

# Status of MODIS and VIIRS Instruments and L1B Products

Jack Xiong<sup>1</sup>, Amit Angal<sup>2</sup>, Vincent Chiang<sup>2</sup>, and Xu Geng<sup>2</sup>

1. Code 618.0, NASA Goddard Space Flight Center, Greenbelt, MD 20771

2. Science Systems and Applications, Inc., Lanham, MD 20706, USA

*with contributions from*

MODIS and VIIRS Characterization Support Team (MCST and VCST), NASA GSFC

# Outline

- **MODIS and VIIRS On-orbit Calibration**
- **Instrument Performance**
- **Level 1B (L1B) Status**
- **Summary**

# MODIS and VIIRS On-orbit Calibration

- **MODIS and VIIRS Instruments**

- Terra: launched on 12/18/1999
- Aqua: launched on 05/04/2002
- S-NPP: launched on 10/28/2011
- NOAA-20: launched on 11/18/2017
- NOAA-21: launched on 11/10/2022
- JPSS-3: ready for spacecraft-level TVAC testing, launch in 2033 (NOAA-23)
- JPSS-4: completed all sensor-level testing; launch in 2028 (NOAA-22)

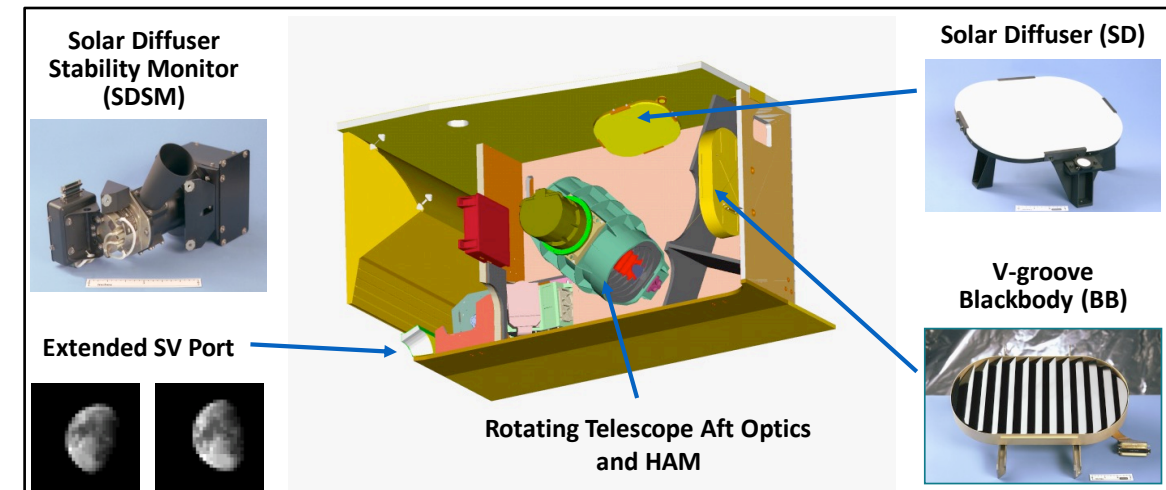
- **On-orbit Calibration**

- Reflective solar bands (RSB): solar diffuser (SD) and SD stability monitor (SDSM), Moon, select EV targets (MODIS)
- Thermal emissive bands (TEB): blackbody (BB)

## VIIRS: a follow-on instrument to MODIS



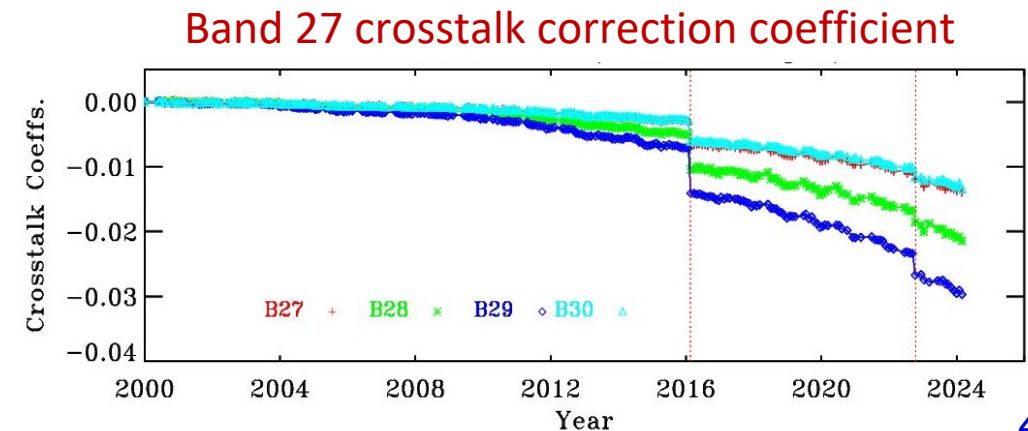
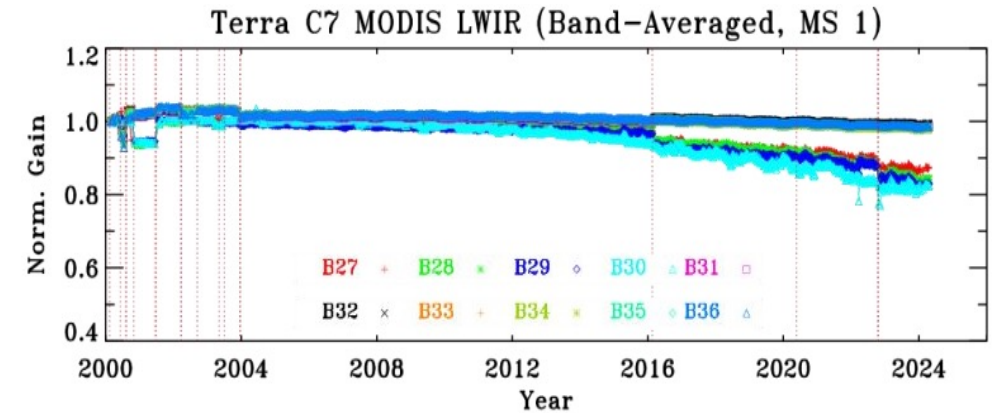
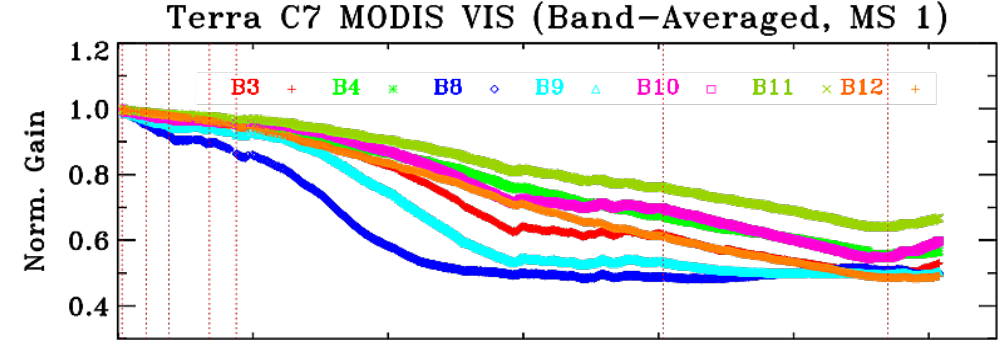
## Similar Calibration Methodologies



MODIS: Spectroradiometric Calibration Assembly (SRCA); VIIRS: Day and Night Band (DNB)

