MODIS/Terra Global Annual 0.01Deg CMG Snow Cover Climatology, Version 1

USER GUIDE

How to Cite These Data

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

Johnston, J.M., J.M. Jacobs, and E. Cho. 2024. *MODIS/Terra Global Annual 0.01Deg CMG Snow Cover Climatology, Version 1*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/9R1AM6NNZLTV. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/NSIDC-0791

National Snow and Ice Data Center

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1 DATA DESCRIPTION

This data set presents new global snow cover classification regimes derived from the MODIS Terra cloud gap-filled NDSI data (MOD10A1F), elevation, and temperature climatology inputs. The six data granules are available as NetCDF (.nc) files, with each containing a unique snow cover parameter spanning 2001 to 2023. The six parameters included in this data set are: (1) snow class climatology (SSC), (2) core snow season length (CSS), (3) snow cover duration (SCD), (4) full snow season length (FSS), (5) snow persistence (SP), and (6) snow season persistence (SSP).

1.1 Parameters

This data set presents six different image-based data files, each containing a different snow cover parameter and corresponding climatology, which represents each parameter averaged for the water years 2001-2023. Each parameter is described in Table 1.

1.2 File Information

1.2.1 Format

Data are provided as NetCDF files.

1.2.2 File Contents

Each file contains a unique parameter variable and corresponding average variable (i.e., climatology) and three global variables, as described in Table 1 and Table 2 below.

Table 1. Description of Unique Variables

File Short Name	Parameters	Description	Unit
SCD	Snow cover duration	Length of time an area was covered by snow	Days
	Snow cover duration climatology	Average snow cover duration	Days
CSS	Core snow season length	Maximum consecutive snow-cover duration	Days
	Core snow season length climatology	Average core snow season length	Days
FSS	Full snow season length	Length of the period between the first and last snow-cover observation	Days

	Full snow season length climatology	Average full snow season length	Days
SP	Snow persistence	Proportional snow cover during a specified snow year, calculated as the number of days with snow cover duration (SCD) divided by the total number of days in the snow year	-
	Snow persistence climatology	Average snow persistence	-
SSP	Snow season persistence	Proportional snow cover for the full snow season (FSS), calculated as snow cover duration (SCD) divided by FSS	-
	Snow season persistence climatology	Average snow season persistence	-
SSC	MODIS snow cover seasonality classification	Snow classification regime • (0) No Snow • (1) Ephemeral Snow • (2) Transitional Snow • (3) Seasonal Snow • (4) Perennial Snow • (255) Fill/Water	Integer between 0 - 4
	Snow seasonality class climatology	Average snow classification	Value between 0 - 4

Table 2. Description of Global Variables

Parameter	Variable	Description	Unit
All	Time	The calendar year in which the snow year ends, defined as [start YYYY, end YYYY] for the following regions: • Northern Hemisphere: [August 1 of YYYY, July 31 of YYYY+ 1] • Southern Hemisphere, [March 1 of YYYY, April 30 of YYYY + 1]	Days since 2000
	Latitude	Coordinates define grid center latitude	Degrees North
	Longitude	Coordinates define grid center longitude	Degrees East

1.2.3 Naming Convention

Date files are named according to the following convention and as described in Table 3.

```
NSIDC-0791_[parameter]_0.01Deg_WY2001-2023_V01.0.nc
```

Table 3. File Naming Variable Descriptions

Variable	Description
NSIDC-0791	NSIDC data set ID
[parameter]	Data parameter contained in file (see Table 1 for full explanation): • SSC: Snow class climatology • CSS: Core snow season length • SCD: Snow cover duration • FSS: Full snow season length • SP: Snow persistence • SSP: Snow season persistence
0.01Deg	Spatial resolution (0.01 degrees)
WY2001-2023	Temporal span of file contents (2001 to 2023 water year)
V01.0	Data set version 1.0
.nc	File extension (NetCDF)

1.3 Spatial Information

1.3.1 Coverage

Global

1.3.2 Resolution

0.01 deg

1.3.3 Geolocation

The following table provides information for geolocating this data set.

Table 4. Geolocation Details

Geographic coordinate system	WGS 84
Datum	WGS 1984
Ellipsoid/spheroid	WGS 84
Units	meters
EPSG code	4326
PROJ4 string	+proj=longlat +datum=WGS84 +no_defs +type=crs
Reference	https://epsg.io/4326

1.4 Temporal Information

1.4.1 Coverage

01 March 2000 to 31 July 2023

1.4.2 Resolution

Varies

2 DATA ACQUISITION AND PROCESSING

2.1 Background

This data set presents six data files derived from MODIS Terra cloud gap-filled NDSI products (MOD10A1F), elevation, and temperature climatology inputs, including: (1) snow class climatology (SSC); (2) core snow season length (CSS); (3) snow cover duration (SCD); (4) full snow season length (FSS); (5) snow persistence (SP); and (6) snow season persistence (SSP).

