Giant rockslides forcing's during the Sarpol-Zahab Mw7.3 earthquake

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UNIVERSITÉ Grenoble Alpes

ISTerre Institut des Sciences de la Terre

National Center for Remote Sensing

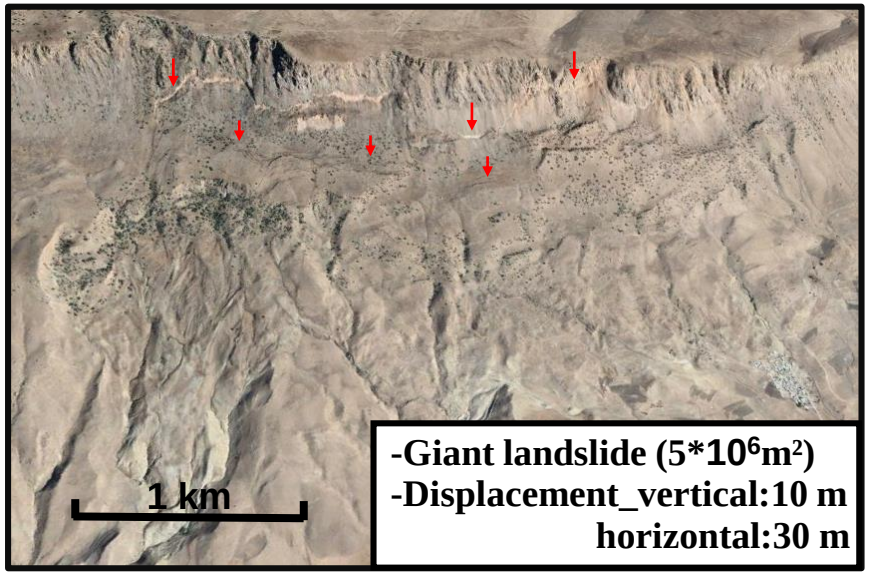
CNRS National Council for Scientific Research

EGU European Geosciences Union

Co-seismic induced-landslides during the Mw7.3 Sarpol-Zahab earthquake

Many co-seismic landslides triggered and reported by locals

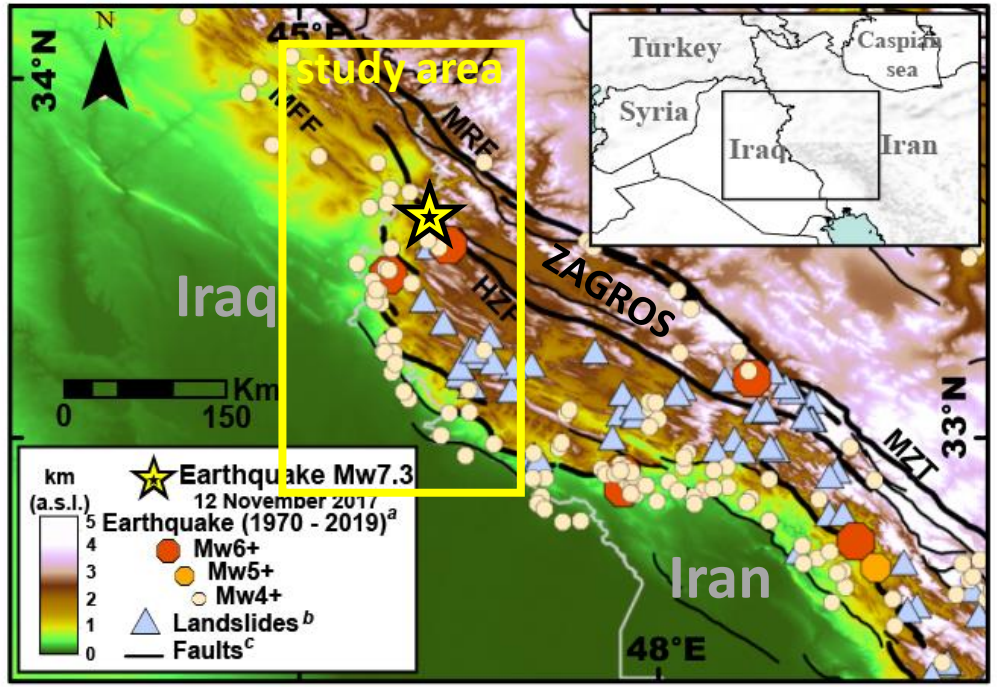
Mela-Kabod landslide



-Giant landslide ($5*10^6 m^2$)
-Displacement_vertical:10 m
horizontal:30 m

Small landslides

Pre-existing giant landslides in the Zagros Mountains



a: United States Geological Survey
b: Ghazipur and Simpson, 2016
c: Hessami et al., 2003

Cheaib et al., in prep

What are the factors controlling the triggering of landslides in this arid region?

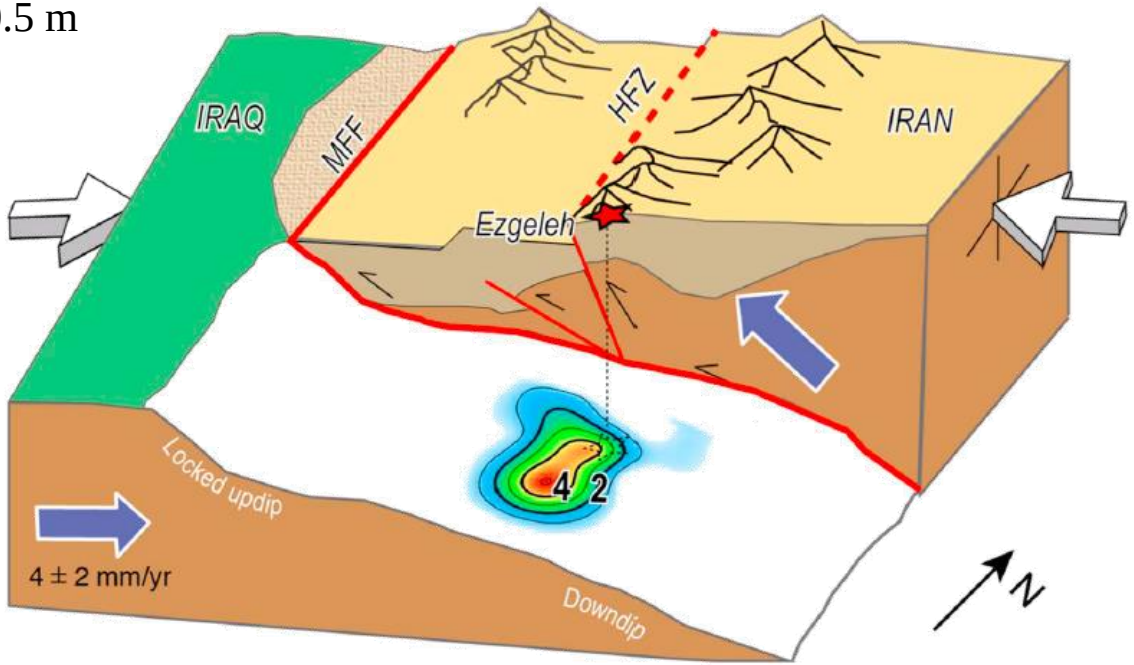
Geological settings and earthquake characteristics

