VIIRS Level-1 Data Product User's Guide

July 2017

1.0 Introduction

This document describes the specifications of the NASA-developed Visible and Infrared Imaging Radiometer Suite (VIIRS) Level-1 data products. These products are produced and distributed by the NASA VIIRS Science Investigator-led Processing Systems (SIPSs) for the Atmosphere, Land and Ocean disciplines. VIIRS is a multidisciplinary instrument being flown on the Joint Polar Satellite System (JPSS) satellites, including the Suomi National Polar-orbiting Partnership (SNPP), which launched in October 2011, and JPSS-1, launching in October 2017.

The products are implemented in the Network Common Data Format Version 4 (NetCDF4), and NetCDF terminology is used in this document. These specifications are given in terms of the logical implementation of the products in NetCDF and are not a physical description of file contents. The format is also compatible with the Hierarchical Data Format Version 5 (HDF5). Therefore, NetCDF4 or HDF5 software can be used to read these products.

User support for the NASA VIIRS Level-1 products is available at the following sites.

Level-1 and Atmosphere Archive and Distribution System (LAADS):

https://ladsweb.nascom.nasa.gov/help/

Ocean Color Forum:

http://oceancolor.gsfc.nasa.gov/forum/oceancolor/forum_show.pl

2.0 References

1. EOS Data Products Handbook, ed. M.D. King, et al, NASA/GSFC, 2003.
2. 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.
3. ICD between Earth Observing System (EOS) Data and Operations System (EDOS) and Science Investigator-led Processing Systems for the Suomi National Polar-Orbiting Partnership (SNPP) Science Data Segment (SDS), 423-ICD-010, May 2015.
4. ICD between Suomi National Polar-Orbiting Partnership (SNPP) Science Data Segment (SDS) Processing and Distribution Elements, 423-ICD-XXX, Draft, September 2015.

3.0 Overview

In November 2013, when NASA issued the Research Opportunities in Space and Earth Sciences (ROSES) solicitation for the VIIRS Science Team, it specified that Level-0 to 1B software would be developed to replace the current IDPS RDR-to-SDR software, and that the Level-0 data would be provided to the SIPSs by the EOS Data and Operations System (EDOS). Following the release of the solicitation, the SNPP Project Scientist, Dr. James Gleason, chartered the formation of the VIIRS Level-1 Algorithm/Software Working Group (L1ASWG), a confederation of personnel from the VIIRS SIPSs and the VIIRS Characterization Support Team (VCST), to perform this software development for VIIRS. The first version of the VIIRS Level-1 software was completed in October 2015.

The 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 interfaces between the software modules are the data products. Specifically, the Level-1A product is the input to the Geolocation, Level-1B and OBC software.
- The nominal granule size is longer than the NOAA VIIRS granules (85.35 seconds). The standard granule period is 6 minutes, but the software will be capable of processing any reasonable granule period.

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.

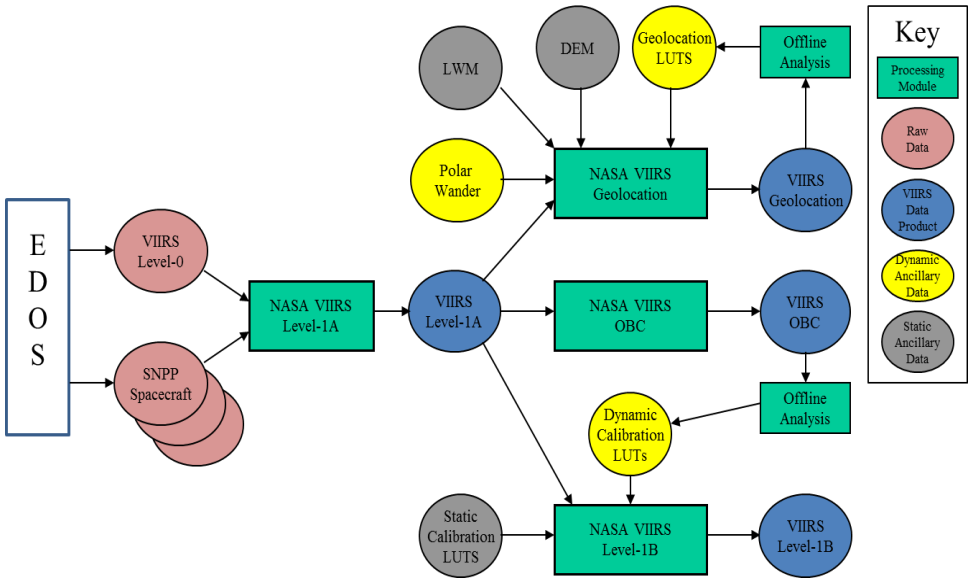

Figure 1 – VIIRS Level-1 Processing Flow

The VIIRS Level-0 and SNPP spacecraft data are delivered by EDOS in the form of Project Data Sets (PDSs). A session-based PDS (S-PDS) contain 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. For the VIIRS and spacecraft T-PDSs, the period is 2 hours. The format of the PDSs is specified in Reference 3, and the format of the VIIRS packets in Reference 2.

The VIIRS Level-1 data products follow the standard NASA Earth Observing System (EOS) definitions for product levels, as specified in Reference 1. They are also designed to be archived in EOSDIS DAACs, and as such, they all include granule metadata as well as processed data. The granule metadata scheme is described in Section 4.1.

As stated above, the VIIRS granule period has been specified to be exactly 6 minutes, synchronized with the UTC 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 also flown on SNPP. The granulation of the VIIRS data is performed during the Level-1A processing, with each granule containing all of the VIIRS scans that start within the granule period.

The Level-1 software is installed, and the data products are generated, archived and distributed, at all three VIIRS discipline SIPSs. The archive and distribution facility of record is the Level-1 and Atmosphere Archive and Distribution Systems (LAADS), which is co-located both physically and organizationally with the Land SIPS.

4.0 Data Product Formats

The following sections describe the product granule-level and object-level metadata for all VIIRS Level-1 data products, the data object dimensions, and the specific structure and content of each data product. All data product field names are shown in bold type. Note that many of the data objects in a product have similar names that differ in only a few characters; for brevity, a single object description is included, with the distinguishing characters indicated as "**[X]**, X = {list or range of values}".

4.1 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.

Table 1 lists all of the granule-level metadata for the VIIRS Level-1 data products. Not all metadata are stored in all data objects, and the table indicates for which of the data objects each attribute is stored. In a few cases, metadata are duplicated in multiple attributes to meet specific system needs or maintain data continuity with heritage sensors.

