MODIS/Terra Snow Cover Daily L3 Global 500m SIN Grid, Version 61

USER GUIDE

How to Cite These Data

As a condition of using these data, you must include a citation:

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

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

National Snow and Ice Data Center

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1 DATA DESCRIPTION

Snow-covered land typically has very high reflectance in visible bands and very low reflectance in shortwave infrared bands. The Normalized Difference Snow Index (NDSI) reveals the magnitude of this difference. The snow cover algorithm calculates NDSI for all land and inland water pixels in daylight using Terra MODIS band 4 (visible green) and band 6 (shortwave near-infrared). The Scientific Data Sets (SDSs) included in this product are listed in Table 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
`NDSI_Snow_Cover`	Gridded NDSI snow cover and data flag values.	NDSI snow cover values and data flags values, stored as 8-bit unsigned integers: 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`	A general estimate of the quality of the algorithm result.	Quality assessment flag values: 0: best 1: good 2: ok 3: poor (not used) 4: other (not used) 211: night 239: ocean 255: unusable input or no data

Parameter	Description	Values
`NDSI_Snow_Cover _Algorithm_Flags_QA`	Algorithm-specific bit flags set for data screens and for inland water.	Bit flag values: Bit 0: Inland water screen Bit 1: Low visible screen failed, snow detection reversed to no snow Bit 2: Low NDSI screen failed, snow detection reversed to no snow Bit 3: Combined temperature/height screen failed • 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. Bit 4: High Shortwave IR (SWIR) refectance screen • Snow pixel with SWIR > 0.45, flag set, snow detection reversed to not snow, OR; • Snow pixel with 0.25 < SWIR ≤ 0.45, flag set to indicate unusual snow conditon, snow detection NOT reversed. Bit 5: Cloud possible screen, probably cloudy Bit 6: Cloud possible screen, probably clear Bit 7: Uncertain snow detection due to low illumination
`NDSI`	Raw NDSI values (i.e. prior to screening).	NDSI Values are scaled by 1 x 10^4. -10000 to 10000: valid values -32768: fill value

Parameter	Description	Values
`Snow_Albedo_Daily_Tile`	Daily snow albedo corresponding to the NDSI_Snow_Cover parameter.	0–100: 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: landmask mismatch 253: BRDF_Failure * 254: non-production_mask
`orbit_pnt`	Pointer to the orbit of the swath mapped into each grid cell. For details, see Section 1.1.2 below.	0-15: valid data range 255: fill value
`granule_pnt`	Pointer for identifying the swath mapped into each grid cell. For details, see the section 'Using the granule_pnt' below.	0-254: valid data range 255: fill value
`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
* Bidirectional Reflectance Distribution Function (Klein and Stroeve, 2002)		

1.1.1 Interpreting the parameter: NDSI_Snow_Cover_Algorithm_Flags_QA

Pixels determined to have some snow present are subjected to a series of screens that have been specifically developed to alleviate snow commission errors (detecting snow where there is no snow) and to flag uncertain snow detections. In addition, snow-free pixels are screened for very low illumination conditions to prevent possible snow omission errors. Screen results, as well as the location of inland water, are stored as bit flags in the `NDSI_Snow_Cover_Algorithm_Flags_QA` SDS. Refer to the Appendix of this document for a detailed description of the Algorithm QA Flags.

To identify bit flag values, convert the decimal grid cell value to its binary equivalent. Bit values default to 0 and are set to 1 if the screen result is true. A visual example of the bit flag format for the decimal value '129' is provided in Figure 1.

