Ambient seismic noise monitoring:

an online application for decision makers;

example of various applications for different slopes configurations.

Alexandra Royer[1], Mathieu Le Breton[2], Antoine Guillemot[2], Noélie Bontemps[2], **Eric Larose**[2], Laurent Baillet[2], Denis Jongmans[2], Fabrice Guyoton[1], Michel Jaboyedoff[3], and Raphael Mayoraz[4]

[1]Geolithe, 181 rue des Bécasses – 38920 CROLLES – FRANCE
[2]Université de Grenoble & CNRS, ISTerre - GRENOBLE, France [3]Institut des Sciences de la Terre, Uni Lausanne, Suisse
[4]SFCEP, Canton du Vallais, Suisse
(eric.larose@univ-grenoble-alpes.fr)

[1] G. Mainsant, E. Larose, C. Brönnimann, D. Jongmans, C. Michoud, M. Jaboyedoff : *Ambient seismic noise monitoring of a clay landslide : toward failure prediction*, J. Geophys. Res. **117**, F01030 (2012).
[2] M. Le Breton, N. Bontemps, A. Guillemot, L. Baillet, E. Larose, Landslide Monitoring Using Seismic Ambient Noise Interferometry: Challenges and Applications, Earth Science Review (under review) (2020)

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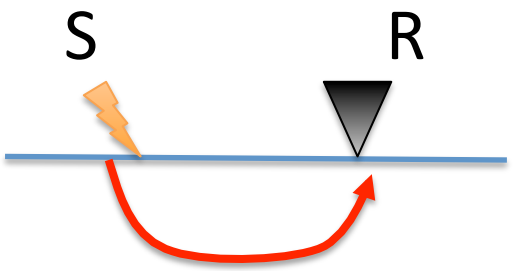

Time of flight

Seismic velocity $v = \sqrt{\frac{rigidity}{density}}$

- dV/V <0
  - > Increase of density (water content)
  - > decrease of stress (acousto-elasticity)
  - > **decrease of rigidity (fracturation/damage)**

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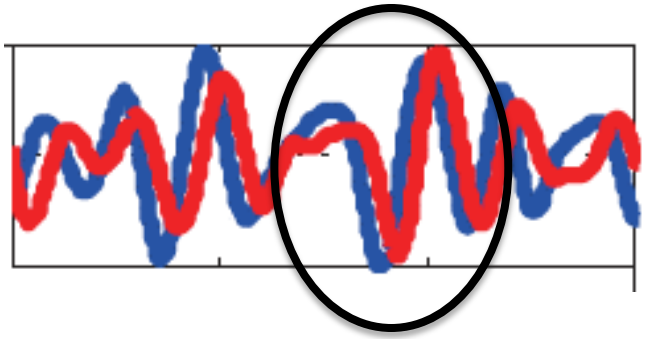
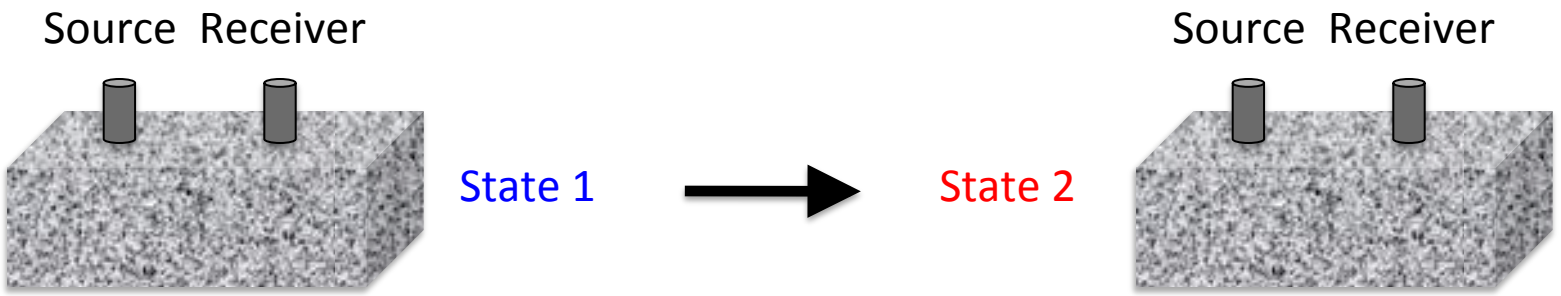
X-correlations-> 2 kinds of changes



1) Relative velocity changes $dV/V=-\tau/t$
   => global macroscopic change

2) Waveform decorrelation
   => Change of structure, geometry
   => fluid injection…



