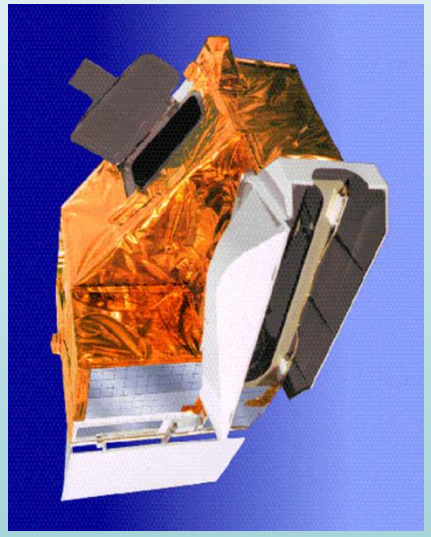
Terra and Aqua MODIS Instrument Status



Jack Xiong (*NASA/GSFC*)

Contributions:

MODIS Characterization Support Team (MCST)

MODIS Science Team Meeting, Silver Spring, MD 20910 (April 15, 2013)

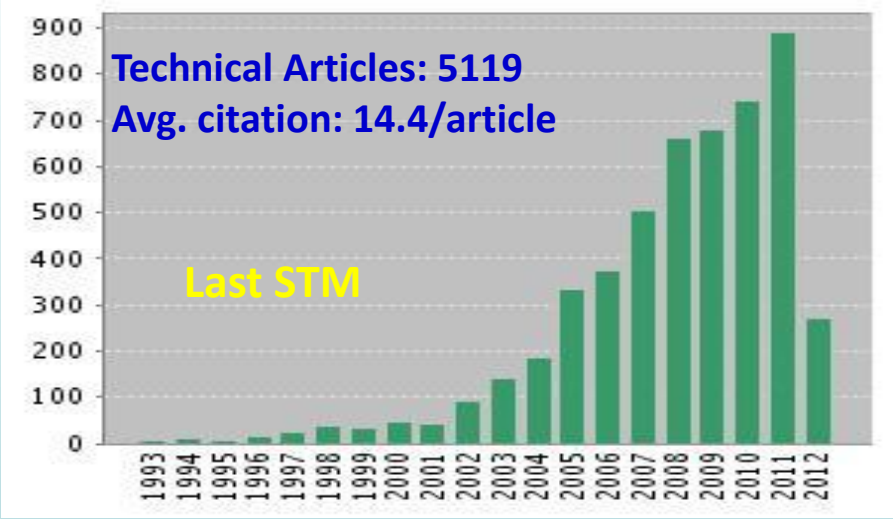
Outline

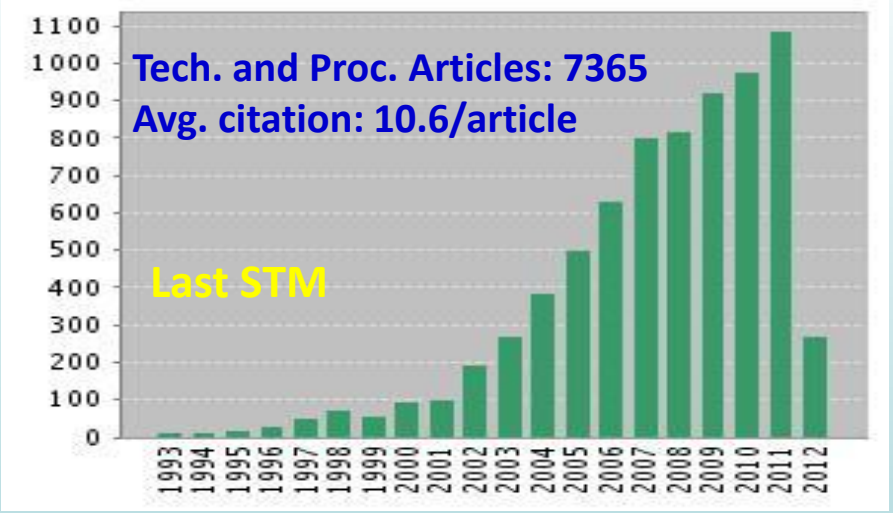
- **Highlights (since last STM)**
- Instrument Operations
- Calibration and Characterization Activities
- On-orbit Performance
- Challenging Issues and Future Efforts
- Summary

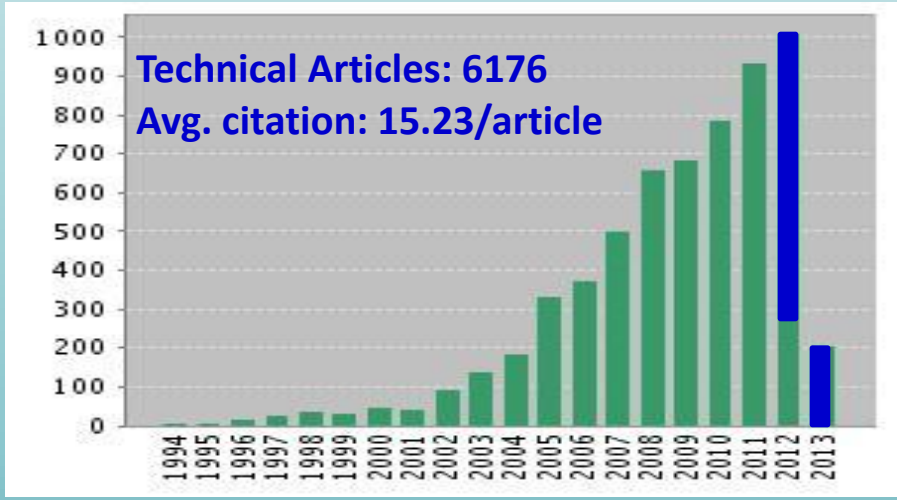
Highlights (since last STM)

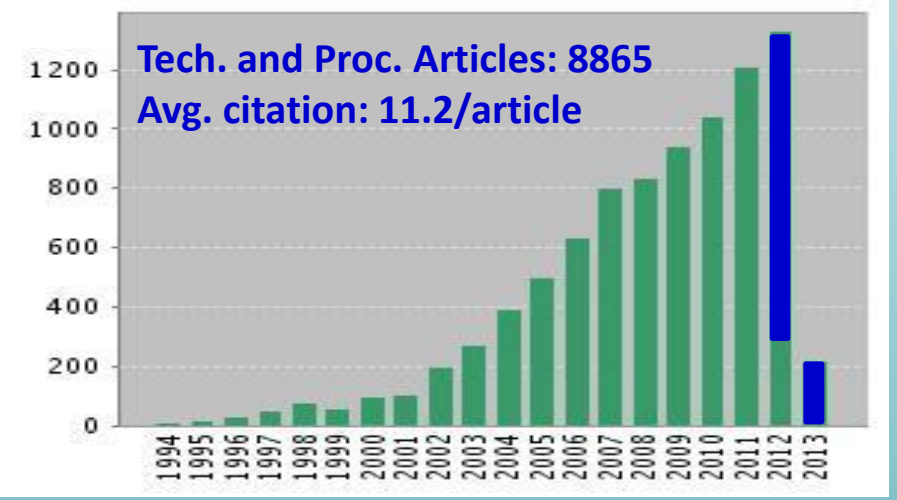
- **Both Terra MODIS (13 years) and Aqua MODIS (11 years) and their on-board calibrators continue to operate and function normally**
- **No new noisy and inoperable detectors in both Terra and Aqua MODIS**
- **Collection 6 L1B reprocessing completed and data released to public**
  - Atmos. and land reprocessing to be started in early May and July 2013
- **Support for Terra and Aqua Senior Review**
- **Support for Aqua AMSR-E spin-up**
- **Aqua MODIS CFPA Performance and Operation Review, March 27, 2013**
  - Previous reviews: May 2010 and April 2012
- **Strong science applications using MODIS observations and data products**
  - Over 1000 new technical article and 1500 new tech article and proceedings combined

MODIS Publication Metrics









Google Scholar "HITS"	May 7, 2008	Jan 24, 2010	May 11, 2011	Apr 26, 2012	April 3, 2013
"NASA Terra":	19000	27100	34100	45000	55800
"NASA Aqua":	8750	11800	16200	19800	26200
"NASA MODIS":	14800	19500	30400	43600	57500

Instrument Operations - 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 and B-side formatter: Sept 17, 2002 - present

- BB nominally set at 290 K
- SD door fixed at "open" since July 02, 2003
  - Large SD degradation
- SRCA operated with 2 10-W lamps since 2006
- CFPA controlled at 83 K (was set 85 K briefly: 3-5 Aug 2000)

Instrument Operations - Aqua MODIS

- Launch: May 04, 2002
- First light: June 24, 2002
- B-side: launch - present

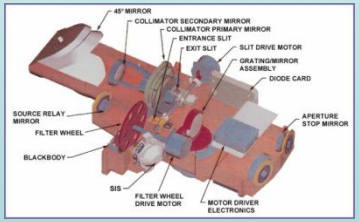
- BB nominally operated at 285 K
- SD calibration: gradually reduced frequency
- SRCA operated with 2 10-W lamps since 2005
- CFPA controlled at 83 K (was set 85 K briefly: 3-5 Aug 2000)
  - Small increase of cold FPA temperatures since 2007

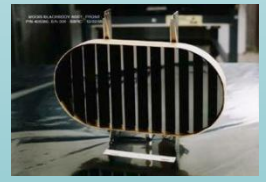
Details on MODIS Instrument Operation and Calibration:
http://mcst.gsfc.nasa.gov/

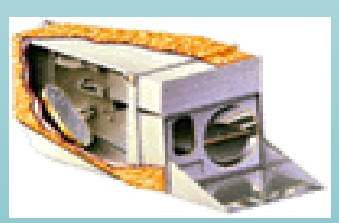
Calibration and Characterization Activities

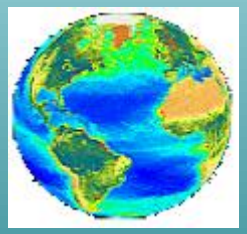
Solar diffuser (SD) and solar diffuser stability monitor (SDSM) for reflective solar bands (RSB) calibration

