MOUNTAINS UNCOVERED

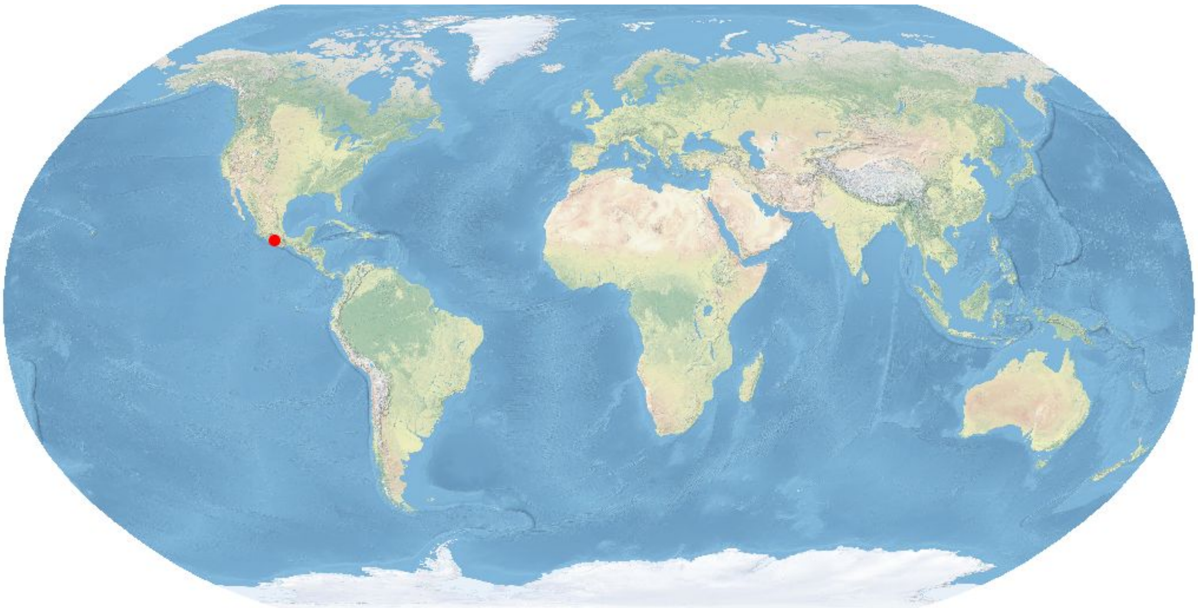
Intercomparable Maps and Statistics for 100 Selected Global Mountain Ranges

Sierra Madre del Sur **#79**

GEO MOUNTAINS
Observing Mountain Environments

Sierra Madre del Sur

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 **Sierra Madre del Sur** mountain range. The index page shows an overview of all mountain ranges in the series.



Location of the Sierra Madre del Sur mountain range [1][2].

Table of Contents

1. General Information

1.1. Administrative

The mountain range if fully within **Mexico**, 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].

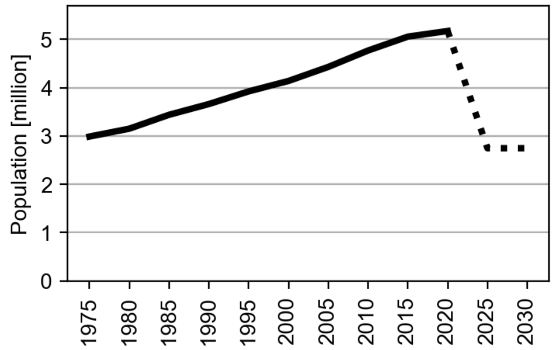
Mexico: 146,920 km² 100%

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 **decrease to 3 million** by 2030. The largest settlements within the mountain range are **Chilpancingo, Orizaba, Tlapa de Comonfort, Río Blanco,** and **Ciudad Mendoza**.

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

Population density (people per km²) in the mountain range.

