MODIS/Terra Snow Cover 8-Day L3 Global 500m SIN Grid, 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 500m SIN Grid, 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/MOD10A2.006. [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

Snow cover in this data set is derived from the Normalized Difference Snow Index (NDSI). 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.

Maximum snow cover extent is generated by reading 8 days of 500 m resolution MOD10A1 tiles. If snow is observed in a cell on any day in the period, the cell is mapped as snow. If no snow is found, the cell is filled with the clear-view observation that occurred most often (e.g. snow free land, lake, etc.). Cloud cover is only reported if the cell was cloud-obscured for all eight days in the period. Each cell's snow/no snow chronology is recorded using bit flags and provided as a separate variable.

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:

```
MOD10A2.A2000049.h31v11.006.2016064132703.hdf

MOD[PID].A[YYYY][DDD].h[NN]v[NN].[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
h[NN]v[NN]	Horizontal tile number and vertical tile number (see “Section 1.4.3 | Grid” for details.)
VVV	Version (Collection) number

Variable	Description
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 range in size from approximately 100 KB to 2.0 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

500 m (at nadir)

1.4.2 Projection

This data set is georeferenced to an equal-area sinusoidal projection. Areas on the grid are proportional to the same areas on Earth and distances are correct along all parallels and the central meridian. Shapes become increasingly distorted away from the central meridian and near the poles. The data are neither conformal, perspective, nor equidistant. Meridians, except for the central meridian, are represented by sinusoidal curves and parallels are represented by straight lines. The central meridian and parallels are lines of true scale. The following table lists some specific projection parameters:

Table 2. Sinusoidal Projection Parameters

Parameter	Value
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)

1.4.3 Grid

Data are gridded in the MODIS Sinusoidal Tile Grid, which comprises 460 non-fill tiles that each cover 10° x 10° at the equator (approximately 1200 km by 1200 km). Although this grid has a nominal 500 m resolution, the true per pixel resolution is 463.31271653 meters in both the X and Y directions. Tiles are labeled with horizontal (h) and vertical (v) indices, starting in the upper left corner with tile h00v00 and proceeding rightward and downward to tile h35v17 in the bottom right corner (see Figure 1):

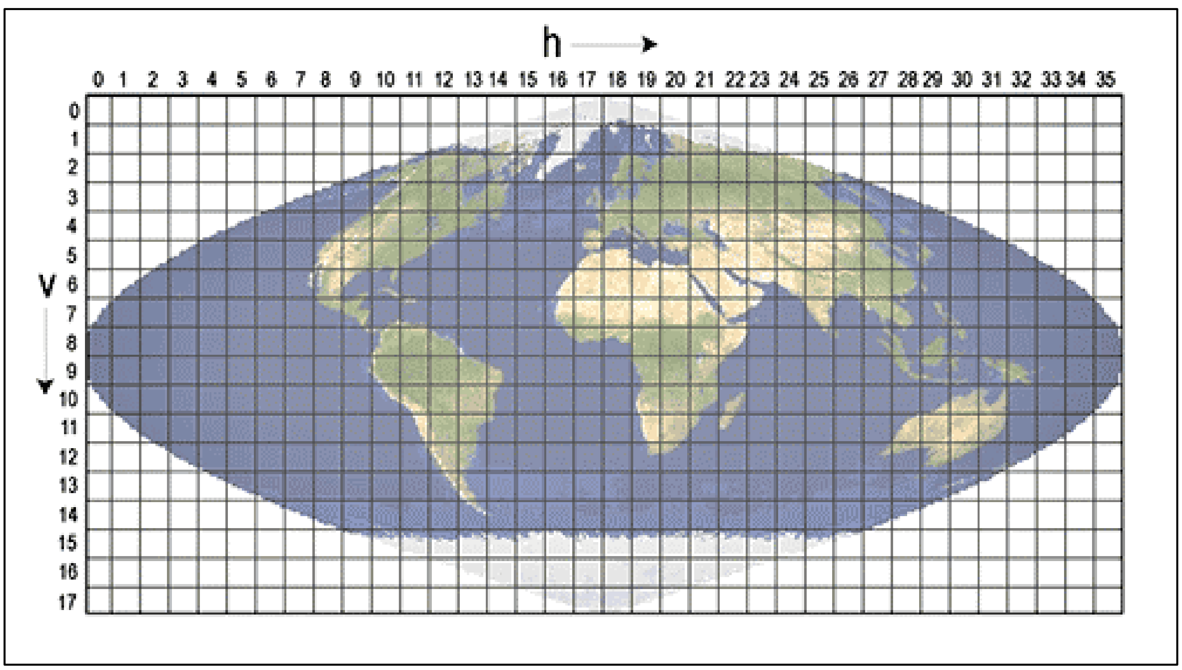

Figure 1. MODIS Sinusoidal Tile Grid. Tiles cover 10° x 10° at the equator or approximately 1200 km by 1200 km. For additional details about the MODIS Sinusoidal Tile Grid, see the NASA MODIS Lands | MODIS Grids Web page.

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

- Tile Bounding Coordinates for the MODIS Sinusoidal Grid
- MODIS Land Discipline Group (MODLAND) Tile Calculator
- Earth Observing System Data and Information System (EOSDIS) Core System Project: Science Data Processing (SDP) Toolkit Home Page
- 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

Tiles in this data set are composited from data acquired during eight day windows. Each year comprises 43 compositing periods. The first period begins on the first day of the year; 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 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.

1.6 Parameters

Maximum snow cover extent and the eight-day snow/no snow chronology for each cell 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 4. Scientific Data Sets and Descriptions

<table>
<tr><th>Scientific Data Set</th><th>Description</th></tr>
<tr><td>Maximum_Snow_Extent</td><td>The maximum snow extent during the eight-day period plus other values. Cells with snow on any day during the period are mapped as snow. Clouds are only reported if all eight days were obscured by clouds. Cells with no snow are filled with the observation that occurred most often. Possible values are:
0: missing data
1: no decision
11: night
25: no snow
37: lake
39: ocean
50: cloud
100: lake ice
200: snow
254: detector saturated
255: fill</td></tr>
<tr><td>Eight_Day_Snow_Cover</td><td>Snow chronology bit flags. Each day has its own bit that is set to: on (1), if snow was observed on that day; or off (0), for no snow, cloud, or missing data. Days/bits are ordered across the byte from right to left:<table><tr><td>bit 7</td><td>bit 6</td><td>bit 5</td><td>bit 4</td><td>bit 3</td><td>bit 2</td><td>bit 1</td><td>bit 0</td></tr><tr><td>day 8</td><td>day 7</td><td>day 6</td><td>day 5</td><td>day 4</td><td>day 3</td><td>day 2</td><td>day 1</td></tr></table>To retrieve the bit flags, convert the integer stored in the SDS into its binary representation. For example, if a cell contains the value 229, expressing that number in binary yields: 11100101.