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







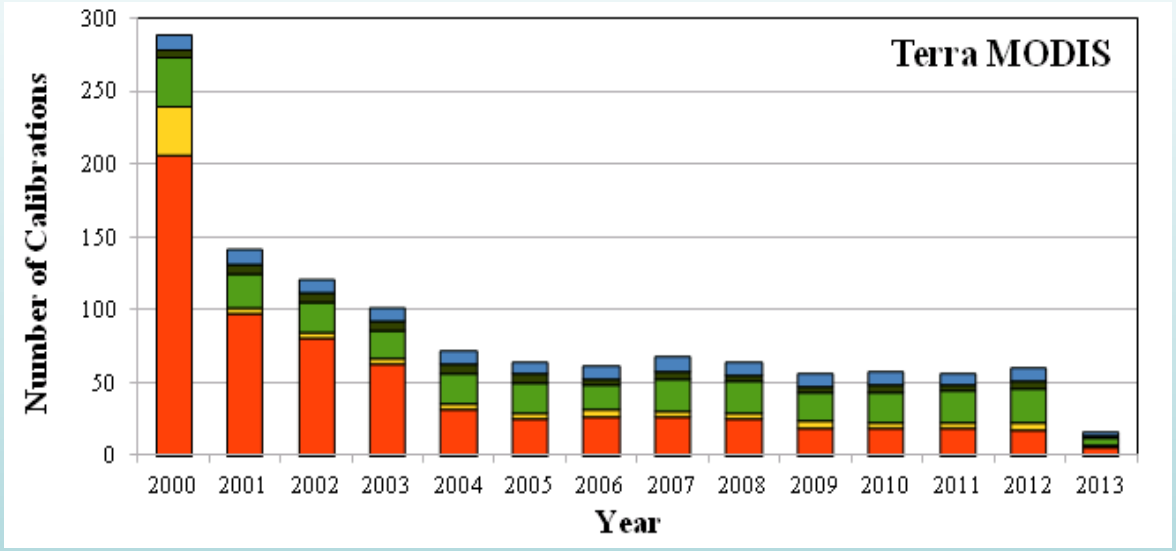


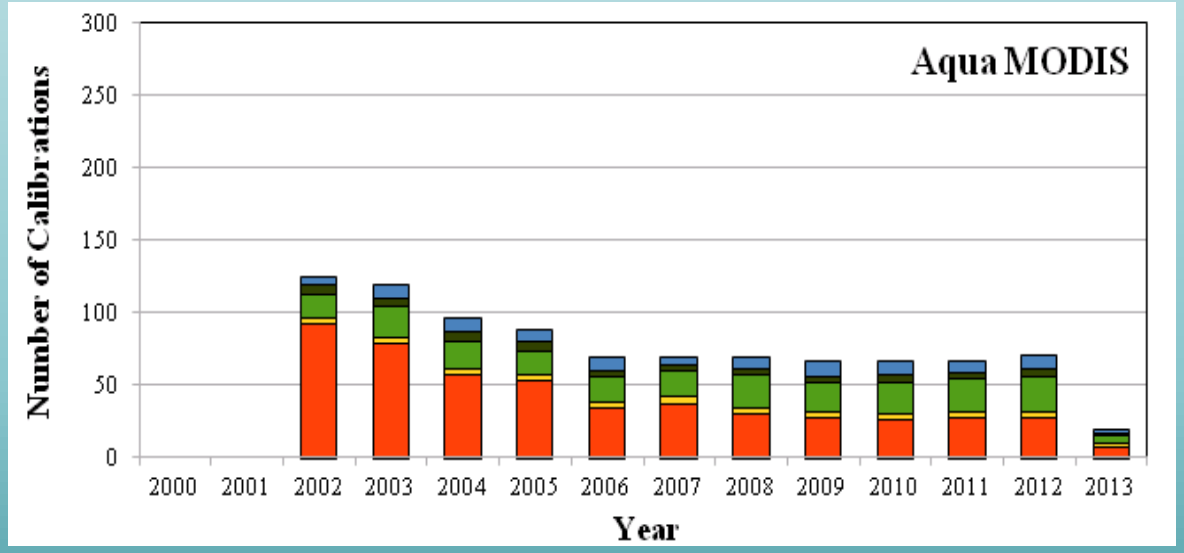
Blackbody (BB) for thermal emissive bands (TEB) calibration

Calibration Maneuvers

Lunar views through SV port

Calibration and Characterization Activities





	Terra	Aqua
Lunar Roll	123	103
PV Ecal	80	60
SRCA	373	248
BB	84	48
SD/SDSM	656	493

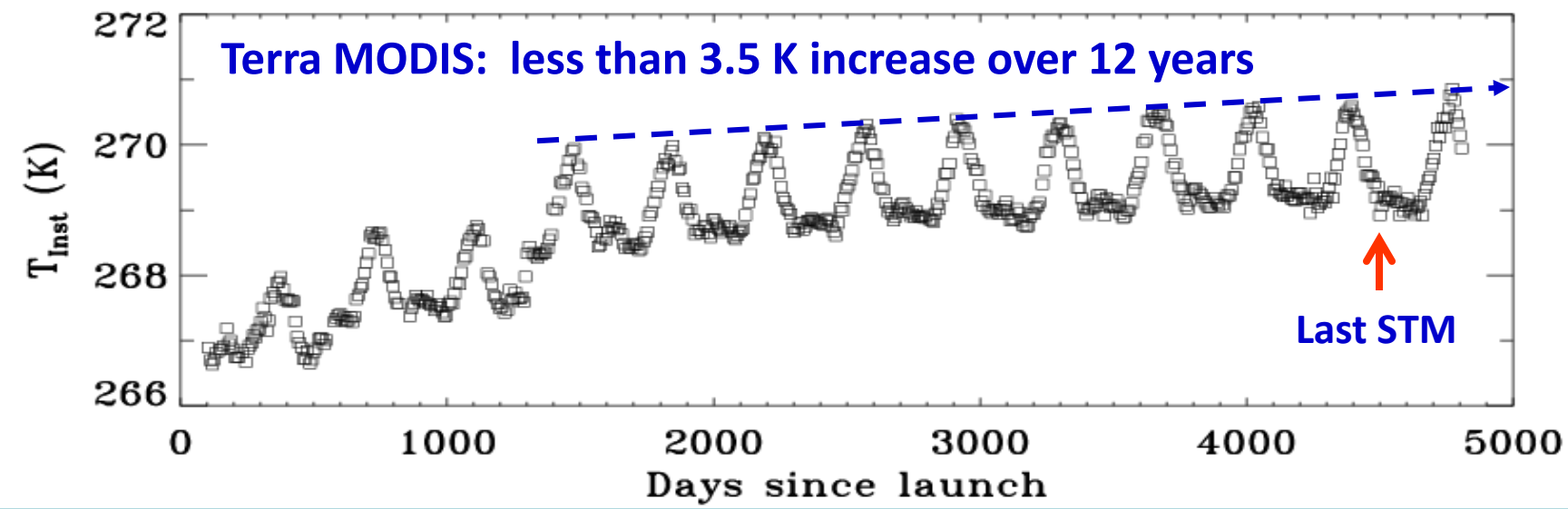
Others:
Maneuvers
Ground Targets
Inter-comparisons
Nighttime day mode ops

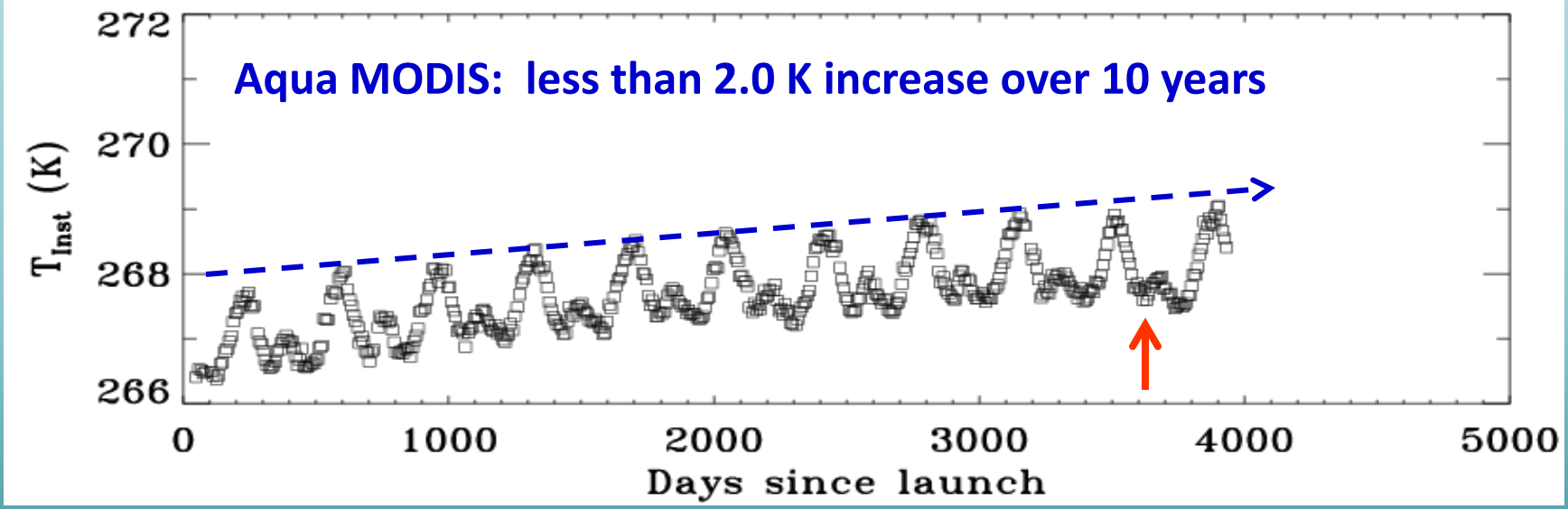
BB WUCD: 270 - 315K; SRCA: 3 modes

On-orbit Performance

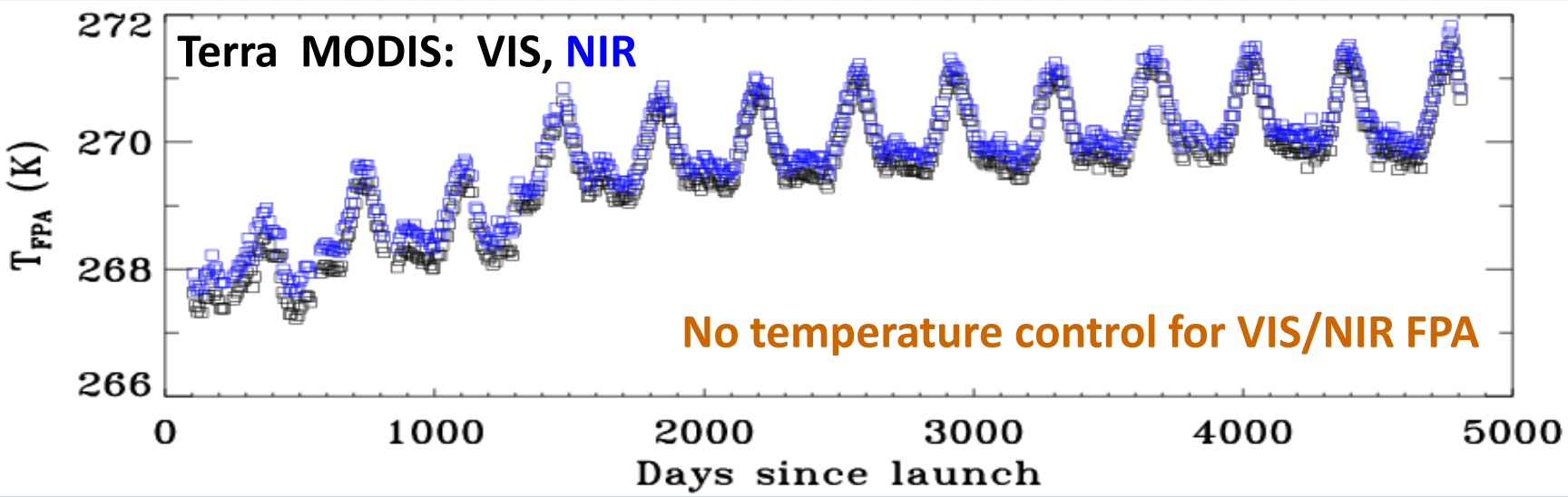
- Instrument and On-board Calibrators (OBC)
- Radiometric
  - Spectral band responses
  - Detector noise characterization
- Spectral
  - Center wavelengths and bandwidths
- Spatial
  - Band-to-band registration (BBR)
- Geometric
  - Geolocation

