NPP/VIIRS: Status and Expected Science Capability

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Project Science Office

Contributions from:

Government VIIRS Data Analysis Working Group

NASA, NOAA/IPO, Aerospace, MIT/Lincoln, Wisconsin

37 members, 20 NASA, 13 Aerospace, 4 MIT LL

(29 East Coast, 6 West Coast, 2 Wisconsin)

NPP Science Team White Papers

Land: M.O Roman & C. Justice; Editors

Ocean: Kevin Turpie; Editor

Atmospheres/Clouds: Bryan Baum; Editor

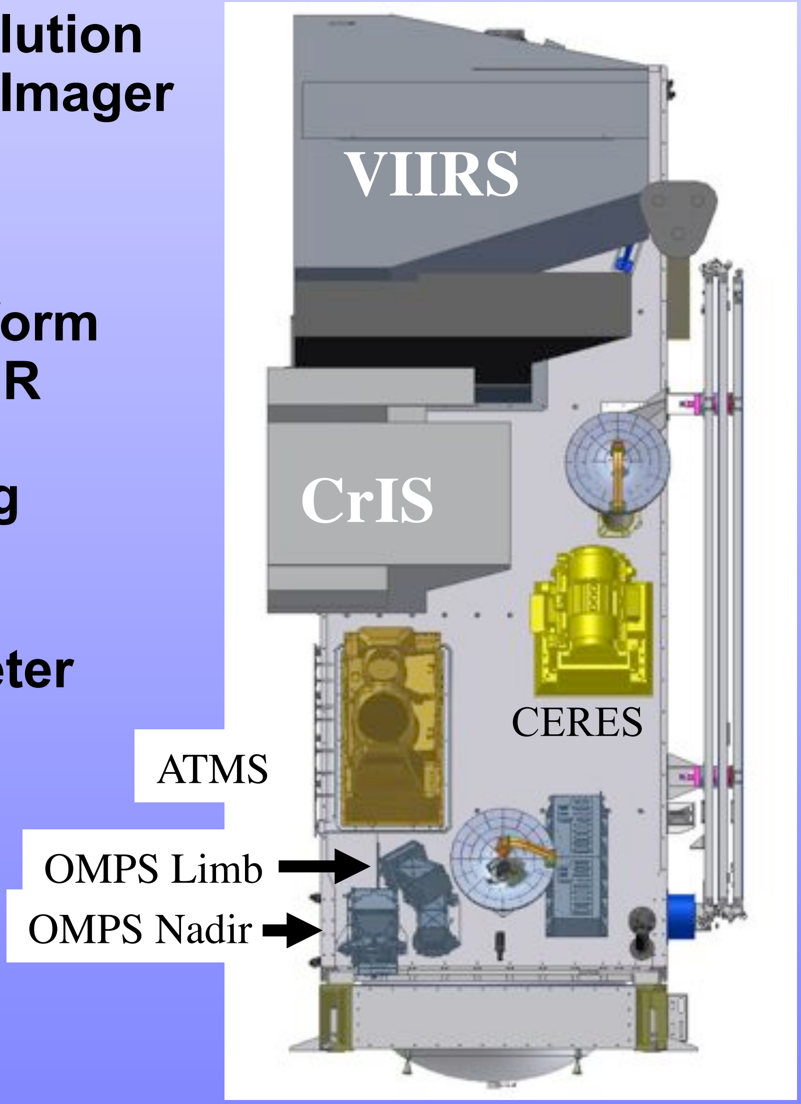
NPP Status: What instruments are on NPP?

VIIRS – Medium resolution Visible& Infra-red Imager

CrIS – Fourier Transform Spectrometer for IR Temperature and Moisture sounding

ATMS – Microwave sounding radiometer

OMPS – Total Ozone Mapping and Ozone Profile measurements



CERES Earth Radiation Budget measurements

Initial concept	**2/07**
Confirmed	**2/08**
On spacecraft	**11/08**

CERES Flight Model 5

CERES scanning radiometer measuring three spectral bands at TOA
- Total (0.3 to >50 μm)
- Shortwave (0.3 to 5.0 μm)
- Longwave Bandpass (8 to 12 μm)

