Aquarius L3 Weekly Polar-Gridded Landscape Freeze/Thaw Data, Version 5

USER GUIDE

How to Cite These Data

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

Roy, A., L. Brucker, M. Prince, A. Royer, and C. Derksen. 2018. *Aquarius L3 Weekly Polar-Gridded Landscape Freeze/Thaw Data, Version 5*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/OV4R18NL3BQR. [Date Accessed].

National Snow and Ice Data Center

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1   DATA DESCRIPTION

This data set consists of weekly gridded landscape freeze/thaw (FT) observations derived from L-band frequency radiometer measurements at 1.4 GHz. This data set includes four FT fields each week: one for each of the three Aquarius radiometer beams, and one combined grid which includes all three beams. The data are distributed on the Equal-Area Scalable Earth Grid, Version 2.0 (EASE-Grid 2.0) with a spatial resolution of 36 km.

In addition, this product provides a complementary FT data set to the 37 GHz MEaSUREs Global Record of Daily Landscape Freeze/Thaw Status, Version 3 (NSIDC-0477) data set, and with intercalibration applied, may be considered for use in extending FT data provided by the SMAP mission (Derksen et al. 2017). The sensitivity of observations acquired at different frequencies (L-band versus 37 GHz) provides a valuable and complementary resource for characterizing the FT state.

1.1 Parameters

This product contains landscape FT data derived from each radiometer on Aquarius, and FT data from all three radiometers combined (Roy et al. 2015), representing a more spatially complete retrieval. The data are gridded and consist of binary grid cell values (Freeze: 1, Thaw: 2).

1.2 Ancillary Data Files

The following ancillary files are also provided:

Coordinates_LandFraction_EASE2_36km_NH_v05.h5
Includes Northern Hemisphere coordinates and land fraction coverage for the Aquarius weekly polar-gridded product on the EASE-Grid 2.0 at 36 km resolution.

Cycle_Date.dat
Includes a list of Aquarius orbit cycle numbers with the corresponding dates of cycle start and end.

1.3 File Information

1.3.1   Format

Data are in HDF5 format. For software and more information, including an HDF5 tutorial, visit the HDF Group's HDF5 website.

1.3.2   File Contents

As shown in Figure 1, the data file consists of one FT grid for each radiometer beam and one FT grid for the combined beams.
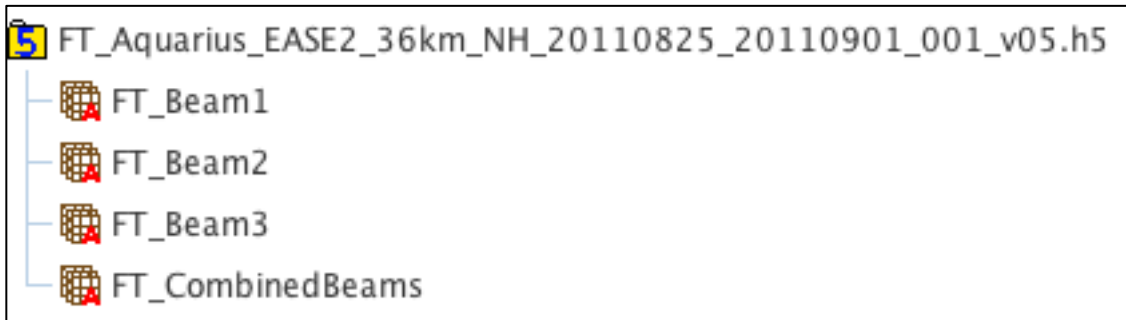


```
5 FT_Aquarius_EASE2_36km_NH_20110825_20110901_001_v05.h5
   ├── FT_Beam1
   ├── FT_Beam2
   ├── FT_Beam3
   └── FT_CombinedBeams
```

Figure 1. HDF File Contents

1.3.3   Naming Convention

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

Example file convention:

`FT_Aquarius_EASE2_36km_NH_yyyymmdd_yyyymmdd_CCL_vXX.h5`

The following table provides the meaning of the file name variables listed above.

Table 1. File Naming Convention

Variable	Description
FT_Aquarius	Freeze Thaw Aquarius
EASE2_36km	Version 2.0 Equal-Area Scalable Earth Grid cells at 36 km
NH	Northern Hemisphere
yyyy	Four-digit year of first/last measurements in the given cycle
mm	Two-digit month of first/last measurements in the given cycle
dd	Two-digit day of first/last measurements in the given cycle
ccl	Three-digit Aquarius orbit cycle number, 3 digits
vXX	Product version number
h5	Indicates HDF5 file format

Example file name:

`FT_Aquarius_EASE2_36km_NH_20110825_20110901_001_V05.h5`

1.3.4   File Size

Each file is between 30 and 45 KB.

