Combined effect of precipitation and earthquakes on the kinematic of a slow moving landslide

The case of the Maca landslide, Colca Valley, Peru

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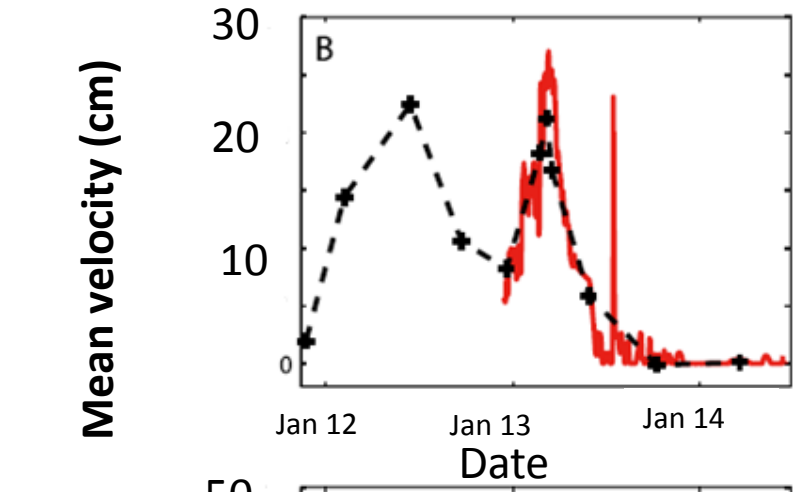
Why studying slow moving landslides ?

- displacement of the ground due to the gravity
- One of the major threat in mountainous area
- Kinematic driven by different forcings
  - rapid landslides (m/s)
  - slow moving landslides (m/an)

