Status of Aqua MODIS and S-NPP VIIRS

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Acknowledgements:

MODIS Characterization Support Team (MCST)
VIIRS Characterization Support Team (VCST)

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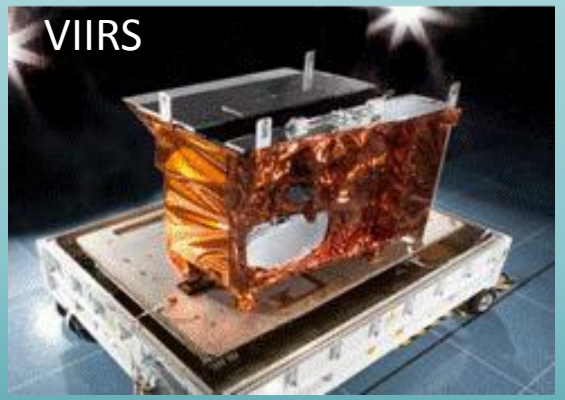
Outline

- MODIS and VIIRS Instruments
- On-orbit Calibration and Characterization
- Performance
- Status of MODIS C6 and VIIRS SDR
- Summary

Focusing on reflective solar bands (RSB) calibration and performance

MODIS and VIIRS Instruments

- **MODIS on both Terra and Aqua**
  - **Terra: Dec. 18, 1999 – Present**
  - **Aqua: May 04, 2002 – Present**
- **VIIRS on S-NPP and JPSS**
  - **Suomi NPP: Oct. 28, 2011 – Present**
  - **JPSS-1: Launch in 2017**



A wide range of applications: 40+ data products from MODIS and 22 EDRs from VIIRS

Key Design Features

Multispectral Scanning Radiometer: MODIS/Scan Mirror; VIIRS/Rotating Telescope

MODIS

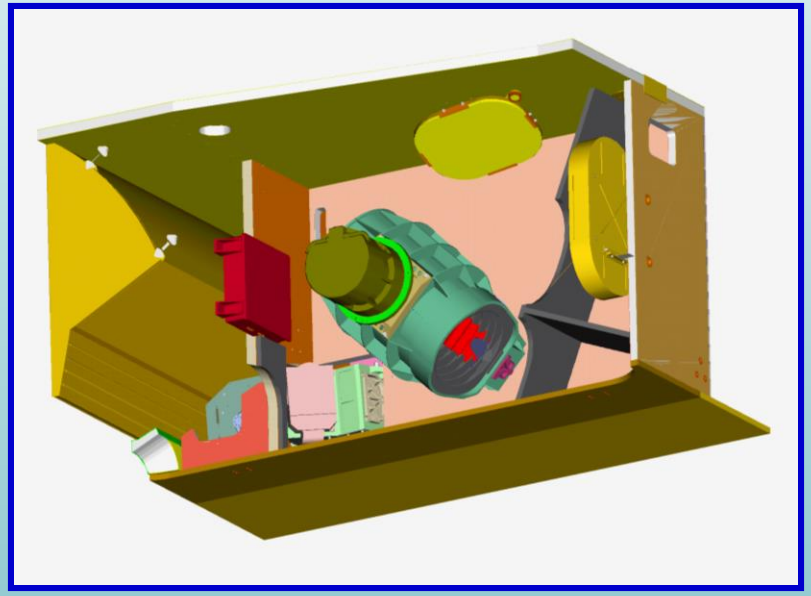
- Purpose: Global observations of land, ocean, & atmosphere parameters at high temporal resolution (< 2 days)
- Spectral range: 36 bands between 0.4 µm and 14.5 µm
  - 20 RSB and 16 thermal emissive bands (TEB)
- Focal plane assemblies (FPA): VIS, NIR, SMIR, and LWIR
- Spatial resolution: 250, 500, 1000 m
- Swath Width: 2230 km
- On-board Calibrators: SD, SDSM, BB, SV, and SRCA
- SD aperture door

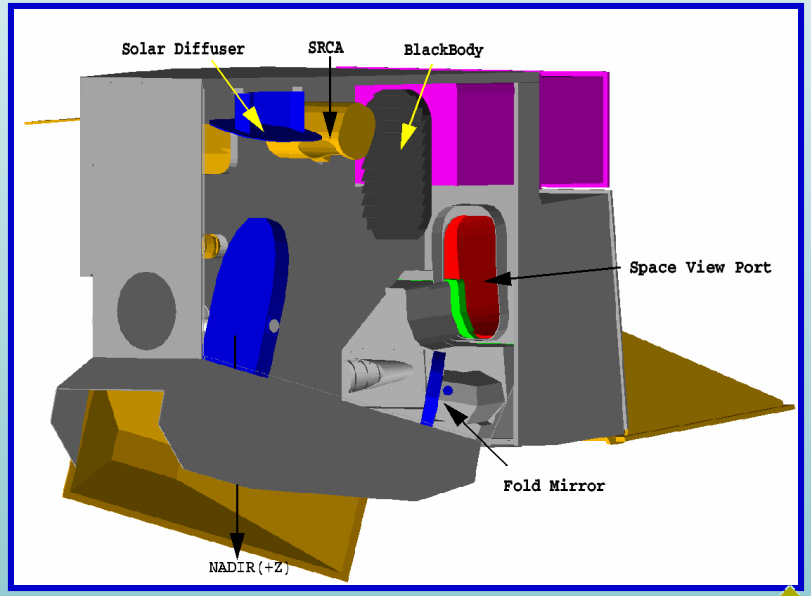
VIIRS

- Purpose: Global observations of land, ocean, & atmosphere parameters at high temporal resolution (daily)
- Spectral range: 22 bands between 0.4 µm and 12.5 µm
  - 14 RSB, 7 TEB, and 1 day night band (DNB)
- Focal plane assemblies (FPA): VIS/NIR, SMIR, and LWIR
- Spatial resolution: 375 and 750 m
- Swath Width: 3000 km
- On-board Calibrators: SD, SDSM, BB, SV,
- Pixel aggregations and bowtie deletion