Operations, Data Processing, Products, and Science are a continuation of experience developed on
- TRMM (1), EOS Terra (2), EOS Aqua (2)

Current Status: On NPP

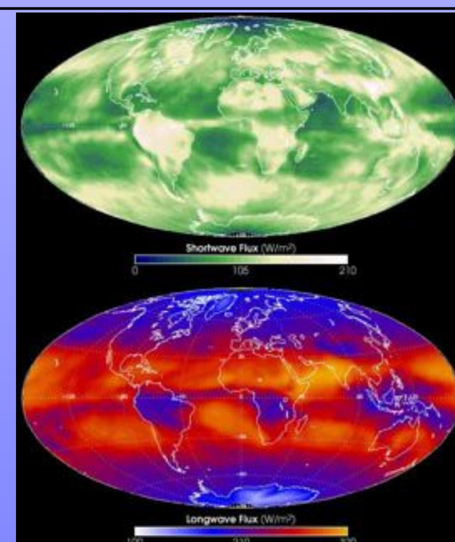
Margins

CERES	Spec	CBE
Mass - kg	50	50
Power (Avg.) - W	50	50
Power (Max) - W	75	75
Data Rate (Avg.) - Kbps	10	10
Data Rate (Max) - Kbps	10	10

Primary CERES Climate Data Records

Reflected Solar Energy

Emitted Thermal Energy



Temperature & Water Vapor Profiles

Advanced Technology Microwave Sounder

- Scanning passive microwave radiometer
- Combines 3 instruments
  - AMSU A1 / A2, MHS
- (22 channels (23GHz - 183GHz)

Status

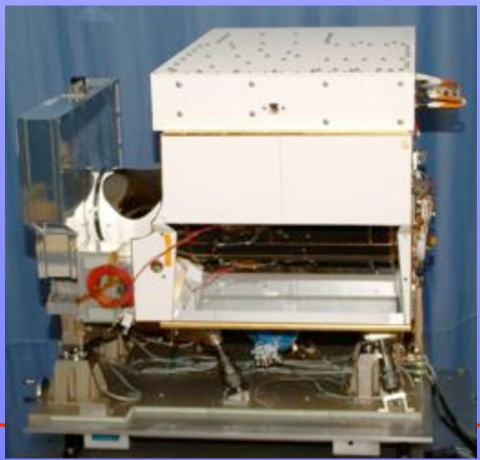
- Flight Model on Spacecraft

Cross-Track Infrared Sounder

- Michelson Interferometer
  3 bands (3.5 µm - 16 µm)

Status

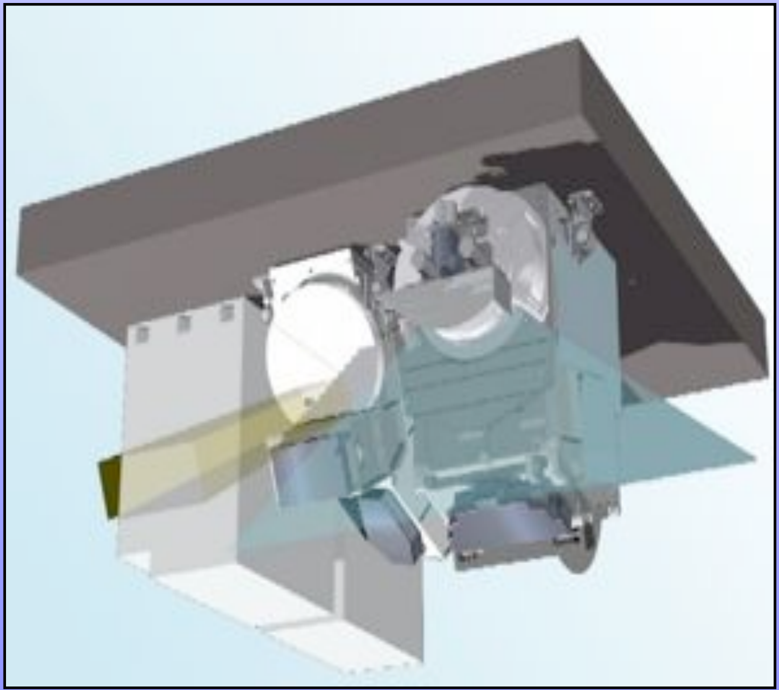
- Flight Unit #1 has finished calibration.
- Electronics Boards Re-built
- Re-Qualifying T/V: Spring 2010
- Ship to NPP: June 2010