Table 2 lists the object-level metadata. Note that only the "**long_name**" attribute is mandatory for all data objects; the other attributes are stored as appropriate. For example, the "units" attribute is only used for data objects which have defined units; the "scale_factor" and "add_offset" attributes are used for data which are computed as floating point values but stored as scaled integers; and the "flag_values", "flag_masks" and "flag_meanings" attributes are used for integer data objects to specify meanings for a limited number of defined values.

The fill values specified using the "_FillValue" attribute is, as much as possible, set to standard values according to the data object type. The standard fill values for each data type are listed in Table 3. Exceptions are noted for individual data fields. If the entire range of the data type is valid for a data object, no fill value is defined.

Table 1 – VIIRS Level-1 Product Granule-level Metadata

Attribute Name	Example	Usage			
		L1A	GEO	L1B	OBC
title	“VIIRS Level-1A”	X	X	X	X
platform	“Suomi NPP”	X	X	X	X
project	“VIIRS L1 Project”	X	X	X	X
product_name	“V2013081085000.L1A_SNPP.nc”	X	X	X	X
LocalGranuleID	“V2013081085000.L1A_SNPP.nc”		X	X	
LongName	“VIIRS/NPP Moderate Resolution Terrain Corrected Geolocation 6-Min L1 Swath 750m”		X	X	
ShortName	“VNP03MOD”		X	X	
instrument	“VIIRS”	X	X	X	X
format_version	2	X	X	X	X
instrument_number	2	X	X	X	X
Conventions	"CF-1.6"	X	X	X	X
institution	"NASA Goddard Space Flight Center”	X	X	X	X
license	"http://science.nasa.gov/earth-science/earth-science-data/data-information-policy/"	X	X	X	X
naming_authority	"gov.nasa.gsfc.sci.oceandata"	X	X	X	X
keywords_vocabulary	"NASA Global Change Master Directory (GCMD) Science Keywords"	X	X	X	X
stdname_vocabulary	"NetCDF Climate and Forecast (CF) Metadata Convention"	X	X	X	X
creator_name	“NASA/GSFC”	X	X	X	X
creator_email	"MODAPSUSO@lists.nasa.gov"	X	X	X	X
creator_url	"http://laadsweb.nascom.nasa.gov"	X	X	X	X
date_created	"2013-12-03T21:17:31Z"	X	X	X	X
ProductionTime	"2013-12-03T21:17:31Z"		X	X	
publisher_name	“NASA/GSFC”	X	X	X	X
publisher_email	"MODAPSUSO@lists.nasa.gov"	X	X	X	X
publisher_url	"http://laadsweb.nascom.nasa.gov"	X	X	X	X
cdm_data_type	“swath”	X	X	X	X
processing_level	“L1A”	X	X	X	X
processing_version	“v2.0.0”		X	X	
history	"l1agen_viirs --outlist l1agen_viirs_outlist.txt"	X	X	X	X
source	“V2013081085000.L1A_SNPP.nc,…”		X		
time_coverage_start	"2013-03-21T08:48:00Z"	X	X	X	X
time_coverage_end	"2013-03-21T08:54:00Z"	X	X	X	X
PGE_StartTime	"2013-03-21T08:48:00Z"		X	X	
PGE_EndTime	"2013-03-21T08:54:00Z"		X	X	
StartTime	"2013-03-21T08:48:00Z"		X	X	
EndTime	"2013-03-21T08:54:00Z"		X	X	
geospatial_lat_units	“Degrees North”		X	X	
geospatial_lon_units	“Degrees East”		X	X	
geospatial_lat_max	44.077		X	X	
geospatial_lat_min	19.686		X	X	
geospatial_lon_max	50.698		X	X	
geospatial_lon_min	12.174		X	X	
NorthBoundingCoordinate	44.077		X	X	
SouthBoundingCoordinate	19.686		X	X	
EastBoundingCoordinate	50.698		X	X	
WestBoundingCoordinate	12.174		X	X	
GringPointLatitude	(24.187, 19.686, 35.0, 44.077)		X	X	

GringPointLongitude	(12.174, 41.459, 50.569, 13.747)		X	X	
GringPointSequenceNo	(1,2,3,4)		X	X	
orbit_number	12345	X		X	X
OrbitNumber	12345		X		
startDirection	"Ascending"	X	X	X	X
endDirection	"Ascending"	X	X	X	X
day_night_flag	"Day"	X		X	X
DayNightFlag	"Day"		X		
number_of_filled_scans	202	X	X		
pixel_offset	500	X			

Table 2 – VIIRS Level-1 Product Object-level Metadata

Attribute Name	Data Type	Example
long_name	Character	"Scan start time"
units	Character	"seconds"
_FillValue	Object[1]	-999.9
valid_min	Object[1]	0.d0
valid_max	Object[1]	"VIIRS"
scale_factor[2]	Object[1]	1.d0
add_offset[2]	Object[1]	0.d0
flag_values[3]	Object[1]	(1, 2, 3, 4)
flag_masks[4]	Object[1]	(1, 2, 4, 8)
flag_meanings[5]	Character	"Substitute_Cal Out_of_Range Saturation Temp_not_Nominal"

[1]Same type as the associated data object
[2]Used for real data stored as scaled integers
[3]The flag_values are mutually exclusive.
[4]The flag_masks describe a number of independent Boolean conditions using bit fields. Any number of bits can be set.
[5]Indicates flag meanings for each value of flag_values or flag_masks

Table 3 – Standard Fill Values for Data Object Types

Data Type	Fill Value
Byte	-1
Unsigned Byte	255
16-bit Integer	-999
Unsigned 16-bit Integer	65535
32-bit Integer	-999
32-bit Float	-999.9
64-bit Float	-999.9

4.2 Object Dimensions

NetCDF supports the use of named dimensions to provide dimensions with meanings that are common across data objects. The dimension names and descriptions used in the VIIRS Level-1 data products are presented in Table 4. Several of these dimensions are shared by multiple data products.