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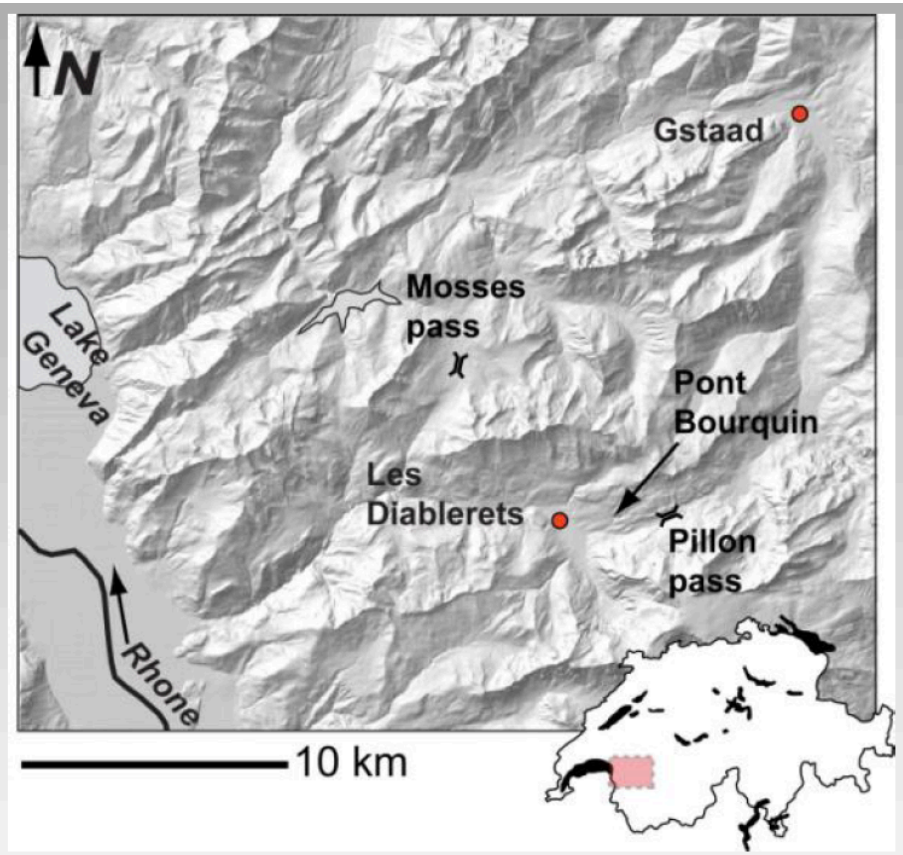
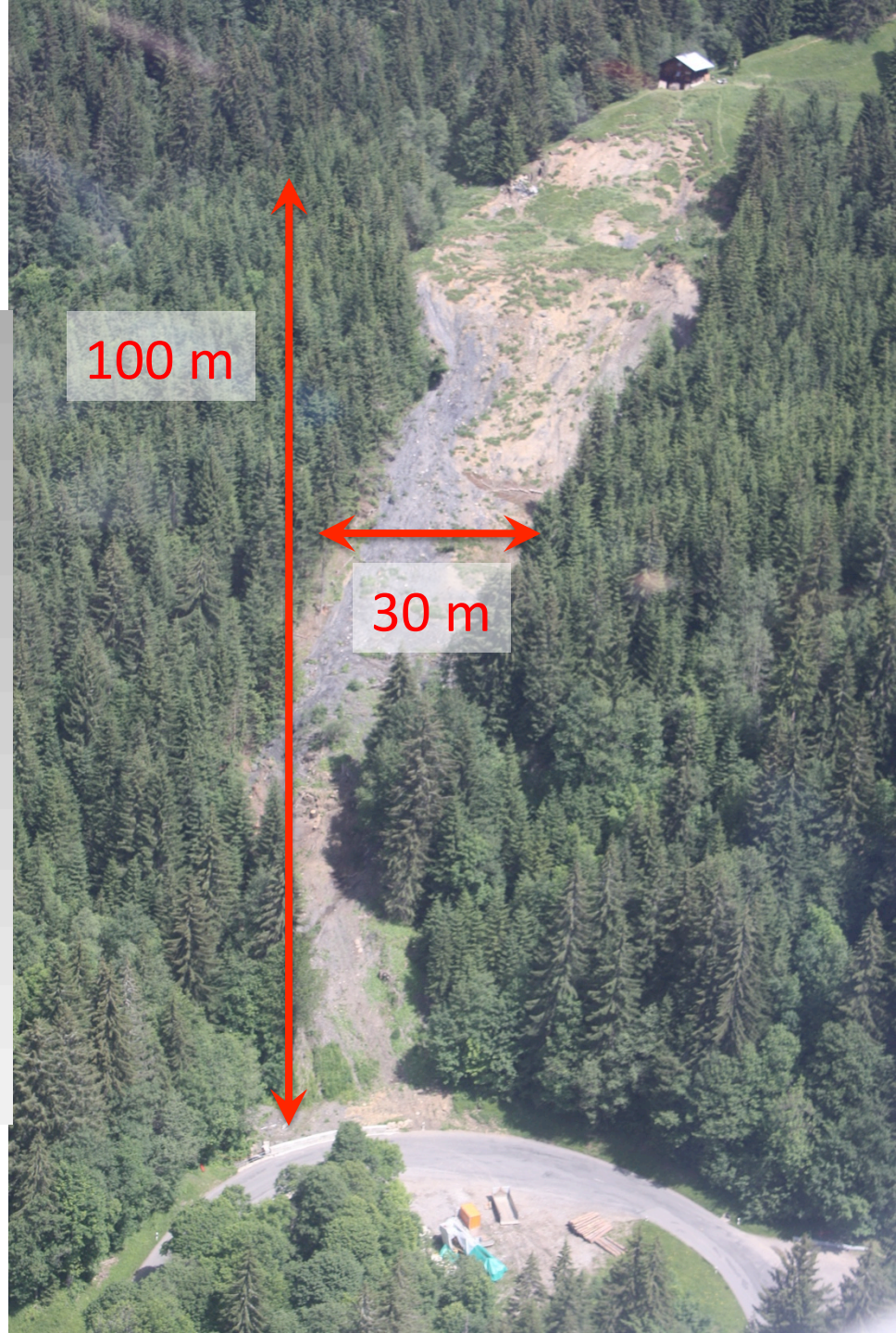
Les Diablerets (Suisse)





