Multi-Sensor Satellite Processing for the Monitoring of Geo-energies

Maria Carmelia RAMLIE[1], Paula OLEA-ENCINA[1], Michele CROSETTO[1], Oriol MONSERRAT[1]
[1] CTTC, Castelldefels, Spain, (mramlie, polea, mcrosetto, omonserrat @cttc.cat)

smile European Doctoral Network on Geo-energy
cttc Centre Tecnològic de Telecomunicacions de Catalunya
Funded by the European Union

Background

Geoenergy often imply injecting (and/or extracting) fluids into (from) the subsurface, which involves coupled thermo-hydro-mechanical-chemical (THMC) processes.

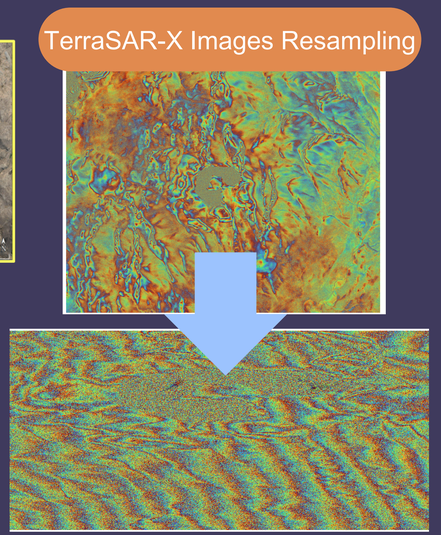
Satellite and remote sensing monitoring can be an efficient and practical aid on monitoring the deformation caused during construction, deployment, and process of geo-energies. Sentinel-1 itself can provide wide range of dataset, accesible for everyone for most places on earth. There are multiple available satellites today with different bands, fulfilling everyone's needs.

Persistent Scatterrer Interferometry

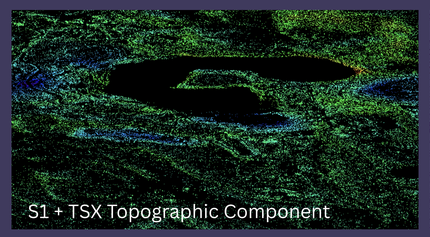
Persistent Scatterer Interferometry. PSI Technique remains a powerful remote sensing method in terms of ground deformation monitoring, which makes it useful for monitoring geoenergy projectt where deformation can be detected. However, PSI technique can still encounter issues related to the area of observation such as moisture, and vegetation, as well as missing dataset.

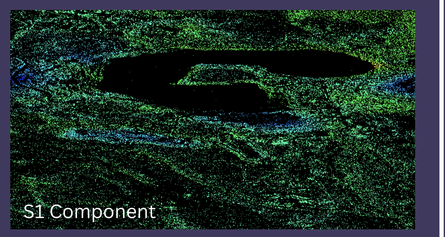
Study of Multi-Sensor Approach

Having multiple and large amount of data will profit the PSI technique result the most. A proposed method is by integrating multiple sensors in one processing chain. For this study, an experimental site is chosen with dataset from Sentinel-1 and TerraSAR-X. The chosen experimental site is Antapaccay Mine, Yauri District, Espinar Province, South Peru. This is large scale open-pit copper mine.



The first step is to convert TerraSAR-X images into Sentinel-1 geometry. This resampling technique utilize DTM, Orbit, and original complex image as the reference.





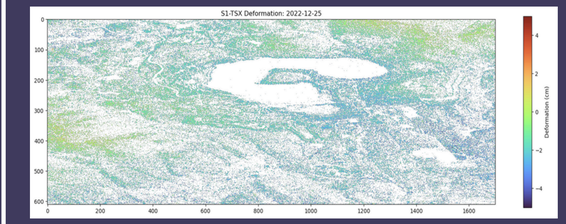
The first integration involves removing the topographic component, up to this point, similarities are present on both dataset.

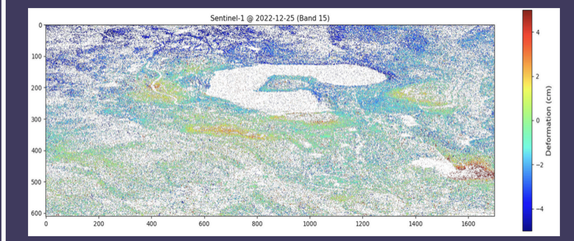
Due to the diverse properties of the dataset an approach to generate the deformation maps is proposed. These approach is separated into 4 stages

Experimental Workflow

Wrapped Interferograms are unwrapped → **Conversion to LOS (Line of Sight) respecting each sensor's properties** $d = \lambda/4\pi\,\phi$, $d_v = d/\cos\theta$ → **Aligning the timeline of TerraSAR-X and Sentinel-1 then appointing a a common date and single pixel as anchor/reference point.**

After the 3 steps, Least Square Inversion method is applied on these interferogram stacks to achieve deformation maps





Result

Currently the result hasn't shown any strong indicator if the proposed method works as intended. There are several causes such as phase unwrapping errors and issues during the resampling stage, especially when it comes to high resolution sensors like TerraSAR-X. A further examination of each individual processing should be conductedd.

Conclusion and Further Research

The eligibility of the multi sensor cannot be say for sure at the current stage, a further study especially on the behaviour of each sensor is necessary especially with the future plan of including NISAR to the workflow, how each individual sensors react to different surface and external factors. A study of comparison between NISAR, Sentinel-1, and TerraSAR-X should be conducted for better understanding.

References:
Bamler, R., & Hartl, P. (1997). Synthetic aperture radar interferometry. Inverse Problems, Volume 14, Number 4. https://doi.org/10.1088/0266-5611/14/4/001, Crosetto, M., Monserrat, O., Cuevas-González, M., Devanthéry, N., & Crippa, B. (2016). Persistent Scatterer Interferometry: A review. ISPRS Journal of Photogrammetry and Remote Sensing, 115, 78–89. https://doi.org/10.1016/j.isprsjprs.2015.10.011,