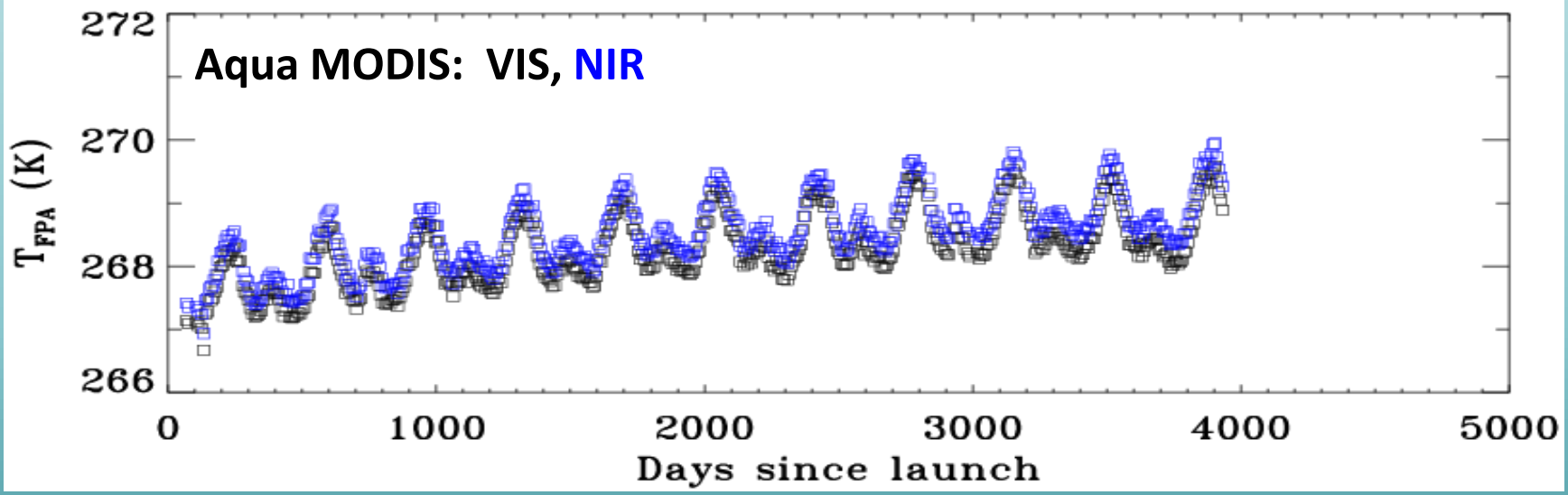
Instrument Temperatures





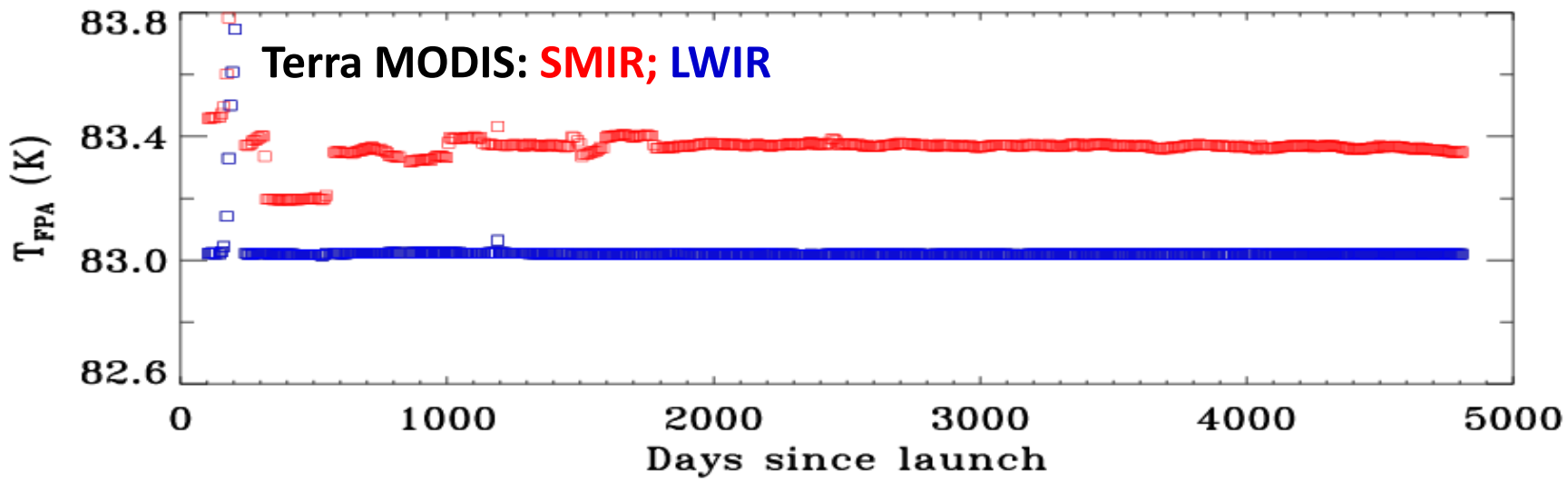
VIS and NIR FPA Temperatures

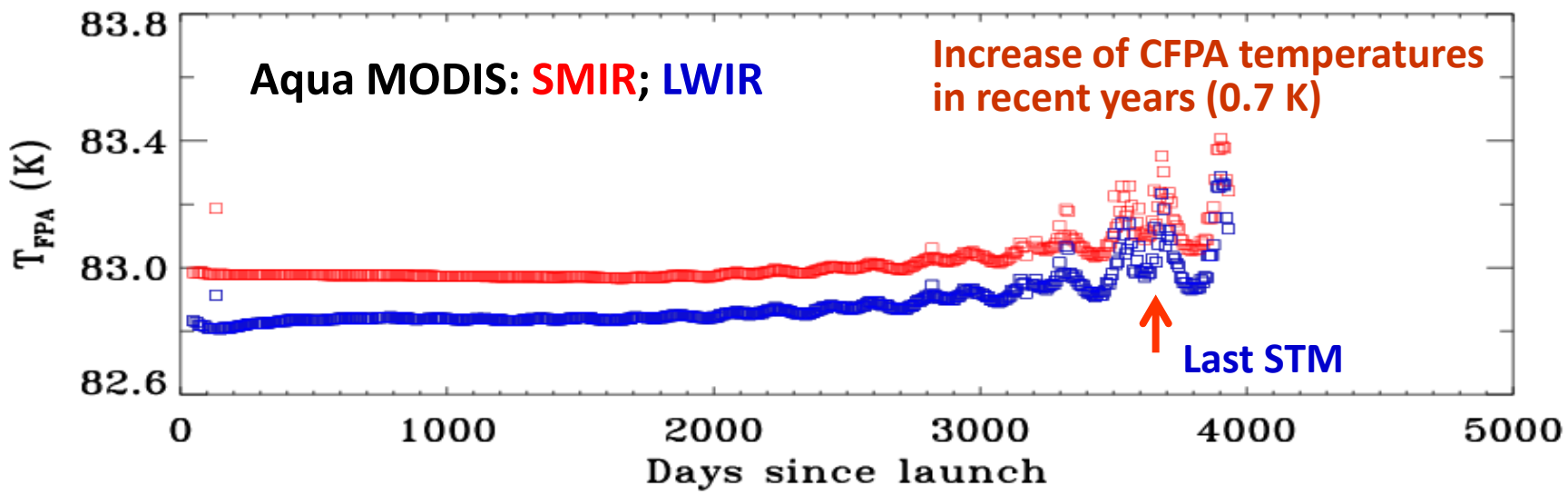




VIS & NIR FPA temperatures: similar to instrument temperatures

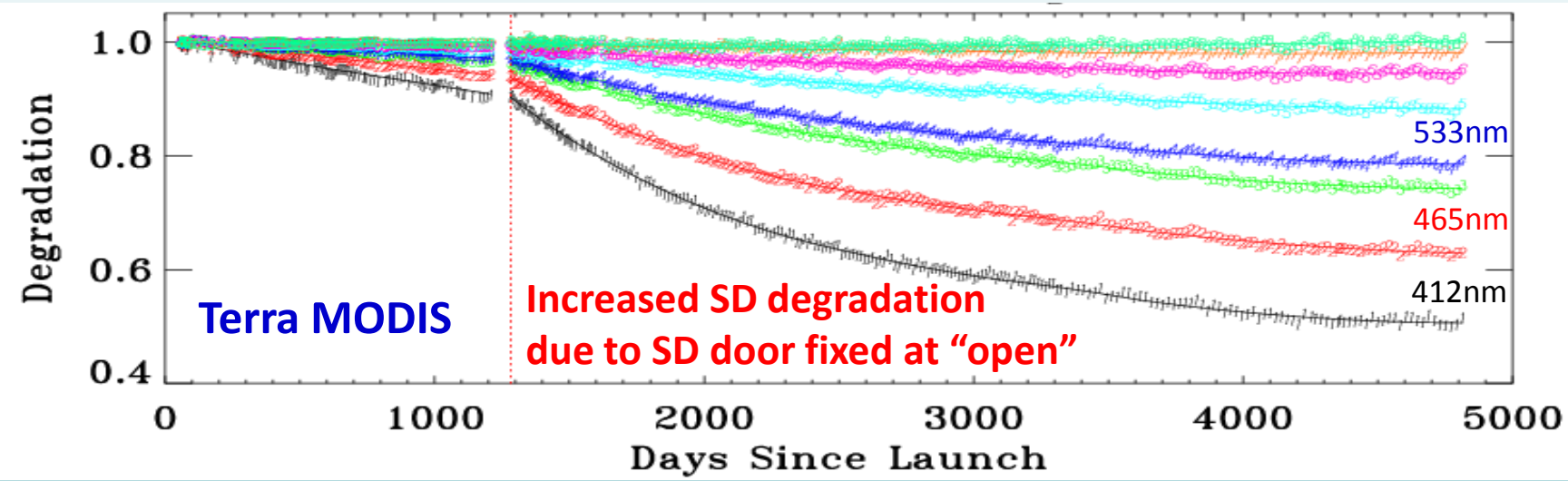
SMIR and LWIR FPA Temperatures

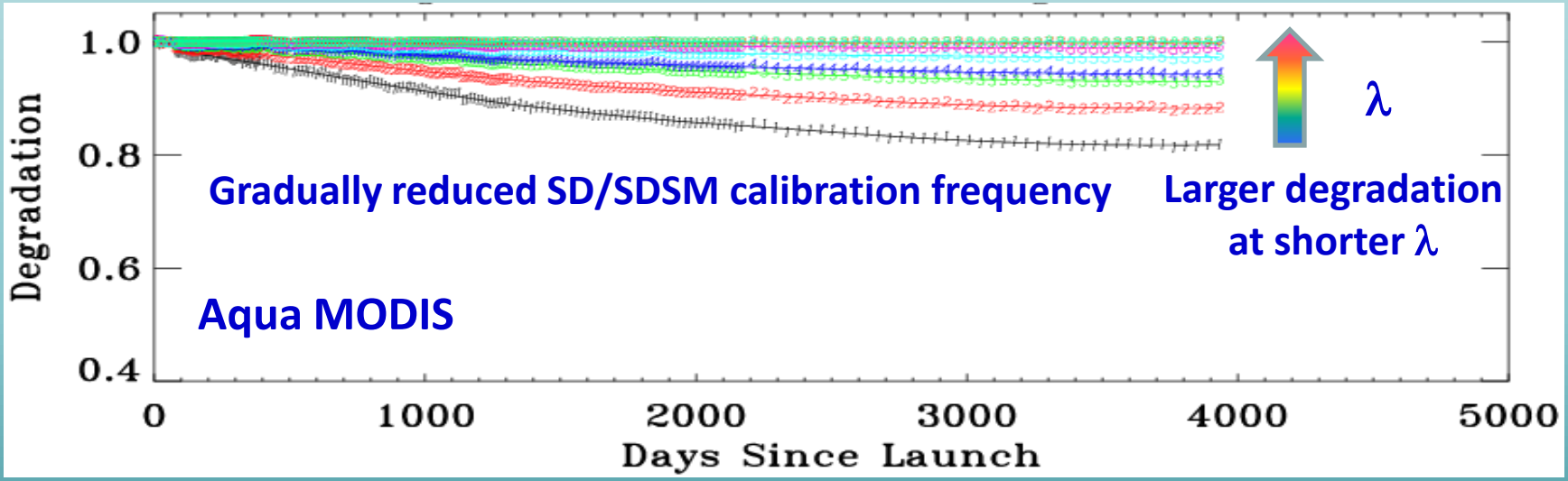




Aqua CFPA Performance and Operation Reviews (5/7/2010, 4/25/2012, 3/27/2013)

