frontiers in Earth Science

EDITORIAL
published: 08 September 2021
doi: 10.3389/feart.2021.754260

Editorial: Geohazards and Risks in High Mountain Regions

Adam Emmer[1], Simon J. Cook[2,3], Holger Frey[4] and Dan H. Shugar[5]*

[1]The Mountain Processes and Mountain Hazards Group (Cascade), Institute of Geography and Regional Science, University of Graz, Graz, Austria, [2]Geography and Environmental Science, University of Dundee, Dundee, United Kingdom, [3]UNESCO Centre for Water Law, Policy and Science, University of Dundee, Dundee, United Kingdom, [4]Department of Geography, University of Zurich, Zurich, Switzerland, [5]Water, Sediment, Hazards, and Earth-Surface Dynamics (waterSHED) Lab, Department of Geoscience, University of Calgary, Calgary, AB, Canada

Keywords: high mountains, hazard assessment, disaster risk reduction, climate change impacts, glacier hazards, landslides, GLOF

Editorial on the Research Topic

Geohazards and Risks in High Mountain Regions

Mountains of the world are fragile eco- and geo-systems that currently face rapid and unprecedented changes associated with global climate change, as well as the expansion of (and exploitation by) societies (Huss et al., 2017; Immerzeel et al., 2020). The retreat and thinning of glaciers, formation of glacial lakes, degradation of mountain permafrost, alteration to mountain stream hydrology, development of large hydropower projects, and the growth of settlements and infrastructure development all illustrate rapid evolution of the world's mountain environments. Changing conditions give rise to further mutual interactions and feedbacks between the atmosphere, cryosphere, hydrosphere, geosphere, biosphere and anthroposphere, some of which with possibly adverse impacts on societies. Extreme events originating in mountain areas can involve large volumes of material, travel long distances downstream of the source zones, and generate disasters when interacting with the anthroposphere. A recent example is the 2021 Chamoli disaster in Uttarakhand, India, documenting existing challenges in predicting extreme magnitude mass movements on the one hand, whilst managing increasing exposure and vulnerability of societies to these processes on the other hand (Shugar et al., 2021).

In this Research Topic, we have collated a set of papers that document a wide range of rapid processes in diverse mountain environments, and an associated wide range of methodological approaches to address them. This collection comprises eight contributions that address a variety of challenges and topics (including different types of geohazards, ranging from general glacial hazards and glacial lake outburst floods to landslides, snow avalanches, and lahars) and geographical regions, spreading from mountain ranges of High Asia (Himalaya – Karakoram – Pamir), Italian Apennines, Peruvian Andes and the Trans-Mexican Volcanic Belt to mountain ranges of Alaska and British Columbia (**Figure 1**). An even larger diversity is observed among the authors of these contributions – 45 authors from 28 institutes located in 13 countries participated in this work.

Two contributions focus on glacial lake outburst floods (GLOFs) and one focuses on glacial hazards in general. Khadka et al. evaluate the susceptibility of glacial lakes to outburst floods in the Mahalangur Himalaya, Nepal. In the first step, the authors compiled an inventory of 345 lakes in the region. Using the analytical hierarchy process, the authors then evaluated the susceptibility of 64 lakes larger than 0.05 km^2, based on the set of six susceptibility indicators, concluding that seven lakes are highly susceptible to generating a GLOF. These findings correspond with previous studies undertaken in the region and further refine the results of existing work by taking smaller lakes into account. The contribution of Abdel-Fattah et al. also deals with glacial lake outburst floods, but in

OPEN ACCESS

Edited and reviewed by:
Carmine Galasso, University College London, United Kingdom

****Correspondence:***
Adam Emmer
adam.emmer@uni-graz.at

Specialty section:
This article was submitted to Geohazards and Georisks, a section of the journal Frontiers in Earth Science

Received: *06 August 2021*
Accepted: *26 August 2021*
Published: *08 September 2021*

