NASA VIIRS Sea Ice Cover Products

Collection 2

User Guide

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1.0 Introduction

The NASA Suomi-National Polar-orbiting Partnership (S-NPP) and Joint Polar Satellite System (JPSS) Visible Infrared Imaging Radiometer Suite (VIIRS) sea ice cover algorithms and data products are nearly identical. The same algorithms are used to ensure continuity of data products and enable development of a climate-data record (CDR) from the sensors. This user guide describes the NASA VIIRS C2 Level-2 (L2) sea ice cover and the Level-3 (L3) daily sea ice cover products produced for the VIIRS instruments on S-NPP and JPSS-1. The JPSS-1 is the first satellite in the planned series of JPSS satellites. Details of the data products, Quality Assessment (QA) data content, and commentary on evaluation and interpretation of data are given for the products. The Addendum section has information regarding products and collection updates.

An objective for VIIRS Collection 2 (C2) is to make the NASA VIIRS sea ice cover detection algorithms compatible with the C6.1 MODIS Terra and Aqua sea ice cover algorithms to ensure continuity of data products and enable development of a CDR from the sensors. The MODIS sea ice products have both sea ice cover and ice surface temperature (IST) data within a single product. For VIIRS sea ice cover and IST are produced as two separate products, each with a separate user guide.

2.0 NASA VIIRS Sea Ice Cover Data Products

The NASA VIIRS sea ice cover data products (Table 1) are produced in the NASA Land Science Investigator-led Processing System (LSIPS) and archived in the National Snow and Ice Data Center (NSIDC) Distributed Active Archive Center (DAAC).

The VIIRS sea ice cover products are referenced by their Earth Science Data Type (ESDT) names. The ESDT name begins with VNP for S-NPP products and with VJ1 for JPSS-1 products. In this guide the combined name beginning of V[NP|J1] is used when the products are the same. When referring to a specific product the unique ESDT name is used. The V[NP|J1]29 is the Level-2 (L2) swath product and V[NP|J1]29P1D is the Level-3 (L3) daily tiled product.

The sea ice cover products are produced in sequence beginning with a L2 swath at a nominal pixel spatial resolution of 375 m with nominal swath coverage of 6400 pixels (across track) by 6464 pixels (along track), consisting of 6 minutes of VIIRS instrument scans. A L2 product is a geophysical product in latitude and longitude orientation. The V[NP|J1]29 product is projected and gridded to a projection to make an intermediate Level-2 gridded (L2G) product. The L2G product is on the EASEGrid-2 North and South polar projections and stored as tiles, each tile being 10° x 10° area of the global projection. V[NP|J1]29 data products are gridded into L2G tiles by mapping the VNP29 pixels into cells of a tile in the map projection grid. The L2G mapping algorithm creates a gridded product used as input to the V[NP|J1]29P1 L3 product. The V[NP|J1]29L2G product is not archived at the NSIDC DAAC. The L3 daily sea ice cover product V[NP|J1]29P1 is on the EASEGrid-2 projection at 375 m spatial resolution.

The V[NP|J1]29 product file format is HDF5 and V[NP|J1]29P1 is in HDF-EOS5 format. Both products are compliant with netCDF Climate and Forecast Metadata Conventions Version 1.6 (CF-1.6) including geolocation. Information on netCDF is at https://www.unidata.ucar.edu/software/netcdf/docs/index.html. Information on Hierarchical Data Format 5 (HDF5) may be found at https://portal.hdfgroup.org. Tools that read either netCDF4 or HDF5 should be able to read the data product. A user should contact the NSIDC DAAC user support group with questions about working with these product formats.

The series of NASA VIIRS sea ice cover products produced in C2 is listed in Table 1. Description of each product, synopsis of the algorithm and commentary on sea ice cover detection, quality assessment (QA), accuracy and errors are presented in following sections.

Table 1. Sea Ice Cover data products.

ESDT	LongName	Level	Format
VNP29	VIIRS/NPP Sea Ice Cover 6-Min L2 Swath 375m	2	HDF5
VNP29P1D	VIIRS/NPP Sea Ice Cover Daily L3 375m EASE-Grid 2.0 Day	3	HDF-EOS5
VJ129	VIIRS/JPSS1 Sea Ice Cover 6-Min L2 Swath 375m	2	HDF5
VJ129P1D	VIIRS/JPSS1 Sea Ice Cover Daily L3 375m EASE-Grid 2.0 Day	3	HDF-EOS5

2.1 Collection and Product Notes

The S-NPP data record begins on 19 January 2012. VNP29 and VNP30 L2 products were available in C1. The L3 VNP29P1 is included in C2.

The JPSS-1 data record begins on 26 October 2018. JPSS-1 products are first available in C2.

The JPSS-1 satellite was declared operational on 30 May 2018 and renamed NOAA-20. NOAA designates satellites with an operational number when declared operational after their on-orbit checkout period. The JPSS-1 name is used in the guide as that name was originally used by LSIPS for identifying data products. The names JPSS-1 and NOAA-20 are interchangeable.

Processing and reprocessing of C2 S-NPP products in LSIPS commenced on 6 September 2022. The C2 User Guide was updated to include revisions to the algorithms and products that have been made since C1.

3.0 V[NP|J1]29

The V[NP|J1]29, product format is HDF5, and is compliant with the netCDF CF-1.6 Climate and Forecast Metadata Conventions Version 1.6 (CF-1.6) for attributes and geolocation of variables. The product contains dimension scales, a geolocation data group, a sea ice cover data group, and local and global attributes. Global attributes describing the time of acquisition, input products, geographic location, production, provenance, and Digital Object Identifier (DOI) are included. Global attributes are listed in Appendix A; they are not described further in this user guide. Variables in V[NP|J1]29 are stored in two data groups. The SeaIceCoverData group contains variables for 1) sea ice cover, 2) Basic_QA, and 3) algorithm QA_Flags. The GeolocationData group contains the latitude and longitude data. A listing of the contents of V[NP|J1]29 is given in Appendix A.

The V[NP|J1]29 product has 6 minutes of scans and nominal has 6464 lines by 6400 pixels. The 'number_of_pixels' in a swath are constant. The 'number_of_lines' in a swath is nominally 6464 in a six-minute swath but may have more or fewer for long or short swaths.

3.1 Geolocation Data

Latitude and longitude data for each pixel in a swath are stored as auxiliary coordinate variables in the GeolocationData group in V[NP|J1]29. The coordinate variables, attributes and datasets follow netCDF CF-1.6 conventions for geolocation. Software tools that work with the netCDF or HDF5 data formats should be able to work with V[NP|J1]29. Description of the GeolocationData group is given in List 1.

