Human populations in the world's mountains: patterns and potential controls

James M. Thornton, Mark A. Snethlage, Roger Sayre, Davnah Urbach, Daniel Viviroli, Daniele Ehrlich, Veruska Muccione, Philippus Wester, Gregory Insarov & Carolina Adler

GEO MOUNTAINS
Observing Mountain Environments

MOUNTAIN RESEARCH INITIATIVE

ADAPTATION AT ALTITUDE
Taking Action in the Mountains

Schweizerische Eidgenossenschaft
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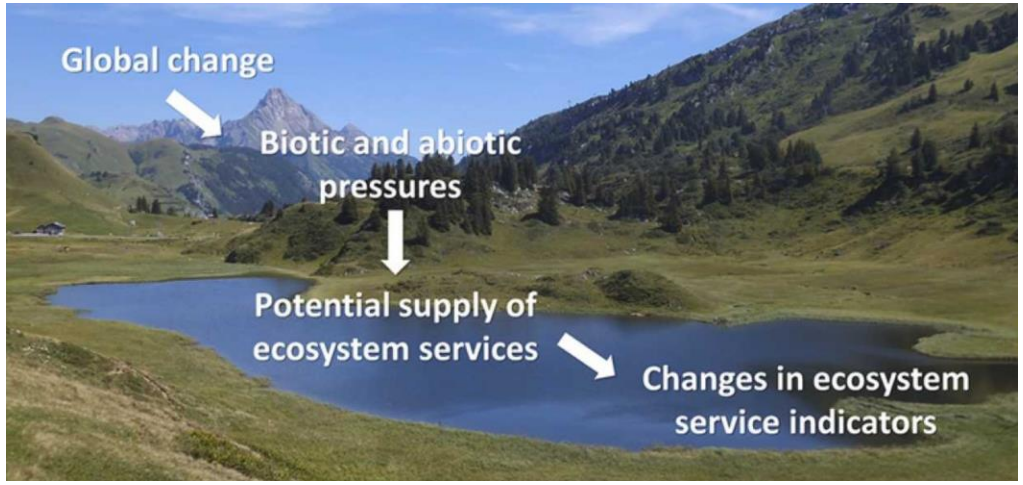
Motivation

- **Strong reciprocal interactions** and **feedbacks** between **human populations / societies** and **biodiversity** in **mountain social-ecological systems under change**:
  - Ecosystem services **>** Human populations / societies (including far downstream)
  - Anthropogenic pressures **>** Ecosystems & biodiversity

- Need **reliable estimates** of mountain populations and their dynamics to ensure any **interventions** are **appropriately resourced** and effective **policies are developed**



