MEaSUREs Northern Hemisphere Polar EASE-Grid 2.0 Daily 6 km Land Freeze/Thaw Status from AMSR-E and AMSR2

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Detailed Data Description

This Earth System Data Record (ESDR) reports a Northern Hemisphere (NH) Polar EASE-Grid 2.0 record of daily landscape Freeze/Thaw (FT) status derived at 6 km resolution from satellite passive microwave remote sensing using the NASA Advanced Microwave Scanning Radiometer for EOS (AMSR-E) and the JAXA Advanced Microwave Scanning Radiometer 2 (AMSR2) series. The algorithm identifies FT state changes based on the dynamic relationship between brightness temperature (T_b) and changes in the aggregate landscape dielectric constant associated with transitions between predominantly frozen and non-frozen conditions. This FT regional data record augments an existing global 25 km resolution FT-ESDR, the MEaSUREs Global Record of Daily Landscape Freeze/Thaw Status, and provides an approximately four-fold improved spatial resolution over the previous product. This improvement is enabled by processing of orbital swath T_b retrievals closer to the native AMSR-E and AMSR2 36.5 GHz sensor footprint.

Format

Data are stored in the following formats:

- Binary (`.bin`)
- GeoTIFF (`.tif`)

The data consists of 3,000 by 3,000 grid of values, for a total of 9,000,000 pixels, where each value (i.e., each 6-km pixel) is stored digitally as an 8-bit byte.

File and Directory Structure

Data are available via HTTPS in the following directory:

`https://daacdata.apps.nsidc.org/pub/DATASETS/nsidc0728_MEASURES_6km_freeze_thaw_v01/`

Within this directory there are three subfolders, `/DAILY_BINARY/`, `/DAILY_GEOTIFF/`, and `/ANNUAL_BINARY_QA/`, with the following structure:

/DAILY_BINARY/

- /2002/
- …
- /2017/

/DAILY_GEOTIFF/

- /2002/
- …
- /2017/

/ANNUAL_BINARY_QA/

- /2002/
- …
- /2017/

The folders /DAILY_BINARY/ and /DAILY_GEOTIFF/ contain the daily records of landscape Freeze/Thaw status, whereas the folder /ANNUAL_BINARY_QA/ contains annual quality assurance (QA) maps describing the relative quality of the PER Freeze/Thaw classification.

File Naming Convention

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

The files in the folders /DAILY_BINARY/ and /DAILY_GEOTIFF/ follow the same naming convention. The files in /ANNUAL_BINARY_QA/ follow a slightly different convention. Variables used in the file names are defined in Table 1.

Example File Names

- AMSR_36V_PM_FT_2002_day357_NH_06km_v01.bin
- AMSR_36V_AM_FT_2013_day359_NH_06km_v01.tif
- AMSR_36V_PM_QA_2017_NH_06km_v01.bin

For example, the file AMSR_36V_PM_FT_2002_day357_NH_06km.bin represents the AMSR sensor, at 36.5 GHz, vertically polarized T_b-based FT classification for composite daily conditions for day 357 of 2002 over the Northern Hemisphere domain and at 6 km spatial resolution.

Naming Conventions

[InstrumentLabel]_[Channel][Polarization]_[OverpassCode]_FT_[Year]_day[DOY]_NH_06km_[Version].[FileExt]

[InstrumentLabel]_[Channel][Polarization]_[OverpassCode]_QA_[Year]_NH_06km_[Version].[FileExt]

Table 1. File name variables and definitions.

Variable	Definition
InstrumentLabel	Sensor: AMSR (for both AMSR-E and AMSR2)

`Channel`	Frequency (GHz): 36
`Polarization`	V (vertical)
`OverpassCode`	Morning overpass (AM), evening overpass (PM), or combined daily AM and PM overpass (CO)
`Year`	4-digit observation year
`DOY`	Day of year
`Version`	v01 (Version 1)
`FileExt`	.bin (binary) .tif (GeoTIFF)

File Size

The total file volume of `.bin` files is approximately 3.9 GB.

The total file volume of `.tif` files is approximately 4 GB.

