Global Land Ice Velocity Extraction from Landsat 8 (GoLIVE), Version 1

USER GUIDE

How to Cite These Data

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

Scambos, T., M. Fahnestock, T. Moon, A. Gardner, and M. Klinger. 2016. *Global Land Ice Velocity Extraction from Landsat 8 (GoLIVE), Version 1*. [Indicate subset used]. Boulder, Colorado USA. National Snow and Ice Data Center. https://doi.org/10.7265/N5ZP442B. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/NSIDC-0710

National Snow and Ice Data Center

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1 DETAILED DATA DESCRIPTION

This data set is a compilation of ice velocity mappings generated from pairs of Landsat 8 panchromatic images. The velocity data are derived from image pairs using images acquired beginning May 2013 to present, and cover all terrestrial permanent ice greater than 5 km2 in an area within the latitude range of 82°S to 82°N. The input Landsat 8 data are now released by the USGS in two stages – an initial Real Time (RT) version, and a revised version with better geolocation. Prior to 01 May 2017, USGS released Pre-Collection 1 data that were used for ice velocity mapping. As a result, three classes of data can be found in the GoLIVE data set:

- Near-real-time velocity data processed from Real Time (RT) Collection 1 Landsat 8 images that were acquired within a two week window prior to the monthly velocity updates. The near-real-time velocity data are replaced at the next monthly reprocessing with archived versions, and are held in the archive for 120 days.
- Collection 1 archive data that is processed from USGS Tier 1 or Tier 2 Collection 1 Landsat 8 images. The archive data are processed monthly and are retained indefinitely.
- Pre-Collection 1 archived data that are generated from Pre-Collection 1 Landsat 8 images aquired prior to 1 May 2017. At present, these data will be retained in the archive indefinitely. At some later time, these may be reprocessed using Collection 1 image data.

For the Antarctic ice sheet, Tier 1 or Tier 2 archive images are paired with scenes acquired within 400 days of acquisition. For the Greenland ice sheet, the image pairs extend back 112 days from more recent acquired image. For all other areas, image pairs are processed over a range no greater than 96 days prior to the more recent acquired image.

The data are generated by an image correlation algorithm that produces grids of ice displacement referenced to in-image rock outcrops, slow moving ice, or if lacking that, using the satellite's geo-positioning (accurate to +/- 5 m). Velocity vector grids are generated at a sample spacing of 300 m from small sub-images (also called "chips") that are either 300 m or 600 m on a side, depending on the region. For example, ice sheet areas are mapped with 600 m x 600 m sub-images, and mountain glaciers are mapped with 300 m x 300 m sub-images. Accuracy of the velocity data varies depending on the time separation between the images, ranging from ~1 m/d per day to ~0.02 m/d per day.

As outlined above, the GoLIVE data archive evolves with upstream processing at the USGS. The first major shift in processing occurred 1 May 2017, when the USGS implemented a new processing scheme classifying data based on methods in image geolocation. Data received prior to 01 May 2017 are known as Pre-Collection 1 and data produced after 01 May 2017 is now Collection 1. Pre Collection 1 data was processed by the NSIDC before archival. Collection 1 data is first processed by the USGS and classified into three Tiers before NSIDC receives the data. Tier

1 and Tier 2 data are archived directly, while near-real-time GoLIVE products are made temporarily available for 120 days post processing.

In addition, Landsat grids over faster flowing regions in Greenland were reprocessed using a higher maximum velocity cutoff. Therefore, in these regions, files may contain more velocity data than what is reported in the initial release of the GoLIVE product.

This large data set includes scenes with significant cloud cover and undetected offset errors. Because the data were developed from images taken under changing snow, cloud cover, and lighting conditions, the data may include apparent areas of ice or topographic motion that are in fact stationary or moving in a different directions. Thus, you are asked to apply your best judgement when using these data, and to use the provided browse images to identify such issues.

1.1 Format

Data are provided in netCDF (`.nc`) format using CF-1.6 conventions. Browse images are in GeoTiff (`.tif`) and PNG (`.png`) format.

1.2 File and Directory Structure

Data are available on the FTP site in the `ftp://dtn.rc.colorado.edu/work/nsidc0710/directory`. Within this directory there are two folders: `nsidc0710_landsat8_golive_ice_velocity_v1.1` and `nsidc0710_landsat8_golive_ice_velocity_v1.1_nrt`.

The `nsidc0710_landsat8_golive_ice_velocity_v1.1` folder contains data folders that are organized according to the Landsat 8 path/row grid and these folders contain T1, T2, and pre-Collection 1 netCDF data files, and corresponding GeoTiff and PNG browse images. These data have undergone final processing.

