



geohazards  
tep

# Optical processing for quantifying Earth surface deformation: the ALADIM, MPIC and DSM-OPT on-demand services

ForM@Ter-MDIS Workshop – Strasbourg and La Petite-Pierre,  
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TERRA)UE  
Advancing Earth Science

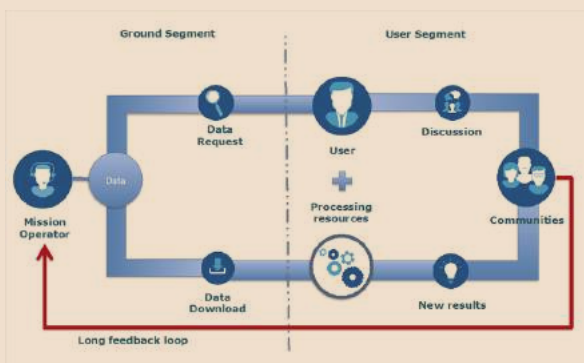
# ESA Thematic Exploitation Platforms

## Thematic Exploitation Platforms - TEPs

- TEPs are an ESA originated **R&D activity on the EO ground segment** to demonstrate the benefit of new technologies for large scale processing of EO data
- TEPs are technology R&D, but still fully user driven



### ➤ *New concept:*



Data and tools are transferred to the user. Transferred many times, replicated in many places, and with data exploitation taking place at users' premises.



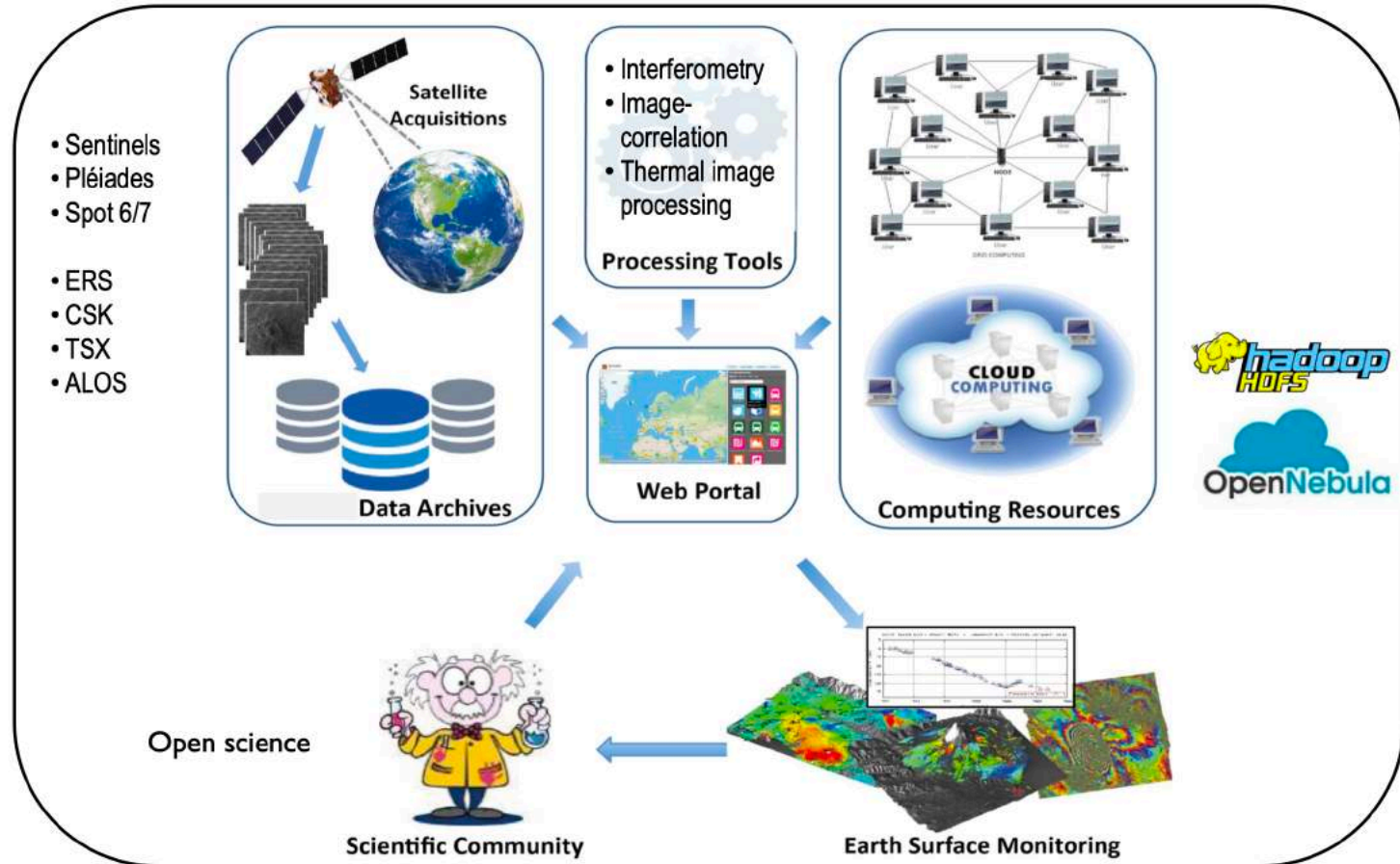
Users access a platform work environment providing the data, tools, and resources.

The user is involved in its governance and invited (and enabled) to share and collaborate.

# The GeoHazards Exploitation Platform

As part of the Thematic Exploitation Platform initiative, ESA is developing the GEP to bring the **user closer to the data** with a focus on new services and products

→ focus on large scale geohazard mapping and monitoring



# Geohazards Exploitation Platform



## How to get access to the Geohazard Exploitation Platform – GEP ?

### ➤ ESA Network of Resources (NoR)

Single access point for **Resource tier** providers (ICT Providers hosting collocated EO data) and **Platform service** providers (built on top of a resource tier provider) for

- **Self-funded user:** Any user world wide requiring for any reason Resource Tier or Platform Services (e.g. Science, Development, Pre-commercial and Commercial) who funds the consumption themselves;
- **User sponsored:** (Science, Development, Pre-commercial) by ESA and other entities via Announcement of Opportunity

➤ Available before end of 2019 for Resource Tier and at the **beginning of 2020 for platform services.**

➤ Application will be selected on the basis of **scientific excellence** and **the practicability to realize the project in due time.**

➤ As pre-requisites,

- Users should **have a nationality or be appointed at universities from ESA Member States** contributing to EOEP5.

*Exceptions can be made for valuable international cooperation activities.*

- Users intent to **publish a paper / poster** acknowledging the 'sponsoring' that was provided by ESA or the external cost waiving entities, promoting both the 'Network of Resources' as well as the used resource/platform providers

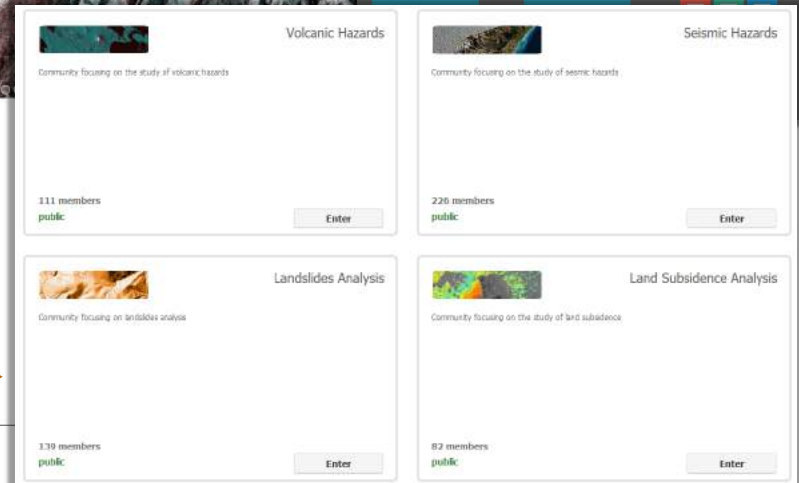
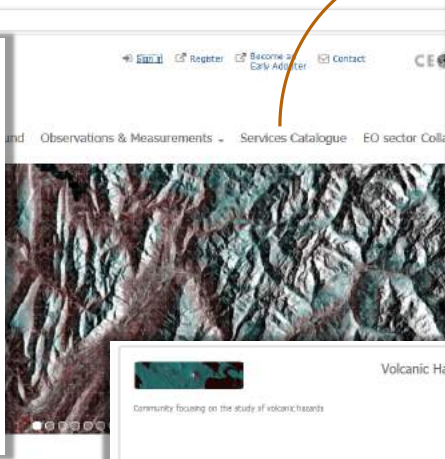
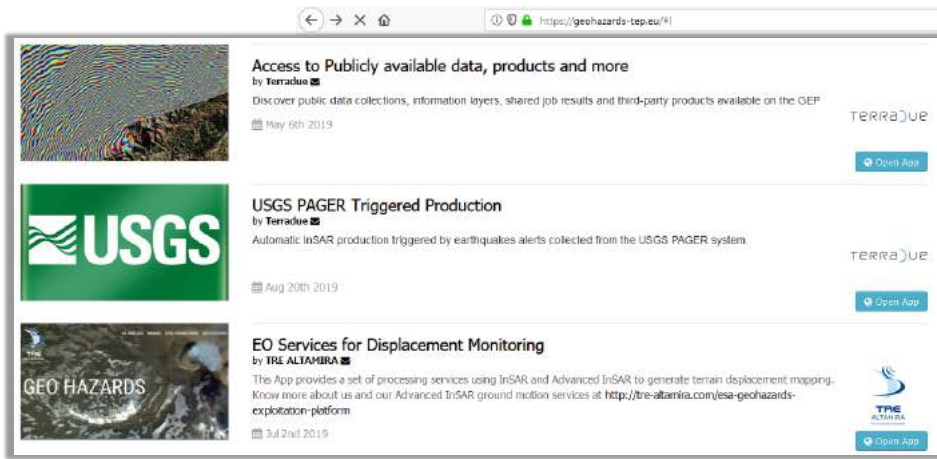
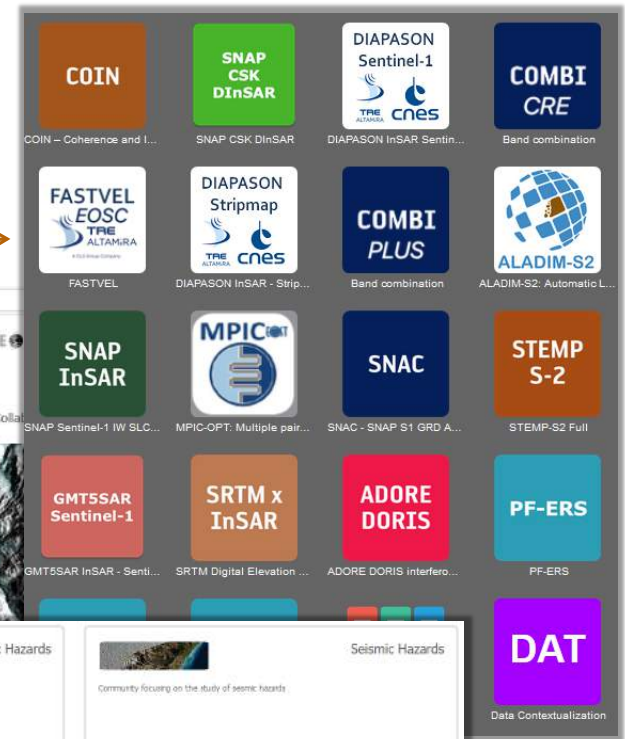
➤ **Sponsoring application form already available via Open Science Earth Observation (OSEO) call:**

<https://eo4society.esa.int/2019/06/07/network-of-resources/>

# GEP – Main features

<http://geohazard-tep.eu>

**Services Catalogue**  
Description of the available services

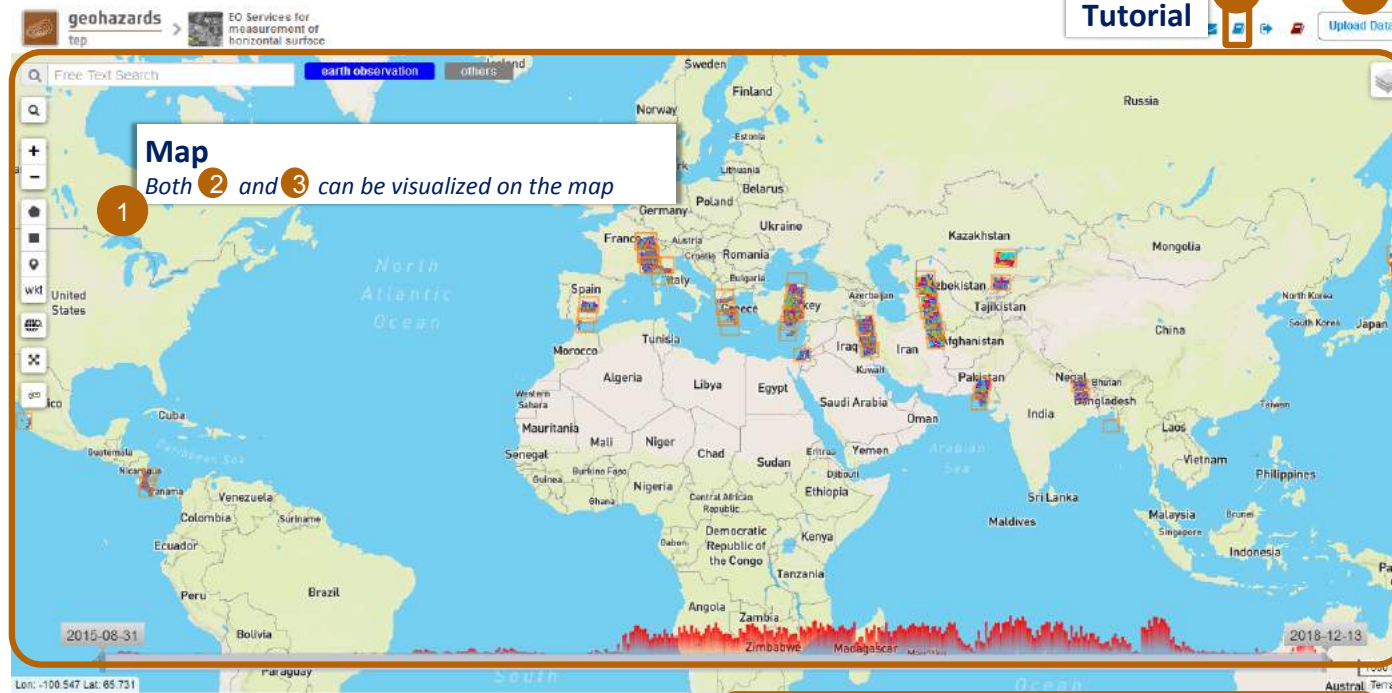


# GEP – Organization of Thematic Apps

7  
Tutorial

6  
Upload Data

5  
Data and Job collections



Processing Services

Services Jobs

Filter services

<b>DSM-PT</b> VAL	<b>DIAPASON</b> Sentinel-1	<b>COIN</b>
<b>SNAP</b> InSAR	<b>DIAPASON</b> Stripmap	<b>ALADIM-VHR</b>
<b>RASTER</b>	<b>ALADIM-S2</b>	<b>MPIC-RT</b>
<b>SNAC</b>	<b>DSM-PT</b>	Data Publication

4  
Service & Jobs

2  
Results of the research

Result for OpenSearch query over type... Total results: 40360

- S-1 Medium-Resolution InSAR Browse Service - Interferometric Phase Terrain Correlated - 2018-12-07T17:22:57 2018-12-13T17:24:13
- S-1 Medium-Resolution InSAR Browse Service - Interferometric Phase Terrain Correlated - 2018-12-07T17:22:57 2018-12-13T17:22:48
- S-1 Medium-Resolution InSAR Browse Service - Interferometric Phase Terrain Correlated - 2018-12-07T17:22:33 2018-12-13T17:23:49
- S-1 Medium-Resolution InSAR Browse Service - Interferometric Phase Terrain Correlated - 2018-12-07T17:22:33 2018-12-13T17:23:23
- S-1 Medium-Resolution InSAR Browse Service - Interferometric Phase Terrain Correlated - 2018-12-07T17:22:33 2018-12-13T17:23:23
- S-1 Medium-Resolution InSAR Browse Service - Interferometric Phase Terrain Correlated - 2018-12-07T17:22:08 2018-12-13T17:22:59
- S-1 Medium-Resolution InSAR Browse Service - Interferometric Phase Terrain Correlated - 2018-12-07T16:32:19 2018-12-13T16:31:47

3  
Data Basket & data packages

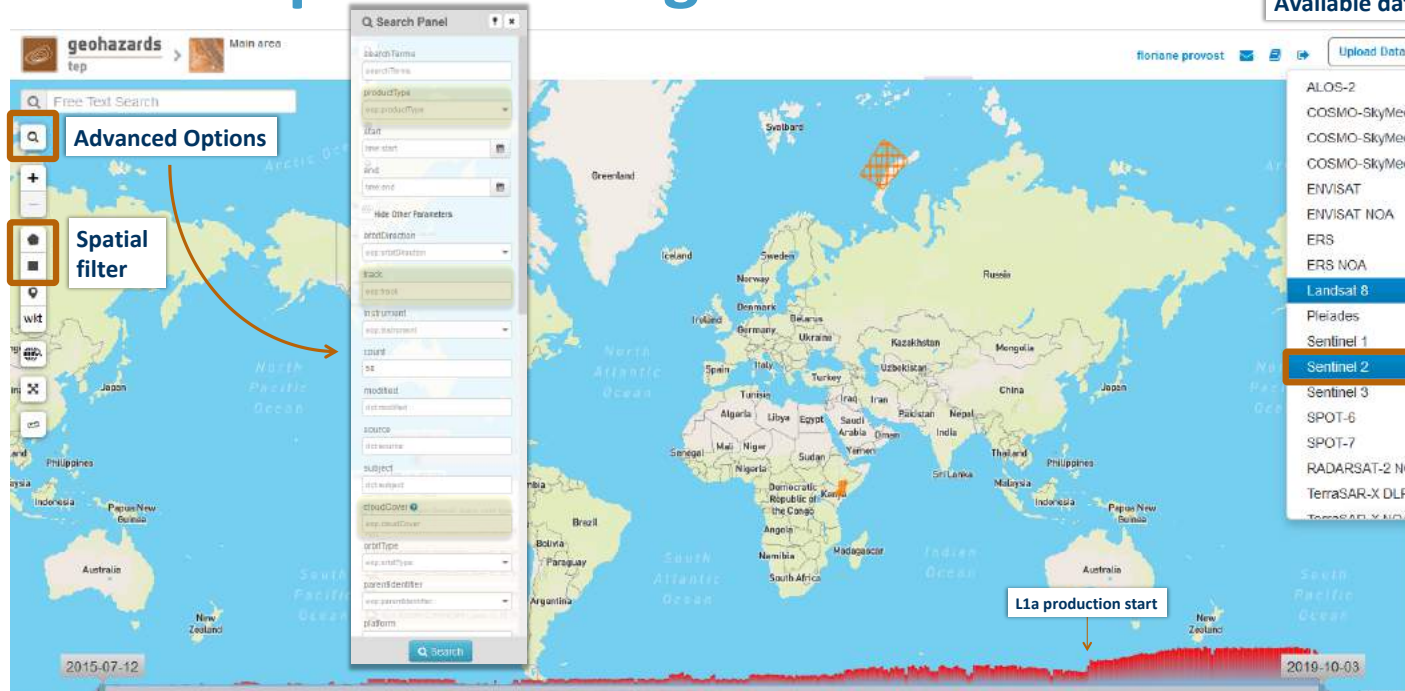
- The data basket enables to select and keep data of interest.
- The data basket can be saved in a data package that can then be downloaded at any time.

