Status of S-NPP VIIRS On-orbit Calibration

Jack Xiong[1], Changyong Cao[2], Vincent Chiang[3] , Jon Fulbright[3], Ning Lei[3]

1. NASA/GSFC; 2. NOAA/STAR; 3. Sigma Space Corp.

Other Contributors: VIIRS Characterization Support Team (VCST)

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Outline

- **Background**
- **On-orbit Operation and Calibration**
- **On-orbit Performance**
  - On-board Calibrators (SD/SDSM and BB)
  - Changes in Spectral Band Responses (or Gains)
  - Changes in Relative Spectral Response (RSR)
  - Detector SNR/NEdT
- **Status of VIIRS SDR Code and LUTs**
- **Summary**

Background

- **Visible/Infrared Imager Radiometer Suite (VIIRS)**
  - Key instrument on S-NPP and future JPSS satellites
  - Spectral bands: 22 (14 RSB, 7 TEB, and 1 DNB)
  - Spectral wavelengths: 0.4-12.4 μm
  - Spatial resolution: 375 m for I bands and 750 m for M bands and DNB
  - Sensor Data Records (SDR): equivalent of MODIS L1B
  - Environmental Data Records (EDR): equivalent of MODIS science data products
- **Strong MODIS Heritage**
  - Design and on-board calibrators
  - Operation and calibration strategies

VIIRS Spectral Bands and Data Products

VIIRS 22 Bands (16 M-Band, 5 I-Band and 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

● Dual gain band

Similar MODIS bands

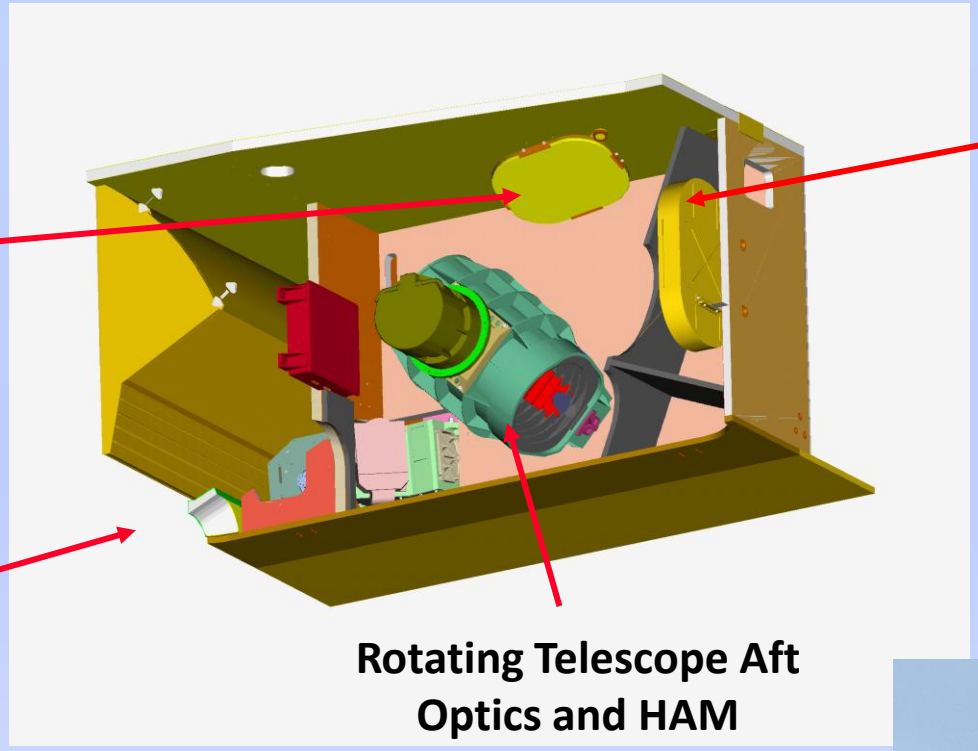
VIIRS 20 EDRs (Land, Ocean, Cloud, Snow)

Name of Product	Group	Type
Imagery *	Imagery	EDR
Precipitable Water	Atmosphere	EDR
Suspended Matter	Atmosphere	EDR
Aerosol Optical Thickness	Aerosol	EDR
Aerosol Particle Size	Aerosol	EDR
Cloud Base Height	Cloud	EDR
Cloud Cover/Layers	Cloud	EDR
Cloud Effective Particle Size	Cloud	EDR
Cloud Optical Thickness/Transmittance	Cloud	EDR
Cloud Top Height	Cloud	EDR
Cloud Top Pressure	Cloud	EDR
Cloud Top Temperature	Cloud	EDR
Active Fires	Land	Application
Albedo (Surface)	Land	EDR
Land Surface Temperature	Land	EDR
Soil Moisture	Land	EDR
Surface Type	Land	EDR
Vegetation Index	Land	EDR
Sea Surface Temperature *	Ocean	EDR
Ocean Color and Chlorophyll	Ocean	EDR
Net Heat Flux	Ocean	EDR
Sea Ice Characterization	Snow and Ice	EDR
Ice Surface Temperature	Snow and Ice	EDR
Snow Cover and Depth	Snow and Ice	EDR