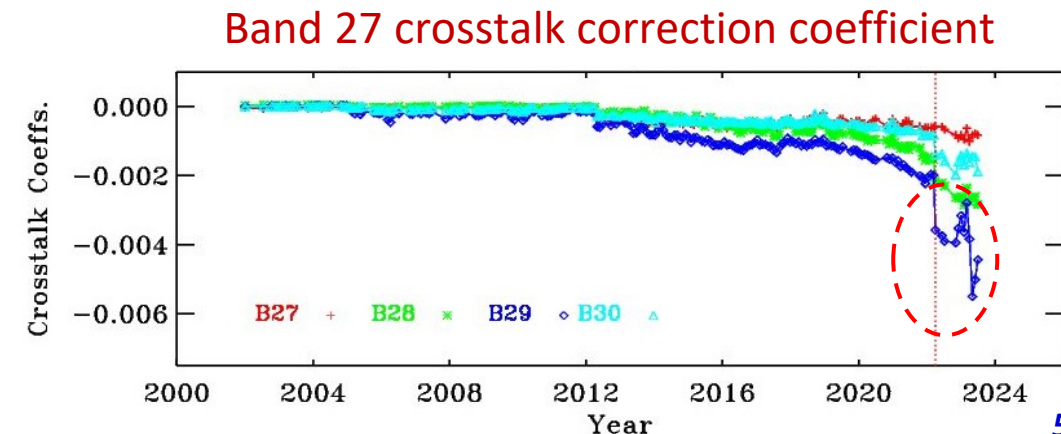
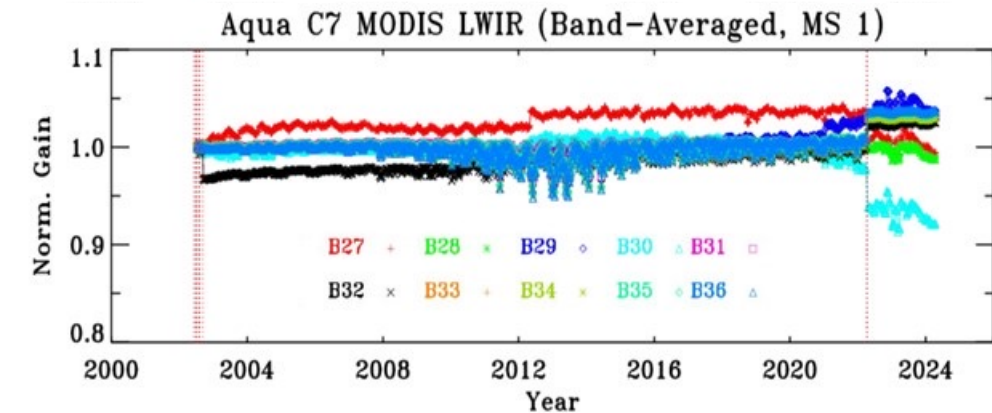
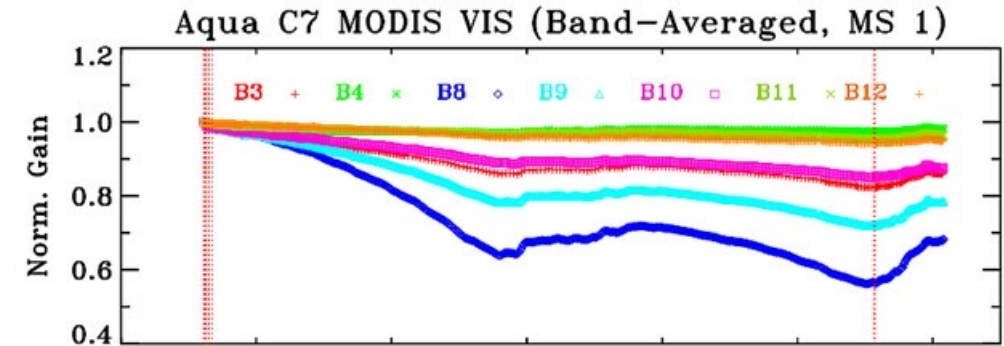
# Instrument Performance: Terra MODIS

- **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)
  - SD door in open position since 2002
- **Radiometric**
  - Large changes in sensor response and RVS at short wavelengths (VIS/NIR bands)
  - Large SD degradation at short wavelengths
  - Changes in sensor performance parameters, especially TEB crosstalk due to instrument safe modes
  - LWIR PV crosstalk correction (implemented since C6.1) remains effective
- **Spatial and Spectral**
  - Band-to-band registration (BBR): stable since launch
  - Center wavelength and bandwidth: changes are within 0.5 nm and 1.0 nm, respectively, for most VIS/NIR bands



# Instrument Performance: Aqua MODIS

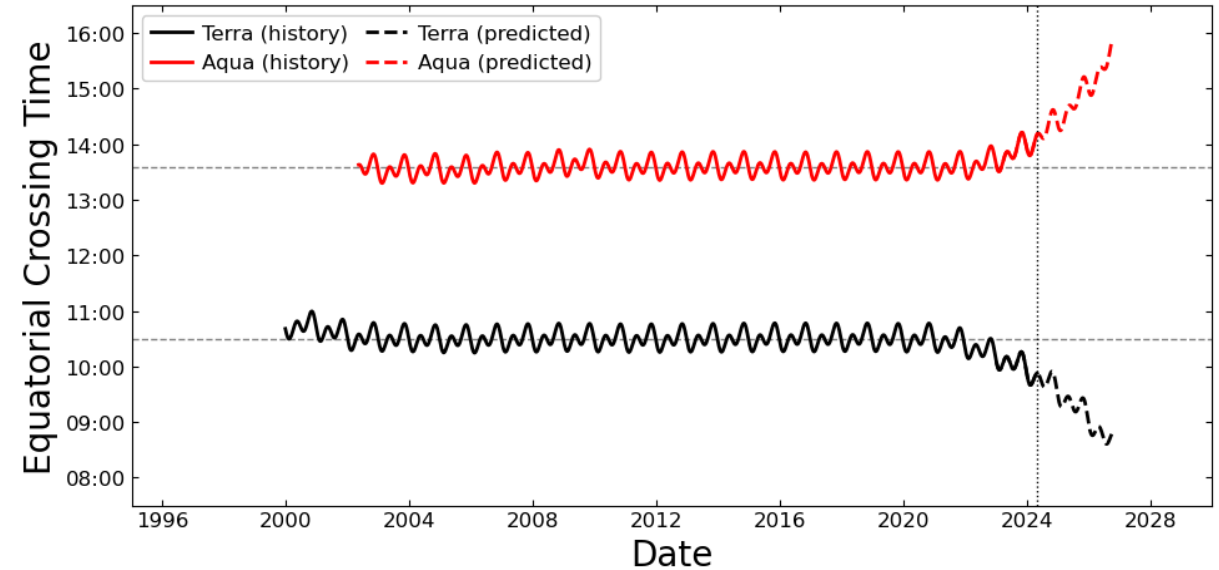
- **Instrument Operations and OBC Functions – Normal**
  - Same B-side configuration since launch
  - CFPA at 83 K; BB at 285 K
- **Radiometric**
  - Large changes in sensor response and RVS at short wavelengths (VIS/NIR bands)
  - Large SD degradation at short wavelengths
  - Changes in sensor performance parameters, especially TEB crosstalk due to instrument safe modes
  - LWIR PV crosstalk correction in C7 and in C6.1 forward processing to address more recent and large increase of the crosstalk effects
- **Spatial and Spectral**
  - Band-to-band registration (BBR): stable since launch
  - Center wavelength and bandwidth: changes are within 0.5 nm and 1.0 nm, respectively, for most VIS/NIR bands



