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Monitoring of glacial and periglacial landforms using terrestrial laser scanning.The case of the Col des Gentianes moraine (Valais, Switzerland)

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Between 1977 and 1979, important civil engineering works were made on the moraine of “Col des Gentianes”, which is situated 2894 meters above the sea level in the region of Mt-Fort, Valais, Switzerland. Two cableway station arrivals, a departure station to the Mt-Fort and a restaurant were built on. This moraine was formed during the last advance of the Tortin glacier during the Little Ice Age. Since 1980, the glacier has melted dramatically and the moraine is creeping. The moraine in front of the cableway departure station to the Mt-Fort sagged by 2 to 4 meters in 30 years. A large volume of ice is still present within the moraine and melting of the ice would make its stability even more precarious.

Since 2007 the moraine is monitored by terrestrial laser scanning (TLS). Two TLS campaigns were made in July and October 2008 and compared to datasets acquired in 2007. The comparison of sequential TLS point clouds enabled the detection and quantification of movements in the moraine: (1) by computing oblique (shortest) or vertical differences, (2) by creating displacement vectors and (3) by profiles across the TLS point clouds.

Between July and October 2008 the Tortin glacier melted by 1 to 2.5 m and the moraine creeped in direction of the glacier by 0.25 to 0.75 m. During the same period, a landslide zone has been clearly identified downslope of the cableway departure station to the Mt-Fort. Important movements between 1.5 to 5 meters were measured on this landslide through the creation of displacement vectors. This landslide scarp is delimited by 0.5 and 1 meter downward displacements in two month. Already in 2007, a less important landslide was identified and some ice had been observed in the scarp zone. The TLS permitted to analyze the distribution of these movements on the entire moraine and not only on few measurement points like given by D-GPS. The computed TLS displacement vectors are in good agreement with annual D-GPS measurements performed on this moraine.

In this study, two types of movements have been identified: (1) Superficial movements, like the landslide, and (2) general creep movements. To explain these movements, two parameters are crucial: (1) The annual melting rate of the glacier below the moraine reached up to 4 m, which has certainly an impact on the stability of the moraine (important movements observed in the landslide zone). The glacier acted as a buttress stabilizing the moraine. The observed glacier retreat and shrinkage causes the destabilisation of the moraine and finally leads to the measured surface movements. (2) The degradation of permafrost (deduced from thermal profiles acquired in a borehole in the moraine), destabilizes the moraine and causes an increase of the creep displacements measured for the whole moraine.

The acceleration of the movements is now actively monitored because they can influence the stability of man-made infrastructures. This study was also the opportunity to test the ability of TLS in monitoring of glacial and periglacial landforms like moraines.