Early Warning Systems in Switzerland – Discussion of Case Examples

GLOFCA Workshop Almaty – October 23, 2024

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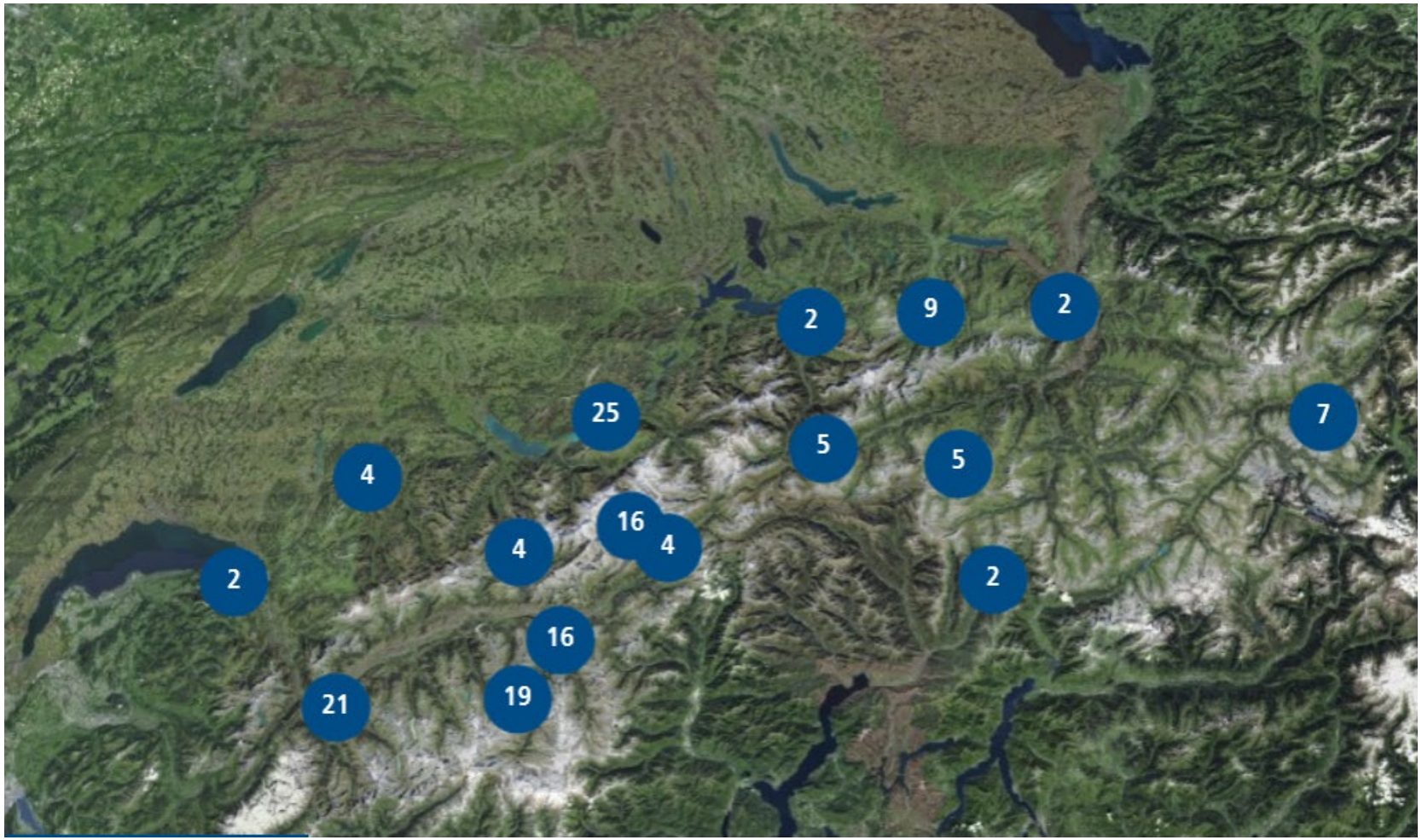
Introduction

Four case examples:

1. Ritigraben
2. Chamoson
3. Münster
4. Brienzergrat



Introduction

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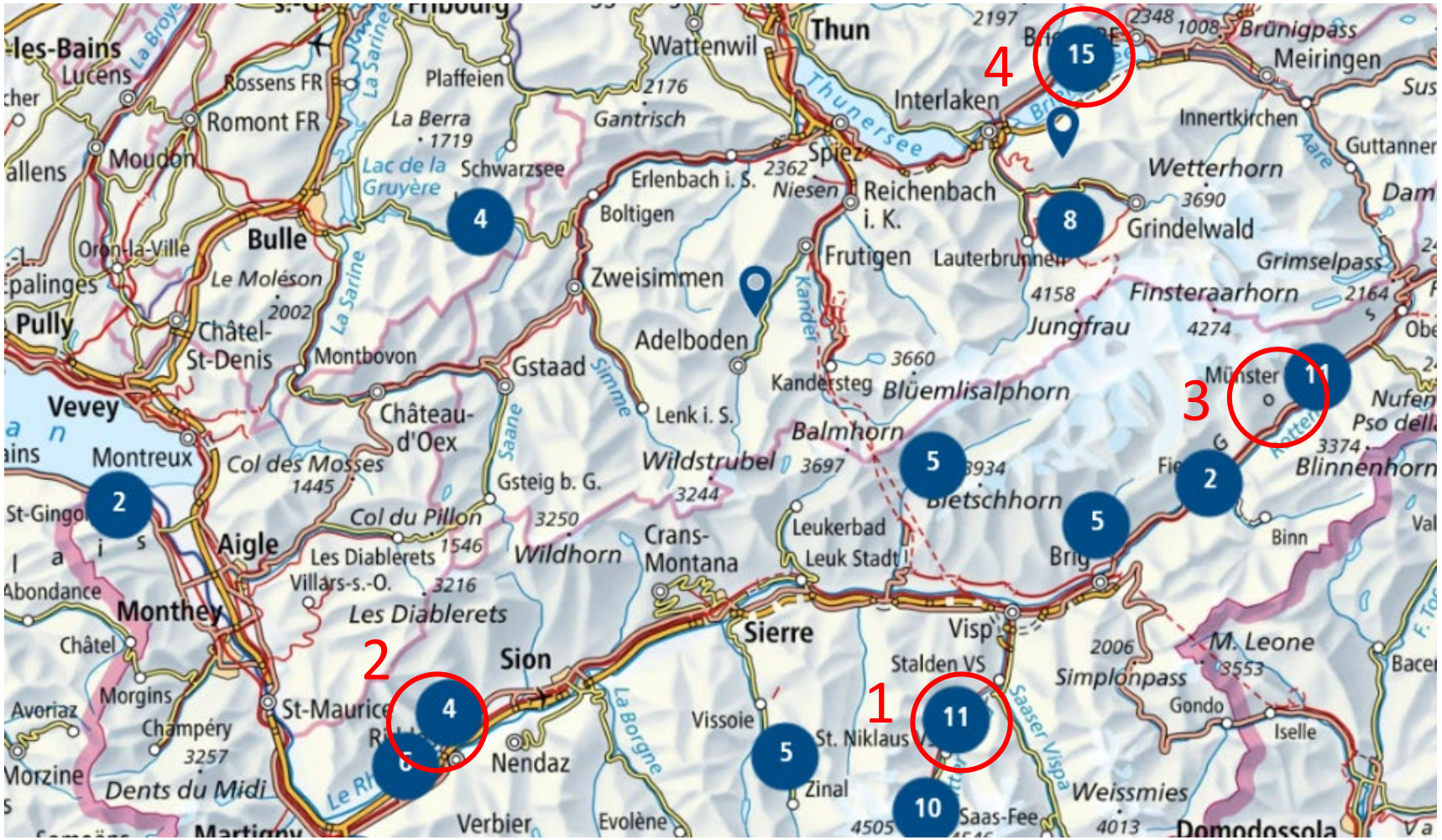


Example 1: Ritigraben

- Only access road / railway to Zermatt
- High touristic and economic importance

Example 1: Ritigraben

- Only access road / railway to Zermatt
- High touristic and economic importance
- Debris flow starts in periglacial area (2600) and reaches the road in the valley bottom (1070)
- Alarm system installed in 1995: 29 years of operation

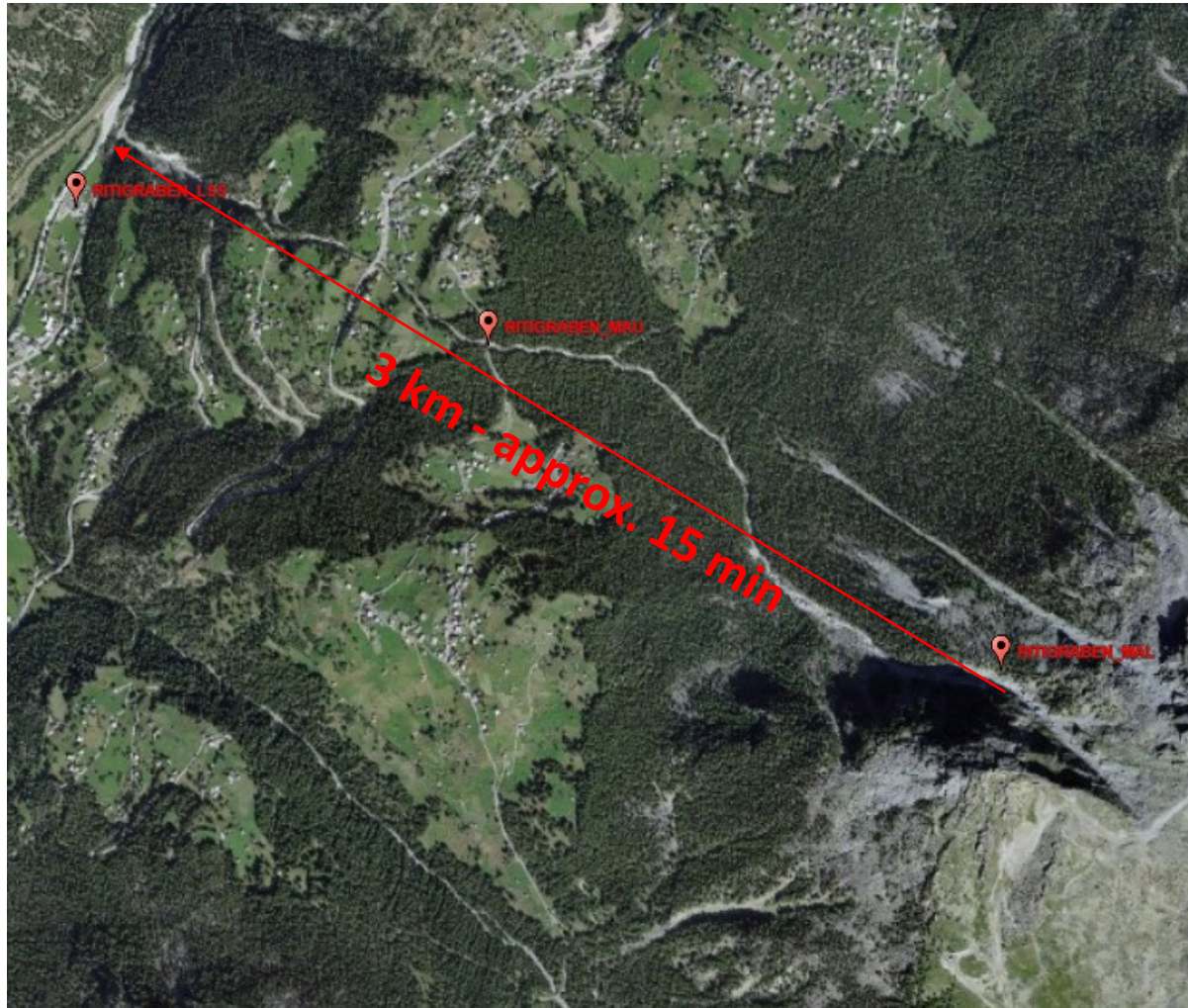
Example 1: Ritigraben

- Event June 21st 2024
- Video from bridge to Grächen
- One of several events

Example 1 – upper detection

- Relatively slow process (2-4 m/s)
- Upper detection from 1995
- 3 km from road (lower bridge)
- Alarm 15 min ahead is too long
- Small events do not reach the road
- Events may start below

→detection further down is preferable



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→detection further down is preferable

- High meteorological noise

→re-installation of geophones 2017

→installation matters!

