Select Northern Hemisphere Glacier Velocity Maps Using Customized autoRIFT and PlanetScope Imagery, Version 1

USER GUIDE

How to Cite These Data

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

Liu, J., M. Gendreau, E. M. Enderlin, and R Aberle. 2025. *Select Northern Hemisphere Glacier Velocity Maps Using Customized autoRIFT and PlanetScope Imagery, Version 1*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/VHFVXHZHOO6P. [Date Accessed].

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National Snow and Ice Data Center

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1 DATA DESCRIPTION

1.1 Summary

This data set consists of velocity maps and error estimates for the following five, surge-type glaciers:

- Medvezhiy Glacier, Pamir mountains
- South Rimo Glacier, the Karakoram
- Sít' Kusá Glacier, St. Elias mountain range, Alaska
- Aavatsmarkbreen Glacier, Spitsbergen, Svalbard
- Nàłùdäy/Lowell Glacier, St. Elias mountain range, Canada

The maps are generated from time series of satellite images using CautoRIFT, an augmented version of NASA's autonomous Repeat Image Feature Tracking (autoRIFT) algorithm[1] for Sentinel-2 and Landsat imagery that improves temporal coverage during periods of rapid glacier motion by incorporating pre-processed, daily high-resolution PlanetScope (PS) images and customized feature tracking parameters for each glacier.

Stable surface masks, area of interest (AOI) and glacier outlines, and ancillary data are also available for each glacier.

1.2 Parameters

Ice component velocities

Ice velocity magnitude

Stable surface error

1.3 File Information

1.3.1 Format

GeoTIFF

ESRI Shapefile

CSV

[1] autoRIFT is an automated cross-correlation technique that estimates ice velocity by tracking feature displacements in time series of optical images.

1.3.2 File Contents

1.3.2.1 Velocity Maps

Velocity data (m/y) are provided as GeoTIFF formatted files. Component velocities (v_x, v_y) and velocity magnitude (v_m) are stored in Band 1 (v_x), Band 2 (v_y), and Band 3 (v_m). Velocity maps also contain summary statistics and details about the coordinate reference system.

1.3.2.2 Stable Surface Masks

Stable surface masks (SSMs) are also provided as GeoTIFFs. SSMs comprise binary rasters, where "1" represents stable (i.e., static) surfaces and 0 represents all other pixels within the AOI.

SSMs are used to mask out any velocities over static surfaces surrounding the glacier and prevent them from being included as input to autoRIFT. As described in the following section, SSMs are also used during post-processing to determine the stable surface error (SSE) for each velocity map.

1.3.2.3 Stable Surface Errors

Each glacier has a corresponding CSV file that contains v_x, v_y, and v_m SSEs for every velocity map at the site. SSE is computed as the root mean squared error (in speed) from all stable surface pixels, according to the stable surface mask.

The CSV file also specifies the satellite platform used to generate each velocity map; the start, end, and midpoint dates of the image pair; the number of days between the images; and the percentage of pixels within the glacier outline that contain data.

CSV files begin with a header that includes the AOI name and spatial bounds, EPSG code/UTM Zone, latitude and longitude of the glacier, and a description of each variable. After the header, data are stored in rows with each row corresponding to an individual velocity map. Each row contains the variables listed in Table 1 separated by commas.

Table 1. CSV File Variable Names and Descriptions

Variable Name	Description
row	Row number (zero-based indexing)
ds1	First image date and time (yyyy-mm-dd hh:mm:ss)[2]
ds2	Second image date and time (yyyy-mm-dd hh:mm:ss)[2]

[2] All times = 00:00:00

Variable Name	Description
min_chip_size	Cross-correlation chip size[3]
sat	Satellite platform: S2 (Sentinel-2); LS (Landsat); PS (PlanetScope)
dt_days	Days between images
data_percent	Percentage of pixels within the glacier outline that contain data values [0 to 100]
err_vx	Stable surface error for x-component of velocity [meters/year]
err_vy	Stable surface error for y-component of velocity [meters/year]
err_v	Stable surface error for speed [meters/year]
mid_date	Date midpoint of the image pair [yyyy-mm-dd]
filename	Name of the GeoTIFF file containing the velocity maps

1.3.2.4 Areas of Interest, Glacier Outlines

AOIs and glacier outlines[4] are provided as shapefiles. Each shapefile consists of four files with the following extensions:

- .shp: main file with feature geometry
- .shx: index file
- .dbf: dBASE table with attribute information
- .prj: coordinate system information

1.3.3 File Naming Conventions

1.3.3.1 Velocity Maps

Example

NSIDC-0801_SR_20190318-20190403_vm_LS_V01.0.tif

Naming Convention

NSIDC-0801_[glacier id]_[date1 – date2]_vm_[platform]_V[nn.n].[ext]

Table 2 describes the variables in the velocity map file naming convention.