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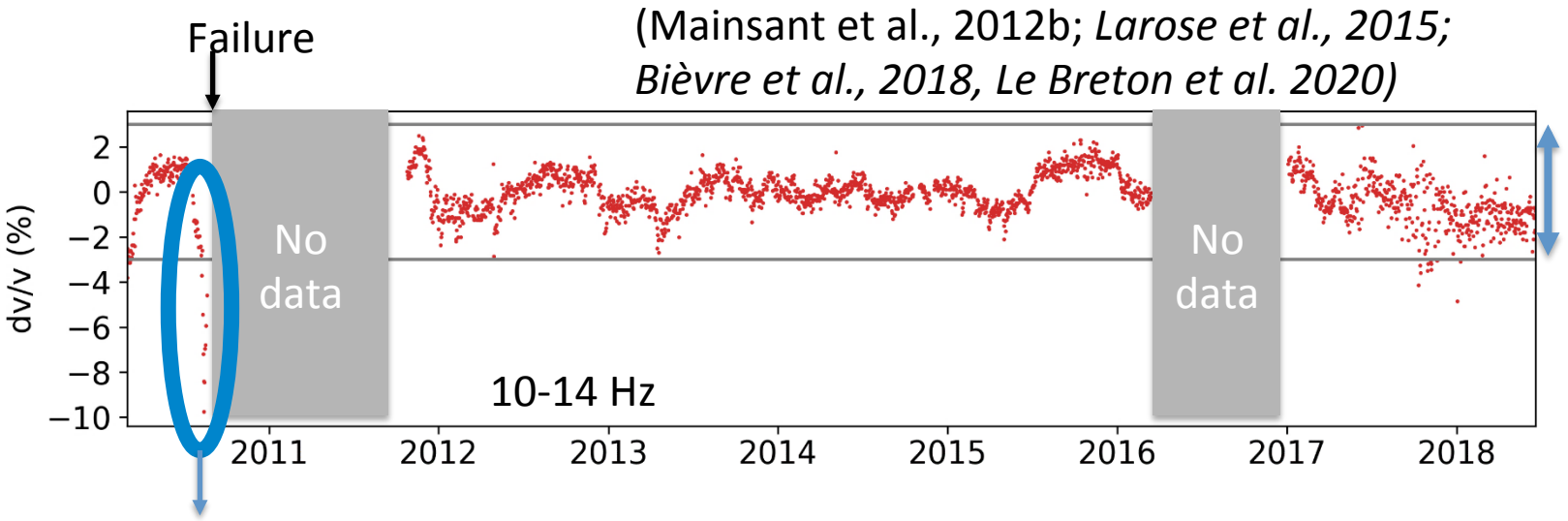

Precursor drop of dv/v observed five days before a major failure
No other major failure since 2010, and no major drop of dv/v

-> Is dV/V a systematic indicator for failure ?
-> What happens after the failure ?
-> role of rainfalls? Earthquakes ?

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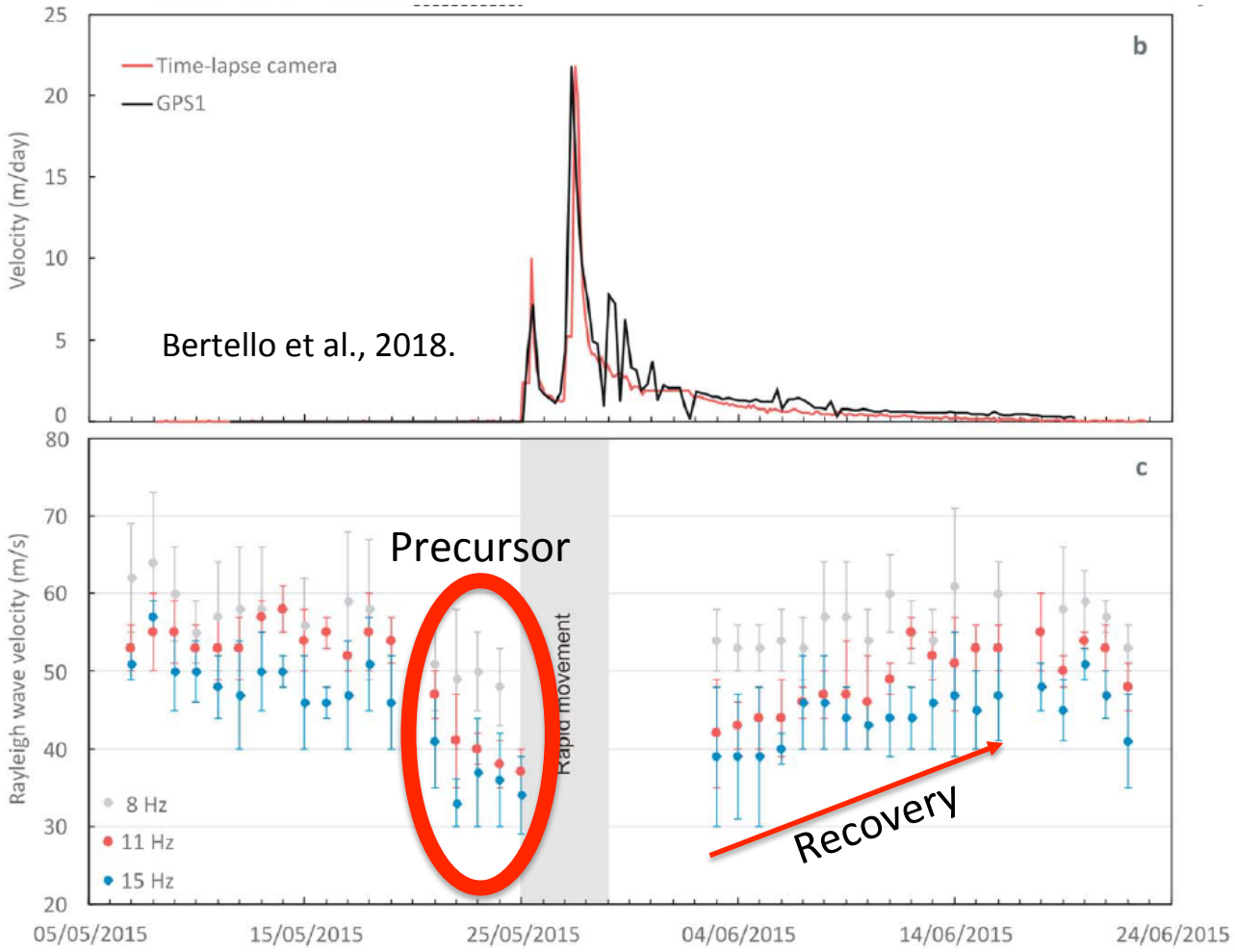
Montevecchio landslide, Italy

