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# Monitoring of the Kleines Nesthorn and the Birch Glacier during the rock avalanche in Blatten

Janine Wetter[1], Maxence Carrel[1], Ólafur Stitelmann[1], Jonas Von Wartburg[1]

[1]*Geoprevent, Räffelstrasse 28, 8045 Zurich, Switzerland*

janine.wetter@geoprevent.com

## Abstract

On May 28th, 2025, a massive rock avalanche buried the village of Blatten, Switzerland under 9 million m3 of ice and rock. Previously installed monitoring systems revealed the impending collapse of the Kleines Nesthorn and the associated collapse of the Birch Glacier. The combined efforts and expertise of specialists coupled with continuous monitoring and data collection from measurement systems in the field supported early hazard detection, protecting the lives of many people. Consulting expert Geoformer together with local authorities requested that Geoprevent installs an interferometric radar, which was done the day Blatten was evacuated. The Geoprevent radar system provided impactful data regarding the displacement of the region around the Birch Glacier, contributing to the data collection which helped steer disaster planning and response. This system records terrain displacement with millimetric precision, independent of rain, snow, fog or darkness. The range and coverage of the radar system are 5 km and 7 km$^2$, respectively. One day prior to the collapse of the glacier, a camera with deformation assessing capabilities was additionally installed on the Eastern moraine of the Birch Glacier to provide further quantitative and qualitative assessment. These images revealed a dramatic scene in the hours before the collapse and showed a rapid movement of the glacier. With this camera-based technology with deformational assessing algorithms, the full monitoring system (radar and cameras) was able to provide data about displacement rates so local experts could monitor and evaluate the situation continuously and develop risk assessments and actions plans. Currently, the installation is changing from an emergency and short-term project to a mid- and long-term monitoring solution supporting safe operations dealing with debris removal and reconstruction in Blatten. The existing systems are supported by additional cameras and GPS systems to provide deeper insights into the instabilities and deformations around the Kleines Nesthorn.

## Keywords

Natural hazards, Hazard monitoring, Blatten Rock Avalanche, Slope Failure, Glacier Collapse.

# 1 Introduction

In 2013, a camera was installed next to the Birch Glacier above Blatten, Switzerland to monitor the Kleines Nesthorn. This camera has provided along-term monitoring dataset of the mountain and the Birch Glacier below. At the end of 2024, Geoprevent installed a camera on the opposite side of the valley just above Blatten to monitor the Birch Glacier and the Birchbach, a torrent channel which has hosted a range of processes. The municipality was concerned that falling ice from the Glacier could trigger avalanches which would be transported in the Birchbach and threaten the Nordic ski slopes below. Beginning of May 2025, residents of Blatten alerted local authorities and consulting experts when they witnessed several rocks falling from the Kleines Nesthorn. In response, a GPS system was installed to gain insights into deformation rates. After only a few days, this GPS system was destroyed by rockfall. Moreover, the pictures from the preinstalled camera revealed a dramatic picture to the experts. The mountain was visibly moving and falling apart. The scope of the situation became clear and the village of Blatten was evacuated on the 19$^{th}$ of May with only little time for people to pack their belongings. On that same day, Geoprevent installed an interferometric radar on the opposite side of the valley to monitor the movements of the Kleines Nesthorn and the Birch Glacier and to provide further data to local experts to support the evacuation efforts.

# 2 Methods – Technologies and Applications

A comprehensive and complementary system of monitoring devices was installed to best capture all aspects of the event. The deployed systems were a Ground Based Interferometric Radar (IBIS-FM) and a camera system which captured high-definition images while also having deformational analysis capabilities. This allowed for redundant analysis occurring at different spatial scales which further supported local decision makers and action plan processes.

## 2.1 Interferometric radar

The IBIS FM system (Fig.1) is a type of Interferometric Synthetic Aperture Radars system (InSAR). InSAR systems have become heavily relied upon as a dependable and robust means to monitor surface deformations (Biggs et al., 2020). Deformation evaluation is based on phase changes where the system measures the phase of the returned signal. A change in the distance between the sensor and the ground will cause a change in the phase value. The difference in phase between two images (InSAR image) is calculated and patterns of displacement are shown on the resulting interferogram (Fig.2). Under favorable conditions, accuracy at the millimeter level can be reached for deformation measurement. In this regard, InSAR technology has been widespread in detecting and monitoring earthquakes, volcanoes, landslide subsidence, and landslides (Chen et al., 1999).