* Product is a Key Performance Parameter (KPP)

VIIRS On-board Calibrators (MODIS Heritage)

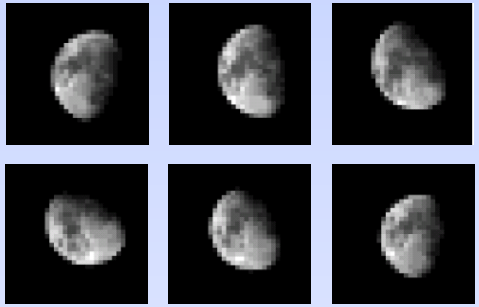
Solar Diffuser with Fixed Screen



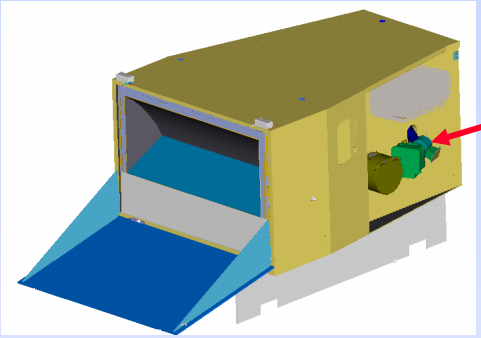
Rotating Telescope Aft Optics and HAM

Blackbody

Extended SV Port



S-NPP VIIRS I1 Lunar Images



Solar Diffuser Stability Monitor

On-orbit Operation and Calibration

Operation and Calibration Activities (Key Events)

- Launch: 10/28/11
- Instrument turn-on: 11/8/11
- Nadir door open: 11/21/11 (first image from VIS/NIR)
- RTA stow (4 times): 12/9/11 – 1/2/12
- Cryo-cooler door open: 1/18/12 (observations from all bands)

- Roll maneuvers: started from 1/4/12 (Lunar calibration)
- Yaw maneuvers; 2/15/12 – 2/16/12 (SD/SDSM screen transmission)
- Pitch maneuvers: 2/20/12 (TEB response versus scan angle)
- OBC calibration activities: SD, SDSM, and BB

Calibration Methodologies

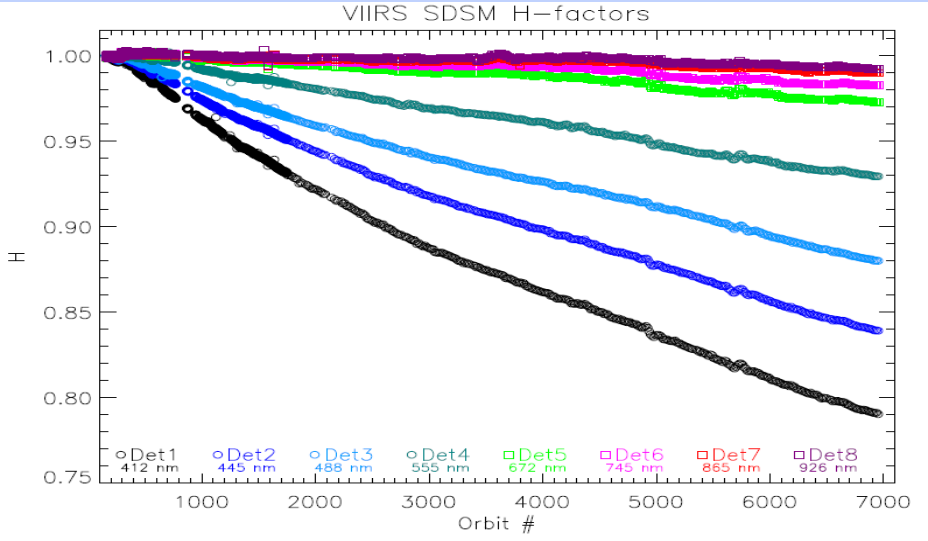
- **Solar Calibration (RSB)**
  - Quadratic calibration algorithm
  - Linear calibration coefficients derived from SD observations
  - SD degradation tracked by SDSM
  - Lunar observation to track RSB calibration stability
    - Regularly scheduled at nearly the same phase angle, implemented via S/C roll maneuvers, observed through SV port with a data sector rotation, referenced to ROLO lunar model
- **BB Calibration (TEB)**
  - Quadratic calibration algorithm
  - Linear calibration coefficients derived from BB observations

