Spatiotemporal ICA/PCA decomposition of optical displacement field stacks: perspective for landslide time series inversion

Floriane Provost[1,2], Jean-Philippe Malet[3]
1. Université de Laval, Québec, Canada
2. ESA/ESRIN, Frascati, Italy
3. CNRS/EOST, Strasbourg, France

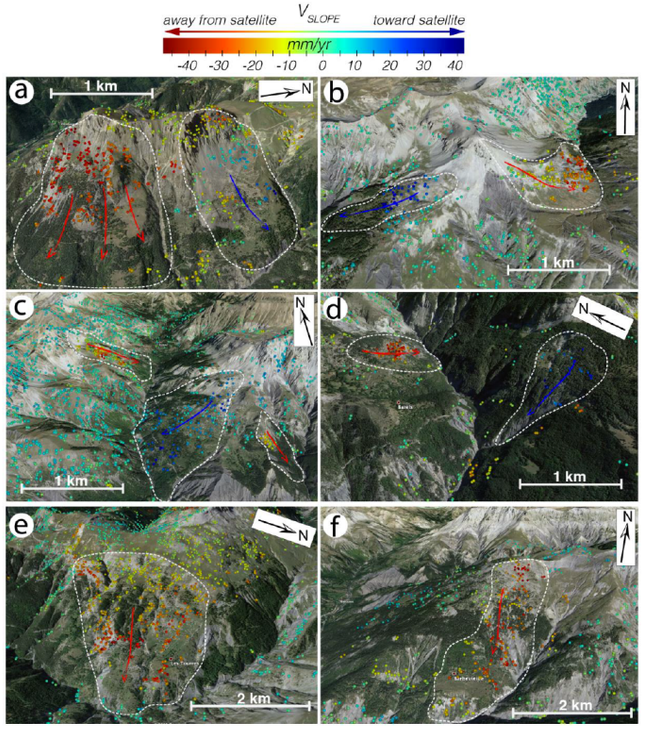
EGU 2021 - April 23, 2021

contact: floriane.provost.1@ulaval.ca

Motivation

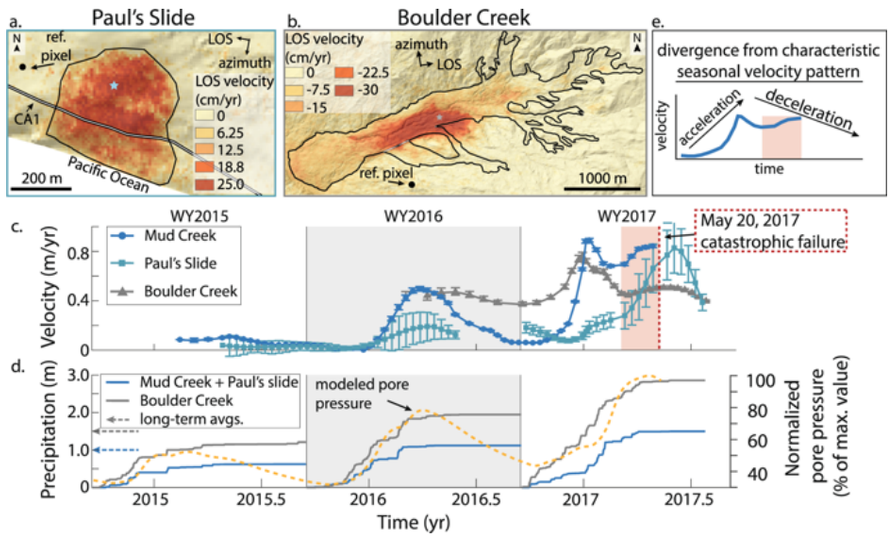
Ground motion monitoring *is key datasets for better understanding, modeling and forecasting geohazards such as* ***volcanoes, landslides or glaciers.***

landslide inventory regional detection



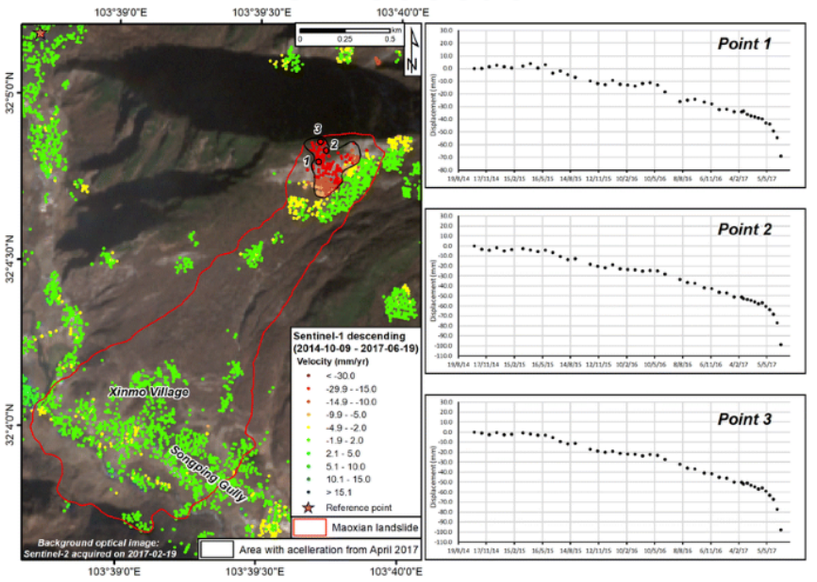
Ghokan et al., 2020

Understanding of the mechanisms controlling the phenomena



Handwerger et al., 2019

Risk management and risk reduction



Kang et al., 2019

local

regional

Ground motion monitoring

Two main techniques *allow to measure ground deformation from satellite acquisitions:*

InSAR



- **Sensitive to motion in the LOS** i.e. sensitive to EW and vertical motion. Poorly sensitive to NS motion.
- Millimetric accuracy.
- **Monitoring of very small (mm) to cm motion**. In case of larger motion, decorrelation usually prevents to monitor the deformation.
- Non sensitive to cloud cover.
- **Only for Radar acquisitions.**

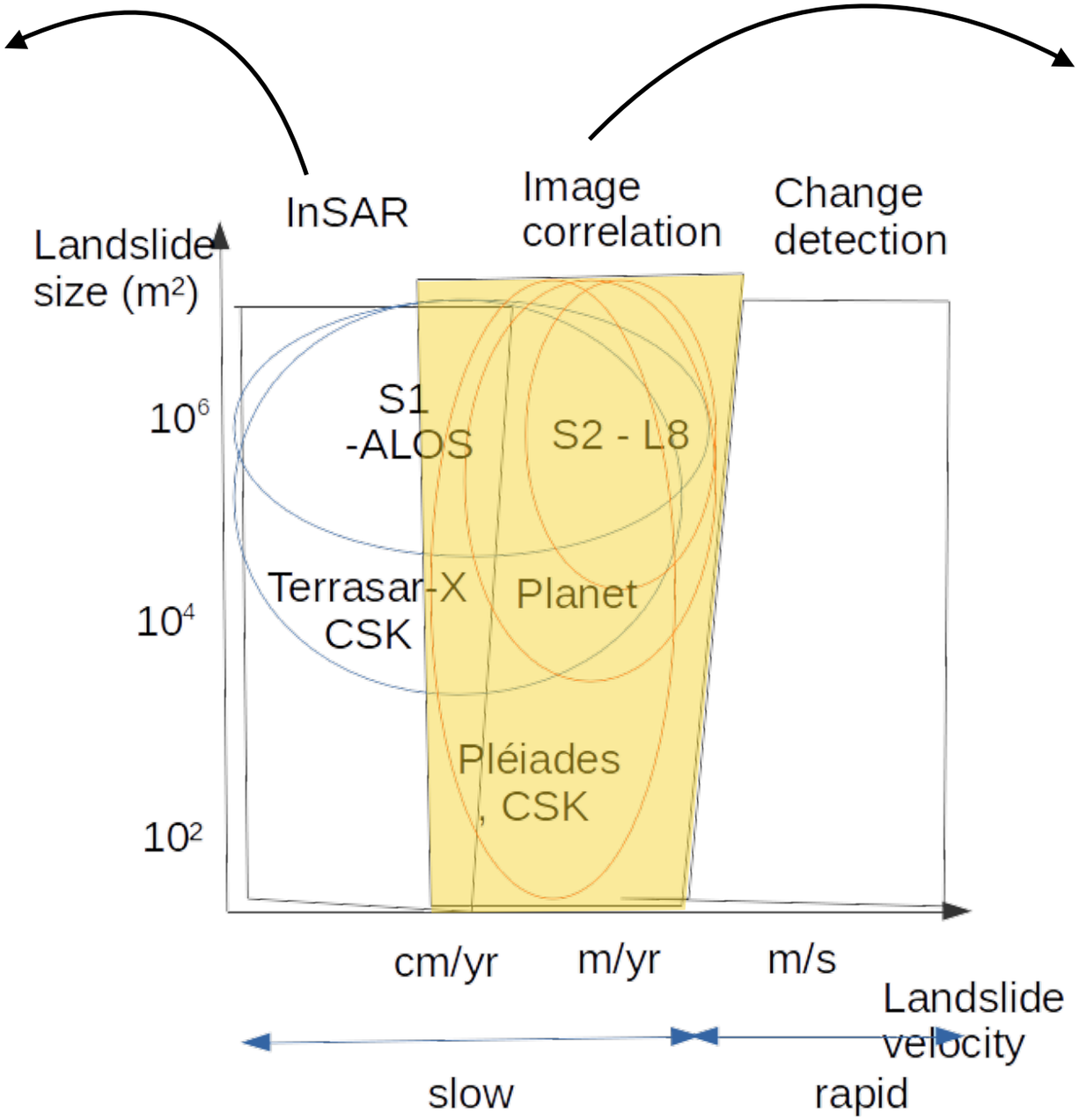
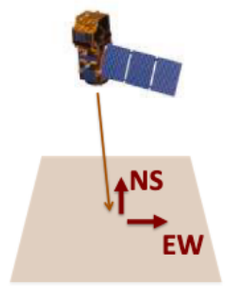


