VIIRS/[NPP|JPSS1|JPSS2] CGF Snow Cover Daily L3 Global 375m SIN Grid, Version 2

USER GUIDE

How to Cite These Data

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

VNP10A1F:

Riggs, G. A. and D. K. Hall. 2021. *VIIRS/NPP CGF Snow Cover Daily L3 Global 375m SIN Grid, Version 2*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/PN50Y51IVNLE. [Date Accessed].

VJ110A1F:

Riggs, G. A. and D. K. Hall. 2021. *VIIRS/JPSS1 CGF Snow Cover Daily L3 Global 375m SIN Grid, Version 2*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/2YJ7GZPW2NNB. [Date Accessed].

VJ210A1F:

Riggs, G. A. and D. K. Hall. 2025. *VIIRS/[NPP|JPSS1|JPSS2] CGF Snow Cover Daily L3 Global 375m SIN Grid, Version 2*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/YAWW1AIS887J. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/VNP10A1F, https://nsidc.org/data/VJ110A1F, AND https://nsidc.org/data/VJ210A1F

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1 DATA DESCRIPTION

These VIIRS Level 3 data sets are daily cloud-gap-filled (CGF) versions of the *VIIRS Snow Cover Daily L3 Global 375m SIN Grid* (V[NP|J1|J2]10A1) products. Grid cells in V[NP|J1|J2]10A1 that are obscured by cloud cover are filled by retaining clear-sky views of the surface from previous days (Hall et al., 2010). A separate parameter is provided which tracks the number of days in each cell since the last clear-sky observation.

Snow-covered land typically has very high reflectance in visible bands and very low reflectance in the shortwave infrared bands. The Normalized Difference Snow Index (NDSI) reveals the magnitude of this difference, with values greater than 0 typically indicating the presence of at least some snow. The VIIRS snow cover algorithm computes NDSI using VIIRS image bands I1 (0.64 µm, visible red) and I3 (1.61 µm, shortwave near-infrared) and then applies a series of data screens designed to alleviate likely errors and flag uncertain snow detections.

VIIRS travels on board the Suomi-NPP and the JPSS-1 and JPSS-2 satellites (the latter two were renamed NOAA-20 and NOAA-21 after they became operational). While VIIRS data from these satellites are stored in separate product series – VNP, VJ1 and VJ2, respectively – the algorithms that produce snow cover data in VIIRS Collection 2.0 are consistent between the three satellite missions and also with MODIS Collection 6.1. This is intended to simplify the process of merging snow cover data from the S-NPP, JPSS-1, JPSS-2, Terra, and Aqua products (Hall et al., 2019; Thapa et al., 2019; Riggs and Hall, 2020; Zhang et al., 2020; and Román et al., 2024.

1.1 Parameters

Scientific Data Sets (SDSs) included in VNP10A1F, VJ110A1F, and VJ210A1F are listed in Table 1.

Table 1. SDS Details

Parameter	Description and Values
`CGF_NDSI_Snow_Cover`	Gridded cloud-gap-filled NDSI snow cover values and data flag values, stored as 8-bit unsigned integers. 0–100: NDSI snow cover valid range 201: no decision; 211: night 237: lake / inland water; 239: ocean 250: cloud; 251: missing L1B data 252: L1B data failed calibration; 253: onboard VIIRS bowtie trim 254: L1B fill; 255: L2 fill

