GFZ Helmholtz Centre Potsdam

# 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

Brinzauls Rockslide, Grison, Switzerland

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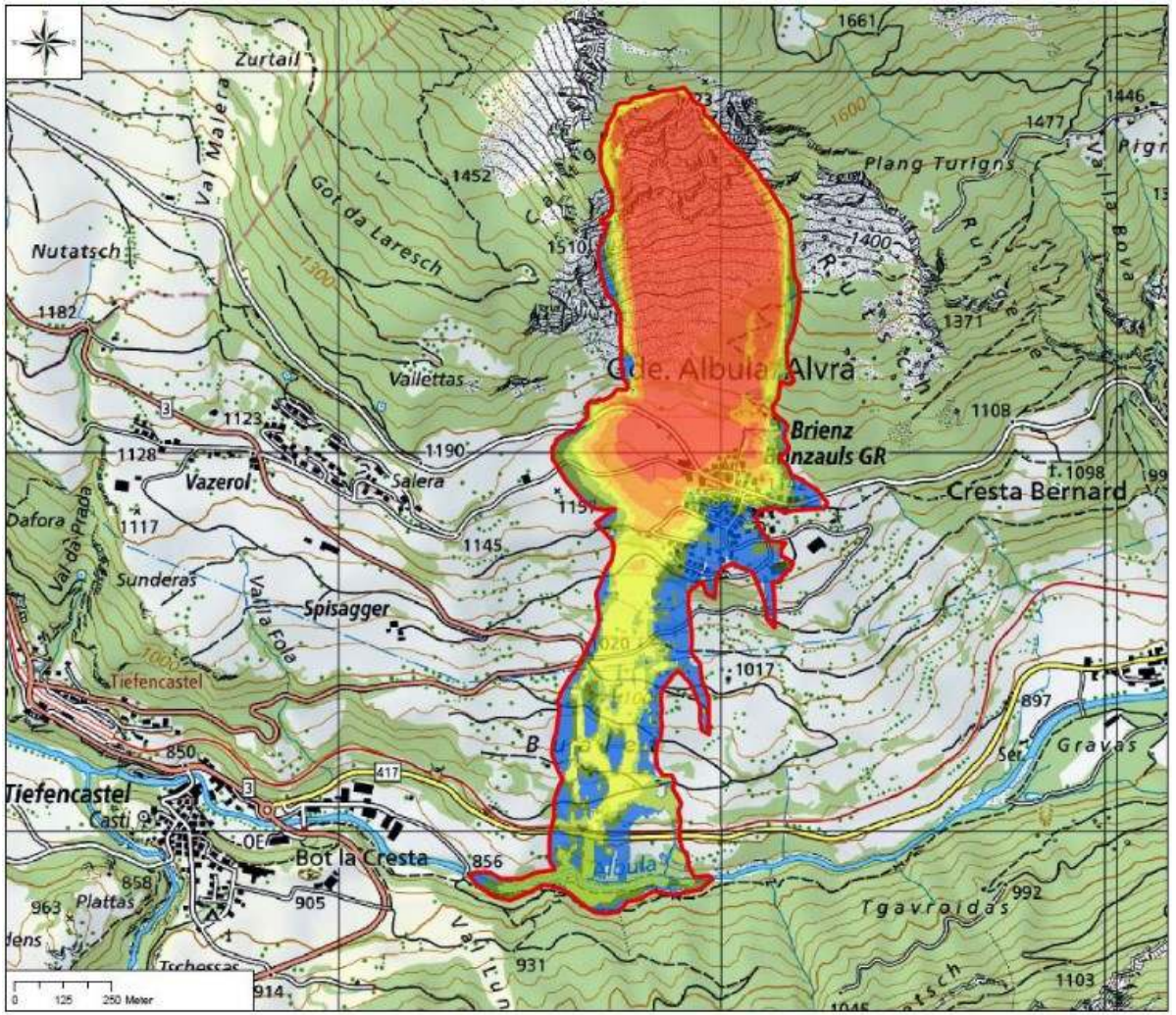
# Potential future trajectories

## DIFFERENT MODEL SOLUTIONS OF SLOPE FAILURE



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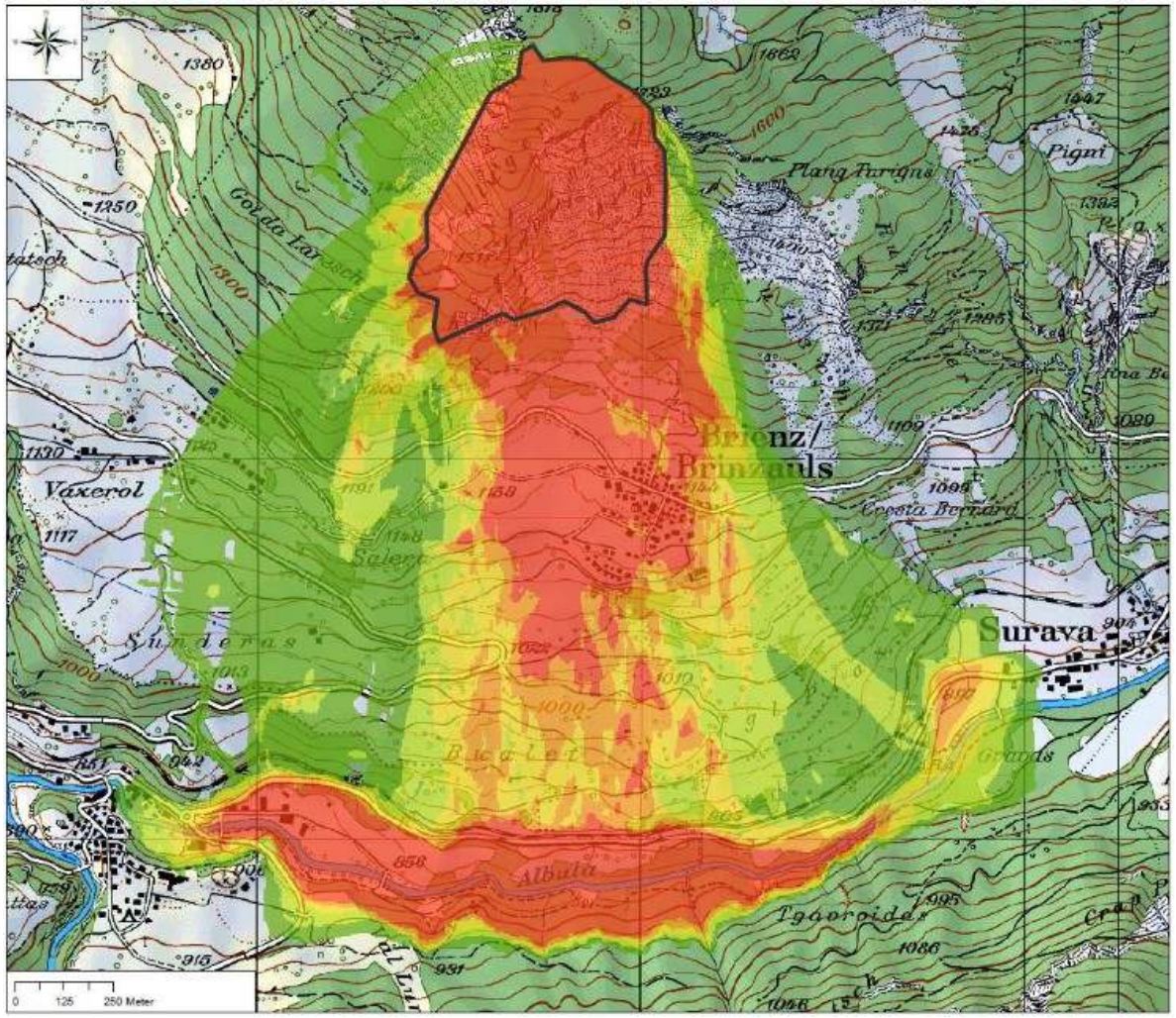
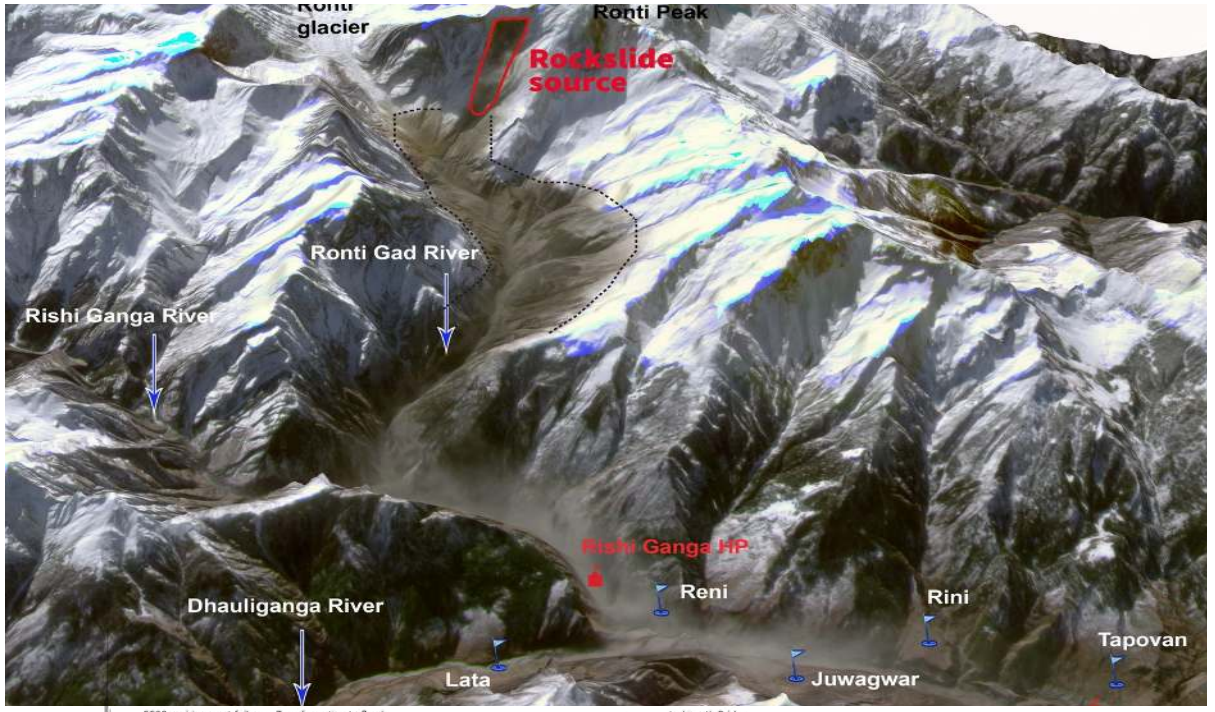
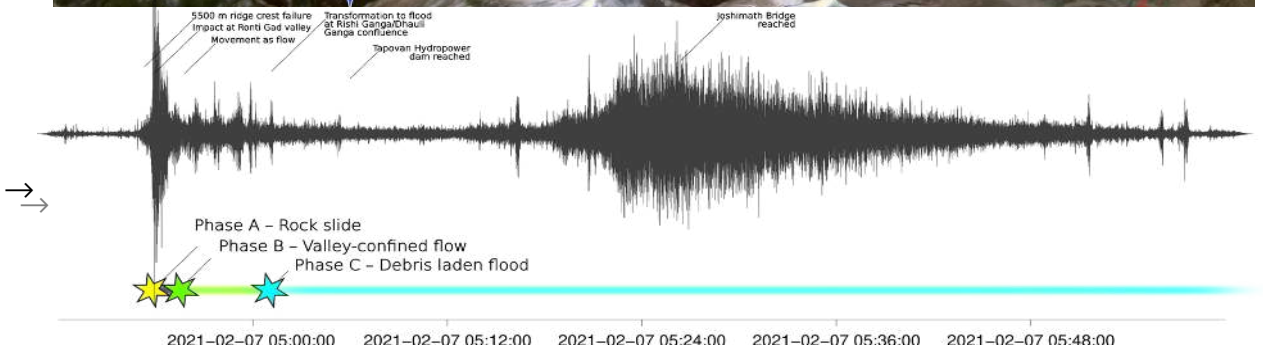
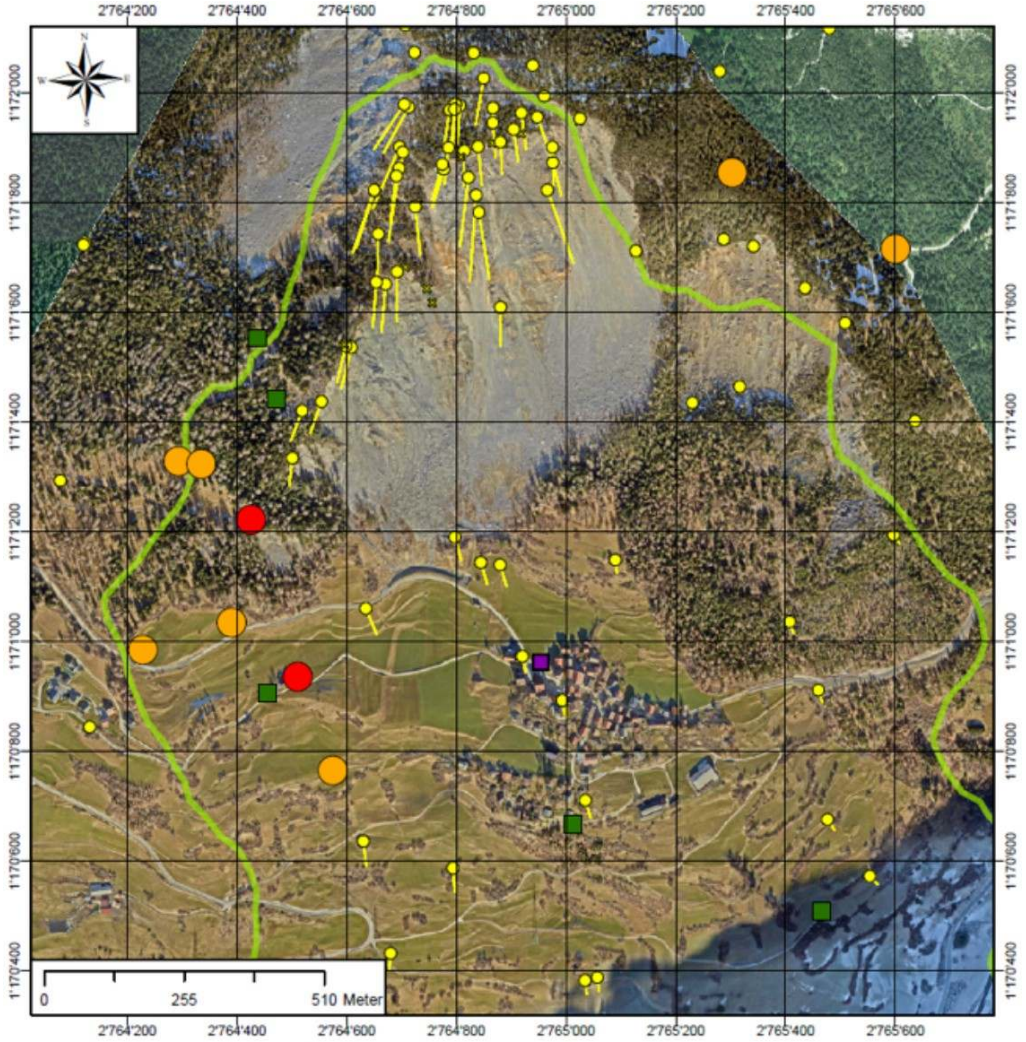