Sarpol-Zahab earthquake

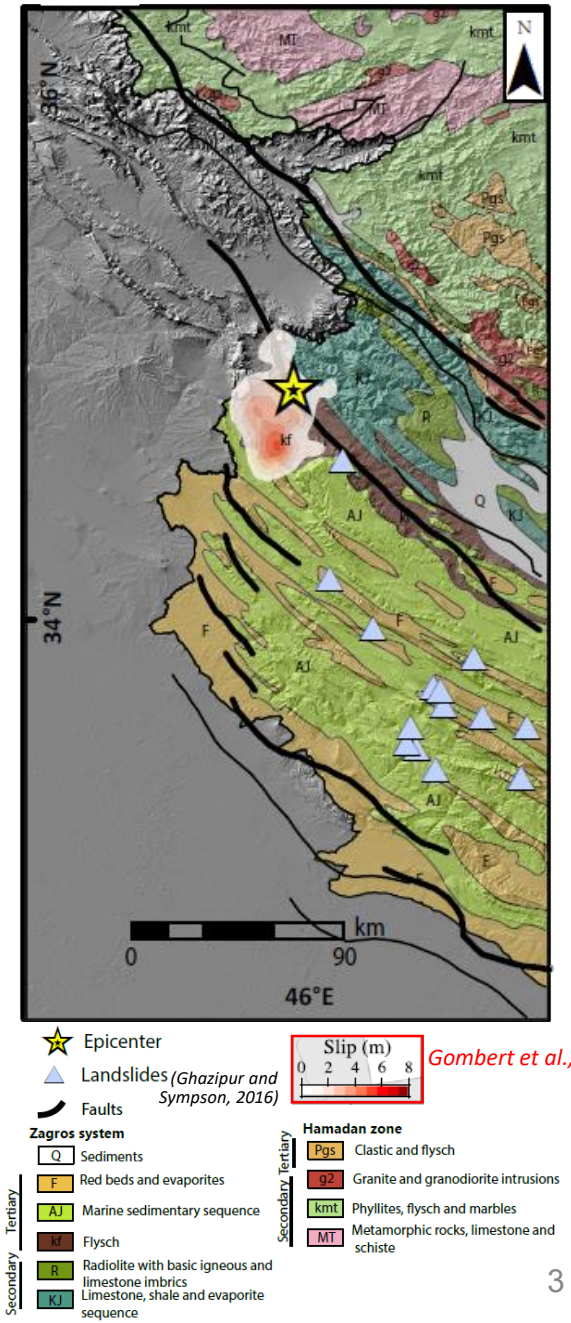
- Mw7.3 on November 12, 2017
- Blind thrust fault
- 14-20 km depth
- Co-seismic slip of 5.5 ± 0.5 m
- Impulsive source

Zagros mountains

- Fold and Thrust Belt
- NW-SE parallel structures
- Sedimentary series
- Semi-arid region (230 mm/yr)
- Many giant landslides



Chen et al., 2018



Study Strategy

Rapid landslides

1- Visual comparison of optical images

Planet scope (3 m)
Oct19-2017– Nov13-2017

Slow-moving landslides

2- Optical image correlation *CosiCorr*

SPOT6-7 (1.5 m)
2014-2017

Displacement > 50 cm /3 yr

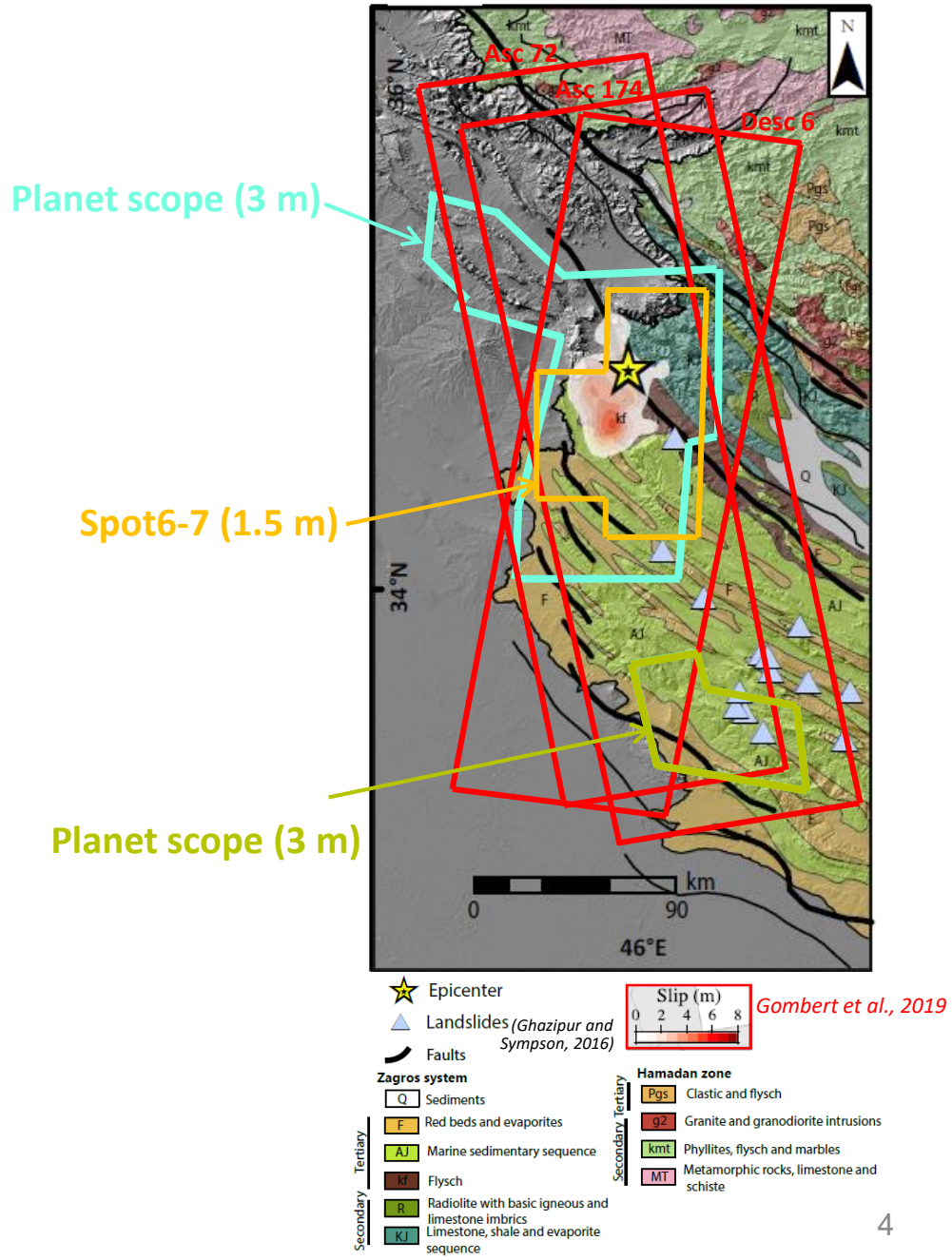
Planet scope (3 m)
Oct19-2017– Nov13-2017