Parameter	Description and Values
`Cloud_Persistence`	Count of consecutive days with cloud cover. 0-254: valid data range 255: fill value
`Daily_NDSI_Snow_Cover`	A copy of the V[NP|J1]10A1 `NDSI_snow_cover` parameter. Same values/flags as in `CGF_NDSI_Snow_Cover`.
`Algorithm_Bit_Flags_QA`	Algorithm-specific bit flags indicating data screen results applied in the V[NP|J1|J2]10 algorithm. These bit flags can be read to assess the quality of an observation, and multiple bit flags masks may be set for an observation. All bits are initialized to “off” (0). A bit is set to “on” (1) if the condition described is encountered: Bit 0: Inland water screen Bit 1: Low visible screen failed, snow detection reversed to no snow Bit 2: Low NDSI screen failed, snow detection reversed to no snow Bit 3: Combined temperature/height screen failed • brightness temperature ≥ 281 K, pixel height < 1300 m, flag set, snow detection reversed to not snow, OR; • brightness temperature ≥ 281 K, pixel height ≥ 1300 m, flag set, snow detection NOT reversed. Bit 4: spare Bit 5: High Shortwave IR (SWIR) reflectance screen • Snow pixel with SWIR > 0.45, flag set, snow detection reversed to not snow, OR; • Snow pixel with 0.25 < SWIR ≤ 0.45, flag set to indicate unusual snow condition, snow detection NOT reversed Bit 6: spare Bit 7: Uncertain snow detection due to low illumination (solar zenith flag)
`Basic_QA`	A general quality assessment for pixels processed for snow: 0-3: valid range, where 0 = best, 1 = good, 2 = poor, 3 = other 211: night; 239: ocean 250: cloud; 251: missing L1B data 252: L1B data failed calibration; 253: bowtie trim 254: L1B fill; 255: no data
`Projection`	Sinusoidal projection attributes: *grid_mapping_name* = "sinusoidal" *longitude_of_central_meridian* = 0. *false_easting* = 0. *false_northing* = 0. *earth_radius* = 6371007.181

1.1.1 Interpreting the `Algorithm_Bit_Flags_QA` parameter

Pixels determined to have some snow present are subjected to a series of screens that have been specifically developed to alleviate snow commission errors (detecting snow where there is no snow) and to flag uncertain snow detections. In addition, snow-free pixels are screened for very low illumination to prevent possible snow omission errors. Screen results, as well as the location of inland water, are stored as bit flags in the `Algorithm_bit_flags_QA` SDS. Refer to Section 3.3.1 of the SNPP/JPSS1 VIIRS Snow Cover Products Collection 2 User Guide (Riggs and Hall, 2021) for details on the individual data screens.

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.

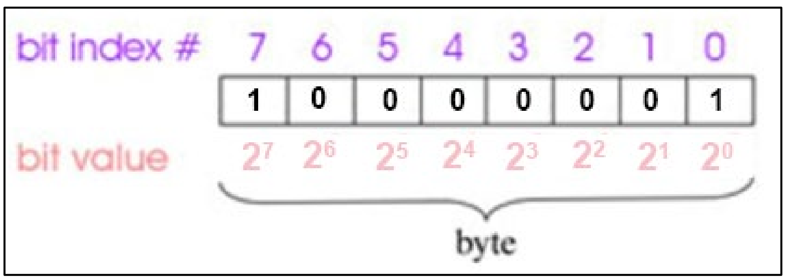

Figure 1. Decoding a bit flag. Bits store values. Bit locations within a byte are numbered, i.e., indexed. Bit positions are indexed from right/LSB (0) to left/MSB (7), and each bit stores the result (0 or 1) of a screen test. The bit values are the index in base 2 and the decimal equivalents are, respectively, 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 (see Table 1).

1.2 File Information

1.2.1 Format

These L3 products are provided in HDF-EOS5 format and use NetCDF Climate and Forecast (CF-1.6) conventions for global and local attributes and to geolocate the variables. For software and more information, visit the HDF-EOS website.

1.2.2 File Contents

As shown in Figure 2, each data file includes three data fields (`CGF_NDSI_Snow_Cover`, `Cloud_Persistance`, and `Daily_NDSI_Snow_Cover`), two data quality fields

(`Algorithm_Bit_Flags_QA` and `Basic_QA`), and an ancillary field with projection attributes (`Projection`). X and Y coordinate arrays are included for the specified projection (`XDim` and `YDim`).