Image correlation

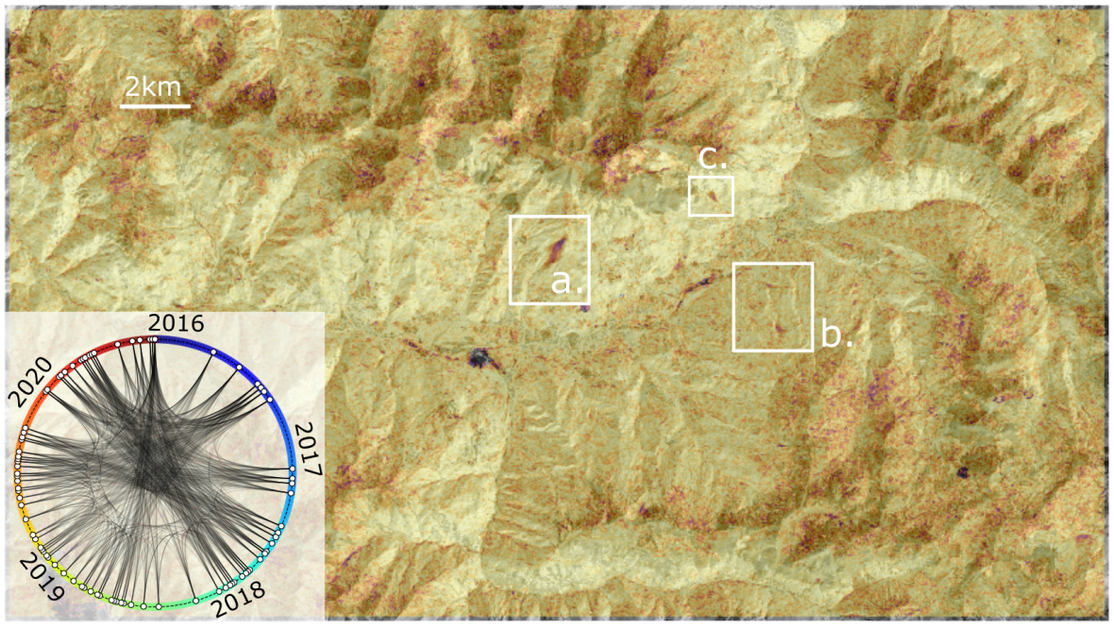


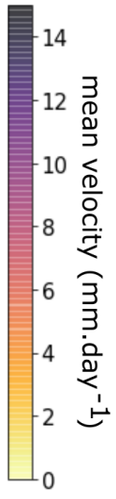
- **Sensitive to horizontal movement**, poorly sensitive to vertical motion.
- Sup-pixel accuracy(in general metric to cm).
- **Monitoring of large movement (metric)**. Smaller movement can also be measured depending on satellite pixel size.
- Sensitive to cloud cover.
- **For Radar or Optical acquisitions.**

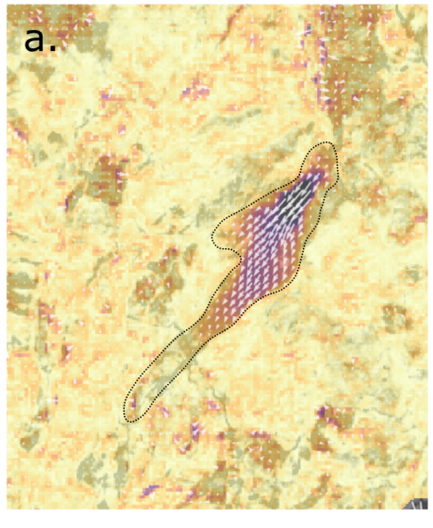
Optical image correlation

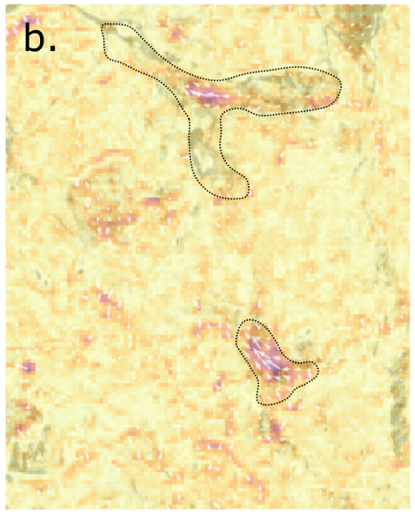
Detection of landslide at regional scale with MPIC-OPT-Slide *a service for optical image correlation*

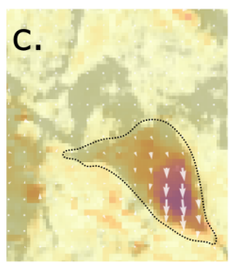
- **Example of the Ubaye valley (French Alps) using the 2015-2020 Sentinel-2 archive:**







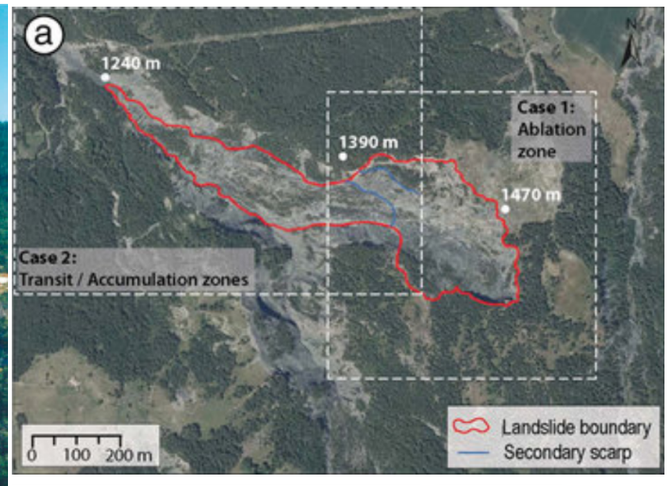




a. La Valette



b. Poche





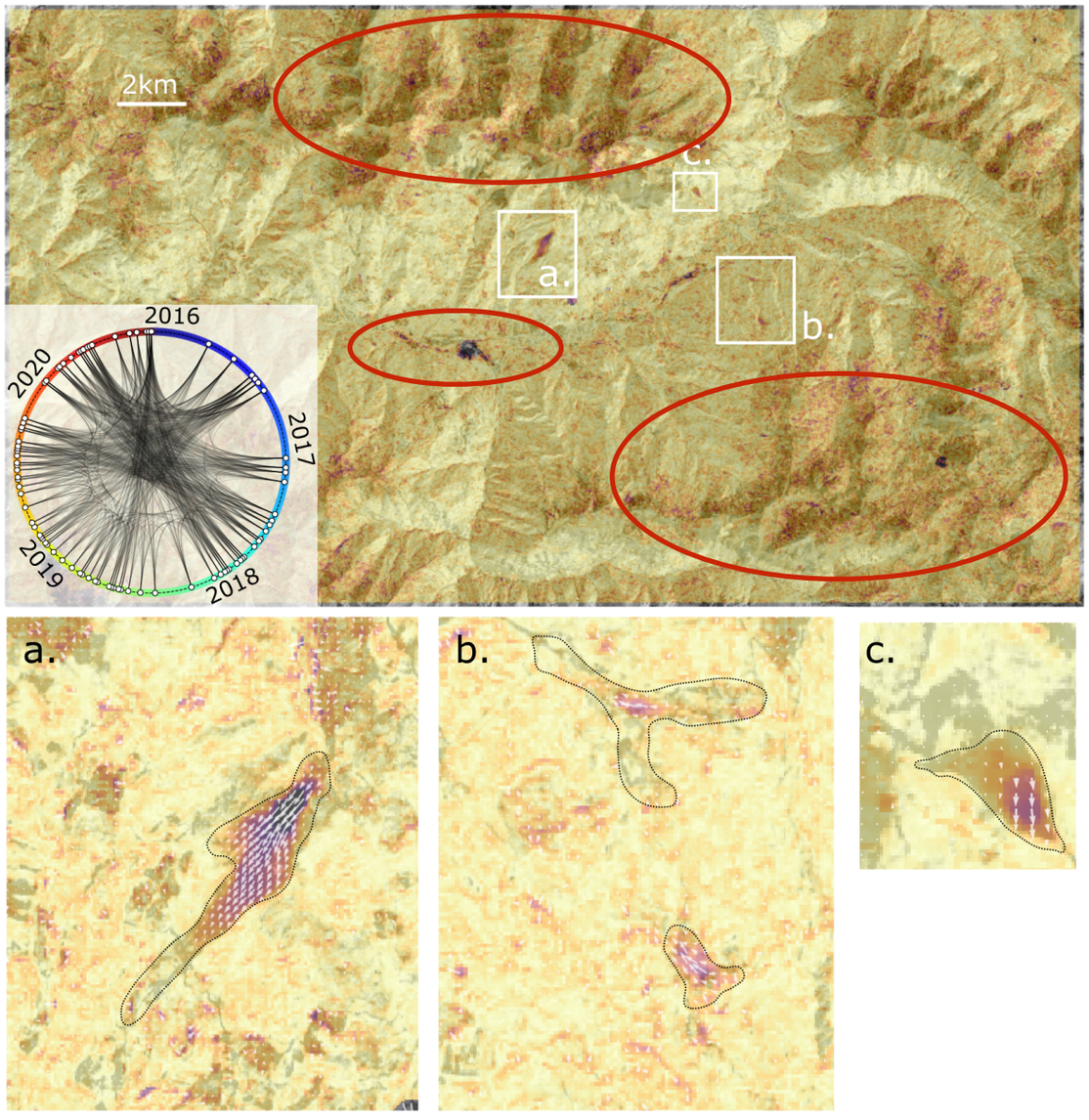
c. Sannières

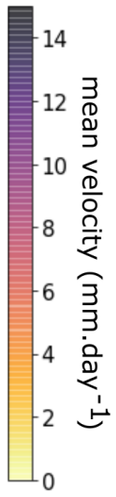
Main landslides can be monitored with Sentinel-2 2015-2020 archive…