List 1. VNP29 GeolocationData.

```
netcdf VNP29.A2019207.2024.002.2021059083158 {
group: GeolocationData {
  variables:
        float latitude(number_of_lines, number_of_pixels) ;
                latitude:_FillValue = -999.f ;
                latitude:valid_range = -90.f, 90.f ;
                latitude:standard_name = "latitude" ;
                latitude:long_name = "Latitude data" ;
                latitude:units = "degrees_north" ;
        float longitude(number_of_lines, number_of_pixels) ;
                longitude:standard_name = "longitude" ;
```

```
                longitude:long_name = "Longitude data" ;
                longitude:units = "degrees_east" ;
                longitude:_FillValue = -999.f ;
                longitude:valid_range = -180.f, 180.f ;
 } // group GeolocationData
```

3.2 SeaIceCoverData

The variables and their attributes in the SeaIceCoverData data group are given in List 2 and described in the following sections.

List 2. VNP29 SeaIceCoverData, variables and attributes.

```
group: SeaIceCoverData {
 variables:
        ubyte Algorithm_QA_Flags(number_of_lines, number_of_pixels) ;
                Algorithm_QA_Flags:coordinates = "latitude longitude" ;
                Algorithm_QA_Flags:long_name = "Algorithm QA Flags for Ice Cover" ;
                Algorithm_QA_Flags:flag_masks = 1UB, 2UB, 4UB, 8UB, 16UB, 32UB, 64UB, 128UB ;
                Algorithm_QA_Flags:flag_meanings = "spare low_visible_screen low_NDSI_screen spare spare
high_SWIR_screen/flag spare solar_zenith_flag" ;
                Algorithm_QA_Flags:comment = "Bit flags are set for select conditions detected by data screens
in the algorithm, multiple flags may be set for a pixel. Default is all bits off" ;
        ubyte SeaIceCover(number_of_lines, number_of_pixels) ;
                SeaIceCover:coordinates = "latitude longitude" ;
                SeaIceCover:long_name = "Sea Ice Cover" ;
                SeaIceCover:valid_range = 0UB, 1UB ;
                SeaIceCover:flag_values = 200UB, 201UB, 211UB, 225UB, 237UB, 250UB, 252UB, 253UB, 254UB ;
                SeaIceCover:flag_meanings = "missing no_decision night land inland_water cloud
unusable_L1B_data bowtie_trim missing_L1B_data" ;
                SeaIceCover:_FillValue = 255UB ;
        ubyte SeaIceCover_Basic_QA(number_of_lines, number_of_pixels) ;
                SeaIceCover_Basic_QA:coordinates = "latitude longitude" ;
                SeaIceCover_Basic_QA:long_name = "Basic QA Ice Cover" ;
                SeaIceCover_Basic_QA:valid_range = 0UB, 4UB ;
                SeaIceCover_Basic_QA:QA_value_meanings = "0-best, 1-good, 2-poor, 3-bad, 4-other" ;
                SeaIceCover_Basic_QA:flag_values = 211UB, 225UB, 237UB, 250UB, 252UB, 253UB, 254UB ;
                SeaIceCover_Basic_QA:flag_meanings = "night land inland_water cloud unusable_L1B_data
bowtie_trim missing_L1B_data" ;
                SeaIceCover_Basic_QA:_FillValue = 255UB ;

 // group attributes:
                :I01_Noisy_Detectors_Count = 0s ;
                :I01_detector_quality_flag_values = 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB,
0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB ;
                :I02_Noisy_Detectors_Count = 0s ;
                :I02_detector_quality_flag_values = 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB,
0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB ;
                :I03_Noisy_Detectors_Count = 0s ;
                :I03_detector_quality_flag_values = 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB,
0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB ;
```

```
                :detector_quality_flag_masks = 1UB, 2UB, 4UB, 8UB, 16UB, 32UB, 64UB, 128UB ;
                :detector_quality_flag_meanings = "Noisy Dead" ;
 } // group SeaIceCoverData
}
```

3.2.1 SeaIceCover

The SeaIceCover variable is the ice cover detected by the algorithm. Sea ice cover is a binary map with 0 for open ocean and 1 for ice. The valid_range of 0 – 1 is given to indicate either 0% ice or 100% ice. Ice concentration is not estimated in the algorithm. To give a complete view of conditions in a scene, cloud, land, and night masks are overlaid using flag_values. The onboard bowtie trim fill data is seen as horizontal stripes on both sides of a swath. An example of SeaIceCover is shown in Figure 1. Local attributes (List 2) describe the data values and the flag_values.

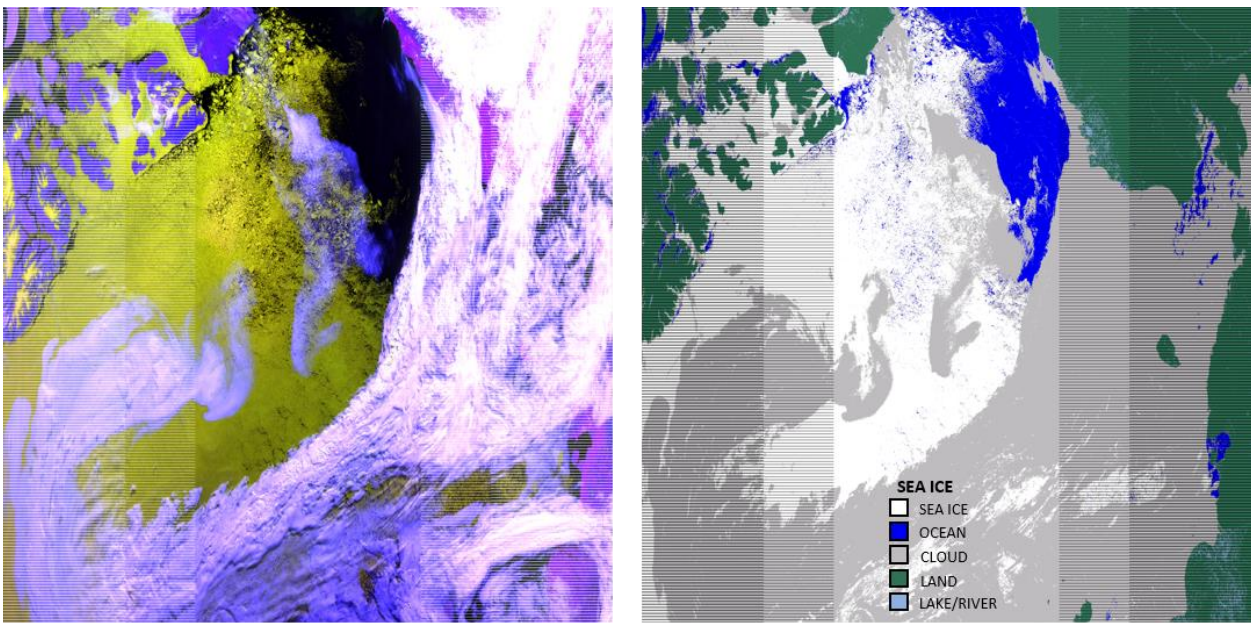

Figure 1. VIIRS image 26 July 2019, 2024 UTC of the Beaufort Sea. False color image (left) of VIIRS bands I2, I1 and I3 (RGB), 375 m, shows ice in shades of yellow and open water as black with clouds in white. The VNP29 SeaIceCover variable with flagged features is shown on the right. Bowtie trim is horizontal stripes on left and right sides of the images. (Images are not projected.)

