REASONING | (UN)KNOWNS | STRATEGY | UAV SFM VIEW | SEISMIC VIEW | SYNTHESIS

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News from the back weathering front

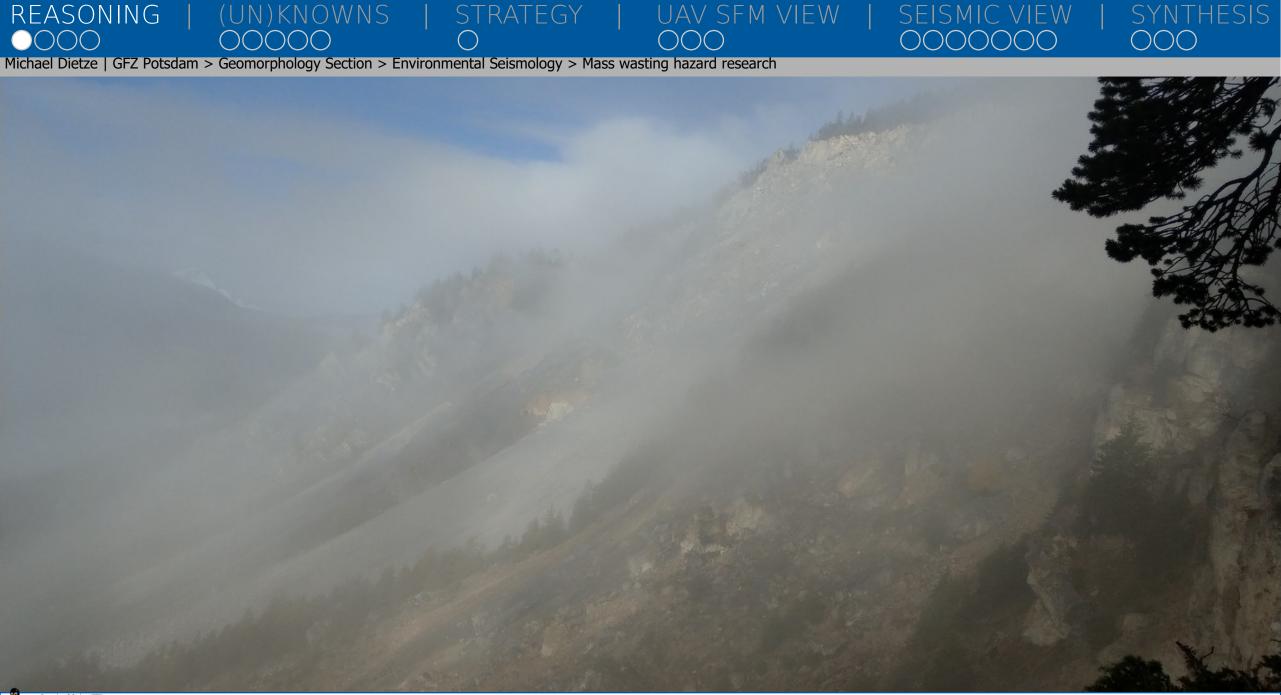
Interaction of deep deformation and surface activity on a Multi-million cubic metre rock slide

1 – GFZ German Research Centre for Geosciences, Geomorphology Section, Potsdam, Germany