Example 1 – middle detection

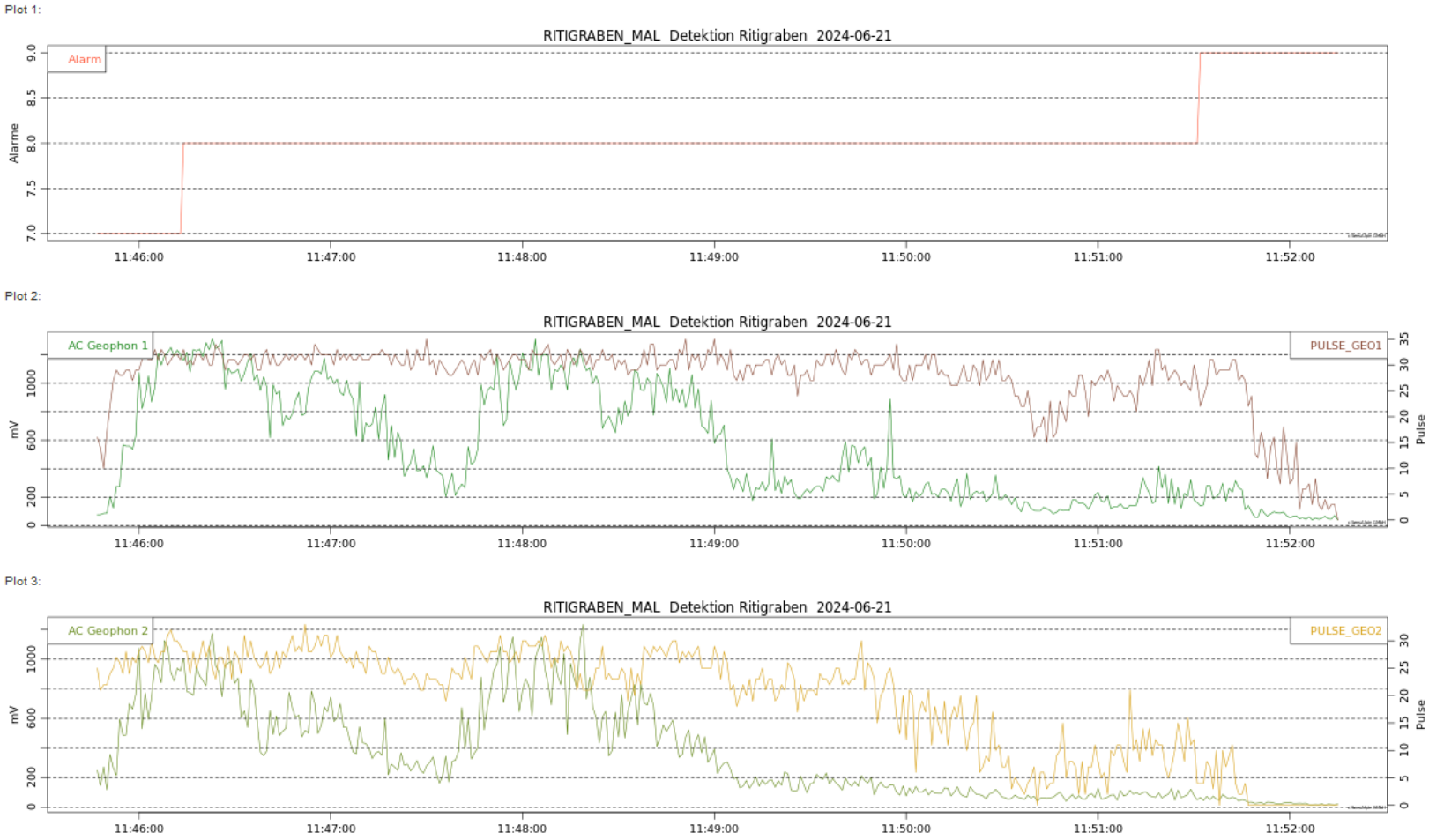
- Middle detection built in 2019
- Level sensor and geophones
- Better alarm quality (event size and shorter lead time)
- Upper station only used for pre-warning

Example 1 – lower detection

- Changed risk situation in 2024
- Lateral silde in lowest section
- Extension with additional sensors in lowest section
- Planning and installation within a few weeks

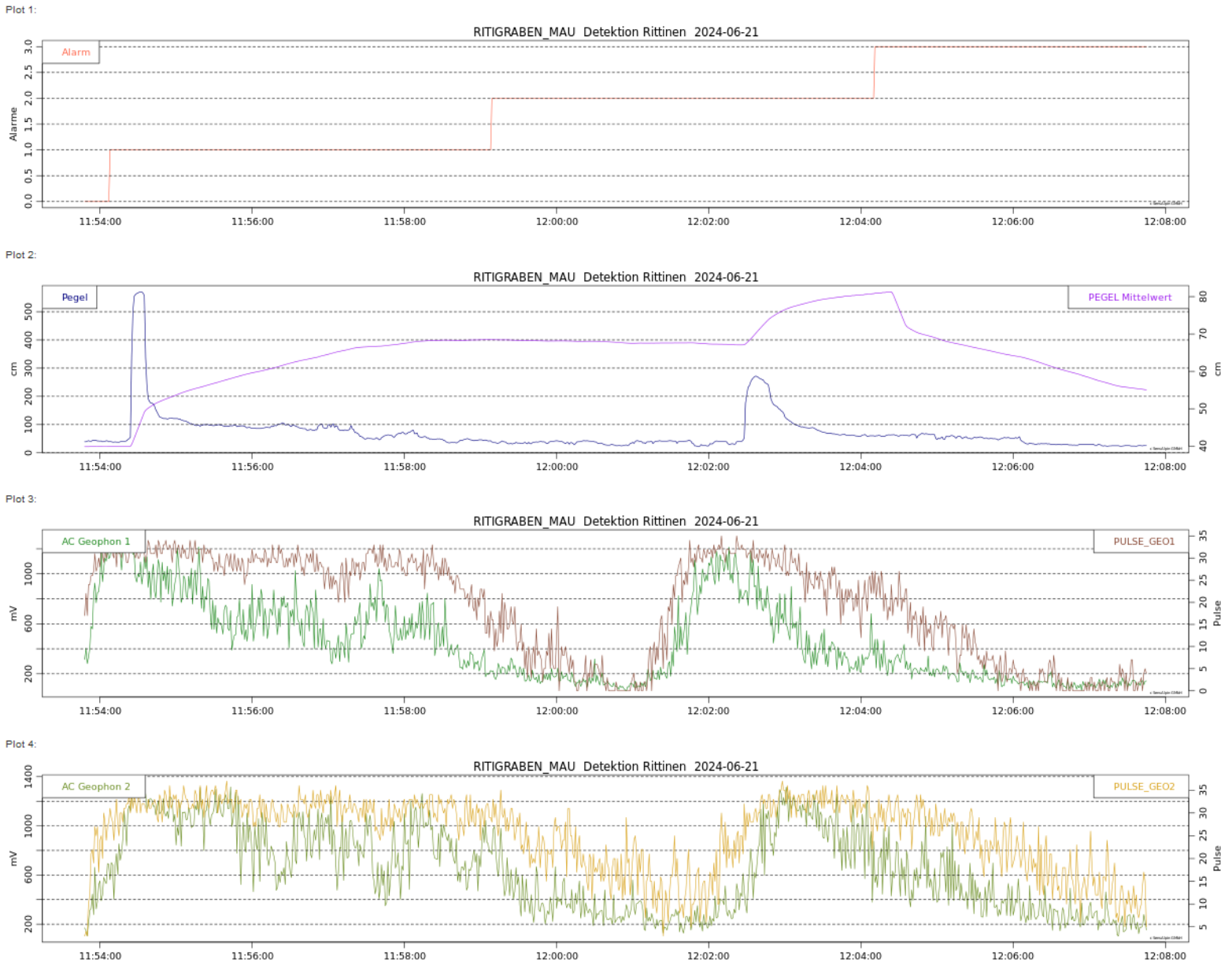
Example 1 – event June 2024

- Events from June 2024 (video)
- Several events within a few hours
- Data from geophones at upper detection



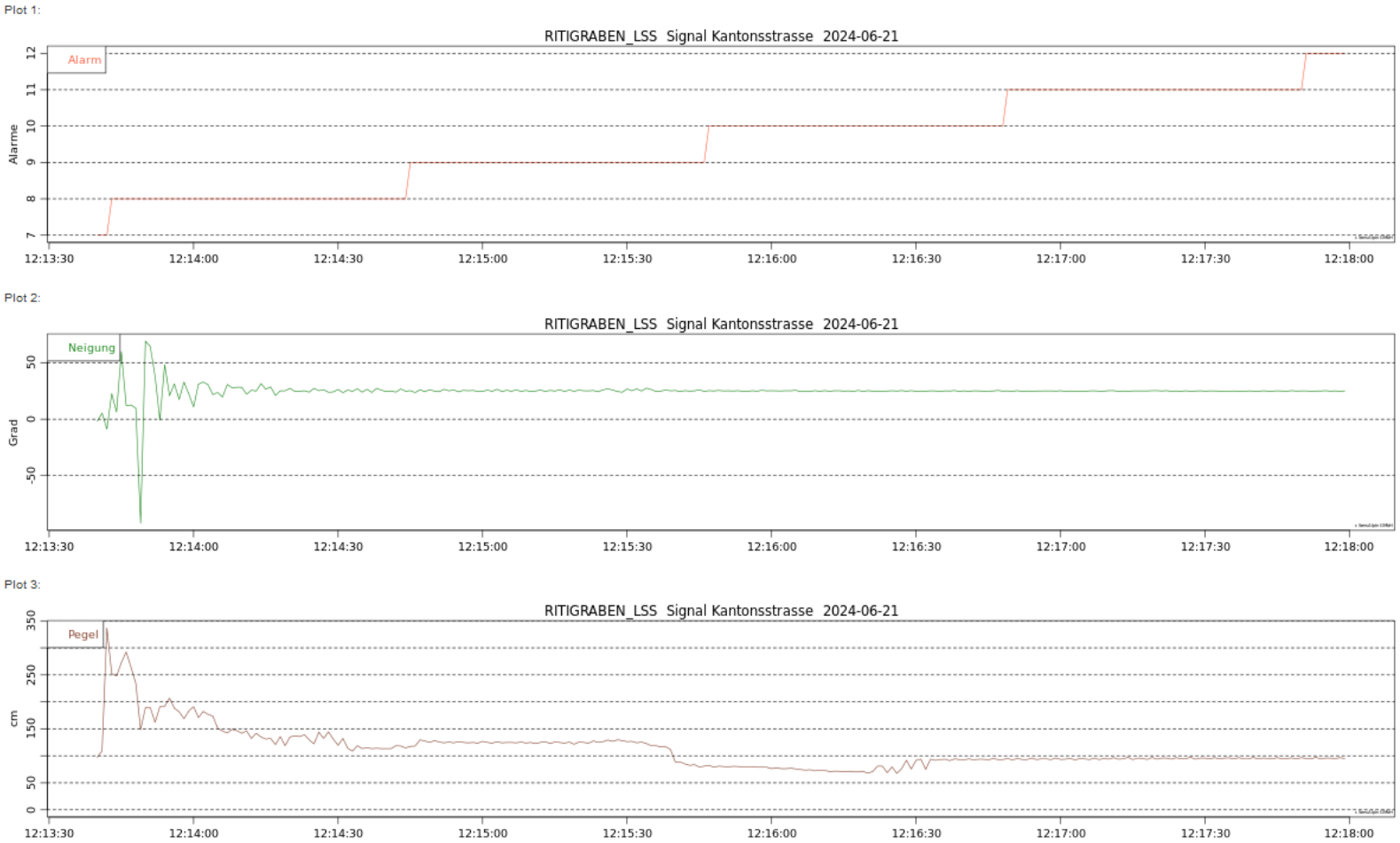
Example 1 – event June 2024

- Middle detection
- Data from level sensor and geophones
- 8 min from upper to middle detection



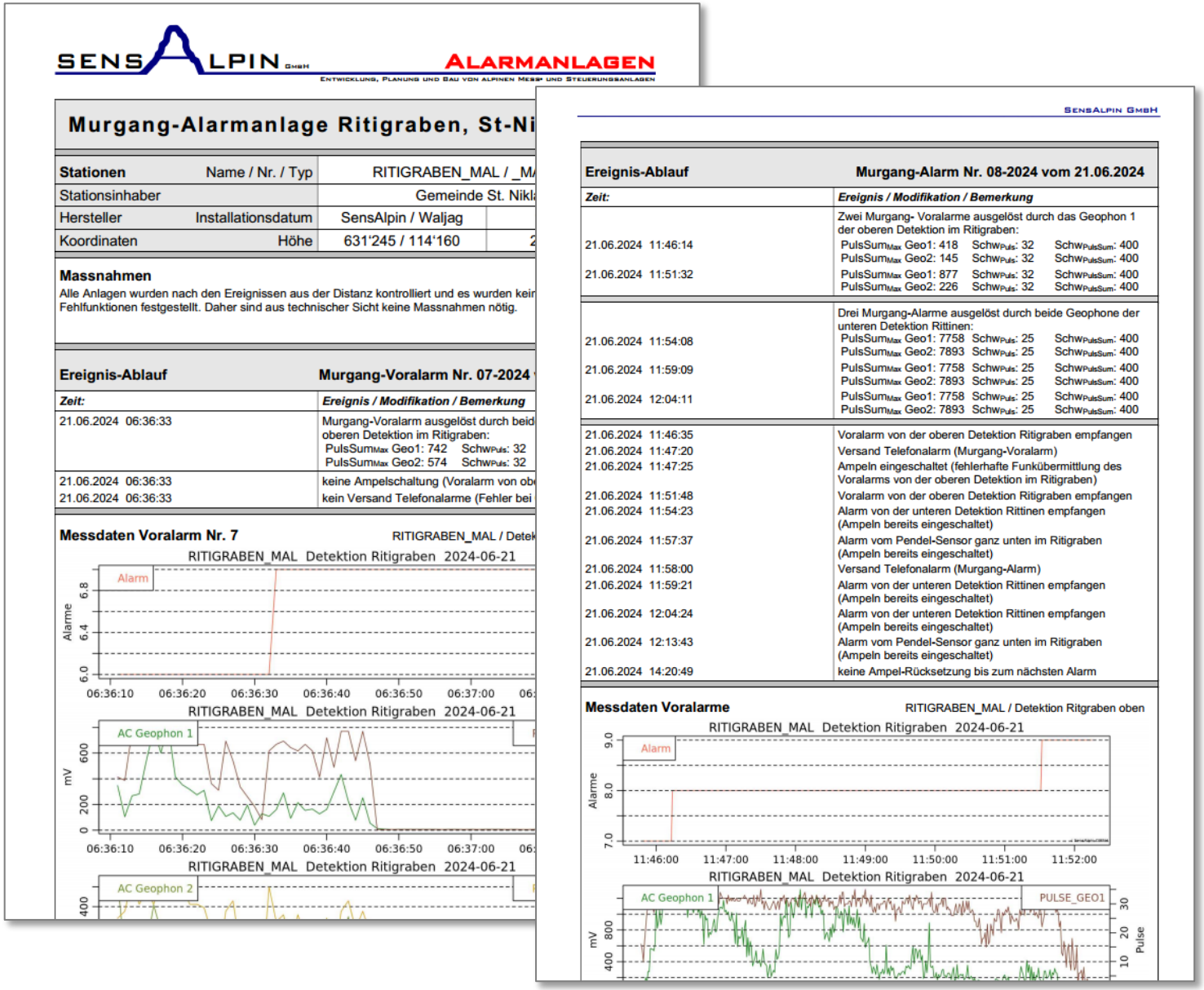
Example 1 – event June 2024

- Lowest section (signal station)
- Data from tilt and level sensor
- 4 min from middle detection to tilt sensor (1st front)
- Repeated alarm of tilt sensor due to programming error



Example 1 – event June 2024

- Events from June 2024 (video)
- Several events within a few hours
- Data from tilt and level sensor from signal station
- 4 min from middle detection to tilt sensor (1st front)
- Event protocol of all system interactions



SENSALPIN GmbH ALARMANLAGEN

Entwicklung, Planung und Bau von alpinen Mess- und Steuerungsanlagen

Murgang-Alarmanlage Ritigraben, St-Ni

Stationen	Name / Nr. / Typ	RITIGRABEN_MAL / _M
Stationsinhaber		Gemeinde St. Nikl
Hersteller	Installationsdatum	SensAlpin / Waljag
Koordinaten	Höhe	631'245 / 114'160

Massnahmen

Alle Anlagen wurden nach den Ereignissen aus der Distanz kontrolliert und es wurden kein Fehlfunktionen festgestellt. Daher sind aus technischer Sicht keine Massnahmen nötig.