# GEP – Explore catalogues

Available data catalogues

EO Data

- ALOS-2
- COSMO-SkyMed Nepal - CEOS
- COSMO-SkyMed NOA
- COSMO-SkyMed VA4
- ENVISAT
- ENVISAT NOA
- ERS
- ERS NOA
- Landsat 8
- Sentinel 1
- Sentinel 2**
- Sentinel 3
- SPOT-6
- SPOT-7
- RADARSAT-2 NOA
- TerraSAR-X DLR



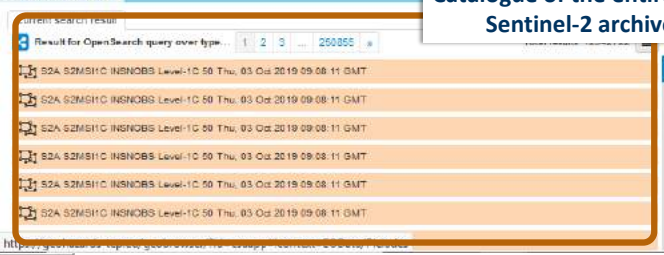
Advanced Options

Spatial filter

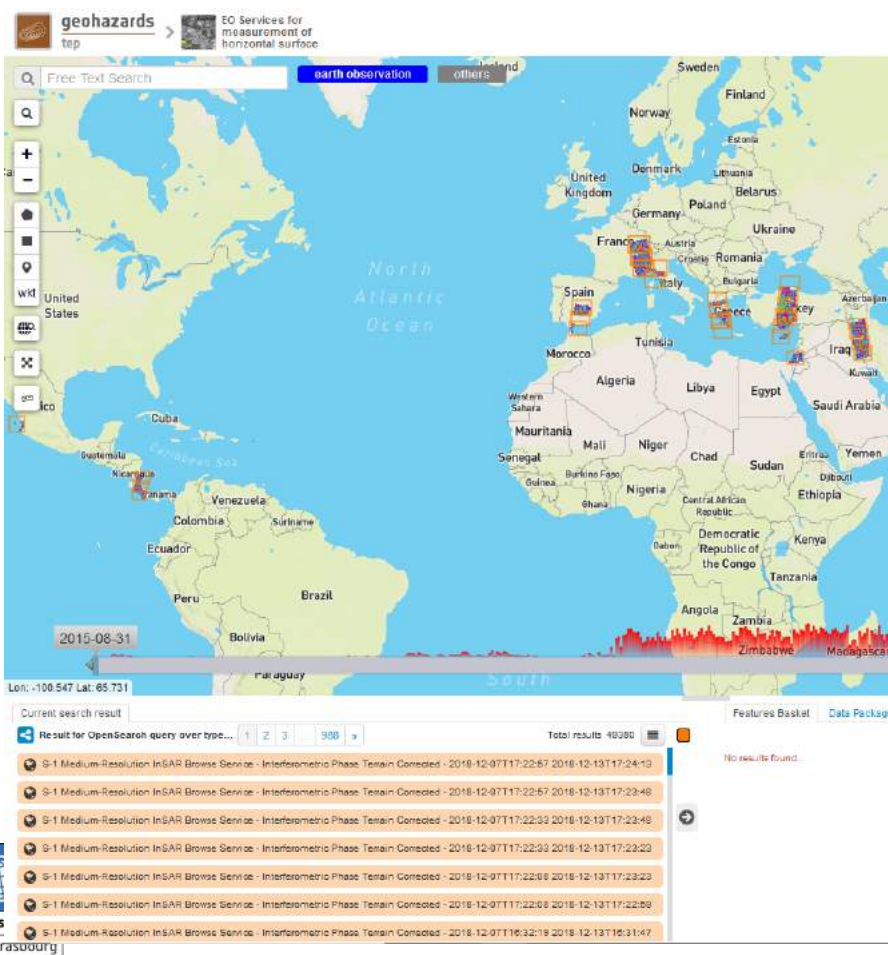
L1a production start

Catalogue of the entire Sentinel-2 archive

Number of acquisitions in time (temporal filter)



# GEP – Processing services



geohazards tep EO Services for measurement of horizontal surface

Free Text Search

earth observation others

2015-08-31

Lon: -100.547 Lat: 65.731

Current search result

Result for OpenSearch query over type... Total results: 40300

- S-1 Medium-Resolution InSAR Browse Service - Interferometric Phase Terrain Consisted - 2018-12-07T17:22:57 2018-12-13T17:24:13
- S-1 Medium-Resolution InSAR Browse Service - Interferometric Phase Terrain Consisted - 2018-12-07T17:22:57 2018-12-13T17:22:48
- S-1 Medium-Resolution InSAR Browse Service - Interferometric Phase Terrain Consisted - 2018-12-07T17:22:33 2018-12-13T17:23:49
- S-1 Medium-Resolution InSAR Browse Service - Interferometric Phase Terrain Consisted - 2018-12-07T17:22:33 2018-12-13T17:23:23
- S-1 Medium-Resolution InSAR Browse Service - Interferometric Phase Terrain Consisted - 2018-12-07T17:22:33 2018-12-13T17:23:23
- S-1 Medium-Resolution InSAR Browse Service - Interferometric Phase Terrain Consisted - 2018-12-07T17:22:08 2018-12-13T17:22:59
- S-1 Medium-Resolution InSAR Browse Service - Interferometric Phase Terrain Consisted - 2018-12-07T16:32:19 2018-12-13T16:31:47



Processing Services

Services Jobs

Filter jobs Show only public

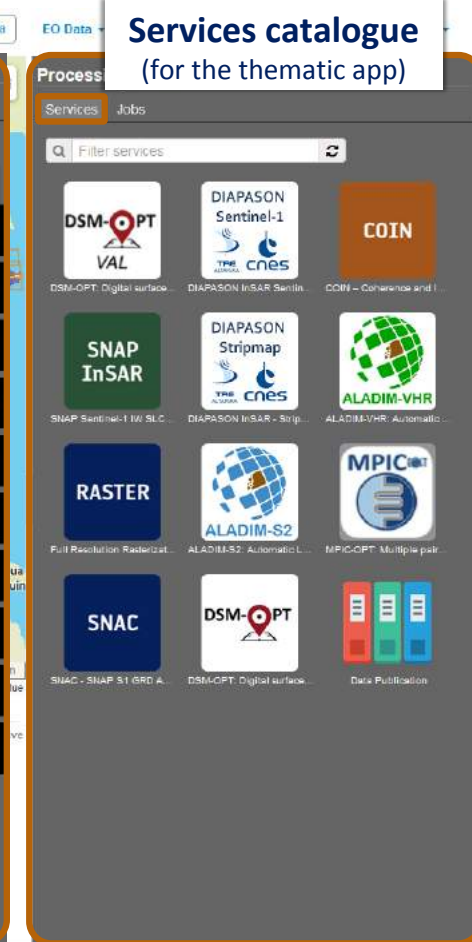
873 jobs found

Filter by job title or owner

Filter by job visibility

- COIN Rome Master 29 Sep run15 SUCCESS
- COIN Rome Master 29 Sep run14 SUCCESS
- COIN Rome Master 29 Sep run13 SUCCESS
- COIN Rome Master 29 Sep run12 SUCCESS
- COIN Rome Master 29 Sep run11 SUCCESS
- COIN Rome Master 29 Sep run10 SUCCESS
- COIN Rome Master 29 Sep run9 SUCCESS
- COIN Rome Master 29 Sep run8 SUCCESS
- COIN Rome Master 29 Sep run7 SUCCESS
- COIN Rome Master 29 Sep run6 SUCCESS

1 2 3 66 Next



Processing Services

Services Jobs

Filter services

DSM-OPT VAL

DIAPASON Sentinel-1 CNES

COIN

SNAP InSAR

DIAPASON Stripmap CNES

ALADIM-VHR

RASTER

ALADIM-S2

MPIC-OPT

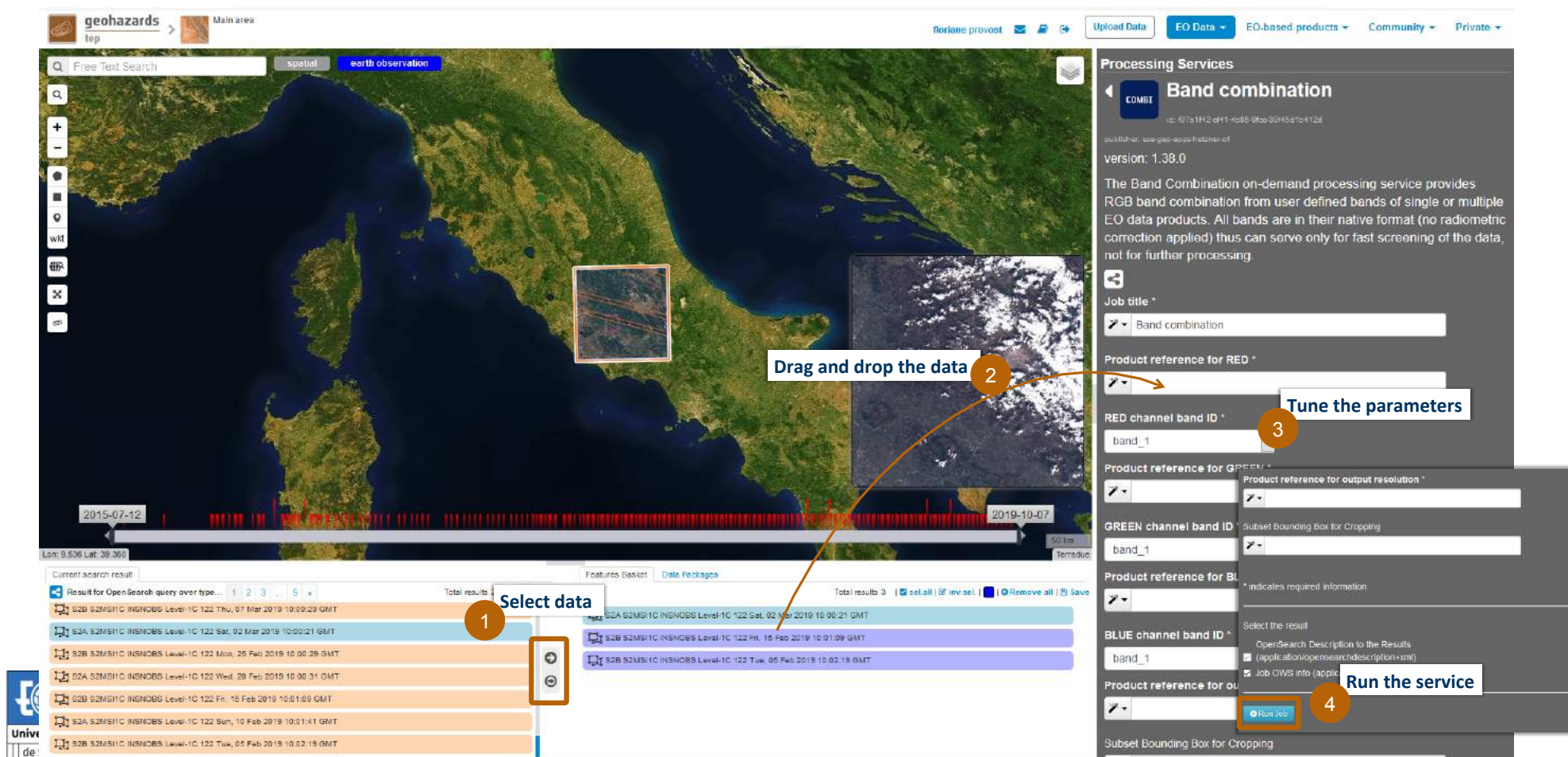
SNAC

DSM-OPT

Data Publication



# GEP – Run a service



The screenshot displays the geohazards tep web interface. The main map area shows a satellite view of a coastal region with a red bounding box and a zoomed-in inset. A timeline at the bottom of the map shows dates from 2015-07-12 to 2019-10-07. Below the map is a search results table with columns for search results, features, and data packages. The processing services panel on the right is titled 'Band combination' and includes fields for job title, product reference, and channel band IDs (RED, GREEN, BLUE). A 'Run Job' button is visible at the bottom of the panel.

**1 Select data**

**2 Drag and drop the data**

**3 Tune the parameters**

**4 Run the service**

# Geohazards Exploitation Platform



Available EO-based products from systematic processing

Upload Data EO Data EO-based products Community Private

- STEMP L8 - Surface Temperature Map
- Sentinel-1 Medium-Resolution InSAR Browse
- Sentinel-1 High-Resolution InSAR Browse
- VEGAN HSP - Hot Spots Detection Maps
- VEGAN VHON - Vegetation Vigor Maps (NDVI)

COIN SNAP CSK DiNSAR DIAPASON Sentinel-1

VEGAN VHON - Vegetation Vigor Maps (NDVI)



SNAC STEMP S-2 GMT5SAR Stripmap GMT5SAR Sentinel-1 SRTM x InSAR ADORIS

geohazards tep Main area

Free Text Search earth observation others

### STEMP L8 – Surface Temperature Map

Unive de

- S-1 Medium-Resolution InSAR Browse Service - Interferometric Phase Terrain Corrected - 2018-12-07T17:22:33 2018-12-13T17:23:23
- S-1 Medium-Resolution InSAR Browse Service - Interferometric Phase Terrain Corrected - 2018-12-07T17:22:09 2018-12-13T17:23:23

### S1 High-resolution InSAR Browse

# GeoHazards Exploitation Platform



The screenshot displays the GeoHazards Exploitation Platform interface. At the top right, the 'geohazards tep' logo is visible. Below it, a navigation bar includes 'floriane provost', 'Upload Data', 'EO Data', 'EO-based products', 'Community', and 'Private'. The 'Community' dropdown menu is open, showing options: 'Publications', 'Terrain Motion Demo', 'Shared Jobs', and 'Shared Products'. A callout box points to the 'Shared Jobs' option with the text: 'Collection of EO products associated to the community Job results and/or updated results Possibility to publish job results with an associated a DOI.'

Three map views are shown, each with a location label in a white box:

- Palu, Sulawesi, Indonesia:** Shows a satellite view of a coastal area with a red and yellow hazard overlay.
- Katmandu, Nepal:** Shows a map of India and surrounding regions with a red and yellow hazard overlay over Nepal.
- Kaikoura, New-Zeland:** Shows a satellite view of a coastal area with a red and yellow hazard overlay.

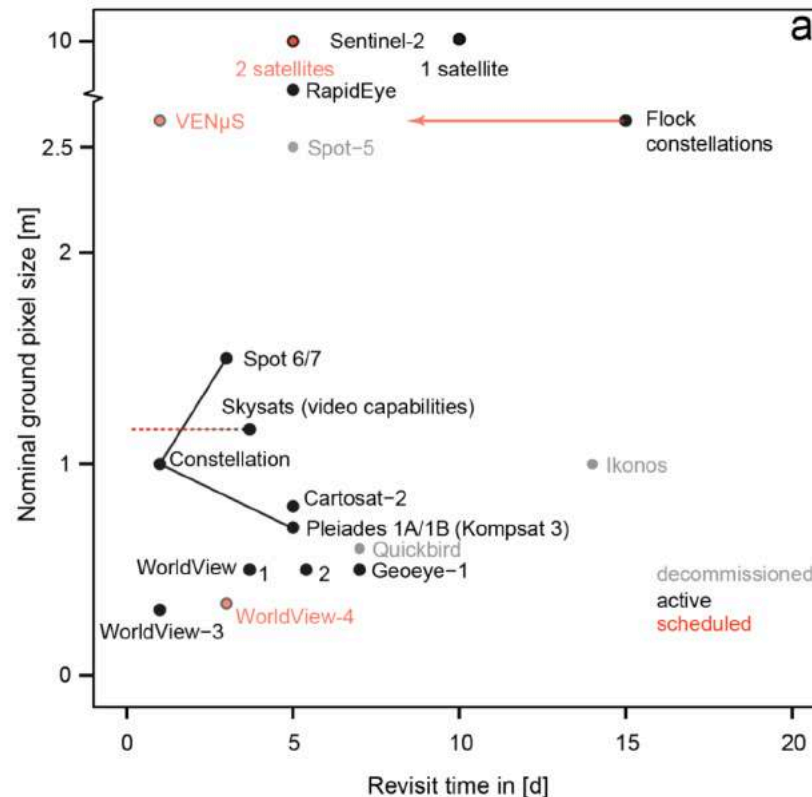
On the right side, there are several service tiles: 'COMBI CRE', 'COMBI', and 'FASTVEL EOSC TRE ALTAIRA'. Below these, a 'Processing Services' section is visible, including a search bar for 'Filter services' and a 'DIAPASON' tile. A 'Demo measurement using DIAPASON and Sentinel-1' pop-up window is also present, showing 'Authors', 'DOI', and 'Description'.

At the bottom left, there is a search results list for 'COIN Rome Master' with various dates and a 'Univ de Strasbourg' logo.

# Multispectral (MS)/Optical data for Earth surface deformation

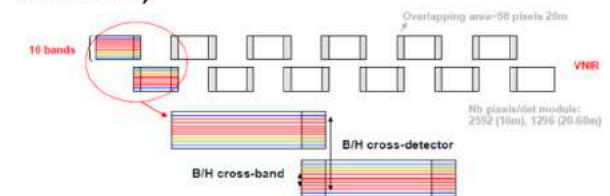
Increasing spatial and temporal resolution of MS/optical satellites

Becomes an opportunity for geohazard mapping, monitoring, and understanding

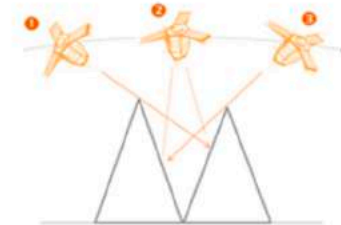


For instance ...

- **Sentinel-2** MSI instrument alone acquires 800 GB/day (2 x 800 GB/day with S-2B)



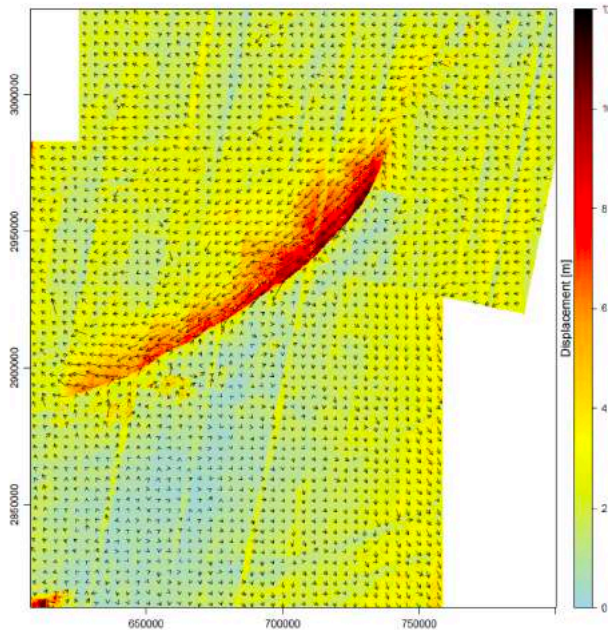
- **Pléiades + SPOT6/7** constellation provide tri-stereo at 0.7 - 1.5 m resolution (< 24h response time)



# Multispectral/Optical data for Earth surface deformation

## Rapid response / mapping

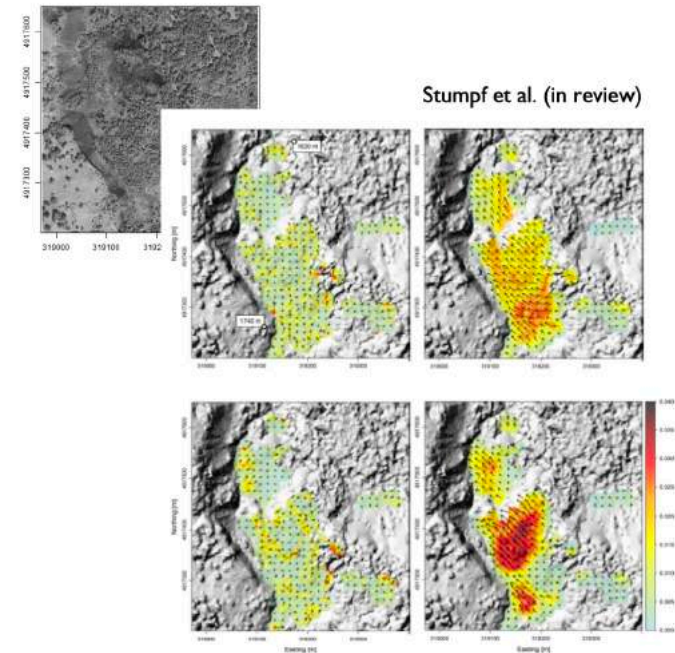
e.g. quantification of surface displacement after major earthquakes (pre/post event images)



Surface slip from the Balochistan earthquake (2013) for Landsat 8 images

## Process monitoring

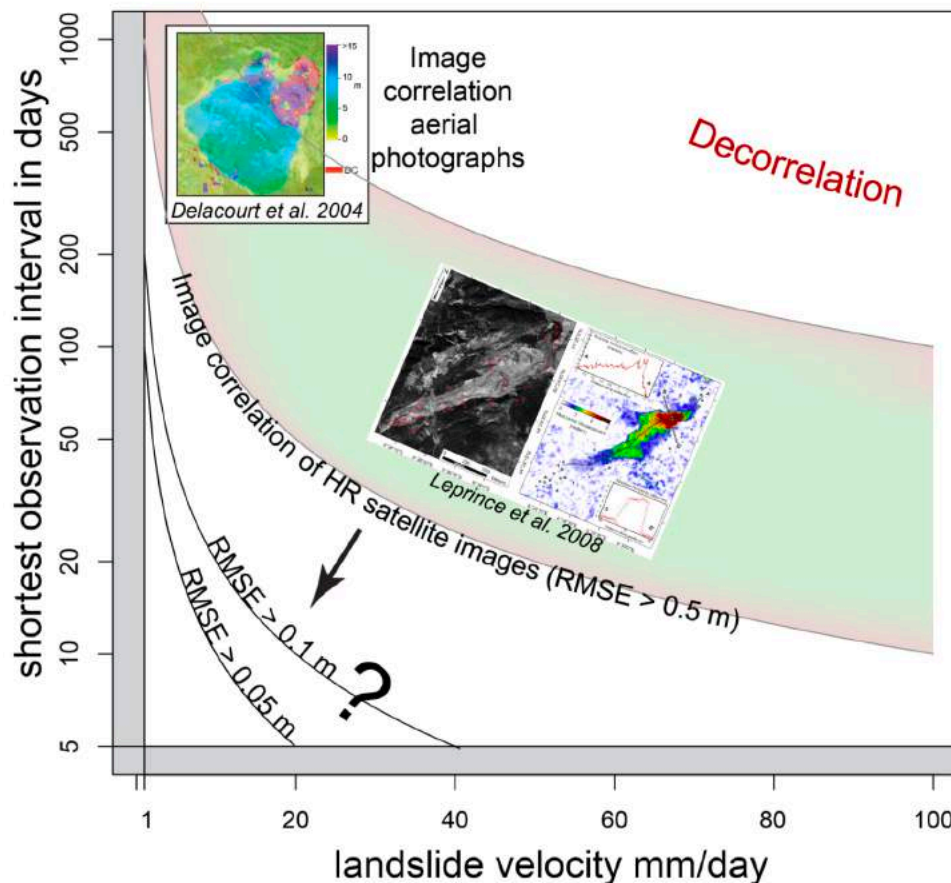
Time-series processing (archives, ongoing fluxes of images)



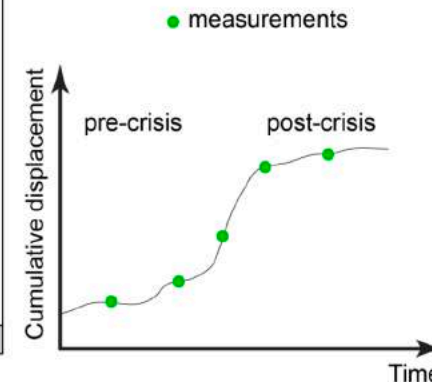
Surface motion of a landslide in the French Alps over two years

Build “generic” and “versatile” services based on optical image correlation for geohazards

# Measuring displacement with MS/optical data - limitations



- Which accuracy is possible with VHR satellite images?
- Can the processing be automated?
- How much ground control?



# MS/Optical services on the Geohazards Exploitation Platform

## EO Services for measurement of horizontal surface displacements

by CNRS – EOST

This App provides a set of services for landslide analysis from optical and SAR images. The processing capabilities integrate softwares and dedicated services for landslide rapid mapping from optical images (ALADIM), landslide displacement field monitoring from stacks of optical images (Service MPI...)



Open App

May 22nd 2019

## Thematic App / Optical services

### Services

### Data

Upload Data EO Data

- Sentinel-1
- Sentinel-2
- Landsat-8
- Pleiades
- SPOT-6
- SPOT-7

The screenshot shows the main interface of the Geohazards Exploitation Platform. It features a world map with a search bar and various navigation controls. Below the map, there are search results and data packages. The search results include:

- S-1 Medium-Resolution InSAR Browse Service - Interferometric Phase Terrain Corrected - 2018-12-07T17:22:57 2018-12-13 T17:24:13
- S-1 Medium-Resolution InSAR Browse Service - Interferometric Phase Terrain Corrected - 2018-12-07T17:22:57 2018-12-13 T17:23:48
- S-1 Medium-Resolution InSAR Browse Service - Interferometric Phase Terrain Corrected - 2018-12-07T17:22:57 2018-12-13 T17:23:48

The data packages section shows:

- training\_areas.shp
- S2\_20190228T073841\_20190325T073609\_36KVD\_cross-validation\_accuracies\_20190711T112614.pdf
- S2\_20190228T073841\_20190325T073609\_36KVD\_cross-validation\_P\_R\_curves\_20190711T112614.pdf
- S2\_20190228T073841\_20190325T073609\_36KVD\_ALADIM\_tr...

The screenshot shows the 'Processing Services' panel, which lists various services available for processing. The services are arranged in a grid, and several are highlighted with red circles:

- DSM-OPT (Digital surface)
- DIAPASON Sentinel-1
- MPIC-OPT (Multiple pairwi...)
- SNAC (SNAP S1 GRD A...)
- SNAP InSAR
- COIN (Coherence and Int...)
- DIAPASON Stripmap
- ALADIM-VHR (Automatic ...)
- RASTER (Resolution Rasterization)
- ALADIM-S2 (Automatic LA...)

