MOUNTAINS UNCOVERED

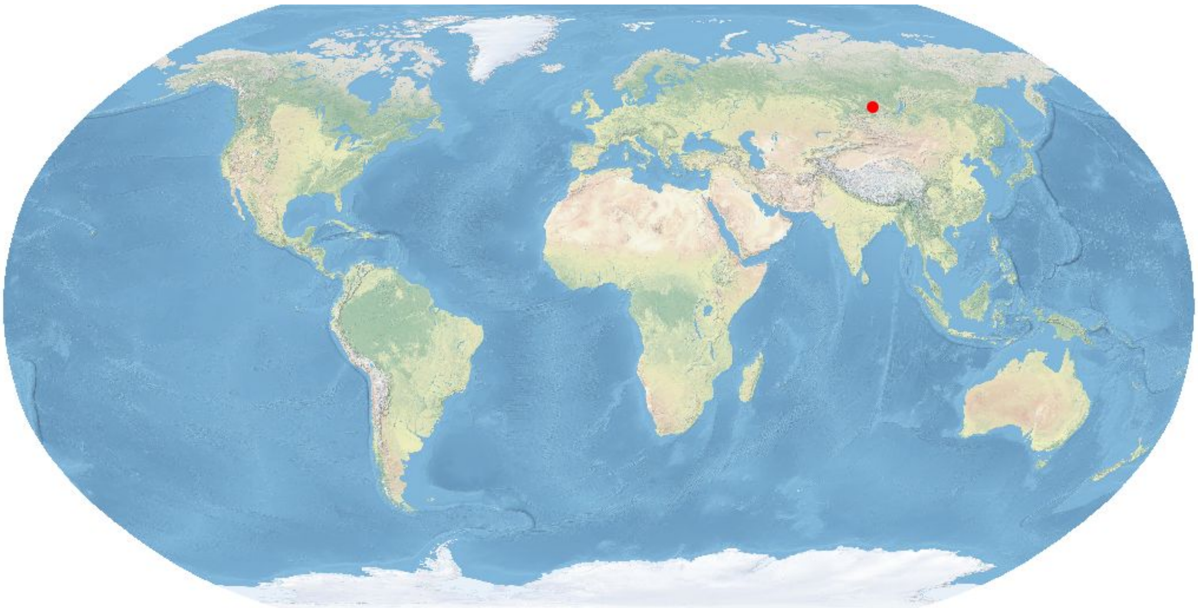
Intercomparable Maps and Statistics for 100 Selected Global Mountain Ranges

Eastern Sayan **#29**

GEO MOUNTAINS
Observing Mountain Environments

Eastern Sayan

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 **Eastern Sayan** mountain range. The index page shows an overview of all mountain ranges in the series.



Location of the Eastern Sayan mountain range [1][2].

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1. General Information

1.1. Administrative

The mountain range has spatial overlap with **two** 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: 128,229 km² 97%

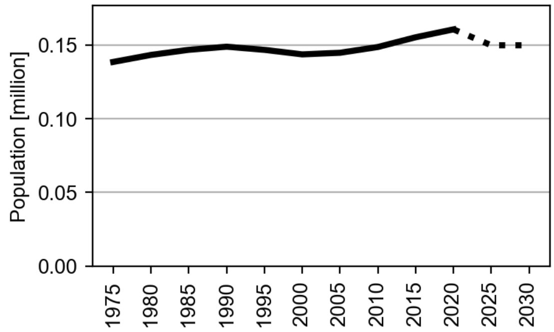
Mongolia: 4,487 km² 3%

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 **160,533** people lived in the area in 2020. This is expected to **decrease to 149,760** by 2030. There are **no large settlements** listed in the populated places database.

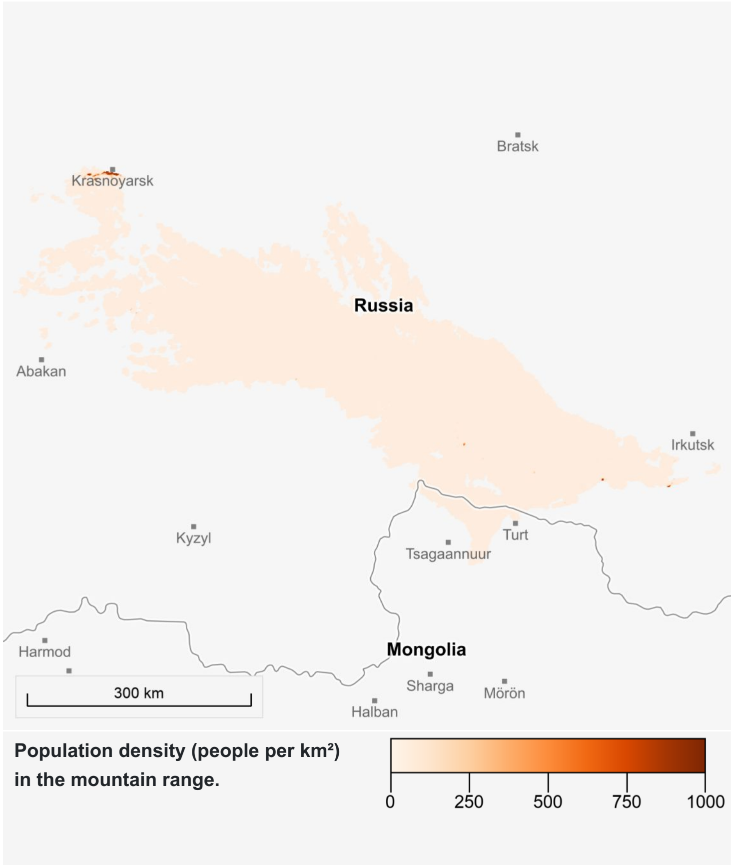
In 2020, the human population in this mountain range was estimated to be 160,533.

