Suomi NPP VIIRS Calibration/ Validation Progress Update

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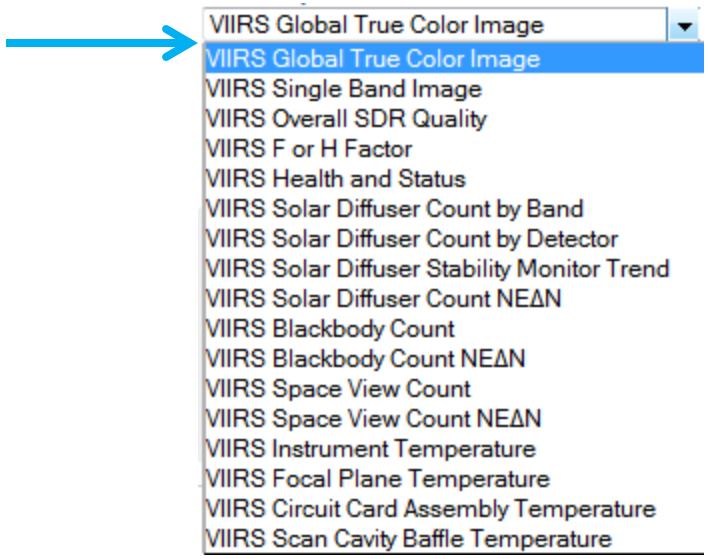
Outlines

- Issues in the VIIRS SDR Calibration
- VIIRS image
- RTA degradation
- VIIRS Signal-to-noise-ratio assessment and projection
- VIIRS geolocation
- VIIRS, MODIS, CrIS, and AVHRR cross comparisons
- VIIRS image striping
- VIIRS performance and milestones
- Summary

VIIRS SDR Calibration/Validation

Instrument parameters(ICVS)
Scan Sync loss (the *synchronization* of RTA and HAM)
BB thermistor #3, #6 ~30 mK variation
VIIRS 1394 anomaly
Software, BB thermistor LUT corrections
RTA degradation due to contamination by tungsten oxide
RTA stowed, rotated



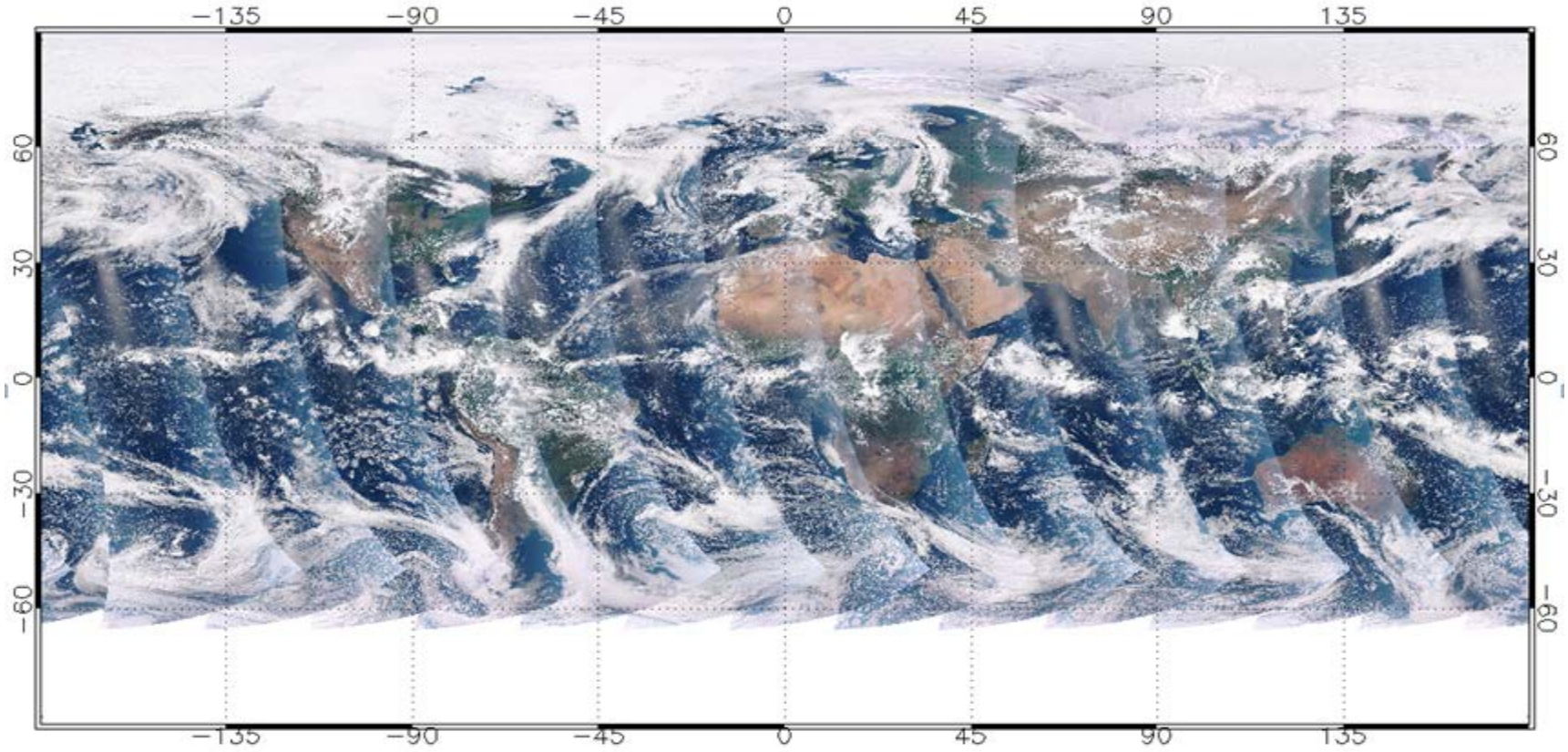
Lunar roll maneuver
Sector rotation
Geolocation, BBR (lunar data), M13 LG
Blackbody warm-up and cool-down
Dynamic range and linearity
A/B-side electronic configuration testing

Degradation model -> AutoCal
Sensor response change due spectrally dependent degradation
Users' guide, ATBD, Conference presentations/Publications
SNO VIIRS/MODIS/CrIS/AVHRR cross comparisons
SDSM screen transmission
M13 LG issues
DNB stray light

Striping
Quality flags
Dual-gain mismatch

VIIRS Global Quick View

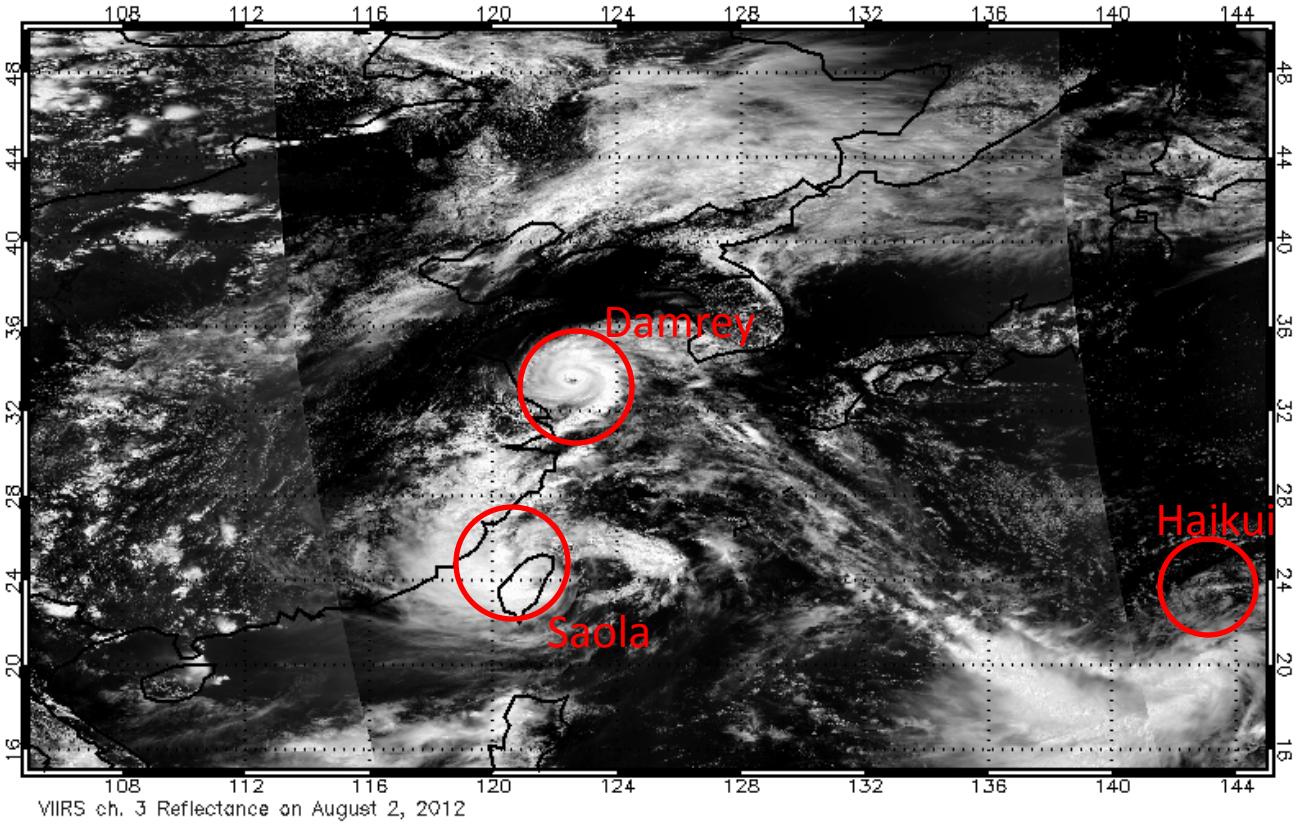
A VIIRS RGB composite image is generated from M3, M4, and M5 bands. This VIIRS global quick-view image serves as a fast check of the VIIRS data quality. Users can also use the image to select their interested scenario: a granule for ocean, land, clear sky, and clouds.



