

MODIS and VIIRS Instrument Status

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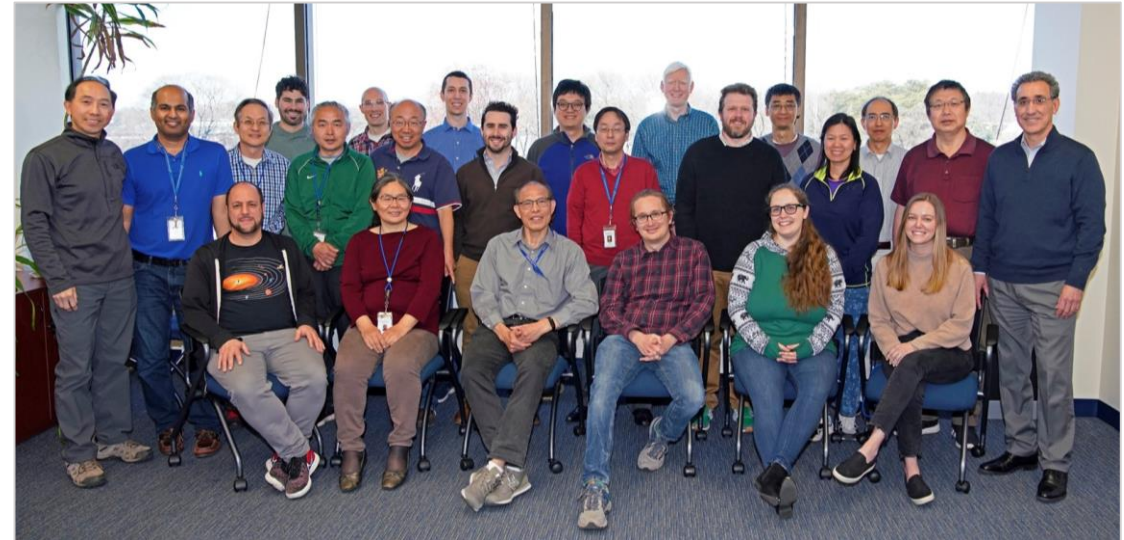
Acknowledgements

Contributions:

- MODIS Characterization Support Team (MCST)
- VIIRS Characterization Support Team (VCST)

Support:

- Terra, Aqua, S-NPP, and JPSS Projects
- Mission/Flight Operation Teams (MOT/FOT)
- MODIS and VIIRS Science Teams
- Instrument Vendor (Raytheon)
- NOAA JPSS Program and VIIRS SDR Team



March 30, 2023

Outline

- **Instrument Status**
 - Terra and Aqua MODIS
 - S-NPP, N-20, and N-21 VIIRS
- **MODIS and VIIRS On-orbit Performance**
- **Current and Future Activities**
- **Summary**



JPSS-2 launch on Nov 10, 2022



1999 →



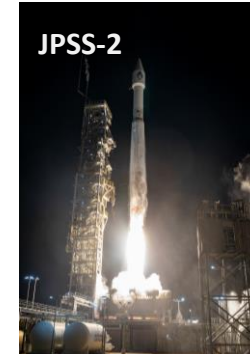
2002 →



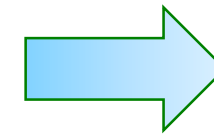
2011 →



2017 →



2022 →

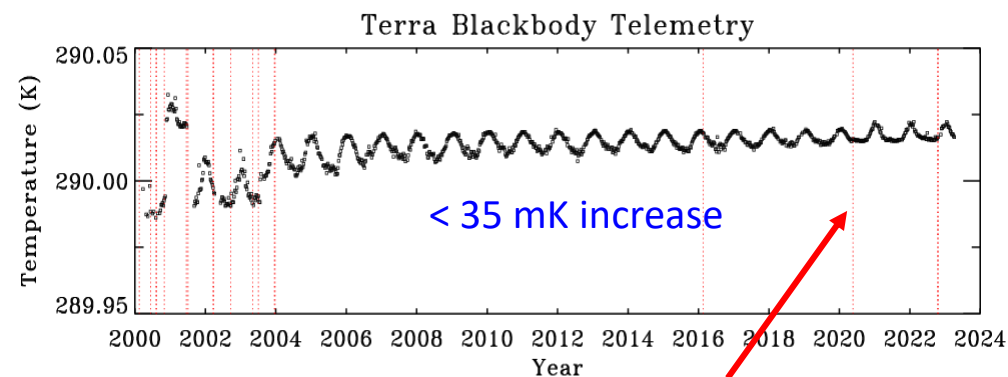
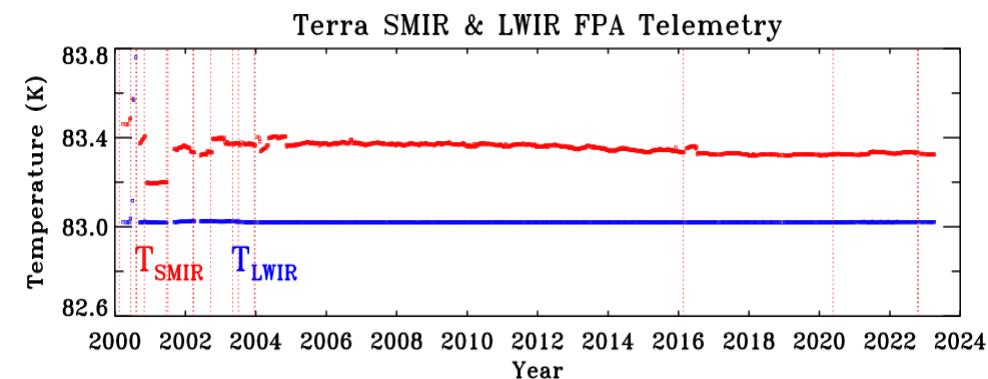
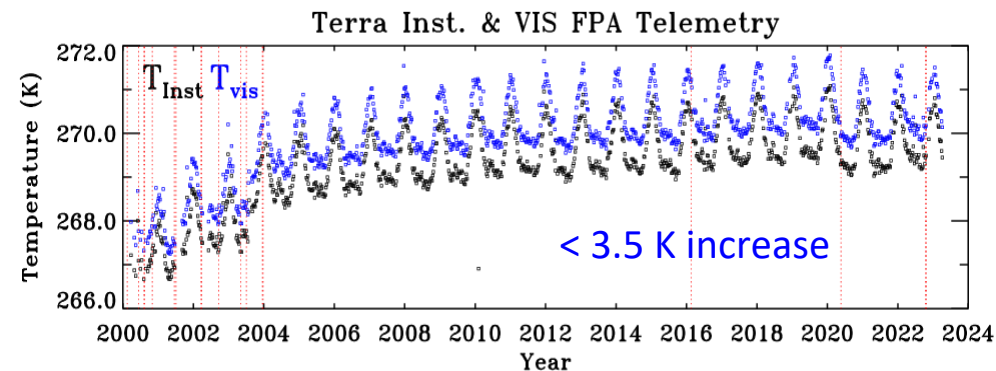


**JPSS-3/4 VIIRS
(2028/2032)**

Instrument Status: Terra MODIS

Instrument Operations and OBC Functions – Normal

- Same configuration (A-side electronics with B-side formatter) since 2003
 - CFPA at 83 K; BB at 290 K (285 K since 04/25/2020)
- Orbit Maneuvers
 - Constellation Exit Maneuvers (CEM) on 10/12/2022 and 10/19/2022
 - Final drag makeup maneuver (DMU) on 07/28/2022
 - Final inclination adjustment maneuver (IAM) on 02/27/2020
- Successful SSR Reset on 09/22/2021
- Standby Mode due to Terra CP/FP Reset on 03/15/2022 (recovered back to Science Normal on 03/16/2022)
- 1 new noisy detector (B6 d13) since last STM in Feb 2021
 - Currently 40 noisy detectors (30 from prelaunch; 35 at-launch) and 2 inoperable detector (B36 d7 and B5 d4)

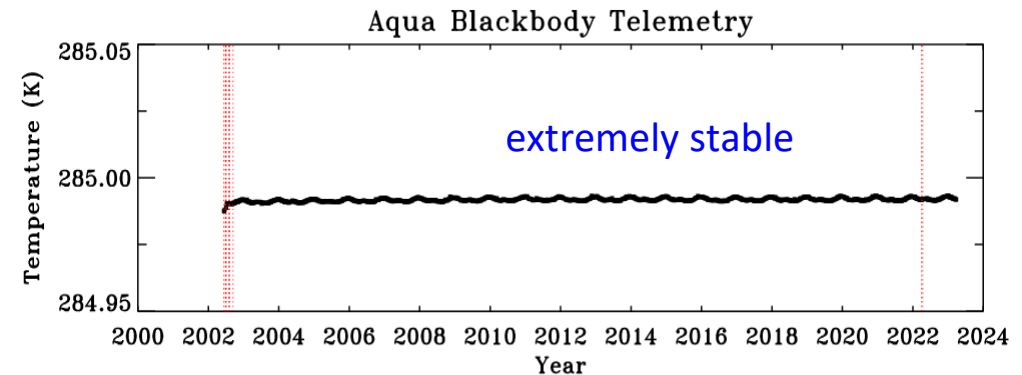
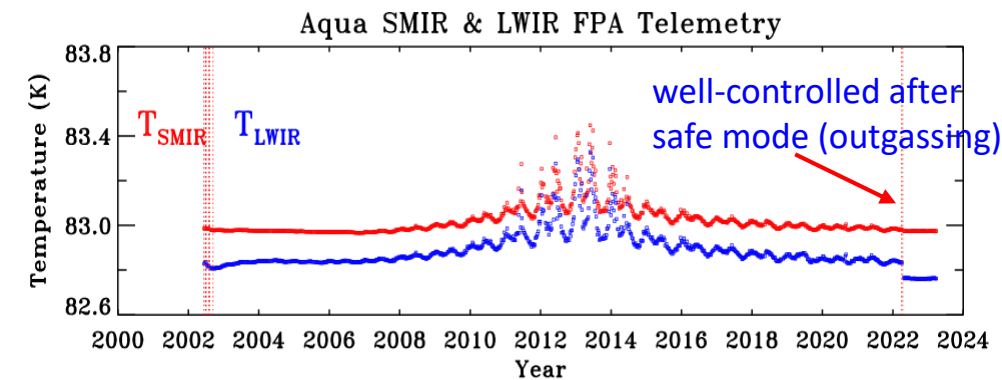
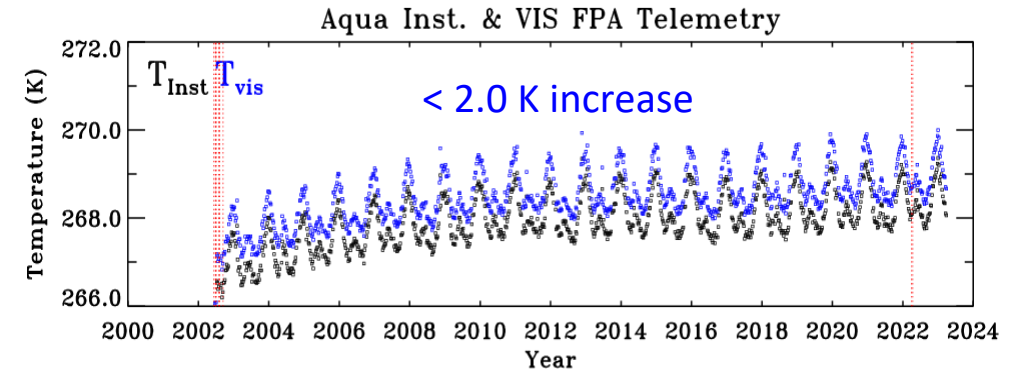


