VIIRS/[NPP|JPSS1|JPSS2] Snow Cover Daily L3 Global 0.05Deg CMG, Version 2

USER GUIDE

How to Cite These Data

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

VNP10C1:

Riggs, G. A. and D. K. Hall. 2021. *VIIRS/NPP Snow Cover Daily L3 Global 0.05Deg CMG, Version 2*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/PHOQ2G589HCC. [Date Accessed].

VJ110C1:

Riggs, G. A. and D. K. Hall. 2021. *VIIRS/JPSS1 Snow Cover Daily L3 Global 0.05Deg CMG, Version 2*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/DNC2SNXE6HJB. [Date Accessed].

VJ210C1:

Riggs, G. A. and D. K. Hall. 2025. *Snow Cover Daily L3 Global 0.05Deg CMG, Version 2*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/C4RONGZ0CHHI. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/VNP10C1, https://nsidc.org/data/VJ110C1, and https://nsidc.org/data/VJ210C1

National Snow and Ice Data Center

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1 DATA DESCRIPTION

These VIIRS Level 3 data sets provide daily estimates of snow cover extent on a global Climate Modeling Grid (CMG) at 0.05-degree spatial resolution. They are produced by gridding the *VIIRS Snow Cover Daily L3 Global 375m SIN Grid* (V[NP|J1|J2]10A1) tile products to the CMG geographic projection. Cloud cover data are also included.

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 VNP10C1, VJ110C1, and VJ210C1 are listed in Table 1.

Table 1. SDS Details

Parameter	Description and Values
Snow_Cover	The percentage of snow-covered land mapped in a grid cell. Cloud observations are not flagged in this variable, despite the cloud value indicated in the flag attributes. Antarctica is intentionally mapped as 100% snow cover. 0–100: snow cover extent valid range 201: no decision 211: night 237: lake / inland water 239: ocean 243: Antarctica 250: cloud 251: missing L1B data 252: L1B data failed calibration 253: onboard VIIRS bowtie trim 254: L1B fill 255: L3 fill

Parameter	Description and Values
Cloud_Cover	The percentage of cloud-covered land mapped in a grid cell. The flag_values and flag_meanings included in Snow_Cover are also included in this parameter. 0-100: cloud cover extent valid range
Clear_Index	The percentage of all non-cloud observations that were mapped in a grid cell. In other words, this map is the inverse of Cloud_Cover; adding both should yield 100% for all valid data cells. The flag_values and flag_meanings included in Snow_Cover are also included in this parameter. 0-100: clear index extent valid range
Basic_QA	The mode of the basic QA values from all observations mapped in a grid cell. If more than one mode exists, the lowest QA value is selected. The flag_values and flag_meanings included in Snow_Cover are also included in this parameter. 0-3: valid range, where 0 = good, 1 = poor, 2 = bad, 3 = other

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 (Snow_Cover, Cloud_Cover, and Clear_Index) and one data quality field (Basic_QA). X and Y coordinate arrays are included for the specified projection (XDim and YDim).

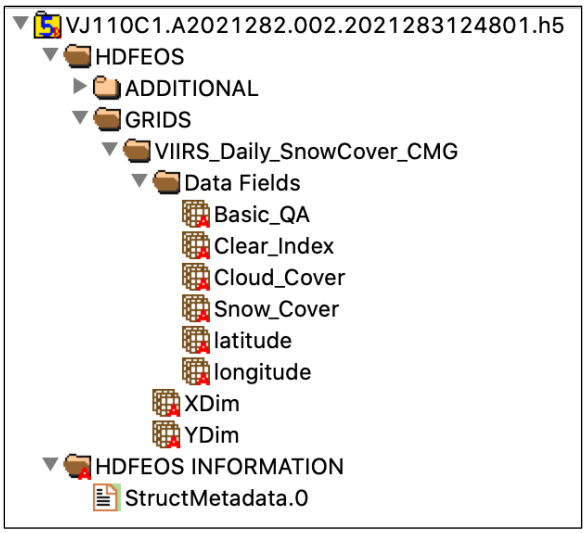

Figure 1. Parameters included in each V[NP|J1|J2]10C1 file, as displayed with HDFView software. All data fields are two-dimensional except for the coordinate variables `latitude` and `longitude`, which are 1D.

