



NPP VIIRS Sensor Data Record (SDR) Data User Readiness

Changyong Cao¹, Frank Deluccia², and Jack Xiong³

¹ NOAA/NESDIS/STAR

² Aerospace

³ NASA/GSFC

July 24, 2011



Topics



- VIIRS Overview
- VIIRS SDR data characteristics
- VIIRS SDR data access
- VIIRS data visualization and analysis tools
- VIIRS SDR Cal/Val
- References
- Summary

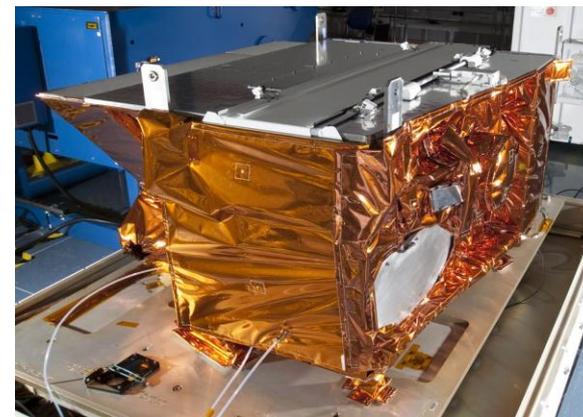


VIIRS Overview

- **Purpose:** Global observations of land, ocean, & atmosphere parameters at high temporal resolution (~ daily)
- **Heritage:** VIIRS builds on a long heritage of operational and research earth observing imaging radiometers with moderate resolution :
 - Advanced Very High Resolution Radiometer (AVHRR) on NOAA and MetOp satellites, with 5 (6) bands, since 1979.
 - Moderate-Resolution Imaging Spectroradiometer (MODIS) on Terra and Aqua, with 36 bands, since 1999.
 - Sea-viewing Wide Field-of-view Sensor (*SeaWiFS*), since 1997.
 - Operational Linescan System (OLS) on DMSP, since 1972.
- **Approach:** Multi-spectral scanning radiometer (22 bands between 0.4 μm and 12 μm) 12-bit quantization
- **Swath width:** 3000 km

Overview of VIIRS Data Products

- VIIRS data products are SDRs: Calibrated and geolocated radiances and reflectances (SDR \approx Level 1B)
- 22 types of SDRs
 - 16 moderate resolution, narrow spectral bands
 - 11 Reflective Solar Bands (RSB)
 - 5 Thermal Emissive Bands (TEB)
 - 5 imaging resolution, narrow spectral bands
 - 3 RSB
 - 2 TEB
 - 1 Day Night Band (DNB) imaging, broadband
- Input to 21 Environmental Data Records (EDRs)
 - Two “Key Performance Parameters” based on the Integrated Operational Requirements Document (IORD) II
 - SST and Imagery



VIIRS Sensor Bands

	Band No.	Wave-length (μm)	Horiz Sample Interval (km Downtrack x Crosstrack)		Driving EDRs	Radiance Range	Ltyp or Ttyp
			Nadir	End of Scan			
VIS/NIR FPA Silicon PIN Diodes	M1	0.412	0.742 x 0.259	1.60 x 1.58	Ocean Color Aerosols	Low High	44.9 155
	M2	0.445	0.742 x 0.259	1.60 x 1.58	Ocean Color Aerosols	Low High	40 146
	M3	0.488	0.742 x 0.259	1.60 x 1.58	Ocean Color Aerosols	Low High	32 123
	M4	0.555	0.742 x 0.259	1.60 x 1.58	Ocean Color Aerosols	Low High	21 90
	I1	0.640	0.371 x 0.387	0.80 x 0.789	Imagery	Single	22
	M5	0.672	0.742 x 0.259	1.60 x 1.58	Ocean Color Aerosols	Low High	10 68
	M6	0.746	0.742 x 0.776	1.60 x 1.58	Atmospheric Corr'n	Single	9.6
	I2	0.865	0.371 x 0.387	0.80 x 0.789	NDVI	Single	25
	M7	0.865	0.742 x 0.259	1.60 x 1.58	Ocean Color Aerosols	Low High	6.4 33.4
CCD	DNB	0.7	0.742 x 0.742	0.742 x 0.742	Imagery	Var.	6.70E-05
S/MWIR PV HgCdTe (HCT)	M8	1.24	0.742 x 0.776	1.60 x 1.58	Cloud Particle Size	Single	5.4
	M9	1.378	0.742 x 0.776	1.60 x 1.58	Cirrus/Cloud Cover	Single	6
	I3	1.61	0.371 x 0.387	0.80 x 0.789	Binary Snow Map	Single	7.3
	M10	1.61	0.742 x 0.776	1.60 x 1.58	Snow Fraction	Single	7.3
	M11	2.25	0.742 x 0.776	1.60 x 1.58	Clouds	Single	0.12
	I4	3.74	0.371 x 0.387	0.80 x 0.789	Imagery Clouds	Single	270 K
	M12	3.70	0.742 x 0.776	1.60 x 1.58	SST	Single	270 K
	M13	4.05	0.742 x 0.259	1.60 x 1.58	SST Fires	Low High	300 K 380 K
	LWIR PV HCT	M14	8.55	0.742 x 0.776	1.60 x 1.58	Cloud Top Properties	Single
M15		10.763	0.742 x 0.776	1.60 x 1.58	SST	Single	300 K
I5		11.450	0.371 x 0.387	0.80 x 0.789	Cloud Imagery	Single	210 K
M16		12.013	0.742 x 0.776	1.60 x 1.58	SST	Single	300 K

