Arctic Soil Freeze/Thaw Status from SMMR and SSM/I, Version 2

USER GUIDE

How to Cite These Data

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

Zhang, T. and R. Armstrong 2003. Arctic Soil Freeze/Thaw Status from SMMR and SSM/I, Version 2. [Indicate subset used]. Boulder, Colorado USA. NSIDC: National Snow and Ice Data Center. https://doi.org/10.7265/c7f8-6t68. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/GGD641

National Snow and Ice Data Center

TABLE OF CONTENTS

1 DATA DESCRIPTION

This data set contains near-surface (< 5 cm) soil freeze/thaw status on snow-free and snow-covered land surfaces over the Arctic terrestrial drainage basin. The near-surface soil freeze/thaw status is determined by using passive-microwave remote sensing data over snow-free land and a numerical model over snow-covered land. Data are projected to a 25 km x 25 km Northern Hemisphere EASE-Grid. Version 2 of this data set greatly extends the temporal coverage and makes use of data from SMMR as well as SSM/I. Data are from October 1978 to June 2004. Data are in ASCII text format and are available via FTP.

1.1 File Information

1.1.1 Format

Data are in ASCII text format, compressed with gzip. Three hundred nine files contain data from October 1998 through June 2004. Each file contains columns for latitude, longitude, and surface type for each day of the month. A two line header indicates the column headers, the year and month, and a key to the values for the surface types. Surface type values are as follows:

1. Snow-free, unfrozen ground
2. Snow-free, frozen ground
3. Snow-covered, unfrozen ground
4. Snow-covered, frozen ground
5. Desert (south of 50°N)
6. Mixed land and ocean
7. Lake or ocean

1.1.2 File Size

One 148.3 MB tarred and compressed file contains 309 individual 10.3 MB files.

1.1.3 Naming Convention

The file-naming convention is "ggd641_freezethaw_arctic.yyyy.mm.txt."

1.2 Spatial Information

1.2.1 Coverage

This data set covers the entire Arctic terrestrial drainage basin. This area includes land with ice or water that empty into the Arctic Ocean, Hudson Bay, James Bay, Hudson Strait, and the Bering Sea. The Arctic drainage basin spans overs regions of seasonally-frozen ground in the south, to

permafrost regions in the north. Continuous permafrost underlies nearly half of the Arctic drainage basin (Brown et al. 1998, Zhang et al. 2000).

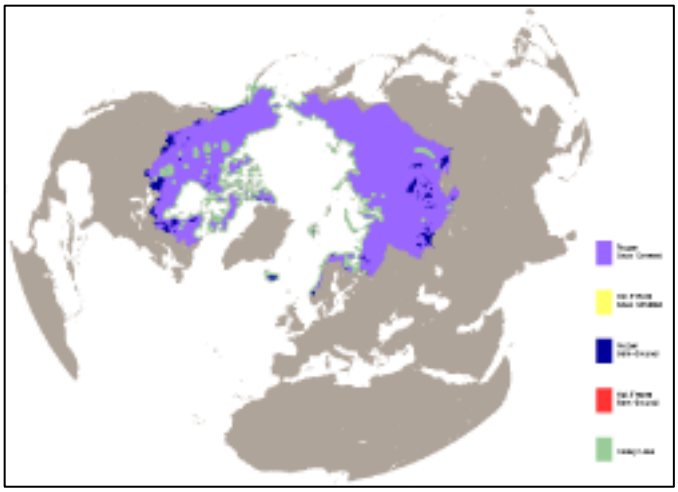

Figure 1. This image, from 02 January 1999, was created from "Arctic Soil Freeze/Thaw Status from SMMR and SSM/I, Version 2" data. It shows the spatial extent of the Arctic terrestrial drainage basin.

1.2.2 Spatial Resolution

Spatial resolution equals 25 km.

1.2.3 Grid Description

Input data are interpolated to a spatial subset of the Northern Hemisphere EASE-Grid projection that represents the Arctic drainage basin. (See All About EASE-Grid for further details.) Data are output to ASCII text format.

1.3 Temporal Information

1.3.1 Coverage

Data are grouped by month from October 1978 through June 2004. Each file contains daily data values.

2 DATA ACQUISITION AND PROCESSING

2.1 Acquisition

Zhang and Armstrong obtained input data from the following sources:

Passive-microwave TBs

This study uses 18-Ghz and 37-Ghz TBs from the Nimbus-7 SMMR Pathfinder Daily EASE-Grid Brightness Temperatures and the 19-GHz and 37-GHz TBs from the DMSP SSM/I-SSMIS Pathfinder Daily EASE-Grid Brightness Temperatures data set, available from NSIDC.

Air Temperature

The National Water and Climate Center (NWCC), Natural Resources Conservation Center (NRCC) of the U.S. Department of Agrictulture provided mean daily and monthly air temperature data. The University of Delaware's Center for Climate Research provided gridded mean monthly air temperatures over the study area. The 0.5° x 0.5° gridded latitude/longitude data were gridded into the 25-km EASE-Grid. Mean daily air temperature was derived from the mean annual air temperature and annual amplitude, which were derived from mean monthly air temperature.

Snow Cover

Zhang and Armstrong calculated snow water equivalent from the Nimbus-7 SMMR Pathfinder Daily EASE-Grid Brightness Temperatures and DMSP SSM/I-SSMIS Pathfinder Daily EASE-Grid Brightness Temperatures data sets, available from NSIDC. The Chang (1987) algorithm, originally used for calculating snow water equivalent from Scanning Multichannel Microwave Radiometer (SMMR) passive-microwave data from 1978 to 1987, was modified for the SSM/I data.

