GEOPREVENT

# MONITORING BIS GLACIER RANDA


PART OF HEXAGON

The monitoring of the Bis glacier is divided into two subsystems: a warning system for long-term observation of the steep glacier slope and an alarm system for ice avalanches resulting from glacier collapses.

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Title Page: A high-resolution camera is installed at the valley bottom and observes the steep part of the Bis glacier.

Figure 1: Several generations of cameras of the escarpment: Our station for the upper deformation analysis is in the foreground.

# CHALLENGE

The Bisgletscher is located on the eastern side of the Weisshorn and Bishorn in the Valais Alps, Switzerland. Ice masses of various size frequently release in the lower part of the glacier due to the steep gradient of more than 60% (in some areas). These ice avalanches, combined with considerable amounts of fresh snow, can reach large dimensions and threaten the village of Randa, the cantonal road (access road to Zermatt) and the Matterhorn Gotthard Railway. The avalanche cone can further dam up Vispa river and create a lake with the potential of flooding.

# SOLUTION

Monitoring of the Bis glacier is divided into two subsystems: a warning system for long-term observation of the steep glacier slope and an alarm system for ice avalanches resulting from glacier collapses. Three high-resolution deformation cameras monitor the long-term glacier movement while our avalanche radar detects ice avalanches in real-time. A combined station with deformation camera and avalanche radar is located in the valley at the village entrance of Randa, a second smaller station is located further up at the escarpment of Bis glacier.

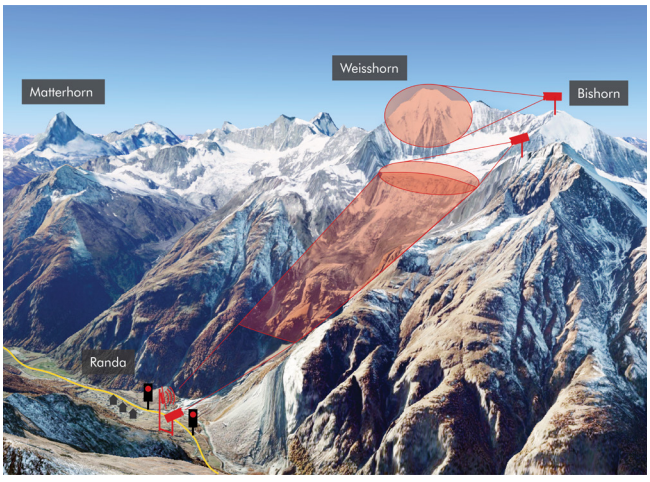



Figure 2: Overview situation.

## AUTOMATED DEFORMATION ANALYSIS

High-resolution cameras in the valley and at the escarpment take pictures of the glacier several times a day and send them to the Geopraevent servers. A sophisticated algorithm then automatically selects the most suitable images for deformation analysis. Subsequently, an elaborate image processing technique compares very small image fields with each other and identifies their displacements including direction. For selected areas, the velocity can further be displayed as a time series. The color scale corresponds to the change in pixels/day, with the pixel size depending on the distance. The measurements primarily serve to detect qualitative changes related to a starting point. All data and images can be viewed by authorized users via the Geopraevent online data portal at any time.

## AVALANCHE RADAR AT 5 KM DISTANCE

In natural hazards, the implementation of alarm systems with automatic road or rail closures requires the consideration of a number of important aspects. The aim is to keep closing times of transport routes as short as possible while at the same time ensuring safety at all times. Depending on the frequency of an event, this can be a challenging task.