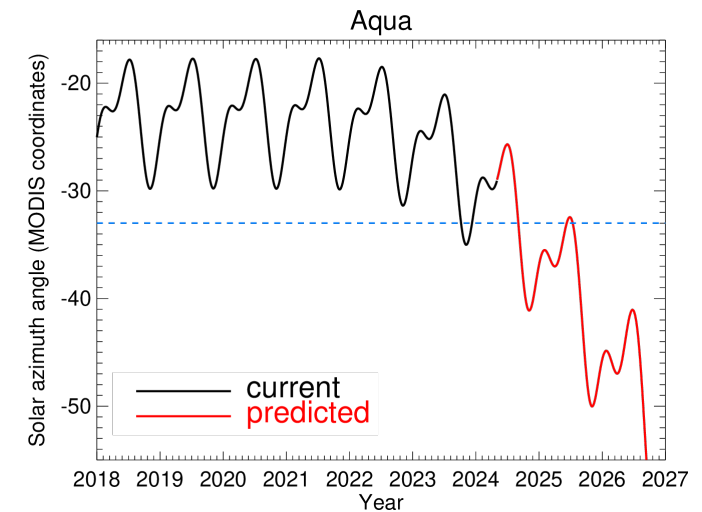
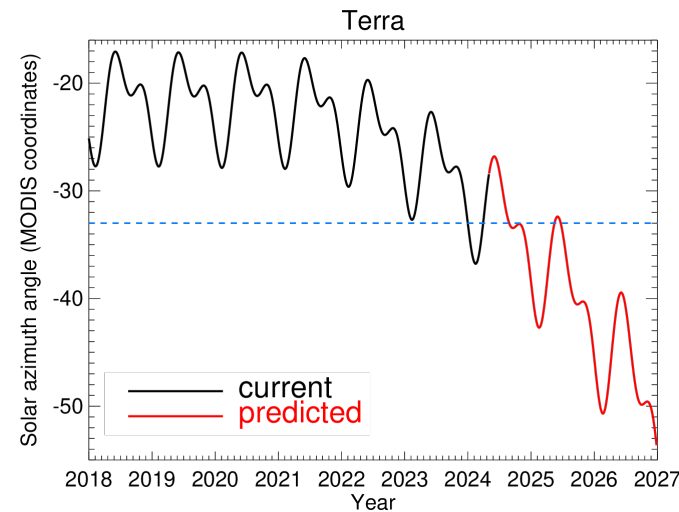


# Terra and Aqua Drifting Orbits and Calibration Impact

- **Terra**
  - Feb 2020: end of regular IAMs
  - Oct 2022: constellation exit maneuvers (CEM), end of regular DMUs, and start of free orbit drift
- **Aqua**
  - Mar 2021: end of regular IAMs
  - Dec 2021: end of regular DMUs and start of free orbit drift
- **Calibration Impact – RSB**
  - Range of SD (SDSM) screen transmission
  - Lunar phase angles
  - 16-day repeat observations



Year	Terra	Aqua
2023	[49, 50]	[-51, -50]
2024	[44, 45]	[-45, -44]
2025	[38, 39]	[-45, -44]
2026	[30, 31]	[-32, -31]



[lunar phase angles range]

# Instrument Performance: S-NPP VIIRS

- **Instrument Operations and OBC Functions – Normal**

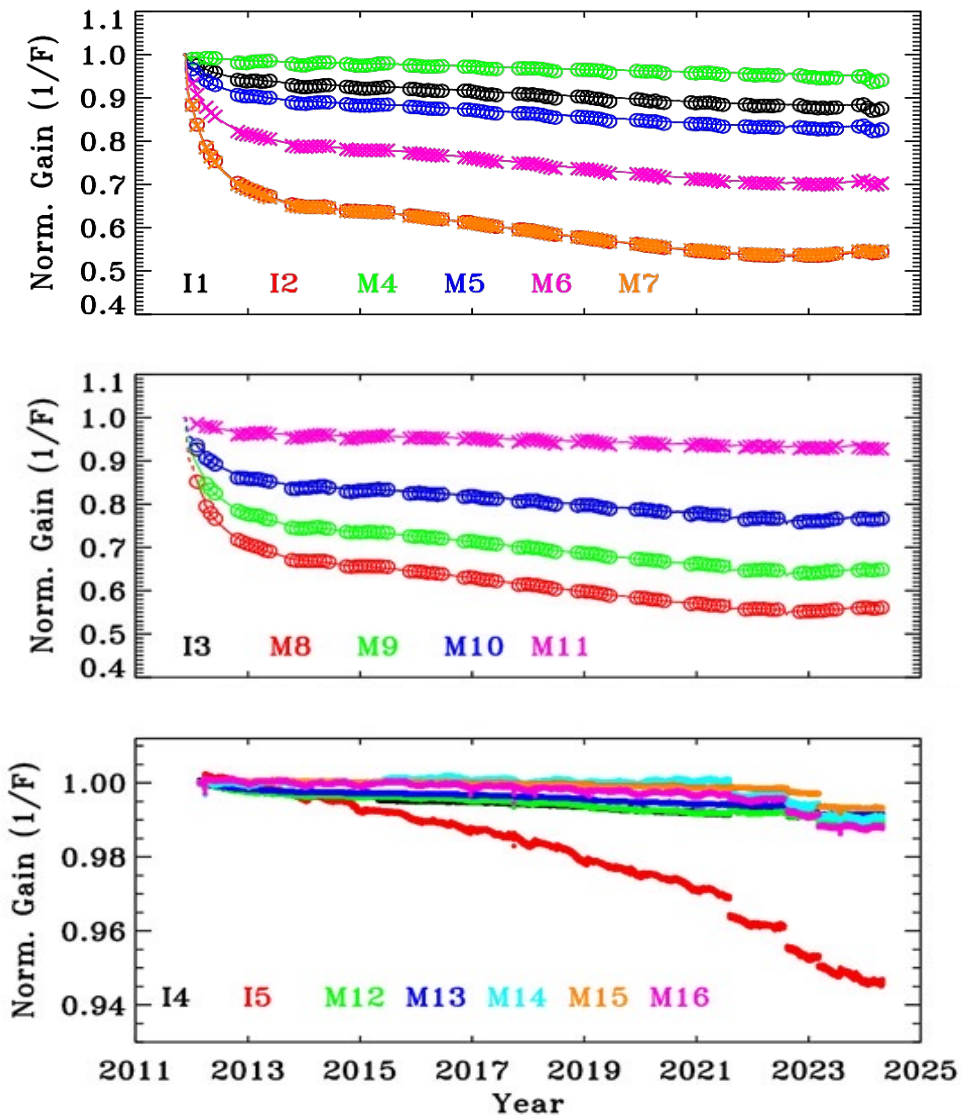
- B-side configuration since launch
- CFPA at 80 K; BB at 292.5 K

- **Radiometric**

- Large degradation in several NIR and SWIR bands, especially at mission beginning (due to RTA mirror coating contamination)
- Large SD degradation at short wavelengths
- A gradual gain decrease for I5 (5.5 % over 12 years)
- DNB stray light correction remains effective