The `nsidc0710_landsat8_golive_ice_velocity_v1.1_nrt` folder contains data folders that are organized according to the Landsat 8 path/row grid, and these folders contain GoLIVE data produced from Real Time (RT) images that have not been processed to either a Tier 1 or Tier 2 category. RT images are replaced by the USGS after 14 to 16 days with Tier 1 or 2 level data. GoLIVE velocity products that are produced using RT Landsat images will be updated in the next monthly cycle and added to the `nsidc0710_landsat8_golive_ice_velocity_v1.1` folder.

1.3 File Naming Convention for Data Processed After 1 May 2017

As of 01 May 2017, the USGS has changed the processing and filename structure of Landsat 8 data. This new Collection 1 data set is used for velocity fields that use imagery from 01 May 2017 onwards. Collection 1 Landsat data are organized into Tiers based on the level of processing. USGS Collection 1 Landsat Tier levels are RT, T1, or T2:

- RT (Real-Time) - newly acquired scenes that use preliminary geolocation
- T1 (Tier 1) - tie-points used in the final scene geolocation
- T2 (Tier 2) - no tie-points used in final geolocation

As a result of this change, the newer GoLIVE products have the processing Tier levels added to their filenames. Velocity products that are produced with RT images and noted with nrt in the filenames will eventually be replaced as the USGS reprocesses imagery and assigns them to Tier 1 or 2 categories.

Users are advised to use T1 and T2 data for their analysis. RT images are replaced by the USGS after 14 to 16 days with Tier 1 or 2 level data. GoLIVE velocity products that use RT input data will be updated in the next monthly cycle to use these final versions.

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

Example Tier 1 and Tier 2 File Names:

```
L8_001_004_016_2017_104_2017_120_T2T2_v1.1.nc
L8_001_004_016_2017_104_2017_120_T2T2_v1.1.png
L8_001_004_016_2017_104_2017_120_T2T2_v1.1.tif
```

```
[satellite]_[path]_[row]_[delt]_[image1year]_[image1doy]_[image2year]_[image2do
y]_[tier level first image second image]_[version]_[file format]
```

Example Near-Real-Time (.nrt) File Names:

```
L8_011_247_016_2017_174_2017_190_T1RT_v1.1_nrt.nc
L8_011_247_016_2017_174_2017_190_T1RT_v1.1_nrt.png
L8_011_247_016_2017_174_2017_190_T1RT_v1.1_nrt.tif
```

```
[satellite]_[path]_[row]_[delt]_[image1year]_[image1doy]_[image2year]_[image2do
y]_[tier level firt image second image]_[version]_[nrt]_[file format]
```

Refer to Table 1 for the valid values for the file name variables listed above.

Table 1. File Naming Convention

Variable	Description
`Satellite`	L8 for Landsat 8
`Path`	Landsat 8 orbit path
`Row`	Landsat 8 orbit row
`Delt`	Time separation between Image 1 and Image 2 reported in days
`Image1year`	Image 1 year acquisition
`Image1doy`	Image 1 acquisition
`Image2year`	Image 2 year acquisition
`Image2doy`	Image 2 day acquisition
`Tier Level`	USGS Collection 1 Landsat Tier Levels are T1, T2, or RT. T1 (Tier 1) - tie-points used in the final scene geolocation T2 (Tier 2) - no tie-points used in final geolocation RT (Real-Time) - newly acquired scenes that use preliminary geolocation.
`nrt`	Near-real-time data - newly acquired scenes that use preliminary geolocation that will eventually be reprocessed and assigned to a T1 or T2 category.
`Version`	Version number of the data
`.File Format`	.nc = netCDF format CF-1.6 .png = PNG format .tif = GeoTiff format

1.4 File Naming Convention for Pre-Collection 1 Data Processed Prior to 1 May 2017

This section explains the file naming convention used for Pre-Collection 1 data with an example.

Example File Name:

```
L8_001_004_016_2014_080_2014_096_v1.1.nc
L8_001_004_016_2014_080_2014_096_v1.1.tif
```

```
[satellite]_[path]_[row]_[delt]_[image1year]_[image1doy]_[image2year]_[image2doy]_[version].nc
```

```
[satellite]_[path]_[row]_[delt]_[image1year]_[image1doy]_[image2year]_[image2doy]_[version].tif
```

Refer to Table 2 for the valid values for the file name variables listed above.

