High Mountain Asia ASCAT Freeze/Thaw/Melt Status, Version 1

USER GUIDE

How to Cite These Data

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

Steiner, N. and K. C. McDonald. 2018. *High Mountain Asia ASCAT Freeze/Thaw/Melt Status, Version 1*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/L319IEPK63VC. [Date Accessed].

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

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

National Snow and Ice Data Center

TABLE OF CONTENTS

1 DETAILED DATA DESCRIPTION

1.1 Parameters

This data set contains bulk landscape frozen or thawed status over seasonally frozen land as well as snowmelt status over glacierized areas for the High Mountain Asia region. Daily Freeze/Thaw/Melt (F/T/M) status is derived from vertically polarized (V-pol) C-band (5.255 GHz) backscatter measurements acquired by the Advanced Scatterometer (ASCAT) on EUMETSAT Metop-A and Metop-B satellites. Swath-ordered observations are spatially enhanced using the Scatterometer Image Reconstruction (SIR) algorithm (Early and Long, 2001), are posted on Earth-fixed 4.45 km grids, and are interpolated to a daily product from the original 3-day, a.m. overpasses. The timings and duration of freeze/thaw over land and snowmelt over glacierized areas are determined from time-series singularities (TSS) as described in Steiner and Tedesco (2014).

1.2 Format

F/T/M data are provided in HDF5 (.h5) format and stored as unsigned 8-bit integers in 500 rows and 800 columns. For information about HDF5, visit the HDF Group's HDF5 website.

GeoTIFFs (.tif) provide daily F/T/M status stored as single-precision, 8-bit integers in 500 rows and 800 columns along with a quality flag.

A browse image in PNG (.png) format accompanies each data file.

An associated Extensible Markup Language (.xml) metadata file is also provided for each data file.

1.3 File Contents

As shown in Figure 1, each HDF5 file is organized into the following main arrays/data fields:

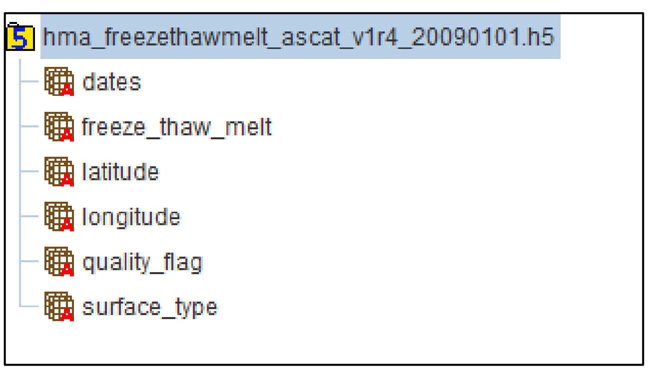

Figure 1. HDF5 File Contents

1.3.1 HDF5 Data Fields

Each daily HDF file contains F/T/M status in the freeze_thaw_melt data field/data set, which has three dimensions: 500 rows, 800 columns, and 1 depth with corresponding latitude, longitude, and dates. Surface states are indicated by either 0 (frozen), 1 (glacier melt), or 2 (thaw). The fill value for pixels containing no data is 255.

The surface_type data field is a static mask that defines glacierized (1) and land (0) areas characterized by the per-pixel seasonal backscatter response. The fill value for pixels containing no data is 255.

The quality_flag data field is a static mask that defines areas where the product accuracy is either high (1) or low (0). High accuracy is defined as accuracies greater than 75%. The per-pixel accuracy is determined at weather stations and estimated spatially using land-surface temperature climatologies from MODIS Land Surface Temperature and Emissivity (MOD11) data.

1.3.2 GeoTIFFs

GeoTIFF files contain the number of thawed days for non-permanent snow/ice and the number of snowmelt days (F/T/M status) for permanent snow/ice. GeoTIFFS are presented as RGB values for bands 1, 2, and 3; band 1 = land thaw, band 2 = glacier melt, and band 3 = QC layer. The fill value for pixels containing no data is 255.

1.3.3 PNG Browse Images

A PNG browse image that displays snowmelt status (blue) is provided with each HDF5 file. Figure 2 shows a sample browse image for this data set.

