we detect to protect

GEO PREVENT

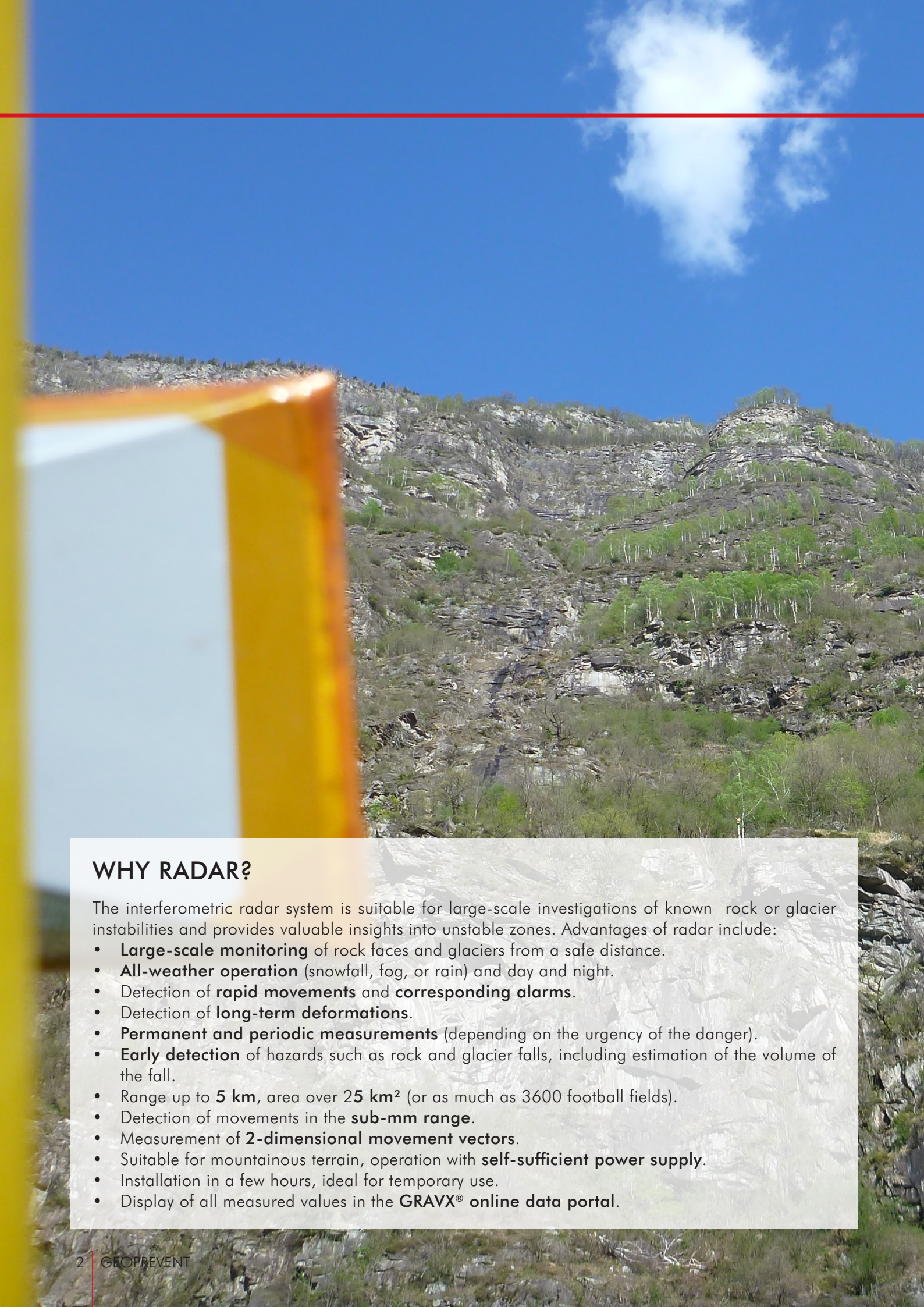
INTERFEROMETRIC RADAR

PART OF HEXAGON

For permanent and/or periodic, weather-independent monitoring of even the smallest deformations on rock faces or glaciers. Measurements with warning option to increase safety during clearance work after an incident or on construction sites.

GEOPRÆVENT AG – part of Hexagon
Räffelstrasse 28
8045 Zurich
Switzerland

Tel. +41 44 419 91 10
info@geoprevent.com



WHY RADAR?

