NASA S-NPP VIIRS Sea Ice Cover Product
Collection 1
User Guide

Version 1.1
Describes
The Swath Level Product

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List of Acronyms

ATBD	Algorithm Theoretical Basis Document
BT	Brightness Temperature
Cx	Collection number
CMG	Climate-Modeling Grid
DOI	Digital Object Identifier
EDR	Environmental Data Record
EOSDIS	Earth Observing System Data Information System
ESDT	Earth Science Data Type
HDF5	Hierarchical Data Format 5
IDPS	Interface Data Processing Segment
L1 / L2 / L3	Level 1, Level 2 or Level 3 data product
LSIPS	Land Science Investigator-led Processing System
MOD29	ESDT of the MODIS L2 sea ice product
MODIS	Moderate-resolution Imaging Spectroradiometer
NDSI	Normalized Difference Snow Index
QA	Quality Assessment
S-NPP	Suomi National Polar-orbiting Partnership
SWIR	Short Wave Infrared
SZA	Solar Zenith Angle
TOA	Top-of-Atmosphere
VIIRS	Visible Infrared Imager Radiometer Suite
VNP29	ESDT name for the VIIRS Level-2 Sea Ice Cover Data Products
VPN29P1D	ESDT name for the VIIRS Level-3 tiled Sea Ice Cover Data Product
VPN29E1D	ESDT name for the VIIRS Level-3 global Sea Ice Cover Data Product
VIS	visible

1.0 Overview

The NASA Suomi-National Polar-orbiting Partnership (S-NPP) Visible Infrared Imaging Radiometer Suite (VIIRS) sea ice cover algorithm and data product leverage analysis and evaluation from the MODIS Sea Ice Products Collection 6 to make nearly-identical algorithms and data products for sea ice cover. The overall objective for VIIRS Collection 1 (C1) is to make the NASA VIIRS sea ice cover detection algorithms compatible with the C6 MODIS Terra and Aqua sea ice cover algorithms to ensure continuity of the data products and enable development of a climate-data record (CDR) from the three sensors. Differences between the MODIS C6 and the NASA VIIRS algorithms originate from the physical differences between the MODIS and VIIRS instruments, including spatial resolution and band locations. The NASA VIIRS sea ice cover data products are produced in the NASA Land Science Investigator-led Processing System (LSIPS). The NASA VIIRS sea ice cover data products are substantially different from the sea ice cover data products generated in the NOAA-Interface Data Processing Segment (IDPS).

This User Guide describes each of the three NASA VIIRS C1 sea ice cover products in sequence from Level 2 to Level 3: 1) sea ice cover swath, 2) daily sea ice cover tiled, and 3) daily climate modeling grid (global). This User Guide is a living document developed in increments for each product as they are scheduled to be released, so it is advisable to check that you are using the latest version. This version (1.0) describes the VIIRS swath level (Level-2) sea ice cover data product, which is the first to be produced by the LSIPS and archived at the NSIDC DAAC. The LSIPS has evolved from the LPEATE, which had the task of generating and evaluating algorithms and products generated with IDPS algorithms. The LSIPS is producing the NASA VIIRS data products and the NSIDC DAAC is distributing them. The VIIRS sea ice cover products are referenced by their Earth Science Data Type (ESDT) root name,VNP29. The ESDTs are produced as a series of products in which data and information are propagated to the higher level products. Details of the data products, Quality Assessment (QA) data content, and commentary on evaluation and interpretation of data are given for each product. The reader is referred to the VIIRS Algorithm Theoretical Basis Document (ATBD) [http://npp.gsfc.nasa.gov/documents.html] (Tschudi et al., 2016) and to Justice et al. (2013) for further details.

The data product format of the VIIRS sea ice data products changes with the data product level. The VNP29 product file format is netCDF4/HDF5 and is compliant with the netCDF Climate and Forecast (CF) Metadata Conventions Version 1.6. Information on netCDF4.2 is at www.unidata.ucar.edu/software/netcdf/docs/index.html, Information on Hierarchical Data Format 5 (HDF5) may be found at https://www.hdfgroup.org/HDF5/. Either netCDF4 or HDF5 tools should be able to read these data products. The Level-3 products, VNP29P1D and VNP29E1D, will be in HDF5-EOS file format. The user should contact the NSIDC DAAC user support group with questions about working with these file formats.