3.2.2 Algorithm_QA_Flags

Algorithm-specific bit flags are set for data screens applied in the algorithm. Pixels that were detected as sea ice have data screens applied and the sea ice detection may be reversed to “not sea ice” or flagged as “uncertain sea ice detection.” Algorithm bit flags are set if a sea ice detection was reversed or flagged as uncertain by one or more data screens applied in the algorithm. Multiple bit flags may be set for a pixel. Some of the bit flags serve a dual purpose, they either reverse sea ice detection or flag an uncertain result. See Section 4.3.1 for a description of data screens. The local attributes flag_mask and flag_meanings describe the bit flags. The bits are numbered 0-7, least significant bit order, and referred to by that numbering in this guide.

3.2.3 SeaIceCover_Basic_QA

This is a basic quality value that indicates quality ranging from best to poor or other providing a user with a convenient value for initial quality assessment of the data. Masked features, e.g., clouds, and land are set in flag_values. The meanings of the QA values are described in the value_meanings attribute. Presenting the basic QA values as a valid_range with corresponding value_meanings attribute is a lingering legacy of how the data values were reported prior to the move to CF conventions.

3.3 Sea Ice Cover Detection Algorithm

A brief description of the algorithm approach is provided to explain the flow of the algorithm and the basic technique used to detect sea ice. A detailed description of the algorithm can be found in the NASA VIIRS ATBD (Tschudi et al., 2017). The algorithm is applied to oceans poleward of 40°N and 50°S.

Sea ice is detected using the Normalized Difference Snow Index (NDSI) (Hall and Riggs, 2011) algorithm that is used in the MODIS C6.1 sea ice algorithm (Riggs et al., 2016). A detailed explanation of the use of NDSI for identifying sea ice is given in the NASA VIIRS sea ice ATBD (Tschudi et al., 2016). Sea ice has a strong visible reflectance and strong short-wave IR absorbing characteristics, in contrast to open water. Additionally, some ice/cloud discrimination is accomplished using the NDSI. The VIIRS Sea Ice Cover algorithm computes the NDSI for each ocean pixel with:

$$NDSI = (I1\ band - I3\ band) / (I1\ band + I3\ band) \quad (1)$$

The VIIRS I1 and I3 bands (375 m resolution) are centered at 0.64 µm and 1.61 µm, respectively. The NASA VIIRS L1B products supported by the VCST and generated by the LSIPS are the inputs to the V[NP|J1]29 algorithm. The cross-calibrated radiance and top-of-atmosphere (TOA) reflectance L1B products are used in C2. Cross-calibration of selected VIS/NIR and SWIR was implemented to mitigate bias observed in TOA reflectance between SNPP and JPSS-1 and to constrain them within 1% using MODIS Aqua as the reference (LDOPE 2022). The C2 L1B products include data on detector calibration and quality flags that are not in C1. Input products are listed in the global attribute InputPointer. The VIIRS L1B reflectance data is converted to top-of-atmosphere (TOA) reflectance and used to calculate NDSI.

Sea ice can be identified using NDSI and the following criteria: if the NDSI > 0.0 then sea ice is detected and data screens using other reflectance features are applied to either confirm the sea ice detection or change it to open water. This sea ice detection algorithm is different from the MODIS sea ice extent algorithm in C6.1; both use the NDSI but here the NDSI threshold is set lower and data screens are applied, whereas in C6.1 the NDSI threshold is higher (0.54) and the only a single data screen is applied.

The algorithm is applied to all ocean pixels poleward of 40°N and 50°S latitude, and in daylight determined as solar zenith angle < 85°. The land/water mask (LWM) from the geolocation product V[NP|J1]03IMG is used to guide processing over oceans. The cloud mask product V[NP|J1]35_L2 is used for cloud masking. The cloud confidence flag is read from V[NP|J1]35_L2. If the cloud confidence flag has a setting of “confident cloudy”, “probably cloudy” or “probably clear” the pixel is masked as “cloud”. If the cloud confidence flag setting is “confident clear” the pixel is processed for sea ice cover. The reflectance data is checked for nominal quality; if unusable data is found it is flagged and the pixel is skipped, otherwise processing continues. The VIIRS bands are also checked for noisy detectors. If a noisy detector is encountered the reflectance from the noisy detector is replaced by the mean reflectance of the corresponding detectors in the preceding and following scan lines. Data screens are applied and QA bit flags are set for pixels processed for sea ice cover and for other conditions, e.g. solar zenith angle.

Data product inputs to the sea ice detection algorithm are listed in Table 2. Collection 2 uses the NASA L1B products as input. The latitude and longitude variables for a swath are copies from the V[NP|J1]03IMG product to the GeolocationData data group of V[NP|J1]29.

Table 2. Data product inputs to the V[NP|J1]29 algorithm.

ESDT	**Variable names**	**Spatial resolution**	**Descriptor**
V[NP|J1]02IMG	I01 I02 I03 I01_quality_flags I02_quality_flags I03_quality_flags	375 m	Reflectance Quality flags
V[NP|J1]03IMG	solar_zenith land_water_mask latitude longitude	375 m	Solar zenith angle Land/water mask Latitude Longitude
V[NP|J1]35_L2	QF1_VIIRSCMIP	750 m	Cloud confidence flag

3.3.1 Data Screens

Several data screens and masks are applied in the algorithm mask clouds to prevent sea ice commission errors, flag uncertain sea ice detections, and flag other conditions. These screens are set as bit flags in the Algorithm_QA_flags variable. The bits in data screens and masks are applied within the algorithm using data read from the VIIRS input data products. Data screens and masks are described in the following subsections.

3.3.2 Land/Water Mask

In C2 the land/water mask (LWM) is read from the V[NP|J1]03IMG product. This is the MODIS LWM adapted to VIIRS. The LWM is used to direct processing for oceans and to create the land and inland water bodies mask in V[NP|J1]29.

3.3.3 Cloud Mask

The LSIPS produced VIIRS cloud mask product, V[NP|J1]35_L2 is an input to the V[NP|J1]29 algorithm. Cloud mask performance was improved though use of a 1 km rolling gridded snow input and a 1 km vegetation index (VI) file, and algorithm improvements for better delineation of snow at higher latitudes in C2 (LDOPE, 2022). (The cloud mask algorithm is a NOAA IDPS legacy product; a description of the cloud mask is in https://www.star.nesdis.noaa.gov/jpss/documents/ATBD/ATBD_EPS_Cloud_Mask_v1.2.pdf) The cloud confidence flag from the V[NP|J1]35_L2 is used to mask clouds. This 750 m cloud mask is applied to the four corresponding 375 m pixels. The cloud confidence flag gives four levels of confidence: “confident clear”, “probably clear”, “probably cloudy”, and “confident cloudy”. If the cloud mask flag is “confident cloudy”, “probably cloudy” or “probably clear” then the pixel is masked as “cloud”. If the cloud mask flag is set as “confident clear” it is interpreted as cloud free.