Landslide forcing

River

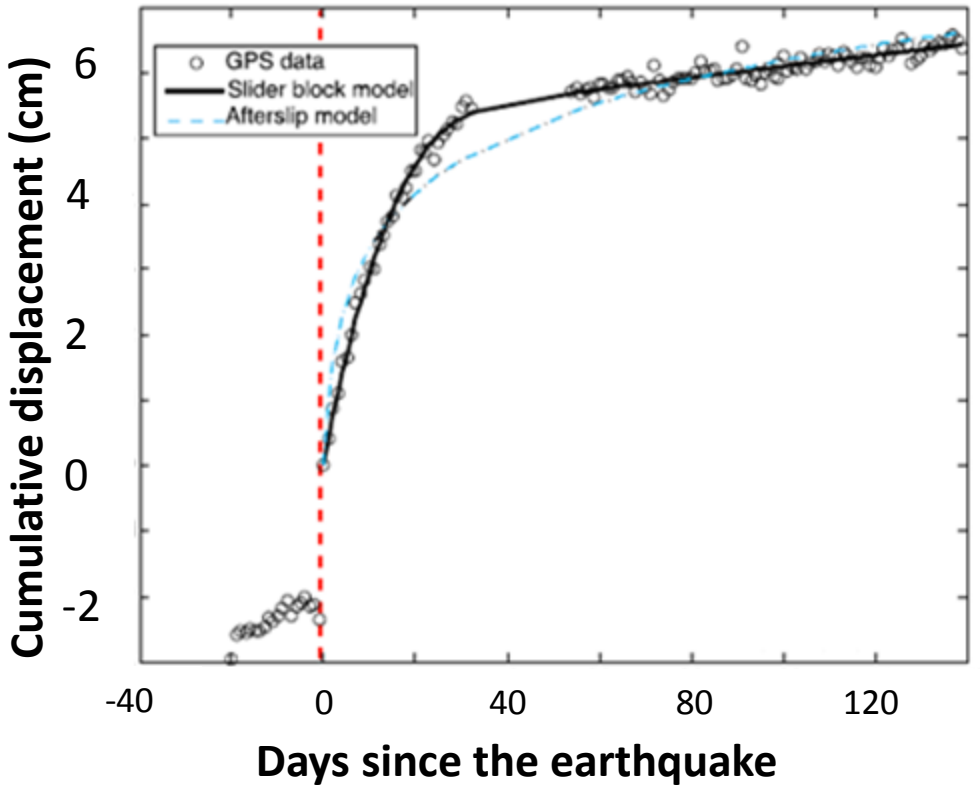
rainfall



Zerathe et al. , 2016

Human activities

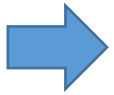
earthquake



Lacroix et al. , 2014

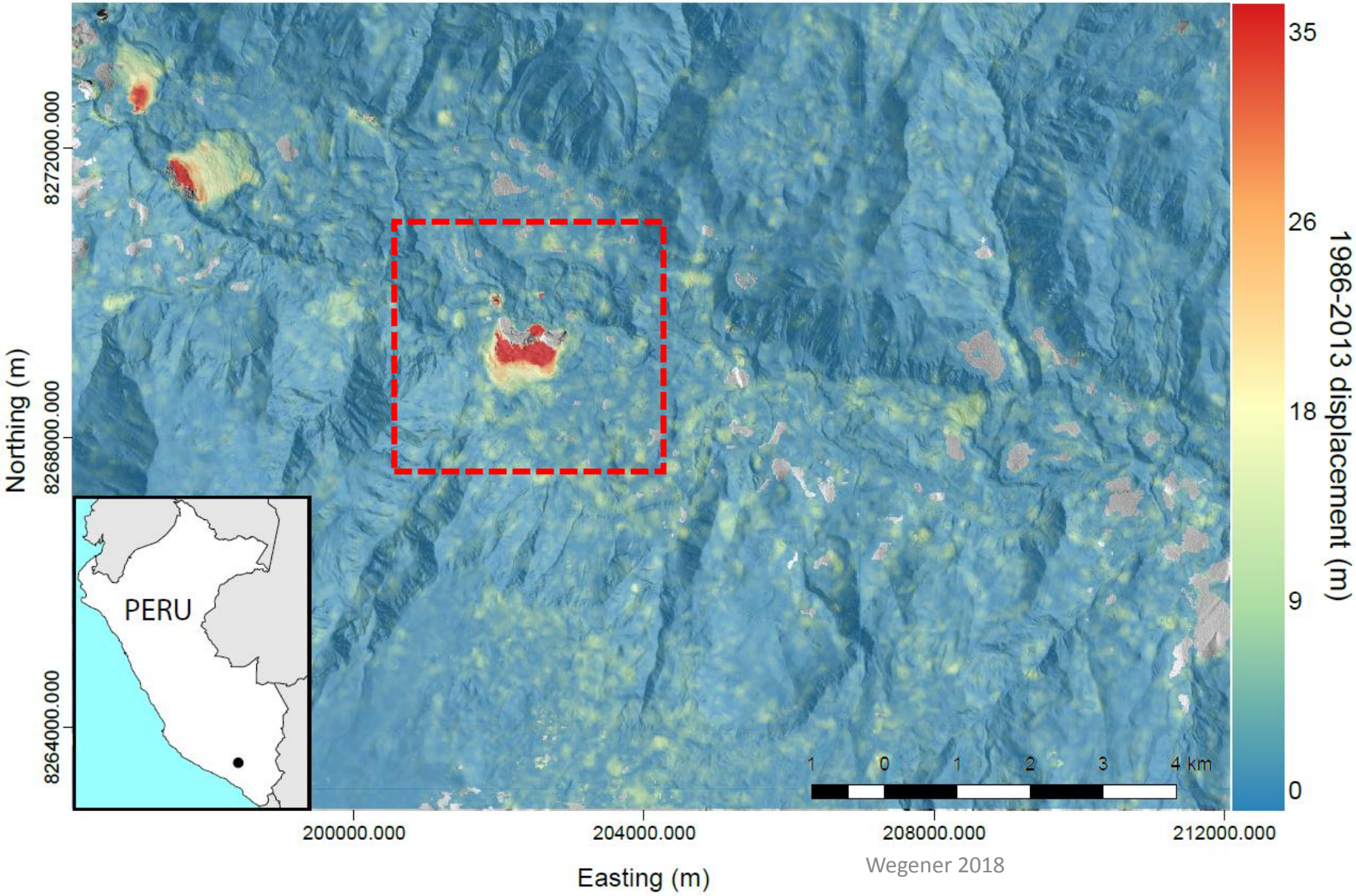
problematic

- To better understand the different mechanisms impacting landslide kinematics in active seismic region where both earthquake and rainfall can combine