Rev. 062708

VIIRS EDRs

- Aerosols**

- Aerosol optical thickness
- Aerosol particle size parameter
- Suspended matter

- Imagery and Clouds**

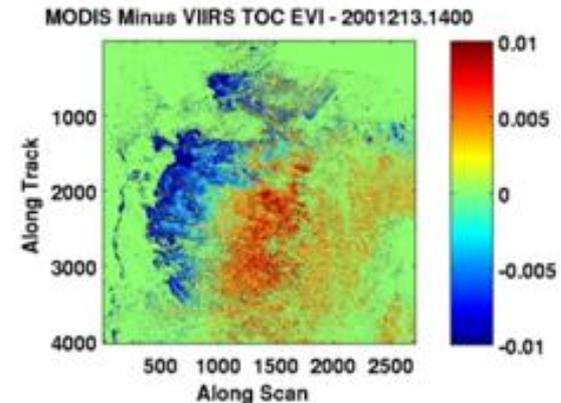
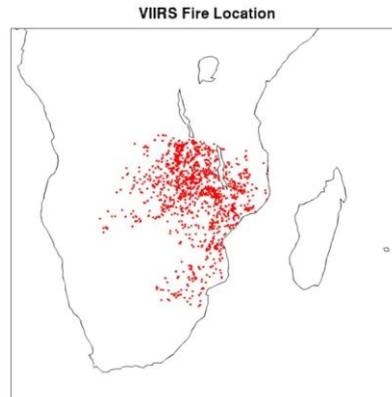
- Imagery
- Cloud mask
- Cloud optical thickness
- Cloud effective particle size parameter
- Cloud top parameters
- Cloud base height
- Cloud cover/layers

Land

- Active Fires
- Land surface Albedo
- Land surface temperature
- Ice surface temperature
- Snow ice characterization
- Snow cover/depth
- Vegetation index
- Surface type

Ocean

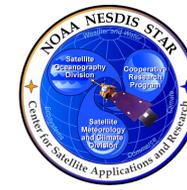
- Sea surface temperature
- Ocean color





VIIRS Prelaunch Performance

(NPP F1 Bands and SNR/NEDT)



