MODIS and VIIRS Instrument Status

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Acknowledgements

Contributions:

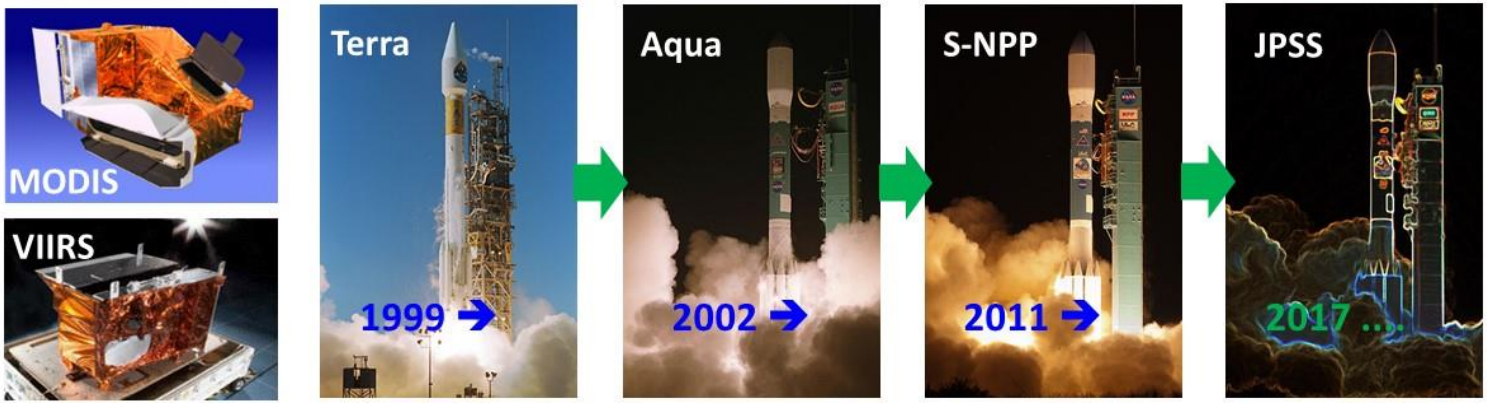
- MODIS Characterization Support Team (MCST)
- MODIS Science Data Support Team (SDST)
- VIIRS Characterization Support Team (VCST)

Support:

- Terra and Aqua Projects, S-NPP Project Science Office (PSO), and JPSS Flight Project
- MODIS/VIIRS Discipline Groups and Representatives
- Terra, Aqua, S-NPP Mission/Flight Operation Teams (MOT/FOT)
- MODIS and VIIRS Instrument Vendor (Raytheon)

Outline

- MODIS and VIIRS Highlights
- MODIS and VIIRS On-orbit Performance
- MODIS C5/C6 and VIIRS SDR/L1B Status (backup slides)
- Future Activities
- Summary



MODIS Highlights

- **Instrument Operations and OBC Functions – Normal**
  - No changes to instrument operation configuration for Terra MODIS since 2003 (currently using A-side electronics and B-side formatter)
  - All B-side configuration for Aqua MODIS since launch
  - Terra spacecraft (S/C) safe mode on Feb 18, 2016
    - It happened on Feb 18, 2016 during a scheduled inclination maneuver when the S/C was yawed to +90° instead of the desired -90°. When attempts were made to slew it back, the edit limits were tripped and caused the S/C to enter the Safe Mode
    - The S/C and all instruments were powered back on without issues after February 24, 2016 and continue to operate nominally
    - Impact on MODIS: 11 (21) noisy detectors in LWIR bands before (after) safe mode; large gain changes (5-15%) in some LWIR PV bands/detectors; gain changes are relatively small (0.5-2.0%) in other spectral bands
  - No new noisy detectors for Aqua MODIS since last STM
  - Noticeable improvement in the control of Aqua MODIS CPFA temperatures

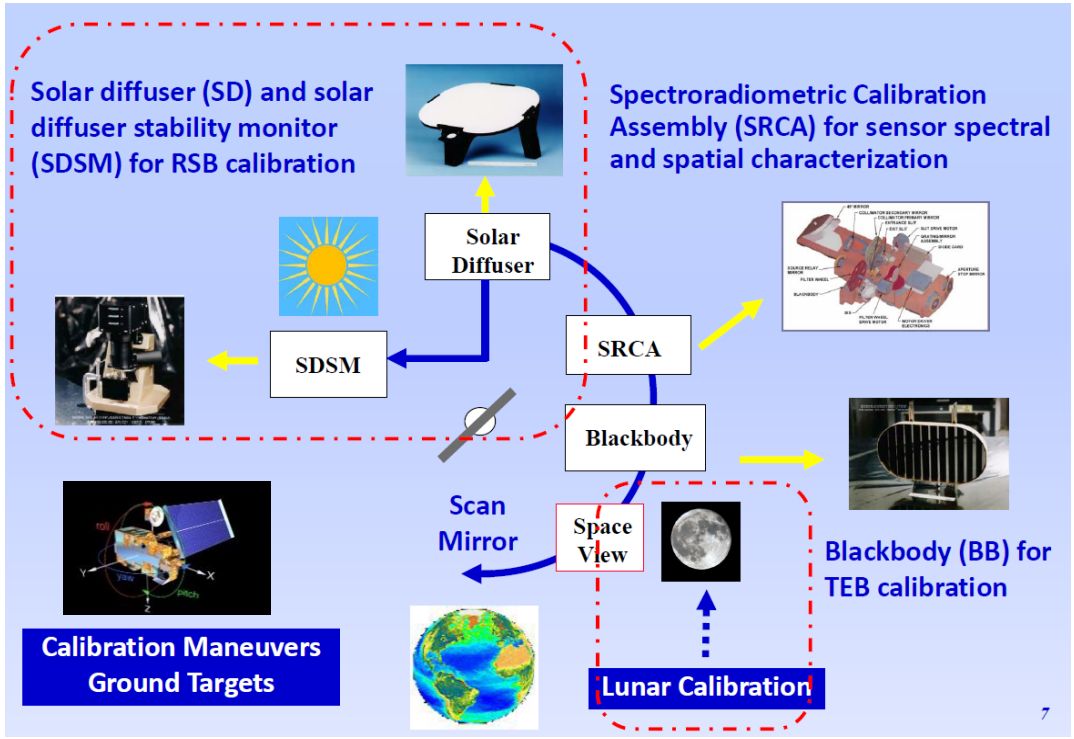
MODIS Highlights

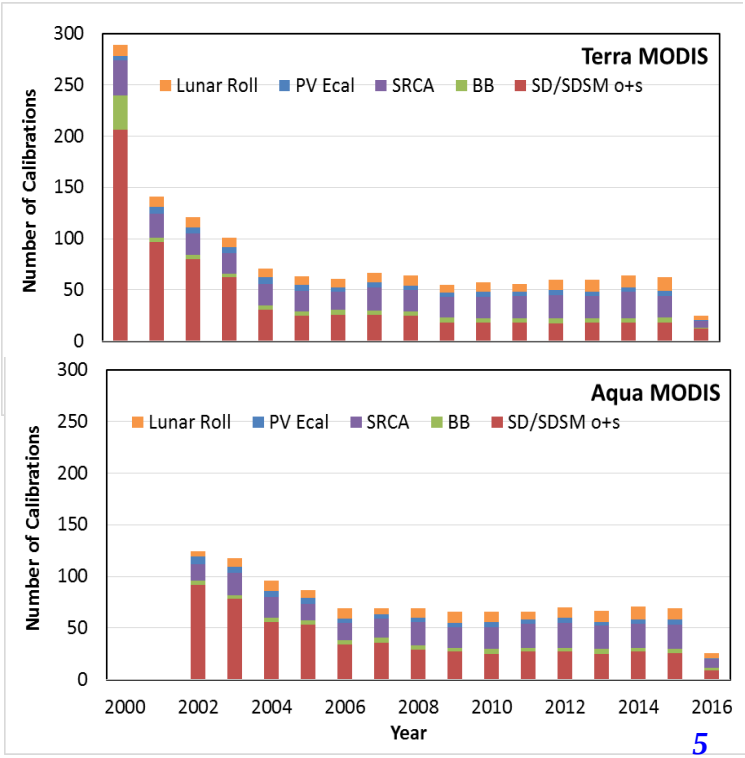
- **Continuous Effort on Sensor Calibration and LUT Delivery**
  - Terra MODIS: C5/C6/OBPG LUT updates: 16/16/13 (19/19/18 in previous year)
  - Aqua MODIS: C5/C6/OBPG LUT updates: 14/16/14 (17/16/14 in previous year)

Calibration Activities

	Terra	Aqua
Lunar Roll:	162 (13*)	136 (13)
PV Ecal:	92 (4)	71 (4)
SRCA:	433 (21)	315 (26)
BB:	99 (4)	61 (4)
SD/SDSM:	715 (17)	571 (35)

