Rutgers Northern Hemisphere 24 km Weekly Snow Cover Extent, September 1980 Onward, Version 1

USER GUIDE

How to Cite These Data

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

Robinson, D. A., and T. W. Estilow. 2021. *Rutgers Northern Hemisphere 24 km Weekly Snow Cover Extent, September 1980 Onward, Version 1*. [Indicate subset used]. Boulder, Colorado USA. NSIDC: National Snow and Ice Data Center. https://doi.org/10.7265/zzbm-2w05. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/G10035

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1 DATA DESCRIPTION

1.1 Summary

This data set provides weekly snow cover extent at a 24 km resolution for the Northern Hemisphere from September 1980 through most recent processing. See Section 1.5 Temporal Information for details. Prior to June 1999, these data were digitized from paper snow charts generated by NOAA analysts and based primarily on the interpretation of visible satellite observations. In the late 1990s, weekly chart production was succeeded by the U.S. National Ice Center (USNIC) Interactive Multisensor Snow and Ice Mapping System (IMS). From June 1999 onward, IMS snow output at 24 km resolution is appended to the record.

1.2 Parameters

The main parameter of this data set is binary snow cover extent (0 = no snow, 1 = snow covered). The snow cover threshold for which a grid cell is considered snow covered is 50% or greater.

1.3 File Information

1.3.1 Format

The data file is in NetCDF4 CF-1.7 format. All weeks are concatenated into a single file.

1.3.2 File Contents

The data variables in the NetCDF file are described in Table 1.

Table 1. NetCDF File Variable Description

Variable	Description
area	Area of each grid cell in km^2 with a valid range of 158.9 to 651.4
polar_stereographic	Coordinate Reference System
land	Binary land/water mask (0 = water, 1 = land)
latitude	Latitude of grid cell center in degrees North with a valid range of 0 to 90
longitude	Longitude of grid cell center in degrees with a valid range of -180 to 180
snow_cover_extent	Binary snow cover (0 = no snow, 1 = snow covered), a default fill value of -127 is used to indicate areas outside of the Northern Hemisphere

Variable	Description
snow_cover_threshold	Scalar variable with the surface_snow_area_fraction (e.g. 0.5 = 50%) at which a binary snow_cover_extent grid cell is considered snow covered.
time	Last day of the week (Monday) in days since 1980-08-25 where the date covers data from the week before. For example, if the date is 2018-12-24, then this represents snow_cover_extent for Tuesday, 2018-12-18 through Monday, 2018-12-24.
x	Projection x coordinate in km
y	Projection y coordinate in km

1.3.3 Directory Structure

The single NetCDF file resides in ftp://sidads.colorado.edu/pub/DATASETS/NOAA/G10035/.

1.4 Spatial Information

1.4.1 Coverage

The data are gridded to a 1024 × 1024 polar stereographic projection with outside edges tangent to the equator. Valid data points cover the Northern Hemisphere with the following bounding coordinates:

Southernmost Latitude: 0° N
Northernmost Latitude: 90° N
Westernmost Longitude: 180° W
Easternmost Longitude: 180° E

1.4.2 Resolution

The nominal 24 km resolution measures 23.685 km per cell in x and y projected coordinates. Grid cell areas vary with latitude; at 60° N (the latitude of true origin), the cell areas are ~563 km^2. Areas range from ~159 km^2 at the equator to ~651 km^2 near the pole.

1.4.3 Geolocation

Table 2 and Table 3 provide information for geolocating this data set.

