The Randolph Glacier Inventory version 7

RGI Consortium

Sep 20, 2023

CONTENTS

The Randolph Glacier Inventory (RGI) is a global inventory of glacier outlines including a set of attributes and other relevant auxiliary information. This user guide provides detailed documentation of the RGI version 7.0 but also includes general information on the RGI and its earlier versions.

Data download

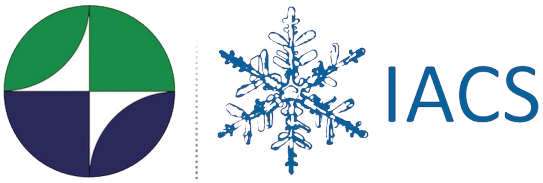
Download the RGI 7.0 files from NSIDC: https://doi.org/10.5067/f6jmovy5navz Cite the RGI: *Dataset reference* Download previous RGI versions: https://www.glims.org/RGI

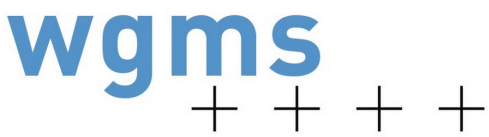
Known issues in RGI 7.0

Currently known issues with the RGI 7.0 dataset are listed here.

Contents

Acknowledgments





RGI version 7.0 was developed by the "Working Group on the Randolph Glacier Inventory (RGI) and its role in future glacier monitoring" of the International Association of Cryospheric Sciences (IACS).

Financial support was provided by several organizations and institutions, in particular IACS, the NASA National Snow and Ice Data Center - Distributed Active Archive Center (NSIDC-DAAC), the World Glacier Monitoring Service (WGMS), the Copernicus Climate Changes Service (C3S), the European Space Agency (ESA) and UNESCO. For a full list of sponsors and acknowledgements, visit *Appendix 3: Acknowledgements*.

RGI 7.0 and this user guide are dedicated to the memory of **Dr. Graham Cogley** (1948-2018), an inspiring

and deeply committed leader and contributor to the RGI, who was instrumental in initiating, developing, generating and curating the RGI from its inception over nearly a decade, demonstrating the value of open data long before these concepts came into widespread popularity, and who embodied the spirit of selfless service to the glaciological community. Graham's spirit of collaboration, meticulous attention to detail, and actioning of the original vision of a global-scale dataset lives on in the RGI 7.0.

License

Part of the text in this user guide regarding the RGI in general and RGI versions prior to v7.0 is based on the RGI v6 Technical Note: *"Randolph Glacier Inventory – A Dataset of Global Glacier Outlines: Version 6.0" by the RGI Consortium, July 2017.*

CHAPTER

ONE

INTRODUCTION

1.1 What is the RGI?

The Randolph Glacier Inventory (RGI) is a globally complete inventory of glacier outlines (excluding the ice sheets in Greenland and Antarctica). It is a subset of the database compiled by the Global Land Ice Measurements from Space (GLIMS) initiative. While GLIMS is a multi-temporal database with an extensive set of attributes, the RGI is intended to be a snapshot of the world's glaciers at a specific target date, which in RGI 7.0 and all previous versions has been set as close as possible to the year 2000 (although in fact its range of dates can still be substantial in some regions). The RGI includes outlines of all glaciers larger than 0.01 km^2, which is the recommended minimum of the World Glacier Inventory.

The RGI was not designed for the measurement of glacier-by-glacier rates of area change, for which the greatest possible accuracy in dating, delineation and georeferencing is essential. While many RGI outlines meet these requirements, the primary focus of the RGI is on achieving global coverage, consistency, and proximity in a specific year. The strength of the RGI lies in its ability to handle large numbers of glaciers simultaneously. This allows, for example, for the estimation of glacier volumes and rates of elevation change at regional and global scales, as well as the simulation of cryospheric responses to climatic forcing.

1.2 Who develops and hosts the RGI?

The RGI has been developed in an international community-driven effort of glaciologists starting in 2010. The inventory was named after "Randolph", a town in New Hampshire, USA, where the team met for one of their meetings [Pfeffer *et al.*, 2014]. In 2014 development of the RGI became the responsibility of the Working Group on the Randolph Glacier Inventory and Infrastructure for Glacier Monitoring, which operated under the International Association of Cryospheric Sciences (IACS). In 2019, a new Working Group was established to build upon the previous achievements and further expand its objectives: the IACS Working Group on the Randolph Glacier Inventory (RGI) and its role in future glacier monitoring and GLIMS.

The RGI datasets are listed on glims.org, and the RGI files can be downloaded through the data portal at the National Snow and Ice Data Center (NSIDC), which is the host for GLIMS.

1.3 Data distribution policy

The RGI may be used freely under the Creative Commons Attribution 4.0 International License with due acknowledgement (by proper referencing, see below). Where appropriate (for example for regional studies), users are invited to cite the analysts who provided the RGI outlines. See *Data description of RGI 7.0* for more details about how to retrieve this information from the RGI, and *Regional revisions in RGI 7.0* for a region-by-region data description.

1.4 Dataset reference

The RGI 7.0 dataset should be cited as:

RGI 7.0 Consortium, 2023. Randolph Glacier Inventory - A Dataset of Global Glacier Outlines, Version 7.0. Boulder, Colorado USA. NSIDC: National Snow and Ice Data Center. doi:10.5067/f6jmovy5navz. Online access: https://doi.org/10.5067/f6jmovy5navz

We request all users to use this reference in publications that use RGI 7.0 data. All names of the consortium are listed in the *RGI 7.0 Consortium*.

This user guide should be cited as:

Maussion, F., Hock, R., Paul, F., Raup, B., Rastner, P., Zemp, M, Andreassen, L., Barr, I., Bolch, T., Kochtitzky, W., McNabb, R. and Tielidze, L: The Randolph Glacier Inventory version 7.0 User guide v1.0, 2023. doi:10.5281/zenodo.8362857. Online access: https://doi.org/10.5281/zenodo.8362857.

This reference should be used when referring to specific details that are not covered elsewhere, for example: *"The aspect sector from glacier X is computed from a 100 m UTM grid (Maussion et al., 2023)."*

Peer-reviewed publication:

A detailed scientific description of the RGI version 7 is in preparation and expected to be published in 2024.

Earlier versions

The RGI 6.0 data set is referenced as: *RGI Consortium, 2017. Randolph Glacier Inventory - A Dataset of Global Glacier Outlines, Version 6. Boulder, Colorado USA. NSIDC: National Snow and Ice Data Center. doi: https://doi.org/10.7265/4m1f-gd79*.

Earlier versions of the user guide (then called Technical Report) are referenced as: "RGI Consortium (2017), Randolph Glacier Inventory – A Dataset of Global Glacier Outlines: Version 6.0. GLIMS Technical Report" and earlier versions as "Arendt et al." (various dates).

A detailed scientific description of the RGI version 3.2 is given by Pfeffer *et al.* [2014].

The **RGI logo** and its variants can be downloaded *here*.

1.5 How to name the RGI versions?

We recommend explicitly stating the version number when referring to a specific version rather than the RGI in general. We recommend the following formats:

- RGI version 7.0
- RGI 7.0 (note the empty space)
- RGI v7.0

1.6 Data sources

All outlines for RGI 7.0 are derived from the GLIMS database and comply with the GLIMS license agreement. Many new outlines used in RGI version 7.0 were submitted by the community to GLIMS in response to calls for data on the GLIMS and Cryolist e-mail listservers (2020-05-13). See *Appendix 2: Full list of contributors* for a list of RGI 7.0 contributors.

Since GLIMS was globally incomplete, earlier RGI versions combined outlines from GLIMS with outlines from other sources, the latter including outlines specifically generated for the purpose of the RGI. These outlines had not yet been submitted to GLIMS, did not meet GLIMS standards, or did not comply with the GLIMS license agreement. GLIMS achieved global coverage by incorporating the missing glacier outlines from RGI version 6.0 and a few other sources. Starting from RGI version 7.0, the workflow has been revised and optimized. The RGI is now entirely derived from the GLIMS database, which means that the RGI 7.0 glacier outlines are a subset of the GLIMS database as of its download date (for RGI 7.0 the cutoff date was May 24th, 2023). The RGI however extends the GLIMS outlines by providing additional products and attributes based on additional algorithms and data sources described in *Data description of RGI 7.0*.

1.7 RGI source code

All code used to generate RGI 7.0 is available on the GLIMS-RGI Github organization:

- GLIMS-RGI/rgi7_scripts: code and scripts generating the RGI out of GLIMS
- GLIMS-RGI/rgi_user_guide: this user guide.

1.8 Version history

Version 7.0, released in September 2023, comes with major outline quality improvements in nearly all RGI regions. In addition new products are available including, for example, outlines of glacier complexes and glacier centerlines. Furthermore, the RGI production has been entirely redesigned to use GLIMS as the sole source of data. The file generation process is now largely automated, extracting from GLIMS the outlines closest to the target date while also relying on expert judgment for the exact choice of available outlines. Open source scripts are used for all dataset creation steps. The file naming convention and attributes have changed substantially, requiring users of previous versions to adapt their data analysis workflow (see *General revisions in RGI 7.0* for more details).

Version 6.0, released in July 2017, has improved coverage of the conterminous US (regions 02-05 and 02-06), Scandinavia (region 08) and Iran (region 12-2). In Scandinavia several hundred smaller glaciers have been added and most glaciers now have exact dates. The flag attributes `RGIFlag` and `GlacType` were reorganized. Surging codes have been added from Sevestre and Benn (2015).

Version 5.0, released in July 2015, had new coverage of most of Asia (RGI regions 10, 13, 14 and 15), with some improved outlines elsewhere. Linkages to the Fluctuations of Glaciers database of the World Glacier Monitoring Service were provided for some glaciers with mass-balance measurements.

Version 4.0 was released in December 2014. The most significant enhancement was the addition of topographic and hypsometric attributes for nearly all glaciers. These new attributes are described in detail below. Many glacier outlines were unchanged in version 4.0, but many more glaciers were assigned dates or date ranges, some names were added or corrected, and the inventory of Alaska was new. Remaining glacier complexes in Bolivia were subdivided, and nominal glaciers were added to correct omissions in the Greater Caucasus. A global grid of glacierized area with 0.5-degree resolution was added.

Version 3.0 was an interim release representing the RGI as of 7 April 2013. It was the basis for the work of Gardner *et al.* [2013]. The main improvements included identification of all tidewater basins, and separation of glacier complexes into glaciers in nearly all regions. **Version 3.2**, released in August 2013, included additional separation of glacier complexes into glaciers, and repairs of some geometry errors. It is the basis for the scientific description and analysis of the RGI by Pfeffer *et al.* [2014].

Version 2.0 also added shapefiles for its first-order and second-order regions.

Version 1.0 of the RGI was released in February 2012. It included a considerable number of unsubdivided ice bodies, which we refer to as glacier complexes, and a considerable number of nominal glaciers, which are glaciers for which only a location and an area are known; they are represented by circles of the appropriate area at the given location. An unofficial update of version 1.0 was provided in April 2012 to replace several regions that had topology errors and repeated polygons. Version 2.0, released in June 2012, eliminated a number of flaws and provided a uniform set of attributes for each glacier. Several outlines were improved, and a number of outlines were added in previously omitted regions.

1.9 Future updates

For the RGI to maintain its fundamental role as reference dataset for the community and policy relevant efforts such as the IPCC, we anticipate future minor updates (e.g. v7.1) to represent changes only in the glacier attributes or data format, not in the outlines themselves (unless exceptional circumstances). Future updates to the RGI will be necessary, and will be the purpose of a subsequent working group to be announced on CRYOLIST at a later date.

1.10 The RGI 7.0 Consortium

CHAPTER

TWO

RGI GLACIER REGIONS

RGI outlines are organized into 20 first-order glacier regions. This is one more than in RGI 6.0 and earlier versions, since former region 19 was split into two regions (*global map*; *Table 1a*). These are further subdivided into second-order regions, of which there are 90 in total in RGI 7.0 (*Table 1b*). Glacier regions are useful for regional assessments of glacier change and other variables.

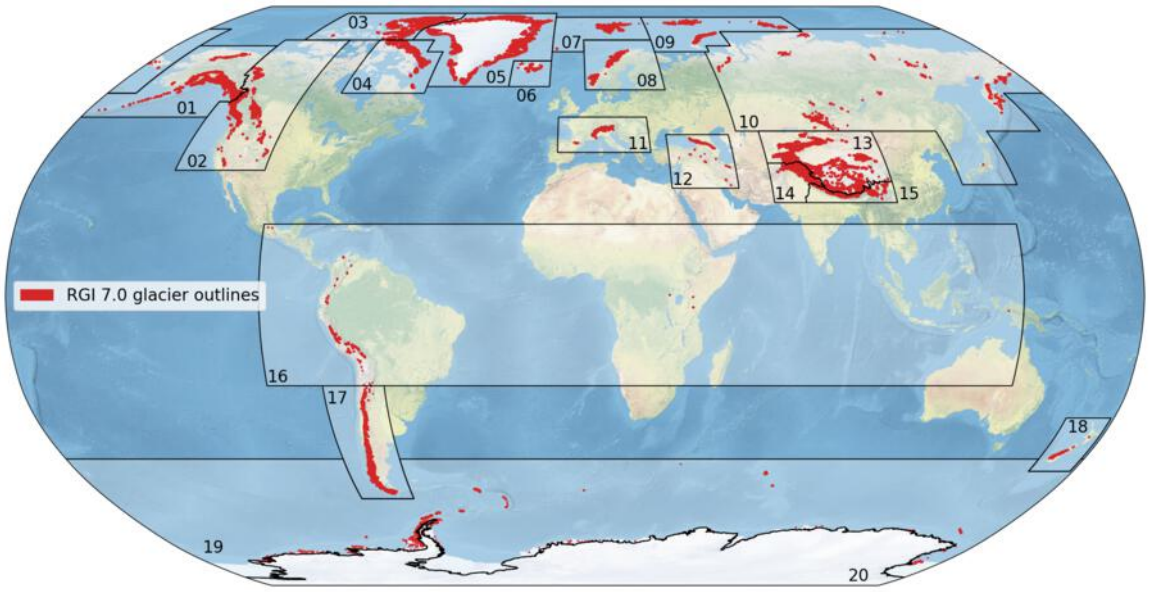


Fig. 2.1: First-order regions of the RGI version 7.0 and glacier locations in red.Download high resolution version.

Data download

Download the RGI 7.0 region files.

First-order regions `10`, `19` and `20` straddle the 180th meridian, and so do the second-order regions `19-15` and `20-01`. For convenience of analysis in a cylindrical-equidistant coordinate system centered on longitude 0°, as in *Figure 1*, the region outlines of `10` and `19-15` appear in the accompanying shapefiles as two polygons, eastern and western.

GTN-G regions

The region outlines have changed slightly between RGI versions, for example to avoid the splitting of glaciers between two regions, to make further analyses more convenient, or because previously not included glaciers were located outside existing region boundaries. For the sake of consistency between global glacier datasets a joint set of regions was recommended by the Global Terrestrial Network for Glaciers (GTN-G) Advisory Board, the Global Land Ice Measurements from Space

initiative (GLIMS), the RGI Working Group of the International Association of Cryospheric Sciences (IACS), and the World Glacier Monitoring Service (WGMS). These glacier regions were implemented first in RGI version 6.0 and are available on the GTN-G website. These region boundaries were slightly modified in RGI version 7.0 and changes also integrated in the GTN-G dataset [GTN-G, 2023].

2.1 Changes from RGI 6.0 to 7.0

Region boundary and name changes

- The region boxes for region `01` (Alaska) used to encompass some islands in the Bering Sea East of Kamtchatka. One of the two boxes, part of subregion `01-03` Alaska Peninsula (Aleutians), contains no glaciers (and probably hasn't for a long time) and is now removed.
- Subregion `05-11` (Greenland Ice Sheet) was removed since it was coarsely defined and the RGI does not include the ice sheet proper.
- The southern boundary of region `12` (Caucasus and Middle East) was shifted south by 2° (from 32°N to 30°N) to encompass a cluster of glaciers which were previously not included.
- Region `19` ("Antarctic and Subantarctic") was split into two first-order regions. Region `19` now solely includes the islands in the periphery of Antarctica, and was renamed to "Subantarctic and Antarctic Islands". A new region `20`, ("Antarctic Mainland") was added to encompass the remaining subregion ("Antarctic Ice Sheet", previously `19-31` and now `20-01`), but it presently contains no glaciers in the RGI (nor has the corresponding former subregion `19-31` in all previous RGI versions).
- Region names in the region shapefiles (and therefore of the associated RGI product files) were harmonized to reflect the most commonly used version in various documents and publications of the RGI. "Arctic Canada, North" and "Arctic Canada, South" have been renamed "Arctic Canada North" and "Arctic Canada South" (comma removed), respectively. The four regions in Asia ("North", "Central", "South West" and "South East") were renamed to "North Asia", "Central Asia", "South Asia West" and "South Asia East", respectively. With this change, none of the regions and subregions in RGI 7.0 have a comma in their name.

Technical changes

- The data type of the `rgi_code` attribute in the first-order region file is now `str` (instead of `int`). The `rgi_code` now has a leading zero, for example `02` instead of `2`.
- All abbreviations in the second-order regions file have been replaced by their full name (e.g. "East Central" instead of "EC")
- The first-order and second-order region files now have a field called `long_code` which contains a string representing the full region name, using the lowercase with underscores format (e.g. `02_western_canada_usa`). This field is used to name the corresponding RGI shapefiles.
- The `WGMS_CODE` column was deleted from all files.
- The `RGI_CODE` column is now called `o1region` (first order files) and `o2region` (second-order files).

Additional details: RGI regions version history

In **RGI 6.0**, the eastern boundaries of regions 13 (Central Asia) and 15 (South Asia East) were extended slightly to the east. A new second-order region 10-07 covering Japan was added to region 10 (North Asia). Region 08-01 (S Norway) was subdivided into regions 08-02 (SW Scandinavia) and 08-03 (SE Scandinavia), with former region 08-02 (N Scandinavia) assuming the code 08-01. Region 02-01 (Melville Island) was transferred to first-order region 03 (Arctic Canada North) as region 03-07, and the other second-order regions of region 02 (Western Canada and US) were renumbered as 02-01 to 02-05. These changes ensure the compatibility of the Glacier Regions dataset of the Global Terrestrial Network for Glaciers (GTN-G) with the RGI regions.

In **RGI 5.0**, the boundary between regions 01 (Alaska) and 02 (Western Canada and US) was refined, and in region 10 (North Asia) the former four second-order regions became six regions conforming with those described by Earl and Gardner (2016). In RGI 4.0, region 10-01, North Asia (North), was extended slightly to the west for better visibility of glaciers in the Polar Urals. Region 11-02, formerly the Pyrenees and Apennines, was enlarged and renamed Southern and Eastern Europe. First-order regions 10 (North Asia) and 11 (Central Europe) were enlarged accordingly.

CHAPTER

THREE

DATA DESCRIPTION OF RGI 7.0

The RGI is provided in shapefiles containing the outlines of glaciers and related data products in geographic coordinates (longitude and latitude, in degrees) which are referenced to the WGS84 datum. Data are organized by first-order region. For each region there is one zipped file containing the RGI shapefile (one file for all glaciers in the region) as well as ancillary files containing additional statistics or hypsometric data.

For each region, RGI 7.0 provides four distinct data products:

- *Glacier product*: includes outlines, attributes and auxiliary data for each individual glacier.
- *Glacier complex product* (new in RGI 7.0): includes outlines of all glacier complexes (defined as contiguous ice masses that encompass all glaciers that share common boundaries), and a reduced number of attributes.
- *Glacier intersects product* (new in RGI 7.0): shapefiles of the "divides" or "boundaries" between adjacent glaciers derived from the glacier product.
- *Glacier centerlines product* (new in RGI 7.0): glacier centerlines computed with a flow routing algorithm.

These four products and associated files are detailed in their corresponding section.

3.1 File naming convention

The name of each region's zipped file starts with `RGI` followed by three product descriptors:

- target year (so far all RGI versions refer to year 2000)
- RGI version number
- type of data product:
  - glacier (`G`)
  - glacier complex (`C`)
  - intersects (`I`)
  - centerlines (`L`)
- RGI region code (obtained from the *RGI region description table*), which consists of the region number and a standardized name

The various product descriptors are separated by hyphens (`-`). For example, `RGI2000-v7.0-G-03_arctic_canada_north.zip` refers to year 2000, RGI version 7.0, the glacier product and the region Arctic Canada North.

In addition to the shapefiles (following the same naming convention), each regional zip file comes with additional data files identified by the addition of descriptors in the filename. Examples:

- `RGI2000-v7.0-C-01_alaska-attributes.csv`

- `RGI2000-v7.0-G-19_subantarctic_antarctic_islands-rgi6_links.csv`

These additional descriptors are documented in each product's description page.

3.2 Entity identifiers

Each entity in each of the RGI 7.0 products (i.e. each glacier, glacier complex, centerline or intersect) is given a unique identifier. The identifiers follow the same convention as the product files, but add an additional unique number per entity to the name. For example:

- `RGI2000-v7.0-G-02-00003` is the third glacier in RGI region 02, for the glacier product of RGI 7.0 and the target year 2000.
- `RGI2000-v7.0-C-11-00005` is the fifth glacier complex in RGI region 11, for the glacier complex product of RGI 7.0 and the target year 2000.
- `RGI2000-v7.0-I-13-00005` is the fifth intersect in RGI region 13, for the glacier intersects product of RGI 7.0 and the target year 2000.

3.3 Detailed product description

- *Glacier product*
- *Glacier complex product*
- *Glacier intersects product*
- *Glacier centerlines product*

3.4 Gridded products

Unlike RGI 6.0, RGI 7.0 does not provide gridded data files. These files were useful only in rare circumstances, and lacked flexibility. It is however fairly straightforward to produce equivalent files using a few lines of code. See Li *et al.* [2021] for details and links to a python implementation.

3.5 Glacier product

This product includes the **glacier outlines** as extracted from GLIMS together with additional data for each individual glacier.

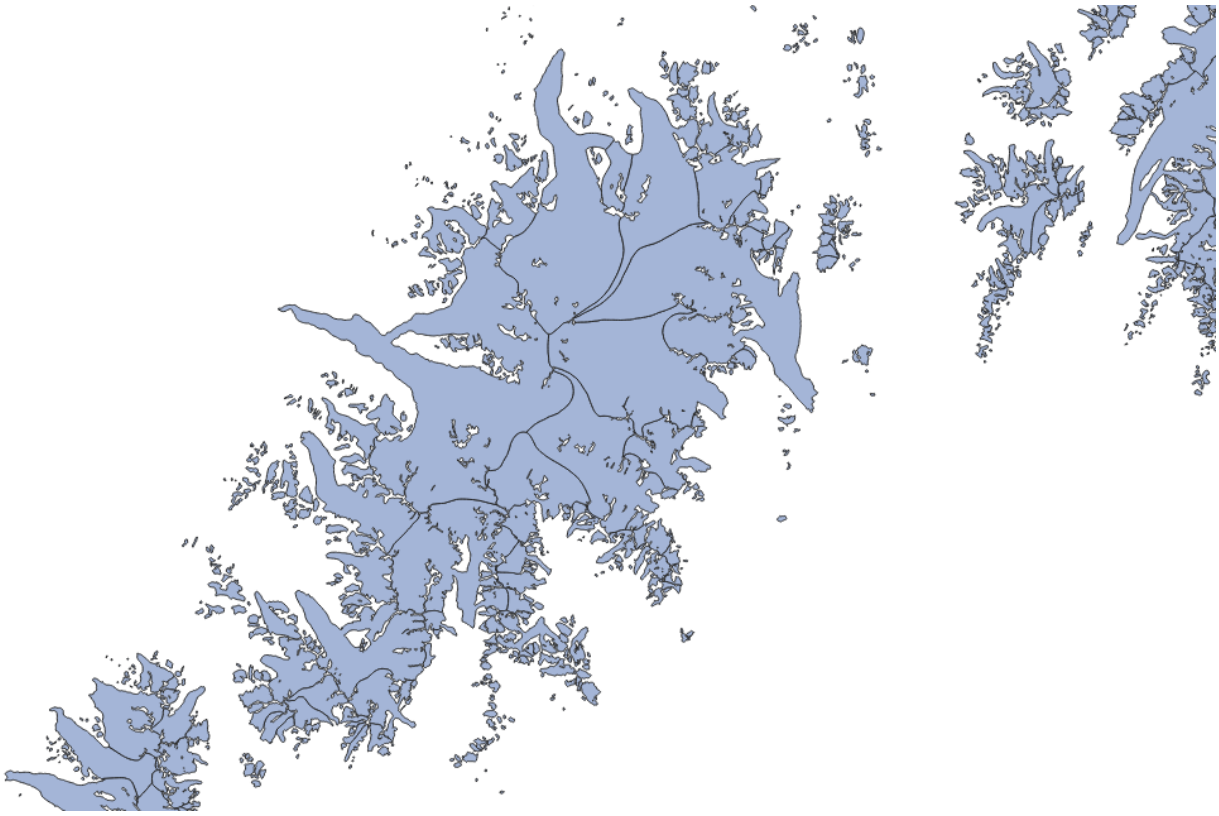


Fig. 3.1: Example of the glacier product (light blue), with outlines in black.

3.5.1 Product files

In the following, file contents are explained using RGI region 01 (Alaska) as example:

RGI2000-v7.0-G-01_alaska.shp RGI **glacier outlines** as a shapefile (with accompanying `.dbf`, `.prj`, `.cpg` and `.shx` files).

RGI2000-v7.0-G-01_alaska-attributes.csv Glacier **attributes** in a `.csv` file. The attributes are strictly the same as those encountered in the shapefile. This file allows users to read glacier attributes without reading the entire shapefile.

RGI2000-v7.0-G-01_alaska-attributes_metadata.json **Description of the attributes** in the glacier product shapefile: full name, description, units, etc. The content of this file is displayed in *Full list of attributes* below.

RGI2000-v7.0-G-01_alaska-submission_info.csv **Information about the data providers** ordered by submission identifier (`subm_id`). Each glacier outline can be attributed to a specific submission via their `subm_id` attribute.

RGI2000-v7.0-G-01_alaska-submission_info_metadata.json **Description of the columns** in the `submission_info.csv` file: full name, description, units, etc. The content of this file is displayed in *Submission info table* below.

RGI2000-v7.0-G-01_alaska-rgi6_links.csv A list of **overlapping outline pairs** between RGI 7.0 and RGI 6.0 describing 1:1, 1:n, n:1 or n:n relationships as well as the overlapping area between them. For example, a perfect match between an RGI 7.0 and RGI 6.0 outline results in a 1:1 relation with 100% area match in both. If a single RGI 6.0 outline was divided into two glaciers for RGI 7.0, a 2:1 relationship (a cluster) would result with two lines in the table with twice 50% area match in RGI 6.0 and twice 100% match in RGI 7.0. In more complex cases the matches are not always perfect and the relationships less straightforward, for example when an outline was remapped.

RGI2000-v7.0-G-01_alaska-hypsometry.csv **Hypsometry** for each glacier, preceded by copies of the glacier's `rgi_id` and `area_km2`. The hypsometry data are given as a comma-separated series of elevation-band areas in the form of integer thousandths of the glacier's total area in km^2 (`area_km2`). The sum of the elevation-band area values is constrained to be 1000. This means that an elevation band's value divided by 10 represents the elevation band's area as a percentage of total glacier area. For example, a value of 500 for a particular elevation bands means that it contains 50% of the total glacier area. The elevation bands are all 50 m in height and their central elevations are listed in the file header record. Within each hypsometry file the elevation bands extend from the lowest glacierized elevation up to the highest glacierized elevation band of the corresponding first-order region.

3.5.2 Full list of attributes

The following attributes are available in the RGI 7.0 shapefiles. For more details, see *Additional information on glacier attributes*.

rgi_id `long_name`: RGI identifier `description`: Unique identifier assigned to a single outline. `datatype`: str `units`: `source`: RGI `rgi6_name`: RGI_Id

o1region `long_name`: First order region `description`: The code of the first-order region to which the glacier belongs. `datatype`: str `units`: `source`: RGI `rgi6_name`: O1Region

o2region `long_name`: Second order region `description`: The code of the second-order region to which the glacier belongs. `datatype`: str `units`: `source`: RGI `rgi6_name`: O2Region

glims_id `long_name`: GLIMS identifier `description`: Non-unique identifier assigned to glaciers by the Global Land Ice Measurements from Space service at NSIDC. `datatype`: str `units`: `source`: GLIMS `rgi6_name`: GLIMS_Id

anlys_id long_name: Analysis identifier description: The unique identifier assigned within GLIMS for a particular outline of a glacier at a particular time. datatype: int units: source: GLIMS rgi6_name:

subm_id long_name: Submission identifier description: Unique identifier assigned by GLIMS to a specific data submission. Allows to obtain information about the analysts and data submitters. datatype: int units: source: GLIMS rgi6_name:

src_date long_name: Outline source date description: The as-of date for the outline (usually the acquisition date of the image), in the format ISO 8601. datatype: str units: date source: GLIMS rgi6_name: BgnDate

cenlon long_name: Center longitude description: Longitude of an approximately central point within the glacier outlines (not the centroid). datatype: float units: degrees source: RGI rgi6_name: CenLon

cenlat long_name: Center latitude description: Latitude of an approximately central point within the glacier outlines (not the centroid). datatype: float units: degrees source: RGI rgi6_name: CenLat

utm_zone long_name: UTM zone description: Number of the UTM zone for this glacier, based on its representative point. Note that this attribute is for information only, the geometries are all in WGS84. datatype: int units: source: RGI rgi6_name:

area_km2 long_name: Glacier area description: Area of the glacier. datatype: float units: km2 source: RGI rgi6_name: Area

primeclass long_name: Primary classification description: WGMS primary classification of the glacier. For a categories description, see user guide. datatype: int units: source: GLIMS rgi6_name:

conn_lvl long_name: Connectivity level description: Level of connection to the Greenland Icesheet (0: no connection; 1: weak connection). datatype: int units: source: GLIMS rgi6_name: Connect

surge_type long_name: Evidence for surging description: Flag indicating if surging behavior has been documented for this glacier. For a categories description, see user guide. datatype: int units: source: GLIMS rgi6_name: Surging

term_type long_name: Glacier terminus type description: Flag indicating the terminus type of the glacier. For a categories description, see user guide. datatype: int units: source: GLIMS rgi6_name: TermType

glac_name long_name: Glacier name description: Glacier name (when available). datatype: str units: source: GLIMS rgi6_name: Name

is_rgi6 long_name: Same as RGI 6.0 outline description: Flag indicating if the outline is the same as in RGI 6.0 (1) or was remapped (0). Note that it does not guarantee strict equivalence of the polygon (in most of the cases it does). datatype: int units: source: RGI rgi6_name:

termlon long_name: Terminus longitude description: Longitude of the lowest elevation point on the glacier outline. datatype: float units: degrees source: RGI rgi6_name:

termlat long_name: Terminus latitude description: Latitude of the lowest elevation point on the glacier outline. datatype: float units: degrees source: RGI rgi6_name:

zmin_m long_name: Minimum elevation description: Minimum elevation (m above sea level) of the glacier. datatype: float units: m source: RGI rgi6_name: Zmin

zmax_m long_name: Maximum elevation description: Maximum elevation (m above sea level) of the glacier. datatype: float units: m source: RGI rgi6_name: Zmax

zmed_m long_name: Median elevation description: Median elevation (m above sea level) of the glacier. datatype: float units: m source: RGI rgi6_name: Zmed

zmean_m long_name: Mean elevation description: Mean elevation (m above sea level) of the glacier. datatype: float units: m source: RGI rgi6_name:

slope_deg long_name: Mean slope description: Mean slope of the glacier surface. datatype: float units: degrees source: RGI rgi6_name: Slope

aspect_deg long_name: Aspect description: The aspect (orientation) of the glacier surface presented as an azimuth relative to 0° at due north. datatype: float units: degrees source: RGI rgi6_name: Aspect

aspect_sec long_name: Aspect sector description: The aspect (orientation) of the glacier surface presented as a category. For a categories description, see user guide. datatype: int units: source: RGI rgi6_name:

dem_source long_name: DEM data source description: The name of the dataset that was used to compute the topography attributes. datatype: str units: source: RGI rgi6_name:

lmax_m long_name: Maximum length description: Length (m) of the longest surface centerline of the glacier. datatype: int units: m source: RGI rgi6_name: Lmax

geometry long_name: Geometry description: Glacier geometry (Polygon) datatype: units: deg source: GLIMS rgi6_name: geometry

3.5.3 Additional information on glacier attributes

Glacier identifiers

One RGI outline in the glacier product corresponds to one glacier. Glaciers are identified with the following attributes:

rgi_id **Unique** identifier attributed by the RGI when constructing the files. These ids are generated automatically (in order of distance to the westernmost outline in a region) and follow the file naming convention described below. **These ids are different from RGI 6.0 and likely to change in future RGI versions**.

glims_id **Non-unique** identifier assigned to glaciers by the Global Land Ice Measurements from Space service at NSIDC. A single glims_id can have multiple outlines, for example at different dates or when a glacier disintegrates.

anlys_id **Unique** identifier assigned within GLIMS for a particular outline of a glacier at a particular time and for a particular submission. **These ids allow to unambiguously trace an outline back to the GLIMS database**, and will not change between future RGI versions if the outline does not change.

Topography attributes

The zmin_m, zmax_m, zmed_m, zmean_m attributes are computed from a Digital Elevation Model (DEM) reprojected onto a locally defined grid for each glacier. The gridded dataset used to compute these attributes (RGI-TOPO) is documented and available on the OGGM documentation.

Each glacier grid is defined in the locally valid UTM zone (utm_zone attribute) and with a grid spacing dx depending on the glacier size: $dx = 14\sqrt{A} + 10$, with dx the grid spacing in meters and A the glacier area in km^2 [Maussion *et al.*, 2019]. If a grid spacing chosen by this formula exceeds 100 m, the grid spacing is fixed to a maximum of 100 m. Effectively, this means that a glacier of the minimum area of 0.01 km^2 will have a grid spacing of 11.4 m, a 8 km^2 glacier a grid spacing of 50 m, and all glaciers above 42 km^2 a grid spacing of 100 m. The chosen DEM product (dem_source attribute) is reprojected onto the local glacier grid and interpolated using cubic resampling with the rasterio library.

The main DEM product used for RGI 7.0 is the Copernicus DEM [Copernicus, 2019] (used for all but 128 glaciers). The COP-DEM products are available at 30 m and 90 m resolution. For all glaciers which grid size is below 60 m we use the 30 m COP-DEM product as source, and use the 90 m COP-DEM product for all other glaciers. If the COP-DEM product is not available for a glacier, we use one of the alternative products RAMP (21 glaciers), DEM3 (20 glaciers), ASTER (14 glaciers), or TANDEM (73 glaciers). We ask our users to refer to the original data sources in their publications if the topography attributes derived from RGI 7.0 play a significant role: refer to for a full reference.

For each glacier, a glacier mask is computed from the outlines and then applied to compute the glacier statistics.

Slope attributes

The `slope_deg`, `aspect_deg`, `aspect_sec` attributes are computed from the same DEM and grid as for the topography attributes described above (RGI-TOPO).

`slope_deg` and `aspect_deg` are computed using a standard trigonometric functions in python. The `aspect_sec` attribute contains information on the orientation of the glacier, classified into the following categories:

Value	Aspect sector	Aspect range
1	North	[337.5°; 22.5°]
2	North-east	[22.5°; 67.5°]
3	East	[67.5°; 112.5°]
4	South-east	[112.5°; 157.5°]
5	South	[157.5°; 202.5°]
6	South-west	[202.5; 247.5°]
7	West	[247.5°; 292.5°]
8	North-west	[292.5°; 337.5°]
9	Not assigned	

Terminus location

The `termlon`, `termlat` attributes mark the longitude and latitude of the last point of the main centerline, guaranteed to be on the glacier outline. It represents (approximately) the location of lowest elevation along the glacier outline. Knowing the terminus location is useful to assign a glacier to a hydrological basin, for example.

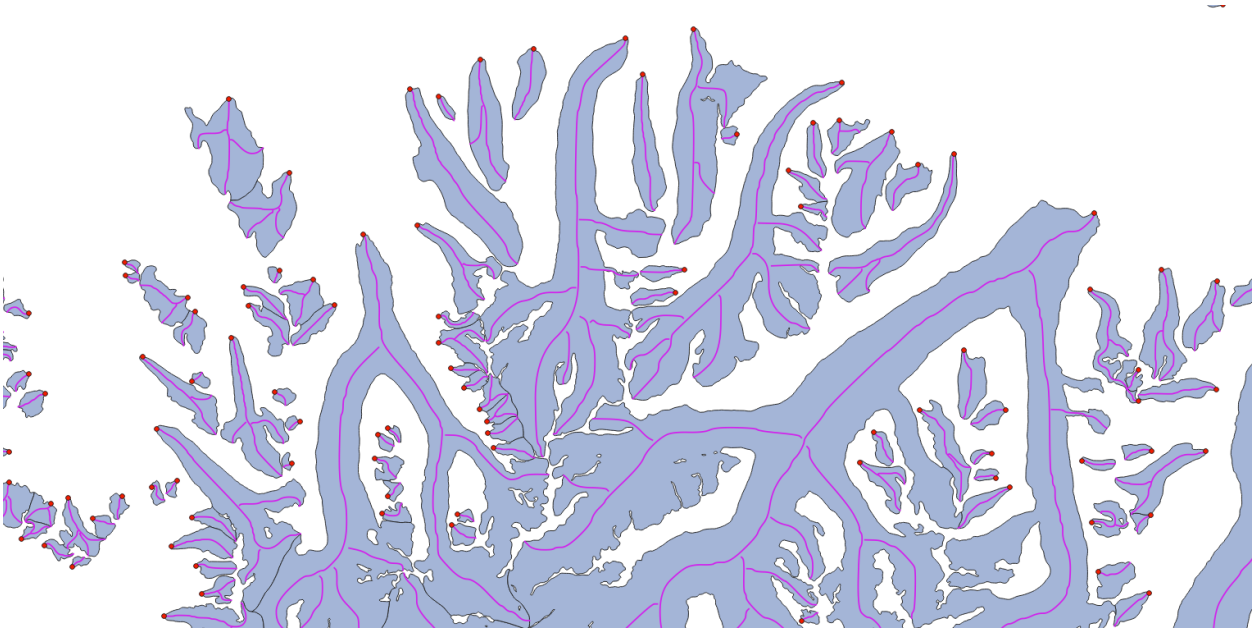


Fig. 3.2: Example of the glacier terminus location (red dots) plotted with the centerlines product (purple) drawn over the glacier product (light blue).

Glacier length

The maximum length (`lmax_m`, in meters) is computed from the main centerline in the RGI 7.0 glacier centerline product. Absolute glacier length is a subjective measure, and principally depends on the chosen "head" of the glacier. The head is distinct from the maximum elevation of the glacier. The centerline algorithm from Kienholz *et al.* [2014] selects potential heads by searching for local maxima along the glacier outline, and then computes all the centerlines joining all heads to the single terminus. The longest of them is selected as the main centerline, which implies that the computed glacier length is often longer than the shortest route from the highest to the lowest point of the glacier.

Surge type

The `surge_type` attribute contains information on evidence for surging, and is based on the following datasets:

- All glaciers marked as surge-type in RGI 6.0;
- The global inventory of Sevestre and Benn [2015];
- An inventory of surge-type glaciers in the Karakoram from Bhambri *et al.* [2017] (region 14);
- An inventory of observed glacier surges in the Pamirs from Goerlich *et al.* [2020] (region 13);
- An inventory of High Mountain Asia surge-type glaciers from Guillet *et al.* [2022] (regions 13, 14, 15);
- Additional inventories compiled by Ruth Krembel, Andreas Kääb, and Frank Paul.

Each inventory was intersected with the RGI 7.0 outlines. For inventories with glacier outlines, intersections smaller than 5% by area were discarded. For inventories with point data, where no intersection was found, the closest glacier to the point was manually chosen based on a comparison with the metadata provided with each inventory. Finally, each glacier in the RGI 7.0 was then assigned the category corresponding to the highest level of confidence based on each inventory (i.e., "observed" > "probable" > "possible" > "not assigned").

Value	Surging
0	No evidence
1	Possible
2	Probable
3	Observed
9	Not assigned

Visit *Global attributes statistics* for glacier counts/area of this attribute in RGI 7.0 and RGI 6.0.

Terminus type

The `term_type` attribute contains information on terminus type. All glaciers in RGI 7.0 have been assigned the "Not assigned" category, except for the marine-terminating glaciers in the northern hemisphere (after Kochtitzky *et al.* [2022]) and in region 17 - Southern Andes (same methodology).

The marine-terminating `term_type` attribute is valid for approximately the year 2000. The only region missing classification for marine-terminating glaciers is RGI 19 (Antarctic and Subantarctic), thus all glaciers that are "not assigned" outside of RGI 19 can be assumed to be land- or lake-terminating for the mapped year.

As of RGI 7.0, no region or glacier has any attributes available for lake-terminating or shelf-terminating glaciers. We aim to add this information in a future update of the RGI.

Value	Terminus type
0	Land-terminating
1	Marine-terminating
2	Lake-terminating
3	Shelf-terminating
9	Not assigned

Visit *Global attributes statistics* for glacier counts/area of this attribute in RGI 7.0 and RGI 6.0.

WGMS primary classification

The WGMS primary classification of the glacier (`primeclass`) is directly fetched from the GLIMS database. It is currently poorly populated, with only few submissions to GLIMS having provided this information.

Digit	Class	Description
0	Miscellaneous	Any type not listed below (please explain)
1	Continental ice sheet	Inundates areas of continental size
2	Icefield	Ice masses of sheet or blanket type of a thickness that is insufficient to obscure the subsurface topography
3	Ice cap	Dome-shaped ice masses with radial flow
4	Outlet glacier	Drains an ice sheet, icefield or ice cap, usually of valley glacier form; the catchment area may not be easily defined
5	Valley glacier	Flows down a valley; the catchment area is well defined
6	Mountain glacier	Cirque, niche or crater type, hanging glacier; includes ice aprons and groups of small units
7	Glacieret and snowfield	Small ice masses of indefinite shape in hollows, river beds and on protected slopes, which has developed from snow drifting, avalanching, and/or particularly heavy accumulation in certain years; usually no marked flow pattern is visible; in existence for at least two consecutive years.
8	Ice shelf	Floating ice sheet of considerable thickness attached to a coast nourished by a glacier(s); snow accumulation on its surface or bottom freezing
9	Rock glacier	Lava-stream-like debris mass containing ice in several possible forms and moving slowly downslope

3.5.4 Submission info table

Each glacier region folder contains a csv file containing information about provenance of the glacier outlines. This file is available for the glacier product only, and allows to associate each outline's `subm_id` (submission identifier) to a specific entry in the GLIMS database. The table contains the following columns:

`subm_id` `long_name`: submission_id `description`: Unique identifier assigned by GLIMS to a specific data submission. Allows to obtain information about the analysts and data submitters. `datatype`: int `units`: `source`: GLIMS `rgi6_name`:

n_outlines long_name: number_of_outlines description: Number of outlines from this submission used in RGI 7.0. datatype: int units: source: RGI rgi6_name:

area_km2 long_name: total_area_of_outlines description: Total area of the outlines from this submission used in RGI 7.0. datatype: float units: km2 source: RGI rgi6_name:

anlys_time long_name: analysis_time description: Representative time the outline analysis was carried out. datatype: str units: date source: GLIMS rgi6_name:

release_dt long_name: release_date description: Date at which the submission was realeased on GLIMS. datatype: str units: date source: GLIMS rgi6_name:

proc_desc long_name: processing_description description: Description of the processing done to create the glacier outlines. datatype: str units: source: GLIMS rgi6_name:

chief_affl long_name: chief_affiliation description: Affiliation of the chief of the regional center or the person(s) who submitted the data. datatype: str units: source: GLIMS rgi6_name:

submitters long_name: submitters description: Person(s) who submitted the data. datatype: str units: source: GLIMS rgi6_name:

analysts long_name: analysts description: Person(s) who created the data. datatype: str units: source: GLIMS rgi6_name:

rc_id long_name: regional_center_id description: GLIMS ID for the regional center. datatype: int units: source: GLIMS rgi6_name:

3.6 Glacier complex product

New in RGI 7.0

The glacier complex product is the result of a spatial merge operation of the glacier product (dissolve in the GIS jargon). The operation is realized on geometries only, which means that any cluster of connected glaciers (however small the connection) will be merged into one entity in the glacier complex product. The resulting inventory has the same area but a smaller or equal number of entities as the glacier product. Only a few attributes from the original glacier product remain after the merge.

The glacier complex product may be preferred over the glacier product for certain applications, for example for distributed glacier flow modeling or for ice thickness inversions.

3.6.1 Product files

In the following, file contents are explained using RGI region 01 (Alaska) as example:

RGI2000-v7.0-C-01_alaska.shp The RGI **glacier complex outlines** as a shapefile (with accompanying .dbf, .prj, .cpg and .shx files).

RGI2000-v7.0-C-01_alaska-attributes.csv Glacier complex **attributes** in a .csv file. The attributes are strictly the same as those encountered in the shapefile. This file allows users to read glacier attributes without reading the entire shapefile.

RGI2000-v7.0-C-01_alaska-attributes_metadata.json **Description of the attributes** in the glacier complex product shapefile: full name, description, units, etc. The content of this file is displayed in *Full list of attributes* below.

RGI2000-v7.0-C-01_alaska-CtoG_links.json **Links** between the glacier complex to the glacier products, in a JSON dictionary. The keys are the glacier complex identifiers (same length as the glacier complex file) and the values are the corresponding glacier product identifiers (one or more depending on the size of the cluster).

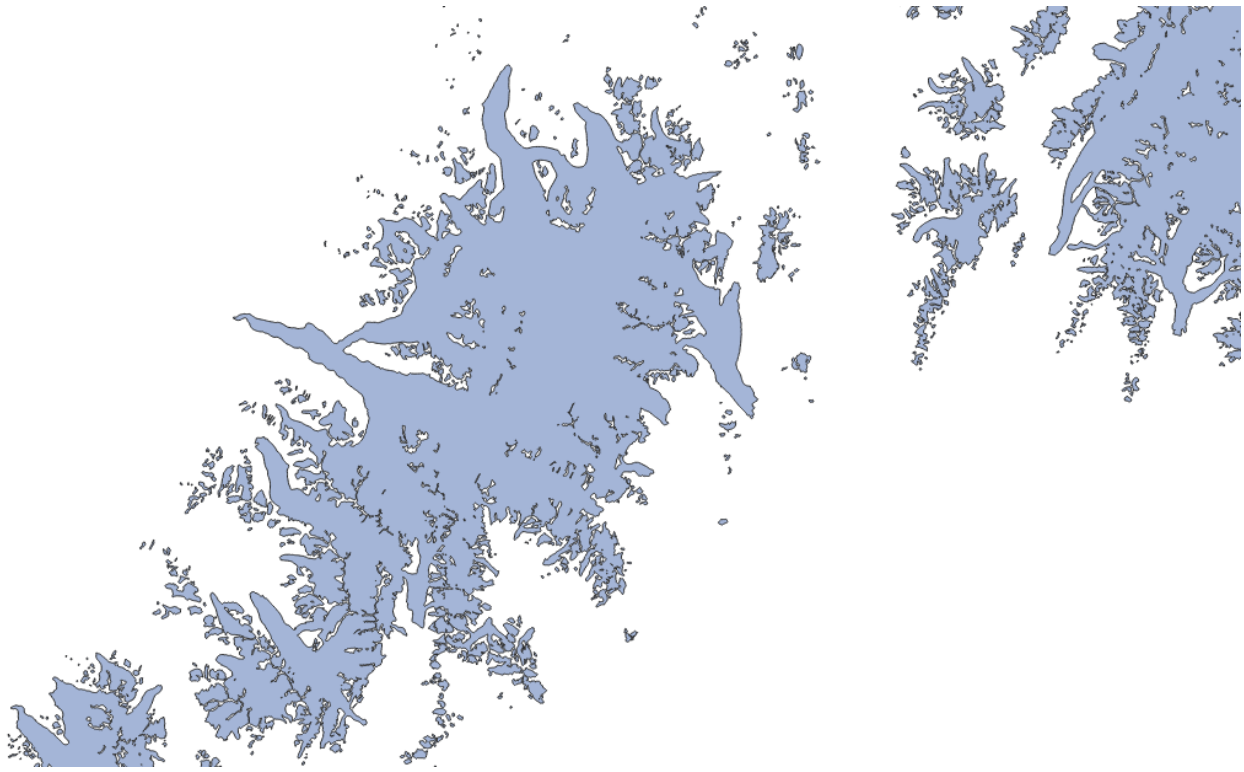


Fig. 3.3: Example of the glacier complex product (light blue), with outlines in black. In comparison with *the glacier product*, the divides between individual glaciers have disappeared and the entire ice mass constitutes one single entity.

3.6.2 Full list of attributes

The following attributes are available in the RGI 7.0 shapefiles.

rgi_id `long_name`: RGI identifier `description`: Unique identifier assigned to a single glacier complex. `datatype`: str `units`: `source`: RGI

o1region `long_name`: First order region `description`: The code of the first-order region to which the glacier belongs. `datatype`: str `units`: `source`: RGI

o2region `long_name`: Second order region `description`: The code of the second-order region to which the glacier belongs. `datatype`: str `units`: `source`: RGI

cenlon `long_name`: Center longitude `description`: Longitude of an approximately central point within the glacier outlines (not the centroid). `datatype`: float `units`: degrees `source`: RGI

cenlat `long_name`: Center latitude `description`: Latitude of an approximately central point within the glacier outlines (not the centroid). `datatype`: float `units`: degrees `source`: RGI

utm_zone `long_name`: UTM zone `description`: Number of the UTM zone for this glacier complex, based on its representative point. Note that this attribute is for information only, the geometries are all in WGS84. `datatype`: int `units`: `source`: RGI

area_km2 `long_name`: Glacier complex area `description`: Area of the glacier complex. `datatype`: float `units`: km2 `source`: RGI

geometry `long_name`: Geometry `description`: Glacier complex geometry (Polygon). `datatype`: `units`: deg `source`: RGI

3.7 Glacier intersects product

New in RGI 7.0

The glacier intersects products includes only the "divides" or "borders" between adjacent glaciers rather than the complete outlines. The resulting geometries are single lines (each with their own id), with attributes `rgi_g_id_1` and `rgi_g_id_2` indicating which glacier entities are adjacent. This product is useful for describing the connection between two glaciers (for example by the length of a common boundary) or for glacier models able to use this kind of information.

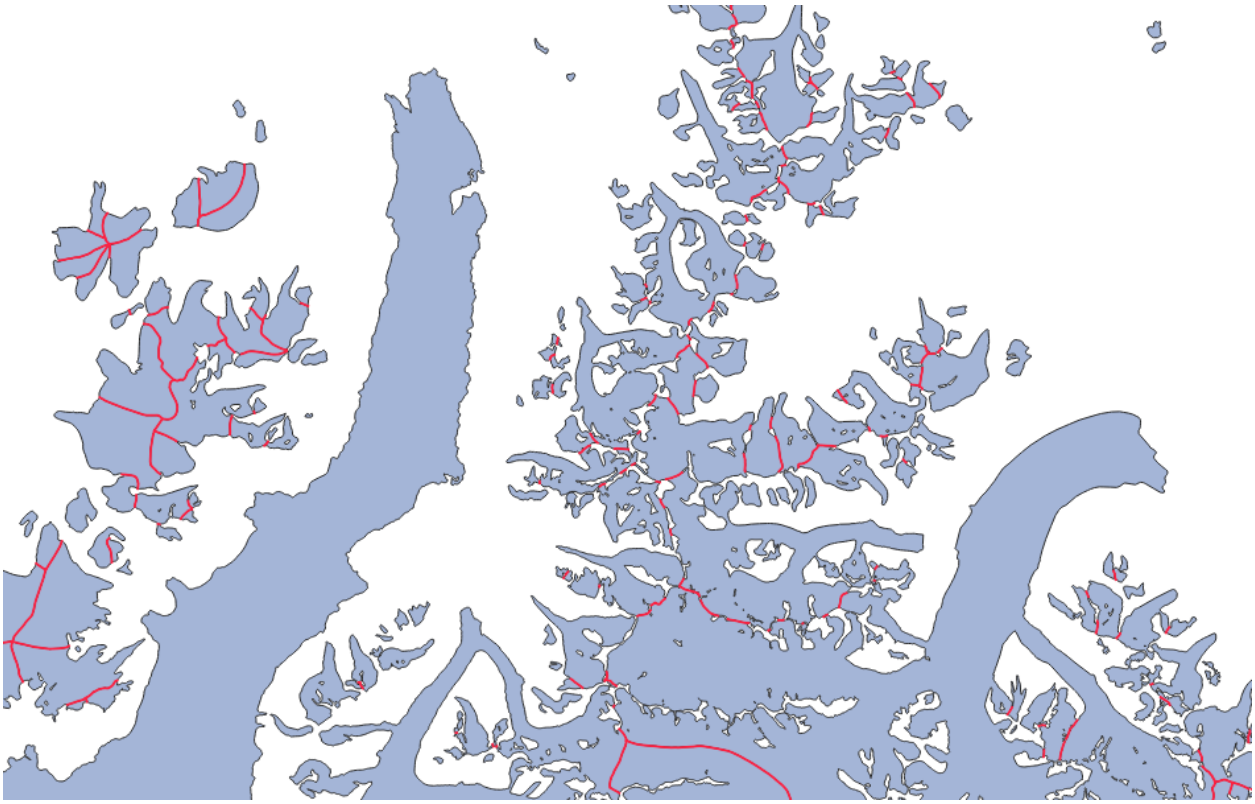


Fig. 3.4: Example of the glacier intersects product (red) drawn over the glacier product (light blue).

3.7.1 Product files

In the following, file contents are explained using RGI region 01 (Alaska) as example:

`RGI2000-v7.0-I-01_alaska.shp` RGI **glacier intersects** as a shapefile (with accompanying `.dbf`, `.prj`, `.cpg` and `.shx` files).

`RGI2000-v7.0-I-01_alaska-attributes.csv` Glacier intersects **attributes** in a `.csv` file. The attributes are strictly the same as those encountered in the shapefile. This file allows users to read glacier attributes without reading the entire shapefile.

`RGI2000-v7.0-I-01_alaska-attributes_metadata.json` **Description of the attributes** in the intersect product shapefile: full name, description, units, etc. The content of this file is displayed in *Full list of attributes* below.

3.7.2 Full list of attributes

The following attributes are available in the RGI 7.0 shapefiles.

rgi_id `long_name`: RGI identifier `description`: Unique identifier assigned to a single intersect line. `datatype`: str `units`: `source`: RGI

rgi_g_id_1 `long_name`: RGI glacier identifier of glacier 1 `description`: Glacier identifier of the intersected glacier number 1. An intersect line is always connecting two glaciers, but the choice of which glacier is listed as 1 is arbitrary. `datatype`: str `units`: `source`: RGI

rgi_g_id_2 `long_name`: RGI glacier identifier of glacier 2 `description`: Glacier identifier of the intersected glacier number 2. An intersect line is always connecting two glaciers, but the choice of which glacier is listed as 2 is arbitrary. `datatype`: str `units`: `source`: RGI

length_m `long_name`: Intersect length `description`: Length of the intersect in meters. `datatype`: float `units`: m `source`: RGI

geometry `long_name`: Geometry `description`: Intersect geometry (LineString). `datatype`: `units`: deg `source`: RGI

3.8 Glacier centerlines product

New in RGI 7.0

The glacier centerlines product contains geometrical centerlines for the main branches and major tributaries of all glaciers in the RGI 7.0 glacier product. The centerlines are computed using a geometrical flow routing algorithm first described by Kienholz *et al.* [2014] and implemented and executed by the Open Global Glacier Model (OGGM) [Maussion *et al.*, 2019]. When using this product, we recommend to cite both publications alongside the standard RGI 7.0 citation to provide a scientific context.

Each glacier contains one centerline along the main trunk of the glacier, as well any number of additional centerlines along tributaries, sorted according to their Strahler number (a measure of branching complexity defined by Strahler [1952], see definition below). The main (i.e.longest) centerline is used to compute the glacier product's maximum length attribute `lmax_m`.

3.8.1 Product files

In the following, file contents are explained using RGI region 01 (Alaska) as example:

RGI2000-v7.0-L-01_alaska.shp RGI **glacier centerlines** as a shapefile (with accompanying `.dbf`, `.prj`, `.cpg` and `.shx` files).

RGI2000-v7.0-L-01_alaska-attributes.csv Glacier centerlines **attributes** in a `.csv` file. The attributes are strictly the same as those encountered in the shapefile. This file allows users to read glacier attributes without reading the entire shapefile.

RGI2000-v7.0-L-01_alaska-attributes_metadata.json **Description of the attributes** in the ceterlines product shapefile: full name, description, units, etc. The content of this file is displayed in *Full list of attributes* below.

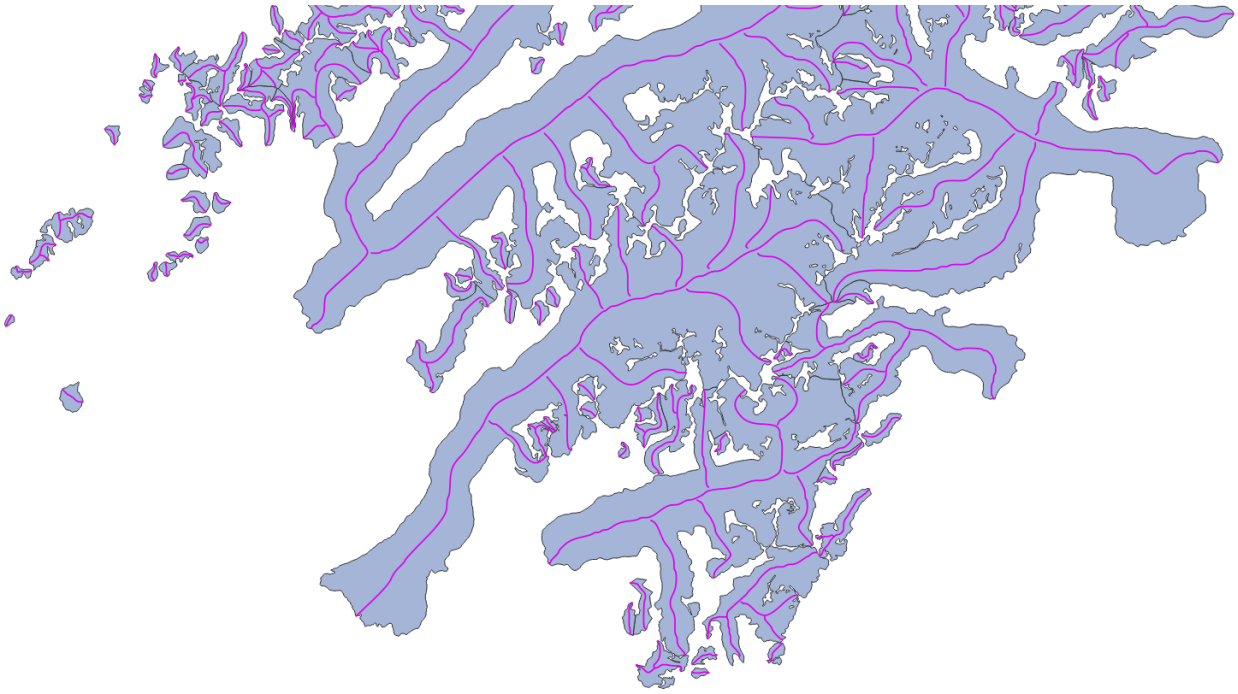


Fig. 3.5: Example of the glacier centerlines product (purple) drawn over the glacier product (light blue).