Table 2. File Naming Convention

Variable	Description
Satellite	L8 for Landsat 8
path	Landsat 8 orbit path
row	Landsat 8 orbit row
Delt	Time separation between Image 1 and Image 2 reported in days
Image1year	Image 1 year acquisition
Image1doy	Image 1 acquisition
Image2year	Image 2 year acquisition
image2doy	Image 2 day acquisition
Version	Version number of the data
.nc	netCDF format CF-1.6
.tif	GeoTiff format
.png	PNG format

1.5 Spatial Coverage

The spatial coverage is limited to scenes which capture land ice features with a coterminous area > 5 km^2. The Randolf Glacier Inventory (RGI) is used in selecting tiles which satisfy the permanent land ice area threshold. Refer to Figures 1, 2, and 3. For more path/row information, go to the USGS EarthExplorer website and the USGS WRS-2 Path/Row to Latitude/Longitude Converter website.

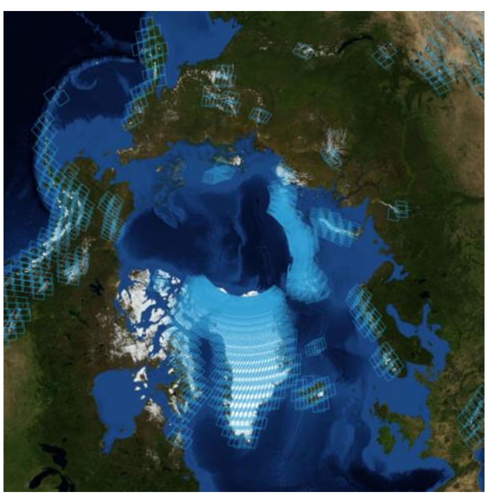

Figure 1. Northern Hemisphere

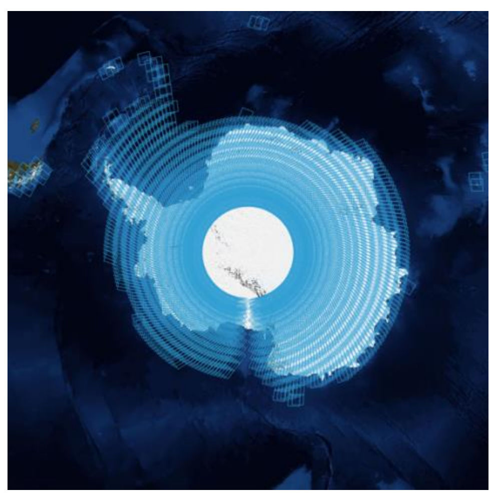

Figure 2. Southern Hemisphere

Figure 3. Global

1.5.1 Spatial Resolution

The data are posted at a grid spacing of 300 m.

1.5.2 Projection and Grid Description

Each data file is presented in the projection of the original Landsat imagery, which is local UTM for scenes outside of Antarctica, and the SCAR Polar Stereographic projection (EPSG:3031) for scenes in Antarctica. Grids are posted at 300 m in these projections.

1.6 Temporal Coverage

May 2013 to present

1.6.1 Temporal Resolution

The Landsat 8 Observatory has a sun-synchronous orbit with a 16-day repeat cycle. Therefore, the time difference (in days) used for image correlation pairs will be a multiple of 16. For example, 16, 32, 48, and 64 days.

The data are updated monthly with new images acquired by Landsat 8 that are then paired with older images acquired within 400 days of the new acquisition for the Antarctic ice sheet, 112 days for the Greenland ice sheet, and 96 days for all other glacierized areas.

1.7 Parameter or Variable

1.7.1 Variable or Parameter for NetCDF Data

The main parameter is ice velocity in m/day.

Table 3. NetCDF File Variables

Variable	Description
vv	magnitude of velocity
vv_masked	magnitude of velocity (masked)
vx	x component of velocity
vx_masked	x component of velocity (masked)
vy	y component of velocity
vy_masked	y component of velocity (masked)
corr	peak correlation value
d2idx2	corr peak curvature in x direction
d2jdx2	corr peak curvature in y direction
del_corr	difference in correlation value between primary and secondary peak
del_i	i pixel offset (positive in image right direction, original image pixel size, no offset correction applied)
del_j	j pixel offset (positive in image down direction, original image pixel size, no offset correction applied)
lgo_mask	land(1) glacier(0) ocean(2) mask Note: not present in Antarctic data.

1.7.2 Sample Data Record

Figures 4, 5, 6, and 7 are sample data images from the `L8_049_118_032_2013_301_2013_333_v1.nc data` file.

Figures 4, 5, and 6 are .png images of the variables `corr`, `del_corr`, and `vv_masked`, and these images were created using Panoply. Figure 7 is a `.tif` browse scene.

