MEaSUREs Greenland Ice Mapping Project (GIMP) Land Ice and Ocean Classification Mask, Version 1

USER GUIDE

How to Cite These Data

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

Howat, I. 2017. *MEaSUREs Greenland Ice Mapping Project (GIMP) Land Ice and Ocean Classification Mask, Version 1*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/B8X58MQBFUPA [Date Accessed].

We also request that you acknowledge the author(s) of this data set by referencing the following peer-reviewed publication:

Howat, I., A. Negrete, and B. Smith. 2014. The Greenland Ice Mapping Project (GIMP) land classification and surface elevation data sets. *The Cryosphere*, 8. 1509-1518. https://doi.org/10.5194/tc-8-1509-2014

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/NSIDC-0714

National Snow and Ice Data Center

TABLE OF CONTENTS

1 DATA DESCRIPTION

This data set provides complete land ice and ocean classification masks posted at 15m, 30m, 90m for the Greenland ice sheet for the years 2000 and 2015. For the year 2000, ice cover was mapped using a combination of orthorectified panchromatic (band-8) imagery from the Landsat 7 Enhanced Thematic Mapper Plus (ETM+), distributed by the US Geological Survey (USGS), and the Canadian Space Agency's (CSA) RADARSAT-1 Synthetic Aperture Radar (SAR) amplitude images. For the year 2015, Landsat-8 Operational Land Imager (OLI) images were used in combination with imagery from RADARSAT-1.

1.1 Parameters

The parameter provided is Land Ice/Ocean Classification. Depending upon the specific mask, the data values (0 or 1) indicate glacier ice or ocean and all other terrain. Please note that the Grounded Ice mask is for the year 2000 and that there are 1 and "NoData" values.

1.2 File Information

1.2.1 Format

Data are available in GeoTIFF (.tif) format.

The data include the following:

- Ice Masks and Ocean Masks for all years at 15 m, 30 m and 90m resolution.
- Grounded Ice Mask for the year 2000 at 90 m resolution.
- 15 m and 30 m resolution ice and ocean masks distributed as a set of 36 tiles numbered based on the Figure 1 schema. The 90 m resolution files are ice-sheet wide.

1.2.2 Naming Convention

The 2000 files are in the folder named 1999-07-01 and the 2015 files are in the folder named 2013-01-15. The values "2000" and "2015" appear in the file names to differentiate the data by the nominal year of the collection.

The following tables explain the file naming convention for the masks included in this data set. See Table 1 for an explanation of the variables for file names for the 15 m and 30 m files and Table 2 for the 90 m files.

Sample 15 m and 30 m file names for tile5_0:

- GimpIceMask_15m_2000_tile5_0_v1.2.tif

- GimpOceanMask_15m_2000_tile5_0_v1.2.tif
- GimpIceMask_30m_2000_tile5_0_v1.2.tif
- GimpOceanMask_30m_2000_tile5_0_v1.2.tif
- GimpIceMask_15m_2015_tile5_0_v1.2.tif
- GimpOceanMask_15m_2015_tile5_0_v1.2.tif
- GimpIceMask_30m_2015_tile5_0_v1.2.tif
- GimpOceanMask_30m_2015_tile5_0_v1.2.tif

Table 1. Naming Convention Description for 15 m and 30 m files

String	Description
Gimp	Greenland Ice Mapping Project
[Ice/Ocean]Mask	IceMask indicates glacier ice, OceanMask indicates ocean and all other terrain
[RR]m	Resolution (15m or 30m)
[YYYY]	Year
tile[C_R]	Column and row of mosaic tile. Tile 0_0 is in the lower left corner, Tile 5_5 is in the upper right (see Figure 1)
v1.2	Version 1.2
.tif	File name extension for GeoTIFF-formatted file

Sample 90 m file names for years 2000 and 2015:

- GimpGroundedIceMask_90m_2000_v.1.2; **available for 2000 data only**
- GimpIceMask_90m_2000_v.1.2
- GimpOceanMask_90m_2000_v.1.2
- GimpIceMask_90m_2015_v.1.2
- GimpOceanMask_90m_2015_v.1.2

Table 2. Naming Convention Description for 90 m files

String	Description
Gimp	Greenland Ice Mapping Project
[GroundedIce/Ice/Ocean]Mask	GroundedIceMask indicates grounded glacier ice; IceMask indicates glacier ice, OceanMask indicates ocean and all other terrain
[RR]m	Resolution (90 m)
[YYYY]	Year
v1.2	version 1.2
.tif	File name extension for GeoTIFF-formatted file

1.3 Spatial Information

1.3.1 Coverage

Southernmost Latitude: 59° N
Northernmost Latitude: 84° N
Easternmost Longitude: 8° E
Westernmost Longitude: 89° W

1.3.2 Resolution

The data are available in 15 m, 30 m, or 90 m resolutions.

1.3.3 Geolocation

Data are provided in standard NSIDC polar stereographic north grid (EPSG: 3413) centered on Greenland. In the 2015 files the EPSG code (3413) and the full name of the projection 'WGS84 / NSIDC Sea Ice Polar Stereographic North' are both included in the file metadata. This is not the case for the 2000 files.

For each year of data, 15 m and 30 m resolution masks are provided in a set of 36 tiles, 6 rows by 6 columns, numbered from 0,0 in the lower left corner to 5,5 in the upper right (see Figure 1). Each tile has dimensions of 249.3 km by 450 km. These dimensions were selected as they are divisible by 15 m, the resolution of USGS's Landsat-7 Enhanced Thematic Mapper Plus (ETM+) panchromatic (band-8) imagery.

This note applies to the 2000 Grounded Ice Mask File

Please note that there is a projection issue with the GimpGroundedIceMask_90m_2000_v1.2.tif file. The data are not in the standard NSIDC polar stereographic north grid due to a small error in the header information; the latitude of origin was set to '7' when it should be '70'. This is planned to be corrected for in a future version of the data set. In the meantime, the user can reproject this file using the following GDAL command:

```
gdalwarp -s_srs EPSG:3413 -t_srs EPSG:3413
GimpGroundedIceMask_90m_2000_v1.2.tif output.tif
```

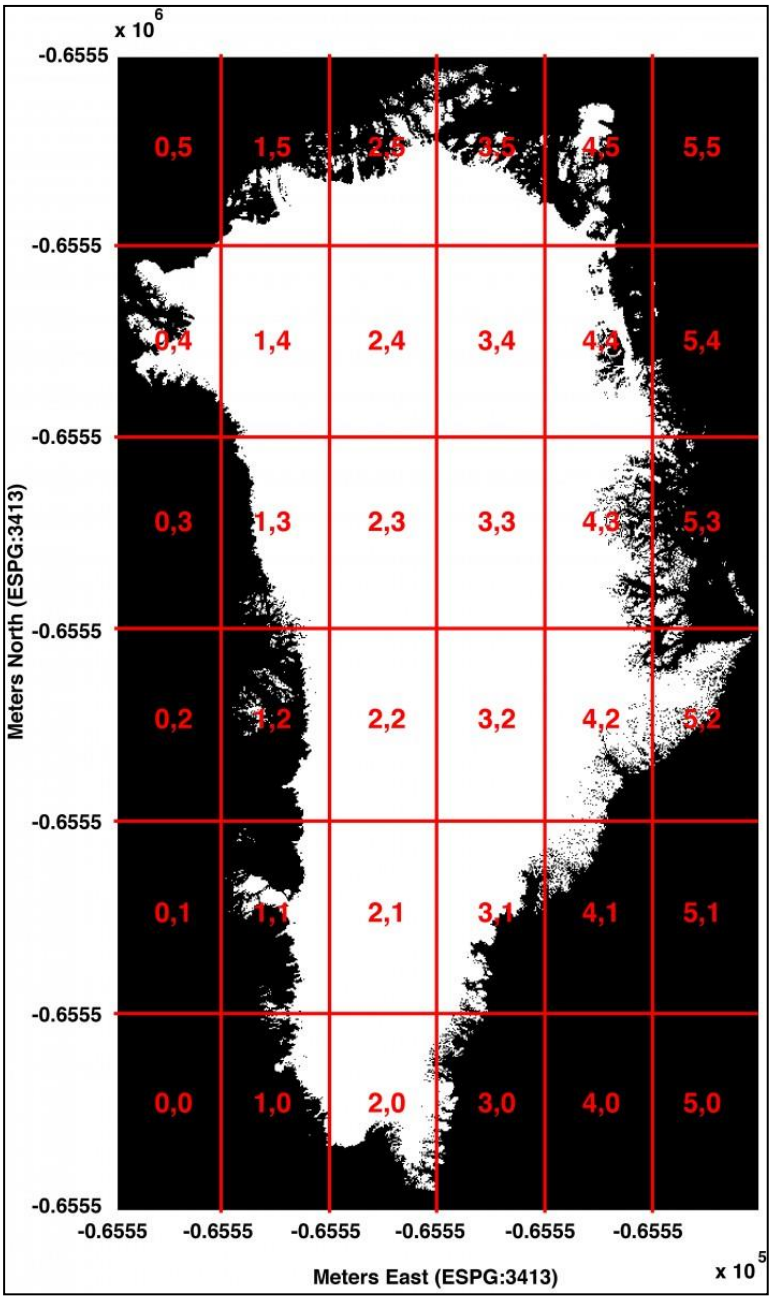

Figure 1. GIMP Landsat-7 ETM+ band-8 and RADARSAT-1 ice mask (90 m resolution) of Greenland with tile boundaries and tile numbers overlain. The map projection is polar stereographic (EPSG 3413).

1.4 Temporal Information

1.4.1 Coverage

The temporal coverage of these data is as follows:

- 2000 files: these files cover the period from 1999 to 2002. For the area north of ~81.2N data from October – December 2000 were used. South of this latitude, data from June-August in the years 1999-2002 were used.
- 2015 files: these files cover a period from 2013 to 2015. The nominal date is 15th August 2015. For the area north of 82.66N data from 15 January – 26 March 2013 were used. South of this latitude, data from 01 July – 30 September 2015 were used.

For more details, please see the Data Acquisition and Processing section of this document.

2 DATA ACQUISITION AND PROCESSING

2.1 Background

Landsat data are commonly used to map snow and ice. Land classification masks provide a method of co-registration of repeat imagery and elevation data to track changes of the ice surface. The ice surface may change with time whereas areas of stationary, exposed bedrock provide a control for measuring ice change. In addition, masks provide an accurate delineation of ice boundaries, which become a benchmark for measuring future ice margin changes.

2.2 Acquisition

The masks for the files dated 2000 were derived from the GIMP 2000 Image Mosaic, created using Landsat 7 ETM+ imagery from USGS and RADARSAT-1 SAR imagery from Applied Physics Laboratory at the University of Washington. USGS Landsat imagery was acquired for the months of July through September in 1999, 2000 and 2001 (mostly 2000) and the RADARSAT imagery was acquired for fall of 2000. For details, see Howat et al., (2014) and Joughin et al., (2010).

The mask files for 2015 were derived from an image mosaic that was created using terrain-corrected Landsat 8 Operational Land Imager (OLI) imagery and RADARSAT-1 imagery. Specifically, the Landsat 8 data were from LC08_L1TP, available from the Land Processes Distributed Active Archive Center. For the area south of 82.66, Landsat 8 imagery from 01 July through 30 September 2015 were used. For the area north of this, RADARSAT-1 SAR imagery (see: NSIDC-0633) from between 15 January and 26 March 2013 were used.

2.3 Processing

The mask files for the year 2000 were created from manual digitization of the panchromatic and pan-sharpened multispectral GIMP 2000 Image Mosaic. The 2015 mask files were created from the manual digitization of a pan-sharpened multispectral image mosaic generated from Landsat-8 and RADARSAT-1 SAR imagery. Using manual methods, the ice margin can be difficult to locate visually in areas of abundant debris and snow cover. Margins of debris-covered ice were identified by breaks in surface slope, emerging melt water streams, color differences and the presence of small melt water ponds typical of debris-covered glaciers.

Similarly, glaciers were differentiated from perennial snowfields by visible crevassing, surface moraines and the existence of a visible toe. Snowfields without these features were not classified as glaciers. Using the same method, the coastline is digitized to produce an ocean mask, with the null of the ice and ocean masks being ice-free terrain. For additional information on processing see, Howat, et al., (2014).

