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Assessing the influence of bedrock discontinuities on glacier fractures using ground-penetrating radar and structure from motion

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The Planpincieux Glacier lies in the Italian side of the Grandes Jorasses massif (Mont Blanc area), toward the Ferret Valley, in the Courmayeur municipality. This is a highly touristic area, visited every year by tens of thousands of people.

In summers 2019 and 2020, large portions of the Montitaz Lobe of the glacier (estimated volumes of 250000 m³ and 500000 m³ respectively) became unstable and menaced the Planpincieux village. According to runout simulations, such volumes could have reached and damaged a small bridge, buildings or the main valley road, depending on the volume involved in the collapse. Therefore, robust volume estimation was required for the realisation of effective safety plans.

To this aim, a helicopter-borne ground-penetrating-radar (GPR) survey was conducted in July 2020 with the novel dual polarization AIRETH system. Such a survey provided the ice thickness (20-60 ±10 m) of the unstable portion and the bedrock topography along transects.

Besides, multiple helicopter and drone photogrammetric surveys were acquired since 2017, which provided the digital terrain model (DTM) and the orthophotos of the glacier using structure from motion (SfM) technique.

Merging GPR and SfM allowed at reconstructing the evolution of the glacier shrinkage in the period where DTMs were available. Moreover, it was possible to assess the correspondence of several bedrock discontinuities with large recurrent fractures.

Even though it is commonly acknowledged that the bedrock topography influences the glacier morphology, their correspondence has been rarely demonstrated in an Alpine glacier.

Since the fractures provoked by the bedrock discontinuities might destabilise the underlying glacier portion, the knowledge of the actual position of such fractures can help in the quantitative evaluation of the glacier instability. This can have a strong impact in the potential glacier-related risk assessment and management.