The interferometric radar system is suitable for large-scale investigations of known rock or glacier instabilities and provides valuable insights into unstable zones. Advantages of radar include:

- **Large-scale monitoring** of rock faces and glaciers from a safe distance.
- **All-weather operation** (snowfall, fog, or rain) and day and night.
- Detection of **rapid movements** and **corresponding alarms**.
- Detection of **long-term deformations**.
- **Permanent and periodic measurements** (depending on the urgency of the danger).
- **Early detection** of hazards such as rock and glacier falls, including estimation of the volume of the fall.
- Range up to **5 km**, area over 25 **km²** (or as much as 3600 football fields).
- Detection of movements in the **sub-mm range**.
- Measurement of **2-dimensional movement vectors**.
- Suitable for mountainous terrain, operation with **self-sufficient power supply**.
- Installation in a few hours, ideal for temporary use.
- Display of all measured values in the **GRAVX® online data portal**.

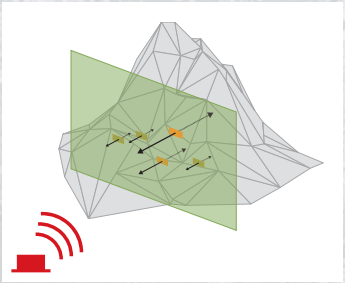
AUTOMATED DEFORMATION ANALYSIS

Permanent and periodic radar measurements using interferometric radar are a highly accurate and reliable tool for determining surface deformations on rock and ice. Interferometric ground-penetrating radar measures relative distance changes between the radar device and the ground surface. This allows deformed surfaces to be identified between two measurements with an accuracy of 1–2 mm at a distance of up to 5 km. Special GEOPREVENT algorithms are used to evaluate and display the data.

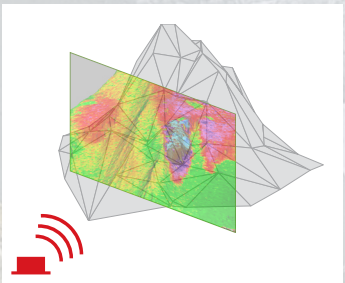
- Improve the assessment of instabilities and verify the prediction by understanding slow uncritical activity.
- Three different algorithms are used to
  - Detect **extremely fast deformations** (12 m/d or 0.5 m/h),
  - Measure deformations that occur **over longer time scales** (mm/d),
  - Detect deformations that occur **over very long periods of time** (mm/month or year).

2D-RADAR MEASUREMENTS

The interferometric radar can be used to precisely locate and quantify ground deformations, with movements in the millimeter range measurable with high spatial resolution. However, it must be clear in which direction a rock mass is moving. This is because the radar only measures the component of the movement in the direction of the beam, i.e., in the direction between the relevant pixel and the location of the radar device. This question is often easy to answer, for example by looking at cracks and fissures.



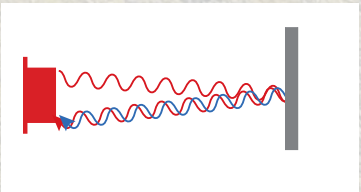
The 2D radar data can be projected onto a numerical model, which simplifies interpretation of the data. Statistical time series of the deformation data can be extracted for certain zones of particular interest, and warning messages (SMS, emails) can be sent when predefined thresholds are exceeded.