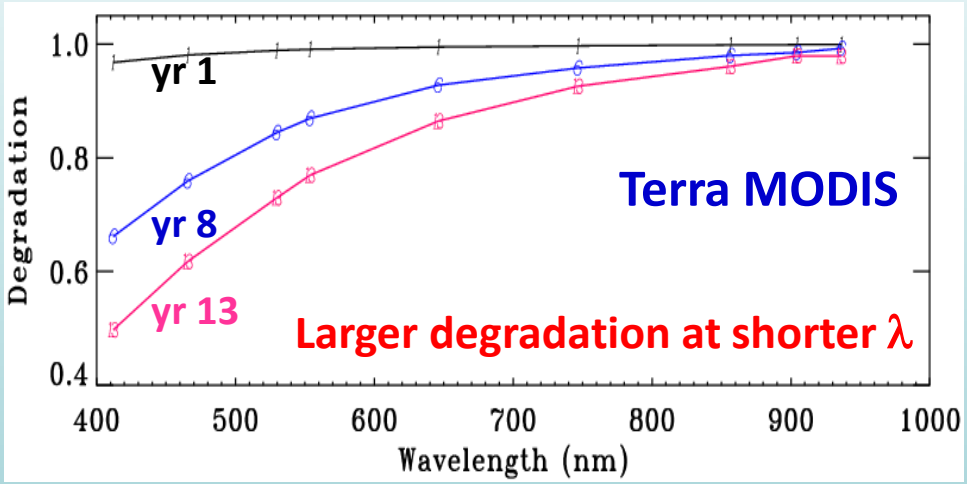
Solar Diffuser (SD) Degradation

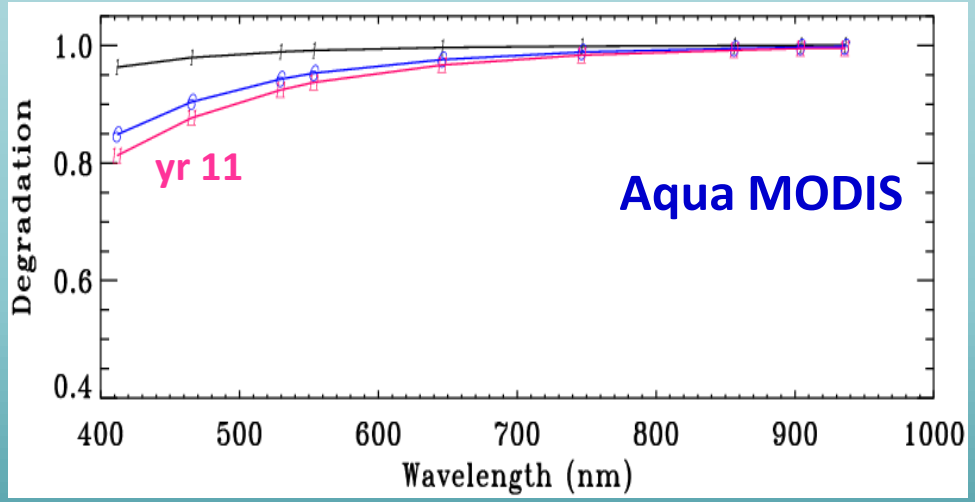




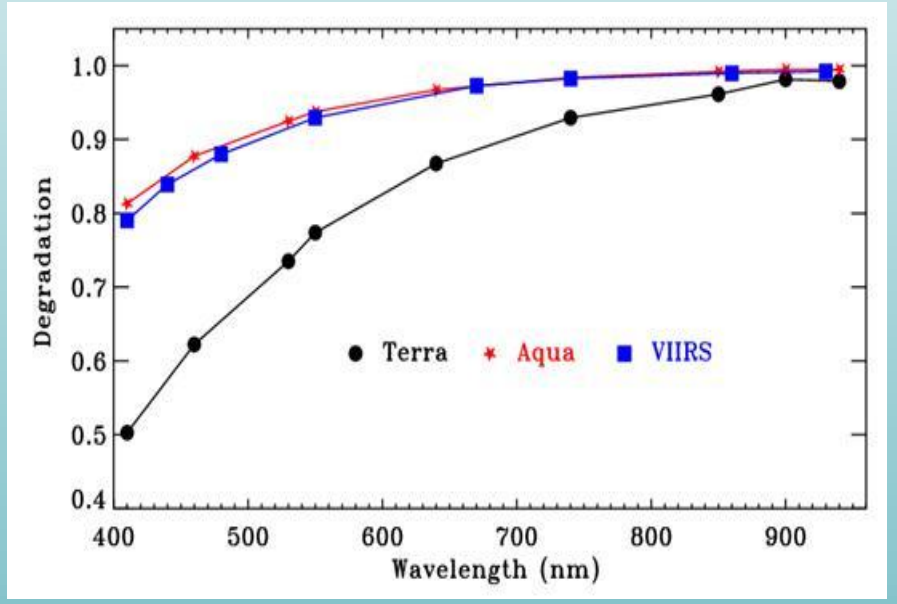
Solar Diffuser (SD) Degradation

SD degradation as a function of λ

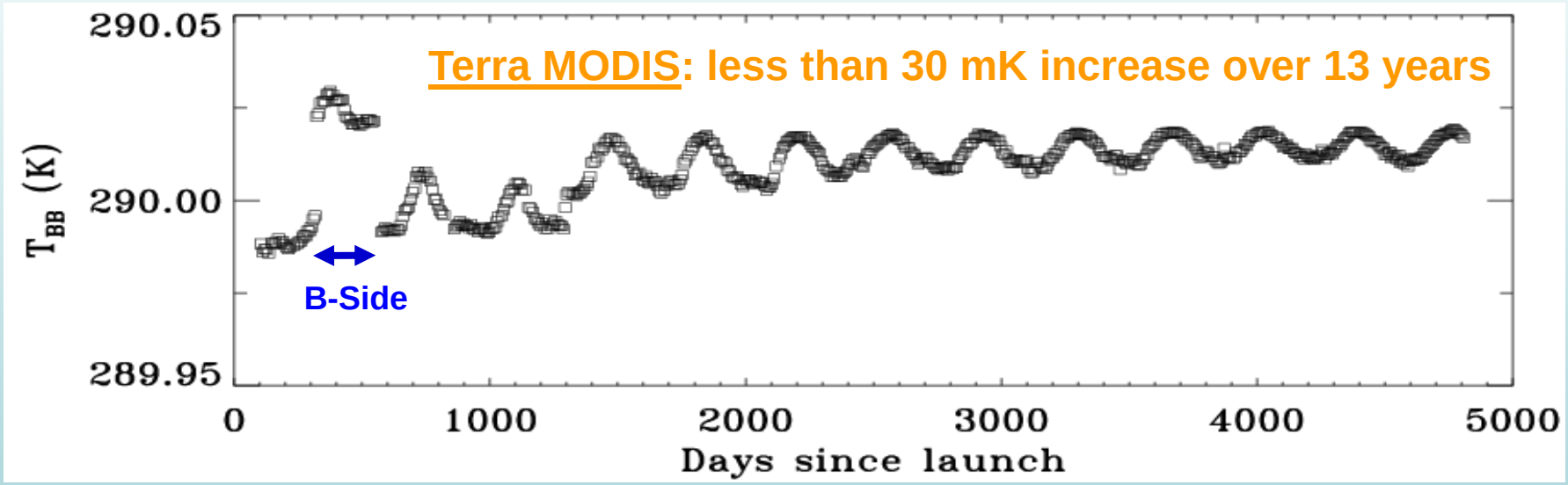


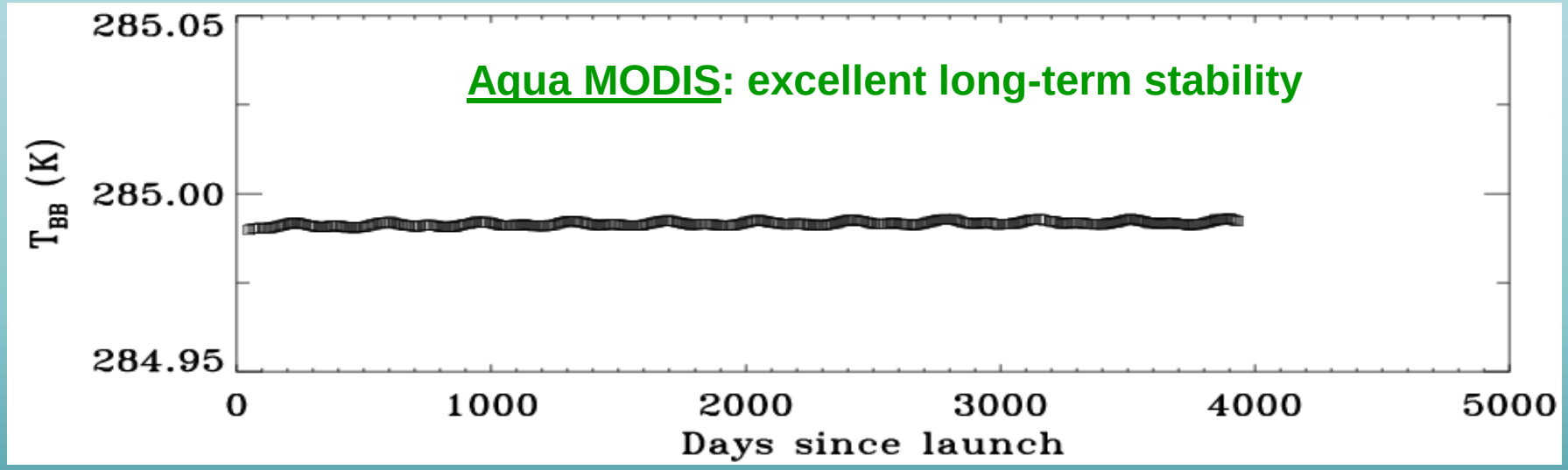


MODIS and VIIRS SD degradation



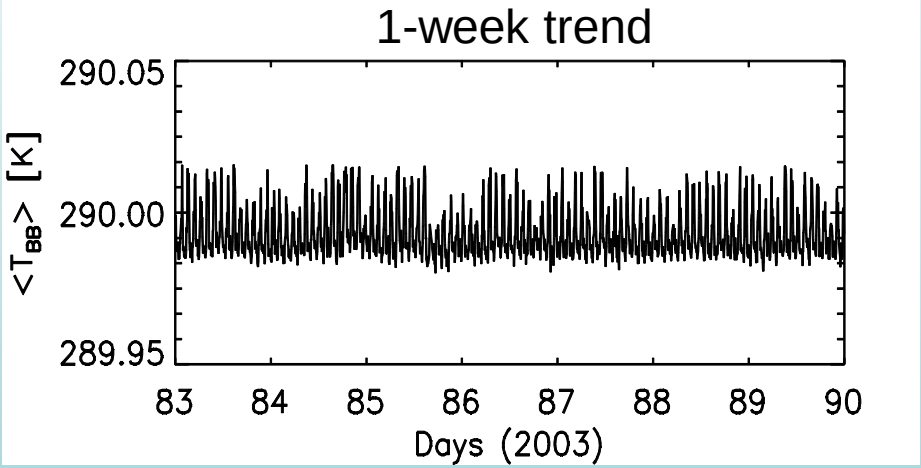
Blackbody Temperatures (nominal operation)

