Terra and Aqua MODIS Instrument Status

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Code 618.0, NASA Goddard Spaced Flight Center

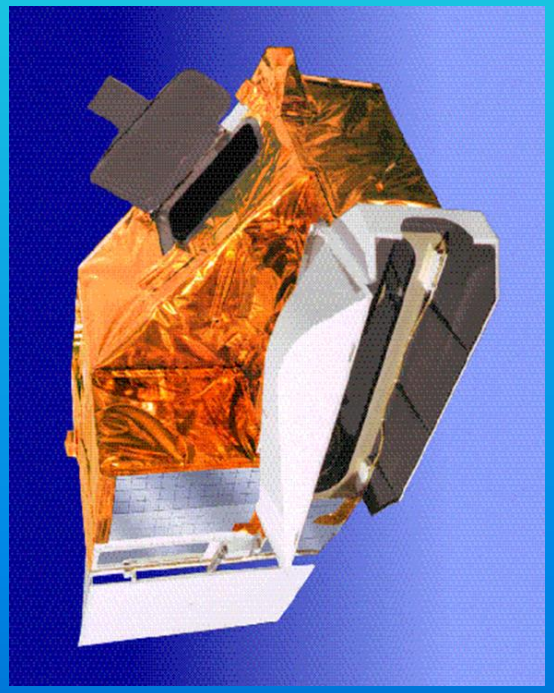
Contributions:

MODIS Characterization Support Team (MCST)

MODIS Science Team Meeting, Silver Spring, MD 20910 (May 7, 2012)

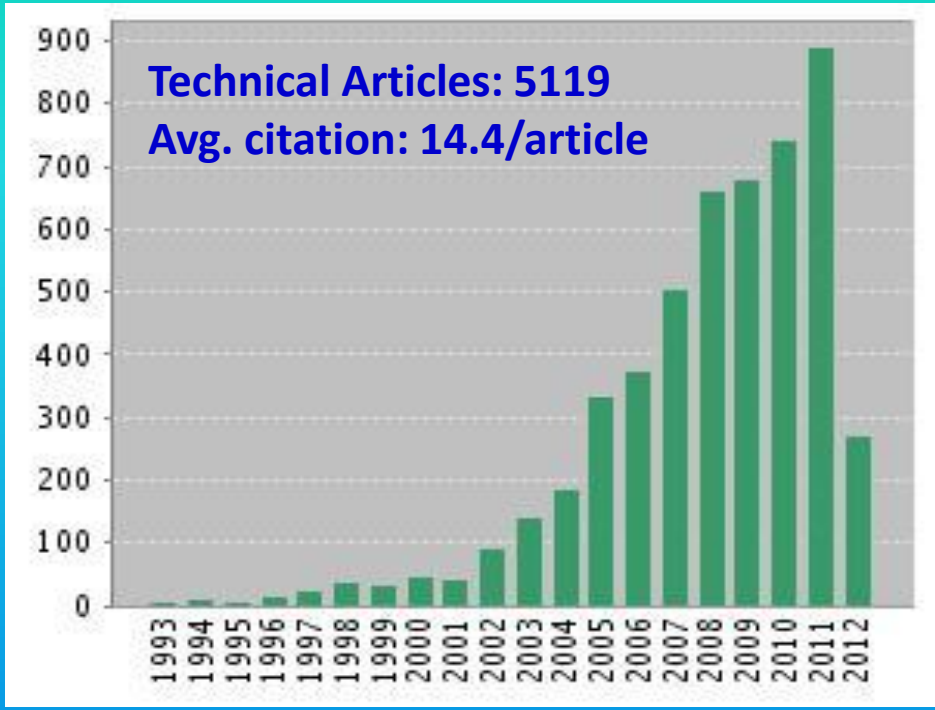
MODerate Resolution Imaging Spectroradiometer (MODIS)

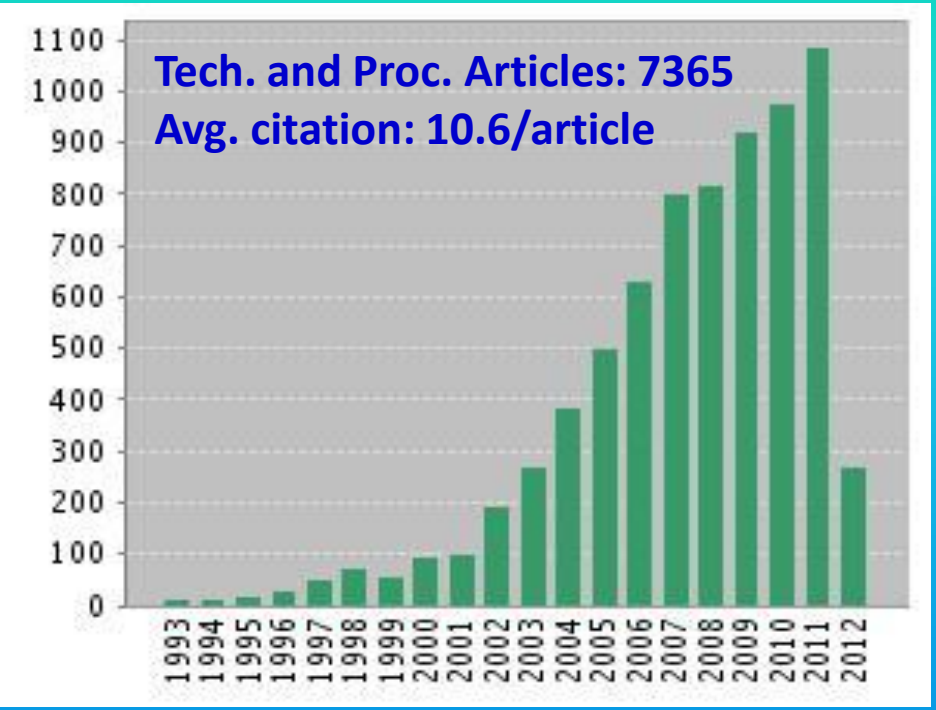
MODIS on both Terra and Aqua missions



Applications: land, oceans, and atmosphere

MODIS Publication Metrics





Google Scholar "HITS"

	May 7, 2008	Jan 24, 2010	May 11, 2011	Apr 26, 2012
NASA Terra:	19000	27100	34100	45000
NASA Aqua:	8750	11800	16200	19800
NASA MODIS:	14800	19500	30400	43600

V. Salomonson

Outline

- **Instrument Operation and Calibration Activities**
- **On-orbit Performance**
  - Instrument and On-board Calibrators
  - Radiometric Performance
  - Geometric Performance
- **Collection 6 (Level 1B)**
- **Challenging Issues and Future Efforts**
- **Summary**

Instrument Operations

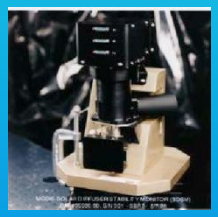
- Terra MODIS
  - A-side: launch to Oct 30, 2000
  - B-side: Oct 30, 2000 to June 15, 2001
  - A-side: July 02, 2001 to Sept 17, 2002
  - A-side electronics and B-side formatter: Sept 17, 2002 to present
  - SD door fixed at “open” since July 02, 2003
- Aqua MODIS
  - B-side configuration: launch to present
  - Cold FPA temperatures show small increase in recent years

Details on MODIS Instrument Operation and Calibration:
http://mcst.gsfc.nasa.gov/

On-orbit Calibration and Characterization

Solar diffuser (SD) and solar diffuser stability monitor (SDSM) for reflective solar bands (RSB) calibration

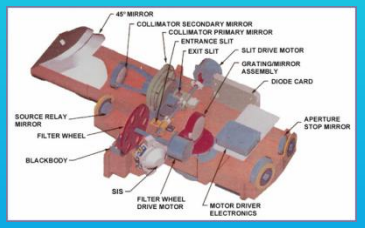
Spectroradiometric Calibration Assembly (SRCA) for instrument spectral and spatial characterization