1.4 Spatial Information

This data set covers latitudes north of the 50° N parallel.

1.4.1   Coverage

Southernmost Latitude: 50° N

Northernmost Latitude: 87.4° N

Westernmost Longitude: 180° W

Easternmost Longitude: 180° E

1.4.2   Resolution

The 3 dB spatial footprint for the three radiometer beams results in a total cross-track resolution of 370 km. The resolution for each of the beams is as follows:

- Beam 1: 74 km along track x 94 km cross track
- Beam 2: 84 x 120 km
- Beam 3: 96 x 156 km

Data are then gridded using the 36 km EASE-Grid 2.0 Northern Hemisphere azimuthal projection.

1.4.3   Geolocation

The following tables provide information for geolocating this data set.

Table 2. Projection Details

Geographic coordinate system	WGS 84
Projected coordinate system	NSIDC EASE-Grid 2.0 North
Longitude of true origin	0
Latitude of true origin	90.00
Datum	WGS 84
Ellipsoid/spheroid	WGS 84
Units	Meters
False easting	0.00
False northing	0.00
EPSG code	6931

PROJ4 string	proj4.defs("EPSG:6931","+proj=laea +lat_0=90 +lon_0=0 +x_0=0 +y_0=0 +ellps=WGS84 +towgs84=0,0,0,0,0,0,0 +units=m +no_defs");
Reference	https://epsg.io/6931

Table 3. Grid Details

Grid cell size (x, y pixel dimensions)	36 km
Number of rows	244
Number of columns	244
Geolocated lower left point in grid	-4356000.14399 W, -4356000.14399 N
Nominal gridded resolution	36.0 km
Grid rotation	None
ulxmap – x-axis map coordinate of the center of the upper-left pixel (XLLCORNER for ASCII data)	4392000.14399
ulymap – y-axis map coordinate of the center of the upper-left pixel (YLLCORNER for ASCII data)	-4356000.14399

1.5 Temporal Information

1.5.1 Coverage

The temporal coverage of this data set extends from 25 August 2011 through 28 May 2015.

> ℹ Due to a power failure on the Satélite de Aplicaciones Científicas (SAC)-D spacecraft on 08 June 2015, data from the NASA Aquarius instrument are no longer being produced. For more information on this event, refer to official announcement; International Spacecraft Carrying NASA's Aquarius Instrument Ends Operations.

1.5.2 Resolution

This data set consists of weekly averages and is generated every seven days.
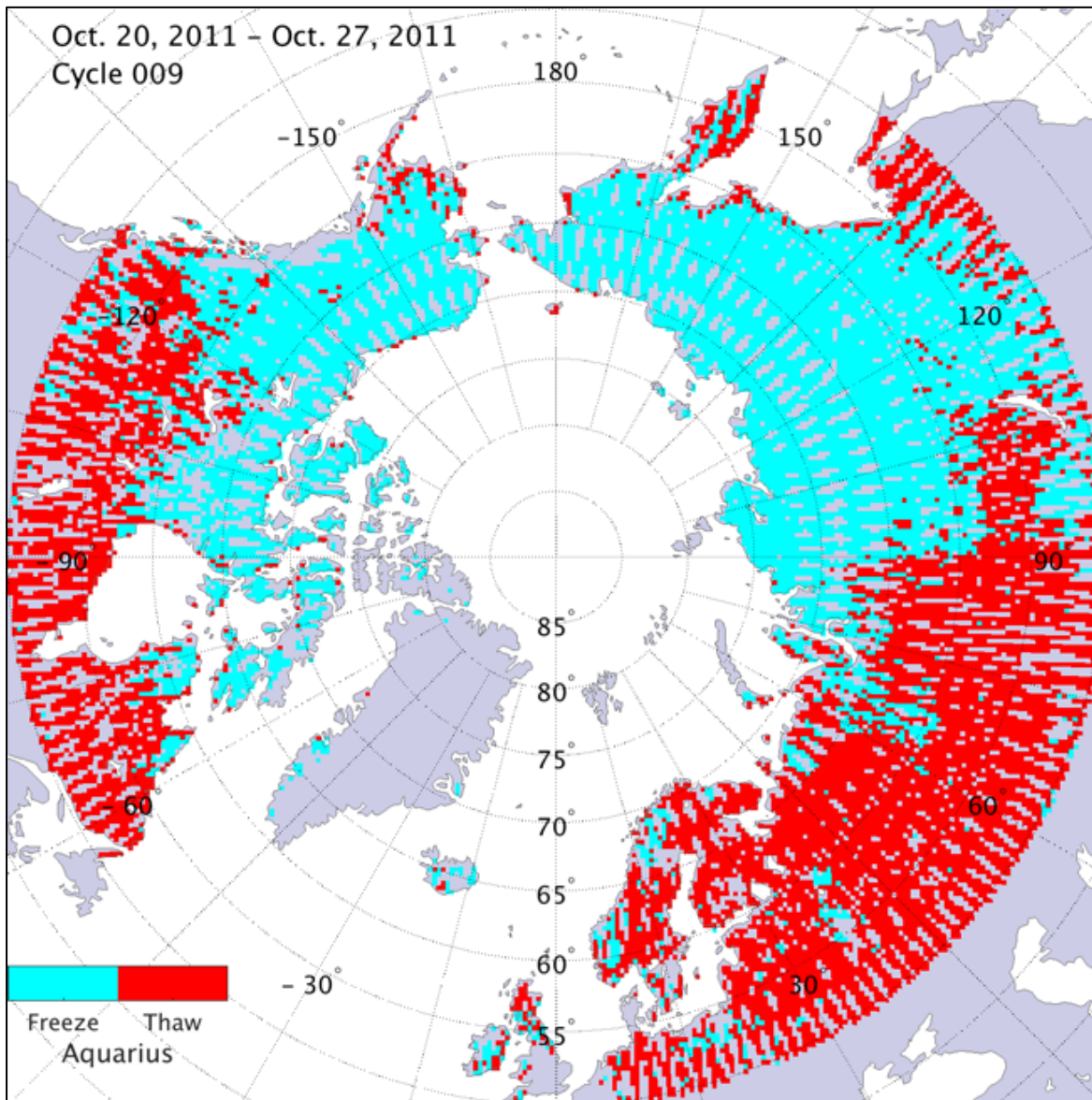
1.5.3   Sample Data Image