[3] The later image in each image pair is divided into patches called “chips,” which are matched within a search range to the earlier (i.e., reference) image. Note that while AutoRIFT iteratively tests larger chip sizes until it succesfully identifies feature displacements, for this data set all chip sizes = 100 m.

[4] Glacier outlines were obtained from the Randolph Glacier Inventory 6.0, a supplement to the Global Land Ice Measurements from Space initiative (GLIMS), Version 1 database.

Table 2. Velocity Map File Name Variables and Descriptions

Variable	Description
NSIDC-0801	Authoritative ID for the "Select Northern Hemisphere Glacier Velocity Maps Using Customized autoRIFT and PlanetScope Imagery" data set
glacier id	One of: • MZ (Medvezhiy Glacier) • SR (South Rimo Glacier) • SK (Sít' Kusá Glacier) • AV (Aavatsmarkbreen Glacier) • LO (Nàłùdäy/Lowell Glacier)
date1 – date2	Dates (yyyymmdd) of image pair used for feature tracking
vm	Velocity map
platform	One of: S2 (Sentinel-2), LS (Landsat), PS (PlanetScope)
Vnn.n	Data set major and minor version number. E.g., V01.0 = Version 1.0
ext	tif (GeoTIFF)

1.3.3.2 Stable Surface Mask, Stable Surface Error, AOI, Glacier Outline

The stable surface mask (ssm), stable surface error (sse), and the AOI and glacier outline shapefiles utilize the following naming convention:

Examples

NSIDC-0801_SR_20190318-20221223_ssm_V01.0.tif
NSIDC-0801_SR_20190318-20221223_sse_V01.0.csv

NSIDC-0801_SR_20190318-20221223_AOI_V01.0.shp
NSIDC-0801_SR_20190318-20221223_AOI_V01.0.shx
NSIDC-0801_SR_20190318-20221223_AOI_V01.0.dbf
NSIDC-0801_SR_20190318-20221223_AOI_V01.0.prj

NSIDC-0801_SR_20190318-20221223_outline_V01.0.shp
NSIDC-0801_SR_20190318-20221223_outline_V01.0.shx
NSIDC-0801_SR_20190318-20221223_outline_V01.0.dbf
NSIDC-0801_SR_20190318-20221223_outline_V01.0.prj

Naming Convention

NSIDC-0801_[glacier id]_[start date – end date]_[param]_V[nn.n].[ext]

Table 3 describes the variables in the ssm, sse, AOI, and glacier outline file naming conventions.

Table 3. SSM, SSE, AOI, and Glacier Outline File Name Variables and Descriptions

Variable	Description
NSIDC-0801	Authoritative ID for the “Select Northern Hemisphere Glacier Velocity Maps Using Customized autoRIFT and PlanetScope Imagery” data set
glacier id	One of: • MZ (Medvezhiy Glacier) • SR (South Rimo Glacier) • SK (Sít' Kusá Glacier) • AV (Aavatsmarkbreen Glacier) • LO (Nàłùdäy/Lowell Glacier)
start date – end date	Date (yyyymmdd) range of images used for all velocity maps at the glacier. E.g., given the complete list of GeoTIFF velocity maps for a given glacier, “start date” corresponds to the earliest “date1”, while “end date” corresponds to the latest “date2” (see Table 2).
param	One of: ssm, sse, AOI, outline
Vnn.n	Major and minor version number. V01.0 = Version 1.0
ext	tif (GeoTIFF); csv (comma separated value); shp, shx, dbf, and prj (shapefile)

1.4 Spatial Information

1.4.1 Coverage

The velocity maps in this data set span the following regions:

Medvezhiy Glacier (MZ)

- North: 38.7041022 °N
- South: 38.6037845 °N
- East: 72.2802216 °E
- West: 72.1118897 °E

South Rimo Glacier (SR)