5 K added to T_{BB} after setting at 285 K (04/25/20)

Instrument Status: Aqua MODIS

Instrument Operations and OBC Functions – Normal

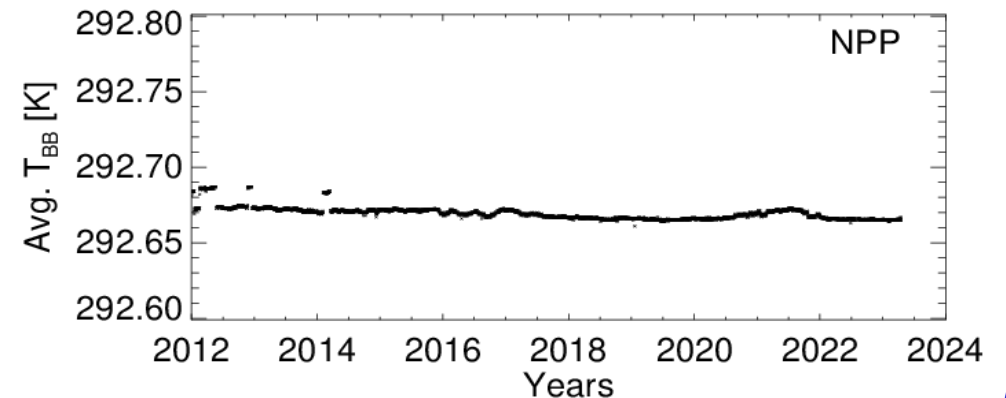
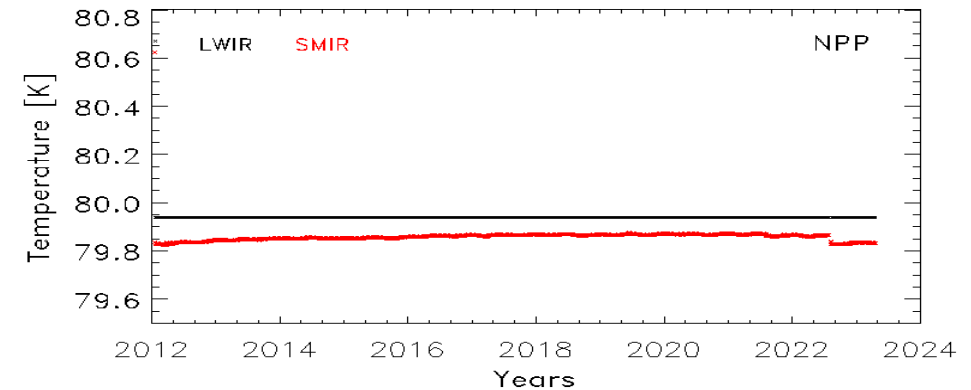
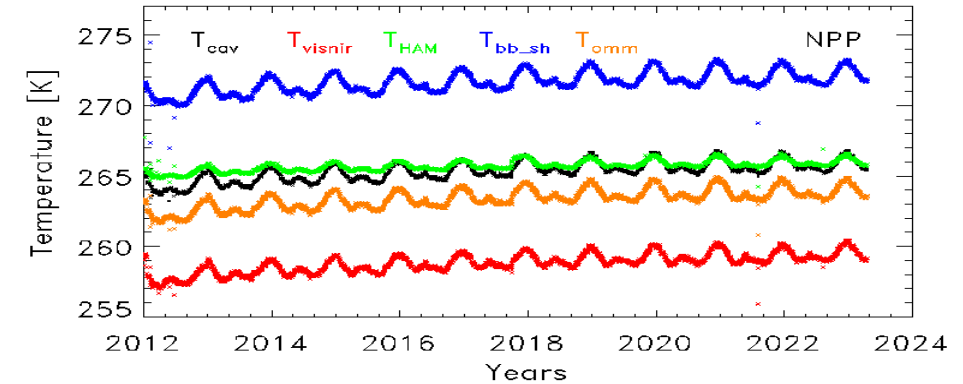
- Same configuration (B-side electronics and formatter) since launch
 - CFPA at 83 K; BB at 285 K
- Orbit Maneuvers
 - Final DMU: 12/01/2021
 - Final IAM: 03/18/2021
- Aqua pitch maneuver on 09/23/2021
- Aqua FMU (Formatter-Multiplexer Unit) anomaly on 02/22/2022; back to nominal operation on 03/23/2022
- Aqua Safe Mode on 03/31/2022; back to nominal operation on 04/13/2022 (with fully controlled CFPA temperatures)
- 3 new noisy detectors (B27 d1 and d3, B30 d1) and 1 new inoperable detector (B6 d4) since last STM
 - Currently 9 noisy detectors (2 from pre-launch; 3 at launch) and 15 inoperable detectors (13 in Band 6)



Instrument Status: S-NPP VIIRS

Instrument Operations and OBC Functions – Normal

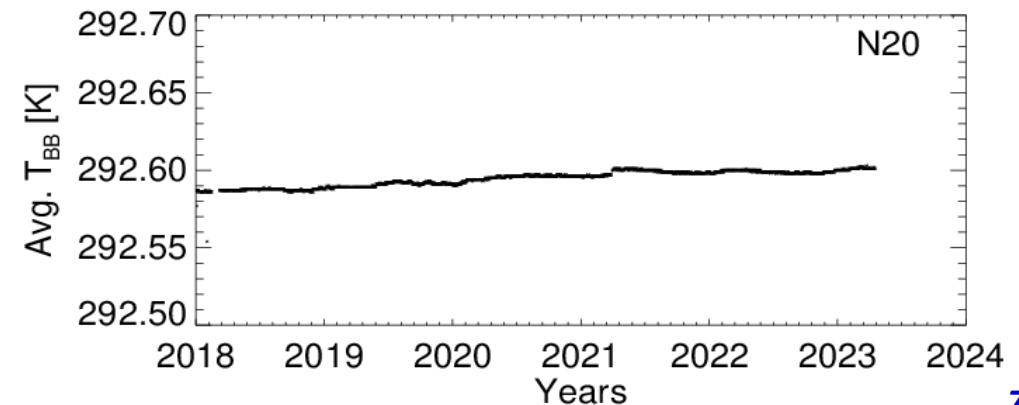
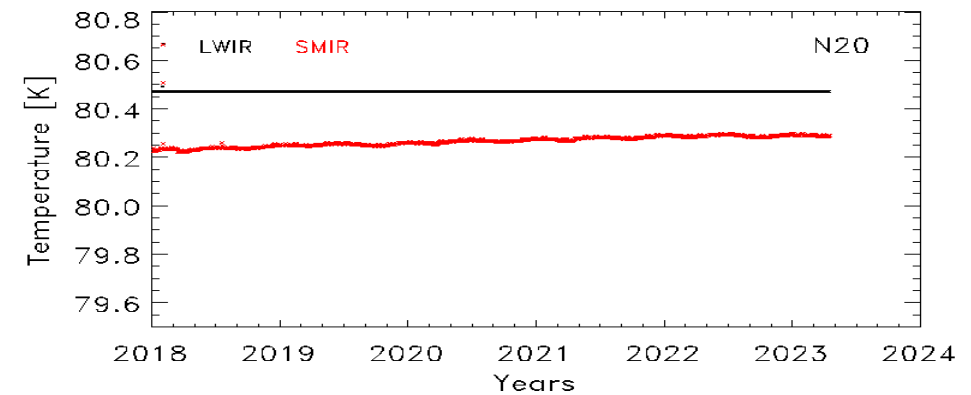
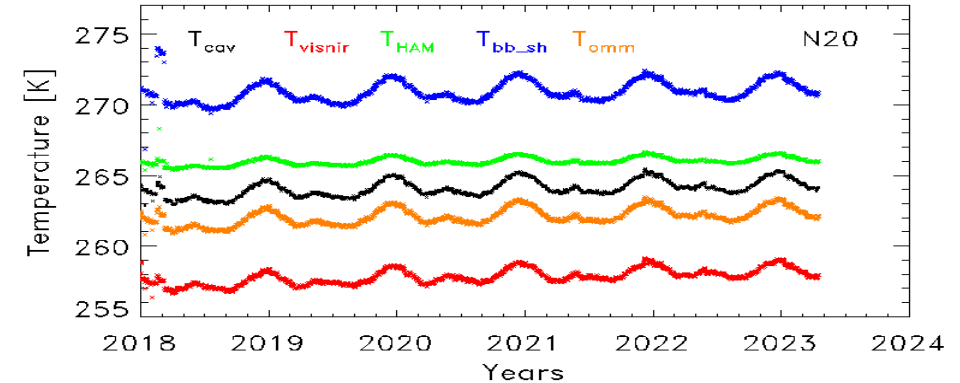
- Same configuration (B-side) since launch
 - CFP A at 80 K; BB at 292.5 K
- Single Board Computer (SBC) Lock-up (petulant mode): 16 since launch (most recent on 6/28/2022)
- Scan Sync Loss between RTA and HAM: 136 since launch (most recent on 9/17/2022)
- S-NPP Safe Mode on 8/3/2021 (after Star Catalog V1.09 upload)
- S-NPP Safe Mode from 7/26 to 8/10/2022
- No new noisy or inoperable detectors since launch
 - All detectors continue to function well



