MODIS/Terra Sea Ice Extent Daily L3 Global 1km EASE-Grid Day, Version 6

USER GUIDE

How to Cite These Data

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

Hall, D. K. and G. A. Riggs. 2015. *MODIS/Terra Sea Ice Extent Daily L3 Global 1km EASE-Grid Day, Version 6*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/MODIS/MOD29P1D.006. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/MOD29P1D

National Snow and Ice Data Center

TABLE OF CONTENTS

1 DETAILED DATA DESCRIPTION

1.1 Format

Data files are provided in HDF-EOS2 (V2.17). JPEG browse images are also available.

HDF-EOS (Hierarchical Data Format - Earth Observing System) is a self-describing file format based on HDF that was developed specifically for distributing and archiving data collected by NASA EOS satellites. For more information, visit the HDF-EOS Tools and Information Center.

As of August 2023, this data set is retired and no longer available for download. We recommend using MODIS/Terra Sea Ice Extent Daily L3 Global 1km EASE-Grid Day, Version 61 as an alternative.

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:

```
MOD29P1D.A2000055.h06v33.006.2015040205201.hdf
MOD[PID].A[YYYY][DDD].[hNN][vNN].[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	MODIS/Terra
PID	Product ID
A	Acquisition date follows
YYYY	Acquisition year
DDD	Acquisition day of year
hNN, vNN	Horizontal tile number, vertical tile number. For further information, see Section 1.4.3.2 Grid.
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

1.2.1 External Metadata File

Each HDF-EOS data file (.hdf) has a corresponding Extensible Markup Language external metadata file (.xml) which contains some of the same internal metadata as the HDF-EOS file plus additional information regarding user support, archiving, and granule-specific post-production Quality Assessment (QA). Note that post-production QA metadata will only be present if the granule was evaluated for QA.

1.3 File Size

Data files are typically between 0.5 - 1.5 MB using HDF compression. XML metadata files are between 5 - 10 KB.

1.4 Spatial Coverage

Coverage is global, however only ocean pixels are evaluated for sea ice.

1.4.1 Latitude Crossing Times

Terra's sun-synchronous, near-polar circular orbit is timed to cross the equator from south to north (ascending node) at approximately 10:30 A.M. local time.

1.4.2 Spatial Resolution

The gridded resolution is approximately 1 km.

1.4.3 Projection and Grid Description

1.4.3.1 Projection

MOD29P1D/MYD29P1D 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

Parameter	Value
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

MOD29P1D/MYD29P1D 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 17 February 2023. Complete global coverage occurs every one to two days (more frequently near the poles). To view daily orbit tracks for the Terra satellite, visit the Space Science and Engineering Center | Terra Orbit Tracks web page.

Over the course of the Terra mission a number of anomalies have resulted in minor data outages. If you cannot locate data for a particular date or time, check the MODIS/Terra Data Outages web page.

1.5.1 Temporal Resolution

Daily

1.6 Parameter or Variable

WARNING: 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).

Sea ice extent and ice surface temperature (IST) are the parameters of interest in this data set. Values represent the best observation from all the swath level observations (MOD29/MYD29) mapped into a grid cell for the day. These data are written to data files as Scientific Data Sets (SDSs) according to the HDF Scientific Data Set Data Model.

Data files also contain important metadata, including HDF-EOS global attributes that are assigned to the file and pre-defined and user-defined local attributes assigned to the data fields. For detailed information about HDF-EOS-specific metadata, see the document An HDF-EOS and Data Formatting Primer for the ECS Project.

The following table lists the SDSs in MOD29P1D/MYD29P1D data files:

Table 3. MOD29P1D/MYD29P1D Scientific Data Sets

Scientific Data Sets	Description
`Sea_Ice_by_Reflectance`	Sea ice extent map stored as coded integers[1]. Pixels are reported as sea ice, ocean, cloud, land, inland water, or other conditions (e.g. missing data). Daylight only.
`Sea_Ice_by_Reflectance_Spatial_QA`	QA data corresponding to the observation selected as the sea ice observation of the day.

Scientific Data Sets	Description
	Stored as coded integers[1]. Values are good, other, or a masked class (e.g. land). Daylight only.
`Ice_Surface_Temperature`	ISTs stored as calibrated data. To convert to kelvins, use `scale_factor` = 0.01 and `add_offset` = 0.0 in the following equation[2]: IST = `scale_factor` × (calibrated data - `add_offset`) The valid range for ISTs is 210 K to 313.20 K.
