



MODIS/Terra Snow Cover Daily 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 Daily 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/MOD10A1.006>. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT <https://nsidc.org/data/MOD10A1>



National Snow and Ice Data Center

TABLE OF CONTENTS

1	DETAILED DATA DESCRIPTION	2
1.1	Format.....	2
1.2	File Naming Convention.....	2
1.3	File Size	3
1.4	Spatial Coverage.....	3
1.4.1	Spatial Resolution.....	3
1.4.2	Projection.....	3
1.5	Grid	4
1.6	Temporal Coverage	5
1.6.1	Temporal Resolution	5
1.7	Parameter	5
1.7.1	Interpreting the NDSI_Snow_Cover_Algorithm_Flags_QA SDS	8
1.7.2	Using granule_pnt	10
2	SOFTWARE AND TOOLS.....	10
2.1	Get Data.....	10
2.2	Software and Tools	10
3	DATA ACQUISITION AND PROCESSING	11
3.1	Mission Objectives	11
3.2	Data Acquisition	11
3.3	Data Processing.....	12
3.4	Derivation Techniques and Algorithms.....	12
3.4.1	Processing Steps.....	12
3.4.2	Version History	13
3.4.3	Error Sources	13
3.5	Quality Assessment	14
3.6	Instrument Description	14
3.6.1	Calibration	15
4	REFERENCES AND RELATED PUBLICATIONS	16
4.1	PUBLISHED RESEARCH.....	17
4.2	Related Data Sets.....	17
4.3	Related Websites	17
5	CONTACTS AND ACKNOWLEDGMENTS.....	18
5.1	Principal Investigators	18
6	DOCUMENT INFORMATION.....	18
6.1	Document Creation Date.....	18
6.2	Document Revision Dates.....	18

1 DETAILED DATA DESCRIPTION

Snow covered land typically has a very high reflectance in visible bands and very low reflectance in the shortwave infrared. The Normalized Difference Snow Index (NDSI) reveals the magnitude of this difference. Snow cover in this data set consists of a single, best observation of the day for each grid cell selected from the MODIS/Terra Snow Cover 5-Min L2 Swath 500m ([MOD10_L2](#)) data set. Each observation represents the best sensor view of surface in the cell based on solar elevation, distance from nadir, and cell coverage.

As of August 2023, this data set is retired and no longer available for download. We recommend using [MODIS/Terra Snow Cover Daily L3 Global 500m SIN Grid, Version 61](#) as an alternative.

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:

MOD10A1.A2000055.h15v01.006.2016061160800.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	Acquisition day of year
h[NN]v[NN]	Horizontal tile number and vertical tile number (see “Section 1.5 Grid” for details.)
VVV	Version (Collection) number
yyyy	Production year

Variable	Description
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 3.5 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)

1.5 Grid

Data are gridded using the MODIS Sinusoidal Tile Grid, which comprises 460 non-fill tiles that each cover 10° x 10° at the equator or 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):

