MOUNTAINS UNCOVERED

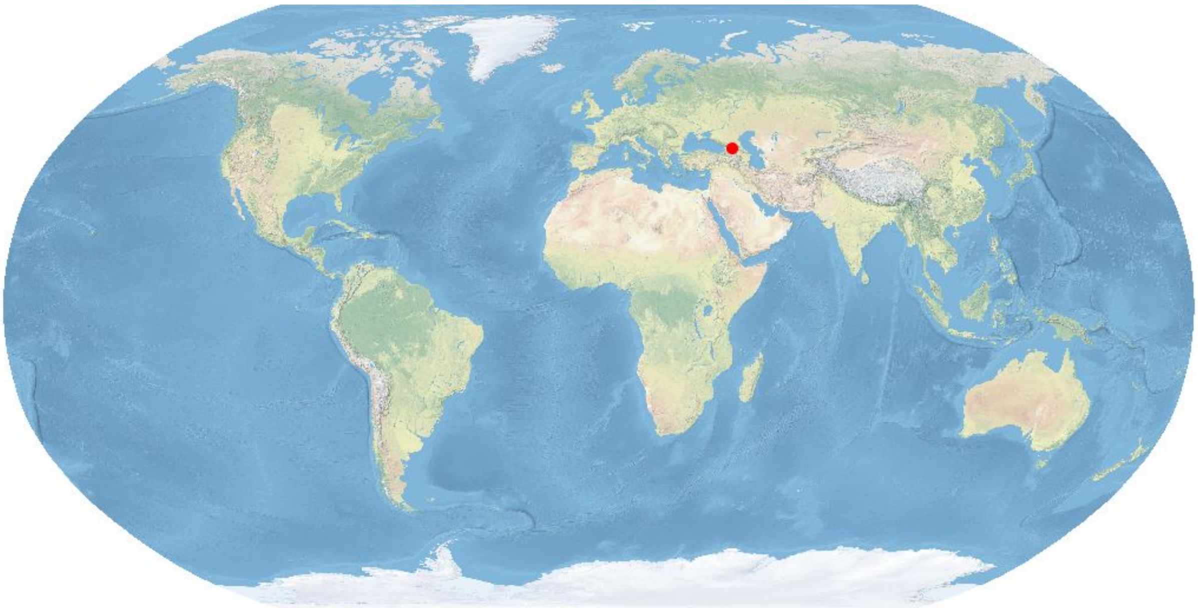
Intercomparable Maps and Statistics for 100 Selected Global Mountain Ranges

Caucasus Mountains #25

GEO MOUNTAINS
Observing Mountain Environments

Caucasus Mountains

The *Mountains Uncovered* series has been developed by GEO Mountains to provide a set of easily understandable and inter-comparable maps, tables, and figures spanning a range of thematic areas for 100 selected global mountain ranges. This is the report for the **Caucasus Mountains** mountain range. The index page shows an overview of all mountain ranges in the series.



Location of the Caucasus Mountains mountain range [1][2].

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1. General Information

1.1. Administrative

The mountain range has spatial overlap with **five** different countries, as shown in Figure 1.1. The overview is based on the GADM dataset [3] of administrative divisions at Level 0.

Figure 1.1. Administrative Overview

Map showing the administrative divisions overlapping with the mountain range.

Data: GADM [3] Background: GMBA [2], GADM [3], Natural Earth [3], Geonames [4], World Bank [22].

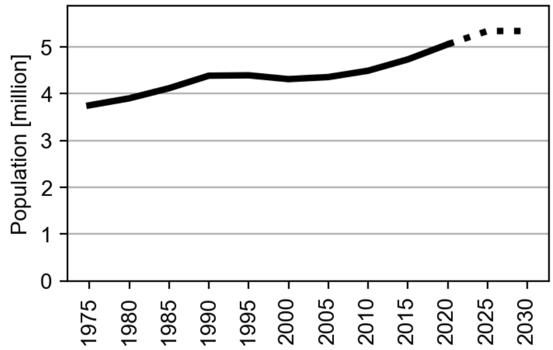
Russia	70,028 km²	44%
Georgia	49,086 km²	31%
Azerbaijan	26,831 km²	17%
Armenia	9,434 km²	6%
Turkey	2,046 km²	1%

1.2. Demographics

Data on the mountain range's human population are sourced from the European Commission's GHS-POP dataset [5]. According to this source, it is estimated that **5 million** people lived in the area in 2020. This is expected to **increase to 5 million** by 2030. The largest settlements within the mountain range are **Vanadzor, Tuapse, Sheki, Shamakhi,** and **Telavi**.

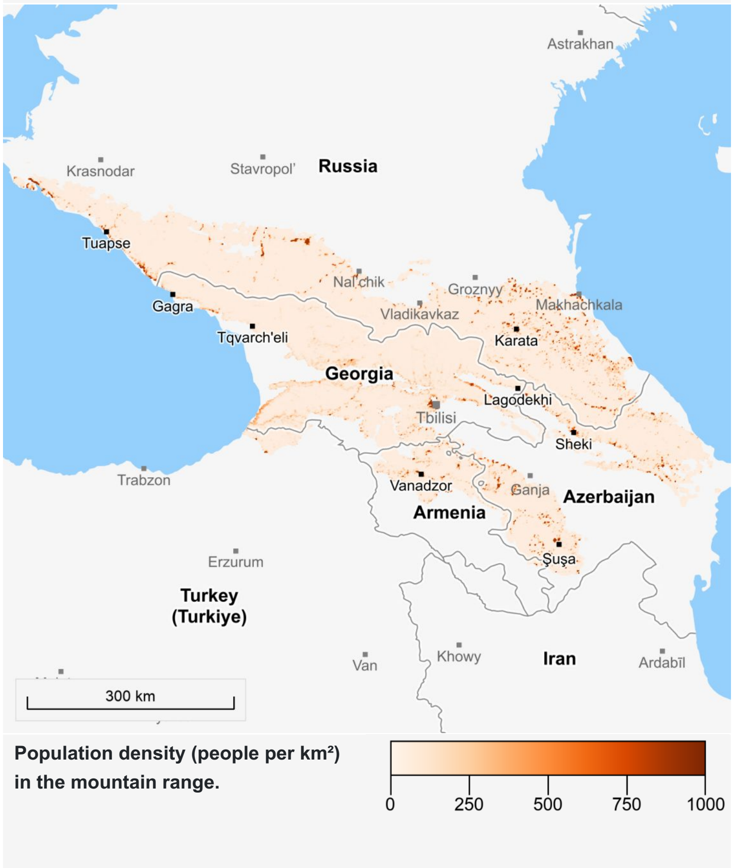
In 2020, the human population in this mountain range was estimated to be 5 million.