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



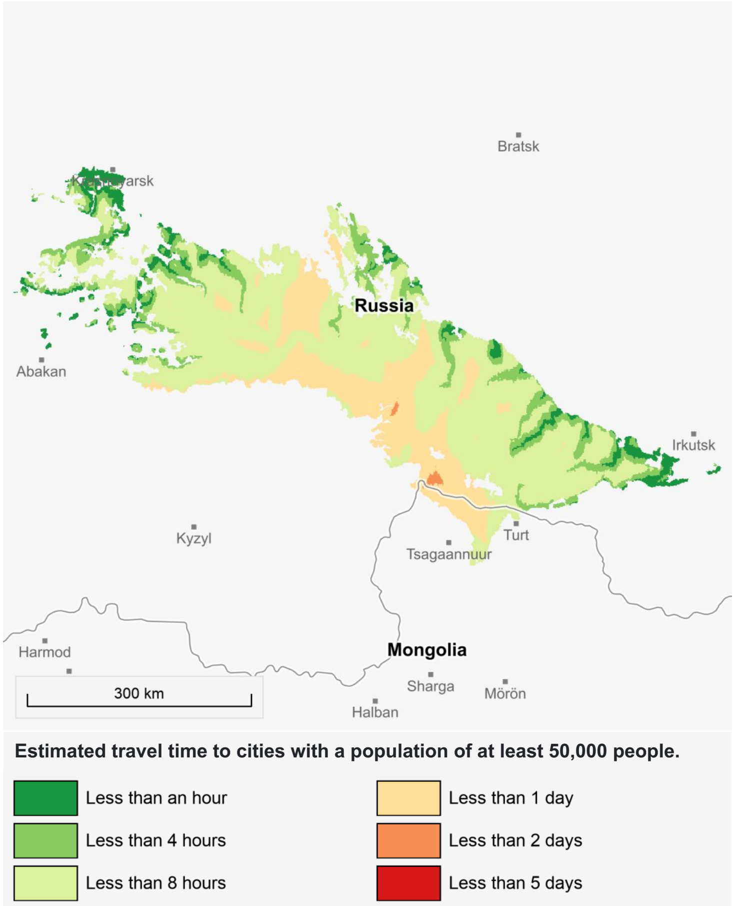
The maps show the population density in the mountain range (Figure 1.3), and estimated travel time to the nearest population centre with more than 50,000 inhabitants (Figure 1.4). Estimated travel time can be useful for evaluating accessibility to services and markets.

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].

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 **0.79**. 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	$3 bn	$2 bn	$3 bn
Human Development Index	0.72	0.70	0.79

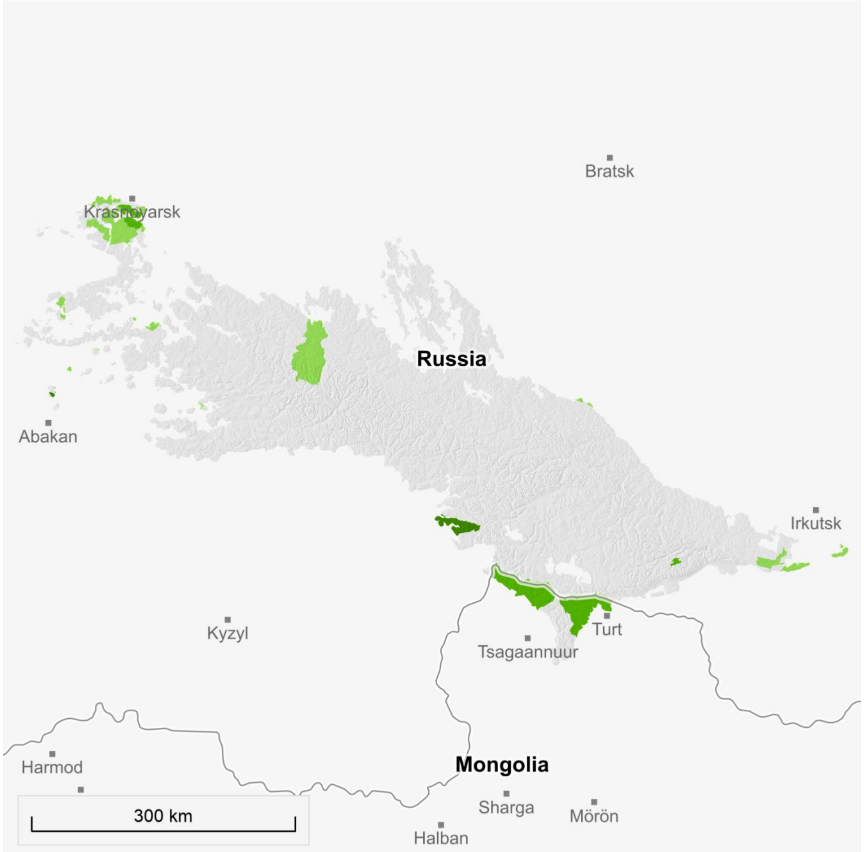
Source: Kummu et al. [7]

The total GDP within this mountain range in 2015 was estimated to be **$3 billion**, an **increase of $264 million 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 **6%** 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 6% of the mountain range is classified as protected in the World Database of Protected Areas.

The largest protected areas are:

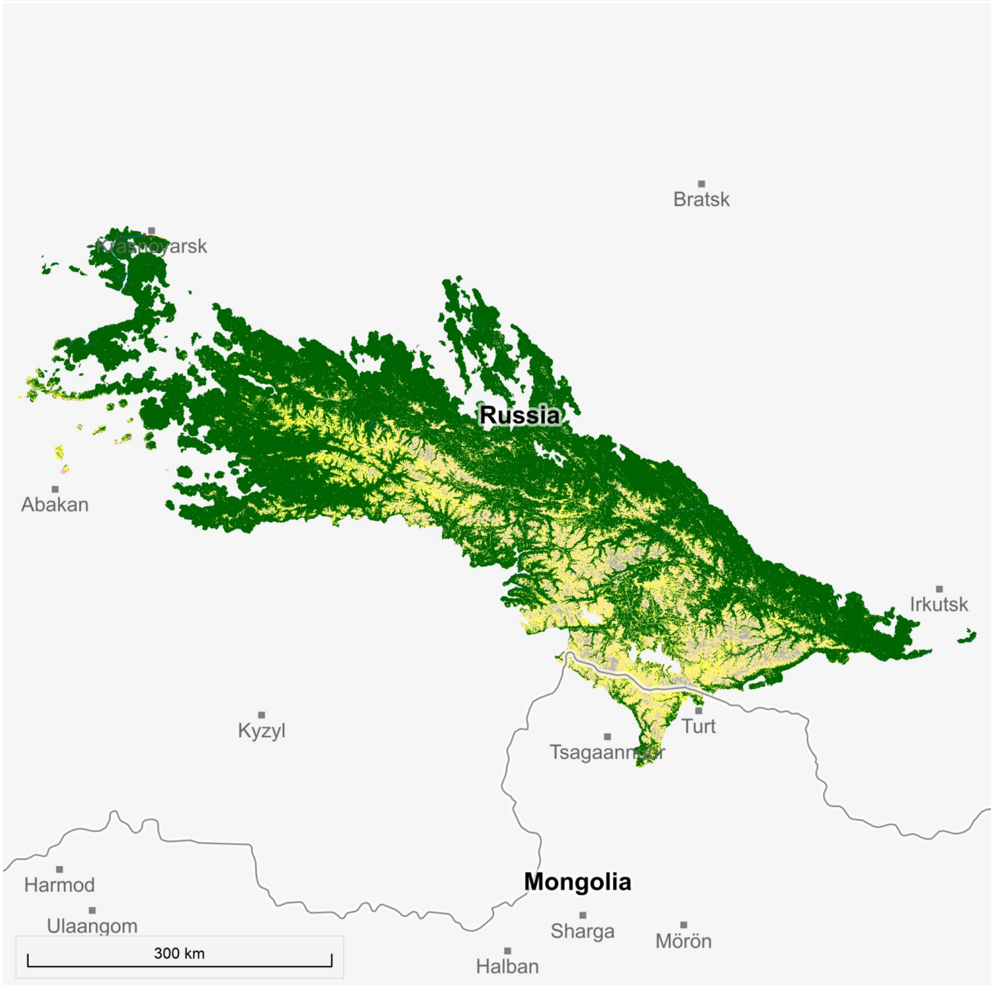
1. **Lake Baikal** 85,508 km²
World Heritage Site (natural or mixed)
2. **Khuvsgul nuur** 11,697 km²
National Park
3. **Tengis-Shishged goliin ai sav** 8,691 km²
National Park
4. **Krasnoyarskij** 3,531 km²
State Natural Zakaznik
5. **Azas** 3,332 km²
State Natural Zapovednik

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 (70.7%), moss and lichen (14.1%),** and **grassland (12.6%)**.

Figure 2.1. Land Cover



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

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

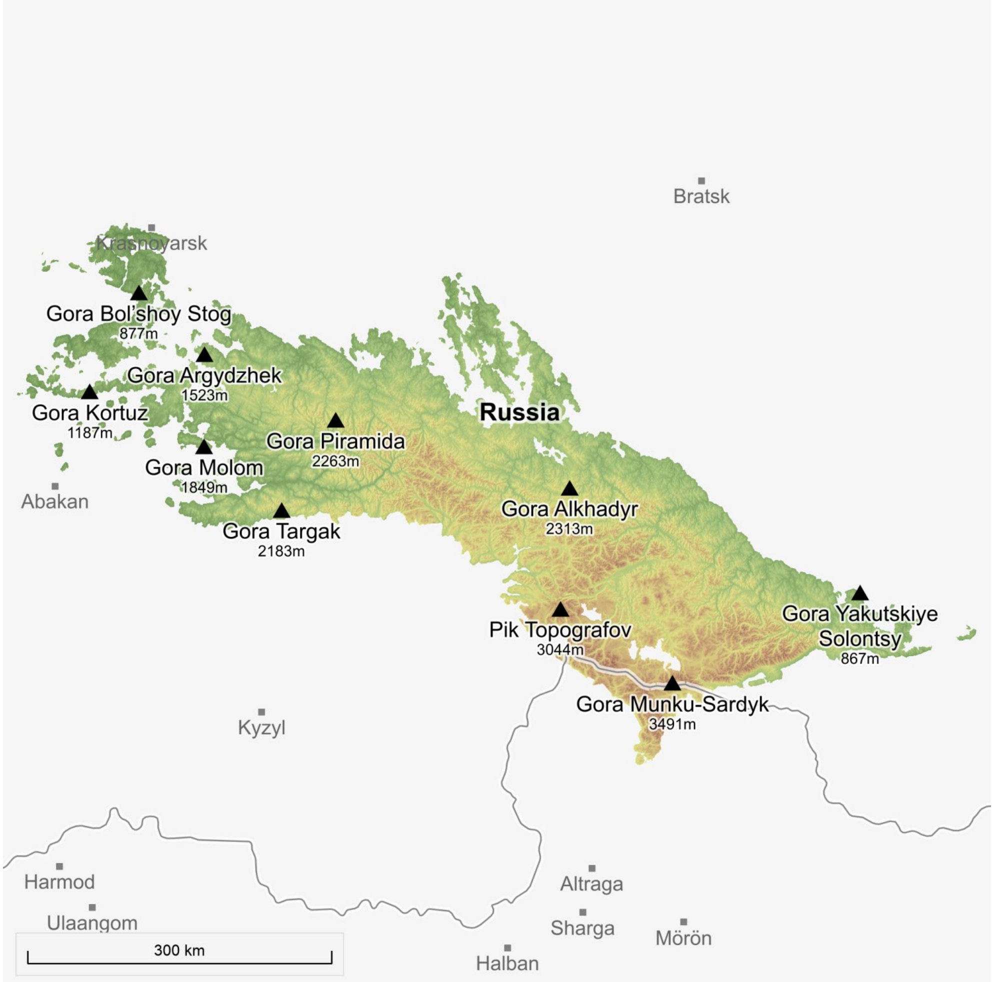
Tree cover	70.7%
Moss and lichen	14.1%
Grassland	12.6%
Bare and sparse	1.8%
Water	0.6%

The European Commission's Global Human Settlement Layer (GHSL) [10] classifies **0.0%** of the mountain range's area as urban centre, **0.0%** as urban cluster, and **99.9% as rural**.

3. Topography

The land surface elevation ranges from a **minimum of 133 m** to a **maximum of 3,491 m at Gora Munku-Sardyk** . The **mean elevation is 1,372 m**. **50%** of the area lies is between **893 m and 1,837 m**, and **90% of the area lies between 524 m and 2,182 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].

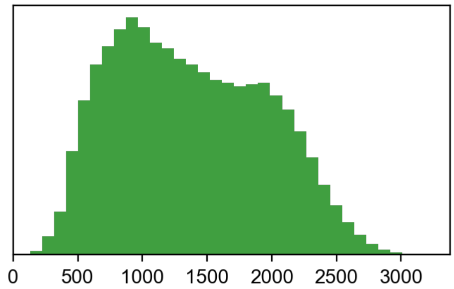


Figure 3.3. Distribution of slope steepness within in the mountain range [21].