Ozone Mapping Profiler Suite

Description

- **Purpose:** Monitors the total column and vertical profile of ozone
- **Predecessor Instruments:** TOMS, SBUV, GOME, OSIRIS, SCIAMACHY
- **Approach:** Nadir and limb push broom CCD spectrometers
- **Swath width:** 2600 km



Status

- **Limb re-manifested**
- **Nadir and Limb has completed TV testing and calibration**
- **Integrated Instrument on spacecraft**

Products: Total ozone maps and SBUV2-like ozone profiles

Higher resolution ozone profiles from Limb instrument

Visible Infrared Imaging Radiometer Suite

Description

- Purpose: Global observations of land, ocean, & atmosphere parameters at high temporal resolution (~ daily)
- Predecessor Instruments: AVHRR, OLS, MODIS, SeaWiFS
- Approach: Multi-spectral scanning radiometer (22 bands between 0.4 µm and 12 µm) 12-bit quantization
- Swath width: 3000 km

Status

- Flight Unit #1 Completed Ambient , Vibration, EMI/EMC and Thermal Vacuum characterization, calibration and shipping!
- VIIRS at Ball
- Integration Review finishes Today
- VIIRS Testing on Spacecraft: Gain, Relative Spectral Response, End-to-End (NIST)

VIIRS in Clean Room with NPP

VIIRS F1 Sensor Gov't Activities

- VIIRS F1 testing program is complete and has provided test data to support 141 performance requirements
  - Based on Cold performance plateau, Program decided to use side B electronics as Primary. However, both A and B sides exhibit largely similar performance.
- NASA team has completed extensive analysis of VIIRS test data
  - Support to test planning and
  - Support of sensor test data analysis, and requirement verification
    - Release more than 130 reports and memos just for TV phase
  - Support to EFR resolution and EDR impact analysis for use-as-is decisions
  - Support to Waiver evaluation, including SDR/EDR impact assessment
- All performance waivers have been evaluated by NGST and reviewed by NASA team
  - Most waivers have small to negligible EDR performance impacts
  - Some waivers indicate need for algorithm revisions and/or changes to Cal/Val
    - Optical crosstalk and OOB is a significant performance impact to Ocean Color & Aerosol, NG is working a mitigation plan for on-orbit EDR algorithms

VIIRS F1 Reflective Bands: Radiometric Performance

Meets all Requirements for:

Signal to Noise Ratio, Dynamic Range, Linearity, Uncertainty, Stability and Polarization

Minor Variances for:

Gain Transition: Gain transition points are well characterized (VIIRS has dual gain bands)

Uniformity: Potential for striping, Plan for post-launch fix if needed

VIIRS F1 Emissive Bands: Radiometric Performance

Meets all Requirements for:

NEdT, Dynamic Range, Gain Transition,
Linearity, Uniformity,
Absolute Radiometric Difference, and Stability

VIIRS F1 Spectral Performance

Meets all Requirements for:

Spectral Band Center, Spectral Bandwidth, Extended Bandwidth

Significant Non-Compliance for: Integrated Out-of-Band Response

Band	Center Wavelength (nm)	Bandwidth (nm)	Requirement Maximum Integrated OOB Response (%)	Measured Maximum Integrated OOB Response (%)
M1	412	20	1.0	3.7
M3	488	20	0.7	1.1
M4	555	20	0.7	4.3
M5	672	20	0.7	3.2
M6	746	15	0.8	1.8

Notes: Smaller non-compliances for emissive bands
Well characterized
Difficult to separate from Cross-talk effects
Gov’t EDR analysis ongoing

VIIRS F1 Spectral Performance

Significant Non-Compliance for: Band-to-Band Crosstalk

Three types of Crosstalk;

Dynamic Electrical Crosstalk: Caused by High Contrast Scenes.