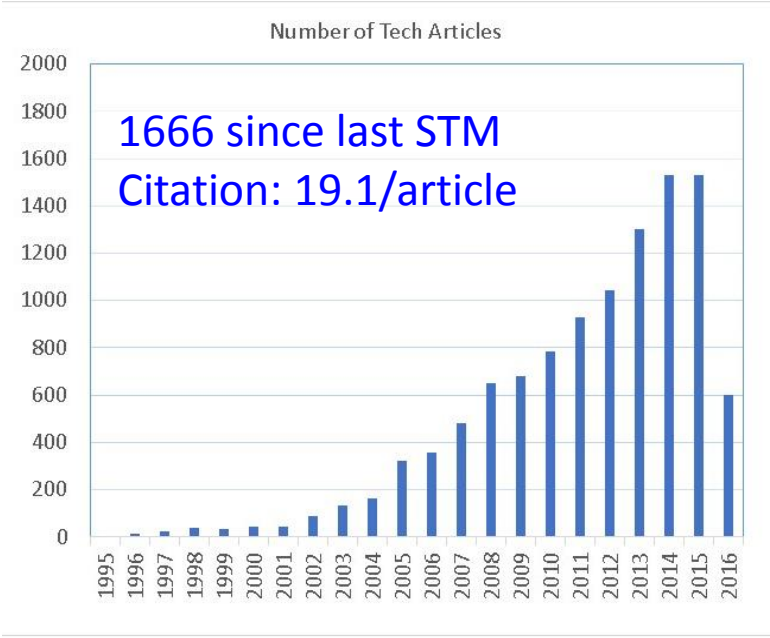
*** (activities) since last STM**

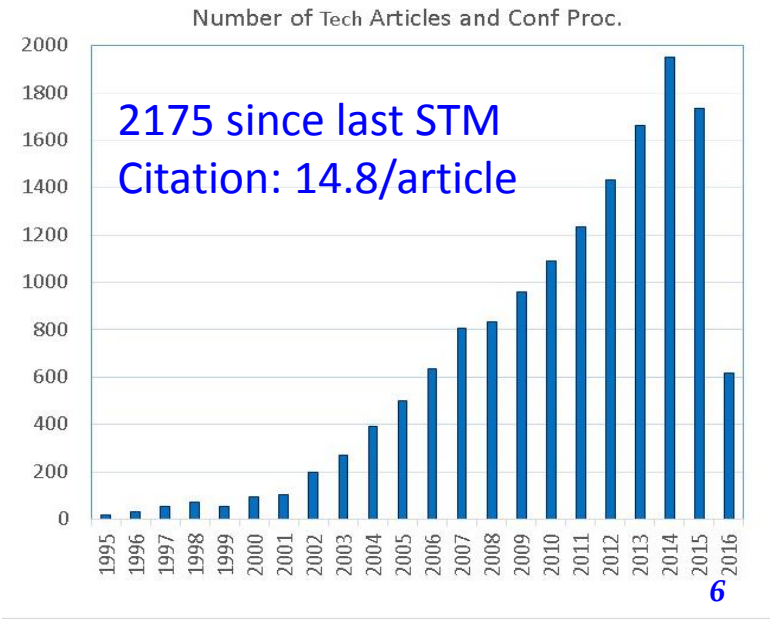




MODIS Highlights

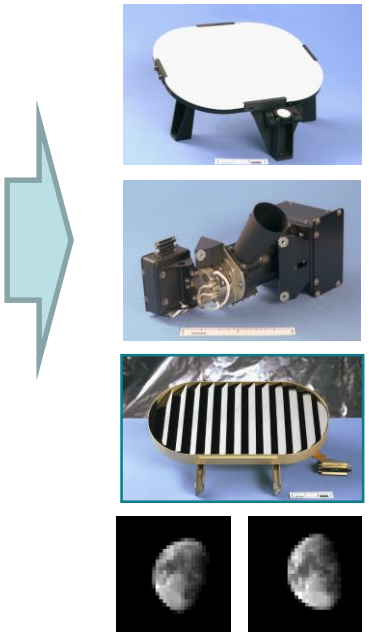
- **C5/C6 Processing and Reprocessing**
  - Backup slides (from SDST)
- **MODIS Publications**
  - 10906 tech articles and 14813 tech article and proc. combined (Web of Science)
- **Technical Meetings and Workshops**
  - MODIS and VIIRS Calibration Workshop on June 06, 2016
  - Aqua MODIS CFPA Performance and Operation Review on May 04, 2016 (previous reviews in 2010, 2012, 2013, 2014, and 2015)
  - Bi-weekly MsWG meetings
  - Technical meetings with science groups
    - Most with OBPG on LUT updates; other topics include Aqua MODIS (B1-4) RVS update strategy and Terra MODIS LWIR PV xtalk assessment





S-NPP VIIRS Highlights

- **Instrument Operations and OBC Functions – Normal**
  - Same operation configurations (B-side) since launch
  - “Scan Sync Loss” between RTA and HAM: 64 since launch (2-3 min); poor geolocation accuracy
  - “Petulant Mode” - the single board computer (SBC) lock-up not occurred since a FSW fix in Dec 2014 (FSW: 0x4016)
  - Optical throughout degradation has nearly leveled off
- **On-orbit Calibration and SDR/L1B LUT Delivery**
  - SD calibration: each orbit; SDSM: 3 times/week
  - BB WUCD: 17 since launch
  - DNB: monthly VROP operation
  - lunar observations: 41 since launch (not all need roll maneuvers)
  - 35 sets of LUTs for RSB (and DNB) delivered for Land SIPS SDR processing of C1.0 and C1.1 (Oct 2012 – present); 9 sets of LUTs delivered to Atmosphere SIPS (Nov 2014 – present)



S-NPP VIIRS Highlights

- **VIIRS Publications**
  - Total number of 264 (citation 8.4/article)
- **Technical Meetings and Workshops**
  - Regular Technical Meetings of VCST and OBPG
  - VIIRS L1B Working Group Meetings
  - VIIRS SDR Meetings (led by NOAA STAR)
- **Continues effort on L1B algorithm and LUT improvements**
  - POC: Fred Patt and Vincent Chiang
  - Latest effort on L1 V2 SW (details in Calibration Workshop materials)

- **J1 and J2 VIIRS Instrument Status**
  - J1 VIIRS currently undergoing SC environment testing (sensor per-launch calibration performance summarized during last year's STM and also at this year's calibration workshop) – launch in early 2017
  - J2 VIIRS recently started its ambient environment testing

MODIS and VIIRS Calibration Workshop

- 24 presenters from MCST/VCST and sci. discipline representatives on a variety of topics (xtalk, polarization, calibration difference)
- 75±5 attendees

MODIS Calibration Workshop (Jack Xiong and Jim Butler, Chairs)	
Introduction (*Jack Xiong*)	8:30 am
Status of MODIS Instrument Operation (*Michael Lucci*)	8:40 am
MODIS L1B and LUT Updates (*Xu Geng*)	8:50 am
MODIS RSB Calibration and Performance (*Amit Angal*)	9:00 am
MODIS TEB Calibration and Performance (*Ben Wang*)	9:30 am
Coffee Break	10:00 am
MODIS Spatial and Spectral Performance (*Dan Link*)	10:30 am
MODIS Geo-location Status (*Gary Lin*)	10:45 am
MODIS Special Calibration Topics (*Aisheng Wu/Truman Wilson*)	11:05 am
Summary (*Jack Xiong*)	11:35 am
Lunch Break	11:45 am
VIIRS Calibration Workshop (Jim Butler and Jack Xiong, Chairs)	
Introduction (*Jack Xiong*)	1:00 pm
Status of VIIRS Instrument Operation (*Vincent Chiang*)	1:05 pm
VIIRS L1B Software Revision 2 Enhancements (*Sam Anderson*)	1:15 am
VIIRS RSB Calibration and Performance (*Ning Lei/Hongda Chen*)	1:25 pm
VIIRS TEB Calibration and Performance (*Jeff McIntire*)	1:55 pm
VIIRS Special Calibration Topics (*Ben Wang*)	2:10 pm
VIIRS Geo-location Status (*Gary Lin*)	2:25 pm
J1 VIIRS Instrument and Calibration Status (*Hassan Oudrari*)	2:40 pm
Coffee Break	3:05 pm

General MODIS and VIIRS Calibration Topics (Jack Xiong and Jim Butler, Chairs)	
L1B VIIRS-MODIS matchup inter-comparisons (*Steve Platnick/Kerry Meyer*)	3:35 pm
Can we link calibration differences to differences in retrieved aerosol properties from MODIS-Terra, MODIS-Aqua, and VIIRS-SNPP (*Rob Levy*)	3:45 pm
Biases in VIIRS-derived aerosol optical depth arising from solar band absolute calibration biases (*Andy Sayer*)	3:55 pm
OBPG update on MODIS Terra gain and polarization sensitivity trending (*Gerhard Meister*)	4:05 pm
MODIS optical throughput degradation and its impacts on calibration (*Shihyan Lee*)	4:15 pm
OBPG update on VIIRS calibration issues (*Gene Eplee*)	4:25 pm
MODIS Terra/Aqua De-trending and Cross-Calibration Analysis with Latest RVS and Polarization Sensitivity Trending (*Alexei Lyapustin*)	4:35 pm
Monitoring the calibration of MODIS and VIIRS over the BELMANIP2 site (*Eric Vermote*)	4:45 pm
Impact of Terra MODIS PV LWIR xtalk on L1 and L2 Products (*Chris Moeller*)	4:55 pm
MODIS and VIIRS Lunar Image Quantitative Analysis - An Update (*Tom Stone*)	5:05 pm
Aqua MODIS and S-NPP VIIRS Calibration Inter-comparison (*Aisheng Wu*)	5:15 pm
Summary (*Jim Butler/Jack Xiong*)	5:25 pm
Adjourn	5:30 pm

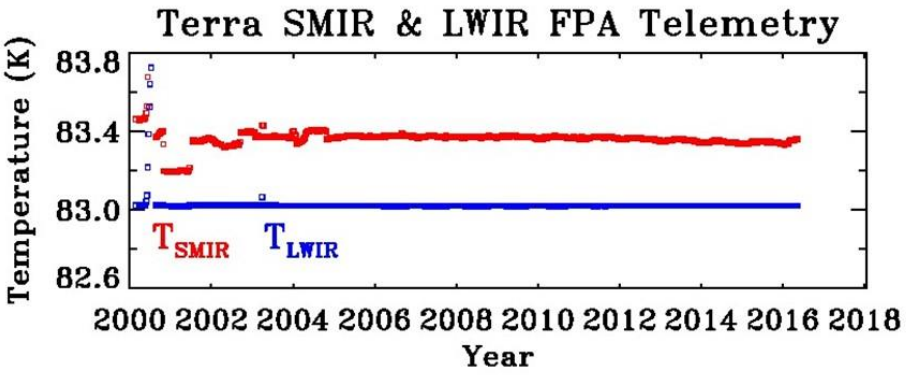
MCST and VCST Presentations:
ftp://mcst.ssaihq.com/pub/temp/

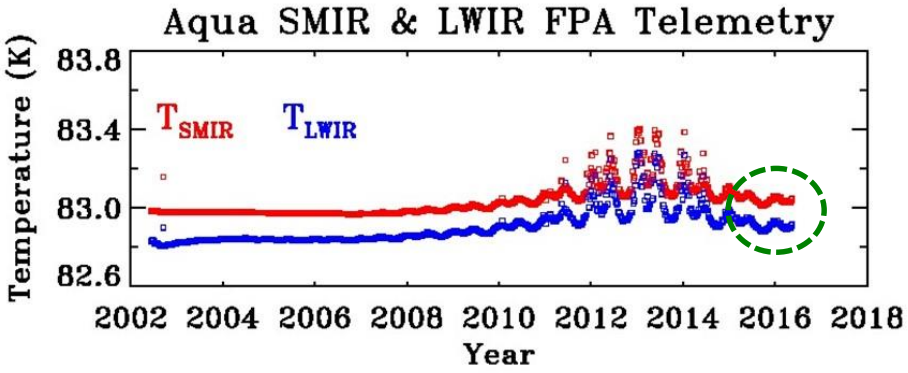
Available at MODIS Website after the STM