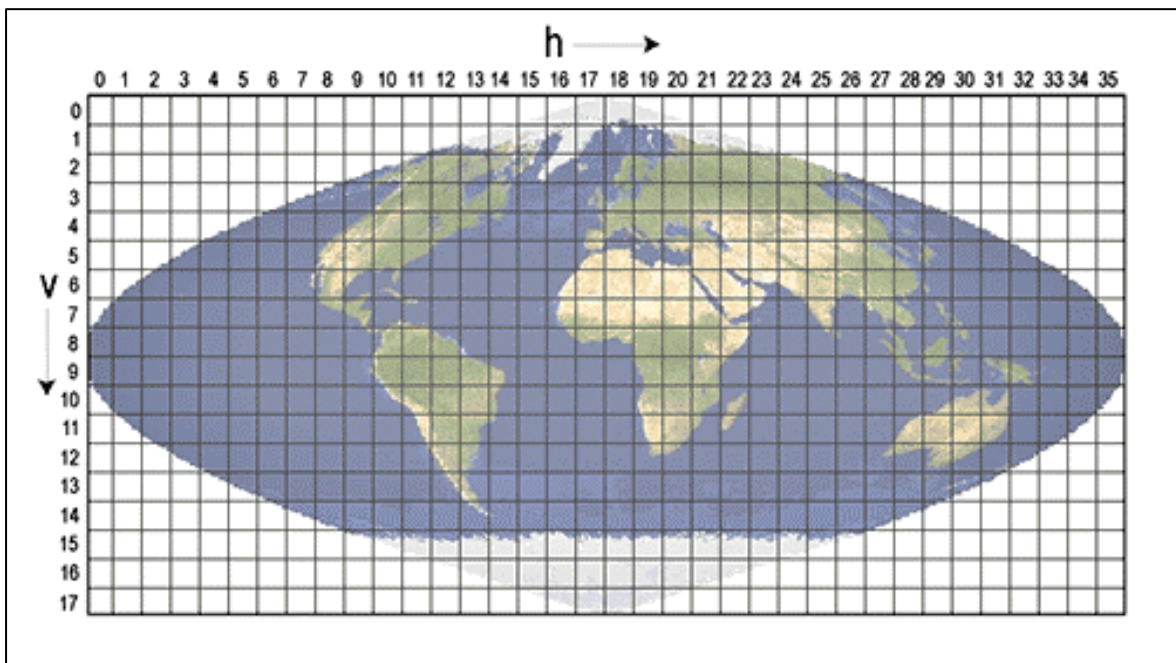


Figure 1. MODIS Sinusoidal Tile Grid. Tiles cover 10° x 10° at the equator or approximately 1200 km by 1200 km. For additional details about the MODIS Sinusoidal Tile Grid, see the [NASA MODIS Lands | MODIS Grids](#) Web page.

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 \(HEG\)](#)

1.6 Temporal Coverage

MODIS Terra data are available from 24 February 2000 to 17 February 2023. 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.

1.6.1 Temporal Resolution

Daily

1.7 Parameter

Note: The snow cover variables in Version 6 of this data set differ substantially from Version 5. Fractional snow cover, binary snow-covered area, and spatial QA (`Fractional_Snow_Cover`, `Snow_Cover_Daily_Tile`, and `Snow_Spatial_QA`) have been discontinued. See Table 3 for details.

NDSI snow cover, raw NDSI, screen results, basic QA, and snow albedo for each pixel are written to the HDF-EOS formatted data files as Scientific Data Sets (SDSs) according to the HDF [Scientific Data Set Data Model](#). In addition, Version 6 includes two SDSs that contain pointers to the swath selected as the observation of the day. The SDSs for this data set are described in the following table:

Table 3. Scientific Data Sets and Descriptions

Scientific Data Set	Description
NDSI_Snow_Cover	<p>NDSI snow cover plus other results. This value is computed for MOD10_L2 and retrieved when the observation of the day is selected. Possible values are:</p> <ul style="list-style-type: none"> 0–100: NDSI snow cover 200: missing data 201: no decision 211: night 237: inland water 239: ocean 250: cloud 254: detector saturated 255: fill
NDSI_Snow_Cover_Basic_QA	<p>A basic estimate of the quality of the algorithm result. This value is computed for MOD10_L2 and retrieved with the corresponding observation of the day. Possible values are:</p> <ul style="list-style-type: none"> 0: best 1: good 2: OK 3: poor (not currently in use) 211: night 239: ocean 255: unusable input or no data