0 250 500 750 1000

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

Figure 1.4. Travel Time

Estimated travel time to cities with a population of at least 50,000 people.

- Less than an hour
- Less than 4 hours
- Less than 8 hours
- Less than 1 day
- Less than 2 days
- Less than 5 days

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 **0.71**. 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	$30 bn	$33 bn	$47 bn
Human Development Index	0.61	0.66	0.71

Source: Kummu et al. [7]

The total GDP within this mountain range in 2015 was estimated to be **$47 billion**, an **increase of $14 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 **7%** 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 7% of the mountain range is classified as protected in the World Database of Protected Areas.

The largest protected areas are:

1. **C.A.D.N.R. 043 Estado de Nayarit** Natural Resources Protection Area	23,365 km²
2. **Tehuacán-Cuicatlán** UNESCO-MAB Biosphere Reserve	4,933 km²
3. **Tehuacán-Cuicatlán** Biosphere Reserve	4,925 km²
4. **Zicuirán-Infiernillo** Biosphere Reserve	2,655 km²
5. **Tehuacán-Cuicatlán Valley: originary habitat of Mesoamerica** World Heritage Site (natural or mixed)	1,459 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 (69.4%), shrubland (18.0%),** and **grassland (10.8%)**.

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

Tree cover	69.4%
Shrubland	18.0%
Grassland	10.8%
Cropland	0.9%
Built-up	0.5%
Water	0.2%
Bare and sparse	0.2%

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 **0.2%** of the mountain range's area as urban centre, **0.5%** as urban cluster, and **99.3% as rural**.

3. Topography

The land surface elevation ranges from a **minimum of -2 m** to a **maximum of 2,950 m at Cerro Tres Mogotes**. The **mean elevation is 1,231 m**. **50%** of the area lies is between **639 m and 1,766 m**, and **90% of the area lies between 243 m and 2,210 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].

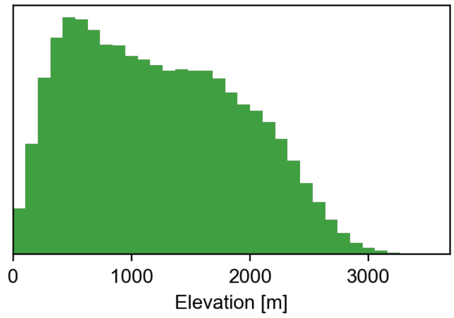


Figure 3.3. Distribution of slope steepness within in the mountain range [21].

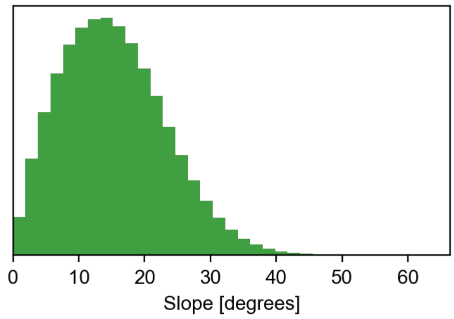


Figure 3.4. Highest peaks in the mountain range according to the Geonames [4] dataset.

1. **Cerro Tres Mogotes**	▲ 2,950 m
2. **Cerro Grande**	▲ 2,850 m
3. **Cerro El Mezcaltepec**	▲ 2,750 m
4. **Cerro Tezquilcatemic**	▲ 2,650 m
5. **Cerro Puerto de Arco**	▲ 2,450 m
6. **Cerro El Roble**	▲ 2,440 m
7. **La Puesta Fea**	▲ 2,320 m
8. **Cerro La Bufa**	▲ 2,320 m
9. **Cerro La Cruz**	▲ 2,210 m
10. **Cerro El Laurel**	▲ 2,180 m