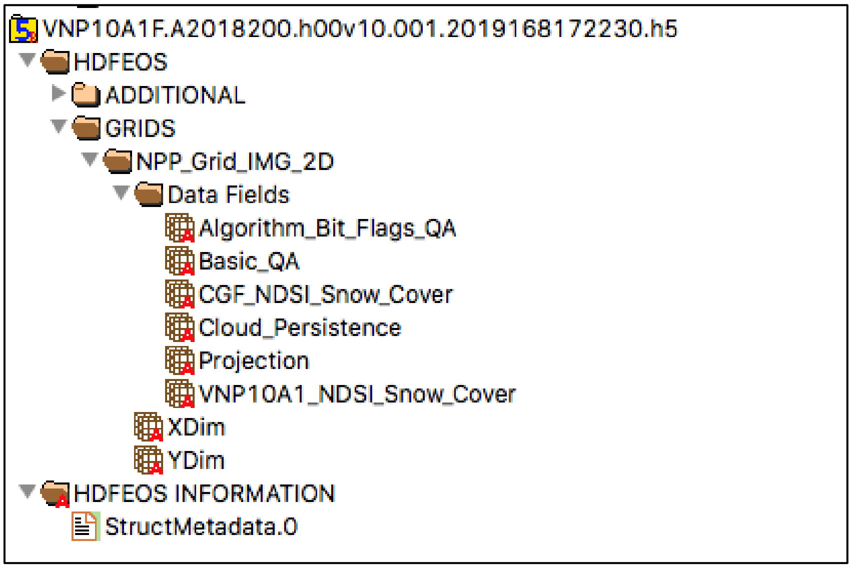

Figure 2. Parameters included in each V[NP|J1|V2]10A1F file, as displayed with HDFView software. All data fields are two-dimensional except for `Projection`, which is an empty, attribute-only field.

The metadata within HDF-EOS5 data files contain global attributes, which store important details about the data, and local attributes such as keys to data fields. Each data file also has a corresponding XML (.xml) metadata file. For detailed information about metadata fields and values, consult the SNPP/JPSS1 VIIRS Snow Cover 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]10A1F.A[YYYY][DDD].h[NN]v[NN].[VVV].[yyyy][ddd][hhmmss].h5`

Table 2. File Name Variables

SAT	Satellite designator: `NP` (Suomi-NPP), `J1` (JPSS-1), or `J2` (JPSS-2)
10A1F	Product ID
A	Acquisition date follows
YYYY	Acquisition year
DDD	Acquisition day of year
h[NN]v[NN]	Horizontal tile number and vertical tile number (see *Grid* section for details)
VVV	Version (Collection) number

`yyyy`	Production year
`ddd`	Production day of year
`hhmmss`	Production hour/minute/second in Greenwich Mean Time (GMT)
`.h5`	HDF-EOS5 formatted data file

File name examples:

`VNP10A1F.A2019011.h02v08.002.2020248134633.h5`

`VJ110A1F.A2021092.h23v04.002.2021093091141.h5`

`VJ210A1F.A2025182.h14v14.002.2025183063150.h5`

1.3 Spatial Information

1.3.1 Coverage

Global

1.3.2 Projection

The V[NP|J1|J2]10A1F data sets are georeferenced to an equal-area sinusoidal projection. Areas on the grid are proportional to the same areas on Earth and distances are correct along all parallels and the central meridian. Shapes become increasingly distorted away from the central meridian and near the poles. The data are neither conformal, perspective, nor equidistant. Meridians, except for the central meridian, are represented by sinusoidal curves and parallels are represented by straight lines. The central meridian and parallels are lines of true scale.

1.3.3 Grid

As shown in Figure 3, data are gridded using the MODIS Sinusoidal Tile Grid, which comprises 460 non-fill tiles that each cover 10° by 10° at the equator or approximately 1,200 km by 1,200 km. Each data granule (file) covers one tile and consists of 3,000 rows and 3,000 columns.

