THALES
Building a future we can all trust

Machine Learning for Dynamical Monitoring of Explosive Volcanoes

Feedback on ESA Network of Resources (NoR)

September 2022

Antoine BLONDEL
Dr Yannick LASNE

Workplan

- Context of the Project
- Motivations of the NoR sponsorship
- Learning about using the GEP and SNAPPING
  - The Geohazard Exploitation Platform and SNAPPING
  - SNAPPING Processing Chains
  - SNAPPING run results (test cases)
- The purposes of SNAPPING products
- Conclusion

Context of the project

Machine Learning for Dynamical Monitoring of Explosive and non-vegetated Volcanoes

- Aims at using ground displacement to identify volcanic activity resumption
- Approach combining Machine/Deep Learning (ML / DL) methods and Differential SAR Interferometry (DInSAR) products
- To be submitted as an ESA OpenCall (batch 7)

Interferometric products generated by the Surface motioN mAPPING (SNAPPING) tool

- Generate relevant ground displacement maps
- Focus on active and hazardous non-vegetated volcanoes
- Creation of a relevant training database
- Assessment of valuable inputs for further ML/DL processing
- Need for a NoR sponsorship

Motivations of the NoR sponsorship

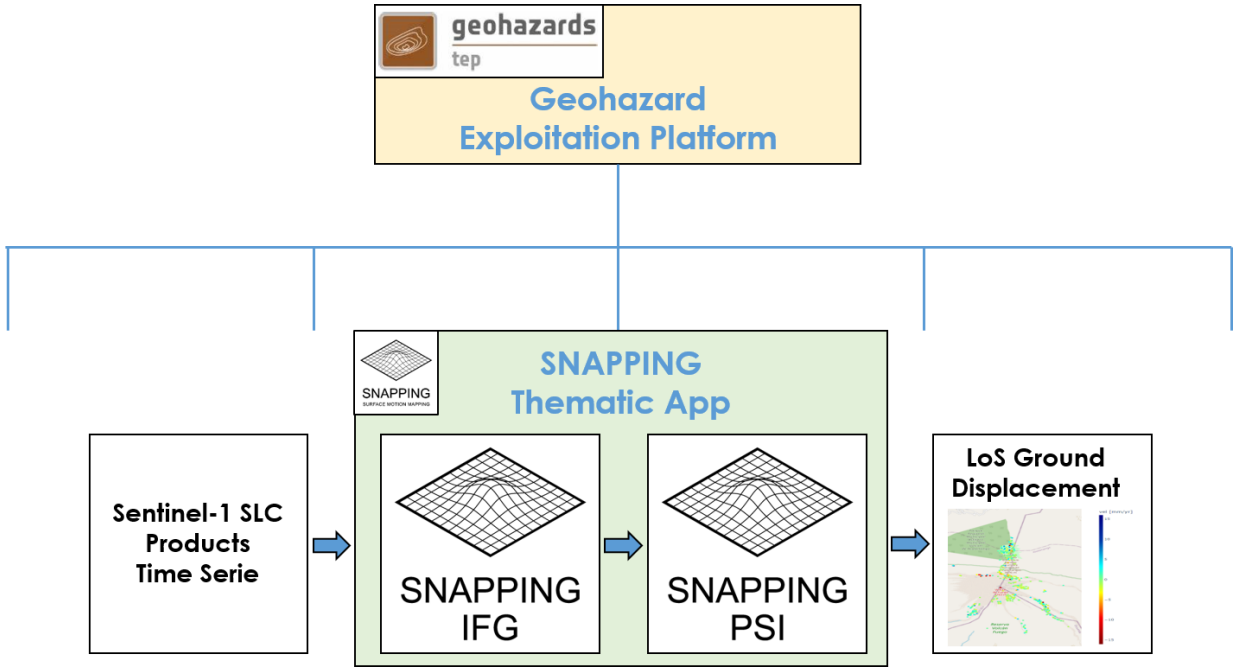
Request procedure

- Application Scenario Description (ASD) to validate the functional scope of our NoR request
  - Approved by the Geohazard Exploitation Platform operator **Terradue**
  - Used to address a 5k€ sponsorship NoR request to make use of the SNAPPING tool through the GEP
- In May 2022, we submitted a NoR request (ID 25207b) to ESA
  - ESA granted us a sponsorship of 5k€ to support expenses on the GEP platform hosting the SNAPPING tool.
  - Terradue provided us with an account upgrade ensuring GEP services access

Such an application procedure allowed us acquiring suitable knowledge on how to use the **GEP** platform, as well as the **SNAPPING** tool, in order to be familiar with the DInSAR generated products and formats, and quickly become experienced in the interfacing of these products with the ML algorithms.