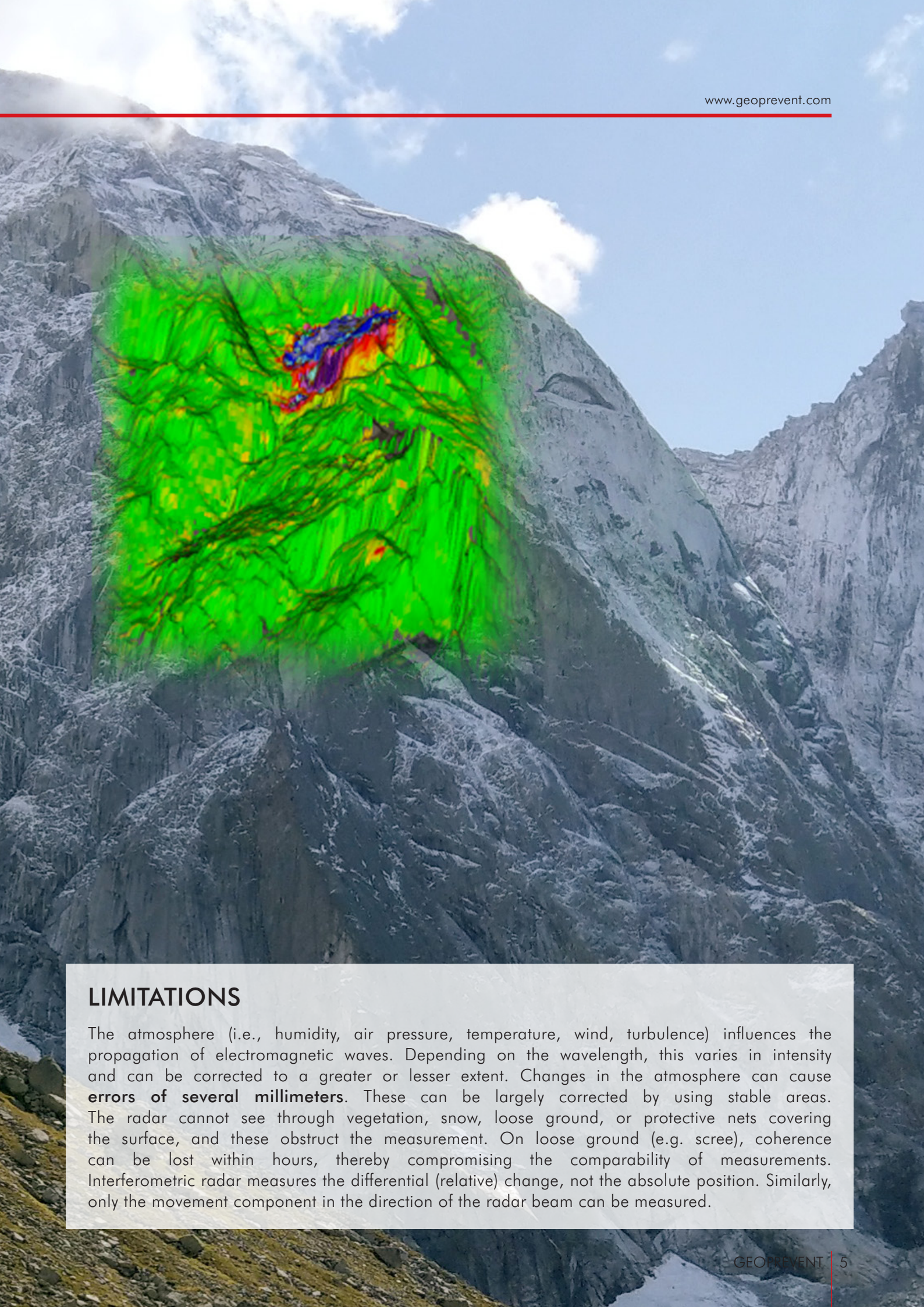


MEASURING PRINCIPLE (SIMPLIFIED)

Radar measures the phase of the reflected microwaves.

- The rock is moving
- Re-measurement from the same location
- Change in the phase of microwaves
- Comparison of two measurements and calculation of deformation





LIMITATIONS

The atmosphere (i.e., humidity, air pressure, temperature, wind, turbulence) influences the propagation of electromagnetic waves. Depending on the wavelength, this varies in intensity and can be corrected to a greater or lesser extent. Changes in the atmosphere can cause **errors of several millimeters**. These can be largely corrected by using stable areas. The radar cannot see through vegetation, snow, loose ground, or protective nets covering the surface, and these obstruct the measurement. On loose ground (e.g. scree), coherence can be lost within hours, thereby compromising the comparability of measurements. Interferometric radar measures the differential (relative) change, not the absolute position. Similarly, only the movement component in the direction of the radar beam can be measured.

COMBINED TECHNOLOGIES

Interferometric radar systems are supplied as complete systems and include the radar hardware, cameras, communication devices, and a self-sufficient power supply, if required. We adapt our systems to local requirements and design them for long-term, fully automatic operation. We use high-quality components that are suitable for harsh winter conditions and represent an energy-efficient solution.

POWER SUPPLY

We use mains power as our power source or, if this is not available, a sophisticated combination of solar cells and a methanol fuel cell. The solar system is dimensioned based on sun simulations at the radar site and the station's power consumption. Solar energy is used when available, while the fuel cell takes over when the weather is bad or when the station is in the shade. The fuel cell and methanol tanks are housed in Pelicases, and the system is designed for one maintenance visit per year to refill the tanks, usually in spring/summer.