Figure 1.2. Population estimates in the mountain range from 1975-2030. The data after 2020 are projections.



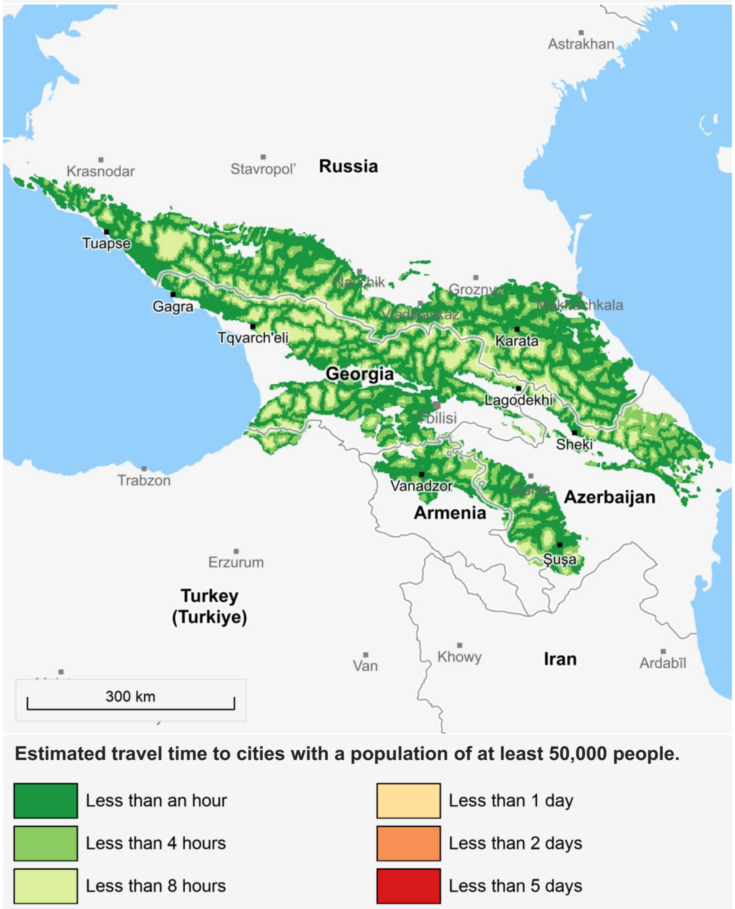
The maps show the population density in the mountain range (Figure 1.3), and estimated travel time to the nearest population centre with more than 50,000 inhabitants (Figure 1.4). Estimated travel time can be useful for evaluating accessibility to services and markets.

Figure 1.3. Population Density



Data: GHS-POP[5]. Background: GMBA [2], GADM [3], Natural Earth [3], Geonames [4], World Bank [22].

Figure 1.4. Travel Time



Data: Nelson/JRC [6]. Background: GMBA [2], GADM [3], Natural Earth [3], Geonames [4], World Bank [22].

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1.3. Development and Economic Indicators

The Human Development Index (HDI) is determined by a combination of indicators such as life expectancy, literacy rate, access to electricity, Gross Domestic Product (GDP), and others. In 2015, the average HDI in this mountain range was estimated to be **0.77**. This is considered to be a **high level of development**.

Table 1.2. GDP and HDI Indicators over Time

	1990	2000	2015
Gross Domestic Product	$33 bn	$19 bn	$48 bn
Human Development Index	0.65	0.67	0.77

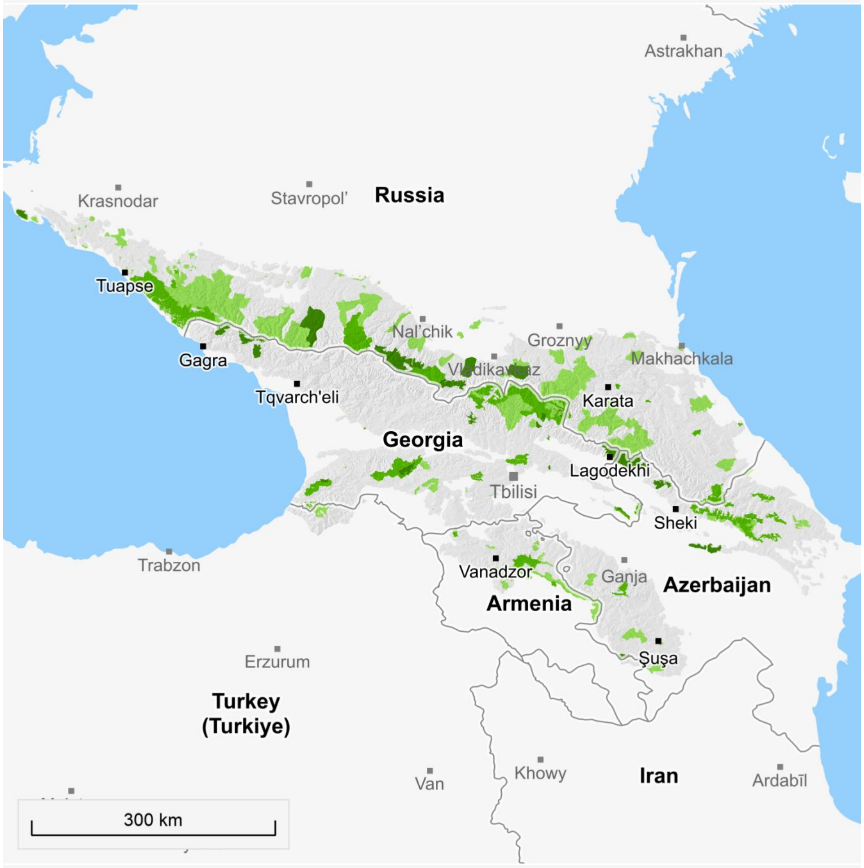
Source: Kummu et al. [7]

The total GDP within this mountain range in 2015 was estimated to be **$48 billion**, an **increase of $29 billion since 2000**. Table 1.2. shows an overview of the HDI and GDP indicators over time.

