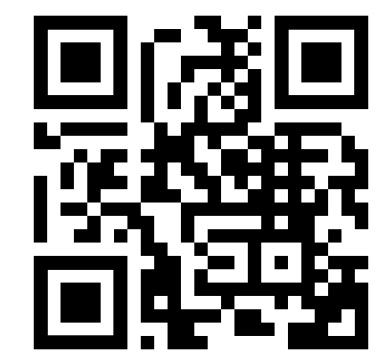


Missions and objectives of the service ISDeform

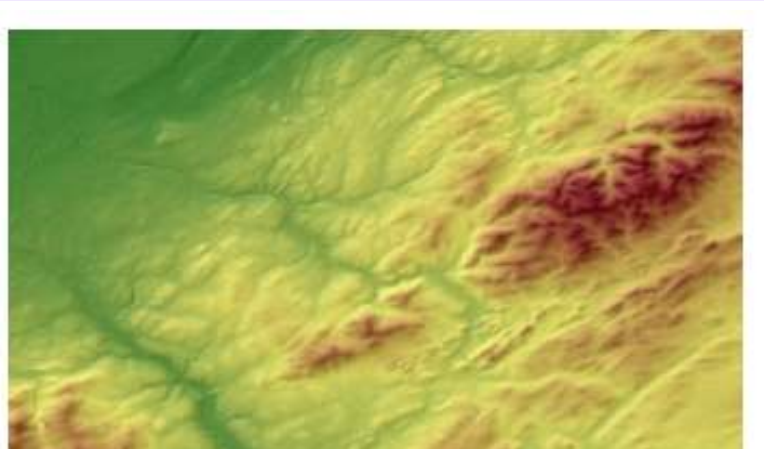
The objective is to monitor the ground deformation associated with natural hazards (e.g. earthquakes, landslides, volcanic activity) using optical and radar satellite imagery.

The mission is to support the French scientific community and its partners in the South in the use and analysis of satellite data by providing:

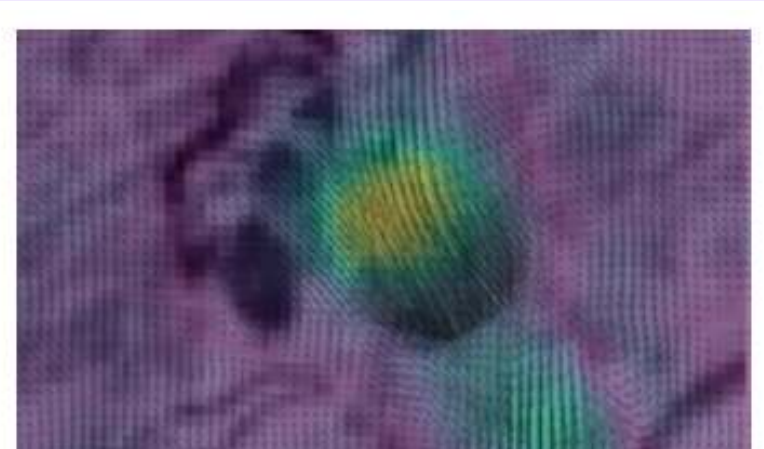
- added-value InSAR/optical products on small targets during a crisis (FAST-SAR)
- on-demand online processing services (GDM-OPT, DSM-OPT, GDM-SAR)
- platforms to access databases and to visualize satellites products (InSARviz)
- communication and formation about the methods and products



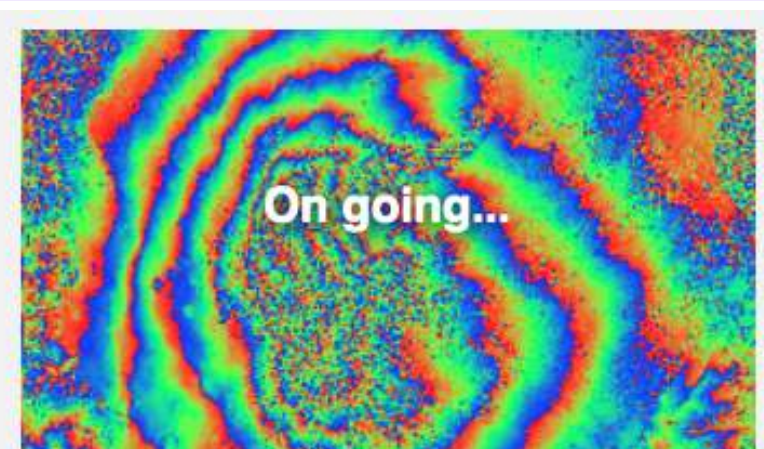
On-demand services: DSM-OPT, GDM-OPT, GDM-SAR



DSM-OPT
DSM-OPT stands for Digital Surface Models from OPTical stereoscopic very-high resolution imagery.




GDM-OPT
GDM-OPT stands for Ground Deformation Monitoring with OPTical image time series.