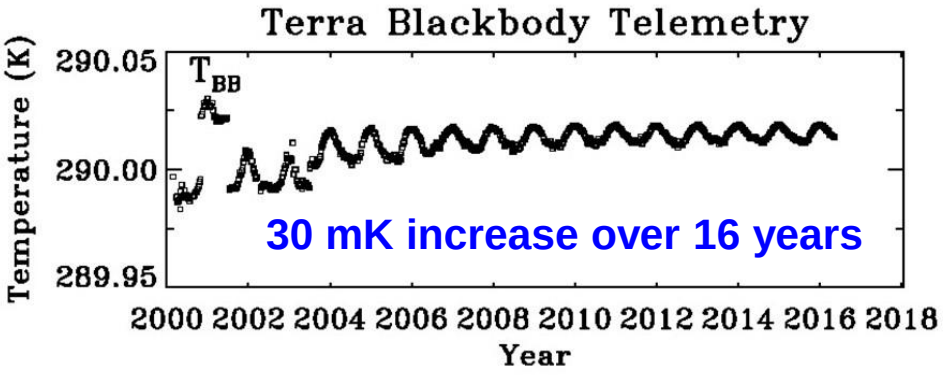
Terra and Aqua MODIS On-orbit Performance

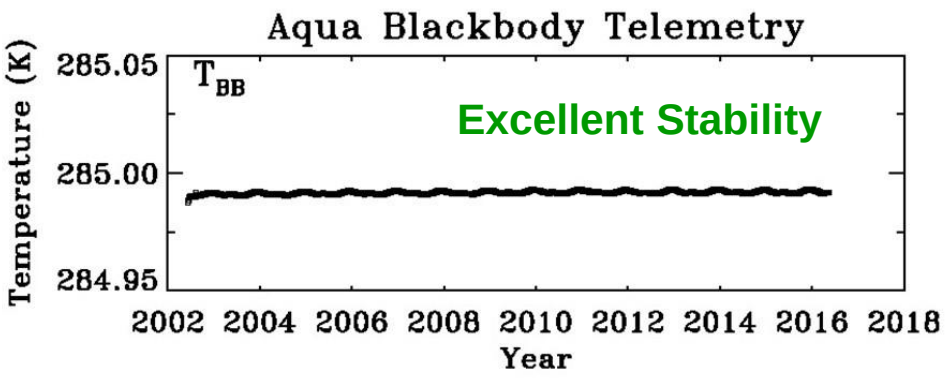
- **Instrument and On-board Calibrators (OBC)**
  - Terra MODIS instrument, VIS/NIR FPA temperature increase: < 3.5 K; CFPA temperatures: very stable; BB temperature increase: < 30 mK: SD degradation: faster than Aqua MODIS (SD door fixed at open since 2003)
  - Aqua MODIS instrument, VIS/NIR FPA temperature increase: < 2.0 K; CFPA temperatures: improved control; BB temperatures: very stable; SD degradation: slower than Terra MODIS
- **Radiometric**
  - Spectral band responses
  - Detector noise characterization
- **Spatial and Spectral (no change since last STM)**
  - Band-to-band registration (BBR): continue to be stable
  - Center wavelengths and bandwidths: changes are within 0.5 nm and 1.0 nm, respectively, for most VIS/NIR bands; relatively large changes for bands with broad bandwidths (bands 1, 18, 19)
- **Geolocation**

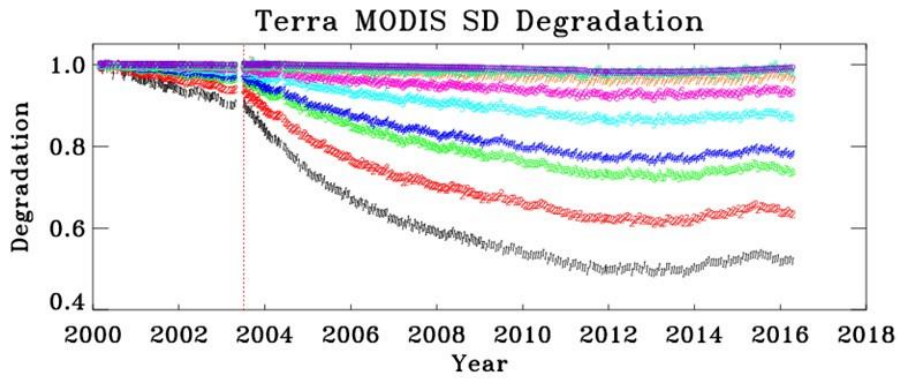
MODIS BB Temperature and SD Degradation

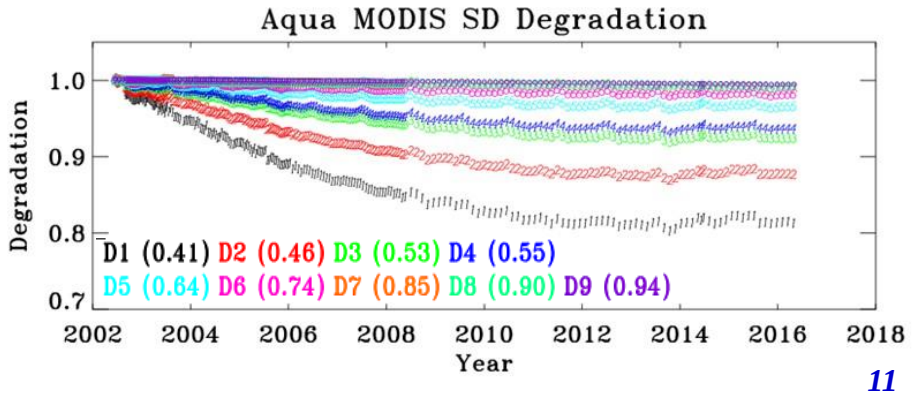








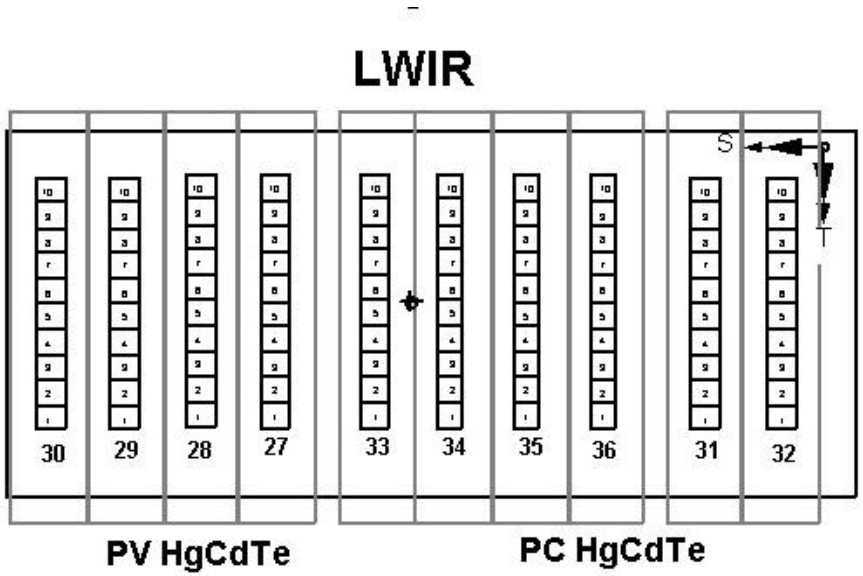




MODIS Detector Noise Characterization

MODIS: 36 spectral bands (on 4 FPAs); a total of 490 individual detectors

- Terra MODIS: 53 noisy detectors (30 from pre-launch; 35 at launch) and 3 inoperable detectors (D6 in B29 D4 and D8 in B30) – 8 noisy detectors and 3 inoperable detectors since last STM
- Aqua MODIS: 10 noisy detectors (2 from pre-launch; 3 at launch) and 15 inoperable detectors (13 in Band 6) – no change since last STM



Terra MODIS:

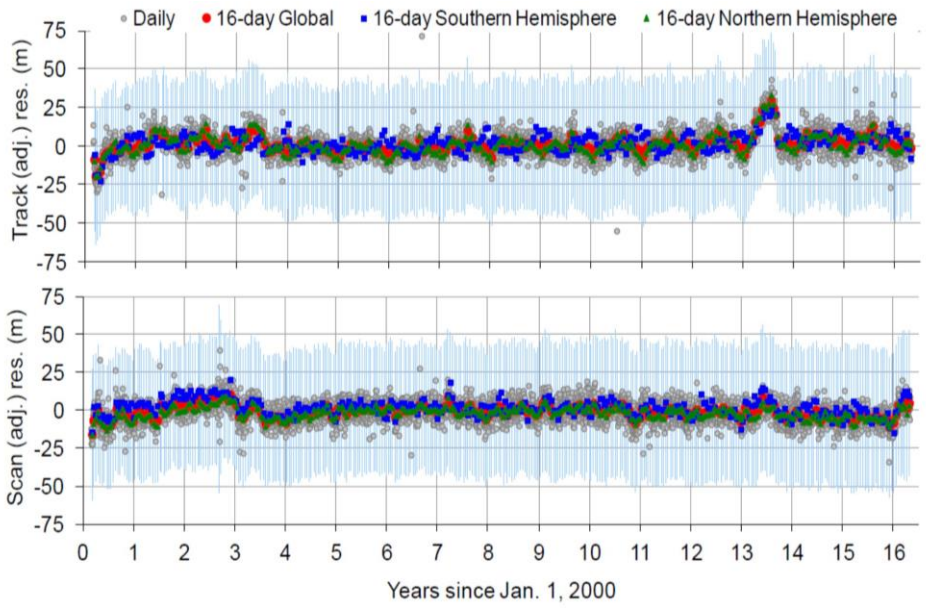
21 of the 26 noisy and inoperable detectors since launch are in LWIR PV bands

