Largest Glaciers and Glacier Complexes in the World, Version 1

USER GUIDE

How to Cite These Data

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

Windnagel, A., and M. Zemp. 2022. *Largest Glaciers and Glacier Complexes in the World, Version 1*. [Indicate subset used]. Boulder, Colorado USA. NSIDC: National Snow and Ice Data Center. https://doi.org/10.7265/0k6h-yn09. [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 provides a list of the three largest glaciers and glacier complexes in each of the 19 glacial regions of the world as defined by the Global Terrestrial Network for Glaciers (GTN-G, 2017). The data are provided in shapefile format with an outline for each of the largest ice bodies along with a number of attributes such as area in km^2. A brief summary of the results can be found in Windnagel and Zemp (2022).

1.2 Background

Glacier monitoring is not a new discipline, however, the answer to the question of which glaciers are the largest in the world has not been rigorously addressed. This data set strives to respond that question through a systematic assessment of the largest glaciers in the 19 primary glacier regions of the world. The first step in that process is to define *glacier* and *glacier complex* plus several other ice terms. The definitions used for this study are from the Glossary of Glacier Mass Balance and Related Terms (Cogley et al., 2011). These definitions are the following (additions with relation to this data set are added in [*brackets*]):

- **Glacier**: A perennial mass of ice, and possibly firn and snow, originating on the land surface by the recrystallization of snow or other forms of solid precipitation and showing evidence of past or present flow. [*compressed snow accumulated over time*]
- **Ice Cap**: A dome-shaped ice body with radial flow, largely obscuring the subsurface topography and generally defined as covering less than 50,000 km^2. That is, it is smaller than an ice sheet.
- **Icefield**: A large ice body that covers mountainous terrain but is not thick enough to obscure all the subsurface topography, its flow therefore not being predominantly radial as is that of an ice cap.
- **Glacier complex**: A number of contiguous glaciers; a generic term for all collections of glaciers that meet at divides [*e.g., icefields or ice caps. Note that both ice caps and icefields typically have outlet glaciers that drain ice from sectors of the accumulation area in individual glacier tongues reaching out into the lowlands*].
- **Ice sheet**: An ice body that covers an area of continental size, generally defined as covering 50,000 km^2 or more.
- **Ice body**: Any continuous mass of ice, possibly including snow and firn, at or beneath the Earth's surface.

While the GTN-G divides the world into 19 primary glacier regions, for this analysis, Region 19 (Antarctic and Subantarctic) was subdivided into two subregions: the Antarctic mainland (subregion 19-31 in GTN-G, 2017) and the Antarctic and Subantarctic islands (subregions 19-01 to 19-24 in GTN-G, 2017). This subdivision was done because the Antarctic ice sheet and the Antarctic and

Subantarctic islands are distinctly different from one another and thus a need to explore both was identified. Note that the Greenland and Antarctic ice sheets are excluded from this analysis, however, glaciers with a connectivity of 0 or 1 (Rastner et al., 2012) in the Greenland periphery and the Antarctic Peninsula are included. See Table 1 for a definition of connectivity level.

Table 1. Connectivity Level Description from Rastner et al. (2012)

Value	Connectivity Description
0	Indicates that the glacier is physically detached from the ice sheet and is not connected.
1	Indicates that the glacier is weakly connected to the ice sheet. This means that the glacier is only in contact with the ice sheet at a well-defined divide in the accumulation zone.
2	Indicates that the glacier is strongly connected. This means that the divide between the glacier and the ice sheet is indistinct in the accumulation zone and/or confluent with an ice-sheet outlet in the ablation zone.

1.3 Parameters

The parameter of this data set is glacier and glacier complex area in km^2.

1.4 File Information

1.4.1 Format

The data are presented in 40 shapefiles, one for each of the 20 regions (Antarctica is split into two subregions) with one for each of the ice types (glaciers or glacier complexes). Each glacier complex shapefile is accompanied by three ancillary text files, one for each of the three largest complexes. These provide the glacier ids that make up each of the complexes. The exception is the Antarctic Mainland shapefile which is only accompanied by one ancillary text file because that region has only one glacier complex. Two comma-separated-value (CSV) files contain compiled lists of the largest glaciers and complexes.