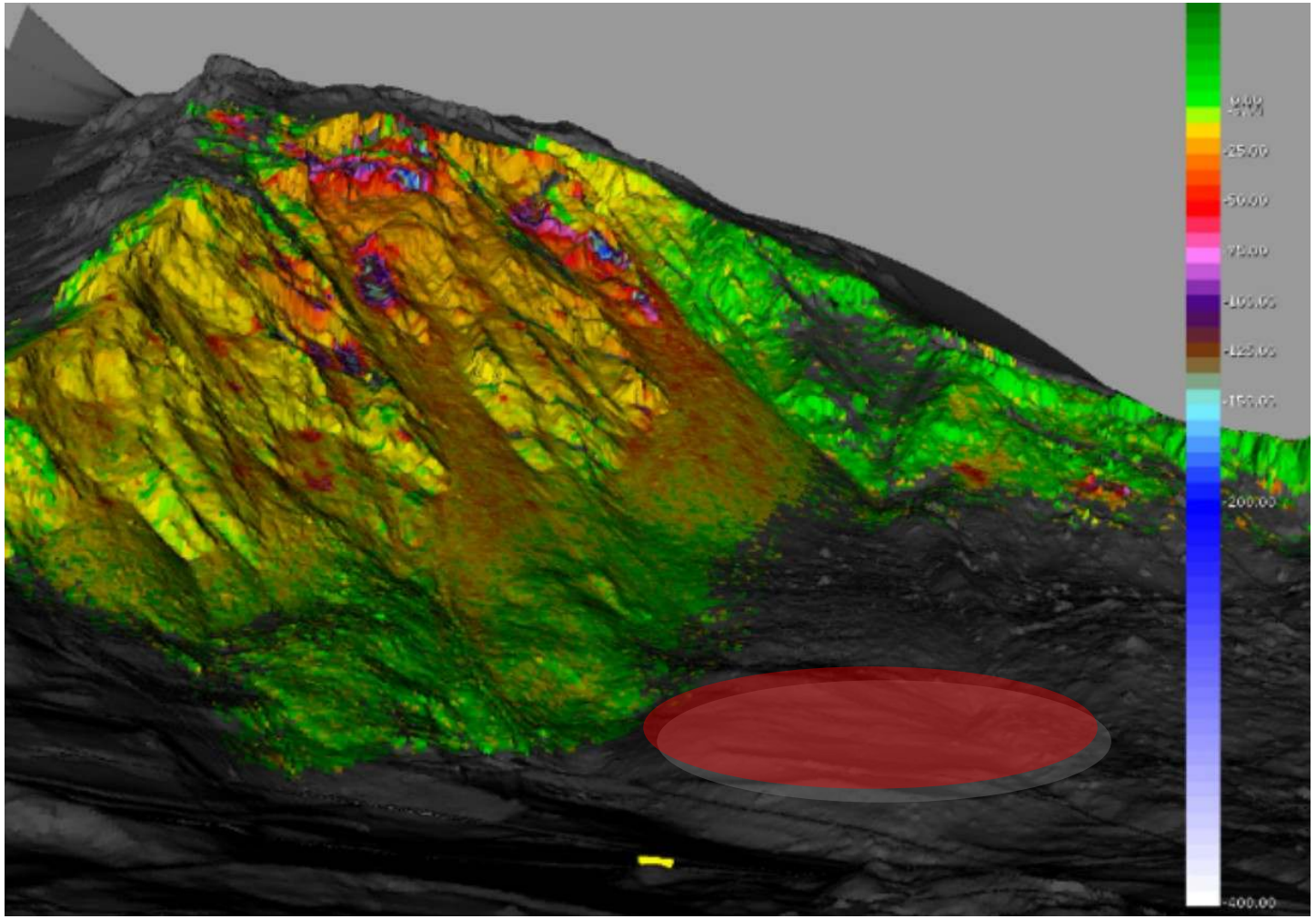



# Existing monitoring efforts

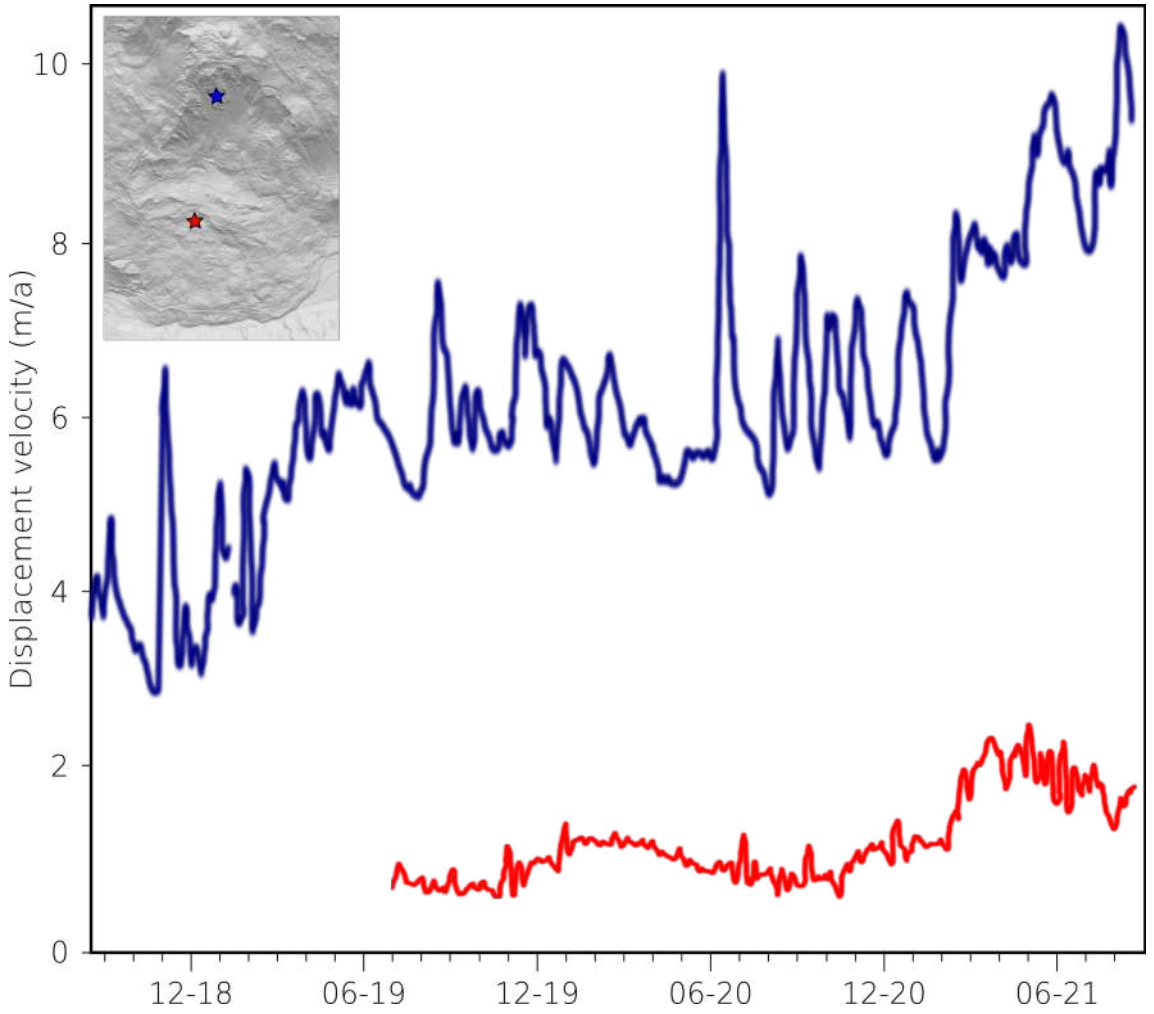
## A COMBINATION OF GNSS STATIONS, REGULARLY SURVEYED TARGETS, AND AN INTERFERROMETRIC RADAR STATION



# 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)

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

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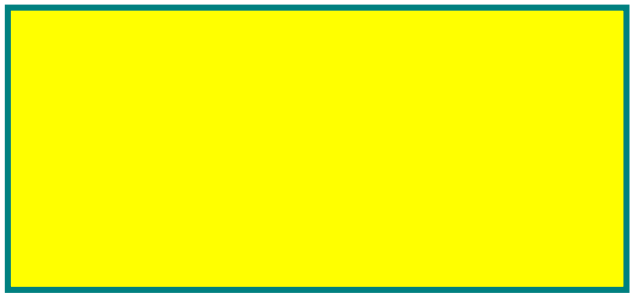
3) Stick-slip motion of the rockslide



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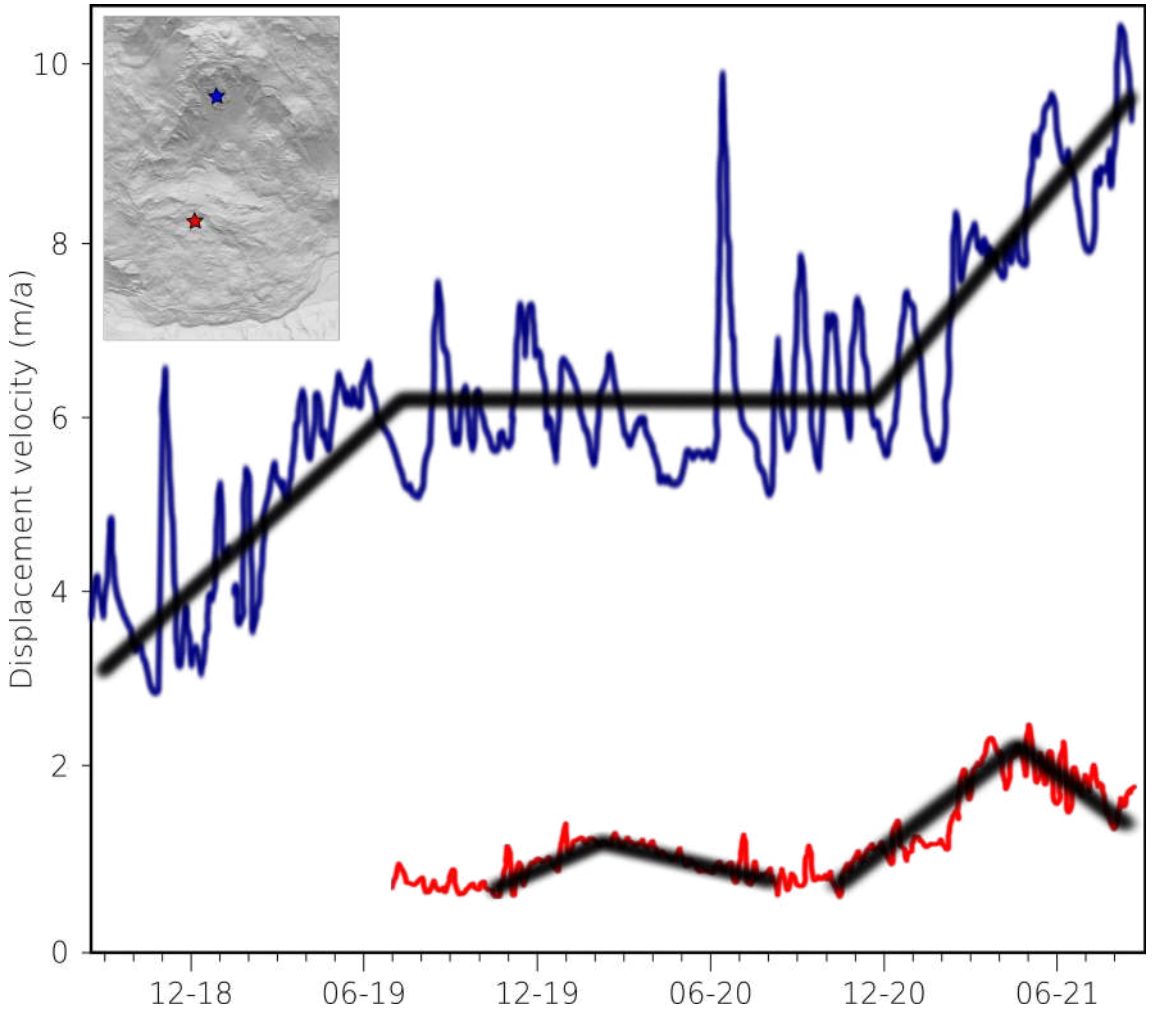



