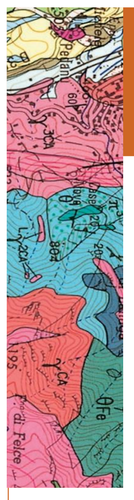

French initiative for the European Ground Motion Service.

Potential for surface motion-related geohazards on the France metropolitan territory.

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Abstract

European Ground Motion Service (EGMS) is a Copernicus initiative being developed with the support/funding of the European Commission and the European Space Agency to monitor ground surface deformation at the continental scale based on Sentinel-1 Synthetic Aperture Radar interferometry. In this perspective, the French national space agency (CNES) has mandated Tre Altamira to generate the first prototype of the service using Sentinel-1 archive covering the France metropolitan territory for the period 2015-2018, providing both average velocities and Time Series in Ascending and Descending orbits. Horizontal East-West / Vertical decomposition is also provided. InSAR measurements have been obtained using patented Tre Altamira SqueeSAR® processing chain.
In this poster, we propose to address the interest of this novel information for the three main natural geohazards affecting France Metropolitan area: clay shrinking/swelling, landslides, and subsidence.
For this purpose, three test sites representative (for France) of each of these phenomena were selected on the basis on the characteristics of the known motion (size of the deformed area, expected velocity, temporal evolution), the known limitations of the spaceborne SAR interferometry (e.g. too fast subsidence motion were excluded) and availability of prior knowledge on this sites (ground based measurements, reported observations and interpretation, …). The proposed sites are Chaingy (Loiret) for the Shrinking/Swelling phenomena, Cauterets in the Pyrenees for the Landslides and Hilsprich (Lorraine) for subsidence (induced by salt dissolution phenomena). Noteworthy is the fact that those phenomena have very diverse surface motion spatial and temporal characteristics: strong seasonal component for clay shrinking/swelling, irregular motion for the others, displacement in 3D for landslides.
This contribution aims at investigating Copernicus EGMS characteristics (e.g. point density, limitations of the InSAR, temporal sampling, …) for providing information required in the assessment of surface deformation-related geohazards or to contribute to the monitoring of the phenomena.

Subsidence

The case of the municipality of Hilsprich in Moselle is associated with a subsidence due to a dissolution of a salt layer in the subsoil. According to Mathieu et al. (2013), this layer would be at least 20 m thick and was located less than 100 m deep based on electrical geophysical techniques. Radar interferometry (used by Raucoules et al., 2013) has made it possible to determine the extent of the impacted zone, which would be approximately 1 km, extending well beyond the zone where the disorders were observed (not directly comparable in terms of interferometric points because the acquisitions do not concern the same dates). The vertical subsidence was 60 to 90 cm from May 2006 to March 2012 and 846 mm from 2008 to September 2018 at maximum deformation. The municipality of Hilsprich is subject to annual leveling campaigns since 2008, the last report of which was done in 2018 (Le Goff, 2018).

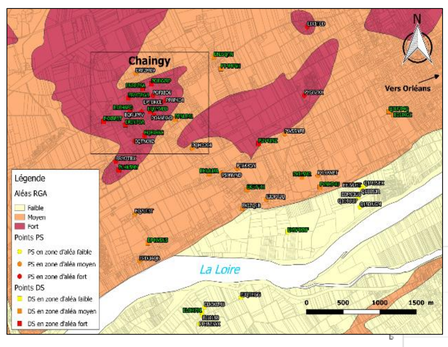
Location of interferometric points and leveling points in the municipality of Hilspich

Cumulative subsidence measured by radar interferometry and leveling since September 2014 around interferometric point 2

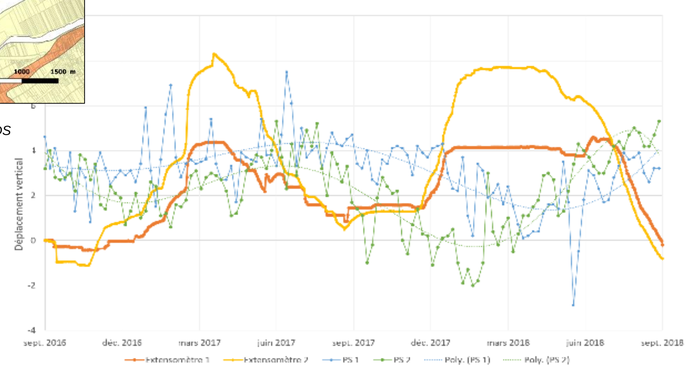
Clay Skrinking-Swelling

The Chaingy site, selected for its movements induced by Clay Shrinking-Swelling, is located west of Orleans, in the Loiret, on a vacant lot of the city, in the middle of houses. According to the local geological map, the terrain is located on Burdigalian (Miocene) sands and clays and has therefore been classified as highly susceptible to Shrinking-Swelling. In fact, the soils are composed of 50 to 80% of clay and swelling minerals. An instrumentation phase, including the installation of extensometers by Gourdier (2018) in 2016, made it possible to measure the deformations undergone by the ground surface. Monitoring and maintenance of the devices revealed up to 8 mm of swelling over the period from January 2017 to April 2018.