On-board Calibrators (OBC)

- Solar Diffuser (SD)
- Solar Diffuser Stability Monitor (SDSM)
- Blackbody (BB)
- Space View (SV)
- Spectroradiometric Calibration Assembly (SRCA) - MODIS only

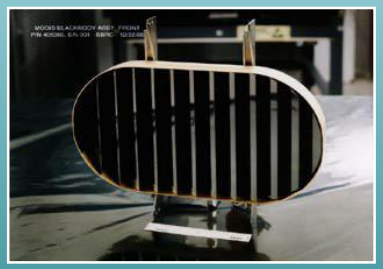




SD

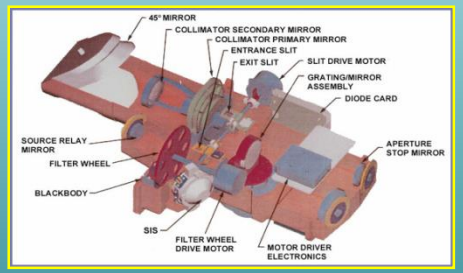
SDSM

BB



SV (moon)

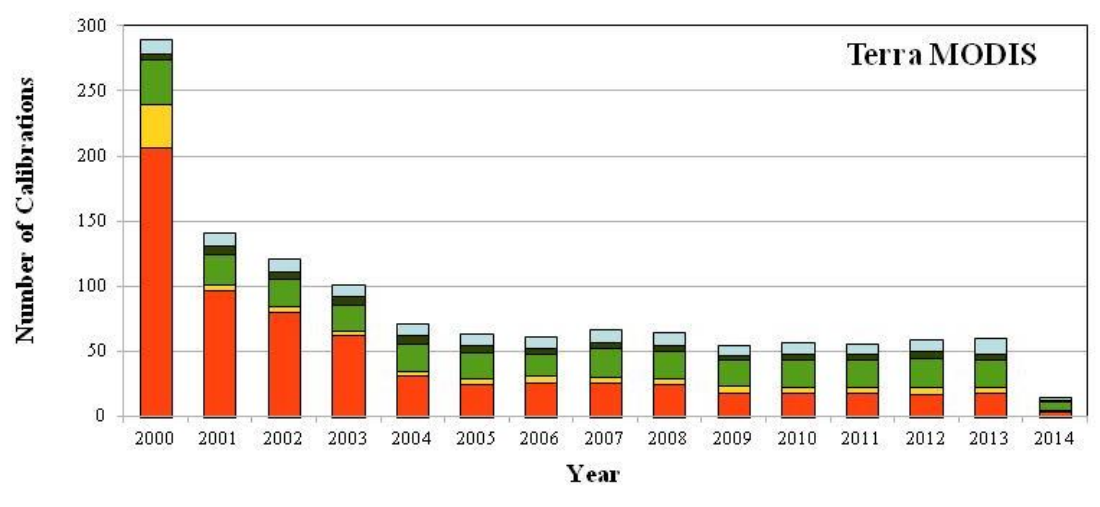
SRCA

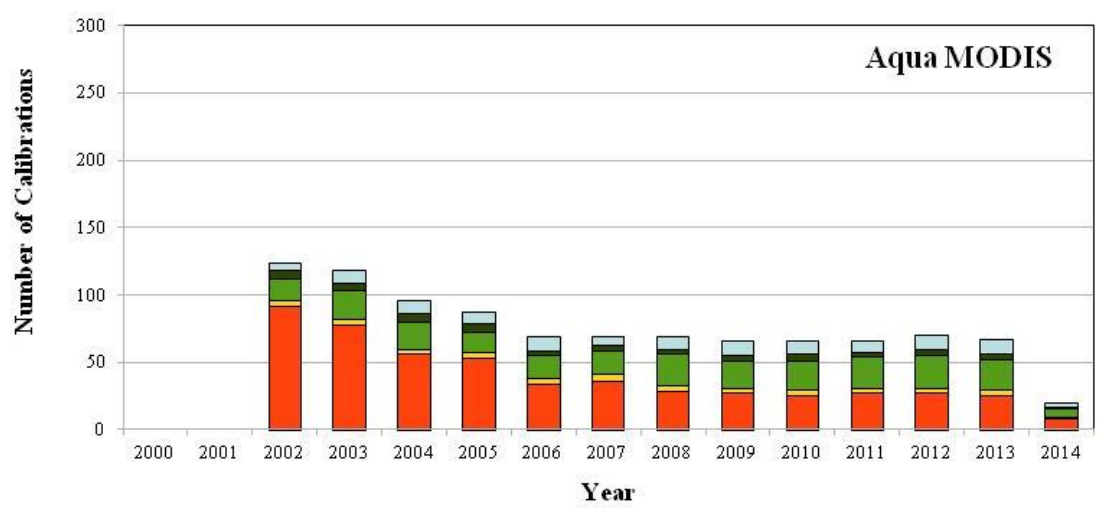


On-orbit Calibration and Characterization (RSB)

