



Status of VIIRS Instrument Operation

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> Acknowledgements: VCST Members NOAA STAR SDR Team JPSS Mission Operation Team

> > October 19, 2018







- Status of S-NPP & NOAA-20 VIIRS operations
 - NOAA-20 (JPSS-1) Launch on Nov 18, 2017
 - Operational Maneuvers
 - Calibration Maneuvers
 - Spacecraft and VIIRS Anomalies
 - RSB Solar Diffuser and Solar Diffuser Stability Monitor Calibrations
 - TEB Blackbody Warm-Up/Cool-Down Calibration
 - DNB VROP Calibration
 - Telemetry Trending



NOAA-20 VIIRS Key Post-Launch Events during ICV



2017			2018
JPSS1 (NOAA-20) Launch 11/18			01/02 Orbit Raising Burn (#6)
VIIRS Power On 11/28			01/03 Cryoradiator Door Open
Science Ops Mode 11/29	emt	×	01/07 Electronic X-talk Test
SDSM 1st Measurement 11/30		Januar	01/10 BB Warm-Up Cool-Down (Full)
Electronics Self Test 12/08			01/17 DNB VROP Cal (New Moon)
Straylight Test 12/08			01/22 BB Warm-Up Cool-Down (Short)
Nadir Aperture Door Open 12/13			01/25 Yaw Maneuvers
Orbit Raising Burn (#1) 12/14	Dec		01/27 Lunar Cal Roll Maneuver
Orbit Raising Burn (#2) 12/17	em l		01/31 Deep Space Pitch Maneuver
DNB 1st VROP Cal (New Moon) 12/18	ber		02/02 Safe Mode
Orbit Raising Burn (#3) 12/20		Jar)	02/15 DNB VROP Cal (New Moon)
Orbit Raising Burn (#4) 12/23		ebru	02/15 Electronics Self test (LWIR Diagnosis)
Orbit Raising Burn (#5) 12/26	2,3	ц	02/16 Raising BB Temperature (LWIR Diagnosis)
Lunar Cal 1st Roll Maneuver 12/29	- 19	1.0	02/21 Telescope Stow (LWIR Diagnosis)
Safe Mode 12/29		P.,	02/26 Lunar Cal Roll Maneuver
		Mar	03/12 Mid-Mission Outgassing





• Drag Make-Up (DMU) Maneuvers

Purpose: To keep near orbital period to ~101.5 minutes.

- S-NPP: 28 DMUs since launch, most recent on 7/17/2018
- N20: 1 DMU on 6/12/2018

• Inclination Adjustment Maneuvers (IAM)

Purpose: To keep equator crossing time between 1325 and 1330.

- S-NPP: 8 IAMs since launch, most recent on 9/27/2018
- N20: None





• Roll Maneuver (Lunar Calibration)

Purpose: To observe the Moon through the Space View port at near-constant lunar phase for lunar calibration - about 9 times per year.

- S-NPP: 59 Lunar observations since launch, most recent on Jun 23, 2018
- N20: 7 Lunar observations since launch, on the same day as S-NPP

Yaw Maneuver

*Purpose: To validate and construct SDSM screen transmittance and SD BRDF*SAS transmittance product - once during ICV.*

- S-NPP: Feb. 15-16, 2012
- N20: Jan 25-26, 2018

Pitch Maneuver

Purpose: To validate TEB response vs. scan-angle (RVS) and measure DNB offset signals - once during ICV.

- S-NPP: Feb 20, 2012
- N20: Jan 31, 2018





Lunar Roll Maneuver (LRM)



Overview: Perform spacecraft roll to view Moon through SV port with lunar phase ~51° and VIIRS to be configured DCR turn-off, fixed high gain, and encoder offset shift to capture Moon image in the EV sector. The on-board Bowtie Deletion algorithm is disabled for N20 only.

S-NPP (I1 image) 2/26/2018



S-NPP: Agg. zone 3 (Nadir)



N20: Agg. zone 1 (Native Resolution)



N20 (I1 image) 2/26/2018





Yaw Maneuvers



Overview: 15 yaws over consecutive orbits at different angles that start in eclipse and reach dwell attitude at sunrise. SDSM calibration for every yaw maneuver orbit.