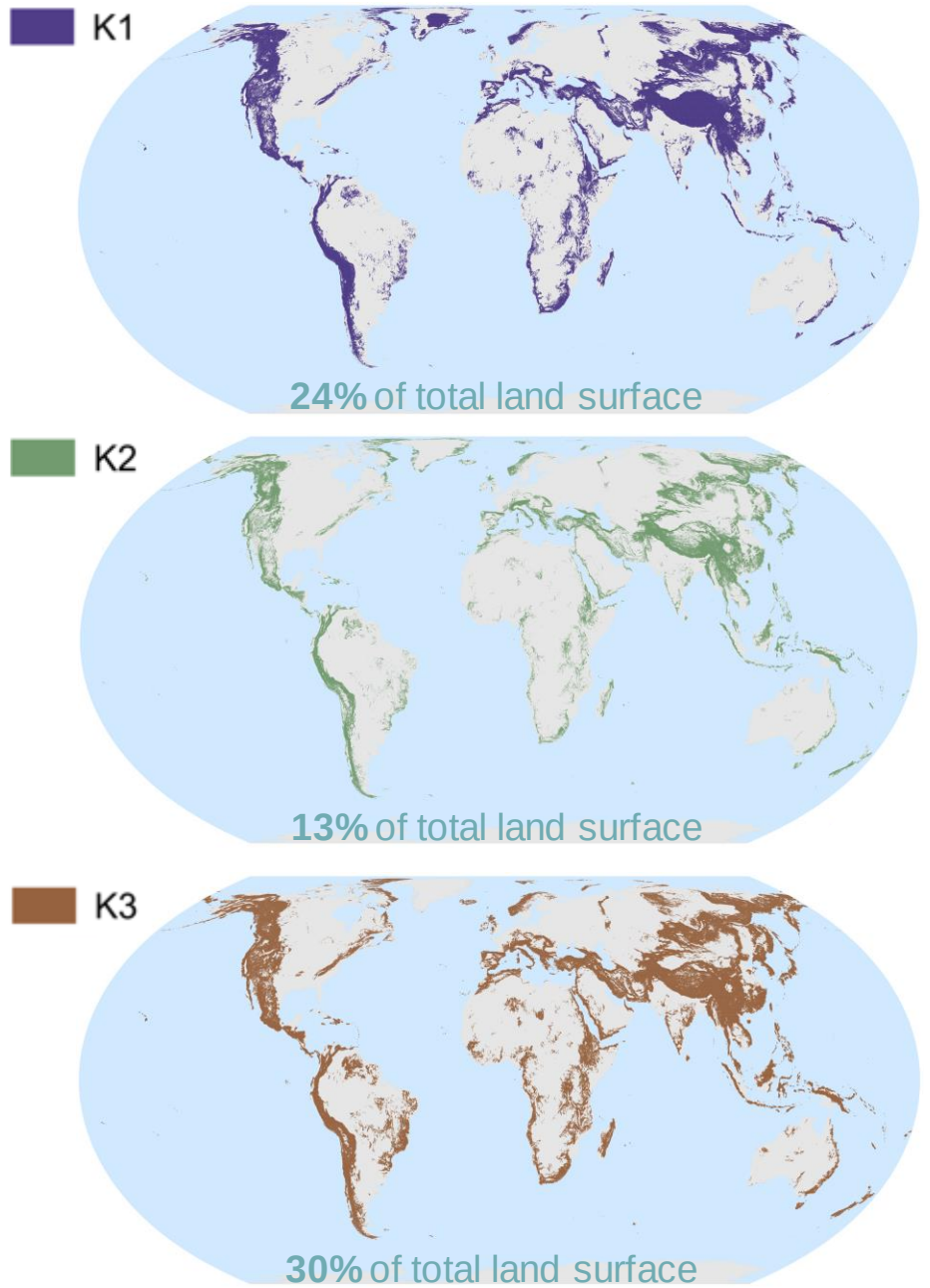
Ebner et al. (2022), *Anthropocene*

The status quo

- Several alternative **mountain delineations**, **gridded population datasets**, and **urban extent datasets exist**
- Previous studies have sought to **combine them** to **quantify human populations in / near mountains globally**

However:

- Only **singular combinations of possible inputs** have been **used**
- **Regional** and **urban mountain population dynamics** have received **much less attention**
- **Little work** on exploring **potential drivers of / influences** on human population density in mountains specifically
- Workflows have **not been consistently reproducible and transparent**



Aim, Research Questions & Methods

To develop and apply a **fully reproducible and efficient workflow** to address several outstanding research questions, such as:

To what extent do estimates of the global human population living in and around mountains depend on input data choices?

How have mountain population counts and densities varied spatially and temporally over recent decades?

How do population density estimates in mountains compare with those of their wider regions?

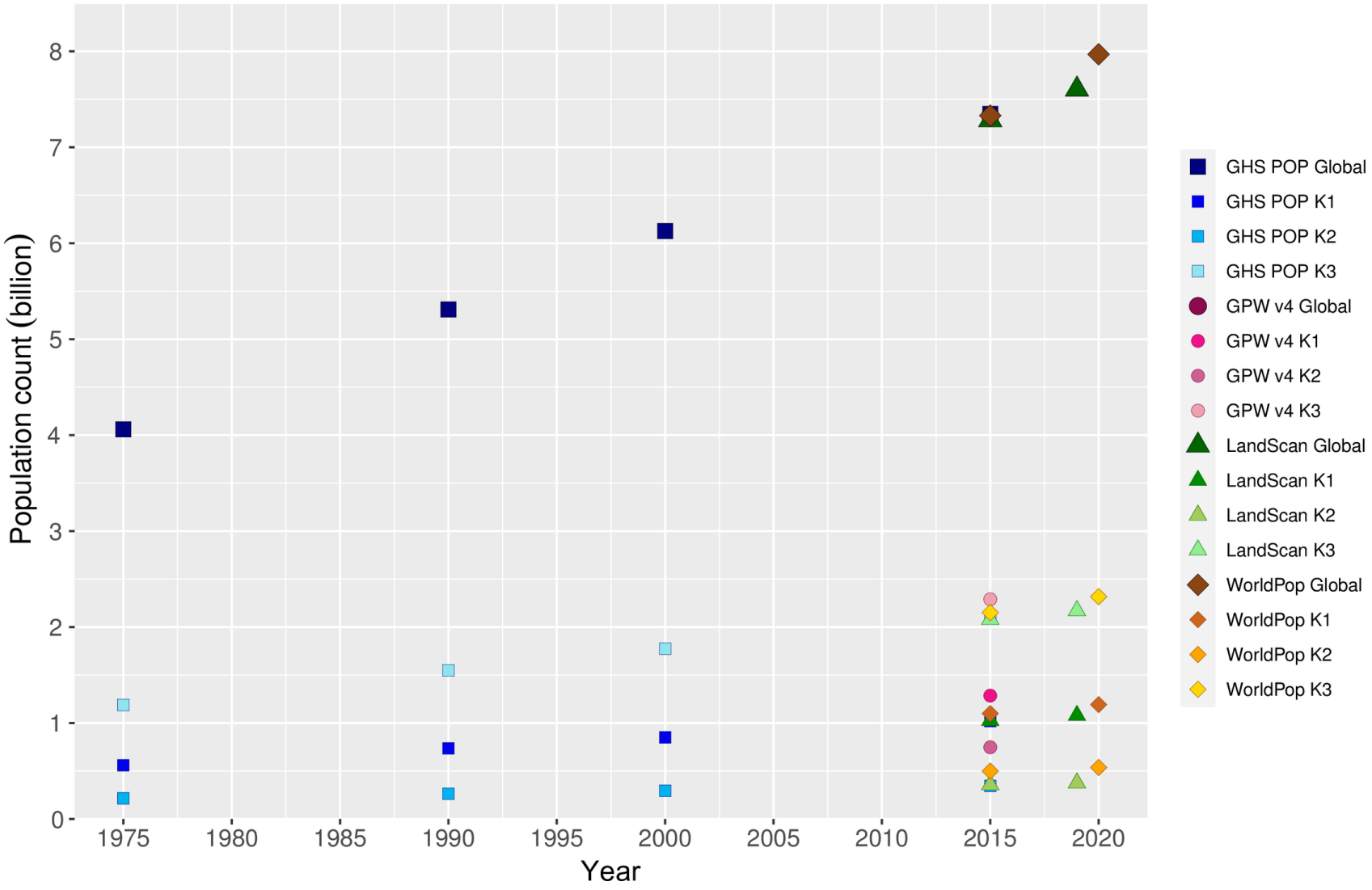
Which mountainous regions are undergoing the most profound population changes?

