MEaSUREs Northern Hemisphere Terrestrial Snow Cover Extent Daily 25km 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:

Robinson, D. A., M. R. Anderson, T. W. Estilow, D. K. Hall, and T. L. Mote. 2015. *MEaSUREs Northern Hemisphere State of Cryosphere Daily 25km EASE-Grid 2.0, Version 1.* [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/MEASURES/CRYOSPHERE/nsidc-0534.001. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/NSIDC-0534

National Snow and Ice Data Center

TABLE OF CONTENTS

1 DETAILED DATA DESCRIPTION

This data set utilizes three variables to represent Northern Hemisphere snow cover and sea ice extent from 1 January 1999 through 31 December 2012. These variables report:

- The location of snow cover and Arctic sea ice, generated by merging Interactive Multisensor Snow and Ice Mapping System (IMS) snow cover from the MEaSUREs Northern Hemisphere Terrestrial Snow Cover Extent Daily 25km EASE-Grid 2.0 data set with Arctic sea ice extent from MEaSUREs Arctic Sea Ice Characterization Daily 25 km EASE-Grid 2.0;
- Melt onset status across the Greenland Ice Sheet and Arctic sea ice, generated by merging the MEaSUREs Greenland Surface Melt Daily 25km EASE-Grid 2.0 and MEaSUREs Arctic Sea Ice Characterization Daily 25 km EASE-Grid 2.0 data sets;
- The level of agreement between three Northern Hemisphere snow cover products, generated by comparing IMS snow cover with MODIS Cloud Gap-Filled (CGF) snow cover and passive microwave-derived snow cover (MW).

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 (NetCDF) Web site.

1.2 File and Directory Structure

Data are available on the HTTPS site in the https://n5eil01u.ecs.nsidc.org/MEASURES/NSIDC-0534.001/ directory.

1.3 File Naming Convention

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

Example File Name:

socd25e2_19990101_v01r01.nc

socdxxe2_yyyymmdd_v01r01.nc

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

Table 1. File Naming Convention

Variable	Description
soc	State of Cryosphere
d	Daily
xx	Resolution (km)
e2	EASE-Grid 2.0
yyyy	Year
mm	Month
dd	Day
v01r01	Version 1.1
.nc	netCDF-formatted file

1.4 File Size

Data files are approximately 2 MB. The entire data set is approximately 10 GB.

1.5 Spatial Coverage

Northern Hemisphere

Southernmost Latitude: 0.0°
Northernmost Latitude: 90.0°
Westernmost Longitude: -180.0°
Easternmost Longitude: 180.0°

1.5.1 Spatial Resolution

25 km

1.5.2 Projection and Grid Description

Data are provided in the 25 km Northern Hemisphere Equal Area Scalable Earth Grid (EASE-Grid) 2.0. Grid dimensions are 720 x 720. For a complete description of EASE-Grid 2.0, visit NSIDC's EASE-Grid 2.0 Format Description page.

1.6 Temporal Coverage

1 January 1999 - 31 December 2012

1.6.1 Temporal Resolution

Daily

1.7 Parameter or Variable

This data set's primary parameters are snow cover, sea ice cover, and status of melt onset. Data files also include latitude and longitude arrays that specify the center of each 25 km EASE-Grid 2.0 cell, coordinate system parameters, and the number of days since the beginning of the data record.

1.7.1 Parameter Description

Data files contain the variables listed in Table 2.

Table 2. Variable Names and Descriptions

Variable Name	Description	Dimensions	Data Type
merged_snow_and_sea_ice_extent	Merged snow and sea ice cover	720 x 720	byte (signed)
status_of_melt_onset	Status of melt onset for Greenland and Arctic sea ice	720 x 720	byte (signed)
snow_agreement_with_ims	Indicates whether CGF and/or MW snow cover agree with IMS[1]	720 x 720	byte (signed)
latitude	Latitude at the center of each 25 km EASE-Grid 2.0 cell	720 x 720	float[2]
longitude	Longitude at the center of each 25 km EASE-Grid 2.0 cell	720 x 720	float[2]
cols	x coordinate, center of 25 km EASE-Grid 2.0 cell (m from origin)	1 x 720	int
rows	y coordinate, center of 25 km EASE-Grid 2.0 cell (m from origin)	720 x 1	int
coord_system	EASE-Grid 2.0 grid and projection parameters	—	char
time	Days since 12/31/1998	—	int

[1]MODIS Cloud Gap-Filled (CGF); passive microwave (MW) derived snow cover; Interactive Multisensor Snow and Ice Mapping System (IMS).
[2]32-bit single precision floating point. Fill value for grid corners = -999.

1.7.2 Parameter Range

The merged_snow_and_sea_ice_extent, status_of_melt_onset,and snow_agreement_with_ims variables (refer to Table 2) use coded integers to indicate the location of snow and sea ice cover, status of melt onset, and whether one or both of the CGF- and MW-derived snow cover products agree with IMS observations over land. The snow cover and sea ice variable also indicates the location of the pole hole. The following tables contain keys to the values stored in these variables.