Groundtrack for JPSS-1 VIIRS Yaws 01/25-26/2018

*Source: JPSS-1 Yaw Maneuver CAM package.





Overview: Perform a +Pitch back-flip spacecraft maneuver to allow VIIRS, CERES, and ATMS to view deep space that start at eclipse entry and return nominal pointing at the end of eclipse.







• Spacecraft Anomaly (since June 2016)

- S-NPP: Safe mode and data loss on 9/29/2017.
- S-NPP: Solar Array (SA) and Bus power anomaly on 4/2/2018 remaining issue.
- N20: Safe mode due to Time of Day (TOD) counter missed on 12/29/2017.

• VIIRS Single Board Computer (SBC) Lock-up ("Petulant Mode")

- S-NPP SBC Lock-ups are mostly 2-4 hrs to get back science mode. FSW 0x4016 for pseudo WDT interrupt to reduce lock-up but not completely. N20 has HW interrupt design to prevent lock-up, and Spacewire replaced Firewire 1394.
- S-NPP: 13 since launch (5 since June 2016), most recent on Feb 13, 2018.
- N20: None.

• VIIRS Scan Sync Loss

- Sync loss between RTA & HAM for short periods 2-3 min resulting in poor geolocation accuracy.
- S-NPP: 96 since launch, most recent on Sep 12, 2018.
- N20: 18 since launch, most recent on Aug 24, 2018.

• Spectral Bands Gain Degradation Anomaly

- S-NPP early mission RSB VisNIR large degradation has leveled off.
- N20 early mission TEB LWIR gain decrease has recovered and remain flat after MMOG.
- DNB stray light contamination on both S-NPP and N20 corrections are applied in L1B.



Blackbody Warm-Up/Cool-Down



Overview: Perform BB warm-up/cool-down (WUCD from ambient ~267 to 315 K, including 8 steps) to determine on-orbit calibration coefficients for TEB and assess detector linearity over the range of temperatures and noise NEdT at T_{typ}.

- S-NPP: 26 since launch; N20: 4 since launch.
- Quarterly activity until June 2018, once a year thereafter.





VIIRS DNB VROP Calibration



Overview: Monthly events during new moon night orbit, over the central Pacific dark ocean and day-night transition. Calibrations for DNB Offset, Dark, and Gain Ratios.

S-NPP ground track prediction to validate DNB Cal schedule for 11/7/2018.







S-NPP

NOAA-20



□ Both S-NPP and N20 instrument temperatures are stable showing seasonal variations.

- □ Cold Focal Plane Assemblies (CFPAs) are well controlled with N20 little higher set point.
- □ S-NPP SMIR CFPA temperature increased by 50 mK since launch.
- □ Warm focal plane VisNIR and DNB temperatures trending are nominal.





VIIRS BB (S-NPP & N20) long-term stability to within a few mK







• Status of VIIRS Operations:

- S-NPP and N20 orbit maintenance continuing.
- Spacecraft roll maneuvers for lunar calibration are ongoing.
- Anomalies still occurring, including Scan Sync Loss events.
- Noisy detector N20 band I3 detector 29 becoming non-functioning.
- SD Cal each orbit; SDSM 3 times/week for S-NPP, daily for N20.
- Warm-Up/Cool-Down for TEB Cal once a year after June 2018.
- DNB VROP operations monthly.
- M11 data are being collected at night.
- VIIRS telemetry and health being monitored, not showing unusual trends.





NASA SNPP/JPSS Level-1 Software Status Update

Fred Patt

October 19, 2018



Background



Why did we do this?

- L1 algorithms, software and product formats under NASA control.
 - 6-minute granules instead of 85 seconds.
 - Daily calibrated data files reduced from 22,000 SDRs to 720 L1Bs.
- Significantly improved support for reprocessing.
 - Permanent archive of L1A and geolocation products.
 - Simplify calibration updates and algorithm tests.
- Raw data feed via NASA (EDOS).