2.0 NASA VIIRS Sea Ice Cover Data Products

The NASA VIIRS sea ice cover data products are listed in Table 1. Sea ice cover data products are produced in sequence beginning with a 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 scans. Products in EOSDIS are labeled as ESDT and have their heritage in the MODIS production system (Wolfe and Ramapriyan, 2010). The ESDT also indicates what spatial and temporal processing has been applied to the data product. Data product levels briefly described are: Level 1B (L1B) is a swath (scene) of VIIRS data in latitude and longitude orientation. A Level 2 (L2) product is a geophysical product that remains in latitude and longitude orientation of L1B. A Level 2 gridded (L2G) product is in a gridded format of the sinusoidal projection for VIIRS land products. At L2G the data products are referred to as tiles, each tile being 10° x 10° area, of the global map projection. L2 data products are gridded into L2G tiles by mapping the L2 pixels into cells of a tile in the map projection grid. The L2G algorithm creates a gridded product necessary for the Level 3 (L3) products. An L3 product is a geophysical product that has been temporally and or spatially manipulated, and is in a gridded map projection format and comes as a tile of the global grid. The VIIRS L3 sea ice products are in the EASE-Grid 2.0 polar projection.

The series of NASA VIIRS sea ice products to be produced in C1 is listed in Table 1. A description of each product, synopsis of the algorithm and commentary on sea ice detection, quality assessment, accuracy and errors is given in following sections.

Attributes (metadata) describing the time of acquisition of the swath, input products, geographic location of swath, production of the data product, provenance and Digital Object Identifier (DOI) of the product are attached to the root group (the file). Those attributes are listed in Appendix A; they are not described further in this user guide.

Table 1: Summary of sea ice cover products produced at the LSIPS.

Products	ESDT	Description
Sea Ice Cover (L2 Daily Swath product)	VNP29	VIIRS/NPP Sea Ice Cover 6-Min Swath 375 m
Sea Ice Cover (L3 Daily Tiled product)	VNP29P1D	VIIRS/NPP Sea Ice Cover Daily L3 Global 375 m EASE-Grid 2.0 (Polar) Day
Sea Ice Cover (L3 CMG Product)	VNP29E1D	VIIRS/NPP Sea Ice Cover Daily L3 Global 4km EASE-Grid 2.0 (Polar) Day

3.0 VNP29

Sea ice is detected using the Normalized Difference Snow Index (NDSI; Hall et al., 2011) algorithm that is used in the MODIS C6 sea ice algorithms (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) (http://npp.gsfc.nasa.gov/documents.html). The sea ice cover product contains a sea ice cover dataset with masks of clouds, night and oceans applied, Quality Assurance (QA) datasets of basic QA and algorithm processing flags, and geolocation datasets of latitude and longitude.

The VNP29, product is netCDF CF compliant and is generated using HDF5 APIs, The product contains dimension scales sea ice cover and geolocation data groups with datasets and attributes and file level attributes. and attributes for the file, data group and datasets. A listing of the contents of VNP29 are given in Appendix A.

3.1 Geolocation Data

Geolocation data are the dimension scales, and the latitude and longitude datasets in the GeolocationData data group (List 1):

List 1. VNP29 Geolocation data.

```
netcdf VNP29.A2015182.1300.008 {
dimensions:
	number_of_lines = 6464 ;
	number_of_pixels = 6400 ;

group: GeolocationData {
  variables:
	float latitude(number_of_lines, number_of_pixels) ;
		latitude:standard_name = "latitude" ;
		latitude:long_name = "Latitude data" ;
		latitude:units = "degrees_north" ;
		latitude:_FillValue = -999.f ;
		latitude:valid_range = -90.f, 90.f ;
	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 SeaIceCover_Data Data Group Variables

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

List 2. VNP29 SeaIceCover_Data, variables and attributes.