Bertello et al., 2018.

Montevecchio landslide, Italy



=> 4 days before the failure : dv/v dropped

=> After the failure : dv/v slowly recovers

Maca landslide, Peru

Bontemps et al. 2020

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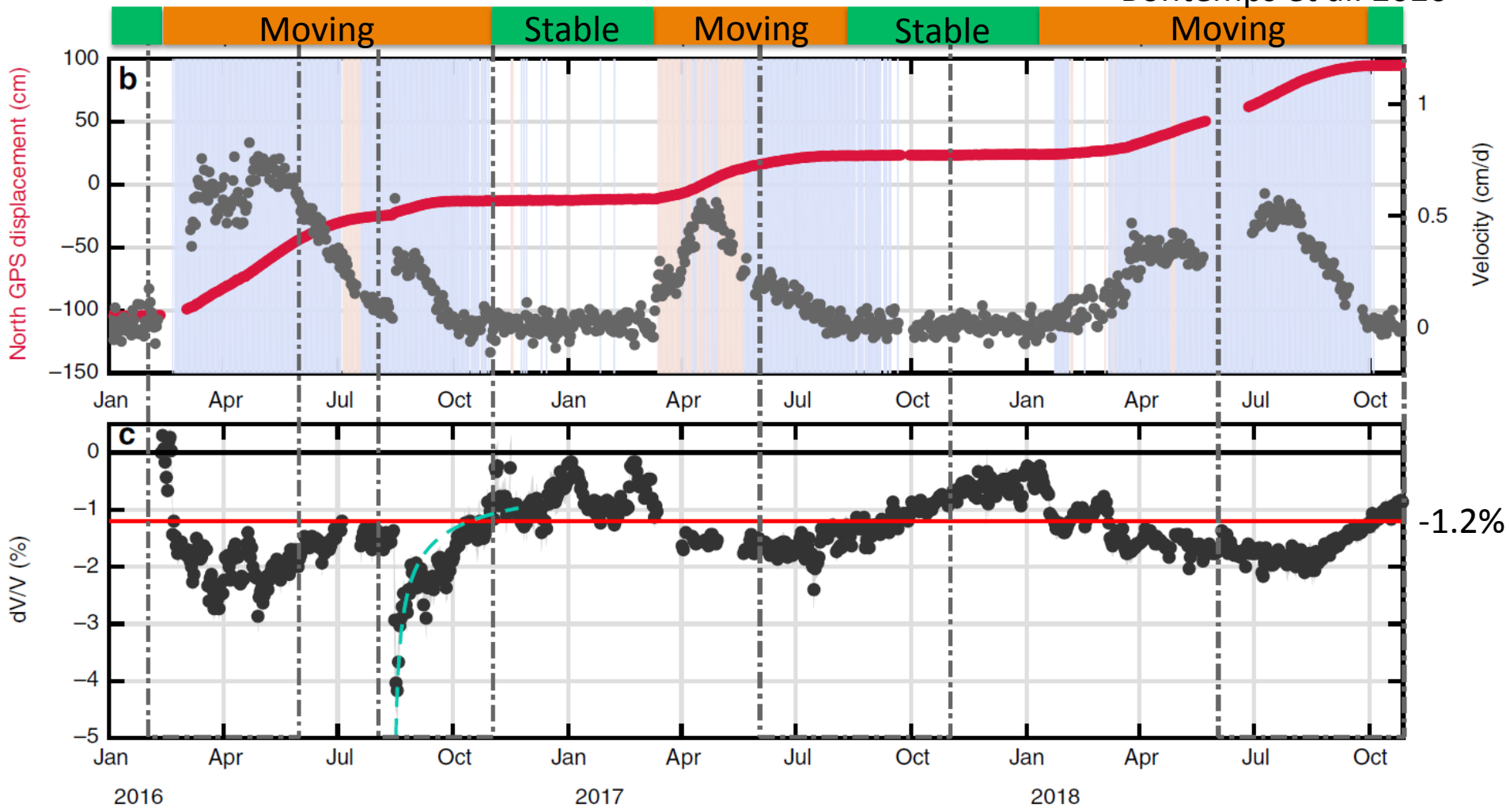
Maca landslide, Peru

