VIIRS/[NPP|JPSS1] Ice Surface Temperature 6-Min L2 Swath 750m, Version 2

USER GUIDE

How to Cite These Data

As a condition of using these data, you must include a citation:

VNP30:

Riggs, G. A., Tschudi, M. A., and D. K. Hall. 2023. *VIIRS/NPP Ice Surface Temperature 6-Min L2 Swath 750m, Version 2*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/SC6UQYYRF79V. [Date Accessed].

VJ130:

Riggs, G. A., Tschudi, M. A., and D. K. Hall. 2023. *VIIRS/JPSS1 Ice Surface Temperature 6-Min L2 Swath 750m, Version 2*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/BW817SEFZ1TT. [Date Accessed].

FOR QUESTIONS ABOUT THESE DATA, CONTACT NSIDC@NSIDC.ORG

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/VNP30 AND https://nsidc.org/data/VJ130

National Snow and Ice Data Center

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1 DATA DESCRIPTION

These VIIRS Level 2 swath data sets contain estimates of sea ice surface temperature (IST), or "skin" temperature at the sea ice surface. Sea IST is an indicator of freeze/thaw processes on ice and has been used to separate thin ice from open water. It also provides coverage of sea ice during polar night at a higher resolution than passive microwave sensors.

Sea IST is computed from VIIRS moderate resolution bands M15 (10.763 µm) and M16 (12.013 µm) using a split-window technique that is consistent with the MODIS Collection 6.1 IST products. Because it is detected with infrared bands, IST is computed for daytime and nighttime over the polar oceans (poleward of 50°N and 50°S). While data are provided both with and without cloud masking, users should be aware that uncertainty of the IST estimates increases substantially under cloud-covered skies.

VIIRS travels on board the Suomi-NPP and JPSS-1 satellites (the latter was renamed NOAA-20 after it became operational). While VIIRS data from these satellites are stored in separate product series – VNP and VJ1, respectively – the algorithms that produce sea ice surface temperature (IST) data in VIIRS Collection 2.0 are consistent between them.

Note: Unlike with MODIS, VIIRS sea ice cover and ice surface temperature (IST) are produced as separate products: V[NP|J1]29 (sea ice cover) and V[NP|J1]30 (IST). This separation allows the data to be produced at the spatial resolution of the underlying acquisition bands, which are 375 m for sea ice cover (I-bands) and 750 m for IST (M-bands).

1.1 Parameters

The Scientific Data Sets (SDSs) included in VNP30 and VJ130 are listed in Table 1.

Table 1. SDS Details

Parameter	Description and Values
`IST`	Ice surface temperature generated by the algorithm, prior to application of the cloud mask. Includes some data flags. Data are in K with a scaling factor of 0.01. 210 – 313: valid range (K) 0: missing — 1: no decision 11: night — 25: land 37: inland water — 39: open ocean

Parameter	Description and Values
`IST_map`	Ice surface temperature with cloud mask applied. Includes some data flags. Data are in K with a scaling factor of 0.01. 210 – 313: valid range (K) 0: missing 1: no decision 11: night 25: land 37: inland water 39: open ocean 50: clouds
`IST_Basic_QA`	A general quality assessment estimate for pixels processed for sea ice temperature. 0-4: valid range, where 0: best, 1: day/good, 2: day/cloud, 3: night/good, 4: night/cloud, 5: other, 6: poor 237: inland water 253: land 254: bowtie trim 255: no data
`QA_Flags`	Bit flags based on QA flags for certain L1B calibrated input data (see Section 2 for more details). All bits are initialized to "off" (0). A bit is set to "on" (1) if the condition described is encountered: Bit 0: L1B_substitue_cal Bit 1: L1B_out_of_range Bit 2: L1B_saturation Bit 3: L1B_temp_not_normal Bit 4: spare Bit 5: spare Bit 6: spare Bit 7: spare

1.1.1 Interpreting the `QA_Flags` parameter

Quality assessment flags from L1B input data have been carried over into the V[NP|J1]30 products and stored as bit flags in the `QA_Flags` SDS. Refer to Section 2 below for more details.