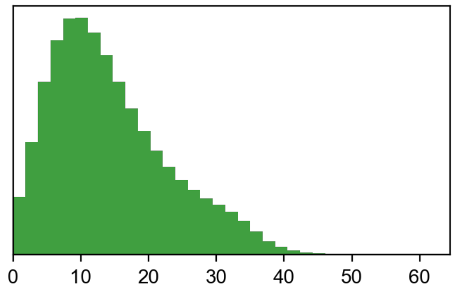


Figure 3.4. Highest peaks in the mountain range according to the Geonames [4] dataset.

1. **Gora Munku-Sardyk**	▲ 3,491 m
2. **Gora Munku-Sasan**	▲ 3,164 m
3. **Pik Topografov**	▲ 3,044 m
4. **Gora Alkhadyr**	▲ 2,313 m
5. **Gora Piramida**	▲ 2,263 m
6. **Gora Targak**	▲ 2,183 m
7. **Gora Ulug-Tayga**	▲ 2,162 m
8. **Gora Molom**	▲ 1,849 m
9. **Gora Moskva**	▲ 1,828 m
10. **Gora Balakhtison**	▲ 1,611 m

4. Climate

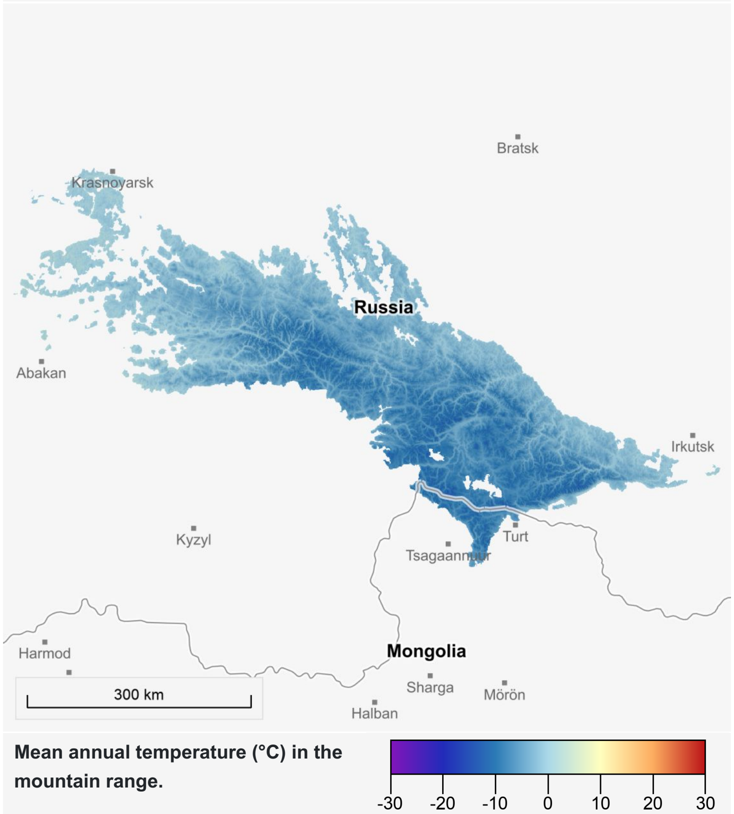
4.1. Temperature and Precipitation

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 -4.4°C**, but it varies geographically from a **minimum of -15.4°C** to a **maximum of 2.8°C**. The temperature data are extracted from the CHELSA climatology dataset [13].

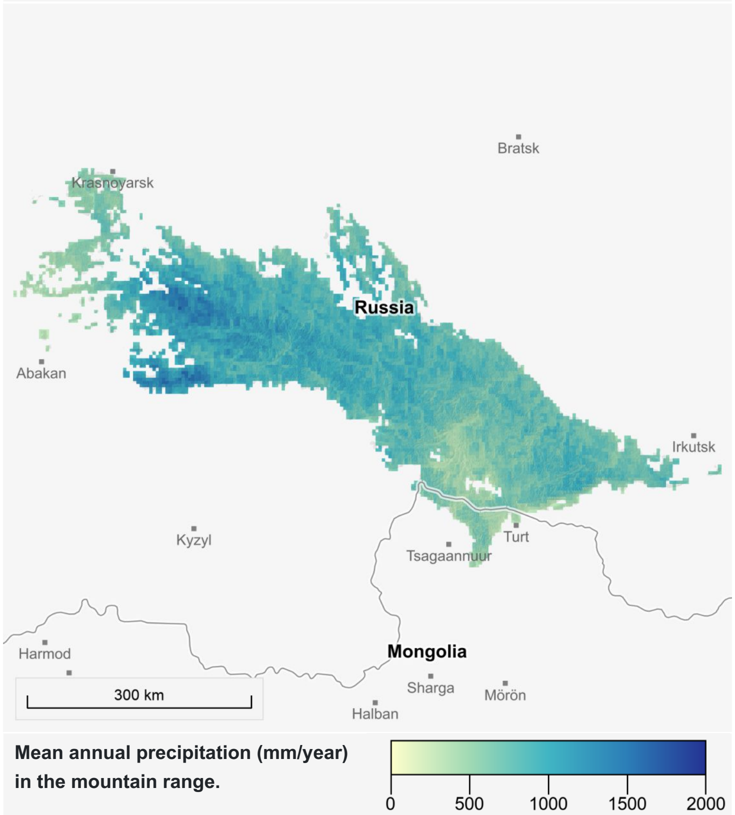
The mean annual precipitation shown in Figure 4.2. The **mean annual precipitation for the entire mountain range is 832 mm**, but it varies geographically from a **minimum of 286 mm** to a **maximum of 1,710**. Precipitation data are bias-corrected for use in mountain environments, and are extracted from CHELSA data in the Precipitation Bias CORrection (PBCOR) dataset [12].