Table 3. Key for merged_snow_and_sea_ice_extent

Value	Description
10	Snow covered land
20	Snow free land
30	Sea ice cover
40	Open water
90	Missing
91	Pole hole
-99	Fill value for grid corners

Table 4. Key for status_of_melt_onset

Value	Description
0	No melt data
51	Melt onset begins prior to file date
52	Melt onset begins on file date
53	Melt onset begins on a future date
-99	Fill value for grid corners

Table 5. Key for snow_agreement_with_ims

Value	Description
0	No other products agree with IMS[1] snow cover
1	One other product agrees (CGF[2] or MW[3])
2	Two others agree (CGF[2] and MW[3])
90	No comparison
-99	Fill value for grid corners
[1]Interactive Multisensor Snow and Ice Mapping System; [2]MODIS Cloud Gap-Filled (CGF); [3]passive microwave (MW) derived snow cover.	

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

Source products for this data set were either downloaded via public Web site or delivered by project investigators directly to Rutgers University for processing. In addition, this data set utilizes the 25 km Land-Ocean-Coast-Ice (LOCI) mask from EASE-Grid 2.0 Land-Ocean-Coastline-Ice Masks Derived from Boston University MODIS/Terra Land Cover Data. The following sections describe how each of the variables in this data set were generated.

3.1 Merged Snow and Sea Ice Cover

3.1.1 Processing Steps

IMS snow cover was obtained directly from the ims_snow_cover_extent variable in MEaSUREs Northern Hemisphere Terrestrial Snow Cover Extent Daily 25km EASE-Grid 2.0. Arctic sea ice extent was obtained directly from the sea_ice_cover variable in MEaSUREs Arctic Sea Ice Characterization Daily 25km EASE-Grid 2.0.

When these variables were reconciled with the 25 km EASE-Grid 2.0 LOCI mask for their respective data sets, changes to the original data were stored using separate codes. For example, the ims_snow_cover_extent variable uses different values to diffentiate between "snow covered land" and "ocean converted to snow covered land." These values were combined for the purposes of this data set. The merged_snow_and_sea_ice_extent variable was generated as follows:

1. Ocean and land pixels from the 25 km EASE-Grid 2.0 LOCI mask were written to an intermediate 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 3;
3. Values for sea ice were written to the array using the coding scheme in Table 3;
4. The data were written to the merged_snow_and_sea_ice_extent NetCDF variable.

3.1.2 Source Data

For details about how the ims_snow_cover_extent and sea_ice_cover variables were generated, see the Data Acquisition and Processing section in the following data sets:

- MEaSUREs Northern Hemisphere Terrestrial Snow Cover Extent Daily 25km EASE-Grid 2.0
- MEaSUREs Arctic Sea Ice Characterization Daily 25km EASE-Grid 2.0

3.2 Status of Melt Onset

3.2.1 Processing Steps

Status of melt onset over Arctic sea ice was sourced directly from the status_of_melt_onset variable in MEaSUREs Arctic Sea Ice Characterization Daily 25km EASE-Grid 2.0. Status of melt onset over Greenland was calculated at the University of Georgia using melt onset dates from MEaSUREs Greenland Surface Melt Daily 25km EASE-Grid 2.0. All input variables were previously reconciled with the 25 km EASE-Grid 2.0 LOCI mask.

Both source data sets identify the onset of melting using brightness temperature data acquired by satellite-borne microwave radiometers. Brightness temperatures reveal the onset of melting because the introduction of liquid water to snow produces a sharp increase in emissivity and a corresponding increase in microwave brightness temperature. As such, a sharp increase in the brightness temperature of the snowpack indicates the introduction of liquid water due to melt onset. Status of melt onset is created by assigning integer values which indicate whether the cell has a melt onset date prior to the current day, on the current day, or later in the year. Cells with no melt onset date are filled with 0 (Table 4). Melt onset is only calculated for days 61-245 of the year. This range corresponds to 2 March through 2 September in non-leap years and 1 March through 1 September in leap years. Days that lie outside this range are filled with 0.

The combined Arctic-Greenland status of melt onset variable for this data set was generated as follows:

- Values for status of melt onset over Arctic sea ice and Greenland were written to an intermediate array using the coding scheme in Table 4;
- The data were written to the status_of_melt_onset NetCDF variable.

3.2.2 Source Data

For more details about the procedures used to determine melt onset status, refer to the Data Acquisition and Processing section in the following data sets:

- MEaSUREs Arctic Sea Ice Characterization Daily 25km EASE-Grid 2.0
- MEaSUREs Greenland Surface Melt Daily 25km EASE-Grid 2.0

3.3 Snow Agreement with IMS

3.3.1 Processing Steps

The snow_agreement_with_ims variable was calculated from the merged_snow_cover_extent variable in MEaSUREs Northern Hemisphere Terrestrial Snow Cover Extent Daily 25km EASE-Grid 2.0. This data set contains daily, Northern Hemisphere snow cover derived from three different source products: the Interactive Multisensor Snow and Ice Mapping System (IMS), MODIS Cloud Gap Filled Snow Cover (CGF), and passive microwave (MW) brightness temperatures. The merged_snow_cover_extent variable specifies for each cell which of the source products report snow. All snow cover variables in this data set were reconciled with the 25 km EASE-Grid 2.0 LOCI mask when created.