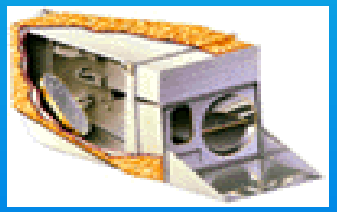


Solar Diffuser

SDSM

SRCA



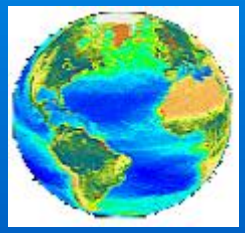


Scan Mirror

Blackbody

Space View

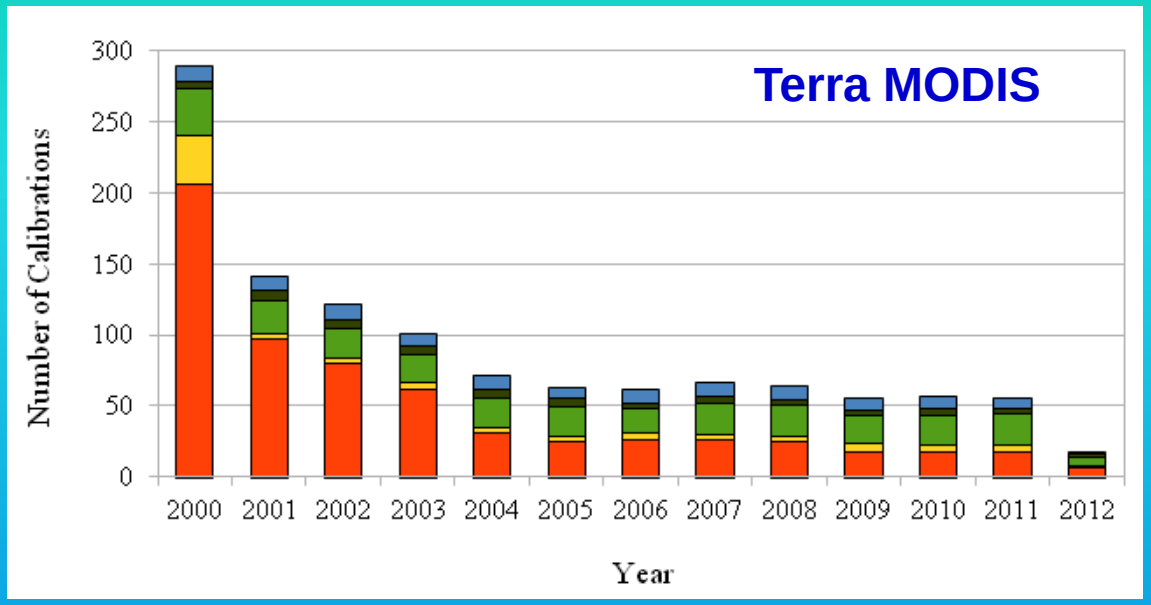
Blackbody (BB) for thermal emissive bands (TEB) calibration

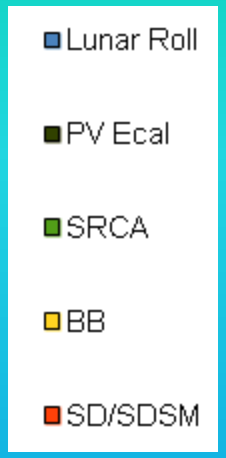


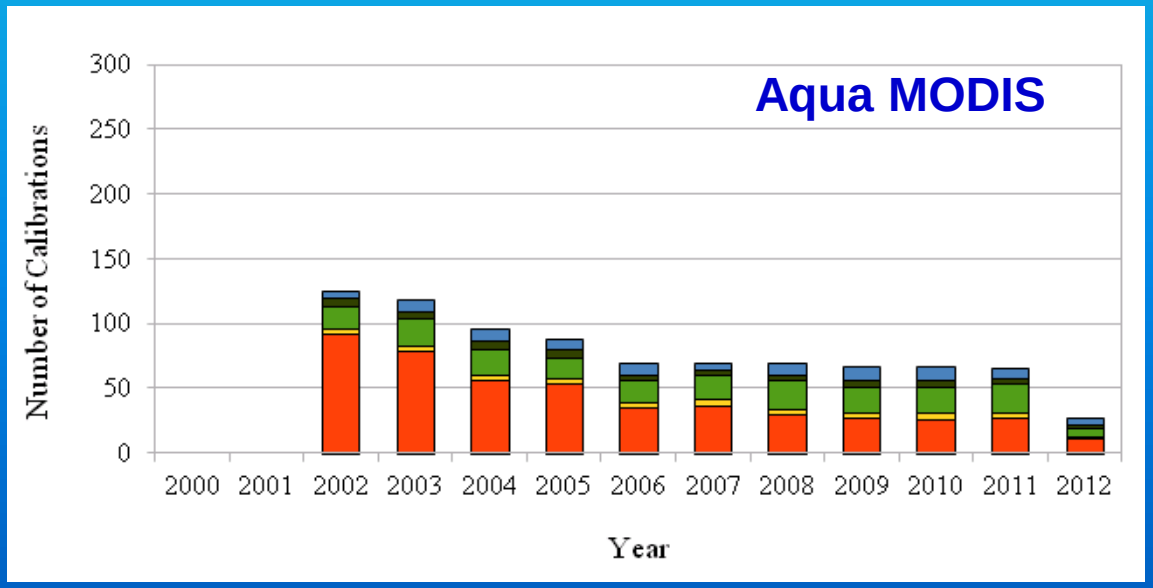
Stability monitoring using ground targets

Lunar views through SV port

Calibration and Characterization Activities







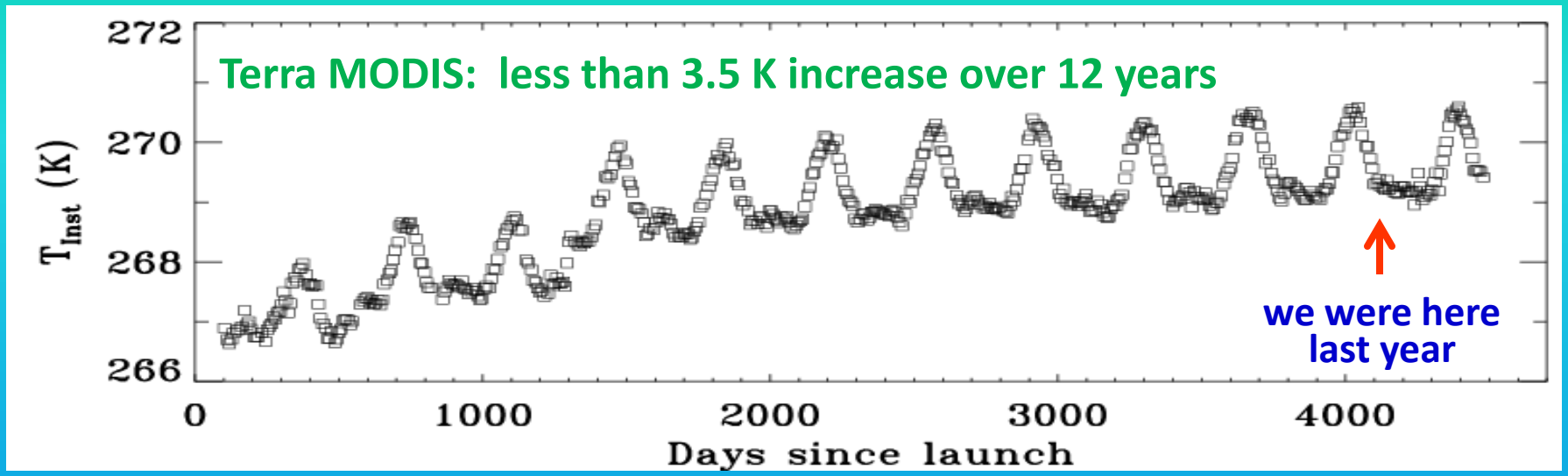
BB warm-up and cool-down (WUCD): 270 - 315K
SRCA: 3 modes

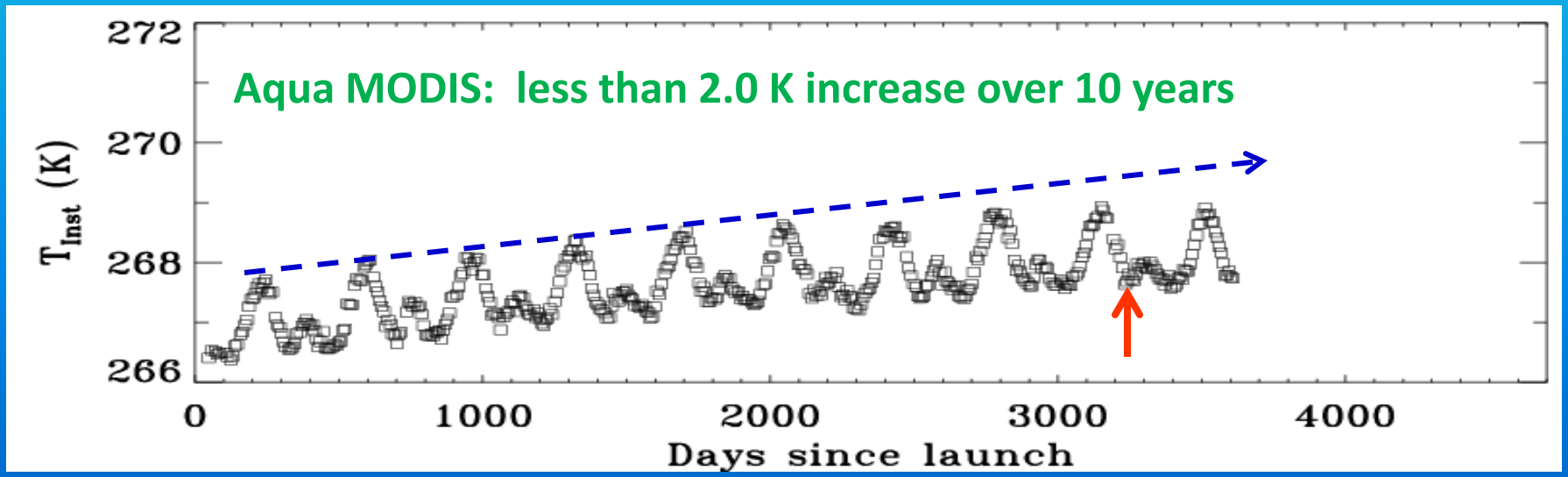
Others:
Maneuvers
Ground Targets
Inter-comparisons
Nighttime day mode ops