1.4.2 File Contents

Shapefiles

Each shapefile contains three outlines for the three largest glaciers or complexes in that region, except for the Antarctic Mainland Glacier Complex file which contains only one because there is only one largest complex in that region. The attributes contained in each shapefile are described in Table 2. Figure 1 shows an example shapefile and its attribute table.

	region_no	reg_name	glac_name	glims_id	rgi_id	area_km2	area_src	date	cenlat	cenlon
1	1	Alaska	Malaspina-Sew...	G219787E60289N	RGI60-01.13696	3362.657999999...	A	2010-09-12	60.17657214616...	-140.428030341...
2	1	Alaska	Bering Glacier	G217991E60521N	RGI60-01.13635	3025.112500000...	A	2010-09-10	60.46068023260...	-142.071557004...
3	1	Alaska	Hubbard Glacier	G220740E60158N	RGI60-01.14443	2834.491500000...	A	2010-09-14	60.42709090040...	-139.500508629...

Figure 1. Example shapefile and attribute table for the largest glaciers in Region 1 (Alaska) using QGIS.

Table 2. Shapefile Attribute Description

Attribute	Description
region_no	Region number with values from 1 through 19. See Table 5 for a list of the regions.
reg_name	Region name
glac_name	Glacier name (only applicable to the glacier shapefiles)
ic_name	Glacier complex name (only applicable to the glacier complex shapefiles)
glims_id	The GLIMS glacier id associated with the glacier, if there is no GLIMS ID then this is set to N/A (only applicable to the glacier shapefiles). Note that for the complex shapefiles, the glacier ids are provided in separate text files due to the large number of ids.
rgi_id	The RGI glacier id associated with the glacier, if there is no RGI ID then this is set to N/A (only applicable to the glacier shapefiles). Note that for the complex shapefiles, the glacier ids are provided in separate text files due to the large number of ids.
area_km2	The area of the polygon outline in km^2
area_src	The source of the area measurement (only applicable to the glacier shapefiles). **A**: Indicates that the area came from an average of the GLIMS and RGI databases **G**: Indicates that this area came from the GLIMS database alone **R**: Indicates that this area came from the RGI database alone **Note:** For the glacier complex shapefiles, the area source can be found in the filename of the associated glacier id text file. If *glims* is in the filename, the source is GLIMS; if *rgi* is in the filename, then the source is RGI.
date	The date of the outline (only applicable to the glacier shapefiles)
min_date	The earliest date of the outlines included in the glacier complex outline (only applicable to the glacier complex shapefiles)

Attribute	Description
max_date	The latest date of the outlines included in the glacier complex outline (only applicable to the glacier complex shapefiles)
cenlat	The latitude of the center point of the polygon outline.
cenlon	The longitude of the center point of the polygon outline.

Ancillary Text Files

The ancillary text files that accompany the glacier complex shapefiles simply contain a comma separated list of all the glacier ids that were used to create a glacier complex. These files do not exist for the glacier shapefiles because the glacier id is an attribute of those shapefiles since it is only one id. Figure 2 shows an example of the contents of an ancillary text file.

```
G042506E43356N, G042488E43308N, G042464E43376N, G042541E43338N,
G042398E43341N, G042386E43332N, G042449E43302N, G042487E43376N,
G042406E43319N, G042398E43333N, G042399E43373N, G042501E43334N,
G042481E43388N, G042410E43308N, G042453E43381N, G042460E43301N,
G042405E43314N, G042405E43364N, G042470E43302N, G042432E43372N,
G042388E43332N, G042404E43354N, G042410E43340N, G042429E43293N,
G042390E43332N, G042543E43332N, G042408E43321N, G042388E43334N,
G042470E43381N, G042388E43356N, G042499E43320N, G042405E43311N,
G042535E43341N, G042470E43307N
```

Figure 2. Comma separated list of the glacier ids for the 2nd largest glacier complex in Region 12 (region-12-2nd-largest-glims-ids.txt)

CSV Files

The two CSV files (one for glaciers and one for glacier complexes) provide a summary of the data in the shapefiles. The first row of each file is a header row with the names of each column that are the same as the attributes in the shapefiles (Table 2).

1.4.3 Directory Structure

All files reside in the this HTTPS folder: https://noaadata.apps.nsidc.org/NOAA/G10037/.