1.4. Protected Areas

Figure 1.3 shows the spatial coverage of protected areas in the mountain range according to the World Database of Protected Areas (WDPA) [8]. A total of **21%** of the mountain range is covered by a protected area. The establishment of protected areas represents a key measure to protect and conserve valuable mountain biodiverisity and ecosystems. These areas vary broadly in their aims, regulations, and effectiveness, however.

Figure 1.3. Protected Areas



Protected areas classified by their IUCN category. Category Ia and Ib are strict nature reserves and wilderness areas, and Category II are usually national parks. Light green represents other types of protected areas.

- IUCN Category Ia and Ib
- IUCN Category II
- Other Protected Areas

Data: World Database of Protected Areas (WDPA) [8]. Background: GMBA [2], GADM [3], Natural Earth [3], Geonames [4], World Bank [22].

A total of 21% of the mountain range is classified as protected in the World Database of Protected Areas.

The largest protected areas are:

1. **Lake Sevan** Ramsar Site, Wetland of International Importance	4,746 km²
2. **Western Caucasus** World Heritage Site (natural or mixed)	2,877 km²
3. **Kavkazskiy** UNESCO-MAB Biosphere Reserve	2,747 km²
4. **Sochinskij nacional`nyj park** National Park	2,077 km²
5. **Sevan** National Park	1,512 km²

2. Land cover

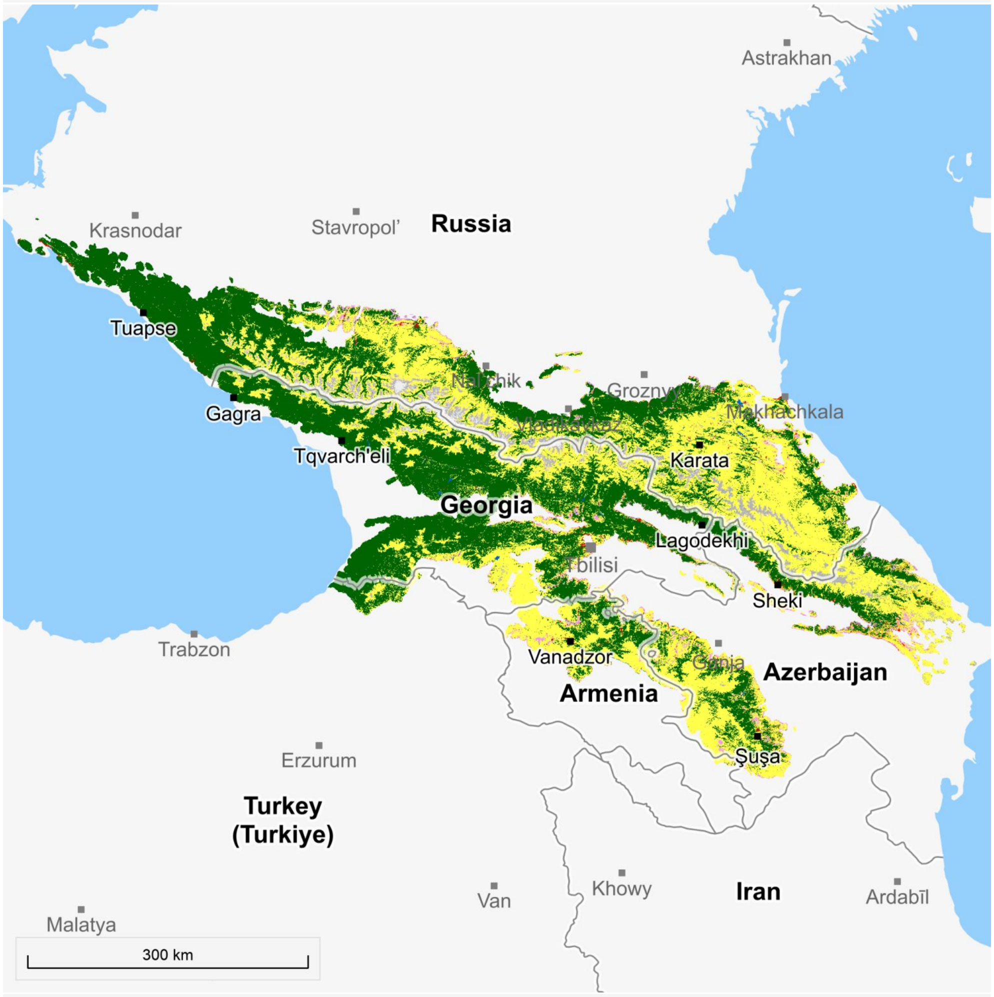
2.1. Land Cover

According to the ESA WorldCover dataset [9], the most dominant land cover types in 2021 were **tree cover (47.0%)** and **grassland (43.4%)**.

Land cover percentages from 2021 for the largest land cover classes in the mountain range.

Tree cover	47.0%
Grassland	43.4%
Bare and sparse	4.1%
Cropland	2.2%
Moss and lichen	1.0%
Snow and ice	0.8%
Shrubland	0.7%
Built-up	0.5%
Water	0.3%

Figure 2.1. Land Cover



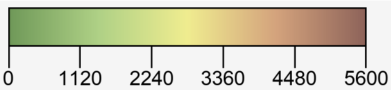
Data: ESA WorldCover. Background: GMBA [2], GADM [3], Natural Earth [3], Geonames [4], World Bank [22].

The European Commission's Global Human Settlement Layer (GHSL) [10] classifies **0.1%** of the mountain range's area as urban centre, **1.1%** as urban cluster, and **98.8% as rural**.