Use of in-situ data

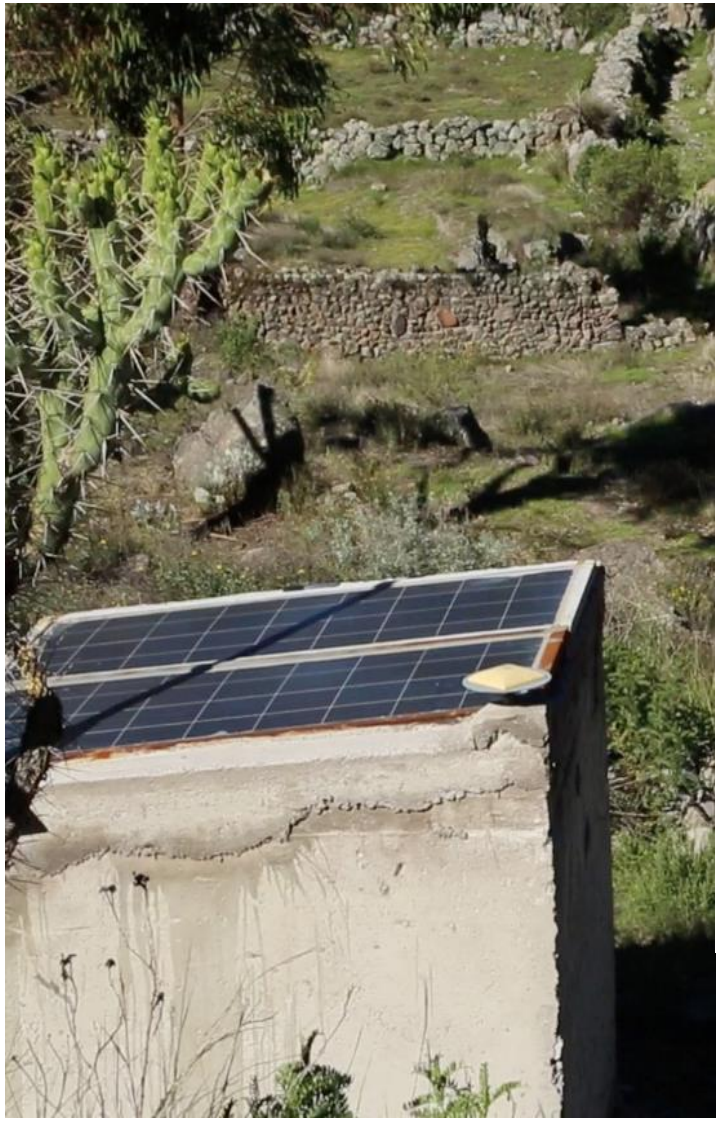
Site of study

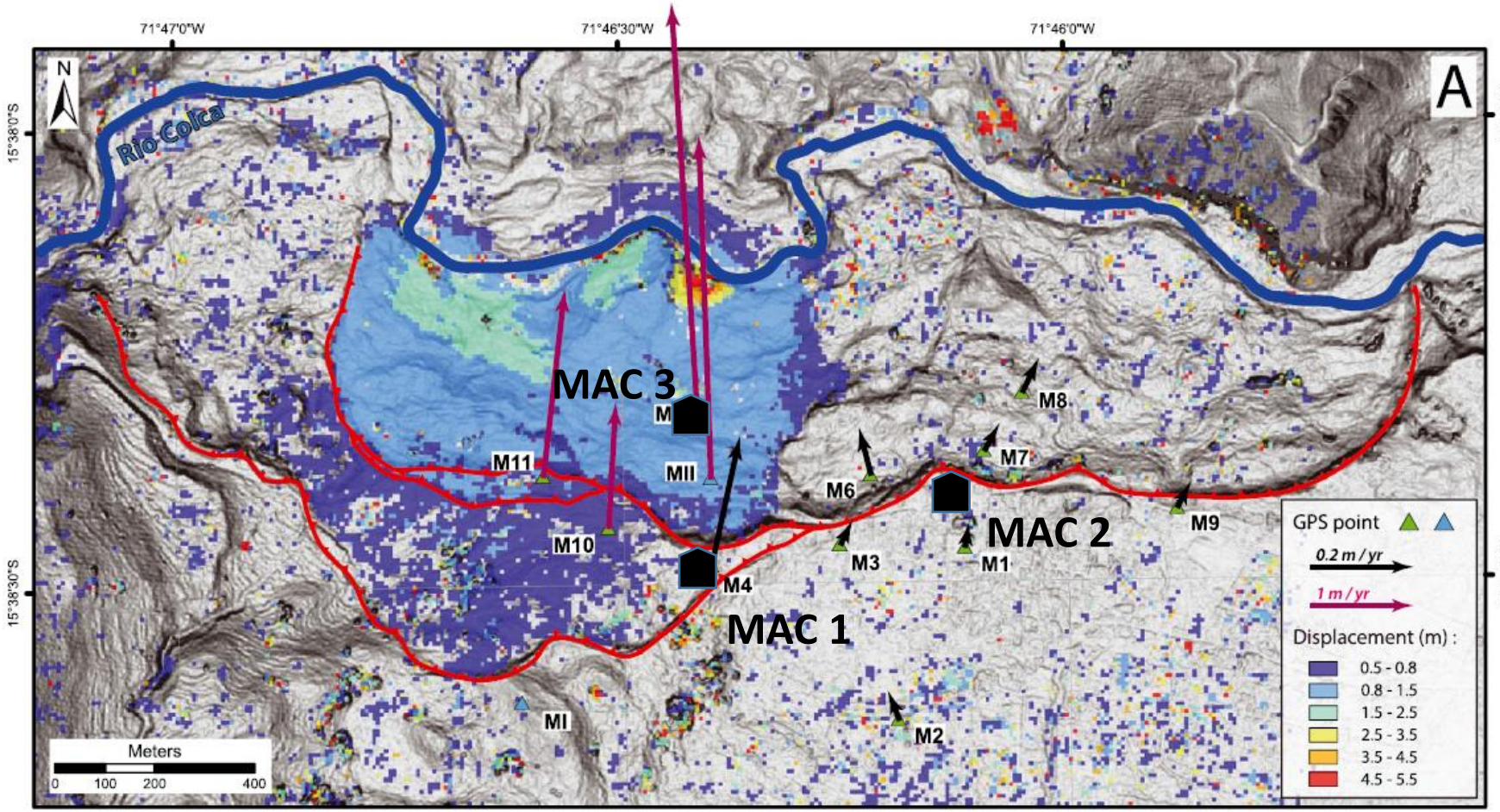


- Colca river contributing to erosion of lacustrine deposits
- Precipitation follows a season cycle
- intense seismic activity