L1ASWG Membership



- Fred Patt (Ocean lead and overall coordinator)
- Vincent Chiang (VCST lead)
- Liam Gumley (Atmosphere lead)
- Gary Lin (Geolocation lead)
- Ed Masuoka (Land lead)
- Sam Anderson (Ocean)
- Sean Bailey (Ocean)
- Carol Davidson (Land)
- Hongda Chen (VCST)
- Sadashiva Devadiga (Land)
- Steve Dutcher (Atmosphere)
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- Bin Tan (Geolocation)
- Kevin Turpie (Ocean)
- Jack Xiong (VCST)
- Robert Wolfe (Geolocation/Land)





- Version 2.0 Release in October 2016
 - Numerous functional and calibration improvements
- Version 3.0 Release in August 2018
 - Full NOAA-20 (JPSS-1) support*
- VCST has released monthly calibration LUT updates
- Software is running at all three NASA SIPS

*Basic support was delivered in late 2017.





Functional Changes

- Add a new uncertainty index field in the L1B product (this is a placeholder in V2.0 while VCST works on the actual implementation).
- Add L1B fill values for missing data states specified by Land team.
- Functionalize L1B code to be able to call from within other programs.
- Unaggregated output for dual-gain bands.
- Single-resolution processing and output (e.g., M-band only) in geolocation.
- Add lunar phase angle and illumination fraction at pixel level for DNB.
- Update L1B TEB band LUTS.
- DEM conversion to NetCDF.
- Program inputs via command line or PCF.
- Partial line processing to process along-scan extracts.





Calibration and Geolocation Changes

- Apply a time-dependent modulated RSR in the calibration algorithm.
- Apply running average of TEB F-factor over scans instead of per-scan value.
- Temperature-dependent calibration coefficients for the RSBs.
- Alternative blackbody thermistor weighting scheme to decrease orbital variation present in the F-factor.
- Alternative calibration when the Moon is in the SV.
- Range limits based on counts instead of radiance.
- Add geolocation limit checks on attitude angles and set flags.
- Use solar irradiance at 1 AU to avoid computations of large numbers.





- Full support for VIIRS-JPSS1 (NOAA-20)
 - Move RTA and HAM encoder start from hardcoded value to element in GEO LUT
 - DNB geolocation update
 - Update/correct several metadata elements
- Modified scaling and brightness temperature table for M13 to improve radiometric resolution
- Add moon phase and illumination for each DNB pixel
- Consolidate files, remove redundant and unused code, reformat code to eliminate duplication and improve maintainability
- Add lunar calibration option where SV is derived from EV for granules captured during sector rotation
- Add attitude, position and velocity vectors for the start and end of each scan











- The Level-1 source code has been configured in a Git repository developed and maintained by the Ocean SIPS.
- Individual development team members create local branches for source code modifications.
- Modified source files are merged into the master branch upon acceptance.
- The repository will be made publicly accessible after the software release has been approved by NOAA/NASA.
 - The Open Source Software Request was submitted.
 - NASA OSSR approval is pending NOAA release of the VIIRS SD source code.
- VCST maintains a separate FTP site for delivery of the dynamic radiometric calibration LUTs.





QUESTIONS?



Radiometric Calibration and Performance of the VIIRS Reflective Solar Bands

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We thank contributions from other VCST members



VIIRS Radiometric Calibration



Solar Diffuser: a calibration source its BRDF change (H-factor) monitored by the SDSM

- τ_{SDSM} (relative) \Box Improved with yaw and
- τ_{SD} BRDF(SDSM; relative) $\int regular$ on-orbit data
- τ_{SD} BRDF(RTA; yaw)

For both SNPP and N20



SNPP VIIRS SD H-factors



• H-factor is angle dependent (on $\phi_{V,SD}$)



SNPP VIIRS SD H-factors





SNPP VIIRS SD H-factors





SNPP VIIRS $H_{RTA} (\phi_{V,SD} = 35.5^{\circ})$



• H-factor decreases more at a shorter wavelength

• $H_{\text{SDSM}}(\lambda, t) = 1 - \beta(t) / \lambda^{\eta_{\text{H}}(t)}$ (SDSM det5-8 &SWIR wavelengths)