On-orbit Performance

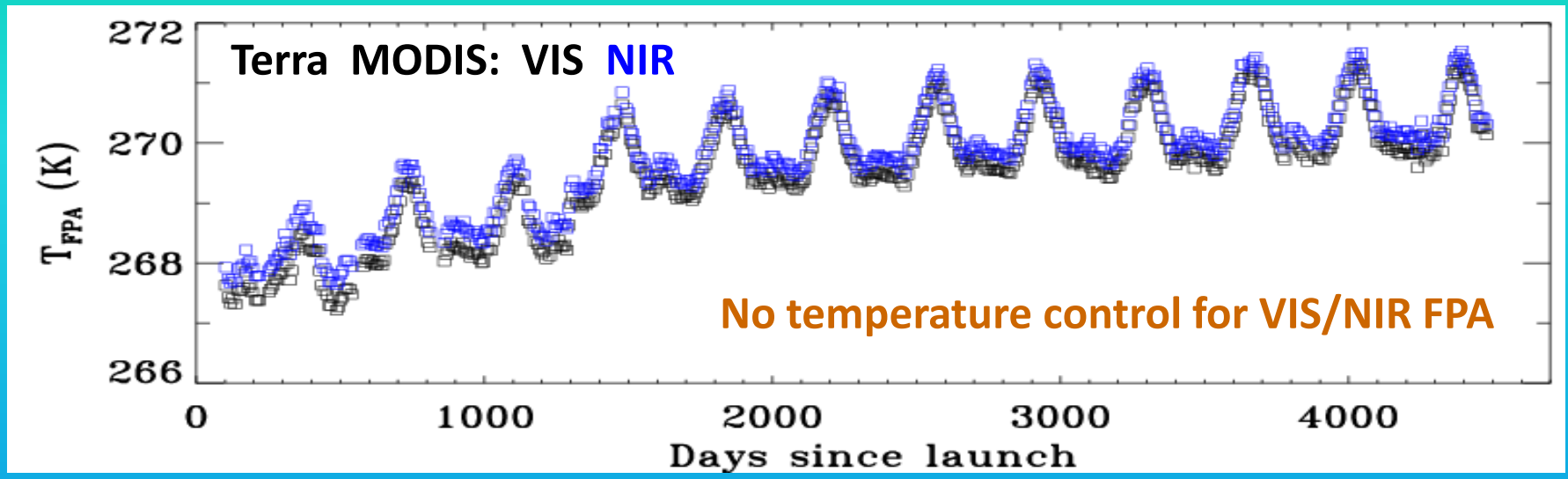
- Instrument and On-board Calibrators (OBC)
- Radiometric Performance
  - Spectral band responses
- Geometric Performance
  - Geolocations
- Spectral and Spatial
  - ✓ Stable performance (back-up slides)