Significance: STAR is closely monitoring the VIIRS performance and serves users.

VIIRS observed tropic cyclones without gap

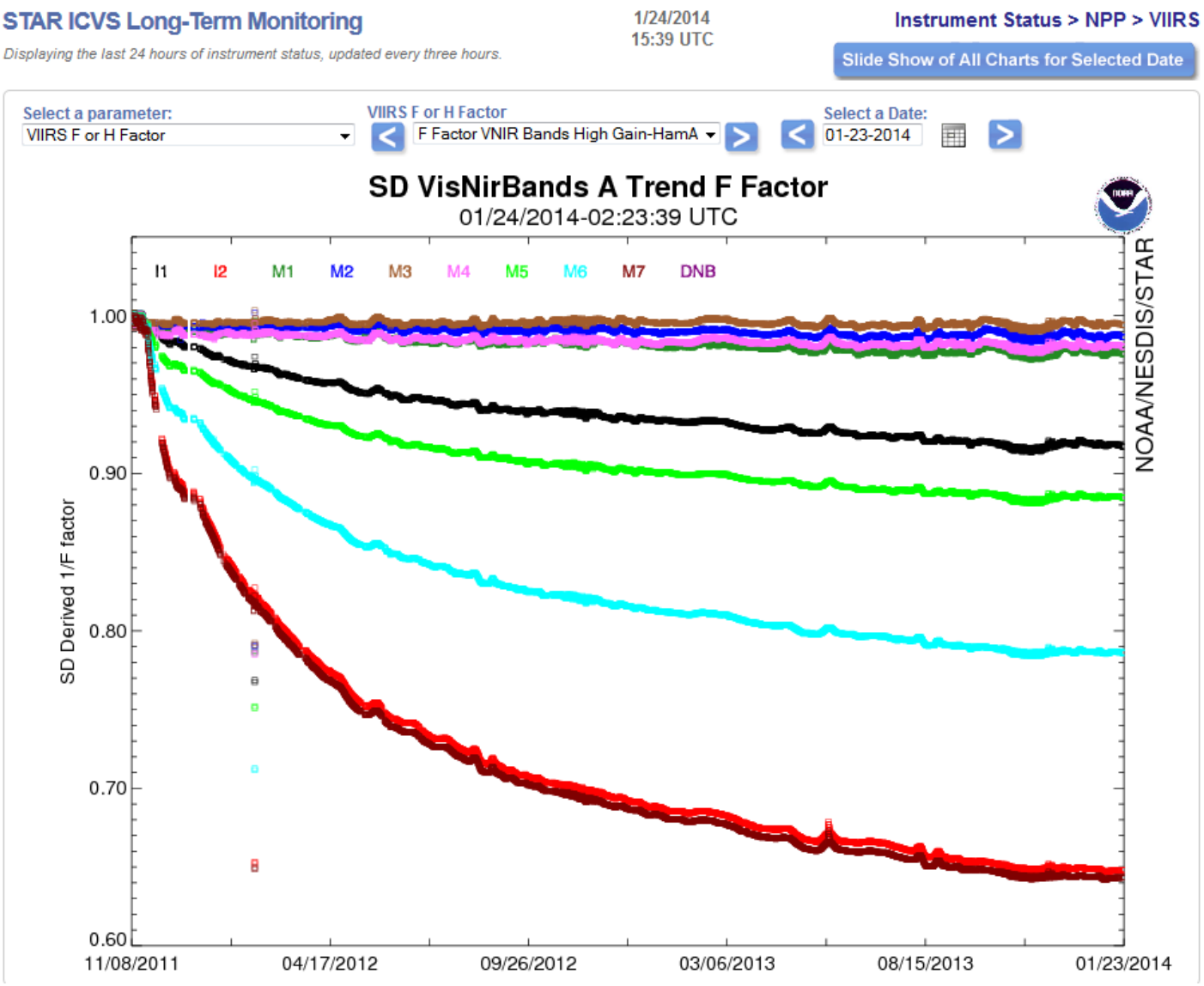
Using the wide swath and the high spatial resolution of the VIIRS, STAR team found the landing of the typhoons Saola and Damrey, and the development of the typhoon Haikui.



VIIRS ch. 3 Reflectance on August 2, 2012

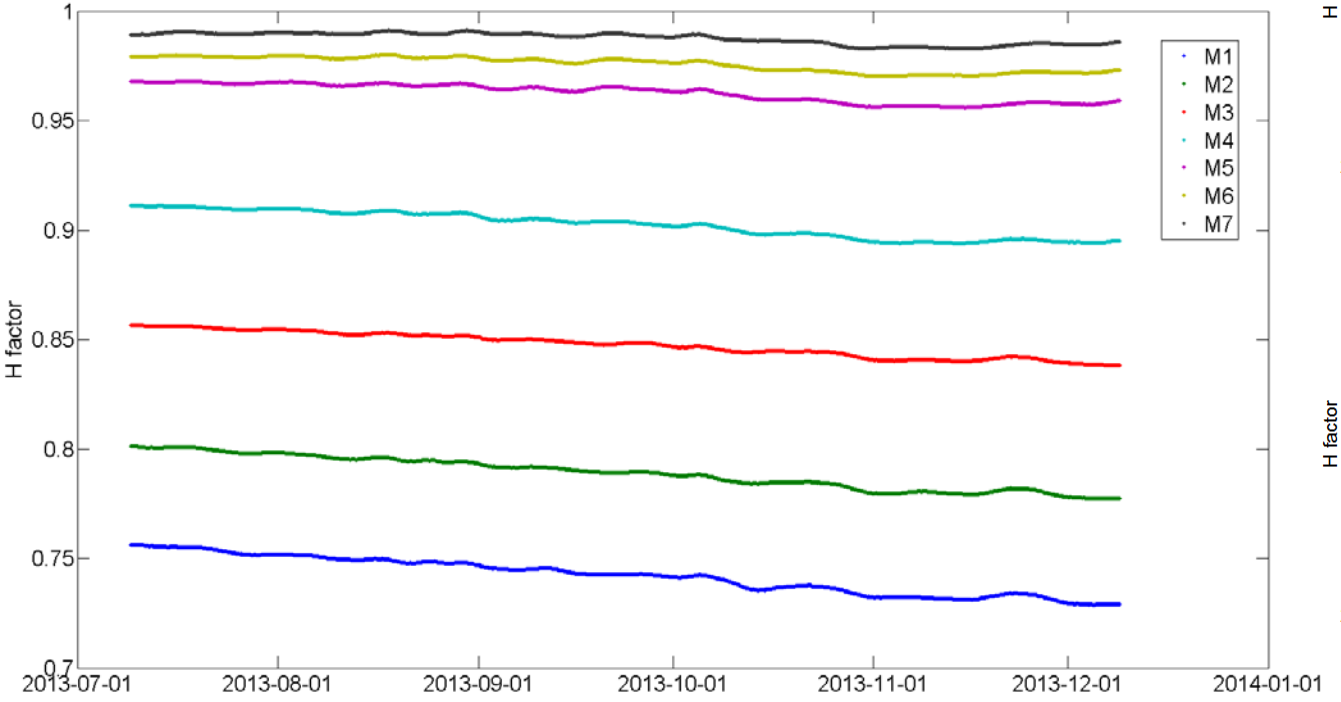
Significance: VIIRS SDRs has wide a swath and high spatial resolution, uniquely for monitoring global tropic cyclones without gap.

