



MODIS and VIIRS Instrument Operations Status

MODIS and VIIRS Characterization Support Teams,
NASA GSFC
(presented by Sarah Schwenger)



*MODIS/VIIRS Calibration Workshop
(May 01, 2023)*

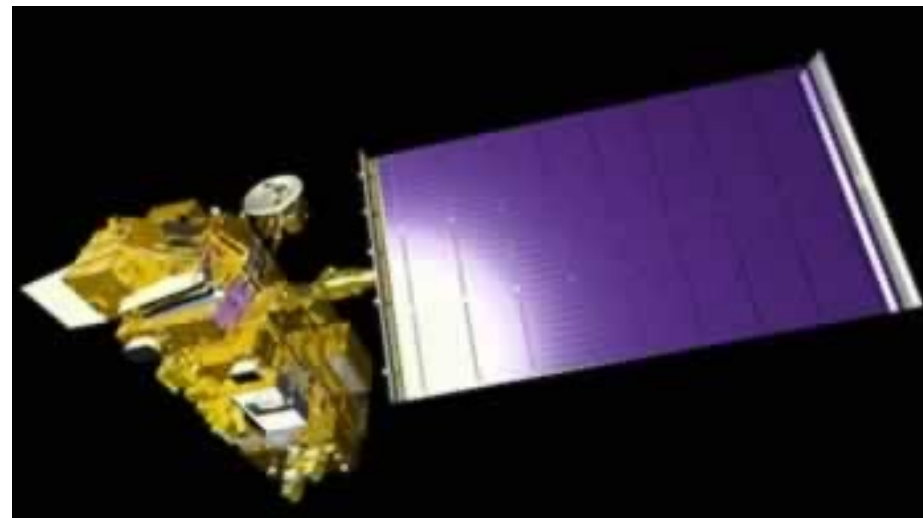




Terra Flight Operations



- Terra Spacecraft Status
 - 23+ years of successful operation. Since the last STM, the MODIS instrument has continued to operate nominally.
 - Solid State Recorder – Full data allocation following successful SSR Reset on September 22, 2021.
 - Orbit Maneuvers: final Drag Make-up July 28, 2022 (2022/209), final Inclination Adjustment February 27, 2020 (2020/058).
 - Constellation Exit Maneuvers October 12, 2022 (2022/285) and October 19, 2022 (2022/292)





MODIS Instrument Operations (Terra)



- **Terra MODIS is healthy and operating nominally**
- **Operational Configuration**
 - A-side: launch to Oct. 30, 2000
 - B-side: Oct. 30, 2000 to June 15, 2001
 - A-side: July 02, 2001 to Sept. 17, 2002
 - A-side electronics and B-side formatter: Sept. 17, 2002 to present
 - Cold FPA (SMIR and LWIR) controlled at 83K
 - SD door fixed to “open” position since July 2003
 - BB temperatures set at 285K since April 25, 2020
- **Events**
 - Terra CP/FP Reset March 15, 2022 sent MODIS to Standby Mode, fully recovered to Science March 16, 2022
 - Terra MODIS in non-standard CEM configuration October 10-21, 2022
- **Special Operations**
 - Preparation for Decommissioning



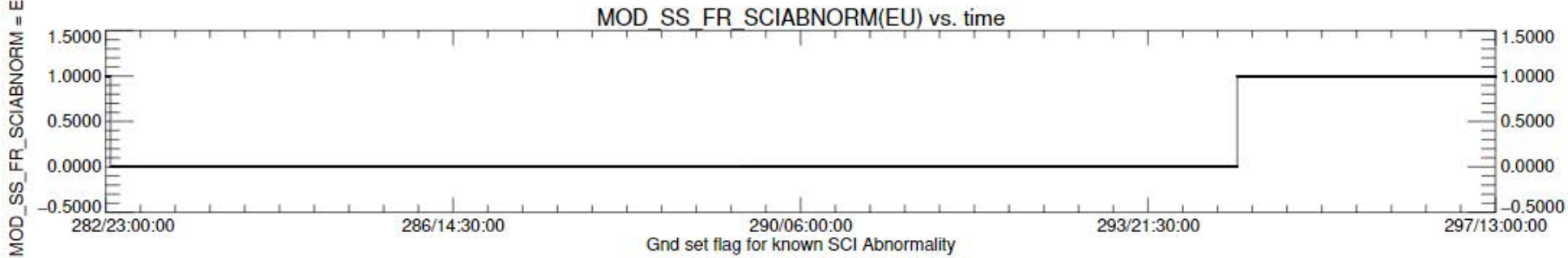
Terra Constellation Exit Maneuvers



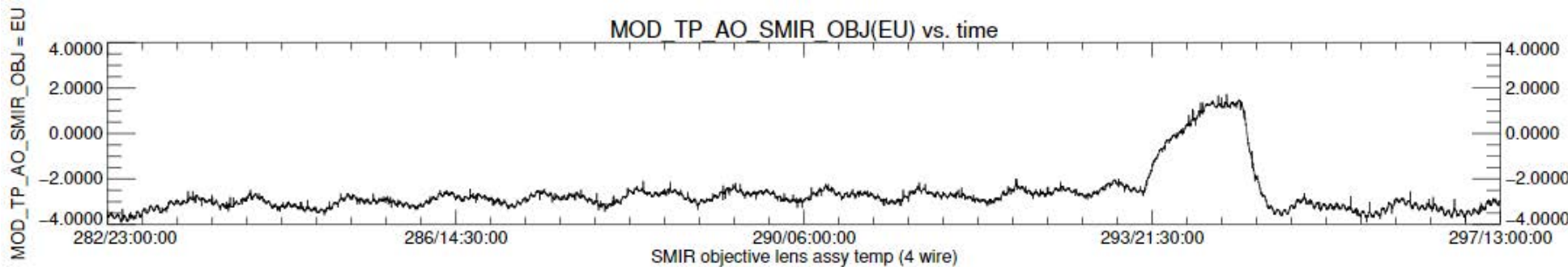
- Terra Constellation Exit Maneuvers were successfully executed on 10/12/22 and 10/19/22.
 - Total altitude lowered by ~5.5 km
- MODIS was transitioned into the following CEM configuration on 10/10/22 (2022/283):
 - Abnormal Science Flag (set via real-time commanding on 10/9/2022)
 - SV and EV doors closed
 - Blackbody off
 - SMIR and LWIR focal planes/heaters off
 - Formatter set to Night Mode
- Following the completion of the CEMs, MODIS recovery began with an Outgas on 10/20/22.
- MODIS was fully transitioned to Science Mode on 10/21/22 (2022/294).
 - Science data outage: 2022/283 03:01:00 – 2022/296 22:30:00
 - To prevent risk to the door motors, the SV and EV doors were opened using revised commanding following signs of door switch degradation.
- Cold focal plane temperatures returned to their set points by 22:30 UTC on 10/23/22.



