



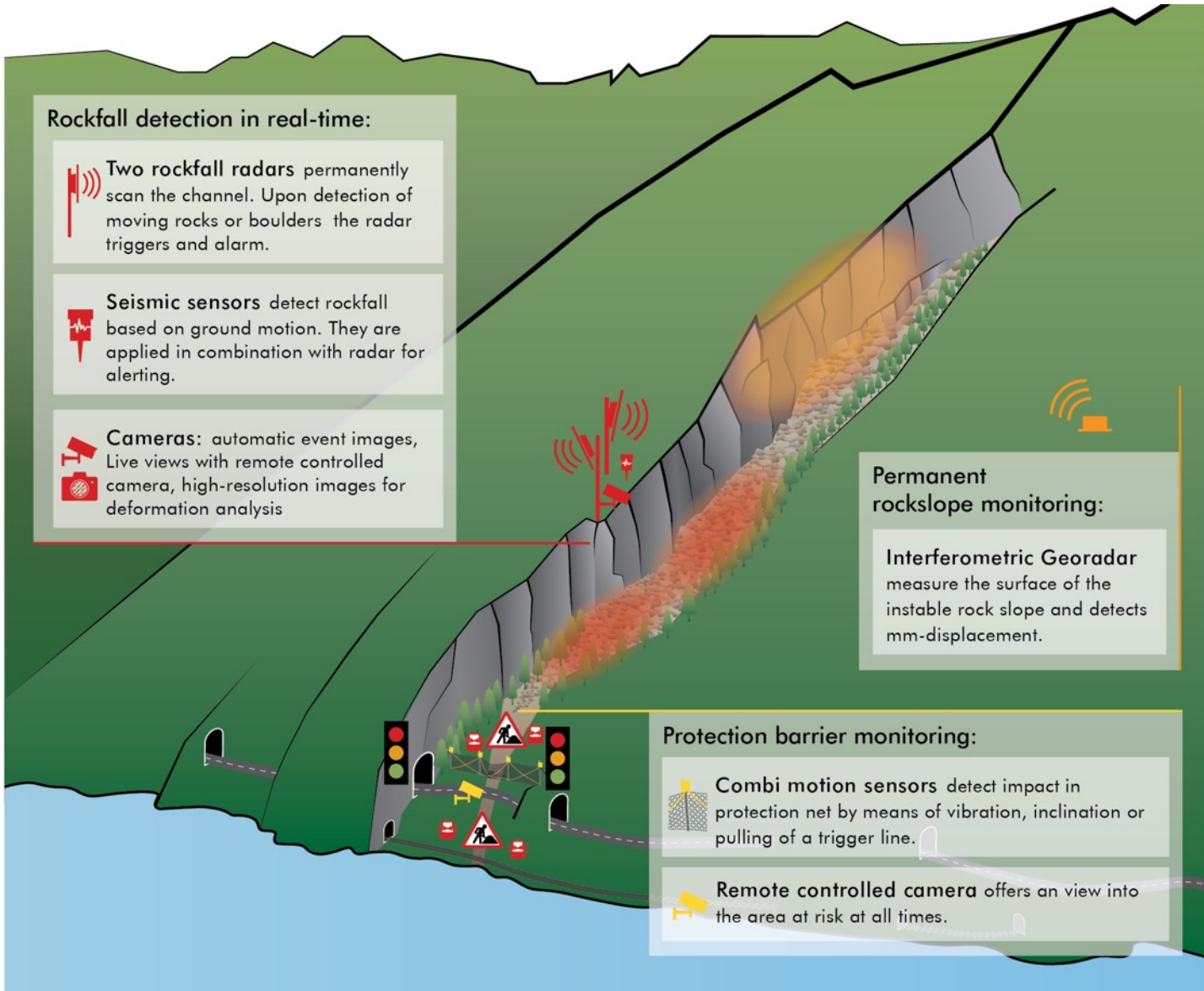
Rockfall Alarm System with Automatic Road Closure for major European North-South Route

