NASA Visible Infrared Imaging Radiometer Suite Level-1B Product User Guide

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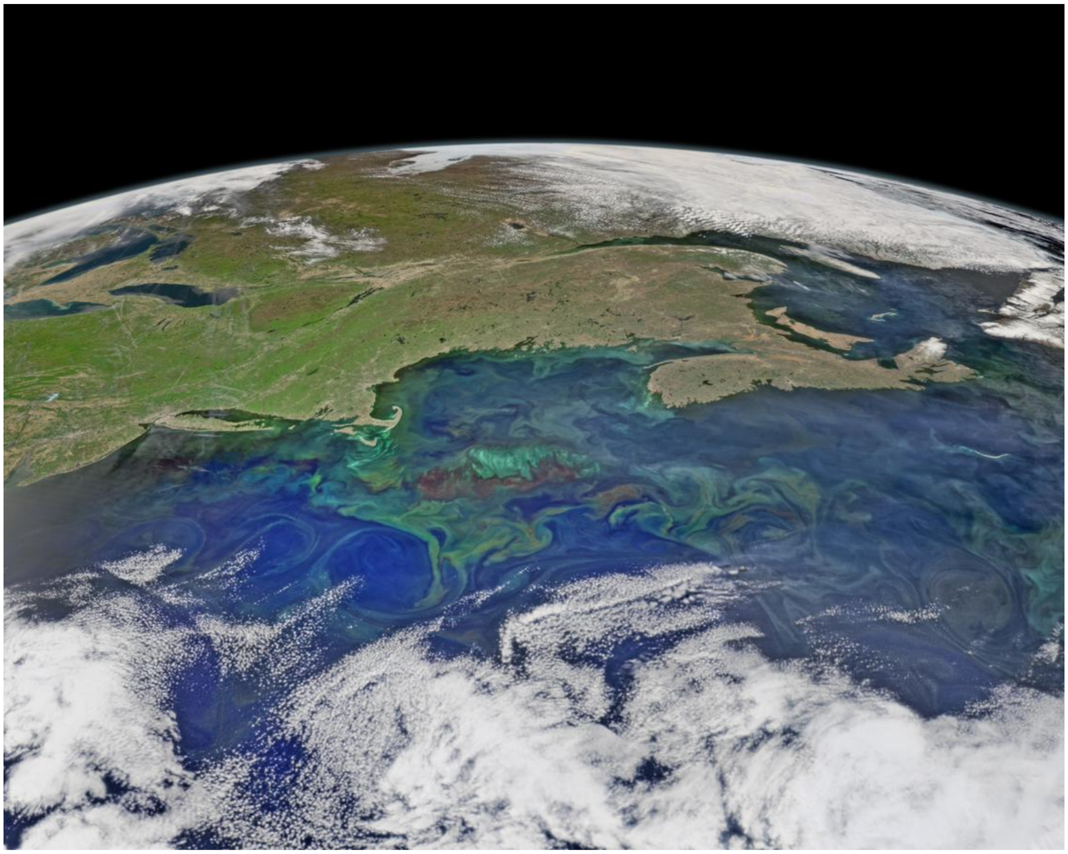

[SNPP VIIRS Gulf of Maine image; May 14, 2015; Credit: Norman Kuring, NASA Ocean Color Group]

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Change-History Log

Version	Date	Change Description
1.0	May 31, 2018	Publicly released version [SNPP VIIRS v1.0]
2.0	August 31, 2019	Publicly released version [SNPP VIIRS v1.0, JPSS-1 VIIRS v2.0]
3.0	August 17, 2021	Publicly released version [SNPP VIIRS v2.0, JPSS-1 VIIRS v2.1]

NASA VIIRS Level-1B Product User Guide

Table of Contents

1.0 Introduction

This User Guide relates to data from both the SNPP- and JPSS-1-derived VIIRS L1 products. Currently, version-2 for SNPP VIIRS and version-2.1 for JPSS-1 VIIRS products define the latest publicly available L1 collections. Wherever appropriate, both the SNPP and JPSS-1 short-name prefixes (VNP and VJ1) are used to indicate the relevance and applicability of the information to both product sources. Any information that is uniquely specific to one sensor or collection-version is appropriately identified and described. Our goal is to maintain one NASA VIIRS Level-1B User Guide that addresses products from both the SNPP and JPSS missions. Check this location for the VIIRS Level-1 change-summary: https://ladsweb.modaps.eosdis.nasa.gov/missions-and-measurements/viirs/VIIRS_Level-1_Change_Summary.pdf

This document describes the specifications of the NASA-developed Visible Infrared Imaging Radiometer Suite (VIIRS) Level-1B data products. These products are generated by the NASA VIIRS Science Investigator-led Processing Systems (SIPS: https://earthdata.nasa.gov/eosdis/sips) for the Atmosphere, Land, and Ocean disciplines, and are archived and distributed by the Level-1 and Atmosphere Archive & Distribution System (LAADS: https://ladsweb.modaps.eosdis.nasa.gov/) Distributed Active Archive Center (DAAC) at the Goddard Space Flight Center (GSFC) in Greenbelt, MD. VIIRS is a multidisciplinary instrument that flies aboard the Suomi National Polar-orbiting Partnership (SNPP) platform, which launched in October 2011, and the Joint Polar Satellite System (JPSS) satellites, the first of which is JPSS-1 (NOAA-20) that was launched in November 2017. Three more JPSS satellites (with a VIIRS instrument as part of their payload) are slated for launch between 2022 and 2032 (http://www.jpss.noaa.gov/mission_and_instruments.html). Consult the NASA JPSS site (https://jointmission.gsfc.nasa.gov/index.html) for additional VIIRS-specific information related to the spacecraft and instruments, ground operations, science objectives, etc.

Following the last reprocessing cycle, the most current version of the publicly available L1 products include the SNPP VIIRS C2 and JPSS-1 (hereafter referred to as J1) C2.1 versions.[1] Regarding the

[1] A note about references to IDPS in this User Guide: Interface Data Processing Segment (IDPS) is one of two segments of the NASA/NOAA Joint Polar Satellite System's (JPSS) ground communications and processing system called the JPSS Common Ground System (CGS). The other segment is the Command, Control and Communications Segment (C3S). The IDPS, operated and maintained by NOAA, is responsible for receiving raw mission data from C3S, and producing and delivering JPSS data products to the user community through NOAA's CLASS archive (https://tinyurl.com/NOAA-CLASS). Given the role of IDPS from the early days of the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP), the first collection of NASA VIIRS Level-1 data products started using IDPS-based algorithms and NASA VCST-developed Look-up Tables (LUT) for radiometric calibration and geolocation. Subsequently, NASA VCST-developed calibration algorithms and LUTs have replaced the IDPS-based Level-1 software sources and inputs.

previous L1 collections, we will continue to produce and archive the heritage Interface Data Processing Segment-derived (IDPS) L1 and its subsequent NASA L1 (C1) versions at least until the time when we have completed the C2 reprocessing of the entire land products portfolio, which may last until sometime through mid-2022.

All L1 products are implemented in the Network Common Data Format Version-4 (NetCDF4), and NetCDF terminology is used in this document. The NetCDF4 format is also compatible with the Hierarchical Data Format Version-5 (HDF5). A hybridized netCDF4–HDF5 approach defines the data format of the VIIRS Level-1 products. This format leverages several individual (extensive use across Earth science disciplines, performance strengths, etc.) as well as collective strengths (extensibility, platform independence, self-describing nature, etc.) of the two data/file storage formats. Both NetCDF4 and HDF5 software tools can handle these products. For additional format-specific information regarding the NASA standard VIIRS products, consult the LAADS FAQs (https://ladsweb.modaps.eosdis.nasa.gov/help/faq/).

The Suomi National Polar-Orbiting Partnership (SNPP) operation served as a bridge mission to provide observation continuity with NASA's Earth Observing System (EOS) and the operational VIIRS instruments aboard the JPSS mission series. A key objective of the VIIRS instrument is to provide data continuity with the EOS Moderate Resolution Imaging Spectroradiometer (MODIS). The NASA-developed VIIRS products are driven by a couple of unique requirements that were part of the 2013 NASA Research Opportunities in Space and Earth Sciences (ROSES) call specifications. The first required the development of a new Level-0 to -1B software that would implement the NASA Level-1B calibration approach, using a calibration look-up table (LUT) developed and maintained by the NASA VIIRS Characterization Support Team (VCST) to generate the VIIRS Level-1B Top-of-Atmosphere (TOA) data product in the heritage MODIS Level-1B format. The second requirement called for the EOS Data and Operations System (EDOS[2]) to provide the Level-0 data to the SIPSs. NASA helped form the VIIRS Level-1 Algorithm/Software Working Group (L1ASWG), which is an alliance of personnel

[2] EDOS, located at GSFC, generates, archives and serves EOS- and SNPP-derived Level-0 reconstructed, unprocessed instrument and payload data at full resolution with all communication artifacts (e.g., synchronization frames, communication headers, duplicate data, etc.) removed for higher-level data processing by various SIPS and DAAC science data processing systems.

from the VIIRS SIPSs and the VCST, who were mandated to develop this new L0 to L1B software for VIIRS. The first version of the SNPP VIIRS Level-1 software was completed in October 2015.

The LAADS DAAC's VIIRS L1-specific milestones include the following:

- Publicly released the NASA-developed SNPP VIIRS L1 C1 products on January 1, 2018.
- Publicly released the NASA-developed JPSS-1 VIIRS L1 C2 products on August 4, 2019.
- Publicly released the NASA-developed SNPP VIIRS L1 C2 products on August 17, 2021.
- Publicly released the NASA-developed JPSS-1 VIIRS L1 C2.1 products on August 17, 2021.

1.1 Acknowledgements

The first rendition of this User Guide was developed using an earlier version compiled by the NASA Ocean SIPS at GSFC. We appreciate and acknowledge their efforts immensely. We also thank the following groups and their staff for their efforts at various stages in the evolution of the NASA VIIRS Level-1 products: VIIRS Level-1 Algorithm/Software Working Group (L1ASWG), NASA VIIRS Characterization Support Team (VCST), NASA VIIRS Geolcation group, and the NASA Earth Science Data and Information System (ESDIS) project.

1.2 Questions/Feedback, etc.

If you have any questions regarding the NASA VIIRS Level-1 products, about this User Guide, or have general feedback, please e-mail them to the LAADS User Services: **MODAPSUSO@lists.nasa.gov**

2.0 VIIRS Instrument Overview

2.1 Design and Heritage

The VIIRS instrument is a whiskbroom scanning radiometer whose field-of-view is 112.56° in the cross-track direction. Orbiting at a nominal altitude of 515 miles (829 km), its swath width is 1901.4 miles (3060 km) and provides full daily daytime and nighttime coverage of Earth. The VIIRS instrument owes its legacy to a number of operational and research instruments that include the following:

- 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) Terra and Aqua platforms.
- Sea-viewing Wide Field-of-view Sensor (SeaWiFS) on GeoEye's SeaStar satellite.
- Operational Linescan System (OLS) on Department of Defense's Defense Meteorological Satellite Program (DMSP) satellites.