Bontemps et al. 2018

The Maca Landslide monitoring

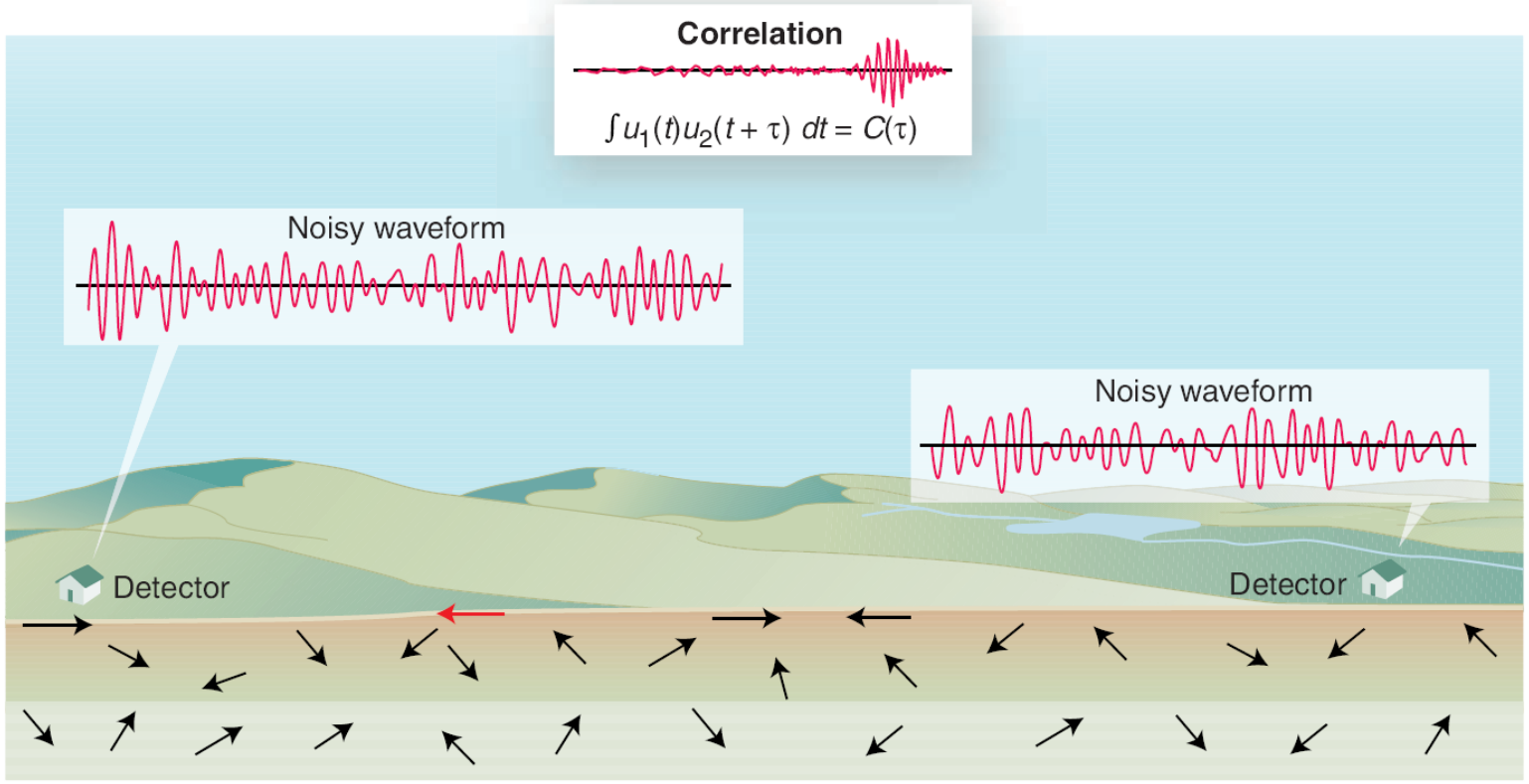




Recording continuously since the beginning of 2016

Zerathe et al., 2016

Method
Ambient noise correlation



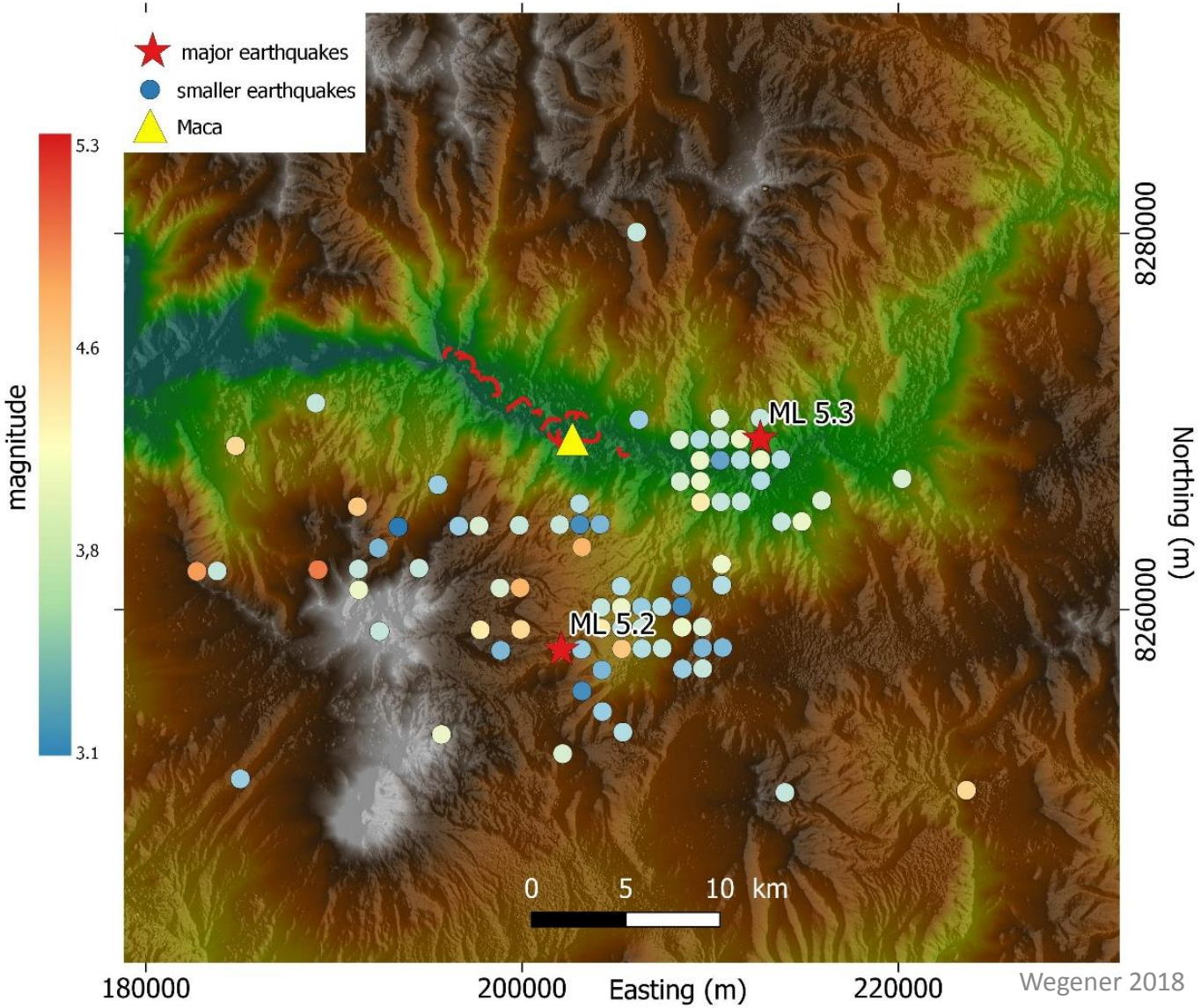
