MODIS/Terra Sea Ice Extent Daily L3 Global 1km EASE-Grid Night, Version 5

USER GUIDE

How to Cite These Data

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

Hall, D. K., V. V. Salomonson, and G. A. Riggs. 2006. *MODIS/Terra Sea Ice Extent Daily L3 Global 1km EASE-Grid Night, Version 5.* [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/4ME6A88Y90P7. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/MOD29P1N

National Snow and Ice Data Center

TABLE OF CONTENTS

1 DETAILED DATA DESCRIPTION

The MODIS science team continually seeks to improve the algorithms used to generate MODIS data sets. Whenever new algorithms become available, the MODIS Adaptive Processing System (MODAPS) reprocesses the entire MODIS collection—atmosphere, land, cryosphere, and ocean data sets—and a new version is released. NSIDC strongly encourages users to work with the most recent version.

Consult the following resources for more information about MODIS Version 5 data, including known problems, production schedules, and future plans:

- MODIS Sea Ice Products User Guide to Collection 5
- The MODIS Snow and Sea Ice Global Mapping Project
- NASA Goddard Space Flight Center | MODIS Land Quality Assessment
- MODIS Land Team Validation | Status for Snow Cover/Sea Ice (MOD10/29)

1.1 Format

MODIS sea ice products are archived in compressed HDF-EOS format, which employs point, swath, and grid structures to geolocate the data fill fields to geographic coordinates. This data compression should be transparent to most users since HDF capable software tools automatically uncompress the data. See the Hierarchical Data Format - Earth Observing System (HDF-EOS) website for more information about the HDF-EOS data format.

Data can also be obtained in GeoTIFF format from Reverb | ECHO, NASA's Next Generation Earth Science Discovery Tool.

Visible data are not acquired when the sensor is observing the surface in darkness; therefore, this night product only contains Ice Surface Temperature (IST) data fields, which are based on thermal data. MOD29P1N/MYD29P1N data sets consist of 951 x 951 cells of tiled data in the Lambert Azimuth Equal Area Projection. Each data granule contains HDF-EOS local attribute fields, which are stored with their associated Scientific Data Set (SDS). Each data granule also contains metadata either stored as global attributes or as HDF-predefined fields, which are stored with each Scientific Data Set (SDS). This information can be found in the MOD29P1N and MYD29P1N Version 5 Local and Global Sea Ice Attributes document.

1.1.1 Description of Data Fields

- Ice Surface Temperature (IST) - IST data are expressed in kelvins and are stored as scaled integer data in HDF-EOS calibrated form. You must convert data to kelvins using the calibration data as given in the HDF predefined local attributes:

IST = scale_factor * (data value - add_offset)

Where:
scale_factor = 0.01
data value = ice surface temperature
add_offset = 0

The valid range for IST is 243 to 274.5 K.

- Ice Surface Temperature Spatial Quality Assessment - this field stores the quality of the algorithm on a pixel-by-pixel basis. QA information tells if the algorithm results were good quality or not, or if other defined conditions were encountered for a pixel. If all the input data and calculations in the algorithm were nominal for a pixel, the QA field is set to good. See MOD29P1N Local Sea Ice Attributes, Version 5 document for more information about QA flags in sea ice products.

1.1.2 External Metadata File

A separate ASCII text file containing metadata with a .xml file extension accompanies the HDF-EOS file. The metadata file contains some of the same metadata as in the product file, but also includes other information regarding archiving, user support, and post production QA relative to the granule ordered. The post-production QA metadata may or may not be present depending on whether or not the data granule has been investigated for quality assurance. The metadata file should be examined to determine if post-production QA has been applied to the granule.

1.2 File Naming Convention

The file naming convention used for this data set is MOD29P1N.A2000057.h12v07.005.2006252061042.hdf. Refer to Table 1 for an explanation of the variables used in the MODIS file naming convention.