Table 4 – Data Object Dimension Names, Descriptions and Sizes

Dimension Name	Description	Size
number_of_scans[1]	VIIRS scans in product[1]	203[1]
number_of_lines[2]	VIIRS scan lines in product[2]	varies[2]
SC_records[1]	S/C diary, ADCS and bus-critical telemetry records[1]	381[1]
Mband_detectors	Number of detectors for M-bands and the DNB	16
Iband_detectors	Number of detectors for I-bands	32
Mband_pixels	Aggregated pixels for single-gain M-bands	3200
Iband_pixels	Aggregated pixels for I-bands	6400
DNB_pixels	Aggregated pixels for the DNB	4064
Mband_samples	Unaggregated pixels for dual-gain M-bands	6304
number_of_pixels[2]	Pixels in each scan line[2]	varies[2]
Mband_cal_samples	Calibrator view samples for M-bands	48
Iband_cal_samples	Calibrator view samples for I-bands	96
DNB_cal_samples	Calibrator view samples for the DNB	64
number_of_Mbands_OBC	Number of M-band onboard calibrator sets (2 for M16)	17
number_of_Ibands	Number of I-bands	5
number_of_DG_bands	Number of dual-gain bands	7
quaternion_elements	Elements in a quaternion	4
vector_elements	Cartesian vector elements	3
EV_APIDs	Number of Earth view APIDs	24
HR_metadata	Bytes of metadata in Earth view header packets	146
cal_metadata	Bytes of metadata in calibration header packet	134
eng_status	Bytes of engineering status data	8
eng_block	Bytes of data in multiple engineering packet data blocks	128
ASP_offsets	Bytes of ASP offset data in engineering packet	3072
SDSM_data	Bytes of SDSM data in engineering packet	256
encoder_reading	Number of telescope and HAM encoder readings	1290
ADCS_block	Bytes of data in ADCS packet	341[3]
bus_crit_block	Bytes of data in bus-critical telemetry packet	193[3]
number_of_LUT_values	Size of TEB band brightness temperature LUTS	65536
mirror_sides	Number of HAM sides	2
number_of_BB_temps	Number of blackbody temperatures	6
SDSM_samples	SDSM measurements per detector and scan	5
SDSM_detectors	Number of SDSM detectors	8

[1]These dimensions can vary according to the product period and the actual number of scans in a product.

[2]These dimensions can vary according to the product type. The M-bands, I-bands, and DNB have 3200, 6400 and 4064 pixels per scan line, respectively. The number of lines in an L1B or Geolocation file will be equal to the product of the number of scans and the number of detectors for that resolution.

[3]These dimensions are platform-specific (SNPP, JPSS-1, etc.)

4.3 Common Scan-level Metadata

All VIIRS Level-1 products store scan-level information in a group named **scan_line_attributes**. The following data objects are common to all of the data products.

scan_start_time (64-bit float, dimension **number_of_scans**); **long_name** = "Scan start time (TAI93)"; start time of VIIRS scans in seconds since 1/1/1993.

scan_end_time (64-bit float, dimension **number_of_scans**); **long_name** = "Scan end time (TAI93)"; end time of VIIRS scans in seconds since 1/1/1993.

HAM_side (unsigned byte, dimension **number_of_scans**); **long_name** = "Half-angle mirror side"; index of HAM side (0 or 1) from HR metadata.

sensor_mode (unsigned byte, dimension **number_of_scans**); **long_name** = "VIIRS sensor mode"; flag variable storing VIIRS sensor mode from HR metadata.

4.4 Level-1A Data Product

The VIIRS Level-1A data product contains the unpacked, raw VIIRS science, calibration and engineering data; the extracted ephemeris and attitude data from the spacecraft diary packets; and the raw ADCS and bus-critical spacecraft telemetry data from those packets, with a few critical fields extracted. These data are stored in the following groups: **scan_line_attributes**, **engineering_data**, **navigation_data**, **onboard_calibration_data**, and **earth_view_data**. The data objects in each group are described below.

4.4.1 **scan_line_attributes**

In addition to the data objects described in 4.3, the Level-1A product **scan_line_attributes** group contains the following scan-level data objects.

scan_[X]_CCSDS_day, X = {**start**, **end**} (16-bit integer, dimension **number_of_scans**); **long_name** = "Scan [X] time day (CCSDS segmented time)"; scan **,** [X] time days since 1/1/1958 from the CCSDS segmented time code.

scan_[X]_CCSDS_msec , X = {**start**, **end**} (32-bit integer, dimension **number_of_scans**); **long_name** = "Scan [X] time milliseconds of day (CCSDS segmented time)"; scan [X] time milliseconds of day from the CCSDS segmented time code.

scan_[X]_CCSDS_usec , X = {**start**, **end**} (16-bit integer, dimension **number_of_scans**); **long_name** = "Scan [X] time microseconds (CCSDS segmented time)"; scan [X] time microseconds from the CCSDS segmented time code.

VIIRS_scan_number (32-bit integer, dimension **number_of_scans**); **long_name** = "VIIRS scan number"; counter of VIIRS scans since last VIIRS power cycle or counter rollover.

HR_metadata (unsigned byte, dimensions **number_of_scans**, **EV_APIDs**, **HR_metadata**); **long_name** = "High-rate first packet metadata"; science packet metadata from the first packet of each VIIRS science packet group.

cal_metadata (unsigned byte, dimensions **number_of_scans**, **cal_metadata**); **long_name** = "Calibration first packet metadata"; calibration packet metadata from the first packet of each VIIRS calibration packet group.

4.4.2 **engineering_data**

The VIIRS engineering data packets contain the non-science data for each scan (e.g. telemetry, instrument settings, HAM and telescope data, SDSM data). Each type of engineering data is stored in a separate data object, but is otherwise unconverted. Selected fields are also unpacked to facilitate downstream processing. The complete description of the engineering data fields is given in Reference 2.

engineering_status (unsigned byte, dimensions **number_of_scans, eng_status**); **long_name** = "Engineering status telemetry".

DPP_config (unsigned byte, dimensions **number_of_scans, eng_block**); **long_name** = "DPP configuration"; digital preprocessor (DPP) commanded settings.

ASP_config (unsigned byte, dimensions **number_of_scans, eng_block**); **long_name** = "Analog signal processor configuration".

DNB_config (unsigned byte, dimensions **number_of_scans, eng_block**); **long_name** = "DNB configuration"; DNB commandable settings.

ASP_offsets (unsigned byte, dimensions **number_of_scans, ASP_offsets**); **long_name** = "Analog signal processor offsets"; ASP offsets for each band and detector.

ASP_analog (unsigned byte, dimensions **number_of_scans, eng_block**); **long_name** = "Analog signal processor analog telemetry".

analog_temperature (unsigned byte, dimensions **number_of_scans, eng_block**); **long_name** = "Analog temperature sensor measurements"; VIIRS temperature telemetry.

SDSM_data (unsigned byte, dimensions **number_of_scans, SDSM_data**); **long_name** = "Solar diffuser stability monitor data"; raw SDSM state and measurement data.

HAM_encoder (unsigned 16-bit integer, dimensions **number_of_scans, encoder_reading**); **long_name** = "HAM encoder readings".

tel_encoder (unsigned 16-bit integer, dimensions **number_of_scans, encoder_reading**); **long_name** = "Telescope encoder readings".

eng_reserved (unsigned byte, dimensions **number_of_scans, eng_block**); **long_name** = "Reserved engineering block data"; unused fields in the engineering packets.

tel_start_enc (16-bit integer, dimension **number_of_scans**); **long_name** = "Telescope encoder count at start of Earth view".