3.3.4 Solar Zenith Angle

Solar zenith angle data from V[NP|J1]03IMG is used to create a night mask and to set a QA flag for low illumination conditions. Low illumination conditions exist at 70° ≤ SZA < 85° which represents a challenging situation for sea ice detection. This QA flag is set in bit7 of Algorithm_QA_Flags for pixels in this SZA range. Night is defined as SZA ≥ 85° and pixels are flagged as night.

3.3.5 Low Visible Data Screen

If TOA reflectance in band I2 is < 0.10 for a pixel detected as sea ice that detection is reversed by setting sea ice to 0 and setting the low visible data screen bit 1 in Algorithm_QA_Flags.

3.3.6 Low NDSI Data Screen

If the NDSI is < 0.1 a pixel is set to no ice cover and the low NDSI flag, bit 2 in Algorithm_QA_Flags is set.

3.3.7 High SWIR Data Screen

If the band I3 reflectance of a pixel detected as sea ice is ≥ 0.45 that detection is changed to 0 and the high SWIR flag, bit 5 in Algorithm_QA_Flags is set.

3.4 Quality Assessment (QA)

Two QA datasets are output: 1) the SeaIceCover_Basic_QA, which gives a value score, and 2) the Algorithm_QA_Flags, which reports results of data screens as flag_masks. The basic QA value is a qualitative estimate of the algorithm result for a pixel. The basic QA value is initialized to the best value and is adjusted based on the quality of the L1B input data and the solar zenith data screen. If the visible reflectance is outside the range of 5-100% but still usable, the QA value is set to “good”. If the SZA is in the range of 70° ≤ SZA < 85°, the QA is set to “poor”, which means increased uncertainty in results because of low illumination. If input data is unusable the QA value is set to “other”. For features that are masked, e.g., land, and night, flag_values are applied.

The Algorithm_QA_Flags dataset contains bit flags of the results of the data screens that are applied in the algorithm. The data screens have a dual purpose, they indicate why a sea ice detection was reversed to 0 and they flag an uncertain sea ice detection or challenging viewing conditions. More than one bit flag may be set because all data screens are applied to a pixel. Bits for the data screens are set if the screen was failed. By examining bit flags, it can be determined if a sea ice detection was changed to 0 by a screen or screens, or if a sea ice observation has certain screens set indicative of an uncertain sea ice detection. More than one data screen can be set for a sea ice detection reversal or for uncertain sea ice detection.

3.4.1 Interpretation of Sea ice Detection Accuracy, Uncertainty and Errors

Several factors that can affect the accuracy of sea ice cover detection and contribute to errors of commission and omission are discussed in the following sub-sections. Confusion between clouds and sea ice is the most common cause of uncertainty and error for sea ice detection. During the summer sea ice detection accuracy may be affected by melt ponds which may be detected as sea ice or as open water. There is also some error in geolocation that may be associated with projecting the swath from latitude and longitude coordinates to a projection. Geolocation error may be notable along coastlines, which may appear to shift from day to day when projected.

3.4.2 Low reflectance

Low solar illumination conditions occurring when the SZA is ≥ 70.0° and near to the day/night terminator are a challenge to sea ice detection. Low reflectance situations in which reflectance is < ~30% across the visible bands is also a challenge for sea ice detection. Low reflectance across the VIS and SWIR can result in relatively small differences between the VIS and SWIR bands and can cause areas of sea ice to not be detected. If VIS reflectance is too low a sea ice detection will be changed to 0 by the low visible data screen. This situation is flagged in bit 1 of the Algorithm_QA_Flags variable. In very low reflectance conditions near the day/night transition sea ice detections can be reversed to 0 by the low reflectance data screen and this situation can be identified where the Algorithm_QA_Flags has a value of 130 (bits 1 and 7 are on). Some types of ice that have low visible reflectance characteristics may be flagged as “not sea ice” by the low visible data screen. Cloud shadows cast on sea ice may be flagged by the low visible data screen causing a sea ice detection to be changed to 0.

3.4.3 High SWIR reflectance

Unusually high SWIR reflectance may be observed in some sea ice situations. High SWIR and high visible reflectance may be observed from some cloud types that were missed, flagged as “certain clear” in the cloud mask which could have an NDSI value in the range of sea ice. The SWIR screen is applied at two thresholds to either reverse a possible sea ice commission error to 0 or to flag a sea ice detection with unusually high SWIR. This flag can be used to determine where uncertain sea ice detections occurred or where sea ice detection was reversed to 0.

3.4.4 Cloud and ice confusion

Cloud and ice confusion in the C2 sea ice cover product is similar to the cloud and ice confusion seen in the MODIS C6.1 sea ice product. Two common sources of cloud and ice confusion are: 1) the cloud mask fails to correctly flag cloudy or clear conditions, and 2) subpixel clouds (cloud mask is 750 m resolution) escape detection.

The cloud mask algorithm uses many tests to detect cloud. Details of the cloud mask algorithm and product can be found in the cloud mask ATBD and user guide. The combination of tests applied to a pixel, the processing path, depends on whether the ocean surface is ice free or has ice cover. An external ice background map and an internal check for sea ice is made in the cloud mask algorithm; if that initial determination for sea ice is incorrect then a wrong processing path is followed and a possible erroneous cloud determination is made; sea ice could be flagged as cloudy, or a cloud is not detected.

Subpixel size clouds that are not detected by the cloud mask algorithm may be erroneously detected as ice because the cloud spectral properties can be similar to the spectral properties of ice. This situation frequently results in sea ice commission errors at the periphery of clouds, especially when cloud formations are composed of scattered small cloud with small clear areas in between. Multilayer cloud formations where there are different types of clouds, both warm and cold, and where cloud shadows fall on clouds, may have some regions of the cloud cover that are not detected as cloud and flagged as certain clear; in those situations, the cloud may be detected as either “sea ice” or as “not sea ice” both would be erroneous results.

3.4.5 Land/water mask

The LSIPS adapted the MODIS LWM to create the VIIRS LWM at 375 m resolution that is stored in the V[NP|J1]03IMG geolocation product. This LWM provides continuity between MODIS and VIIRS data products. The MODIS LWM was derived from the University of Maryland (UMD) 250 m MODIS Water Mask data product (Carroll et al., 2009). The UMD 250 m Water Mask was converted to a 500 m seven class land/water mask for use in the production of MODIS products in C6.1 That MODIS LWM new land/water mask more accurately provides the location of water bodies [https://landweb.modaps.eosdis.nasa.gov/QA_WWW/forPage/MODIS_C6_Water_Mask_v3.pdf (02/10/23)].