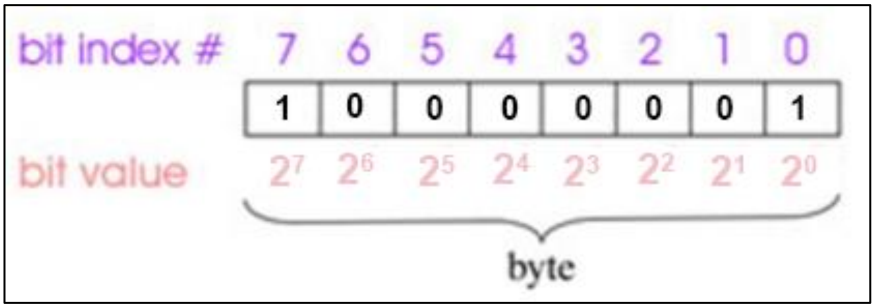

Figure 1. Bit flag format. The bit index positions are numbered from right (bit index 0) to left (bit index 7), and each index stores the result of a screen test. The bit values from right to left solve respectively to 1, 2, 4, 8, 16, 32, 64, and 128. In this example, bit index 0 and bit index 7 are set to true (1) with corresponding bit values 2^0 and 2^7 equaling '1' and '128', which, when summed equal '129'.

1.1.2 Using orbit_pnt

The 'orbit_pnt' SDS includes pointer values for identifying the orbit of the swath mapped into each grid cell. The pointer references by index the list of orbit numbers written to the ORBITNUMBERARRAY metadata object in 'ArchiveMetadata.0'.

1.1.3 Using granule_pnt

The 'granule_pnt' SDS includes pointer values for identifying the swath mapped into each grid cell. The GRANULEPOINTERARRAY metadata object written to 'ArchiveMetadata.0' 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.

1.2 File Information

1.2.1 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.

1.2.2 Data File

As shown in Figure 2, each data file includes three data fields (`NDSI_Snow_Cover`, `NDSI`, and `Snow_Albedo_Daily_Tile`), two data quality fields (`NDSI_Snow_Cover_Basic_QA` and `NDSI_Snow_Cover_Algorithm_Flags_QA`), two ancillary data fields (`orbit_pnt` and `granule_pnt`), three geolocation fields (Projection, `XDim` and `YDim`), and three metadata fields (`ArchiveMetadata.0`, `CoreMetadata.0`, and `StructMetadata.0`).

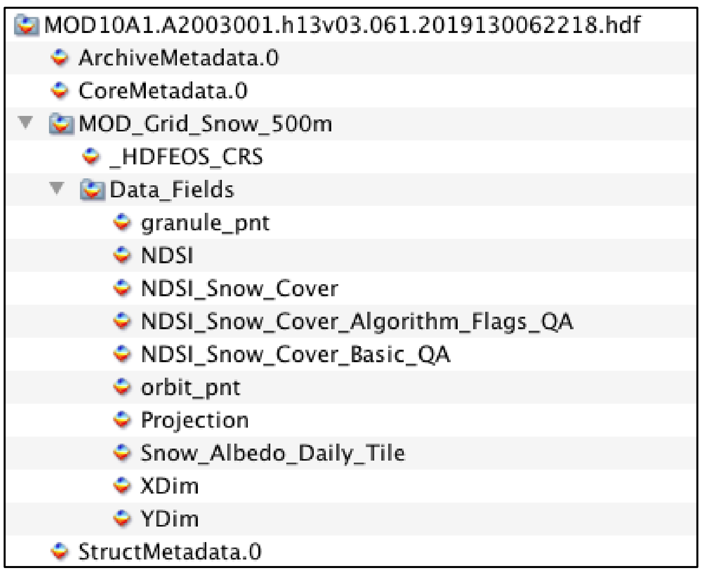

Figure 2. This figure shows the fields included in each data file as displayed with Panoply software.

1.2.3 Ancillary Files

A browse image file (`.jpg`) and metadata file (`.xml`) are provided with each data file.

1.2.4 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:

`MOD10A1.A2003001.h13v03.061.2019130062218`

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.

1.3 Spatial Information

1.3.1 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)

1.3.2 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.

1.3.3 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.