Instrument Status: N-20 VIIRS

Instrument Operations and OBC Functions – Normal

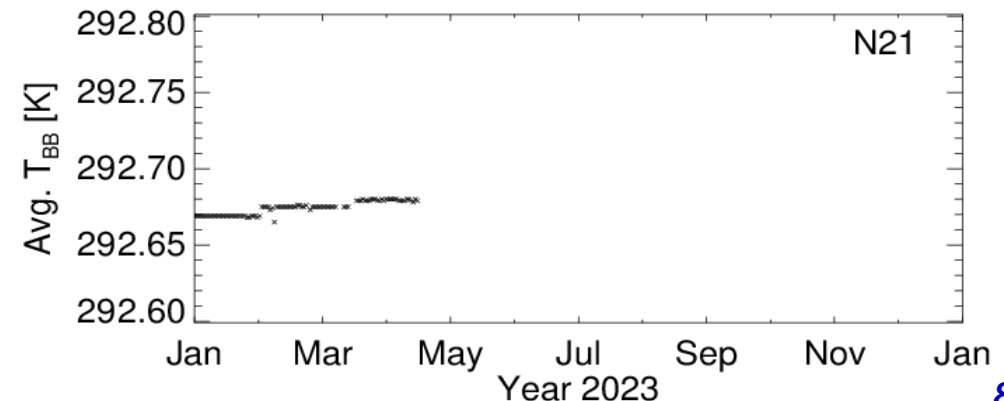
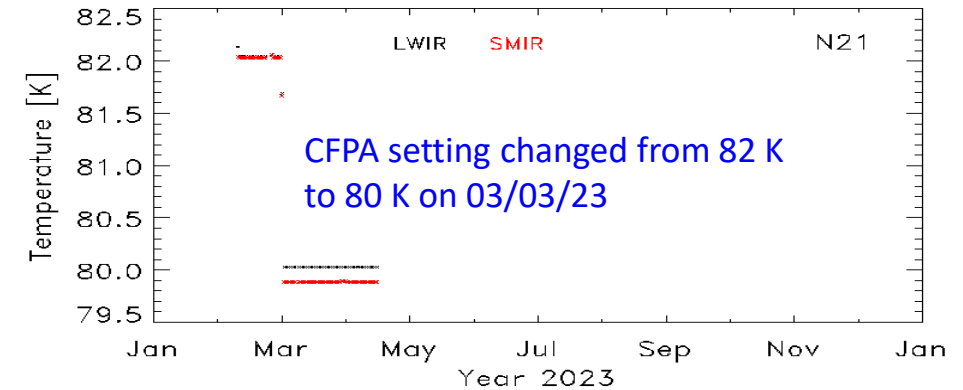
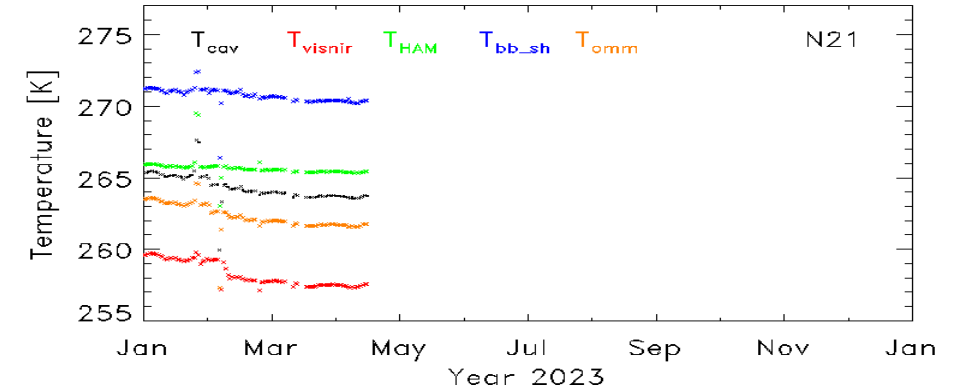
- Same configuration (A-side) since launch
 - CFPA at 80 K; BB at 292.5 K
- SBC Lock-up: none
- Scan Sync Loss between RTA and HAM: 87 since launch (most recent on 1/23/2023)
- VIIRS RTA (rotating telescope assembly) anomaly due to SEU (single event upset) on 2/14/2021; data outage for ~ 6 hours
- No new noisy or inoperable detectors since launch
 - 1 noisy detector at launch (I3 D29)



Instrument Status: N-21 VIIRS

Instrument Operations and OBC Functions – Normal

- Same configuration (A-side) since launch
 - CFP A at 80 K (82 K prior to 03/03/2023); BB at 292.5 K
- SBC Lock-up: none
- Scan Sync Loss between RTA and HAM: 7 since launch (most recent on 4/23/2023)
- **N-21 primary Ka-Transmitter (KATX-1) anomaly** on 12/16/2022; the secondary Ka-Transmitter (KATX-2) activation on 2/2/2023 (48 days of data gap).
- MMOG (mid-mission outgassing) on 02/23/2023
- All PLT activities, including initial calibration maneuvers, completed
- No new noisy or inoperable detectors since launch
 - All detectors continue to function well



MODIS and VIIRS Spectral bands and On-orbit Calibration

VIIRS Band	Spectral Range (um)	Nadir HSR (m)	MODIS Band(s)	Range	HSR
DNB	0.500 - 0.900				
M1	0.402 - 0.422	750	8	0.405 - 0.420	1000
M2	0.436 - 0.454	750	9	0.438 - 0.448	1000
M3	0.478 - 0.498	750	3 10	0.459 - 0.479 0.483 - 0.493	500 1000
M4	0.545 - 0.565	750	4 or 12	0.545 - 0.565 0.546 - 0.556	500 1000
I1	0.600 - 0.680	375	1	0.620 - 0.670	250
M5	0.662 - 0.682	750	13 or 14	0.662 - 0.672 0.673 - 0.683	1000 1000
M6	0.739 - 0.754	750	15	0.743 - 0.753	1000
I2	0.846 - 0.885	375	2	0.841 - 0.876	250
M7	0.846 - 0.885	750	16 or 2	0.862 - 0.877 0.841 - 0.876	1000 250
M8	1.230 - 1.250	750	5	SAME	500
M9	1.371 - 1.386	750	26	1.360 - 1.390	1000
I3	1.580 - 1.640	375	6	1.628 - 1.652	500
M10	1.580 - 1.640	750	6	1.628 - 1.652	500
M11	2.225 - 2.275	750	7	2.105 - 2.155	500
I4	3.550 - 3.930	375	20	3.660 - 3.840	1000
M12	3.660 - 3.840	750	20	SAME	1000
M13	3.973 - 4.128	750	21 or 22	3.929 - 3.989 3.929 - 3.989	1000 1000
M14	8.400 - 8.700	750	29	SAME	1000
M15	10.263 - 11.263	750	31	10.780 - 11.280	1000
I5	10.500 - 12.400	375	31 or 32	10.780 - 11.280 11.770 - 12.270	1000 1000
M16	11.538 - 12.488	750	32	11.770 - 12.270	1000

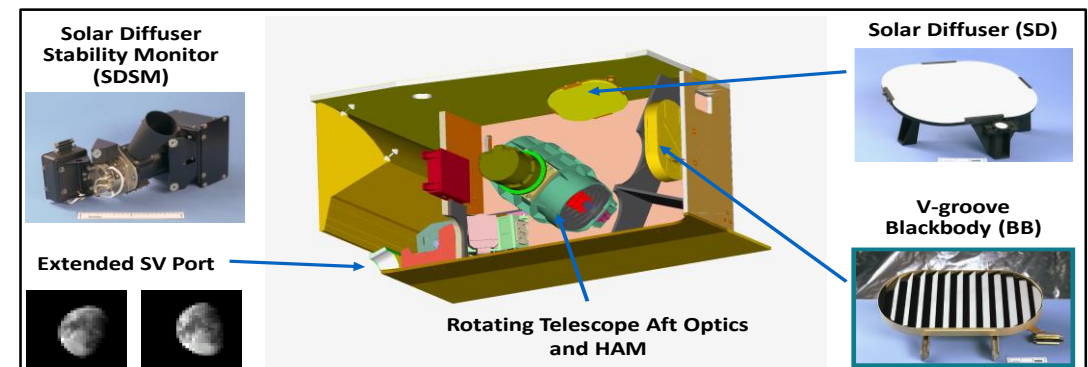
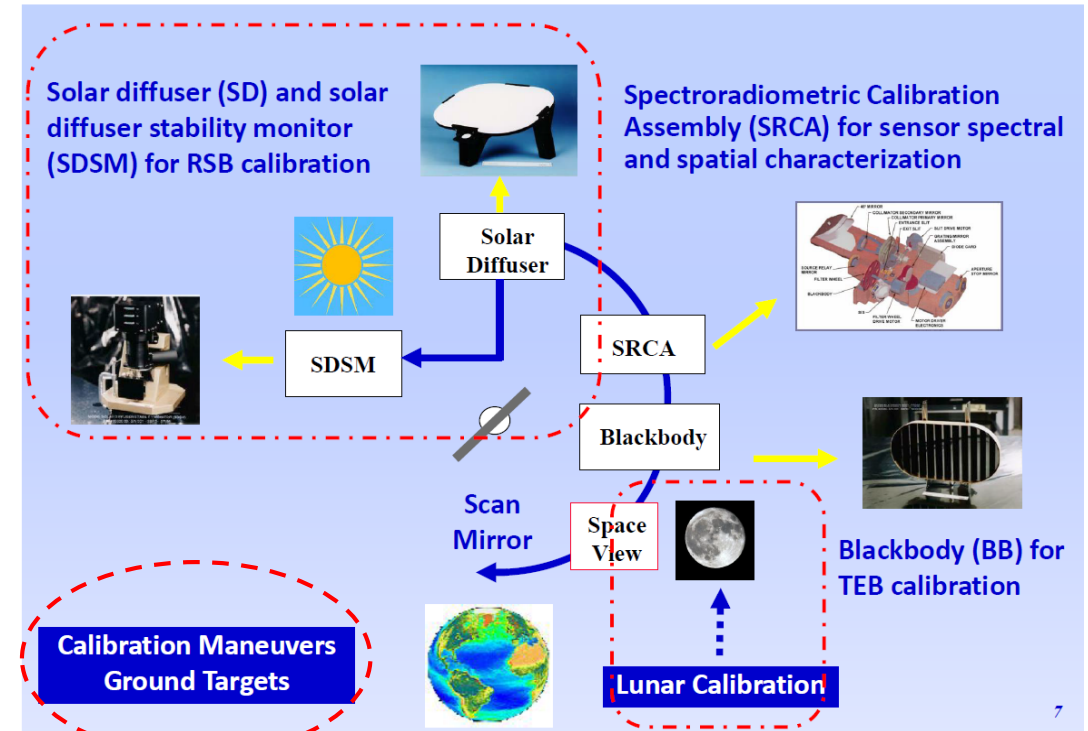
Dual Gain: M1-M5, M7, M13