Ereignis-Ablauf — **Murgang-Voralarm Nr. 07-2024**

Zeit:	Ereignis / Modifikation / Bemerkung
21.06.2024 06:36:33	Murgang-Voralarm ausgelöst durch beid oberen Detektion im Ritigraben: PulsSum$_{Max}$ Geo1: 742 Schw$_{Puls}$: 32 PulsSum$_{Max}$ Geo2: 574 Schw$_{Puls}$: 32
21.06.2024 06:36:33	keine Ampelschaltung (Voralarm von ob
21.06.2024 06:36:33	kein Versand Telefonalarme (Fehler bei

Messdaten Voralarm Nr. 7 RITIGRABEN_MAL / Detek

SensAlpin GmbH

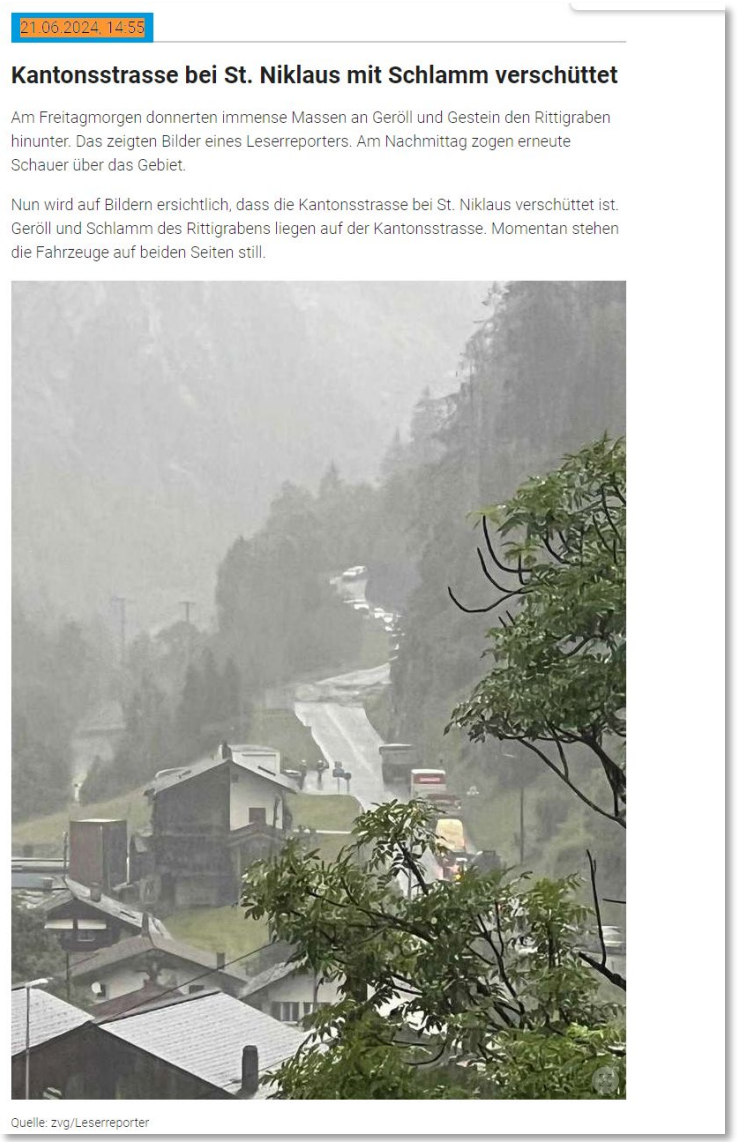
Ereignis-Ablauf — **Murgang-Alarm Nr. 08-2024 vom 21.06.2024**

Zeit:	Ereignis / Modifikation / Bemerkung
21.06.2024 11:46:14	Zwei Murgang- Voralarme ausgelöst durch das Geophon 1 der oberen Detektion im Ritigraben: PulsSum$_{Max}$ Geo1: 418 Schw$_{Puls}$: 32 Schw$_{PulsSum}$: 400 PulsSum$_{Max}$ Geo2: 145 Schw$_{Puls}$: 32 Schw$_{PulsSum}$: 400
21.06.2024 11:51:32	PulsSum$_{Max}$ Geo1: 877 Schw$_{Puls}$: 32 Schw$_{PulsSum}$: 400 PulsSum$_{Max}$ Geo2: 226 Schw$_{Puls}$: 32 Schw$_{PulsSum}$: 400
21.06.2024 11:54:08	Drei Murgang-Alarme ausgelöst durch beide Geophone der unteren Detektion Rittinen: PulsSum$_{Max}$ Geo1: 7758 Schw$_{Puls}$: 25 Schw$_{PulsSum}$: 400 PulsSum$_{Max}$ Geo2: 7893 Schw$_{Puls}$: 25 Schw$_{PulsSum}$: 400
21.06.2024 11:59:09	PulsSum$_{Max}$ Geo1: 7758 Schw$_{Puls}$: 25 Schw$_{PulsSum}$: 400 PulsSum$_{Max}$ Geo2: 7893 Schw$_{Puls}$: 25 Schw$_{PulsSum}$: 400
21.06.2024 12:04:11	PulsSum$_{Max}$ Geo1: 7758 Schw$_{Puls}$: 25 Schw$_{PulsSum}$: 400 PulsSum$_{Max}$ Geo2: 7893 Schw$_{Puls}$: 25 Schw$_{PulsSum}$: 400
21.06.2024 11:46:35	Voralarm von der oberen Detektion Ritigraben empfangen
21.06.2024 11:47:20	Versand Telefonalarm (Murgang-Voralarm)
21.06.2024 11:47:25	Ampeln eingeschaltet (fehlerhafte Funkübermittlung des Voralarms von der oberen Detektion im Ritigraben)
21.06.2024 11:51:48	Voralarm von der oberen Detektion Ritigraben empfangen
21.06.2024 11:54:23	Alarm von der unteren Detektion Rittinen empfangen (Ampeln bereits eingeschaltet)
21.06.2024 11:57:37	Alarm vom Pendel-Sensor ganz unten im Ritigraben (Ampeln bereits eingeschaltet)
21.06.2024 11:58:00	Versand Telefonalarm (Murgang-Alarm)
21.06.2024 11:59:21	Alarm von der unteren Detektion Rittinen empfangen (Ampeln bereits eingeschaltet)
21.06.2024 12:04:24	Alarm von der unteren Detektion Rittinen empfangen (Ampeln bereits eingeschaltet)
21.06.2024 12:13:43	Alarm vom Pendel-Sensor ganz unten im Ritigraben (Ampeln bereits eingeschaltet)
21.06.2024 14:20:49	keine Ampel-Rücksetzung bis zum nächsten Alarm

Messdaten Voralarme RITIGRABEN_MAL / Detektion Ritgraben oben

Example 1 - Conclusions

- System needed improvement over time
  - Concept remained in principle
  - Alarm scheme revised with additional detection
  - Improvements in sensor setup
  - Changed risk situation
- Road closure time successfully shortened
- Partial disfunction does not affect security
- Close collaboration between system operator and intervention forces



21.06.2024, 14:55

Kantonsstrasse bei St. Niklaus mit Schlamm verschüttet

Am Freitagmorgen donnerten immense Massen an Geröll und Gestein den Rittigraben hinunter. Das zeigten Bilder eines Leserreporters. Am Nachmittag zogen erneute Schauer über das Gebiet.

Nun wird auf Bildern ersichtlich, dass die Kantonsstrasse bei St. Niklaus verschüttet ist. Geröll und Schlamm des Rittigrabens liegen auf der Kantonsstrasse. Momentan stehen die Fahrzeuge auf beiden Seiten still.

Quelle: zvg/Leserreporter

Example 2: Chamoson

- 3 debris flow channels that lead into the village Chamoson
- roads in densely populated area concerned
- many players involved
- complex alarm scheme

Example 2: Chamoson

Pluvio stations 4CHM5 and 4CHM6

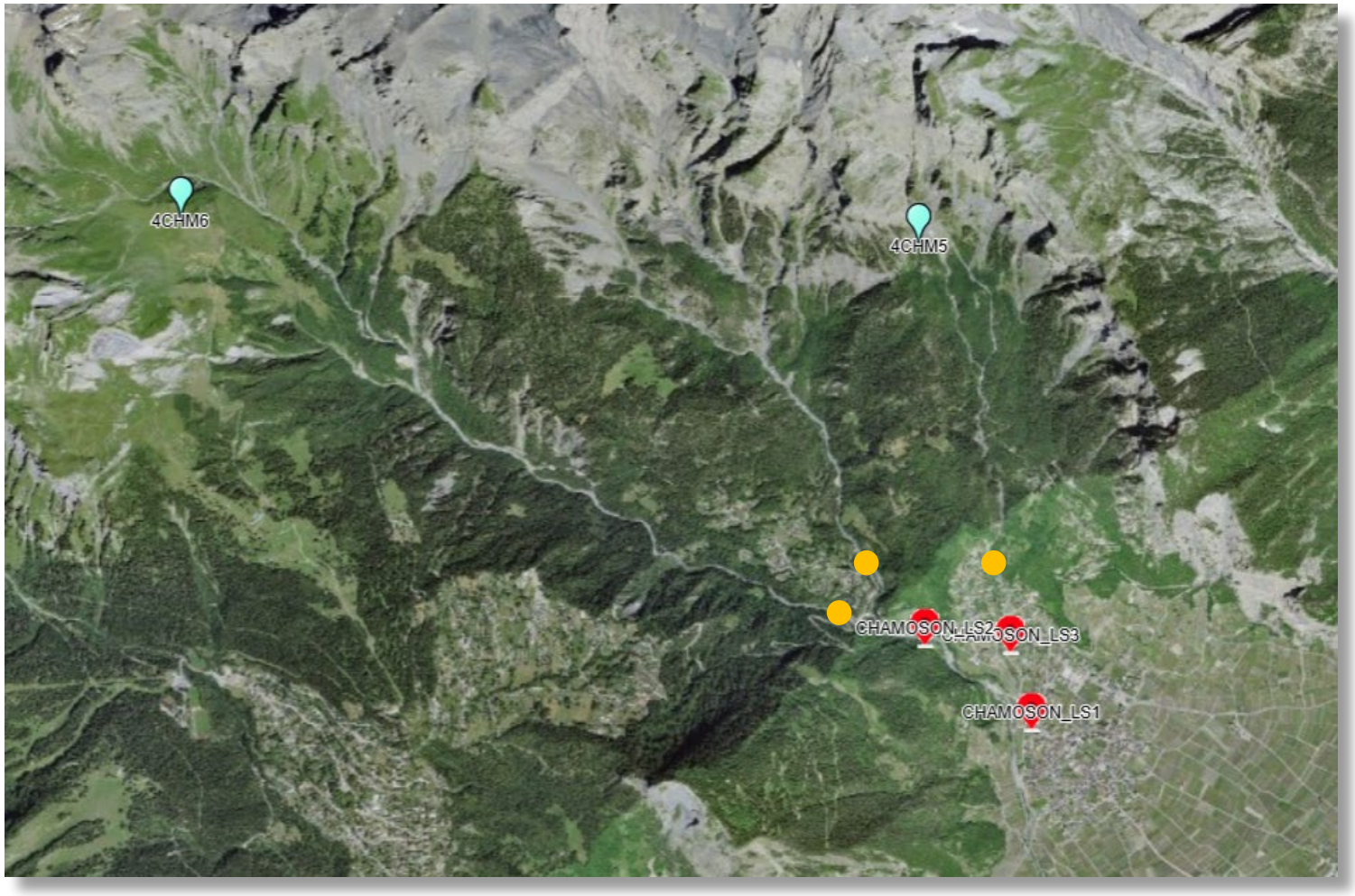
Pre-phase 2007 - 2022

- 2 pluviometric stations (2007 and 2020)
- rain gauges
- air temperature and humidity
- acoustic rain and hail sensor (4CHM6)
- snow height sensor (4CHM6)