Figure 4.1. Mean Annual Temperature



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

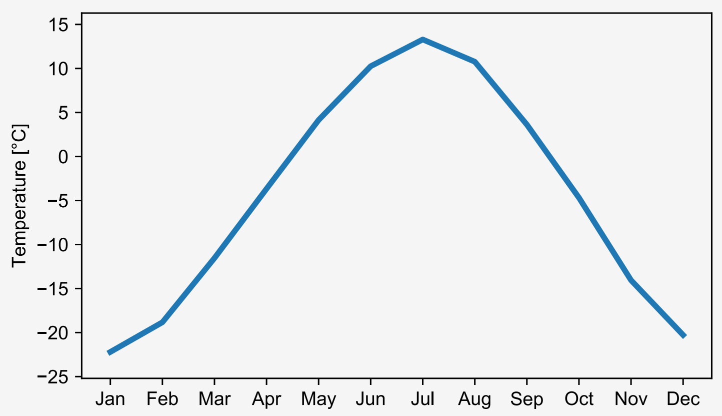
Figure 4.2. Mean Annual Precipitation



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

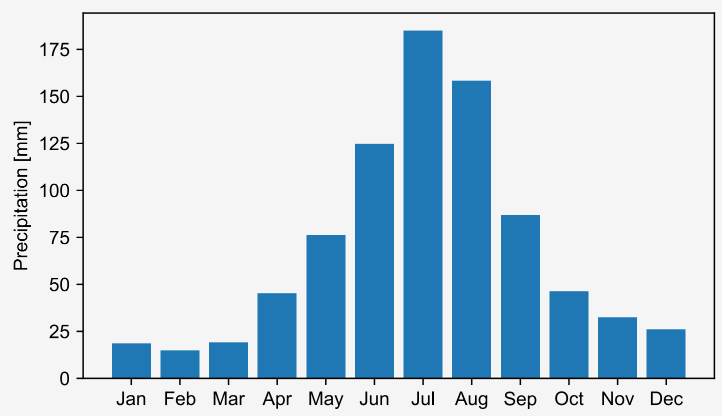
The mean monthly temperature across the entire mountain range shown in Figure 4.3, and varies from a **maximum of 13.3°C in July** to a **minimum of -22.2°C in January**. Equivalent statistics for precipitation are shown in Figure 4.4, which vary from a **maximum of 185 mm in July** to a **minimum of 15 mm in February**.

Figure 4.3. Mean Monthly Temperature



Data: CHELSA [13].

Figure 4.4. Mean Monthly Precipitation

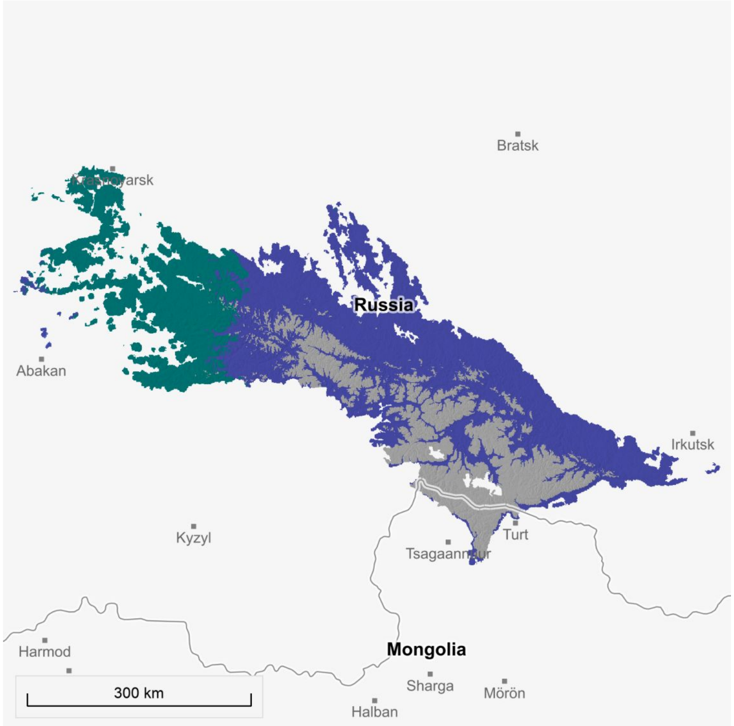


Data: CHELSA/PBCOR [12].

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].

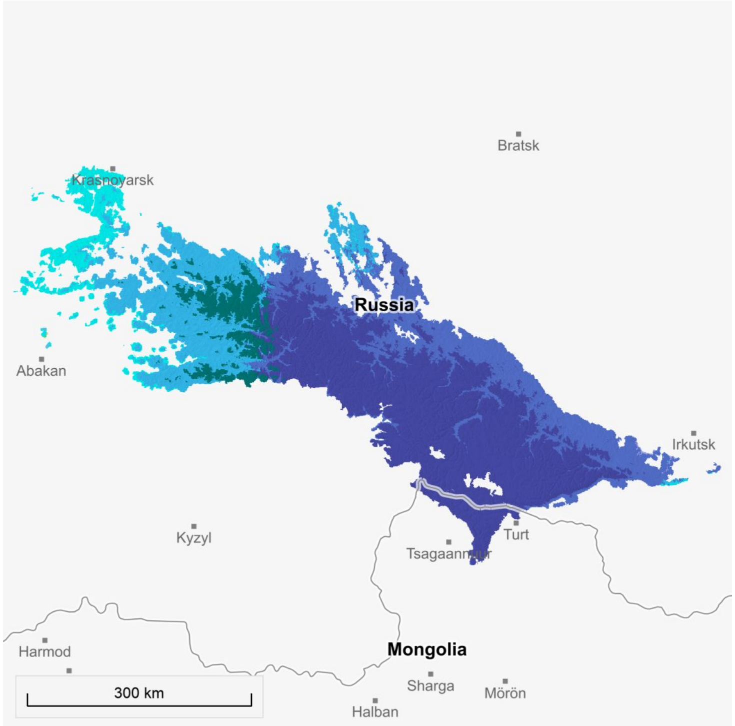
Figure 4.5. Current Climate Classifications



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].

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

Classification		Current	Future	Change
Dwc	Cold, dry winter, cold summer	51.9%	46.1%	▼ 5.8%
ET	Polar, tundra	24.7%	0.0%	▼ 24.7%
Dfc	Cold, no dry season, cold summer	23.4%	6.0%	▼ 17.4%
Dwb	Cold, dry winter, warm summer	0.0%	22.0%	▲ 22.0%
Dfb	Cold, no dry season, warm summer	0.0%	18.9%	▲ 18.9%
Dfa	Cold, no dry season, hot summer	0.0%	6.8%	▲ 6.8%

Source: GloH2O [14].