- **Both MODIS and VIIRS RSB are calibrated using a solar diffuser (SD) and solar diffuser stability monitor (SDSM) system**
  - SD provides calibration reference with bi-directional reflectance factor (BRF)
  - SDSM tracks on-orbit changes in SD BRF
  - More frequent SD and SDSM calibration for VIIRS
  - Gradually reduced SD and SDSM calibration frequency for Aqua MODIS
- **Both MODIS and VIIRS regularly schedule and make lunar observations**
  - Fixed phase angles for each instrument
  - Spacecraft roll maneuvers
  - Lunar irradiance reference: ROLO
- **MODIS spatial and spectral characterization (MODIS only)**
  - 3 configurations for SRCA: radiometric, spatial, and spectral

MODIS Calibration and Characterization Activities





Through 3/31/14

	Terra	Aqua
Lunar Roll	136	110
PV Ecal	71	60
SRCA	313	264
BB	90	52
SD/SDSM	671	517

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

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

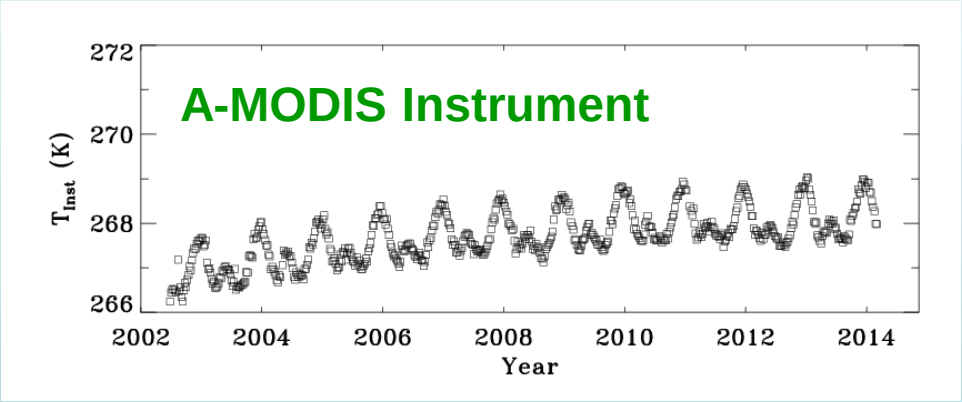
On-orbit Performance

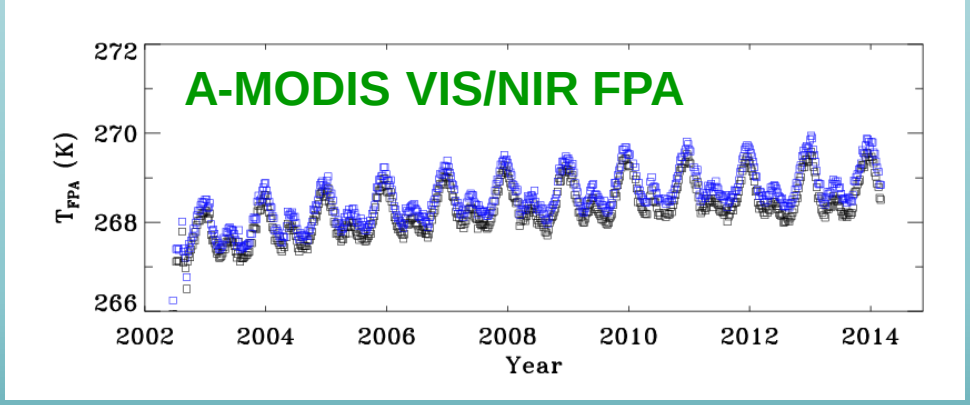
- **Instrument and On-board Calibrators (OBC)**
  - Instrument operation and OBC functions: normal
  - Changes in Aqua MODIS instrument temperature: 1.5 K since launch
  - Changes in S-NPP VIIRS instrument temperature: 0.5 K since launch
  - SD Degradation: larger degradation at shorter wavelength
- **Radiometric**
  - Spectral band responses (from SD and lunar calibration)
  - Calibration inter-comparison
- **Spectral and Spatial (MODIS)**
  - Center wavelengths and bandwidths
  - Band-to-band registration (BBR)

