Timing and Statistics of Autumn and Spring Annual Snow Cover for the Northern Hemisphere, 1972 to 2000, Version 1

USER GUIDE

How to Cite These Data

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

Dye, D. 2005. *Timing and Statistics of Autumn and Spring Annual Snow Cover for the Northern Hemisphere, 1972 to 2000, Version 1*. [Indicate subset used]. Boulder, Colorado USA. NSIDC: National Snow and Ice Data Center. https://doi.org/10.7265/N5F18WNC. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/G02168

National Snow and Ice Data Center

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1 OVERVIEW

NSIDC has a number of data sets that address the spatial properties of seasonal snow cover. Generally, these are daily, weekly, or monthly time series of the spatial distribution of snow cover based on satellite data. Snow distribution is described in digital maps. In contrast, the subject data set addresses the spatial distribution of temporal features of snow cover. That is, it depicts the spatial distribution of the annual timing of snow-cover disappearance in spring, the timing of the onset of snow cover in autumn, and the duration of the annual snow-free period. These data are applicable to climate research as well as research in terrestrial ecology and biogeochemical cycling. Results from the data contributor's research reveal a positive trend in the snow free period (DSF) of 5 to 6 days per decade and suggest that alterations in the timing of snow cover may have an impact on the terrestrial ecosystem (Dye 2002).

This data set comprises a time series of annual snow cover data for the Northern Hemisphere (covering land primarily above 45 degrees North) from 1972 to 2000. Data are presented for land areas that exhibited snow cover in each of the 29 years. Variables are the week of snow disappearance, the week of snow cover onset, and the duration of the snow-free period. These variables were derived from operational NOAA weekly snow cover charts that have been quality controlled by the Rutgers University Global Snow Lab. For each year of the 29-year period, there are three binary files with data in an 89 x 89 cell grid. The week of the first detected snow cover in the fall is included in the WFS file, the week of the last observed snow cover in the spring is given in the WLS file, and the duration of snow-free period in weeks is given in the DSF file. Data are also provided in ASCII format summary files. In addition, summary statistics for each parameter are provided. These are grids of the mean and the standard deviation for the three parameters. Gridded latitude and longitude files are also included with this data set.

2 DETAILED DATA DESCRIPTION

2.1 Data File Description

Data are in a polar stereographic projection with the straight vertical longitude from the Pole (the central meridian) at 80 degrees W and the standard parallel at 60 degrees N. The data are in an 89 by 89 cell grid. There are three parameters:

- WLS = week of last observed snow cover in the spring (one file per year from 1972 to 2000, or a total of 29 files)
- WFS = week of snow cover onset in the autumn (one file per year from 1972 to 2000, or a total of 29 files)
- DSF = duration of snow-free period (one file per year from 1972 to 2000, or a total of 29 files)

Parameter values range from 1 to 52 weeks. Values of 0 represent missing data (see Data Acquisition and Processing). There are a total of 87 binary parameter files.

To complement the binary files, there are three ASCII text files (one for each parameter) that cover the entire time series (see Sample Data Record below).

Statistics files are also available. There is one mean and one standard deviation grid file per parameter per 29-year period (a total of twelve statistics files). The statistics files are in 32-bit floating point arrays and the units in the statistics files are weeks.

Four grid files are also included. These latitude (grid_lat.bin) and longitude (grid_lon.bin) grids (little-endian) and grid_lat_BE.bin and grid_lon_BE.bin (big-endian) can be used to georeference the data. They are in 32-bit floating point arrays. BE stands for big-endian in the file names.

The figures below illustrate DSF, WFS and WLS for a single year, 2000. They are shown with the corresponding summary statistics. The figures (provided by D. Dye) were created using the binary files.