		Specification										
	Band No.	Driving EDR(s)	Spectral Range (um)	Horiz Sample Interval (km) (track x Scan)		Band Gain	Ltyp or Ttyp (Spec)	Lmax or Tmax	SNR or NEdT (K)	Measured SNR or NEdT (K)	SNR Margin (%)	
				Nadir	End of Scan							
Reflective Bands	VisNIR	M1	Ocean Color Aerosol	0.402 - 0.422	0.742 x 0.259	1.60 x 1.58	High Low	44.9 155	135 615	352 316	723 1327	105% 320%
		M2	Ocean Color Aerosol	0.436 - 0.454	0.742 x 0.259	1.60 x 1.58	High Low	40 146	127 687	380 409	576 1076	51.5% 163%
		M3	Ocean Color Aerosol	0.478 - 0.498	0.742 x 0.259	1.60 x 1.58	High Low	32 123	107 702	416 414	658 1055	58.2% 155%
		M4	Ocean Color Aerosol	0.545 - 0.565	0.742 x 0.259	1.60 x 1.58	High Low	21 90	78 667	362 315	558 882	54.1% 180%
		I1	Imagery EDR	0.600 - 0.680	0.371 x 0.387	0.80 x 0.789	Single	22	718	119	265	122.7%
		M5	Ocean Color Aerosol	0.662 - 0.682	0.742 x 0.259	1.60 x 1.58	High Low	10 68	59 651	242 360	360 847	49% 135%
		M6	Atmosph. Correct.	0.739 - 0.754	0.742 x 0.776	1.60 x 1.58	Single	9.6	41	199	394	98.0%
		I2	NDVI	0.846 - 0.885	0.371 x 0.387	0.80 x 0.789	Single	25	349	150	299	99.3%
		M7	Ocean Color Aerosol	0.846 - 0.885	0.742 x 0.259	1.60 x 1.58	High Low	6.4 33.4	29 349	215 340	545 899	154% 164%
Emissive Bands	S/WMIR	M8	Cloud Particle Size	1.230 - 1.250	0.742 x 0.776	1.60 x 1.58	Single	5.4	165	74	349	371.6%
		M9	Cirrus/Cloud Cover	1.371 - 1.386	0.742 x 0.776	1.60 x 1.58	Single	6	77.1	83	247	197.6%
		I3	Binary Snow Map	1.580 - 1.640	0.371 x 0.387	0.80 x 0.789	Single	7.3	72.5	6	165	2650.0%
		M10	Snow Fraction	1.580 - 1.640	0.742 x 0.776	1.60 x 1.58	Single	7.3	71.2	342	695	103.2%
		M11	Clouds	2.225 - 2.275	0.742 x 0.776	1.60 x 1.58	Single	0.12	31.8	10	18	80.0%
		I4	Imagery Clouds	3.550 - 3.930	0.371 x 0.387	0.80 x 0.789	Single	270	353	2.5	0.4	84.0%
		M12	SST	3.660 - 3.840	0.742 x 0.776	1.60 x 1.58	Single	270	353	0.396	0.12	69.7%
Emissive Bands	LWIR	M13	Fires	3.973 - 4.128	0.742 x 0.259	1.60 x 1.58	High Low	300 380	343 634	0.107 0.423	0.044 --	59% --
		M14	Cloud Top Properties	8.400 - 8.700	0.742 x 0.776	1.60 x 1.58	Single	270	336	0.091	0.054	40.7%
		M15	SST	10.263 - 11.263	0.742 x 0.776	1.60 x 1.58	Single	300	343	0.07	0.028	60.0%
		I5	Cloud Imagery	10.500 - 12.400	0.371 x 0.387	0.80 x 0.789	Single	210	340	1.5	0.41	72.7%
	M16	SST	11.538 - 12.488	0.742 x 0.776	1.60 x 1.58	Single	300	340	0.072	0.036	50.0%	

HSI uses 3 in-scan pixels aggregation at Nadir

Courtesy of H. Oudrari

VIIRS Relative Spectral Response (RSR)

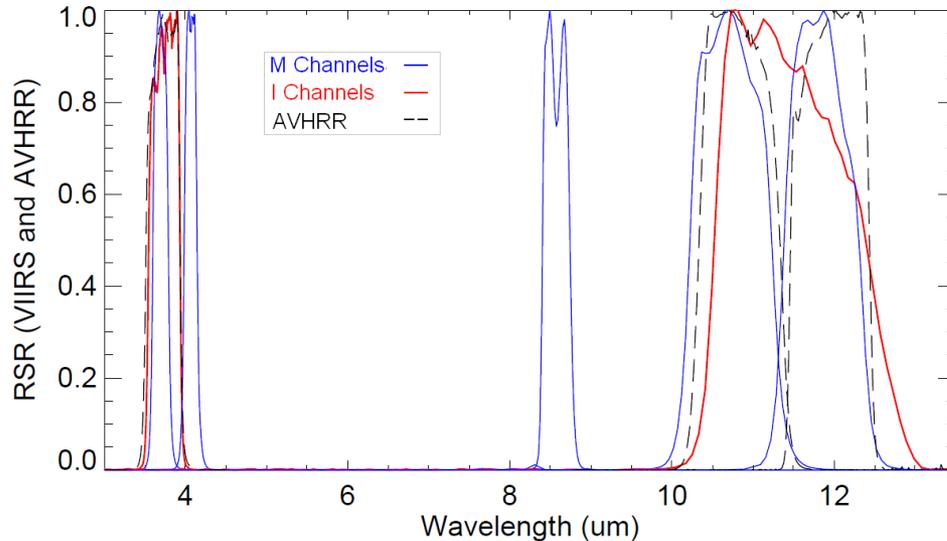
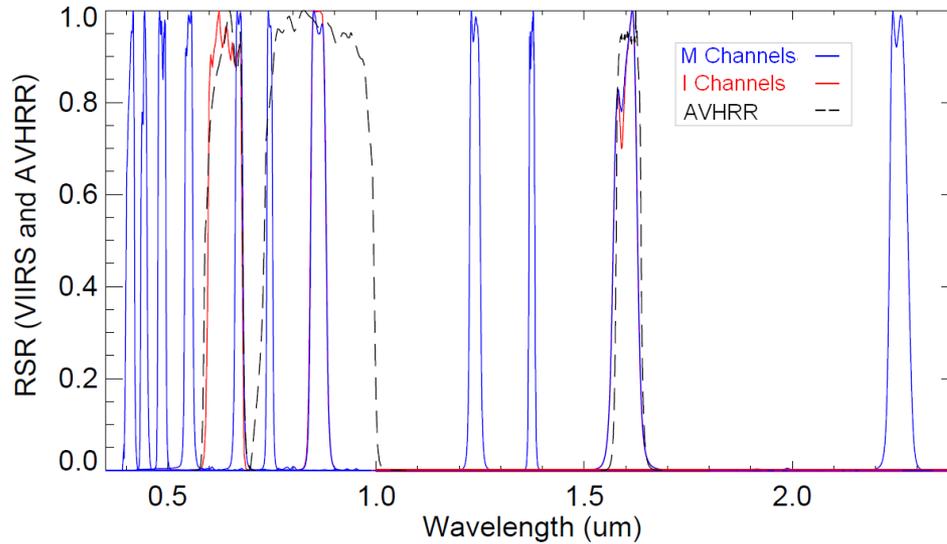
- VIIRS RSR now available (except for DNB) at <https://www.star.nesdis.noaa.gov/jpss/VIIRS>

