



MEaSURES Polar EASE-Grid 2.0 Daily 6 km Land Freeze/Thaw Status from AMSR-E and AMSR2, Version 2

USER GUIDE

How to Cite These Data

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

Kim, Y., J. S. Kimball, J. Du, and J. Glassy. 2021. *MEaSURES Polar EASE-Grid 2.0 Daily 6 km Land Freeze/Thaw Status from AMSR-E and AMSR2, Version 2*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. doi: <https://doi.org/10.5067/BDY2V548E07C>. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT <https://nsidc.org/data/NSIDC-0728>



National Snow and Ice Data Center

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i The title of this data set (NSIDC-0728) has changed for Version 2. The Version 1 title, “MEaSURES Northern Hemisphere Polar EASE-Grid 2.0 Daily 6 km Land Freeze/Thaw Status from AMSR-E and AMSR2,” was updated to reflect the addition of Southern Hemisphere coverage.

1 DATA DESCRIPTION

This data set reports the global, daily freeze/thaw (F/T) status of the landscape at 6 km resolution on EASE-Grid 2.0 Northern Hemisphere (NH) and Southern Hemisphere (SH) polar grids. Daily F/T status is determined using annually calibrated, seasonal thresholds derived from the dynamic relationship between satellite brightness temperature (T_b) and changes in the aggregate, landscape dielectric constant associated with transitions between predominantly frozen and non-frozen conditions.

T_b data were acquired by:

- The Advanced Microwave Scanning Radiometer - Earth Observing System (AMSR-E)
- The Advanced Microwave Scanning Radiometer 2 (AMSR2) on board the Japan Aerospace Exploration Agency (JAXA) GCOM-W1 satellite

Collocated observations from the Microwave Radiation Imager (MWRI) on board the Chinese Feng Yun 3B satellite are used to calibrate the AMSR-E and AMSR2 records and bridge the 2011–2012 coverage gap between the AMSR-E instrument malfunction and the beginning of the AMSR2 mission.

1.1 Parameters

Daily F/T status reports the condition in a cell as either frozen or thawed. In addition, morning (AM) and afternoon (PM) F/T statuses in a cell are combined to report the following once-per-day composite (CO) classification:

- Frozen (AM and PM frozen)
- Thawed (AM and PM thawed)
- Transitional (AM frozen, PM thawed)
- Inverse transitional (AM thawed, PM frozen)

Annual quality assurance (QA) indicates the relative quality of each grid cell’s mean annual F/T status based on the potential negative impacts of open water cover, terrain complexity, length of F/T transitional season, and F/T threshold uncertainty.

Annual accuracy is assessed relative to daily maximum and minimum air temperature measurements from global WMO weather network stations. Values represent the percentage of

satellite-derived, daily F/T determinations per year that are consistent with in situ WMO measurements.

1.2 File Information

1.2.1 Format

Data are available in the following formats:

- GeoTIFF (daily F/T status, annual QA)
- Binary (daily F/T status, annual QA, annual accuracy)

GeoTIFF files can be accessed using QGIS (free, open Source), ESRI ArcGIS, or similar geographical information systems.

Binary files require more specialized tools to access, such as the open source software package ImageJ. Table 1 contains details about the binary file headers for this data set.

Table 1. Binary Header Details

Number of bands in file	1
Number of bits per pixel per band	Daily F/T status: 8 QA and accuracy: 32
Organization of bands in image file	N/A
Byte order	Little-endian

1.2.2 File Contents

All data files contain 3000 × 3000 (row × column) rasters.

1.2.2.1 Daily F/T Status (GeoTIFF, Binary)

Data are stored as 8-bit unsigned integers using the following schemes:

AM, PM

- 0 – frozen
- 1 – thawed

CO

- 0 – AM and PM frozen
- 1 – AM and PM thawed
- 2 – AM frozen, PM thawed (transitional)
- 3 – AM thawed, PM frozen (inverse transitional)

Additional Values

- 252 – no data
- 253 – non-cold constraint area
- 254 – 100% open water

1.2.2.2 Annual QA (GeoTIFF, Binary)

Data are stored as 32-bit floating point values that range from 0.0 to 1.0. QA values should be interpreted as follows:

- Low: $QA < 0.70$
- Moderate: $0.70 \leq QA \leq 0.80$
- Good: $0.80 \leq QA \leq 0.90$
- Best: $QA > 0.90$
- No data = -9999

1.2.2.3 Annual Accuracy (Binary)

Accuracy is expressed as the percentage of daily F/T retrievals per year that are consistent with daily maximum and minimum air temperatures measured by WMO weather stations. Percentages range from 0.0 to 100.0. A value of -9999 indicates no data.

