Monitoring of the Weissmies Glacier before the Failure Event of September 10, 2017 with Radar Interferometry and High-Resolution Deformation Camera

Lorenz Meier[1], Mylène Jacquemart[1], Richard Steinacher[1], Dominik Jäger[1], Martin Funk[2]

[1] *Geopraevent AG, Technoparkstrasse 1, 8005 Zurich, Switzerland*
[2] *ETH Zurich, Laboratory of Hydraulics, Hydrology and Glaciology, 8093 Zurich, Switzerland*

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Introduction

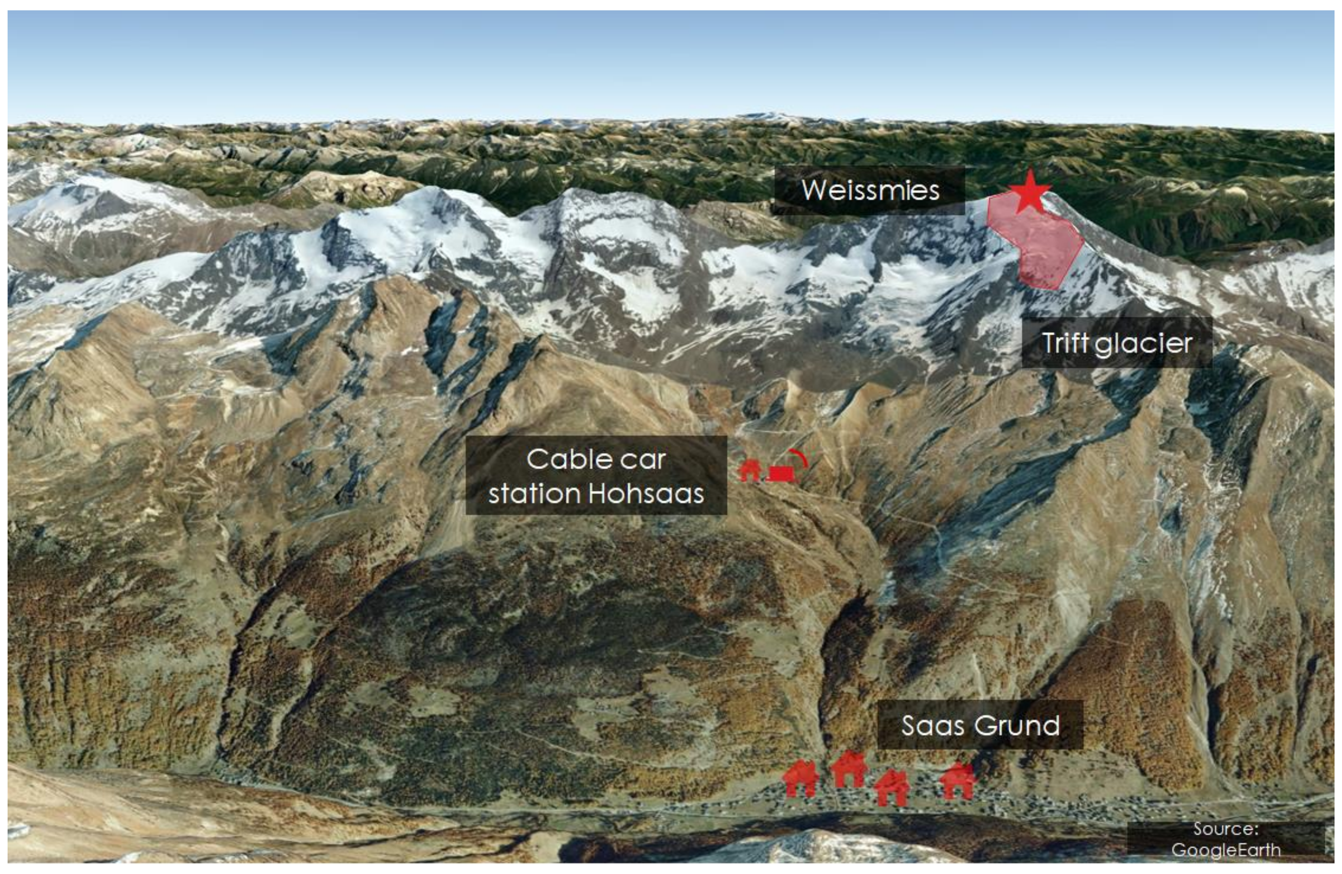


Figure 1: Saas Grund at the base of Weissmies: The interferometric radar and the high-resolution camera are mounted in combination or alternately at the cable car station Hohsaaas.