Lunar observations for sensor BBR and MTF characterization

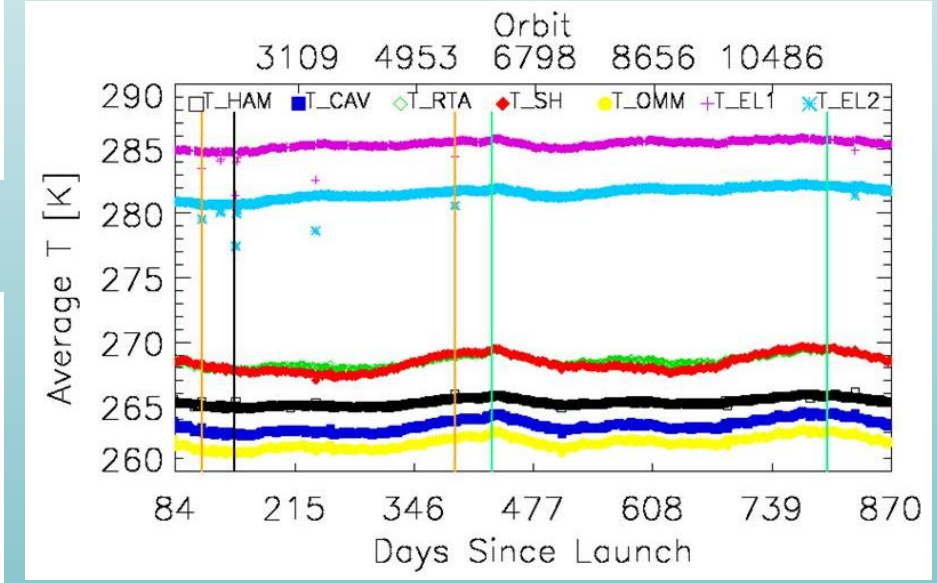
Demonstrated for MODIS
Implmented for VIIRS

Instrument and FPA Temperatures

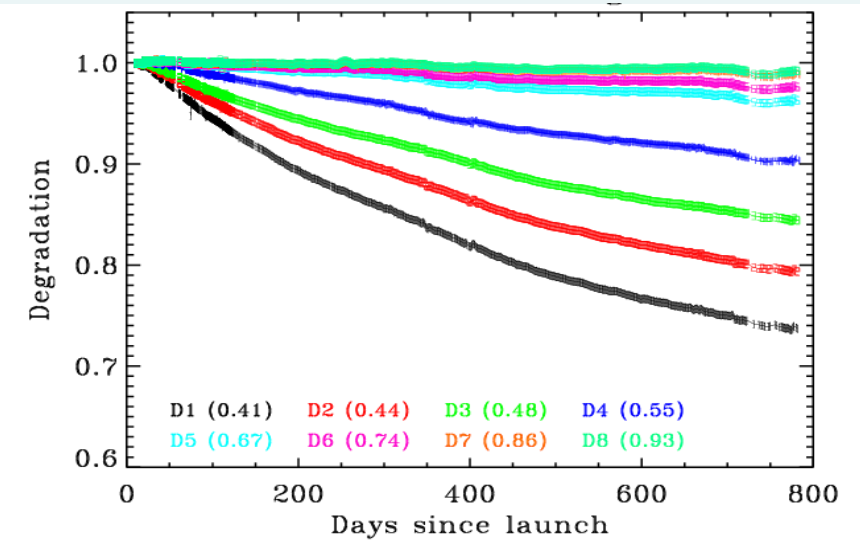




S-NPP VIIRS Key Temperatures



Solar Diffuser (SD) Degradation

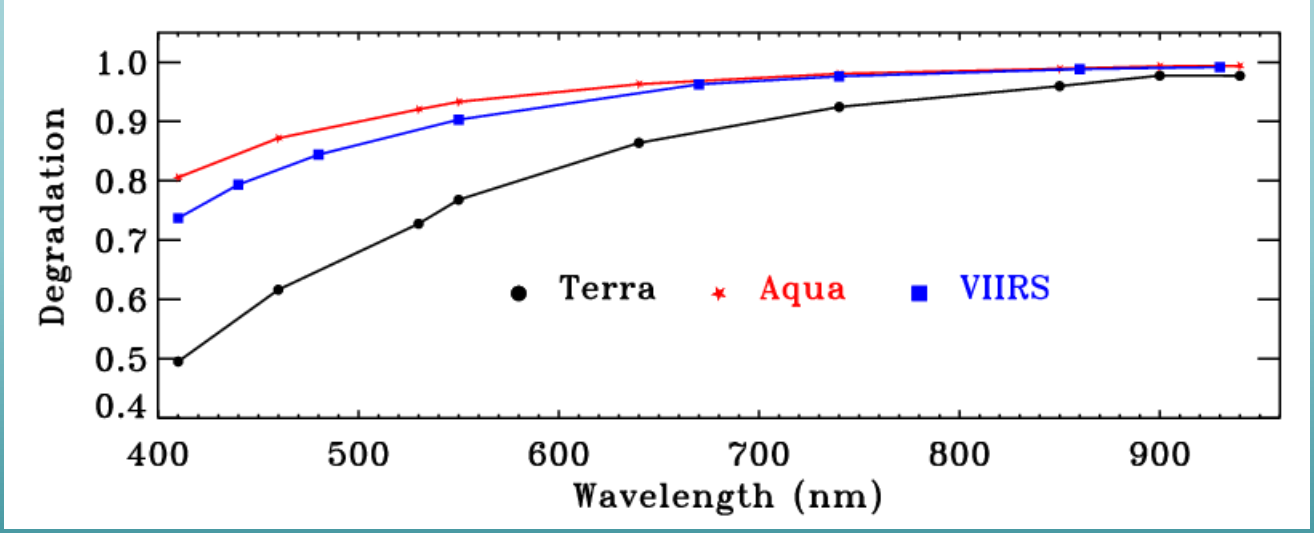


VIIRS SD Degradation

(As of Jan 2014)