2.2 VIIRS band configuration and related details

The VIIRS instrument offers 22 spectral bands that cover the EM spectrum between 0.402 µm and 12.49 µm. This range includes 16 moderate-resolution bands (M-bands) that have an at-nadir spatial resolution of 750 meters, 5 image-resolution bands with a spatial resolution of 375 meters at-nadir, and a single panchromatic Day-Night band (DNB) with a spatial resolution of 750 meters across the entire scan. The M-bands comprise 11 Reflective Solar bands (RSB) and 5 Thermal Emissive bands (TEB), while the I-bands comprise 3 RSBs and 2 TEBs (Table-1). Six of the 11 RSBs are dual-gain reflective solar bands, and offer a wider dynamic range to support ocean color applications without saturating the sensor by observing high reflectance targets including land surfaces and clouds. The DNB, with its three gain stages, affords a dynamic range in the order of 10^7.

	Band	Wavelength (µm)	Spatial Res. at-Nadir (m)	Gain
	Image-resolution Bands			
RSBs	I1	0.600 – 0.680	375	Single
	I2	0.846 – 0.885	375	Single
	I3	1.580 – 1.640	375	Single
TEBs	I4	3.550 – 3.930	375	Single
	I5	10.50 – 12.40	375	Single
	Moderate-resolution Bands			
Reflective Solar Bands	M1	0.402 – 0.422	750	High/Low
	M2	0.436 – 0.454	750	High/Low
	M3	0.478 – 0.498	750	High/Low
	M4	0.545 – 0.565	750	High/Low
	M5	0.662 – 0.682	750	High/Low
	M6	0.739 – 0.754	750	Single
	M7	0.846 – 0.885	750	High/Low
	M8	1.230 – 1.250	750	Single
	M9	1.371 – 1.386	750	Single
	M10	1.580 – 1.640	750	Single
	M11	2.225 – 2.275	750	Single
Thermal Emissive Bands	M12	3.660 – 3.840	750	Single
	M13	3.973 – 4.128	750	High/Low
	M14	8.400 – 8.700	750	Single
	M15	10.263 – 11.263	750	Single
	M16	11.538 – 12.488	750	Single
	Day-Night band	0.500 – 0.900	750 [Across entire scan]	Low | Mid | High

Table-1: VIIRS – Wavelength ranges, At-Nadir Spatial Resolution, and Band Gain

Note: The VCST has confirmed that the JPSS-1/NOAA-20-based VIIRS instrument's I3 image-band's detector-29 is extremely noisy. Based on the recommendation of the VIIRS Science Team, the L1B products will retain the original calibrated values instead of fill-values. This applies to both the C2 and C2.1 collections. The JPSS-1 VIIRS L1B pixel-level quality flag for "Noisy_Detector" indicates this anomaly (vide Tables-C.1 and C.2).

2.3 On-board aggregation, aggregation zones, and bow-tie deletion

To minimize the growth of pixels toward the end of the scan generally observed in data acquired by MODIS, AVHRR and other instruments, VIIRS has implemented a unique method to aggregate pixels along the scan. Hence, this renders VIIRS spatial resolutions for nadir and end-of-scan pixels more comparable. This pixel aggregation is performed on-board for the Earth-view data from single-gain M-bands and the I-bands. Such along-scan aggregations for the dual-gain M-bands are carried out during ground processing to match the on-board single-gain aggregation. The DNB, by design, has no significant pixel growth since the DNB Charge-Coupled Device's (CCD) array elements are arranged to maintain a near-constant 742-m pixel size across an entire scan.

To save transmission bandwidth, VIIRS has implemented an on-board process to remove bow-tie observations that eliminates duplicate pixels in the off-nadir spaces where several pixels from adjacent scans overlap. This on-board processing of the raw data does produce visual artifacts in the Level-1 swath and downstream Level-2 products that are removable through interpolation of the samples as part of the geolocation process.

2.4 Reflective solar band and Thermal emissive band calibration

To assure sensor on-orbit calibration, the VIIRS instrument carries a set of on-board calibrators (OBC), which include a solar diffuser (SD) and a solar diffuser stability monitor (SDSM) primarily used for the RSB calibration and a blackbody (BB) for the TEBs. The VIIRS RSBs, including the DNB low-gain stage, are calibrated each orbit by a SD panel made of space-grade spectralon placed behind a solar attenuation screen (SAS). On-orbit changes in SD bidirectional reflectance distribution function (BRDF) are regularly tracked by the SDSM through alternate and near-simultaneous measurements of the sunlight, passing through a fixed attenuation screen, and that reflected off the SD panel. The SDSM has 8 detectors (D1-D8), covering wavelengths from 0.41 to 0.93 μm. Similar to MODIS, the VIIRS SD degradation is strongly wavelength-dependent, with larger degradation at shorter wavelengths. The SDSM (for SNPP VIIRS) was operated more frequently during the early mission, and then changed to 3 times per week. The RSB detectors signal-to-noise ratios (SNR) are calculated using SD observations over a wide range of input signals. The noise characterization performances are monitored on-orbit regularly.

Using the same strategy developed for MODIS, lunar observations by roll maneuvers have also been regularly scheduled for both (SNPP and JPSS-1) VIIRS instruments and used to track their RSB calibration stability. The VIIRS lunar observations are made through its Space View (SV) port, and with Moon phase angles that are typically between -51.5° and -50.5°. Due to the roll-angle limitation and safety concern for the spacecraft, the lunar observations are scheduled approximately 8 to 10 times each year. In general, the lunar calibration results are consistent with its SD calibration to within ±1.0%.

The TEBs are calibrated by an on-board blackbody on a scan-by-scan basis. The temperature-controlled BB is monitored by 6 embedded thermistors traceable to the National Institute of Standards and Technology (NIST), and protected from stray light by a shield plate. During instrument nominal operations, the BB temperature is controlled at 292.7 K. On a quarterly basis, a BB warm-up and cool-down (WUCD) operation is performed with its temperatures varying between 267 K (the instrument ambient) and 315 K. The data collected during BB WUCD have been used to monitor on-orbit changes in TEB detectors' offset and nonlinear calibration coefficients. The TEB detectors' noise characterization is performed using BB WUCD data at different temperatures (radiances) in terms of noise equivalent temperature differences (NEΔT).

2.5 Uncertainty Index

The uncertainty index (UI) in the L1B SDS layer holds an 8-bit integer for each pixel. These integers represent the estimate of the uncertainty in each measurement of reflectance for the RSBs and radiance for the TEBs and DNB [1][2][3]. A fill-value of -1 is set when observation data is missing or when the data cannot be calibrated. The indices take on values of 0 through 127. A value of 127 represents a 100% uncertainty value or above. The L1B computes and reports the Uncertainty Index corresponding to the measured percent uncertainty, and is derived from the uncertainty index through the following formula:

Uncertainty_in_percent = 1.0 + scaling_factor * UI^2

The scaling_factor values for all the bands are the same per L1B design. The attributes are provided for convenience to those downstream users who convert the uncertainty index to percent uncertainty.

3.0 NASA VIIRS Level-1 Processing Flow

The NASA VIIRS Level-1 software and data products largely follow the model previously developed for MODIS:

- The software includes separate executable modules for Level-1A, Geolocation, Onboard Calibrator (OBC) and Level-1B processing.
- The Level-1A product provides the input to the Geolocation, Level-1B and OBC software.
- The nominal temporal duration of the NASA VIIRS L1 granule is 6-minutes (360 seconds) in contrast to a NOAA VIIRS L1 granule, which is 85.35 seconds.

The VIIRS Level-1 processing flow is illustrated in Figure-1, which shows the processing software modules, input data types (raw, dynamic ancillary, static ancillary), look-up tables (LUTs) and data products.

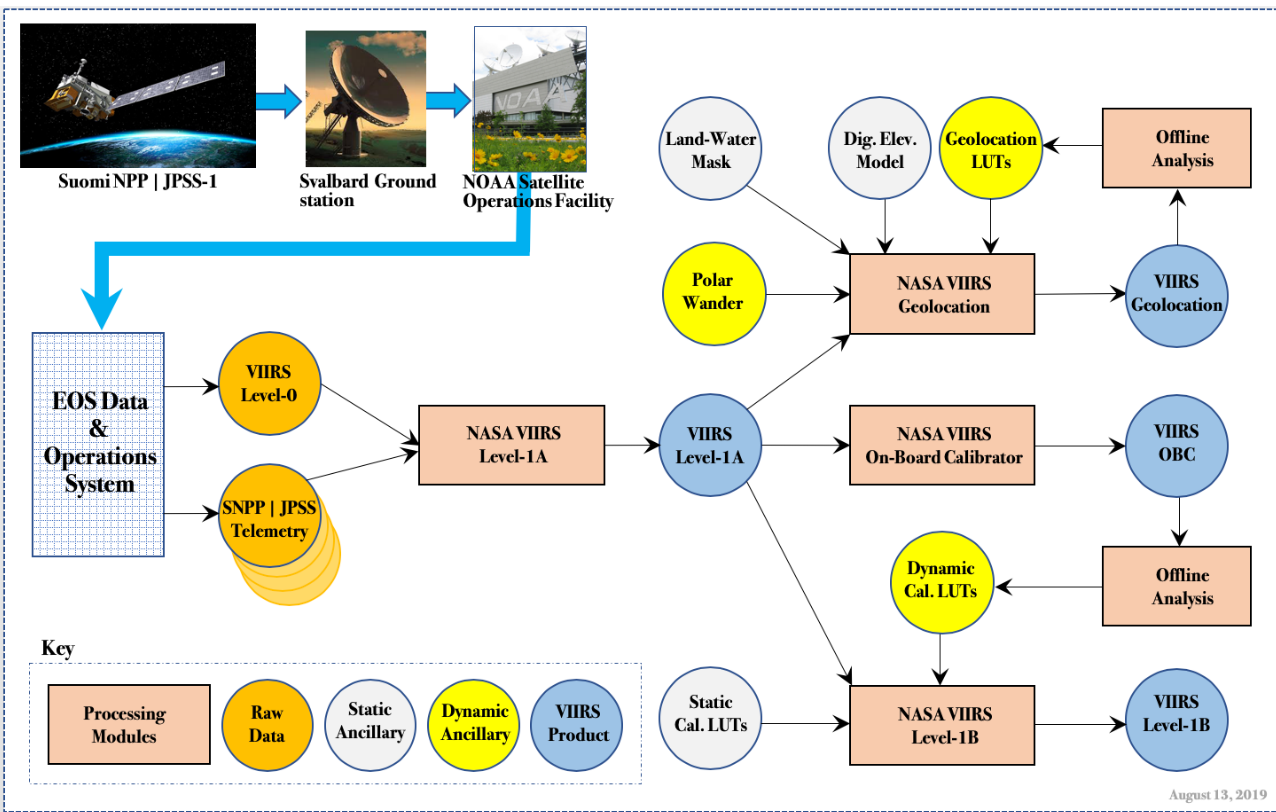

Figure-1: NASA VIIRS Level-1 Processing Flow

The NOAA Satellite Operations Facility (NSOF) in Suitland, MD acquires the SNPP and J1 VIIRS raw instrument data via the Svalbard Ground station in Norway. EDOS receives, from the NSOF-based JPSS Command, Control and Communications Segment JPSS Stored Mission Data Hub (C3S JSH), Annotated Virtual Channel Data Units (aVCDU) for both SNPP and J1missions to perform Level-0 processing before delivering them to the relevant NASA SIPS [5]. EDOS-produced Level-0 data are called Production Data Sets (PDS) that are of two types: A session-based PDS (S-PDS) contains instrument or spacecraft packet data for a single downlink (approximately 1 orbit), while a time-based PDS (T-PDS) contains data for a specified time period that spans 2 hours. The PDS formats are specified in Reference [7], and that of the VIIRS packets in Reference [6].