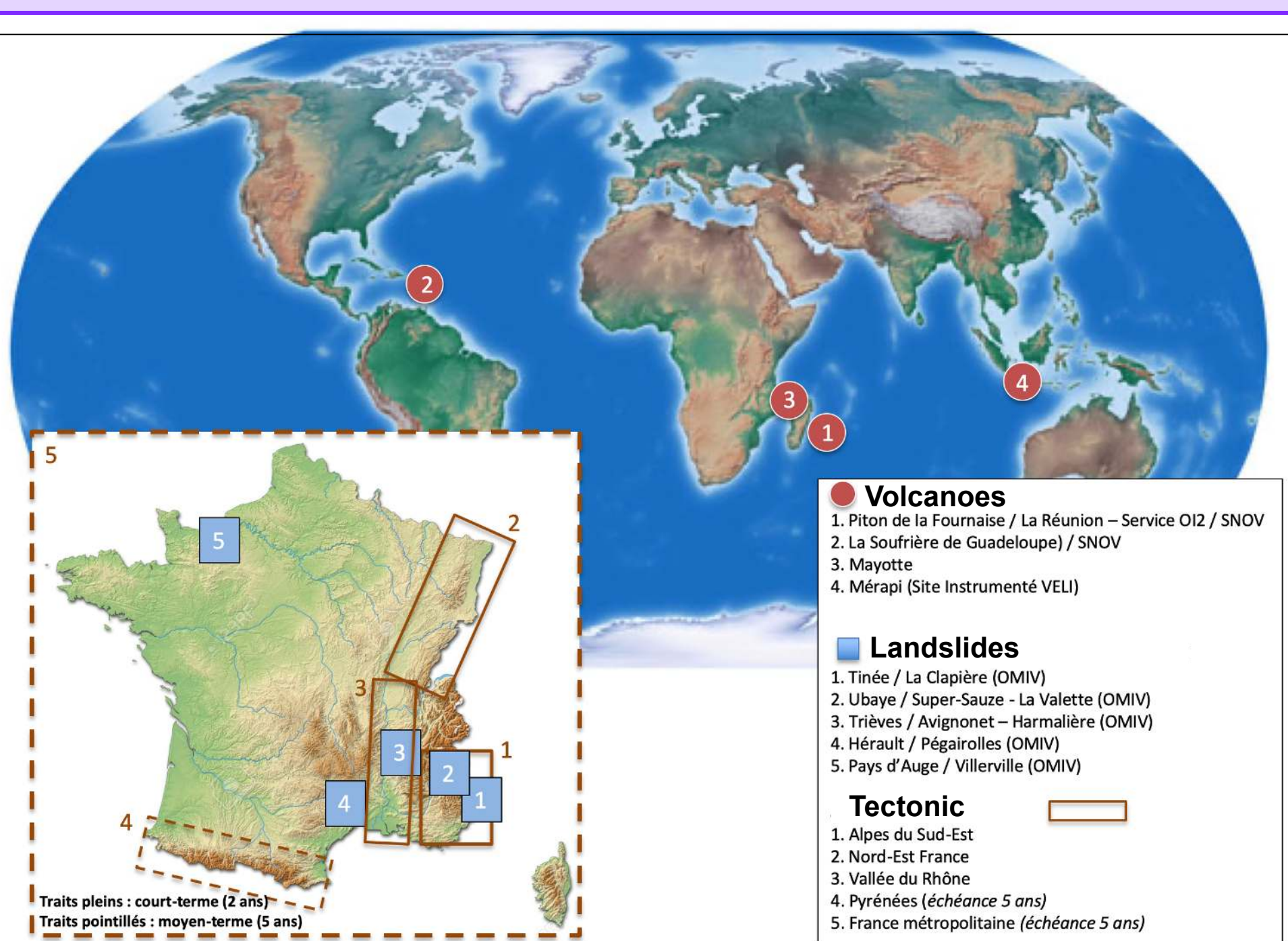


GDM-SAR
GDM-SAR stands for Ground Deformation Monitoring with InSAR image time series.

<https://en.poletterresolide.fr/on-demand-processing/#/> (see Poster E. Pathier - 14 Sept 5-7 pm)



Main targets covered by the service ISDeform



Volcanoes

1. Piton de la Fournaise / La Réunion - Service OI2 / SNOV
2. La Soufrière de Guadeloupe / SNOV
3. Mayotte
4. Merapi (Site Instrumenté VEI)