HAM_start_enc (16-bit integer, dimension **number_of_scans**); **long_name** = "HAM encoder count at start of Earth view".

scan_encoder_delta (16-bit integer, dimension **number_of_scans**); **long_name** = "Scan encoder delta shift"; shift applied to start of scan, e.g., for a sector rotation.

se_[X]_teleHAM_scansyn, X = {a,b} (unsigned byte, dimension **number_of_scans**); **long_name** = "[X]-side telescope and HAM synch".

se_[X]_anlg_pwr_on, X = {a,b} (unsigned byte, dimension **number_of_scans**); **long_name** = "Analog Power on SE [X]".

servo_in_use (unsigned byte, dimension **number_of_scans**); **long_name** = "Servo In Use (A or B)"; telescope servo in use.

se_[X]_tele_pos_known, X = {a,b} (unsigned byte, dimension **number_of_scans**); **long_name** = "Telescope Position Known SE [X]".

se_[X]_mtrs_stopped, X = {a,b} (unsigned byte, dimension **number_of_scans**); **long_name** = "Motor State SE [X]".

4.4.3 navigation_data

The **navigation_data** group contains spacecraft data and associated time tags spanning the granule period. The data are stored at the original sample rate (1 second). Additional samples are included at the start and end of the period to support geolocation processing. This includes: unpacked ephemeris and attitude data from the S/C diary packets; raw attitude determination and control system (ADCS) and bus-critical telemetry data; and selected fields extracted from the ADCS and bus-critical telemetry.

att_time (64-bit float, dimension **SC_records**); **long_name** = "Attitude sample time (TAI93)"; time of attitude samples in seconds since 1/1/1993.

att_quat (32-bit float, dimensions **SC_records, quaternion_elements**); **long_name** = "Attitude quaternions (J2000 to spacecraft)"; attitude quaternions from S/C diary in the J2000 frame.

orb_time (64-bit float, dimension **SC_records**); **long_name** = "Orbit vector time (TAI93)"; time of ephemeris samples in seconds since 1/1/1993.

orb_pos (32-bit float, dimensions **SC_records, vector_elements**); **long_name** = "Orbit position vectors (ECR)"; **_FillValue** = -9999999.; orbit position vectors from S/C diary ephemeris data, in the Earth-centered rotating reference frame.

orb_vel (32-bit float, dimensions **SC_records, vector_elements**); **long_name** = "Orbit velocity vectors (ECR)"; **_FillValue** = -9999999.; orbit velocity vectors from S/C diary ephemeris data, in the Earth-centered rotating reference frame.

bus_time (64-bit float, dimension **SC_records**); **long_name** = "Bus critical telemetry time (TAI93)"; bus-critical packet time tags in seconds since 1/1/1993.

adstate (unsigned byte, dimension **SC_records**); l**ong_name** = "Current ADCS State".

adsolution (unsigned byte, dimension **SC_records**); **long_name** = "ADCS Attitude Solution Source"; source of S/C diary attitude (two star trackers, one star tracker, or gyros only).

adcs_time (64-bit float, dimension **SC_records**); **long_name** = "ADCS telemetry time (TAI93)"; ADCS packet time tags in seconds since 1/1/1993.

adfftid (16-bit integer, dimension **SC_records**); **long_name** = "Fixed Frame Table Target ID".

admandone (unsigned byte, dimension **SC_records**); **long_name** = "Maneuver Done flag"; maneuver state flag.

bus_critical_tlm (unsigned byte, dimensions **SC_records, bus_crit_block**); **long_name** = "Bus Critical Telemetry"; raw data from bus-critical telemetry packet.

ADCS_tlm (unsigned byte, dimensions **SC_records, ADCS_block**); **long_name** = "ADCS Telemetry"; raw data from ADCS telemetry packet.

4.4.4 onboard_calibration_data

The **onboard_calibration_data** group contains the measurements from the onboard calibrator views – solar diffuser (SD), space view (SV) and blackbody (BB) – for each band and scan: The calibration data in the packets are compressed onboard, and are uncompressed as part of the Level-1A processing before being stored in the data products.

[X]_M, X = {SD, SV, BB} (16-bit integer, dimensions **number_of_Mbands_OBC**, **number_of_scans**, **band_detectors**, **Mband_cal_samples**); **long_name** = "[X] data for

M-bands"; calibrator view data for all of the M-bands. Note that Band M16 has two sets of calibrator view data (16A and 16B).

[X]_I, X = {SD, SV, BB} (16-bit integer, dimensions **number_of_Ibands**, **number_of_scans**, **Iband_detectors**, **Iband_cal_samples**); **long_name** = "[X] data for I-bands"; calibrator view data for all of the I-bands.

[X]_DNB, X = {SD, SV, BB} (16-bit integer, dimensions **number_of_scans**, **Mband_detectors**, **DNB_cal_samples**); **long_name** = "[X] data for DNB"; calibrator view data for the DNB.

DNB_sequence (unsigned byte, dimension **number_of_scans**); **long_name** = "DNB aggregation mode"; DNB aggregation mode from calibration metadata.

4.4.5 **earth_view_data**

The **earth_view_data** group contains the Earth view science data measurements for each band and scan. The science data in the packets are compressed onboard, and are uncompressed as part of the Level-1A processing before being stored in the data products. The science data for each band are stored in a separate data object.

EV_[X], X = {M01 through M16} (16-bit integer, dimensions **number_of_scans**, **Mband_detectors**, **Mband_samples**); **long_name** = "Earth view data for band [X]"; uncompressed, reconstructed Earth view counts for each M-band.

EV_[X], X = {I01 through I05} (16-bit integer, dimensions **number_of_scans**, **Iband_detectors**, **Iband_pixels**); **long_name** = "Earth view data for band [X]"; uncompressed, reconstructed Earth view counts for each I-band.

EV_DNB_[X], X = {HGS, MGS, LGS} (16-bit integer, dimensions **number_of_scans**, **Mband_detectors**, **DNB_pixels**); **long_name** = "Earth view data for DNB [X]"; uncompressed, reconstructed Earth view counts for each DNB; note that the MGS and LGS data are only collected when commanded.

4.5 Geolocation Data Product

The VIIRS Geolocation data product contains the viewed locations for the VIIRS science data, and related data including sensor and solar angles, height, range, and the land/water mask. There are separate products for each resolution (M-band, I-band, DNB). These data are stored in the following groups: **scan_line_attributes**, **navigation_data**, and **geolocation_data**. The data objects in each group are described below.