A large part of the glacierized northwest face of Weissmies recently became unstable.

The situation at Weissmies is critical because the glacier immediately below the unstable part is frequently travelled by mountaineers on their way to the summit of Weissmies. Besides that, large avalanches with several 100'000 m^3 off the northwest face of Weissmies pose a threat to infrastructure and people in the valley.

We installed a **combination of radar and camera-based systems to monitor the instability** and provide advance warning.

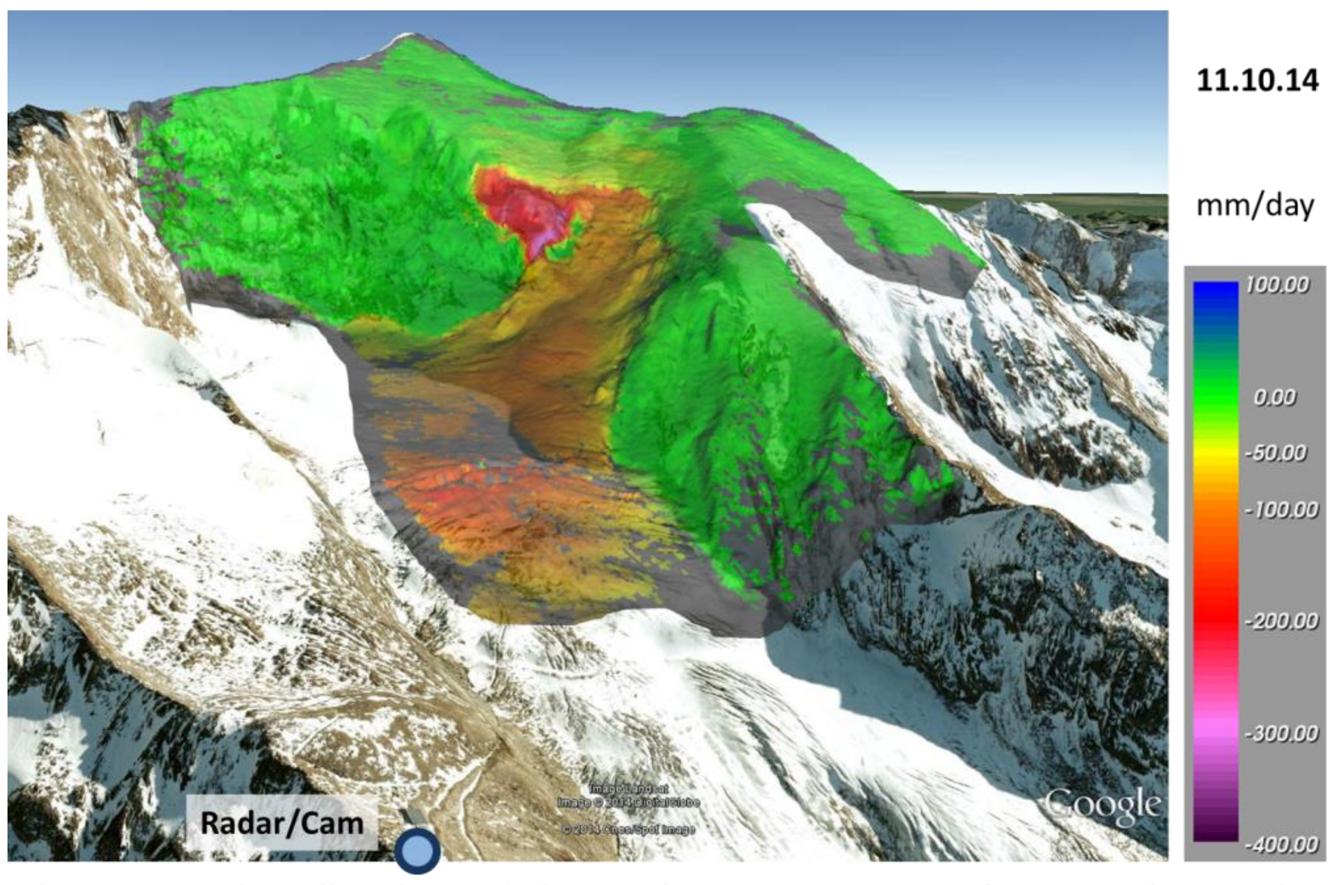
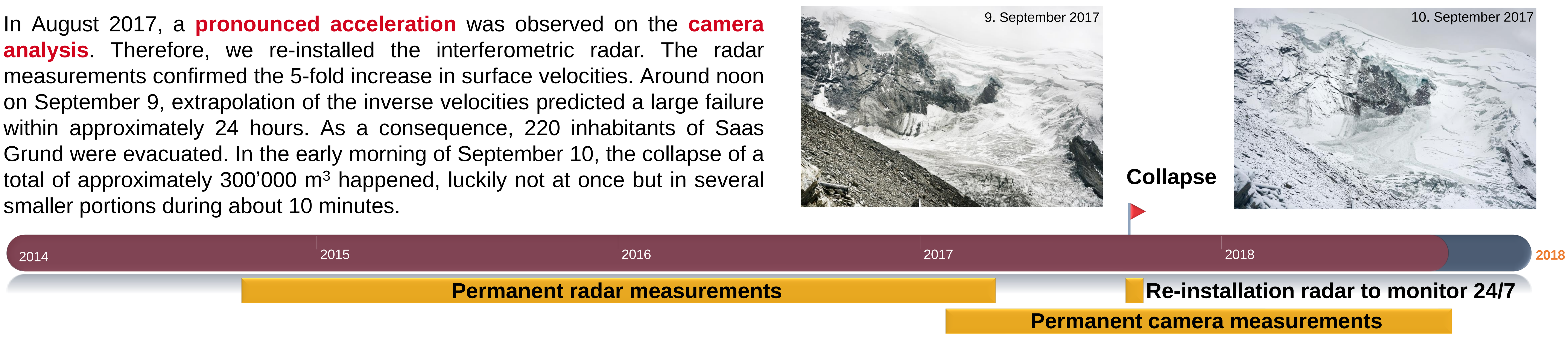