On-orbit Performance

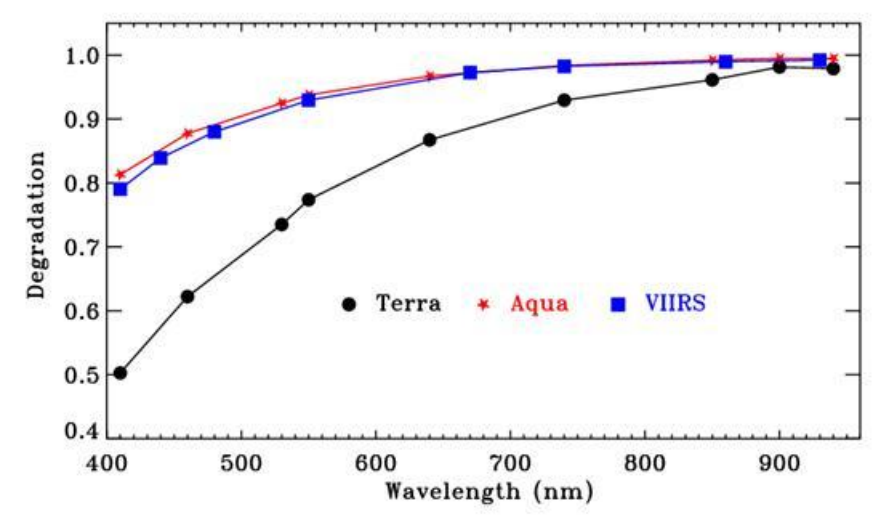
- **On-board Calibrators**
  - SD, SDSM, and BB
- **Changes in Spectral Band Response**
  - Reflective Solar Bands (RSB) and Thermal Emissive Bands (TEB)
- **Changes in Relative Spectral Response (RSR)**
  - Modulated RSR for VIS/NIR Bands
- **Detector SNR and NedT**