2 – GeoInventure, Thalwil, Switzerland

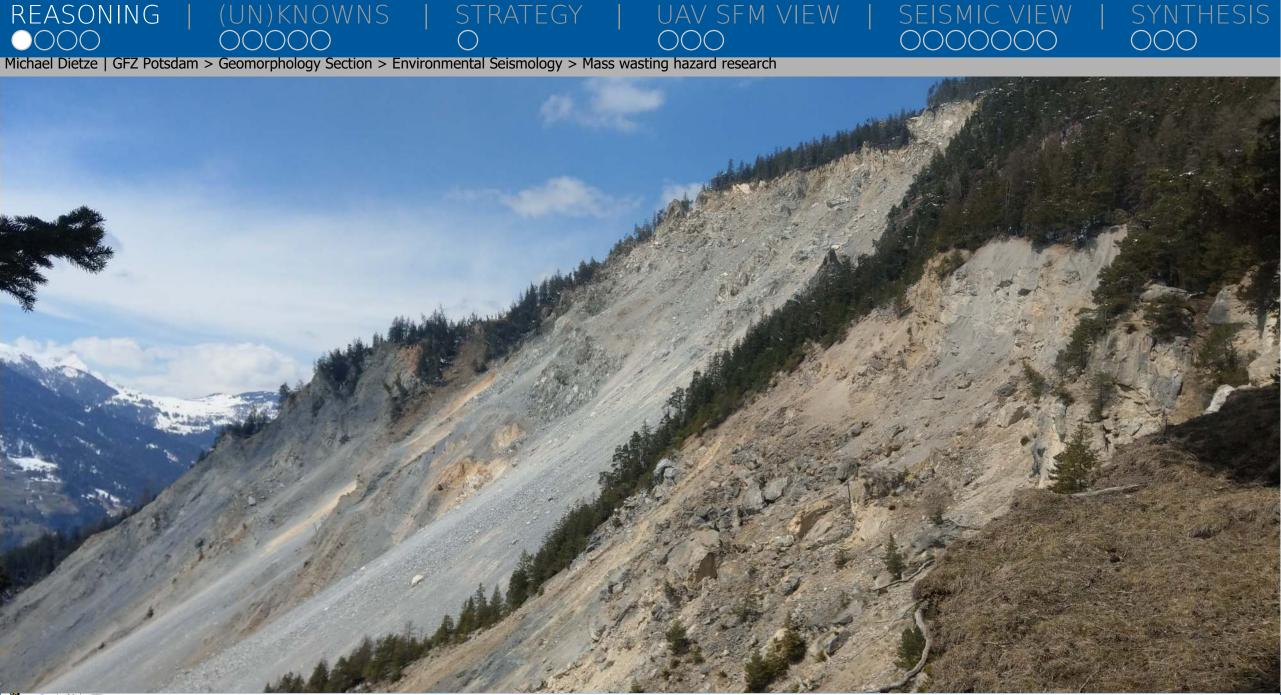




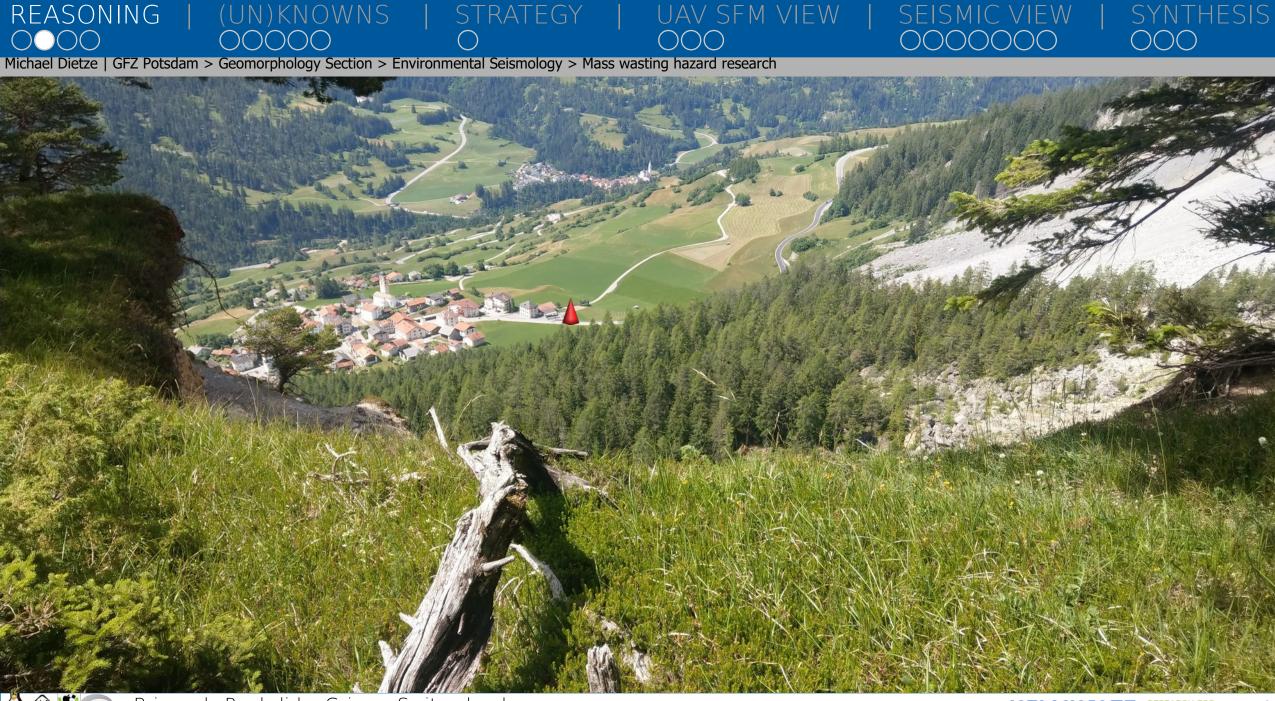








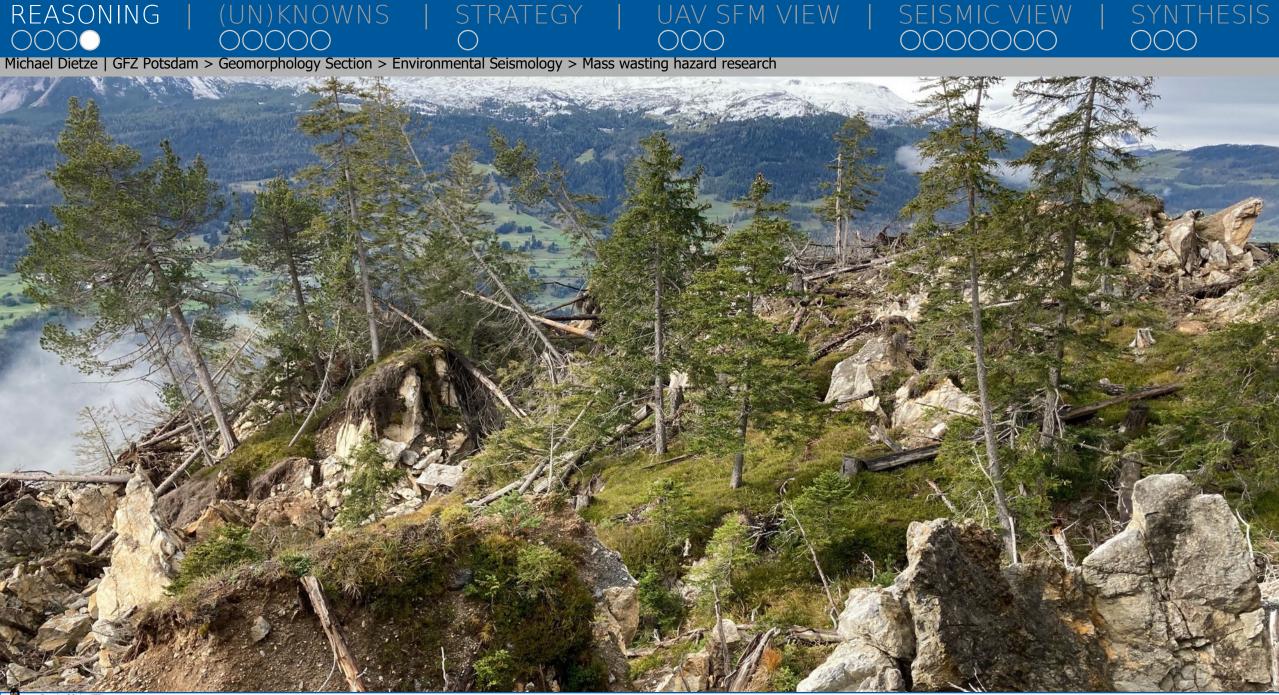










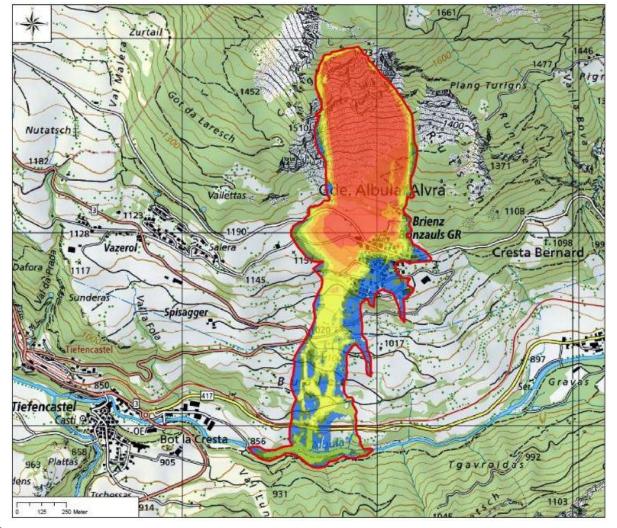




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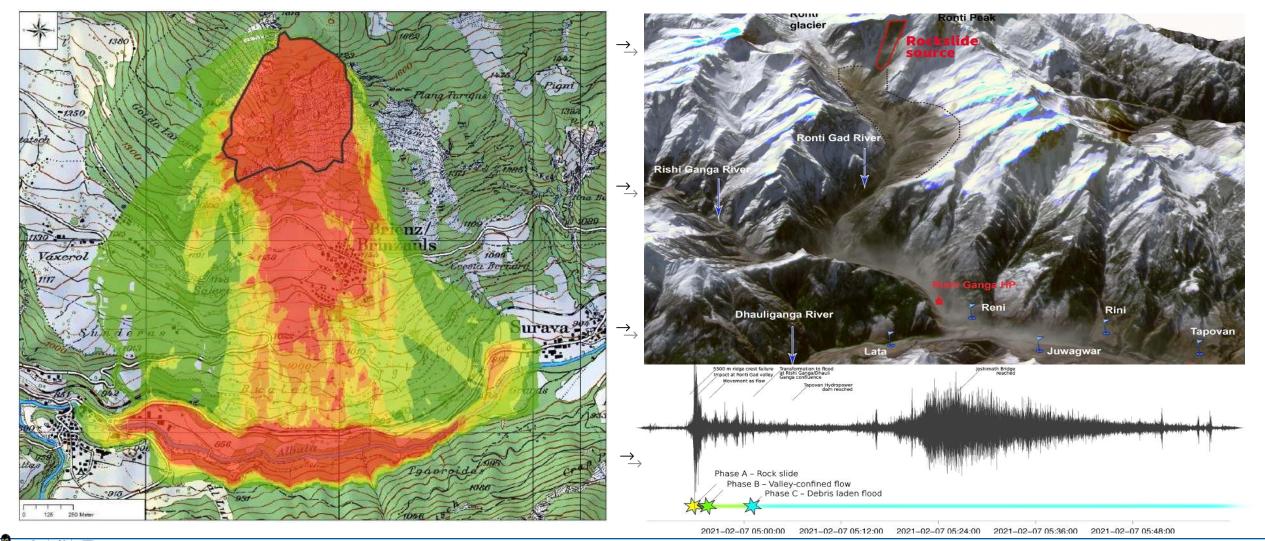
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Potential future trajectories DIFFERENT MODEL SOLUTIONS OF SLOPE FAILURE





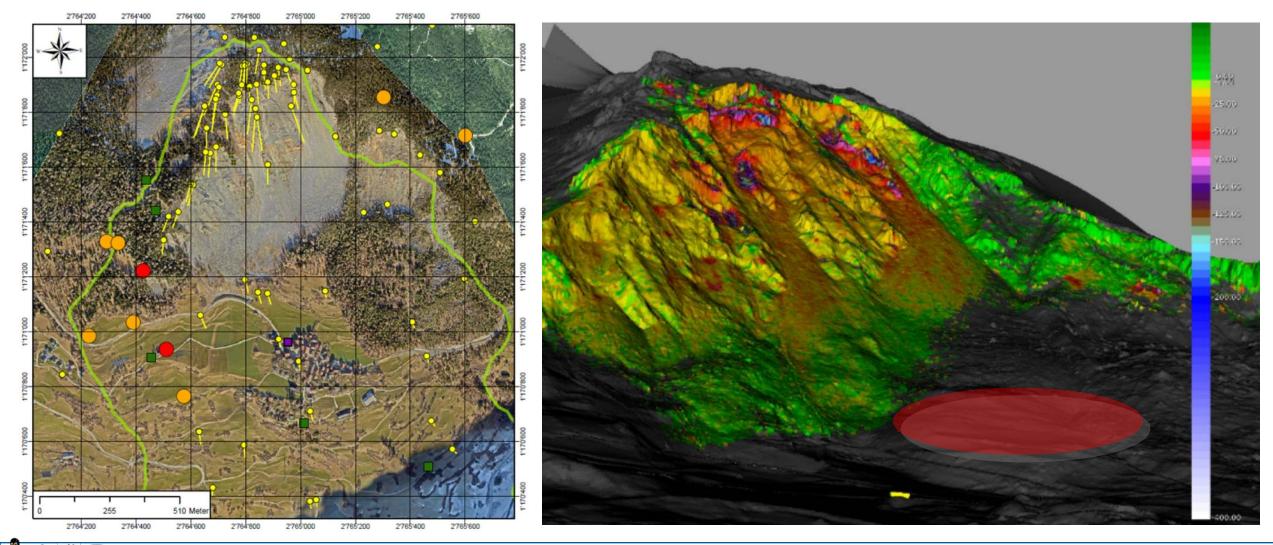
Potential future trajectories DIFFERENT MODEL SOLUTIONS OF SLOPE FAILURE