Optical image correlation

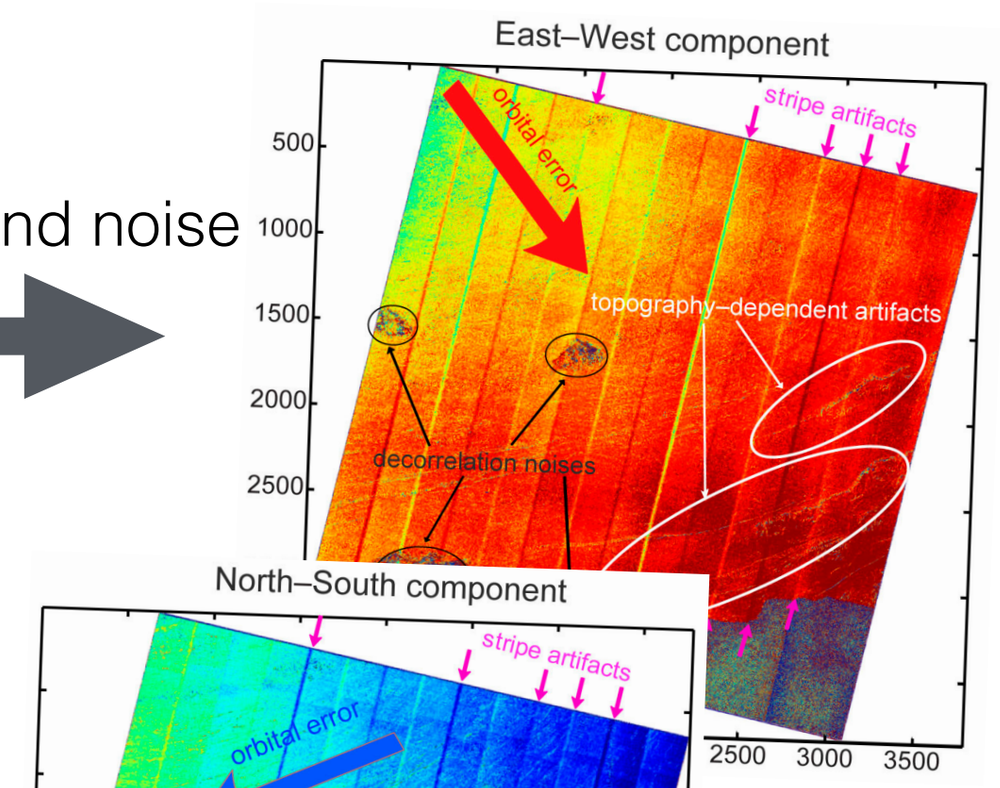
Detection of landslide at regional scale

- **Example of the Ubaye valley (French Alps)**





error and noise



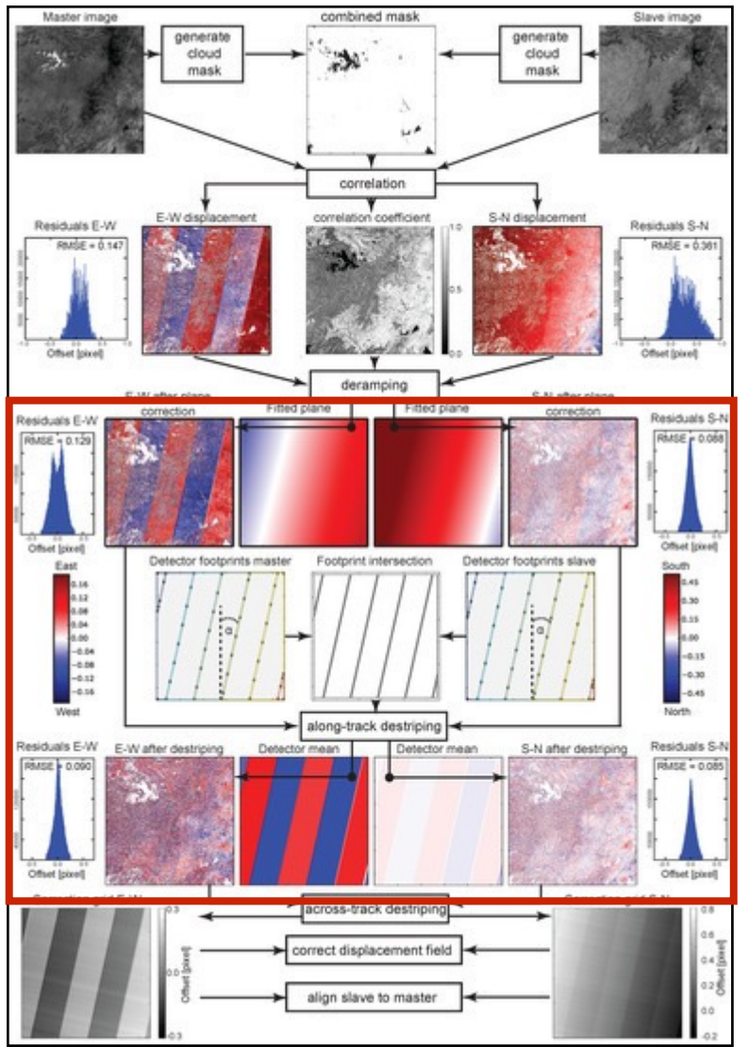
Ding et al., 2016

… Presence of noise and error preventing automatic and robust detection of active slopes

Independent Component Analysis

Current strategy to correct errors vs. ICA/PCA analysis

Masking

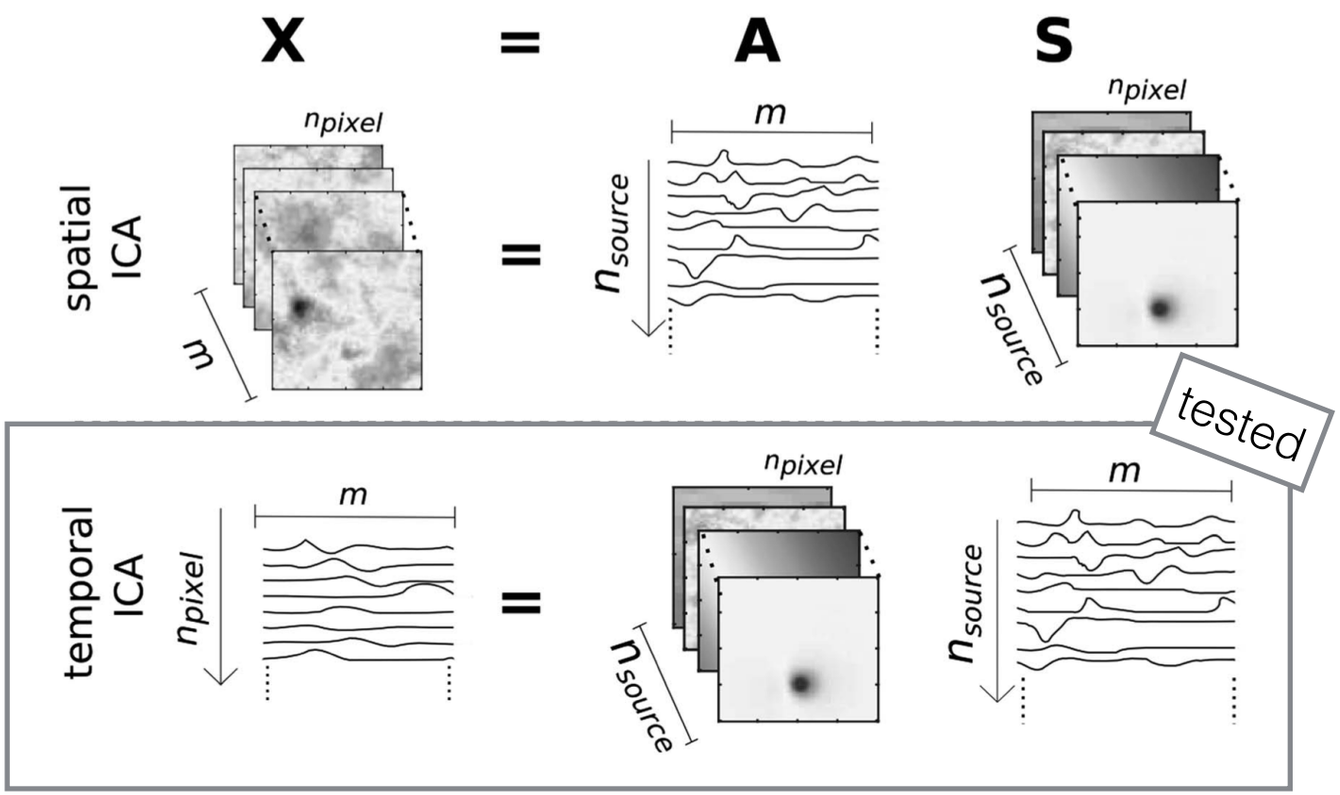


Corrections

Correlation

Robust and efficient for the main sources of error (ramp, stripes) but inefficient for topographic artifacts

