STAR VIIRS SDR CalVal Overview

Quanhua (Mark) Liu, Slawomir Blonski, and Changyong Cao

with contributions from Fuzhong Weng, Sirish Uprety, Scott Hu,

Dave Pogorzala, Sean Shao, and Yan Bai

April 5, 2012

VIIRS SDR Tasks Assigned to NOAA/STAR

Cao (management lead) and De Luccia (technical lead) coordinate and execute the 58 VIIRS SDR cal/val tasks defined in the OPSCON.

Task #	Description	lead	Progress
RAD-7	SDR COMPARISON WITH MODEL	Cao	CRTM model is used to investigate the difference between measured and simulated BTs.
RAD-8	SDR COMPARISON WITH AVHRR	Cao, Xiong	VIIRS SDR and NOAA-19 AVHRR 1b data are compared.
RAD-9	SDR COMPARISON WITH MODIS	Cao, Xiong	Intensive VIIRS SDR and MODIS L1b data are analyzed.
PTT-1	OPERABILITY, NOISE, SNR VERIFICATION	Cao, Schwarting	Independent analysis on gain and noise are performed.
PTT-2	RDR HISTOGRAM ANALYSIS	Cao	Ongoing
PTT-3	NOISE AND SNR FOR UNIFORM EV SCENES	Cao, Moyer	Dome C and uniform ocean analysis
PTT-4	DNB OFFSET VERIFICATION	Cao, Rauch	DNB image investigation
PTT-5	ELECTRONIC GAIN MEASUREMENT	Cao, Florio	Telemetry monitoring
PTT-6	RADIOMETRIC PERFORMANCE MONITORING	STAR/Aero	Web-based monitoring system monitoring SDSM, SV, EV counts
PTT-7	TELEMETRY TRENDING MONIRORING	STAR/Aero	Web-based monitoring system monitoring telemetry temperatures

RAD-7: SDR Comparison with Model

Objective:

To perform a qualitative evaluation of top-of-atmosphere (TOA) radiances from select scenes.

Methods and Tools:

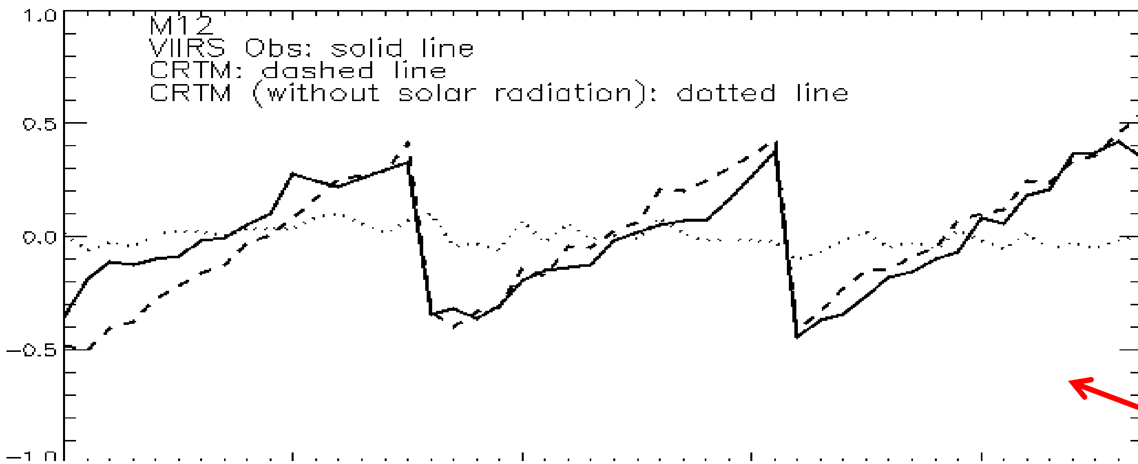
Use VIIRS SDR, ECMWF inputs and CRTM

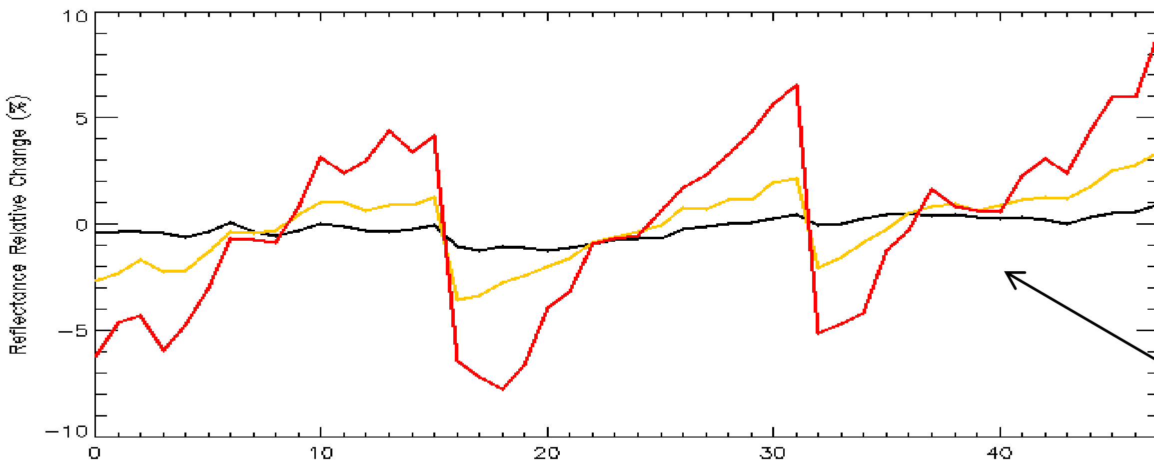
Results and Recommendations:

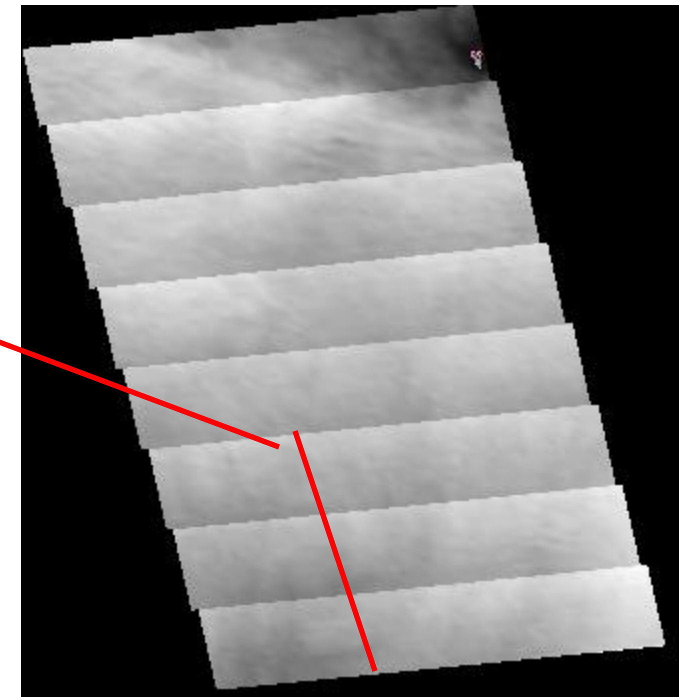
Measurements and CRTM simulations for the VIIRS thermal bands agree well. CRTM is powerful for determining the root cause of M12 striping during daytime.

The VIIRS measurements and the CRTM simulations on M6 and M7 are needed.

VIIRS and CRTM Modeling for M12 Striping Investigation (RAD-7)







M1, M4, and M11 measured (R-Rm)/Rm *100

The STAR team applied the CRTM to simulate the VIIRS SDR data. It is found that the M12 striping reported by the SST EDR team is caused by the difference in VIIRS azimuth angles among detectors.

Detailed CRTM Calculation for the striping (RAD-7)

Detector #	$\tau(\theta_{sat})$	ϕ_{sat}	BRDF	**A**	**B**	R	Brightness temperature
1	0.73685	80.368	0.04253	0.51055	0.10590	0.61645	302.666
2	0.73649	80.543	0.04309	0.50923	0.10717	0.61641	302.648
3	0.73700	80.717	0.04365	0.51022	0.10873	0.61894	302.738
4	0.73645	80.892	0.04422	0.50964	0.10999	0.61962	302.769
5	0.73705	81.066	0.04479	0.51114	0.11159	0.62273	302.871
6	0.73628	81.241	0.04537	0.51147	0.11280	0.62427	302.931
7	0.73701	81.415	0.04596	0.51164	0.11448	0.62612	302.987
8	0.73596	81.589	0.04656	0.51074	0.11566	0.62640	303.020
9	0.73673	81.764	0.04715	0.51175	0.11739	0.62914	303.115
10	0.73557	81.938	0.04776	0.51124	0.11855	0.62978	303.153
11	0.73641	82.113	0.04837	0.51120	0.12036	0.63157	303.230
12	0.73509	82.287	0.04901	0.51134	0.12155	0.63289	303.316
13	0.73562	82.461	0.04962	0.51180	0.12325	0.63505	303.396
14	0.73486	82.636	0.05026	0.51057	0.12461	0.63518	303.417
15	0.73526	82.810	0.05089	0.50993	0.12629	0.63622	303.439
16	0.73565	82.985	0.05154	0.50998	0.12812	0.63810	303.560

$$R = \tau(\theta_{sat})[\varepsilon B(T_s) + (1-\varepsilon)R_{atm\_d}] + R_{atm\_u} + F_0 \cos(\theta_{sun})\tau(\theta_{sun}) BRDF(\theta_{sun}, \theta_{sat}, \phi_{sun} - \phi_{sat})\tau(\theta_{sat})$$

A **B**

RAD-8: SDR Comparison with AVHRR

Objective:

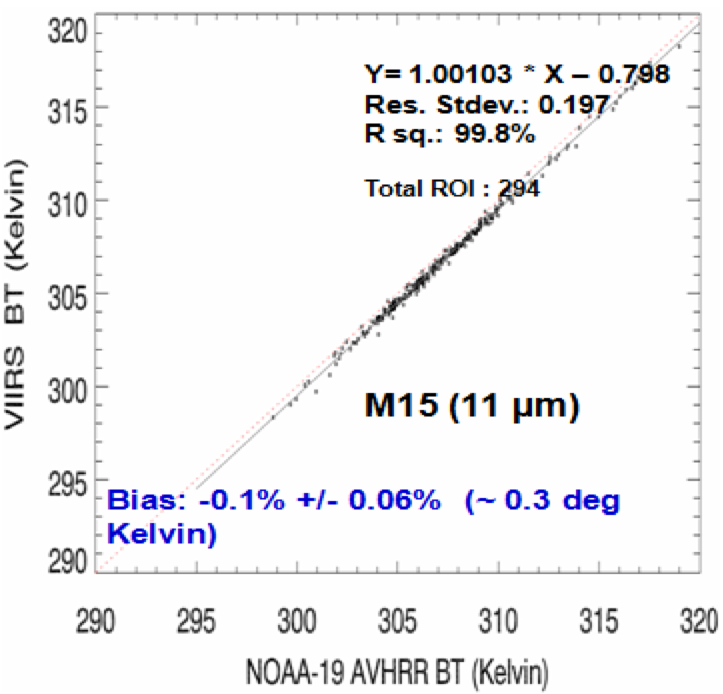
To compare VIIRS retrieved TOA radiance with AVHRR retrieved TOA radiance.

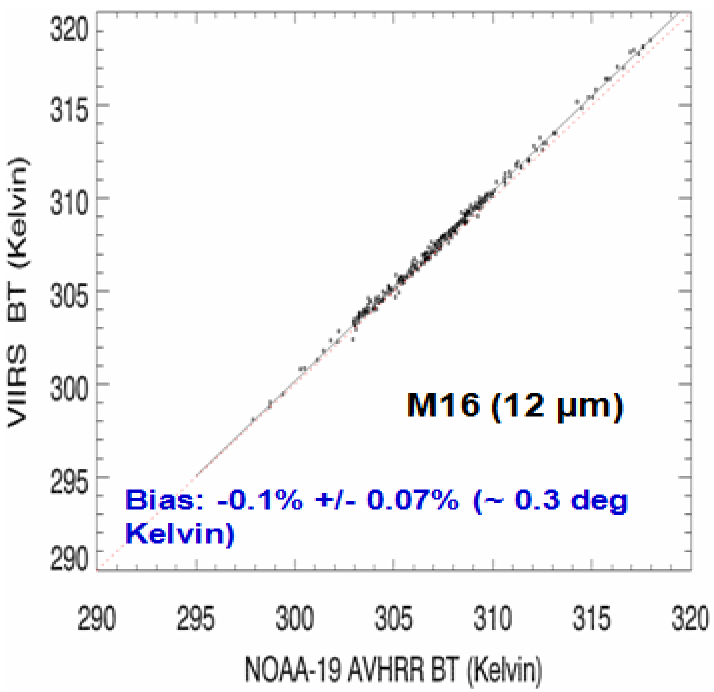
Methods and Tools:

Use SNO orbit prediction, VIIRS SDR, and AVHRR 1b readers and data, statistical tools.

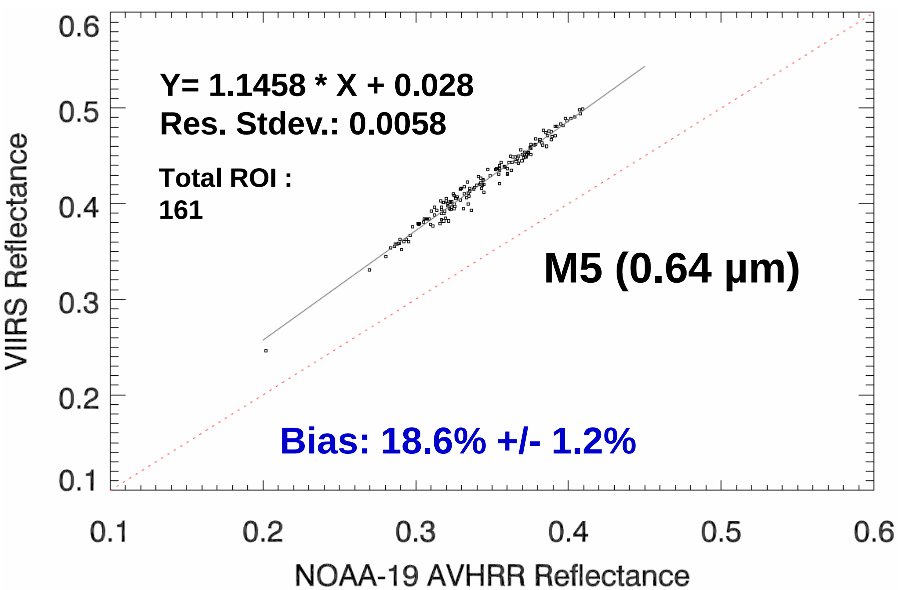
Results and Recommendations:

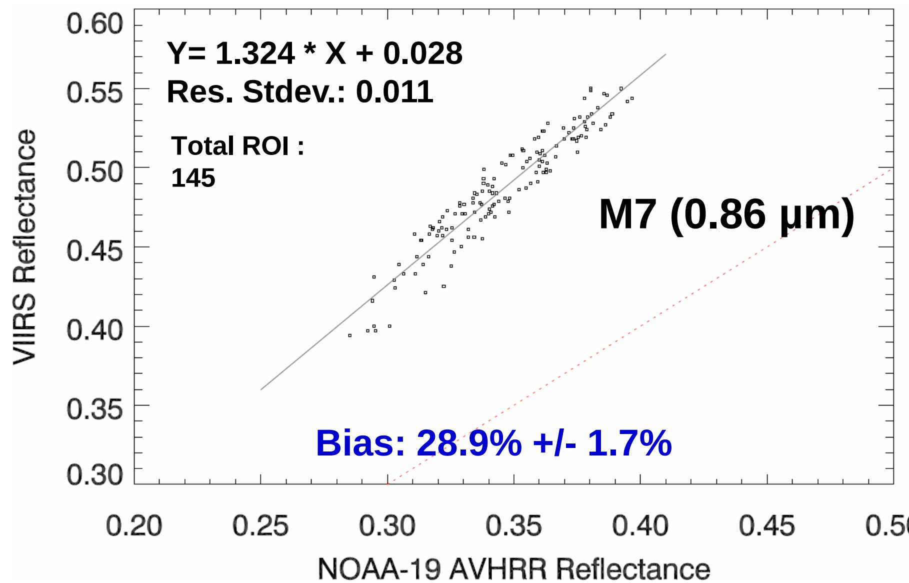
VIIRS and AVHRR TEBs agree (~ 0.3 K). VIIRS and AVHRR RSB agree with the slope. Large bias in RSB needs to be further investigated.