- **Focal plane fix reduced this for FM1**

Static Electrical Crosstalk: feature of ROICs

- **VIIRS non-compliant with requirements**
- **VIIRS requirements are much stricter than MODIS**
- **Well characterized, EDR Assessment ongoing**

Optical Crosstalk

VIIRS F1 Spectral Performance

Significant Non-Compliance for: Band-to-Band Crosstalk

Optical Crosstalk
The VIIRS Integrated Filter Assembly (IFA), as built, scatters light across the focal plane detector.
This optical scattering is caused by defects in the multi-layer deposition manufacturing process. It is expected that this will be fixed for FM2.

This effect is referred to as optical crosstalk; light from one band in one pixel is measured in another pixel. Test data was taken to quantify the amount of optical crosstalk.

The data products that are affected are Ocean Color and Aerosol Optical Depth. The quantitative analysis of the optical cross talk is expected to be reported in early February 2010.

NGAS has proposed a correction method. Their methodology is still undergoing government peer-review.

VIIRS F1 Spatial Performance

Meets Requirements for or only minor non-compliances:

- **Line Spread Function:**
  - **Scan and Track DFOV**
  - **Scan and Track MTF**
  - **Scan and Track HSR**
- **Band-to-Band Registration**

Pixel growth to “1.5 km x 1.5 km” at to the edge of scan

Summary

- VIIRS F1 test program is complete and has provided good test data to assess sensor performance.
- Effort by both Government and Contractor is still ongoing to finalize VIIRS F1 Performance Assessments, and to generate on-orbit LUTs for SDR algorithm
- NASA team presentations and posters will provide detailed performance assessments, issues and recommendations for performance parameters.

VIIRS EDR Performance: IPO Requirements

- For most of the EDRs which are not dependent on precise multi-wavelength radiometric calibration (all the EDRs except Ocean Color and Aerosol Optical Depth), the VIIRS instrument performance is expected to be pretty good.
- The VIIRS EDRs will meet their operational performance requirements, with the exception of Ocean Color (and possibly AOD)

VIIRS EDR Performance:
NASA Science Requirements

Given satisfactory VIIRS performance;

- **EOS data continuity requires algorithm continuity**
- **Similar physics is needed to reduce systematic errors**
- **Not all current VIIR EDRS use current MODIS algorithms**

Need to adapt where instruments differ,

- **MODIS and VIIRS do not have all the same bands**
- **Band Aggregation is a challenge**

VIIRS EDR Performance: NASA Science Requirements

Atmospheres: Cloud Properties

See Bryan Baum in Atmosphere Breakout

Significant Instrumental differences;

MODIS has CO_2 and H_2O bands

Cloud Mask; Good collaboration

Other Cloud Properties: cloud top height/temperature/pressure, optical thickness, and effective particle size

Major algorithmic differences; no CO_2 slicing bands for cloud height

Minor differences in assumptions for phase function, spectral albedo, ice cloud scattering, max cloud optical thickness

Significant Work needed for EOS Continuity

VIIRS EDR Performance:
NASA Science Requirements

Atmospheres; Aerosols:

Current IDPS uses MODIS Collection 5

Current version does not have Deep Blue AOT retrieval over bright land surfaces

High priority candidate for IDPS update

VIIRS EDR Performance: NASA Science Requirements

Ocean Color: NPP will be a challenge due to spectral cross-talk and may be improved for NPOESS C1 & C2.

Current IDPS Algorithm lacks many features of current NASA Algorithms

Calibration Maneuvers need to be finalized

Sea Surface Temperature: Good VIIRS performance. Uses Similar algorithm as EOS (from Miami)

VIIRS EDR Performance: NASA Science Requirements

Land:

IDPS products should meet operational needs

Land Surface Reflectance, Surface Albedo, and Vegetation Index have significant algorithmic differences with current EOS products

Active Fires products are a special case due to instrumental differences. Research product being developed for MODIS continuity

NASA's NPP Science Role

- **Climate data record (CDR): "a time series of measurements of sufficient length, consistency, and continuity to determine climate variability and change." (NRC: CDRs from Env. Sat. 2004)**
  - **"CDR" Definition of Consistent:**
    - **all temporal sensor artifacts removed**
    - **no obvious interannual discontinuities unattributable to natural variability**
    - **all known mission-dependent biases removed or quantified**
    - **similar data quality and structure**
- **The NPP Science Charter is to:** ***Continue the scientific data record started in the "EOS era."***
- **NICST/E Group to remove "all temporal sensor artifacts"**
- **NPP Science Team to "quantify and remove all known mission-dependent biases" removed or quantified and to provide similar data quality and structure"**
- **Reprocessing will be required to produce Consistent, Integrated EOS/NPP/ NPOESS Satellite data records.**

Questions?