SNPP VIIRS H_{RTA} at SWIR λ

• $H_{\text{SDSM}}(\lambda, t) = 1 - \beta(t) / \lambda^{\eta_{\text{H}}(t)}$





SNPP VIIRS SDSM Detector Gains



- Gain decreases the most for detector 8, by ~ 42% currently



SNPP VIIRS F-factors (C2.0)



- Gain decreases the most for the I2 and M7 bands: down ~ 42%



Radiometric Performance 1: SNRtyp



- SNRs are well above requirements
- the SNRs decrease over time, due to tungsten oxide darkening effect from the RTA mirrors



SNRtyp Trending: when to reach SNRspec?



- SNR decreases the quickest for the I2 band, starting to be smaller than spec. about 25 years after launch



Radiometric Performance 2: Bias in $\tau_{SD}BRDF_{RTA}(0)$



• Disagreement between on-orbit data determined and prelaunch $\tau_{SD}BRDF_{RTA}(t = 0)$ exceeds 0.5%: over the sweet spot

N. Lei, X. Xiong, and J. McIntire, "Suomi NPP VIIRS solar diffuser screen transmittance model and its applications", Appl. Opt. 56(31), pp. 8676-8686, 2017, doi: 10.1364/AO.56.008676.


13



 A large probability that the bias in H_{RTA} can exceed 1.5% (SNOs for fixed detectors in a band: middetectors)

N. Lei, X. Chen, T. Chang, and X. Xiong, "Positional dependence of the SNPP VIIRS SD BRDF degradation factor", *Proc. SPIE*, vol. 10423, Nov. 2017, Art ID. 1042317, doi: 10.1117/12.2277715.



• Comparisons with Aqua MODIS (Aisheng Wu of VCST)



• TOA reflectance (SNPP VIIRS) exceeds Aqua MODIS by ~ 2%

A. Wu, X. Xiong, T. Chang, and C. Cao, "Initial assessment of radiometric performance of N20 VIIRS reflective solar bands using vicarious approaches", *Proc. SPIE*, vol. 10781, 2018, paper ID: 10781-33.







- N20 H_{SDSM} decreases with time slightly slower than SNPP H_{SDSM}



N20 SDSM Detector Gain



- SDSM detector gains decrease with similar rates, except perhaps for detector 4

- detector 4: nearly unchanged for SNPP and down about 2% for N20



N20 VIIRS RSB F-factors



- Quite flat F-factor vs time curves: no gain degradation (SNPP VIIRS F-factor goes up due to RTA mirror darkening effect)





- SNRs are well above requirements and stable, values similar to the SNPP SNRs at the mission start, except for M11



- (1) Desert sites reflectance comparison- N20 VIIRS RSBs are about 4% lower than SNPP's
- (2) Lunar observations: comparing measured lunar irradiance with the ROLO model result
 - N20 about 3-4% lower than SNPP



SNPP VIIRS RSB Calibration Improvements

- since Apr 24, 2018, NOAA IDPS deltaC LUT has been used
- solar azimuth dependence of the H-factor applied to all VISNIR bands
- used 6-yr of lunar F-factors to derive H_{RTA} from H_{SDSM}





- used both yaw and regular on-orbit data to improve the screens
 significantly reduced H-factor undulations
- used wavelength power law to determine H-factor at SWIR wavelengths
 - H-factor at the M8 band wavelength has decreased by more than 0.2% and the amount of the decrease will increase with time





- **– S-NPP:**
 - (1) examine prelaunch calibration coefficients
 - (2) apply positional dependence of the H-factor
 - (3) track potential changes in VIIRS RVS
- N20
 - (1) apply angular dependence to the H-factor
 - (2) improve the screens with more reliable regular on-orbit data
 - (3) examine prelaunch calibration coefficients
 - (4) examine positional dependence of the H-factor

N20 H_{SDSM}: Angular Dependence (initial results)



- Same amount of solar declination angular dependence of ${\rm H}_{\rm SDSM}$ at the same value of ${\rm \,H}_{\rm SDSM}$