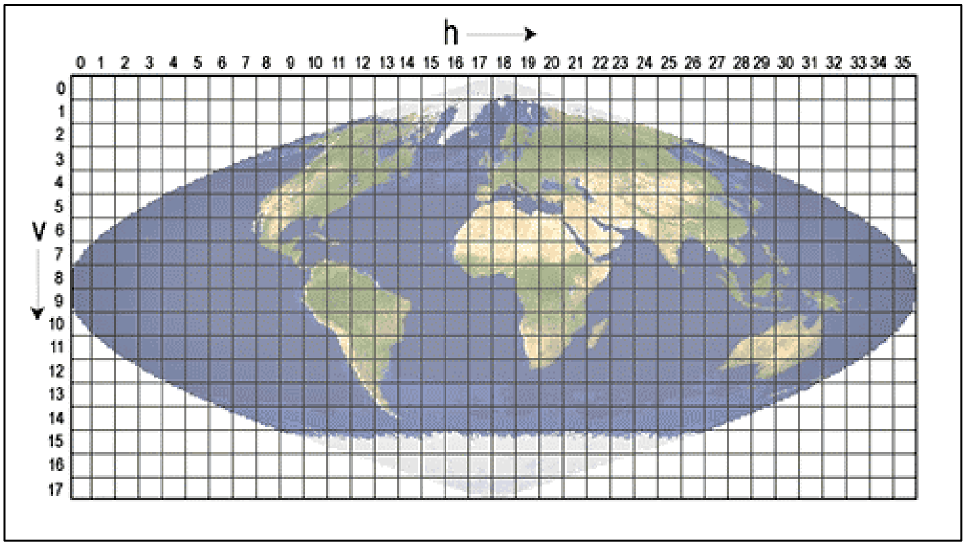

Figure 3. The MODIS Sinusoidal Tile Grid

1.3.4 Resolution

The nominal spatial resolution is 375 meters.

1.3.5 Geolocation

The following tables provide information for geolocating this data set.

Table 3. Projection Details

Region	Global
Geographic coordinate system	WGS84
Projected coordinate system	Sinusoidal Grid
Longitude of true origin	0°
Latitude of true origin	0°
Scale factor at longitude of true origin	1.0
Datum	WGS 84
Ellipsoid/spheroid	6371007.181000 meters
Units	Meter
False easting	0°
False northing	0°
EPSG code	N/A
PROJ4 string	+proj=sinu +lon_0=0 +x_0=0 +y_0=0 +ellps=WGS84 +datum=WGS84 +units=m +no_defs
Reference	https://modis-land.gsfc.nasa.gov/MODLAND_grid.html

Table 4. Grid Details

Grid cell size (x, y pixel dimensions)	375 m
Number of rows	3000
Number of columns	3000
Nominal gridded resolution	375 m
Grid rotation	N/A
Upper left corner point (m)	`XDim(0)`, `YDim(0)`
Lower right corner point (m)	`XDim(2999)`, `YDim(2999)`

1.4 Temporal Information

1.4.1 Coverage

VNP10A1F data are available from 19 January 2012 to present.

VJ110A1F data are available from 5 January 2018 to present.

VJ210A1F data are available from 10 February 2023 to present

Because computation of the NDSI depends on visible light, data are not produced for the night phase of each orbital period or for those portions of fall and winter in polar regions when viewing conditions are too dark. If you cannot locate data for a particular date or time, check the MODIS & VIIRS Data Outages Web page.

1.4.2 Resolution

Daily

2 DATA ACQUISITION AND PROCESSING

2.1 Background

The snow detection algorithm in VIIRS Collection 2.0 is consistent with MODIS Collection 6.1. For a detailed description of the MODIS snow detection algorithm, see Hall et al. (2001). For a revised explanation of the NDSI snow cover algorithm theory, see the Riggs et al. (2015). The MODIS and VIIRS snow cover algorithms both use the NDSI snow detection algorithm, albeit adjusted for sensor and input data differences.

The purpose of these CGF snow cover products is to provide daily cloud-free maps of snow cover. The `CGF_NDSI_snow_cover` parameter provides an estimate of the snow cover that might exist under current cloud cover.

2.2 Instrumentation

The Visible Infrared Imaging Radiometer Suite (VIIRS) instrument collects visible and infrared imagery in 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.

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. Table 5 lists technical specifications for the VIIRS instrument, and 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)

Table 5. 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-2 and JPSS-1 fly on the same orbit, with the former preceding by 20 minutes and the latter 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)
Design Life	7 years

2.3 Inputs

These V[NP|J1]10A1F Level-3 data sets are generated from VIIRS/[NPP|JPSS1] Snow Cover Daily L3 Global 375m SIN Grid, Version 2 data sets.