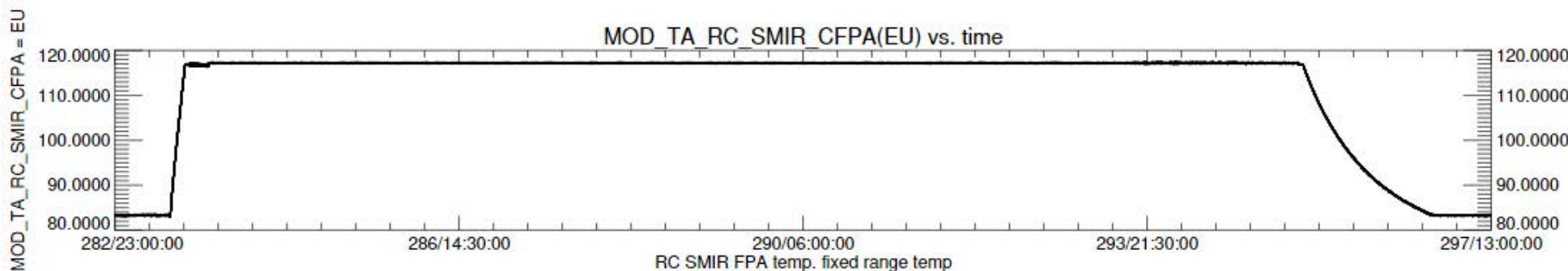
Terra Constellation Exit Maneuvers



← ABNORM flag from 283/00:12:04 to 294/19:59:49 denotes when MODIS in a non-standard configuration



← Instrument temperature during operations. Highest temperatures caused by outgas operations.



← SMIR cold focal plane temperature. Similar to LWIR focal plane temperature.

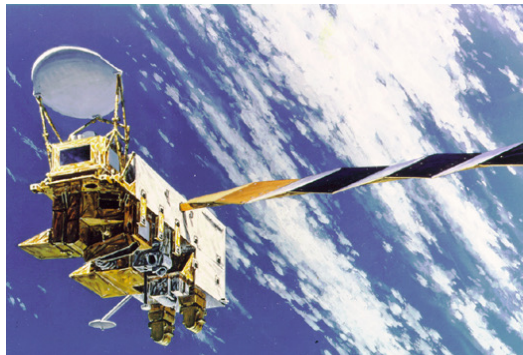
← This telemetry point saturates at 118 K



Aqua Flight Operations



- Aqua Spacecraft Status
 - 21+ years of successful operations. Since the last STM, the MODIS instrument continues to operate nominally.
 - Solid State Recorder – Full data allocation
 - Orbit Maneuvers: final Drag Make-up December 1, 2021 (2021/335), final Inclination Adjustment March 18, 2021 (2021/077).
 - In free drift, orbit no longer maintained
 - Aqua experienced a Formatter-Multiplexer Unit (FMU) anomaly on February 22, 2022 (2022/053). The spacecraft was recovered to nominal operation following an FMU Reset on March 23, 2022 (2022/082)
 - Aqua transitioned to Safe on March 31, 2022, recovery and Power Controller swap was successfully executed on April 13, 2022





MODIS Instrument Operations (Aqua)

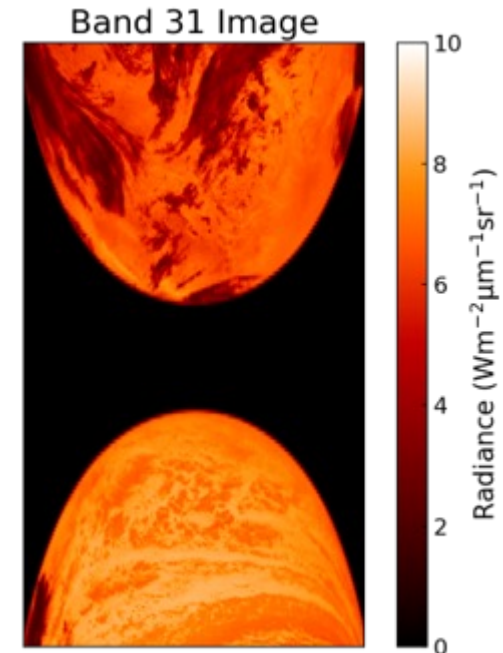
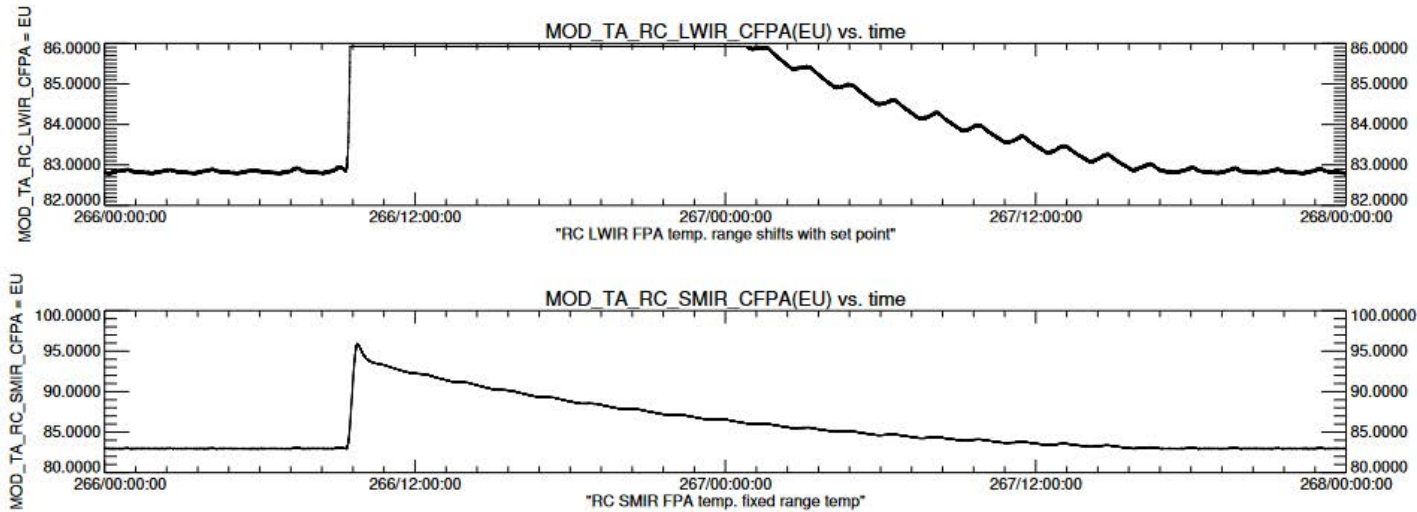


- **Aqua MODIS is healthy and operating nominally**
- **Operational Configuration (No change since last STM)**
 - Same B-side configuration since launch
 - BB temperatures set at 285K
 - Cold FPA (SMIR and LWIR) controlled at 83K - recovered cooler margin post outgas
- **Events**
 - Deep Space Calibration (September 2021)
 - FMU Anomaly Recovery – No impact on MODIS health, in STANDBY during recovery period. A portion of lost MODIS data has been recovered using direct broadcast data.
 - Safe Mode triggered by spacecraft transition to Safe (March 31, 2022 – April 15, 2022)
- **Concerns**
 - Passed projected lifetime limit on SD door movements (July 2012)
- **Special Operations**
 - Preparation for Decommissioning



Aqua Deep Space Calibration

- Aqua FOT prepared and executed a pitch maneuver to allow for deep space calibrations.
- MODIS requested a calibration that includes a view of the Moon at a near-nadir angle.
- The Deep Space Lunar Calibration was executed successfully on September 23, 2021 (2021/266).