- Spacecraft-Level Testing

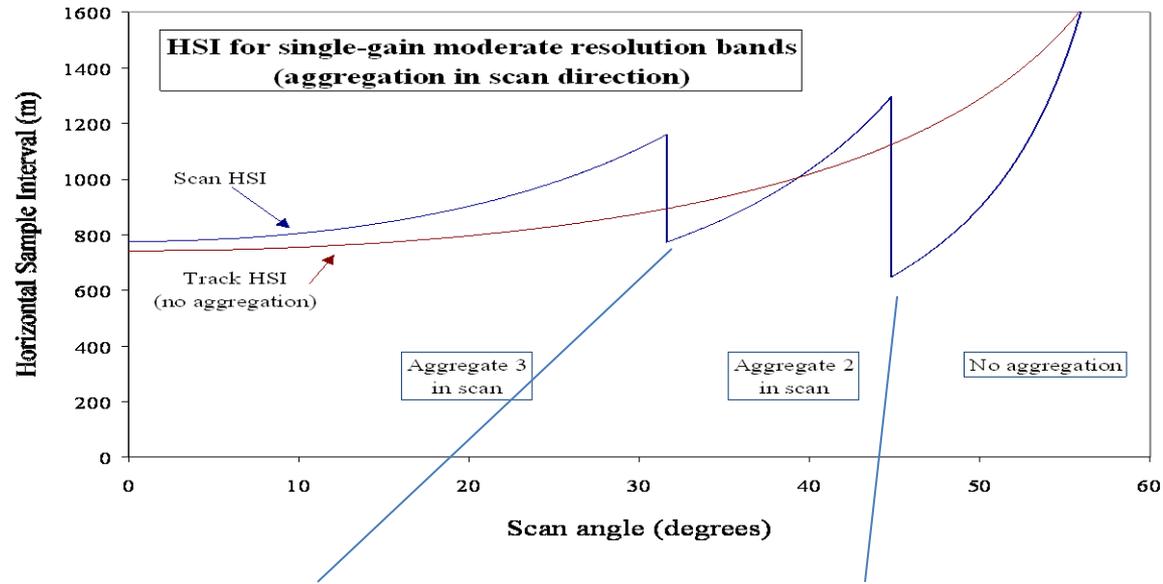
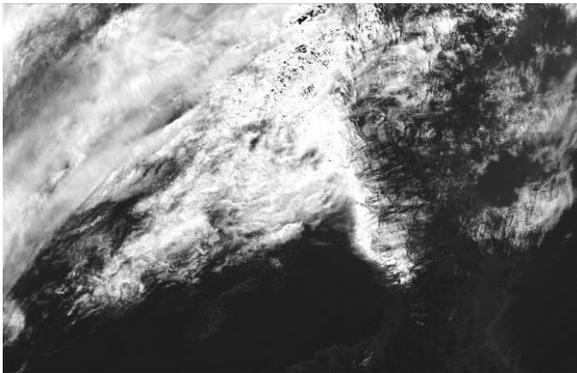
- Instrument-Level Testing

- Provided by the government team

- Comparison with AVHRR (to the right)



