

Early warning systems for landslides in Switzerland

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Mountain Hydrology and Mass Movements

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Shallow abrupt landslides

Official Swiss natural hazard warning portal

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Federal Administration admin.ch

Natural Hazards Portal

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Current natural hazards situation in Switzerland

Updated on: 09.09.2016, 13:00

location / ZIP
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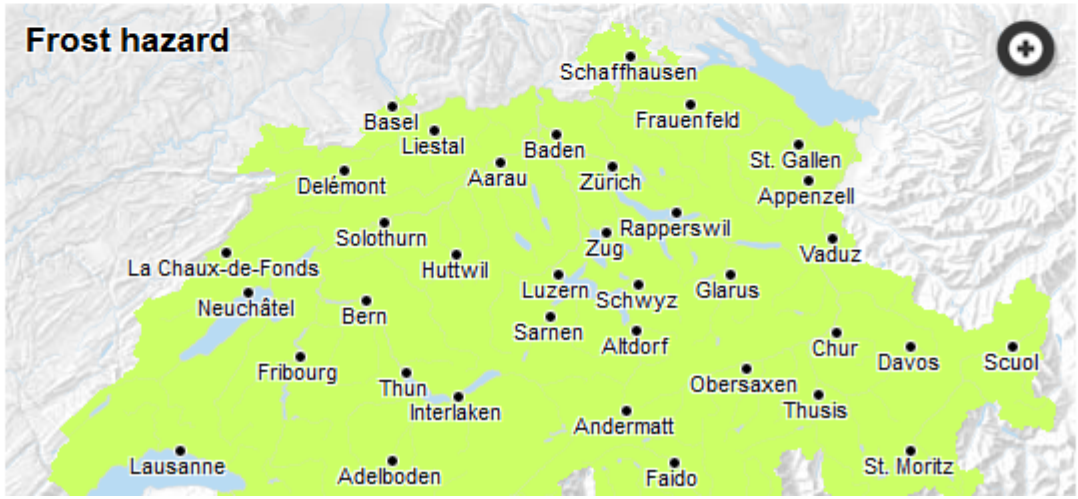
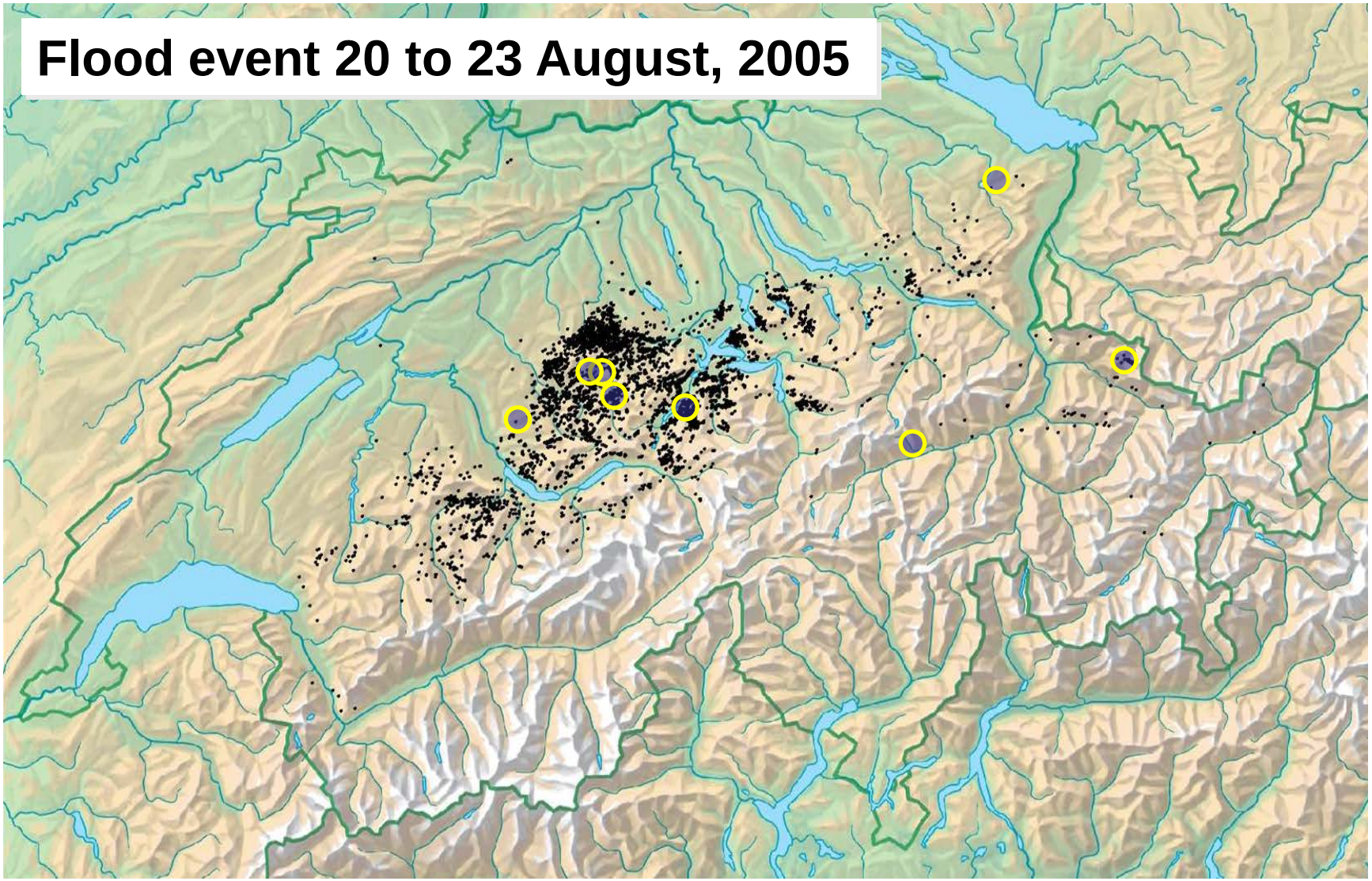


Danger levels

- 5 Very high danger
- 4 High danger
- 3 Considerable danger
- 2 Moderate danger
- 1 No or minor danger
- No danger level