COMMUNICATION

All data and images are transferred to the GEOPREVENT cloud for storage and display. In addition, the system sends status and condition data for functional monitoring, and the GEOPREVENT operations team can remotely access the system to troubleshoot problems if necessary. Data communication is possible via various channels, either via existing networks such as GSM, Ethernet, or fiber optics, or we can set up dedicated radio links with repeater stations or satellite communication.

24/7 MONITORING INCLUDED

We continuously monitor all our systems around the world to ensure they are functioning properly. Automated health checks check critical system parameters and notify the GEOPREVENT team in case of irregularities. Our operations team can access all systems and check settings, fine-tune the radar, and perform upgrades.

ADDITIONAL OPTIONS

The interferometric radar can be combined with various additional options. Some of these options are described below. However, this list is not exhaustive, and we are always happy to discuss other requirements and solutions.

ROCKFALL RADAR – AUTOMATIC ALERTING

The interferometric radar can be supplemented with rockfall radar and thus upgraded to an alarm system that triggers automatic measures, such as closing a road or railway line or evacuating a construction site. Common alarm devices include traffic signs, automatic barriers, and audiovisual sirens. As a rule, we also carry out automatic reopening if the event has not reached the road. This keeps closure times short and allows road users to continue their journey within a few minutes of the alarm.

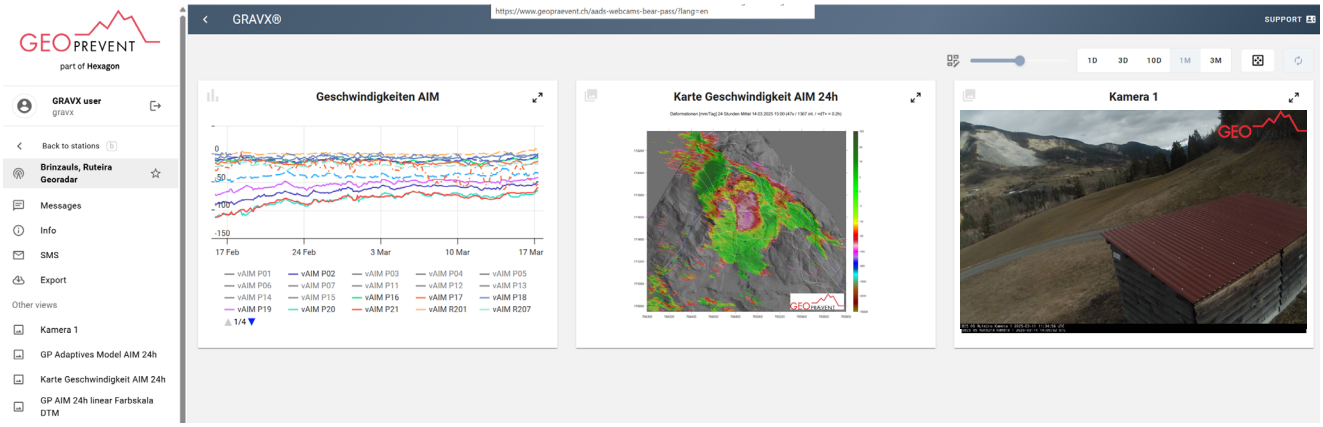
INTEGRATED CAMERAS

The interferometric radar system can be supplemented with a camera. We use remote-controlled cameras with pan-tilt-zoom (PTZ) functionality or high-resolution, highly energy-efficient camera systems. Thermal imaging cameras or other models can also be added. The camera generates regular status images and, on request, close-ups of predefined zones (e.g., avalanche trigger areas). Users can control the PTZ cameras directly via the data portal and view a live image of the situation on site via smartphone, tablet, or PC.

GRAVX® ONLINE DATA PORTAL

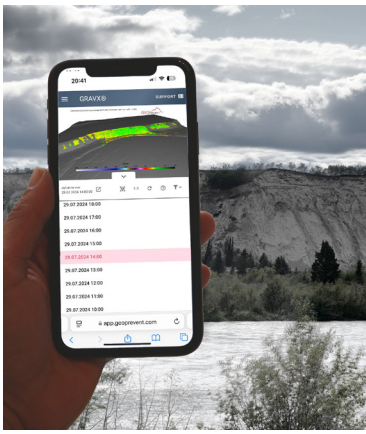
The GRAVX® online data portal connects, visualizes, and archives rockfall and condition data and provides you with the relevant information conveniently via your preferred end devices, i.e., smartphone, tablet, or PC. The GRAVX® online data portal is based on state-of-the-art technology and offers secure storage of your measurement data with password-protected user access. Users simply log in to the browser-based portal; no software installation is required on the devices.