SD Degradation

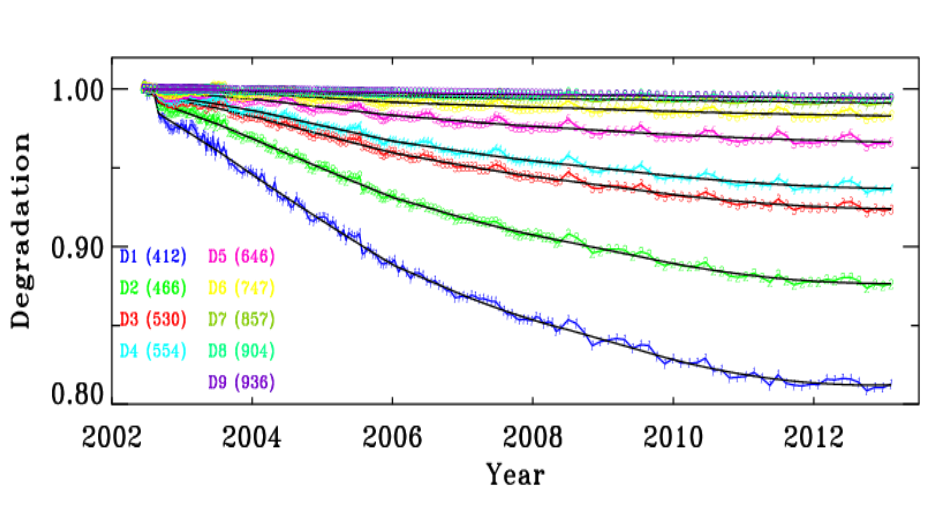
S-NPP VIIRS



Similar to MODIS with strong wavelength dependence



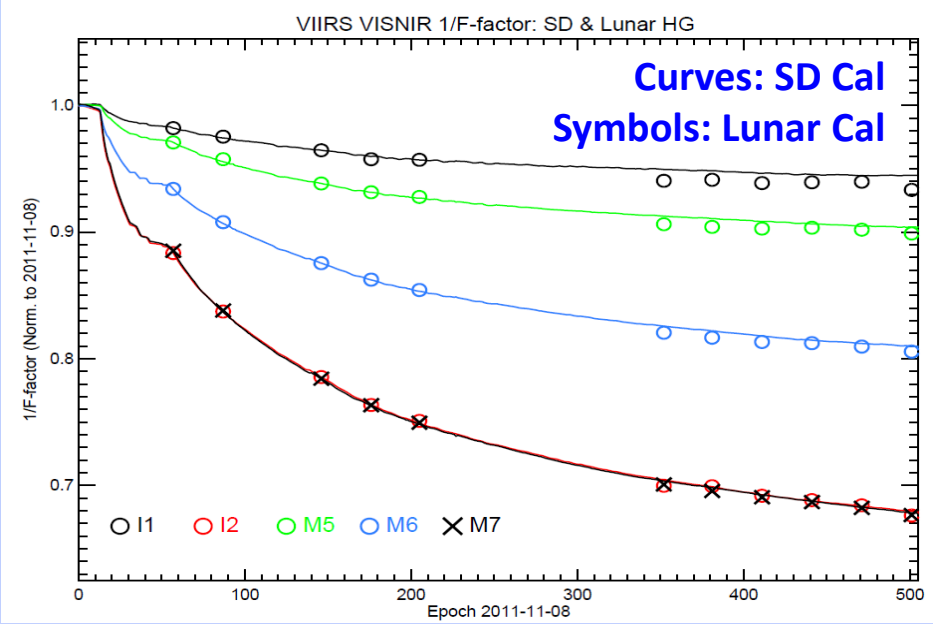
Aqua MODIS

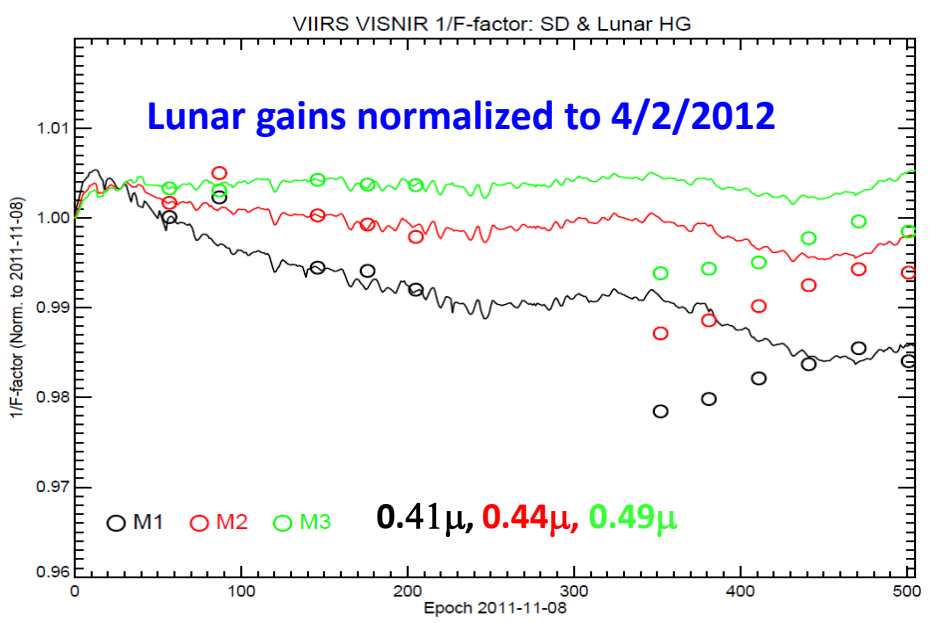


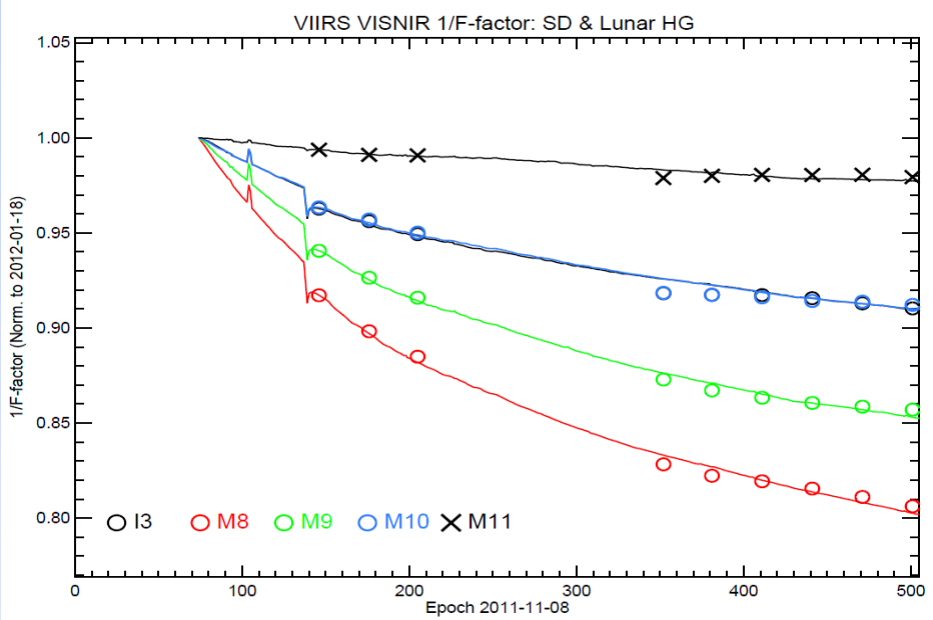
VIIRS has no SD door:

Large degradation in SD BRF at short wavelengths

Changes in Spectral Band Response (RSB)