3.8.2 Full list of attributes

The following attributes are available in the RGI 7.0 shapefiles. For more details on some of them, see *Additional information on centerline attributes*.

rgi_id long_name: RGI identifier description: Unique identifier assigned to a single intersect line. datatype: str units: source: RGI

rgi_g_id long_name: RGI glacier identifier description: Glacier ID to which the centerline belongs. datatype: str units: source: RGI

segment_id long_name: Segment identifier description: Integer number uniquely identifying this centerline within the glacier. The main centerline is always last. datatype: int units: source: RGI

is_main long_name: Is main centerline description: Integer number indicating whether the centerline in the main centerline (1) or not (0). There is only one main centerline per glacier. datatype: int units: source: RGI

outflow_id long_name: Outflow segment identifier description: Each secondary centerline flows into another centerline. This identifier points to the segment_id to which this centerline flows to. datatype: int units: source: RGI

strahler_n long_name: Strahler number of this centerline. description: Strahler number (hydrological order) of the centerline, from lowest (1, line without tributaries but with possible descendants) to highest (the main centerline). datatype: int units: source: RGI

length_m long_name: Centerline length description: Length of the centerline in meters. datatype: int units: m source: RGI

geometry long_name: Geometry description: Centerline geometry (LineString). datatype: units: deg source: RGI

3.8.3 Additional information on centerline attributes

The centerlines and their attributes are computed by OGGM [Maussion *et al.*, 2019], which implements an algorithm described by Kienholz *et al.* [2014]. The implementation in OGGM follows closely the description by Kienholz *et al.* [2014], but it is coded in a different framework and thus may lead to slightly different results (the OGGM implementation is coded entirely in python, while the original implementation relied on ArcGIS tools). Neither the original algorithm nor its implementation in OGGM are perfect, and it is likely that centerlines on individual glaciers would be drawn differently by a human or other algorithms. We note that we do not use any velocity product but rely purely on geometric and topographic considerations.

Strahler number

The Strahler number `strahler_n` is a measure of branching complexity defined by [Strahler, 1952] commonly used in hydrological applications. A Strahler number of 1 indicates a centerline without any tributaries. A Strahler number of 2 indicates a centerline with one or more upstream tributaries of the same order, i.e. each of them having a Strahler number of 1. If a centerline with a Strahler number of 2 meets a downglacier centerline, the latter is assigned a Strahler number of 3. This ordering is important for mass flow routing. Each centerline contains a reference to its descendant, and this reference might be used by models to transfer mass from the tributaries towards the main centerline.

Main centerline

The main centerline of the glacier is the longest of all centerlines connecting the multiple glacier "heads" to one single terminus. The centerline algorithm selects potential heads by searching for local elevation maxima along the glacier outline, and then computes all the centerlines joining all heads to the terminus. The longest is selected as the main centerline, which implies that the computed glacier length is usually longer than the shortest route from the highest to the lowest point of the glacier.

CHAPTER

FOUR

GENERAL REVISIONS IN RGI 7.0

4.1 Overview

Despite considerable improvements over time, RGI 6.0 still suffered from quality issues in many regions, mostly related to inclusion of seasonal snow, missing glaciers or debris-covered parts, geolocation issues, outline artefacts, nominal glaciers (represented by circles) and ice divides at wrong locations. Furthermore, 35 % of all RGI 6.0 outlines were dated to five or more years away from the target year 2000 (this number is down to 23 % in RGI 7.0).

RGI 7.0 is substantially improved and enhanced compared to RGI 6.0 thanks to several major changes:

- The quality of outlines is substantially improved in many regions due to inclusion of new updated inventory data.
- New attributes are available, while others were removed or renamed/redefined.
- Outlines of contiguous glacier complexes are available ("glacier complex" product) in addition to the outlines of each individual glaciers.
- New data files including shapefiles of common boundaries of individual glaciers as well as glacier centerlines have been added ("intersects" and "centerlines" products).
- All outlines and attributes are derived exclusively from GLIMS.
- A new largely automated workflow was developed to generate the RGI from the GLIMS database with the code publicly available to ensure reproducibility.
- Filename conventions are updated.

Important: Compared to previous versions, the RGI version 7 represents a fundamental change in the data processing workflow and file formatting. Returning users will have to adapt their analysis scripts and routines for them to work with RGI 7.0.

4.2 Changes to the glacier outlines

RGI 7.0 contains substantial improvements in outline quality in many regions of the world. See *Regional revisions in RGI 7.0* for detailed description of changes in each region.

4.3 Data processing workflow

Previous RGI versions were generated largely in an ad-hoc manner based on data collected from GLIMS and many individual contributors. Although highly successful in generating the first near-complete global glacier inventory and releasing almost annual updates until 2017, the exact procedures are not fully documented, and code and tools used to generate the dataset are not publicly available. A major goal in RGI 7.0 was to largely automate the process with open-source code, and rely exclusively on GLIMS as data source for the RGI glacier outlines.

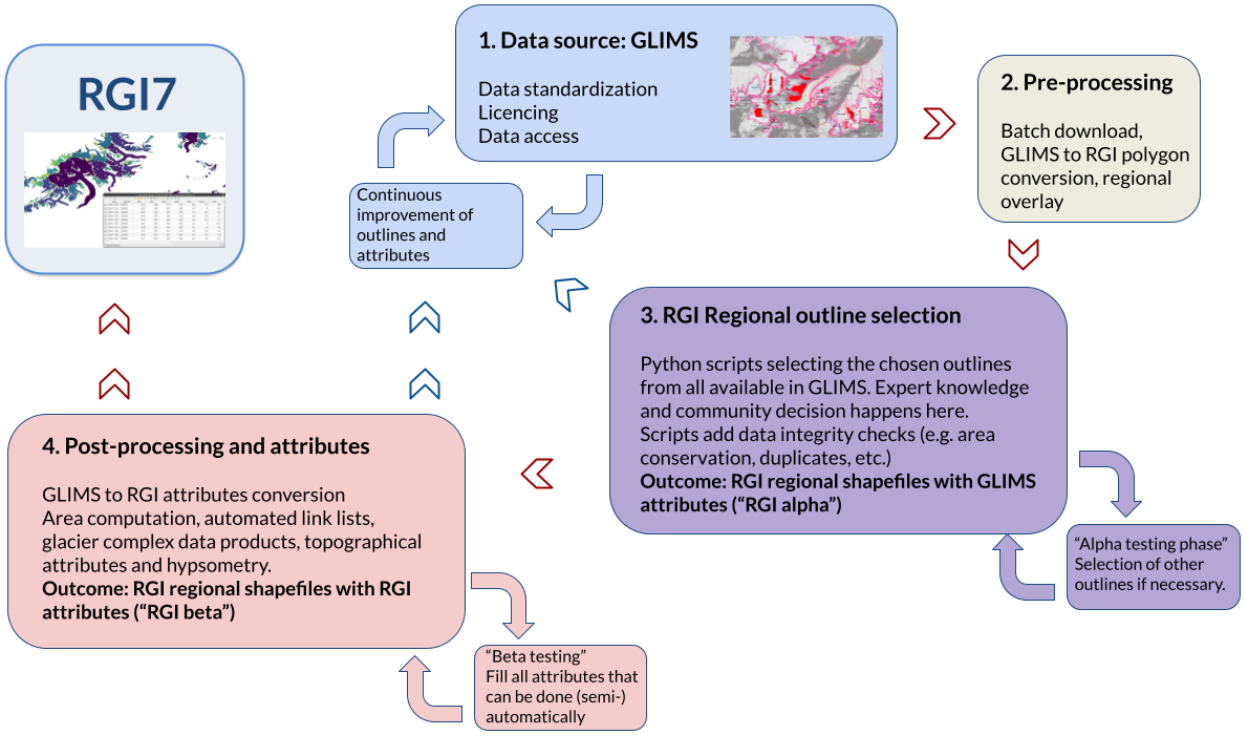


Fig. 4.1: Schematic illustration of the RGI 7.0 data production workflow.

The entire production workflow for RGI 7.0 is implemented in Python and is accessible through this repository. Here, we provide a summary of the key production steps:

1. **Submission of glacier inventories**: Working groups and analysts continuously submit glacier inventories to GLIMS. This process is often unguided, with data submissions made alongside publications or national inventory deliveries. The RGI Working Group occasionally guided mapping priorities by identifying regions that require improvements, and issuing public requests for data on the GLIMS and Cryolist e-mail listservers (2020-05-13).

2. **GLIMS database processing**: The complete GLIMS database was downloaded and processed on the RGI 7.0 production server. This processing involves converting GLIMS outlines to the RGI format (a different data model), cropping the GLIMS files to RGI regions, and performing preliminary data quality checks.

3. **Outline selection and data integrity checks (alpha version)**: A Python script was generated for each RGI region based on the decisions made by the RGI consortium regarding which outline submissions to include in the RGI. This selection process is documented in the section *Inventory selection process* below. Technical data integrity checks were then conducted for the outlines to be integrated into the RGI 7.0 (see *Quality control and data integrity*). The output at this stage is referred to as the "alpha version". The alpha version is a subset of GLIMS, and it does not yet have RGI attributes or follow RGI naming conventions (except for the organization in first order regions).**Alpha version review process**: The alpha version was shared with the RGI consortium for review and comments, and the community was invited to provide feedback via email or GitHub. This process sometimes led to changes or updates in the inventories themselves. For example in Region 19 (Subantarctic and Antarctic Islands) the review process

revealed several problems that were addressed by remapping several outlines. Once an inventory was amended or replaced, it was uploaded to GLIMS as a new submission and needed to be downloaded again for the RGI. Thus, the RGI alpha review process was an iterative process spanning over the course of roughly one year.

4. **Attributes generation (beta version)**: Following the completion of the alpha phase, the regional files were automatically processed into their "beta version," which is the pre-final dataset. Beta files adhere to all RGI requirements, including attributes, names, identifiers, etc. A significant part of the processing workflow involved computing automated attributes such as glacier topography or generating additional products (e.g., the "intersects" or "glacier complex" products). To ensure consistency, the same processing script was applied to all regions.**Beta version review process**: Similar to the alpha phase, the beta version was shared with the RGI consortium for review and discussion with feedback requested within 15 days. After addressing the review comments, no further changes to the outlines were permitted, except for cases where major flaws in the outlines were discovered subsequently.
5. **Generation of RGI 7.0**: The RGI steering committee approved the RGI 7.0 dataset on August 23rd, 2023. The glacier outlines are extracted from the GLIMS database downloaded from the NSIDC-DAAC servers on May 24th, 2023. The final RGI 7.0 dataset was created by renaming the beta files and storing them in a permanent repository on September 19th, 2023.

4.4 Inventory selection process

The two main goals for RGI 7.0 were (a) to improve outline quality over RGI 6.0, and (b) to bring outlines as close as possible to the target year 2000. To select outlines for RGI 7.0 the following steps were taken:

1. **New outlines generated after the release of RGI 6.0 were collected from several sources**: (a) outlines already existing in GLIMS, (b) datasets published in the literature but not yet submitted to GLIMS, and (c) outlines sent to the RGI Working Group (or directly submitted to GLIMS) in response to an open call for data in (2020-05-13).
2. **All available datasets were scrutinized in terms of quality and proximity to the target year**. The most suitable datasets were chosen as they were or after modification by the RGI Working Group based on satellite images to enhance the quality of both outlines and ice divides or to bring them closer to the target year 2000.
3. In regions without any new datasets the RGI 6.0 outlines were adopted if they were deemed to be of sufficient quality. Where this was not the case, **an effort was made by the RGI Working Group to generate new datasets by remapping the region from scratch or by modifying the RGI 6.0 outlines based on satellite imagery**. Since it is highly laborious and time-consuming, this effort could only be done in selected regions where RGI 6.0 had significant quality issues. Many members of the RGI Working Group were instrumental in this effort.

4.5 Data and file format

In RGI 7.0 data and file formats were revised to enhance readability and accessibility for both humans and machines. While maintaining a general familiarity with the RGI 6.0 format, we addressed inconsistencies and implemented a set of rules for generating the data files and data fields. These rules include:

- **Script-generated files**: All files were generated using scripts, minimizing the likelihood of human errors during typing or processing. However, it is important to note that this does not guarantee the absence of errors.
- **Metadata and documentation**: All file attributes received accompanying metadata and documentation, providing additional information and context.
- **Lowercase naming conventions**: File names and field attribute names were converted to lowercase to avoid the previous mix of lower case and upper case notation.
- **Standardized file naming conventions**: Files were named according to predefined conventions, allowing for easier machine reading and processing. For instance, the region identifiers are stored in the region description shapefile, enabling the opening of corresponding outline shapefiles in a scripted manner.

Any deviations from these rules should be considered as errors or oversights and will be addressed in future versions.

4.6 Quality control and data integrity

Since the RGI is a subset of GLIMS, all characteristics of GLIMS are inherited by the RGI, including any problems or inaccuracies present in the outlines. However, the RGI workflow incorporates several data integrity checks on the GLIMS data:

1. **Comparison with original datasets**: Whenever possible, such as when access to the original inventories is available (e.g., GAMDAMv2, Sakai [2019]), the RGI dataset (and thus the associated GLIMS data) could be verified against the original dataset. This process helped to identify a few errors in the GLIMS data ingestion workflow. It served as a rough data integrity check.
2. **Detection of duplicated outlines**: The RGI workflow identifies duplicated outlines by ensuring that no representative point of one outline overlaps with another outline. This filtering process removed a small number of duplicate outlines that exist in GLIMS.
3. **Polygon validity**: The RGI workflow checks the validity of polygon geometries. Approximately 2% of the geometries extracted from GLIMS for RGI 7.0 were considered "invalid" based on the Open Geospatial Consortium Implementation Standard. To rectify this, the RGI workflow employs Shapely's `make_valid` function, which eliminates erroneous self-intersections or sliver polygons. The correction process ensures that each glacier's area is preserved within a tolerance of 0.1 km^2 or 0.1 %. In rare cases where this could not be achieved, one GLIMS entry was split into two geometries, effectively adding two glaciers to the RGI instead of just one.
4. **Overlapping area correction**: The RGI workflow checks for and resolves overlapping areas by intersecting geometries with a common boundary and removing overlaps where necessary. However, such cases were rare.

It is important to note that these data integrity checks may result in some outlines in RGI 7.0 differing slightly from the ones stored in GLIMS, although the differences are often imperceptible. Despite these minor discrepancies, the benefits of correcting outlines in response to these data integrity checks are considered to outweigh any deviations from the GLIMS database.

CHAPTER

FIVE

REGIONAL REVISIONS IN RGI 7.0

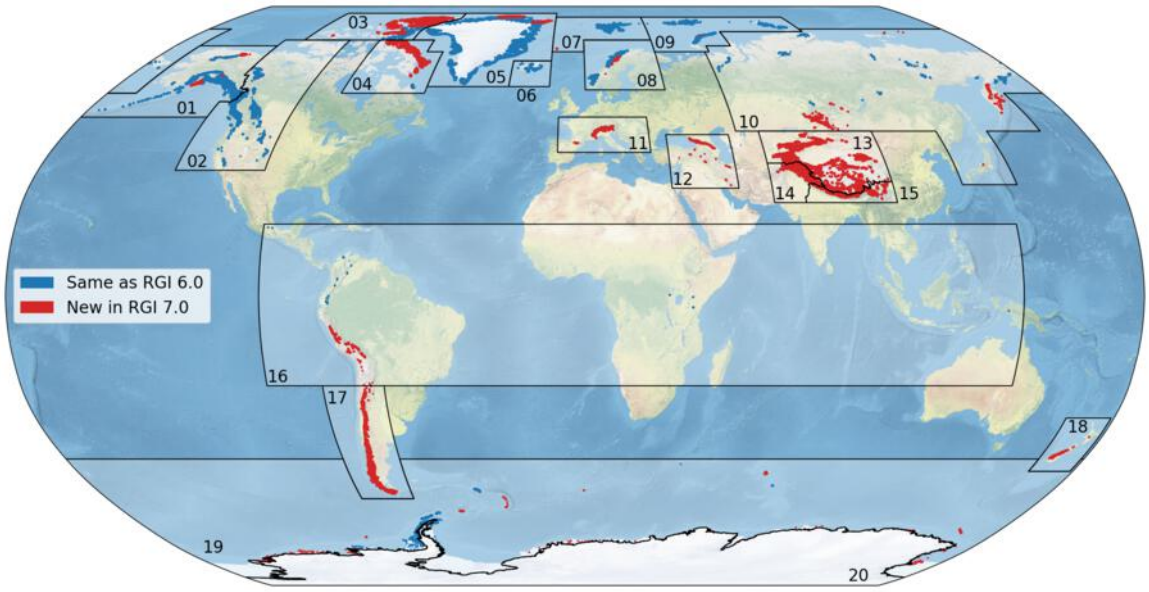


Fig. 5.1: First-order regions of the RGI version 7.0 and glacier locations.In red, outlines which are new in RGI 7.0. In blue, outlines which didn't change since RGI 6.0.Download high resolution version.

In RGI 7.0, 200734 of the 274531 outlines are taken from new inventories. **This means that 73 % of all RGI 7.0 glacier outlines are new or updated, representing an improvement for 42 % of the global area.**

Table: *Regional glacier areas and counts in RGI 6.0 and RGI 7.0*

Regional changes:

01: Alaska 02: Western Canada and USA 03: Arctic Canada North 04: Arctic Canada South 05: Greenland Periphery 06: Iceland 07: Svalbard and Jan Mayen 08: Scandinavia 09: Russian Arctic 10: North Asia

11: Central Europe 12: Caucasus and Middle East 13: Central Asia 14: South Asia West 15: South Asia East 16: Low Latitudes 17: Southern Andes 18: New Zealand 19: Subantarctic and Antarctic Islands 20: Antarctic Mainland

5.1 Regional glacier areas and counts in RGI 6.0 and RGI 7.0

The table below summarizes the glacier area and count of each first-order region and their differences (in %) between RGI 6.0 and RGI 7.0 (small differences in area or number do not necessarily mean no changes in quality; see each region's documentation for details):

Summary table Download this table as csv

	AreaRGI 6.0 (km^2)	AreaRGI 7.0 (km^2)	AreaDiff. (%)	CountRGI 6.0	CountRGI 7.0	CountDiff. (%)
01: Alaska	86725	86708	0.0	27108	27509	1.5
02: Western Canada and USA	14524	14521	0.0	18855	18730	-0.7
03: Arctic Canada North	105111	105370	0.2	4556	5216	14.5
04: Arctic Canada South	40888	40538	-0.9	7415	11009	48.5
05: Greenland Periphery	89717	90482	0.9	19306	19994	3.6
06: Iceland	11060	11060	0.0	568	568	0.0
07: Svalbard and Jan Mayen	33959	33959	0.0	1615	1666	3.2
08: Scandinavia	2949	2948	0.0	3417	3410	-0.2
09: Russian Arctic	51592	51595	0.0	1069	1069	0.0
10: North Asia	2410	2643	9.6	5151	7155	38.9
11: Central Europe	2092	2124	1.5	3927	4079	3.9
12: Caucasus and Middle East	1307	1407	7.6	1888	2275	20.5
13: Central Asia	49303	50344	2.1	54429	75613	38.9
14: South Asia West	33568	33075	-1.5	27988	37562	34.2
15: South Asia East	14734	16049	8.9	13119	18587	41.7
16: Low Latitudes	2341	1929	-17.6	2939	3695	25.7
17: Southern Andes	29429	27674	-6.0	15908	30634	92.6
18: New Zealand	1162	886	-23.7	3537	3018	-14.7
19: Subantarctic and Antarctic Islands	132867	133432	0.4	2752	2742	-0.4
20: Antarctic Mainland	0	0	0.0	0	0	0.0
Global	705739	706744	0.1	215547	274531	27.4

5.2 01: Alaska

The region encompasses all glaciers in the state of Alaska, USA, and also all those glaciers in the Yukon Territory and British Columbia, Canada, that are part of the icefields that straddle the US/Canada border. On its southeastern boundary, the region ends just north of Prince Rupert, British Columbia and just south of the end of the Alaska border. From there the region extends inland to the divide between Gulf of Alaska and Arctic drainages.

Subregions

- 01-01: North Alaska
- 01-02: Alaska Range (Wrangell/Kilbuck)
- 01-03: Alaska Peninsula (Aleutians)

- 01-04: West Chugach Mountains (Talkeetna)
- 01-05: Saint Elias Mountains
- 01-06: North Coast Ranges

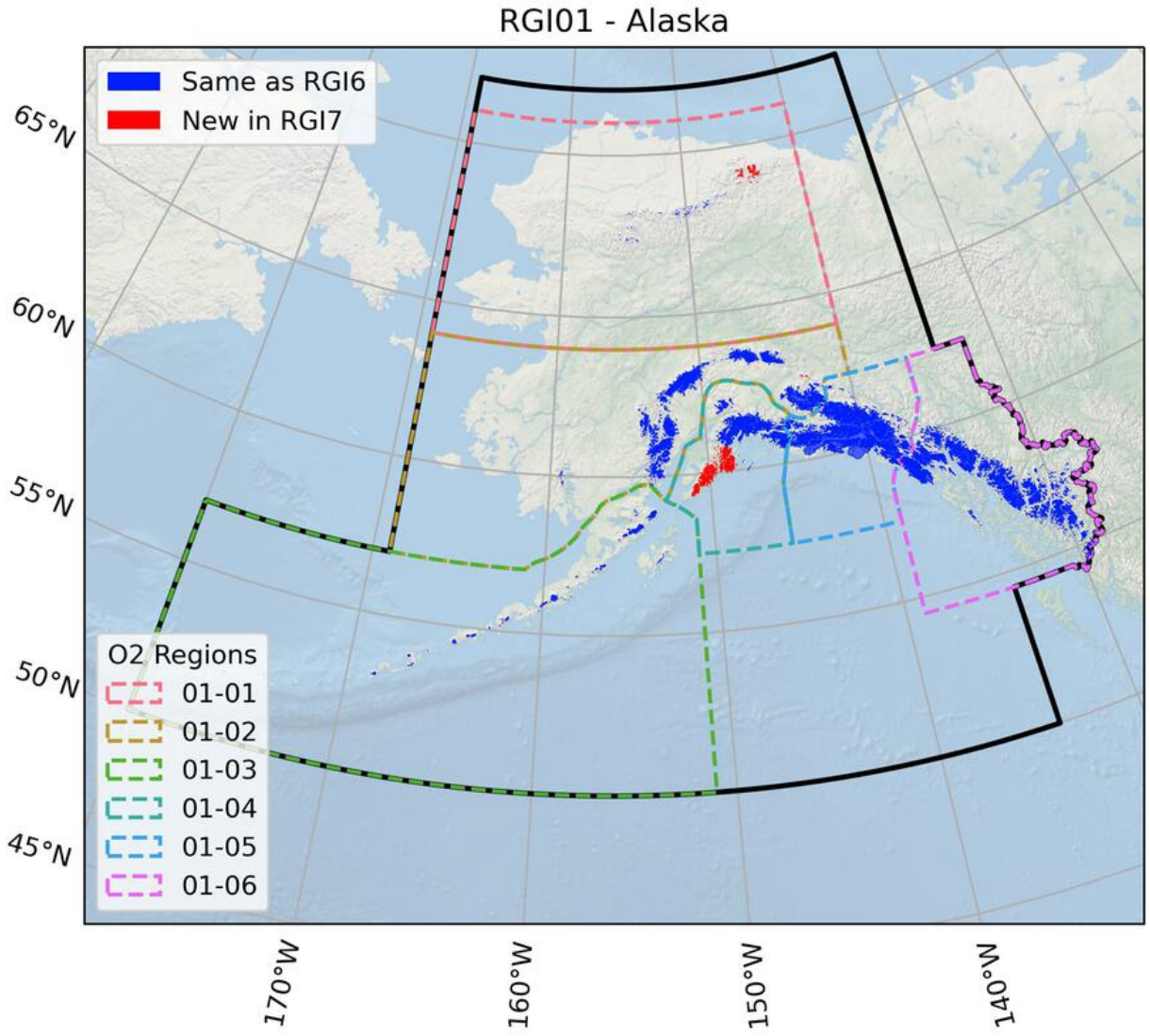


Fig. 5.2: Regional glacier area. Download high resolution version.

5.2.1 Changes from version 6.0 to 7.0

Brooks Range (01-01)

Many glacier outlines from the inventory by Kienholz *et al.* [2015] were corrected using manual glacier delineation with Landsat scenes from 2000, 2005, and 2007 and high-resolution images of the ESRI Basemap ("World imagery") to aid in outline interpretation (submission 810). A large number of missing smaller glaciers or glacier parts were added, glacier parts in shadow or under debris cover were corrected and the partly strong generalization of outlines was improved.

Alaska Range (01-02)

In total 42 previously unmapped glaciers were added. These were manually mapped using Landsat 7 imagery from August 1999 (submission 766).

Kenai Peninsula (01-04)

The glacier outlines from Kienholz *et al.* [2015] were corrected manually using the dataset for 2005 by Yang *et al.* [2020] and Landsat images from July and August 2005 as a guide. The main changes include the addition of several, mostly very small glaciers, removal of wrongly mapped seasonal snow, improved outlines for several debris-covered glaciers and a few topological corrections such as the connection / separation of individual glaciers or adjustment of ice divides using the AW3D30 DEM (submission 889).

N Coast Ranges (01-06)

Three outlines were updated to correct geometry errors (submission 756).

Attributes

RGI 6.0 included for each glacier a label for the terminus type attribute, including a list of lake-terminating glaciers. However, in RGI 7.0 only marine terminating glaciers were assigned (based on Kochtitzky *et al.* [2022]), despite the presence of lake-terminating glaciers in this region. Updating this attribute is planned for the next version of the RGI.

5.2.2 Additional information

Data sources and analysts

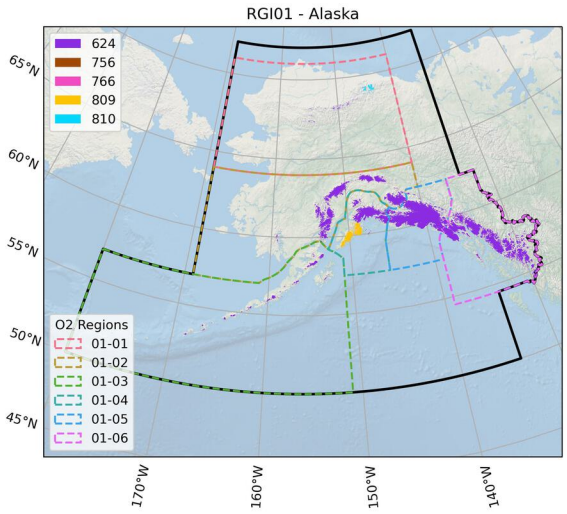


Fig. 5.3: Submission IDs used for this region Download high resolution version.

Glacier outline providers to GLIMS

This list includes the providers of the outlines used in the RGI 7.0 as generated automatically from the GLIMS outlines metadata. We acknowledge that the list may be incomplete due to omissions in the GLIMS database.

Submission 624 Submitter: Cogley, Graham.**Number of outlines**: 25304. **Area**: 82291.9km^2. **Release date**: 2015-07-16.**Analysts**: Beedle, Matthew; Berthier, Etienne; Bolch, Tobias; Burgess, Evan; Cogley, Graham; Forster, Richard; Giffen, Bruce A.; Hall, Dorothy K.; Kienholz, Christian; LeBris, Raymond; Manley, William.

Submission 756 Submitter: Bolch, Tobias.**Number of outlines**: 3. **Area**: 7.1km^2. **Release date**: 2021-10-10.**Analysts**: Beedle, Matthew; Berthier, Etienne; Bolch, Tobias; Burgess, Evan; Cogley, Graham; Forster, Richard; Giffen, Bruce A.; Hall, Dorothy K.; Kienholz, Christian; LeBris, Raymond; Manley, William.

Submission 766 Submitter: McNabb, Robert.**Number of outlines**: 42. **Area**: 10.7km^2. **Release date**: 2020-07-22.**Analysts**: McNabb, Robert.

Submission 809 Submitter: Yang, Ruitang.**Number of outlines**: 1736. **Area**: 4120.4km^2. **Release date**: 2022-10-31.**Analysts**: Paul, Frank; Yang, Ruitang.

Submission 810 Submitter: Paul, Frank.**Number of outlines**: 424. **Area**: 277.6km^2. **Release date**: 2023-01-09.**Analysts**: Beedle, Matthew; Berthier, Etienne; Bolch, Tobias; Burgess, Evan; Cogley, Graham; Forster, Richard; Giffen, Bruce A.; Hall, Dorothy K.; Kienholz, Christian; LeBris, Raymond; Manley, William; Paul, Frank.

Reviewers Davies, Bethan; McNabb, Robert;

Regional statistics

Figure: Outlines source date

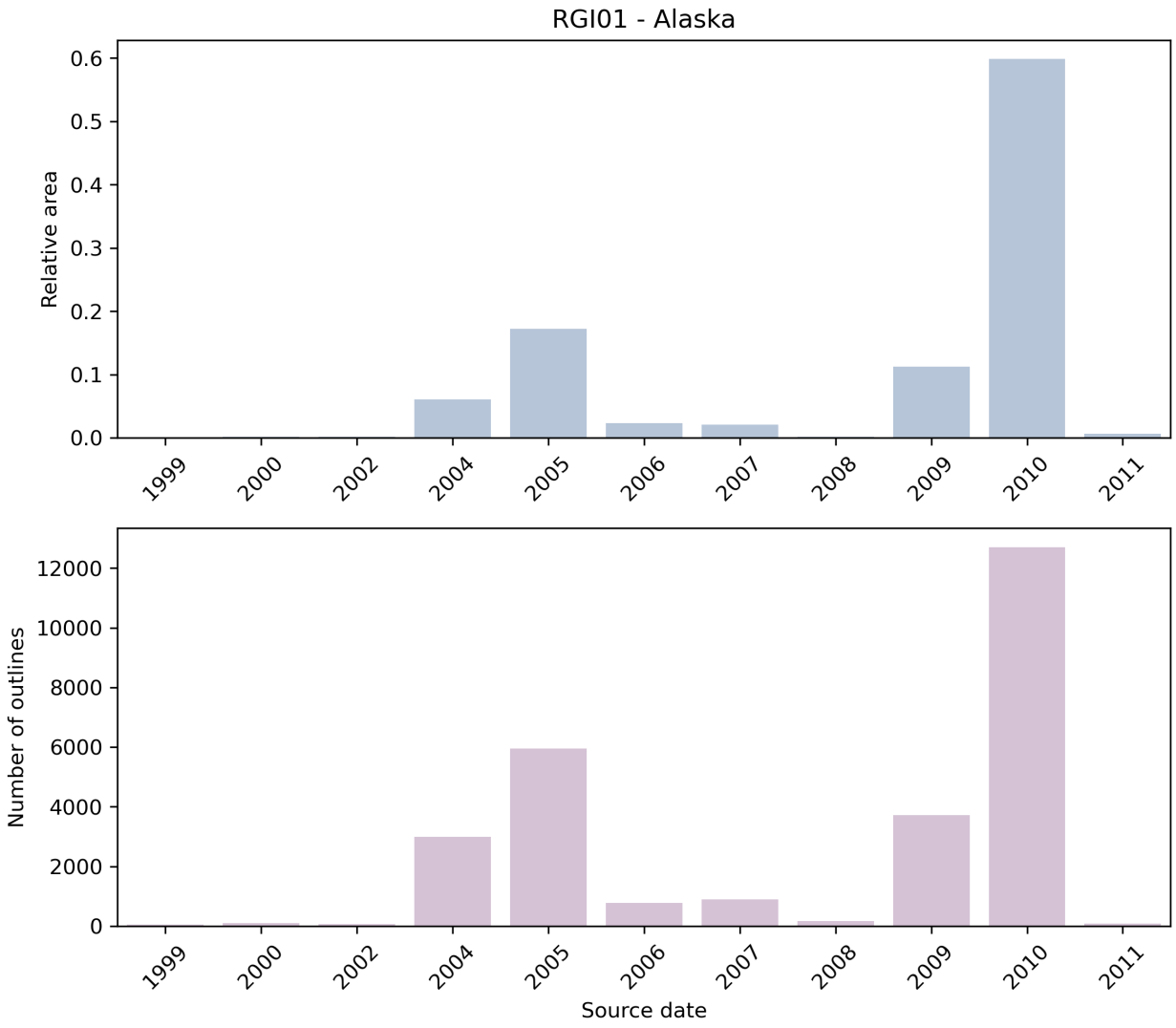


Fig. 5.4: Distribution of the outline dates per area (top) and number (bottom)

Figure: Glacier area histogram

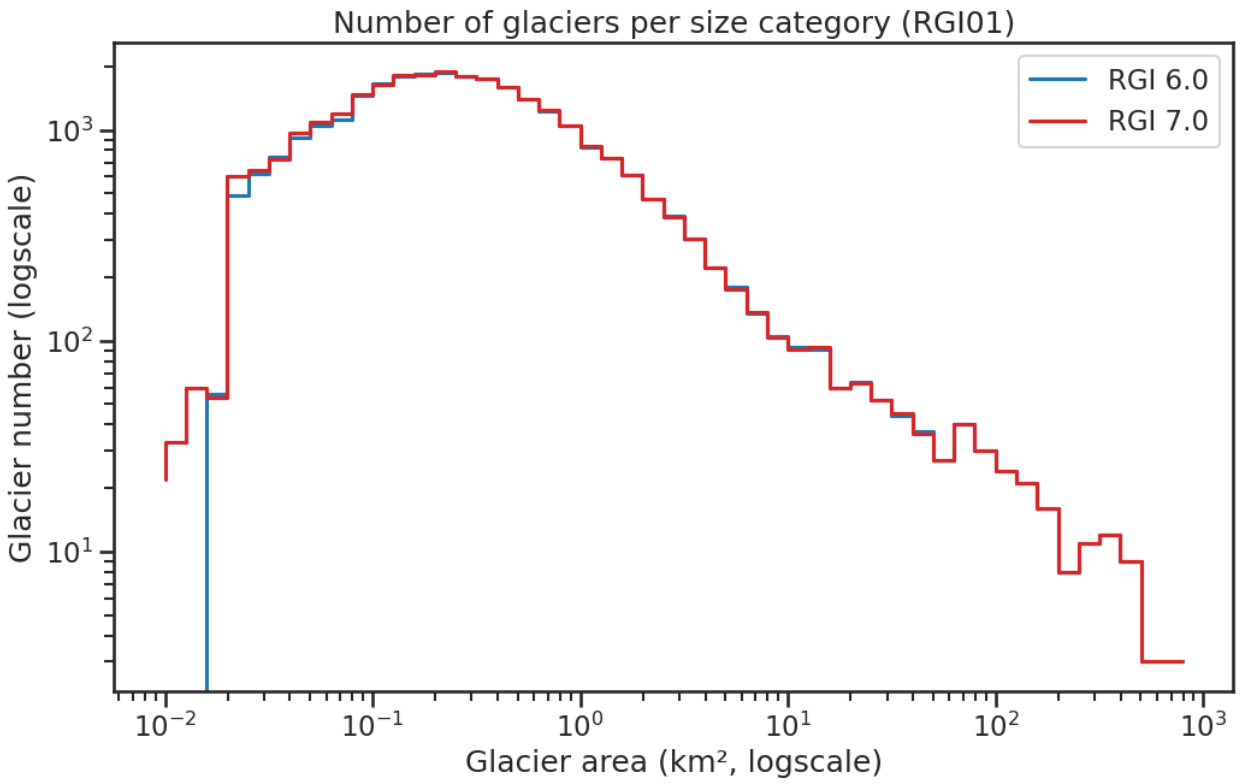


Fig. 5.5: Number of glaciers per size category (log-log scale).

Table: Terminus type statistics Regional number of glaciers (N) and area (km^2) per terminus type in RGI 7.0 and RGI 6.0. Note that the default designation in RGI 7.0 is now "Not assigned", while in RGI 6.0 lake-terminating glaciers and shelf-terminating glaciers were identified in some regions. The RGI region 19 is entirely labelled as "Not assigned" in RGI 7.0.

Value	Terminus type	RGI 7.0 (N)	RGI 6.0 (N)	RGI 7.0 (Area)	RGI 6.0 (Area)
0	Land-terminating	0	26909	0	58355
1	Marine-terminating	56	51	10986	11650
2	Lake-terminating	0	148	0	16721
3	Shelf-terminating	0	0	0	0
9	Not assigned	27453	0	75721	0

Table: Surge type statistics Regional number of glaciers (N) and area (km^2) per surge type attribute in RGI 7.0 and RGI 6.0.

Value	Surge type	RGI 7.0 (N)	RGI 6.0 (N)	RGI 7.0 (Area)	RGI 6.0 (Area)
0	No evidence	26852	0	48777	0
1	Possible	128	24	1443	266
2	Probable	244	32	11358	447
3	Observed	285	167	25129	3021
9	Not assigned	0	26885	0	82992

Version history

Changes from Version 5.0 to 6.0 None.

Changes from Version 4.0 to 5.0 The boundary between region 01-06 (N Coast Ranges) and regions 02-03 (S Coast Ranges) and 02-04 (N Rocky Mtns) was refined, with transfers of three glaciers to region 01-06 from 02-03 and four to 02-03 from 01-06 in consequence. Links were added to 7 glaciers in the WGMS mass-balance database.

Changes from Version 3.2 to 4.0 A new inventory [Kienholz *et al.*, 2015], including topographic and hypsometric attributes, replaces the former inventory of Alaska. We checked and, if necessary, adapted glacier divides using measured velocity fields from Burgess *et al.* [2013], resulting in substantial changes in many glacier outlines. The velocity fields cover all major icefields and roughly 50% of the total Alaskan glacierized area. Differences are most substantial for icefields and for glaciers with divides initially derived from the USGS DEM from the 1950s (e.g., Harding Icefield) rather than more modern DEMs. We also checked for remaining outlining errors (e.g., snow misclassified as ice) and adapted outlines manually where necessary. The updated outlines were used to derive the topographic and hypsometric attributes from the modern DEMs [Kienholz *et al.*, 2014]. In addition, we completed the RGI fields `GlacType` and `BgnDate` for all glaciers and added more glacier names, such that 585 glaciers now have names allocated.

Changes from Version 3.0 to 3.2 None.

Changes from Version 2.0 to 3.0 Additional improvements were made to the St. Elias, Lake Clark and Juneau Icefields regions. All remaining DCW outlines were replaced with more detailed recent outlines.

Changes from Version 1.0 to Version 2.0 Three glaciers in the Kigluaik Mountains of western central Alaska (01-01) were added as nominal circles from WGI-XF. Glaciers in Katmai and Lake Clark National Parks have been updated to 2006-2010 IKONOS imagery. The entire Stikine Icefield region has been updated using modern imagery. Glaciers at the head of Lynn Canal, and in the eastern portion of the Western Chugach Mountains near Cordova, have been updated. Extensive improvements have been made to the Wrangell/St. Elias region. What is included in RGI version 2.0 is a partially edited version of Berthier *et al.* [2009] and Beedle *et al.* [2008] outlines, updated to circa 2010 Landsat 7 ETM+ imagery for the Wrangell Mountains, 2006-2010 IKONOS imagery for the US portion of St. Elias, and Canadian topographic maps for the Canadian portion of the St Elias. Between V1.0 and V2.0 we have focused on capturing the largest area changes occurring primarily at low elevations; however some regions remain unmodified between V1.0 and V2.0.

Version 1.0 Numerous groups contributed Alaska glacier outlines. Bris *et al.* [2011] mapped the Kenai Peninsula, Tordillo, Chigmit and Chugach Mountains using Landast TM scenes acquired between 2005-2009. They used automated (band-ratioing) glacier mapping techniques with additional manual editing to deal with incorrect classification of debris-covered glaciers. Drainage divides in the accumulation region were derived from the USGS DEM. Bolch *et al.* [2010] contributed outlines for the Coast Mountains. As part of a mapping effort by the National Park Service (NPS), the University of Alaska Fairbanks (UAF) has been mapping all glaciers in NPS boundaries, as well as glaciers connected to but not within park boundaries, for two time periods (USGS 1950s map dates, and most recent satellite imagery). For this effort UAF has in many regions started with existing, older outlines and updated them to the most modern imagery available. These include outlines from Berthier *et al.* [2009], Beedle *et al.* [2008], and outlines provided by B. Giffen, D.K. Hall and W.F. Manley. UAF has updated these outlines to circa 2010 pan-sharpened 15 m resolution Landsat 7 ETM+ scenes, 5 m resolution imagery from the SPOT SPIRIT initiative (dating approximately 2007; Korona *et al.* [2009]) and 2006-2010 IKONOS imagery. UAF Geophysical Institute internal funding and National Science Foundation funding has also been used to support digitizing efforts in the Alaska Range, Chugach Mountains and Juneau Icefield glaciers. Nearly all of these regions are based on 2010 imagery. The University of Utah (E.W. Burgess, R.R. Forester, J. Lund) created outlines for the Stikine Icefield region derived from 1980s Landsat 5 imagery. W.F. Manley provided all outlines for Brooks Range glaciers. Glaciers along the Aleutian Island chain are taken from Berthier *et al.* [2009]. Glaciers other than those mapped by Bris *et al.* [2011] were delineated using an automated algorithm described by Kienholz *et al.* [2013]. USGS digital elevation models as well as the ASTER GDEM v1 were used as sources of elevation information.

5.3 02: Western Canada and USA

The region encompasses all glaciers in western Canada and the USA not included in Region 01.

Subregions

- 02-01: Mackenzie and Selwyn Mountains
- 02-02: South Coast Ranges
- 02-03: North Rocky Mountains
- 02-04: Cascade Range and Sierra Nevada
- 02-05: South Rocky Mountains

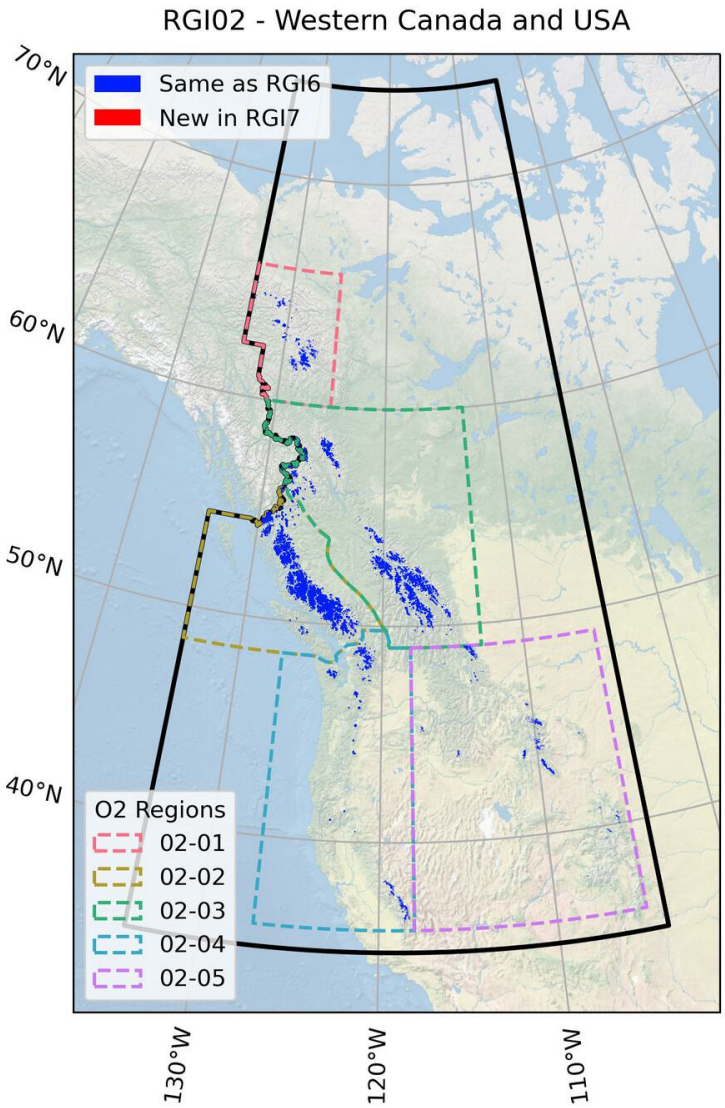


Fig. 5.6: Regional glacier area. Download high resolution version.

5.3.1 Changes from version 6.0 to 7.0

None.

5.3.2 Additional information

Data sources and analysts

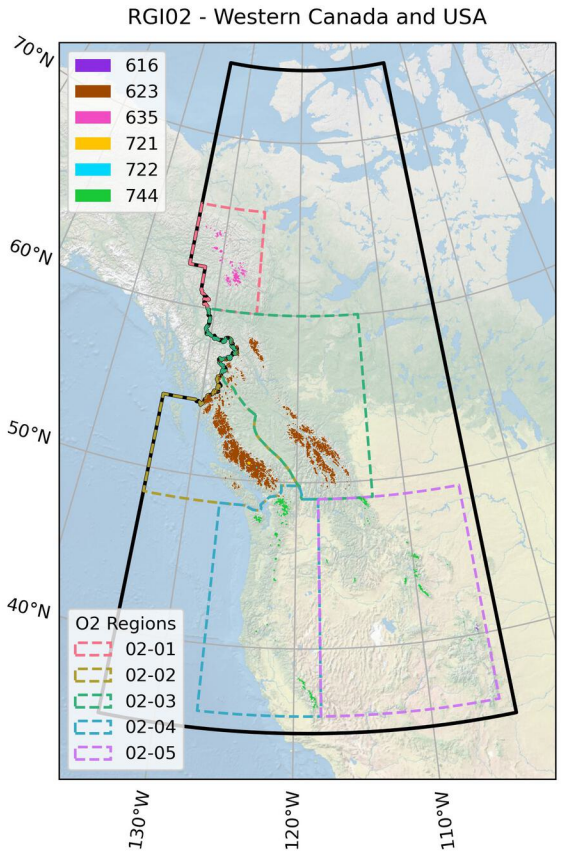


Fig. 5.7: Submission IDs used for this region Download high resolution version.

Glacier outline providers to GLIMS

This list includes the providers of the outlines used in the RGI 7.0 as generated automatically from the GLIMS outlines metadata. We acknowledge that the list may be incomplete due to omissions in the GLIMS database.

Submission 616 Submitter: Hoffman, Matthew.**Number of outlines**: 32. **Area**: 1.1km^2. **Release date**: 2016-07-26.**Analysts**: Fountain, Andrew G.; Hoffman, Matthew.

Submission 623 Submitter: Bolch, Tobias.**Number of outlines**: 12459. **Area**: 13046.6km^2. **Release date**: 2009-06-27.**Analysts**: Bolch, Tobias.

Submission 635 Submitter: Cogley, Graham.**Number of outlines**: 1235. **Area**: 656.5km^2. **Release date**: 2015-07-16.**Analysts**: Berthier, Etienne; Bolch, Tobias; Cogley, Graham; Kienholz, Christian.

Submission 721 Submitter: Bolch, Tobias.**Number of outlines**: 1. **Area**: 136.9km^2. **Release date**: 2009-06-27.**Analysts**: Bolch, Tobias.

Submission 722 Submitter: Bolch, Tobias.**Number of outlines**: 1. **Area**: 10.2km^2. **Release date**: 2009-06-27.**Analysts**: Bolch, Tobias.

Submission 744 Submitter: Fountain, Andrew G..**Number of outlines**: 5002. **Area**: 670.2km^2. **Release date**: 2016-02-26.**Analysts**: Fountain, Andrew G..

Reviewers None

Regional statistics

Figure: Outlines source date

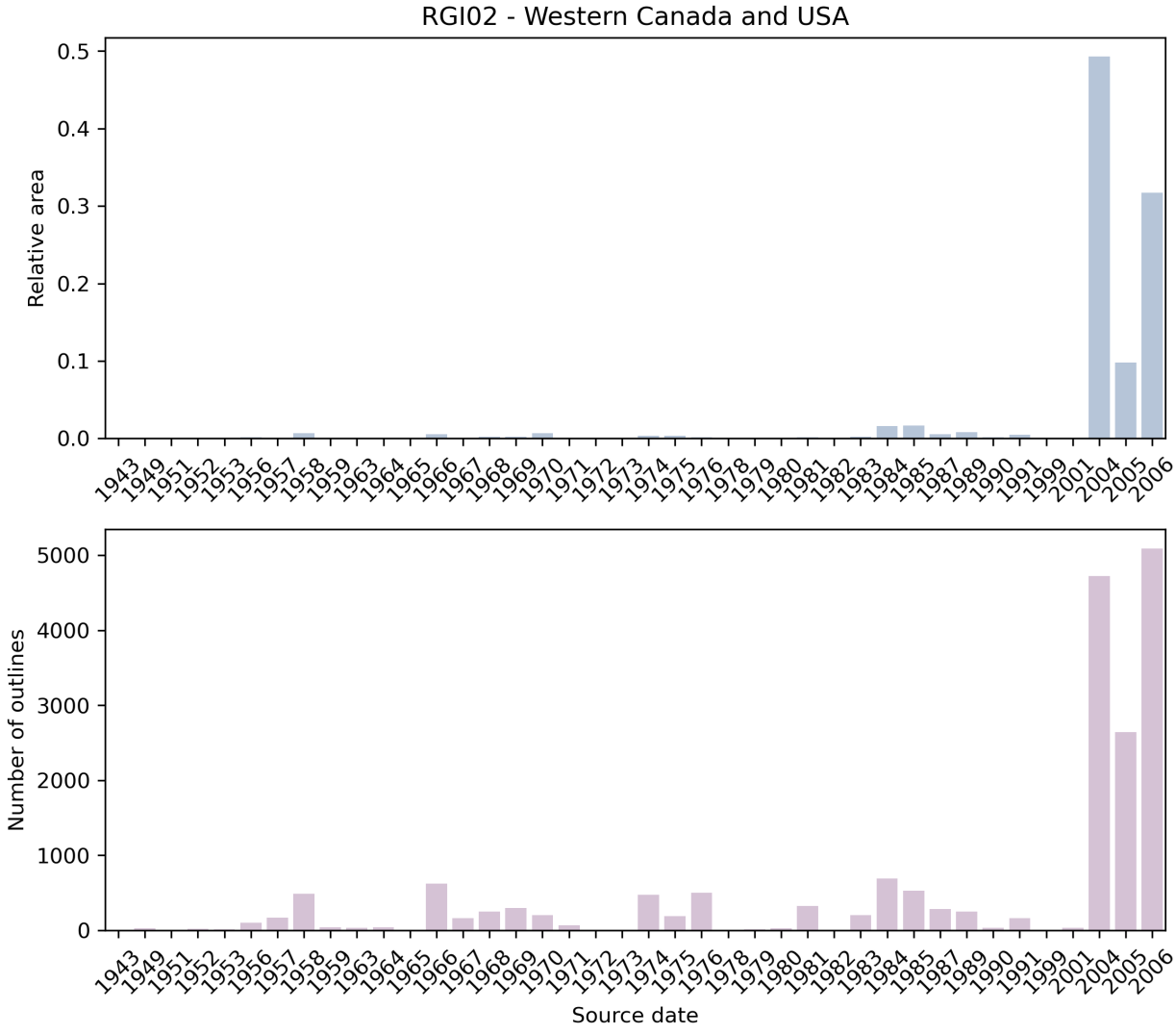


Fig. 5.8: Distribution of the outline dates per area (top) and number (bottom)

Figure: Glacier area histogram

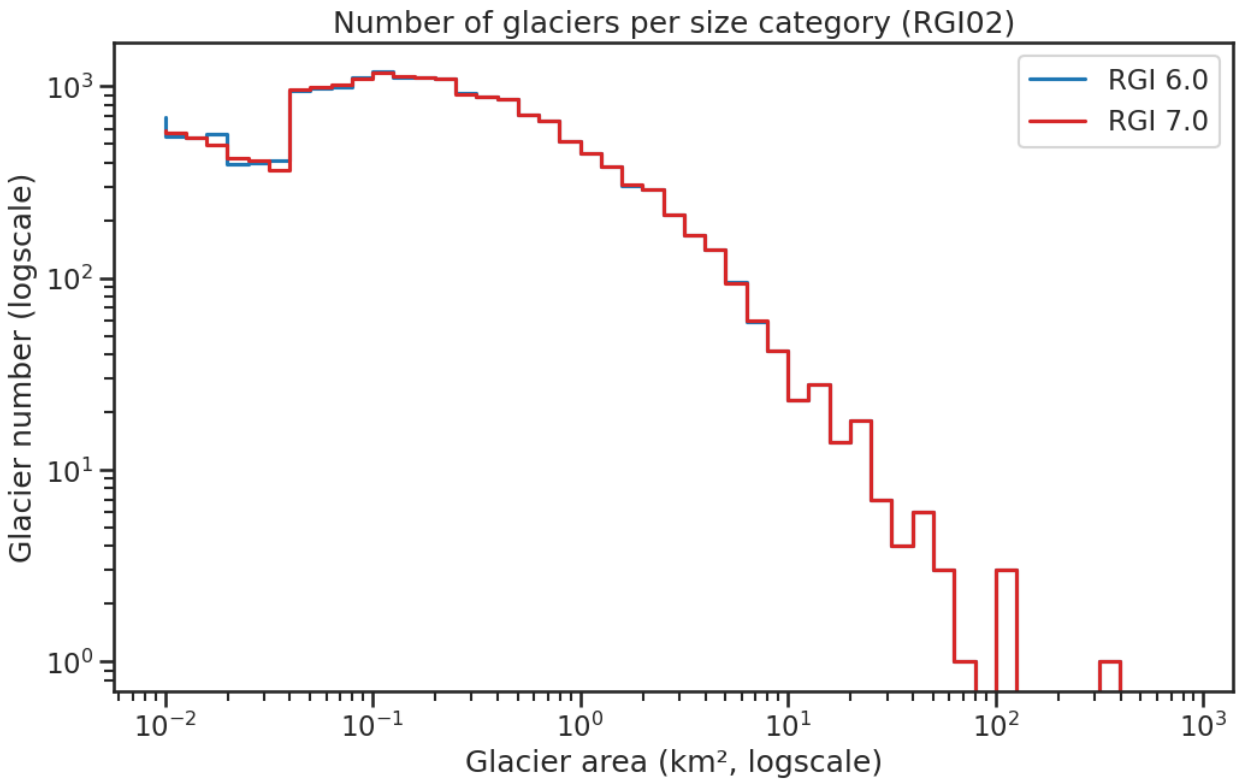


Fig. 5.9: Number of glaciers per size category (log-log scale).

Table: Terminus type statistics Regional number of glaciers (N) and area (km^2) per terminus type in RGI 7.0 and RGI 6.0. Note that the default designation in RGI 7.0 is now "Not assigned", while in RGI 6.0 lake-terminating glaciers and shelf-terminating glaciers were identified in some regions. The RGI region 19 is entirely labelled as "Not assigned" in RGI 7.0.

Value	Terminus type	RGI 7.0 (N)	RGI 6.0 (N)	RGI 7.0 (Area)	RGI 6.0 (Area)
0	Land-terminating	0	18855	0	14524
1	Marine-terminating	0	0	0	0
2	Lake-terminating	0	0	0	0
3	Shelf-terminating	0	0	0	0
9	Not assigned	18730	0	14521	0

Table: Surge type statistics Regional number of glaciers (N) and area (km^2) per surge type attribute in RGI 7.0 and RGI 6.0.

Value	Surge type	RGI 7.0 (N)	RGI 6.0 (N)	RGI 7.0 (Area)	RGI 6.0 (Area)
0	No evidence	18730	17619	14521	13867
1	Possible	0	0	0	0
2	Probable	0	0	0	0
3	Observed	0	0	0	0
9	Not assigned	0	1236	0	657

Version history

Changes from Version 5.0 to 6.0 The seven glaciers on Melville Island were transferred from former region 02-01 to region 03-07, with ids 03.04552 to 03.04558. In regions 02-04 (Cascade Ra and Sa Nevada) and 02-05 (S Rocky Mtns), all but a few Canadian outlines were replaced from an inventory taken from maps of scale 1:24,000 [Fountain *et al.*, 2006] and from outlines provided for Rocky Mountain National Park by M. Hoffman [Hoffman *et al.*, 2007]. (These regions were formerly numbered 02-05 and 02-06.) The previous coverage, also from Fountain *et al.* [2006], was from 1:100,000-scale maps. In consequence the glacier counts in the two regions increased several-fold, to 3202 in region 02-04 and 1967 in region 02-05, and their total areas increased to 529 km2 and 149 km2 respectively. The new outlines all have dates, unlike the old outlines, and it was possible to identify all 28 of those with measurements in the WGMS mass-balance database. The map dates range from the 1940s to the 1980s. The Rocky Mountain National Park outlines are from 2001.

Changes from Version 4.0 to 5.0 The boundary between region 01-06 (N Coast Ranges) and regions 02-03 (S Coast Ranges) and 02-04 (N Rocky Mtns) was refined, with transfers of three glaciers to region 01-06 from 02-03 and four to 02-03 from 01-06 in consequence.Links were added to 21 glaciers in the WGMS mass-balance database.

Changes from Version 3.2 to Version 4.0 145 exterior GLIMSIds were replaced. Topographic and hypsometric attributes were added.

Changes from Version 3.0 to 3.2 None.

Changes from Version 2.0 to Version 3.0 Glacier complexes were separated into single glaciers in the northern part of the region.

Changes from Version 1.0 to Version 2.0 The glaciers on Melville Island (formerly region 02-01, now "03-07") were represented in version 1.0 by DCW outlines and have been replaced by Canvec outlines taken from Region 03. DCW outlines for the Mackenzie Mountains and Selwyn Mountains (formerly region 02-02, now "02-01"), on the boundary between Yukon and the North West Territories, were replaced by Canvec outlines provided by M. Sharp and J.G. Cogley.

Version 1.0 Glaciers in BC and Alberta (2nd order regions: 02-02: S Coast Ranges, 02-03: N Rocky Mountains) were mapped using orthorectified Landsat 5 TM scenes from the years 2004 and 2006 obtained by British Columbia Government, Ministry of Forests and Range. We selected the TM3/TM5 band ratio for glacier mapping. For the entire study area, we used improved British Columbia TRIM glacier outlines as a mask to minimize misclassification due to factors such as seasonal snow. When using this mask, we assumed that glaciers did not advance between 1985 and 2005, an assumption that holds for practically all non-tidewater glaciers in western North America. The mask also maintained consistency in the location of the upper glacier boundary and the margins of nunataks. This consistency is important where seasonal snow hampers correct identification of the upper glacier boundary. We mapped only glaciers larger than 0.05 km2, as a smaller threshold would include many features that were most likely snow patches. In addition, all snow and ice patches that were not considered to be perennial ice in the TRIM data were eliminated and hence, we minimize deviations in glacier areas that could arise from interpretative errors or major variations in snow cover. The resulting glacier polygons were visually checked for gross errors based on the procedures previously discussed, and fewer than 5% of the glaciers were manually improved. We derived glacier drainage basins based on a flowshed algorithm using the TRIM DEM and a buffer around each glacier. More information can be found in Bolch *et al.* [2010].Data for the US south of 49°N (02-04: Cascade Ra and Sa Nevada, 02-05: S Rocky Mtns, Fountain et al., 2007; http://glaciers.us) were derived from the GLIMS database. Glaciers in Yukon (Mackenzie Mountains and Selwyn Mountains (formerly region 02-02, now 02-01)) and Mellville Island (formerly region 02-01, now 03-07) were taken from the digital chart of the world (DCW).

5.4 03: Arctic Canada North

The region encompasses all glaciers in Canada north of 74°N including the heavily glacierized Ellesmere and Devon Islands.

Subregions

- 03-01: North Ellesmere Island
- 03-02: Axel Heiberg and Meighen Island
- 03-03: North Central Ellesmere Island
- 03-04: South Central Ellesmere Island
- 03-05: South Ellesmere Island (Northwest Devon)
- 03-06: Devon Island
- 03-07: Melville Island

5.4.1 Changes from version 6.0 to 7.0

Ellesmere Island: Second-order region 03-01

Glacier outlines and ice divdes were replaced as RGI 6.0 outlines suffered from incorrect ice divides, missing rock outcrops, missing (mostly very small) glaciers and a geolocation shift. Glaciers were remapped using glacier outlines by White [2019] as a base but modifying them using four Landsat ETM+ scenes acquired in July 2000. The editing included a mix of manual and automated corrections. For the northernmost regions outside the coverage of Landsat the "World imagery" layer of the ESRI Basemap was used instead. Some smaller ice shelves were excluded.

Other regions

For other subregions on Ellesmere Island as well as the Axel Heiberg Island ice caps, Sydkap Ice Cap, Agassiz Ice Cap, and glaciers west of Sydkap, and west of Manson Ice Field, RGI 6.0 outlines were adjusted to improve their quality, and glacier divides were replaced. Several previously omitted glaciers west of Prince of Wales Ice Cap were added.

