# Mountains and climate change: a short introduction


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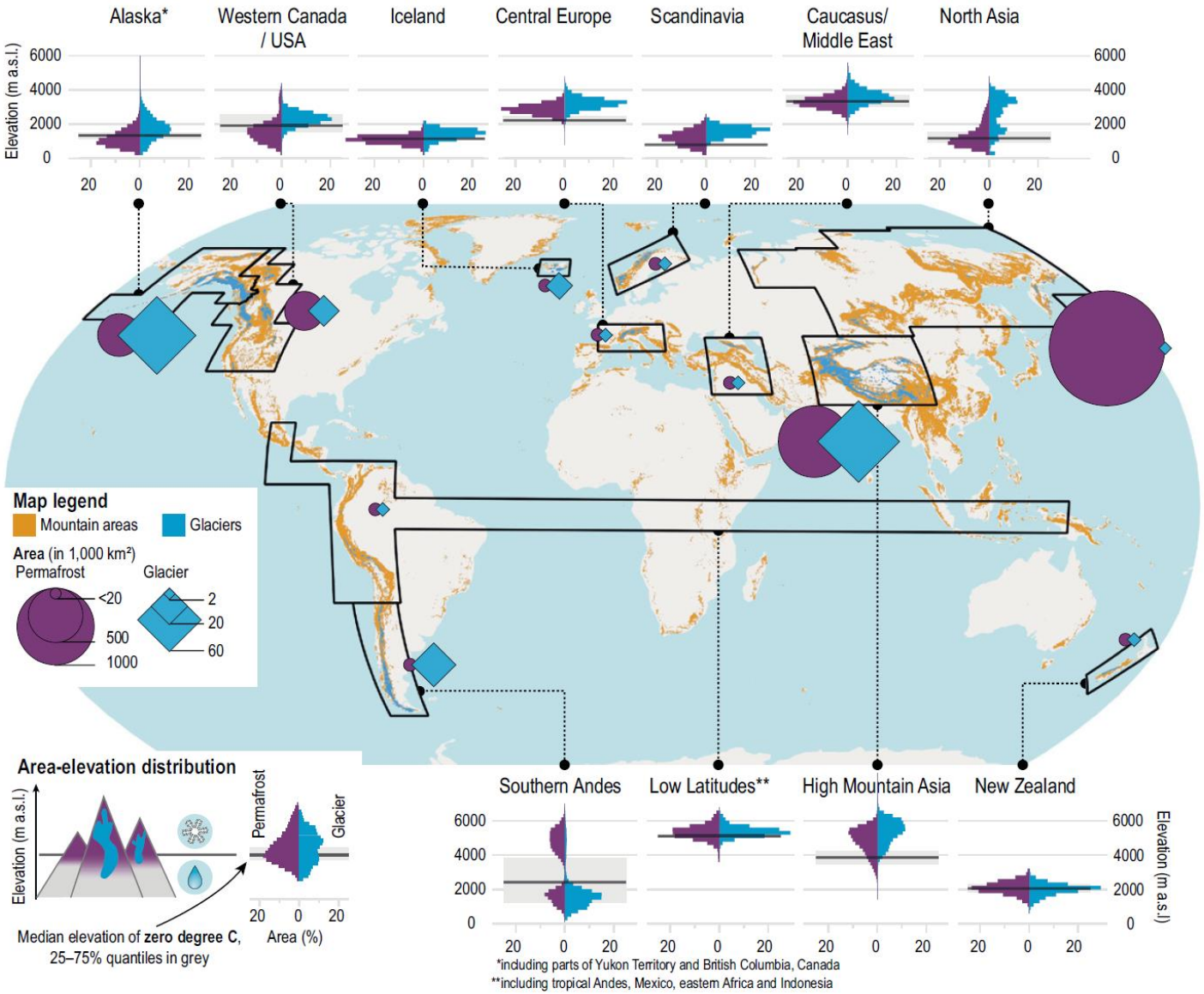
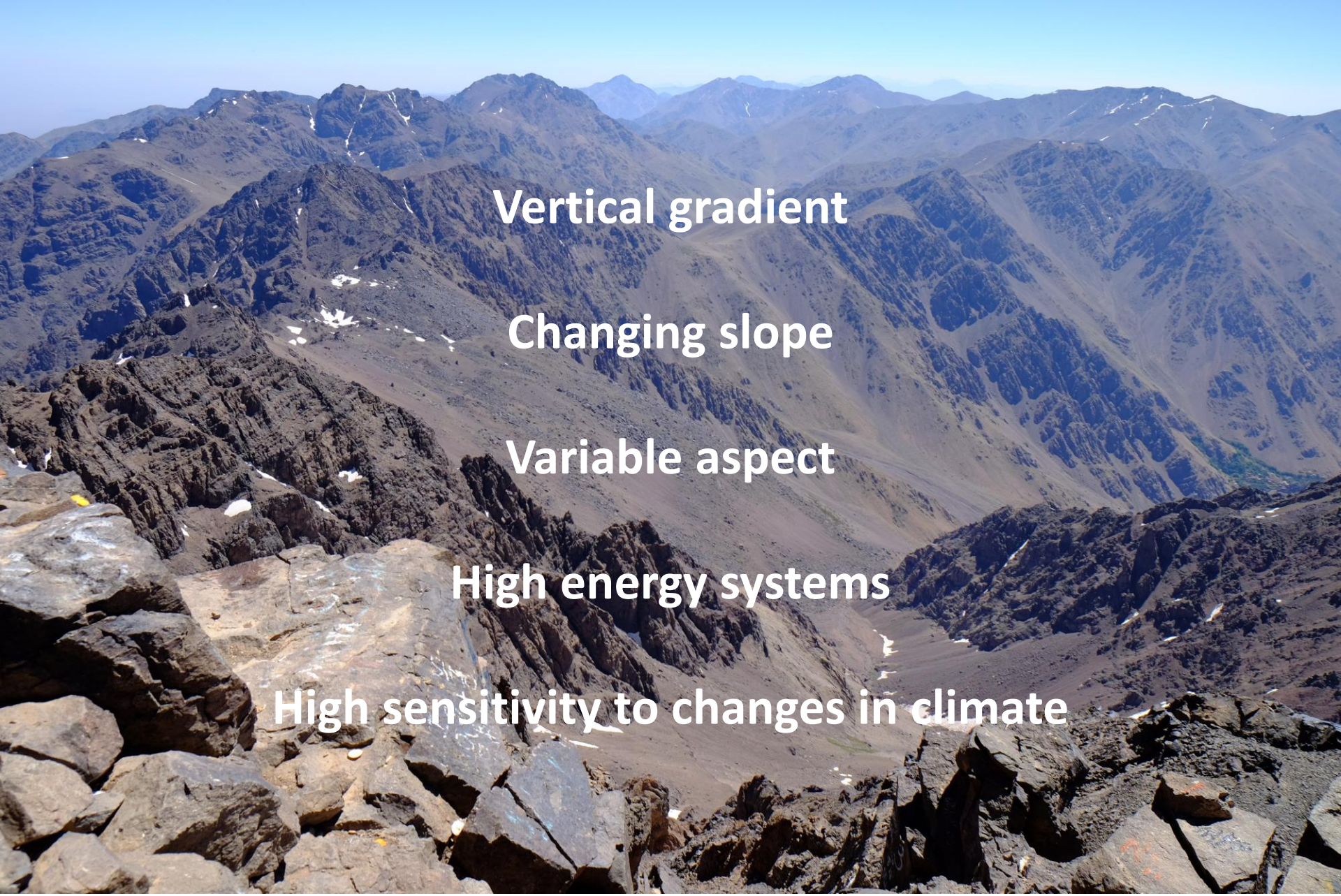
# World Mountains and Cryosphere