VIIRS and AVHRR SNO Comparison (RAD-8)





- Bias=(VIIRS-AVHRR)*100%/VIIRS
- **Spectrally Induced Bias at Libya**
  - **Ch1: 9.69% +/- 0.306%   Ch2: 15.14% +/- 2.37%**
  - The actual bias for AVHRR Ch1 is 8.9% and for Ch2 is 13.7%.
  - Large bias for channel 1 could be due to calibration issue whereas for channel 2, it could be due to water vapor absorption.

Note: the spectrally induced bias for channel 2 (given above) was calculated at NOAA-Libya site whereas this SNOx comparison is performed at different location in Africa. Thus water vapor variability might be much different.

RAD-9: SDR Comparison with MODIS

Objective:

To compare VIIRS retrieved TOA radiance with MODIS retrieved TOA radiance.

Methods and Tools:

Use SNO orbit prediction, VIIRS SDR, and MODIS readers, and analysis tools.

Results and Recommendations:

VIIRS and MODIS TEBs agree well by considering the difference in spectral response between VIIRS and MODIS. VIIRS and MODIS RSB agree, too.

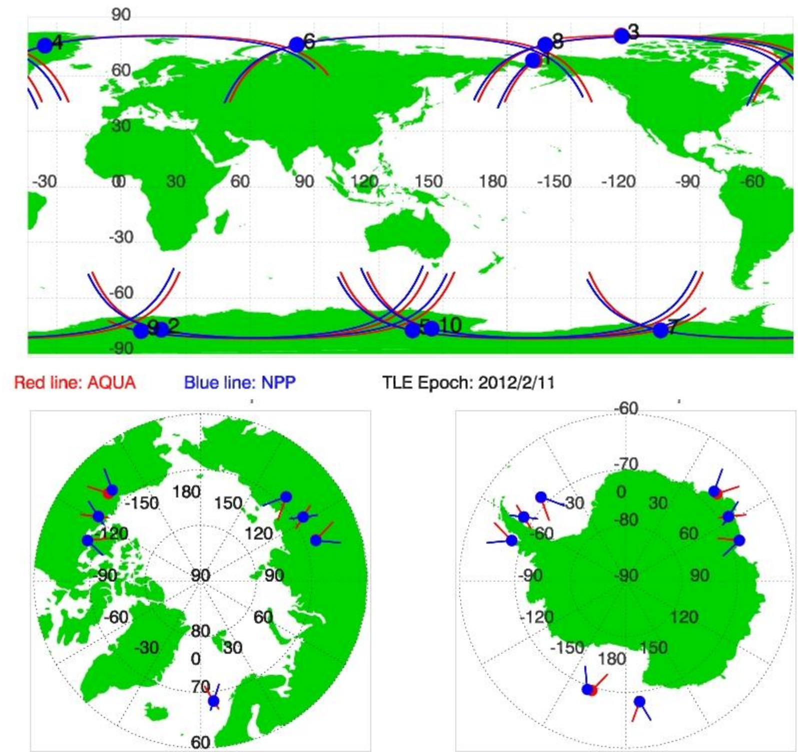
Further comparisons are necessary for monitoring the VIIRS RSB degradation.

SNO Prediction and Analysis

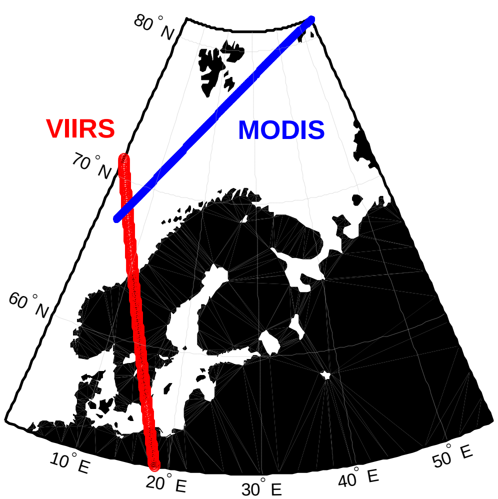
- Based on information from the NOAA/STAR/NCC SNO (simultaneous nadir overpass) prediction website, https://cs.star.nesdis.noaa.gov/NCC/SNOPredictions, included all SNO datasets acquired by NPP VIIRS and by MODIS from both Aqua and Terra between February 14 and March 20, 2012
- For each SNO, averaged valid VIIRS and MODIS pixels from a 12-km by 12-km area selected at the intersection of the satellite ground tracks (16×16 750-m pixels for VIIRS and 12×12 1-km pixels for MODIS): typically provides closer spatial coincidence than temporal one (still within ~1-2 min.)
- The NPP – Aqua SNOs occurred over snow-covered Antarctica (some at the Dome C site), providing bright surfaces in the VisNIR bands, while the NPP – Terra SNOs occurred over northern Siberia, Scandinavia, and ocean (both dark and bright scenes)

Table of predicted SNOs for the next 14.0 days since TLE Epoch: 2/11/2012

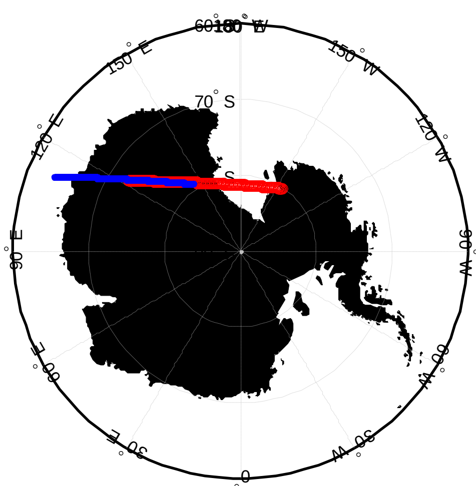
Index	Date (AQUA)	Time (AQUA)	AQUA Lat,Lon	Date (NPP)	Time (NPP)	NPP Lat,Lon	Distance(km)	Time Diff (sec)
1	02/12/2012	14:07:39	68.18,-167.05	02/12/2012	14:06:26	68.31,-168.01	42.15	73
2	02/12/2012	14:54:19	-76.97, 18.64	02/12/2012	14:54:19	-76.97, 18.68	1.08	0
3	02/12/2012	15:41:09	81.79,-126.79	02/12/2012	15:42:22	81.33,-126.43	50.45	73
4	02/15/2012	06:21:38	76.25, -35.59	02/15/2012	06:20:45	76.25, -35.60	0.21	53
5	02/15/2012	07:10:43	-77.31, 135.83	02/15/2012	07:11:07	-77.32, 135.89	1.70	24
6	02/17/2012	22:37:58	76.73, 81.90	02/17/2012	22:37:29	76.73, 81.94	1.10	29
7	02/17/2012	23:27:13	-77.31,-108.29	02/17/2012	23:28:02	-77.30,-108.40	2.89	49
8	02/20/2012	14:54:28	76.76,-162.13	02/20/2012	14:54:24	76.75,-162.23	2.77	4
9	02/20/2012	15:43:35	-77.71, 9.21	02/20/2012	15:44:48	-77.70, 9.18	0.76	73
10	02/23/2012	06:21:41	-76.37, 144.76	02/23/2012	06:20:44	-76.37, 144.78	0.54	57



NPP and Terra SNO Example

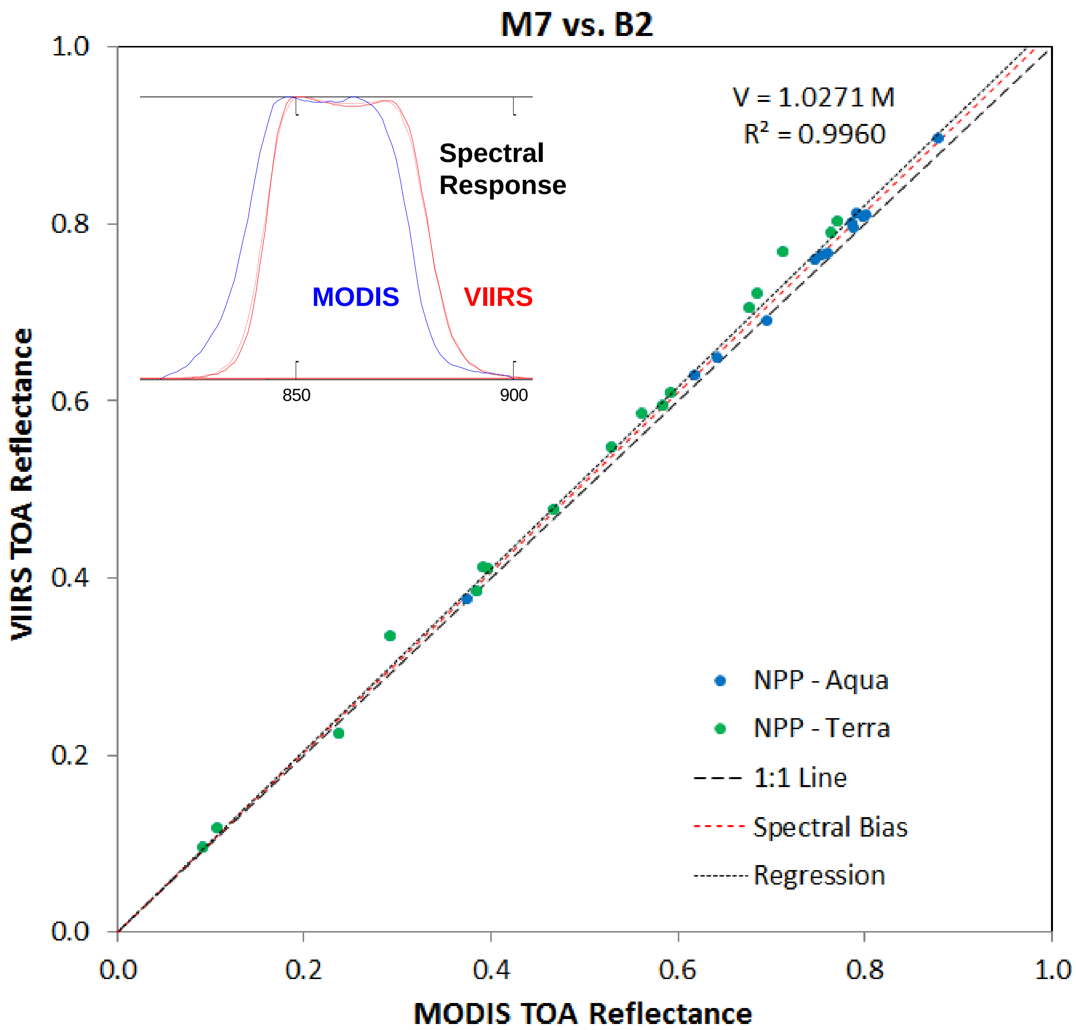


NPP and Aqua SNO Example



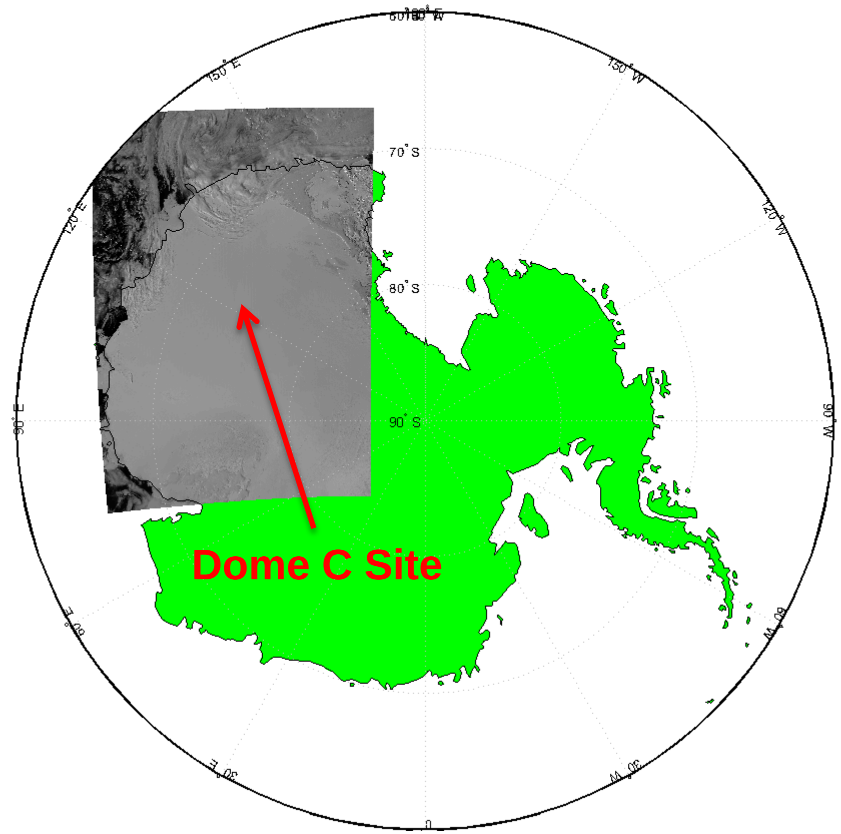
VIIRS vs. MODIS SNO Comparisons (RAD 9)