=> Monitoring of tiny changes in the soil properties

$$Vs = \sqrt{\frac{\mu}{\rho}}$$

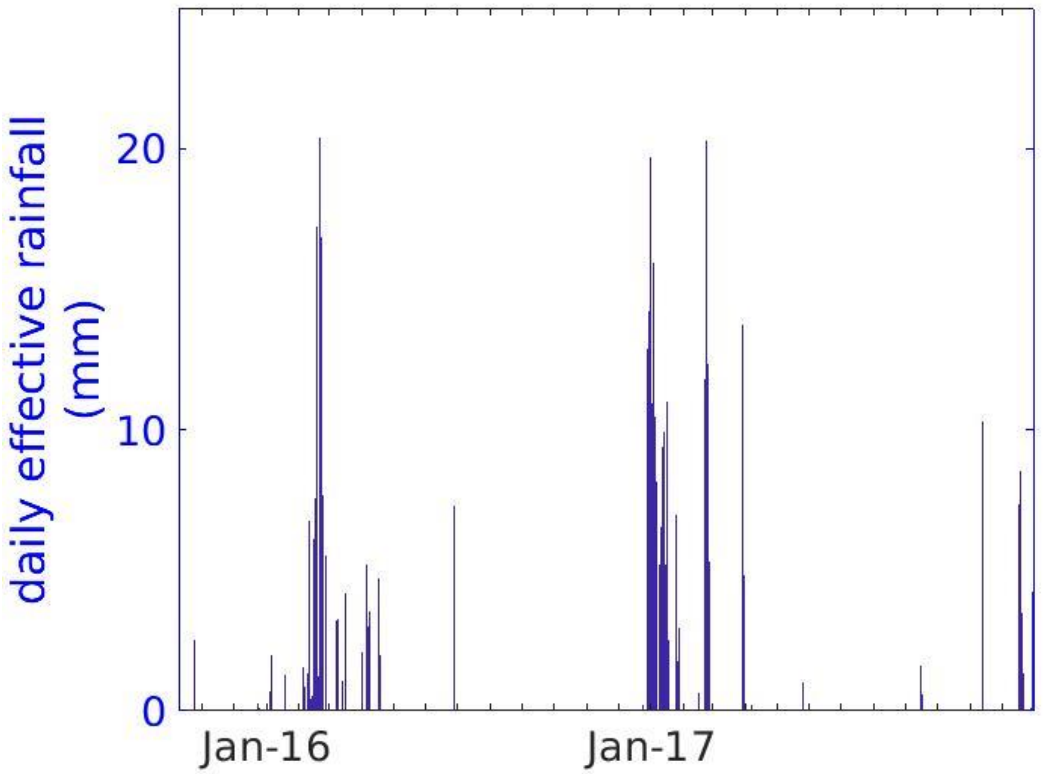
↘ In rigidity (μ)
↗ Increase in density (ρ)
} Vs ↘

Weaver (Phys. Rev. Lett. 2001; Science 2005)