Hock et al (2019)



Vertical gradient

Changing slope

Variable aspect

High energy systems

High sensitivity to changes in climate

# Rich and complex mosaics of natural and socio-ecological systems

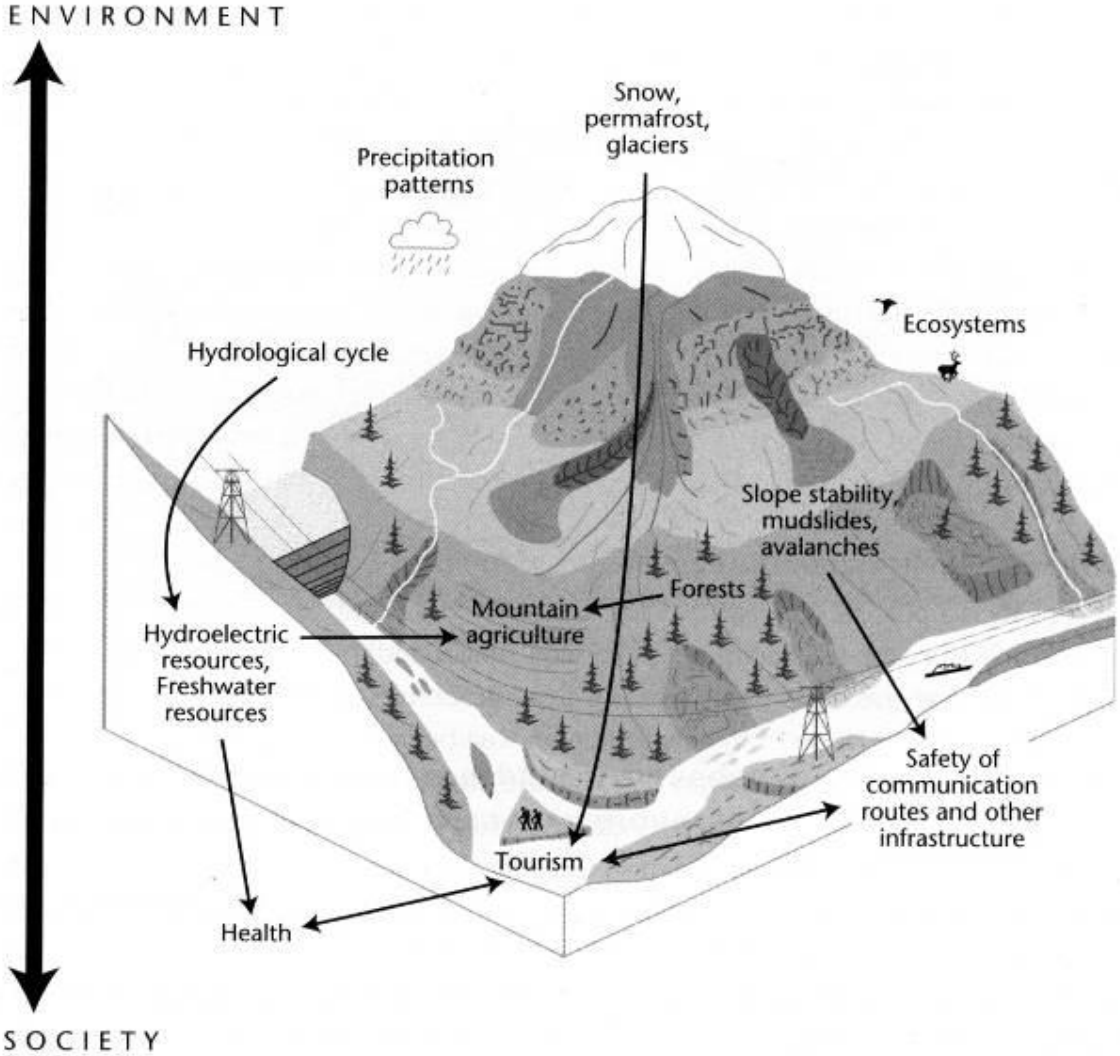
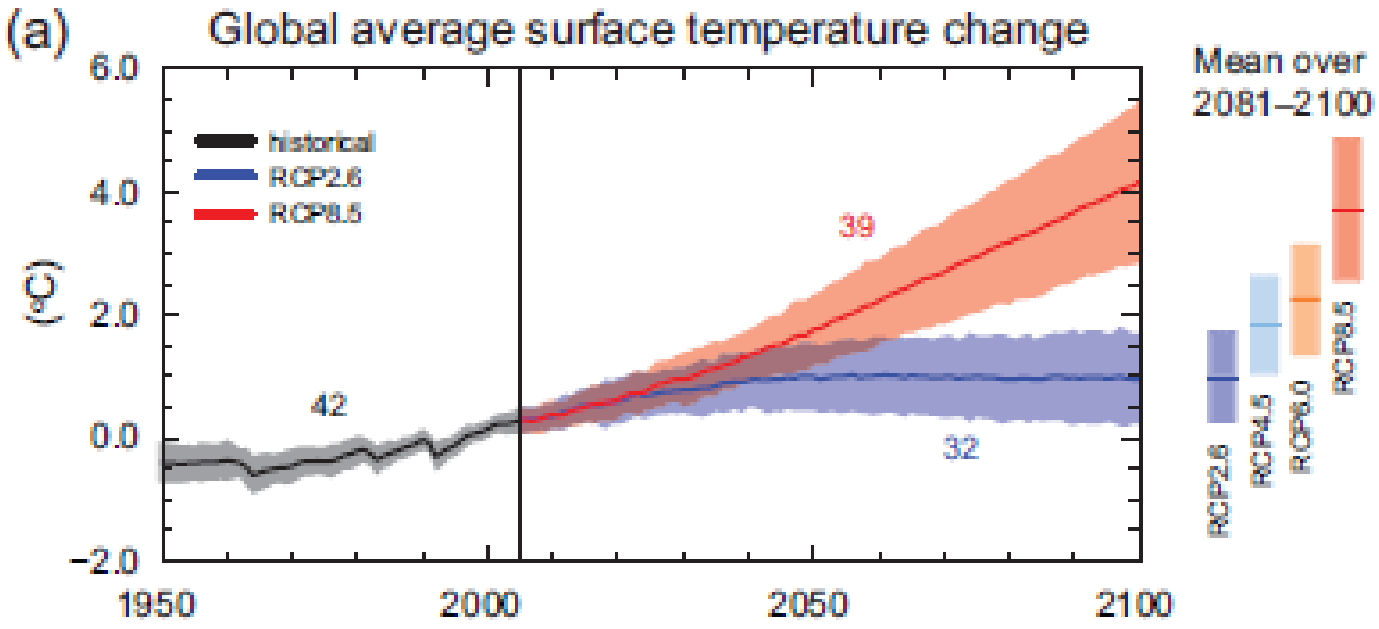