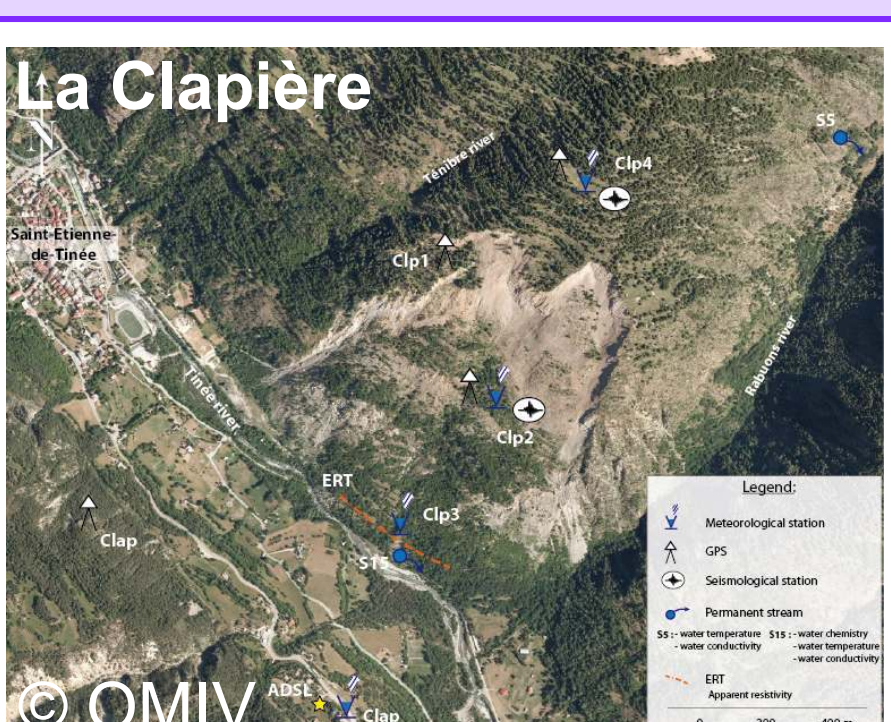
Landslides

1. Tinière / La Clapière (OMIV)
2. Ulvays / Super-Sauze - La Valette (OMIV)
3. Trièves / Avignonnet - Harmallière (OMIV)
4. Héroult / Pégarolles (OMIV)
5. Pans d'Auge / Villerville (OMIV)


Tectonic

1. Alpes du Sud-Est
2. Nord-Est France
3. Vallée du Rhône
4. Pyrénées (Échanceur 5 ans)
5. France métropolitaine (Échanceur 5 ans)

La Clapière



Piton de la Fournaise

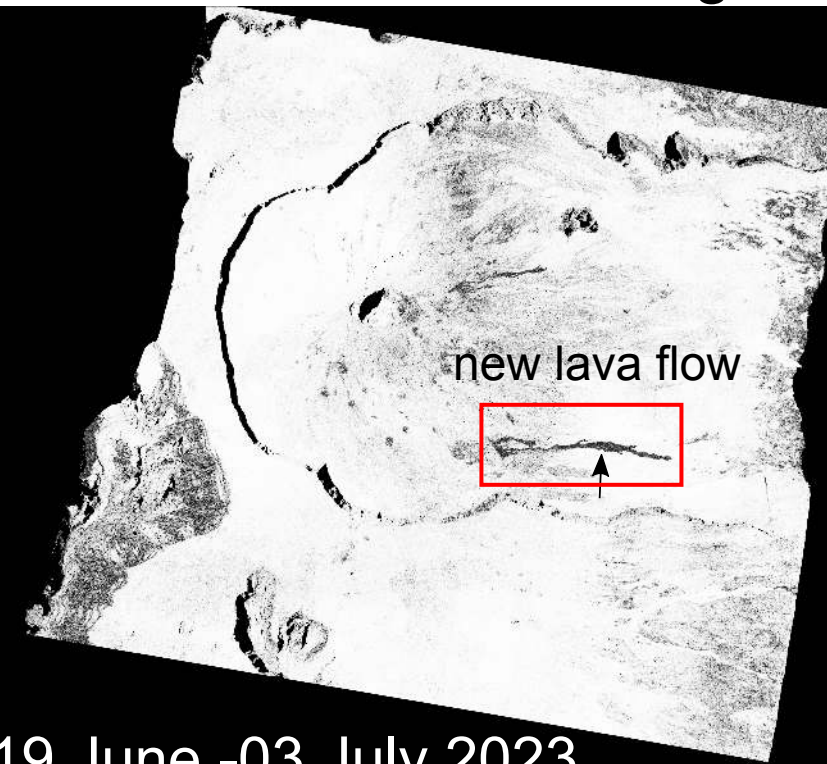


Processing of multiple sensors during a crisis

In addition of Sentinel-1, the processing of other radar images as well as optical images provides complementary information that supports the monitoring of natural hazards.

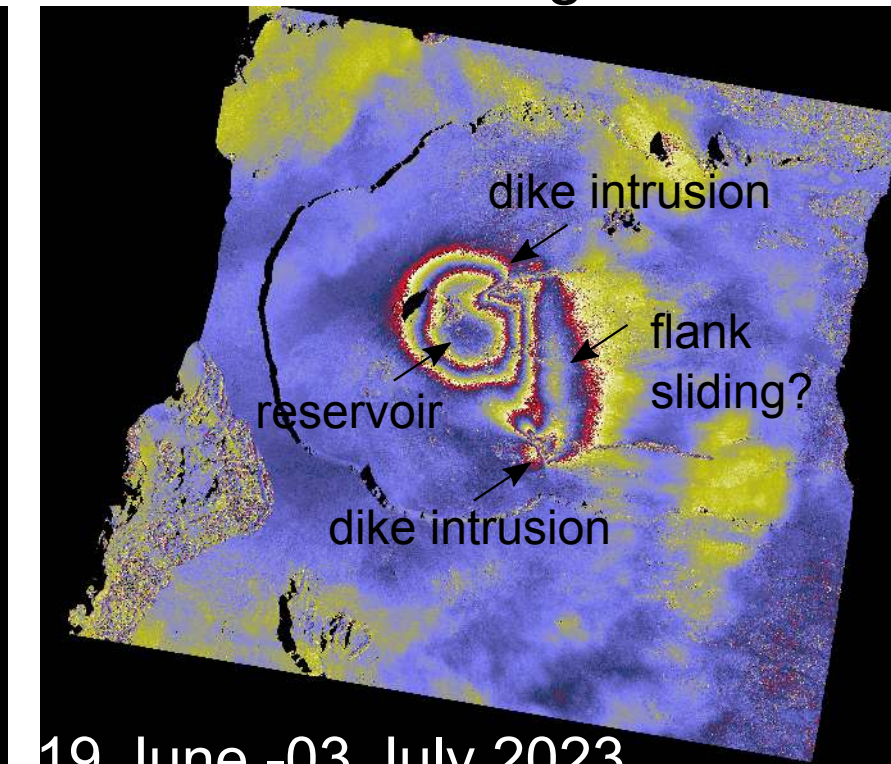
July 2023 eruption at Piton de la Fournaise