1.4.4 Naming Convention

Shapefiles

The shapefiles are named according to the following convention and as described in Table 3.

```
region-XX-largest-icetype.ext
```

Table 3. Shapefile Naming Convention

Variable	Description
region-xx	Identifies the region number where xx is a 1- or 2-digit number from 1 to 19. See Table 5 for a list of the regions and their names and Figure 3 for a map.
icetype	Identifies the largest ice formation represented in the data file: glaciers = glaciers complexes = glacier complexes
largest	Indicates that this contains that largest outlines for the region
.ext	The file extension of the data file. .zip: zipfile containing the shapefile and its ancillary files .shp: shapefile .cpg, .dbf, .prj, and .shx: ancillary data files associated with the shapefile

Ancillary Text Files

The ancillary ASCII text files are named according to the following convention and as described in Table 4

`region-xx-rank-largest-src.txt`

Table 4. ASCII Text File Naming Convention

Variable	Description
region-xx	Identifies the region number where xx is a 1- or 2-digit number from 1 to 19. See Table 5 for a list of the regions and their names and Figure 3 for a map.
rank	Indicates the ranking of the glacier that this file belongs to. 1st: These ids belong to the first largest glacier in the region indicated by region_xx 2nd: These ids belong to the second largest glacier in the region indicated by region_xx 3rd: These ids belong to the third largest glacier in the region indicated by region_xx
largest	Indicates that this contains ids for the largest outlines for the region
src	Indicates the source of the outlines glims-id: GLIMS rgi-id: RGI
.txt	Indicates that this is an ASCII text file

CSV Files

The two CSV files are named `compiled-glacier-sizes.csv` and `compiled-complex-sizes.csv` and contain the complete list of the three largest glaciers and glacier complexes, respectively.

1.5 Spatial Information

1.5.1 Coverage

The coverage of this data set is global. The data have been divided into 19 glacial regions (GTN-G, 2017). Figure 3 shows the outline of each of these 19 regions and lists the names and coordinates of each by region number.