1.2.3 Directory Structure

Data are available via direct download (HTTPS). The data directory contains the following top-level folders:

/ANNUAL_ACCURACY/

/ANNUAL_QA/

/DAILY_BINARY/

/DAILY_GEOTIFF/

Each top-level folder contains subfolders, one for each year of the data record (i.e., 2002, 2003, 2004...) that contain the data files for that year.

1.2.4 Naming Convention

1.2.4.1 Daily F/T Status

Daily F/T status files utilize the following naming convention:

Example File Name

AMSR_36V_AM_FT_2002_day153_NH_06km_v02.1.tif

Naming Convention

AMSR_36V_[overpass]_FT_[year]_day[nnn]_[hemisphere]_06km_[version].[ext]

Table 2. Daily F/T Status File Name Variables and Descriptions

Variable	Description
overpass	AM (morning), PM (evening), or CO (composite)
year	Four-digit year
nnn	Three-digit day of the year
hemisphere	NH (Northern Hemisphere) or SH (Southern Hemisphere)
version	2.1 (GeoTIFF) or 2.0 (binary). See “Table 6. Version History Summary” for details.
ext	tif (GeoTIFF) or bin (binary)

1.2.4.2 Annual QA and Annual Accuracy

Annual QA and annual accuracy files utilize the following naming convention:

Example File Names

AMSR_36V_PM_QA_2002_NH_06km_v02.bin

AMSR_36V_AM_FT_2003_accuracy_NH_06km_v02.bin

Naming Convention

AMSR_36V_[overpass]_QA_[year]_[hemisphere]_06km_v02.[ext]

AMSR_36V_[overpass]_FT_[year]_accuracy_[hemisphere]_06km_v02.[ext]

Table 3. Annual QA and Accuracy File Name Variables and Descriptions

Variable	Description
overpass	AM (morning), PM (evening)
year	Four-digit year
hemisphere	NH (Northern Hemisphere) or SH (Southern Hemisphere)
ext	tif (GeoTIFF) or bin (binary)

1.3 Spatial Information

1.3.1 Coverage

Coverage is global, comprising all NH and SH land areas affected by seasonal frozen temperatures including urban, barren, snow and ice, and open water body dominant grid cells.

1.3.2 Resolution

6 km

1.3.3 Geolocation

The following tables provide information about geolocating this data set:

Table 4. Geolocation Details for NSIDC EASE-Grid 2.0 North and South

Geographic coordinate system	WGS 84
Projected coordinate system	NH: NSIDC EASE-Grid 2.0 North
	SH: NSIDC EASE-Grid 2.0 South
Longitude of true origin	0°
Latitude of true origin	NH: 90°
	SH: -90°
Scale factor at longitude of true origin	N/A
Datum	WGS 84
Ellipsoid/spheroid	WGS 84
Units	meters
False easting	0
False northing	0

EPSG code	NH: 6931 (NSIDC EASE-Grid 2.0 North)
	SH: 6932 (NSIDC EASE-Grid 2.0 South)
PROJ4 string	NH: +proj=laea +lat_0=90 +lon_0=0 +x_0=0 +y_0=0 +ellps=WGS84 +towgs84=0,0,0,0,0,0 +units=m +no_defs SH: +proj=laea +lat_0=-90 +lon_0=0 +x_0=0 +y_0=0 +ellps=WGS84 +towgs84=0,0,0,0,0,0 +units=m +no_defs
Reference	http://epsg.io/6931 http://epsg.io/6932

