MODIS/Aqua Sea Ice Extent and IST Daily L3 Global 4km EASE-Grid Day, 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/Aqua Sea Ice Extent and IST Daily L3 Global 4km EASE-Grid Day, Version 5*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/RKM0XZ7TPNRS. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/MYD29E1D

National Snow and Ice Data Center

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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)

This data set is retired and no longer available for download. The most up-to-date version of this data can be accessed on the NSIDC website here.

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) Web site 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.

Each data granule contains the following HDF-EOS local attribute fields, which are stored with their associated Scientific Data Set (SDS):

- Sea Ice by Reflectance North Pole (NP)
- Sea Ice by Reflectance South Pole (SP)
- Ice Surface Temperature NP
- Ice Surface Temperature SP

Each data granule also contains metadata either stored as global attributes or as HDF-predefined fields associated with each SDS.

1.1.1 Description of Data Fields

- Sea Ice by Reflectance NP and SP - the sea ice algorithm identifies pixels as being sea ice, ocean, cloud, land, inland water, or other condition. Sea ice is distinguished from open water based on reflective properties. Results are stored as integer values.
- Ice surface temperature NP and SP - 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 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 = 0.0

  The valid range for IST is 223.20 to 313.20 K.

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 Quality Assessment (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 QA. The metadata file should be examined to determine if post-production QA has been applied to the granule.

1.2 File Naming Convention

This section explains the file naming convention used for this MODIS data set with an example. Note that MODIS Terra data file names begin with MOD. MODIS Aqua file names being with MYD.

Example File Name:

```
MYD29E1D.A2002186.005.2006256010347.hdf
MYD[PID].A[YYYY][DDD].[VVV].[yyyy][ddd][hhmmss].hdf
```

Refer to Table 1 for the valid values for the file name variables listed above.

Table 1. Valid Values for MODIS File Name Variables

Variable	Description
MOD MYD	MODIS/Terra MODIS/Aqua
29E1D	Product ID
A	Acquisition date follows
YYYY	Acquisition year
DDD	Acquisition day of year
VVV	Version (Collection) number
yyyy	Production year
ddd	Production day of year
hhmmss	Production hour/minute/second in GMT
.hdf	HDF-EOS formatted data file

1.3 File Size

Data files are typically between 0.5 - 6.0 MB using HDF compression. XML metadata files are between 5 - 10 KB.

1.4 Spatial Coverage

Each file contains two data grids: one for the Arctic and one for the Antarctic at 4 km gridded resolution. Both grids combined provide global coverage; however, the sea ice algorithm is applied only to ocean pixels.

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

The gridded resolution is approximately 4 km.

1.4.3 Projection and Grid Description

1.4.3.1 Projection

MOD29E1D/MYD29E1D 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
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

MOD29E1D/MYD29E1D data are gridded in the original EASE-Grid. Data files contain separate 4501 x 4501 arrays for the Northern and Southern Hemisphere, centered on the North Pole and South Pole.

See the MODIS Land team's MODIS Grids Web page for information about all the projections and grids used for MODIS data sets. For a complete description of EASE-Grid, see NSIDC's EASE-Grid Data | Overview page.

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 can not 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

The content of MODIS sea ice data files differs between day and night because visible data are not acquired when Earth's surface is dark. Thermal data are acquired during both day and nighttime. Users should be aware of the following:

- Swath data acquired during daylight, or during a mix of day and night mode, contain variables for both sea ice extent and ice surface temperature;
- Swath data acquired completely in night mode contain only the ice surface temperature variable;
- Daily sea ice data sets are split into separate files for day and night.

The DayNightFlag object, a metadata value stored with the CoreMetadata.0 global attribute, indicates whether the entire swath was acquired during daylight (day), darkness (night), or a mix of day and night (both).

1.6.1 Parameter Description

IST values are given in kelvins and the values for all classes are scaled by 100.

1.6.2 Parameter Range

Refer to the MOD29E1D and MYD29E1D Local Sea Ice Attributes, Version 5 document for a key to the meaning of the scaled values in the Sea Ice by Reflectance North Pole NP, the Sea Ice by Reflectance South Pole SP, the Ice Surface Temperature NP, and the Ice Surface Temperature SP.

2 SOFTWARE AND TOOLS

2.1.1 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

2.1.2 Data Anlysis Tools

The following software tools can help you analyze the data:

- Land Processess 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 more information regarding the theory for sea ice mapping and ice surface temperature retrieval, please see “Section 3.1 | Theory of Measurements” in the MODIS/Aqua Sea Ice Extent 5-Min L2 Swath 1km, Version 5 (MYD29) documentation.

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 Web Site 2006), (NASA's Aqua Web Site 2006), and (NASA's EOS Web Site 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 Derivation Techniques and Algorithms

MOD29E1D/MYD29E1D data are generated by mapping MOD29P1D/MYD29P1D data at approximately 1 km resolution into a polar input grid at 1 km resolution. The input grid is then mapped to an approximately 4 km resolution output grid modeled on the original EASE-Grid. The gridded input observation nearest the center of an output grid cell is assigned as the output value for that grid cell. Approximately every fourth input grid cell is mapped into a sequential output grid cell.

3.3.2 Error Sources

As with any upper level product, anomalies in the input data may carry through to the output product. The following product is input to the MODIS daily sea ice algorithm:

- MODIS/Aqua Sea Ice Extent Daily L3 Global 1km EASE-Grid Day (MOD29P1D)

In addition, sea ice and IST features may sometimes lack continuity, especially in the polar summer season. This can occur because pixels are obtained from different swaths separated in time, during which sea ice and clouds may have moved.

3.4 Quality Assessment

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

QA data has been omitted from this data set because it aims to provide a general view of hemispheric sea ice by compositing subsampled MOD29P1D/MYD29P1D data. The Science Team anticipates reporting QA in a future version based on further evaluation and validation of the data.

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
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 SETS

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

6.1 Publication Date

February 2004

6.2 Date Last Updated

September 2023