Learning about using the GEP and SNAPPING [1/4]

The **Geohazard Exploitation Platform** and **SNAPPING**



Learning about using the GEP and SNAPPING [2/4]

What we learnt about **SNAPPING Processing Chains**

> InterFerogram Generation

- Main parameters:
  - AOI based coregistration → the higher the area, the better the coregistration, but the higher the computing time
  - Input time series duration → at least 80 dates to get consistent results
- Feedback:
  - Long computing time (~24h for ~80 S1-SLC products)
  - The generation of some interferometric pairs can result in errors
- Outputs of interest:
  - Common DInSAR products: stack of differential interferograms, coherency maps

> Permanent Scatterers Interferometric processing

- Main parameters:
  - Amplitude dispersion → interferometric coherence threshold, affects the quality of PS targets
  - Range/Azimuth patch numbers → parallelization level
  - Reference area → area of zero average motion
  - Atmospheric filtering and Topo-dependant atmospheric signal → removes the atmospheric phase shift contribution
- Outputs of interest:
  - LoS displacement time series
  - Average LoS displacement rates
  - LoS displacement rates uncertainties
  - LoS incidence angles

Learning about using the GEP and SNAPPING [3/4]

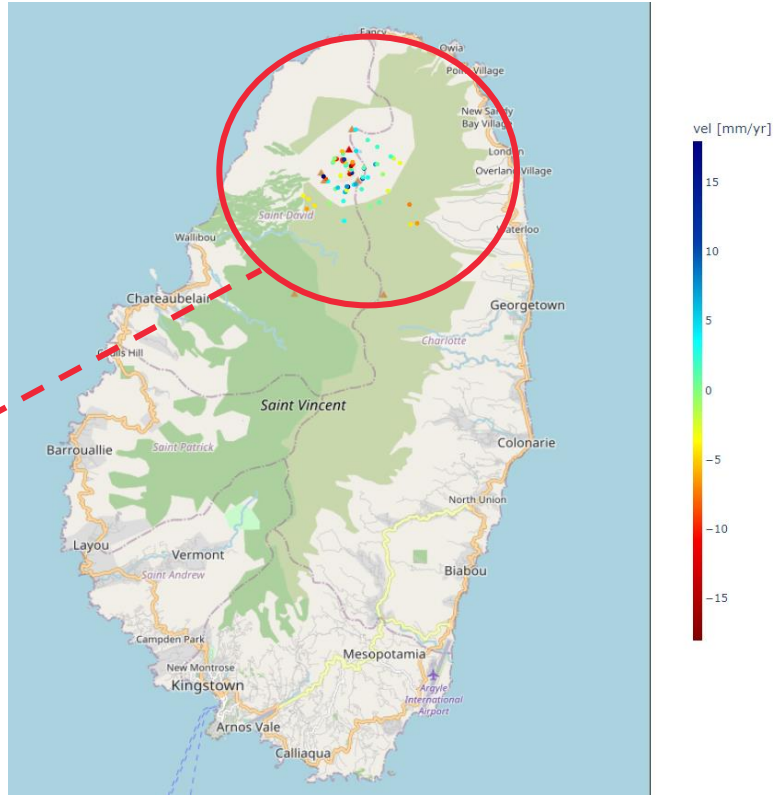
SNAPPING run results [test case n°1]

La Soufriere, Saint Vincent and the Grenadines

- Input:
  - AOI : POLYGON((-61.2013 13.315,-61.1523 13.315,-61.1523 13.3484,-61.2013 13.3484,-61.2013 13.315))
  - Observation period: 12/2020 – 06/2021 (30 dates)
  - Orbit 156

- Output:
  - Only 68 Permanent Scatterers

→ **Too low number of PS** for the projected ML/DL processing. Caused by a **dense vegetation** coverage over the AOI, resulting in low interferometric coherences.