The snow class climatology product presents a new 5-class snow cover classification regime, including: (1) No Snow, (2) Ephemeral Snow, (3) Transitional Snow, (4) Seasonal Snow, and (5) Perennial Snow. Each class presents unique characteristics in terms of persistence, timing, and unique isolated periods of snow cover and is observationally based.

2.2 Processing

Processing methods used to produce this data set include: (1) using preexisting MOD10A1F data to derive a fully gap-filled daily snow cover record, and (2) using that record to create a new snow regime classification framework based on machine learning algorithms. Brief summaries of these methods can be found below, while a full description is available in Johnson et al. (2024).

2.2.1 Derivation of Gap-Filled Snow Cover Record

- Regridding: The Normalized Difference Snow Index (NDSI) values (Riggs et al., 2016) from MOD10A1F are remapped from their original 500 m resolution to a 0.01° global grid. If cases of multiple values are present within a single grid cell, a spatial mean was calculated.
- Conversion: NDSI values are converted to binary snow-covered area (SCA) values, using a threshold of 0.1 where values below 0.1 are set to 0 and values above 0.1 are set to 1.

- False Classification Removal: False snow observations were eliminated from the data by using a 0.1° × 0.1° moving window to reclassify regions with > 50% classified pixels (land or snow) and <33% snow cover as *land*.
- Masking: Snow cover over land is defined using the global land mask from Mikelson et al. (2021). Additionally, high latitude regions over Antarctica and Greenland where snow is present > 95% of the time are classified as *perennial snow*.
- Snow Line Gap-filling: Global snow-cover probabilities estimated using MOD10A1 data, in conjunction with elevation data (SRTM30_PLUS; Becker et al., 2009), and air temperature data (ERA5-Land; Muñoz-Sabater et al., 2021), were used to define the minimum snow line elevation.
- Temporal Gap-filling: Regions unclassified due to temporal gaps in the MOD10A1F data were filled by using a 0.1° × 0.1° moving window to classify regions with > 33% data points classified as snow as *snow* and the remaining regions as *land*.

2.2.2 Creation of Snow Regime Classification Framework

- Masks are applied to regions of *perennial snow* (>92% yearly snow cover) or *no snow*, which are excluded from the machine-learning classification process.
- Snow-Covered Area (SCA) metrics were calculated from the remaining regions and normalized.
- A combination of unsupervised and supervised machine learning steps were applied to the calculated SCA metrics in the following order: (1) principal component analysis; (2) k-means clustering; and (3) decision tree classification and optimization.
- The output of the machine learning process classifies the remaining regions as either having *ephemeral*, *transitional*, or *seasonal snow*.

2.3 Quality, Errors, and Limitations

Known limitations to the methods used to produce this new snow regime classification include the potential misidentification of high persistence snow in regions actually characterized by white ground features (such as sand or salt flats) adjacent to water bodies. This is due to the chosen NDSI threshold used when calculating the binary snow-covered area values. The use of a lower NDSI threshold (0.1) was employed to minimize missed snow classification in regions with forest cover. Gap-filling and interpolation over very high latitude regions (>80°N/S) can also lead to artifacts in the data. Manual corrections were applied to the data set to offset these potential limitations. Additional details regarding known errors and limitations to this data set can be found in Johnston et al. (2024).

3 VERSION HISTORY

Table 5. Version History Summary

Version	Release Date	Description of Changes
1	April 2024	Initial release

4 RELATED DATA SETS

MODIS/Terra Snow Cover Daily L3 Global 500m SIN Grid, Version 6.1

MODIS/Terra CGF Snow Cover Daily L3 Global 500m SIN Grid, Version 6.1

5 RELATED WEBSITES

MODIS: Overview

6 REFERENCES

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Muñoz-Sabater, J., Dutra, E., Agustí-Panareda, A., Albergel, C., Arduini, G., Balsamo, G., Boussetta, S., Choulga, M., Harrigan, S., Hersbach, H., Martens, B., Miralles, D. G., Piles, M., Rodríguez-Fernández, N. J., Zsoter, E., Buontempo, C., and Thépaut, J.-N. (2021). ERA5-Land: a state-of-the-art global reanalysis dataset for land applications, Earth Syst. Sci. Data, 13, 4349–4383, https://doi.org/10.5194/essd-13-4349-2021

7 DOCUMENT INFORMATION

7.1 Publication Date

April 2024

7.2 Date Last Updated

April 2024