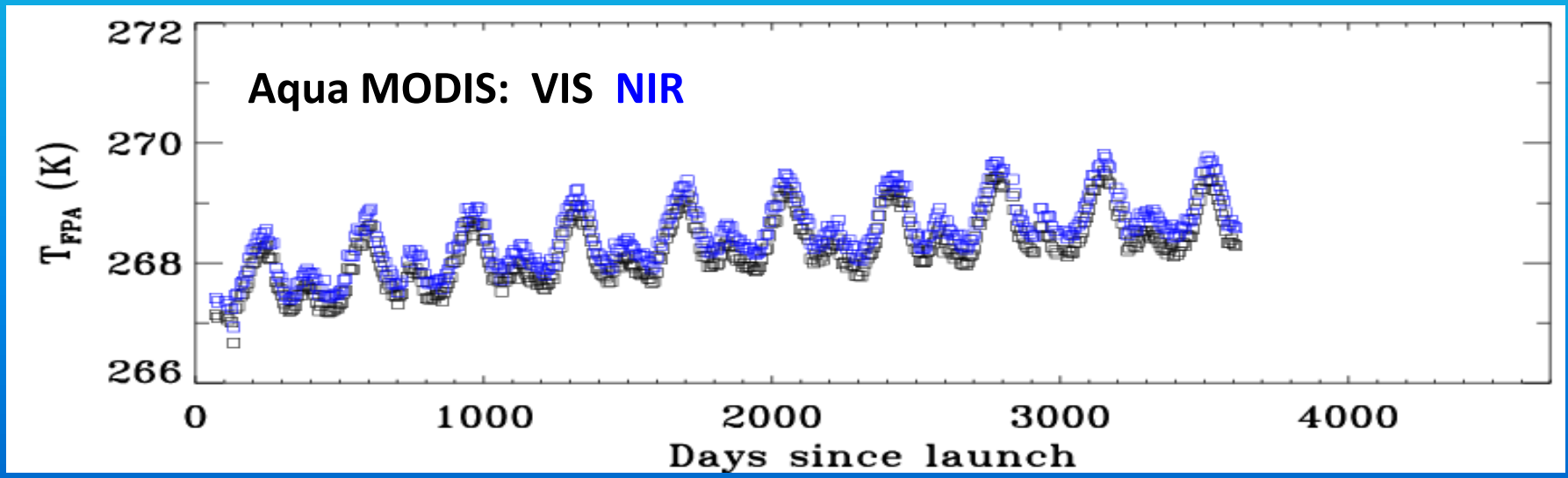
Instrument Temperatures





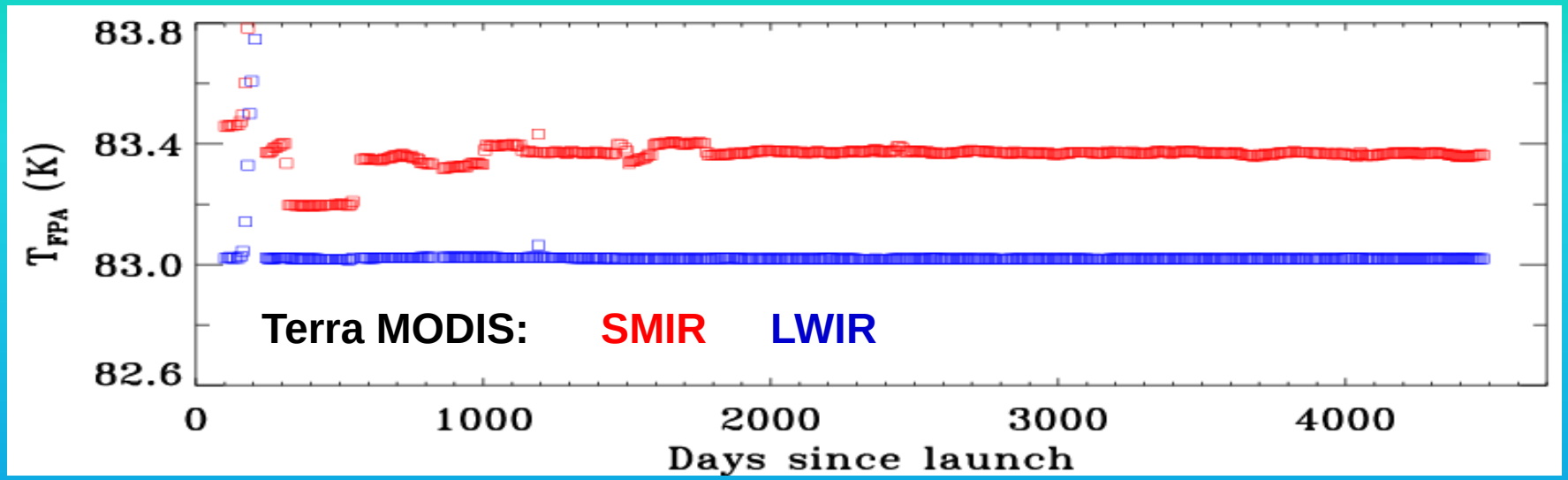
VIS and NIR FPA Temperatures

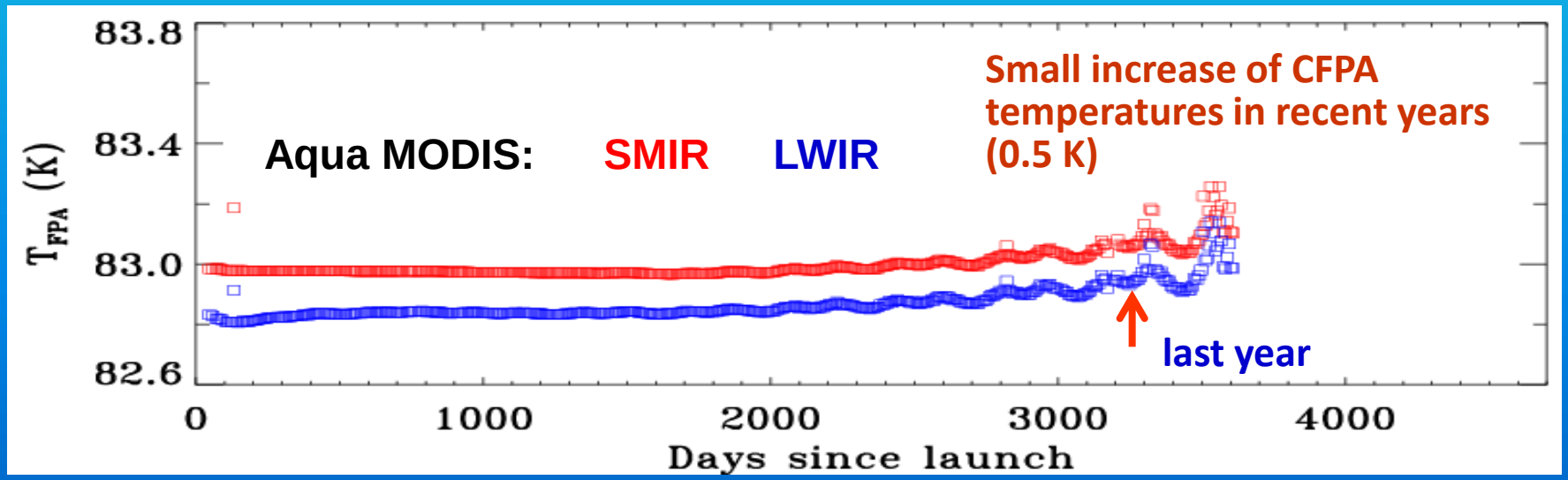




VIS & NIR FPA temperatures: similar to instrument temperatures

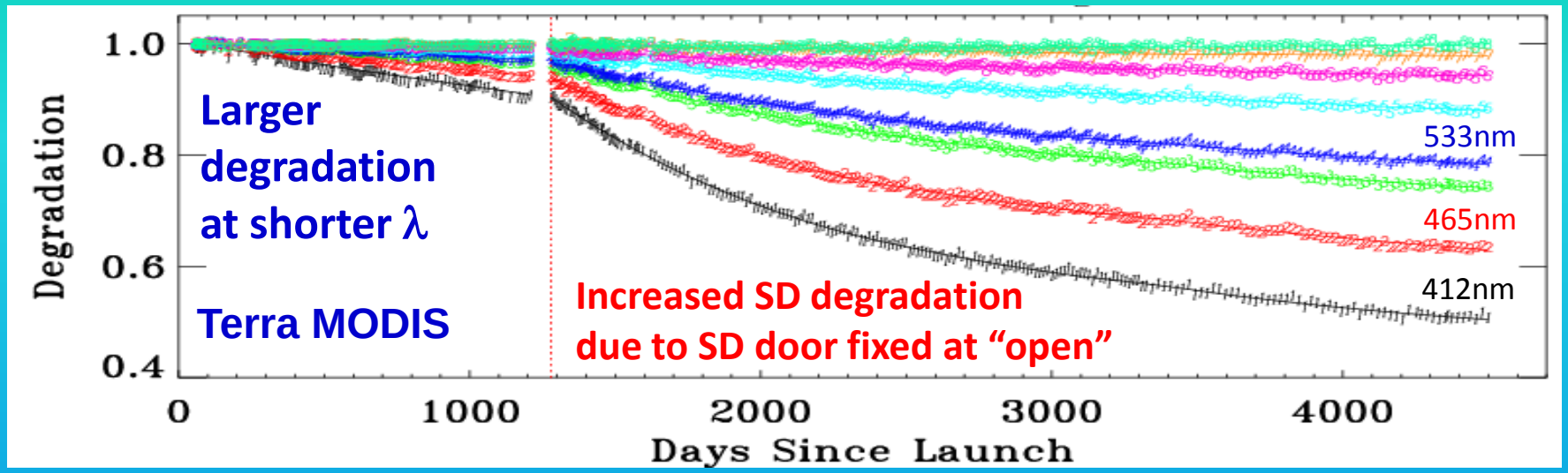
SMIR and LWIR FPA Temperatures

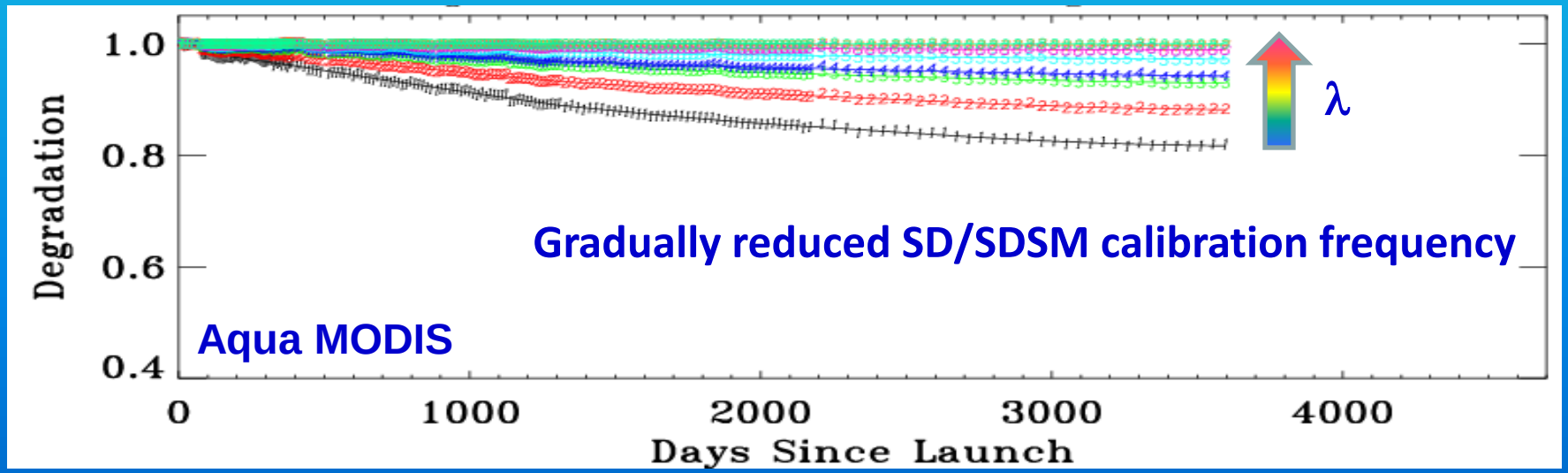




Performance Reviews (May 7, 2010, Apr 25, 2012): no change to operations

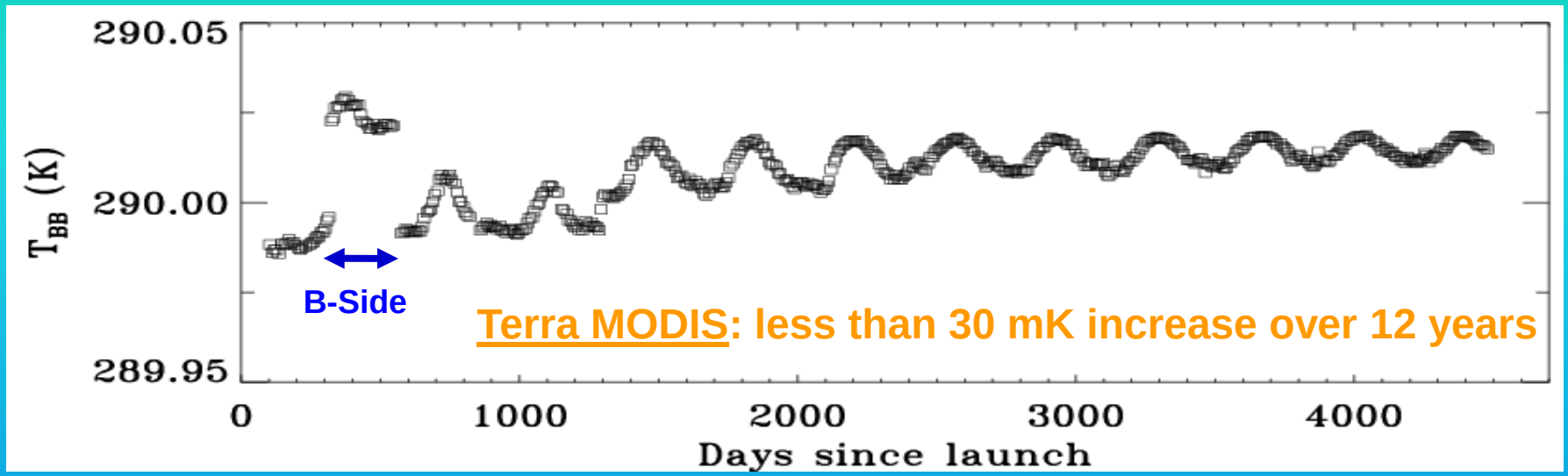