Lorenz Meier, Susanne Wahlen, Gian Darms
GEOPREVENT AG – Zurich, Switzerland



- Axenstrasse = major North-South connection through Swiss Alps
- 16'000 vehicles/day
- Juli 18, 2019: heavy rainfall triggered rockfall in Gumpisch valley above road
- 12-ton boulder crossed road and stopped below
- Large debris accumulations still present from recent rockfall event upvalley
- Road operator closed route for safety reasons
- Design & development of early warning system in only few weeks

Overview of installed early warning system





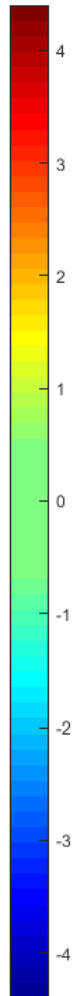
- Permanent rock slope monitoring for detection of slow movements (mm/day – mm/months)
- For early detection of further large failures further up debris channel

- interferometric radar with autonomous power supply (fuel cell and solar panels)
- Connected with online data portal

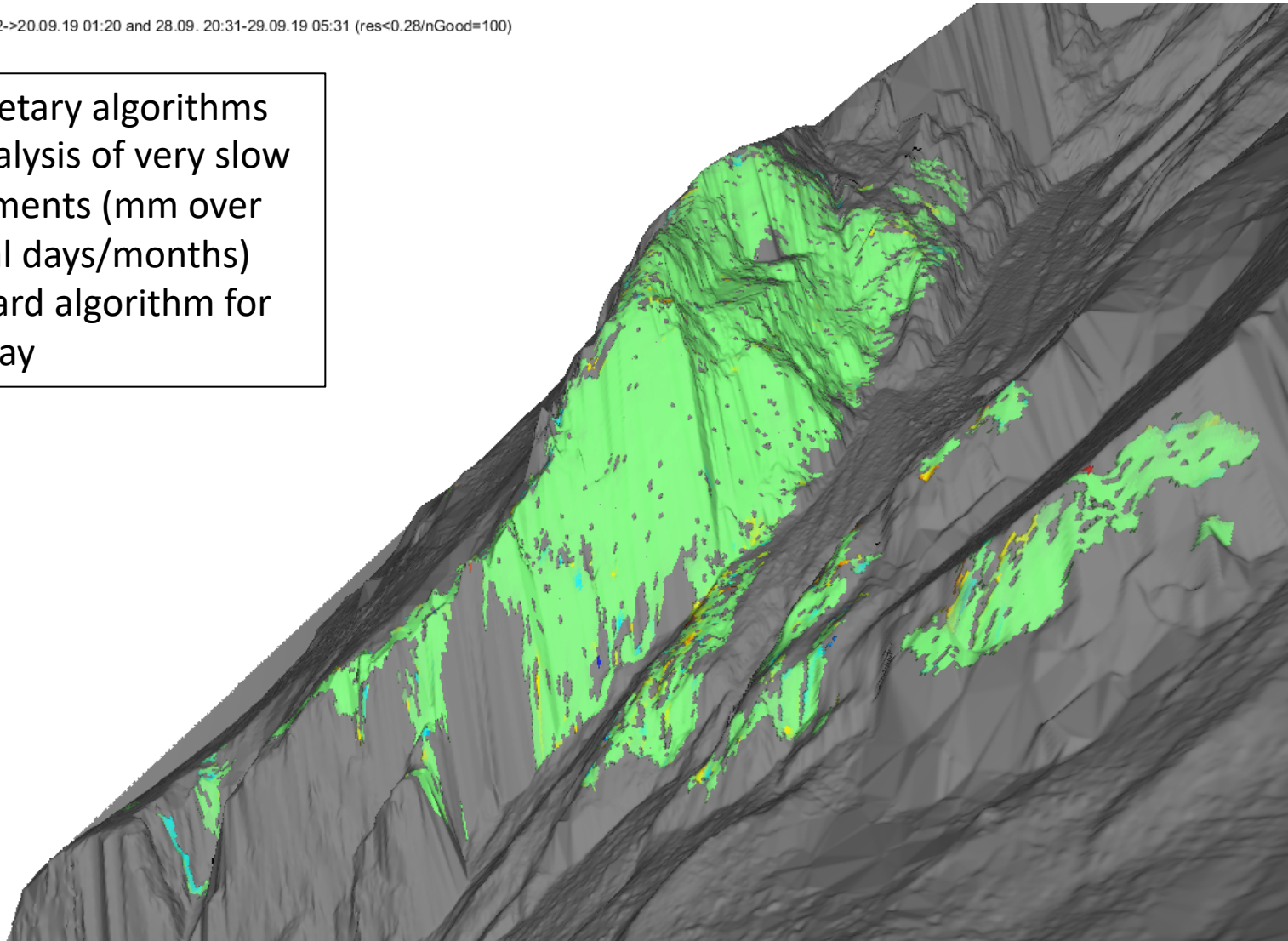


Deformations in mm after 10 days

Deformation mm 9.8 days between 19.09. 03:22->20.09.19 01:20 and 28.09. 20:31-29.09.19 05:31 (res<0.28/nGood=100)



- Proprietary algorithms for analysis of very slow movements (mm over several days/months)
- Standard algorithm for mm/day