4. Climate

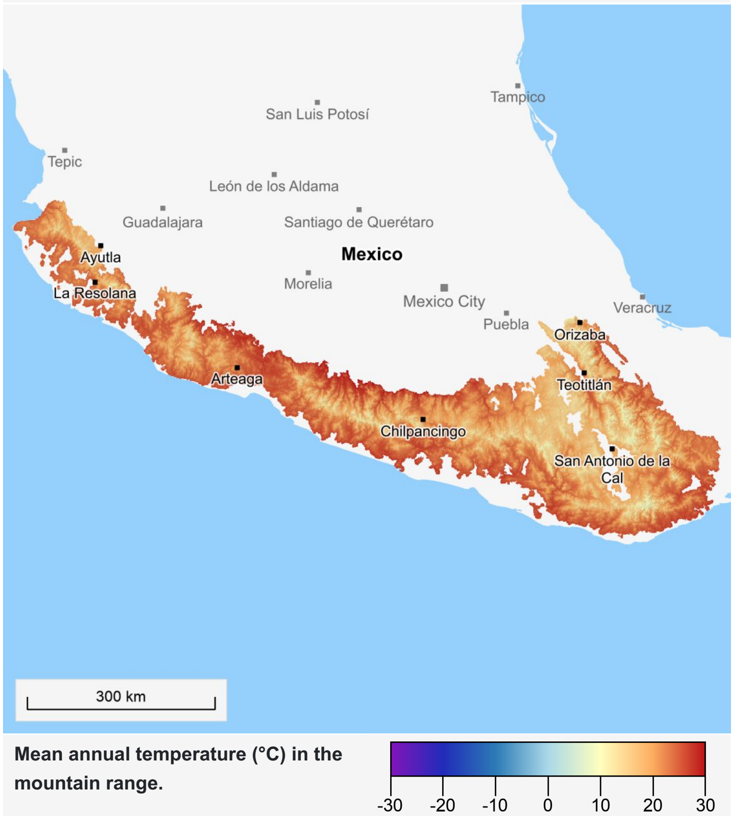
4.1. Temperature and Precipitation

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 20.8°C**, but it varies geographically from a **minimum of 6.1°C** to a **maximum of 30.1°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 1,303 mm**, but it varies geographically from a **minimum of 459 mm** to a **maximum of 4,634**. Precipitation data are bias-corrected for use in mountain environments, and are extracted from CHELSA data in the Precipitation Bias CORrection (PBCOR) dataset [12].