ALOS-2 coherence image



19 June -03 July 2023

ALOS-2 interferogram



19 June -03 July 2023


new lava flow

dike intrusion

flank sliding?

reservoir

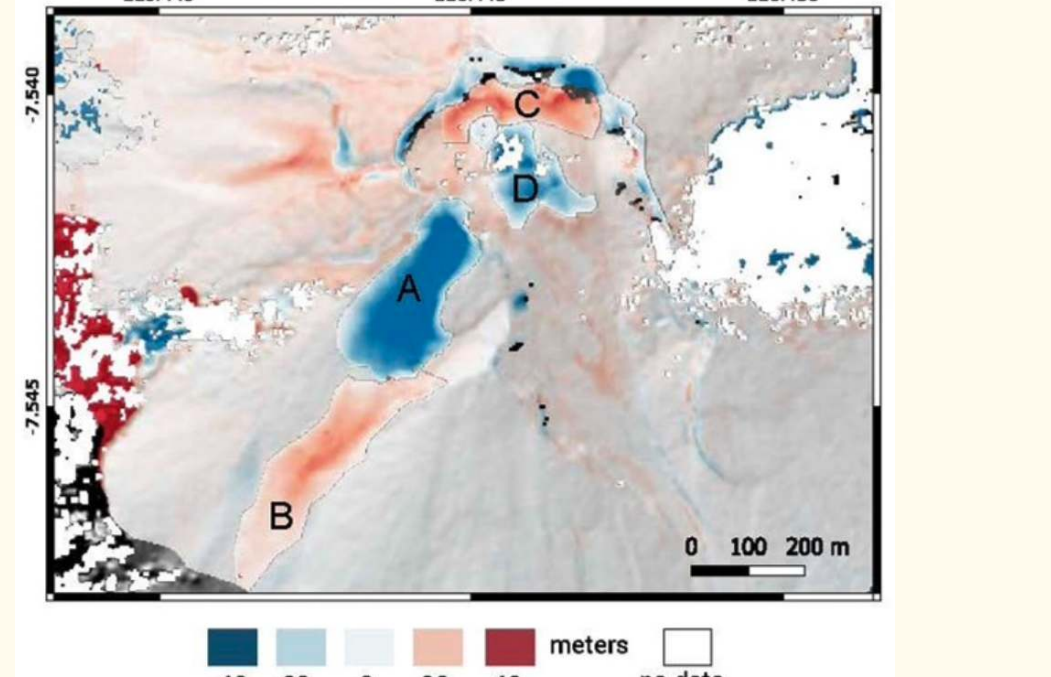
Coherence maps derived from radar images were used to map lava flows at Piton de la Fournaise during the eruption.



CIEST²: Scientific and Technical Intervention and Expertise Cell

- Agreement between 6 French organizations
- Activation to obtain Pleiades programming
- Information of topographic changes
- Encourage the dissemination of results

2020 eruption at Merapi [3]



Pleiades DEM difference between September 2019 and November 2020 (©CNES, AIRBUS)