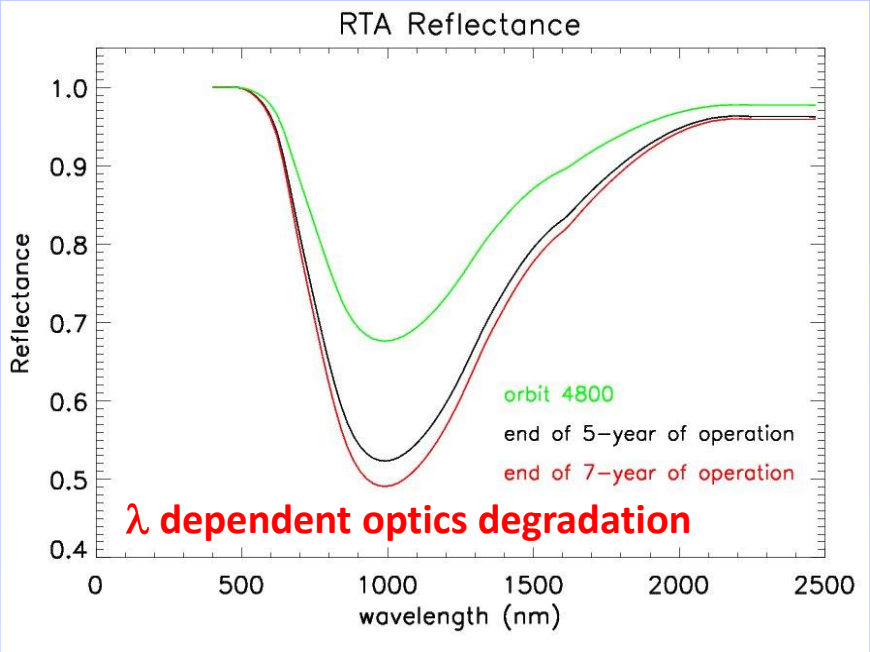
Little change for HAM side and AOI dependence

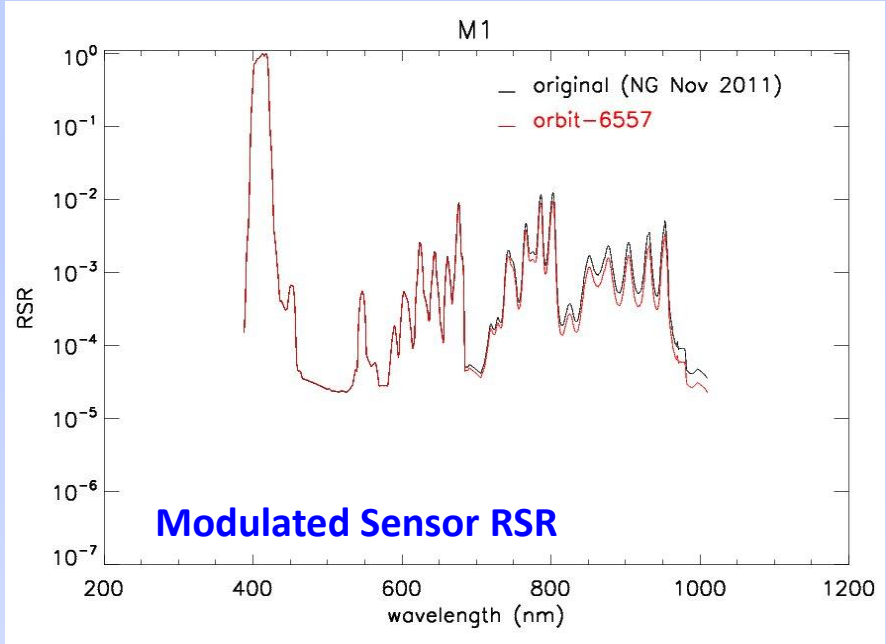
Large changes in NIR/SWIR response

Noticeable SD and Lunar calibration difference in VIS (M1-M3)

Changes in Relative Spectral Response

Mirror Degradation has impact on sensor relative spectral response and radiometric calibration quality





Modulate RSR has recently applied to SDR Calibration and Data Production

BB and TEB Stability

Small orbital variations with similar amplitude for thermistor pairs located at the same scan angle. Thermistors 3 and 6, located at the top of the BB (furthest from the EV), have the largest variation.