Current Launch Date: September 2011

LRD: No earlier than 15.5 months after delivery of last instrument

View of NPP from Back of Spacecraft

Photo Courtesy of Ball Aerospace

Other VIIRS F1 TV Issues and Concerns

Issue	Description	Results and Impact
Spikes	Large sample spikes in the sensor signal observed for few bands during operational mode, only on A-side (Redundant) Electronics	NG is preparing mitigation plans to correct for the bit flip leading to spikes, and to Implement alternative geolocation algorithm (potential loss of RTA/HAM encoder timestamps).
Vignetting	Observed at FU1 TV Cold functional plateau, but goes away when sensor temperature warms up closer to TV Cold performance. Vignetting was not noticeable at any Performance plateau (Cold, Nominal, Hot).	Program has provided STOP model #6 that includes vignetting compoent. Need to verify that the model is validated, and can be used on orbit for any anomaly simulation and mitigation/correction approach.
VisNIR crosstalk / OOB	Spectral measurment using SpMA and spetial measurements using SpMA and Polarizer sheets are showing large optical OOB in some bands and optical crosstalk/leaks between bands.	Crosstalk coefficient maps are being used to assess impact on SDRs and EDRs. Uncertainty assessment still to be finalized, including contributions from the SpMa stability and characterization, the allignment, NFR, and electronics.
Gain bit crosstalk effect	Some bands calibration results are showing dependency on other bands gain status (High Gain vs Low Gain).	Need to consider this term in the final calibration error budget and impact assessments.
M1 and M11 tail and side lobe artifacts	LSF measurements have revealed side lobe features for M11 and M1. M11 side lobe might be attributed to field stop reflections, and M1 side lobe might be contributed to optical crosstalk.	Need further modeling, to determine impact since on orbit illumination will have broad spectrum. It is not known how this side lobe is going to be varying on orbit (Ghosting shift if coming from mechanical part).
Gain transition noise	Increase of radiance non linearity and noise for dual gain bands at approximately 10% below Lmax.	Analysis done only with ambient phase testing and have shown low impact on some EDRs. Need further assessments based on TV testing.
End-to-End Testing	VIIRS on-board RSB calibration (e.g. SD, SDSM) is not tested yet.	Preparations to get this testing implemented at the Spacecraft Level at Ball are ongoing, using laser sources.

Table # 17/18: Emissive Bands Radiometric Calibration Accuracy Requirements

		Scene Temperature				
Band	λ_c (μm)	190K	230K	270K	310K	340K
M12	3.7	N.A.	7.0%	0.7%	0.7%	0.7%
M13	4.05	N.A.	5.7%	0.7%	0.7%	0.7%
M14	8.55	12.3%	2.4%	0.6%	0.4%	0.5%
M15	10.763	2.1%	0.6%	0.4%	0.4%	0.4%
M16	12.013	1.6%	0.6%	0.4%	0.4%	0.4%