Solar Diffuser (SD) Degradation

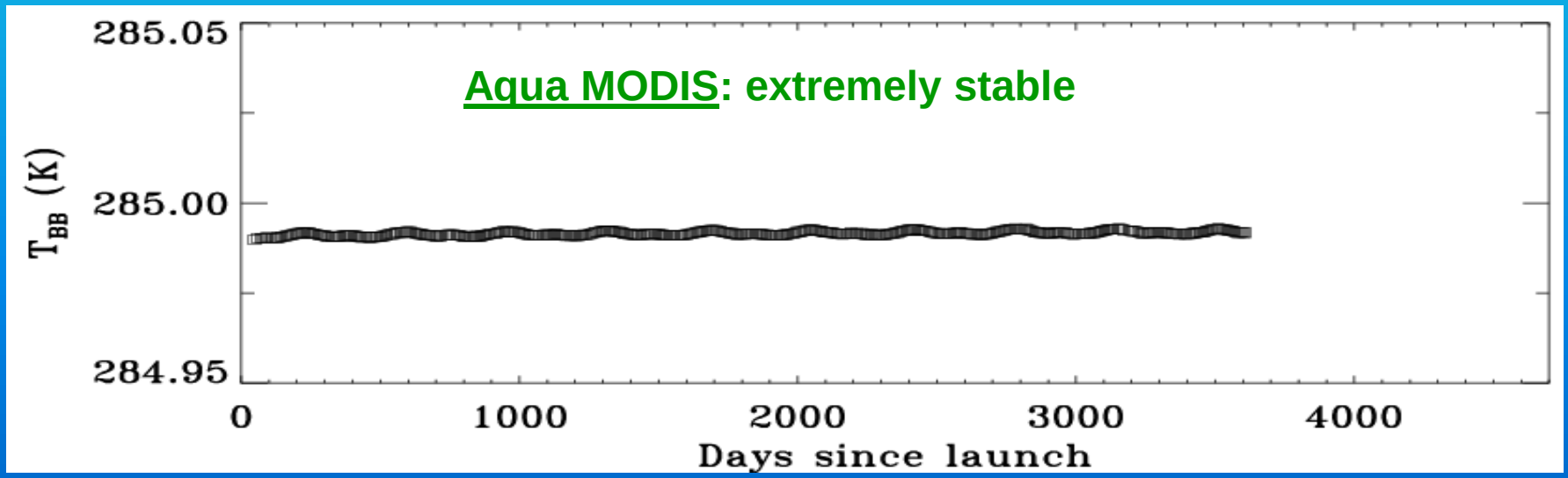




On-board SD used for Reflective Solar Bands (RSB) calibration

Blackbody Temperatures (nominal operation)

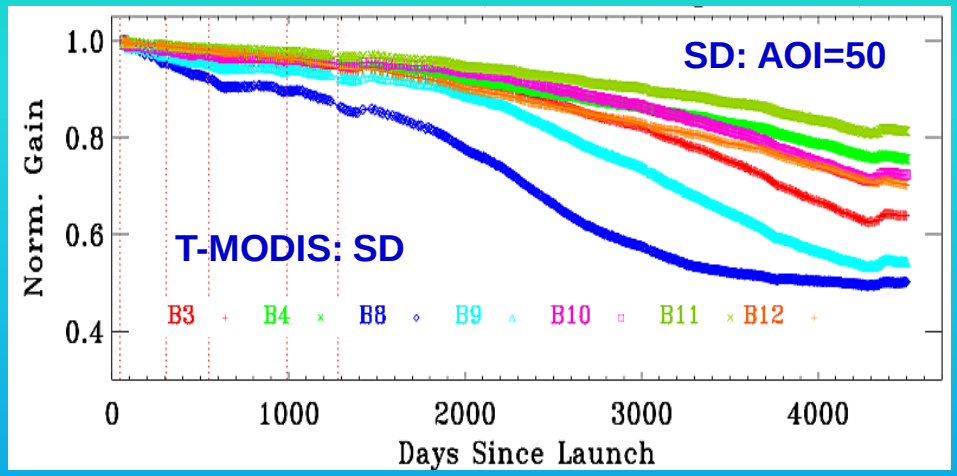


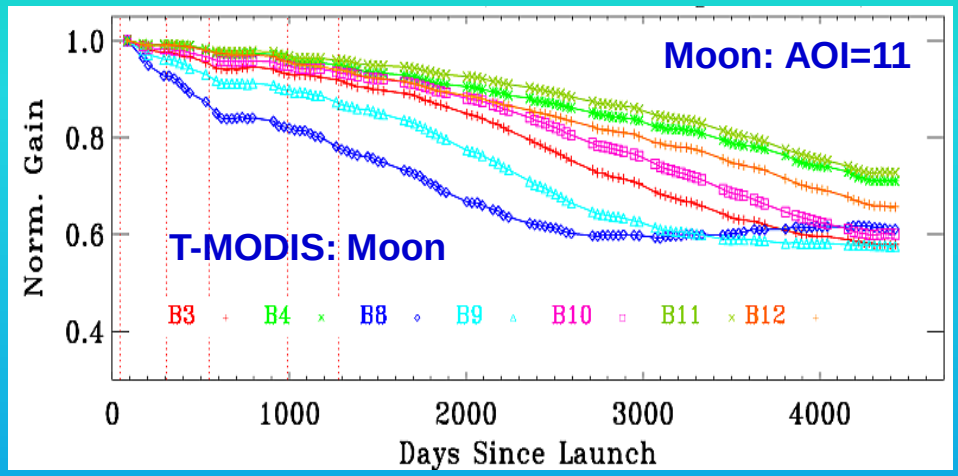


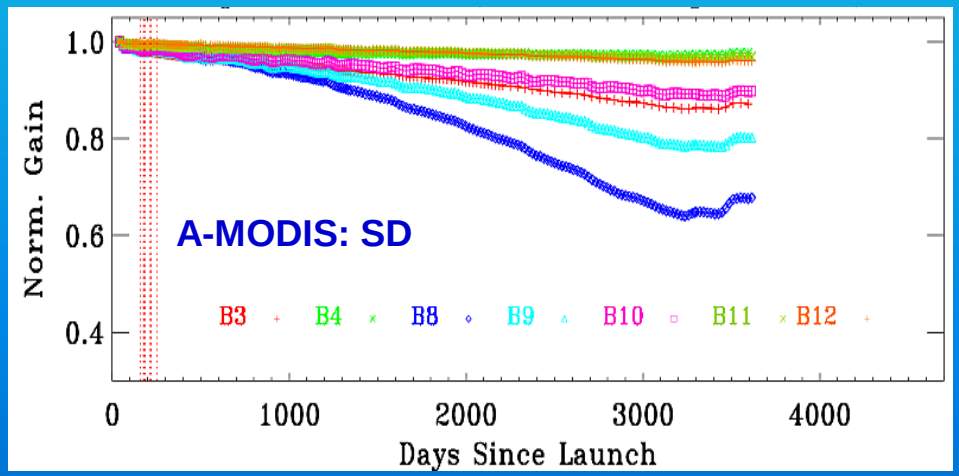
On-board BB used for Thermal Emissive Bands (TEB) calibration

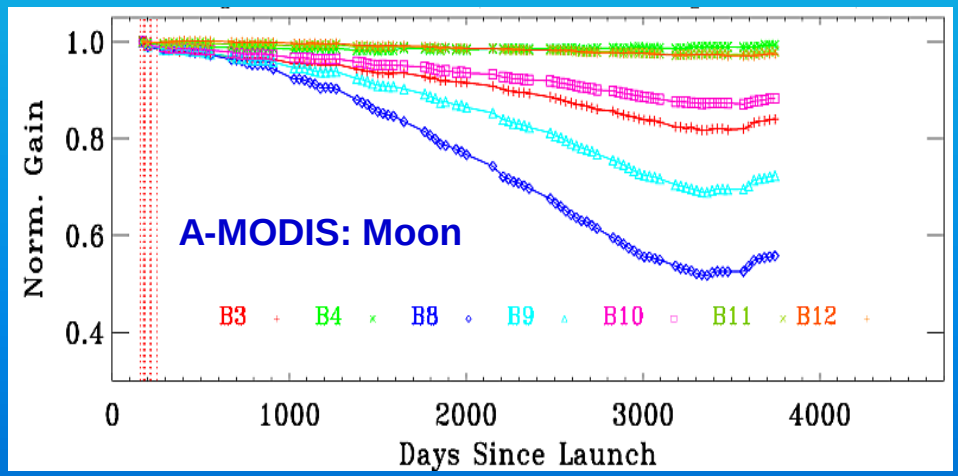
Spectral Band Responses (VIS)