Figure 2: Visualisation of the radar coverage. Whereas the rocky part is stable, the radar detects velocities around 20 cm/day at the glacier surface in October 2014.

System Description and Results

In August 2017, a **pronounced acceleration** was observed on the **camera analysis**. Therefore, we re-installed the interferometric radar. The radar measurements confirmed the 5-fold increase in surface velocities. Around noon on September 9, extrapolation of the inverse velocities predicted a large failure within approximately 24 hours. As a consequence, 220 inhabitants of Saas Grund were evacuated. In the early morning of September 10, the collapse of a total of approximately 300'000 m^3 happened, luckily not at once but in several smaller portions during about 10 minutes.



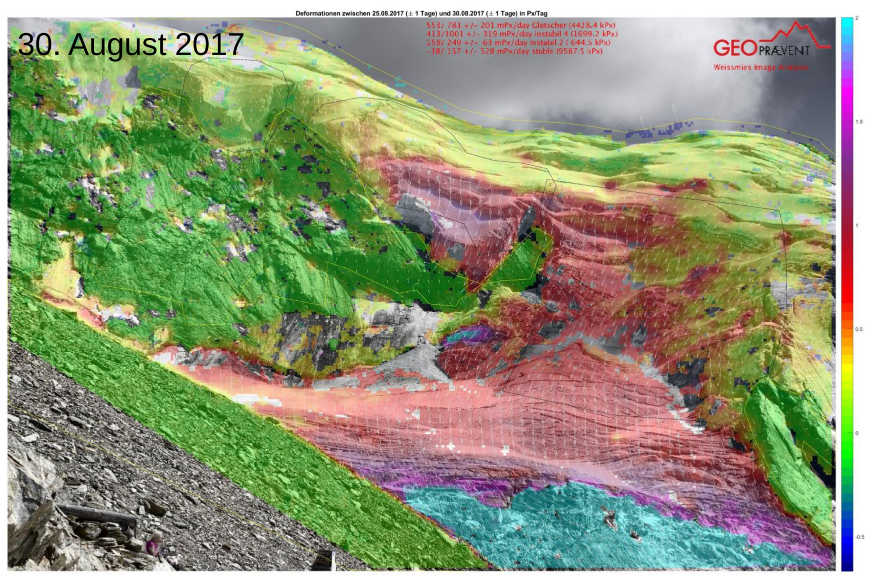
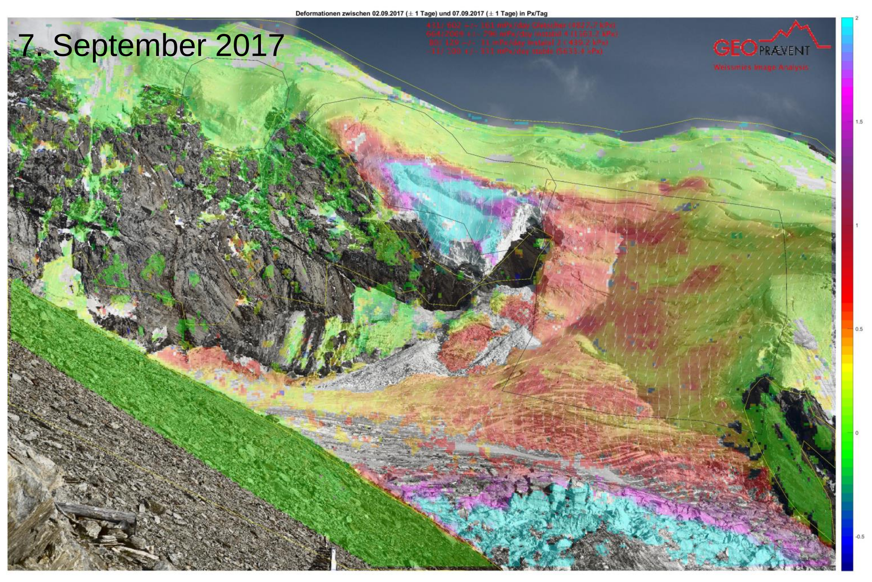