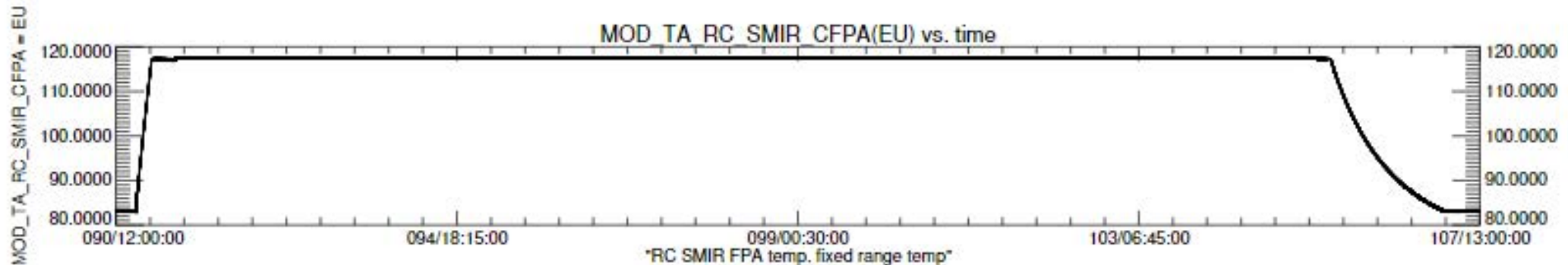
- Pitch slew began 2021/266 09:12:28z and completed 2021/266 09:55:13z.
- Cold focal plane temperatures increased while warm focal plane temperatures decreased as expected during pitch maneuver. All focal planes returned to pre-maneuver temperatures by 2021/267 18:00:00z.



Aqua Safe Mode Event

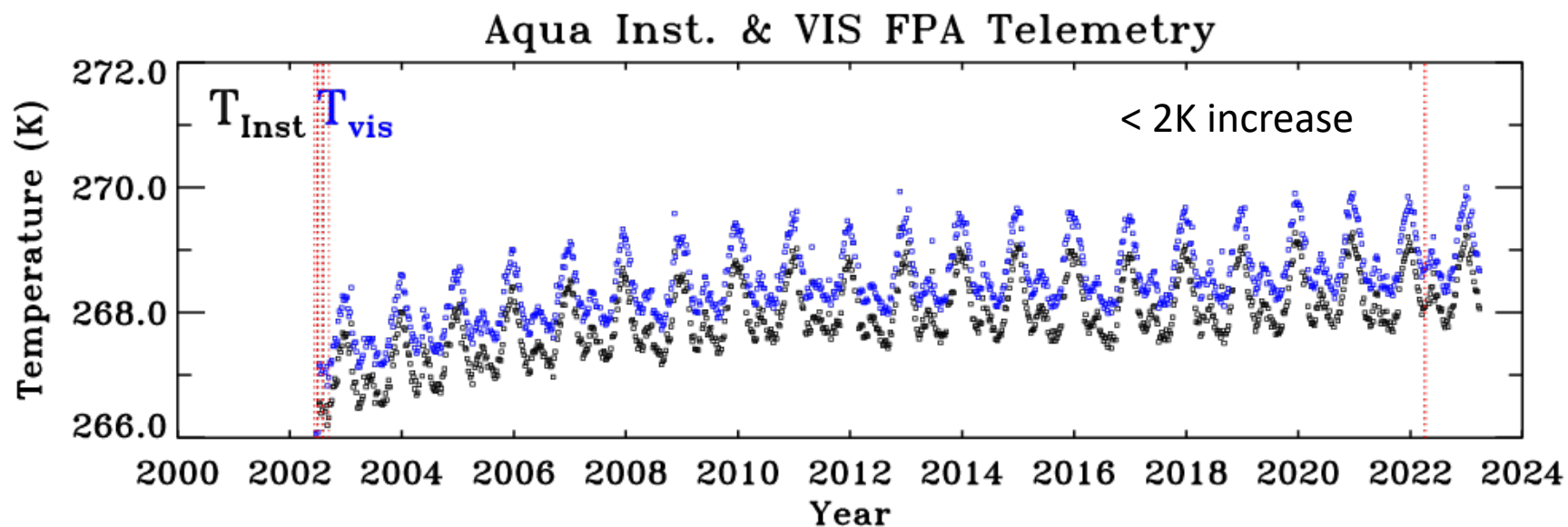
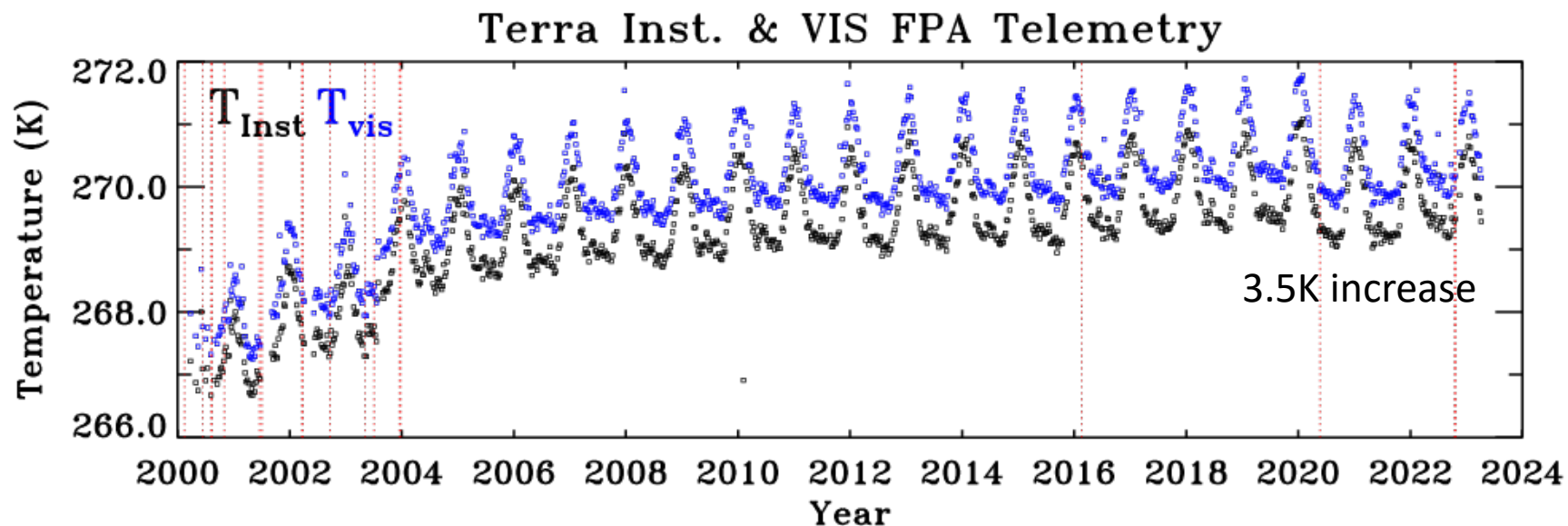