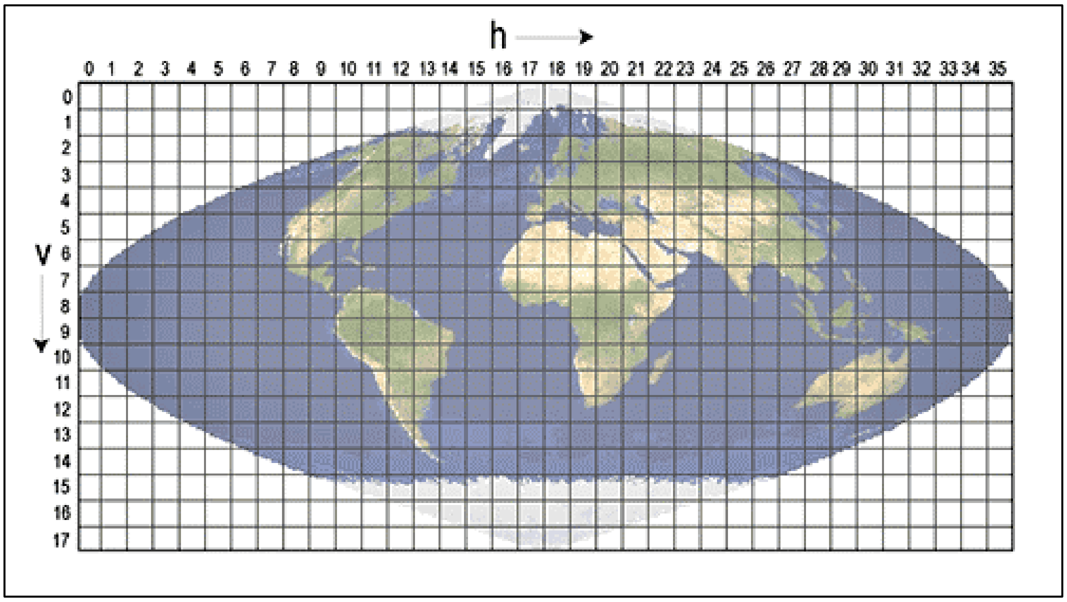

Figure 3. MODIS Sinusoidal Tile Grid

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

1.3.4 Resolution

The nominal spatial resolution is 500 meters.

1.3.5 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)

1.4 Temporal Information

1.4.1 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.

1.4.2 Resolution

Daily

1.5 Sample Data Image

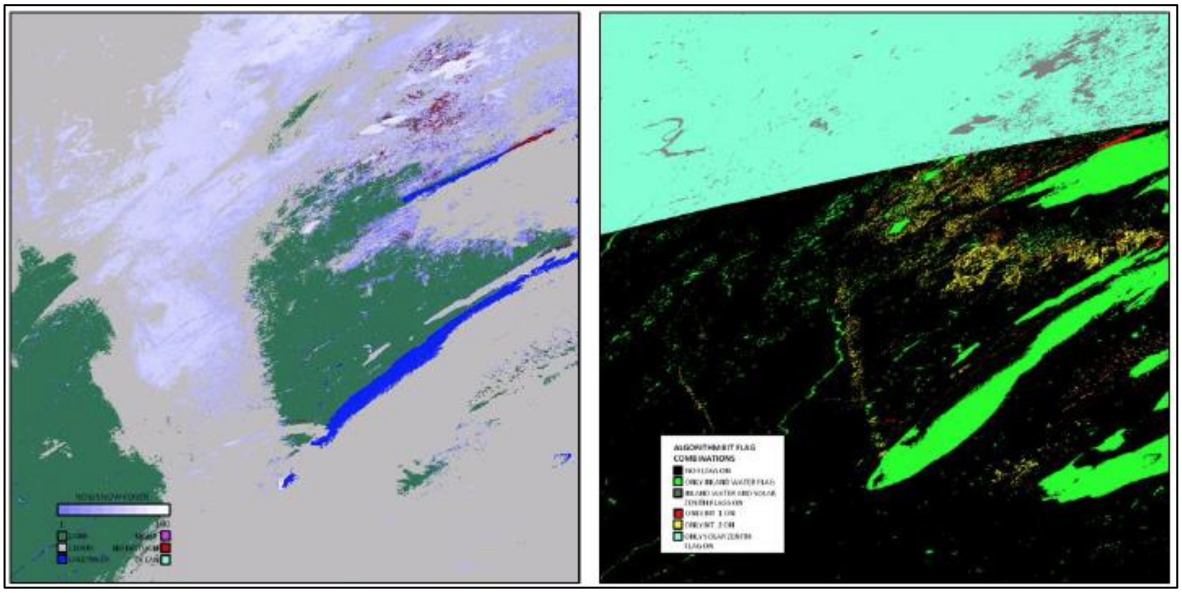

Figure 4. This figure shows daily NDSI_Snow_Cover (left) and NDSI_Snow_Cover_Algorithm_Flags_QA (right), acquired on 14 January 2003, from MOD10A1 tile h11v04, covering an area in the western Great Lakes region of North America.