11 of the 21 occurred after the safe hold event in Feb 2016

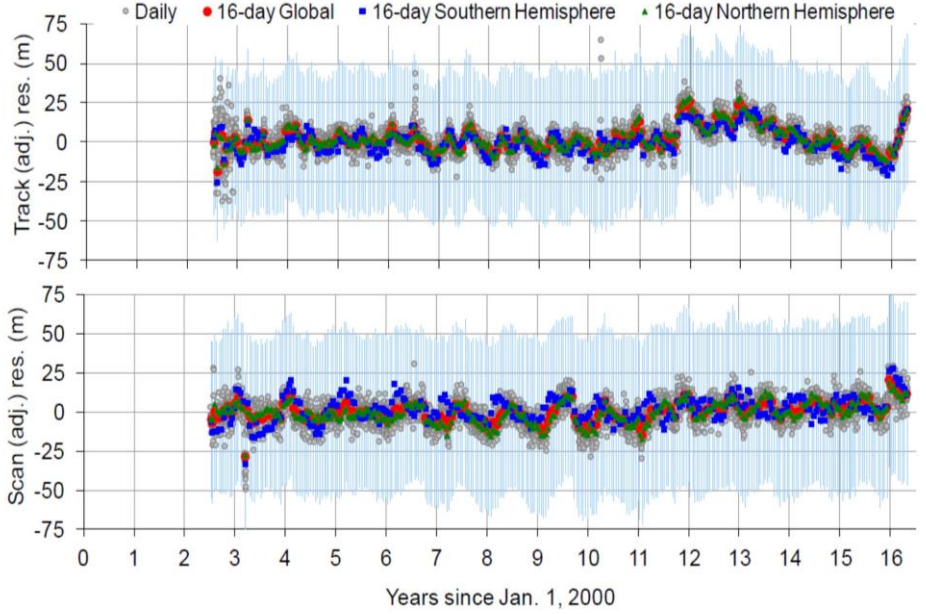
MODIS Geolocation Performance

Terra and Aqua MODIS Geolocation Performance Remains Satisfactory (same as last year)

Terra MODIS RMSE (C6)
Track: 43 m Scan: 44 m



Aqua MODIS RMSE (C6)
Track: 46 m Scan: 53 m



Daily 16-day Global 16-day Southern Hemisphere 16-day Northern Hemisphere

Terra track direction jump - due to a delayed implementation/update of Geo LUTs (from 01/01/2013 to 08/10/2013).

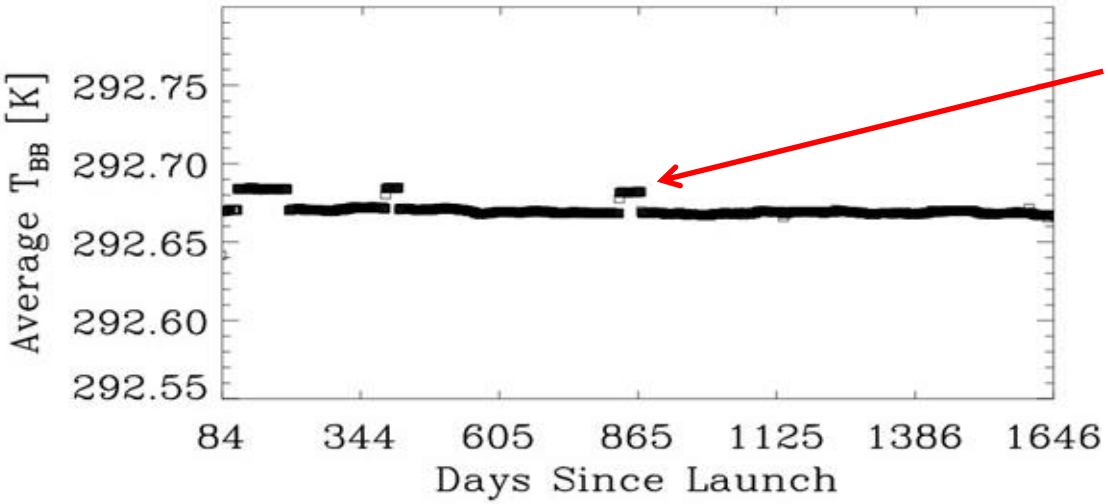
Aqua track direction jump at the end of 2011 (now it's back to "normal") - need to model it and update the LUT.

S-NPP VIIRS On-orbit Performance

- **Instrument and On-board Calibrators (OBC)**
  - Instrument and FPA temperatures: stable
  - SD degradation: relatively large (similar to Terra MODIS)
  - BB stability: very stable (similar to Aqua MODIS)
- **Radiometric**
  - Spectral band responses (different from MODIS)
    - Large changes in NIR and SWIR (due to mirror contamination)
    - Small changes in VIS, MWIR, and LWIR
  - Detector noise characterization (better performance than specification)
    - Noticeable changes in NIR and SWIR are due optical throughput degradation
- **Spatial and Spectral**
  - Band-to-band registration (BBR): stable (tracked using lunar observations)
  - Mirror contamination => wavelength dependent optics degradation
- **Geolocation**

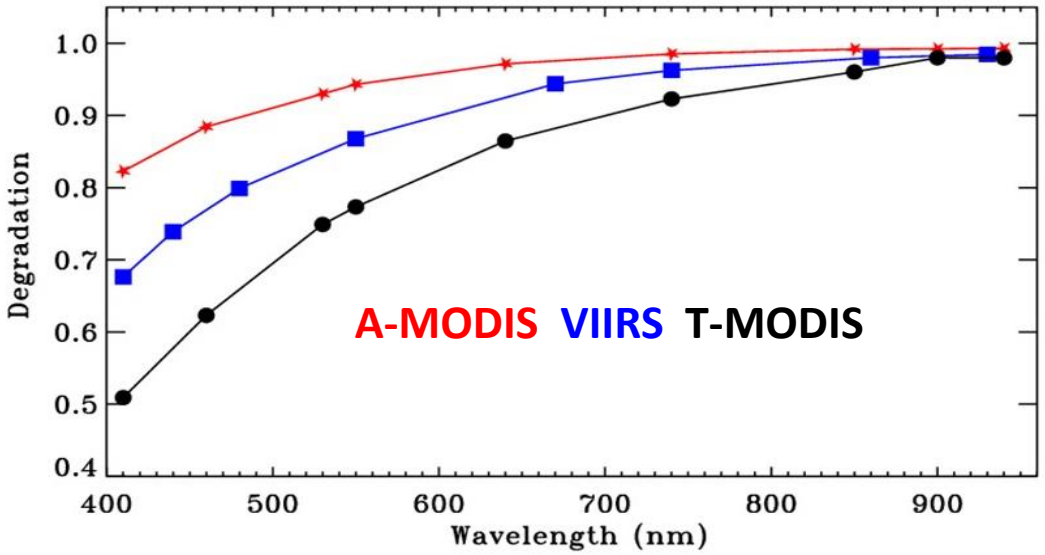
S-NPP VIIRS BB Temperature and SD Degradation

BB Temperatures



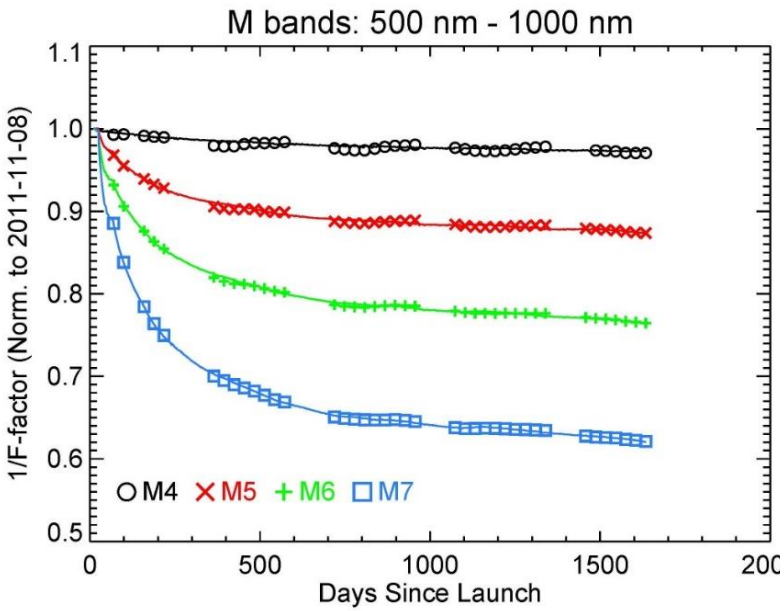
- ~15 mK offsets due to the use of two different T_{BB} settings
- Long-term stability to within a few mK