```
group: SeaIceCover_Data {
  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:_FillValue = 0UB ;
		Algorithm_QA_Flags:flag_masks = "1b, 2b, 4b, 8b, 16b, 32b, 64b, 128b" ;
		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_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:mask_values = 211UB, 225UB, 237UB, 250UB, 252UB, 253UB,
254UB ;
```

```
                    SeaIceCover_Basic_QA:mask_meanings = "211-night, 225-land, 237-inland_water, 250-
cloud, 252-unusable_L1B_data, 253-bowtie_trim, 254-no_L1B_data" ;
                    SeaIceCover_Basic_QA:_FillValue = 255UB ;
          ubyte SeaIceCover_Map(number_of_lines, number_of_pixels) ;
                    SeaIceCover_Map:mask_values = 200UB, 201UB, 211UB, 225UB, 237UB, 250UB,
252UB, 253UB, 254UB ;
                    SeaIceCover_Map:mask_meanings = "200-missing, 201-no_decision, 211-night, 225-
land, 237-inland_water, 250-cloud, 252-unusable_L1B_data, 253-bowtie_trim, 254-no_L1B_data" ;
                    SeaIceCover_Map:_FillValue = 255UB ;
                    SeaIceCover_Map:coordinates = "latitude longitude" ;
                    SeaIceCover_Map:long_name = "Sea Ice Cover map with masks" ;
                    SeaIceCover_Map:valid_range = 0UB, 100UB ;
  } // group SeaIceCover_Data
```

3.2.1 SeaIceCover_Map

The SeaIceCover_Map variable is the sea ice cover generated by the algorithm. Sea ice cover is a binary map with 0 for open ocean and 100 for sea ice. This is interpreted as no sea ice in a pixel (0%) to complete sea ice in a pixel (100%). To give a complete view of conditions in the scene, cloud, night and land masks are overlaid. The onboard bowtie trim fill data is retained in the variable which is seen as horizontal stripes on both sides of a swath. An example of the sea ice dataset SeaIceCover_Data is shown in Figure 1. Local attributes (List 2) describe the data and mask values.

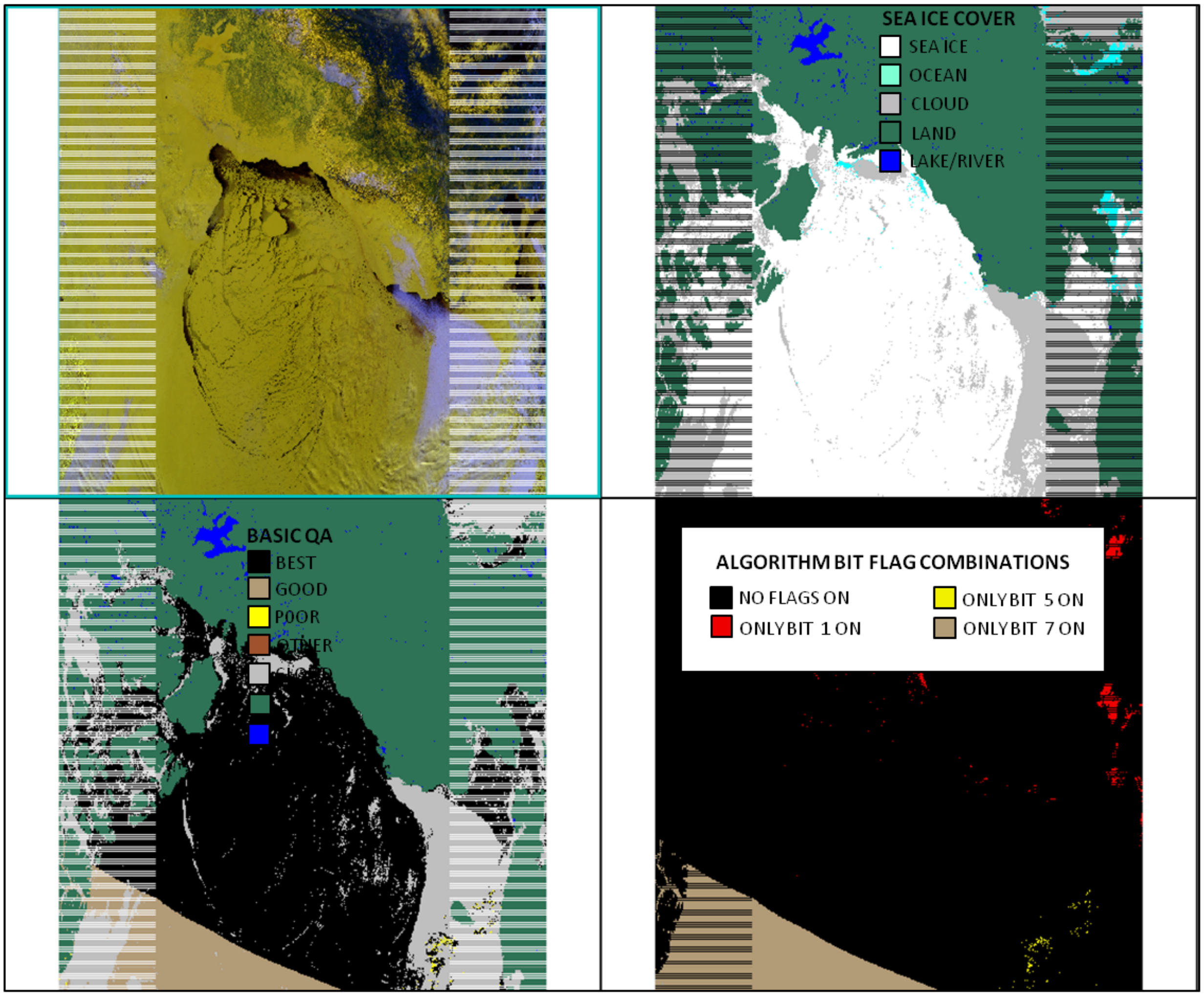

Figure 1. VNP29 21 April 2016, 2054 UTC. Sea ice cover in the Beaufort Sea is shown in the NDSI_Sea_ice_Cover map, upper right. A false color image using VIIRS bands I1, I2 and I3, upper left, of the swath shows sea ice in shades of yellow, clouds in white and open ocean as very dark. The SeaIceCover_Basic_QA is the lower left panel and a selection of the bit flags from the Algorithm_QA_Flags dataset is shown in the lower right.

3.2.2 Algorithm_QA_flags

Algorithm-specific bit flags are set for the data screens applied in the algorithm. All pixels that were detected as sea ice have data screens applied. 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, as they either reverse sea ice detection or flag an uncertain result. See Section 3.3.1 for a description of data screens.

3.2.3 SeaIceCover_Basic_QA

This is a basic quality value that indicates quality ranging from best to poor to provide a user with a convenient value for initial quality assessment of the data. Masked features, e.g. clouds and land are set to a masked value. Attributes describing the QA values are attached.