Displacement > 30 cm

3- InSAR: Interferometry Synthetic Aperature Radar

Sentinel-1
Oct19-2017– Nov13-2017

Displacement > 1 cm

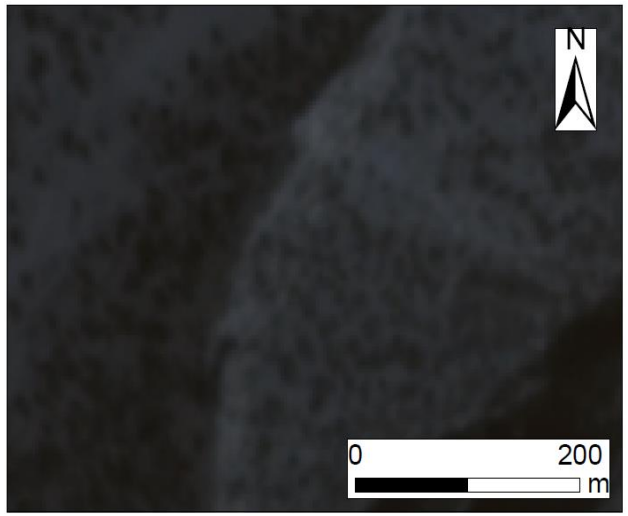


“Rapid” landslides inventory results

360 landslides detected

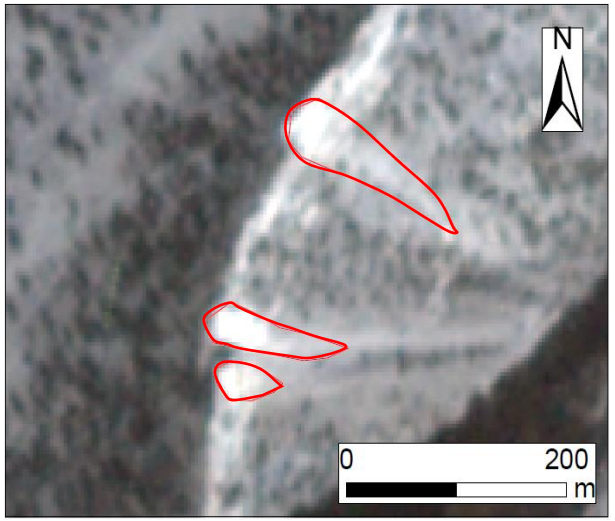
- **Relatively small size (10^2 - 10^4 m^2)**
- **Typically debris and rock falls**
- **Oligocene to Permian sedimentary rocks**