- An Aqua spacecraft anomaly occurred on 2022/090 (March 31, 2022)
 - “Unexpected Power Controller Swap”
- A controller swap results in a spacecraft transition to SAFE, which triggers MODIS to transition to SAFE.
- When in SAFE mode, all MODIS doors are closed, the scan mirror assembly stops, and the blackbody is turned off.
- Following the completion of the spacecraft recovery, MODIS recovery to nominal Science Mode began on 4/13/2022 with an Outgas procedure.
- MODIS was successfully transitioned to Science on 4/15/2022 (2022/105).
- Cold focal plane temperatures returned to their set points by 03:00 UTC on 04/17/2022





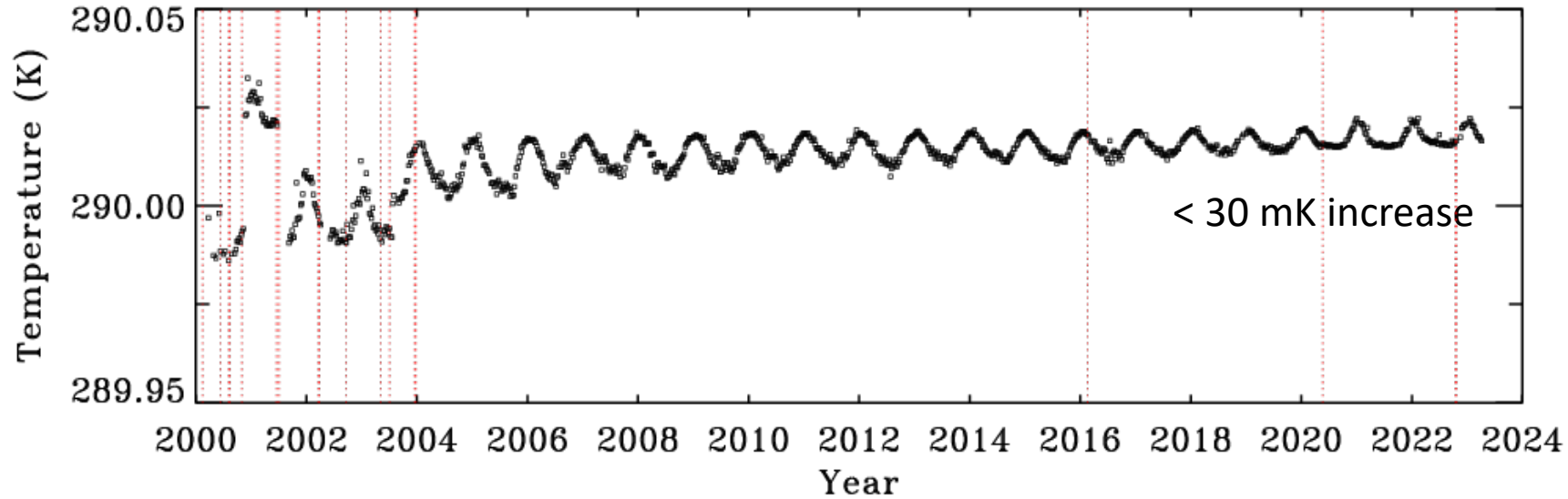
Instrument Temperature Trends





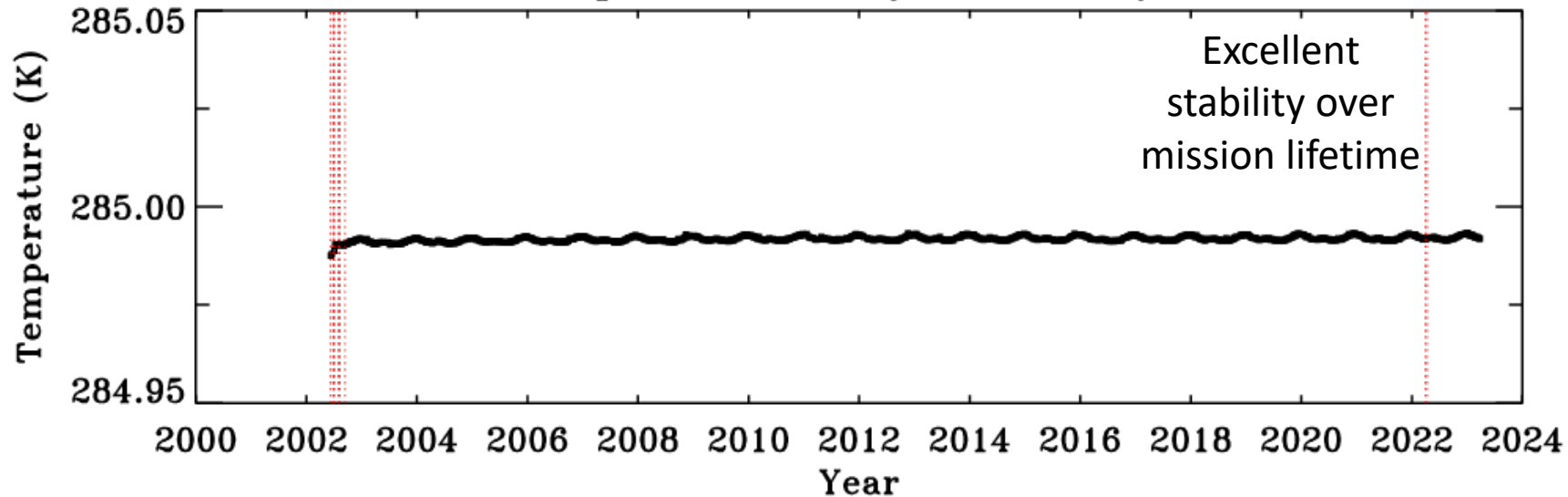
BB Temperature Trends

Terra Blackbody Telemetry



4.96K added to values after April 25, 2020 to match trend after setpoint change from 290K to 285K