VIIRS Spatial Sampling Characteristics





VIIRS SDR Data Characteristics



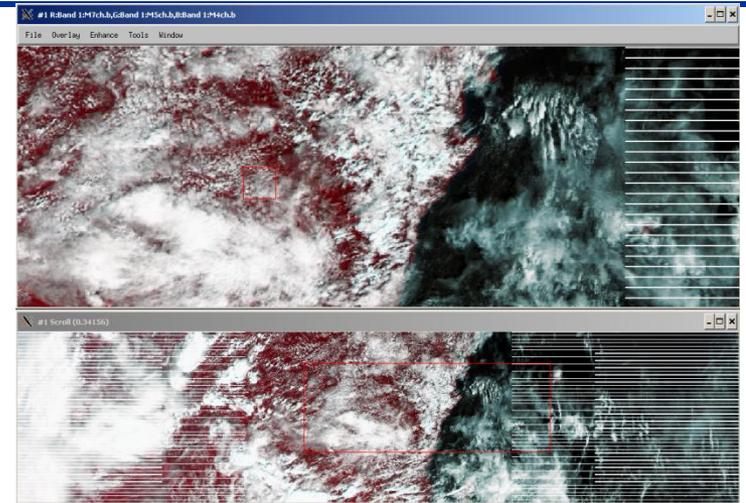
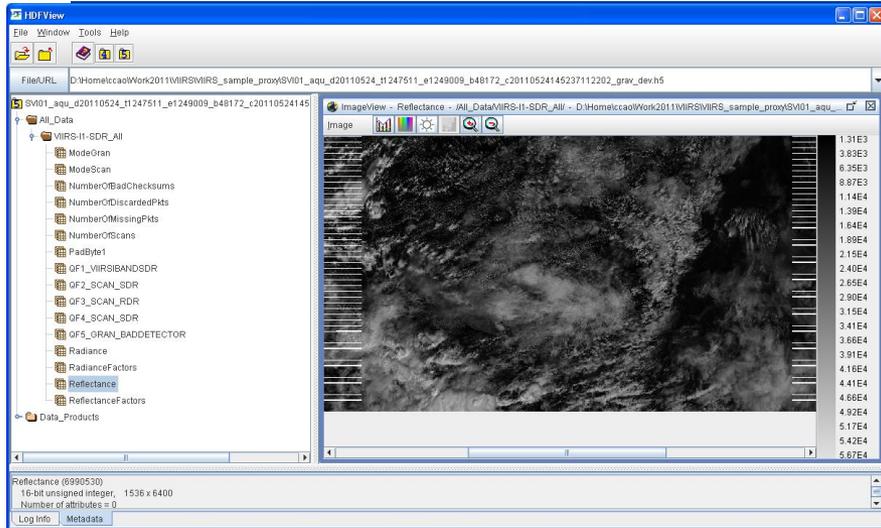
Basics facts:

- All data available in .HDF 5 format (see appendix in user's guide for content)
- One granule:
 - M-bands: 768 rows x 3200 columns, corresponding to 48 scan-lines from 16 detectors
 - I-bands: 1536 rowsx6400 columns, corresponding to 48 scan-lines from 32 detectors.
- One .hdf file per band. Tools needed to combine granules and bands

VIIRS has Large Data Volume (about 1TB/day)

Products	One granule	One orbit (70 granules)	One day (14 orbits)
RDR	71.9	5,033	70,462
DNB SDR	143.7	10,059	140,826
I-Band SDR	570.5	39,935	559,090
M 16 channels SDR	308.3	21,581	302,134
Total	1,094.4	76,608	1,072,512

VIIRS Data Visualization and Analysis Software Survey



Software	Availability	Functionality	Recommended Usage	Note
HDF Viewer	Free	Limited analysis capability	Quick look	Limited analytical capabilities
ENVI	COTS	Advanced image analysis capabilities	Data visualization and analysis	.HDF5 compatibility requires plug-in
McIDAS-V	Free	End user oriented comprehensive	Best for global and regional analysis	Written in Java; with limited VIIRS support
QCV	Internal use	Specialized software	Quality assurance	Consists of Matlab routines
IDL/Matlab	license			