N20 F-factor from H_{RTA} : initial results



- Change in M1 F-factor by 1.2% at ~ mission day 315
- Much better agreement with lunar F-factors



- Both SNPP and N20 SD H-factors and SDSM detector gains decrease with time
- SNPP F-factors increase with time whereas N20 F-factors are flat over time
- Both SNPP and N20 SNRs keep above spec. by large margins
- SNPP 2-4% higher than N20 in retrieved reflectance
- SNPP SD screen transmittance and/or prelaunch BRDF have biases larger than 0.5%
- Angular dependence of the H-factor has been taken care of for the SNPP but not yet for the N20
- Positional dependence of the H-factor has not been taken care of for both the SNPP and the N20



Back-ups







S-NPP and JPSS-1 VIIRS Thermal Emissive Bands On-Orbit Performance and Calibration

Jeff McIntire, Yonghong Li, Amit Angal, Sergey Gusev, Vincent Chiang, and Jack Xiong

VCST, NASA/GSFC

Acknowledgements: VIIRS SDR Team Members VCST Members

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- **TEB calibration overview**
- JPSS-1 LWIR degradation anomaly
- On-orbit performance
 - BB performance
 - Detector short-term stability and long-term response (F-factors)
 - Detector noise characterization (NEdT)
 - Trending during WUCD
- Improvements
 - Improvements already implemented
 - Future improvements
- Conclusions





5 M-bands and 2 I-bands, covering wavelengths from 3.7 to 12 μm



Calibrated using an on-board blackbody (BB):

- Scaling factor "F-factor" is derived and applied each scan.
- Warm-up and cool-down (WUCD) cycles are performed quarterly in the past (now yearly) to fully characterize TEB detector response, including offset and nonlinear terms.





VIIRS Earth View radiance is retrieved following ATBD Eq. (116)

$$L_{EV}(B,\theta) = \frac{F(B)\sum_{i=0}^{2}c_{i}(B)dn^{i}(B) - \Delta L_{bg}(B,\theta)}{RVS(B,\theta)},$$

dn: detector response c_i: calibration coefficients RVS: response versus scan-angle

where the $\Delta L_{bg}(B, \theta)$ is the background difference between the EV and SV path:

$$\Delta L_{bg}(B,\theta) = (RVS(B,\theta) - RVS_{SV}(B)) \left[\frac{(1 - \rho_{RTA}(B))}{\rho_{RTA}(B)} L_{RTA} - \frac{1}{\rho_{RTA}(B)} L_{HAM} \right],$$

The F-factor is derived each scan for each band, detector, and HAM side:



and the aperture radiance from the BB is:

$$L_{ap}(B) = \varepsilon L_{BB} + (1 - \varepsilon)(F_{RTA}L_{RTA} + F_{SH}L_{SH} + F_{CAV}L_{CAV})$$



<u>Anomaly:</u> larger than expected degradation in LWIR gains in early mission. Cause traced to icing on LWIR dewar window. Mid-mission outgassing performed to remove ice.
 <u>Pre-Outgas</u>: normalized gains for bands decreased by 0.8 % (M15) and 1.5 % (I5 and M16).
 <u>Post-Outgas</u>: the LWIR gains recovered after the outgassing (within 0.2 % relative to the first measurement after the cryo-door opened). Gains have been relatively stable since.



Instrument Temperatures Trend



SNPP





- Discontinuities in the instrument temperatures trends generally coincident with discontinuities in the F-factor trends shown on previous slide.
- Some seasonality apparent in the SNPP instrument temperature trends. The SNPP F-factor for LWIR bands shows similar seasonality.
- There is a small increasing trend of SNPP SMWIR focal plane temperature, which explains the trend observed in SNPP MWIR bands F-factor (I4, M12, M13).



BB Performance – SNPP





Short-term stability (scan-by-scan T_{BB}):

- Orbital variations of individual thermistors up to 40 mK.
- Variations in average temperature ~ 20 mK.
- Temperature difference between individual thermistors up to ~ 60 mK.
- BB uniformity meets the requirement with standard deviation less than 30 mK.