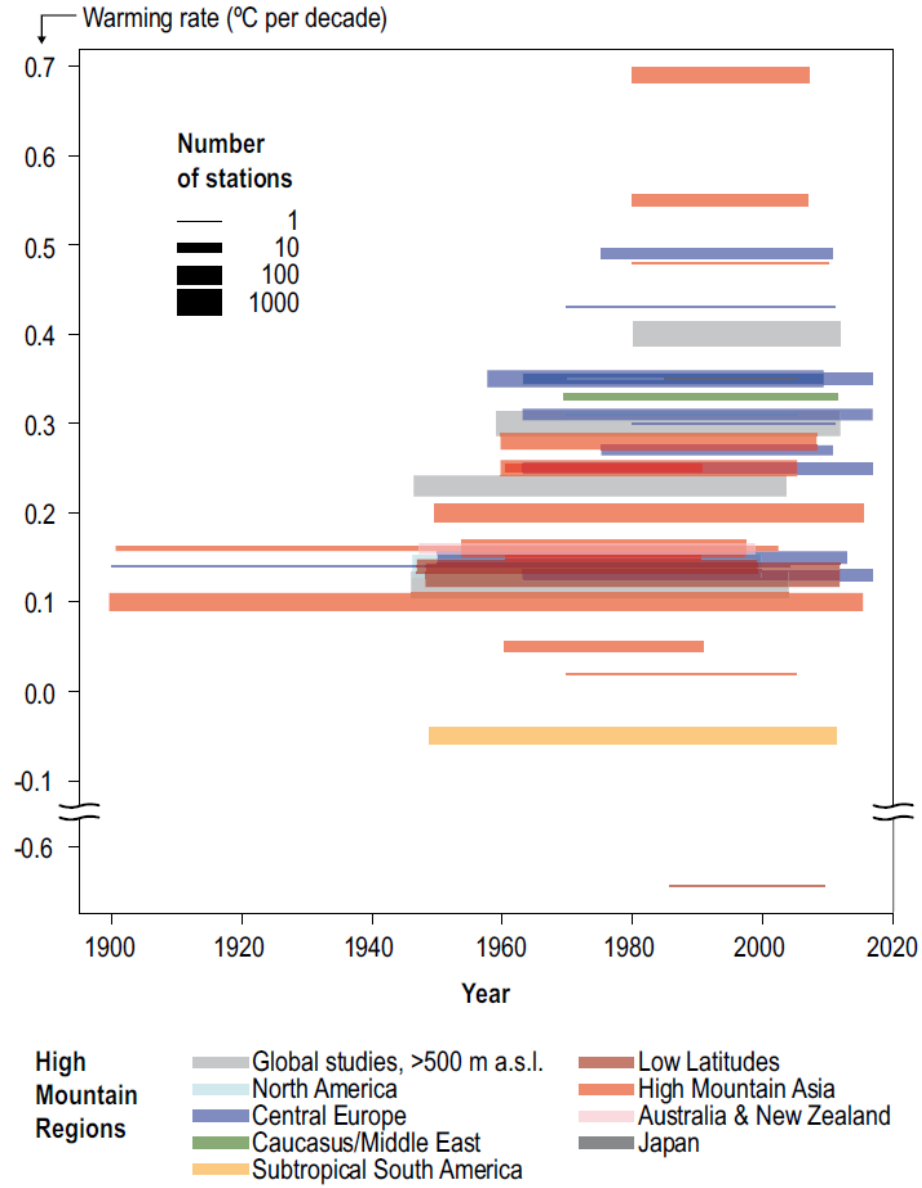

***Figure 12.9*** *Links between global environmental change and socio-economic activity in mountains*
Source: *modified from Beniston (2000).*