What proportion of the mountain population can be considered "urban", and to what extent are recent population change and urban extent change in mountains spatially related?

To what extent are mountain population densities within individual mountain regions related to topographic, climatic, and protected-area variables, and how have these dependencies changed in time and space over recent decades?

- ❑ **Exclusively open-source data** and (script-based) **software applied**

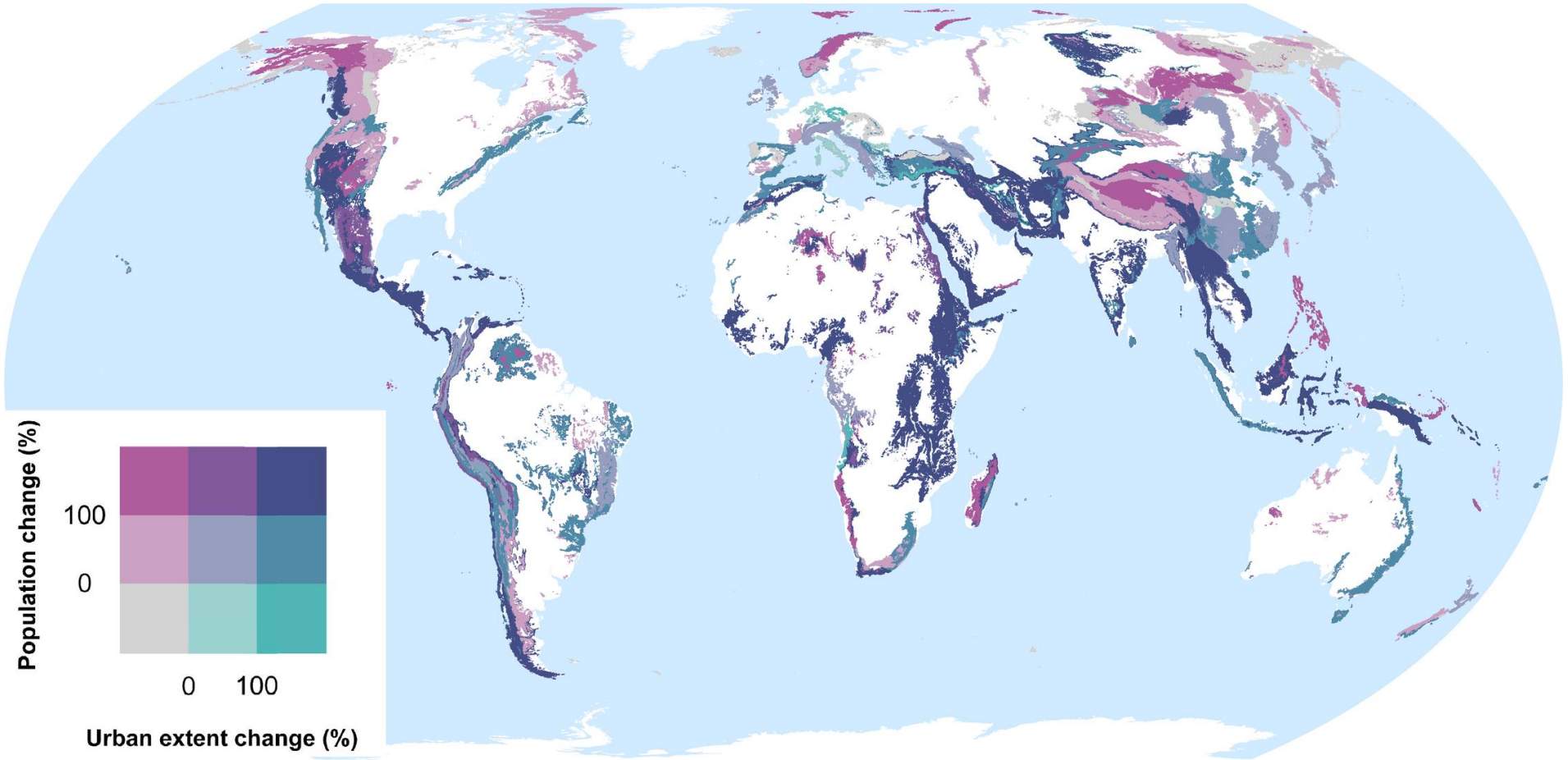
Global mountain population



- 2015 "Global mountain population" ranged from **344 m to 2.29 bn**, depending on the dataset combinations used
- How one delineates mountains makes a **considerable difference!**
- Choice of **population data secondary**, but still influential

Population vs. Urban Extent Change

At **“sub-mountain range scale”** (GMBA Mountain Inventory v2), from **1975 to 2015**
(according to one selected combination of population and urban extent data):