MODIS: bands 33-36

1 DNB
(0.5-0.9 μm)

14 RSB
(0.4-2.3 μm)

7 TEB
(3.7-12 μm)



Terra MODIS Performance

- **Radiometric**

- Large changes in sensor response and RVS at short wavelengths (VIS/NIR bands)
- Discontinuities in sensor performance parameters (e.g. TEB gains and crosstalk coefficients) due to sensor Safe Mode
- Large SD degradation at short wavelengths
- Terra LWIR PV crosstalk correction in C6.1 remains effective

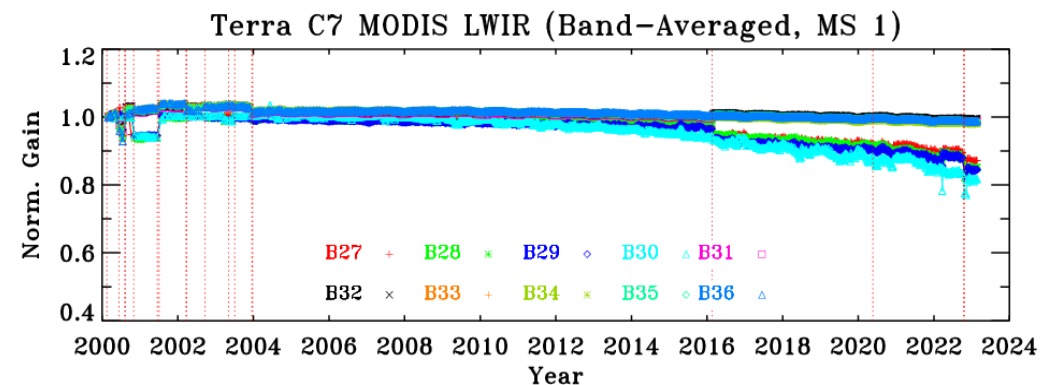
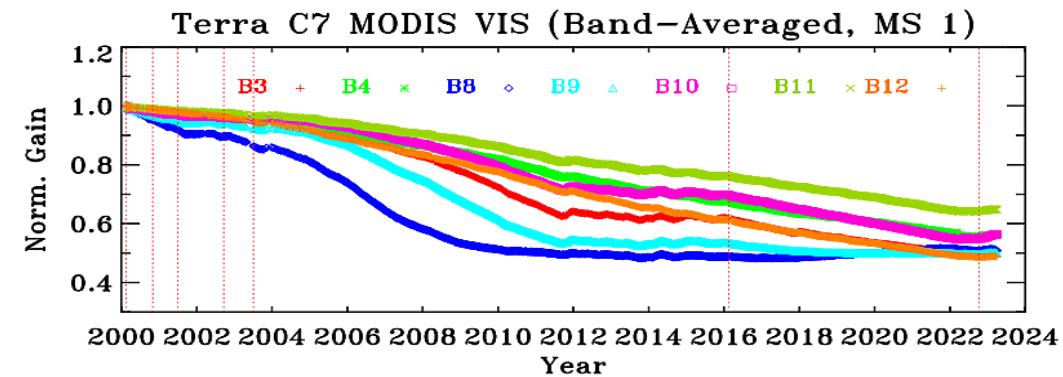
- **Spatial and Spectral**

- Band-to-band registration (BBR): stable since launch
- VIS/NIR center wavelengths and bandwidths: changes are within 0.5 nm and 1.0 nm, respectively, except for bands (1, 2, 17) with broad bandwidths

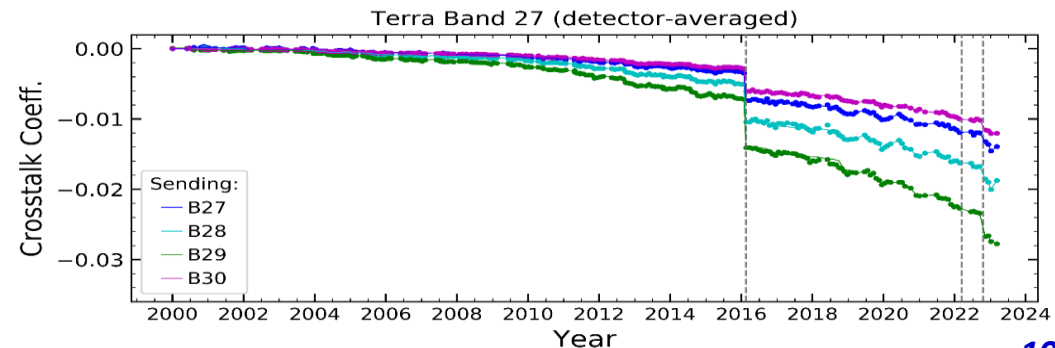
- **Geolocation**

- C6.1 RMSE Track: 43 m; Scan: 45 m, nadir equivalent

Spatial, Spectral, and Geolocation Performance Examples
Provided in Backup Slides



crosstalk correction coefficient



Aqua MODIS Performance

- **Radiometric**

- Large changes in sensor response and RVS at short wavelengths (VIS/NIR bands)
- Discontinuities in sensor performance parameters (e.g. TEB gains and crosstalk coefficients) due to sensor Safe Mode
- Large SD degradation at short wavelengths
- Aqua LWIR PV crosstalk correction is applied to C7 (entire mission) and C6.1 (forward only) to address more recent increase of the crosstalk effects

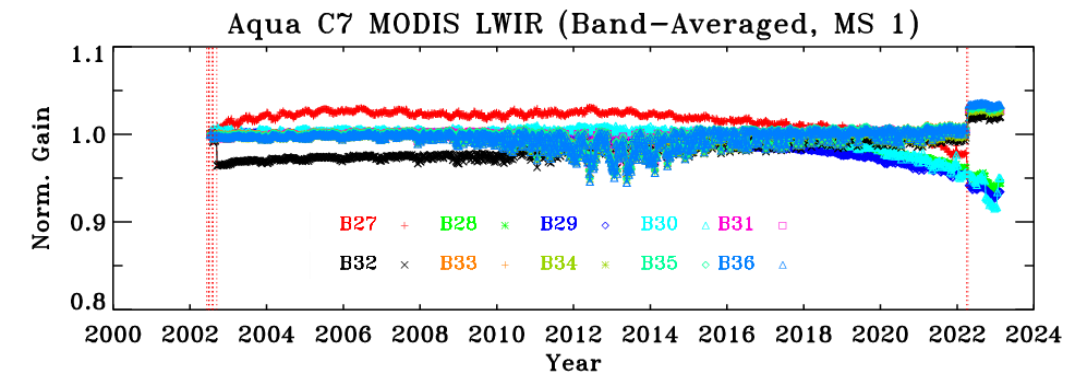
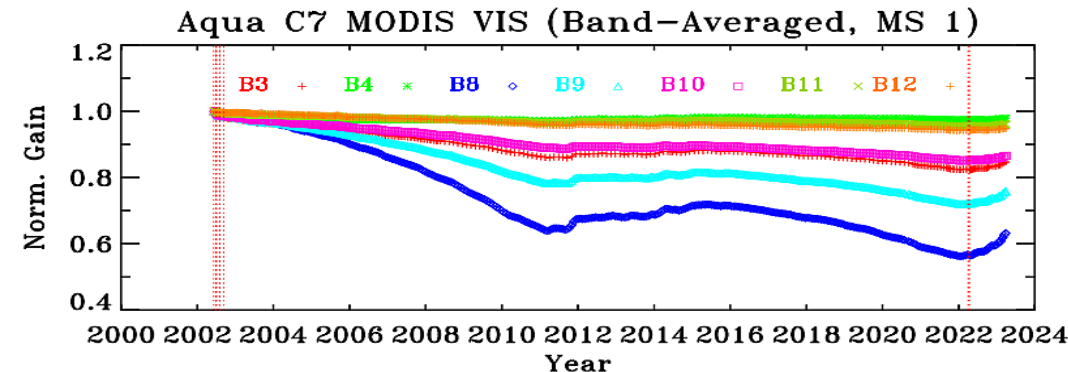
- **Spatial and Spectral**

- Band-to-band registration (BBR): stable since launch
- VIS/NIR center wavelengths and bandwidths: changes are within 0.5 nm and 1.0 nm, respectively.

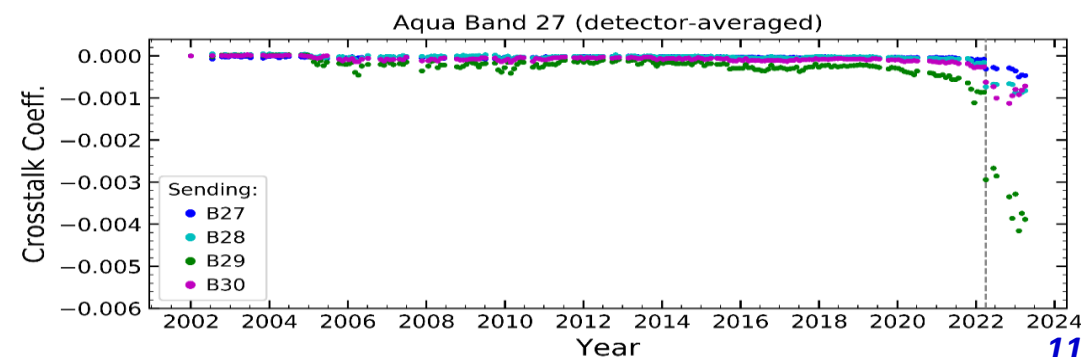
- **Geolocation**

- C6.1 RMSE Track: 46 m; Scan: 54 m, nadir equivalent

Spatial, Spectral, and Geolocation Performance Examples
Provided in Backup Slides