### Products

# Practical: MDIS Thematic App

Connect on: <https://geohazards-tep.eu>

TERRADUE

HOME ABOUT US NEWSROOM PEOPLE ELLIP SIGN IN

geohazards tep

SIGN IN TO ACCESS PLATFORM SERVICES

Use your TerraDUE account credentials

Username or Email

jeanphilippe.malet@unistra.fr

Password (forgot your password)

.....

Sign in

New here ? [Create a free account](#)

Or, use your credentials from a trusted Identity Provider

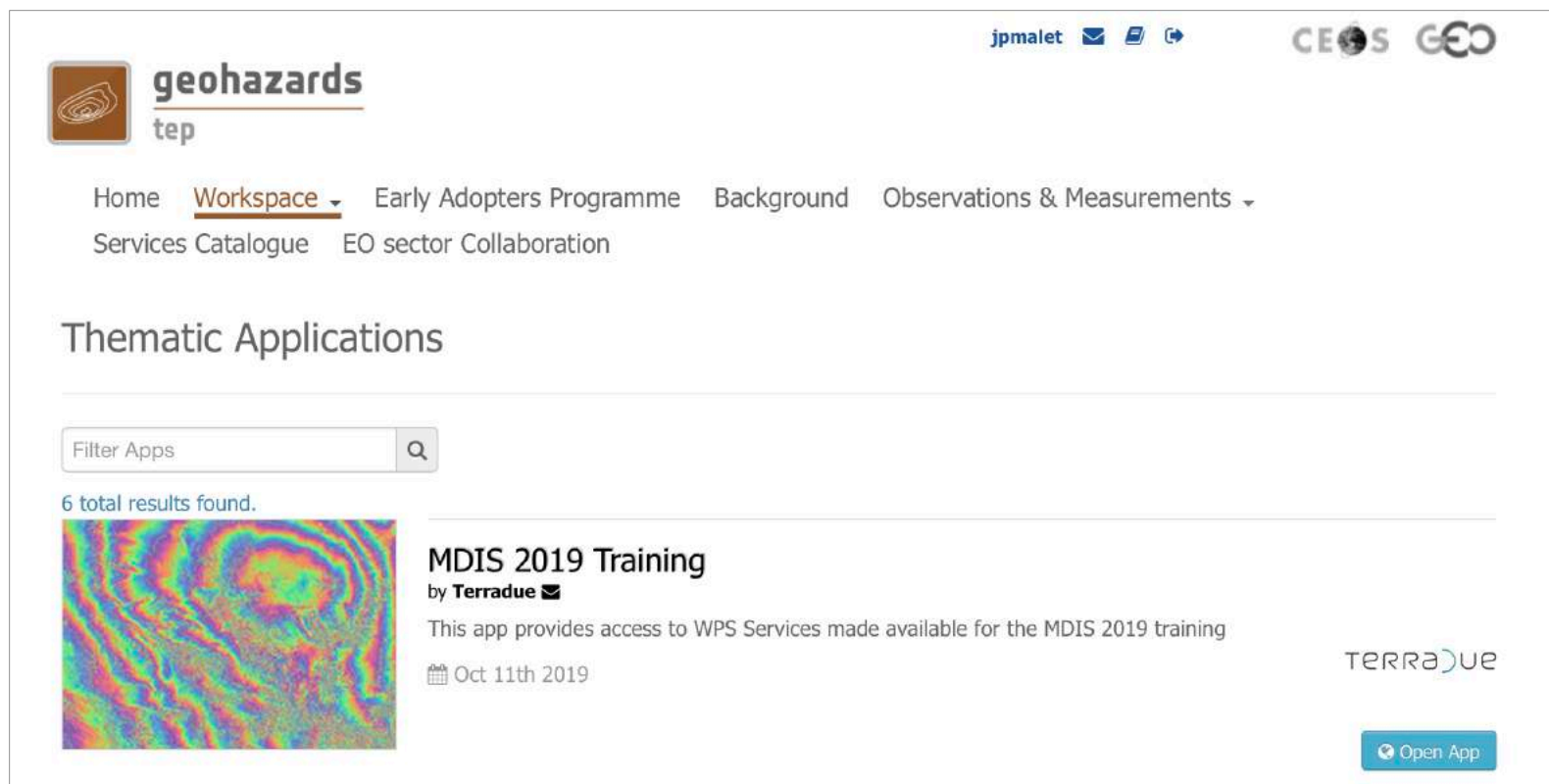
esa Sign in with ESA EO

EUROPEAN OPEN SCIENCE CLOUD Sign in with EOSC

G in YAHOO!



# Practical: MDIS Thematic App



The screenshot shows the user interface of the 'geohazards tep' website. At the top right, there are navigation icons for 'jpmalet', email, a document, and a share icon, along with the 'CEOS GEO' logo. The main header includes the 'geohazards tep' logo and a navigation menu with items: 'Home', 'Workspace' (highlighted with a dropdown arrow), 'Early Adopters Programme', 'Background', 'Observations & Measurements' (with a dropdown arrow), 'Services Catalogue', and 'EO sector Collaboration'. Below the header is a section titled 'Thematic Applications'. A search bar labeled 'Filter Apps' with a magnifying glass icon is present. Below the search bar, it states '6 total results found.' The first result is 'MDIS 2019 Training' by 'Terradue'. It features a colorful satellite-style image of a landscape. The text for this result includes 'This app provides access to WPS Services made available for the MDIS 2019 training' and a date 'Oct 11th 2019'. The 'TERRADUE' logo is visible to the right of the result, and a blue 'Open App' button is located at the bottom right of the result card.

# Detecting and mapping landslides

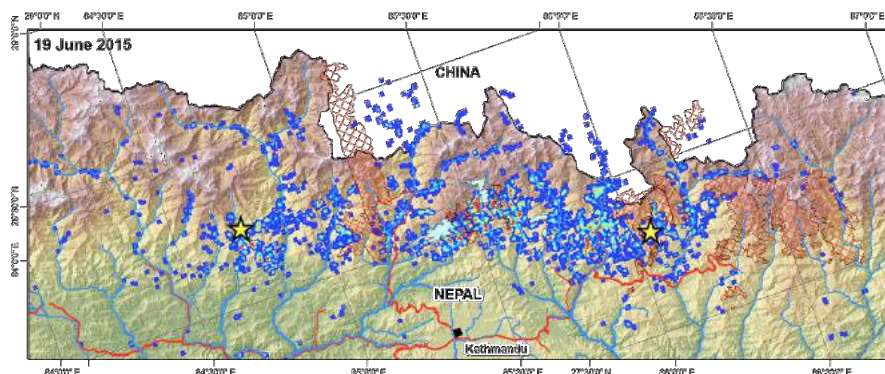
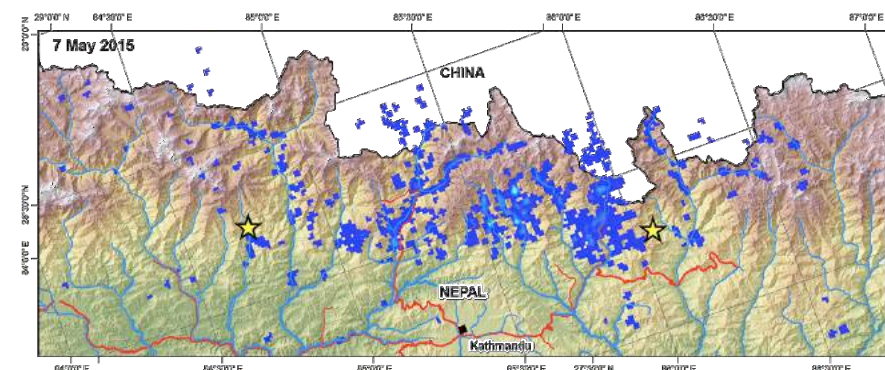
**Motivation: building landslide inventories from space**



Earthquakes and extreme rainfall (typhoons) can cause >1000s to 100,000s landslides.

Landslide inventories are key elements for all phases of DRM cycle

EO data is a useful source of information ... but there is a lack of fast and standard procedures to produce accurate and operational inventories



Williams et al. (2017):  
Landslide inventory map post-Gorkha earthquake



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Advancing Earth Science

# Detecting and mapping landslides

**Motivation: building landslide inventories from space**



Many landslides triggered on 15 March 2019 in Mozambique by Tropical Cyclone Idai

Sentinel 2 imagery gives the opportunity to rapidly and efficiently detect and map landslides in very short time

**ALADIM**: an automated and generic IA-based change detection algorithm tailored for multispectral images



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Advancing Earth Science

# Detecting and mapping landslides

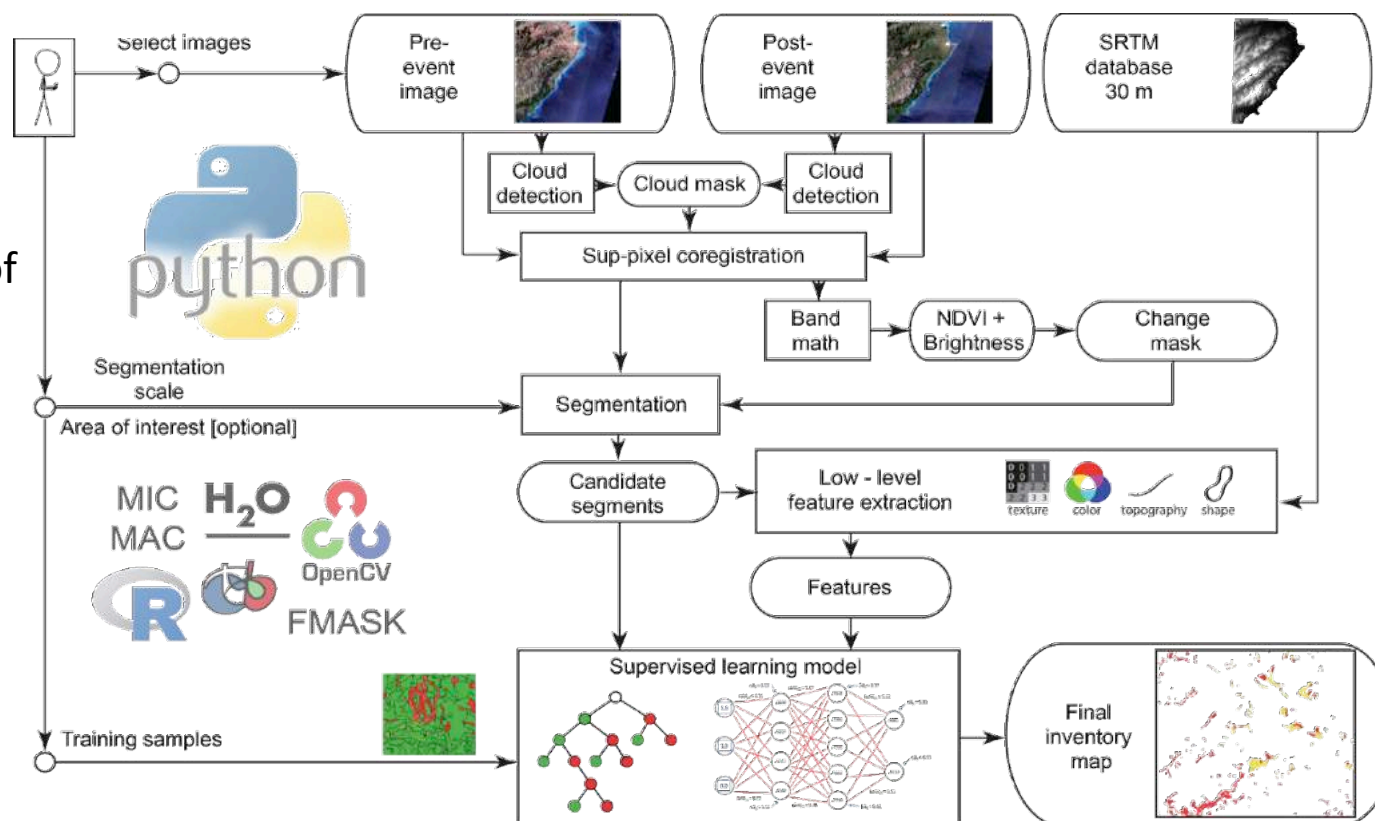
ALADIM service: Automatic landslide detection and inventory mapping



**Image sources:** MRO (S2) + VHRO (ortho-images)

**Approach:** Supervised change detection method - Selection of image features – Machine Learning

**Computation:** HPC + cloud-based implementation (dockerisation)



# Detecting and mapping landslides

## ALADIM service: Automatic landslide detection and inventory mapping



### Region of Interest and digitalization of a few training sample

See note: [https://terradue.github.io/doc-tep-geohazards/tutorials/aladim\\_input\\_dataset\\_preparation.html](https://terradue.github.io/doc-tep-geohazards/tutorials/aladim_input_dataset_preparation.html)

geohazards tep Site Page « ADORE DORIS ALADIM-S2: Au... » Source TERRADUE

## ALADIM-S2 and ALADIM-VHR: Preparation of input datasets

### ALADIM-S2 and ALADIM-VHR: Preparation of input datasets

Creation of the landslide initial training samples: training\_samples.shp

Creation of the training areas: training\_areas.shp

Creation of the AOI – Area of Interest: aoi.shp

#### Creation of the landslide initial training samples: training\_samples.shp

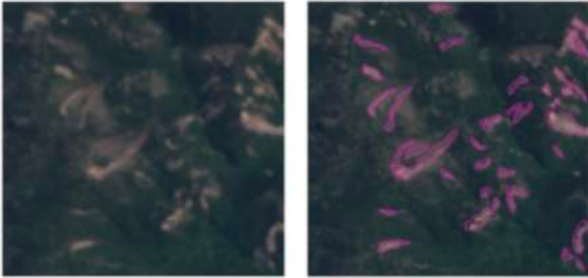
The first mandatory shape file is composed of the **training samples**. The landslide training samples should be :

- Digitized (image interpretation) on the post-event imagery;
- Representative of the distribution of landslide sizes (with the digitalization of small, medium and large landslide sizes);
- Digitized over the complete range of landscape properties (e.g. low, medium and high slope gradients; low, medium and high image reflectance values).

The training samples should comprise a minimum number of landslide events (e.g. typically 5%) of the expected total number of landslide events over the study areas.

The training samples should be recorded in \*.shp file format, and created out of the GEP Platform. The training samples should be presented as a polygon shapefile with one single layer. It is typically a good starting point to divide the study area with a grid and select about 10 grid cells in which all landslides are mapped to construct the training sample. Please assure that the training samples shapefile does not contain NULL geometries or other geometry problems.

Name the shapefile like this: **training\_samples.shp**

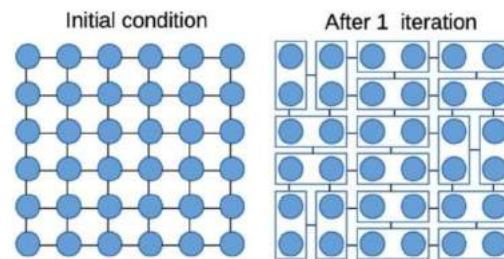


# Detecting and mapping landslides

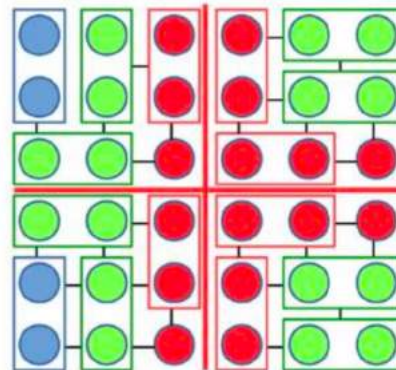
ALADIM service: Automatic landslide detection and inventory mapping



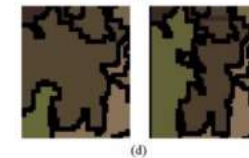
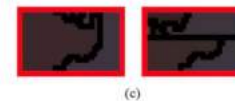
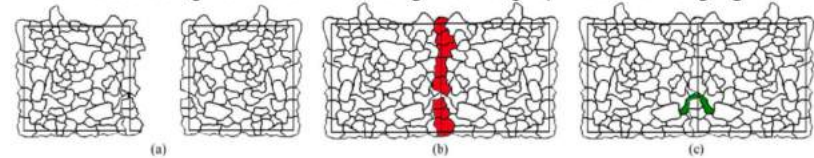
Segmentation: parallel implementation of a region-merging algorithm



Segmentation on tiles yields different Segments (red)



Tile-based segmentation with margins and graph-based merging



# Detecting and mapping landslides

## ALADIM service: Automatic landslide detection and inventory mapping



### Feature extraction

Name	Derived from	Number
Area	Polygons	1
Flow accumulation (mean, variance)	DEM	2
Distance to drainage (mean, variance)	DEM	2
Distance to crest (mean, variance)	DEM	2
Flow direction (mean, variance)	DEM	1
Slope (mean, variance)	DEM	2
Topographic wetness index (mean, variance)	DEM	2
Fraction of stream pixels (mean, variance)	DEM	2
NDVI (mean, variance, change)	NDVI, pre-and post-images	6
Band values (mean, variance)	10 bands, pre-and post-images	40
Reflectance (mean, variance, change)	Average reflectance visible bands, pre-and post-images	6
Circularity	Polygons	1
Circularity (Haralick)	Polygons	1
Convexity	Polygons	1
Eccentricity (bounding box)	Polygons	1
Eccentricity (eigen vectors)	Polygons	1
Elongation	Polygons	1
Rectangularity	Polygons	1
Solidity	Polygons	1
GLCM contrast (topo-guided)	DEM, panchromatic	2
GLCM correlation (topo-guided)	DEM, panchromatic	2
GLCM entropy (topo-guided)	DEM, panchromatic	2
GLCM mean	panchromatic	1
<b>TOTAL</b>		<b>83</b>

# Detecting and mapping landslides

## ALADIM service: Automatic landslide detection and inventory mapping



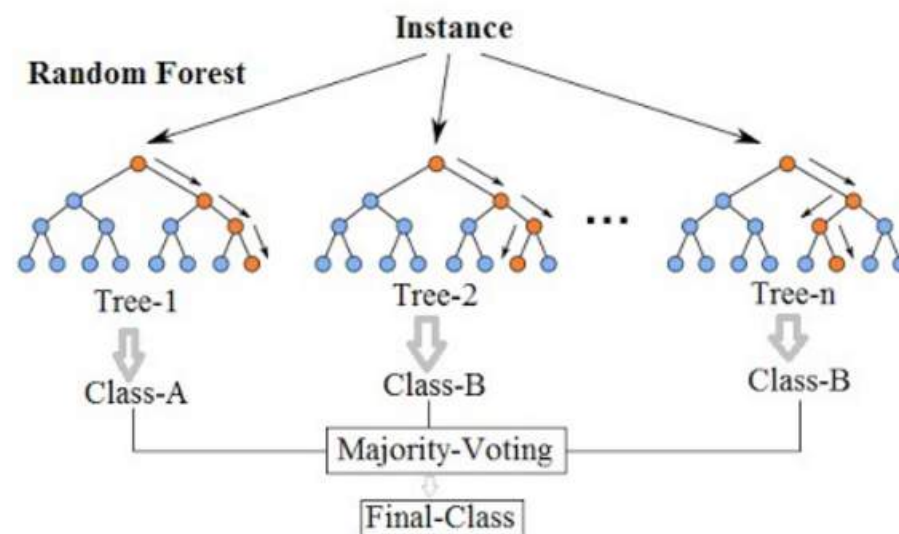
### Classification: machine learning using a Random Forest classifier

#### Principle

- Build a large amount of decision trees (>500) from a training set.
- Each tree is built from a sub-sample of the training set (2/3 of the training set).
- Each node is built by testing randomly  $< \sqrt{n}$  attributes ( $n$ =total number of attributes).
- Different thresholds are tested for the attributes.
- A node is built for the attributes that maximizes a gain function (e.g. Gini coeff.) between two classes.
- When a node is pure (contain only one classe) the tree stops.

#### Advantages

- Fast.
- Proven to be the most accurate method for a wide range of applications.
- Allow the use of a large number of attributes.
- Minimize over-fitting.
- Handle non-linear data.
- Unbiased estimation of the accuracy: Out Of Bag uses 1/3 of the training set to test the model.
- Estimate the attribute importance.
- Allow unsupervised classification and outlier detection.





# Detecting and mapping landslides

**ALADIM service: Automatic landslide detection and inventory mapping**



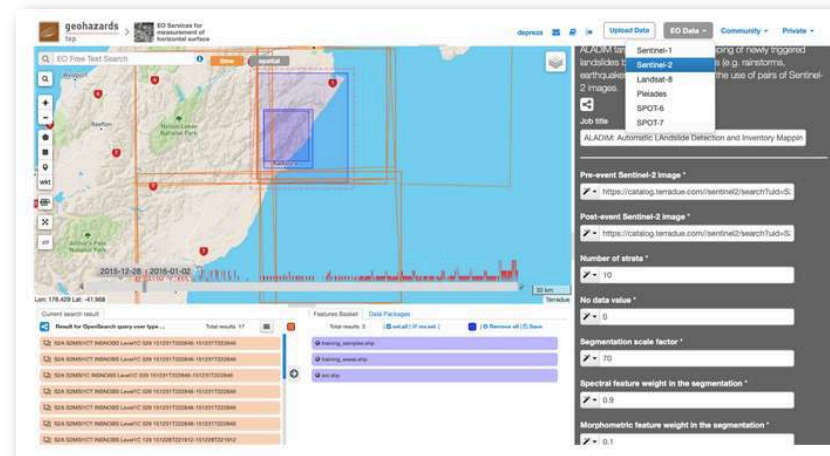
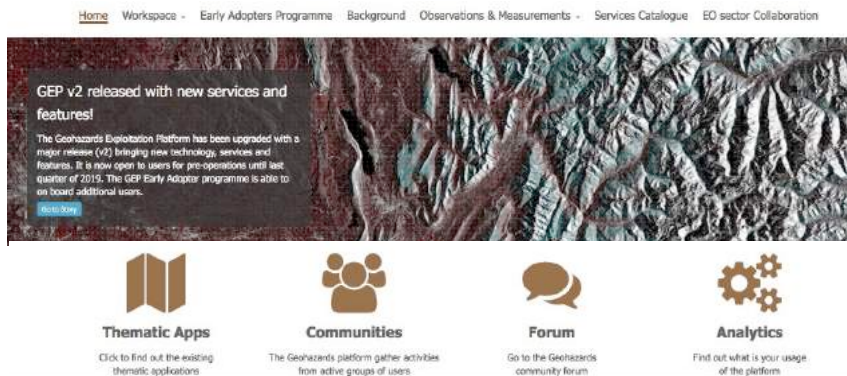
Available on



→ ALADIM-S2



and ALADIM-VHR



Service selection

Service use

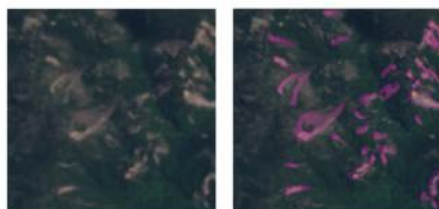


# Detecting and mapping landslides

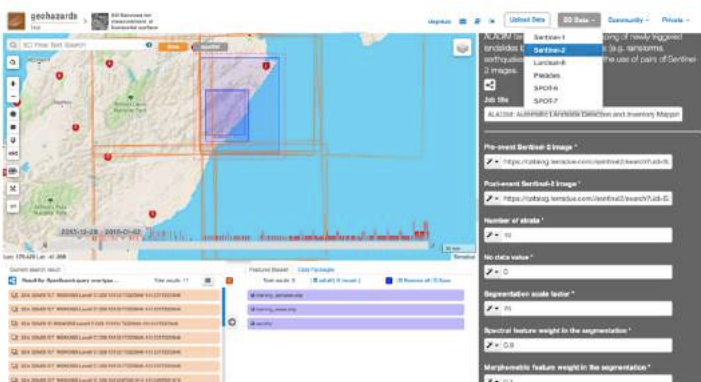
## ALADIM service: Step by Step



### 1. Creation of a landslide initial training sample



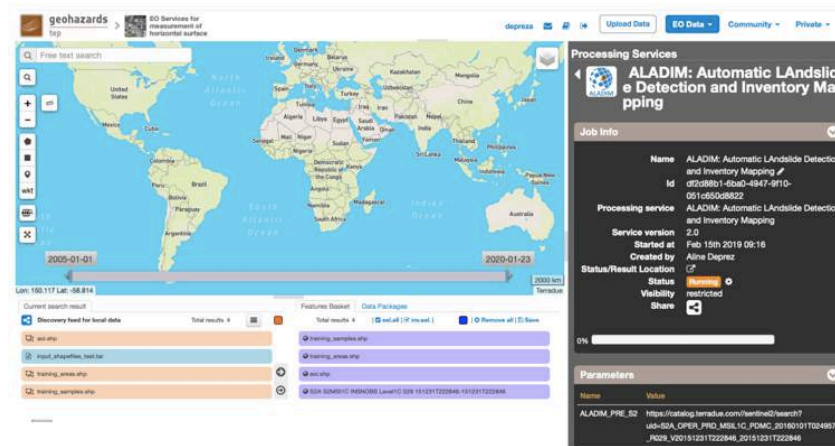
### 2. Selection of input data



### 3. Setting of the parameters

- Segmentation scale factor,
- Usage of cloud mask,
- Grid code,
- Sun elevation & azimuth ...