Or 22,000,000 m³ → Chamoli event (Cook, Rekapalli, Dietze et al., 2021, Science)



Existing monitoring efforts A COMBINATION OF GNSS STATIONS, REGULARLY SURVEYED TARGETS, AND AN INTERFERROMETRIC RADAR STATION

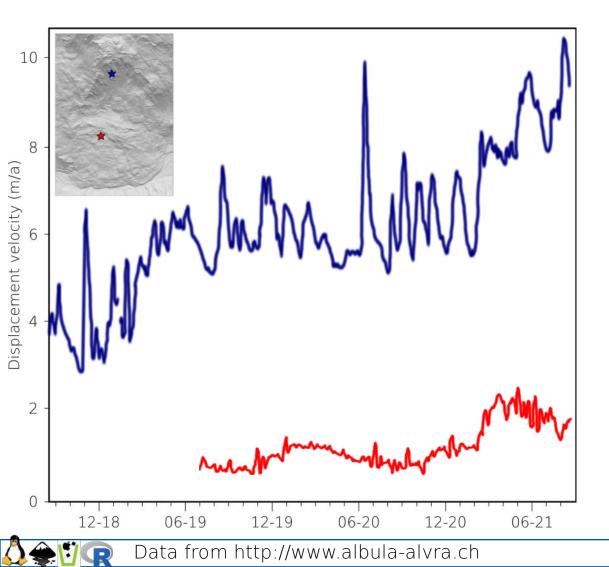


Data from www.albula-alvra.ch





Deep process expressions THE SENSIBLE EFFECTS OF DEEP SEATED DEFORMATION OF THE ROCKSLIDE AND DOWNSLOPE LANDSLIDE



1) Decoupled displacement history

2) Increasing displacement speed (<1 m per month)



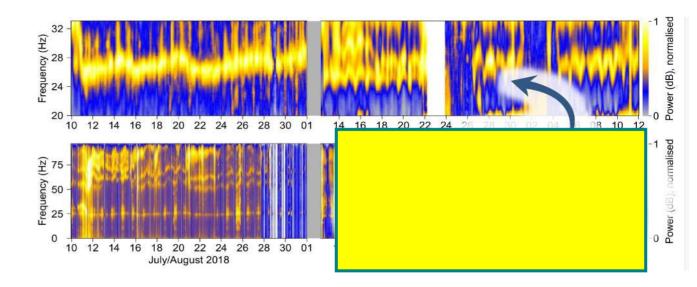


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2) Increasing displacement speed (<1 m per month)

3) Stick-slip motion of the rockslide



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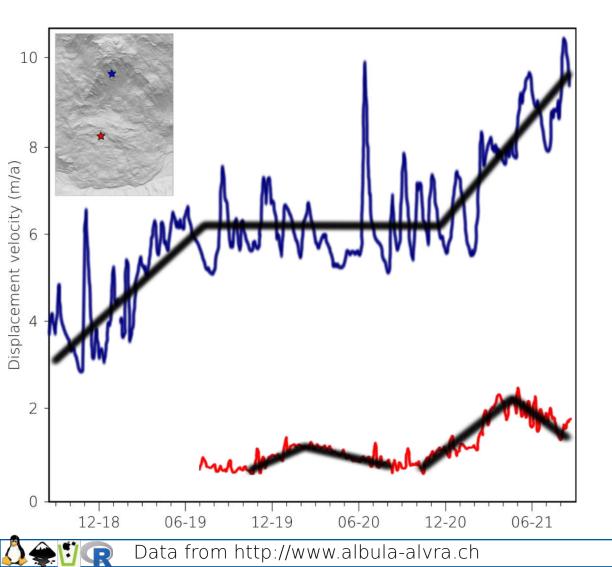
Data from http://www.albula-alvra.ch

Dietze et al. (2021, ESPL)

REASONING (UN)KNOWNS STRATEGY UAV SFM VIEW SEISMIC VIEW SYNTHESIS OOO OOO OO OO OO OOO OOO OOO OOO Michael Diotro Commercial Section > Environmental Seismelagy > Mass westing based research OOOOOOO OOO OOO OOO

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Deep process expressions THE SENSIBLE EFFECTS OF DEEP SEATED DEFORMATION OF THE ROCKSLIDE AND DOWNSLOPE LANDSLIDE



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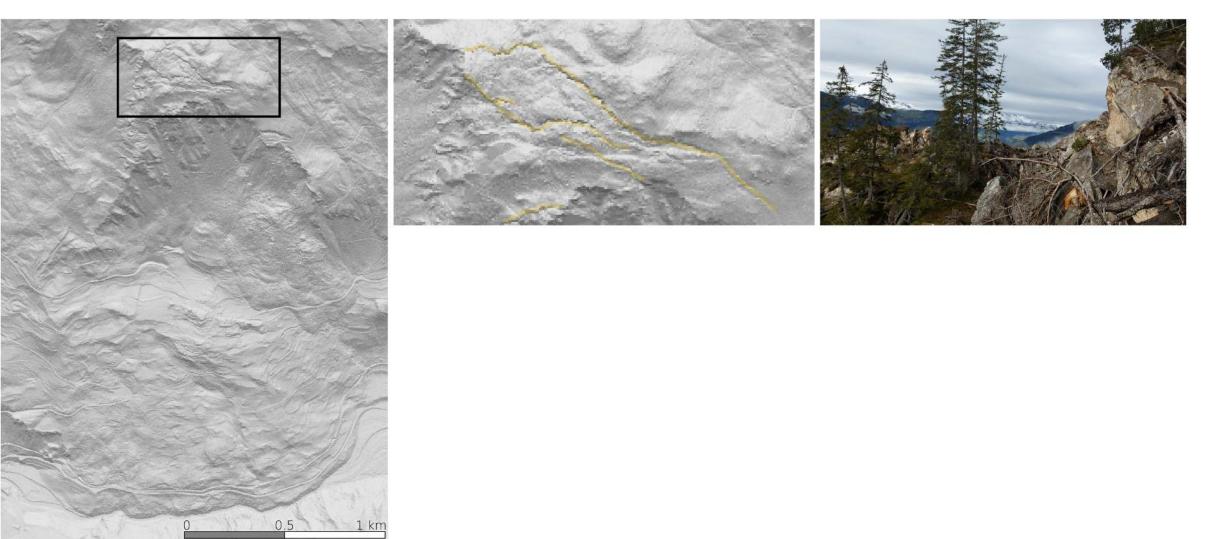
3) Stick-slip motion of the rockslide

- 4) Different periodicities in the forcing
 - event-based activity of the rockslide
 - inter-annual trends in the rockslide
 - seasonal trends in the landslide





A closer and more objective view of the area DEFORMATION OF THE UPPER PART OF THE ROCKSLIDE

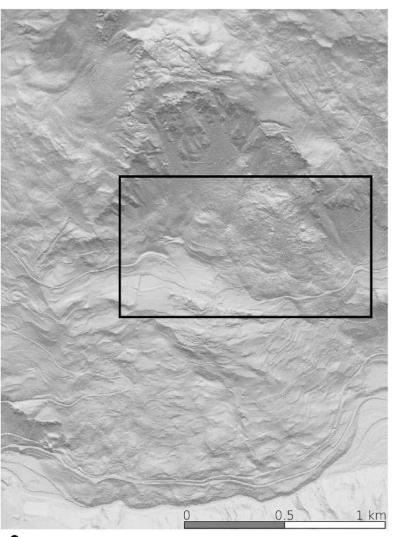








A closer and more objective view of the area TRANSITION OF THE ROCKSLIDE TO THE LANDSLIDE

