



MEaSURES Northern Hemisphere Terrestrial Snow Cover Extent Weekly 100km EASE-Grid 2.0, Version 1

USER GUIDE

How to Cite These Data

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

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National Snow and Ice Data Center

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1 DETAILED DATA DESCRIPTION

This data set consists of weekly 100 km snow cover extent for the Northern Hemisphere. The presence of snow is determined from two sources:

- The NOAA/NCDC Northern Hemisphere Snow Cover Extent Climate Data Record (SCE CDR)
- A gap-filled record of snow cover derived from satellite passive microwave brightness temperatures (MW). The MW record is constructed from the following data sets:
 - [Nimbus-7 SMMR Pathfinder Daily EASE-Grid Brightness Temperatures](#)
 - [DMSP SSM/I-SSMIS Pathfinder Daily EASE-Grid Brightness Temperatures](#)

Separate variables report whether the SCE CDR and MW record indicate the presence of snow. A third variable merges the other two into a single representation of snow cover by using codes to specify whether none, one, or both the SCE CDR and MW record indicate snow.

1.1 Format

Data files are formatted in Network Common Data Form, Version 4 (NetCDF-4) (.nc) following version 1.6 of the Climate and Forecast (CF) metadata conventions. For more information about working with NetCDF formatted data, visit the UCAR Unidata [Network Common Data Form](#) Web site.

1.2 File Naming Convention

This section explains the file naming convention used for this data set with an example.

Example File Name: nhtsw100e2_19661004_19661010_v01r01.nc

nhtswxxx2_YYYYMMDD_yyyymmdd_v01r01.nc

Refer to Table 1 for the valid values for the file name variables listed above.

Table 1. File Naming Convention Description

Variable	Description
nhts	Northern Hemisphere Terrestrial Snow
w	Weekly
xxx	Resolution (km)
e2	EASE-Grid 2.0
YYYYMMDD	First day of week (year, month, and day)
yyyymmdd	Last day of week (year, month, and day)
v01r01	Version 1.1
.nc	netCDF-formatted file

1.3 File Size

Data files are approximately 160 KB. The entire data set is approximately 375 MB.

1.4 Spatial Coverage

Northern Hemisphere:

Southernmost Latitude: 0.0°

Northernmost Latitude: 90.0°

Westernmost Longitude: -180.0°

Easternmost Longitude: 180.0°

1.4.1 Spatial Resolution

100 km

1.4.2 Projection and Grid Description

Data are provided at 100 km resolution in the Northern Hemisphere Equal Area Scalable Earth Grid 2.0 (EASE-Grid 2.0). Grid dimensions are 180 x 180. For a complete description of EASE-Grid 2.0, visit NSIDC's [EASE-Grid 2.0 Format Description](#) page.

This data set also utilizes a corresponding EASE-Grid 2.0, 100 km Land-Ocean-Coast-Ice (LOCI) mask that is derived from the Boston University MOD12Q1 V004 Land Cover Product (BU-MODIS) and distributed by NSIDC. To view documentation and obtain the BU-MODIS LOCI 100 km mask, visit the [EASE-Grid 2.0 Land-Ocean-Coastline-Ice Masks Derived from Boston University MODIS/Terra Land Cover Data](#) Web page.

1.5 Temporal Coverage

This data set extends from 3 October 1966 to 31 December 2012; however, users should note that the MW data record begins later, on 1 January 1979. Prior to this date, land cells in the MW gap-filled snow cover variable are filled with a value of 90 (missing).

1.5.1 Temporal Resolution

This data set consists of weekly snow cover. Each week runs from Tuesday through the following Monday.