2 DATA ACQUISITION AND PROCESSING

2.1 Background

The objective for the MODIS snow cover algorithm in Collection 6.1 (C6.1) is to minimize snow cover detection errors of omission and commission for the purpose of mapping snow cover extent (SCE) accurately on the global scale. The algorithm is the same as that used in Collection 6.0 (C6.0), with minor revisions made for the low visible reflectance screen and to the quality information flags. Specific updates to the snow cover algorithm in C6.1 include:

- The low visible reflectance screen for snow cover using bands 2 and 4 was lowered to 0.07 reflectance from 0.10.
- Two algorithm bit flags are set in the MOD35_L2 cloud mask and confidence flags of 'probably cloudy' and 'probably clear' are set in the algorithm flags QA dataset.

Based on these algorithm enhancements, users should expect to see fewer 'no decision' results in C6.1 data sets. In general, the lowering of the visible reflectance screen has been observed to change 'no decision' results to 'snow' or 'not snow'; 'no decision' results are limited to very low,

< 0.07, reflectance situations. The MODIS cloud mask (MOD35_L2) flags for 'probably cloudy' and 'probably clear' are now included in the 'NDSI_Snow_Cover_Algorithm_Flags_QA' SDS so they can be used to evaluate possible cloud/snow confusion situations.

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 (e.g., 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.

2.3 Processing

This Level-3 data set is generated from the *MODIS/Terra Snow Cover 5-Min L2 Swath 500m* (MOD10_L2) product.

2.3.1 Snow Cover

A gridding algorithm maps all MOD10_L2 C6.1 swaths into an intermediate snow cover product (MOD10GA), which is not archived at NSIDC. The algorithms which select the day's best snow cover observation and compute snow albedo are incorporated into the MOD10GA generation process.

Once the data have been gridded, the selection algorithm identifies the best observation from the one to several MOD10_L2 C6.1 swaths mapped into each grid cell. The criteria used to select these swaths include: which observations were acquired nearest local solar noon, which were nearest the orbit nadir, and which offer the greatest coverage in the cell. The MOD10GA generation process stores 'NDSI_Snow_Cover', '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 a revised explanation of the NDSI snow cover algorithm theory, see the NASA VIIRS Snow Cover ATBD (Riggs et al., 2015). The MODIS and VIIRS snow cover algorithms both use the NDSI snow detection algorithm, albeit adjusted for sensor and input data product differences.

2.3.2 Snow Albedo

The Snow Albedo algorithm used in C6.1 is the same algorithm used in C6.0. Snow albedo is calculated during the MOD10GA generation process for all NDSI snow cover observations. Once the best MOD10_L2 C6.1 observations have been selected, snow albedo is calculated for corresponding pixels in the MOD09GA land-surface reflectance product using the visible and near-infrared (VNIR) bands. An anisotropic response function is used to correct for the anisotropic scattering effects of snow in non-forested areas; snow-covered forests are assumed to be Lambertian reflectors. Land cover type is read from the MODIS combined land cover product (MCDLCHKM). Slope and aspect data for the correction are derived from the Global 30 Arc-second (GTOPO30) digital elevation model (DEM). The narrow band albedos are then converted to a broadband albedo for snow. For a detailed description of the snow albedo algorithm see Klein and Stroeve, 2002.

2.4 Quality Information

2.4.1 Basic Quality Assurance

Basic quality assurance (QA) values are stored in 'NDSI_Snow_Cover_Basic_QA' parameter. These 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 (SZA) is in range of 70° ≤ SZA < 85°, the QA is set to 'ok', which indicates an increased uncertainty stemming from low illumination. If the input data are unusable, the QA value is set to 'other'. Features that are masked, like 'night' and 'ocean', use the same values as the 'NDSI_Snow_Cover' parameter.