Independent Component Analysis

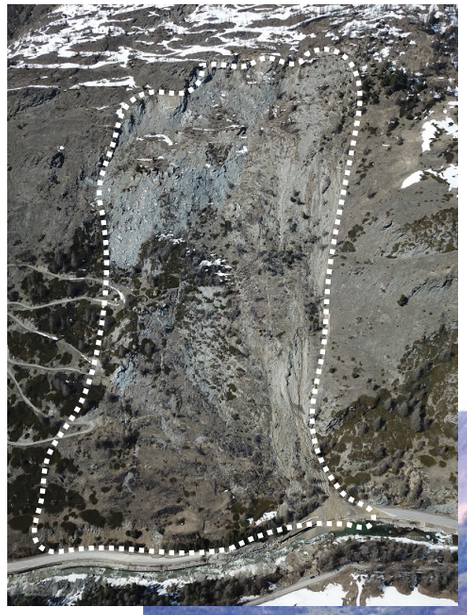


No *a priori* information
separation of independent sources in time or space

Method

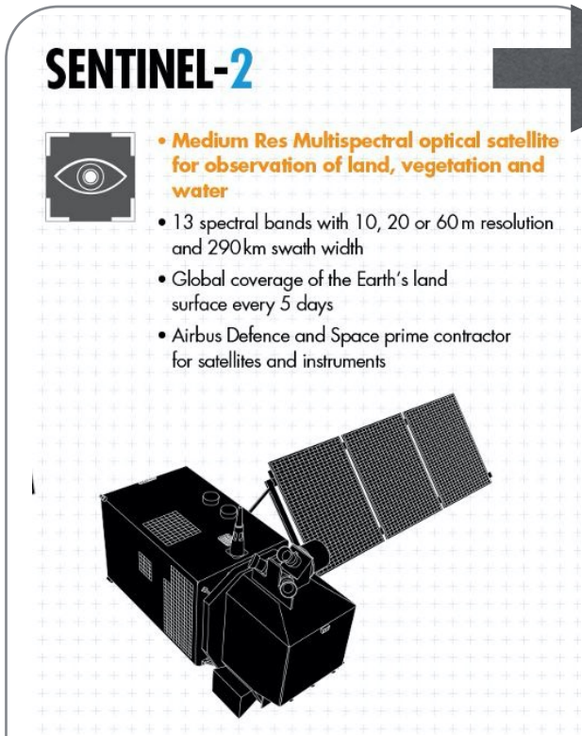
Study sites

Aiguilles (French Alps)



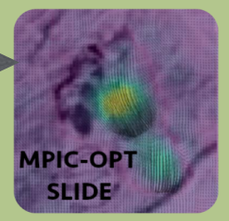


Data



all images of the 2015-2020 archive with a cloud cover < 20%

Image correlation algorithm



MPIC-OPT SLIDE

Tailored for landslide displacement monitoring with velocity from 10s cm/day to m/day with the current archive of Sentinel-2

Number of input images : 100 maximum

Two correlator : MicMac / GéFolki

Mult-temporal stack and detection of persistent motion

Outputs

displacement grids

mean velocity (from the stack of displacement grids)

mean velocity (from the time series inversion)

Independent Component Analysis

Analysis of the sources extracted from the t-ICA

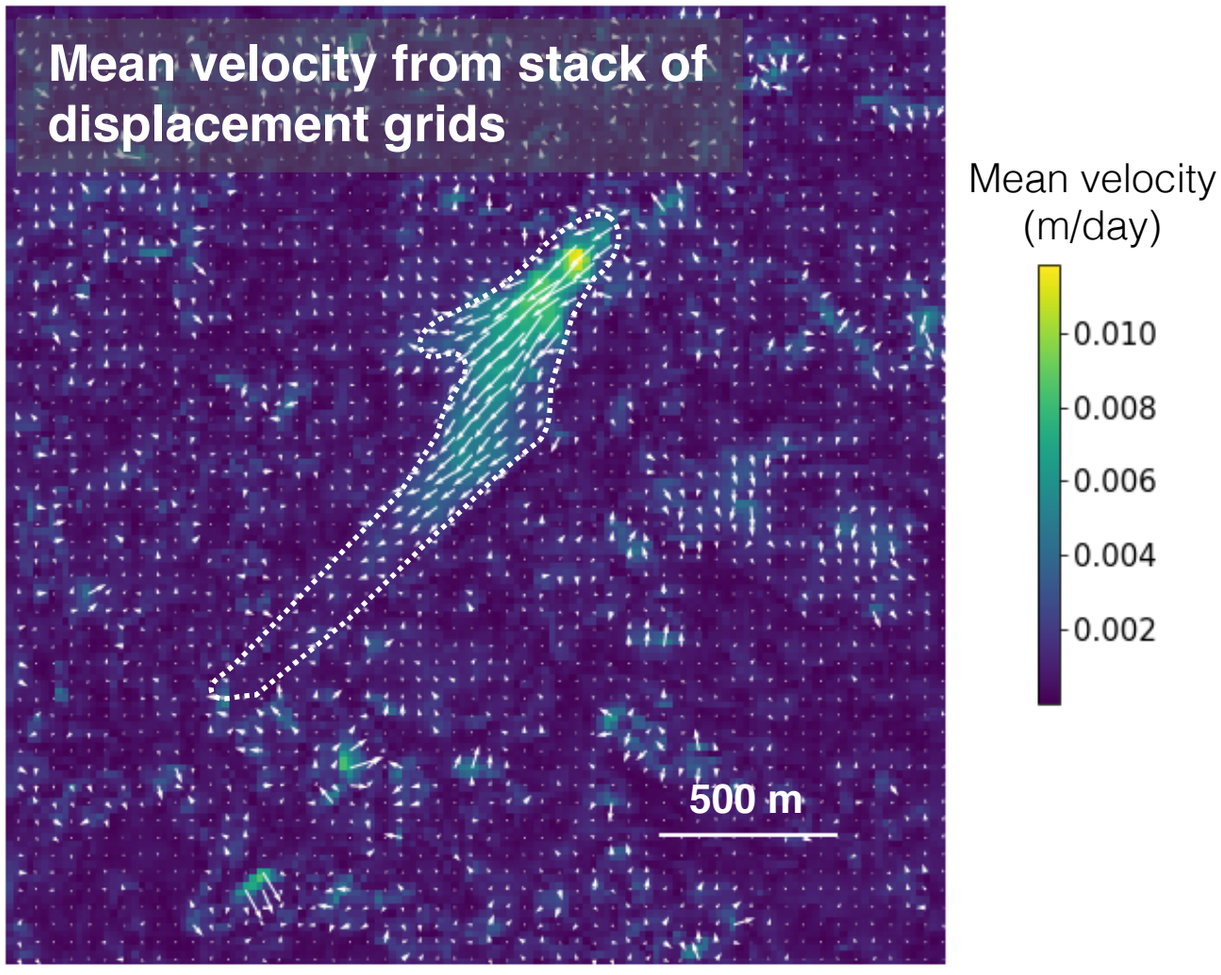
Reconstruction of the deformation pattern with the removal of sources of noise

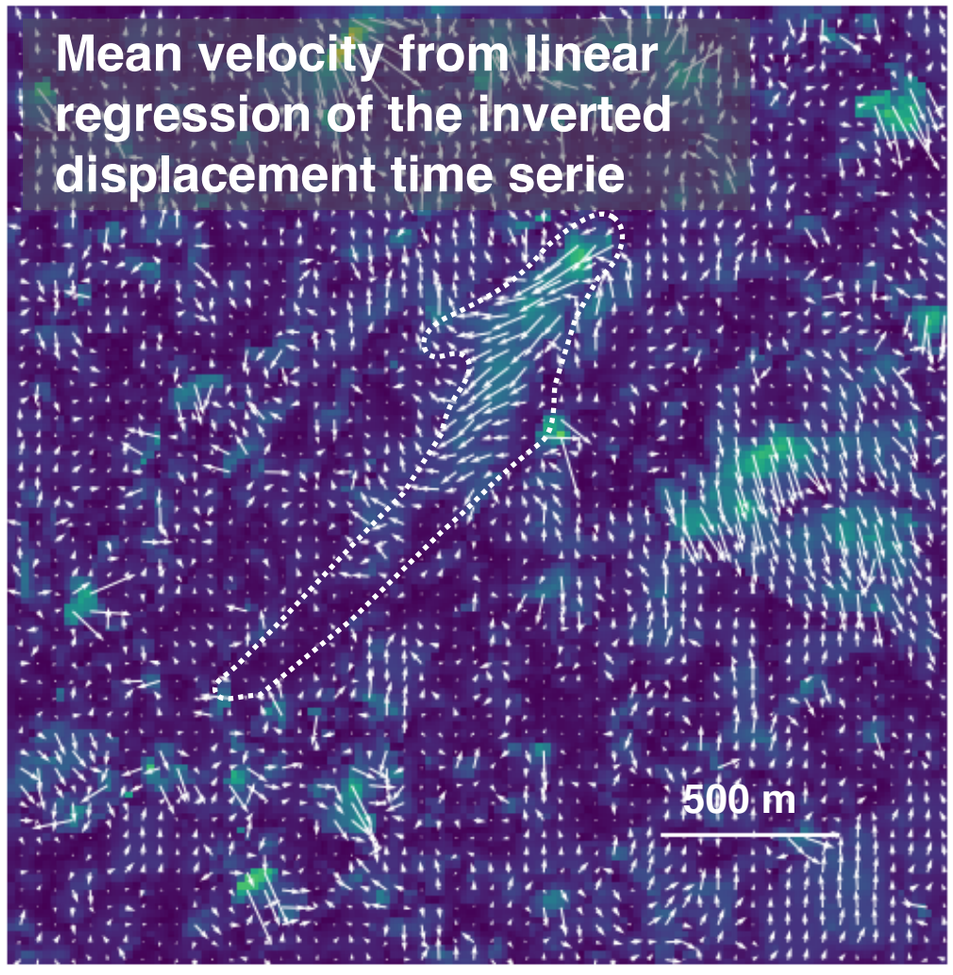
Site 1: Lavalette landslide



Results of the MPIC-OPT-SLIDE service:

Image correlation parameters
pair network : 500-1500 days
correlator: MicMac





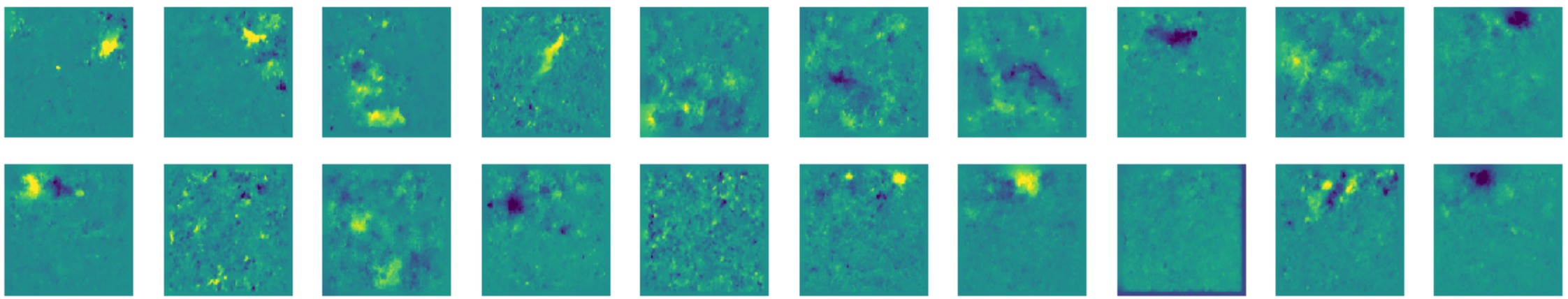
Site 1: Lavalette landslide



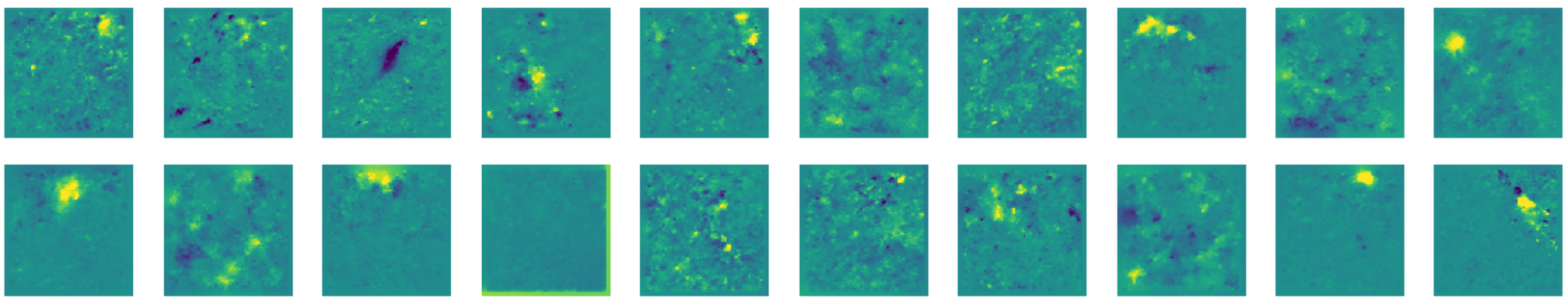
t-ICA décomposition:

Number of sources: 20 to set for the ICA decomposition
Number of displacement grids: 1612
Number of acquisition dates: 87

Sources for EW displacements



Sources for NS displacements





Site 1: Lavalette landslide



t-ICA décomposition:

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Sources for EW displacements

Sources

Sources corresponding to the landslide displacement
and selected to retrieve the displacement time serie