NOAA/STAR ICVS

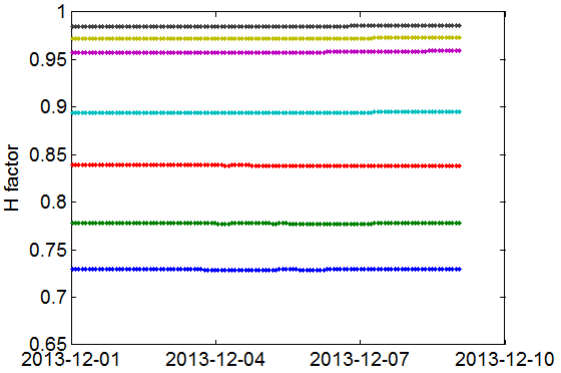


SD Monitoring in RSBAutoCal

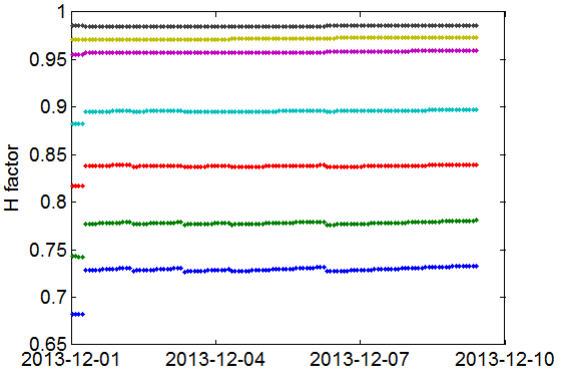
- Conducted long-term testing of the calibration coefficients generated by the prototype RSBAutoCal implemented in ADL
- Observed good agreement between SD monitoring in RSBAutoCal and in the current, off-line procedure
- Preliminary H factors derived by the operational RSBAutoCal in IDPS closely match those from the prototype code



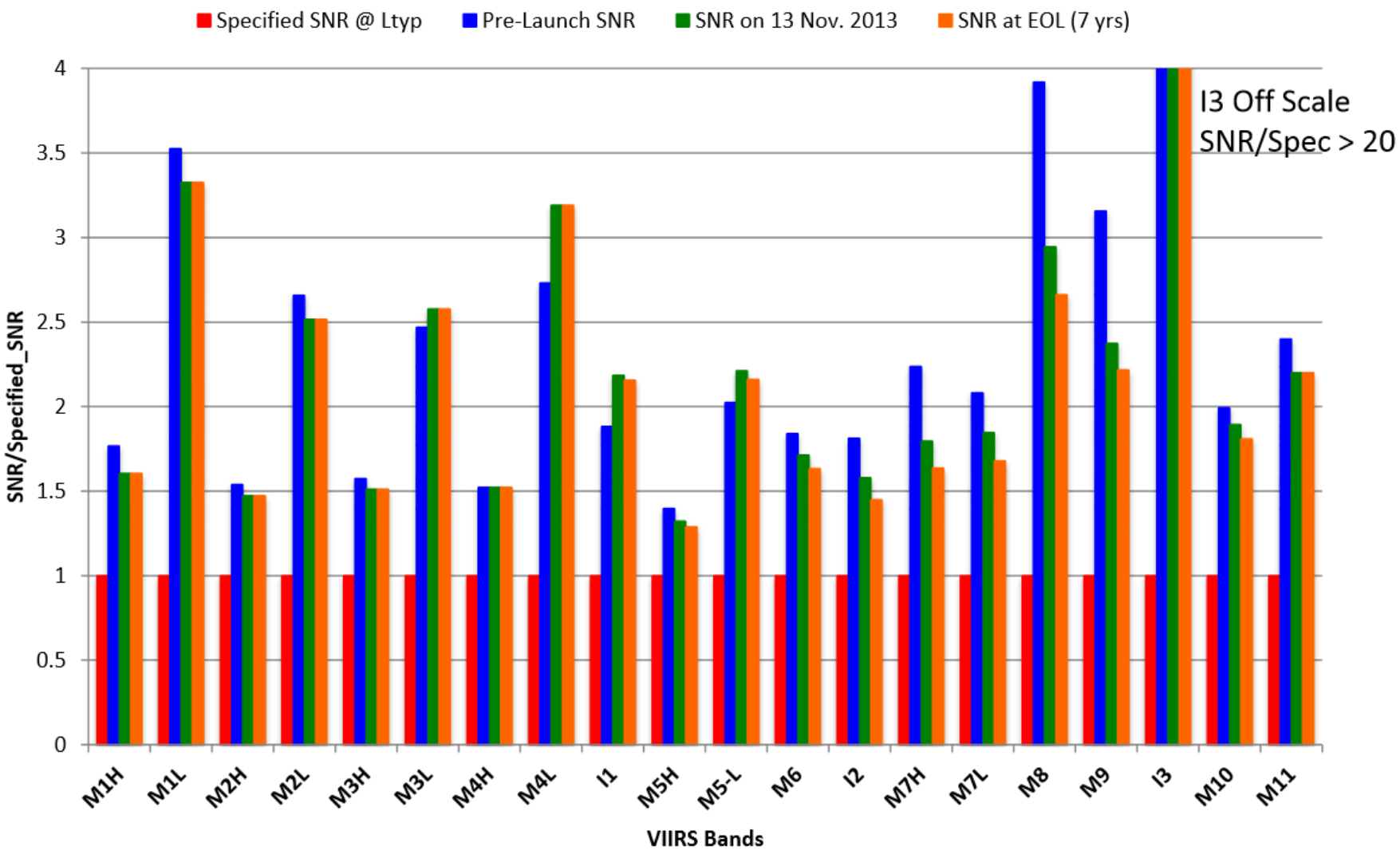
Prototype RSBAutoCal



Operational RSBAutoCal



SNR Assessment and Projection



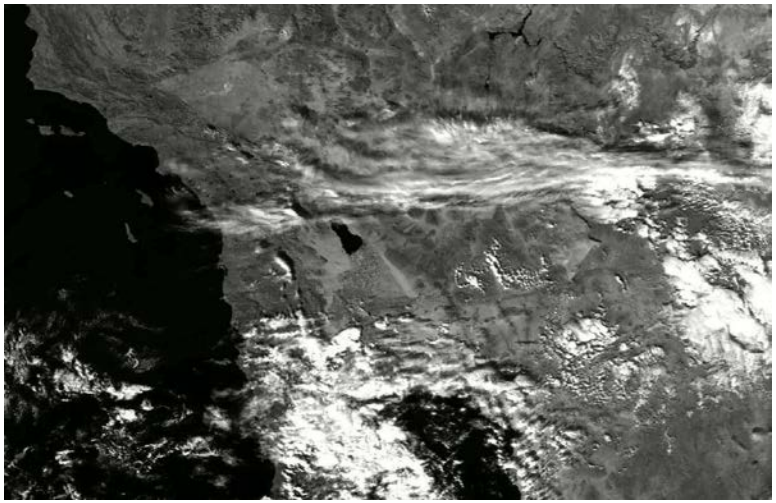
Courtesy Frank J. De Luccia @ Aerospace Corporation

VIIRS Geolocation Verification with MODIS

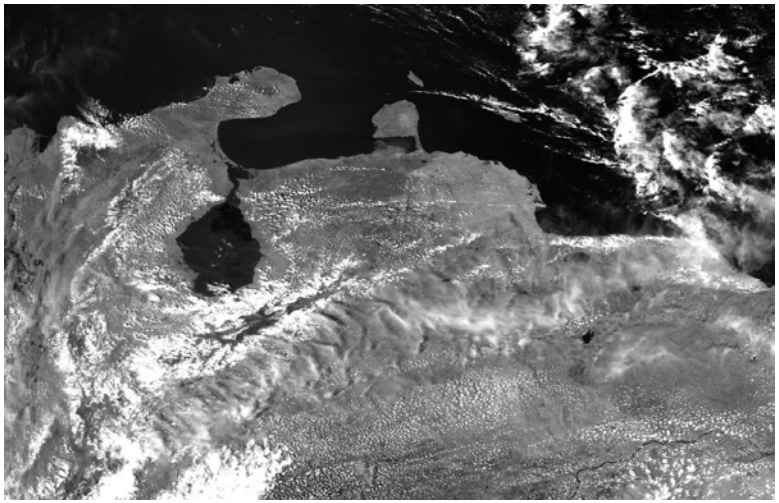
Using the SNO prediction to investigate the geolocation consistency between the VIIRS and MODIS. The differencing animation image shows cloud movement, but also geolocation discrepancy for land features.
After the VIIRS new geolocation LUT was implemented, the “land movement” issue was resolved (see lower-right image).