Citation:
Emmer A, Cook SJ, Frey H and Shugar DH (2021) Editorial: Geohazards and Risks in High Mountain Regions. Front. Earth Sci. 9:754260. doi: 10.3389/feart.2021.754260

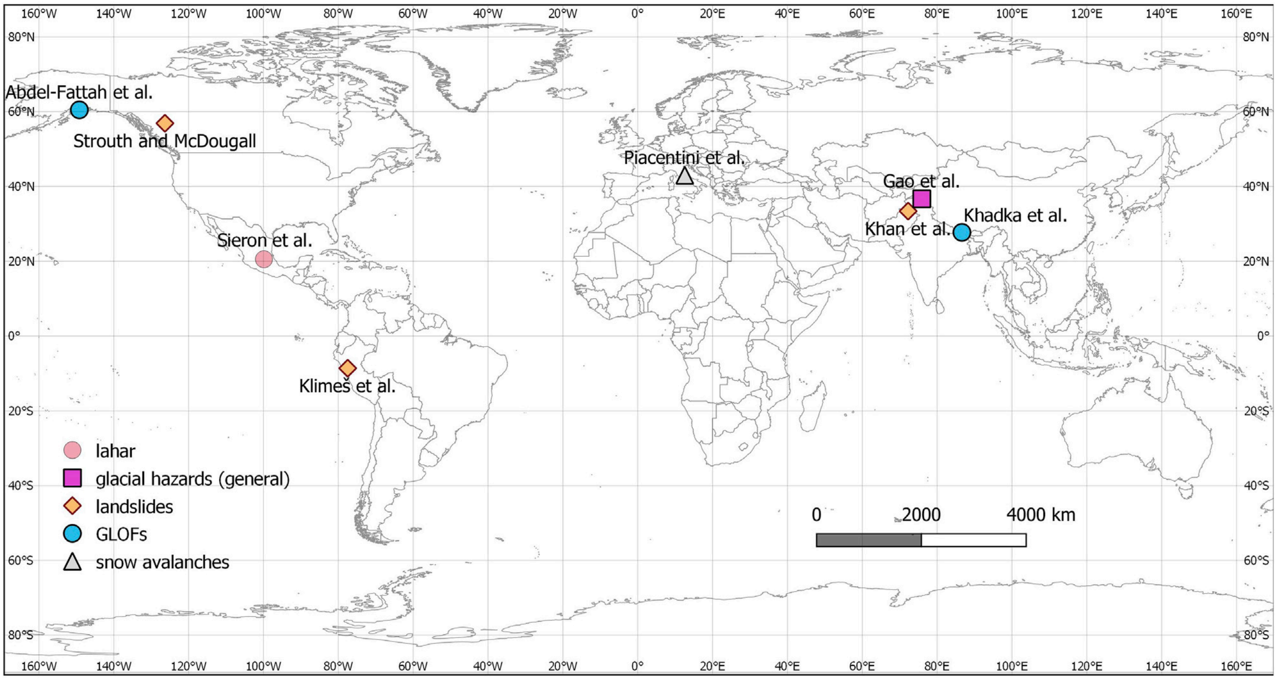

FIGURE 1 | Topical and geographical distribution of contributions in this Research Topic.

Alaska. The authors employed participatory approaches in order to investigate how communities exposed to GLOF risk utilize publicly available informational products, concluding that community-based knowledge development in cooperation with information developers can help in better understanding and enhanced preparedness for hazardous events such as GLOFs. Gao et al. synthesized the major glacier hazards along the Karakoram Highway using published reports supplemented by remote sensing data. They found that glacial lake outburst floods are most commonly associated with sudden advances of glaciers, called surges. They report that surge activity has been increasing in the past decade, which may lead to an increased flood risk in the future.

