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The open-air laboratory of the Grandes Jorasses glaciers. An opportunity for developing close-range remote sensing monitoring systems

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Glaciological phenomena can have a strong impact on human activities in terms of hazards and freshwater supply. Therefore, scientific observation and continuous monitoring are fundamental to investigate their current state and recent evolution. Strong efforts in this field have been spent in the Grandes Jorasses massif (Mont Blanc area), where several break-offs and avalanches from the Planpincieux Glacier and the Whympfer Serac (Grandes Jorasses Massif) threatened the Planpincieux hamlet in the past. In the last decade, multiple close-range remote sensing surveys have been conducted to study the glaciers.

Two time-lapse cameras monitor the Planpincieux Glacier since 2013. Its surface kinematics is measured with digital image correlation. Image analysis techniques allowed at classifying different instability processes that cause break-offs and at estimating their volume. The investigation revealed possible break-off precursors and a monotonic relationship between glacier velocity and break-off volume, which might help for risk evaluation.

A robotised total station monitors the Whympfer Serac since 2009. The extreme high-mountain conditions force to replace periodically the stakes of the prism network that are lost.

In addition to these permanent monitoring systems, five campaigns with different commercial terrestrial interferometric radars have been conducted between 2013 and 2019. In 2020, two terrestrial GBSAR were installed for the improvement of the monitoring network of both glaciers. The adopted monitoring network is also composed by a Doppler radar that controls the potential detachment of ice blocks from the frontal part of the Planpincieux glacier. Besides, helicopter-borne LiDAR, terrestrial laser scanner and structure from motion applied to photo mosaics acquired by helicopter and UAV provided a dense series of high-resolution DTMs. Finally, new helicopter ground-penetrating radar campaigns were conducted in 2020 to evaluate the Planpincieux and Grandes Jorasses glaciers' thickness.

The survey activity conducted in the Grandes Jorasses area in the last decade is probably one of the most variegated in the European Alps. Thereby, this area has become an open-air laboratory for experimenting with new technological or methodological solutions for glaciological close-range remote sensing monitoring which might be applicable in other contexts.