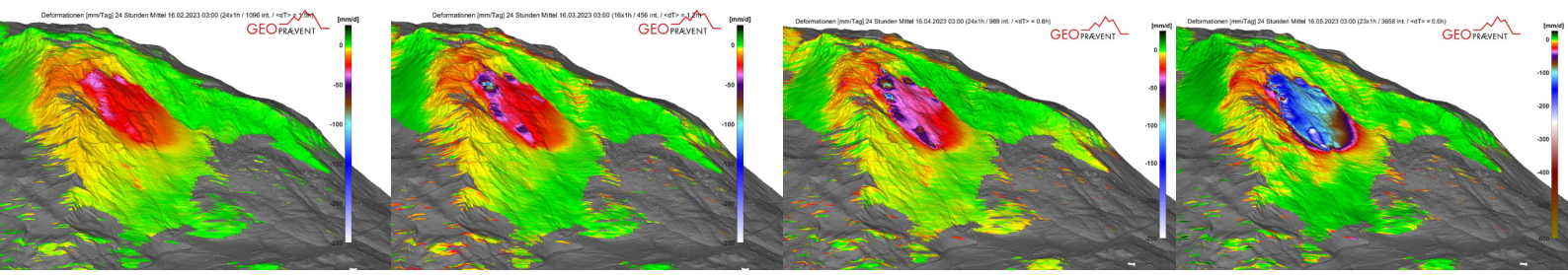
GRAVX® enables easy navigation and provides an overview of all system data. Rockfall events are georeferenced on a map with an intensity heat map or event trajectories. Corresponding event images and properties are displayed in the same view. All lists can be filtered by time or image type. The image viewing function is a handy tool for checking and comparing image details. Additional functions include remote control of cameras and an alarm center for reopening transport routes.



ANYTIME – ANYWHERE

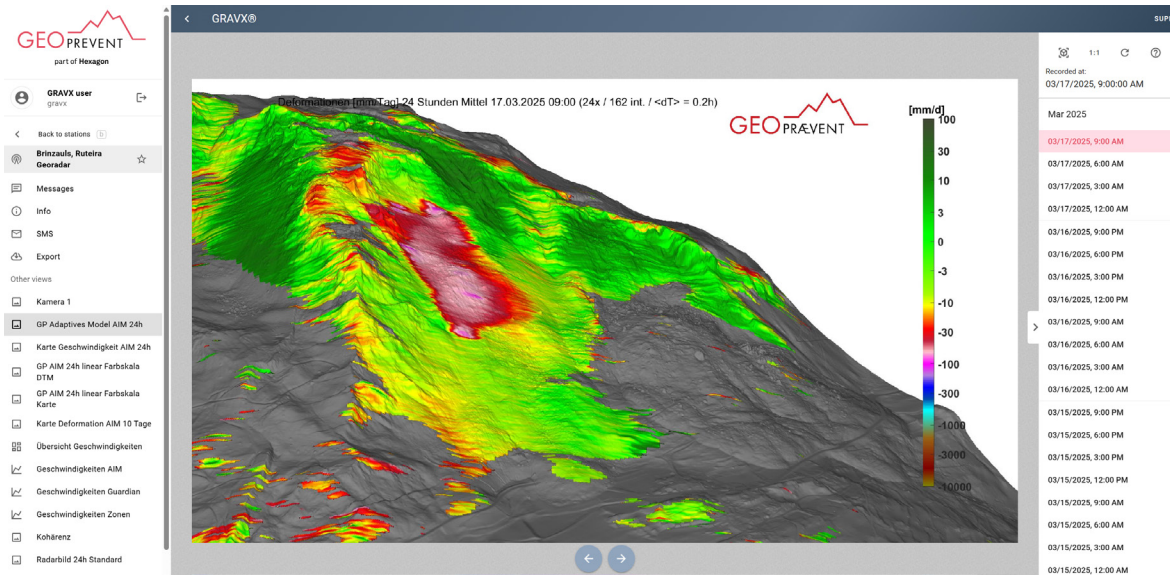
The GRAVX® online data portal can be accessed anytime, anywhere, whether via smartphone, tablet, or PC. The images and deformation data are already available in the field. SMS and emails can be sent when an event begins or ends, or when certain areas are reached. Different user levels allow certain functions to be restricted, such as traffic light control. GRAVX® also offers a message board for communication with the project team and GEOPREVENT employees.

