MODIS/Terra Snow Cover 8-Day L3 Global 500m Grid, 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. A. Riggs. 2021. *MODIS/Terra Snow Cover 8-Day L3 Global 500m SIN Grid, 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/MOD10A2.061. [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 DATA DESCRIPTION

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, ocean, etc.). Cloud cover is only reported if the cell was cloud-obscured for all eight days in the period.

Snow cover is detected using 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. The Scientific Data Sets (SDSs) included with this product are described 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
`Maximum_Snow_Extent`	Maximum snow extent observed over an eight-day period.	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
`Eight_Day_Snow_Cover`	Snow chronology bit flags for each day in the eight-day observation period.	Bit flag values: Bit 0: day 1 Bit 1: day 2 Bit 2: day 3 Bit 3: day 4 Bit 4: day 5 Bit 5: day 6 Bit 6: day 7 Bit 7: day 8

Parameter	Description	Values
`Projection`	Sinusoidal projection attributes.	N/A
`XDim`	Projected upper left X coordinate for each pixel in km.	Coordinate value range for data set: -20015.109354 to 20015.109354
`YDim`	Projected upper left Y coordinate for each pixel in km.	Coordinate value range for data set: -10007.554677 to 10007.554677

1.2 Sample Data Image

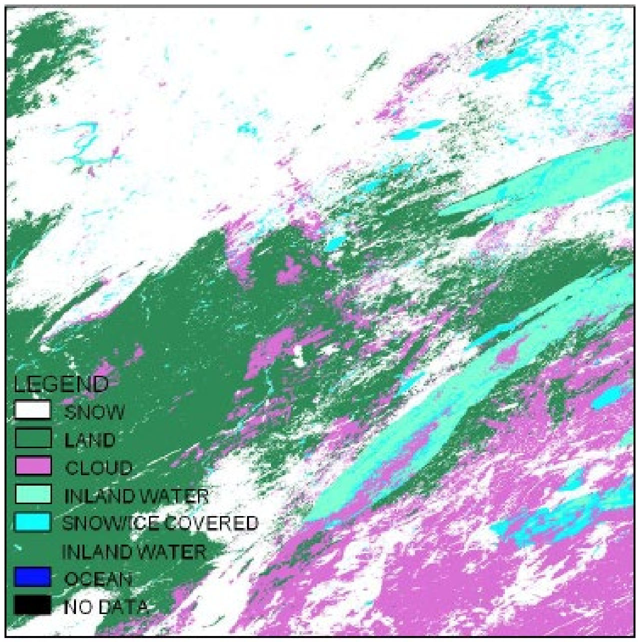

Figure 1. This figure shows MOD10A2 eight-day snow cover extent for tile h11v04 observed 1 January 2003.

1.3 File Information

1.3.1 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 Data File

As shown in Figure 2, each data file includes two data fields (`Eight_Day_Snow_Cover` and `Maximum_Snow_Extent`), three georeferencing fields (`Projection`, `XDim` and `YDim`), and three metadata fields (`ArchiveMetadata.0`, `CoreMetadata.0`, and `StructMetadata.0`).

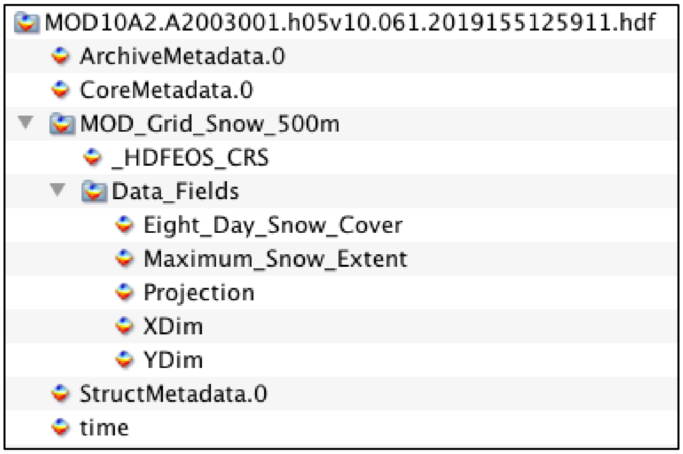

Figure 2. This figure shows the fields included in each data file as displayed with Panoply software.

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].h[NN]v[NN].[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
`h[NN]v[NN]`	Horizontal tile number and vertical tile number (see Grid section for details)
`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:

`MOD10A2.A2003001.h05v10.061.2019155125911.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.

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

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.

1.4.3 Grid

As shown in Figure 3, data are gridded using the MODIS Sinusoidal Tile Grid, which comprises 460 non-fill tiles that each cover 10° by 10° at the equator or approximately 1200 km by 1200 km. Each data granule covers one tile and consists of 2,400 rows and 2,400 columns at a nominal spatial resolution of 500 m and a true per pixel resolution of 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.