3. Topography

The land surface elevation ranges from a **minimum of -15 m** to a **maximum of 5,642 m at Mount Elbrus**. The **mean elevation is 1,543 m**. **50%** of the area lies is between **892 m and 2,115 m**, and **90% of the area lies between 332 m and 2,673 m**. Figure 3.1 shows a shaded relief elevation map based on the MERIT DEM [11] and a selection of peaks from the Geonames dataset [4]. The distribution of land surface elevation strongly affects local climatic and living conditions in mountains.

Figure 3.1. Elevation and Peaks



Shaded relief map showing elevation (in metres above sea level) and a selection of peaks in the mountain range.

Data: MERIT DEM [11], Geonames [4]. Background: GMBA [2], GADM [3], Natural Earth [3], Geonames [4], World Bank [22].

Figure 3.2. Distribution of elevation within in the mountain range [11].

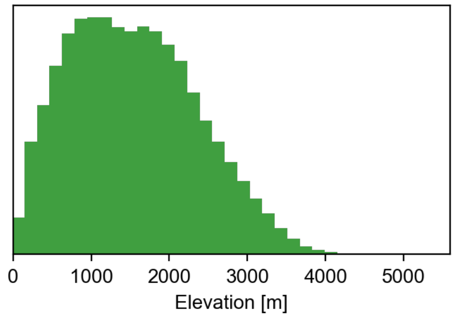


Figure 3.3. Distribution of slope steepness within in the mountain range [21].

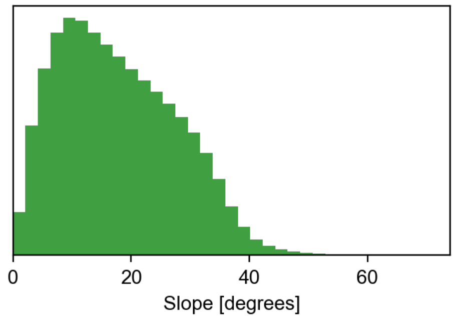


Figure 3.4. Highest peaks in the mountain range according to the Geonames [4] dataset.

1. **Mount Elbrus**	▲ 5,642 m
2. **Gora Dykhtau**	▲ 5,204 m
3. **Gora Shkhara**	▲ 5,201 m
4. **Gora Koshtantau**	▲ 5,152 m
5. **Mount Dzhangitau**	▲ 5,058 m
6. **Gora Kazbek**	▲ 5,033 m
7. **Mta Gistola**	▲ 4,859 m
8. **Mta Tetnuldi**	▲ 4,852 m
9. **Gora Dzhimara**	▲ 4,780 m
10. **Mta Ushba**	▲ 4,700 m

4. Climate

4.1. Temperature and Precipitation

Precipitation and temperature combine to control local weather and climate, with implications for water availability, vegetation growing conditions, snow and ice accumulation, and extreme events such as floods and droughts.

The mean annual temperature across the mountain range is shown in Figure 4.1. The **mean annual temperature for the entire mountain range is 5.4°C**, but it varies geographically from a **minimum of -19.0°C** to a **maximum of 15.4°C**. The temperature data are extracted from the CHELSA climatology dataset [13].

The mean annual precipitation shown in Figure 4.2. The **mean annual precipitation for the entire mountain range is 1,179 mm**, but it varies geographically from a **minimum of 225 mm** to a **maximum of 3,606**. Precipitation data are bias-corrected for use in mountain environments, and are extracted from CHELSA data in the Precipitation Bias CORrection (PBCOR) dataset [12].

Figure 4.1. Mean Annual Temperature

Mean annual temperature (°C) in the mountain range.

-30 -20 -10 0 10 20 30

Data: CHELSA [13]. Background: GMBA [2], GADM [3], Natural Earth [3], Geonames [4], World Bank [22].

Figure 4.2. Mean Annual Precipitation

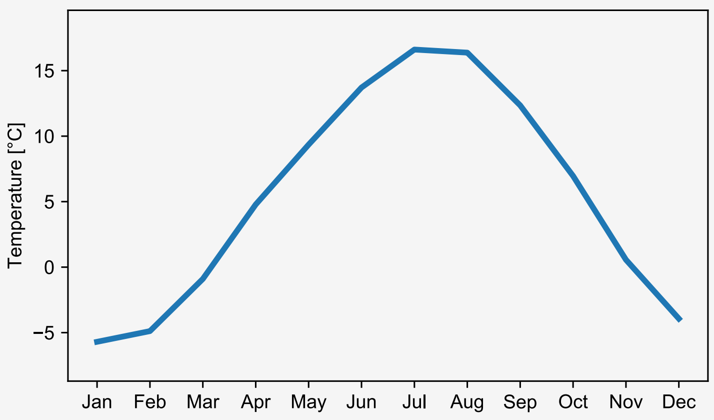
Mean annual precipitation (mm/year) in the mountain range.

0 1000 2000 3000 4000

Data: CHELSA/PBCOR [12]. Background: GMBA [2], GADM [3], Natural Earth [3], Geonames [4], World Bank [22].

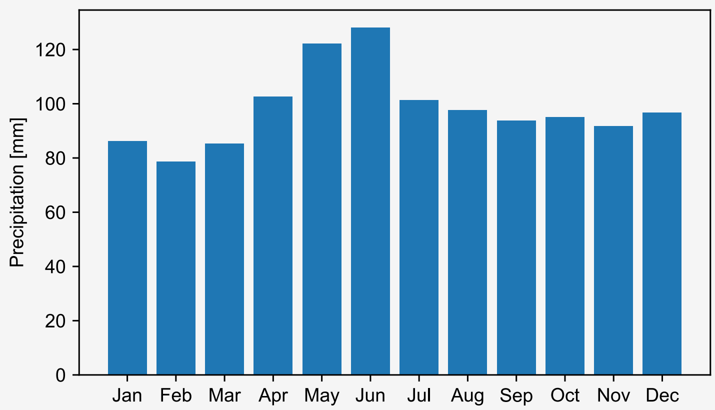
The mean monthly temperature across the entire mountain range shown in Figure 4.3, and varies from a **maximum of 16.6°C in July** to a **minimum of -5.7°C in January**. Equivalent statistics for precipitation are shown in Figure 4.4, which vary from a **maximum of 128 mm in June** to a **minimum of 79 mm in February**.