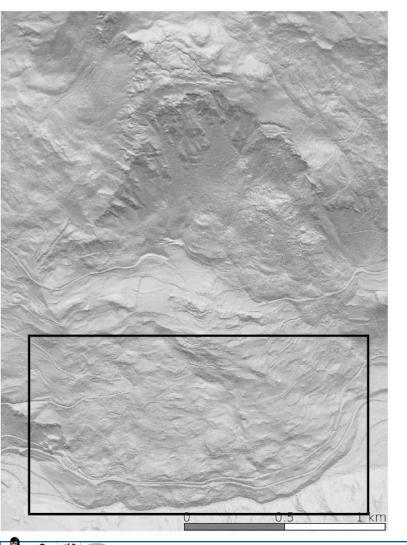


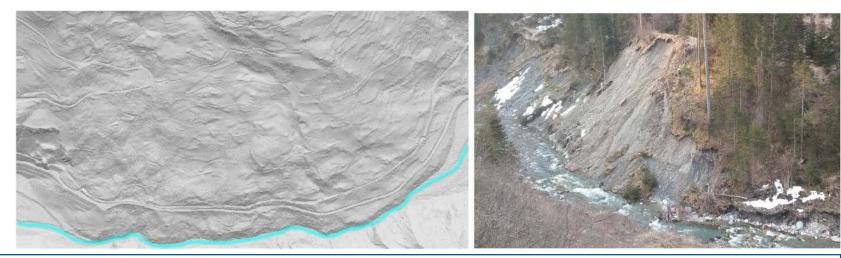






A closer and more objective view of the area DEFLECTION OF THE ALBULA RIVER BY THE DEFORMING LANDSLIDE



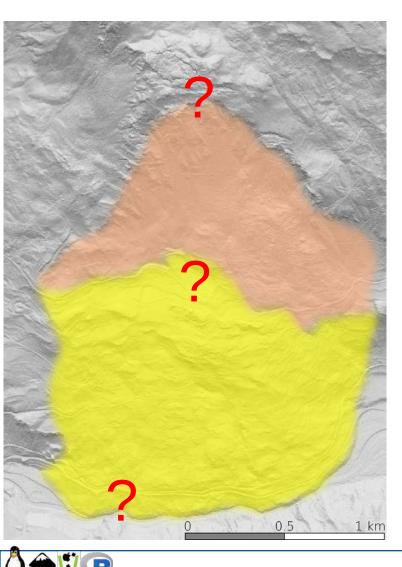




Data from SwissTopo

A closer and more objective view of the area THREE THEMATIC FIELDS TO BE EXPLORED

(UN)KNOWNS



REASONING

1) Rock slope activity

STRATEGY

- What drives rock mass movement
- Where is the failure plane and how is it evolving?

uav sfm view

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2) Hazard mitigation

- (How well) can we detect rockfall of variable evolution type?
- How big are the masses and how fast are they travelling?
- What controls and triggers the events?

3) Landscape connectivity

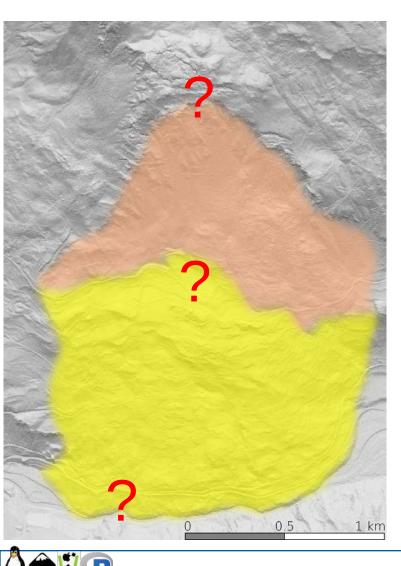
- What are the mutual feedbacks between hillslope and river?
- How much sediment is injected to the Albula?
- How does the rockslide couple to the landslide?



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A closer and more objective view of the area THREE THEMATIC FIELDS TO BE EXPLORED

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UAV SFM VIEW

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SEISMIC VIEW

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SYNTHESIS

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How to approach the problem(s)?







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Surface change within six years COMPARISON OF UAV-SFM-DEM AND Swiss Topo DEM

30 (m) **0**





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Surface change within six years COMPARISON OF UAV-SFM-DEM AND Swiss Topo DEM

30

Data from SwissTopo from 2014 & UAV survey from 2021 (thanks Kristen!)



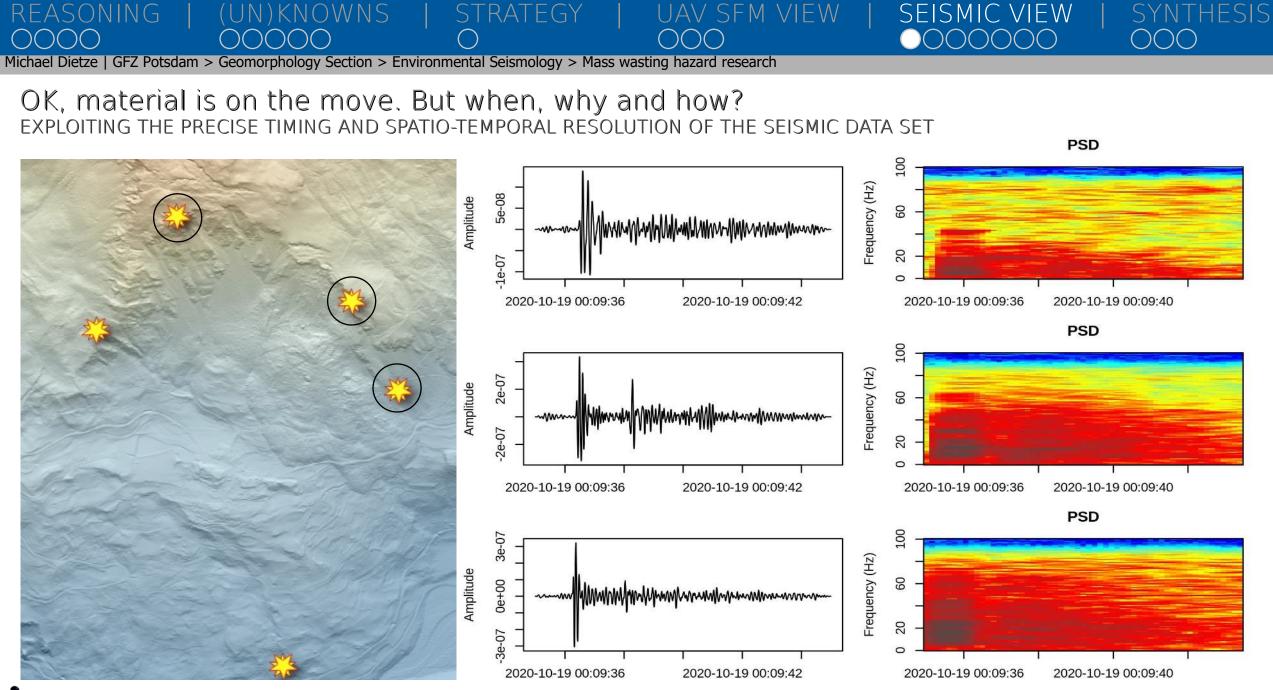
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Surface change within six years COMPARISON OF UAV-SFM-DEM AND Swiss Topo DEM





Bei ROT akute Steinschlaggefah



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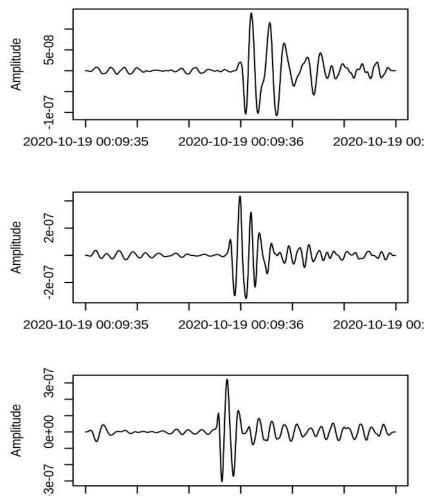
STRATEGY

OK, material is on the move. But when, why and how? COMPARING TWO SEISMIC LOCATION TECHNIQUES REGARDING THEIR AGREEMENT

Seismograms (5-10 Hz)

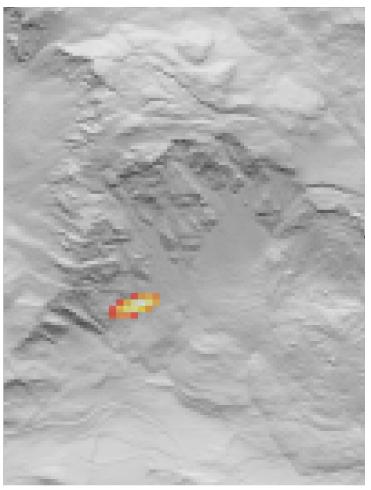
UN)KNOWNS

REASONING



Location (signal migration)