1) Decoupled displacement history

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

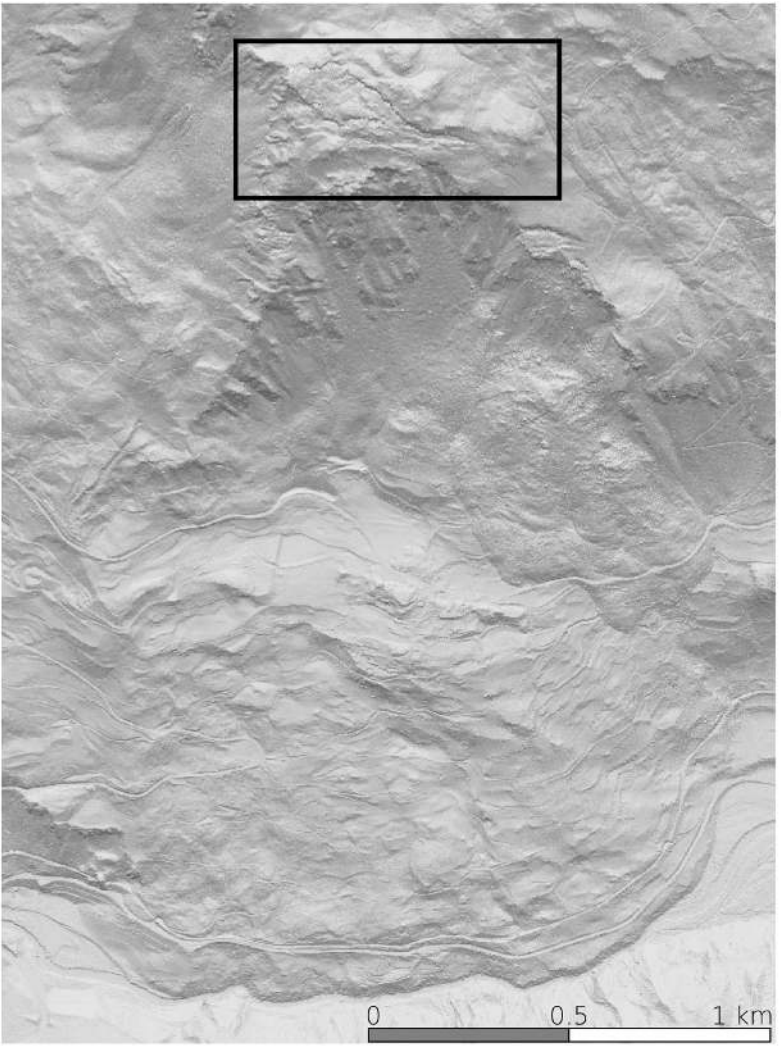
3) Stick-slip motion of the rockslide

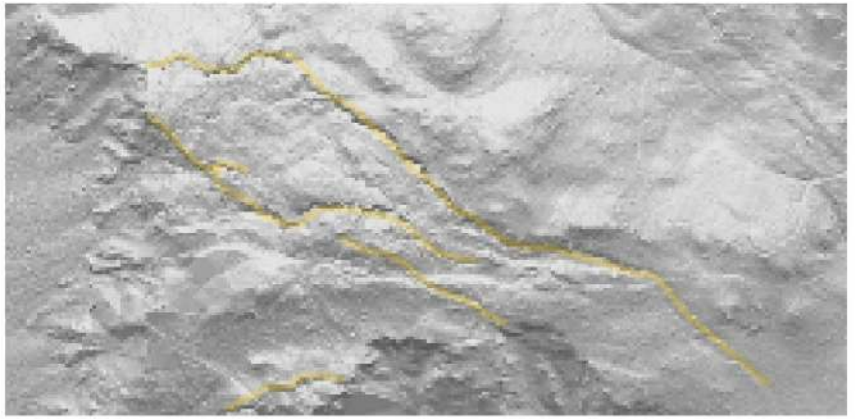
4) Different periodicities in the forcing
   - event-based activity of the rockslide
   - inter-annual trends in the rockslide
   - seasonal trends in the landslide

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

# A closer and more objective view of the area

## DEFORMATION OF THE UPPER PART OF THE ROCKSLIDE



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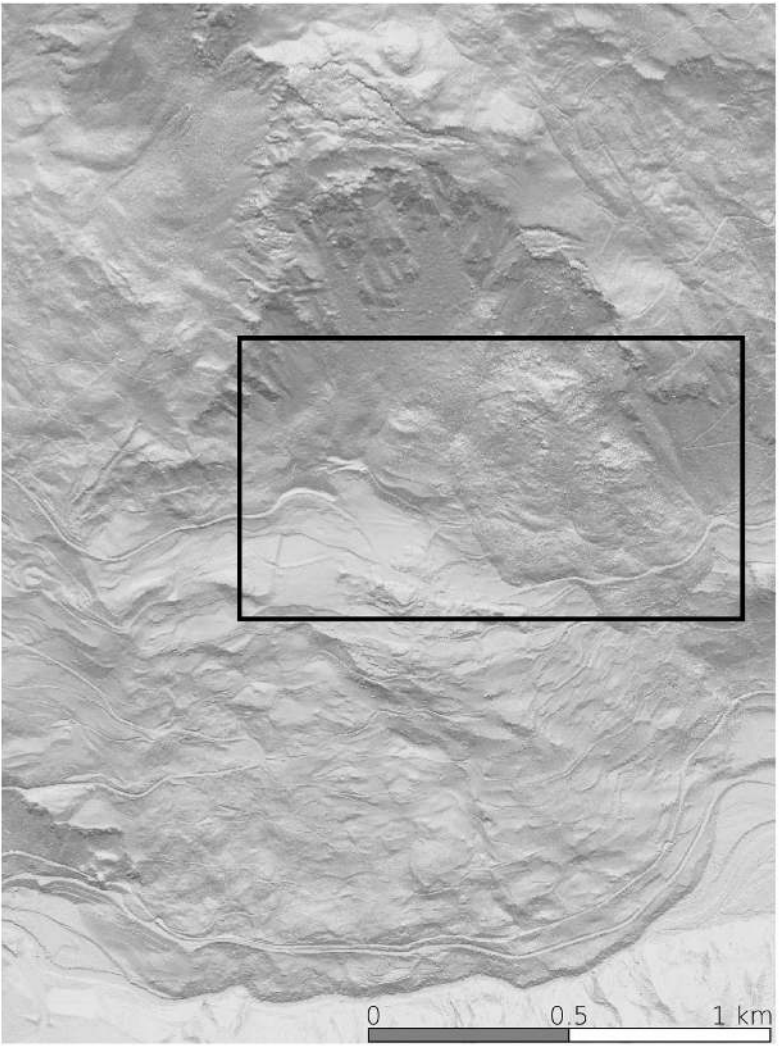
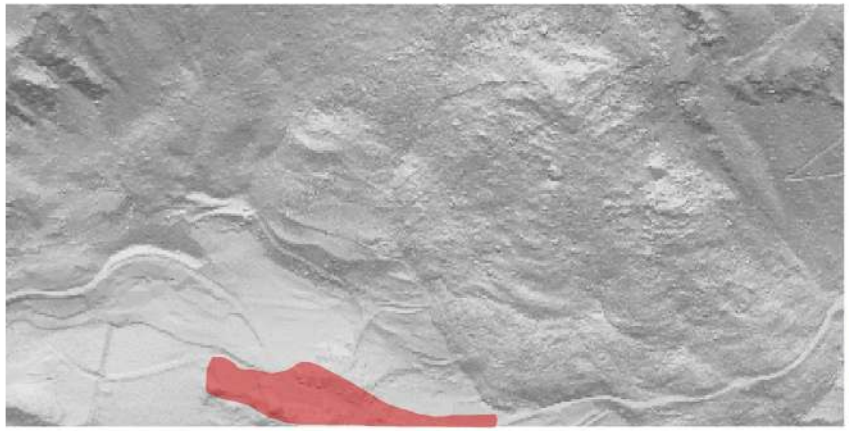
## TRANSITION OF THE ROCKSLIDE TO THE LANDSLIDE



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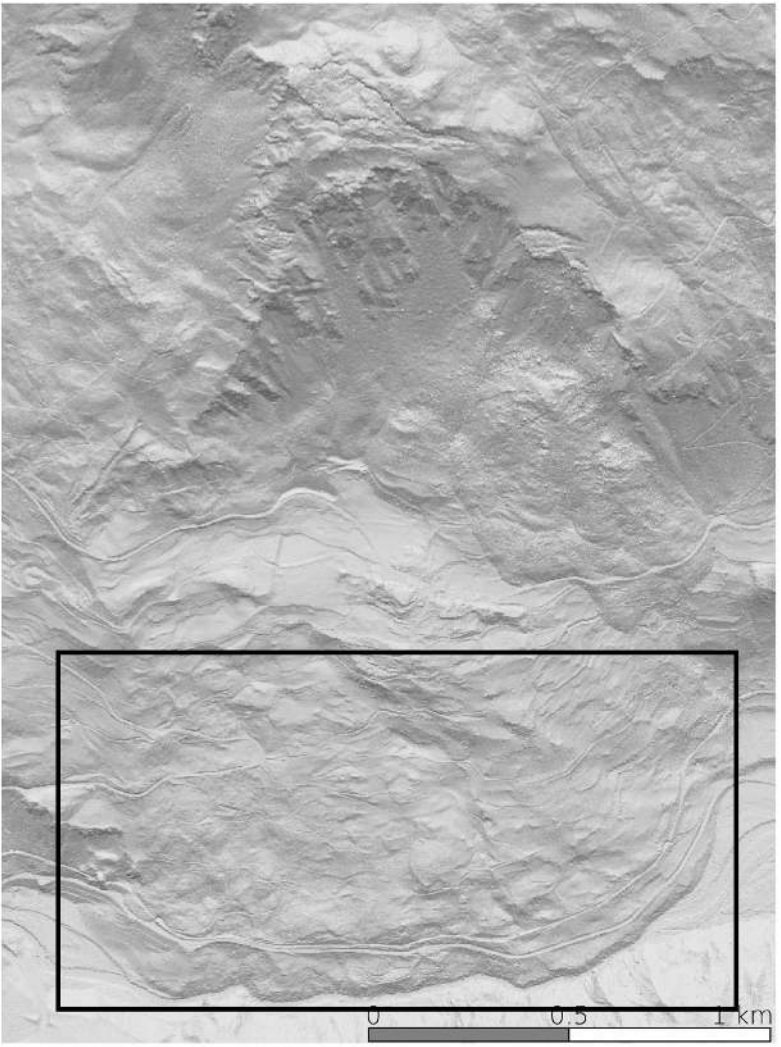
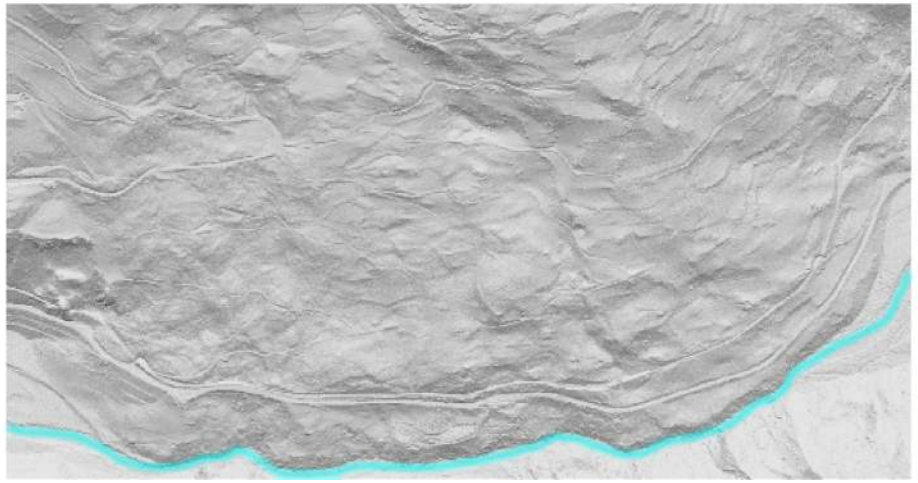
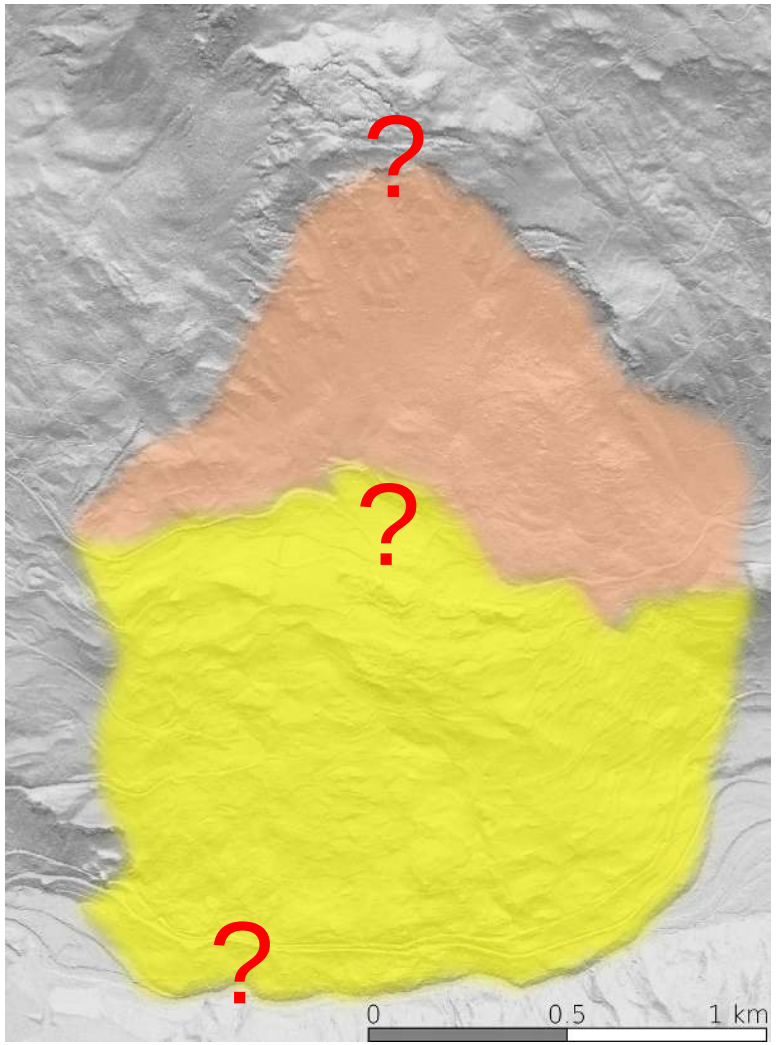
## DEFLECTION OF THE ALBULA RIVER BY THE DEFORMING LANDSLIDE



# A closer and more objective view of the area

## THREE THEMATIC FIELDS TO BE EXPLORED




1) Rock slope activity
   - What drives rock mass movement
   - Where is the failure plane and how is it evolving?