Swiss television (SRF) warnings (non-official)

Recent occurrence of landslides

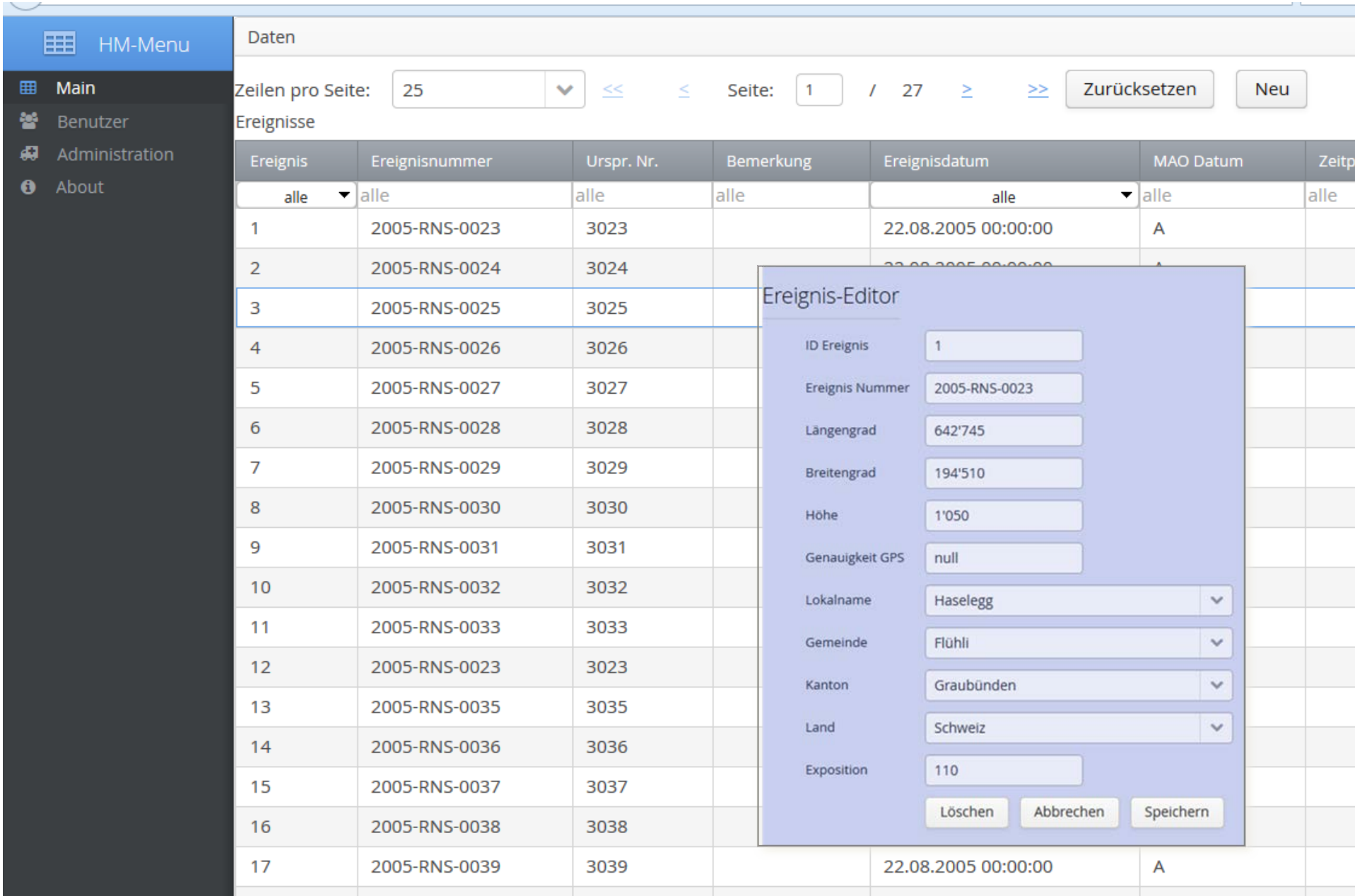


- Mapped landslides
- Detailed WSL- field inventories

Recent occurrence of landslides

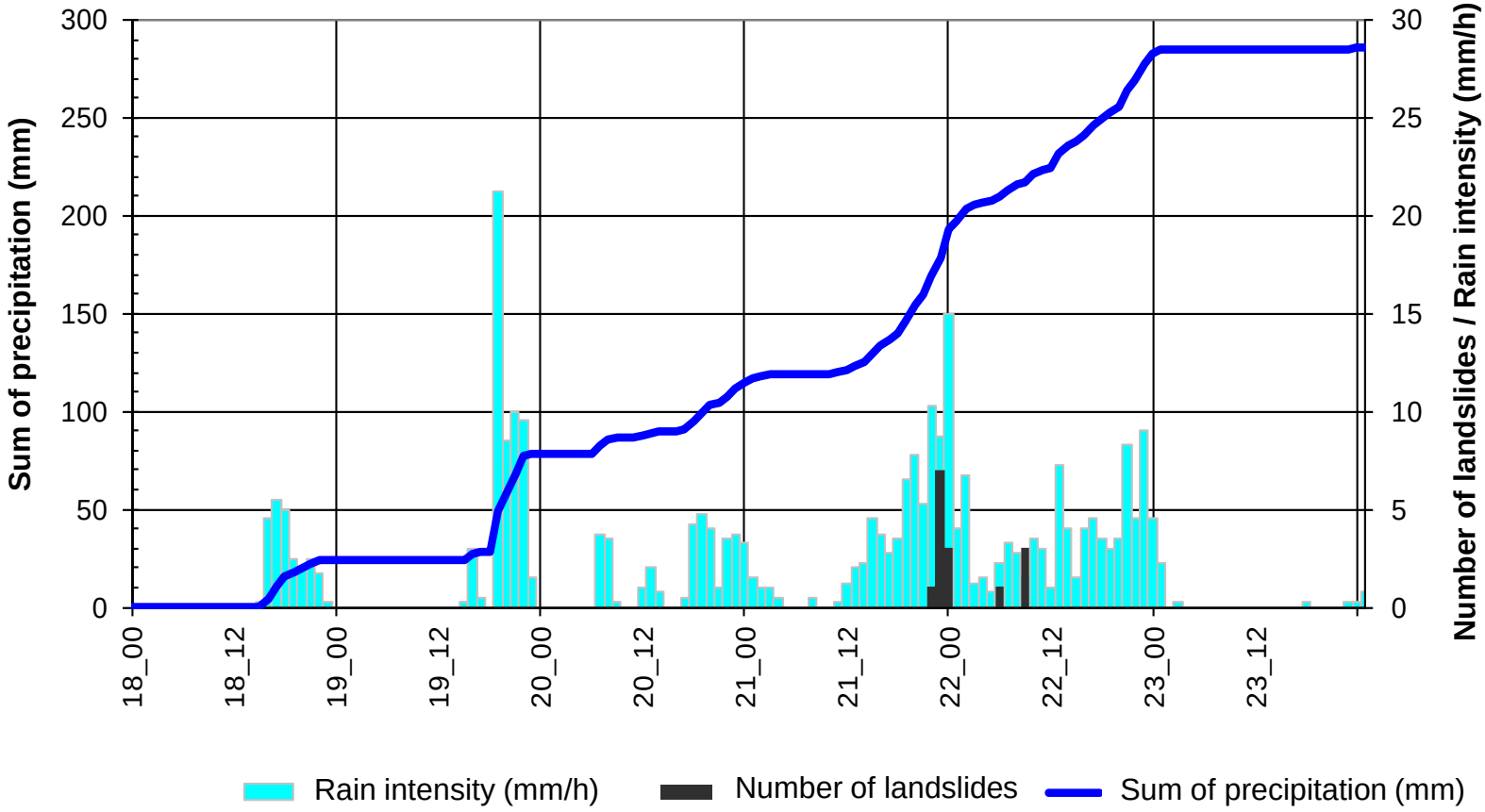
Location	Date	Sum of precipitation (mm)	Duration (h)	Number of documented landslides
Sachseln	15.8.1997	150	2	280
Appenzell	31.8.-1.9.2002	120	9	107
Napf	15.-16.7.2002	60	3	64
Surselva	14.-16.11.2002	252	63	35
Entlebuch	18.-23.8.2005	269	72	66
Prättigau	18.-23.8.2005	185	72	63
Napf	18.-23.8.2005	241	72	54
