

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

Figure 1: Long-term monitoring of Weissmies glacier was performed using DEFOX® PRO camera with 42 megapixel resolution.

EXTENSIVE LONG-TERM MONITORING

DEFOX[®] PRO camera is the ideal solution for cost-efficient, area-wide monitoring of instabilities in rock and ice. It enables fully automated deformation analysis to monitor unstable slopes, rock faces or glaciers at safe distance and with an accuracy of a few centimetres. The deformation image colour codes movement, velocity and direction of small pixel fields within the monitored area (see title page). Online time series of the measured velocities can be displayed for interesting areas. In case the system detects a significant acceleration, we apply velocity analysis to estimate the approximate collapse time (Figure 2).

All deformation analyses, high-resolution images and time series are available to authorized users at any time via the Geoprevent online data portal (PC, tablet, mobile).

DEFOX® PRO camera generates high-quality deformation analyses based on automatic selection and comparison of high-resolution images. Good visibility of the surveillance area along with identifiable surface structures are a prerequisite. Deformation analysis is not possible (or only to a limited extent) if the unstable area has no visual contrasts.



Figure 2: Inverse velocity analysis of the Weissmies glacier instability, recorded by long-term monitoring with the DEFOX® PRO camera. For precise analysis and collapse time estimation, we installed an interferometric georadar shortly before.

Figure 3: DEFOX® PRO camera takes several highresolution 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

DEFOX® PRO camera enables quick and easy identification and quantification of movement behaviour within an instability. We have developed an analysis technique for high-quality and precise deformation analysis based on optical data. The deformation analysis determines displacements of very small image fields into the two deformation components perpendicular to the viewing direction. Image processing involv es 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. According to r equirements, we project the deformation onto a digital elevation model and convert the displacement velocity into meters/day.

Deformation analysis quality depends to a large extent on image selection and the evaluation algorithm applied. We use high resolution cameras (42 megapixels) with HDR option (High Dynamic Range). HDR processing usually optimizes difficult lighting condit ions by generating more contrast. This increases the potential area of evaluation and leads to the best outcomes.

SOPHISTICATED ALGORITHMS

DEFOX® PRO camera takes pictures of the monitored area sev eral times a day and transmits the images to the Geoprevent servers for image analys is. There, a proprietary algorithm automatically selects suitable images from all availa ble imagery from within the monitoring interval. The algorithm automatically considers weat her and lighting effects and prepares the selected photos for image processing. Subsequently, our high-performance computers carry out the computation-intensive and fully automat ic image analysis. For quality control, we generate several deformation images and aut omatically compare them for plausibility checks. The analysis interval can be selected as required. Authorized users can access eformation analyses, all imagery 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. Automatic evaluation algorithms independently distinguish between displacement and light changes.

The data portal's image viewer feature offers to zoom into a region of interest in full resolution and to review image series of this particular section.

DEFOX® PRO CAMERA SYSTEM SOLUTION

DEFOX® PRO 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 their course of motion over longer time periods. On request, automatic notification at threshold exceeding is available. Time series data can further 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. Access to high-resolution images, deformation analyses or time series data is provided for authorised users via PC, tablet or smartphone. Where requested, users can trigger highresolution images manually at any time. Additionally, the portal's image viewer provides a convenient tool to study and compare interesting image section in utmost detail (Figure 4).

SERVICE

The online data portal is permanently maintained and updated by Geoprevent's 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 DEFOX® PRO camera system can be combined or extended with various 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 optical methods, the interferometric georadar functions independently of 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, we recommend to supplemented or replace DEFOX® PRO camera 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 both within a few hours).

AVALANCHE OR ROCKFALL RADAR

Combining DEFOX® PRO camera with a Doppler radar for avalanches or rockfall enables automatic detection of fast mass movements independent of visibility conditions (Figure 6). Through this approach, events are detected as they happen and allow to take immediate actions (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 deeper lying movements. These measuring instruments allow to detect 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 lines in real time, if required.



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

REFERENCE PROJECTS

Geoprevent developed the automatic deformation analysis based on the DEFOX® PRO camera in 2017 and continuously advances its hardware and software. DEFOX® PRO camera has been applied to monitor various natural hazard processes, such as glaciers, landslides or rockfall areas. The following customer projects give an insight into the wide application range. Further information and reference projects are available at www.geoprevent.com.

WEISSMIES GLACIER COLLAPSE, SWITZERLAND

The Weissmies glacier above the well-known tourist resort of Saas Grund was monitored for several years using various monitoring technologies. In spring 2017, we installed DEFOX® PRO camera for long-term monitoring of the Weissmies glacier and only a few months later DEFOX® PRO camera showed a strong acceleration of the unstable glacier area. Inverse velocity analysis indicated an imminent collapse. For more precise observation and since a period of bad weather was imminent, we reinstalled the georadar temporarily. As predicted based on radar data, the collapse occurred a few days later.

MOOSFLUH LANDSLIDE MONITORING, SWITZERLAND

Moosfluh is a large landslide zone in the region of Aletsch glacier, the largest Alpine glacier in Europe. In recent years, the existing old slide has accelerated considerably due to the steady retreat of the glacier. The instability at the back slope of a popular mountain resort has since developed into an active landslide area with frequent small collapses. DEFOX® PRO camera has been observing the long-term development of the slide area from the opposite slope for several years. Numerous small break-off events (even in winter with snow) were correctly anticipated using deformation images days before their occurrence (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 and subsequent avalanches are not uncommon and have caused extensive damage several times in the village of Randa in the valley bottom. Since installation of the first DEFOX® PRO camera in 2017, we have expanded the monitoring setup at this location: The comprehensive warn and alarm system now consists of three DEFOX® PRO cameras (valley bottom, escarpment and hanging glacier) and an avalanche radar for automatic ice avalanche detection with immediate closure of road and railway lines (Figure 8 and 9).

Figure 8: High-alpine installation of DEFOX® PRO camera for long-term monitoring of the Weisshorn hanging glacier. The system at 4133 m a.s.l. operates all year round.



TECHNICAL DATA DEFOX® PRO CAMERA

DEFOX® PRO camera for automatic deformation analysis is available in three different models, which differ mainly in their resolution and range. HDR further optimises contrast and helps to increase the evaluable area.

| Camera model | HD Essential | 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 analysis with DEFOX® PRO camera at the escarpment of Bis glacier.



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).



ROCKFALL



FLOODS



GLACIERS



LANDSLIDES



GLACIAL LAKES



AVALANCHES



DEBRIS FLOWS



SAFETY NETS



PEOPLE

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