Long-term trend of daily-averaged T_{BB}

- Stable to within a few mK.
- ~15 mK offsets were due to the use of two different T_{BB} settings.





BB Performance – JPSS-1







Detector Short-term Stability (F factors – SNPP)



Detector responses (Ffactors) show small orbital variations:

- ±0.2 % or less on a per scan basis
- ±0.1 % or less on a per granule basis
 Would using averaged F-factors improve SDR product?

F-factor orbital variations correlate with T_{BB} variations and instrument temperatures variations.

F-factor shown for orbits 35875 – 35879 for HAM side A.





0.998

0.997

0.996

0.994

0.993

0

factor

ш 0.995







M15

0

20

40

Granules



86





Detector Short-term Stability (F factors – JPSS-1)



Detector responses (Ffactors) show small orbital variations:

- ±0.2 % or less on a ⊢^m per scan basis
- ±0.1 % or less on a per granule basis
 Would using averaged F-factors improve SDR product?

F-factor orbital variations correlate with T_{BB} variations and instrument temperatures variations.

F-factor shown for orbits 4477 – 4481 for HAM side A.





Detector Long-term Response (F factor)



Daily average F-factor trend:

- For SNPP ~7 years; for JPSS-1 ~ 1 year.
- SNPP F-factors are very stable. I5 shows the most noticeable trend of ~2.0 %, while the rest of the bands are within 0.8 % (I4).
- JPSS-1 F-factors showed anomaly in early mission due to icing; outgassing brought F-factors back to original values and are now stable to within 0.3%.
- Discontinuities in the trends are generally coincident with anomalies during which the cold FPA and / or the instrument temperatures changed.
- Some small seasonal cycles appear in SNPP.







$$NEdT = \frac{NEdL}{\partial L/\partial T} = \frac{L}{SNR \,\partial L/\partial T}$$

- NEdT routinely trended at ~292 K: stable since the CFPA temperatures reached ~80 K (SNPP) or ~80.5 K (JPSS-1). Band averaged values are within 0.2 K for I bands and 0.07 K for M bands
- NEdT at T_{TYP} derived periodically from BB WUCD data: stable and meeting the sensor design requirements by a wide margin.





Detector Noise Characterization (NEdT)



Band	T _{TYP} [K]	NEdT at T _{TYP} [K]				
		Requirement	SNPP		JPSS-1	
			2/2012	6/2018	1/2018	6/2018
I4	270	2.5	0.408	0.409	0.392	0.392
I5	210	1.5	0.384	0.400	0.420	0.422
M12	270	0.396	0.128	0.118	0.101	0.103
M13	300	0.107	0.042	0.040	0.039	0.039
M14	270	0.091	0.053	0.055	0.049	0.049
M15	300	0.070	0.029	0.027	0.024	0.024
M16	300	0.072	0.028	0.029	0.031	0.031

NEdT at T_{TYP} (derived from cool-down data) TEB bands continue to meet the sensor design requirements



Band Average c₁ – SNPP



• Band-average c_1 coefficients, derived from the 26 WUCD through June 2018, are shown in red (WU data), and blue (CD data) and compared to prelaunch (green). I5 c_1 shows a noticeable trend, consistent with results from F-factor trending.

• Band-average c_1 coefficients derived during WUCD cycles are within 1.9 % on average (at M16 CD) from pre-launch values.

• An offset between WU and CD results is present throughout the 26 WUCDs, most prominently for the LWIR bands.





Band Average c₁ – JPSS-1



• Band-average c_1 coefficients, derived from the 4 WUCD through June 2018, are shown in red (WU data), and blue (CD data) and compared to prelaunch (green).

• The c_1 from the 1st WU is lower for the LWIR; the other 3 WUCD are consistent.

• Band-average c_1 coefficients derived during WUCD cycles are within 3 % on average (at M16 CD) from pre-launch values.