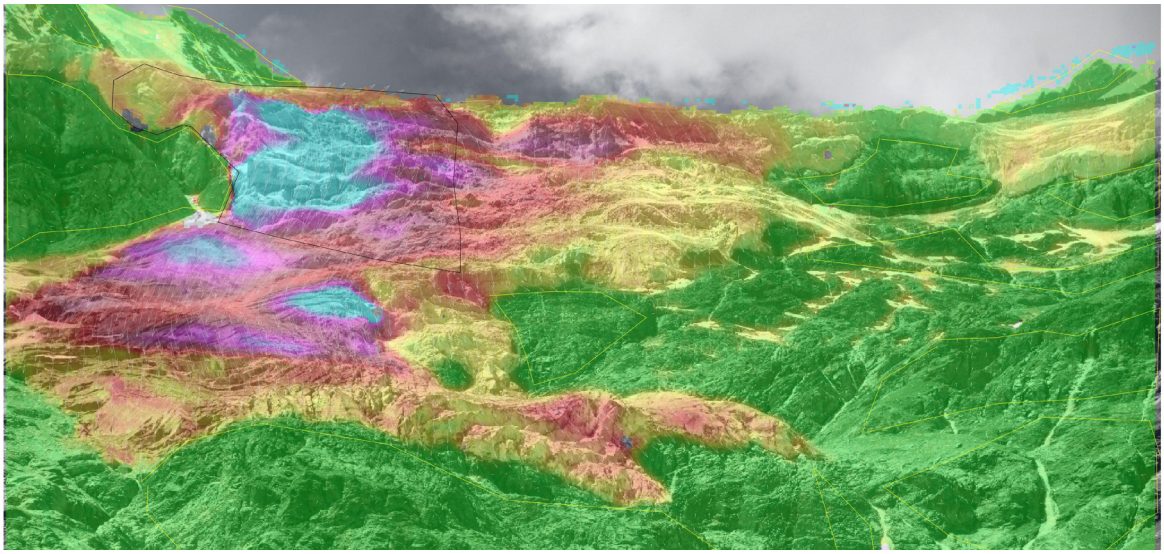


Figure 3: Deformation analysis of the Bis glacier from the valley camera station at a distance of up to 5 km.

## THIS IS HOW THE ROAD AND RAIL CLOSURE WORKS

Our comprehensive glacier monitoring system includes an avalanche radar for the real-time detection of avalanches of various sizes in the glacier area between 1500 and 3300 metres above sea level. After a test winter (2017/18) and the evaluation of more than 500 events, we connected the system to the existing road and rail traffic lights at the end of January and activated automatic closure and reopening. The challenge was to find a trade-off between the number of closures and "false alarms". By "false alarm" we understand in this context when an avalanche correctly triggers a closure without actually reaching the danger zone (i.e. railway tracks, road). The following graphics give an overview of the implemented closing and opening sequence. Data analysis revealed that the greatest avalanche activity occurs in the area of the glacier escarpment. Most avalanches start there and terminate shortly below, only a few large avalanches reach the valley floor. We defined two alarm zones with different warning times in order to close the railway and road early enough and at the same time keep the number of closures to a minimum. Upon detection of an avalanche in the upper alarm zone, the radar closes the railway tracks (60 seconds warning time). Should the avalanche also reach the alarm zone for the road, the radar closes the road

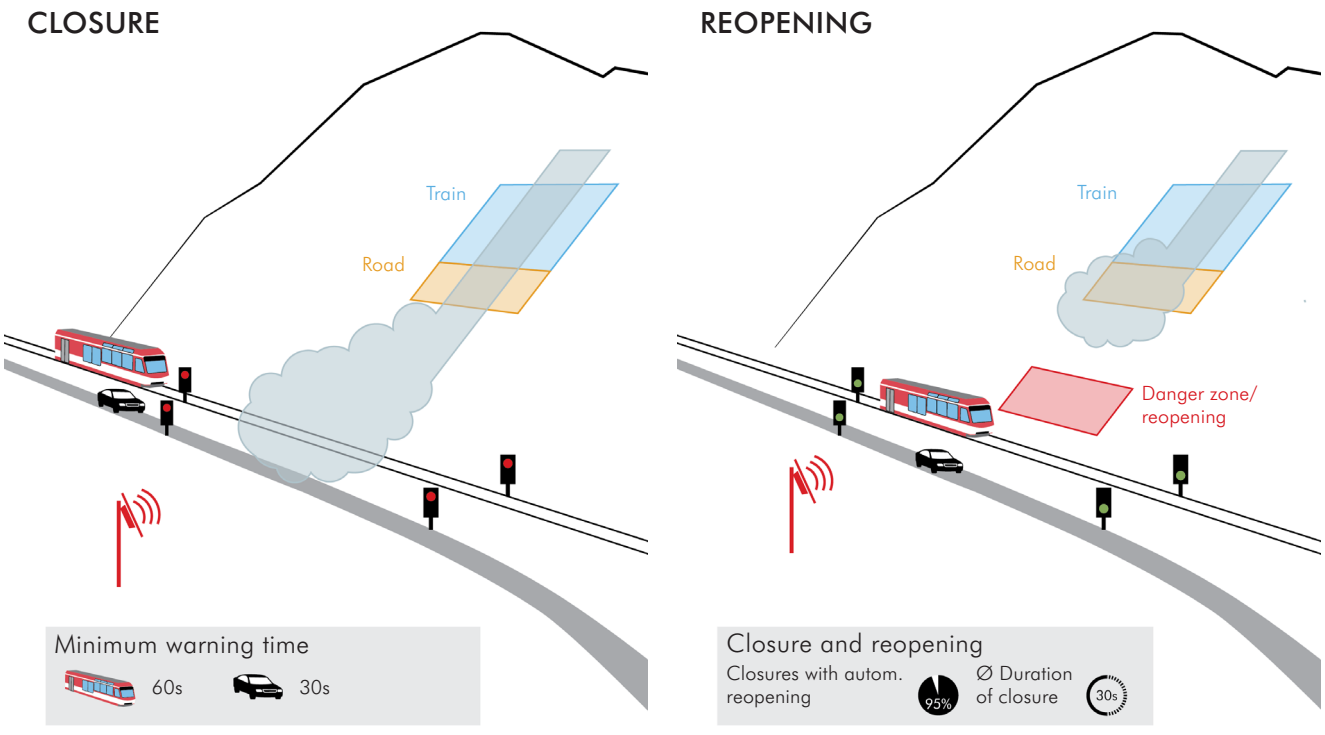



Figure 4: Schematic overview of the automatic road and rail closure in Randa.