4.5.1 **scan_line_attributes**

In addition to the data objects described in 4.3, the Geolocation product **scan_line_attributes** group contains the following scan-level data objects.

ev_mid_time (64-bit float, dimension **number_of_scans**); **long_name** = "Earth view mid time (TAI93)"; mid-time of VIIRS scans in seconds since 1/1/1993.

scan_quality (16-bit integer, dimension **number_of_scans**); **long_name** = "Geolocation scan quality flags"; bit-mapped flag indicating geolocation quality at the scan level; see Table 5 for explanations of each flag meaning.

Table 5 – Geolocation Scan Quality Flags

Bit	Flag Meaning	Description
0 (LSB)	SCE_side_A_B	Scan control electronics (SCE) side (1 = B)
1	SCE_side_invalid	Invalid SCE side telemetry
2	Sector_rotation[1]	Invalid HAM or telescope encoder data
3	Encoder_degraded	Earth view sector rotation (i.e., non-nominal EV start)
4	SAA	Spacecraft in the South Atlantic Anomaly
5	Solar_eclipse	Spacecraft in a solar eclipse
6	Lunar_eclipse	Lunar eclipse
7	HAM_side	HAM side indicator

[1]Both bits are set to indicate missing encoder data.

4.5.2 **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).

att_quat_ev (32-bit float, dimensions **number_of_scans, quaternion_elements**); **long_name** = "Attitude quaternions at EV mid-times (J2000 to spacecraft)"; attitude quaternions interpolated to **ev_mid_time**, in J2000 frame.

att_ang[X], X = {start, mid, end} (32-bit float, dimensions **number_of_scans, vector_elements**); **long_name** = "Attitude angles (roll, pitch, yaw) at EV [X]-times"; attitude angles at EV start, mid and end times.

orb_pos_ev[X], X = {start, mid, end} (32-bit float, dimensions **SC_records, vector_elements**); **long_name** = "Orbit position vectors at EV [X]-times (ECR)"; orbit position vectors interpolated to EV start, mid and end times, in Earth-centered rotating reference frame.

orb_vel_ev[X], X = {start, mid, end} (32-bit float, dimensions **SC_records, vector_elements**); **long_name** = "Orbit velocity vectors at EV [X]-times (ECR)"; orbit velocity vectors interpolated to EV start, mid and end times, in Earth-centered rotating reference frame.

solar_j2000 (32-bit float, dimensions **number_of_scans**, **vector_elements**); **long_name** = "Solar unit vectors in J2000 frame"; solar unit vector at **ev_mid_time** in the J2000 frame.

solar_inst (32-bit float, dimensions **number_of_scans**, **vector_elements**); **long_name** = "Solar unit vectors in VIIRS frame"; solar unit vector at **ev_mid_time** in instrument frame.

earth_sun_distance (32-bit float, dimension **number_of_scans**); **long_name** = "Earth-Sun distance"; Earth-to-Sun distance at **ev_mid_time** in AU.

lunar_j2000 (32-bit float, dimensions **number_of_scans**, **vector_elements**); **long_name** = "Lunar unit vectors in J2000 frame"; lunar unit vector at **ev_mid_time** in the J2000 frame.

lunar_inst (32-bit float, dimensions **number_of_scans**, **vector_elements**); **long_name** = "Lunar unit vectors in VIIRS frame"; lunar unit vector at **ev_mid_time** in instrument frame.

earth_moon_distance (32-bit float, dimension **number_of_scans**); **long_name** = "Earth-Moon distance"; Earth-to-Moon distance at **ev_mid_time** in meters.

4.5.3 **geolocation_data**

The **geolocation_data** group contains the viewed locations and related data for each pixel at the product resolution. All angles are in degrees.

latitude (32-bit float, dimensions **number_of_lines, number_of_pixels**); **long_name** = "Latitudes of pixel locations".

longitude (32-bit float, dimensions **number_of_lines, number_of_pixels**); **long_name** = "Longitudes of pixel locations".

height (16-bit integer, dimensions **number_of_lines, number_of_pixels**); **long_name** = "Terrain height at pixel locations". Note that this will be set to zero if the terrain correction is not performed during geolocation processing.

range (16-bit integer, dimensions **number_of_lines, number_of_pixels**); **long_name** = "Satellite-to-pixel range".

sensor_azimuth (16-bit integer, dimensions **number_of_lines, number_of_pixels**); **long_name** = "Sensor azimuth angle at pixel locations"; azimuth of the viewed location-to-instrument vector.

sensor_zenith (16-bit integer, dimensions **number_of_lines, number_of_pixels**); **long_name** = "Sensor zenith angle at pixel locations"; zenith of the viewed location-to-instrument vector.

solar_azimuth (16-bit integer, dimensions **number_of_lines, number_of_pixels**); **long_name** = "Solar azimuth angle at pixel locations"; azimuth of the viewed location-to-Sun vector.

solar_zenith (16-bit integer, dimensions **number_of_lines, number_of_pixels**); **long_name** = "Solar zenith angle at pixel locations"; zenith of the viewed location-to-Sun vector.

lunar_azimuth (16-bit integer, dimensions **number_of_lines, number_of_pixels**); **long_name** = "Lunar azimuth angle at pixel locations"; azimuth of the viewed location-to-Moon vector; DNB only.

lunar_zenith (16-bit integer, dimensions **number_of_lines, number_of_pixels**); **long_name** = "Lunar zenith angle at pixel locations"; zenith of the viewed location-to-Moon vector; DNB only.

moon_illumination_fraction (16-bit integer, **dimensions number_of_lines, number_of_pixels**); **long_name** = "Lunar illumination fraction viewed at pixel locations"; fraction of Sun-illuminated Moon surface facing the Earth at viewed locations; DNB only.

moon_phase_angle (16-bit integer, **dimensions number_of_lines, number_of_pixels**); **long_name** = "Lunar phase angle viewed at pixel locations"; lunar phase angle between pixel-Moon_Sun; DNB only.

land_water_mask (unsigned byte, **dimensions number_of_lines, number_of_pixels**); **long_name** = "Land/Water mask at pixel locations".

quality_flag (unsigned byte, dimensions **number_of_lines, number_of_pixels**); **long_name** = "Geolocation pixel quality flags"; bit-mapped flag indicating geolocation quality at the pixel level; see Table 6 for explanations of each flag meaning.