Figure 4.3. Mean Monthly Temperature



Data: CHELSA [13].

Figure 4.4. Mean Monthly Precipitation



Data: CHELSA/PBCOR [12].

4.2. Climate Classifications

Figures 4.5 and Figure 4.6 show Köppen-Geiger climate classifications for the present day (1980-2016) and for projected future conditions (2071-2100), respectively. Future conditions are derived from an ensemble of 32 climate model projections under the RCP 8.5 "business-as-usual" scenario [14].

Figure 4.5. Current Climate Classifications

Köppen-Geiger climate classification for the present day (1980-2016).

Data: GloH2O [14]. Background: GMBA [2], GADM [3], Natural Earth [3], Geonames [4], World Bank [22].

Figure 4.6. Future Climate Classifications

Köppen-Geiger climate classification for ensemble mean projected future conditions (2071-2100) under the RCP 8.5 scenario.

Data: GloH2O [14]. Background: GMBA [2], GADM [3], Natural Earth [3], Geonames [4], World Bank [22].

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Table 4.1. Changes in climate classifications between current (1980-2016) and future (2071-2100) conditions

Classification		Current	Future	Change
Dfb	Cold, no dry season, warm summer	47.7%	38.0%	▼ 9.7%
Dfc	Cold, no dry season, cold summer	20.7%	6.1%	▼ 14.6%
ET	Polar, tundra	9.9%	0.3%	▼ 9.6%
Cfa	Temperate, no dry season, hot summer	7.0%	25.9%	▲ 18.8%
BSk	Arid, steppe, cold	7.0%	15.5%	▲ 8.5%
Dfa	Cold, no dry season, hot summer	4.8%	11.4%	▲ 6.6%
Cfb	Temperate, no dry season, warm summer	2.8%	0.4%	▼ 2.4%
Csa	Temperate, dry summer, hot summer	0.0%	1.7%	▲ 1.7%
BSh	Arid, steppe, hot	0.0%	0.7%	▲ 0.7%

Source: GloH2O [14].

5. Hydrology

According to the GRDC Major River Basins dataset, **two major basins** intersect the mountain range [15]. The **Kura has the most overlap with 33%** and drains into the **Caspian Sea**.

Within the mountain range, there are a total of **seven dams** listed in the Global Reservoirs and Dams (GRanD) database [16]. The main usages of these dams are **hydroelectricity (4)** and **irrigation (3)**. The total capacity of these dams is estimated to be **4,921 million m³**. Figure 5.1 shows major rivers, basins, and dams (red points) that intersect with this mountain range.

Figure 5.1. Major Rivers, Basins, and Dams.

Data: GRDC [15], GRaND [16]. Background: GMBA [2], GADM [3], Natural Earth [3], Geonames [4], World Bank [22].

Kura → Caspian Sea	33.0%
Kuban → Black Sea	12.0%

Dams in this mountain range with the most capacity [16].

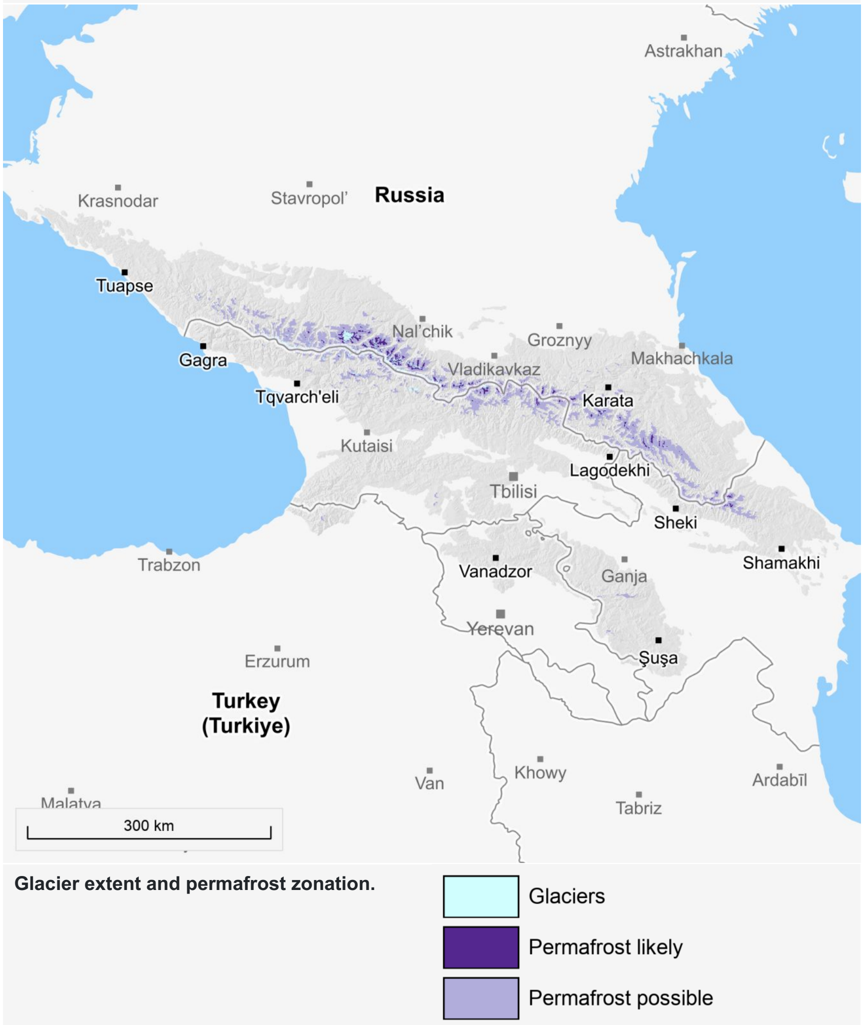
Chirkey	2,780 Mm³
Aparan	91 Mm³
Zhinvali	520 Mm³

6. Cryosphere

6.1. Glaciers and Permafrost

The Randolph Glacier Inventory dataset contains **1,637 glaciers** that intersect with this mountain range [17]. They cover a **total area of 1,182 km² (0.7%)**. In addition to the glaciers, it is estimated that under favourable conditions, permafrost occurance is possible across **14,407 km² (9.1%)**, and is likely across at least **1,920 km² (1.2%)**. Figure 6.1 shows glaciers and permafrost extents. Glaciers and permafrost represent (largely non-renewable) water sources for mountain people and ecosystems, and can be implicated in hazardous events.