$$\Delta\overline{T}_{(T_3,T_6)} = 0.037\ \mathrm{K}$$

$$\Delta\overline{T}_{(T_2,T_5)} = 0.011\ \mathrm{K}$$

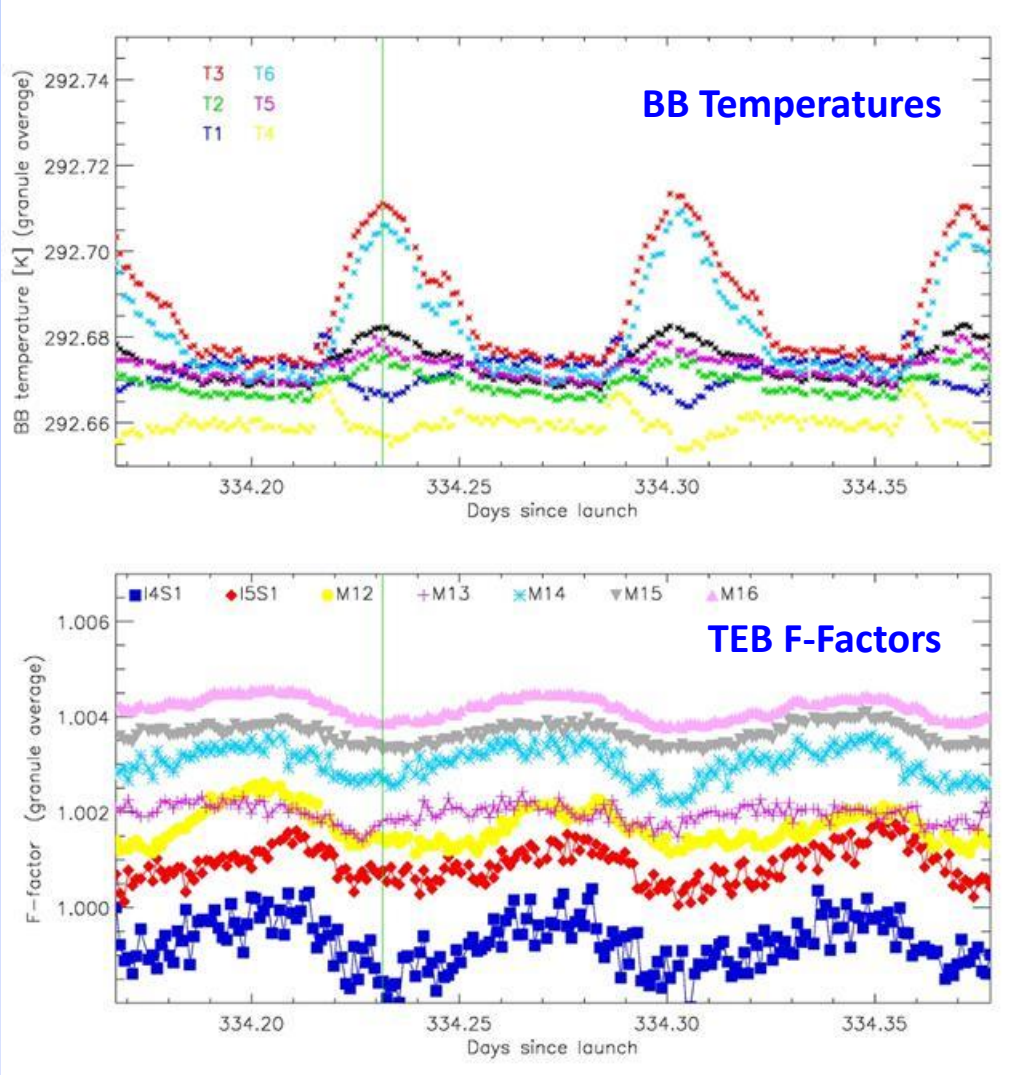
$$\Delta\overline{T}_{(T_1,T_4)} = 0.014\ \mathrm{K}$$

$$\Delta\overline{T}_{(T_1,T_2,T_3,T_4,T_5,T_6)} = 0.014\ \mathrm{K}$$

F-factors at nominal temperature show periodic variations of 0.2%, which are correlated with the BB temperature variations.