Bontemps et al. 2020



⇒ The landslide moves when the dv/v < 1.2%

⇒ Motion is triggered by Earthquake + Rainfall

⇒ dv/v slowly recovers after the failure

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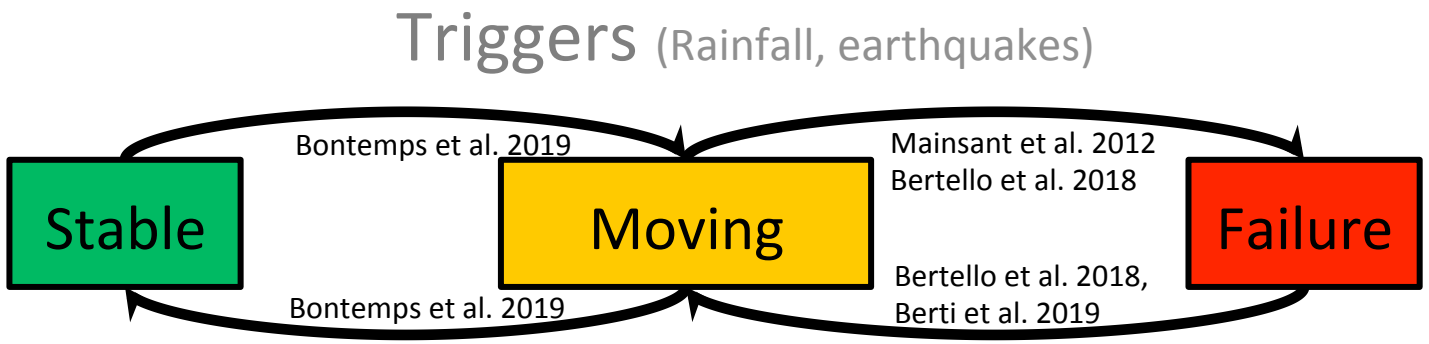
Synthesis : three states of stability observed

The transition between states happens when the dv/v crosses a threshold



Le Breton et al. 2020

dv/v, an indicator of landslide stability…

⇒ Before failure (precursor)

⇒ But also after the failure (recovery)

Question : is the dv/v also influenced by the environment ?

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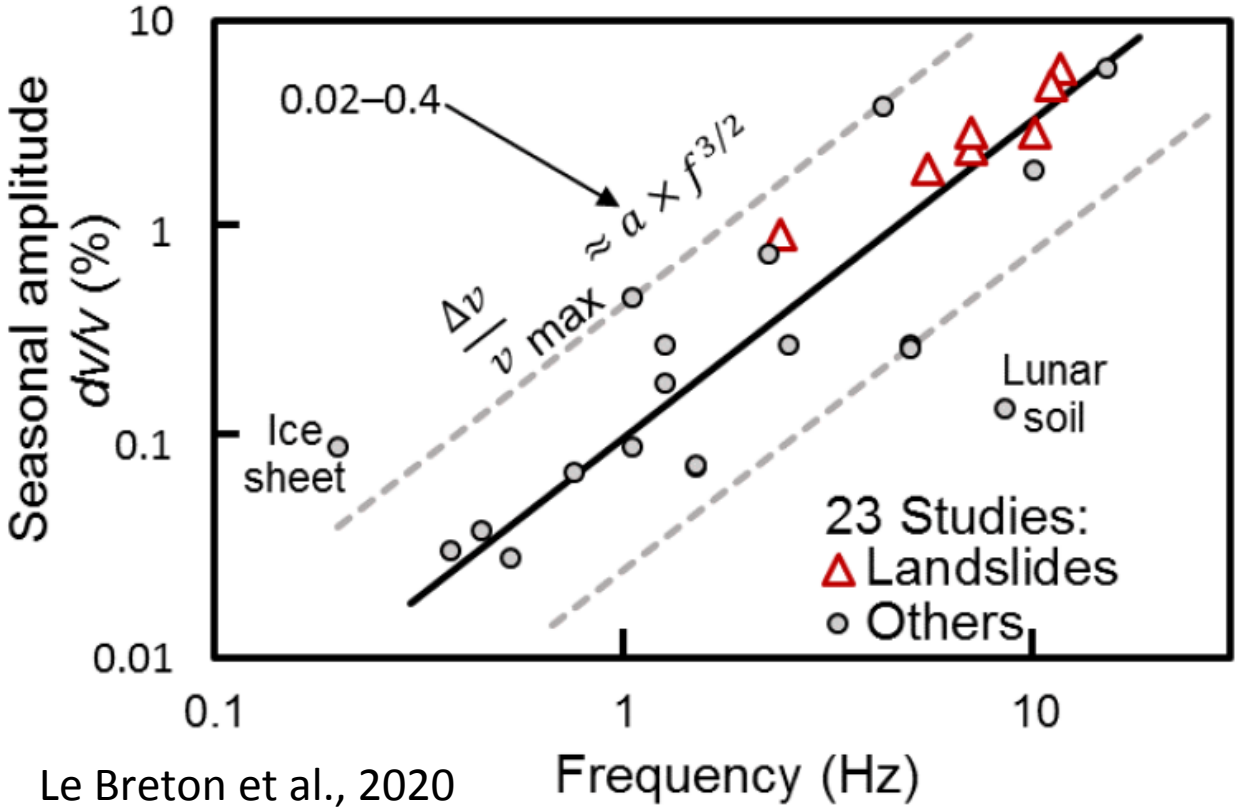
Seasonal amplitude of the dv/v



Le Breton et al., 2020

⇒ Dv/v fluctuates seasonaly, not only on landslides

⇒ Fluctuation amplitude depends on frequency (proxy to investigation depth)