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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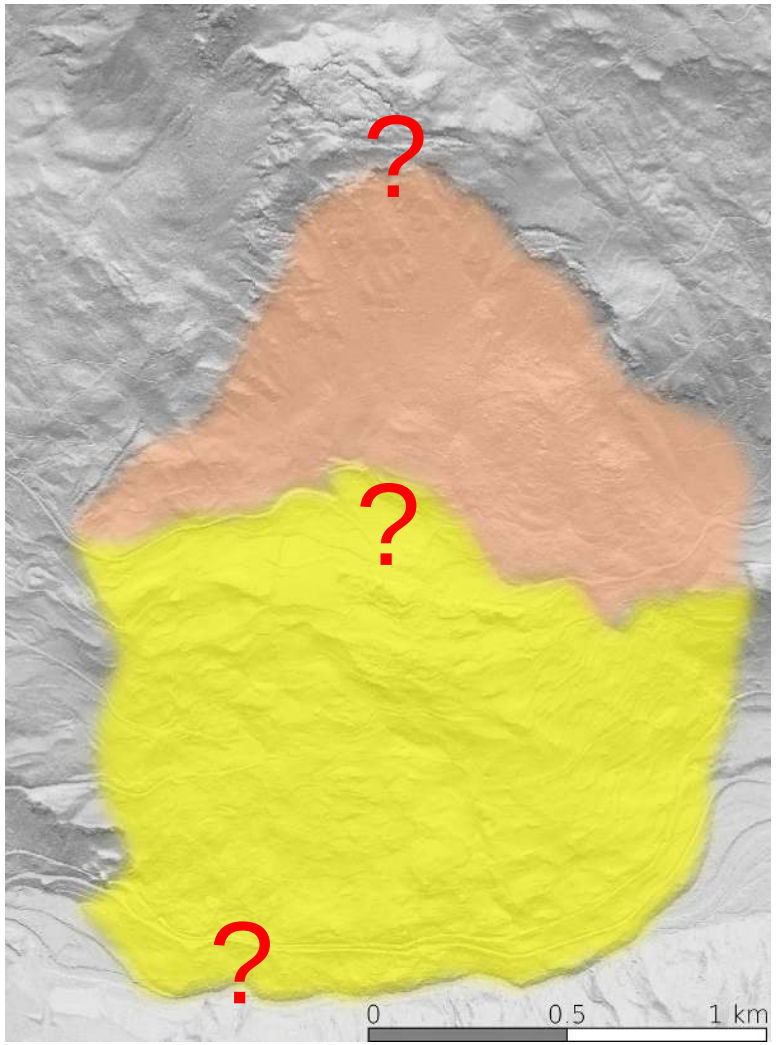


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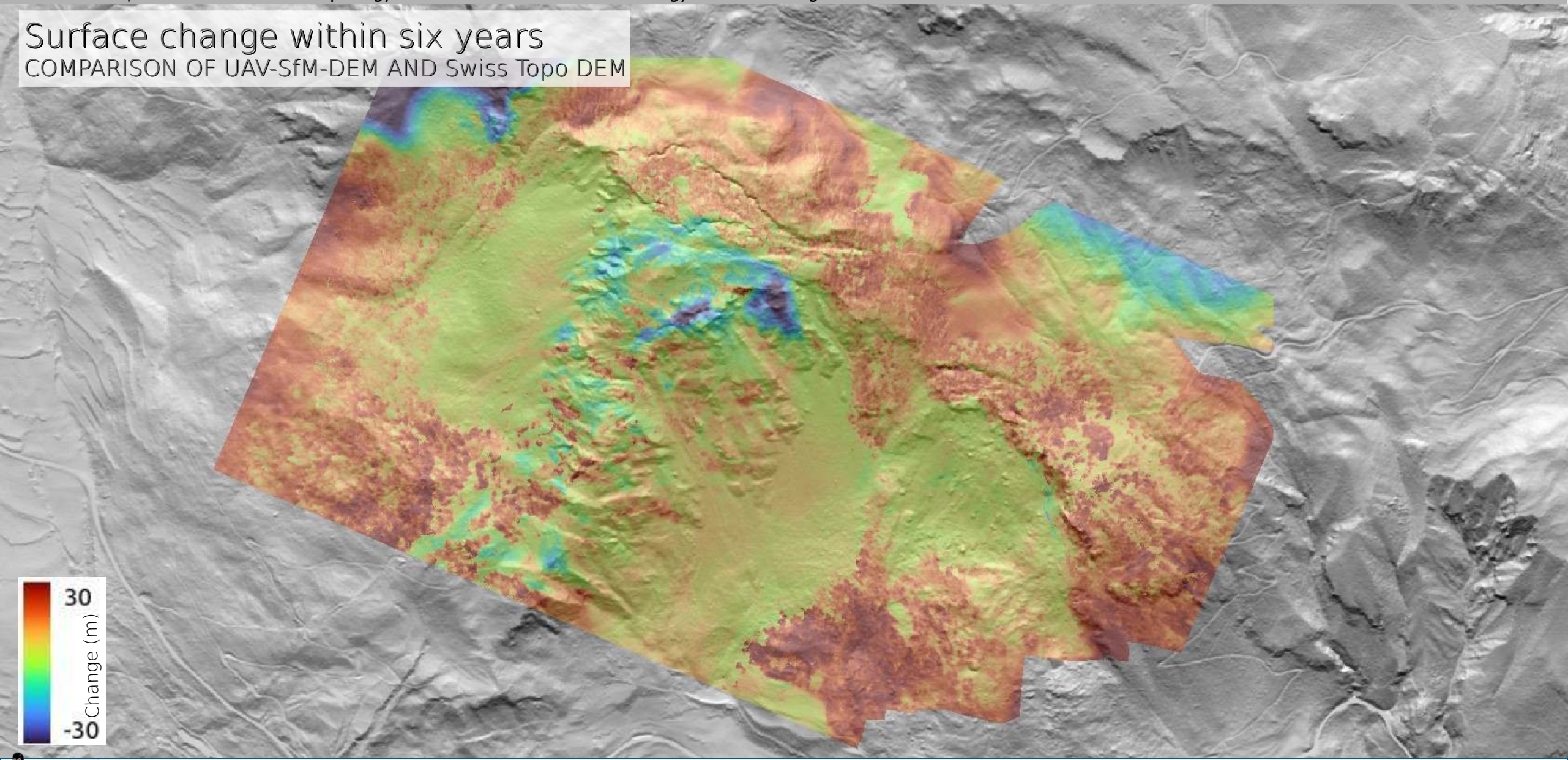
# How to approach the problem(s)?

## INSTRUMENTATION AND PERIODIC SENSING DESIGN

800 m

# Surface change within six years

## COMPARISON OF UAV-SfM-DEM AND Swiss Topo DEM



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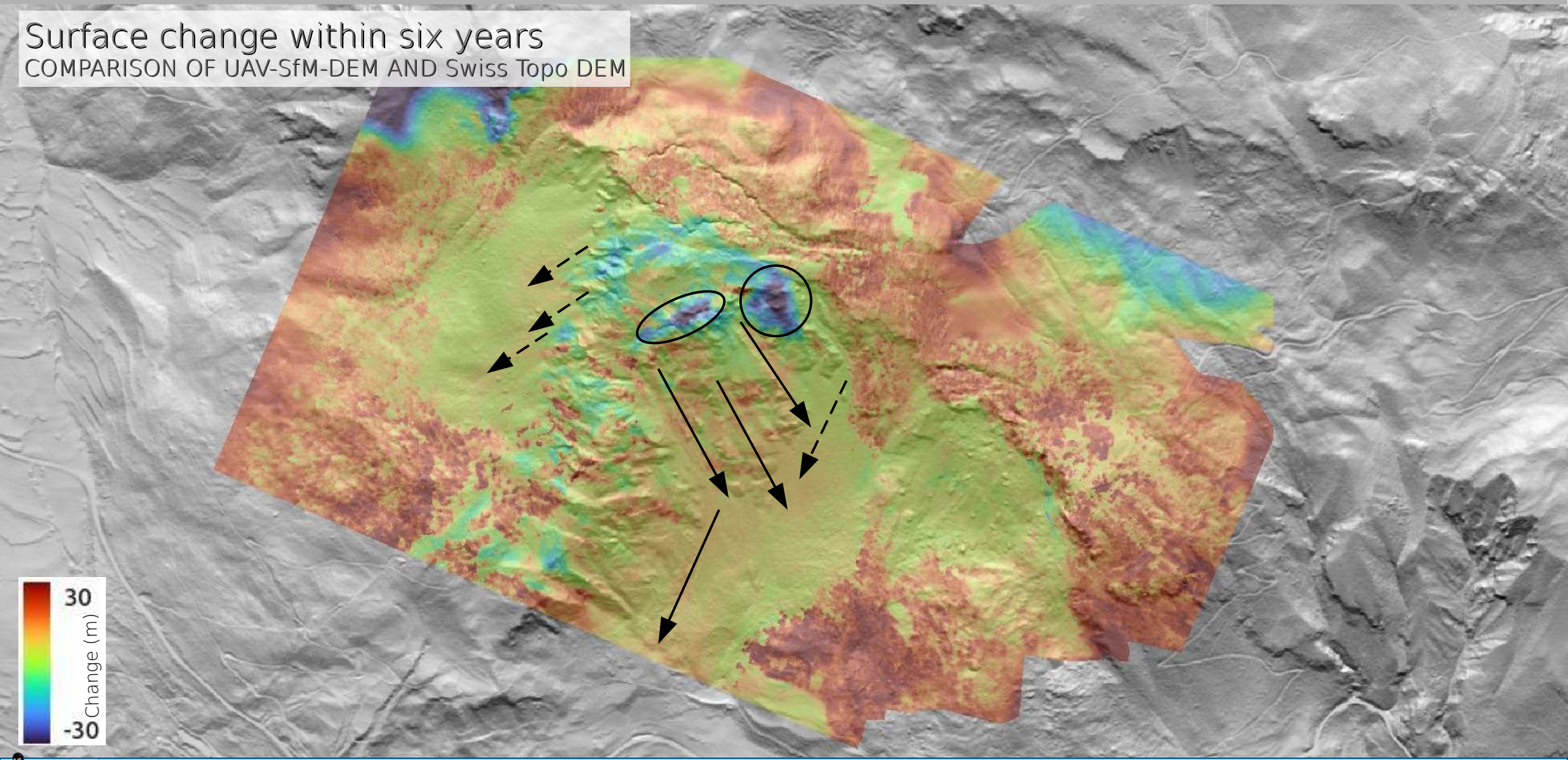
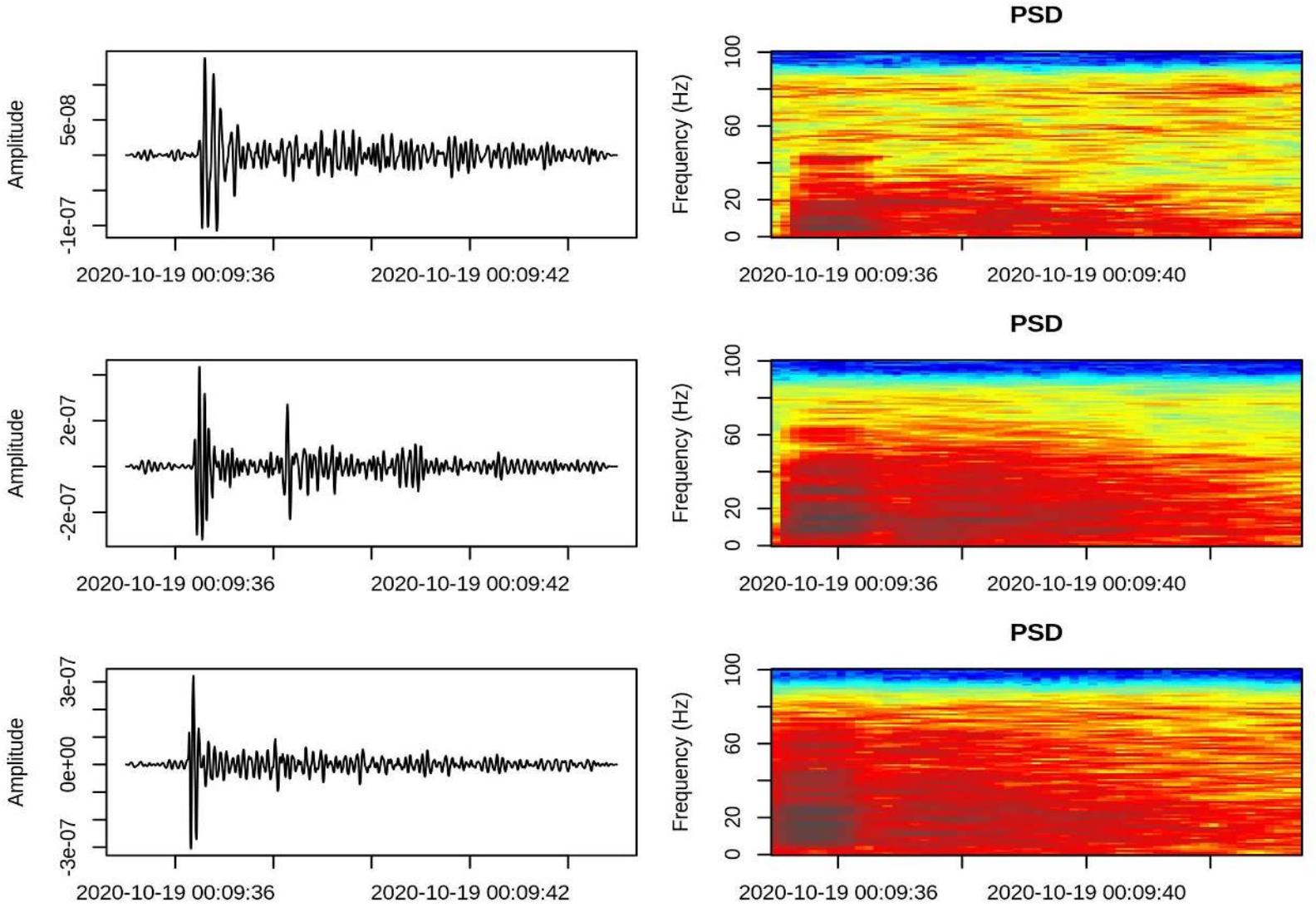


