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Climate warming and stability of cold hanging glaciers Lessons from the gigantic 1895 Altels break-off

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The Altels hanging glacier broke off on September 11, 1895. The ice volume of this catastrophic rupture was estimated to 4.10^6 cubic meters and is the largest ever observed ice fall event in the Alps. However, the causes of this collapse are not entirely clear. Based on previous studies, we reanalyzed this break-off event, with help of a new numerical model. This model, initially developed by Faillettaz et al. (2010) for gravity-driven instabilities, was applied to this glacier. It takes into account the progressive maturation of a heterogeneous mass towards a gravity-driven instability, characterized by the competition between frictional sliding and tensile cracking. We use an array of sliding blocks on an inclined (and curved) basal surface, which interact via elastic-brittle springs. A realistic state- and rate-dependent friction law is used for the block-bed interaction. We model the evolution of the inner material properties of the ice and its progressive damage eventually leading to failure, by means of a stress corrosion law governing the rupture of the springs.

It appeared that such a break-off event could only happen when the basal friction at the bedrock is reduced in a restricted area, possibly induced by the storage of infiltrated water within the glacier. This result seems to be confirmed by the hot summers prior to the collapse. Moreover, a two-step behavior could be evidenced: (i) A first quiescent phase, without visible changes, with a duration depending on the rate of basal changes. (ii) An active phase with a rapid increase of basal motion within a few days. As a consequence, a crown crevasse opens within a few days (which was observed) prior the final collapse. This means that the destabilization process of a hanging glacier due to a progressive warming of the ice/bed interface towards a temperate regime is expected to occur without easily visible signs until a few days prior to the break-off event.

In a more general context, global climate warming may influence the stability of cold hanging glaciers. As the rupture process takes some time to develop and external precursors are only visible shortly before the break-off, some hanging glacier still, at least partially, frozen to the bedrock may currently be in an unstable phase.

References

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