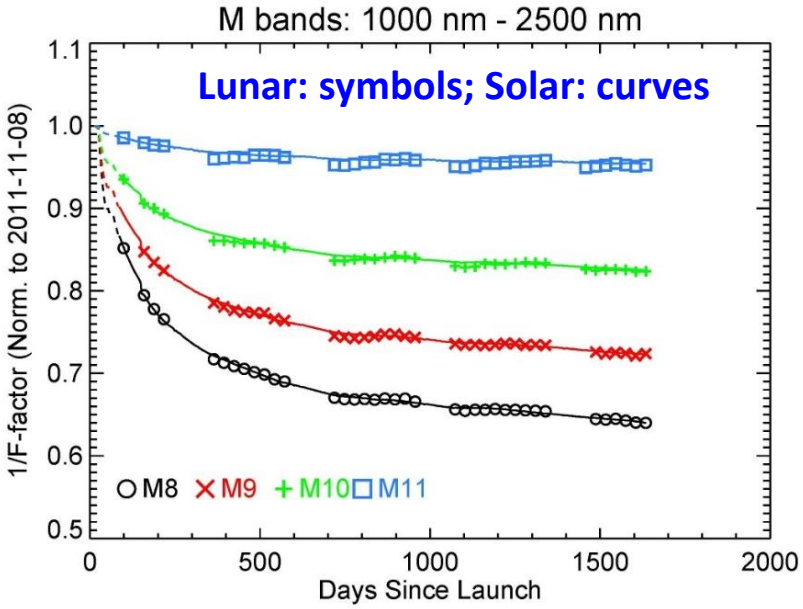
SD Degradation

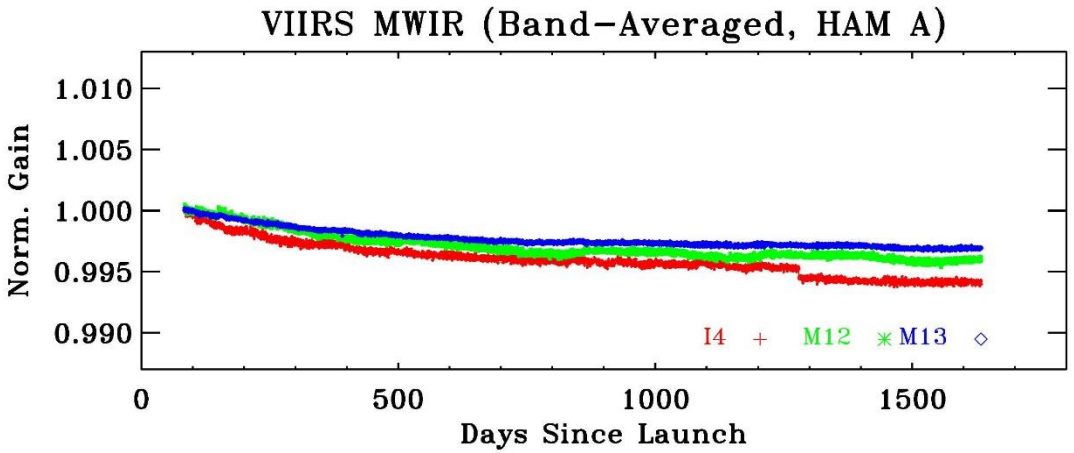


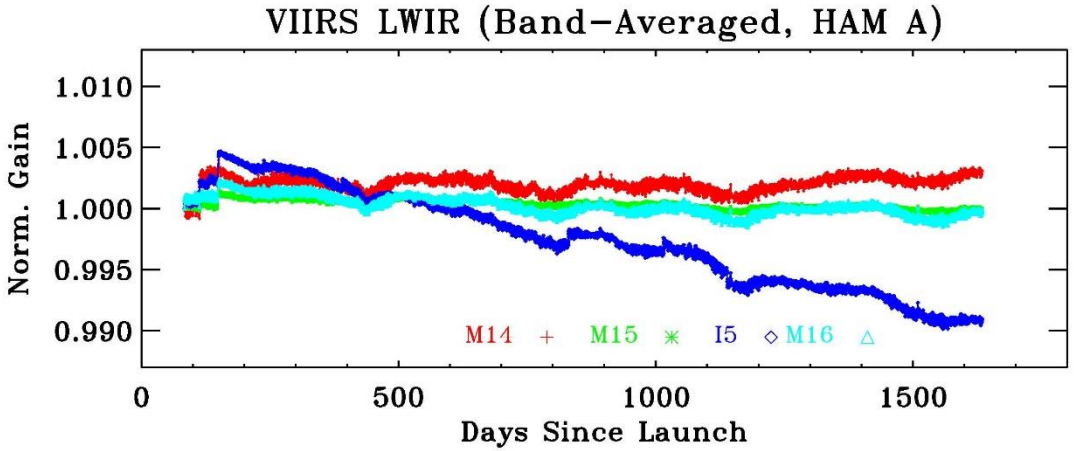
- Large SD degradation at short wavelength
- Increased SD degradation in Terra MODIS after its SD door fixed at “Open”
- VIIRS has no SD door

S-NPP VIIRS Spectral Band Responses (Gains)





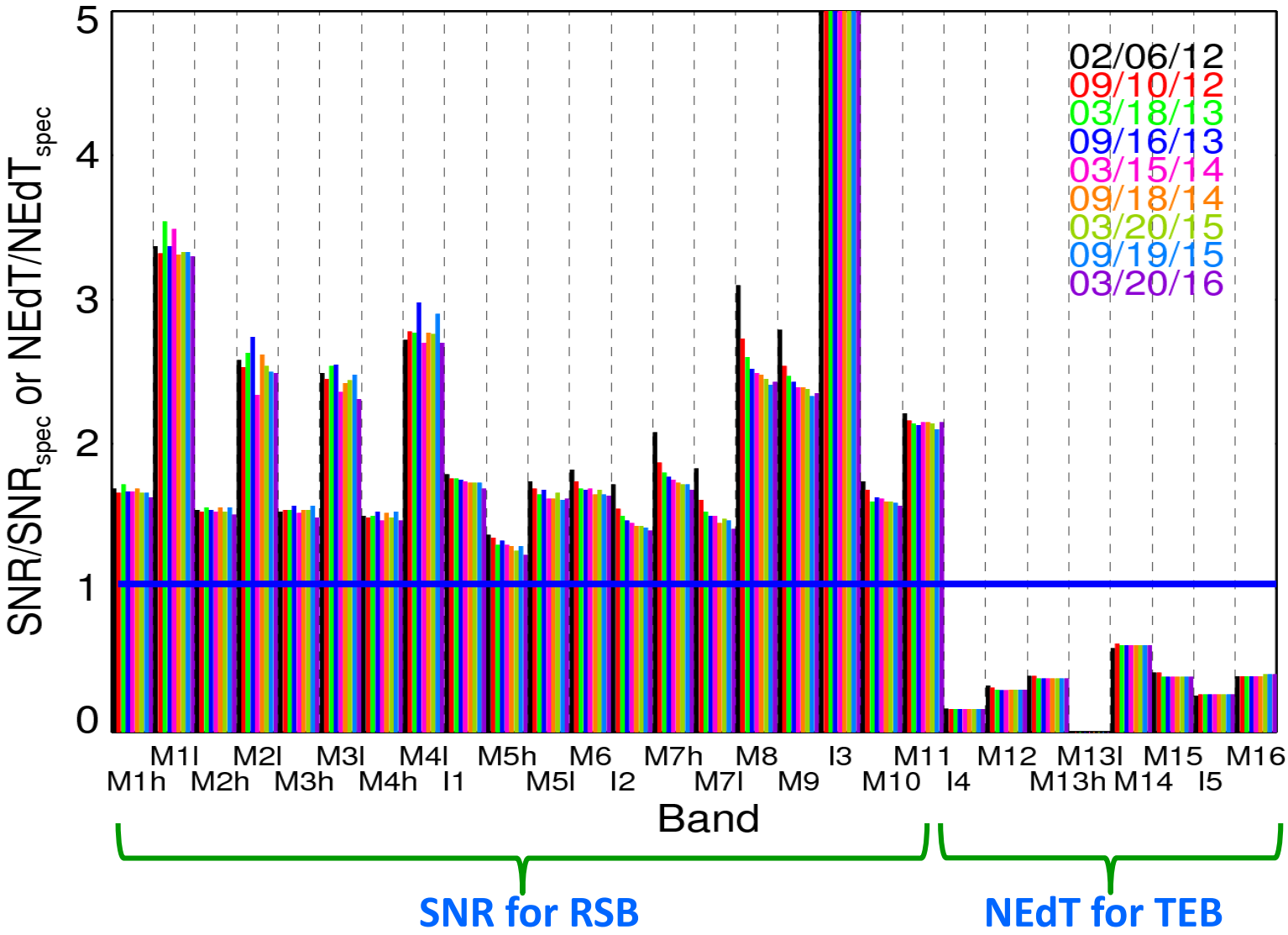




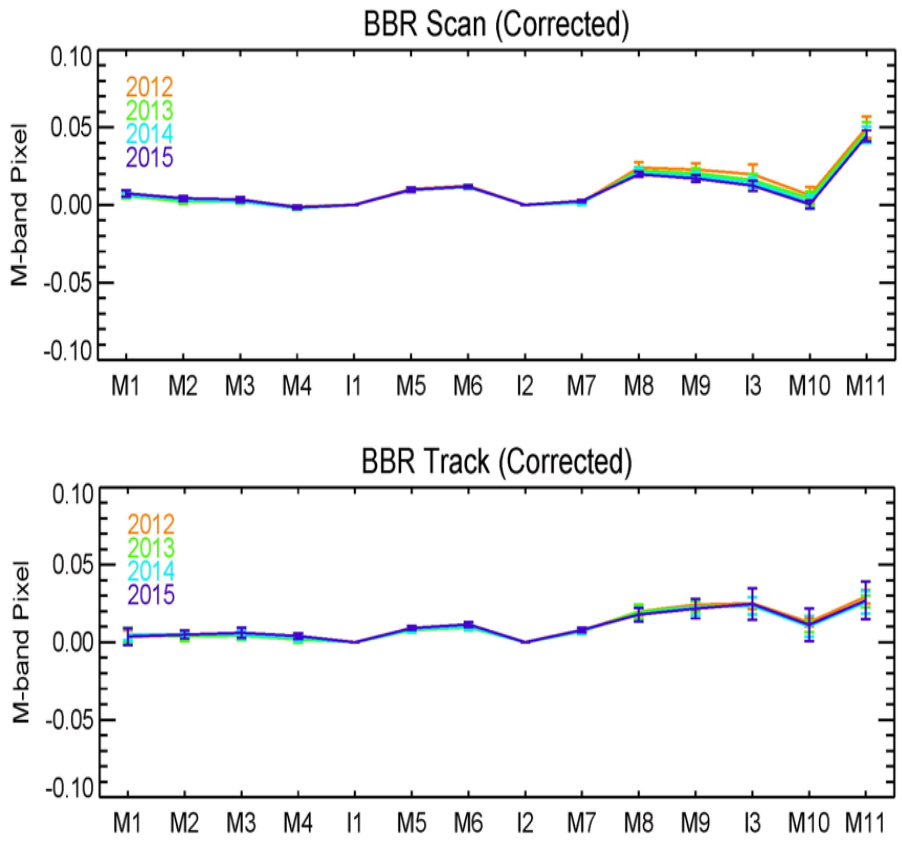
- Large changes in NIR and SWIR (due to mirror contamination)
- Small changes in VIS, MWIR, and LWIR