Volume

The total data set volume is approximately 8.2 GB.

Spatial Coverage

The geographical range encompasses the Northern Hemisphere.

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

The FT-ESDR domain encompasses all Northern Hemisphere land areas affected by seasonal frozen temperatures, including urban, barren land, snow-ice, and open water body dominant grid cells.

Spatial Resolution

Data are gridded at 6 km.

Projection and Grid Description

The data are projected using a polar aspect Lambert azimuthal equal-area projection with the WGS 84 datum (EASE-Grid 2.0 North; Brodzik et al. 2014). The EPSG code for this projection is 6931. Refer to Table 2 for the defining pixel coordinates of the 6-km grid used with this projection.

Table 2. Grid coordinates.

Location in grid	Pixel
Upper left corner	-9,000,000; 9,000,000
Lower left corner	-9,000,000; -9,000,000
Upper right corner	9,000,000; 9,000,000
Lower right corner	9,000,000; -9,000,000
Center	0; 0

Temporal Coverage

02 June 2002 to 31 December 2017

Temporal Resolution

Daily

Parameter or Variable

Parameter Description

The daily AM and PM FT statuses report frozen (0) or thawed (1) conditions in a cell for the corresponding morning or afternoon overpass. In addition to the AM and PM statuses as single values, the FT-ESDR provides a combined (CO) daily classification of the predominantly frozen or non-frozen conditions of the landscape for each grid cell. Four discrete FT metrics are distinguished from the AM and PM T_b retrievals using the following scheme: AM and PM frozen (0); AM and PM thawed (1); AM frozen, PM thawed (2); AM thawed, PM frozen (3). Note that values 2 and 3 occur only in the combined FT status files. The FT-ESDR domain and the associated cold-constraint areas were defined using ERA-Interim daily minimum surface air temperatures (SAT) and a simple cold temperature constraint index (CCI) as described in Kim et al. (2017). Refer to Table 3 for the individual status classifications.

Table 3. FT-ESDR 8-bit integer data identifiers.

Classification	Data Identifiers
Frozen (AM/PM frozen)	0
Thawed (AM/PM thawed)	1
Transitional (AM frozen and PM thawed)	2
Inverse Transitional (AM thawed and PM frozen)	3
No FT status available	252[(1)]
Non-cold constraint area	253[(2)]
100% open water	254

[(1)] Value 252 is used to denote areas with no FT data, for example due to unavailable FT reference states or thresholds.

[(2)] Value 253 denotes land areas outside of the FT classification domain where ecosystem processes are not significantly affected by cold season constraints, i.e., where the estimated average number of frozen days is less than a minimum threshold of 5 days per year.

Sample Data Record

Refer to Figure 1 for a sample data record of the selected daily combined (CO) FT-ESDR classification results for 2016, where (a) DOY = 100, (b) DOY = 200, (c) DOY = 300, and (d) DOY = 360. White and gray colors denote respective open water bodies and land areas outside of the FT-ESDR domain. The four colors denote AM and PM frozen (FR, blue), AM and PM thawed (NF, red), AM frozen and PM thawed (TR, yellow) and AM thawed and PM frozen (INV-TR, green) status.