⇒ The same processes may occur on landslides or on stable grounds

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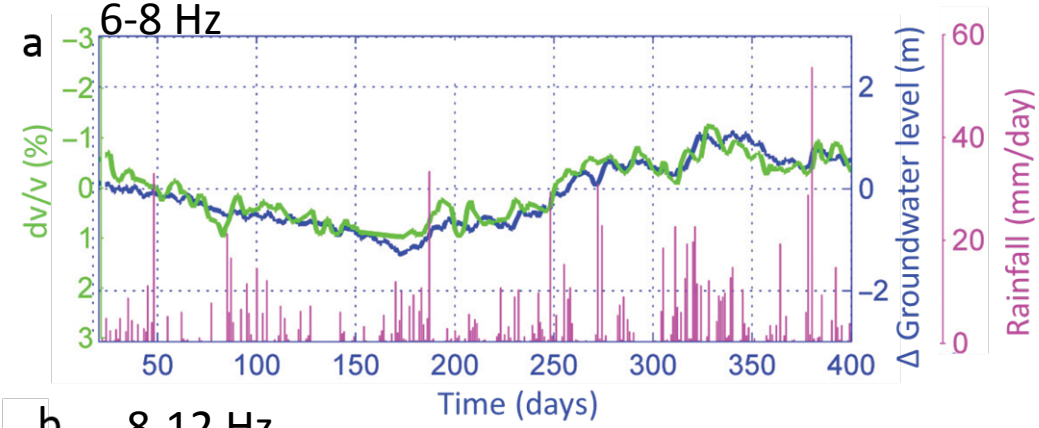
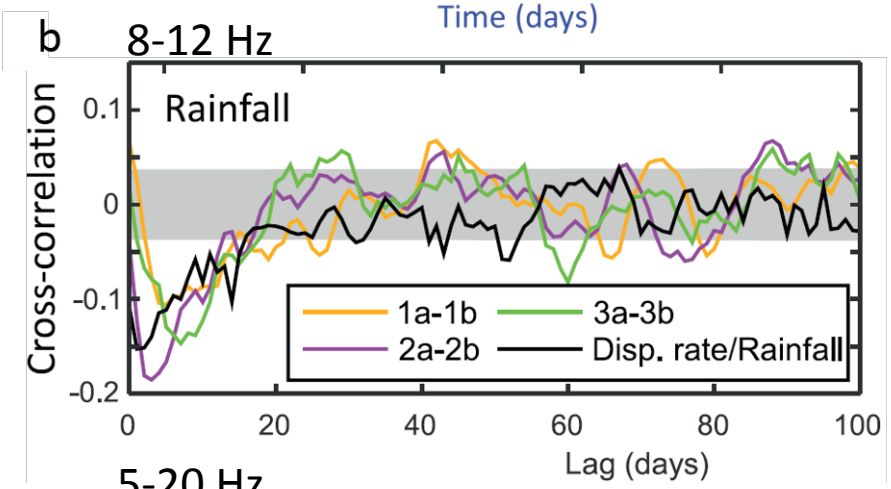
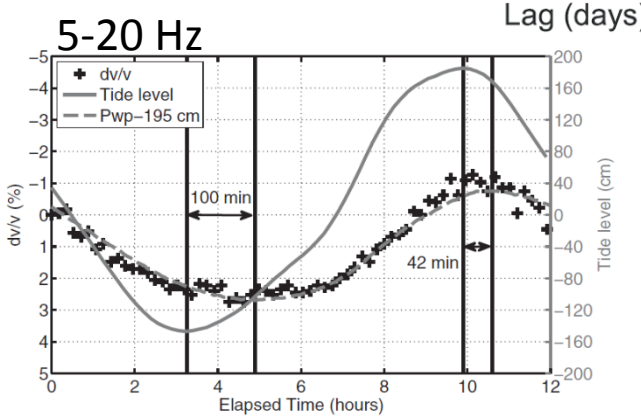
Influence of groundwater



Yearly negative correlation between groundwater and dv/v, on Utiku landslide (Voisin et al. 2016)



Rainfall is correlated with a negative peak of dv/v, on Pont-Bourquin landslide (Bièvre et al. 2018)



Groundwater level is negatively correlated, on a 12-hour periods, created by tides, on a coast (Planès et al., 2017)

=> Groundwater elevation has a major (negative) influence on the dv/v

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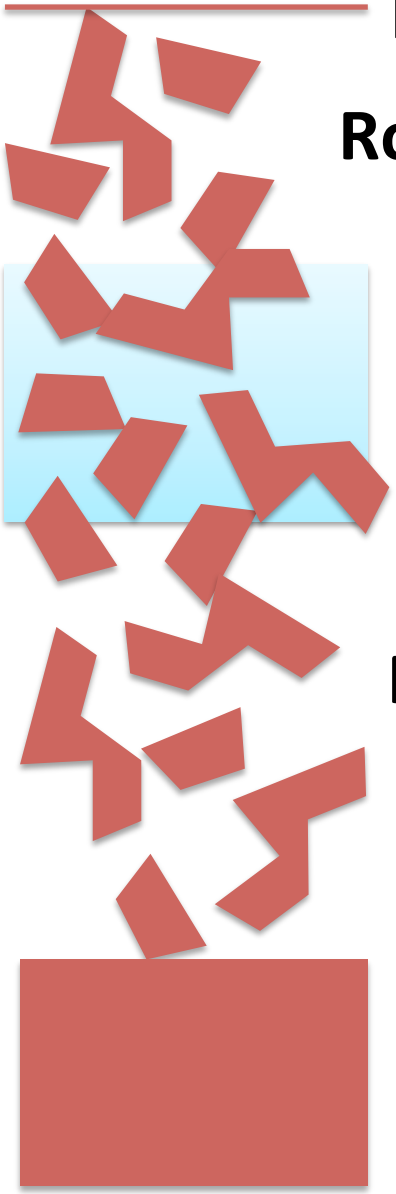
Rocky Glacier « Gugla » – Wallis (CH)

