MODIS/Terra Snow Cover 8-Day L3 Global 500m SIN Grid, 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 Snow Cover 8-Day L3 Global 500m SIN Grid, Version 5*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/C574UGKQQU1T. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/MOD10A2

National Snow and Ice Data Center

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1 DETAILED DATA DESCRIPTION

This data set contains data fields for maximum snow cover extent over an eight-day compositing period and a chronology of snow occurrence observations in compressed Hierarchical Data Format-Earth Observing System (HDF-EOS) format, along with corresponding metadata. MOD10A2 consists of 1200 km by 1200 km tiles of 500 m resolution data gridded in a sinusoidal map projection. The Moderate Resolution Imaging Spectroradiometer (MODIS) snow cover data are based on a snow mapping algorithm that employs a Normalized Difference Snow Index (NDSI) and other criteria tests. New in V005 is fractional snow cover, where the percent snow cover is estimated on a pixel by pixel basis. The snow albedo data array added in Version 4 (V004) continues with a provisional status.

Please visit the following sites for more information about the V005 data, known data problems, the production schedules, and future plans:

- MODIS Snow Products User Guide to Collection 5
- NASA Goddard Space Flight Center: MODIS Adaptive Processing System (MODAPS) Services
- The MODIS Snow and Sea Ice Global Mapping Project: Project Description
- 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.

Algorithms that generate snow cover products are continually being improved as limitations become apparent in early versions of data. As a new algorithm becomes available, a new version of data is released. Users are encouraged to work with the most current version of MODIS data available, which is the highest version number.

1.1 Format

MODIS snow products are archived in compressed HDF-EOS format, which employs point, swath, and grid structures to geolocate the data fields to geographic coordinates. This data compression should be transparent to most users since HDF capable software tools automatically uncompress the data. Various software packages, including several in the public domain, support the HDF-EOS data format. See section 2.0 Software and Tools for details. Also, see the Hierarchical Data Format - Earth Observing System (HDF-EOS) Web site for more information about the HDF-EOS data format, as well as tutorials in uncompressing the data and converting data to binary format.

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

MOD10A2 consists of 2400 x 2400 cells of tiled data in a sinusoidal projection. Each data granule contains the following 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 SDS.

A Summary of MOD10A2/MYD10A2 Bit Values provides an interpretation of bit values and resulting integer values for the Eight Day Snow Cover Field.

1.1.1 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 was investigated for quality assessment. The metadata file should be examined to determine if post-production QA was applied to the granule.

1.2 File Naming Convention

The following file naming convention is common to all Level 3 MODIS Land products:
`MOD10A2.A2003138.h03v06.005.2006.143062148.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	MODIS/Terra
10A2	Type of product
A	Acquisition date
2003	Year of data acquisition
138	Day of year of data acquisition (In this case, day 138. The date in the granule is the first day of data in the eight-day file.)
h03v06	Horizontal tile number and vertical tile number. See the MODIS Sinusoidal Grid (SIN) as a reference.

Variable	Explanation
005	Version number
2006	Year of production (2006)
143	Day of year of production (Day 143)
062148	Hour/minute/second of production in Greenwich Mean Time (GMT) (06:21:48)
hdf	HDF-EOS data format

1.3 File Size

Data files are typically between 0.5 - 3 MB using HDF compression.

New in V005, MOD10A2 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 7 or more.

1.4 Spatial Coverage

Coverage is global, but only tiles over land are produced for MOD10A2. The following resources can help you select and work with MOD10A2 tiles:

- MODIS Tile Bounding Coordinates for the MODIS SIN
- MODIS MODLAND Tile Calculator
- HDF-EOS to GeoTIFF Conversion Tool (HEG)
- Hierarchical Data Format - Earth Observing System (HDF-EOS): Geolocating HDF-EOS Data

1.4.1 Latitude Crossing Times

The local equatorial crossing time of the Terra satellite is approximately 10:30 A.M. in a descending node with a sun-synchronous, near-polar, circular orbit.

1.4.2 Spatial Resolution

Gridded resolution is 500 m.