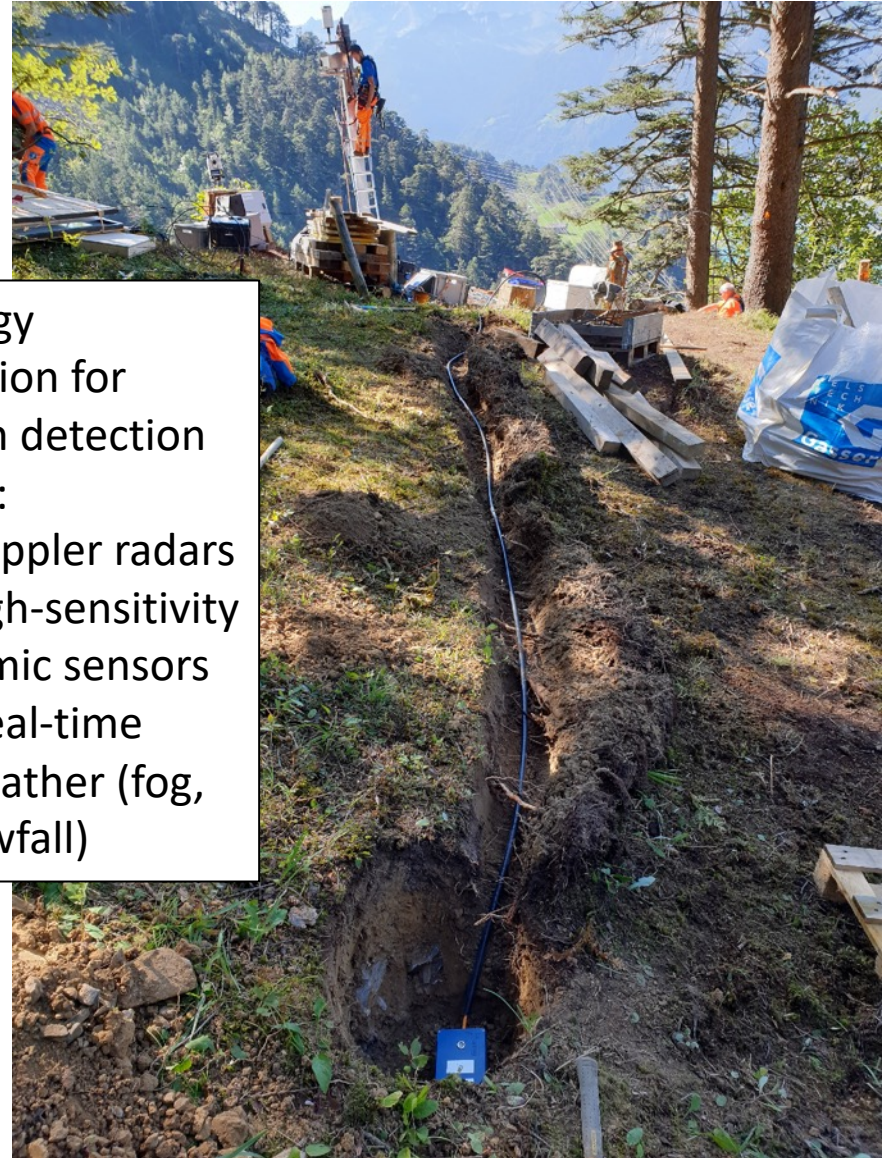




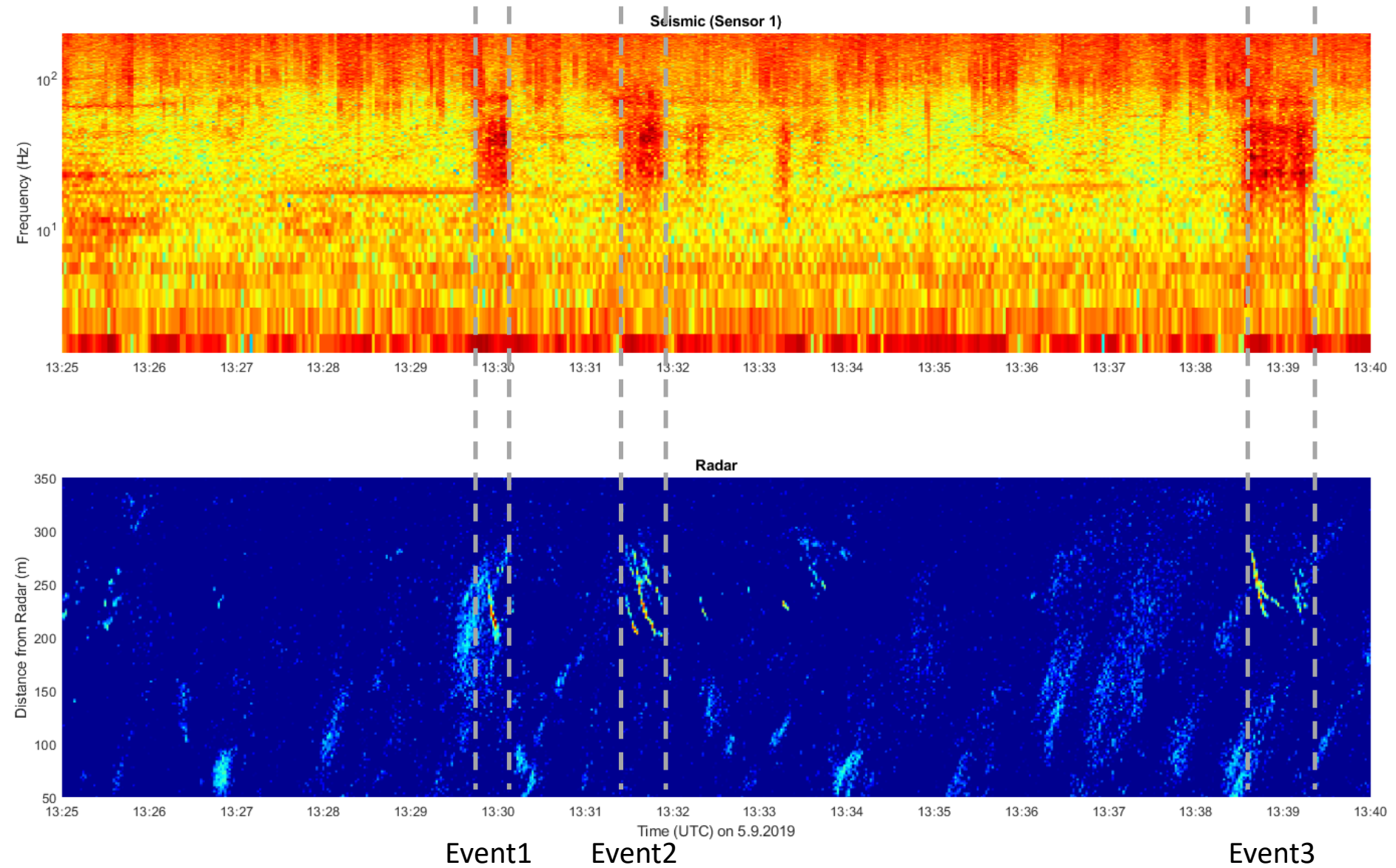
- Automatic detection of fast movements in real-time (rockfall, debris flow)
- Monitoring of debris channel for detection of slow movements

