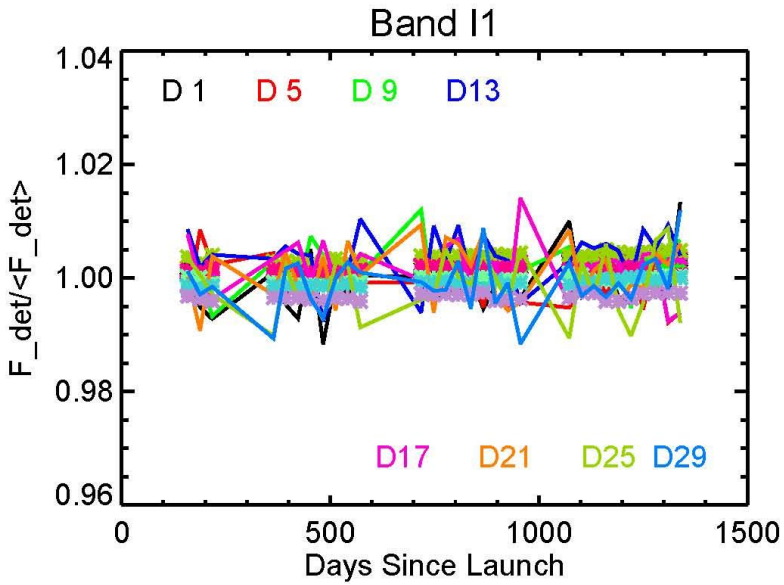
Modulated RSR applied

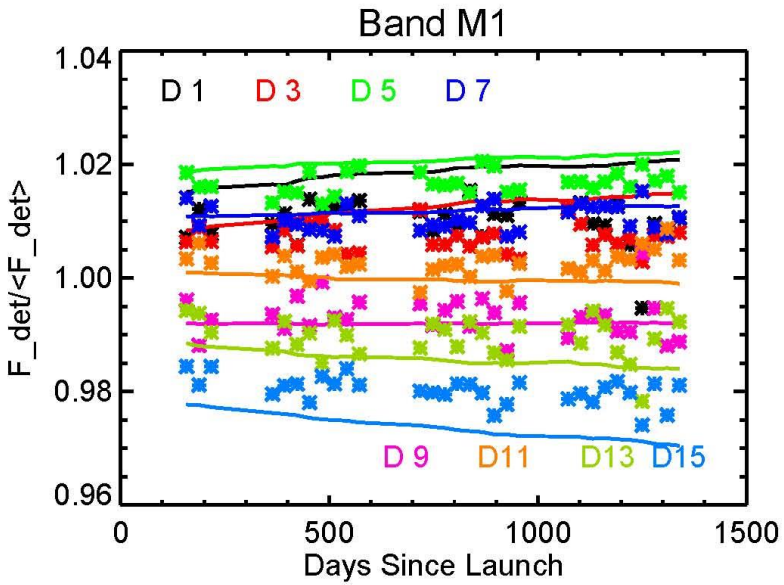
M1	0.41
M2	0.45
M3	0.49
M4	0.56
I1	0.64
M5	0.67
M6	0.75
I2	0.87
M7	0.87
M8	1.24
M9	1.38
I3	1.61
M10	1.61
M11	2.25