Figure 6.1. Glacier and Permafrost Extents



Data: Randolph Glacier Inventory [17], Permafrost Zonation Index [18]. Background: GMBA [2], GADM [3], Natural Earth [3], Geonames [4], World Bank [22].

The Randolph Glacier Inventory lists **1,637 glaciers** within this mountain range, covering a **total area of 1,182 km²**.

6.2. Snow Cover

The proportion of the mountain range's area that is covered by snow each month on average (according to monthly snow cover data between 2000-2020 by ESA's Climate Change Initiative [18]) is shown in Figure 6.2.

The average snow covered area varies between **a minimum in August of 224 km² (0.1%)** (Figure 6.3) and a **maximum in February of 56,820 km² (35.9%)** (Figure 6.4). Snow cover extent acts as an indicator of seasonal downstream water availability, is a crucial factor in winter tourism, and is a key determinant of vegetation growing conditions.

Figure 6.2. Monthly mean snow covered area percentage (2000-2020) [18].

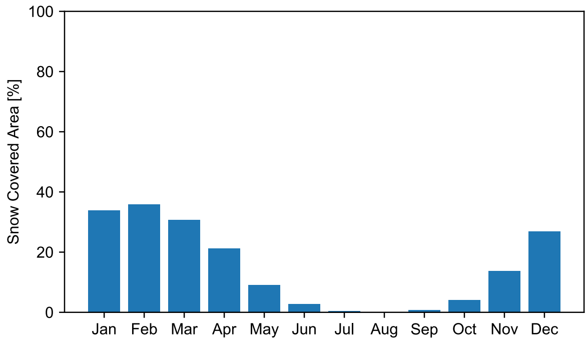


Figure 6.3. Mean Snow Covered Area (August)

Data: ENVEO/ESA-CCI [17]. Background: GMBA [2], GADM [3], Natural Earth [3], Geonames [4], World Bank [22].

Figure 6.4. Mean Snow Covered Area (February)

Data: ENVEO/ESA-CCI [17]. Background: GMBA [2], GADM [3], Natural Earth [3], Geonames [4], World Bank [22].

7. Measurement Locations

The GEO Mountains Inventory of In Situ Observational Infrastructure (v2.0) lists a total of **184 measurement sites** in this mountain range [20]. Their locations are shown as red dots in Figure 7.1. In situ measurements are crucial for a range of scientific and practical application in mountains, yet the locations of measurement sites are often difficult to gain an appreciation of. Measurement sites include weather and climate stations, river gauging stations, networks of stations, experimental basins, and others.

Figure 7.1. Locations of Measurement Sites

Data: GEO Mountains [20]. Background: GMBA [2], GADM [3], Natural Earth [3], Geonames [4], World Bank [22].

According to the GEO Mountains Inventory of In Situ Observational Infrastructure, there are 184 measurement sites in this mountain range

References

1. Natural Earth Data. Via https://www.naturalearthdata.com.

2. GMBA Mountain Inventory v2. Snethlage, M.A., Geschke, J., Spehn, E.M., Ranipeta, A., Yoccoz, N.G., Körner, Ch., Jetz, W., Fischer, M. & Urbach, D. A hierarchical inventory of the world's mountains for global comparative mountain science. Nature Scientific Data. https://doi.org/10.1038/s41597-022-01256-y (2022). Dataset: Snethlage, M.A., Geschke, J., Spehn, E.M., Ranipeta, A., Yoccoz, N.G., Körner, Ch., Jetz, W., Fischer, M. & Urbach, D. GMBA Mountain Inventory v2. GMBA-EarthEnv. https://doi.org/10.48601/earthenv-t9k2-1407 (2022).

3. GADM Global Administrative Divisions. Via https://www.gadm.org/.

4. Geonames geographical database. Via https://www.geonames.org/.

5. GHS-POP layer of the Global Human Settlement Dataset. Dataset: Schiavina M., Freire S., MacManus K. (2022): GHS-POP R2022A - GHS population grid multitemporal (1975-2030).European Commission, Joint Research Centre (JRC) PID: http://data.europa.eu/89h/d6d86a90-4351-4508-99c1-cb074b022c4a, doi:10.2905/D6D86A90-4351-4508-99C1-CB074B022C4A

6. Global Accessibility Map. Via https://forobs.jrc.ec.europa.eu/products/gam/.

7. Kummu, M., Taka, M. & Guillaume, J. Gridded global datasets for Gross Domestic Product and Human Development Index over 1990–2015. Sci Data 5, 180004 (2018). https://doi.org/10.1038/sdata.2018.4

8. UNEP-WCMC and IUCN (2022), Protected Planet: The World Database on Protected Areas (WDPA) Cambridge, UK: UNEP-WCMC and IUCN. Available at: www.protectedplanet.net.

9. ESA WorldCover project 2023. Contains modified Copernicus Sentinel data, processed by ESA WorldCover consortium 2021. Via: https://esa-worldcover.org/.

10. Global Human Settlement Dataset (SMOD Layers). Schiavina M., Melchiorri M., Pesaresi M. (2022): GHS-SMOD R2022A - GHS settlement layers, application of the Degree of Urbanisation methodology (stage I) to GHS-POP R2022A and GHS-BUILT-S R2022A, multitemporal (1975-2030)European Commission, Joint Research Centre (JRC) PID: http://data.europa.eu/89h/4606d58a-dc08-463c-86a9-d49ef461c47f, doi:10.2905/4606D58A-DC08-463C-86A9-D49EF461C47F

11. MERIT DEM. Yamazaki D., D. Ikeshima, R. Tawatari, T. Yamaguchi, F. O'Loughlin, J.C. Neal, C.C. Sampson, S. Kanae & P.D. Bates A high accuracy map of global terrain elevations Geophysical Research Letters, vol.44, pp.5844-5853, 2017 doi: 10.1002/2017GL072874. Available via http://hydro.iis.u-tokyo.ac.jp/~yamadai/MERIT_DEM/.

