Capability Enhancements, Changes, and Limitations of Joint Polar Satellite System (JPSS) -1 Compared to Suomi-National Polar-orbiting Partnership (S-NPP)

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  - S-NPP vs JPSS-1
  - Instruments
  - Orbital Dynamics
- Enhancements, Changes, and Limitations
  - Spacecraft
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- J-1 KPP Readiness
  - ATMS, CrIS, VIIRS Imagery

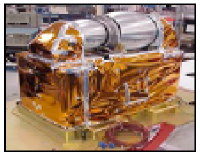
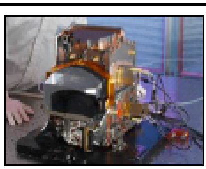
JPSS Program History

- The National Polar-orbiting Operational Environmental Satellite System (NPOESS) was an agreement between DoD, NOAA, and NASA to acquire a series of sun-synchronous, weather-monitoring satellites.
- In 2010, the NPOESS was dissolved. DoD and NOAA were directed to acquire their own satellite systems. DoD would be responsible for the morning orbit and NOAA would be responsible for the early afternoon orbit.
- The DoD program became known as the Defense Weather Satellite System (DWSS), a follow-on to the Defense Meteorological Satellite Program (DMSP). The DWSS was terminated in 2012.
- On the civilian side the Joint Polar Satellite System (JPSS) tasked NOAA and NASA to acquire a series of five satellites as a follow-on to NOAA's Polar Operational Environmental Satellites (POES).
- The first in the series is known as Suomi National Polar-orbiting Partnership (S-NPP). The rest are named JPSS-1, -2, -3, and -4.

S-NPP vs JPSS-1

- S-NPP is a risk-reduction inter-program mission that launched on October 28, 2011.
- It was designed to bridge the gap between POES and JPSS while testing new instrument technology. It has surpassed its design life of 5 years and continues to successfully produce scientific data.
- J-1 is currently slated to launch NET October 24, 2017.
- J-1 will provide critical, near-real time data inputs to National Weather Service (NWS) models, improve forecasting in the Alaskan region, and extend the 30+ year continuous history of climate data records collected by remote sensing satellite technology.

Instruments

JPSS Instrument		Measurement
	**ATMS** - Advanced Technology Microwave Sounder	ATMS and CrIS together provide profiles of atmospheric temperature, moisture, and pressure
	**CrIS** - Cross-track Infrared Sounder	
	**VIIRS** – Visible Infrared Imaging Radiometer Suite	Provides daily high-resolution imagery and radiometry across the visible to long wave infrared spectrum
	**OMPS** - Ozone Mapping and Profiler Suite	Spectrometer with UV bands for ozone total column measurements
	**CERES** – Clouds and the Earth's Radiant Energy System	Scanning radiometer which supports studies of Earth Radiation Budget

Orbital Dynamics

- S-NPP and JPSS-1 will share identical orbit dynamics separated by half an orbit (~50 minutes) during nominal operations.

Orbital Parameter	Value
Operational Altitude	828 km – 856 km
Mean SMA	7202.15 km
Eccentricity	0.0010 – 0.0013
Mean Inclination	98.72 km
Mean Argument of Perigee	90 degrees
Local Time of Ascending Node Crossing	13:30 +/- 10 min (13:25 +/- 1 min Operational)
Groundtrack Repeat Cycle	16 Days (227 revs per cycle)
Groundtrack Control Band	+/- 20 km
Period	6090 s or 101.5 min