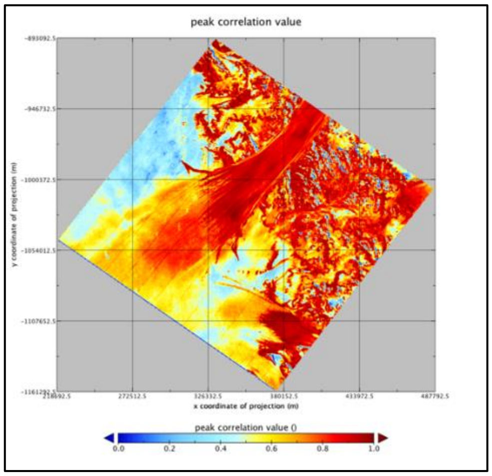

Figure 4. Peak Correlation Value

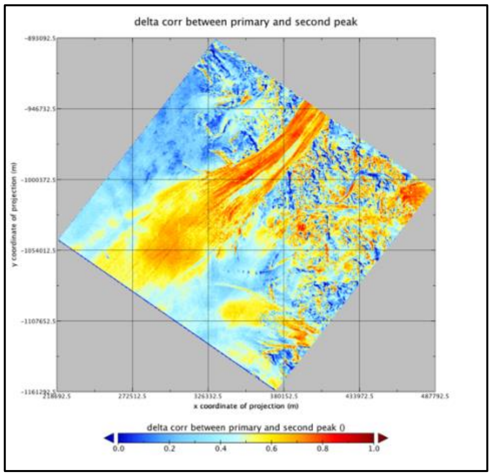

Figure 5. Delta Corr between Primary and Second Peak

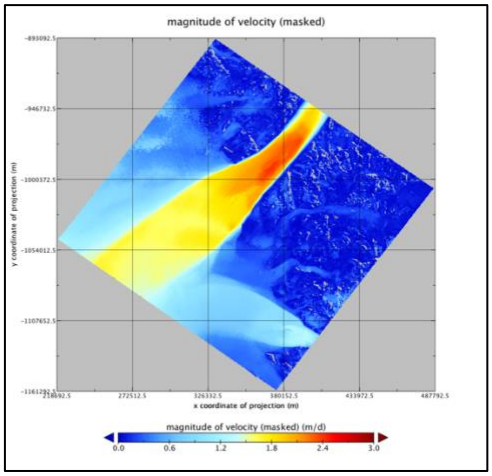

Figure 6. Magnitude of Velocity (Masked)

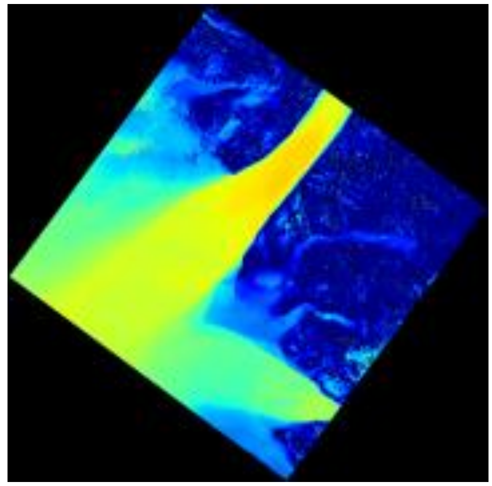

Figure 7. Tif Browse Scene

2 SOFTWARE AND TOOLS

You can use any data analysis and plotting tools that work with netCDF or GeoTIFF files. The following is a list of these types of tools that we recommend:

- Panoply
- QGIS
- ArcGIS
- NCView
- ENVI

You can also use path and row tools to get the nearest scene center latitude and longitude coordinates or convert from WRS-2 path/row to latitude/longitude.

3 DATA ACQUISITION AND PROCESSING

High-quality optical satellite-image-based ice velocity mapping over the ice sheets and large glaciated areas is enabled by the high radiometric resolution and internal geometric accuracy of Landsat 8's Operational Land Imager (OLI). The 12-bit radiometric quantization and 15-m pixel-scale resolution of OLI panchromatic imagery enables displacement tracking of both high-contrast crevasse and debris areas as well as subtle snow-drift patterns on ice sheet surfaces at ~1 m precision (0.1 pixel). Ice sheet and snowfield features persist for typically 16 to 64 days, and up to 400+ days, depending primarily on snow accumulation rates. This results in spatially continuous mapping of ice flow, extending the mapping capability beyond crevassed areas. (Fahnestock et al., 2015).

3.1 Data Acquisition Methods

Landsat 8 Level-1 terrain corrected (L1T) panchromatic band images acquired in 2013 and 2014 were obtained from the USGS. Beginning in 2015 and going forward, data are acquired via AWS Public Data Sets and Google Earth Engine, although all scenes originate from the USGS EROS data processing center. Images are obtained where land ice > 5 km2 and cloud cover is less than 50%. The Randolf Glacier Inventory (RGI) is used to select tiles that satisfy the permanent land ice area threshold, and cloud cover in the Landsat 8 metadata guides additional scene filtering.