2.4 Processing

The CGF daily snow cover map is generated by using a previous day non-cloud observation when the current day is a cloud observation. The VIIRS CGF algorithm inputs the current day V[NP|J1]10A1 snow cover and V[NP|J1|J2]10A1F snow cover from the previous day. The current day CGF snow cover field is generated by replacing the current day's V[NP|J1|J2]10A1 cloud-covered observations with V[NP|J1|J2]10A1F non-cloud (clear view) observations from the previous day. Cloud persistence is tracked by incrementing or resetting the count of consecutive days of cloud cover in each grid cell in the `Cloud_Persistence` parameter. When a cloud-free observation occurs, the cloud persistence count is reset to `0`. If the current day is cloudy, then the count is incremented by one day.

The `Basic_QA` and the `Algorithm_Bit_Flags_QA` parameters in V[NP|J1|J2]10A1F are also set to the current day non-cloud observation corresponding QA data value of V[NP|J1|J2]10A1 or replaced with the previous day V[NP|J1|J2]10A1F values if current day observation is cloud. The V[NP|J1|J2]10A1F also contains a copy of the current day V[NP|J1|J2]10A1 NDSI_Snow_Cover variable to facilitate comparison with the CGF_NDSI_Snow_Cover variable.

The CGF snow cover products are produced as a 12-month sequence corresponding to the United States Geological Service (USGS) "water year" beginning on 1 October and ending on 30 September of each year for the Northern Hemisphere. For the Southern Hemisphere, the water year is 1 July to 30 June. On the first day of the water year (or first day of temporal coverage) V[NP|J1|J2]10A1F is produced as a copy of V[NP|J1|J2]10A1 and cloud persistence values are set to `1` for grid cells that are cloud-covered. Over time the V[NP|J1|J2]10A1F gap-filled cloud cover will eventually decline to zero, as non-cloud observations replace cloud observations. Typically, it takes five to seven days to reach a nearly cloud free map, but this depends on the season and location.

Fill data originating from orbit gaps or missing parts of V[NP|J1|J2]10 swaths (which are passed on to V[NP|J1|J2]10A1) are replaced with a non-fill data value from the previous day's V[NP|J1|J2]10A1F snow cover, and the cloud persistence count is incremented by one. In addition, some V[NP|J1|J2]10A1 entire tiles are missing for certain days in the data record. In this case, the algorithm repeats the previous day's V[NP|J1|J2]10A1F snow cover as the current day and increments the cloud persistence count by one for all cells. The global attribute *MissingDaysOfV[NP|J1|J2]10A1* reports the number of missing days for the tile.

A user can determine if V[NP|J1|J2]10A1F is the first day of a time series or a day in the series by reading the global attribute *FirstDayOfSeries*. This attribute is set to `Y` for the first day in a time series and to `N` for all other days in the time series. The global attribute *TimeSeriesDay* stores the count of days in the series since the first day (i.e., the value of `N` if different from zero).

For information on the snow cover detection algorithm, please refer to the V[NP|J1|J2]10 User Guide. For information on the transfer of snow cover data from swath to the sinusoidal grid, please refer to the V[NP|J1|J2]10A1 User Guide. For more details on the algorithms of any of these and/or the CGF products, please refer to the SNPP/JPSS1 VIIRS Snow Cover Products Collection 2 User Guide (Riggs and Hall, 2021) or the Algorithm Theoretical Basis Documents (ATBDs; Hall et al., 2001 and Riggs et al., 2015).

2.5 Quality Information

The two QA parameters included with the data, `Basic_QA` and `Algorithm_Bit_Flags_QA`, are originally produced in the Level-2 products (V[NP|J1|J2]10) and carried over to V[NP|J1|J2]10A1, passing on to V[NP|J1|J2]10A1F as described above. The `Basic_QA` parameter is a general quality value assigned to grid cells in the swath products, while the `Algorithm_Bit_Flags_QA` parameter reports the results of individual data screens carried out in the production of the Level-2 snow cover data. By examining the bit flags, users can determine if any of the data screens: a) changed a pixel's initial result from “snow” to “not snow”; or b) flagged snow cover in a pixel as “uncertain”. See Section 1.1.1 above for instructions on how to decode the screen results. For details on the individual data screens, refer to Section 3.3.1 of the SNPP/JPSS1 VIIRS Snow Cover Products Collection 2 User Guide.