Spacecraft

- Ka Band and Ground Station Contacts
- Data in the HRD Data Stream

NOAA JPSS Website, JPSS-1

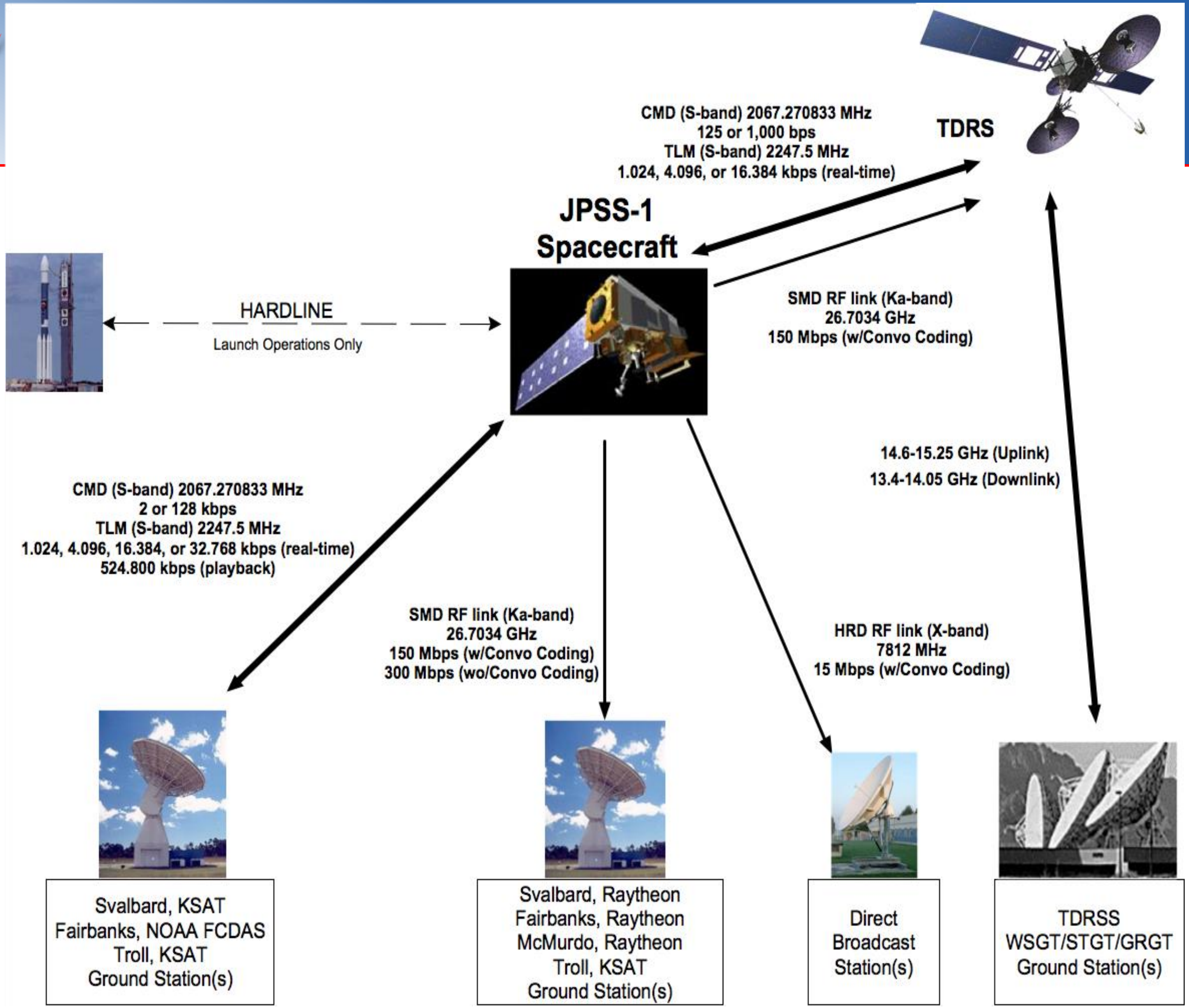
Ka Band & Ground Station Contacts

Ka Band Transmitter

- On S-NPP, S-Band is used to downlink Stored Mission Data (SMD) to Ground or TDRS.
- On J-1, SMD will be downlinked to the Ground or TDRS via a high data rate Ka band antenna at a rate of 150 or 300 Mbps. The Ka band has the ability to downlink an entire orbit of data in 4 minutes.

Ground Station Contacts

- S-NPP completes a SMD playback once per orbit at Svalbard.
- J-1 will complete a SMD playback twice per orbit. Once at Svalbard and once at McMurdo.
- SMD data can alternately be downlinked via TDRS.
- This will improve data latency for J-1 over S-NPP.



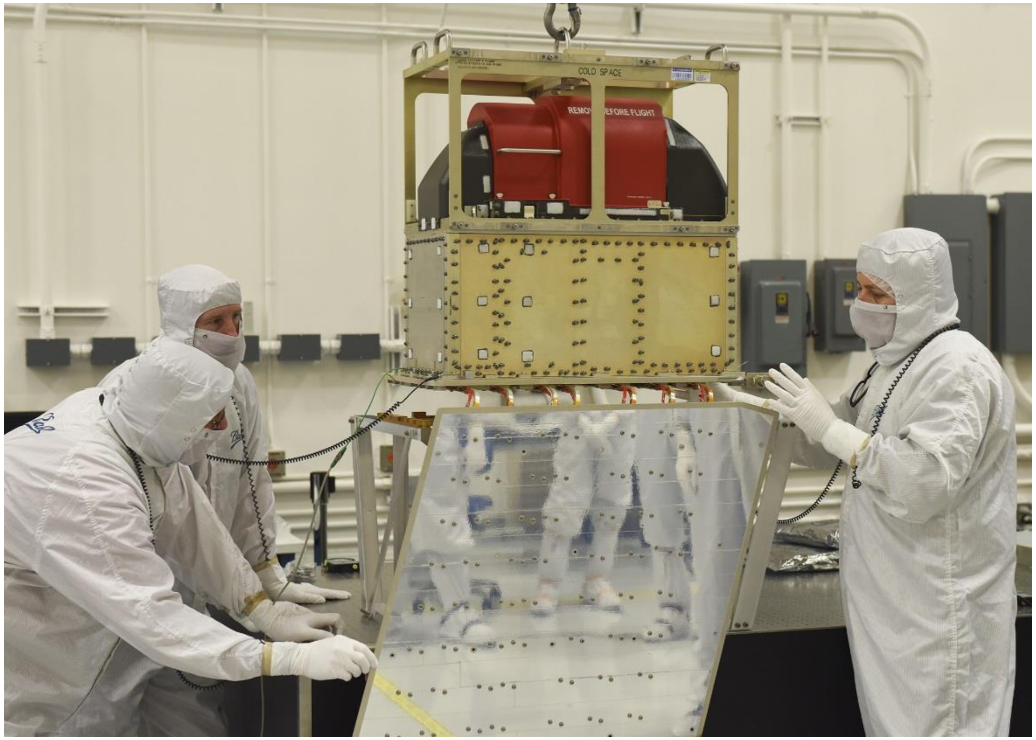
470-00020, Revision C, Joint Polar Satellite System (JPSS) Program, Code 470 Joint Polar Satellite System -1 (JPSS-1) Mission Concept of Operations

Data in the HRD Data Stream

- On S-NPP and J-1, High-Rate Data (HRD) is broadcast in real-time to the direct readout community via X-band at 7812 MHz.
- On S-NPP, SMD and HRD are coupled. If HRD exceeds 15 Mbps during downlink then SMD data may be permanently lost.
- To prevent this CrIS Full Spectral FOVs 4 and 6, VIIRS M7, OMPS Science Limb, and CERES Science are removed from the Daytime HRD data stream.
- On J-1, SMD and HRD are decoupled. If HRD exceeds 15 Mbps during downlink there will be no impact to SMD data.
- If a partial packet is discovered in the HRD data stream, then at most one CADU data zone will be deleted to re-establish data continuity.