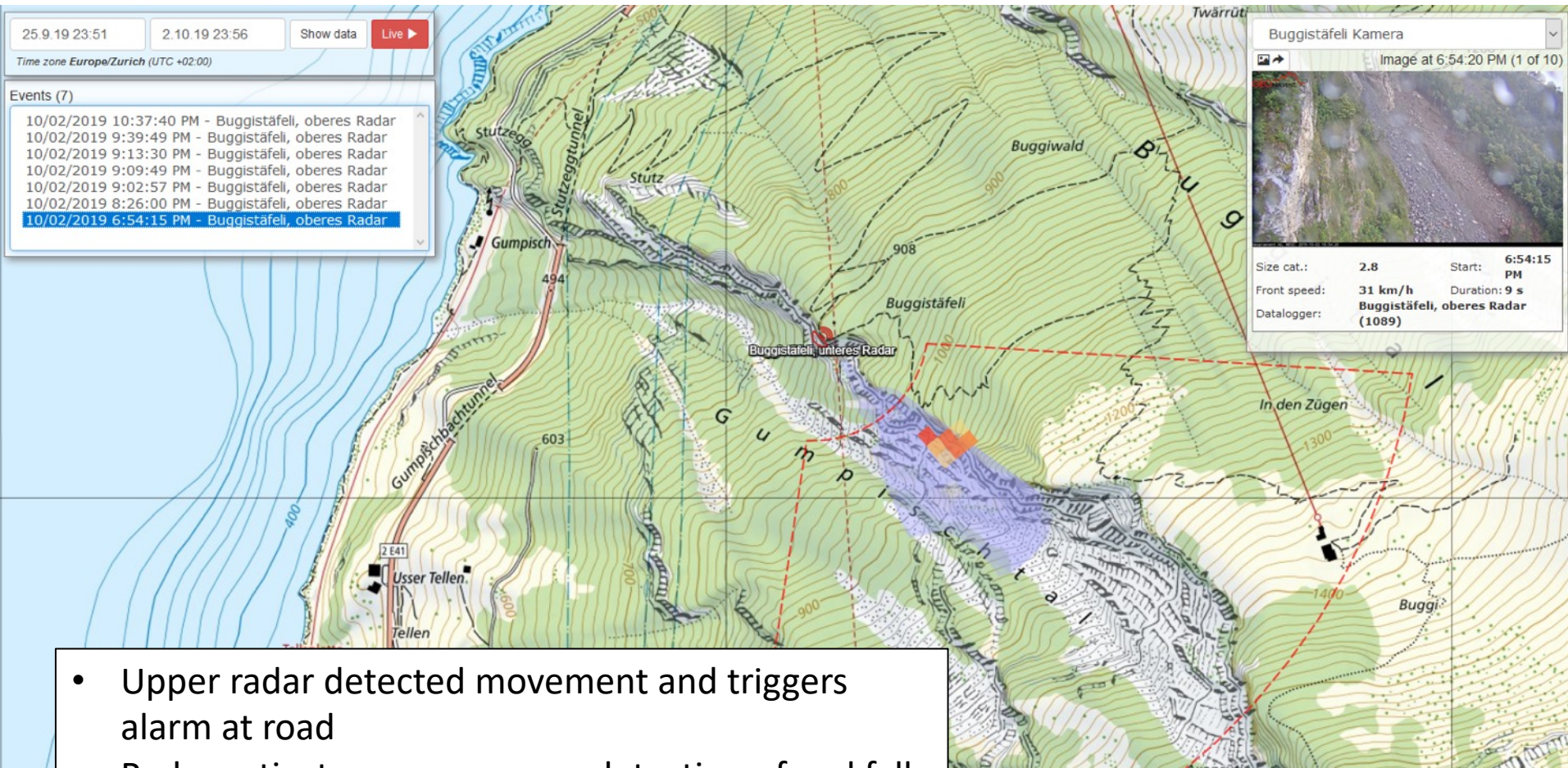


- Technology combination for maximum detection reliability:
 - 2 Doppler radars
 - 3 high-sensitivity seismic sensors
- Both in real-time
- In any weather (fog, rain, snowfall)



Examples: 5. September 2019





- Upper radar detected movement and triggers alarm at road
- Radar activates camera upon detection of rockfall