# Surface change within six years

## COMPARISON OF UAV-SfM-DEM AND Swiss Topo DEM

# OK, material is on the move. But when, why and how?

## EXPLOITING THE PRECISE TIMING AND SPATIO-TEMPORAL RESOLUTION OF THE SEISMIC DATA SET



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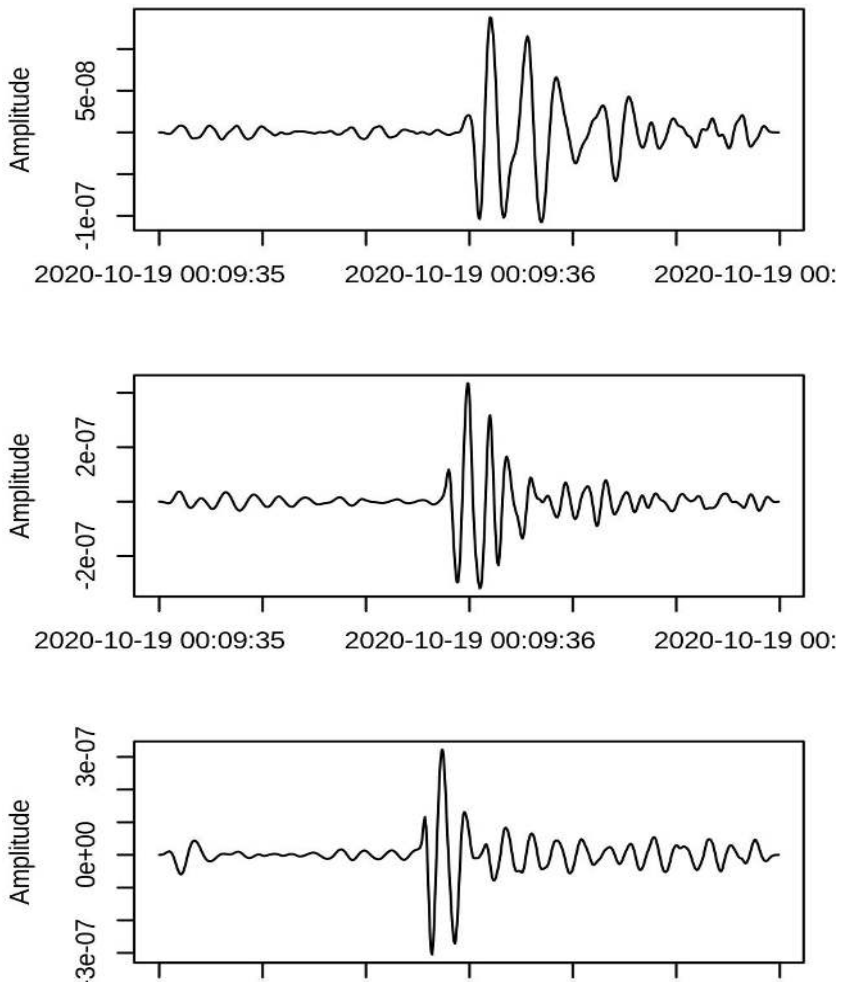
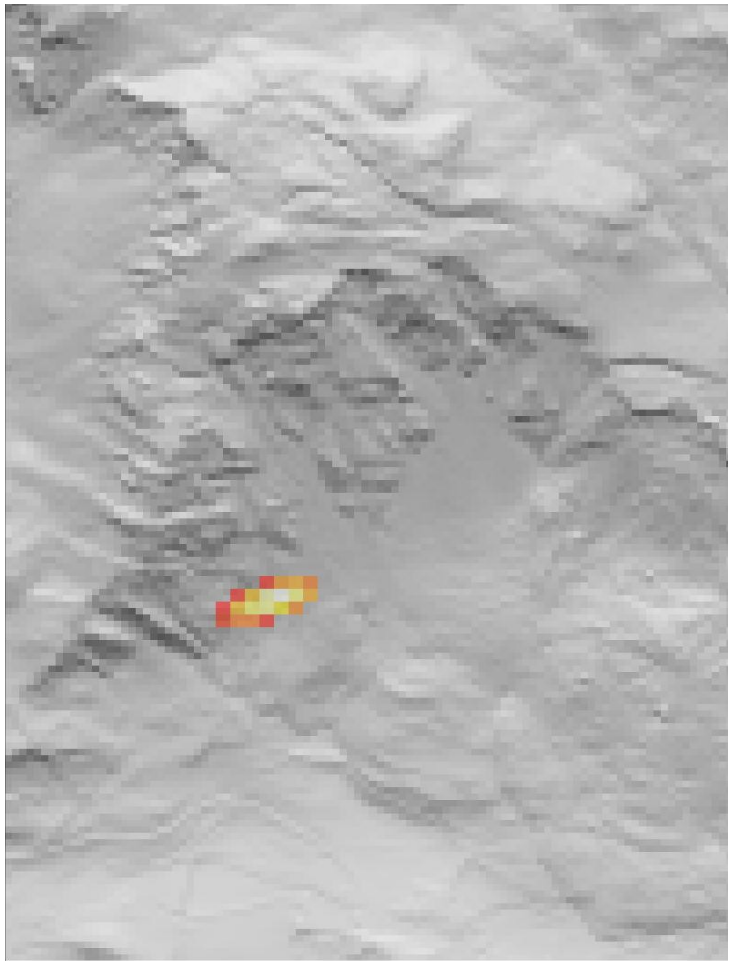
## COMPARING TWO SEISMIC LOCATION TECHNIQUES REGARDING THEIR AGREEMENT

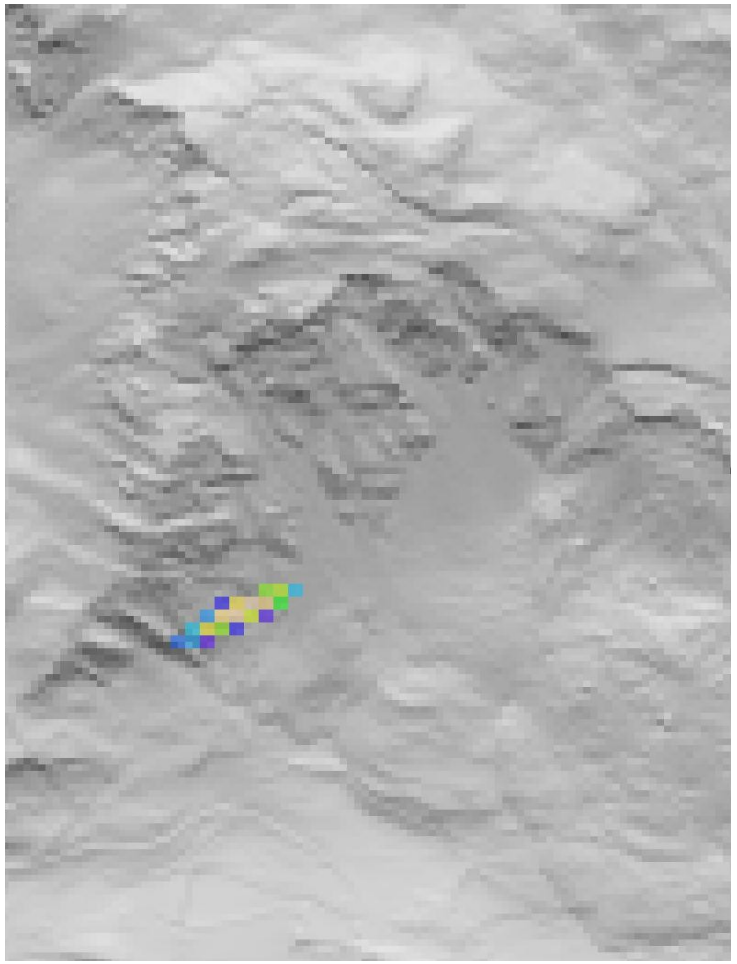
### Seismograms (5-10 Hz)




### Location (signal migration)

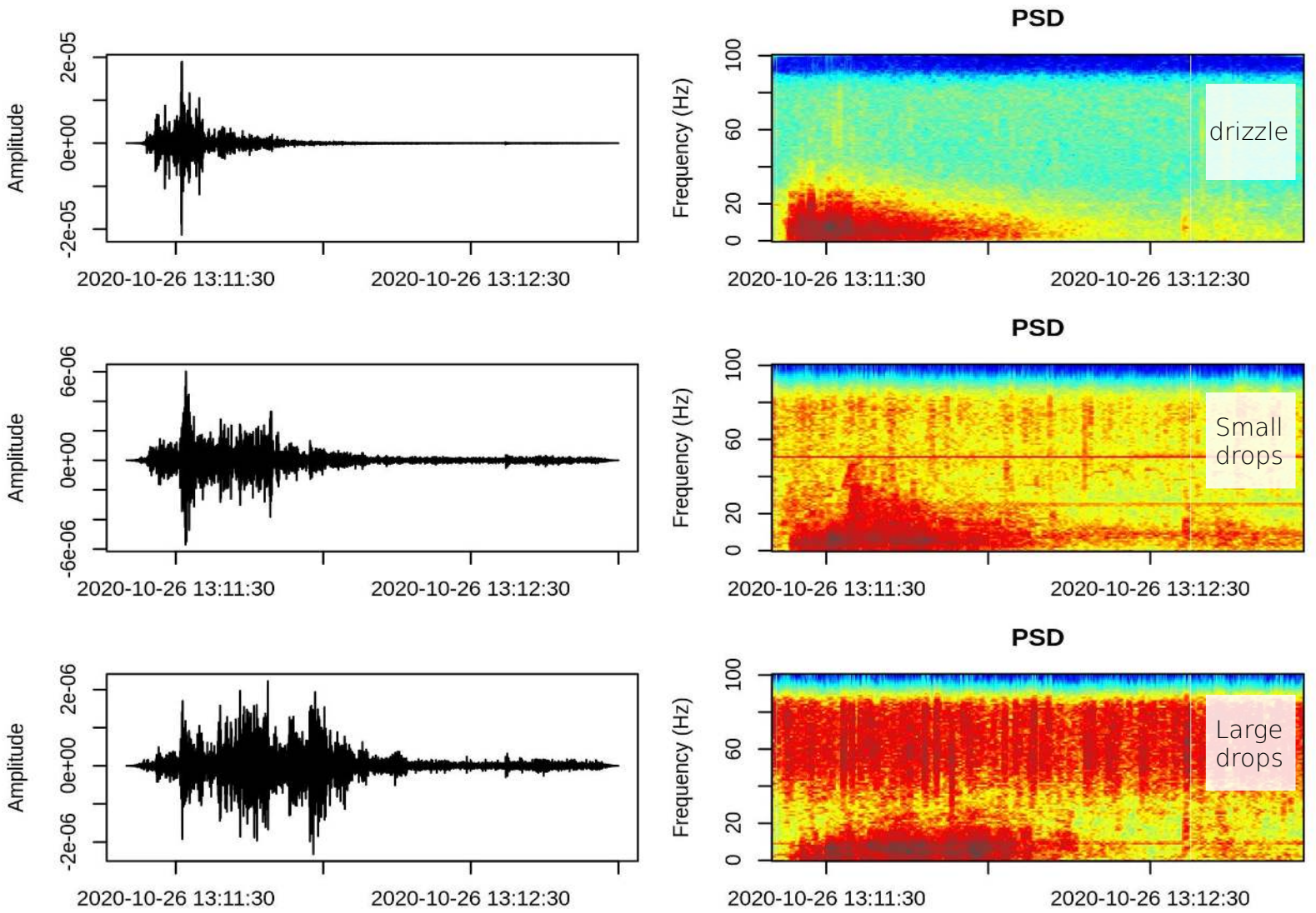


### Location (amplitude modelling)



# OK, material is on the move. But when, why and how?

## ENCOUNTERING MOBILE SOURCES AND SPATIALLY DIFFERING WEATHER CONDITIONS



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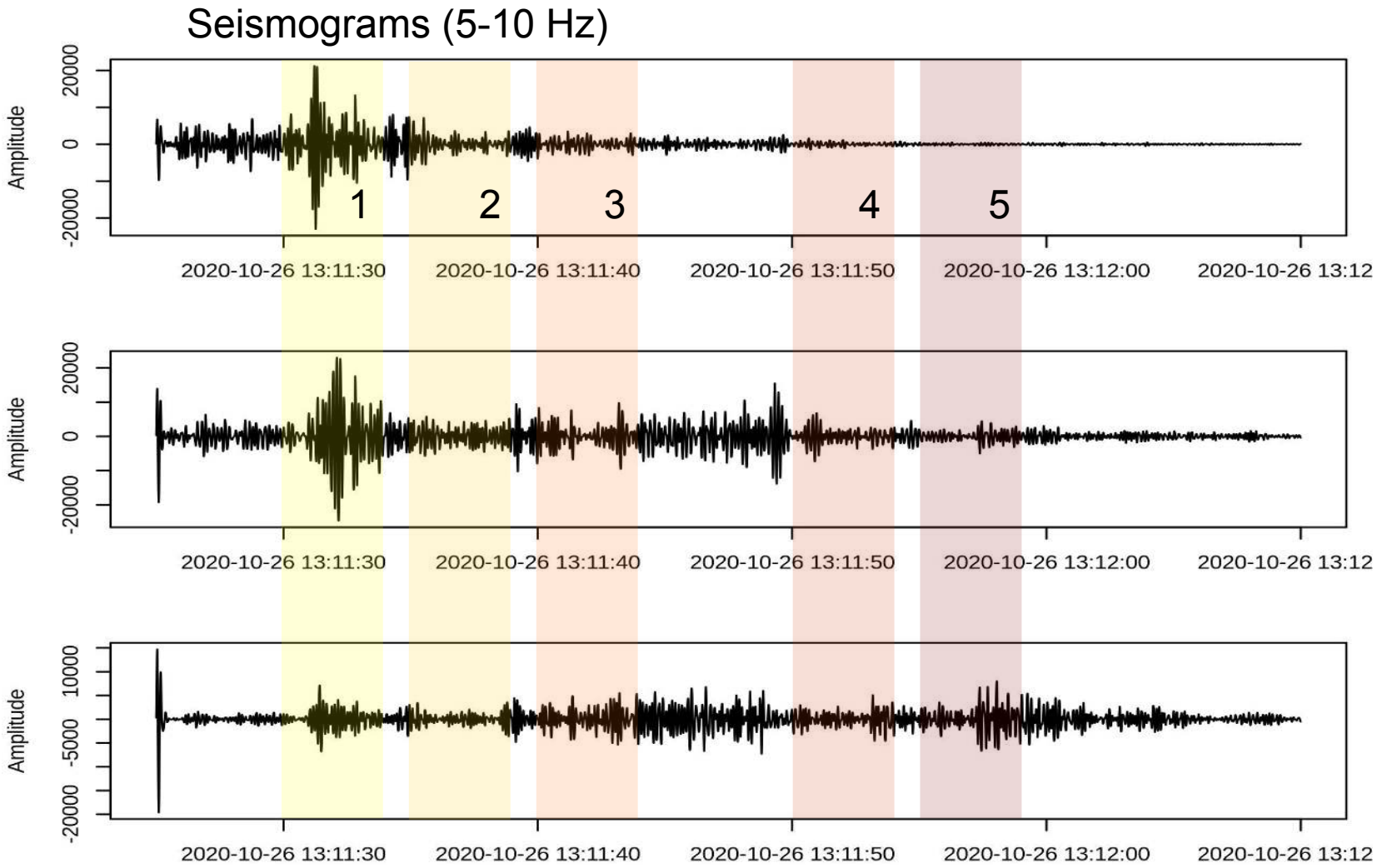
## TIME RESOLVED LOCATION ESTIMATES OF A MOBILE SEISMIC SOURCE