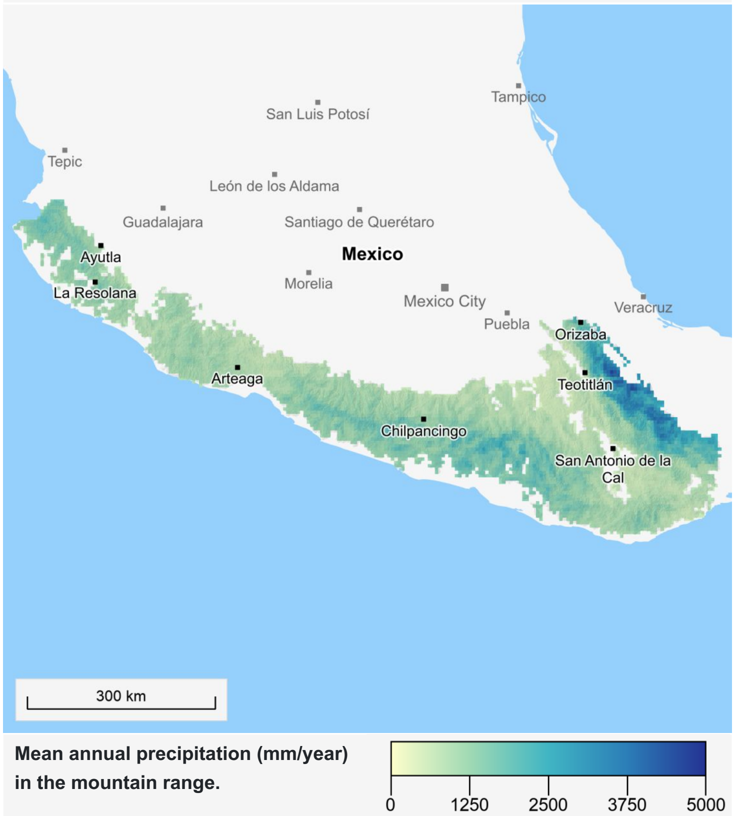
Figure 4.1. Mean Annual Temperature



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

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

Figure 4.2. Mean Annual Precipitation

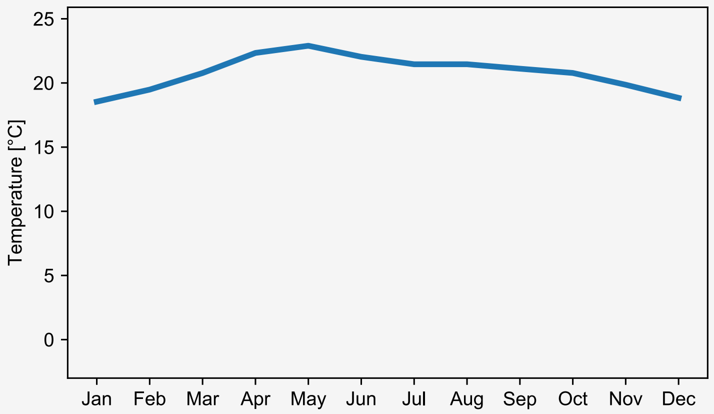


Mean annual precipitation (mm/year) in the mountain range.

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

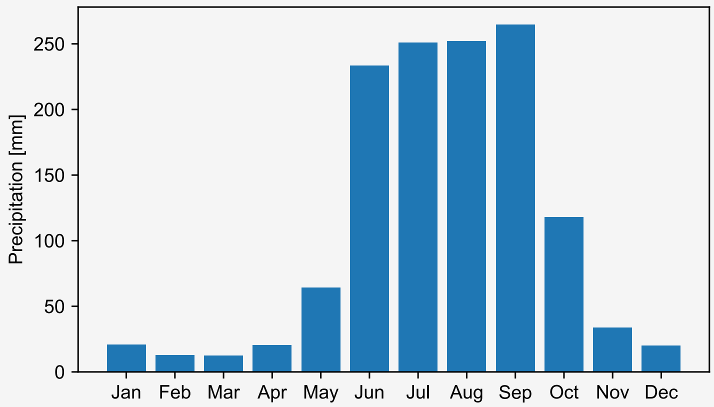
The mean monthly temperature across the entire mountain range shown in Figure 4.3, and varies from a **maximum of 22.9°C in May** to a **minimum of 18.5°C in January**. Equivalent statistics for precipitation are shown in Figure 4.4, which vary from a **maximum of 265 mm in September** to a **minimum of 12 mm in March**.

Figure 4.3. Mean Monthly Temperature



Data: CHELSA [13].