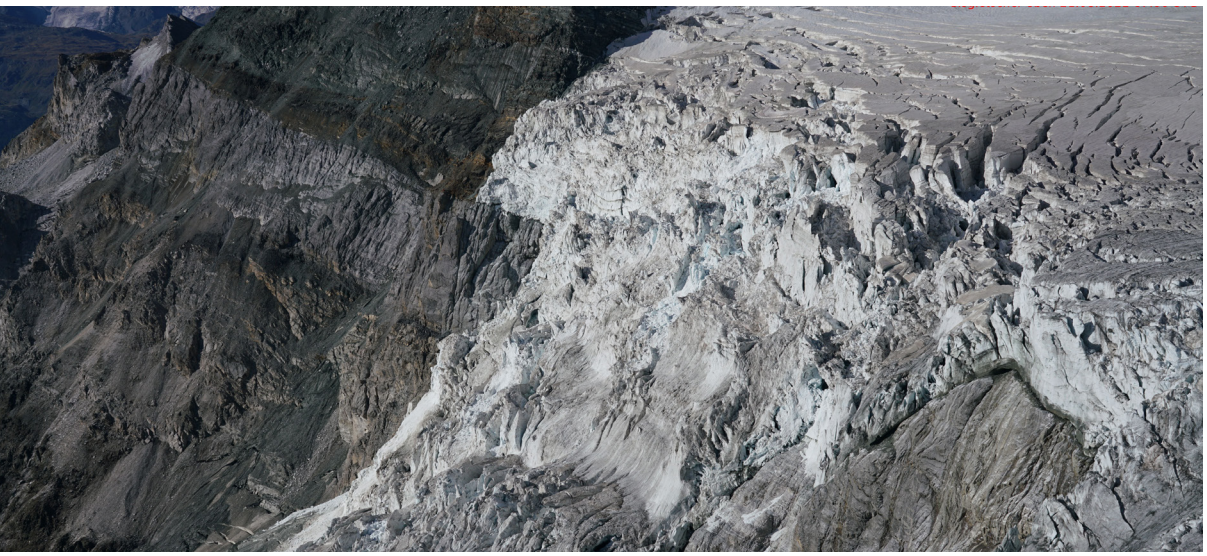
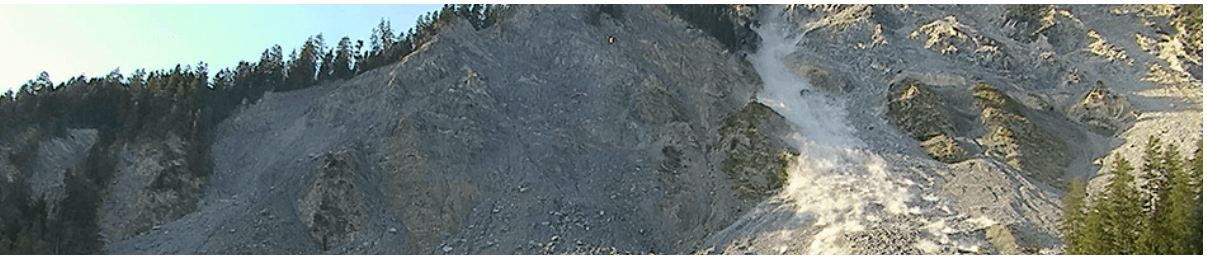


Figure 5: High-resolution image of the camera from 21 August 2022 from the escarpment.

section as well (30 seconds warning time). Automatic reopening happens when the avalanche did not reach the danger zone (95% of cases during the test winter). In the remaining 5% of cases, the avalanche reached the danger zone while the tracks and road were closed. The closure must be cancelled manually after a condition check of tracks and road. This can be done, for example, remotely via the webcam on the online data portal. The webcam offers convenient live views of the situation at any time, even at night thanks to infrared floodlights.

## FIRST USE AFTER ONLY A FEW DAYS

On 5 February 2019 at 10:29 a large avalanche occurred after a glacier collapse and triggered the automatic closure of the railway and road (video above or here). The avalanche radar detected the starting avalanche at 10:29:46 a.m., 15 seconds later the avalanche reached the alarm zone of the train, another 37 seconds later that of the road. By the time the powder cloud reached the tracks, 2 minutes 17 seconds had passed since closure. The webcam installed at the railway crossing recorded the avalanche.



## ALARM AND MONITORING SYSTEMS FOR NATURAL HAZARDS

Geopraevent provides alarm and monitoring solutions for a wide range of natural hazards. We either monitor the hazard zone to measure precursors of an event or we detect the event itself and automatically trigger alarms. Geopraevent also provides technology to detect people in the hazard zone (e.g. prior to avalanche blastings).

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