`Ice_Surface_Temperature_Spatial_QA`	QA data corresponding to the observation selected as the IST observation of the day. Stored as coded integers[1]. Values are good, other, or a masked class (e.g. land).

[1]Coded integer keys are stored as Local Attributes with the corresponding SDS.
[2]Values for scale_factor and add_offset are stored as Local Attributes with the IST SDS.

1.7 Sample Data

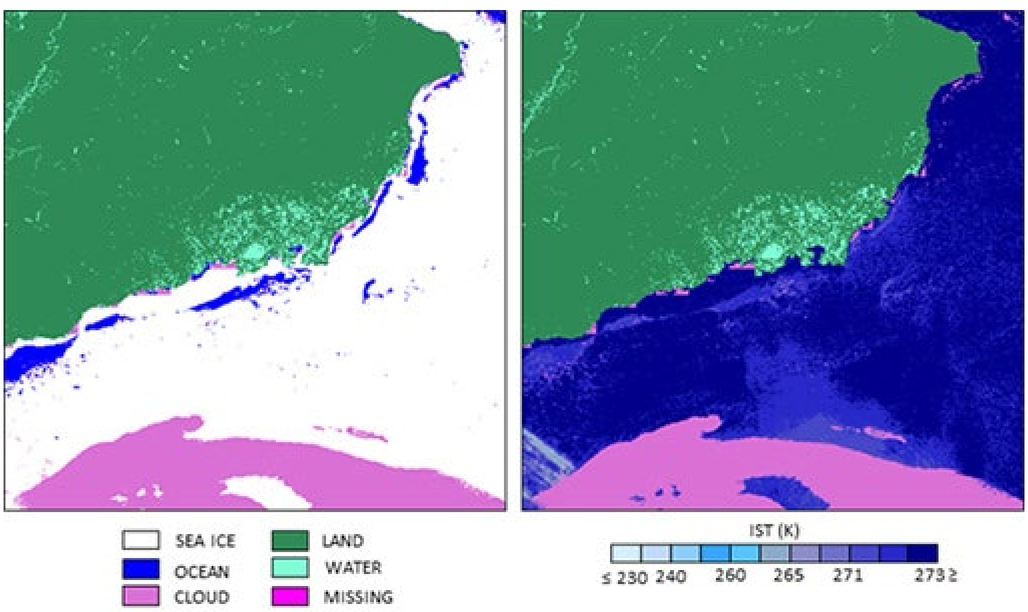

Figure 1. Typical MODIS 1 km sea ice extent (left) and IST (right) data (tile h08, v07). The north coast of Lisburne Peninsula, AK and the Chukchi Sea appear in the upper right corner. The same region is shown in Figure 2 of the MODIS/Terra Sea Ice Extent 5-Min L2 Swath 1km (MOD29), Version 6 user guide.

2 SOFTWARE AND TOOLS

The following sites can help you identify the right MODIS data for your study:

- NASA's Earth Observing System Data and Information System | Near Real-Time Data
- NASA Goddard Space Flight Center: MODIS Land Global Browse Images

The following resources are available to help users work with MODIS data:

- The HDF-EOS to GeoTIFF Conversion Tool (HEG) can reformat, re-project, and perform stitching/mosaicing and subsetting operations on HDF-EOS objects.
- HDFView is a simple, visual interface for opening, inspecting, and editing HDF files. Users can view file hierarchy in a tree structure, modify the contents of a data set, add, delete and modify attributes, and create new files.
- What is HDF-EOS? an NSIDC FAQ
- The MODIS Conversion Toolkit (MCTK) plug-in for ENVI can ingest, process, and georeference every known MODIS data set, including products distributed with EASE-Grid projections. The toolkit includes support for swath projection and grid reprojection and comes with an API for large batch processing jobs.

3 DATA ACQUISITION AND PROCESSING

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. Version 6 (also known as Collection 6) is the most recent version of MODIS sea ice data available from NSIDC. NSIDC strongly encourages users to work with the most recent version.

Consult the following resources for more information about MODIS Version 6 data, including known problems, production schedules, and future plans:

- MODIS Sea Ice Products User Guide to Collection 6
- 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)

WARNING: The MODIS Version 6 (Collection 6) sea ice extent and ice surface temperature algorithms and products are the same as Version 5. However, Version 6 updates to algorithm inputs - in particular, the L1B calibrated radiances, land and water mask, and cloud mask products - have improved the sea ice outputs. Additional details are provided on the MODIS | Data Versions page and in Section 3.4 Quality Assessment of this user guide.

3.1 Theory of Measurements

For more 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, Version 6 (MOD29) documentation.

3.2 Data Acquisition

The MODIS sensor contains a system whereby visible light from 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 generated. 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 downlinked to ground receiving stations. 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.

3.3 Data Processing

The MODIS Science Team develops the algorithms used to detect snow cover and sea ice. The MODIS Data Processing System (MODAPS) generates the MODIS data sets and transfers them to NSIDC. The following sections outline the approach that the algorithm uses to generate the sea ice extent and ice surface temperature maps. Users seeking a fuller description should consult the MODIS Sea Ice Products User Guide to Collection 6.

3.3.1 Derivation Techniques and Algorithms

The MOD29P1D/MYD29P1D data sets comprise single observations drawn from the many MOD29/MYD29 swath level observations acquired during the day at each location. A scoring algorithm selects the most favorable daily observation based on solar elevation, observation coverage in a grid cell, and distance from nadir. The underlying objective aims to select daytime reflectance observations that are near nadir, acquired near noon local time, and cover a large area in a grid cell. Because MODIS collects both visible and thermal data in day mode, the scoring algorithm uses visible data to determine the observation of the day for both reflectance and thermal data. The score for each observation is given by:

$$\text{score} = (0.5 \times \text{solar elevation}) + (0.3 \times \text{observation coverage}) + (0.2 \times \text{distance from nadir})$$

The observation with the highest score for a grid cell is selected as the observation for the day. The corresponding thermal observation is utilized as the IST observation of the day. In situations where the day and night terminator lies within a tile, the IST is mapped on both sides of the terminator; as such, daytime granules may contain regions where IST is mapped without corresponding sea ice by reflectance data.