19 Oct 2017



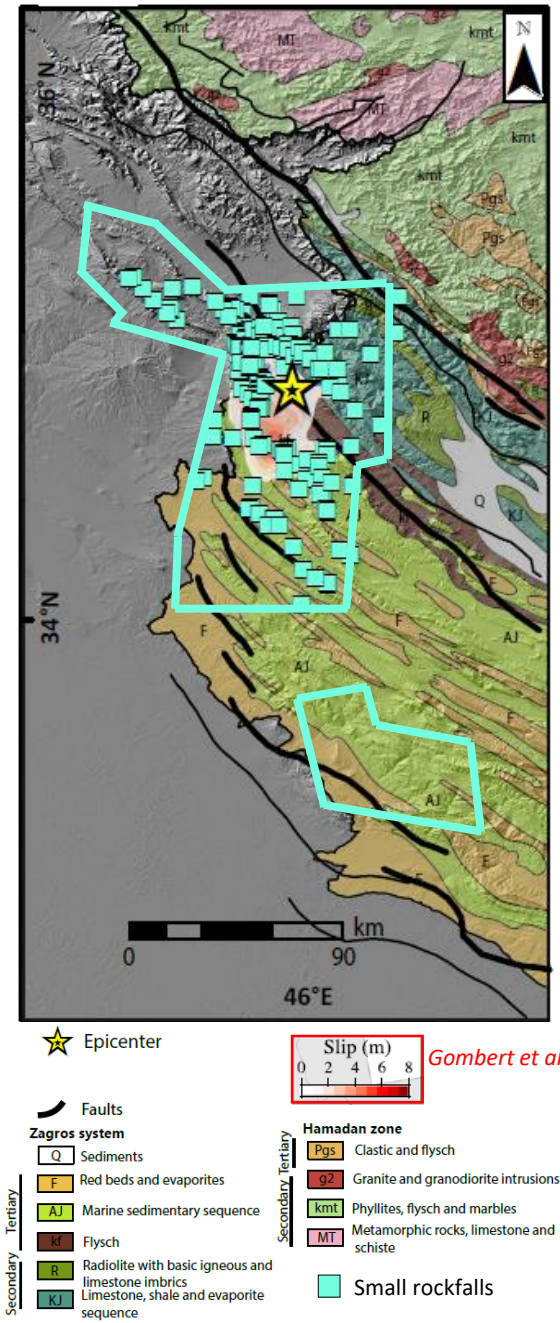
Before

13 Nov 2017



After

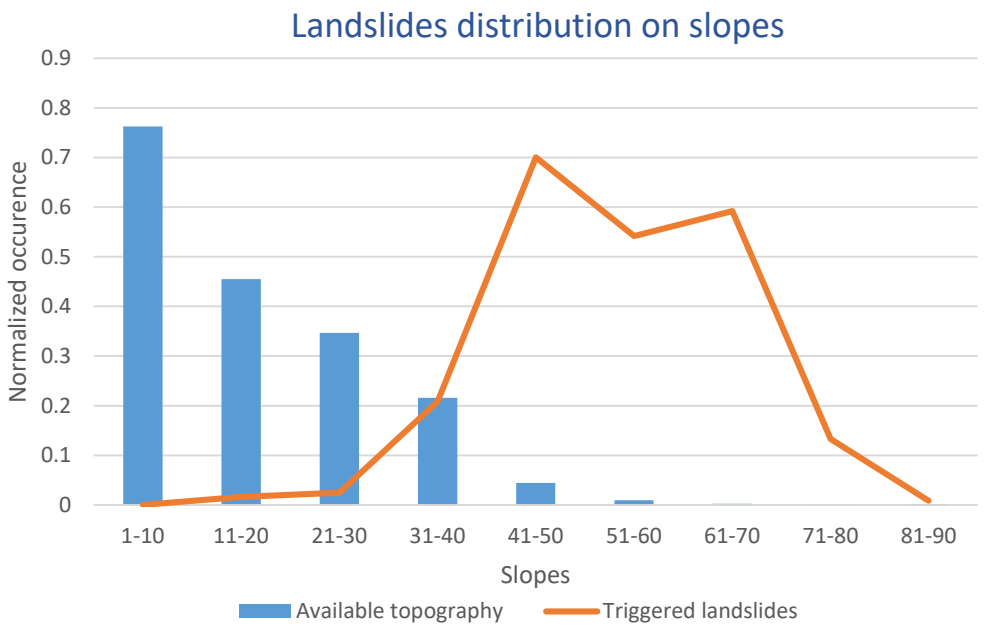
Cheaib et al., in prep

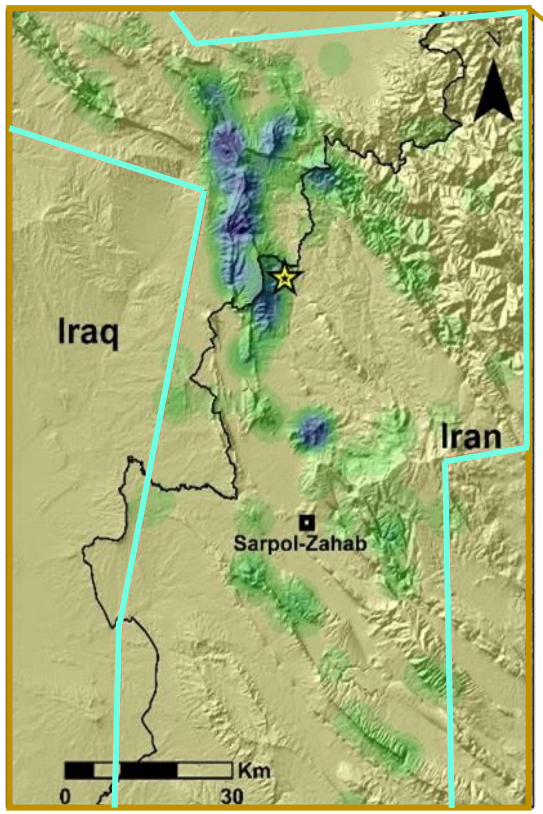


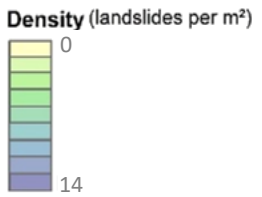
“Rapid” landslides inventory results

360 landslides detected

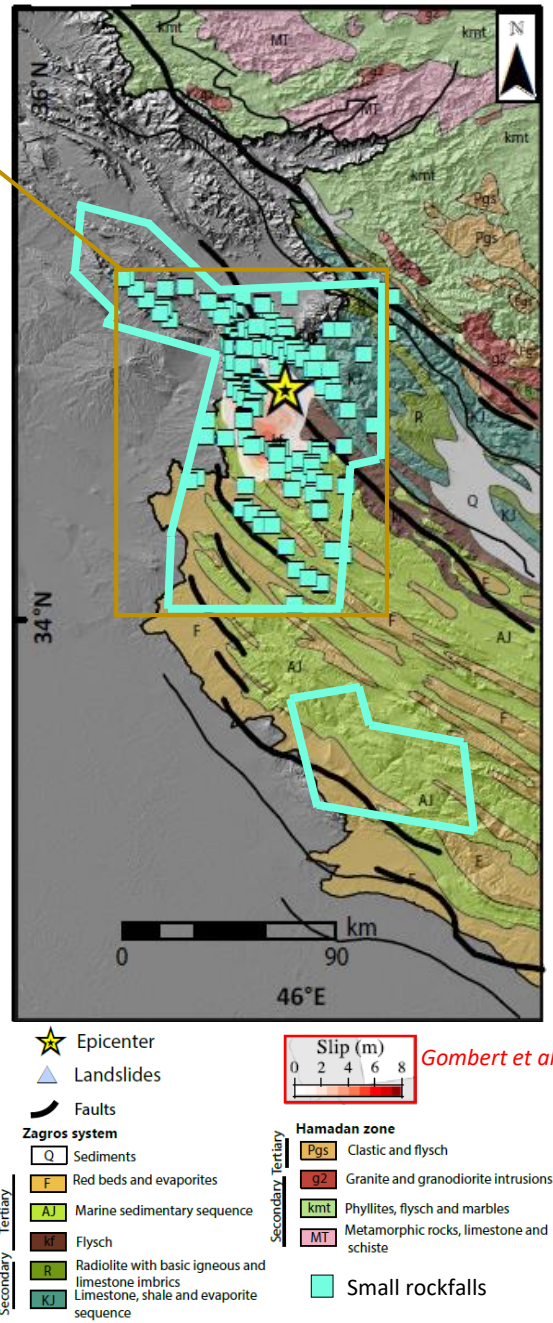
- **Relatively small size (10^2 - 10^4 m^2)**
- **Typically debris and rock falls**
- **Oligocene to Permian sedimentary rocks**
- **Concentrated 40 km around the epicenter (85%)**
- **Slopes: 40° to 65°**