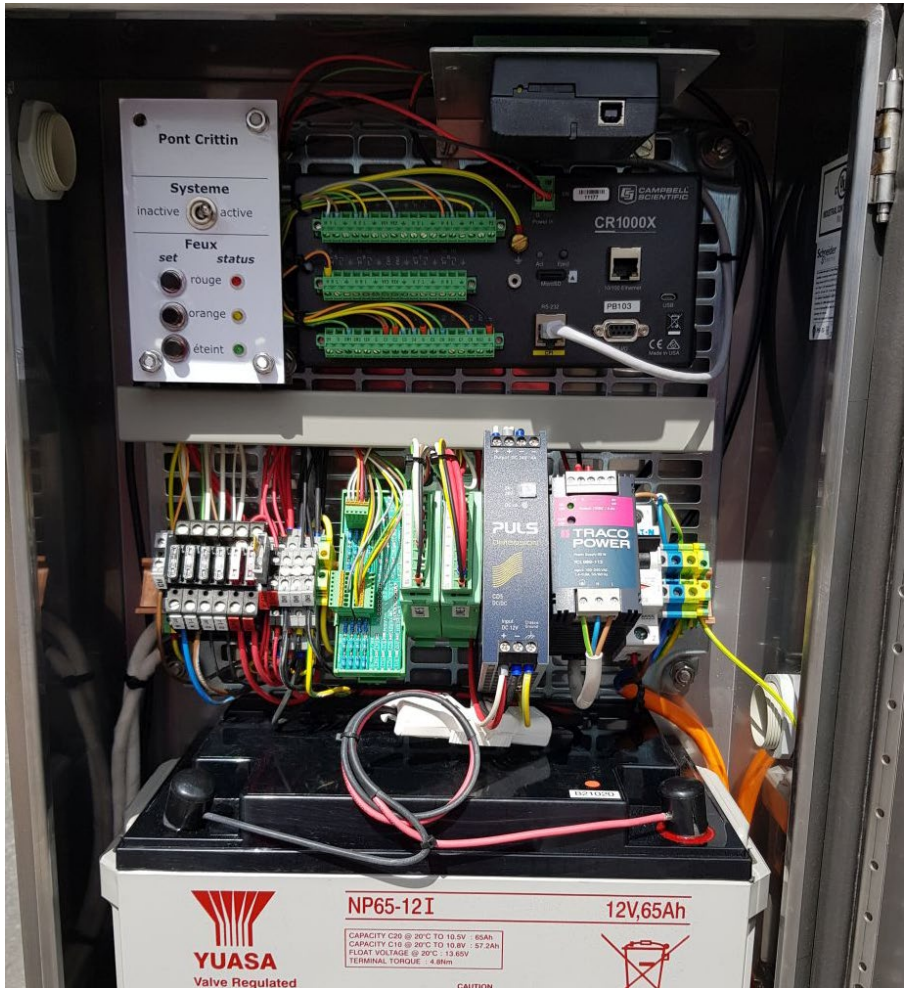
Example 2 – Debris flow warning/alarm system

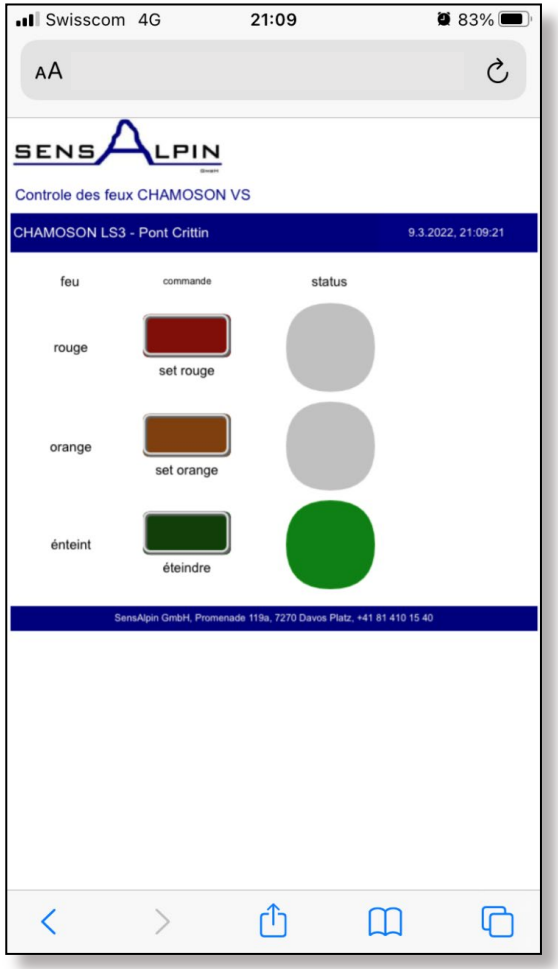
First phase 2022 - 2024

- 2 pluviometric stations (cyan)
- 3 discharge level radar (orange – existing sensors from third party CREALP – OTT HydroMet)
- 3 road stretches with traffic lights (red)
- warning to construction sites in riverbed



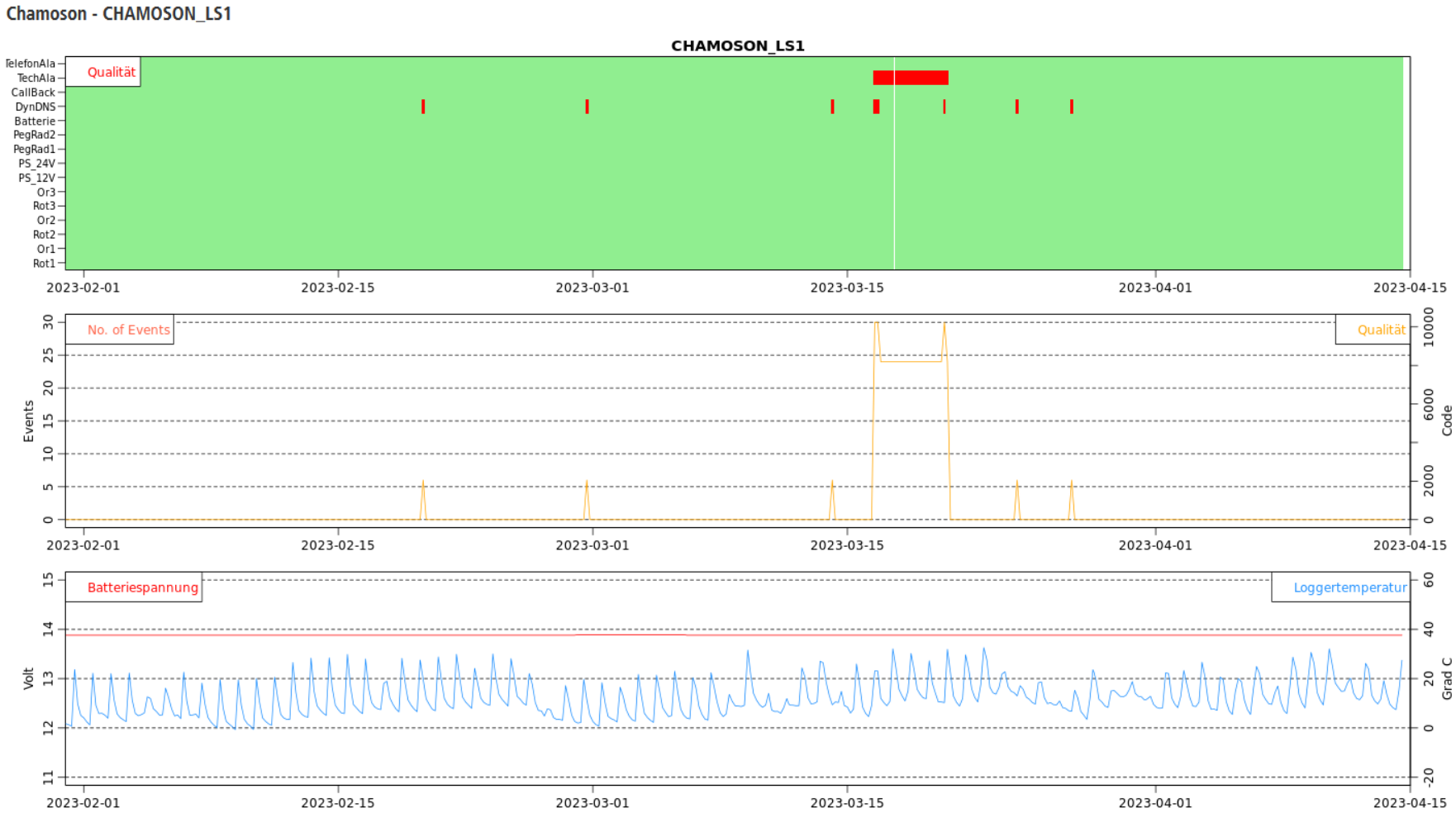
Example 2 – Signal stations





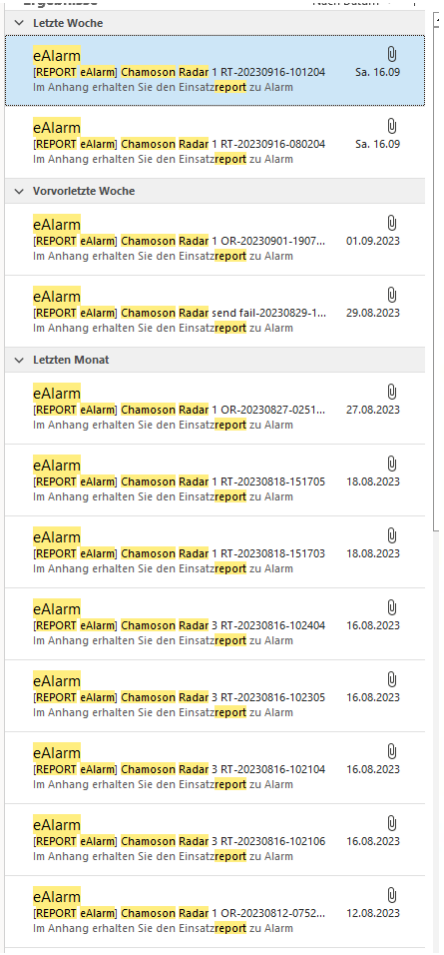
Example 2 – System monitoring of signal stations

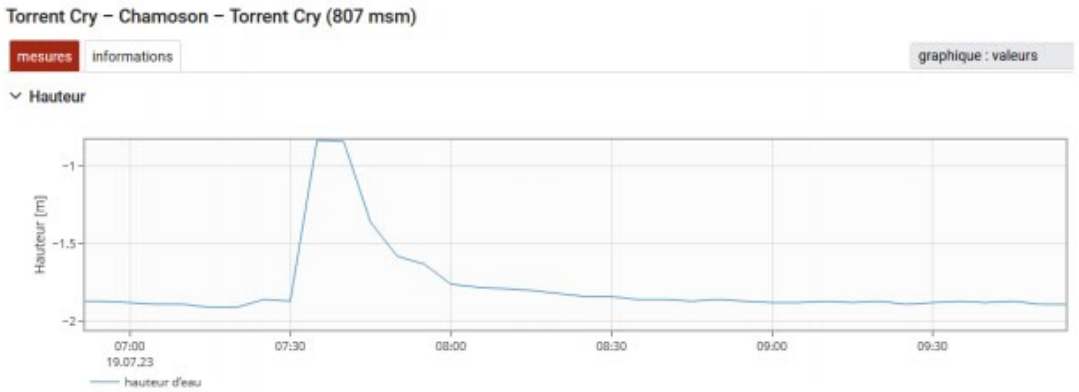
- cables to traffic lights monitored
- connection test every 10 min
- short interruptions of mobile connection
- accepted risk of partial failure



Example 2 – Events 2023

- Debris flow events occurred but were missed by the level radar
- Signals on orange from pluvio stations
- Insufficient recording resolution of measurements (every 2 min)
- After adaption of recording resolution many fault alarms