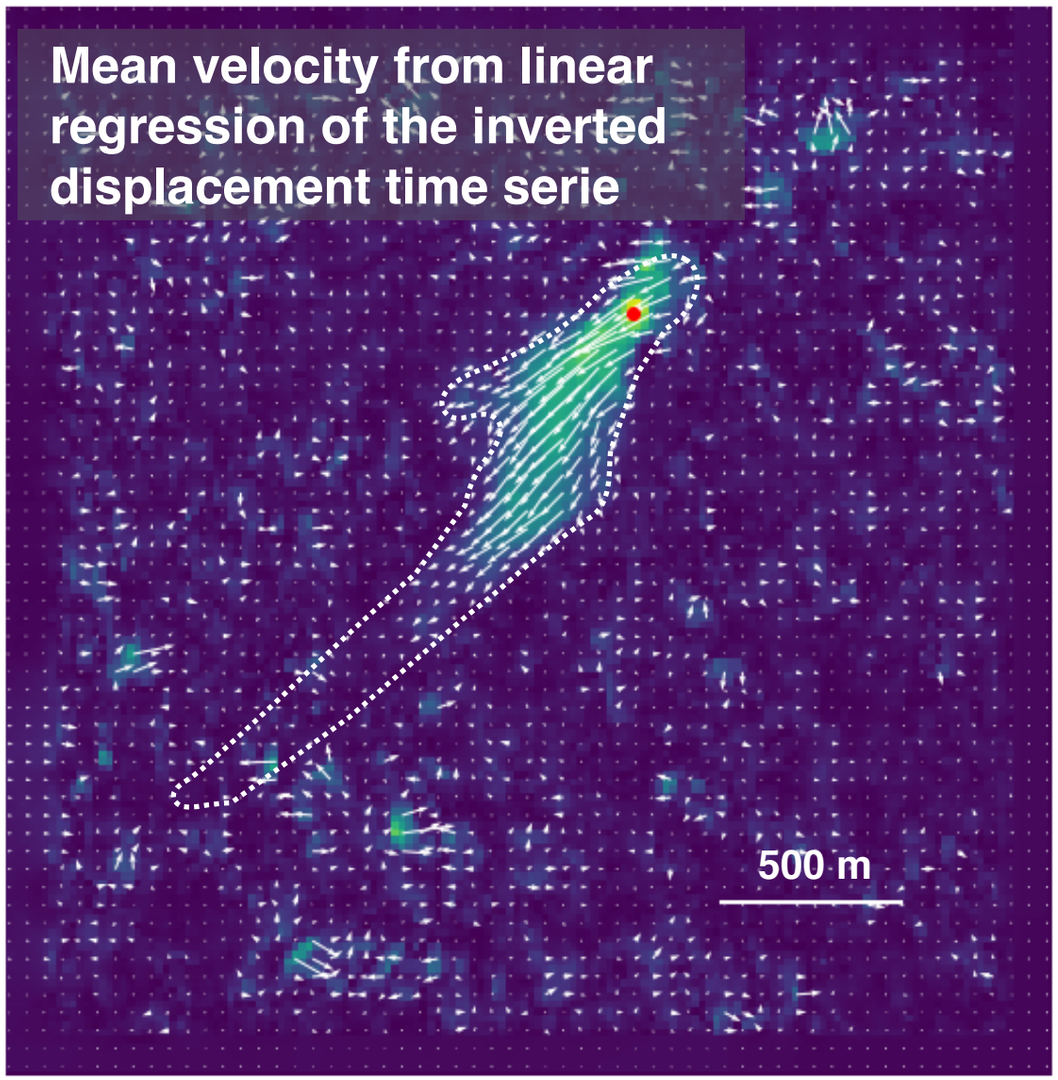
−0.02 0.00 0.02

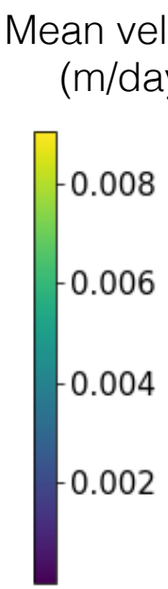
Site 1: Lavalette landslide

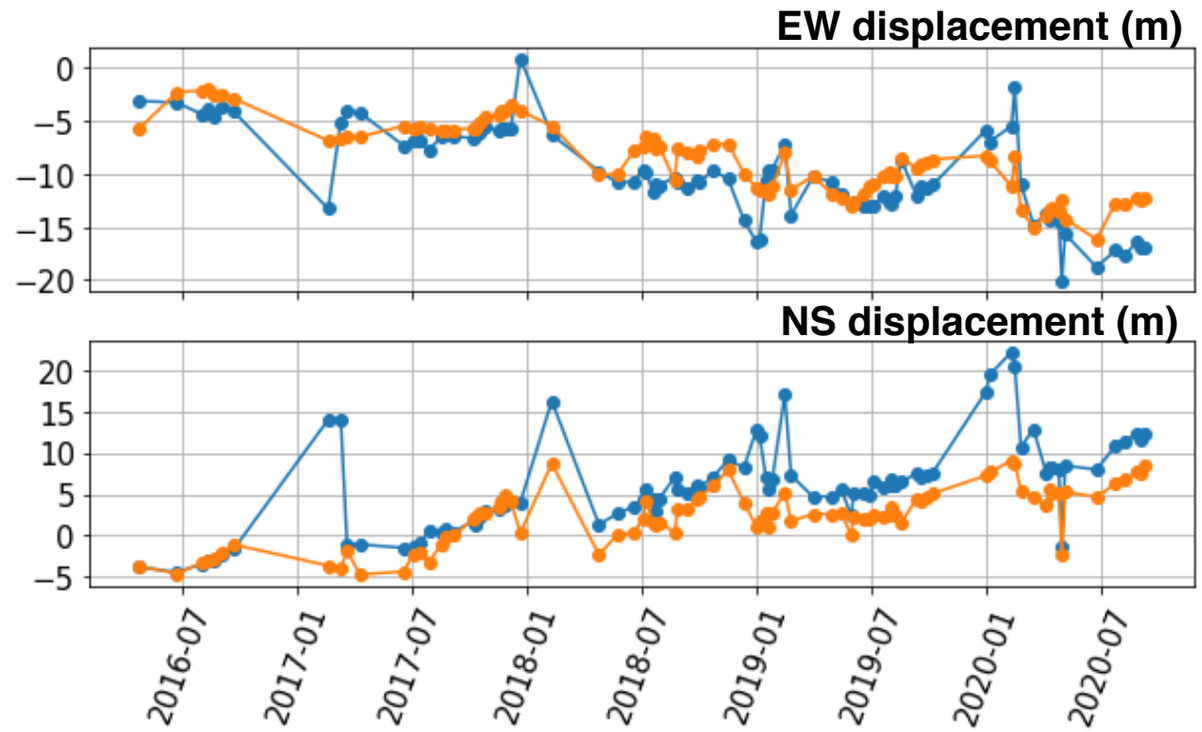


Results of the inversion of the selected ICA

Number of sources: 20







Inversion of all displacement grids
Inversion of the selected ICA

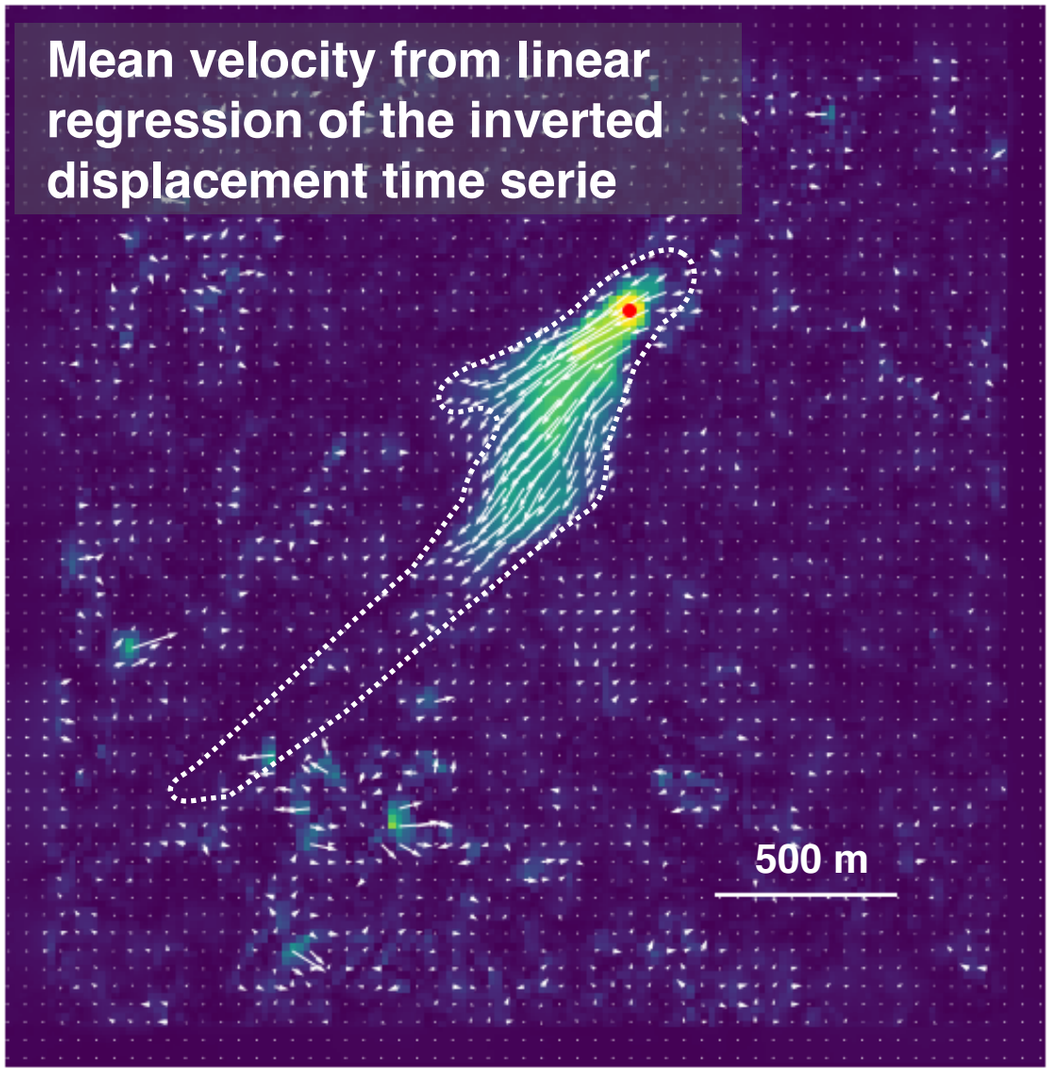
Inverting selected ICA improves the general SNR in space and time