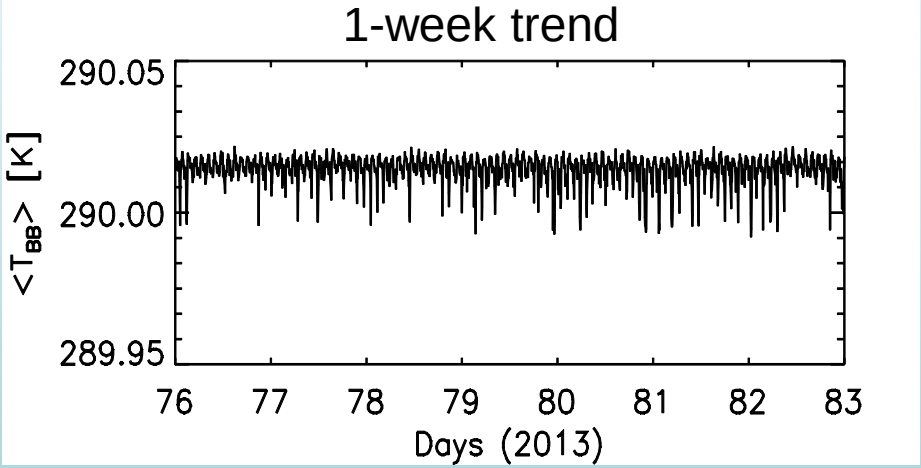


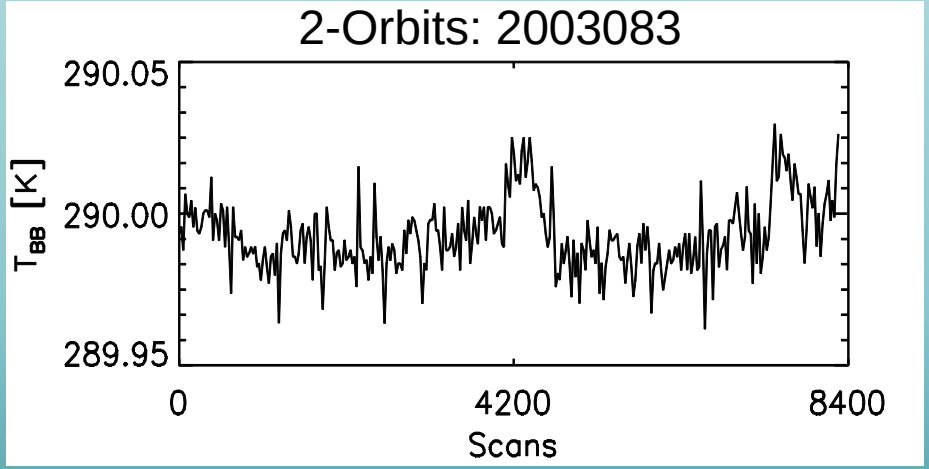


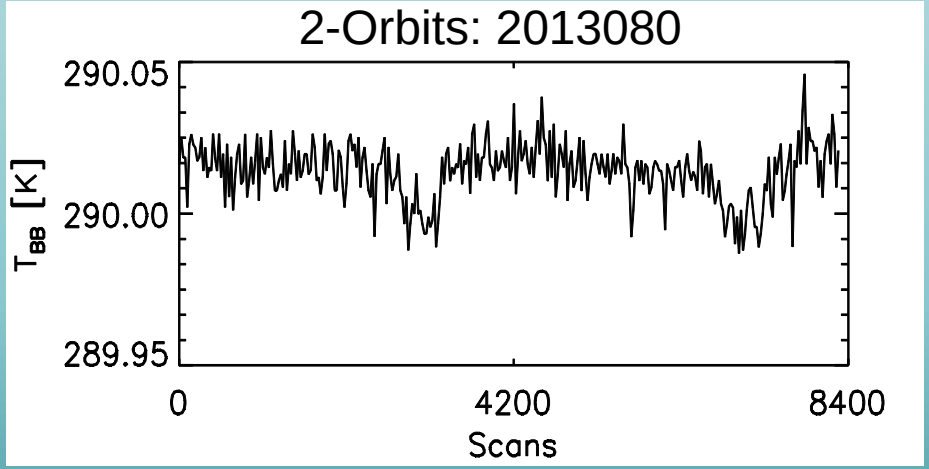
Blackbody Temperatures (nominal operation)

Terra MODIS: short-term



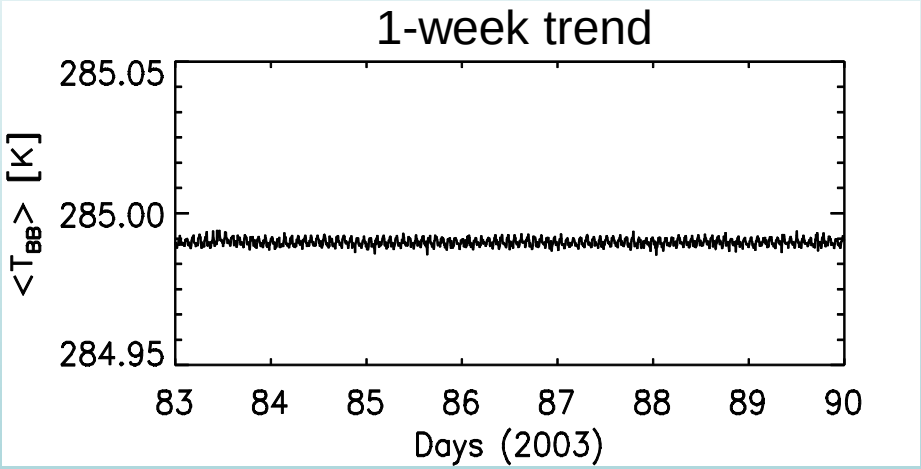


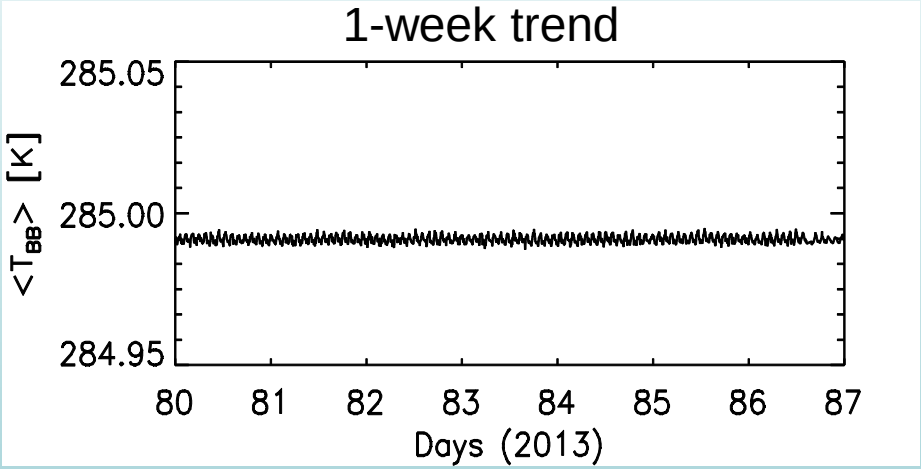


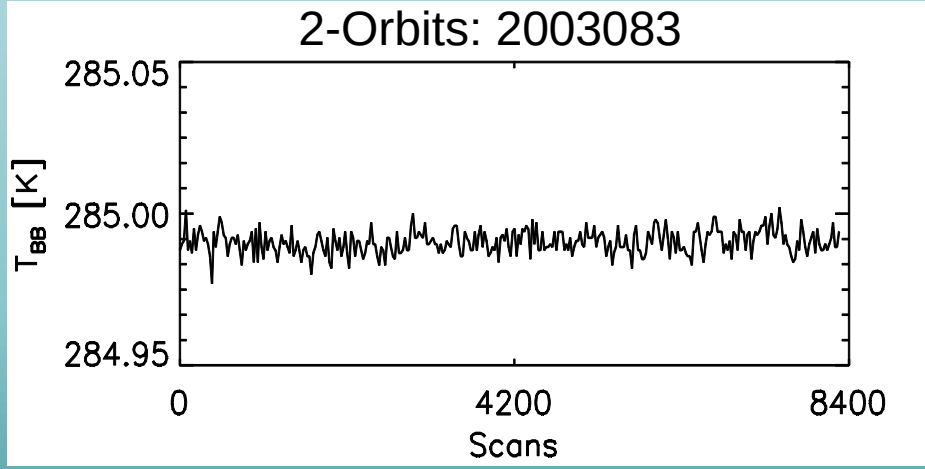


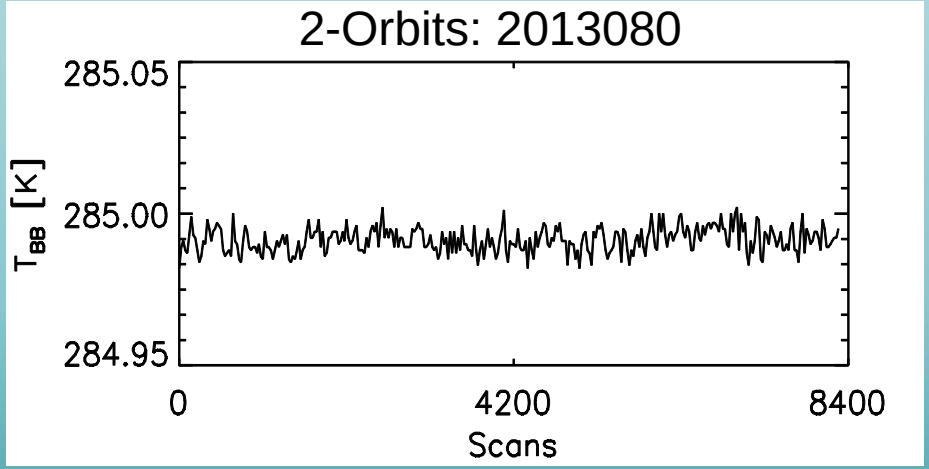
Blackbody Temperatures (nominal operation)

