MODIS/Terra Snow Cover Monthly L3 Global 0.05Deg CMG, 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 Monthly L3 Global 0.05Deg CMG, Version 5*. [Indicate subset used]. Boulder, Colorado USA. NSIDC: National Snow and Ice Data Center. https://doi.org/10.5067/IPPLURB6RPCN. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/MOD10CM

National Snow and Ice Data Center

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1 DETAILED DATA DESCRIPTION

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. No major changes were made to this data set from the previous version.

Please visit the following sites for more information about the V005 data, known data problems, production schedule, 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.

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 the Software and Tools section below 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.

MOD10CM V005 data consists of 7200 columns by 3600 rows of global arrays of monthly mean fractional snow cover extent. Each data granule contains the following HDF-EOS fields:

- Snow Cover Monthly CMG Field
- Snow Spatial QA Field

Each data granule also contains metadata either stored as global attributes or as HDF-predefined fields, which are stored with their associated Scientific Data Set (SDS).

1.1.1 Description of Data Fields

- Snow Cover Monthly CMG - Average fractional snow cover for the month is derived from a month of MODIS/Terra Snow Cover Daily L3 Global 0.05Deg CMG (MOD10C1) products.
- Snow Spatial QA - this field stores the quality of the algorithm on a pixel-by-pixel basis. QA information tells if the algorithm results were good quality or other quality, or if other defined conditions were encountered for a pixel. If all the input data and calculations in the algorithm were nominal for a pixel, the QA field is set to good quality. See the MOD10CM and MYD10CM Local Snow Attributes document for more information about QA flags in sea ice products.

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 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 file naming convention common to all MODIS Level 3 global products is `MOD10CM.A2000061.005.2006272184905.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
10CM	Type of product
A	Acquisition date
2000	Year of data acquisition
061	Day of year of data acquisition (day 61)
005	Version number
2006	Year of production (2006)
272	Day of year of production (day 272)
184905	Hour/minute/second of production in GMT (18:49:05)
hdf	HDF-EOS data format

1.3 File Size

Data files are typically between 1.0 - 50.0 MB using HDF-internal compression.

Note: This data set uses internal HDF data compression. The extent to which compression reduces the file size varies from image to image, but generally it is a factor of 10 or more.

1.4 Spatial Coverage

Coverage is global; however, snow cover is calculated for only tiles that include land. A ±55 degree scanning pattern at 705 km altitude achieves a 2330 km swath with global coverage every one to two days. The following resources can help you select and work with MOD10CM tiles:

- HEG HDF-EOS to GeoTIFF Conversion Tool
- MODIS Land Discipline Group (MODLAND) Tile Calculator

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 0.05 degrees.

1.4.3 Projection and Grid Description

1.4.3.1 Projection

This data set is in a 0.05 degree CMG.

1.4.3.2 Grid

The CMG products contain global snow cover arrays of 7200 columns by 3600 rows. Each cell is 0.05 degree resolution. For more information about the CMG, see the MODIS Land | MODIS Grids Web page.

1.5 Temporal Coverage

MODIS Terra data extend from 24 February 2000 to present.

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 cannot find it, please visit the MODIS/Terra Data Outages Web page.

1.5.1 Temporal Resolution

Temporal resolution is monthly.

1.6 Parameter or Variable

Text goes here

1.6.1 Parameter Description

The snow averaging algorithm for this product computes the average fractional snow cover for the month for each pixel. Mean monthly snow extent is the primary variable of interest in this data set.

1.6.2 Parameter Range

Refer to the MOD10CM and MYD10CM Local Snow Cover Attributes, Version 5 document for a key to the meaning of the coded integer values in the Snow Cover Monthly CMG Field and the Snow Spatial QA 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 Land Global Browse Images
- MODIS: MODLAND Tile Calculator

2.2 Data Analysis Tools

- Land Processes Distributive Active Archive Center: MODIS Reprojection Tool: Software tools that reproject MODIS data to other projections.
- HDF-EOS to GeoTIFF Conversion Tool (HEG): 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 (mosaicking), and metadata 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 ENVI plugin (available as of 08/04/2016 via GitHub) 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 “Section 3.1 | Theory of Measurements” 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, the flagship 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. The MODAPS is responsible for product generation and transfer of products to NSIDC.