ATMS

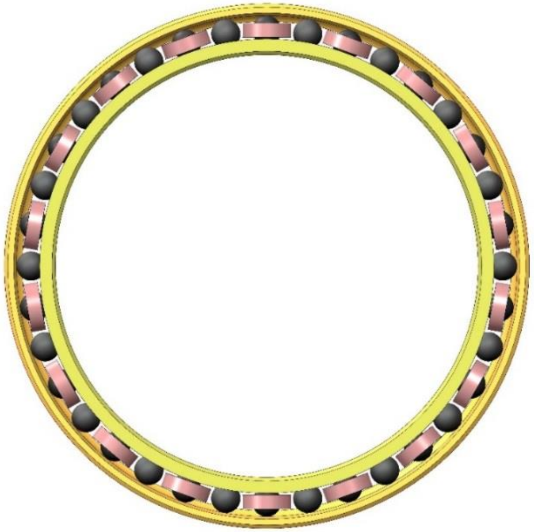
- Scan Drive Bearings
- G-Shelf SRFs
- Full Radiance Calibration



NOAA JPSS Website, ATMS

Scan Drive Bearings

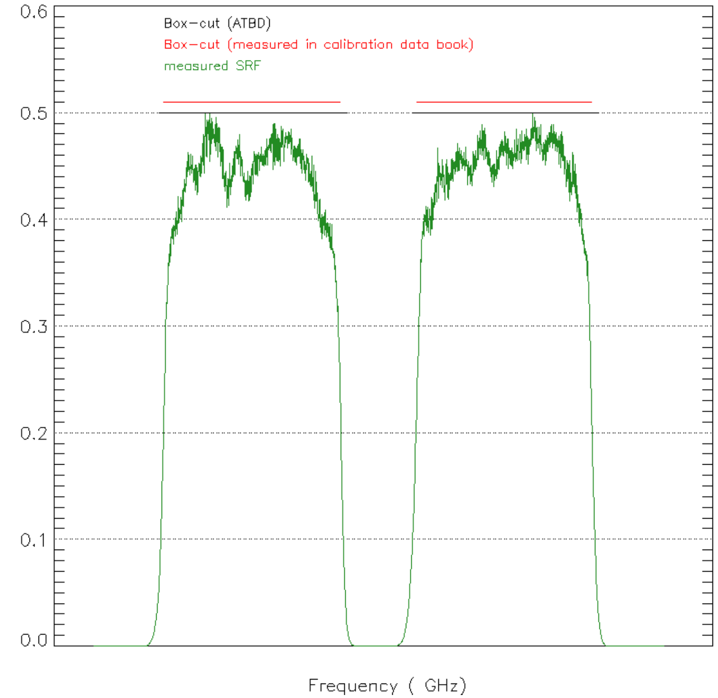
- The S-NPP ATMS scan drive bearing is made with Teflon toroid retainers. Every other bearing ball is enclosed in a toroid ring. When moving in one direction, the toroids tend to get pinned and wear patterns develop that make it difficult to re-orient the toroid.
  - To prevent undue wear and increase longevity, ATMS data collection is halted 2x per orbit in the polar regions to complete a series of scan reversals. This maneuver is thought to re-orient and re-lubricate the bearing balls.
- The J-1 ATMS scan drive bearing has a phenolic retainer. It is one solid piece impregnated with lubricant that surrounds each bearing ball.



S-NPP ATMS bearing (left). J-1 ATMS bearing (right).
John Cymerman, NASA ATMS Engineer.

G-Shelf SRFs

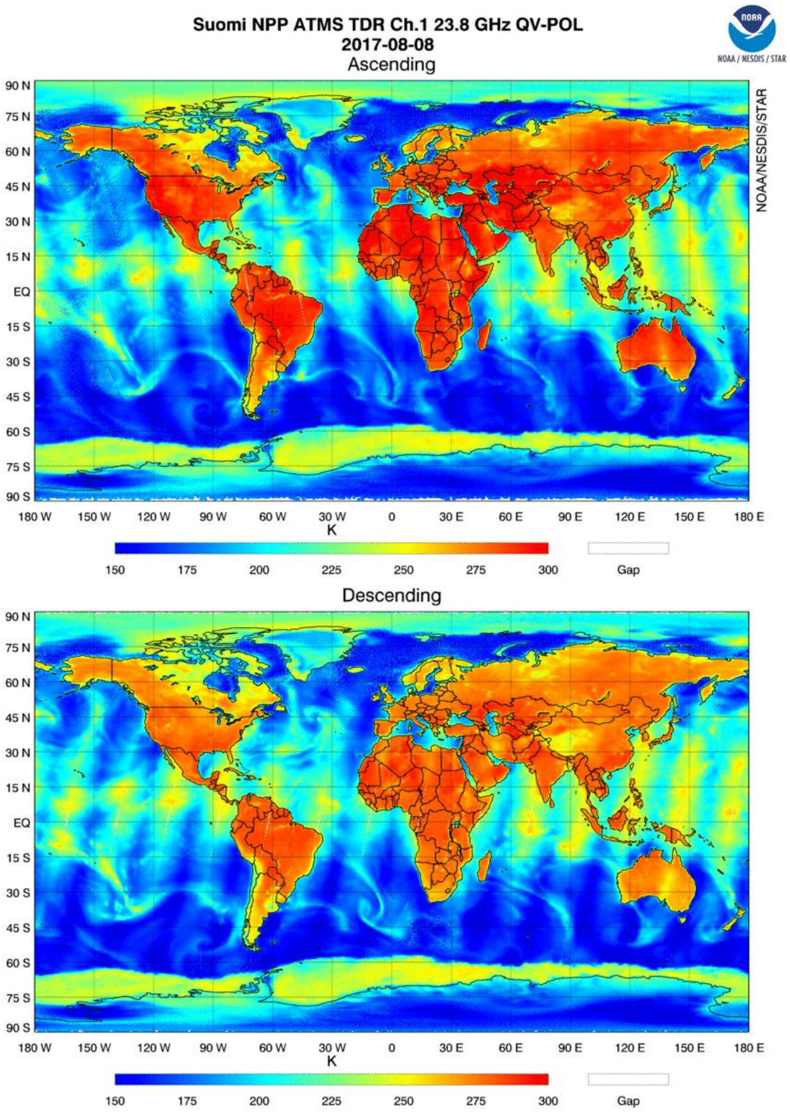
- The G-Shelf is comprised of Ch. 18-22, which are used for weather forecasting and atmospheric moisture profiles.
- For J-1, more stringent requirements were levied to improve G-Shelf scene response function (SRF) characterization.
- Following ATMS re-work in 2017 G-Shelf SRFs were not re-measured due to schedule constraints and the old SRFs were deemed invalid due to testing methodology.