1.6 Parameter or Variable

Snow cover extent, the parameter of interest in this data set, is represented by three different NetCDF variables. Data files contain additional variables that specify the latitude and longitude at the center of each EASE-Grid 2.0 cell, grid and projection parameters, and the number of days since 3 October 1966. Table 2 lists this data set's variable names with brief descriptions:

Table 2. Variable Names and Descriptions

Variable Name	Description	Dimensions	Data Type
weekly_climate_data_record_snow_cover_extent	Snow cover derived from NOAA/NCDC SCE CDR	180 x 180	byte (signed)
passive_microwave_gap_filled_snow_cover_extent	Snow cover derived from MW	180 x 180	byte (signed)
merged_snow_cover_extent	Codes indicating whether the SCE CDR and/or MW report snow	180 x 180	byte (signed)
latitude ¹	Latitude at the center of each 25 km EASE-Grid 2.0 cell	180 x 180	float ²
longitude ¹	Longitude at the center of each 25 km EASE-Grid 2.0 cell	180 x 180	float ²
cols	x coordinate, center of 100 km EASE-Grid 2.0 cell (m from origin)	1 x 180	int
rows	y coordinate, center of 100 km EASE-Grid 2.0 cell (m from origin)	180 x 1	int
coord_system	EASE-Grid 2.0 grid and projection parameters	—	char
time	Days since 10/03/1966	—	int
¹ Fill value for grid corners: -999 ² 32-bit single precision floating point			

1.6.1 Parameter Range

The two snow cover variables derived from individual sources indicate the location of snow and, where applicable, where the original data were changed to reconcile the source data's land-cover mask with the BU-MODIS LOCI 100 km mask described in the 1.4.2 section. In the merged snow cover extent variable, land and water areas, as well as permanent ice values masking out most of Greenland and some other areas, correspond to the BU-MODIS LOCI 100 km mask.

Refer to the following tables for keys to the values stored in the snow cover extent variables.

Table 3. Key for weekly_climate_data_record_snow_cover_extent

Value	Description
10	Snow covered land
11	Ocean converted to snow covered land
20	Snow free land
21	Ocean converted to snow free land
40	Ocean
41	Snow covered land converted to ocean
42	Snow free land converted to ocean
-99	Fill value for grid corners

Table 4. Key for passive_microwave_gap_filled_snow_cover_extent

Value	Description
10	Snow covered land
20	Snow free land
30	Permanent ice covered land
40	Ocean
90	Missing
-99	Fill value for grid corners

Table 5. Key for merged_snow_cover_extent

Value	Description
10	CDR and passive microwave report snow
11	CDR only reports snow
12	Passive microwave only reports snow
20	Snow free land
30	Permanent ice covered land
40	Ocean
-99	Fill value for grid corners

2 SOFTWARE AND TOOLS

2.1 Software and Tools

Unidata at the University Corporation for Atmospheric Research maintains an extensive list of freely available [Software for Manipulating or Displaying NetCDF Data](#).

3 DATA ACQUISITION AND PROCESSING

The following sections detail the source data and snow cover extent variables utilized by this data set.

3.1 NOAA/NCDC Northern Hemisphere Snow Cover Extent Climate Data Record

The weekly NOAA/NCDC Northern Hemisphere Snow Cover Extent (SCE) Climate Data Record (CDR) combines two snow cover products into a continuous SCE record that spans October 1966 to present.

Prior to May 1999, the SCE CDR is based on weekly, satellite-derived Northern Hemisphere snow cover extent maps. These maps were initially produced by trained NOAA meteorologists visually interpreting photographic copies of shortwave imagery, and as time progressed, new sources of imagery as they became available. This portion of the SCE CDR was previously re-processed for the NOAA Northern Hemisphere weekly snow cover extent product developed at Rutgers University.

From June 1999 onward, the SCE CDR is derived from National Ice Center (NIC) Interactive Multisensor Snow and Ice Mapping System (IMS) 24 km snow cover maps. The IMS maps are reformatted to correspond to the spatial and temporal resolution of the earlier NOAA product (pre-June 1999) and appended to the data record to produce the full SCE CDR.