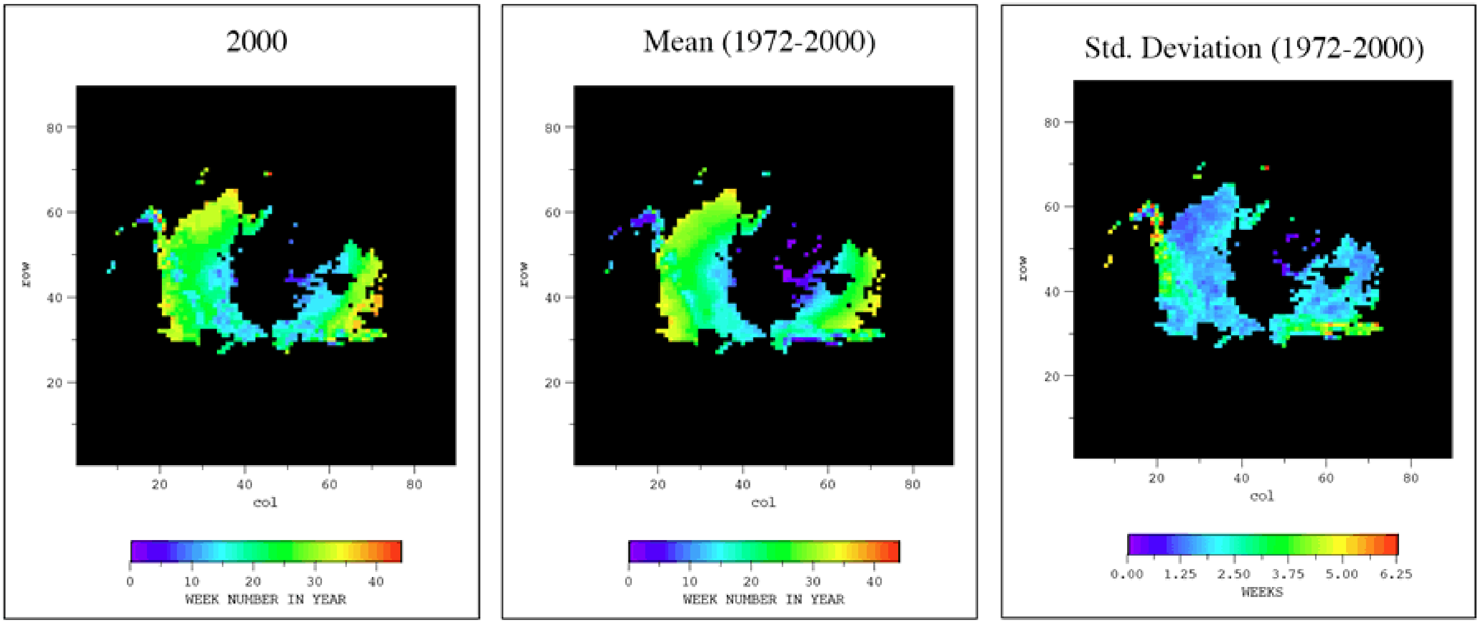

Figure 1. DSF: Duration of Annual Snow-Free Period

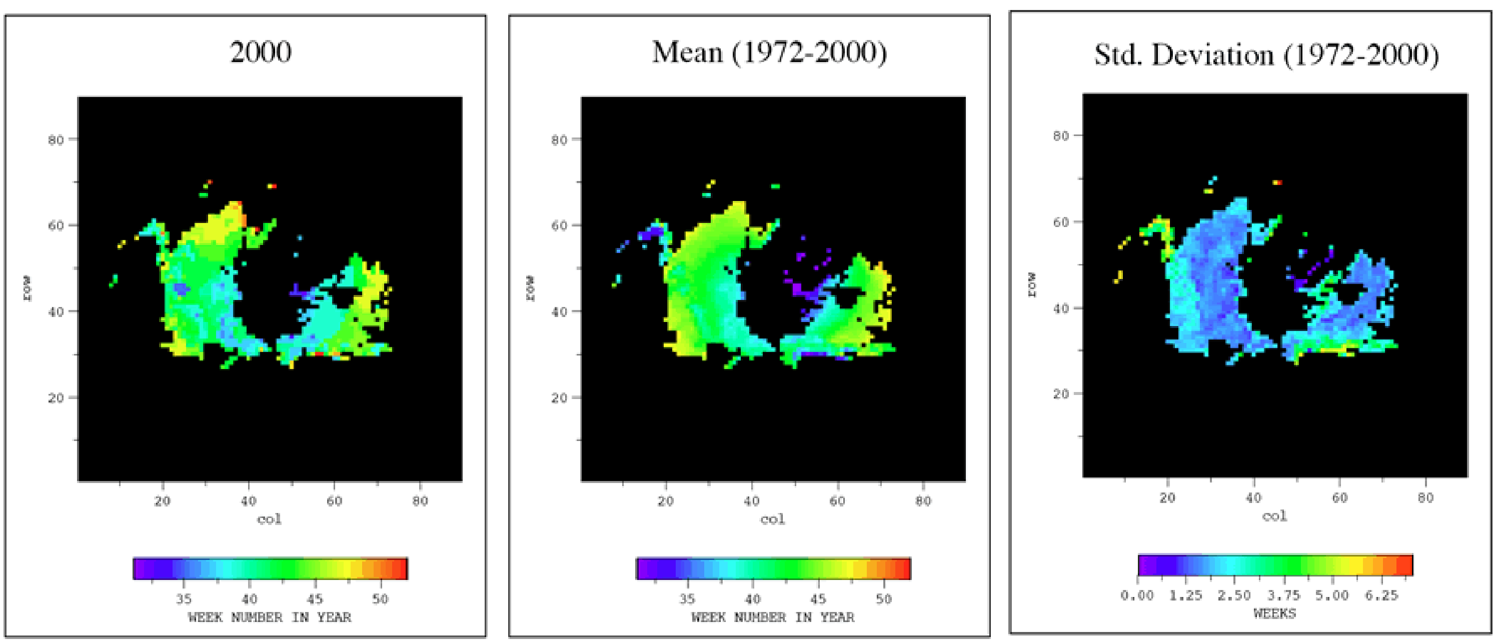

Figure 2. WFS: Week of First Observed Snow-Cover in Autumn

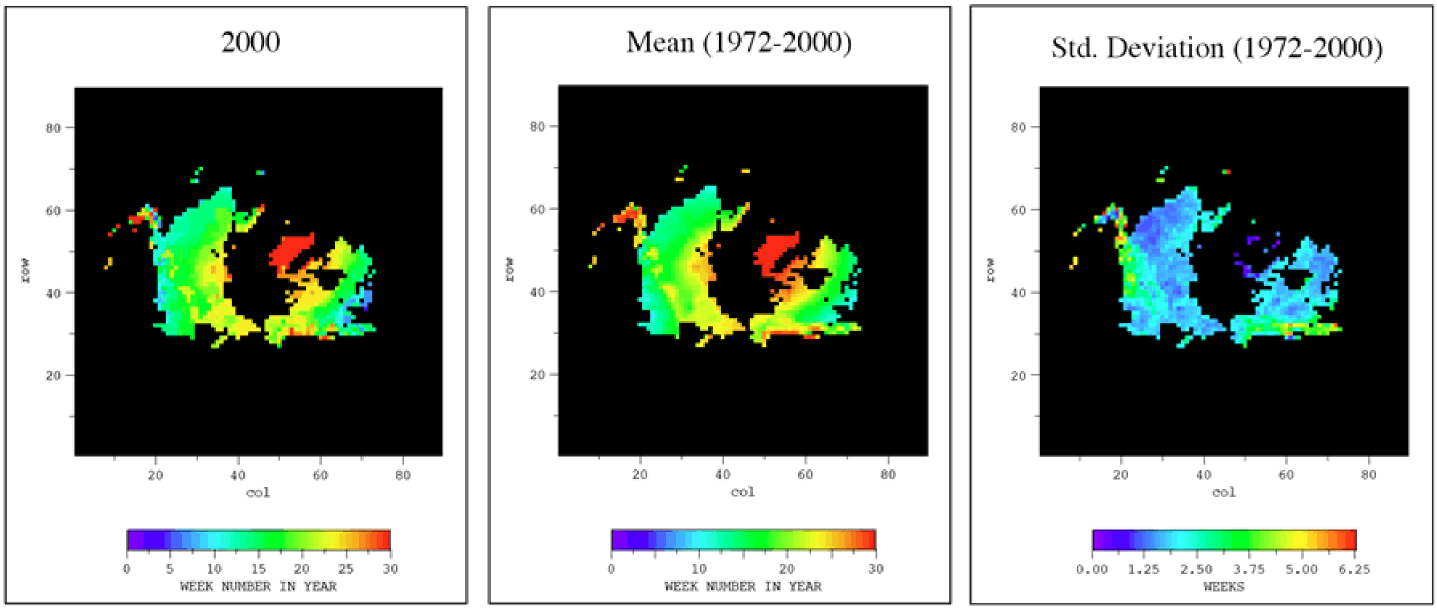

Figure 3. WLS: Week of Last Observed Snow-Cover in Spring

2.2 File and Directory Structure

The data are available via HTTPS: https://noaadata.apps.nsidc.org/NOAA/G02168/. Data on the HTTPS site are arranged in directories. The full directory structure is outlined below.

Data/ Parent data directory
Binary/ Yearly parameter files (WFS, WLS and DSF)
ASCII/ Twenty-nine year time-series, 1 file per parameter
Statistics/ Mean and standard deviation files, 1 file per parameter

little-endian/
big-endian/
Grids/ Latitude and longitude grids

little-endian/
big-endian/

2.3 File Naming Convention

2.3.1 Binary

`wlsYYYY_byte.bin` (for example: `wls1972_byte.bin`)