- Creation of automatic event image series



- Webcam takes event images
- Live-webcam can be used to inspect channel any time via online data portal
- Pan-tilt-zoom functionality



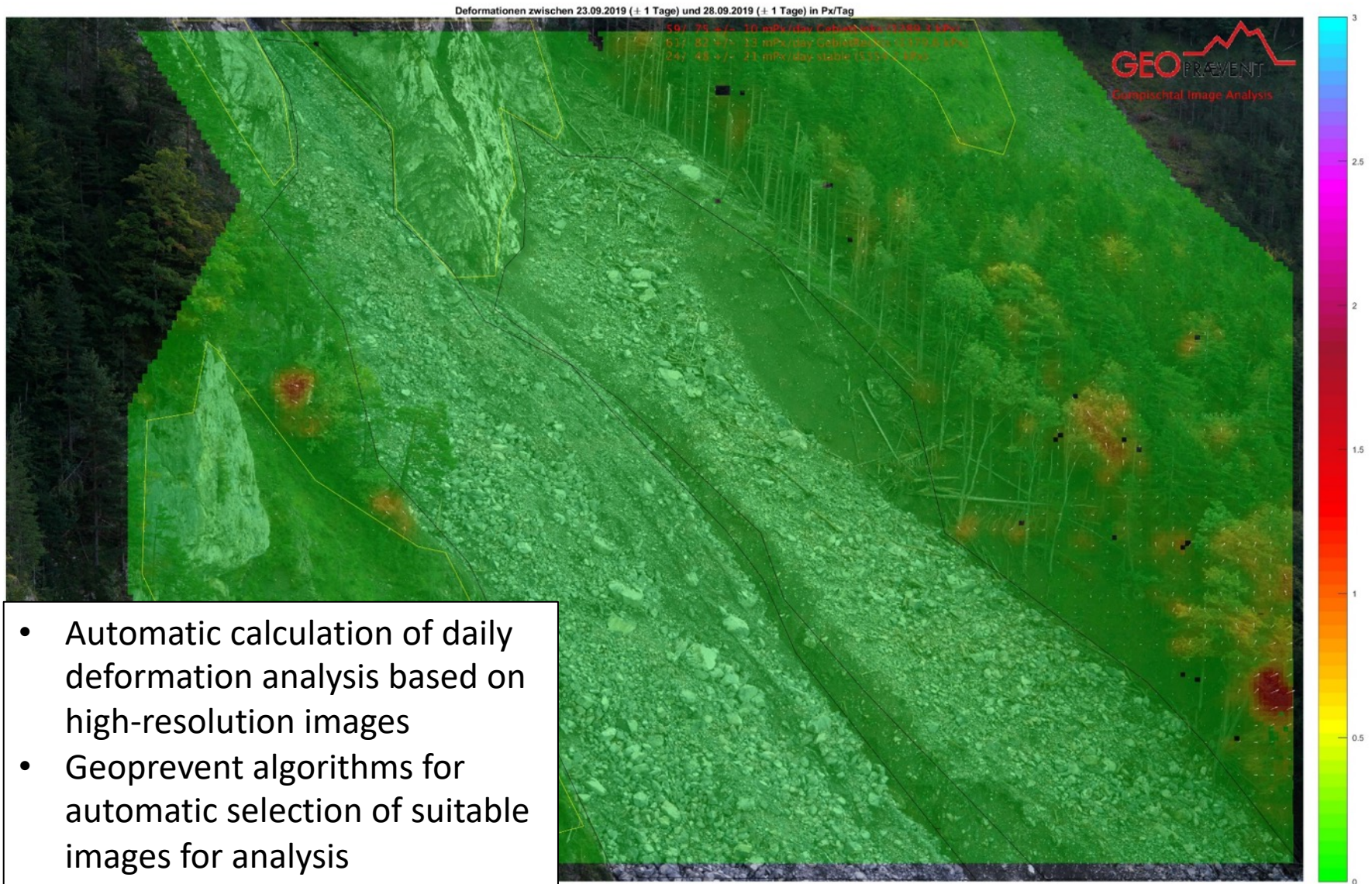
- Two high-resolution cameras
- For automatic deformation analysis of debris channel
- For remote, detailed inspection of single rocks/boulders