In the monitoring area, the radar relies on a surface that remains as unchanged as possible throughout the entire field of view to be able to compare measurements as accurately as possible. One measure of such changes is the coherence of the data. Coherence ranges between 0 (data completely incoherent) and 1 (data perfectly coherent). Therefore, interferometric coherence describes the accuracy in determining the interferometric phase. Coherence is evaluated through spatial covariance, indicating radar reflection similarity over time. High spatial covariance indicates a more stable phase signal and a higher quality interferogram. Decorrelation across multiple IBIS-FM acquisitions inhibits displacement measurements across all individual pixels so that only pixels that maintain a coherent signal over time can be used for displacement analysis. Therefore, having coherent pixels in the region of interest is vital for retrieving reliable displacement results (Chen et al., 2025). Factors that can reduce coherence (Abdel-Hamid et al., 2021):

- Dense vegetation
- Complex topography
- Large deformation gradients,
- SAR observation geometry
- Atmospheric conditions

The IBIS FM system supplied by Geoprevent supported data acquisition and processing at set time intervals. Data processing and deformation computations are done using three separate algorithms: the Adaptative Interferometric Model (AIM), IDS Guardian model, and the Repeat Pass (RPT) model. The three algorithms can be summarized accordingly:

**AIM** – Based on interferograms with short and long time periods leading to high accuracies down to few, mm/day up to very fast movements up to 15 m/day, mostly aggregated over a 24-hour interval to

reduce sensitivity to daily atmospheric cycles. Some filtering occurs e.g., surface movements can be recorded in response to rain, daytime atmospheric changes, etc.

**IDS Guardian** - Less sensitive but more reactive to fast accelerations, for deformations from 10 mm/day up to 1.5 m/day, uses interferograms with a short time base for the most recently acquired consecutive scans. Sometimes masks uncertain areas as stable.

**RPT** - Compares measurements from two time periods separated by days up to years looks for pairs with matching atmospheric conditions, coherent areas are sensitive to 1mm/period, ambiguities above ±4.4 mm/ RPT period.

Using three algorithms contributes to minimizing limitations (Chen et al., 1999), as each algorithm is structured to process data with varying sensitivities to different velocity ranges. These algorithms calculate slope velocities in the measured area and aggregate maximal and median deformation rates within the specified regions of interest (ROI).

Due to the very spontaneous installation, the radar was initially powered through the local infrastructure network. When this power supply was no longer available, it was powered by a methanol fuel cell and later also over solar panels.



Fig. 1 The interferometric radar with its view on the Kleines Nesthorn and the Birch Glacier (left) and the methanol tanks and the fuel cell that were used in the first weeks after the Blatten landslide (right).

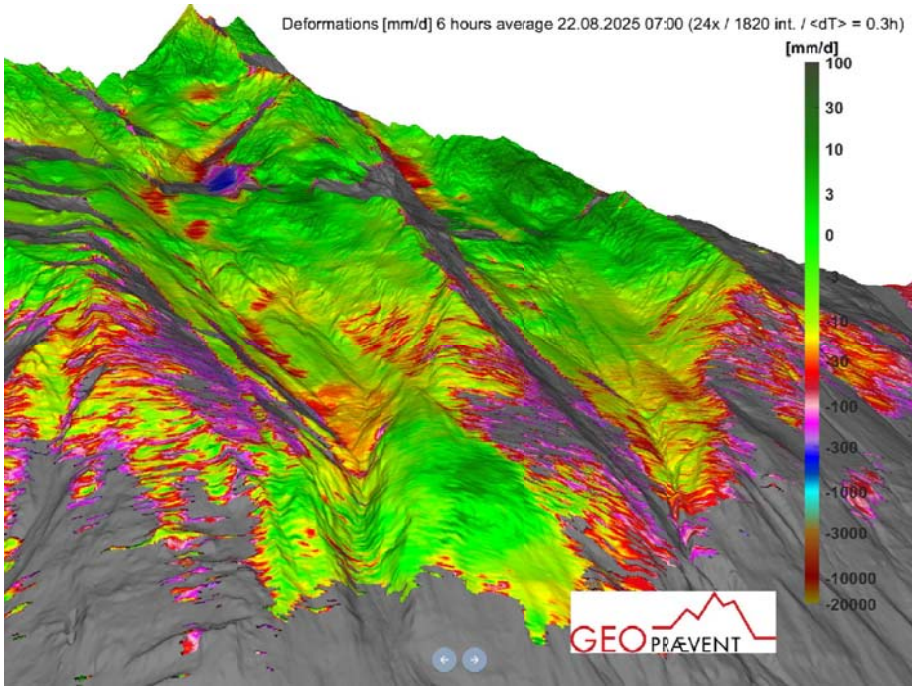



Fig. 2 Example of a deformation analysis from the 22nd of August 2025 (after the event) based on the data of the interferometric radar in mm/d.