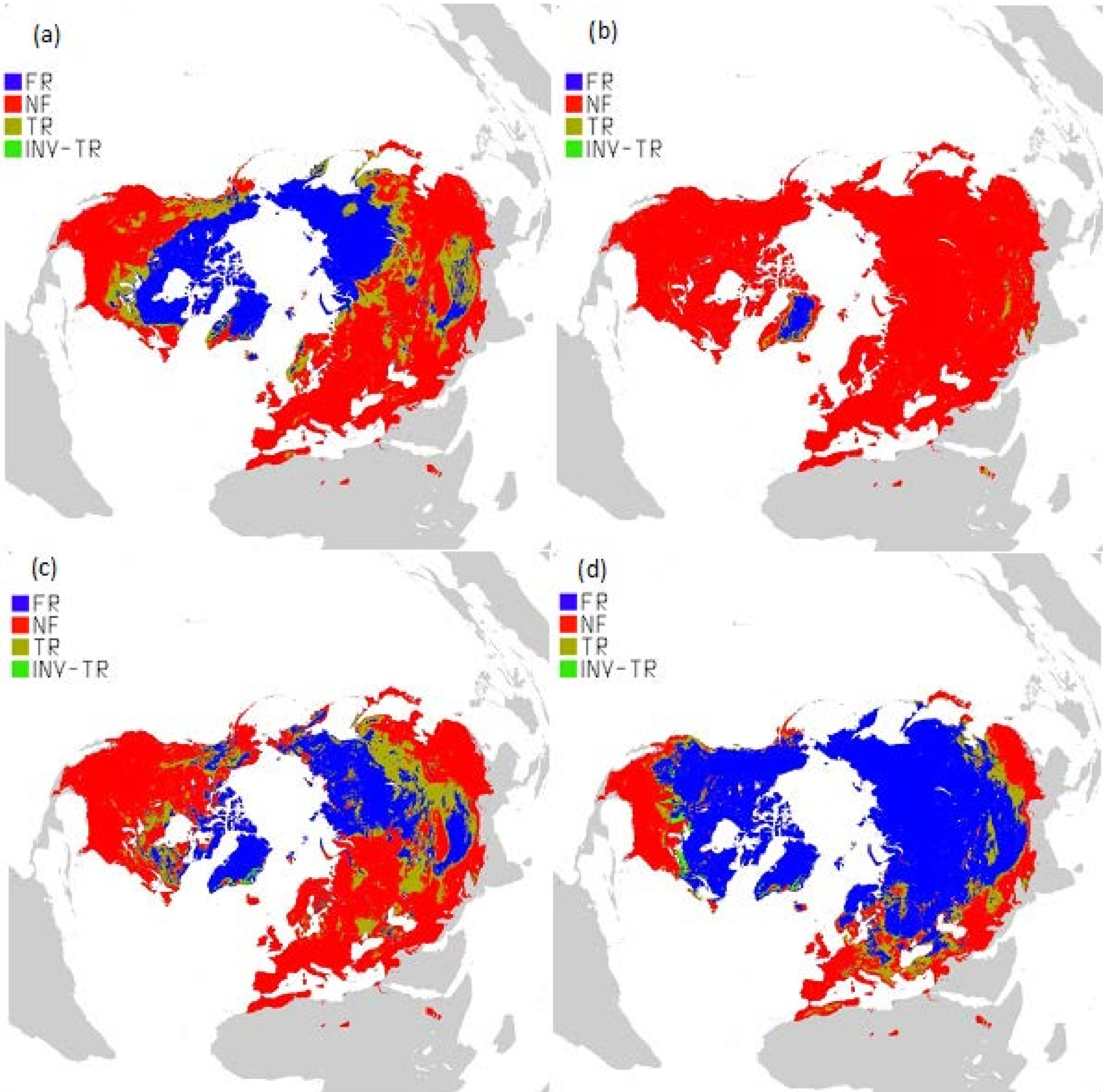

Figure 1. Selected Daily Combined (CO) FT-ESDR Classification Results for 2016.

Software and Tools

GeoTIFF files may be viewed with the following tools:

- ESRI ArcGIS
- QGIS
- Other Geographical Information System (GIS) software

Data Acquisition and Processing

Theory of Measurements

The FT state parameter quantifies the predominant frozen or non-frozen state of the landscape and is closely linked to changes in the surface energy budget and evapotranspiration (Zhang et al. 2011), vegetation growth and phenology (Kim et al. 2014a), snowmelt dynamics (Kim et al. 2015), permafrost extent and stability (Park et al. 2016), terrestrial carbon budgets and land-atmosphere trace gas exchange (Kim et al. 2014b). Satellite-borne passive microwave sensors are particularly well-suited to monitoring global FT status of the landscape because they are strongly sensitive to changes in dielectric properties at the surface that correspond to frozen and thawed states, are relatively insensitive to atmospheric contamination, and do not require solar illumination. The following sections outline the approach used to infer FT state changes from remotely sensed T_b. For a complete description, see Kim et al. (2011).