UAV SFM VIEW



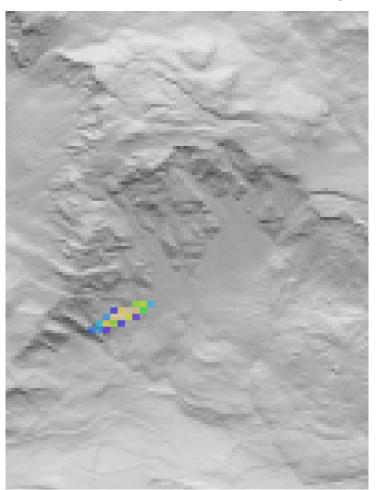
Location (amplitude modelling)

SYNTHESIS

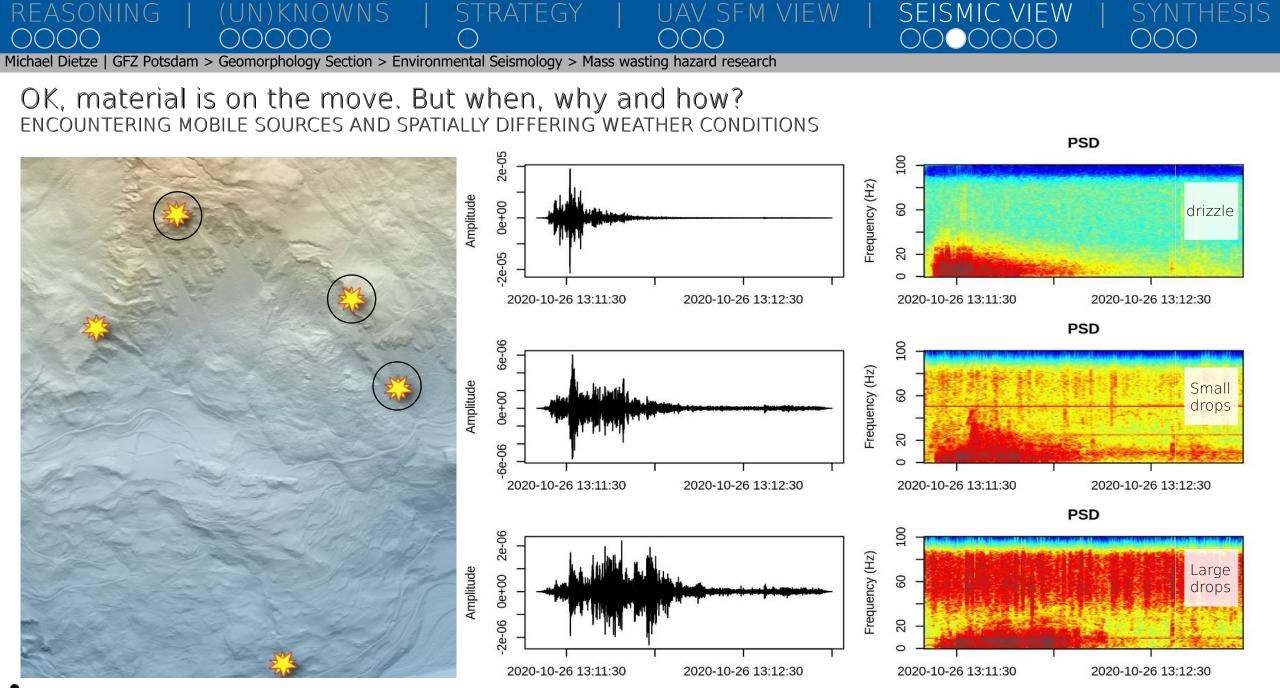
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SEISMIC VIEW

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Dietze et al (2017, Esurf), (2021, JGR-ES)

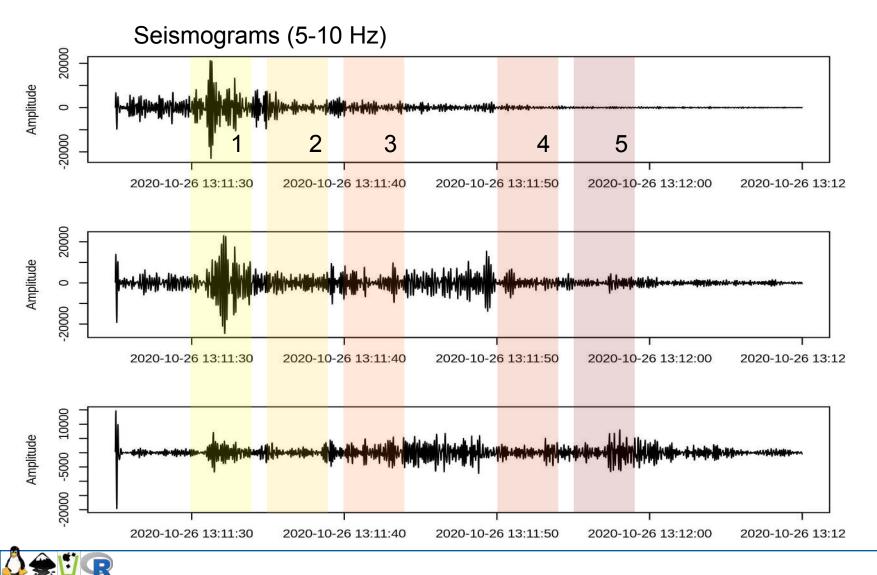


HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

25

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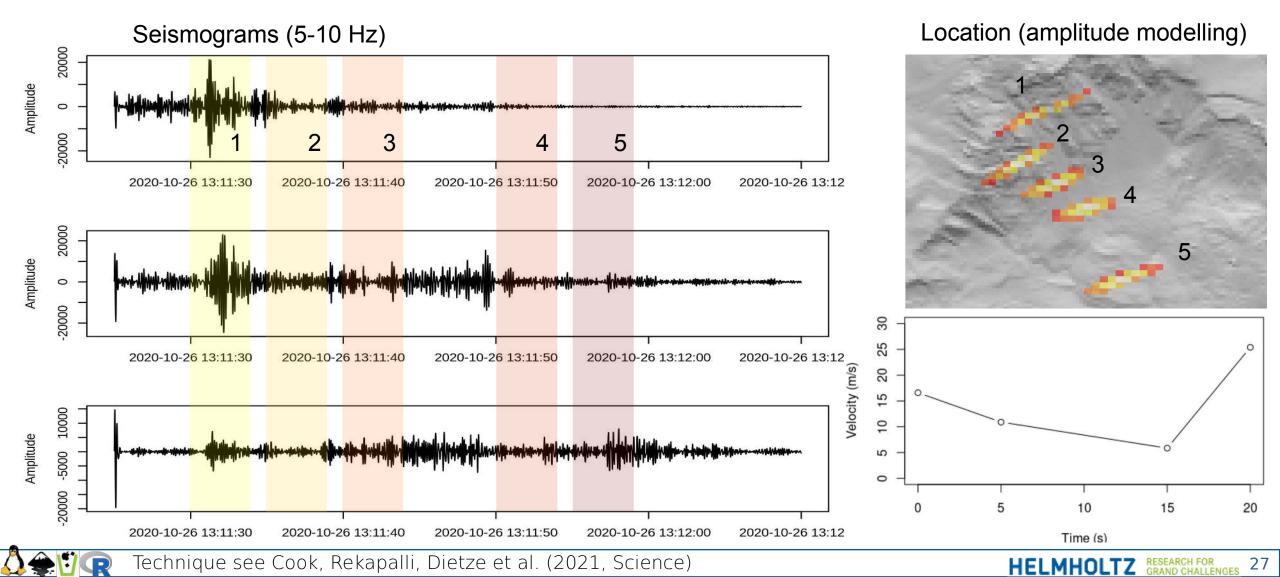
OK, material is on the move. But when, why and how? TIME RESOLVED LOCATION ESTIMATES OF A MOBILE SEISMIC SOURCE



HELMHOLTZ RESEARCH FOR GRAND CHALLENGES 26

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OK, material is on the move. But when, why and how? TIME RESOLVED LOCATION ESTIMATES OF A MOBILE SEISMIC SOURCE ALLOWS TRACKING AND VELOCITY ESTIMATES





From single events to the statistics of a larger catalogue (N = 321) THE RICHNESS OF SEISMIC FEATURES OF THE DATA SET