Band	Center Wavelength (nm)	Calibration Uncertainty
I4	3740	5.0%
I5	11450	2.5%

Equivalent or Better Performance Was Achieved on MODIS

TABLE 5. VIIRS Spectral band optical requirements

Band	Center Wavelength (nm)	Tolerance on Center Wavelength (± nm)	Bandwidth (nm)	Tolerance on Bandwidth (± nm)	OOB Integration Limits (lower, upper) (nm)	Maximum Integrated OOB Response (%)	Character-ization Uncertainty (nm)
M1	412	2	20	2	≥376, ≤444	1.0	1
M2	445	3	18	2	≥417, ≤473	1.0	1
M3	488	4	20	3	≥455, ≤521	0.7	1
M4	555	4	20	3	≥523, ≤589	0.7	1
M5	672	5	20	3	≥638,≤706	0.7	1
M6	746	2	15	2	≥721, ≤771	0.8	1
M7	865	8	39	5	≥801, ≤929	0.7	1.3
M8	1240	5	20	4	≥1205, ≤1275	0.8	1
M9	1378	4	15	3	≥1351, ≤1405	1.0	1
M10	1610	14	60	9	≥1509, ≤1709	0.7	2.3
M11	2250	13	50	6	≥2167, ≤2333	1.0	1.9
M12	3700	32	180	20	≥3410, ≤3990	1.1	3.7
M13	4050	34	155	20	≥3790, ≤4310	1.3	3
M14	8550	70	300	40	≥8050, ≤9050	0.9	11
M15	10763	113	1000	100	≥9700, ≤11740	0.4	10.8
M16	12013	88	950	50	≥11060, ≤13050	0.4	6
DNB	700	14	400	20	≥470, ≤960	0.1	1
I1	640	6	80	6	≥565, ≤715	0.5	1
I2	865	8	39	5	≥802, ≤928	0.7	1.3
I3	1610	14	60	9	≥1509, ≤1709	0.7	2.3
I4	3740	40	380	30	≥3340, ≤4140	0.5	3.7
I5	11450	125	1900	100	≥9900, ≤12900	0.4	20

[1] The values given under "OOB Integration Limits" are the specified limits on the 1% relative response points.
[2] The OOB integration limits will be the 1% response points determined during sensor characterization.

TABLE 12. Dynamic range requirements for VIIRS Sensor reflective bands

			Single Gain		Dual Gain			
					High Gain		Low Gain	
Band	Center Wavelength (nm)	Gain Type	Lmin	Lmax	Lmin	Lmax	Lmin	Lmax
M1	412	Dual	-	-	30	135	135	615
M2	445	Dual	-	-	26	127	127	687
M3	488	Dual	-	-	22	107	107	702
M4	555	Dual	-	-	12	78	78	667
M5	672	Dual	-	-	8.6	59	59	651
M6	746	Single	5.3	41.0	-	-	-	-
M7	865	Dual	-	-	3.4	29	29	349
M8	1240	Single	3.5	164.9	-	-	-	-
M9	1378	Single	0.6	77.1	-	-	-	-
M10	1610	Single	1.2	71.2	-	-	-	-
M11	2250	Single	0.12	31.8	-	-	-	-
I1	640	Single	5	718	-	-	-	-
I2	865	Single	10.3	349	-	-	-	-
I3	1610	Single	1.2	72.5	-	-	-	-

Spectral radiance (Lmin and Lmax) has units of watt m-2 sr-1 µm-1.

TABLE 13. Dynamic range requirements VIIRS Sensor emissive bands

			Single Gain		Dual Gain			
					High Gain		Low Gain	
Band	**Center Wavelength (nm)**	**Gain Type**	**Tmin**	**Tmax**	**Tmin**	**Tmax**	**Tmin**	**Tmax**
M12	3700	Single	230	353	-	-	-	-
M13	4050	Dual	-	-	230	343	343	634
M14	8550	Single	190	336	-	-	-	-
M15	10763	Single	190	343	-	-	-	-
M16	12013	Single	190	340	-	-	-	-
I4	3740	Single	210	353	-	-	-	-
I5	11450	Single	190	340	-	-	-	-

TABLE 14: Sensitivity requirements for VIIRS Sensor reflective bands

			Single Gain		Dual Gain			
					High Gain		Low Gain	
Band	Center Wavelength (nm)	Gain Type	Ltyp	SNR	Ltyp	SNR	Ltyp	SNR
M1	412	Dual	-	-	44.9	352	155	316
M2	445	Dual	-	-	40	380	146	409
M3	488	Dual	-	-	32	416	123	414
M4	555	Dual	-	-	21	362	90	315
M5	672	Dual	-	-	10	242	68	360
M6	746	Single	9.6	199	-	-	-	-
M7	865	Dual	-	-	6.4	215	33.4	340
M8	1240	Single	5.4	74	-	-	-	-
M9	1378	Single	6	83	-	-	-	-
M10	1610	Single	7.3	342	-	-	-	-
M11	2250	Single	0.12	10	-	-	-	-
I1	640	Single	22	119	-	-	-	-
I2	865	Single	25	150	-	-	-	-
I3	1610	Single	7.3	6	-	-	-	-

Notes:
The units of spectral radiance for Ltyp are watt m-2 sr-1 μm-1.
The SNR column shows the minimum required (worst-case) SNR that applies at the end-of-scan.