Earthquake recorded between 2016 and 2017

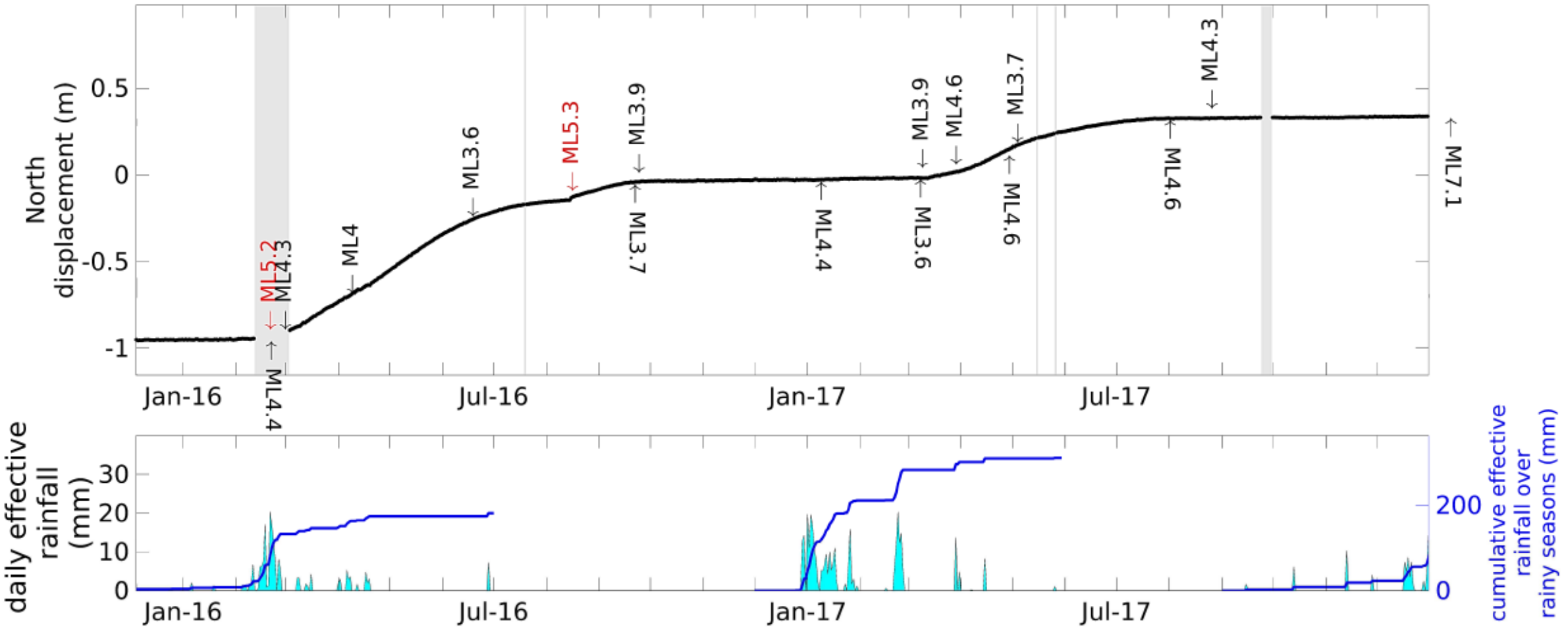


Effective precipitation recorded between 2016 and 2017

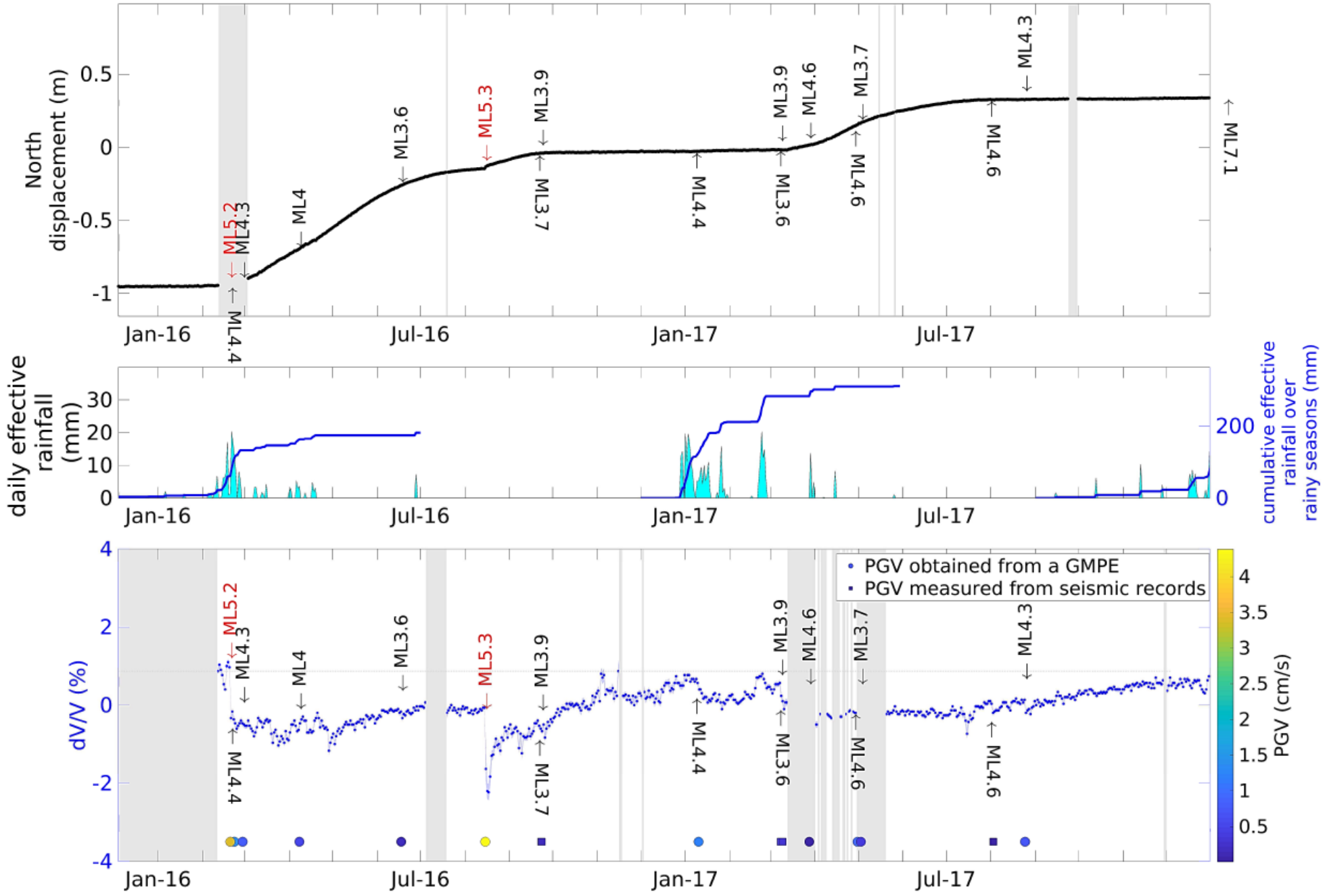


Wegener 2018

GPS measurements

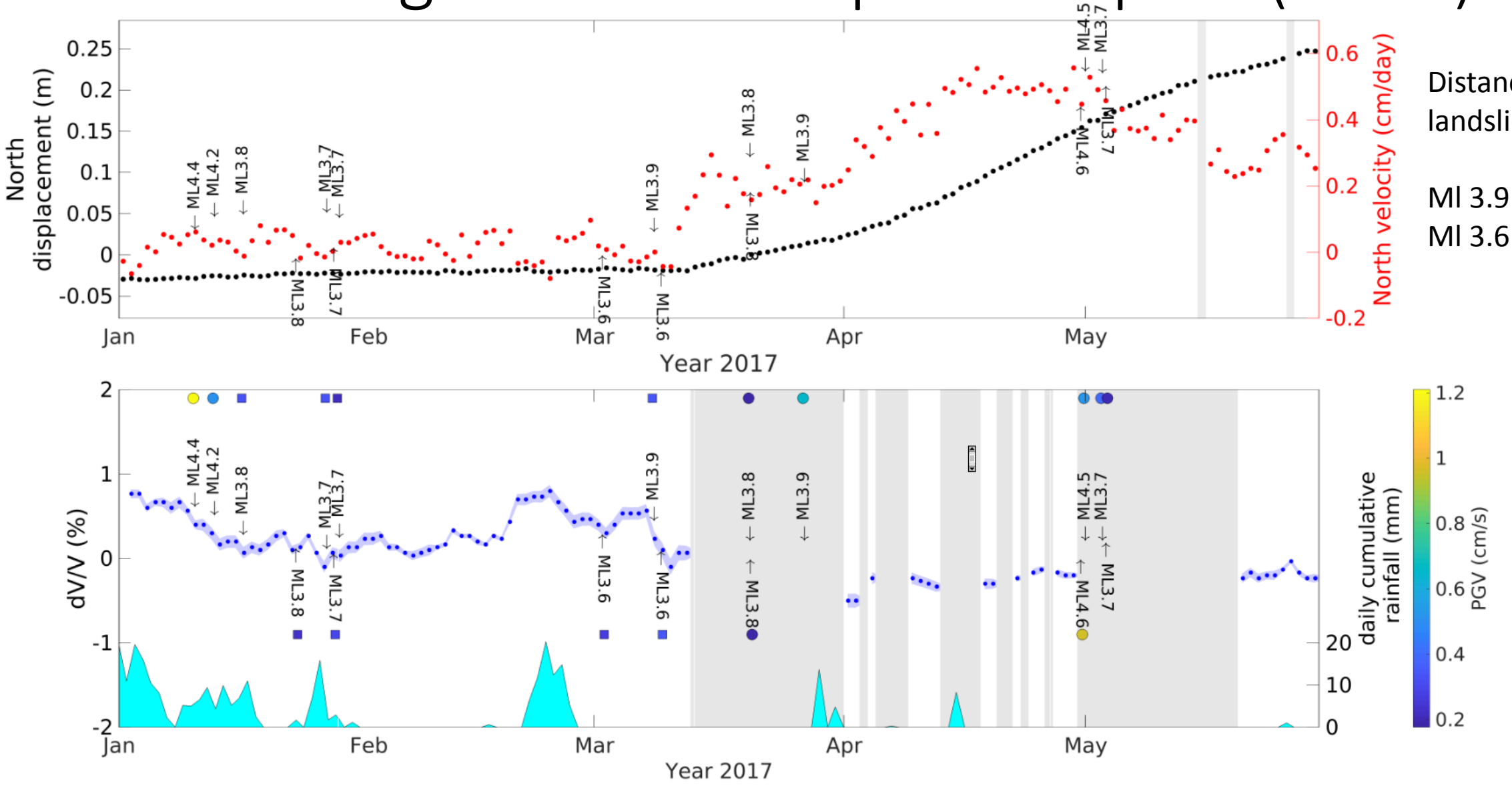


- Combined effect of precipitation and earthquake observable with GPS