5.4.2 Additional information

Data sources and analysts

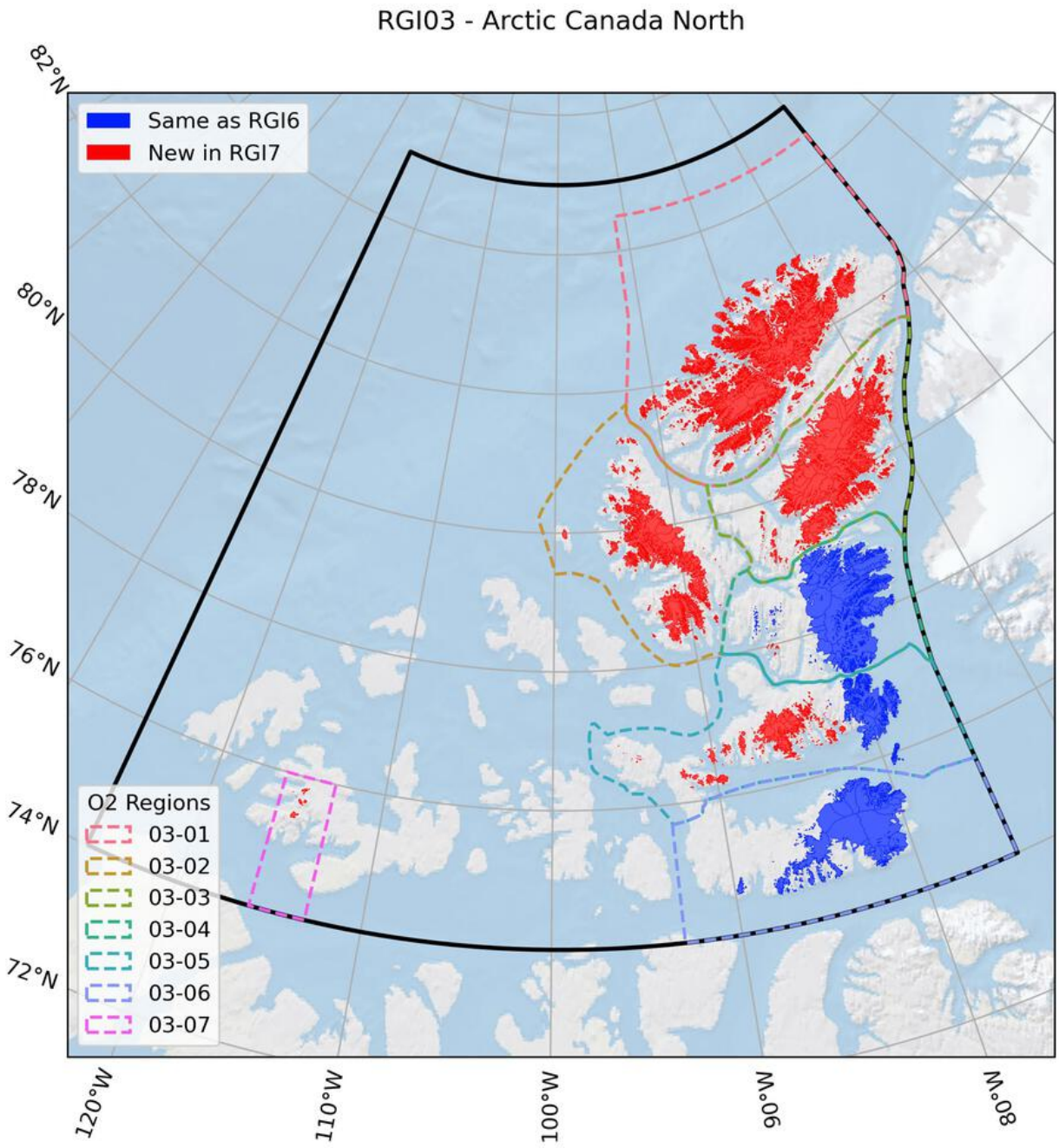


Fig. 5.10: Regional glacier area. Download high resolution version.

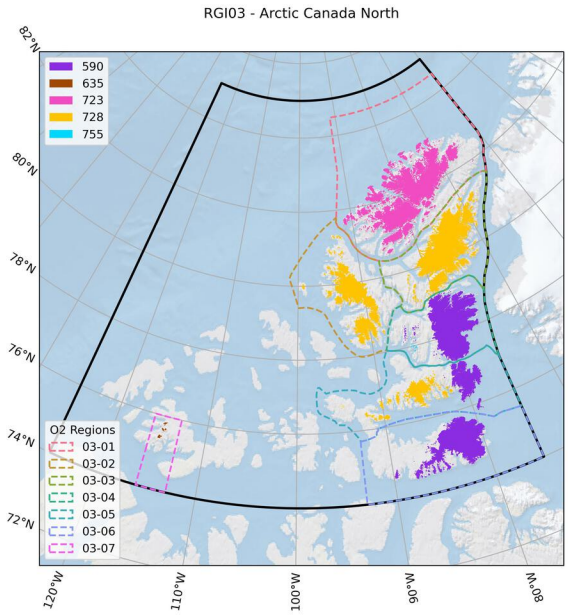


Fig. 5.11: Submission IDs used for this region Download high resolution version.

Glacier outline providers to GLIMS

This list includes the providers of the outlines used in the RGI 7.0 as generated automatically from the GLIMS outlines metadata. We acknowledge that the list may be incomplete due to omissions in the GLIMS database.

Submission 590 Submitter: Bolch, Tobias.**Number of outlines**: 652. **Area**: 39842.3km^2. **Release date**: 2015-07-15.**Analysts**: Barrand, Nick; Burgess, Dave; Cawkwell, Fiona; Copland, Luke; Filbert, Katie; Gardner, Alex; Hartmann, G; OCallaghan, P; Paul, Frank; Sharp, Martin; Wolken, G.; Wyatt, F..

Submission 635 Submitter: Cogley, Graham.**Number of outlines**: 7. **Area**: 128.2km^2. **Release date**: 2015-07-16.**Analysts**: Berthier, Etienne; Bolch, Tobias; Cogley, Graham; Kienholz, Christian.

Submission 723 Submitter: Paul, Frank.**Number of outlines**: 2573. **Area**: 27690.4km^2. **Release date**: 2021-09-03.**Analysts**: Paul, Frank; Rastner, Philipp; White, Adrienne.

Submission 728 Submitter: Kochtitzky, William.**Number of outlines**: 1961. **Area**: 37675.5km^2. **Release date**: 2021-08-27.**Analysts**: Copland, Luke; Kochtitzky, William; Thomson, Laura; Zajaczkiwsky, Sophie.

Submission 755 Submitter: Kochtitzky, William.**Number of outlines**: 23. **Area**: 33.9km^2. **Release date**: 2021-12-26.**Analysts**: Kochtitzky, William.

Reviewers Kochtitzky, William;

Regional statistics

Figure: Outlines source date

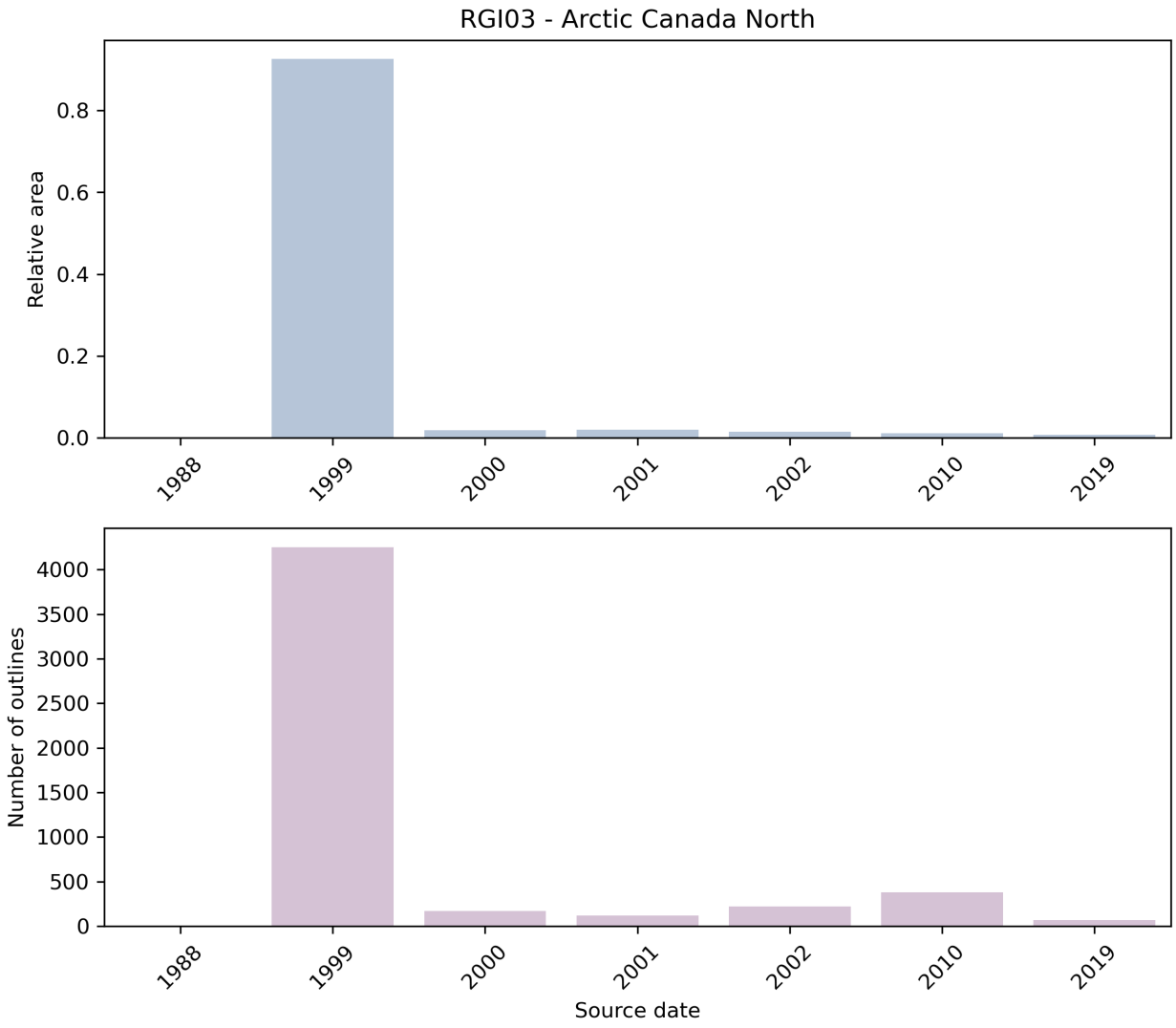


Fig. 5.12: Distribution of the outline dates per area (top) and number (bottom)

Figure: Glacier area histogram

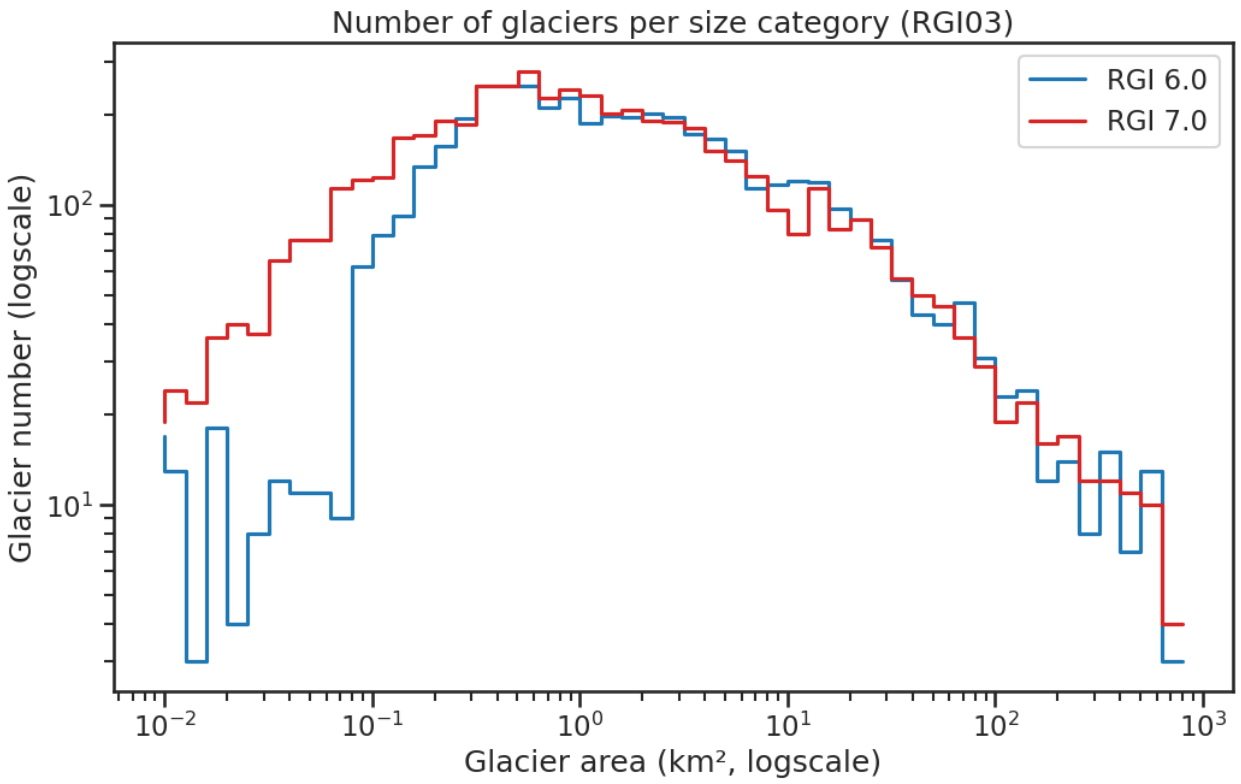


Fig. 5.13: Number of glaciers per size category (log-log scale).

Table: Terminus type statistics Regional number of glaciers (N) and area (km^2) per terminus type in RGI 7.0 and RGI 6.0. Note that the default designation in RGI 7.0 is now "Not assigned", while in RGI 6.0 lake-terminating glaciers and shelf-terminating glaciers were identified in some regions. The RGI region 19 is entirely labelled as "Not assigned" in RGI 7.0.

Value	Terminus type	RGI 7.0 (N)	RGI 6.0 (N)	RGI 7.0 (Area)	RGI 6.0 (Area)
0	Land-terminating	0	4298	0	56000
1	Marine-terminating	238	258	49691	49111
2	Lake-terminating	0	0	0	0
3	Shelf-terminating	0	0	0	0
9	Not assigned	4978	0	55680	0

Table: Surge type statistics Regional number of glaciers (N) and area (km^2) per surge type attribute in RGI 7.0 and RGI 6.0.

Value	Surge type	RGI 7.0 (N)	RGI 6.0 (N)	RGI 7.0 (Area)	RGI 6.0 (Area)
0	No evidence	5145	4499	69295	75945
1	Possible	34	25	13457	12279
2	Probable	16	11	5639	4098
3	Observed	21	15	16979	12731
9	Not assigned	0	6	0	59

Version history

Changes from Version 5.0 to 6.0 Glacier complex RGI50-03.04540, added in version 5.0, was subdivided into 11 outlet glaciers with ids 03.04541 to 03.04551. The seven glaciers on Melville Island were transferred from former region 02-01 to region 03-07, with ids 03.04552 to 03.04558.The source for hypsometry was changed from the ASTER GDEM2 to the ViewfinderPanoramas DEM3.

Changes from Version 4.0 to 5.0 Names were assigned to some glaciers on Axel Heiberg Island. Glacier RGI40-03.00840 was subdivided into RGI50-03.04538 (Thompson Glacier) and RGI50-03.04539 (White Glacier). Alexander Trishchenko (Canada Centre for Remote Sensing, Ottawa) pointed out that an ice cap of 126 km2 on Colin Archer Peninsula, northwest Devon Island was missing, and it was added (RGI50-03.04540).Links were added to 4 glaciers in the WGMS mass-balance database.

Changes from Version 3.2 to 4.0 One exterior GLIMSId was replaced. Topographic and hypsometric attributes were added.

Changes from Version 3.0 to 3.2 Glaciers were delineated from the glacier complexes using the delineation algorithm developed by Kienholz *et al.* [2013] and applied to the 1:250000 Canadian Digital Elevation Data (CDED). Some minor manual editing was done to remove obvious blunders.

Changes from Version 2.0 to 3.0 None

Changes from Version 1.0 to Version 2.0 Canvec outlines of the Melville Island glaciers, which were mistakenly duplicated in region 03 in version 1.0, were transferred to region 02.

Version 1.0 Glacier outlines were created from late summer, cloud-free 1999-2003 Landsat 7 (ETM+) imagery and from 2000-2003 ASTER imagery. A normalized-difference snow index (NDSI) was calculated for all Landsat imagery to identify snow- and ice-covered terrain. Empirically derived thresholds were applied to refine these classifications and to separate snow from glacier ice. A clumping procedure was then applied to the classified snow and ice data to delineate contiguous groups of pixels, followed by an elimination procedure, which removed small clusters of non-ice pixels. Gridded snow and ice data were then converted to polygons and edited manually to correct misclassifications. Small portions of some areas within this region were not adequately imaged by Landsat, due to either persistent cloudiness or shadowing. Consequently, in these areas manual digitization of ASTER imagery was used to capture glacier outlines.Outlines for Devon Island were provided by D. Burgess and were derived from 1999/2000 velocity maps.

5.5 04: Arctic Canada South

The region encompasses all glaciers in northeast Canada south of 74°N including Baffin Island and Northern Newfoundland.

Subregions

- 04-01: Bylot Island
- 04-02: West Baffin Island
- 04-03: North Baffin Island
- 04-04: Northeast Baffin Island
- 04-05: East Central Baffin Island
- 04-06: South East Baffin Island
- 04-07: Cumberland Sound

- 04-08: Frobisher Bay
- 04-09: Labrador

5.5.1 Changes from version 6.0 to 7.0

Baffin Island and Bylot Island

The RGI 6.0 glacier outlines were modified using end-of-summer Landsat 7 ETM+ images acquired between 1999 and 2002. Corrections included the addition of missing glaciers or glacier parts (incl. debris cover), removal of seasonal snow and new drainage divides based on a flow direction grid derived from the ArcticDEM at 10 m resolution and the surface flow fields (magnitudes) by Millan *et al.* [2022]. For the southern part of Baffin Island (incl. parts of Penny Ice Cap) RGI 6.0 outlines were replaced by new outlines based on three Landsat 7 ETM+ scenes. Several small ice patches in the south of Baffin Island were added after visual inspection of the ESRI Basemap.

5.5.2 Additional information

Data sources and analysts

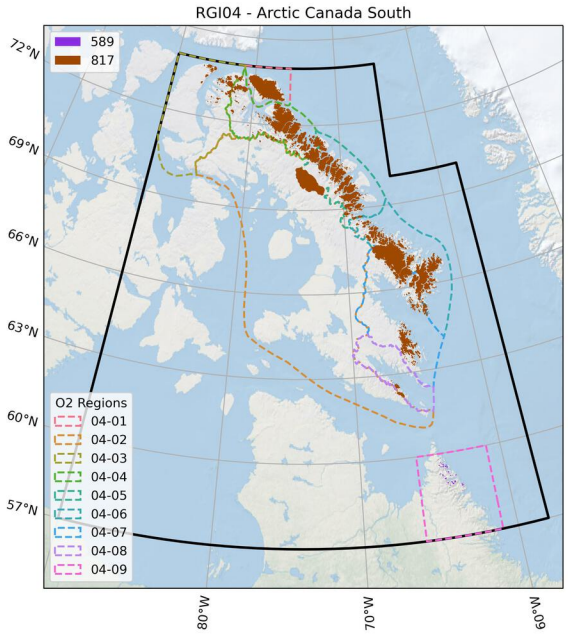


Fig. 5.15: Submission IDs used for this region Download high resolution version.

Glacier outline providers to GLIMS

This list includes the providers of the outlines used in the RGI 7.0 as generated automatically from the GLIMS outlines metadata. We acknowledge that the list may be incomplete due to omissions in the GLIMS database.

Submission 589 Submitter: Bolch, Tobias.**Number of outlines**: 103. **Area**: 19.8km^2. **Release date**: 2015-07-15.**Analysts**: Barrand, Nick; Burgess, Dave; Cawkwell, Fiona; Copland, Luke; Filbert, Katie; Gardner, Alex; Hartmann, G; OCallaghan, P; Paul, Frank; Sharp, Martin; Wolken, G.; Wyatt, F..

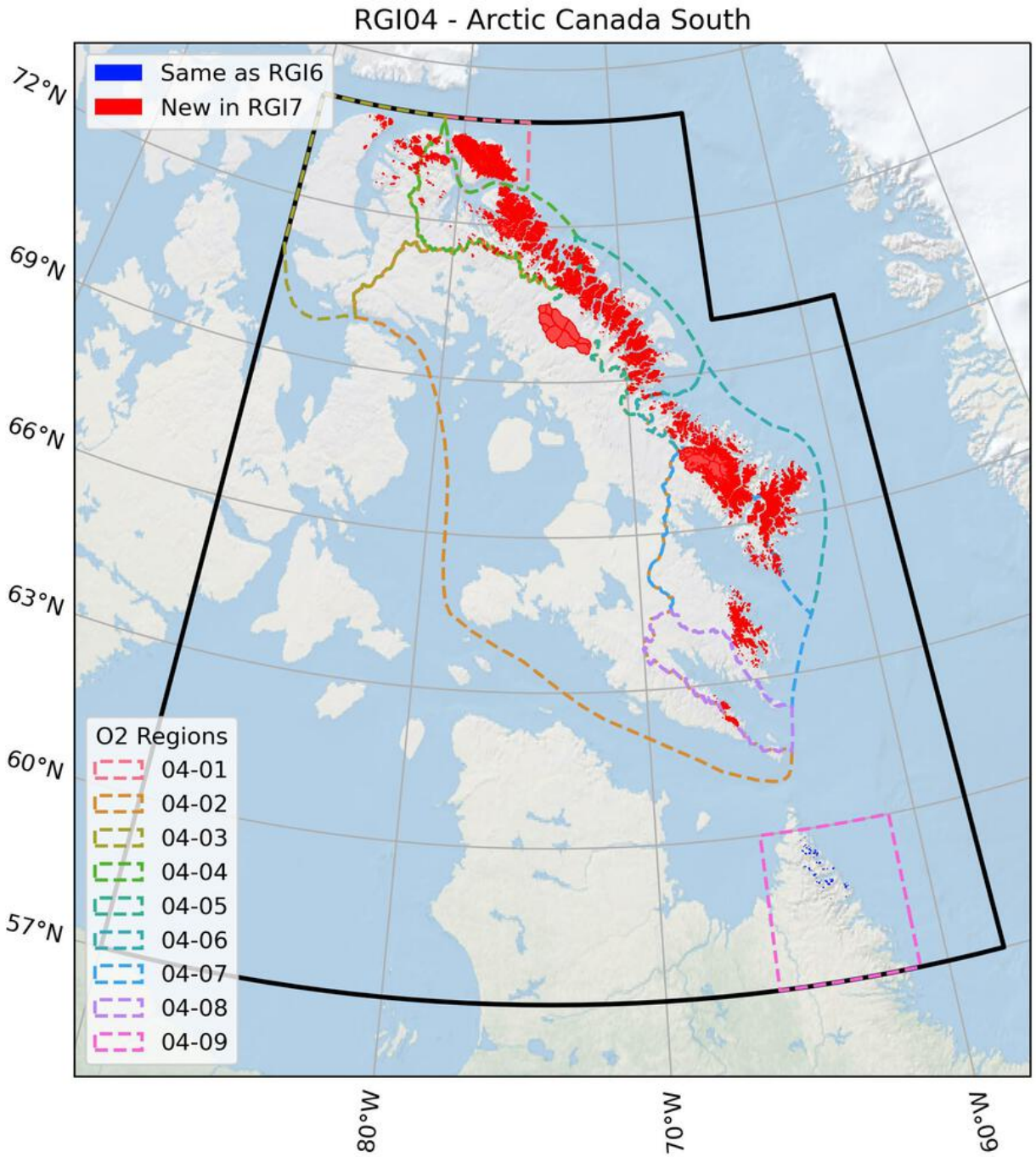


Fig. 5.14: Regional glacier area. Download high resolution version.

Submission 817 **Submitter**: Paul, Frank.**Number of outlines**: 10906. **Area**: 40518.3km^2. **Release date**: 2023-03-01.**Analysts**: Mabileau, Laure; Paul, Frank; Rastner, Philipp.

Reviewers Kochtitzky, William;

Regional statistics

Figure: Outlines source date

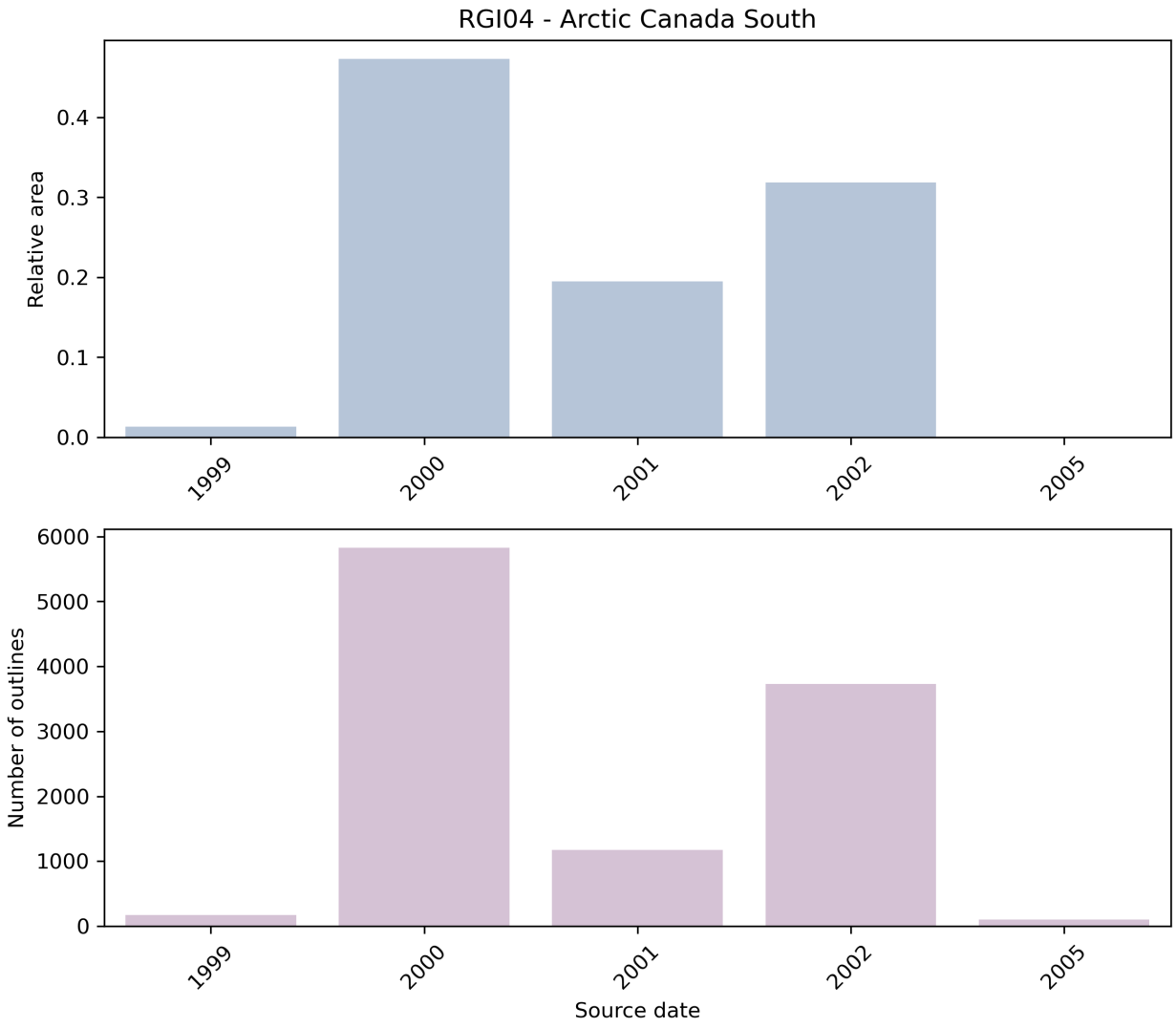


Fig. 5.16: Distribution of the outline dates per area (top) and number (bottom)

Figure: Glacier area histogram

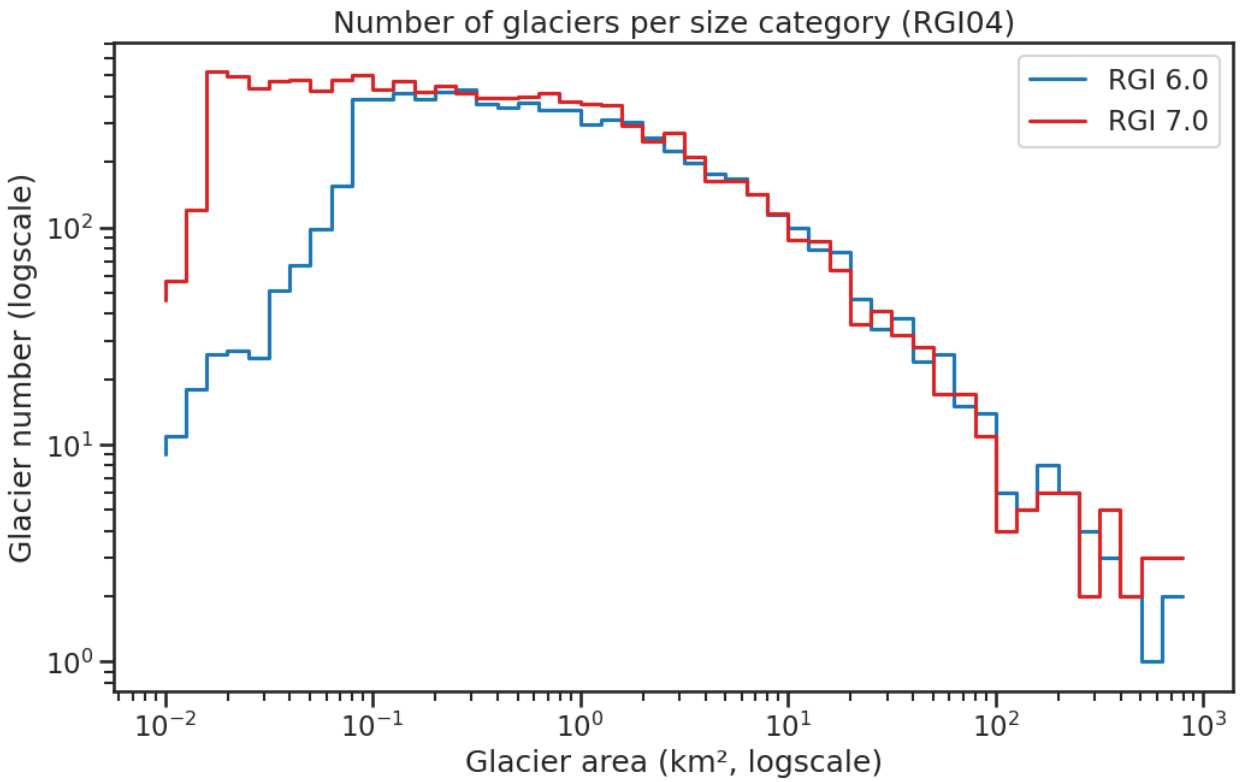


Fig. 5.17: Number of glaciers per size category (log-log scale).

Table: Terminus type statistics Regional number of glaciers (N) and area (km^2) per terminus type in RGI 7.0 and RGI 6.0. Note that the default designation in RGI 7.0 is now "Not assigned", while in RGI 6.0 lake-terminating glaciers and shelf-terminating glaciers were identified in some regions. The RGI region 19 is entirely labelled as "Not assigned" in RGI 7.0.

Value	Terminus type	RGI 7.0 (N)	RGI 6.0 (N)	RGI 7.0 (Area)	RGI 6.0 (Area)
0	Land-terminating	0	7347	0	37859
1	Marine-terminating	85	68	3342	3030
2	Lake-terminating	0	0	0	0
3	Shelf-terminating	0	0	0	0
9	Not assigned	10924	0	37196	0

Table: Surge type statistics Regional number of glaciers (N) and area (km^2) per surge type attribute in RGI 7.0 and RGI 6.0.

Value	Surge type	RGI 7.0 (N)	RGI 6.0 (N)	RGI 7.0 (Area)	RGI 6.0 (Area)
0	No evidence	11002	0	36536	0
1	Possible	0	0	0	0
2	Probable	6	2	3776	3823
3	Observed	1	0	227	0
9	Not assigned	0	7413	0	37065

Version history

Changes from Version 5.0 to 6.0 Seven pairs of glacier outlines in east-central Baffin Island were found to have spurious divides that were actually the edges of maps. These pairs were merged: the surviving members of each pair, with the deleted members in parentheses, are RGI60-04.00408 (04.00465); 04.00413 (04.00415); 04.00416 (04.00412) 04.00420 (04.00419); 04.00424 (04.00425); 04.00433 (04.00423); 04.00467 (04.00464).The source for hypsometry was changed from the ASTER GDEM2 to the ViewfinderPanoramas DEM3 (http://www.viewfinderpanoramas.org/).

Changes from Version 4.0 to 5.0 All glaciers in region 04-09, Labrador, were replaced with information from the inventory of Way *et al.* [2014].Links were added to 5 glaciers in the WGMS mass-balance database.

Changes from Version 3.2 to 4.0 Eight exterior GLIMSIds were replaced. Topographic and hypsometric attributes were added.Glacier 04.06811, which duplicated glacier 04.06813 in version 3.2, was removed.

Changes from Version 3.0 to 3.2 Glaciers were delineated from the glacier complexes using the delineation algorithm developed by Kienholz *et al.* [2013] and applied to the 1:250000 Canadian Digital Elevation Data (CDED). Some minor manual editing was done to remove obvious blunders.

Changes from Version 2.0 to 3.0 None.

Changes from Version 1.0 to Version 2.0 Outlines for 27 glaciers in Labrador (region 04-09) were added, provided by P. O'Callaghan, N. Barrand, F. Wyatt and M. Sharp, University of Alberta.

Version 1.0 Glacier complex outlines were compiled from 214 CanVec maps, a digital cartographic reference product of Natural Resources Canada. An additional 5500 km2 of glacier area in central Baffin Island not covered by Edition 9 of the CanVec data set were taken from an expanded inventory based on Paul and Kääb [2005] and Svoboda and Paul [2009]. All outlines in this expanded inventory were created from late-summer Landsat 7 ETM+ imagery acquired between 1999 and 2002. Of the CanVec maps, 13 were based on late-summer SPOT 5 imagery acquired between 2006–2010 and seven on 1958 or 1982 aerial photographs. A small fraction of ice coverage is missed by the Canvec dataset because of incorrect classification over debris-covered ice and supraglacial lakes. The misclassification is very noticeable for outlet glaciers where medial moraines are not identified as glacier ice. Glaciers were delineated with the algorithm of Kienholz *et al.* [2013] and edited manually where necessary.

5.6 05: Greenland Periphery

The region encompasses all glaciers not connected or only weakly connected to the ice sheet as defined by connectivity levels 0 and 1 in [Rastner *et al.*, 2012].

Subregions

- 05-01: Greenland Periphery

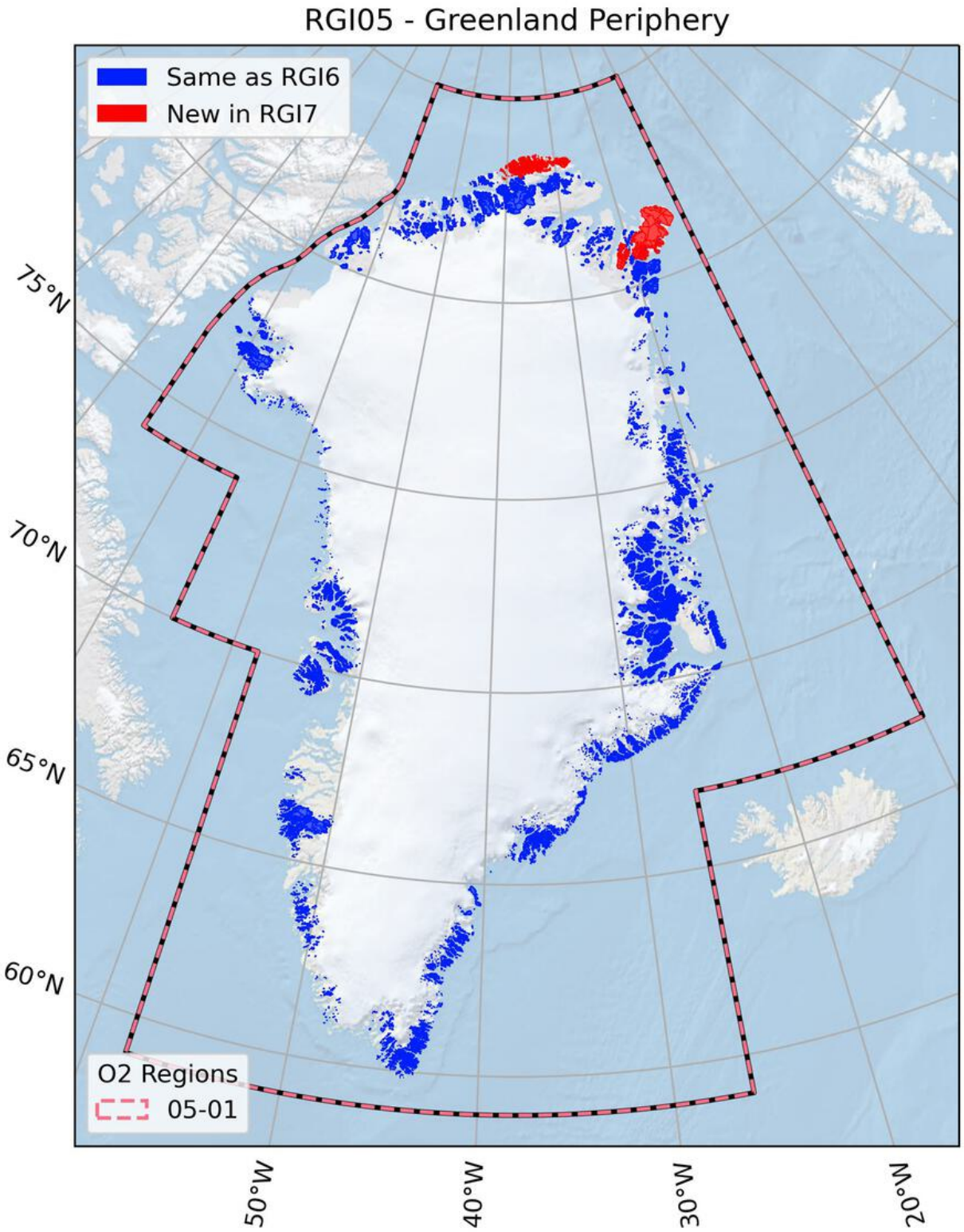


Fig. 5.18: Regional glacier area. Download high resolution version.

5.6.1 Changes from version 6.0 to 7.0

Northernmost tip of Greenland

RGI 6.0 glacier outlines in the very north of Greenland suffered from low quality due to their location outside the Landsat field of view. Therefore glaciers in two areas in the very north of Greenland were replaced by new outlines derived from orthoimages from 1978 provided by Korsgaard *et al.* [2016] and hillshade representations of the ArcticDEM. Some seasonal snow complicated outline detection at higher elevations; thus some overestimation of glacier area is likely. ASTER scenes closer to the target year (2000) were not considered since these are affected by clouds or seasonal snow, however, it was assumed that glacier area changes in this region between 1978 and 2000 are relatively small.

Flade Isblink Icecap

The Flade Isblink Icecap was not fully subdivided into individual glaciers in RGI 6.0. This was rectified in RGI 7.0 by adding ice divides.

Other changes

Glaciers with connectivity level 2 [Rastner *et al.*, 2012] **have been removed entirely from the RGI 7.0**, since they are typically not included in mass change assessments or projections of glaciers outside the ice sheet. This change removes a source of confusion when differentiating between glaciers and the ice sheet proper. See the "Version history" section below for a description of the connectivity levels and why they were included in previous versions.

5.6.2 Additional information

Data sources and analysts

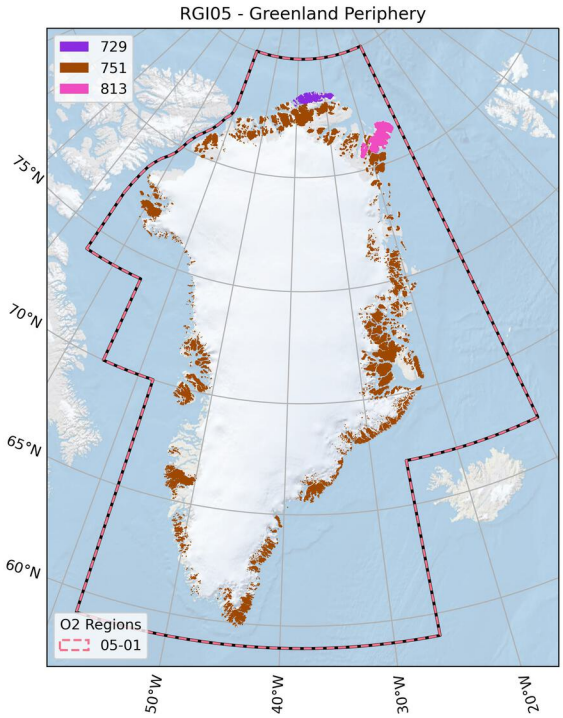


Fig. 5.19: Submission IDs used for this region Download high resolution version.

Glacier outline providers to GLIMS

This list includes the providers of the outlines used in the RGI 7.0 as generated automatically from the GLIMS outlines metadata. We acknowledge that the list may be incomplete due to omissions in the GLIMS database.

Submission 729 **Submitter**: Paul, Frank.**Number of outlines**: 715. **Area**: 3233.0km^2. **Release date**: 2021-07-12.**Analysts**: Paul, Frank; Rastner, Philipp.

Submission 751 **Submitter**: Cogley, Graham.**Number of outlines**: 19079. **Area**: 77020.3km^2. **Release date**: 2014-12-01.**Analysts**: Bolch, Tobias; Howat, Ian; LeBris, Raymond; Moelg, Nico; Negrete, A.; Paul, Frank; Rastner, Philipp.

Submission 813 **Submitter**: McNabb, Robert.**Number of outlines**: 200. **Area**: 10228.3km^2. **Release date**: 2023-02-01.**Analysts**: McNabb, Robert.

Reviewers Langley, Kirsty;

Regional statistics

Figure: Outlines source date

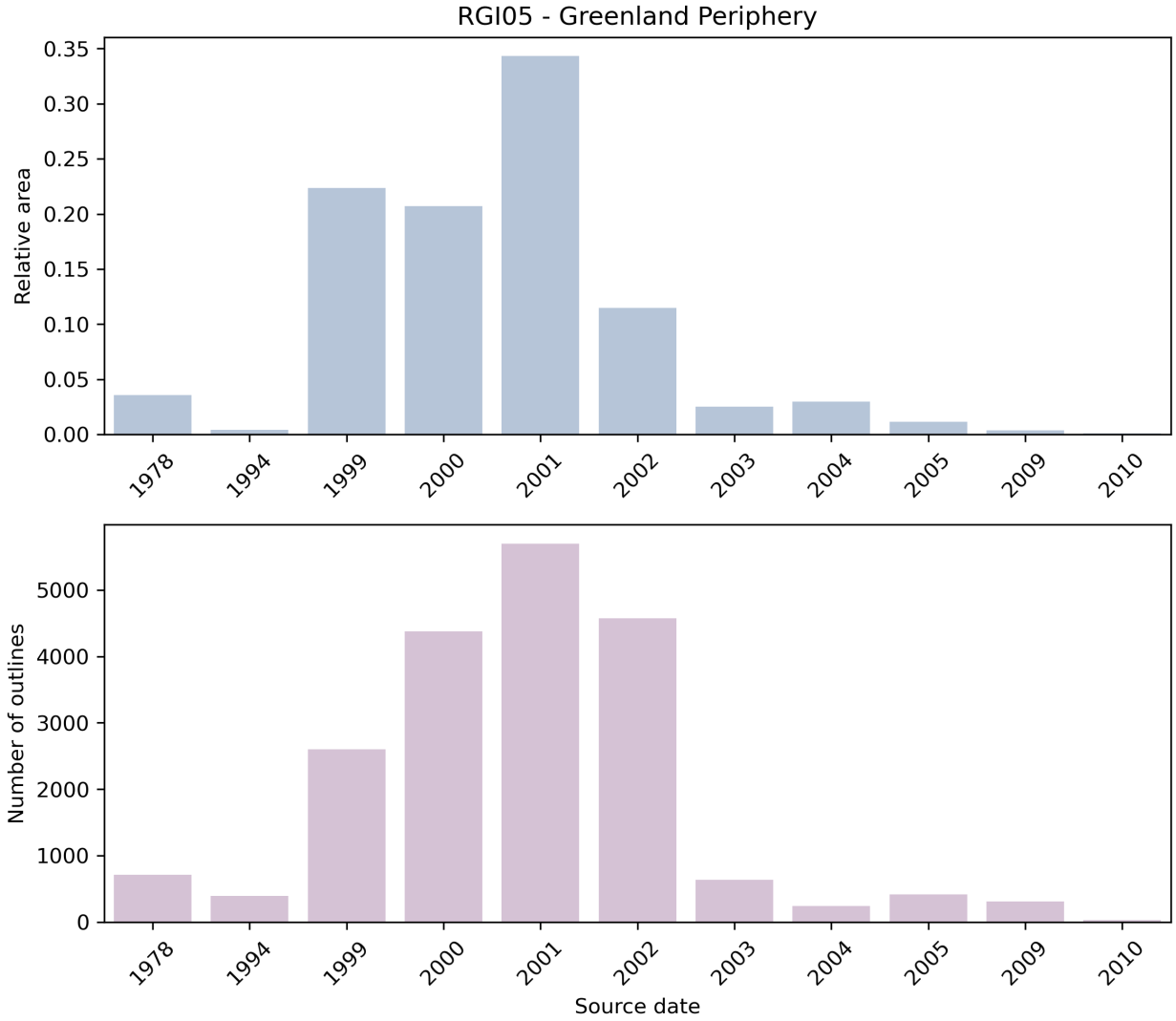


Fig. 5.20: Distribution of the outline dates per area (top) and number (bottom)

Figure: Glacier area histogram

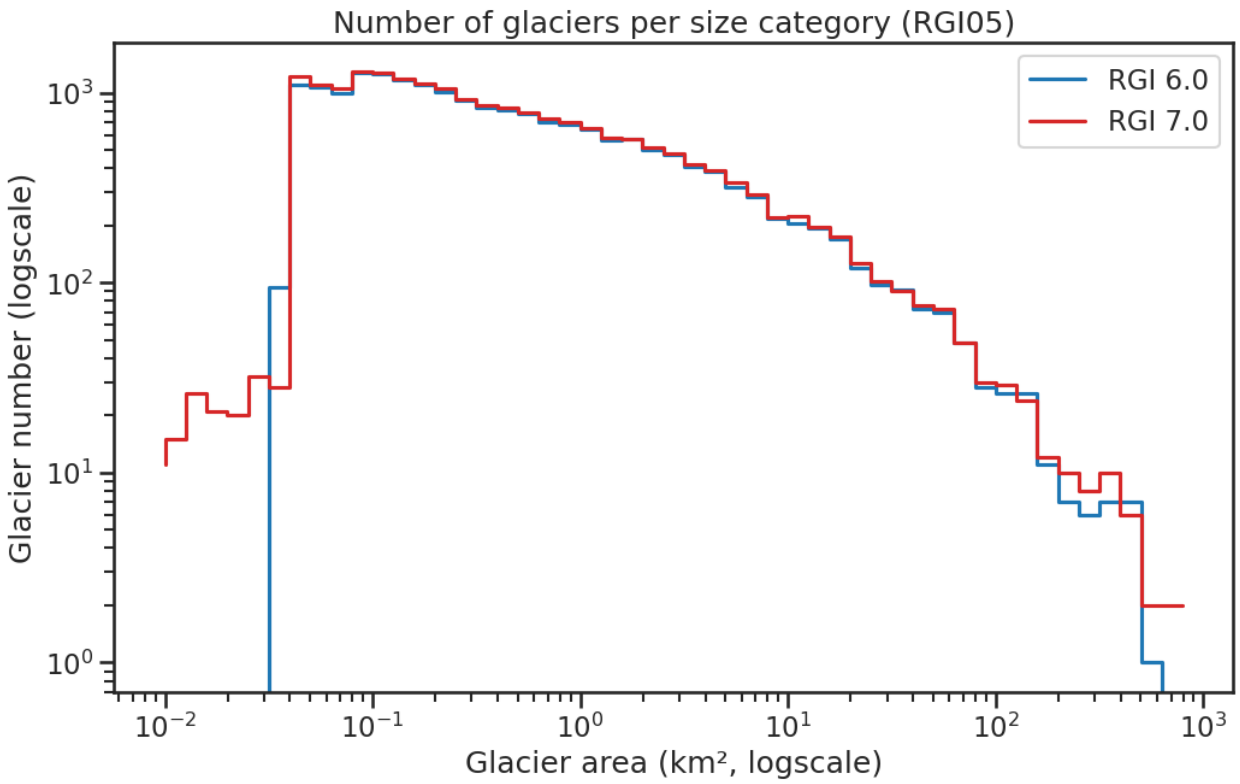


Fig. 5.21: Number of glaciers per size category (log-log scale).

Table: Terminus type statistics Regional number of glaciers (N) and area (km^2) per terminus type in RGI 7.0 and RGI 6.0. Note that the default designation in RGI 7.0 is now "Not assigned", while in RGI 6.0 lake-terminating glaciers and shelf-terminating glaciers were identified in some regions. The RGI region 19 is entirely labelled as "Not assigned" in RGI 7.0.

Value	Terminus type	RGI 7.0 (N)	RGI 6.0 (N)	RGI 7.0 (Area)	RGI 6.0 (Area)
0	Land-terminating	0	18550	0	58611
1	Marine-terminating	507	756	25980	31106
2	Lake-terminating	0	0	0	0
3	Shelf-terminating	0	0	0	0
9	Not assigned	19487	0	64502	0

Table: Surge type statistics Regional number of glaciers (N) and area (km^2) per surge type attribute in RGI 7.0 and RGI 6.0.

Value	Surge type	RGI 7.0 (N)	RGI 6.0 (N)	RGI 7.0 (Area)	RGI 6.0 (Area)
0	No evidence	19901	0	88407	0
1	Possible	1	0	1	0
2	Probable	71	74	1069	1172
3	Observed	21	14	1005	682
9	Not assigned	0	19218	0	87863

Version history

Changes from Version 5.0 to 6.0 None.

Changes from Version 4.0 to 5.0 A link was added to the record of Mittivakkat Glacier in the WGMS mass-balance database.

Changes from Version 3.2 to 4.0 46 exterior GLIMSIds were replaced. Topographic and hypsometric attributes were added.19 glaciers appeared twice in version 3.2. One member of each such pair was removed.

Changes from Version 3.0 to 3.2 A planimetric offset was discovered in parts of Greenland in version 3.0. This offset was repaired.

Changes from Version 2.0 to Version 3.0 Coverage of Greenland is new in version 3.0, and is described in detail by Rastner *et al.* [2012]. In all, 73 satellite images were processed. Glacier complexes were subdivided using a flowshed algorithm. An enhanced form of the algorithm for identifying glaciers other than the Greenland Ice Sheet was developed. In addition to the connectivity rule described below (see Version 1.0), a "topographic heritage rule" was added. Glaciers adjoining the ice sheet were first assigned to level CL2 (strongly connected) or level CL1 (weakly connected). Unassigned glaciers adjoining one or more level-2 glaciers were then assigned the same connectivity, and likewise for glaciers adjoining level-1 glaciers. The remaining unassigned glaciers, those not connected to the ice sheet at all, were assigned to level CL0.Glaciers of all three connectivity levels are included in the RGI. Rastner et al. recommend that CL2 glaciers be treated as part of the ice sheet, for which purpose they can be identified using Connect. The total extent of CL0 and CL1 glaciers, 89731 km2, is well in excess of any previous estimate of the extent of glaciers in the Greenland periphery. Adding the CL2 glaciers and the ice sheet, Rastner et al. estimate a glacierized area for Greenland as a whole of 1.808±0.004 × 106 km2. This lies between the two estimates suggested by Kargel *et al.* [2012], 1.801±0.016 × 106 km2 and 1.824±0.016 × 106 km2; these estimates are statistically indistinguishable from but more uncertain than that of Rastner et al.

Changes from Version 1.0 to Version 2.0 None.

Version 1.0 Distinguishing between what is considered ice sheet versus glaciers is a challenge, and depends on the scientific application. While the distinction is clear for the numerous fully detached glaciers, there are several regions where, although there is a physical connection to the main ice sheet, the ice mass is either a valley glacier in mountainous terrain, or it forms its own ice dome and is largely uncoupled from the ice sheet dynamics. Therefore, for applications such as extrapolation of laser altimetry data, some researchers consider that such ice masses should be categorized as glaciers rather than as part of the ice sheet.In the RGI, all ice masses with a possible but uncertain drainage divide are assigned to the ice sheet (e.g. on the Geikie Plateau), and all others to the local (or peripheral) glaciers. The latter are either not connected to the ice sheet at all, clearly separable (e.g. by mountain ridges) in the accumulation region, or only in contact with ice sheet outlets in the ablation region.Indeed, there is room for discussion on individual decisions, but for the purpose of the RGI we just need to start somewhere. The separation in the accumulation area is done along drainage divides derived from DEM-based watershed analysis.The glaciers north of ~81°N were not available from Landsat data and were provided by the Greenland Mapping Project [Howat *et al.*, 2014].The semi-automated glacier mapping applied to the 64 Landsat scenes that were processed is based on a band ratio (ETM+ Band 3/Band 5) with an additional threshold in band 1 for better mapping of glacier areas in cast shadow. It is based on Paul and Kääb [2005] and described for a part of western Greenland in Citterio *et al.* [2009]. Debris-covered glacier parts as well as wrongly classified sea ice, icebergs or lakes were corrected manually in the vector domain. A 3 by 3 median filter is applied for image smoothing and glaciers smaller than 0.05 km2 are not considered. Wrongly classified regions with seasonal snow could not always be corrected.

5.7 06: Iceland

This region encompasses all glaciers in Iceland.

Subregions

- 06-01: Iceland

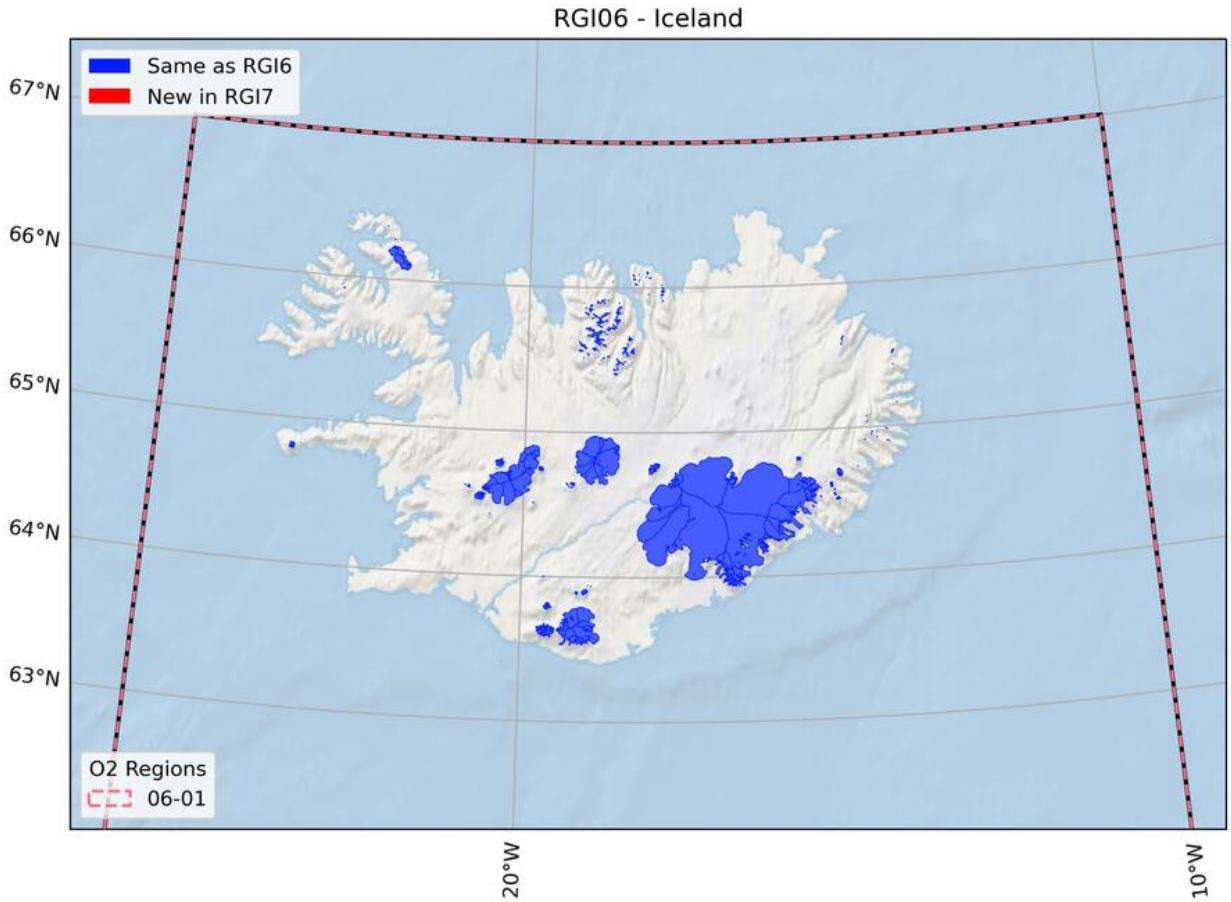


Fig. 5.22: Regional glacier area. Download high resolution version.

5.7.1 Changes from version 6.0 to 7.0

None.

5.7.2 Additional information

Data sources and analysts

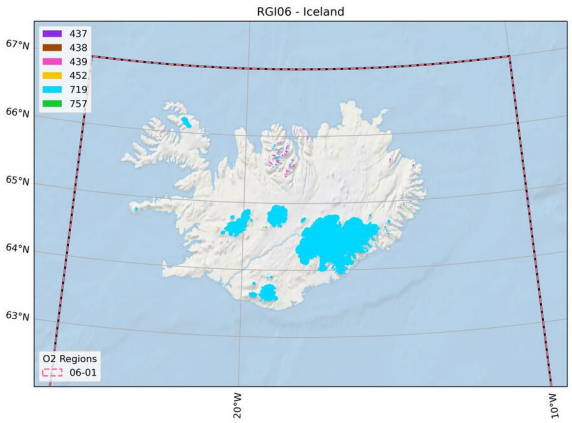


Fig. 5.23: Submission IDs used for this region Download high resolution version.

Glacier outline providers to GLIMS

This list includes the providers of the outlines used in the RGI 7.0 as generated automatically from the GLIMS outlines metadata. We acknowledge that the list may be incomplete due to omissions in the GLIMS database.

Submission 437 Submitter: Sigurdsson, Oddur.**Number of outlines**: 26. **Area**: 7.1km^2. **Release date**: 2007-03-21.**Analysts**: Sigurdsson, Oddur.

Submission 438 Submitter: Sigurdsson, Oddur.**Number of outlines**: 5. **Area**: 0.8km^2. **Release date**: 2007-03-21.**Analysts**: Sigurdsson, Oddur.

Submission 439 Submitter: Sigurdsson, Oddur.**Number of outlines**: 154. **Area**: 95.2km^2. **Release date**: 2007-03-21.**Analysts**: Sigurdsson, Oddur.