- Compared TOA (top-of-atmosphere) reflectance measured by VIIRS and MODIS at the SNO sites (accounts for solar zenith angle differences)
- Because of differences between spectral responses of VIIRS and MODIS bands, reflectance data do not match exactly (1:1 line)
- The effect of the spectral response difference on the measured reflectance (spectral bias) was recently estimated using satellite hyperspectral data collected over the Antarctic Dome C site (Cao et al., submitted for publication)
- Ratios of the VIIRS band M7 and MODIS band 2 data agree very well with the prediction from that study (Spectral Bias line)
- This comparison confirms accuracy of the current radiometric calibration for VIIRS band M7, which is the band the most affected by the mirror degradation anomaly
- Other VIIRS bands also display high correlation with MODIS counterparts (next slide): estimates of spectral biases for these bands are ongoing
- While Terra provides so far most of the low reflectance data, a small bias between Aqua and Terra data can be seen (will investigate)



Antarctic Dome C Observations (RAD 10)

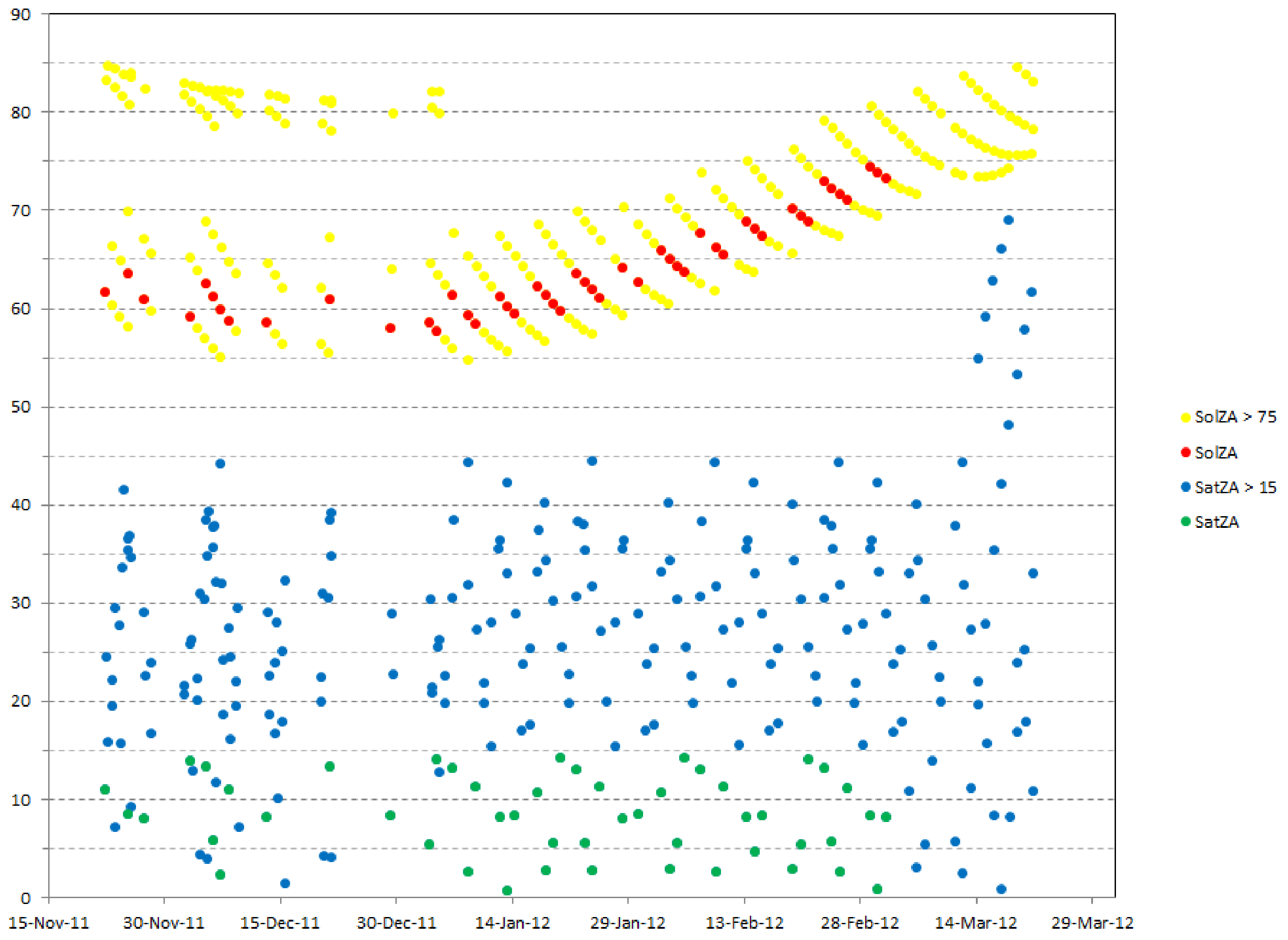
- The Antarctic Dome C site is located in the High Polar Plateau Region at 75°06’S, 123°21’E with mean elevation of 3.2 km above sea level
- The site has the following characteristics that make it very suitable for radiometric calibration and validation of satellite sensors:
  - Surface is flat and covered with uniformly distributed, permanent snow
  - Temperatures are extremely cold and stable, except for seasonal variability
  - Skies are clear most of the time, with more than 75% of days being cloud free
  - Atmosphere above the site has low water vapor and aerosol loading, thus atmospheric effects are small
- TOA (top-of-atmosphere) reflectance measured by VIIRS at the Dome C site was averaged over a 48×48-pixel area to reduce effects of radiometric response non-uniformity (striping)
- To mitigate BRDF effects, band ratios were calculated between the bands M1, M2, M4 to M7, and the band M3



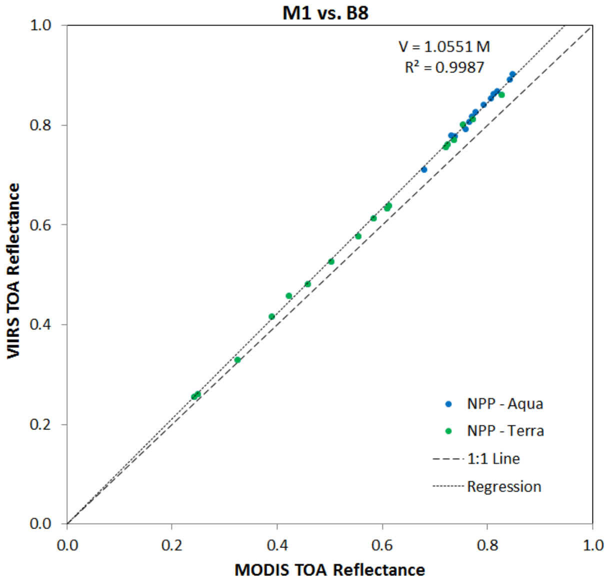
SVM05_npp_d20120124_t0722155_e0727559_b01247_c20120124183134736309_noaa_ops

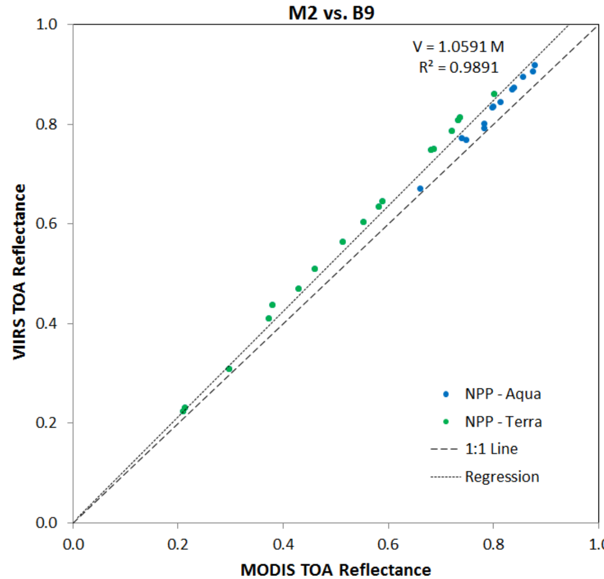
Dome C Solar and NPP VIIRS Geometries

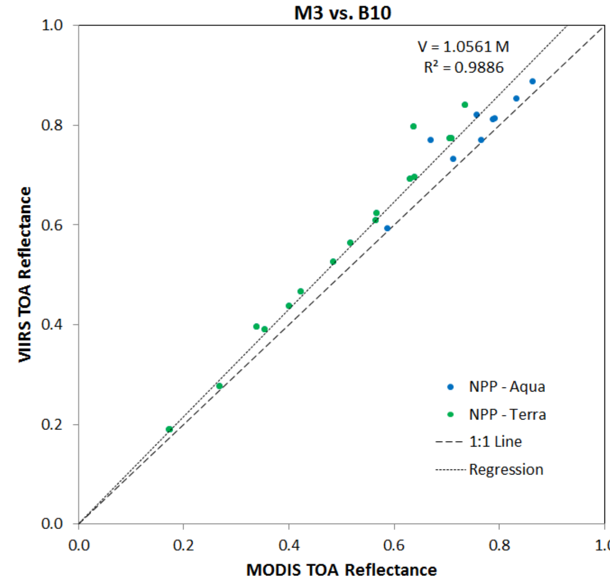
Data points with solar zenith angle larger than 75° or satellite zenith angle larger than 15° were excluded from the analysis

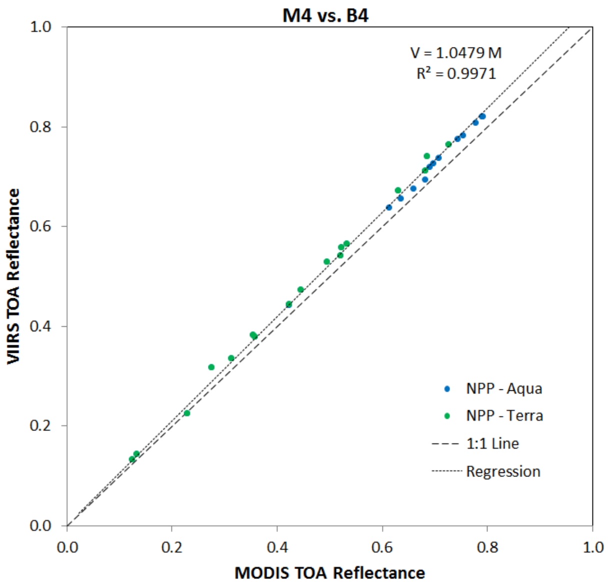


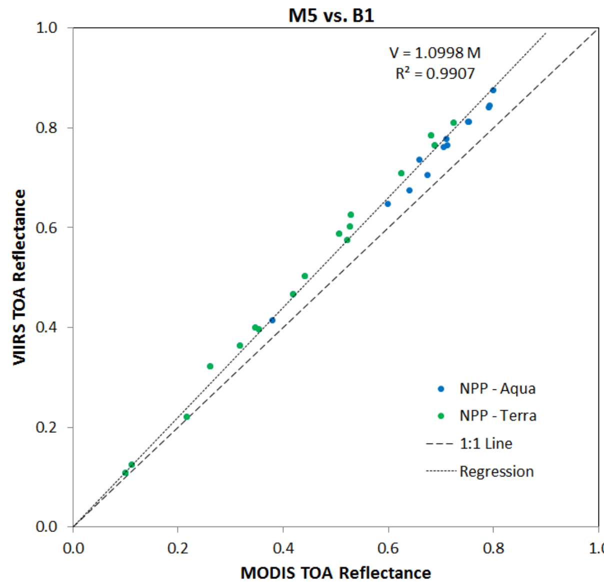
VIIRS vs. MODIS SNO Comparisons (cont.)











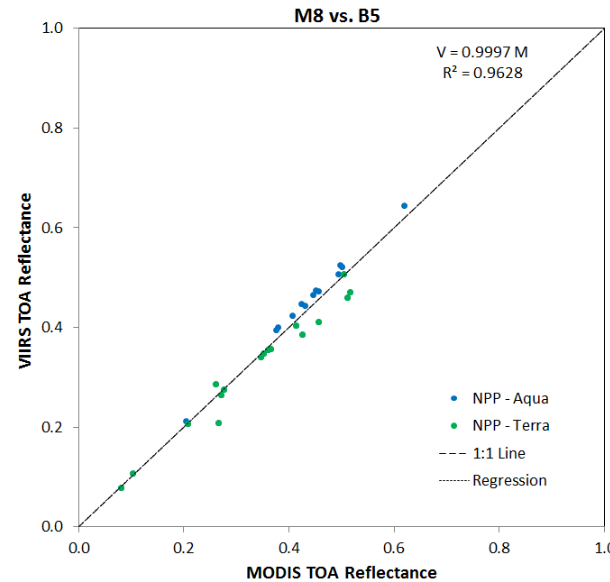
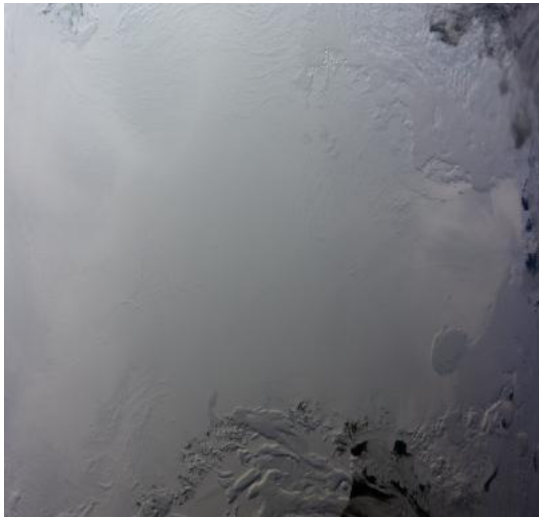
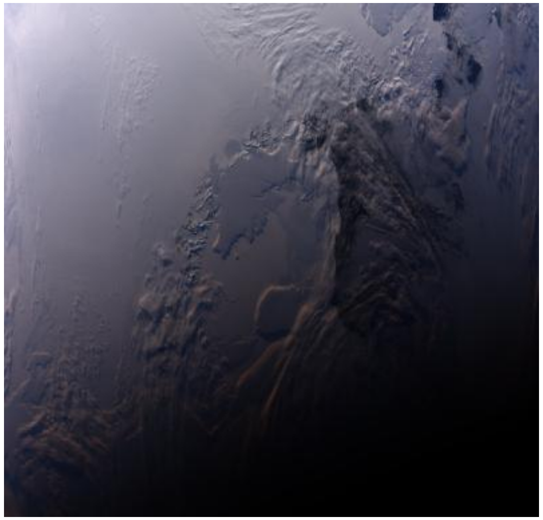


Image Quality Analysis: Striping (IMG 2)

- Procedure:
  - Used both Antarctic and ocean scenes
    - Antarctic scenes are usually bright, but near terminator they may be as dark as ocean scenes
  - Selected the most uniform area from each scene
    - Typically 160×200 pixels
  - Averaged radiance values for each row over all columns in the selected area
  - Points for each detector were plotted with different color
  - Periodicity of image profiles tests scene uniformity
  - Presented results are only for bands M1 and M2
    - More uncertainty in striping analysis for the other VisNIR bands