The sea ice and IST QA values are drawn from the corresponding MOD29/MYD29 sea ice and IST observations selected as the observation of the day. No quality assessment is performed in this product's algorithm. All QA is inherited from MOD29/MYD29.

The input data to MOD29P1D/MYD29P1D are read from intermediate, level-2 gridded products that are produced by mapping all MOD29/MYD29 swaths from a calendar day to grid cells of the Lambert Azimuthal Equal-Area (polar grid) projection. These necessary intermediates (see Table 4) are used as inputs to the daily gridded sea ice products and are neither retained nor archived at NSIDC.

For details about the sea ice and ice surface temperature data used as input to this data set, see the Derivation Techniques and Algorithms section in the MODIS/Terra Sea Ice Extent 5-Min L2 Swath 1km, Version 6 (MOD29) documentation.

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 products are input to the MODIS daily sea ice algorithm:

Table 4. Inputs to the MODIS Terra Daily Sea Ice Algorithm

Short Name	Long Name	Data Used
MOD29PGD[1]	MODIS/Terra Sea Ice Extent Daily L2G Global 1km EASE-Grid Day	Sea ice IST and QA
MODMGPGD[1]	MODIS/Terra Geolocation Angles Daily L2G Global 1km EASE-Grid Day	Solar and sensor geometry
MODPTPGD[1]	MODIS/Terra Observation Pointers Daily L2G Global 1km Polar Grid Day	Number of observations, coverage observation swath and location

[1]Intermediate product neither retained nor distributed by NSIDC.

Some error in geolocation may be associated with projecting from latitude and longitude coordinates to this data set's EASE-Grid Lambert Azimuthal 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.

Artifacts due to using a coarse-resolution cloud mask to set the ice background flag may appear as clouds having straight edges, and possibly ninety degree corners.

IST is mapped in the region of darkness 85° to 90° solar zenith angle whereas sea ice extent is not. As such, in the terminator region the sea ice extent and IST maps will have different spatial coverages. Furthermore, over the polar regions the number of MODIS acquisitions in daylight varies with the seasons. During the boreal summer, small regions in the Arctic can be imaged many times—in perhaps as many as fourteen swaths—during a 24 hour period. Users should carefully consider which level of sea ice data will best meet their research or application. The objective of the daily sea ice algorithm is to report the putative best observation of a day based primarily on time of overpass and viewing angle, with best defined as nearest local solar noon and closest to nadir. This also maps swath inputs as contiguous spatially and temporally in a tile, with mixed observations occurring along the edges of overlapping swaths. As such, the daily sea ice product may not best suit some users because it only includes one observation out of all the accessible observations in the swath. Sea ice moves, clouds move, the satellite passes overhead rough every 99 minutes: all factors that users should consider when deciding which data to use and how to interpret the daily gridded sea ice data sets.

3.3.3 Version History

See the MODIS Data Versions page for the history of MODIS snow and sea ice product versions.

3.4 Quality Assessment

All QA is inherited from the MOD29 sea ice data set. The Sea_Ice_by_Reflectance_Spatial_QA and Ice_Surface_Temperature_Spatial_QA data fields contain the corresponding QA data for the sea ice and ice surface temperature observations selected by the algorithm as the observation of the day. No automated quality assessment is performed within this algorithm. QA data are stored as coded integers and indicate whether algorithm results were nominal, abnormal, or if other defined conditions were encountered.

For more information about the quality indicators utilized by MOD29, see the Quality Assessment section of the MODIS/Terra Sea Ice Extent 5-Min L2 Swath 1km (MOD29), Version 6 user guide.

In addition, the NASA Goddard Space Flight Center: MODIS Land Quality Assessment website provides updated quality information for all MODIS land products.

3.5 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 5 contains the instruments' technical specifications:

Table 5. MODIS Technical Specifications

Variable	**Description**
Orbit	705 km altitude, 10:30 A.M. ascending node (Terra), sun-synchronous, near-polar, circular
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.

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4.1 Published Research

See MODIS | Published Research for a list of studies that used MODIS data from NSIDC.

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 Web Sites

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

4.4 Contacts and Acknowledgments

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5 DOCUMENT INFORMATION

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