Mark Liu, *Highlights of the Suomi NPP and JPSS-1 ATMS Calibration*

- To mitigate, the NOAA ATMS team will use the boxcar SRFs, bandwidths, and frequencies given in the ATBD as well as work with the STAR ICVS team, Community Radiative Transfer Model (CRTM) community, and NOAA/NCEP colleagues to verify and evaluate J1 ATMS performance. Improved SRFs may be developed after launch.

Full Radiance Calibration



- ATMS Full Radiance became operational on S-NPP with the transition to operations of Block 2.0 on March 8, 2017.
- ATMS Full Radiance will be the baseline at launch for J-1.
- Previously, ATMS was calibrated using a Rayleigh-Jeans (R-J) approximation, which is known to break down at higher frequencies and lower scene temperatures.
- Adopting a radiance-based algorithm also creates continuity between current and heritage sounder products.

NOAA STAR ICVS Website

CrIS

- Full Spectral Resolution

NOAA JPSS Website, CrIS

Full Spectral Resolution

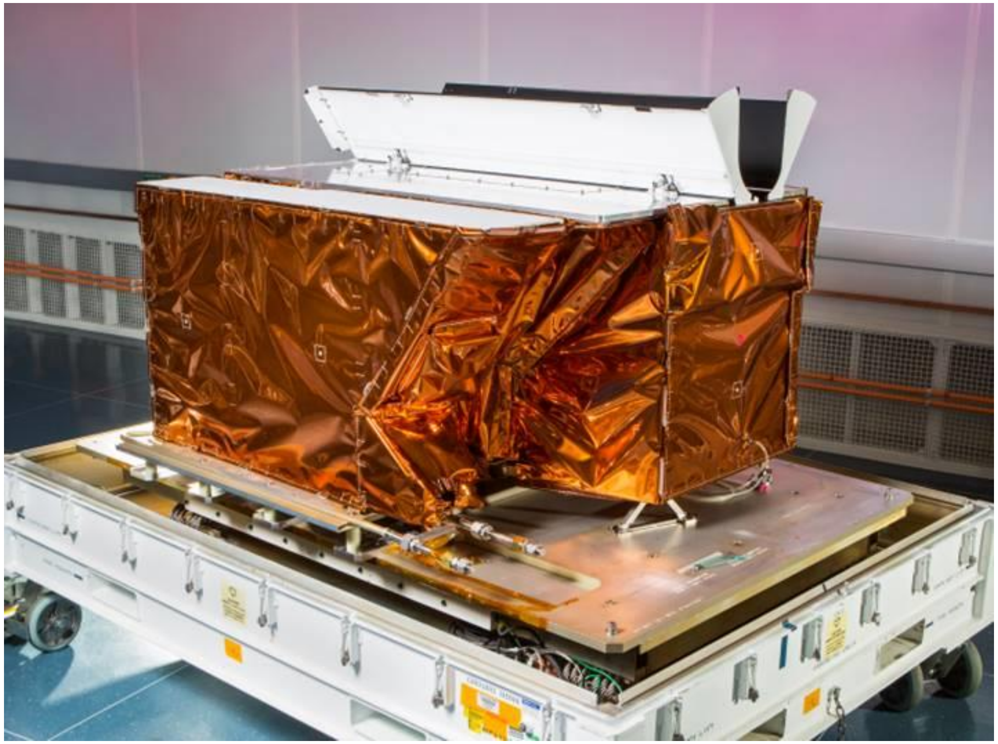
- Full Spectral Resolution (FSR) became operational on S-NPP with the transition to operations of Block 2.0 on March 8, 2017.
- FSR and Truncated Spectral Resolution (TSR) will continue to be produced on S-NPP.
- FSR is the baseline for J-1. Both TSR and FSR will be produced at launch of J-1, but only FSR will be distributed to the user community.

Frequency Band	Spectral Range (cm^{-1})	Number of Channels	Spectral Resolution (cm^{-1})
LWIR	650 to 1095	713 (713)	0.625 (0.625)
MWIR	1210 to 1750	865 (433)	0.625 (1.25)
SWIR	2155 to 2550	633 (159)	0.625 (2.5)