3.4.6 Geolocation accuracy

Geolocation accuracy of NASA VIIRS products is very high, in the range of 10 - 60 m providing consistently high accuracy in mapping of the VIIRS data products. Small errors in geolocation are negligible in the L2 products, however geolocation error may be observed in projected products from day to day as a shifting of features, e.g., slight changes in the location of a lake on the projected grid.

4.0 V[NP|J1]29P1D

The daily gridded, tile sea ice cover product contains the mode of observations from the V[NP|J1]29 observations that were mapped to a grid cell. The V[NP|J1]29 swath products (Sec. 4.0) are mapped and gridded to a tile of the EASE-Grid2 North and South polar projections with approximately 10° x 10° extent and 2720 x 2720 grid cells at 375 m resolution in LSIPS L2G processing to create the V[NP|J1]29PGD product, containing observations in compact format. The V[NP|J1]29PGD is the input to the V[NP|J1]29P1D algorithm. The V[NP|J1]29PGD is an intermediate product not archived at the NSIDC DAAC.

The V[NP|J1]29P1D product is in HDF-EOS5 format and follows CF-1.6 conventions for attributes and for geolocation. The product contains variables attached to the grid and a Projection variable with local attributes of projection information. Global attributes provide information on provenance, production, and summary statistics. A listing of V[NP|J1]29P1D structure and contents is given in Appendix B. The contents of a file are described in Sec. 5.1 and the sea ice cover mode algorithm is described in Sec. 5.2. An example of the V[NP|J1]29P1D sea ice cover variable is shown in Figure 2.

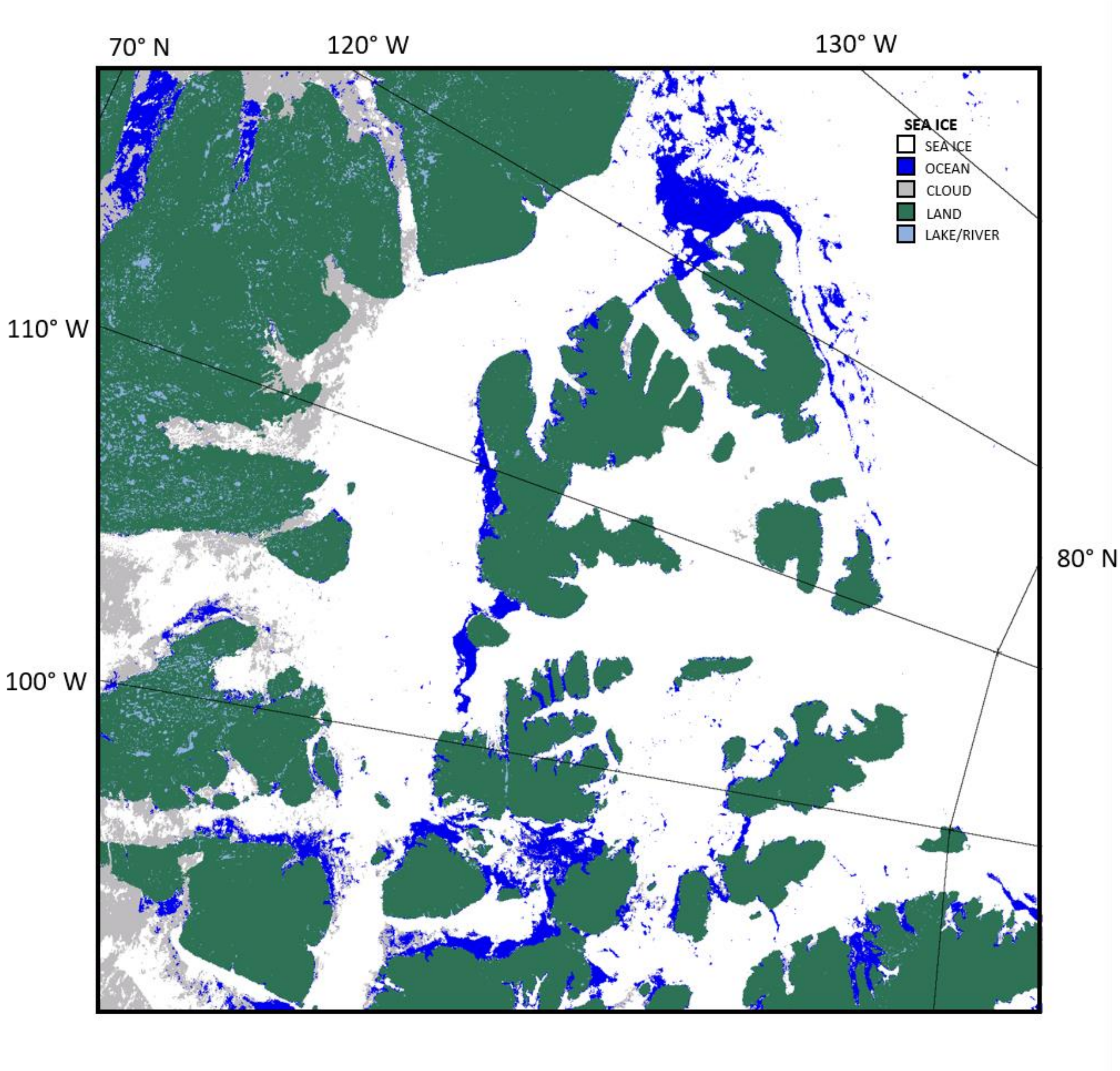

Figure 2. Sea ice cover for 26 July 2019 in the Canadian Archipelago region. Sea ice cover is the mode of observations from the VNP29 products mapped to cells in the grid. Image is projected on Lambert azimuthal polar projection. From VNP29P1D.A2019207.h07v08.002.*.h5.

4.1 Variables

There are four variables with local attribute in the product: SeaIceCover_mode, SeaIceCover_nobs, n_obs, and Projection. The variables and attributes are listed in Appendix B and briefly described in the following sections.

4.1.1 SeaIceCover_mode

The SeaIceCover_mode is the mode of the V[NP|J1]29 observations mapped into a grid cell. The mode is the observation that appeared most frequently in all the observations on a day.

4.1.2 SeaIceCover_nobs

The SeaIceCover_nobs is the count of sea ice cover observations, from all the VNP29 observations mapped into a grid cell.

4.1.3 n_obs

The n_obs is the count of all the V[NP|J1]29 observations mapped into a grid cell.

4.1.4 Projection

The Projection variable is empty. The projection parameters are attached to the Projection as local attributes by CF-1.6 conventions for geolocation.

4.2 Sea Ice Cover Daily Algorithm

The algorithm reads and un-compacts the intermediate L2G V[NP|J1]29PGD product to create a stack of VNP29 observations for each grid cell. The mode of the V[NP|J1]29 observations in the stack is calculated and written as the result in the SeaIceCover_mode variable. The total number of observations in the V[NP|J1]29 valid_range and flag_values is summed and written to the n_obs variable. The number of sea ice cover observations, 0 or 1, is summed and written to the SeaIceCover_nobs variable.