# 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

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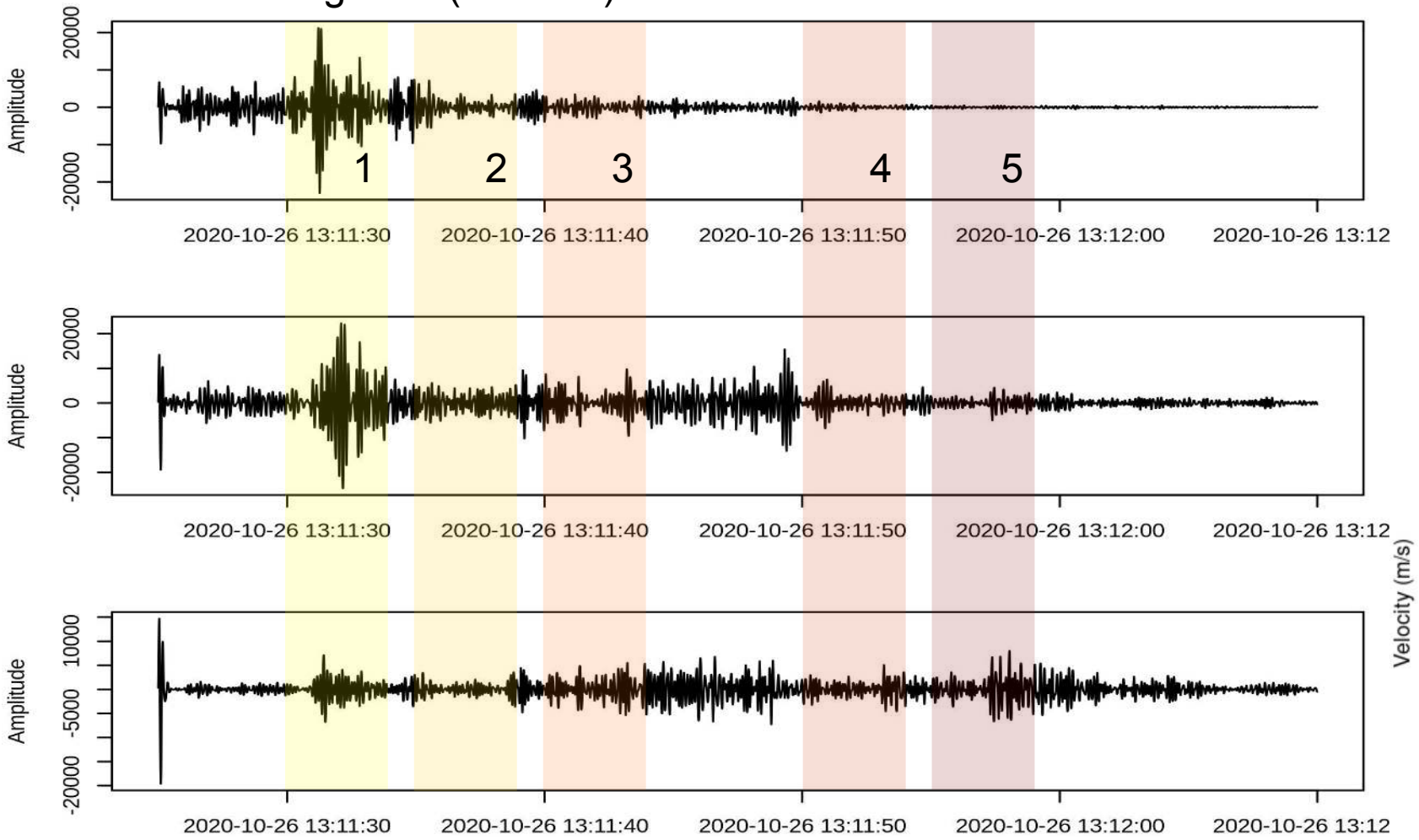


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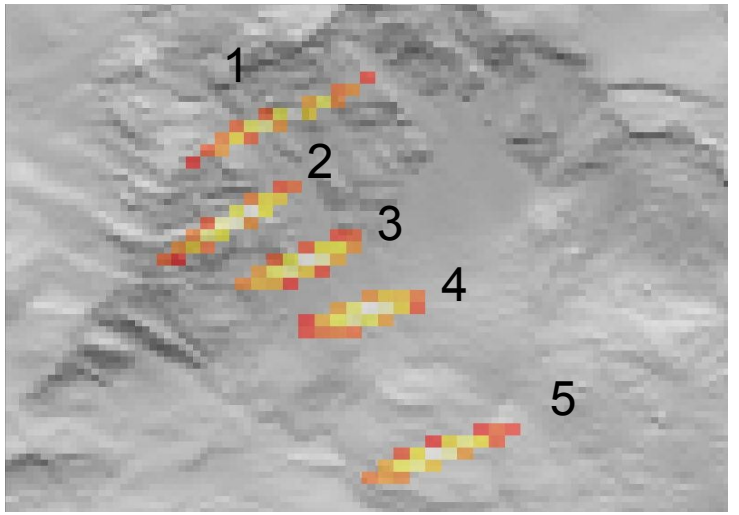
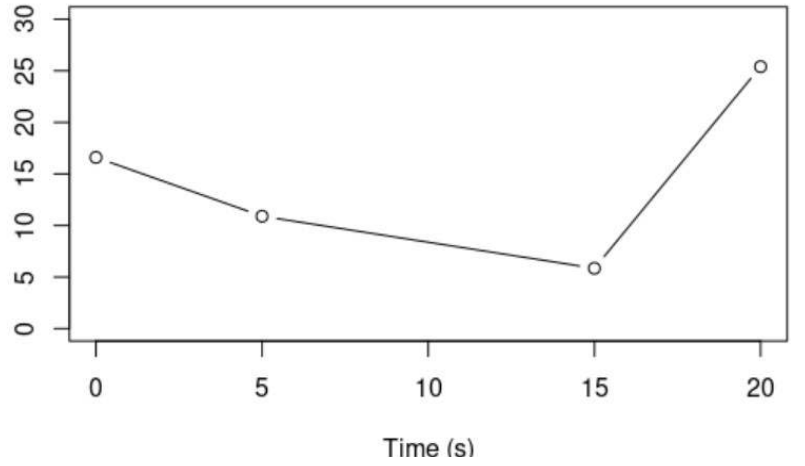
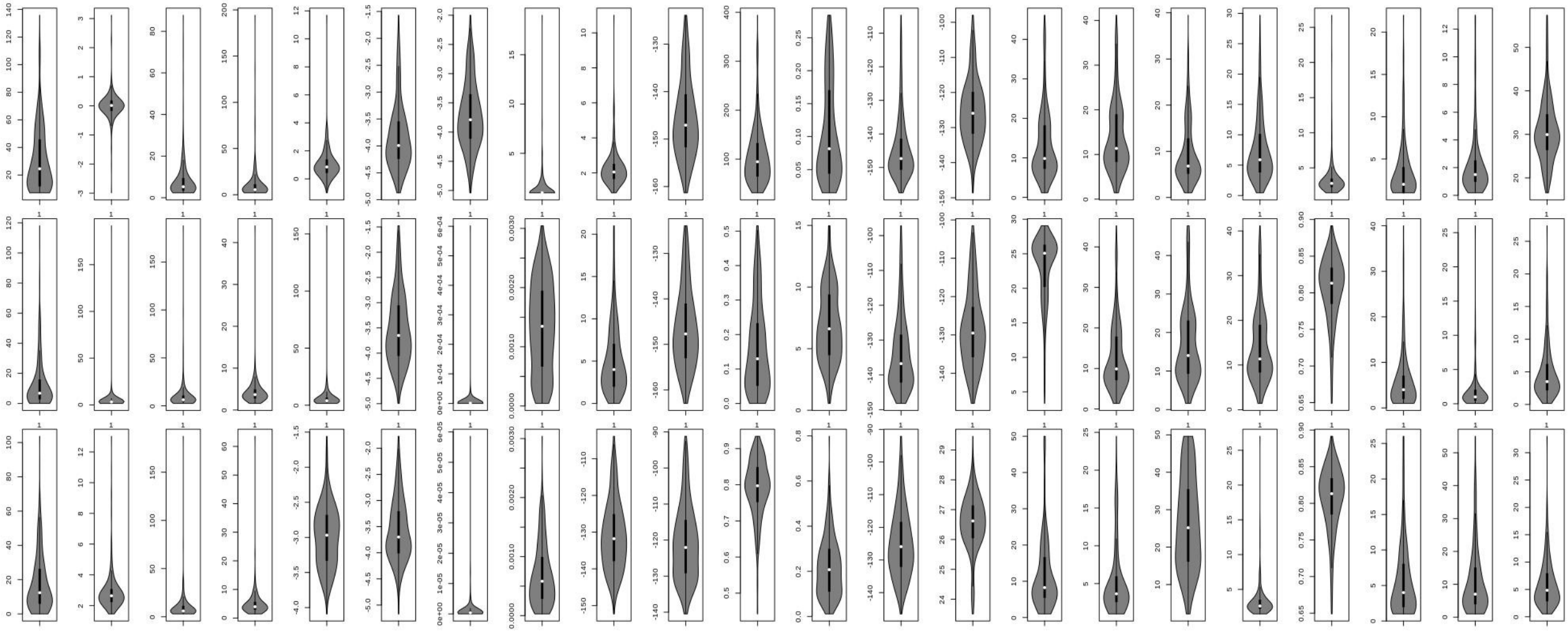


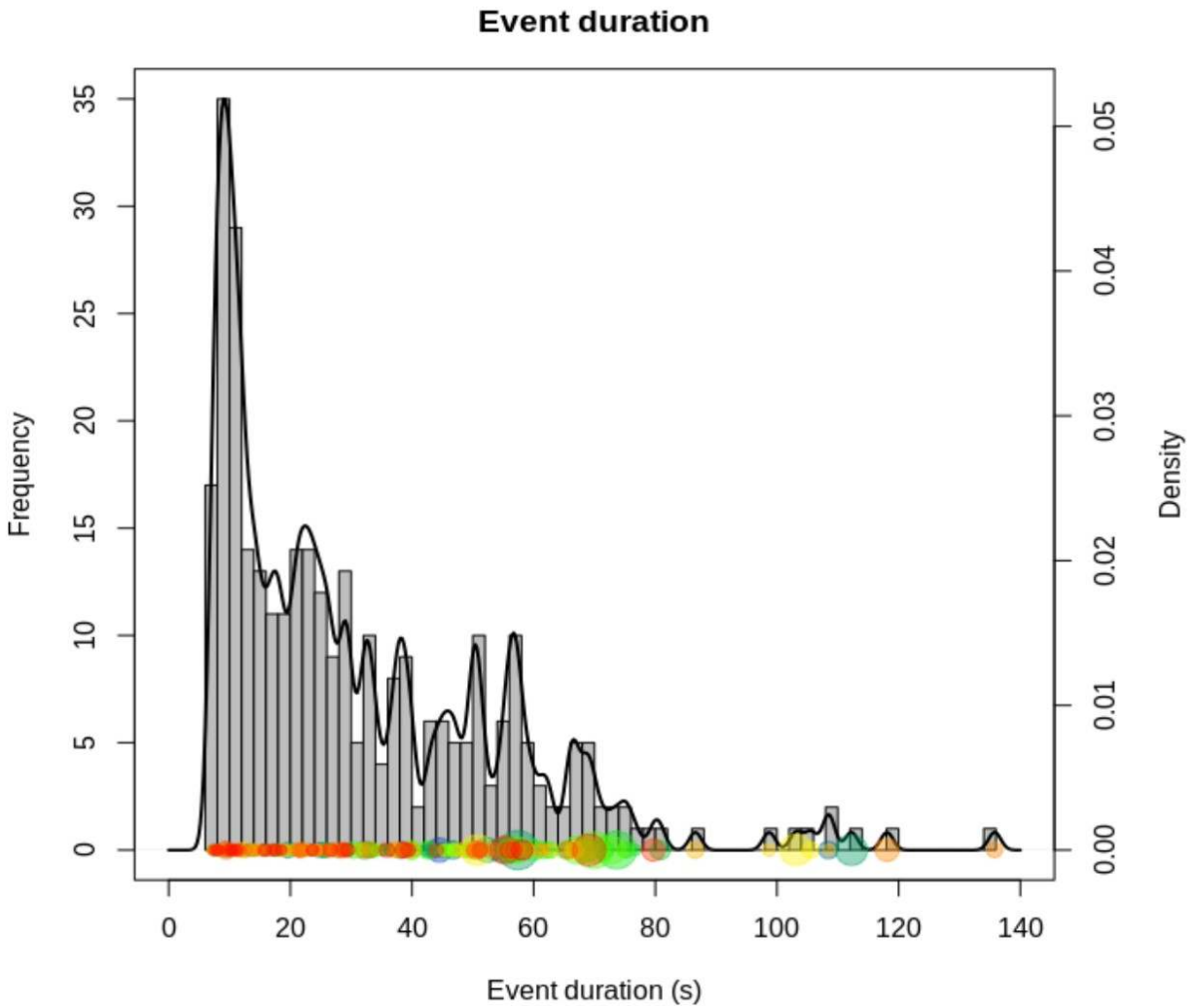
# From single events to the statistics of a larger catalogue (N = 321)