### 2.2 Camera System with Deformation analysis– PROCam

Just one day before the event in Blatten, Geoprevent installed a PROCam next to the Birch Glacier (Fig.3, left). The camera system includes an HDR function, several photos are taken in succession and an algorithm then combines these images so that all image sections are optimally lit. The effective resolution for a certain application mainly depends on the focal length used, the surface texture and the slope angle. From these images, the deformations are calculated (Fig.3, right). The calculation of the deformation is based on an analysis of the displacements in the image: high-contrast transitions are detected in two images, and their displacement is estimated (cross-correlation algorithm). Because of the very high resolution and sophisticated image analysis algorithms, deformations in the range of a few centimeters at a distance of several kilometers can be detected in good weather conditions. The deformations relate to the image plane and are calculated in pixels/day. Using a digital elevation model, they can be automatically converted into metric units, e.g. meters or centimeters. Moreover, the PROCam at the Birch Glacier is an energy self-sufficient system (without a power mains connection) using a solar panel and a battery. The camera itself is installed in a housing with an integrated fan to prevent snow buildup on the lens. This camera helped the local authorities as it gave an insight into the movements and processes that happen on the glacier. It also revealed the very high speed the glacier had in the last few hours before the collapse.

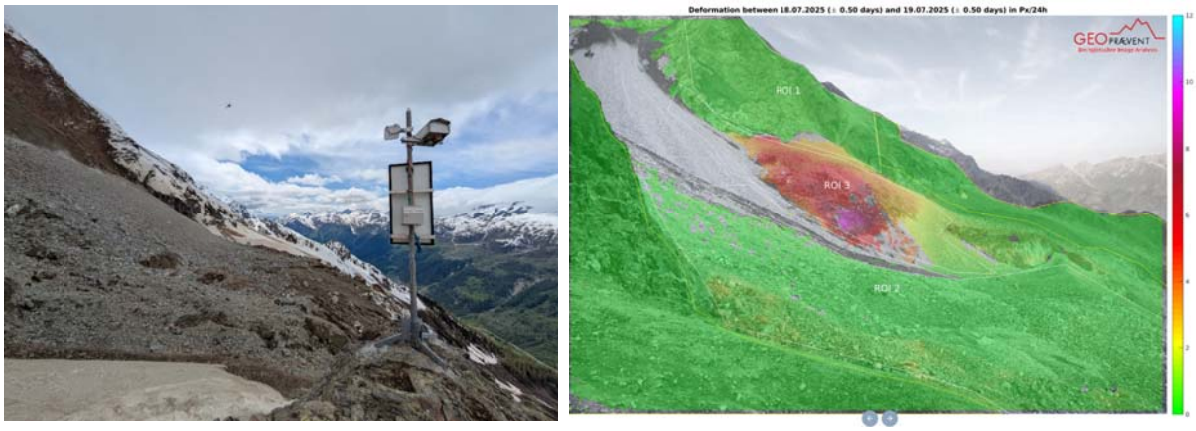



Fig. 3 The PROCam next to the Birch Glacier (left). This picture shows the situation before the landslide and an example of the deformation analysis (right) from the PROCam at the Birch Glacier (the analysis is from July, so after the landslide event).

## 3 Conclusion and Outlook

After the slope failure event that buried the village of Blatten, Geoprevent installed further monitoring devices around the Kleines Nesthorn and the Birch and Nest Glacier. Fig. 4 illustrates the comprehensive monitoring program that was installed to monitor the Kleines Nesthorn and Blatten. Another system, called a PTZ (pant-tilt-zoom) camera was installed on the Schafbärg to monitor the activities on the opposite (to the failure) aspect of the Kleines Nesthorn to help consulting experts and the municipality evaluate the risk of further collapse (Fig.5). This camera provides real-time remote insights into the site conditions and can be controlled remotely. Moreover, it takes periodic pictures from predefined positions. As with all the other systems, this camera is utilized as an energy self-sufficient system (solar). Moreover, another PROCam (see Camera System with Deformation analysis– PROCam