Submission 452 Submitter: Sigurdsson, Oddur.**Number of outlines**: 16. **Area**: 7.0km^2. **Release date**: 2007-03-21.**Analysts**: Sigurdsson, Oddur.

Submission 719 Submitter: Sigurdsson, Oddur.**Number of outlines**: 365. **Area**: 10947.5km^2. **Release date**: 2014-12-01.**Analysts**: Sigurdsson, Oddur.

Submission 757 Submitter: Sigurdsson, Oddur.**Number of outlines**: 2. **Area**: 2.1km^2. **Release date**: 2021-10-10.**Analysts**: Sigurdsson, Oddur.

Reviewers None;

Regional statistics

Figure: Outlines source date

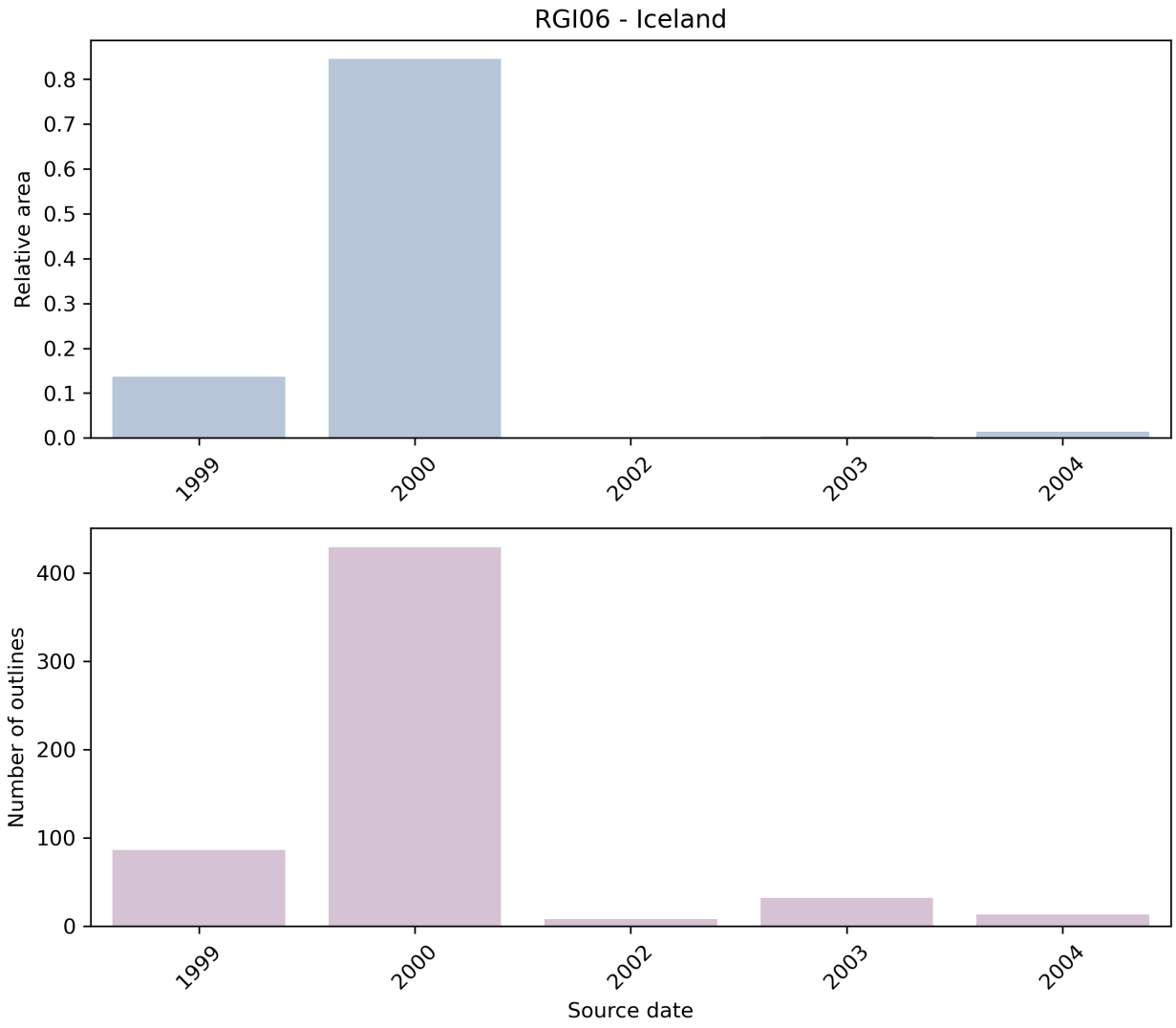


Fig. 5.24: Distribution of the outline dates per area (top) and number (bottom)

Figure: Glacier area histogram

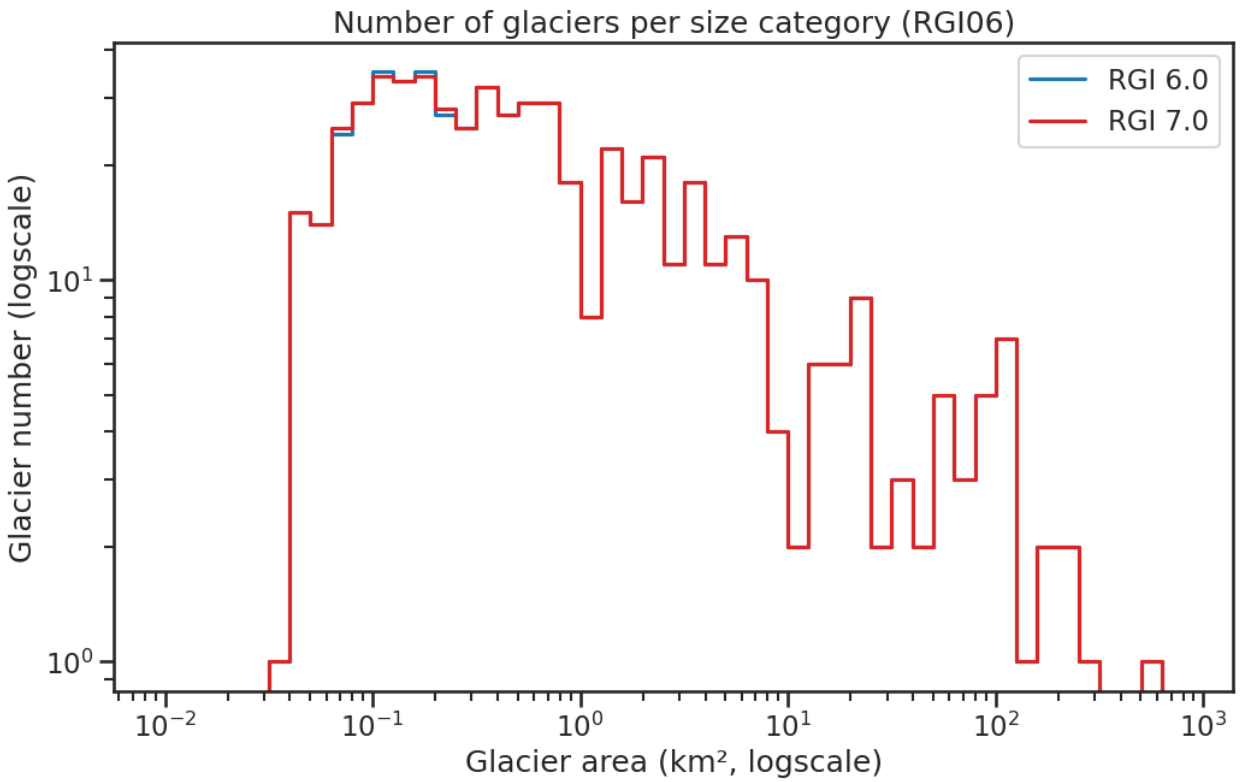


Fig. 5.25: Number of glaciers per size category (log-log scale).

Table: Terminus type statistics Regional number of glaciers (N) and area (km^2) per terminus type in RGI 7.0 and RGI 6.0. Note that the default designation in RGI 7.0 is now "Not assigned", while in RGI 6.0 lake-terminating glaciers and shelf-terminating glaciers were identified in some regions. The RGI region 19 is entirely labelled as "Not assigned" in RGI 7.0.

Value	Terminus type	RGI 7.0 (N)	RGI 6.0 (N)	RGI 7.0 (Area)	RGI 6.0 (Area)
0	Land-terminating	0	568	0	11060
1	Marine-terminating	1	0	1068	0
2	Lake-terminating	0	0	0	0
3	Shelf-terminating	0	0	0	0
9	Not assigned	567	0	9992	0

Table: Surge type statistics Regional number of glaciers (N) and area (km^2) per surge type attribute in RGI 7.0 and RGI 6.0.

Value	Surge type	RGI 7.0 (N)	RGI 6.0 (N)	RGI 7.0 (Area)	RGI 6.0 (Area)
0	No evidence	544	545	3169	3195
1	Possible	0	1	0	1
2	Probable	0	1	0	130
3	Observed	24	21	7891	7734
9	Not assigned	0	0	0	0

Version history

Changes from Version 5.0 to 6.0 The source for hypsometry was changed from the ASTER GDEM2 to the ViewfinderPanoramas DEM3 (http://www.viewfinderpanoramas.org/).

Changes from Version 4.0 to 5.0 Links were added to 9 glaciers in the WGMS mass-balance database.

Changes from Version 3.2 to 4.0 One exterior GLIMSId was replaced. Topographic and hypsometric attributes were added.

Changes from Version 3.0 to 3.2 Glaciers were delineated from the glacier complexes.

Changes from Version 2.0 to Version 3.0 None.

Changes from Version 1.0 to Version 2.0 None.

Version 1.0 Outlines of glacier complexes in Iceland were added to the GLIMS database by O. Sigurðsson and extracted therefrom by J.G. Cogley, who merged nunataks with the glacier complexes containing them. Most outlines were acquired from 1999–2004 ASTER and SPOT5 imagery; some in the north of Iceland were acquired from oblique aerial photographs.

5.8 07: Svalbard and Jan Mayen

This region encompasses all glaciers in Svalbard and Jan Mayen.

Subregions

- 07-01: Svalbard
- 07-02: Jan Mayen

5.8.1 Changes from version 6.0 to 7.0

Jan Mayen

The RGI 6.0 glacier outlines referred to 1975, and therefore were replaced by new outlines closer to the target year 2000. Outlines were mapped from a Landsat 7 ETM+ scene (217-010) acquired on 13 September 2002 with the band ratio method (panchromatic band divided by the resampled SWIR band) and some manual corrections. New ice divides were derived from a flow direction grid that was calculated from the ArcticDEM (5 m mosaic).

5.8.2 Additional information

Data sources and analysts

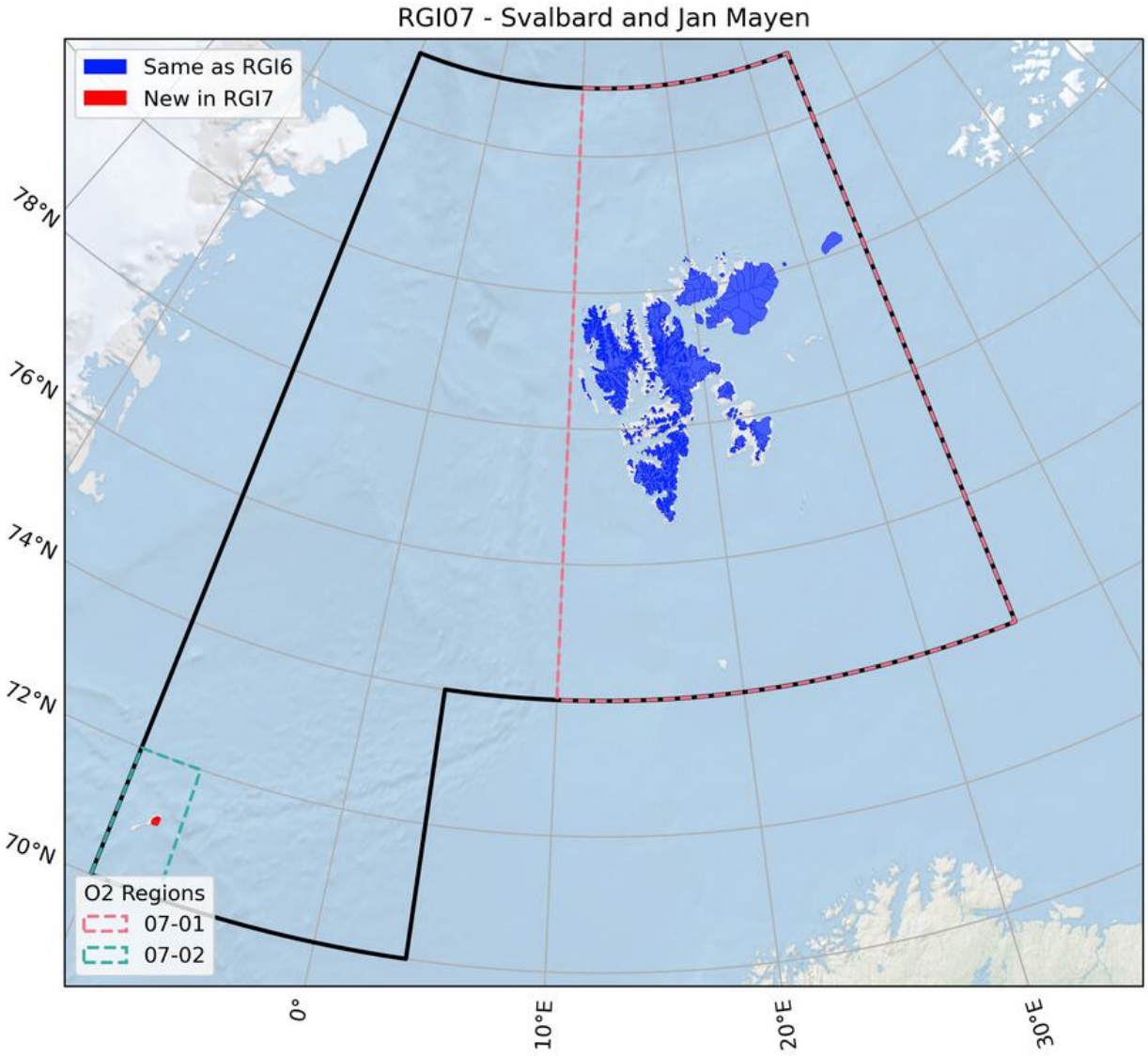


Fig. 5.26: Regional glacier area. Download high resolution version.

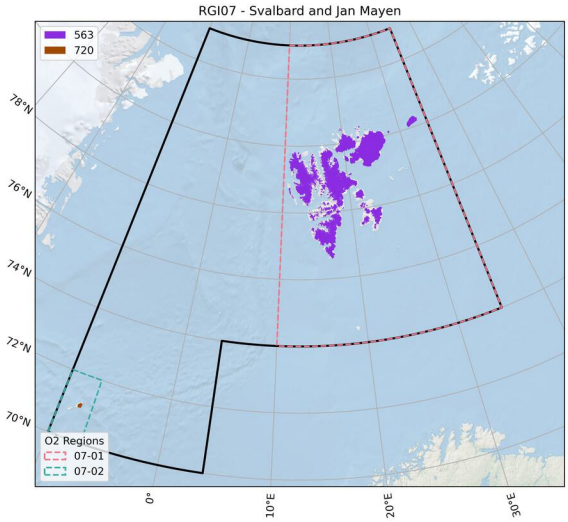


Fig. 5.27: Submission IDs used for this region Download high resolution version.

Glacier outline providers to GLIMS

This list includes the providers of the outlines used in the RGI 7.0 as generated automatically from the GLIMS outlines metadata. We acknowledge that the list may be incomplete due to omissions in the GLIMS database.

Submission 563 **Submitter**: Koenig, Max.**Number of outlines**: 1583. **Area**: 33841.4km^2. **Release date**: 2012-12-04.**Analysts**: Koenig, Max; Nuth, Chris.

Submission 720 **Submitter**: Paul, Frank.**Number of outlines**: 83. **Area**: 117.5km^2. **Release date**: 2021-08-03.**Analysts**: Paul, Frank.

Reviewers None;

Regional statistics

Figure: Outlines source date

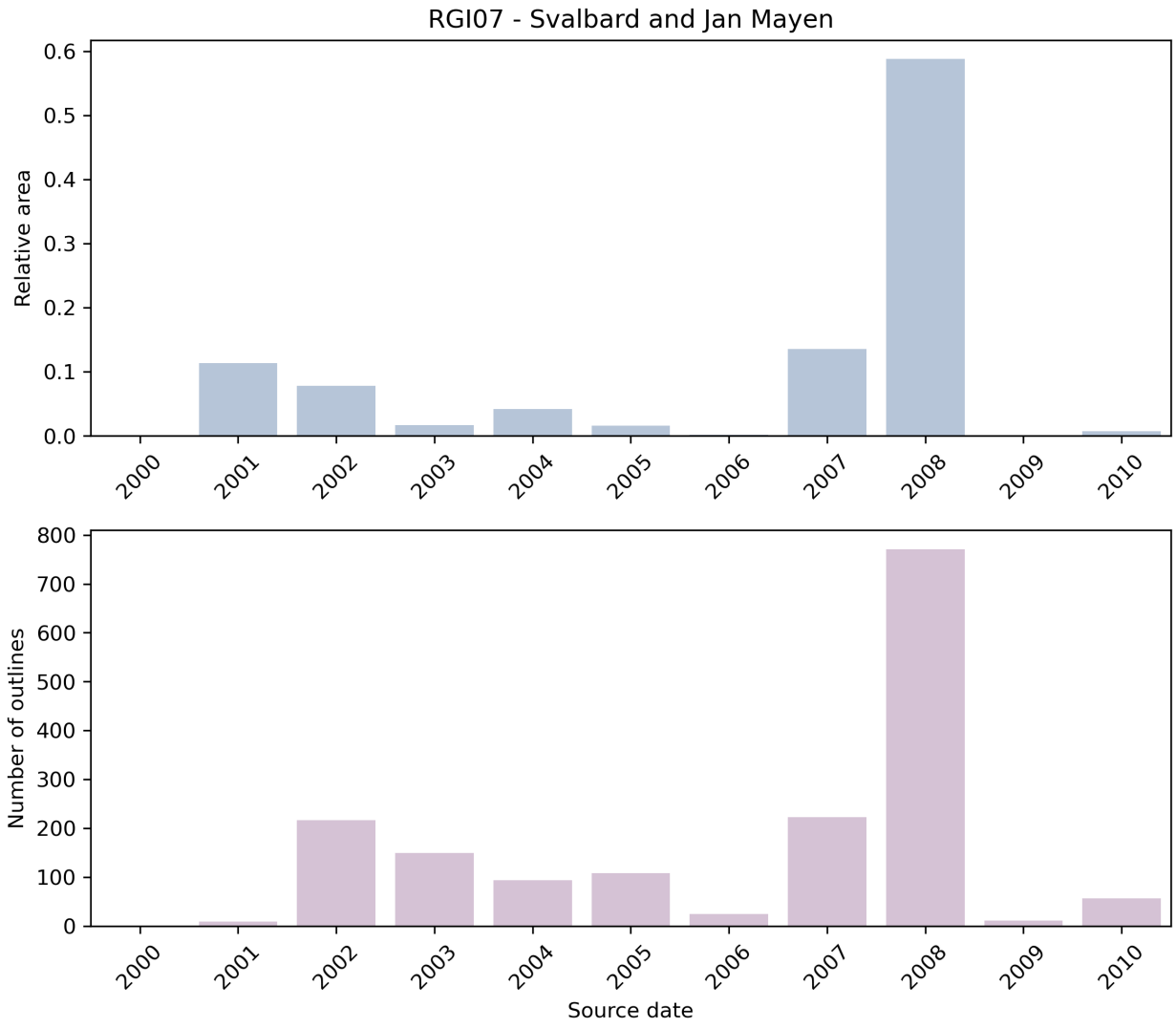


Fig. 5.28: Distribution of the outline dates per area (top) and number (bottom)

Figure: Glacier area histogram

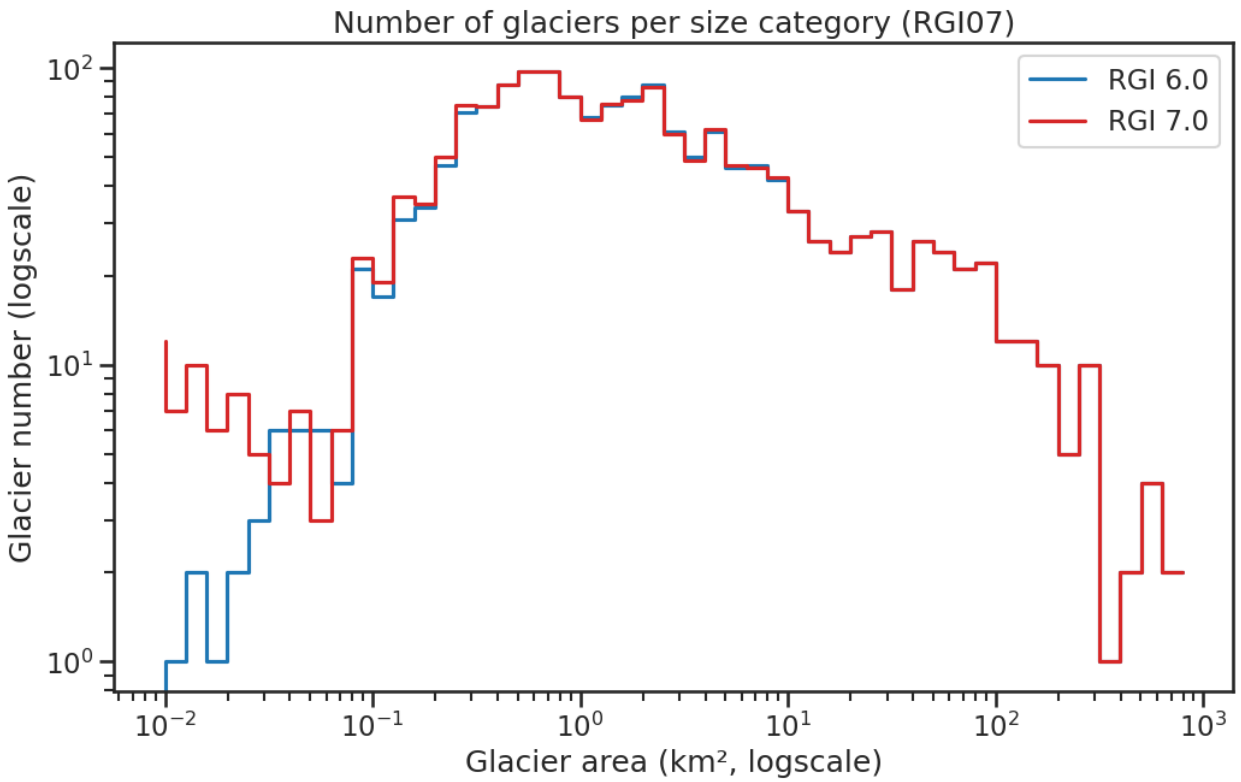


Fig. 5.29: Number of glaciers per size category (log-log scale).

Table: Terminus type statistics Regional number of glaciers (N) and area (km^2) per terminus type in RGI 7.0 and RGI 6.0. Note that the default designation in RGI 7.0 is now "Not assigned", while in RGI 6.0 lake-terminating glaciers and shelf-terminating glaciers were identified in some regions. The RGI region 19 is entirely labelled as "Not assigned" in RGI 7.0.

Value	Terminus type	RGI 7.0 (N)	RGI 6.0 (N)	RGI 7.0 (Area)	RGI 6.0 (Area)
0	Land-terminating	0	1474	0	19069
1	Marine-terminating	196	141	24051	14890
2	Lake-terminating	0	0	0	0
3	Shelf-terminating	0	0	0	0
9	Not assigned	1470	0	9908	0

Table: Surge type statistics Regional number of glaciers (N) and area (km^2) per surge type attribute in RGI 7.0 and RGI 6.0.

Value	Surge type	RGI 7.0 (N)	RGI 6.0 (N)	RGI 7.0 (Area)	RGI 6.0 (Area)
0	No evidence	1403	1324	16656	17259
1	Possible	103	103	2879	3256
2	Probable	35	37	2276	3581
3	Observed	125	103	12148	9741
9	Not assigned	0	48	0	121

Version history

Changes from Version 5.0 to 6.0 The source for hypsometry was changed from the ASTER GDEM2 to the ViewfinderPanoramas DEM3 (http://www.viewfinderpanoramas.org/).

Changes from Version 4.0 to 5.0 Links were added to 9 glaciers in the WGMS mass-balance database.

Changes from Version 3.2 to 4.0 One exterior GLIMSId was replaced. Topographic and hypsometric attributes were added.In earlier versions, dates were omitted for 119 glaciers (total area 9,770 km2). They have now been restored from the inventory of Nuth *et al.* [2013]. The new dates were extracted from file `cryoclim_gao_sj_2001-2010.zip`, downloaded from https://data.npolar.no/dataset/89f430f8-862f-11e2-8036-00505bad0004. The newly-dated glaciers, RGI40-07.01449 to RGI40-07.01567, were matched on-screen one by one between RGI 4.0 and the Nuth shapefile.

Changes from Version 3.0 to 3.2 None.

Changes from Version 2.0 to Version 3.0 None.

Changes from Version 1.0 to Version 2.0 Outlines of the glaciers on Jan Mayen (07-02) were digitized by J.G. Cogley from Hagen *et al.* [1993].

Version 1.0 The Svalbard inventory is described in more detail by Nuth *et al.* [2013].Three primary data sets are used. The main sources are SPOT5-HRS DEMs and orthoimages provided within the framework of the IPY-SPIRIT (SPOT 5 stereoscopic survey of Polar Ice: Reference Images and Topographies) Project [Korona *et al.*, 2009]. The SPOT5-HRS collects 5m panchromatic stereo images that are stereoscopically processed into 40m DEMs, then used to generate the orthoimages. Five SPIRIT scene acquisitions from 2007-2008 cover 71% of the glacier area. The secondary source is 23 scenes from the ASTER sensor in the form of automatically generated DEMs and orthoimages (AST14DMO products downloaded from NASA) covering 16% of the glacier area. Cloud-free scenes are not available for 2007-2008, and therefore data from as early as 2001 are used. For less than 14% of the glacier area, a suitable SPOT5-HRS or ASTER scene was not available. For these glaciers, 11 orthorectified Landsat scenes are used. Furthermore, additional Landsat and ASTER scenes are used to aid digitization decisions about the seasonal snow cover.The original glacier delineation and glacier identification system is based on the Hagen *et al.* [1993] atlas, which conforms to WGI standards but is only available as a hard copy. Therefore, digitized national datasets are the base glacier masks from which to begin the inventory [König *et al.*, 2014]. From this original dataset, we manually re-delineated the individual glacier basins based upon the Hagen *et al.* [1993] Atlas and updated by trimming the front position and the lateral edges below the ELA. Since the original national dataset was derived by cartographers, many of the mask segments above the ELA contained snow covered valley walls and gullies (not perennially snow covered). These are, to the best of our ability, clipped from the masks by visually analyzing the recent satellite archives of ASTER and Landsat.

5.9 08: Scandinavia

This region encompasses all glaciers in Scandinavia. Glaciers on Svalbard are included in region 07.

Subregions

- 08-01: North Scandinavia
- 08-02: Southwest Scandinavia
- 08-03: Southeast Scandinavia

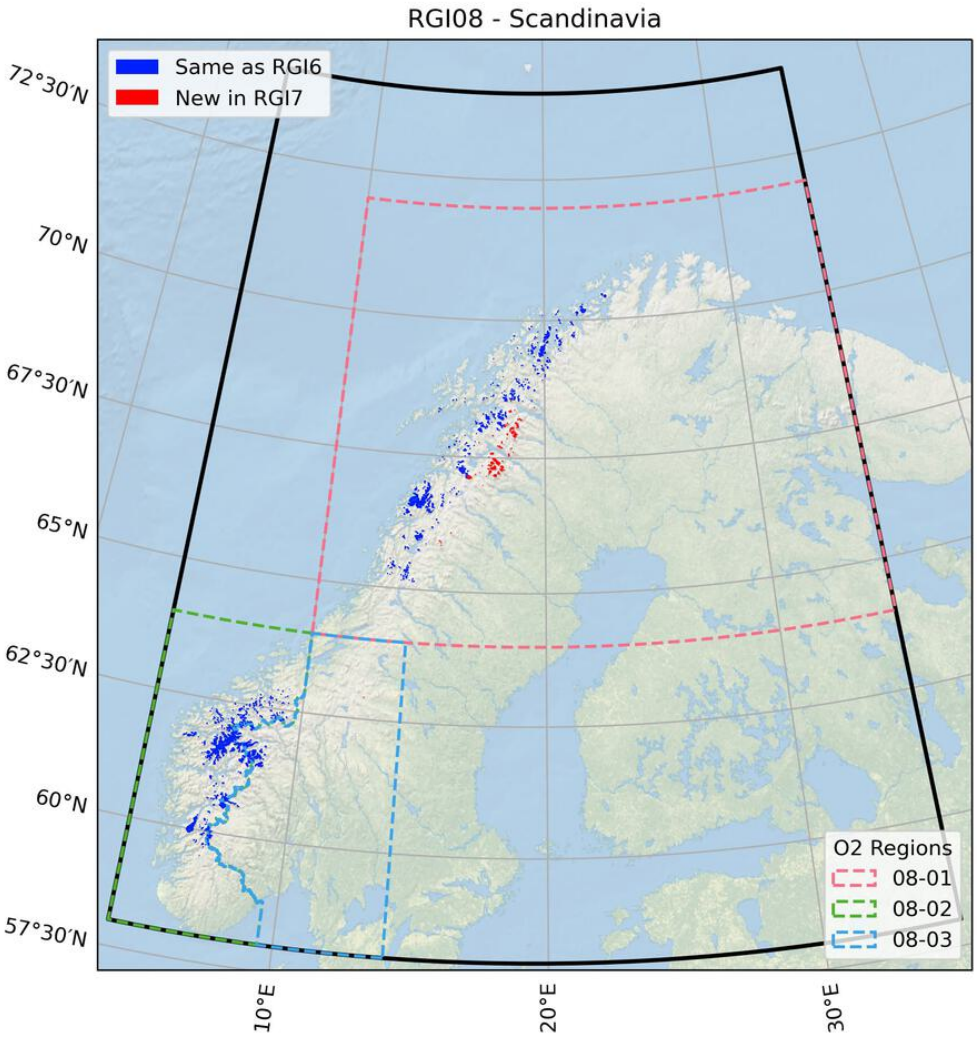


Fig. 5.30: Regional glacier area. Download high resolution version.

5.9.1 Changes from version 6.0 to 7.0

Kebnekaise massif in Sweden

All glaciers near the Kebnekaise massif have been corrected for a map projection shift. Four "nominal glaciers" (glaciers represented by a circle since no outlines were available) in the east of the region were deleted, as they do not appear to be glaciers.

5.9.2 Additional information

Data sources and analysts

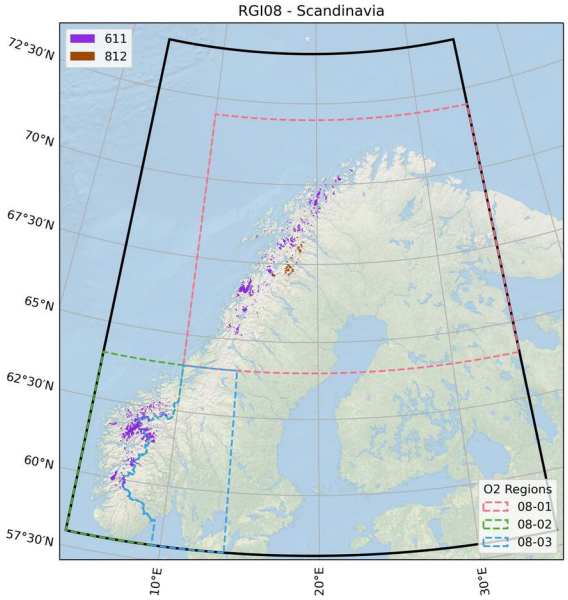


Fig. 5.31: Submission IDs used for this region Download high resolution version.

Glacier outline providers to GLIMS

This list includes the providers of the outlines used in the RGI 7.0 as generated automatically from the GLIMS outlines metadata. We acknowledge that the list may be incomplete due to omissions in the GLIMS database.

Submission 611 **Submitter**: Winsvold, Solveig Havstad.**Number of outlines**: 3141. **Area**: 2674.8km^2. **Release date**: 2012-12-13.**Analysts**: Andreassen, Liss Marie; Winsvold, Solveig Havstad.

Submission 812 **Submitter**: Frank, Thomas.**Number of outlines**: 269. **Area**: 273.0km^2. **Release date**: 2023-01-02.**Analysts**: Brown, Ian; Frank, Thomas; Hansson, Erik.

Reviewers Mannerfelt, Erik;

Regional statistics

Figure: Outlines source date

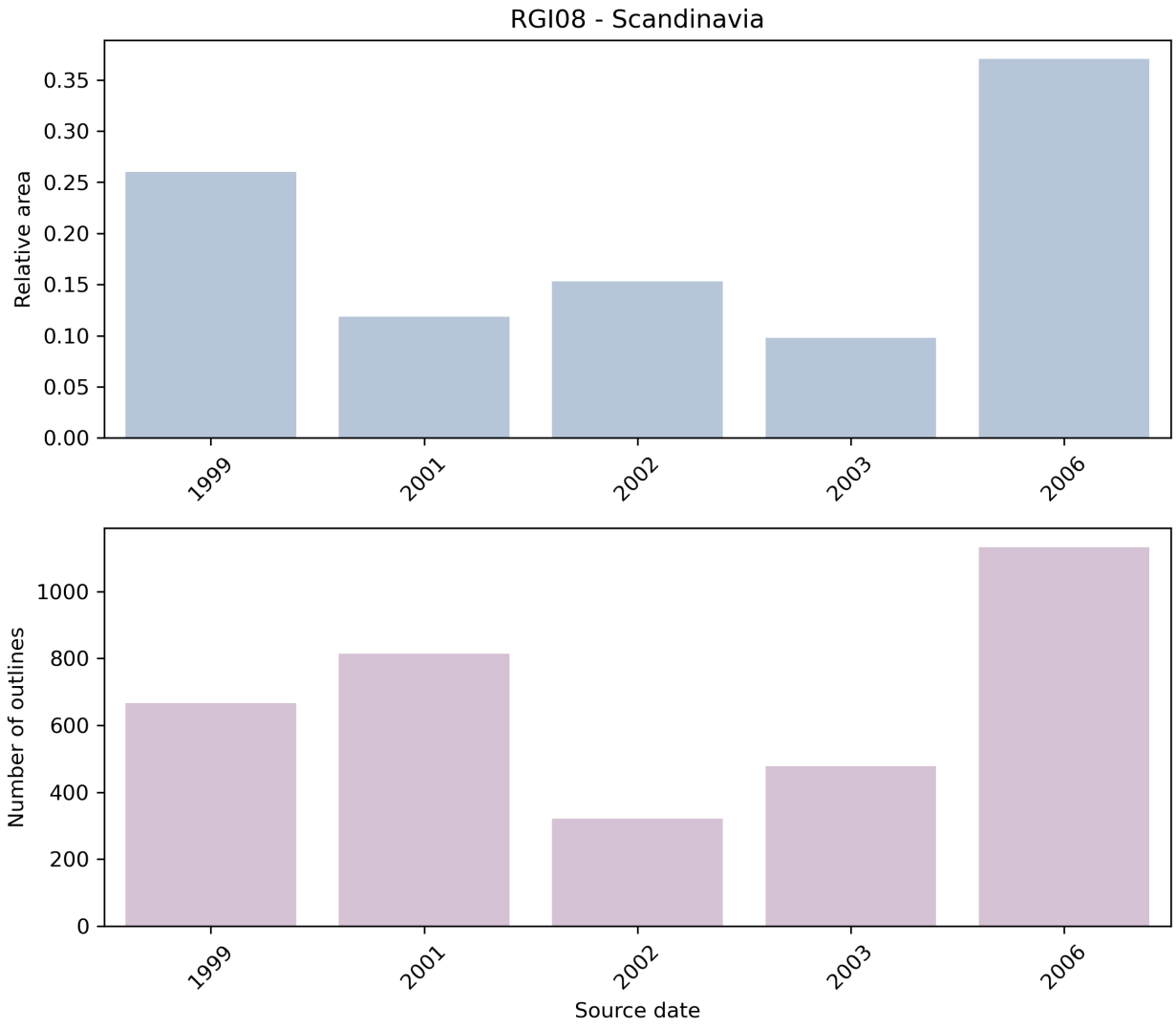


Fig. 5.32: Distribution of the outline dates per area (top) and number (bottom)

Figure: Glacier area histogram

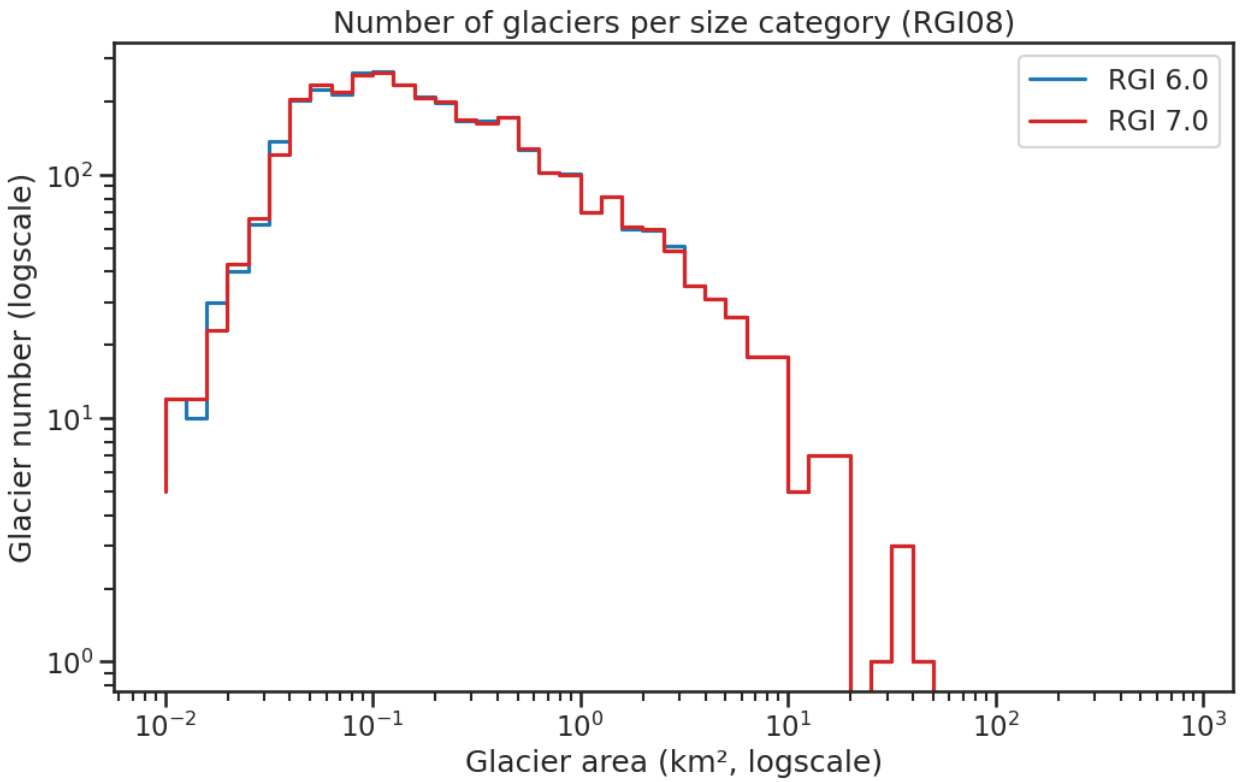


Fig. 5.33: Number of glaciers per size category (log-log scale).

Table: Terminus type statistics Regional number of glaciers (N) and area (km^2) per terminus type in RGI 7.0 and RGI 6.0. Note that the default designation in RGI 7.0 is now "Not assigned", while in RGI 6.0 lake-terminating glaciers and shelf-terminating glaciers were identified in some regions. The RGI region 19 is entirely labelled as "Not assigned" in RGI 7.0.

Value	Terminus type	RGI 7.0 (N)	RGI 6.0 (N)	RGI 7.0 (Area)	RGI 6.0 (Area)
0	Land-terminating	0	3417	0	2949
1	Marine-terminating	0	0	0	0
2	Lake-terminating	0	0	0	0
3	Shelf-terminating	0	0	0	0
9	Not assigned	3410	0	2948	0

Table: Surge type statistics Regional number of glaciers (N) and area (km^2) per surge type attribute in RGI 7.0 and RGI 6.0.

Value	Surge type	RGI 7.0 (N)	RGI 6.0 (N)	RGI 7.0 (Area)	RGI 6.0 (Area)
0	No evidence	3410	0	2948	0
1	Possible	0	0	0	0
2	Probable	0	0	0	0
3	Observed	0	0	0	0
9	Not assigned	0	3417	0	2949

Version history

Changes from Version 5.0 to 6.0 Exact dates were obtained for Norwegian glaciers from information submitted to GLIMS by L.M. Andreassen after the release of RGI version 1.0; see Andreassen *et al.* [2012]. A further 885 glaciers, mostly small, were added from the same source. The Swedish and Norwegian parts of Salajekna (RGI60-08.03553), area 26.8 km^2, were merged.The source for hypsometry was changed from the ASTER GDEM2 to the ViewfinderPanoramas DEM3 (http://www.viewfinderpanoramas.org/).

Changes from Version 4.0 to 5.0 Links were added to 24 glaciers in the WGMS mass-balance database.

Changes from Version 3.2 to 4.0 Four exterior GLIMSIds were replaced. Topographic and hypsometric attributes were added.

Changes from Version 3.0 to 3.2 None.

Changes from Version 2.0 to Version 3.0 Glaciers were delineated from glacier complexes.

Changes from Version 1.0 to Version 2.0 Four glaciers in the Khibiny Mountains of the Kola Peninsula (08-02) were added as nominal circles from WGI-XF.

Version 1.0 The glacier outlines for Norway are based on Landsat (TM and ETM+) imagery from 1999-2006.The Swedish glacier outlines use imagery from SPOT5 and SPOT4 (dates not provided). In some regions these outlines were updated against September 2008 Swedish Land Survey imagery available on Google Earth.The glacier mapping is a contribution to the CryoClim and GloGlacier projects and is documented in Andreassen *et al.* [2012] for whole of Norway. Mapping of subregions is described in Andreassen *et al.* [2008] for Jotunheimen, Paul and Andreassen [2009] for Svartisen, and Paul *et al.* [2011] for the Jostedalsbreen region.

5.10 09: Russian Arctic

This region encompasses all glaciers on the islands in the Russian Arctic including Novaya Zemlya, Severnaya Zemlya, Franz Josef Land, Ushakov Island and Victoria Island.

Subregions

- 09-01: Franz Josef Land
- 09-02: Novaya Zemlya
- 09-03: Severnaya Zemlya

5.10.1 Changes from version 6.0 to 7.0

Basin divides were corrected for three outlet glaciers on the northwest side of Novaya Zemlya (`RGI60-09.00741`, `RGI60-09.00743`, `RGI60-09.00744`).

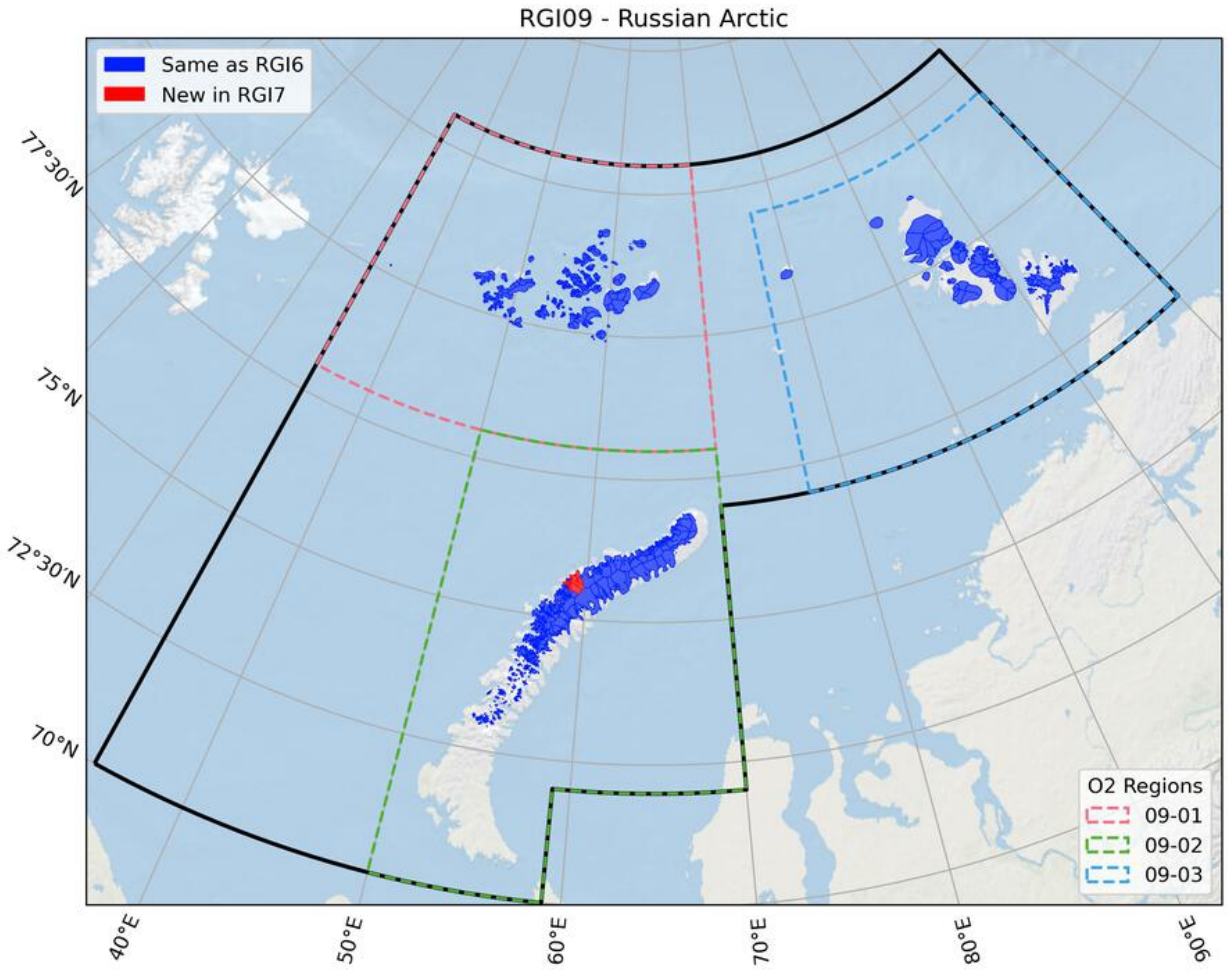


Fig. 5.34: Regional glacier area. Download high resolution version.

5.10.2 Additional information

Data sources and analysts

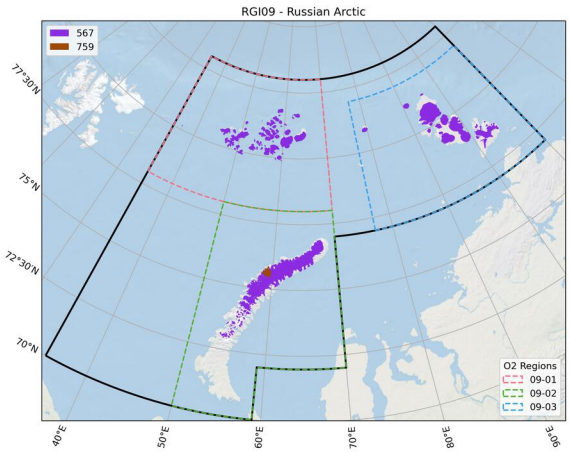


Fig. 5.35: Submission IDs used for this region Download high resolution version.

Glacier outline providers to GLIMS

This list includes the providers of the outlines used in the RGI 7.0 as generated automatically from the GLIMS outlines metadata. We acknowledge that the list may be incomplete due to omissions in the GLIMS database.

Submission 567 **Submitter**: Koenig, Max.**Number of outlines**: 1066. **Area**: 50753.2km^2. **Release date**: 2013-03-25.**Analysts**: Moholdt, Geir.

Submission 759 **Submitter**: Kochtitzky, William.**Number of outlines**: 3. **Area**: 841.8km^2. **Release date**: 2021-09-09.**Analysts**: Kochtitzky, William.

Reviewers Kochtitzky, William;

Regional statistics

Figure: Outlines source date

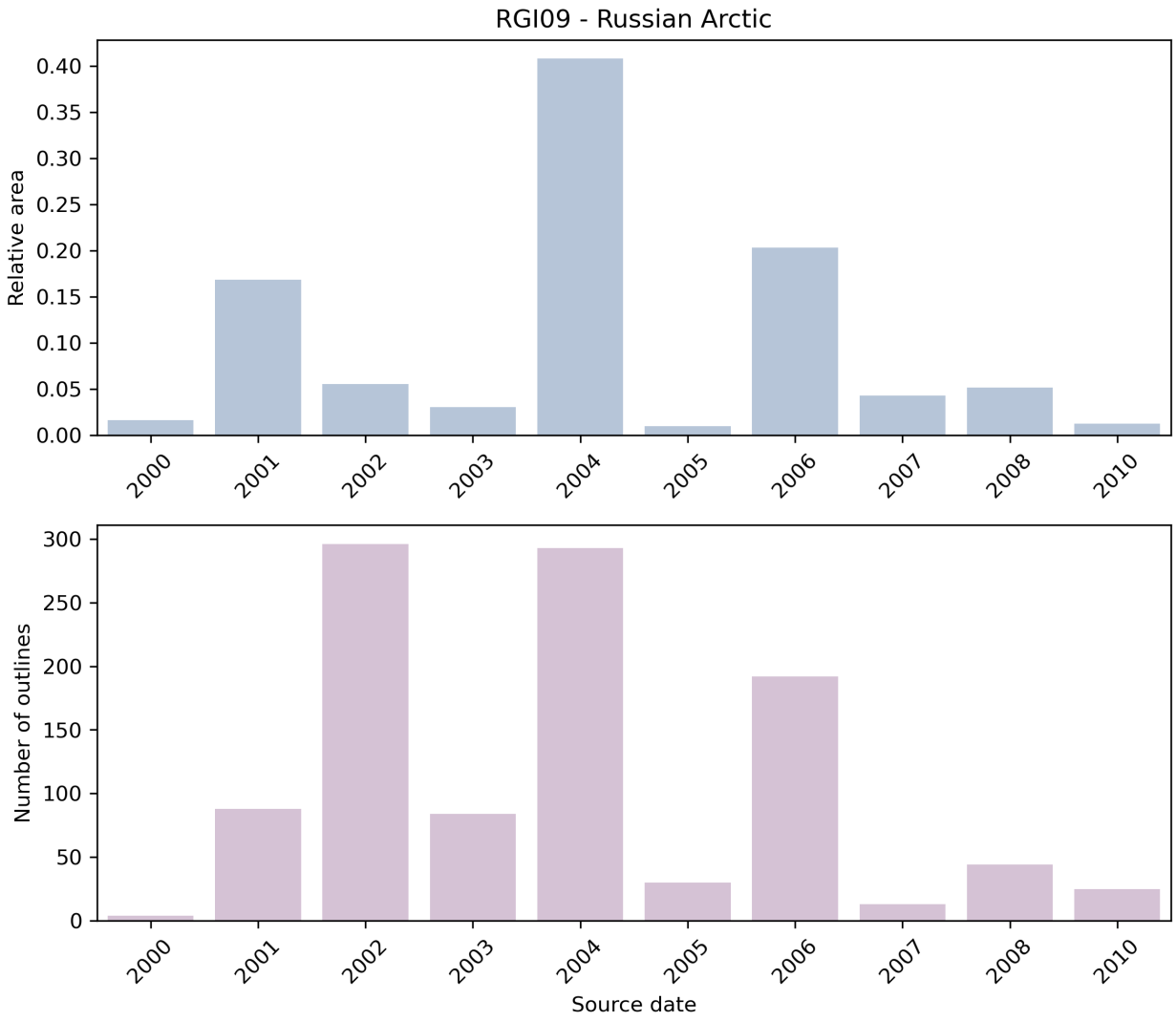


Fig. 5.36: Distribution of the outline dates per area (top) and number (bottom)

Figure: Glacier area histogram

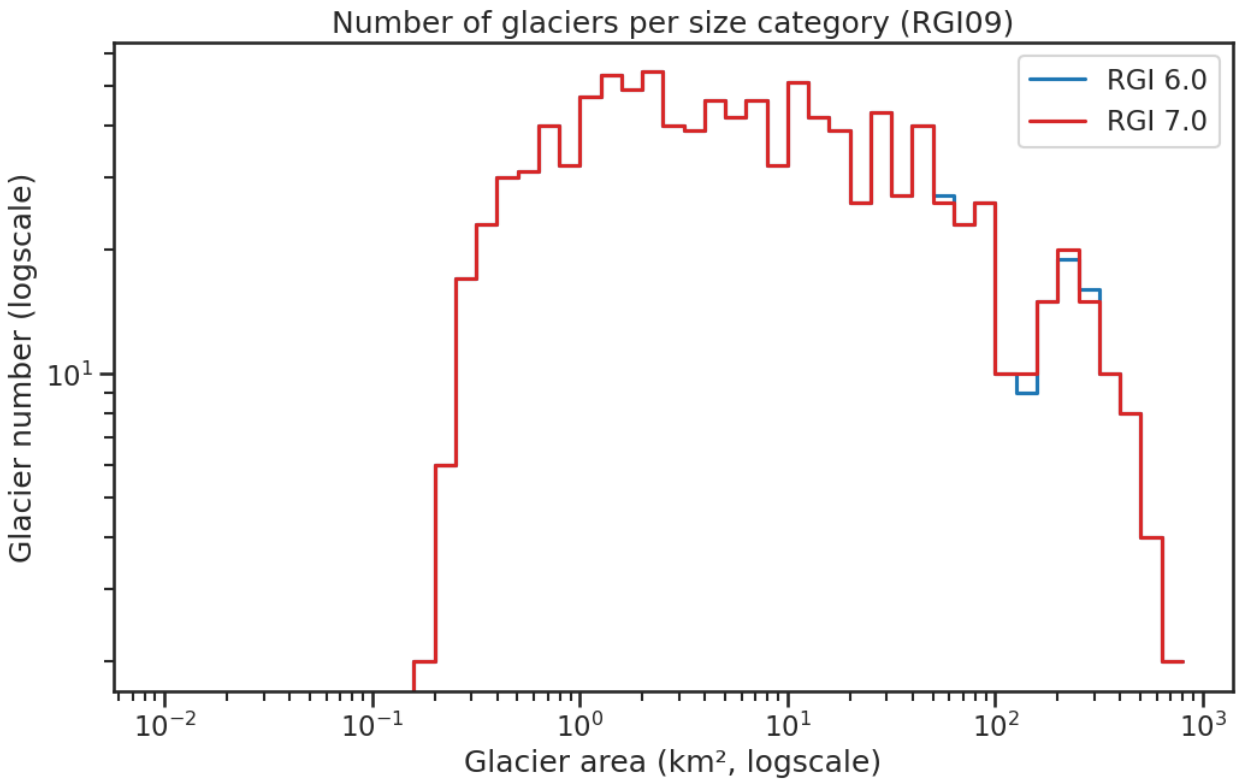


Fig. 5.37: Number of glaciers per size category (log-log scale).

Table: Terminus type statistics Regional number of glaciers (N) and area (km^2) per terminus type in RGI 7.0 and RGI 6.0. Note that the default designation in RGI 7.0 is now "Not assigned", while in RGI 6.0 lake-terminating glaciers and shelf-terminating glaciers were identified in some regions. The RGI region 19 is entirely labelled as "Not assigned" in RGI 7.0.

Value	Terminus type	RGI 7.0 (N)	RGI 6.0 (N)	RGI 7.0 (Area)	RGI 6.0 (Area)
0	Land-terminating	0	690	0	18158
1	Marine-terminating	415	375	37299	32615
2	Lake-terminating	0	4	0	819
3	Shelf-terminating	0	0	0	0
9	Not assigned	654	0	14296	0

Table: Surge type statistics Regional number of glaciers (N) and area (km^2) per surge type attribute in RGI 7.0 and RGI 6.0.

Value	Surge type	RGI 7.0 (N)	RGI 6.0 (N)	RGI 7.0 (Area)	RGI 6.0 (Area)
0	No evidence	1033	0	41145	0
1	Possible	15	16	4440	4847
2	Probable	14	13	3463	3052
3	Observed	7	4	2548	1554
9	Not assigned	0	1036	0	42138

Version history

Changes from Version 5.0 to 6.0 The source for hypsometry was changed from the ASTER GDEM2 to the ViewfinderPanoramas DEM3 (http://www.viewfinderpanoramas.org/).

Changes from Version 4.0 to 5.0 Four glaciers (RGI50-09.00498, RGI50-09.00515, RGI50-09.00967, RGI50-09.00968) on October Revolution Island, Severnaya Zemlya, formerly with TermType = 1, were given the TermType code 5 because they flow into the Matusevich Ice Shelf.

Changes from Version 3.2 to 4.0 Topographic and hypsometric attributes were added.

Changes from Version 3.0 to 3.2 None.

Changes from Version 2.0 to Version 3.0 Glaciers were delineated from glacier complexes.

Changes from Version 1.0 to Version 2.0 The Matusevich Ice Shelf, which was the only ice shelf in the inventory, was removed.

Version 1.0 The inventory was constructed as part of a mass balance study of the Barents/Kara Sea region [Moholdt *et al.*, 2012]. It covers all glaciers and ice caps in Novaya Zemlya (22,100 km2), Severnaya Zemlya (16,400 km2), Franz Josef Land (12,700 km2), Ushakov Island (320 km2) and Victoria Island (6 km2). Glacier complexes were manually digitized from orthorectified satellite imagery acquired during summers between 2000 and 2010. SPIRIT SPOT5 scenes [Korona *et al.*, 2009] were used for most of Novaya Zemlya, while the best available Landsat scenes were used elsewhere. All visible nunataks were cut out from the glacier polygons, and snowfields were only included if they seemed to be a part of a glacier. Ice shelves in Franz Josef Land (<50 km2) were included as parts of the glacier polygons, while the Matusevich Ice Shelf in Severnaya Zemlya (~200 km2) was delineated into a separate polygon. The estimated total glacier area of the region (51,500 km2) is 9% smaller than that of the World Glacier Inventory [Ohmura, 2009]. This large deviation is probably due to a combination of long-term glacier retreat and methodological differences in glacier delineation.

5.11 10: North Asia

The region encompasses all glaciers in Asia not included in regions 09 and 12 to 15.