3.2 Derivation Techniques and Algorithms

Data are generated with an image correlation software, Python Correlation (PyCorr), that produces grids of ice displacement referenced to adjacent rock outcrops or using the satellite's geo-positioning (accurate to ±5 m). The method computes a correlation between two small sub-scenes, or chips, of greyscale data. To map ice flow, chips containing features from one image are compared to a range of possible matching features in a second image. The best match is determined by generating a normalized cross-correlation surface composed of the cross correlations of chips at each integer pixel offset. Mathematical interpolation of the primary peak in this surface allows determination of feature offset at the sub-pixel level. (Fahnestock et al., 2015).

For more details regarding the derivation techniques used, please refer to Fahnestock et al. (2015).

3.3 Processing Steps

As of 01 May 2017, the USGS has changed the processing and filename structure of Landsat 8 data. This new Collection 1 data set is used for velocity fields that use imagery from 01 May 2017 onwards. Collection 1 Landsat data are organized into Tiers based on the level of processing. USGS Collection 1 Landsat Tier levels are RT, T1, or T2:

- RT (Real-Time) - newly acquired scenes that use preliminary geolocation
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- T2 (Tier 2) - no tie-points used in final geolocation

As a result of this change, the newer GoLIVE products have the processing Tier levels added to their filenames. Velocity products that are produced with RT images and noted with nrt in the filenames will eventually be replaced as the USGS reprocesses imagery and assigns them to Tier 1 or 2 categories.

Users are advised to use T1 and T2 data for their analysis. RT images are replaced by the USGS after 14 to 16 days with Tier 1 or 2 level data. GoLIVE velocity products that use RT input data will be updated in the next monthly cycle to use these final versions. For more information regarding Landsat 8 Collection Tiers, please see the What are Landsat Collection Tiers? web page.

3.3.1 High-Pass Spatial Filtering

A Gaussian high pass filter with an ~3 pixel standard deviation (~50 m) is applied to the original panchromatic band imagery to highlight localized patterns of brightness variation. This filtering scheme isolates the surface features that are advected with the ice flow, substantially improving displacement retrievals.

3.3.2 Normalized Cross-Correlation

To measure surface displacements between pairs of Landsat 8 OLI panchromatic images resulting from ice flow, peaks in normalized cross-correlation surfaces are calculated at integer pixel offsets between image chips. Cross-correlations using a source chip at integer pixel offsets relative to a larger template chip from a later image is then performed, fitting the peak of the correlation surface to estimate the chip offset to the sub-pixel level. Source chips range from 20 to 40 pixels on a side, or ~300 m to 600 m on the ground.

3.3.3 Grid Spacing

For ice sheets, source chips are 600 m (40 pixels) on a side and are posted to an output grid spacing of 300 m (20 pixels) over an area in common between the images in a pair. This grid spacing results in 50 percent overlap of pixels used in adjacent chips, resulting in velocities that are partially dependent of each other. For all other regions, source chips are 300 m (20 pixels) on a side, and sampled on the same scale, resulting in adjacent velocities that are independent of one another. These differences in chip sizes greatly improve returns over the interior of ice sheets, by using a larger number of pixels in the cross-correlation; and over narrow valley glaciers, by using smaller source chips.

3.3.4 Correlation Strength

The peak correlation value `corr`, the difference between the peak correlation value and the second highest peak in the correlation surface `del_corr`, and curvature of the peak in two dimensions are also recorded `d2idx2` and `d2jdx2`. These metrics facilitate the recognition of erroneous matches, for example, incorrect peak selection, poorly defined or missing peaks due to noise, and allow for error estimates of each match. These methods are relatively common in cross-correlation image processing, and are discussed more extensively elsewhere in Pan et al. (2009).

3.3.5 Sub-Pixel Offset Determination

To facilitate accurate displacement measurement, the algorithm takes advantage of the tendency for ice sheet and glacier images to have a smoothly varying correlation surface in the vicinity of a valid match. A bivariate cubic spline is used to fit the peak in the integer-pixel offset correlation surface, and then find the sub-pixel location of the spline peak. For computational efficiency, a maximum gradient search is performed on the splined surface in the x and y directions, locating the peak to within ~0.01 pixel. The resulting offset fields show smoothly varying values, suggesting that the data are not being over-fit. The smoothly varying sub-pixel displacement field, particularly in the slow-moving areas, demonstrates the fidelity of both the internal image geometry and the derived offsets (Fahnestock et al., 2015).

Note: For more details regarding processing, refer to Fahnestock et al. (2015).