Residuals	Error (Nadir)	Spec (Nadir)	Error (EOS)	Spec (EOS)
Track mean	-9 m		-20 m	
Scan mean	-7 m		-46 m	
Track RMSE	73 m	133 m	161 m	500 m
Scan RMSE	61 m	133 m	398 m	500 m

Courtesy, Wolfe et al., Dec. 19, 2013



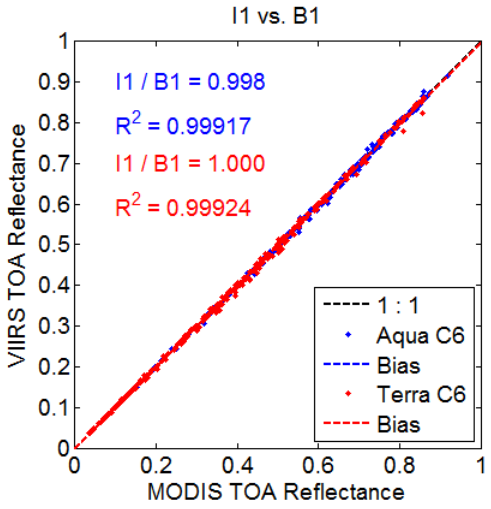
Differencing image shows geolocation discrepancy at 30:55 Dec 20, 2011

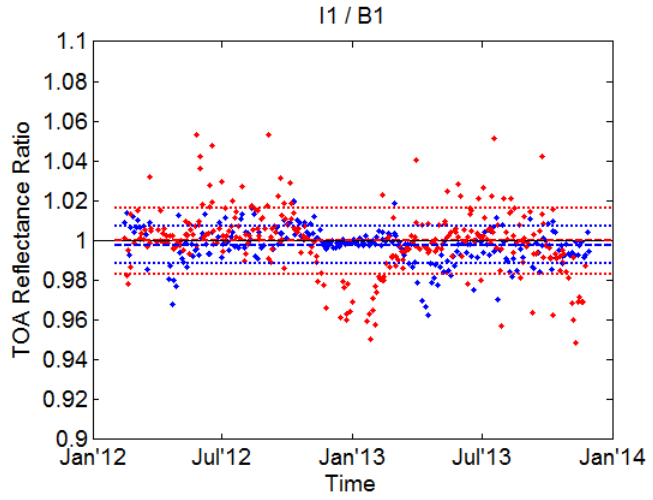


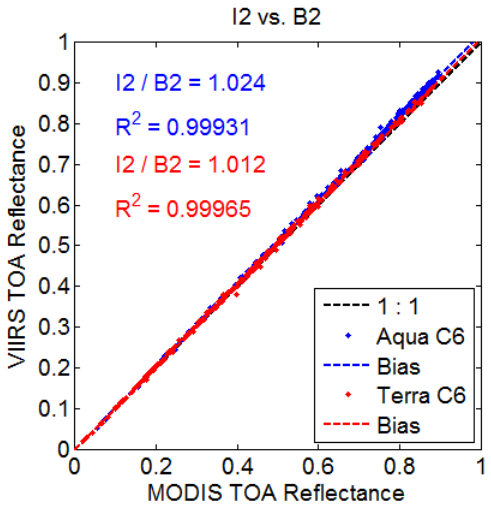
Animation image at 18:05 Feb 25, 2012

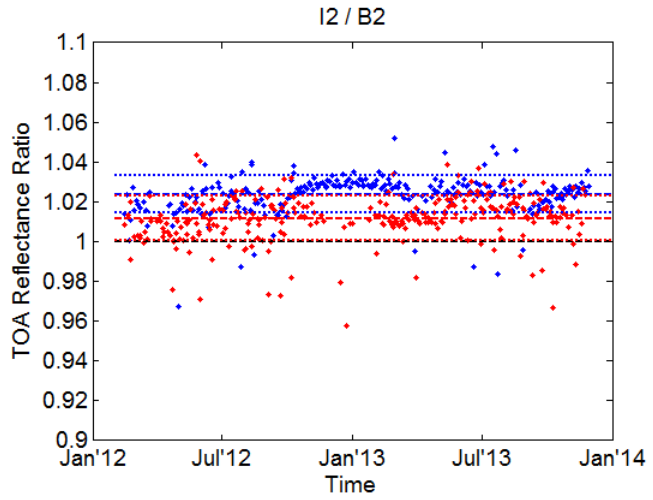
SNO Comparisons for Imaging Bands

- For the VIIRS VisNIR Imaging bands (I1 and I2) and the corresponding MODIS bands 1 and 2 (used in NDVI calculations):
  - There is no bias when comparing NPP VIIRS band I1 with MODIS band 1 on both Aqua and Terra
  - There are only small biases between VIIRS band I2 and MODIS band 2 on Aqua (~2%) and Terra (~1%)
- Improvements to VIIRS radiometric calibration have generated more consistent SNO comparisons since mid-November 2012
- I2 is one of the bands most affected by the VIIRS telescope throughput degradation (due to tungsten oxide contamination), but weekly updates of the calibration coefficients have provided stability for the radiometric products