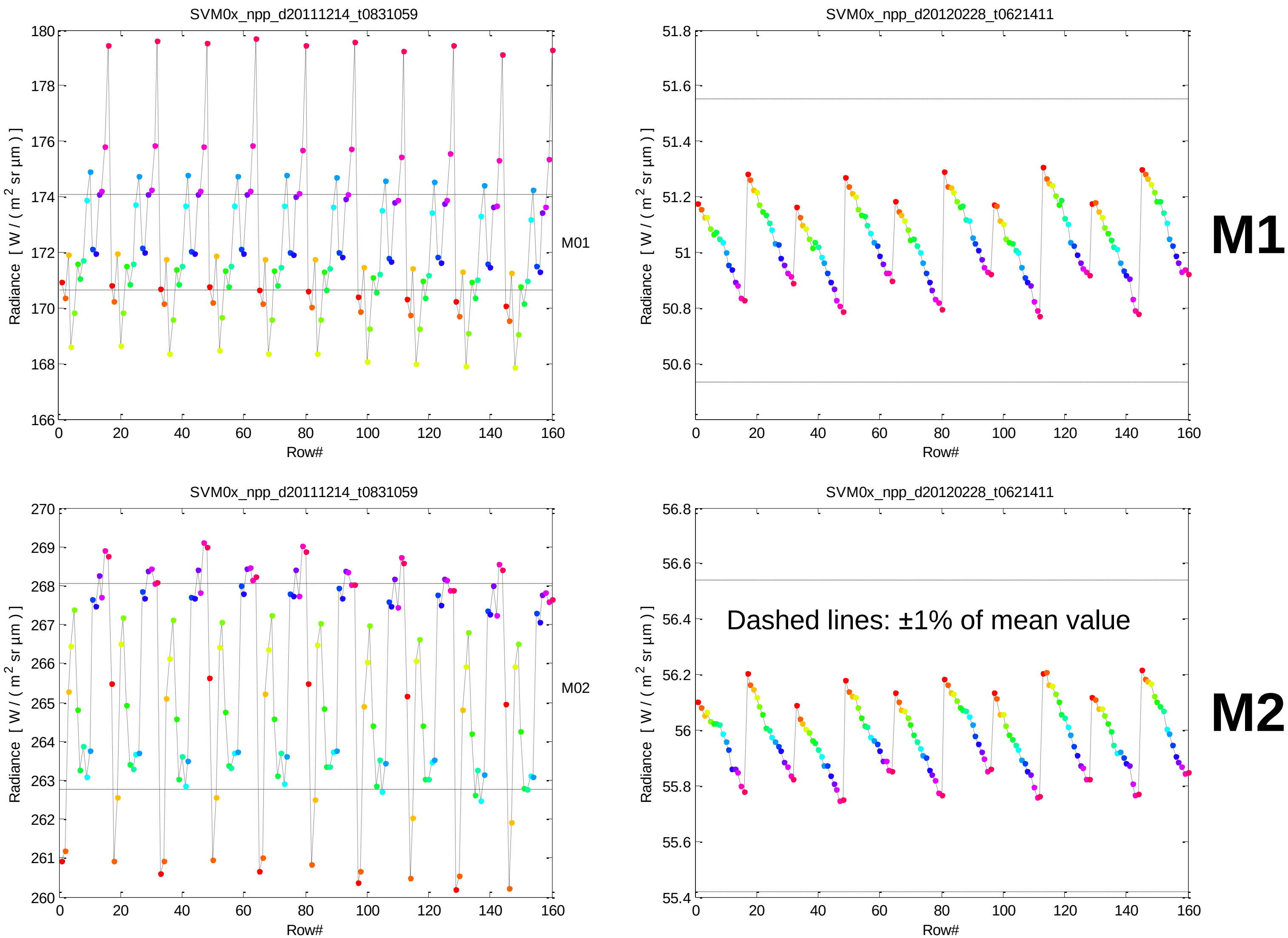
2011-12-14 8:31 UTC



2012-02-28 6:21 UTC

Uniformity Improvement with LUT Updates (PTT-3)

Striping is greatly reduced since the LUT updates are derived from the on-orbit solar diffuser measurements

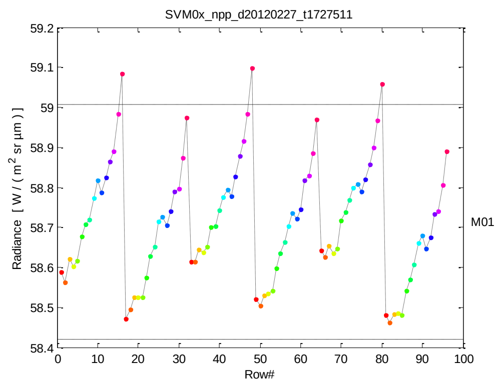


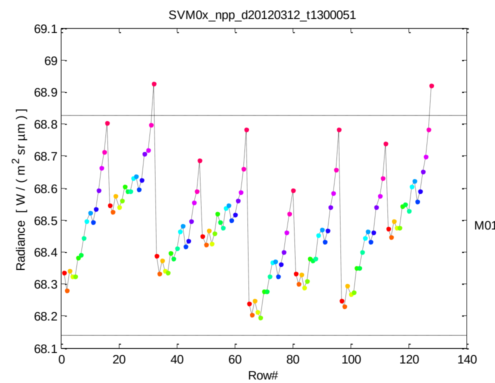
Early, nominal LUT **Updated LUT**

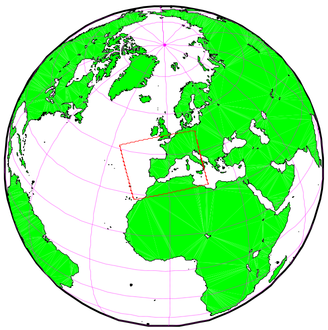
Striping Dependence on Solar Geometry (PTT-3)

Northern Hemisphere

Dashed lines: ±0.5% of mean value

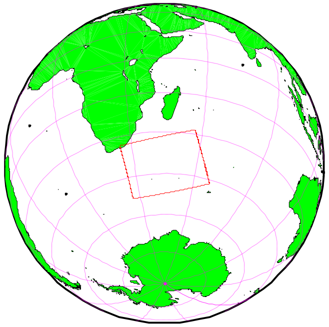
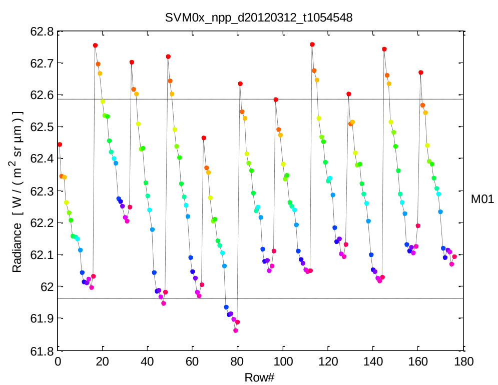



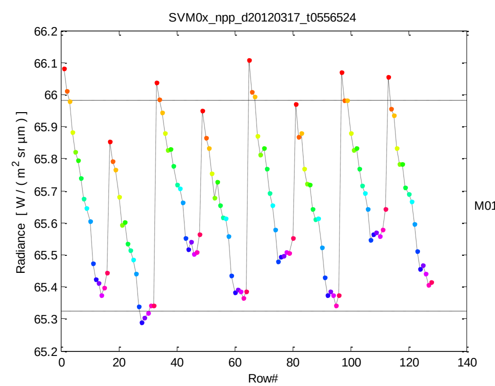


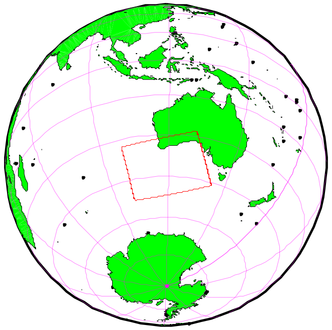


Southern Hemisphere

M1





- Reversal in detector sensitivity suggests that striping is not caused by imperfect radiometric calibration
- Striping may be due to differences in polarization sensitivity
- If flat-fielding correction is applied, it should be adjusted for each scene

Predictions of Sensitivity Degradation

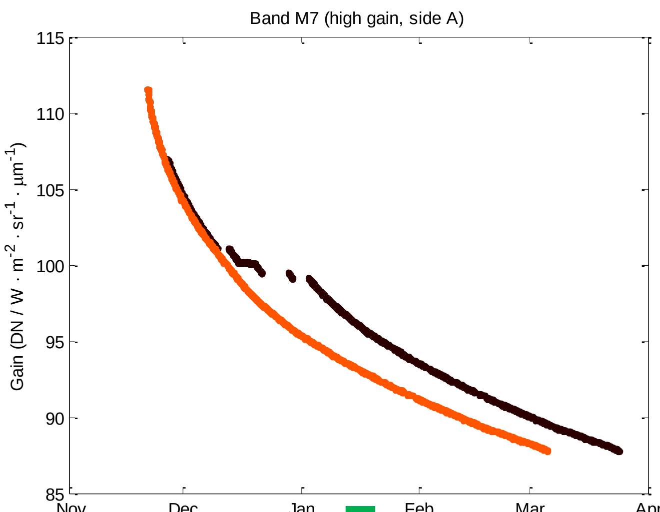
Linear Gain / Offset Approach:

- $Gain = \frac{dn}{L_{SD}}$
- $dn = DN_{SD} - DN_{SV}$
- $L_{SD} = \cos\vartheta_{inc} \cdot \tau_{sds} \cdot \frac{E_{sun}}{d^2} \cdot BRDF_{SD}$

Approximations:

- ϑ_{inc} smooth function of time
- $\tau_{sds} = 0.117$
- $d^{-2} = 1 + 0.033 \cdot \cos(2\pi \cdot DOY/365.25)$
- $BRDF_{SD} = \pi^{-1}$

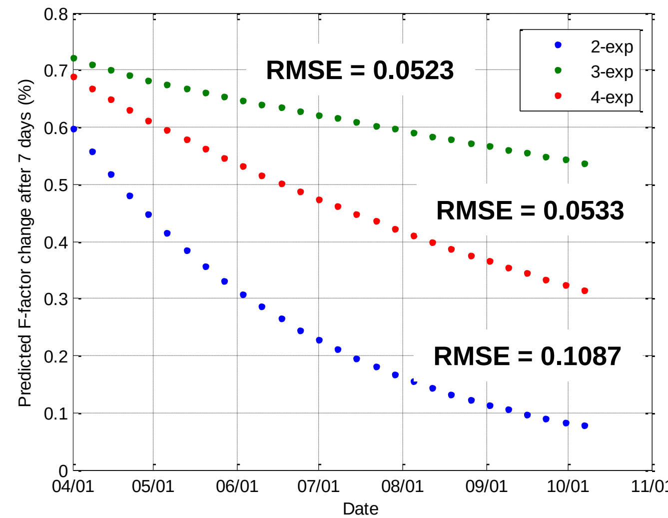
E_{sun} ($mW \cdot m^{-2} \cdot nm^{-1}$)		
M1	1705.70 ±	2.67
M2	1906.01 ±	1.43
M3	1991.44 ±	1.04
M4	1843.31 ±	0.49
M5	1507.15 ±	0.51
M6	1278.25 ±	0.26
M7	960.90 ±	0.11
I1	1606.40 ±	0.64
I2	961.39 ±	0.21

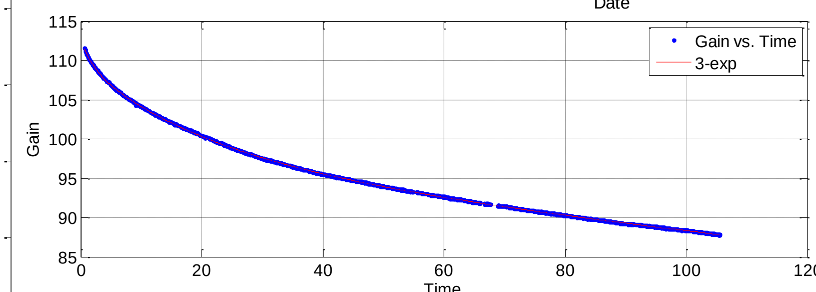


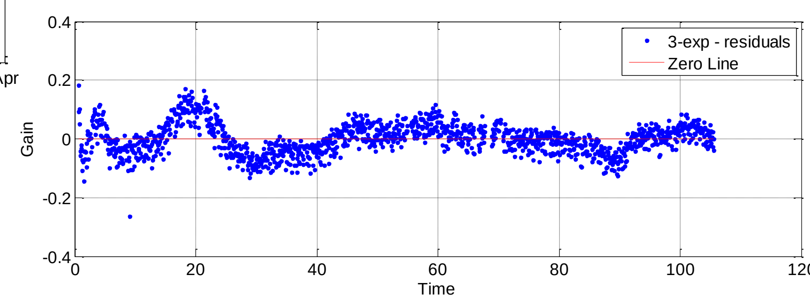
- Band M7
- Detector 8
- High gain
- HAM A

Multi-exponential non-linear optimization

Error estimates with weekly LUT updates

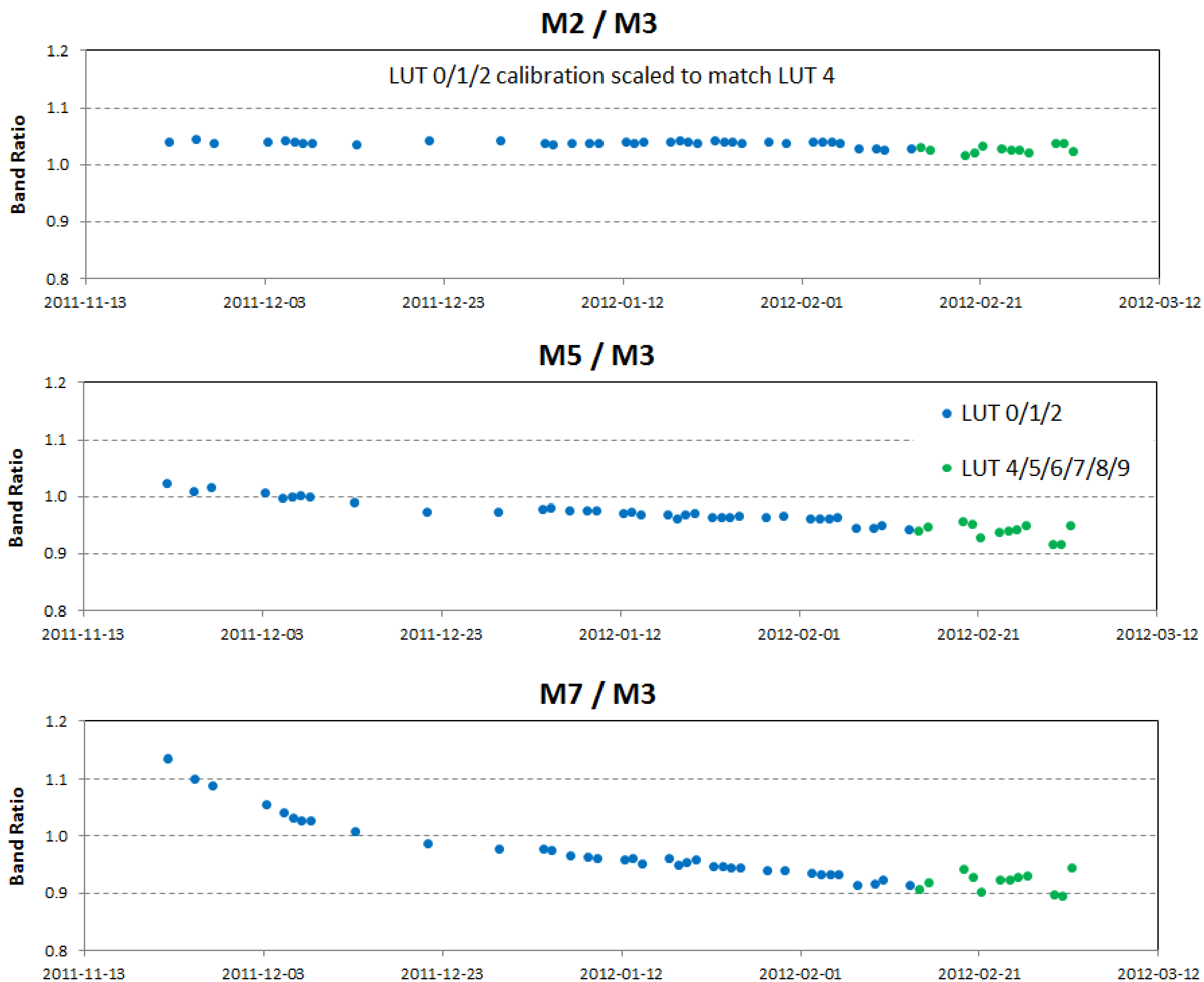






Monitoring VIIRS Sensitivity Degradation

- Antarctic Dome C data have shown that VIIRS Earth View (EV) measurements changed with time similarly to the onboard solar diffuser observations
- Changes of radiometric response are similar both in spectral dependence and in magnitude:
  - The “blue” band M2 is almost stable
  - The “red” band M5 is moderately affected (~10% change over 3-4 months)
  - The largest decline occurs for the NIR band M7 (~20%)
- Scaling of earlier measurements according to calibration coefficient lookup table (LUT) changes shows continuity of radiometric responses
- Weekly LUT updates have stabilized radiometric responses starting with LUT 4 (unfortunately the ending of austral summer increased uncertainty of recent Dome C measurements)