Arron Layns, *JPSS-1 ORR Section 8G: Algorithm Status and Readiness*

VIIRS

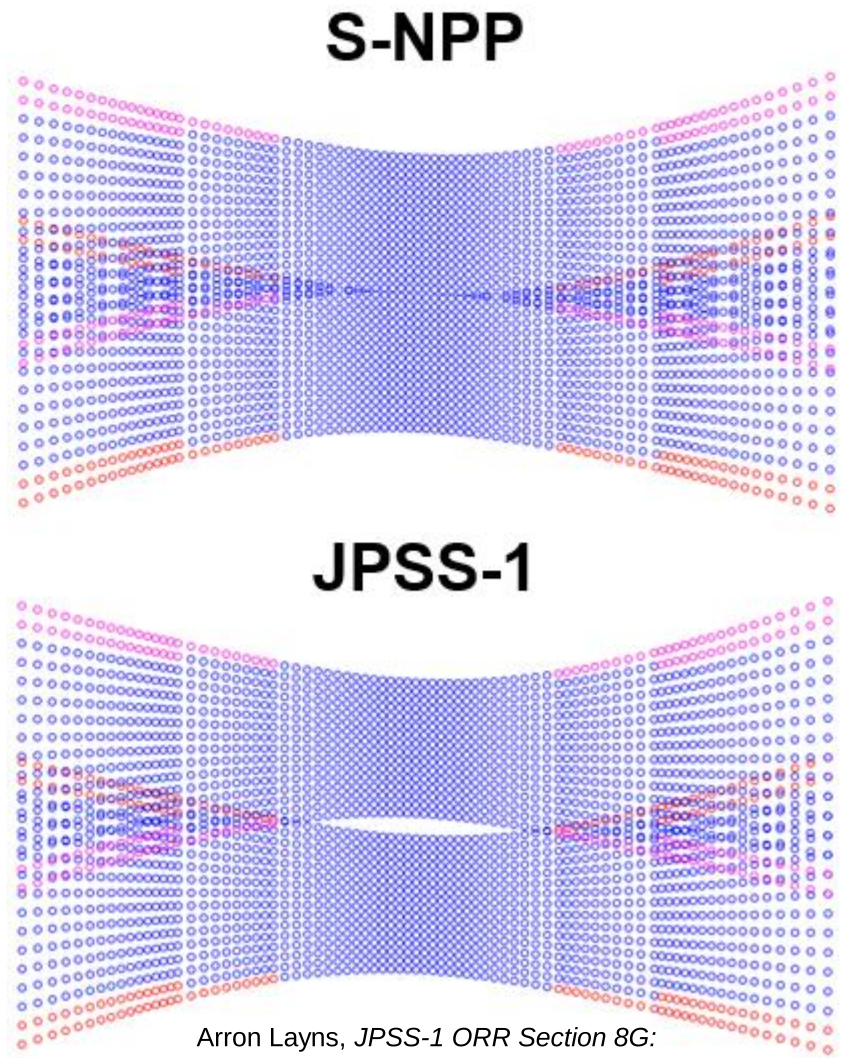
- Scan-to-Scan Underlap
- Scan Sync Loss
- DNB Stray Light
- DNB Aggregation
- Polarization
- M11 at Night



NOAA JPSS Website, VIIRS

Scan-to-Scan Underlap

- J-1 VIIRS will have a scan-to-scan underlap in the along-track direction.
- The Effective Focal Length (EFL) was shortened to improve band-to-band registration without accounting for Earth's rotation.
- V_PRD-11430, which states that underlap is allowed to be 5% of a pixel (19m for I-bands, 37m for M-bands), is not met.
- Underlap from 15 S – 50 N. Worst case of 90m at 15 N.
- Greatest impact to point source data collection (ie. human light sources, agricultural fires, volcanic activity).



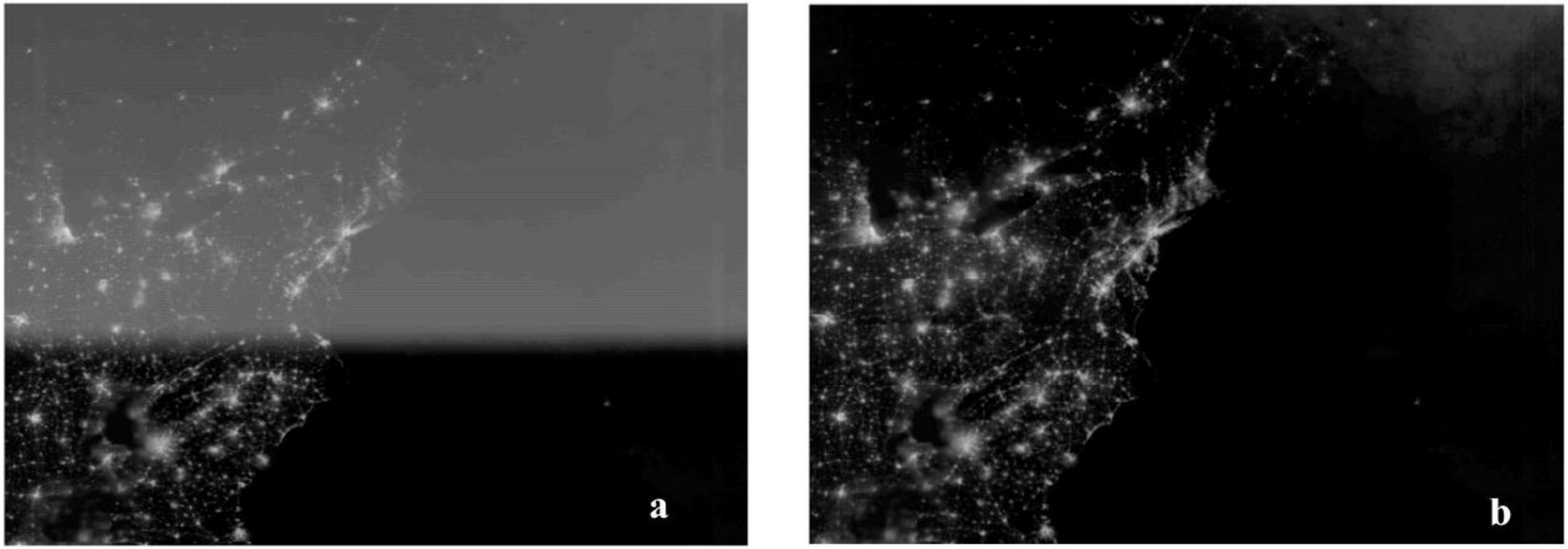
Arron Layns, *JPSS-1 ORR Section 8G: Algorithm Status and Readiness*

Scan Sync Loss

- S-NPP VIIRS has a Scan Sync Loss Susceptibility.
- There have been 80 scan sync losses that range from 12 to 100 seconds, with the majority being the longer variety.
- There were 4 events in 2011, 20 events in 2012, 11 events in 2013, 6 events in 2014, 11 events in 2015, 17 events in 2016, and 11 events so far in 2017.
- Probable root cause for the long events has been attributed to two inches of rotating telescope assembly (RTA) motor cable that are unshielded. Similarly, the short duration sync losses are attributed to a lack of shielding on a short section of the half angle mirror (HAM) motor cable.
- The vendor did a better job of shielding these cables in entirety on J-1 so we expect to not see any scan sync losses on J-1