Table 5. Grid Details

Grid cell size (x, y pixel dimensions)	6,000 m x 6,000 m
Number of rows	3000
Number of columns	3000
Geolocated lower left point in grid	Left: -8999999.9988 Bottom: -9000000.0012
Nominal gridded resolution	6 km
Grid rotation	0
ulxmap – x-axis map coordinate of the center of the upper-left pixel (XLLCORNER for ASCII data)	8,995,000.0012
ulymap – y-axis map coordinate of the center of the upper-left pixel (YLLCORNER for ASCII data)	-8,995,000.0012

1.4 Temporal Information

1.4.1 Coverage

2 June 2002 – 31 December 2021

1.4.2 Resolution

Daily

2 DATA ACQUISITION AND PROCESSING

2.1 Background

The frozen/non-frozen state of the landscape is closely linked to numerous components of the climate system, including: changes in the surface energy budget and evapotranspiration;

vegetation growth and phenology; snow-melt dynamics; permafrost extent and stability; terrestrial carbon budgets; and land-atmosphere trace gas exchanges.

Satellite passive microwave sensors are particularly well-suited to identifying F/T status because they are strongly sensitive to changes that occur in surface dielectric properties when the landscape transitions between frozen and thawed states, and because they are relatively insensitive to atmospheric contamination and do not require solar illumination (McDonald and Kimball, 2005; Kim et al., 2011, 2012).

This Version 2 data set was generated using similar protocols as Version 1. The following sections outline the approach used to infer F/T state changes from remotely sensed T_b . A more detailed description of the methods, algorithm performance, and product accuracy are available in Kim et al. (2017).

i This data set augments the MEaSURES Global Record of Daily Landscape Freeze/Thaw Status Earth System Data Record ([NSIDC-0477](#)) provided at 25 km resolution in the original EASE-Grid cylindrical, equal-area projection.

2.2 Acquisition

This Earth System Data Record (ESDR) is derived from AM and PM T_b measurements (36.5 GHz, vertical polarization) acquired by AMSR-E and AMSR2 from 2 June 2002 through 31 December 2021. Following Du et al. (2014), Microwave Radiation Imager (MWRI)* observations were used to calibrate the AMSR-E and AMSR2 records and bridge the 2011–2012 coverage gap between the end of AMSR-E data acquisition and the beginning of AMSR2.

i The AMSR-E 36.5 GHz swath footprint has a native resolution of 14 km x 8 km. The resolution of the AMSR2 L1R footprint is 12 km x 7 km.

*The MWRI was deployed in November 2010. The instrument has a similar configuration and data acquisition times as AMSR-E and AMSR2.

2.3 Processing

The calibrated, gap-filled T_b record was re-projected to 6 km Northern and Southern Hemisphere EASE-Grid 2.0 polar grids using the Inverse Distance Squared spatial interpolation described in Du et al. (2017).

Ascending and descending orbital T_b time series are then processed separately to obtain AM (01:30), PM (13:30), and CO daily FT conditions (see “Section 1.1 Parameters”).

F/T status is determined using a modified seasonal threshold algorithm (MSTA) and annually calibrated, T_b reference conditions (per pixel) derived from 6 km daily surface air temperature (SAT) records. To generate 6 km SATs, coarser (0.25°) ERA5 reanalysis data were down-sampled (Hersbach et al., 2020) using temperature lapse rates defined from an Aqua MODIS land surface temperature climatology and a digital elevation map.

Over NH permanent snow and ice regions, F/T status is determined using an Adaptive Threshold algorithm (ADT) that analyzes T_b time series in a given year and grid cell. In areas with seasonal melting, the algorithm applies a “Breaks For Additive Seasonal and Trend” (BFAST) approach (Verbesselt et al., 2012), which detects the abrupt change point between adjacent frozen and thawed periods and determines the corresponding F/T reference T_b value.

In areas without persistent snow and ice melting, diurnal change signals from ascending and descending retrievals are used to confirm diurnal F/T events and compute reference T_b values.