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]10C1.A[YYYY][DDD].[VVV].[yyyy][ddd][hhmmss].h5`

Table 2. File Name Variables

`SAT`	Satellite designator: `NP` (Suomi-NPP), `J1` (JPSS-1), or `J2` (JPSS-2)
`10C1`	Product ID
`A`	Acquisition date follows
`YYYY`	Acquisition year
`DDD`	Acquisition day of year
`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:

VNP10C1.A2019199.002.2021273154130.h5

VJ110C1.A2021336.002.2021337094722.h5

VJ210C1.A2024001.002.2025282190607.h5

1.3 Spatial Information

1.3.1 Coverage

Global

1.3.2 Projection

MODIS CMG data sets are provided in geographic latitude/longitude coordinates. For additional details about the MODIS CMG see the NASA MODIS Lands | MODIS Grids web page.

1.3.3 Resolution

0.05°

1.3.4 Geolocation

The following tables provide information for geolocating this data set.

Table 3. Projection Details

Region	Global
Geographic coordinate system	WGS84
Projected coordinate system	Geographic Lat/Lon
Longitude of true origin	0°
Latitude of true origin	0°
Scale factor at longitude of true origin	1.0
Datum	WGS 84
Ellipsoid/spheroid	WGS 84
Units	degrees
False easting	0°
False northing	0°
EPSG code	4326
PROJ4 string	+proj=longlat +datum=WGS84 +no_defs
Reference	https://epsg.io/4326

Table 4. Grid Details

Grid cell size (x, y pixel dimensions)	0.05°, 0.05°
Number of rows	3600
Number of columns	7200
Nominal gridded resolution	0.05°
Grid rotation	N/A
Geolocated upper left point in grid	-180.0°(x), 90.0°(y)
Geolocated lower right point in grid	180.0°(x), -90.0°(y)

1.4 Temporal Information

1.4.1 Coverage

VNP10C1 data are available from 19 January 2012 to present.
VJ110C1 data are available from 5 January 2018 to present.
VJ210C1 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 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 product differences.

This data set provides daily global maps of the snow cover extent, cloud cover extent, and clear index extent. Snow cover extent and cloud cover extent are provided as the percentage of snow-covered land or cloud-covered land mapped in the CMG cell. The clear index extent is provided as

the percentage of all land observations in the cell that were clear, thus producing an estimate of the amount of land surface that was observable.

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). All three satellites complete a sun-synchronous, near-circular polar orbit in sequence, each crossing the equator within a 75-minute span. JPSS-2 crosses the equator from south to north at approximately 1:10 p.m. local time (and from north to south at 1:10 a.m.), followed by S-NPP at approximately 1:30 p.m. local time, and finally JPSS-1 at approximately 2:20 p.m. local time.

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)

Variable	Description
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|JPSS2] Snow Cover Daily L3 Global 375m SIN Grid, Version 2 data sets.

2.4 Processing

The V[NP|J1|J2]10C1 CMG binning algorithm is used to calculate the snow cover extent, cloud cover extent, and associated quality values mapped to CMG cells. The algorithm maps 375 m V[NP|J1|J2]10A1 `NDSI_Snow_Cover` observations into 0.05° (approx. 5 km) CMG cells. If the NDSI value is in the 1-100 range, it is tallied as 'snow'; if the observation is 0, it is tallied as 'no snow'. Snow cover in the CMG cell is computed as the percentage of snow observation counts relative to the total number of observations mapped in the grid cell. The total observation count considers 'snow'/'no-snow', 'cloud', and any flag values.