FAST-SAR: routine processing of Sentinel-1 images

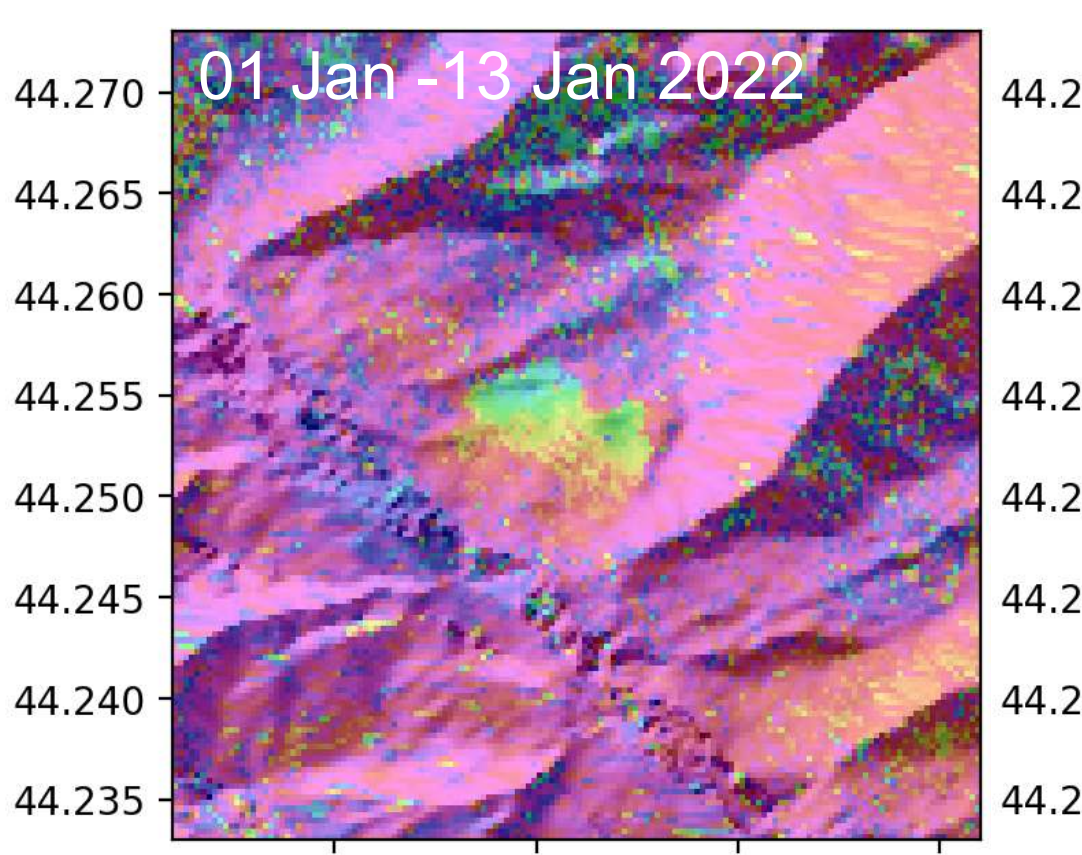
FAST-SAR: Fully Automated SAR processing on Small Targets
Objective: routine monitoring of ground deformation / **Method:** InSAR
Targets: landslides and volcanoes on French territory / **Dataset:** Sentinel-1 / **Processing:** NSBAS

Delivery of new products ~30 min after a new SLC is available

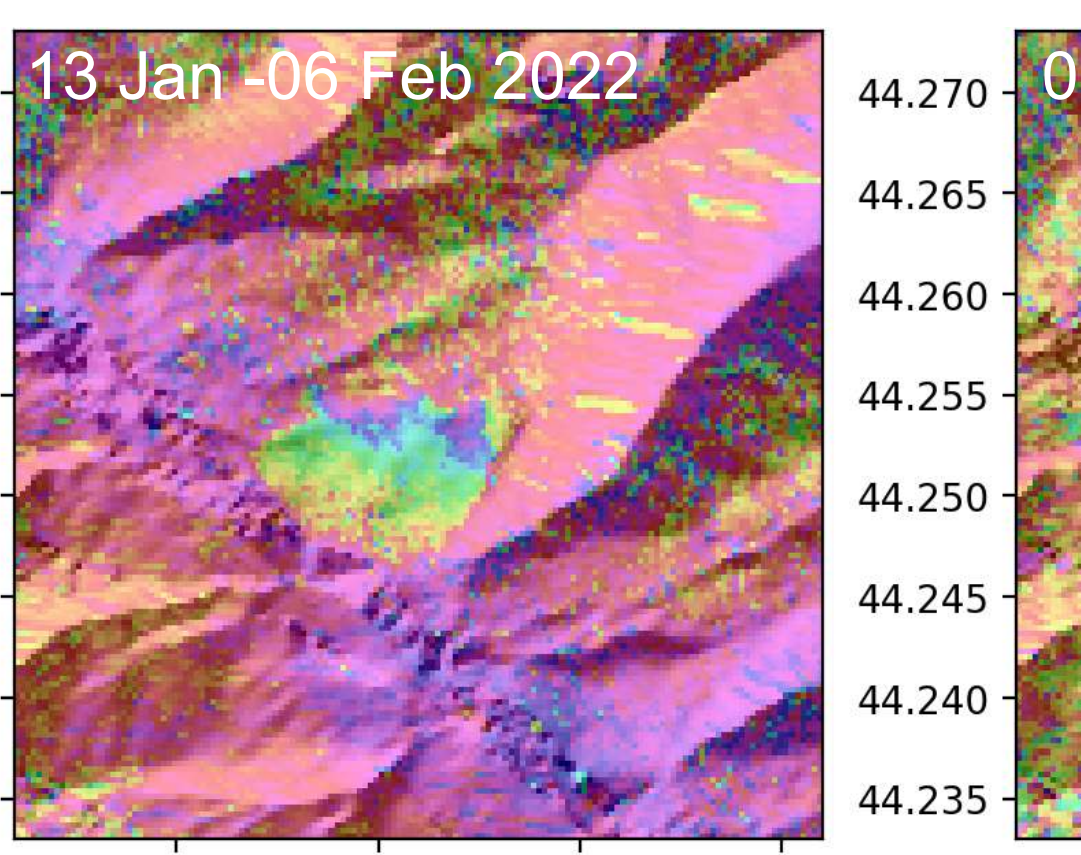
```

    graph LR
    A[Check for new data <br/> <math>< 1\text{min}</math>] --> B[Download SLC <br/> PEPS, ASF <br/> ~10min]
    B --> C[Process new interferograms <br/> 6 closed pairs <br/> ~10min]
    C --> D[Filtering <br/> ~5min]
    D --> E[Unwrapping <br/> ~5min]
    E --> F[Publish Products <br/> ~5min]
    D --> G[Atmo corrections <br/> ERA5, GACOS, GNSS]
    G --> H[Time series <br/> under development]
    
```