`dsf YYYY_byte.bin` (for example: `dsf1972_byte.bin`)
`wfs YYYY_byte.bin` (for example: `wfs1972_byte.bin`)
where YYYY = four-digit year

2.3.2 ASCII

`parameter1972_2000.txt` (for example: `wls1972_2000.txt`) where parameter = `wls`, `wfs` or `dsf`

2.3.3 Statistics

`parameter1972_2000_sd.bin` and `parameter1972_2000_mean.bin`
where sd = standard deviation of the data values from 1972 to 2000 and mean = the mean of the data values from 1972 to 2000

2.3.4 Grids

There is one latitude (`grid_lat.bin`) and one longitude grid (`grid_lon.bin`) for little-endian and one latitude (`grid_lat_BE.bin`) and longitude file (`grid_lon_BE.bin`) for Unix users. BE stands for big-endian in the file names. These files can be used to georeference the data.

2.4 File Size

Binary WFS, WLS and DSF yearly files = 7,921 bytes
Binary statistics (mean and standard deviation) and georeferencing files (latitude and longitude files) = 31,684 bytes
ASCII files = 950,520 bytes

2.5 Sample Data Record

Data correspond to cells in an 89 by 89 cell grid. The ASCII files have the following structure:

```
Data structure: 35 fixed format columns (c1-c35), fortran format
(i2,x,i2,f6.2,f8.2,29(i3),2(f6.2))
```

Column Number	Description
1	Grid cell column
2	Grid cell row
3	Grid cell latitude (grid cell center)
4	Grid cell longitude (grid cell center); East is positive and West is negative
5-33	WLS, WFS or DSF for years 1972 to 2000
34	mean of WLS, WFS or DSF from 1972 to 2000
35	standard deviation of WLS, WFS or DSF from 1972 to 2000

Here is a sample of the first four records from a WFS ASCII file (wfs1972_2000.txt). The contents of each column are given above. Note that for these grid cells, the data values are 0, indicating that they are masked:

1 1 0.66 -125.00 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0.00 0.00
1 2 1.32 -125.67 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0.00 0.00
1 3 1.99 -126.35 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0.00 0.00
1 4 2.64 -127.04 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0.00 0.00

2.6 Spatial and Temporal Coverage and Resolution

- Spatial Coverage: Northern Hemisphere (most cells with data are above 45° N, with the exception of some high elevation areas of limited spatial extent)
- Spatial Resolution: grid cell dimensions of about 140 km x 140 km to 205 km x 205 km, covering about 16,000 square km to 42,000 square km respectively.
- Temporal Coverage: 1972 to 2000
- Temporal Resolution: 1 file per parameter per year

2.7 Quality Assessment

By inspecting visible band satellite imagery, analysts from the NOAA Office of Satellite Data Processing and Distribution (OSDPD), Satellite Services Division (SSD), Satellite Analysis Branch (SAB), produced an analogue Northern Hemisphere snow/ice map. (More recently, production of this product has taken place in a digital environment. (See IMS Daily Northern Hemisphere Snow and Ice Analysis at 4 km and 24 km Resolution and NOAA Operational Daily Snow Cover Analysis pages for more information.) The weekly version of this product is the basis for the subject data set. Studies cited in Dye (2002) note that the NOAA snow charts have limitations because they are created using visible band imagery. For example, the snow cover can be difficult to detect due to "low solar illumination and high solar zenith angles, dense forest cover and cloud cover". According to Dye (2002), these limitations reduce the reliability of the data set more significantly for local or regional scale studies than for global analyses.

This study did not incorporate direct validation techniques, because there is not a practical way to validate broad scale estimates of snow-covered area. Instead, the author used the relationship between the snow cover cycle and the snow-covered area as an alternative method for assessing validity of the data, stating that "a strong correlation between interannual fluctuations in SCA (snow covered area) and WLS, WFS and DSF can provide additional confidence in results from the snow-cover cycle analysis." See Dye (2002) for more information.

The NOAA snow product has been widely used in climate studies, but it is important to note that it is an operational product. That is, it is produced in near real time to meet operational needs, and may have inconsistencies that render it unsuitable for climatological studies. Work done at the Rutgers University Climate Laboratory Global Snow Lab addresses these inconsistencies.

3 SOFTWARE AND TOOLS

3.1 Get Data

The data are available via HTTPS: https://noaadata.apps.nsidc.org/NOAA/G02168/. Most image processing software can read the binary data from this data set.

3.1.1 Importing Binary Data into ENVI

Environment for Visualizing Images (ENVI) software is one software program commonly used to view binary data. The parameter binary files can be imported into ENVI. The steps below were tested with ENVI 4.0 on a Windows XP platform. Steps may vary if using another version of the software. These instructions illustrate how to import and view a parameter binary file in ENVI.

1. Open ENVI from the Start menu.
2. Select File -> "Open Image File".
3. Browse to the binary image and "Open" the image file.
4. A "Header Info" box should appear. Input the following information:
   Samples: 89
   Lines: 89
   Bands: 1
   Offset: 0
   xstart: 1
   ystart: 1
   Data Type: Byte
   Byte Order: Network (IEEE)
   ENVI Standard
   BSQ
   Select "OK"
5. Select Band 1 -> "Load Band". The image should display correctly in ENVI.

4 DATA ACQUISITION AND PROCESSING

To create a digital chart series from the analogue data, NOAA analysts overlaid an 89 by 89 cell grid with a cell size of about 16,000 square kilometers at low latitudes to 42,000 square kilometers at high latitudes. Analysts determined whether a cell was snow-covered or not by looking at visible satellite imagery for the last observable clear day in the week. According to Robinson et al. (1993, 1995) cited in Dye (2002), the fifth day of the week was the most commonly used day in the week. Cells with more than 50% snow cover were assigned a value of 1, and cells with less than 50% snow cover were assigned a value of 0.