To interpret bit flag values, convert the decimal grid cell value to its binary equivalent. Bit values default to 0 and are set to 1 if the screen result is true. Figure 1 shows how to convert the decimal value 129 to bit flags.

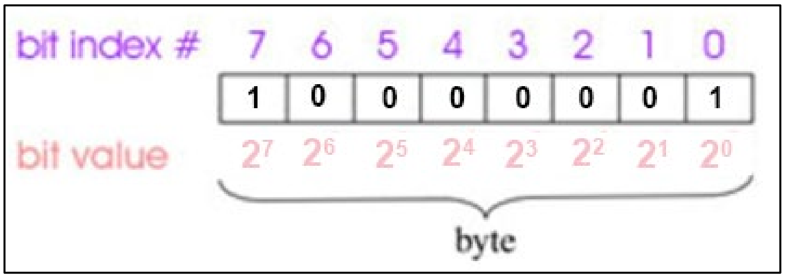

Figure 1. Decoding a bit flag. Bits store values. Bit locations within a byte are numbered, i.e., indexed. Bit positions are indexed from right (0) to left (7), and each bit stores the result (0 or 1) of a screen test. The bit values are the index in base 2 and solve respectively to 1, 2, 4, 8, 16, 32, 64, and 128. In this example, the decimal value 129 is equal to 128+1 (or

2^7+2^0), meaning that the conditions specified in Bit 7 and Bit 0 were encountered.

1.2 File Information

1.2.1 Format

These swath L2 products are available in NetCDF-4/HDF5 and use NetCDF Climate and Forecast (CF-1.6) conventions for global and local attributes and to geolocate the variables.

NetCDF is a set of software libraries and self-describing, machine-independent data formats that are specifically designed to help create, access, and share array-oriented scientific data sets. Note that NetCDF-4 is not a file format. It is a convention for storing data as HDF using the NetCDF data model. For more information, visit the HDF Group's Knowledge Base and Unidata's NetCDF Documentation.

1.2.2 File Contents

As shown in Figure 2, each data file includes two data fields (`IST` and `IST_map`), two data quality fields (`IST_Basic_QA` and `QA_Flags`), and two geolocation data fields (`latitude` and `longitude`). All variables are two-dimensional, with a typical size of 3232 by 3200 (the along-track swath dimension size can be 3248, 3232, or 3216, depending on the file).

Name	Long Name	Type
▼ VJ130.A2021101.1154.002...	VIIRS Ice Surface Temperature	Local File
▼ Geolocation_Data	Geolocation_Data	—
latitude	Latitude data	Geo2D
longitude	Longitude data	Geo2D
▼ IST_Data	IST_Data	—
IST	Ice Surface Temperature	Geo2D
IST_Basic_QA	Basic QA of Ice Surface Temperature	Geo2D
IST_map	Ice Surface Temperature with masks	Geo2D
QA_Flags	Algorithm QA Flags for IST	Geo2D

Figure 2. *IST_Data* and *GeolocationData* groups and their respective data fields included in each VNP30 and VJ130 file, as displayed with Panoply software.

NetCDF-4/HDF5 data files contain metadata including global attributes, which store important details about the data, and local attributes such as keys to data fields. In addition, each data file has a corresponding XML (.xml) metadata file. For detailed information about metadata fields and values, consult the SNPP/JPSS1 VIIRS Ice Surface Temperature Products Collection 2 User Guide.

1.2.3 Naming Convention

Files are named according to the following convention and as described in Table 2.