VIIRS has no SD door

MODIS & VIIRS SD Degradation



T-MODIS SD door fixed at open since July 2003

A-MODIS SD door is closed when no calibration is scheduled

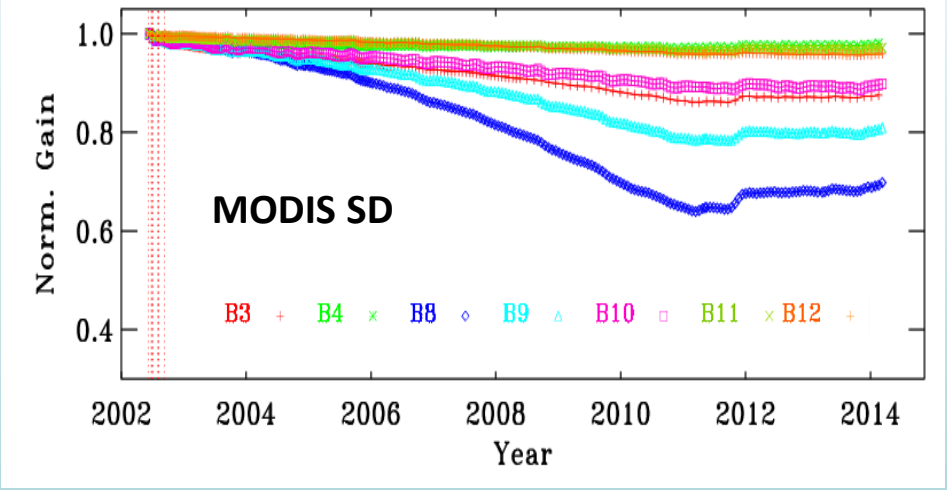
S-NPP VIIRS: 2 Yr

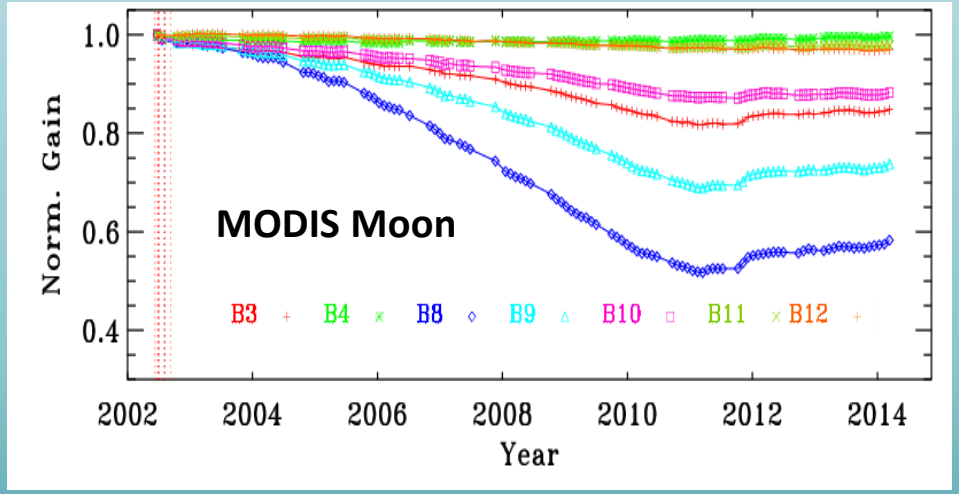
Aqua MODIS: 11.5 Yr