The VIIRS Level-1 data products follow the standard NASA EOS definitions for product levels, as specified in Reference [4]. Given the requirement to archive them at EOSDIS DAACs, they include standard processed data products along with their granule metadata. The metadata for the VIIRS Level-1 data products are stored as NetCDF4/HDF5 attributes. The granule-level metadata are stored as attributes at the file-level, while the object-level metadata are stored using attributes attached to the individual data objects. An Interface Control Document (ICD) describes the SNPP Science Data Segment elements, specific to each SIPS' processing and distribution responsibilities, and their interfaces in Reference [8].

As stated above, a VIIRS granule's temporal duration is specified to last exactly 6 minutes, which is synchronized with the UTC (Coordinated Universal Time) day. This was chosen at the request of the VIIRS Atmosphere team for compatibility with the Cross-track Infrared Sounder (CrIS) data products; CrIS is part of the instrument payload in every JPSS mission. The granulation of the VIIRS data is performed during the Level-1A processing, with each granule containing all the VIIRS scans that start within the granule period.

The same Level-1 software is installed at all three VIIRS discipline-SIPSs (i.e., Atmosphere, Land, and Ocean) that each produce domain-specific higher-level products. VIIRS atmosphere products generated by the Atmosphere SIPS at the Space Science and Engineering Center (SSEC), University of Wisconsin, Madison are transmitted to LAADS for archiving and distribution. VIIRS land products generated by Land SIPS at GSFC are transmitted to the Land Processes DAAC in Sioux Falls, SD for archiving and distribution. Land-SIPS-produced cryosphere products are exported to the National Snow and Ice Data Center (NSIDC) DAAC in Boulder, CO for archiving and distribution. VIIRS ocean products generated by the Ocean SIPS are archived and distributed by the Ocean Biology DAAC at GSFC. VIIRS Level-1 products are produced by Land SIPS, and archived and distributed via the LAADS DAAC at GSFC.

This User Guide primarily describes the data structure and contents of the following two sets of VIIRS Level-1 Geolocation (Section 4.0) and Level-1B calibrated radiance products (Section 5.0) for both the SNPP- and J1-derived products; each set contains three products (Table-2). Please note that *VNP* is the prefix within the short-names for SNPP products while *VJ1* indicates their J1-derived source. The long-names contain *NPP* and *JPSS1* to indicate their sources, respectively.

ESDT Short-name	Long-name
	Geolocation
VNP | VJ1 03IMG	VIIRS/(NPP | JPSS1) Imagery Resolution Terrain Corrected Geolocation 6-Min L1 Swath 375m
VNP | VJ1 03MOD	VIIRS/(NPP | JPSS1) Moderate Resolution Terrain Corrected Geolocation 6-Min L1 Swath 750m
VNP | VJ1 03DNB	VIIRS/(NPP | JPSS1) Day/Night Band Resolution Terrain Corrected Geolocation 6-Min L1 Swath 750m
	Calibrated Radiance
VNP | VJ1 02IMG	VIIRS/(NPP | JPSS1) Imagery Resolution 6-Min L1B Swath 375m
VNP | VJ1 02MOD	VIIRS/(NPP | JPSS1) Moderate Resolution 6-Min L1B Swath 750m
VNP | VJ1 02DNB	VIIRS/(NPP | JPSS1) Day/Night Band 6-Min L1B Swath 750m

Table-2: NASA SNPP and J1 VIIRS L1 Geolocation and L1B Calibrated Radiance products

4.0 Level-1 Geolocation Data Products

The VIIRS Geolocation data products contain the geographical coordinate locations, i.e., the latitudes and longitudes for every pixel location/observation, and related data including sensor and solar zenith and azimuth angles, height, range, land/water mask, and quality flags. Separate products exist for each resolution (I-band, M-band, Day-Night Band (DNB)). These products, in netCDF4/HDF5 format, are stored in the following three data groups: **geolocation_data**, **navigation_data** and **scan_line_attributes**. These names reflect the exact style (i.e., lower-case, underscores, etc.) as encoded in the netCDF metadata. The following tables provide detailed specifications of the variables under each of these three data groups. The VIIRS geolocation products for each resolution (I-, M-band, and DNB) also contain several global metadata attributes; check Appendix A for a sample of the J1 VIIRS

L1 (VJ103IMG) product's global attributes. Consult Reference [11] to understand SNPP VIIRS' prelaunch and on-orbit geometric calibration and characterization.

4.1 geolocation_data

Table-3 specifies the geolocation Science Data Set (SDS) variables within the 375-m VNP|VJ103IMG geolocation products, whose image dimensions are 6464 rows by 6400 pixels.

SDS layer	Units	Bit-type	Fill-value	Valid range	Scale factor
Terrain height at pixel locations	meters	16-bit integer	-32768	Max = 10000 Min = -1000	1.0
Land/Water mask at pixel locations	NA	8-bit unsigned integer	255	Flag values = 0, 1, 2, 3, 4, 5, 6, 7*	NA
Latitudes of pixel locations	degrees_north	32-bit floating point	-999.9	Max = 90.0 Min = -90.0	NA
Longitudes of pixel locations	degrees_east	32-bit floating point	-999.9	Max = 180.0 Min = -180.0	NA
Geolocation pixel quality flags	NA	8-bit unsigned integer	NA	Flag masks = 1, 2, 4, 8**	NA
Satellite-to-pixel range	meters	16-bit integer	-32768	Max = 32767 Min = 0	100.0
Sensor azimuth angle at pixel locations	degrees	16-bit integer	-32768	Max = 18000 Min = -18000	0.01
Sensor zenith angle at pixel locations	degrees	16-bit integer	-32768	Max = 18000 Min = 0	0.01
Solar azimuth angle at pixel locations	degrees	16-bit integer	-32768	Max = 18000 Min = -18000	0.01
Solar zenith angle at pixel locations	degrees	16-bit integer	-32768	Max = 18000 Min = 0	0.01

* Land-water mask flag meanings: 0 = Shallow_Ocean, 1 = Land, 2 = Coastline, 3 = Shallow_Inland, 4 = Ephemeral, 5 = Deep_Inland, 6 = Continental, 7 = Deep_Ocean

** Geolocation pixel quality flag meanings: 1 = Input_invalid, 2 = Pointing_bad, 4 = Terrain_bad, 8 = SolarAngle_bad

Table-3: Geolocation SDS variables in the 375-m VNP|VJ103IMG geolocation products

Table-4 outlines the geolocation SDS variables in the 750-m VNP|VJ103MOD geolocation products whose image dimensions are 3232 lines by 3200 pixels.

SDS layer	Units	Bit-type	Fill-value	Valid range	Scale factor
Terrain height at pixel locations	meters	16-bit integer	-32768	Max = 10000 Min = -1000	1.0
Land/Water mask at pixel locations	NA	8-bit unsigned integer	255	Flag values = 0, 1, 2, 3, 4, 5, 6, 7*	NA
Latitudes of pixel locations	degrees_north	32-bit floating point	-999.9	Max = 90.0 Min = -90.0	NA
Longitudes of pixel locations	degrees_east	32-bit floating point	-999.9	Max = 180.0 Min = -180.0	NA
Geolocation pixel quality flags	NA	8-bit unsigned integer	NA	Flag masks = 1, 2, 4, 8**	NA
Satellite-to-pixel range	meters	16-bit integer	-32768	Max = 32767 Min = 0	100.0
Sensor azimuth angle at pixel locations	degrees	16-bit integer	-32768	Max = 18000 Min = -18000	0.01
Sensor zenith angle at pixel locations	degrees	16-bit integer	-32768	Max = 18000 Min = 0	0.01
Solar azimuth angle at pixel locations	degrees	16-bit integer	-32768	Max = 18000 Min = -18000	0.01
Solar zenith angle at pixel locations	degrees	16-bit integer	-32768	Max = 18000 Min = 0	0.01
Water present flag	NA	16-bit integer	-32768	Flag values = 0, 2, 4, 6, 8***	NA

* Land-water mask flag meanings: 0 = Shallow_Ocean, 1 = Land, 2 = Coastline, 3 = Shallow_Inland, 4 = Ephemeral, 5 = Deep_Inland, 6 = Continental, 7 = Deep_Ocean

** Geolocation pixel quality flag meanings: 1 = Input_invalid, 2 = Pointing_bad, 4 = Terrain_bad, 8 = SolarAngle_bad

*** Water present flag meanings: 0 = no Imagery Resolution pixels contain ocean, 2 = 1 Imagery Resolution pixel contains ocean, 4 = 2 Imagery pixels, 6 = 3 Imagery pixels, 8 = 4 Imagery pixels

Table-4: Geolocation SDS variables in the 750-m VNP|VJ103MOD geolocation products

Table-5 specifies the geolocation SDS variables within the 750-m VNP|VJ103DNB geolocation products, whose image dimensions are 3232 rows by 4064 pixels.

SDS layer	Units	Bit-type	Fill-value	Valid range	Scale factor
Terrain height at pixel locations	meters	16-bit integer	-32768	Max = 10000 Min = -1000	1.0
Land/Water mask at pixel locations	NA	8-bit unsigned integer	255	Flag values = 0, 1, 2, 3, 4, 5, 6, 7*	NA
Latitudes of pixel locations	degrees_north	32-bit floating point	-999.9	Max = 90.0 Min = -90.0	NA
Longitudes of pixel locations	degrees_east	32-bit floating point	-999.9	Max = 180.0 Min = -180.0	NA
Lunar azimuth at pixel locations	degrees	16-bit integer	-32768	Max = 18000 Min = -18000	0.01
Lunar zenith at pixel locations	degrees	16-bit integer	-32768	Max = 18000 Min = 0	0.01
Moon illumination fraction at pixel locations	percent	16-bit integer	-32768	Max = 10000 Min = 0	0.01
Moon phase angle at pixel locations	degrees	16-bit integer	-32768	Max = 18000 Min = 0	0.01
Geolocation pixel quality flags	NA	8-bit unsigned integer	NA	Flag masks = 1, 2, 4**	NA
Satellite-to-pixel range	meters	16-bit integer	-32768	Max = 32767 Min = 0	100.0
Sensor azimuth angle at pixel locations	degrees	16-bit integer	-32768	Max = 18000 Min = -18000	0.01
Sensor zenith angle at pixel locations	degrees	16-bit integer	-32768	Max = 18000 Min = 0	0.01
Solar azimuth angle at pixel locations	degrees	16-bit integer	-32768	Max = 18000 Min = -18000	0.01
Solar zenith angle at pixel locations	degrees	16-bit integer	-32768	Max = 18000 Min = 0	0.01

* Land-water mask flag meanings: 0 = Shallow_Ocean, 1 = Land, 2 = Coastline, 3 = Shallow_Inland, 4 = Ephemeral, 5 = Deep_Inland, 6 = Continental, 7 = Deep_Ocean

** Geolocation pixel quality flag meanings: 1 = Input_invalid, 2 = Pointing_bad, 4 = Terrain_bad

Table-5: Geolocation SDS variables in the 750-m VNP|VJ103DNB geolocation products

4.2 navigation_data

The navigation_data group contains the ephemeris and attitude data for each scan, along with input values for additional information used in geolocation (Sun and Moon vectors). Table-5 below provides detailed specifications of the navigation-related variables for the 375-m I-band, and 750-m M-band and DNB products.