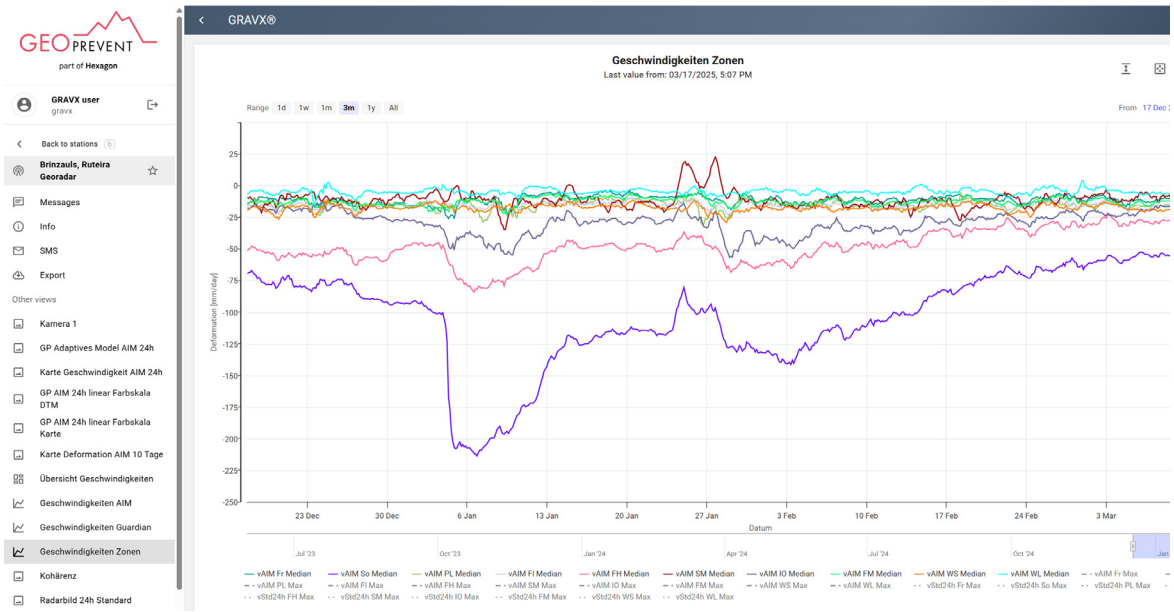


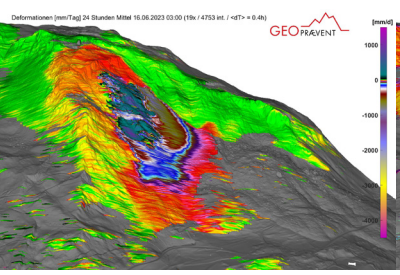


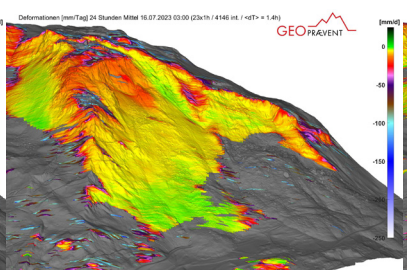
DEFORMATIONS AND VELOCITIES

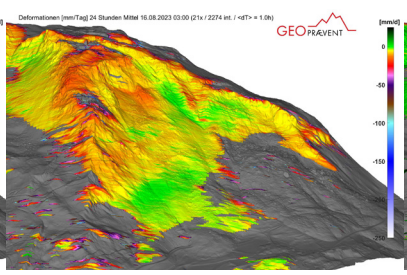
The interferometric ground-penetrating radar scans the slope as required (hourly, daily, monthly) and stores the data in the data portal. Special algorithms are used to calculate the deformations from the scans. The images below show the landslide in Brienz/Brinzauls at a distance of 3 km from the radar location. The lower plot shows data on the velocities of predefined zones on the slope over a specific period of time.