PTT-1: Operability, Noise, SNR Verification

Objective:

To verify detector operability, noise, and SNR of all detectors in all bands and gain states; to verify the absence of artifacts in calibration view data. Task repeated through the life of the sensor to monitor performance.

Methods and Tools:

Use OBC-IP data, analysis tools for verifying detector operability and calculating gain, SNR, and noise.

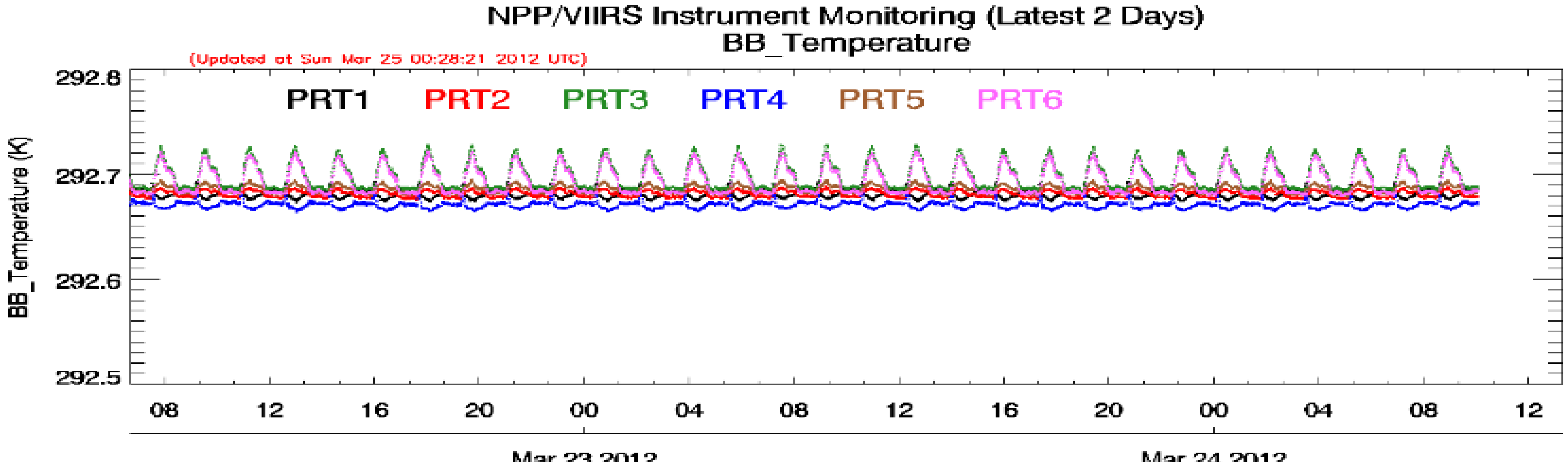
Results and Recommendations:

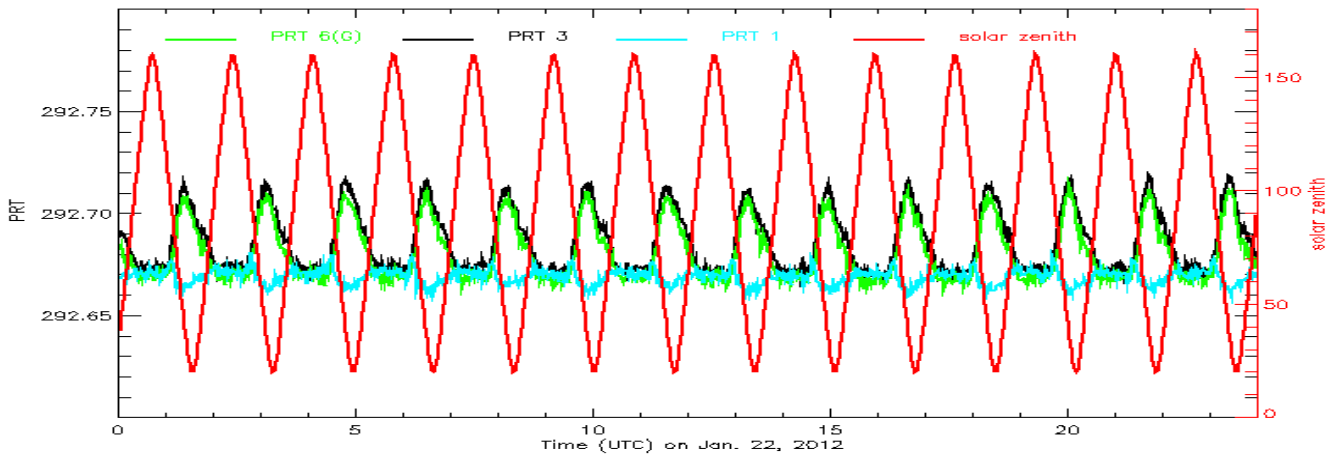
VIIRS TEBs are stable and preliminary results indicate the performance better than specification.

There still have margins for RSB.

Monitoring the VIIRS RSB degradation continues.

STAR PRT Temperature Monitoring (PTT-1, PTT-7)





The periodically variation of PRT #3 and #6 highly correlates with solar zenith angle at the Earth's surface.

http://www.star.nesdis.noaa.gov/smcd/jcsda/nsun/NPP/ipm_telemetry_npp_spacecraft.php

PTT-2: RDR Histogram Analysis

Objective:

To verify normal digitization performance.

Methods and Tools:

RDR, SDR extractor, RDR EV Visualization and Analysis, Accumulate data over multiple orbits to generate histograms in raw count (digital number; DN) space and then look for under filled and overfilled DN bins.

Results and Recommendations:

Sync scan data loss are identified.

Works on RDR EV visualization are needed.

PTT-3: Noise and SNR for Uniform EV Scene

Objective:

To calculate signal standard deviation from uniform Earth view (EV) scenes; to evaluate the signal-to-noise ratio (SNR); and to calculate noise/SNR for calibrator views and at various radiance levels.

Methods and Tools:

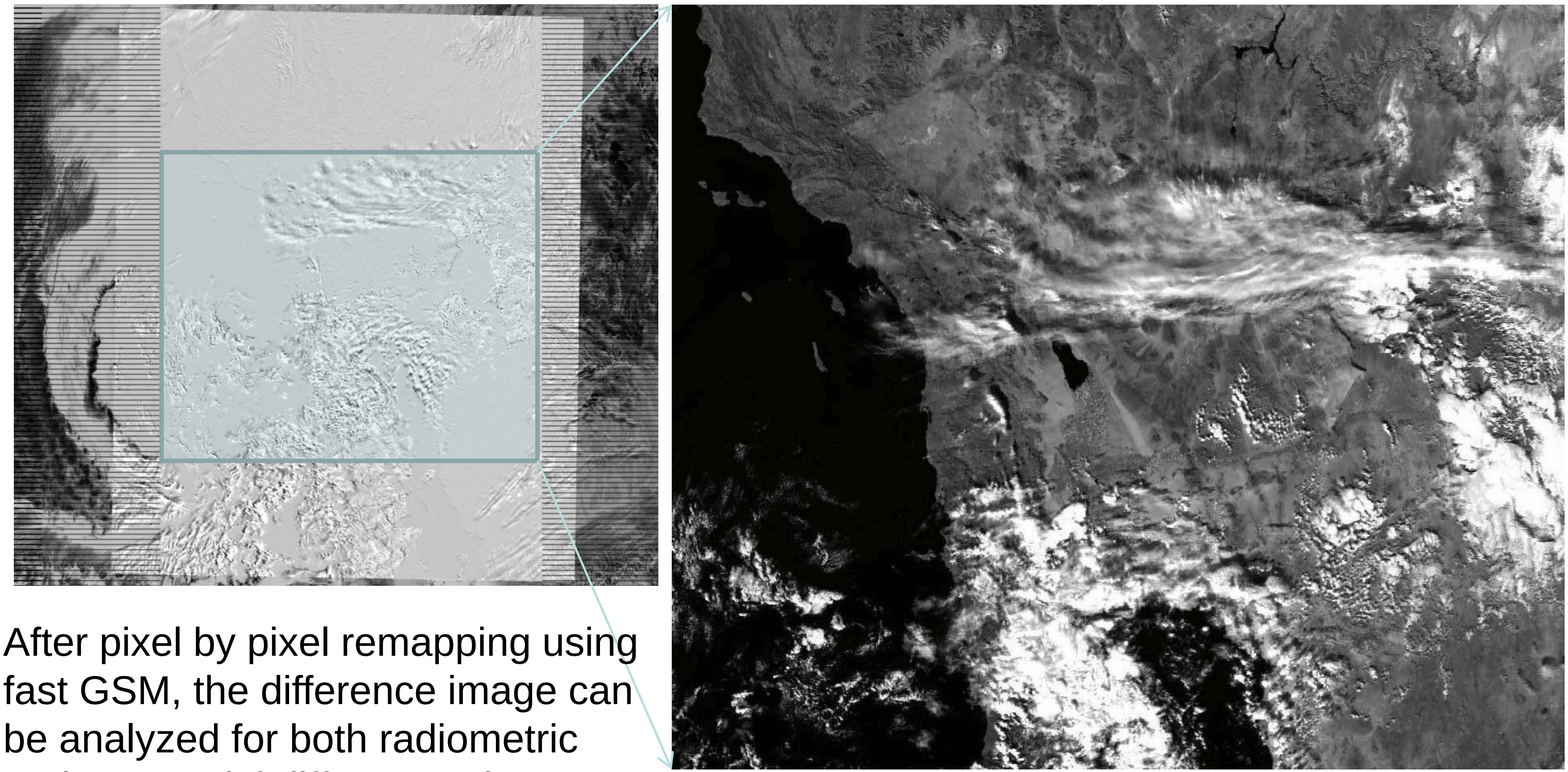
Use VIIRS, CrIS SDRs, MODIS data, SNO orbit prediction, analysis tools

Results and Recommendations:

Results from Dome-C and uniform ocean scenes show that VIIRS TEBs have good performance within 0.3 K. The correlation between VIIRS and MODIS RSB is larger than 0.9.

Double difference (using CRTM) may be useful to remove natural variation for determining noise and SNR over uniform EV scenes.

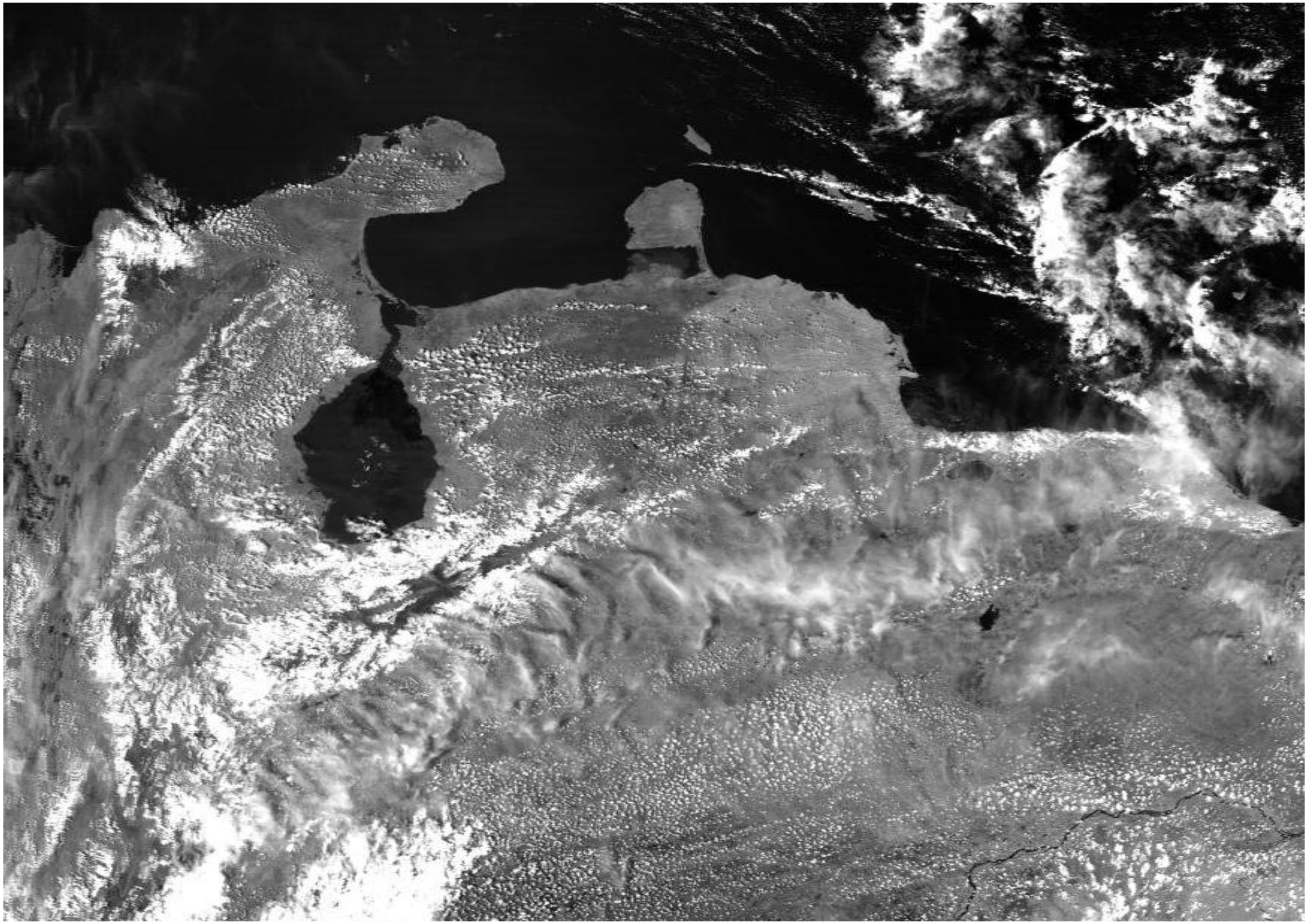
Radiometric and Geospatial Differences between VIIRS and MODIS (PTT-3)