2.6 Errors

Given the VIIRS CGF products are direct derivatives of the V[NP|J1|J2]10A1 data sets, users should be aware of the main sources of error affecting the upstream products.

2.6.1 Snow Cover

The NDSI technique for snow detection has been shown to be a robust indicator of snow around the globe. Numerous studies using the MODIS snow products have reported accuracy statistics under cloud-free conditions in the range of 88-93% (see list of publications on the NASA MODIS website). The S-NPP snow cover is 98% consistent with MODIS snow cover (Thapa et al., 2019). Accuracy of the VIIRS snow cover detection algorithm (from S-NPP data) is similar to the accuracy reported for the MODIS sensors, varying with landscape (Zhang et al., 2020). Accuracy assessments using using JPSS-1 and JPSS-2 data were not available when this document was written.

Warm surfaces, low reflectance in the visible range (which may falsely lead to low positive NDSI), unusually high SWIR reflectance, cloud/snow confusion, lake ice, and bright surface features are conditions known to adversely affect snow cover detection and may also interfere with the data screens, leading to uncertainty and errors in snow cover reporting. These conditions and their implications are discussed in detail in the SNPP/JPSS1 VIIRS Snow Cover Products Collection 2 User Guide.

Snow cover on the Antarctica Peninsula – While the continent of Antarctica is mostly ice- and snow-covered year-round, some changes are observable on the Peninsula. The snow cover detection algorithm is run for the region without any Antarctica-specific processing paths. The resulting snow cover map may show some erroneous snow-free areas due to the great difficulty in detecting clouds over Antarctica. Similarity in reflectance and lack of thermal contrast between clouds and ice/snow cover, sometimes related to thermal inversions, are major challenges to accurate snow/cloud discrimination over Antarctica. Users interested in snow cover data for that area should scrutinize the V[NP|J1|J2]10A1F products for accuracy and quality.

2.6.2 Swath Selection

Choosing a single, best observation of the day results in a weave or stitch pattern along the edges of adjacent swaths. This pattern is most apparent where cloud cover changed between the acquisition times of overlapping swaths. In addition, users may encounter interwoven cloud and clear observations in images with snow cover. Differences in viewing geometry can also produce discontinuities in regions where adjacent swaths overlap.

2.6.3 Geolocation

Geolocation error may be visible due to a) uncertainty in swath geolocation and b) the process of gridding and projecting the swaths into the MODIS Sinusoidal Tile Grid from day to day. This latter effect, a so-called geolocation wobble, is most commonly observed as daily shifts in the position of a lake, by one or more cells, in the horizontal or vertical directions. Thus, compositing tiles over the course of several consecutive days may result in blurred lake outlines and other small features.

3 VERSION HISTORY

Table 6. Version History Summary

Version / Collection	Release Date	Description of Changes
V2 / C2	January 2026	Initial release of VJ210A1F
V2 / C2	June 2023	Certain global and local attributes were revised to conform with NetCDF CF-1.6 conventions. C1 local attributes *mask_values* and *mask_meanings* were renamed as *flag_values* and *flag_meanings*, respectively. The `Projection` parameter was added to conform with CF-1.6 conventions on projection of data. Initial release of VJ110A1F.
V1 / C1	22 August 2019	Initial release of VNP10A1F.

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

Hall, D.K., Riggs, G.A. and Salomonson, V.V. 2001. Algorithm Theoretical Basis Document (ATBD) for MODIS Snow and Sea Ice-Mapping Algorithms. Guide. NASA Goddard Space Flight Center, Greenbelt, MD.

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Zhang, H., Zhang, F., Che, T., and Wang, S. 2020. Comparative evaluations of VIIRS daily snow cover product with MODIS for snow detection in China based on ground observations. *Science of the Total Environment*, **724**: 138156, https://doi.org/10.1016/j.scitotenv.2020.138156.

7 DOCUMENT INFORMATION

7.1 Publication Date

June 2023

7.2 Date Last Updated

January 2026