Aqua Blackbody Telemetry

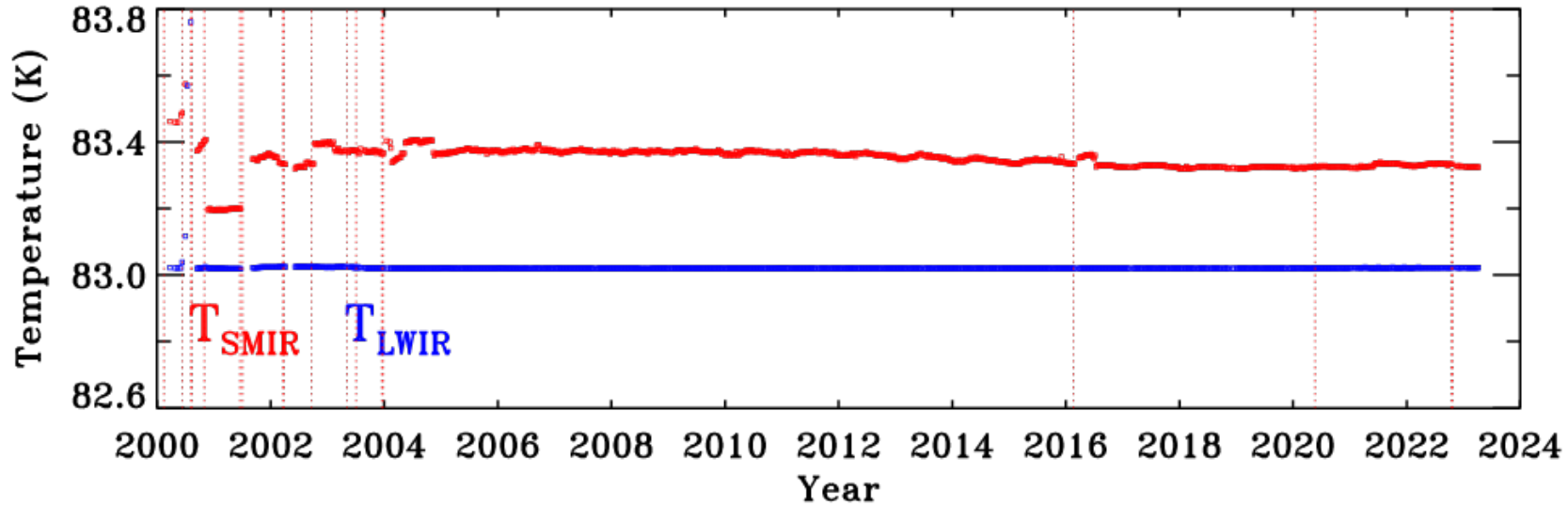




CFPA Temperature Trends

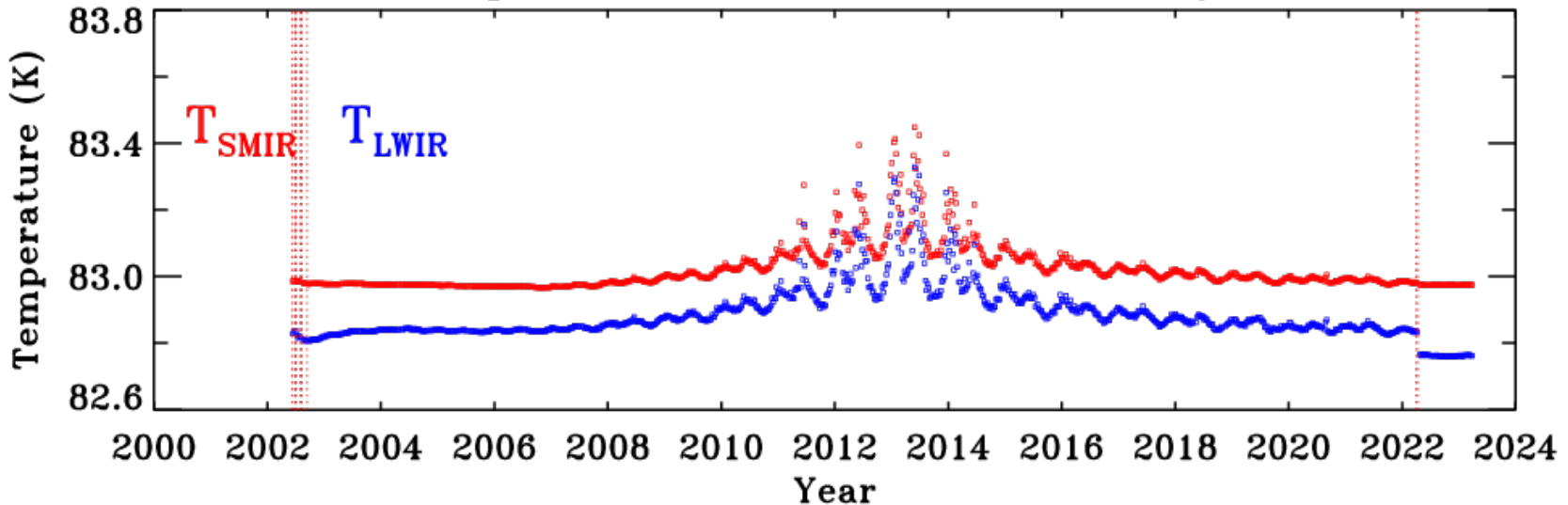


Terra SMIR & LWIR FPA Telemetry



Very stable over lifetime

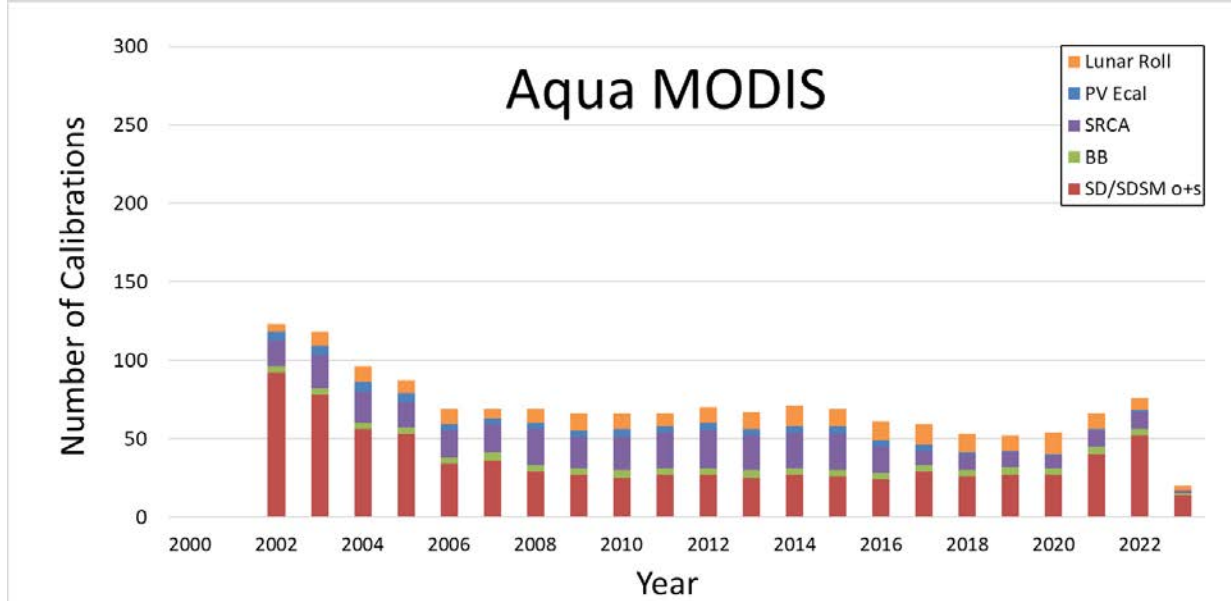
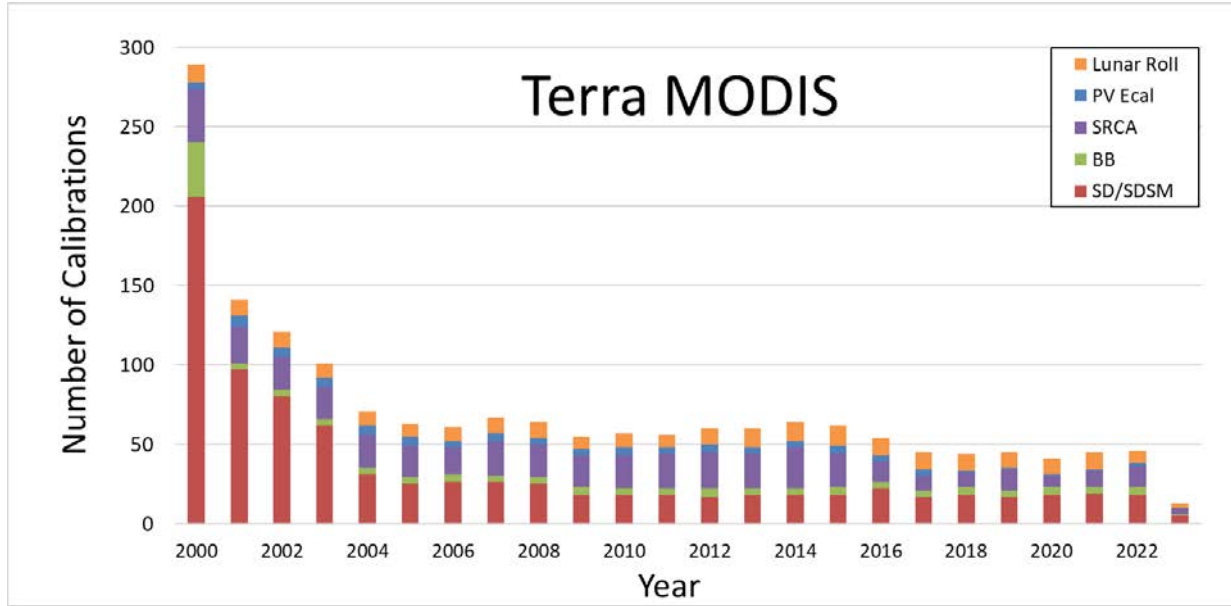
Aqua SMIR & LWIR FPA Telemetry



Improved performance in recent years, especially after the 2022 outgas operation



MODIS Calibration Operations





VIIRS Instrument Operations (SNPP)



- **SNPP VIIRS is healthy and operating nominally**
- **Operational Configuration**
 - B-side: launch to date
 - Cold FPA (SMIR and LWIR) nominally controlled at 80K
 - BB controlled at 292.5 K. Annual warm-up cool down events. 32 since launch, most recent on 3/14/2023
 - SD calibration every orbit. SDSM operated weekly since 5/13/2019
 - Regular lunar roll maneuvers for RSB stability monitoring. 98 Lunar observations since launch, most recent on May 1, 2023
 - Monthly DNB VROP calibrations
- **Events since the last STM (Feb 2021)**
 - 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.
 - VIIRS Single Board Computer (SBC) Lock-up (“Petulant Mode”): 16 since launch, most recent on 6/28/2022. No impact on instrument performance, 2-4 hours to return to science mode (improved design in N20 and N21 VIIRS to prevent lockups)
 - Scan sync loss: 136 since launch, most recent on 9/17/2022



VIIRS Instrument Operations (NOAA-20)



- **NOAA-20 VIIRS is healthy and operating nominally**
- **Operational Configuration**
 - A-side: launch to date
 - Cold FPA (SMIR and LWIR) nominally controlled at 80K
 - BB controlled at 292.5 K. Annual warm-up cool down events. 9 since launch, most recent on 3/28/2023
 - SD calibration every orbit. SDSM operated weekly since 3/4/2019
 - Regular lunar roll maneuvers for RSB stability monitoring. 46 Lunar observations since launch, on the same day as S-NPP.
 - Monthly DNB VROP calibrations