Eriz	4.7.2012	80	2	25
Total				659

Web-application landslide database



Precipitation thresholds for single events

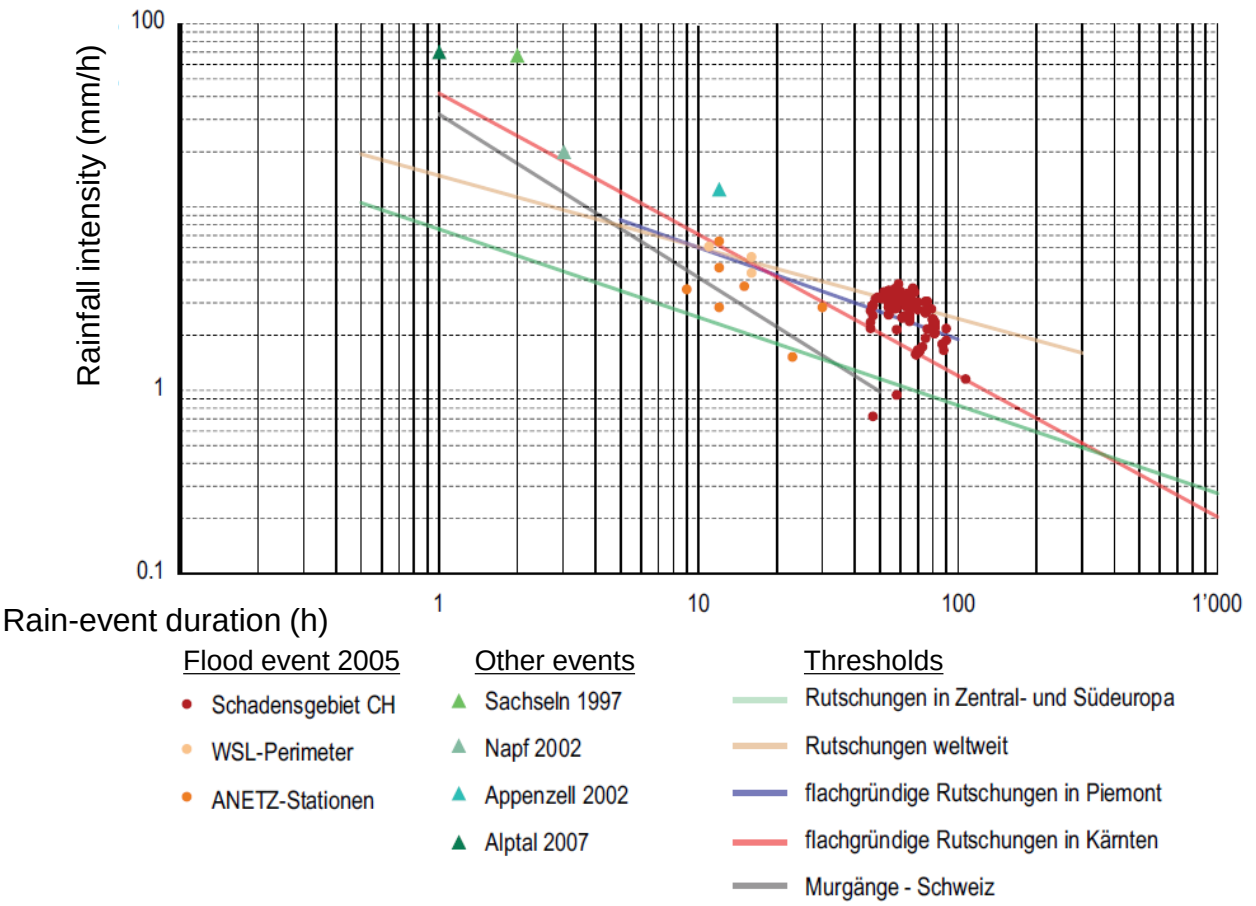
Example: 18 to 23 August, 2005 – Entlebuch region (central Switzerland)



Precipitation thresholds for single events

Example: 18 to 23 August, 2005 – Entlebuch region (central Switzerland)

Zum Vergleich eingetragen sind in der Grafik Linien kritischer Schwellenwerte für die Prozessauslösung, ermittelt für verschiedene Gebiete und Prozesse (nach Guzzetti et al., 2007).