Figure 3: An image processing algorithm **automatically** determines the surface deformations based on the camera pictures.



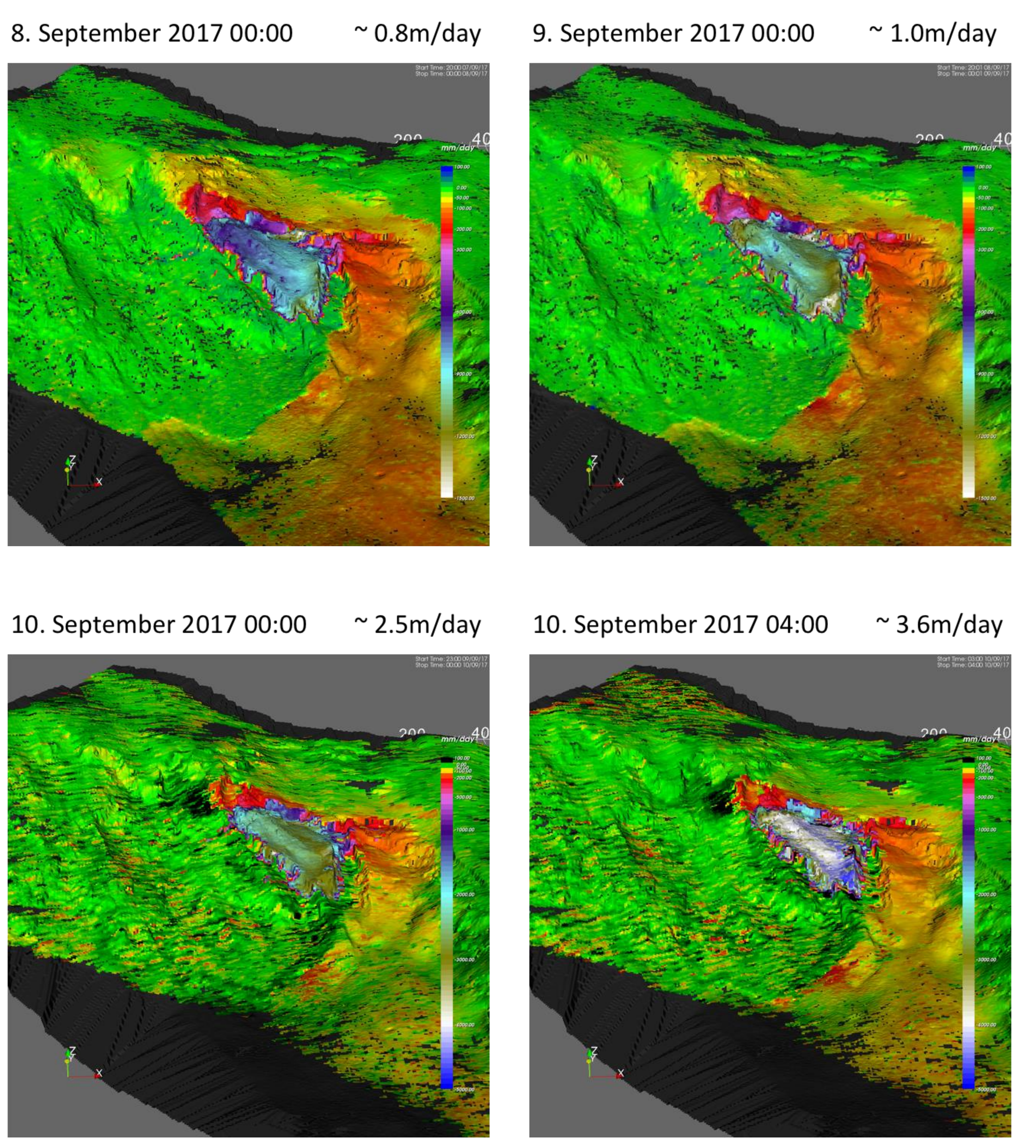


Figure 4: Development of surface velocities as measured by the radar on the unstable part of the glacier during the two days prior to failure.

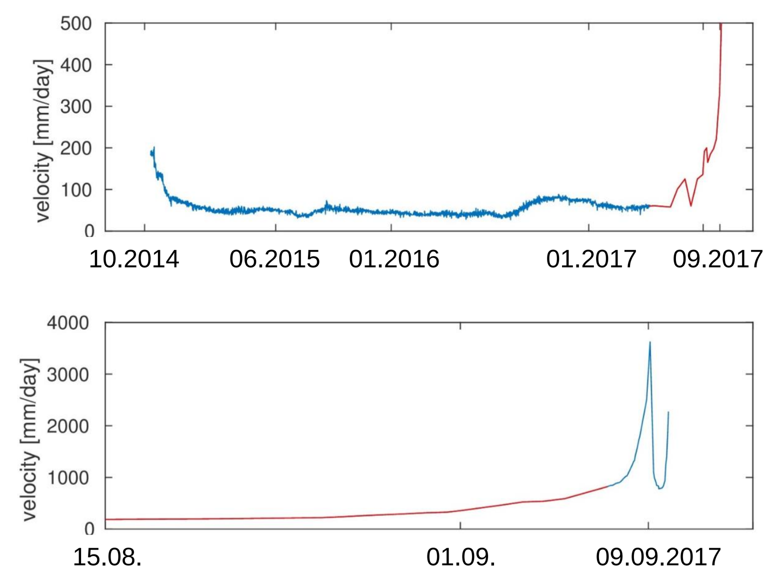
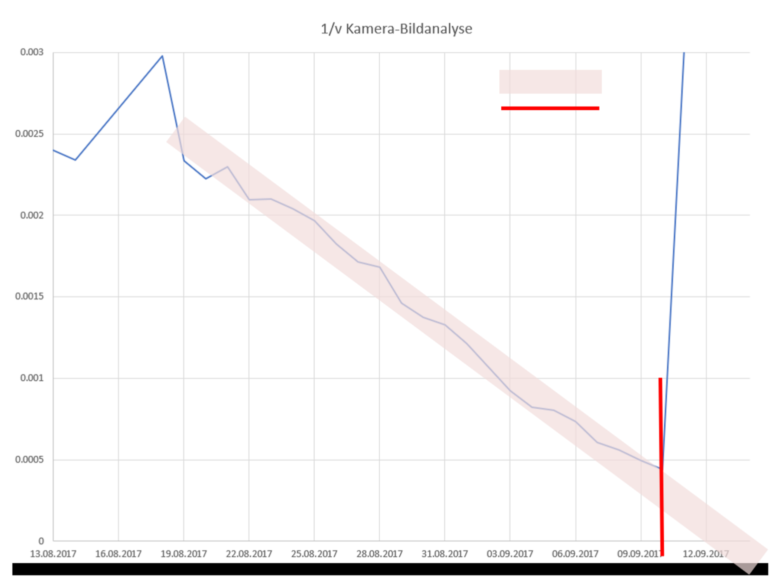


Figure 5 (left): Surface velocities measured since October 2014. Radar measurements are plotted in blue, velocities measured with the high-resolution camera system are plotted in red.

Figure 6 (right): Inverse plotting of the velocities measured since mid August 2017 **by the camera**.

Already by the end of August it was clear that a failure would happen within a few weeks.



Conclusion

Both the **interferometric radar and** the **high-resolution camera** are suitable tools for measuring surface flow fields of a glacier instability. The camera is a more cost-effective tool than the radar. But while the radar-based system works both at night and during bad weather, the camera-based component requires good visibility.

As such, the two instruments **can complement each other to ensure year-round monitoring of an instability**, with the radar providing 24/7 and all-weather tool necessary for emergency operations when a failure is imminent.

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