Table 6 – Geolocation Pixel Quality Flags

Bit	Flag Meaning	Description
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

4.6 Level-1B Data Product

The Level-1B data product contains the calibrated values for the VIIRS science, along with quality flags. There are separate products for each resolution (M-band, I-band, DNB). The data are stored in the following groups: **scan_line_attributes**, and **observation_data**. The data objects in each group are described below. A detailed description of the quality flags and a comparison with the current IDPS SDR flags is provided in Appendix A.

4.6.1 **scan_line_attributes**

In addition to the data objects described in 4.3, the Level-1B product **scan_line_attributes** group contains the following scan-level data objects.

ev_mid_time (64-bit float, dimension **number_of_scans**); **long_name** = "Earth view mid time (TAI93)"; mid-time of VIIRS scans in seconds since 1/1/1993.

scan_quality (unsigned byte, dimension **number_of_scans**); **long_name** = "Scan quality flags"; bit-mapped flag indicating data quality at the scan level; see Table 7 for explanations of each flag meaning.

scan_state_flags (unsigned byte, dimension **number_of_scans**); **long_name** = "Scan state flags"; bit-mapped flag indicating the VIIRS state for each scan.

Table 7 – Level-1B Scan Quality Flags

Bit	Flag Meaning	Description
0 (LSB)	Moon_in_SV_KOB	Moon is within a specified angular range of SV port
1	EV_Data	No Earth view data available to calibrate
2	Sensor_Mode	VIIRS Sensor in other than day or night mode.
3	Scan_Sync	Scan sync failure
4	Tel_Start	Telescope start data not in nominal operational range
5	BB_Temp	Black body temperatures not nominal
6	LWIR_Temp	LWIR focal plane temperatures not nominal

4.6.2 **observation_data**

The **observation_data** group contains the calibrated science data and the pixel-level quality flags. As stated above, the data for each resolution are stored in a separate data product. The M and I-band data are stored as scaled integers, while the DNB data are stored as floating point values because of their dynamic range.

For the reflective solar bands (RSBs), scale factor, offset and units attributes are provided for both reflectance and radiance values. The standard attributes shown in Table 2 are used for reflectance, and the radiance scaling is performed using the attributes **radiance_scale_factor** and **radiance_add_offset**. ***Note:*** the stored reflectance is actually the product of the true reflectance and the cosine of the solar zenith angle at the pixel location; in order to obtain the reflectance, the reconstituted reflectance must be divided by the cosine of solar zenith.

For the thermal emissive bands (TEBs), 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 into the brightness temperature LUTs.

Each calibrated data object also includes the **flag_values** and **flag_meanings** attributes, to specify individual fill values for each missing data state.

M[X], X = {01 – 11} (unsigned 16-bit integer, dimensions **number_of_lines**, **number_of_pixels**); **long_name** = "M-band [X] earth view reflectance"; calibrated RSB M-band science data.

M[X], X = {12 – 16} (unsigned 16-bit integer, dimensions **number_of_lines**, **number_of_pixels**); **long_name** = "M-band [X] earth view radiance"; calibrated TEB M-band science data.

M[X]_quality_flags, X = {01 – 16)} (unsigned 16-bit integer, dimensions **number_of_lines**, **number_of_pixels**); **long_name** = "M-band [X] quality flags"; bit-mapped quality flags for the M-bands; see Table 8 for explanations of each flag meaning.

M[X]_uncert_index, X = {01 – 16)} (byte, dimensions **number_of_lines**, **number_of_pixels**); **long_name** = "M-band [X] uncertainty index"; computed uncertainty index for each M-band.

M[X]_brightness_temperature_lut, X = {12 – 16} (32-bit float, dimension **number_of_LUT_values**); **long_name** = "M-band [X] brightness temperature lookup table"; LUT for radiance to brightness temperature conversion.

I[X], X = {01 – 03} (unsigned 16-bit integer, dimensions **number_of_lines**, **number_of_pixels**); **long_name** = "I-band [X] earth view reflectance"; calibrated RSB I-band science data.

I[X], X = {04 – 05} (unsigned 16-bit integer, dimensions **number_of_lines**, **number_of_pixels**); **long_name** = "I-band [X] earth view radiance"; calibrated TEB I-band science data.

I[X]_quality_flags, X = {01 – 05} (unsigned 16-bit integer, dimensions **number_of_lines**, **number_of_pixels**); **long_name** = "I-band [X] quality flags"; bit-mapped quality flags for the I-bands; see Table 8 for explanations of each flag meaning.

I[X]_uncert_index, X = {01 – 05)} (byte, dimensions **number_of_lines**, **number_of_pixels**); **long_name** = "I-band [X] uncertainty index"; computed uncertainty index for each I-band.

I[X]_brightness_temperature_lut, X = {04, 05} (32-bit float, dimension **number_of_LUT_values**); **long_name** = "I-band [X] brightness temperature lookup table"; LUT for radiance to brightness temperature conversion.

DNB_observations (32-bit float, dimensions **number_of_lines**, **number_of_pixels**); **long_name** = " DNB observations at pixel locations"; calibrated DNB science data.

DNB_quality_flags (unsigned 16-bit integer, dimensions **number_of_lines**, **number_of_pixels**); **long_name** = "DNB quality flags"; bit-mapped quality flags for the DNB; see Table 9 for explanations of each flag meaning.

DNB_uncert_index (byte, dimensions **number_of_lines**, **number_of_pixels**); **long_name** = "DNB uncertainty index"; computed uncertainty index for the DNB.

Table 8 – Level-1B M and I-band Pixel Quality Flags

Bit	Flag Meaning	Description
0 (LSB)	Substitute_Cal	Granule-average has been substituted for SV and/or BB
1	Out_of_Range	L1A earth view counts and/or calibrated radiance out of range (see Appendix A)
2	Saturation	L1A earth view counts ≥ 4095.
3	Temp_not_Nominal	Measured temperatures outside nominal range
4[1]	Low_Gain	One or more low-gain samples in aggregation
5[1]	Mixed_Gain	Mix of high- and low-gain samples in aggregation
6[1]	DG_Anomaly	Dual-gain anomaly
7[1]	Some_Saturation	One or more samples in aggregation have L1A earth view counts that are either saturated or out of range
8	Bowtie_Deleted	Data excluded by VIIRS for bowtie deletion
9	Missing_EV	Packet missing or corrupted in transmission
10	Cal_Fail	Calibration failure
11	Dead_Detector	Detector is not producing valid data

[1]Dual-gain M-bands only

Table 9 – Level-1B DNB Pixel Quality Flags

Bit	Flag Meaning	Description
0 (LSB)	Substitute_Cal	Granule-average has been substituted for SV and/or BB
1	Out_of_Range	L1A earth view counts and/or calibrated radiance out of range (see Appendix A)
2	Saturation	Earth view counts ≥ 8191.
3	Temp_not_Nominal	Measured temperatures outside nominal range
4	Stray_light	Stray light region
5 – 8	Not used	
9	Missing_EV	Packet missing or corrupted in transmission
10	Cal_Fail	Calibration failure
11	Dead_Detector	Detector is not producing valid data

4.7 OBC Data Product

The OBC data product contains the onboard calibrator measurements, selected engineering fields that have been extracted from the raw engineering data, and navigation data. These data are stored in the following groups: **scan_line_attributes**, **engineering_data**, **navigation_data**, and **onboard_calibration_data**. The data objects in each group are described below.