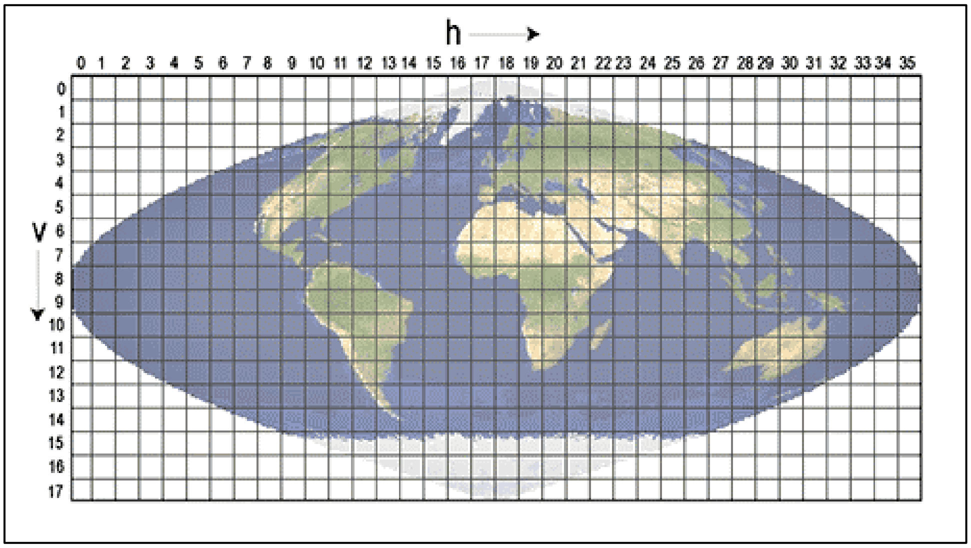

Figure 3. MODIS Sinusoidal Tile Grid

The Software and Tools section below lists resources that can help the user select and work with gridded MODIS data.

1.4.4 Resolution

The nominal spatial resolution is 500 meters.

1.4.5 Geolocation

The following tables provide information for geolocating this data set.

Table 3. Projection Details

Region	Global
Geographic coordinate system	WGS84
Projected coordinate system	Sinusoidal Grid
Longitude of true origin	0°
Latitude of true origin	0°
Scale factor at longitude of true origin	1.0
Datum	WGS 84
Ellipsoid/spheroid	6371007.181000 meters
Units	Meter
False easting	0°
False northing	0°
SR-ORG code	6974

PROJ4 string	+proj=sinu +lon_0=0 +x_0=0 +y_0=0 +ellps=WGS84 +datum=WGS84 +units=m +no_defs
Reference	https://spatialreference.org/ref/sr-org/6974/html/

Table 4. Grid Details

Region	Global
Grid cell size (x, y pixel dimensions)	500 m
Number of rows	2400
Number of columns	2400
Nominal gridded resolution	500 m
Grid rotation	N/A
Geolocated upper left point in grid	-20015109.354(x), 10007554.677(y)
Geolocated lower right point in grid	20015109.354(x), -10007554.677(y)

1.5 Temporal Information

1.5.1 Coverage

MODIS Terra data are available from 18 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.

Note: The start date for MOD10A2 C6.1 begins 8-days earlier then the start date for MOD10A2 C6.0. This was done in order to align the MOD10A2 C6.1 start date with the full eight-day compositing period, as described in Table 5. However, the actual days with data are the same for both collections.

1.5.2 Resolution

The temporal resolution is eight-days. Tiles are composited from data acquired during eight day windows. Each year is comprised of 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 5 lists the days covered by each compositing period:

Table 5. 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.

2 DATA ACQUISITION AND PROCESSING

2.1 Background

This data set provides the maximum snow extent observed over an eight-day period. The maximum snow extent represents snow that was observed on one or more days within the eight-day period. The days in the period in which snow was observed are mapped as a bit flag chronology of observed snow cover. Only clear-view (cloud-free) observations are used for detecting snow cover. However, if cloud-cover was observed for all eight days, then cloud-cover is reported for the grid cell. An eight-day compositing period was chosen because that is the ground track repeat period of the Terra and Aqua satellites (Masuoka et al., 1998).

2.2 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, such as 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.

2.3 Processing

The maximum snow cover extent for an eight-day period is mapped by compositing eight days of data from the MOD10A1 'NDSI_Snow_Cover' array. If snow cover is found in a cell for any day in the period, the cell is mapped as snow in the 'Maximum_Snow_Extent' SDS. The 'NDSI_Snow_Cover' input is also filtered to reduce snow commission errors (detecting snow where there is no snow) and to produce a more spatially consistent snow map. NDSI values in the range of $0 < \text{NDSI} \leq 10$ are interpreted as uncertain and not counted in the 'Maximum_Snow_Extent' SDS.

If no snow is found in the eight-day 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. This logic minimizes cloud-cover extent and 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 a bit flag index in the 'Eight_Day_Snow_Cover' SDS. Each of the eight bits in this variable represents one day in the compositing period. For each day snow is observed in the cell, the bit corresponding to that day is set to on (1). Days with no snow, cloud cover, or 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). See Figure 4 for additional details.

Occasionally, eight days of observations are not available due to problems acquiring data or generating the product. In this situation, the algorithm is designed to run with as few as two days of input. If there is only one clear-view day on input, the product will not be produced. The number of days included in the period are written to the 'Number_of_input_days' file-level metadata attribute.

In addition, the input dates and the input period are written to the 'Days_input' and 'Eight_day_period' file-level metadata attributes.

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
day 8	day 7	day 6	day 5	day 4	day 3	day 2	day 1

Figure 4: This figure provides a graphic representation of snow chronology bit flags. Days/bits are ordered across the byte from right to left. To retrieve the bit flags, convert the integer stored in the SDS into its binary equivalent. 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.

2.4 Quality Assessment

No product-specific QA is provided with this data set.

2.5 Errors

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 data set is intended to provide users with a map of maximum snow 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.

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. For a more detailed discussion of potential sources of error, including examples, see the 'MODIS Snow Products Collection 6.1 User Guide' (Riggs et al., 2019).

2.6 Instrumentation

2.6.1 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

2.6.2 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 shortwave 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 VERSION HISTORY

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

4 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
- MODIS Land Discipline Group (MODLAND) Tile Calculator
- Tile Bounding Coordinates for the MODIS Sinusoidal Grid

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.

5 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)

6 CONTACTS AND ACKNOWLEDGMENTS

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7 REFERENCES

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8 DOCUMENT INFORMATION

8.1 Publication Date

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8.2 Date Last Updated

December 2021