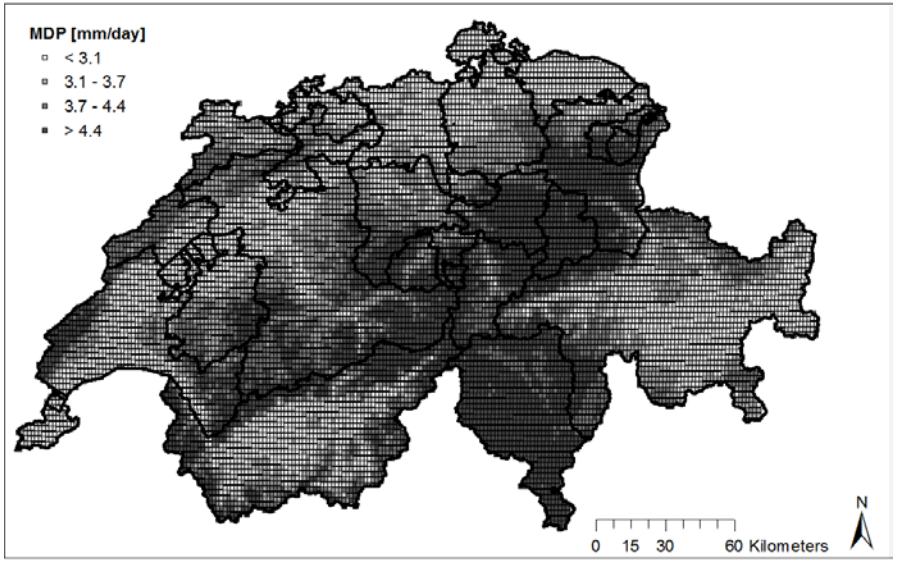


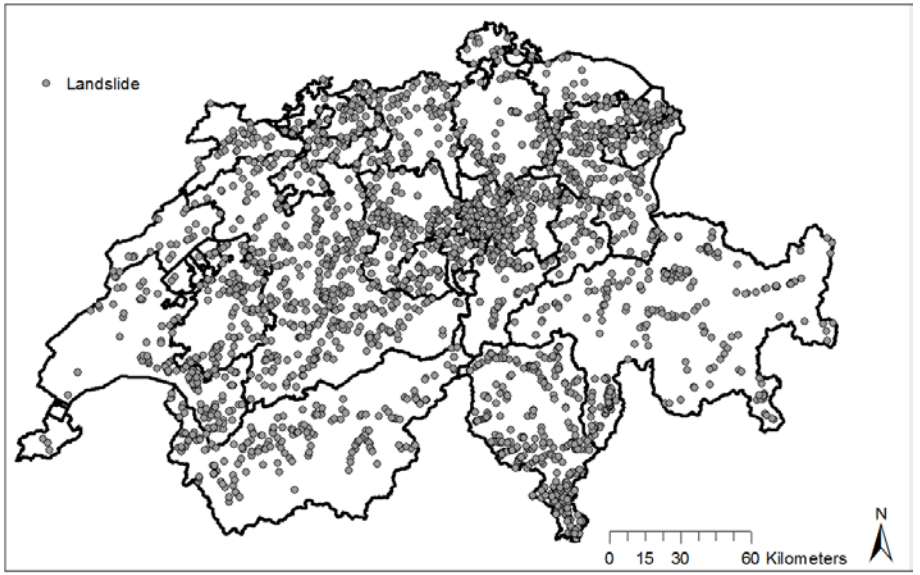
Precipitation thresholds at the national scale

Data:

a) Gridded MeteoSwiss dataset RhiresD (2 x 2 km resolution; daily sum of precip.; since 1961; interpolation of 420 rain gauges)

b) Swiss flood and landslide damage database (operated by WSL since 1972)

