GEOPRÆVENT

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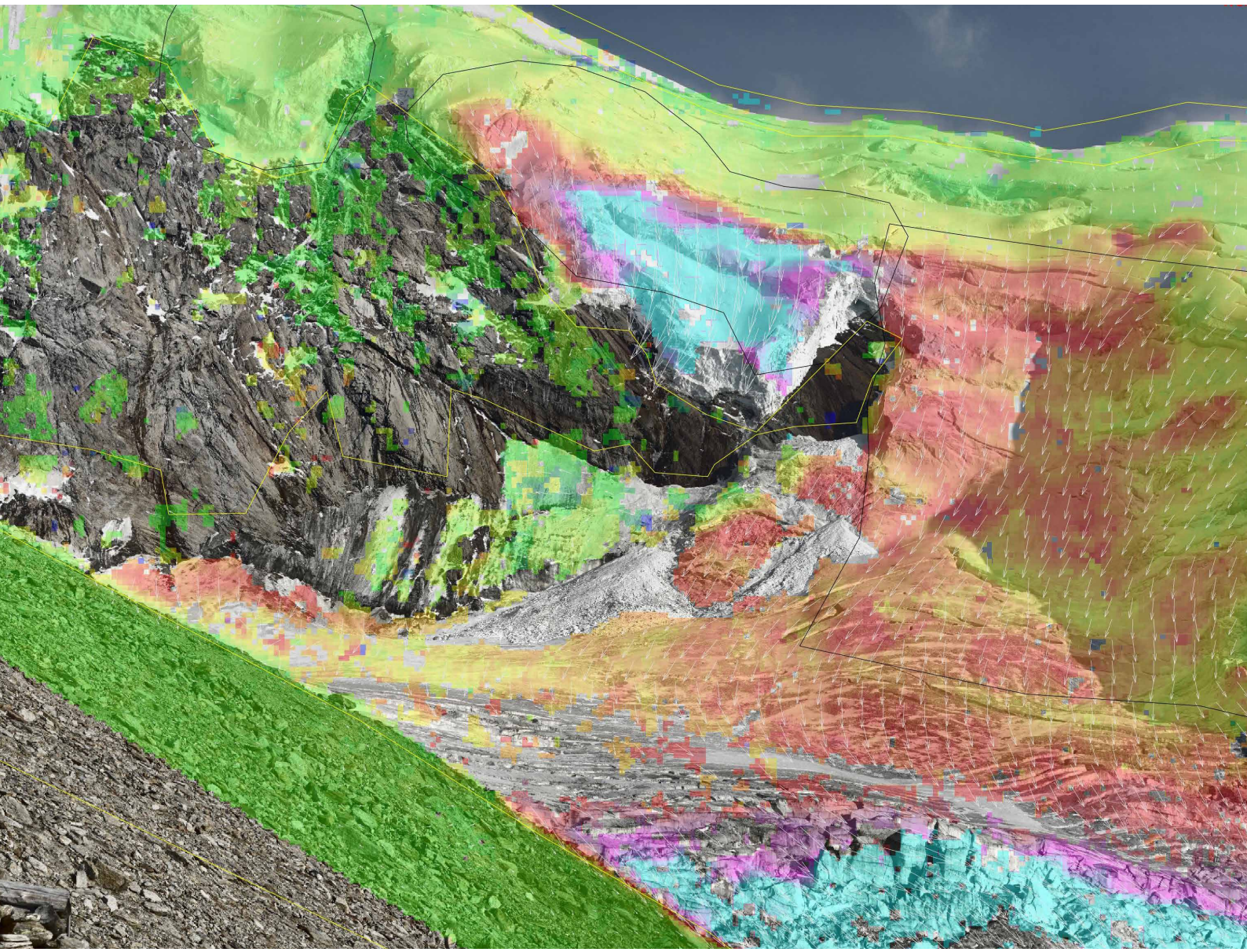
DEFORMATION CAMERA



Automated optical deformation analysis for long-term monitoring of instabilities in rock and ice based on high-resolution images and sophisticated image processing methods.

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Figure 1: Long-term monitoring of the unstable Weissmies glacier was performed using a deformation camera with 42 megapixel resolution.

Title page: Deformation analysis of the Weissmies glacier shortly before the collapse of the unstable glacier area in September 2017.