Table 2. Geolocation Details

Geographic coordinate system	N/A
Projected coordinate system	Polar stereographic projection on a sphere with radius of 6371200.0 meters
Longitude of true origin	80° W
Latitude of true origin	60° N
Scale factor at longitude of true origin	1
Datum	Semimajor axis = 6371200.0 meters Inverse flattening = 0.0
Ellipsoid/spheroid	Spheroid
Units	km
False easting	0
False northing	0
EPSG code	N/A
PROJ4 string	+proj=stere +lat_0=90 +lat_ts=60 +lon_0=-80 +k_0=1 +x_0=0 +y_0=0 +a=6371200 +b=6371200 +units=km
WKT	PROJCS["unspecified”, GEOGCS["unspecified datum based on NOAA w3fb05 routine”, DATUM["unspecified”, SPHEROID["unspecified",6371200,0]], PRIMEM["Greenwich",0,AUTHORITY["EPSG","8901"]], UNIT["degree",0.01745329251994328,AUTHORITY["EPSG","9122"]]], PROJECTION["Polar_Stereographic”], PARAMETER["latitude_of_origin",60], PARAMETER\"central_meridian",-80], PARAMETER["false_easting",0], PARAMETER["false_northing",0], PARAMETER["scale_factor",1], UNIT["kilometre",1,AUTHORITY["EPSG","9036"]], AXIS["X",OTHER], AXIS["Y",OTHER]]

Table 3. Grid Details

Nominal grid cell size (x, y pixel dimensions)	23.685 km x 23.685 km
Number of rows	1024
Number of columns	1024
Geolocated lower left point in grid	-125.0000, -20.5374
Nominal gridded resolution	24 km
Grid rotation	80° W longitude below the pole
ulxmap – x-axis map coordinate of the center of the upper-left pixel	-12,114.755
ulymap – y-axis map coordinate of the center of the upper-left pixel	12,114.998

1.5 Temporal Information

1.5.1 Coverage

The data span 26 August 1980 to 05 September 2022. The plan is to update this data set on an annual basis every September.

1.5.2 Resolution

The data are at a weekly resolution, with each data point represented by the last day of the week (Monday) in the time variable (with the time variable expressed in number of days since 25 August 1980). Each weekly data granule represents snow cover extent (SCE) for seven days spanning from Tuesday through Monday. For example, the first week in the dataset represents SCE for 26 August 1980 through 01 September 1980. Note: The data from June 1999 to present are not an average of the daily data for a week, but simply the Monday snapshot of the data, which are considered to represent the data from the previous week.

2 DATA ACQUISITION AND PROCESSING

2.1 Background

NOAA weekly maps of SCE were generated from late 1966 through May 1999 by analysts who relied primarily on visible satellite imagery to identify snow and ice cover (Robinson et al., 1993; Estilow et al. 2015). These maps were previously digitized at 190 km resolution (Robinson et al., 2012) and in this dataset they are digitized at 24 km resolution starting from late 1980. Northern Hemisphere snow charts are produced at 24 km resolution on a daily basis since 1999 using the IMS data from the USNIC (Ramsay, 1998; Helfrich et al., 2007).

2.2 Acquisition

Paper copies of the NOAA weekly snow maps scanned for this dataset are located at Rutgers University. Several maps missing from the collection were acquired from NOAA's National Centers for Environmental Information (NCEI), University of Colorado Boulder, and the USNIC. IMS 24 km data were pulled from the NOAA/NESDIS Environmental Satellite Processing and Distribution System (ESPDS).

2.3 Processing

Processing steps are summarized below. For more in-depth details on IMS product generation, see the user guide for *IMS Daily Northern Hemisphere Snow and Ice Analysis at 1 km, 4 km, and 24 km Resolutions, Version 1* (U.S. National Ice Center, 2008).

Processing of paper snow charts from Rutgers:

1. Scan weekly paper snow charts spanning from September 1980 through May 1999 to high-resolution raster files.
2. Geo-reference and rectify snow-chart raster files to the native projection using ArcMap Version 10.7 (*Environmental Systems Research Institute, Redlands, CA*).
3. Manually trace snow extent boundaries directly to vector layers with QGIS Desktop Version 3.2.3 (*QGIS Association*) using a Microsoft Surface Studio workstation.
4. Verify and quality control snow boundary shapefiles. Three Rutgers analysts review one another's snow extent polygons.
5. Snow extent polygons are then intersected with 24 km grid centroid X,Y coordinates calculated at Rutgers using IDL 8.8.0 (*L3Harris Geospatial, Broomfield, CO)* employing grid parameters provided by NSIDC (U.S. National Ice Center, 2008). Grid coordinates also apply to a standardized land/water mask matching the 24 km IMS product.