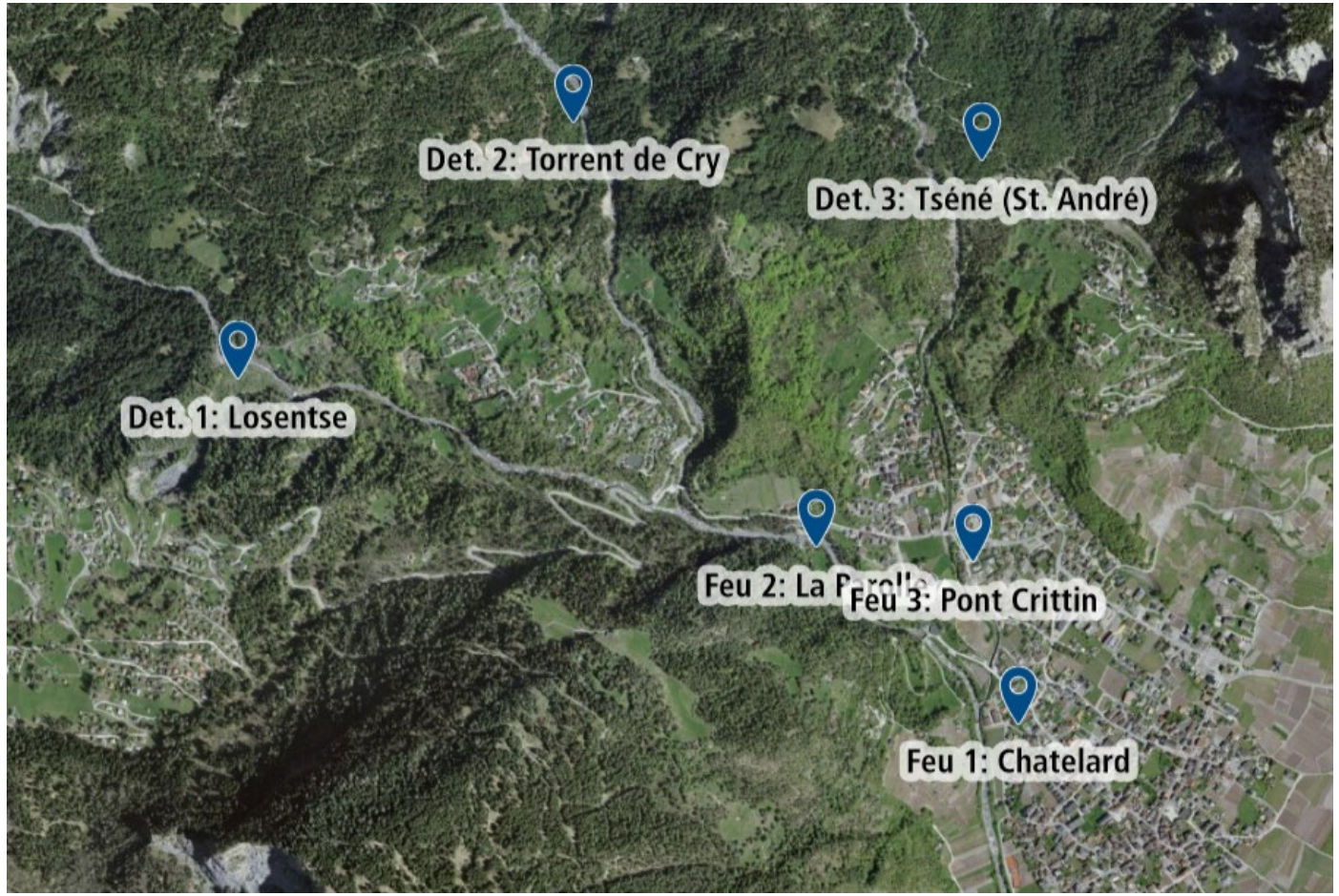




Example 2 – system extension in spring 2024

Second phase

- Three new detections
- Two geophones each
- Level radar system from 3rd party deconnected

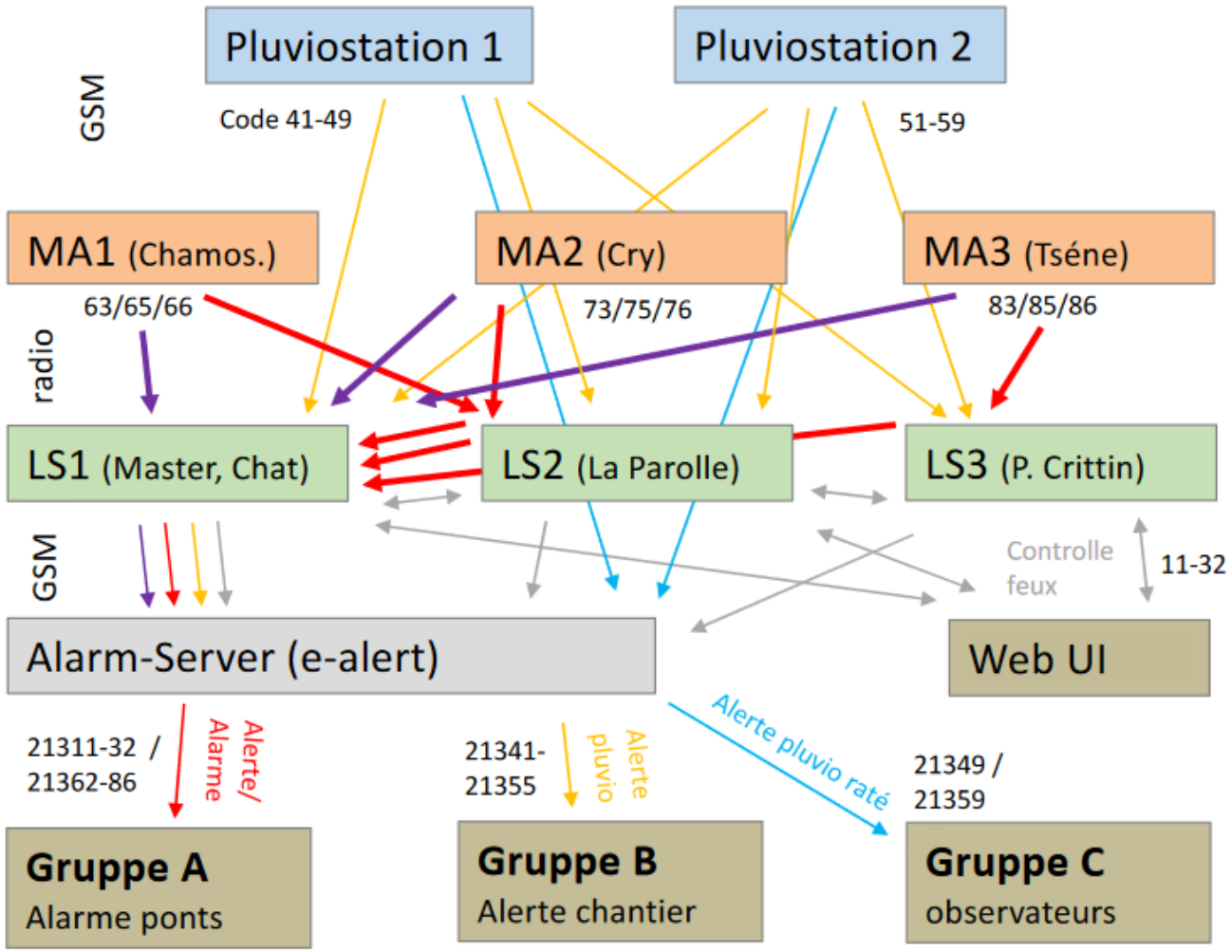


System extension in spring 2024: Detection MA1

System extension in spring 2024: Detection MA2

System extension in spring 2024: Detection MA3

Example 2 – Alarm scheme



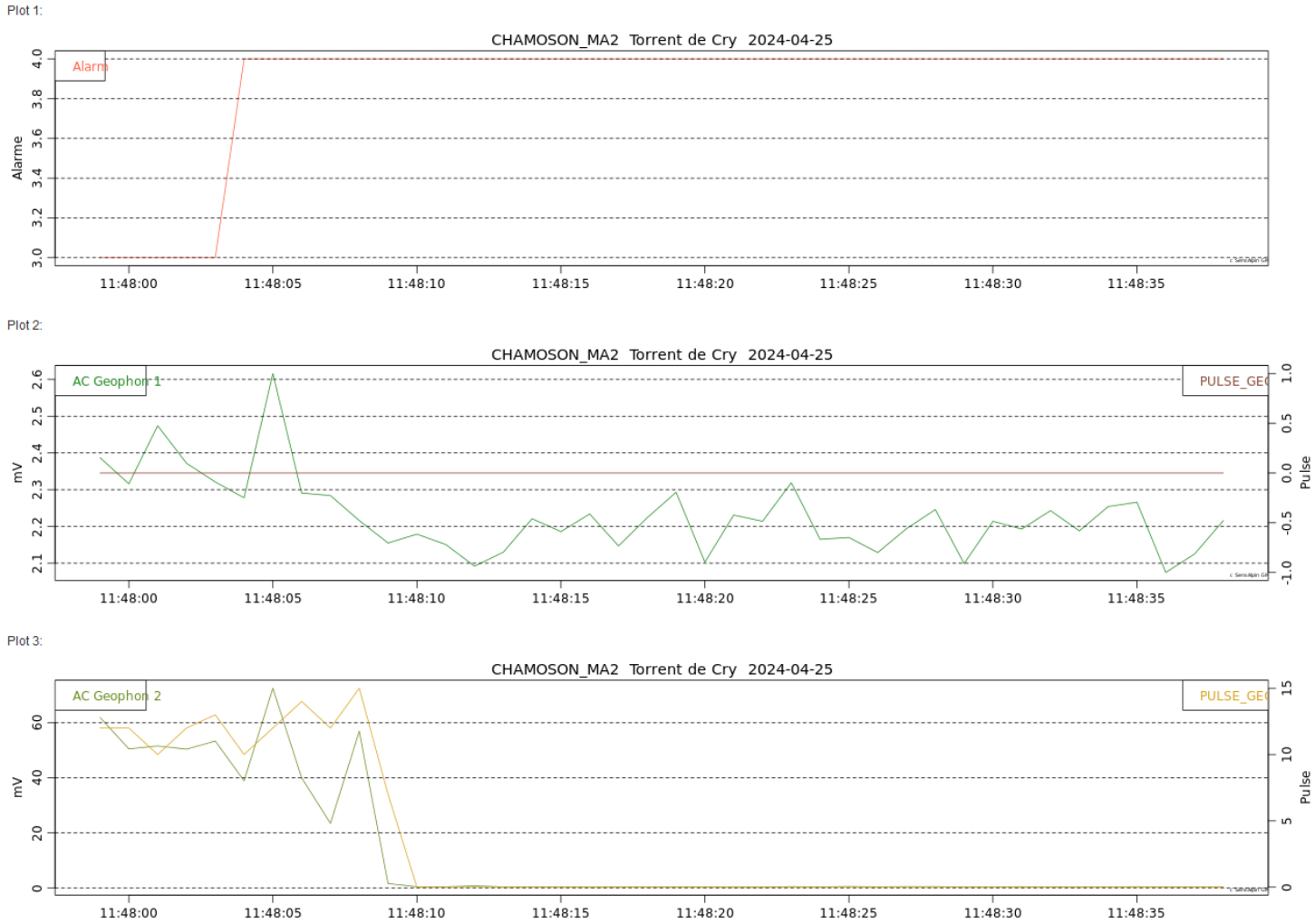
	Évènement	Message SMS	Diffusion	déclencheur	Code
géophones	MA1 set rouge	Alarme Geophones Losentse : feux LS1+2 rouge	Groupe A	LS1	21763
	MA2 set rouge	Alarme Geophones Torrent de Cry : feux LS1+2 rouge	Groupe A	LS1	21773
	MA3 set rouge	Alarme Geophones Tsene (St-A) : feux rouge	Groupe A	LS1	21783
	MA1 test Alert	TEST ! Alert de test Losentse (pas changement des feux)	Groupe A	LS1	21765
	MA2 test Alert	TEST ! Alert de test Torrent de Cry (pas changement des feux)	Groupe A	LS1	21775
	MA3 test Alert	TEST ! Alert de test Tséné (pas changement des feux)	Groupe A	LS1	21785
pluviomètre	Chamosentse – 4CHM6 Sum20min > 7mm	Alerte pluvio Chamosentse : orage – feux orange si pas déjà rouge	Groupe A	LS1	21751
	Chamosentse – 4CHM6 Sum1h > 25mm	Alerte pluvio Chamosentse : pluie intense – feux orange si pas déjà rouge	Groupe A	LS1	21752
	Chamosentse – 4CHM6 Sum24h > 75mm	Alerte pluvio Chamosentse : pluie longue durée – feux orange si pas déjà rouge	Groupe A	LS1	21753
	Chamosentse – 4CHM6 Sum10min > 200 grêlons	Alerte pluvio Chamosentse : grêle – feux orange si pas déjà rouge	Groupe A	LS1	21754
	Chamosentse – 4CHM6 Sum1h > 5mm	Alerte pluvio Chamosentse : pluie – chantier sortir du lit	Groupe B	LS1	21755
	Chamosentse – 4CHM6 Alert send failed	Chamosentse Alerte pluvio 4CHM6: mauvaise transmission d'alert - activer feux manuellement ou informer chantier	Groupe C	4CHM6	direct (21759)
	Tsene – 4CHM5 Sum20min > 7mm	Alerte pluvio Tséné : orage – feux orange si pas déjà rouge	Groupe A	LS1	21741
	Tsene – 4CHM5 Sum1h > 25mm	Alerte pluvio Tséné : pluie intense – feux orange si pas déjà rouge	Groupe A	LS1	21742
	Tsene – 4CHM5 Sum24h > 75mm	Alerte pluvio Tséné : pluie longue durée – feux orange si pas déjà rouge	Groupe A	LS1	21743
	Tsene – 4CHM5 Sum1h > 5mm	Alerte pluvio Tséné : pluie – chantier sortir du lit	Groupe B	LS1	21745
	Tsene – 4CHM5 Alert send failed	Tsene Alerte pluvio 4CHM5: mauvaise transmission d'alert - activer feux manuellement ou informer chantier	Groupe C	4CHM5	direct (21749)
utilisateures	LS1 set orange	Alerte observateur : feux Châtelard orange	Groupe A	LS1	21711
	LS1 set rouge	Alarme observateur : feux Châtelard rouge	Groupe A	LS1	21712
	LS2 set orange	Alerte observateur : feux La Parolle orange	Groupe A	LS2	21721
	LS2 set rouge	Alarme observateur : feux La Parolle rouge	Groupe A	LS2	21722
	LS3 set orange	Alerte observateur : feux Pont Crittin orange	Groupe A	LS3	21731
	LS3 set rouge	Alarme observateur : feux Pont Crittin rouge	Groupe A	LS3	21732
alarmes techniques	LS1 tech alarm	Châtelard technischer Alarm	TechAla	LS1	21710
	LS2 tech alarm	La Parolle technischer Alarm	TechAla	LS2	21720
	LS3 tech alarm	Pont Crittin technischer Alarm	TechAla	LS3	21730
	MA1 tech alarm	MA1 Losentse technischer Alarm	TechAla	LS1	21766
	MA2 tech alarm	Det. Cry technischer Alarm	TechAla	LS1	21776
	MA3 tech alarm	Det. Tséne St.Andre technischer Alarm	TechAla	LS1	21786