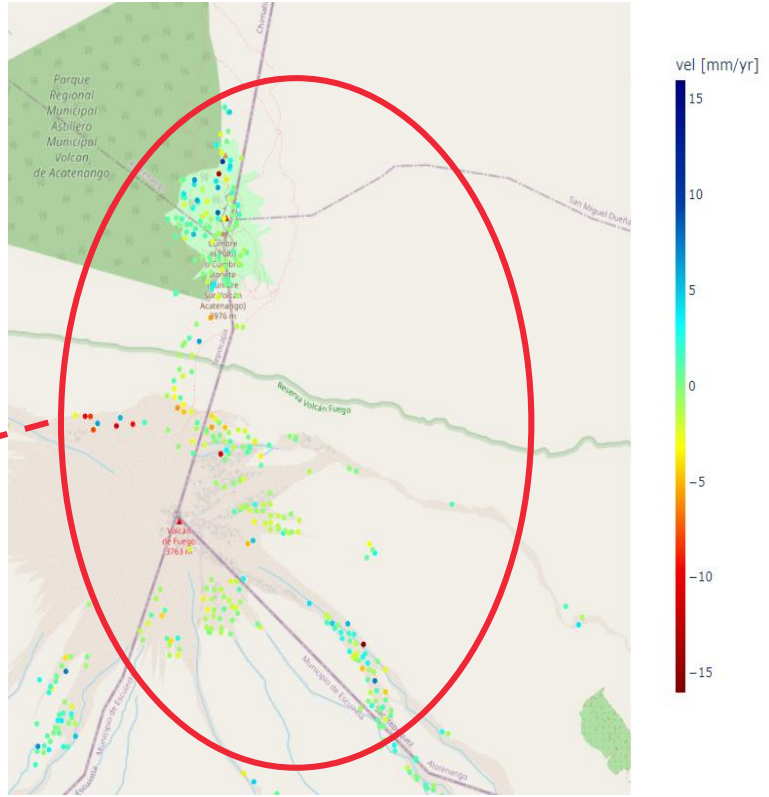
Learning about using the GEP and SNAPPING [4/4]

SNAPPING run results [test case n°2]

Volcan de Fuego, Guatemala

- Input:
  - AOI : POLYGON((-90.9186 14.4421,-90.8437 14.4421,-90.8437 14.5171,-90.9186 14.5171,-90.9186 14.4421))
  - Observation period: 07/2017-01/2019 (84 dates)
  - Orbit 136
- Output:
  - 395 Permanent Scatterers

→ Lower vegetation coverage on the active zone, resulting in more PS. However, SNAPPING is able to provide with more relevant and interpretable displacement maps (~10000 PS over a similar spatial extent)



The purposes of SNAPPING products [1/2]

Our project aims at using **ground displacement** products generated with SNAPPING as inputs to **ML/DL algorithms**

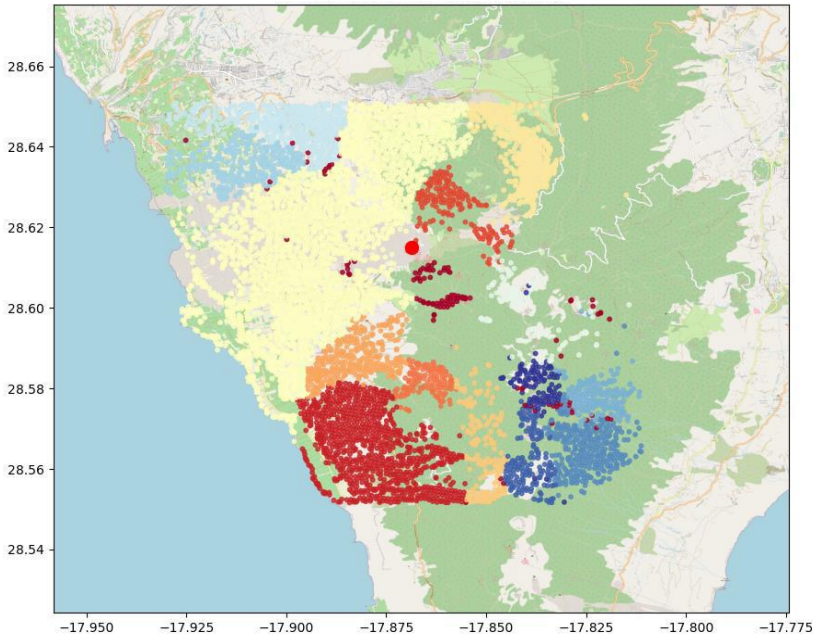
- Such algorithms shall be able to **identify abnormal volcanic activity** in the AOI
- Thus, the NoR sponsorship has been fundamental for us to **assess the potential of SNAPPING products** to tackle our objectives