Terra MODIS: 14 Yr

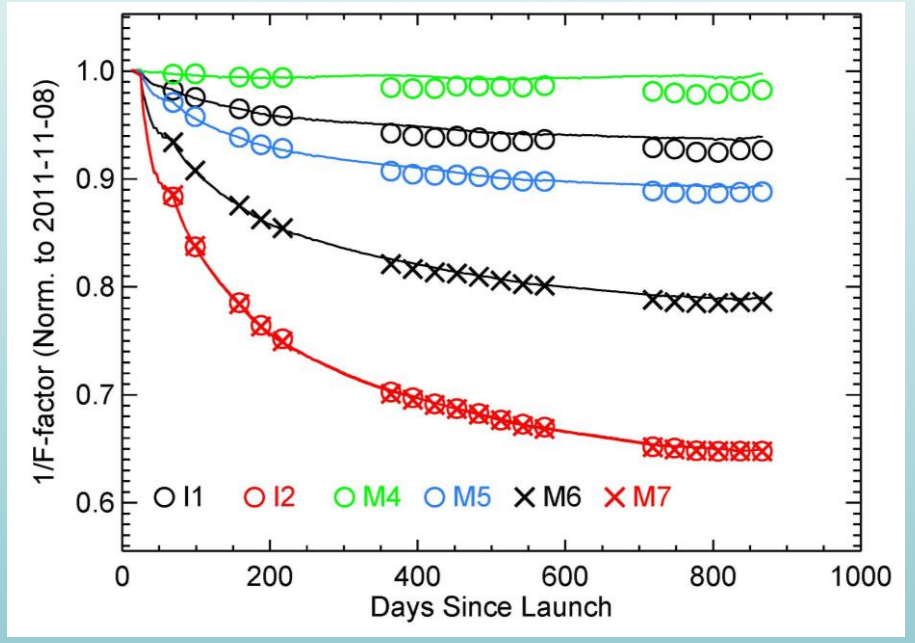
Spectral Band Responses

Band Averaged, MS1 or HAM-A





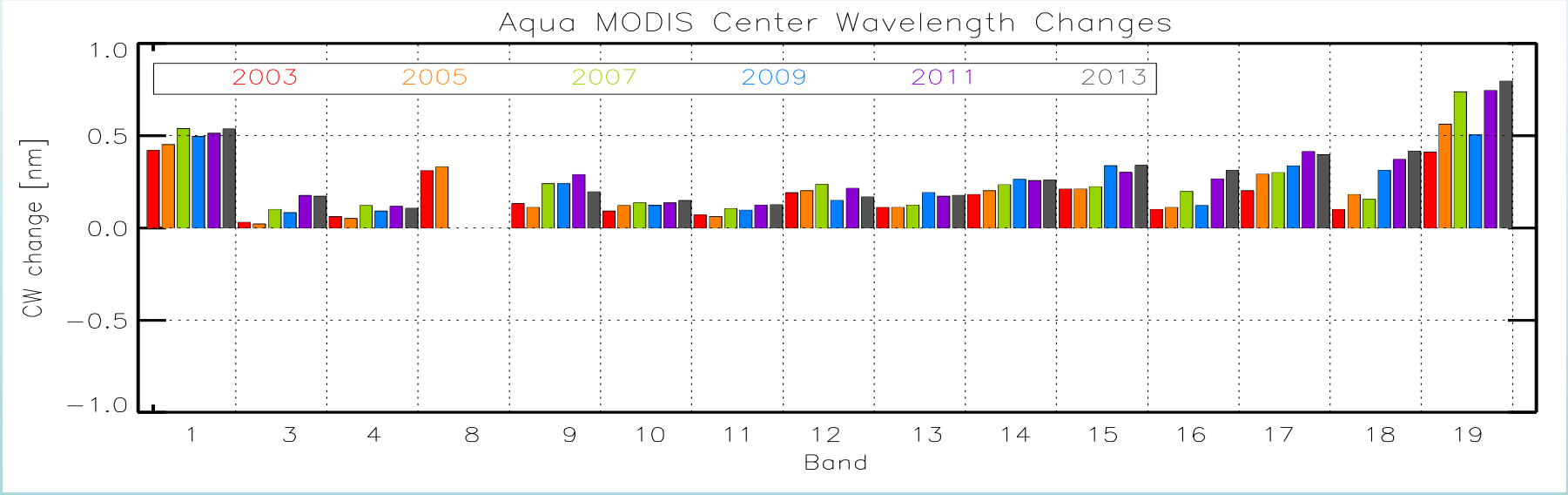
VIIRS SD and Moon

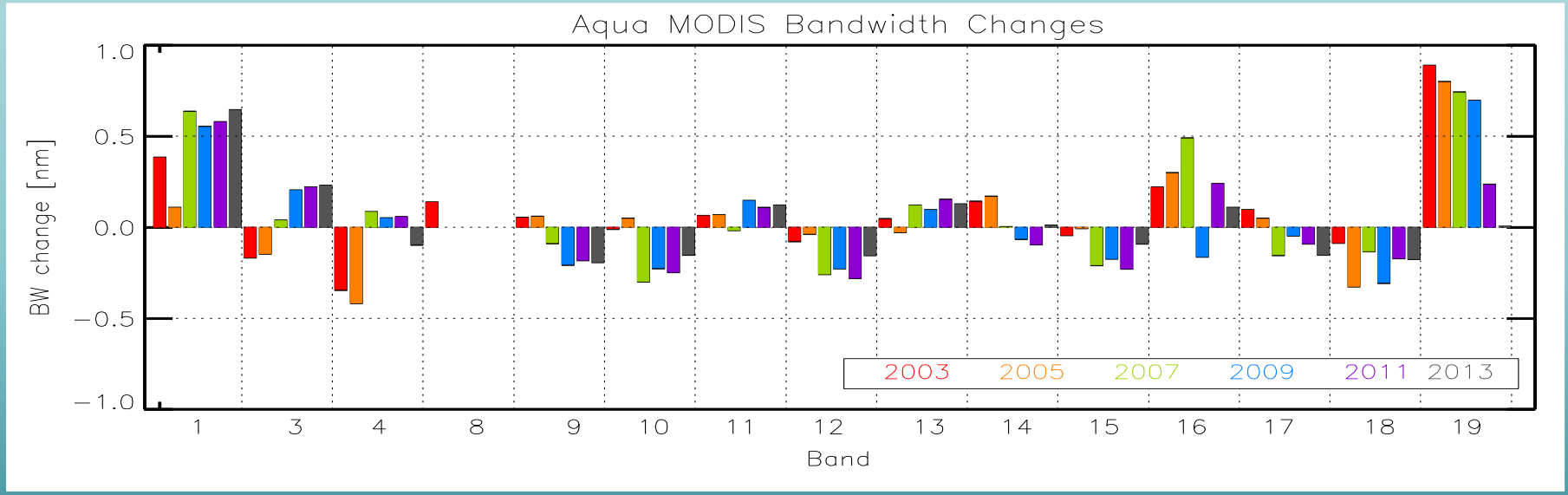


SD and lunar calibration made at different AOI for MODIS (same for VIIRS)