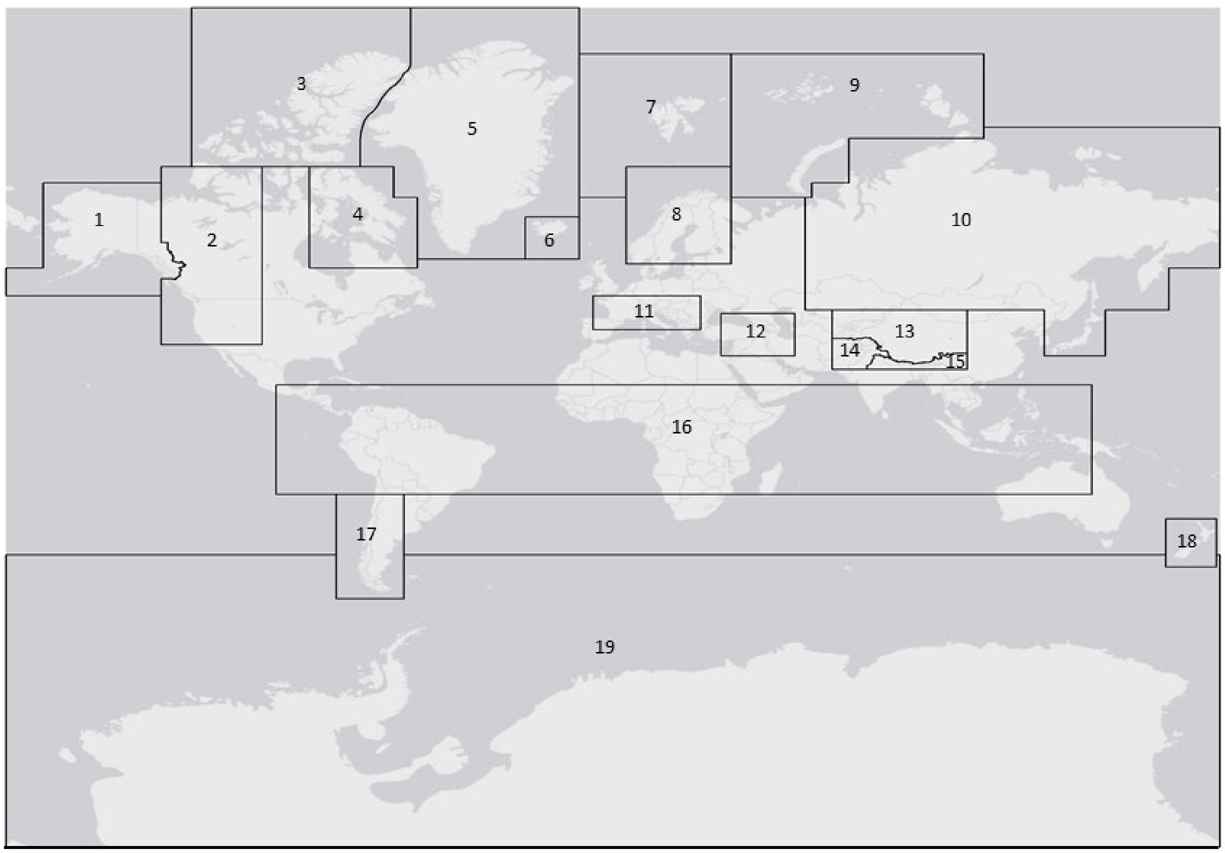

Figure 3. World map with the 19 GTN-G glacier regions outlined.

Table 5. List of the GTN-G region numbers, names, and coordinates. Note: These are bounding coordinates only and not the actual coordinates of each region since not all regions are rectangular.

Region No.	Region Name	Bounding Box Coordinates	Region No.	Region Name	Bounding Box Coordinates
1	Alaska	N Latitude: 72° N S Latitude: 50° N E Longitude: 127° W W Longitude: 180° W	11	Central Europe	N Latitude: 50° N S Latitude: 40° N E Longitude: 26° E W Longitude: 6° W
2	Western Canada and USA	N Latitude: 74° N S Latitude: 35° N E Longitude: 104° W W Longitude: 134° W	12	Caucasus and Middle East	N Latitude: 45° N S Latitude: 31° N E Longitude: 54° E W Longitude: 32° W
3	Arctic Canada, North	N Latitude: 85° N S Latitude: 74° N E Longitude: 60° W W Longitude: 125° W	13	Asia, Central	N Latitude: 46° N S Latitude: 28° N E Longitude: 105° E W Longitude: 65° W
4	Arctic Canada, South	N Latitude: 74° N S Latitude: 57° N E Longitude: 58° W W Longitude: 90° W	14	Asia, South West	N Latitude: 37.5° N S Latitude: 26° N E Longitude: 82.5° E W Longitude: 65° W
5	Greenland Periphery	N Latitude: 85° N S Latitude: 59° N E Longitude: 10° W W Longitude: 75° W	15	Asia, South East	N Latitude: 32° N S Latitude: 26° N E Longitude: 105° E W Longitude: 75.4° W
6	Iceland	N Latitude: 67° N S Latitude: 59° N E Longitude: 10° W W Longitude: 26° W	16	Low Latitudes	N Latitude: 20° N S Latitude: 25° S E Longitude: 142° E W Longitude: 100° W
7	Svalbard and Jan Mayen	N Latitude: 83° N S Latitude: 70° N E Longitude: 35° E W Longitude: 10° W	17	Southern Andes	N Latitude: 25° S S Latitude: 57° S E Longitude: 62° W W Longitude: 82° W
8	Scandinavia	N Latitude: 74° N S Latitude: 58° N E Longitude: 35° E W Longitude: 4° E	18	New Zealand	N Latitude: 34° S S Latitude: 49° S E Longitude: 179° E W Longitude: 164° E
9	Russian Arctic	N Latitude: 83° N S Latitude: 70° N E Longitude: 110° E W Longitude:35° E	19	Antarctic and Subantarctic	N Latitude: 45° S S Latitude: 90° S E Longitude: 180° E W Longitude: 180° W
10	Asia, North	N Latitude: 78° N S Latitude: 31° N E Longitude: 180° E W Longitude:57° E			

1.5.2 Resolution

These data are in a vector format, so resolution does not apply.

1.5.3 Geolocation

The coordinate reference system of the shapefiles is EPSG 4326 (WGS 84).