### 4. Launching the job



# Detecting and mapping landslides

Application for Mozambique Cyclone Idai - March 2019 - S2 data



The screenshot shows the 'geohazards' web application interface. At the top, there is a search bar with the text 'Free text search'. Below the search bar is a satellite map of a mountainous region. The map has a timeline at the bottom with dates '2005-01-01' and '2020-01-23'. The map coordinates are 'Lon: 32.756 Lat: -19.853'. On the right side of the map, there is a metadata panel with the following fields:

APE_WEIGHT	
ALADIM_SEG_MI	3
N_SIZE	
ALADIM_SUN_AZ	75.5730, 54.9723
IMUTH	
ALADIM_SUN_EL	29.962, 34.4068
EVIATION	
ALADIM_POSITIV	0.5
E_THRESHOLD	
ALADIM_GRID_C	36KVD
ODE	
ALADIM_USE_CL	True
OUD_MASK	
ALADIM_SHAPES	https://ecast.terradue.com/v2api/search/depreza/results?uid=FAFB3B034B791766E1DA11A0ECCD82A3D461D166

Below the map, there is a 'Discovery feed for local data' section with a list of 10 results. The first result is 'ALADIM-landsides-inventory-map'. To the right of the map, there is a 'Features Basket' section with 'Total results 0' and 'No results found'. At the bottom right, there is a 'Success' message: 'The job was completed successfully.' Below the success message, there are sections for 'Results', 'XML Result', and 'Technical Support'.



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# Detecting and mapping landslides

Application for Mozambique Cyclone Idai - March 2019 - S2 data



The screenshot shows the geohazards application interface. The main map displays satellite imagery with a brown landslide area. The interface includes a search bar, map controls, and a metadata panel on the right. The metadata panel lists various parameters for the landslide detection job.

Parameter	Value
APE_WEIGHT	
ALADIM_SEQ_MI	3
N_SIZE	
ALADIM_SUN_AZ	75.5730, 54.9723
IMUTH	
ALADIM_SUN_EL	29.962, 34.4088
EVIATION	
ALADIM_POSITIV	0.5
E_THRESHOLD	
ALADIM_GRID_C	36KVD
ODE	
ALADIM_USE_CL	True
OD_MASK	
ALADIM_SHAPES	<a href="https://recast.terraue.com/t2api/search/depreza/results?uid=FAFB3B034B791786E1DA11A0ECCD92A3D461D168">https://recast.terraue.com/t2api/search/depreza/results?uid=FAFB3B034B791786E1DA11A0ECCD92A3D461D168</a>

**Success**  
The job was completed successfully.

**Results**  
Found layers in the result. Show results

**XML Result**

**Technical Support**



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# Detecting and mapping landslides

Application for Mozambique Cyclone Idai - March 2019 - S2 data



The screenshot shows the TerraUE web application interface. The main map displays a satellite view of a mountainous region with blue overlays indicating landslide areas. The interface includes a search bar, navigation controls, and a metadata panel on the right.

**Metadata Panel:**

- APE\_WEIGHT: 1
- ALADIM\_SEG\_MI: 3
- N\_SIZE: 1
- ALADIM\_SUN\_AZ: 75.5730, 54.9723
- IMUTH: 1
- ALADIM\_SUN\_EL: 29.962, 34.4068
- EVIATION: 1
- ALADIM\_POSITIV: 0.5
- E\_THRESHOLD: 1
- ALADIM\_GRID\_C: 36KVD
- ODE: 1
- ALADIM\_USE\_CL: True
- OLD\_MASK: 1
- ALADIM\_SHAPES: <https://ecast.terraue.com/2api/search/depreza/results?uid=FAFB5B0348791766E1DA11A0ECCD92A3D461D168>

**Discovery feed for local data:**

- ALADIM\_landslides\_trainboxy\_map
- ALADIM\_post\_event\_image
- ALADIM\_post\_event\_image\_panchromatic
- ALADIM\_pre\_event\_image
- ALADIM\_pre\_event\_image\_panchromatic
- ALADIM\_training\_sample
- S2-20190209T075841-20190305T075609-36KVD-ALADIM-training-sample-29160

**Success Message:**

Success  
The job was completed successfully.

**Results:** Found layers in the result. Show results

**XML Result:** Show results

**Technical Support:** Show results



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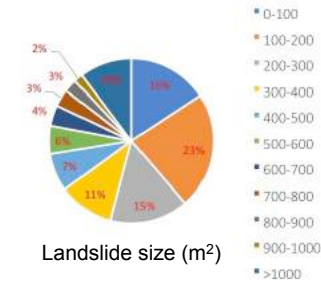
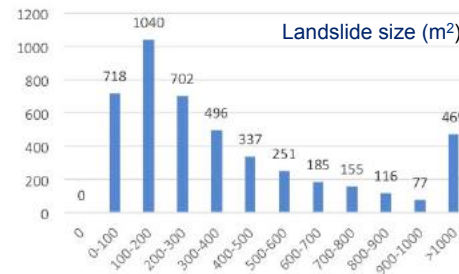
# Detecting and mapping landslides

## Use of landslide inventory maps



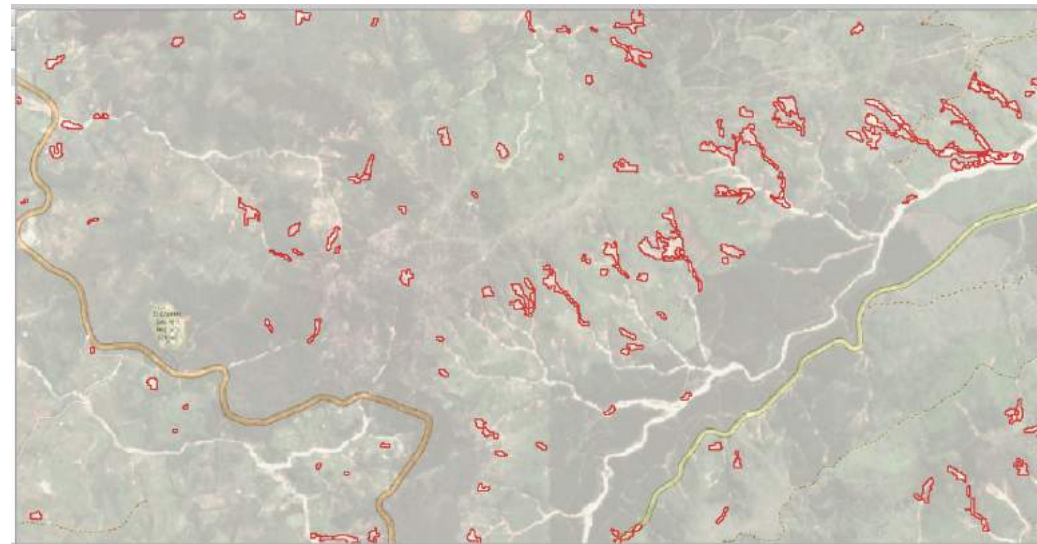
Computation of indicators / statistics

- *Landslide number,*
- *Landslide surface,*
- *Landslide density maps,...*



Overlay of the landslide inventory maps with:

- *Exposure maps,*
- *Population density maps, ...*
- *Correlation with triggers (rainfall, ETQ  $M_w$ )*



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# Detecting and mapping landslides

## Other application – ALADIM-VHR: Haiti landslide inventory



The screenshot shows the 'geohazards' web application interface. At the top, there is a search bar with the text 'Free text search'. Below the search bar is a large satellite image of a landslide area, with a date range from 2005-01-01 to 2020-01-23. The image is overlaid with a grid and a scale bar indicating 500 meters. To the right of the image is a panel with technical details for the landslide, including parameters like ALADIM\_SEG\_SC, ALADIM\_SEG\_C, ALADIM\_SEG\_S, ALADIM\_SEG\_MI, N\_SIZE, ALADIM\_SUN\_AZ, IMUTH, ALADIM\_SUN\_EL, EVATION, ALADIM\_POSITIV, E\_THRESHOLD, and ALADIM\_SHAPE. Below the image is a 'Discovery feed for local data' section with a list of results, including 'ALADIM\_pos\_event\_image', 'ALADIM\_pos\_event\_image\_panchromatic', 'ALADIM\_training\_sample', and several PDF files related to cross-validation and accuracy. A 'Success' message is displayed at the bottom right, stating 'The job was completed successfully.' Below the success message is a 'Results' section with a 'Show results' button and a 'Technical Support' link.



# Detecting and mapping landslides

## Other application – ALADIM-VHR: Haiti landslide inventory



The screenshot shows the geohazards web application interface. The main map displays a satellite view of a mountainous region with white lines indicating detected landslides. The interface includes a search bar, map controls, and a search results list. The search results list shows several items, including ALADIM training samples and validation data. The metadata panel on the right displays technical details for the selected result, including coordinates, elevation, and a URL to the result.

Parameter	Value
ALADIM_SEG_SC	400
ALE	
ALADIM_SEG_C	0.9
OLOR_WEIGHT	
ALADIM_SEG_S	0.1
HAPE_WEIGHT	
ALADIM_SEG_M	3
N_SIZE	
ALADIM_SUN_AZ	90.4447,31.1773
IMUTH	
ALADIM_SUN_EL	64.28840,40.22012
EVATION	
ALADIM_POSITIV	0.5
E_THRESHOLD	
ALADIM_SHAPE	https://ecast.terraue.com/2api/search/deproza
S	/results?uid-13A7C8CFB05EE68776646F2F78F25BD
	AA441209E



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# Detecting and mapping landslides

## Other application – ALADIM-VHR: Haiti landslide inventory



The screenshot shows the geohazards web application interface. The main map displays a satellite view of a mountainous region with landslide inventory data overlaid. The interface includes a search bar, map controls, a data table, and a success message.

**Current search result**

Discovery feed for local data	Total results: 10
ALADIM landslides_inventory_map	
ALADIM_post_event_image	
ALADIM_post_event_image_panchromatic	
ALADIM_pre_event_image	
ALADIM_pre_event_image_panchromatic	
ALADIM_training_sample	
cc90_20160108_20170211_ALADIM_training_sample_20190712T104027.tif	

**Metadata Table:**

PROPERTY	VALUE
ALADIM_SEG_SC	400
ALE	
ALADIM_SEG_C	0.9
CLOR_WEIGHT	
ALADIM_SEG_S	0.1
HAPE_WEIGHT	
ALADIM_SEG_MI	3
N_SIZE	
ALADIM_SUN_AZ	90.4447311773
IMUTH	
ALADIM_SUN_EL	64.288404022012
EVATION	
ALADIM_POSITIV	0.5
E_THRESHOLD	
ALADIM_SHAPE	https://recast.terraue.com/2api/search/depreza/results?uid=13A7C8CFB05EE68776646F2F78F25B0AA441200E

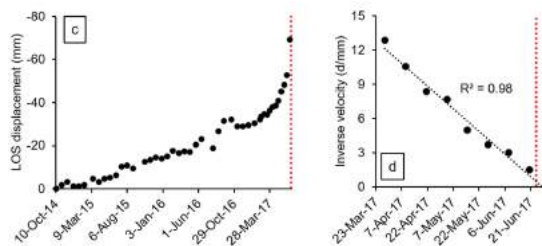
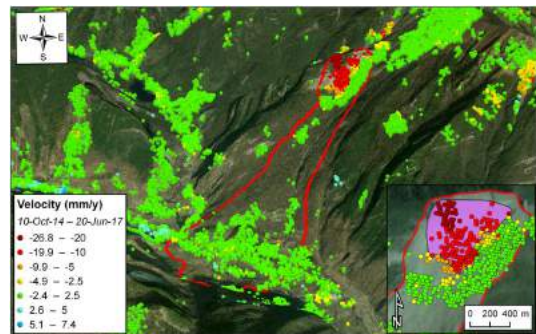
**Success Message:** The job was completed successfully.



# Quantifying tectonic deformation and monitoring landslide motion

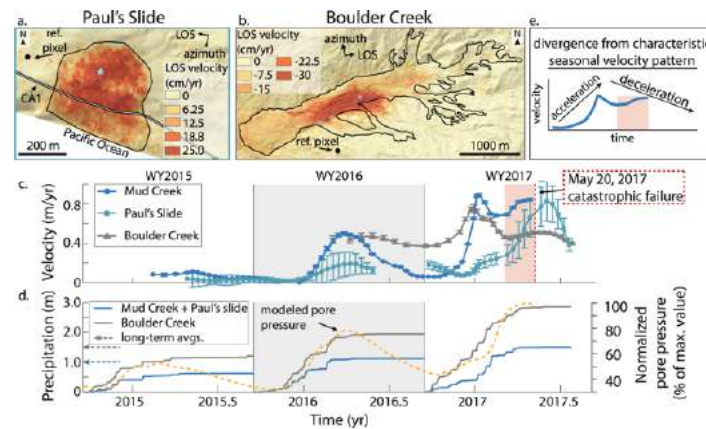
Surface motion monitoring for geohazards

## Risk management and risk



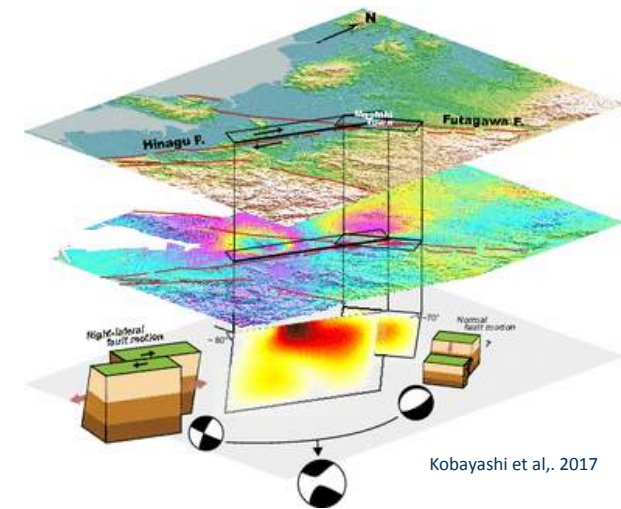
Kang et al., 2019

## Better understanding of the mechanisms controlling the phenomena



Handwerker et al., 2019

## Modelling of the phenomena



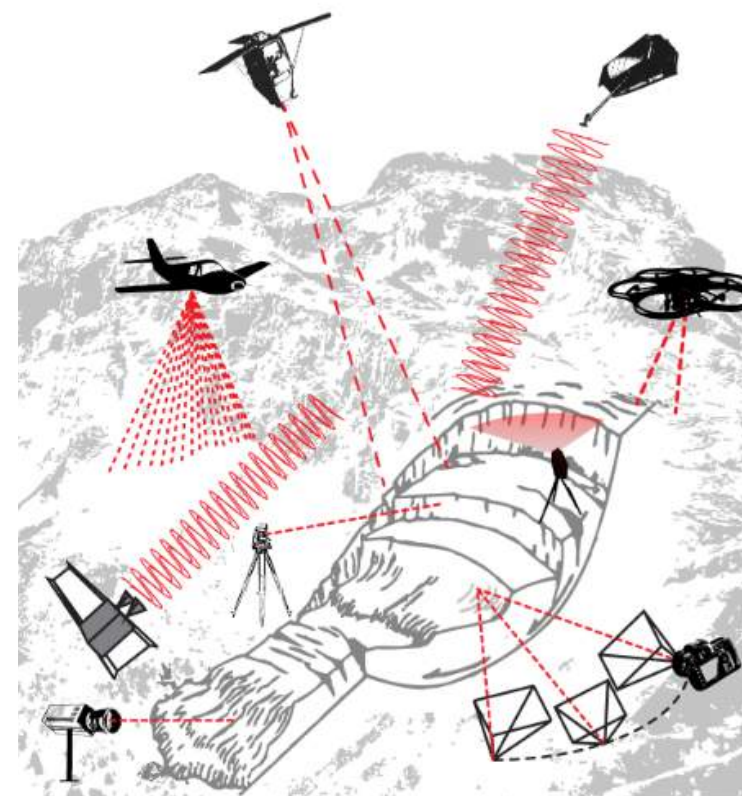
Kobayashi et al., 2017

# Quantifying tectonic deformation and monitoring landslide motion

## Surface motion monitoring instruments and techniques

Methods	Measure	Instrument
GNSS	3D displacement at 1 point	Ground-based
Tacheometer	LOS motion at 1 point	Ground-based
Levelling	Z motion at 1 point	Ground-based
LiDAR	3D reconstruction	Ground-based, airborne
Photogrammetry	3D reconstruction	Ground-based, airborne, space borne
InSAR	LOS motion over a large area	Ground-based, airborne, space borne
Image Correlation	2D motion in the plane perpendicular to LOS	Ground-based, airborne, space borne

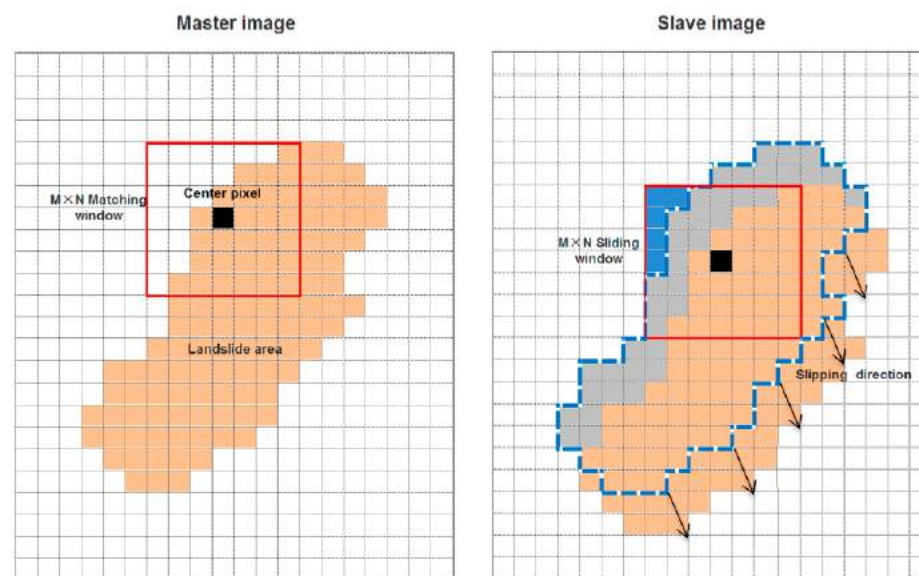
➔ The 3 last methods are ground-based or space-borne allowing a large range of spatial resolution and revisit frequency



# Quantifying tectonic deformation and monitoring landslide motion

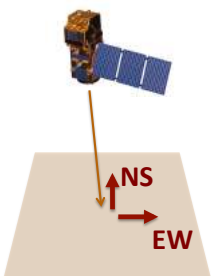
## Image correlation – sub-pixel offset or feature tracking

- Measure internal misalignment using a moving template window, while measuring displacements that occurred in the time span between two acquisitions.
- Measure the displacement in the plan perpendicular to the camera LOS (ie. in case of nadir looking space borne, measure of horizontal motion).
- Different approaches have been implemented:  
Normalized Cross-Correlation  
Correlation in the frequency domain, etc.
- Different algorithms are available: CsiCorr (Caltech), MicMac (IGN), AMES (NASA), GeoFolki (ONERA), MathWorks-normxcorr2, DPIV, , etc.




# Quantifying tectonic deformation and monitoring landslide motion

Image correlation – sub-pixel offset or feature tracking – advantages/limitations



**Space borne Optical Image Correlation**

- **Sensitive to Horizontal movement,** Non 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.**



**Space borne 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 cas of larger motion, decorrelation usually prevents to monitor the deformation.
- **Non sensitive to cloud cover.**



This two techniques are complementary to retrieve the complete 3D displacement for different magnitude of deformation

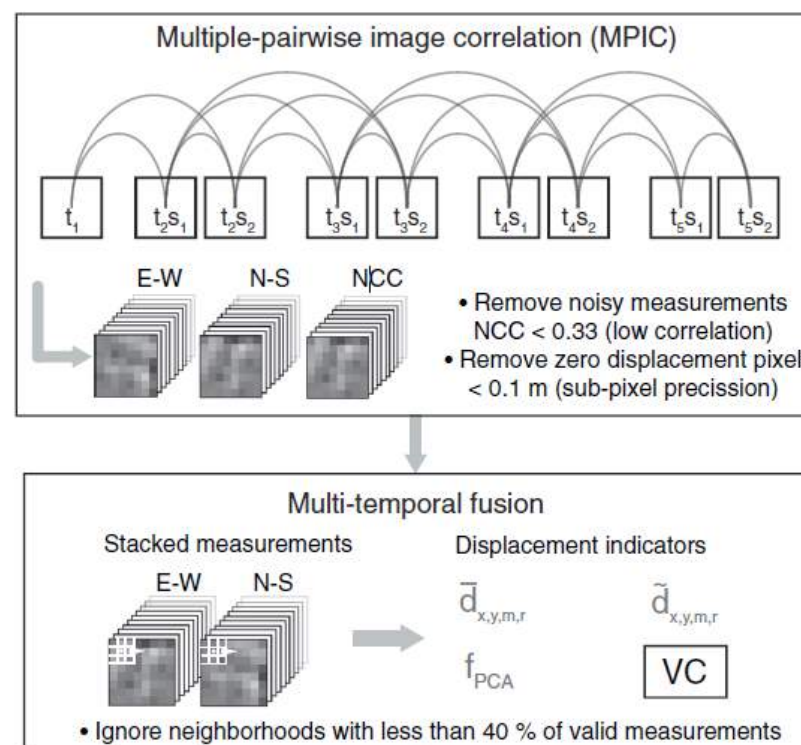
# Quantifying tectonic deformation and monitoring landslide motion

## Description of the MPIC processing chain

- MPIC stands for **Multiple-Pairwise Image Correlation**.
- The MPIC service comprises two main steps:
  1. The MPIC itself,
  2. A multi-temporal fusion that compute different features of the displacement time series in order to detect **persistent motion pattern**.