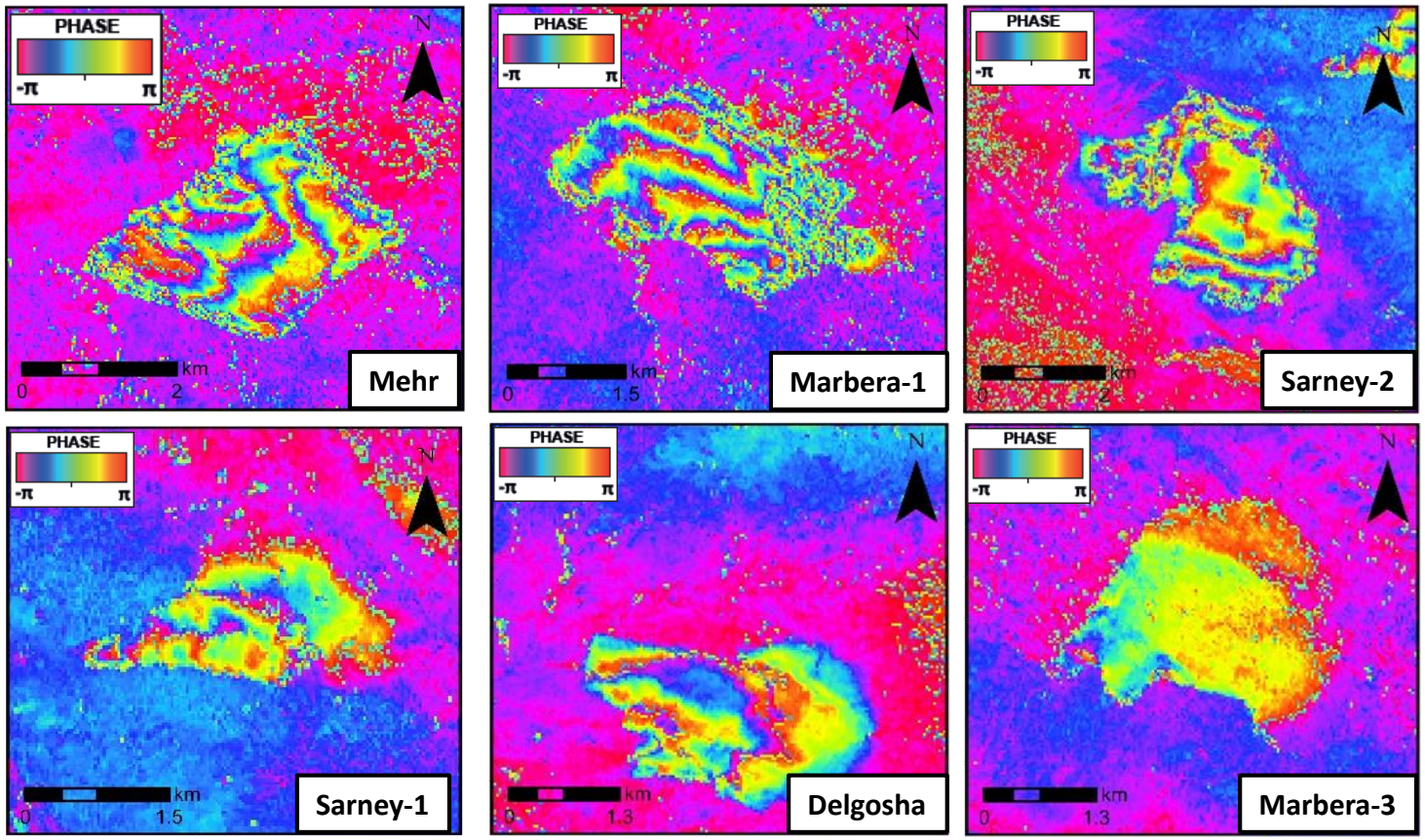
Cheaib et al., in prep



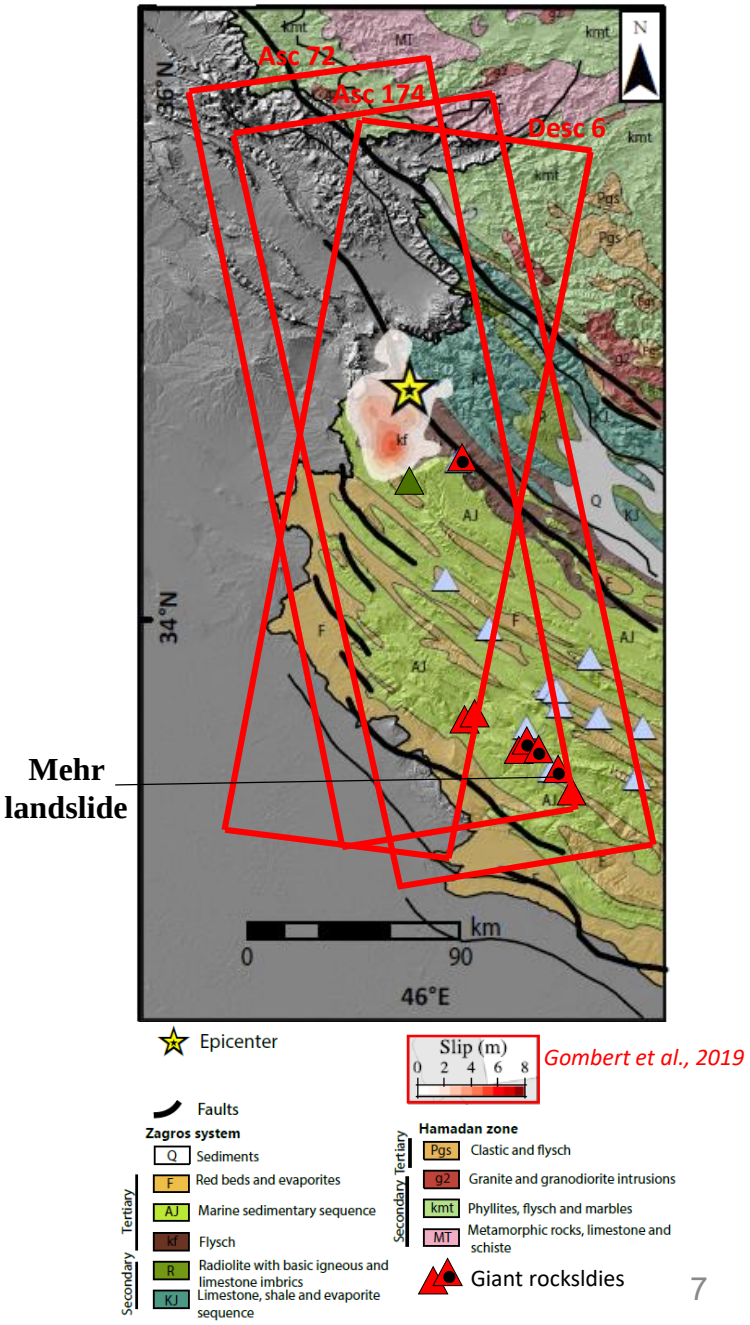
Giant "slow-moving" landslides detection

9 giant landslides detected

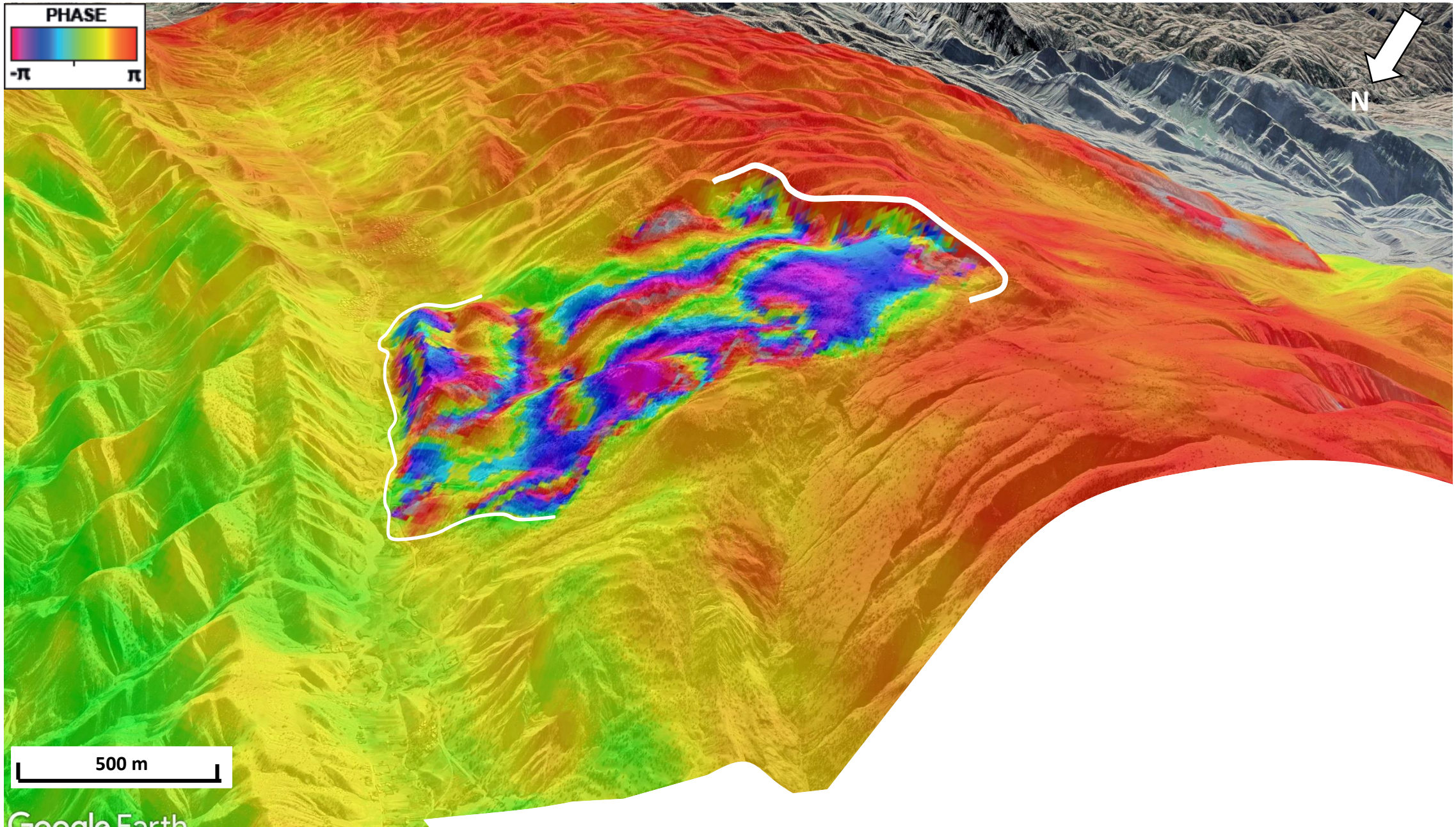
- **Giant (**3 to 15 **km^2)**
- **Far field !! (140-180 km away from the epicenter)**
- **Several fringes with sharp discontinuity**