3.3 Sea ice 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 VIIRS Sea Ice Cover algorithm utilizes a variation of the NDSI algorithm to detect sea ice and is similar to the MODIS Sea Ice Extent algorithm by Hall et al. (2001), The algorithm is applied to oceans poleward of 50°N and 50°S.

The basis of the NASA VIIRS Sea Ice Cover algorithm is the use of the Normalized Difference Snow Index (NDSI) to separate sea ice from open water. Sea ice has a strong visible reflectance and strong short-wave IR absorbing characteristics, in contrast to open water. Additionally, some snow/cloud discrimination is accomplished using the NDSI. The VIIRS Sea Ice Cover algorithm computes the NDSI for each pixel with:

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

The VIIRS I1 and I3 bands are image quality (resolution = 375m) and centered at 0.64 µm and 1.61 µm, respectively.

Using NDSI values sea ice can be identified using the following criteria: if the NDSI ≥ 0.4 and the visible reflectance (VIIRS I2 band) is greater than 0.11, then the pixel contains sea ice (Tschudi et al., 2017),. This threshold has been successfully used in the MODIS sea ice extent NDSI algorithm [*Hall et al*., 2001].

The general flow of the Sea Ice Cover algorithm is shown in Figure 3. The algorithm is run for all ocean pixels for VIIRS image-band swaths poleward of 50°N and 50°S latitude, and in daylight determined by a solar zenith angle < 85°. The NASA VIIRS land/water mask is used to guide processing over oceans and mask the land, Next, the cloud confidence flag is read from the CMIP to create the cloud mask. The LPEATE CMIP is used in C1. In C2 the NASA cloud mask product will be used. If the CMIP cloud confidence flag has a setting of “confident cloudy” or “probably cloudy” or “probably clear” the pixel is masked as cloud. If the CMIP cloud confidence flag setting is “confident clear” the pixel is cloud free and processed for sea ice cover. The reflectance data is checked for nominal quality. If unusable data is found it is flagged and the pixel skipped, otherwise processing continues. Data screens are applied and QA bit flags are set for pixels processed for sea ice cover .

Data product inputs to the sea ice detection algorithm are listed in Table 2. Collection 1 uses the LPEATE version of input products. The latitude and longitude data for a swath are read from the NPP_IMFTS_L1 product and written into the GeolocationData data group of VNP29.

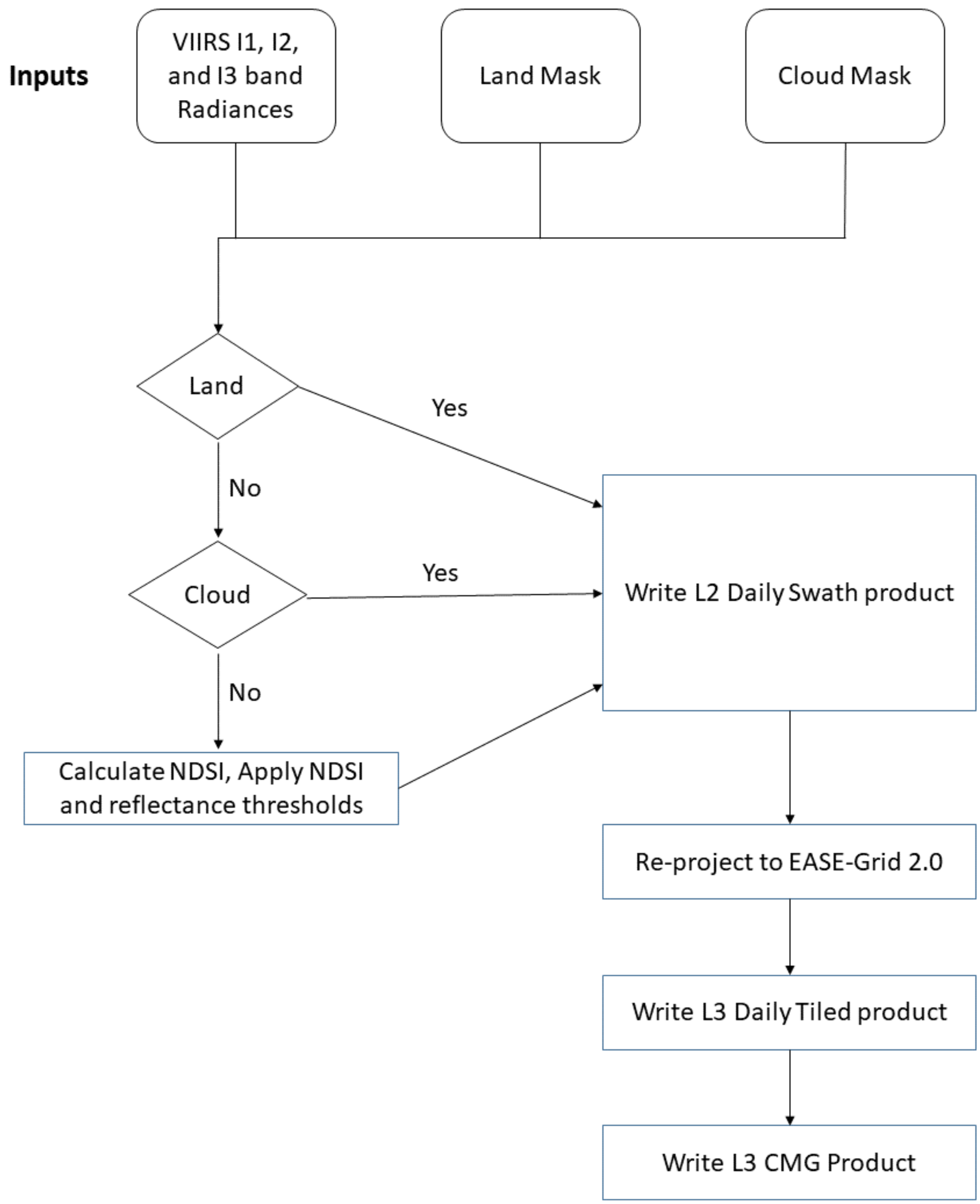

Figure 2: Suomi-NPP NASA VIIRS Sea Ice Cover Algorithm Flow Chart.

Table 2. Data product inputs to the VNP29 C1 algorithm.

ESDT	Dataset names	Spatial resolution	Descriptor
NPP_VIAES_L1	Reflectance_I1 Reflectance_I2 Reflectance_I3 QF_VIIRSIBANDSDR_I1 QF_VIIRSIBANDSDR_I2 QF_VIIRSIBANDSDR_I3	375 m	Reflectance Quality flags