Aqua MODIS: short-term



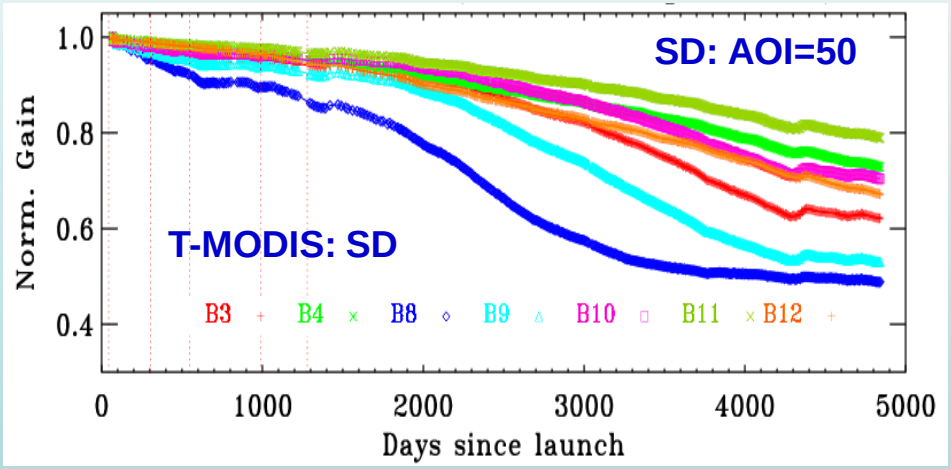


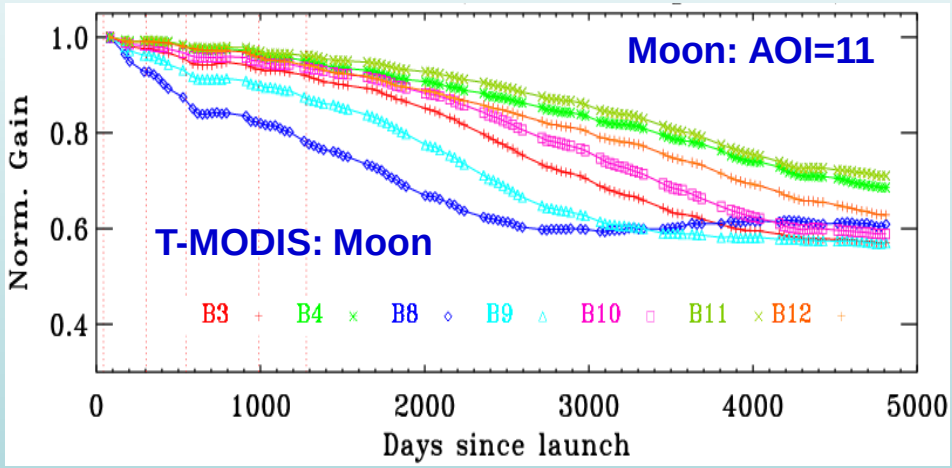


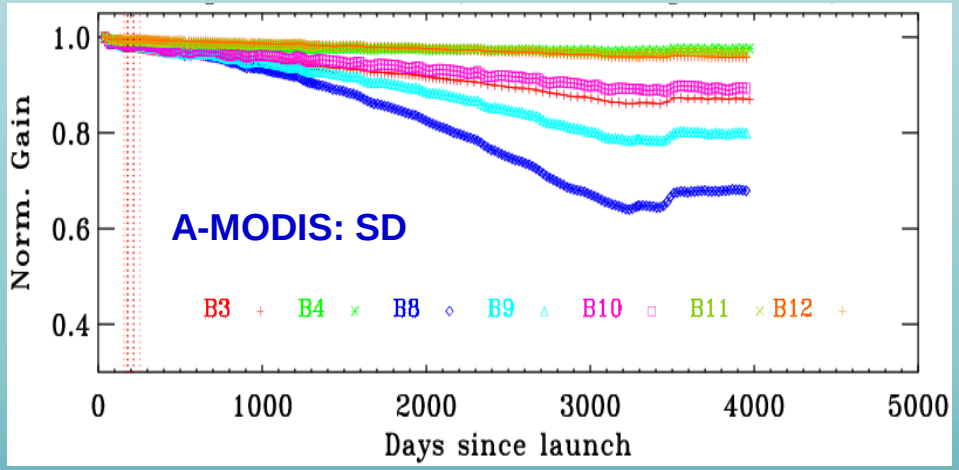


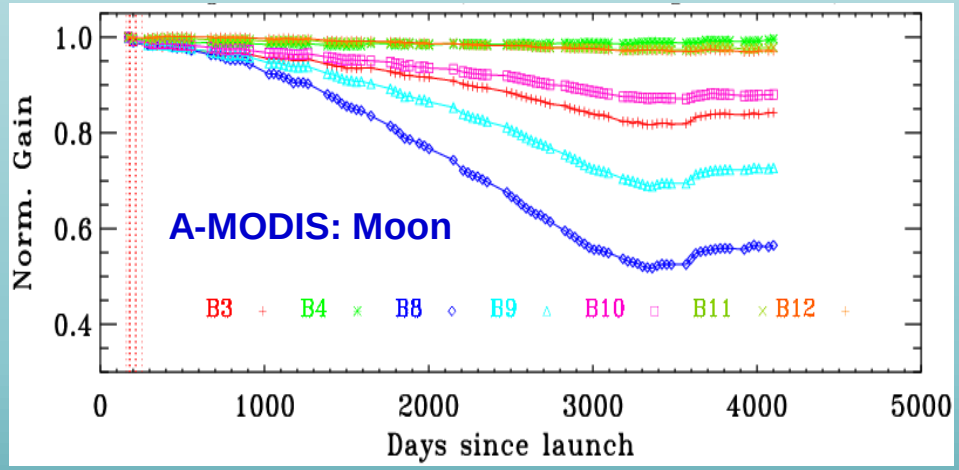
Spectral Band Responses (VIS)

Band Averaged, Mirror Side 1







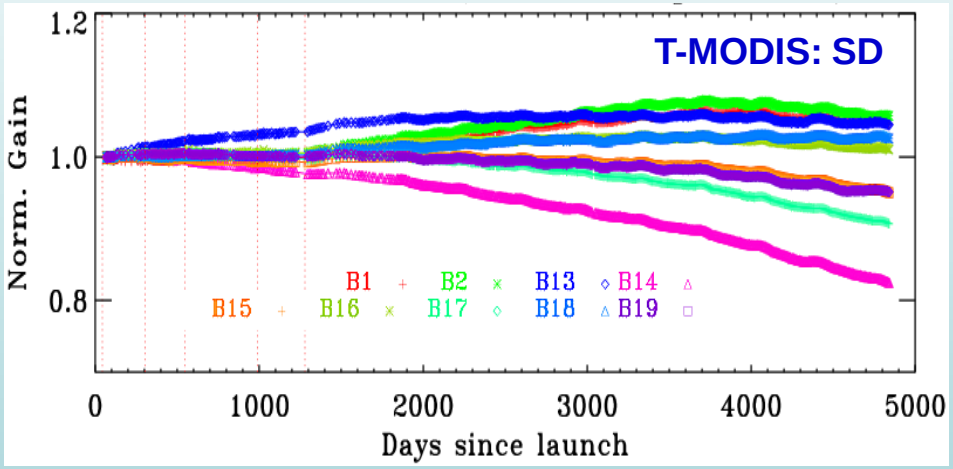


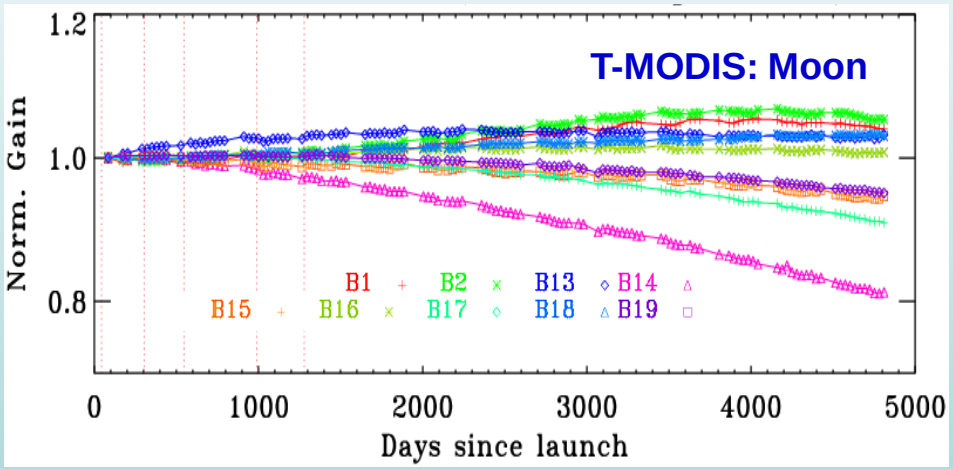
Larger changes at shorter wavelengths

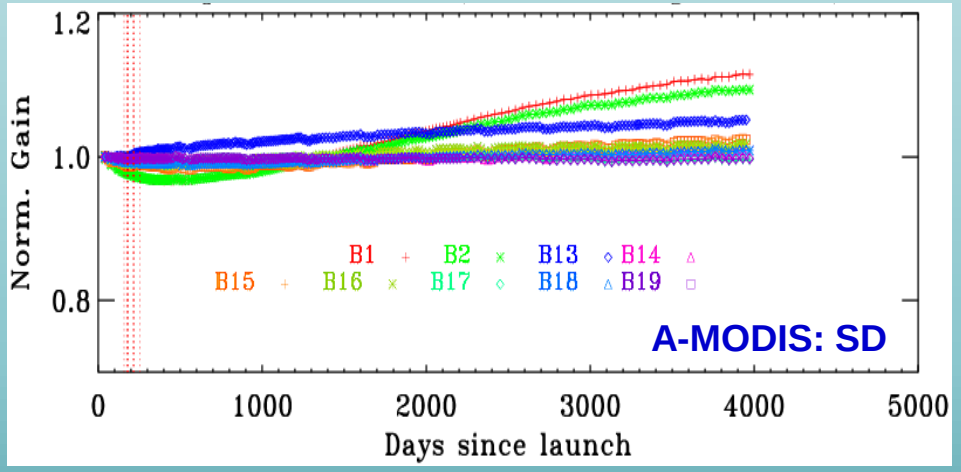
Wavelength, AOI, and mirror side dependent (small MS diff. in A-MODIS)

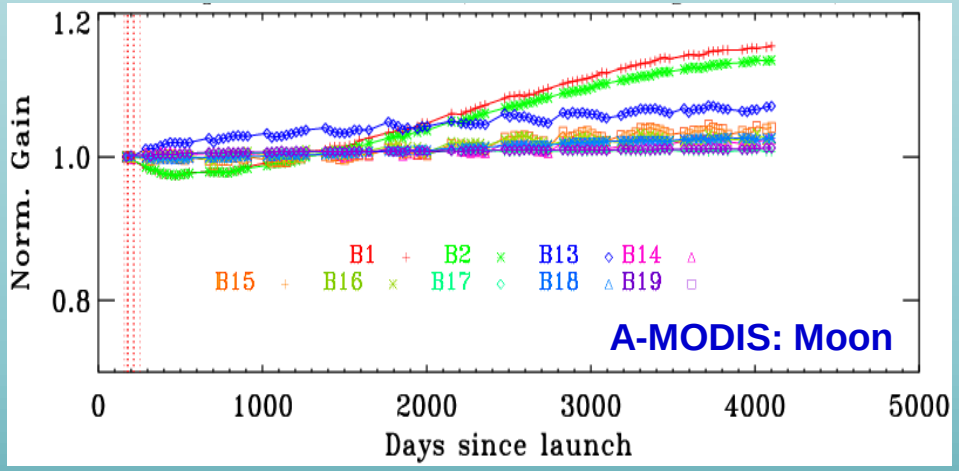
Spectral Band Responses (NIR)