Cheaib et al., in prep



Example of the giant **Mehr landslide** (170 km from epicenter)



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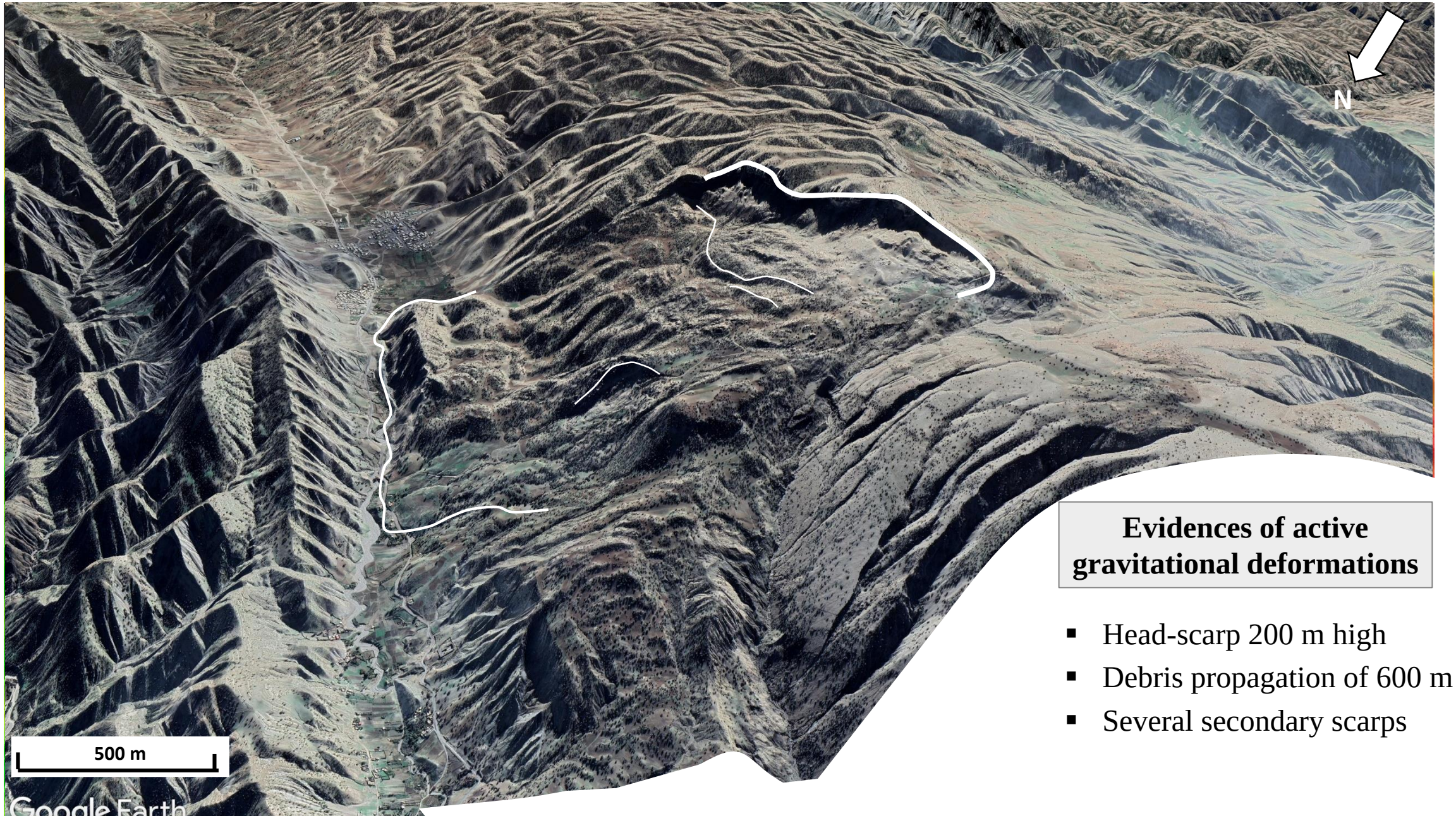
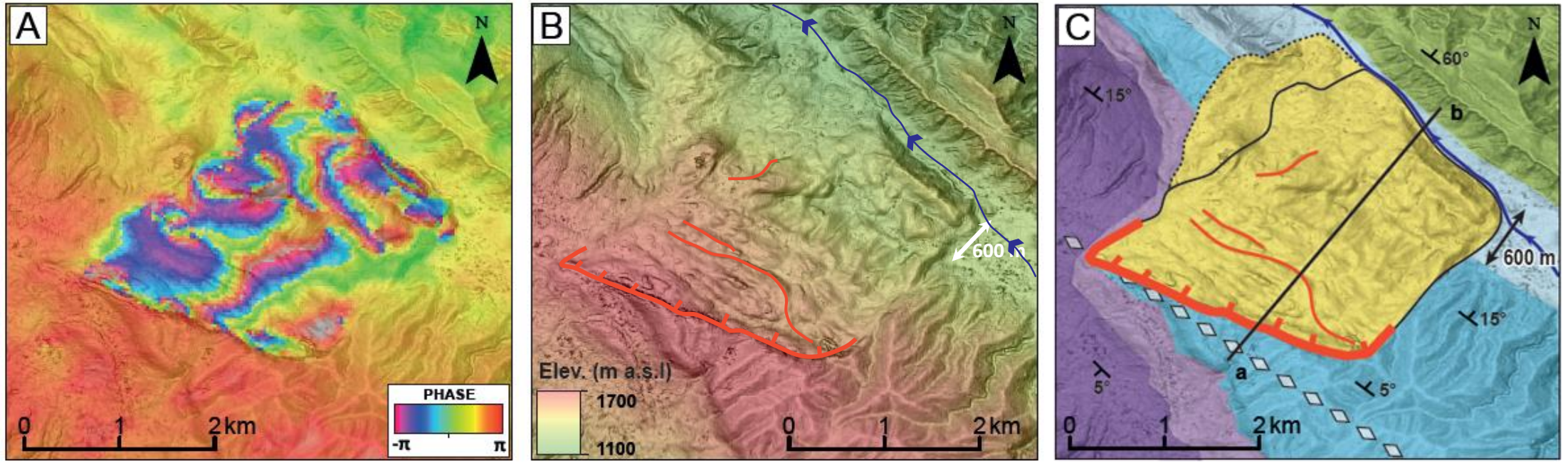