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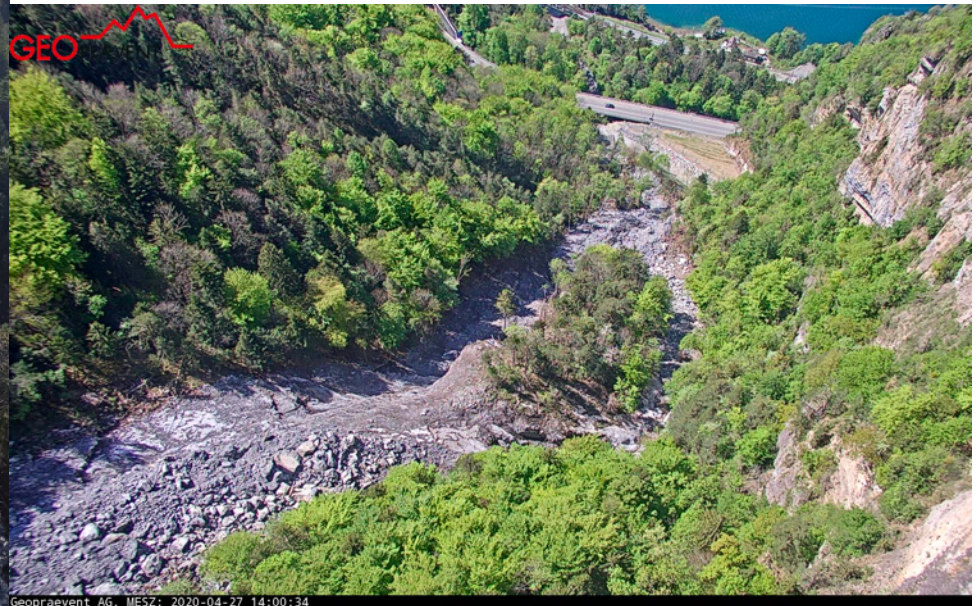


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- View of debris channel
- Short warning time of 20-30 s → immediate road closure required
- But many events remain small and do not reach road?
- How to avoid unnecessary closures?



Geopraevent AG, MES2: 2020-04-27 14:00:34



- Installation of combination sensors in protection barriers above road
- Automatic detection of impact by boulder or debris flow passage

Example:

- Radar detects rockfall in debris channel above → immediate road closure
- No impact in protection barriers → automatic reopening of road after 2 min



→ Only short closure for road users

Thanks for your attention!



More information on www.geoprevent.com
or contact us directly:

GEO PREVENT AG
Technoparkstrasse 1
CH-8005 Zurich
Switzerland
Ph. + 41 44 419 91 10

Lorenz.Meier@geopraevent.com
Susanne.Wahlen@geoprevent.com