Figure 2. Sample Data Image

This image shows Aquarius, Northern Hemisphere, 36 km FT coverage for the week of 20, October 2011.

File name: `FT_Aquarius_EASE2_36km_NH_3beams_20111020_20111027_009_v05`

2   DATA ACQUISITION AND PROCESSING

2.1 Source

The source used to derive this FT data set is the Aquarius L3 Weekly Polar-Gridded Brightness Temperature and Sea Surface Salinity, Version 5 (AQ3_TB) data set.

2.2 Derivation Techniques and Algorithms

The FT classification algorithm used to derive this product is based on a seasonal threshold approach (STA), using frost factor index (FFrel; Eq. 1) introduced by Rautiainen et al. (2014), where FF_{NPR} is the frost factor based on the NPR between brightness temperatures at vertical and horizontal polarizations (TB_V and TB_H; Eq. 2). FF_{fr} and FF_{th} are reference frozen and thawed frost factors obtained respectively by averaging the five minimum and maximum FF_{NPR} values of 2012 and 2013.

$$FFrel = \frac{FF_{NPR} - FF_{fr}}{FF_{th} - FF_{fr}}$$

(Equation 1)

$$FF_{NPR} = \frac{TB_V - TB_H}{TB_V + TB_H}$$

(Equation 2)

A threshold (τ) was determined by optimization to classify the surface as frozen or thawed if the FFrel is lower or higher than the threshold (Eq. 3).

$$\text{If } FFrel < \tau \rightarrow \text{freeze}$$
$$\text{or if } FFrel > \tau \rightarrow \text{thaw}$$

(Equation 3)

The thresholds optimized in Roy et al. (2015) over Northern America for three basic land covers (tundra, forest, and open land) were applied over the Northern Hemisphere using the Land Cover Classifications derived from the Boston University MODIS/Terra Land Cover, Version 1 (NSIDC-0610). Based on this product the thresholds found in Roy et al. (2015) were used to create FT maps for each radiometer. Refer to Roy et al. 2015 for a detailed description of the Landscape FT algorithm.

2.3 Processing

The following processing steps were applied to brightness temperature (T_b) inputs to produce this data set:

1. **Calculate the normalized polarization ratio (NPR) for FT conditions**
   The NPR for the freeze and thaw conditions of each pixel are calculated by averaging the

> five lowest (July and August) and five highest (January and February) NPR values idenified during the study period.

2. **Identify land cover types for each pixel**
   EASE-Grid 2.0 Land Cover Classifications derived from Boston University MODIS/Terra Land Cover, Version 1 (NSIDC-0610) is used to identify the main land cover type in each pixel (tundra, forest, prairie or water). All pixels containing more than 20% water were masked.

3. **Create FT maps for each beam**
   Based on the MODIS Land Cover product, a thresholding approach is applied to distinguish frozen and thawed surface states (Roy et al. 2015).

4. **Create a composite map**
   The three FT grids are blended to create a more spatially complete retrieval.