Figure 4.4. Mean Monthly Precipitation

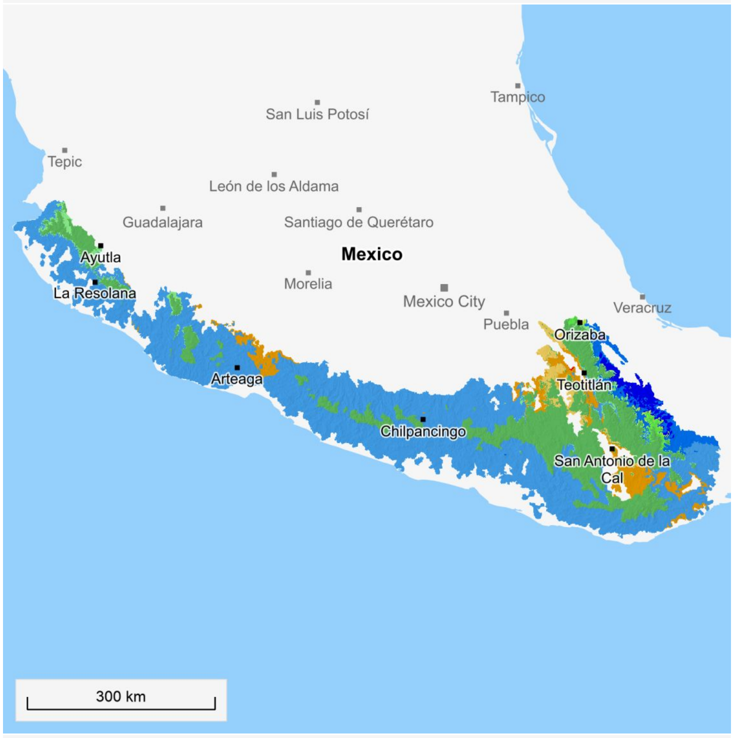


Data: CHELSA/PBCOR [12].

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
Aw	Tropical, savannah	59.3%	60.8%	▲ 1.6%
Cwb	Temperate, dry winter, warm summer	24.5%	7.5%	▼ 17.0%
BSh	Arid, steppe, hot	6.1%	23.2%	▲ 17.1%
Am	Tropical, monsoon	3.3%	5.4%	▲ 2.1%
Cwa	Temperate, dry winter, hot summer	2.2%	3.0%	▲ 0.9%
BSk	Arid, steppe, cold	2.1%	0.1%	▼ 2.0%
Af	Tropical, rainforest	1.9%	0.0%	▼ 1.9%

Source: GloH2O [14].

5. Hydrology

According to the GRDC Major River Basins dataset, **three major basins** intersect the mountain range [15]. The **Papaloapan has the most overlap with 14%** and drains into the **Gulf of Mexico**.

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 **irrigation (4)** and **hydroelectricity (3)**. The total capacity of these dams is estimated to be **16,274 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].

Basin	Drains into	Overlap
Papaloapan	Gulf of Mexico	14.0%
Verde	North Pacific	11.0%
Armeria	North Pacific	2.0%

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

El Infiernillo	9,340 Mm³
Cerro de Oro	4,400 Mm³
Presidente Benito Juarez	942 Mm³

6. Cryosphere

6.1. Glaciers and Permafrost

According to the Randolph Glacier Inventory dataset there are **no glaciers** in this mountain range [17].