D. Robinson, Rutgers University Climate Laboratory, corrected inconsistencies in the land mask throughout the digitized snow map time series. D. Dye obtained the corrected series from D. Robinson, Rutgers University Global Snow Lab, in 2001.

The weekly snow charts cover observation periods that correspond to sequential day numbers that vary from year to year. To make the data set consistent so that direct comparisons in snow cover timing between years was possible, each weekly file was assigned a week number (1-52) corresponding to a fixed sequence of day numbers (1-7, 8-14, etc.) starting on the first day of the year. The weekly file was assigned to the week number that it overlapped by four or more days. This introduced a temporal uncertainty of 0-3 days. The small effect of leap year on the date of the vernal equinox (0.2 days over 29 years) was neglected.

The analysis included cells that contained at least one observation of snow cover in both the nominal spring (January 1 to July 31) and autumn (August 1 to December 31) periods. Grid cells that did not satisfy this criterion for every year in the 29-year series were masked. Masking resulted in a spatial extent that included most of North America and Eurasia north of 45 degrees N, with the exception of Europe.

For cells that were not masked, the week number of the last week of snow cover in spring (WLS) and the week number of the first week with snow cover in autumn (WFS) were determined. Spring and autumn were defined as weeks 1-30 (January-July) and weeks 31-52 (August - December) respectively. The duration of the snow-free period (DSF) was derived from the following equation:

$$DSF_n = WFS_n - WLS_n - 1$$

where n denotes the year, with valid values falling between 1972 and 2000.

The analysis included cells that contained at least one observation of snow cover in both the spring and autumn periods. Cells not meeting this criterion for every year in the 29-year series were masked. Masking resulted in a spatial extent that included most of North America and Eurasia north of 45 degrees N, with the exception of Europe.

When quantifying the snow-free period (DSF), transient snow-free periods were ignored. These periods were defined as snow-free periods that can occur either after the first-observed snow cover in the autumn or before the last-observed snow observation in the spring.

5 REFERENCES AND RELATED PUBLICATIONS

Dye, D.G. 2002. Variability and trends in the annual snow-cover cycle in Northern Hemisphere land areas, 1972-2000. Hydrological Processes 16: 3065-3077.

Robinson, D.A., Dewey, K.F., and R.R. Heim Jr. 1993. Global snow cover monitoring: an update. Bulletin of the American Meteorological Society 74: 1689-1696.

Robinson, D.A. Frei, A. and M. C. Serreze. 1995. Recent variations and regional relationships in Northern Hemisphere snow cover. Annals of Glaciology 21:71-76.

5.1 Related NSIDC Data Collections

- Northern Hemisphere EASE-Grid Weekly Snow Cover and Sea Ice Extent Version 3: Makes use of the quality-controlled NOAA snow cover record beginning in 1966 (provided by Robinson).
- IMS Daily Northern Hemisphere Snow and Ice Analysis at 4 km and 24 km Resolution: The current operational snow map product produced by NOAA National Environmental Satellite, Data and Information Service, replacing the weekly product upon which the subject data set is based.
- MEaSUREs Northern Hemisphere Terrestrial Snow Cover Extent Weekly 100km EASE-Grid 2.0: Offers users weekly 100 km Northern Hemisphere snow cover extent.

5.2 Other Related Data Collections

- Rutgers University Global Snow Lab provides an interface for viewing a research quality version of the operational NOAA snow maps, along with extensive documentation on the NOAA data product.
- NOAA Climate Data Record of Northern Hemisphere Snow Cover Extent: Provides a high-quality Climate Data Record (CDR) of Snow Cover Extent for the Northern Hemisphere.

6 CONTACTS AND ACKNOWLEDGMENTS

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7 DOCUMENT INFORMATION

7.1 Document Authors

Lisa Ballagh and Florence Fetterer wrote this documentation based on the cited references and information provided by Dennis Dye.

7.2 Publication Date

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7.3 Date Last Updated

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