Soil Temperature

The National Water and Climate Center (NWCC), Natural Resources Conservation Center (NRCC) of the U.S. Department of Agrictulture provided hourly soil temperature data at depths of 0 cm, 5 cm, 10 cm, 20 cm, 40 cm, 80 cm, 100 cm, and 150 cm. Ground surface temperature is measured only at a few selected sites. This study uses soil temperature data at 5-cm depth from all sites.

2.2 Processing

This data set is derived from a frozen-soil algorithm that combines passive-microwave remote sensing and numerical modeling methods. The first step is to compile the input data described in the Data Source section of this document. Using available ground-based and satellite data, Zhang and Armstrong determine where snow exists over the study area. Over snow-free land, they use a frozen-soil algorithm using SMMR and SSM/I data to detect near-surface freeze/thaw status. Over snow-covered land areas, they use a one-dimensional heat transfer numerical model with phase change to detect soil freeze/thaw status.

Passive-microwave algorithm

SSM/I 19-GHz and 37-GHz vertically-polarized T_Bs discriminate frozen ground from unfrozen ground over prairie soils, using the following equation:

$(T_B(37V) - T_B(19V))/18 < 0$

and

$T_B(37V) < 258.2$ K

A similar approach is used with the SMMR data using the 18-Ghz and 37-Ghz channels.

Mixed land and water pixels provide misleading information on the land surface freeze and thaw status; therefore, areas up to approximately 50 km from the coasts of large water bodies are masked out.

Numerical model

This study uses a numerical model for one-dimensional heat transfer with phase change to simulate the soil freezing and thawing processes with or without snow cover. This model has shown excellent previous results for active-layer depth and soil temperatures when driven by well-known boundary conditions and forcing parameters at specific locations (Zhang, Osterkamp, and Stamnes 1996).

3 RELATED WEBSITES

All About EASE-Grid

4 REFERENCES

Armstrong , R.L., and M.J. Brodzik. 2002. *Northern Hemisphere EASE-Grid weekly snow cover and sea ice extent, Version 2*. Boulder, CO: National Snow and Ice Data Center. CD-ROM.

Brodzik, M.J. 1997. EASE-Grid: A versatile set of equal-area projections and grids. Boulder, CO, USA: National Snow and Ice Data Center.

Brown, J., O.J. Ferrians, Jr., J.A. Heginbottom, and E.S. Melnikov. 1998. *Digital Circum-Arctic map of permafrost and ground-ice conditions. In International Permafrost Association, Data and Information Working Group, comp. Circumpolar Active-Layer Permafrost System (CAPS), version 1.0.* Boulder, CO: National Snow and Ice Data Center. CD-ROM.

Chang, A.T.C., J.L. Foster, and D.K. Hall. 1987. Nimbus-7 SMMR derived global snow cover parameters. *Annals of Glaciology* 9:39-44.

Global Soil Data Task. 2000. Global gridded surfaces of selected soil characteristics. International Geosphere-Biosphere Programme - Data and Information Services (IGBP-DIS). Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center.

Goodrich, L.E. 1982. Efficient numerical technique for one-dimensional thermal problems with phase change. *International Journal of Heat and Mass Transfer* 21:615-621.

Holden, J.B., C.J. Vörösmarty, S. Frolking, and R. Lammers. 2001. A large-scale water balance model for permafrost terrain. *Arctic and Alpine Research.* In press.

Kalnay, E., M. Kanamitsu, R. Kistler, W. Collins, D. Deaven, L. Gandin, M. Iredell, S. Saha, G. White, J. Woolen, Y. Zhu, M. Chelliah, W. Ebisuzaki, W. Higgens, J. Janowiak, K.C. Mo, C. Ropelewski, J. Wang, A. Leetma, R. Reynolds, R. Jenne, and D. Joseph. 1996. The NCEP/NCAR 40-year reanalysis project. *Bulletin of the American Meteorological Society* 77:437-471.

Meteorological Service of Canada (MSC). 2000. *Canadian Snow Data CD-ROM. Downsview*, Ontario, Canada: Meteorological Service of Canada, CRYSYS Project, Climate Processes and Earth Observation Division.

Oelke, C., T. Zhang, M. Serreze, and R. Armstrong. 2003. Regional-scale modeling of soil freeze/thaw over the Arctic Drainage Basin. *Journal of Geophysical Research-Atmospheres* 108(D10) (May).

Sturm, M., J. Holmgren, and G.E. Liston. 1995. A seasonal snow cover classification system for local to global applications. *Journal of Climate* 8:1261-1283.

Zhang, T., and R.L. Armstrong. 2001. Soil freeze/thaw cycles over snow-free land detected by passive microwave remote sensing. *Geophysical Research Letters* 28(5): 763-766.

Zhang, T., J.A. Heginbottom, R.G. Barry, and J. Brown. 2000. Further statistics on the distribution of permafrost and ground-ice in the Northern Hemisphere. *Polar Geography* 24(2):126-131.

Zhang, T., R.G. Barry, K. Knowles, J.A. Heginbottom, and J. Brown. 1999. Statistics and characteristics of permafrost and ground ice distribution in the Northern Hemisphere. *Polar Geography* 23(2):147-169.

Zhang, T., T.E. Osterkamp, and K. Stamnes. 1996. Influence of the depth hoar layer of the seasonal snow cover on the ground thermal regime. *Water Resources Research* 32(7):2075-2086.

5 DOCUMENT INFORMATION

5.1 Publication Date

May 2003

5.2 Date Last Updated

20 January 2021