1.6 Temporal Coverage and Resolution

The dates of the glacier outlines range from 1972 to 2014 and the dates of the glacier complex outlines range from 1956 to 2015. Each glacier outline is single point in time and each glacier complex outline is comprised of many glacier outlines that cover a range of dates.

2 DATA ACQUISITION AND PROCESSING

2.1 Acquisition

The two databases used in the analysis to create this data set were the GLIMS Version 20190304 database (GLIMS Consortium, 2005) accessed from https://doi.org/10.7265/N5V98602 and the RGI Version 6.0 database (RGI Consortium, 2017) accessed from https://doi.org/10.7265/N5-RGI-60.

2.2 Processing

Below is a brief description of the steps taken to determine the largest glaciers and glacier complexes. The major goal for this processing was to create a code base that allowed for automatic, reproducible analysis. Thus, the code can be rerun when newer versions of the input data become available. Some manual analysis was unavoidable, however, as noted in the steps below. Further details can be found in Windnagel (2022) and Windnagel et al. (2022). Note that Region 19 (Antarctic and Subantarctic) was divided into two subregions and the Greenland and Antarctic ice sheets are excluded from this analysis, however, the Greenland periphery and the Antarctic Peninsula are included. See section 1.2 Background for details. They python code used for this analysis can be found on GitHub: https://github.com/windnage/wgms-glacier-project.

Glacier Selection Steps

1. Queried both the GLIMS and RGI databases for all 20 regions and extracted lists of the 10 largest glaciers based on the glacier area attribute.
2. Reviewed the area results and filtered down to the three largest for each region from both databases.

3. Compared the results between the two. In cases where a glacier's size differed between GLIMS and RGI, compared the dates of the measurements and chose the one with the more recent date. If the measurement dates matched (same year), the areas were averaged. **Note**: In several instances, the three largest did not match between the two databases. In these cases, again, the date of the outline was checked and the one with the more recent outline was chosen. For example, in Region 17 (Southern Andes), the three largest from GLIMS were Pio XI Glacier, Upsala Glacier, and O'Higgins Glacier; and the three largest from RGI were Pio XI Glacier, Viedma Glacier, and Upsala Glacier, with O'Higgins ranking 5th largest. However, the dates for the RGI outlines for Viedma and O'Higgins are from the year 2000. The date of the outlines from GLIMS are from 2007, so those outlines were chosen as the three largest.
4. Saved the three largest glacier outlines to a shapefile with specific attributes that describe the outline. See Table 2.

Glacier Complex Selection Steps

Note that the GLIMS databases alone was used for the glacier complex analysis except for the Greenland Periphery (Region 5) and the Antarctic and Subantarctic Islands (Region 19I) where RGI had to be used. For the Greenland Periphery, RGI was used because it contains glacier/ice sheet connectivity information (Table 1) and GLIMS does not. For the Antarctic and Subantarctic Islands, RGI was used because it does not contain any of the Antarctic Mainland glaciers so this made it easily adaptable for selecting only the island glaciers. Below are the steps for determining the glacier complexes.

1. Identified the glacier complex outlines by dissolving (merging) individual glacier outlines that share common boundaries with one or more neighboring glaciers at their common ice divides. This created a glacier complex polygon outline.
2. Computed the area of each glacier complex polygon outline using a Python planar area function in an equal-area projection.
3. Reviewed the area results and obtained the three largest complexes for each region.
4. Saved the three largest glacier complex outlines to a shapefile with certain attributes that describe the outline (Table 2).
5. Wrote all the glacier ids that comprised a glacier complex to a text file.

2.3 Quality, Errors, and Limitations

See Windnagel (2022) and Windnagel et al. (2022) for a discussion of quality, errors, and limitations.

3 VERSION HISTORY

Table 6. Version History Summary

Version	Release Date	Description of Changes
1	May 2022	Initial release

4 RELATED DATA SETS

- GLIMS Glacier Database
- Randolph Glacier Inventory - A Dataset of Global Glacier Outlines, Version 6
- GTN-G Glacier Regions
- Glacier Photograph Collection

5 RELATED WEBSITES

- GTN-G Fluctuations of Glaciers (FoG) Database

6 CONTACTS AND ACKNOWLEDGMENTS

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8 DOCUMENT INFORMATION

8.1 Author

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8.2 Publication Date

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8.3 Revision History

No revisions