Three contributions deal with landslides in different parts of the world. Strouth and McDougall present a new database of landslide fatalities in British Columbia since 1880. Landslides are the most common type of disaster in British Columbia, yet a comprehensive and accurate accounting of the fatalities associated with these events was lacking. They found that landslide-induced fatalities are rare in British Columbia, averaging about one per year in the past decade. The authors also found that the number of fatalities has been dropping even as population has increased markedly. They conclude that loss of life may not be the most important consequence to consider for risk management, at least in the British Columbia context. Other variables, including property damage, economic losses, and transportation services disruption may be more appropriate. Khan et al. have undertaken a multi-method approach to the investigation of the surface and sub-surface structure of an unstable slope in northern Pakistan, which threatens the village of Mayun as well as a major highway. Geomorphological field observations are integrated with UAV (uncrewed aerial vehicle) imagery and GPR (ground penetrating radar) investigations to determine the nature and extent of slope deformation and instability. Klimeš et al. present a study on the assessment of slope stability of a paraglacial rock wall in the Safuna region, Peru, which experienced a landslide and a subsequent glacial lake outburst in 2002. They apply geological surveys, geotechnical lab experiments and engineering geological modeling combined with current and historic digital elevation models to reconstruct the history and current condition of this slope. They find that the geological and geotechnical conditions, combined with the glacier retreat and thinning, were crucial for the 2002 failure, but also they see a high slope failure hazard currently and recommend implementation of a slope movement monitoring system at this site.

The remaining two contributions focus on lahars and snow avalanches. Sieron et al. investigate the effect of Hurricane Ernesto in the triggering of a lahar event on Mexico's highest volcanic peak, Citlatépetl (Pico de Orizaba) in August 2012. In a forensic study using on-site and satellite-based precipitation data, pre-event terrain reconstruction, field evidence, satellite imagery and UAV photogrammetry, the triggering of the initial debris-flow, starting at >4,400 m a.s.l, is reconstructed. By also taking into account glacier history, permafrost conditions and properties of the involved sediments, concepts of lahar initiation and channel excavation are developed and verified. An outlook on future hazard development is also given. Piacentini et al. describe seismically-induced snow avalanches in the Abruzzo Region in

Central Italy. By integrating the analysis of the seismic catalogue, avalanche inventory, 3D numerical modelling and stability analysis, this study highlights the possibly underestimated role of earthquakes in the occurrence of snow avalanches in space and time. Building on two detailed case studies (2009 and 2017), the authors concluded that the lagged response to earthquakes may explain anomalous avalanche clusters that were observed.

As a concluding remark, we believe that individual papers from our collection can contribute to a better understanding of dynamic mountain environments, processes and their interactions with societies, and help in sustainable development and disaster risk reduction efforts in the world's mountain regions.

REFERENCES

Huss, M., Bookhagen, B., Huggel, C., Jacobsen, D., Bradley, R. S., Clague, J. J., et al. (2017). Toward Mountains without Permanent Snow and Ice. *Earth's Future* 5, 418–435. doi:10.1002/2016ef000514

Immerzeel, W. W., Lutz, A. F., Andrade, M., Bahl, A., Biemans, H., Bolch, T., et al. (2020). Importance and Vulnerability of the World's Water Towers. *Nature* 577, 364–369. doi:10.1038/s41586-019-1822-y

Shugar, D. H., Jacquemart, M., Shean, D., Bhushan, S., Upadhyay, K., Sattar, A., et al. (2021). A Massive Rock and Ice Avalanche Caused the 2021 Disaster at Chamoli, Indian Himalaya. *Science* 373, 300–306. online first. doi:10.1126/science.abh4455

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

AUTHOR CONTRIBUTIONS

The idea of and concept of this Research Topic came out from the discussion among the guest editors. AE drafted the initial version of this editorial. All authors contributed to the writing process of the editorial and approved the final version of it.

ACKNOWLEDGMENTS

We thank the various authors for submitting their work to this Research Topic and the reviewers who agreed to review individual contributions.