



frared Imaging Radiomete

VIIRS TEB Detector-Level RSR Performance Effects

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VIIRS Thermal Emissive Band (TEB) Detector-Level Relative Spectral Response (RSR) Investigation











- Provided by NG: system-level measurements performed in **TVAC** [IDPS Operational RSRs]
- » Six VIIRS scan angles tested:

[0.0°, 10.744°, 21.566°, 32.568°, 43.932°, 56.063°]

» Sensor altitude of 829 km (at equator)





¹Images Courtesy of JPSS VIIRS SDR Radiometric Calibration ATBD







Simulated Radiance Data:

- **RTM:** MODTRAN (v5.3.2) »
- **Spectral Range:** 3333 to 741 wn (3 to 13.5 μm) »
- Spectral Resolution: 1 wn »
- Time of Day: Nighttime »
- Atmospheric profiles: (6 Atmospheres) Tropical, Mid Latitude » Summer (MLS), Mid Latitude Winter (MLW), U.S. Standard (USS), Sub-Arctic Summer(SAS), Sub-Arctic Winter (SAW)
- Boundary Layer Aerosol: Maritime VIS = 23 km »
- Surface Target: Water »
- Surface Emissivity: 0.985 »
- Surface Temperature: 3 SST temperatures used for » each atmosphere $(T_{min}, T_{nominal}, T_{max})$



¹http://www.ospo.noaa.gov/Products/ocean/sst/contour/index.html

6 MODTRAN Standard Atmospheres²





9 Altitude	E-8 1E-5 0.01 500 1000 H ₂ O (atm cm / km)	10 1500 2000 1E-8 1E-6	1E-4 0.005 0.010 0.015 0.020 O ₃ (atm cm / km)
	Tropical [K]	MLS/MLW/USS [K]	SAS/SAW [K]
	200 15 (17 0)		

T _{min}	290.15 (17 C)	273.70 (0.6 C)	271.71 (-1.4 C)
T _{nominal}	297.75 (24.6 C)	287.15 (14 C)	277.75 (4.6 C)
T _{max}	306.15 (33 C)	299.15 (26 C)	283.15 (10 C)

Temperature Range: 271.71 to 306.15 K

²Atmospheric graphics courtesy of MODTRAN Users Manual (5.3)



Example of Competing Atmospheric Effects

 \rangle



Primary Atmospheric Contributors



Tropical Atm @ T_{max} - atmospheric Transmission term dominates



MLS Atm @ T_{min} - atmospheric Upwelling radiance term dominates



Total Radiance





MODTRAN Derived Radiance:

NADIR (0°) & OFF-NADIR (56.063°)









- » Calculated channel effective spectral radiance (L_{eff}) for each VIIRS TEB:
 - Using the detector-level & band averaged RSR data and the MODTRAN simulated radiances [Eq 1]
- » Converted radiance to effective temperature (T_{eff}) using a LUT of radiance and temperature pairs approach

Analysis:

» Qualitative & quantitative analysis conducted *Metric of comparison:*

$$\Delta T_{eff} = T_{eff \, detector \, RSR} - T_{eff \, band \, avg. \, RSR}$$

Interpreted as:

 $\Delta T_{eff} = (T_{eff \ band \ avg. \ RSR} - Operational \ [IDPS])$

Note:

- 1) Radiometric differences between the band average & detector level RSRs, when viewing a calibration source, are small relative to system requirements
- 2) Radiometric differences between the band average & detector level RSRs, when viewing earth scenes, can be larger due to earth & atm. spectral phenomenology

Goal: determine if any atmospheric dependencies exist between VIIRS TEB band average and detector-level RSRs



Assumptions:

- Target is water
- Considered only global SST

temperature ranges for this study

- Clear Sky Scenes
- Nighttime conditions only
- Restricted study to only consider system spectral response effects



M12 Detector-Level RSRs



M12 Detector-Level and Band Avg. RSRs















Detector-Level RSR - Band Avg. RSR (All Atms) at NADIR

Detector-Level RSR - Band Avg. RSR (All Atms) at 56.063 deg OFF-NADIR



¹NEΔT values approximated using the interpolated values [Figure 6, Cao et al. 2013



