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Risk of steep glacier collapse in the Alps will considerably increase due to climate warming

Glaciers are sensitive indicators of climate change. This study focused on hanging glaciers in the French Alps, where warming is increasing the risk of glaciers collapsing. The authors applied a state-of-the-art numerical model to a particularly hazardous glacier in Mont Blanc to simulate how it will respond to climate change. The results suggest the glacier may become unstable in the current century, posing a risk to the inhabitants of the valley below.

Glaciers make up around 10%[1] of the world's total land area and are constantly moving under their own weight. At high elevation, glaciers can be stable on a very steep slope due to their cold temperature and 'hanging' glaciers can be formed. There, glaciers are often terminated by ice blocks called 'seracs' at the point where the slope becomes too steep to support any glacier.

Hanging glaciers are localised in the accumulation zone where snow is accumulated every year to be progressively compressed into ice. This accumulated snow forms a layer of granular or crystalline snow — 'firn' — that can undergo substantial warming as a result of climate change and increasing surface melting. This warming then propagates toward the bedrock until the temperature between the ice and the rock eventually reaches melting point, leading to potential glacier collapse. Modelling how future warming may affect glacier stability is therefore essential to protect the valleys below, which may be densely populated.

In this study, researchers applied a numerical modelling framework to model changes to ice temperature and to predict the volume of ice that may become unstable under future conditions. The 3D model simulates the thermal and mechanical response of the glacier to climate change in terms of changes to its thickness, temperature, density, water content and speed of movement. The authors, funded by European programmes ACQWA[2] and GlaRiskAlp[3], applied the model to the Taconnaz glacier in the Mont Blanc area of France. This glacier is of special interest, as it sits above inhabited areas in the Chamonix valley.

The simulations, constrained by borehole temperature measurements, revealed that the glacier and its surface snow were generally cold until 1980, when significant increases in air temperature caused a temperate layer of snow to form in the lower part of the glacier. By 2012, this layer had reached a depth of 20 metres. Furthermore, from the 20th century to 2012, the volume of temperate ice increased from 2% of the total glacier volume to approximately 10%. This is alarming because, as the temperature of the firn increases, it shows that the whole glacier is warming and could reach the melting point at its base, leading to collapse.

The authors say extension of the temperate ice to the bedrock is inevitable and future simulations suggest that the lower section of the glacier may reach melting point around 2080 for the warmest climate scenario.

For this scenario, temperate ice would comprise 40% of the glacier's total volume by 2100. The authors say the Taconnaz glacier poses a high risk for the populated region below, and that the results of their numerical model should help public authorities to better assess the hazard and establish precautionary measures.

Many cold glaciers in the Alps are at similar elevations to Taconnaz and subject to similar warming. In light of the climate projections, the authors say any steep hanging glaciers below 4000 metres above sea level are likely to become partially temperate by the end of the century. The observation and modelling of these similar glaciers should be a priority. The researchers say their numerical model provides a useful framework to do this, but state that each individual glacier requires a specially adapted model.

1. US National Snow & Ice Data Centre. See: https://nsidc.org/cryosphere/glaciers/questions/what.html
2. Assessing Climate impacts on the Quantity and quality of Water (ACQWA) was supported by the European Commission under the Seventh Framework Programme. See: http://www.acqwa.ch/
3. GlaRiskAlp was part-funded by the European Commission through the European Regional Development Fund. See: http://www.glariskalp.eu/