S-NPP VIIRS Detector Noise Characterization

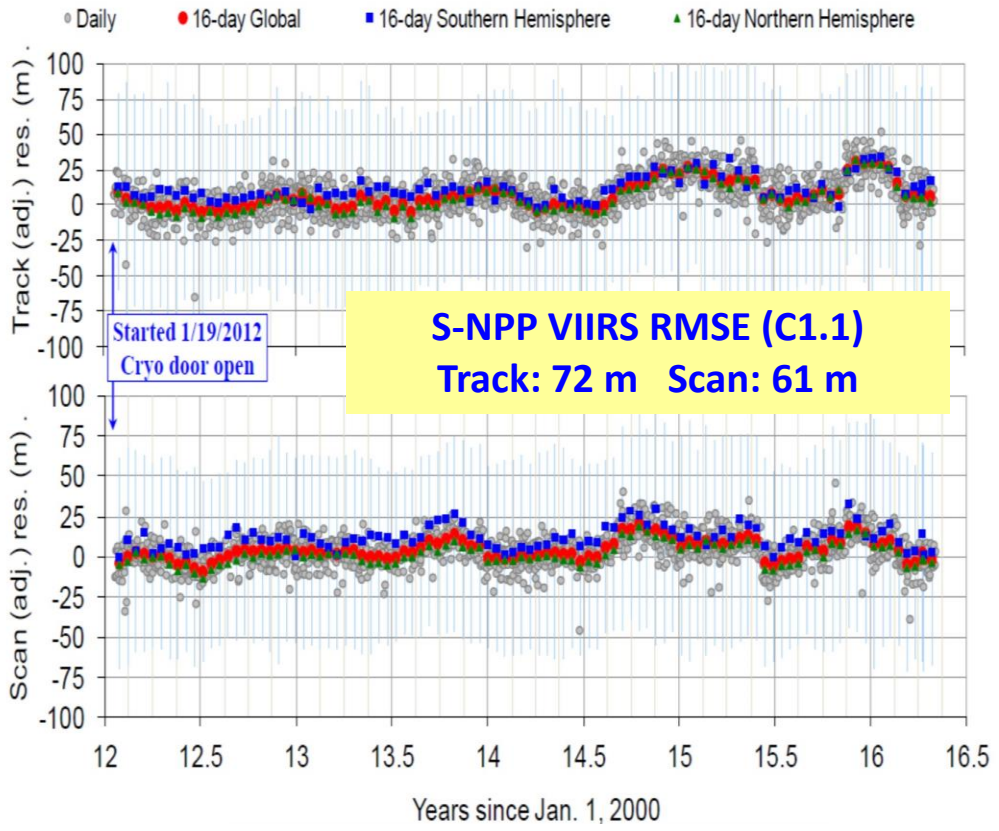
$SNR/SNR_{SPEC} > 1$ or $NEdT/NEdT_{SPEC} < 1$: better performance



S-NPP VIIRS Spatial Characterization and Geolocation



Geolocation



S-NPP VIIRS RMSE (C1.1)
Track: 72 m Scan: 61 m

- Methodology was developed for MODIS BBR characterization using lunar observations (validated using MODIS on-board SRCA)
- On-orbit BBR is very stable in both scan and track directions

Terra MODIS RMSE (C6)
Track: 43 m Scan: 44 m

Aqua MODIS RMSE (C6)
Track: 46 m Scan: 53 m

Future Activities

- **Future work to address existing and new challenging issues in Terra and Aqua MODIS**
  - Changes in VIS/NIR response versus scan-angle (RVS) – continuing effort
  - Changes in Terra MODIS polarization sensitivity and impact on sensor's earth view response trending – progress has been made in recent years
  - Uncertainty due to correction for large SD degradation and SD degradation correction for SWIR bands – further improvement (for more spectral bands)
  - Terra LWIR PV Xtalk impact and correction – testing latest correction algorithm
  - Noisy detectors and their impact on calibration – more serious in Terra MODIS LWIR PV bands
- **VIIRS calibration effort**
  - Enhanced calibration and validation effort in support of VIIRS data reprocessing and NASA L1 SW development/improvement
  - Improved use of SD and lunar calibration
  - Tracking potential changes in VIIRS RVS
- **MODIS and VIIRS calibration consistency and impact on science products**
  - Extensive calibration and validate effort and science support

Future Activities

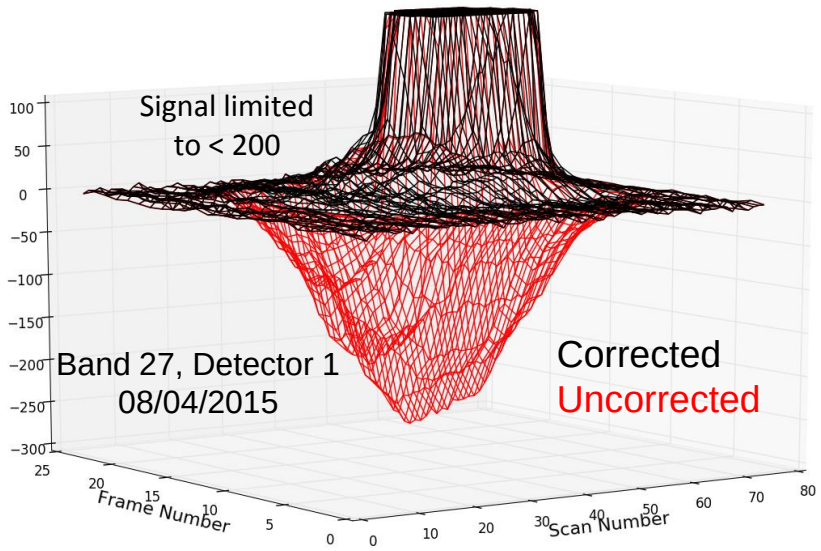
- **J1 and J2 VIIRS calibration work**
  - Support to current J1 VIIRS testing in SC environment
  - Support to ongoing J2 VIIRS sensor ambient environment testing
  - Support to J1 launch (early 2017) and J1 VIIRS intensive calibration and validation (ICV)
- **Senior Review 2017**
  - Kick off in December, 2016
  - Proposal due in March, 2017
  - 7^{th} for Terra; 6^{th} for Aqua; and 1^{st} for S-NPP (?)

Example: Electronic Crosstalk in the LWIR PV Bands of Terra MODIS

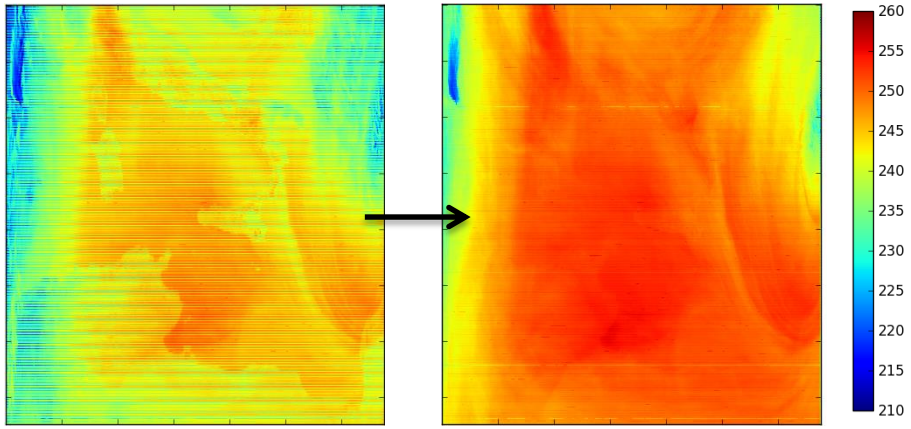
- Calibration Issues Associated with Electronic Crosstalk
  - Band-to-band signal contamination during sampling among the LWIR PV bands
  - False drift in the trending radiometric calibration coefficients
  - Detector-to-detector differences result in image striping and overall poor quality images
  - False land features observed in Bands 27-28
  - False cloud detection in the Band 29 – Band 31 cloud mask due to radiometric offset
- Our Approach
  - Developed lunar-based and electronics based physical models and an empirical model to correct the contamination
  - Derived correction coefficients for using lunar based approach for the full mission
  - L1B granule testing of our coefficients show better quality images. Good removal of false features and suppression of radiometric calibration coefficient drift.
- Current Issues
  - Continue to monitor the impact of the safe-mode event on the crosstalk contamination
  - Assess the impact of our correction on downstream science products
  - Finalize our implementation and begin forward processing of the L1B granules

Example Corrections from the Lunar Based Algorithm

Correcting the Lunar Signal

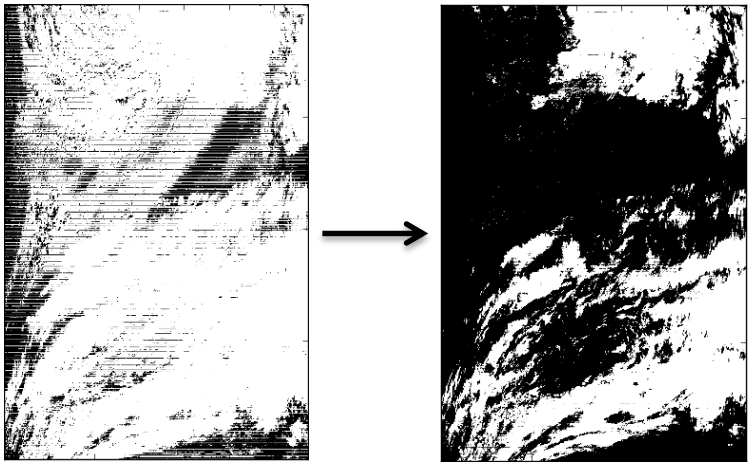


De-striping and Land Feature Removal in Band 27



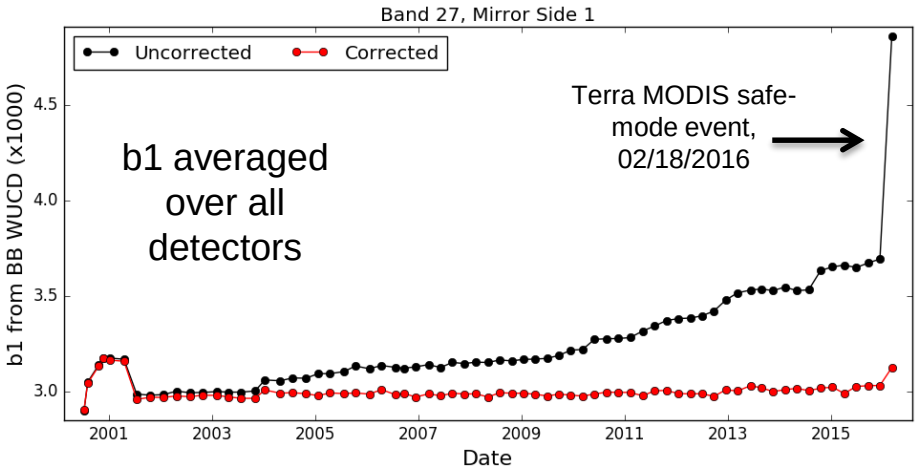
Granule 2015183.1005

Removal of False Clouds from B29 – B31 Cloud Mask



Granule 2015182.1345

Gain Coefficient Drift Correction



Summary

- Both Terra MODIS (16 years) and Aqua MODIS (14 years) and their on-board calibrators continue to operate and function normally
- Dedicated effort by MCST (and SDST) and support from science algorithm developers remain critical to MODIS instrument calibration/data product quality
- Challenging issues identified for both MODIS instrument calibration will be investigated and addressed for future improvements of data processing/reprocessing
- SNPP VIIRS on-orbit performance (4.5 years) has become very stable
- Effort from VCST is vital in support of SIPS for producing the improved and consistent VIIRS data products
- Multiple and major instrument calibration activities in the coming year will be more challenging for both MCST and VCST

Backup Slides

MODIS C5 Forward Processing Status

- Forward processing (C5 Land, and C51 Atmosphere) is typically 1-2 days behind real time.
- The C4.1 LST (C4 code with C5 L1 input) is processed and archived at LAADS.
- C5/C5.1/C4.1 processing to be continued for a year after completion of the C6 land and atmosphere reprocessing.
- Products from the C5 processing are expected to be available from DAAC for a year after completion of the C6 land reprocessing. C5 processing could be discontinued in late 2016 or Spring 2017.
- NRT processing (C5 Land, C51 Atmosphere and C6 Land and Atmosphere) is completed typically 2 – 2.5 hours after acquisition of data.

