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UNIFIED DATABASE OF GEORGIAN GLACIERS

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Absract. *The* Georgian Glaciers *database integrates historical records from the* Catalog of Glaciers of the Former Soviet Union *(hereinafter referred to as the Catalog), topographic maps from the 1960s, and satellite remote sensing (SRS) imagery acquired in 2010 (SRS-1), 2015 (SRS-2), and 2020 (SRS-3). These datasets include imagery from Landsat 5, 7, and 8 satellites (15–30 m resolution) and the commercial Azercosmos satellite SPOT 6 (1–1.5 m resolution). All data are archived at the Institute of Hydrometeorology, Georgian Technical University.*

Key words*: Georgian Glaciers, Glacier Catalog, Satellite Remote Sensing, Topographic Maps, Glacier Database*

Introduction

Global open-access glacier databases often contain inaccuracies in preserved glacier contours. To address this, overlaying elevation data derived from satellite imagery and digital terrain models, supplemented by expert analysis, conducted contour refinement. High-resolution 3D imagery enabled precise delineation of watershed boundaries – an essential step for accurate glacier mapping.

Historical inconsistencies were identified in the original Catalog, which were corrected by comparing glacier outlines from SRS data with those depicted on classified Soviet-era topographic maps (scale 1:50,000). These maps, originally compiled for military use, were unavailable to the public during the 20th century.

As part of an international initiative aligned with the GLIMS (Global Land Ice Measurements from Space) methodology, glacier boundaries were manually digitized. For each period, key parameters were extracted from the Catalog, including glacier area, morphological type, orientation, length, minimum and maximum elevation, firn line altitude, and ablation zone extent.

Glaciers were categorized by area into: 1. **Small**: 0.1–0.5 km² (green), 2. **Medium**: 0.5–2.0 km² (gray) and 3.**Large**: >2.0 km² (blue).

Additionally, **snowfields** (**extinct glaciers** (red) were identified. Snowfields – composed of snow, firn, and ice – typically form in sheltered areas and may represent remnants of glacier degradation. Due to their limited size, snowfields were excluded from detailed analysis.

Glacier Attribute Table Structure

The *Georgian Glaciers* database is organized into structured tables that document glacier characteristics across the glacial basins of Western and Eastern Georgia. Each table is divided into **eight thematic blocks**, representing key physical attributes: 1. Area, 2. Morphological type, 3. General exposure, 4. Maximum length, 5. Minimum height, 6. Maximum height, 7. Firn line elevation, 8. Ablation area.

These blocks are preceded by **three universal identifiers**:

- **Ordinal Number**: Sequential index within the table
- **Glacier Name / Local Number**: As recorded in the Catalogue or assigned in the first glacier catalogue compiled by K.I. Podozersky (1911) [1]
- **WGI ID**: A 12-character identification code from the World Glacier Inventory

Column Structure

Each thematic block contains **10 columns**, designed for comparative analysis across multiple data sources:

No	Description
1	Glacier ID from the Catalogue Scheme
2	Glacier attribute value from the Catalogue (corrected value shown after a slanted line in the Area block)
3	Glacier ID from Topographic Map (highlighted in brown)
4	Attribute value from Topographic Map
5	Glacier ID from SRS-1 (highlighted in brown)
6	Attribute value from SRS-1
7	Glacier ID from SRS-2 (highlighted in brown)
8	Attribute value from SRS-2
9	Glacier ID from SRS-3 (highlighted in brown)
10	Attribute value from SRS-3

This tabular format provides a clear and user-friendly interface for comparing glacier characteristics across historical and satellite datasets. All satellite-derived attributes were processed using **GIS (Geographic Information Systems)** technologies.

Each block consists of 10 columns. The columns contain: 1. Glacier ”According to the Catalog Scheme No.”; 2. The value of the glacier characteristic corresponding to the block name ”According to the Catalog” (the corrected value according to the topographic map is indicated after the slanted line in the area block); 3. Glacier ”According to the Topographic Map No.” (the column is highlighted in brown); 4. The value of the glacier characteristic corresponding to the block name “According to the Topographic Map; 5. Glacier ”According to the Topographic Map No. 1” (the column is highlighted in brown); 6. The value of the glacier characteristic corresponding to the block name “According to the Topographic Map No. 1”; 7. Glacier ”According to the Topographic Map No. 2” (the column is highlighted in brown); 8. The value of the glacier characteristic corresponding to the block name ”According to SRS 2”; 9. Glacier ”According to SRS 3” (column highlighted in brown); 10. The value of the glacier characteristic corresponding to the block name ”According to SRS 3”. Such a distribution is visible and convenient for the user. Using SRS, all characteristics of the glacier are determined using GIS (Geo-Information Systems) technologies.