- Co-seismic drop of the seismic surface wave velocity
  => decrease of the rigidity
- Long term effect of precipitation following a strong shaking event

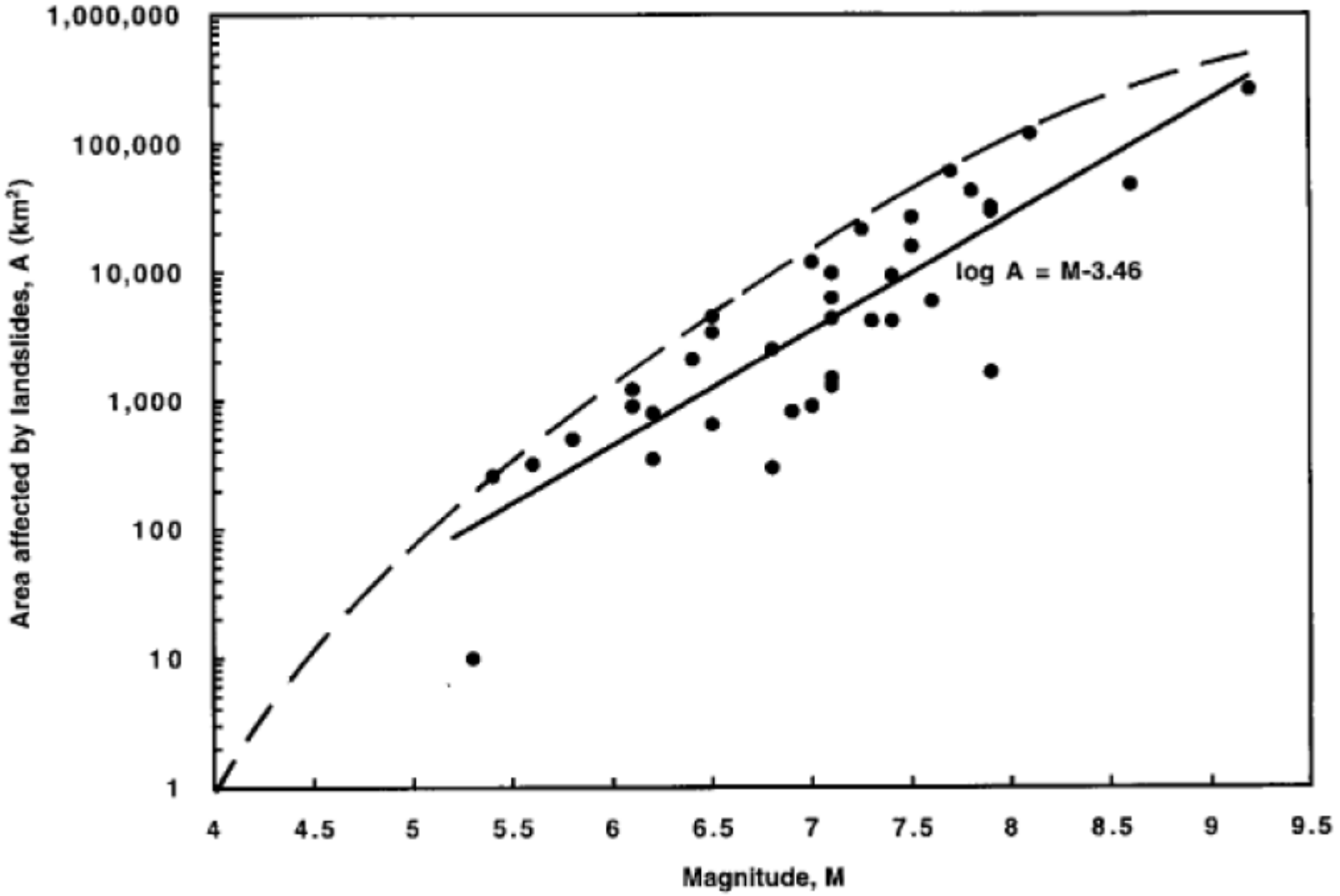
Small magnitude earthquake impact (Ml<4)



Distance source – landslide :

Ml 3.9 => 7km
Ml 3.6 => 3.5 km

Small magnitude earthquake impact (Ml<4)



- Keefer (1984) and Keefer and Wilson (1989).

Conclusions

- We can see a combination of earthquake and precipitation from GPS time-series
- acceleration of the landslide following low magnitude earthquakes (Ml<4)
- One possible mechanism at the origin is the damage of the soil that ease the way of precipitation into the ground

Thank you for your attention