- North: 35.4419895 °N
- South: 35.2267909 °N

- East: 77.6655226 °E
- West: 77.3183406 °E

Sít' Kusá Glacier (SK)

- North: 60.2800575 °N
- South: 59.9016126 °N
- East: 139.4144551 °W
- West: 140.175999 °W

Aavatsmarkbreen Glacier (AV)

- North: 78.7800952 °N
- South: 78.6133048 °N
- East: 12.7046985 °E
- West: 11.5497732 °E

Nàłùdäy/Lowell Glacier (LO)

- North: 60.4731365 °N
- South: 60.1011977 °N
- East: 137.8206057 °W
- West: 138.6933945 °W

Figure A-1 in “Appendix A | Glacier Locations” shows the locations of all five glaciers.

1.4.2 Resolution

100 m (minimum chip size)

1.4.3 Geolocation

Data are provided in the following Universal Transverse Mercator (UTM) zones:

Medvezhiy Glacier (MZ)

EPSG:32642

WGS 84 / UTM zone 42N

South Rimo Glacier (SR)

EPSG:32643

WGS 84 / UTM zone 43N

Sít' Kusá Glacier (SK)

EPSG:32607

WGS 84 / UTM zone 7N

Aavatsmarkbreen Glacier (AV)

EPSG:32633

WGS 84 / UTM zone 33N

Nàłùdäy/Lowell Glacier (LO)

EPSG:32608

WGS 84 / UTM zone 8N

1.5 Temporal Information

1.5.1 Coverage

Temporal coverage varies depending on the glacier:

Medvezhiy Glacier (MZ)

- 05 March 2019 – 26 December 2022

South Rimo Glacier (SR)

- 18 March 2019 – 23 December 2022

Sít' Kusá Glacier (SK)

- 16 January 2020 – 16 October 2021

Aavatsmarkbreen Glacier (AV)

- 10 March 2020 – 28 September 2021

Nàłùdäy/Lowell Glacier (LO)

- 19 January 2021 – 27 November 2022

1.5.2 Resolution

Temporal resolution varies depending on the glaciers' flow speeds and image availability. For glaciers with flow ≥5 m/d (SK, LO, and SR), velocities were determined from image pairs separated by between 5 and 60 days. Velocities for glaciers with speeds <5 m/d (MZ and AV) velocities were mapped using images separated by 14 to 60 days. As such, the number of available velocity maps varies depending on the glacier.

2 DATA ACQUISITION AND PROCESSING

2.1 Background

The NASA Making Earth System Data Records for Use in Research Environments (MEaSUREs) Inter-Mission Time Series of Land Ice Velocity and Elevation (ITS_LIVE) Program uses autoRIFT to generate ice velocity time series for a global inventory of glaciers and ice sheets. However, these time series can be incomplete due to gaps in the cloud-free satellite image record and the failure of standard feature-tracking parameters (e.g., search range, chip size, or estimated displacement) to capture rapid changes in glacier velocity. This data set demonstrates that autoRIFT can be augmented with pre-processed, daily high-resolution PS imagery, plus customized feature tracking parameters at each glacier, to fill in these gaps and recover rapid glacier accelerations.

2.2 Acquisition

Inputs to the CautoRIFT pipeline include:

- Sentinel-2 (Multi-Spectral Instrument 10 m, near-infrared band)
- Landsat 8 and 9 (Operational Land Imager 15 m, panchromatic band)
- PS2, PS2.SD, PSB.SD optical images (<5 m resolution)
- Auxiliary geospatial files (specific to each site):
  - Glacier outline shapefile
  - Area of interest (AOI) shapefile
  - Digital elevation model (DEM) covering the AOI
  - 5 m resolution GeoTIFF covering the AOI, to standardize the spatial resolution of all images
- Optional inputs:
  - Reference velocity map
  - Stable surface mask

2.3 Processing

In summary, pre-processing consists of cropping the PS images to the AOI and using Sentinel-2 harmonized and normalized data to transform the input PS reflectance coefficients to match the Sentinel-2 MSI spectral response. DEMs are used to guide the down-slope search in the autoRIFT algorithm and to georeference the output velocity map.

Figure 1 shows a flowchart of the steps used to process PS imagery used as input to CautoRIFT.

