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Design and operation of a comprehensive and permanent rock slope deformation monitoring system at the Great Aletsch Glacier (Switzerland)

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Most geodetic monitoring systems of rock slope instabilities include a series of stable reference points. However, detailed studies of Alpine rock slopes with long term Global Navigation Satellite Systems (GNSS), high-resolution tilt meters and Total Stations (TPS) have shown unequivocally, that truly stable points are very rare. The underlying causes of such natural movements are long- and short-periodic reversible deformations of stable slopes caused by annual and daily changes of pore pressure and temperature in fractured rock masses. These movements impact TPS measurements and cause inconsistencies in the reference frame which, if not accounted for, will introduce systematic errors in the calculated deformation pattern and time series. This complex situation can be found in many mountain slopes. However, detailed measurements and analyses of the superposition of reversible slope deformations and gravitational mass movements of active instabilities are not existing.

At the terminus of the Great Aletsch Glacier a comprehensive permanent deformation and displacement monitoring system has been installed, which allows to investigate large scale reversible deformations as well as active rock slope instabilities (Moosfluh and Driest) in response to rapid glacier retreat. The system includes 2 high-precision TPS stations with automated reflector recognition, 58 reflectors, 4 GNSS stations, climate sensors, and 2 high-resolution tilt meters and provides a fully automated survey with high accuracies over distances up to 2 km. The self-sustaining monitoring systems at Aletsch are installed at two high-alpine locations, remotely operated and automatically collect data on a set time schedule mainly at night. Deformation artefacts from thermal and wind disturbances of total stations' pillars and climatic refraction are studied with separate monitoring programs.

We describe various aspects of the design, construction, testing and practical operation of this unique monitoring system, such as the construction of a light but stable pillar of the Total Station, lightening protection in a high alpine environment, the influence of various weather protection boxes and window materials, the setup for data transmission with poor network coverage and the protection of reflectors installed in rockfall-exposed areas with snow coverage in winter. First results after one year of measurements are shown as examples.