Example 2 – System monitoring of detection stations

- cables to geophones monitored → technical alarms
- radio communication very simple and stable
- monitoring data to check function and sensitivity of geophone

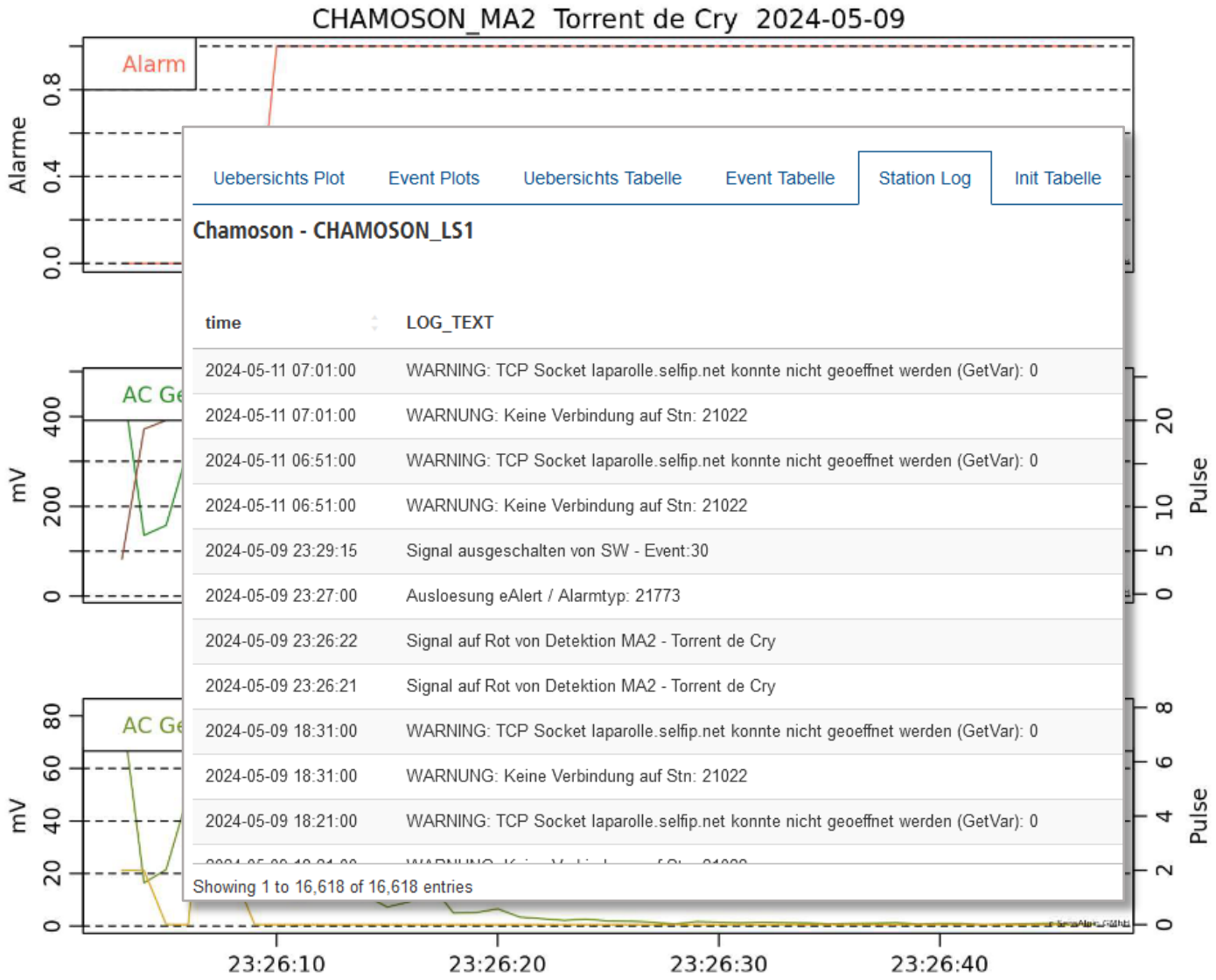
Example 2 – Initial test April 2024

- System active from installation on April 25, 2024
- Test and training with local observers on installation day
- Entire alarm chain tested
- System configuration very sensitive until first events!
- Chance of false positive



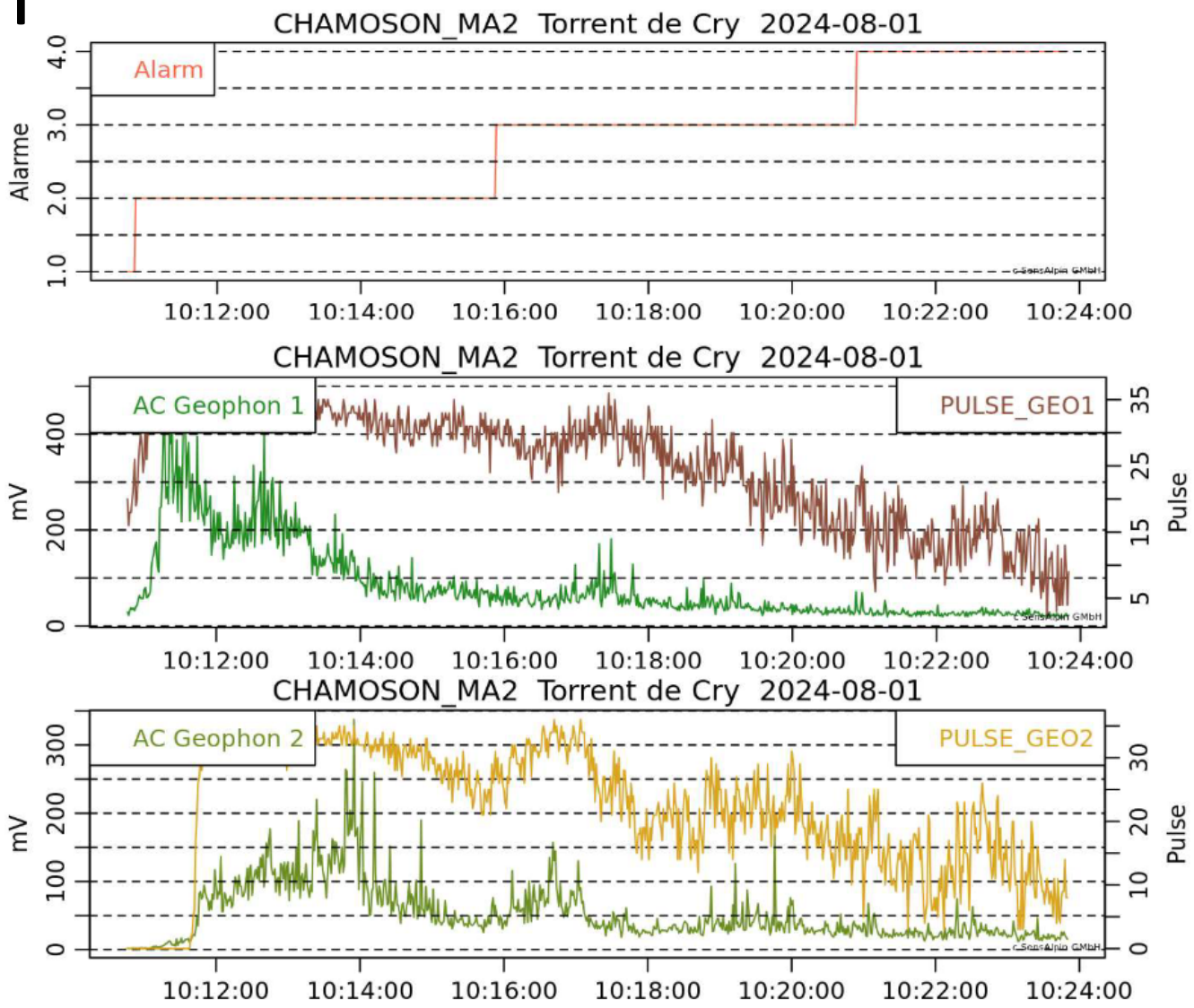
Example 2 – First alarm

- Earthquake May 9, 2024
- Amplitude 3.7 at 25 km
- Every 2-5 years
- Triggered alarm with initial settings:
  - vTrigger 50 mV
  - pulsSum 120
- Unclear manipulation of operators in the following



Example 2 – Second alarm

- Debris flow, August 1, 2024
- Here local observer turn traffic lights on red 5 min before event
- Event slightly too small to cause harm
- Report of each event
- Trigger level not adapted



Example 2 – Events 2024

système d'alarme de laves torrentielles CHAMOSON VS

station	**CHAMOSON_MA2**	Murgang-Detektion Torrent de Cry	AE 24 009
propriétaire		Commune de Chamoson	
fournisseur	date d'installation	SensAlpin GmbH	24.04.2024
coordonnées	altitude	582'028, 118'401	904

événement **alarme no. 2-4-2024 du 01.08.2024**

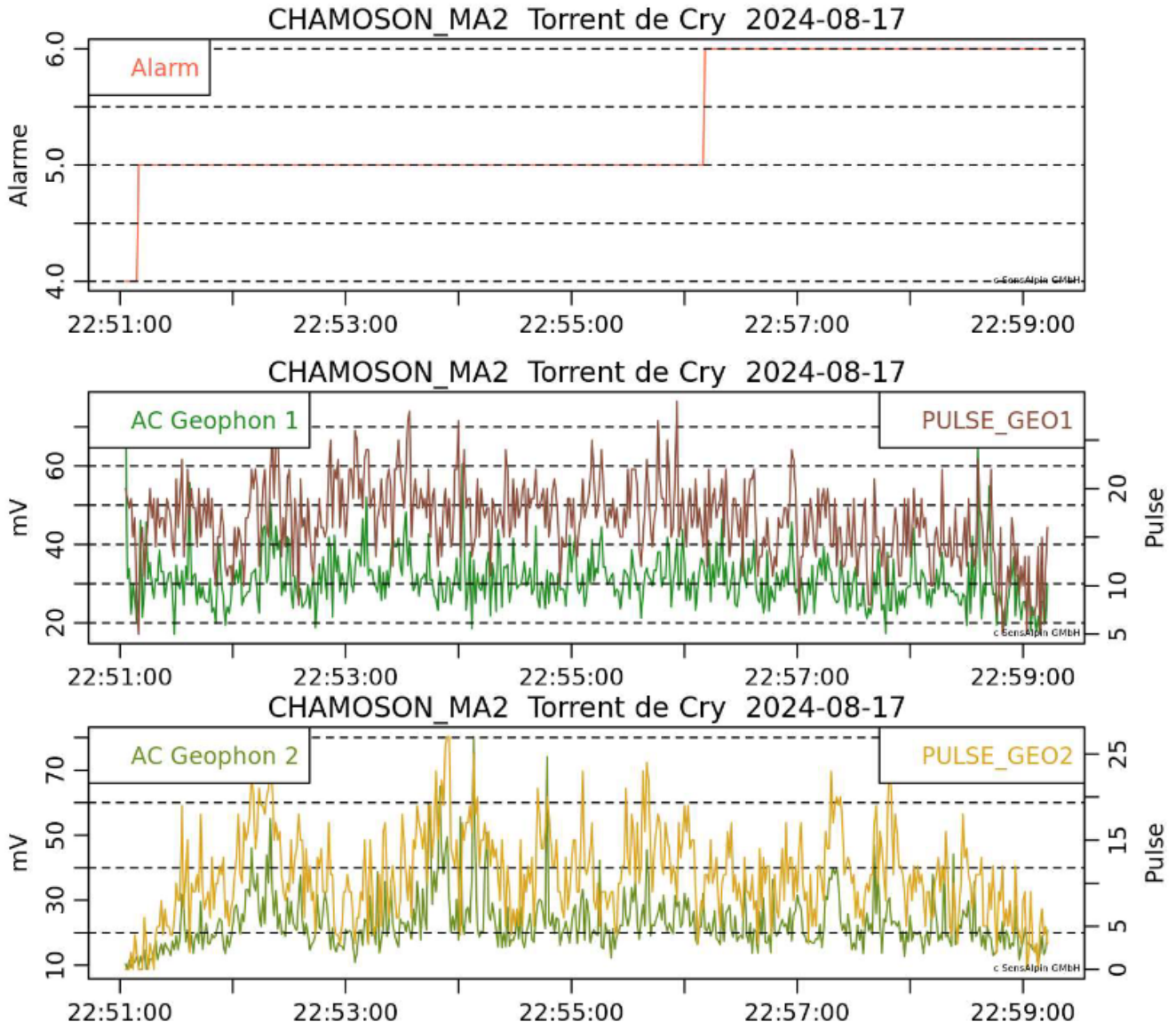
temps :	***événement / modification / remarques***
2024-08-01 10:00:01	Feux sur orange par station pluviometrique Chamosentse
2024-08-01 10:05:19	Feu LS1 Chatelard sur rouge par observateur via l'interface web (Thierry Varone)
2024-08-01 10:10:52	alarme déclenchée par les deux géophones: Geo1 $PSum_{Max}$:7999 V_{Trig}: 50 $Schw_{Puls}$: 20 $Schw_{PulsSum}$: 120 Geo2 $PSum_{Max}$:7999 V_{Trig}: 50 $Schw_{Puls}$: 20 $Schw_{PulsSum}$: 120
2024-08-01 10:11:02	Alarmes transmises aux feux LS1 - Chatelard et LS2 - La Parolle
2024-08-01 10:12:00	envoi des messages d'alarme par *eAlarm emergency*
2024-08-01 10:20:39	feux éteints par l'interface web (ensuit remis a rouge par alarm 4 et étendue de nouveau 10:21:00 et 10:21:07)

Example 2 - Third alarm

- Event with increased discharge but no debris flow on August 17, 2024
- After discussion with local observer addaption of trigger level:
  - vTrigger 200 mV
  - pulsSum 150

→Only event 2 would now cause alarm!