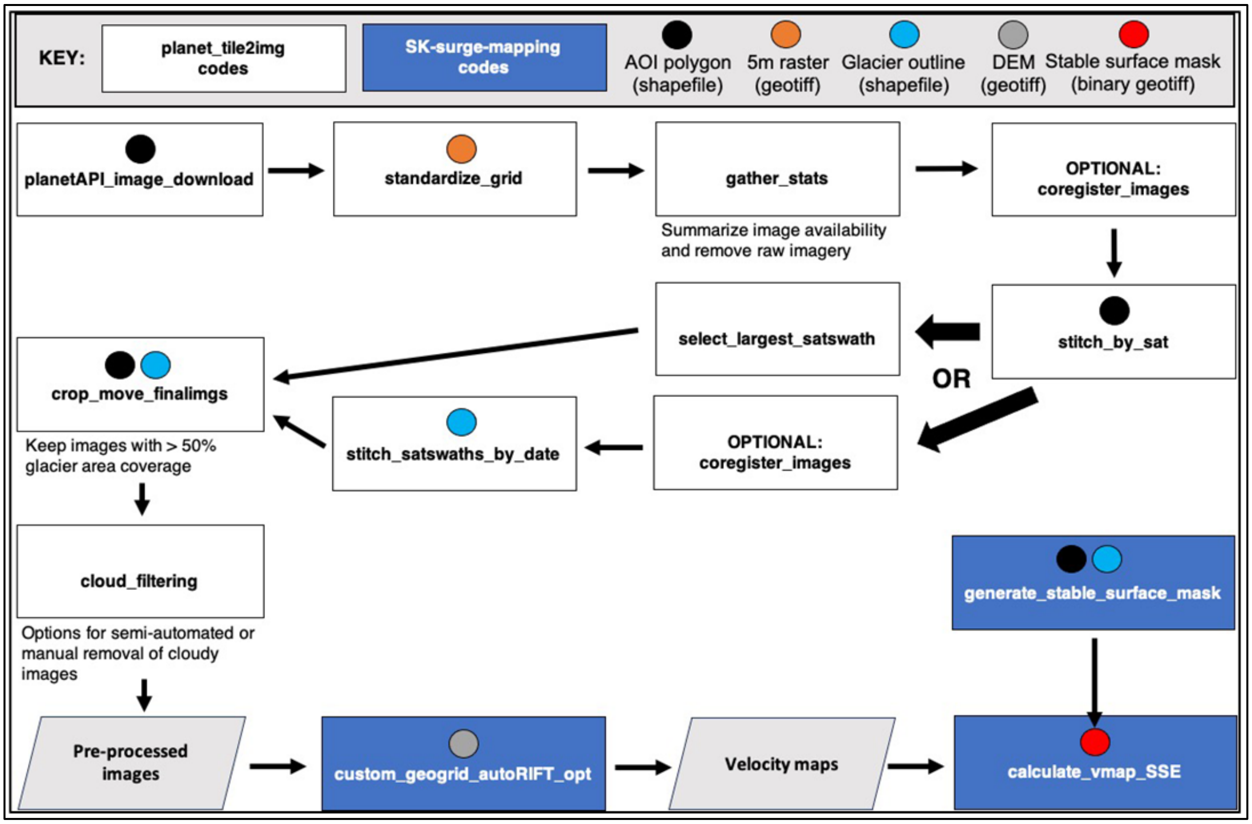

Figure 1. Flowchart showing the preprocessing pipeline for PS imagery used as input to CautoRIFT. Each rectangle corresponds to a Python script. Circles within the rectangles correspond to inputs to that script. Image from Liu, et al. 2024.

For a complete description of the CautoRIFT pipeline, see Liu, et al. 2024. The PlanetScope image pre-processing pipeline ("CryoGARS-Glaciology/planet_tile2img") is available from GitHub at https://doi.org/10.5281/zenodo.10632745. The custom CautoRIFT code is available from the "jukesliu/CautoRIFT: v1.1.1" GitHub repository at https://doi.org/10.5281/zenodo.11372310.