SDS layer	Units	Bit-type	Fill-value	Valid range	Scale factor
Attitude angles (roll, pitch, yaw) at EV end-times	degrees	32-bit floating point	-999.9	Max = 180.0 Min = -180.0	NA
Attitude angles (roll, pitch, yaw) at EV mid-times	degrees	32-bit floating point	-999.9	Max = 180.0 Min = -180.0	NA
Attitude angles (roll, pitch, yaw) at EV start-times	degrees	32-bit floating point	-999.9	Max = 180.0 Min = -180.0	NA
Attitude quaternions at EV mid-times (J2000 to spacecraft)	NA	32-bit floating point	-999.9	Max = 1.0 Min = -1.0	NA
Earth-Moon distance	meters	32-bit floating point	-999.9	Max = 4.2E8 Min = 3.5E8	NA
Earth-Sun distance	AU	32-bit floating point	-999.9	Max = 1.02 Min = 0.98	NA
Lunar unit vectors in VIIRS frame	NA	32-bit floating point	-999.9	Max = 1.0 Min = -1.0	NA
Lunar unit vectors in J2000 frame	NA	32-bit floating point	-999.9	Max = 1.0 Min = -1.0	NA
Orbit position vectors at EV end-times (ECR)	meters	32-bit floating point	-9999999.0	Max = 7300000.0 Min = -7300000.0	NA
Orbit position vectors at	meters	32-bit floating point	-9999999.0	Max = 7300000.0	NA

EV mid-times (ECR)				Min = -7300000.0	
Orbit position vectors at EV start-times (ECR)	meters	32-bit floating point	-9999999.0	Max = 7300000.0 Min = -7300000.0	NA
Orbit velocity vectors at EV end-times (ECR)	meters/second	32-bit floating point	-9999999.0	Max = 7600 Min = -7600	NA
Orbit velocity vectors at EV mid-times (ECR)	meters/second	32-bit floating point	-9999999.0	Max = 7600 Min = -7600	NA
Orbit velocity vectors at EV start-times (ECR)	meters/second	32-bit floating point	-9999999.0	Max = 7600 Min = -7600	NA
Solar unit vectors in VIIRS frame	NA	32-bit floating point	-999.9	Max = 1.0 Min = -1.0	NA
Solar unit vectors in J2000 frame	NA	32-bit floating point	-999.9	Max = 1.0 Min = -1.0	NA

Table-6: Navigation SDS variables in the 375-m VNP|VJ103IMG, 750-m VNP|VJ103MOD and VNP|VJ103DNB geolocation products

4.3 scan_line_attributes

The scanline attributes group within the geolocation product contain a number of scan-level data objects for all channels that are described in the following table.

SDS layer	Units	Bit-type	Fill-value	Valid range	Scale factor
Earth view mid time (TAI93)	seconds	64-bit floating point	-999.9	Max = 2.0E9 Min = 0.0	NA
Half-angle mirror side	NA	8-bit unsigned integer	255	Max = 1 Min = 0	NA
Scan end time (TAI93)	seconds	64-bit floating point	-999.9	Max = 2.0E9 Min = 0.0	NA
Geolocation scan quality flags	NA	16-bit integer	-999	Flag masks = 1, 2, 3, 4, 8, 12, 16, 32, 64, 128, 256, 512, 1024, 2048, 4096*	NA
Scan start time (TAI93)	seconds	64-bit floating point	-999.9	Max = 2.0E9 Min = 0.0	NA

VIIRS sensor mode	NA	8-bit unsigned integer	255	Flag values = 0, 1, 2, 3, 4, 5, 6**	NA

* Geolocation scan quality flag meanings: 1 = eaGap_small, 2 = eaGap_medium, 3 = eaGap_large, 4 = HAMRTA_encoder_corrupt_fullScan, 8 = HAMRTA_encoder_corrupt_partScan, 12 = HAMRTA_encoder_missing_packets 16 = SAA, 32 = Solar_eclipse, 64 = Lunar_eclipse (DNB_only), 128 = Spare (Unused), 256 = SCE_Side_A_B, 512 = SCE_side_invalid, 1024 = HAM_non_nominal_start, 2048 = Synch_loss, 4096 = Sector_rotation

** VIIRS sensor mode flag meanings: 0 = Launch, 1 = Activation, 2 = Outgas, 3 = Diagnostic, 4 = Day, 5 = Night, 6 = Safe

Note specific to the SAA flag mask: The Quality Flag for SAA is supported for the days when a solar or a lunar eclipse occurs (e.g., https://eclipse.gsfc.nasa.gov/solar.html, https://eclipse.gsfc.nasa.gov/lunar.html).

Table-7: Scanline SDS variables in the 375-m VNP|VJ103IMG, 750-m VNP|VJ103MOD and VNP|VJ103DNB geolocation products

5.0 Level-1B Calibrated Radiance Products

The VIIRS Level-1B products contain calibrated radiance values, quality flags, uncertainty indices, and an array of related information that are contained in three data groups: **observation data**, **scan_line_attributes**, and **diagnostics**; data exist in separate products for each resolution (I-bands, M-bands, and DNB). What follows are detailed specifications of the variables for each data group. A detailed description of the quality flags and a comparison with the current IDPS SDR flags is provided in Appendix-A. The VIIRS L1B products for each resolution (I-, M-band, and DNB) also contain several global metadata attributes; check Appendix B for a sample of the SNPP VIIRS L1B (VNP02IMG) product's global attributes. Reference [10] provides an assessment of the early on-orbit performance of the VIIRS instrument aboard the SNPP platform.

5.1 observation data

The **observation_data** group contains the calibrated science data and the pixel-level quality flags. The I- and M-band data are stored as scaled integers, while the DNB data are stored as floating-point values given their dynamic range. For the reflective solar bands (RSB), scale factor, offset and unit attributes are provided for both reflectance and radiance values. The stored reflectance is actually the product of the true reflectance and the cosine of the solar zenith angle at the pixel location; you need to divide the reconstituted reflectance by the cosine of solar zenith to obtain reflectance. The radiance and reflectance offset values, for the RSBs, are both 0.

For the thermal emissive bands (TEB), LUTs for the radiance-to-brightness temperature conversion are also included. To determine the brightness temperature corresponding to each radiance, the scaled integer values are used as indices for the brightness temperature LUTs.

I-bands 01 – 03 Earth-view reflectance variables

SDS layer	Bit-type	Radiance Units	Fill-value	Valid range	Radiance scale factor*	Scale factor	Flag values
I-band 01 EV reflectance	16-bit unsigned integer	watts/m^2/steradian/μm	65535	Max = 65527 Min = 0	0.010461028	1.9991758E-5	65532, 65533, 65534**
I-band 02 EV reflectance	16-bit unsigned integer	watts/m^2/steradian/μm	65535	Max = 65527 Min = 0	0.006181275	1.9991758E-5	65532, 65533, 65534**
I-band 03 EV reflectance	16-bit unsigned integer	watts/m^2/steradian/μm	65535	Max = 65527 Min = 0	0.0015760256	1.9991758E-5	65532, 65533, 65534**

* Radiance scale factor values are granule-dependent

* * Flag meanings: 65532 = Missing_EV, 65533 = Bowtie_Deleted, 65534 = Cal_Fail

I-bands 04 – 05 Earth-view radiance variables

SDS layer	Bit-type	Radiance Units	Fill-value	Valid range	Add offset	Scale factor	Flag values
I-band 04 EV radiance	16-bit unsigned integer	watts/m^2/steradian/μm	65535	Max = 65527 Min = 0	0.0016703	6.104354E-5	65532, 65533, 65534*
I-band 05 EV radiance	16-bit unsigned integer	watts/m^2/steradian/μm	65535	Max = 65527 Min = 0	0.141121	3.815221E-5	65532, 65533, 65534*

* Flag meanings: 65532 = Missing_EV, 65533 = Bowtie_Deleted, 65534 = Cal_Fail

I-bands 04 – 05 Brightness Temperature LUT

SDS layer	Bit-type	Radiance Units	Fill-value	Valid range
I-band 04 Brightness Temperature LUT	32-bit floating-point	Kelvin	-999.9	Max = 361.77588 Min = 208.00002
I-band 05 Brightness Temperature LUT	32-bit floating-point	Kelvin	-999.9	Max = 423.33734 Min = 150.0

I-bands 01 – 05 Quality flags

SDS layer	Bit-type	Flag masks
I-bands 01 – 05 quality flags	16-bit unsigned integer	1, 2, 4, 8, 256, 512, 1024, 2048, 4096*

* Flag meanings: 1 = Substitute_Cal, 2 = Out_of_Range, 4 = Saturation, 8 = Temp_not_Nominal, 256 = Bowtie_Deleted, 512 = Missing_EV, 1024 = Cal_Fail, 2048 = Dead_Detector, 4096 = Noisy_Detector

I-bands 01 – 05 Uncertainty indices

SDS layer	Bit-type	Units	Fill-value	Valid range	Conversion	Scale factor
I-band 01 – 05 uncertainty indices	16-bit integer	percent	-1	Max = 127 Min = 0	1.0 + scale * index^2	0.006138

Table-8: Observation data variables (reflectance, radiance, BT, QA, uncertainty) in the 375-m VNP|VJ102IMG L1B calibrated radiance products

M-bands 01 – 11 Earth-view reflectance variables

SDS layer	Bit-type	Radiance Units	Fill-value	Valid range	Radiance scale factor*	Scale factor	Flag values
M-band 01 EV reflectance	16-bit unsigned integer	watts/m²/steradian/μm	65535	Max = 65527 Min = 0	0.010990608	1.9991758E-5	65532, 65533, 65534**
M-band 02 EV reflectance	16-bit unsigned integer	watts/m²/steradian/μm	65535	Max = 65527 Min = 0	0.011957901	1.9991758E-5	65532, 65533, 65534**
M-band 03 EV reflectance	16-bit unsigned integer	watts/m²/steradian/μm	65535	Max = 65527 Min = 0	0.0128436815	1.9991758E-5	65532, 65533, 65534**
M-band 04 EV reflectance	16-bit unsigned integer	watts/m²/steradian/μm	65535	Max = 65527 Min = 0	0.012003864	1.9991758E-5	65532, 65533, 65534**
M-band 05 EV reflectance	16-bit unsigned integer	watts/m²/steradian/μm	65535	Max = 65527 Min = 0	0.0098244045	1.9991758E-5	65532, 65533, 65534**
M-band 06 EV reflectance	16-bit unsigned integer	watts/m²/steradian/μm	65535	Max = 65527 Min = 0	0.008220849	1.9991758E-5	65532, 65533, 65534**
M-band 07 EV reflectance	16-bit unsigned integer	watts/m²/steradian/μm	65535	Max = 65527 Min = 0	0.0061797476	1.9991758E-5	65532, 65533, 65534**
M-band 08 EV reflectance	16-bit unsigned integer	watts/m²/steradian/μm	65535	Max = 65527 Min = 0	0.002928277	1.9991758E-5	65532, 65533, 65534**