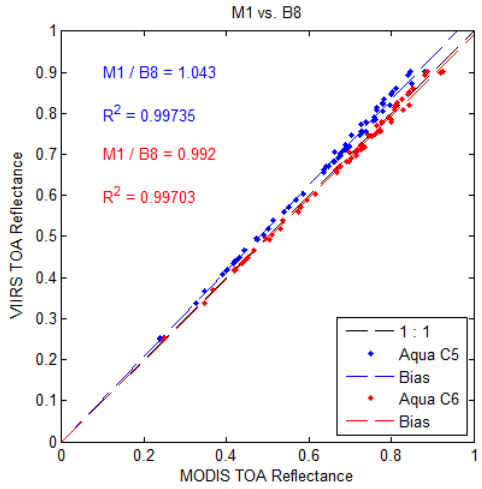


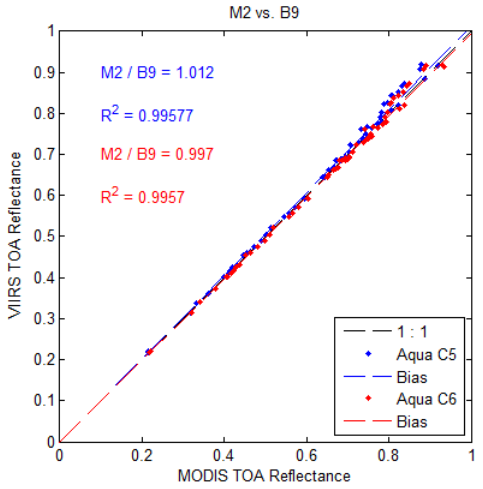


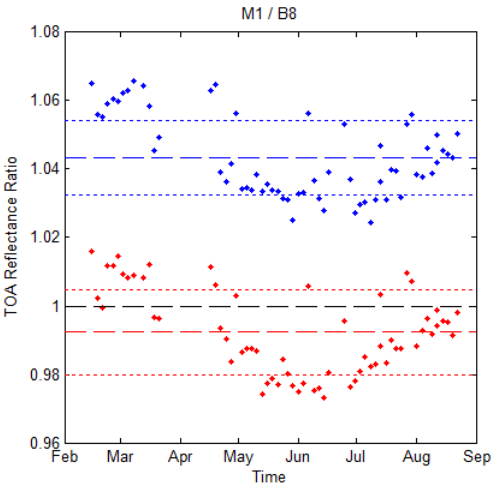


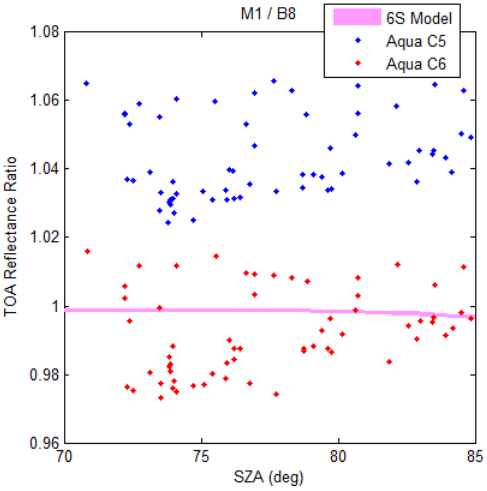
MODIS Collection 5 vs. Collection 6

- Aqua MODIS radiometric calibration has been recently improved in production of Collection 6 datasets
- The largest change has occurred for bands 8 and 9 that are comparable with VIIRS bands M1 and M2, respectively
- When, instead of Collection 5 data, Aqua MODIS Collection 6 data are used in SNO comparisons with VIIRS :
  - ➢ M1 bias is reduced from +4% to -1%
  - ➢ M2 bias is reduced from 1% to near zero
- Observed temporal variation of the M1 bias may be due to VIIRS polarization sensitivity (will investigate)
- 6Sv radiative transfer modeling conducted for VIIRS band M1 (including out-of-band response) and for MODIS band 8 (using a snow surface reflectance and a range of atmospheric conditions) agrees better with the Collection 6 data



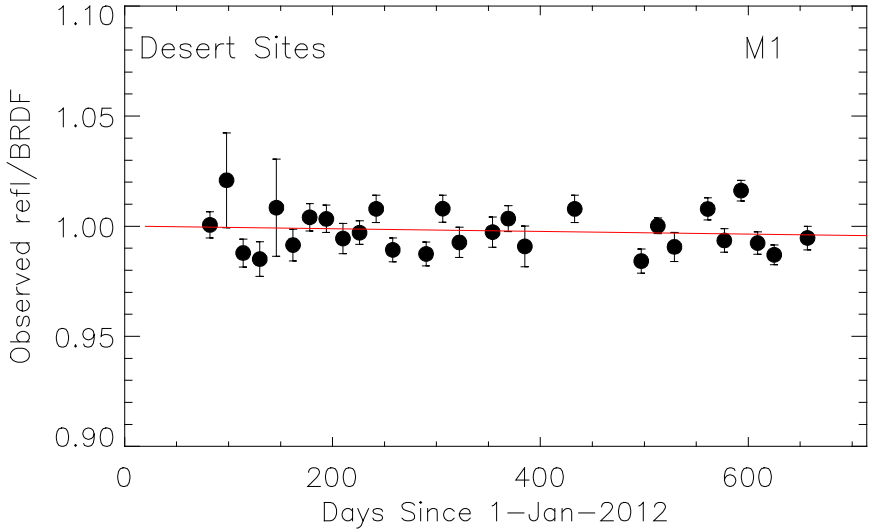


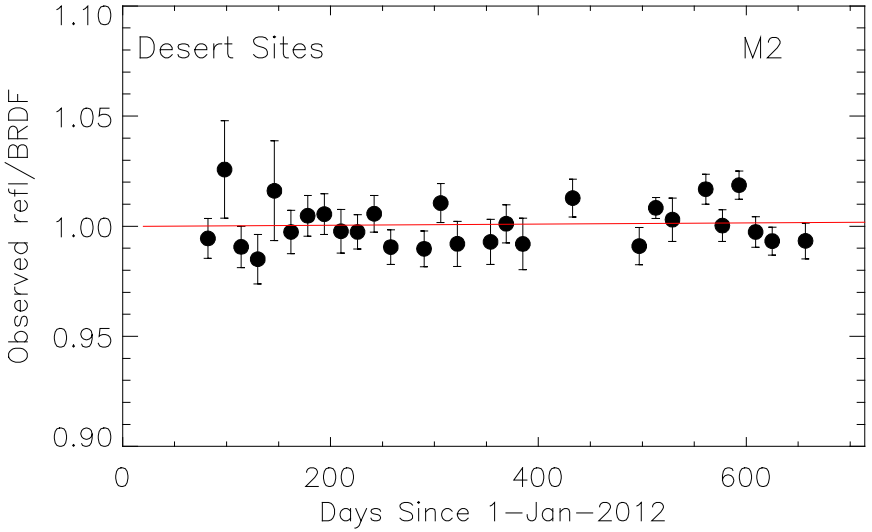


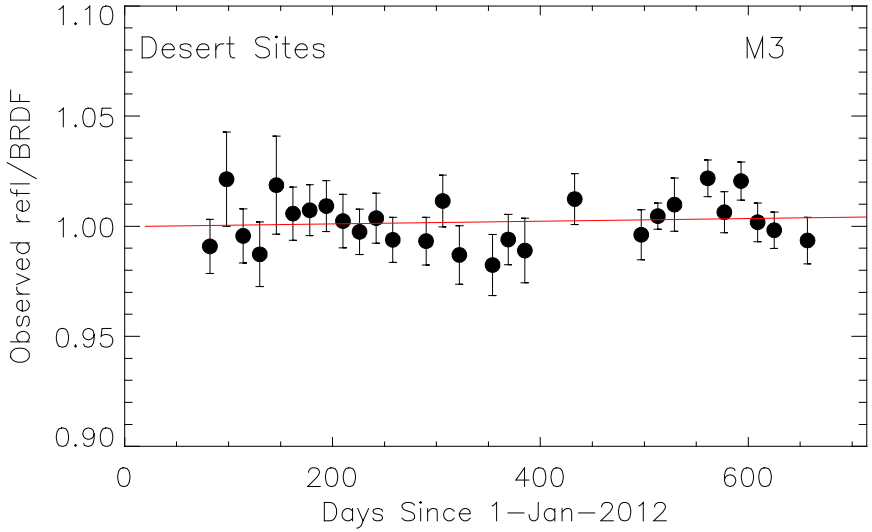


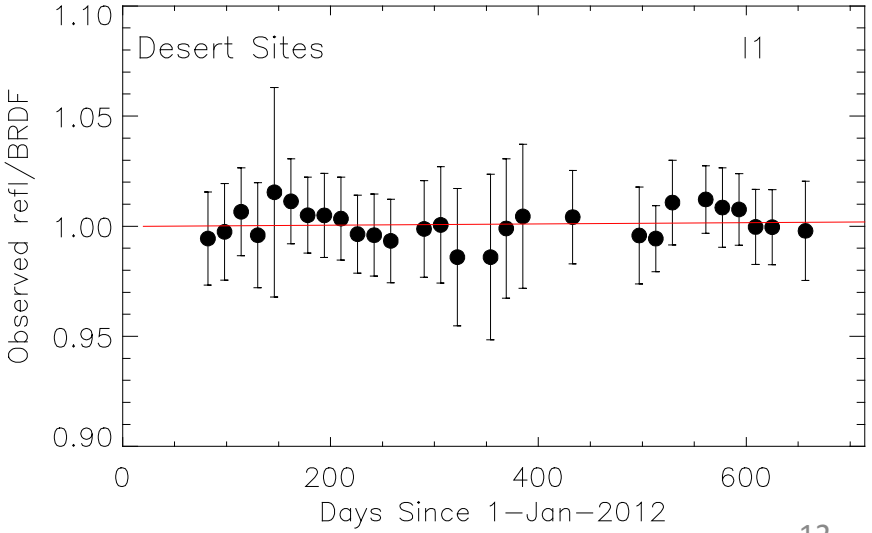
VIIRS Reflectance Trends for Libya-4

Using SDRs reprocessed with calibration coefficients improved by the NASA VIIRS Calibration Support Team