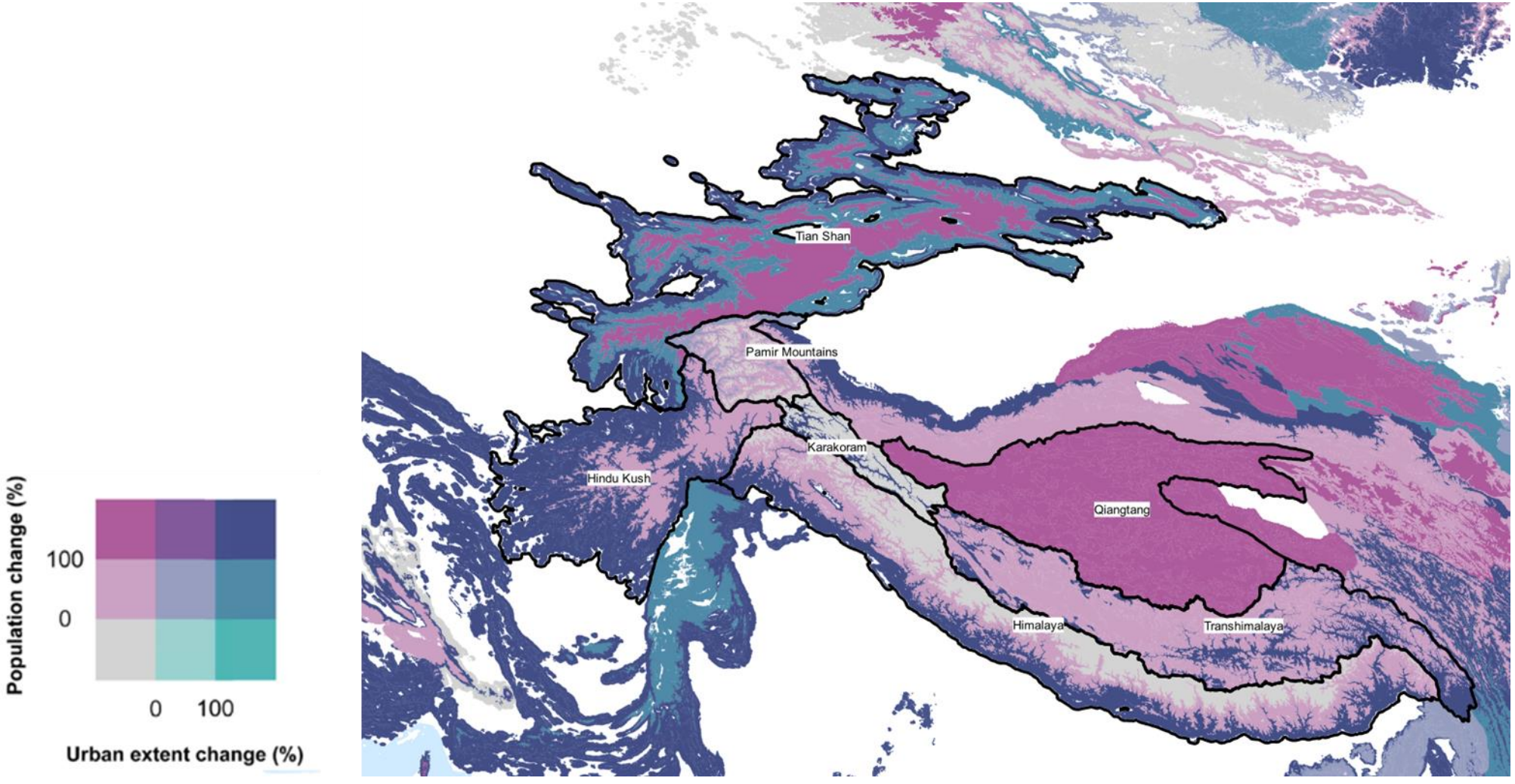


Snethladge et al. (2022),
Scientific Data

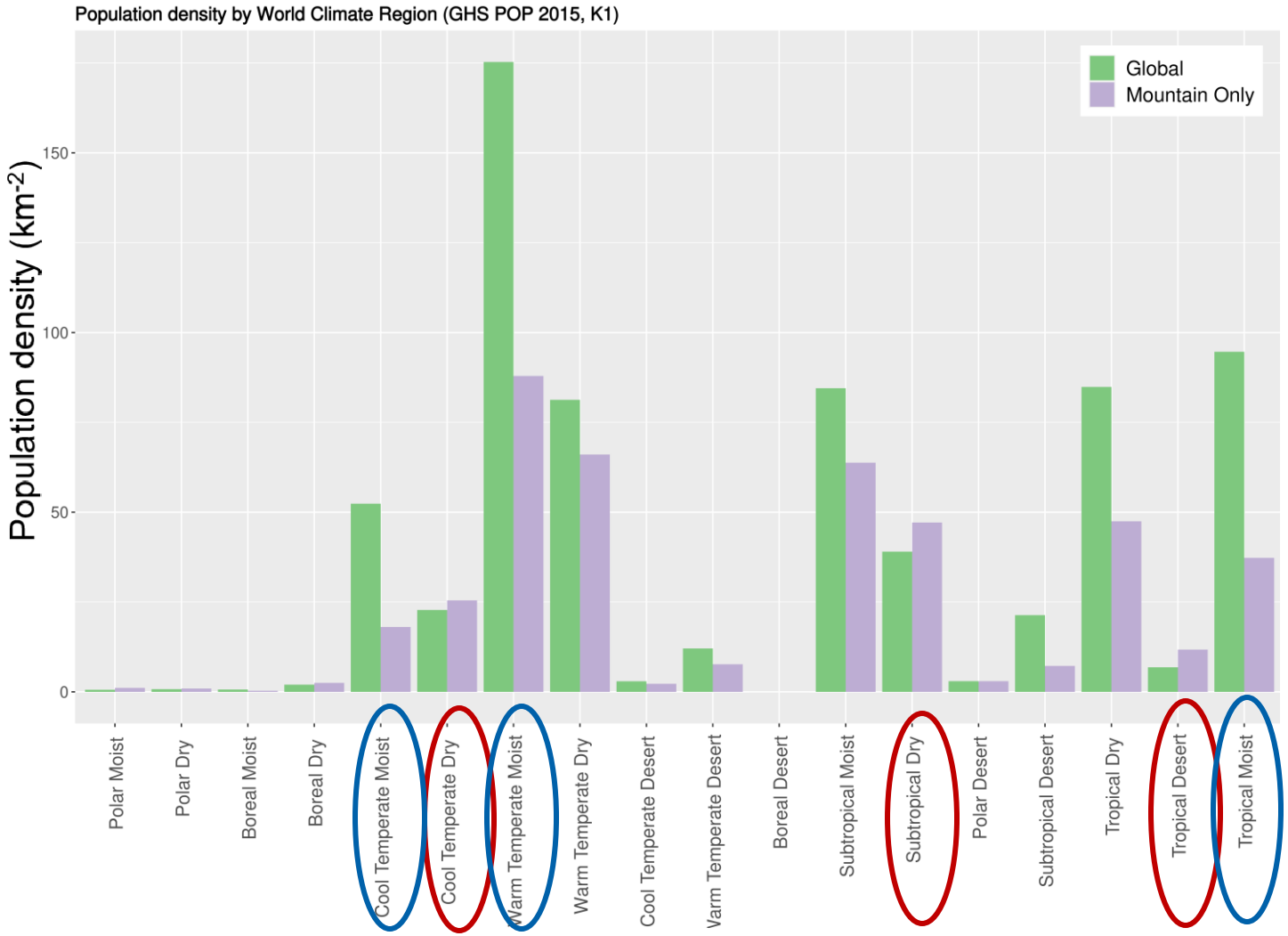
https://ghsl.jrc.ec.europa.eu/

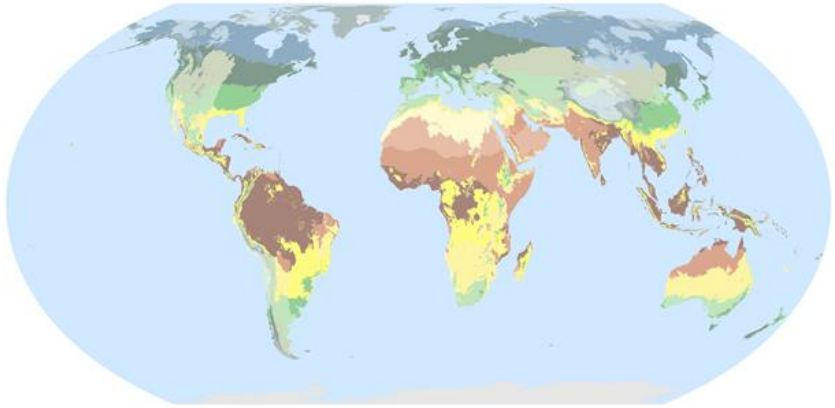
Population vs. Urban Extent Change (HMA)

At **“sub-mountain range scale”** (GMBA Mountain Inventory v2), from **1975 to 2015**
(according to one selected combination of population and urban extent data):