M-band 09 EV reflectance	16-bit unsigned integer	watts/m^2/steradian/μm	65535	Max = 65527 Min = 0	0.0023088641	1.9991758E-5	65532, 65533, 65534**
M-band 10 EV reflectance	16-bit unsigned integer	watts/m^2/steradian/μm	65535	Max = 65527 Min = 0	0.0015735304	1.9991758E-5	65532, 65533, 65534**
M-band 11 EV reflectance	16-bit unsigned integer	watts/m^2/steradian/μm	65535	Max = 65527 Min = 0	4.8158638E-4	1.9991758E-5	65532, 65533, 65534**

* Radiance scale factor values are granule-dependent

* * Flag meanings: 65532 = Missing_EV, 65533 = Bowtie_Deleted, 65534 = Cal_Fail

M-bands 12 – 16 Earth-view radiance variables

SDS layer	Bit-type	Radiance Units	Fill-value	Valid range	Add offset	Scale factor	Flag values
M-band 12 EV radiance	16-bit unsigned integer	watts/m^2/steradian/μm	65535	Max = 65527 Min = 0	8.34405E-4	7.630442E-5	65532, 65533, 65534*
M-band 13 EV radiance	16-bit unsigned integer	watts/m^2/steradian/μm	65535	Max = 65527 Min = 0	0.00108056	0.008088269	65532, 65533, 65534*
M-band 14 EV radiance	16-bit unsigned integer	watts/m^2/steradian/μm	65535	Max = 65527 Min = 0	0.00219747	3.5100034E-4	65532, 65533, 65534*
M-band 15 EV radiance	16-bit unsigned integer	watts/m^2/steradian/μm	65535	Max = 65527 Min = 0	0.0048362	3.6626123E-4	65532, 65533, 65534*
M-band 16 EV radiance	16-bit unsigned integer	watts/m^2/steradian/μm	65535	Max = 65527 Min = 0	0.00390568	3.2047858E-4	65532, 65533, 65534*

* Flag meanings: 65532 = Missing_EV, 65533 = Bowtie_Deleted, 65534 = Cal_Fail

M-bands 12 – 16 Brightness Temperature LUT

SDS layer	Bit-type	Radiance Units	Fill-value	Valid range
M-band 12 Brightness Temperature LUT	32-bit floating-point	Kelvin	-999.9	Max = 372.42026 Min = 203.0
M-band 13 Brightness Temperature LUT	32-bit floating-point	Kelvin	-999.9	Max = 665.9161 Min = 192.00003
M-band 14 Brightness Temperature LUT	32-bit floating-point	Kelvin	-999.9	Max = 355.17572 Min = 120.0
M-band 15 Brightness Temperature LUT	32-bit floating-point	Kelvin	-999.9	Max = 374.59943

				Min = 110.99999
M-band 16 Brightness Temperature LUT	32-bit floating-point	Kelvin	-999.9	Max = 375.87753 Min = 102.99999

M-bands Quality flags

SDS layer	Bit-type	Flag masks
M-band 01 – 05, 07, 13 quality flags	16-bit unsigned integer	1, 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024, 2048, 4096*
M-band 06, 08 – 12, 14 – 16 quality flags	16-bit unsigned integer	1, 2, 4, 8, 256, 512, 1024, 2048, 4096**

* Flag meanings: 1 = Substitute_Cal, 2 = Out_of_Range, 4 = Saturation, 8 = Temp_not_Nominal, 16 = Low_Gain, 32 = Mixed_Gain, 64 = DG_Anomaly, 128 = Some_Saturation, 256 = Bowtie_Deleted, 512 = Missing_EV, 1024 = Cal_Fail, 2048 = Dead_Detector, 4096 = Noisy_Detector

** Flag meanings: 1 = Substitute_Cal, 2 = Out_of_Range, 4 = Saturation, 8 = Temp_not_Nominal, 256 = Bowtie_Deleted, 512 = Missing_EV, 1024 = Cal_Fail, 2048 = Dead_Detector, 4096 = Noisy_Detector

M-bands 01 – 16 Uncertainty indices (for 16 separate bands)

SDS layer	Bit-type	Units	Fill-value	Valid range	Conversion	Scale factor
M-band 01 – 16 uncertainty indices	16-bit integer	percent	-1	Max = 127 Min = 0	1.0 + scale * index^2	0.006138

Table-9: Observation data variables (reflectance, radiance, BT, QA, uncertainty) in the 750-m VNP|VJ102MOD L1B calibrated radiance products

DNB observations

SDS layer	Bit-type	Radiance Units	Fill-value	Valid range
DNB observations at pixel locations	32-bit floating point	watts/cm^2/steradian	-999.9	Max = 0.04 Min = 0.0

DNB Quality flags

SDS layer	Bit-type	Flag masks
DNB quality flags	16-bit unsigned integer	1, 2, 4, 8, 16, 256, 512, 1024, 2048, 4096*

* Flag meanings: 1 = Substitute_Cal, 2 = Out_of_Range, 4 = Saturation, 8 = Temp_not_Nominal, 16 = Stray_light, 256 = Bowtie_Deleted, 512 = Missing_EV, 1024 = Cal_Fail, 2048 = Dead_Detector, 4096 = Noisy_Detector

Table-10: Observation data variables in the 750-m VNP|VJ102DNB L1B calibrated radiance products

5.2 scan_line_attributes

Scanline attributes (I-bands, M-bands, DNB)

SDS layer	Bit-type	Units	Fill-value	Valid range	Flag masks
Earth-view mid-time (TAI93)	64-bit floating point	seconds	-999.9	Max = 2.0E9 Min = 0.0	NA
Scan end time (TAI93)	64-bit floating point	seconds	-999.9	Max = 2.0E9 Min = 0.0	NA
Scan start time (TAI93)	64-bit floating point	seconds	-999.9	Max = 2.0E9 Min = 0.0	NA
Scan quality flags	8-bit unsigned integer	NA	255	NA	1, 2, 4, 8, 16, 32, 64*
Scan state flags	8-bit unsigned integer	NA	255	NA	1, 2, 4**

* Scan quality flag meanings: 1 = Moon_in_SV_KOB, 2 = EV_Data, 4 = Sensor_Mode, 8 = Scan_Sync, 16 = Tel_Start, 32 = BB_Temp, 64 = LWIR_Temp

** Scan state flag meanings: 1 = HAM_Side, 2 = Electronics_Side, 4 = Night_Mode

Table-11: Scanline attributes in the SNPP | JPSS-1 L1B calibrated radiance product for all resolutions

5.3 diagnostics

This group contains a set of diagnostic arrays that are available for the Level-1B I-band and M-band products that are used in calibration-specific testing and analysis. Given that most application users will probably not use these datasets, a more detailed explanation of the specifications of this group is not warranted.

6.0 NASA VIIRS Level-1B: Product Status, Filenames, Data Ordering/Handling, etc.

The NASA VIIRS L1B suite of products are deemed science quality following an extensive evaluation of their radiometric calibration and geolocation behavior performed by the VCST and VIIRS Geolocation group. The six L1 products, identified in Table-1, are being produced from the beginning of the mission in January 19th 2012 for SNPP, and from January 5th 2018. To reiterate, the six products identified earlier include the following:

VNP | VJ103IMG – VIIRS/JPSS1 Imagery Resolution Terrain Corrected Geolocation 6-Min L1 Swath 375m

VNP | VJ103MOD – VIIRS/ JPSS1 Moderate Resolution Terrain Corrected Geolocation 6-Min L1 Swath 750m

VNP | VJ103DNB – VIIRS/ JPSS1 Day/Night Band Res. Terrain Corrected Geoloc. 6-Min L1 Swath 750m

VNP | VJ102IMG – VIIRS/ JPSS1 Imagery Resolution 6-Min L1B Swath 375m

VNP | VJ102MOD – VIIRS/ JPSS1 Moderate Resolution 6-Min L1B Swath 750m

VNP | VJ102DNB – VIIRS/ JPSS1 Day/Night Band 6-Min L1B Swath 750m

File Naming Convention:

Syntax: **ESDT.AYYYYDDD.HHMM.VID.YYYYDDDHHMMSS.Format**

Example (SNPP): **VNP02IMG.A2015080.0800.001.2017260093934.nc**

Example (J1): **VJ102IMG.A2018008.0130.002. 2019156013358.nc**

ESDT	Earth Science Data Type or Shortname
A	Stands for Acquisition
YYYYDDD	Data acquisition year and Day-of-year per the Julian Calendar
HHMM	Acquisition Hour and Minute
VID	Data collection's Version ID
YYYYDDDHHMMSS	Processing year, Day-of-year (Julian), UTC time (hour, minutes, seconds)
Format	File format suffix, which in the above case represents netCDF4/HDF5

The above file naming convention applies to all the six L1 products (i.e., the L1B calibrated radiance (VNP02 and VJ102) and L1 geolocation (VNP03 and VJ103) products).

These products are available to acquire via both search and order, and from direct online access:

Search & Order interface: https://ladsweb.modaps.eosdis.nasa.gov/search/

Earthdata portal: https://earthdata.nasa.gov/

LAADS Web Direct online access interface URLs:

ESDT/Short-name	Description	Direct Online Access Tiny URL
VNP03IMG	SNPP VIIRS I-Resolution Geolocation	https://tinyurl.com/VNP03IMG
VNP03MOD	SNPP VIIRS M-Resolution Geolocation	https://tinyurl.com/VNP03MOD
VNP03DNB	SNPP VIIRS Day-Night Band Geolocation	https://tinyurl.com/VNP03DNB
VNP02IMG	SNPP VIIRS I-Resolution Calibrated Radiance	https://tinyurl.com/VNP02IMG
VNP02MOD	SNPP VIIRS M-Resolution Calibrated Radiance	https://tinyurl.com/VNP02MOD
VNP02DNB	SNPP VIIRS Day-Night Band Calibrated Radiance	https://tinyurl.com/VNP02DNB
VJ103IMG	JPSS-1 VIIRS I-Resolution Geolocation	https://tinyurl.com/VJ103IMG
VJ103MOD	JPSS-1 VIIRS M-Resolution Geolocation	https://tinyurl.com/VJ103MOD
VJ103DNB	JPSS-1 VIIRS Day-Night Band Geolocation	https://tinyurl.com/VJ103DNB
VJ102IMG	JPSS-1 VIIRS I-Resolution Calibrated Radiance	https://tinyurl.com/VJ102IMG
VJ102MOD	JPSS-1 VIIRS M-Resolution Calibrated Radiance	https://tinyurl.com/VJ102MOD
VJ102DNB	JPSS-1 VIIRS Day-Night Band Calibrated Radiance	https://tinyurl.com/VJ102DNB

As mentioned in the introduction, these products are produced and packaged in a hybridized netCDF4/HDF5 format that both NetCDF4 and HDF5 software can handle. Among the open-source software tools the following are good choices:

Panoply: http://www.giss.nasa.gov/tools/panoply/

HDFView: https://support.hdfgroup.org/products/java/hdfview/

QGIS: http://www.qgis.org/en/site/

Sentinel Application Platform Toolboxes: https://step.esa.int/main/download/snap-download/

Explorer series: http://www.space-research.org/

Check the LAADS Web's tools page that provides information on a variety of tools, services, and programmatic access to data that you could explore: https://ladsweb.modaps.eosdis.nasa.gov/tools-and-services/

UCAR (http://www2.ucar.edu/) has compiled a large list of open-source and proprietary software packages that handle netCDF data. Not all of them will necessarily handle all NASA standard VIIRS products, but it is worth checking this list:
http://www.unidata.ucar.edu/software/netcdf/software.html

For additional format-specific information regarding the NASA standard VIIRS products, consult the LAADS FAQs (https://ladsweb.modaps.eosdis.nasa.gov/help/faq/).

