MODIS/Aqua 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/Aqua 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. doi: https://doi.org/10.5067/MODIS/MYD10A1.006. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/MYD10A1

National Snow and Ice Data Center

TABLE OF CONTENTS

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/Aqua Snow Cover 5-Min L2 Swath 500m (MYD10_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.

Note: Version 6 incorporates a recently developed Quantitative Image Restoration (QIR) technique that restores Aqua MODIS band 6 data to scientific quality. Thus the snow detection algorithms are now the same for Aqua and Terra. See "Section 3.3 | Derivation Techniques and Algorithms" for additional details.

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:

```
MYD10A1.A2003001.h18v15.006.2016062165512.hdf

MYD[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
MYD	MODIS/Aqua
PID	Product ID
A	Acquisition date follows
YYYY	Acquisition year
DDD	Acquisition day of year

Variable	Description
h[NN]v[NN]	Horizontal tile number and vertical tile number (see “Section 1.4.3 | Grid” 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

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. Aqua's sun-synchronous, near-polar circular orbit is timed to cross the equator from south to north (ascending node) at approximately 1:30 P.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 Aqua's orbital path:

- Daily Aqua 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 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):

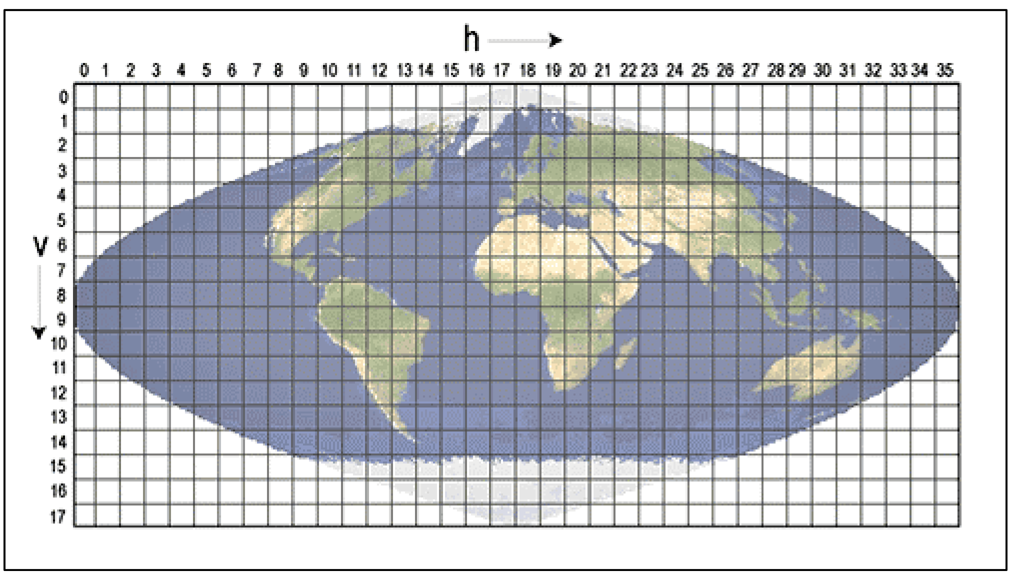

Figure 1. MODIS Sinusoidal Tile Grid. Tiles cover 10° x 10° at the equator or approximately 1200 km by 1200 km. For additional details about the MODIS Sinusoidal Tile Grid, see the NASA MODIS Lands | MODIS Grids Web page.

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)

1.5 Temporal Information

MODIS Aqua data are available from 04 July 2002 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 Aqua mission have resulted in minor data outages. If you cannot locate data for a particular date or time, check the MODIS/Aqua Data Outages Web page.

1.5.1 Temporal Resolution

Daily

1.6 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 2 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	NDSI snow cover plus other results. This value is computed for MYD10_L2 and retrieved when the observation of the day is selected. Possible values are: 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 basic estimate of the quality of the algorithm result. This value is computed for MYD10_L2 and retrieved with the corresponding observation of the day. Possible values are: 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	Bit flags indicating screen results and the presence of inland water. See "Section 1.6.1 | Interpreting the NDSI_Snow_Cover_Algorithm_Flags_QA SDS" for a description. These flags are set when MYD10_L2 is generated and retrieved with the corresponding observation of the day. Bits are set to on (1) as follows: Bit 0: Inland water Bit 1: Low visible screen failed. Snow detection reversed. Bit 2: Low NDSI screen failed. Snow detection reversed. Bit 3: Combined temperature/height screen failed. On means *either*: 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: Shortwave IR (SWIR) reflectance anomalously high. On means *either*: Snow pixel with SWIR > 0.45, flag set, snow detection reversed to not snow, OR; Snow pixel with 25% < SWIR <= 45%, flag set to indicate unusual snow conditon, snow detection NOT reversed. Bit 5: spare Bit 6: spare Bit 7: solar zenith screen failed, uncertainty increased.
NDSI	Raw NDSI (i.e. prior to screening) reported in the range 0–10,000. Values are scaled by 1 x 10^4. This value is computed for MYD10_L2 and retrieved with the corresponding observation of the day

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 1.6.2 | Using granule_pnt" for more information.