Scientific Data Set	Description
NDSI_Snow_Cover_Algorithm_Flags_QA	<p>Bit flags indicating screen results and the presence of inland water. See “Section 1.7.1 Interpreting NDSI_Snow_Cover_Algorithm_Flags_QA” for a description. These flags are set when MOD10_L2 is generated and retrieved with the corresponding observation of the day. Bits are set to on (1) as follows:</p> <p>Bit 0: Inland water</p> <p>Bit 1: Low visible screen failed. Snow detection reversed.</p> <p>Bit 2: Low NDSI screen failed. Snow detection reversed.</p> <p>Bit 3: Combined temperature/height screen failed. On means <i>either</i>: brightness temperature ≥ 281 K, pixel height < 1300 m, flag set, snow detection reversed to not snow, OR; brightness temperature ≥ 281 K, pixel height ≥ 1300 m, flag set, snow detection NOT reversed.</p> <p>Bit 4: Shortwave IR (SWIR) reflectance anomalously high. On means <i>either</i>: Snow pixel with SWIR > 0.45, flag set, snow detection reversed to not snow, OR; Snow pixel with $25\% < \text{SWIR} \leq 45\%$, flag set to indicate unusual snow condition, snow detection NOT reversed.</p> <p>Bit 5: spare</p> <p>Bit 6: spare</p> <p>Bit 7: solar zenith screen failed, uncertainty increased.</p>
NDSI	<p>Raw NDSI (i.e. prior to screening) reported in the range 0–10,000. Values are scaled by 1×10^4. This value is computed for MOD10_L2 and retrieved with the corresponding observation of the day</p>

Scientific Data Set	Description
Snow_Albedo_Daily_Tile	Snow albedo plus other results. Possible values are: 1–100: snow albedo 101: no decision 111: night 125: land 137: inland water 139: ocean 150: cloud 151: cloud detected as snow 250: missing 251: self-shadowing 252: land mask mismatch 253: BRDF failure 254: non-production mask
orbit_pnt	Pointer to the orbit number of the swath that was selected as the observation of the day. The pointer references by index the list of orbit numbers written to the ORBITNUMBERARRAY metadata object in ArchiveMetadata.0.
granule_pnt	Pointer to the granule (swath) that was mapped into the tile. The pointer references the corresponding value in the GRANULEPOINTERARRAY metadata object written to ArchiveMetadata.0. See “Section 1.7.2 Using granule_pnt” for more information.

1.7.1 Interpreting the NDSI_Snow_Cover_Algorithm_Flags_QA SDS

Pixels determined to have some snow present are subjected to a series of screens that have been specifically developed to alleviate snow commission and omission associated with the most common error sources. In addition, snow-free pixels are screened for very low illumination conditions to prevent possible snow omission errors. Screen results, as well as and the location of inland water, are stored as bit flags in the NDSI_Snow_Cover_Algorithm_Flags_QA SDS. The following sections describe each data screen and the conditions that result in its bit flag being set.

1.7.1.1 Low Visible Reflectance Screen

This screen is applied to prevent errors from occurring when the reflectance is too low for the algorithm to perform well, such as in very low illumination or on surface features with very low reflectance. This screen is also applied to pixels that have no snow cover present (snow-free pixels) to prevent possible snow omission. If the MODIS Band 2 reflectance is ≤ 0.10 or the Band 4 reflectance is ≤ 0.11 , the pixel fails the screen and is set to no decision in the NDSI snow cover

SDS. The results of this screen are tracked in bit 1 of the NDSI_Snow_Cover_Algorithm_Flags_QA SDS.

1.7.1.2 Low NDSI screen

Pixels detected as having snow cover with $0.0 < \text{NDSI} < 0.10$ are reversed to no snow and flagged by setting bit 2 in the NDSI_Snow_Cover_Algorithm_Flags_QA SDS. This flag can be used to find pixels where snow cover detections were reversed to not snow.

1.7.1.3 Estimated surface temperature and surface height screen

This screen serves a dual purpose by linking estimated surface temperature with surface height. It is used to alleviate errors of commission at low elevations that appear spectrally similar to snow but are too warm. It is also used to flag snow detections at high elevations that are warmer than expected. Using the estimated MODIS Band 31 brightness temperature (T_b), if snow is detected in a pixel with height < 1300 m and $T_b \geq 281$ K, the pixel is reversed to not snow and bit 3 is set in the NDSI_Snow_Cover_Algorithm_Flags_QA SDS. If snow is detected in a pixel with height ≥ 1300 m and $T_b \geq 281$ K, the pixel is flagged as unusually warm by setting bit 3 in the NDSI_Snow_Cover_Algorithm_Flags_QA SDS.