3.3.6 Adjustment of Geolocation Errors

Despite the improvement in geolocation accuracy with Landsat 8, residual geolocation errors (+/- 5 m) often remain, introducing an artificial offset between the images in a tracked pair. This is particularly problematic for closely-spaced pairs (16- and 32-day separations). Since most geolocation errors in Landsat 8 present themselves as nearly planar shifts between image pairs, errors can largely be corrected without impeding the ability to detect and accurately map real ice displacement. In many areas, this can be achieved through identification of exposed bedrock. However, Landsat 8 scenes without bedrock outcrops commonly exist on ice sheets (Scambos et al., 1992). For those scenes, slow moving (20–40 m/yr) or near-zero (<20 m/yr) areas based on recent InSAR-based compilations (LISA for Antarctica and Joughin et al., 2010 for Greenland), shifts in x and y are applied to the entire Landsat-derived displacement grid to have these areas align with earlier InSAR results of ice flow (Rignot et.al., 2011).

If more than two percent Landsat velocity mapping overlies near-zero flow areas, a correction is applied so that the mean Landsat speed is zero in the overlap. If the near-zero overlap area is less than two percent of the Landsat mapping, scalar x and y shifts are solved for and applied to Landsat data such that the mean of all overlapping x and y velocities for slow moving areas match InSAR mappings. No correction is applied if the area covered by velocities <40 m/yr totals less than two percent of the mapped area. This approach assumes that slow moving ice experiences small absolute changes in ice speed. The majority of known ice flow speed changes in the ice sheets are occurring near the coasts, in areas of moderate to high flow speed (Fahnestock et al., 2015).

3.4 Version History

Table 4. Version History

Version Number	Date	Description of Change
Version 1.1	August 2017	GoLIVE data processed after 1 May 2017 is processed using Landsat Collection 1 data from the USGS. The filename convention changed slightly for files produced using Landsat Collection 1 images. In addition, Landsat grids over faster flowing regions in Greenland were reprocessed using a higher maximum velocity cutoff; therefore, for these regions, the Version 1.1 files may contain more velocity data than was previously reported in Version 1.
Version 1	November 2016	Initial release. Includes velocity data produced using Landsat Pre-Collection 1 data from the USGS (June 2013 through April 2017).

3.5 Errors and Limitations

Errors in offset determinations result from a combination of two sources:

- those due to the failure of the cross-correlation to accurately capture pixel offset
- improper correction for the existing geolocation errors between the two images.

The cross-correlation may fail to accurately capture pixel offsets because of signal-to-noise issues, pattern repetition in the feature being tracked, or the influence of a pattern that is not due to ice motion, such as a shift in shadow from a ridge line on an east-west trending glacier as the sun changes elevation with the seasons. While it is not possible to mask out all poor matches, it is possible to recognize regions that behave in a spatially consistent manner and that show little offset in non-moving areas. Mitigation strategies for correcting the existing geolocation errors between Landsat 8 image pairs depend on the information available for recognizing the issue.

3.5.1 Glaciated Areas Other than Antarctica and Greenland

A land/glacier/ocean mask `lgo_mask` identifying glaciated areas was developed using glacier outlines of the Randolf Glacier Inventory (RGI). For these regions, unmasked offsets over land pixels are evaluated, and one of several strategies is applied:

- If XXXX grid points over land with `corr` and `del_corr` values above the masking threshold exist, then a bilinear spline is fit to the x and y offsets of the land grid points. The spline correction is then applied to all x and y offsets over the image, minimizing the reported offsets over the land, and in most cases, improving the ice velocity measurements by removing the impact artificial offsets due to geolocation errors.
- If less than YYYY, output grid points meet the `corr` and `del_corr` criteria, constants for both x and y offsets are used.

- If less than 500 grid points are available, no offset correction is applied. The type of offset correction applied is recorded as `del_i`, `del_j` in the NetCDF files.

Where:

`xxxx` = if at least 1000 grid points over land

`yyyy` = If less than 1000 grid points over land

3.5.2 Antarctica

For Antarctica, where there is very little land to constrain the geolocation offsets between image pairs, the determined offsets are compared with the slow-moving regions in an ice sheet velocity mosaic. The logic in doing this is that ice flowing slower than 40 m/yr is not likely to change, while flow variability in outlet glaciers may be larger. Details of this type of correction are discussed in Fahnestock et al. (2015). Several strategies are applied to Antarctic pairs, depending on the amount and character of the slow moving ice in areas that had unmasked offset determinations:

- If there were less than 500 valid output grid points over ice slower than 40 m/yr, no offset correction was applied.
- If more than 2000 unmasked grid points over ice are slower than 40 m/yr, then constant x and y offsets are calculated and applied to the x and y offsets measured over the whole scene.
- If the majority of slow moving ice grid points are over ice slower than 20 m/yr, and the above correction could not be applied, then ice is taken to be stationary and constant x and y offsets were calculated over these areas and applied to the x and y offset fields for the whole image.