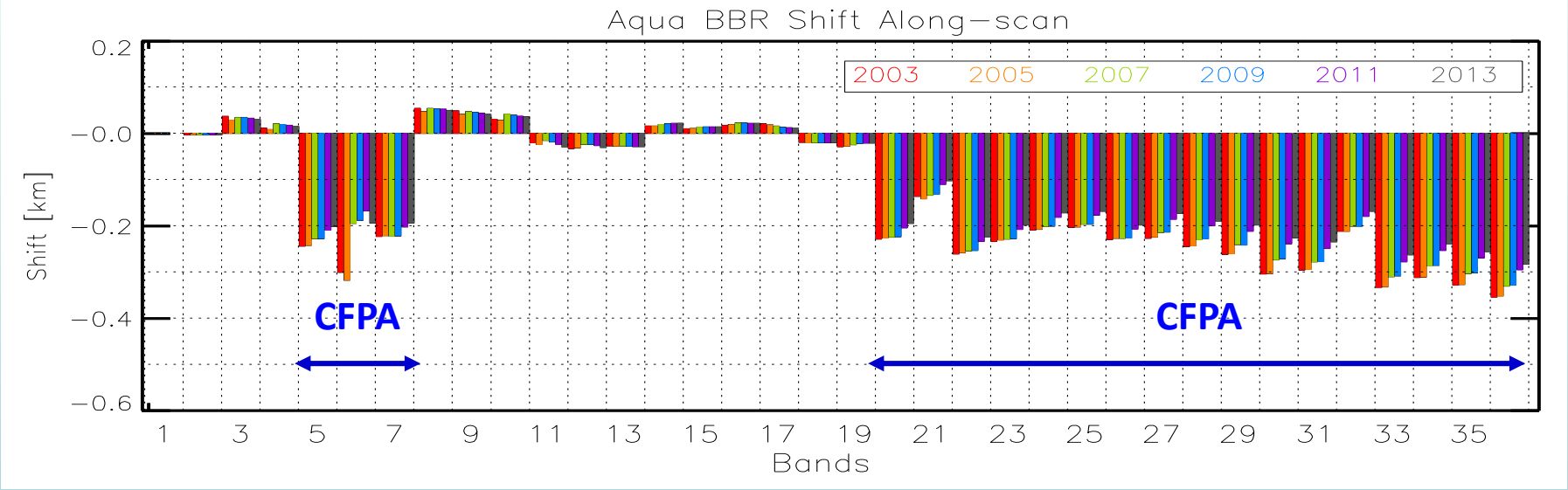
MODIS: large degradation at VIS; VIIRS: large degradation at NIR/SWIR

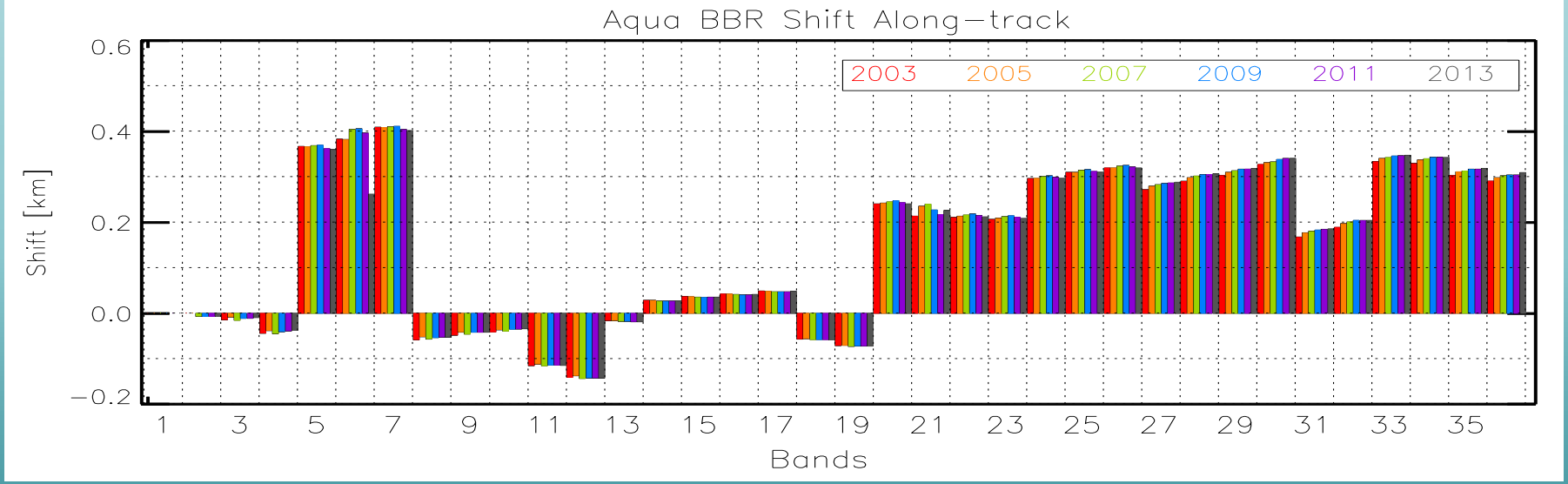
Aqua MODIS Spectral Characterization (VIR/NIR)