Subregions

- 10-01: Ural Mountains
- 10-02: Central Siberia
- 10-03: Cherskiy/Suntar Khayata Ranges
- 10-04: Altay and Sayan
- 10-05: Northeast Russia
- 10-06: East Chukotka
- 10-07: Japan

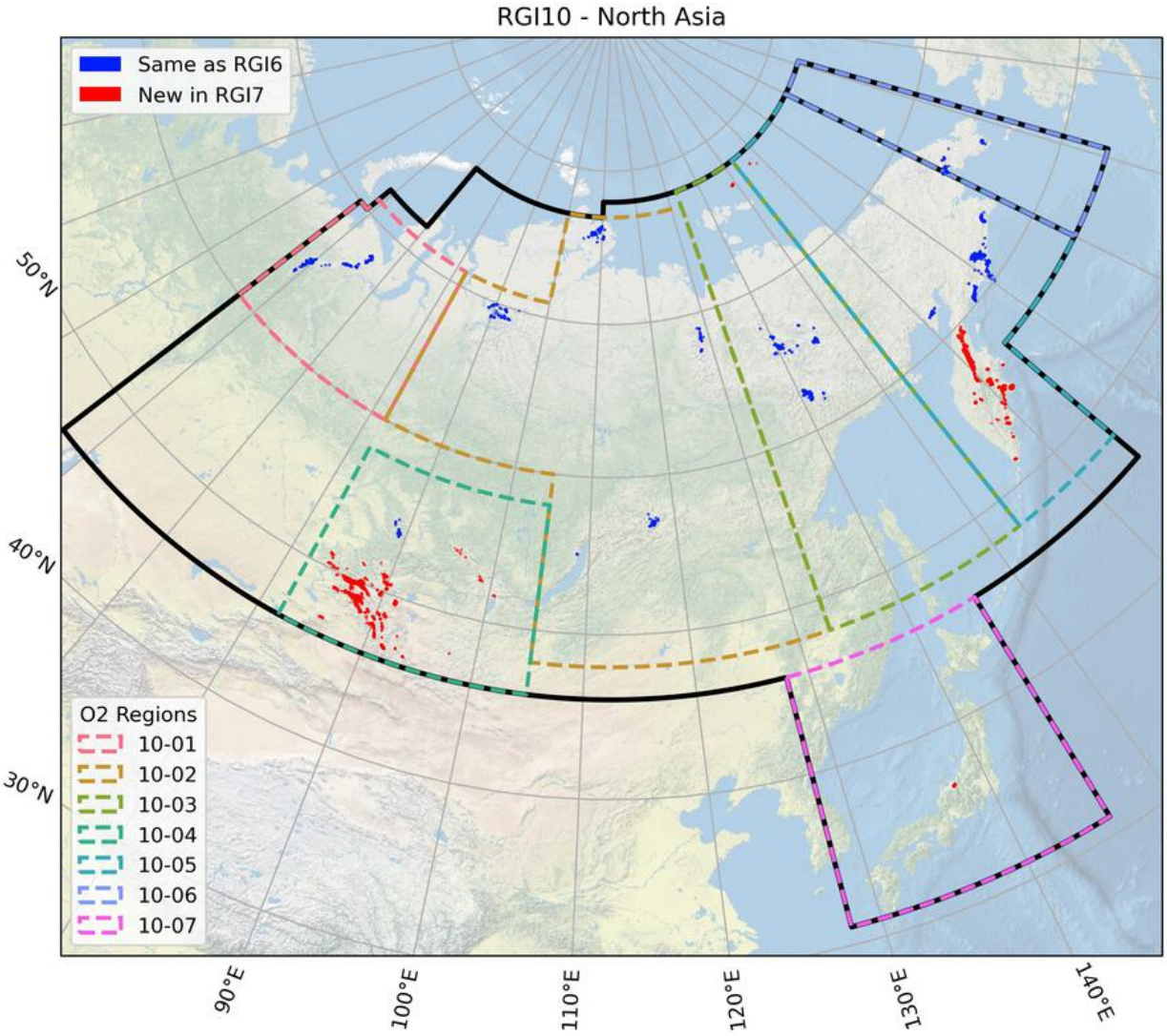


Fig. 5.38: Regional glacier area. Download high resolution version.

5.11.1 Changes from version 6.0 to 7.0

Altay and Sayan

All glacier outlines in Altay and Sayan (subregion 10-04) were replaced by GAMDAM inventory version 2 [Sakai, 2019].

Kamchatka

All glacier outlines in Kamchatka (southern part of subregion 10-05) were remapped. The main issues with RGI 6.0 were related to wrongly included seasonal snow and rock glaciers as well as missing debris-covered and other small glaciers. Several new datasets became available after RGI6.0 including the dataset by Lynch *et al.* [2016] mostly based on year 2000 outlines, the dataset for the period 2007-2019 described in the review by Khromova *et al.* [2019] with local corrections by A.Y. Muraviev, and an ASTER-derived dataset from 2002 just for the "Middle Range" of Kamchatka provided by T. Khromova. These datasets were collectively analyzed and edited using Landsat 7 panchromatic images from 2000 and 2002 as well as the "World imagery" layer of the ESRI Basemap for most of the regions. The latter images were mostly used to distinguish debris-covered glaciers from rock glaciers and to identify small ice bodies that were not included in previous inventories due to complete snow cover. The AW3D30 DEM was used to create a flow direction grid for correction of ice divides.

De Long Islands

Glaciers in the De Long Islands, Russia (subregion 10-03), were nominal circles in RGI 6.0, and are now appropriately included with digitized boundaries and divides based on Landsat imagery from 1999.

Japan

Five small glaciers (subregion 10-07) that have been recently documented [Arie *et al.*, 2022] were added. Outline dates range from 1996 to 2019, with most of the area (~80%) dating to 1998-2002.

5.11.2 Additional information

Data sources and analysts

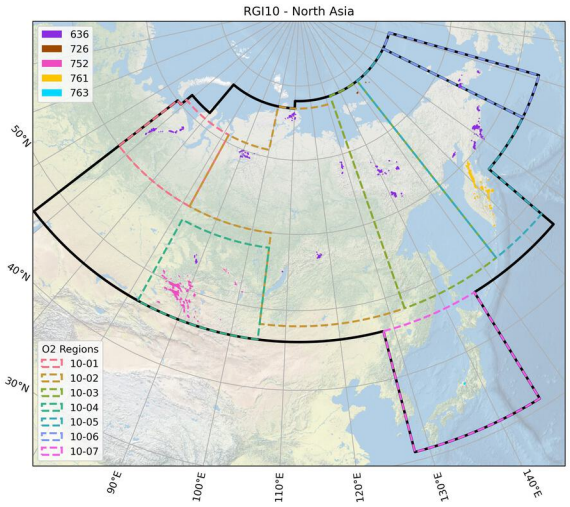


Fig. 5.39: Submission IDs used for this region Download high resolution version.

Glacier outline providers to GLIMS

This list includes the providers of the outlines used in the RGI 7.0 as generated automatically from the GLIMS outlines metadata. We acknowledge that the list may be incomplete due to omissions in the GLIMS database.

Submission 636 Submitter: Cogley, Graham.**Number of outlines**: 1646. **Area**: 394.0km^2. **Release date**: 2015-07-16.**Analysts**: Cogley, Graham; Earl, Lucas; Gardner, Alex; Raup, Bruce H..

Submission 726 Submitter: Kochtitzky, William.**Number of outlines**: 12. **Area**: 73.0km^2. **Release date**: 2021-09-01.**Analysts**: Kochtitzky, William.

Submission 752 Submitter: Sakai, Akiko.**Number of outlines**: 3001. **Area**: 1245.2km^2. **Release date**: 2018-08-24.**Analysts**: Sakai, Akiko.

Submission 761 Submitter: Paul, Frank.**Number of outlines**: 2491. **Area**: 929.9km^2. **Release date**: 2022-05-11.**Analysts**: Barr, Iestyn; Khromova, Tatiana; Muraviev, Anton; Paul, Frank; Rastner, Philipp.

Submission 763 Submitter: Arie, Kenshiro.**Number of outlines**: 5. **Area**: 0.5km^2. **Release date**: 2022-07-20.**Analysts**: Arie, Kenshiro.

Reviewers Barr, Iestyn; Khromova, Tatiana;

Regional statistics

Figure: Outlines source date

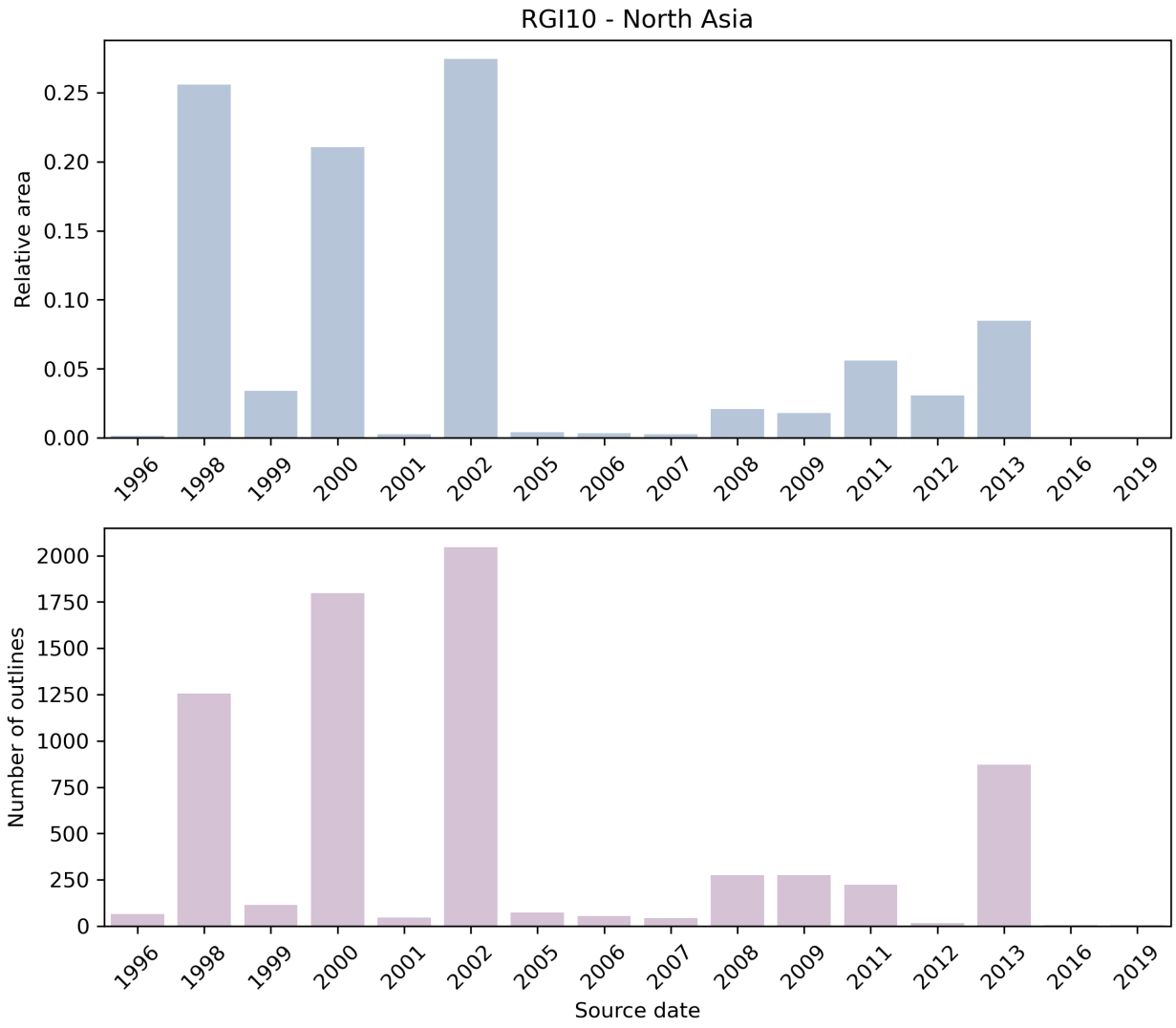


Fig. 5.40: Distribution of the outline dates per area (top) and number (bottom)

Figure: Glacier area histogram

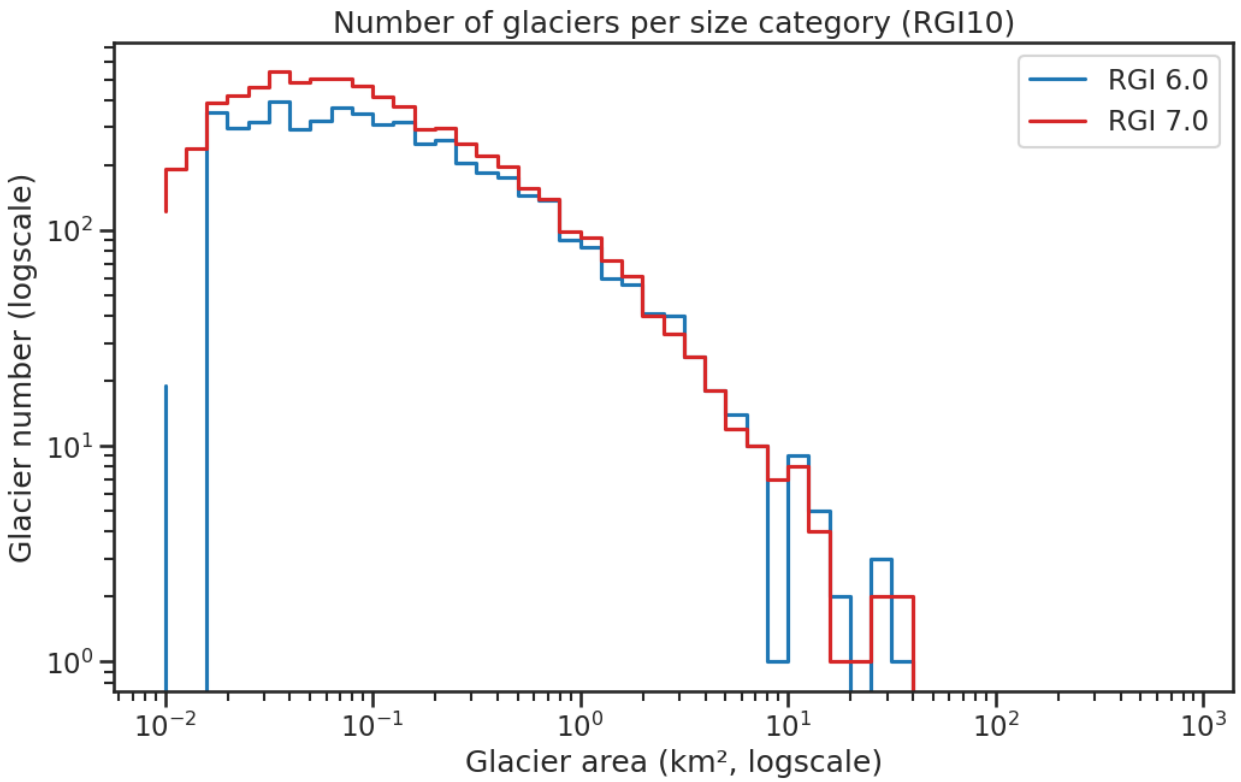


Fig. 5.41: Number of glaciers per size category (log-log scale).

Table: Terminus type statistics Regional number of glaciers (N) and area (km^2) per terminus type in RGI 7.0 and RGI 6.0. Note that the default designation in RGI 7.0 is now "Not assigned", while in RGI 6.0 lake-terminating glaciers and shelf-terminating glaciers were identified in some regions. The RGI region 19 is entirely labelled as "Not assigned" in RGI 7.0.

Value	Terminus type	RGI 7.0 (N)	RGI 6.0 (N)	RGI 7.0 (Area)	RGI 6.0 (Area)
0	Land-terminating	0	5149	0	2408
1	Marine-terminating	1	2	14	3
2	Lake-terminating	0	0	0	0
3	Shelf-terminating	0	0	0	0
9	Not assigned	7154	0	2628	0

Table: Surge type statistics Regional number of glaciers (N) and area (km^2) per surge type attribute in RGI 7.0 and RGI 6.0.

Value	Surge type	RGI 7.0 (N)	RGI 6.0 (N)	RGI 7.0 (Area)	RGI 6.0 (Area)
0	No evidence	7151	0	2536	0
1	Possible	0	0	0	0
2	Probable	0	0	0	0
3	Observed	4	2	106	19
9	Not assigned	0	5149	0	2391

Version history

Changes from Version 5.0 to 6.0 For some glaciers the source for hypsometry was changed from the ASTER GDEM2 to the ViewfinderPanoramas DEM3 (http://www.viewfinderpanoramas.org/).An error in the minimum elevation of 11 glaciers was detected. It had been set wrongly to 0 and that value was reset to missing. The corresponding hypsometric lists were also set to missing.

Changes from Version 4.0 to 5.0 The inventory of mainland North Asia was replaced in its entirety from Earl and Gardner [2016]. Nominal glaciers remain on Wrangell Island (3 km2) and the De Long Islands (Jeanette, Henrietta, Bennet; 81 km2). Glaciers in Chukotka (regions 10-05 and 10-06; Sedov 1997) that formerly appeared only in the RGI global grid are represented explicitly in version 5.0.Glacier outlines retired from version 4.0 will be added to GLIMS if they are not in GLIMS already.Links were added to 12 glaciers in the WGMS mass-balance database.The four second-order regions of earlier RGI versions were replaced by six regions conforming to those of Earl and Gardner [2016]. The outlines of the two sets of regions differ in detail, but all glaciers are in the same region in both the source and the RGI.

Changes from Version 3.2 to 4.0 One exterior GLIMSId was replaced. Topographic and hypsometric attributes were added, although this could not be done for most glaciers in North Asia, of which 2,832 out of 4,403 are nominal glaciers.The addition of dates for glaciers in the Chinese Altay is described under Region 13: Central Asia.

Changes from Version 3.0 to 3.2 None.

Changes from Version 2.0 to Version 3.0 All of the glaciers represented as circles were regenerated from WGI-XF [Cogley, 2009]. Some of them have not just nominal shapes but nominal positions, being derived from the Soviet Katalog Lednikov, which in each drainage basin gives full information only for glaciers larger than 0.1 km2. Only a total number and total area are given for glaciers smaller than 0.1 km2. In WGI-XF these small glaciers are all assigned a common position roughly in the centre of their basins, and an equal share of the listed small-glacier area. Obviously these and other nominal glaciers should not be used for purposes other than calculating total glacierized area.Some DCW outlines were found to overlie mountain ranges whose ice cover was already represented by nominal glaciers. These duplicate DCW outlines were removed.

Changes from Version 1.0 to Version 2.0 The DCW outlines of glacier complexes in Mongolia were replaced by outlines of glaciers digitized by J.G. Cogley from Soviet military maps. Their dates range between 1968 and 1983.14 glaciers in the Tajgonos Peninsula, northwest of Kamchatka (10-02) were added as nominal circles from WGI-XF.

Version 1.0 About one third of the glacier outlines in North Asia were manually delineated from Landsat TM/ETM+ or ASTER imagery. Missing areas were filled by a glacier layer compiled by B. Raup [Raup *et al.*, 2000] from the Digital Chart of the World (DCW) and the World Glacier Inventory [World Glacier Monitoring Service (WGMS), 1998].

5.12 11: Central Europe

The region encompasses all glaciers in Europe outside Scandinavia (region 08). More than 99% of the glacier area is located in the European Alps and the Pyrenees. The term “Central Europe ” has been chosen to differentiate this glacier region from the one in northern Europe (region `08`, Scandinavia), fully aware that the geographical extent is commonly different when used in other contexts.

Subregions

- 11-01: Alps
- 11-02: Southeast Europe

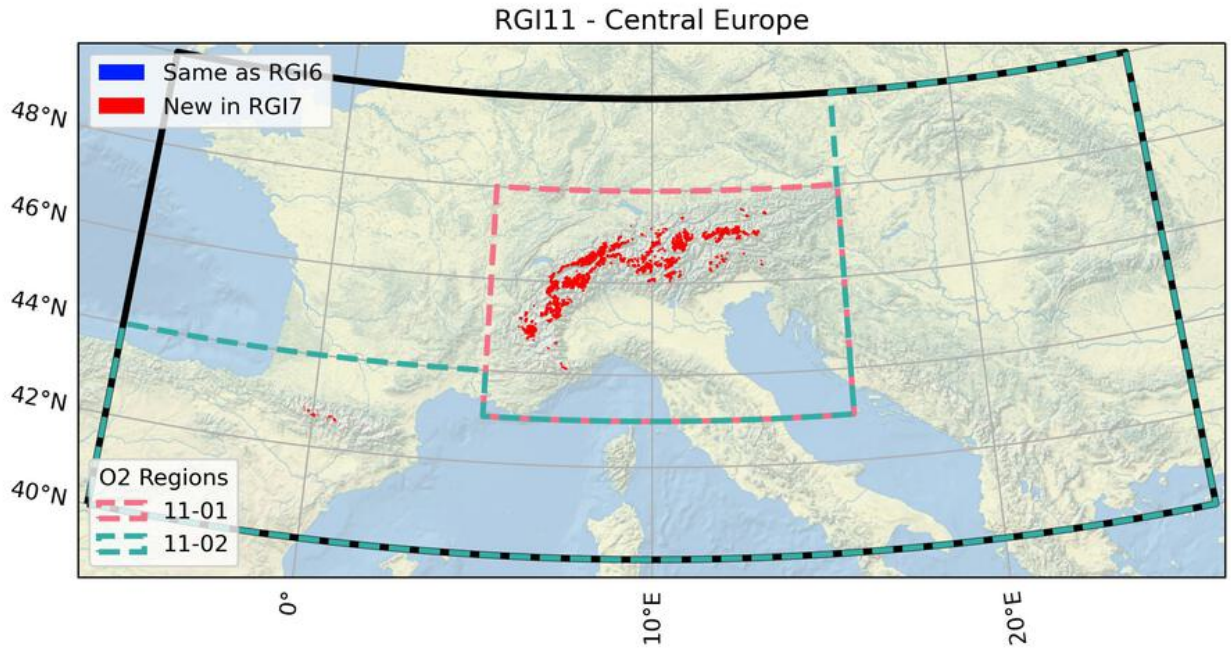


Fig. 5.42: Regional glacier area. Download high resolution version.

5.12.1 Changes from version 6.0 to 7.0

European Alps

The RGI 6.0 outlines from 2003 were revised due to missing glaciers (in particular in the Dolomites), wrongly mapped debris-covered glaciers, errors in geolocation (Maritime Alps) and topology issues such as overlapping outlines (Mt. Blanc region). For the corrections we used the same Landsat 5 TM images as for the inventory adopted in the RGI 6.0 [Paul *et al.*, 2011], glacier outlines and Sentinel-2 images from the inventory by [Paul *et al.*, 2020], and very high-resolution images from the "World imagery" layer of the ESRI Basemap. The entire region is shown as "new" on the map, but we estimate that only about 1/5 of the outlines changed.

Pyrenees

In the Pyrenees, outlines were replaced by an updated inventory by Eñaut Izagirre using Landsat 7 ETM+ imagery from August and September 2000. The updated inventory is based on an earlier inventory from 1984 [Serrat and Ventura, 1993]. Due to the very small size of these glaciers, the manual delineation of the outlines was supported by the use of high-resolution aerial orthophotos taken by the Spanish National Geographic Institute in September 1999 and July 2000.

Other regions

Three glaciers in Montenegro, Albania, as well as the Calderone glacier (Italy) previously included in the RGI 6.0 are no longer available in RGI 7.0 since they were not in GLIMS (see "Version history" below for more details about these glaciers).

5.12.2 Additional information

Data sources and analysts

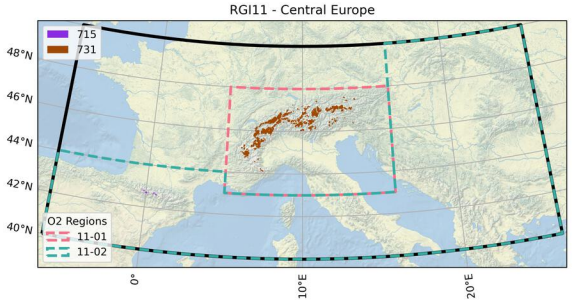


Fig. 5.43: Submission IDs used for this region Download high resolution version.

Glacier outline providers to GLIMS

This list includes the providers of the outlines used in the RGI 7.0 as generated automatically from the GLIMS outlines metadata. We acknowledge that the list may be incomplete due to omissions in the GLIMS database.

Submission 715 Submitter: Izagirre, Eñaut.**Number of outlines**: 45. **Area**: 4.2km^2. **Release date**: 2020-05-27.**Analysts**: Izagirre, Eñaut.

Submission 731 Submitter: Paul, Frank.**Number of outlines**: 4034. **Area**: 2120.1km^2. **Release date**: 2021-10-09.**Analysts**: Frey, Holger; Le Bris, Raymond; Paul, Frank; Rastner, Philipp.

Reviewers Huss, Matthias; Rabatel, Antoine;

Regional statistics

Figure: Outlines source date

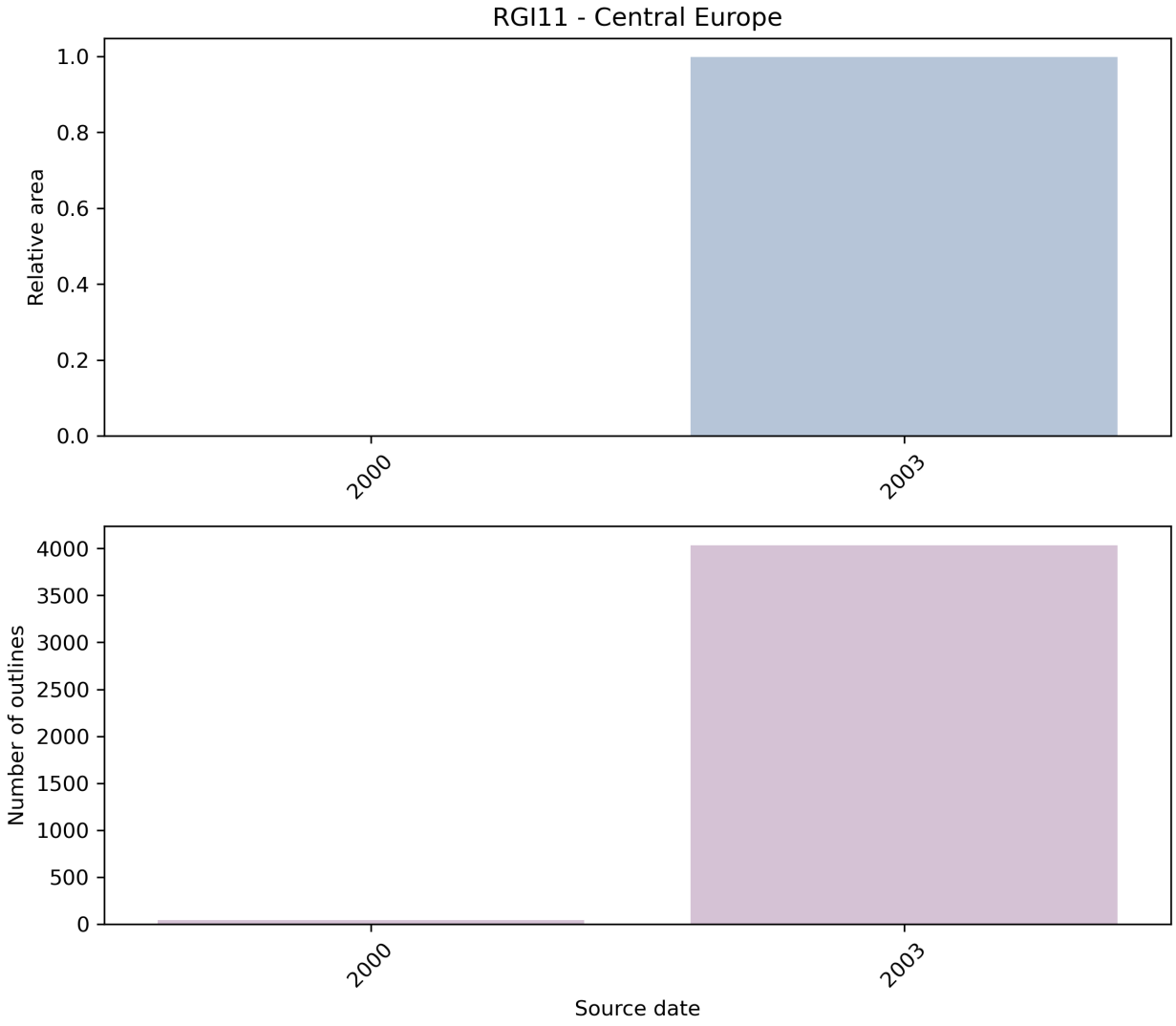


Fig. 5.44: Distribution of the outline dates per area (top) and number (bottom)

Figure: Glacier area histogram

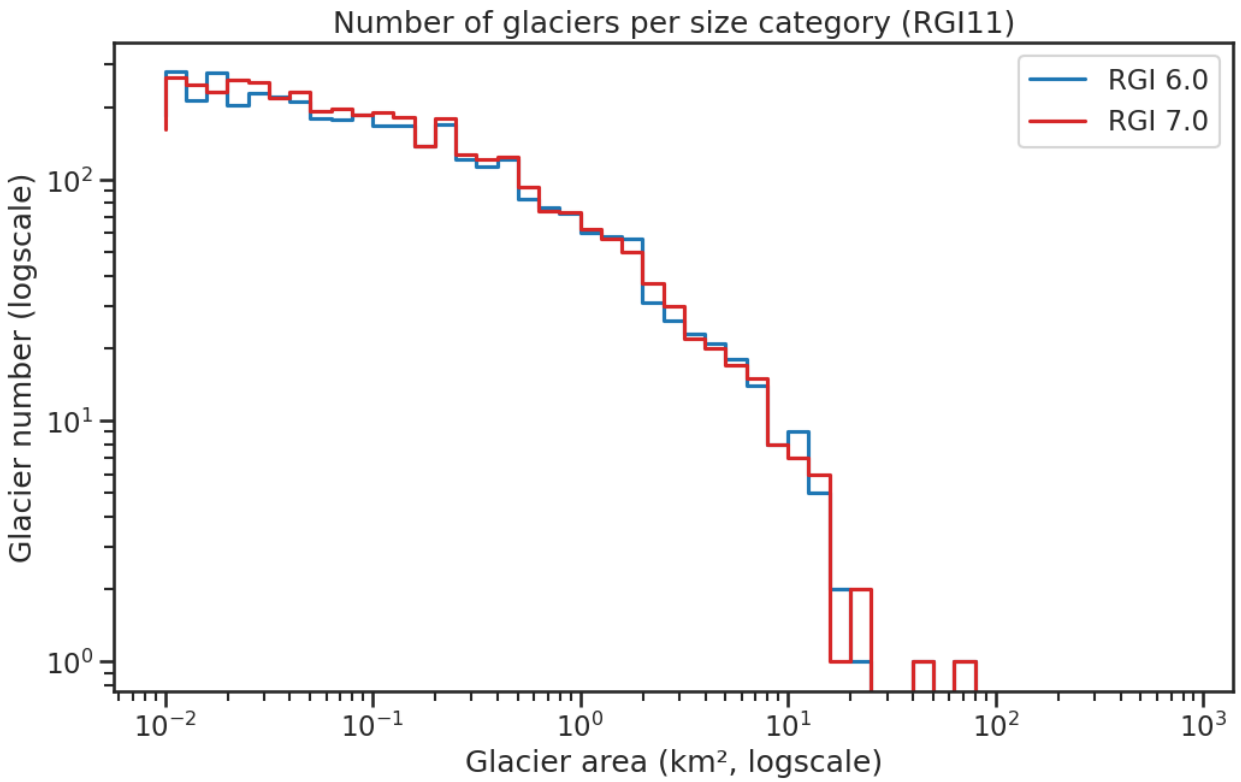


Fig. 5.45: Number of glaciers per size category (log-log scale).

Table: Terminus type statistics Regional number of glaciers (N) and area (km^2) per terminus type in RGI 7.0 and RGI 6.0. Note that the default designation in RGI 7.0 is now "Not assigned", while in RGI 6.0 lake-terminating glaciers and shelf-terminating glaciers were identified in some regions. The RGI region 19 is entirely labelled as "Not assigned" in RGI 7.0.

Value	Terminus type	RGI 7.0 (N)	RGI 6.0 (N)	RGI 7.0 (Area)	RGI 6.0 (Area)
0	Land-terminating	0	3927	0	2092
1	Marine-terminating	0	0	0	0
2	Lake-terminating	0	0	0	0
3	Shelf-terminating	0	0	0	0
9	Not assigned	4079	0	2124	0

Table: Surge type statistics Regional number of glaciers (N) and area (km^2) per surge type attribute in RGI 7.0 and RGI 6.0.

Value	Surge type	RGI 7.0 (N)	RGI 6.0 (N)	RGI 7.0 (Area)	RGI 6.0 (Area)
0	No evidence	4075	107	2104	8
1	Possible	2	2	7	7
2	Probable	0	0	0	0
3	Observed	2	2	13	13
9	Not assigned	0	3816	0	2064

Version history

Changes from Version 5.0 to 6.0 The nominal glaciers in France and Italy, added in version 5.0, were replaced from Gardent *et al.* [2014] (outlines from 2003) and Smiraglia *et al.* [2015] (outlines from 2005–2012).

Changes from Version 4.0 to 5.0 The 108 nominal glaciers in the Pyrenees were replaced by 31 glaciers (representing late 2011) from a recent inventory by Renaud Marti, Université de Toulouse. The location (GLIMSId, CenLon, CenLat) of Gh del Calderone in the Appennines was corrected; its outline was added from a map in Gellatly *et al.* [1994]. Six glacierets in the Maritime Alps [Gellatly *et al.*, 1994], two in Slovenia [Triglav Čekada *et al.*, 2012], one in Montenegro [Hughes, 2008] and two in Albania [Milivojević *et al.*, 2008] were added, the outlines being taken from maps in the source publications. Some Balkan ice bodies documented in these sources and in Grunewald *et al.* [2006] were not assimilated because they were smaller than the RGI threshold of 0.01 km2.The Bavarian glaciers were added from Hagg *et al.* [2012].51 nominal glaciers in the Maritime and Cottian Alps (France and Italy) and 67 nominal glaciers in the Dolomitic Alps (Italy) were added from WGI-XF [Cogley, 2009].Links were added to 31 glaciers in the WGMS mass-balance database.

Changes from Version 3.2 to 4.0 Five exterior GLIMSIds were replaced. Topographic and hypsometric attributes were added.

Changes from Version 3.0 to 3.2 None.

Changes from Version 2.0 to Version 3.0 None.

Changes from Version 1.0 to Version 2.0 109 glaciers in the Pyrenees, and one in the Apennines, were added as nominal circles from WGI-XF. Together they constitute region 11-02.

Version 1.0 The glacier outlines for this region are derived from ten Landsat TM images acquired during two months in the summer of 2003 using band-ratio images. Drainage divides for individual glaciers were derived from the void-filled SRTM DEM (from CGIARS) in a resampled version with 60 m spatial resolution. All further details are documented in Paul *et al.* [2011]. About 30-50 km2 of glaciers are not mapped, mainly very small glaciers located in Italy (Brenta and Dolomites) and Germany, covered by debris or located under local orographic clouds.

5.13 12: Caucasus and Middle East

The region encompasses all glaciers between 30°E and 54°E and 30°N and 45°N. More than 99% of the glaciers are located in the Caucasus.

Subregions

- 12-01: Caucasus and Middle East
- 12-02: Middle East

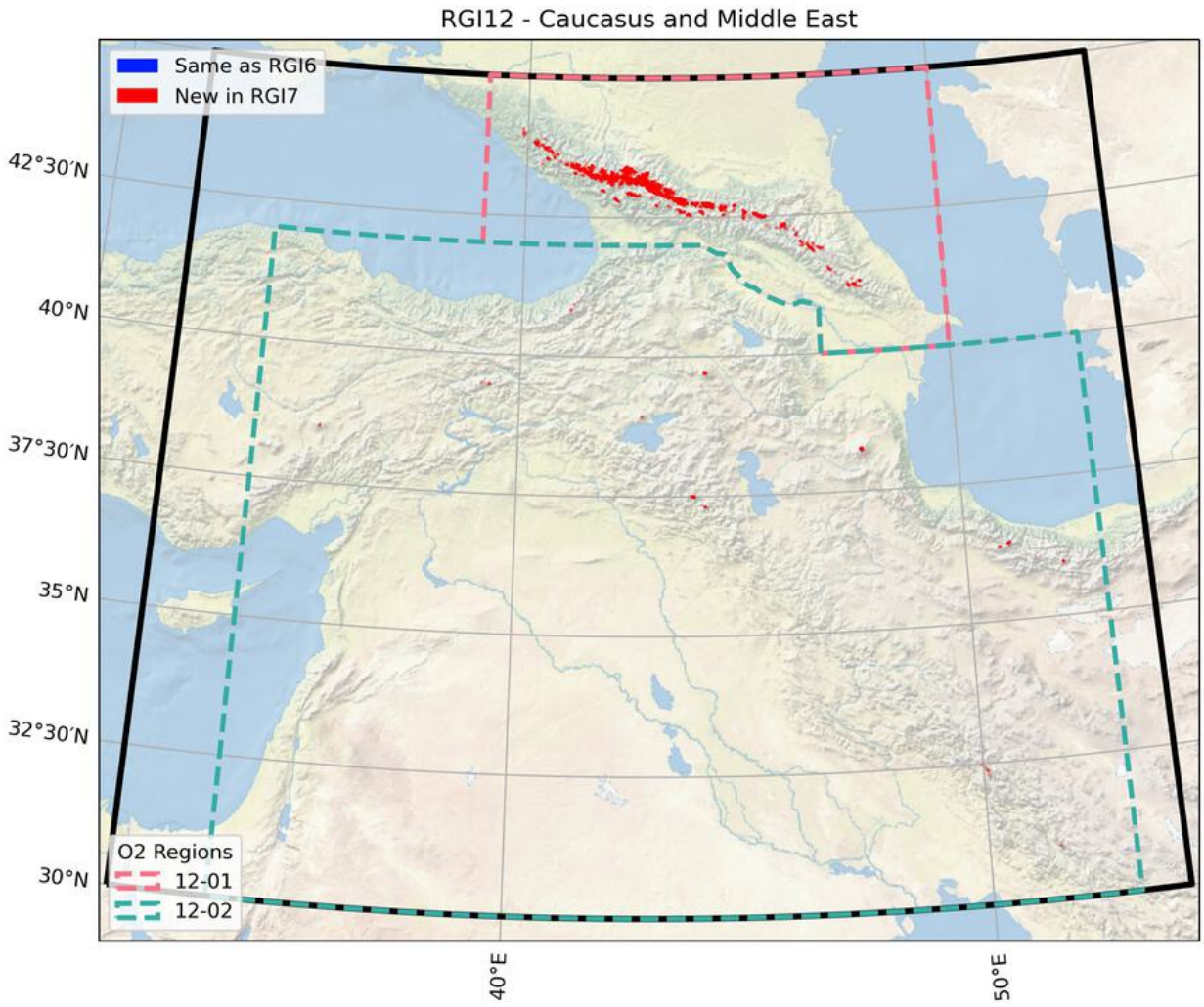


Fig. 5.46: Regional glacier area. Download high resolution version.

5.13.1 Changes from version 6.0 to 7.0

All RGI6.0 outlines have been replaced, representing a considerable change and improvement to RGI 6.0.

Caucasus

The RGI 6.0 inventory for the Greater Caucasus, which includes 95% of the region's glaciers, was based on ASTER and Landsat imagery from 1999–2004 [Khromova *et al.*, 2016]. Since the data set has geolocation issues, and missing glaciers in the eastern and western Greater Caucasus are included as "nominal glaciers" (circles covering an area equivalent to glacier size), the entire data set was replaced in RGI 7.0 by manually digitized outlines from Tielidze *et al.* [2022] primarily based on Landsat scenes from 1999-2002.

Middle East

Most RGI 6.0 glacier outlines were mapped based on ASTER imagery from 2004-2006 (Turkey) and Landsat scenes from 2011 (Iran), however, a closer look revealed that most of these outlines were snow patches and not actual glaciers. Therefore, outlines were remapped based on Landsat imagery from 1998-2001.

5.13.2 Additional information

Data sources and analysts

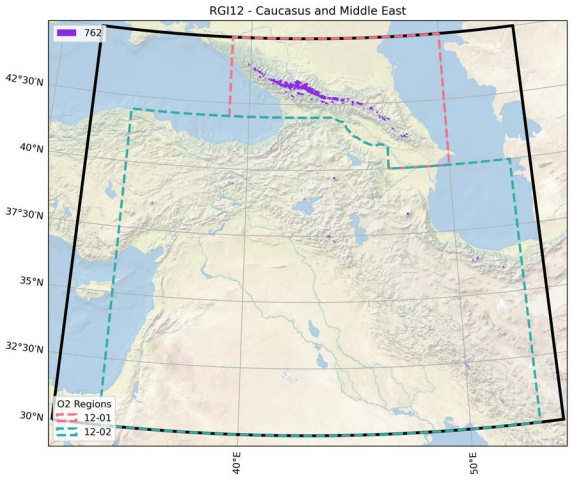


Fig. 5.47: Submission IDs used for this region Download high resolution version.

Glacier outline providers to GLIMS

This list includes the providers of the outlines used in the RGI 7.0 as generated automatically from the GLIMS outlines metadata. We acknowledge that the list may be incomplete due to omissions in the GLIMS database.

Submission 762 Submitter: Tielidze, Levan.**Number of outlines**: 2275. **Area**: 1406.7km^2. **Release date**: 2021-09-09.**Analysts**: Tielidze, Levan.

Reviewers None;

Regional statistics

Figure: Outlines source date

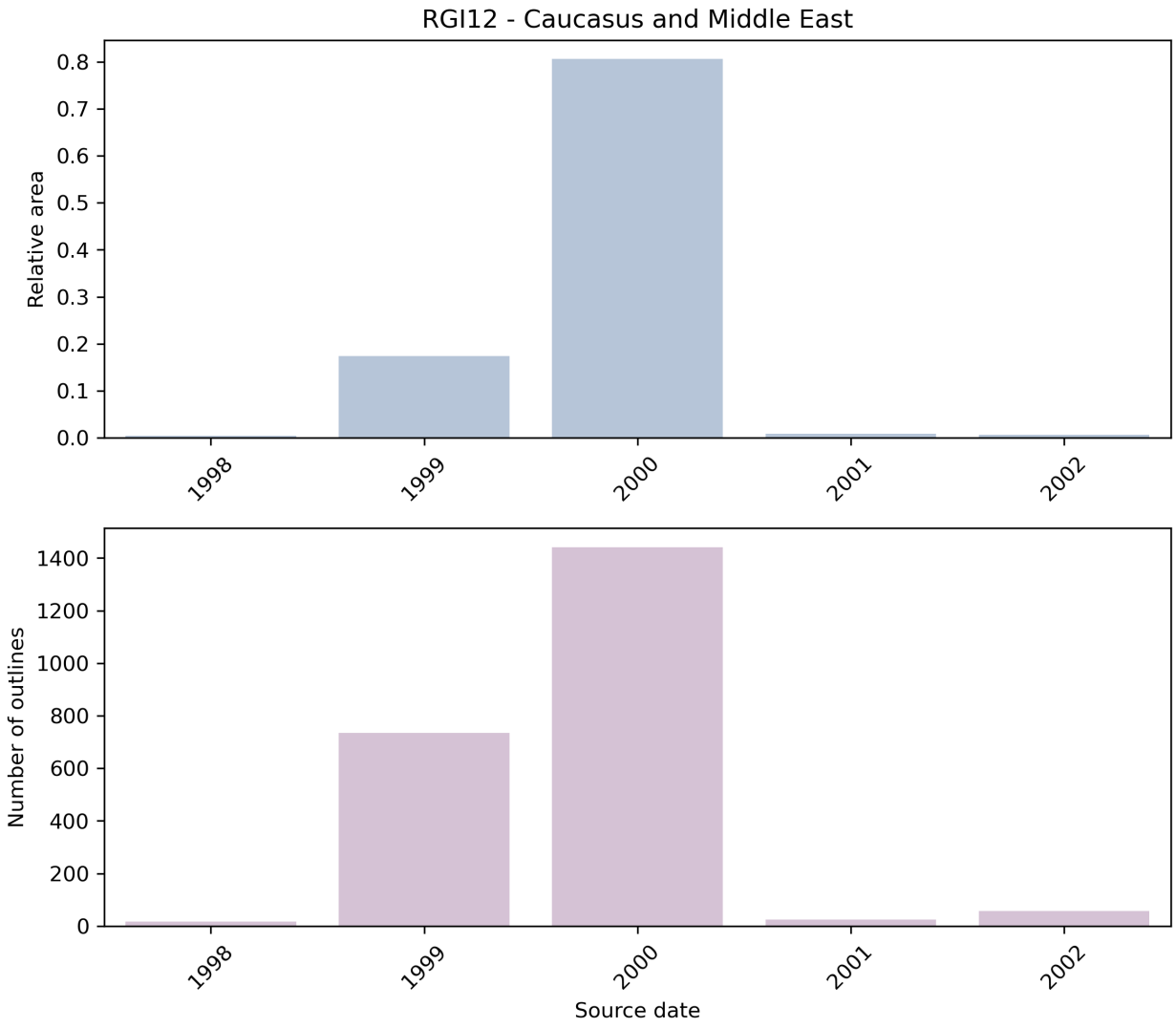


Fig. 5.48: Distribution of the outline dates per area (top) and number (bottom)

Figure: Glacier area histogram

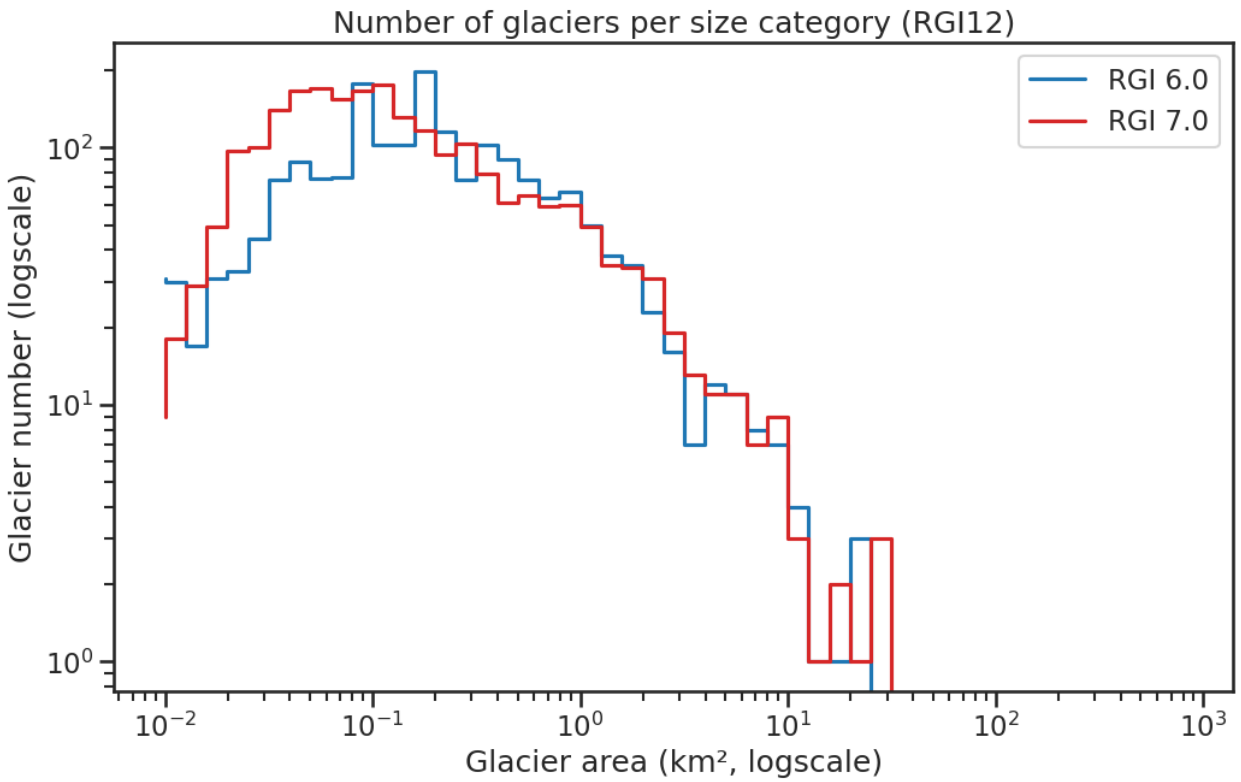


Fig. 5.49: Number of glaciers per size category (log-log scale).

Table: Terminus type statistics Regional number of glaciers (N) and area (km^2) per terminus type in RGI 7.0 and RGI 6.0. Note that the default designation in RGI 7.0 is now "Not assigned", while in RGI 6.0 lake-terminating glaciers and shelf-terminating glaciers were identified in some regions. The RGI region 19 is entirely labelled as "Not assigned" in RGI 7.0.

Value	Terminus type	RGI 7.0 (N)	RGI 6.0 (N)	RGI 7.0 (Area)	RGI 6.0 (Area)
0	Land-terminating	0	1888	0	1307
1	Marine-terminating	0	0	0	0
2	Lake-terminating	0	0	0	0
3	Shelf-terminating	0	0	0	0
9	Not assigned	2275	0	1407	0

Table: Surge type statistics Regional number of glaciers (N) and area (km^2) per surge type attribute in RGI 7.0 and RGI 6.0.

Value	Surge type	RGI 7.0 (N)	RGI 6.0 (N)	RGI 7.0 (Area)	RGI 6.0 (Area)
0	No evidence	2264	0	1345	0
1	Possible	0	0	0	0
2	Probable	5	4	17	7
3	Observed	6	3	44	34
9	Not assigned	0	1881	0	1266

Version history

Changes from Version 5.0 to 6.0 The 37 nominal glaciers in Iran, derived from Moussavi *et al.* [2009], were replaced by 200 glacier outlines submitted to GLIMS by Neamat Karimi (Ministry of Energy, Teheran).

Changes from Version 4.0 to 5.0 Links were added to 7 glaciers in the WGMS mass-balance database.

Changes from Version 3.2 to 4.0 One exterior GLIMSId was replaced. Topographic and hypsometric attributes were added.As noted by Shahgedanova *et al.* [2014], version 3.2 omitted glaciers in the western and eastern Greater Caucasus. These omissions have been partly rectified by adding nominal glaciers from WGI-XF Cogley [2009]. The 339 added glaciers, with date ranges 1965–1976, cover 155 km2 and also include some in the central Greater Caucasus (on the Svanets and Lechkhum Ranges to the south of the main ridge of the Caucasus) and in the Lesser Caucasus in Armenia.

Changes from Version 3.0 to 3.2 None.

Changes from Version 2.0 to Version 3.0 Outlines of the glaciers of Turkey were provided by M.A. Sarıkaya [Sarıkaya and Tekeli, 2014].

Changes from Version 1.0 to Version 2.0 The 37 glaciers of Iran (12-02) were added as nominal circles from Moussavi *et al.* [2009].The information available for Turkey [Kurter, 1991] was not adequate for placing the individual glaciers, which have a total area of 22.9 km2.

Version 1.0 Outlines of glaciers in the Caucasus were obtained from the GLIMS database.

5.14 13: Central Asia

Regions `13`, `14`, `15` comprise the region that is often referred to as High Mountain Asia. Region 13 encompasses all glaciers south of 46°N in the Tien Shan (also called Tian Shan), the Pamir and the mountain ranges on the Tibetan Plateau but excluding those included in regions `14` and `15`. The term “Central Asia” has been chosen to differentiate the four RGI regions in Asia outside the Arctic, fully aware that the geographical extent is commonly different when used in other contexts.

Subregions

- 13-01: Hissar Alay
- 13-02: Pamir (Safed Khirs / West Tarim)
- 13-03: West Tien Shan
- 13-04: East Tien Shan (Dzhungaria)
- 13-05: West Kun Lun
- 13-06: East Kun Lun (Altyn Tagh)
- 13-07: Qilian Shan
- 13-08: Inner Tibet
- 13-09: Southeast Tibet

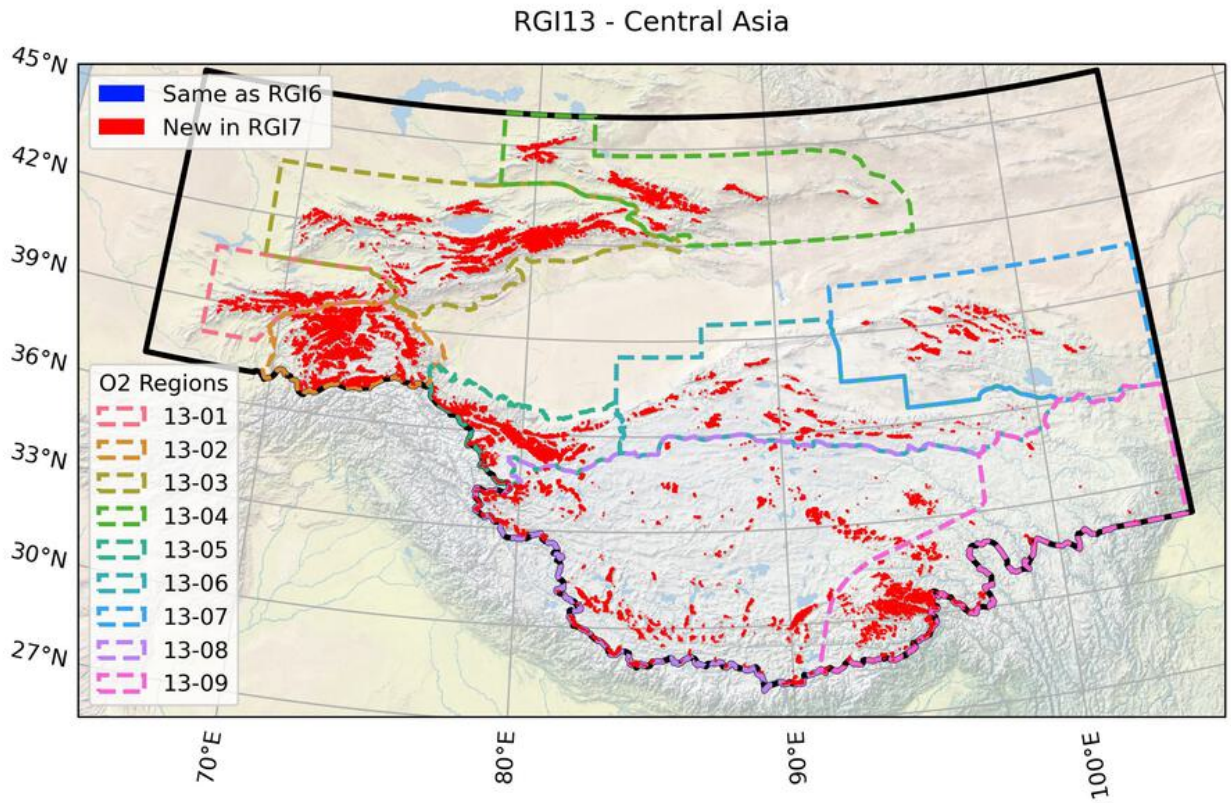


Fig. 5.50: Regional glacier area. Download high resolution version.

5.14.1 Changes from version 6.0 to 7.0

All previous outlines have been replaced by the GAMDAM glacier inventory version 2 GGI [Sakai, 2019], also named GGI18. The glaciers were manually mapped based on Landsat TM and ETM+ summer imagery with most scenes being from the year 2002. Earlier and later scenes were used in case of unsuitable scenes within this year.

5.14.2 Additional information

Data sources and analysts

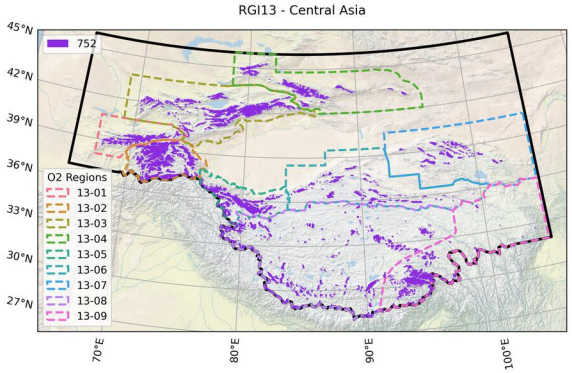


Fig. 5.51: Submission IDs used for this region Download high resolution version.

Glacier outline providers to GLIMS

This list includes the providers of the outlines used in the RGI 7.0 as generated automatically from the GLIMS outlines metadata. We acknowledge that the list may be incomplete due to omissions in the GLIMS database.

Submission 752 **Submitter**: Sakai, Akiko.**Number of outlines**: 75613. **Area**: 50344.0km^2. **Release date**: 2018-08-24.**Analysts**: Sakai, Akiko.

Reviewers None;

Regional statistics

Figure: Outlines source date

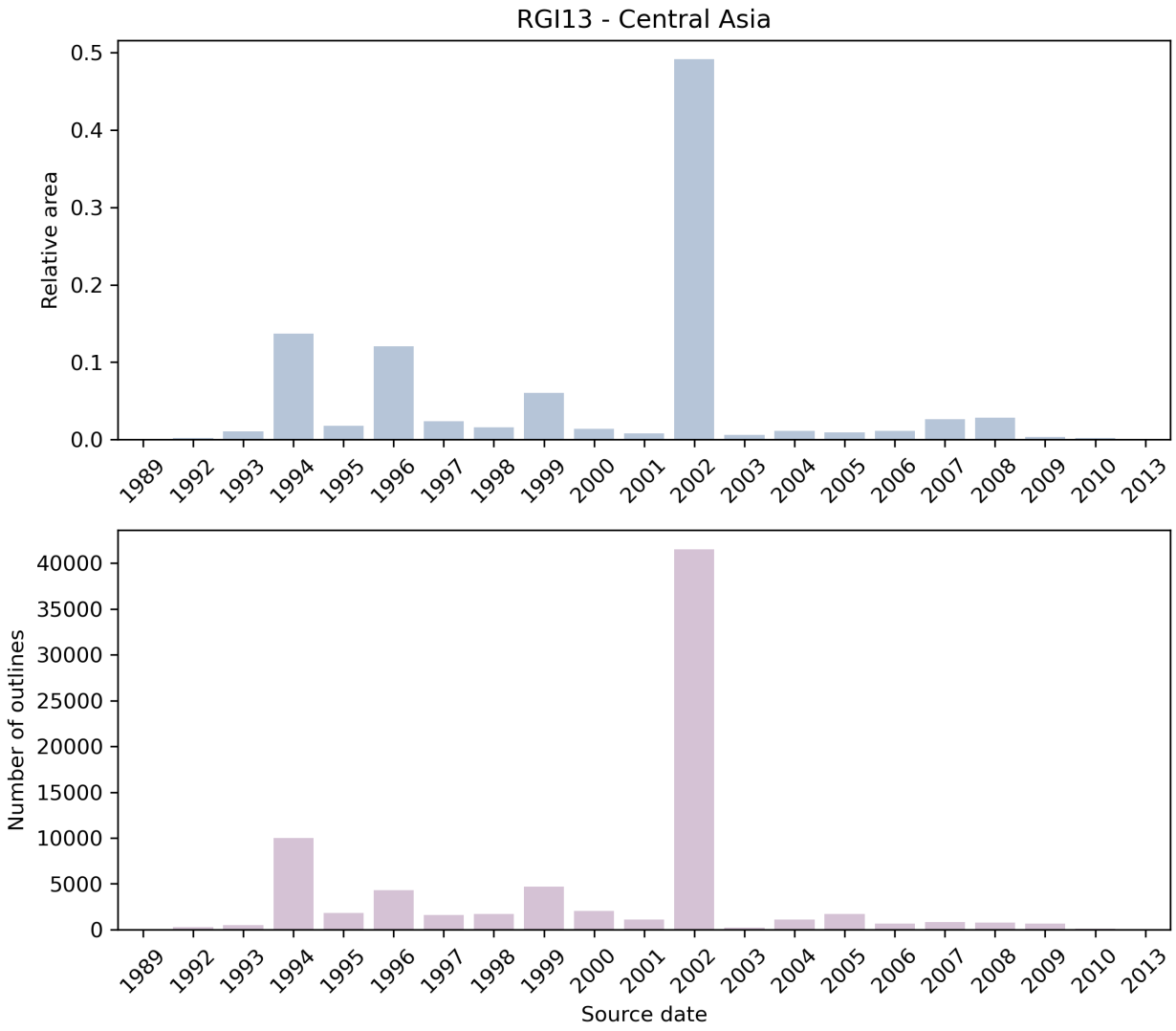


Fig. 5.52: Distribution of the outline dates per area (top) and number (bottom)

Figure: Glacier area histogram

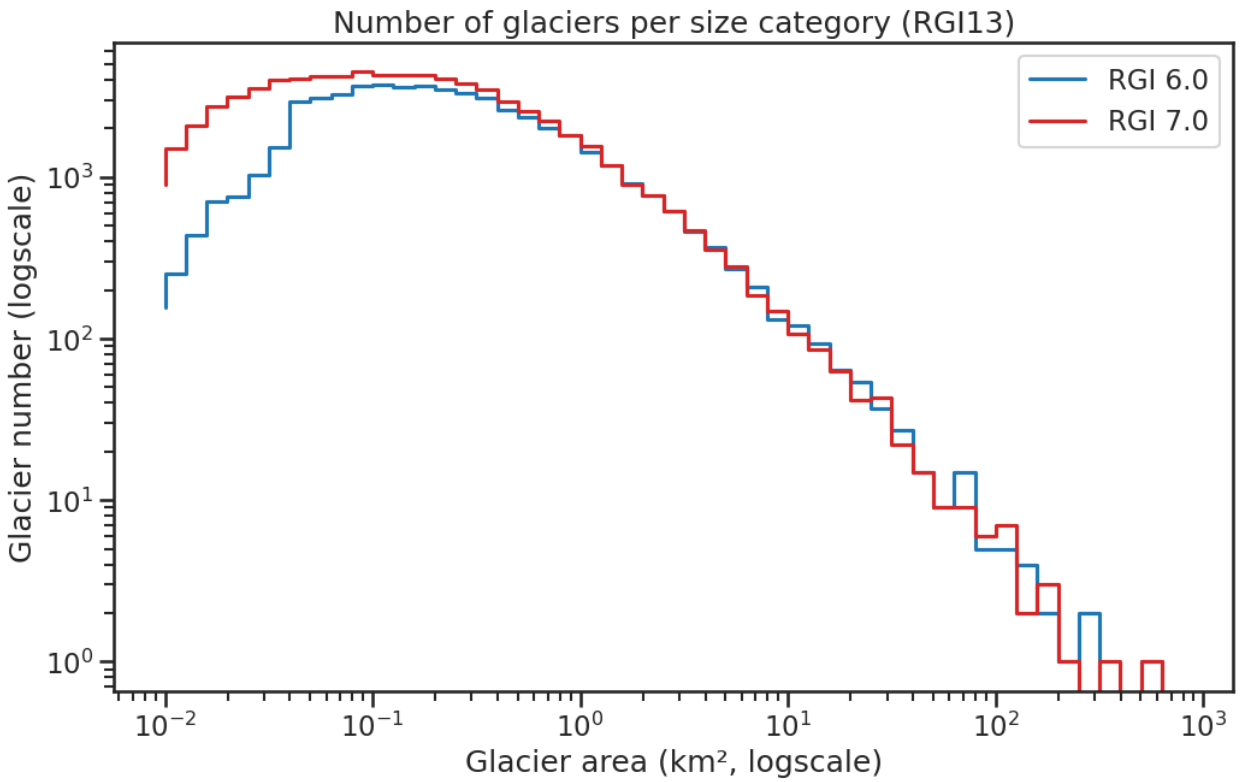


Fig. 5.53: Number of glaciers per size category (log-log scale).