Band Averaged, Mirror Side 1









A few NIR bands show gain increase over time

Detector Noise Characterization

- **36 Spectral Bands with 490 individual detectors**
  - No new noisy detectors since last STM
- **Terra: 45 noisy detectors (30 from pre-launch : 35 at launch) and no inoperable detectors**
- **Aqua: 7 noisy detectors (2 from pre-launch: 3 at launch) and 15 inoperable detectors (13 in Band 6)**

Time	Event	Noisy Band (Detector)
Pre-launch		B7(all), B36(all)
2000055.1527	Nadir Door Open	B5(4,16), B7(all), B33(1), B34(7,8), B36(all)
2000160.0000	CFPA Lost Control	B5(4,16), B7(all), B30(5) B33(1), B34(7,8), B36(all)
2000218.2210	Formatter Anomaly	B5(4,16), B7(all), B27(6), B30(5), B33(1), B34(6,7,8), B36(all)
2000304.1420	Switch to B-Side	B5(4,16), B7(all), B27(6), B30(5), B33(1), B34(6,7,8), B36(all)
2001019.1415	N/A	B5(4,16), B7(all), B27(6), B30(5, 8), B33(1), B34(6,7,8), B36(all)
2001183.2245	Switch to A-Side	B5(4), B7(all), B27(6), B30(5, 8), B33(1), B34(6,7,8), B36(all)
2002078.1615	Safe Mode	B5(4), B7(all), B27(6), B28(3), B30(5,8), B33(1), B34(5,6,7,8), B36(all)
2003350.1305	Safe Mode	B5(4), B7(all), B27(1,6), B28(8), B30(5,8), B33(1), B34(6,7,8), B36(all)
2005130.1345	(Day)	B5(4), B7(all), B27(1,6), B28(1,8), B29(6), B30(5,8), B33(1), B34(6,7,8), B36(all)
2005309.1510	N/A	B5(4), B7(all), B27(1,6), B28(8,9), B29(6), B30(5,8), B33(1), B34(6,7,8), B36(all)
2006155.0210	(Night)	B5(4), B7(all), B27(1,6), B28(8), B29(6), B30(3,5,8), B33(1), B34(6,7,8), B36(all)
2007193.1155	(Day)	B5(4), B7(all), B27(1,6), B28(8), B29(6), B30(3,5,8), B33(1), B34(6,7,8), B36(all)
2008308.0900	SAA (Night)	B5(4), B7(all), B27(1,2,3,6), B28(8), B29(6), B30(1,3,5,8), B33(1), B34(6,7,8), B36(all)

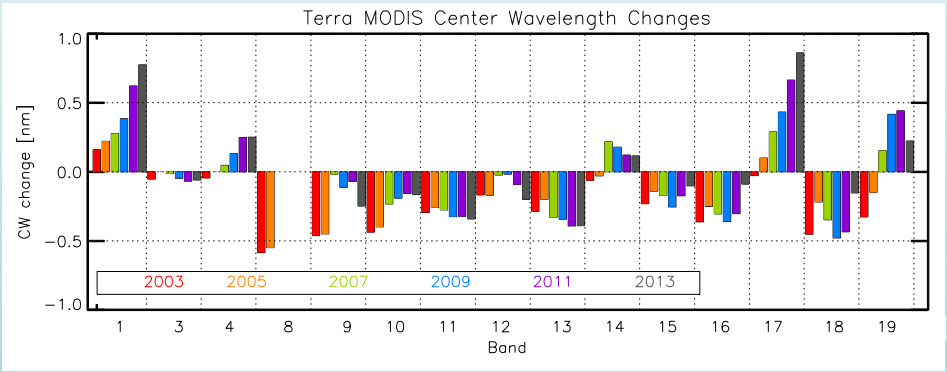
Time	Event	Noisy Band (Detector)	Inoperable Band (Detector)
Pre-launch		B6(17), B20(10)	B5(20), B6(2,12-14,16,18-20), B36(5)
2002175.2324	Nadir Door Open	B6(7,9,17)	B5(20), B6(2,4-6,10,12-16,18-20), B36(5)
2005010.1715	(Day)	B6(7,9,17), B27(3)	B5(20), B6(2,4-6,10,12-16,18-20), B36(5)
2007359.1020	N/A	B6(7,9,17), B27(3), B29(8)	B5(20), B6(2,4-6,10,12-16,18-20), B36(5)
2008038.1750	(Day)	B6(7,9,17), B27(3), B29(2,8)	B5(20), B6(2,4-6,10,12-16,18-20), B36(5)
2012022.1510	SAA (Day)	B6(7,9,17), B27(3), B29(2,6, 8)	B5(20), B6(2,4-6,10,12-16,18-20), B36(5)

Radiometric Performance Summary

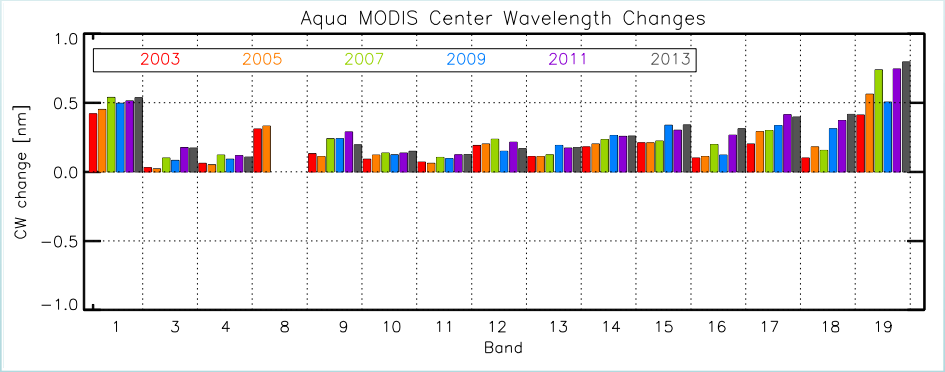
- **Shorter wavelength VIS bands show larger degradation**
  - Strong wavelength, mirror side, and scan angle dependence
  - MS difference in Aqua MODIS is much smaller than Terra MODIS
- **A few NIR bands show gain increases over time**
- **Changes in SWIR responses are very small**
  - SWIR bands are located on CFPA with MWIR bands
- **TEB (MWIR and LWIR) responses have been very stable**
  - Less than 2% changes over entire mission, except up to 10% for Terra LWIR PV bands 27-30
- **Overall SNR and NEdT performance remains satisfactory**
  - Only 1 new noisy detector in last 3 years