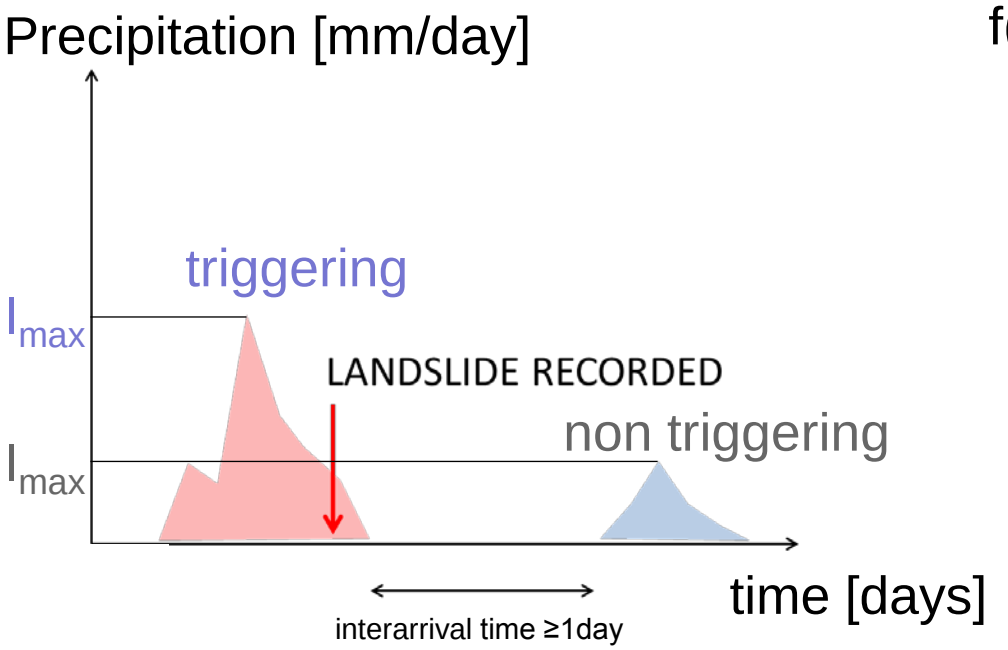


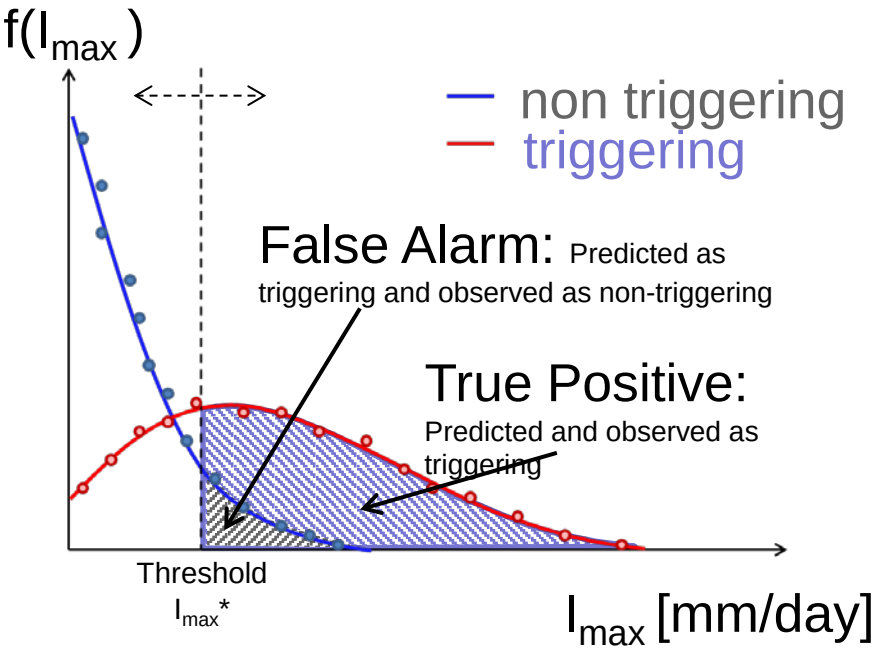


Precipitation thresholds at the national scale

Method:

- **Objective**: maximize the **ratio** of True Positive and minimize the **ratio** of False Alarms (True Skill Statistic)
- **Variable**: threshold as value of Maximum Daily Intensity (I_{max}) of an event (series of consecutive rainy days)

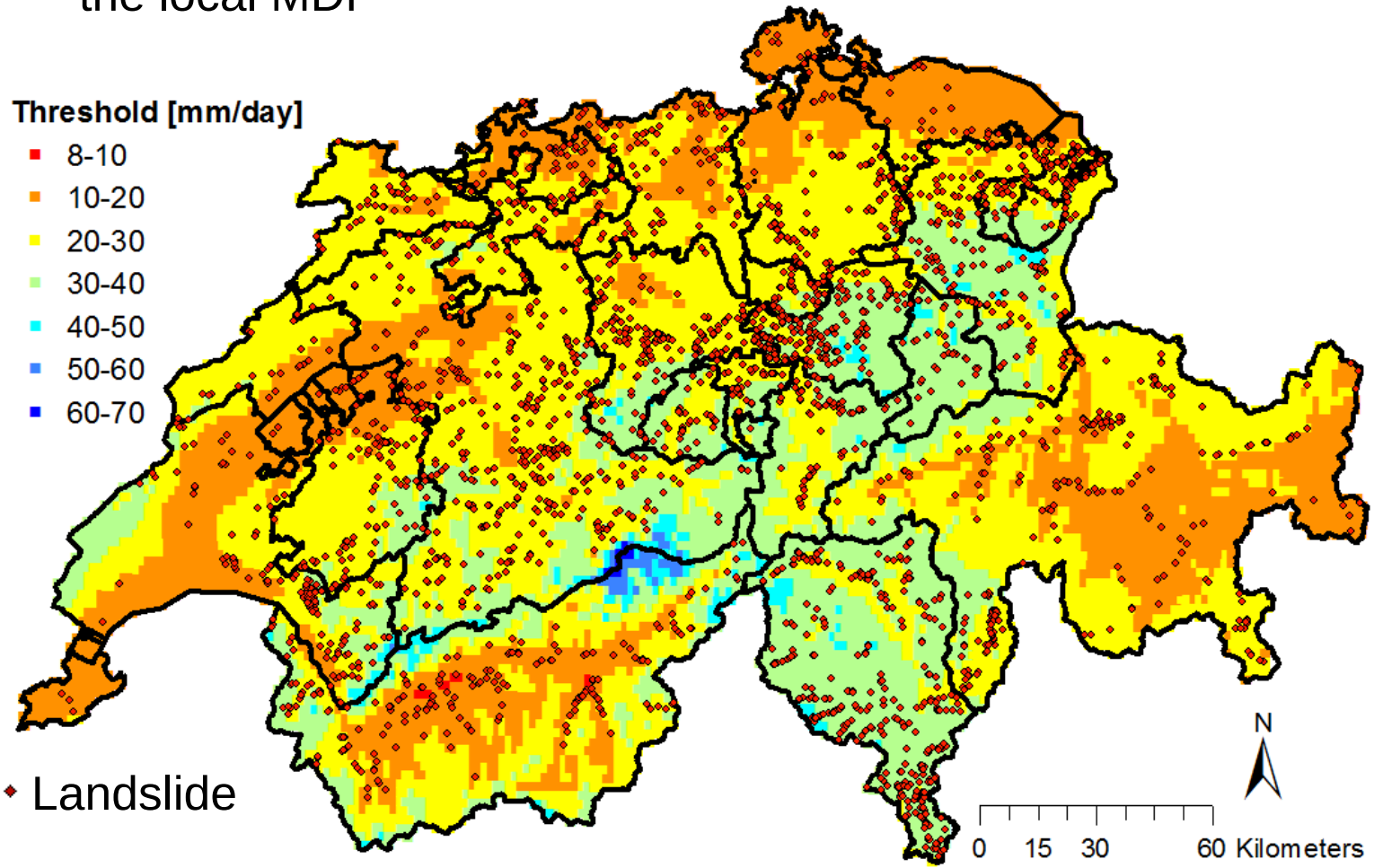




Precipitation thresholds at the national scale

Result:

- Best threshold (I_{max}/MDP) obtained for four regions separated depending on their MDP
- Definition of I_{max} threshold for each 2*2km cell depending on the local MDP



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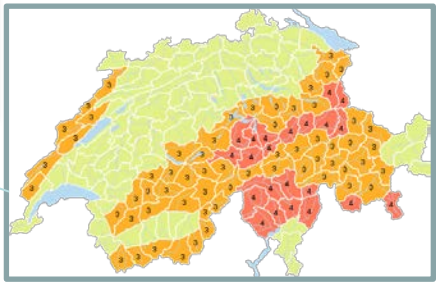
Concept for Early Warning System

Forecast and warning concept for **landslides in Switzerland** based on precipitation thresholds and soil-wetness modelling

Climatological input → Landslide Forecasting and Warning System → Hazard map with associated uncertainty

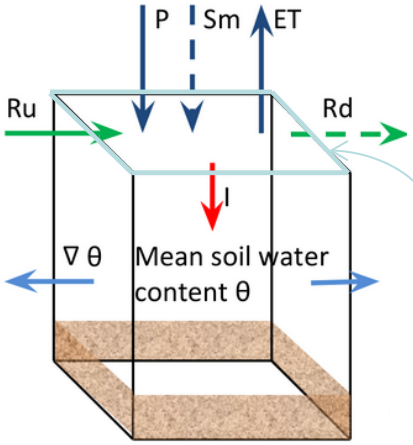


Numerical Weather Prediction Model forecast (COSMO)

Temperature, Precipitation

1. Landscape Scale Wetness Simulation

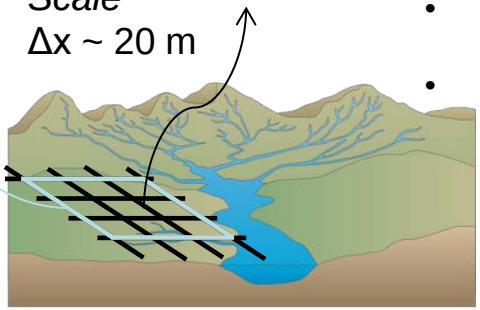
Δx = 1-2 km



Soil properties:
D, soil type, K(θ), λ

2. Downscaling to Hillslope Scale

Δx ~ 20 m



- θ-redistribution by topographic methods
- physically-based modelling of slope failure

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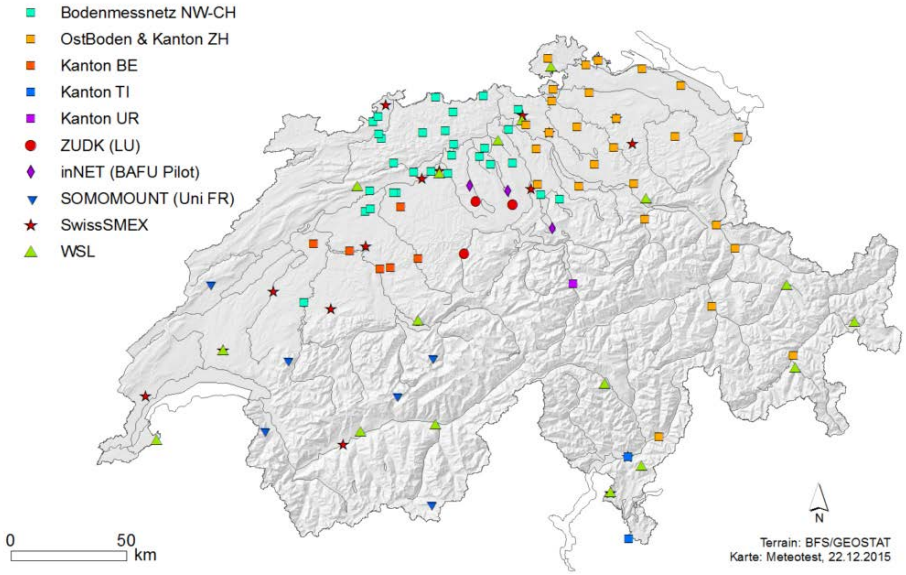
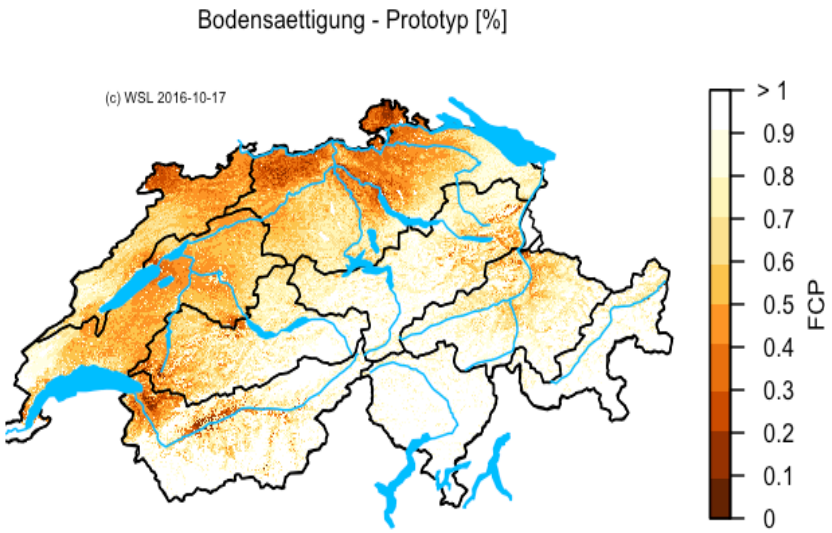
Current soil moisture information in Switzerland

Real-time measurements operated by different (federal and cantonal) institutions



- Only few measurements in pre-alpine and alpine area
- A national soil moisture measurement network is in planning