7.0 Known Calibration issues/updates in the NASA SNPP & JPSS-1 VIIRS L1B products

SNPP VIIRS L1B Collection-1-specific:

The RSB calibration coefficient F-factor is retrieved from sunlit SD observations. The SD observation relies on the knowledge of the SD BRDF change factor, namely the H-factor calculated from SDSM measurements. One of the issues on the H-factor is that it is both incident and outgoing sunlight direction-dependent but the SDSM only directly measures the H(SDSM) [9]. The H(SDSM) does not depend on solar azimuth angle relative to the SD screen, but H(RTA) does, evidenced by the yearly undulations of the retrieved F-factors for the VISNIR bands, using H(SDSM). So, VCST has added azimuth dependence as a multiplicative factor to H(SDSM) to remove the yearly undulations. Additionally, the F-factors derived from the SD calibrations are compared and adjusted by the lunar observations [10]. Some of the small periodic differences between the solar diffuser and lunar calibration are likely caused by the current lunar reference model.

On SNPP VIIRS, the large degradation in NIR/SWIR spectral region was primarily due to the wavelength-dependent degradation of the RTA mirror reflectance, caused by the contamination that occurred during the pre-launch mirror-coating process. Therefore, the VIIRS on-orbit calibration requires the use of time-dependent relative spectral response (RSR), or the modulated RSR; this requirement is extremely important for the DNB as well due to its broad bandwidth.

The L1B DNB product is greatly impacted by stray light. Although there are time-dependent stray light correction LUTs in Level-1B to reduce the contamination, such correction is not perfect. The evidence of stray light contamination after the correction is still visible in Level-1B, especially in nighttime orbits near the terminator regions.

SNPP VIIRS L1B Collection-2-specific:

In C2, the changes to the L1B radiometric LUT include the following:

1. More accurate retrieval of the RSB detector gains by applying 7 years of lunar calibration data, with improvements up to 1.3% with vicarious Earth-scene data, affecting L1B product trends by up to 1% and resulting in the removal of unexpected Earth-view striping and yearly undulations.

2. More accurate retrieval of the DNB detector gains and offsets, resulting in some removal of nighttime Earth-view striping.

JPSS-1 VIIRS L1B Collection-2-specific:

In C2 JPSS-1 VIIRS L1B data, there is no discernible improvement over C1 per se, because the C1 L1B test was not officially released by the Land team. Here is a brief description of what′s newly implemented in JPSS-1 VIIRS C2:

1. Add noisy detector quality flag in L1B; assign band I3 detector 29 as a noisy detector.
2. More accurate and smoother on-orbit RSB gain trends, that affects the L1B product trends by up to 1%.

8.0 Acronyms

AVHRR	Advanced Very-High Resolution Radiometer
BB	Blackbody
CCD	Charge-Coupled Device
CLASS	Comprehensive Large Array-Data Stewardship System [NOAA's online archive]
CrIS	Cross-track Infrared Sounder
DMSP	Defense Meteorological Satellite Program
DN	Digital Number (the raw digital signal measured at the detector)
DNB	Day-Night Band
ECR	Earth-Centered Rotational [Also referred to as ECEF: Earth-Centered, Earth-Fixed]
EDOS	EOS Data and Operations System
EM	Electromagnetic
EOS	Earth Observing System
EOSDIS	Earth Observing System Data and Information System
ESDIS	Earth Science Data and Information System
ESDT	Earth Science Data Type
EV	Earth View
GSFC	Goddard Space Flight Center
HAM	Half-Angle Mirror
HAM/RTA	Half-Angle Mirror/ Rotating Telescope Assembly
HDF	Hierarchical Data Format
IDPS	Interface Data Processing Segment
ICD	Interface Control Document
JPSS	Joint Polar Satellite System
L1ASWG	Level-1 Algorithm/Software Working Group
LAADS	Level-1 and Atmosphere Archive & Distribution System
LOS	Line-of-Sight
LPDAAC	Land Processes Distributed Active Archive Center
LSB	Least-Significant Bit
LUT	Look-Up Table
LWIR	Longwave Infrared

MODAPS	MODIS Adaptive Processing System
MODIS	Moderate Resolution Imaging Spectroradiometer
NASA	National Aeronautics and Space Administration
NEΔT	Noise-Equivalent Temperature Differences
NetCDF	Network Common Data Format
NIR	Near Infrared
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NPOESS	National Polar-orbiting Operational Environmental Satellite System Preparatory Project
NPP	NPOESS Preparatory Project
NSIDC	National Snow and Ice Data Center
NSOF	NOAA Satellite Operations Facility (Suitland, MD)
OBC	Onboard Calibration
OLS	Operational Linescan System
POES	Polar-orbiting Environmental Satellites
RTA	Rotating Telescope Assembly
QA	Quality Assurance
QF	Quality Flag
RSB	Reflective Solar Bands
RSR	Relative Spectral Response
ROSES	Research Opportunities in Space and Earth Sciences (NASA)
SAA	South Atlantic Anomaly
SAS	Solar Attenuation Screen
S/C	Spacecraft
SCE	Scan Controller Electronics
SD	Solar Diffuser
SDR	Sensor Data Record
SDS	Science Data Set
SDSM	Solar Diffuser Stability Monitor
SeaWiFS	Sea-viewing Wide Field-of-view Sensor
SIPS	Science Investigator-led Processing System
SNPP	Suomi National Polar-Orbiting Partnership

SNR	Signal-to-Noise Ratio
S-PDS	Session-based Production Data Set
SSEC	Space Science and Engineering Center
SV	Space View
SWIR	Shortwave Infrared
TAI93	International Atomic Time [from the French: *Temps Atomique International*]
TEB	Thermal Emissive Bands
TOA	Top-of-Atmosphere
T-PDS	Time-based Production Data Set
UI	Uncertainty Index
UTC	Coordinated Universal Time
VCST	VIIRS Characterization Support Team
VIIRS	Visible Infrared Imaging Radiometer Suite
WUCD	Warm-Up and Cool-Down

9.0 References

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[3] Chiang, K. V., McIntire, J., and Xiong, X. (2017). VIIRS Thermal Emissive Bands L1B Calibration Uncertainty, *IEEE International Geoscience & Remote Sensing Symposium*, 4197–4200.

[4] EOS Data Products Handbook, ed. M.D. King, et al., NASA/GSFC, 2003.

[5] ICD between Joint Polar Satellite System (JPSS) Common Ground System (CGS) to National Aeronautics and Space Administration (NASA) Science Data Segment (SDS), 474-00412, Revision E, April, 2019.

[6] Mission Data Format Control Book National Polar-Orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP) (MDFCB), Revision G, 429-05-02-42, June 2014.

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[8] ICD between Suomi National Polar-Orbiting Partnership (SNPP) Science Data Segment (SDS) Processing and Distribution Elements, 423-ICD-013, Draft, September 2016.

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[12] Wolfe, R. E., Lin, G., Nishihama, M., Tewari, K. P., Tilton, J. C., and Isaacman, A. R. (2013). Suomi NPP VIIRS prelaunch and on-orbit geometric calibration and characterization, *Journal of Geophysical Research: Atmospheres*, 118 (20): 11,508-11,521, doi: 10.1002/jgrd.50873.

Appendix-A: NASA VIIRS JPSS-1 Level-1 I-Band Geolocation Product's Global Attributes

Global Attribute	Value
project	VIIRS L1 Project
institution	NASA Goddard Space Flight Center, VIIRS L1 Processing Group
platform	JPSS-1
instrument	VIIRS
processing_level	L1
VersionId	002
SatelliteInstrument	JP1 VIIRS
ProcessingCenter	MODAPS-NASA
publisher_name	LAADS
publisher_url	http//ladsweb.nascom.nasa.gov
publisher_email	modis-ops@lists.nasa.gov
ShortName	VJ103IMG
LongName	VIIRS/JPSS1 Imagery Resolution Terrain Corrected Geolocation 6-Min L1 Swath 375m
title	title = VIIRS I-band Geolocation Data
product_name	VJ103IMG.A2018008.0130.002.2019156005902.nc
LocalGranuleID	VJ103IMG.A2018008.0130.002.2019156005902.nc
AlgorithmType	SCI
AlgorithmVersion	NPP_PR03_VCST v3.0.0
PGE_Name	PGE501
PGEVersion	3.0.18
processing_version	v3.0.0
ProcessingEnvironment	Linux minion7051 3.10.0-957.5.1.el7.x86_64 #1 SMP Fri Feb 1 14:54:57 UTC 2019 x86_64 x86_64 x86_64 GNU/Linux
date_created	2019-06-04T20:59:24Z
ProductionTime	2019-06-04T20:59:24Z
time_coverage_start	2018-01-08T01:30:00.000Z
time_coverage_end	2018-01-08T01:36:00.000Z
PGE_StartTime	2018-01-08 01:30:00.000
PGE_EndTime	2018-01-08 01:36:00.000
StartTime	2018-01-08 01:30:00.000
EndTime	2018-01-08 01:36:00.000
RangeBeginningDate	2018-01-08
RangeEndingDate	2018-01-08
RangeBeginningTime	01:30:00.000000
RangeEndingTime	01:36:00.000000
keywords_vocabulary	NASA Global Change Master Directory (GCMD) Science Keywords
stdname_vocabulary	NetCDF Climate and Forecast (CF) Metadata Convention
creator_name	VIIRS L1 Processing Group
creator_email	modis-ops@lists.nasa.gov
creator_url	http//ladsweb.nascom.nasa.gov
publisher_name	LAADS
publisher_url	http//ladsweb.nascom.nasa.gov

publisher_email	modis-ops@lists.nasa.gov
identifier_product_doi_authority	http//dx.doi.org
identifier_product_doi	10.5067/VIIRS/VJ103IMG.002
GRingPointLatitude	-56.952755f, -49.92339f, -64.245804f, -77.04124f // float
GRingPointLongitude	165.12527f, -148.51352f, -118.98022f, 153.72331f // float
GRingPointSequenceNo	1, 2, 3, 4 // int
NorthBoundingCoordinate	-49.92339f // float
SouthBoundingCoordinate	-78.031265f // float
EastBoundingCoordinate	-118.98022f // float
WestBoundingCoordinate	153.72331f // float
geospatial_lat_units	degrees_north
geospatial_lon_units	degrees_east
geospatial_lat_min	-78.031265f // float
geospatial_lat_max	-49.92339f // float
geospatial_lon_min	153.72331f // float
geospatial_lon_max	-118.98022f // float
startDirection	Ascending
endDirection	Ascending
DayNightFlag	Day
cdm_data_type	swath
format_version	2 // int
number_of_filled_scans	201 // int
orbit_number	720 // int
TAI93_leapseconds	10 // int
_NCProperties	version=1 | netcdflibversion=4.4.1.1 | hdf5libversion=1.8.17
instrument_number	3 // int
Conventions	CF-1.6
_CoordSysBuilder	ucar.nc2.dataset.conv.CF1Convention
license	http//science.nasa.gov/earth-science/earth-science-data/data-information-policy/
naming_authority	gov.nasa.gsfc.VIIRSland
history	geolocate_viirs.exe PGE501.1.AS5200.JP1VIIRS.2018-008T01:30.NA.2019-156T00:58:55.193619532.pcf
source	VJ101.A2018008.0130.002.2019155235525.nc, VIIRS_J1_CMN_LUT_v3.0.0.5_20190429_vcst.nc, VIIRS_J1_GEO_LUT_v3.0.0.3-RPY6_vcst.nc, off_USNO-PolarWander-UT1-ANC_Ser7_USNO_000f_20180105_201801050000Z_20180105000224Z_ee20180112120000Z_np.ascii
InputPointer	VJ101.A2018008.0130.002.2019155235525.nc, off_USNO-PolarWander-UT1-ANC_Ser7_USNO_000f_20180105_201801050000Z_20180105000224Z_ee20180112120000Z_np.ascii, VIIRS_J1_CMN_LUT_v3.0.0.5_20190429_vcst.nc, VIIRS_J1_GEO_LUT_v3.0.0.3-RPY6_vcst.nc