File naming convention:

`V[SAT]30.A[YYYY][DDD].[HHMM].[VVV].[yyyy][ddd][hhmmss].nc`

Table 2. File Name Variables

`SAT`	Satellite designator: `NP` (Suomi-NPP) or `J1` (JPSS-1)
`30`	Product ID
`A`	Acquisition date follows
`YYYY`	Acquisition year
`DDD`	Acquisition day of year
`HHMM`	Acquisition hour and minute in Greenwich Mean Time (GMT)
`VVV`	Version (Collection) number
`yyyy`	Production year
`ddd`	Production day of year
`hhmmss`	Production hour/minute/second in GMT
`.nc`	NetCDF formatted data file

File name examples:

`VNP30.A2019195.2224.002.2020281095941.nc`

`VJ130.A2021101.1048.002.2021101163052.nc`

1.3 Spatial Information

VNP30 and VJ130 data files contain six minutes of swath data (a scene), during which the instrument sweeps out 202 (and occasionally 203) cross-track scans along a 12 km viewing path. VIIRS Moderate-resolution (M) bands are equipped with 16 detectors and thus the L2 scenes typically contain 3,232 M-band pixels in the along-track direction. The instrument's ±56.28° Earth-view scan width produces 3,200 M-band pixels in the cross-track direction.

VIIRS orbits the globe about 14 times a day and as such, most locations on Earth are imaged at least once per day and more frequently where swaths overlap (at higher latitudes). Suomi-NPP's sun-synchronous, near-circular polar orbit is timed to cross the equator from south to north at approximately 1:30 p.m. local time (and from north to south at 1:30 a.m.). JPSS-1 follows the same orbit, lagging S-NPP by 50 minutes.

The following sites offer tools that track and predict each satellite's orbital path:

- Space Science and Engineering Center (SSEC) Polar Orbit Tracks
- NASA LaRC Satellite Overpass Predictor (includes viewing zenith, solar zenith, and ground track distance to specified lat/lon)

1.3.1 Coverage

Coverage is global, however IST is only computed for ocean pixels poleward of 50ºN and 50ºS.

1.3.2 Resolution

VIIRS M-bands have a spatial resolution of 750 m at nadir.

1.3.3 Geolocation

These L2 swath data are not projected. Latitude and longitude data for each pixel in a swath are stored as auxiliary coordinate variables in the *GeolocationData* group found in each VNP30 and VJ130 file. The coordinate variables, attributes, and datasets follow netCDF CF-1.6 conventions for geolocation.

1.4 Temporal Information

1.4.1 Coverage

VNP30 data are available from 19 January 2012 to present.
VJ130 data are available from 5 January 2018 to present.

If you cannot locate data for a particular date or time, check the MODIS & VIIRS Data Outages Web page.

1.4.2 Resolution

Each data file contains six minutes of an orbital swath.

The satellites orbit the Earth from pole-to-pole approximately every 101 minutes, observing low latitude locations twice per day (once during daytime and once during nighttime). At higher latitudes, observations are more frequent due to overlapping swaths (up to 14 per day at the poles). The satellites repeat the exact orbit every 16 days.

2 DATA ACQUISITION AND PROCESSING

2.1 Background

The sea ice surface temperature algorithm in VIIRS Collection 2.0 utilizes a split-window technique to estimate IST poleward of 50ºN and 50ºS. It uses the same method employed in MODIS 6.1 IST products, but with VIIRS-specific coefficients. A major caveat of the algorithm is that it is applicable only to clear-sky conditions. Inadequate cloud-masking may result in significant error in estimating the IST. For a detailed description of the VIIRS IST algorithm, see Tschudi et al. (2016). The following sections offer a brief summary of the process.

2.2 Instrumentation

The Visible Infrared Imaging Radiometer Suite (VIIRS) instrument collects visible and infrared imagery on 22 spectral bands ranging from 0.412 to 12.01 micrometers. Sixteen moderate resolution bands (M-bands), five imaging resolution bands (I-bands), and one panchromatic day-night band (DNB) acquire spatial resolutions at nadir of 750 m, 375 m, and 750 m, respectively (see the VIIRS Bands and Bandwidth Technical Reference for details on wavelength and resolution of individual bands). More details about the VIIRS instrument are available in the VIIRS Sensor Data Record User Guide and the JPSS VIIRS Radiometric Calibration Algorithm Theoretical Basis Document.