## THE RICHNESS OF SEISMIC FEATURES OF THE DATA SET



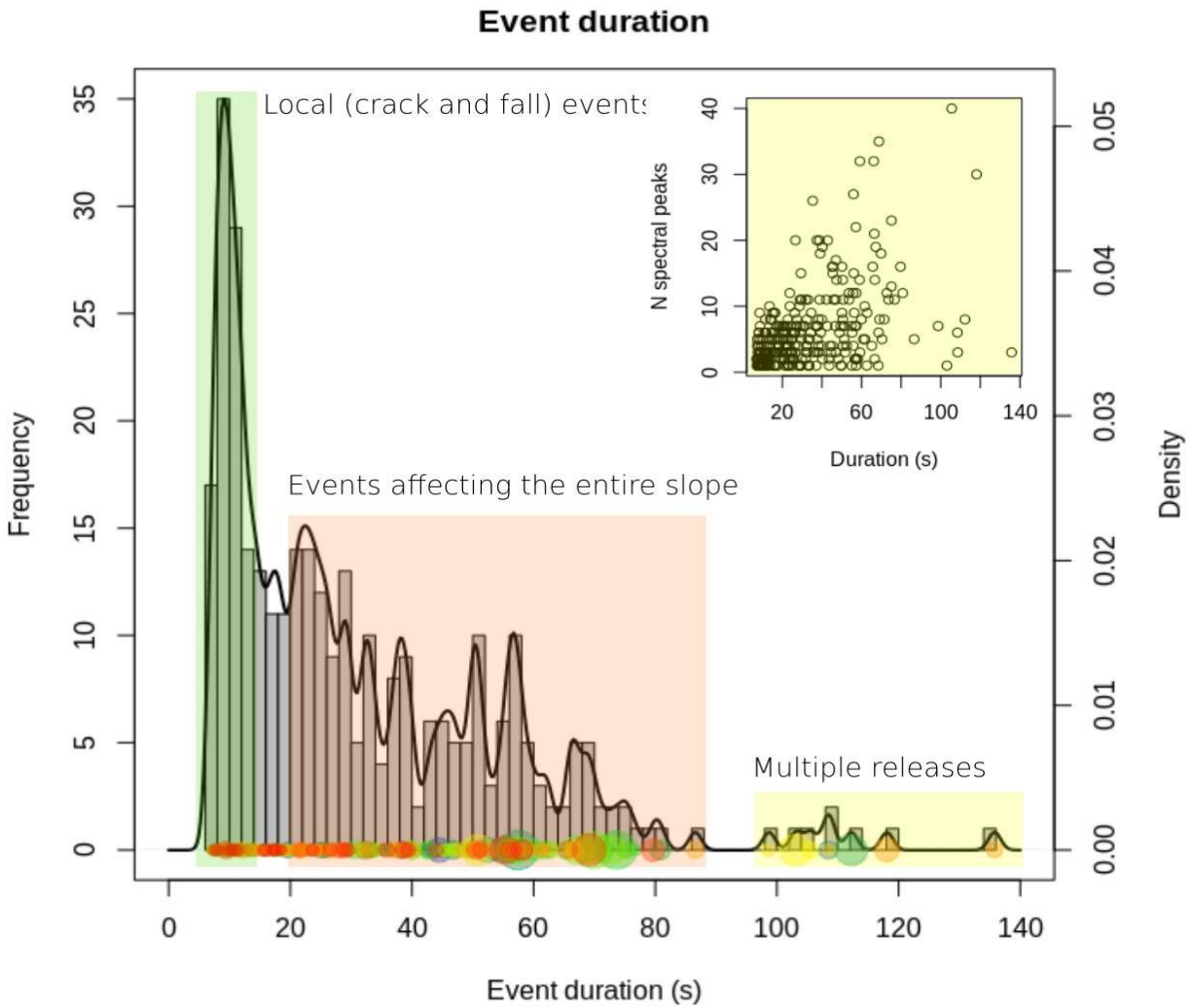
# How long do slope events last?

## DURATION (AND SEISMIC EVOLUTION)



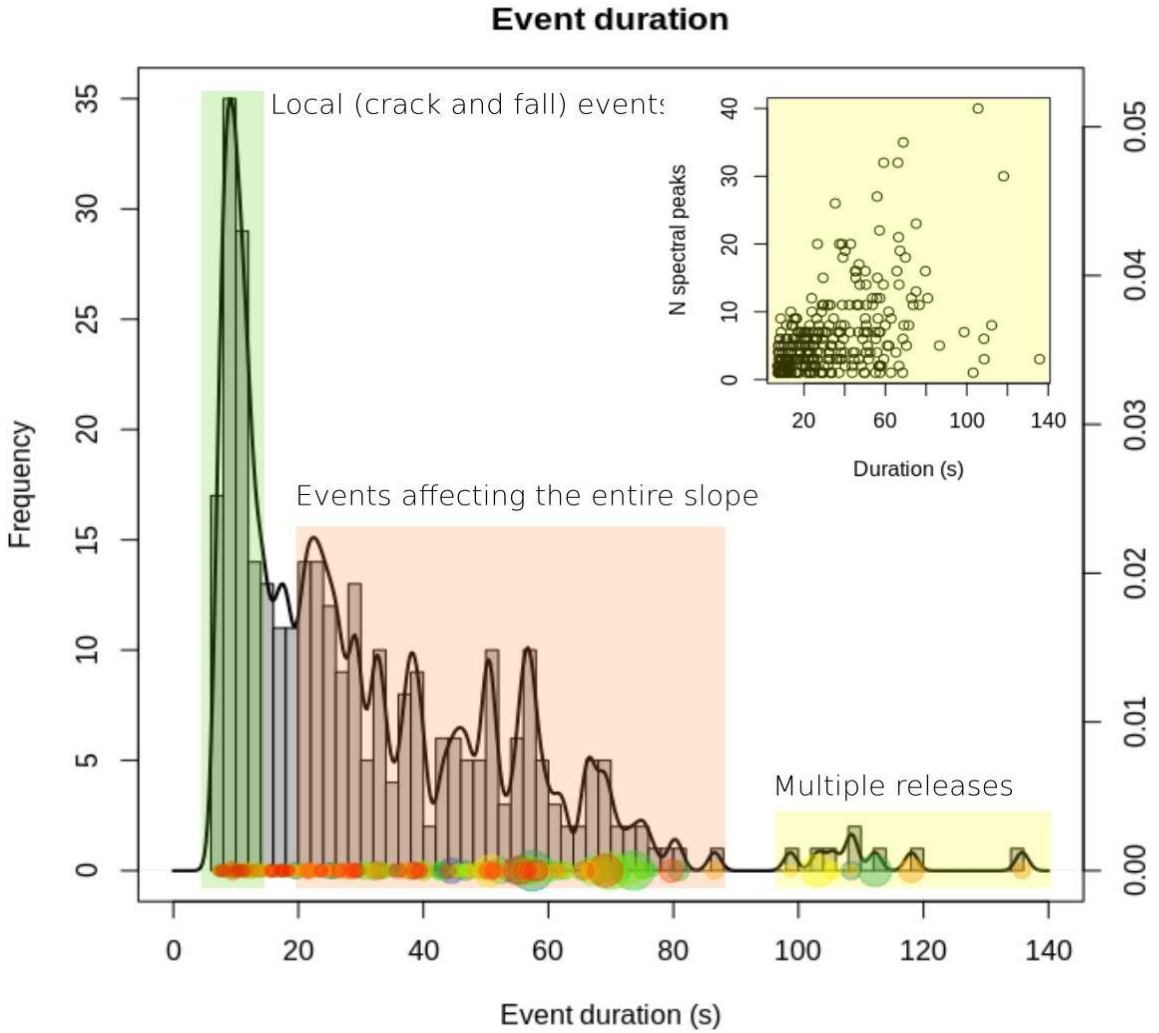
# How long do slope events last?

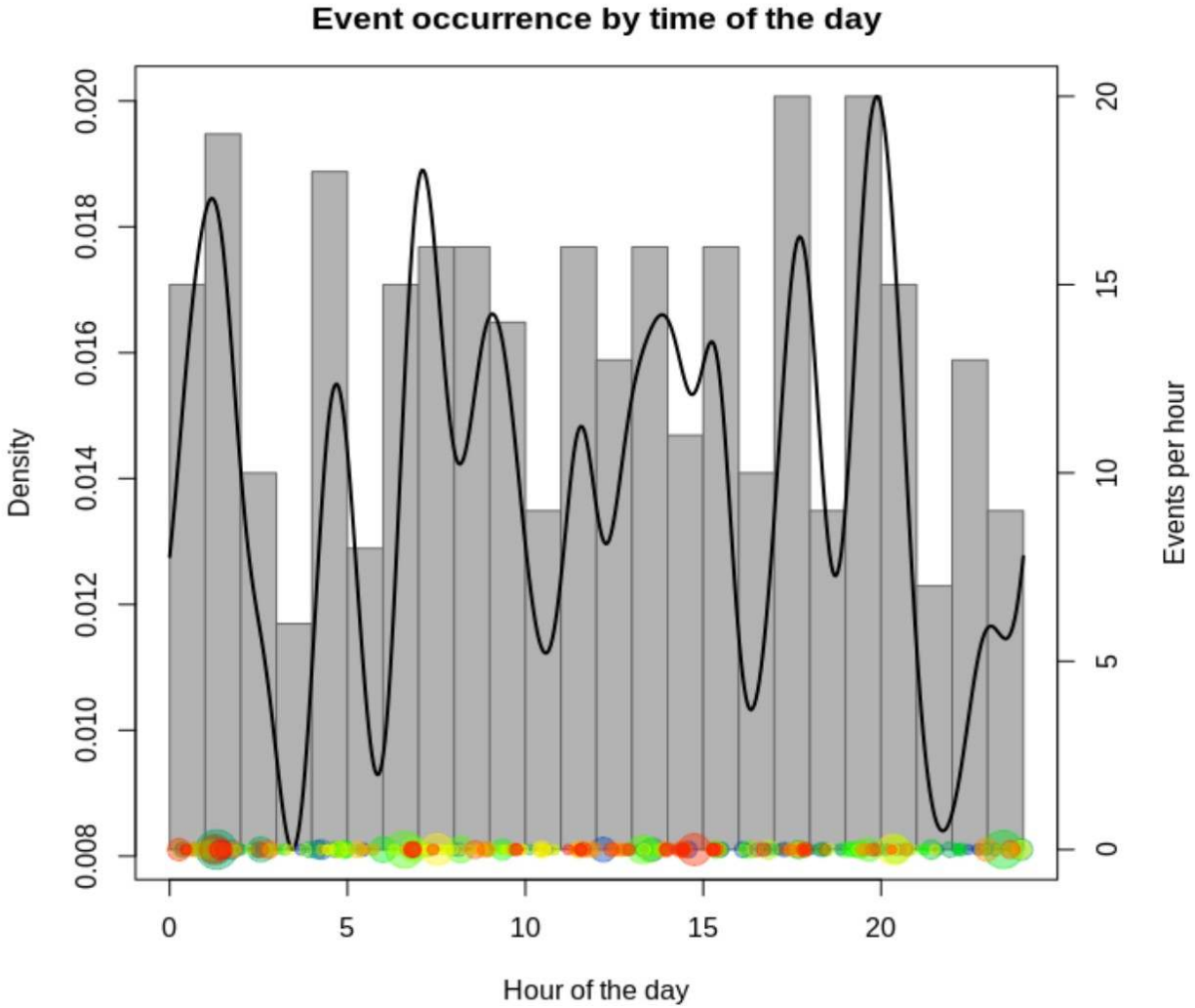
## DURATION (AND SEISMIC EVOLUTION) FORMS THREE CLUSTERS OF EVENT TYPES



# How long do slope events last? And when do they happen?

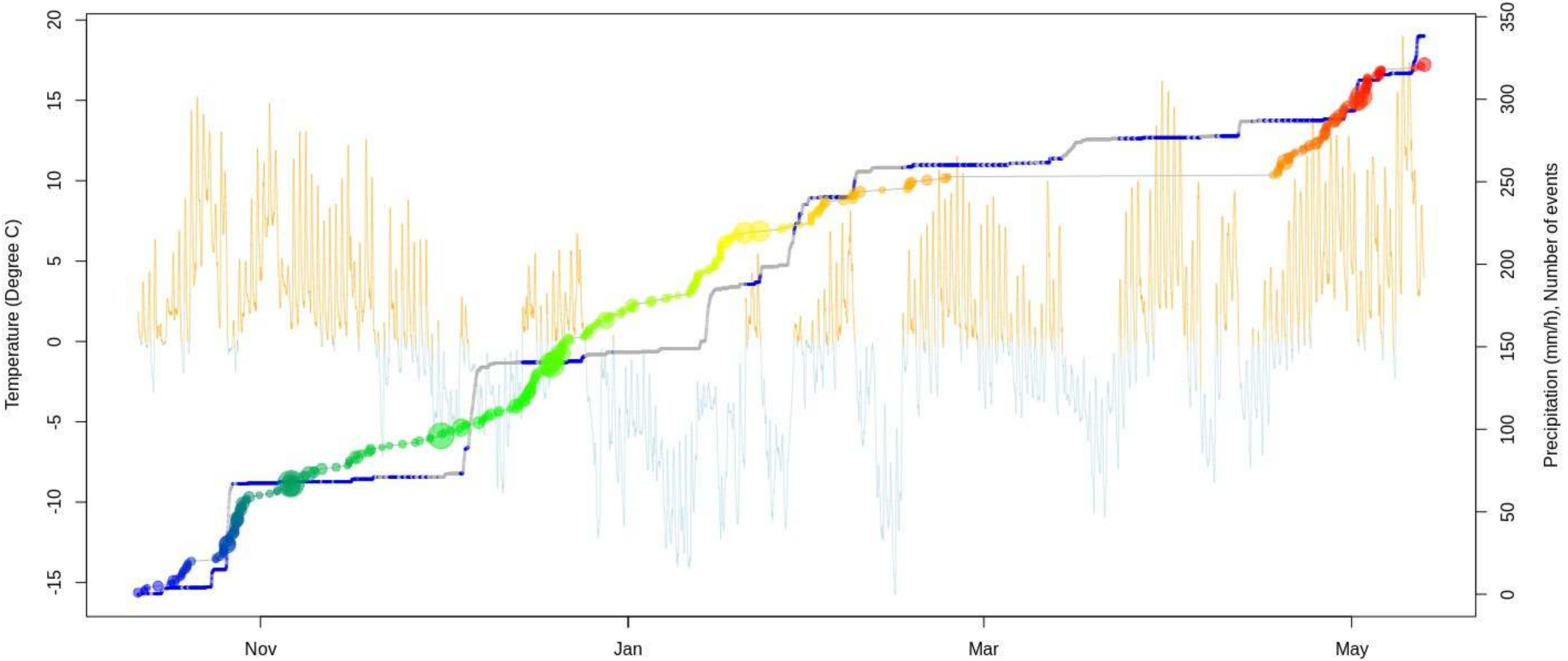
## DURATION (AND SEISMIC EVOLUTION) FORMS THREE CLUSTERS OF EVENT TYPES, BUT NO DIURNAL PREFERENCE OF ACTIVITY