Table: Terminus type statistics Regional number of glaciers (N) and area (km^2) per terminus type in RGI 7.0 and RGI 6.0. Note that the default designation in RGI 7.0 is now "Not assigned", while in RGI 6.0 lake-terminating glaciers and shelf-terminating glaciers were identified in some regions. The RGI region 19 is entirely labelled as "Not assigned" in RGI 7.0.

Value	Terminus type	RGI 7.0 (N)	RGI 6.0 (N)	RGI 7.0 (Area)	RGI 6.0 (Area)
0	Land-terminating	0	54429	0	49303
1	Marine-terminating	0	0	0	0
2	Lake-terminating	0	0	0	0
3	Shelf-terminating	0	0	0	0
9	Not assigned	75613	0	50344	0

Table: Surge type statistics Regional number of glaciers (N) and area (km^2) per surge type attribute in RGI 7.0 and RGI 6.0.

Value	Surge type	RGI 7.0 (N)	RGI 6.0 (N)	RGI 7.0 (Area)	RGI 6.0 (Area)
0	No evidence	74535	8269	39045	4265
1	Possible	338	323	886	1036
2	Probable	324	193	2470	1673
3	Observed	416	61	7943	1855
9	Not assigned	0	45583	0	40474

Version history

Changes from Version 5.0 to 6.0 None.

Changes from Version 4.0 to 5.0 Regions 13, 14 and 15 are entirely new in version 5.0. being taken from Nuimura *et al.* [2015], Guo *et al.* [2015] and as-yet unpublished work at the Technical University of Dresden and University of Zürich. *Remark (2023): the outlines have now been published: Mölg* et al. *[2018]*. The Dresden/Zürich outlines cover the Karakoram in region 14.The GAMDAM inventory of Nuimura *et al.* [2015] covers all of High Mountain Asia (including RGI region 10-04). The Second Chinese Glacier Inventory (CGI2) of Guo *et al.* [2015] covers China. The GAMDAM outlines are nearly all from 1999–2003 and thus conform with the recommendation of Paul *et al.* [2009] to select imagery as close to 2000 as possible. However they exclude thin ice on headwalls and tend to have areas smaller than those measured in conformance with GLIMS guidelines [Raup and Khalsa, 2007]. The CGI2 inventory has outlines mostly from a target period of 2006–2010, but includes older outlines from the First Chinese Glacier Inventory (CGI1) where suitable imagery could not be found within the target period.A final decision about selection for the RGI from these extensive sources awaits detailed intercomparison. RGI version 5.0 incorporates those CGI2 outlines that are not from CGI1, and GAMDAM outlines in areas of remaining CGI1 coverage as well as areas outside China other than the Karakoram.Glacier outlines retired from version 4.0 will be added to GLIMS if they are not in GLIMS already.Links were added to 17 glaciers in the WGMS mass-balance database.

Changes from Version 3.2 to 4.0 45 exterior GLIMSIds were replaced. Topographic and hypsometric attributes were added.An effort was made to recover as many dates as possible for High Mountain Asia as a whole. Duplication was avoided by creating disjunct polygons for each source, including the Chinese Glacier Inventory (CGI). The outlines of most RGI glaciers on Chinese territory were obtained from the GLIMS database before the RGI system of attributes was adopted. Some of the other sources of dates for High Mountain Asia were partly on Chinese territory.The dates of CGI glaciers were recovered from the 24 May 2011 version of GLIMS. The CGI and RGI outlines were matched by computing arc distances between their GLIMSId locations. Because some work was done for the RGI on correcting mislocated CGI glaciers, this operation was not straightforward. By inspection of trial results, and bearing in mind that the aim was only to place the glacier within the outline of its source image or air photograph, a separation not exceeding 2 km was found sufficient to assign the CGI date accurately to its closest RGI counterpart. Of 50,458 glaciers within the CGI polygon, 38% had exactly matching locations, 43% had separations within 300 m, and 1.4% (709) failed the 2-km test of proximity. Thus the CGI yielded 37,769 new dates, covering 53,192 km2, for RGI 4.0.The glacier inventory of the Nyainqentanghla Range in southeastern Tibet by Bolch *et al.* [2010] was one of the sources for RGI 3.2, and the necessary dates for 789 glaciers (area 796 km2) were recovered from that paper. The mountain range was subdivided into three dated polygons, each representing a different source image or set of images.Most of the O2Region codes in earlier versions were incorrect and have been corrected.Where Chinese RGI glaciers could be matched with confidence to their equivalents in GLIMS, their 12-character WGI identification codes were added to the Name field.

Changes from Version 3.0 to 3.2 None.

Changes from Version 2.0 to Version 3.0 Glacier outlines in much of the central Tien Shan were replaced by the inventory of Osmonov *et al.* [2013]. The outlines were mapped semi-automatically and manually based on Landsat TM data from ~2008. This inventory is superior to the former data as the geolocation is correct while the other data obtained from the GLIMS data base had inhomogeneous shifts. In the Pamir, several outlines from the DCW were replaced by semi-automatically mapped outlines based on Landsat TM/ETM+ data from ~2000. The large offset between the GLIMS data and data from the CGI in eastern Pamir was reduced.

Changes from Version 1.0 to Version 2.0 None.

Version 1.0 Large parts of Central Asia are covered by the GLIMS database, which consists in China of data from the first Chinese Glacier Inventory [Shi *et al.*, 2009] and is of heterogeneous and generally slightly lower quality (more generalized) than the other glacier data used here. It has also to be noted that some of the GLIMS data in Central Asia have a shift in location. Large parts of the Tien Shan in Kazakhstan and Kyrgyzstan were mapped manually or semi-automatically using ratio images from ASTER and Landsat data (e.g. Kutuzov and Shahgedanova, 2009; Kriegel *et al.* [2013]). Important missing areas such as the Central Pamirs, Naryn basin, northern Tien

Shan [Bolch, 2007] and the Dzhungarian Alatau were mapped semi-automatically with manual corrections using Landsat TM/ETM+ scenes. The glacier inventory for the Nyainqentanglha Range in Tibet was taken from Bolch *et al.* [2010].Remaining missing areas were filled by a glacier layer compiled by B. Raup [Raup *et al.*, 2000] from the Digital Chart of the World (DCW) and the World Glacier Inventory. The DCW outlines are in western Kyrgyzstan (region 13-03), the Hissar Alay (13-01), the Safed Khirs (northern Afghanistan) and parts of the southwest Pamir (13-02).

5.15 14: South Asia West

Regions `13`, `14`, `15` comprise the region that is often referred to as High Mountain Asia. Region 14 encompasses all glaciers in the Hindu Kush, the Karakoram (including the Taxkozuk range in the North), in Western Himalaya and the glaciers on the south-eastern Tibetan Plateau that drain into the Indus River.

Subregions

- 14-01: Hindu Kush
- 14-02: Karakoram
- 14-03: West Himalaya

5.15.1 Changes from version 6.0 to 7.0

All previous outlines have been replaced by the GAMDAM glacier inventory version 2 GGI [Sakai, 2019], also named GGI18. The glaciers were manually mapped based on Landsat TM and ETM+ summer imagery with most scenes being from the year 2002. Earlier and later scenes were used in case of unsuitable scenes within this year.

5.15.2 Additional information

Data sources and analysts

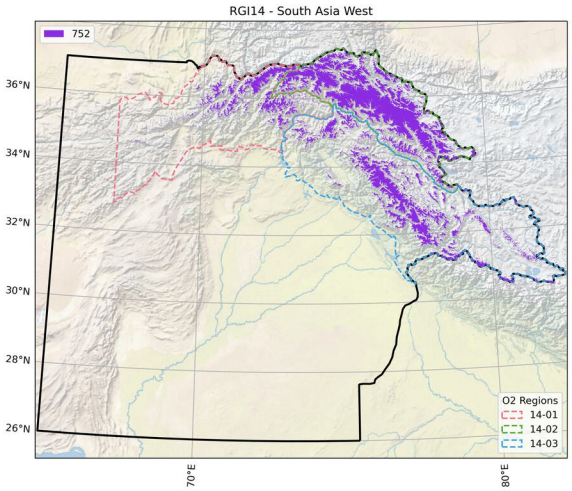


Fig. 5.55: Submission IDs used for this region Download high resolution version.

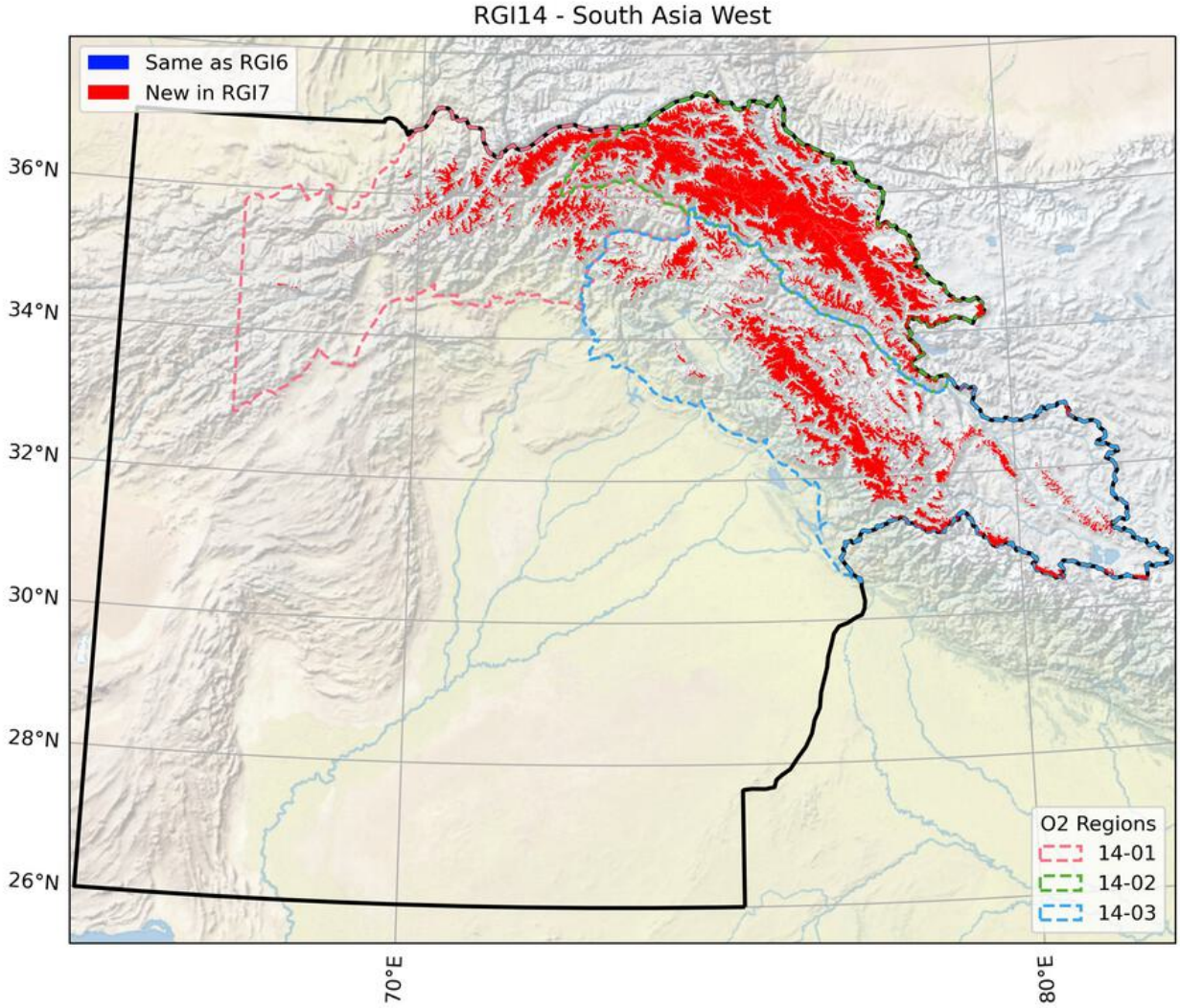


Fig. 5.54: Regional glacier area. Download high resolution version.

Glacier outline providers to GLIMS

This list includes the providers of the outlines used in the RGI 7.0 as generated automatically from the GLIMS outlines metadata. We acknowledge that the list may be incomplete due to omissions in the GLIMS database.

Submission 752 Submitter: Sakai, Akiko.**Number of outlines**: 37562. **Area**: 33075.1km^2. **Release date**: 2018-08-24.**Analysts**: Sakai, Akiko.

Reviewers None;

Regional statistics

Figure: Outlines source date

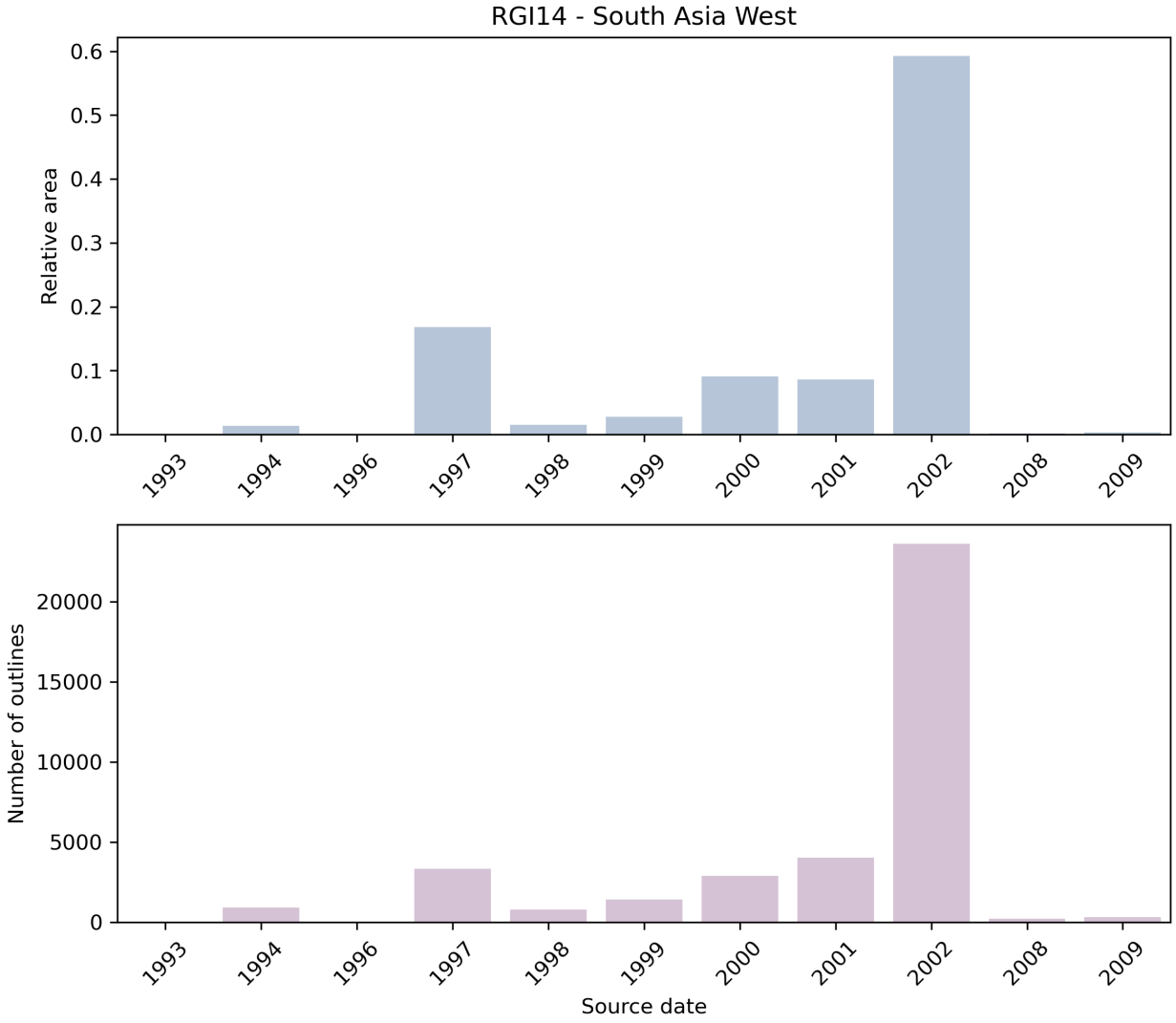


Fig. 5.56: Distribution of the outline dates per area (top) and number (bottom)

Figure: Glacier area histogram

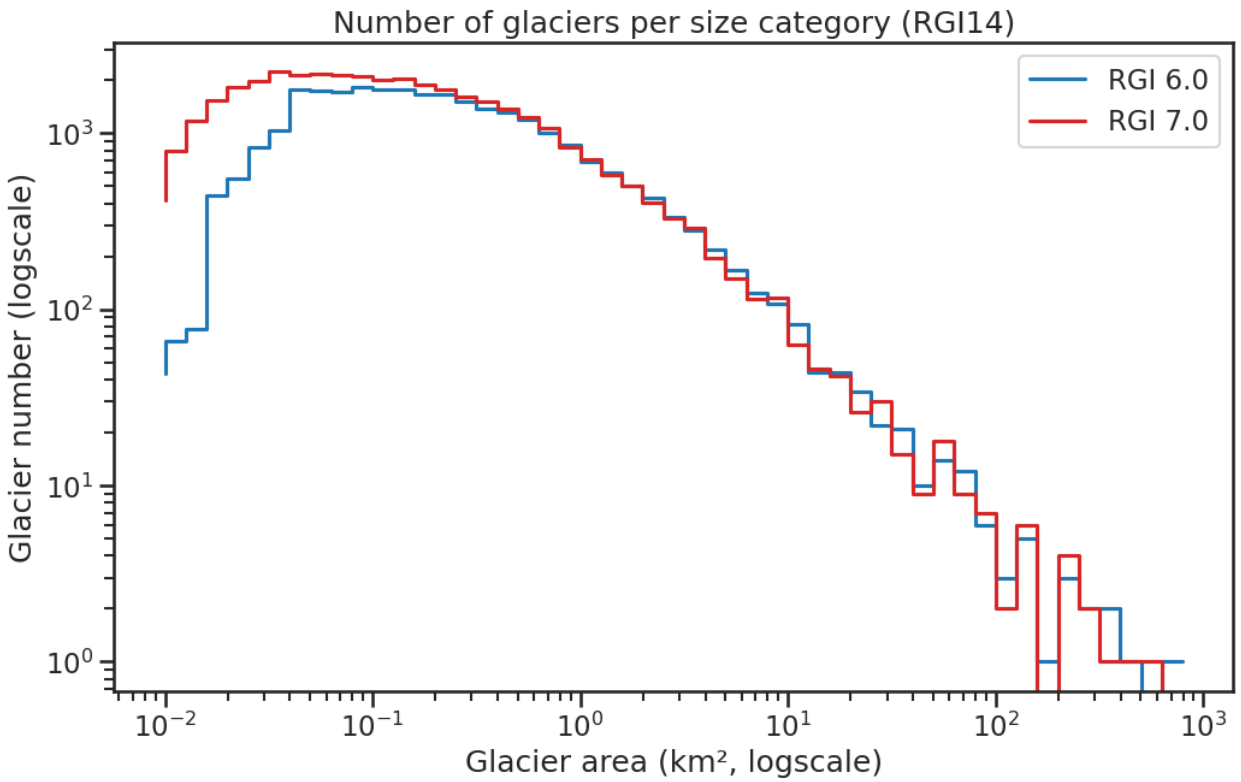


Fig. 5.57: Number of glaciers per size category (log-log scale).

Table: Terminus type statistics Regional number of glaciers (N) and area (km^2) per terminus type in RGI 7.0 and RGI 6.0. Note that the default designation in RGI 7.0 is now "Not assigned", while in RGI 6.0 lake-terminating glaciers and shelf-terminating glaciers were identified in some regions. The RGI region 19 is entirely labelled as "Not assigned" in RGI 7.0.

Value	Terminus type	RGI 7.0 (N)	RGI 6.0 (N)	RGI 7.0 (Area)	RGI 6.0 (Area)
0	Land-terminating	0	27988	0	33568
1	Marine-terminating	0	0	0	0
2	Lake-terminating	0	0	0	0
3	Shelf-terminating	0	0	0	0
9	Not assigned	37562	0	33075	0

Table: Surge type statistics Regional number of glaciers (N) and area (km^2) per surge type attribute in RGI 7.0 and RGI 6.0.

Value	Surge type	RGI 7.0 (N)	RGI 6.0 (N)	RGI 7.0 (Area)	RGI 6.0 (Area)
0	No evidence	37223	10104	21746	12879
1	Possible	6	13	35	1731
2	Probable	103	14	1161	1362
3	Observed	230	41	10133	4144
9	Not assigned	0	17816	0	13452

Version history

Changes from Version 5.0 to 6.0 None.

Changes from Version 4.0 to 5.0 Regions 13, 14 and 15 are entirely new in version 5.0. being taken from Nuimura *et al.* [2015], Guo *et al.* [2015] and as-yet unpublished work at the Technical University of Dresden and University of Zürich. *Remark (2023): the outlines have now been published: Mölg* et al. *[2018]*. The Dresden/Zürich outlines cover the Karakoram in region 14.All were adopted for RGI version 5.0. Parts of region 14 not covered by this source were taken from the Second Chinese Glacier Inventory (CGI2) of Guo *et al.* [2015], and from the GAMDAM inventory of Nuimura *et al.* [2015] in areas outside the coverage of CGI2.Glacier outlines retired from version 4.0 will be added to GLIMS if they are not in GLIMS already.Links were added to 3 glaciers in the WGMS mass-balance database.

Changes from Version 3.2 to 4.0 36 exterior GLIMSIds were replaced. Topographic and hypsometric attributes (section 3.2) were added.Dates were added from two regional inventories that were sources for RGI 3.2. A BgnDate of 2 August 2002 was assigned to 1,184 glaciers (area 3,118 km2) in the basin of the upper Shyok River [Bhambri *et al.*, 2013]. Dates for 11,531 glaciers (area 9,124 km2) in northwestern India [Frey *et al.*, 2012] were recovered by comparing the GLIMS version of the inventory with the RGI 3.2 version, matching glaciers by their GLIMSIds, and transferring the dates from the GLIMS version.Elsewhere in the Himalayan range, most of the RGI glacier outlines are from reports of the International Centre for Integrated Mountain Development (ICIMOD). Polygons were generated to enclose the glaciers inventoried by Sah *et al.* [2005] in Uttarakhand and by Mool *et al.* [2005] in northern Pakistan and the upper Indus basin. The RGI 3.2 glaciers within each polygon were assigned the date of the corresponding image, verified by comparison with the glacier-by-glacier lists in the source.See Region 13: Central Asia for the recovery of dates for Chinese glaciers. Where RGI glacier outlines from the first Chinese Glacier Inventory could be matched with confidence to their equivalents in GLIMS, their 12-character WGI identification codes were added to the Name field.

Changes from Version 3.0 to 3.2 None.

Changes from Version 2.0 to Version 3.0 None.

Changes from Version 1.0 to Version 2.0 Six glaciers in the Ghorband River basin, Afghanistan (region 14-01) were added as nominal circles from WGI-XF. The Ghorband is one of the headwaters of the Kabul River and thus of the Indus. It is possible that more Afghan glaciers remain to be identified further to the southwest.

Version 1.0 Large parts of the Himalaya and Karakoram are covered by the GLIMS database, to which they were originally contributed by T. Khromova. For the RGI, GLIMS was used as the source where no other was available, mainly on the northern slopes of the Himalayas and the northeastern part of the Karakoram. In these regions, the GLIMS database consists mostly of data from the first Chinese Glacier Inventory [Shi *et al.*, 2009] and is of heterogeneous and generally slightly lower quality than the other glacier data used here. Glacier outlines compiled by ICIMOD were used for parts of the Karakoram. The outlines in the Shyok River basin (northeastern Karakoram) are from Bhambri *et al.* [2013]. For parts of northwestern India, glacier inventory data compiled by the GlobGlacier project of the European Space Agency (ESA) [Paul *et al.*, 2009] was used; the information was compiled from Landsat ETM+ and ALOS PALSAR data [Frey *et al.*, 2012]. For a few regions in the Karakoram, no suitable glacier data was available. We therefore compiled new glacier outlines in these regions based on Landsat ETM+ data from the years 2002, 2009, and 2010.

5.16 15: South Asia East

Regions `13`, `14`, `15` comprise the region that is often referred to as High Mountain Asia. Region 15 encompasses (a) all the glaciers of western and central Himalaya that drain into the Ganges and Yarlung Tsango/ Brahmaputra, (b) all glaciers in the eastern Himalaya, apart from the glaciers on the north slope of the greater Himalaya that drain into Lake Puma Yumco (close to Bhutan) and on the northern slope of the Namcha Barwa Himal (the easternmost section of the Himalaya), and (c) all glaciers in the south-eastern part of the Nyainqntanglha (also "Nyenchen Tanglha") Mountains and the Hengduan Shan.

Subregions

- 15-01: Central Himalaya
- 15-02: East Himalaya
- 15-03: Hengduan Shan

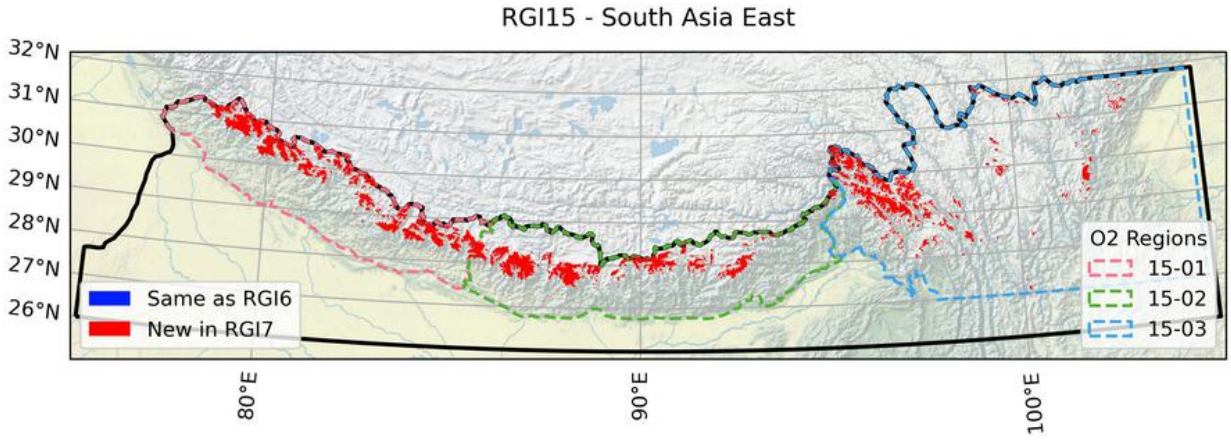


Fig. 5.58: Regional glacier area. Download high resolution version.

5.16.1 Changes from version 6.0 to 7.0

All previous outlines have been replaced by the GAMDAM glacier inventory version 2 GGI [Sakai, 2019], also named GGI18. The glaciers were manually mapped based on Landsat TM and ETM+ summer imagery with most scenes being from the years 1994, 1998, 1999, 2002 and 2005. Some scenes from the period 1992 - 2010 were used in case of unsuitable scenes within these years. In the Khumbu region outlines were manually mapped based on very-high resolution satellite imagery (WorldView, Pléiades, Ikonos) and DEM differencing results from King *et al.* [2020].

5.16.2 Additional information

Data sources and analysts

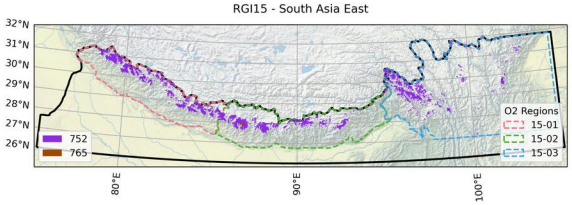


Fig. 5.59: Submission IDs used for this region Download high resolution version.

Glacier outline providers to GLIMS

This list includes the providers of the outlines used in the RGI 7.0 as generated automatically from the GLIMS outlines metadata. We acknowledge that the list may be incomplete due to omissions in the GLIMS database.

Submission 752 Submitter: Sakai, Akiko.**Number of outlines**: 18578. **Area**: 15964.1km^2. **Release date**: 2018-08-24.**Analysts**: Sakai, Akiko.

Submission 765 Submitter: Bolch, Tobias.**Number of outlines**: 9. **Area**: 85.3km^2. **Release date**: 2022-05-01.**Analysts**: Bolch, Tobias.

Reviewers Bolch, Tobias;

Regional statistics

Figure: Outlines source date

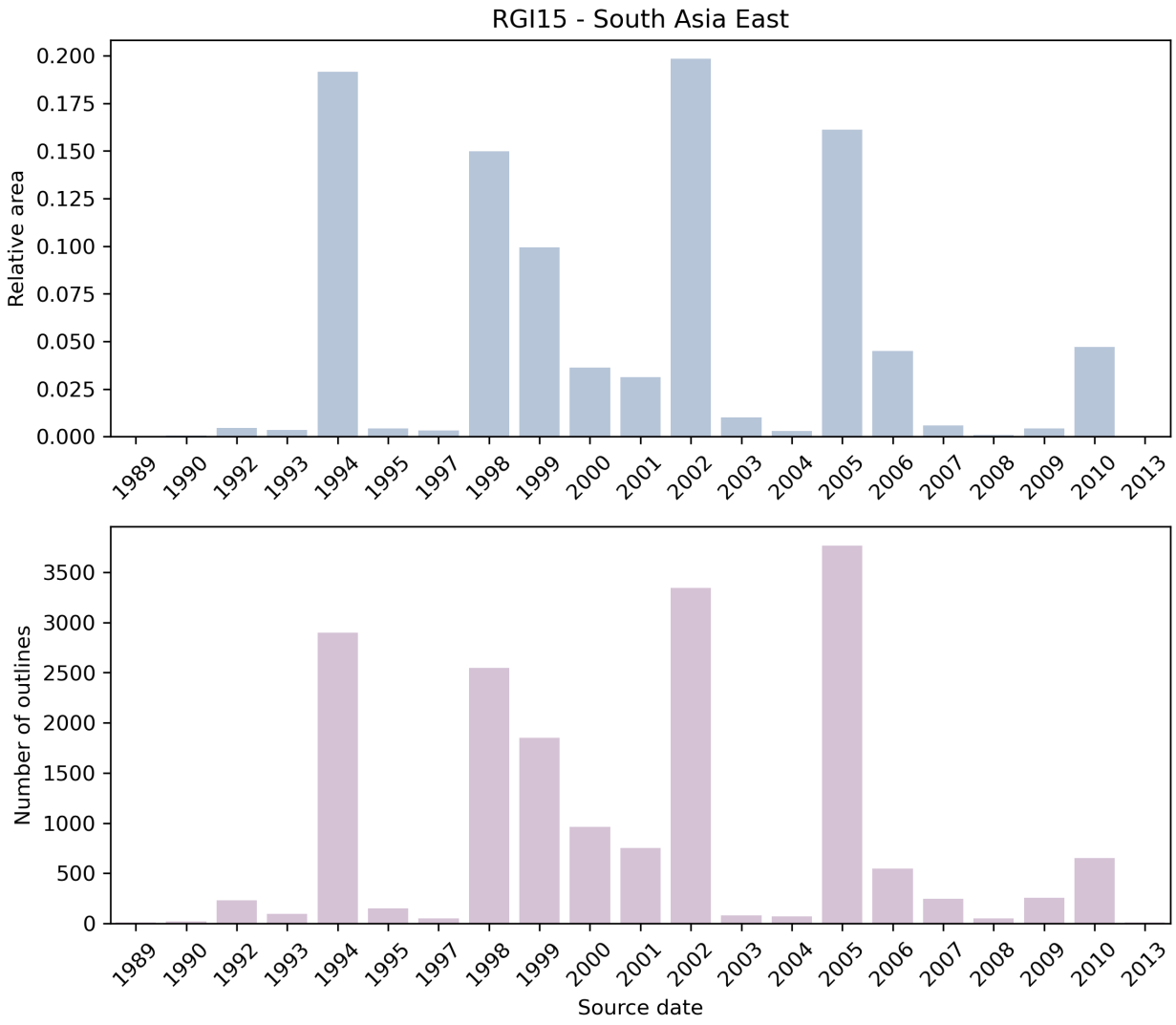


Fig. 5.60: Distribution of the outline dates per area (top) and number (bottom)

Figure: Glacier area histogram

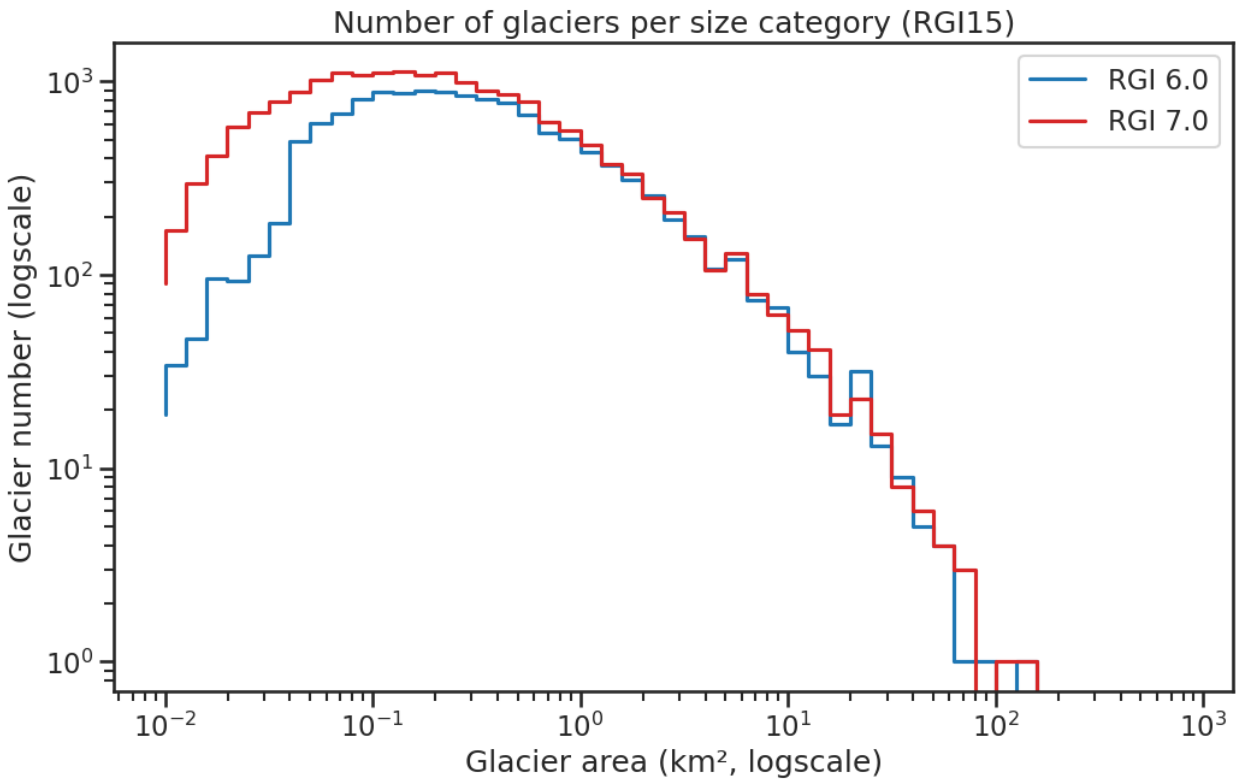


Fig. 5.61: Number of glaciers per size category (log-log scale).

Table: Terminus type statistics Regional number of glaciers (N) and area (km^2) per terminus type in RGI 7.0 and RGI 6.0. Note that the default designation in RGI 7.0 is now "Not assigned", while in RGI 6.0 lake-terminating glaciers and shelf-terminating glaciers were identified in some regions. The RGI region 19 is entirely labelled as "Not assigned" in RGI 7.0.

Value	Terminus type	RGI 7.0 (N)	RGI 6.0 (N)	RGI 7.0 (Area)	RGI 6.0 (Area)
0	Land-terminating	0	13119	0	14734
1	Marine-terminating	0	0	0	0
2	Lake-terminating	0	0	0	0
3	Shelf-terminating	0	0	0	0
9	Not assigned	18587	0	16049	0

Table: Surge type statistics Regional number of glaciers (N) and area (km^2) per surge type attribute in RGI 7.0 and RGI 6.0.

Value	Surge type	RGI 7.0 (N)	RGI 6.0 (N)	RGI 7.0 (Area)	RGI 6.0 (Area)
0	No evidence	18575	0	15810	0
1	Possible	1	1	165	180
2	Probable	6	1	20	29
3	Observed	5	0	54	0
9	Not assigned	0	13117	0	14526

Version history

Changes from Version 5.0 to 6.0 None.

Changes from Version 4.0 to 5.0 Regions 13, 14 and 15 are entirely new in version 5.0. being taken from Nuimura *et al.* [2015], Guo *et al.* [2015] and as-yet unpublished work at the Technical University of Dresden and University of Zürich. *Remark (2023): the outlines have now been published: Mölg* et al. *[2018]*. The Dresden/Zürich outlines cover the Karakoram in region 14.The GAMDAM inventory of Nuimura *et al.* [2015] covers all of High Mountain Asia (including RGI region 10-04). The Second Chinese Glacier Inventory (CGI2) of Guo *et al.* [2015] covers China and Arunachal Pradesh. The GAMDAM outlines are nearly all from 1999–2003 and thus conform with the recommendation of Paul *et al.* [2009] to select imagery as close to 2000 as possible. However they exclude thin ice on headwalls and in that sense are not in conformance with GLIMS guidelines [Raup and Khalsa, 2007]. The CGI2 inventory has outlines mostly from a target period of 2006–2010, but includes older outlines from the First Chinese Glacier Inventory (CGI1) where suitable imagery could not be found within the target period.A final decision about selection for the RGI from these extensive sources awaits detailed intercomparison. RGI version 5.0 incorporates those CGI2 outlines that are not from CGI1, and GAMDAM outlines in areas of remaining CGI1 coverage as well as areas outside China.Glacier outlines retired from version 4.0 will be added to GLIMS if they are not in GLIMS already.Links were added to 5 glaciers in the WGMS mass-balance database.

Changes from Version 3.2 to 4.0 Nine exterior GLIMSIds were replaced. Topographic and hypsometric attributes were added.Dates were recovered for as many glaciers as possible. For Bhutan, a polygon enclosing the glaciers inventoried by ICIMOD was created and subdivided into three polygons, one for each of the image sets from which the glaciers were identified. The RGI 3.2 glaciers within each polygon were assigned the date of the corresponding image, verified by comparison with the glacier-by-glacier lists in the source. Equivalent procedures were adopted for Sikkim and the basins of the Pum (upper Arun) and Poi and Rongxer (upper Bhote–Sun Koshi and Tama Koshi) rivers. Glaciers elsewhere in Nepal were assigned a date range from 2008 to 2009 (ICIMOD), consistent with those in earlier versions.See Region 13: Central Asia for the recovery of dates for Chinese glaciers. Where RGI glacier outlines from the first Chinese Glacier Inventory could be matched with confidence to their equivalents in GLIMS, their 12-character WGI identification codes were added to the Name field.

Changes from Version 3.0 to 3.2 None.

Changes from Version 2.0 to Version 3.0 Outlines of the glaciers of Burma, provided by S. Bajracharya, were added.

Changes from Version 1.0 to Version 2.0 None.

Version 1.0 Large parts of the Himalaya are covered by the GLIMS database. For the RGI, GLIMS was used as the source where no other was available, mainly on the northern slopes of the Himalayas. In these regions, the GLIMS database consists mostly of data from the first Chinese Glacier Inventory [Shi *et al.*, 2009] and is of heterogeneous and generally slightly lower quality than the other glacier data used here. Glacier outlines compiled by ICIMOD were used for the central and eastern Himalayas. For Nepal, more recent information from 2008 and 2009 is available and was used here (ICIMOD).

5.17 16: Low Latitudes

The region encompasses all glaciers in the tropics and sub-tropics (25°S-20°N) including glaciers in South America, Africa and Indonesia.

Subregions

- 16-01: Low-latitude Andes
- 16-02: Mexico
- 16-03: East Africa

- 16-04: New Guinea

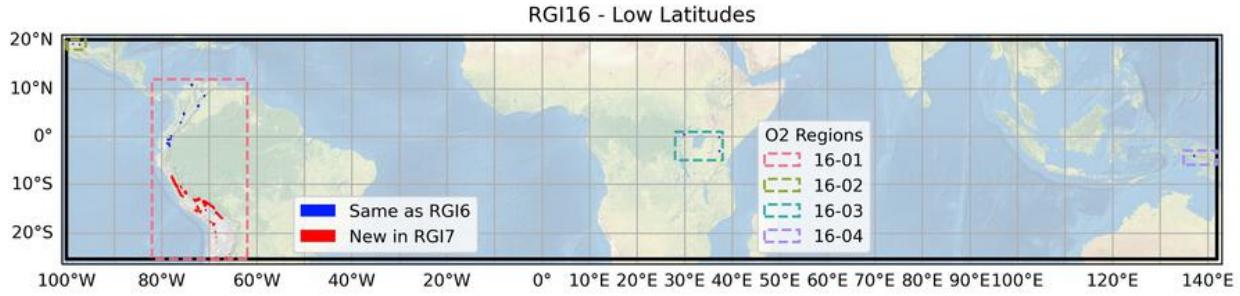


Fig. 5.62: Regional glacier area. Download high resolution version.

5.17.1 Changes from version 6.0 to 7.0

Peru and Bolivia

All RGI 6.0 outlines were replaced since they had been derived from satellite images with adverse snow conditions acquired over a 10-year period. Many outlines assumed a triangular shape during raster-vector conversion, and had ice divides in the wrong place. The outlines in RGI 7.0 are based on 17 Landsat 5 TM scenes that were acquired in 1998 with excellent snow conditions for mapping. Outlines for clean glaciers were created from a simple red/SWIR band ratio with scene specific thresholds. After raster-vector conversion, wrongly mapped lakes were removed and missing debris-cover was manually added. New ice divides were derived from the 30 m resolution Copernicus DEM using the divides in RGI 6.0 as a base. The interpretation was supported by glacier outlines from the national glacier inventory of Peru and the "World imagery" layer of the ESRI basemap.

Chile and Argentina

Some glaciers in northern Chile and Argentina were replaced. Details are given in *17: Southern Andes*.

5.17.2 Additional information

Data sources and analysts

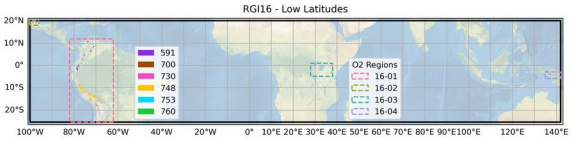


Fig. 5.63: Submission IDs used for this region Download high resolution version.

Glacier outline providers to GLIMS

This list includes the providers of the outlines used in the RGI 7.0 as generated automatically from the GLIMS outlines metadata. We acknowledge that the list may be incomplete due to omissions in the GLIMS database.

Submission 591 **Submitter**: Cogley, Graham.**Number of outlines**: 158. **Area**: 169.2km^2. **Release date**: 2015-07-16.**Analysts**: Kienholz, Christian; Miles, Evan; Sharp, Martin; Wyatt, F..

Submission 700 Submitter: Hidalgo, Lidia Ferri.**Number of outlines**: 17. **Area**: 1.5km^2. **Release date**: 2018-09-04.**Analysts**: Castro, Mariano; Gargantini, Hernán; Gimenez, Melisa; Hidalgo, Lidia Ferri; Masiokas, Mariano; Pecker Marcosig, Ivanna; Pitte, Pierre; Ruiz, Lucas; Zalazar, Laura.

Submission 730 Submitter: Barcaza, Gonzalo.**Number of outlines**: 20. **Area**: 9.4km^2. **Release date**: 2018-07-24.**Analysts**: Albornoz, Amapola; Arias, Victor; Barcaza, Gonzalo; Garcia, Juan-Luis; Nussbaumer, Samuel; Tapia, Guillermo; Valdes, Javier; Videla, Yohan.

Submission 748 Submitter: Paul, Frank.**Number of outlines**: 3495. **Area**: 1734.7km^2. **Release date**: 2021-09-02.**Analysts**: Goerlich, Franz; Paul, Frank; Rastner, Philipp.

Submission 753 Submitter: Maussion, Fabien.**Number of outlines**: 4. **Area**: 13.6km^2. **Release date**: 2022-04-18.**Analysts**: Cáceres, B.; Francou, B.; Jordan, S.; Peñafiel, A.; Ungerechts, L..

Submission 760 Submitter: Maussion, Fabien.**Number of outlines**: 1. **Area**: 0.1km^2. **Release date**: 2022-04-19.**Analysts**: Kienholz, Christian; Miles, Evan; Sharp, Martin; Wyatt, F..

Reviewers Prinz, Rainer; Rabatel, Antoine;

Regional statistics

Figure: Outlines source date

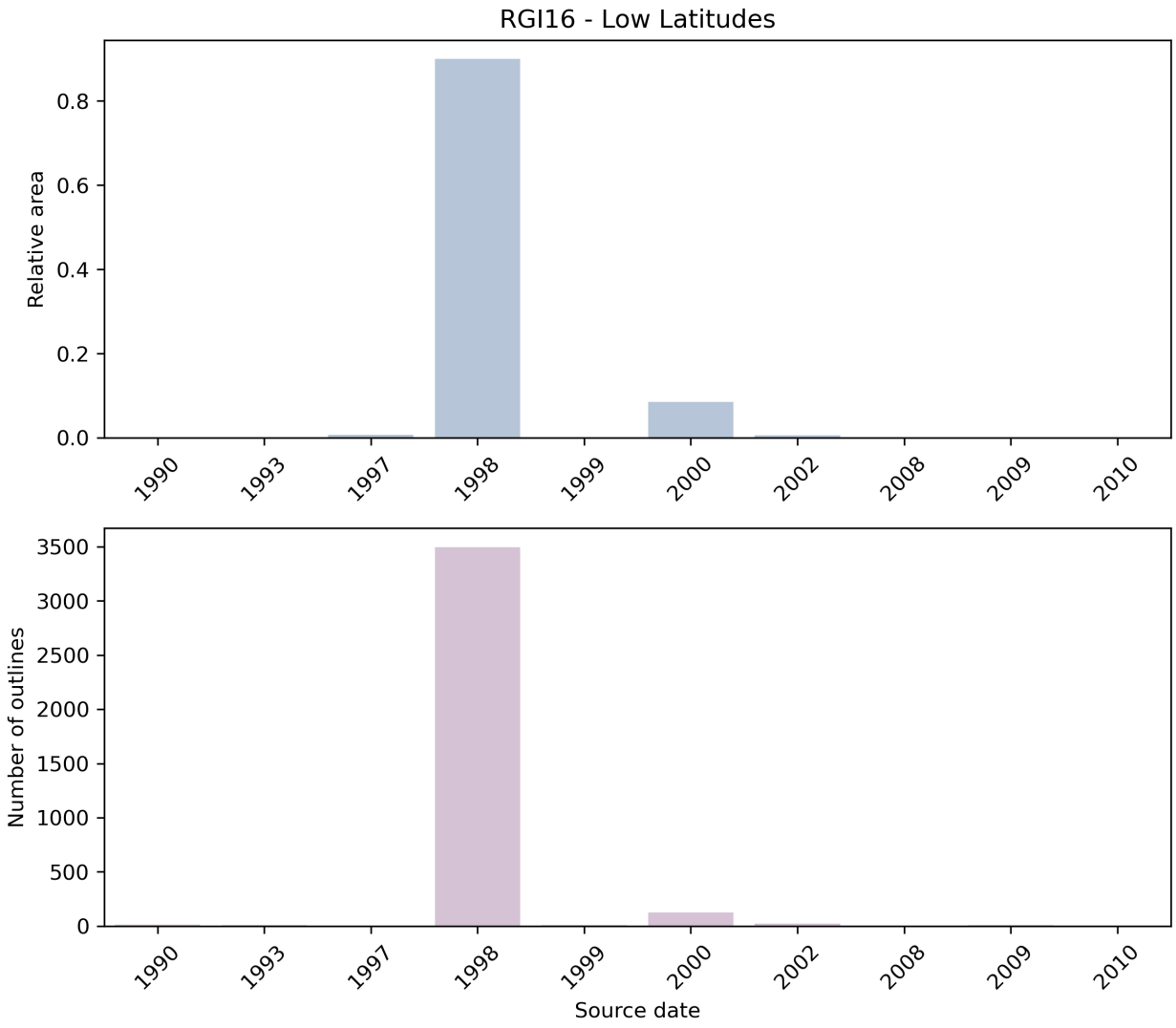


Fig. 5.64: Distribution of the outline dates per area (top) and number (bottom)

Figure: Glacier area histogram

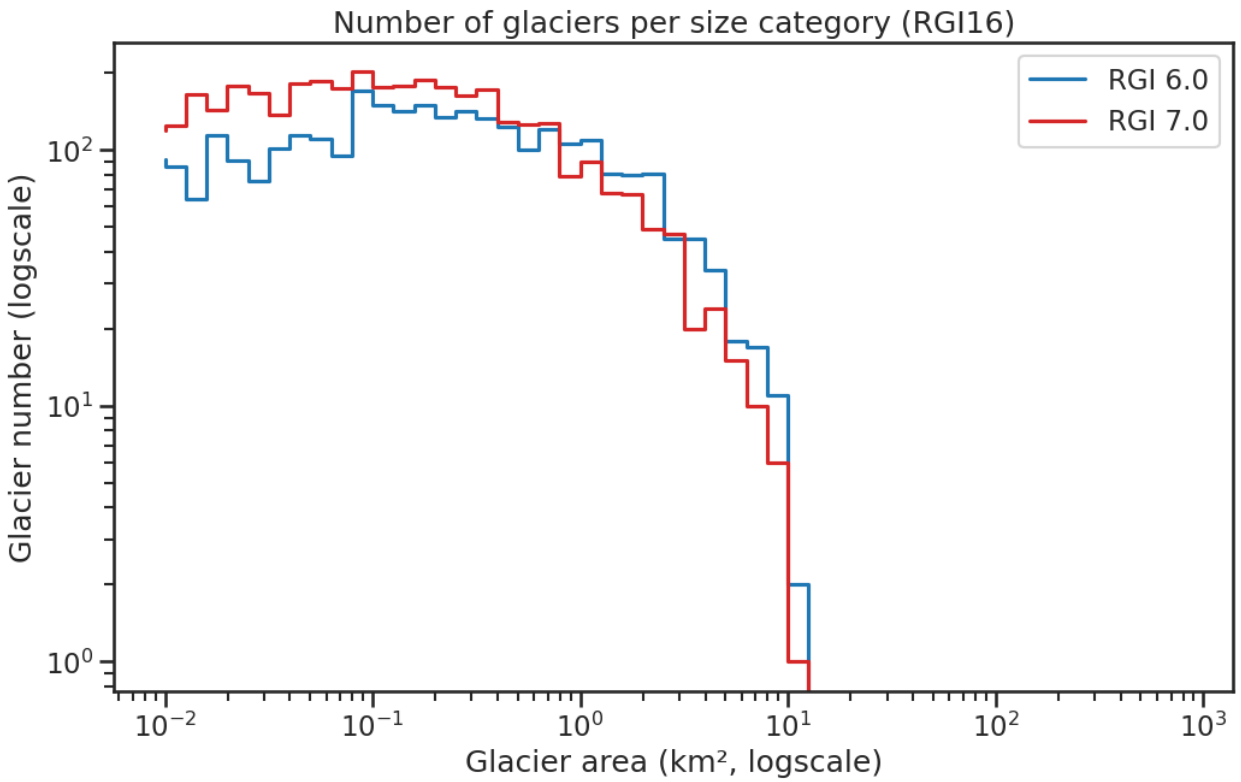


Fig. 5.65: Number of glaciers per size category (log-log scale).

Table: Terminus type statistics Regional number of glaciers (N) and area (km^2) per terminus type in RGI 7.0 and RGI 6.0. Note that the default designation in RGI 7.0 is now "Not assigned", while in RGI 6.0 lake-terminating glaciers and shelf-terminating glaciers were identified in some regions. The RGI region 19 is entirely labelled as "Not assigned" in RGI 7.0.

Value	Terminus type	RGI 7.0 (N)	RGI 6.0 (N)	RGI 7.0 (Area)	RGI 6.0 (Area)
0	Land-terminating	0	2939	0	2341
1	Marine-terminating	0	0	0	0
2	Lake-terminating	0	0	0	0
3	Shelf-terminating	0	0	0	0
9	Not assigned	3695	0	1929	0

Table: Surge type statistics Regional number of glaciers (N) and area (km^2) per surge type attribute in RGI 7.0 and RGI 6.0.

Value	Surge type	RGI 7.0 (N)	RGI 6.0 (N)	RGI 7.0 (Area)	RGI 6.0 (Area)
0	No evidence	3695	48	1929	8
1	Possible	0	0	0	0
2	Probable	0	0	0	0
3	Observed	0	0	0	0
9	Not assigned	0	2891	0	2333

Version history

Changes from Version 5.0 to 6.0 Coverage of the glaciers of Cotopaxi, Ecuador, was replaced with outlines for 1997 digitized from Jordan *et al.* [2005]).

Changes from Version 4.0 to 5.0 Links were added to 2 glaciers in the WGMS mass-balance database.

Changes from Version 3.2 to 4.0 94 exterior GLIMSIds were replaced. Topographic and hypsometric attributes were added.The 81 remaining glacier complexes in the Bolivian Andes were subdivided by C. Kienholz into 159 glaciers. RGIIds for the whole of region 16 were altered in consequence.

Changes from Version 3.0 to 3.2 Outlines of the glaciers of Mexico were replaced with outlines provided by E. Burgess, and the nominal glaciers of east Africa and New Guinea were replaced with outlines provided by N.J. Cullen and A. Klein respectively. Note that several glacier complexes are still present in southern Peru and western Bolivia.

Changes from Version 2.0 to Version 3.0 Some outlines in northern Chile were improved.

Changes from Version 1.0 to Version 2.0 Outlines of the glaciers of Mexico (16-02) were digitized by J.G. Cogley from maps in "Satellite Image Atlas of Glaciers of the World – North America". 59 glaciers in east Africa (16-03) and seven in New Guinea (16-04) were added as nominal circles from WGI-XF. See the RGI v6 Technical Note for an extended summary of quality controls conducted by E.S. Miles, University of British Columbia.

Version 1.0 Shapefiles were created from late-summer, cloud-free Landsat 7 ETM+ imagery acquired prior to the 2003 scan line corrector (SLC) failure. To identify glacier surfaces, a normalized difference snow index (NDSI) was calculated using bands 5 and 2 for the red and near-infrared bands respectively. A threshold of approximately 0.5-0.65 was used to identify dirty/shady/bare ice, and one from 0.65-0.99 to identify snow-covered ice. Gridded files were then converted to polygons and additional manual editing was carried out to eliminate incorrectly classified regions.

5.18 17: Southern Andes

The region encompasses all glaciers in South America south of 25°S.

Subregions

- 17-01: Patagonia
- 17-02: Central Andes

5.18.1 Changes from version 6.0 to 7.0

All glaciers in RGI 6.0 were replaced by new outlines.

The RGI 6.0 glacier outlines suffered from reduced quality due to the presence of seasonal snow, missing debris-covered glaciers, incorrectly mapped ice divides and data processing artefacts. RGI 7.0 outlines are based on the new national glacier inventories of Argentina [Zalazar *et al.*, 2020] and Chile [Barcaza *et al.*, 2017]. The former was derived from a range of sensors (ALOS, ASTER, Landsat, SPOT4) with images acquired between 2004 and 2013. The latter was derived from Landsat ETM+ imagery acquired between 2000 and 2003. Both national inventories included rock glaciers which were removed for RGI 7.0. The classes MN (snow field) and GCGE (mixed debris-covered / rock glacier) in the Argentina inventory were also removed. Data gaps and overlaps along the national boundary as well as wrongly placed drainage divides were corrected in the merged data set using the "World imagery" layer of the ESRI basemap and a flow direction grid derived from the AW3D30 DEM, respectively. In some regions (e.g. Tierra del Fuego) missing glaciers

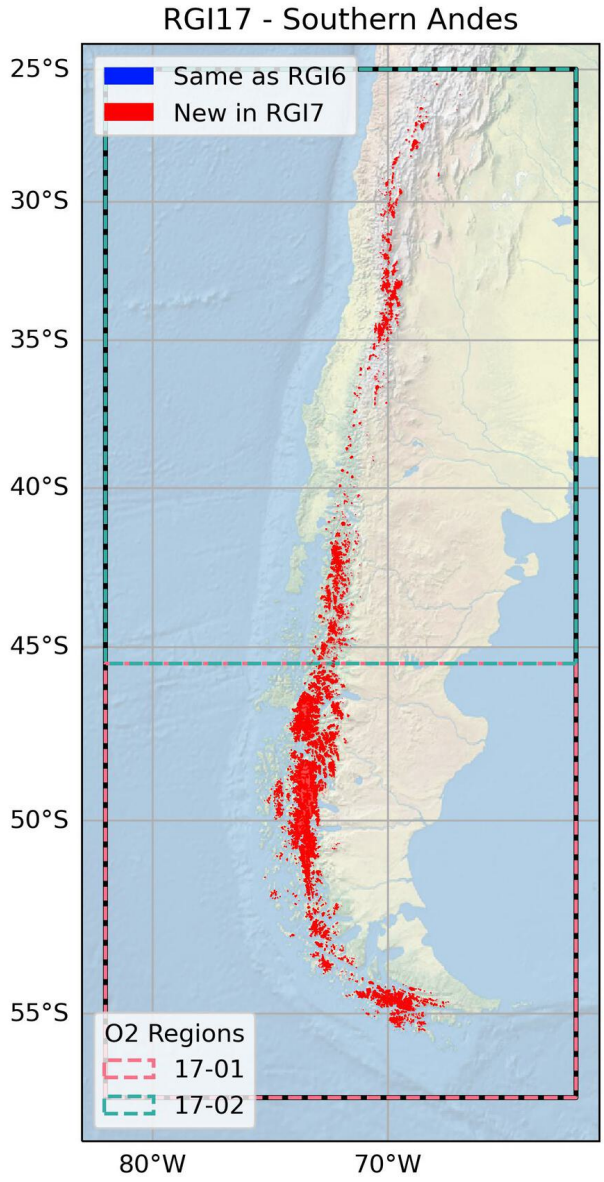


Fig. 5.66: Regional glacier area. Download high resolution version.

were added and the extent of glaciers that were too large in the Argentian and Chilean inventories was reduced using Landsat images from around the year 2000.