Exemple: Landslide La Clapière



01 Jan -13 Jan 2022




13 Jan -06 Feb 2022




06 Feb -26 Mar 2022

LOS phase change (rad)

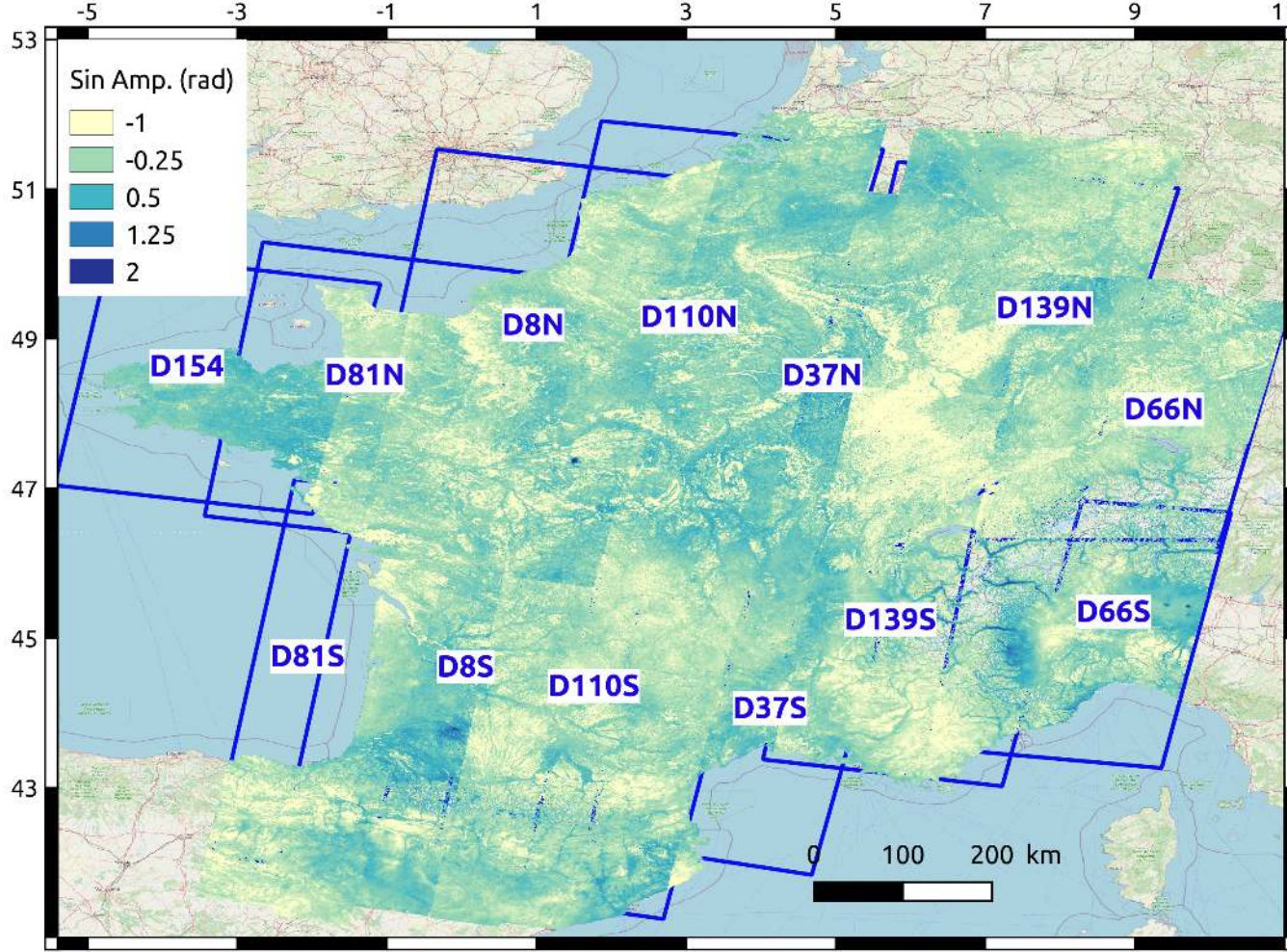


FLATSIM: ForM@Ter Large-scale multi-Temporal Sentinel-1 Interferometry processing chain



8 projects in 2020
9 projects in 2022

- Objective: massive processing of Sentinel-1 to measure surface deformation on a continental scale
- Integration of NSBAS processing within CNES architecture (HPC, PEPS) [1,2]
- Total surface processed: > 20 million km²
- Spatial resolution: 30m for interferograms ; 120/240m for time series
- 9 contributions at Fringe 2023 showing the results




Amplitude of the spring-autumn seasonal displacement in France (blue = uplift in autumn) derived from the 2014-2021 Sentinel-1 descending time series (see Poster M.-P. Doin - 12 Sept 5-7 pm)