Processing of the IMS digital data

1. Obtain all of the Monday IMS snow cover data from June 1999 to present from NOAA/NESDIS ESPDS.
2. Apply quality control to IMS snow output from June 1999 to February 2004 to correct land/water mask inconsistencies.
3. Append IMS snow output from each Monday starting in June 1999 to the weekly paper-chart record ending in May 1999 that was created from the paper charts processing described above. Note: The data from June 1999 to present are not an average of the daily data for a week, but simply the Monday snapshot of the data, which are considered to represent the data from the previous week.
4. Write metadata and output variables to NetCDF for the entire time series.

2.4 Quality, Errors, and Limitations

2.4.1 Quality Assessment

Weekly SCE maps spanning the pre-IMS period (September 1980 through May 1999) are most accurate where cloud-free satellite imagery is available, snow cover is slow-changing or stable, and solar illumination levels are high (Wiesnet et al., 1987; Robinson et al., 1993). In areas with low illumination, dense forests that mask underlying snow, or where cloud cover is persistent, the expertise and judgement of the analyst grows in importance. Snow maps are produced with no formal algorithm, thus changes in mapping methodologies have occurred over time (see Section 2.5 Instrumentation) and there are differences in production of the historical (pre-IMS) data compared with the IMS period (Ramsay, 1998; Helfrich et al., 2007). Other factors that may impact SCE quality include updated map coastline templates over time and the georegistration of weekly paper maps.

Because snow extent is charted on the last day the surface is observed (Robinson and Frei, 2000), SCE maps are heavily weighted towards the end of the week. There are known inconsistencies in some mountainous areas (e.g. the Tibetan Plateau) due to difficulties in discriminating patchy snow from clouds in visible satellite imagery. Mapped snow extent may persist in places where the snow line cannot be delineated toward week's end due to cloud cover.

Similar to earlier NOAA snow charting, IMS analysts integrate new data sources and instruments into the mapping process as they become available. The IMS workstation itself has been upgraded over time, most notably in early 2004 when 4 km output was introduced alongside the daily 24 km snow and ice product. Monday IMS snow extent is used to represent each week from June 1999 onward (the post-IMS period), as pre-IMS charts are heavily weighted towards the end of the week. Except for application of the standardized land/water mask throughout, there is currently no adjustment or post-processing performed to improve continuity between the pre- and post-IMS data periods at 24 km resolution.

2.4.2 Product Resolution and SCE Area

SCE areas calculated from this 24 km weekly product were compared with SCE areas generated using the existing 190 km snow extent climate data record (CDR) (Robinson et al., 2012). Hemispheric and continental SCE areas from both datasets track well. This was expected because the 190 km resolution SCE CDR was digitized from the same paper maps as this 24 km product. However, the 24 km weekly SCE generally shows less SCE area than the CDR, particularly during the winter months.

These lower SCE totals from the re-digitized 20-year historical record compared to the original 190 km totals can be explained by several factors. The higher resolution of the 24 km raster grid leads to more accurate coastlines. Much of the downward shift between the SCE areas can be attributed to the improved land/water mask in the 24 km product. This effectively crops SCE over inland lakes and where the larger 190 km grid cells spill over into the sea.

A similar effect is observed along some terrestrial snow lines, with 190 km grid cells missing sub-grid scale variations in SCE that are captured at higher resolution. Owing to the projection, the resulting differences are more pronounced at higher latitudes as grid cell areas increase closer to the pole. Other contributing factors may include SCE mapping improvements in typically cloudy areas and mountainous regions over time. Work continues to quantify the shift in SCE areas between the two products and determine how it emerges regionally and seasonally.

2.4.3 Missing Data

There are two weeks missing from the paper record, with efforts to find these maps continuing. To fill these gaps, weeks ending 17 Mar 1986 and 29 Dec 1986 are duplicates of the preceding and subsequent weekly maps, respectively. These weeks were chosen to best fit the hemispheric SCE areas of adjacent weeks.