Spectral Characterization Performance

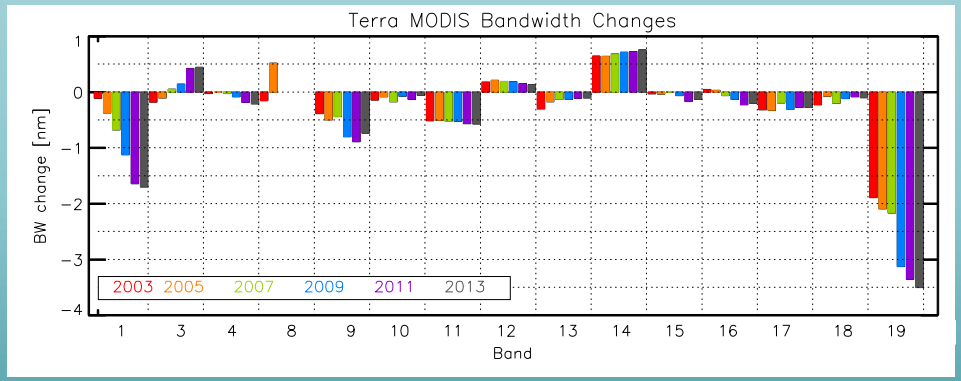
Terra MODIS CW Change



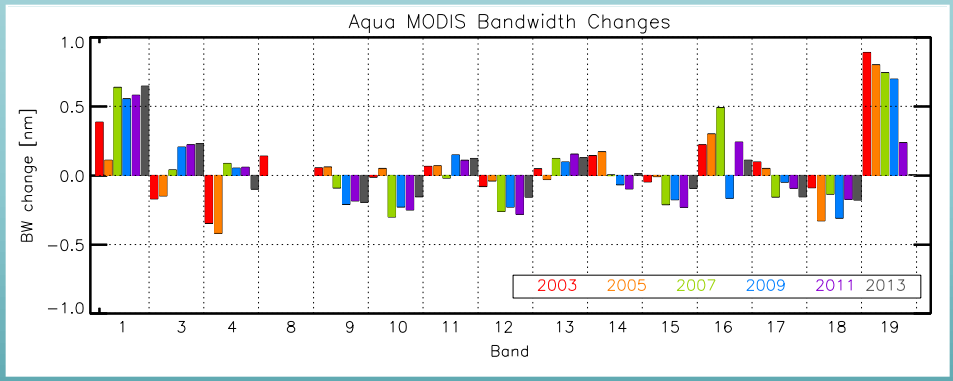
Aqua MODIS CW Change



Terra MODIS BW Change

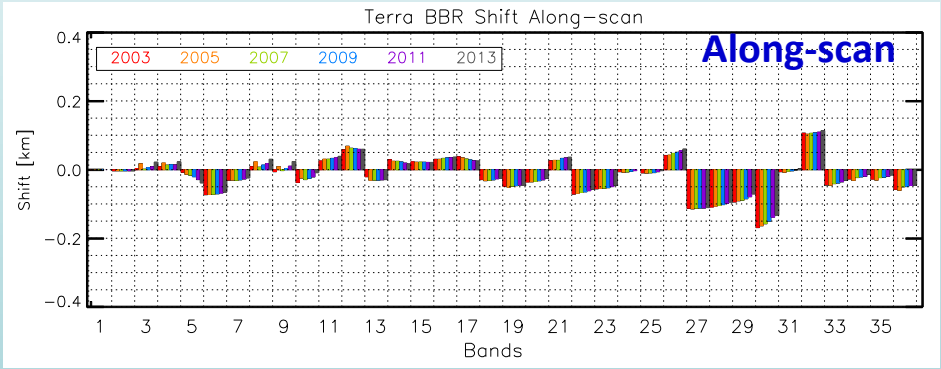


Aqua MODIS BW Change

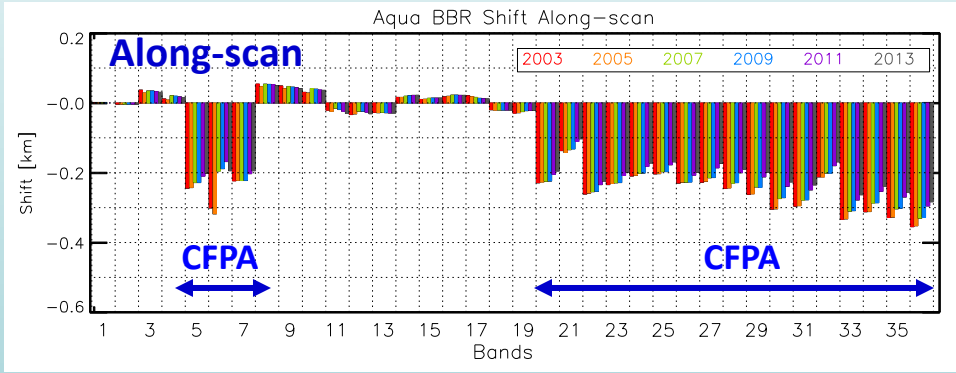


Spatial Characterization Performance

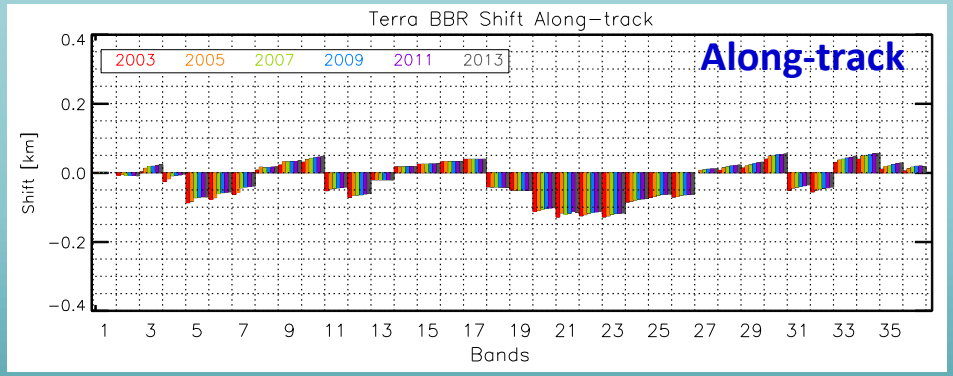
Terra MODIS along-scan BBR



Aqua MODIS along-scan BBR



Terra MODIS along-track BBR



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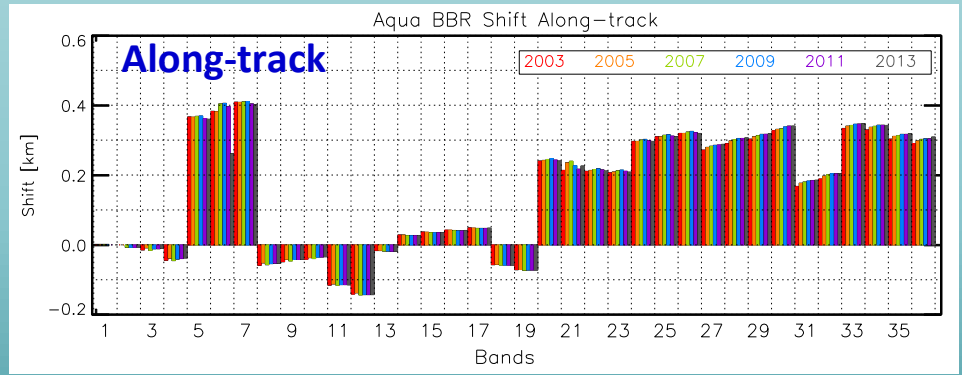
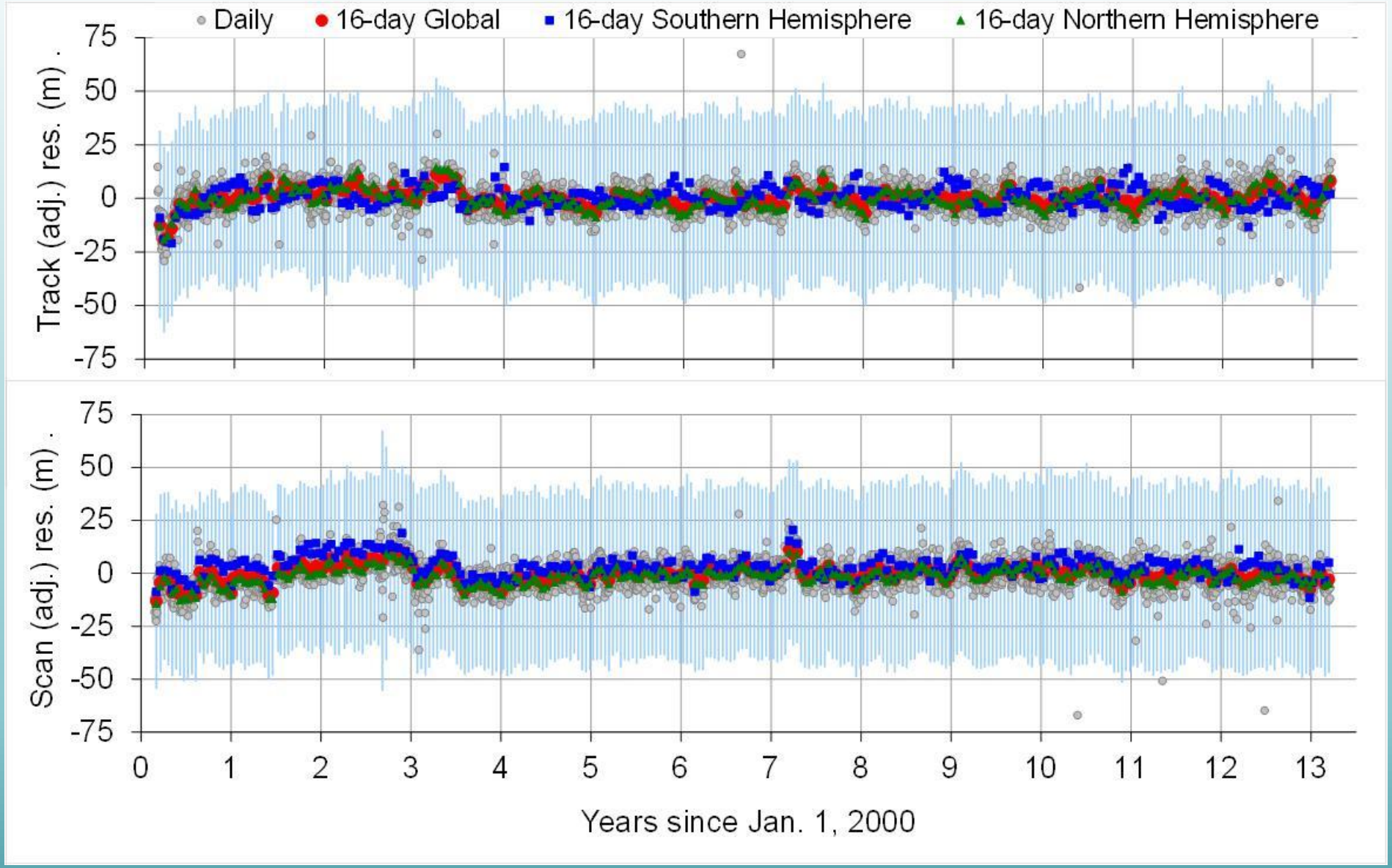


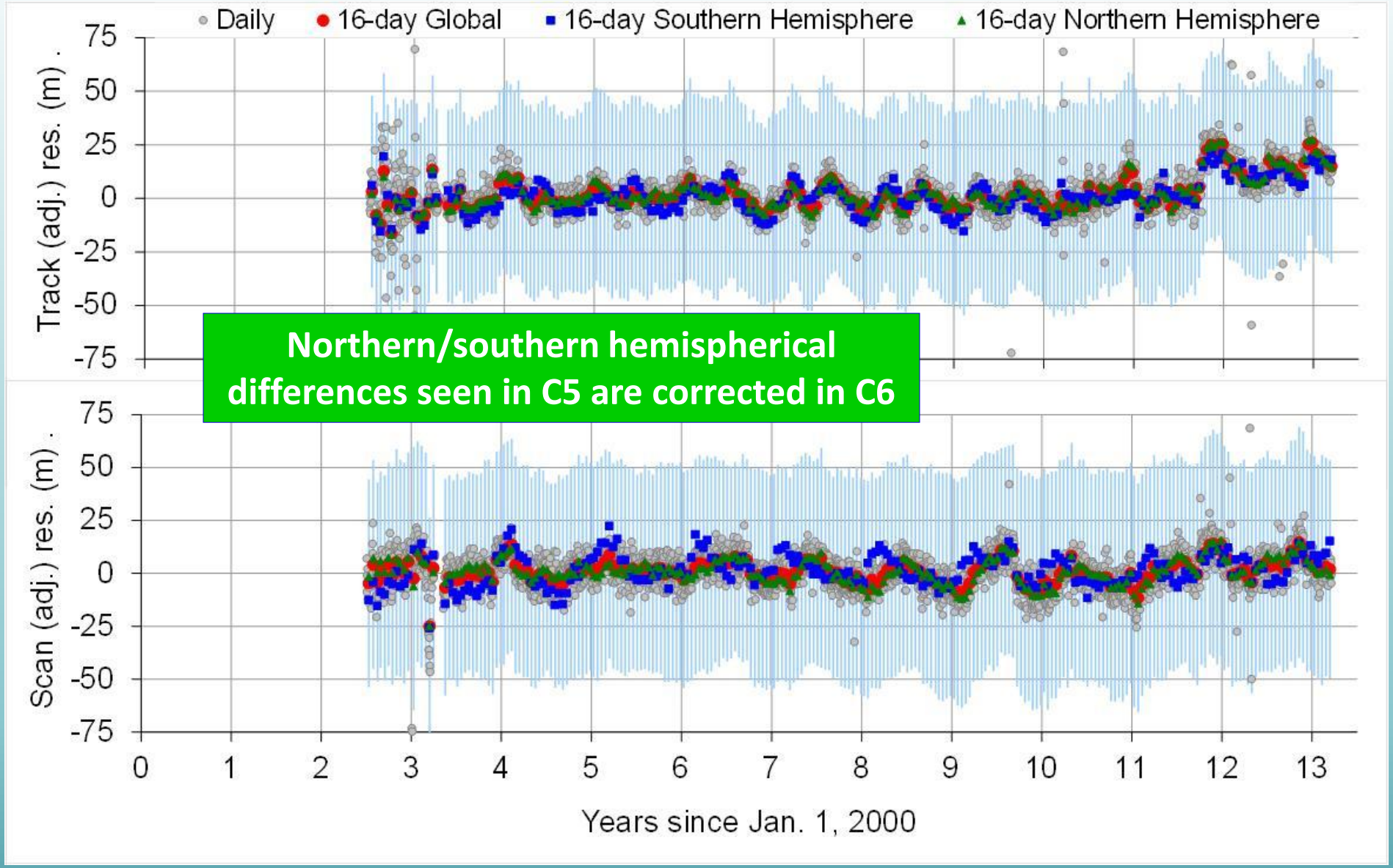
Aqua BBR: a known issue since pre-launch

Terra MODIS Geolocation Results (C6)



Robert Wolfe et al. RMSE Track: 42 m Scan: 42 m

Aqua MODIS Geolocation Results (C6)



Robert Wolfe et al. RMSE Track: 46 m Scan: 51m

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 predictability for the long-term trend
- **Strong wavelength dependent SD degradation (larger at shorter λ), especially in Terra MODIS**

- **Future efforts**
  - Improve RSB RVS characterization using ground targets (new methodologies)
  - Examine and mitigate the impact of large SD degradation on SD/SDSM calibration accuracy and potentially on the detector RSR
  - Further reduce calibration impact due to gradual increase of Aqua CFPA temperatures
  - Characterize Terra and Aqua MODIS calibration consistency

Summary

- Both Terra and Aqua MODIS continue to operate normally
- Instrument on-board calibrators remain capable of all design functions
- Overall sensor performance has been satisfactory (very few noisy detectors in recent years)
- Decade long high quality MODIS data products have significantly contributed to a broad range of scientific studies and applications
- Dedicated calibration and characterization effort, including good communication with the science and user community, has become critically important for future improvement