Table 1. Variable Explanation for MODIS File Naming Convention

Variable	Explanation
MOD MYD	MODIS/Terra MODIS/Aqua
29P1N	Type of product
A	Acquisition date
2000	Year of data acquisition
057	Day of year of data acquisition (day 57)
h12v07	Horizontal tile number and vertical tile number. For further information, see Section 1.4.3.2 Grid.
005	Version number
2006	Year of production (2006)

Variable	Explanation
252	Day of year of production (day 252)
061042	Hour/minute/second of production in GMT (06:10:42)
hdf	HDF-EOS data format

1.3 File Size

Data files are typically between 0.05 - 1.5 MB using HDF compression.

Note: New in V005, data files now use HDF data compression. The extent to which compression reduces the file size varies from image to image, but generally it is a factor of 10 or more.

1.4 Spatial Coverage

Coverage is global; however, only ocean pixels are run through the sea ice algorithm.

1.4.1 Latitude Crossing Times

The local equatorial crossing time of the Terra (Aqua) satellite is approximately 10:30 a.m. (1:30 p.m.), in a descending (ascending) node with a sun-synchronous, near-polar, circular orbit.

1.4.2 Spatial Resolution

Gridded resolution is 1 km.

1.4.3 Projection and Grid Description

1.4.3.1 Projection

MOD29P1N/MYD29P1N data sets utilize polar tile grids based on the Lambert Azimuthal Equal-Area projection. Meridians are straight lines that intersect at the poles while lines of latitude are circles with their centers at either pole. The following table lists some of the key parameters for this projection:

Table 2. Lambert Azimuthal Equal Area Map Projection Parameters

Parameter	Value
Earth radius	6371228.0 meters
Projection origin	North: 90° lat, 0° lon South: -90° lat, 0° lon
Orientation	North: 0° lon, oriented vertically at bottom South: 0° lon, oriented vertically at top

Parameter	Value
Upper left corner (m)	-9058902.1845(x) 9058902.1845(y)
Lower right corner (m)	9058902.1845(x) -9058902.1845(y)
Scale (m)	1002.7010(x) 1002.7010(y)

1.4.3.2 Grid

MOD29P1N/MYD29P1N data files are provided as tiles of data gridded in the original EASE-Grid Lambert Azimuthal Equal Area map projection. Tiles contain 951 x 951 cells. The global tile grid is partitioned into separate Northern and Southern Hemisphere polar grids, with half of the tiles (313) in the north and half in the south. The coordinate system, designated by (horizontal, vertical) ordered pairs, starts with (h00,v00) in the upper left corner of the northern grid and proceeds rightward (horizontal) and downward (vertical) to tile (h18, v18) in the bottom right. The southern grid begins where the northern grid ends, with tile (h00,v20) in the upper left and tile (v18,h38) in the lower right.

Additional information about this grid is available on the following web pages, including bounding coordinates for each tile, maps that show tile locations for the Northern and Southern Hemisphere grids, and the MODLAND Tile Calculator tool, which can convert between MODIS tile numbers and latitude/longitude:

- EASE-Grid Tile Locations and Bounding Coordinates for MODIS Sea Ice Products
- MODIS MODLAND Tile Calculator

For descriptions of all the projections and grids used for MODIS data sets, see the MODIS Land team's MODIS Grids web page. A complete description of EASE-Grid is available at EASE-Grid Data | Overview.

1.5 Temporal Coverage

MODIS Terra data extend from 24 February, 2000 to present.
MODIS Aqua data extend from 4 July, 2002 to present.

Over the course of the Terra and Aqua missions, a number of anomalies have resulted in data gaps. If you are looking for data for a particular date or time and cannot find it, please visit the MODIS/Terra Data Outages and MODIS/Aqua Data Outages web pages.

1.5.1 Temporal Resolution

Daily

1.6 Parameter or Variable

1.6.1 Parameter Description

In the IST field, pixels classified as cloud free ocean contain an IST value in kelvins, and pixel values are scaled by 100 for all classes. The IST algorithm was designed for sea ice; however, IST values are provided for all ocean areas that are not classified as cloud.

