MODIS/Terra Sea Ice Extent Daily L3 Global 1km EASE-Grid Day, Version 61

USER GUIDE

How to Cite These Data

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

Hall, D. K. and G. Riggs. 2021. *MODIS/Terra Sea Ice Extent Daily L3 Global 1km EASE-Grid Day, Version 61*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/MODIS/MOD29P1D.061. [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

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1 DATA DESCRIPTION

This data set consists of sea ice extent and ice surface temperature (IST) mapped into 10° by 10° tiles at a resolution of 1 km for Northern and Southern Hemispheres grids. Sea ice is detected using the Normalized Difference Snow Index (NDSI) and ice surface temperature (IST) is estimated using the split-window technique. Snow-covered sea ice typically has a very high reflectance in visible bands and very low reflectance in the shortwave infrared; the NDSI reveals the magnitude of this difference. The MODIS sea-ice algorithm calculates NDSI for all ocean pixels in daylight using Terra MODIS visible bands 4 and 6 and Ice Surface Temperature (IST) during both day and night using Terra MODIS thermal bands 31 and 32. The Scientific Data Sets (SDSs) included in this product are listed in Table 1 and a sample image of the data is provided in Figure 1.

The terms "Version 61" and "Collection 6.1" are used interchangeably in reference to this release of MODIS data.

1.1 Parameters

Table 1. SDS Details

Parameter	Description	Values
`Ice_Surface_Temperature`	IST is stored as calibrated data (scaled integers). Use the equation below to convert to K: $IST = scale\_factor * (calibrated\_data - add\_offset)$ where $scale\_factor = 0.01$ and $add\_offset = 0.0$.[1] The valid range for ISTs is 210 K to 313.20 K.	0.0: missing 1.0: no decision 11.0: night 25.0: land 37.0: inland water 39.0: open ocean 50.0: cloud 243-273: expected range of IST calibrated data values 655.35: fill
`Ice_Surface_Temperature_Spatial_QA`	General quality estimate of the IST algorithm output	0: good quality 1: other quality 253: land mask 254: ocean mask 255: fill

Parameter	Description	Values
`Sea_Ice_by_Reflectance`	Sea ice extent	0: missing 1: no decision 11: night 25: land 37: inland water 39: ocean 50: cloud 200: sea ice 253: land mask 255: fill
`Sea_Ice_by_Reflectance _Spatial_QA`	General quality estimate of the Sea Ice algorithm output	0: good quality 1: other quality 253: land mask 254: ocean mask 255: fill

[1] Values for $scale\_factor$ and add_offset are also stored as Local Attributes with the IST SDSs