) was installed on the opposite aspect of the Kleines Nesthorn next to the Nest Glacier. This camera detects glacial deformations and provides an additional monitoring system to evaluate the opposite (to the failure) aspect of Kleines Nesthorn. Finally, multiple GNSS sensors were installed throughout the slope of the Kleines Nesthorn (Fig.6). These sensors enable precise automated measurement of surface point movements for vertical, and horizontal (E/W, N/S, absolute) displacements from the initial position, with position measurements supplied every hour. They use advanced multi-band Real-Time Kinematic (RTK) technology and edge processing to deliver millimetric precision with great reliability, even in remote environments and harsh conditions. Two sensors broke shortly after their installation due to the on-going rockfall. Currently it is under evaluation, how the long-term monitoring system will look like. This is strongly linked with the planned activities and construction works on the debris cone, which are not known yet and very difficult to foresee due to the still high danger in the area.

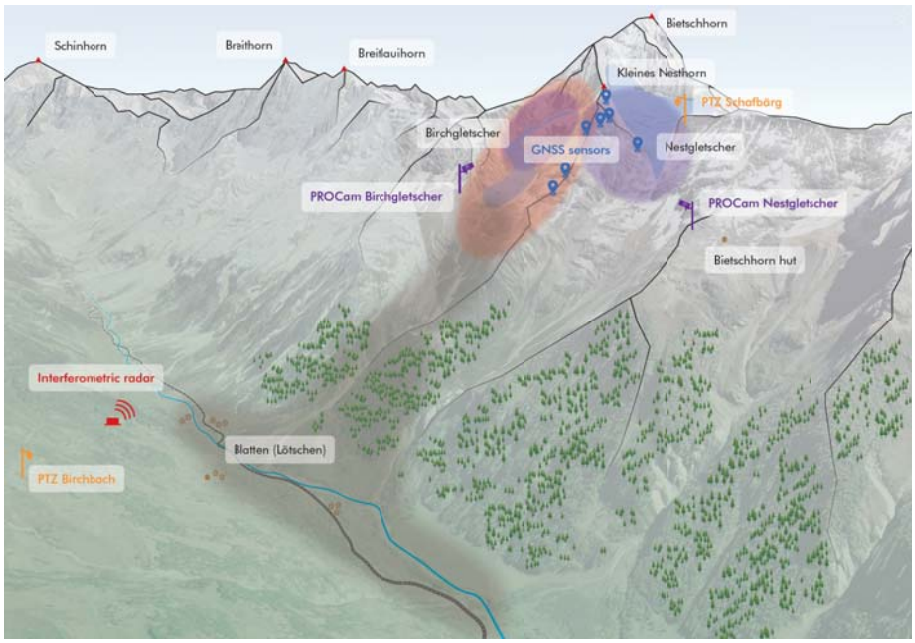



Fig. 4 Overview of all the systems installed by Geoprevent around the Kleines Nesthorn and the Birch Glacier above Blatten.



Fig. 5 The PTZ camera on the Schafbärg with a view on the Nest Glacier and the Kleines Nesthorn. The picture on the right shows the camera during a field visit some months later.



Fig. 6 Two GNSS sensors that were installed around the Kleines Nesthorn. They are powered by solar panels.

# References

Abdel-Hamid, A., Dubovyk, O., & Greve, K. (2021). The potential of sentinel-1 insar coherence for grasslands monitoring in Eastern Cape, South Africa. International Journal of Applied Earth Observation and Geoinformation, 98, 102306. https://doi.org/10.1016/j.jag.2021.102306

Chen, Yongqi & ZHANG, Guobao & Ding, Xiaoli & LI, Zhilin. (1999). Monitoring Earth S urface Deformations with InSAR Technology: Principle and Some critical Issues. Journal of Geospatial Engineering. 2.

Chen, Y., Dai, K., Chang, L., Li, Z., Zhuo, G., Liu, X., & Shao, Y. (2025). Improved landslide monitoring in low-coherence mountainous areas: A coherence-enhanced multitemporal insar approach. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 18, 20690–20707. https://doi.org/10.1109/jstars.2025.3596713

Biggs, J., Wright, T.J. How satellite InSAR has grown from opportunistic science to routine monitoring over the last decade. Nat Commun 11, 3863 (2020). https://doi.org/10.1038/s41467-020-17587-6