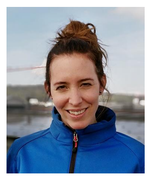
Automatic Deformation Analysis with Cloud Processing of High-Resolution Images with Examples of Veslemannen (Norway) and Trift Glacier (Switzerland)

INTERPRAEVENT
2021 – Norway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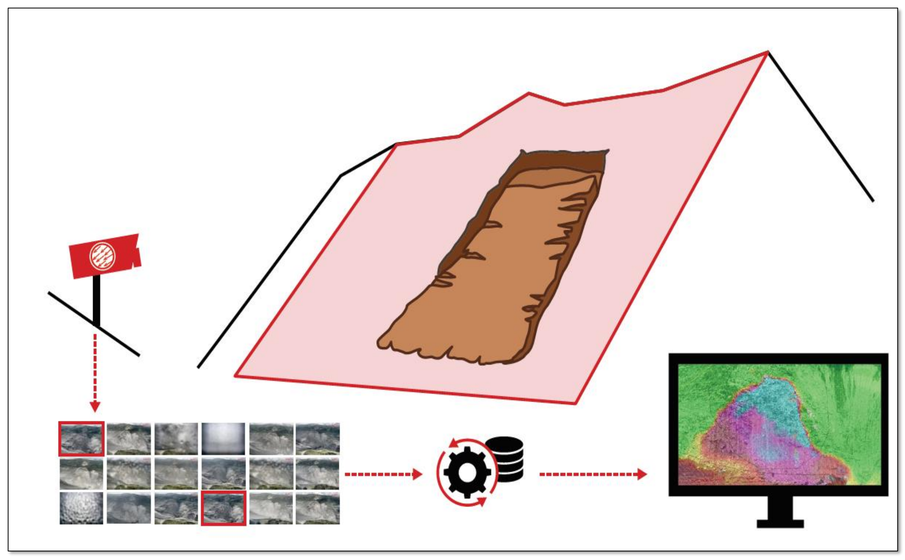
INTRODUCTION

Various measurements technologies exist for surface deformation monitoring of unstable slopes, such as landslides, rock instabilities or glaciers. We noticed that there is a lack of an automatic, cost effective technology for continuous long-term monitoring enabling large-scale surveillance of slope dynamics and simple acceleration detection at an early stage.

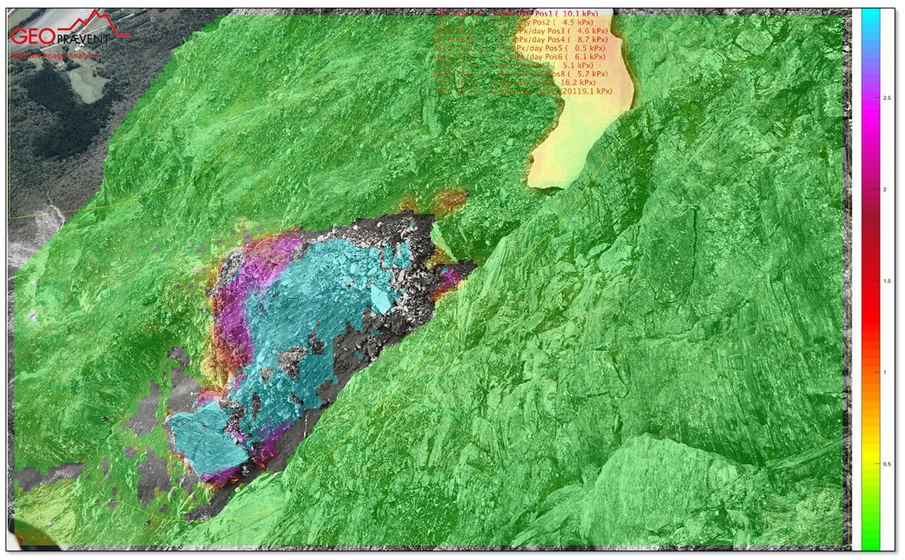


METHODS

We developed a fully automatic deformation analysis based on high-resolution images, smart image selection and proprietary evaluation algorithms. The camera system consists of a 42-MP camera, autonomous power supply and data transmission to our cloud. Several times a day, the system triggers images and uploads them to our cloud where a selection algorithm eliminates unsuitable images (e.g. due to weather, exposure) by analysing image characteristics. The best image combinations for a given interval are determined based on maximum attribute match. Automatic selection is vital for process automation and is a key features of our application compared to conventional image analysis based on manual selection. Image analysis is based on cross correlation and runs for several hours on our high-performance computers. The 2D-deformation analysis is projected onto an image and shows the displacement colour-coded including movement direction. In addition, we calculate time series of defined image fields providing an overview of long-term surface displacement dynamics.