NPP_IMFTS_L1	SolarZenithAngle	375 m	Solar zenith angle
VNP35_L2	QF1_VIIRSCMIP QF2_VIIRSCMIP	750 m	Cloud confidence flag Land/water mask

3.3.1 Data Screens

Several data screens, masks and thresholds are applied in the algorithm to mask clouds, prevent sea ice commission errors, flag uncertain sea ice detections, and set QA bit flags. Data screens and masks are applied within the algorithm using data read from the VIIRS input data products. No ancillary data are used in the algorithm. Data screens and masks used are described in following subsections.

3.3.1.1 Land/Water Mask

In Collection 1 the land/water mask is read from the LPEATE version of VNP35_L2 and used to direct processing for oceans and to create the land and inland water bodies mask in VNP29. The algorithm does not perform ice detection on inland waters.

3.3.1.2 Cloud Mask

The cloud confidence flag from the LPEATE version of VNP35_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” or “probably cloudy”, or “probably clear” then the pixel is masked as “cloud.” If the cloud mask flag is set “confident clear,” it is interpreted as cloud free.

3.3.1.3 Solar Zenith Angle

Solar zenith angle data from NPP_IMFS_L2 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. A QA flag is set for pixels in this solar zenith range. That flag is bit 7 of the Algorithm_QA_Flags. Night is defined as SZA ≥ 85° and pixels are masked as night.

3.3.1.4 Low Visible Data Screen

If reflectance in band I2 is < 0.10 for a pixel it is set to "no decision" and the low visible data screen bit flag, bit 1 in Algorithm_QA_Flags is set.

3.3.1.5 Low NDSI Data Screen

If the NDSI is < 0.1 a pixel is set to "not sea ice" and the low NDSI flag, bit 2 in Algorithm_QA_Flags is set.

3.3.1.6 High SWIR Data Screen

If the band I3 reflectance of a pixel detected as sea ice is ≥ 0.45 that result is changed to "not sea ice" and the high SWIR flag, bit 5 in Algorithm_QA_Flags is set.

3.3.2 Quality Assessment (QA)

Two QA datasets are output: 1) the SeaIceCover_Basic_QA, which gives a simple value score, and 2) the Algorithm_QA_Flags, which report results of data screens as bit flags. The basic QA value is a qualitative estimate of the algorithm result for a pixel. It 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. ocean and night, the mask 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 serve two purposes: 1) they indicate why a sea ice detection was reversed to "not sea ice," and 2) they represent a QA flag for 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 to "on" if the screen was failed. By examining the bit flags a user can determine if a sea ice result was changed to a "not sea ice" result by a screen or screens, or if a sea ice pixel has certain screens set to "on" indicative of an uncertain sea ice detection.