The subsequent proof of concept (PoC) internally developed at Thales has shown promising preliminary results

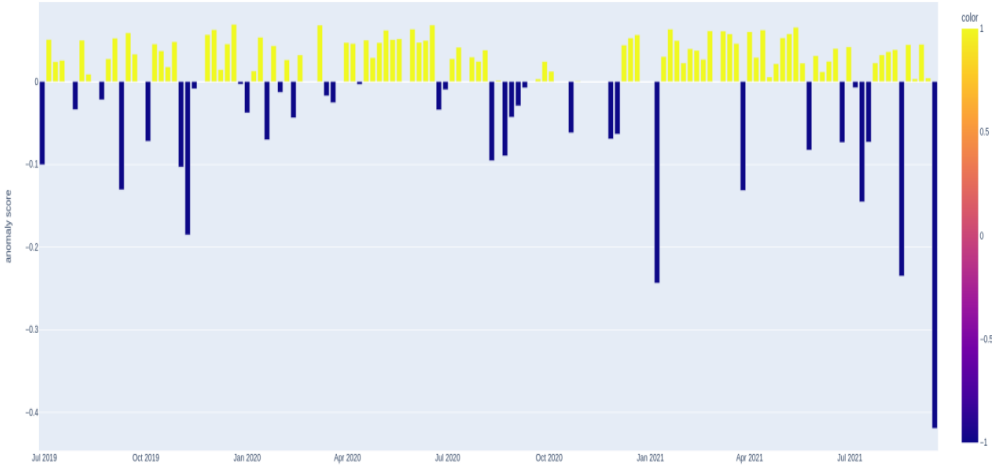
- It has highlighted the importance of both a large amount of PSs with high interferometric coherence and significantly long time series over relevant AOIs

The purposes of SNAPPING products [2/2]

Preliminary PoC results



Classification of PSs



Anomaly detection in the ground displacement time serie of a PS

Conclusion

- The ESA **NoR sponsorship** has enabled us to get a glimpse of the **potential of SNAPPING products** as inputs for ML/DL algorithms tackling the **dynamic monitoring of explosive and non-vegetated volcanoes**.
- Generation of the first products has highlighted the importance of **InSAR expertise**
  - Indeed, the choice of the AOI, the time series and SNAPPING processing chains parametrization affect the quality of the measurements as well as the amount of PSs
  - However, such quality comes at the cost of a long processing time. Therefore, we expect a lot from future SNAPPING upgrades such as the **Full Resolution** PSI processing chain

→ In other terms, the **NoR** sponsorship acts as a first **milestone** on the roadmap of our project we aim at submitting as an **ESA OpenCall**.

Your Contacts

Feel free to contact us, should you have any questions regarding the **Machine Learning for Dynamical Monitoring of Explosive Volcanoes** project.

InSAR processing

- **Dr Yannick LASNE** yannick.lasne@thalesgroup.com
- **Antoine BLONDEL** antoine.blondel@thalesgroup.com

Machine/Deep Learning

- **Sylvain TANGUY** sylvain-s.tanguy@thalesgroup.com
- **Aurélien LAC** aurelien.lac@thalesgroup.com

Thales Services Numériques

290 Allée du Lac

31670 Labège, FRANCE