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Potential precursors of ice failures in the Planpincieux glacier

Niccolò Dematteis, Daniele Giordan, and Paolo Allasia

Geohazard Monitoring Group, Research Institute for Hydro-Geological Protection, National Council of Research of Italy, Turin, Italy (niccolo.dematteis@irpi.cnr.it)

At the state of art, the prediction of the instant and magnitude of glacier-related natural hazards (e.g., ice or snow avalanches, water outbursts) is quite difficult and uncertain. Such phenomena are often triggered by ice detachments from the glacier body. Recent studies revealed that in particular cases it is possible to identify potential precursors of ice detachments in cold glaciers. The precursors can be a combination of meteorological conditions, fracture and crevasse widening and ice temperature change. Conversely, temperate glaciers are more complex to model, therefore it is quite difficult to forecast failure events.

In our work, we present the relationship between the surface velocity and the detached ice volumes as a possible identification of potential precursors of failure events from the snout of the Planpincieux temperate glacier, in the Italian side of the Mont Blanc massif. The area has been monitored by a monoscopic visual-based system (VBS) equipped with SLR camera that acquired one image per hour during the months from May to October in the years 2015, 2016 and 2017.

We processed the photographs through the image cross-correlation (ICC) techniques to measure the surface kinematics of the lower part of the glacier. Besides the surface velocity, the visual data allowed us to directly observe the morphological evolution of the glacier. In particular, we were able to identify the ice detachments triggered from the snout and to roughly estimate the volume of the collapses.

During the three years, we observed a peculiar behavior of the frontal sector. In the warm seasons, a large crevasse widened approximately at the same position just above the snout, suggesting a geometrical trigger of such phenomenon. Moreover, the glacier motion showed two or three sharp accelerations per year, culminated with great ice detachments; opposite decelerations occurred immediately after. This process can be represented as the action of the elastic energy due to the released of potential energy.

Overall, we registered 87 failures with a volume greater than 100 m^3 of which 8 events with volumes included between 5000 and 60000 m^3. We found out that the volume of the collapses exponentially increased with the surface velocity (R^2 = 0.68). Moreover, we observed a failure probability greater than 50% when the velocity exceed 55 cm/day.

The study we conducted evidenced the relationship between velocity and failure volume and it allowed the analysis of the dynamics and rheology of the glacier.