12. GloH2O PBCOR dataset: Beck, H. E., T. R. McVicar, M. Zambrano-Bigiarini, C. Alvarez-Garret, O. M. Baez-Villanueva, J. Sheffield, D. Karger, and E. F. Wood, 2020Bias correction of global high-resolution precipitation climatologies using streamflow observations from 9372 catchmentsJournal of Climate 33, 1299–1315, doi:10.1175/JCLI-D-19–0332.1

13. CHELSA V2.1 climatologies. Karger, D.N., Conrad, O., Böhner, J., Kawohl, T., Kreft, H., Soria-Auza, R.W., Zimmermann, N.E., Linder, P., Kessler, M. (2017): Climatologies at high resolution for the Earth land surface areas. Scientific Data. 4 170122. https://doi.org/10.1038/sdata.2017.122 Available via: https://chelsa-climate.org/

14. Beck, H.E., N.E. Zimmermann, T.R. McVicar, N. Vergopolan, A. Berg, E.F. Wood. Present and future Köppen-Geiger climate classification maps at 1-km resolutionScientific Data 5:180214, doi:10.1038/sdata.2018.214 (2018)

15. GRDC (2020): Major River Basins of the World / Global Runoff Data Centre, GRDC. 2nd, rev. ext. ed. Koblenz, Germany: Federal Institute of Hydrology (BfG). Available via https://www.bafg.de/GRDC/

16. Lehner, B., C. Reidy Liermann, C. Revenga, C. Vörösmarty, B. Fekete, P. Crouzet, P. Döll, M. Endejan, K. Frenken, J. Magome, C. Nilsson, J.C. Robertson, R. Rodel, N. Sindorf, and D. Wisser. 2011. High-resolution mapping of the world's reservoirs and dams for sustainable river-flow management. Frontiers in Ecology and the Environment 9 (9): 494-502.

17. Randolph Glacier Inventory 6.0. Via: https://www.glims.org/RGI/

18. Permafrost Zonation Index. Gruber, S. 2012: Derivation and analysis of a high-resolution estimate of global permafrost zonation, The Cryosphere, 6, 221-233 Via https://climatedataguide.ucar.edu/climate-data/global-permafrost-zonation-index-map

19. ESA-CCI Snow Cover Fraction data. Via: https://snow-cci.enveo.at/

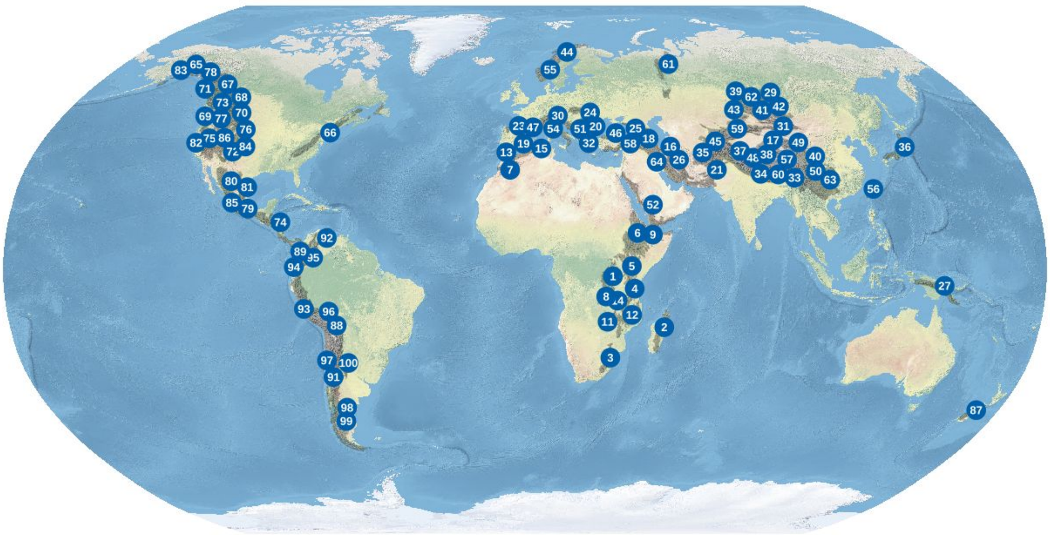
20. GEO Mountains (2022). Inventory of in situ mountain observational infrastructure, v2.0. DOI: 10.6084/m9.figshare.14899845.v2 Via: https://www.geomountains.org/resources/resources-surveys/inventory-of-in-situ-observational-infrastructure

21. Amatulli, G., McInerney, D., Sethi, T. et al. Geomorpho90m, empirical evaluation and accuracy assessment of global high-resolution geomorphometric layers. Sci Data 7, 162 (2020). https://doi.org/10.1038/s41597-020-0479-6

22. World Bank administrative boundaries and disputed borders (2023) via https://datacatalog.worldbank.org/search/dataset/0038272

Index

The index shows an overview of the 100 mountain ranges in version v1.0 of the *Mountains Uncovered* series.



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About the Series

Aims

The *Mountains Uncovered* series (v1.0) aims to provide an easily understandable overview of the key characteristics of 100 selected mountain ranges around the world. Comparisons between mountain ranges can also readily be made. The series was developed by collating and visualising a variety of current global scale data products. We hope that the series will be a useful resource for researchers, policy-makers, environmental managers, educators, and others seeking to better understand the Earth's major mountain regions, and that over time it will inspire the generation of additional datasets, analyses, and products.