1.2 Sample Image

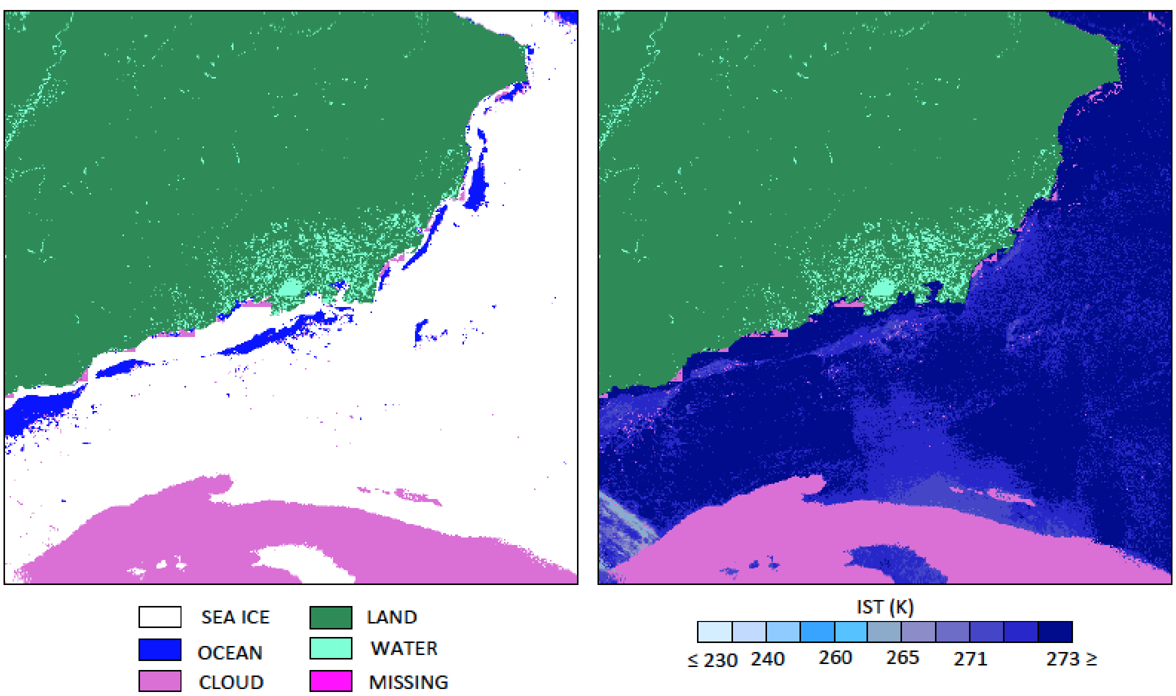

Figure 1. This figure shows MOD29P1D 1 km sea ice extent (left) and IST (right), from tile h08v07, acquired on 23 Feb. 2015. The left image shows the north coast of Lisburne Peninsula, AK and the Chukchi Sea is shown in the right image. This same region is displayed in Figure 1 of the MOD29 data set documentation.

1.3 File Information

1.3.1 File Format

Data are provided in HDF-EOS2 format and are stored as 8-bit unsigned integers. For software and more information, visit the HDF-EOS website.

1.3.2 File Contents

As shown in Figure 2, each data file includes two data fields (Ice_Surface_Temperature and Sea_Ice_by_Reflectance), two data quality fields (Ice_Surface_Temperature_Spatial_QA and Sea_Ice_by_Reflectance_Spatial_QA), and three metadata fields (ArchiveMetadata.0, CoreMetadata.0, and StructMetadata.0).

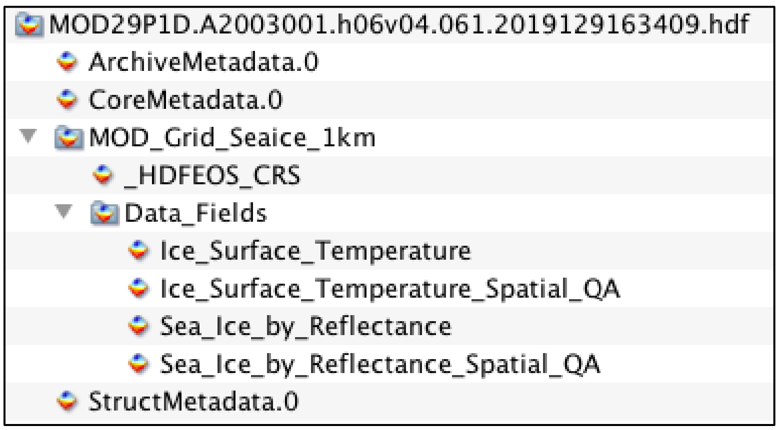

Figure 2. This figure shows the MOD29P1D fields included in each data file as displayed with Panoply software.

1.3.3 Ancillary Files

A browse image file (`.jpg`) and metadata file (`.xml`) are provided with each data file.

1.3.4 Naming Convention

Files are named according to the following convention and as described in Table 2.

File naming convention:

`MOD[PID].A[YYYY][DDD].[hNN][vNN].[VVV].[yyyy][ddd][hhmmss].hdf`

Table 2. File Name Variables

`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
`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

File name example:

`MOD29P1D.A2003001.h06v04.061.2019129163409.hdf`

Note: Data files contain important metadata, including global attributes that are assigned to the file and local attributes like coded integer keys that provide details about the data fields. In addition, each HDF-EOS data file has a corresponding XML 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. Refer to the MODIS Sea Ice Products User Guide to Collection 6.1 for additional information.