Population Density by Climatic Regions





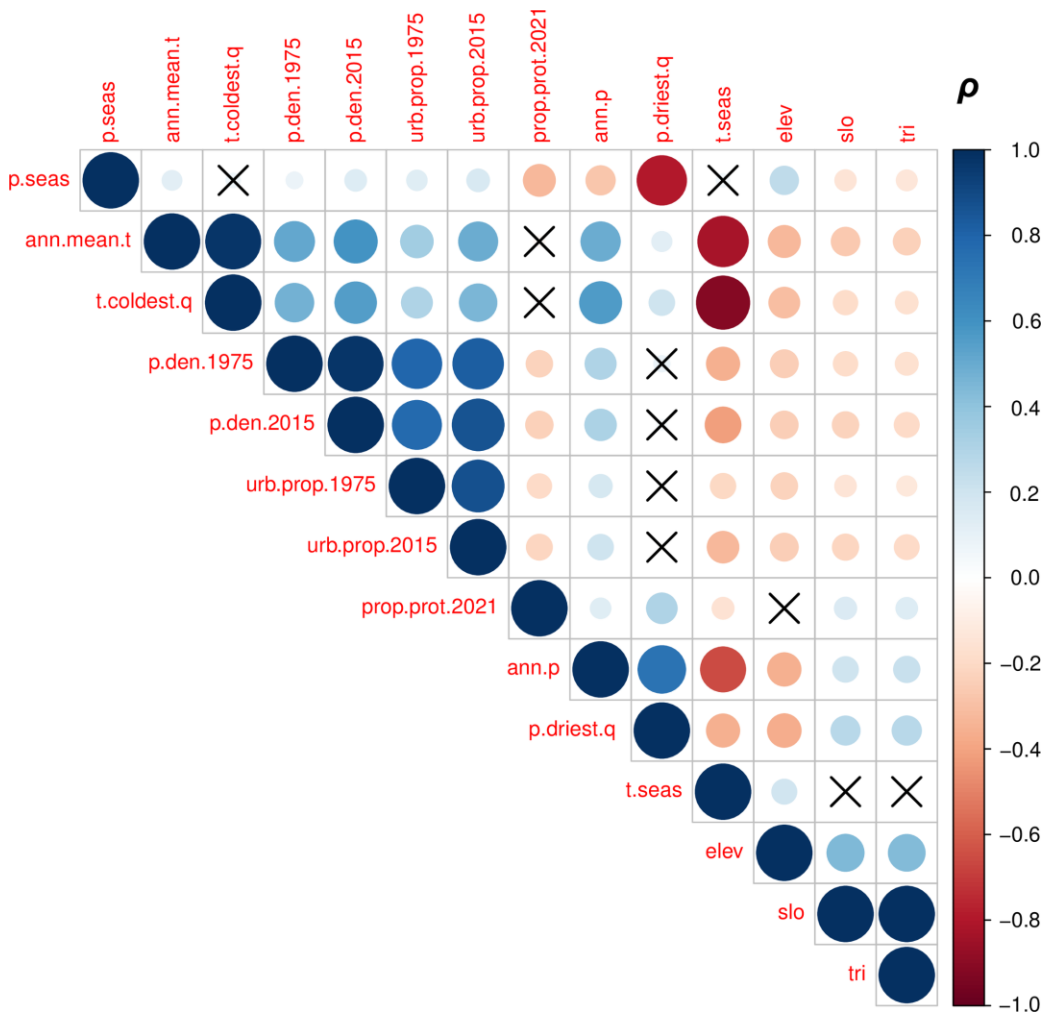
World Climate Regions

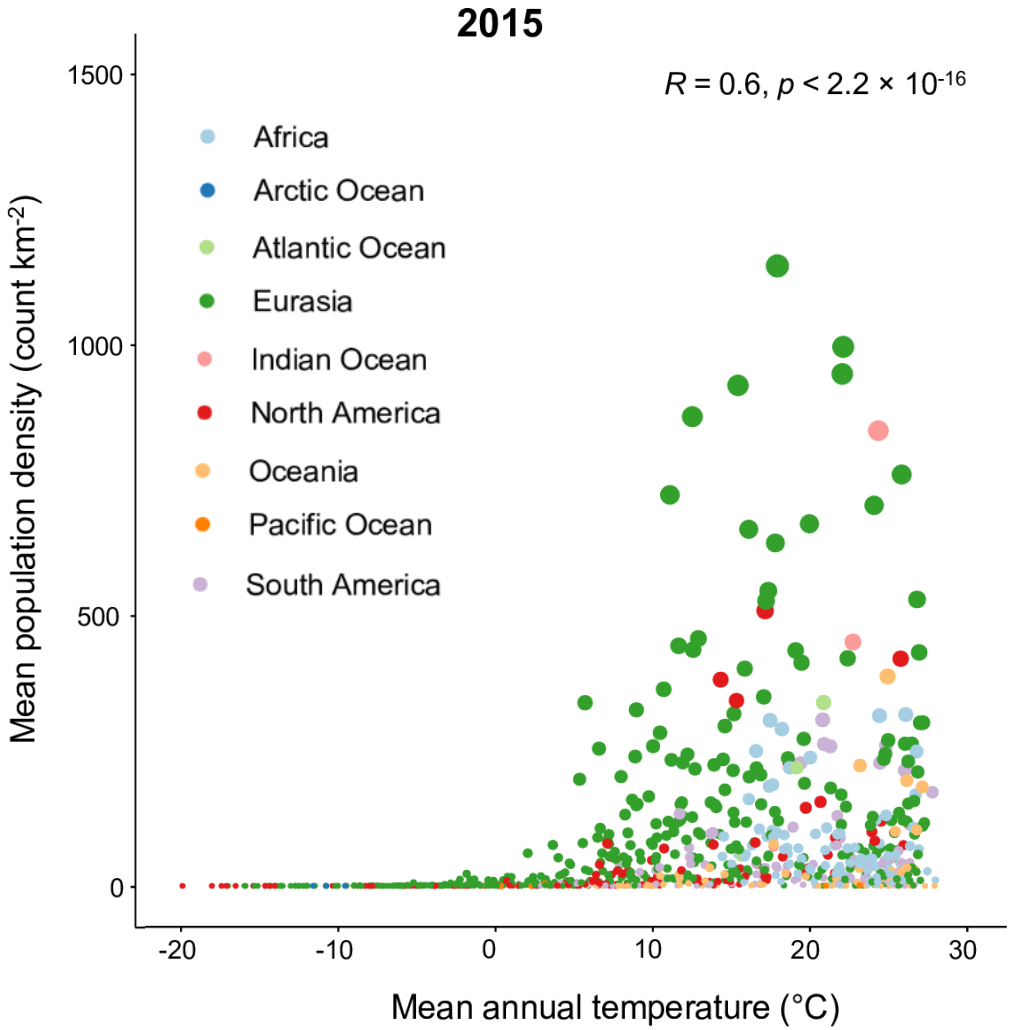
- Polar Moist
- Polar Dry
- Boreal Moist
- Boreal Dry
- Cool Temperate Moist
- Cool Temperate Dry
- Warm Temperate Moist
- Warm Temperate Dry
- Cool Temperate Desert
- Warm Temperate Desert
- Boreal Desert
- Subtropical Moist
- Subtropical Dry
- Polar Desert
- Subtropical Desert
- Tropical Dry
- Tropical Desert
- Tropical Moist

Sayre et al. (2020),
Global Ecology and Conservation

Further Analysis of Potential Controls / Drivers

- **Population density** (1975 and 2015) **vs. numerous climatic, topographic**, and **other potential covariates** (e.g. protected area proportions, urban extent proportions), again at sub-mountain range scale:

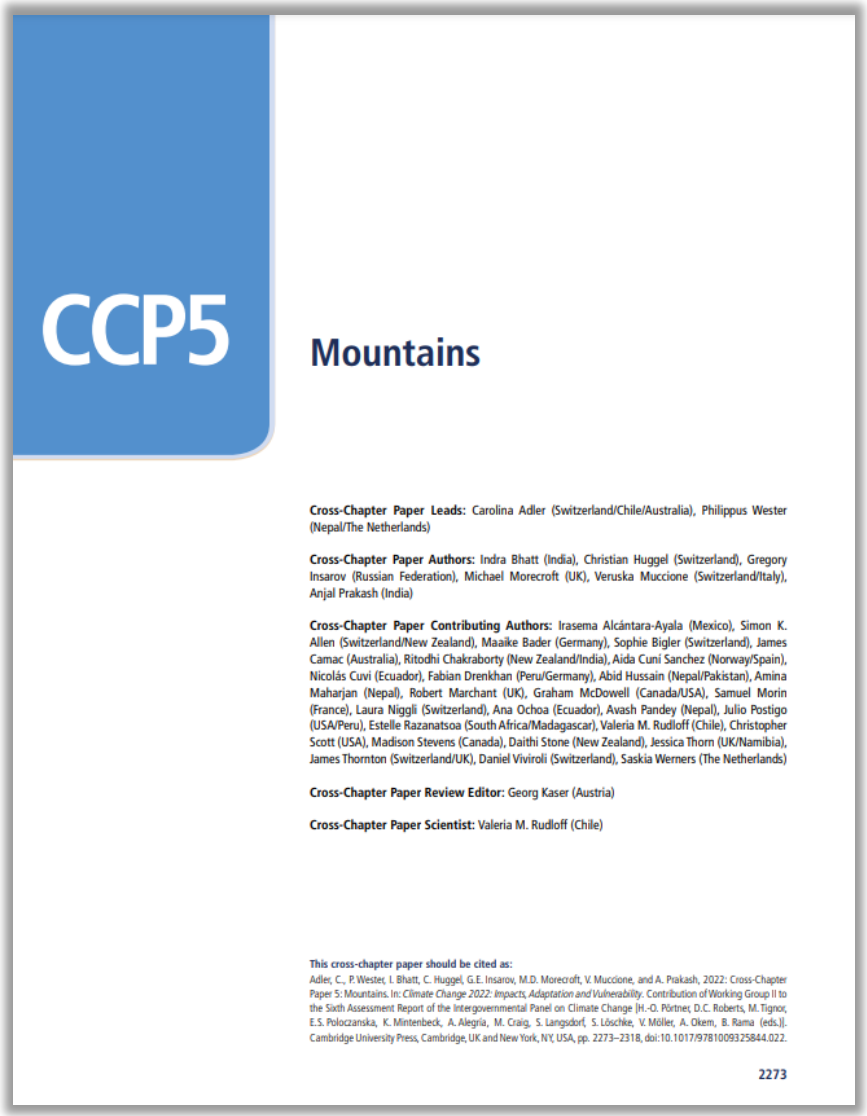




Conclusions

- **Variability in mountain population estimates** is **dominated by the choice of mountain delineation**
- In many regions, **population increases over recent decades have been associated with strong urbanization in both extent and population**, although population and urbanization trends are **disconnected in some regions**
- In **parts of Africa especially**, **mean mountain population densities** are **notably higher than densities more generally,** suggesting that **mountains provide important "refugia"** for human populations in certain dry and/or hot climate zones
- At **"sub-mountain range scale",** moderate and high mountain population densities occur **under a relatively wide range** of **climatological and topographic conditions**, although **climatic controls** (especially temperature) are **generally stronger** and **may have strengthened over time**
- These findings **could help inform future projections of mountain population dynamics** under **coupled climatic** and **demographic scenarios**
- **Transparency & reproducibility are key** if society / decision makers are to **trust scientific outputs**, but are **still often lacking!** (though the situation is improving thanks to many funders, publishers, GEO, and others)

Conclusions



CCP5

Mountains

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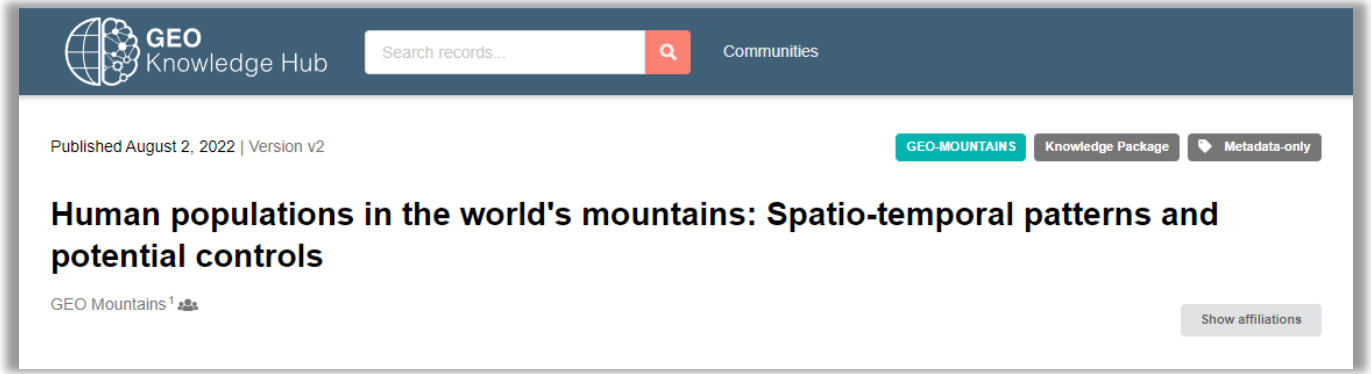