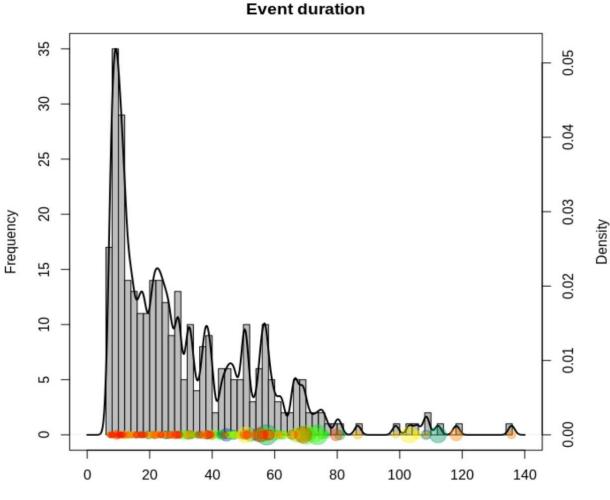
20 40 60 80 100 120 140					50 45 40 35 30 25 20 15	50 45 40 35 30 25 20					0.05 0.10 0.15 0.20 0.25	-150 -140 -130 -120 -110	1-150 -140 -120 -110 -100				0 5 10 15 20 25 30		20 1 1 1 1 1 1 1 1	
	0 50 100 150	0 50 100 150	0 10 20 30 40	0 20 100 15 0 100 15	50 45 40 35 30 25 20 -	00 1604 2604 3604 4604 5604 6	0000 010000 00000		-160 -150 -140 -130	0.0 0.1 0.2 0.3 0.4 0	2 - 10		-140 -130 -120	5 10 15 20 25	10 20 30 40 40 40	0 10 20 30 40		0.65 0.70 0.75 0.80 0.85	0 10 20 10	0 5 10 15 20 25
				4.0 3.5 3.0 2.5 2.0 4.5	50 45 40 35 30 25 20	00+100 1e-05 2e-05 3e-05 4e-05 5e-05 6e-05		1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1			0.0 0.2 0.4 0.6 0.8		24 25 26 27 28 29				2 10 15 20 25 1 1 1 1 2			0 5 10 15 20 25 30

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How long do slope events last? DURATION (AND SEISMIC EVOLUTION)



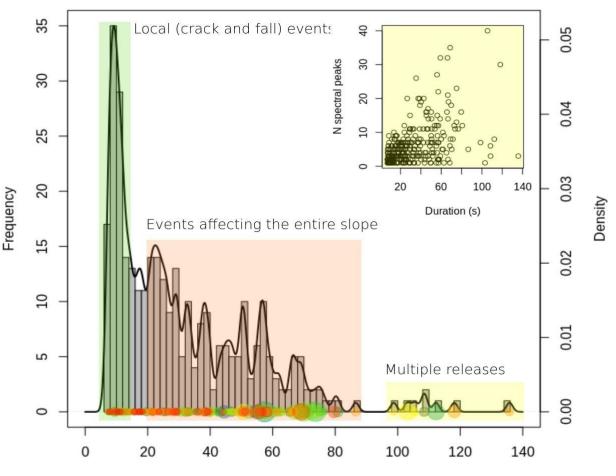
Event duration (s)



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How long do slope events last? DURATION (AND SEISMIC EVOLUTION) FORMS THREE CLUSTERS OF EVENT TYPES

Event duration

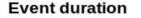


Event duration (s)



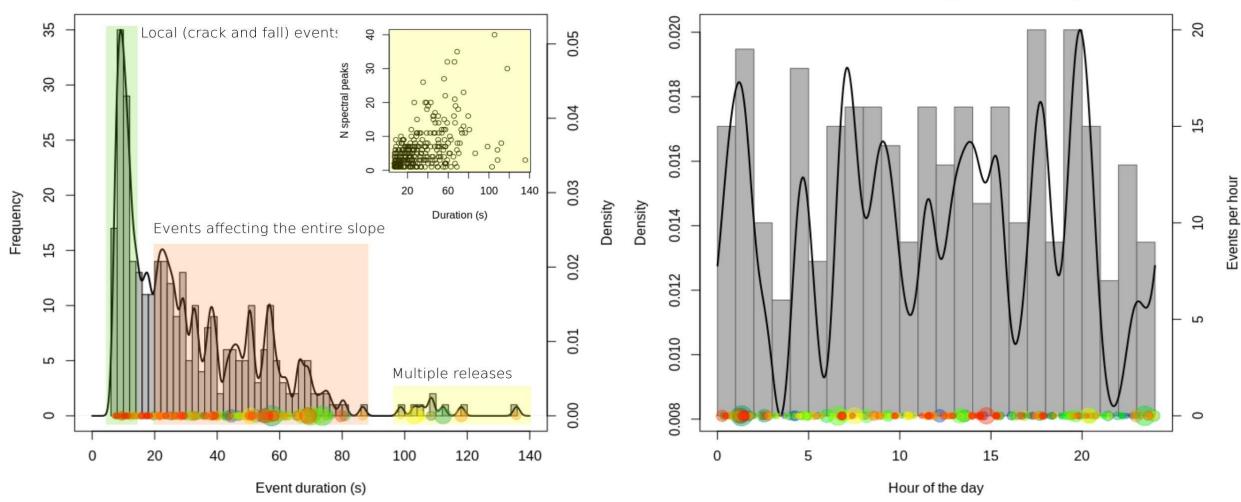
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How long do slope events last? And when do they happen? DURATION (AND SEISMIC EVOLUTION) FORMS THREE CLUSTERS OF EVENT TYPES, BUT NO DIURNAL PREFERENCE OF ACTIVITY



Event occurrence by time of the day

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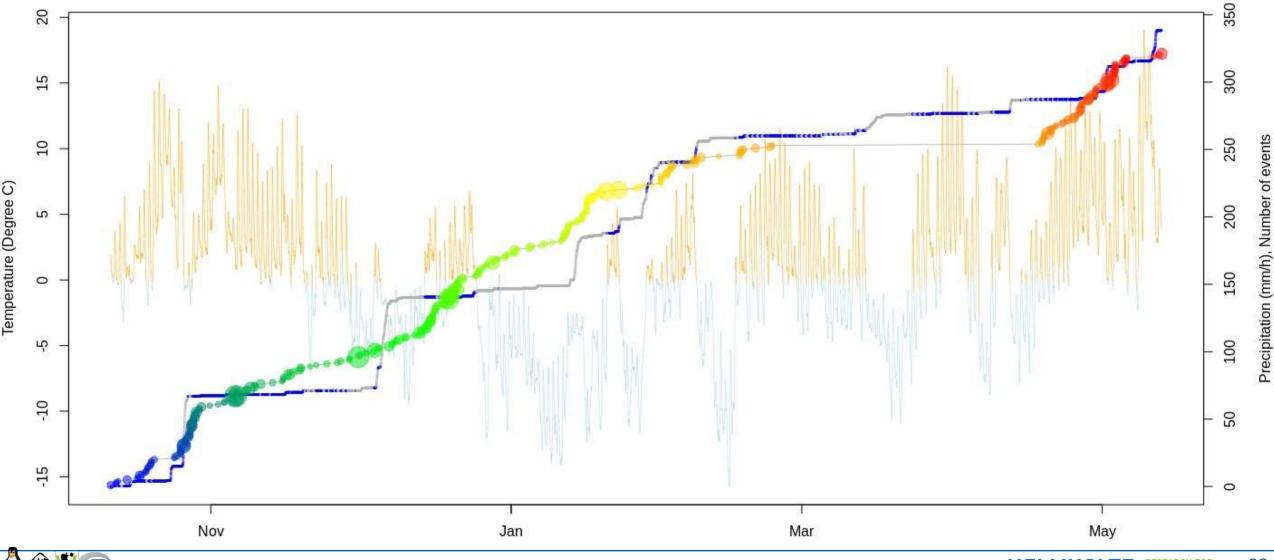




REASONING UAV SFM VIEW SEISMIC VIEW UN)KNOWNS SYNTHESIS RAIEGY 000000 $\bigcirc\bigcirc\bigcirc\bigcirc$

