VIIRS/NPP Ice Surface Temperature 6-Min L2 Swath 750m, Version 1

USER GUIDE

How to Cite These Data

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

Tschudi, M., G. Riggs, D. K. Hall, and M. O. Román. 2017. *VIIRS/NPP Ice Surface Temperature 6-Min L2 Swath 750m, Version 1*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/VIIRS/VNP30.001. [Date Accessed].

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

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

National Snow and Ice Data Center

TABLE OF CONTENTS

1 DETAILED DATA DESCRIPTION

The VIIRS sea ice surface temperature (IST) algorithm and output data have been designed to be compatible with Version 6 MODIS ISTs from Aqua and Terra, to ensure continuity between the collections and facilitate climate-data records (CDRs) from the three sensors. Differences in the algorithms reflect physical differences between the instruments, for example spatial resolution and the location of spectral bands.

Note: Unlike MODIS, VIIRS sea ice cover and ice surface temperature (IST) are being produced as separate products: VNP29 (sea ice cover) and VNP30 (this data set). This decision allows the data to be produced at the spatial resolution of the underlying acquisition bands: 375 m for sea ice cover (I-band) and 750 m for IST (M-band).

1.1 Format

Data files are provided in NetCDF-4/HDF5 (`.nc`) format, following the NetCDF Climate and Forecast (CF) Metadata Conventions (Version 1.6). JPEG browse images are also available.

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 HDF5 Home Page and Unidata's NetCDF Documentation website.

1.2 File Contents

VNP30 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 M-bands are equipped with 16 detectors and thus VNP30 M-band scenes typically contain 3,232 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.

1.3 File Naming Convention

VIIRS file names begin with a product identifier (VNP30) followed by the acquisition date and time. Dates are specified as a 4-digit year and 3-digit day of the year. Acquisition times are specified as HHMM and reflect the start time of the 6-minute scene, beginning with 0000 and ending with 2354. Table 1 describes the full VIIRS file naming convention.

```
VNP[PID].A[YYYY][DDD].[HHMM].[VVV].[yyyy][ddd][hhmmss].nc
```

Example File Name:

VNP30.A2012019.0000.001.2017261222822.nc

Table 1. Variables in the VNP29 File Naming Convention

Variable	Description
VNP	VIIRS Suomi NPP
PID	Product ID
A	Acquisition date follows
YYYY	Acquisition year
DDD	Acquisition day of year
HHMM	Acquisition hour and minute in GMT
VVV	Version (Collection) number
yyyy	Production year
ddd	Production day of year
hhmmss	Production hour/minute/second in GMT
.nc	NetCDF-4/HDF5 formatted data file

NetCDF-4/HDF5 data files contain important metadata including global attributes, which store details about the data, and local attributes such as keys to data fields. In addition, each data file has a corresponding XML metadata file. For detailed information about metadata fields and values, consult the NASA S-NPP VIIRS Ice Surface Temperature Products Collection 1 User Guide.

1.4 Spatial Coverage

Coverage is global, however IST values are only valid for polar oceans (pixels poleward of 55°).

To locate the VIIRS sensor at a given time, the following sites offer tools that track and predict NPP's orbital path:

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

1.4.1 Spatial Resolution

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

1.5 Temporal Coverage

Data are available from 19 January 2012 to present. IST is calculated for both daytime and nighttime scenes. If you cannot locate data for a particular date or time, check the VIIRS Data Outages web page.

1.5.1 Temporal Resolution

VIIRS scans the entire globe every one to two days. As such, most locations on Earth are imaged at least once per day and more frequently where swaths overlap, for example near the poles. Suomi NPP's sun-synchronous, near-circular polar orbit is timed to cross the equator from south to north (ascending node) at approximately 1:30 P.M. local time. The repeat cycle is 16 days (quasi 8-day).

1.6 Parameter or Variable

VNP30 data files contain two NetCDF-4/HDF5 groups: `IST_Data` and `Geolocation_Data`. The following sections describe the data sets that are stored within these groups.

1.6.1 IST_Data Group

IST

This data set contains ice surface temperatures with no cloud mask applied. It is provided for users who wish to determine or interpret cloud cover from either the ancillary QA data or from a cloud data product of their choosing. Users should note, however, that the IST algorithm is only valid under *clear sky conditions*. When clouds are present, IST estimates can contain significant errors.

IST_map

This data set contains IST data with the cloud mask overlaid to provide a view of the cloud conditions in the scene. See Cloud Masking below for details.

IST_Basic_QA

The basic QA value provides users with a general quality assessment (best, good, or poor) for each pixel that was processed for IST. The approach is similar to the MODIS IST products, but expanded to include day vs. night and cloud cover. Mask values for land, inland water, and bow tie trim are also included.

