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PostMinQuake
RFCS RESEARCH PROJECT

WP 6 : Monitoring Strategies

Task 6.3 Monitoring of surface deformation using interferometric images from satellites and continuous GNSS data. Subtask: Test Area of Gardanne mine

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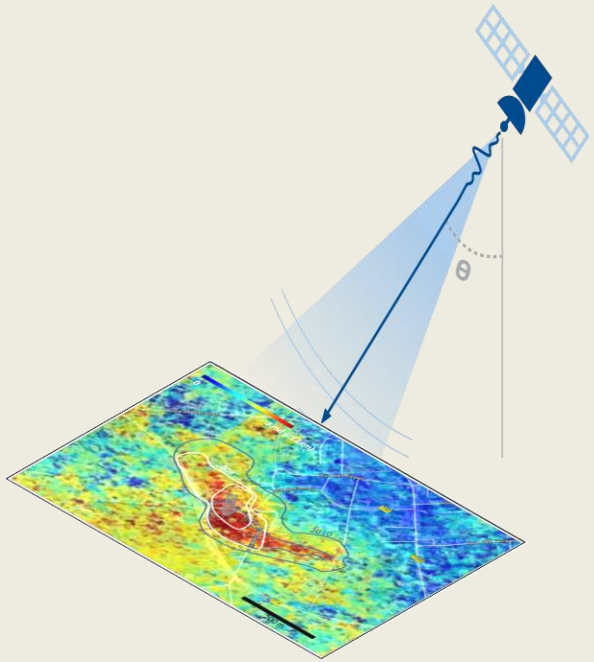
Institution: BRGM
Country: FRANCE

WP 6 : Monitoring Strategies

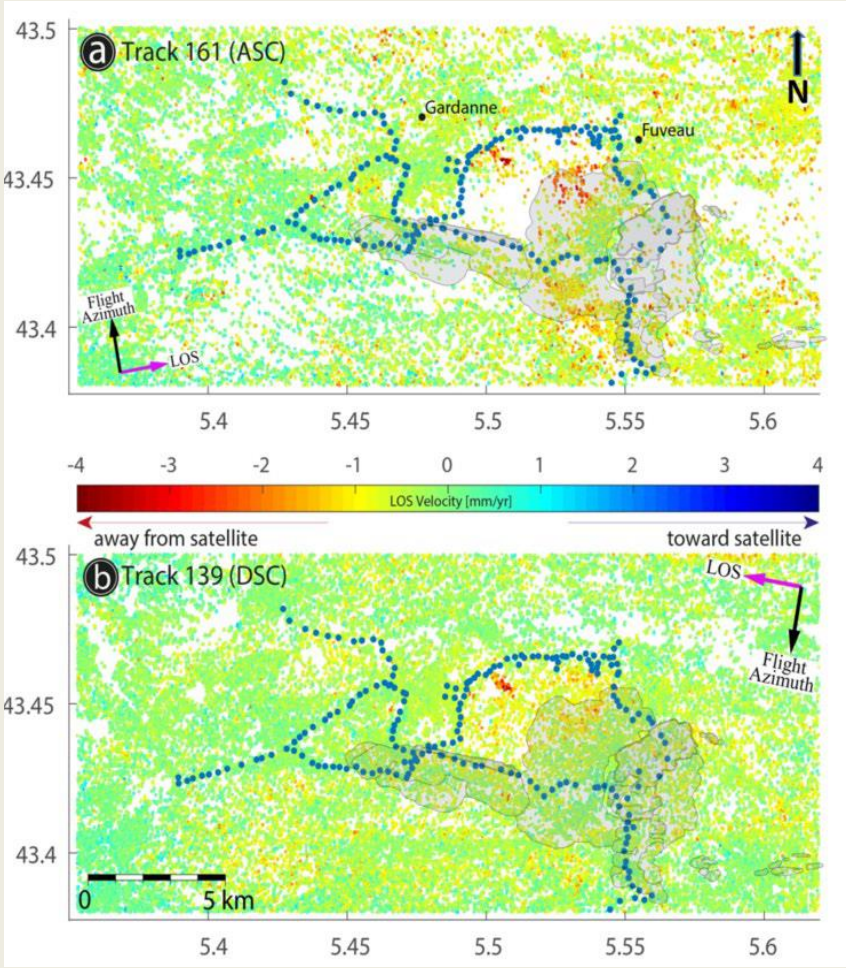
Task 6.3 Monitoring of surface deformation using interferometric images from satellites and continuous GNSS data.
Subtask: Test Area of Gardanne mine

Objective:

Monitoring of surface effects of underground instabilities by space-borne SAR interferometry (INSAR/PSI analysis).
Interest of the method: precision, density of measured points and it allows experts to “go back in time” and study the events before and at the beginning of a crisis.