V[NP|J1]29PGD grid cells that are _FillValue are output as_FillValue. V[NP|J1]29PGD grid cells that have 0 observations are output as _FillValue. If a grid cell has only one observation, then that observation is written as the result. If a grid cell has all observations of flag_values then the result is that flag_values if only a single value is found or is the mode of flag_values if multiple flag_values, e.g., land or cloud, are found.

4.3 Interpretation of Sea Ice Cover Accuracy, Uncertainty and Errors

Factors that affect accuracy and uncertainty of V[NP|J1]29 sea ice detection are propagated through to analysis of the sea ice cover mode. No screening of the V[NP|J1]29 observations is done in the V[NP|J1]29P1D algorithm. The SeaIceCover_nobs and n_obs variables provide information on how many of the observations for a day were sea ice cover observations. Reasons for those counts to be different are that there were a mix of observations e.g., clouds, or night observed from different orbits of the day.

Discriminating between clouds and sea ice cover is very challenging. Accuracy of cloud detection over sea ice is difficult to evaluate. The LSIPS cloud mask product V[NP|J1]35_L2 is applied in the L2 sea ice cover algorithm producing V[NP|J1]29. Clouds are masked using the V[NP|J1]35_L2 cloud confidence flag, only “certain clear” observations are considered clear; all other values are interpreted as cloud obscured (c.f. Section 3.3). If there is sea ice/cloud confusion (error) in the L2 observation, that confusion is propagated into the sea ice cover calculation.

Geolocation error associated with mapping of swath observations from the swath to the grid projection is typically less than a grid cell. Geolocation may be observable as changes in location of land and ocean cells or sea ice observations along coastlines from day to day.

The V[NP|J1]29P1D algorithm is different from the MODIS daily sea ice cover (MOD29P1) algorithm which selected only the “best” observation on a day (Riggs et al., 2016). If using both MODIS and VIIRS sea ice cover products, the differences in satellites, sensors and algorithms should be considered.

5.0 Related Web Sites

Suomi-NPP
https://www.nasa.gov/mission_pages/NPP/main/index.html (1/30/23)

Suomi-NPP VIIRS Land
https://viirsland.gsfc.nasa.gov/Products/NASA/ISTESDR.html (1/30/23)

VIIRS
VIIRS Land: https://viirsland.gsfc.nasa.gov/ (1/30/23)

MODIS and VIIRS Snow and Ice Global Mapping Project
https://modis-snow-ice.gsfc.nasa.gov (1/30/23)

Imagery and Data Product Viewing
Worldview: https://worldview.earthdata.nasa.gov (1/30/23)
LDOPE Global Browse: https://landweb.modaps.eosdis.nasa.gov/cgi-bin/browse/browseMODIS.cgi (1/30/23)

NSIDC Data Ordering & User Services
National Sea ice and Ice Data Center: https://nsidc.org/data/viirs (1/30/23)

HDF5
The HDF Group: https://www.hdfgroup.org/solutions/hdf5 (1/30/23)

NetCDF4
https://www.unidata.ucar.edu/software/netcdf/docs/index.html (1/30/23)

6.0 References

Carroll, M., J. Townshend, C. DiMiceli, P. Noojipady and R. Sohlberg (2009), A new global raster water mask at 250 meter resolution, *International Journal of Digital Earth*, 2(4):291-308.

Hall, D.K., and G.A. Riggs (2011), Normalized-Difference Snow Index (NDSI), Encyclopedia of Sea ice, Ice and Glaciers, Springer Netherlands, pp. 779-780.

LDOPE (2022), VIIRS Land C2 Changes, https://landweb.modaps.eosdis.nasa.gov/NPP/forPage/VIIRS Land C2 Changes 09152022.pdf. (accessed 02/10/23)

Riggs, G.A., D.K. Hall and M.O. Román (2016), MODIS sea ice products user guide for Collection 6 (C6).

Tschudi, M.A., Riggs, G.A., D.K. Hall and M.O. Román, 2017: VIIRS sea ice cover product algorithm theoretical basis document (ATBD), at same online location as this user's guide.

Acronyms

ATBD	Algorithm Theoretical Basis Document
Cx	Collection number x
CDR	Climate Data Record
CF-1.6	Climate and Forecast Metadata Conventions Version 1.6DAAC Distributed Active Archive Center
DOI	Digital Object Identifier
EASE	Equal-Area Scalable Earth
EOSDIS	Earth Observing System Data Information System
ESDT	Earth Science Data Type
HDF5	Hierarchical Data Format 5
IST	Ice Surface Temperature
JPSS	Joint Polar Satellite System
JPSS-1	Joint Polar Satellite System, first satellite in the system
L1B / L2	Level 1B, Level 2 data product
LDOPE	Land Data Operational Products Evaluation
LSIPS	Land Science Investigator-led Processing System
LWM	Land/Water Mask
MODIS	Moderate-resolution Imaging Spectroradiometer
NASA	National Aeronautics and Space Administration
netCDF	Network Common Data Form
NDSI	Normalized Difference Snow Index
NIR	Near Infrared Reflectance
NOAA	National Oceanic and Atmospheric Administration
NOAA-20	National Oceanic and Atmospheric Administration polar orbiting satellite number 20. Formerly known as JPSS-1
NSIDC	National Snow and Ice Data Center
QA	Quality Assessment
S-NPP	Suomi National Polar-orbiting Partnership
SWIR	Short Wave Infrared
SZA	Solar Zenith Angle
TOA	Top-of-Atmosphere
VCST	VIIRS Characterization Support Team
VI	Vegetation Index
VIIRS	Visible Infrared Imager Radiometer Suite
VIS	Visible reflectance
VJ129	ESDT name for the JPSS-1 VIIRS Level-2 Sea Ice Cover Data Product
VJ129P1D	ESDT name for the JPSS-1 VIIRS Level-3 Daily Sea Ice Cover Data Product
VNP29	ESDT name for the S-NPP VIIRS Level-2 Sea Ice Cover Data Product
VNP29P1D	ESDT name for the S-NPP VIIRS Level-3 Daily Sea Ice Cover Data Product