Evidences of active gravitational deformations

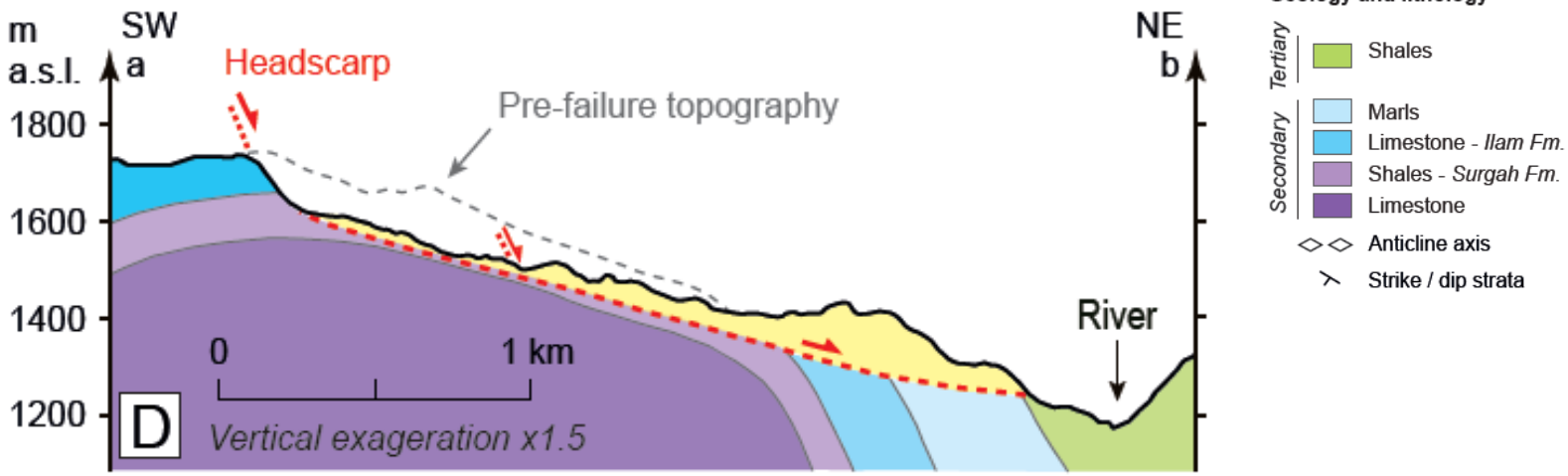
- Head-scarp 200 m high
- Debris propagation of 600 m
- Several secondary scarps

Example of the giant **Mehr landslide** (170 km from epicenter)



Pre-existing giant rockslide
3 km long, 2.5 km wide
Volume = ~0.5 km^3

Geology: Limestone block sliding on shale layer
Slope: 5 to 15°

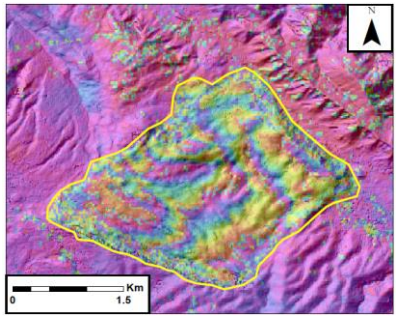


Cheaib et al., in prep

Example of the giant **Mehr rockslide** (170 km from epicenter)

Minimum

Number of fringes



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How to quantify the co-seismic displacement ?

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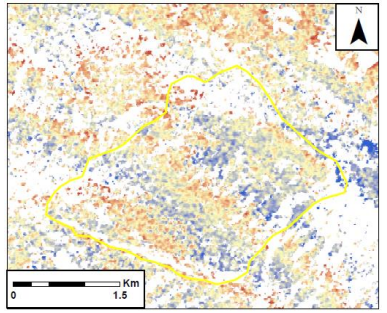
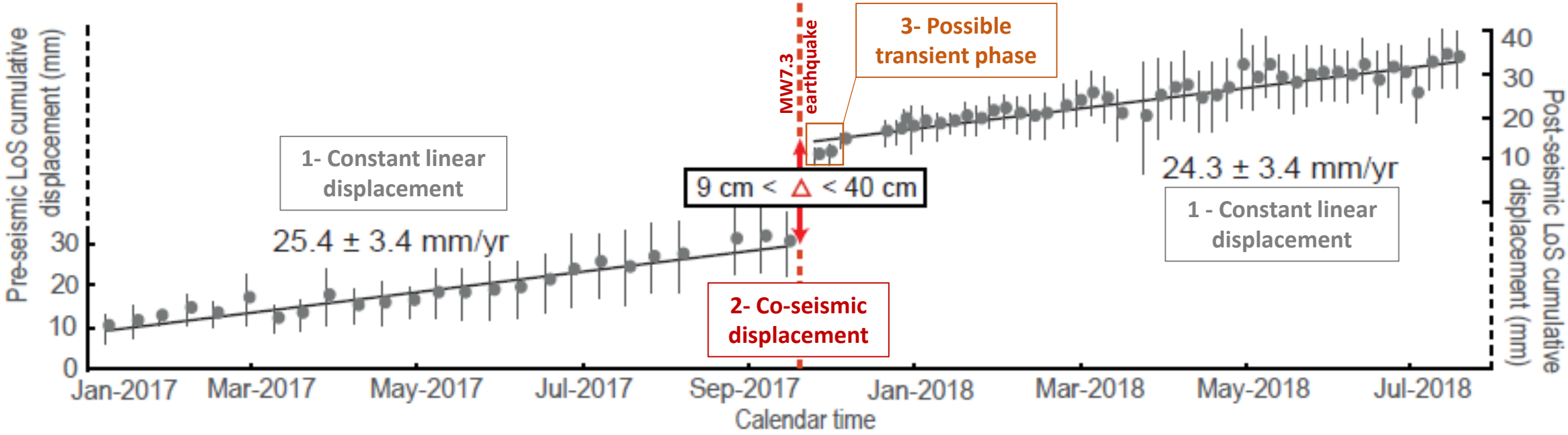


Maximum

Correlation threshold

Co-seismic displacement range : few cm to 1 m

Time-series computed over 18 months framing the earthquake:



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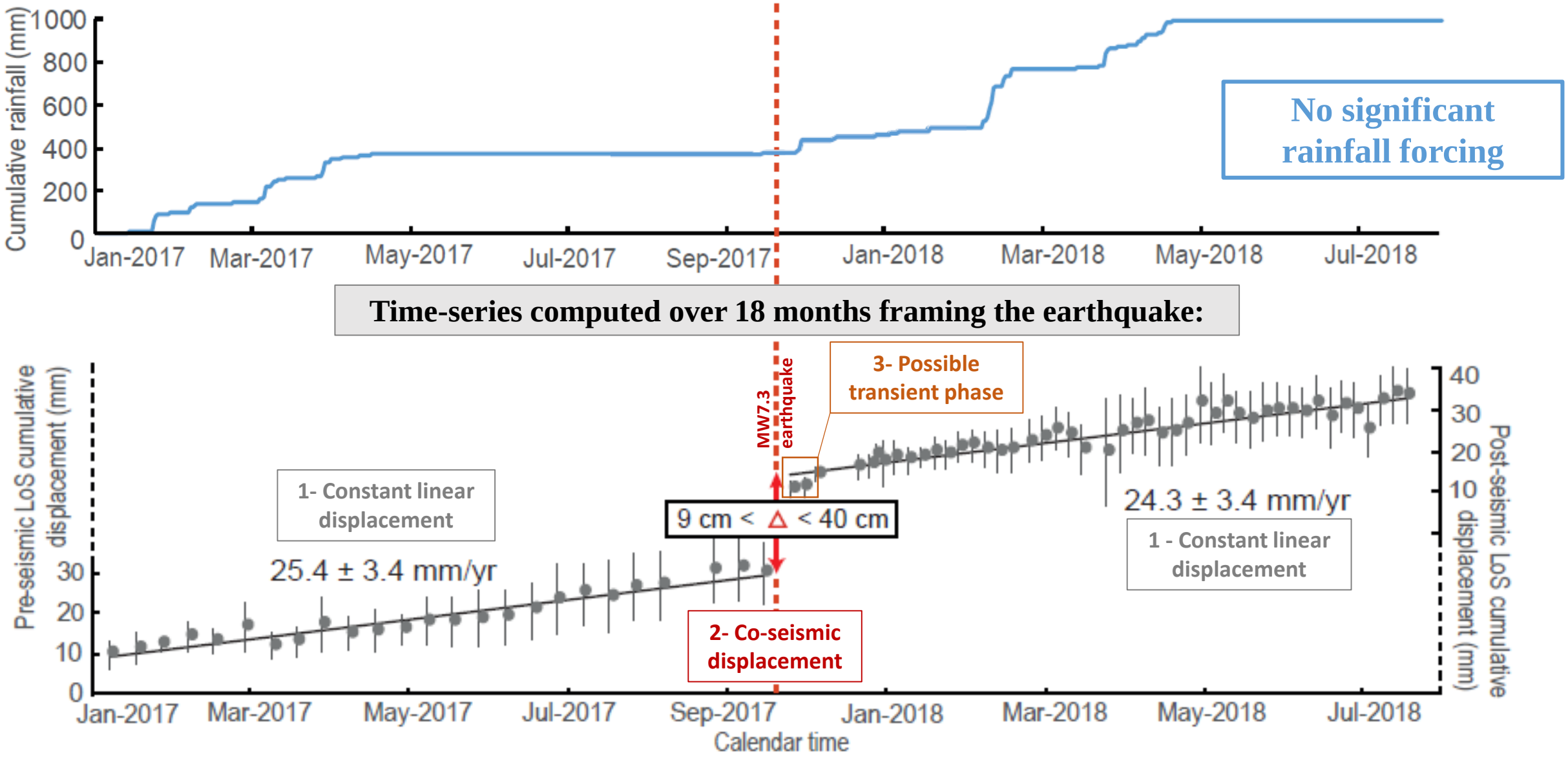
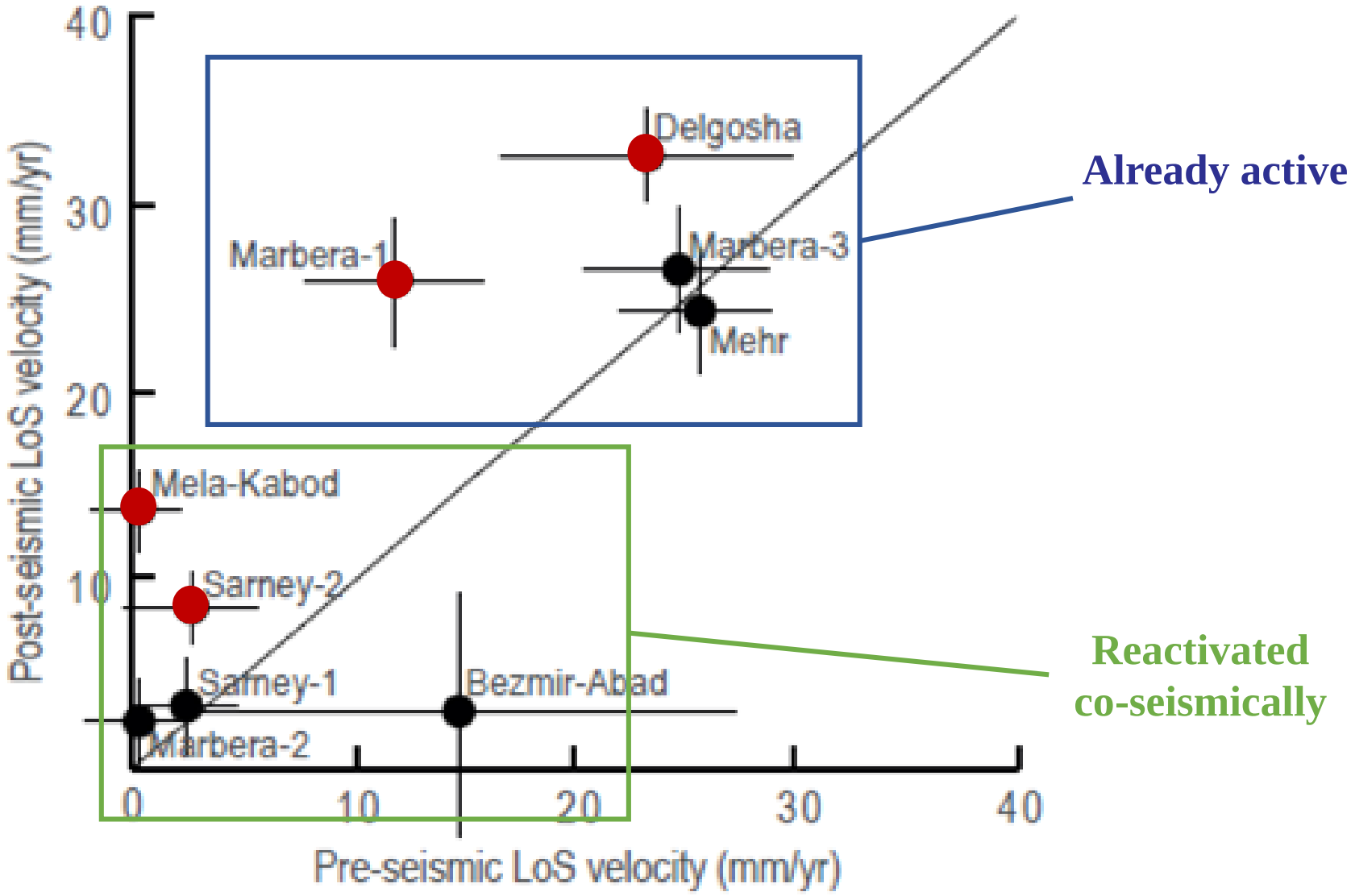


Time-series analysis for the nine giant rockslides

Four rockslides accelerated post-seismically



Time-series computed over 18 months framing the earthquake

Main conclusions

Landslides induced by the Mw7.3 Sarpol-Zahab earthquake :

- **369 mass-movements**

  - **360 small debris and rock falls (10^3 m^2)**, mostly concentrated **in the epicenteral area**

  - **9 giant rockslides** (10^6 m^2) , 140 to 180 km from the epicenter

Giant rockslides characteristics:

- **Pre-existing giant rockslides were co-seismically activated (few cm to 1 m)**
- **Carbonate blocks sliding over shale layer**
- **Probable relaxation phase observed for ~20 days after the earthquake**
- **Earthquake-induced persistent acceleration of four rockslides**
- **Rainfall have no significant impact**

Perspective:
Ongoing investigation on seismic site effects

Cheaib et al., in prep