1.6.2 Parameter Range

Refer to the MOD29P1N and MYD29P1N Version 5 Local and Global Sea Ice Attributes document for a key to the meaning of the coded integer values in the Ice Surface Temperature Field.

2 SOFTWARE AND TOOLS

2.1 Data Access Aids

The following sites can help you select appropriate MODIS data for your study:

- MODIS Rapid Response System
- NASA Goddard Space Flight Center: MODIS Land Global Browse Images

2.2 Data Analysis Tools

The following software tools can help you analyze the data:

- Land Processes Distributive Active Archive Center: MODIS Swath Reprojection Tool Distribution Page: Software tools that read HDF-EOS files containing MODIS swath data and produce native binary HDF-EOS Grid or GeoTIFF files of gridded data in different map projections.
- HEG HDF-EOS to GeoTIFF Conversion Tool: This free tool converts many types of HDF-EOS data to GeoTIFF, native binary, or HDF-EOS grid format. It also has reprojection, resampling, subsetting, stitching (mosaicing), and metadata preservation and creation capabilities.
- NCSA HDFView: The HDFView is a visual tool for browsing and editing the National Center for Supercomputing Applications (NCSA) HDF4 and HDF5 files. Using HDFView, you can view a file hierarchy in a tree structure, create a new file, add or delete groups and datasets, view and modify the content of a dataset, add, delete, and modify attributes, and replace I/O and GUI components such as table view, image view, and metadata view.

- Hierarchical Data Format - Earth Observing System (HDF-EOS): NSIDC provides more information about the HDF-EOS format, tools for extracting binary and ASCII objects from HDF, information about the hrepack tool for uncompressing HDF-EOS data files, and a list of other HDF-EOS resources.
- The MODIS Conversion Toolkit (MCTK): A free plugin for ENVI that can ingest, process, and georeference every known MODIS data product using either a graphical widget interface or a batch programmatic interface. This includes MODIS products distributed with EASE-Grid projections.

3 DATA ACQUISITION AND PROCESSING

3.1 Theory of Measurements

For information regarding the theory for sea ice mapping and ice surface temperature retrieval, please see the Theory of Measurements section in the MODIS/Terra Sea Ice Extent 5-Min L2 Swath 1km (MOD29), Version 5 user guide.

3.2 Data Acquisition Methods

3.2.1 Source or Platform Mission Objectives

MODIS is a key instrument aboard Terra and Aqua, the flagship satellites of NASA's Earth Observing System (EOS). The EOS includes a series of satellites, a data system, and the world-wide community of scientists supporting a coordinated series of polar-orbiting and low inclination satellites for long-term global observations of the land surface, biosphere, solid Earth, atmosphere, and oceans that together enable an improved understanding of the Earth as an integrated system. MODIS is playing a vital role in the development of validated, global, and interactive Earth system models able to predict global change accurately enough to assist policy makers in making sound decisions concerning the protection of our environment (NASA's MODIS website 2006, NASA's Terra website 2006, and NASA's EOS website 2006).

3.2.2 MODIS Snow and Sea Ice Global Mapping Project Objectives

Within this overall context, the objectives of the MODIS snow and ice team are to develop and implement algorithms that map snow and ice on a daily basis, and provide statistics of the extent and persistence of snow and ice over eight-day periods. Data at 500 m resolution enables sub-pixel snow mapping for use in regional and global climate models. A study of sub grid-scale snow-cover variability is expected to improve features of a model that simulates Earth radiation balance and land-surface hydrology (Hall et al., 1998).