1.4.3 Projection

MOD10A2 V005 data are georeferenced to an equal-area sinusoidal projection. The following Web sites provide links to the software tools that either read data in a sinusoidal projection or convert sinusoidal to other projections:

- Earth Observing System Data and Information System (EOSDIS) Core System Project: Science Data Processing Toolkit Home Page
- LP DAAC: MODIS Reprojection Tool Distribution Page
- HEG HDF-EOS to GeoTIFF Conversion Tool

In the sinusoidal projection, areas on the data grids are proportional to the same areas on the Earth, and distances are correct along all parallels and the central meridian. Shapes are increasingly distorted away from the central meridian and near the poles. Finally, the data are neither conformal, perspective, nor equidistant.

Meridians are represented by sinusoidal curves except for the central meridian, and parallels are represented by straight lines. The central meridian and parallels are straight lines of true scale. Specific parameters are listed in Table 2:

Table 2. Sinusoidal Projection Parameters

Earth radius	6371007.181000 meters
Projection origin	0° latitude, 0° longitude
Orientation	0° longitude, oriented vertically at top
Upper left corner point (m)	-20015109.354(x), 10007554.677(y)
Lower right corner point (m)	20015109.354(x), -10007554.677(y)
True scale (m)	463.31271653(x), 463.31271653(y)

1.4.4 Grid Description

The MOD10A2 daily product is gridded in equal area tiles. Each tile consists of a 1200 km by 1200 km data array, which corresponds to 2400 by 2400 pixels at 500 m resolution. Although this product is referred to as having a 500 m grid, the true pixel resolution is 463.31271653 m in both X and Y directions. This allows for 2400 pixel by 2400 pixel tiles, each tile covering exactly 10 degrees of latitude vertically.

The MODIS MODLAND Tile Calculator converts between MODIS tile image/coordinates or map coordinates in meters and latitude/longitude coordinates.

1.5 Temporal Coverage

Data extend from 24 February 2000 to 26 December 2016.

1.5.1 Temporal Resolution

Temporal resolution is eight days, one half of the exact ground track repeat period of 16 days. Eight-day periods begin on the first day of the year and extend into the next year. In some cases, there may not be eight days of input. You should check the Number of Input Days, Days Input, and Eight Day Period global attributes to find out what days are covered. See the Product Specific Global Attributes section of the MOD10A2 and MOD10A2 Global Attributes document for these global attributes. The product is only produced if at least two days of input are available for the eight-day period. The data file name indicates the first day in the eight-day period. Table 3 lists the days covered by each compositing period:

Table 3. Eight-day Compositing Periods

Period	Days	Period	Days	Period	Days	Period	Days
1	1-8	13	97-104	25	193-200	37	289-296
2	9-16	14	105-112	26	201-208	38	297-304
3	17-24	15	113-120	27	209-216	39	305-312
4	25-32	16	121-128	28	217-224	40	313-320
5	33-40	17	129-136	29	225-232	41	321-328
6	41-48	18	137-144	30	233-240	42	329-336
7	49-56	19	145-152	31	241-248	43	337-344
8	57-64	20	153-160	32	249-256	44	345-352
9	65-72	21	161-168	33	257-264	45	353-360
10	73-80	22	169-176	34	265-272	46	361-368[1]
11	81-88	23	177-184	35	273-280	—	—
12	89-96	24	185-192	36	281-288	—	—

[1]Includes 2 or 3 days from the next year.

Over the course of the Terra mission, there have been a number of anomalies that have resulted in dropouts in the data. If you are looking for data for a particular date or time and can not find it, please visit the MODIS/Terra Data Outages Web page.

1.6 Parameter or Variable

1.6.1 Parameter Description

The snow mapping algorithm classifies pixels as snow, snow-covered lake ice, cloud, water, land, or other. Maximum Snow Extent and Eight Day Snow Cover are the primary variables of interest in this data set.

1.6.2 Parameter Range

Refer to the MOD10A2 and MYD10A2 Global and Local Snow Cover Attributes, Version 5 document for a key to the meaning of the coded integer values in the Maximum Snow Extent Field.

A Summary of MOD10A2/MYD10A2 Bit Values provides an interpretation of bit values and resulting integer values for the Eight Day Snow Cover 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 Data
- MODIS: MODLAND Tile Calculator

2.2 Data Analysis Tools

- 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 this topic, please see the Theory of Measurements section in the MODIS/Terra Snow Cover 5-Min L2 Swath 500m, Version 5 documentation (MOD10_L2).