4.7.1 **scan_line_attributes**

In addition to the data objects described in 4.3, the OBC product **scan_line_attributes** group contains the following scan-level data objects.

sv_mid_time (64-bit float, dimension **number_of_scans**); **long_name** = Space view mid time (TAI93)"; mid-time of VIIRS space vew in seconds since 1/1/1993.

sd_mid_time (64-bit float, dimension **number_of_scans**); **long_name** = "Solar diffuser mid time (TAI93)"; mid-time of VIIRS solar diffuser vew in seconds since 1/1/1993.

bb_mid_time (64-bit float, dimension **number_of_scans**); **long_name** = "Blackbody mid time (TAI93)"; mid-time of VIIRS blackbody view in seconds since 1/1/1993.

VIIRS_scan_number (32-bit integer, dimension **number_of_scans**); **long_name** = "VIIRS scan number"; counter of VIIRS scans since last VIIRS power cycle or counter rollover.

4.7.2 **engineering_data**

The **engineering_data** group contains selected VIIRS engineering data fields that have been extracted from the raw engineering packet data. The data objects are summarized in Table 10.

4.7.3 **navigation_data**

The **navigation_data** group contains the ephemeris and attitude data at the SD view times, along with input values for additional information used in calibration (Sun and Moon vectors).

att_quat_sd (32-bit float, dimensions **number_of_scans, quaternion_elements**); **long_name** = "Attitude quaternions at SD mid-times (J2000 to spacecraft)"; attitude quaternions interpolated to **sd_mid_time**, in the J2000 frame.

orb_pos_sd (32-bit float, dimensions **SC_records, vector_elements**); **long_name** = "Orbit position vectors at SD mid-times (ECR)"; **_FillValue** = -9999999.; orbit position vectors interpolated to **sd_mid_time**, in the Earth-centered rotating reference frame.

orb_vel_sd (32-bit float, dimensions **SC_records, vector_elements**); **long_name** = "Orbit velocity vectors at SD mid-times (ECR)"; **_FillValue** = -9999999.; orbit velocity vectors interpolated to **sd_mid_time**, in the Earth-centered rotating reference frame.

solar_j2000 (32-bit float, dimensions **number_of_scans**, **vector_elements**); **long_name** = "Solar unit vectors in J2000 frame"; solar unit vector at **sd_mid_time** in the J2000 frame.

solar_inst (32-bit float, dimensions **number_of_scans**, **vector_elements**); **long_name** = "Solar unit vectors in VIIRS frame"; solar unit vector at **sd_mid_time** in instrument frame.

earth_sun_distance (32-bit float, dimension **number_of_scans**); **long_name** = "Earth-Sun distance"; Earth-to-Sun distance at **sd_mid_time** in AU.

lunar_j2000 (32-bit float, dimensions **number_of_scans**, **vector_elements**); **long_name** = "Lunar unit vectors in J2000 frame"; lunar unit vector at **sd_mid_time** in the J2000 frame.

lunar_inst (32-bit float, dimensions **number_of_scans**, **vector_elements**); **long_name** = "Lunar unit vectors in VIIRS frame"; lunar unit vector at **sd_mid_time** in instrument frame.

Table 10 – Extracted VIIRS Engineering Data Fields

Name	Type	Dimensions
i1_asp_offset	16-bit integer	**number_of_scans, mirror_sides, Iband_detectors**
i2_asp_offset	16-bit integer	**number_of_scans, mirror_sides, Iband_detectors**
i3_asp_offset	16-bit integer	**number_of_scans, mirror_sides, Iband_detectors**
i4_asp_offset	16-bit integer	**number_of_scans, mirror_sides, Iband_detectors**
i5_asp_offset	16-bit integer	**number_of_scans, mirror_sides, Iband_detectors**
m1_asp_offset	16-bit integer	**number_of_scans, mirror_sides, Iband_detectors**
m2_asp_offset	16-bit integer	**number_of_scans, mirror_sides, Iband_detectors**
m3_asp_offset	16-bit integer	**number_of_scans, mirror_sides, Iband_detectors**
m4_asp_offset	16-bit integer	**number_of_scans, mirror_sides, Iband_detectors**
m5_asp_offset	16-bit integer	**number_of_scans, mirror_sides, Iband_detectors**
m6_asp_offset	16-bit integer	**number_of_scans, mirror_sides, Iband_detectors**
m7_asp_offset	16-bit integer	**number_of_scans, mirror_sides, Iband_detectors**
m8_asp_offset	16-bit integer	**number_of_scans, mirror_sides, Iband_detectors**
m9_asp_offset	16-bit integer	**number_of_scans, mirror_sides, Iband_detectors**
m10_asp_offset	16-bit integer	**number_of_scans, mirror_sides, Iband_detectors**
m11_asp_offset	16-bit integer	**number_of_scans, mirror_sides, Iband_detectors**
m12_asp_offset	16-bit integer	**number_of_scans, mirror_sides, Iband_detectors**
m13_asp_offset	16-bit integer	**number_of_scans, mirror_sides, Iband_detectors**
m14_asp_offset	16-bit integer	**number_of_scans, mirror_sides, Iband_detectors**
m15_asp_offset	16-bit integer	**number_of_scans, mirror_sides, Iband_detectors**
m16a_asp_offset	16-bit integer	**number_of_scans, mirror_sides, Iband_detectors**
m16b_asp_offset	16-bit integer	**number_of_scans, mirror_sides, Iband_detectors**
dp_dnb_1a_1b_stage	unsigned byte	**number_of_scans**
dp_dnb_tmg_mode	unsigned byte	**number_of_scans**
dp_dnb_dark_sub_eth	unsigned byte	**number_of_scans**
bb_tmps	16-bit integer	**number_of_scans, number_of_BB_temps**
mf_tel_blkhd_py	16-bit integer	**number_of_scans**
mf_scan_cavity_nxp	16-bit integer	**number_of_scans**
mf_scan_cavity_baf_pz	16-bit integer	**number_of_scans**
mf_scan_cavity_baf_nz	16-bit integer	**number_of_scans**
ap_lw_cca	16-bit integer	**number_of_scans**
ap_vn_cca	16-bit integer	**number_of_scans**
dp_dnb_cca	16-bit integer	**number_of_scans**
ap_sm_cca	16-bit integer	**number_of_scans**
mf_ao_blkhd_px_nz	16-bit integer	**number_of_scans**
mf_ao_blkhd_nx_pz	16-bit integer	**number_of_scans**
mf_stopassy_baff_nz	16-bit integer	**number_of_scans**
mf_fold_mirror_blkhd	16-bit integer	**number_of_scans**
mf_HAM_blkhd	16-bit integer	**number_of_scans**