Citation and Sharing

The *Mountains Uncovered* series (v1.0) has been developed on the basis of exclusively open global spatial datasets. In turn, all visualisations, statistics, and code generated are shared under the Creative Commons BY 4.0 license. You may use, distribute, and reproduce the product in any medium, provided appropriate acknowledgement is given. Please cite the series as:

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GEO Mountains assumes no responsibility and accepts no liability for the product's use, and remains neutral with respect to the locations of any borders and the place names shown in the third-party datasets employed.

Limitations

Users should note that data and information are limited in many mountain regions around the world. As a result, the figures, maps, and graphs presented in this series are associated with uncertainties, and these uncertainties must be taken into account when interpreting the information given.

To ensure that any comparisons made between individual mountain ranges are as fair as possible, global-scale datasets were used (without any additional modification). Consequently, the series does not necessarily represent a compendium of the "best" data available in any given mountain range or local area, but rather a common, generally intercomparable set. For applications at local and regional scales, alternative datasets to those shown may be more suitable.

Indeed, in parallel to the ongoing development of the global series, more local and regional "bottom-up" engagements and activities to improve the quality and availability of data should also be undertaken, since data on these scales also play a crucial role in supporting decision-making for the benefit of mountain people and ecosystems.

Get Involved

While many global mountain regions remain notoriously data-scarce, new datasets are being released regularly. If you are aware of any datasets you would like us to consider including in a potential future release, please provide the necessary details via this form. Likewise, if you become aware of any errors, omissions, or other potential modifications that could be made in a future version, please let us know via the same form. By taking these actions, you will help us expand the scope and improve the impact of the *Mountains Uncovered* series. Feedback concerning the underlying datasets will be collated and shared with the relevant organisations or data providers.

Contact

For any general queries or comments, please contact: geomountains@mountainresearchinitiative.org

Many thanks for your interest, support, and contributions to global mountain data, policy, and education!

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Developed with: Geofolio

A contribution from: ADAPTATION AT ALTITUDE — Taking Action in the Mountains; MOUNTAIN RESEARCH INITIATIVE

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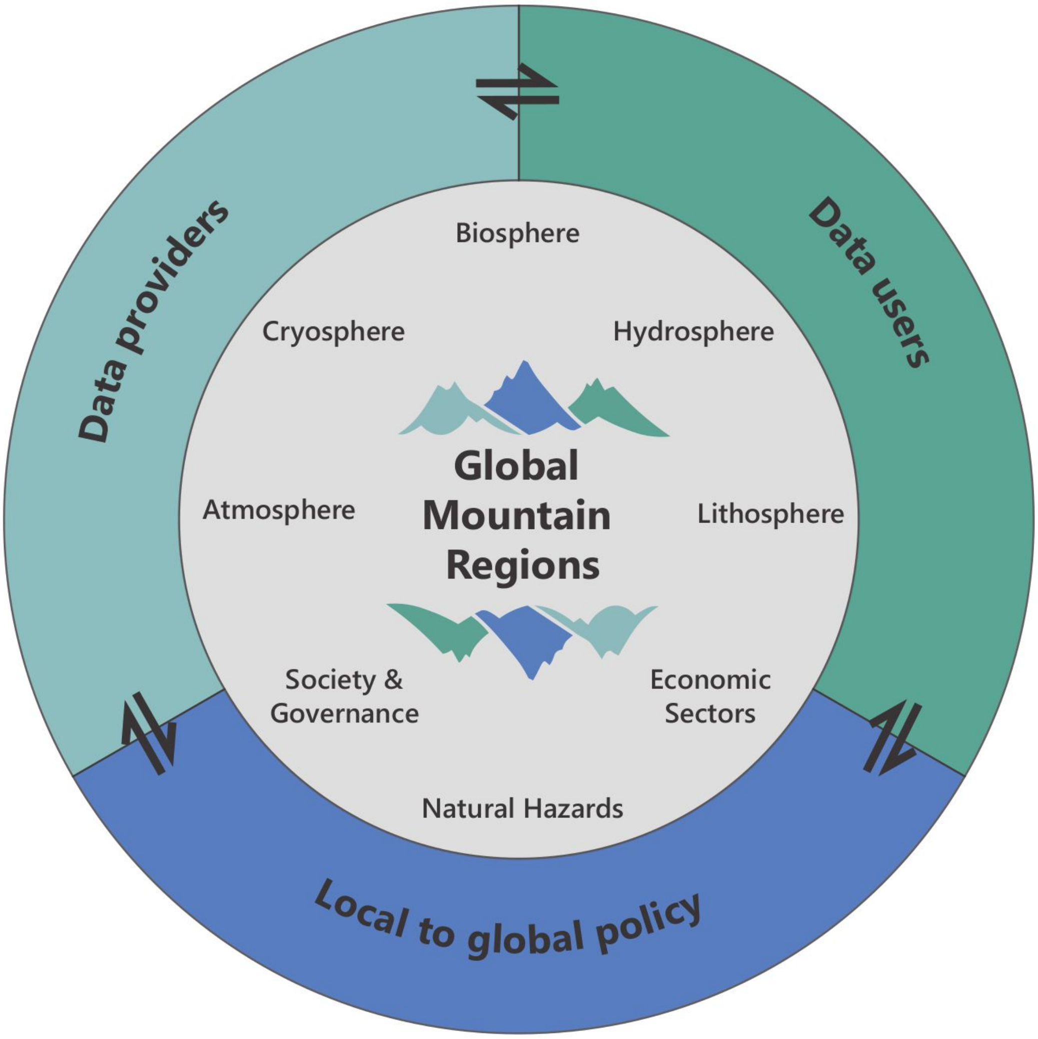
Swiss Agency for Development and Cooperation SDC

GEO MOUNTAINS
Observing Mountain Environments

About GEO Mountains

GEO Mountains is an Initiative of the Group on Earth Observations (GEO). It aims to bring together research institutions and mountain observation networks to enhance the discoverability, accessibility, and use of a wide range of relevant data and information pertaining to environmental and socio-economic systems – both in situ and remotely sensed – across global mountain regions. In doing so, we hope to help facilitate scientific advancements and support decision makers at local, national, and regional levels. The figure below illustrates the scope of the Initiative.



GEO Mountains is an open and inclusive network. We aspire to follow the principles of open data and open science wherever possible.

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