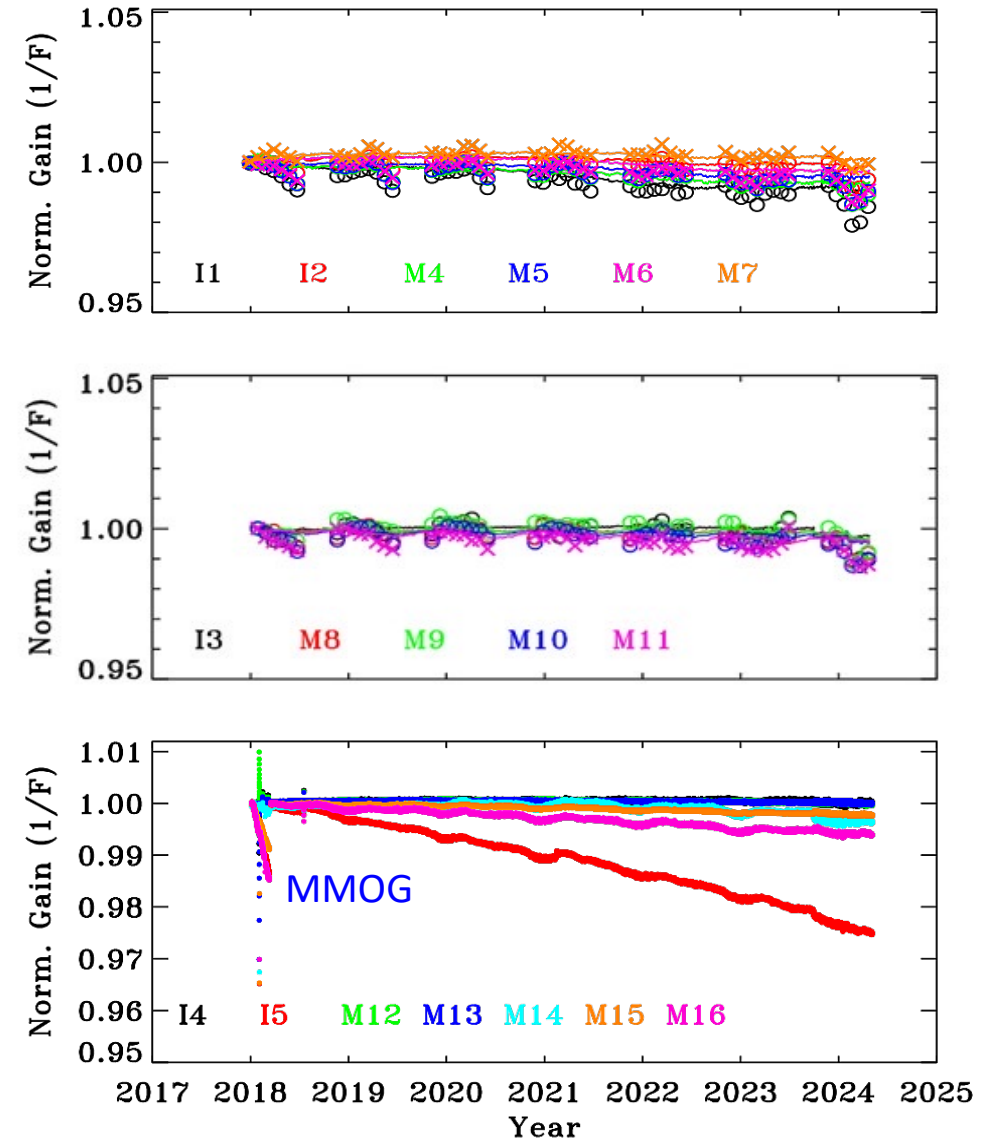
- **Spatial and Spectral**

- Band-to-band registration (BBR): stable since launch
- Relative spectral response (RSR): on-orbit modulated RSR for RSB (and DNB)



# Instrument Performance: N-20 VIIRS

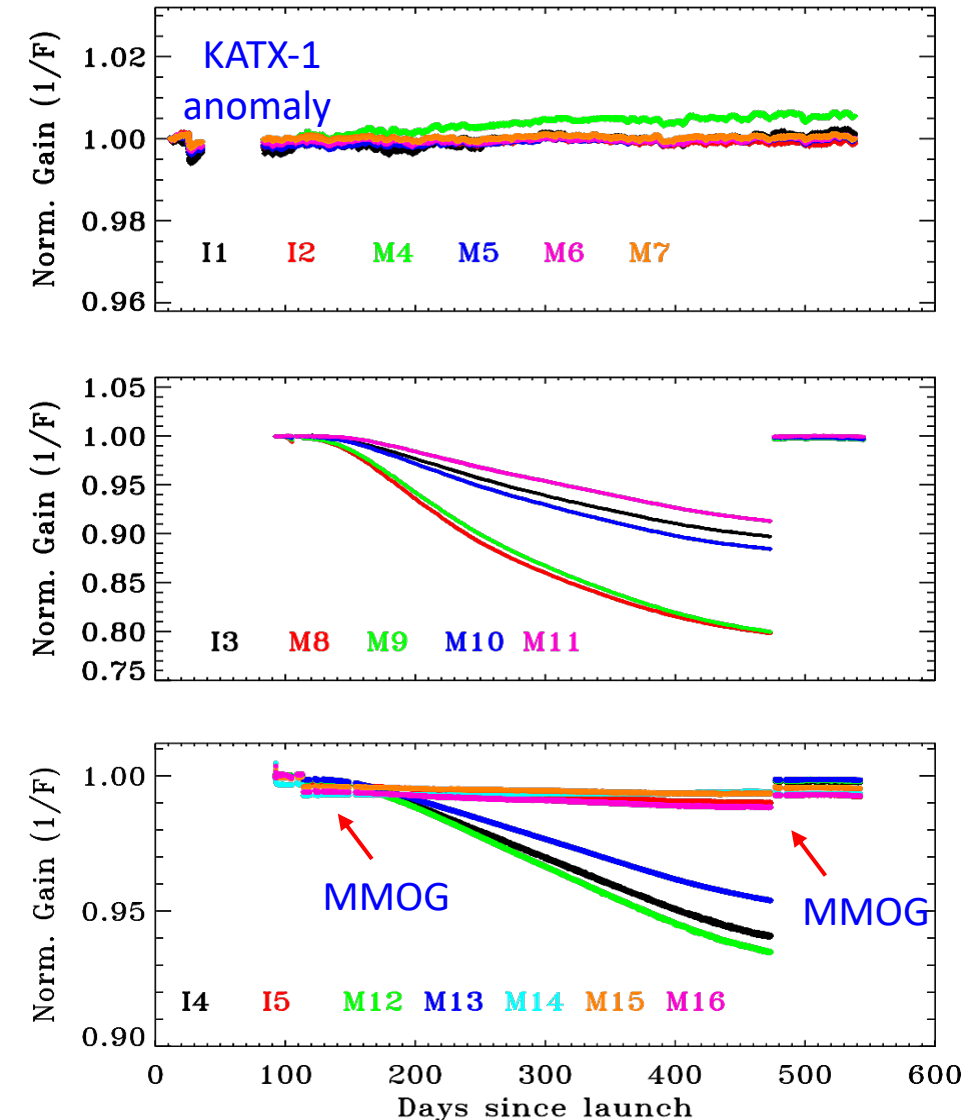
- **Instrument Operations and OBC Functions – Normal**
  - A-side configuration since launch
  - CFPA at 80 K; BB at 292.5 K
  - 1 MMOG (mid-mission outgassing)
- **Radiometric**
  - RSB responses (detector gains) have been extremely stable over the entire mission
  - Large SD degradation at short wavelengths
  - Most TEB gains have remained stable since an early MMOG
  - A gradual gain decrease for I5 (2.6 % over 6 years) - similar to S-NPP
  - DNB stray light (< S-NPP) correction remains effective
- **Spatial and Spectral**
  - Band-to-band registration (BBR): stable since launch
  - Relative spectral response (RSR): pre-launch characterization