Read from right to left, the flags indicate that snow was observed in the cell on days 1, 3, 6, 7, and 8 of the compositing period, while no snow was observed on days 2, 4, and 5.</td></tr>
</table>

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
- MODIS Land Team Validation | Status for Snow Cover/Sea Ice (MOD10/29)

3.4 Derivation Techniques and Algorithms

MOD10A1, the input to this data set, is generated by mapping a best observation of the day from the MODIS/Terra 5 minute swath data set (MOD10_L2) into each cell of the MODIS 500 m Sinusoidal Grid (see the MOD10A1 documentation for details). Maximum snow extent for the period is mapped by compositing eight days of MOD10A1 snow cover. The algorithm reads eight days of MOD10A1 tiles and if snow cover with a value of NDSI > 10 is found in a cell for any day in the period, the cell is mapped as snow in the `Maximum_Snow_Extent` SDS. To reduce snow commission errors and produce a more spatially consistent snow map, values in the range of 0 < NDSI ≤ 10 are interpreted as uncertain and not counted toward maximum snow cover.

If no snow is found in the period, the algorithm maps the cell with the clear-view observation that occurred most often. Cells are only mapped to cloud if all eight days in the period are cloud-obscured. Although this logic minimizes cloud cover extent, it biases the output toward clear views because only clear views are used to determine composite observations. To catch any unexpected conditions, cells are mapped to no decision if a composite observation is not determined in the algorithm.

The snow/no snow chronology for each cell is written to the `Eight_Day_Snow_Cover` SDS. Each of the eight bits in this variable represents one day in the compositing period. On days that snow is observed the cell, the bit corresponding to that day is set to on (1). Days with no snow, cloud cover, and missing data are left unset (0). Days are ordered chronologically across the byte from right to left, from day 1 (bit 0) to day 8 (bit 7).

Because eight days of observations may not be available due to problems acquiring data or generating the product, the algorithm was designed to run with as few as two days of input. No product is generated if only a single day is available. Three global attributes—`Number of input days`; `Days input`; and `Eight day period`—are are written to the metadata that specify how many and which days were used to produce the tile.

3.4.1 Version History

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

3.4.2 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% to 93%. The eight day snow cover extent data set is intended to provide users with a map of maximum snow cover extent during the eight-day window and a record of days on which snow cover was observed. Although this data set's accuracy is typically similar to its MOD10A1 input, compositing snow commission errors over eight days into a single tile can increase the error percentage spatially and temporally, even after uncertain snow detections are filtered as previously described.

Accuracy and errors in MOD10A1 originate in the MOD10_L2 swath product. In the eight-day snow maps, errors associated with MOD10_L2 snow/cloud confusion typically manifest as snow in locations and seasons where snow is impossible or very unlikely. These errors accumulate from each day and occur in different locations on different days, thus increasing the spatial extent of errors when composited into the eight-day snow cover maps.

Finally, anomalies in the input data to MOD10_L2 propagate to the output. Table 3 in the MOD10_L2 documentation lists the products that are used as input to the snow detection algorithm. For a more detailed discussion of potential sources of error, including examples, consult the MODIS Snow Products Collection 6 User Guide.

3.5 Quality Assessment

No product specific QA is provided with this data set.

3.6 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 5 contains the instruments' technical specifications:

Table 5. 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

Variable	Description
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

3.6.1 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 Spectroradiometic 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

- MODIS/Terra Snow Cover Daily L3 Global 500m Grid, Version 6 (MOD10A1)
- MODIS/Aqua Snow Cover 8-Day L3 Global 500m Grid, Version 6 (MYD10A2)
- MODIS Data Sets @ NSIDC

4.3 Related Web Sites

- MODIS @ NASA Goddard Space Flight Center
- The MODIS Snow and Sea Ice Global Mapping Project

5 CONTACTS AND ACKNOWLEDGMENTS

5.1 Principal Investigators

Miguel O. Román

NASA Goddard Space Flight Center

Mail Code: 619

Greenbelt , MD 20771

Dorothy K. Hall

NASA Goddard Space Flight Center

Mail Code 615

Greenbelt, MD 20771

George A. Riggs

NASA Goddard Space Flight Center

Science Systems and Applications, Inc.

Mail stop 615

Greenbelt, MD 20771

6 DOCUMENT INFORMATION

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