3.2.3 Data Collection System

The MODIS sensor contains a system whereby visible light from the earth passes through a scan aperture and into a scan cavity to a scan mirror. The double-sided scan mirror reflects incoming light onto an internal telescope, which in turn focuses the light onto four different detector assemblies. Before the light reaches the detector assemblies, it passes through beam splitters and spectral filters that divide the light into four broad wavelength ranges. Each time a photon strikes a detector assembly, an electron is created. Electrons are collected in a capacitor where they are eventually transferred into the preamplifier. Electrons are converted from an analog signal to digital data, and down linked to ground receiving stations.

3.2.4 Data Acquisition and Processing

The EOS Ground System (EGS) consists of facilities, networks, and systems that archive, process, and distribute EOS and other NASA earth science data to the science and user community. For example, ground stations provide space to ground communication. The EOS Data and Operations System (EDOS) processes telemetry from EOS spacecraft and instruments to generate Level-0 products, and maintains a backup archive of Level-0 products. The NASA Goddard Space Flight Center: MODIS Adaptive Processing System (MODAPS) Services is currently responsible for generation of Level-1A data from Level-0 instrument packet data. These data are then used to generate higher level MODIS data products, including MOD10_L2. MODIS snow and ice products are archived at the NSIDC Distributed Active Archive Center (DAAC) and distributed to EOS investigators and other users via external networks and interfaces. Data are available to the public through a variety of interfaces.

3.3 Derivation Techniques and Algorithms

The MODIS science team is responsible for algorithm development. The MODIS Data Processing System (MODAPS) is responsible for product generation and transfer of products to NSIDC.

3.3.1 Processing Steps

For more information regarding the processing steps used as the input to this data set, please see the Processing Steps section in the MODIS/Terra Sea Ice Extent 5-Min L2 Swath 1km (MOD29), Version 5 user guide.

MOD29P1N data are generated from the temporary gridded product MOD29PGN, which is created by mapping all night pixels in the MOD29 swath product acquired over a 24-hour period to their earth locations on the Lambert Azimuthal Equal Area projection. As a result, multiple observations can be associated with each cell in the grid. When multiple observations are available, the

algorithm selects the observation that is nearest nadir and has the greatest coverage of the grid cell based on a weighted scoring function.

3.3.2 Error Sources

As with any upper-level product, the characteristics of or anomalies in input data may carry through to the output data product. The following products are input to MOD29P1N:

- MOD29PGN - MODIS/Terra Sea Ice Extent Daily L2G Global 1km EASE-Grid Night, which is further described in the MODIS Sea Ice Products User Guide to Collection 5.

In addition, because sea ice varies in concentration from near zero to 100 percent, it can show temperatures within a pixel due to sub-pixel effects. Melt ponds and leads in the summer months affect the emissivity of the ice surface, therefore affecting the calculation of ice surface temperature (Hall et al., 1998). The presence of even very thin clouds or fog within the field of view prevent obtaining an accurate IST (Hall et al., 2004). Recent studies in the Arctic and Antarctic have shown that under clear sky conditions the IST are accurate to better than ± 1.5 over the 245-270 K range for all ice types.

3.4 Quality Assessment

All MODIS/Terra and MODIS/Aqua sea ice products are considered validated or at stage 2 meaning that accuracy has been assessed over a widely distributed set of locations and time periods via several ground-truth and validation campaigns.

Quality indicators for MODIS sea ice data can be found in the following three places:

- AutomaticQualityFlag and the ScienceQualityFlag metadata objects and their corresponding explanations: AutomaticQualityFlagExplanation and ScienceQualityFlagExplanation located in the CoreMetadata.0 global attributes
- Custom local attributes associated with each SDS, for example Ice Surface Temperature
- The Spatial QA SDS that accompanies each data field, for example, Ice Surface Temperature Spatial QA.

These quality indicators are generated during production or in post-production scientific and quality checks of the data product. See the MOD29P1N and MYD29P1N Version 5 Local and Global Sea Ice Attributes document for more information on local and global attributes.