Beniston (2000)

# CMIP5 Multimodel simulated time-series (1950-2100) (IPCC 2014)



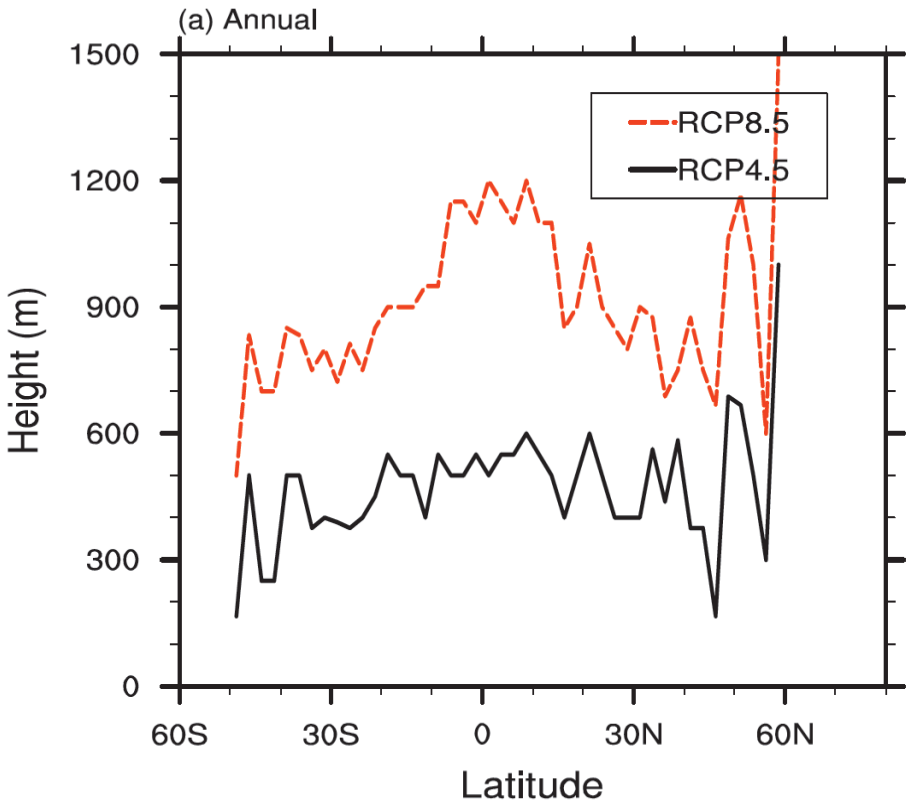
# Trends in air temperature change in mountain regions




Hock et al (2019)

**Figure 2.2 |** Synthesis of trends in mean annual surface air temperature in mountain regions, based on 4672 observation stations (partly overlapping) aggregated in 38 datasets reported in 19 studies. Each line refers to a warming rate from one dataset, calculated over the time period indicated by the extent of the line. Colours indicate mountain region (Figure 2.1), and line thickness the number of observation stations used. Detailed references are found in Table SM2.2, which also provides additional information on trends for individual seasons and other temperature indicators (daily minimum or maximum temperature).

# Projected rise of freezing levels along the American Cordillera from 1981-200 to 2081-2100




Kohler et al (2014)