MANNEN, NORWAY

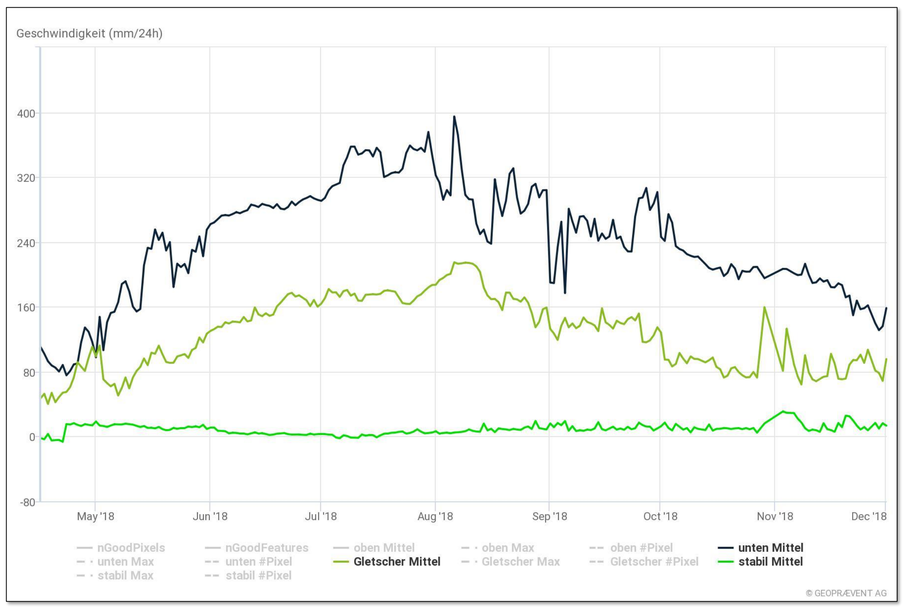
The highly unstable mountain portion of Mannen, called Veslemannen, has been monitored for years with various measurement instruments[1].In late 2018, The Norwegian Water Resources and Energy Directorate (NVE) extended the setup with the deformation analysis to monitor the instability from the plateau above. Once most snow had melted by early July 2019, daily deformation analysis

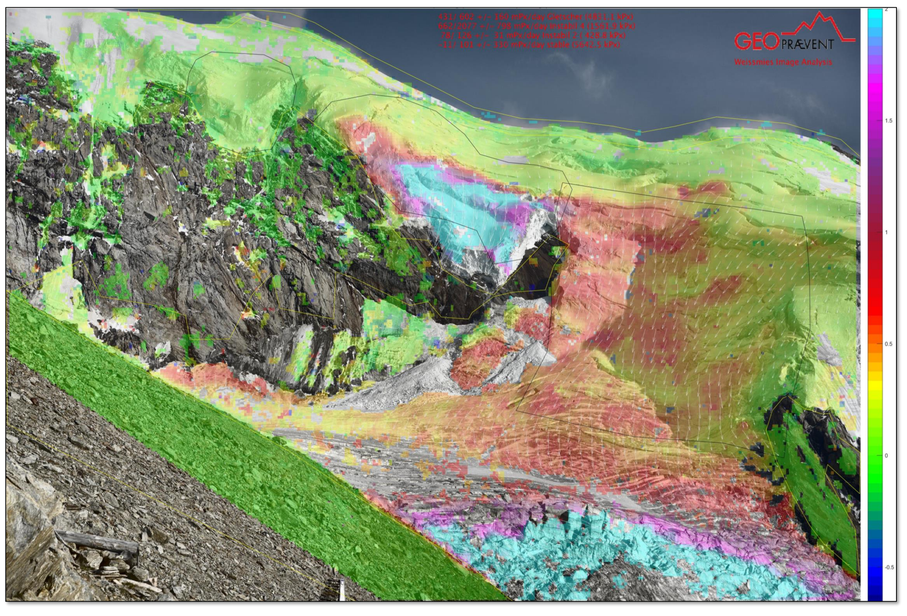


indicated significant displacements. In the following weeks, the unstable area increased in size with simultaneously accelerating displacement rates until the slope failed on September 5, 2019.

TRIFT GLACIER, SWITZERLAND

In 2017, we installed the very first deformation camera at Weissmies for long-term monitoring of Trift Glacier. In August the same year, deformation analysis showed a clear acceleration of the glacier flow rate and indicated an imminent collapse of the unstable glacier part. An inverse velocity analysis performed end of August 2017 pointed to a failure in mid-September. At this point, the monitoring setup had to be adjusted, and we additionally applied the interferometric georadar to provide more detailed data with all-weather availability. Based on the measurements, we were able to predict the time of the event with a few hours accuracy and minimize precautionary evacuations to the night of glacier collapse[2] on 10 September 2017.





RESULTS & DISCUSSION

Since development of optical deformation analysis in 2017, we have installed more than 30 automatic stations for landslide, rock instability and glacier monitoring in Switzerland, France, Norway, the US and China.

CONCLUSIONS

Optical deformation analysis based on high-resolution images has proven to be a convenient and cost-effective tool for automatic, long-term monitoring of instabilities, including landslides, rock faces and glaciers, where vegetation and weather is not an issue.

REFERENCES:

1 Kristensen, L., Czekirda, J., Penna, I. et al. Movements, failure and climatic control of the Veslemannen rockslide, Western Norway. Landslides (2021). https://doi.org/10.1007/s10346-020-01609-x

2 Laboratory of Hydraulics, Hydrology and Glaciology of ETH Zürich (2018). Annual Report 2017. Pages 57 45-47. Available at: https://ethz.ch/content/dam/ethz/special-interest/baug/vaw/vaw-dam/documents/das-institut/jahresberichte/2010-2019/jahresbericht-2017.pdf. Last accessed April 8, 2021