IMS daily 24 km snow maps are produced by trained analysts at NIC using an interactive workstation application to incorporate a wide variety of satellite imagery, derived mapped products, and surface observations. Data sources include:

Visible and Infrared Spectral Data

- Advanced Very High Resolution Radiometer (AVHRR) Channels 1 & 3
- Geostationary Operational Environmental Satellite (GOES) East and West
- Meteosat 7

- Meteosat Second Generation (MSG)
- Moderate Resolution Imaging Spectroradiometer (MODIS) Channel 8
- Multi-functional Transport Satellite (MTSAT)
- Suomi National Polar-Orbiting Partnership

Ancillary Data

- Surface Observations (METAR)

Derived Data

- Air Force Weather Agency (AFWA) Snow Depth
- Advanced Microwave Scanning Radiometer for EOS (AMSR-E)
- Advanced Microwave Sounding Unit (derived snow, ice, and rain)
- Advanced Scatterometer (ASCAT)
- Envisat Advanced Synthetic Aperture Radar (ASAR) operating in Global Monitoring Mode
- SSMI/S (Derived snow, ice and rain)
- NASA Quick Scatterometer (QuikSCAT)
- NOAA Office of Satellite Data Processing and Distribution (OSDPD) Automated Multisensor Snow and Ice
- National Operational Hydrologic Remote Sensing Center (NOHRSC) Snow Data Assimilation System (SNODAS)
- United States Air Force Snow and Ice Analysis Product

For a complete description of the algorithm used to create the SCE CDR, see the [Climate Algorithm Theoretical Basis Document \(C-ATBD\): Northern Hemisphere Snow Cover Extent \(pdf\)](#).

3.1.1 Data Acquisition

The SCE CDR was downloaded via FTP from the [Climate Data Record Program](#) at the National Climatic Data Center (listed under Terrestrial CDRs).

3.1.2 Processing Steps

The SCE CDR was first re-gridded to EASE-Grid 2.0 with [Mapx](#) and then compared with the BU-MODIS LOCI 100 km mask. In cases where an ocean pixel was converted to land, the discrepancy was reconciled by using a 3x3 moving box filter. With the converted cell in the center, surrounding land cells were examined and if more than 50 percent of the original surrounding land cells were snow covered, the cell was assigned a snow cover value. Otherwise the cell was determined to be snow-free land. Once reconciled with the BU-MODIS LOCI 100 km mask, the data were written to the `weekly_climate_data_record_snow_cover_extent` variable.

3.2 Passive Microwave Brightness Temperature Gap-Filled Snow Cover

3.2.1 Data Acquisition

Passive microwave brightness temperatures were obtained from two data sets distributed by NSIDC: [Nimbus-7 SMMR Pathfinder Daily EASE-Grid Brightness Temperatures](#) and [DMSP SSM/I-SSMIS Pathfinder Daily EASE-Grid Brightness Temperatures, Version 2](#). These data were acquired over a 34-year span by the SMMR instrument on board Nimbus-7 and the SSM/I and SSMIS instruments carried by Defense Meteorological Satellites Program (DMSP) satellites F8, F11, F13, and F17.

Table 6 lists the satellites, instruments, and date ranges used for this data set. Use the links to view detailed descriptions of each satellite's mission.

Table 6. Satellite and Instrument Date Ranges

Satellite	Instrument	Dates
Nimbus 7	SMMR	1 January 1979 – 30 June 1987
F8	SSM/I	1 July 1987 – 14 December 1991
F11	SSM/I	15 December 1991 – 31 December 1995
F13	SSM/I	1 January 1996 – 31 December 2007
F17	SSMIS	1 January 2008 – 31 December 2012

3.2.2 Processing Steps

The following steps were used to convert brightness temperatures into snow cover. SSM/I F13 was used as the standard sensor to ensure a consistent data record:

1. SMMR brightness temperatures were converted to SSM/I F08 using the linear regression described in Jezek et al., 1991.
2. F08 values (including SMMR values from Step 1) were converted to F11 based on Abdalati et al., 1995. F11 brightness temperatures were then converted to F13 using regression equations from Stroeve et al., 1998.
3. SSMIS F17 brightness temperatures were converted to SSM/I F13 based on the methodology in Meier et al., 2011. Ascending and descending passes were averaged into daily average brightness temperatures.
4. The presence of snow was identified where the 19/37 GHz and 22/85 GHz (91 GHz for SSMIS) vertical polarization frequency gradients exceed minimum thresholds. Additionally, the brightness temperature for the 37 GHz channels (horizontal and vertical polarization) and

85GHz (vertical polarization) must not exceed a maximum threshold. The approach is conceptually similar and uses the same frequency gradients and channels as the AMSR-E Snow Water Equivalent Algorithm. Refer to the text by Chang and Rango, 2000 for further information. Thresholds were set to achieve a 60 percent probability of detecting snow, determined by: hemispheric comparison with IMS snow; snow depth observations from available stations including the Global Historical Climatology Network, cooperative stations, and the Meteorological Service of Canada; and daily average brightness temperatures during the 2005-2006 snow season. The thresholds are listed in Table 7.

Table 7. Criteria for Identifying Snow

Channel	Threshold
19V–37V	> 7 K
22V–85V (22V–91V)	> 8 K
37V	< 256 K
37H	< 243 K
85V	< 253 K

5. At locations where the elevation exceeds 1500 meters above mean sea level, the 19/37 GHz and 22/85 GHz frequency gradients were reduced by 0.001 K and 0.002 K per meter elevation, respectively. This correction was applied because passive microwave snow retrievals overestimate snow-covered area in high elevation locations, and in particular the Tibetan Plateau, because the decrease in atmospheric thickness increases the spectral gradient. Refer to the text by Savoie et al., 2009 for further information. The coefficients were determined by a comparison with high elevation (>1500 m) locations in the same manner discussed in Step 2.
6. In regions with a maximum snow-covered albedo ≤ 58 percent, the 19/37 GHz and 22/85 GHz frequency gradients were increased by 3 K and 4 K, respectively. Because snow that falls through the canopy may not be apparent when on the ground (Foster et al., 1991), passive microwave snow retrievals underestimate snow covered area in densely forested locations such as the boreal forests. To account for this effect, a maximum snow covered albedo data set (Robinson et al., 1985) was re-gridded to EASE Grid 2.0 and used to identify regions in which snow cover is spectrally masked by vegetation. Coefficients were determined by comparing areas with maximum snow covered albedo $\leq 58\%$ in the same manner discussed in step 2.
7. The criteria described in Step 2, as modified in steps 3 and 4, were applied to the daily average brightness temperatures to determine the presence or absence of snow.

8. Areas of missing data were reduced by employing a six-day gap-fill method. If data were missing for a given date, the previous day's data was retained as the observation for the current day for up to five days prior.
9. The resulting daily gap-filled snow cover map was re-gridded to 25 km EASE-Grid 2.0 using [Mapx](#). A maximum snow cover extent mask was also applied based on all cells with IMS data that indicated snow on any date during a given month.
10. Intermediate weekly files were generated for the MW-derived snow variable by selecting Monday's snow cover (the data week runs from Tuesday through the following Monday) as the representative value for each cell, each week. If Monday's data was missing, Sunday's was used instead. If neither day was available, the weekly snow cover for that cell was filled as missing. This approach was adopted primarily to match the weekly SCE CDR product, which is generated using Monday's IMS data.
11. Weekly snow cover files were re-gridded to 100 km EASE-Grid 2.0 using [Mapx](#).
12. Areas of permanent ice and ocean were masked using the BU-MODIS LOCI 100 km mask. Discrepancies arising from land mask mismatches were reconciled using the 3x3 box filter approach described in the 3.2.2 for the SCE CDR.
13. The final weekly data were written to the `passive_microwave_gap_filled_snow_cover_extent` variable.