3 VERSION HISTORY

Version 1 (initial release)

4 RELATED DATA SETS

MEaSUREs ITS_LIVE Landsat Image-Pair Glacier and Ice Sheet Surface Velocities, Version 1

5 REFERENCES

Liu, J., Gendreau, M., Enderlin, E. M., & Aberle, R. (2024). Improved records of glacier flow instabilities using customized NASA autoRIFT (CautoRIFT) applied to PlanetScope imagery. In The Cryosphere (Vol. 18, Issue 8, pp. 3571–3590). Copernicus GmbH. https://doi.org/10.5194/tc-18-3571-2024

6 DOCUMENT INFORMATION

6.1 Publication Date

April 2025

6.2 Date Last Updated

April 2025

APPENDIX A – GLACIER LOCATIONS

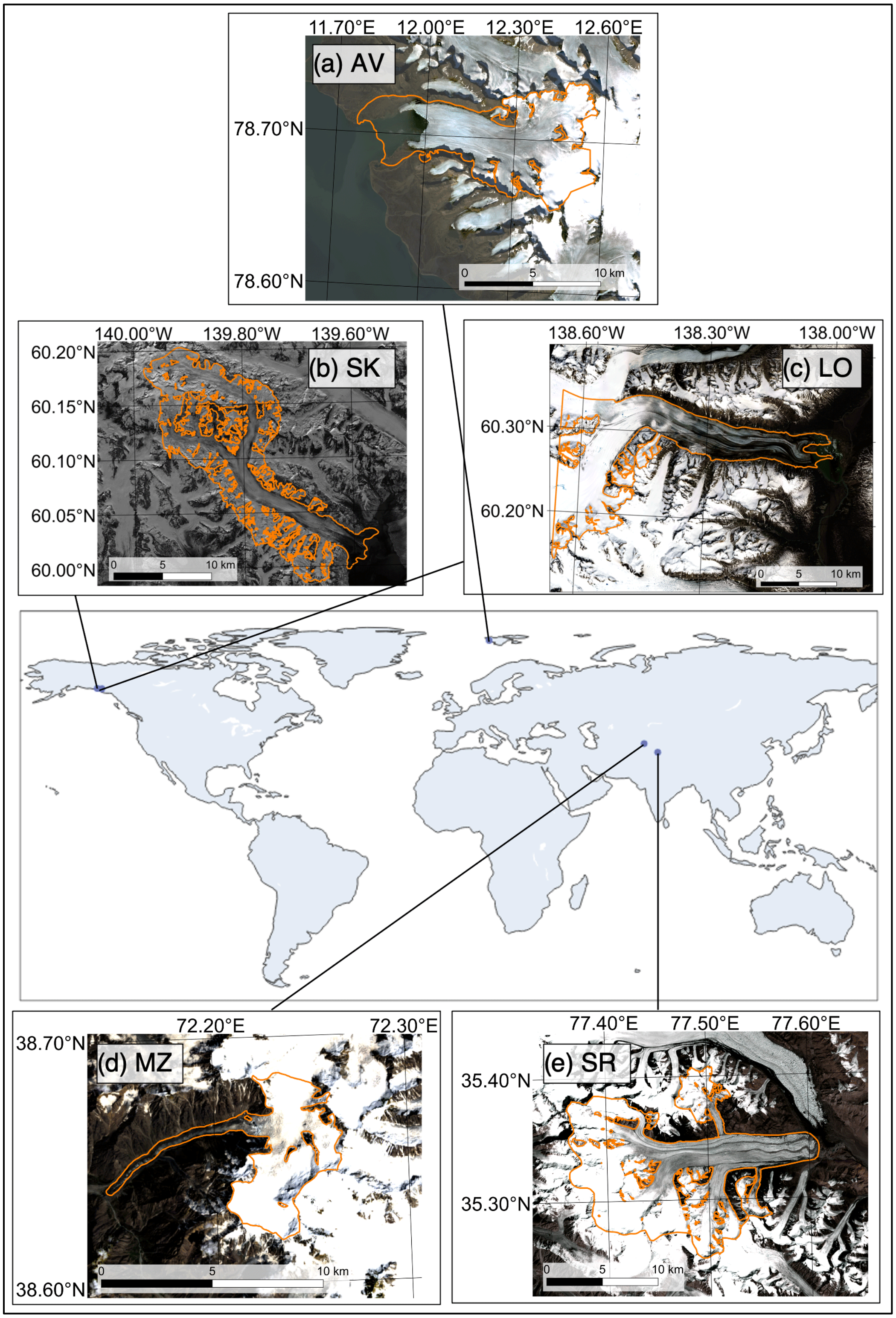

Figure A - 1. Locations of the five glacier sites. Image from Liu, et al. 2024.