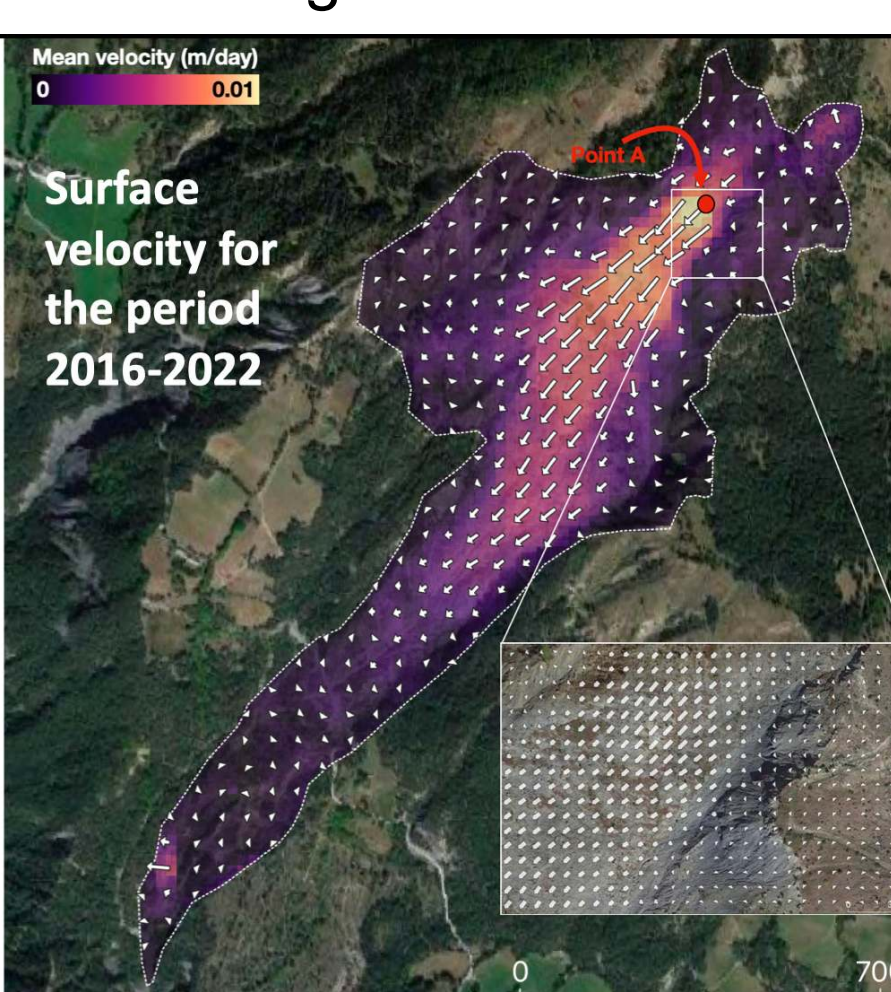
GDM-OPT: on-demand processing of optical images

GDM-OPT: Ground Deformation Monitoring with OPTical images
Objective: detection of ground displacements / **Method:** multiple-pairwise image matching
Targets: earthquakes, landslides, glaciers / **Dataset:** Sentinel-2 / **Processing:** MicMac/GéFolki [4]

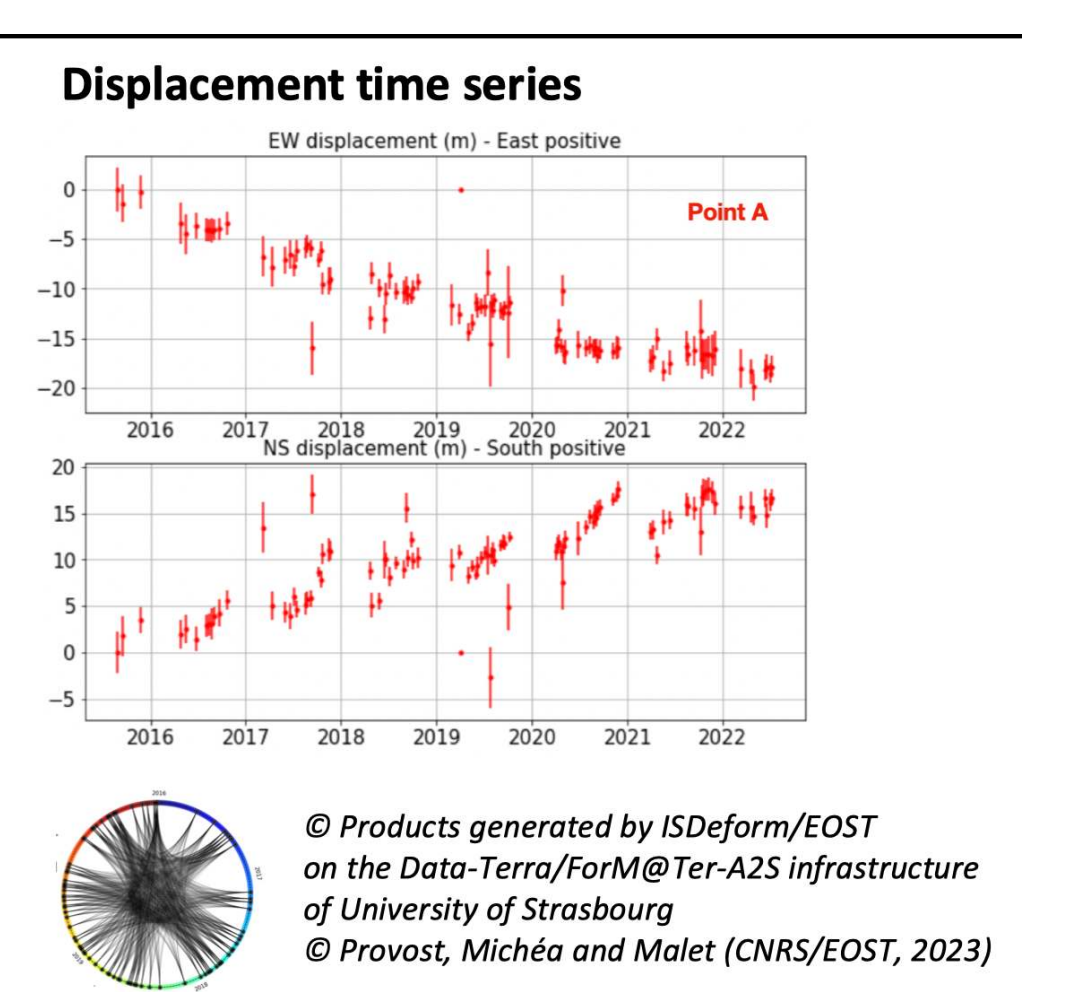
GDM-OPT-SLIDE has been used to generate time series of horizontal displacements for several landslides in the French Alps for 2016-2022, using MicMac for the correlation, CO-REGIs for the correction of the image offsets and TIO algorithm for the time series inversion.