# Precipitation change in mountains under high emissions scenario (1950-2000 to 2070)

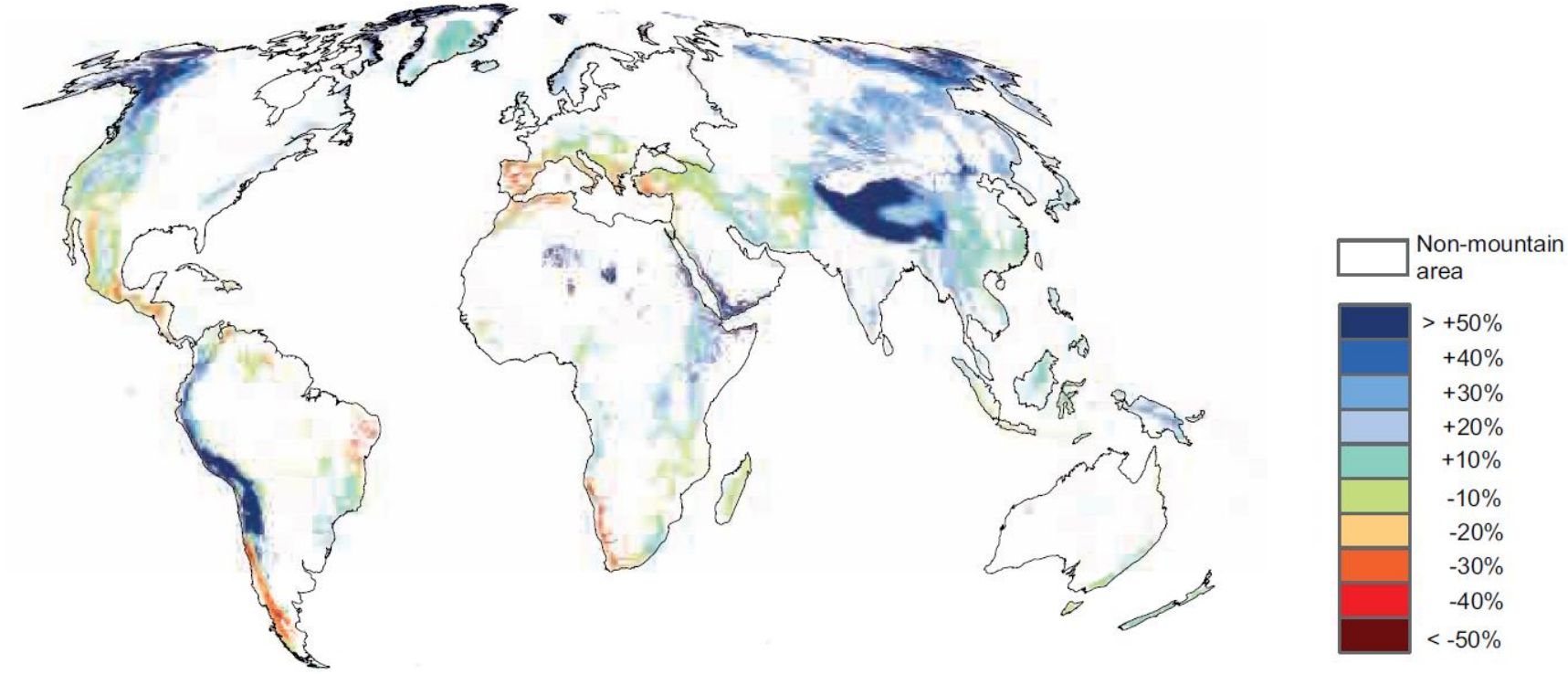



Figure 2.4. Percentage change of annual precipitation between 1950–2000 and 2070, based on the high emissions scenario RCP8.5. Precipitation data from IPCC (2014). Definition of mountain regions according to Kapos (modified). Courtesy of Andreas Heinimann and Lukas Wuersch (Centre for Development and Environment and Institute of Geography, University of Bern)

Kohler et al (2014)