Band Averaged, Mirror Side 1





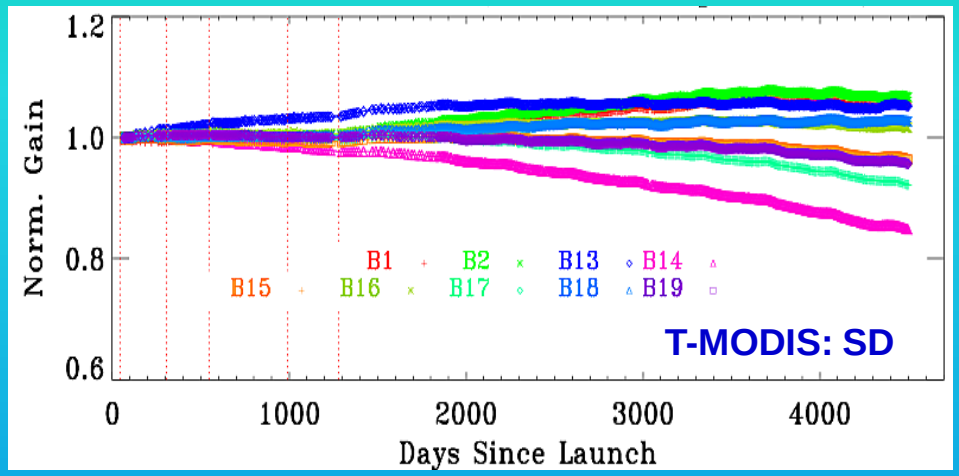


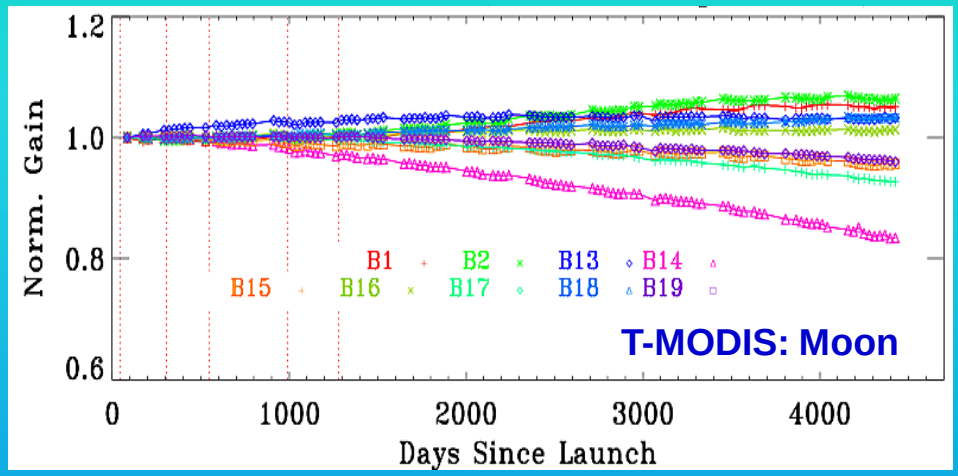


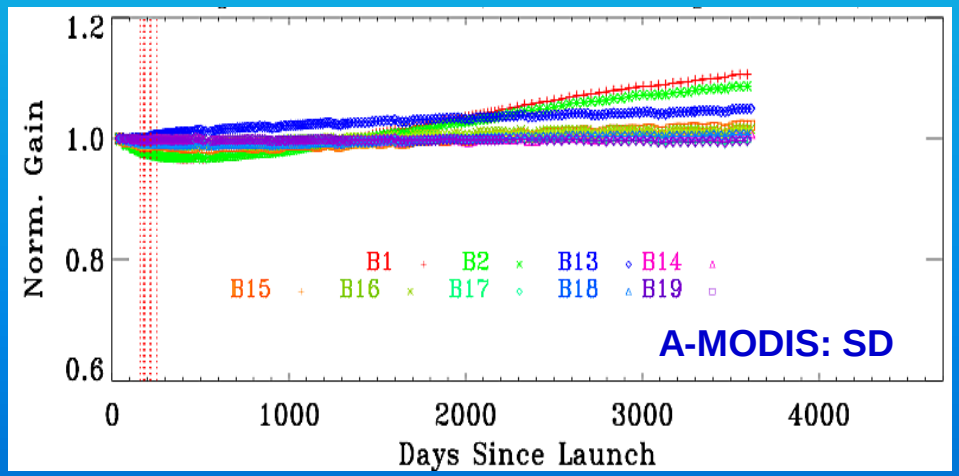
Terra/Aqua difference (large change at shorter wavelengths)
Wavelength, AOI, and mirror side dependent (small MS diff. in A-MODIS)

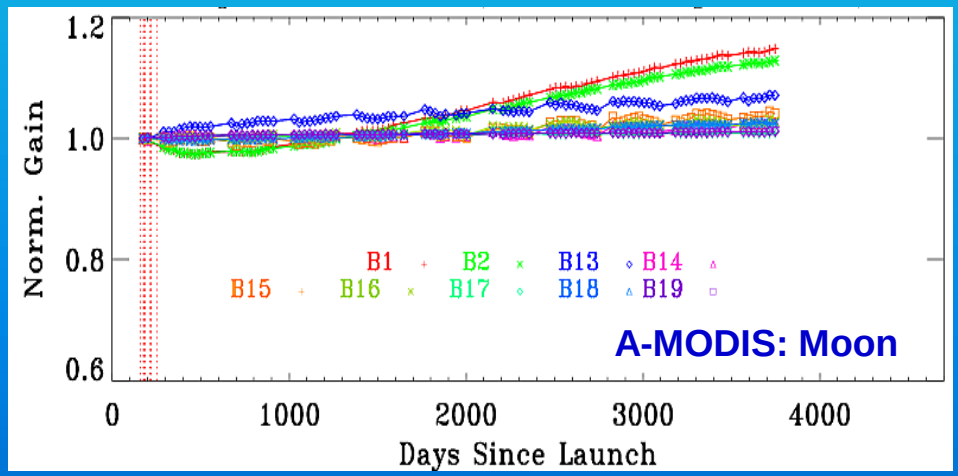
Spectral Band Responses (NIR)