# Instrument Performance: N-21 VIIRS

- **Instrument Operations and OBC Functions – Normal**
  - A-side configuration since launch
  - CFPA at 80 K (82 K prior to 03/03/2023); BB at 292.5 K
  - 2 MMOG (mid-mission outgassing)
- **Radiometric**
  - Stable responses (detector gains) for most spectral bands (VIS/NIR/LWIR) under the same operating condition
  - The SWIR and MWIR gains returned to at-launch levels and remained stable after the 2<sup>nd</sup> MMOG (Feb 2024)
  - Large SD degradation at short wavelengths
  - DNB stray light (< N-20 < S-NPP) correction also applied
- **Spatial and Spectral**
  - Band-to-band registration (BBR): stable since launch
  - Relative spectral response (RSR): pre-launch characterization



# S-NPP, N-20, and N-21 Orbit Configuration

- **NOAA-20 Re-phasing (RPH) Campaign Successfully Completed: March 20, 2024 - April 4, 2024**
  - To maintain  $\frac{1}{2}$  orbit (50 minutes) separation between JPSS primary (N-21) and secondary (N-20) satellites.
  - No observable changes in the VIIRS performance - some data during the maneuver unavailable due to low geolocation accuracy



# MODIS L1B Status

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- Versions in operation
  - Collection 6.1: Terra V6.2.2; Aqua V6.2.3
  - No changes to C6.1 L1B code or processing in the past year
  - Special support to NASA OBPG with regular LUT updates
- C7 L1B code/LUT are undergoing science testing
  - 1<sup>st</sup> set of code/LUT delivered in March 2021 with subsequent improvements/changes made to address a few issues caused by recent instrument safe hold events
  - C7 L1B reprocess is expected to start in summer 2024 – January 2025
- Completed merging of most C7 RSB calibration algorithm changes into C6.1 forward production
  - Phase-in period: Aqua – March 2023 to May 2023; Terra – March 2023 to March 2024

# MODIS C7 Reprocessing Plan (Tentative)

- C7 MODIS L1B (Aug 2024 – Jan 2025)
  - MODIS L1B algorithm changes and LUT delivered by MCST but there are still few outstanding issues like:
    - Terra band 30 trend
    - Aqua Band 29 crosstalk correction factor scaling
  - C7 L1 PGEs and downstream select set of C61 L2 atmosphere and land PGEs integrated for test production
  - Science test and verification of calibration changes by land and atmosphere science teams is in progress
  - Geolocation change delivery in June 2024
- C7 Atmosphere reprocessing (early 2025 – Fall 2025)
  - Algorithm change delivery and integration in progress
- C7 Land reprocessing (early 2025 – Fall 2026) .
  - Currently in planning

# VIIRS L1B Status

- S-NPP L1B C2 is ongoing at Land SIPS – LSIPS Archive Set 5200 using L1B software V3.1.
- S-NPP L1B C1 is ongoing at Land SIPS for Level-2 downstream process – LSIPS Archive Set 5000 (using SDR Mx software and LUT) and 5110 (using L1B software V2.0).
- NOAA-20 (JPSS-1) C2.1 is ongoing – LSIPS Archive SET 5201 using L1B software V3.1.
- NOAA-21 (JPSS-2) L1B is ongoing – LSIPS Archive SET 5200 using L1B software V3.2 and VCST LUTs.
  - On-orbit L1B LUTs have been delivered to SIPS for ongoing Cal/Val (July 2023), including the first mission consistent LUTs derived using parameters from on-orbit yaw maneuvers
  - Another update for the mission long LUTs with improvements to the RSB and DNB calibrations is in progress (expected May 2024)
    - Improved screen transmission (yaw + regular SD data)
    - Striping reduction for VIS/NIR bands
    - DNB stray light correction, DN0 update, MGS (HGS) RSR
    - Use of TSIS-1 HSRS in RSB and DNB calibration

} **To be applied to S-NPP and N-20 in their future reprocessing**



# Summary

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- Both Terra and Aqua MODIS and their OBC continue to operate and function normally
- Strategies have been developed and implemented to mitigate the calibration impact due to drifting orbits (both Terra and Aqua )
- Extensive efforts made to address recent increase of LWIR PV crosstalk resulting from spacecraft and instrument anomalies and associated impact on L1B data quality and to continue support C7 science testing
- Overall performance of VIIRS is better than MODIS in terms of its calibration stability, with an exception of S-NPP NIR/SWIR at the mission beginning
- N-20 VIIRS has been stable over the entire mission
- N-21 VIIRS performance has also now become stable following the 2<sup>nd</sup> MMOG
- A new update of mission long consistent N-21 VIIRS L1B LUTs is in progress - to be delivered in late May and used for science testing in support of its data reprocessing