3.3 Merged Snow Cover Extent

3.3.1 Processing Steps

Once source snow cover variables were re-gridded and reconciled with the BU-MODIS LOCI 100 km mask, the merged snow cover extent variable was generated as follows:

1. BU-MODIS LOCI 100 km ocean and land pixels were written to an array.
2. Values for snow covered land and ocean converted to snow covered land were written to the array using the coding scheme in Table 5.
3. BU-MODIS LOCI 100 km permanent ice values were written to the array.
4. The data were written to the `merged_snow_cover_extent` variable.

3.3.2 Version History

Version 1.1 was released in July, 2015. Refer to Table 8 for this data set's version history:

Table 8. Version History

Version	Description
V1.1 (Jul, 2015)	Added 1D arrays named <code>cols</code> and <code>rows</code> that contain x and y coordinates (meters from origin) of the projection. v01r01 appended to data file names.
V1 (Dec, 2014)	Initial version

3.3.3 Error Sources

Missing data represents the biggest impact to data quality, as all the input products lack some daily files during the period of record.

The SCE CDR snow cover maps were not constructed according to a formal algorithm, but instead relied on the expertise of trained analysts. Because the IMS workstation software at NIC is continually being evaluated and improved, changes in mapping methodologies have occurred over time.

For the passive microwave derived snow cover, errors in the input data may carry through to the output. Potential errors in passive microwave brightness temperatures are described in the Error Sources sections of the [Nimbus-7 SMMR Pathfinder Daily EASE-Grid Brightness Temperatures](#) and [DMSP SSM/I-SSMIS Pathfinder Daily EASE-Grid Brightness Temperatures](#) documentation.

3.4 Sensor or Instrument Description

The Nimbus-7 Scanning Multichannel Microwave Radiometer observed Earth at five frequencies, in both horizontal and vertical polarization, from 26 October 1978 to 21 August 1987. For a detailed description, see NSIDC's [Scanning Multi-channel Microwave Radiometer \(SMMR\)](#) Web page.

The Special Sensor Microwave/Imager is a seven-channel, four frequency, orthogonally polarized passive microwave radiometric system flown aboard DMSP satellites F8, F10, F11, F12, F13, and F15. Its successor, the Special Sensor Microwave Imager/Sounder, is a 24-channel passive microwave radiometer carried by DMSP F17. For detailed descriptions of these instruments, see NSIDC's [Special Sensor Microwave Imager \(SSM/I\)](#) and [Special Sensor Microwave Imager/Sounder \(SSMIS\)](#) Web pages.

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4.1 Related Data Collections

- [MEaSURES Northern Hemisphere Terrestrial Snow Cover Extent Daily 25km EASE-Grid 2.0](#)
- [MEaSURES Arctic Sea Ice Characterization Daily 25km EASE-Grid 2.0](#)
- [MEaSURES Greenland Surface Melt Daily 25km EASE-Grid 2.0](#)
- [MEaSURES Northern Hemisphere State of Cryosphere Daily 25km EASE-Grid 2.0](#)
- [MEaSURES Northern Hemisphere State of Cryosphere Weekly 100km EASE-Grid 2.0](#)
- [NOAA/NCDC Northern Hemisphere Snow Cover Extent Climate Data Record](#)
- [Nimbus-7 SMMR Pathfinder Daily EASE-Grid Brightness Temperatures](#)
- [DMSP SSM/I-SSMIS Pathfinder Daily EASE-Grid Brightness Temperatures](#)

4.2 Related Websites

- [MEaSURES Data: Overview](#)
- [Northern Hemisphere Snow and Ice Climate Data Records at Rutgers University](#)

5 CONTACTS AND ACKNOWLEDGMENTS

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6 DOCUMENT INFORMATION

6.1 Publication Date

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6.2 Date Last Updated

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