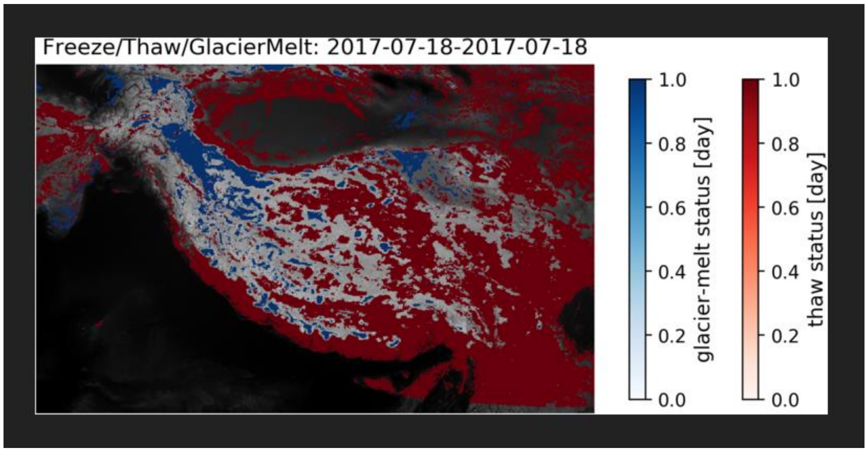

Figure 2. Sample Browse Image

1.4 File Naming Convention

All files are named according to the convention shown in the following example. Variables used in the file names are defined in Table 1.

Example

HMA_freezethawmelt_ascat_v1r4_20160101.h5

Naming Convention

HMA_freezethawmelt_ascat_v1r4_[yyyymmdd].[ext]

Table 1. File Naming Conventions

Variable	Description
HMA_freezethawmelt_ascat	Data set ID/abbreviation for this High Mountain Asia (HMA) product
v1r4	Version 1r4
ascat	Advanced Scatterometer
yyyymmdd	Acquisition date in 4-digit year, 2-digit month, 2-digit day format
.ext	File extensions include: • .h5: HDF5 data file • .png: PNG browse file • .tif: GeoTIFF file • .xml: XML metadata file

1.5 Spatial Coverage

Northernmost Latitude: 44.683° N

Southernmost Latitude: 19.125° N

Easternmost Longitude: 105.577° E

Westernmost Longitude: 63.427° E

Coverage extends to portions of the following eleven countries:

- Afghanistan
- Bhutan
- China
- India
- Kazakhstan
- Kyrgyzstan

- Myanmar
- Nepal
- Pakistan
- Tajikistan
- Uzbekistan

1.6 Spatial Resolution

The data are posted to a 4.45 km grid.

1.7 Geolocation Information

The following tables provide information for geolocating this data set.

Table 2. Geolocation Parameters

Geographic coordinate system	WGS84
Projected coordinate system	Lambert Azimuthal Equal Area
Longitude of true origin	105
Latitude of true origin	40
Scale factor at longitude of true origin	1
Datum	WGS84
Ellipsoid/spheroid	WGS84
Units	Meters
False easting	0
False northing	0
EPSG code	(pending)
PROJ4 string	+proj = laea + lat_0 = 40 + lon_0 = 105 + x_0 = 0 + y_0 = 0 + datum = WGS84 + units = m + no_defs
Reference	(pending)

Table 3. Grid Details

Grid cell size (x and y pixel dimensions)	4.45 km x 4.45 km
Number of rows	800
Number of columns	500
Geolocated lower left point in grid	19.1250 N, 71.2722 E
Nominal gridded resolution	4.45 km

Grid rotation	0
ulxmap – x-axis map coordinate of the center of the upper-left pixel	-3510000.0
ulymap – y-axis map coordinate of the center of the upper-left pixel	525000.0

1.8 Temporal Coverage

Data coverage spans from 01 January 2009 to 12 October 2017.

Note: The full-time range of this freeze/thaw/melt product includes ASCAT data from two different platforms: Metop-A and Metop-B, with the transition Metop-A to Metop-B occurring in 2012. Which exact sensor was used for each granule is difficult to reconstruct, but it is expected that the data from the two sensors are similar enough to not affect the interpretation of this product. Should you need this information, please contact NSIDC User Services.

1.9 Temporal Resolution

Each daily Level-3 data file is produced from 3-day composites of ascending orbit observations generated every two days. These are interpolated to a daily time step in time-series analysis.

2 SOFTWARE AND TOOLS

For HDF5 software and information, visit the HDF Group's HDF5 website.

GeoTIFF files with embedded geospatial metadata can be accessed using GIS software such as QGIS and ArcGIS, or command-line tools such as the Geospatial Data Abstraction Library (GDAL) utilities and API.

3 DATA ACQUISITION AND PROCESSING

3.1 Sensor

For a detailed description of ASCAT, visit the ASCAT instrument page at the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) Metop website.

3.2 Data Source

These data were generated from Level-1B (L1B) backscatter measurements (ASCAT L1B SZF) acquired by the EUMETSAT Metop-A and Metop-B satellites. Enhanced resolution ASCAT data were then obtained from the NASA sponsored Scatterometer Climate Record Pathfinder Program, Center for Remote Sensing at Brigham Young University (BYU/CRS/SCP) courtesy of David G. Long.