2.4 Quality, Errors, and Limitations

2.4.1 Error Estimates

Uncertainty in these classification masks arise from three sources of error:

1. Image pixel resolution,
2. Image geo-registration, and
3. Erroneous selection or non-selection of pixels (i.e., mapping error).

All error sources are expected to vary randomly in space. However, there is likely a systematic component due to geo-registration over distances equivalent to the size of a single image (e.g., 185 km for Landsat 7). This is due to errors in the registration model used to orthorectify the image, which typically is ±5 m, or one third of a pixel for L1T-processed imagery.

Image pixel resolution contributes a random error of one pixel for each ice boundary pixel. The position of any point of the ice margin has an uncertainty of 21 m. The total error for a given area of ice is then (8N)1/2x2, where N is the number of boundary pixels and x is the pixel posting in meters.

Erroneous selection or non-selection of pixels can be due to debris cover, shadows and misidentification by the operator, as well as the ambiguity of delineating an ice boundary at glacier fronts ending in packs of icebergs. Without ground control, delineation of the ice edge in areas of debris cover, terminal moraines and persistent snow cover is subjective. These errors are difficult to quantify. Due to ambiguity in the ice edge and operator error, estimations were done by

comparing mappings performed by three different operators over the same area. On average, each operator identified 24.21 km (1614 pixels) of ice margin over the common area, with a 660 m (44 pixels) difference between the maximum and minimum mappings, giving an estimated error of ±3 percent. This error, however, is expected to vary widely by particular location and size of area considered (Howat et al., 2014).

See Howat et al., (2014) for more information regarding the quality and processing methods used to produce this data set.

2.5 Instrumentation

2.5.1 Description

The 2000 masks were produced from images acquired by the USGS's Landsat 7 Enhanced Thematic Mapper Plus (ETM+) and Canadian Space Agency's Synthetic Aperture Radar (SAR) from the RADARSAT-1 satellite.

The 2015 masks were produced from images acquired by the USGS's Landsat 8 OLI and the Canadian Space Agency RADARSAT-1 satellite.

3 SOFTWARE AND TOOLS

A variety of Geographical Information System (GIS) software packages will work with GeoTIFF files, including ArcGIS, ENVI, GDAL, and QGIS.

4 VERSION HISTORY

Table 3. Version History Summary

Version	Release Date	Description of Changes
1	February 2017	Initial release
1.1	April 2017	This version corrects the location of the upper left pixel in each GeoTIFF file. The previous version incorrectly specified the location of the upper left pixel as the distance in meters from the north pole to the center of the upper left pixel. The corrected location of the upper left pixel is the distance in meters from the north pole to the upper left corner of the upper left pixel. This correction effectively shifted the location by one-half pixel to the upper left relative to their positions in the previous version. Only the geolocation metadata in each GeoTIFF has changed; the dataarray is the same as in the previous version.

Version	Release Date	Description of Changes
1.2	May 2021	This update includes the following: • Ice and ocean masks for the year 2015 were added. A grounded ice mask for 2015 was not included with the update. • The year, "2000" was added to existing file names to differentiate them from the 2015 files.

5 RELATED DATA SETS

Greenland Ice Mapping Project (GIMP)

6 RELATED WEBSITES

Alaska Satellite Facility

Byrd Polar Research Center Glacier Dynamics Research Group

Canadian Space Agency

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7 CONTACTS AND ACKNOWLEDGMENTS

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8 REFERENCES

Howat, I. M., A. Negrete, and B. E. Smith. 2014. The Greenland Ice Mapping Project (GIMP) land classification and surface elevation datasets. *The Cryosphere*, 8(4): 1509-1518. https://doi.org/10.5194/tc-8-1509-2014

Joughin, I., B. E. Smith, I. M. Howat, T. Scambos, and T. Moon. 2010. Greenland flow variability from ice-sheet-wide velocity mapping. *Journal of Glaciology*, 56: 415–430.

9 DOCUMENT INFORMATION

9.1 Publication Date

February 2017

9.2 Date Last Updated

10 May 2021