**Inputs:** Several optical acquisitions – Sentinel 2

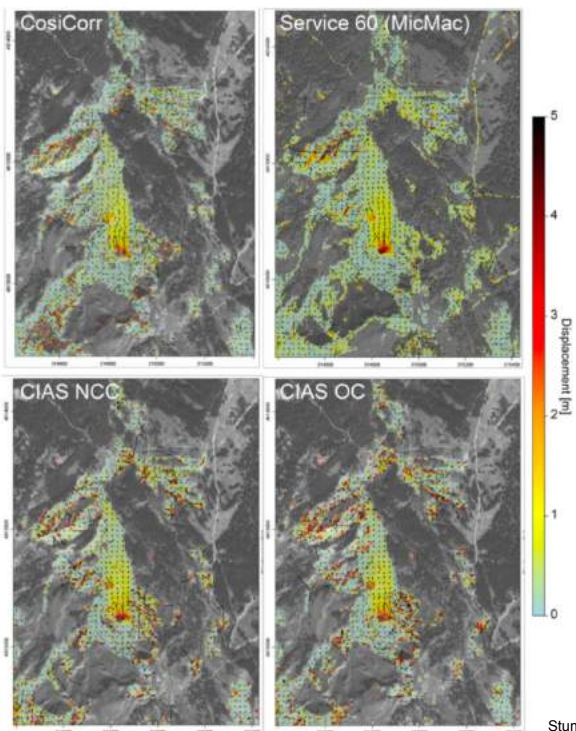
**Outputs:** Correlation coefficient for each pair of images  
 Cloud masks  
 EW and NS displacement for each pair of images  
 Mean absolute velocity EW and NS  
 Mean displacement magnitude in meters  
 Vector coherence



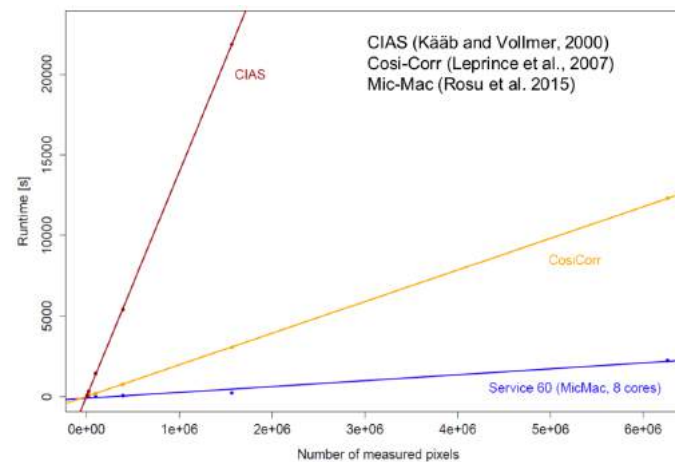
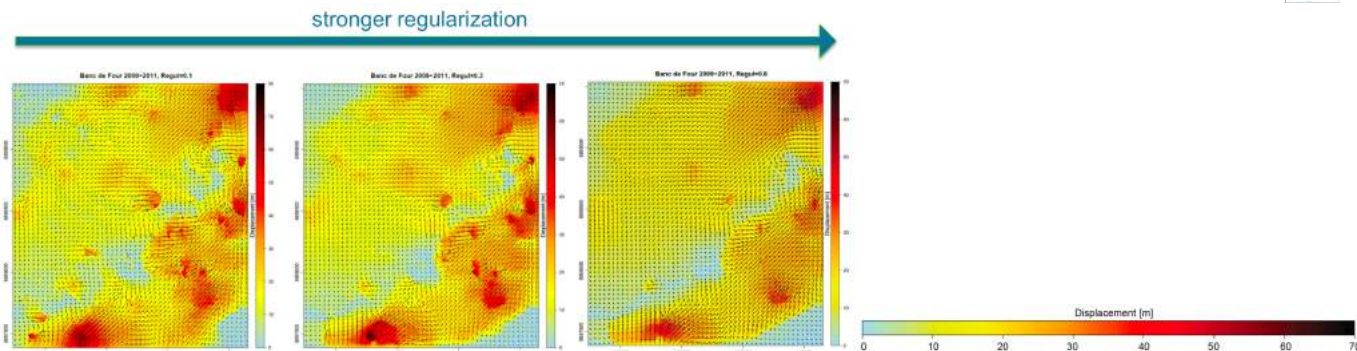
# Quantifying tectonic deformation and monitoring landslide motion

## Parameterization

- Effect of image correlation algorithms and parameterization



- Effect of increasing spatial regularization strength



- Effect of runtime scaling

Stumpf et al. (2016)

# Quantifying tectonic deformation and monitoring landslide motion

## Description of the MPIC processing chain

### ➤ MPIC

**MicMac**, developed by IGN, is used to compute the NCC and the sub-pixel displacement.

*MicMac was chosen among other algorithm because of its regularization method, it produces smoother results with less noise and smaller windows size.*

### ➤ Multi-temporal fusion

$$\bar{d}_{x,y,m,r} = \left\| \left( \frac{1}{|\Delta X|} \sum_{i=1}^{|\Delta X|} \Delta X_i \right), \left( \frac{1}{|\Delta Y|} \sum_{i=1}^{|\Delta Y|} \Delta Y_i \right) \right\|$$

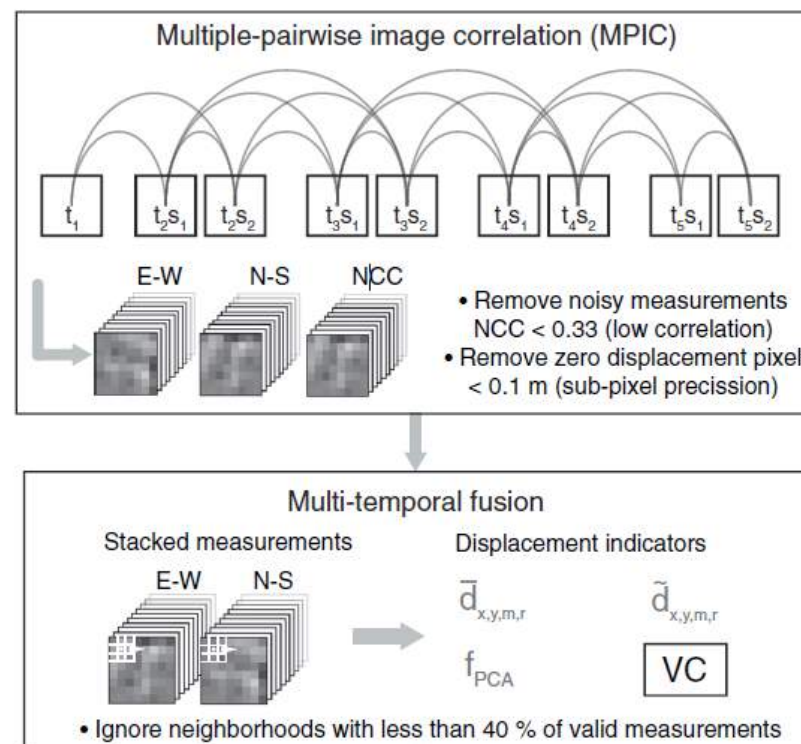
#### Mean displacement

Account for persistent of the movement in space and time.

$$VC = \frac{\left\| \left( \sum_{i=1}^{|\Delta X|} \Delta X_i \right), \left( \sum_{i=1}^{|\Delta Y|} \Delta Y_i \right) \right\|}{\sum_{i=1}^{|\Delta X|} \|\Delta X_i, \Delta Y_i\|}$$

#### Vector Coherence

Account for coherence of the direction and magnitude of the motion in space and time.





# Quantifying tectonic deformation and monitoring landslide motion

## MPIC – algorithm details

### 1. Cloud mask

Computed with python function *Fmask* (Zhu, Z. and Woodcock, C.E., 2015) for each Sentinel-2 acquisition, then combined.

### 2. Correlation

Computed with *MicMac* for all pairs.

### 3. Deramping

Correct systematic offset resulting mainly from translation and rotation.

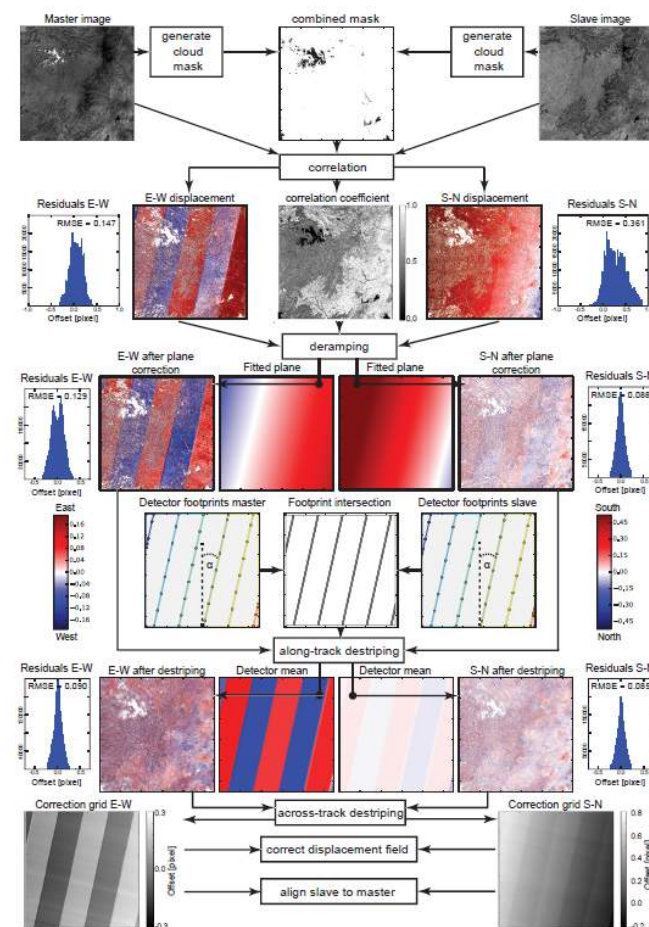
$$\Delta x_{a,i} = a_x + b_x x_{r,i} + c_x y_{r,i}$$

$$\Delta y_{a,i} = a_y + b_y x_{r,i} + c_y y_{r,i}$$

Modelling of the ramp

### 4. De-striping

Correct small systematic image offsets which manifest as along-track striping artefacts which are particularly visible in the EW component but can also be observed in the NS component (for Sentinel-2). This is due to staggered sensor arrays of push broom satellite such as Sentinel-2.



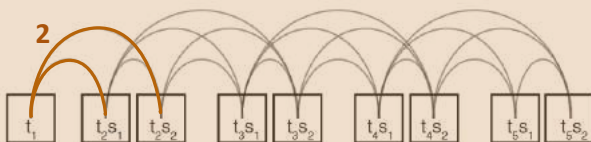
Stumpf et al., 2018



# Quantifying tectonic deformation and monitoring landslide motion

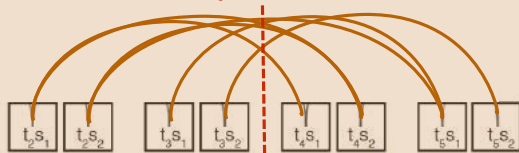
## Description of the MPIC parameters on GEP

Defines how many pairs will be created considering the temporal order of the selected images.

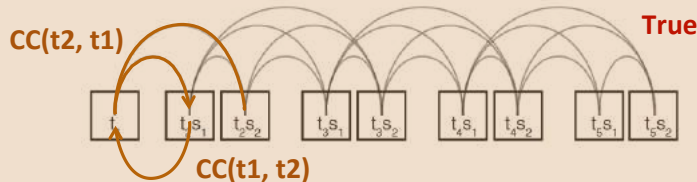


Sentinel-2 tile > can be found in the product name after the "T"  
Ex: S2A\_MSIL1C\_20170223T222531\_N0204\_R029\_T59GQP\_20170223T222726

Split the time series into two subsets and pairs will only be formed among members of different subsets. Default: **NONE**. **Split date**



If set to **True** backward matching will be performed for each pair.



Job title \*  
MPIC-OPT: Multiple pairwise optical image correlatic

Sentinel-2 products (at least 2) \*  
<https://catalog.terradue.com/sentinel2/search?uid=>

Sentinel-2 band \*  
B04

Temporal matching range \*  
2

Sentinel-2 tile \*  
59GQP

Split date (yyyy-MM-ddTHH) \*

Activate backward matching \*  
True

Window size \*  
3

Decorrelation threshold \*  
0.2

Spatial matching range \*  
1

Regularization parameter \*  
0.3

**Caution:** choosing to compute a large number of pairs rapidly increase computing time and resources.

**Comment:** Setting this parameter can be particularly interesting for an earthquake, the splitting date being the earthquake date.

**Caution:** If set to True, it will increase computing time and resources.

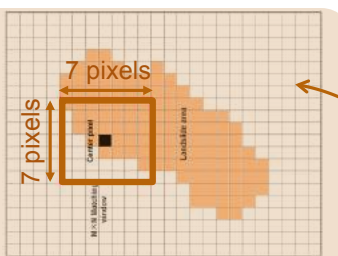


# Quantifying tectonic deformation and monitoring landslide motion

## Description of the MPIC parameters on GEP

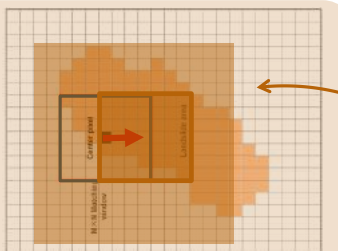
Size of the template used for matching among the input images.

Default value: 3 (i.e. 7x7pixel window size).



Matches with a correlation coefficient below this threshold will be discarded.

Defines the search range in pixel for finding matches. The actual search range is computed from this parameter as  $\text{round}(\text{Spatial matching range}/0.8)+2$ .



Controls the smoothness of the expected motion field. Increasing the regularization parameter is putting greater emphasis on a smooth motion field where neighbouring pixels will have similar displacement values.

Job title \*

MPIC-OPT: Multiple pairwise optical image correlatic

Sentinel-2 products (at least 2) \*

<https://catalog.terradue.com/sentinel2/search?uid=>

Sentinel-2 band \*

B04

Temporal matching range \*

2

Sentinel-2 tile \*

59GQP

Split date (yyyy-MM-ddTHH) \*

Activate backward matching \*

True

Window size \*

3

Decorrelation threshold \*

0.2

Spatial matching range \*

1

Regularization parameter \*

0.3

A smaller window will allow to better reconstruct small scale variations while at the same time can lead to more noise. Vice versa larger window sizes will lead to greater robustness against noise while smoothing small scale details.

This parameter should be adjusted according to the maximum expected displacement taking into account also the possible coregistration bias of the input images.

# Quantifying tectonic deformation and monitoring landslide motion



## MPIC for tectonic deformation – Comparison to other results

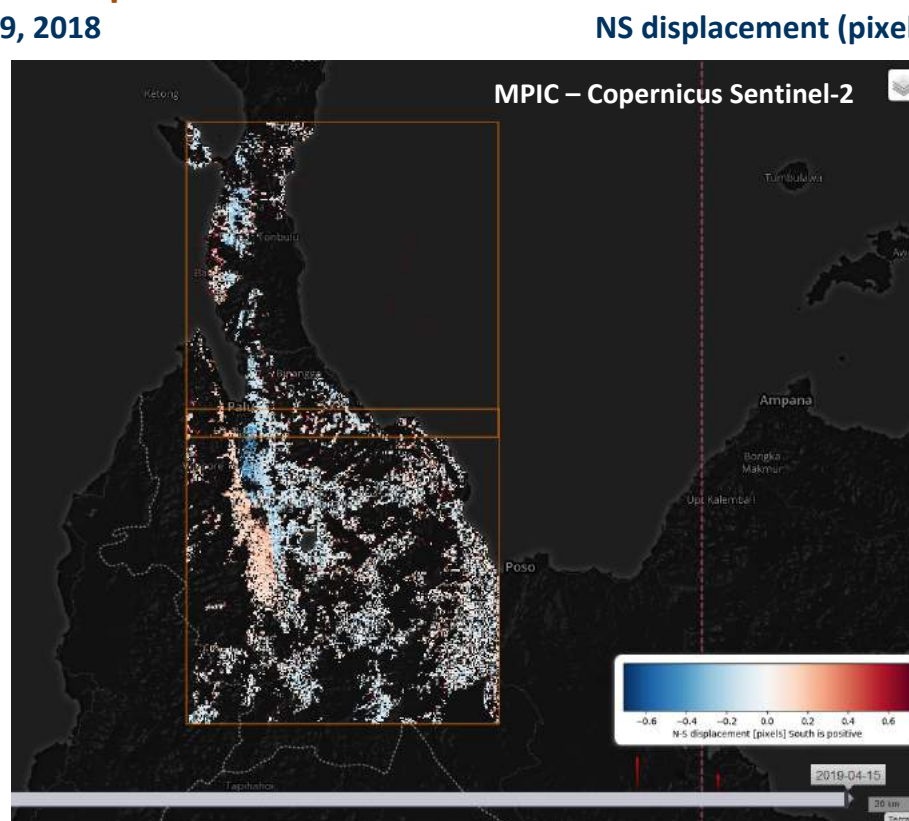
➤ Mw 7.5 Sulawesi Earthquake - Sep 29, 2018



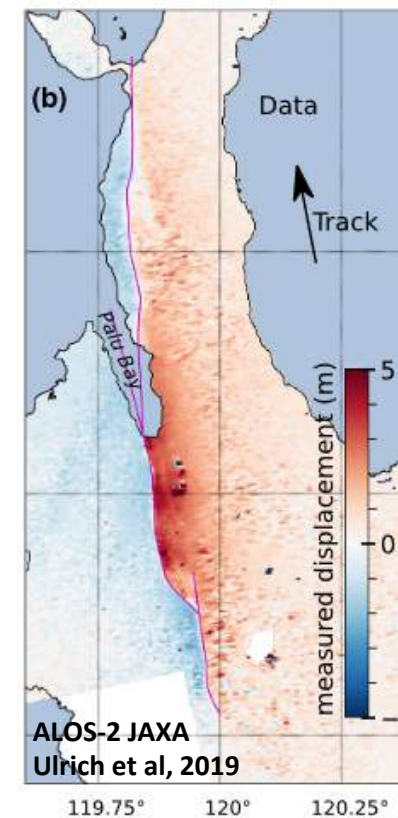
**JOBS:** MPIC-OPT-Palu2018 - 50MRD  
 MPIC-OPT-Palu2018 - 50MRE  
**Inputs:** 2 images,  
 2018/09/17 – 2018/10/02



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Along track displacement (m)



# Quantifying tectonic deformation and monitoring landslide motion

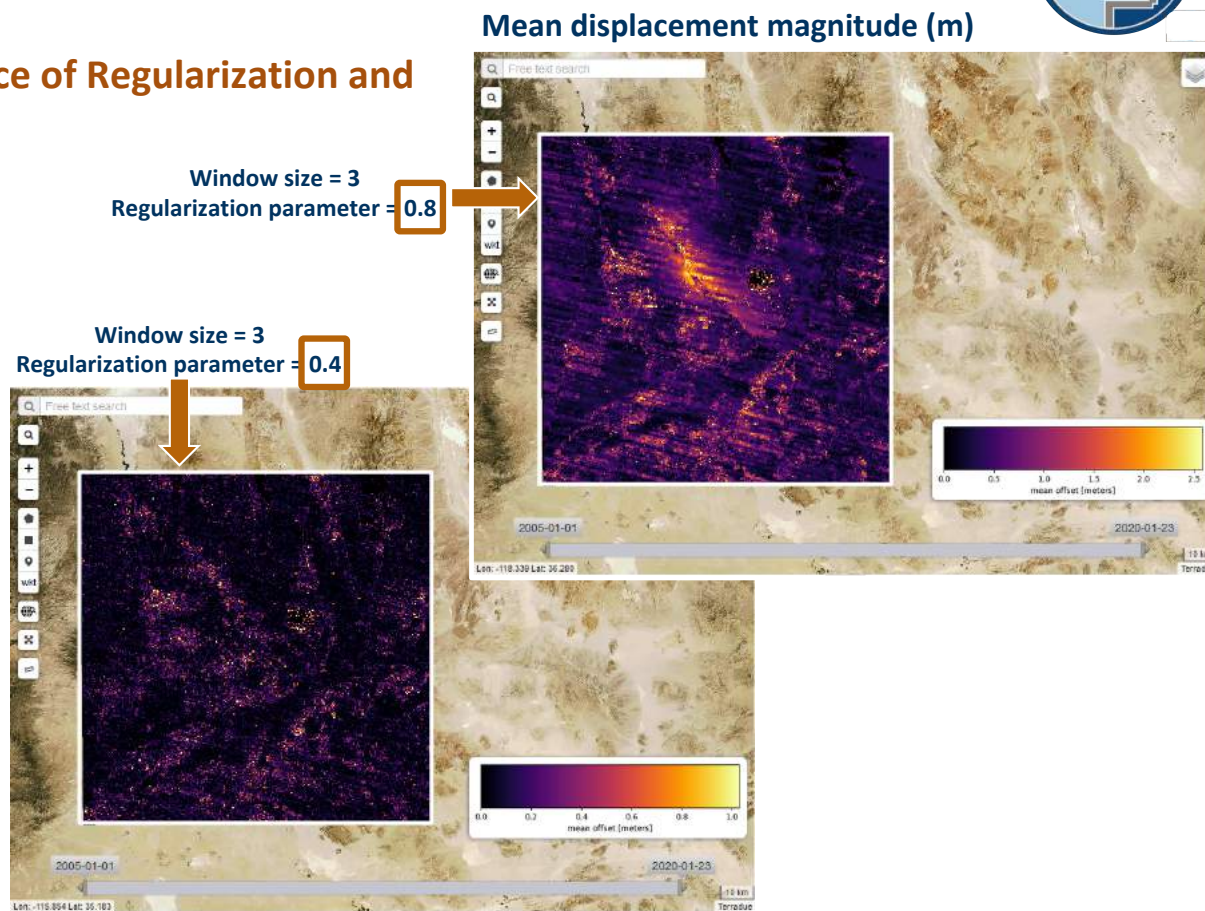
## MPIC for tectonic deformation – Influence of Regularization and windows size parameters

### ➤ Ridgecrest earthquake sequence - July, 2019



**JOBS:** MPIC-OPT S2B Ridgecrest EQ 20190628-20190708  
 MPIC-OPT - Ridgecrest EQ 2019 – reg0.8  
 MPIC-OPT - Ridgecrest EQ 2019 - win7