2.4.2 Bit Flags

Bit flags are stored in the 'NDSI_Snow_Cover_Algorithm_Flags_QA' parameter and are used to report data screen results. 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.' See the 'MODIS Snow Products Collection 6.1 User Guide' (Riggs et al., 2019) for details regarding how each data screen should be interpreted.

2.5 Errors

2.5.1 Snow Cover

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%.

Uncertainty associated with detecting NDSI snow cover is presented in the MOD10_L2 User Guide and the 'MODIS Snow Products Collection 6.1 User Guide' (Riggs et al., 2019).

2.5.2 Albedo

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, such as 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.

2.5.3 Swath Selection

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.

2.5.4 Geolocation

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.

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 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
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.
- 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.

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

March 2021

8.2 Date Last Updated

March 2021

APPENDIX - DATA SCREENS

This appendix provides a description of the data screen tests applied in the 'NDSI_Snow_Algorithm_bit_flags_QA' SDS.

INLAND WATER SCREEN: BIT 0

Inland water bodies are identified using bit 0. The pixels identified by this flag are set to '237' in the 'NDSI_Snow_Cover' SDS.

LOW VISIBLE REFLECTANCE SCREEN: BIT 1

This screen is used to prevent errors from occurring when the reflectance is too low for the algorithm to perform well. The screen is applied to non-cloud pixels with NDSI ≥ 0.0. If the visible reflectance from MODIS band 2 or band 4 is < 0.07, bit 1 is set and a value of 'no decision' is set for pixels in the 'NDSI_Snow_Cover' SDS.

LOW NDSI SCREEN: BIT 2

This screen is used to prevent errors from occurring where the difference between visible and shortwave reflectance is very small, thus resulting in very low but positive NDSI values. Uncertain snow detections or snow commission errors are common when 0.0 ≤ NDSI < 0.1. Therefore, if NDSI < 0.1 a snow detection is reversed to 'not snow', and bit 2 is set. This flag can be used to find pixels where snow cover detections were reversed to 'not snow'.

ESTIMATED SURFACE TEMPERATURE AND SURFACE HEIGHT SCREEN: BIT 3

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 (Tb), if snow is detected in a pixel with height < 1300 m and Tb ≥ 281 K, the pixel is reversed to 'not snow' and bit 3 is set. If snow is detected in a pixel with height ≥ 1300 m and Tb ≥ 281 K, the pixel is flagged as 'unusually warm' and bit 3 is set.

HIGH SWIR REFLECTANCE SCREEN: BIT 4

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 shortwave infrared reflectance (SWIR) is anomalously high. Snow typically has a SWIR reflectance of less than 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 is set. Snow pixels with 0.25 < SWIR ≤ 0.45 are flagged as having an 'unusually high SWIR' and bit 4 is set.

CLOUD POSSIBLE SCREENS: BITS 5 & 6

This screen is utilized to identify cloud conditions using the 'Unobstructed FOV Quality Flag' from the MOD35_L2 product. If the MOD35_L2 quality flag is 'confident cloudy' the pixel is masked as 'cloud' and bit 5 is set to 'probably cloudy'. If the MOD35_L2 quality flag is set 'confident clear,' 'probably clear' or 'probably cloud' the condition is interpreted as 'clear' by the algorithm and the bit 6 flag is set to 'probably clear'. These cloud confidence flags are included to enable the snow cover to be evaluated with respect to cloud/snow confusion situations.

SOLAR ZENITH SCREEN: BIT 7

This screen is utilized to identify low illumination conditions. When solar zenith angles exceed 70°, the low illumination challenges snow cover detection. As such, pixels with solar zenith angles > 70° are flagged by setting bit 7. This solar zenith mask is set across the entire swath. **Note**: night is defined as a solar zenith angle ≥ 85°. Night pixels are assigned a value '211' in the 'NDSI_Snow_Cover_Algorithm_Flags_QA' SDS and the 'NDSI_Snow_Cover' SDS.