After pixel by pixel remapping using fast GSM, the difference image can be analyzed for both radiometric and geospatial differences between VIIRS and MODIS

Differencing image not only shows cloud movement (within ~10mins), but also geolocation discrepancies for land features

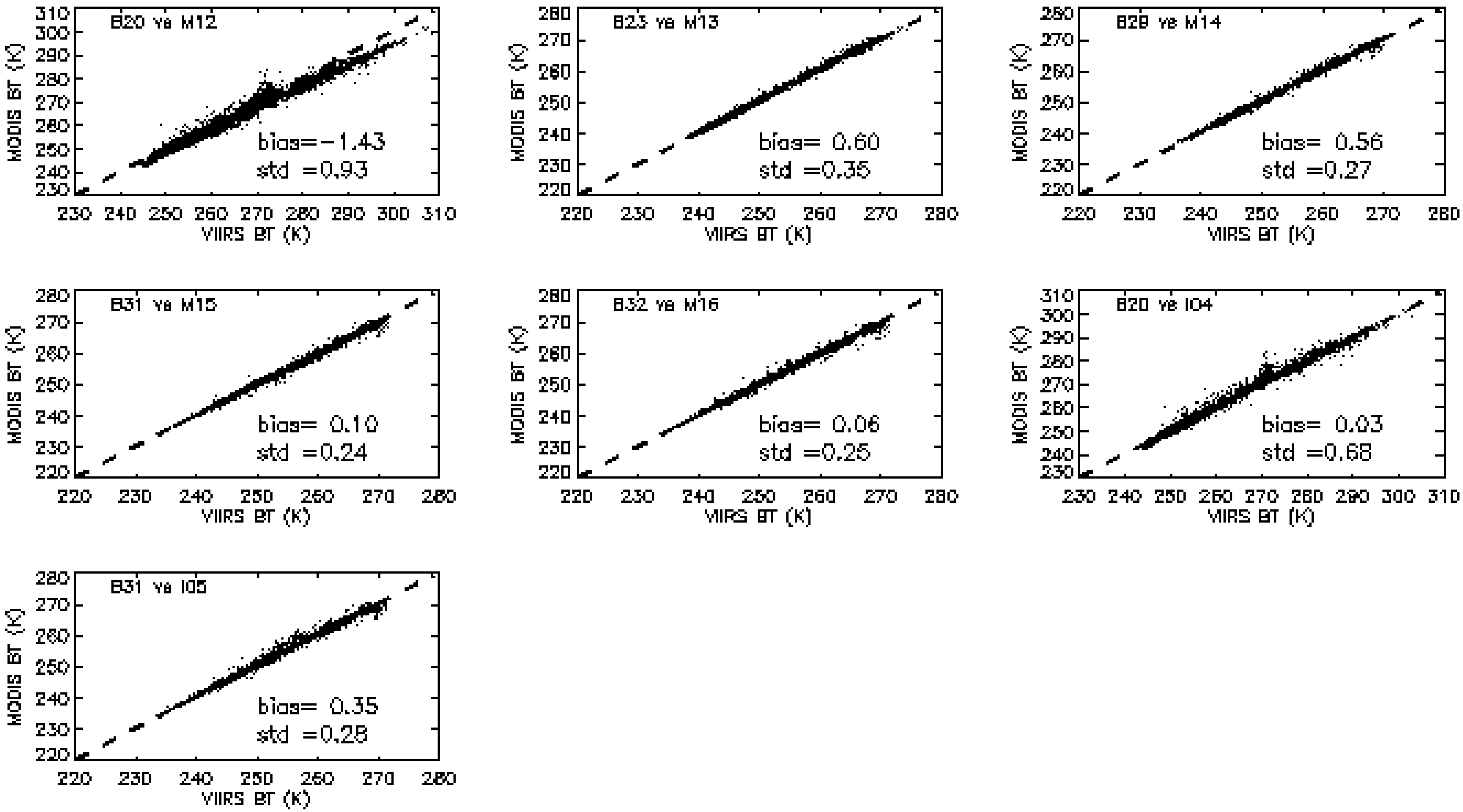
VIIRS and MODIS Comparison After Geolocation Error Fixed



cloud movement (within ~10mins), new possibility to derive wind vectors.

18:00, February 25 2012

VIIRS and MODIS Comparison (Feb. 25) (PTT-3)



Bias = MODIS - VIIRS

PTT-4: DNB Offset Verification

Objective:

Verify that DNB offset Algorithm Support Function (ASF) performs properly.

Methods and Tools:

DNB image and analysis tools

Results and Recommendations:

DNB image quality was investigated and a high quality DN image was sent to JPSS program office per request.

PTT-5: Electronic Gain Measurement

Objective:

To determine the sensitivity of the electronic gain to variations in sensor electronic and thermal state.

Methods and Tools:

RDR extractor, Calibrator View Visualization and Analysis

Results and Recommendations:

VIIRS 3D visualization model is generated.

PTT-6: Radiometric Performance Monitoring

Objective:

To calculate and monitor NedT, S/N, and Gains.

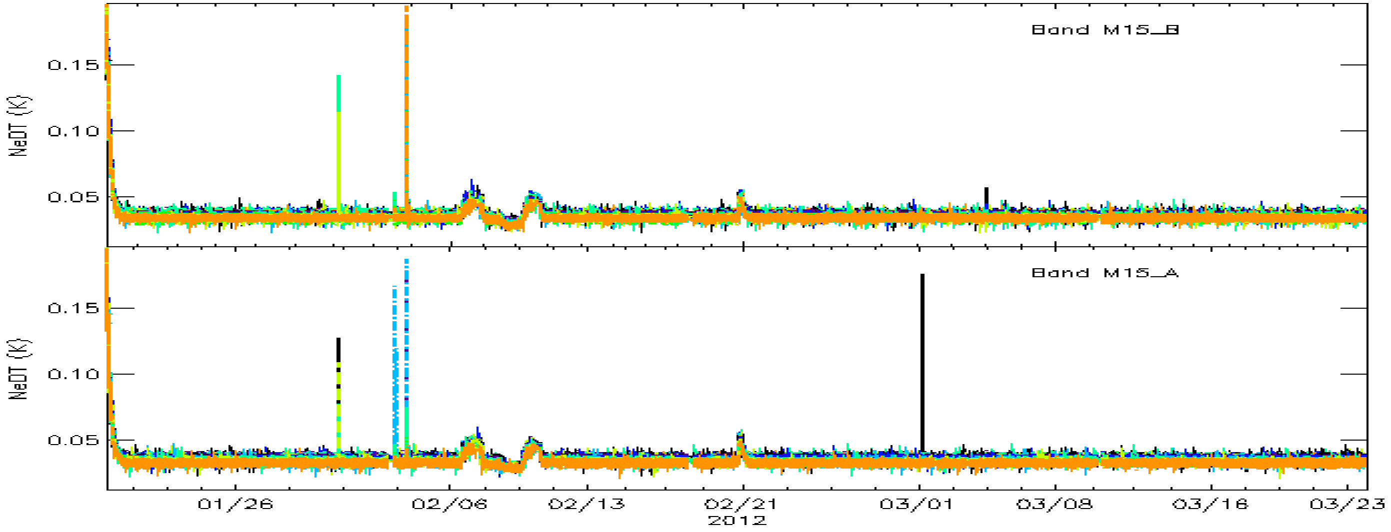
Methods and Tools:

OBC-IP reader, VIIRS LUTs, NOAA calibration tools, long-term monitoring system

Results and Recommendations:

NEdT, NEdN, and Gain for VIIRS TEBs are stable. Our RSB gain parameter also predicted the RSB degradations.

STAR monitoring system provided visualized figures for VIIRS calibration teams.



PTT-7: Telemetry Trending and Monitoring

Objective:

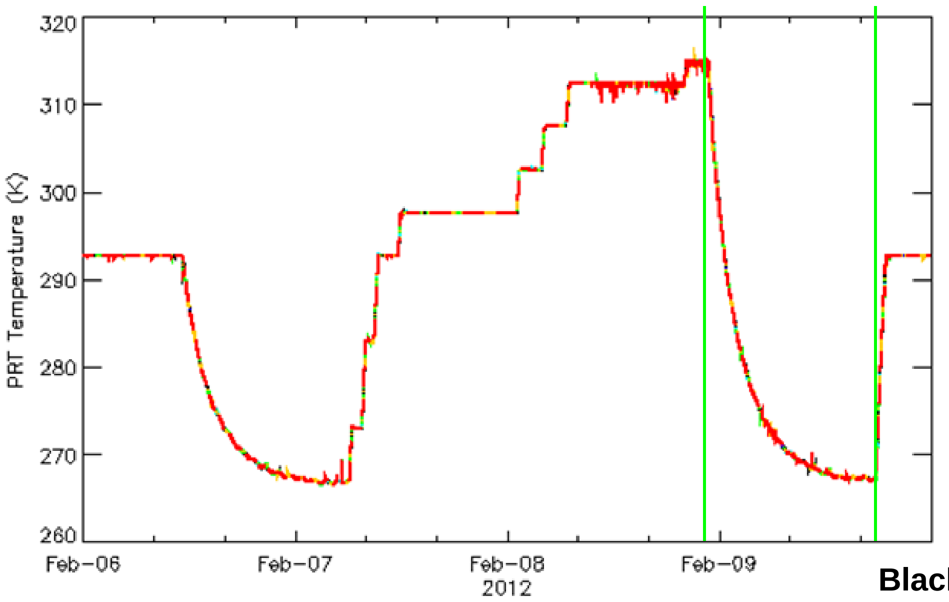
To monitor telemetry parameters.

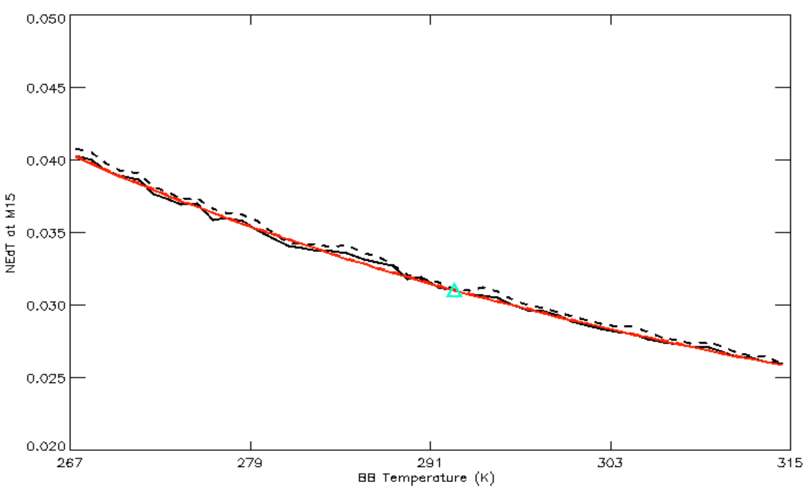
Methods and Tools:

OBC-IP reader, VIIRS LUTs, long-term monitoring system

Results and Recommendations:

STAR monitoring system provided visualized figures for VIIRS telemetry parameters.





Black solid and dashed lines are for measured values at HAM A and B sides. Lines in red are predicted based on single operational BB temperature (see green triangle).

Interactions with Users, SDR and EDR Teams

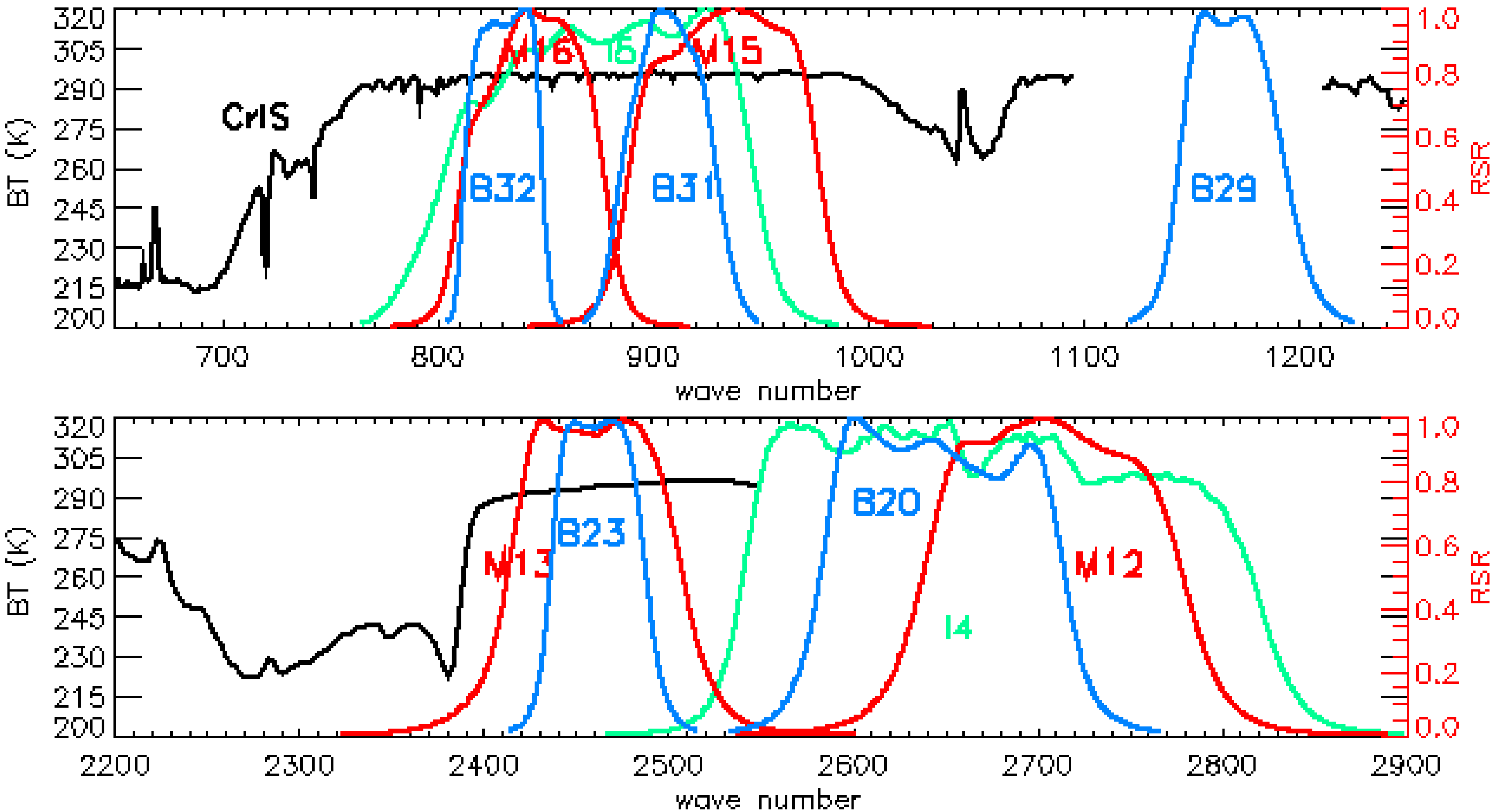
- Worked closely with EDR teams (e.g. SST, Ocean Color, fire and vegetation, etc EDR teams), NCEP, and JCSDA.