• An offset between WU and CD results is present throughout the 4 WUCDs, most prominently for the LWIR bands.





c₀ and c₂ Coefficients – SNPP







c₀ and c₂ Coefficients – JPSS-1



0.02

0.01

0.00

-0.01

0.02

0.01

0.00

-0.01

0.05

0.00

-0.05

0.05

-0.05

-0.10

00

S

00

00 0.00



 $c_{0LUT} \pm 0.1$ (LWIR)



F-factors Orbital Variation Reduction – SNPP





• F-factor orbital variations are present, on the order of $\pm 0.05 - 0.1$ %.

• Changing the BB thermistor weighting can reduce the F-factor orbital variations. Using T3 and T6 yield less variation for most bands (except M12 and M13).

• Improving the background model which would also reduce the F-factor orbital variations.

• F-factor shown for orbits 35875 – 35879 for HAM side A.



F-factors Orbital Variation Reduction – JPSS-1





• F-factor orbital variations are present, on the order of $\pm 0.05 - 0.1$ %.

• Changing the BB thermistor weighting can reduce the F-factor orbital variations. Using T3 and T6 yield less variation for most bands (except I4 and M12).

• Improving the background model which would also reduce the F-factor orbital variations.

• F-factor shown for orbits 4477 – 4481 for HAM side A.



F-factors During WUCD



- The F-factor shows some variation during the WUCD, resulting from effects not captured in the thermal model.
- SNPP variation in M14 M16 was the largest; JPSS-1 variation is smaller for these bands and comparable for the other bands.







- NASA L1B TEB improvements
 - Modified scaled integer table for M13 to increase radiometric resolution at low radiance / BT
 - Alternative calibration option for Moon in the SV
 - Updated Delta-C LUT with correct temperature dependence
 - Option added to use running average of the F-factor
- NASA L1B TEB improvements in progress
 - Uncertainty index added to products
 - Improve flagging of HAM/RTA sync loss scans



Conclusions



- An anomaly was observed in the JPSS-1 TEB F-factors in the early mission. This was traced to icing on the LWIR dewar window. A mid-mission outgassing was performed and the F-factors recovered to close to their original values.
- On-orbit BB long-term performance for SNPP (~7 years) and JPSS-1 (~1 year) is very stable. Short-term (orbital) temperature variations are present but generally within the uniformity requirement of 30 mK.
- Detector response (F-factor) trending is stable for both SNPP and JPSS-1. For SNPP, I5 shows the maximum band-average trend of 2.0 % followed by M12 and I4; for JPSS-1, the maximum trend is 0.3% (I5). Small orbital variations are present (±0.0.5 – 0.1 %).
- The TEB detector noise characteristics are very stable for both instruments. The NEdT at T_{TYP} is compliant with the requirements.
- Improvements: scaled integer for M13, Moon in SV update, Delta-C LUT update, running average F-factor.




Back Up

VIIRS DNB On-orbit Calibration and Performance

VIIRS Characterization Support Team October 19, 2018





- DNB RSR and Degradation Behavior
- DNB On-orbit Performance and Trending
- Stray-light Estimation and Performance
- Summary

S-NPP DNB RSR Behavior





S-NPP VIIRS RSB and DNB Degradation





- □ RSB have experienced the largest degradation in the first year.
- □ DNB has about 20% degradation entire mission.
- ❑ DNB Moon irradiance trending matches well with SD gain trending.





LGS Gain Calculation:

• **SD** radiance: $L_{SD} = \frac{\cos\theta_{SD} \cdot RVS_{SD} \cdot \int BRDF(\lambda)\tau_{sds}H(\lambda,t)RSR(\lambda,t)\Phi(\lambda)d\lambda}{4\pi d_{SD-SUN}^2}$

SD-SUN angle, HAM relative response at SD AOI, transmittance of pinhole screen, SD degradation index, relative spectral response, solar spectral power distribution.