The screens and bit flags have a dual purpose-- some flag where sea ice detection was reversed or flag sea ice detection as “uncertain.” More than one data screen can be “on” for a sea ice detection reversal or for uncertain sea ice detection.

3.4 Interpretation of Sea ice Detection Accuracy, Uncertainty and Errors

The targeted uncertainty of the NASA Sea Ice Cover Product is 5%, i.e. 95% of the viewable surface should be correctly classified as either sea ice or open water. Some error in geolocation may be associated with projecting from latitude and longitude coordinates to this data set's EASE2-Grid Polar equal area projection. Geolocation error may be notable along coast lines, which may appear to shift from day to day between cells of the grid. Errors in sea ice detection are more probable in the summer, when melt ponds may be detected as open water, causing the algorithm to classify sea ice as open water. Similar errors may occur where sea ice is in low concentration in an EASE-2 grid cell.

3.4.1 Low reflectance

Low solar illumination conditions occurring when the SZA is ≥ 70.0° and near to the day/night terminator are a challenge for sea ice detection. Low reflectance situations in which reflectance is < ~30% across the visible bands is also a challenge. 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 pixel is set to “no decision” and the low VIS data screen bit flag is set.

3.4.2 High SWIR reflectance

Unusually high SWIR reflectance may be observed for some sea ice situations. This can occur with some types of clouds that are not masked by the VIIRS Cloud Mask. A SWIR screen is applied at two thresholds to either reverse a possible sea ice commission error or flag sea ice detection with unusually high SWIR. A user can check this bit flag to determine where uncertain sea ice detections occurred or where sea ice detection was reversed to “not sea ice.”

3.4.3 Cloud and sea ice confusion

Cloud/sea ice confusion in the C1 sea ice cover product is similar to the cloud/sea ice confusion seen in the MODIS C6 sea ice product. Two common sources of cloud/sea ice confusion are: 1) the cloud mask does not correctly flag cloudy or clear conditions, and 2) subpixel clouds (cloud mask is at 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 VIIRS Cloud Mask ATBD and user guide. The combination of tests applied to a pixel depends on whether the ocean surface is open ocean or has sea ice cover. An external sea ice/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 the wrong processing path is followed and a possible erroneous cloud determination is made, e.g. flagging sea ice as ‘certain cloud.’

Subpixel size clouds that escape detection by the VIIRS Cloud Mask algorithm may be erroneously detected as sea ice because the cloud spectral properties can cause an underlying sea ice-free surface to appear similar to sea ice. This situation frequently results in sea ice commission errors at the periphery of clouds, especially when cloud formations of scattered, popcorn-like clouds are present over vegetated landscapes. 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 which may then be detected as sea ice in the algorithm.