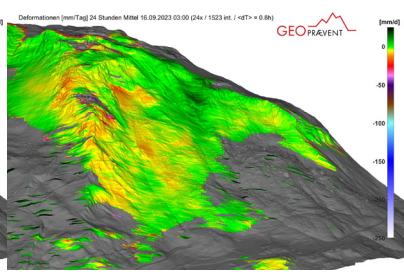








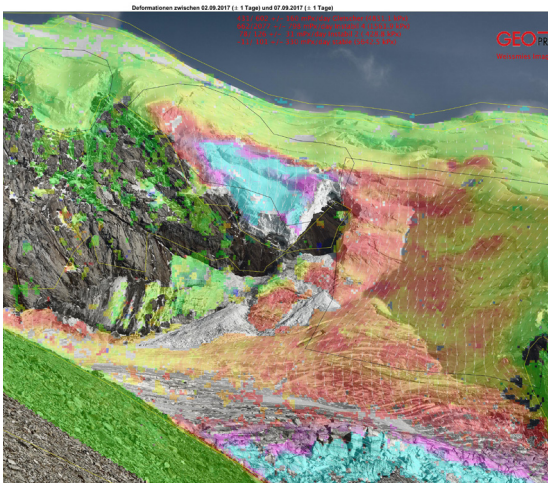




REFERENCE PROJECTS

GLACIER MONITORING WEISSMIES, SWITZERLAND

In 2014, GEOPREVENT installed an interferometric radar to continuously monitor the unstable area on the Weissmies Glacier. In August 2017, deformation analysis showed a significant acceleration of the unstable glacier area. Based on radar measurements and expert assessments by glaciologists, the time of the glacier collapse was predicted for the early morning of September 10, 2017. The glacier continued to accelerate and eventually moved toward the valley at a speed of 3.5 m/day before breaking off in several events in the early morning of September 10, 2017, as expected.



BARRY ARM LANDSLIDE (ALASKA), USA

The Barry Arm landslide is a large landslide area in Alaska. A rapid slide down the slope could trigger a tsunami, causing life-threatening waves and currents in the adjacent fjords. To monitor the situation, GEOPREVENT has installed a self-contained interferometric radar on a rocky outcrop opposite the endangered area, which precisely records the movements of the slope over various periods of time and thus provides information about the slope's stability.

WHITEHORSE, CANADA

Since 2023, GEOPREVENT has been operating an interferometric radar in Whitehorse, Canada, which monitors the embankment along the Yukon River. The road that runs below the embankment has been buried by landslides several times. Monitoring and automatic closure of the road are intended to ensure that no vehicles or people are in the affected area in the event of another incident.

VISSOIE (VALAIS), SWITZERLAND

The rock mass above the cantonal road between Siders and Vissoie in Valais is very unstable. During the night of March 23 to 24, 2024, a landslide buried the road, and a few days later, a boulder weighing over a ton broke through the protective gallery of the road. To ensure that the cleanup and repair work can be carried out safely, GEOPREVENT has installed an interferometric radar on the opposite slope. This will allow the slope to be monitored and the construction site to be alerted in the event of another incident.

TECHNICAL DATA INTERFEROMETRIC RADAR

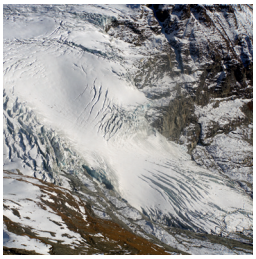
Range:	Up to 5 km
Cover:	Up to 25 km²
Accuracy:	Detection of deformations in the sub-mm range, realistically approx. 1 mm (in the direction of view)
Resolution:	4 mrad, i.e. approx. 4 m pixel width at a distance of 1 km
Power supply:	Suitable for high altitudes, operation with self-sufficient power supply (solar power, fuel cell), mains power
Software:	Deformation algorithm, online data portal
Integration:	Online data portal, smartphone, tablet
Warning:	Automatic warning option
Installation:	Quick, just a few hours

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).

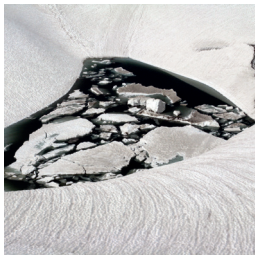
ROCKFALL

FLOODS



GLACIERS

LANDSLIDES



GLACIAL LAKES

AVALANCHES

DEBRIS FLOWS

SAFETY NETS

PEOPLE

GEOPRÆVENT AG – part of Hexagon
Räffelstrasse 28
8045 Zurich
Switzerland

Tel. +41 44 419 91 10
info@geoprevent.com

More info: www.geoprevent.com

Follow us on: