MEaSUREs Greenland Ice Velocity: Selected Glacier Site Velocity Maps from InSAR, Version 4

USER GUIDE

How to Cite These Data

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

Joughin, I., I. Howat, B. Smith, and T. Scambos. 2021. *MEaSUREs Greenland Ice Velocity: Selected Glacier Site Velocity Maps from InSAR, Version 4*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/GQZQY2M5507Z. [Date Accessed].

Literature Citation

As a condition of using these data, we request that you acknowledge the author(s) of this data set by referencing the following peer-reviewed publication.

Joughin, I., B. Smith, I. Howat, T. Scambos, and T. Moon. 2010. *Greenland Flow Variability from Ice-Sheet-Wide Velocity Mapping*, Journal of Glaciology. 56. 415-430. https://doi.org/10.3189/002214310792447734

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/NSIDC-0481

National Snow and Ice Data Center

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1 DATA DESCRIPTION

1.1 Parameters

This data set reports selected Greenland glacier site velocity in meters per year. The `vv` files report velocity magnitude whereas the `vx` and `vy` files contain the velocity components in the x- and y-directions as defined by the polar stereographic grid. These are true velocity values, not subject to the distance distortions present in a polar stereographic grid. Small gaps have been filled via interpolation, identifiable as locations where velocity data are present but no error estimates exist. Radar-derived velocities are determined using a combination of conventional InSAR and speckle tracking techniques.

The data contain error estimates (`ex` and `ey`) for all non-interpolated, radar-derived velocity vectors. These estimates include the statistical uncertainty associated with the phase and speckle tracking error. See Joughin (2002) for more detail on errors and how they are computed.

-1 represents the missing data value for the velocity magnitude (`vv`) and error estimates (`ex`, `ey`) and is set as the attribute in all files. The missing data value for the velocity component (`vx`, `vy`) files is -2e+9.

1.2 File Information

1.2.1 Format

For each grid and existing time period, the ice velocity magnitude (`vv`), its components (`vx`, `vy`), and the corresponding error estimates (`ex`, `ey`) are provided in cloud optimized Geographic Tagged Image File Format (GeoTIFF). JPEG images of velocity magnitude (vv) are provided as well as an ASCII formatted metadata file containing source satellite acquisition information.

1.3 Naming Convention

Files are named according to the following convention:

`[Source]_[grid]_[startdate]_[enddate]_[nominaltime]_[parameter]_[version][.ext]`

As an example, below are listed all the files for grid E61.10N for the 19-30 April 2014 period in version 4.0:

- `TSX_E61.10N_19Apr14_30Apr14_09-16-09_vv_v04.0.tif`
- `TSX_E61.10N_19Apr14_30Apr14_09-16-09_vx_v04.0.tif`
- `TSX_E61.10N_19Apr14_30Apr14_09-16-09_vy_v04.0.tif`
- `TSX_E61.10N_19Apr14_30Apr14_09-16-09_ex_v04.0.tif`

- TSX_E61.10N_19Apr14_30Apr14_09-16-09_ey_v04.0.tif
- TSX_E61.10N_19Apr14_30Apr14_09-16-09_v04.0.jpg
- TSX_E61.10N_19Apr14_30Apr14_09-16-09_v04.0.meta

Table 1. File Naming Variables and Descriptions

Variable	Description
Source	Data Source: TSX TSX: denotes the twin satellites TerraSAR-X / TanDEM-X (TSX / TDX)
grid	Example: (E61.10N) Explanation: whether it is on the East (E), West (W), or South (S) coast latitude (for E and W) or longitude (for S and N) in decimal degrees. See Figure 1 for grid locations.
startdate	Date of first image (DDMMMYY)
enddate	Date of second image (DDMMMYY)
nominaltime	Nominal time for image pair (HH-MM-SS)
parameter	Velocity magnitude, velocity component, or error estimate; .tif files only vv: velocity magnitude vx: x component of velocity vy: y component of velocity ex: error of x component ey: error of y component
Version	Version of the data set, V04.0
.ext	File types available: .tif = GeoTIFF .jpg = JPEG file; visualization of the velocity magnitude .meta = ASCII text file; contains the Central Julian date, the date for each image, nominal time (HH:MM:SS) for the pair, sensor combinations, geographical information, and production date

1.4 Spatial Information

1.4.1 Coverage

This data set contains velocity data for most of the outlet glaciers for the Greenland Ice Sheet. It is presented by study sites, with a total of 55 grids. Figure 1 indicates the locations of all grids on a map of Greenland. See Appendix A for a larger version of this image.

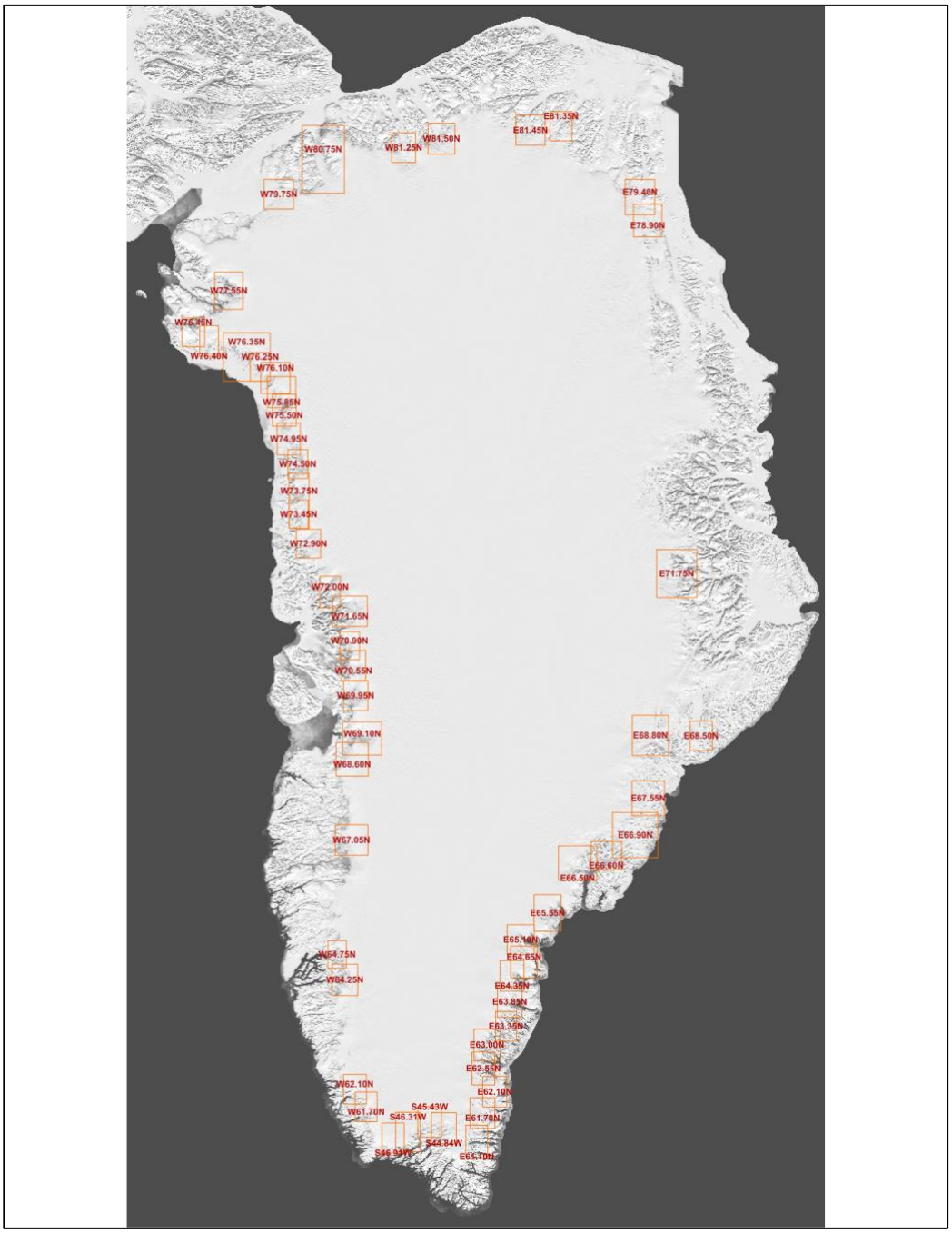

Figure 1. Grid Locator Map. For a larger version of this image, see Appendix A.

1.4.2 Resolution

100 meters

1.4.3 Projection

Data are provided in subregions of a polar stereographic grid with a standard latitude of 70° N and a rotation angle of -45° (sometimes specified as a longitude of 45° W). With this convention, the y-axis extends south from the North Pole along the 45° W meridian.

The origin specifies the polar stereographic coordinates for the center of the lower left pixel, i.e., the first sample in the file. This specification, using the middle of the reference pixel, differs from that used in some GeoTIFF and other formats where the reference coordinates are specified for the outer corner of the reference pixel.

1.5 Temporal Information

1.5.1 Coverage

Start Date: 12 June 2008
End Date: 03 May 2021

Data for 2008 were only obtained for three grids on a trial basis. Most grids have data starting in 2009.

This data set undergoes periodic updates as new data are collected and processed. Please check the Temporal Coverage table (available as an Excel spreadsheet under the Technical References tab) for a complete list of available dates by grid and by year.

1.5.2 Resolution

The temporal resolution varies between 11, 22, and 33 days on an 11-day repeat cycle.

2 DATA ACQUISITION AND PROCESSING

2.1 Theory of Measurements

The ice velocity maps in this data set were created using Synthetic Aperture Radar (SAR) data from the German Aerospace Center's (DLR) twin satellites TerraSAR-X / TanDEM-X (TSX/TDX). The methods include a combination of speckle tracking and conventional interferometry. See Joughin (2002) for more detail.

2.2 Processing

2.2.1 Baseline fits

The data are fit to a common set of ground control points as described by Joughin et. al., (2010). Each image pair used in the mosaic requires a 1-to 6-parameter fit for the baseline parameters. The larger Sentinel-1 scenes utilized in other Greenland Ice Mapping Project (GIMP) products, need a linear or quadratic solution to account for the along track variation. Often with much smaller TSX scenes, which contain fewer control points, fewer parameters are needed (1 being calibrating with a single constant).

To resolve for periods with poorly controlled data and sparce ground control points, adequate control points from other years were substituted, producing improved consistency of the data from year to year. While this procedure may mask some true change, far larger errors occur when not applying this approach.

2.2.2 Potential Artifacts

The data are posted to 200 m grid. However, the true resolution is several hundred meters. Posting represents the spacing between samples and should not be confused with the resolution at which the data were collected. Many small glaciers are resolved outside the main ice sheet, The velocity of narrow glaciers (<1 km) represents an average of moving ice and stationary rock. As a result, while the glacier may be visible in the map, the actual speed may be underestimated. Like narrow glaciers, interpolation of the velocity of smaller glaciers, produces artifacts. The interpolated value is derived from nearby rock, causing apparent stationary regions in the middle of otherwise active flow. The data have been screened to remove most of these artifacts, but should be used with caution.

2.2.3 Interpolated Points

Small gaps in the final maps have been filled via interpolation. These points can be identified as those that have valid velocity data but no corresponding error estimate. See Joughin et al. (2002) for more detail on errors and how they were computed.

2.2.4 Areas with No Data

Areas with no data correspond either to regions where no data were acquired or where the interferometric or optical correlation was insufficient to produce an estimate. This occurs most often in areas with high snow accumulation. The no data value for vv, ex, and ey files is -1. The no data value for vx, vy and dT is -2e9.

2.2.5 Geometric Terrain Correction

For images acquired prior to 2015, the processing steps included the MEaSUREs GIMP DEM V1 (NSIDC-0645). Images created from data acquired on or after January 1, 2015 were processed with a modified version of MEaSUREs Greenland Ice Mapping Project (GIMP) Digital Elevation Model from GeoEye and WorldView Imagery, Version 1, (NSIDC-0715) to account for the evolving ice sheet geometry. The modified version of the DEM differs from the published one in that it uses geoidal heights for the ocean and has a resolution of 270 m. A field in the .meta file indicates which DEM was used in the processing (the modified nsidc-0715 DEM is DEM V2 and the DEM from nsidc-0645 is DEM V1).

As a result of the different DEMs, there may be geolocation and other systematic differences when comparing images prior to 2015 with images from 2015 and after. Such artifacts are most likely to be found in regions with strong elevation changes or where there are large changes in terminus position.

Across versions of NSIDC-0481, other input data, algorithms, processing steps, and uncertainty estimates remain the same regardless of the DEM used in processing.