- Established and maintained the SDR/EDR web blog on CasaNosa.

- Got help from EDR teams and users, e.g., JCSDA (CRTM model), SST EDR team (VIIRS BT anomaly during BB WUCD), which led to the finding of errors in the VIIRS parameter file.

- Supported the EDR teams and our users, for example, we helped JCSDA correct the error in using VIIRS RSR.

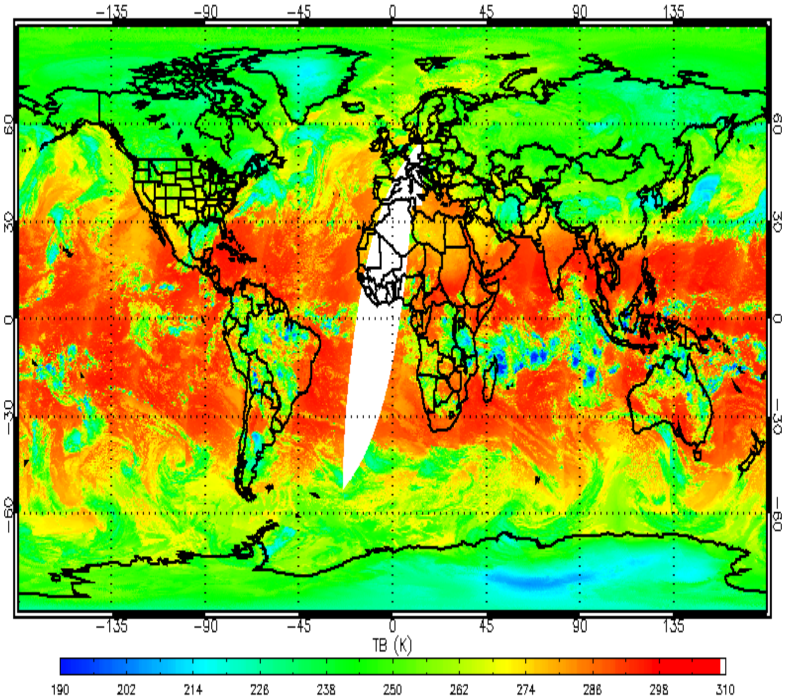
RSR-TEB

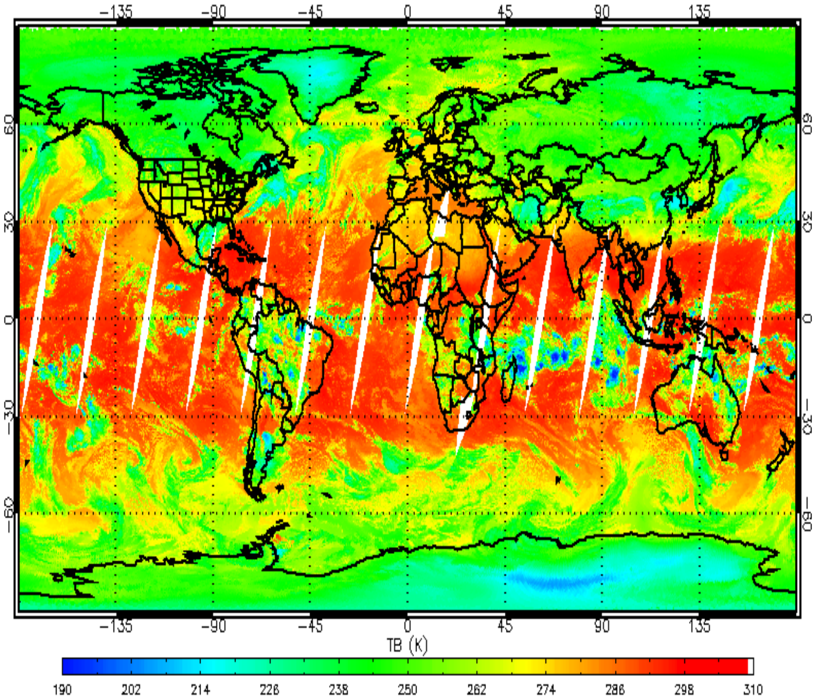


CrIS
M16
I5
M15
B32
B31
B29
BT (K)
RSR
wave number
M13
B23
B20
M12
I4

VIIRS and CrIS Brightness Temperature Comparison

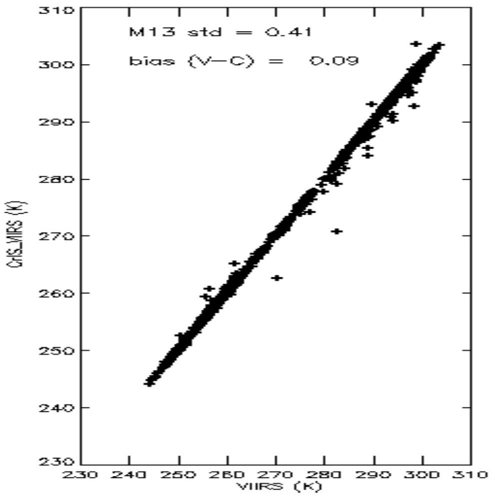
CrIS convolved with VIIRS M15 RSR

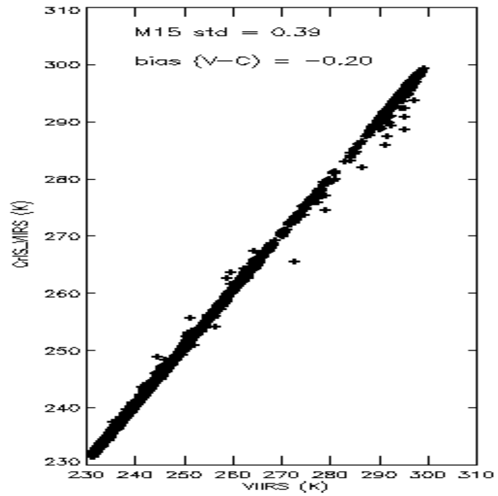


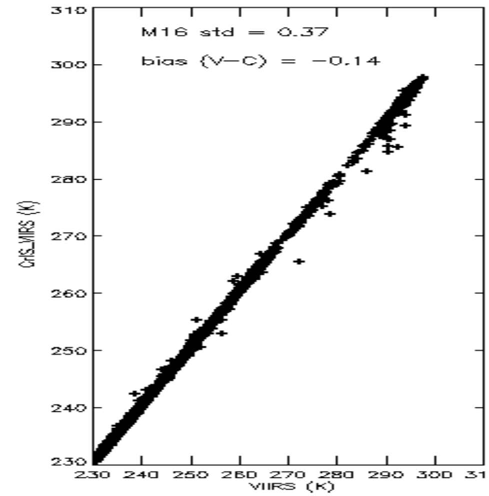


Golden day Feb. 25, 2012

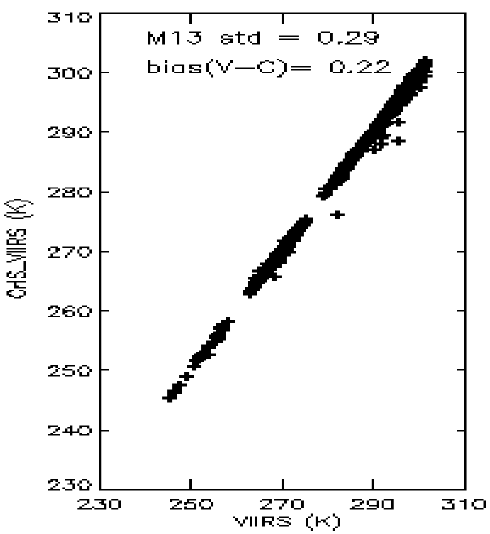
VIIRS and CrIS Comparison

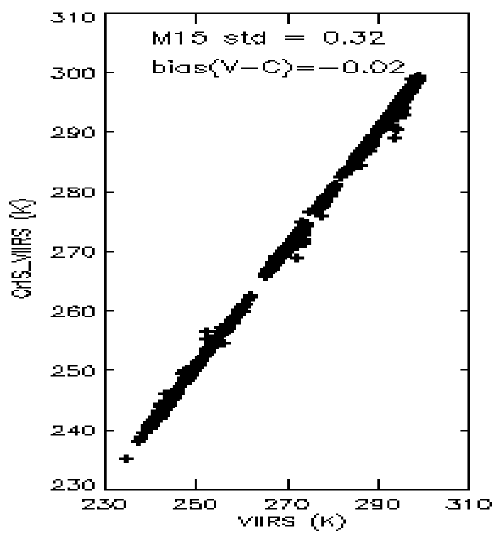


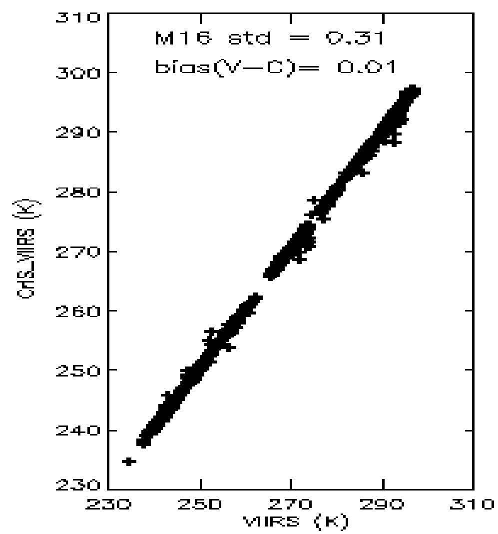




2/25/12







3/18/12

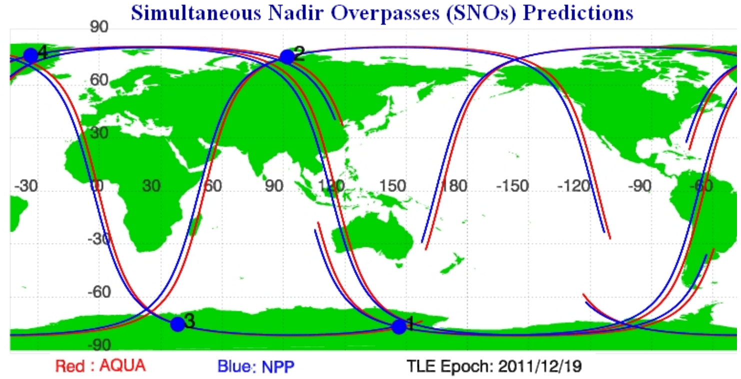
New Progress in SNO Prediction and Routine Use for NPP

- The Simultaneous Nadir Overpass (SNO) prediction software has been upgraded with the latest version of the orbital perturbation algorithm and a graphic interface

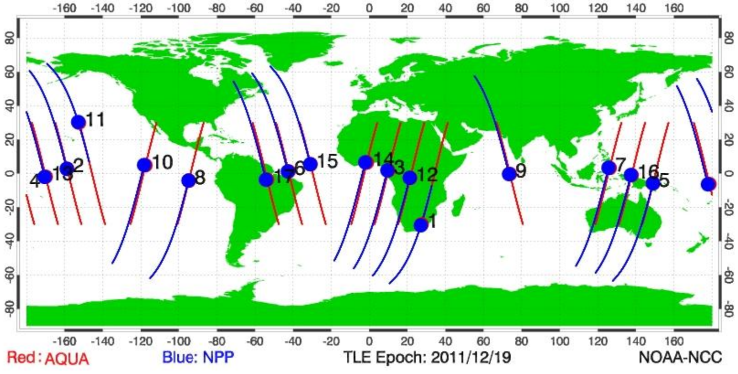
- New capabilities developed to predict both traditional SNOs and SNOx extended to the low latitudes

- The new system has been predicting routinely since NPP launch, and predicted SNOs with Aqua/MODIS are being used for VIIRS channel responsivity diagnosis

- The SNOs as well as daily NPP orbital ground track predictions are readily available on the NCC website at: https://cs.star.nesdis.noaa.gov/NCC/SNOPredictions



Index	Date	Time (AQUA)	AQUA Lat,Lon	NPP Lat,Lon	Distance(km)	Time Diff (sec)
1	12/21/2011	06:20:44	-76.77, 146.48	-76.77, 146.53	1.13	39
2	12/23/2011	21:47:58	75.93, 91.98	75.93, 91.93	1.46	11
3	12/26/2011	13:15:08	-75.29, 38.37	-75.29, 38.38	0.26	62
4	12/29/2011	06:20:26	76.76, -33.47	76.76, -33.49	0.67	43



Summary

- VIIRS Thermal Emissive Bands are stable and preliminary results showed TEB performance exceed the specification.
- VIIRS M12 striping at daytime is mainly caused by the difference in VIIRS azimuth angles among detectors. CRTM can simulate the striping effect.
- VIIRS, MODIS and AVHRR agree well over the SNO scenes.
- VIIRS and CrIS cross check can be performed at any time and any location. Both sensors for TEB agree well.
- Updates of the radiometric lookup tables for VIIRS Reflective Solar Bands have improved calibration and uniformity of radiometric response
- With the LUT updates, radiometric calibration is stable and agrees well with MODIS measurements (barring small spectral biases)
- LUT updates should be applied more frequently than on the weekly basis: the planned scan-by-scan update should be implemented as soon as possible