2.4 Quality, Errors, and Limitations

F/T accuracy has been primarily assessed in relation to daily minimum and maximum air temperature measurements recorded by the global WMO weather station network (4761 ± 904 stations). Daily SAT_{min} and SAT_{max} records were used to define daily frozen ($SAT \leq 0^\circ C$) and non-frozen ($SAT > 0^\circ C$) status and compared with F/T status determinations by the algorithm. Spatial classification accuracy is expressed as the proportion of stations where the daily F/T classification is consistent with station SAT measurement-based F/T estimates.

Overall, mean annual F/T spatial classification accuracies* in the NH are approximately $86.6\% \pm 0.8$ (AM) and $93.2\% \pm 0.4$ (PM). Mean annual SH accuracies are approximately $92.4\% \pm 1.2$ (AM) and $99.0\% \pm 0.2$ (PM).

F/T classification accuracy shows strong seasonal and annual variability and is generally lower during active F/T transition periods, when spatial heterogeneity in landscape F/T processes is maximized (Kim et al. 2017). Daily F/T spatial classification accuracy is defined for each product daily granule from pixel-wise comparisons of FT classification accuracy in relation to co-located weather station network daily air temperature (SAT_{min} , SAT_{max}) measurements (Kim et al. 2017)

*Inter-annual standard deviation.

2.5 Instrumentation

2.5.1 Description

2.5.1.1 AMSR-E

AMSR-E is a 12-channel, 6-frequency passive microwave radiometer launched on 4 July 2004 on the NASA Aqua satellite. It measures T_b at 6.925, 10.65, 18.7, 23.8, 36.5, and 89.0 GHz (vertical and horizontal polarization). The AMSR-E instrument malfunctioned and stopped collecting science data on 4 Oct 2011.

2.5.1.2 AMSR2

AMSR2 is a 16-channel, 7-frequency passive microwave radiometer launched on 18 May 2012 on board the JAXA GCOM-W1 satellite. It measures T_b at 6.925, 7.3, 10.65, 18.7, 23.8, 36.5, and 89.0 GHz (vertical and horizontal polarization). The AMSR2 instrument is still active.

2.5.1.3 MWRI

The MWRI is a 10-channel, 5-frequency passive microwave radiometer launched with the Fen Yung 3B satellite on 4 November, 2010. It measures T_b at 10.65, 18.7, 23.8, 36.5, and 89.0 GHz (vertical and horizontal polarization). The MWRI is still active.

3 SOFTWARE AND TOOLS

GeoTIFF files can be accessed using QGIS (free, open Source), ESRI ArcGIS, or similar geographical information systems.

Binary files require more specialized tools to access, such as the open source software package ImageJ.

4 VERSION HISTORY

Table 6. Version History Summary

Version	Release Date	Description of Changes
V2.1	August 2023	<p>Minor version updates:</p> <ul style="list-style-type: none"> • Temporal coverage extended through 31 Dec. 2021 • Daily GeoTIFFs from 2002-2020 replaced. Although the data in these files were not changed, the file metadata was updated to match a new standard for all daily GeoTIFF files begun with the 2021 temporal coverage extension. The updated GeoTIFFs (and all new daily GeoTIFFs going forward) can be identified by "v02.1" in the file names.
V2	September 2021	<p>Changes for Version 2 include:</p> <ul style="list-style-type: none"> • SH coverage added. • Title changed: "Northern Hemisphere" was replaced with "Polar" to reflect new spatial coverage • Temporal coverage was extended through the end of 2021 • Modified seasonal threshold algorithm (MSTA) adopted that determines references conditions based on down-sampled 0.25° ERA5 reanalysis data.
V1.1	November 2020	<p>Daily binary files from 1 January 2017 to 31 December 2017 were replaced with updated versions due to bad F/T values in the original files. Although the bad data appears to have been isolated to the months of March – December, all 2017 data was replaced as a precaution.</p>
V1	December 2017	<p>Initial release</p>

5 RELATED DATA SETS

[MEaSURES Global Record of Daily Landscape Freeze/Thaw Status](#)

6 RELATED WEBSITES

[Freeze/Thaw Earth System Data Record](#) at the University of Montana

7 CONTACTS AND ACKNOWLEDGMENTS

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8 REFERENCES

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9 DOCUMENT INFORMATION

9.1 Publication Date

September 2021

9.2 Date Last Updated

August 2023