Example of Observed Phenomenology in Suomi NPP VIIRS: M12



Date: May 6, 2014 **Time:** 06:35 UTC





Average of 6 Six Scans (91 pixels/detector) Over a

NPP VMAE L1.A2014126.0635.P1 03002.2014126121715.hdf



M13 Detector-Level RSRs



M13 Detector-Level and Band Avg. RSRs













NE ΔT (270 to 300 K) = ~0.2 to 0.1 K

Detector-Level RSR - Band Avg. RSR (All Atms) at NADIR

Detector-Level RSR - Band Avg. RSR (All Atms) at 56.063 deg OFF-NADIR





Example of Observed Phenomenology in Suomi NPP VIIRS: M13



Date: May 6, 2014 **Time:** 06:35 UTC



Average of 6 Six Scans (91 pixels/detector) Over a "Uniform" Ocean ROI: M13



NPP VMAE L1.A2014126.0635.P1 03002.2014126121715.hdf



M14 Detector-Level RSRs



16

















Detector-Level RSR - Band Avg. RSR (All Atms) at NADIR

Detector-Level RSR - Band Avg. RSR (All Atms) at 56.063 deg OFF-NADIR





Example of Observed Phenomenology in Suomi NPP VIIRS: M14



Date: May 6, 2014 **Time:** 06:35 UTC







Average of 6 Six Scans (91 pixels/detector) Over a

"Uniform" Ocean ROI: M14

NPP VMAE L1.A2014126.0635.P1 03002.2014126121715.hdf



M15 Detector-Level RSRs





M15 Detector-Level and Band Avg. RSRs









Detector-Level RSR - Band Avg. RSR (All Atms) at NADIR

Detector-Level RSR - Band Avg. RSR (All Atms) at 56.063 deg OFF-NADIR





Example of Observed Phenomenology in Suomi NPP VIIRS: M15



Average of 6 Six Scans (91 pixels/detector) Over a "Uniform" Ocean ROI: M15



NPP VMAE L1.A2014126.0635.P1 03002.2014126121715.hdf









M16a Detector-Level RSRs



M16a Detector-Level and Band Avg. RSRs















Detector-Level RSR - Band Avg. RSR (All Atms) at NADIR

Detector-Level RSR - Band Avg. RSR (All Atms) at 56.063 deg OFF-NADIR





M16b Detector-Level RSRs



M16b Detector-Level and Band Avg. RSRs











 $NE\Delta T$ (270 to 300 K) = ~0.03 K

Detector-Level RSR - Band Avg. RSR (All Atms) at NADIR

Detector-Level RSR - Band Avg. RSR (All Atms) at 56.063 deg OFF-NADIR





Example of Observed Phenomenology in Suomi NPP VIIRS: M16



Date: May 6, 2014 **Time:** 06:35 UTC





Average of 6 Six Scans (91 pixels/detector) Over a

NPP VMAE L1.A2014126.0635.P1 03002.2014126121715.hdf



I4 Detector-Level RSRs



I4 Detector-Level and Band Avg. RSRs









 $14 (\Delta T_{eff} = T_{eff \ detector \ RSR} - T_{eff \ band \ avg. \ RSR})$







Example of Observed Phenomenology in Suomi NPP

VIIRS: I4







Average of 6 Six Scans (128 pixels/detector) Over a

"Uniform" Ocean ROI: 14

NPP VMAE L1.A2014126.0635.P1 03002.2014126121715.hdf



I5 Detector-Level RSRs



I5 Detector-Level and Band Avg. RSRs





 $15 (\Delta T_{eff} = T_{eff \, detector \, RSR} - T_{eff \, band \, avg. \, RSR})$







 $I5 (\Delta T_{eff} = T_{eff \ detector \ RSR} - T_{eff \ band \ avg. \ RSR})$







Example of Observed Phenomenology in Suomi NPP

VIIRS: 15



Date: May 6, 2014 **Time:** 06:35 UTC





Average of 6 Six Scans (128 pixels/detector) Over a

"Uniform" Ocean ROI: 15

NPP VMAE L1.A2014126.0635.P1 03002.2014126121715.hdf



Summary



- Band average processing meets specification although not optimal
- » Atmospheric effects can amplify differences between detectors
- » Detector-level processing is ideal
- Detector-Level atmospheric dependencies were observed in all bands
 - M12 & M14 demonstrated the weakest atmospheric dependencies
 - M13 & I5 demonstrated the strongest atmospheric dependencies
 - Evident in observed data
- » Odd/Even pattern observed in most channels

Future work:

- Discuss findings with EDR teams on possibilities of detector level processing
- Further investigate image artifacts found in observed data

	NADIR [0°]			OFF-NADIR [56.063°]		
	ABS(T _{eff detector RSR} - T _{eff band avg. RSR}) [K]			ABS(T _{eff detector RSR} - T _{eff band avg. RSR}) [K]		
Band	Min	Max	Mean	Min	Max	Mean
M12	0.000	0.007	0.002	0.000	0.012	0.003
M13	0.012	0.162	0.078	0.000	0.159	0.077
M14	0.000	0.014	0.001	0.000	0.018	0.002
M15	0.000	0.030	0.005	0.000	0.049	0.009
M16a	0.000	0.019	0.003	0.000	0.028	0.004
M16b	0.000	0.020	0.002	0.000	0.030	0.004
14	0.000	0.021	0.004	0.000	0.035	0.007
15	0.000	0.062	0.012	0.000	0.093	0.021





BACKUP



M12



M12 Detector-Level RSRs





M13



M13 Detector-Level RSRs









M14 Detector-Level RSRs









M15 Detector-Level RSRs











M16a Detector-Level RSRs



