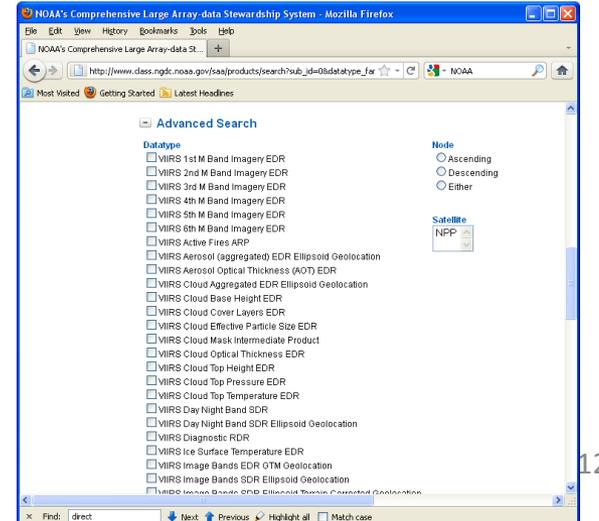


VIIRS Data Distribution and Access



- Centrals:
 - NOAA/NESDIS, Suitland, MD
 - Air Force Weather Agency (AFWA), Offutt Air Force Base, Omaha, NE
- CLASS: www.class.noaa.gov
- GRAVITE: for registered users
 - Send request to JPSS program office (gordon.fesenger@noaa.gov, or richard.ullman@nasa.gov)
 - Upon approval, receive email from JPSS with account
 - Information about GTP available on <https://www.star.nesdis.noaa.gov/jpss>
 - Minor glitches for GTP software as well as instructions (will be fixed soon).
 - Firewall issues within your organization (work with IT)
 - Finally “GTP auth” in a command window (must have command line argument, or will get unspecified error).
 - List files available and download (just like ftp).

- NASA PEATE
- Direct Readout

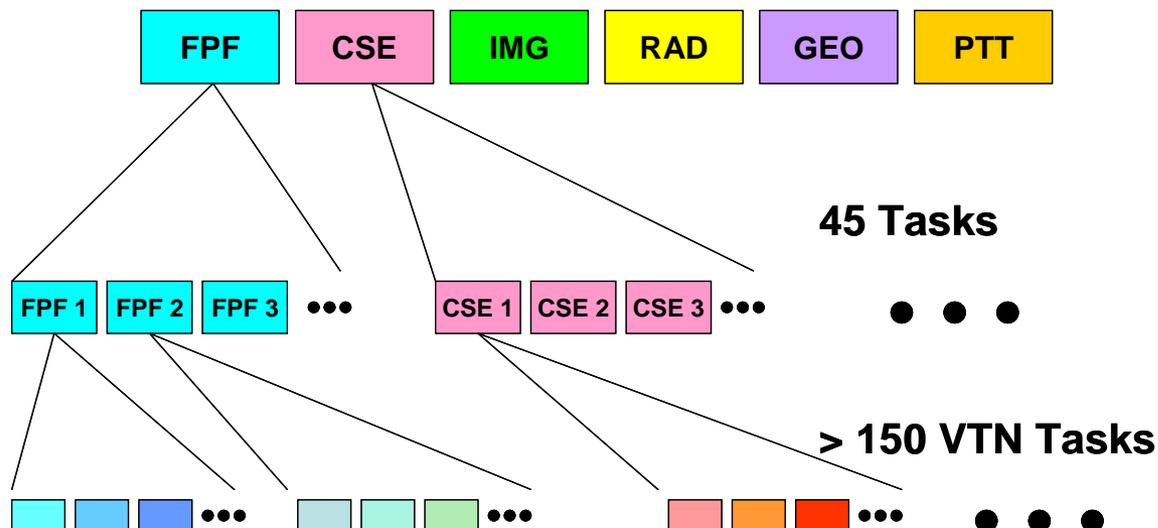


SDR Product Maturity Levels

- **Beta**
 - Early release product, initial calibration applied, minimally validated and may still contain significant errors
 - Available to allow users to gain familiarity with data formats and parameters
 - Product is not appropriate as the basis for quantitative scientific publications studies and applications
- **Provisional**
 - Product quality may not be optimal
 - Incremental product improvements are still occurring as calibration parameters are adjusted with sensor on-orbit characterization
 - General research community is encouraged to participate in the QA and validation of the product, but need to be aware that product validation and QA are ongoing
 - Users are urged to contact NPOESS NPP Cal/Val Team representatives prior to use of the data in publications
- **Validated/Calibrated**
 - On-orbit sensor performance characterized and calibration parameters adjusted accordingly
 - Ready for use by the Centrals, and in scientific publications
 - There may be later improved versions