Aqua MODIS Spatial Characterization





Status of MODIS Data Collection 6

- Planned as early as Jan, 2008
- Development, including all the changes to algorithms and LUTs, completed (reviewed and approved) Feb, 2012
- C6 data processing started Feb, 2012 for Aqua and Aug, 2012 for Terra
- Products released to public July, 2012 for Aqua and Nov, 2012 for Terra
- C6 L1B processed data can be downloaded: http://ladsweb.nascom.nasa.gov/

Changes in MODIS L1B (RSB)

- **SD degradation at 936 nm included (previous degradation normalized at 936 nm)**
- **Time dependent RVS for all VIS/NIR bands, including bands 13-16**
- **Detector bias corrections (derived from EV data) and detector dependent RVS applied to Terra bands 3, 8-12 and Aqua bands 8-12**
- **EV response trending used to correct calibration drifts noticeable in recent years at different AOIs (including SD AOI) for Terra bands 1-4, 8, 9, 10 (added) and Aqua 8-9**
  - SD to provide radiometric calibration reference
  - Lunar trending to track on-orbit radiometric change
  - EV trending at different AOIs to track on-orbit changes in RVS

Status of VIIRS SDR Code/LUTs

- **IDPS VIIRS SDR Code/LUTs (radiometric)**
  - 18 code versions post launch; numerous LUT updates.
  - Improved LUT update strategy (on demand -> weekly -> automated).
- **VIIRS SDR Cal/Val Maturity Levels**
  - Beta review: April 5, 2012
  - Provisional review: October 24, 2012
  - Validated review: December 19, 2013

Improved SD BRF and screen transmission and SDSM screen transmission LUT

Moon in space view algorithm (RSB)

Modulate relative spectral response (RSR)

RSB auto-calibration in SDR

Status of VIIRS SDR Code/LUTs

- **NASA Land PEATE SDR Code/LUTs and Data Reprocess (C1.0 and C1.1)**
  - Enabling independent data quality assessment and validation, and improvements
  - 12 sets of LUTs for VISNIR/SWIR and DNB delivered to Land PEATE for SDR/EDR assessment and data reprocess.
    - Jan 31, 2013: LUTs from Jan 2012 to Jan 2013 generated using IDPS algorithm Mx6.3 but with smoothed functions to remove outliers.
    - Nov 13, 2013: LUTs from Jan 2012 to Oct 2013 generated with calibration improvements based on Mx6.4, including SD/SDSM screen transmission, SD BRDF, RTA mirrors degradation model, modulated RSRs, and smoothed fitting functions.
    - Mar 21, 2014: LUTs from Jan 2012 to Feb 2014 generated with "best" sensor characterization improvements based on Mx7.2 algorithm for Land PEATE reprocess Collection 1.1, including DNB Stray Light Correction algorithm and smoothed fitting functions.

Challenging Issues and Future Efforts

- **Large changes in MODIS VIS response**
  - Mirror side, wavelength, and AOI dependent => RVS
  - Impact on mirror polarization sensitivity => Uncertainty
  - Less predictability for the long-term trend
- **Large change in VIIRS NIR/SWIR response**
  - Wavelength dependent => RSR
- **Strong wavelength dependent SD degradation (larger at shorter λ)**
  - Much faster in S-NPP VIIRS (no SD door) than Aqua MODIS
- **Future efforts**
  - Improve MODIS RSB RVS characterization using ground targets (new methodologies)
  - Evaluate and reduce the impact due to modulated RSR for VIIRS
  - Examine and mitigate the impact of large SD degradation on SD/SDSM calibration accuracy and potentially on the detector RSR
  - Characterize S-NPP VIIRS and Aqua MODIS calibration consistency (or difference) => **Reference Calibration from Aqua MODIS to S-NPP VIIRS**

Summary

- **Both Aqua MODIS and S-NPP VIIRS continue to operate normally**
- **All on-board calibrators remain capable of all their design functions**
- **Dedicated calibration and characterization effort has been and will continue to be critically important to**
  - maintain sensor performance and data quality
  - address challenging issues
  - enable future improvements

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, M12

7 TEB

Product Maturity Definition

- **Beta (L+150)**
  - **Early release product, initial calibration applied, minimally validated and may still contain significant errors**
  - **Available to allow users to gain familiarity with data formats and parameters**
  - **Product is not appropriate as the basis for quantitative scientific publications studies and applications**

- **Provisional (Beta+2mo)**
  - **Product quality may not be optimal**
  - **Incremental product improvements are still occurring as calibration parameters are adjusted with sensor on-orbit characterization**
  - **General research community is encouraged to participate in the QA and validation of the product, but need to be aware that product validation and QA are ongoing**
  - **Users are urged to contact NPP Cal/Val Team representatives prior to use of the data in publications**

- **Validated/Calibrated (L+1 yr)**
  - **On-orbit sensor performance characterized and calibration parameters adjusted accordingly**
  - **Ready for use by the Centrals, and in scientific publications**
  - **There may be later improved versions**
  - **There will be strong versioning with documentation**