TABLE 15: Sensitivity requirements for VIIRS Sensor emissive bands

			Single Gain		Dual Gain			
					High Gain		Low Gain	
Band	Center Wavelength (nm)	Gain Type	Ttyp	NEdT	Ttyp	NEdT	Ttyp	NEdT
M12	3700	Single	270	0.396	-	-	-	-
M13	4050	Dual	-	-	300	0.107	380	0.423
M14	8550	Single	270	0.091	-	-	-	-
M15	10763	Single	300	0.070	-	-	-	-
M16	12013	Single	300	0.072	-	-	-	-
I4	3740	Single	270	2.500	-	-	-	-
I5	11450	Single	210	1.500	-	-	-	-

Mission Success

- **The NPP Mission Success is determined by its capabilities**
  - **to provide continuation of a group of earth system observations initiated by the Earth Observing System (EOS) Terra, Aqua and Aura missions and**
  - **by its ability to reduce the risks associated with its advance observational capabilities as they are being transitioned from the NASA research program into the NPOESS operational program in support of both the Department of Defense (DoD) and NOAA**
    - These include pre-operational risk reduction demonstration and validation for selected NPOESS instruments, and algorithms, as well as ground data processing, archive and distribution.

VIIRS Spectral, Spatial, & Radiometric Attributes

		Band No.	Wave-length (μm)	Horiz Sample Interval (km Downtrack x Crosstrack)		Driving EDRs	Radi-ance Range	Ltyp or Ttyp	Signal to Noise Ratio (dimensionless) or NEΔT (Kelvins)		
				Nadir	End of Scan				Required	Predicted	Margin
VIS/NIR FPA	Silicon PIN Diodes	M1	0.412	0.742 x 0.259	1.60 x 1.58	Ocean Color	Low	44.9	352	441	25%
						Aerosols	High	155	316	807	155%
		M2	0.445	0.742 x 0.259	1.60 x 1.58	Ocean Color	Low	40	380	524	38%
						Aerosols	High	146	409	926	126%
		M3	0.488	0.742 x 0.259	1.60 x 1.58	Ocean Color	Low	32	416	542	30%
						Aerosols	High	123	414	730	76%
		M4	0.555	0.742 x 0.259	1.60 x 1.58	Ocean Color	Low	21	362	455	26%
						Aerosols	High	90	315	638	102%
		I1	0.640	0.371 x 0.387	0.80 x 0.789	Imagery	Single	22	119	146	23%
		M5	0.672	0.742 x 0.259	1.60 x 1.58	Ocean Color	Low	10	242	298	23%
						Aerosols	High	68	360	522	45%
		M6	0.746	0.742 x 0.776	1.60 x 1.58	Atmospheric Corr'n	Single	9.6	199	239	20%
		I2	0.865	0.371 x 0.387	0.80 x 0.789	NDVI	Single	25	150	225	50%
		M7	0.865	0.742 x 0.259	1.60 x 1.58	Ocean Color	Low	6.4	215	388	81%
						Aerosols	High	33.4	340	494	45%
CCD		DNB	0.7	0.742 x 0.742	0.742 x 0.742	Imagery	Var.	6.70E-05	6	5.7	-5%
S/MWIR	PV HgCdTe (HCT)	M8	1.24	0.742 x 0.776	1.60 x 1.58	Cloud Particle Size	Single	5.4	74	98	32%
		M9	1.378	0.742 x 0.776	1.60 x 1.58	Cirrus/Cloud Cover	Single	6	83	155	88%
		I3	1.61	0.371 x 0.387	0.80 x 0.789	Binary Snow Map	Single	7.3	6.0	97	1523%
		M10	1.61	0.742 x 0.776	1.60 x 1.58	Snow Fraction	Single	7.3	342	439	28%
		M11	2.25	0.742 x 0.776	1.60 x 1.58	Clouds	Single	0.12	10	17	66%
		I4	3.74	0.371 x 0.387	0.80 x 0.789	Imagery Clouds	Single	270 K	2.500	0.486	415%
		M12	3.70	0.742 x 0.776	1.60 x 1.58	SST	Single	270 K	0.396	0.218	82%
		M13	4.05	0.742 x 0.259	1.60 x 1.58	SST	Low	300 K	0.107	0.063	69%
						Fires	High	380 K	0.423	0.334	27%
LWIR	PV HCT	M14	8.55	0.742 x 0.776	1.60 x 1.58	Cloud Top Properties	Single	270 K	0.091	0.075	22%
		M15	10.763	0.742 x 0.776	1.60 x 1.58	SST	Single	300 K	0.070	0.038	85%
		I5	11.450	0.371 x 0.387	0.80 x 0.789	Cloud Imagery	Single	210 K	1.500	0.789	90%
		M16	12.013	0.742 x 0.776	1.60 x 1.58	SST	Single	300 K	0.072	0.051	42%