Data Acquisition Methods

The AMSR-E 36.5 GHz orbital swath T_b data have a native footprint resolution of 14 km x 8 km (Kawanishi et al., 2003), while the similar frequency T_b orbital swath (L1R) data from AMSR2 have a native 12 km x 7 km footprint resolution (Imaoka et al. 2010; Imaoka et al. 2012). The AMSR-E and AMSR2 swath T_b data were re-projected to a 6 km polar EASE-Grid 2.0 projection format using an Inverse Distance Squared spatial interpolation approach following previously established methods (Du et al. 2017).

The data were primarily derived using similar calibrated overlapping daily morning (AM) and afternoon (PM) overpass radiometric T_b measurements at 36.5 GHz (V-pol) frequency from the AMSR-E and AMSR2 series. The resulting FT-ESDR represents a consistent, daily FT polar record that extends over a 16-year (2002 to 2017) observation period, ensuring cross-sensor consistency through double-differencing calibration of AMSR2 to AMSR-E T_b records (Du et al. 2014). Double-differencing calibration was conducted using similar frequency collocated overlapping T_b records from the FY-3B Microwave Radiation Imager (MWRI), which was applied to fill the temporal T_b gaps for 2011-2012 period (Du et al. 2014).

Derivation Techniques and Algorithms

The FT classification algorithm uses a temporal change detection of radiometric T_b time-series that identifies FT transition sequences by exploiting the dynamic temporal T_b response to differences in the aggregate landscape dielectric constant that occur as the landscape transitions between predominantly frozen and non-frozen conditions (McDonald and Kimball 2005; Kim et al. 2011; Kim et al. 2012). Satellite ascending and descending orbital T_b time series are processed separately to produce information on AM, PM and composite daily FT conditions (CO). Additional variables distinguished by the FT-ESDR include transitional (AM frozen and PM thawed) or inverse transitional (AM thawed and PM frozen) conditions. Detailed descriptions of the FT-ESDR methods, algorithm performance, and product accuracy are provided by Kim et al. (2017).

Sensor or Instrument Description

The Advanced Microwave Scanning Radiometer - Earth Observing System (AMSR-E) is a twelve-channel, six-frequency, passive-microwave radiometer system aboard the NASA Earth Observing System Aqua Satellite. The instrument measures horizontally and vertically polarized T_b at 6.9 GHz, 10.7 GHz, 18.7 GHz, 23.8 GHz, 36.5 GHz, and 89.0 GHz. Spatial resolution of the individual measurements varies from 5.4 km at 89 GHz to 56 km at 6.9 GHz. AMSR-E was developed and provided by the Japan Aerospace Exploration Agency (JAXA, Contractor: Mitsubishi Electric Corporation) with close cooperation of U.S. and Japanese scientists. The AMSR-E instrument aboard Aqua was modified from the design used for AMSR, which flew on the Japanese ADEOS-2 satellite. See NSIDC's AMSR-E Instrument Description page for more information.

The Advanced Microwave Scanning Radiometer 2 (AMSR2) was launched aboard the Global Change Observation Mission (GCOM-W1) satellite on 17 May 2012. The AMSR2 antenna rotates once every 1.5 seconds and obtains data over a 1,450 km swath. This configuration acquires a set of daytime and nighttime data every two days that covers more than 99 percent of the Earth. Except for a 7.3 GHz channel designed to mitigate radio frequency interference, the AMSR2 channel set is identical to AMSR-E.

The Microwave Radiation Imager (MWRI) is one of the eleven instruments aboard the Feng Yun 3B (FY-3B) satellite, which was launched on 05 November 2010 (Yang et al. 2011). FY-3B is the second satellite of the FY-3 series, China's second-generation polar-orbiting meteorological satellites. MWRI observations are used to bridge the temporal gap between AMSR-E and AMSR2 measurements and are based on similarly calibrated 36.5 GHz T_b retrievals.

References and Related Publications

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Related Data Collections

- MEaSUREs Global Record of Daily Landscape Freeze/Thaw Status

Related Web Sites

- Freeze/Thaw Earth System Data Record

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