# Changes in mountain hazards driven by cryospheric changes

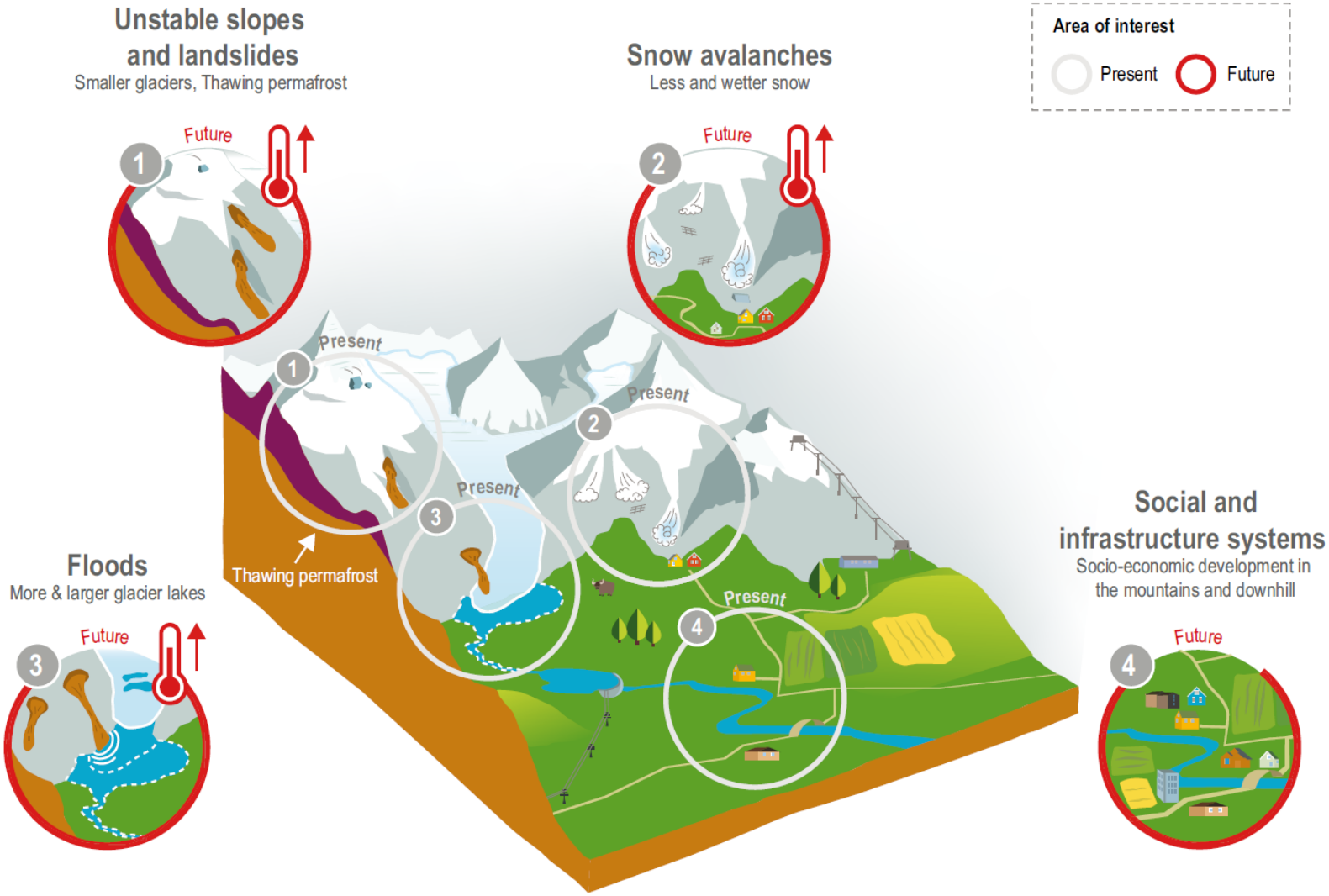



**Figure 2.7 |** Anticipated changes in high mountain hazards under climate change, driven by changes in snow cover, glaciers and permafrost, overlay changes in the exposure and vulnerability of individuals, communities, and mountain infrastructure.