Users may want to develop filters for their particular study areas taking into consideration the fact that cloud conditions are typically transient, and thus cloud/sea ice commission errors can possibly be filtered temporally or spatially or by a combination of filters.

3.4.4 Land/water mask

The land/water mask in C1 is read from the LPEATE VNP35_L2. It is not the same land/water mask that is used in MODIS data processing. For C2 the MODIS C6 land/water mask will be adapted for VIIRS and stored in the VNP03_IMG product. That land/water mask will be used in C2 of VNP29.

The MODIS land/water mask was derived from the UMD 250m MODIS Water Mask data product (UMD Global Land Cover Facility http://glcf.umd.edu/data/) (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 to maintain continuity with the land/water mask used in C5. The new land/water mask more accurately provides the location of water bodies [http://landweb.nascom.nasa.gov/QA_WWW/forPage/MODIS_C6_Water_Mask_v3.pdf]. Thus LSIPS adapted the MODIS land/water mask to create the VIIRS land/water mask in the geolocation product.

3.4.5 Geolocation accuracy

Geolocation accuracy in NASA VIIRS is very high, providing consistent high accuracy in mapping of the VIIRS data products. The very small errors in geolocation are negligible in the L2 products, however, geolocation error may be observed in the daily gridded products as a shifting of features, e.g., changes in the location of a lake in cells from day to day. That possible cell shifting of features in daily gridded products will be addressed in a later version of this user guide.

3.5 Related Web Sites

Suomi-NPP
http://npp.gsfc.nasa.gov/suomi.html

VIIRS
VIIRS Land: http://viirsland.gsfc.nasa.gov/
MODIS Sea ice/Ice Global Mapping Project:
http://modis-sea ice-ice.gsfc.nasa.gov

Imagery and Data Product Viewing
Worldview: https://worldview.earthdata.nasa.gov
LANCE: https://wiki.earthdata.nasa.gov/display/GIBS/2015/12/10/VIIRS+is+Here
https://earthdata.nasa.gov

NSIDC Data Ordering & User Services
National Sea ice and Ice Data Center: http://nsidc.org/data/viirs

HDF5
The HDF Group: https://www.hdfgroup.org/HDF5/

NetCDF4
www.unidata.ucar.edu/software/netcdf/docs/index.html

3.6 References

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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.

Wolfe, R.E. and H.K. Ramapriyan (2010), Scaling the pipe: NASA EOS Terra data systems at 10, *Proceedings of the Geoscience and Remote Sensing Symposium (IGARSS), 2010*, Honolulu, HI, 25 – 30 July, 2010, 1300 – 1303.

Appendix A

Listing of the contents of VNP29 – the VIIRS Sea Ice Cover product