Calculate LGS gain coefficient: $L_{SD} = c_1 \cdot dn$

Dark Offset:

- Select dark data as sun declination angles in 40°~140°.
- Use the minimum of fitted values in SV/BB/SD as dark signal

Cross-stage Gain Ratios:

Compute daily average gain ratio: MGS/LGS, HGS/MGS

MGS and HGS Gain Coefficients:

- MGS gain = LGS gain * MGS/LGS
- HGS gain = MGS gain * (HGA/MGS +HGB/MGS)/2

Gains/Offsets Use Recent 1-year Data with a Linear-fit for L1B

S-NPP DNB F-factor and Offset Trending

STREELUTE STORE

S-NPP VIIRS DNB Mode:1 HAM A MODE 1 HAM A 755 2.8 OBC_dark (LGS) 750 (x10⁻⁶ 2.7 LGS_F 745 2.6 740 2.5 MODE 1 HAM A 500 1000 2000 2500 0 1000 1500 2000 S-NPP VIIRS DNB Mode:1 HAM A 500 2500 7.6 270 dark (MGS) 7.4 MGS_F (x10⁻⁹) 260 7.2 250 OBC 7.0 240 6.8 230 6.6 500 1000 MODE 1 HAM A 2000 2500 0 500 1500 0 1000 2000 2500 S-NPP VIIRS DNB Mode:1 HAM A 1.70 960 940 1.65 dark (HGA) HGS_F (x10⁻¹¹) 920 1.60 900 1.55 OBC 880 1.50 860 1.45 0 500 1000 1500 2000 2500 500 1000 1500 2000 2500 0 Days since launch Days since launch

S-NPP DNB Gain Ratio (H/M and M/L)











N20 VCST vs IDPS: F-factor and Gain Ratio





N20 VCST vs IDPS: Dark Offsets





DNB Stray-light Estimation and Predication



EV Signals Considered

- ▶ Use EV data from terminator crossing area during new moon.
- ► Separate EV samples into 127 bins of 32 pixels each (4064=127x32).

Stray Light Estimation

- Produce correction LUT for each hemisphere, detector, HAM, sample and SZA.
- Update correction LUT per month (every new moon)

Stray Light Predication

- Stray-light pattern follows yearly Earth-Sun spacecraft geometry cycle.
- ▶ <u>IDPS</u> uses the same month one-year-ago LUT.
- ▶ <u>VCST</u> uses all previous LUTs via a data fusion mechanism.









- **J1/N20 VIIRS DNB Image:** *at 07:44:57am, July 13, 2018*
- **S-NPP VIIRS DNB Image:** *at 06:56:35am, July 13, 2018*

N20 and S-NPP Straylight Radiance Level



- Northern hemisphere (NH) and southern hemisphere (SH) are plotted at the center sample index 2032 (*July 13, 2018, 6~7am*).
- N20 straylight radiance level is about 1/3 ~ 1/2 that of S-NPP.
- SH is more complex as both SD and EV straylight are involved.







- **DNB image before cryo-door open:** 06:11:33am 01/01/2018
- **DNB image after cryo-door open:** 06:36:52am, 01/05/2018
- Straylight obviously increased in two areas marked on the right image.



N20 Before and After Cryo-door-open



S-NPP DNB Straylight: Northern Hemisphere





Before Correction

After Correction

DNB image Northern hemisphere *at 22:16:11, September 9, 2018.*

N20 DNB Straylight: Northern Hemisphere







DNB image Northern hemisphere *at 07:44:57am, July 13, 2018.*

N20 DNB Straylight: Southern Hemisphere







DNB image Southern hemisphere *at 23:36:36pm, July 13, 2018.*





- S-NPP DNB on-orbit performance and trending have been presented.
 - RSB degradation behavior is normal. LGS gain/offset are in stable trending, and gain coefficients gradually increase over time.
 - 2. HGS gain coefficients have large fluctuations convolving gain ratios of H/M and M/L.
- N20 DNB early mission on-orbit performance has been illustrated.
 - **1**. LGS gain trending is stable comparing with the S-NPP early mission.
 - 2. LGS gain, dark-offset and MGS/LGS ratio are matched well with IDPS. However, HGS/MGS ratio has a relatively large difference.
- Stray-light correction results have been presented.
 - S-NPP results show the effectiveness of current algorithms.
 - 2. Further algorithm developments/enhancements are needed to deal with the edge straylight features in N20.