Appendix A

Example of V[NP|J1]29 product contents.

```
netcdf VNP29.A2022075.1718.002.2023031153634 {
dimensions:
	number_of_lines = 6496 ;
	number_of_pixels = 6400 ;

// global attributes:
		:PercentOceanInSwath = "43.4%" ;
		:SeaIceCover = "21.7%" ;
		:CloudCoverOcean = "76.9%" ;
		:ClearViewOcean = "23.1%" ;
		:RangeEndingDate = "2022-03-16" ;
		:GRingPointLatitude = 56.431, 64.8774, 44.112, 38.6261 ;
		:PGE_EndTime = "2022-03-16 17:24:00.000" ;
		:NorthBoundingCoordinate = 65.1938f ;
		:DayNightFlag = "Day" ;
		:ShortName = "VNP29" ;
		:creator_email = "modis-ops@lists.nasa.gov" ;
		:AlgorithmVersion = "NPP_PR29 1.0.0" ;
		:license = "http://science.nasa.gov/earth-science/earth-science-data/data-information-
policy/" ;
		:SouthBoundingCoordinate = 38.6261f ;
		:VersionID = "002" ;
		:Resolution = "Imagery" ;
		:EndTime = "2022-03-16 17:24:00.000" ;
		:SatelliteInstrument = "NPP_OPS" ;
		:EastBoundingCoordinate = -45.5459f ;
		:title = "VIIRS Sea Ice Cover" ;
		:naming_authority = "gov.nasa.gsfc.VIIRSland" ;
		:SensorShortname = "VIIRS" ;
		:PGENumber = "508" ;
		:AlgorithmType = "SCI" ;
		:identifier_product_doi = "10.5067/GKJ486GAV3HH" ;
		:stdname_vocabulary = "NetCDF Climate and Forecast (CF) Metadata Convention" ;
		:project = "VIIRS Land SIPS Sea Ice Cover Project" ;
		:PGE_StartTime = "2022-03-16 17:18:00.000" ;
		:GRingPointLongitude = -101.634, -45.5459, -47.3131, -83.7025 ;
		:institution = "NASA Goddard Space Flight Center" ;
		:ProcessingCenter = "LandSIPS" ;
		:ProductionTime = "2023-01-31 15:36:34.000" ;
		:publisher_email = "nsidc@nsidc.org" ;
		:publisher_name = "NSIDC" ;
		:PGEVersion = "2.0.5" ;
		:LocalGranuleID = "VNP29.A2022075.1718.002.2023031153634.nc" ;
		:creator_url = "https://ladsweb.modaps.eosdis.nasa.gov" ;
		:RangeEndingTime = "17:24:00.000000" ;
		:processing_level = "Level 2" ;
		:InputPointer =
"VNP35_L2.A2022075.1718.002.2023031151303.hdf,VNP02CCIMG.A2022075.1718.002.202302714155
2.nc,VNP03IMG.A2022075.1718.002.2022078182659.nc" ;
```

```
                :PlatformShortName = "SUOMI-NPP" ;
                :LongName = "VIIRS/NPP Sea Ice Cover 6-Min L2 Swath 375m" ;
                :Conventions = "CF-1.6" ;
                :GRingPointSequenceNo = 1, 2, 3, 4 ;
                :RangeBeginningTime = "17:18:00.000000" ;
                :creator_name = "VIIRS Land SIPS Processing Group" ;
                :PGE_Name = "PGE508" ;
                :cdm_data_type = "swath" ;
                :keywords_vocabulary = "NASA Global Change Master Directory (GCMD) Science
Keywords" ;
                :WestBoundingCoordinate = -101.634f ;
                :identifier_product_doi_authority = "https://doi.org" ;
                :ProcessingEnvironment = "Linux minion20267 5.4.0-1064-fips #73-Ubuntu SMP Mon
Oct 17 18:45:19 UTC 2022 x86_64 x86_64 x86_64 GNU/Linux" ;
                :StartTime = "2022-03-16 17:18:00.000" ;
                :RangeBeginningDate = "2022-03-16" ;
                :publisher_url = "https://nsidc.org" ;

group: GeolocationData {
  variables:
        float latitude(number_of_lines, number_of_pixels) ;
                latitude:_FillValue = -999.f ;
                latitude:valid_range = -90.f, 90.f ;
                latitude:standard_name = "latitude" ;
                latitude:long_name = "Latitude data" ;
                latitude:units = "degrees_north" ;
        float longitude(number_of_lines, number_of_pixels) ;
                longitude:standard_name = "longitude" ;
                longitude:long_name = "Longitude data" ;
                longitude:units = "degrees_east" ;
                longitude:_FillValue = -999.f ;
                longitude:valid_range = -180.f, 180.f ;
  } // group GeolocationData

group: SeaIceCoverData {
  variables:
        ubyte Algorithm_QA_Flags(number_of_lines, number_of_pixels) ;
                Algorithm_QA_Flags:coordinates = "latitude longitude" ;
                Algorithm_QA_Flags:long_name = "Algorithm QA Flags for Ice Cover" ;
                Algorithm_QA_Flags:flag_masks = 1UB, 2UB, 4UB, 8UB, 16UB, 32UB, 64UB, 128UB ;
                Algorithm_QA_Flags:flag_meanings = "spare low_visible_screen low_NDSI_screen
spare spare high_SWIR_screen_or_flag spare solar_zenith_flag" ;
                Algorithm_QA_Flags:comment = "Bit flags are set for select conditions detected by data
screens in the algorithm, multiple flags may be set for a pixel. Default is all bits off" ;
        ubyte SeaIceCover(number_of_lines, number_of_pixels) ;
                SeaIceCover:coordinates = "latitude longitude" ;
                SeaIceCover:long_name = "Sea Ice Cover" ;
                SeaIceCover:valid_range = 0UB, 1UB ;
                SeaIceCover:flag_values = 200UB, 201UB, 211UB, 225UB, 237UB, 250UB, 252UB,
253UB, 254UB ;
                SeaIceCover:flag_meanings = "missing no_decision night land inland_water cloud
unusable_L1B_data bowtie_trim missing_L1B_data" ;
                SeaIceCover:_FillValue = 255UB ;
        ubyte SeaIceCover_Basic_QA(number_of_lines, number_of_pixels) ;
```

```
                SeaIceCover_Basic_QA:coordinates = "latitude longitude" ;
                SeaIceCover_Basic_QA:long_name = "Basic QA Ice Cover" ;
                SeaIceCover_Basic_QA:valid_range = 0UB, 4UB ;
                SeaIceCover_Basic_QA:QA_value_meanings = "0-best, 1-good, 2-poor, 3-bad, 4-other" ;
                SeaIceCover_Basic_QA:flag_values = 211UB, 225UB, 237UB, 250UB, 252UB, 253UB,
254UB ;
                SeaIceCover_Basic_QA:flag_meanings = "night land inland_water cloud
unusable_L1B_data bowtie_trim missing_L1B_data" ;
                SeaIceCover_Basic_QA:_FillValue = 255UB ;

  // group attributes:
                :I01_Noisy_Detectors_Count = 0s ;
                :I01_detector_quality_flag_values = 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB,
0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB,
0UB, 0UB, 0UB, 0UB, 0UB ;
                :I02_Noisy_Detectors_Count = 0s ;
                :I02_detector_quality_flag_values = 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB,
0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB,
0UB, 0UB, 0UB, 0UB, 0UB ;
                :I03_Noisy_Detectors_Count = 0s ;
                :I03_detector_quality_flag_values = 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB,
0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB, 0UB,
0UB, 0UB, 0UB, 0UB, 0UB ;
                :detector_quality_flag_masks = 1UB, 2UB, 4UB, 8UB, 16UB, 32UB, 64UB, 128UB ;
                :detector_quality_flag_meanings = "Noisy Dead" ;
  } // group SeaIceCoverData
}
```

