MODIS/Terra Snow Cover 8-Day L3 Global 0.05Deg CMG, 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. 2016. *MODIS/Terra Snow Cover 8-Day L3 Global 0.05Deg CMG, 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/MOD10C2.006. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/MOD10C2

National Snow and Ice Data Center

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1 DETAILED DATA DESCRIPTION

This data set is generated from Normalized Difference Snow Index (NDSI) snow cover. Snow covered land 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. MOD10A2 eight-day maximum snow extent observations at 500 m resolution are mapped into 0.05 degrees (approx. 5 km) CMG cells, binned by observation type (e.g. snow, snow-free land, cloud, etc.), and tallied. Snow and cloud cover percentages are generated by computing the ratio of snow or cloud observation counts to the total number of land observations mapped into the CMG cell.

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.

1.2 File Naming Convention

Example File Name:

```
MOD10C2.A2000049.006.2016064132927.hdf
MOD[PID].A[YYYY][DDD].[VVV].[yyyy][ddd][hhmmss].hdf
```

Refer to Table 1 for descriptions of the file name variables listed above.

Table 1. Variables in the MODIS File Naming Convention

Variable	Description
MOD	MODIS/Terra
PID	Product ID
A	Acquisition date follows
YYYY	Acquisition year
DDD	Day of year, first day of 8-day compositing period
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

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. For detailed information about MODIS metadata fields and values, consult the MODIS Snow Products Collection 6 User Guide.

1.3 File Size

Data files are approximately 6 MB.

1.4 Spatial 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)

1.4.1 Spatial Resolution

0.05°

1.4.2 Projection

MODIS CMG data sets are produced in a Geographic Lat/Lon projection. This simple projection treats geographical longitude and latitude degrees as if they were x- and y-coordinates in a plane. Figure 1 shows the geographical lat/lon projection known as Plate Carrée, which plots longitude and latitude degrees as coordinates on the x and y axes, respectively:

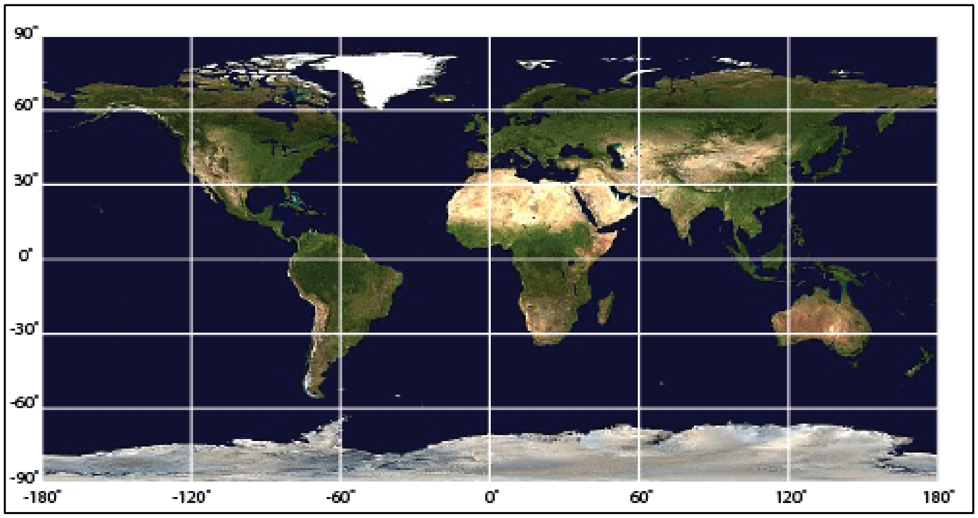

Figure 1. Plate Carrée projection.

1.4.3 Grid

The MODIS CMG consists of 7200 columns by 3600 rows. Each cell has a resolution of 0.05 degrees (approximately 5 km). The upper-left corner of the upper-left cell is -180.00 degrees longitude, 90.00 degrees latitude. The lower-right corner of the lower right cell is -180.00 degrees longitude, -90.00 degrees latitude. For additional details about the MODIS Climate Modeling Grid, see the NASA MODIS Lands | MODIS Grids Web page.

The following resources can help you select and work with gridded MODIS data:

- HDF-EOS to GeoTIFF Conversion Tool (HEG)

1.5 Temporal Coverage

MODIS Terra data are available from 24 February 2000 to present. However, because the NDSI depends on visible light, data are not produced when viewing conditions are too dark. In addition, anomalies over the course of the Terra mission 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

This data set is generated from observations acquired during successive eight-day periods. Each year comprises 46 periods; the first period begins on the first day of the year and the last period begins on day 361 and extends either two or three days into the following year (leap years vs non-leap years). Table 2 lists the days covered by each period:

Table 2. 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.							

1.6 Parameters

Note: The `Eight_Day_CMG_Confidence_Index` variable in Version 5 has been replaced with `Eight_Day_CMG_Clear_Index`. See Table 3 for details.