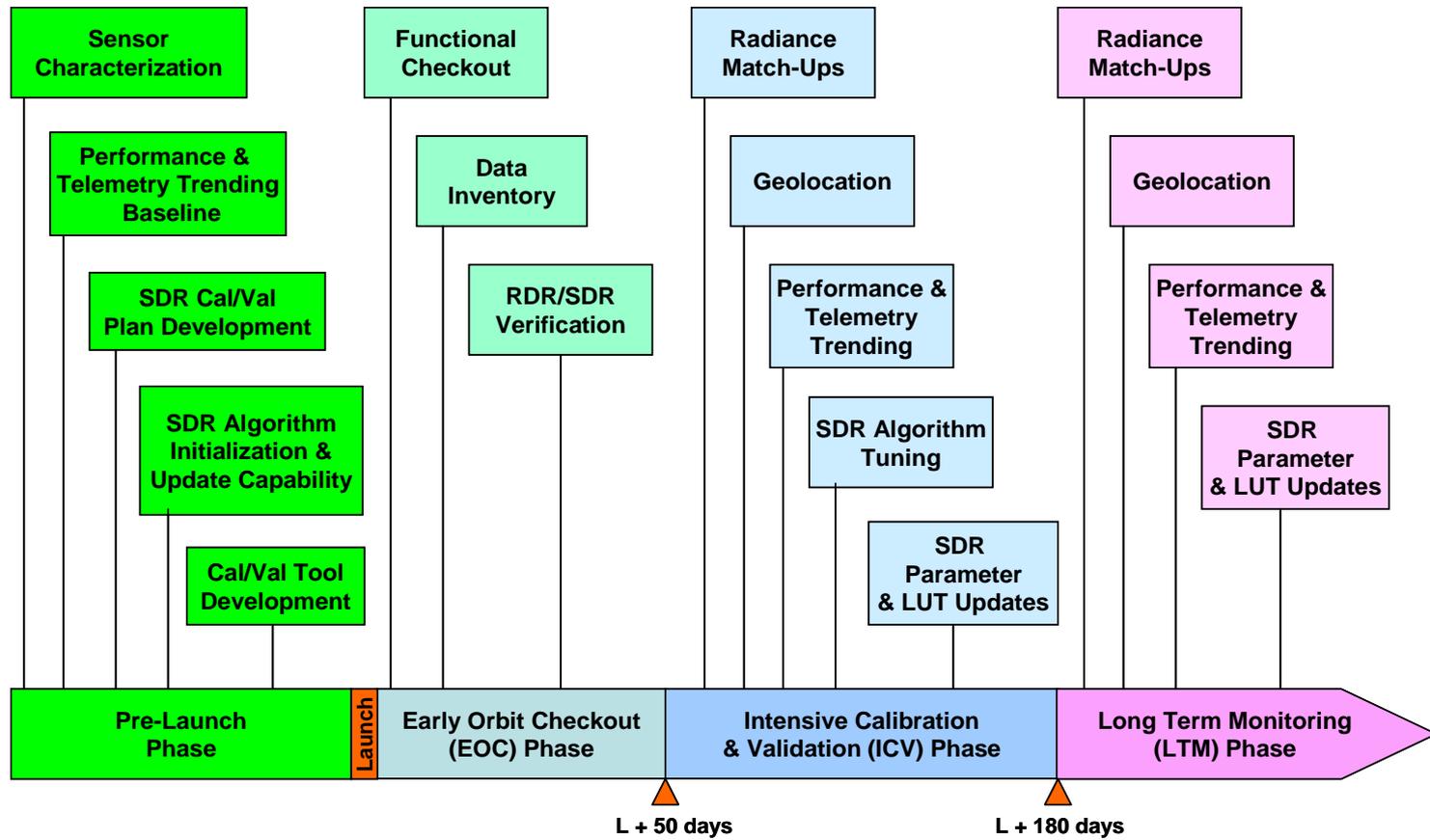
VIIRS Calibration/Validation

6 Task Categories



- **Functional Performance and Format Evaluation (FPF):** FPF tasks involve evaluating instrument functions and verifying the correctness of data formats. Performed early in the mission, and will not be repeated unless the instrument suffers a catastrophic event.
- **Calibration System Evaluation (CSE):** CSE tasks evaluate the performance of the onboard calibration system and update the calibration algorithm databases accordingly.
- **Image Quality Evaluation (IMG):** IMG tasks evaluate the quantitative and qualitative spatial performance characteristics of the instrument.
- **Radiometric Evaluation (RAD):** RAD tasks evaluate the radiometric performance of the data product algorithm. Radiometric evaluation will include evaluation of spectral characteristics since changes in these characteristics relative to the pre-launch baseline will mainly manifest themselves as in-band radiometric errors.
- **Geolocation Evaluation (GEO):** GEO tasks evaluate the geolocation accuracy of the data product.
- **Performance and Telemetry Trending (PTT):** PTT tasks evaluate long-term changes in the performance of both the instrument and the data product.

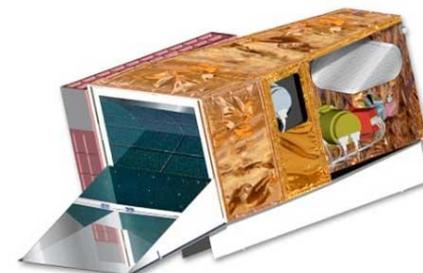
VIIRS Cal/Val Activities by Phase



VIIRS On-orbit Calibration Activities

- **On-board Calibrators**

- Solar diffuser (SD) and solar attenuation screen (SAS) system for RSB and DNB calibration (every orbit)
- Solar diffuser stability monitor (SDSM) for SD degradation monitoring (regularly scheduled)
- V-grooved blackbody for TEB calibration (scan-by-scan)
- Space view (SV) for instrument background