3.2 Data Acquisition Methods

3.2.1 Source or Platform Mission Objectives

MODIS is a key instrument aboard the Terra satellite, a core component 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.

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.

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 downlinked 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 MODIS Adaptive Processing

System (MODAPS) 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. 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. MODAPS is responsible for product generation and transfer of products to NSIDC.

3.3.1 Processing Steps

The algorithm first checks that the dates from MOD10A1 input data match those from the intended MOD10A2 time range, and then orders the data chronologically. Multiple days of observations for a cell are examined. If snow cover is found for any day, then the cell in the Maximum Snow Extent field is labeled as snow. If no snow is found, but there is one value that occurs more than once, that value is placed in the cell. For example, if a pixel is classified as water for five days, cloud for one day, land for one day, and night for one day, it would be ultimately labeled as water. If mixed observations occur, for example, land and cloud for more than one day in a given pixel, the algorithm assumes a cloud-free period and labels a pixel with the observed value. This logic minimizes cloud-cover extent, such that a cell needs to be cloud-obscured for all days in order to be labeled cloud. If all observations for a cell are analyzed but a classification cannot be determined, then that cell is labeled as no decision. A chronology of snow occurrence is recorded in the Eight Day Snow Cover field. The eight bits within a byte correspond to eight days of data. If snow is found in a pixel for a given day, the corresponding bit in the Eight Day Snow Cover field is set to a value of one.

3.3.2 Error Sources

As with any upper level product, the characteristics of and/or anomalies in input data may carry through to the output data product. The following product is input to the algorithms used to create the MYD10A2 product:

- MYD10A1 - MODIS/Aqua Snow Cover Daily L3 Global 500m Grid, Version 5

3.4 Quality Assessment

Quality indicators for MODIS snow data can be found in the following 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 Scientific Data Set, for example, Maximum Snow Extent.

These quality indicators are generated during production or in post-production scientific and quality checks of the data product. For more information on local and global attributes, go to the following documents:

- MOD10A2 and MYD10A2 Global and Local Local Snow Cover Attributes, Version 5

The AutomaticQualityFlag is automatically set according to conditions for meeting data criteria in the snow mapping algorithm. In most cases, the flag is set to either Passed or Suspect, and in rare instances it may be set to Failed. Suspect means that a significant percentage of the data were anomalous and that further analysis should be done to determine the source of anomalies. The AutomaticQualityFlagExplanation contains a brief message explaining the reason for the setting of the AutomaticQualityFlag. The ScienceQualityFlag and the ScienceQualityFlagExplanation are set after production, either after an automated QA program is run or after the data product is inspected by a qualified snow scientist. Content and explanation of this flag are dynamic so it should always be examined if present.

The algorithm tests for a variety of anomalous conditions and sets the pixel value accordingly if such conditions are detected. Summary statistics about missing data, the percent cloud cover, the percent of good or other quality data, and snow cover percent are calculated and placed in the metadata for each product.

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

3.5 Sensor or Instrument Description

3.5.1 Principles of Operation

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 a 705 km altitude 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, 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 wave-infrared, and long wave-infrared spectral regions.

3.5.2 Technical Specifications

Table 4. Technical Specifications

Orbit	705 km, 1:30 p.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 x 1.6 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	Six years

3.5.3 Spectral Bands

For information on the 36 spectral bands provided by the MODIS instrument, see the MODIS Spectral Bands Table.

3.5.4 Sensor or Instrument Measurement Geometry

The MODIS scan mirror assembly uses a continuously rotating double-sided scan mirror to scan ±55 degree, with a 20.3 rpm. The viewing swath is 10 km along track at nadir, and 2330 km cross track at ±55 degree.

3.5.5 Manufacturer of Sensor or Instrument

MODIS instruments were built to NASA specifications by Santa Barbara Remote Sensing, a division of Raytheon Electronics Systems.

3.5.6 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 shortwave infrared bands. The Solar Diffuser Stability Monitor (SDSM) 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 (SRCA) 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.

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4.1 Related Data Collections

See MODIS Data | Data Sets for a complete list of MODIS snow and sea ice products available from NSIDC.

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