4.7.4 **onboard_calibration_data**

The **onboard_calibration_data** group contains the measurements from the onboard calibrator views – solar diffuser (SD), space view (SV) and blackbody (BB) – for each band and scan: The calibration data in the packets are compressed onboard, and are uncompressed as part of the Level-1A processing before being stored in the data products. The gain states for the dual-gain bands and the SDSM data are also stored in this group.

[X]_M, X = {SD, SV, BB} (16-bit integer, dimensions **number_of_Mbands_OBC**, **number_of_scans**, **band_detectors**, **Mband_cal_samples**); **long_name** = "[X] data for M-bands"; calibrator view data for all of the M-bands. Note that Band M16 has two sets of calibrator view data (16A and 16B).

[X]_I, X = {SD, SV, BB} (16-bit integer, dimensions **number_of_Ibands**, **number_of_scans**, **Iband_detectors**, **Iband_cal_samples**); **long_name** = "[X] data for I-bands"; calibrator view data for all of the I-bands.

[X]_DNB, X = {SD, SV, BB} (16-bit integer, dimensions **number_of_scans**, **Mband_detectors**, **DNB_cal_samples**); **long_name** = "[X] data for DNB"; calibrator view data for the DNB.

OBC_gain_states (unsigned byte, dimensions **number_of_DG_bands, number_of_scans, Mband_detectors**); **long_name** = "Calibrator view gains for dual-gain M-bands".

SDSM_position (unsigned byte, dimension **number_of_scans**); **long_name** = "SDSM position"; SDSM position during operation (SD, Sun, instrument).

SDSM_sample (32-bit float, dimensions **number_of_scans, SDSM_detectors, SDSM_samples**); **long_name** = "SDSM sample"; converted SDSM measurements.

APPENDIX A – VIIRS Level-1B QUALITY FLAGS

A.1 INTRODUCTION

The VIIRS Level-1B scan and pixel quality flagging scheme is derived from the corresponding IDPS SDR pixel quality flagging scheme. It conveys as much useful information as those in the IDPS SDR format while using fewer bits. This leaves several bits available for reporting of conditions specific to particular band categories, such as the reporting of gain state information for the dual-gain bands. This section provides a description of both the VIIRS Level-1B quality flags and the IDPS SDR quality flags to support the understanding of how they differ.

A.2 PIXEL QUALITY FLAG

A.2.1 VIIRS L1B Pixel Quality Flag Approach

The VIIRS L1B product uses the following pixel-level quality flags for the M and I 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 and/or calibrated radiance out of range (see Table A-1)
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

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

1. 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.
2. 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

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

Value	Meaning	Description
1	Substitute_Cal	Granule-average substitution has been made for SV and/or BB (e.g., moon-in-SV).
2[1]	Out_of_Range	Earth view counts and/or calibrated radiance out of range (see Table A-1)
4[1]	Saturation	L1A Earth view counts ≥ 8191
8	Temp_not_Nominal	Measured temperatures (black body, focal plane) outside nominal range
16	Straylight	Stray light region
512	Missing_EV	Packet missing or corrupted in transmission
1024	Cal_Fail	Calibration failure
2048	Dead_Detector	Detector is not producing valid data

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

1. If a pixel raw DN value equals or exceeds the DN limit of 8191, the pixel "Saturation" quality flag is set, and the DN value is set to 8191.
2. If a pixel raw DN value exceeds the "Out-of-Range" value, the pixel "Out of Range" quality flag is set.

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 pixel quality “poor” bit has been excluded from the VIIRS L1B. It is excluded because there are now an adequate number of bits to explicitly identify all the conditions that have been regarded as the basis for characterizing a pixel as having "poor" quality.

Table A-1 – Out-of-range thresholds

Band	DN Saturation	DN Out of Range	Reflectance Range	Radiance Range[2]
I1	4095	3400	1.31	N/A
I2	4095	3400	1.31	N/A
I3	4095	3400	1.31	N/A
I4	4095	4095	N/A	4.0
I5	4095	4095	N/A	24.0
M1	4095	3700	1.31	N/A
M2	4095	3700	1.31	N/A

M3	4095	3700	1.31	N/A
M4	4095	3700	1.31	N/A
M5	4095	3700	1.31	N/A
M6	4095	2600 (TBR)	1.31	N/A
M7	4095	3700	1.31	N/A
M8	4095	4095	1.31	N/A
M9	4095	4095	1.31	N/A
M10	4095	4095	1.31	N/A
M11	4095	4095	1.31	N/A
M12	4095	4095	N/A	4.50
M13	4095	4095	N/A	600.0
M14	4095	4095	N/A	24.0
M15	4095	4095	N/A	25.0
M16	4095	4095	N/A	22.0
DNB	8191	7860	N/A	0.04

[2] Watts/meter^2/steradian/micrometer

A.2.2 IDPS SDR Pixel Quality Flag Approach

The IDPS Calibration algorithm uses the available pixel-level 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 subset of aggregated pixels are 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 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 are saturated.
- Dual-gain anomaly – Applies only to DG bands, and is very common.
- Moon in SV KOB –
- Scans near by 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 is 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 in the case of software failure.
- Bad coefficients – Should never occur except in the case of software failure.
- Bad thermal value – Applies only to TEB bands; should never occur except in the case of software failure.
- Bad interpolation value – Applies only to TEB bands; should never occur except in the case of software failure.

A.3 SCAN QUALITY FLAG

A.3.1 VIIRS L1B Scan Quality Flagging

In the VIIRS L1B, we have consolidated the scan-level quality flags from being across three QF data sets, as they are in the IDPS SDR, to two.

The **scan_state_flags** object in the VIIRS L1B, provides information on the HAM side, Electronics side, and Night Mode.

The **scan_quality_flags** object in the VIIRS L1B, 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 perjorative, 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	Black body temperatures not nominal
64	LWIR_Temp	LWIR focal plane temperatures not nominal

A3.2 IDPS SDR Scan Quality Flags

The IDPS SDRs contain the following scan-level 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.”