5. Hydrology

According to the GRDC Major River Basins dataset, **two major basins** intersect the mountain range [15]. The **Yenisey has the most overlap with 100%** and drains into the **Kara Sea**.

Within the mountain range, there are a total of **one dams** listed in the Global Reservoirs and Dams (GRanD) database [16]. The main usage of this dams is **hydroelectricity (1)**. The total capacity of these dams is estimated to be **73,300 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].

Yenisey → Kara Sea	100.0%
Ob → Kara Sea	0.0%

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

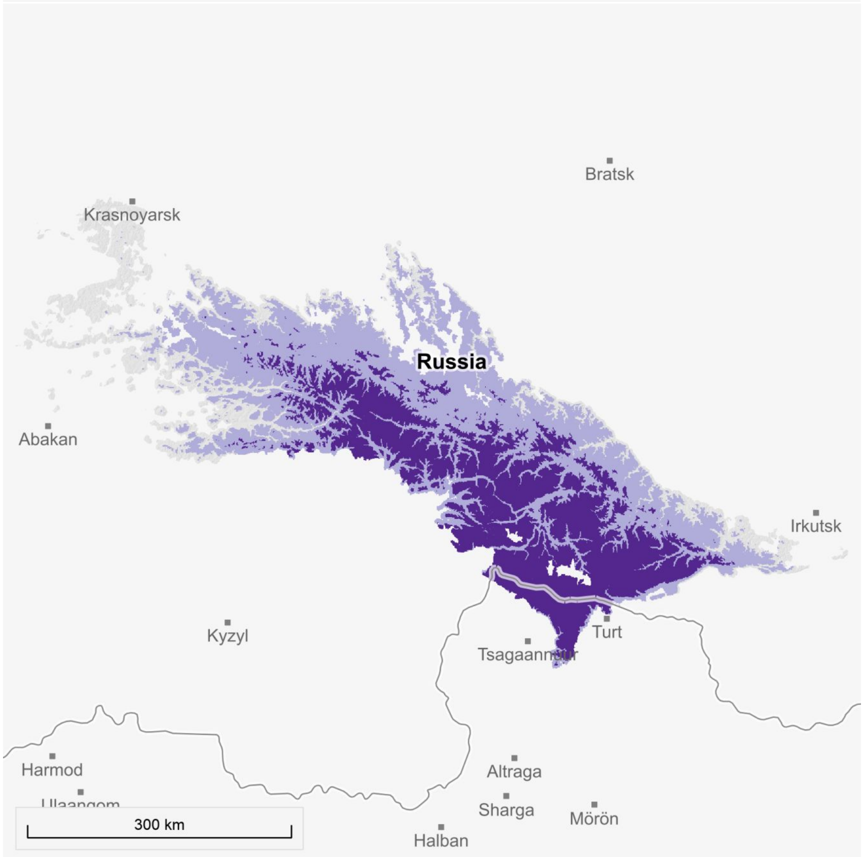
Krasnoyarsk	73,300 Mm³

6. Cryosphere

6.1. Glaciers and Permafrost

The Randolph Glacier Inventory dataset contains **128 glaciers** that intersect with this mountain range [17]. They cover a **total area of 12 km² (0.0%)**. In addition to the glaciers, it is estimated that under favourable conditions, permafrost occurance is possible across **105,188 km² (79.0%)**, and is likely across at least **44,450 km² (33.4%)**. 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



Glacier extent and permafrost zonation.

- Glaciers
- Permafrost likely
- Permafrost possible

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 **128 glaciers** within this mountain range, covering a **total area of 12 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 July of 187 km² (0.1%)** (Figure 6.3) and a **maximum in March of 62,049 km² (46.6%)** (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].

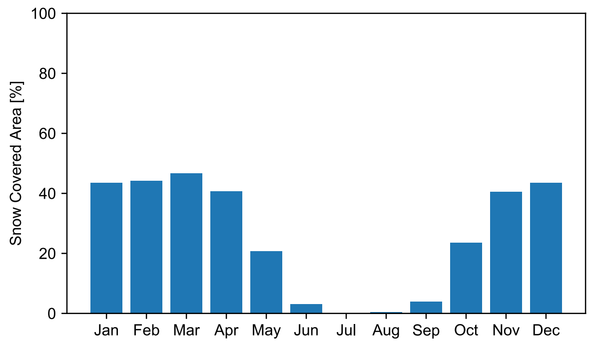
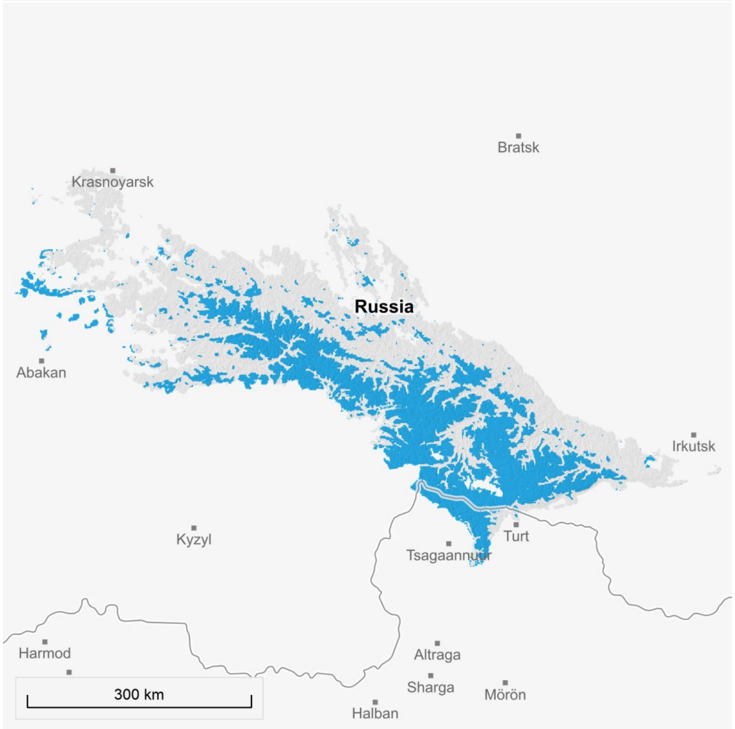


Figure 6.3. Mean Snow Covered Area (July)

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 (March)