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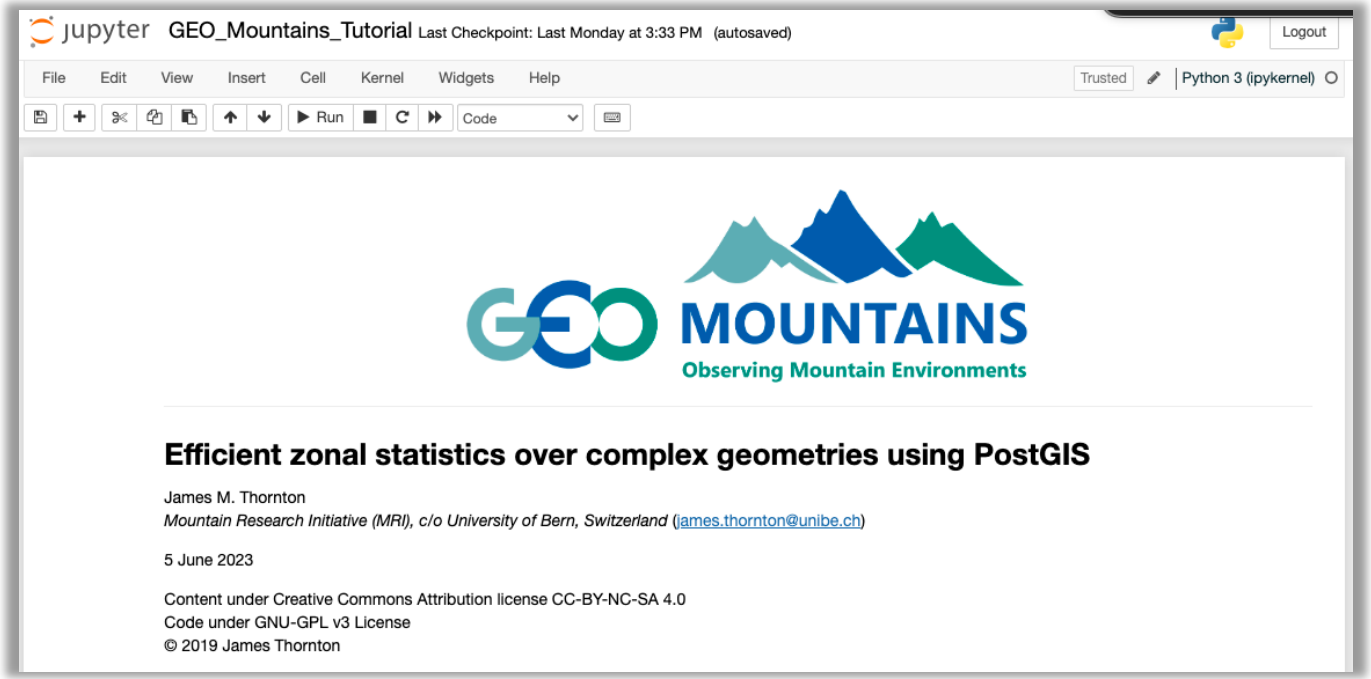

jupyter GEO_Mountains_Tutorial Last Checkpoint: Last Monday at 3:33 PM (autosaved)

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Trusted | Python 3 (ipykernel)

Run Code

GEO MOUNTAINS
Observing Mountain Environments

Efficient zonal statistics over complex geometries using PostGIS

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5 June 2023

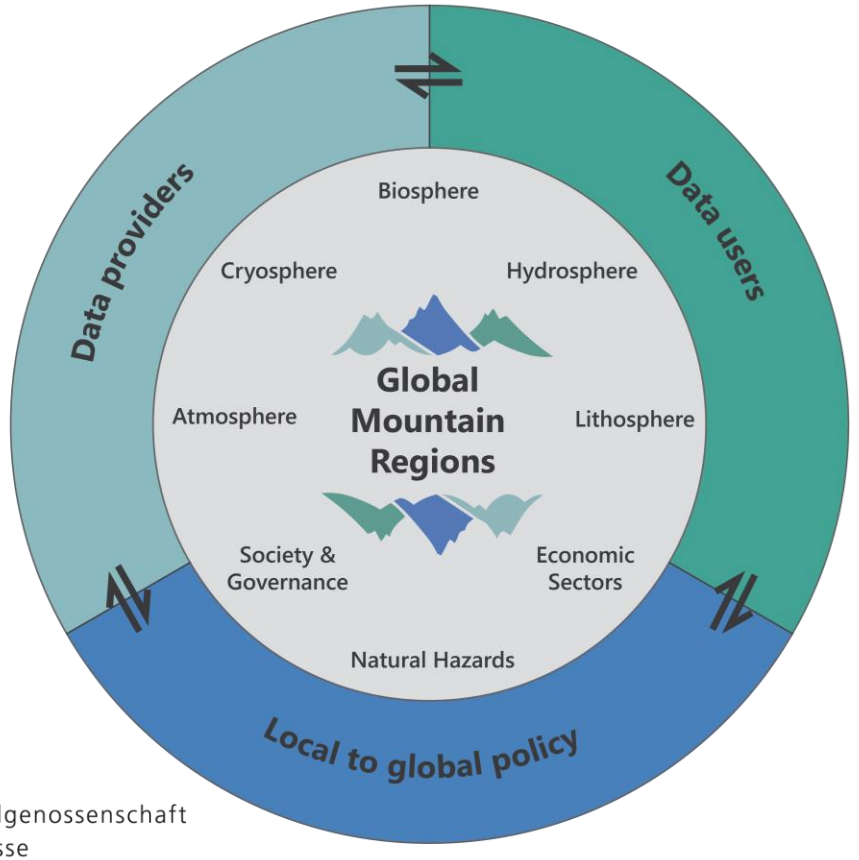
GEO Mountains

GEO MOUNTAINS
Observing Mountain Environments

The Global Network for Observations and Information in Mountain Environments

Objectives:

- To **increase** the **discoverability**, **accessibility**, and **use** of **mountain data**
- To **apply mountain data and information** for **scientific**, **policy**, and **practical impact**
- To **build** and **share capacity across** a community of mountain researchers, practitioners, and policy makers



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Many thanks!

Thornton et al. (2022). Human populations in the world's mountains: spatio-temporal patterns and potential controls, *PLOS ONE, 17(7)*, e0271466. doi: 10.1371/journal.pone.0271466

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