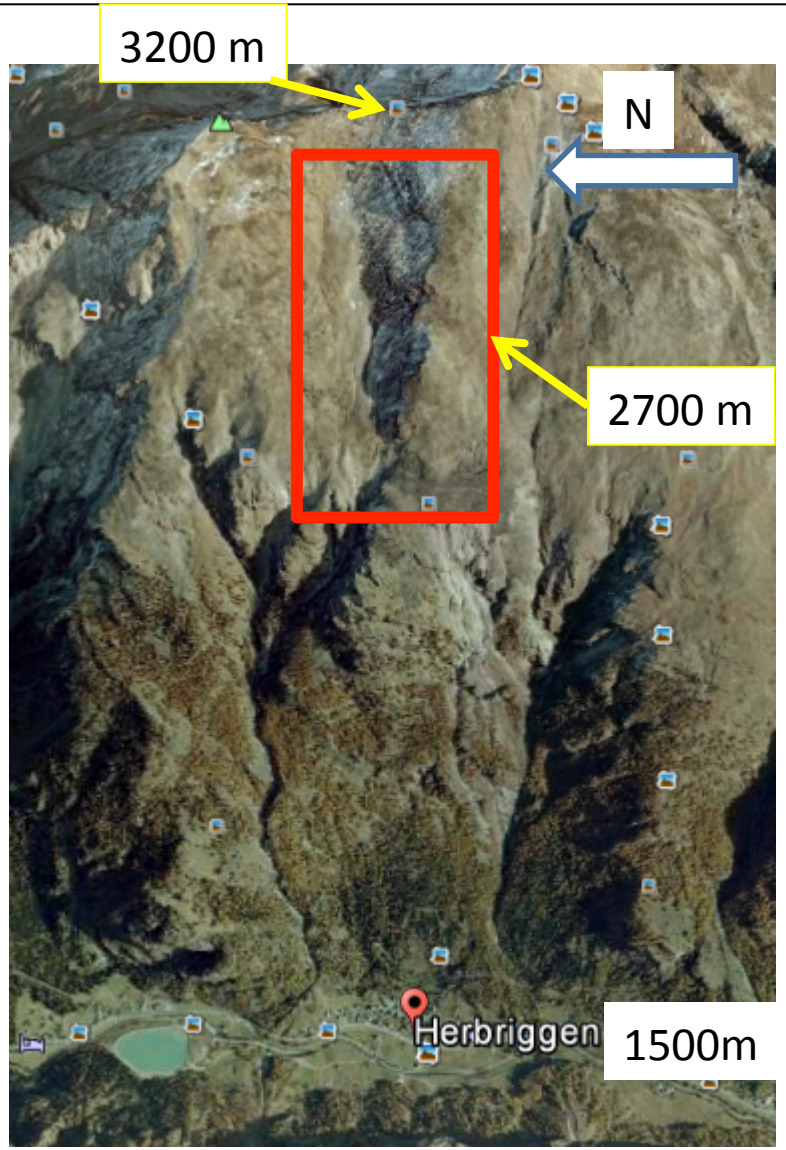


Rock+sand+clay

Ice

Rock+sand+clay

bedrock



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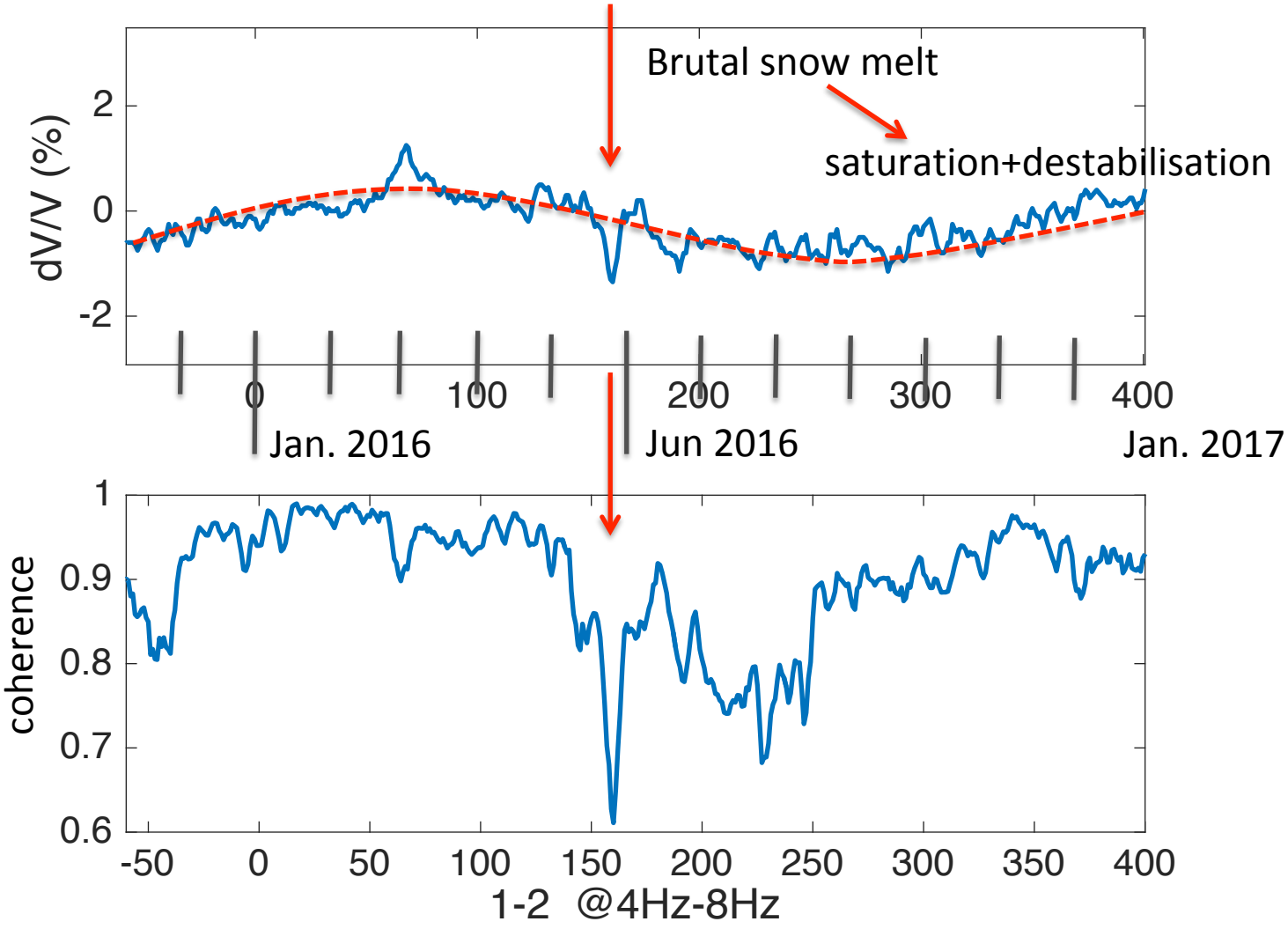
Permafrost monitoring