ID WGI consists of 12 characters. The World Catalog Identification Code consists of 12 characters. For example: SU4G09301009 and SU4G08012096. The meaning of the character according to the order (position) is discussed below:

1 and 2 – SU means that the glacier is located in the former Soviet Union;

3 – The glacier is located in Europe (4) or Asia (5). In our case, we have the symbol 4.

4 – Indicates the location of a glacier within a certain river basin. For Asia The symbols are A, B, C, D, E, F, T, V, X, and For Europe – C, E, X, Y, H, G. Let's decipher the symbols of the basins of the glacial rivers of Georgia from the symbols: from the symbols of the rivers of Asia, the symbol T means the rivers of the Black Sea basin, which flow from the southern slopes of the Caucasus, and from the symbols of the rivers of Europe, the symbol G indicates that the glacier is located in the Tergi Basin;

5 and 6 are symbols of the glacier name and correspond to the volume number of the catalog, which in turn corresponds to the volume number of the “Catalog of Surface River Resources of the USSR” (20 volumes in total). The glaciers of Georgia are presented in volumes 8 and 9.

7 – is the symbol for the name of the glacier and corresponds to the issue number of the catalog volume. Each volume has no more than 7 issues, and if the volume has only one issue, the 7th symbol is 0;

8 and 9 – are symbols of the name of the glacier and correspond to the part of the release. There can be a total of 21 parts in a release, and if the release has only 1 part, 00 is written.

10, 11 and 12 – are symbols for the glacier name and correspond to the glacier number in the catalog section. There can be from 4 to 996 glaciers in a section.

For clarity, let's decode the identification code of the SU4G09301009 glacier in WGI:

1. SU – The glacier is located in the former Soviet Union.
2. 4 – The glacier is located in Europe.
3. G − The glacier belongs to the Tergi River basin;

4. 09 – We need to find the 9th volume,
5. 3rd edition,
6. In part 1 and
7. Its serial number is 9.

Let's also decrypt SU4G08012096

1. SU – The glacier is located in the former Soviet Union;
2. 4 – The glacier is located in Europe;
3. G − The glacier belongs to the Tergi River basin;
4. 08 – We need to find the 8th volume,
5. 0 release,
6. In section 12 and
7. Its serial number is 96.

Eight blocks:

1. Area

Glacier areas in km^2 are calculated by the catalogue with an accuracy of 0.01 km^2 , and by the SRS with an accuracy of 0.000001 km^2. These values of the SRS data allow us to observe the degradation of glaciers with greater accuracy.

2. Morphological type

As a result of expert assessment, the morphological types of mountain glaciers in Georgia have been established: Corrie, Valley and Hanging glaciers, as well as transitional types − Corrie-Valley, Hanging-Corrie, Hanging-Valley, Corrie-Hanging.

3. General exposure

Using a modern method for determining glacier exposure, which is proven and accepted worldwide [2 , 3] , the following options are presented in the resulting table with the corresponding designations: West, East, South, Southwest, Southeast, North, Northwest, Northeast.

4. Maximum length

The maximum length of the glacier in meters is given in the catalog, and on the images obtained with the SRS it is determined by the length of an additional line drawn manually from the extreme upper part of the glacier contour to the tip of the glacier tongue.

5. Minimum height

The minimum height of the glacier is determined in meters using a digital terrain model (DEM).

6. Maximum height

The maximum height of the glacier is determined in meters by the digital terrain model (DEM).

7. Height of the firn line

The Geffer method was used to determine the height of the firn line, as the firn line of the glaciers of Georgia is determined by this method in the glacier catalogue.

According to Geffer, the height of the firn line is the arithmetic mean between the average height of the surrounding relief of the firn basin and the height of the end of the glacier tongue. The average height of the highest two or more peaks around the glacier basin is added to the height of the end of the glacier tongue, and the arithmetic mean of these two values is calculated [4]. It should be noted that it was possible to determine the height of the firn line by this method only for some glaciers.

8. The ablation area

The ablation area is the total number of pixels from the height of the firn line to the lowest point of the glacier multiplied by the area of one pixel gives the current area of glacier ablation.

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