The daily MOD10C1 products for a month are used to generate the monthly MOD10CM product. The algorithm computes a filtered average fractional snow cover value for each cell in the CMG. A daily snow percentage value for a cell must have a Confidence Index (CI) greater than 70 percent to be included in the average and the contribution of a cell to the monthly average is

Contribution = 100 * Day_CMG_Snow_Cover/Day_CMG_Confidence_Index

The CI was developed to provide users with an estimate of confidence in the snow value reported for a cell. CI values are stored in the Day_CMG_Confidence_Index SDS. This index indicates how confident the algorithm is that the snow percentage in a cell is a good estimate based on data such as snow, snow-free land, cloud, and other, binned into the grid cell. A high CI is indicative of cloudless conditions and good data values, and that the snow percentage reported is a very good estimate. A low CI is indicative of a lot of cloud cover and that the snow percentage may not be a good estimate because of the cloud cover obscuring all or parts of a cell. A simplified example is given below to demonstrate the calculations for percent snow, percent cloud, and the CI.

A 5 km (0.05°) CMG grid cell has 50 500m observations distributed as follows:

snow observations: 20
snow-free land observations: 15
cloud obscured observations: 10
other, but not water, observations: 5

The percent of snow is computed as:

Snow Percent = 100 * (Number of snow observations) / (number of cloudless land and other land observations)
Snow Percent = 100 * 20 / (20 + 15 + 10 + 5)
Snow Percent = 40

The percent of cloud is computed as:

Cloud Percent = 100 * (Number of cloud observations) / (number of cloudless land and other land observations)
Cloud Percent = 100 * 10 / (20 + 15 + 10 + 5)
Cloud Percent = 20

The CI is computed as:

CI = 100 * (Number of clear land observations) / (number of cloudless land and other land observations)
CI = 100 * (20 + 15) / (20 + 15 + 10 + 5)
CI = 70

A number of possible combinations of snow, cloud, and land, and the CI calculated for them, are listed in Table 2. The highest CI is always associated with clear view conditions at any percentage of snow cover. When clouds completely obscure the surface, the CI is 0 because the surface is not seen. In situations where there are only snow and cloud observations in a cell, the CI will be the same as the percent snow; thus, low values are indicative of extensive cloud cover and high values are indicative of low cloud cover. In situations where there is a mix of snow, cloud, and land, the CI is indicative of the level of confidence that the reported snow percentage estimates the snow in the cell despite the cloud cover. In those situations, the CI has higher values with low cloud amounts at any snow amount, but the CI decreases as cloud cover increased indicating decreased confidence in the estimated snow percentage.

Table 2. Sample Calculations for CI

Snow Count	Cloud Count	Land Count	Percent Snow	Percent Cloud	Confidence Index (CI)
0	0	50	0	0	100
25	0	25	50	0	100
50	0	0	100	0	100
0	25	25	0	50	50
0	50	0	0	100	0
25	25	0	50	50	50
10	40	0	20	80	20
40	10	0	80	20	80
25	10	15	25	10	80
10	25	15	20	50	50
40	5	5	80	5	90
5	5	40	5	5	90
5	35	10	5	70	30

As a result, the contribution of a cloud free daily observation to the mean is the observed snow fraction Day_CMG_Snow_Cover, while the contribution of mixed snow/cloud fractions is increased by up to 30 percent (100/70 where 70 is the minimum CI used) under the assumption that some fraction of the snow cover is covered by cloud. If there are no days in the month where a cell had a CI greater than 70, the value for the cell is reported as no decision. If the resulting mean fractional snow cover for the month is less than 10 percent, the value is replaced by 0 percent since such low magnitudes are considered to be erroneous snow originating in the MOD10_L2 algorithm that have been propagated through the higher level products.

3.3.1 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 MOD10CM product:

- MOD10C1 - MODIS/Terra Snow Cover Daily L3 Global 500m, 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, Snow Cover
- Snow Spatial QA field.

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 one of the following documents:

- MOD10CM and MYD10CM Local Snow Cover Attributes, Version 5
- MOD10CM and MYD10CM Global 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 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 3. Technical Specifications

Orbit	705 km, 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 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.

4 REFERENCES AND RELATED PUBLICATIONS

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4.2 Related Data Sets

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

5 CONTACTS AND ACKNOWLEDGMENTS

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6 DOCUMENT INFORMATION

6.1 Publication Date

December 2006

6.2 Date Last Updated

September 2023