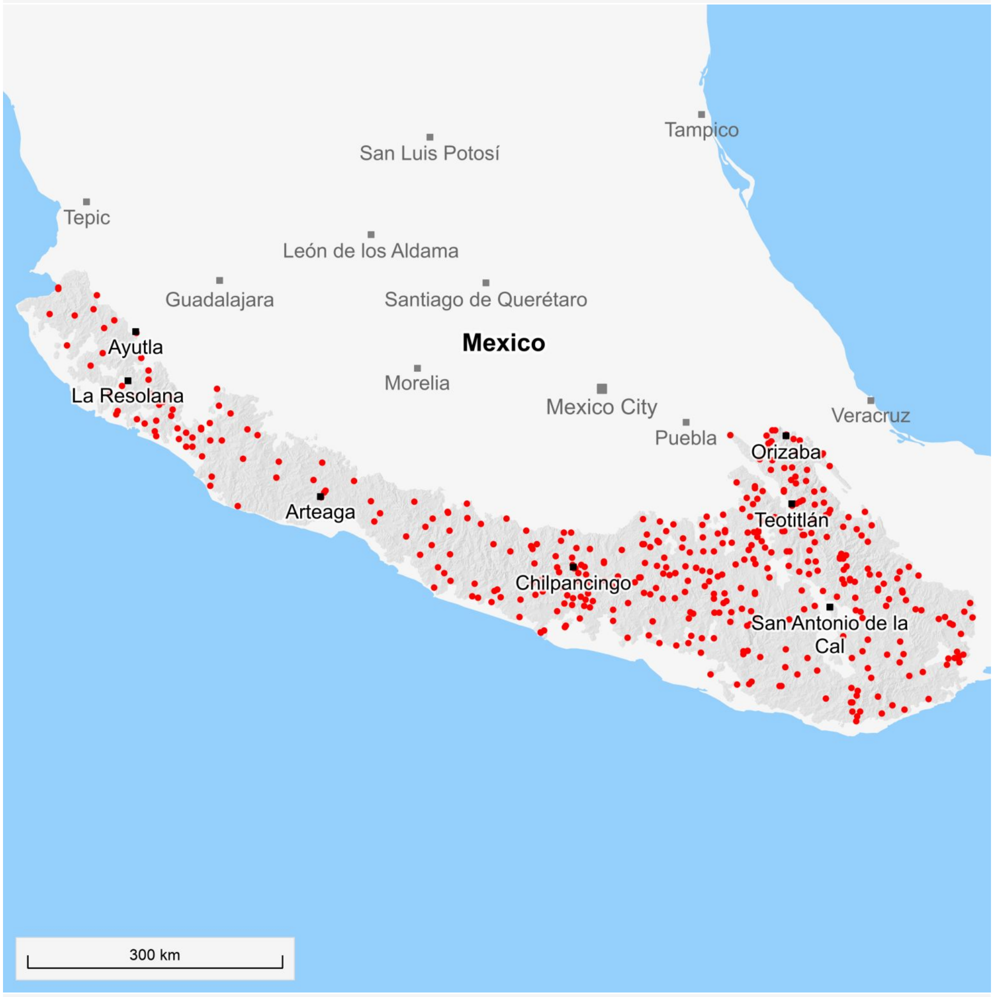
6.2. Snow Cover

The average snow covered area in this mountain range does not exceed 1%, even in the coldest months. Maps and charts of snow covered area are therefore not shown.

7. Measurement Locations

The GEO Mountains Inventory of In Situ Observational Infrastructure (v2.0) lists a total of **428 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 428 measurement sites in this mountain range

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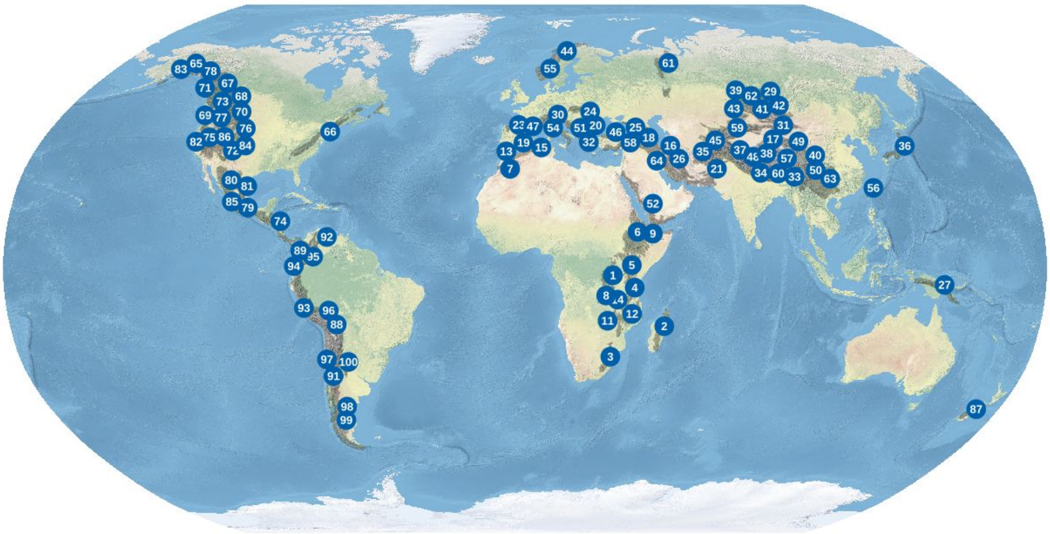
Index