The snow_agreement_with_ims variable offers a different representation of snow cover in that it compares the IMS, CGF, and MW products using IMS as a baseline. Integer values specify the number of products that agree with IMS observations: zero (none), one (CGF or MW), or two (CGF and MW). snow_agreement_with_ims was generated as follows:

1. Agreement totals were calculated and written to an intermediate array using the coding scheme in Table 5.
2. Areas where no comparison was performed due to missing data and areas covered by permanent ice in the 25 km EASE-Grid 2.0 LOCI mask were written to the array using the coding scheme in Table 5.
3. The data were written to the snow_agreement_with_ims NetCDF variable.

3.3.2 Source Data

IMS snow cover is produced by trained analysts at the National Ice Center, using an interactive workstation application to incorporate a wide variety of satellite imagery, derived map products, and surface observations. For more information about IMS snow cover, visit the U.S. National Ice Center IMS Products Web page.

MODIS Cloud Gap Filled Snow Cover (CGF) was derived from the MODIS/Terra Snow Cover Daily L3 Global 0.05Deg CMG fractional snow cover product. MODIS, the Moderate Resolution Spectroradiometer, is a key instrument onboard Terra, the flagship satellite in NASA's Earth Observing System platform. Cloud gap-filled daily snow cover maps are produced using a simple algorithm that fills cloud-obscured grid cells with a previous day's observation of the ground, up to a maximum of five days. For more information about the MODIS cloud-gap-filling algorithm, refer to the Data Acquisition and Processing Section of MEaSUREs Northern Hemisphere Terrestrial Snow Cover Extent Daily 25km EASE-Grid 2.0 and Hall, et al 2010 for more information.

Passive microwave snow cover was derived from DMSP SSM/I-SSMIS Pathfinder Daily EASE-Grid Brightness Temperatures. This data set contains passive microwave brightness temperatures acquired by the Special Sensor Microwave/Imager (SSM/I) and Special Sensor Microwave Imager/Sounder (SSMIS) instruments onboard Defense Meteorological Satellite Program (DMSP) satellites. For a description of the processing steps used to generate snow cover from passive microwave brightness temperatures, see MEaSUREs Northern Hemisphere Terrestrial Snow Cover Extent Daily 25km EASE-Grid 2.0 for more information.

3.3.3 Version History

Version 1.1 was released in July, 2015. Refer to Table 6 for this data set's version history:

Table 6. Version History

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

3.3.4 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 IMS snow cover maps are not constructed according to a formal algorithm, but instead rely on the expertise of trained analysts using the IMS workstation. Because the IMS workstation software is continually being evaluated and improved, changes in mapping methodologies have occurred over time. Error sources in the MODIS Cloud Gap Filled Snow Cover product are discussed in detail in Hall et al., 2010. For the passive microwave derived snow cover, errors in the input data may carry through to the output. For details about potential errors in passive microwave brightness temperatures, refer to the error source section in DMSP SSM/I-SSMIS Pathfinder Daily EASE-Grid Brightness Temperatures for more information.

4 REFERENCES AND RELATED PUBLICATIONS

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4.1 Related Data Collections

- MEaSUREs Northern Hemisphere Terrestrial Snow Cover Extent Daily 25km EASE-Grid 2.0
- MEaSUREs Northern Hemisphere Terrestrial Snow Cover Extent Weekly 100km 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 Weekly 100km EASE-Grid 2.0
- IMS Daily Northern Hemisphere Snow and Ice Analysis at 4 km and 24 km Resolution
- DMSP SSM/I-SSMIS Pathfinder Daily EASE-Grid Brightness Temperatures
- MODIS/Terra Snow Cover Daily L3 Global 0.05Deg CMG
- EASE-Grid 2.0 Land-Ocean-Coastline-Ice Masks Derived from Boston University MODIS/Terra Land Cover Data

4.2 Related Websites

- The MODIS Snow & Sea Ice Global Mapping Project
- Northern Hemisphere Snow and Ice Climate Data Records at Rutgers University

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5.1 Acknowledgments

These data were generated with support from Award NNX08AP34A from the NASA Making Earth System Data Records for Use in Research Environments (MEaSUREs) Program.

The investigators wish to thank:

- Mary Jo Brodzik at NSIDC for technical assistance, gridding and software support, and for advice regarding the EASE Grid-2.0 format;
- Donna Scott at NSIDC for technical support, documentation and metadata support, and for serving as this project's liaison;
- Jeff Miller of Wyle, Inc. and the NASA Goddard Space Flight Center for programming support for the MODIS CGF snow product;
- Members of the Northern Hemisphere Snow and Ice MEaSUREs team, including Angela Bliss, Gina Henderson, and Mark Tschudi.

6 DOCUMENT INFORMATION

6.1 Publication Date

January 2015

6.2 Date Last Updated

29 December 2020