EXTENSIVE LONG-TERM MONITORING

The deformation camera is the ideal solution for cost-efficient, area-wide monitoring of instabilities in rock and ice. The fully automated deformation analysis enables monitoring of unstable slopes, rock faces or glaciers at safe distance and with an accuracy of a few centimetres. The deformation image colour codes where and how fast the smallest image fields move within the monitored area while arrows indicate the direction of the movement (see title page). Online time series of the measured velocities can be displayed for selected areas. On detection of accelerations, further velocity analysis can be applied to estimate the collapse (Figure 2). Authorized users can access all deformation analyses and high-resolution images including zoom options (Figure 1) at any time via the online data portal.

The deformation analysis is an optical method based on automatic comparison of high-resolution images. Good visibility of the surveillance area along with identifiable surface structures are hence a prerequisite. If there are none visual contrasts in the unstable area (e.g. white snow surfaces), it is not possible (or with limited use) to perform deformation analysis.

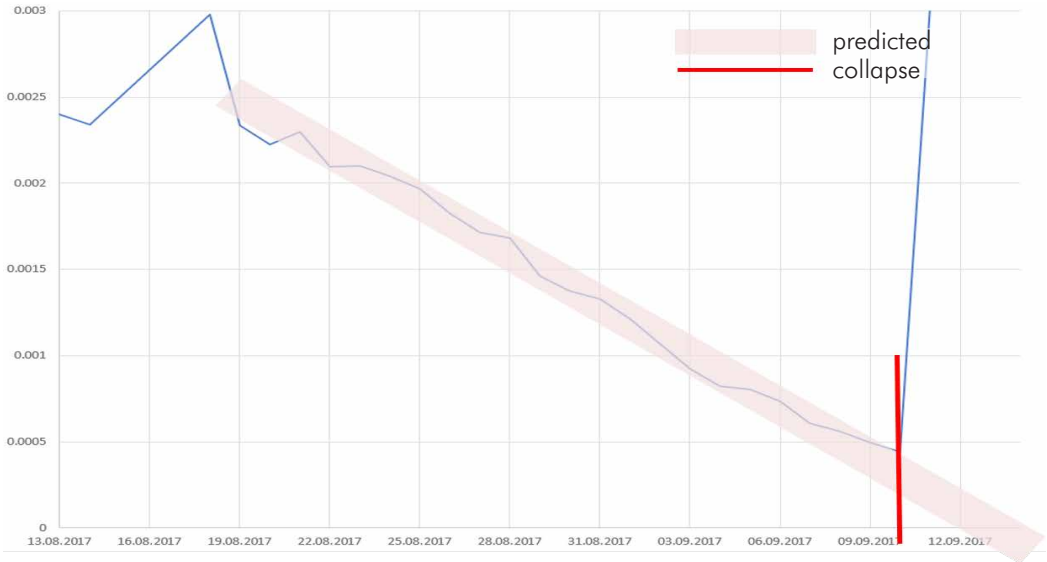


Figure 2: Inverse velocity analysis of the unstable glacier area at Weissmies indicates the time of the collapse. For precise analysis, an interferometric radar was installed shortly before collapse.