- **Events since the last STM (Feb 2021)**
 - NOAA-20: VIIRS RTA stop due to single upset event for 6 hours on 2/14/2021.
 - Scan sync loss: 136 since launch, most recent on 9/17/2022



VIIRS Instrument Operations (NOAA-21)



- **NOAA-21 VIIRS launched on Nov 10, 2022. VIIRS operating nominally.**
- **Operational Configuration**
 - A-side: launch to date
 - Cold FPA (SMIR and LWIR) controlled at 80K (Operated at 82K from Feb 8 to March 3, 2023)
 - BB controlled at 292.5 K. 2 warm-up cool down events since launch, most recent on 3/12/2023
 - SD calibration every orbit. SDSM operated once per day since February 14, 2023
 - Regular lunar roll maneuvers for RSB stability monitoring. 3 Lunar observations since launch, on the same day as S-NPP and N20 VIIRS.
 - Monthly DNB VROP calibrations
- **Notable events**
 - NOAA-21: S/C primary Ka-Transmitter (KATX-1) anomaly on 12/16/2022 without science data for all instruments onboard via KATX. The secondary transmitter (KATX-2) activation on 2/2/2023 after 48 days of data gap.
 - NOAA-21 early mission TEB gain decrease has recovered after MMOG. However, the RSB SWIR and TEB MWIR gains continue to show degradation
 - Scan sync loss: 5 since launch, most recent on 4/17/2023



IOT Backup Slides



Future Operational Considerations



- Aqua MODIS CFWA temperature control
 - Currently set at 83K
 - Minimal impact on science data
- SRCA Lamps
 - Aqua currently has 1 working 10 W lamp
 - No change in frequency since last STM (decreased in 2017)
- Aqua SD door movements
 - Passed projected lifetime limit on movements
 - No reduction in frequency of SD calibration activities planned

SD Door Movements	PL to 11/2019	11/2019 to present	Total	Design Lifetime	% Used
Terra*	2146	0	2146	3022	71.01
Aqua ⁺	3574	376	3950	3022	130.71

* As of 07/02/2003, SD Door in fixed 'open' position with screen in place

+ Aqua reached designed lifetime of door movement on DOY 2012/191 (July 2012).