crosstalk correction coefficient



S-NPP VIIRS Performance

- **Radiometric**

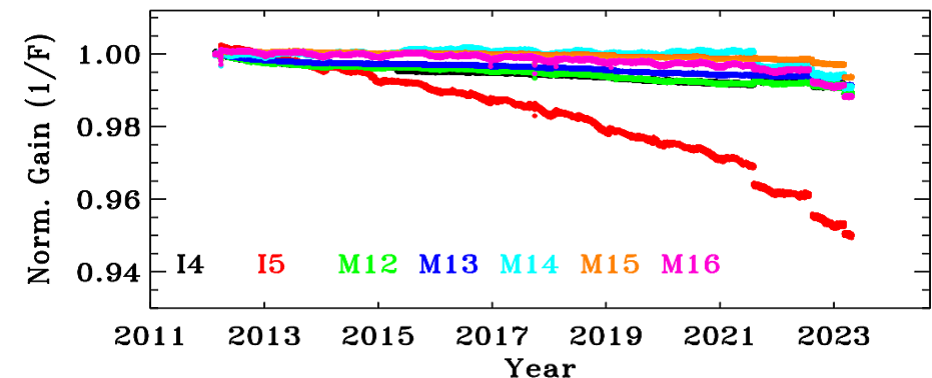
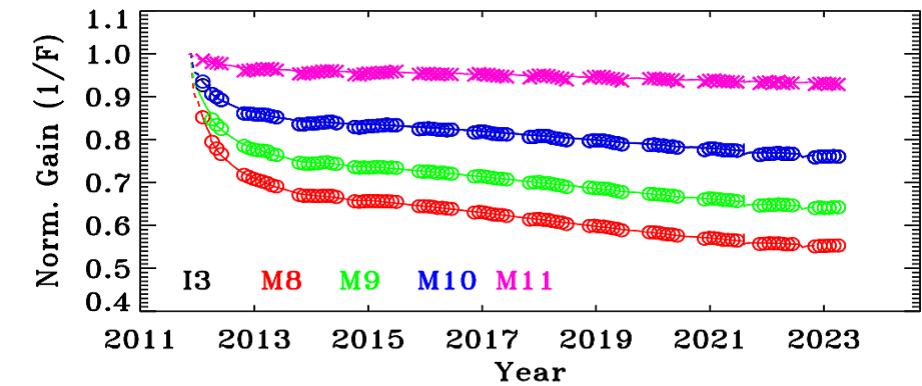
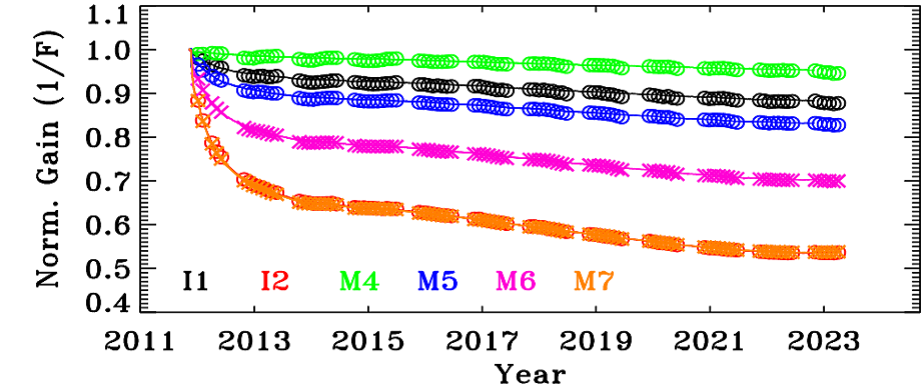
- Large degradation in several NIR and SWIR bands, especially at mission beginning (a known issue due to RTA mirror coating contamination)
- Large SD degradation at short wavelengths
- A gradual gain decrease for I5 (5% over 11 years)
- DNB stray light correction remains effective

- **Spatial and Spectral**

- Band-to-band registration (BBR): stable since launch
- Relative spectral response (RSR): on-orbit modulated RSR (large impact on DNB calibration)

- **Geolocation**

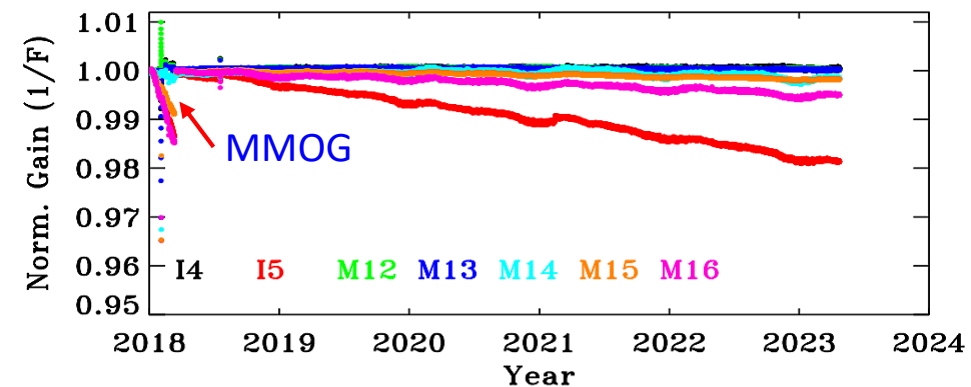
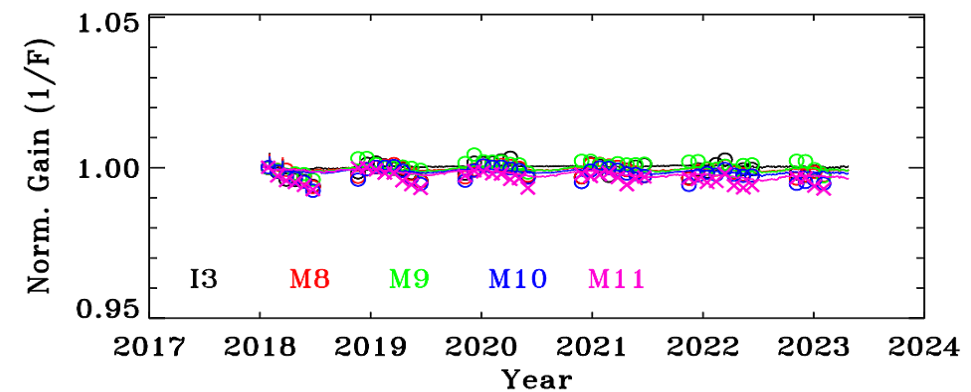
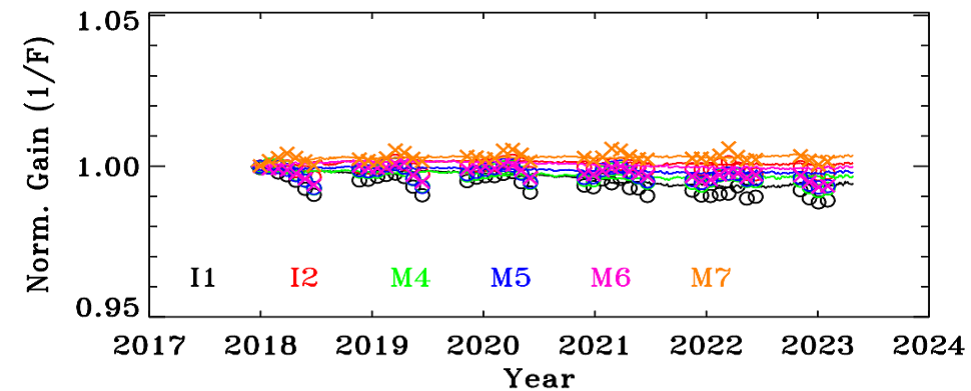
- C2 RMSE Track: 59 m; Scan: 48 m



Spatial and Geolocation Performance Examples Provided in Backup Slides

N-20 VIIRS Performance

- **Radiometric**
 - RSB responses (detector gains) have been **extremely stable over the entire mission**
 - Large SD degradation at short wavelengths
 - TEB gains have remained stable since MMOG (mid-mission outgassing), a **gain decrease for I5 (similar to SNPP; 1.8% over 5 years)**
 - DNB stray light correction remains effective
- **Spatial and Spectral**
 - Band-to-band registration (BBR): stable since launch
 - Relative spectral response (RSR): pre-launch characterization
- **Geolocation**
 - C2.1 RMSE Track: 57 m; Scan: 47 m



Spatial and Geolocation Performance Examples Provided in Backup Slides

N-21 VIIRS Performance

- **Radiometric**

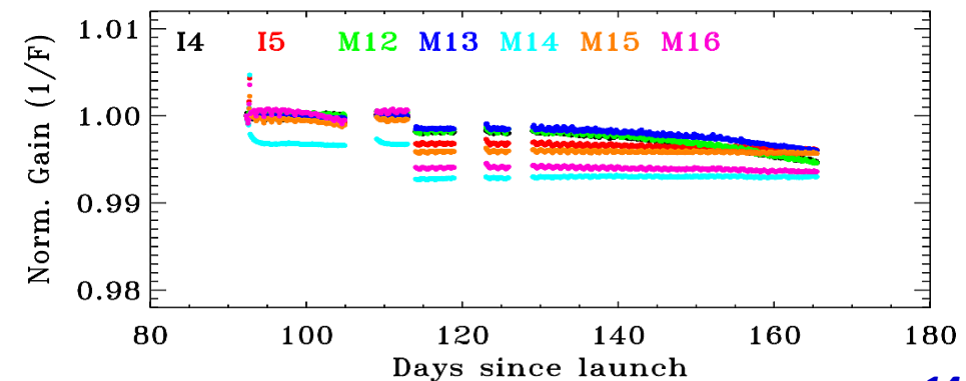
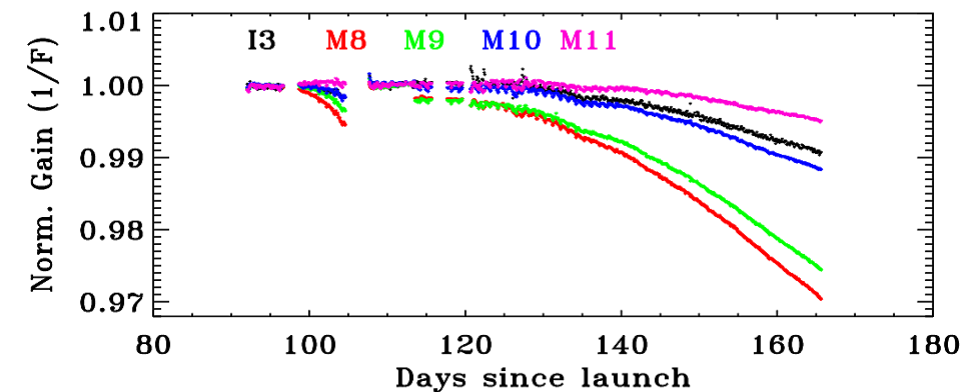
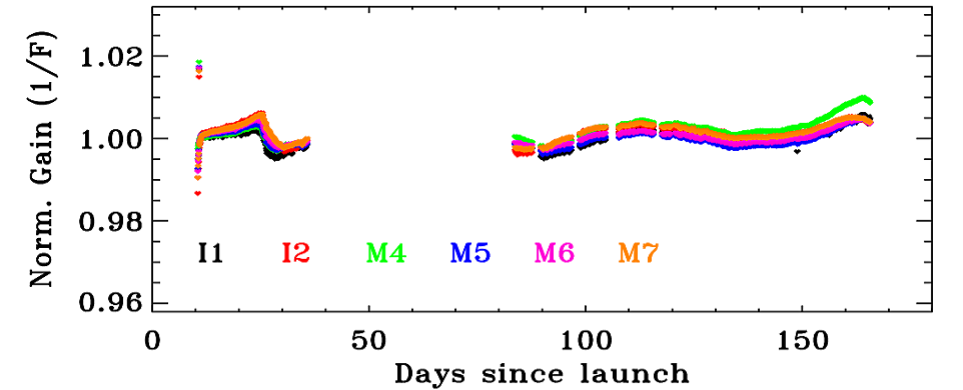
- Stable responses (detector gains) for most spectral bands (VIS/NIR/LWIR) under the same operating condition
- Relatively large decrease in SWIR (M8, M9) responses
- Small decrease in MWIR (I4, M12, M13) responses
- Large SD degradation at short wavelengths
- DNB stray light: smaller than S-NPP and N-20