3.5.3 Greenland

Greenland presents a hybrid of the previous two situations. Here we have significant non-ice-covered land around the ice sheet margins, and also large areas in the interior for which a landsat scene would have no land pixels for reference. In response to this hybrid condition, a correction scheme similar to the Antarctic cases is carried out, but the idea of treating land pixels as zero velocity points along with the areas of slow moving ice is included. Here, a bilinear fit is applied to `vx` and `vy` components of the offset. If less than 1000 grid points over land valid pixels are available, a constant offset is calculated and used, or, in the case of less than 500 points being available, no correction is applied.

3.6 Data Quality

NetCDF files contain variables which describe data quality. The correlation strength `corr` and difference between the highest and second highest correlation value `del_corr` describe the confidence and accuracy of vector displacement, respectively. `corr` > 0.3 and `del_corr` > 0.15 indicate both high confidence and high accuracy. These thresholds were used in creating masks for scalar flow speed `vv` and velocity components `vx` and `vy`. The masked variables are denoted as `vv_masked`, `vx_masked`, and `vy_masked`. Although the masked files contain significantly less noise than the unmasked fields, users should be aware that the masked fields may still contain pixels that are visibly incorrect. More importantly, there are values in the unmasked data that did not pass the masking threshold. Both masked and unmasked fields as well as the `corr` and `del_corr` fields are provided for users to investigate threshold values appropriate for their study area.

3.7 Assessing Quality in the Data

The following browse images show the scalar ice flow speed `vv` for a GoLIVE image tile in southeastern Greenland (path 233, row 016; 62º 51'N, 42º 26'W). The images are oriented with North directed upwards, such that the interior of the Greenland Ice Sheet is to the left (west), and the Atlantic Ocean to is the right (east). Warm colors indicate faster ice speeds, flowing from west to east, and deep blue colors represent stationary or near-stationary features. The images show both high quality velocity retrievals and issues presented by cloud cover and/or uncorrected offset errors to aid in assessing data quality. The georeferenced imagery (`.tif` file sharing the same name as the data file in `.nc` format) shows the speed of ice flow to emphasize variations at low speeds.

Figure 8 is a scene with little residual offset error over land on the right side of the image. On the left-hand side of the image is the ice sheet interior, where ice speeds are slow. Higher speeds are seen in the glacial troughs. There are a few data gaps on the left due to cloud cover in one of the images used for velocity determination.

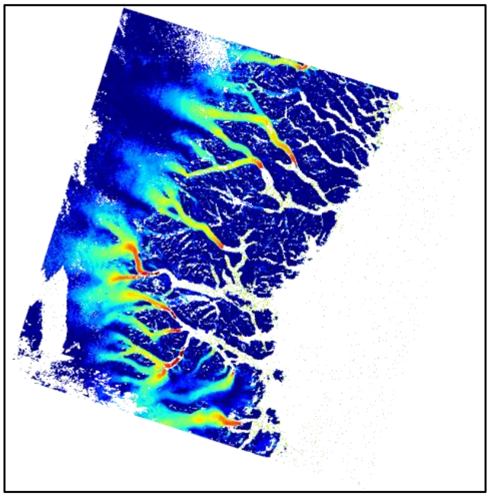

Figure 8. High Accuracy, High Confidence Scalar Ice Flow Speed

In Figure 9, both the left and right sides of the image are impacted by clouds, resulting in random pixels with reported speeds that did not get masked at the applied correlation thresholds. The fact that the land between the glaciers in the center of the image is shown to be uniformly stationary means that the offset correction was still successful, and that the ice speeds in this center section will still be accurate.

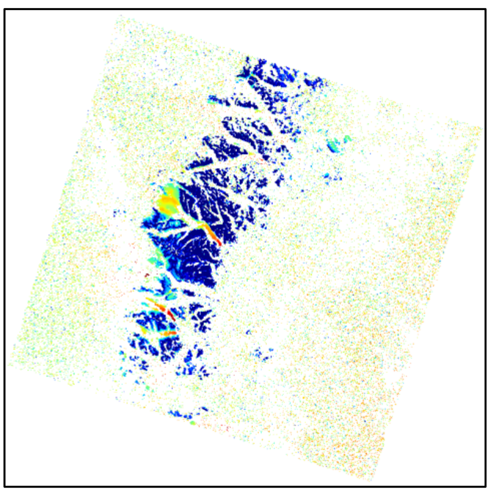

Figure 9. Clouds Impacting the Image correlation in Both the West and East

In Figure 10, there are a set of problems with the offset correction. Only a small ribbon of zero motion, oriented north-south, exists across the exposed land, becoming non-zero to the left (west) where the land between the glaciers is shown to be moving. Further west, the interior of the ice sheet is shown at higher speed than is reasonable. Automated recognition of issues presented here are slated for future versions of the data product, but the user is cautioned to access the suitability of some scenes for their application. These types of errors are generally due to misregistration of the original Landsat panchromatic scenes. The geolocation error here is large compared to the flow speed. This problem is common in scenes separated by 16 days.