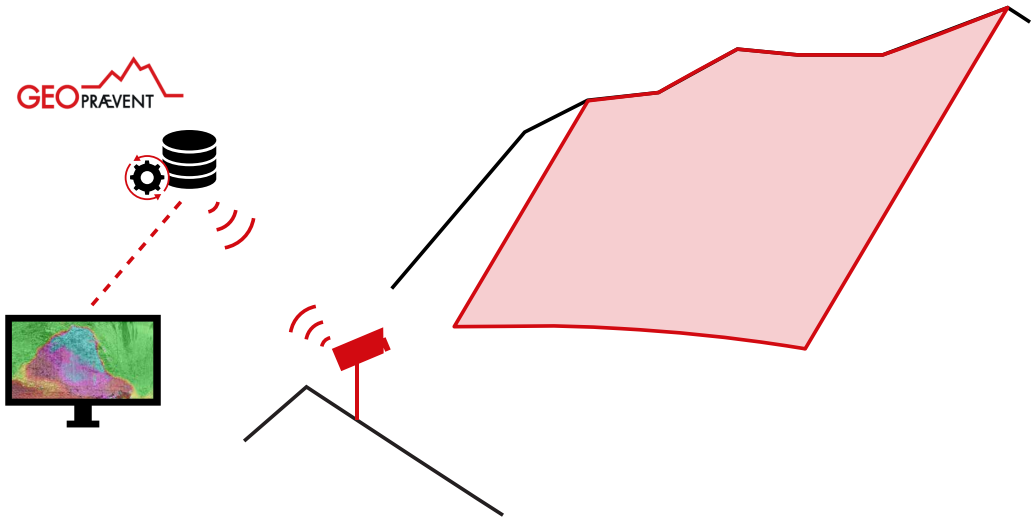


Figure 3: The deformation camera takes several high-resolution images of the unstable area and transmits the data to the Geoprevent servers. There, an algorithm searches for suitable images that are subsequently compared with each other. The final deformation analysis is then displayed to users on the online data portal.

AUTOMATED DEFORMATION ANALYSIS

The deformation camera facilitates a quick and easy identification and quantification of movement behaviour within an instability. Geoprevent have developed an analysis technique for high-quality and precise deformation analyses on the basis of optical data. The deformation analysis determines displacements of very small image fields into the two deformation components perpendicular to the viewing direction. The process involves automatic correlation of suitable image pairs with a complex algorithm. To ensure reliable information, the moving area requires the size of at least a few pixels. The deformations can be projected onto a digital elevation model and converted into meters.

To a large extent, the quality of the deformation analysis depends on the image selection and the evaluation algorithm applied. We use high resolution cameras (42 megapixels) with HDR option (High Dynamic Range). HDR processing can optimize difficult lighting conditions by generating more contrast. This increases the possible evaluation area and leads to best results.

SOPHISTICATED ALGORITHMS

The deformation camera takes pictures of the monitored area several times a day and transmits the images to the Geoprevent servers for image analysis. It is on the servers that a novel algorithm automatically selects suitable images in terms of weather and lighting whilst preparing them for image processing. Following this, the computationally intensive and fully automated image analysis is completed on Geoprevent's high-performance computers. The algorithm can autonomously distinguish between light/shadow and a real shift. For quality control, several deformation images are generated and compared. The analysis interval can be selected as required. Commonly, deformation analysis is computed every night with upload to the online data portal the following morning. Authorized users can access deformation analyses, all images as well as Live-images anytime via online data portal.

Figure 4: The same image section left (8 AM) and right (12 PM) with different light and shadow conditions. The automatic evaluation algorithms can independently distinguish between displacement and changes in light.

The data portal offers the opportunity to review series of images whilst remaining zoomed in on a region of interest at full resolution.

DEFORMATION CAMERA SYSTEM SOLUTION

The deformation camera is a complete system solution including the camera and all necessary components for autonomous operation along with online access to data and images. In specific cases it is also possible to integrate the deformation camera into an existing system. Please contact us for an individual offer.

IMAGE ANALYSIS

The deformation analysis is continuously processed on Geoprevent's powerful processors with subsequent uploads to the data portal. Additionally, we log the velocity of predefined areas to represent its course of motion over longer time periods. On request, automatically notifications are sent when a critical threshold is exceeded. The time series data can be used to predict impending collapses by analysing inverse velocities.

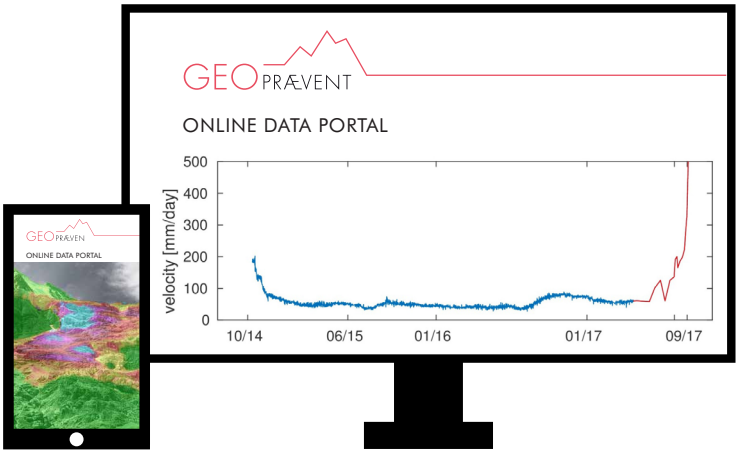
The analysis interval is freely selectable; by default, the system performs a daily deformation analysis, but time intervals of two days, one week or seasonally different intervals are also possible.