Terra/Aqua MODIS OBC Operations



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Activity	PL to 03/2021	03/2021 – present	Total
SD/SDSM#	797	40	837
BB WUCD	120	10	130
SRCA*	480	24	504
Electronic Cal	102	3	105
Lunar Roll	215	18	233

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Activity	PL to 03/2021	03/2021 - present	Total
SD/SDSM#	701	100	801
BB WUCD	81	9	90
SRCA*	361	21	382
Electronic Cal	80	2	82
Lunar Roll	195	18	213

Open & Screened Activities counted independently

* Includes Spatial, Spectral, and Radiometric

11/2019 = last Science Team Meeting



SRCA Calibrations



- Terra – 504 SRCA Calibrations
- Aqua – 382 SRCA Calibrations
- Lamps well within lifetime usage margins
- Aqua Lamp #4 Failure - 2016

Lamp Power		10W				1W	
Lamp #		1	2	3	4	1	2
Terra	Usage (hr)	400.0	172.1	190.3	152.0	596.9	327.0
	Life (hr)	500	500	500	500	4000	4000
	percent	80.0%	Failed on 11-20-2004	Failed on 2-18-2006	30.4%	14.9%	8.2%
Aqua	Usage (hr)	390.2	188.1	205.7	135.0	533.8	320.1
	Life (hr)	500	500	500	500	5000	5000
	percent	78.0%	Failed on 4-14-2003	Failed on 6-28-2005	Failed on 6-30-2016	10.7%	6.4%



Terra CP/FP Reset



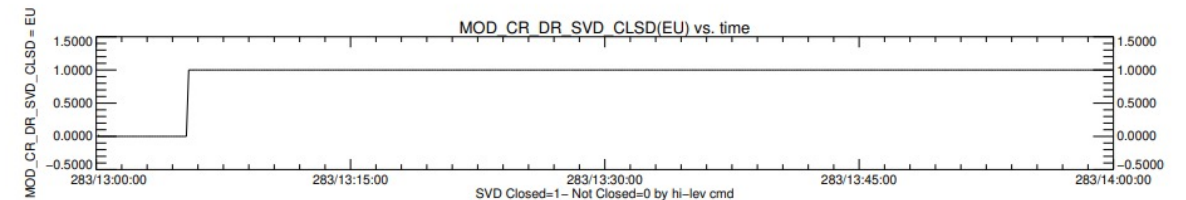
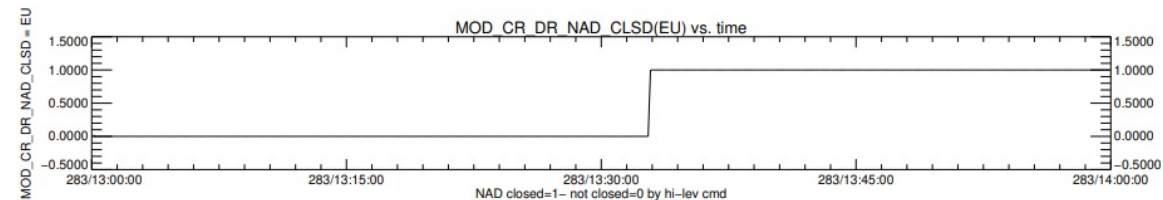
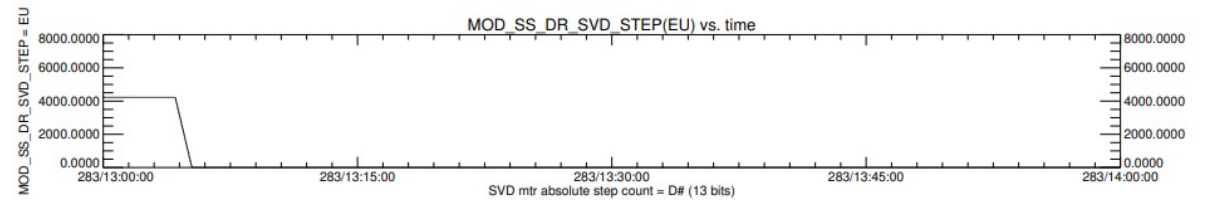
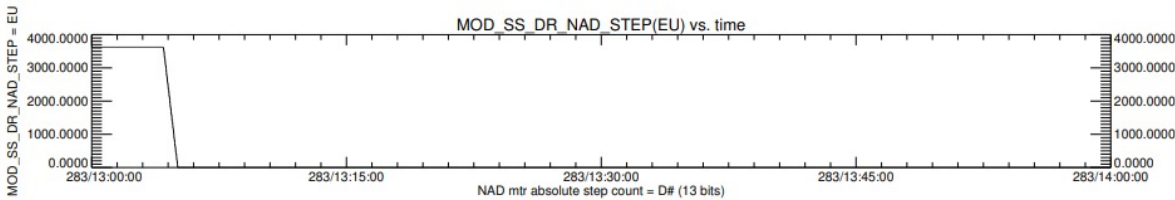
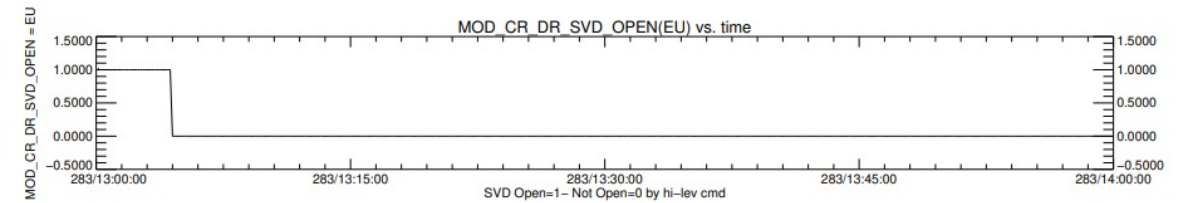
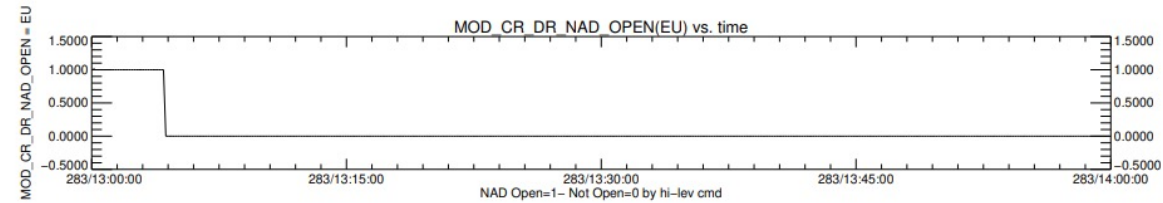
- An on-orbit anomaly occurred on 3/15/22 (2022/074) at 08:54, causing the Terra MODIS format processor (FP) and command processor (CP) to reset and send MODIS to Standby Mode.
- No indication from MODIS telemetry on what caused the reset. The reset information showed an Auxil_Reset, which is only used during hardware testing.
- Because the CP and FR reset, MODIS IOT needed to send commands to bring MODIS back to nominal Science configuration in addition to re-uploading all CP and FP patches which were in place before the resets.
- Due to the large number of patches, those that were deemed important for instrument safety were executed on 3/15/22 and those important for science continuity were executed on 3/16/22.