**Inputs:** 2 images,  
 2019/06/28 – 2019/07/08



# Quantifying tectonic deformation and monitoring landslide motion

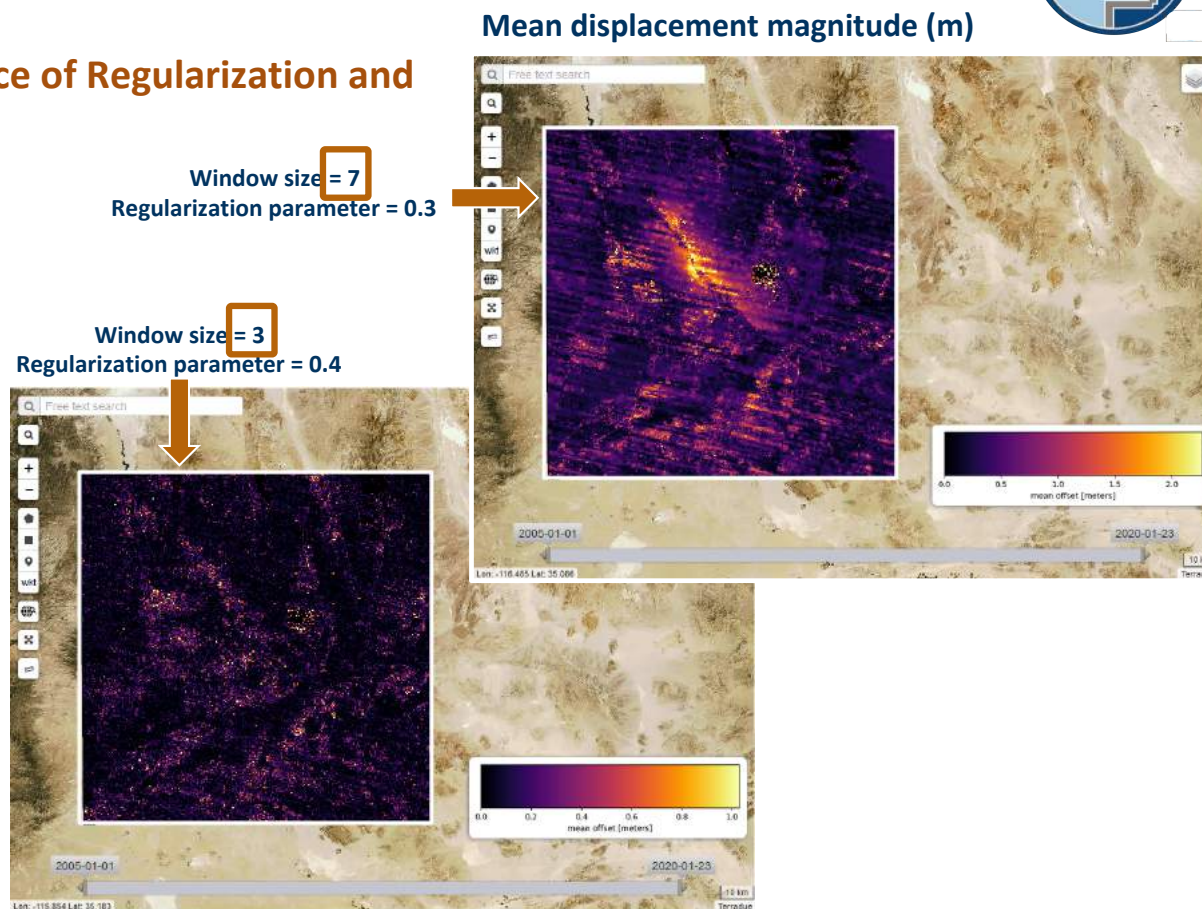
## MPIC for tectonic deformation – Influence of Regularization and windows size parameters

### ➤ Ridgecrest earthquake sequence - July, 2019



**JOBS:** MPIC-OPT S2B Ridgecrest EQ 20190628-20190708  
 MPIC-OPT - Ridgecrest EQ 2019 – reg0.8  
 MPIC-OPT - Ridgecrest EQ 2019 - win7

**Inputs:** 2 images,  
 2019/06/28 – 2019/07/08



# Quantifying tectonic deformation and monitoring landslide motion

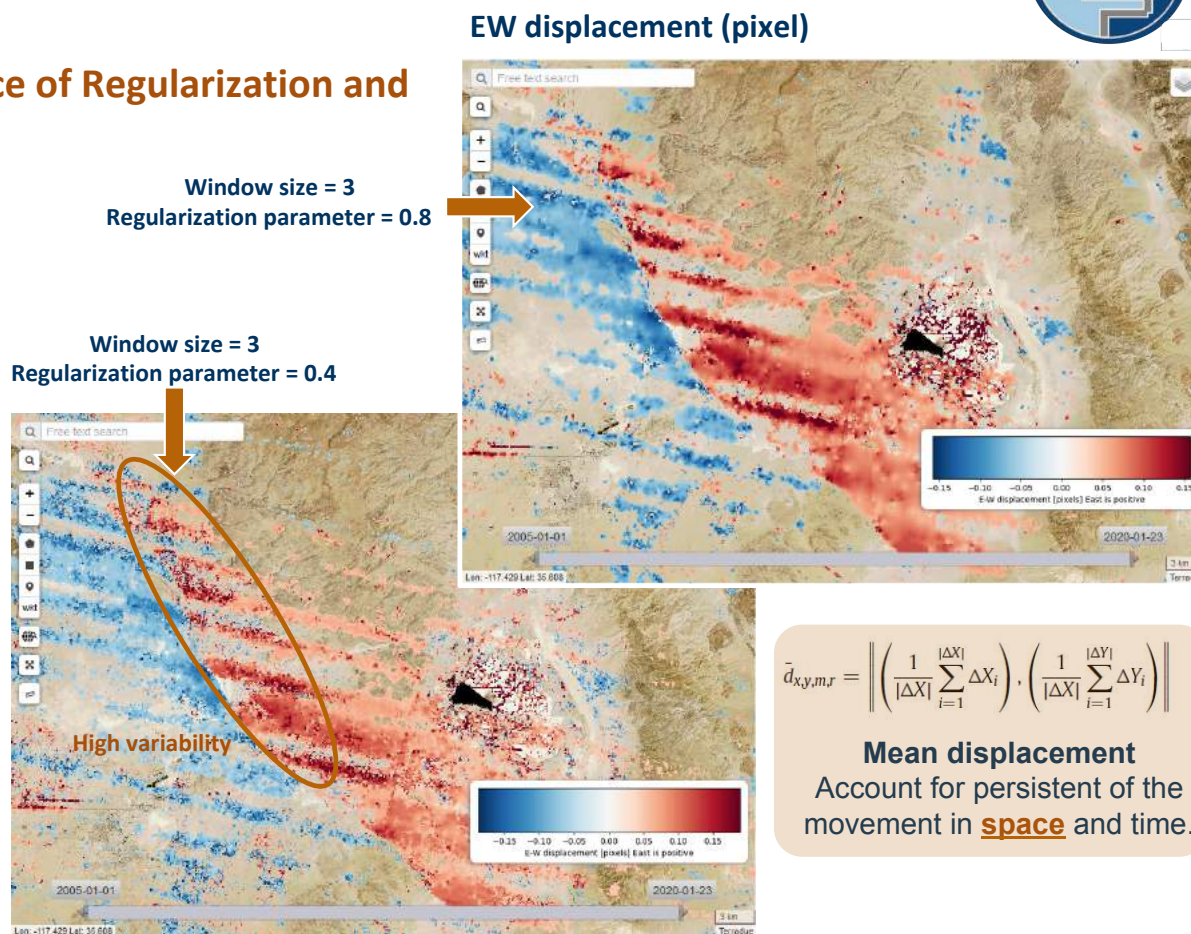
## MPIC for tectonic deformation – Influence of Regularization and windows size parameters

### ➤ Ridgecrest earthquake sequence - July, 2019



**JOBS:** MPIC-OPT S2B Ridgecrest EQ 20190628-20190708  
 MPIC-OPT - Ridgecrest EQ 2019 – reg0.8  
 MPIC-OPT - Ridgecrest EQ 2019 - win7

**Inputs:** 2 images,  
 2019/06/28 – 2019/07/08



$$\bar{d}_{x,y,m,r} = \left\| \left( \frac{1}{|\Delta X|} \sum_{i=1}^{|\Delta X|} \Delta X_i \right), \left( \frac{1}{|\Delta Y|} \sum_{i=1}^{|\Delta Y|} \Delta Y_i \right) \right\|$$

**Mean displacement**  
 Account for persistent of the movement in **space** and time.

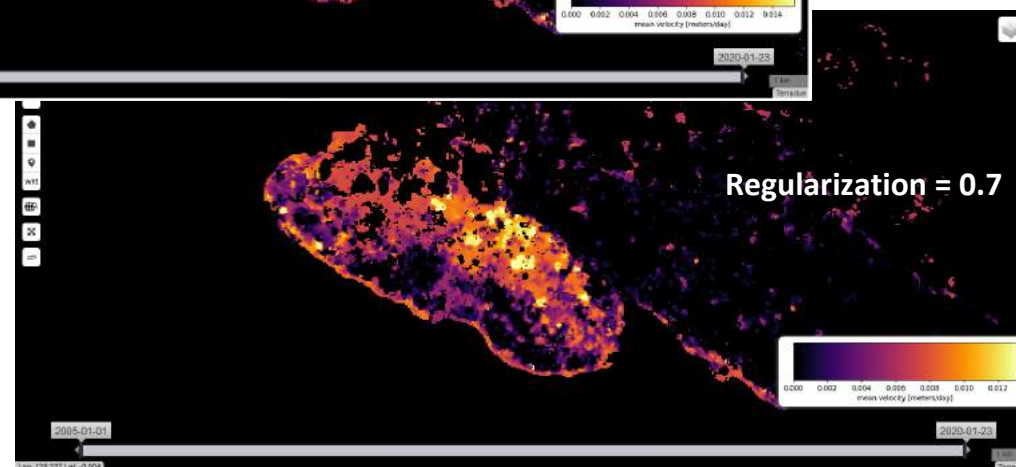
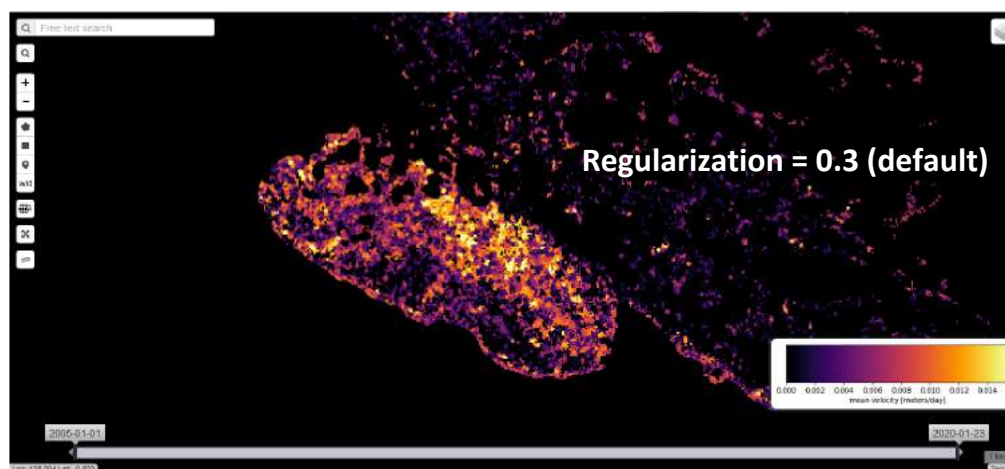
# Quantifying tectonic deformation and monitoring landslide motion

## Effect of the regularization parameter

➤ Mw 7.2 Halmahera Earthquake, July 14, 2019



Mean EW velocity (m/days)



### JOBS:

MPIC-OPT - Halmahera earthquake 2019

MPIC-OPT - Halmahera earthquake 2019 – reg0.7

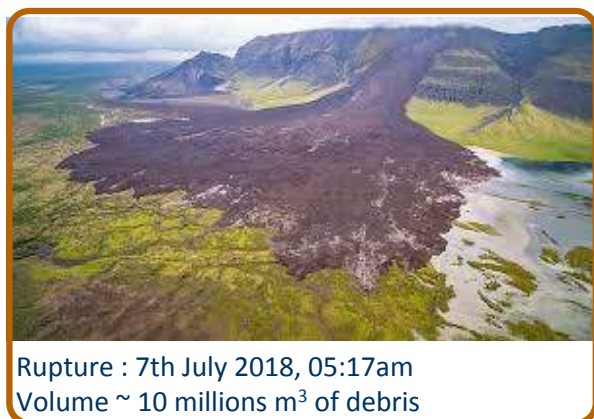
Inputs: 2 images, 2018/11/12 - 2019/08/09



# Quantifying tectonic deformation and monitoring landslide motion

## Monitoring landslide motion – pre-rupture signal

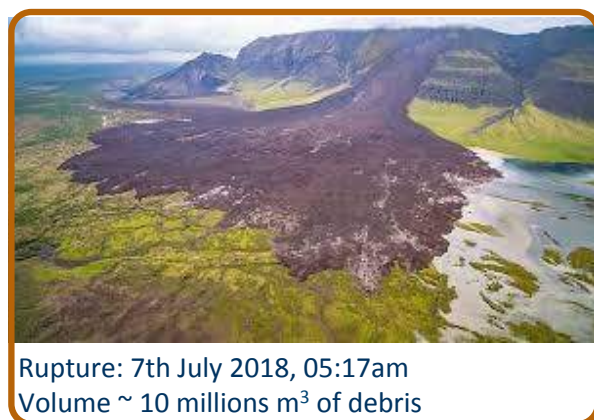
➤ Fagraskógarfjall landslide , Iceland



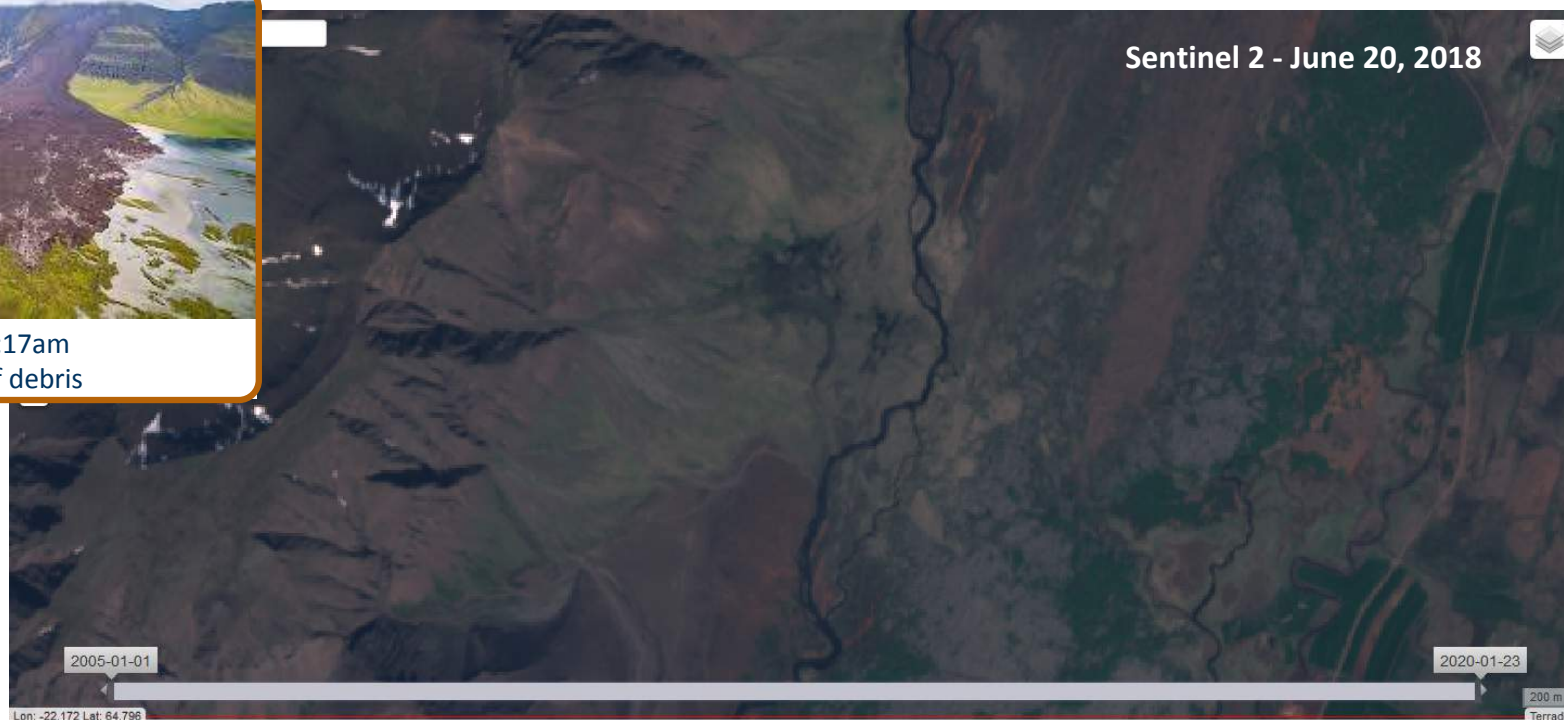
# Quantifying tectonic deformation and monitoring landslide motion

## Monitoring landslide motion – pre-rupture signal

➤ Fagraskógarfjall landslide , Iceland



Rupture: 7th July 2018, 05:17am  
Volume ~ 10 millions m<sup>3</sup> of debris



# Quantifying tectonic deformation and monitoring landslide motion

## Monitoring landslide motion – pre-rupture signal

➤ Fagraskógarfjall landslide , Iceland

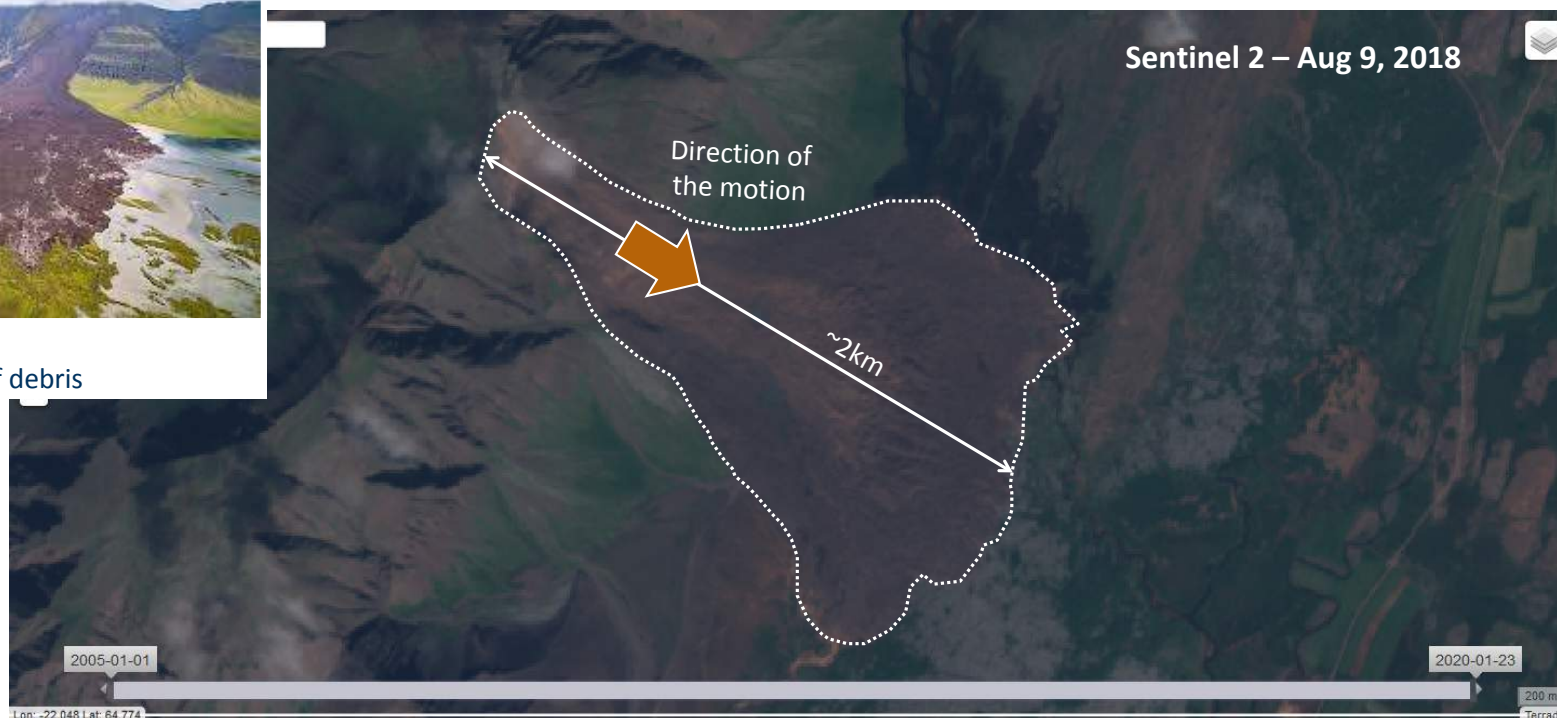
**JOB:**

Full Resolution Rasterization - Fagraskógarfjall 2018 landslide

**Inputs:** 2 images, 2018/06/20 – 2018/08/09



7th July 2018, 05:17am  
Volume ~ 10 millions m<sup>3</sup> of debris



# Quantifying tectonic deformation and monitoring landslide motion

## Monitoring landslide motion – pre-rupture signal

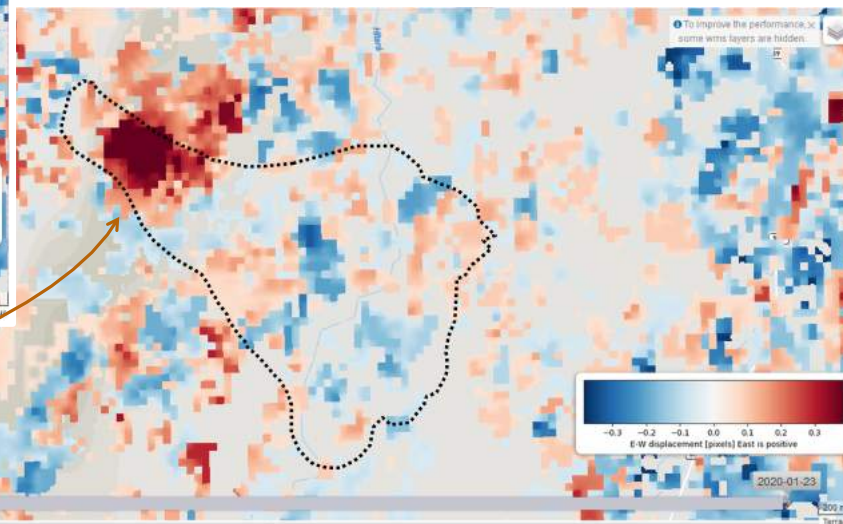
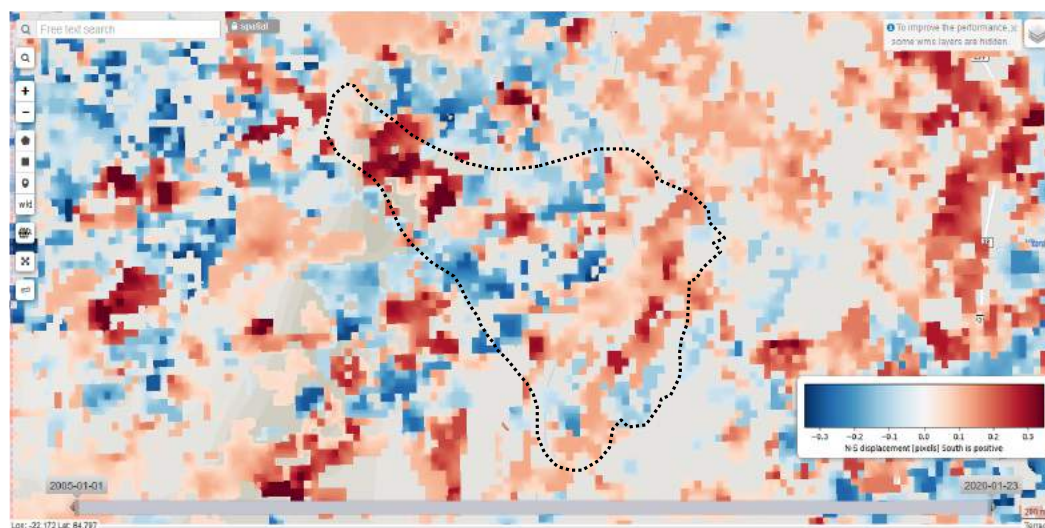
➤ Fagraskógarfjall landslide , Iceland

**JOB:**

MPIC-OPT - Fagraskógarfjall 2018 landslide

**Inputs:** 2 images, 2017/05/21 – 2018/06/20

EW (left) and NS (right) displacement (pixel)



Metric displacement are recorded in the year preceding the rupture....