- **Spatial and Spectral**

- Band-to-band registration (BBR): stable since launch (preliminary with limited measurements)
- Relative spectral response (RSR): pre-launch characterization

- **Geolocation**

- “C2” RMSE Track: 61 m; Scan: 48 m



Spatial and Geolocation Performance Examples Provided in Backup Slides

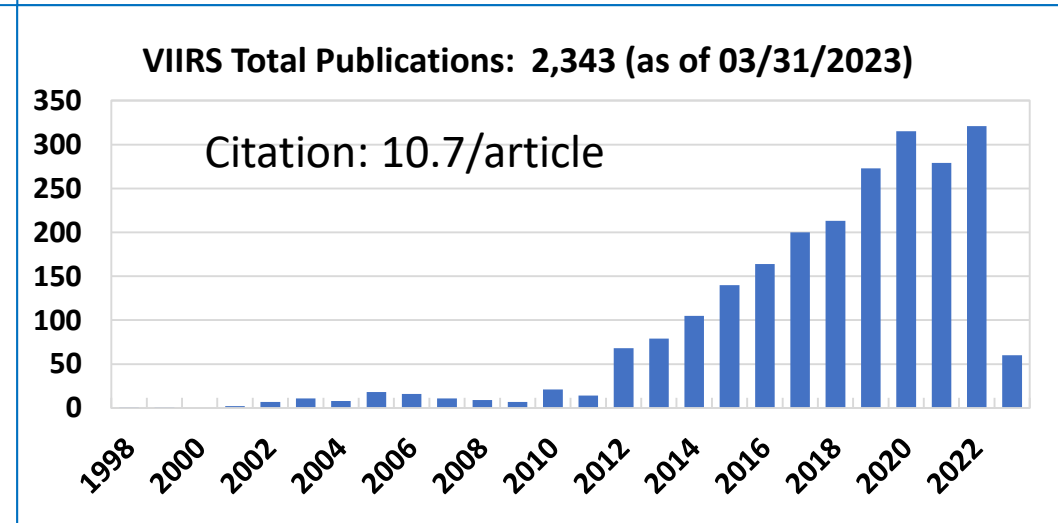
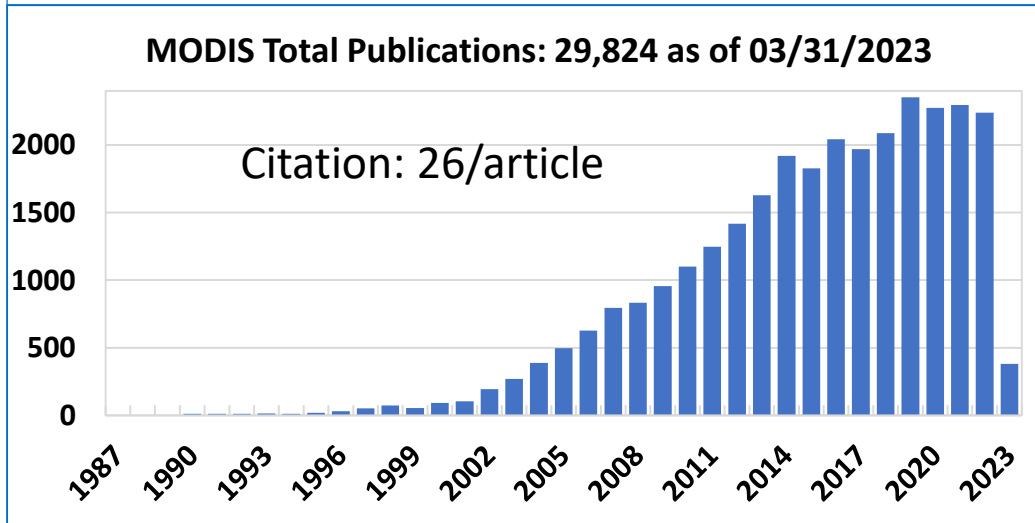
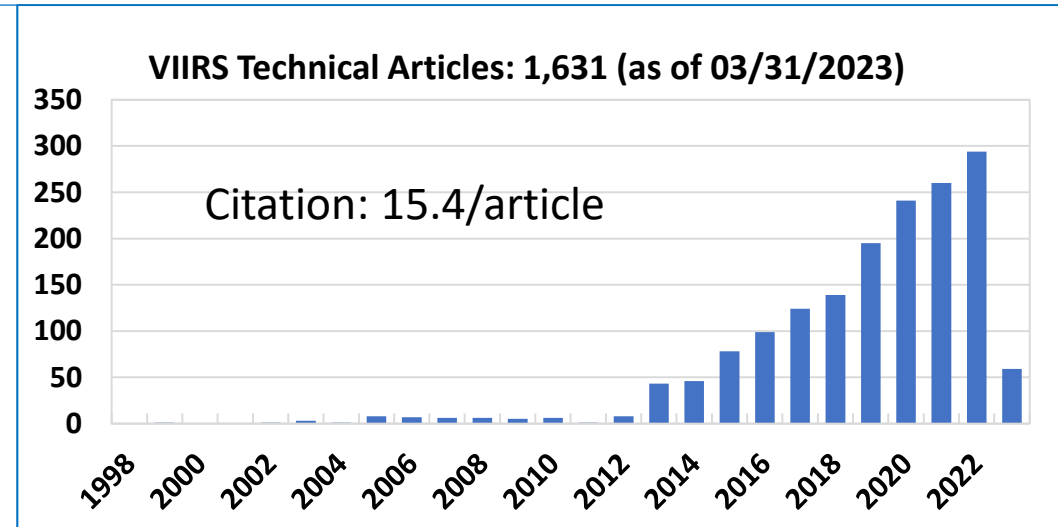
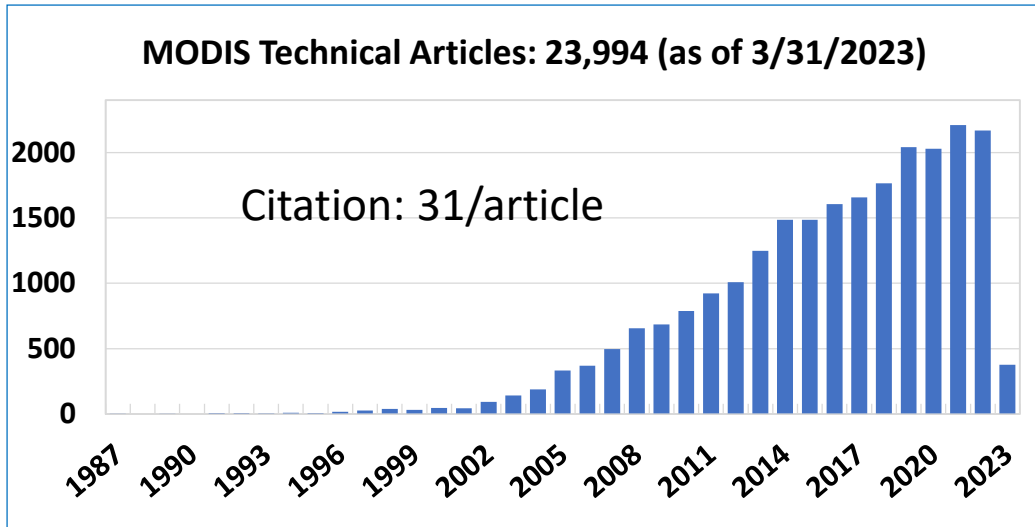
Current and Future Activities: Terra and Aqua MODIS

- Continue to monitor sensor performance and to derive and update calibration LUTs in support of C6.1 data production ([C6 data production ended in April 2023](#))
- Update C7 calibration LUTs regularly when forward production begins (C7 mission-long LUTs were initially delivered for science testing in March 2021 and later updated through Dec 2022, including several RSB and TEB algorithm enhancements and L1B code changes).
- Continue to monitor and address [crosstalk impact on Terra and Aqua PV LWIR bands 27-30](#). As Aqua crosstalk contamination continues to increase after recent safe mode, further adjustments may be needed to improve calibration accuracy, long-term stability, and image striping.
- Monitor and update crosstalk correction for [select MWIR detectors \(included in C7\)](#)
- Implement C7 RSB algorithm changes into C6.1 forward production (started March 2023 with gradual phase-in over several months)
- [Enhance and expand post-CEM calibration strategies](#) in support of extended Terra and Aqua MODIS missions (use of OBC and lunar observations, vicarious calibration targets, and alternative approaches) – to address impact due to drifting orbits
- Support Terra and Aqua FOT for planning and preparation of special end-of-mission maneuvers and decommissioning activities

Current and Future Activities: S-NPP, N-20, and N-21 VIIRS

- Continue to monitor sensor performance and to derive and update calibration LUTs in support of SIPS for VIIRS data production (S-NPP, N-20, and N-21) **with special effort on changes in N-21 SWIR response**
- Continue to monitor detector-to-detector calibration differences and implement corrections as necessary (already applied in S-NPP C2 for a few VIS bands; **likely to extend to N-20 SWIR bands**)
- Continue to track VIIRS calibration stability, including potential changes in the RVS, using different EV targets and DCC
- Complete and implement the saturation rollover pixel flagging and uncertainty index for all three instruments, including L1B code changes.
- **Further improve N-21 VIIRS RSB calibration** (SDSM Sun view screen transmittance, use of both SD and lunar measurements for LUT updates, ...)
- Further improve DNB calibration accuracy and stray light characterization and correction
- Develop strategies to assess and address S-NPP, N-20, and N-21 RSB calibration differences (a major challenge for producing consistent long-term data records)

MODIS and VIIRS Publications



Summary

- Both Terra and Aqua MODIS and their OBC continue to operate and function normally
- S-NPP, N-20, and N-21 VIIRS and their OBC continue to operate and function normally
- On-orbit changes in sensor responses and key performance parameters are well characterized using OBC measurements, lunar observations, and select earth view targets (e.g. PICS and DCC); further improvements for N-21 is expected as more calibration data sets become available
- Overall performance of VIIRS is more stable than MODIS
- Strategies have been developed and implemented to address calibration challenges due to recent drifting orbits (Terra and Aqua)
- Continuing efforts by the MCST and VCST to
 - Characterize and monitor sensor performance
 - Address issues identified, including changes of sensor characteristics resulting from spacecraft and instrument anomalies and calibration differences among sensors
 - Derive and deliver calibration parameters in support of sensor L1B and science data processing and reprocessing (MODIS C6.1/C7 and VIIRS C2.0/C2.1)