3.3 Theory of Measurements

This F/T/M product is derived using a temporal change detection approach that has been previously developed and successfully applied using time-series satellite remote sensing radar backscatter and radiometric brightness temperature data from a variety of sensors and spectral wavelengths. The approach used for this product is to identify the landscape F/T/M transition by identifying the temporal response of backscatter to changes in the dielectric constant of the landscape components that occur as the water within the components transitions between frozen and non-frozen conditions.

Classification algorithms assume that the large changes in dielectric constant occurring between frozen and non-frozen conditions dominate the corresponding backscatter temporal dynamics across the seasons, rather than other potential sources of temporal variability such as changes in canopy structure and biomass or large precipitation events. This assumption is valid for most areas of the terrestrial cryosphere.

3.4 Derivation Techniques and Algorithms

This section has been adapted from Steiner and Tedesco (2014).

3.4.1 Melt Detection Using Wavelets

The duration of seasonal melting over high mountain regions of Asia was derived using a wavelet analysis. A wavelet transform unfolds a one-dimensional (1D) time series of $\sigma 0$ into a two-dimensional (2D) power spectrum of position and scale, (i.e. inverse frequency). The wavelet transform can evaluate localized variability of a backscatter time series using a series of convolutions with a dilating and translating wave-like function (Daubechies, 1992). For time-series singularity (TSS) detection, the wavelet transform is used as a differential operator in that it was able to approximate the derivative of a smoothed data series at each time location. As melting and refreezing events cause large variations in $\sigma 0$, they appear as local maxima or minima in the wavelet transform.

Wavelet analysis methods have previously been applied to snowmelt detection: specifically, Liu et al. (2005) apply a wavelet-based methodology to identify large changes in measured brightness temperature values associated with melting events over Antarctica. An approach similar to Liu et al. (2005) was applied to derive these data, but with several key differences:

This approach is applied using active microwave (C-band 5.255 GHz v-pol) measurements. Note: Ku-band 13.4 GHz measurements are used in Steiner and Tedesco (2014).

Melt and refreezing events are identified and classified using singularity detection (Mallat and Hwang, 1992), where melting and thaw events appear as discontinuous events in the backscatter time series.

The following quality control steps are applied for F/T/M detection, and a mask is applied to locations where these three criteria are not achieved. There must be:

1 dB minimum change during F/T/M events

A significant difference between the frozen and thawed or snowmelt state from the mean frozen state, defined as 2 standard deviations

An elevation greater than 700 meters above sea level (m. asl.)

3.5 Processing Steps

Freeze/thaw/melt is derived during an intermediate Level-2 processing step of the input Level-1B from ASCAT σ0 data done by SCP. During the Level-2 processing step, the F/T/M algorithm utilizes a wavelet-based approach to convert enhanced resolution ASCAT σ0 measurements to F/T/M state. Figure 3 shows the algorithm and processing flow chart for this data set.

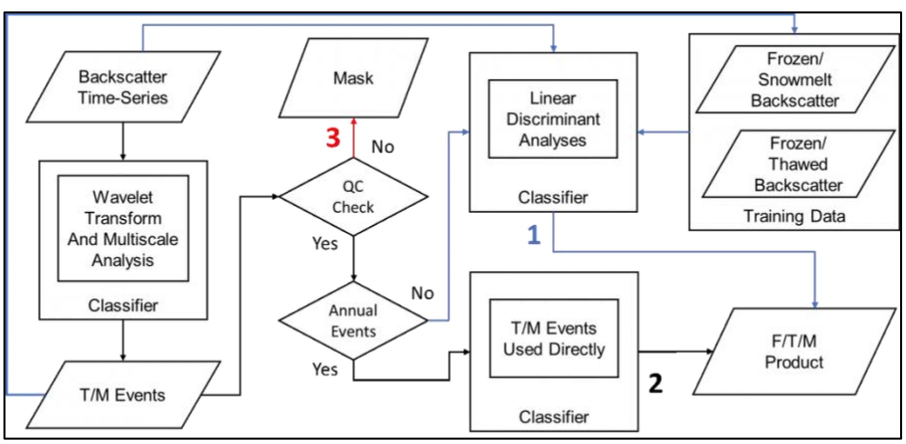

Figure 3. Algorithm/Processing Flow Chart

Path 1 (blue): The F/T/M product is determined using thawing or melting (T/M) events detected using wavelet-based methods. Path 2 (black): If there are no annual T/M that meet QC for a particular year, a linear discriminant analysis is used for that year only. Path 3 (red): A mask is applied if there are no valid T/M events for any years.