ONLINE DATA PORTAL

The online data portal provides an overview of all collected data. Authorized users can access the online data portal at any time with their personalized login and call up high-resolution images, deformation analyses or time series data. Additionally, high-resolution images can be taken remotely manually at any time. The data portal also features a special image display that allows switching between different images even when in zoomed mode (Figure 4).

SERVICE

The online data portal is permanently maintained and updated by the Geoprevent team in Switzerland. We continuously monitor all measuring stations and react if necessary within the agreed response time (minimum 6 hours, maximum 1 week).



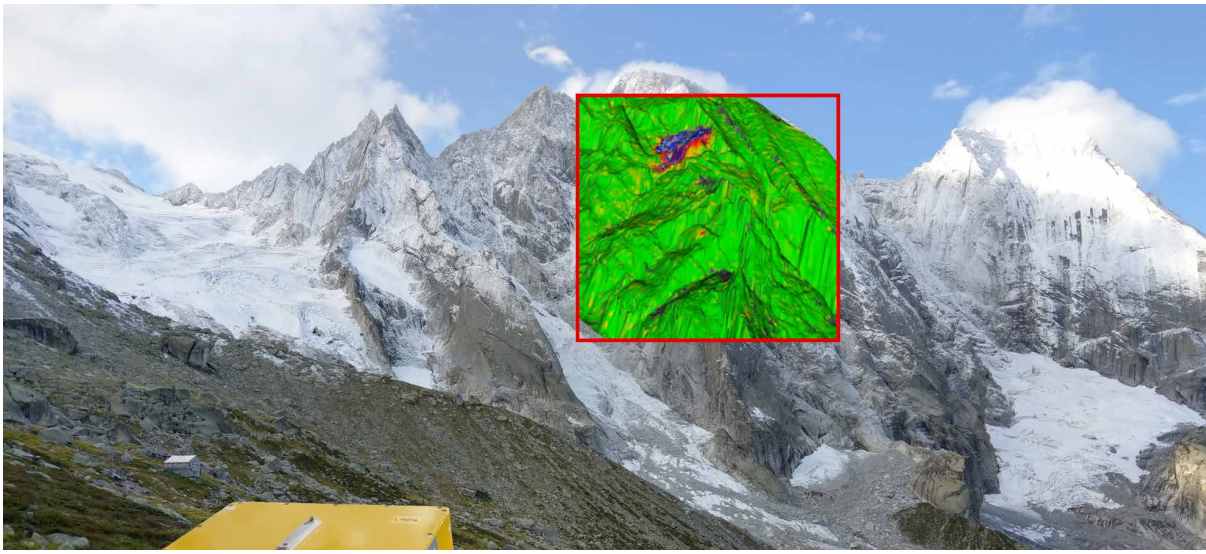


Figure 5: The interferometric georadar continuously scans the monitored area and reliably detects displacements in the sub-mm range regardless of weather.

ADDITIONAL OPTIONS

The deformation camera monitoring system can be combined or extended with different additional options depending on the application. In the case of acute instabilities we recommend to supplement the camera with the interferometric georadar. The georadar is able to measure deformations with greater sensitivity as well as in any weather condition.

INTERFEROMETRIC GEORADAR

Unlike the deformation camera, the interferometric georadar functions independently of the weather and time of day. It sees at night, as well as through fog or snow (Figure 5). In addition to its robustness to environmental conditions, the interferometric georadar is characterized by its high measurement accuracy (sub-mm to mm) for deformations within a large monitoring area. In critical situations, for example when the acceleration has exceeded a significant threshold and/or during long periods of bad weather, the deformation camera must be replaced or supplemented with the interferometric georadar. By applying inverse velocity analysis it is possible to predict an imminent collapse relatively precisely (e.g. Weissmies glacier collapse in 2017, Preonzo rockfall in 2012).

AVALANCHE OR ROCKFALL RADAR

The combination with a Doppler radar for avalanches or rockfall enables the automatic detection of fast mass movements independent of visibility conditions (Figure 6). Through this approach, events such as ice avalanches on glaciers, are detected when they happen with immediate action (e.g. automatic road closure). Another application is to monitor rockfall activity objectively and in any visibility condition - with automatic notification if activity increases.