Analogously, cloud cover is computed as the percentage of cloud observation counts relative to the total number of observations mapped in the grid cell. A clear index is calculated as the percentage of observations that were not flagged as 'cloud'.

A CMG-specific land mask was derived from the University of Maryland 1km global land cover data set for use with the binning algorithm. A CMG cell containing 12% or greater land is processed as land, if less than 12% it is considered ocean. This threshold was selected as a balance that minimized snow errors along coasts yet was sensitive to mapping snow in those areas.

An inland water mask is created from the `Algorithm_bit_flags_QA` parameter from the input V[NP|J1|J2]10A1 data. Grid cells that have all night observations, or have a mix of night, snow, no snow, or cloud as input are flagged as 'night'. If no observations are found for the grid cell, it is flagged as 'fill'.

Finally, a global "snow impossible" mask specifically developed for the CMG is applied to block erroneous snow detections associated with cloud/snow confusion in regions of the world where snow is not expected to occur (e.g., the Amazon, the Sahara, the Great Sandy Desert).

Because of the great difficulty in discriminating between clouds and snow over Antarctica in the Level-2 snow detection and cloud mask algorithms, Antarctica is intentionally mapped as 100% snow cover in the `Snow_Cover` parameter of these Level-3 products. It is also flagged as "Antarctica" in all the data fields. These data sets should not be used for the purpose of observing actual snow cover in Antarctica.

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 `Basic_QA` for a grid cell is equal to the basic QA mode of all the observations mapped in a grid cell. If more than one mode is detected for a grid cell, the lowest QA value is selected.

2.6 Errors

Accuracy, uncertainty, and errors in snow cover extent are dependent on accuracy of the snow cover detection algorithm applied in the swath level products V[NP|J1]10. Uncertainty in geolocation accuracy of observation may be introduced throughout the data processing levels as sensor observations are mapped to latitude and longitude geolocation in L2 and further mapped to projected grids in L3 products. Sources of possible snow and cloud confusion in the lower-level products might also propagate into these L3 products.

3 VERSION HISTORY

Table 6. Version History Summary

Version / Collection	Release Date	Description of Changes
V2 / C2	January 2026	Initial release of VJ210C1
V2 / C2	June 2023	Initial release of VNP10C1 and VJ110C1.

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.

Hall, D.K., G.A. Riggs, N.E. DiGirolamo and M.O. Román, 2019: Evaluation of MODIS and VIIRS cloud-gap-filled snow-cover products for production of an Earth science data record, Hydrol. Earth Syst. Sci., 23:5227-5241, https://doi.org/10.5194/hess-23-5227-2019.

Riggs, G.A., Hall, D.K. and Roman, M.O. 2015. VIIRS Snow Cover Algorithm Theoretical Basis Document (ATBD). NASA Goddard Space Flight Center, Greenbelt, MD. (See PDF)

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Riggs, G.A. and Hall, D.K. 2021. NASA VIIRS Snow Cover Products, Collection 2: User Guide. (See PDF)

Román, M.O., Justice, C., Paynter, I., Boucher, P.B., Devadiga, S., Endsley, A., Erb, A., Friedl, M., Gao, H., Giglio, L., Gray, J.M., Hall, D., Hulley, G., Kimball, J., Knyazikhin, Y., Lyapustin, A., Myneni, R.B., Noojipady, P., Pu, J., Riggs, G., Sarkar, S., Schaaf, C., Shah, D., Tran, K.H., Vermote, E., Wang, D., Wang, Z., Wu, A., Ye, Y., Shen, Y., Zhang, S., Zhang, S., Zhang, X., Zhao, M., Davidson, C., and Wolfe, R. 2024. Continuity between NASA MODIS Collection 6.1 and VIIRS Collection 2 land products. Remote Sensing of Environment, Vol. 302, 113963: https://doi.org/10.1016/j.rse.2023.113963.

7 DOCUMENT INFORMATION

7.1 Publication Date

June 2023

7.2 Date Last Updated

January 2026