QA_Flags

For Version 1, QA_Flags is a placeholder with all pixels set to the fill value 255. Future versions will utilize data screens to test for conditions that confound the IST algorithm and store the results as bit flags.

1.6.2 Geolocation_Data Group

Latitude, Longitude

Separate latitude and longitude data sets at 750 m resolution are provided to geolocate observations in the IST data sets. Each latitude/longitude pair corresponds to the center of a pixel (M-band sensor) in the data arrays.

In addition, data files contain two HDF5 dimension scales—`number_of_lines` and `number_of_pixels`—as defined by Version 1.6 of the NetCDF Climate and Forecast (CF) Metadata Conventions. Dimension scales allow GIS programs like HDFView, Panoply, and GDAL (versions 2.1.2 and higher) to properly map data arrays from index space to geographic coordinate space.

> **Warning:** At this time, ArcGIS and QGIS do not properly geolocate VIIRS swath-level data because they utilize Geospatial Data Abstraction Library (GDAL) libraries which are older than Version 2.1.2. Please contact the vendors for more information. Still have questions? Email NSIDC User Services.

Consult the following tables for additional details about the variables described above, including coded integer keys, data types, and scaling factors:

Table 2. VNP30 Variable Names and Descriptions

Variable Name	Description
`IST`	IST plus other results (16-bit unsigned integers). Valid IST range is 21,000 – 31,000; scale factor to recover IST in kelvins = 0.01. Valid values are: 0: missing 100: no decision 1100: night 2500: land 3700: inland water 3900: open ocean 65535: fill
`IST_map`	IST with cloud mask applied (16-bit unsigned integers). Valid range is 21,000 – 31,000; scale factor to recover IST in kelvins = 0.01. Valid values are: 0: missing 100: no decision 1100: night 2500: land 3700: inland water 3900: open ocean 5000: cloud 65535: fill

Variable Name	Description
`IST_Basic_QA`	General quality assessment (best, good, poor, or cloud) for pixels processed for IST (8-bit unsigned integers). Separate values are provided for day and night. Mask values indicate land, inland water, and bow tie trim. Valid values are: 0: best 1: day good 2: day cloud 3: night good 4: night cloud 5: other 6: poor 237: inland water 253: land mask 254: bow tie trim
`QA_Flags`	Placeholder for a future version. All array locations set to the fill value 255.
`latitude`	750 m resolution (3232 x 3200) latitude array.
`longitude`	750 m resolution (3232 x 3200) longitude array.

Table 3. VNP30 Dimension Scale Data Sets

Variable Name	Description
`number_of_lines`	HDF5 scalar data set/NetCDF shared dimension. 32-bit floating point (3232,1)
`number_of_pixels`	HDF5 scalar data set/NetCDF shared dimension, 32-bit floating point (3200,1)

2 SOFTWARE AND TOOLS

VIIRS NetCDF4/HDF5 data files can be accessed using either NetCDF4 or HDF5 tools. In addition, NASA has two online tools that can help you find the right data for your project. Worldview offers users an interactive interface to view full-resolution, global, near real-time satellite imagery projected on Earth. EarthData allows users to search for and order NASA data sets.

3 DATA ACQUISITION AND PROCESSING

3.1 Derivation Techniques and Algorithms

As with MODIS, the VIIRS sea IST algorithm is based on the work of Key et al., 1997, who demonstrated that a split window technique is accurate enough for most climate process studies. One major caveat, however, is that this approach requires clear skies. Cloud-contaminated pixels can result in significant IST errors. The method in Key et al. expands upon Key and Haefliger, 1992 and has been validated in Key et al., 2013; Yu et al., 1995; Lindsay and Rothrock, 1994; and Massom and Comiso, 1994.

Table 4 lists the products that are input to the VIIRS IST algorithm. All input products have a spatial resolution of 750 m.

Table 4. Input products to the VIIRS sea ice cover algorithm

Product	Data Arrays	Descriptor
NPP_VMAES_L1	BrightnessTemperature_M15	Brightness Temperature
	QF_VIIRSIBANDSDR_M15	Poor quality flag
	BrightnessTemperature_M16	Brightness Temperature
	QF_VIIRSIBANDSDR_M16	Poor quality flag
	SolarZenithAngle	Solar zenith angle
	SatelliteZenithAngle	Satellite zenith angle
VNP35_L2	QF1_VIIRSCMIP (bits 2-3)	Cloud confidence flag
	QF2_VIIRSCMIP (bits (0-2)	Land/water mask

3.1.1 IST Algorithm

VIIRS IST is computed from band M15 (10.763 µm) and M16 (12.013 µm) brightness temperatures in the NPP_VMAES_L1 product, using the split-window method of Yu et al. (1995), updated for VIIRS as follows:

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

In the IST equation, T_{11} and T_{12} are the brightness temperatures (K) for VIIRS 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.[1] The algorithm utilizes separate coefficient sets for the Arctic and Antarctic in three different temperature ranges: < 240; 240K — 260 K; and > 260 K. IST is calculated for all polar ocean water bodies in daylight and nighttime.

