

Review of the manuscript: egosphere-2024-2509

Massive permafrost rock slide under warming polythermal glacier (Bliggspitze, Austria)

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The manuscript is a back analyses of a multimillion cubic meter rock slide at Bliggspitze on 29 June 2007. It is based on a detailed geological/structural model of the failure zone, remote sensing data of the glacial extension of the Bliggferner glacier and its change, on-site temperature data from the failed mountain as well as metrological data from close by meteorological stations, data on springs from the slope, electric resistivity tomography on the slope from after failure as well as laboratory experiments on rock samples from the mountain and advanced 2D stability modelling using the software UDEC.

The topic is extremely timely as it relates slope stability to climate change. This case is particular interesting and unique as it investigates a rockslide that forms subglacial, and the study is unique in its depth in this environment adding to multiple studies in permafrost environment that are less related to glacial ice decay. The manuscript is very well written and balanced. Assumptions are well highlighted, and uncertainties based on the limited amount of data thoroughly discussed. Sensitivity tests were carried out and are well described. This manuscript puts light on changes that will occur in the high alpine but also artic environment with potential hazardous consequences for society.

I can only suggest minor revisions/technical corrections to this well written manuscript with a high quality and well-developed figures.

My suggestions are:

Add “slope stability analysis” into the title.

Add coordinate system in all maps or block diagrams

Add view position of all photos presented into the maps

Add directions to the photos eg. NW-SE in upper right and left

Figure 16 is too small in size in the manuscript, it is difficult to read, consider enlarging

Add more references from outside the Alps to the reference list which will set a more global perspective. E.g. some suggestions:

Line: 33:

Geertsema, M., Menounos, B., Bullard, G., Carrivick, J. L., Clague, J., Dai, C., et al. (2022). The 28 November 2020 landslide, tsunami, and outburst flood—A hazard cascade associated with rapid deglaciation at Elliot Creek, British Columbia, Canada. *Geophysical research letters*, 49(6), e2021GL096716.

Svennevig, K., Hicks, S. P., Forbriger, T., Lecocq, T., Widmer-Schmidrig, R., Mangeney, A., et al. (2024). A rockslide-generated tsunami in a Greenland fjord rang Earth for 9 days. *Science*, 385(6714), 1196-1205.

Kuhn, D., Torizin, J., Fuchs, M., Hermanns, R., Redfield, T., & Balzer, D. (2021). Back analysis of a coastal cliff failure along the Forkastningsfjellet coastline, Svalbard: Implications for controlling and triggering factors. *Geomorphology*, 389, 107850.

Line 39:

Svennevig, K., Dahl-Jensen, T., Keiding, M., Merryman Boncori, J. P., Larsen, T. B., Salehi, S., et al. (2020). Evolution of events before and after the 17 June 2017 rock avalanche at Karrat Fjord, West Greenland – a multidisciplinary approach to detecting and locating unstable rock slopes in a remote Arctic area. *Earth Surf. Dynam.*, 8(4), 1021-1038. doi:10.5194/esurf-8-1021-2020.

Line 41: (Rewrite the paragraph before accordingly)

Ballantyne, C. K., Sandeman, G. F., Stone, J. O., & Wilson, P. (2014). Rock-slope failure following Late Pleistocene deglaciation on tectonically stable mountainous terrain. *Quaternary Science Reviews*, 86, 144-157.

Hermanns, R. L., Schleier, M., Böhme, M., Blikra, L. H., Gosse, J., Ivy-Ochs, S., et al. (2017) 'Rock-Avalanche Activity in W and S Norway Peaks After the Retreat of the Scandinavian Ice Sheet' *Workshop on World Landslide Forum*. Springer, pp. 331-338.

Line 504:

Geertsema, M., Menounos, B., Bullard, G., Carrivick, J. L., Clague, J., Dai, C., et al. (2022). The 28 November 2020 landslide, tsunami, and outburst flood—A hazard cascade associated with rapid deglaciation at Elliot Creek, British Columbia, Canada. *Geophysical research letters*, 49(6), e2021GL096716.

Line 618: (here there are references missing at all) Some suggestions:

Willenberg, H., Evans, K. F., Eberhardt, E., Spillmann, T., & Loew, S. (2008). Internal structure and deformation of an unstable crystalline rock mass above Randa (Switzerland): Part II - Three-dimensional deformation patterns. *Engineering Geology*, 101(1-2), 15-32.
doi:<http://dx.doi.org/10.1016/j.enggeo.2008.01.016>.

Brideau, M.-A., Yan, M., & Stead, D. (2009). The role of tectonic damage and brittle rock fracture in the development of large rock slope failures. *Geomorphology*, 103(1), 30-49.
doi:<http://dx.doi.org/10.1016/j.geomorph.2008.04.010>.

Welkner, D., Eberhardt, E., & Hermanns, R. L. (2010). Hazard investigation of the Portillo Rock Avalanche site, central Andes, Chile, using an integrated field mapping and numerical modelling approach. *Engineering Geology*, 114(3-4), 278-297.
doi:<http://dx.doi.org/10.1016/j.enggeo.2010.05.007>.

Brideau, M.-A., & Stead, D. (2012). Evaluating kinematic controls on planar translational slope failure mechanisms using three-dimensional distinct element modelling. *Geotechnical and Geological Engineering*, 30, 991-1011.

Lines 775-785:

I would also suggest discussing against:

Geertsema, M., Menounos, B., Bullard, G., Carrivick, J. L., Clague, J., Dai, C., et al. (2022). The 28 November 2020 landslide, tsunami, and outburst flood—A hazard cascade associated with rapid deglaciation at Elliot Creek, British Columbia, Canada. *Geophysical research letters*, 49(6), e2021GL096716.

Svennevig, K., Hicks, S. P., Forbriger, T., Lecocq, T., Widmer-Schmidrig, R., Mangeney, A., et al. (2024). A rockslide-generated tsunami in a Greenland fjord rang Earth for 9 days. *Science*, 385(6714), 1196-1205.

Some minor typos:

Line 307: there seems to be one or more words missing

Line 317: a space missing after “glacier,”

Line 319: consider “up-glacier” and “fracture band”

Line 330: is rather a repetition of the method section

Line 386: May be rewrite “The picture ...”

Line 412: Figure number is missing.

Line 451 and 454: consider writing in the same wording: “ice-free stage” and “glacier-free conditions” reads as if different aspects are meant. If indeed different aspects are meant make clearer the difference in both sentences.

Line 459 a space is missing after the bracket

Line 804 the “,” should be positioned prior to the line break