DNB Stray Light

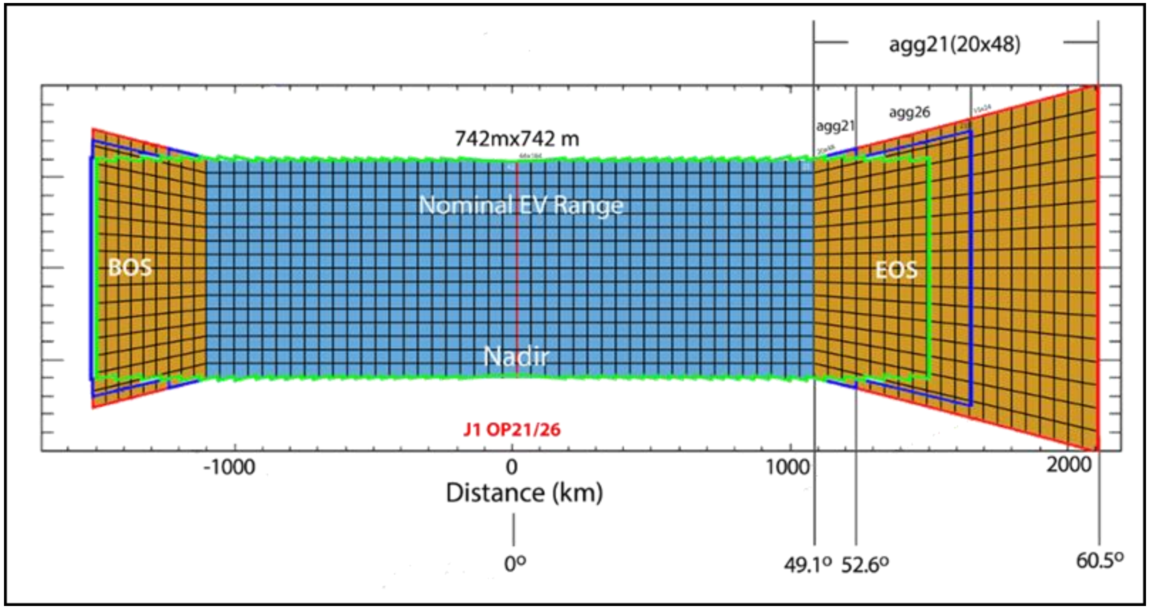
- On S-NPP, stray light appears in the DNB on the night side of the terminator before the satellite passes into eclipse.
- Stray light can be mitigated to a degree in the code, but current stray light modeling does not correlate well with on-orbit data.
- For J-1, the vendor tried to address stray light by incorporating additional testing and adding optical tape to eliminate potential light sneak paths.



East Coast: 7/8/12, Steve Mills, *Suomi NPP VIIRS DNB Stray Light Characterization and Correction Using Calibration View Data*

DNB Aggregation

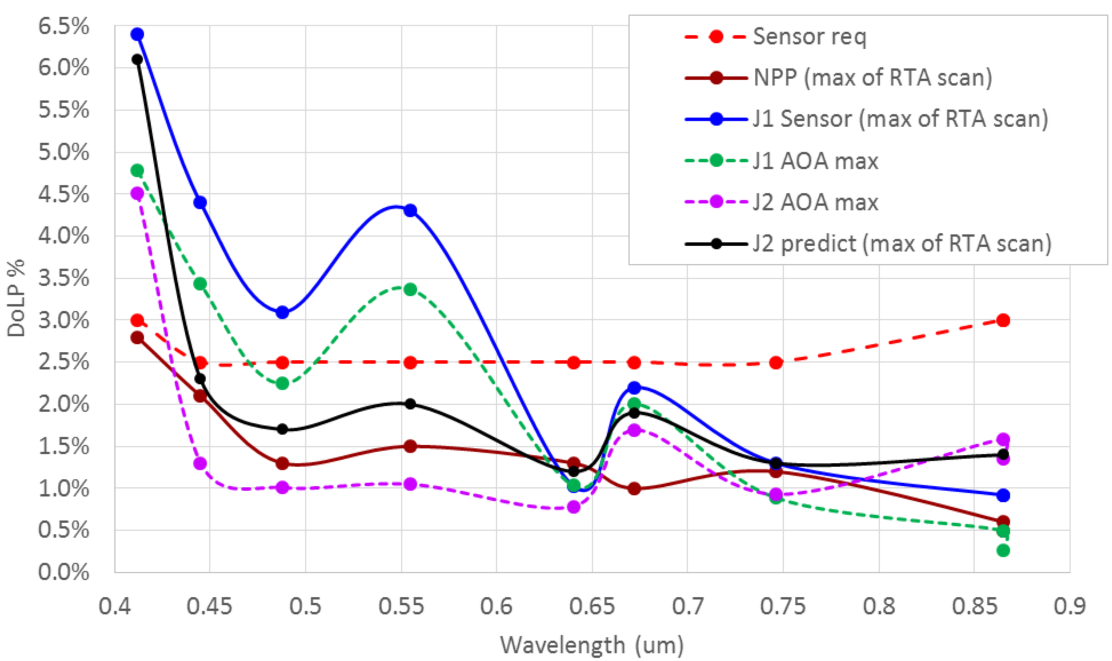
- J-1 VIIRS DNB nonlinearity is worse at higher aggregations than S-NPP. Aggregation maintains spatial resolution across the entire scan. There are a total of 32 aggregations for VIIRS DNB to maintain this resolution [green].
- Agg Mode 21/26 [blue] and 21 [red] are possible mitigation approaches.
- Agg Mode 21 is the baseline for J-1. Every aggregation above 21 will stay at 21. This will sacrifice spatial resolution for decreased nonlinearity.