Backup Slides

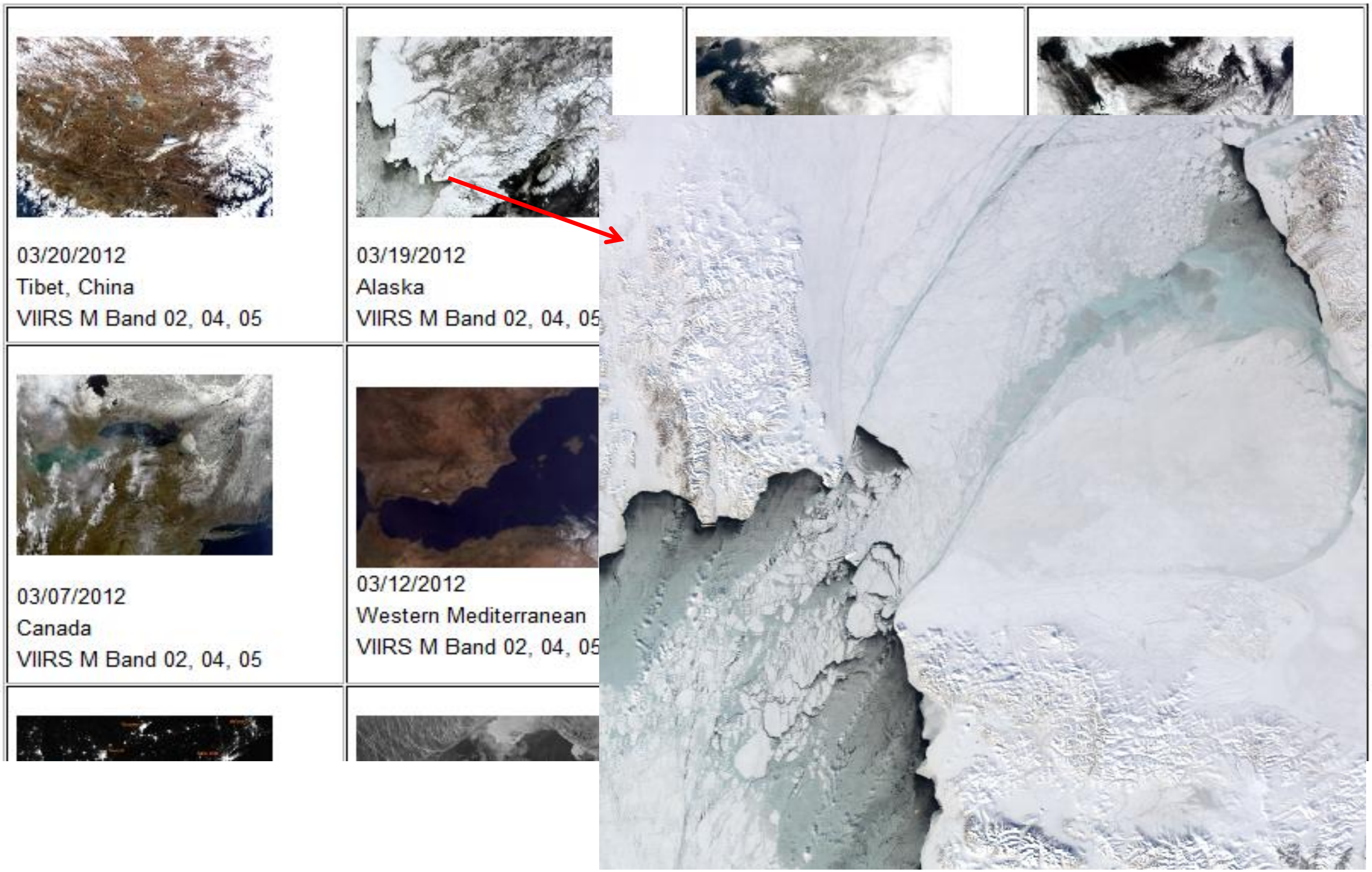
VIIRS Spectral, Spatial, and Radiometric Characteristics

Table is adapted from VIIRS user guide and the measured values (last two columns) are revised with RSB data calculated from the updated Murphy results by Aerospace and STAR TEB values (March 8, 2012) which agree with NASA's results.

				Specification							Onboard performance	
		Band No.	Driving EDR(s)	Spectral Range (um)	Horiz Sample Interval (km) (track x Scan) Nadir	Horiz Sample Interval (km) (track x Scan) End of Scan	Band Gain	Ltyp or Ttyp (Spec)	Lmax or Tmax	Spec SNR or NEdT (K)	Measured SNR or NEdT (K)	SNR Margin (%)
Reflective Bands	VisNIR	M1	Ocean Color Aerosol	0.402 - 0.422	0.742 x 0.259	1.60 x 1.58	High Low	44.9 155	135 615	352 316	578 974	64.2% 208%
Reflective Bands	VisNIR	M2	Ocean Color Aerosol	0.436 - 0.454	0.742 x 0.259	1.60 x 1.58	High Low	40 146	127 687	380 409	564 975	48.5% 138%
Reflective Bands	VisNIR	M3	Ocean Color Aerosol	0.478 - 0.498	0.742 x 0.259	1.60 x 1.58	High Low	32 123	107 702	416 414	611 1003	46.5% 142%
Reflective Bands	VisNIR	M4	Ocean Color Aerosol	0.545 - 0.565	0.742 x 0.259	1.60 x 1.58	High Low	21 90	78 667	362 315	522 846	44% 168%
Reflective Bands	VisNIR	I1	Imagery EDR	0.600 - 0.680	0.371 x 0.387	0.80 x 0.789	Single	22	718	119	215	81%
Reflective Bands	VisNIR	M5	Ocean Color Aerosol	0.662 - 0.682	0.742 x 0.259	1.60 x 1.58	High Low	10 68	59 651	242 360	321 673	33% 86.9%
Reflective Bands	VisNIR	M6	Atmosph. Correct	0.739 - 0.754	0.742 x 0.776	1.60 x 1.58	Single	9.6	41	199	355	78.7%
Reflective Bands	VisNIR	I2	NDVI	0.846 - 0.885	0.371 x 0.387	0.80 x 0.789	Single	25	349	150	251	67.7%
Reflective Bands	VisNIR	M7	Ocean Color Aerosol	0.846 - 0.885	0.742 x 0.259	1.60 x 1.58	High Low	6.4 33.4	29 349	215 340	435 636	102% 87%
Reflective Bands	S/MWIR	M8	Cloud Particle Size	1.230 - 1.250	0.742 x 0.776	1.60 x 1.58	Single	5.4	165	74	233	215%
Reflective Bands	S/MWIR	M9	Cirrius/Cloud Cover	1.371 - 1.386	0.742 x 0.776	1.60 x 1.58	Single	6	77.1	83	231	179%
Reflective Bands	S/MWIR	I3	Binary Snow Map	1.580 - 1.640	0.371 x 0.387	0.80 x 0.789	Single	7.3	72.5	6	149	2383%
Reflective Bands	S/MWIR	M10	Snow Fraction	1.580 - 1.640	0.742 x 0.776	1.60 x 1.58	Single	7.3	71.2	342	550	60.9%
Reflective Bands	S/MWIR	M11	Clouds	2.225 - 2.275	0.742 x 0.776	1.60 x 1.58	Single	0.12	31.8	10	21.8	118%
Emissive Bands	S/MWIR	I4	Imagery Clouds	3.550 - 3.930	0.371 x 0.387	0.80 x 0.789	Single	270	353	2.5	0.4	84.0%
Emissive Bands	S/MWIR	M12	SST	3.660 - 3.840	0.742 x 0.776	1.60 x 1.58	Single	270	353	0.396	0.13	67%
Emissive Bands	S/MWIR	M13	SST Fires	3.973 - 4.128	0.742 x 0.259	1.60 x 1.58	High Low	300 380	343 634	0.107 0.423	0.042 --	60% --
Emissive Bands	LWIR	M14	Cloud Top Properties	8.400 - 8.700	0.742 x 0.776	1.60 x 1.58	Single	270	336	0.091	0.06	34%
Emissive Bands	LWIR	M15	SST	10.263 - 11.26	0.742 x 0.776	1.60 x 1.58	Single	300	343	0.07	0.03	57%
Emissive Bands	LWIR	I5	Cloud Imagery	10.500 - 12.40	0.371 x 0.387	0.80 x 0.789	Single	210	340	1.5	0.4	73%
Emissive Bands	LWIR	M16	SST	11.538 - 12.48	0.742 x 0.776	1.60 x 1.58	Single	300	340	0.072	0.03	58%

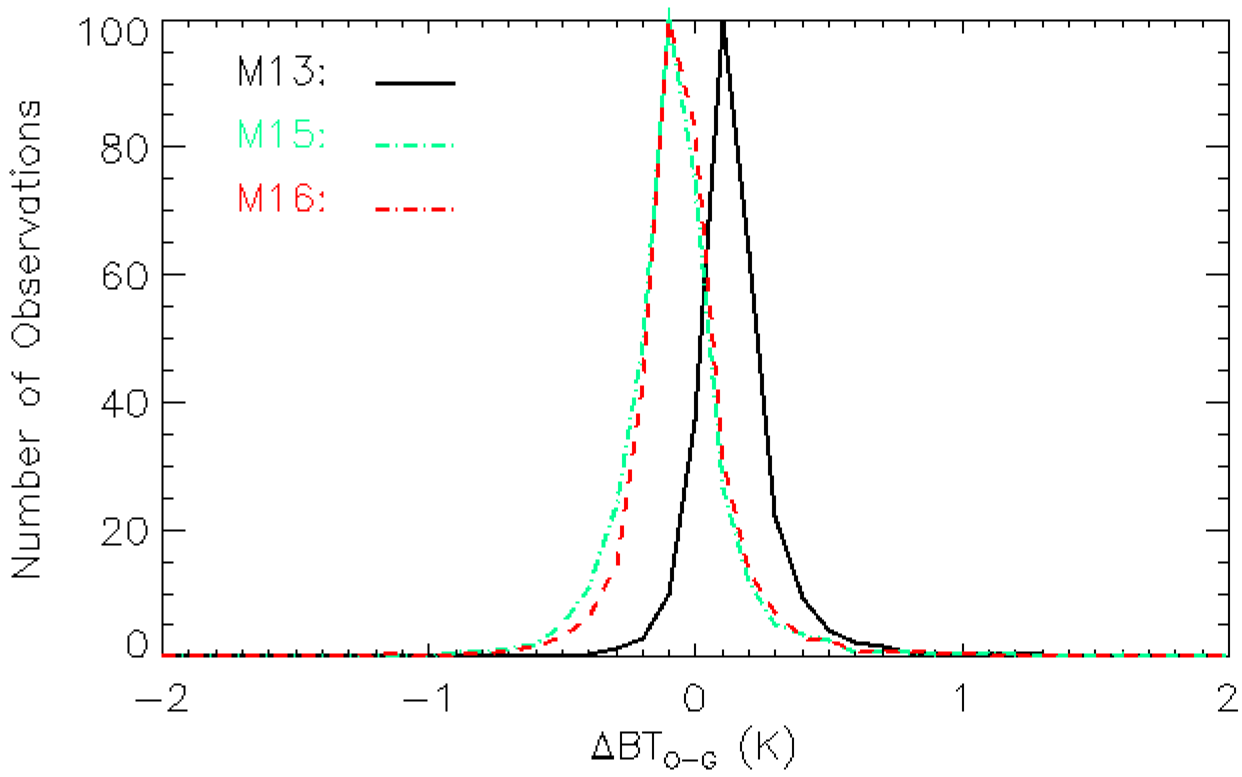
HSI uses 3 in-scan pixels aggregation at Nadir

VIIRS Image Gallery

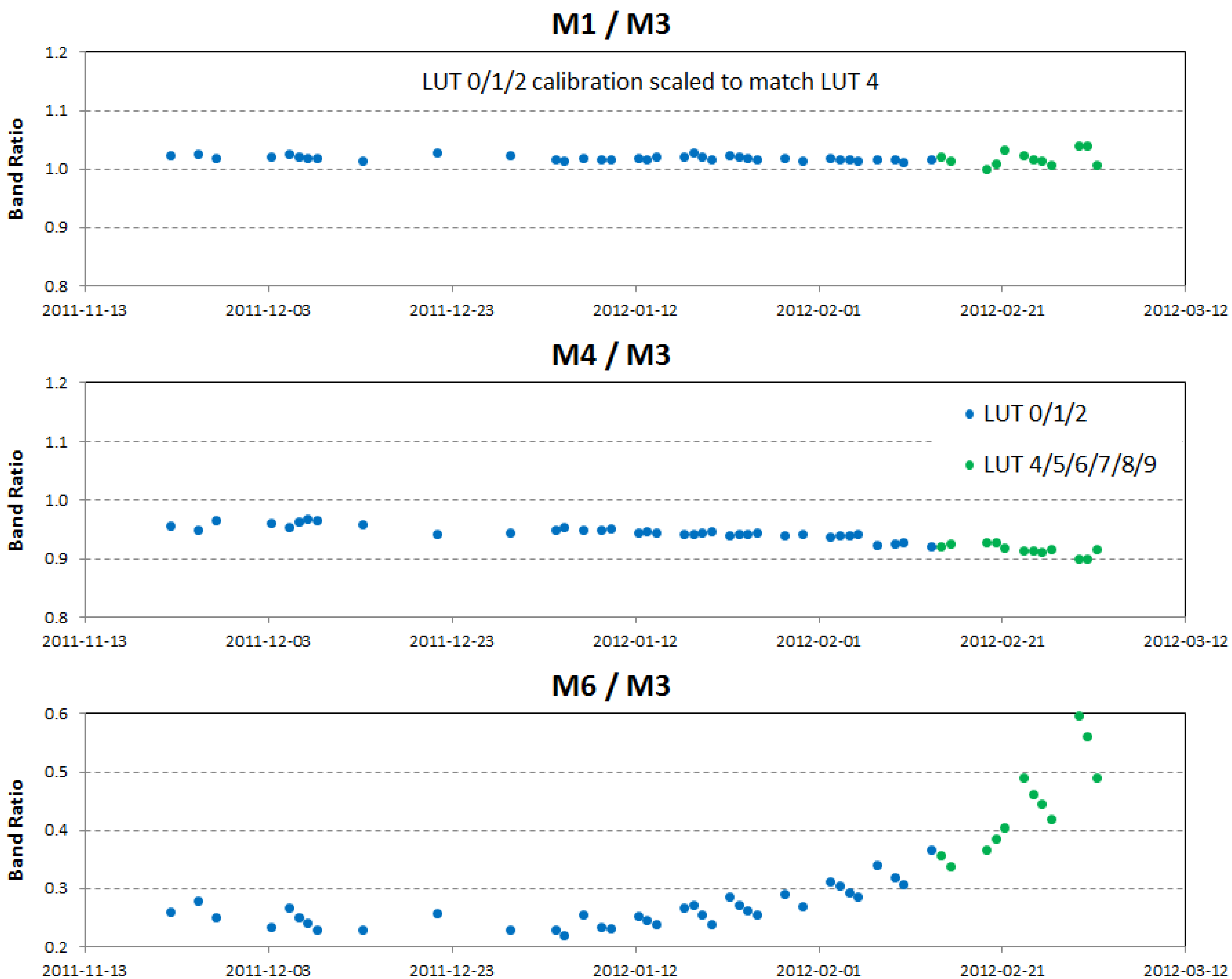


https://cs.star.nesdis.noaa.gov/NCC/VIIRSImageGallery

Histogram for VIIRS and CrIS Comparison



Monitoring Sensitivity Degradation (cont.)



VIIRS vs. MODIS SNO Comparisons (cont.)