CRACK AND EXTENSOMETERS

Local measurements are performed if a certain rock area should be observed more closely. Crack meters measure the width of a cleft and extensometers are applied for lower lying movements. These measuring instruments enable to detect the smallest movements of individual rock sections and, if necessary, to alert if a predefined threshold value is exceeded. However, installation in a hazard zone may be dangerous.

Figure 6: The avalanche radar detects ice and snow avalanches in any weather and automatically closes road or railway sections in real time, if required.

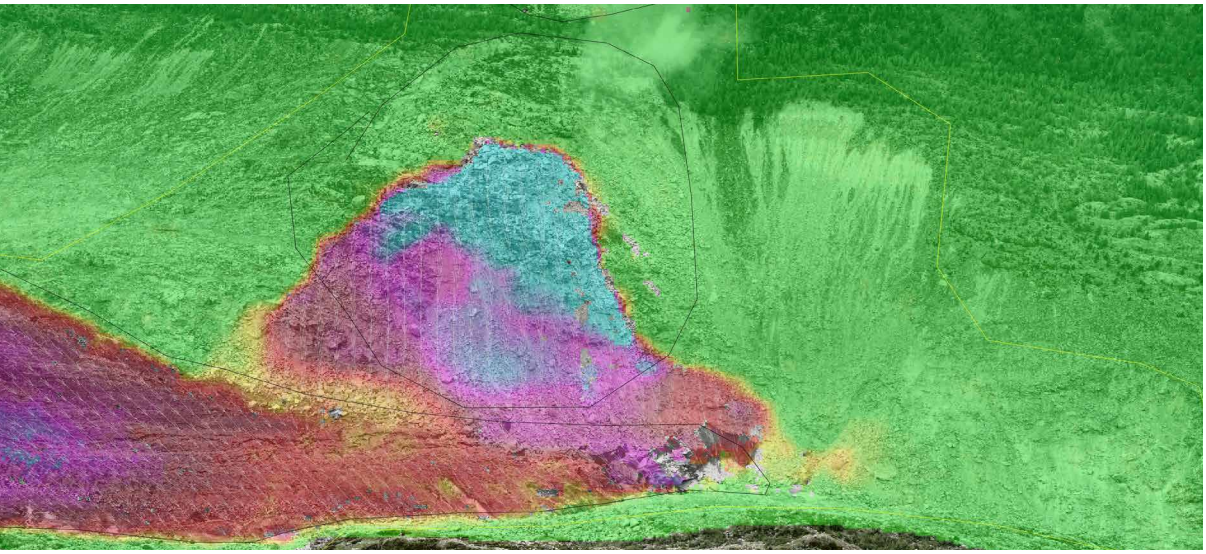


Figure 7: Deformation analysis of the Moosfluh landslide in June 2018 (light blue area). The Aletsch Glacier with glacier tongue is visible below.

REFERENCE PROJECTS

Geoprevent developed this automatic deformation analysis at the beginning of 2017 and tested it for several months in parallel with the interferometric georadar. Since we have installed several deformation cameras and continuously keep developing the image analysis. The following customer projects provide an insight into the applications of our deformation camera technology.
Further information and reference projects can be found at: www.geoprevent.com.

WEISSMIES GLACIER COLLAPSE, SWITZERLAND

At the end of August 2017, the deformation camera showed strong accelerations of the unstable glacier region which had been monitored for a long-term. Inverse velocity analysis indicated an imminent collapse. Following this, the interferometric radar was installed for more precise observation of the glacier. As predicted, the collapse occurred only a few days later.

MOOSFLUH LANDSLIDE MONITORING, SWITZERLAND

Moosfluh is a large slide area on the edge of the largest alpine glacier, the Aletsch Glacier. Due to the steady glacial retreat, an existing slide has accelerated considerably. Several small break-off events (even in winter with snow) were correctly anticipated in the deformation analysis days before they occurred (Figure 7).

MONITORING BIS GLACIER, SWITZERLAND

The Bis glacier in the Valais Alps has a very steep gradient of up to 60%. Large ice falls and consequently avalanches are not uncommon and have caused extensive damage several times in the village of Randa in the valley bottom. Since 2017, the glacier has been monitored by two deformation cameras (Figures 8 and 9). At the same time, the avalanche radar detects starting ice avalanches and automatically closes the road.