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Online monitoring application

In partnership with Geolithe and Geolithe Innov, engineers-consultants in geology, geophysics and geotechnical science, an online monitoring application is now available:

- Interactive visualization of data for comparison
- Updated data every day/hour
- Alert by email/sms
- Possibility to map sensors and visualize data on 4D model with Rimnat®

http://app.surveillance-geolithe.fr
http://rim-nat.fr

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Online software for processing and visualization

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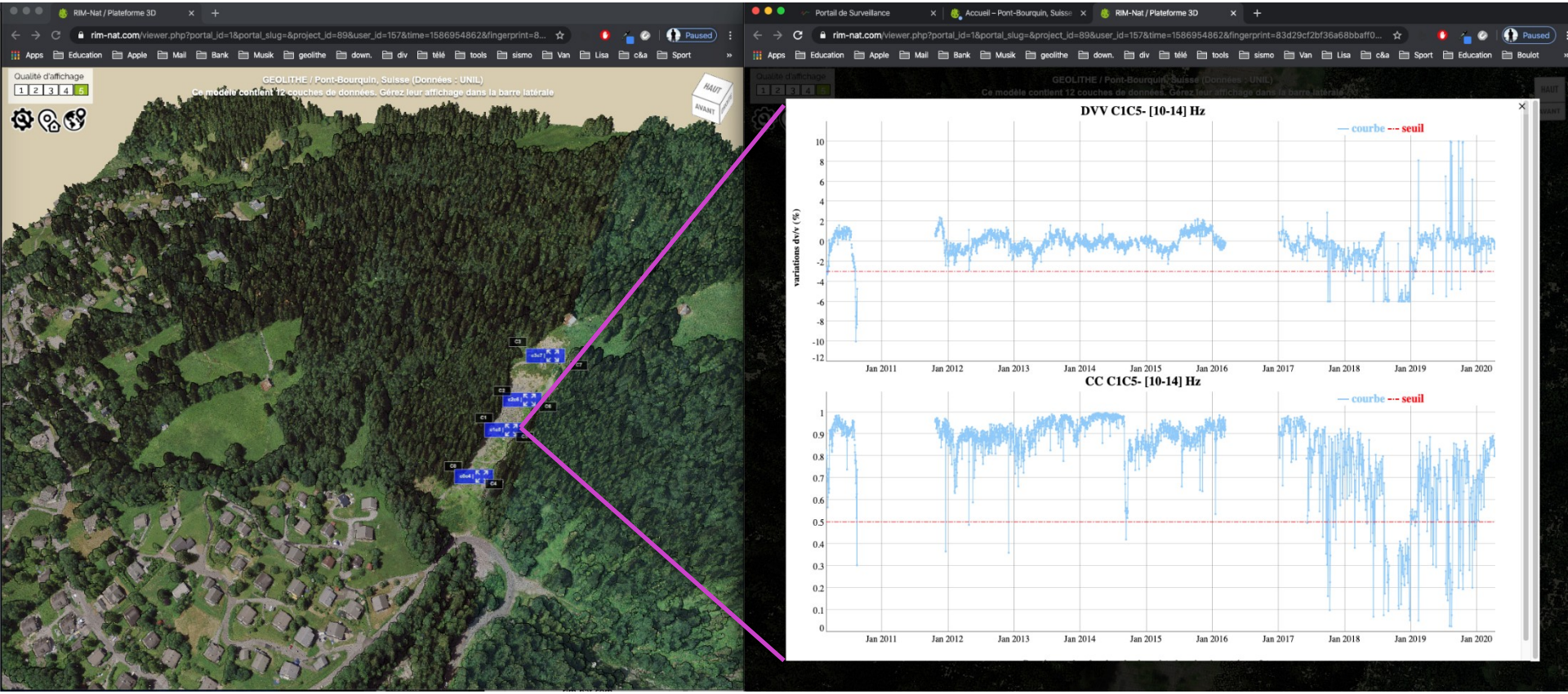
Visualization of the data on a DEM



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dv/v ⇔ landslide displacement

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