[1]Obtained via personal communication from J. Key, NOAA-NESDIS, and Y. Liu, University of Wisconsin Madison.

3.1.2 Cloud Masking

Clouds are masked using the 750 m Cloud Detection Results & Confidence Indicator flag in the VIIRS Cloud Mask product (VNP35_L2). When that flag is set to “confident cloudy” or “probably cloudy,” the pixel is labeled as cloud obscured in the IST map.

3.1.3 Data Screens

The algorithm checks the M15 and M16 quality flag (QF), and if the flag has any value other than good the IST_basic_QA value is set to poor. Subsequent versions of the algorithm will incorporate additional data screens and store the results as bit flags in the QA_Flags data field. However, at this time the QA_Flags data field is a placeholder; all pixels contain the fill value 255.

3.1.4 Bow Tie Effect

VIIRS M bands have 16 rectangular detectors in the along-track direction, oriented with the smaller dimension along-scan. The detector size and scan timing are designed to produce a scan width at nadir that matches the ground-track distance traveled by satellite during one scan period, thus leaving no gap between adjacent scans. However, the along-track width of the VIIRS scan at Earth's surface increases from 11.7 km at nadir to 25.8 km at ±56.28°, due primarily to the increasing distance between the sensor and the ground and Earth's curvature. As a result, the scan footprint has the shape of a bow tie (see Figure 1).

Adjacent scans thus begin to visibly overlap at angles greater than approximately 19°, and in M bands by more than 1 pixel at angles greater than 32°. To save transmission bandwidth, VIIRS removes duplicated pixels in off-nadir portions of scans; however, this introduces visual artifacts in the raw swath images. Users who wish may remove these artifacts via interpolation when images are displayed. Note, however, that the artifacts do not appear in higher-level products in which the scans have been projected and gridded onto Earth’s surface.

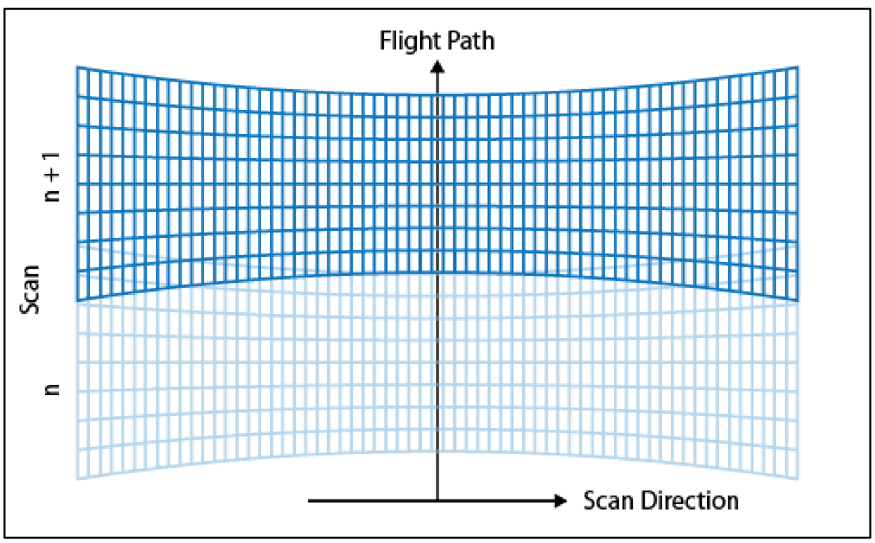

Figure 1. Illustration of the bow tie effect. Increasing scan width away from nadir leads to pixel overlap in adjacent scans.

3.1.5 Quality Assessment

The IST algorithm is accurate to approximately ±1 K (Key et al., 2013). The Science Team is continuing to assess this product's accuracy via comparison with the MODIS IST swath product and NASA Operation IceBridge airborne IST data.

Additional information is available in the NASA S-NPP VIIRS Ice Surface Temperature Products Collection 1 (C1) User Guide and the Suomi-NPP VIIRS Ice Surface Temperature Algorithm Theoretical Basis Document (ATBD).

3.2 Error Sources

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.