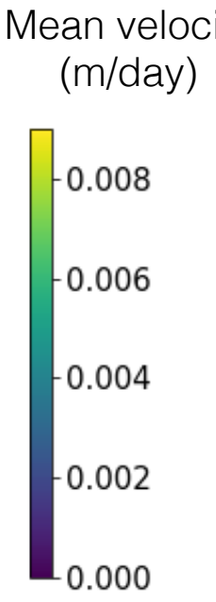
Site 1: Lavalette landslide

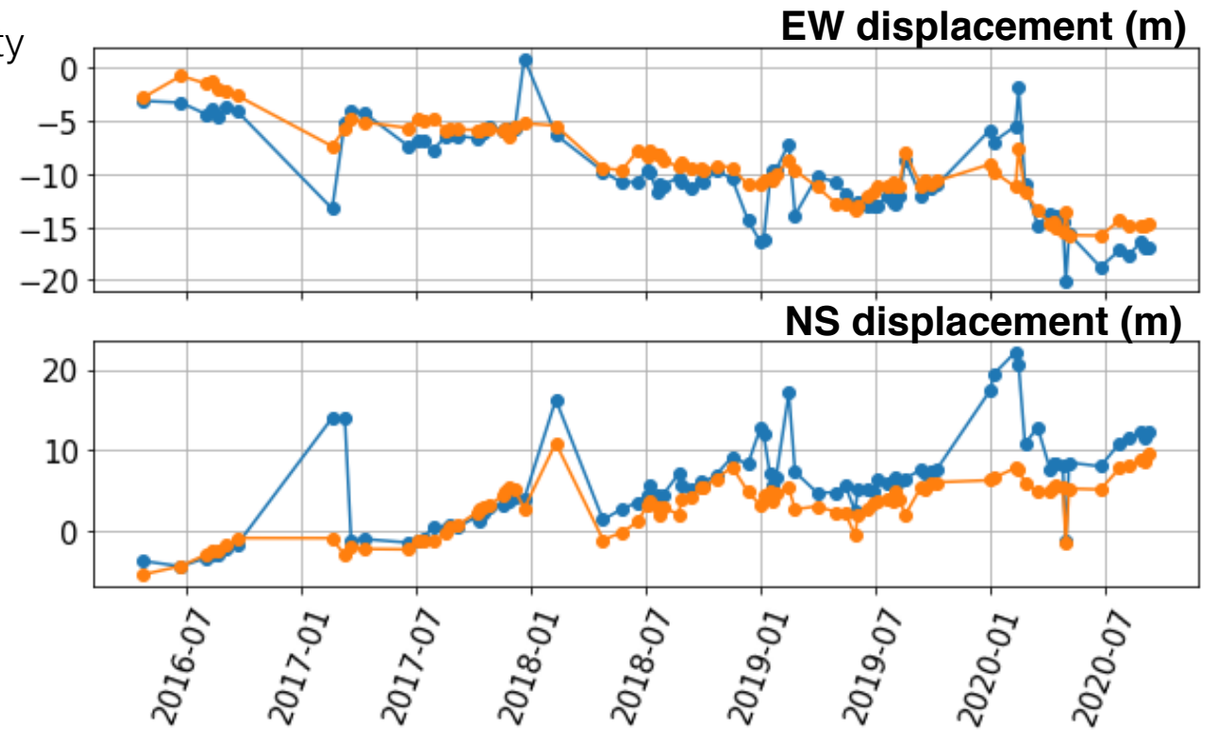


Influence of the number of sources

Number of sources: 60



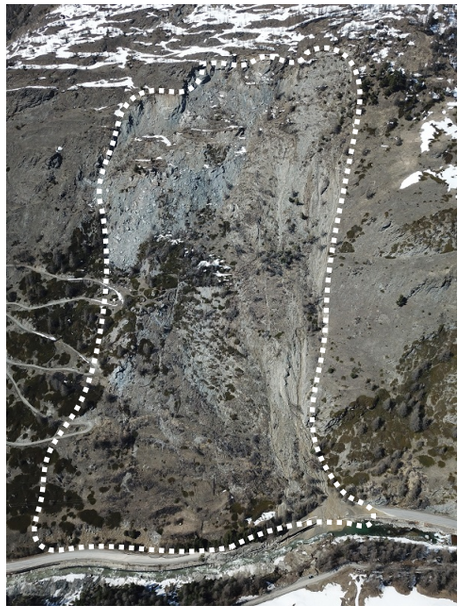




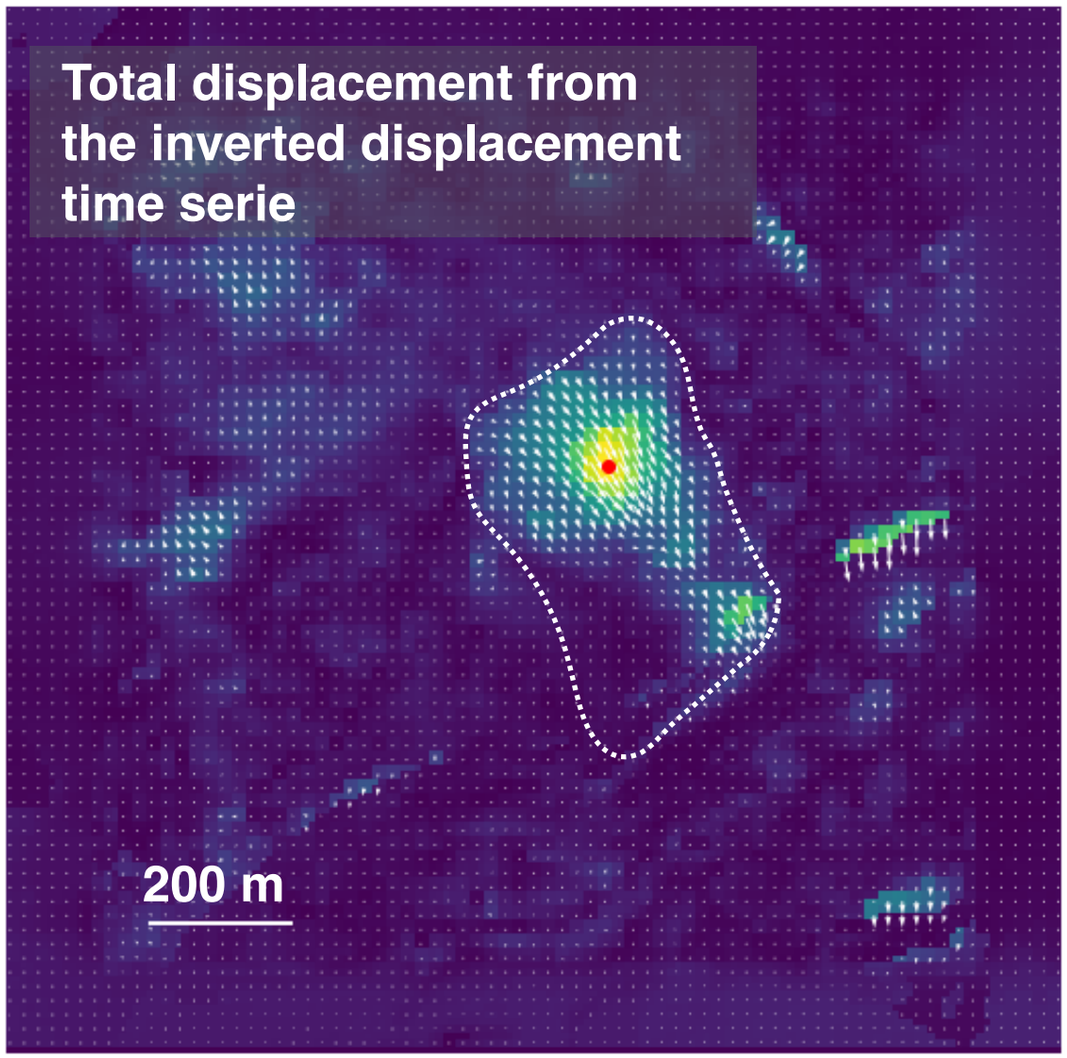
Inversion of all displacement grids
Inversion of the selected ICA

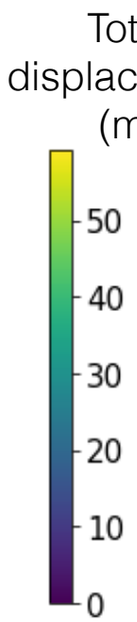
Increasing the number of sources reduces the spatial noise as well as the temporal spikes