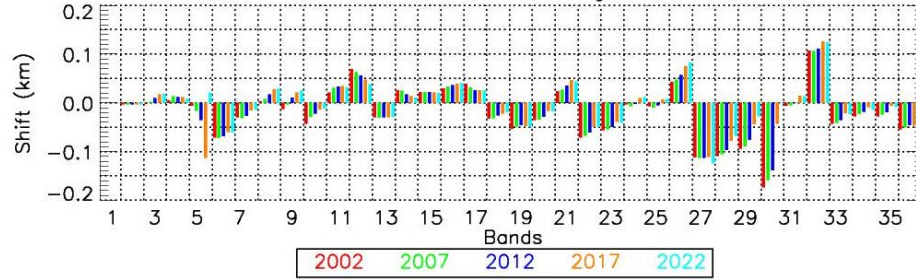
More Details in Presentations at MODIS and VIIRS Calibration Workshop (May 1, 2023)

Backup Slides

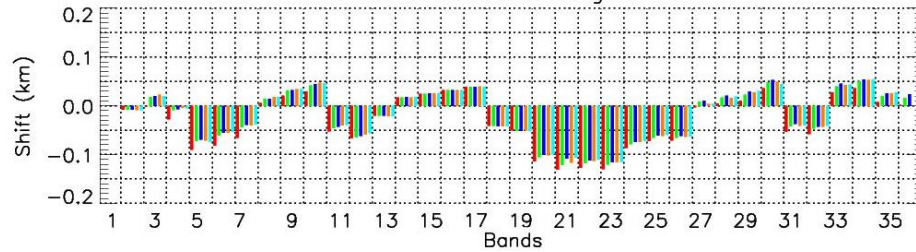
MODIS Spatial and Spectral Characterization