# Backup Slides

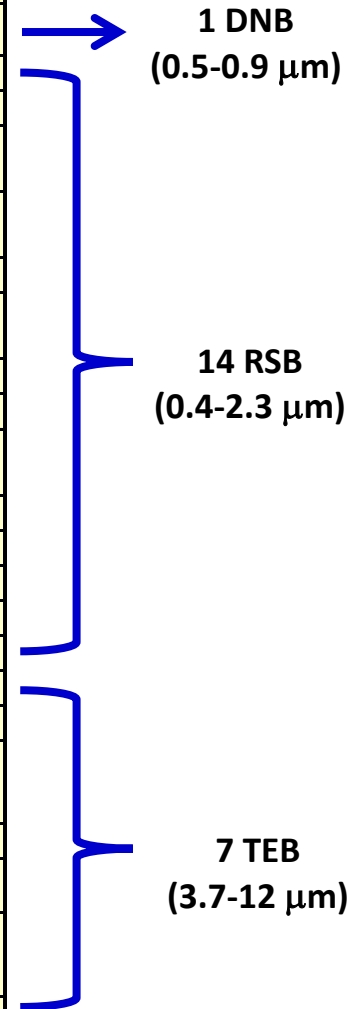
# MODIS and VIIRS On-orbit Calibration

## MODIS and VIIRS Spectral Bands

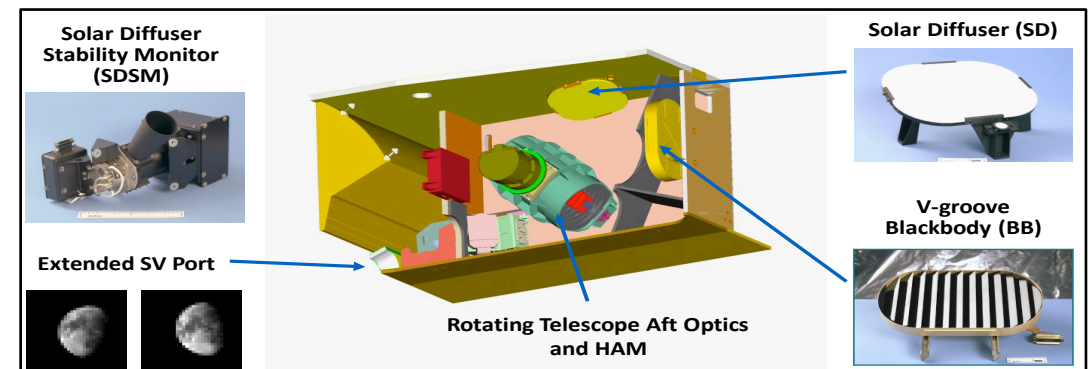
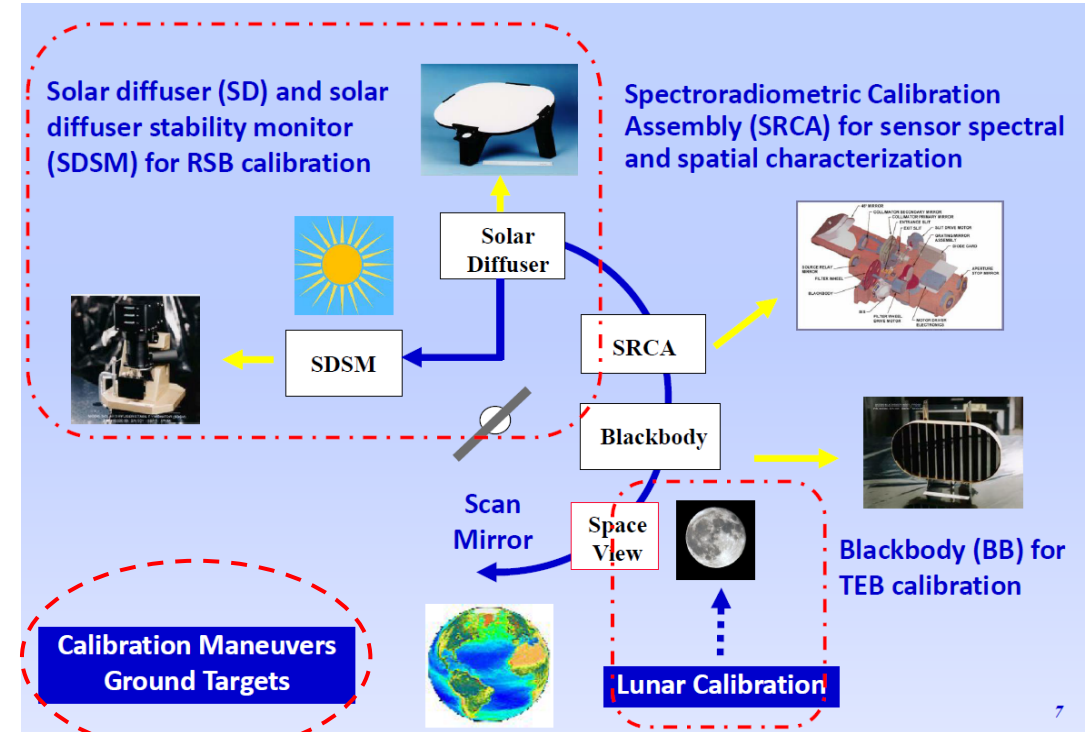
VIIRS Band	Spectral Range (um)	Nadir HSR (m)	MODIS Band(s)	Range	HSR
DNB	0.500 - 0.900				
M1	0.402 - 0.422	750	8	0.405 - 0.420	1000
M2	0.436 - 0.454	750	9	0.438 - 0.448	1000
M3	0.478 - 0.498	750	3 10	0.459 - 0.479 0.483 - 0.493	500 1000
M4	0.545 - 0.565	750	4 or 12	0.545 - 0.565 0.546 - 0.556	500 1000
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



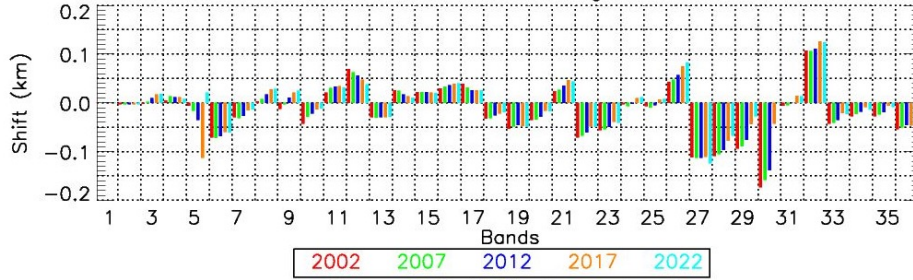
## Similar Calibration Methodologies



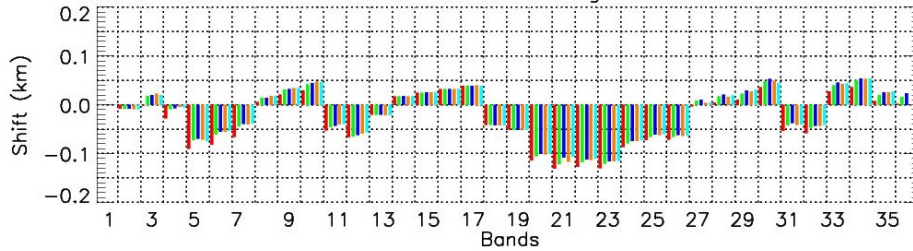
# MODIS Spatial and Spectral Characterization