2.4 Quality

To evaluate uncertainties, this FT product (AQ3_FT) was compared with the 37 GHz MEaSUREs Global Record of Daily Landscape Freeze/Thaw Status (NSIDC-0477). NSIDC-0477 is another satellite FT product also derived from passive microwave observations, but at a higher frequency of 37 GHz.

The assessment was carried out during the overlapping period between 2011 and 2014. Results show that 77.1% of AQ3_FT and NSIDC-0477 grid cells have an agreement better than 80%. Their differences vary with land cover type (tundra, forest, and open land), and with freezing and thawing periods. The best agreement is obtained during the thawing transition and over forested areas, with differences between product mean freeze or thaw onsets of under 0.4 weeks. Over tundra, AQ3_FT tends to detect freeze onset two to five weeks earlier than NSIDC_0477, likely due to FT sensitivity to the different frequencies used. Analysis with 30 mean surface air temperature time series from six in situ meteorological stations shows that the main discrepancies between AQ3_FT and NSIDC-0477 are related to false frozen retrievals in summer for some AQ3_FT regions.

Refer to Prince et al. (2018) for a detailed description of the similarities and differences between AQ3_FT (L-band) and NSIDC-0477 (Ka-Band) FT products.

2.5 Sensor and Instrument Description

Aquarius/SAC-D is a collaboration between NASA and the Argentine space agency Comisión Nacional de Actividades Espaciales (CONAE), with participation from Brazil, Canada, France, and Italy. The Aquarius instrument was built jointly by the NASA Jet Propulsion Laboratory and NASA Goddard Space Flight Center.

The Aquarius instrument includes three radiometers and one scatterometer. The radiometers measure brightness temperature at 1.414 GHz in the horizontal and vertical polarizations (TB$_H$ and TB$_V$).

The table below summarizes the radiometer instrument characteristics.

Table 4. Aquarius Instrument Characteristics

Instrument	Characteristics
3 radiometers in push-broom alignment	- Frequency: 1.413 GHz (L-band) - Bandwidth: less than or equal to 26 MHz - Swath width: 390 km - Science data block period: 1.44 sec - Beam footprints: 74 km along track x 94 km cross track, 84 x 120 km, and 96 x 156 km, for a total cross track resolution of 390 km - Beam incidence angles: 29.36°, 38.49° and 46.29° - Beams point away from the sun

The orbit parameters of the SAC-D spacecraft include:

- 98 minute sun-synchronous
- 6 p.m. ascending orbit, 6 a.m descending orbit
- 657 km equatorial altitude (655 km minimum, 685 km maximum over the orbit)
- Weekly ground-track repeat interval

3 SOFTWARE AND TOOLS

A MATLAB reader is available for loading and mapping Aquarius L3 polar-gridded weekly FT data. This tool is provided by the Principal Investigator as a service to the user community. Please note that support for the program is limited. Bug reports, comments, and suggestions for improvement are welcome. Please send comments to nsidc@nsidc.org.

The links below provide access to software for reading and viewing HDF5 data files.

- HDFView: A visual tool for browsing and editing HDF4 and HDF5 files.
- Panoply: A visual tool for plotting geo-gridded arrays from NetCDF, HDF, and GRIB data sets

4 RELATED DATA SETS

MEaSUREs Global Record of Daily Landscape Freeze/Thaw Status, Version 4
SMAP L3 Radiometer Northern Hemisphere Daily 36 km EASE-Grid Freeze/Thaw State, Version 1

SMAP Enhanced L3 Radiometer Northern Hemisphere Daily 9 km EASE-Grid Freeze/Thaw State, Version 1
Arctic Soil Freeze/Thaw Status from SMMR and SSM/I, Version 2
Arctic EASE-Grid Freeze and Thaw Depths, 1901 - 2002, Version 1

5   CONTACTS AND ACKNOWLEDGMENTS

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6   REFERENCES

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Rautiainen, K., Lemmetyinen, J., Schwank, M., Kontu, A., Ménard, C., Mätzler, C., Drusch, M., Wiesmann, A., Ikonen, J., and Pulliainen, J. 2014. Detection of soil freezing from L-band passive microwave observations. *Remote Sensing of Environment*, 147:206–218.

Roy, A., Royer, A., Derksen, C., Brucker, L., Langlois, A., Mialon, A., and Kerr, Y. (2015). Evaluation of spaceborne L-band radiometer measurements for terrestrial freeze/thaw retrievals in Canada. *Journal of Selected Topics on Applied Earth Observations in Remote Sensing,* 8(9):4442-4459.

7 DOCUMENT INFORMATION

7.1 Publication Date

01 August 2018

7.2 Date Last Updated

19 September 2019