1.6.1 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.

1.6.1.1 Low Visible Reflectance Screen

This screen is applied to prevent errors from occuring 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.

1.6.1.2 Low NDSI screen

Pixels detected as having snow cover with 0.0 < 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.

1.6.1.3 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 (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 in the NDSI_Snow_Cover_Algorithm_Flags_QA SDS. If snow is detected in a pixel with height ≥ 1300 m and Tb ≥ 281 K, the pixel is flagged as unusually warm by setting bit 3 in the NDSI_Snow_Cover_Algorithm_Flags_QA SDS.

1.6.1.4 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 < SWIR reflectance ≤ 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.

1.6.1.5 Solar zenith screen

When solar zenith angles exceed 70°, the low illumination challenges snow cover detection. As such, pixels with solar zenith angles > 70° 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 ≥ 85°. Night pixels are assigned a value 211.

1.6.1.6 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.

1.6.2 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.

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
- Aqua Project Science | Aqua Earth-Observing Satellite Mission
- 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

Fifteen of the 20 band 6 detectors on the Aqua MODIS failed shortly after launch, a 75 percent signal loss that has precluded using this band for snow detection. However, a Quantitative Image Restoration (QIR) technique was recently developed (Gladkova et al., 2012) that restores Aqua MODIS band 6 data to scientific quality. Version 6 incorporates this technique to produce an intermediate, calibrated radiances product with band 6 restored: MYD02HKM_QIR (this product is not retained). Aside from this step, the snow detection algorithm is the same for Aqua and Terra.

For MYD10_L2, the algorithm detects snow by computing the Normalized Difference Snow Index (NDSI) (Hall and Riggs, 2011) from MYD02HKM_QIR. 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 MYD10_L2 swaths into an intermediate snow cover product (MYD10GA) 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 MYD10GA generation process. Note that MYD10GA 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 MYD10_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 MYD10GA 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 MYD10A1.

For more information about the MYD10_L2 data set, see the MODIS/Aqua 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 MYD10GA generation process, the algorithm is the same as Version 5. Once the best MYD10_L2 observations have been selected, snow albedo is calculated for the corresponding pixels in the MYD09GA land-surface reflectance product using the MYD09GA 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 Errors 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 produces 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 MYD10_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 MYD02HKM input radiance data and the solar zenith angle screen. If the MYD02HKM 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° ≤ solar zenith angle < 85°, 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. “Section 1.6.1 |

Interpreting the NDSI_Snow_Cover_Algorithm_Flags_QA SDS" 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 MYD10_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, 1:30 A.M. ascending node (Aqua), 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

Variable	Description
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.

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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/Aqua Snow Cover 5-Min L2 Swath 500m, Version 6 (MYD10L2)

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

4.3 Related Web Sites

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

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