To generate this product, the processing software executes the following steps:

- Backscatter time-series data are subsetted from gridded, enhanced resolution data from the SCP.
- Converts ASCAT σ0 measurements to F/T/M state and classifies these states on a grid cell-by-cell basis for unmasked portions of the F/T/M domain through the following steps:
    1) CWT and multiscale analysis are used to determine melting, thawing (M/T), and refreeze events.
    2) A quality control step determines if M/T events appear to be within expected magnitudes and over valid locations (σ0 change > 1 dB and location >700 m [a.m.s.l.]). Locations that fail this test for all years are masked (Fig. 3, red).
    3) The timings of T/M and refreeze events are used to define the F/T/M state (Fig 2., black). If QC fails for any one year (Fig. 3, blue), training data from other years are used in a linear discriminant analysis to determine F/T/M states.

See Steiner and Tedesco (2014) for more detailed description of multiscale analysis and the determination of M/T and refreeze events.

3.6 Error Sources

Figure 4 shows the backscatter response when precipitation or vegetation dynamics are present.

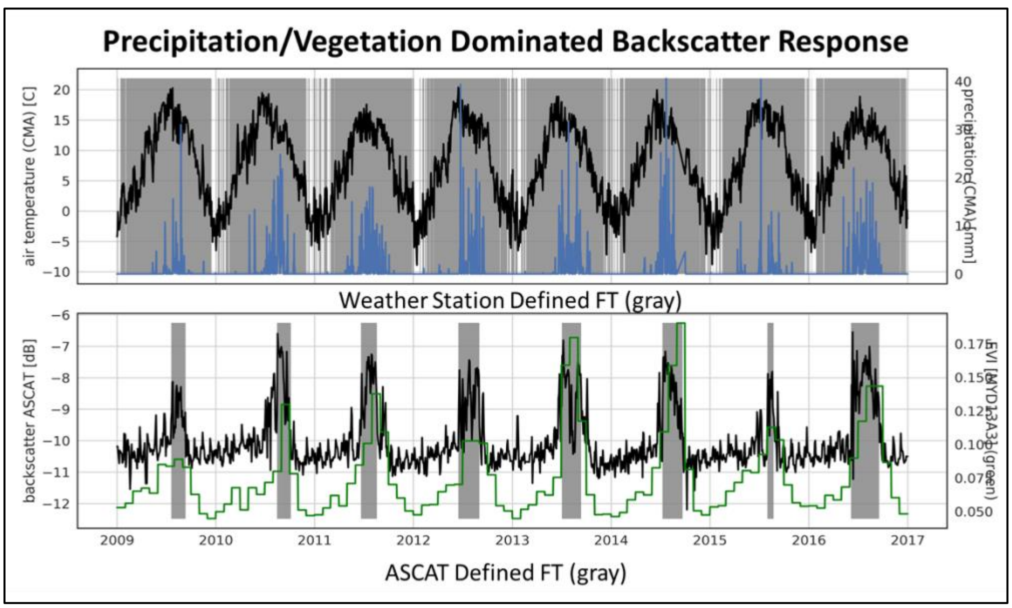

Figure 4. The F/T/M algorithm assumes that seasonal backscatter change is dominated by the introduction of liquid water at the surface since much of the cryosphere is bound in ice, the timing of which is controlled by seasonal snowmelt. A high degree of error is introduced when precipitation or vegetation dynamics drive these changes.

4 REFERENCES AND RELATED PUBLICATIONS

Early, D. S. and D. G. Long. 2001. Image reconstruction and enhanced resolution imaging from irregular samples. IEEE Transactions on Geoscience and Remote Sensing, 39(2):291-302.

Liu, J. P., J. A. Curry, W. B. Rossow, J. R. Key, and X. Wang. 2005. Comparison of surface radiative flux data sets over the Arctic Ocean. J. Geophys. Res., 110, C02015. https://doi.org/10.1029/2004JC002381.

Steiner, N. and M. Tedesco. 2014. A wavelet melt detection algorithm applied to enhanced-resolution scatterometer data over Antarctica (2000-2009). The Cryosphere, 8:25-40. https://doi.org/10.5194/tc-8-25-2014.

4.1 Related Data Collections

High Mountain Asia Data

4.2 Related Websites

Contribution to High Asia Runoff from Ice & Snow (CHARIS) Project
Global Land Ice Measurements from Space (GLIMS) Project
NSIDC Scientific Data Search

5 CONTACTS

Nick Steiner, Kyle McDonald
Earth and Atmospheric Science
The City College of New York
Marshak Hall; Rm. 925
New York, NY 10031

6 ACKNOWLEDGMENTS

These data were generated through funding from the NASA Cryosphere program and the NASA HiMAT project (NNX16AQ88G).

7 DOCUMENT INFORMATION

7.1 Publication Date

July 2018

7.2 Date Last Updated

05 August 2020