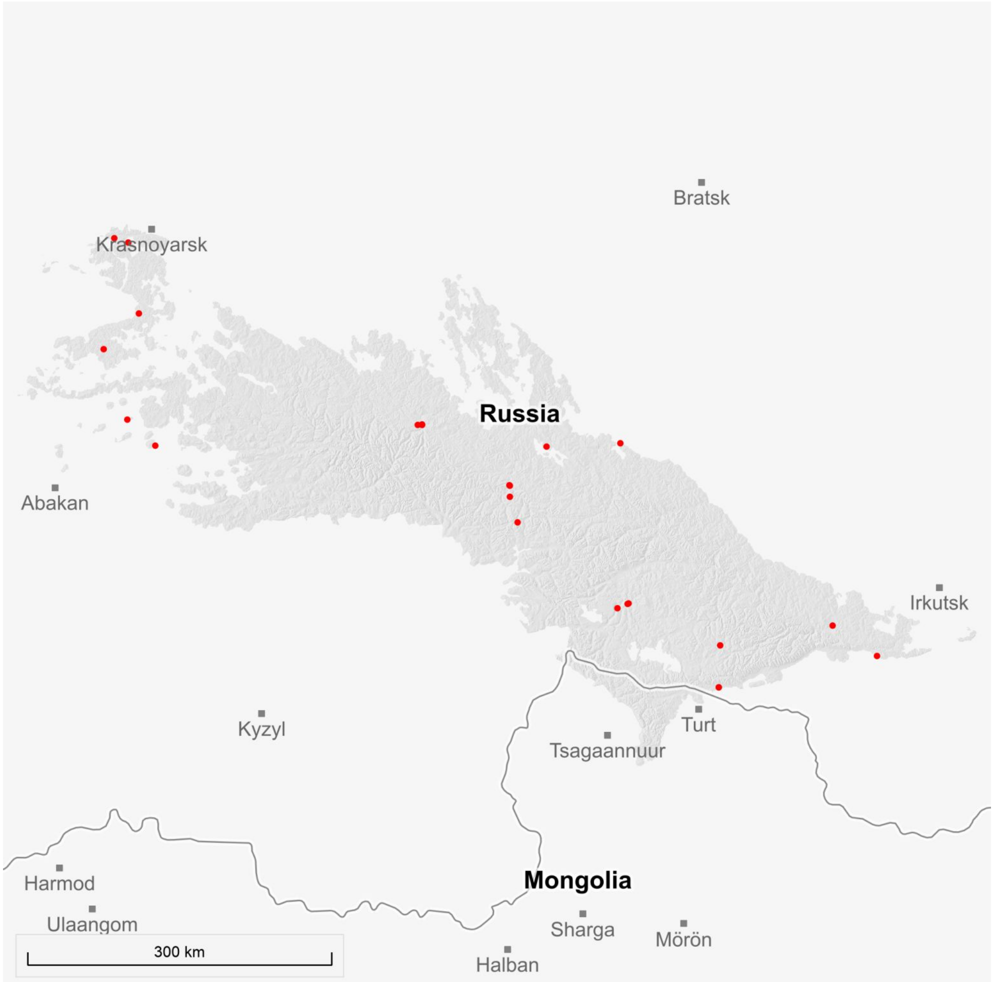


Data: ENVEO/ESA-CCI [17]. Background: GMBA [2], GADM [3], Natural Earth [3], Geonames [4], World Bank [22].

7. Measurement Locations

The GEO Mountains Inventory of In Situ Observational Infrastructure (v2.0) lists a total of **23 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 23 measurement sites in this mountain range

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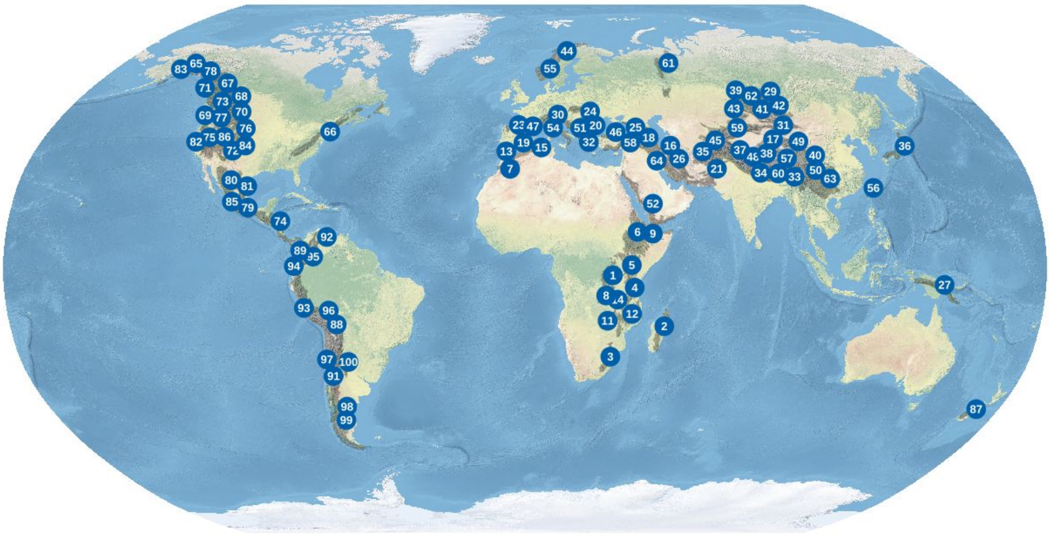
Index

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



Africa

1. Albertine Rift Mountains
2. Central Range (Madagascar)
3. Drakensberg
4. Eastern Arc Mountains
5. Eastern Rift mountains
6. Ethiopian Highlands
7. High Atlas Range
8. High Plateaux of Katanga
9. Horn of Africa Highlands
10. Middle Atlas
11. Northeastern Great Escarpment
12. Plateau of Mozambique
13. Rif
14. Southern Rift Mountains
15. Tell Atlas

Eurasia

16. Alborz Mountains
17. Altyn-Tagh
18. Armenian Highlands
19. Baetic System
20. Balkan Mountains
21. Balochistan Ranges
22. Bayan Har Mountains
23. Cantabrian Mountains
24. Carpathian Mountains
25. Caucasus Mountains

Eurasia (continued)