Appendix-B: NASA VIIRS SNPP Level-1B I-Band Cal. Rad. Product's Global Attributes

Global Attribute	Value
project	VIIRS L1 Project
institution	NASA Goddard Space Flight Center, VIIRS L1 Processing Group
platform	Suomi-NPP
instrument	VIIRS
processing_level	L1B
VersionId	001
SatelliteInstrument	NPP_OPS
ProcessingCenter	MODAPS-NASA
publisher_name	LAADS
publisher_url	http//ladsweb.nascom.nasa.gov
publisher_email	modis-ops@lists.nasa.gov
ShortName	VNP02IMG
LongName	VIIRS/NPP Imagery Resolution 6-Min L1B Swath 375m
title	VIIRS I-band Reflected Solar Band and Thermal Emissive Band Data
product_name	VNP02IMG.A2015080.0800.001.2017260093934.nc
LocalGranuleID	VNP02IMG.A2015080.0800.001.2017260093934.nc
AlgorithmType	SCI
AlgorithmVersion	NPP_PR02 v2.0.3
PGE_Name	PGE502
processing_version	v2.0.3
ProcessingEnvironment	Linux minion7371 3.10.0-514.10.2.el7.x86_64 #1 SMP Fri Mar 3 000405 UTC 2017 x86_64 x86_64 x86_64 GNU/Linux
date_created	2017-09-17T053935Z
ProductionTime	2017-09-17T053935Z
time_coverage_start	2015-03-21T080000.000Z
time_coverage_end	2015-03-21T080600.000Z
PGE_StartTime	2015-03-21 080000.000
PGE_EndTime	2015-03-21 080600.000
StartTime	2015-03-21 080000.000
EndTime	2015-03-21 080600.000
RangeBeginningDate	2015-03-21
RangeEndingDate	2015-03-21
RangeBeginningTime	080000.000000
RangeEndingTime	080600.000000
keywords_vocabulary	NASA Global Change Master Directory (GCMD) Science Keywords
stdname_vocabulary	NetCDF Climate and Forecast (CF) Metadata Convention
creator_name	VIIRS L1 Processing Group
creator_email	modis-ops@lists.nasa.gov
creator_url	http//ladsweb.nascom.nasa.gov
publisher_name	LAADS
publisher_url	http//ladsweb.nascom.nasa.gov
publisher_email	modis-ops@lists.nasa.gov
identifier_product_doi_authority	http//dx.doi.org
identifier_product_doi	10.5067/VIIRS/VNP02IMG.001

GRingPointLatitude	40.8053f, 46.4726f, 25.6544f, 21.1982f // float
GRingPointLongitude	54.4834f, 92.1422f, 93.8716f, 64.2577f // float
GRingPointSequenceNo	1, 2, 3, 4 // int
NorthBoundingCoordinate	46.491714f // float
SouthBoundingCoordinate	21.198215f // float
EastBoundingCoordinate	93.88381f // float
WestBoundingCoordinate	54.483364f // float
startDirection	Ascending
endDirection	Ascending
DayNightFlag	Day
cdm_data_type	swath
format_version	2 // int
instrument_number	2 // int
number_of_filled_scans	202 // int
orbit_number	17592 // int
Conventions	CF-1.6
license	http//science.nasa.gov/earth-science/earth-science-data/data-information-policy/
naming_authority	gov.nasa.gsfc.VIIRSland
history	LSIPS_calibrate_viirs.exe PGE502.1.AS5110.NPP_OPS.2015-080T0800.NA.2017-260T093647.153568594.pcf diagnostics
source	VNP01.A2015080.0800.001.2017259064453.nc, VNP01.A2015080.0754.001.2017259064909.nc, VNP01.A2015080.0806.001.2017259064053.nc, VIIRS_NPP_CAL_STATIC_LUT_v2.0.0.13_20170831_vcst.nc, VIIRS_NPP_CAL_RSB_DYNAMIC_LUT_20120103_20170930_v2.0.0.13_20170831_vcst.nc, VIIRS_NPP_CAL_DNB_DYNAMIC_LUT_20120121_20170930_v2.0.0.13_20170831_vcst.nc, VIIRS_NPP_CAL_STRAYLIGHT_DYNAMIC_LUT_20120123_20170920_v2.0.0.13_20170831_vcst.nc, VIIRS_NPP_CMN_LUT_v2.0.0.13_20170831_vcst.nc, VIIRS_NPP_GEO_LUT_v2.0.0.13_20170831_vcst.nc, off_USNO-PolarWander-UT1-ANC_Ser7_USNO_000f_20150320_201503200000Z_20150320001003Z_ee20150327120000Z_np.h5
InputPointer	VNP01.A2015080.0800.001.2017259064453.nc, VNP01.A2015080.0754.001.2017259064909.nc, VNP01.A2015080.0806.001.2017259064053.nc, VIIRS_NPP_CAL_STATIC_LUT_v2.0.0.13_20170831_vcst.nc, VIIRS_NPP_CAL_RSB_DYNAMIC_LUT_20120103_20170930_v2.0.0.13_20170831_vcst.nc, VIIRS_NPP_CAL_DNB_DYNAMIC_LUT_20120121_20170930_v2.0.0.13_20170831_vcst.nc, VIIRS_NPP_CAL_STRAYLIGHT_DYNAMIC_LUT_20120123_20170920_v2.0.0.13_20170831_vcst.nc, VIIRS_NPP_CMN_LUT_v2.0.0.13_20170831_vcst.nc, VIIRS_NPP_GEO_LUT_v2.0.0.13_20170831_vcst.nc, off_USNO-PolarWander-UT1-ANC_Ser7_USNO_000f_20150320_201503200000Z_20150320001003Z_ee20150327120000Z_np.h5

Appendix-C: NASA VIIRS Level-1B Pixel and Scan Quality Flags

The NASA VIIRS Level-1B pixel and scan quality flagging scheme is derived from the corresponding NOAA's Interface Data Processing Segment (IDPS) Sensor Data Record (SDR) pixel QA framework. It conveys as much useful information as those in the IDPS SDR format while using fewer bits. This leaves several bits available to report conditions specific to particular band categories, such as reporting gain state information for the dual-gain bands.

Appendices C and D describe the NASA VIIRS Level-1B quality flags (pixel and scan), and NASA VIIRS geolocation quality flags (pixel and scan) respectively; Appendices E and F describe the IDPS VIIRS SDR Level-1B quality flags (pixel and scan), and IDPS VIIRS SDR geolocation quality flags (pixel and scan) respectively. The IDPS-specific descriptions are provided only to document the current QA framework's historical evolution.

VIIRS L1B Pixel Quality Flags

The VIIRS L1B product uses the following pixel-level quality flags for the I and M Bands:

Value	**Flag Meaning**	**Description**
1 (LSB)	Substitute_Cal	Granule-average has been substituted for SV and/or BB
2[1]	Out_of_Range	Earth view counts &/or cal. radiance out of range (see Table A.3)
4[1]	Saturation	L1A Earth view counts ≥ 4095
8	Temp_not_Nominal	Measured temperatures outside nominal range
16[2]	Low_Gain	One or more low-gain samples in aggregation
32[2]	Mixed_Gain	Mix of high- and low-gain samples in aggregation
64[2]	DG_Anomaly	Dual-gain anomaly
128[2]	Some_Saturation	One or more samples in aggregation have L1A Earth view counts that are either saturated or out of range
256	Bowtie_Deleted	Data excluded by VIIRS for bowtie deletion
512	Missing_EV	Packet missing or corrupted in transmission
1024	Cal_Fail	Calibration failure
2048	Dead_Detector	Detector is not producing valid data
4096	Noisy_Detector	Noisy Detector

[1] The criteria for assigning Saturation and Out_of_Range pixel quality flags are:

- If a pixel raw DN value equals or exceeds the DN limit of 4095, the pixel ″Saturation″ quality flag is set, and the DN value is set to 4095.
- If a pixel raw DN value exceeds the ″Out-of-Range″ value, the pixel ″Out of Range″ quality flag is set.

[2] Dual-gain M-bands only. Application of Low-Gain and Mixed-Gain pixel flags is as follows:

- One sample aggregation: high-gain 00; low-gain 01
- Two sample aggregation: all high-gain 00; all low-gain 01; mixed 11
- Three sample aggregation: all high-gain 00; all low-gain 01; two low-gain 11; two high-gain 10

Table-C.1: VIIRS Level-1B pixel quality flags for I- and M-bands

The VIIRS L1B uses the following pixel-level quality flags for the Day-Night Band:

Value	Meaning	Description
1	Substitute_Cal	Granule-average is substituted for SV and/or BB (e.g., moon-in-SV)
2[1]	Out_of_Range	Calibrated radiance less than 0 or greater than band-dependent value
4[1]	Saturation	L1A Earth view counts ≥ 4095
8	Temp_not_Nominal	Measured temperatures (blackbody, focal plane) outside nominal range
16	Straylight	Stray light region
256	Bowtie_Deleted	Data excluded by VIIRS for bowtie deletion
512	Missing_EV	Packet missing or corrupted in transmission
1024	Cal_Fail	Calibration failure
2048	Dead_Detector	Detector is not producing valid data
4096	Noisy_Detector	Noisy Detector

[1] The criteria for assigning "Saturation" and "Out_of_Range" pixel quality flags include the following:

a) If a pixel's raw DN value equals or exceeds the DN limit of 4095, the quality flag is set to ″Saturation,″ and the pixel radiance is set to "Reported Range" value (Refer to Table C.3).

Table-C.2: VIIRS Level-1B pixel quality flags for the DNB

Out-of-Range Thresholds

The range thresholds are based on values contained in the Mx8.10 version of the IDPS Software configuration file entitled ProCmnProductDictionary_CFG.xml. The only large discrepancy between Reported Range and Good Range occurs in the case of M6.