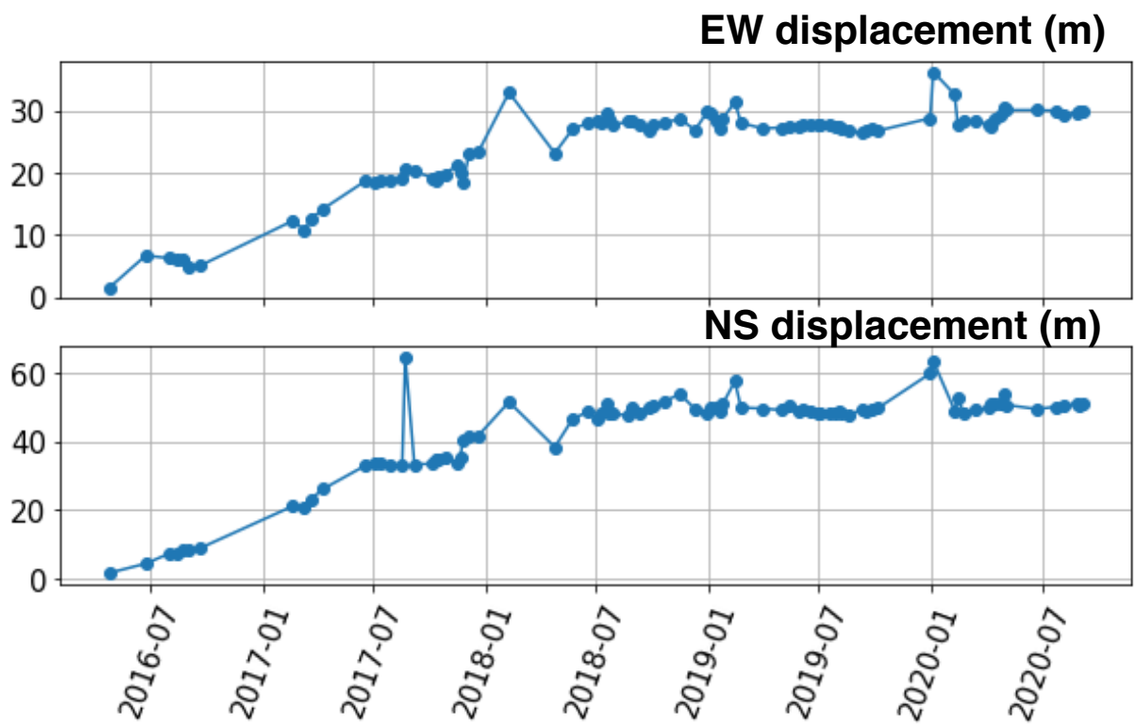
Site 2: Aiguilles landslide



Results of the inversion of the selected ICA

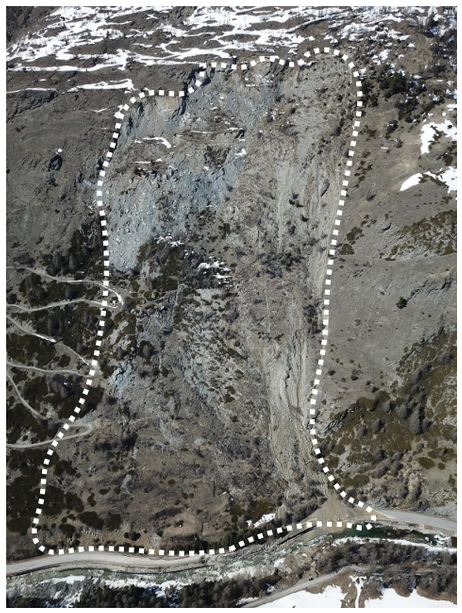






Inverting selected ICA improves the general SNR in space and time

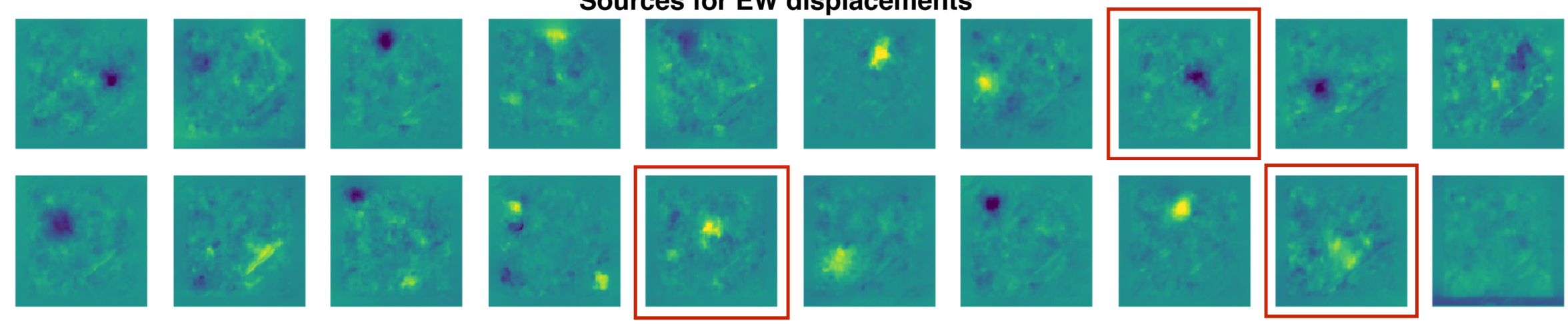
Site 2: Aiguilles landslide



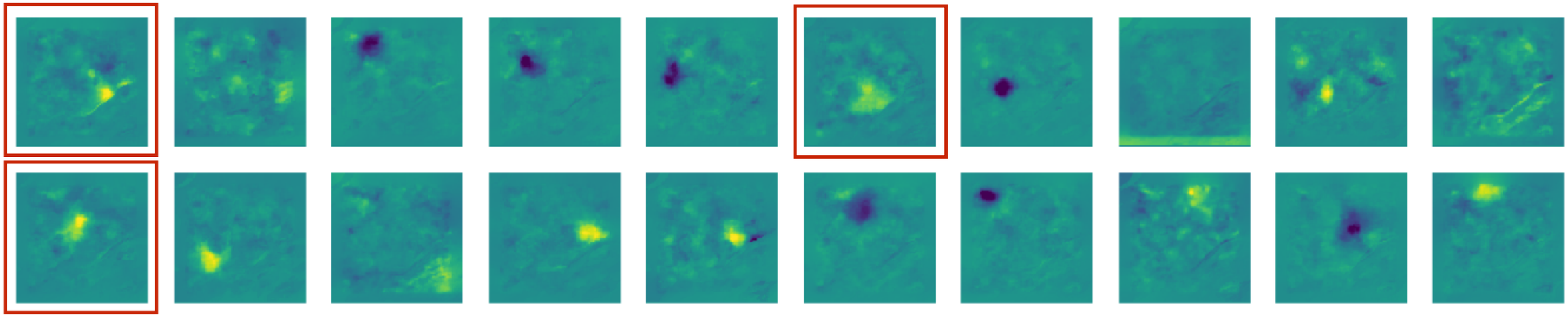
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Sources for EW displacements

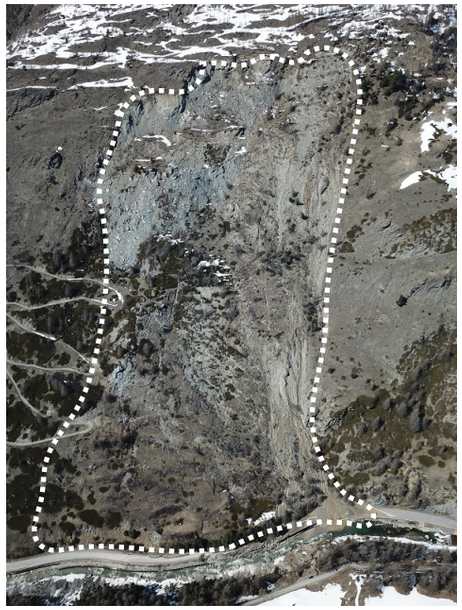


Sources for NS displacements



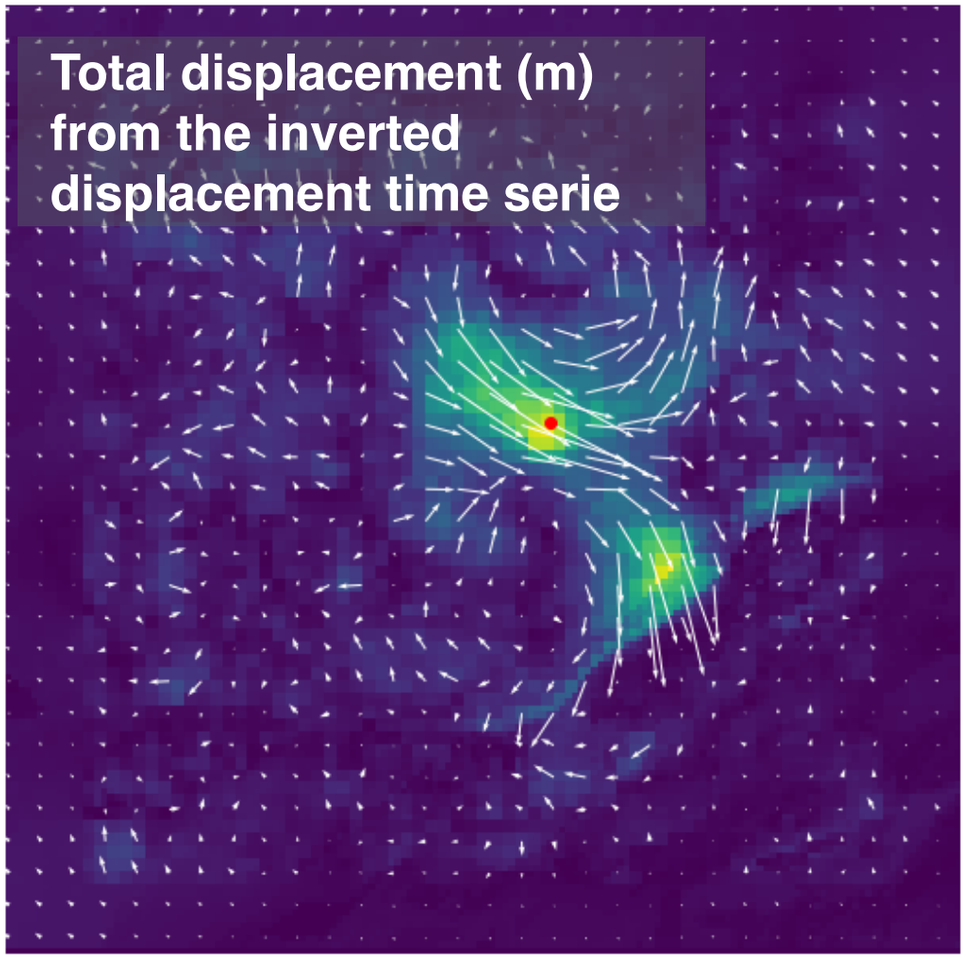


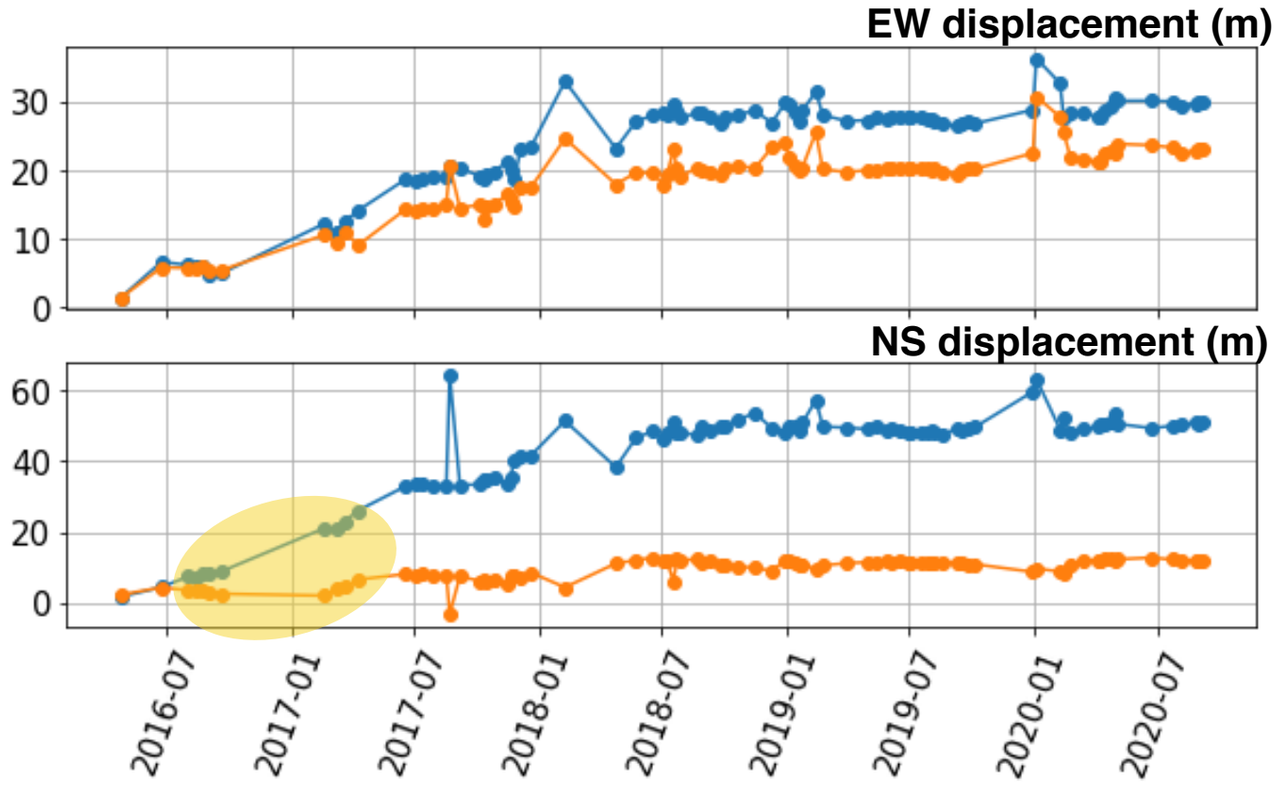
Site 2: Aiguilles landslide



t-ICA décomposition:

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Inversion of all displacement grids
Inversion of the selected ICA

Conclusion and perspectives

- *The t-ICA decomposition was tested on two landslides : Lavalette and Aiguilles (French Alps)*
- *`ICA approach is interesting to remove spatio-temporal noise especially in the case of linear deformation (Site 1: Lavalette landslide)*
- *In the case of more complex deformation like on the Aiguilles landslide, it is more difficult to select the ICA and retrieve the strong acceleratetion of 2016-2017*
- *The results vary with the assumption of the number of sources*

- *Test the strategy of Gaddes et al, 2019 to detect automatically the ICA of interest*
- *Test the strategy on larger area where multiple landslides are present*