Band Averaged, Mirror Side 1







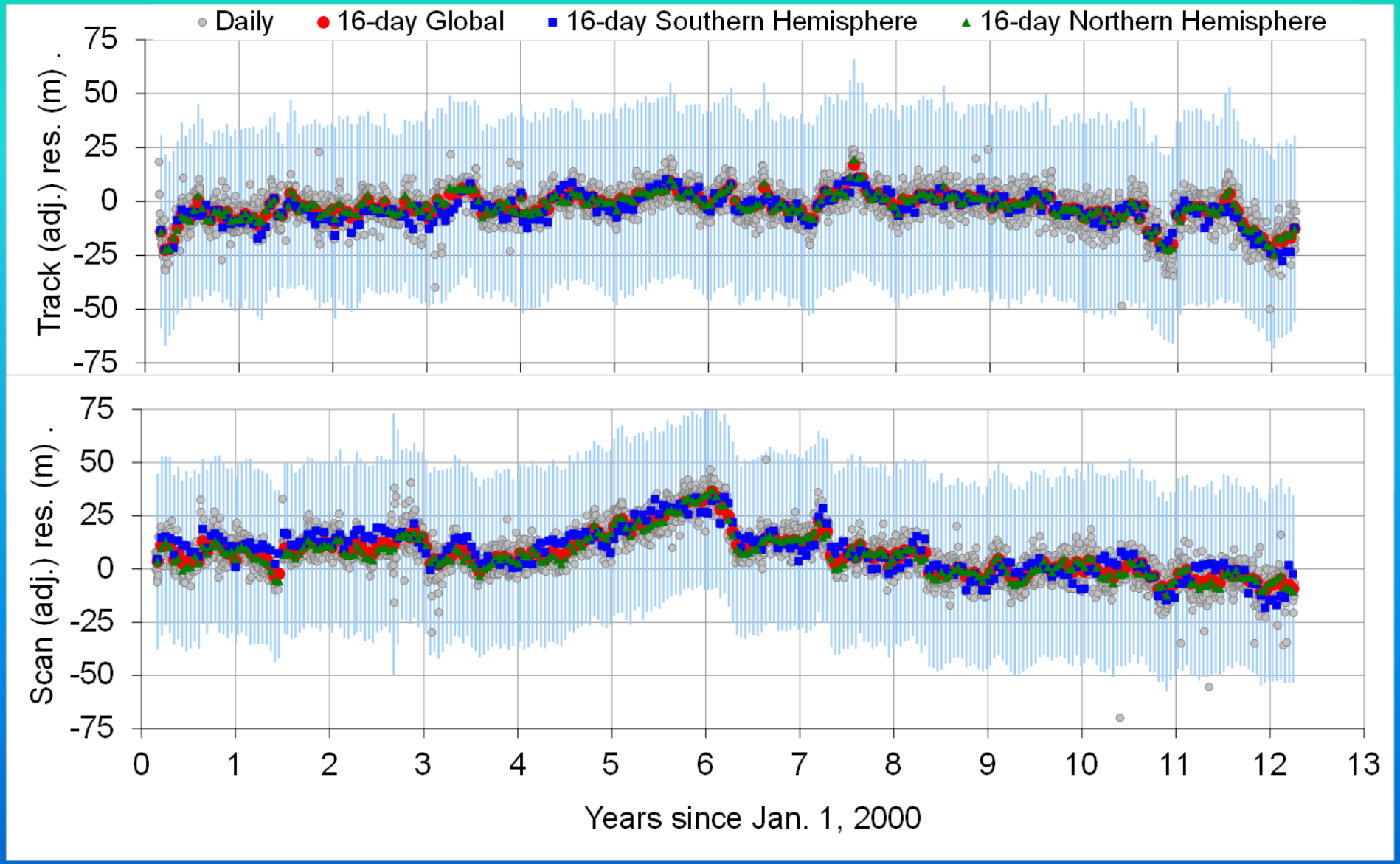


A few NIR bands show gain increase over time

Radiometric Performance Summary

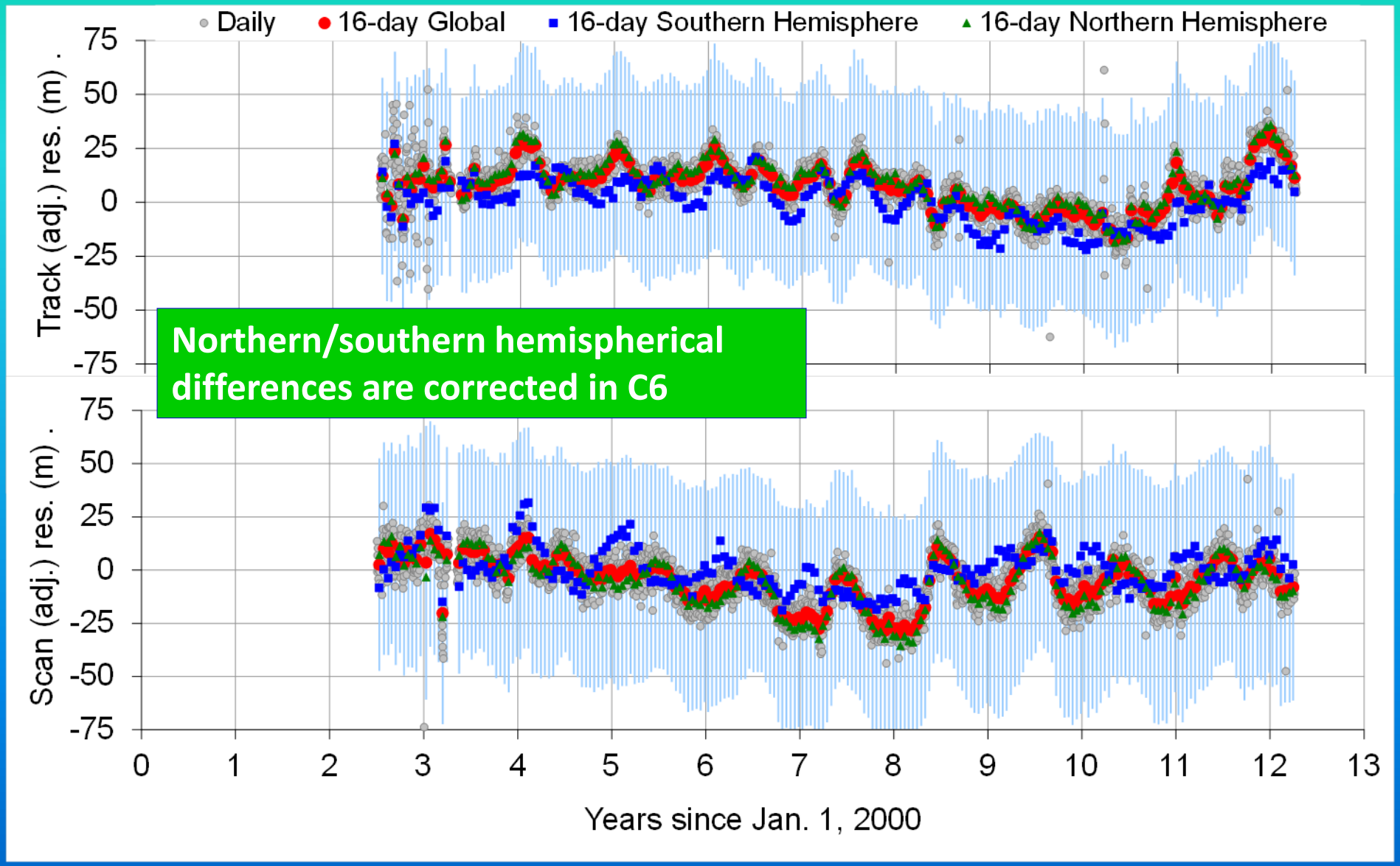
- Shorter wavelength VIS bands show larger degradation
  - Strong wavelength, mirror side, and scan angle dependent
  - MS difference in Aqua MODIS is much smaller than Terra MODIS
- A few NIR bands show gain increases over time
- Changes in SWIR responses have been very small
  - SWIR bands are located on CFPA with MWIR bands
- All TEB (MWIR and LWIR) performance has been stable (less than 2% change over entire missions)
  - Exception: Up to 10% response changes in Terra LWIR PV bands (27-30)
- Overall SNR and NEdT performance remains satisfactory
  - Only 1 new noisy detectors in last 3 years

Terra MODIS Geolocation Results (C5)



Robert Wolfe et al. Track RMS: 43m (C5) Scan RMS: 44m (C5)

Aqua MODIS Geolocation Results (C5)



Robert Wolfe et al. Track RMS: 48m (C5) Scan RMS: 53m (C5)

Collection 6 (L1B)

- Explicit fill value (SI = 65531) is used in L1B for inoperable detectors
  - Interpolation was applied in C5
- New detector QA flag for noisy and inoperable sub-samples
  - SI = 65525 for inoperable sub-samples (only apply to bands 1-7)
- FPA temperature correction is applied to default b1 (TEB linear calibration coefficient)
  - Default b1 only used when T_{BB} is above T_{SAT} for Aqua bands 33, 35, and 36 during BB WUCD
- Improved algorithms for uncertainty (UC) calculation in L1B
  - UC is computed based on L1B calibration and retrieval algorithms and sensor on-orbit performance (scene, time, AOI dependent)

Changes or Improvements from C5 to C6 (L1B)

Collection 6 (L1B)

- SD degradation at 936 nm is applied (0.6% in Aqua over 10 years)
  - Previous SD degradation is normalized at this wavelength
- Time dependent RVS applied to bands 13-16
  - Approach developed to monitor bands 13-16 lunar calibration stability (some pixels saturate when viewing the Moon)
- Detector dependent RVS
  - Mainly applied to VIS bands (e.g. Aqua bands 8-12)
- RSB calibration coefficients (m1) and RVS are derived at the same time using observations to the SD, Moon, and "pseudo-invariant" targets at different AOIs
  - Mainly applied to VIS bands (e.g. Aqua bands 8-9)

Changes or Improvements from C5 to C6 (L1B)

Collection 6 (C6) Reprocessing Plan

- C6 L1 and Cloud Mask/Profiles
  - C6 Aqua L1 and Cloud Mask/Profiles reprocessing completed, and the data is still in validation process by Atmos team
  - C6 Terra L1 and CloudMask/Profiles PGEs are baselined, and being tested by atmosphere and Land science teams
  - Plan to start C6 Terra L1 and Cloud Mask/Profiles data reprocessing in the summer of 2012 and complete the reprocessing in 3 months
- C6 Land and Atmospheres reprocessing
  - Atmospheres C6 reprocessing planned at 70x, hopefully starting in Fall 2012
  - Land C6 reprocessing will proceed at >30x and is expected to start in Oct 2012.
- LP and NSIDC DAACs will ingest land products into their archives at these production rates
- All C5/5.1 MODIS products will be archived in LAADS until the next complete reprocessing (C6.x or C7)

Details: Next Presentation by Ed Masuoka

G. Ye et al.

Challenging Issues and Future Efforts

- Large changes in VIS spectral band/detector response
  - Mirror side, wavelength, and AOI dependent
  - Impact on mirror polarization sensitivity
  - Less predictable trend
- Large SD degradation at short wavelengths, especially in Terra MODIS
  - Impact on SD calibration accuracy
- Effort to reduce the uncertainty of RSB RVS derived using ground targets
- Continue to monitor and examine the impact due to gradual increase of Aqua CFPA temperatures
- Continue to monitor and evaluate calibration consistency between Terra and Aqua MODIS
  - Scene dependent differences (offsets and trends)

Summary

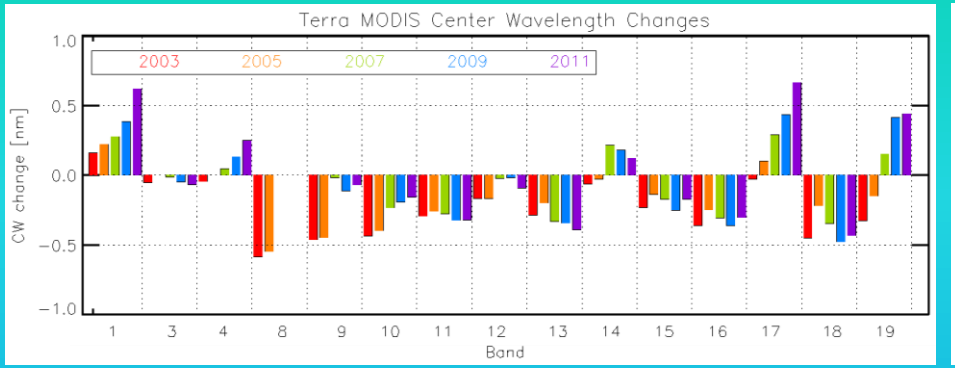
- Both Terra and Aqua MODIS continue to operate normally
- MODIS data products have significantly contributed to the science and user community
- Overall sensor performance has been satisfactory
- Dedicated calibration and characterization effort remains critical
- Communication between calibration and science discipline has become increasingly important