Snow cover percentage, cloud cover percentage, and data quality metrics are written to the HDF-EOS formatted data files as Scientific Data Sets (SDSs) according to the HDF Scientific Data Set Data Model. The SDSs for this data set are described in the following table:

Table 3. Scientific Data Sets and Descriptions

Scientific Data Set	Description
Eight_Day_CMG_Snow_Cover	Percentage of snow cover observations plus other results. Value = the ratio of MOD10A2, 500 m snow cover observations to the total number of land observations mapped into the CMG cell. Possible values are: 0–100: eight-day, maximum snow cover percentage 107: lake ice 111: night 237: inland water 239: ocean 250: cloud obscured water 253: data not mapped 255: fill Note: Antarctica deliberately mapped as snow. Snow cover percentage set to 100.
Eight_Day_CMG_Cloud_Obscured	Percentage of input cells obscured by clouds plus other results. Value = the ratio of MOD10A2, 500 m cloud observations to the total number of land observations mapped into the CMG cell. Note: MOD10A2 cells only report cloud if the cell was obscured by clouds on all eight days of the period. Possible values are: 0–100: percentage of cells obscured by clouds 107: lake ice 111: night 237: inland water 239: ocean 250: cloud obscured water 252: Antarctica mask 253: data not mapped 255: fill Note: Antarctica deliberately mapped as snow. Value set to 252 (masked).

Scientific Data Set	Description
Eight_Day_CMG_Clear_Index	Percentage of non-cloud input cells plus other results. Value = the ratio of MOD10A1, 500 m non-cloud observations to the total number of land observations mapped into the CMG cell. Low values indicate low confidence in the snow cover fraction due to extensive, persistent cloud cover. Note: the MOD10A2 algorithm infers a surface condition if any clear-sky views are available. Cells are only filled as cloud if they were obscured by clouds on all eight days of the period. A clear index = 0 does not indicate cloud-free conditions, but only that none of the MOD10A2 input cells were completely cloud obscured. Possible values are: 0–100: clear index 107: lake ice 111: night 237: inland water 239: ocean 250: cloud obscured water 253: data not mapped 255: fill Note: Antarctica deliberately mapped as snow. Clear index set to 100 (clear).
Snow_Spatial_QA	Basic QA plus other results. Value = good or other quality, based on counts of MOD10A2, 500 m basic QA values mapped into the CMG cell. Values of best (0), good (1), and ok (2) are counted as good quality (0); poor (3) and other (4) are counted as other (1). CMG cells report the greater of the two counts. Possible values are: 0: good quality 1: other quality 237: inland water 239: ocean 252: Antarctica mask 253: data not mapped 255: fill Notes: Antarctica deliberately mapped as snow. QA set to 252 (masked); Data files contain the metadata attribute "Mask_value=254." This attribute refers to the Version 5 ocean mask value and can be disregarded. Version 6 utilizes the convention ocean = 239 to be consistent with the other MODIS snow cover products.

2 SOFTWARE AND TOOLS

2.1 Get Data

Data are available via HTTPS.

2.2 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.
- 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.
- NSIDC's Hierarchical Data Format | Earth Observing System (HDF-EOS) Web page contains information about HDF-EOS, plus tools to extract binary and ASCII objects, instructions to uncompress and geolocate HDF-EOS data files, and links to obtain additional HDF-EOS resources.

3 DATA ACQUISITION AND PROCESSING

3.1 Mission Objectives

MODIS is a key instrument onboard NASA's Earth Observing System (EOS) Aqua and Terra satellites. The EOS includes satellites, a data collection system, and the world-wide community of scientists supporting a coordinated series of polar-orbiting and low inclination satellites that provide long-term, global observations of the land surface, biosphere, solid Earth, atmosphere, and oceans. As a whole, EOS is improving our understanding of the Earth as an integrated system. MODIS plays a vital role in developing validated, global, and interactive Earth system models that can predict global change accurately enough to assist policy makers in making sound decisions about how best to protect our environment. For more information, see:

- NASA's Earth Observing System
- NASA Terra | The EOS Flagship
- NASA MODIS | Moderate Resolution Imaging Spectroradiometer

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 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 snow cover 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 Snow Products Collection 6 User Guide
- The MODIS Snow and Sea Ice Global Mapping Project
- NASA Goddard Space Flight Center | MODIS Land Quality Assessment
- Product Quality Documentation for MOD10C1, C6

3.4 Derivation Techniques and Algorithms

3.4.1 Processing Steps

MOD10C2 is generated using a version of the MOD10C1 algorithm that has been adapted to utilze MOD10A2 eight-day data as input. The algorithm maps 500 m, MOD10A2 observations into 0.05° (approx. 5 km) CMG cells and bins and counts each observation by type, for example snow cover, cloud cover, and snow-free land. Snow and cloud cover percentage are computed as the ratio of the number of snow or cloud observations to the total number of land observations mapped into the CMG cell. These ratios are expressed as percentages in the SDSs. Because MOD10A2 reports snow cover if snow is found in a cell for any day in the period, the MOD10C2 snow map represents the maximum snow cover extent in each CMG cell during the eight-day period.