- **Spacecraft Maneuvers**

- Roll maneuvers for lunar observations (near monthly scheduled)
 - Track RSB radiometric stability
- Yaw maneuvers (during SC initial checkout, repeat late if necessary)
 - Evaluate SD SAS and SDSM sun view screen transmission
- Pitch maneuvers (during SC initial checkout, repeat late if necessary)
 - Validate TEB response versus scan angle (RVS)

VIIRS/NPP Postlaunch Intercalibration with MODIS/Aqua

Simultaneous Nadir Overpass (SNO) will occur at different latitudes, every 2-3 days, between NPP and Aqua

NPP will be right above Aqua even in the low latitudes from time to time (SNOx for extension) providing excellent opportunities for inter-comparisons

NPP/VIIRS and Aqua/MODIS channels can be directly compared at the SNOx, while comparisons with AVHRR can be made at polar SNO locations

Inter-comparisons at SNOx will greatly reduce the uncertainties

**Excellent SNOx event:
NPP is on top of AQUA**



Example SNOx event between NPP and Aqua



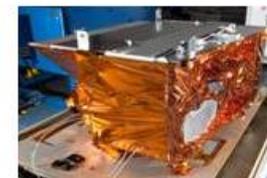
NOAA Satellites and Information

National Environmental Satellite, Data, and Information Service



JPSS/VIIRS Website

The VIIRS will provide continuity in operational Earth observations at moderate resolution following the heritage sensors. It supports studies of the physical and biological properties of land and ocean surfaces, and of cloud and aerosol properties. VIIRS is designed to provide moderate-resolution, radiometrically accurate images of the entire Earth twice daily. It is a wide-swath (3,040 km) instrument with spatial resolutions of 370 m and 740 m at nadir. Its 22 bands span the spectrum between 0.412 μm and 11.5 μm .



VIIRS builds on an extremely long heritage of operational and research-grade sensors, whose origins extend back several decades, including:

- Advanced Very-high Resolution Radiometer (AVHRR), on NOAA's Polar-orbiting Environmental Satellites (POES).
- Moderate-resolution Imaging Spectroradiometer (MODIS), on NASA's Earth Observing System (EOS).
- Operational Linescan System (OLS), on DoD's Defense Meteorological Satellite Program (DMSP)

VIIRS will provide data for producing a large number of Environmental Data Records (EDRs), including:

Aerosols: Aerosol optical thickness, Aerosol particle size parameter, Suspended matter

Imagery and Clouds: Imagery, Cloud mask, Cloud optical thickness, Cloud effective particle size parameter, Cloud top parameters, Cloud base height, Cloud cover/layers

Land: Active Fires, Land surface Albedo, Land surface temperature, Ice surface temperature, Snow ice characterization, Snow cover/depth, Vegetation index, Surface type.

Ocean: Sea surface temperature, Ocean color

[HOME](#)

[VIIRS News](#)

[User's Guide](#)

[Spectral Response](#)

[Software Tools](#)

[Data Access](#)

[User readiness presentation](#)

[Monthly Reports](#)

[JPSS Internal Materials](#)

[CasaNosa](#)

[Links](#)



Resources



- VIIRS documents (<https://www.star.nesdis.noaa.gov/jpss/VIIRS>)
 - VIIRS Sensor Data Record (SDR) User's Guide
 - NPP VIIRS Spectral Response Functions
- Software tools:
 - HDF viewer (<http://www.hdfgroup.org/hdf-java-html/hdfview/>)
 - ENVI (COTS software package: <http://www.itvis.com/language/en-us/productsservices/envi.aspx>)
 - McIDAS V (<http://www.ssec.wisc.edu/mcidas/software/v/>)
 - Quality Characterization and Visualization (QCV Matlab package)
 - IDL
 - Matlab
- Data distribution and access:
 - Centrals:
 - NOAA/NESDIS, Suitland, MD
 - Air Force Weather Agency (AFWA), Offutt Air Force Base, Omaha, NE
 - CLASS: www.class.noaa.gov
 - Gravite: for registered users
 - Direct Readout

Summary

- With 21 EDRs and 2 KPPs, VIIRS has a broad and large user base.
- VIIRS SDR has large data volume which requires adequate hardware and software skills
- Software, documentation, and sample data are readily available on the VIIRS website
- The government team has developed a comprehensive cal/val plan to ensure data quality
- The VIIRS SDR team is ready for NPP launch



Acknowledgements



- Thank the entire VIIRS SDR team for their hard work and contributions
- Thank the JPSS and STAR management for providing resources
- Thank the users for continuing using NOAA satellite data