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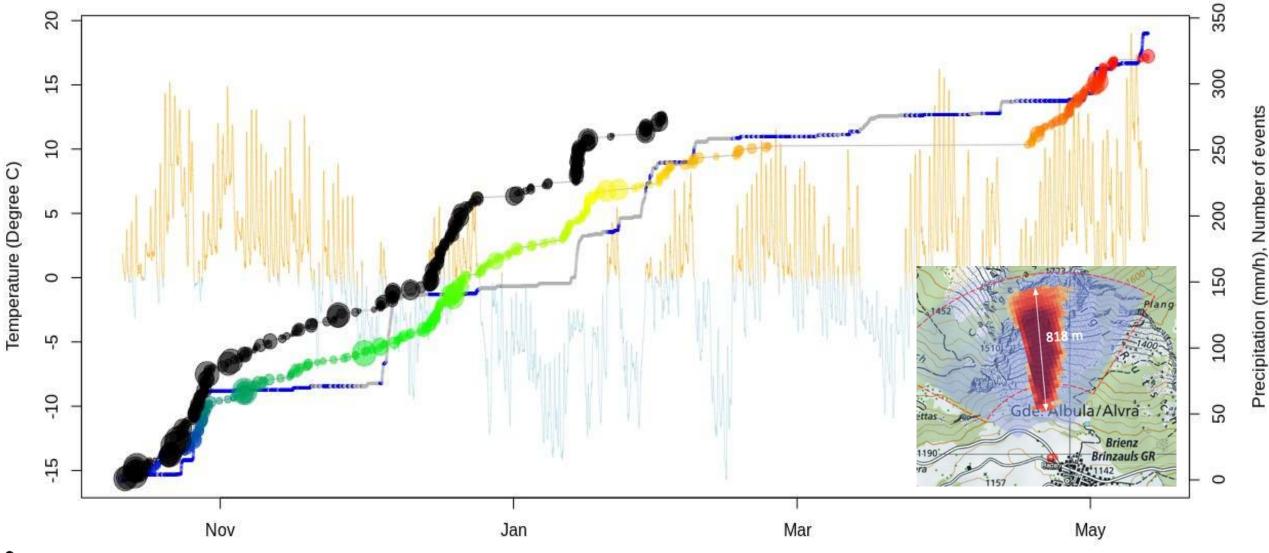
When do events happen, how large are they, and what causes them? EVENT OCCURRENCE WITH TIME AND DRIVERS SHOWS BACKGROUND ACTIVITY AND CYCLIC PEAKS



HELMHOLTZ RESEARCH FOR GRAND CHALLENGES 32

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How well does the seismic approach match independent techniques? SEISMIC AND DOPPLER RADAR APPROACHES SENSE DIFFERENT EVENTS

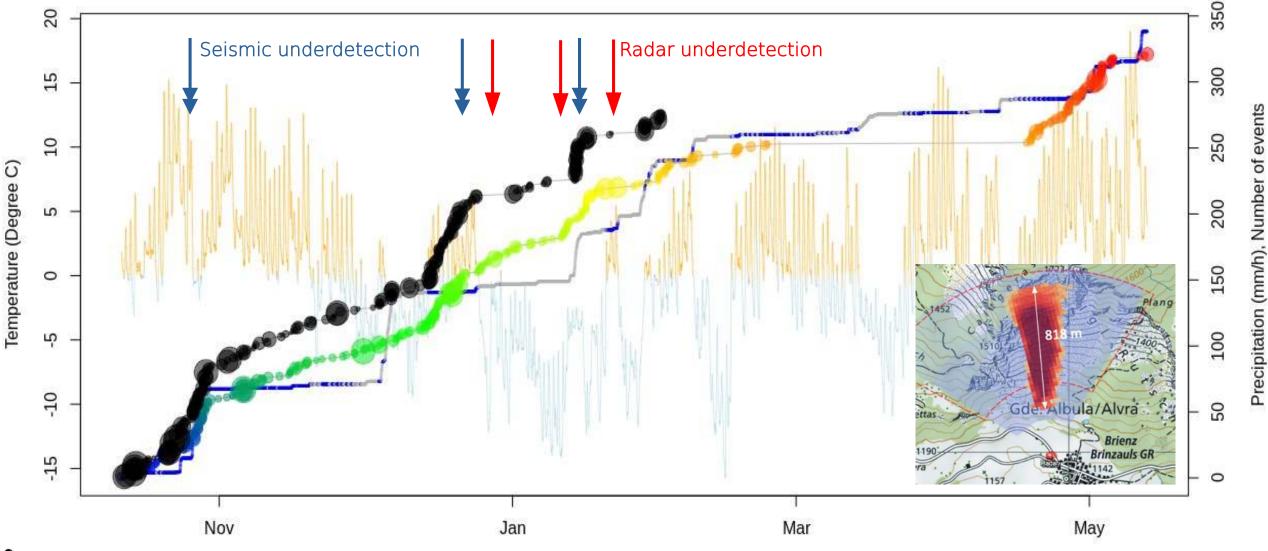




Ulivieri et al. (2020) HELMHOLTZ RESEARCH FOR 33

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How well does the seismic approach match independent techniques? SEISMIC AND DOPPLER RADAR APPROACHES SENSE DIFFERENT EVENTS





Ulivieri et al. (2020) HELMHOLTZ RESEARCH FOR 34

To wrap up... CONCLUSIONS EMERGING FROM THE CURRENT LIFE TIME OF THE STUDY

KNOWNS

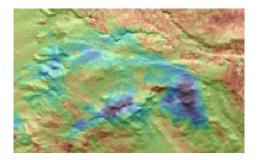
1) Surface deformation patterns show contribution of both deep and shallow processes

- Subsidence of fragmented blocks, causing frequent rockfall releases
- Transport as well as (temporary) deposition in gullies and along base of the slope

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SEM VIEW

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SYNTHESIS

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REASONING



To wrap up... conclusions emerging from the current life time of the study

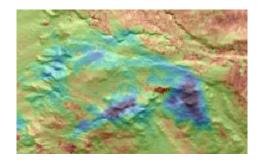
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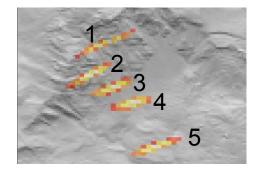
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2) Hazard mitigation focus preferentially on rapid surface processes

- Activity clusters determined by subsidence and surface topography
- Three classes of events: local cracks, single rockfalls, repeated activity
- Next urgent step: implementing real time detection, quantification, notification



SYNTHESIS





REASONING



To wrap up... conclusions emerging from the current life time of the study

1) Surface deformation patterns show contribution of both deep and shallow processes

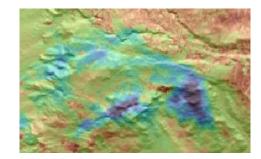
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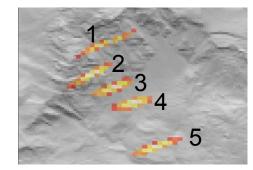
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3) Landscape connectivity

- Two evident coupling cases: rockslide-landslide & landslide-channel-hillslope
- Next step: quantifying volume exchange, drivers, and coupling mechanisms



SYNTHESIS







REASONING

To wrap up... conclusions emerging from the current life time of the study

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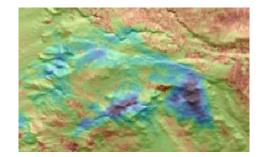
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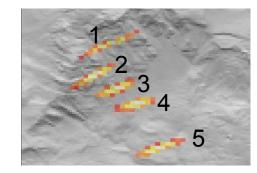
3) Landscape connectivity

- Two evident coupling cases: rockslide-landslide & landslide-channel-hillslope
- Next step: quantifying volume exchange, drivers, and coupling mechanisms
- But: there is more than the Alps and we have urgent case studies close-by...