1.7.1.4 High SWIR reflectance screen

This screen also serves a dual purpose by: a) preventing non-snow features that appear similar to snow from being detected as snow; b) allowing snow to be detected where snow-cover short-wave infrared reflectance (SWIR) is anomalously high. Snow typically has a SWIR reflectance of less than about 0.20; however, this value can be higher under certain conditions like a low sun angle. The SWIR reflectance screen thus utilizes two thresholds. Snow pixels with SWIR reflectance > 0.45 are reversed to not snow and bit 4 of NDSI_Snow_Cover_Algorithm_Flags_QA SDS is set. Snow pixels with $0.25 < \text{SWIR reflectance} \leq 0.45$ are flagged as having an unusually high SWIR for snow by setting bit 4 in the NDSI_Snow_Cover_Algorithm_Flags_QA SDS.

1.7.1.5 Solar zenith screen

When solar zenith angles exceed 70° , the low illumination challenges snow cover detection. As such, pixels with solar zenith angles $> 70^\circ$ are flagged by setting bit 7 in the NDSI_Snow_Cover_Algorithm_Flags_QA SDS. This solar zenith mask is set across the entire swath. **Note:** night is defined as a solar zenith angle $\geq 85^\circ$. Night pixels are assigned a value 211.

1.7.1.6 Lake Ice

Ice/snow covered lake ice are detected by applying the snow algorithm specifically to inland water bodies. These data are provided so that the MODIS user community can evaluate the efficacy of

this technique. Inland water bodies are flagged by setting bit 0 in the `NDSI_Snow_Cover_Algorithm_Flags_QA` SDS. Users can extract or mask inland water in the NDSI snow cover SDS using this flag. The algorithm relies on the basic assumption that a water body is deep and clear and therefore absorbs all of the solar radiation incident upon it. Water bodies with algal blooms, high turbidity, or other relatively high reflectance conditions may be erroneously detected as snow/ice covered.

Note: Version 6 utilizes a new land/water mask derived from the University of Maryland Global Land Cover Facility's UMD 250m MODIS Water Mask. To maintain continuity between Version 5 and Version 6, the UMD 250m MODIS Water Mask was converted from a 250 m, two-class map to 500 meters resolution and seven classes for use in all MODIS products. The conversion is detailed in [Development of an Operational Land Water Mask for MODIS Collection 6](#).

1.7.2 Using `granule_pnt`

The `GRANULEPOINTERARRAY` metadata object written to the `ArchiveMetadata.0` structure contains a pointer for each granule that was staged for input to a tile; however, more granules are staged than are actually used. Each granule that is mapped into a tile is assigned a unique positive pointer value, while those that are not are assigned a value of -1. To determine the swath origin of a cell observation, link all the pointers in `GRANULEPOINTERARRAY` (by index) to the corresponding list of dates and times in `GRANULEBEGINNINGDATETIMEARRAY`. Then locate the granule in `GRANULEPOINTERARRAY` with the pointer value contained in `granule_pnt` and use its index to extract the date and beginning-time string from `GRANULEBEGINNINGDATETIMEARRAY`.

2 SOFTWARE AND TOOLS

2.1 Get Data

Data are available via [HTTPS](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.
- [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.

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

3.4.1 Processing Steps

3.4.1.1 Snow Cover

The MOD10_L2 snow cover algorithm detects snow by computing the Normalized Difference Snow Index (NDSI) (Hall and Riggs, 2011) from MODIS Level 1B calibrated radiances. Data screens are then applied to alleviate errors of commission and to flag uncertain snow detections. The final output consists of NDSI snow cover plus the location of clouds, water bodies, and other algorithm results of interest to data users.

To generate the daily 500 m data set, a gridding algorithm maps all MOD10_L2 swaths into an intermediate snow cover product (MOD10GA) which is then used as input. Starting with this version (Version 6), the algorithms which select the day's best snow cover observation and compute snow albedo have been incorporated into the MOD10GA generation process. Note that MOD10GA is an intermediate product and is not archived at NSIDC.