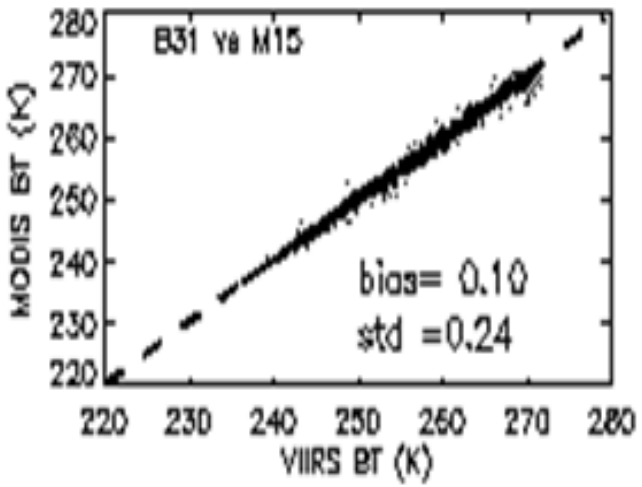


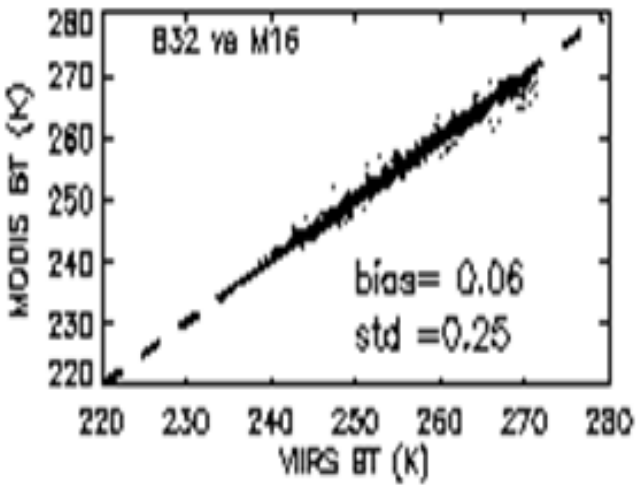




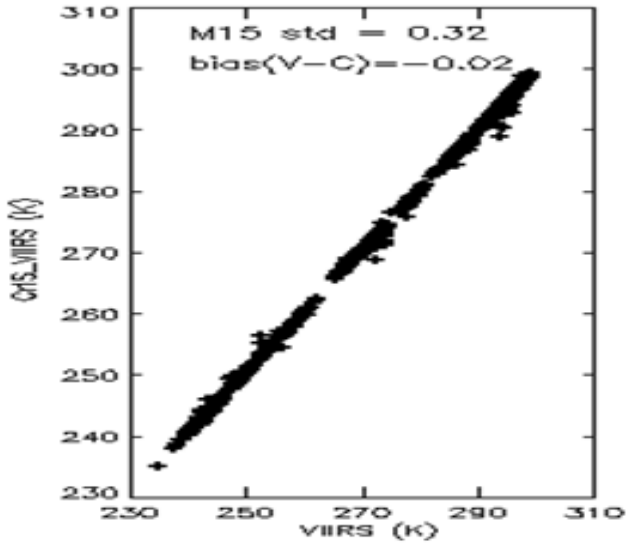
Normalized to MODIS reflectance (BRDF)

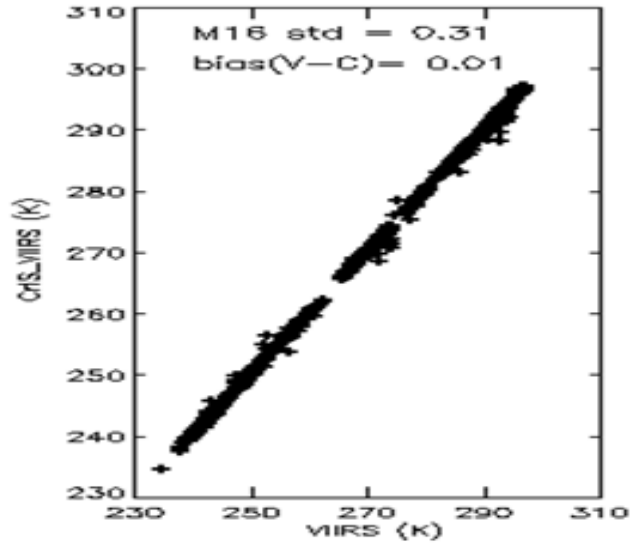
VIIRS TEB Comparisons





VIIRS vs MODIS

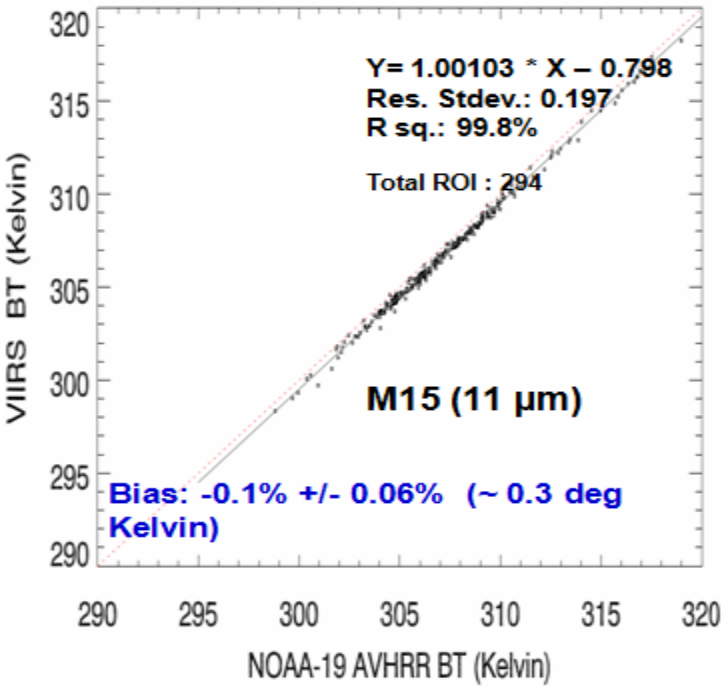


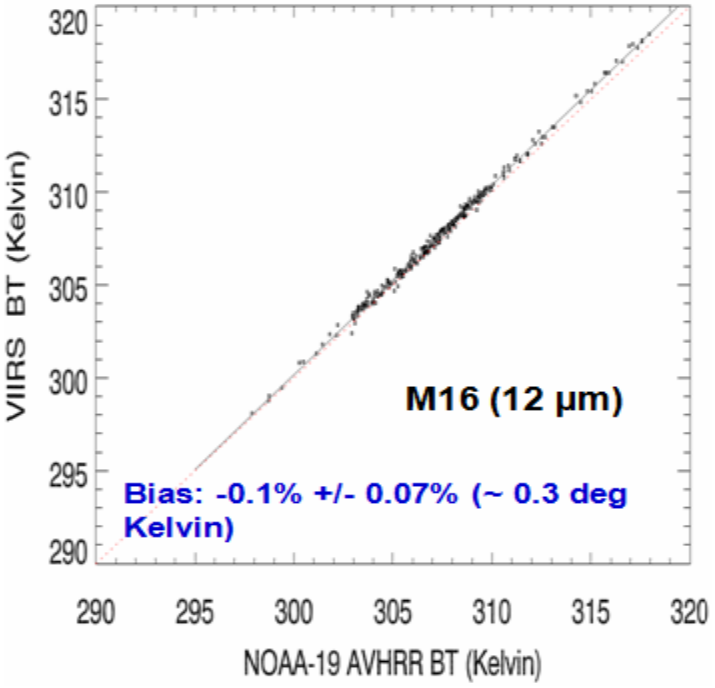


VIIRS vs CrIS

SDR Comparison with AVHRR

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.