Backup Slides

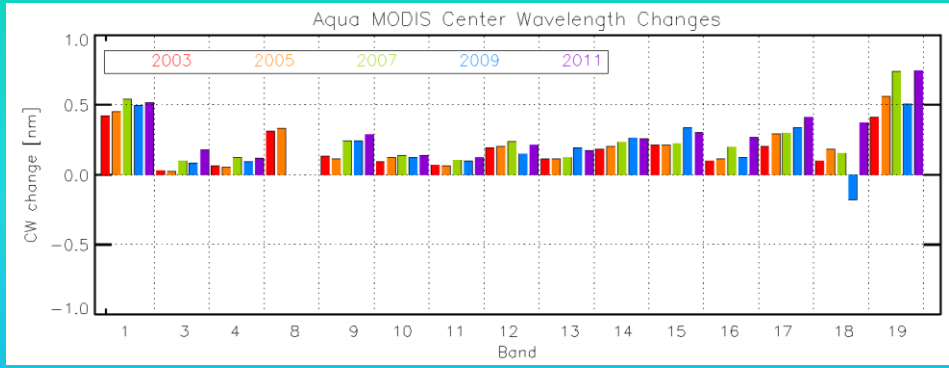
Performance Summary

- Radiometric (36 spectral bands with 490 individual detectors)
  - Only 1 new noisy detector since last STM (Aqua band 29 D6)
  - 45 noisy detectors (30 from pre-launch; 35 at launch) and no inoperable detectors for Terra MODIS
  - 7 noisy detectors (2 from pre-launch; 3 at launch) and 15 inoperable detectors (13 in band 6) for Aqua MODIS
- Spectral (VIS/NIR bands only)
  - Changes in center wavelengths and bandwidths are less than 0.5 and 1.0 nm, respectively, for most spectral bands (only a few exceptions)
- Spatial (all bands)
  - On-orbit band-to-band registrations (BBR) have been stable for both Terra and Aqua MODIS
  - Large BBR offsets in Aqua MODIS between cold FPA and warm FPA band pairs (a known problem since pre-launch)

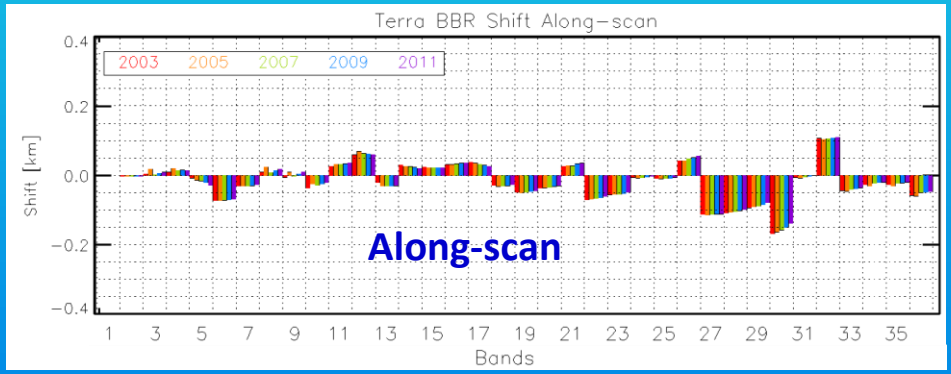
Terra MODIS CW Change

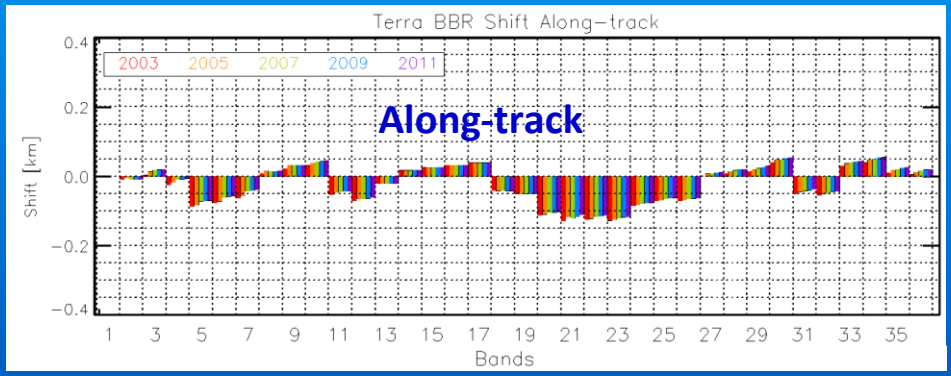


Aqua MODIS CW Change

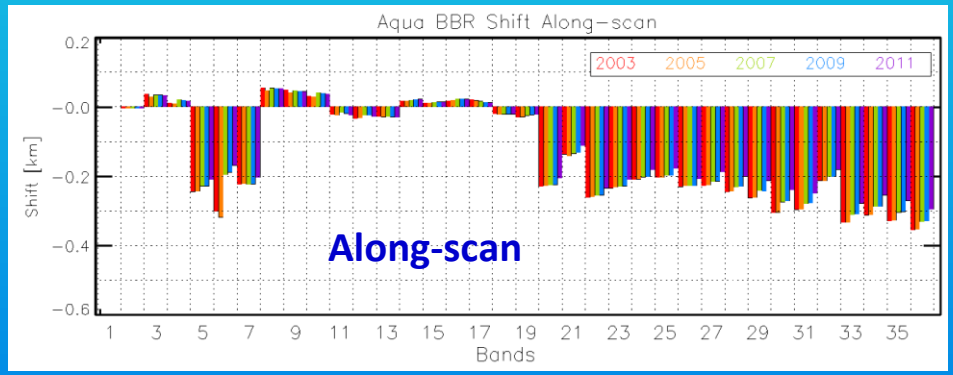


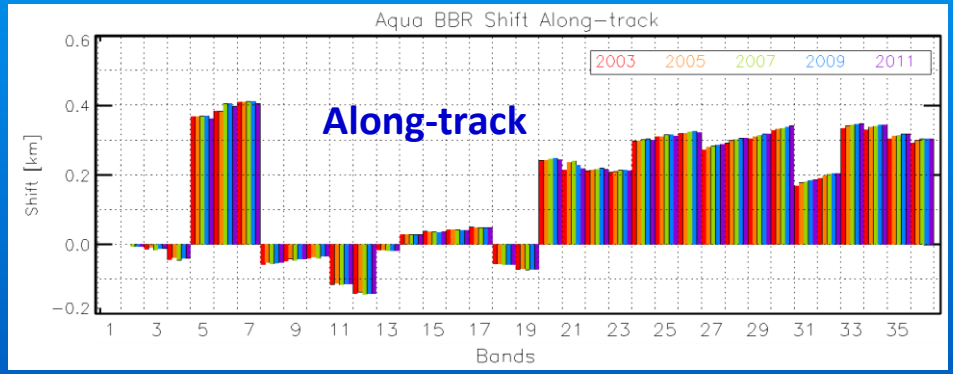
Terra MODIS BBR





Aqua MODIS BBR





Collection 5 (C5) Processing Status

- Forward processing is typically 1-2 days behind real time
- NRT processing is typically 1.5 hours after observations
- C5.1 Aqua and Terra Atmosphere data reprocessing completed except that Terra Deep Blue SDS parameters are fill values after 1/1/2008 due to lack of available polarization correction data
- Land C5.1 and C5.5 data reprocessing either completed or still running. The C4.1 LST (C4 code with C5 L1 input) is processed and archived along with C5/C5.1
- C5/C5.x products will be generated through the completion of C6 reprocessing

MODIS Specifications and Applications

Primary Use	Band	Bandwidth (nm)	Spectral Radiance[1]	Required SNR
Land/Cloud/Aerosols Boundaries	1	620 - 670	21.8	128
	2	841 - 876	24.7	201
Land/Cloud/Aerosols Properties	3	459 - 479	35.3	243
	4	545 - 565	29	228
	5	1230 - 1250	5.4	74
	6	1628 - 1652	7.3	275
	7	2105 - 2155	1	110
Ocean Color/ Phytoplankton/ Biogeochemistry	8	405 - 420	44.9	880
	9	438 - 448	41.9	838
	10	483 - 493	32.1	802
	11	526 - 536	27.9	754
	12	546 - 556	21	750
	13	662 - 672	9.5	910
	14	673 - 683	8.7	1087
	15	743 - 753	10.2	586
	16	862 - 877	6.2	516
Atmospheric Water Vapor	17	890 - 920	10	167
	18	931 - 941	3.6	57
	19	915 - 965	15	250

Primary Use	Band	Bandwidth (nm)	Spectral Radiance[1]	Required NEDT(K)
Surface/Cloud Temperature	20	3.660 - 3.840	0.45 (300K)	0.05
	21	3.929 - 3.989	2.38 (335K)	0.2
	22	3.929 - 3.989	0.67 (300K)	0.07
	23	4.020 - 4.080	0.79 (300K)	0.07
Atmospheric Temperature	24	4.433 - 4.498	0.17 (250K)	0.25
	25	4.482 - 4.549	0.59 (275K)	0.25
Cirrus Clouds Water Vapor	26	1.360 - 1.390	6	150 (SNR)
	27	6.535 - 6.895	1.16 (240K)	0.25
	28	7.175 - 7.475	2.18 (250K)	0.25
Cloud Properties	29	8.400 - 8.700	9.58 (300K)	0.05
Ozone	30	9.580 - 9.880	3.69 (250K)	0.25
Surface/Cloud Temperature	31	10.780 - 11.280	9.55 (300K)	0.05
	32	11.770 - 12.270	8.94 (300K)	0.05
Cloud Top Altitude	33	13.185 - 13.485	4.52 (260K)	0.25
	34	13.485 - 13.785	3.76 (250K)	0.25
	35	13.785 - 14.085	3.11 (240K)	0.25
	36	14.085 - 14.385	2.08 (220K)	0.35

[1] Spectral Radiance values are (W/m^2-μm-sr)

- *20 reflective solar bands (RSB: bands 1-19, and 26) from 0.41 - 2.2μm*
- *16 thermal emissive bands (TEB: bands 20-25, 27-36) from 3.5 - 14.4μm*