MODIS/Terra Sea Ice Extent and IST Daily L3 Global 4km 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 and IST Daily L3 Global 4km 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/MOD29E1D.006. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/MOD29E1D

National Snow and Ice Data Center

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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 and IST Daily L3 Global 4km 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:

```
MOD29E1D.A2002185.006.2015040211331.hdf
```

```
MOD[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	MODIS/Terra
PID	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

1.2.1 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 - 6.0 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 north to south (descending node) at approximately 10:30 A.M. local time.

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

Parameter	Value
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 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. The MOD29E1D/MYD29E1D data set is generated by remapping 1 km resolution daily sea ice extent data from MOD29P1D/MY29P1D to a 4 km resolution grid. The gridded input observation nearest the center of the output grid cell is assigned to that grid cell. As such, approximately every fourth input grid cell is mapped to the output grid. No QA data is provided. The purpose of this data set is to composite subsampled MOD29P1D/MYD29P1D data and provide users with a general view of hemispheric sea ice. The data are written to data files as Scientific Data Sets (SDSs) according to the HDF Scientific Data Set Data Model.

MOD29E1D/MYD29E1D 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 An HDF-EOS and Data Formatting Primer for the ECS Project.

The following table lists the SDSs in MOD29E1D/MYD29E1D data files:

Table 3. MOD29E1D/MYD29E1D Scientific Data Sets

Scientific Data Sets	Description
Northern Hemisphere	
Sea_Ice_by_Reflectance_NP	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.
Ice_Surface_Temperature_NP	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.
Southern Hemisphere	
Sea_Ice_by_Reflectance_SP	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.

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

1.7 Sample Data

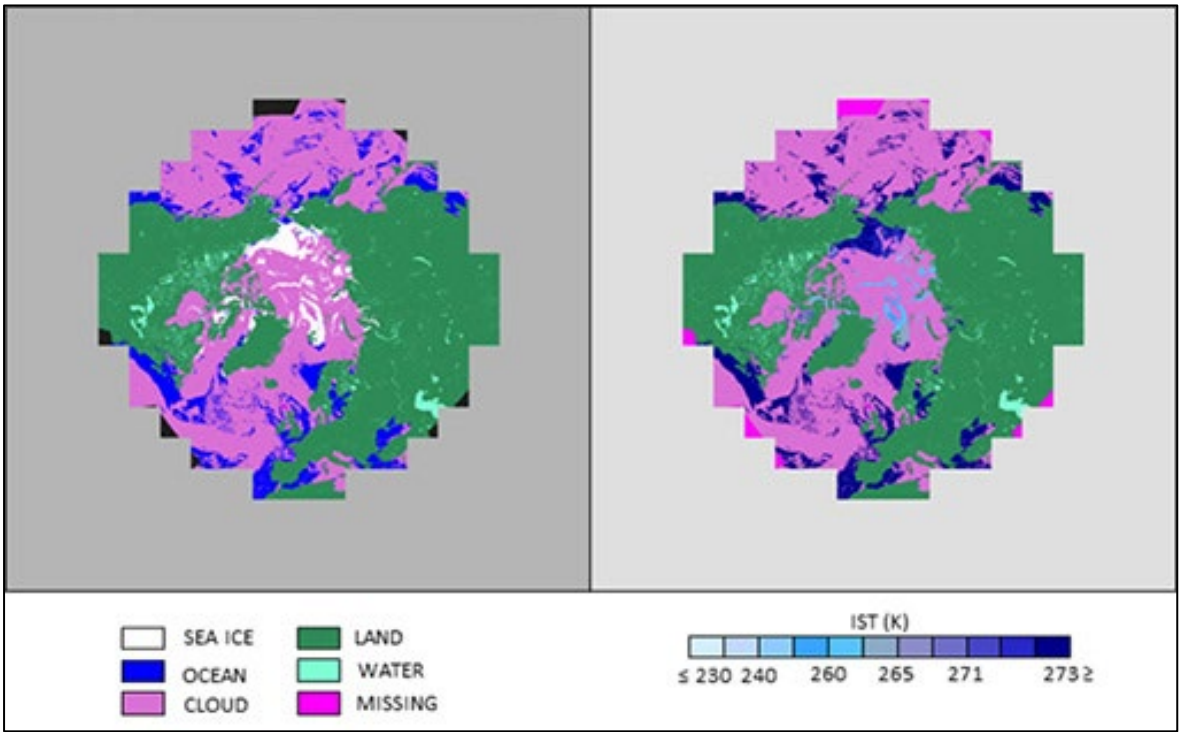

Figure 1. Typical MODIS 4 km daily Northern Hemisphere sea ice extent (left) and IST (right) data.

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 the Quality Assessment section 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 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

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/Terra 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.

3.3.3 Version History

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

3.4 Quality Assessment

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 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 Terra space vehicles were built to NASA specifications by Santa Barbara Remote Sensing, a division of Raytheon Electronics Systems. Table 4 contains the instruments' technical specifications:

Table 4. MODIS Technical Specifications

Variable	Description
Orbit	705 km altitude, 10:30 A.M. descending 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)

Variable	Description
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

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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 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

5 CONTACTS AND ACKNOWLEDGMENTS

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6 DOCUMENT INFORMATION

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