1.4 Spatial Information

1.4.1 Coverage

Coverage is global. 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. Complete global coverage occurs every one to two days (more frequently near the poles). The following sites offer tools that track and predict Terra's orbital path:

- Daily Terra Orbit Tracks, Space Science and Engineering Center, University of Wisconsin-Madison
- NASA LaRC Satellite Overpass Predictor (includes viewing zenith, solar zenith, and ground track distance to specified lat/lon)

1.4.2 Projection

Lambert Azimuthal Equal Area EASE-GRID

1.4.3 Grid

Data files are provided as tiles of data gridded in the original EASE-Grid Lambert Azimuthal Equal Area map projection. Tiles contain 951 rows by 951 columns. The global tile grid is partitioned into separate Northern Hemisphere and Southern Hemisphere polar grids. Half of the tiles (313) are in the Northern Hemisphere and half are in the Southern Hemisphere. The coordinate system is composed of horizontal and vertical ordered pairs. The northern grid extends from tile h00,v00 in the upper left corner to tile h18,v18 in the lower right corner. The southern grid extends from tile h00,v20 in the upper left corner to tile v18,h38 in the lower right corner.

See the EASE-Grid Tile Locations and Bounding Coordinates for MODIS Sea Ice Products technical reference for additional grid information. The MODIS MODLAND Tile Calculator can be used to convert geographic coordinates to tile/image coordinates (and vice-versa).

1.4.4 Resolution

The gridded resolution is approximately 1 km.

1.4.5 Geolocation

Table 3 and Table 4 provide geolocation information for this data set.

Table 3. Projection Details

Region	Northern Hemisphere	Southern Hemisphere
Geographic coordinate system	N/A	N/A
Projected coordinate system	NSIDC EASE-Grid North	NSIDC EASE-Grid South
Longitude of true origin	0°	0°
Latitude of true origin	90°	-90°
Scale factor at longitude of true origin	N/A	N/A
Datum	N/A	N/A
Ellipsoid/spheroid	International 1924 Authalic Sphere	International 1924 Authalic Sphere
Units	Meter	Meter
False easting	0°	0°
False northing	0°	0°
EPSG code	3408	3409

PROJ4 string	+proj=laea +lat_0=90 +lon_0=0 +x_0=0 +y_0=0 +a=6371228 +b=6371228 +units=m +no_defs	+proj=laea +lat_0=-90 +lon_0=0 +x_0=0 +y_0=0 +a=6371228 +b=6371228 +units=m +no_defs
Reference	http://epsg.io/3408	http://epsg.io/3409

Table 4. Grid Details

Region	**Northern Hemisphere**	**Southern Hemisphere**
Grid cell size (x, y pixel dimensions)	1 km	1 km
Number of rows	951	951
Number of columns	951	951
Nominal gridded resolution	1 km	1 km
Grid rotation	N/A	N/A
Geolocated upper left point (m)	-9058902.1845(x), 9058902.1845(y)	-9058902.1845(x), 9058902.1845(y)
Geolocated lower right point (m)	9058902.1845(x), -9058902.1845(y)	9058902.1845(x), -9058902.1845(y)

1.5 Temporal Information

1.5.1 Coverage

The temporal coverage of this data set extends from 24 February 2000 to the present. During 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.

1.5.2 Resolution

Daily

2 DATA ACQUISITION AND PROCESSING

2.1 Acquisition

MODIS scans the entire globe every one to two days. As such, most locations on Earth are imaged at least once per day and more frequently where swaths overlap (e.g. near the poles). Terra's sun-synchronous, near-circular polar orbit is timed to cross the equator from north to south (descending node) at approximately 10:30 A.M. local time.

Ongoing changes in the Terra orbit

The Terra flight operations team conducted Terra's last inclination adjust maneuver to maintain Terra's orbit in February 2020. The inclination adjust maneuvers were used to control the platform's 10:30 AM mean local time (MLT) equator crossing. Terra will continue to drift and is expected to reach a 10:15 AM MLT in October 2022. At that time, the flight operations team will have Terra exit the Earth Sciences Constellation and lower Terra to an altitude of 694 km by performing two retrograde maneuvers. MLT will continue to drift after these maneuvers, reaching 9:00 AM around December 2025. Terra MODIS will remain operational and generate the full suite of products until the end of the mission in December 2025.

Earlier crossing times for a morning platform like Terra mean lower solar elevations leading to more prevalent shadows. This decrease in orbit altitude alters the spatial coverage of the sensor including possible gaps in spatial sampling, decreased spatial coverage, and higher spatial resolution. Products are mostly expected to be science quality except for reduced grid size (from lower altitude) and without a strict 16-day repeat of observations (from drift and changing orbit).