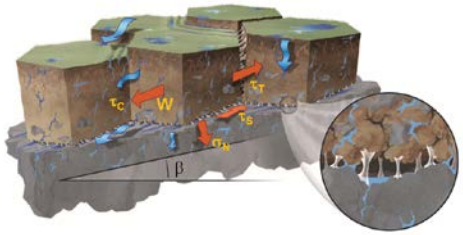
Real-time simulation (daily) with a hydrological model (PREVAH) by WSL

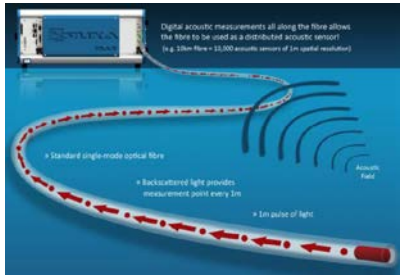


- Spatial resolution: 200 x 200 m
- Meteorological input:

New directions towards a Swiss landslide EWS

Project TRAMM (Triggering of Rapid Mass Movements) 2006-15



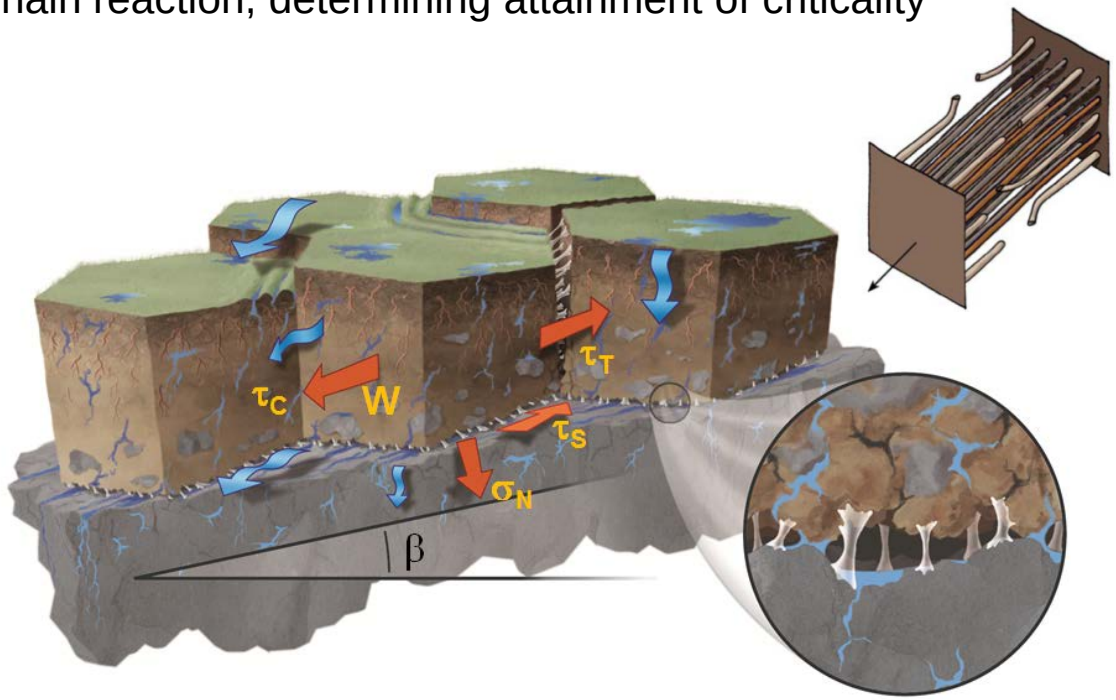


Publication: Stähli et al. 2015. Nat. Hazards Earth Syst. Sci., 15, 905–917.

New directions towards a Swiss landslide EWS

New numerical hydro-mechanical triggering model (STEP-TRAMM)

- System discretized in interconnected soil columns with hydro-mechanical properties as a function of soil type
- Modelled hydrology defines spatio-temporal water content pattern, determining local load, shear, tensile and compressive soil strength
- Incorporation of **strength threshold** leads to abrupt failure of mechanical bonds and chain reaction, determining attainment of criticality