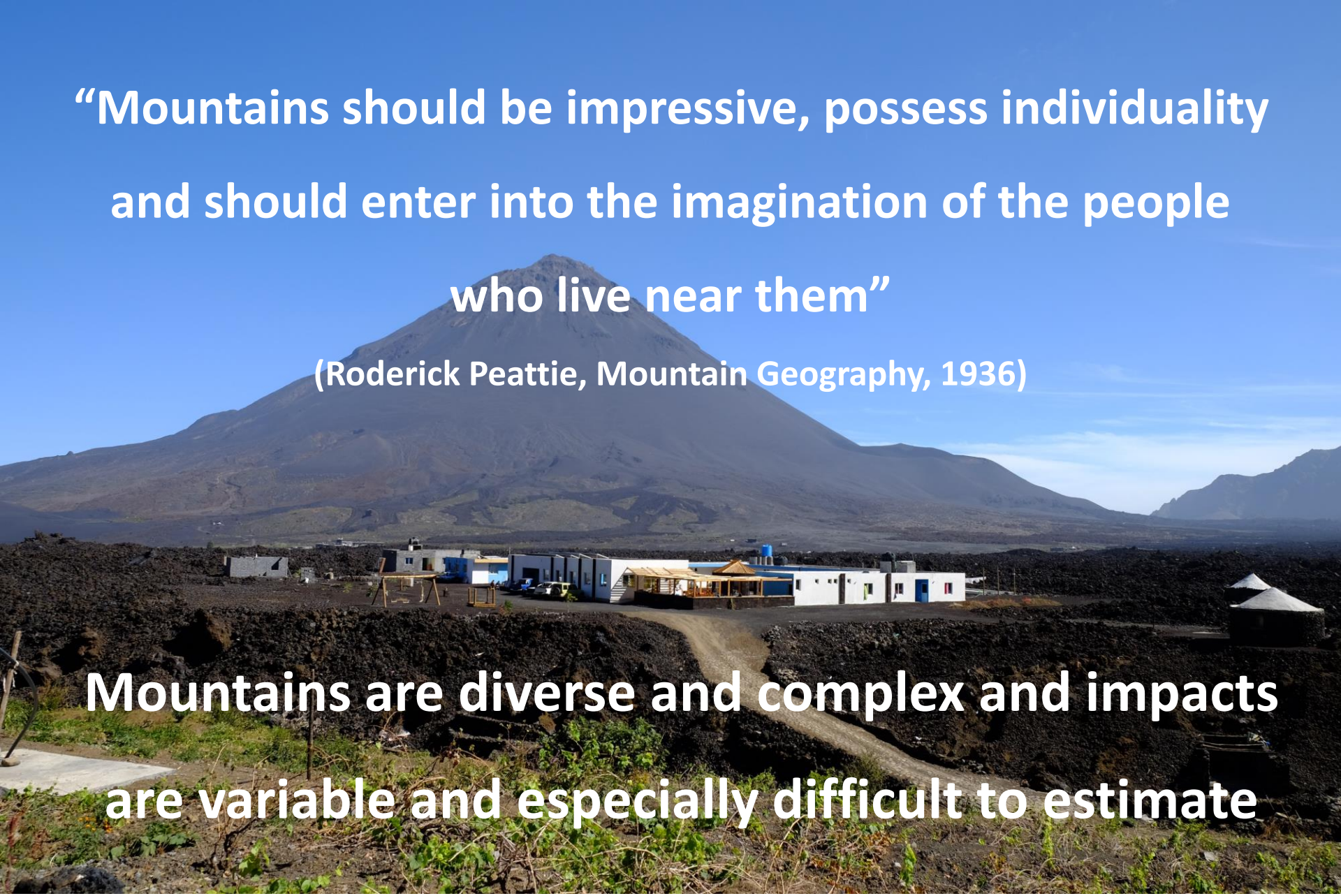
Hock et al (2019)

## Changes in the cryosphere and their impacts on mountain regions (Hock et al., 2019):

- The current trends in **mountain cryosphere change** should continue and should be intensified (very high confidence).
- **Cultural and natural heritage** (e.g. high glaciated mountains in many World Heritage sites), as well as **tourism and recreation activities** should be **negatively affected** by cryosphere changes in many regions (high confidence).
- **Snow, glaciers and permafrost will continue declining** in almost all regions during the XXI century (High confidence).
- Most **natural hazards** will change in frequency, magnitude and affected areas, following the decline in the cryosphere (high confidence)
- **River discharge in catchments** dominated by snow and glaciers will continue to change in amount and sazonality as a response to the decline in snow and glaciers (very high confidence) with **negative impacts in agriculture, hydroelectrical power production and water quality** in some regions (medium confidence).

**Main impacts of climate change in mountain regions (Kohler et al. 2014):**

- Water resources (mountains supply c. 50% of the Global population)
- Natural hazards (increase of extreme events, thawing permafrost and melting glaciers)
- Biodiversity (c. 50% of biodiversity hotspots are in mountains)
- Poverty and food security (12% of the World population lives in mountains, regions which are economically less developed).



“Mountains should be impressive, possess individuality and should enter into the imagination of the people who live near them”

(Roderick Peattie, Mountain Geography, 1936)

**Mountains are diverse and complex and impacts are variable and especially difficult to estimate**

Beniston, M. 2000. Environmental change in mountains and uplands, Arnold. London.

IPCC (2013). Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Hock, R., G. Rasul, C. Adler, B. Cáceres, S. Gruber, Y. Hirabayashi, M. Jackson, A. Kääb, S. Kang, S. Kutuzov, A. Milner, U. Molau, S. Morin, B. Orlove, and H. Steltzer, 2019: High Mountain Areas. In: *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate* [H.-O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Alegría, M. Nicolai, A. Okem, J. Petzold, B. Rama, N.M. Weyer (eds.)]. In press.

Kohler, T., Wehrli, A. & Jurek, M., eds. 2014. *Mountains and climate change: A global concern*. Sustainable Mountain Development Series. Bern, Switzerland, Centre for Development and Environment (CDE), Swiss Agency for Development and Cooperation (SDC) and Geographica Bernensia. 136 pp.