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:

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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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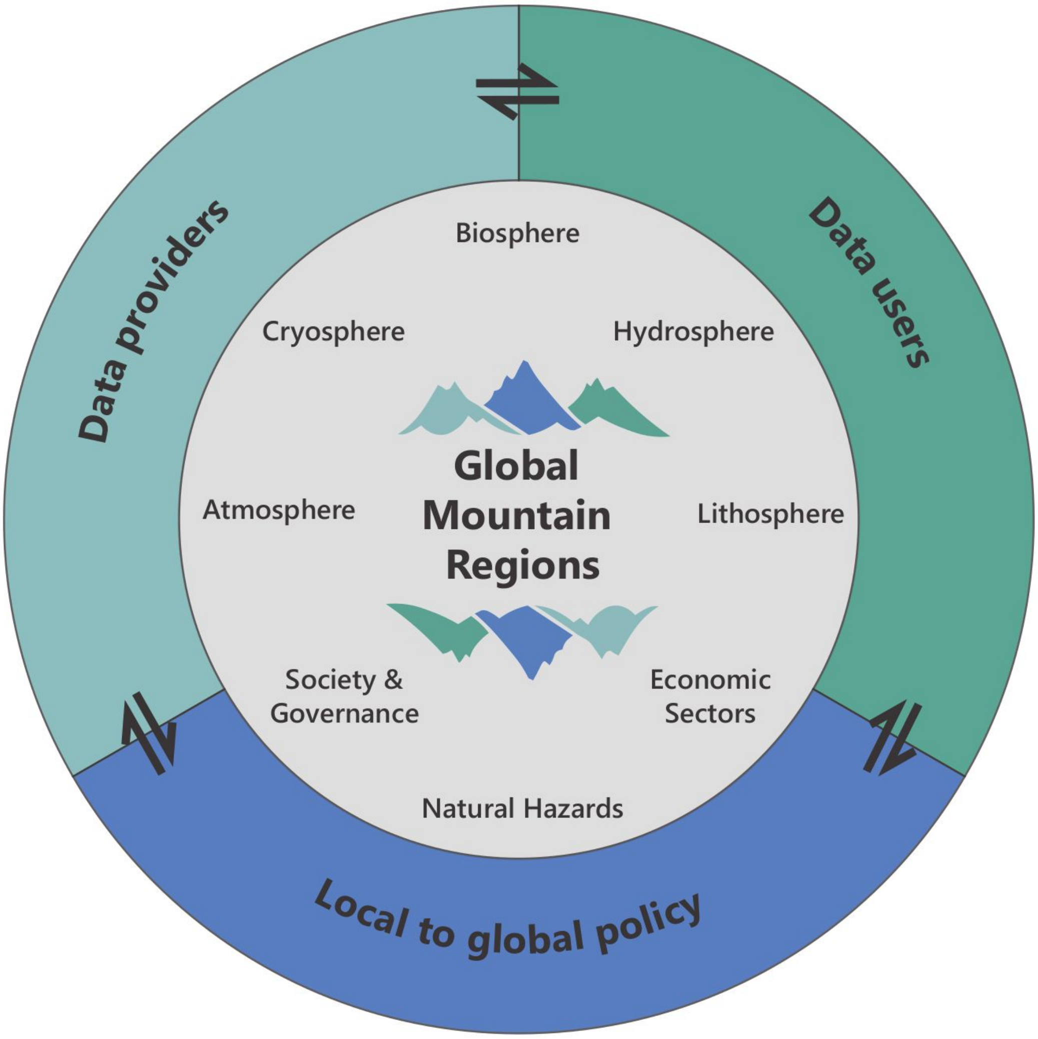
GEO MOUNTAINS
Observing Mountain Environments

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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