Once the data have been gridded, the selection algorithm uses several criteria to identify the best observation from the one to several MOD10_L2 swaths which were mapped into each grid cell. The criteria were chosen to obtain the best sensor view of the surface for detecting snow cover: specifically, observations which were acquired nearest local solar noon, nearest the orbit nadir track, and which offer the greatest coverage in the cell. The MOD10GA generation process stores the selected observation's NDSI_Snow_Cover, NDSI_Snow_Cover_Basic_QA,

NDSI_Snow_Cover_Basic_QA, and NDSI (raw) as separate SDSs, calculates descriptive QA statistics, and then writes the data and metadata into MOD10A1.

For more information about the MOD10_L2 data set, see the MODIS/Terra Snow Cover 5-Min L2 Swath 500m, Version 6 [documentation](#).

3.4.1.2 Snow Albedo

Although snow albedo in Version 6 is computed during the MOD10GA generation process, the algorithm is the same as Version 5. Once the best MOD10_L2 observations have been selected, snow albedo is calculated for the corresponding pixels in the [MOD09GA](#) land-surface reflectance product using the MOD09GA visible and near infrared (VNIR) bands. Land cover type is read from the MODIS combined land cover product (MCDLCHKM) and an anisotropic response function corrects for anisotropic scattering effects in non-forested areas. Snow-covered forests are assumed to be Lambertian reflectors. The snow albedo algorithm is described in Klein and Stroeve, 2002. Additional details about all the MODIS snow cover data sets are available in the [Algorithm Theoretical Basis Document](#) (ATBD).

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% to 93%. For this data set, choosing a single, best observation of the day results in a weave or stitch pattern along the edges of adjacent swaths. This pattern is most apparent where cloud cover changed between the acquisition times of overlapping swaths. In addition, users may encounter interwoven cloud and clear observations in images with snow cover. Differences in viewing geometry can also produce discontinuities in regions where adjacent swaths overlap.

Geolocation error may be visible due to: a) uncertainty in swath geolocation; and b) the process of gridding and projecting the swaths into the MODIS Sinusoidal Tile Grid from day to day. This latter effect, a so-called geolocation wobble, is most commonly observed as daily shifts in the position of a lake by one or more cells in the horizontal or vertical directions. Thus, compositing tiles over the course of several consecutive days may result in blurred lake outlines.

Snow albedo is estimated to be within 10% of surface measured values, based on both published studies (see Klein and Stroeve, 2002 and Tekeli et al., 2006) and unpublished evaluations. However, this estimate assumes optimal conditions for the algorithm, such as a level surface and

complete snow cover in the cell. Errors could be much higher where the conditions are less favorable for determining snow albedo, for example over steep mountain terrain. Note that this data set does not report snow albedo-specific QA. The MODIS Science Team is still investigating the best way to express this metric.

Finally, anomalies in the input data can propagate to the output. Table 3 in the [MOD10_L2 documentation](#) lists the products that are used as input to the snow cover 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

Quality Assessment (QA) in Version 6 consists of:

- Basic QA values stored in `NDSI_Snow_Cover_Basic_QA`
- Bit flags stored in `NDSI_Snow_Cover_Algorithm_Flags_QA` that report data screen results

Basic QA values provide a qualitative estimate of the algorithm result for a pixel based on the input data and solar zenith data. The basic QA value is initialized to "best" and then adjusted as needed based on the quality of the MOD02HKM input radiance data and the solar zenith angle screen. If the MOD02HKM data (TOA reflectance) lie outside the range of 5% to 100% but are still usable, the QA value is set to good. If the solar zenith angle is in range of $70^\circ \leq \text{solar zenith angle} < 85^\circ$, the QA is set to okay to indicate the increased uncertainty stemming from low illumination. If the input data are unusable, the QA value is set to "other." The conditions for a poor result are not defined (i.e. this value is not currently used). Features that are masked, like night and ocean, use the same values as the snow cover SDS.