# Quantifying tectonic deformation and monitoring landslide motion

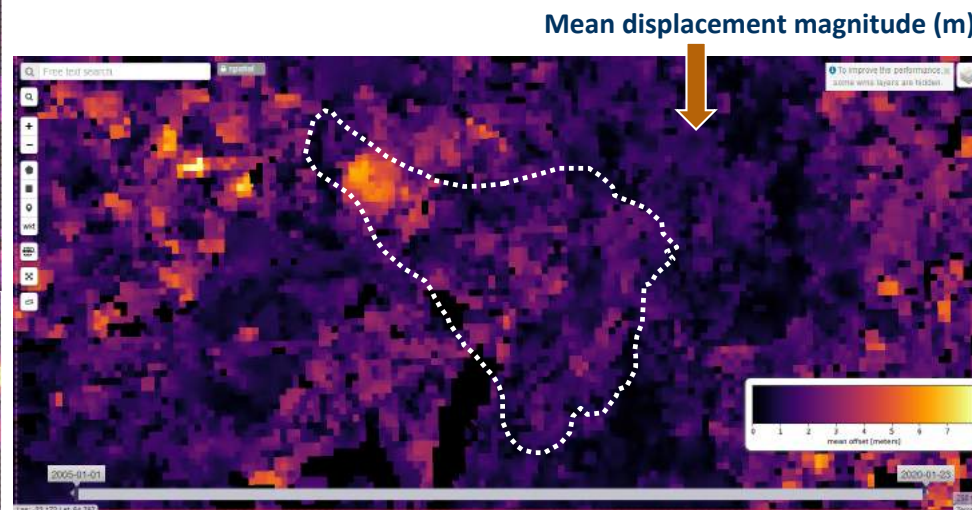
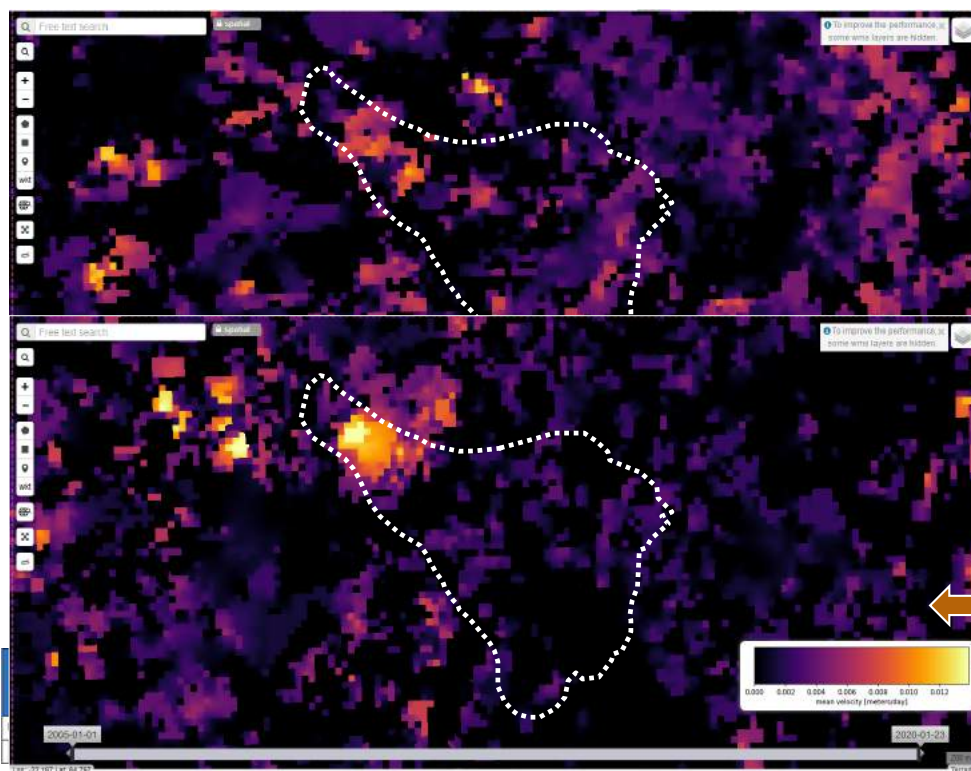
## Monitoring landslide motion – pre-rupture signal

➤ Fagraskógarfjall landslide , Iceland

### JOB:

MPIC-OPT - Fagraskógarfjall 2018 landslide

Inputs: 2 images, 2017/05/21 – 2018/06/20



NS (upper left) and EW (lower left) mean velocity (m/day)

Mean displacement magnitude (m)

# Quantifying tectonic deformation and monitoring landslide motion



## Monitoring glacier motion –

➤ Mer de glace, French Alps, France



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# Quantifying tectonic deformation and monitoring landslide motion



## Monitoring glacier motion –

➤ Mer de glace, French Alps, France

### JOBS:

MPIC-OPT – Chamonix2016-2018

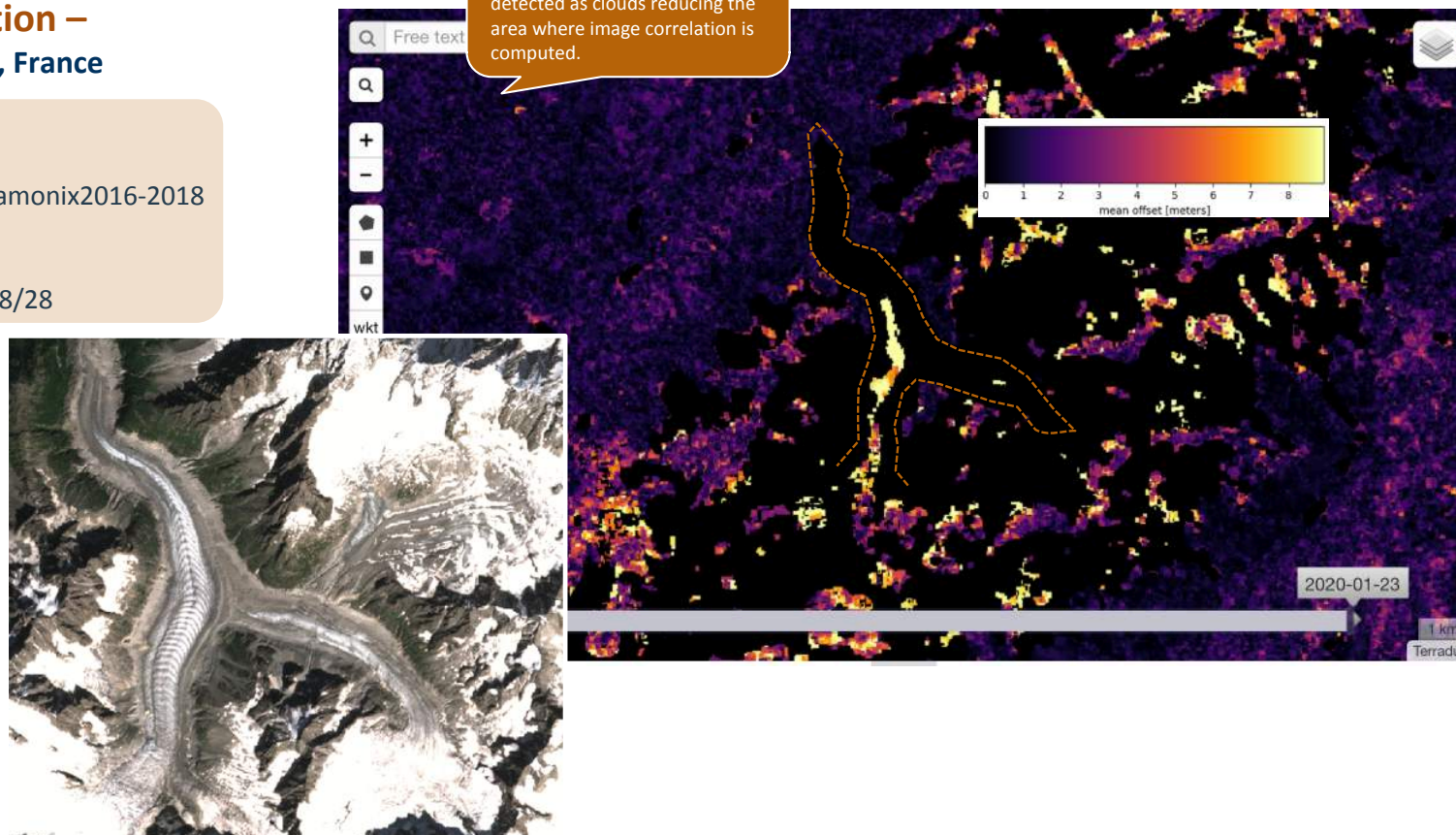
Full Resolution Rasterization - Chamonix2016-2018

### Inputs: 3 images,

2016/08/13, 2017/10/07, 2018/08/28

See the cloud masks quality.  
Most of the glacier areas are  
detected as clouds reducing the  
area where image correlation is  
computed.

Mean displacement magnitude (m)



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# Quantifying tectonic deformation and monitoring landslide motion



## Monitoring glacier motion –

- Miage glacier , French Alps, France



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# Quantifying tectonic deformation and monitoring landslide motion

## Monitoring glacier motion –

➤ Miage glacier , French Alps, France

### JOBS:

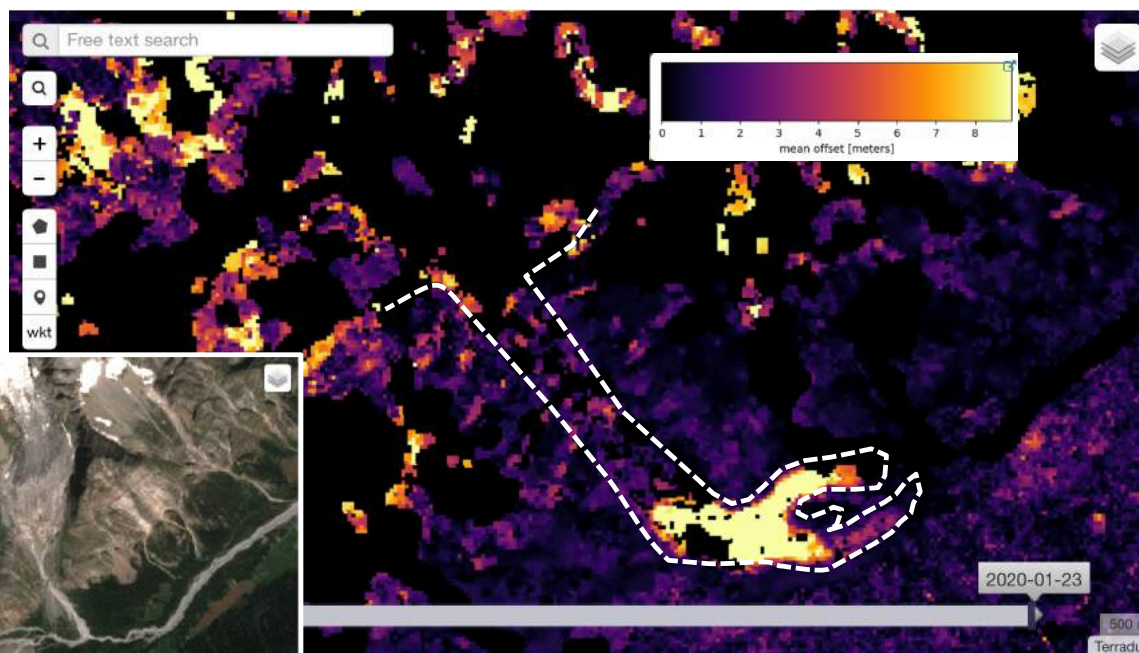
MPIC-OPT – Chamonix2016-2018

Full Resolution Rasterization - Chamonix2016-2018

### Inputs: 3 images,

2016/08/13, 2017/10/07, 2018/08/28

Mean displacement magnitude (m)



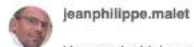
# Creating high-resolution surface models



DSM-OPT service on-line on GEP: creation of High-Resolution Digital Surface Models (HR-DSMs) and orthophotos from Pléiades stereo-images

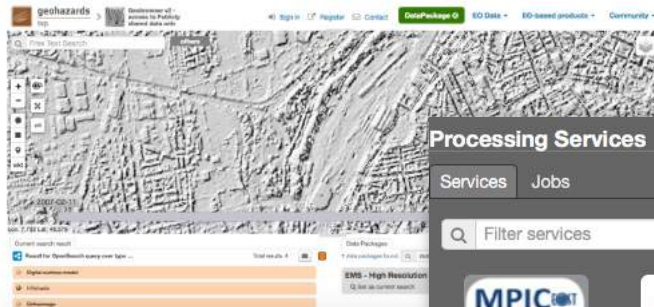
## New GEP service from CNRS EOST - DSM-OPT for the generation of surface models from Pléiades satellite data

gep-blog



jeanphilippe.malet 1 Mar 5


You need a high resolution surface model to analyse the traces of a fault rupture, to calculate the elevation differences (depletion, accumulation) following a large landslide, to estimate the volume of lava flows on volcanoes and estimate effusive rates, or integrate an accurate topography in InSAR processing? The new GEP service DSM-OPT from CNRS-EOST is for you! This service allows the generation of digital surface models (DSMs) and the respective ortho-images from stereo- and tri-stereo Pléiades images using the MicMac open source library. An example of the service results using stereo-images over the complex urban landscape of Strasbourg is presented below, and is also posted [here](#).




**Processing Services**

Services Jobs


Filter services



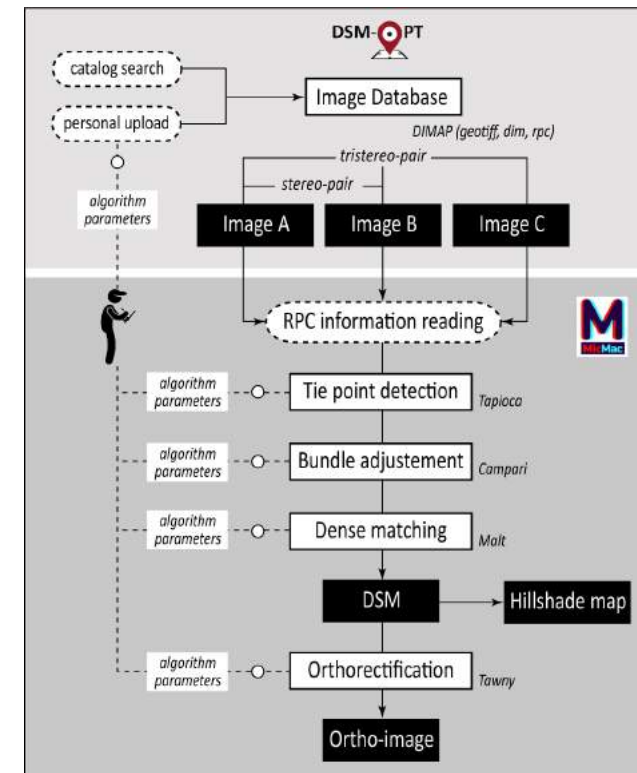
MPIC-OPT: Multiple pairwi...



ALADIM: Automatic LAnda...



DSM-OPT: Digital surface ...



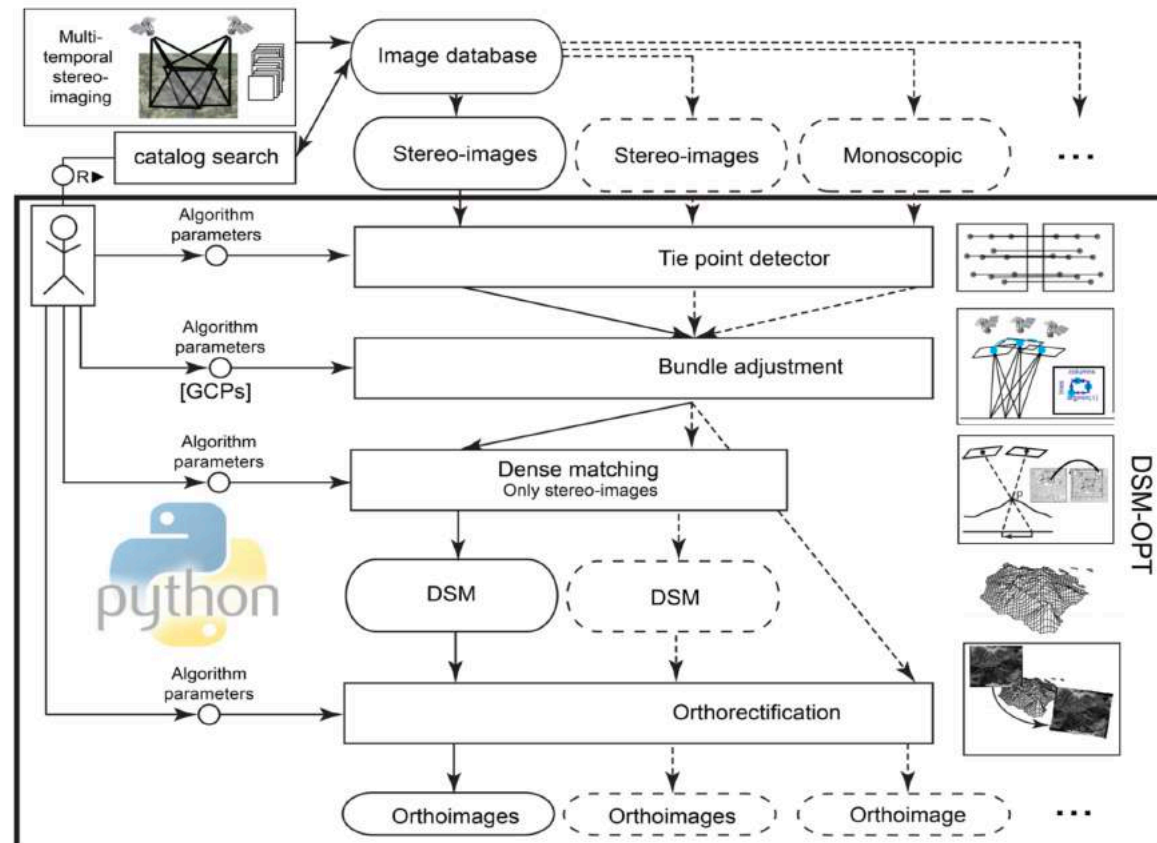
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# Creating high-resolution surface models



Tutorial: <https://terradyne.github.io/doc-tep-geohazards/tutorials/dsm-opt.html>

- DSM-OPT pipeline



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# Creating high-resolution surface models

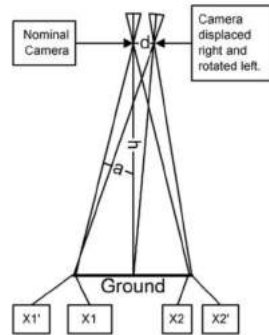


- Bundle adjustment with Rational Polynomial Functions (RPC)

- Modern VHR stereo satellite images are provided with RPCs

$$l = \frac{F_1(U, V, W)}{F_2(U, V, W)}$$

$$s = \frac{F_3(U, V, W)}{F_4(U, V, W)}$$

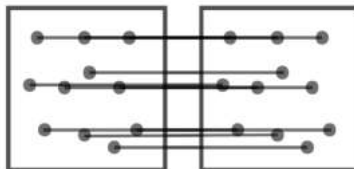


- Those models are typically biased and induce due to imprecise knowledge of the satellite orbit