Table 3 lists technical specifications for the VIIRS instrument:

Table 3. VIIRS Technical Specifications

Variable	Description
Orbit	829 km (nominal) altitude, 1:30 p.m. mean local solar time, sun-synchronous, polar, near-circular (Suomi-NPP orbit; JPSS-1 flies on the same orbit, lagging by 50 minutes)
Scan Rate	1.779 sec/rev or 202.3 deg/sec
Swath Dimensions	3060 km (cross track) by ~12 km (along track at nadir) – nearly global coverage every day
Size	1.34 m x 1.41 m x 0.85 m
Weight	275 kg
Power	319 W (single orbit average)
Data Rate	7.674 Mbps (average), 10.5 Mbps (max)
Quantization	12 bits
Spatial Resolution (at nadir)	375 m (Imagery resolution bands) 750 m (Moderate resolution bands)

Variable	Description
Design Life	7 years

2.3 Inputs

Table 4 lists the data products that are input to the VIIRS sea ice surface temperature algorithm. These data are used to check the quality of radiance measurements, identify land and water pixels, detect ice/snow on water, and compute screen pass/fail thresholds:

Table 4. VIIRS data product inputs to the V[NP|J1]30 algorithm

ESDT	Variables (description)	Center wavelength	Spatial resolution
V[NP|J1]02MOD	M15 radiance & brightness temperature look-up tables, M15 quality flags	10.763 µm	750 m
	M16 radiance & brightness temperature look-up tables, M16 quality flags	12.013 µm	
V[NP|J1]03MOD	latitude, longitude, solar_zenith (angle), sensor_zenith land_water_mask	N/A	750 m
V[NP|J1]35_L2	QF1_VIIRSCMIP (cloud confidence flag)	N/A	750 m

2.4 Processing

What follows is a brief description of the algorithm approach and the basic method used to calculate IST. A detailed description of the algorithm can be found in Tschudi et al. (2016) and in references therein. Sea IST is computed using the split-window method from Yu et al. (1995) – the same technique used for the MODIS C6.1 IST products but with VIIRS-specific coefficients – with brightness temperatures from VIIRS bands M15 (10.763 µm) and M16 (12.013 µm) as described below:

$$IST = a + b \cdot T_{11} + c \cdot (T_{11} - T_{12}) + d \cdot [(T_{11} - T_{12}) \cdot (\sec q - 1)]$$

In the IST equation, T_{11} and T_{12} are the brightness temperatures (K) for bands M15 and M16, respectively; q is the scan angle from nadir. The coefficients a, b, c, and d compensate for atmospheric effects (primarily humidity) and are empirically determined (see Tschudi et al., 2016 for details and references). The algorithm utilizes separate coefficient sets for the Arctic and Antarctic in three different temperature ranges: < 240 K, 240 K—260 K, and > 260 K. IST is calculated for all polar ocean pixels in daylight and nighttime.

Clouds are masked with the V[NP|J1]35_L2 cloud confidence flag, which is the same product used in MODIS C6.1. If the flag indicates “confident clear” for an observation, then the observation is interpreted as “clear”. If the flag value is ‘confident cloudy’, ‘probably clear’ or ‘probably cloudy’ then the observation is interpreted as ‘cloud obscured’. This interpretation is intended to minimize cloud/ice confusion. Cloud mask performance was improved through use of 1 km rolling gridded snow inputs and a 1 km vegetation index (VI) file, and algorithm improvements for better delineation of snow at higher latitudes in C2 as described in VIIRS Land C2 Changes.