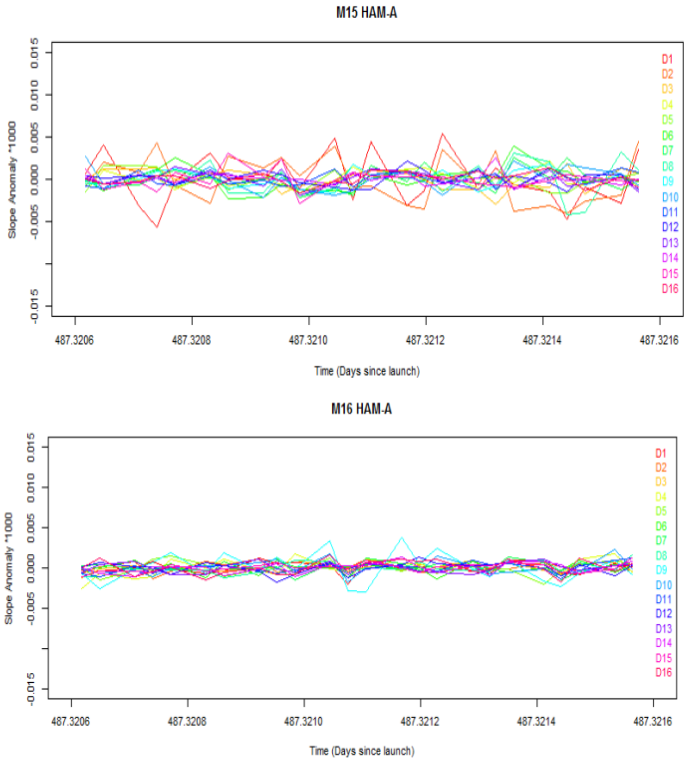


VIIRS M15 Image Striping

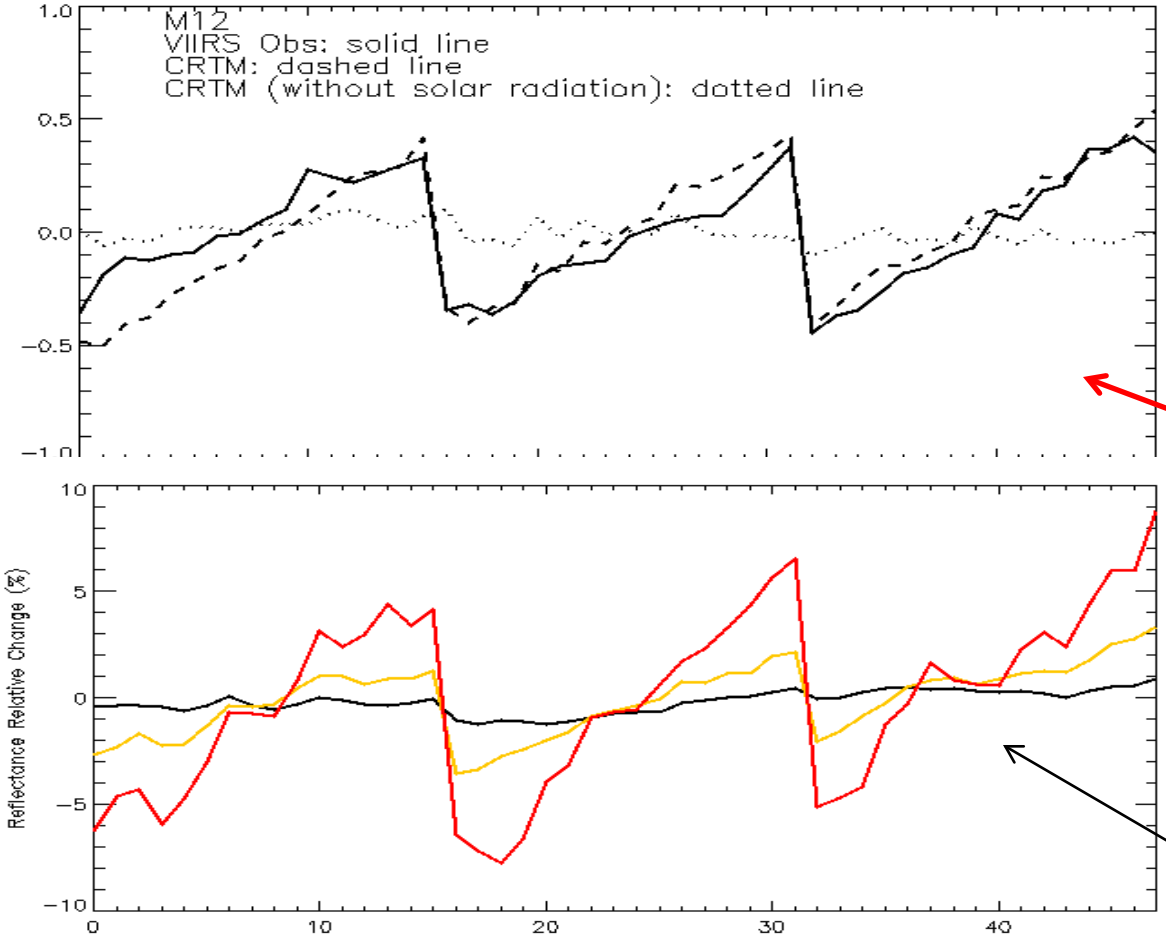
Solar diffuser view helped in identifying the M15 detectors with less stable gains which appears to be the major root cause for SST striping.

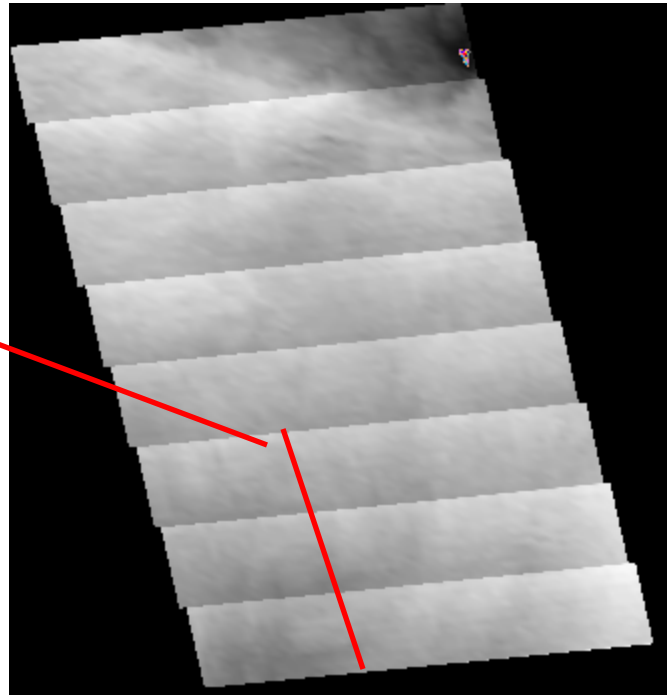
D1, D2, and D8 for M15 gains are not as stable as the other detectors which is identified as the root cause for the striping.

Striping is at noise level which has little impact on meeting the requirement, nevertheless SST amplifies the striping by ~4x.