26. Central Iranian Range
27. Central Range (Papua New Guinea)
28. Dinaric Alps
29. Eastern Sayan
30. European Alps
31. Gobi-Altai Mountains
32. Hellenides
33. Hengduan Shan
34. Himalaya
35. Hindu Kush
36. Honshu
37. Karakoram
38. Kunlun Mountains
39. Kuznetsk Alatau
40. Min Mountains
41. Mongolian Altai
42. Mongolian Highlands
43. Northern Altai
44. Northern Scandes
45. Pamir Mountains
46. Pontic Mountains
47. Pyrenees
48. Qiangtang
49. Qilian Mountains
50. Qionglai Shan

Eurasia (continued)

51. Rila-Rhodope Massif
52. Sarawat Mountains
53. Sistema Iberico
54. South European Highlands
55. Southern Scandes
56. Taiwan
57. Tanggula Mountains
58. Taurus Mountains
59. Tian Shan
60. Transhimalaya
61. Ural Mountains
62. Western Sayan
63. Yunnan-Guizhou Plateau
64. Zagros Mountains

North America

65. Alaska Range
66. Appalachian Mountains
67. British Columbia Interior
68. Canadian Rockies
69. Cascade Range (North America)
70. Central Montana Rocky Mountains
71. Coast Mountains
72. Colorado Plateau
73. Columbia Mountains
74. Cordillera Centroamericana
75. Great Basin Ranges

North America (continued)

76. Greater Yellowstone Rockies
77. Idaho-Bitterroot Rocky Mountains
78. Saint Elias Mountains
79. Sierra Madre del Sur
80. Sierra Madre Occidental
81. Sierra Madre Oriental
82. Sierra Nevada (USA)
83. South-Central Alaska
84. Southern Rocky Mountains
85. Trans-Mexican Volcanic Belt
86. Western Rocky Mountains

Oceania

87. Southern Alps (New Zealand)

South America

88. Altiplano
89. Cordillera Central (Northern Andes)
90. Cordillera Central (Central Andes)
91. Cordillera de la Costa (Chile)
92. Cordillera de Mérida
93. Cordillera Occidental (Central Andes)
94. Cordillera Occidental (Northern Andes)
95. Cordillera Oriental (Northern Andes)
96. Cordillera Oriental (Central Andes)
97. Dry Andes
98. Meseta Patagónica
99. Patagonian Andes
100. Sierras Pampeanas

GEO MOUNTAINS
Observing Mountain Environments

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:

GEO Mountains (2023). The Mountains Uncovered Series: Intercomparable Maps and Statistics for 100 Selected Global Mountain Ranges (v1.0). doi: 10.5281/zenodo.8010166

Before the reuse of the products, the licence terms associated with the underlying third-party datasets should be carefully checked, and those datasets should also be appropriately cited; please see the reference list provided for further details and links.

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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A contribution from:

ADAPTATION AT ALTITUDE
Taking Action in the Mountains

MOUNTAIN RESEARCH INITIATIVE

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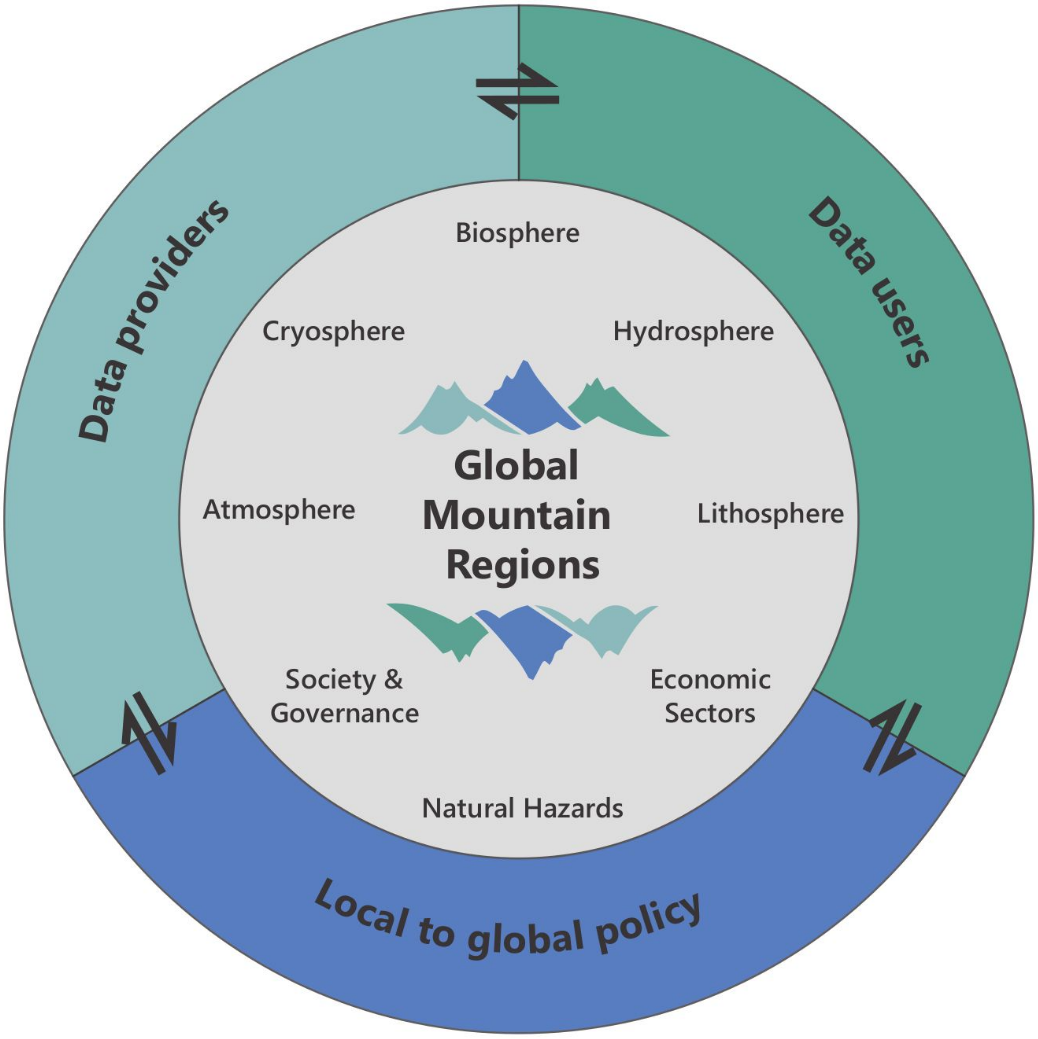
About GEO Mountains

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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