## Terra MODIS

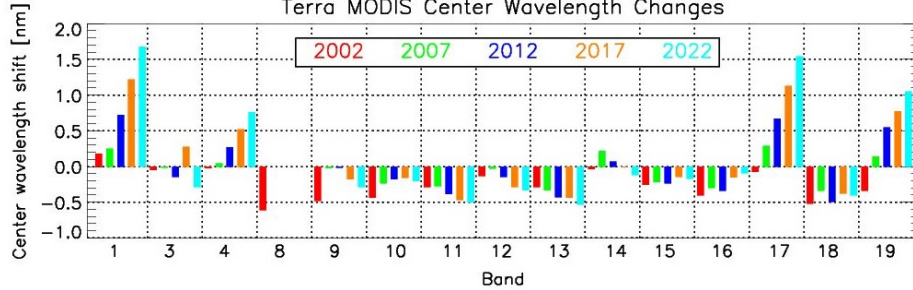
Terra BBR Shift Along-scan



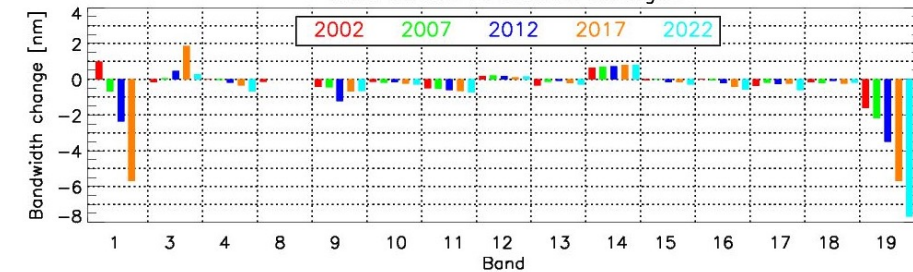
Terra BBR Shift Along-track



Terra MODIS Center Wavelength Changes

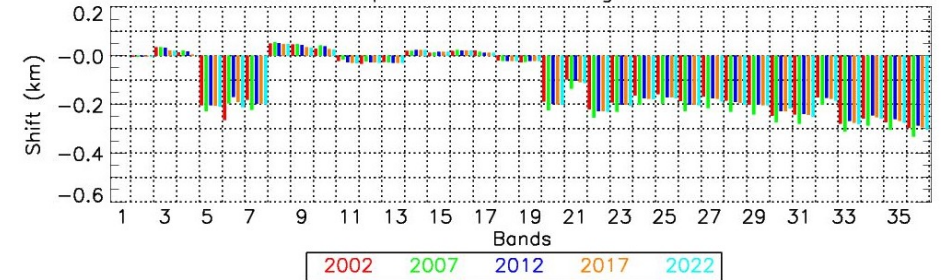


Terra MODIS Bandwidth Changes

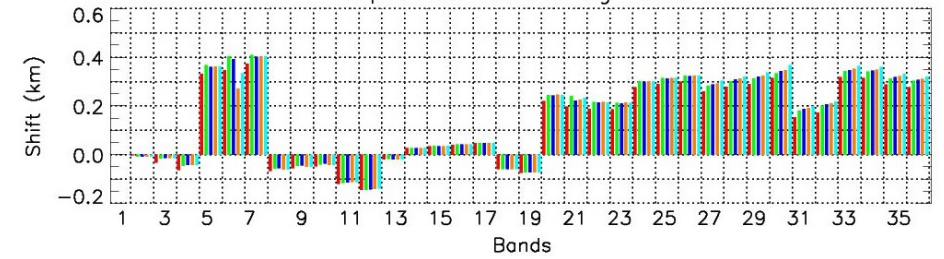


## Aqua MODIS

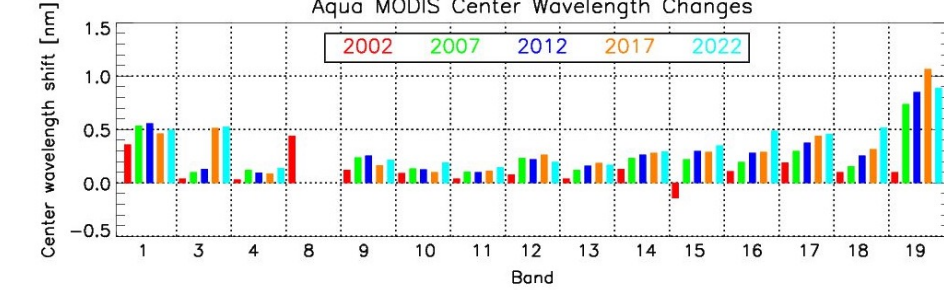
Aqua BBR Shift Along-scan



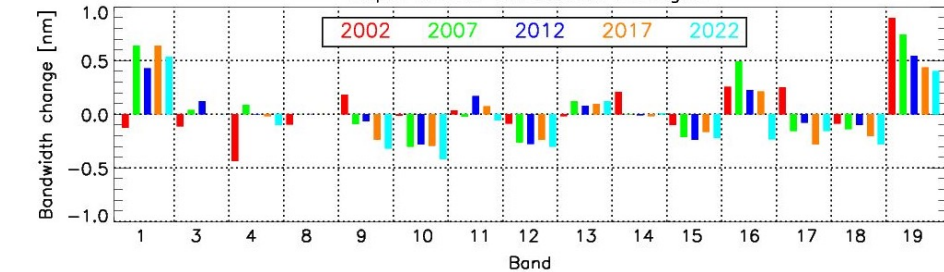
Aqua BBR Shift Along-track



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

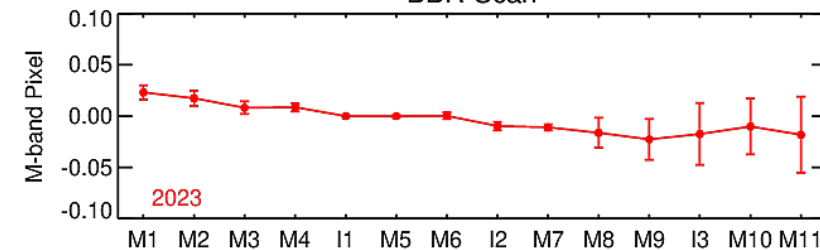
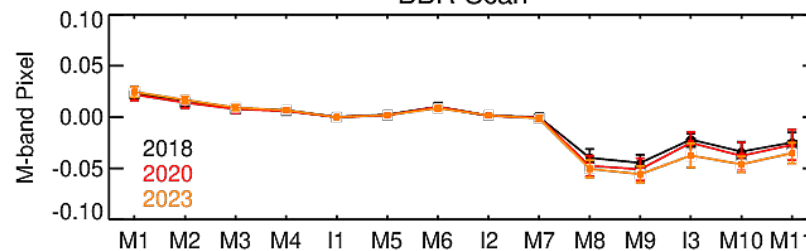
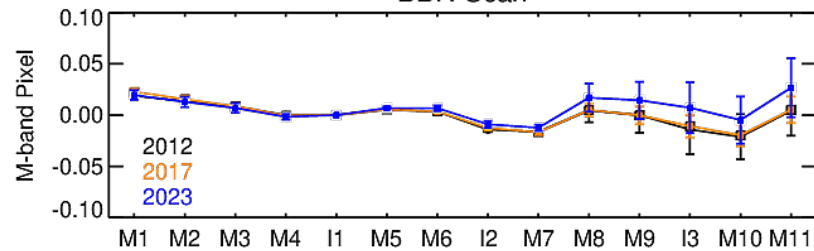
## N-20 VIIRS

## N-21 VIIRS

BBR Scan

BBR Scan

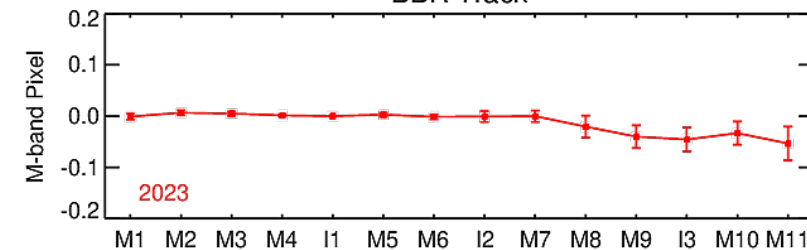
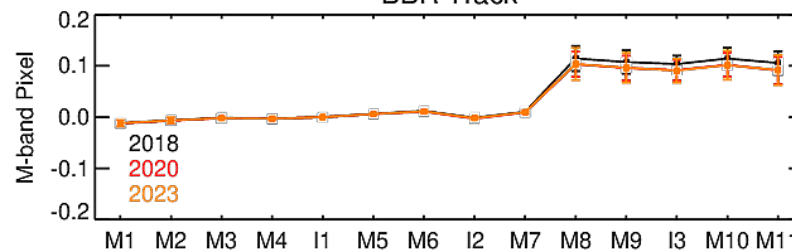
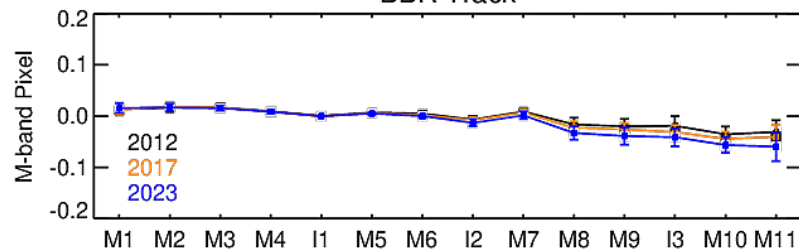
BBR Scan