Figure 8: Deformation camera station at Randa installed to monitor Bis glacier from the valley bottom.

TECHNICAL DATA DEFORMATION CAMERA

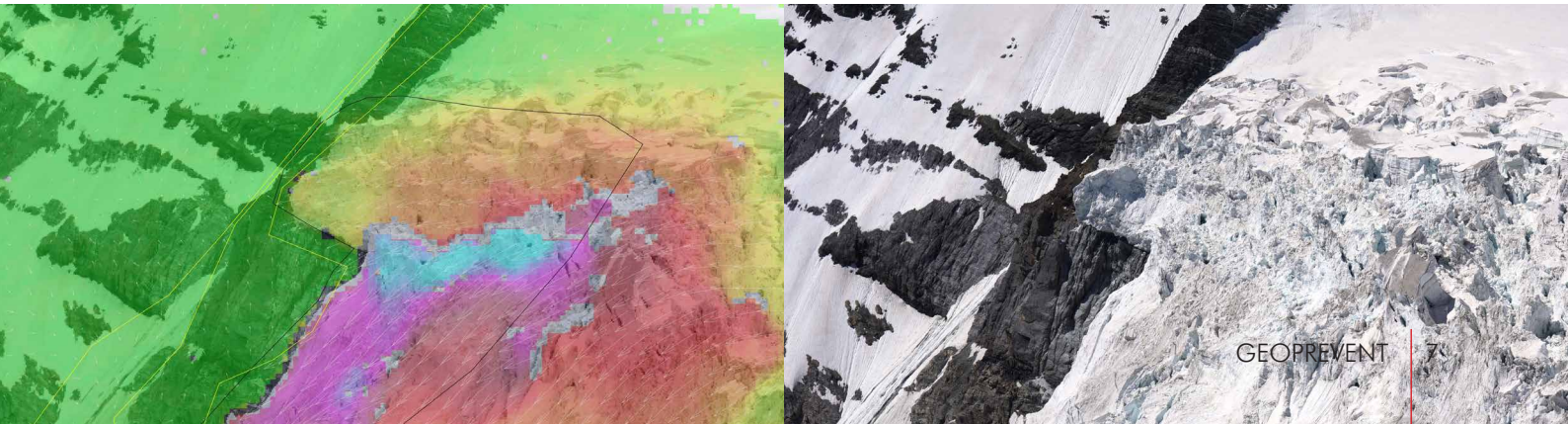
Three different camera models are available for deformation analysis, which differ mainly in their resolution and range. HDR further optimizes contrast and thus helps to increase the evaluable area.

Camera model	HD Essentiell	SuperHD	SuperHD-plus
Camera resolution (MP = Megapixel)	20 - 24 MP	42 MP	42 MP
HDR processing	-	-	included
Measurement accuracy deformation analysis	<2 cm/day*	<3 cm/day**	<3 cm/day**
Range	1000 m	3000 m	3000 m
Weight	14 kg	14.5 kg	15 kg

*at a distance of 1000 m and lens with a focal length of 85 mm
** at a distance of 3000 m and lens with a focal length of 135 mm

Power consumption: max. 40 W
Power supply: grid power, solar panel
Software: Deformation analysis, image selection algorithm, online data portal
Integration: online data portal, smartphone, tablet
Alarm: automatic alert at exceeding predefined threshold
Installation: quick, few hours

Figure 9: Deformation camera at the escarpment of Bis glacier.

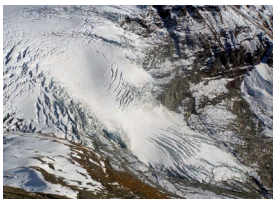


ALARM AND MONITORING SYSTEMS FOR NATURAL HAZARDS

Geoprevent 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. Geoprevent also provides technology to detect people in the hazard zone (e.g. prior to avalanche blastings).

ROCKFALL

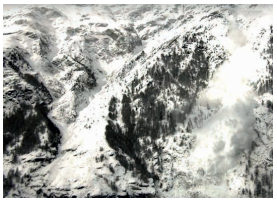
FLOODS



GLACIERS

LANDSLIDES

GLACIAL LAKES



AVALANCHES

DEBRIS FLOWS

SAFETY NETS

PEOPLE

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