La Valette landslide, South East France



Surface velocity for the period 2016-2022



Displacement time series

Time series for the La Valette landslide, including the horizontal displacement, mean velocity maps at 10 m spatial resolution, and inverted time series.

On-site formations for partners in Peru

Three on-site formations were delivered in 2022-2023 in Peru:

- Optical image correlation for detecting and monitoring landslides
 Location: INGEMET, Arequipa - Dates: August 2022 - Speaker: P. Lacroix^{1,2}
- InSAR processing for monitoring volcanoes
 Location: INGEMET, Arequipa - Dates: 7-11 November 2022
 Speakers: V. Pinel^{1,2}, L. Pousse^{1,2}, B. Lovery²
- Satellite monitoring of natural hazards in mountains area
 Location: UMSA, Huaraz - Dates: 16-25 August 2023
 Speakers: P. Lacroix^{1,2}, A. Racoviteanu^{1,3}, D. Cusicanqui², R. Basantes⁵, A. Soruco⁶, B. Lehman^{2,7}, S. Zerathe^{1,2}

¹IRD, ²ISTerre, ³IGE, ⁴CNRS, ⁵Yaha Tech Univ. (Ecuador), ⁶UMSA (Bolivia), ⁷CNRS



Credit: V. Pinel



Credit: P. Lacroix

Online formation for a broad audience

Scientists of different laboratories (GET, IGE, ISTerre, LISTIC) have collaborated to design the MOOC ORISAT (Observation des Risques naturels par SATellites) with the technical support from the University of Grenoble Alpes. The MOOC primarily targets a broad audience and registration is free for all. Videos are in French with the option of English or Spanish subtitles.

Registration is now open. Please join us!

What will you learn?

- ✓ Learn the principles of remote sensing
- ✓ Identify the remote sensing data available and its potential
- ✓ Choose the data to use according to your problem or your studied area
- ✓ Interpret the delivered products and be aware of their uncertainties

Course plan (2h/week during 7 weeks)

- Natural hazards and remote sensing
- Which method for which application?
- InSAR and time series
- Image correlation and photogrammetry
- Earthquakes and volcanoes
- Landslides and glaciers
- Artificial intelligence monitoring



Enrollment: From July 3, 2023 to Oct. 30, 2023
 Course: From Oct. 3, 2023 to Nov. 17, 2023
 Languages: English, spanish and french
 Log in to enroll

[1] Doin, M.-P., Lodge, F., Guillaso, S., Jolivet, R., Lasserre, C., Ducret, G., Grandin, R., Pathier, E., Pinel, V. (2011). Presentation of the small baseline NSBAS processing chain on a case example: The Etna deformation monitoring from 2003 to 2010 using Envisat data. In Proceedings of FRINGE 2011 ESA Workshop, Frascati, Italy, 19-23 September 2011, ESA Publication SP-697.
 [2] Thollard, F., Clesse, D., Doin, M.-P., Donadieu, J., Durand, P., Grandin, R., Lasserre, C., Laurent, C., Deschamps-Ostanciaux, E., Pathier, E., Pointal, E., Roy, C., Specht, B. (2021). FLATSIM: The ForM@Ter Large-Scale Multi-Temporal Sentinel-1 Interferometry Service, Remote Sens. 13 (18), 3734. doi:10.3390/rs13183734.
 [3] Grémion, S., Pinel, V., Shreve, T., Beauce, F., Putra, R., Solikhin, A., ... & Humaida, H. (2023). Tracking the evolution of the summit lava dome of Merapi volcano between 2018 and 2019 using DEMs derived from TanDEM-X and Pleiades data. Journal of Volcanology and Geothermal Research, 433, 107732.
 [4] Provost, F., Michéa, D., Malet, J. P., Boissier, E., Pointal, E., Stumpf, A., ... & Bally, P. (2022). Terrain deformation measurements from optical satellite imagery: The MPIC-OPT processing services for geohazards monitoring. Remote Sensing of Environment, 274, 112949.