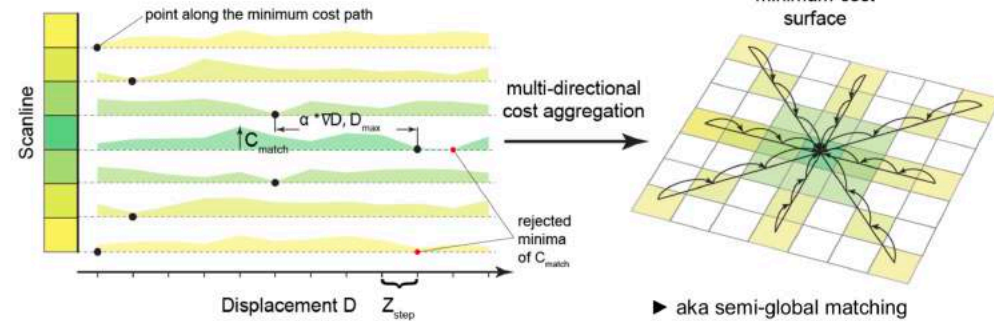
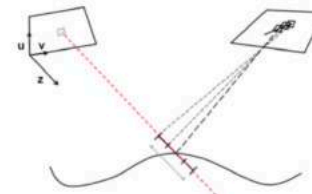
- Bias terms are added to the model and estimated based on tie points and ground control points

$$l + A_0 + A_1l + A_2s = \frac{F_1(U, V, W)}{F_2(U, V, W)}$$

$$s + B_0 + B_1l + B_2s = \frac{F_3(U, V, W)}{F_4(U, V, W)}$$



- Dense matching



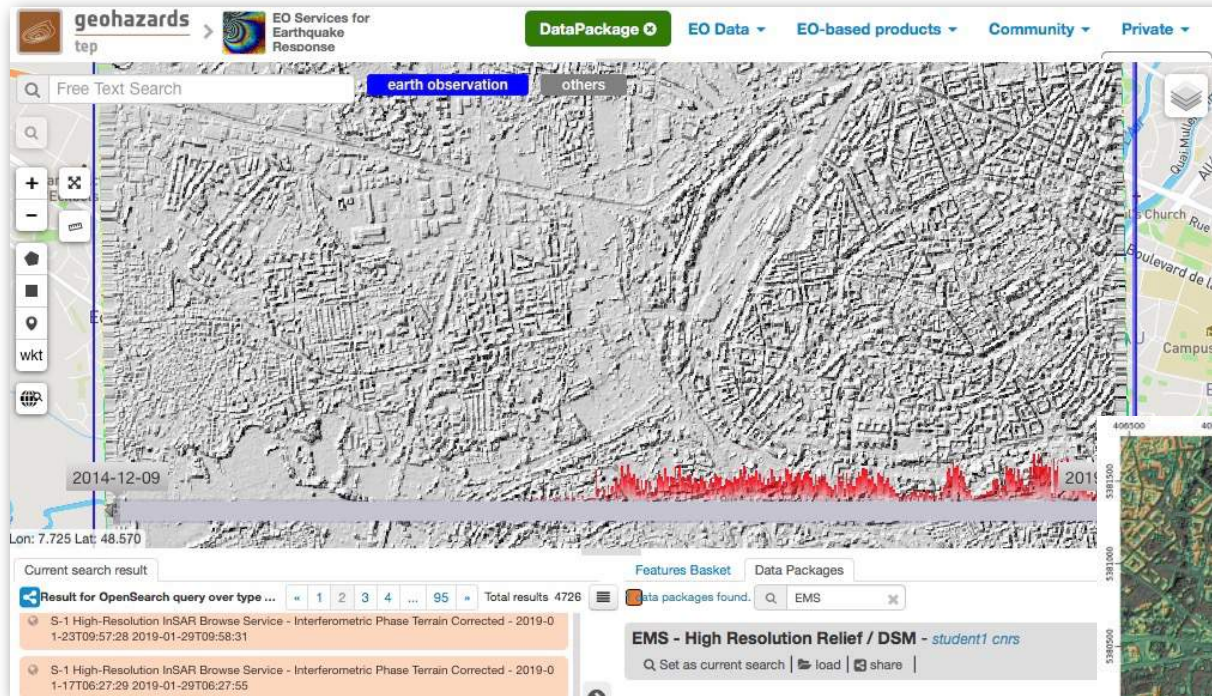
$$C_{glob} = \sum_{k=1}^N C_{match} + C_{trans}$$

$$C_{trans} = \alpha * \nabla D$$

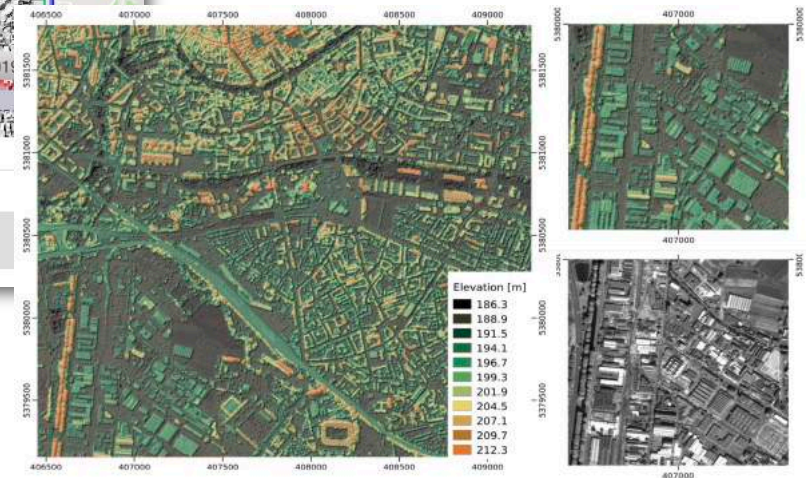
$$\nabla D > \nabla D_{max} \Rightarrow C_{trans} \rightarrow +\infty$$

dynamic programming to determine approximate minimum-cost surface

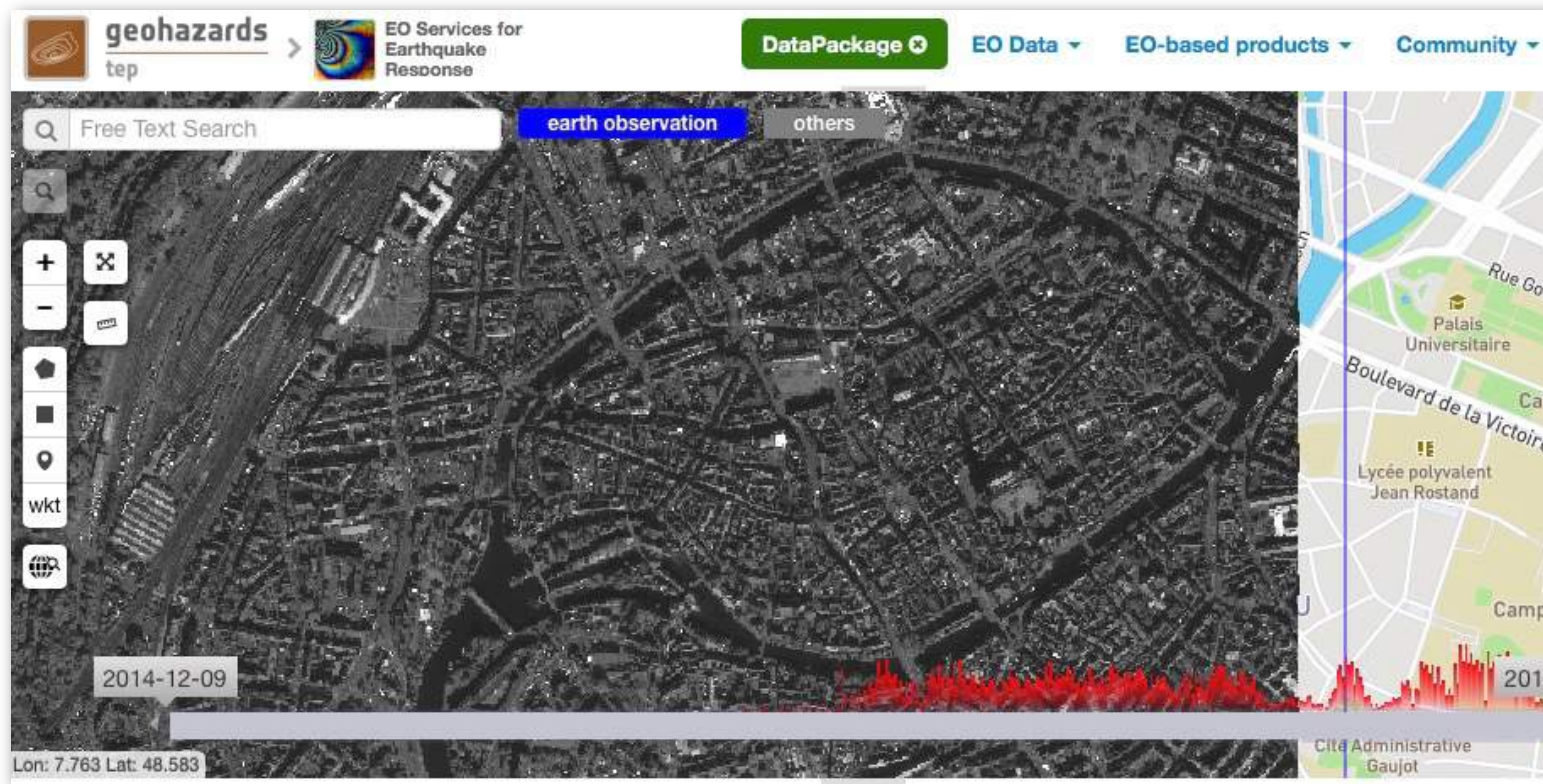
# Creating high-resolution surface models



Hillshade of a HR-DSM (0.5m) over the city of Strasbourg / Pléiades stereo of Sept. 2016



# Creating high-resolution surface models

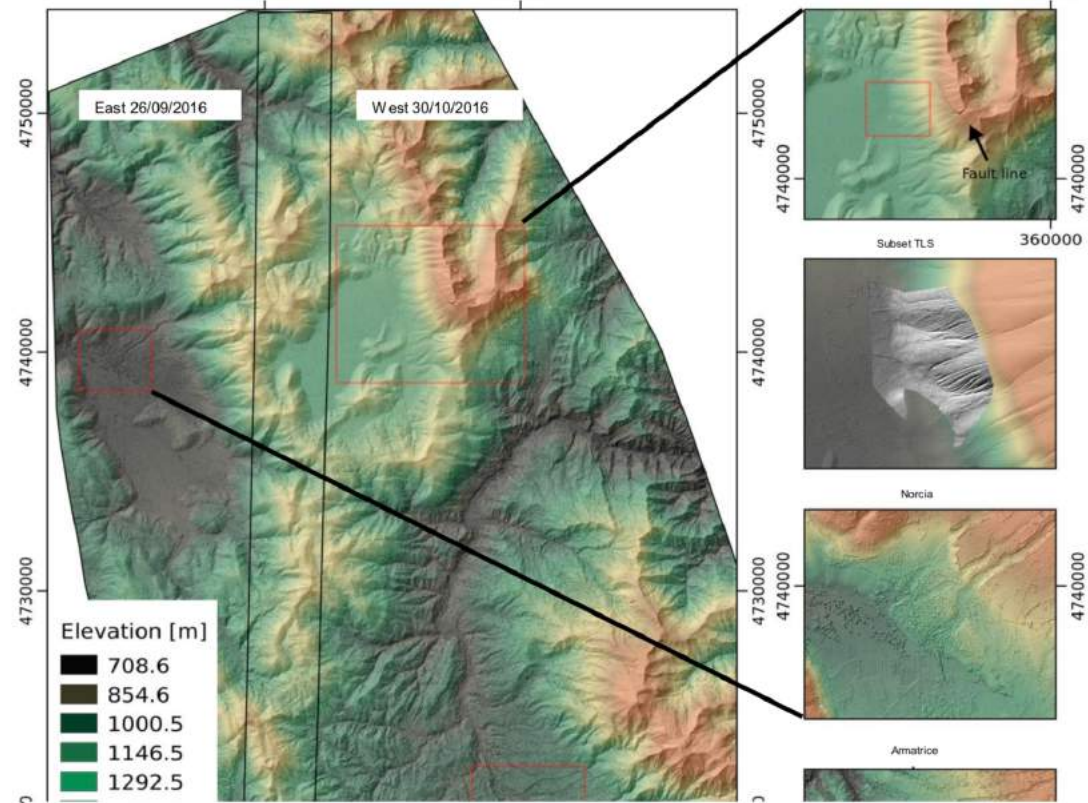


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Ortho-image of a HR-DSM (0.5m) over the city of Strasbourg / Pléiades stereo of Sept. 2016

# Creating high-resolution surface models

Application:  
morpho-structures mapping



Hillshade of a HR-DSM (0.5m) over Norcia / N. Apennines ETQ. -2016 / Pléiades stereo of Sept. 2016



# Creating high-resolution surface models

**Application:**  
**sediment budget analysis**

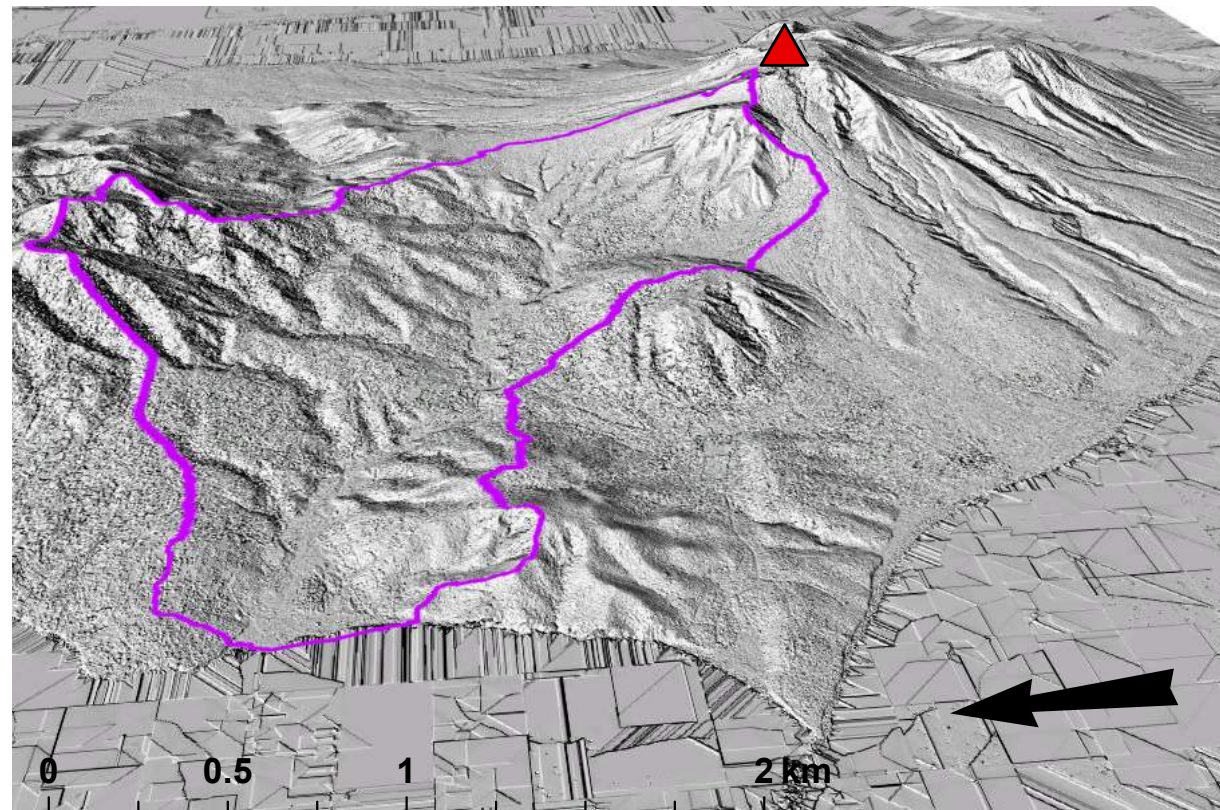


Hillshade of a HR-DSM (0.5m) over Soufriere Hills / Montserrat



Pléiades image of Soufriere Hills Volcano, 2017.  
(purple shows Belham Valley catchment)

Significant deposition of volcanoclastic material in the Belham River Valley between 1995–2010  
Channel prone to hazardous rain-triggered lahars and associated geomorphic changes  
Our new 2019 DSM will be compared with a LIDAR DSM made in 2010 to quantify erosion and deposition in different parts of the valley.



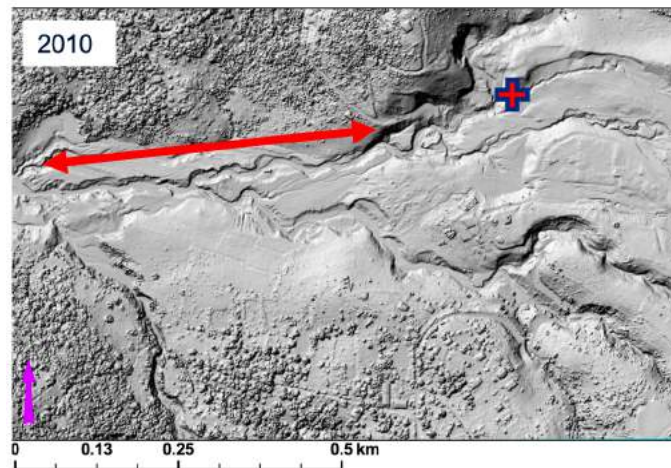


# Creating high-resolution surface models



**Application:**  
**sediment budget analysis**

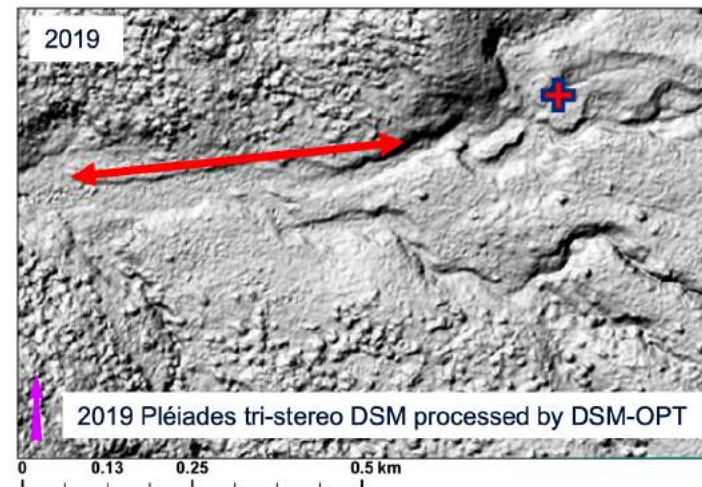
2010 1m LiDAR DSM (Montserrat Volcano Observatory)





Area shown in the example target areas below (green box)



Hillshade of a HR-DSM (0.5m)  
 over Soufriere Hills / Montserrat



Qualitative observations:

-  Channel widening and straightening (removal of pyroclastic terraces)
-  Deep channel incision and increased sinuosity.



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# Creating high-resolution surface models

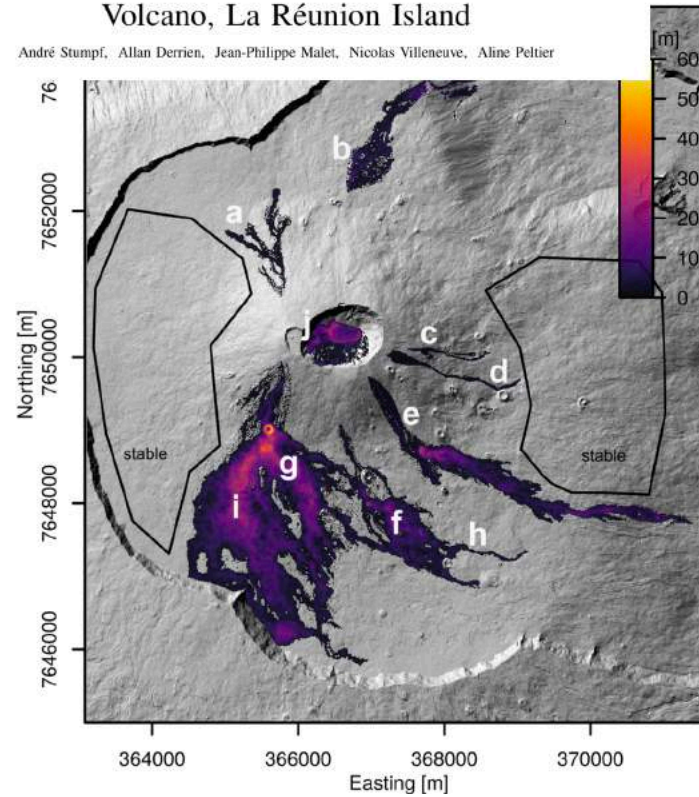
**Application:**  
lava flow volume  
quantification



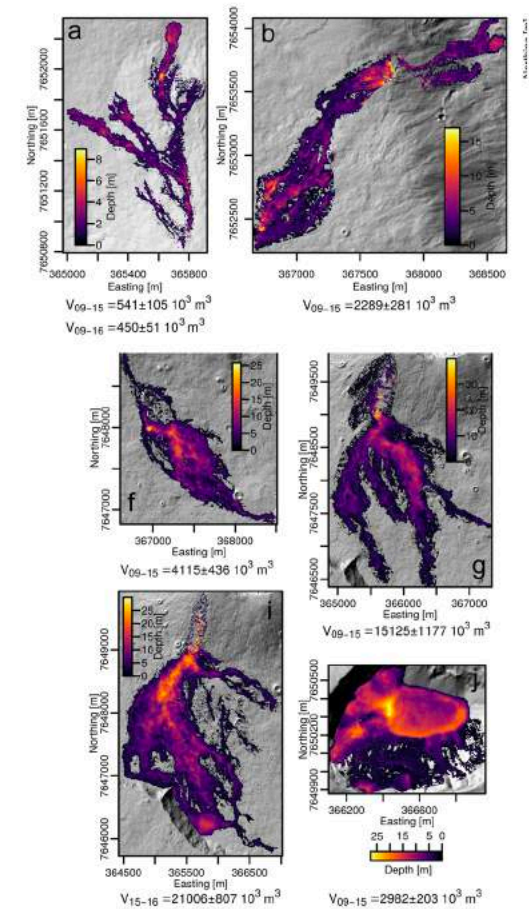
IEEE GEOSCIENCE AND REMOTE SENSING LETTERS

## High Resolution Satellite Photogrammetry for Lava Flow Volume Estimation at Piton de la Fournaise Volcano, La Réunion Island

André Stumpf, Allan Derrien, Jean-Philippe Malet, Nicolas Villeneuve, Aline Peltier



Hillshade of a HR-DSM (0.5m) over Piton de la Fournaise / La Réunion



# Creating high-resolution surface models



**A key issue: managing sensor Licence and distribution of products**

Airbus Defense & Space May 2017

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**LICENCE TO USE PLEIADES PRODUCTS GRANTED  
AT A PREFERENTIAL PRICE BY CNES TO CATEGORY 1 INSTITUTIONAL  
USERS AND ASSIMILATED CATEGORY 1 INSTITUTIONAL USERS UNDER  
THE ISIS - PLEIADES PROGRAMME**

**Please read the terms and conditions of this User Licence Agreement carefully before placing any orders for Protected Products.**

**INTRODUCTION**

In the framework of the public service delegation agreement concerning the operations of the Pleiades satellites concluded between CNES and Airbus DS (subsequently referred to as the "DSP"), Airbus DS has committed itself to distribute Pleiades products and services for the benefit of **AUTHORISED INSTITUTIONAL USERS** in order to fulfill their responsibilities in the frame of their institutional mission for **NON-COMMERCIAL SERVICES**.

CNES and Airbus DS have opened the ISIS programme to Pleiades products allowing eligible users (European scientific community) to obtain Pleiades images under special ISIS programme preferential pricing conditions, based on DSP Category 1 pricing.

Accomplishing any of the following acts implies acceptance by the **USER** of the terms of the present Licence Agreement (hereinafter "Licence"):

Management of the Pléiades licence via  
GEP (for CEOS-related images)

# On-going works and next steps ...



- As a GEP service: integrate the possibility of digitizing training samples on-line
- In terms of methods:
  - integrate other VHRO sensors (Planets, Worldview, Deimos, etc) for further applicability
  - develop a SAR (amplitude-based, coherence-based) change detection method
  - integrate active learning sampling



- As a GEP service: propose an earthquake-related service (4 images) and a landslide/glacier related service (times series)
- In terms of methods:
  - integrate other VHRO sensors (Planets, Worldview, Deimos, etc) for further applicability
  - integrate optical flow derived matching techniques to take into account more complex motion patterns
  - increase the size of the time series (ESA/Unistra-A2S federation of resources)
  - I integrate refined Sentinel-2 geometric correction for mountainous areas and detection of seasonal motion



- In terms of methods:
  - integrate other VHRO sensors with stereo-photogrammetric acquisitions
  - integrate DSM-related scenarios / parameterization and topography fusion



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**geohazards**

tep

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**David Michéa** - [michea@unistra.fr](mailto:michea@unistra.fr)

**Jean-Philippe Malet** - [jeanphilippe.malet@unistra.fr](mailto:jeanphilippe.malet@unistra.fr)



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