5.18.2 Additional information

Data sources and analysts

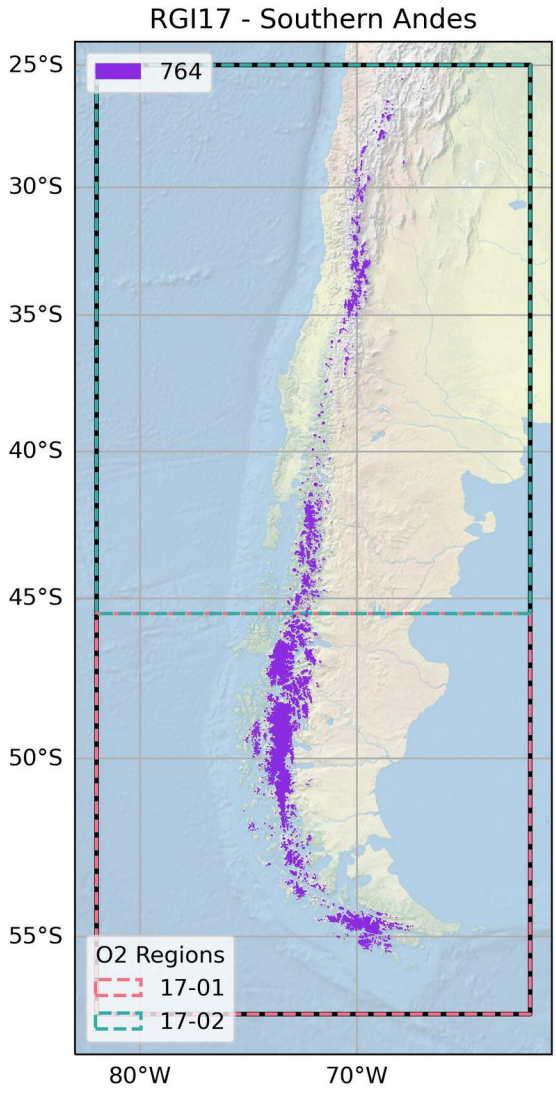


Fig. 5.67: Submission IDs used for this region Download high resolution version.

Glacier outline providers to GLIMS

This list includes the providers of the outlines used in the RGI 7.0 as generated automatically from the GLIMS outlines metadata. We acknowledge that the list may be incomplete due to omissions in the GLIMS database.

Submission 764 Submitter: Paul, Frank.**Number of outlines**: 30634. **Area**: 27674.4km^2. **Release date**: 2022-05-11.**Analysts**: Albornoz, Amapola; Arias, Victor; Barcaza, Gonzalo; Bown, Francisca; Castro, Mariano; Garcia,

Juan-Luis; Gargantini, Hernán; Gimenez, Melisa; Hidalgo, Lidia Ferri; Masiokas, Mariano; Nussbaumer, Samuel; Paul, Frank; Pecker Marcosig, Ivanna; Pitte, Pierre.

Reviewers Rabatel, Antoine;

Regional statistics

Figure: Outlines source date

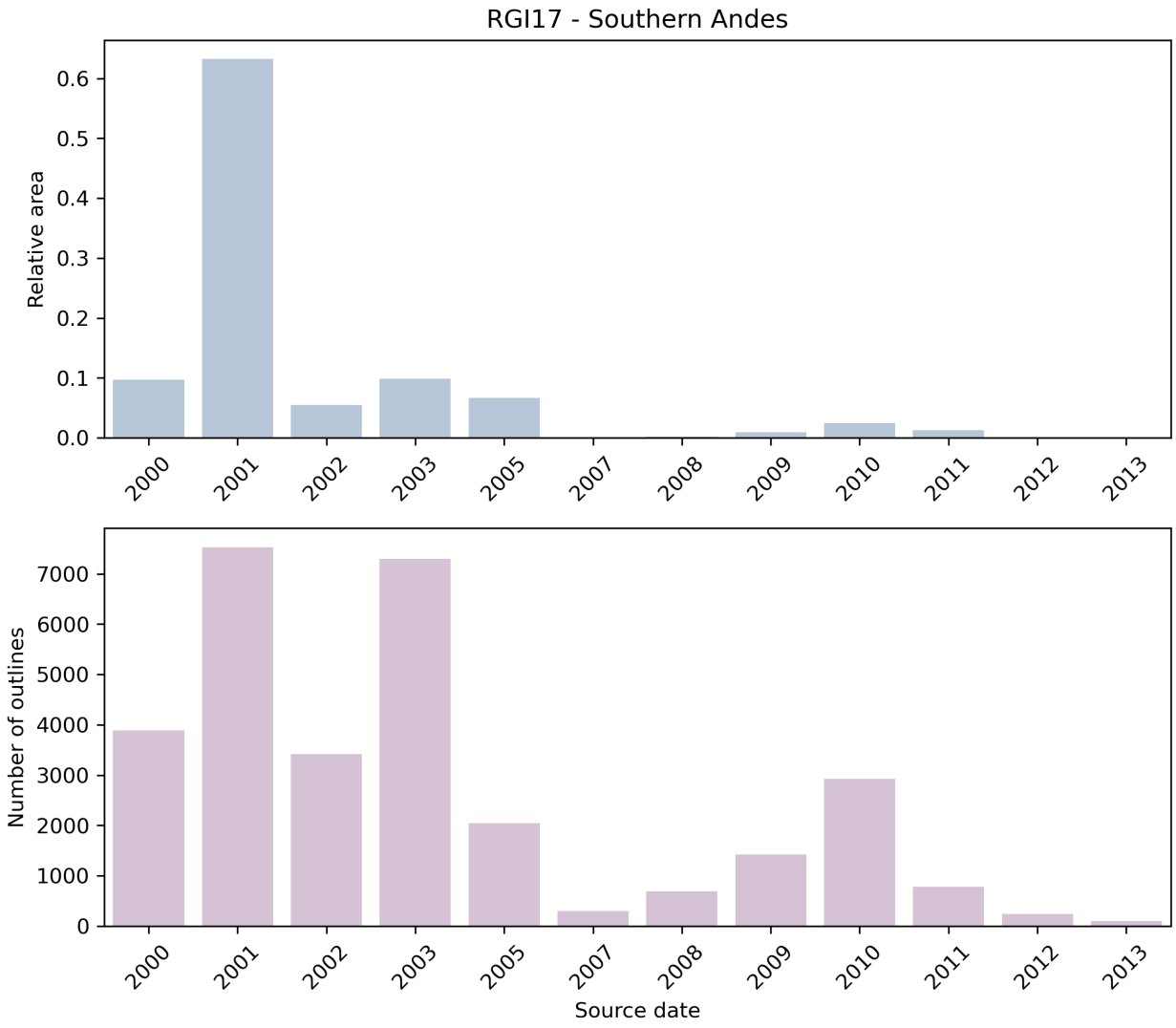


Fig. 5.68: Distribution of the outline dates per area (top) and number (bottom)

Figure: Glacier area histogram

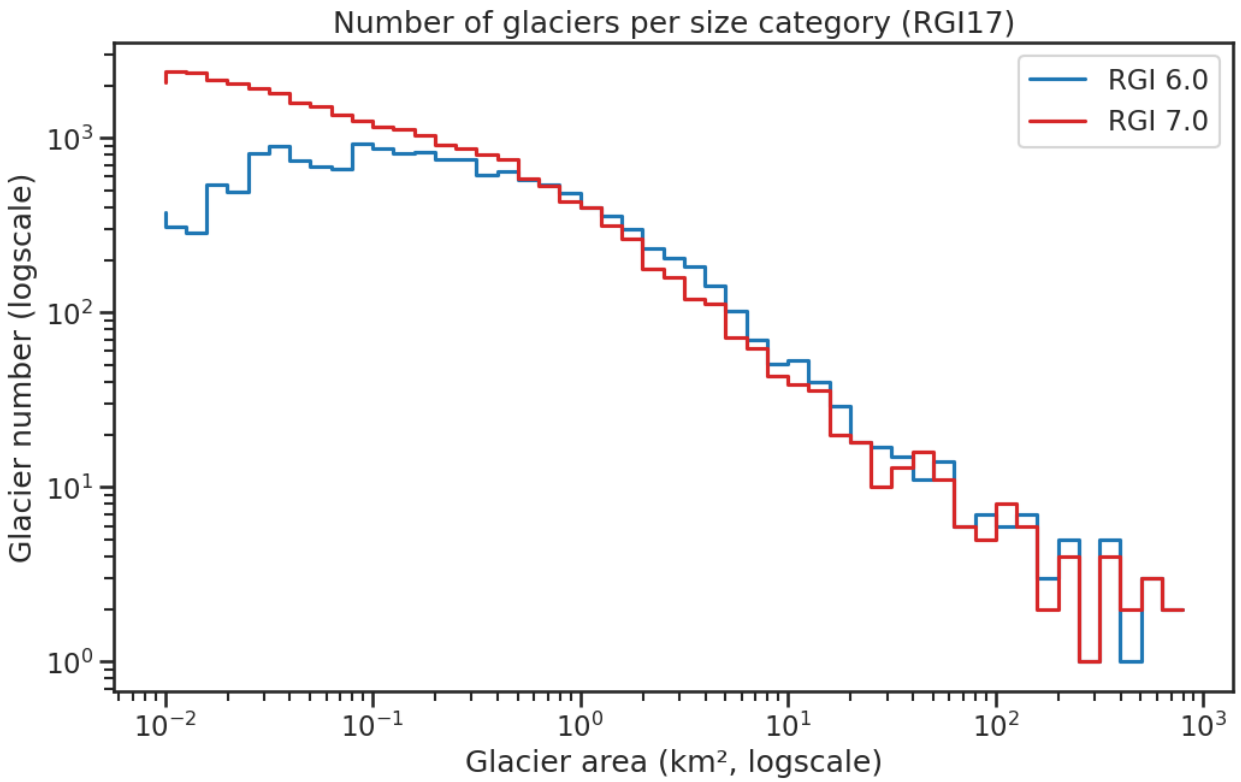


Fig. 5.69: Number of glaciers per size category (log-log scale).

Table: Terminus type statistics Regional number of glaciers (N) and area (km^2) per terminus type in RGI 7.0 and RGI 6.0. Note that the default designation in RGI 7.0 is now "Not assigned", while in RGI 6.0 lake-terminating glaciers and shelf-terminating glaciers were identified in some regions. The RGI region 19 is entirely labelled as "Not assigned" in RGI 7.0.

Value	Terminus type	RGI 7.0 (N)	RGI 6.0 (N)	RGI 7.0 (Area)	RGI 6.0 (Area)
0	Land-terminating	0	15690	0	12237
1	Marine-terminating	62	85	6871	7057
2	Lake-terminating	0	133	0	10135
3	Shelf-terminating	0	0	0	0
9	Not assigned	30572	0	20804	0

Table: Surge type statistics Regional number of glaciers (N) and area (km^2) per surge type attribute in RGI 7.0 and RGI 6.0.

Value	Surge type	RGI 7.0 (N)	RGI 6.0 (N)	RGI 7.0 (Area)	RGI 6.0 (Area)
0	No evidence	30603	0	26132	0
1	Possible	2	1	21	19
2	Probable	1	1	4	3
3	Observed	28	15	1517	1538
9	Not assigned	0	15891	0	27869

Version history

Changes from Version 5.0 to 6.0 Coverage of the North Patagonian Ice Field was replaced with outlines for 2001 [Rivera *et al.*, 2007] obtained from GLIMS.Names of glaciers in the North and South Patagonian Icefields were added.

Changes from Version 4.0 to 5.0 Links were added to 2 glaciers in the WGMS mass-balance database.

Changes from Version 3.2 to 4.0 68 exterior GLIMSIds were replaced. Topographic and hypsometric attributes (section 3.2) were added.

Changes from Version 3.0 to 3.2 None.

Changes from Version 2.0 to Version 3.0 Substantial revisions were made by N. Mölg in central Chile [Paul and Mölg, 2014] and in the mountains surrounding the North and South Patagonian Icefields.

Changes from Version 1.0 to Version 2.0 See the RGI v6 Technical Note for an extended summary of quality controls conducted by E.S. Miles, University of British Columbia.

Version 1.0 Shapefiles were created from late-summer, cloud-free Landsat 7 ETM+ imagery acquired prior to the 2003 SLC failure. To identify glacier surfaces, a normalized difference snow index (NDSI) was calculated using bands 5 and 2 for the red and near-infrared bands respectively. A threshold of approximately 0.5-0.65 was used to identify dirty/shady/bare ice, and one from 0.65-0.99 to identify snow-covered ice. Gridded files were then converted to polygons and additional manual editing was carried out to eliminate incorrectly classified regions.Shapefiles for the South Patagonian Icefield were provided by H. De Angelis [De Angelis, 2014].

5.19 18: New Zealand

The region encompasses all glaciers in New Zealand.

Subregions

- 18-01: New Zealand

5.19.1 Changes from version 6.0 to 7.0

All glaciers in RGI 6.0 were replaced by new outlines.

Glacier outlines in RGI 6.0 were mostly from 1978 (partly from 1988) and thus outdated due to large changes in glacier area by year 2000. Outlines were replaced by new outlines based on the glacier inventory by Baumann *et al.* [2021], which had been derived from Sentinel-2 and Landsat 8 images acquired in 2016. Most of their outlines were manually adjusted for RGI 7.0 to come closer to the target year 2000 using Landsat 7 ETM+ images (pan-band) mostly acquired in 2000 (partly in 2002). Interpretation was further supported by Sentinel-2 images from 2016 and 2019 as well as the "World imagery" layer of the ESRI Basemap. The extent of several (mostly small) glaciers was not adjusted when the available satellite images from 2000 or 2002 suffered from clouds or adverse snow conditions. All ice divides were recalculated from the national 15 m resolution DEM of New Zealand. The modifications applied to the inventory by Baumann *et al.* [2021] are further detailed in Paul *et al.* [2023].

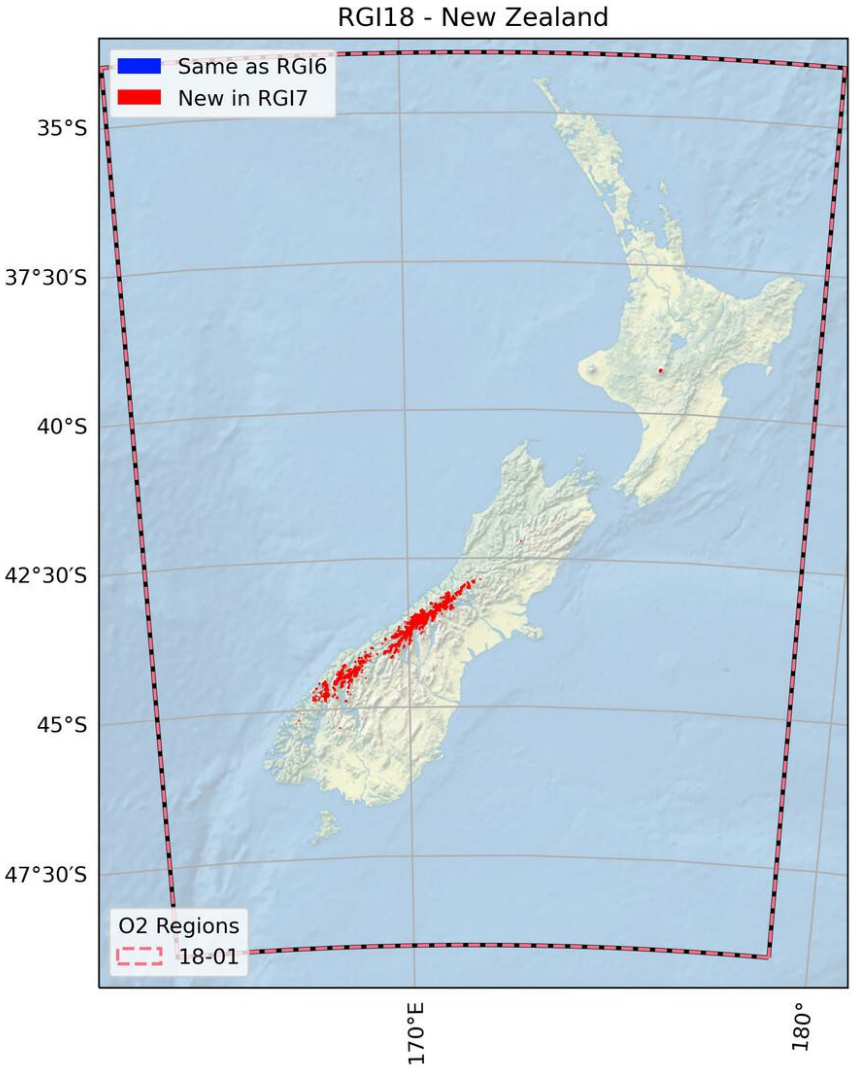


Fig. 5.70: Regional glacier area. Download high resolution version.

5.19.2 Additional information

Data sources and analysts

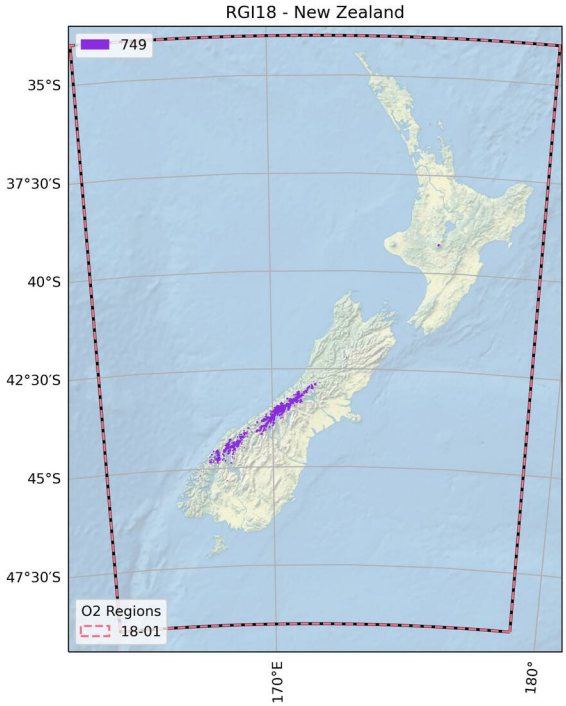


Fig. 5.71: Submission IDs used for this region Download high resolution version.

Glacier outline providers to GLIMS

This list includes the providers of the outlines used in the RGI 7.0 as generated automatically from the GLIMS outlines metadata. We acknowledge that the list may be incomplete due to omissions in the GLIMS database.

Submission 749 Submitter: Paul, Frank.**Number of outlines**: 3018. **Area**: 886.4km^2. **Release date**: 2021-09-02.**Analysts**: Baumann, Sabine; Paul, Frank; Rastner, Philipp.

Reviewers None;

Regional statistics

Figure: Outlines source date

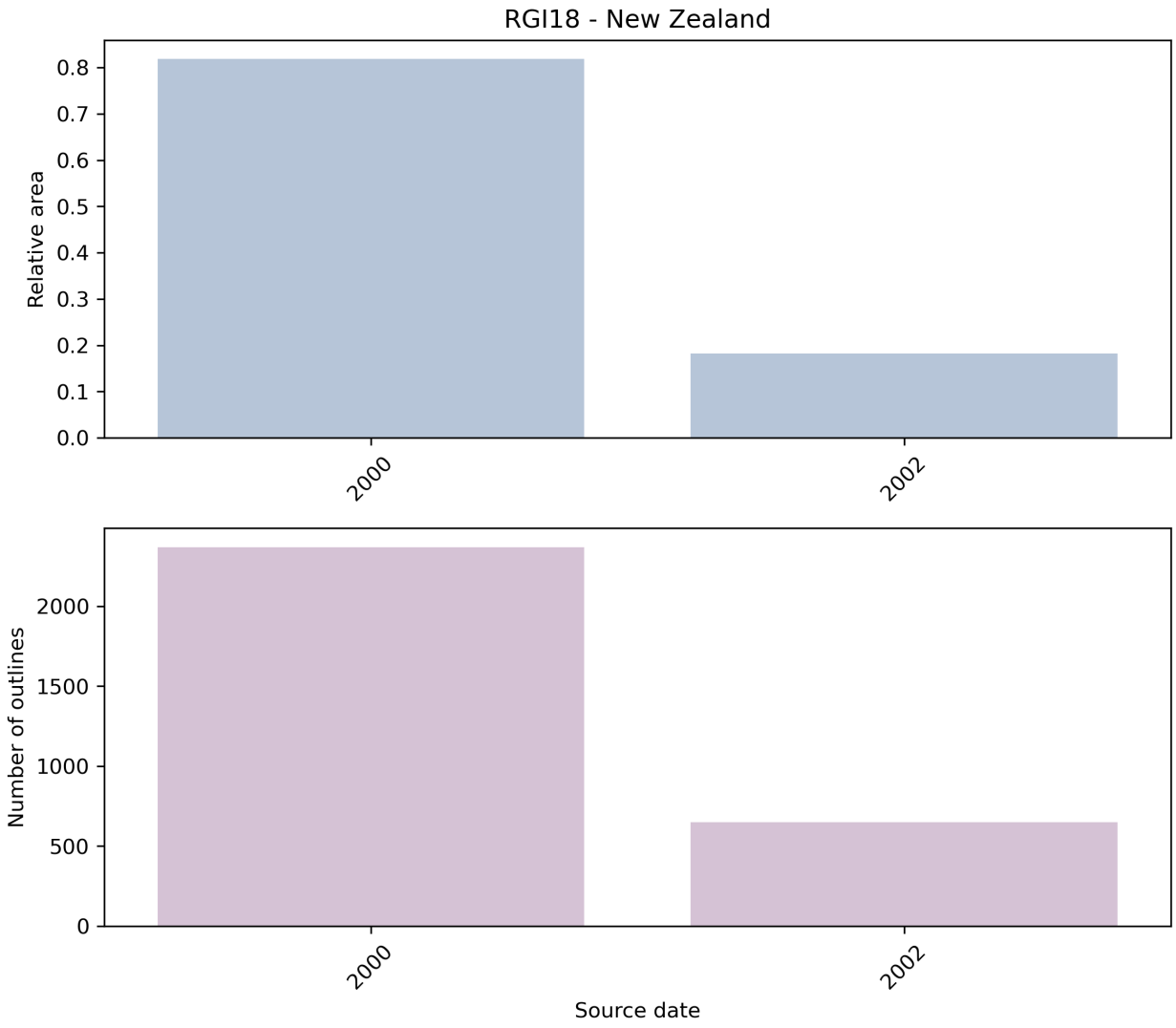


Fig. 5.72: Distribution of the outline dates per area (top) and number (bottom)

Figure: Glacier area histogram

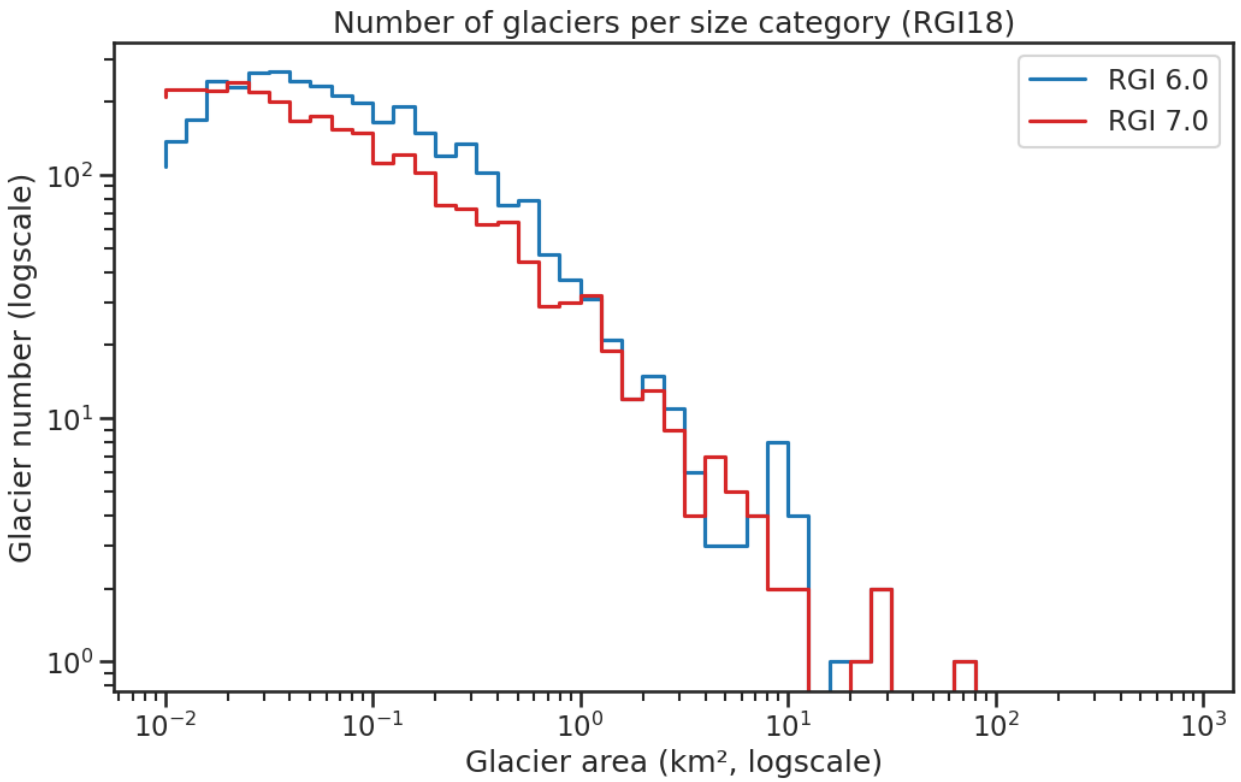


Fig. 5.73: Number of glaciers per size category (log-log scale).

Table: Terminus type statistics Regional number of glaciers (N) and area (km^2) per terminus type in RGI 7.0 and RGI 6.0. Note that the default designation in RGI 7.0 is now "Not assigned", while in RGI 6.0 lake-terminating glaciers and shelf-terminating glaciers were identified in some regions. The RGI region 19 is entirely labelled as "Not assigned" in RGI 7.0.

Value	Terminus type	RGI 7.0 (N)	RGI 6.0 (N)	RGI 7.0 (Area)	RGI 6.0 (Area)
0	Land-terminating	0	3537	0	1162
1	Marine-terminating	0	0	0	0
2	Lake-terminating	0	0	0	0
3	Shelf-terminating	0	0	0	0
9	Not assigned	3018	0	886	0

Table: Surge type statistics Regional number of glaciers (N) and area (km^2) per surge type attribute in RGI 7.0 and RGI 6.0.

Value	Surge type	RGI 7.0 (N)	RGI 6.0 (N)	RGI 7.0 (Area)	RGI 6.0 (Area)
0	No evidence	3018	0	886	0
1	Possible	0	0	0	0
2	Probable	0	0	0	0
3	Observed	0	0	0	0
9	Not assigned	0	3537	0	1162

Version history

Changes from Version 5.0 to 6.0 None.

Changes from Version 4.0 to 5.0 Links were added to 4 glaciers in the WGMS mass-balance database.

Changes from Version 3.2 to 4.0 89 exterior GLIMSIds were replaced. Topographic and hypsometric attributes were added.

Changes from Version 3.0 to 3.2 None.

Changes from Version 2.0 to Version 3.0 Glaciers were delineated from glacier complexes.

Changes from Version 1.0 to Version 2.0 None.

Version 1.0 New Zealand outlines are derived from 1978 aerial imagery at a scale of 1:150,000 as used for the NZ Topo50 maps (Chinn, 2001). The shapefile can be downloaded from: http://data.linz.govt.nz/#/layer/287-nz-mainland-ice-polygons-topo-150k/.

5.20 19: Subantarctic and Antarctic Islands

The region encompasses all glaciers on the islands in the periphery of mainland Antarctica, except those covered by ice rises within ice shelves. Some remote islands in the Southern ocean are also included. The region does not include glaciers on mainland Antarctica.

Subregions

- 19-01: Subantarctic (Pacific)
- 19-02: South Shetlands and South Orkney
- 19-03: Subantarctic (Atlantic)
- 19-04: Subantarctic (Indian)
- 19-05: Balleny Islands
- 19-11: E Queen Maud Land 7A
- 19-12: Amery Ice Shelf 7B
- 19-13: Wilkes Land 7C
- 19-14: Victoria Land 7D
- 19-15: Ross Ice Shelf 7E
- 19-16: Marie Byrd Land 7F
- 19-17: Pine Island Bay
- 19-18: Bellingshausen Sea 7H1
- 19-19: Alexander Island 7H2
- 19-20: West Antarctic Peninsula 7I1
- 19-21: Northeast Antarctic Peninsula 7I2
- 19-22: Southeast Antarctic Peninsula 7I3
- 19-23: Ronne-Filchner Ice Shelf 7J

- 19-24: W Queen Maud Land 7K

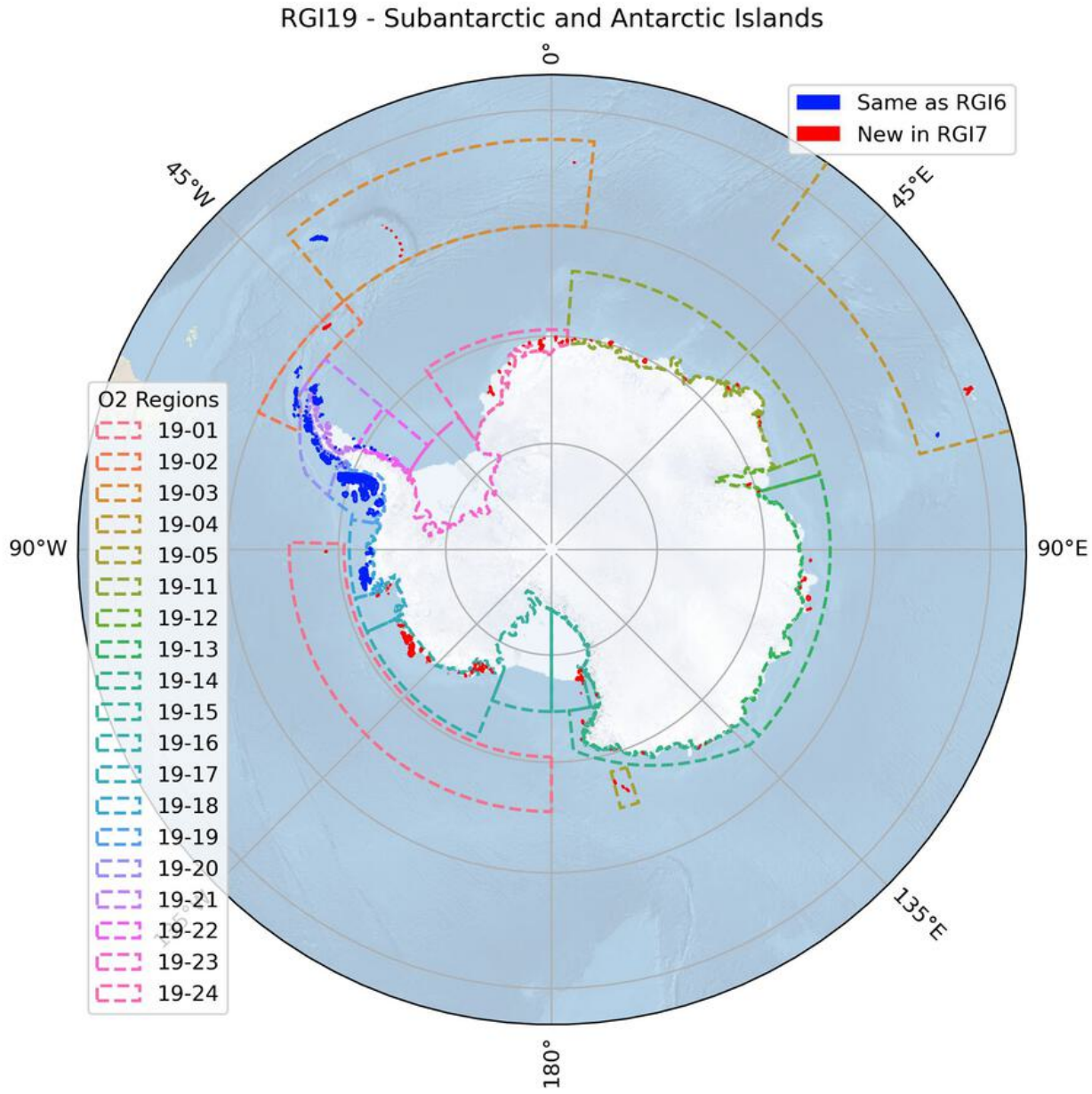


Fig. 5.74: Regional glacier area. Download high resolution version.

5.20.1 Changes from version 6.0 to 7.0

Region `19` (previously "Antarctic and Subantarctic") was split into two first-order regions. Region `19` in RGI 7.0 now solely includes the islands in the periphery of Antarctica, and was renamed to "Subantarctic and Antarctic Islands". A new region `20`, ("Antarctic Mainland") was added to encompass the remaining subregion ("Antarctic Ice Sheet", previously `19-31` and now `20-01`).

Most RGI 6.0 outlines originated from Bliss *et al.* [2013] based on topographical maps from the Antarctic Digital Database [Scientific Committee on Antarctic Research, 2000] (see Bliss *et al.* [2013] for details). For RGI 7.0, glaciers in the following subregions were remapped using satellite imagery from around year 2000, and georeferencing issues were corrected (shifts, deformation, etc. See github discussion here and here):

- 19-01: Subantarctic (Pacific)
- 19-02: South Shetlands and South Orkney
- 19-03: Subantarctic (Atlantic)
- 19-04: Subantarctic (Indian)
- 19-05: Balleny Islands
- 19-11: E Queen Maud Land 7A
- 19-12: Amery Ice Shelf 7B
- 19-13: Wilkes Land 7C
- 19-14: Victoria Land 7D
- 19-15: Ross Ice Shelf 7E
- 19-16: Marie Byrd Land 7F
- 19-17: Pine Island Bay
- 19-24: W Queen Maud Land 7K

Several wrongly mapped icebergs and other bodies were removed. Some larger ice caps were manually divided into individual glaciers, especially in subregions 19-15 and 19-16. Altogether, glacier area changes between RGI 6.0 and RGI 7.0 are small (+0.1%) but the quality of the inventory has considerably improved.

An important discussion about RGI outlines in region 19 has been triggered by two recent publications: Millan *et al.* [2022] and Hock *et al.* [2023], raising the question whether certain outlines in RGI belong to the ice sheet or the glacier category. We acknowledge the need for discussion and coordination within the scientific community to avoid double counting, but chose not to change the current separation in the RGI without consensus from both the glacier and ice-sheet research communities.

Kerguelen Islands (second-order region 19-04)

Glacier outlines in RGI 6.0 were from the 1960s and partly very roughly digitized. All outlines were replaced in RGI 7.0 based on a much improved and more recent (year 2001) data set in the GLIMS database (submissions 527 and 528). Since this data set does not include the south-western and northern part of the island, these regions were remapped. As suitable satellite images are not available for this region close to the target year 2000, images from 2010 (Landsat 7) and 2018 (Landsat 8) in the north, and images from 2018 (Landsat 8) and 2022 (Sentinel-2) in the southwest were used to map the glaciers. Furthermore, some missing smaller glaciers in the south-east of the main ice cap were added and some of the existing outlines were corrected. The "World imagery" layer of the ESRI Basemap was locally used to aid in the interpretation. The AW3D30 DEM was used to derive a flow direction grid and correct ice divides.

Attributes

RGI 6.0 included for each glacier a label for the terminus type attribute (`term_type`). However, in RGI 7.0 all glaciers received the label `Not assigned`, despite the prevalence of marine and shelf-terminating glaciers in this region. Updating this attribute is planned for the next version of the RGI.

5.20.2 Additional information

Data sources and analysts

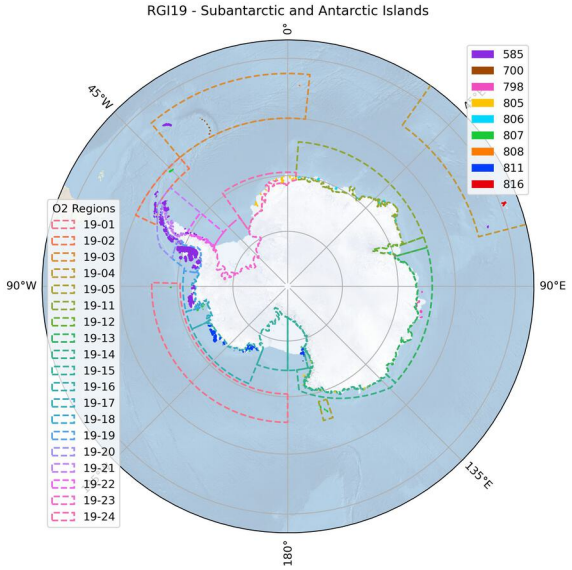


Fig. 5.75: Submission IDs used for this region Download high resolution version.

Glacier outline providers to GLIMS

This list includes the providers of the outlines used in the RGI 7.0 as generated automatically from the GLIMS outlines metadata. We acknowledge that the list may be incomplete due to omissions in the GLIMS database.

Submission 585 Submitter: Bliss, Andrew.**Number of outlines**: 1759. **Area**: 98180.0km^2. **Release date**: 2015-07-01.**Analysts**: Berthier, Etienne; Bliss, Andrew; Cogley, Graham; LeBris, Raymond; Paul, Frank.

Submission 700 Submitter: Hidalgo, Lidia Ferri.**Number of outlines**: 31. **Area**: 242.8km^2. **Release date**: 2018-09-04.**Analysts**: Castro, Mariano; Gargantini, Hernán; Gimenez, Melisa; Hidalgo, Lidia Ferri; Masiokas, Mariano; Pecker Marcosig, Ivanna; Pitte, Pierre; Ruiz, Lucas; Zalazar, Laura.

Submission 798 Submitter: Berthier, Etienne.**Number of outlines**: 7. **Area**: 2684.6km^2. **Release date**: 2022-10-01.**Analysts**: Berthier, Etienne; Lebreton, Jerome.

Submission 805 Submitter: McNabb, Robert.**Number of outlines**: 68. **Area**: 6529.7km^2. **Release date**: 2022-10-01.**Analysts**: McNabb, Robert.

Submission 806 Submitter: McNabb, Robert.**Number of outlines**: 23. **Area**: 2985.6km^2. **Release date**: 2022-10-01.**Analysts**: McNabb, Robert.

Submission 807 Submitter: Kochtitzky, William.**Number of outlines**: 212. **Area**: 1656.7km^2. **Release date**: 2022-11-11.**Analysts**: Cha, Leo; Gould, Luke; Kochtitzky, William; Merrill, Paige-Marie.

Submission 808 Submitter: Kochtitzky, William.**Number of outlines**: 11. **Area**: 43.5km^2. **Release date**: 2022-12-15.**Analysts**: Kochtitzky, William.

Submission 811 Submitter: McNabb, Robert.**Number of outlines**: 174. **Area**: 20568.3km^2. **Release date**: 2022-10-01.**Analysts**: McNabb, Robert.

Submission 816 Submitter: Paul, Frank.**Number of outlines**: 457. **Area**: 541.4km^2. **Release date**: 2023-03-01.**Analysts**: Mabileau, Laure; Paul, Frank; Rastner, Philipp.

Reviewers Berthier, Etienne; McNabb, Robert; Kochtitzky, William;

Regional statistics

Figure: Outlines source date

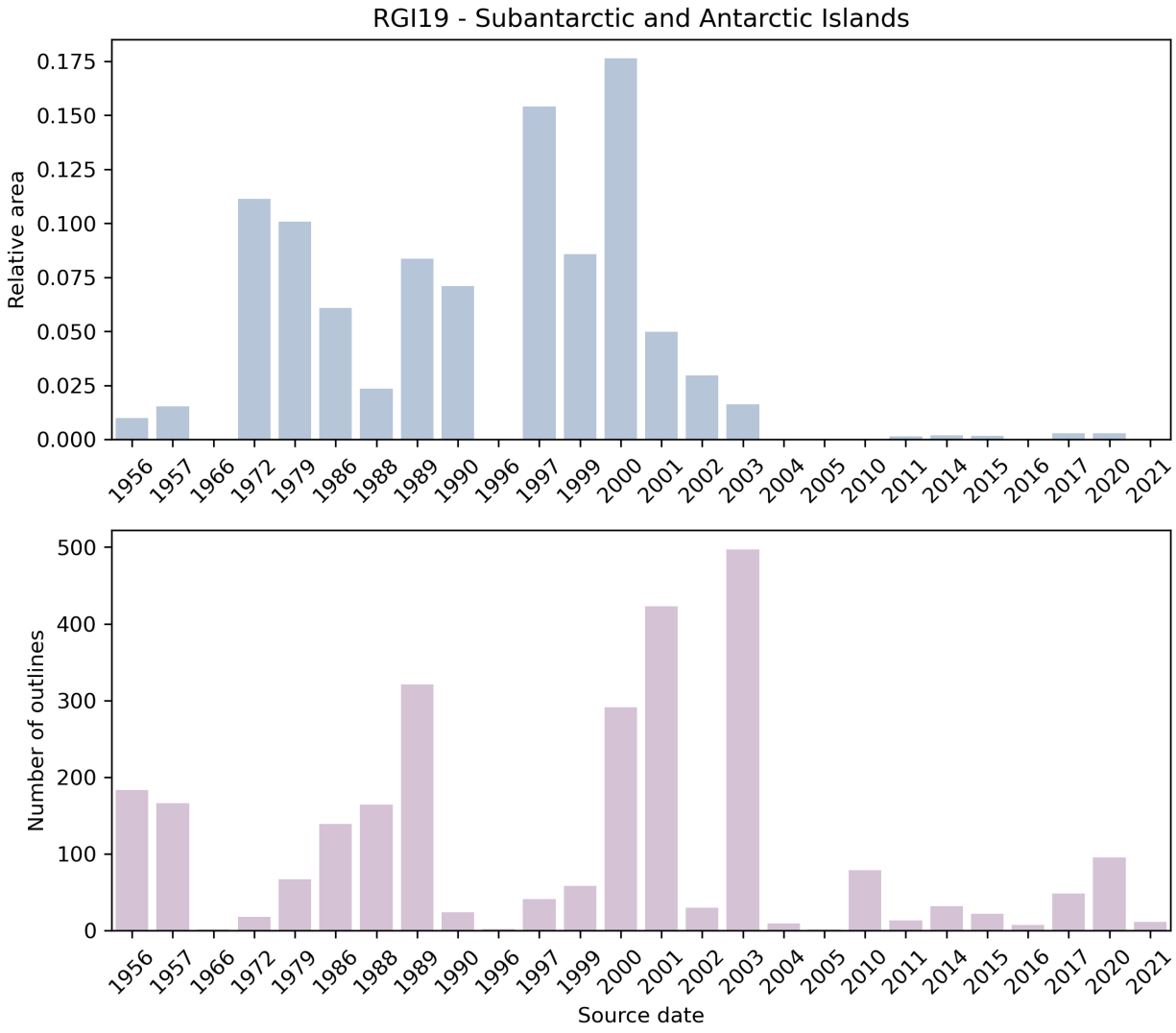


Fig. 5.76: Distribution of the outline dates per area (top) and number (bottom)

Figure: Glacier area histogram

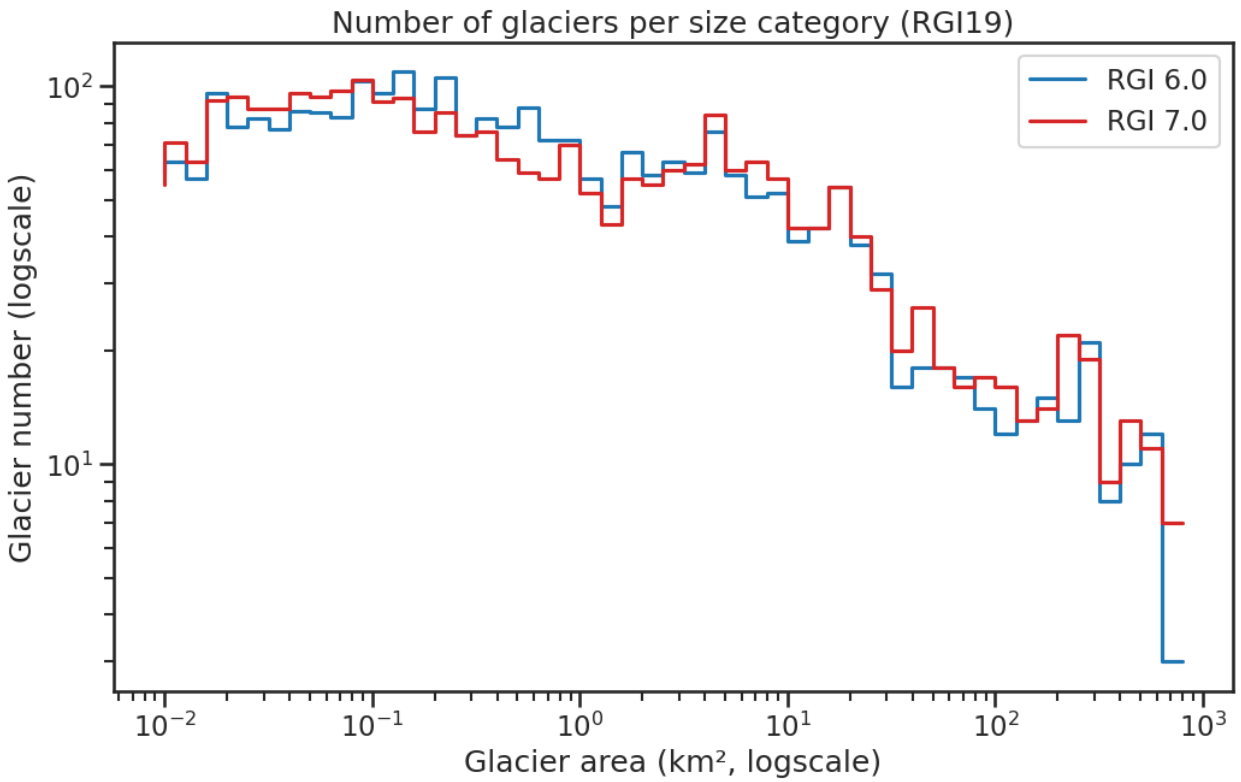


Fig. 5.77: Number of glaciers per size category (log-log scale).

Table: Terminus type statistics Regional number of glaciers (N) and area (km^2) per terminus type in RGI 7.0 and RGI 6.0. Note that the default designation in RGI 7.0 is now "Not assigned", while in RGI 6.0 lake-terminating glaciers and shelf-terminating glaciers were identified in some regions. The RGI region 19 is entirely labelled as "Not assigned" in RGI 7.0.

Value	Terminus type	RGI 7.0 (N)	RGI 6.0 (N)	RGI 7.0 (Area)	RGI 6.0 (Area)
0	Land-terminating	0	1231	0	1360
1	Marine-terminating	0	1339	0	48053
2	Lake-terminating	0	17	0	316
3	Shelf-terminating	0	165	0	83138
9	Not assigned	2742	0	133432	0

Table: Surge type statistics Regional number of glaciers (N) and area (km^2) per surge type attribute in RGI 7.0 and RGI 6.0.

Value	Surge type	RGI 7.0 (N)	RGI 6.0 (N)	RGI 7.0 (Area)	RGI 6.0 (Area)
0	No evidence	2742	0	133432	0
1	Possible	0	0	0	0
2	Probable	0	0	0	0
3	Observed	0	0	0	0
9	Not assigned	0	2752	0	132867

Version history

Changes from Version 5.0 to 6.0 None.

Changes from Version 4.0 to 5.0 Links were added to 2 glaciers in the WGMS mass-balance database.

Changes from Version 3.2 to Version 4.0 Two exterior GLIMSIds were replaced. Topographic and hypsometric attributes (section 3.2) were added.The main source for RGI region 19 was the Antarctic Digital Database ADD [Scientific Committee on Antarctic Research, 2000], compiled for glaciological purposes by Bliss *et al.* [2013]. In RGI 3.2, 34,041 km2 of Antarctic glaciers had dates and 47,961 km2 had date ranges. Most of these were obtained from attributes of coastal and other line segments in the ADD. Of the remaining 50,866 km2 of glaciers, it was possible to recover dates and date ranges for 35,148 km2 from chapter 5 (Bibliography) of the ADD manual [Scientific Committee on Antarctic Research, 2000]. This bibliography gives detailed summaries of ADD revisions organized by the tiles into which the database is subdivided, and further by the 16 maps into which each tile is subdivided. For many tiles, but not all, the bibliography lists source images and their dates. Unfortunately the bibliography has not been updated since 2000, and so there is some doubt about the assignment of dates. Often, however, it was possible to verify, for example by inspecting Google Earth, that there have been no perceptible revisions in recent years.

Changes from Version 2.0 to Version 3.2 None.

Changes from Version 2.0 to Version 3.0 The TerminusType character of the GlacType attribute was coded following Paul *et al.* [2009], with the addition of code 5 for shelf-terminating glaciers. Classification was done visually using imagery from a variety of sources. In a few instances, more than one terminus type applied to a particular glacier. Each such glacier was assigned the code representing the longest part of its perimeter.

Changes from Version 1.0 to Version 2.0 The ice cover of Peter the First Island in the Bellingshausen Sea was taken from the ADD in version 1.0. In version 2.0 it is replaced by the outlines of 26 glaciers from an inventory by J.G. Cogley [Cogley *et al.*, 2014].

Version 1.0 Outlines of glacier complexes on islands peripheral to the mainland of Antarctica were obtained from the Antarctic Digital Database (ADD Consortium, 2000). A. Bliss manually classified the ADD's "land" polygons into continent, ice rise, ice cap, and glacier-complex polygons. Ice rises, and ice bodies on the continental mainland, are not included in this inventory. Nor are ice shelves. The classification was based on the surface morphology and surface flow velocities observed in data from Landsat, the RADARSAT Antarctic Mapping Project DEM, and the MEaSUREs InSAR-based Antarctic Velocity Map. On islands with prominent nunataks, glacier complexes were subdivided into individual glaciers following Kienholz *et al.* [2013]. More details on the processing of these outlines are given by Bliss *et al.* [2013].Outlines of glaciers on most of the Subantarctic islands were obtained by E. Berthier and J.G. Cogley from various sources including satellite imagery and maps [Cogley *et al.*, 2014]. For King George Island in the South Shetland Islands, outlines were downloaded from KGIS, the King George Island Geographic Information System, a now defunct web site created by F. Rau and S. Vogt, University of Freiburg. Separate outlines of "glacier basins" and ice-free areas were harmonized and merged to form glacier outlines containing nunataks. For Kerguelen, outlines are from Berthier *et al.* [2009]. Outlines of South Georgia glaciers were mapped by F. Paul from a Landsat ETM+ scene from 2003 using a band 3/5 ratio and manual corrections for icebergs and water (removed), and debris-cover (added); some regions covered by seasonal snow might be included.

5.21 20: Antarctic Mainland

The region encompasses mainland Antarctica. In the RGI, the region does not include any glaciers (yet).

Subregions

- 20-01: Antarctic Mainland

5.21.1 Changes from version 6.0 to 7.0

This region was added in RGI 7.0. The previous first-order region `19` was split into two regions: former subregion `19-31` was removed from region `19` and now defines the new first-order region `20`. The split was motivated by the fact that RGI 7.0 and all previous versions included a complete inventory of the glaciers on the islands in the periphery of mainland Antarctica, but no glaciers on the mainland itself, although inventories (though incomplete) exist.

5.21.2 Additional information

Version history

This region was added in v7.0

CHAPTER

SIX

GLOBAL STATISTICS

This section provides plots and tables summarizing some basic statistics of the RGI 7.0 compared to RGI 6.0. A table comparing the area and number of glaciers per region can be found and downloaded in *Regional glacier areas and counts in RGI 6.0 and RGI 7.0*.

6.1 Target year

Number of glaciers (%) within intervals around the target year 2000 in RGI 6.0 and RGI 7.0.

Outline year	RGI 6.0 (%)	RGI 7.0 (%)
2000 ± 2 years	48.9	58
2000 ± 2-5 years	15.9	18.7
2000 ± 5-10 years	27	19.5
2000 ± > 10 years	8.2	3.8

6.2 Size classes

Number of glaciers (N) and percentage of total number per size class in RGI 6.0 and RGI 7.0.

Area	RGI 6.0 (N)	RGI 6.0 (%)	RGI 7.0 (N)	RGI 7.0 (%)
< 1 km^2	170576	79.1	229626	83.6
1-10 km^2	38054	17.7	38081	13.9
10-100 km^2	5955	2.8	5830	2.1
> 100 km^2	962	0.4	994	0.4
Total	215547	100	274531	100

6.3 Global attributes statistics

Table: Terminus type statistics Number of glaciers (N) and area (km^2) per terminus type in RGI 7.0 and RGI 6.0. Note that the default designation in RGI 7.0 is now "Not assigned", while in RGI 6.0 lake-terminating glaciers and shelf-terminating glaciers were identified in some regions. The RGI region 19 is entirely labelled as "Not assigned" in RGI 7.0.

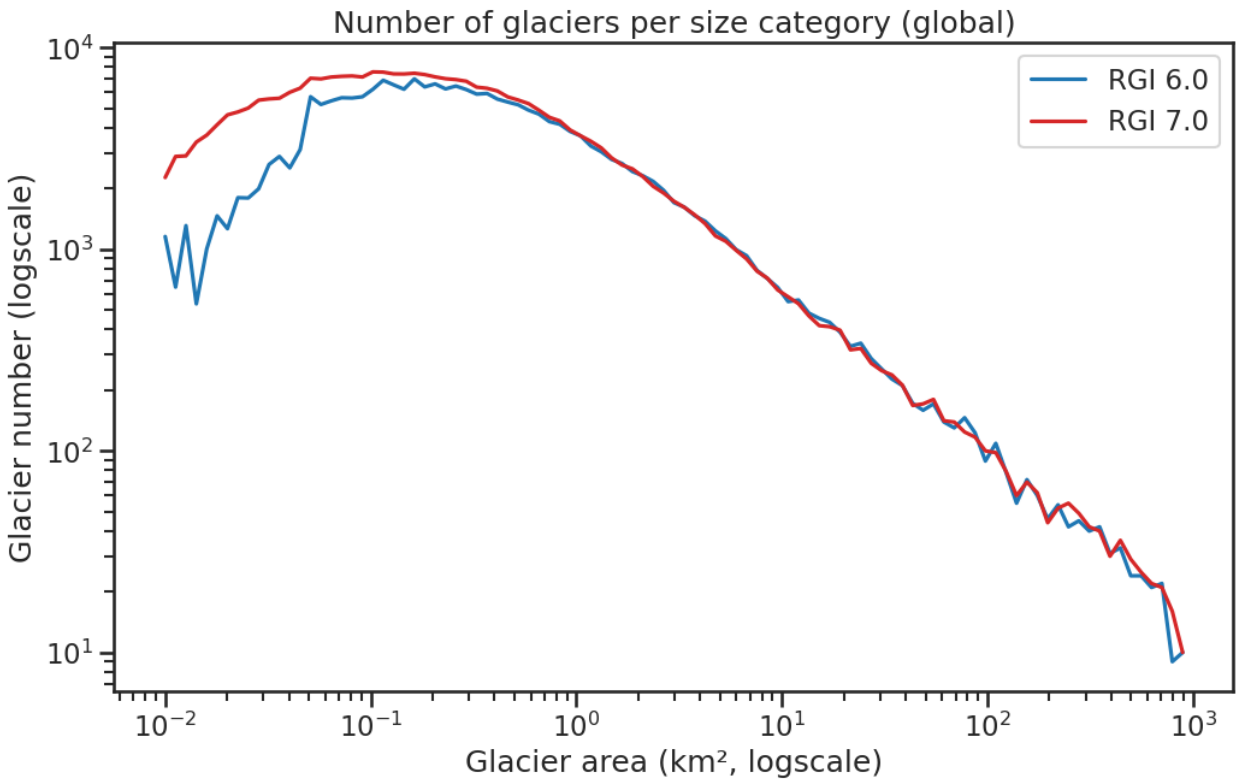


Fig. 6.1: Number of glaciers per size category (log-log scale). A flatter curve for the smaller area classes indicates that many uncharted glaciers in RGI 6.0 have been captured in RGI 7.0.

Value	Terminus type	RGI 7.0 (N)	RGI 6.0 (N)	RGI 7.0 (Area)	RGI 6.0 (Area)
0	Land-terminating	0	212005	0	397096
1	Marine-terminating	1561	3075	159302	197514
2	Lake-terminating	0	298	0	27172
3	Shelf-terminating	0	169	0	83958
9	Not assigned	272970	0	547442	0

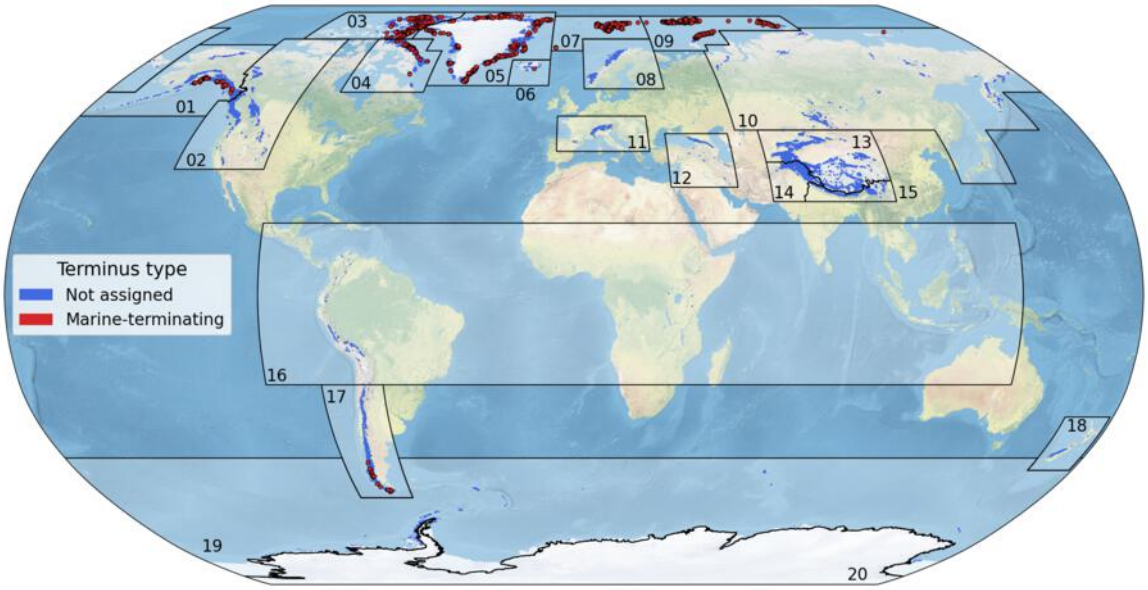


Fig. 6.2: Terminus type (`term_type`) attribute distribution in RGI 7.0. Download high resolution version.

Table: Surge type statistics Number of glaciers (N) and area (km^2) per surge type attribute in RGI 7.0 and RGI 6.0.