BBR Track

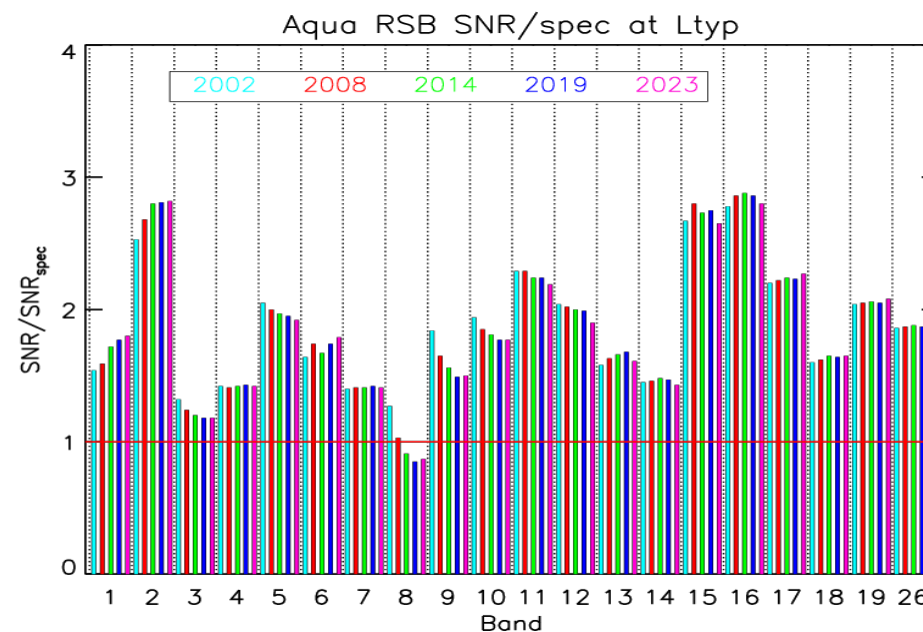
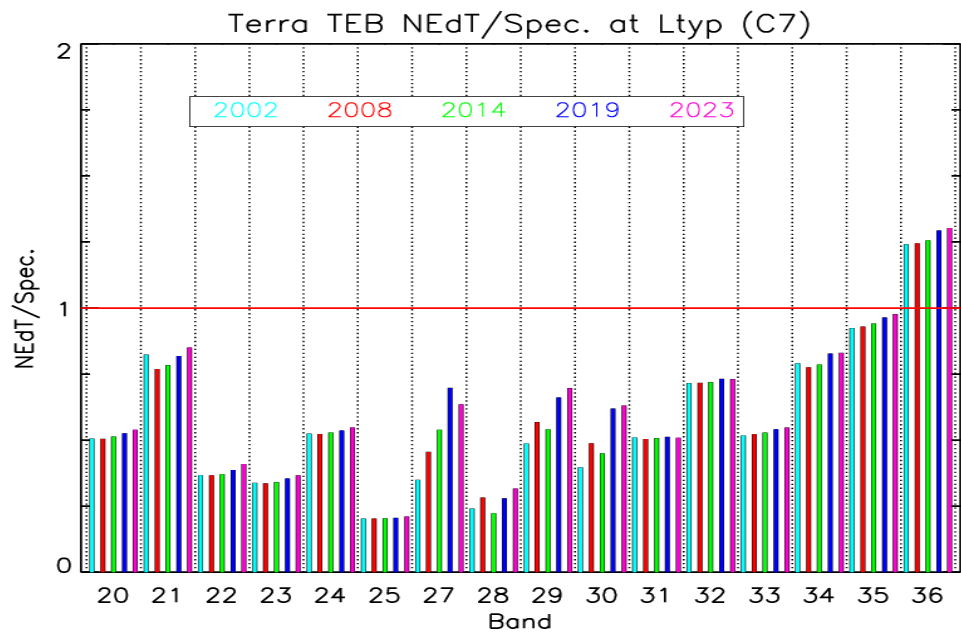
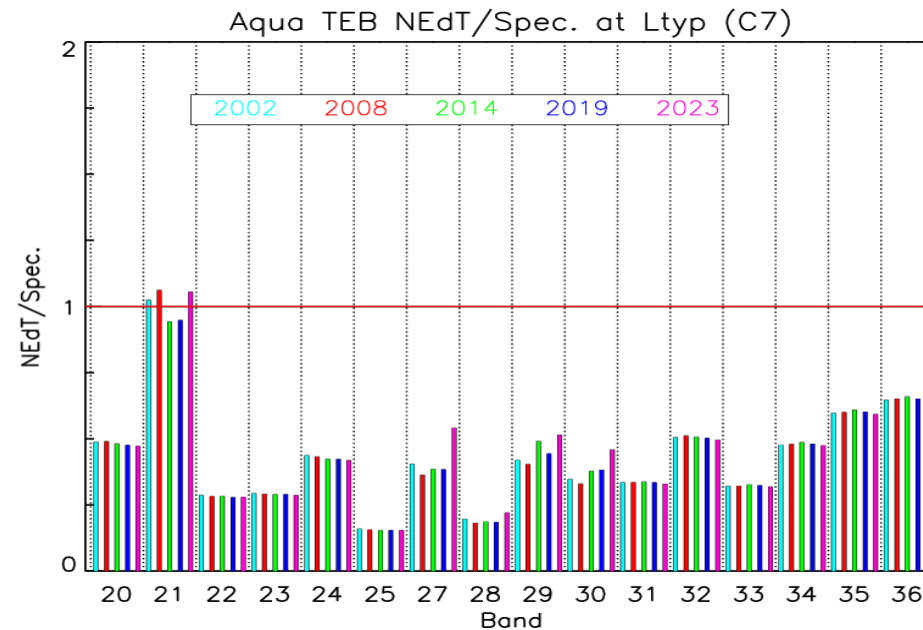
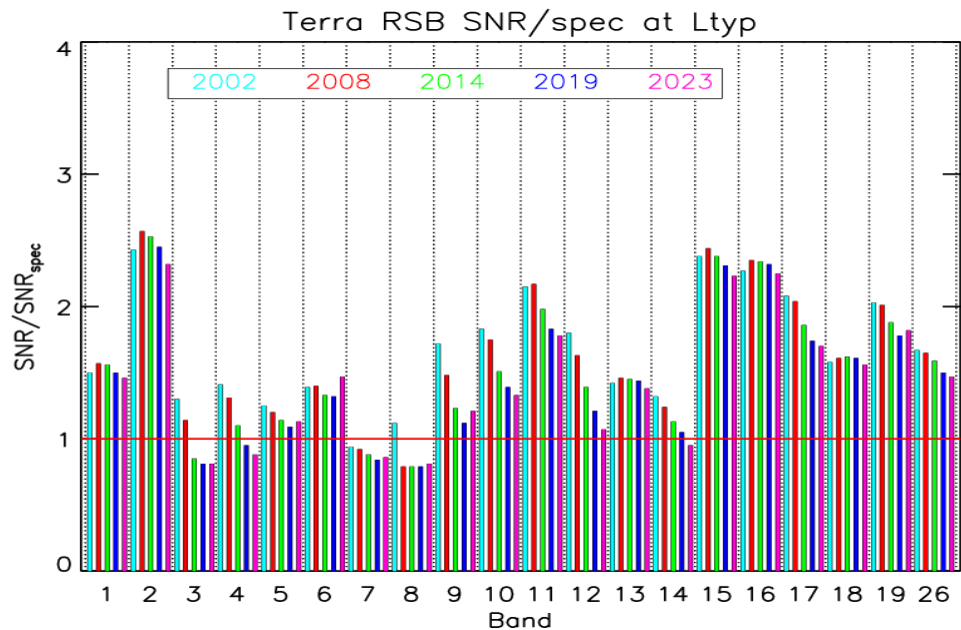
BBR Track

BBR Track





# MODIS SNR NEdT



# VIIRS SNR NEdT

