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Evolution of a highly vulnerable ice-cored moraine: Col des Gentianes, Swiss Alps

L. Ravanel (1,2), C. Lambiel (1), T. Oppikofer (3,4), B Mazotti (3), and M. Jaboyedoff (3)

(1) Institute of geography, University of Lausanne, Lausanne, Switzerland (Ludovic.Ravanel@univ-savoie.fr, christophe.lambiel@unil.ch), (2) EDYTEM lab, University of Savoie - CNRS, Le Bourget du Lac, France, (3) Institute of geomatics and risk analysis, University of Lausanne, Lausanne, Switzerland, (4) Geological Survey of Norway, Trondheim, Norway

Rock mass movements are dominant in the morphodynamics of high mountain rock slopes and are at the origin of significant risks for people who attend these areas and for infrastructures that are built on (mountain huts, cable cars, etc.). These risks are becoming greater because of permafrost degradation and glacier retreat, two consequences of the global warming. These two commonly associated factors may affect slope stability by changing mechanical properties of the interstitial ice and modifying the mechanical constraints in these rock slopes.

Between 1977 and 1979, significant works were carried out on the Little Ice Age moraine of the Tortin glacier at the Col des Gentianes (2894 m), in the Mont Fort area (Verbier, Switzerland), for the construction of a cable car station and a restaurant. Since the early 1980s, the glacier drastically retreated and the moraine became unstable: its inner slope has retreated for several meters. Various observations and geoelectric measurements indicate that significant volume of massive ice mass is still present within the moraine (ice-cored moraine). Its melting could therefore increase the instability of the moraine.

Since 2007, the moraine is surveyed by terrestrial laser scanning (TLS) in order to characterize its evolution: 8 campaigns were conducted between July 2007 and October 2011. The comparison of the high resolution 3D models so obtained allowed the detection and quantification of mass movements that have affected the moraine over this period, essentially by calculating difference maps (shortest oblique distances between two models).

Between July 2007 and October 2011, 7 landslides were measured, involving volumes between 87 and 1138 m3. The most important of these occurred during the summers 2009 and 2011. TLS data also allowed identifying: (i) two main areas affected by slower but sometimes substantial movements (displacements of blocks on more than 2 m during a summer period); (ii) significant deposits of anthropogenic materials and their mechanical readjustments; and (iii) a loss of thickness of the glacier approaching 10 m at the foot of the moraine.

Except for the morphological changes related to the landscaping of ski-runs, mass movements identified by TLS since 2007 are mainly resulting from glacier retreat and, to a lesser extent, to permafrost creep and degradation.