The targeted uncertainty of the NASA VIIRS IST product is ±1 K over a measurement range of 213 K – 275 K. Previous estimates based on comparisons with the MODIS IST product approach this value overall, but show generally higher uncertainty (2 K - 3 K) for ISTs above 250 K (Key et al., 2013), with VIIRS cooler than MODIS. Measurement uncertainty is defined as the root-mean-square of the measurement errors.

3.3 Instrument Description

The VIIRS instrument is a whiskbroom scanning radiometer with 22 bands (see VIIRS Bands and Bandwidths) covering the spectrum between 0.412 μm and 12.01 μm. 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. M-bands include 11 Reflective Solar Bands (RSB) and 5 Thermal Emissive Bands (TEBs). I-bands include 3 RSBs and 2 TEBs. More details about the VIIRS instrument are available in the Visible Infrared Imaging Radiometer Suite (VIIRS) Sensor Data Record (SDR) User's Guide and the Joint Polar Satellite System (JPSS) VIIRS Radiometric Calibration Algorithm Theoretical Basis Document (ATBD). Table 5 lists select technical specifications for the VIIRS instrument:

Table 5. VIIRS Specifications

Variable	Description
Orbit	829 km (nominal) altitude, 1:30 P.M. ascending node, sun-synchronous, near-polar, circular
Scan Rate	1.779 sec/rev, 202.3 deg/sec
Scan Width	±56.28° (Earth view)
Imaging Optics	19.1 cm aperture, 114 cm focal length
Swath Dimensions	3060 km cross-track, 12 km along track at nadir
Samples per Band	M-bands: 6304 samples at 0.312 mrad/sample (3200 aggregated pixels) I-bands: 12608 samples at 0.156 mrad/sample (6400 aggregated pixels) DNB: 4064 pixels at 0.149 to 0.894 mrad/pixel
Weight	275 kg
Power	200 W (single orbit average)

Variable	Description
Data Rate	10.5 Mbps (max)
Quantization	12 bit –14 bit A/D converters for lower noise
Launch date	28 October, 2011
Design Life	7 years (5-year mission)

4 REFERENCES AND RELATED PUBLICATIONS

4.1 References

Justice, C.O., M.O. Román, I. Csiszar, E.F. Vermote, R.E. Wolfe, S.J. Hook, M. Friedl, Z. Wang, C.B. Schaaf, T. Miura, M. Tschudi, G. Riggs, D.K. Hall, A.L. Lyapustin, S. Devadinga, C. Davidson, and E.J. Masuoka. 2013. Land and cryosphere products from Suomi NPP VIIRS: Overview and status. *Journal of Geophysical Research – Atmospheres*, 118(17): 9753-9765. http://dx.doi.org/10.1002/jgrd.50771

Key, J., J. Collins, C. Fowler, and R. Stone. 1997. High-latitude surface temperature estimates from thermal satellite data. Remote Sensing of the Environment. 61: 302-309. https://doi.org/10.1016/S0034-4257(97)89497-7

Key, J. and M. Haefliger. 1992. Arctic ice surface temperature retrieval from AVHRR thermal channels. *Journal of Geophysical Research*. 97(D5): 5885-5893. http://dx.doi.org/10.1029/92JD00348

Key, J. R., et al. 2013. Snow and ice products from Suomi NPP VIIRS. Journal of Geophysical Research – *Atmospheres*, 118: 12,816–12,830. http://dx.doi.org/10.1002/2013JD020459

Lindsay, R.W. and D.A. Rothrock. 1994. Arctic sea ice surface temperature from AVHRR. *Journal of Climate*, 7: 174–183. https://doi.org/10.1175/1520-0442(1994)007<0174:ASISTF>2.0.CO;2

Liu, Y., et al. 2015. Validation of the Suomi NPP VIIRS Ice Surface Temperature Environmental Data Record. *Remote Sensing*, 7:17258-17271. http://dx.doi.org/10.3390/rs71215880

Massom, R., and J.C. Comiso. 1994. The classification of Arctic sea ice types and the determination of surface temperature using advanced very high resolution radiometer data. *Journal Geophysical Research*, 99(C3): 5201-5218. http://dx.doi.org/10.1029/93JC03449

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.

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

Yu, Y. and D.A. Rothrock. 1996. Thin ice thickness from satellite thermal imagery. *Journal of Geophysical Research*, 101(C11): 25,753-25,766. http://dx.doi.org/10.1029/96JC02242

4.2 Related Websites

- NASA Goddard Space Flight Center | Polar Orbiting Missions | Suomi-NPP
- NASA Goddard Space Flight Center | Suomi-NPP VIIRS Land
- MODIS Snow/Ice Global Mapping Project
- Earthdata | VIIRS is Here

5 DOCUMENT INFORMATION

5.1 Publication Date

August 2017

5.2 Date Last Updated

30 March 2021