The snow map also includes lake ice coverage. The number of inland water body observations are counted using the water flag in the MOD10A1 `NDSI_Snow_Cover_Algorithm_Flags_QA` SDS. If the water body has more lake ice observations than open water, a value of 107 is set in the output.

A CMG-specific, 0.05 degrees land mask is used with the binning algorithm. This land mask was derived from the University of Maryland 1km Land Cover data set. CMG cells which contain 12 percent or greater land are considered land and analyzed; cells with less than 12 percent land are considered ocean. This threshold was selected as a balance between remaining sensitive enough to map snow along coasts and minimizing snow detection errors in these regions.

Persistent cloud cover—eight consecutive days of cloud obscuration—is recorded in the `Eight_Day_CMG_Cloud_Obscured` SDS. This array reports the fraction of 500 m, MOD10A2 cloud observations to the total number of land observations mapped into the CMG cell. Because MOD10A2 only reports cloud in cells that were obscured for all eight days of the period, the `Eight_Day_CMG_Cloud_Obscured` SDS represents the fraction of 500 m input cells whose surface was unobservable for the entire period.

Viewing conditions in the CMG cell, relative to persistent cloud cover, can be inferred from the eight-day Clear Index (CI). This value reports the percentage of all MOD10A2 land observations mapped into the cell that were not obscured by clouds for eight consecutive days, thus providing an estimate of the amount of land surface that was observable on at least one day of the period. Low values indicate low confidence in the snow cover fraction due to extensive, persistent cloud cover. A high CI indicates that relatively few input cells were completely obscured. Users should note, however, that the MOD10A2 algorithm infers a surface condition if any clear-sky views are available for a cell. A determination of snow or snow-free land, for example, can be based on anywhere from 1 - 8 days of observations, and partial cloud-obscuration is not tracked in this data set. As such, a clear index = 0 does not indicate that clouds were not present, but only that no MOD10A2 input cells were blocked from view by clouds for eight consecutive days. For more details about the MOD10A2 snow cover algorithm, see the Section “Derivation Techniques and Algorithms” in the MOD10A2 documentation.

Polar darkness extent is based on the latitude of the CMG cell nearest the equator that is full of night observations. All CMG cells poleward of that latitude are filled as night. This approach was adopted so that a neat demarcation of night and day is visible in the CMG.

Antarctica has been masked as 100 percent snow covered to improve the visual quality of data. As such, this data set cannot be used to map snow in Antarctica. For users who wish to evaluate Antarctica, the MOD10_L2 data set offers a higher resolution and contains more data and information about accuracy and error.

3.4.2 Version History

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

3.4.3 Error Sources

The NDSI technique has proven to be a robust indicator of snow cover. Numerous investigators have utilized MODIS snow cover data sets and reported accuracy in the range of 88 percent to 93 percent. The daily CMG offers a synoptic view of maximum snow cover extent during eight-day windows plus persistent cloud cover and optionally the clear index. Snow cover and cloud cover are written to separate data arrays so that users can consider how best to interpret and use the snow cover map and whether to combine it with the cloud cover data.

Snow commission errors, in general the most apparent type of error, are typically associated with cloud cover and may appear on any day in conjunction with clouds. These errors may spread in spatial extent over the course of eight days and manifest as low-percentage, maximum snow fractions. Based on experience, a majority of the most probable snow commission errors can be filtered by interpretting snow cover with a value of NDSI < 20 as snow-free. However, this approach may mask out actual snow along the periphery of snow-covered regions.

The algorithm for this data set does not screen for errors; QA values are only provided to indicate whether the input data were valid or invalid or if a special condition like polar darkness was encountered. Users should analyze the snow cover map and choose for themselves an interpretation that minimizes the most probable errors and yet applies the data in a reasonable manner to track maximum snow cover extent.

Snow errors are ultimately propagated from the first data set in the MODIS snow suite of products, MOD10_L2, into MOD10A1, MOD10A2, and then this data set. For more detail about potential error sources in the input data, see the “Derivation Techniques and Algorithms” section in the MOD10_L2 documentation and the MODIS Snow Products Collection 6 User Guide.

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 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)
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 Collections

- MODIS/Terra Snow Cover 8-Day L3 Global 500m Grid, Version 6 (MOD10A2)
- MODIS/Terra Snow Cover 5-Min L2 Swath 500m, Version 6 (MOD10_L2)
- MODIS/Aqua Snow Cover 8-Day L3 Global 0.05Deg CMG, Version 6 (MYD10C2)
- MODIS Data Sets @ 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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