Bit flags can be used to investigate results for all pixels which have been processed for snow. By examining the bit flags, users can determine if any of the data screens: a) changed a pixel's initial result from "snow" to "not snow"; or b) flagged snow cover in a pixel as uncertain. The "Section 1.7.1 | Interpreting `NDSI_Snow_Cover_Algorithm_Flags_QA`" above describes each data screen and the conditions that result in its bit flag being set .

The basic QA and bit flags are both determined when MOD10_L2 is generated. These data are retrieved with the corresponding observation of the day.

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 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

3.6.1 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 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

Hall, D.K., and G.A. Riggs. 2011. Normalized-difference snow index (NDSI). Encyclopedia of Snow, Ice and Glaciers, Encyclopedia of Earth Sciences Series. 779-780. doi:

http://dx.doi.org/10.1007/978-90-481-2642-2_376.

Derksen, C. and R. Brown. 2012. Spring snow cover extent reductions in the 2008-2012 period exceeding climate model projections. *Geophysical Research Letters* (39). Art. #L19504. doi:

<http://dx.doi.org/10.1029/2012GL053387>.

Gladkova, I., M., Bonev G. Grossberg, P. Romanov, and F. Shahriar. 2012. Increasing the accuracy of MODIS/Aqua snow product using quantitative image restoration technique. *IEEE Geoscience and Remote Sensing Letters* 9(4):740-743. doi:

<http://dx.doi.org/10.1109/LGRS.2011.2180505>.

Klein, A.G. and J. Stroeve. 2002. Development and validation of a snow albedo algorithm for the MODIS instrument. *Annals of Glaciology* 34:45-52. doi:

<http://dx.doi.org/10.3189/172756402781817662>.

Masuoka, E., A. Fleig, R.E. Wolfe, and F. Patt. 1998. Key characteristics of MODIS data products. *IEEE Transactions on Geoscience and Remote Sensing* 36(4):1313-1323.

Riggs, George A. and Dorothy K. Hall. 2016. *MODIS Snow Products Collection 6 User Guide*. <https://nsidc.org/sites/nsidc.org/files/files/MODIS-snow-user-guide-C6.pdf>.

Salomonson, V.V. and I. Appel. 2004. Estimating the fractional snow covering using the normalized difference snow index. *Remote Sensing of Environment* 89(3):351-360. doi:

<http://dx.doi.org/10.1016/j.rse.2003.10.016>.

Salomonson, V.V. and I. Appel, 2006: Development of the Aqua MODIS NDSI fractional snow cover algorithm and validation results, *IEEE Transactions on Geoscience and Remote Sensing* 44(7):1747-1756. doi: <http://dx.doi.org/10.1109/TGRS.2006.876029>.

Tekeli, A.E., A. Sensoy, A. Sorman, Z. Akyürek, and Ü. Sorman. 2006. Accuracy assessment of MODIS daily snow albedo retrievals with in situ measurements in Karasu basin, Turkey. *Hydrological Processes* 20:705–721. doi: <http://dx.doi.org/10.1002/hyp.6114>.

Wolfe, R.E., D.P. Roy, and E. Vermote. 1999. MODIS land data storage, gridding and compositing methodology: level 2 grid. *IEEE Transactions on Geoscience and Remote Sensing* 36(4):1324-1338.

Wolfe, R.E. 2006. MODIS Geolocation. *Earth Science Satellite Remote Sensing*, Eds. Qu J.J, Wei, G, Menas, K, Murphy, R.E. and Salomonson, VV. Springer Berlin Heidelberg. 50-73. doi: http://dx.doi.org/10.1007/978-3-540-37293-6_4.

Wolfe, R.E. and M. Nishihama. 2009. Trends in MODIS geolocation error analysis. *Proc. SPIE* 7452, *Earth Observing Systems XIV*, 74520L (August 24, 2009). doi: <http://dx.doi.org/10.1117/12.826598>.

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 5-Min L2 Swath 500m, Version 6 \(MOD10L2\)](#)
- [MODIS/Aqua Snow Cover Daily L3 Global 500m Grid, Version 6 \(MYD10A1\)](#)
- [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

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

6.1 Document Creation Date

February 2004

6.2 Document Revision Dates

August 2007

March 2016

December 2021

August 2023