VIIRS Bands and Products

VIIRS 22 Bands:

16 M_ Band, 5 I_Band and 1 DNB

VIIRS Band	Spectral Range (um)	Nadir HSR (m)	MODIS Band(s)	Range	HSR
DNB	0.500 - 0.900				
● M1	0.402 - 0.422	750	8	0.405 - 0.420	1000
● M2	0.436 - 0.454	750	9	0.438 - 0.448	1000
● M3	0.478 - 0.498	750	3 10	0.459 - 0.479 0.483 - 0.493	500 1000
● M4	0.545 - 0.565	750	4 or 12	0.545 - 0.565 0.546 - 0.556	500 1000
I1	0.600 - 0.680	375	1	0.620 - 0.670	250
● M5	0.662 - 0.682	750	13 or 14	0.662 - 0.672 0.673 - 0.683	1000 1000
M6	0.739 - 0.754	750	15	0.743 - 0.753	1000
I2	0.846 - 0.885	375	2	0.841 - 0.876	250
● M7	0.846 - 0.885	750	16 or 2	0.862 - 0.877 0.841 - 0.876	1000 250
M8	1.230 - 1.250	750	5	SAME	500
M9	1.371 - 1.386	750	26	1.360 - 1.390	1000
I3	1.580 - 1.640	375	6	1.628 - 1.652	500
M10	1.580 - 1.640	750	6	1.628 - 1.652	500
M11	2.225 - 2.275	750	7	2.105 - 2.155	500
I4	3.550 - 3.930	375	20	3.660 - 3.840	1000
M12	3.660 - 3.840	750	20	SAME	1000
● M13	3.973 - 4.128	750	21 or 22	3.929 - 3.989 3.929 - 3.989	1000 1000
M14	8.400 - 8.700	750	29	SAME	1000
M15	10.263 - 11.263	750	31	10.780 - 11.280	1000
I5	10.500 - 12.400	375	31 or 32	10.780 - 11.280 11.770 - 12.270	1000 1000
M16	11.538 - 12.488	750	32	11.770 - 12.270	1000

● Dual gain band

VIIRS 24 EDRs

Land, Ocean, Atmosphere, Snow

Name of Product	Group	Type
Imagery *	Imagery	EDR
Precipitable Water	Atmosphere	EDR
Suspended Matter	Atmosphere	EDR
Aerosol Optical Thickness	Aerosol	EDR
Aerosol Particle Size	Aerosol	EDR
Cloud Base Height	Cloud	EDR
Cloud Cover/Layers	Cloud	EDR
Cloud Effective Particle Size	Cloud	EDR
Cloud Optical Thickness/Transmittance	Cloud	EDR
Cloud Top Height	Cloud	EDR
Cloud Top Pressure	Cloud	EDR
Cloud Top Temperature	Cloud	EDR
Active Fires	Land	Application
Albedo (Surface)	Land	EDR
Land Surface Temperature	Land	EDR
Soil Moisture	Land	EDR
Surface Type	Land	EDR
Vegetation Index	Land	EDR
Sea Surface Temperature *	Ocean	EDR
Ocean Color and Chlorophyll	Ocean	EDR
Net Heat Flux	Ocean	EDR
Sea Ice Characterization	Snow and Ice	EDR
Ice Surface Temperature	Snow and Ice	EDR
Snow Cover and Depth	Snow and Ice	EDR

* Product has a Key Performance attribute