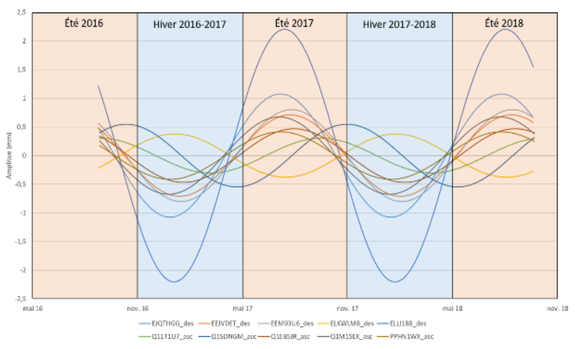
Ext 1 and 2 extensometer location map and SqueeSARTM PS 1 and 2 vertical points in the city of Chaingy



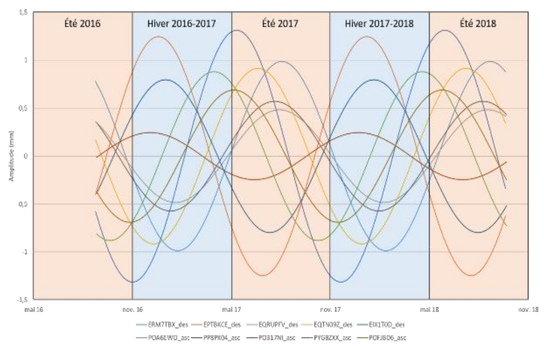
Clay Swelling Hazard map and location of PS and DS analyzed in the area of Chaingy



Comparison between extensometers and vertical displacement data of SqueeSAR® points at Chaingy from September 2016 to August 2018



Annual cyclical movements for 10 PS in low Shrinking-Swelling hazard area



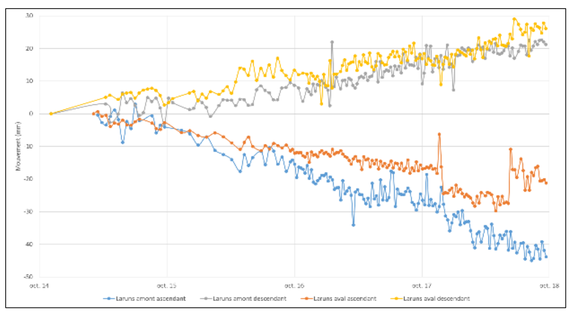
Annual cyclical movements for 10 PS in strong Shrinking-Swelling hazard area

Landslides

A list of places of interest in terms of ground movements in the Pyrenees and in the Alps was drawn from the SqueeSAR® data set. The InSAR measurements were compared with landslide data from the research project SAMCO (Society Adaptation for Coping with Mountain Risks in Global Change COntext) carried out in the Pyrenees between 2013 and 2016 in which the BRGM was involved, as well as BD-RTM (Restauration des Terrains de Montagne) data bases. Here, the occurrence of the hazard is considered. Mountainous areas do not allow an ideal density of InSAR measurement points mainly because of the land cover (presence of vegetation) but also because of the slopes orientations which prevent from detecting common measurements points in both ascending and descending orbits for vertical and East-West decomposition.

Interferometric points in ascending orbit in the municipality of Laruns (Pyrenees)

Interferometric points in descending orbit in the municipality of Laruns



Time series of interferometric points in the commune of Laruns

Conclusion

The analysis of InSAR measurements generated by Tre Altamira upon CNES initiative and in the perspective of the future EGMS was conducted. Those InSAR measurements, generated from the SqueeSAR® analysis of Sentinel-1 data over France metropolitan territory constitutes a first proptotype of the Ground Motion Service. The objective of the study was then to evaluate the suitability of those data for the detection of motion over areas affected by know phenomena for a preliminary evaluation of the characteristics of the EGMS. We focus on three phenomena: shrinking-swelling of clays, subsidence and landslides.
- The leveling data acquired at Hilsprich is consistent with the SqueeSAR® measurements. The density of measurement points could potentially be improved for a better adequation to the scale of the phenomenom.
- The analysis of the Time Series of the interferometric points on the test site of Chaingy allowed to highlight the difference of behavior between the zones less affected by the shrinking-swelling phenomenon and those presenting a higher hazard.
- Mass motions in the Pyrenees and the Alps have been identified in the SqueeSAR® data; however, they are not consistent with the data already available on géorisques.gouv.fr or on the BD-RTM risk management databases; this is undoubtedly linked on the one hand to the non-exhaustiveness of the inventories, and on the other hand to the typology of the movements listed. Indeed, the EGMS detects ***large-scale*** landslides (hundreds to thousands of meters) and with quite continuous speed, whereas the slips already recorded in databases are often slips that have been triggered over a short period of time, and which cannot be detected by radar interferometry. *In situ* missions could be envisaged, looking for hints to support these hypotheses.

In conclusion, the availability of a ground motion study at national scale is unique. InSAR measurements provided by the future EGMS will complement existing in-situ data and will contribute to complete motion inventories.

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