Details on the impact of the Constellation Exit on the quality of the product are being compiled and will be posted when available.

2.2 Sources

This level-3 data set is generated from the *MODIS/Terra Sea Ice Extent Daily L2G Global 1km EASE-Grid Day* (MOD29PGD) product (which is an intermediate product, neither retained nor distributed by NSIDC). MOD29PGD is generated by mapping all MOD29 swaths acquired in day mode, for a calendar day, to grid cells of the Lambert Azimuthal Equal-Area (polar grid) projection, EASE-Grid. Grids are generated for both the Northern and Southern Hemispheres, with each grid containing 313 tiles, consisting of approximately 10 x 10 degrees of coverage. Table 5 lists the MODIS C6.1 products that are used as inputs to the MODIS daily sea ice algorithm.

Table 5. Inputs to the MODIS snow algorithm

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

2.3 Processing

The MOD29PGD product contains multiple MOD29 swath observations mapped into each grid cell. The daily sea ice algorithm uses a scoring algorithm to select the 'best' observation of the day from each MOD29PGD grid cell based on solar elevation, observation coverage in the grid cell, and the observation distance from nadir. The algorithm objective is to select daytime reflectance observations, that are near nadir, acquired near noon local time, and cover a large area in the 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:

$$score = (0.5 * solar\ elevation) + (0.3 * observation\ coverage) + (0.2 * distance\ from\ nadir)$$

The observation with the highest score for a grid cell is selected as the observation for the day. The corresponding thermal observation is selected as the IST observation of the day. In situations where the day and night terminator fall 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.

For a detailed description of the MODIS sea ice detection algorithm, see the Algorithm Theoretical Basis Document (Hall et al., 2001).

Note: 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).

2.4 Quality Information

The 'Ice_Surface_Temperature_Spatial_QA' and 'Sea_Ice_by_Reflectance_Spatial_QA' values are drawn from the corresponding MOD29 QA parameters. No quality assessment is performed in this product's algorithm; all QA is inherited from MOD29. For additional information about the quality indicators utilized by MOD29, see the MODIS Sea Ice Products User Guide to Collection 6 (Riggs et., 2015).

2.4.1 Errors

As with any upper level product, anomalies present in the input data may carry through to the output product. Specific sources of error are described in the sections below.

2.4.1.1 Geolocation

Some error in geolocation may be associated with projecting from geographic coordinates (latitude and longitude) 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.

2.4.1.2 Cloud Mask

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.

2.4.1.3 IST

IST is mapped in the region of darkness solar zenith angle (85° to 90°) whereas sea ice extent is not. As such, in this 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 some regions in the Arctic can be observed by as many as fourteen swaths during a 24 hour period.

2.4.1.4 Swath Seams

The objective of the daily sea ice algorithm is to select the best observation of a day based on the overpass time and the viewing angle. This technique maps swath inputs as contiguous spatially and temporally in a tile, with a mixing of swath observations occurring along the edges of overlapping swaths. This mixing of swath observations may result in swath seams, which manifest as a weave pattern in the data where there is a difference in cloud cover or surface features between adjacent swaths.

2.4.1.5 Suitability

Users should carefully consider which level of sea ice data will best meet their research or application. This daily sea ice product may not be suitable for all users because it only includes one observation out of the many observations available in MOD29.

2.5 Instrumentation

2.5.1 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 five refractive objective assemblies, one each for the visible, near-infrared, shortwave infrared, middle-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 6 contains the instruments' technical specifications:

Table 6. 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)
Design Life	6 years

2.5.2 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.

3 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.

4 RELATED WEBSITES

The following resources provide additional information about MODIS Version 6.1 data, including known problems, production schedules, and future plans:

- The MODIS Snow and Sea Ice Global Mapping Project
- NASA LDOPE | MODIS/VIIRS Land Product Quality Assessment
- MODIS Land Team Validation | Status for Snow Cover/Sea Ice (MOD10/29)

5 CONTACTS AND ACKNOWLEDGMENTS

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6 REFERENCES

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7 DOCUMENT INFORMATION

7.1 Publication Date

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7.2 Date Last Updated

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