VIIRS and CRTM Modeling for M12 Striping Investigation





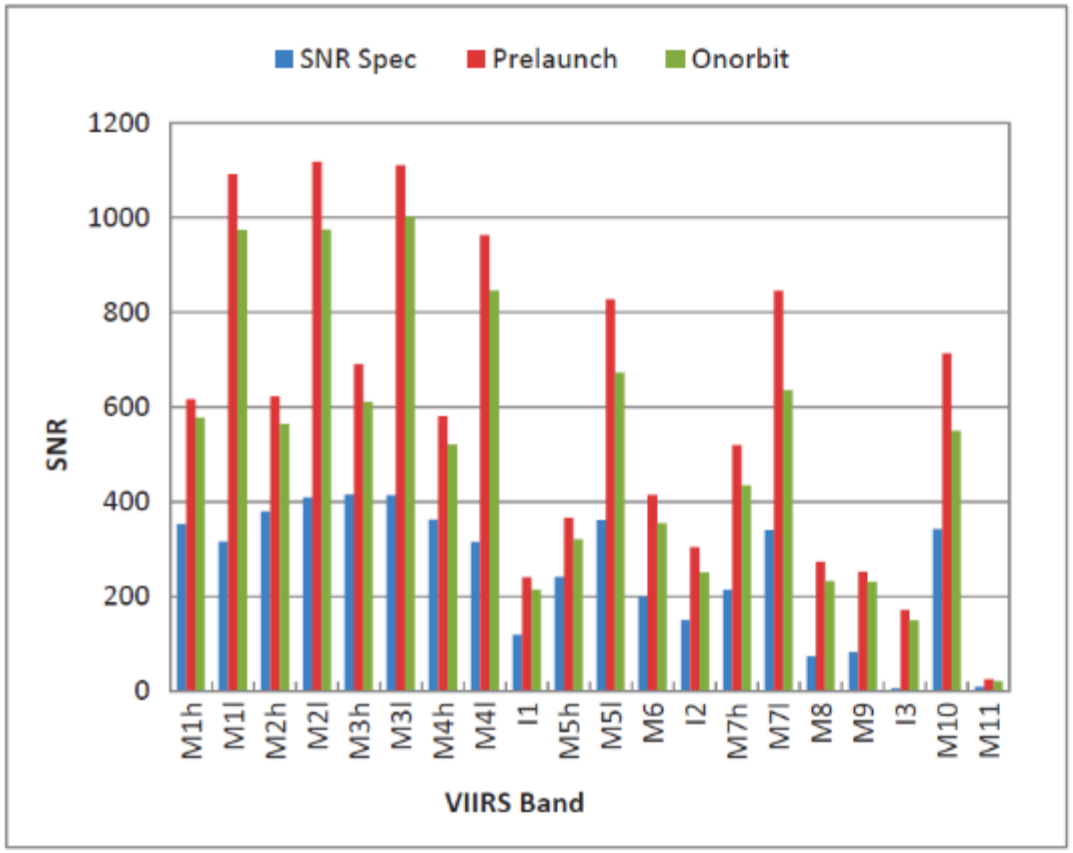
M1, M4, and M11 measured
(R-Rm)/Rm *100

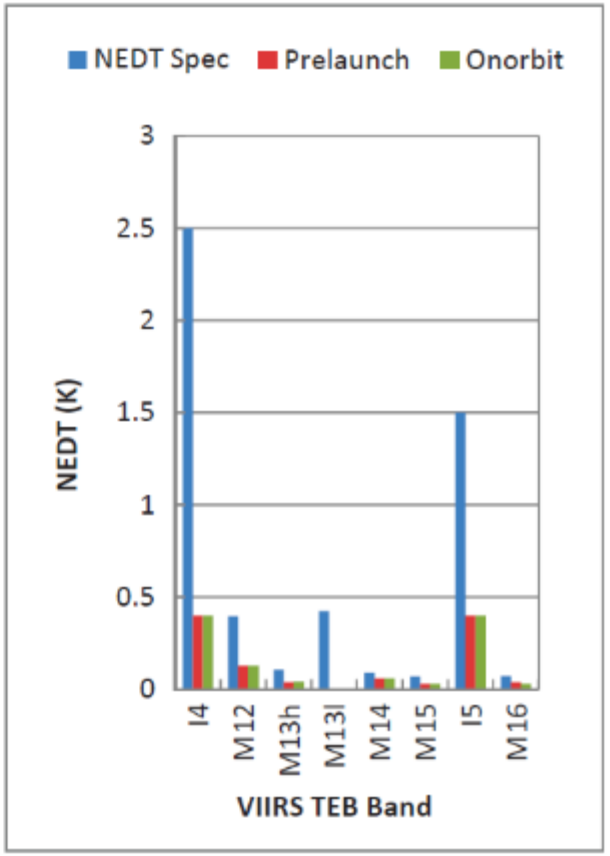
The STAR team applied the CRTM to simulate the VIIRS SDR data.
It is found that the M12 striping reported by the SST EDR team is caused by the difference in VIIRS azimuth angles among detectors.

VIIRS Milestones

Band	Driving EDR(s)	Center Wavelength (μm)	Equiv. Width (μm)	Horizontal Sample Interval (km) (track × scan)		Band Gain	Ltyp or Ttyp (Spec)	Lmin or Tmin	Lmax or Tmax	Spec SNR or NEdT (K)	On Orbit SNR or NEdT (K)	MODIS equiv. band
				Nadir	End of Scan							
VisNIR												
M1	Ocean Color Aerosol	0.411	0.0198	0.75×0.75	1.60x1.58	H	44.9	30	135	352	588	B8
						L	155		615	316	1045	
M2	Ocean Color Aerosol	0.444	0.0143	0.75×0.75	1.60x1.58	H	40	26	127	380	572	B9
						L	146		687	409	1010	
M3	Ocean Color Aerosol	0.486	0.0190	0.75×0.75	1.60x1.58	H	32	22	107	416	628	B10
						L	123		702	414	988	
M4	Ocean Color Aerosol	0.551	0.0209	0.75×0.75	1.60x1.58	H	21	12	78	362	534	B4/B12
						L	90		667	315	856	
I1	Imagery EDR	0.639	0.0775	0.375x0.375	0.80x0.79	S	22	5	718	119	214	B1
M5	Ocean Color Aerosol	0.672	0.02	0.75×0.75	1.60x1.58	H	10	9	59	242	336	B13/B1
						L	68		651	360	631	
M6	Atmosph. Correct.	0.745	0.0146	0.75×0.75	1.60x1.58	S	9.6	5.3	41	199	368	B15
I2	NDVI	0.862	0.0394	0.375x0.375	0.80x0.79	S	25	10.3	349	150	264	B2
M7	Ocean Color Aerosol	0.862	0.0387	0.75×0.75	1.60x1.58	H	6.4	3.4	29	215	457	B16/B2
						L	33.4		349	340	631	
DNB	NCC Imagery	0.700	0.200	0.75×0.75	0.75×0.75	LG/MG/HG	3E-9	3E-9	0.02	6	>9	-
S/MWIR												
M8	Cloud Particle Size	1.238	0.0271	0.75×0.75	1.60x1.58	S	5.4	3.5	165	74	221	B5
M9	Cirrus/Cloud Cover	1.375	0.0150	0.75×0.75	1.60x1.58	S	6	0.6	77.1	83	227	B26
I3	Binary Snow Map	1.602	0.0572	0.375x0.375	0.80x0.79	S	7.3	1.2	72.5	6	149	B6
M10	Snow Fraction	1.602	0.0587	0.75×0.75	1.60x1.58	S	7.3	1.2	71.2	342	586	B6
M11	Clouds	2.257	0.0467	0.75×0.75	1.60x1.58	S	0.12	0.12	31.8	10	22	B7
I4	Imagery Clouds	3.753	0.360	0.375x0.375	0.80x0.79	S	270	210	353	2.5	0.4	B20
M12	SST	3.697	0.192	0.75×0.75	1.60x1.58	S	270	230	353	0.396	0.12	B20
M13	SST/Fires	4.067	0.165	0.75×0.75	1.60x1.58	H	300	230	343	0.107	0.04	B23
						L	380		634	0.423		
LWIR												
M14	Cloud Top Properties	8.578	0.324	0.75×0.75	1.60x1.58	S	270	190	336	0.091	0.06	B29
M15	SST	10.729	0.990	0.75×0.75	1.60x1.58	S	300	190	343	0.07	0.03	B31
I5	Cloud Imagery	11.469	1.75	0.375x0.375	0.80x0.79	S	210	190	340	1.5	0.4	B31
M16	SST	11.845	0.866	0.75×0.75	1.60x1.58	S	300	190	340	0.072	0.03	B32

VIIRS Performance





VIIRS Milestones

Milestone	Description	Date
1	NPP launch	10/28/2011
2	VIIRS turned on	11/08/2011
3	VIIRS door open (VIS)	11/21/2011
4	VIIRS Cryo-cooler door open (IR)	01/18/2012
5	NOAA CLASS SDR available	02/07/2012
6	Beta maturity	04/05/2012*
7	Provisional maturity	10/24/2012*
8	Validated maturity	12/19/2013*

* SDR Review date

IDPS RSB data products generally perform very well.

TEB is excellent.

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

Summary

- IDPS RSB data products generally perform very well.
- RSBAutoCal for generating calibration has been implemented.
- VIIRS Thermal Emissive Bands are stable and exceed the specification.
- D1, D2, and D8 for M15 gains are not as stable as the other detectors which is identified as the root cause for the striping.
- 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, CrIS, and AVHRR agree well over the SNO scenes.
- VIIRS DNB Straylight Correction implemented (Aug. 2013); tool kit has been evaluated by STAR.
- Implementation of modulated RSR (April 2013).
- NASA lunar approach and the NOAA BB WUCD method potentially solved M13 LG calibration issue.
- Higher accuracy demanded by ocean color requirements.
- Bias between M15 and CrIS at low temperature.
- I2/M7 correlation analysis