MODIS C6 Reprocessing Status

- **L1, Geolocation, and L1B**
  - C6 reprocessing of Terra and Aqua completed in 2012.
  - Forward processing of Terra and Aqua L1B started in 2012 and is currently at leading edge.
  - Terra L1B “reprocessed” in August 2014 to address trending in Band 5.
  - C6 L1 Products have been available to public since late 2012 from LAADS.

MODIS C6 Reprocessing Status

- **Atmosphere Products**
  - Reprocessing of L2 products from Aqua MODIS started in Dec 2013 and completed in April 2014.
  - Reprocessing of L2 products from Terra MODIS started in Oct 2014 and completed in March 2015.
  - Reprocessing of L3 product from Aqua MODIS completed in April 2015, and Terra MODIS in Sept 2015.
  - C6 Products have been available to public from LAADS: L2 Aqua MODIS since Jan 2014 and Terra MODIS since Dec 2014; L3 Aqua MODIS since May 2015 and Terra MODIS since Oct 2015.

Details in Reports at the Atmosphere break out session

MODIS C6 Reprocessing Status

- **Land Products**
  - Reprocessing of Tier1 block of products, including Land Surface Reflectance, Vegetation Index, LAI/FPAR, GPP, Sea-Ice, and Active Fire started in Feb 2015 and completed in Jan 2016. Forward processing of these products started in Jan 2016. These data have been released to public.
  - Reprocessing of Teir1 block products BRDF-Albedo and Land Surface Temperature products and Tier 2 Snow product expected to complete in August 2016.
  - C6 Algorithm changes for Teir2 block products, including MAIAC, LST from JPL, Burned Area, Land Cover and Land Cover Dynamics, VCF, Evapotranspiration, Daily Radiation and PAR, are currently under development and science testing. Reprocessing of these products will start following approval of the C6 algorithms by the product PIs.

Details in Reports at the Land Break out session

S-NPP VIIRS Land SIPS

- **Forward processing**
  - Generates the VIIRS Land L1B SDRs, L2 swath products (IPs and EDRs) using mix of IDPS OPS PGEs and Land SIPS variation of IDPS PGEs, and the L3 gridded products using the Land SIPS DDR algorithms.
  - L1B SDRs are generated from processing of NASA L1A using IDPS SDR calibration algorithms.
  - Products are generated in HDF4/HDF4-EOS format and are available to public from AS 3002 of LAADS. Most L2 and L3 daily products have retention period of 30 days. Some L3 daily and n-day products may be available for longer mission period.
  - Products were generated using the incremental build versions from IDPS, with build version Mx8.11 in use since March 4, 2016. Land SIPS will not install any future IDPS algorithm revisions.
  - Processing of data prior to April 1, 2016 used IDPS RDRs aggregated to ~5min granules. Since then Land SIPS processing has been using the 5min granules of NASA L1A generated from the NASA L0 data.

Details in Reports at the Land Break out session

S-NPP VIIRS Land SIPS

- **C1.1 reprocessing**
  - Generated VIIRS land data products from beginning of the NPP mission (Feb 19, 2012) through Jan 31, 2016.
  - Included L1B SDRs, L1/L2 swath products (IPs and EDRs) generated using the Mx7.2 based IDPS OPS algorithms and Land SIPS variation of the IDPS algorithms, and L3 daily and n-day tiled products generated using the DDR algorithms based on the C5/C6 MODIS L2G/L3 algorithms.
  - L1B SDRs are generated using the calibration LUTs provided by the NASA VCST.
  - Products are in HDF4/HDF4-EOS format and is available to public from AS 3110 of LAADS.

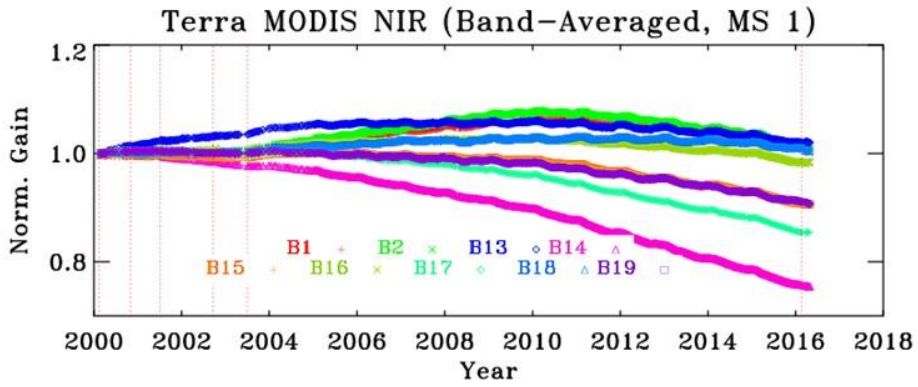
Details in Reports at the Land Break out session

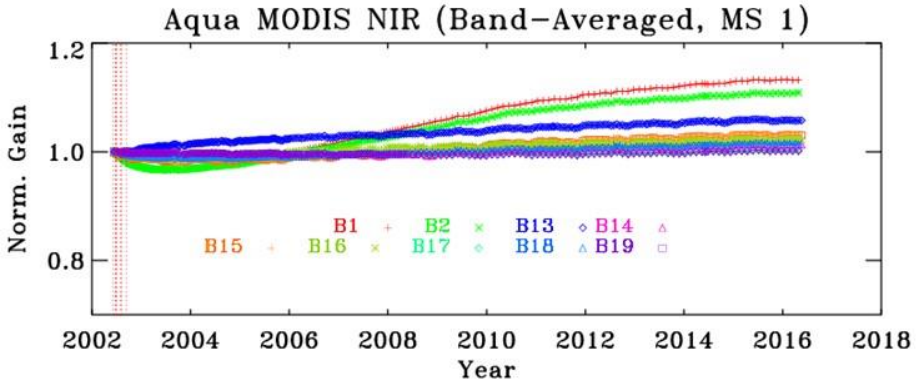
S-NPP VIIRS Land SIPS

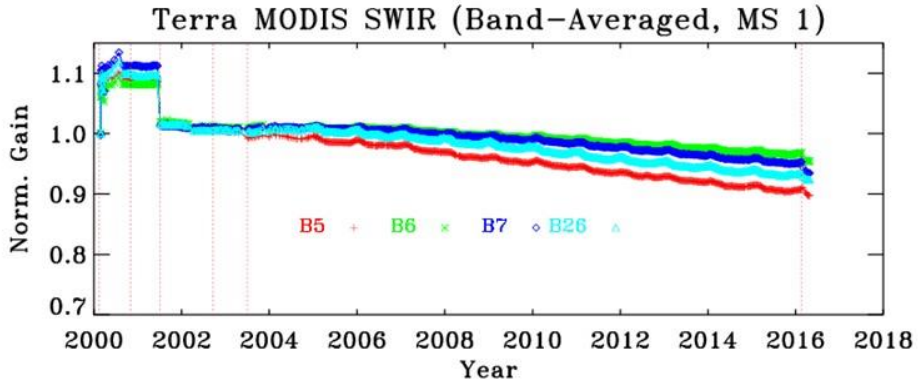
- **V1 Processing**
  - Will generate the MODIS heritage VIIRS products proposed by the NASA VIIRS science team.
  - L1B is generated by processing the NASA L1A using the NASA calibration algorithm and L1B LUTs provided by the NASA VCST.
  - L2 and L3 products are generated using the NASA science team delivered algorithms. Science team delivered algorithms are used in the V1 forward processing and reprocessing when they are approved by the science teams.
  - Algorithms for Land Surface Reflectance, Fire and Snow product are currently in science testing. Processing of Land Surface Reflectance Product suite is expected start in June 2016.
  - L1/L2 products are in HDF5/netcdf4 and L3/L4 products are in HDF5-EOS format.
  - Products are available to public from LP-DAAC and from LAADS.
  - NRT processing of VIIRS LSR and Fire products with Session-based L0 data is completed typically about 3.5 hrs after acquisition of data.