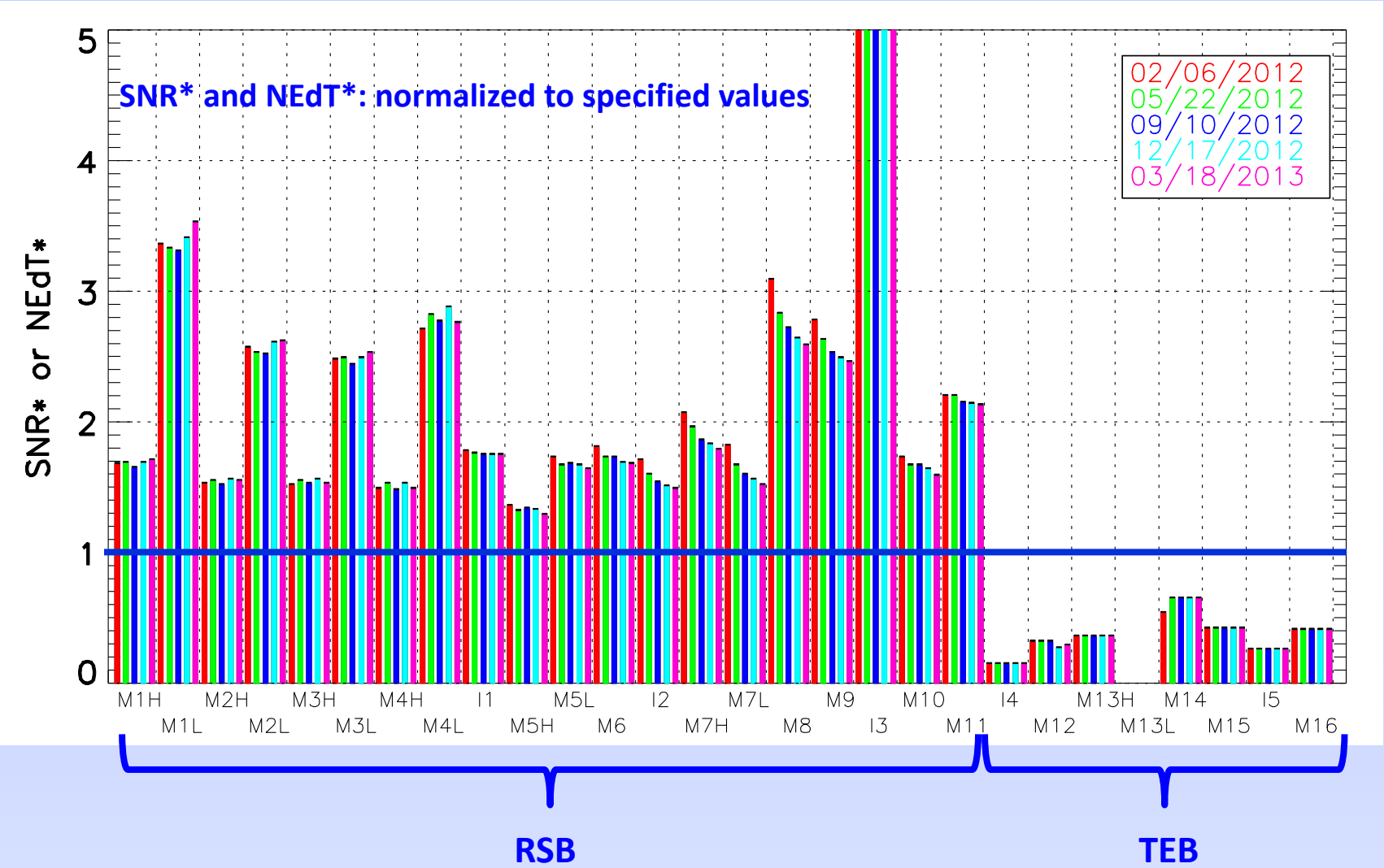
Long-term drift is small (< 0.5%)

Orbits: 4743, 4744, 4745



*** For clarity the F-factors are shifted.**

Detector SNR (RSB) and NEdT (TEB)



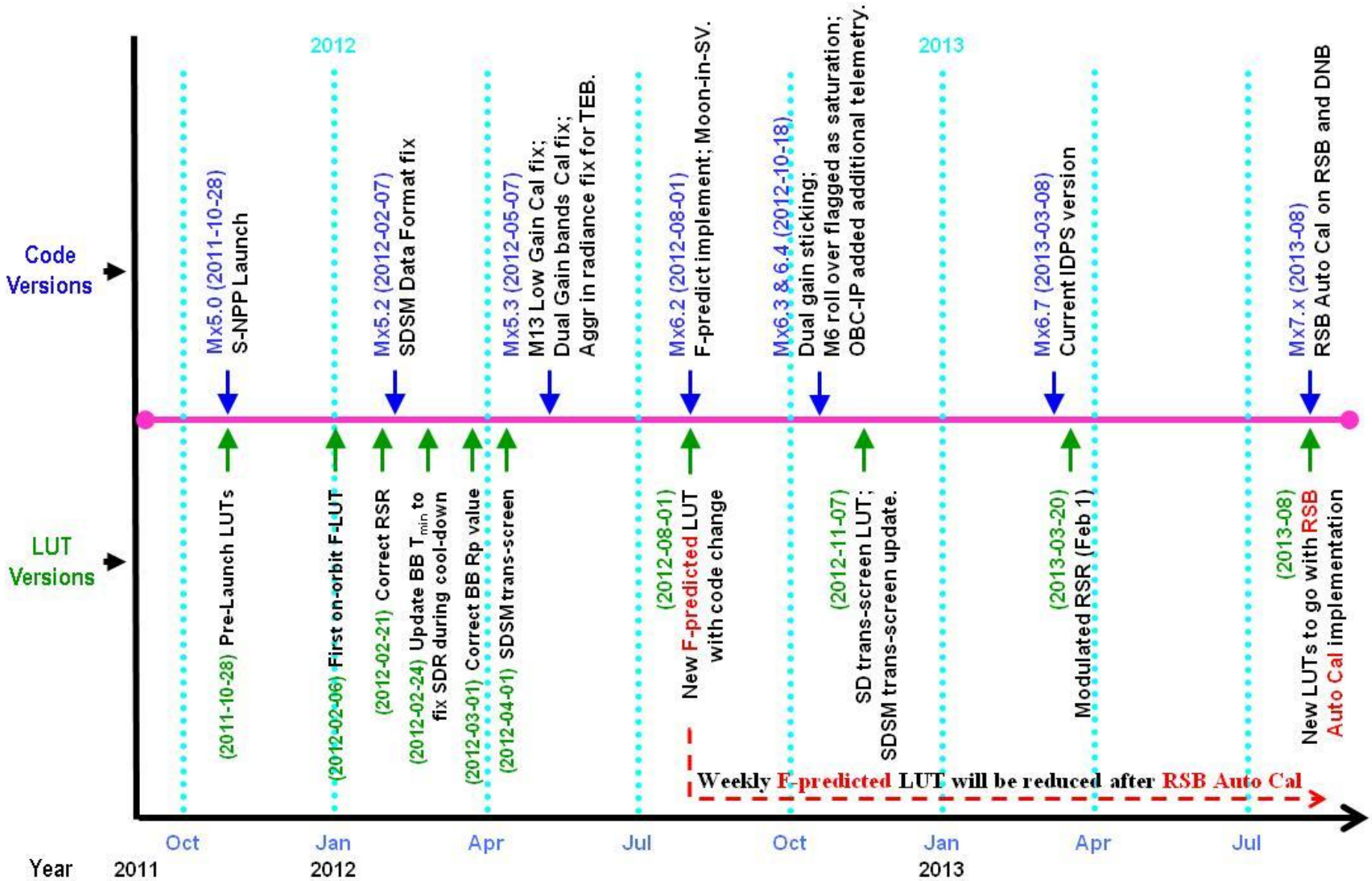
For RSB: SNR* > 1 means performance better than specified requirements