Terra Constellation Exit Maneuvers - Doors



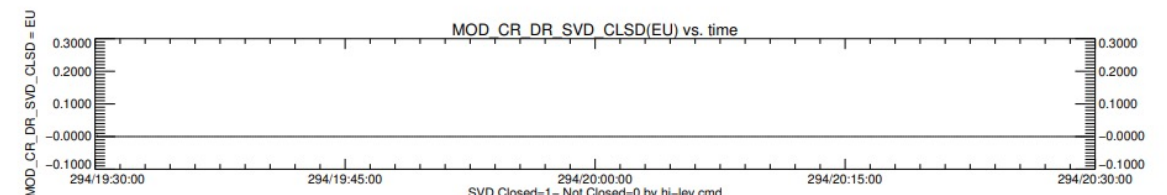
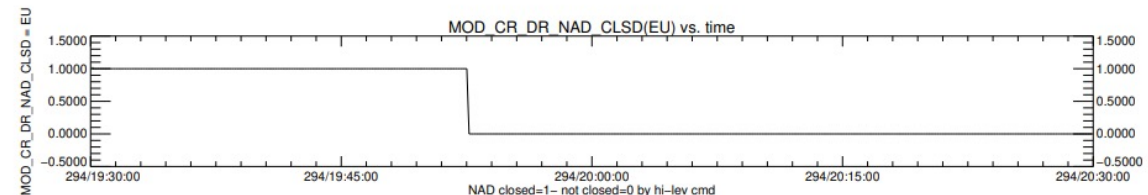
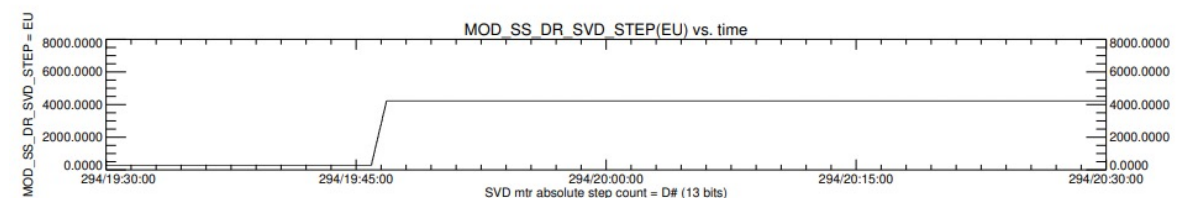
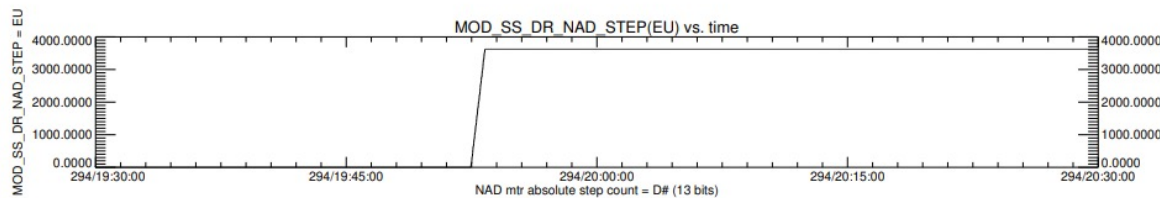
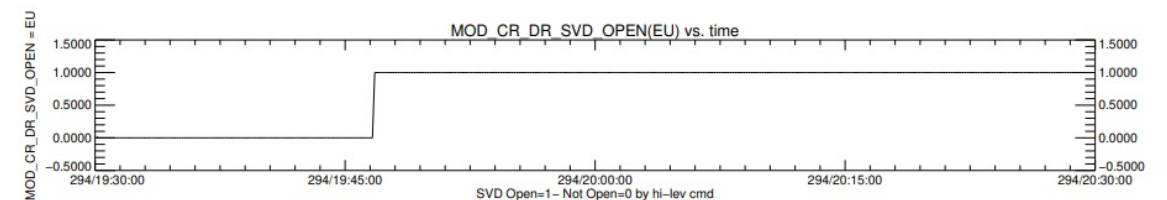
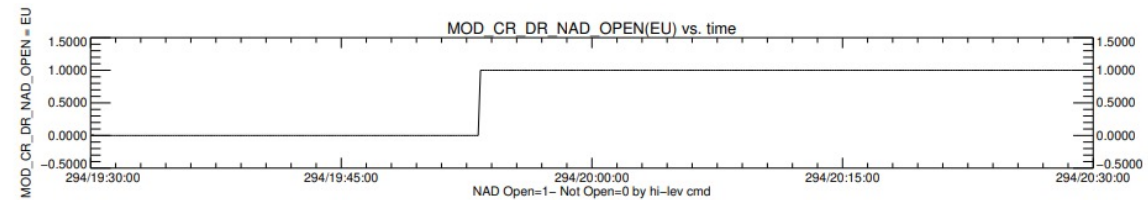
- As part of MODIS pre-CEM operations, the Nadir and SV doors were commanded to be closed at 2022/283 13:04:00.
- Both door open switches read NOT_OPEN as the motors began stepping down. The SVD CLOSED switch read CLOSED within 14 seconds of the door step count reaching 0, while the Nadir door CLOSED switch read CLOSED 27 minutes after the door step count reached 0.
- During the door closure, the CP registered two events indicating that the SVD and NAD triggers had not been found. MODIS software handled this properly by stepping the doors the set amount.





Terra Constellation Exit Maneuvers - Doors

- Because the door closed switches did eventually change as expected, it was deemed the doors had moved properly and the delay in door switch telemetry was the result of the switches getting older.
- There is a concern that the door switch delay could result in stepping the doors beyond their limits and overdriving the door motors.
- Following the CEMs, MODIS IOT, in close co-ordination with the MODIS Software Engineer, Raytheon, decided it would be safer to replace the door-opening commands, MOD_SVD_TO_OPEN and MOD_NAD_TO_OPEN, that depend on the door switches with a command that step the doors a fixed amount, MOD_STEP_DOOR, and does not depend on door switches.
- MODIS IOT intends to use these step commands to move the doors moving forward.





Decommissioning Plans



Aqua

Expected End of Mission:

- December 2023 (possible extension to September 2026)
- Perigee Lowering Maneuvers performed 1 month prior

MODIS Decommissioning Configuration:

- Command to Standby Mode (Blackbody off)
- Command to Safe Mode (NADIR and SV doors closed)
- Command MODIS off

Terra

Expected End of Mission:

- February 2024 (possible extension to April 2027)
- Perigee Lowering Maneuvers performed 1 month prior

MODIS Decommissioning Configuration:

- Command to Safe Mode (Blackbody off, NADIR and SV doors closed)