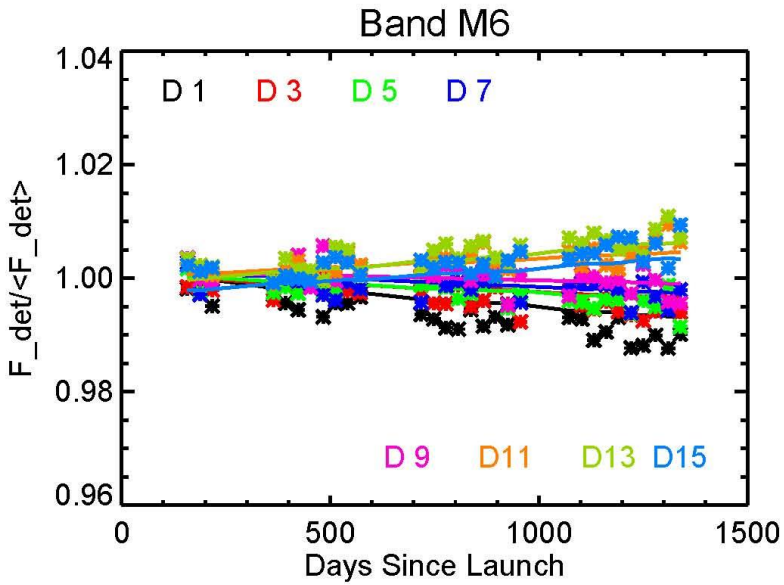
Future Efforts

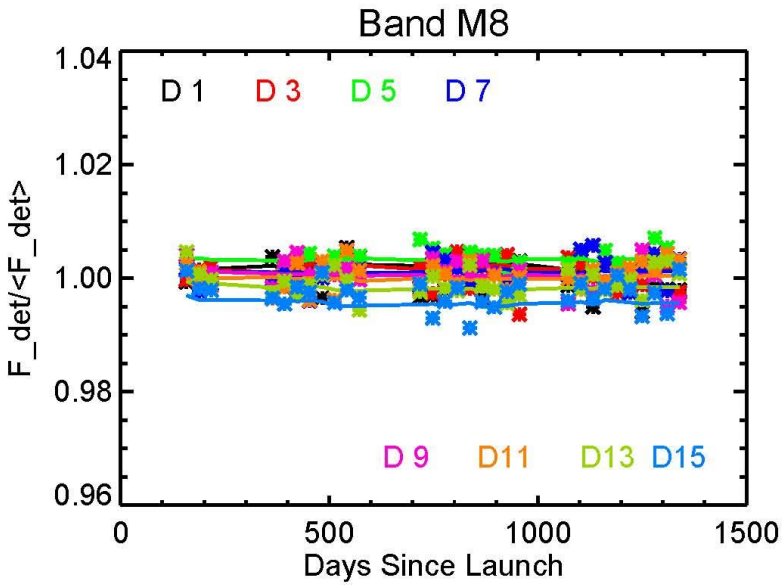
- **Combine SD and Lunar Calibration for Improved SDR LUTs**
  - SD and lunar observations are made at the same AOI
  - Remove potential impact due to SD degradation (SDSM and SD degradation uniformity)
- **Use Lunar Observations to and Characterize and Reduce Detector to Detector Calibration Differences**
  - MODIS experience and lessons applied
  - Small differences in a few VIIRS spectral bands
- **Improve Lunar Calibration**
  - Absolute (effort by NIST/USGS and by GSICS)
  - Relative (response trending and calibration inter-comparison)

Detector to Detector Calibration Differences



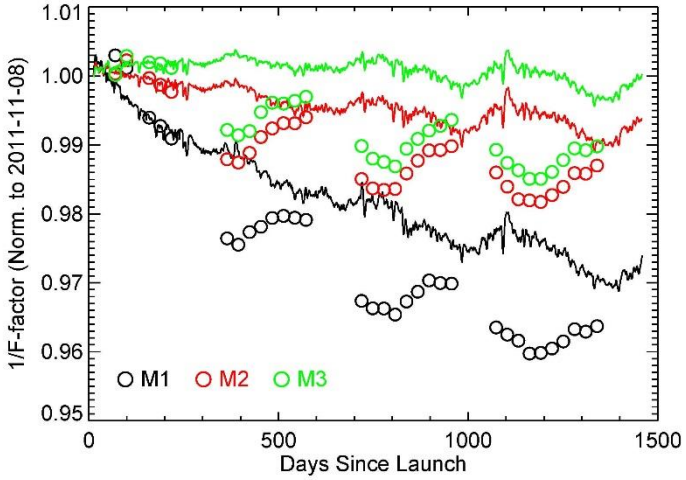


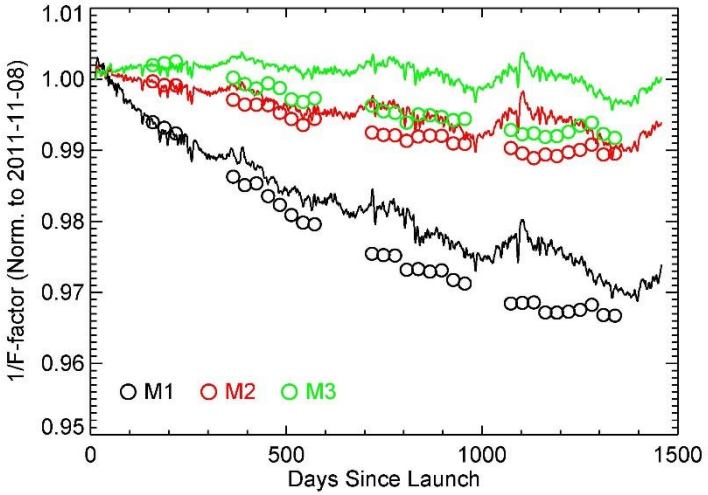




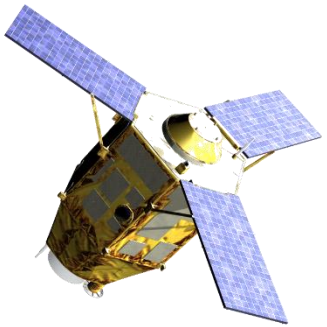
Approaches for Lunar Calibration Improvements

With an empirical libration correction





Impact due to lunar phase angles



Pleiades: POLO