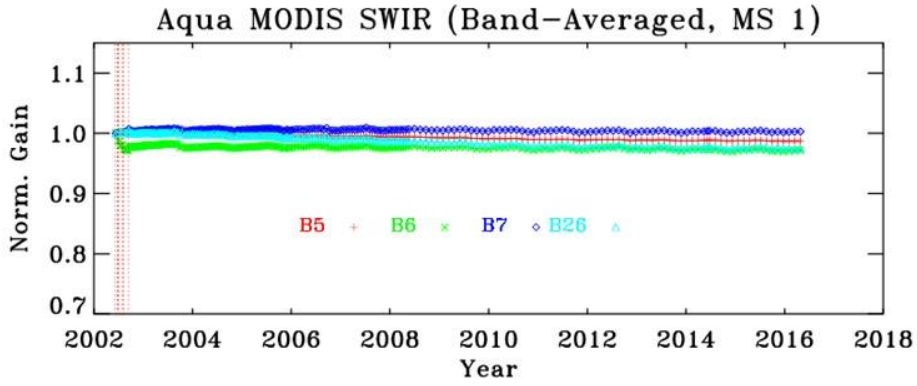
Details in Reports at the Land Break out session

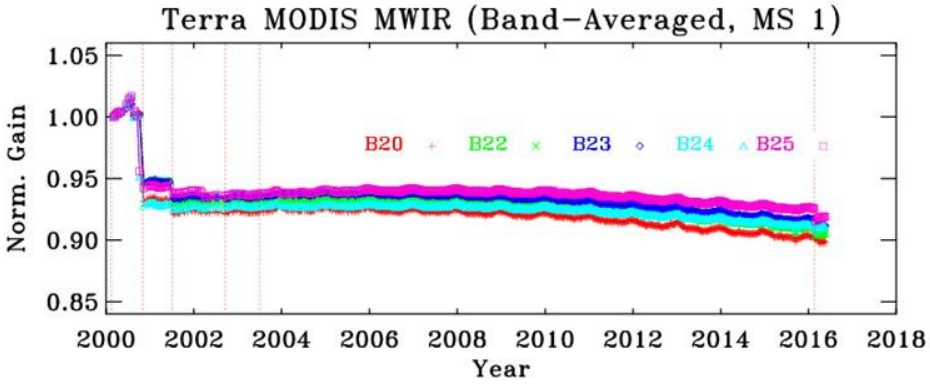
MODIS Spectral Band Responses (Gains)

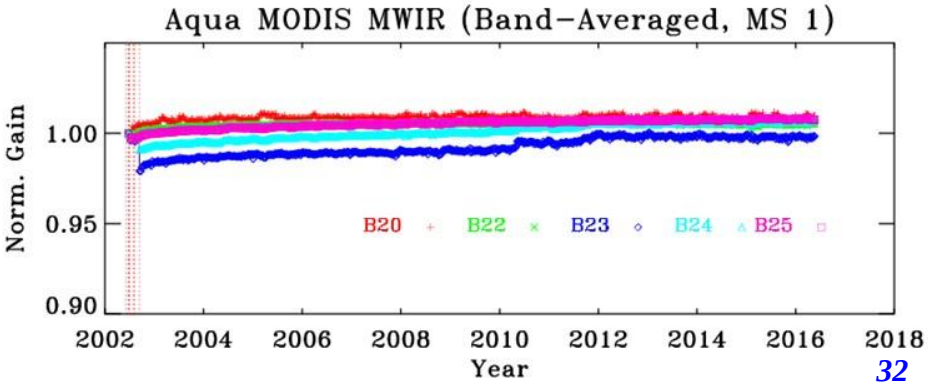












MODIS Instrument Operation

☺ **No Changes to both Instrument Operation Configurations and OBC fucntions since Last Science Team Meeting (details on MCST website)**

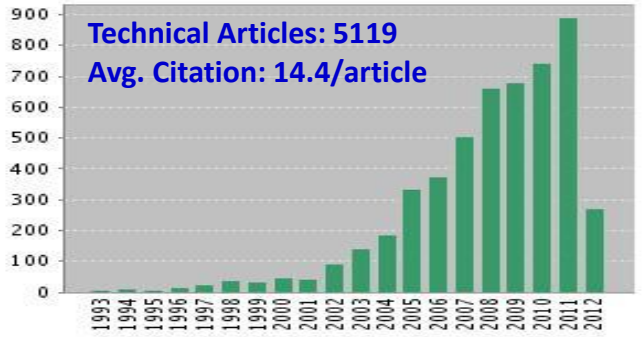
Terra MODIS

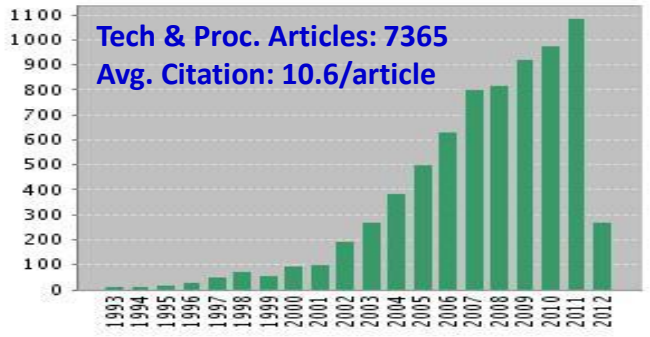
- Launch: Dec 18, 1999
- First light: Feb 24, 2000
- A-side: launch - Oct 30, 2000
- B-side: Oct 30, 2000 - June 15, 2001
- A-side: July 02, 2001 - Sept 17, 2002
- A-side electronics & B-side formatter: since Sept 17, 2002
- BB nominally set at 290 K
- SD door fixed at "open" since July 02, 2003
- SRCA operated with 2 10-W lamps since 2006
- CFPA controlled at 83 K (briefly at 85 K: 3-5 Aug 2000)

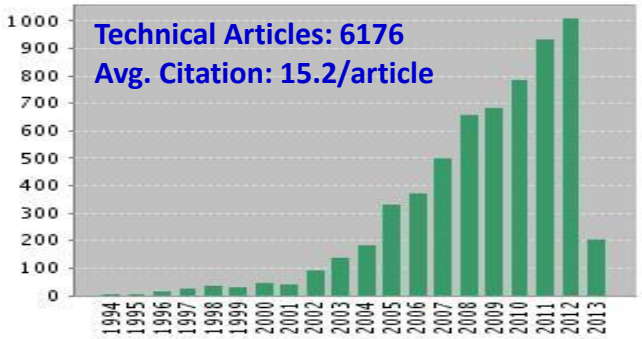
Aqua MODIS

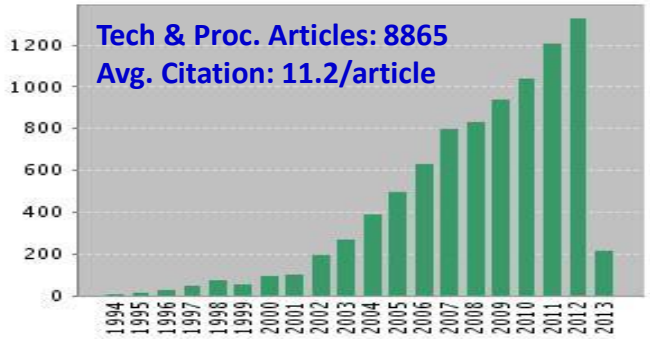
- Launch: May 04, 2002
- First light: June 24, 2002
- B-side: launch - present
- BB nominally operated at 285 K
- SD calibration: gradually reduced frequency
- SRCA operated with 2 10-W lamps since 2005
- CFPA controlled at 83 K (small increase of CFPA temperatures since 2007)

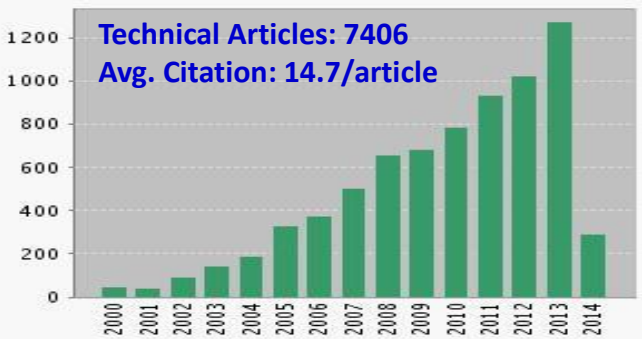
MODIS Publication Metrics

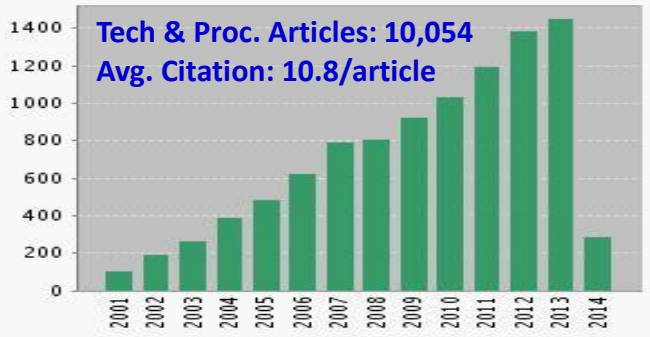


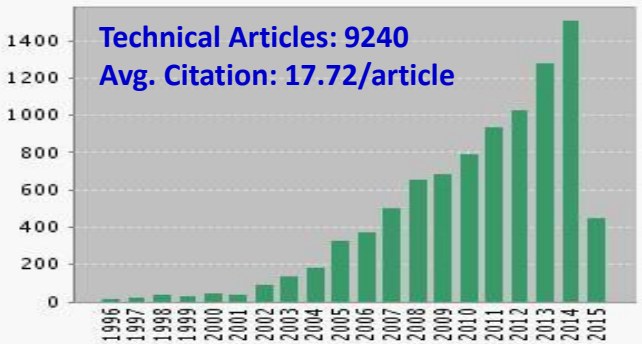


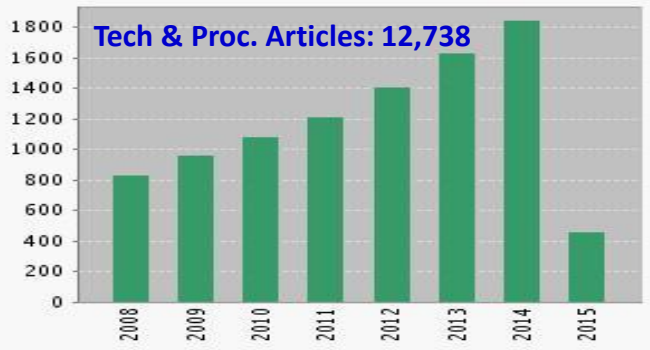












Goggle Scholar (05/12/2015)

NASA Hubble: 114,000

NASA MODIS: 76,500

NASA Landsat: 54,800

Goggle Scholar (05/31/2016)

NASA Hubble: 149,000

NASA MODIS: 101,000

NASA Landsat: 68,100

VIIRS and MODIS Spectral Bands

16 Moderate (radiometric) bands, 5 Imaging bands, 1 DNB

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

1 DNB

14 RSB
(0.4-2.3 μm)

Dual Gain Bands:
M1-M5, M7, M13

7 TEB