- Further increase of trigger levels possible after more experiance



Example 2 - Conclusions

- Detection based on level sensors not successfull
- Revised system concept with three additional geophone detection stations
- Clear communication of initial system configuration
- Efficient system calibration with feedback from local obervers
- Maintenance contracts to keep system fully functional

Example 3: Münster

- Debris flow alarm system to secure excavation work in basin
- Two detection stations
- One signal station with flashlight and siren
- Webcam to monitor retention basin
- Upper detection with 2 geophones
- Lower detection with 2 geophones and level sensor

Example 3 – System overview

- Debris flow alarm system to secure excavation work in basin
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- One signal station with flashlight and siren
- Webcam to monitor retention basin
- Upper detection with 2 geophones
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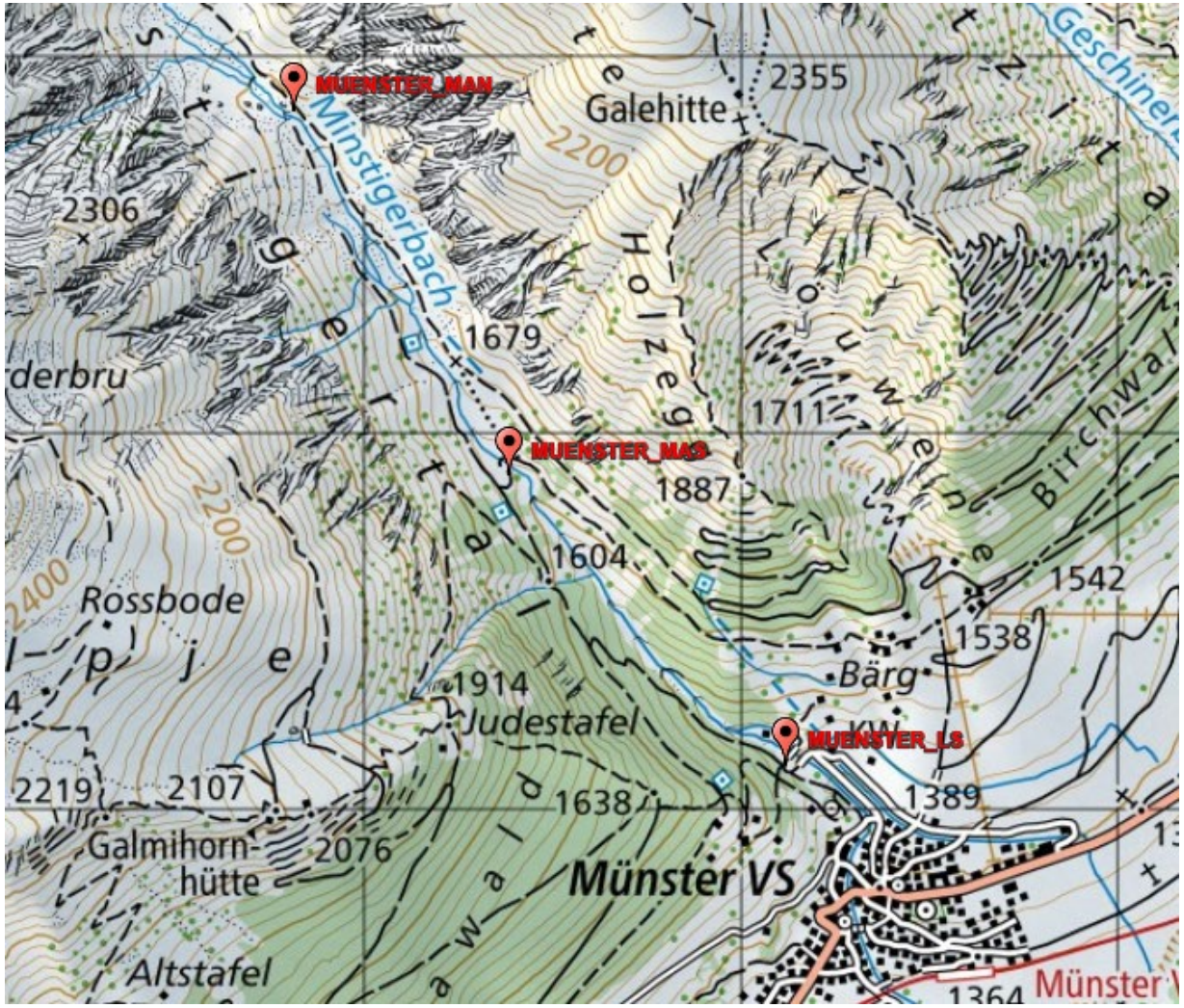


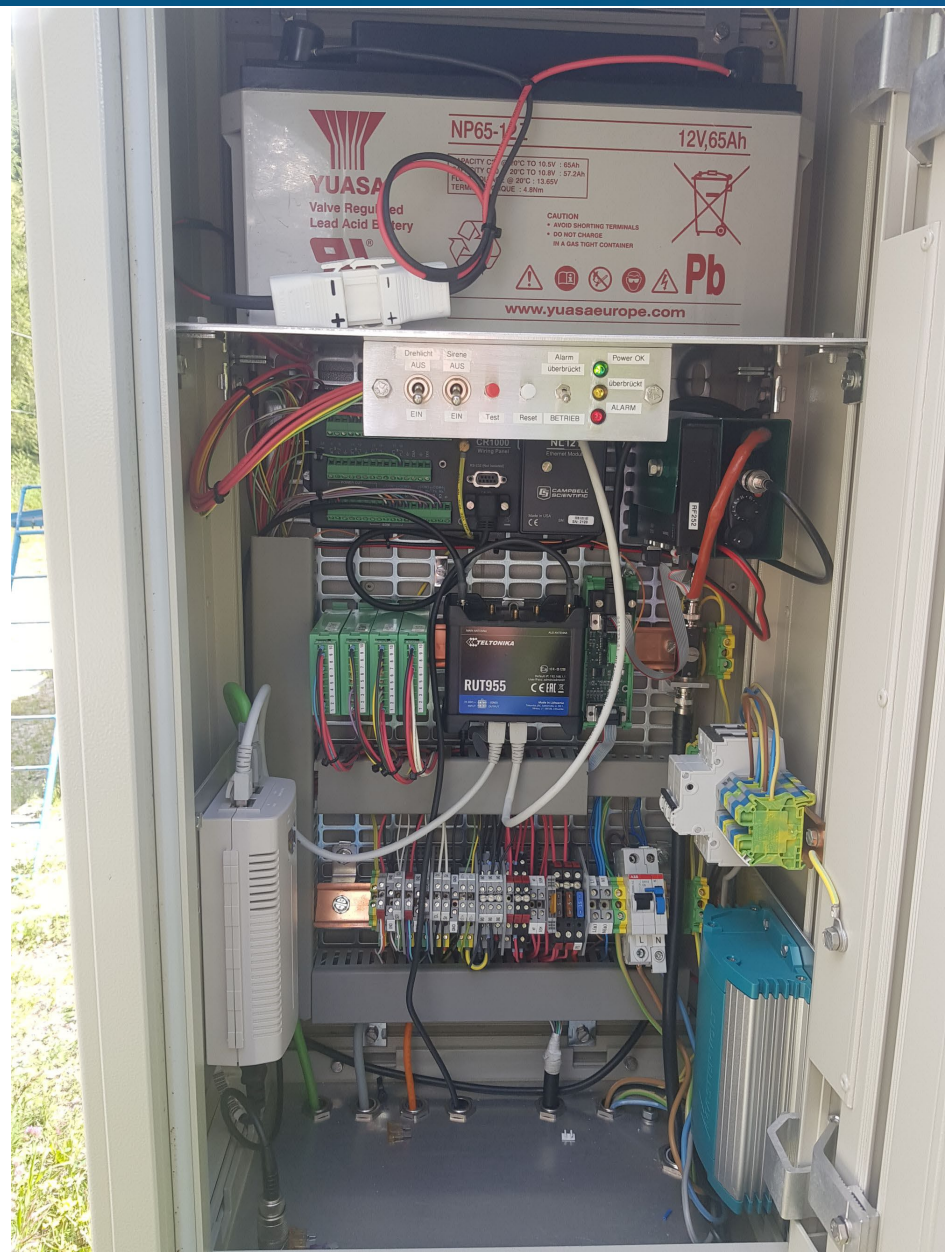
Example 3 – Event June 30, 2024

- Rock from lower detection collapsed
- Worst case scenario
- Station issued alarm
- Station continued operation after falling into stream
- Temporary backup was installed within two weeks

Example 3 – Event June 30, 2024

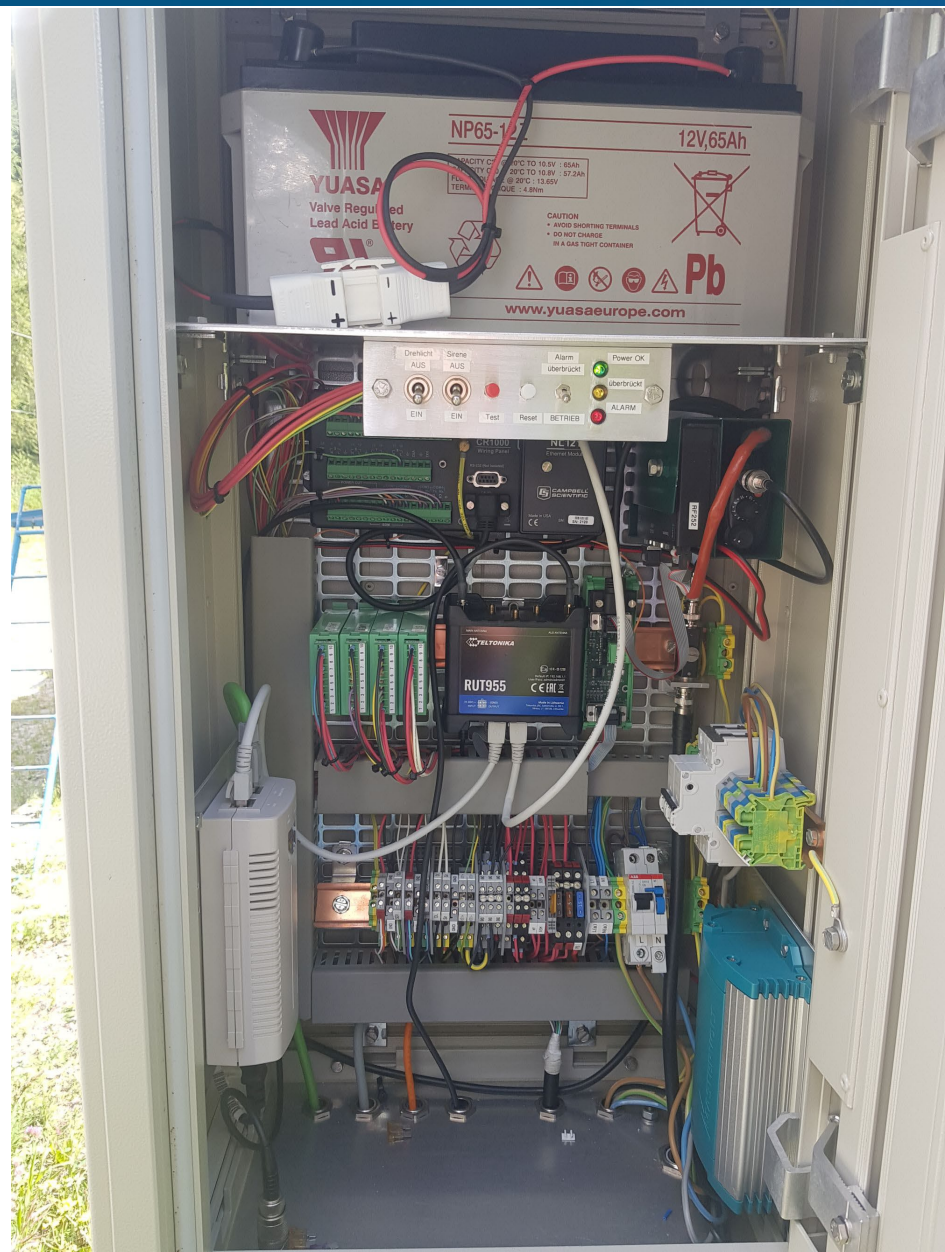
Example 3 – Webcam setup

- Industrial grad router and webcam
- IP communication needed for standard setup



Example 3 – Webcam setup

- Industrial grad router and webcam
- IP communication needed for standard setup
- Real time connection possible
- Power supply from grid



Example 3 – Webcam pictures

Example 3 – Conclusions

- Dam worked well
- EWS important to alarm authorities and secure excavation
- Station issues alarm in worst case before being distroyed → geophone detection or upstream position of sensors
- Our setup of webcams needs internet connection (GSM reception)
- Realtime access to webcam is challenging with solar power supply

Example 4 – Brienzergrat

- large alarm system covering seven avalanche / debris flow paths
- events start at 1800 m asl. and reach the lake at 564 m asl.
- 3 institutions:
  - road service (canton Bern)
  - railway company (Zentralbahn)
  - community (Oberried)