Note to Users: For version 4 of this product, an additional correction was made to the DEM V2 to address a horizontal shift of 15 m identified in version 3 data, resulting in some changes to the data between version 3 and version 4. While in general the differences are minor (~< 1m/yr), very large differences (> 1000 m/yr) may occur at isolated pixels near steep calving fronts or other steep slopes. Points in these regions should always be treated with some degree of caution. Even with these extreme outliers, the root-mean-square differences are < 2 m/yr for the entire map.

2.3 Quality, Errors, and Limitations

All non-interpolated, radar-derived velocity components (vx, vy) include error estimates. Error estimates include the statistical uncertainty associated with the phase and speckle tracking error inherent in the SAR data. Formal errors agree reasonably well compared with errors determined from GPS data (Joughin, 2002). However, the true uncertainty is likely larger and these estimates should be used as an indication of relative quality rather than as absolute error.

2.4 Instrumentation

2.4.1 Description

The twin satellites TerraSAR-X (TSX) and TanDEM-X (TDX) fly in close formation, only a few hundred meters apart. For each time period in this data set, velocities were estimated from pairs of images. For any given pair, the images were obtained from either one or both satellites such that the source combinations equal TSX/TSX, TSX/TDX, or TDX/TDX.

3 SOFTWARE AND TOOLS

To view the GeoTIFF files use Geographical Information System (GIS) software packages, such as QGIS and ArcGIS.

4 VERSION HISTORY

Table 2. Version History

Version	Release Date	Description of Changes
1	May 2011	Initial release
1.1	February 2016	GeoTIFF file format added; binary format discontinued; contains improved temporal sampling for the Jakobshavn Isbrae, Helheim, and Kangerdlugssuaq glaciers. The improved sampling addresses previous artifacts related to slope discontinuities at these glaciers' termini for the years 2009 – 2016
1.2	May 2017	Renamed files to include the nominal time for pair; added 3 TSX subdirectories missing from their respective region directories; removed extraneous files from several TSX subdirectories; included .meta files for metadata
2	February 2020	1. Full reprocessing with accumulated minor updates. Output should be generally consistent with previous versions. 2. The GeoTIFFs are now cloud optimized and include scale-down by 2 and 4 pyramids. 3. Velocity magnitude is now included as a separate tiff to be consistent with other velocity products (so now there are vx, vy, and vv tiffs). 4. Correction of browse images (distortions, color bar placement, watermark, and color-scale consistency.) 5. Addition of consistent NoData values 6. Temporal coverage was extended.
3	August 2020	This version contains the following changes: • For images acquired prior to 2015, the processing steps included the MEaSUREs GIMP DEM V1 (NSIDC-0645). • Images acquired after 2015 were processed with a modified version of MEaSUREs Greenland Ice Mapping Project (GIMP) Digital Elevation Model from GeoEye and WorldView Imagery, Version 1 (NSIDC-0715). See section 2.2.5 for details. • A field has been added to the .meta file to indicate which DEM was used in the processing.
4	June 2021	This version contains the following changes: • Updated temporal coverage • Use of GDAL 3.2.1 to create cloud optimized GeoTIFFs • Data reprocessed utilizing a corrected DEM. See user note in section 2.2.5

5 RELATED DATA SETS

- MEaSUREs Greenland Ice Sheet Velocity Map from InSAR Data
- MEaSUREs Greenland Annual Ice Sheet Velocity Mosaics from SAR and Landsat
- MEaSUREs Greenland Quarterly Ice Sheet Velocity Mosaics from SAR and Landsat
- MEaSUREs Greenland Monthly Ice Sheet Velocity Mosaics from SAR and Landsat

6 RELATED WEBSITES

- MEaSUREs at NSIDC | Overview
- NASA MEaSUREs Projects

7 CONTACTS AND ACKNOWLEDGMENTS

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8 REFERENCES

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Joughin, I., Kwok, R., & Fahnestock, M. (1996). Estimation of ice-sheet motion using satellite radar interferometry: method and error analysis with application to Humboldt Glacier, Greenland. *Journal of Glaciology*, 42(142), 564–575. https://doi.org/10.3189/s0022143000003543

9 DOCUMENT INFORMATION

9.1 Publication Date

29 June 2021

9.2 Date Last Updated

01 October 2021

APPENDIX A: Grid Locator Image