Band	Good Range	Reported Range
I1	862.01	862.01
I2	419.04	419.04
I3	87.21	87.21
I4	4.65933	4.65933
I5	22.8356	22.8356
M1	738.21	738.21
M2	824.6	824.6
M3	842.52	842.52
M4	800.5	800.5
M5	781.28	781.28
M6	41.09	60.09
M7	418.84	862.01
M8	198.02	419.04
M9	92.61	87.21
M10	85.48	85.48
M11	38.18	38.18
M12	4.41080	4.41163
M13	605.769	605.770
M14	26.1792	26.1814
M15	25.5562	25.5611
M16	22.1870	22.1910

Table-C.3: Out-of-range thresholds

For the TEB, the brightness temperature LUT covers the Radiance Range exactly. That is, the maximum allowable radiance integers (65227) should correspond to the Radiance Range values. So, the maximum brightness temperature should also correspond to the Radiance Range value.

Note that the IDPS SDR "poor" pixel quality bit has been excluded from the VIIRS L1B because there now exist an adequate number of bits to explicitly identify all the conditions that are regarded as the basis to characterize a pixel as having ″poor″ quality.

VIIRS L1B Scan Quality Flags

In the VIIRS Level-1B, we have consolidated the scan-level quality flags from being across three quality flag (QF) data sets, as they exist in the IDPS SDR, to two. The **scan_state_flags** object in the VIIRS Level-1B, provides information on the HAM side, Electronics side, and Night Mode.

The **scan_quality_flags** object in the VIIRS Level-1B is the scan-level quality flag. This provides information pertaining to the condition of an entire scan, which in some cases results in the entire scan being uncalibrated. Note that flag names are provided without their associated pejorative, e.g., EV_Data rather than No_EV_Data, and Sensor_Mode rather than Sensor_Mode_not_Operational.

Value	**Meaning**	**Description**
1	Moon_in_SV_KOB*	Moon position relative to space view port is within a specified angular range
2	EV_Data	No earth view data available to calibrate
4	Sensor_Mode	VIIRS Sensor in mode other than day or night mode
8	Scan_Sync	Scan sync failure
16	Tel_Start	Telescope start data not in nominal operational range
32	BB_Temp	Blackbody temperatures not nominal
64	LWIR_Temp	LWIR focal plane temperatures not nominal

* SV_KOB = Space View Keep-Out Box

Table-C.4: VIIRS Level-1B scan quality flags

Appendix-D: NASA VIIRS Geolocation Pixel and Scan Quality Flags

The NASA VIIRS geolocation pixel and scan quality flagging scheme is derived from the corresponding NOAA's IDPS SDR Geolocation pixel quality flagging scheme. This appendix describes the NASA Level-1B geolocation quality flags including details regarding their metadata.

VIIRS L1 Geolocation Pixel Quality Flags

The VIIRS Geolocation product (VNP|VJ1 03[IMG, MOD]) uses the following pixel quality flags for the IMG and MOD Bands.

Bit	Flag	Description of flag meaning when set
0 (LSB)	Input_invalid	Invalid ephemeris, attitude or mirror encoder data
1	Pointing_bad	Earth intersection near or off limb
2	Terrain_bad	Terrain correction failure
3	Solar Angle_bad	Solar angles are invalid
4-7	Spare	N/A

Table-D.1: VIIRS Geolocation pixel quality flags for I- and M-bands

The VIIRS Geolocation product (VNP|VJ1 03[DNB]) uses the following pixel quality flags for the DNB:

Bit	Flag	Description of flag meaning when set
0 (LSB)	Input_invalid	Invalid ephemeris, attitude or mirror encoder data
1	Pointing_bad	Earth intersection near or off limb
2	Terrain_bad	Terrain correction failure
3-7	Spare	N/A

Table-D.2: VIIRS Geolocation pixel quality flags for DNB

VIIRS L1 Geolocation Scan Quality Flags

The VIIRS geolocation product's (VNP|VJ1 03[IMG, MOD, DNB]) scan-line attributes include "scan quality" which defines the following scan-quality-related bits, flags, and their meanings:

Value	Flag	Description of flag meaning when set
1	eaGap_small	Missing data <= Small gap
2	eaGap_medium	Small gap < Missing data <= Granule Boundary
3	eaGap_large	Granule Boundary < Missing data
4	HAMRTA_encoder_corrupt_fullScan	HAM side is invalid, the HAM or Telescope encoders are invalid, or the servo controller(s) for HAM or Telescope are invalid
8	HAMRTA_encoder_corrupt_partScan	The HAM or Telescope impulse is degraded
12	HAMRTA_encoder_missing_packets	The engineering packed doesn't have HAM encoder data
16	SAA	Triggered if it is too close to the South Atlantic Anomaly (SAA)
32	solar_eclipse	The sun and moon overlap in the sky in any calculated location. Calculated at top and bottom rows, at first, middle, and last columns
64	lunar_eclipse(DNB_only)	Moon is above horizon for any calculated location. Calculated at top and bottom rows, at first, middle, and last columns
126	spare(unused)	…
256	SCE_Side_A_B	0 = side A, 1 = side B
512	SCE_side_invalid	Invalid or unknown SCE side
1024	HAM_non-nominal_start	Ham encoder start does not match value in LUT. Ignored for synch loss or sector rotation
2048	Synch_loss	When HAM and Telescope encoders are out of synch
4096	Sector_rotation	Telescope encoder start does not match value in LUT

Table-D.3: VIIRS Geolocation scan quality flags for the I-, M-bands, and DNB

Appendix-E: IDPS VIIRS Level-1B SDR Pixel and Scan Quality Flags

The information provided in Appendices E and F relate to the Collection-1 IDPS-version of the VIIRS products' Level-1 (geolocation) and Level-1B (calibrated radiance) quality flags, both at pixel- and scan-levels. Specific short-names for the geolocation products are NPP_IMFTS_L1 (I-bands) and NPP_MOFTS_L1 (M-bands); those for the calibrated radiance products include NPP_VIAES_L1 (I-bands), NPP_VMAES_L1 (M-bands), and NPP_VDNES_L1 (DNB). Production of the C1 IDPS SNPP VIIRS L1 products will continue through the summer of 2022.

IDPS L1B SDR Pixel Quality Flags

The IDPS Calibration algorithm uses the available pixel quality flag (QF1) bits as follows.

Value	Meaning	Description
1[1]	Poor	The conditions that produce a poor pixel rating are listed in the next paragraph
2	No_Calibration	Qualifies fill value; a restatement that the pixel cannot be calibrated and is a fill-value
4	Some_Saturation	Qualifies poor; applies only to dual-gain bands where a subset of aggregated pixels is saturated
8	All_Saturation	Qualifies poor; applies to a saturated earth-view
16	No_EV	Qualifies fill value; the RDR earth-view is a fill-value
32[2]	No_Cal	Qualifies fill value; SV or BB is a fill-value, a condition that should never occur except for software failure
48	No_Therm	Qualifies fill value; thermistor data is missing
64 or 128	Out_of_range	Out_of_range: Qualifies poor; the calibrated radiance exceeds or is less than its usable range

[1] In the IDPS Calibration algorithm, a pixel is designated as poor for any of the following reasons:

- Radiance out of range, high or low – Very common for some bands (e.g., M6).
- All saturation – Earth-view DN exceeds or is equal to 4095.
- Some saturation – Applies only to DG bands where a subset of aggregated samples is saturated.
- Dual-gain anomaly – Applies only to DG bands, and is very common.
- Moon in SV KOB – Moon position relative to space view port is within a specified angular range.
- Scans nearby a sync loss scan – Applies only to DG bands.
- SV gain-state is fill – Applies only to DG bands, but is useless because it can never happen unless SV contains fill.
- LWIR focal plane temperature not nominal – Applies only to LWIR TEB bands.

- Stray-light region – Applies only to DNB band.

[2] In the IDPS Calibration algorithm, a pixel is assigned as no-calibrate (fill value) for any of the following reasons:

- Bowtie region.
- RDR scan-data is fill.
- Telescope start not nominal.
- Synchronization loss.
- Any calibration software failure of unspecified nature.
- Night scan – Applies only to most RSB bands.
- Dead detector.
- RDR earth-view fill value.
- SV/BB fill value – Should never occur except when a software failure occurs.
- Bad coefficients – Should never occur except when a software failure occurs.
- Bad thermal value – Applies only to TEB bands; should never occur except when a software failure occurs.
- Bad interpolation value – Applies only to TEB bands; should never occur except when a software failure occurs.

Table-E.1: IDPS VIIRS L1B SDR pixel-level quality flag bits

IDPS L1B SDR Scan Quality Flags

The IDPS SDRs contain the following scan quality flags:

QF2 – uses two bits to indicate the HAM-side and Moon in the SV.

QF3 – indicates checksum failures in the VIIRS packet data, an extremely rare occurrence.

QF4 – indicates reduced data quality for a scan, specifically the "combined number of steps required to find a replacement for missing thermistor or calibration source data."

Appendix-F: IDPS VIIRS L1 Geolocation Pixel and Scan Quality Flags

IDPS L1 Geolocation Pixel Quality Flags

The IDPS geolocation algorithm uses the available pixel-level quality flag (QF1) bits as follows.

Bit	Flag	Description of flag meaning when it is set
0	Input Quality	Any of the S/C ephemeris or attitude data is invalid or the encoder data is invalid
1	Pointing	The sensor Line of Sight does not intersect the geoid, is near the limb, or has invalid sensor angles.
2	Terrain	The algorithm could not obtain a valid terrain value.
3	Solar Angle	The solar angles are invalid.
4-7	Spare	N/A

Table-F.1: IDPS VIIRS L1 Geolocation pixel quality flags for the I-, M-bands, and DNB

IDPS L1 Geolocation Scan Quality Flags

The IDPS VIIRS L1 geolocation scan-level quality flags contain two 8-bits, QF1 and QF2:

Bit	Flag Description	Value
0-1	Interpolation Stage	0: Nominal – E&A data available 1: Missing data <= Small gap 2: Small gap < Missing data <= Granule boundary 3: Missing data > Granule boundary
2-3	HAM/RTA Encoder Flag	0: Good data – all encoder data is valid 1: Bad data – either HAM encoders, RTA encoders or both corrupted for the entire scan 2: Degraded data – either HAM encoders, RTA encoders or both are corrupted within the scan. 3: Missing data – Missing encoder data for the scan (dropped engineering packets)
4	Above South Atlantic Anomaly	0: False 1: True

5	Solar Eclipse	0: False 1: True
6	Lunar Eclipse (DNB only)	0: False 1: True
7	HAM Side	0: Mirror Side A 1: Mirror Side B

Table-F.2: IDPS VIIRS L1 Geolocation scan quality flags for the I-, M-bands, and DNB (QF1)

Bit	Flag Description	Value
0-1	Scan Controller Electronics (SCE) Side	0: Side A on 1: Side B on 2: Invalid State
2-4	Geo Scan Start State Flag	0: Nominal 1: Non-Nominal HAM start: run 2: HAM/RTA Sync Loss: run 4: Sector Rotation: run
5-7	Spare	N/A

Table-F.3: IDPS VIIRS L1 Geolocation scan quality flags for the I-, M-bands, and DNB (QF2)