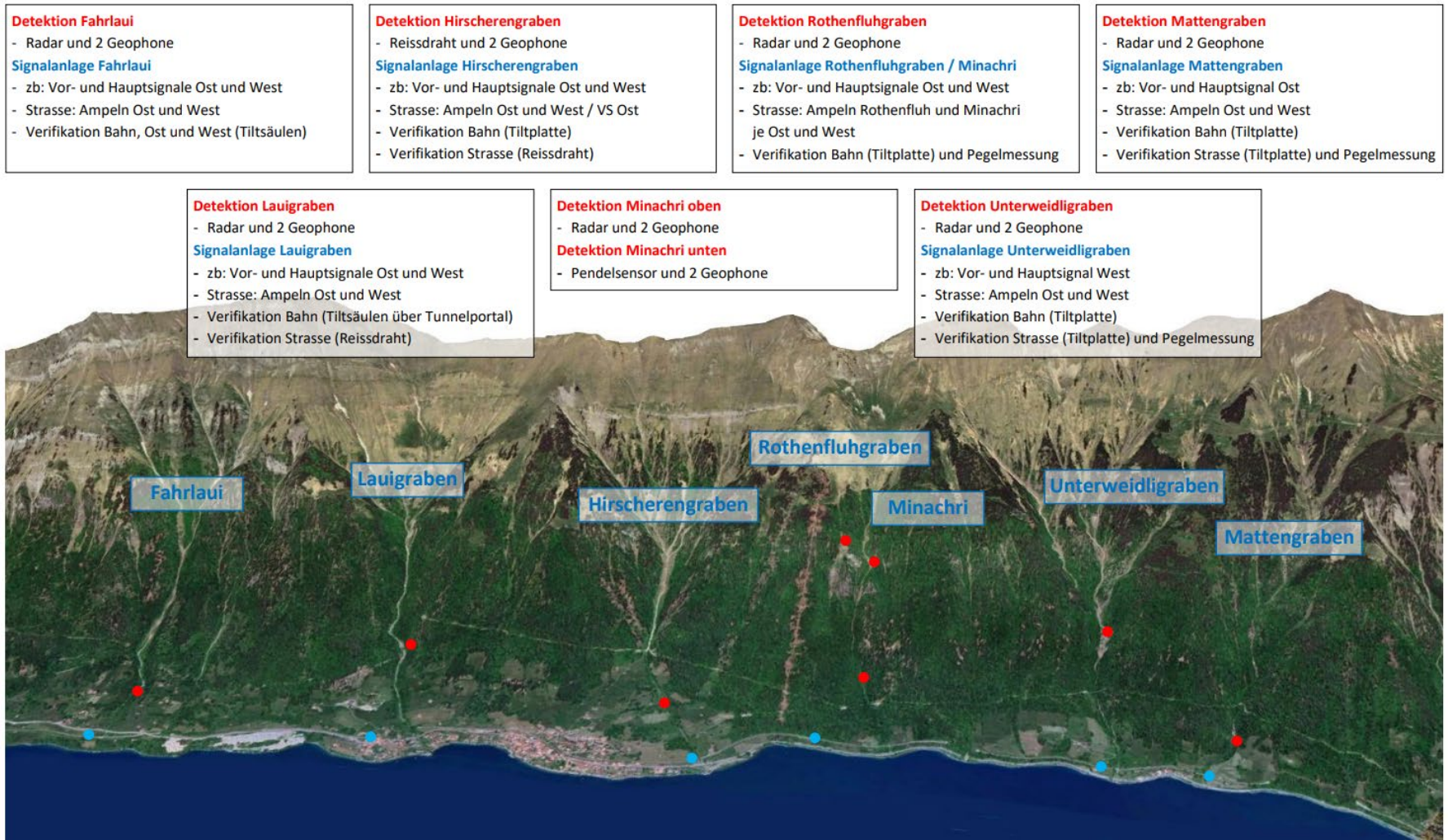
Hirscherengraben

Example 4 – Brienzergrat

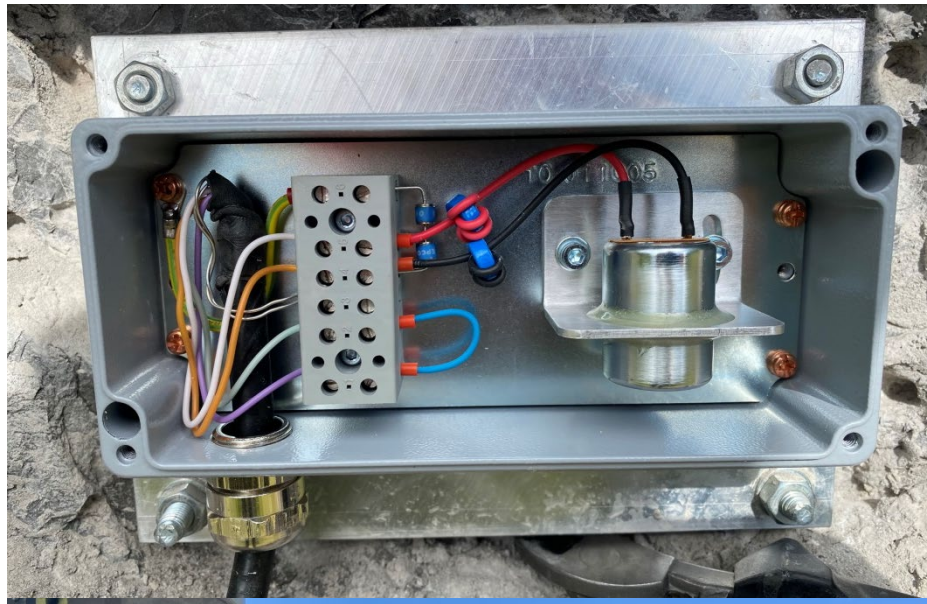
8 detection stations

6 signal stations with verification

35 traffic lights (road & railway)



Example 4 – Detection Minachri

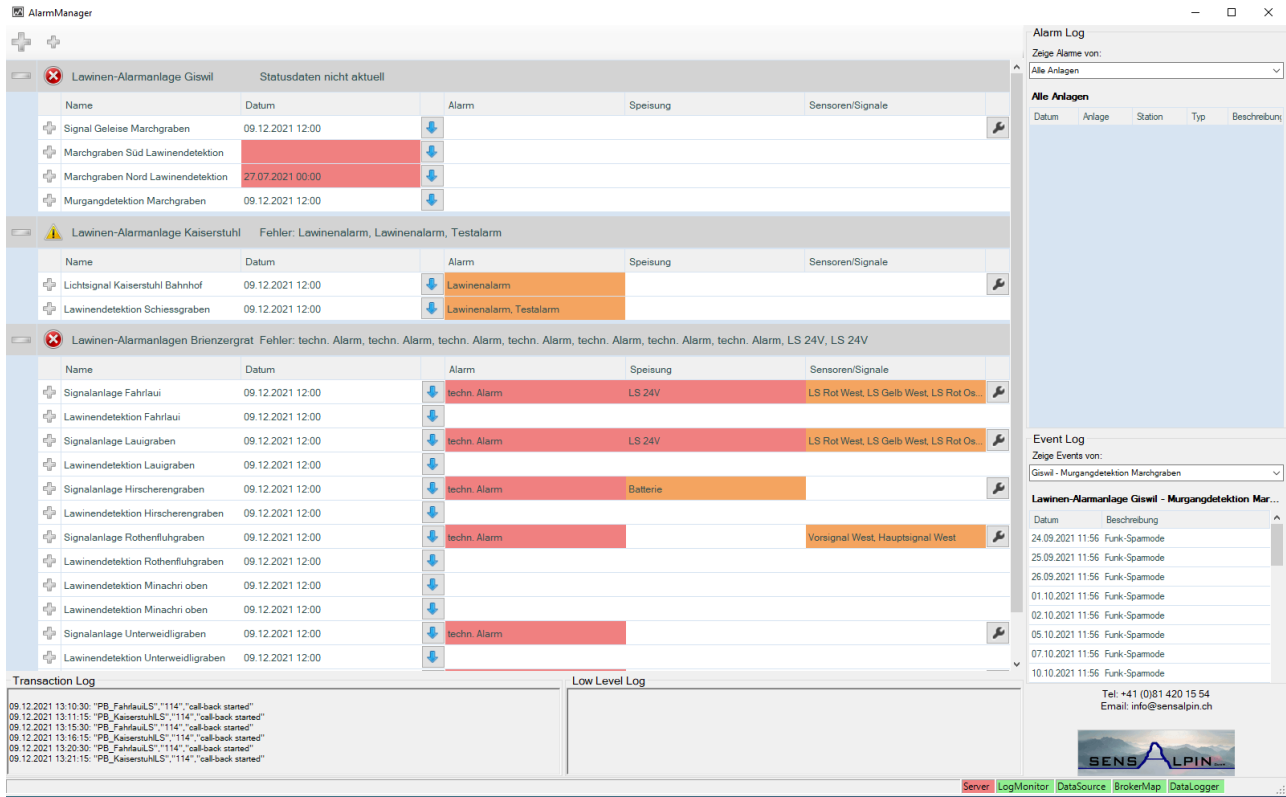


Example 4 – Verification

- Verification at bridges / beside railway by tilt sensors or rip cords to confirm runout
- Different alarm criteria for road and railway
- Interaction between different traffic lights

Controls

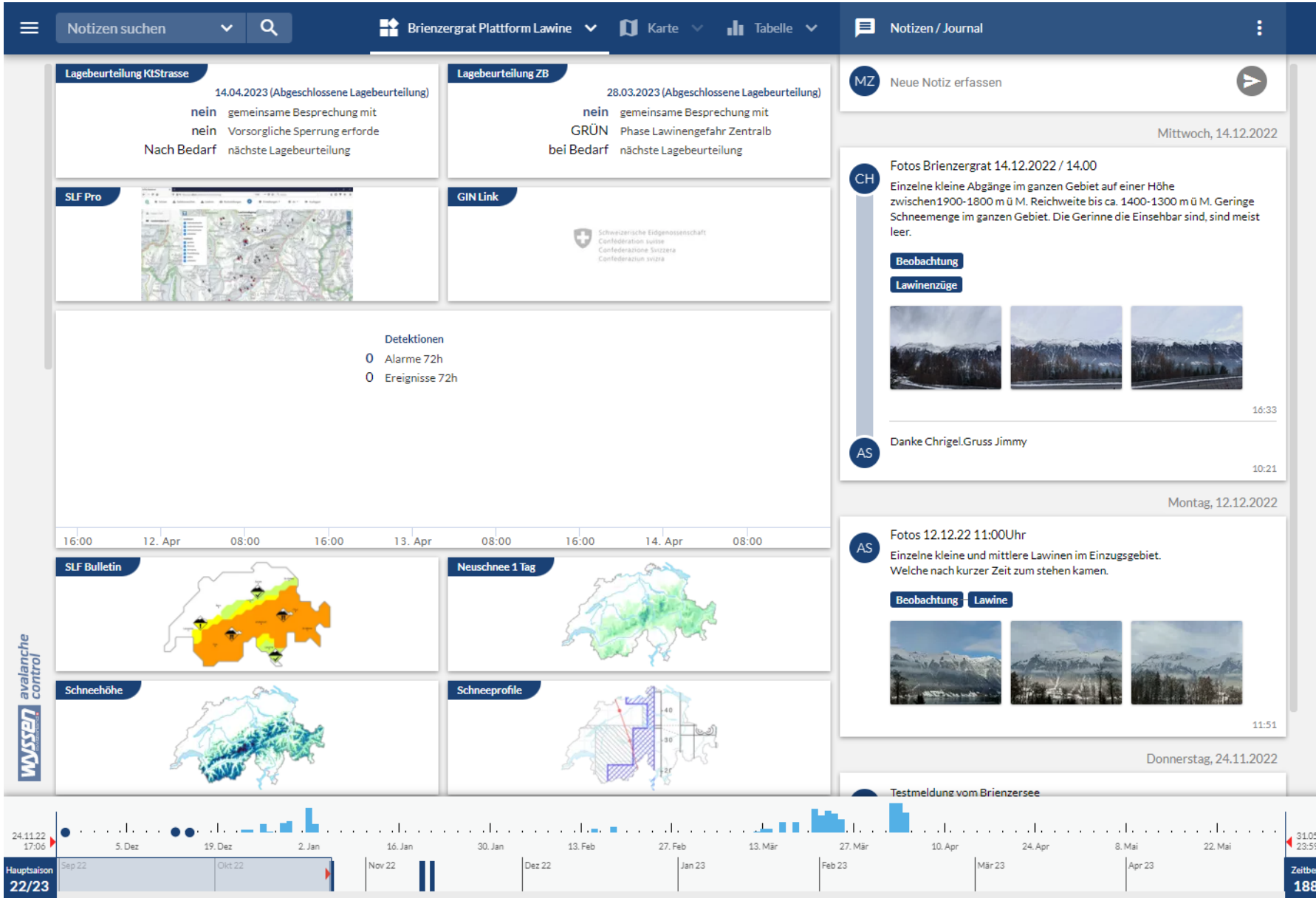
- Different control interfaces for different users
- Key control to turn off road traffic lights
- Visual software interface for railroad lights
- Controls in control cabinet for backup and maintenance work



Info Platform

Wyssen AC cockpit:

- baseline info
- bring together users / exchange
- hazard assessment
- event reports



Example 4 - Conclusions

- Efficient and reliable detection by standardized setup (2 geophones and doppler radar)
- Simple mechanical sensors as verification
- These sensors can be used to further reduce false positive
- Signal controls and management tools for user interaction are important at this size of project

Key messages

Appropriate design and clear communication

- ✓System is well adapted to the local hazard situation
- ✓Communication links are reliable and efficiently used
- ✓System is properly installed and tested
- ✓Plan calibration phase for system training
- ✓System monitoring and maintenance established
- ✓Clear role definition and action plan of different players
- ✓Clear interfaces and responsibilities of authorities

Links

www.sensalpin.ch

https://www.sensalpin.ch/en/applications/natural-hazards-alerting/

swisstopo-map-sensalpin

data-portal-sensalpin

Sketch