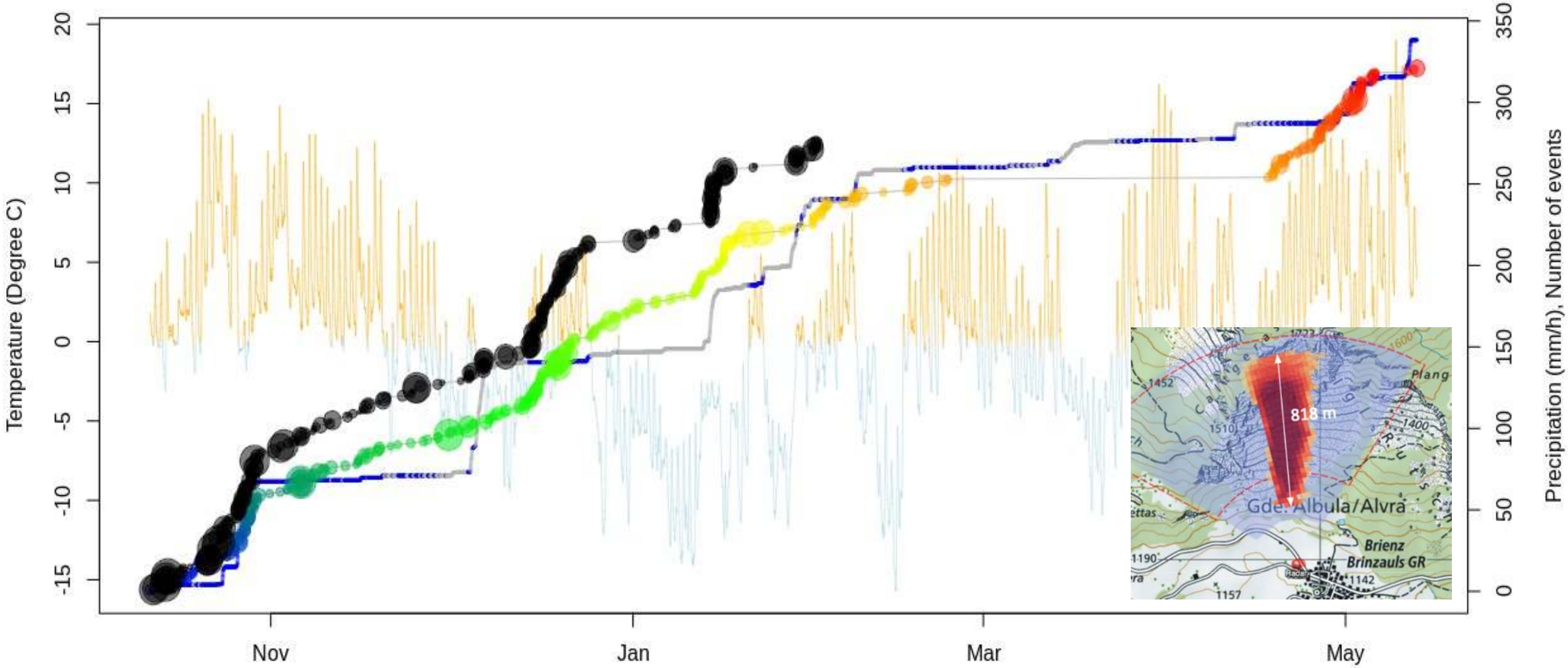
# When do events happen, how large are they, and what causes them?

## EVENT OCCURRENCE WITH TIME AND DRIVERS SHOWS BACKGROUND ACTIVITY AND CYCLIC PEAKS



# How well does the seismic approach match independent techniques?

## SEISMIC AND DOPPLER RADAR APPROACHES SENSE DIFFERENT EVENTS



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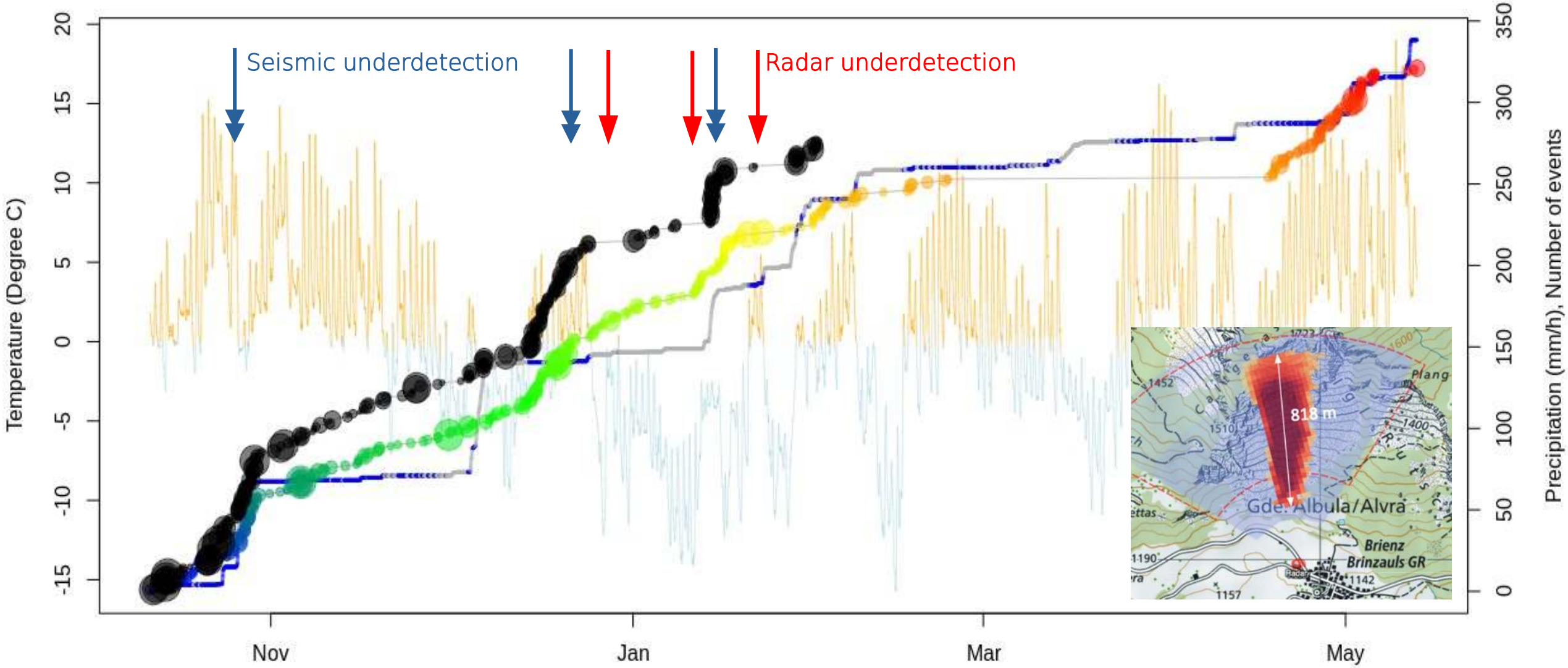
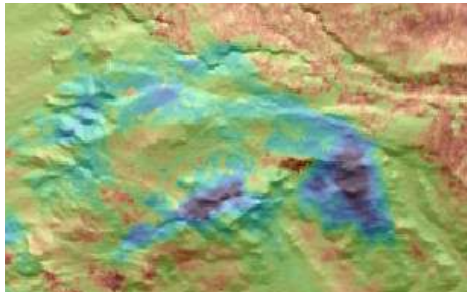


# To wrap up…

## CONCLUSIONS EMERGING FROM THE CURRENT LIFE TIME OF THE STUDY

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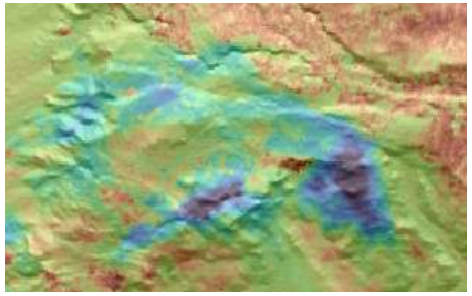
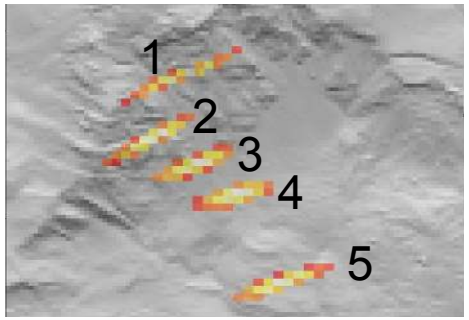


2) Hazard mitigation focus preferentially on rapid surface processes
   - Activity clusters determined by subsidence and surface topography
   - Three classes of events: local cracks, single rockfalls, repeated activity
   - Next urgent step: implementing real time detection, quantification, notification



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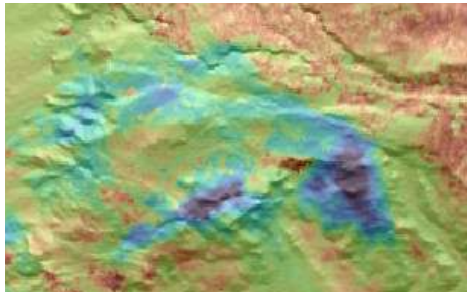

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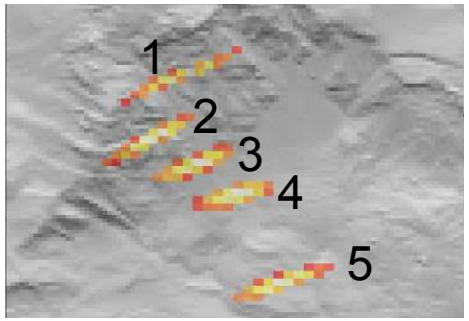


3) Landscape connectivity
   - Two evident coupling cases: rockslide–landslide & landslide–channel–hillslope
   - Next step: quantifying volume exchange, drivers, and coupling mechanisms

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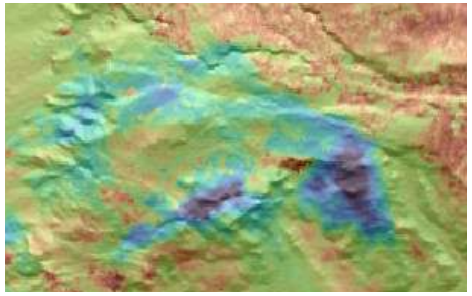

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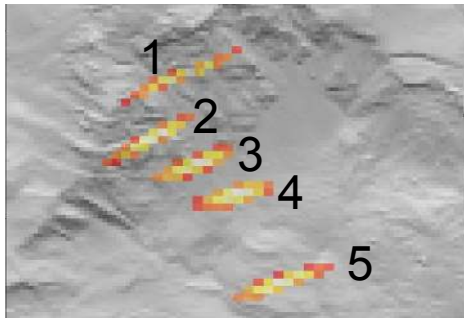


3) Landscape connectivity
   - Two evident coupling cases: rockslide–landslide & landslide–channel–hillslope
   - Next step: quantifying volume exchange, drivers, and coupling mechanisms
   - But: there is more than the Alps and we have urgent case studies close-by…

# To expand the scope...

## TRANSFERRING KNOWLEDGE FROM THE ALPS TO ANOTHER, RECENTLY ACTIVATED LANDSCAPE

# 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)

# To expand the scope...

## TRANSFERRING KNOWLEDGE FROM THE ALPS TO ANOTHER, RECENTLY ACTIVATED LANDSCAPE

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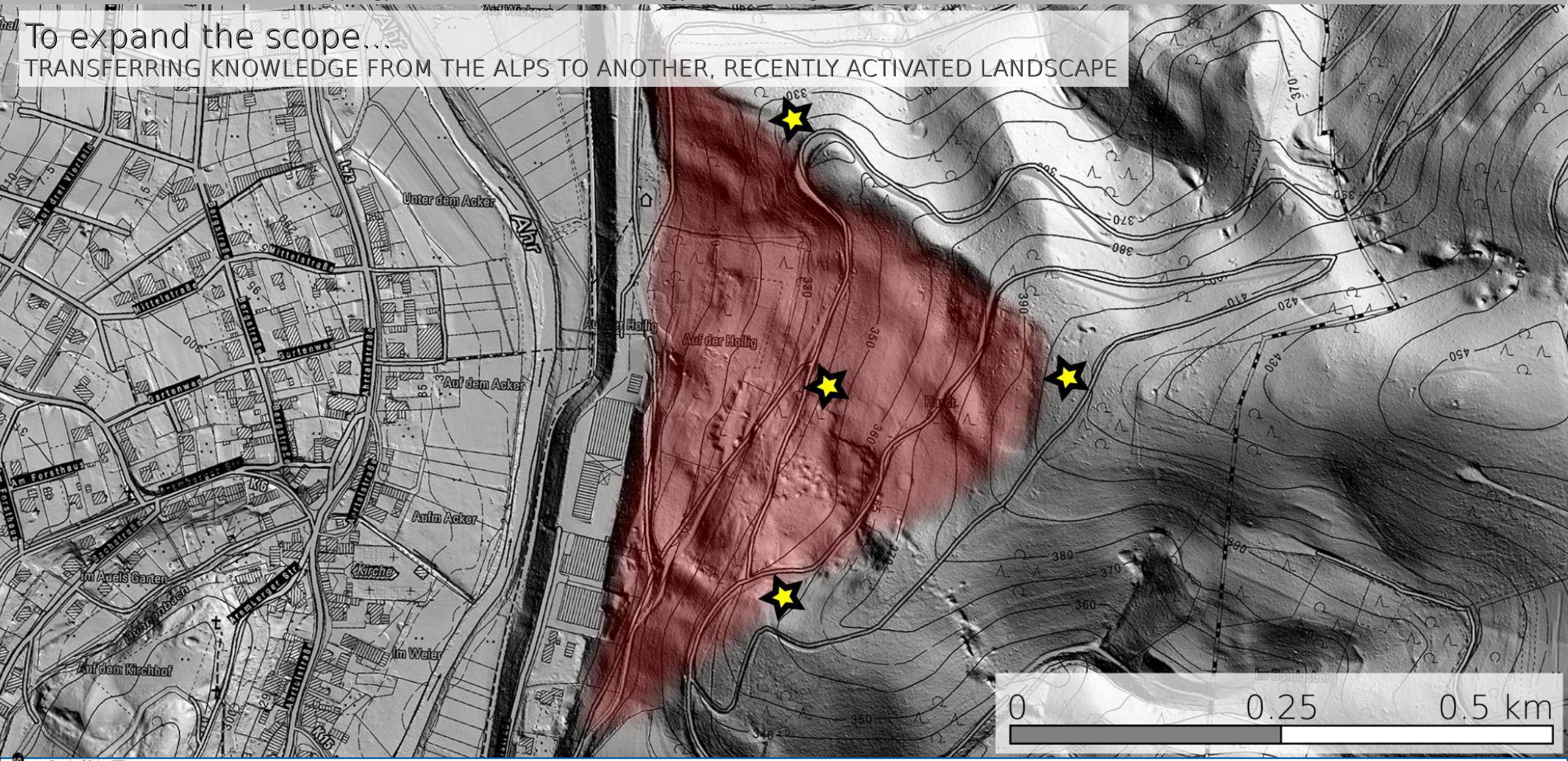

# Thanks!