YEG-Article-7/2025

# How does climate change impact human activities in alpine regions? — A case study of the mountainous areas in northern Italy

**Yu Zhang**

**Department of Earth Science, University of Turin, Turin, Italy**

***yu.zhang@unito.it***

## 1. Introduction

In recent years, the intensification of global climate change has significantly impacted geological hazards in alpine regions (Stoffel et al., 2014; Wang et al., 2024). Climate warming has accelerated the melting of mountain glaciers, increasing the risk of ice avalanches (Ballesteros-Cánovas et al., 2018; Eckert et al., 2024). The increase in freeze-thaw cycles and extreme rainfall events has also destabilized rock layers, raising the likelihood of landslides and debris flows. Additionally, permafrost degradation due to climatic influences further contributes to these hazards. These natural disasters can alter the distribution of crustal stress, potentially triggering seismic activity, which, in turn, can induce secondary geological hazards, exacerbating the complexity and destructive power of these events. Northern Italy, surrounded by the Alps, is a typical alpine region characterized by high altitudes, low temperatures, and perennial snow and ice cover. This region has been increasingly troubled by geological hazards due to global warming, which has constrained numerous human activities. The tourism industry, agriculture, animal husbandry, water resources, and infrastructure have all been significantly affected, posing threats to the lifestyle and safety of residents. Therefore, it is imperative to implement improved measures to prevent or reduce the occurrence of geological hazards.

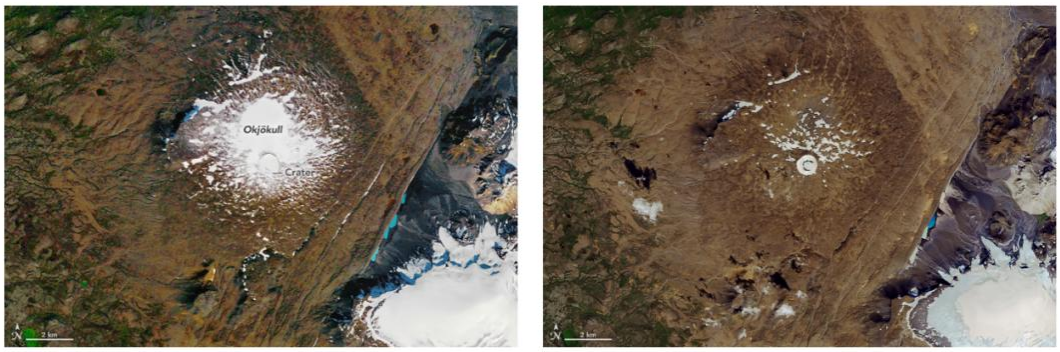


Figure 1 Okjökull glacier melt, is the first famous glacier in Iceland to be victimized by climate change (Bruns, 2021). Left: 07.09.1986. Right: 01.08.2019 (CGTN., 2019)



## 2. Status Quo and Future Implications

I have established research goals that consider the geological environment and conditions in the mountainous regions of northern Italy. My study aims to use acoustic emission (AE)-based machine learning approaches to understand crack propagation and rock degradation under different confining pressures during freeze-thaw cycles. By numerically simulating multiple freeze-thaw cycles and recording AE data, I aim to develop a high-precision machine learning model capable of accurately predicting the crack propagation paths and the rock degradation extent of rock samples. This research will deepen our understanding of rock mechanical behavior and provide new methods and technical support for assessing the durability of engineering and mountain structures, with significant implications for civil engineering and geological disaster prediction.

Currently, I am using the PFC (Particle Flow Code) discrete element analysis software to perform numerical modeling, following the methodologies outlined in King's article (King et al., 2021). This modeling replicates the stress-strain mechanisms, AE behavior, energy changes, AE size distribution, and fracture modes of Alzo granite from northern Italy under various confining pressures, using triaxial stress loading. The results obtained so far have validated the accuracy of my numerical modeling and confirmed the correctness of the modeling approach, thus providing a solid foundation for the planned numerical modeling of freeze-thaw cycle studies.

## 3. Conclusion

The northern Italian alpine region is characterized by high altitudes, low temperatures, and perennial snow and ice cover. It is a hub of human activity, featuring numerous tourist destinations, agricultural and pastoral areas, and is especially renowned as a skiing destination in winter, attracting people from around the world. These attributes make it an ideal research area for my study. Italy provides an open and vibrant academic environment. Collaborative exchanges with various researchers not only broaden my academic horizons but also provide invaluable insights and suggestions, significantly propelling my research forward. The combination of the unique characteristics of the northern Italian alpine region and the supportive academic environment in Italy offers me an optimal setting to pursue my research objectives. Ultimately, my research will provide insights into the degradation and mechanical behavior of rocks under freeze-thaw conditions in high-altitude cold regions, aiding in the identification of potential damage risks, reducing the risks associated with human activities, and enhancing engineering safety.

**Acknowledgments**

This work is financially supported by the China Scholarship Council, No.202208410062. The author thanks Prof. S.C. Vinciguerra for his valuable comments and assistance in writing the article.

**References**

Bruns C J (2021). Grieving Okjökull: discourses of the Ok glacier funeral. In Bødker, H and Morris, HE (eds), Climate Change and Journalism. Negotiating Rifts of Time. London, New York, NY: Routledge, pp. 121–135. eBook ISBN: 9781003090304.

Ballesteros-Cánovas J A, Trappmann D, Madrigal-González J, Eckert N, Stoffel M (2018). Climate warming enhances snow avalanche risk in the Western Himalayas. Proceedings of the National Academy of Sciences, 2018, 115(13): 3410-3415. https://doi.org/10.1073/pnas.1716913115.

CGTN: Picture. NASA highlights Iceland glacier's disappearance with satellite photos. VCG Photo. 18 Aug 2019. Web. 20 Oct 2024. https://news.cgtn.com/news/2019-08-18/-NASA-highlights-Iceland-glacier-s-disappearance-on-satellite-photos-Jgkg3qszcI/index.html#.

Eckert N, Corona C, Giacona F, Gaume J, Mayr S, Herwijnen A, Hagenmuller P, Stoffel M (2024). Climate change impacts on snow avalanche activity and related risks. Nature Reviews Earth & Environment, 1-21. https://doi.org/10.1038/s43017-024-00540-2.

King T, Vinciguerra S, Burgess J, Benson P, De Siena L (2021). Source mechanisms of laboratory earthquakes during fault nucleation and formation. Journal of Geophysical Research: Solid Earth, 126(5): e2020JB021059. https://doi.org/10.1029/2020JB021059.

Stoffel M, Tiranti D, Huggel C (2014). Climate change impacts on mass movements—case studies from the European Alps. Science of the Total Environment, 493: 1255-1266. https://doi.org/10.1016/j.scitotenv.2014.02.102.

Wang H, Bin-Bin W, Cui P, Ma Y, Wang Y, Hao J, et al. (2024). Disaster effects of climate change in High-Mountain Asia: State of art and scientific challenges. Advances in Climate Change Research, 15(3), 367-389. https://doi.org/10.1016/j.accre.2024.06.003.

**Author Responsibility Disclaimer**

During the preparation of this work, the author did not utilize ChatGPT or any similar software to generate content and took full responsibility for the publication's content. Additionally, the author is responsible for referencing all figures, tables, and information shared in this article.