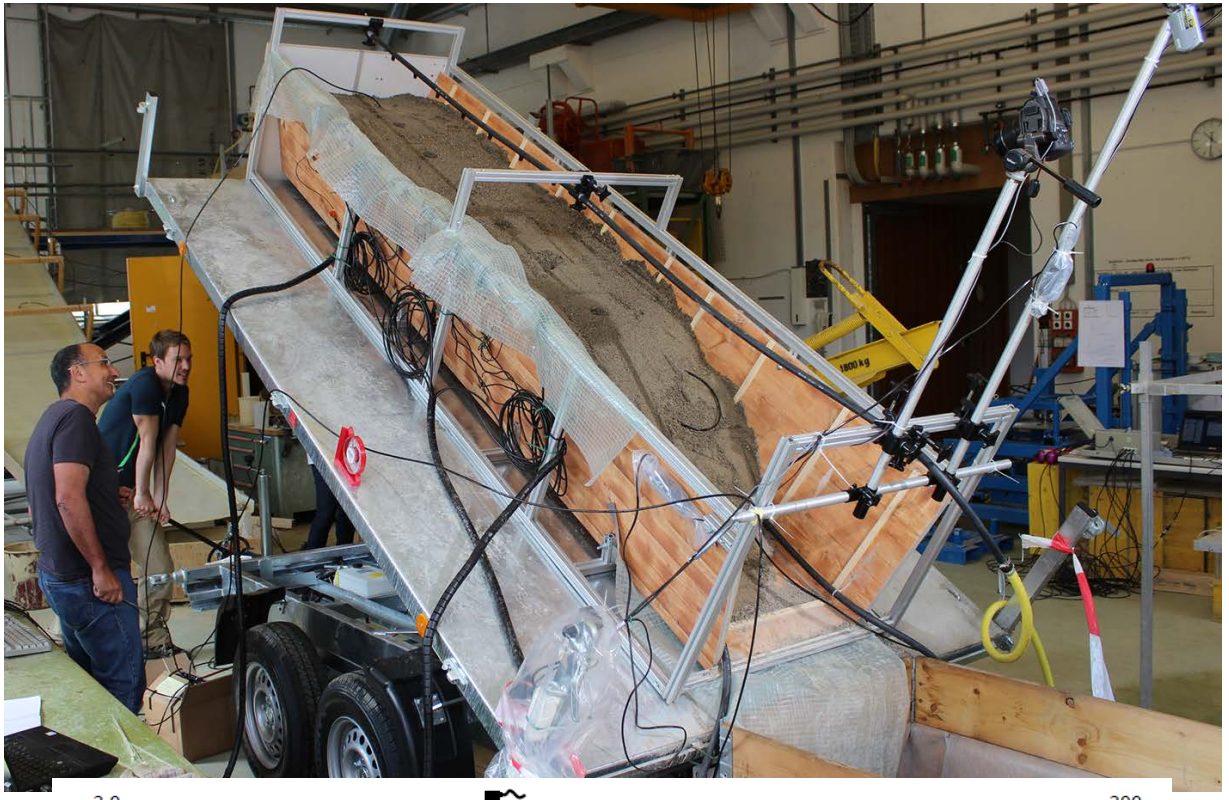


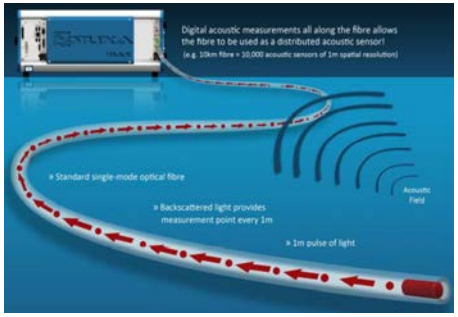
Publication: Lehmann, P., and Or, D. 2012. Water Resour. Res., 48, W03535.

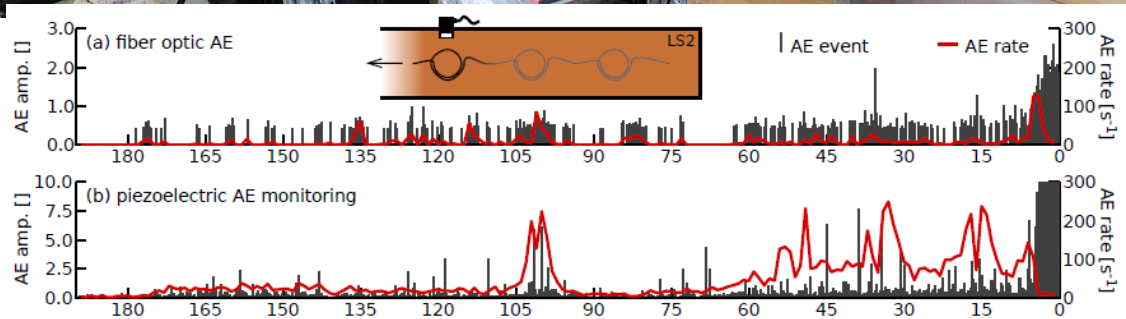
New directions towards a Swiss landslide EWS

Fiber-optic high-resolution acoustic emission (AE) monitoring of failure in Earth material

- Lab-experiment conducted by G. Michlmayr, D. Or (ETH Zürich), Silixa Ltd. and others
- Feasability study of Fiber-optic based AE monitoring as an indicator of landslide precursors
- Gravel material, inclination: 26º, artificial irrigation







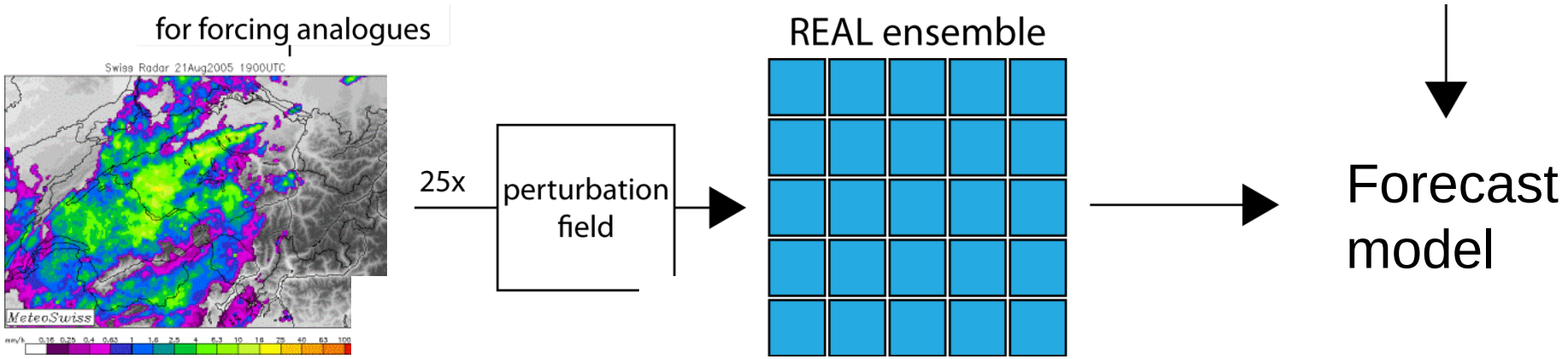
New directions towards a Swiss landslide EWS

Full-scale hillslope triggering experiment Rüdlingen

- Forested hillslope at the border of the Rhine river (38 to 40^{o} inclination, 7 x 35 m area).
- Dense monitoring of precipitation, soil moisture, ground-water table, 2-d saturation (ERT), surface displacement and acoustic emissions.
- Artificial irrigation of the entire slope until failure.

Radar Ensemble REAL

current radar QPE



Perturbation field

- detailed knowledge about the space-time variance and autocovariance of the weather radar errors
- Stochastic simulation techniques

Conclusions

- At present, no Swiss-wide landslide EWS is at hand
- A precipitation-based EWS with modelled soil wetness is under development and may become operational within the next few years
- Ideas to include precursors or incipient failures into a future landslide EWS are existing, but today still far from implementation.

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