```
netcdf VNP29.A2015182.1300.001.2017257154705 {
dimensions:
        number_of_lines = 6464 ;
        number_of_pixels = 6400 ;

// global attributes:
                :Percent_ocean_in_swath = "63.3%" ;
                :IceCover = "2.1%" ;
                :CloudCover = "85.2%" ;
                :RangeEndingDate = "2015-07-01" ;
                :LPEATE_AlgorithmVersion = "NPP_PR29 1.0.0" ;
                :Conventions = "CF-1.6" ;
                :creator_name = "VIIRS Land SIPS Processing Group" ;
                :InputPointer =
"VNP35_L2.A2015182.1300.001.2017257154044.hdf,NPP_VIAES_L1.A2015182.1300.001.2017102161
621.hdf,NPP_IMFTS_L1.A2015182.1300.001.2017102001716.hdf" ;
                :institution = "NASA Goddard Space Flight Center" ;
                :processing_level = "Level 2" ;
                :Resolution = "Imagery" ;
                :cdm_data_type = "swath" ;
                :keywords_vocabulary = "NASA Global Change Master Directory (GCMD) Science
Keywords" ;
                :license = "http://science.nasa.gov/earth-science/earth-science-data/data-information-
policy/" ;
                :naming_authority = "gov.nasa.gsfc.VIIRSland" ;
                :ProxyDataType = "Operational Data" ;
                :identifier_product_doi = "10.5067/VIIRS/VNP29.001" ;
                :PGE_StartTime = "2015-07-01 13:00:00.000" ;
                :ProcessVersion = "001" ;
                :RangeEndingTime = "13:06:00.000000" ;
                :identifier_product_doi_authority = "http://dx.doi.org" ;
                :title = "VIIRS Sea Ice Cover" ;
                :EndTime = "2015-07-01 13:06:00.000" ;
                :StartTime = "2015-07-01 13:00:00.000" ;
                :creator_email = "modis-ops@lists.nasa.gov" ;
                :publisher_name = "LAADS" ;
                :ProcessingEnvironment = "Linux minion7112 3.10.0-514.10.2.el7.x86_64 #1 SMP Fri
Mar 3 00:04:05 UTC 2017 x86_64 x86_64 x86_64 GNU/Linux" ;
                :creator_url = "http://ladsweb.nascom.nasa.gov" ;
                :Platform_Short_Name = "NPP" ;
                :PGEVersion = "1.0.0" ;
                :stdname_vocabulary = "NetCDF Climate and Forecast (CF) Metadata Convention" ;
                :LocalGranuleID = "VNP29.A2015182.1300.001.2017257154705.nc" ;
                :PGE_EndTime = "2015-07-01 13:06:00.000" ;
                :AlgorithmType = "OPS" ;
                :SatelliteInstrument = "NPP_OPS" ;
                :ShortName = "VNP29" ;
                :publisher_email = "modis-ops@lists.nasa.gov" ;
                :RangeBeginningDate = "2015-07-01" ;
                :RangeBeginningTime = "13:00:00.000000" ;
                :ProductionTime = "2017-09-14 15:47:05.000" ;
```

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			:LongName = "VIIRS/NPP Sea Ice Extent 6-Min L2 Swath 375m" ;
			:project = "VIIRS Land SIPS Sea Ice Cover Project" ;
			:InstrumentShortname = "VIIRS" ;
			:PGE_Name = "PGE508" ;
			:publisher_url = "http://ladsweb.nascom.nasa.gov" ;

group: GeolocationData {
  variables:
		float latitude(number_of_lines, number_of_pixels) ;
			latitude:standard_name = "latitude" ;
			latitude:long_name = "Latitude data" ;
			latitude:units = "degrees_north" ;
			latitude:_FillValue = -999.f ;
			latitude:valid_range = -90.f, 90.f ;
		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: SeaIceCover_Data {
  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:_FillValue = 0UB ;
			Algorithm_QA_Flags:flag_masks = "1b, 2b, 4b, 8b, 16b, 32b, 64b, 128b" ;
			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_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:mask_values = 211UB, 225UB, 237UB, 250UB, 252UB, 253UB,
254UB ;
			SeaIceCover_Basic_QA:mask_meanings = "211-night, 225-land, 237-inland_water, 250-
cloud, 252-unusable_L1B_data, 253-bowtie_trim, 254-no_L1B_data" ;
			SeaIceCover_Basic_QA:_FillValue = 255UB ;
		ubyte SeaIceCover_Map(number_of_lines, number_of_pixels) ;
			SeaIceCover_Map:mask_values = 200UB, 201UB, 211UB, 225UB, 237UB, 250UB,
252UB, 253UB, 254UB ;
			SeaIceCover_Map:mask_meanings = "200-missing, 201-no_decision, 211-night, 225-
land, 237-inland_water, 250-cloud, 252-unusable_L1B_data, 253-bowtie_trim, 254-no_L1B_data" ;
			SeaIceCover_Map:_FillValue = 255UB ;
			SeaIceCover_Map:coordinates = "latitude longitude" ;
			SeaIceCover_Map:long_name = "Sea Ice Cover map with masks" ;
			SeaIceCover_Map:valid_range = 0UB, 100UB ;
  } // group SeaIceCover_Data
}
```