IST is calculated for polar oceans during both day and night. Day or night observations are determined by the solar zenith angle (SZA) of an observation. Day observations are those with a solar zenith angle < 85°, night observations are at a solar zenith angle ≥ 85°. Solar zenith data is read from the geolocation product V[NP|J1]03MOD. The same IST equation and coefficients are used for day and night observations. Day and night observations are flagged in the `IST_Basic_QA` variable.

2.5 Quality Assessment

Two QA variables are provided with the data: the `IST_Basic_QA`, which gives a simple value, and the `QA_Flags`, which contains results of data screens from the L1B input data as bit flags. The `IST_Basic_QA` value is a qualitative estimate of the algorithm result for a pixel. It is initialized to the best value and then set based on the quality of the L1B input data, day or night observation, and the cloud mask confidence flag value. The `QA_Flags` bit flags are set depending on the quality flags of the M15 and M16 radiance data.

2.6 Interpretation of IST Detection Accuracy, Uncertainty and Errors

Because sea ice can vary in concentration from near zero to 100 percent within a 750 m pixel, computed ISTs can vary across a scene due to mixed-pixel effects. In addition, the presence of melt ponds and leads in the summer months affects the emissivity of the surface and therefore IST calculations.

Cloud masking is perhaps the greatest challenge for IST estimation from satellite observation, as the accuracy of the cloud mask varies greatly between day and night observations. In daylight, the cloud mask is cloud-biased resulting in greater cloud coverage than may exist. In darkness, the cloud mask is biased toward clear conditions, resulting in lack of cloud coverage when there probably is some.

Validation of NASA VIIRS IST data has been performed primarily with airborne IST measurements collected during the NASA Operation IceBridge and with the MODIS IST products. The targeted uncertainty of the VIIRS IST product is ±1 K over a measurement range of 213-275 K.

Previous estimates based on comparisons with the MODIS IST product are overall within the targeted uncertainty, just slightly higher uncertainty (2-3 K) for ISTs higher than 250 K, where VIIRS trends cooler than MODIS. Measurement uncertainty is defined as the root-mean-square of the measurement errors. When compared against IceBridge airborne IST measurements, VIIRS IST was found to be within ±1 K. Refer to the SNPP/JPSS1 VIIRS Ice Surface Temperature Products Collection 2 User Guide (Riggs et al., 2021) for more details on these recent validation efforts.

3 VERSION HISTORY

Table 5. Version History Summary

Version / Collection	Release Date	Description of Changes
V2 / C2	June 2023	QA flag values and meanings related to the calibration of L1B input data were carried over to the L2 swath files. Initial release of VJ130.
V1 / C1	08 August 2017	Initial release of VNP30.

4 RELATED DATA SETS

VIIRS data @ NSIDC

MODIS data @ NSIDC

5 RELATED WEBSITES

NASA Goddard Space Flight Center | Suomi-NPP VIIRS Land

MODIS Snow/Ice Global Mapping Project

Earthdata | VIIRS is Here

6 REFERENCES

Riggs, G. A., M. A. Tschudi, and D. K. Hall. 2021. NASA VIIRS Ice Surface Temperature Products Collection 2 User Guide. (See PDF)

Tschudi, M.A., G. A. Riggs, D.K. Hall, and M.O. Román. 2016. Suomi-NPP VIIRS Ice Surface Temperature Algorithm Theoretical Basis Document (ATBD). 16pp. NASA Goddard Space Flight Center, Greenbelt MD. (See PDF)

Yu, Y., A. Rothrock, and R.W. Lindsay. 1995. Accuracy of sea ice temperature derived from the Advanced Very High Resolution Radiometer. *Journal of Geophysical Research*, 100(C3): 4525-4532. http://dx.doi.org/10.1029/94JC02244

7 DOCUMENT INFORMATION

7.1 Publication Date

June 2023

7.2 Date Last Updated

June 2023