Terra MODIS

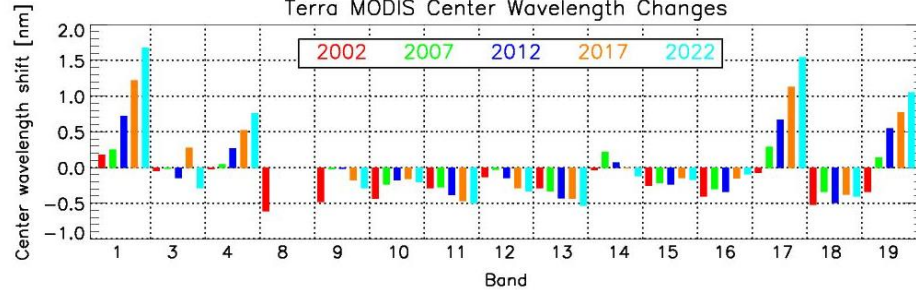
Terra BBR Shift Along-scan



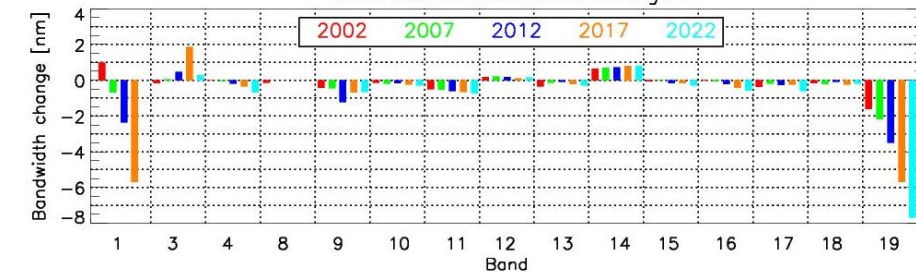
Terra BBR Shift Along-track



Terra MODIS Center Wavelength Changes

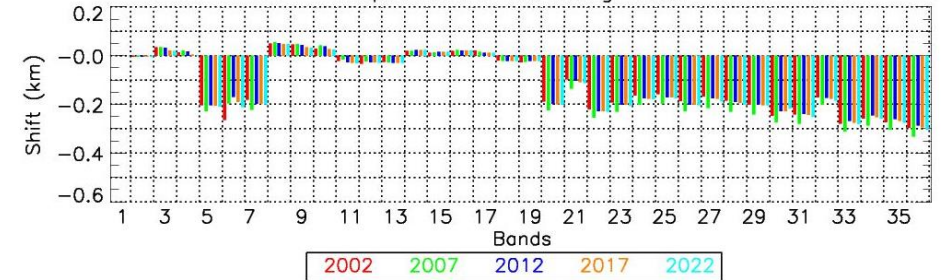


Terra MODIS Bandwidth Changes

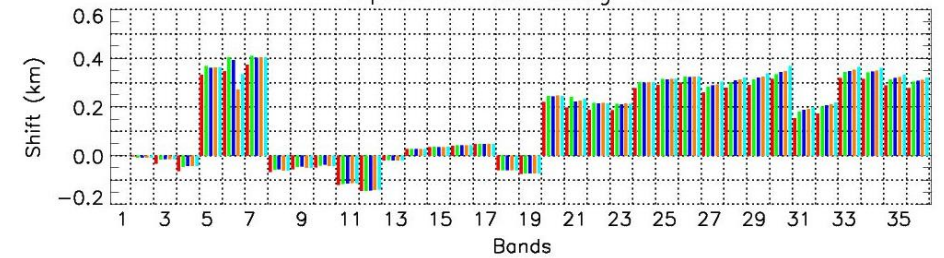


Aqua MODIS

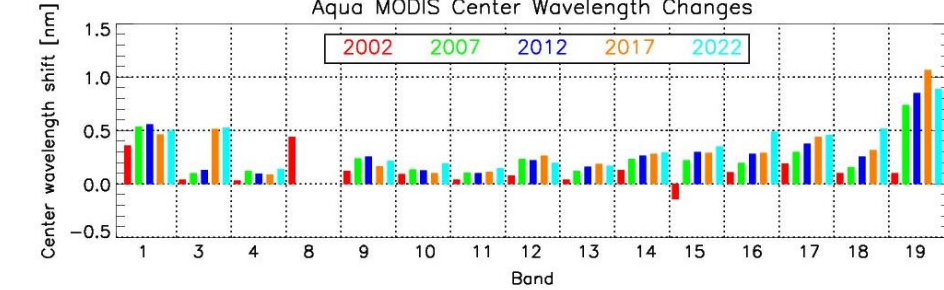
Aqua BBR Shift Along-scan



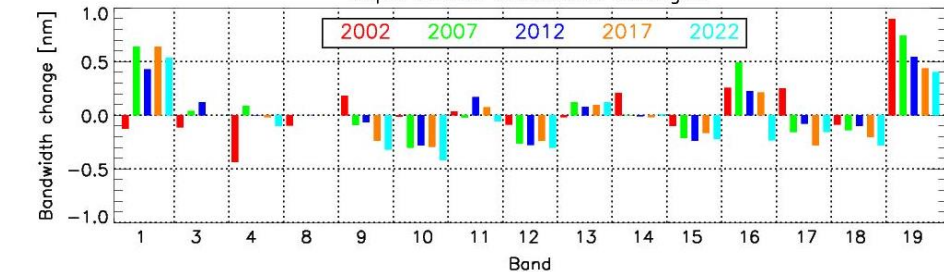
Aqua BBR Shift Along-track



Aqua MODIS Center Wavelength Changes



Aqua MODIS Bandwidth Changes



Along-scan BBR

Along-track BBR

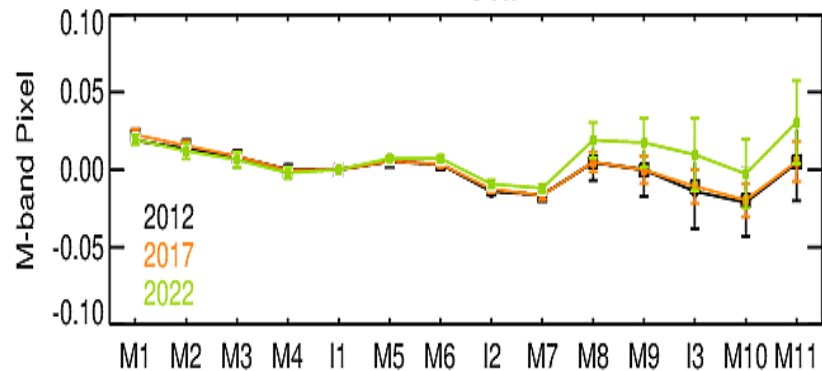
Changes in CW

Changes in BW

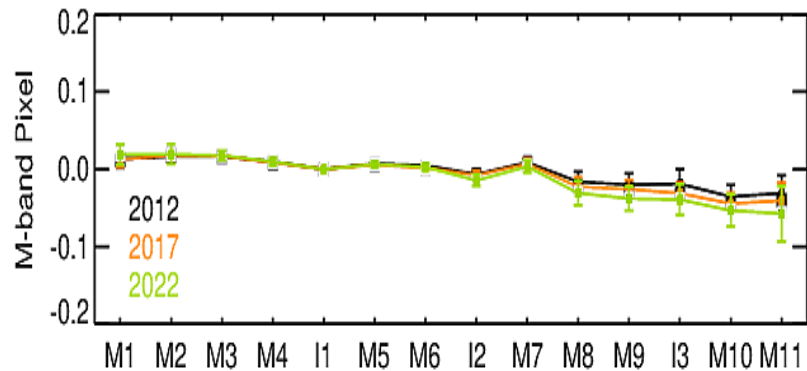
VIIRS Spatial Characterization

S-NPP VIIRS

BBR Scan

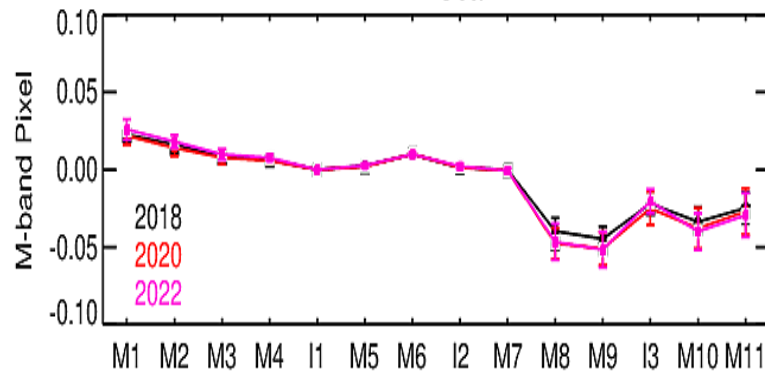


BBR Track

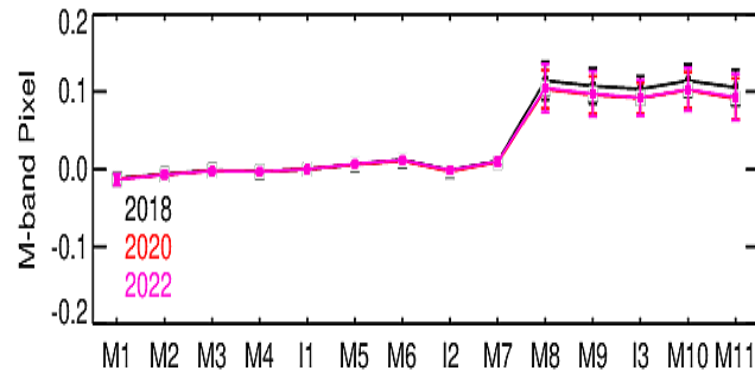


N-20 VIIRS

BBR Scan

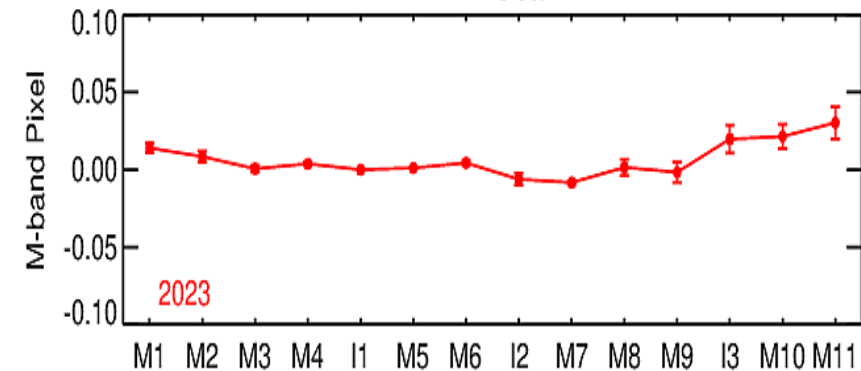


BBR Track

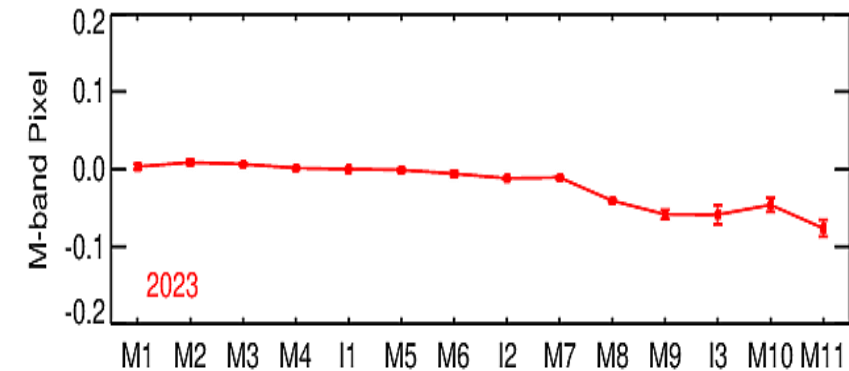


N-21 VIIRS

BBR Scan



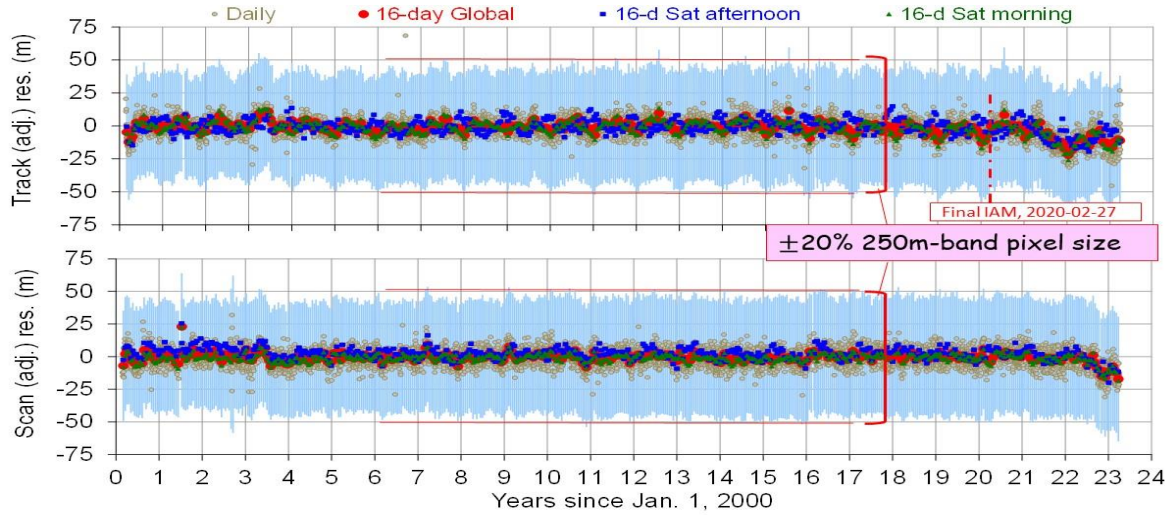
BBR Track



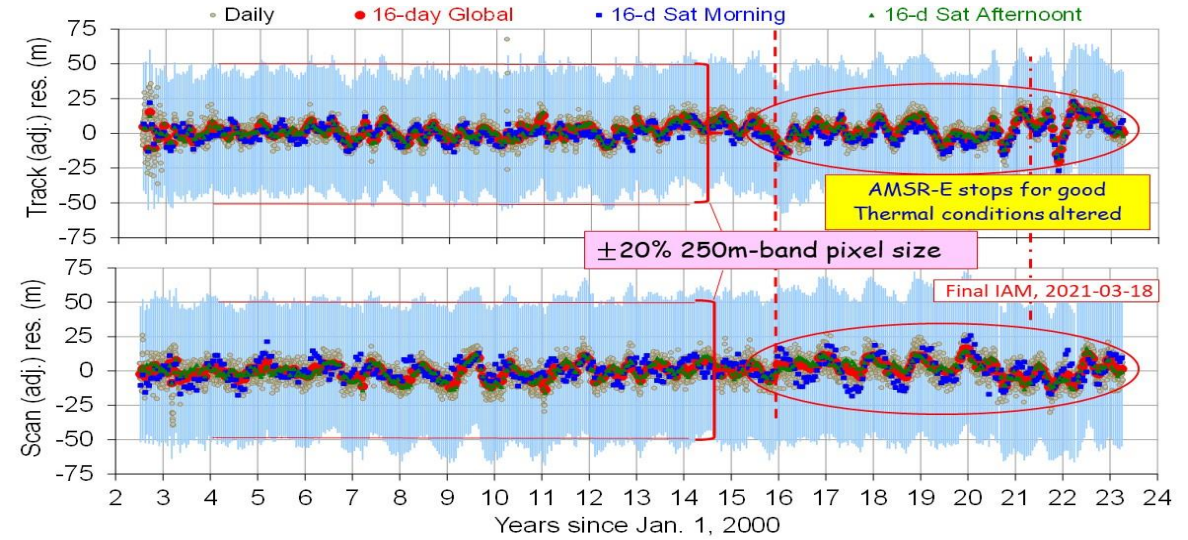
N-21 results are based on the average from the first two lunar observations

MODIS and VIIRS Geolocation

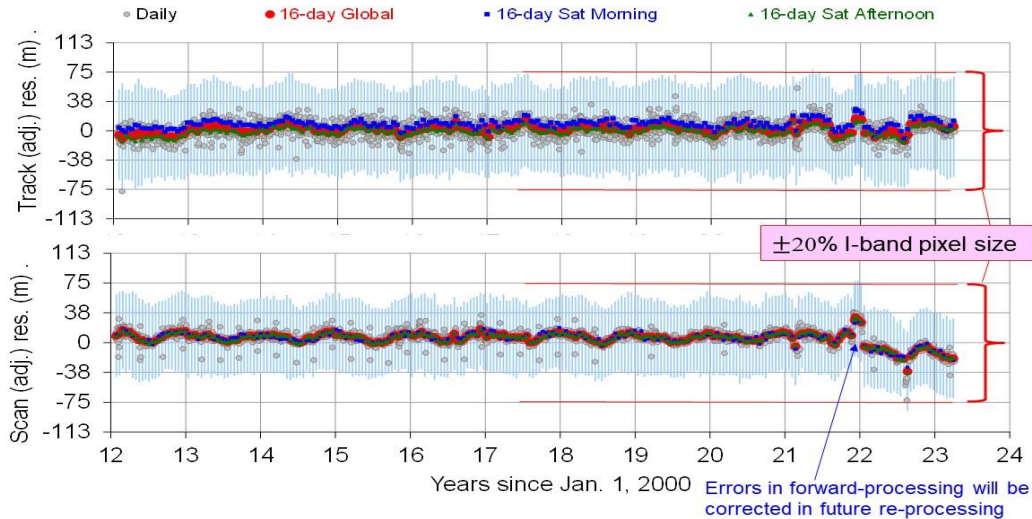
Track: 43 m; Scan: 45 m (Terra C6.1)



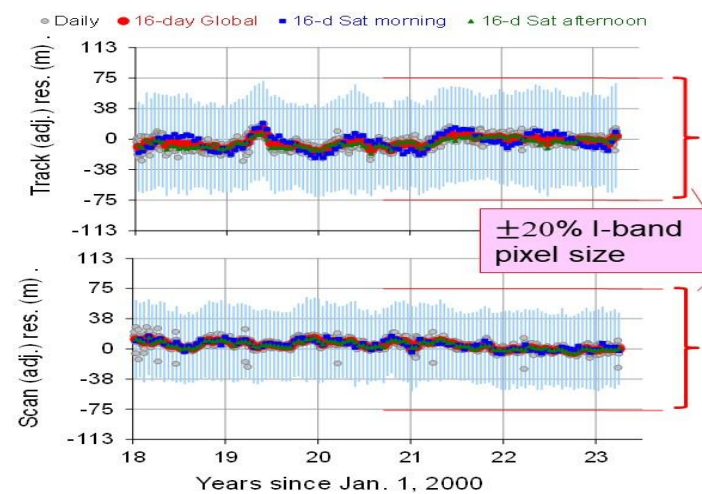
Track: 46 m; Scan: 54 m (Aqua C6.1)



Track: 59 m; Scan: 48 m (S-NPP C2)



Track: 57 m; Scan: 47 m (N-20 C2.1)



Track: 61 m; Scan: 48 m (N-21 C2)