For TEB: NEdT* < 1 means performance better than specified requirements

Status of VIIRS SDR Code/LUTs

- **IDPS VIIRS SDR Code/LUTs (radiometric)**
  - 6 code versions
  - 9 major LUT updates (weekly updates not included)
  - Improved LUT update strategy (on demand -> weekly -> auto cal)
- **VCST Effort**
  - Independent validation and improvements for SDR code/LUTs
  - Two sets of F-LUTs for VISNIR/SWIR and DNB delivered to Land PEATE for SDR/EDR assessment and reprocess.
    - Jan 31, 2013: LUTs from Jan 2012 to Jan 2013 generated using existing IDPS algorithm but with smoothed functions to remove outliers.
    - Apr 19, 2013: LUTs from Jan 2012 to Mar 2013 generated with "best" sensor characterization improvements, including SD/SDSM screen transmission, SD BRDF, RTA mirrors degradation model, modulated RSRs, and smoothed fitting functions.

Major IDPS SDR Code/LUTs Update Timeline (Radiometric)



VIIRS SDR Data Access and Calibration Knowledge Base

- The VIIRS SDR team developed the Calibration Knowledge base at https://cs.star.nesdis.noaa.gov/NCC/VIIRS with a wealth of information including user's guide, relative spectral response, SNO predictions, image gallery, VIIRS Events, publication database, conference presentations, etc.

- VIIRS SDR data is available to the public on the NOAA CLASS archive at http://www.class.noaa.gov, and the ftp site: ftp://ftp-npp.class.ngdc.noaa.gov/

Reference:

Cao, C., F. Deluccia, X. Xiong, R. Wolfe, and F. Weng, 2013, Early On-orbit Performance of the VIIRS onboard the S-NPP Satellite, IEEE Transactions on Geoscience and Remote Sensing, in press.
DOI: 10.1109/TGRS.2013.2247768

Summary

- **VIIRS continues to operate and calibrate satisfactorily (as planned and expected)**
  - SD/SDSM, BB (warm-up and cool-down), and lunar calibration activities are regularly performed
  - Changes in sensor response are accurately tracked by the on-board calibrators
  - Calibration LUTs are frequently updated
- **Overall on-orbit performance meets the design requirements (such as SNR/NEdT)**
- **Continuous and dedicated calibration efforts are critical for maintaining SDR data and calibration quality**
- **The modulated RSRs, as a result of mirror degradation, have been developed and applied to sensor SDR calibration and data production.**

MODIS L1B Collection 6 Status

- **MODIS L1B Collection 6**
  - **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/**

MODIS Data Collection 6 Status

C6 Aqua L1+CloudMask/Atmos Profile data reprocessing started in Feb 2012

C6 Aqua L1+CloudMask/Atmos Profile data forward production started Dataday = June 27, 2012

C6 Aqua L1+CloudMask/Atmos Profile data release date: July 18, 2012

C6 Terra L1+CloudMask/Atmos Profile data reprocessing started in Aug 2012

C6 Terra L1+CloudMask/Atmos Profile forward production started from Dataday = Sept 30, 2012

C6 Terra L1+CloudMask/Atmos Profile data release date: Nov 05, 2012

C6 Atmos reprocessing starting date: early May 2013

C6 Land reprocessing starting date: early July 2013