Value	Surge type	RGI 7.0 (N)	RGI 6.0 (N)	RGI 7.0 (Area)	RGI 6.0 (Area)
0	No evidence	271901	42515	566418	127426
1	Possible	630	509	23334	23622
2	Probable	825	383	31254	19376
3	Observed	1175	448	85738	43066
9	Not assigned	0	171692	0	492249

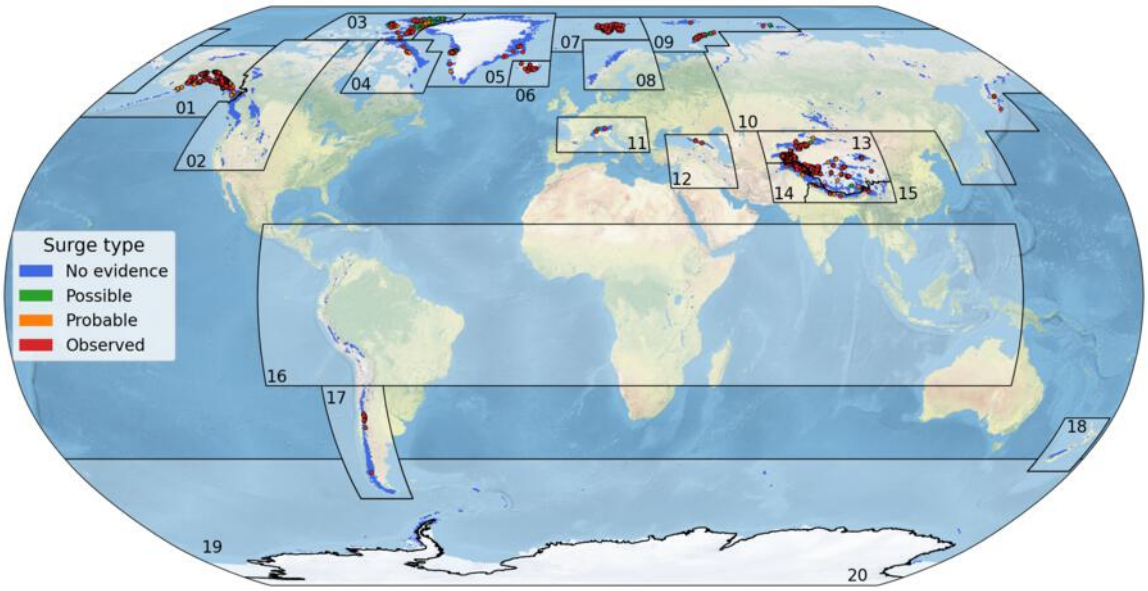


Fig. 6.3: Surge type (`surge_type`) attribute distribution in RGI 7.0. Download high resolution version.

CHAPTER

SEVEN

REFERENCES

CHAPTER

EIGHT

APPENDIX 1: GLACIER COUNT/AREA PER REGION

8.1 First-order regions

Summary of glacier counts and areas of all 20 first-order regions in the RGI 7.0.

Download this table as csv

Region	Full name	Code	Count	Area (km^2)
01	Alaska	01_alaska	27509	86708
02	Western Canada and USA	02_western_canada_usa	18730	14521
03	Arctic Canada North	03_arctic_canada_north	5216	105370
04	Arctic Canada South	04_arctic_canada_south	11009	40538
05	Greenland Periphery	05_greenland_periphery	19994	90482
06	Iceland	06_iceland	568	11060
07	Svalbard and Jan Mayen	07_svalbard_jan_mayen	1666	33959
08	Scandinavia	08_scandinavia	3410	2948
09	Russian Arctic	09_russian_arctic	1069	51595
10	North Asia	10_north_asia	7155	2643
11	Central Europe	11_central_europe	4079	2124
12	Caucasus and Middle East	12_caucasus_middle_east	2275	1407
13	Central Asia	13_central_asia	75613	50344
14	South Asia West	14_south_asia_west	37562	33075
15	South Asia East	15_south_asia_east	18587	16049
16	Low Latitudes	16_low_latitudes	3695	1929
17	Southern Andes	17_southern_andes	30634	27674
18	New Zealand	18_new_zealand	3018	886
19	Subantarctic and Antarctic Islands	19_subantarctic_antarctic_islands	2742	133432
20	Antarctic Mainland	20_antarctic_mainland	0	0
Global			274531	706744

8.2 Second-order regions

Summary of glacier counts and areas of all 90 second-order regions in the RGI 7.0.

Download this table as csv

	Full name	Code	Count
01-01	North Alaska	01-01_north_alaska	706
01-02	Alaska Range (Wrangell/Kilbuck)	01-02_alaska_range_wrangell_kilbuck	5812
01-03	Alaska Peninsula (Aleutians)	01-03_alaska_peninsula_aleutians	872
01-04	West Chugach Mountains (Talkeetna)	01-04_west_chugach_mountains_talkeetna	4529
01-05	Saint Elias Mountains	01-05_saint_elias_mountains	5039
01-06	North Coast Ranges	01-06_north_coast_ranges	10551
02-01	Mackenzie and Selwyn Mountains	02-01_mackenzie_and_selwyn_mountains	1235
02-02	South Coast Ranges	02-02_south_coast_ranges	7390
02-03	North Rocky Mountains	02-03_north_rocky_mountains	5063
02-04	Cascade Range and Sierra Nevada	02-04_cascade_range_and_sierra_nevada	3127
02-05	South Rocky Mountains	02-05_south_rocky_mountains	1915
03-01	North Ellesmere Island	03-01_north_ellesmere_island	2573
03-02	Axel Heiberg and Meighen Is	03-02_axel_heiberg_and_meighen_is	624
03-03	North Central Ellesmere Island	03-03_north_central_ellesmere_island	902
03-04	South Central Ellesmere Island	03-04_south_central_ellesmere_island	261
03-05	South Ellesmere Island (Northwest Devon)	03-05_south_ellesmere_island_northwest_devon	633
03-06	Devon Island	03-06_devon_island	216
03-07	Melville Island	03-07_melville_island	7
04-01	Bylot Island	04-01_bylot_island	616
04-02	West Baffin Island	04-02_west_baffin_island	96
04-03	North Baffin Island	04-03_north_baffin_island	597
04-04	Northeast Baffin Island	04-04_northeast_baffin_island	1953
04-05	East Central Baffin Island	04-05_east_central_baffin_island	1905
04-06	South East Baffin Island	04-06_south_east_baffin_island	3036
04-07	Cumberland Sound	04-07_cumberland_sound	2620
04-08	Frobisher Bay	04-08_frobisher_bay	83
04-09	Labrador	04-09_labrador	103
05-01	Greenland Periphery	05-01_greenland_periphery	19994
06-01	Iceland	06-01_iceland	568
07-01	Svalbard	07-01_svalbard	1583
07-02	Jan Mayen	07-02_jan_mayen	83
08-01	North Scandinavia	08-01_north_scandinavia	1832
08-02	Southwest Scandinavia	08-02_southwest_scandinavia	1216
08-03	Southeast Scandinavia	08-03_southeast_scandinavia	362
09-01	Franz Josef Land	09-01_franz_josef_land	412
09-02	Novaya Zemlya	09-02_novaya_zemlya	480
09-03	Severnaya Zemlya	09-03_severnaya_zemlya	177
10-01	Ural Mountains	10-01_ural_mountains	161
10-02	Central Siberia	10-02_central_siberia	394
10-03	Cherskiy/Suntar Khayata Ranges	10-03_cherskiy_suntar_khayata_ranges	427
10-04	Altay and Sayan	10-04_altay_and_sayan	3033
10-05	Northeast Russia	10-05_northeast_russia	3091
10-06	East Chukotka	10-06_east_chukotka	44
10-07	Japan	10-07_japan	5

continues o

Table 8.1 – continued from previous page

	Full name	Code	Count
11-01	Alps	11-01_alps	4034
11-02	Southeast Europe	11-02_southeast_europe	45
12-01	Caucasus and Middle East	12-01_caucasus_and_middle_east	2181
12-02	Middle East	12-02_middle_east	94
13-01	Hissar Alay	13-01_hissar_alay	5340
13-02	Pamir (Safed Khirs / West Tarim)	13-02_pamir_safed_khirs_west_tarim	15744
13-03	West Tien Shan	13-03_west_tien_shan	14682
13-04	East Tien Shan (Dzhungaria)	13-04_east_tien_shan_dzhungaria	6255
13-05	West Kun Lun	13-05_west_kun_lun	7906
13-06	East Kun Lun (Altyn Tagh)	13-06_east_kun_lun_altyn_tagh	3854
13-07	Qilian Shan	13-07_qilian_shan	3256
13-08	Inner Tibet	13-08_inner_tibet	11185
13-09	Southeast Tibet	13-09_southeast_tibet	7391
14-01	Hindu Kush	14-01_hindu_kush	6857
14-02	Karakoram	14-02_karakoram	17559
14-03	West Himalaya	14-03_west_himalaya	13146
15-01	Central Himalaya	15-01_central_himalaya	6127
15-02	East Himalaya	15-02_east_himalaya	5503
15-03	Hengduan Shan	15-03_hengduan_shan	6957
16-01	Low-latitude Andes	16-01_low_latitude_andes	3647
16-02	Mexico	16-02_mexico	7
16-03	East Africa	16-03_east_africa	36
16-04	New Guinea	16-04_new_guinea	5
17-01	Patagonia	17-01_patagonia	17454
17-02	Central Andes	17-02_central_andes	13180
18-01	New Zealand	18-01_new_zealand	3018
19-01	Subantarctic (Pacific)	19-01_subantarctic_pacific	15
19-02	South Shetlands and South Orkney	19-02_south_shetlands_and_south_orkney	401
19-03	Subantarctic (Atlantic)	19-03_subantarctic_atlantic	550
19-04	Subantarctic (Indian)	19-04_subantarctic_indian	489
19-05	Balleny Islands	19-05_balleny_islands	50
19-11	East Queen Maud Land 7A	19-11_east_queen_maud_land_7a	22
19-12	Amery Ice Shelf 7B	19-12_amery_ice_shelf_7b	1
19-13	Wilkes Land 7C	19-13_wilkes_land_7c	7
19-14	Victoria Land 7D	19-14_victoria_land_7d	54
19-15	Ross Ice Shelf 7E	19-15_ross_ice_shelf_7e	111
19-16	Marie Byrd Land 7F	19-16_marie_byrd_land_7f	63
19-17	Pine Island Bay 7G	19-17_pine_island_bay_7g	17
19-18	Bellingshausen Sea 7H1	19-18_bellingshausen_sea_7h1	20
19-19	Alexander Island 7H2	19-19_alexander_island_7h2	119
19-20	West Antarctic Peninsula 7I1	19-20_west_antarctic_peninsula_7i1	637
19-21	Northeast Antarctic Peninsula 7I2	19-21_northeast_antarctic_peninsula_7i2	166
19-22	Southeast Antarctic Peninsula 7I3	19-22_southeast_antarctic_peninsula_7i3	6
19-23	Ronne-Filchner Ice Shelf 7J	19-23_ronne_filchner_ice_shelf_7j	0
19-24	West Queen Maud Land 7K	19-24_west_queen_maud_land_7k	14
20-01	Antarctic Mainland	20-01_antarctic_mainland	0
Global			274531

CHAPTER

NINE

APPENDIX 2: FULL LIST OF CONTRIBUTORS

All contributors listed by name below are part of the RGI 7.0 consortium.

9.1 IACS working group

IACS Working Group on the Randolph Glacier Inventory (RGI) and its role in future glacier monitoring and GLIMS.

Chairs:

- **Regine Hock**
- **Fabien Maussion**

Steering Committee:

- **Frank Paul**
- **Philipp Rastner**
- **Bruce Raup**
- **Michael Zemp**

9.2 Implementation

Main developer:

- **Fabien Maussion**

Contributors:

- **Matthias Dusch**: topography tools and notebooks
- **Alexander Fischer**: topography tools and notebooks
- **Stephan Galos**: regional outline selection and implementation
- **James Lea**: Google Earth Engine review tool
- **Robert McNabb**: regional maps
- **Bruce Raup**: GLIMS database
- **Francesc Roura-Adserias**: centerlines product
- **Patrick Schmitt**: glacier complex and intersects products
- **Ethan Welty**: linkage between RGI 7.0 and RGI 6.0

9.3 Open outlines review process

Iestyn Barr, Etienne Berthier, Tobias Bolch, Bethan Davies, Matthias Huss, Tatiana Khromova, William Kochtitzky, Kirsty Langley, Erik Mannerfelt, Fabien Maussion, Robert McNabb, Frank Paul, Rainer Prinz, Antoine Rabatel, Philipp Rastner, Levan Tielidze.

9.4 Attributes

- **William Kochtitzky**: terminus type
- **Mylène Jacquemart, Robert McNabb**: surge type

9.5 User guide

Written by **Fabien Maussion, Regine Hock**, based on the RGI v6 Technical Note led by Graham Cogley.

Contributions to regional revisions sections: **Liss Marie Andreassen, Iestyn Barr, Tobias Bolch, William Kochtitzky, Robert McNabb, Frank Paul, Levan Tielidze.**

9.6 Glacier outline providers to GLIMS

This list includes the providers of the outlines used in the RGI 7.0 as generated automatically from the GLIMS outlines metadata. We acknowledge that the list may be incomplete due to omissions in the GLIMS database. All known omissions as of July 3rd, 2023 are listed at the bottom of this page.

- **Albornoz, Amapola** (Region: 16, 17. Subm ID: 730, 764. N outlines: 30654. Area: 27683.8 km^2)
- **Andreassen, Liss Marie** (Region: 08. Subm ID: 611. N outlines: 3141. Area: 2674.8 km^2)
- **Arias, Victor** (Region: 16, 17. Subm ID: 730, 764. N outlines: 30654. Area: 27683.8 km^2)
- **Arie, Kenshiro** (Region: 10. Subm ID: 763. N outlines: 5. Area: 0.5 km^2)
- **Barcaza, Gonzalo** (Region: 16, 17. Subm ID: 730, 764. N outlines: 30654. Area: 27683.8 km^2)
- **Barr, Iestyn** (Region: 10. Subm ID: 761. N outlines: 2491. Area: 929.9 km^2)
- **Barrand, Nick** (Region: 03, 04. Subm ID: 589, 590. N outlines: 755. Area: 39862.1 km^2)
- **Baumann, Sabine** (Region: 18. Subm ID: 749. N outlines: 3018. Area: 886.4 km^2)
- **Beedle, Matthew** (Region: 01. Subm ID: 624, 756, 810. N outlines: 25731. Area: 82576.6 km^2)
- **Berthier, Etienne** (Region: 01, 02, 03, 19. Subm ID: 585, 624, 635, 756, 798, 810. N outlines: 28739. Area: 184225.8 km^2)
- **Bliss, Andrew** (Region: 19. Subm ID: 585. N outlines: 1759. Area: 98180.0 km^2)
- **Bolch, Tobias** (Region: 01, 02, 03, 04, 05, 15. Subm ID: 589, 590, 623, 624, 635, 721, 722, 751, 756, 765, 810. N outlines: 59277. Area: 213522.5 km^2)
- **Bown, Francisca** (Region: 17. Subm ID: 764. N outlines: 30634. Area: 27674.4 km^2)
- **Brown, Ian** (Region: 08. Subm ID: 812. N outlines: 269. Area: 273.0 km^2)
- **Burgess, Dave** (Region: 03, 04. Subm ID: 589, 590. N outlines: 755. Area: 39862.1 km^2)

- **Burgess, Evan** (Region: 01. Subm ID: 624, 756, 810. N outlines: 25731. Area: 82576.6 km^2)
- **Castro, Mariano** (Region: 16, 17, 19. Subm ID: 700, 764. N outlines: 30682. Area: 27918.6 km^2)
- **Cawkwell, Fiona** (Region: 03, 04. Subm ID: 589, 590. N outlines: 755. Area: 39862.1 km^2)
- **Cha, Leo** (Region: 19. Subm ID: 807. N outlines: 212. Area: 1656.7 km^2)
- **Cogley, Graham** (Region: 01, 02, 03, 05, 10, 16, 19. Subm ID: 585, 591, 624, 635, 636, 751, 756, 810. N outlines: 49615. Area: 259124.8 km^2)
- **Copland, Luke** (Region: 03, 04. Subm ID: 589, 590, 728. N outlines: 2716. Area: 77537.6 km^2)
- **Cáceres, B.** (Region: 16. Subm ID: 753. N outlines: 4. Area: 13.6 km^2)
- **Earl, Lucas** (Region: 10. Subm ID: 636. N outlines: 1646. Area: 394.0 km^2)
- **Filbert, Katie** (Region: 03, 04. Subm ID: 589, 590. N outlines: 755. Area: 39862.1 km^2)
- **Forster, Richard** (Region: 01. Subm ID: 624, 756, 810. N outlines: 25731. Area: 82576.6 km^2)
- **Fountain, Andrew G.** (Region: 02. Subm ID: 616, 744. N outlines: 5034. Area: 671.3 km^2)
- **Francou, B.** (Region: 16. Subm ID: 753. N outlines: 4. Area: 13.6 km^2)
- **Frank, Thomas** (Region: 08. Subm ID: 812. N outlines: 269. Area: 273.0 km^2)
- **Frey, Holger** (Region: 11. Subm ID: 731. N outlines: 4034. Area: 2120.1 km^2)
- **Garcia, Juan-Luis** (Region: 16, 17. Subm ID: 730, 764. N outlines: 30654. Area: 27683.8 km^2)
- **Gardner, Alex** (Region: 03, 04, 10. Subm ID: 589, 590, 636. N outlines: 2401. Area: 40256.1 km^2)
- **Gargantini, Hernán** (Region: 16, 17, 19. Subm ID: 700, 764. N outlines: 30682. Area: 27918.6 km^2)
- **Giffen, Bruce A.** (Region: 01. Subm ID: 624, 756, 810. N outlines: 25731. Area: 82576.6 km^2)
- **Gimenez, Melisa** (Region: 16, 17, 19. Subm ID: 700, 764. N outlines: 30682. Area: 27918.6 km^2)
- **Goerlich, Franz** (Region: 16. Subm ID: 748. N outlines: 3495. Area: 1734.7 km^2)
- **Gould, Luke** (Region: 19. Subm ID: 807. N outlines: 212. Area: 1656.7 km^2)
- **Hall, Dorothy K.** (Region: 01. Subm ID: 624, 756, 810. N outlines: 25731. Area: 82576.6 km^2)
- **Hansson, Erik** (Region: 08. Subm ID: 812. N outlines: 269. Area: 273.0 km^2)
- **Hartmann, G** (Region: 03, 04. Subm ID: 589, 590. N outlines: 755. Area: 39862.1 km^2)
- **Hidalgo, Lidia Ferri** (Region: 16, 17, 19. Subm ID: 700, 764. N outlines: 30682. Area: 27918.6 km^2)
- **Hoffman, Matthew** (Region: 02. Subm ID: 616. N outlines: 32. Area: 1.1 km^2)
- **Howat, Ian** (Region: 05. Subm ID: 751. N outlines: 19079. Area: 77020.3 km^2)
- **Izagirre, Eñaut** (Region: 11. Subm ID: 715. N outlines: 45. Area: 4.2 km^2)
- **Jordan, S.** (Region: 16. Subm ID: 753. N outlines: 4. Area: 13.6 km^2)
- **Khromova, Tatiana** (Region: 10. Subm ID: 761. N outlines: 2491. Area: 929.9 km^2)
- **Kienholz, Christian** (Region: 01, 02, 03, 16. Subm ID: 591, 624, 635, 756, 760, 810. N outlines: 27132. Area: 83530.6 km^2)
- **Kochtitzky, William** (Region: 03, 09, 10, 19. Subm ID: 726, 728, 755, 759, 807, 808. N outlines: 2222. Area: 40324.3 km^2)
- **Koenig, Max** (Region: 07, 09. Subm ID: 563, 567. N outlines: 2649. Area: 84594.6 km^2)
- **Le Bris, Raymond** (Region: 11. Subm ID: 731. N outlines: 4034. Area: 2120.1 km^2)

- **LeBris, Raymond** (Region: 01, 05, 19. Subm ID: 585, 624, 751, 756, 810. N outlines: 46569. Area: 257776.9 km^2)
- **Lebreton, Jerome** (Region: 19. Subm ID: 798. N outlines: 7. Area: 2684.6 km^2)
- **Mabileau, Laure** (Region: 04, 19. Subm ID: 816, 817. N outlines: 11363. Area: 41059.6 km^2)
- **Manley, William** (Region: 01. Subm ID: 624, 756, 810. N outlines: 25731. Area: 82576.6 km^2)
- **Masiokas, Mariano** (Region: 16, 17, 19. Subm ID: 700, 764. N outlines: 30682. Area: 27918.6 km^2)
- **Maussion, Fabien** (Region: 16. Subm ID: 753, 760. N outlines: 5. Area: 13.7 km^2)
- **McNabb, Robert** (Region: 01, 05, 19. Subm ID: 766, 805, 806, 811, 813. N outlines: 507. Area: 40322.5 km^2)
- **Merrill, Paige-Marie** (Region: 19. Subm ID: 807. N outlines: 212. Area: 1656.7 km^2)
- **Miles, Evan** (Region: 16. Subm ID: 591, 760. N outlines: 159. Area: 169.3 km^2)
- **Moelg, Nico** (Region: 05. Subm ID: 751. N outlines: 19079. Area: 77020.3 km^2)
- **Moholdt, Geir** (Region: 09. Subm ID: 567. N outlines: 1066. Area: 50753.2 km^2)
- **Muraviev, Anton** (Region: 10. Subm ID: 761. N outlines: 2491. Area: 929.9 km^2)
- **Negrete, A.** (Region: 05. Subm ID: 751. N outlines: 19079. Area: 77020.3 km^2)
- **Nussbaumer, Samuel** (Region: 16, 17. Subm ID: 730, 764. N outlines: 30654. Area: 27683.8 km^2)
- **Nuth, Chris** (Region: 07. Subm ID: 563. N outlines: 1583. Area: 33841.4 km^2)
- **OCallaghan, P** (Region: 03, 04. Subm ID: 589, 590. N outlines: 755. Area: 39862.1 km^2)
- **Paul, Frank** (Region: 01, 03, 04, 05, 07, 10, 11, 16, 17, 18, 19. Subm ID: 585, 589, 590, 720, 723, 729, 731, 748, 749, 751, 761, 764, 809, 810, 816, 817. N outlines: 82159. Area: 324906.4 km^2)
- **Pecker Marcosig, Ivanna** (Region: 16, 17, 19. Subm ID: 700, 764. N outlines: 30682. Area: 27918.6 km^2)
- **Peñafiel, A.** (Region: 16. Subm ID: 753. N outlines: 4. Area: 13.6 km^2)
- **Pitte, Pierre** (Region: 16, 17, 19. Subm ID: 700, 764. N outlines: 30682. Area: 27918.6 km^2)
- **Rastner, Philipp** (Region: 03, 04, 05, 10, 11, 16, 18, 19. Subm ID: 723, 729, 731, 748, 749, 751, 761, 816, 817. N outlines: 46768. Area: 154674.5 km^2)
- **Raup, Bruce H.** (Region: 10. Subm ID: 636. N outlines: 1646. Area: 394.0 km^2)
- **Ruiz, Lucas** (Region: 16, 19. Subm ID: 700. N outlines: 48. Area: 244.2 km^2)
- **Sakai, Akiko** (Region: 10, 13, 14, 15. Subm ID: 752. N outlines: 134754. Area: 100628.3 km^2)
- **Sharp, Martin** (Region: 03, 04, 16. Subm ID: 589, 590, 591, 760. N outlines: 914. Area: 40031.4 km^2)
- **Sigurdsson, Oddur** (Region: 06. Subm ID: 437, 438, 439, 452, 719, 757. N outlines: 568. Area: 11059.7 km^2)
- **Tapia, Guillermo** (Region: 16. Subm ID: 730. N outlines: 20. Area: 9.4 km^2)
- **Thomson, Laura** (Region: 03. Subm ID: 728. N outlines: 1961. Area: 37675.5 km^2)
- **Tielidze, Levan** (Region: 12. Subm ID: 762. N outlines: 2275. Area: 1406.7 km^2)
- **Ungerechts, L.** (Region: 16. Subm ID: 753. N outlines: 4. Area: 13.6 km^2)
- **Valdes, Javier** (Region: 16. Subm ID: 730. N outlines: 20. Area: 9.4 km^2)
- **Videla, Yohan** (Region: 16. Subm ID: 730. N outlines: 20. Area: 9.4 km^2)
- **White, Adrienne** (Region: 03. Subm ID: 723. N outlines: 2573. Area: 27690.4 km^2)
- **Winsvold, Solveig Havstad** (Region: 08. Subm ID: 611. N outlines: 3141. Area: 2674.8 km^2)

- **Wolken, G.** (Region: 03, 04. Subm ID: 589, 590. N outlines: 755. Area: 39862.1 km^2)
- **Wyatt, F.** (Region: 03, 04, 16. Subm ID: 589, 590, 591, 760. N outlines: 914. Area: 40031.4 km^2)
- **Yang, Ruitang** (Region: 01. Subm ID: 809. N outlines: 1736. Area: 4120.4 km^2)
- **Zajaczkiwsky, Sophie** (Region: 03. Subm ID: 728. N outlines: 1961. Area: 37675.5 km^2)
- **Zalazar, Laura** (Region: 16, 19. Subm ID: 700. N outlines: 48. Area: 244.2 km^2)

Additional GLIMS contributors reported by the community

These contributors were missing from GLIMS metadata as of July 28th, 2023 and were added to the RGI consortium list manually:

- **Herreid, Sam** (Region: 01. Subm ID: 624)
- **Lynch, Colleen** (Region: 10. Subm ID: 761)
- **Menounos, Brian** (Region: 02. Subm ID: 623)
- **Rich, Justin** (Region: 01. Subm ID: 624)
- **Wheate, Roger** (Region: 02. Subm ID: 623)
- **Ruiz, Lucas** (Region 17. Subm ID: 764)
- **Zalazar, Laura** (Region 17. Subm ID: 764)

Reported omissions after the release of RGI 7.0 are listed here.

CHAPTER

TEN

APPENDIX 3: ACKNOWLEDGEMENTS

Funding for RGI 7.0 was provided by:

- the **International Association of Cryospheric Sciences (IACS)**, under the auspices of the International Union of Geodesy and Geophysics (IUGG). Funds were used to organize meetings and employ student helpers.
- the **UNESCO** Programme and Budget 2022-2023 (41C/5), Major Programme II, Output 3.SC2: "Water science, innovation, education, management, cooperation and governance bolstered for a water secure world in a changing environment" and within the framework of the theme: "Supporting Member States to address hydrological challenges, extremes and water scarcity". Funds (granted to Fabien Maussion) were used to employ student helpers.
- the **World Glacier Monitoring Service (WGMS)**. Funds were used to employ student helpers.
- the **Copernicus Climate Changes Service (C3S)** implemented by the European Centre for Medium Range Weather Forecasts (ECMWF). Funds supported the glacier mapping in regions 01, 03, 04, 05, 07, 10, 11, 16, 17, 18, and 19 by Frank Paul and Philipp Rastner.
- the **ESA project Glaciers_cci** (Grant 4000127593/19/I-NB). Funds supported the glacier mapping in regions 04 and 18 by Frank Paul.
- the **National Aeronautics and Space Administration (NASA) and the National Snow and Ice Data Center Distributed Active Archive Center (NSIDC DAAC)**, grants NNG13HQ03C, 80GSFC18C0102 and 80GSFC23CA035.

Computing resources and data storage for the RGI7 generation process: **Ben Marzeion, Timo Rothenpieler**

RGI logo: **Anne Maussion**, Atelier Les Gros Yeux

RGI and GLIMS permanent data storage: **National Snow and Ice Data Center Distributed Active Archive Center (NSIDC DAAC)**

For his decades-long support of the GLIMS database: **Bruce Raup**

For their vision and pioneering work in initiating the RGI: **Graham Cogley, Georg Kaser, Tad Pfeffer**

> We also acknowledge the countless individuals who have mapped glaciers around the world and submitted the data to GLIMS, and the institutions supporting their work.

CHAPTER

ELEVEN

APPENDIX 4: HOW TO CONTRIBUTE

Your feedback is highly appreciated! While RGI 7.0 has been released, we will continue to work towards improving the RGI and releasing updated versions.

We encourage the community to contribute to the RGI by *reporting an issue* or *contributing with ideas, workflows or code*. We also welcome *feedback on the user guide*. New glacier inventories have to be *submitted to GLIMS* before they can be considered for future RGI versions.

11.1 Report an issue to the RGI

Currently known issues with the RGI 7.0 dataset are listed here: https://github.com/GLIMS-RGI/rgi_issue_tracker. Feel free to report any problem there!

11.2 Contribute to the user guide

This user guide is written in the markdown format and rendered to a website with the JupyterBook tool. You will find all necessary help about the markdown format on their respective documentation pages.

You can explore the markdown files by exploring this repository on github or by downloading it. The structure of the repository should be self explanatory after a bit of exploration. In case of doubt, each page on the RGI user guide (including this one) offers a "download" button in the top right allowing to download the file displayed on screen.

To contribute text or content, you have several choices:

1. Modify the file on github directly or by opening a pull-request. This requires a github account, and some knowledge about its functioning. If you are unfamiliar with github and have no time to learn, move to 2.
2. Download the file you want to edit, make the edits in the the markdown file, and send it to us. This requires downloading the files, and to understand the basic structure of the documentation.
3. Finally, if it is easiest for you, you can send us your feedback or request per e-mail.

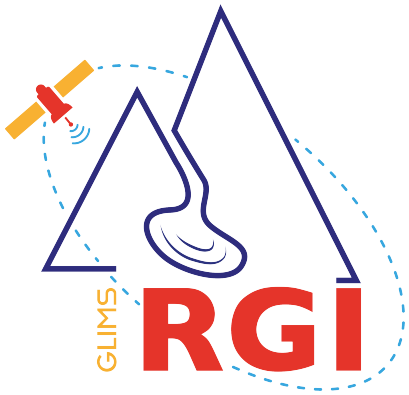
11.3 Contribute with a new glacier inventory

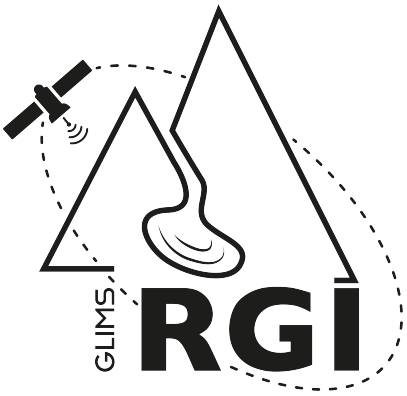
If you have an inventory that you think might be suitable for future RGI versions, please submit it to the GLIMS database. After this is done, open an issue on our tracker to let us know that a new inventory is available. It will be considered for future RGI versions.

11.4 Contribute with ideas, workflows or code

If you have any idea or suggestion, get in touch with us via our issue tracker. We try to keep all discussions as open as possible, and your idea might have been suggested already.

11.5 The RGI logo





The RGI logos are free to use. Downloads:

- svg
- png
- jpg (low resolution)
- blue
- black
- white

BIBLIOGRAPHY

[1] L. M. Andreassen, F. Paul, A. Kääb, and J. E. Hausberg. Landsat-derived glacier inventory for Jotunheimen, Norway, and deduced glacier changes since the 1930s. *The Cryosphere*, 2(2):131–145, oct 2008. doi:10.5194/tc-2-131-2008.

[2] Liss M Andreassen, Solveig H Winsvold, F. Paul, and J. E. Hausberg. *Inventory of Norwegian Glaciers*. Volume 38. NVE Rapport, 2012. ISBN 9788241008269. URL: https://publikasjoner.nve.no/rapport/2012/rapport2012_38.pdf.

[3] Kenshiro Arie, Chiyuki Narama, Ryohei Yamamoto, Kotaro Fukui, and Hajime Iida. Characteristics of mountain glaciers in the northern Japanese Alps. *The Cryosphere*, 16(3):1091–1106, mar 2022. doi:10.5194/tc-16-1091-2022.

[4] Gonzalo Barcaza, Samuel U. Nussbaumer, Guillermo Tapia, Javier Valdés, Juan-Luis García, Yohan Videla, Amapola Albornoz, and Víctor Arias. Glacier inventory and recent glacier variations in the Andes of Chile, South America. *Annals of Glaciology*, 58(75pt2):166–180, jul 2017. doi:10.1017/aog.2017.28.

[5] Sabine Baumann, Brian Anderson, Trevor Chinn, Andrew Mackintosh, Catherine Collier, Andrew M. Lorrey, Wolfgang Rack, Heather Purdie, and Shaun Eaves. Updated inventory of glacier ice in New Zealand based on 2016 satellite imagery. *Journal of Glaciology*, 67(261):13–26, feb 2021. doi:10.1017/jog.2020.78.

[6] M. J. Beedle, M. Dyurgerov, W. Tangborn, S. J.S. Khalsa, C. Helm, B. Raup, R. Armstrong, and R. G. Barry. Improving estimation of glacier volume change: A GLIMS case study of Bering Glacier System, Alaska. *Cryosphere*, 2(1):33–51, 2008. doi:10.5194/tc-2-33-2008.

[7] Etienne Berthier, Raymond Le Bris, Laure Mabileau, Laurent Testut, and Frédérique Rémy. Ice wastage on the Kerguelen Islands (49°S, 69°E) between 1963 and 2006. *Journal of Geophysical Research: Earth Surface*, 114(3):1–11, 2009. doi:10.1029/2008JF001192.

[8] R Bhambri, K Hewitt, P Kawishwar, and B Pratap. Surge-type and surge-modified glaciers in the Karakoram. *Scientific Reports*, 7(1):15391, nov 2017. doi:10.1038/s41598-017-15473-8.

[9] R. Bhambri, T. Bolch, P. Kawishwar, D. P. Dobhal, D. Srivastava, and B. Pratap. Heterogeneity in glacier response in the upper Shyok valley, northeast Karakoram. *The Cryosphere*, 7(5):1385–1398, sep 2013. doi:10.5194/tc-7-1385-2013.

[10] Andrew Bliss, Regine Hock, and J. Graham Cogley. A new inventory of mountain glaciers and ice caps for the Antarctic periphery. *Annals of Glaciology*, 54(63):191–199, jul 2013. doi:10.3189/2013AoG63A377.

[11] T. Bolch, T. Yao, S. Kang, M. F. Buchroithner, D. Scherer, F. Maussion, E. Huintjes, and C. Schneider. A glacier inventory for the western Nyainqentanglha Range and the Nam Co Basin, Tibet, and glacier changes 1976-2009. *The Cryosphere*, 4(3):419–433, sep 2010. doi:10.5194/tc-4-419-2010.

[12] Tobias Bolch. Climate change and glacier retreat in northern Tien Shan (Kazakhstan/Kyrgyzstan) using remote sensing data. *Global and Planetary Change*, 56(1-2):1–12, mar 2007. doi:10.1016/j.gloplacha.2006.07.009.

[13] Tobias Bolch, Brian Menounos, and Roger Wheate. Landsat-based inventory of glaciers in western Canada, 1985–2005. *Remote Sensing of Environment*, 114(1):127–137, jan 2010. doi:10.1016/j.rse.2009.08.015.

[14] Tobias Bolch, Brian Menounos, and Roger Wheate. Landsat-based inventory of glaciers in western Canada, 1985–2005. *Remote Sensing of Environment*, 114(1):127–137, jan 2010. doi:10.1016/j.rse.2009.08.015.

[15] R. Le Bris, F. Paul, H. Frey, and T. Bolch. A new satellite-derived glacier inventory for western Alaska. *Annals of Glaciology*, 52(59):135–143, 2011. doi:10.3189/172756411799096303.

[16] Evan W. Burgess, Christopher F. Larsen, and Richard R. Forster. Summer melt regulates winter glacier flow speeds throughout Alaska. *Geophysical Research Letters*, 40(23):6160–6164, 2013. doi:10.1002/2013GL058228.

[17] Michele Citterio, Frank Paul, Andreas P. Ahlstrøm, Hans F. Jepsen, and Anker Weidick. Remote sensing of glacier change in West Greenland: accounting for the occurrence of surge-type glaciers. *Annals of Glaciology*, 50(53):70–80, sep 2009. doi:10.3189/172756410790595813.

[18] J. Graham Cogley. A more complete version of the World Glacier Inventory. *Annals of Glaciology*, 50(53):32–38, sep 2009. doi:10.3189/172756410790595859.

[19] J. Graham Cogley, Etienne Berthier, and Shavawn Donoghue. Remote Sensing of Glaciers of the Subantarctic Islands. In *Global Land Ice Measurements from Space*, pages 759–780. Springer Berlin Heidelberg, Berlin, Heidelberg, 2014. doi:10.1007/978-3-540-79818-7_32.

[20] Copernicus. Copernicus DEM - Global and European Digital Elevation Model (COP-DEM). 2019. doi:10.5270/ESA-c5d3d65.

[21] Lucas Earl and Alex Gardner. A satellite-derived glacier inventory for North Asia. *Annals of Glaciology*, 57(71):50–60, 2016. doi:10.3189/2016AoJ71A008.

[22] A.G. Fountain, M. Hoffman, K. Jackson, H. Basagic, Nylen T., and D. Percy. Digital outlines and topography of the glaciers of the American West. Technical Report, USGS, 2006.

[23] Holger Frey, Frank Paul, and Tazio Strozzi. Compilation of a glacier inventory for the western Himalayas from satellite data: methods, challenges, and results. *Remote Sensing of Environment*, 124:832–843, sep 2012. doi:10.1016/j.rse.2012.06.020.

[24] Marie Gardent, Antoine Rabatel, Jean-Pierre Dedieu, and Philip Deline. Multitemporal glacier inventory of the French Alps from the late 1960s to the late 2000s. *Global and Planetary Change*, 120:24–37, sep 2014. doi:10.1016/j.gloplacha.2014.05.004.

[25] Alex S. Gardner, Geir Moholdt, J Graham Cogley, Bert Wouters, Anthony a Arendt, John Wahr, Etienne Berthier, Regine Hock, W Tad Pfeffer, Georg Kaser, Stefan R M Ligtenberg, Tobias Bolch, Martin J Sharp, Jon Ove Hagen, Michiel R van den Broeke, and Frank Paul. A Reconciled Estimate of Glacier Contributions to Sea Level Rise: 2003 to 2009. *Science.*, 340(6134):852–857, may 2013. doi:10.1126/science.1234532.

[26] A. F. Gellatly, C. Smiraglia, J.M. Grove, and R. Latham. Recent variations of Ghiacciaio del Calderone, Abruzzi, Italy. *Journal of Glaciology*, 40(136):486–490, jan 1994. doi:10.1017/S0022143000012351.

[27] A.F. Gellatly, J.M. Grove, R. Latham, and R.J Parkinson. Observations of the glaciers in the Southern Maritime Alps (Italy). *Revue de géomorphologie dynamique*, 43(3):93–107, 1994.

[28] Franz Goerlich, Tobias Bolch, and Frank Paul. More dynamic than expected: an updated survey of surging glaciers in the Pamir. *Earth System Science Data*, 12(4):3161–3176, dec 2020. doi:10.5194/essd-12-3161-2020.

[29] Karsten Grunewald, Weber, Scheithauer, and Haubold. Mikrogletscher im Piringebirge (Bulgarien). *Zschr. Gletscherkunde und Glazialgeologie*, 39:99–114, 2006.

[30] GTN-G. GTN-G Glacier Regions. 2023. doi:10.5904/gtng-glacreg-2023-07.

[31] Gregoire Guillet, Owen King, Mingyang Lv, Sajid Ghuffar, Douglas Benn, Duncan Quincey, and Tobias Bolch. A regionally resolved inventory of High Mountain Asia surge-type glaciers, derived from a multi-factor remote sensing approach. *The Cryosphere*, 16(2):603–623, feb 2022. doi:10.5194/tc-16-603-2022.

[32] Wanqin Guo, Shiyin Liu, Junli Xu, Lizong Wu, Donghui Shangguan, Xiaojun Yao, Junfeng Wei, Weijia Bao, Pengchun Yu, Qiao Liu, and Zongli Jiang. The second Chinese glacier inventory: data, methods and results. *Journal of Glaciology*, 61(226):357–372, jul 2015. doi:10.3189/2015JoG14J209.

[33] Jon Ove Hagen, Olav Liestøl, Erik Roland, and Torild Jørgensen. *Glacier atlas of Svalbard and Jan Mayen*. Norsk Polarinstitutt Meddelelser, 1993. ISBN 82-7666-066-5.

[34] Wilfried Hagg, Christoph Mayer, Elisabeth Mayr, and Achim Heilig. Climate and glacier fluctuations in the Bavarian Alps in the past 120 years. *Erdkunde*, 66(2):121–142, jun 2012. doi:10.3112/erdkunde.2012.02.03.

[35] Regine Hock, Fabien Maussion, Ben Marzeion, and Sophie Nowicki. What is the global glacier ice volume outside the ice sheets? *Journal of Glaciology*, 69(273):204–210, feb 2023. doi:10.1017/jog.2023.1.

[36] Matthew J. Hoffman, Andrew G. Fountain, and Jonathan M. Achuff. 20th-century variations in area of cirque glaciers and glacierets, Rocky Mountain National Park, Rocky Mountains, Colorado, USA. *Annals of Glaciology*, 46:349–354, sep 2007. doi:10.3189/172756407782871233.

[37] I. M. Howat, A. Negrete, and B. E. Smith. The Greenland Ice Mapping Project (GIMP) land classification and surface elevation data sets. *The Cryosphere*, 8(4):1509–1518, aug 2014. doi:10.5194/tc-8-1509-2014.

[38] Philip D. Hughes. Response of a montenegro glacier to extreme summer heatwaves in 2003 and 2007. *Geografiska Annaler: Series A, Physical Geography*, 90(4):259–267, dec 2008. doi:10.1111/j.1468-0459.2008.00344.x.

[39] E. Jordan, L. Ungerechts, B. Cáceres, A. Peñafiel, and B. Francou. Estimation by photogrammetry of the glacier recession on the Cotopaxi Volcano (Ecuador) between 1956 and 1997 / Estimation par photogrammétrie de la récession glaciaire sur le Volcan Cotopaxi (Equateur) entre 1956 et 1997. *Hydrological Sciences Journal*, dec 2005. doi:10.1623/hysj.2005.50.6.949.

[40] J. S. Kargel, A. P. Ahlstrøm, R. B. Alley, J. L. Bamber, T. J. Benham, J. E. Box, C. Chen, P. Christoffersen, M. Citterio, J. G. Cogley, H. Jiskoot, G. J. Leonard, P. Morin, T. Scambos, T. Sheldon, and I. Willis. Brief communication Greenland's shrinking ice cover: "fast times" but not that fast. *The Cryosphere*, 6(3):533–537, may 2012. doi:10.5194/tc-6-533-2012.

[41] T Khromova, G Nosenko, A Muraviev, S Nikitin, L Chernova, and N Zverkova. Mountain Area Glaciers of Russia in the 20th and the Beginning of the 21st Centuries. In Gregory B Greenwood and J F Shroder, editors, *Mountain Ice and Water*, volume 21 of Developments in Earth Surface Processes, pages 47–129. Elsevier, 2016. doi:10.1016/B978-0-444-63787-1.00002-0.

[42] Tatiana Khromova, Gennady Nosenko, Stanislav Nikitin, Anton Muraviev, Valeria Popova, Ludmila Chernova, and Vera Kidyaeva. Changes in the mountain glaciers of continental Russia during the twentieth to twenty-first centuries. *Regional Environmental Change*, 19(5):1229–1247, jun 2019. doi:10.1007/s10113-018-1446-z.

[43] C. Kienholz, J. L. Rich, a. a. Arendt, and R. Hock. A new method for deriving glacier centerlines applied to glaciers in Alaska and northwest Canada. *The Cryosphere*, 8(2):503–519, mar 2014. doi:10.5194/tc-8-503-2014.

[44] Christian Kienholz, Sam Herreid, Justin L. Rich, Anthony A. Arendt, Regine Hock, and Evan W. Burgess. Derivation and analysis of a complete modern-date glacier inventory for Alaska and northwest Canada. *Journal of Glaciology*, 61(227):403–420, 2015. doi:10.3189/2015JoG14J230.

[45] Christian Kienholz, Regine Hock, and Anthony a. Arendt. A new semi-automatic approach for dividing glacier complexes into individual glaciers. *Journal of Glaciology*, 59(217):925–937, oct 2013. doi:10.3189/2013JoG12J138.

[46] Owen King, Atanu Bhattacharya, Sajid Ghuffar, Alex Tait, Sam Guilford, Aurora C. Elmore, and Tobias Bolch. Six Decades of Glacier Mass Changes around Mt. Everest Are Revealed by Historical and Contemporary Images. *One Earth*, 3(5):608–620, nov 2020. doi:10.1016/j.oneear.2020.10.019.

[47] William Kochtitzky, Luke Copland, Wesley Van Wychen, Romain Hugonnet, Regine Hock, Julian A. Dowdeswell, Toby Benham, Tazio Strozzi, Andrey Glazovsky, Ivan Lavrentiev, David R. Rounce, Romain Millan, Alison Cook, Abigail Dalton, Hester Jiskoot, Jade Cooley, Jacek Jania, and Francisco Navarro. The unquantified mass loss of Northern Hemisphere marine-terminating glaciers from 2000–2020. *Nature Communications*, 13(1):5835, oct 2022. doi:10.1038/s41467-022-33231-x.

[48] Jérôme Korona, Etienne Berthier, Marc Bernard, Frédérique Rémy, and Eric Thouvenot. SPIRIT. SPOT 5 stereoscopic survey of Polar Ice: Reference Images and Topographies during the fourth International Po-

lar Year (2007–2009). *ISPRS Journal of Photogrammetry and Remote Sensing*, 64(2):204–212, mar 2009. doi:10.1016/j.isprsjprs.2008.10.005.

[49] Niels J. Korsgaard, Christopher Nuth, Shfaqat A. Khan, Kristian K. Kjeldsen, Anders A. Bjørk, Anders Schomacker, and Kurt H. Kjær. Digital elevation model and orthophotographs of Greenland based on aerial photographs from 1978–1987. *Scientific Data*, 3(1):160032, may 2016. doi:10.1038/sdata.2016.32.

[50] David Kriegel, Christoph Mayer, Wilfried Hagg, Sergiy Vorogushyn, Doris Duethmann, Abror Gafurov, and Daniel Farinotti. Changes in glacierisation, climate and runoff in the second half of the 20th century in the Naryn basin, Central Asia. *Global and Planetary Change*, 110:51–61, nov 2013. doi:10.1016/j.gloplacha.2013.05.014.

[51] A Kurter. Glaciers of Turkey. *Glaciers of the Middle East and Africa*, pages G1–G30, 1991.

[52] Max König, Christopher Nuth, Jack Kohler, Geir Moholdt, and Rickard Pettersen. A digital glacier database for svalbard. In *Global Land Ice Measurements from Space*, pages 229–239. 2014. doi:10.1007/978-3-540-79818-7_10.

[53] Yaojun Li, Fei Li, Donghui Shangguan, and Yongjian Ding. A new global gridded glacier dataset based on the Randolph Glacier Inventory version 6.0. *Journal of Glaciology*, 67(264):773–776, aug 2021. doi:10.1017/jog.2021.28.

[54] Colleen M. Lynch, Iestyn D. Barr, Donal Mullan, and Alastair Ruffell. Rapid glacial retreat on the Kamchatka Peninsula during the early 21st century. *The Cryosphere*, 10(4):1809–1821, aug 2016. doi:10.5194/tc-10-1809-2016.

[55] Fabien Maussion, Anton Butenko, Nicolas Champollion, Matthias Dusch, Julia Eis, Kévin Fourteau, Philipp Gregor, Alexander H. Jarosch, Johannes Landmann, Felix Oesterle, Beatriz Recinos, Timo Rothenpieler, Anouk Vlug, Christian T. Wild, and Ben Marzeion. The Open Global Glacier Model (OGGM) v1.1. *Geoscientific Model Development*, 12(3):909–931, mar 2019. doi:10.5194/gmd-12-909-2019.

[56] Milovan Milivojević, Ljubomir Menković, and Jelena Ćalić. Pleistocene glacial relief of the central part of Mt. Prokletije (Albanian Alps). *Quaternary International*, 190(1):112–122, nov 2008. doi:10.1016/j.quaint.2008.04.006.

[57] Romain Millan, Jérémie Mouginot, Antoine Rabatel, and Mathieu Morlighem. Ice velocity and thickness of the world's glaciers. *Nature Geoscience*, 15(2):124–129, feb 2022. doi:10.1038/s41561-021-00885-z.

[58] Geir Moholdt, Bert Wouters, and Alex S. Gardner. Recent mass changes of glaciers in the Russian High Arctic. *Geophysical Research Letters*, 39(10):n/a–n/a, may 2012. doi:10.1029/2012GL051466.

[59] Pradeep Kumar Mool, Samjwal Ratna Bajracharya, Basanta Shrestha, Sharad Prasad Joshi, Rakhshan Roohi Naz, Arshad Ashraf, Rozina Chaudhry, Syed Amjad Hussain, and M. Hamid Chaudry. Indus Basin: Inventory of Glaciers and Glacial Lakes and Identification of Potential Glacial Lake Outburst Floods (GLOFs) Affected by Global Warming in the Mountains of Himalayan Region. Technical Report 4, ICIMOD, 2005.

[60] M.S. Moussavi, M.J. Valadan Zoej, F. Vaziri, M.R. Sahebi, and Y. Rezaei. A new glacier inventory of Iran. *Annals of Glaciology*, 50(53):93–103, sep 2009. doi:10.3189/172756410790595886.

[61] Nico Mölg, Tobias Bolch, Philipp Rastner, Tazio Strozzi, and Frank Paul. A consistent glacier inventory for Karakoram and Pamir derived from Landsat data: distribution of debris cover and mapping challenges. *Earth System Science Data*, 10(4):1807–1827, oct 2018. doi:10.5194/essd-10-1807-2018.

[62] T. Nuimura, A. Sakai, K. Taniguchi, H. Nagai, D. Lamsal, S. Tsutaki, A. Kozawa, Y. Hoshina, S. Takenaka, S. Omiya, K. Tsunematsu, P. Tshering, and K. Fujita. The GAMDAM glacier inventory: a quality-controlled inventory of Asian glaciers. *The Cryosphere*, 9(3):849–864, may 2015. doi:10.5194/tc-9-849-2015.

[63] C. Nuth, J. Kohler, M. König, A. von Deschwanden, J. O. Hagen, A. Kääb, G. Moholdt, and R. Pettersson. Decadal changes from a multi-temporal glacier inventory of Svalbard. *The Cryosphere*, 7(5):1603–1621, oct 2013. doi:10.5194/tc-7-1603-2013.

[64] Atsumu Ohmura. Completing the World Glacier Inventory. *Annals of Glaciology*, 50(53):144–148, sep 2009. doi:10.3189/172756410790595840.

[65] Azamat Osmonov, Tobias Bolch, Chen Xi, Alishir Kurban, and Wanqing Guo. Glacier characteristics and changes in the Sary-Jaz River Basin (Central Tien Shan, Kyrgyzstan) – 1990–2010. *Remote Sensing Letters*, 4(8):725–734, aug 2013. doi:10.1080/2150704X.2013.789146.

[66] F. Paul, R.G. Barry, J.G. Cogley, H. Frey, W. Haeberli, A. Ohmura, C.S.L. Ommanney, B. Raup, A. Rivera, and M. Zemp. Recommendations for the compilation of glacier inventory data from digital sources. *Annals of Glaciology*, 50(53):119–126, sep 2009. doi:10.3189/172756410790595778.

[67] F. Paul, H. Frey, and R. Le Bris. A new glacier inventory for the European Alps from Landsat TM scenes of 2003: challenges and results. *Annals of Glaciology*, 52(59):144–152, sep 2011. doi:10.3189/172756411799096295.

[68] Frank Paul and Liss M. Andreassen. A new glacier inventory for the Svartisen region, Norway, from Landsat ETM+ data: challenges and change assessment. *Journal of Glaciology*, 55(192):607–618, sep 2009. doi:10.3189/002214309789471003.

[69] Frank Paul, Liss M. Andreassen, and Solveig H. Winsvold. A new glacier inventory for the Jostedalsbreen region, Norway, from Landsat TM scenes of 2006 and changes since 1966. *Annals of Glaciology*, 52(59):153–162, sep 2011. doi:10.3189/172756411799096169.

[70] Frank Paul, Sabine Baumann, Brian Anderson, and Philipp Rastner. Deriving a year 2000 glacier inventory for New Zealand from the existing 2016 inventory. *Annals of Glaciology*, pages 1–11, apr 2023. doi:10.1017/aog.2023.20.

[71] Frank Paul and Andreas Kääb. Perspectives on the production of a glacier inventory from multispectral satellite data in Arctic Canada: Cumberland Peninsula, Baffin Island. *Annals of Glaciology*, 42:59–66, sep 2005. doi:10.3189/172756405781813087.

[72] Frank Paul and Nico Mölg. Hasty retreat of glaciers in northern Patagonia from 1985 to 2011. *Journal of Glaciology*, 60(224):1033–1043, jul 2014. doi:10.3189/2014JoG14J104.

[73] Frank Paul, Philipp Rastner, Roberto Sergio Azzoni, Guglielmina Diolaiuti, Davide Fugazza, Raymond Le Bris, Johanna Nemec, Antoine Rabatel, Mélanie Ramusovic, Gabriele Schwaizer, and Claudio Smiraglia. Glacier shrinkage in the Alps continues unabated as revealed by a new glacier inventory from Sentinel-2. *Earth System Science Data*, 12(3):1805–1821, aug 2020. doi:10.5194/essd-12-1805-2020.

[74] W. Tad Pfeffer, Anthony a. Arendt, Andrew Bliss, Tobias Bolch, J. Graham Cogley, Alex S. Gardner, Jon-Ove Hagen, Regine Hock, Georg Kaser, Christian Kienholz, Evan S. Miles, Geir Moholdt, Nico Mölg, Frank Paul, Valentina Radić, Philipp Rastner, Bruce H. Raup, Justin Rich, and Martin J. Sharp. The Randolph Glacier Inventory: a globally complete inventory of glaciers. *Journal of Glaciology*, 60(221):537–552, jul 2014. doi:10.3189/2014JoG13J176.

[75] P. Rastner, T. Bolch, N. Mölg, H. Machguth, R. Le Bris, and F. Paul. The first complete inventory of the local glaciers and ice caps on Greenland. *The Cryosphere*, 6(6):1483–1495, dec 2012. doi:10.5194/tc-6-1483-2012.

[76] B.H. Raup, H.H. Kieffer, T.M. Hare, and J.S. Kargel. Generation of data acquisition requests for the ASTER satellite instrument for monitoring a globally distributed target: glaciers. *IEEE Transactions on Geoscience and Remote Sensing*, 38(2):1105–1112, mar 2000. doi:10.1109/36.841989.

[77] Bruce Raup and Siri Jodha Singh Khalsa. GLIMS Analysis Tutorial. Technical Report 2, NSIDC, 2007.

[78] Andrés Rivera, Toby Benham, Gino Casassa, Jonathan Bamber, and Julian A. Dowdeswell. Ice elevation and areal changes of glaciers from the Northern Patagonia Icefield, Chile. *Global and Planetary Change*, 59(1-4):126–137, oct 2007. doi:10.1016/j.gloplacha.2006.11.037.

[79] M. Sah, G. Philip, P.K. Mool, S. Bajracharya, and B. Shrestha. Uttaranchal Himalaya India: Inventory of Glaciers and Glacial Lakes and the Identification of Potential Glacial Lake Outburst Floods (GLOFs) Affected by Global Warming in the Mountains of Himalayan Region. Technical Report, ICIMOD, 2005.

[80] Akiko Sakai. Brief communication: Updated GAMDAM glacier inventory over high-mountain Asia. *The Cryosphere*, 13(7):2043–2049, jul 2019. doi:10.5194/tc-13-2043-2019.

[81] Mehmet Akif Sarıkaya and Ahmet Emre Tekeli. Satellite Inventory of Glaciers in Turkey. In *Global Land Ice Measurements from Space*, pages 465–480. Springer Berlin Heidelberg, Berlin, Heidelberg, 2014. doi:10.1007/978-3-540-79818-7_21.

[82] D. Serrat and J. Ventura. Glaciers of the Pyrenees, Spain and France. In R.S. Williams and J.G. Ferrigno, editors, *Satellite Image Atlas of Glaciers of the World, USGS Professional Paper 1386-E-2*, pages 49–61. 1993.

[83] Heïdi Sevestre and Douglas I Benn. Climatic and geometric controls on the global distribution of surge-type glaciers: implications for a unifying model of surging. *Journal of Glaciology*, 61(228):646–662, jul 2015. doi:10.3189/2015JoG14J136.

[84] M. Shahgedanova, G. Nosenko, S. Kutuzov, O. Rototaeva, and T. Khromova. Deglaciation of the Caucasus Mountains, Russia/Georgia, in the 21st century observed with ASTER satellite imagery and aerial photography. *The Cryosphere*, 8(6):2367–2379, dec 2014. doi:10.5194/tc-8-2367-2014.

[85] Yafeng Shi, Chaohai Liu, and Ersi Kang. The Glacier Inventory of China. *Annals of Glaciology*, 50(53):1–4, sep 2009. doi:10.3189/172756410790595831.

[86] Claudio Smiraglia, Roberto Sergio Azzoni, Carlo D'agata, Davide Maragno, Davide Fugazza, and Guglielmina Adele Diolaiuti. The evolution of the Italian glaciers from the previous data base to the new Italian inventory. preliminary considerations and results. *Geografia Fisica e Dinamica Quaternaria*, 38(1):79–87, 2015. doi:10.4461/GFDQ.2015.38.08.

[87] Arthur N Strahler. Hypsometric (Area - Altitude) Analysis of Erosional Topography. *Geological Society of America Bulletin*, 63(11):1117–1142, 1952. doi:10.1130/0016-7606(1952)63[1117:HAAOET]2.0.CO;2.

[88] Felix Svoboda and Frank Paul. A new glacier inventory on southern Baffin Island, Canada, from ASTER data: I. Applied methods, challenges and solutions. *Annals of Glaciology*, 50(53):11–21, sep 2009. doi:10.3189/172756410790595912.

[89] Levan G. Tielidze, Gennady A. Nosenko, Tatiana E. Khromova, and Frank Paul. Strong acceleration of glacier area loss in the Greater Caucasus between 2000 and 2020. *The Cryosphere*, 16(2):489–504, feb 2022. doi:10.5194/tc-16-489-2022.

[90] Robert G. Way, Trevor Bell, and Nicholas E. Barrand. An inventory and topographic analysis of glaciers in the Torngat Mountains, northern Labrador, Canada. *Journal of Glaciology*, 60(223):945–956, jul 2014. doi:10.3189/2014JoG13J195.

[91] Adrienne White. *Glacier changes across Northern Ellesmere Island*. PhD thesis, Université d'Ottawa/University of Ottawa, 2019.

[92] Ruitang Yang, Regine Hock, Shichang Kang, Donghui Shangguan, and Wanqin Guo. Glacier mass and area changes on the Kenai Peninsula, Alaska, 1986–2016. *Journal of Glaciology*, 66(258):603–617, aug 2020. doi:10.1017/jog.2020.32.

[93] Laura Zalazar, Lidia Ferri, Mariano Castro, Hernán Gargantini, Melisa Gimenez, Pierre Pitte, Lucas Ruiz, Mariano Masiokas, Gustavo Costa, and Ricardo Villalba. Spatial distribution and characteristics of Andean ice masses in Argentina: results from the first National Glacier Inventory. *Journal of Glaciology*, 66(260):938–949, dec 2020. doi:10.1017/jog.2020.55.

[94] Hernán De Angelis. Hypsometry and sensitivity of the mass balance to changes in equilibrium-line altitude: the case of the Southern Patagonia Icefield. *Journal of Glaciology*, 60(219):14–28, jul 2014. doi:10.3189/2014JoG13J127.

[95] Scientific Committee on Antarctic Research. Antarctic Digital Database Version 3.0. 2000.

[96] Mihaela Triglav Čekada, Matija Zorn, Viktor Kaufmann, and Gerhard Karl Lieb. Measurements of small alpine glaciers: examples from Slovenia and Austria. *Geodetski vestnik*, 56(03):443–461, 2012. doi:10.15292/geodetski-vestnik.2012.03.443-461.

[97] World Glacier Monitoring Service (WGMS). Into the Second Century of Worldwide Glacier Monitoring–Prospects and Strategies. Technical Report, World Glacier Monitoring Service (WGMS), 1998.