Some winter SCE maps are demarcated with a small circle labeled “dark” due to insufficient illumination in satellite imagery within the Arctic Circle. Where land grid cells intersect these dark areas, they are diagnosed as snow covered.

2.5 Instrumentation

2.5.1 Description

Data prior to June 1999 are based on satellite-derived paper maps of Northern Hemisphere SCE produced weekly by trained NOAA meteorologists. These analysts determined snow and ice boundaries using visible satellite imagery. Various platforms and instruments were incorporated into the SCE mapping process as they became available (e.g., Advanced Very High Resolution (AVHRR), Visible and Infrared Spin Scanning Radiometer Atmospheric Sounder (VAS)). Due to cloud cover, weekly maps typically show SCE boundaries on the last day that the surface in a given region was seen.

Starting in June 1999, map production was shifted to interactive workstations designed for digital SCE mapping. IMS operators access a variety of primarily visible but also available microwave satellite imagery, derived snow products (e.g., Advanced Microwave Scanning Radiometer 2 (AMSR-2), Visible Infrared Imaging Radiometer Suite (VIIRS)), and surface observations to delineate snow and ice cover. Much like its predecessor, IMS does not utilize a formal algorithm to generate hemispheric SCE charts. Various sources of imagery and animated image loops are employed by the analyst to produce IMS snow maps on a daily basis.

3 VERSION HISTORY

Table 4. Version History Summary

Version	Release Date	Description of Changes	Citation
1.0	September 2021	Initial Release	Robinson, D. A., and T. W. Estilow. 2021. *Rutgers Northern Hemisphere 24km Weekly Snow Cover Extent, September 1980 onward, Version 1*. [Indicate subset used]. Boulder, Colorado USA. NSIDC: National Snow and Ice Data Center. https://doi.org/10.7265/zzbm-2w05. [Date Accessed].

4 RELATED DATA SETS

- IMS Daily Northern Hemisphere Snow and Ice Analysis at 1 km, 4 km, and 24 km Resolutions, doi: https://doi.org/10.7265/N52R3PMC.
- NOAA Climate Data Record (CDR) of Northern Hemisphere (NH) Snow Cover Extent (SCE), doi: https://dx.doi.org/10.7289/V5N014G9.
- Northern Hemisphere EASE-Grid 2.0 Weekly Snow Cover and Sea Ice Extent, Version 4, doi: https://doi.org/10.5067/P7O0HGJLYUQU
- MEaSUREs Northern Hemisphere Terrestrial Snow Cover Extent Weekly 100km EASE-Grid 2.0, Version 1, doi: https://doi.org/10.5067/MEASURES/CRYOSPHERE/nsidc-0531.001.
- MEaSUREs Northern Hemisphere State of Cryosphere Weekly 100km EASE-Grid 2.0, Version 1, doi: https://doi.org/10.5067/MEASURES/CRYOSPHERE/nsidc-0535.001.
- Canadian Meteorological Centre (CMC) Daily Snow Depth Analysis Data, Version 1, doi: https://doi.org/10.5067/W9FOYWH0EQZ3

5 RELATED WEBSITES

- Rutgers University Global Snow Lab, https://snowcover.org
- U.S. National Ice Center, IMS Snow and Ice Products, https://usicecenter.gov/Products/ImsHome

6 CONTACTS AND ACKNOWLEDGMENTS

6.1 Contacts

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- Sean Helfrich, Water Surface Conditions (WSC)/SAR Applications Lead, NOAA/NESDIS/Center for Satellite Applications and Research (STAR), formerly of U.S. National Ice Center
- Nancy Ritchey, Archive Branch Chief, and Mark Seiderman, Meteorologist, Center for Weather and Climate, NOAA NCEI
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7 REFERENCES

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8 DOCUMENT INFORMATION

8.1 Author

This document was created and edited by A. Windnagel with significant text contributions from T. Estilow.

8.2 Publication Date

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