Arron Layns, *JPSS-1 ORR Section 8G: Algorithm Status and Readiness*

Polarization

- S-NPP met spec in all bands. J-1 required a waiver for M1 – M4:
  - M1: 6.4% (spec of 3%), M2: 4.4% (spec of 2.5%), M3: 3.1% (spec of 2.5%), M4: 4.3% (spec of 2.5%)
- Polarization is due to a Vis/ NIR filter coating change.
- Increased polarization results in polarization error and band stripping in the Sensor Data Record (SDR) products.



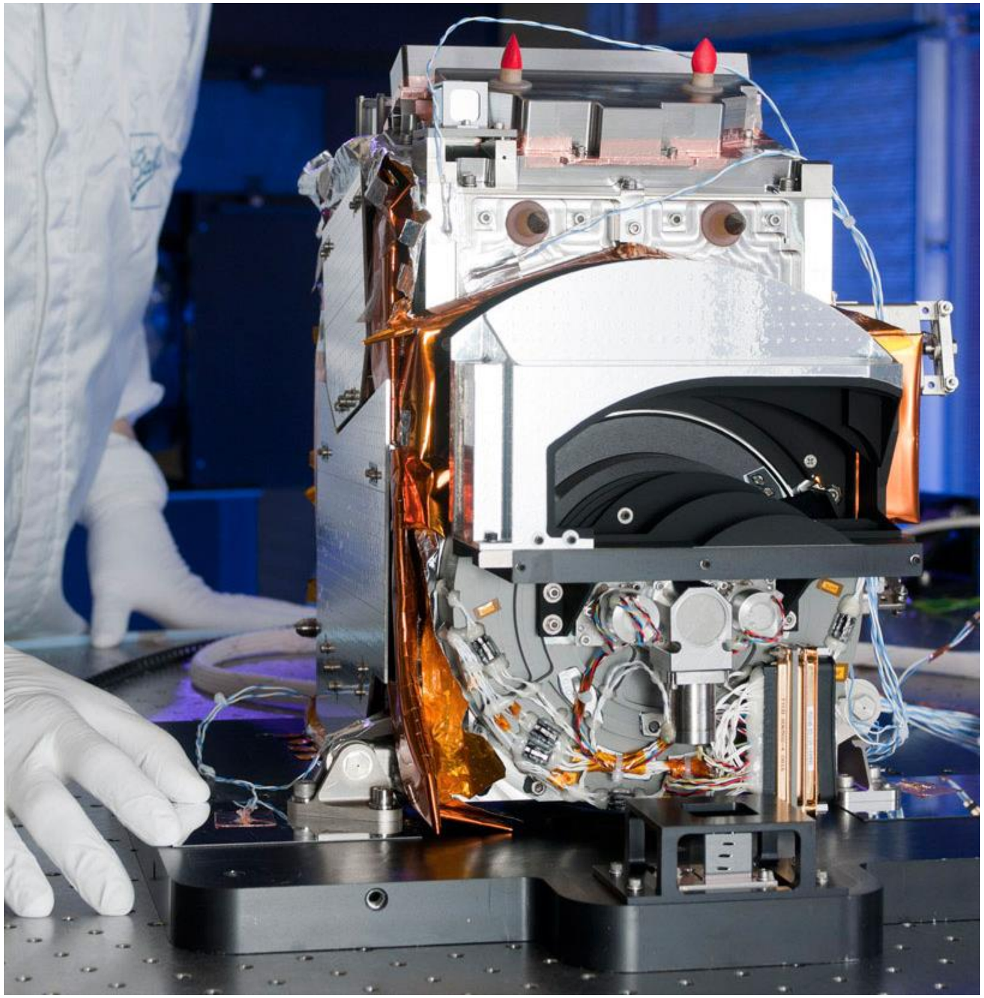
Raytheon, *EFR3599 J2 Polarization Sensitivity Non-Compliance Type I*

VIIRS M11 at Night

- The VIIRS Nightfire algorithm uses a multispectral Plank curve fitting to detect combustion sources. The spectral bands used are the DNB, M7, M8, M10, and M12-M16.
- Currently, 40% of all fire detections result in a failed Plank curve fitting due to insufficient spectral sampling. Additionally, high energy particle strikes in the SAA and auroral zones cause false detections.
- Adding M11 helps address these deficiencies.
- M11 at Night will go operational on S-NPP on August 24, 2017.
- M11 at Night will be the baseline on J-1 at launch.