Appendix B

Example of a V[NP|J1]29P1 product contents.

```
netcdf VNP29P1D.A2022075.h04v09.002.2023031155344 {

// global attributes:
        :identifier_product_doi = "10.5067/F6WVWUR3AH3W" ;
        :RangeEndingDate = "2022-03-16" ;
        :VerticalTileNumber = "09" ;
        :InstrumentShortname = "VIIRS" ;
        :Cloud_Extent = "71.3%" ;
        :DataResolution = "375m" ;
        :creator_url = "https://ladsweb.modaps.eosdis.nasa.gov" ;
        :EndTime = "2022-03-16 23:59:59" ;
        :TileID = "71004009" ;
        :NorthBoundingCoord = 53.531209 ;
        :SatelliteInstrument = "NPP_OPS" ;
        :creator_name = "VIIRS Land SIPS Processing Group" ;
        :_FillValue_Extent = "0.0%" ;
        :publisher_name = "NSIDC" ;
        :LongName = "VIIRS/NPP Sea Ice Cover Daily L3 Global 375m EASE-Grid 2.0 Day" ;
        :ProcessVersion = "002" ;
        :Ocean_Extent = "2.7%" ;
        :naming_authority = "gov.nasa.gsfc.VIIRSland" ;
        :InputPointer = "VNP29PGD.A2022075.h04v09.002.2023031154600.hdf" ;
        :PGEVersion = "2.0.1" ;
        :creator_email = "modis-ops@lists.nasa.gov" ;
        :VersionID = "002" ;
        :SouthBoundingCoord = 42.949871 ;
        :RangeEndingTime = "23:59:59.000" ;
        :GRingSequence = 1., 2., 3., 4. ;
        :identifier_product_doi_authority = "https://doi.org" ;
        :SeaIceCover_Extent = "28.7%" ;
        :Night_Extent = "0.0%" ;
        :GranuleEndingDateTime = "2022-03-16 17:18:00.000,2022-03-16 17:24:00.000,2022-
03-16 19:00:00.000,2022-03-16 19:06:00.000" ;
        :ProcessingCenter = "LandSIPS" ;
        :Conventions = "CF-1.6" ;
        :ProcessingEnvironment = "Linux minion20243 5.4.0-1064-fips #73-Ubuntu SMP Mon
Oct 17 18:45:19 UTC 2022 x86_64 x86_64 x86_64 GNU/Linux" ;
        :HorizontalTileNumber = "04" ;
        :PGE_Name = "PGE544" ;
        :EastBoundingCoord = -75.97367 ;
        :PGE_EndTime = "2022-03-16 23:59:59.000" ;
        :GRingLongitude = -78.690068, -90., -90., -75.963757 ;
        :ShortName = "VNP29P1D" ;
        :StartTime = "2022-03-16 00:00:00" ;
        :DayNightFlag = "Day" ;
        :RangeBeginningTime = "00:00:00.000" ;
        :publisher_url = "https://nsidc.org" ;
        :GRingLatitude = 42.949871, 43.920034, 53.531209, 52.364583 ;
        :PGENumber = "544" ;
```

```
                    :RangeBeginningDate = "2022-03-16" ;
                    :PlatformShortName = "SUOMI-NPP" ;
                    :PGE_StartTime = "2022-03-16 00:00:00.000" ;
                    :GranuleBeginningDateTime = "2022-03-16 17:12:00.000,2022-03-16
17:18:00.000,2022-03-16 18:54:00.000,2022-03-16 19:00:00.000" ;
                    :SensorShortName = "VIIRS" ;
                    :AlgorithmVersion = "NPP_PR29P1 1.0.0" ;
                    :publisher_email = "nsidc@nsidc.org" ;
                    :LocalGranuleID = "VNP29P1D.A2022075.h04v09.002.2023031155344.h5" ;
                    :Land_Extent = "97.3%" ;
                    :AlgorithmType = "SCI" ;
                    :WestBoundingCoord = -90. ;
                    :ProductionTime = "2023-01-31 15:53:44.000" ;

group: HDFEOS {

  group: ADDITIONAL {

    group: FILE_ATTRIBUTES {
      } // group FILE_ATTRIBUTES
    } // group ADDITIONAL

  group: GRIDS {

    group: VIIRS_Grid_L2g_2d {
      dimensions:
          XDim = 2720 ;
          YDim = 2720 ;
      variables:
          double XDim(XDim) ;
                    XDim:units = "m" ;
                    XDim:standard_name = "projection_x_coordinate" ;
                    XDim:long_name = "x coordinate of projection" ;
          double YDim(YDim) ;
                    YDim:standard_name = "projection_y_coordinate" ;
                    YDim:long_name = "y coordinate of projection" ;
                    YDim:units = "m" ;

      group: Data\ Fields {
        dimensions:
          phony_dim_2 = 1 ;
        variables:
          int Projection(phony_dim_2) ;
                    Projection:grid_mapping_name = "lambert_azimuthal_equal_area" ;
                    Projection:longitude_of_projection_origin = 0. ;
                    Projection:latitude_of_projection_origin = 90. ;
                    Projection:false_easting = 0. ;
                    Projection:false_northing = 0. ;
          ubyte SeaIceCover_mode(YDim, XDim) ;
                    SeaIceCover_mode:long_name = "Sea Ice Cover mode of observations" ;
                    SeaIceCover_mode:valid_range = 0UB, 1UB ;
                    SeaIceCover_mode:_FillValue = 255UB ;
                    SeaIceCover_mode:flag_values = 200UB, 201UB, 211UB, 225UB, 237UB, 250UB,
252UB, 253UB, 254UB ;
```

```
                    SeaIceCover_mode:flag_meanings = "missing no_decision night land inland_water cloud
unusable_L1B_data bowtie_trim missing_L1B_data" ;
                    SeaIceCover_mode:grid_mapping = "Projection" ;
          ubyte SeaIceCover_nobs(YDim, XDim) ;
                    SeaIceCover_nobs:long_name = "count of SeaIceCover observations" ;
                    SeaIceCover_nobs:valid_range = 0UB, 127UB ;
                    SeaIceCover_nobs:_FillValue = 255UB ;
                    SeaIceCover_nobs:grid_mapping = "Projection" ;
          byte n_obs(YDim, XDim) ;
                    n_obs:long_name = "count of all observations" ;
                    n_obs:valid_range = 0b, 127b ;
                    n_obs:_FillValue = -1b ;
                    n_obs:grid_mapping = "Projection" ;
      } // group Data\ Fields
    } // group VIIRS_Grid_L2g_2d
   } // group GRIDS
  } // group HDFEOS

group: HDFEOS\ INFORMATION {
  variables:
          string StructMetadata.0 ;

  // group attributes:
                    :HDFEOSVersion = "HDFEOS_5.1.16" ;
  } // group HDFEOS\ INFORMATION
}
```