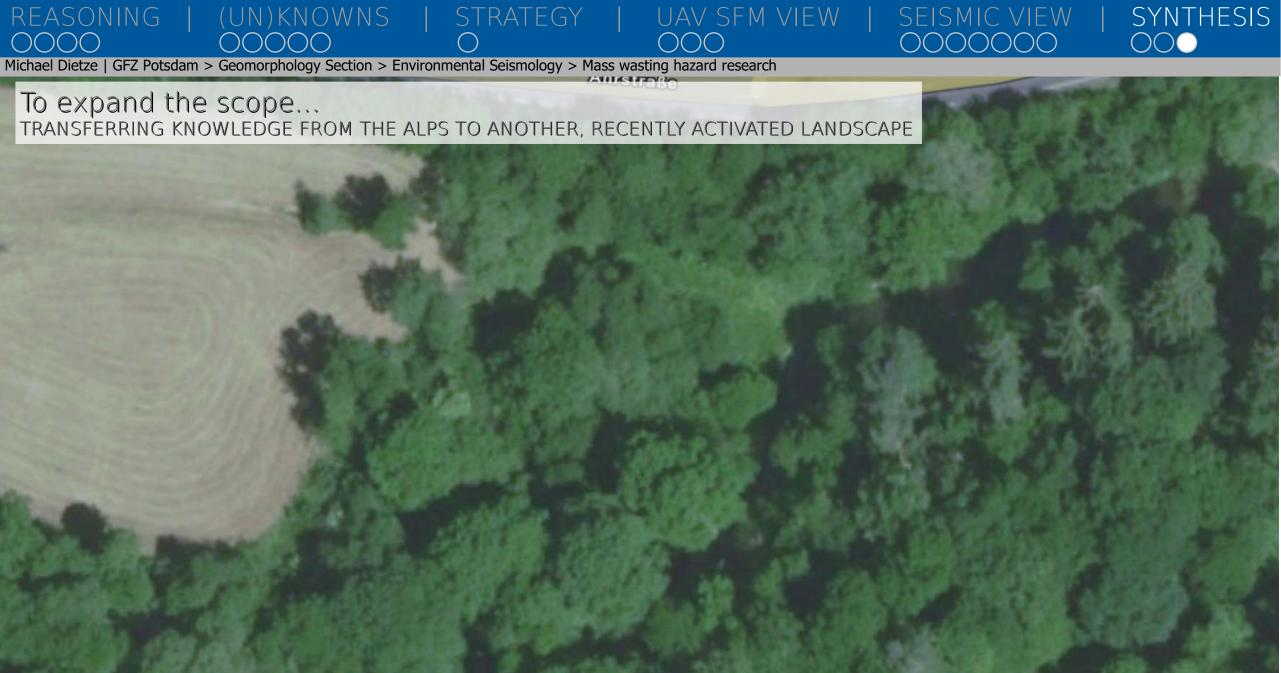
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SYNTHESIS











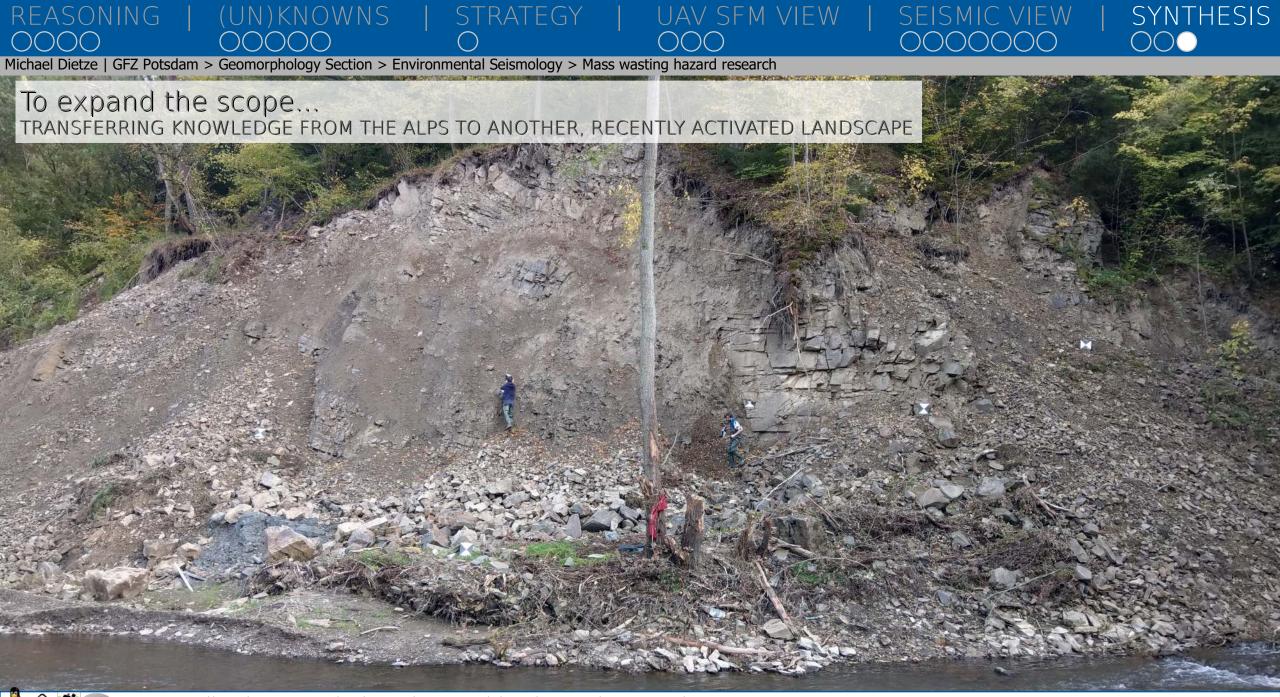
Dietze & Öztürk (2021, Science) **HELMHOLTZ** RESEARCH FOR 39

SYNTHESIS REASONING STRATEGY UAV SFM VIEW SEISMIC VIEW $\overline{\bigcirc}$ $\bigcirc]$ 00000 $\bigcirc\bigcirc\bigcirc\bigcirc$ 0000000Michael Dietze | GFZ Potsdam > Geomorphology Section > Environmental Seismology > Mass wasting hazard research To expand the scope... TRANSFERRING KNOWLEDGE FROM THE ALPS TO ANOTHER, RECENTLY ACTIVATED LANDSCAPE



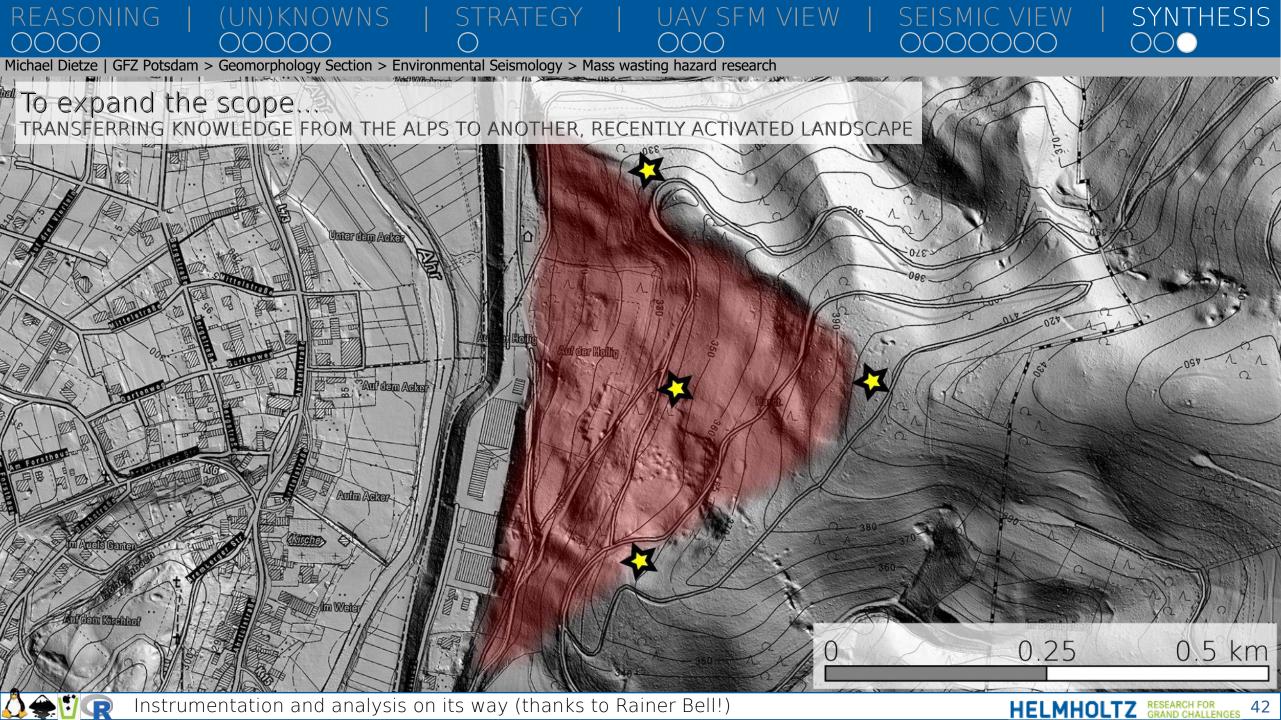
A rockslide somewhere in the Ahr valley near Müsch

Dietze & Öztürk (2021, Science) HELMHOLTZ RESEARCH FOR 40



Data collection & analysis on its way (thanks to Alex Beer!)









Whatever we do, let's focus on the important things.