OMPS

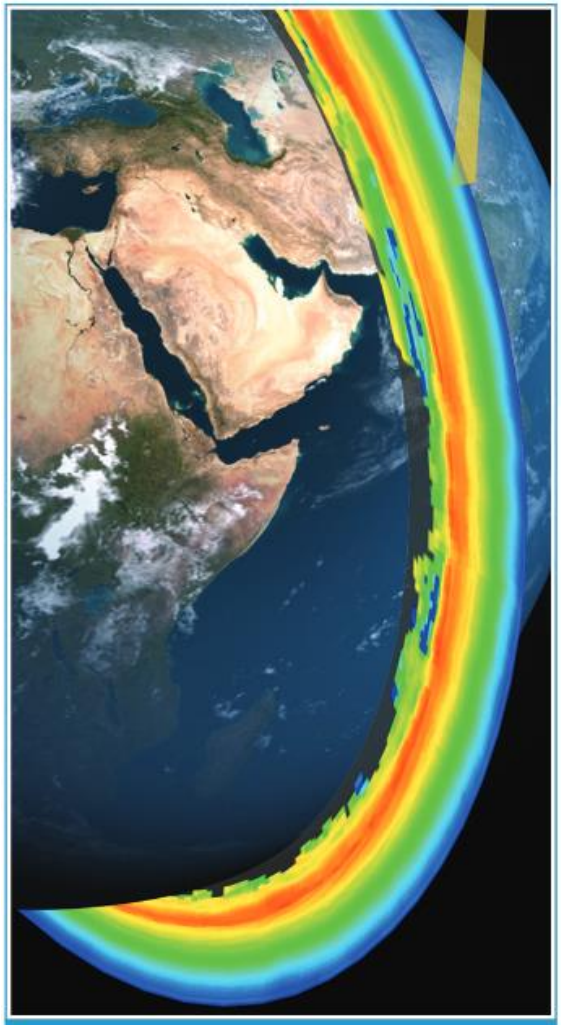
- Limb Instrument
- TC/NP Resolution



NOAA JPSS Website, OMPS

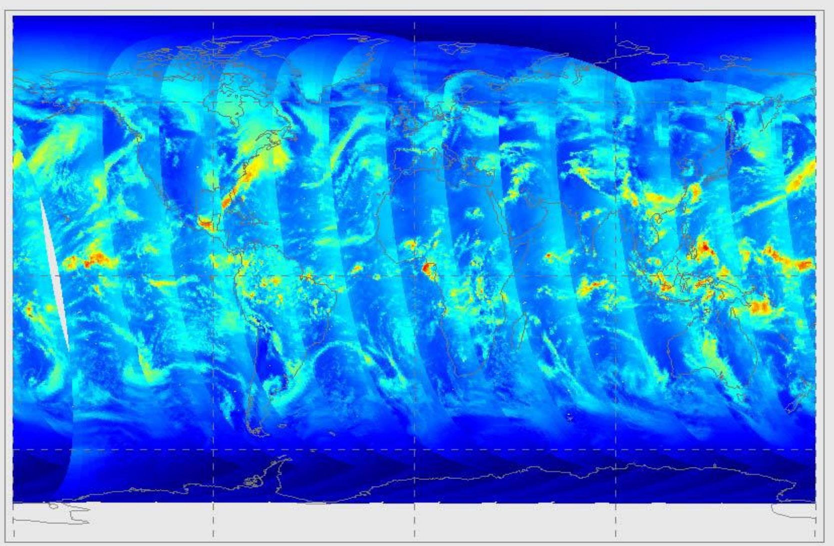
Limb Instrument

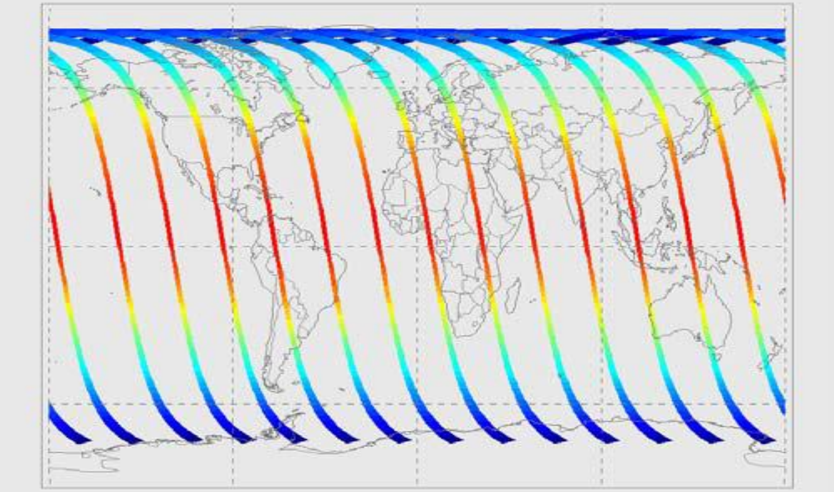
- S-NPP OMPS is comprised of three instruments: the Nadir Mapper, Nadir Profiler, and Limb Profiler.
- The Nadir Mapper provides daily global coverage of total column ozone, which is useful for monitoring spatial ozone distribution, especially with relation to the Antarctic ozone hole.
- The Nadir Profiler monitors the long-term health of ozone in the upper stratosphere.
- The Limb Profiler monitors changes to ozone in the lower stratosphere and upper troposphere, which is more complex due to variations induced by climate change.
- J-1 OMPS does not feature a Limb Profiler, but it will return for J-2.



NASA/NOAA, Cross-section of ozone thickness taken from S-NPP OMPS

Total Column/Nadir Profiler Resolution


J01 OMPS TC Radiance mW m^{-2} nm^{-1} sr^{-1} 2017/08/06 at 331.6nm


J01 OMPS NP Radiance mW m^{-2} nm^{-1} sr^{-1} 2017/08/06 at 282.9nm

- Current resolution on S-NPP OMPS Nadir Mapper (TC) and NP:
  - S-NPP TC: 50 x 50 km (Low Res, 35 cells x 5 scans)
  - S-NPP NP: 250 x 250 km (Low Res, 1 cell x 1 scan)
- Baseline resolution on J-1 OMPS Nadir Mapper (TC) and NP:
  - J-1 TC: 50 x 50 km (Low Res, 35 cells x 5 scans)
  - J-1 NP: 50 x 50 km (Medium Res, 5 cells x 5 scans)
- Possible Improvements:
  - Higher resolution for S-NPP TC post J-1 launch
  - J-1 TC: 50 x 17 km (Medium Res, 35 cells x 15 scans)

Ding Liang, *Integrated Cal/Val System (ICVS) for OMPS*

J-1 KPP Readiness

- Agreement for Key Performance Parameters (KPPs) to reach Provisional Maturity by L+90:
  - ATMS SDRs, CrIS SDRs, and VIIRS Imagery EDRs (>60°N, Alaska Region)
- Cal/Val plans are developed and ready for implementation
- Given no anomalies and instrument performance similar to S-NPP, we expect all J-1 SDRs in addition to the KPPs and VIIRS Imagery EDRs to reach or be close to Provisional Maturity by L+90.
- ATMS SDRs: No table or algorithm updates expected.
- CrIS SDRs: No table or algorithm updates expected on the Ground.
- VIIRS Imagery EDRs:
  - Initial imagery band verification will be completed elsewhere as a proxy for Alaska, which will be in total darkness through L+90.
  - DNB stray light annual variation is characterized in monthly table updates. It will take approximately 1 year to create and update these tables for J-1. Users should ignore the impact of stray light on DNB acceptability at L+90.