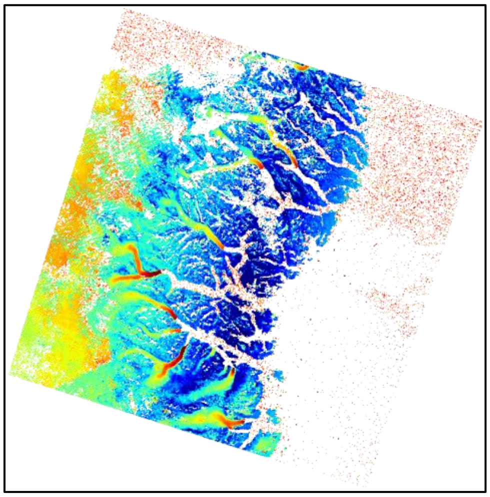

Figure 10. Uncorrected Offsets that Impact Most of the GoLIVE Scene

Figure 11 shows a temporary issue for the first data release. In July of 2016 the USGS switched to a more accurate elevation model for terrain correction in Greenland and Svalbard. Some data granules scenes corrected before this switch and afterward, resulting in an apparent line of discontinuity. The issue will not be present when collected updated imagery from these regions, which should happen during the first quarter of 2017. Aside from the north-south oriented line of discontinuity, topographic features are also manifest as changes in flow speed– higher elevations are offset differently than lower elevations.

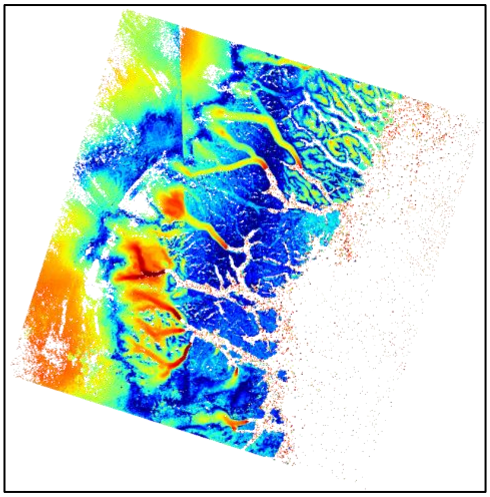

Figure 11. Temporary Issues Caused by an Update to the USGS Elevation Model that Occurred between the Dates that the Images were Captured

Thus, this large data set includes scenes with significant cloud cover and undetected offset errors. Because the data were developed from images taken under changing snow and cloud cover and lighting conditions, the data may include areas where motion is mapped that is not actually moving. Thus, you are asked to apply your best judgement when using these data, and to use the provided browse images to identify such issues.

3.8 Sensor or Instrument Description

The platform and sensor used for this data set is listed below.

Platform: Landsat 8

Sensor: Operation Land Imager (OLI)

4 REFERENCES AND RELATED PUBLICATIONS

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Scambos, T.A., Haran, T.M., Fahnestock, M.A., Painter, T.H., & Bohlander, J. (2007). MODIS-based Mosaic of Antarctica (MOA) data sets: continent-wide surface morphology and snow grain size. Remote Sensing of Environment, 111(2), 242-257. http://dx.doi.org/10.1016/j.rse.2006.12.020

4.1 Related Data Collections

Antarctic Ice Velocity Data

MEaSUREs InSAR-Based Antarctica Ice Velocity Map

MEaSUREs Greenland Ice Velocity: Selected Glacier Site Velocity Maps from InSAR

MEaSUREs InSAR-Based Ice Velocity Maps of Central Antarctica: 1997 and 2009

MEaSUREs InSAR-Based Ice Velocity of the Amundsen Sea Embayment, Antarctica

MEaSURES Greenland Ice Velocity: Selected Glacier Site Velocity Maps from Optical Images

MEaSUREs Multi-year Greenland Ice Sheet Velocity Mosaic

MEaSUREs Greenland Ice Sheet Velocity Map from InSAR Data

4.2 Related Websites

USGS EarthExplorer

USGS Landsat 8

Landsat 8 Path/Row Grid

WRS-2 Path/Row to Latitude/Longitude Converter

Randolf Glacier Inventory

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6 DOCUMENT INFORMATION

6.1 Publication Date

November 2016

6.2 Date Last Updated

April 2024