The ScienceQualityFlag and the ScienceQualityFlagExplanation may be updated after production, either after an automated QA program is run or after the data product is inspected by a qualified scientist. Content and explanation of this flag are dynamic so it should always be examined if

present in the external metadata file. A sampling of products will be inspected. Random sampling or support of specific events, such as field campaigns, may also be conducted.

The IST Spatial QA and Sea Ice by Reflectance Spatial QA data fields provide additional information on algorithm results for each pixel within a spatial context, and are used as a measure of usefulness for sea ice data. QA data are stored as coded integer values and tell if algorithm results were nominal, abnormal, or if other defined conditions were encountered for a pixel (Riggs, Hall, and Salomonson, 2006).

The NASA Goddard Space Flight Center: MODIS Land Quality Assessment website provides updated quality information for each product.

3.5 Sensor or Instrument Description

The MODIS instrument provides 12-bit radiometric sensitivity in 36 spectral bands ranging in wavelength from 0.4 µm to 14.4 µm. Two bands are imaged at a nominal resolution of 250 m at nadir, five bands at 500 m, and the remaining bands at 1000 m. A ±55-degree scanning pattern at an altitude of 705 km achieves a 2330 km swath with global coverage every one to two days.

The scan mirror assembly uses a continuously rotating, double-sided scan mirror to scan ±55 degrees, and is driven by a motor encoder built to operate 100 percent of the time throughout the six-year instrument design life. The optical system consists of a two-mirror, off-axis afocal telescope which directs energy to four refractive objective assemblies, one each for the visible, near-infrared, short- and mid-wavelength infrared, and long wavelength infrared spectral regions.

The MODIS instruments on the Terra and Aqua space vehicles were built to NASA specifications by Santa Barbara Remote Sensing, a division of Raytheon Electronics Systems. Table 3 contains the instruments' technical specifications:

Table 3. MODIS Technical Specifications

Variable	Description
Orbit	705 km altitude, sun-synchronous, near-polar, circular. Equatorial crossing times: Terra: 10:30 A.M., descending node Aqua: 1:30 P.M., ascending node
Scan Rate	20.3 rpm, cross track
Swath Dimensions	2330 km (cross track) by 10 km (along track at nadir)
Telescope	17.78 cm diameter off-axis, afocal (collimated) with intermediate field stop
Size	1.0 m x 1.6 m x 1.0 m
Weight	228.7 kg

Variable	Description
Power	162.5 W (single orbit average)
Data Rate	10.6 Mbps (peak daytime); 6.1 Mbps (orbital average)
Quantization	12 bits
Spatial Resolution	250 m (bands 1-2) 500 m (bands 3-7) 1000 m (bands (8-36)
Design Life	6 years

3.5.1 Calibration

MODIS has a series of on-board calibrators that provide radiometric, spectral, and spatial calibration of the MODIS instrument. The blackbody calibrator is the primary calibration source for thermal bands between 3.5 µm and 14.4 µm, while the Solar Diffuser (SD) provides a diffuse, solar-illuminated calibration source for visible, near-infrared, and short-wave infrared bands. The Solar Diffuser Stability Monitor tracks changes in the reflectance of the SD with reference to the sun so that potential instrument changes are not incorrectly attributed to changes in this calibration source. The Spectroradiometric Calibration Assembly provides additional spectral, radiometric, and spatial calibration.

MODIS uses the moon as an additional calibration technique and for tracking degradation of the SD by referencing the illumination of the moon since the moon's brightness is approximately the same as that of the Earth. Finally, MODIS deep space views provide a photon input signal of zero, which is used as a point of reference for calibration.

For additional details about the MODIS instruments, see NASA's MODIS | About web page.

4 REFERENCES AND RELATED PUBLICATIONS

4.1 References

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4.2 Related Data Collections

See MODIS | Data Sets for all the MODIS snow cover and sea ice data sets available from NSIDC.

4.3 Related Websites

- MODIS @ NASA Goddard Space Flight Center
- The MODIS Snow and Sea Ice Global Mapping Project

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6 DOCUMENT INFORMATION

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