The presented study aims at identifying possible low residual post-mining movements on the Gardanne site (Bassin Houiller de Provence). With this goal, a satellite radar interferometric study using data from Sentinel-1 A/B satellites using a PSI method (Persistent Scatterers Interferometry) was implemented. During the PostMinQuake project (in the framework of the Work Package 6) two analysis were carried out. The first (presented in the mid-term report) covered the December 2014 - July 2020 period on the basis of the first observations it was decided a second processing covering all April 2015 - December 2022 period by including two additional years to the processed Sentinel-1 data set.

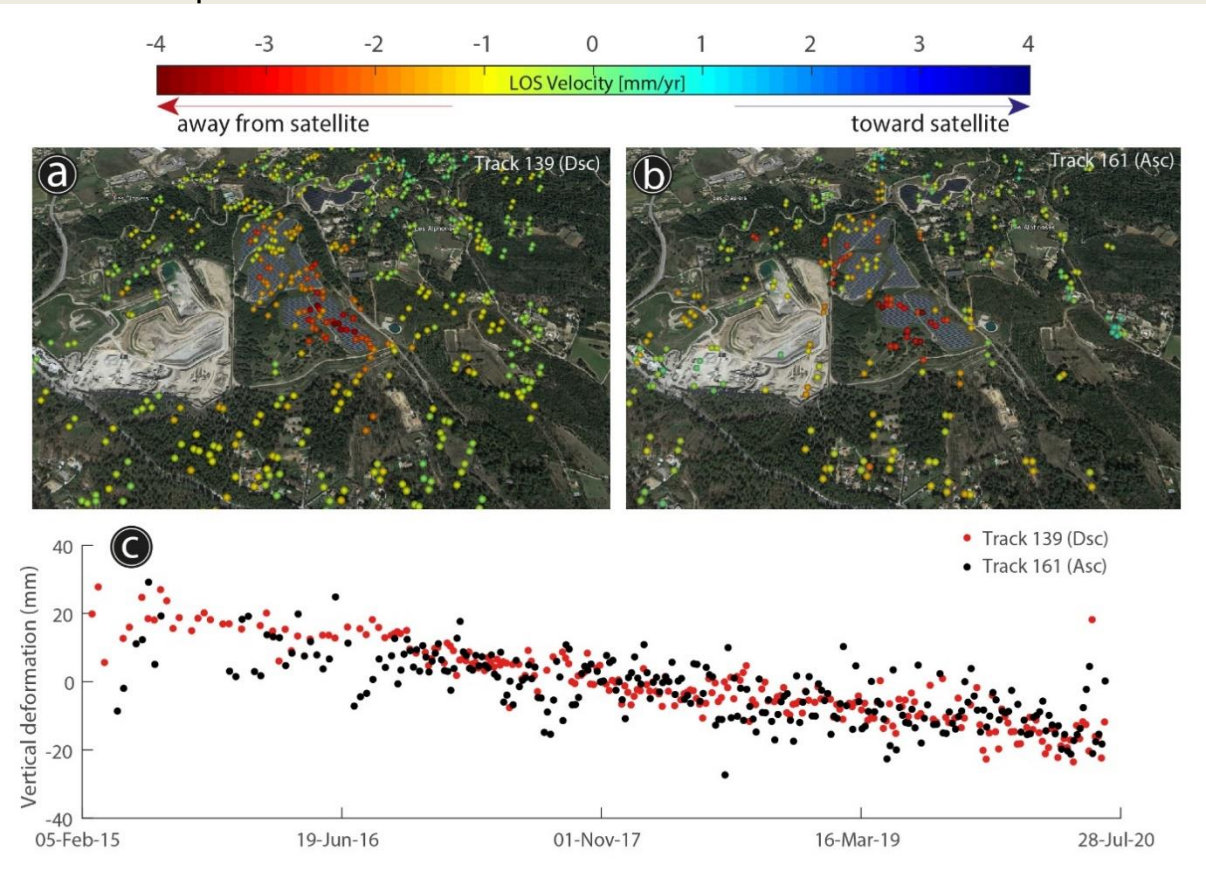


Average line-of-sight (LOS) ground deformation velocities (Dec 2014 – July 2020) obtained from ascending orbit T161 (a) and descending orbit T139 (b). Negative speeds (warm colours) represent movement of the ground away from the satellite and positive speeds (cool colours) represent movement towards the satellite. Blue dots indicate the location of levelling points provided by DPSM. The shaded polygons represent the mining area of the Provence mining basin.

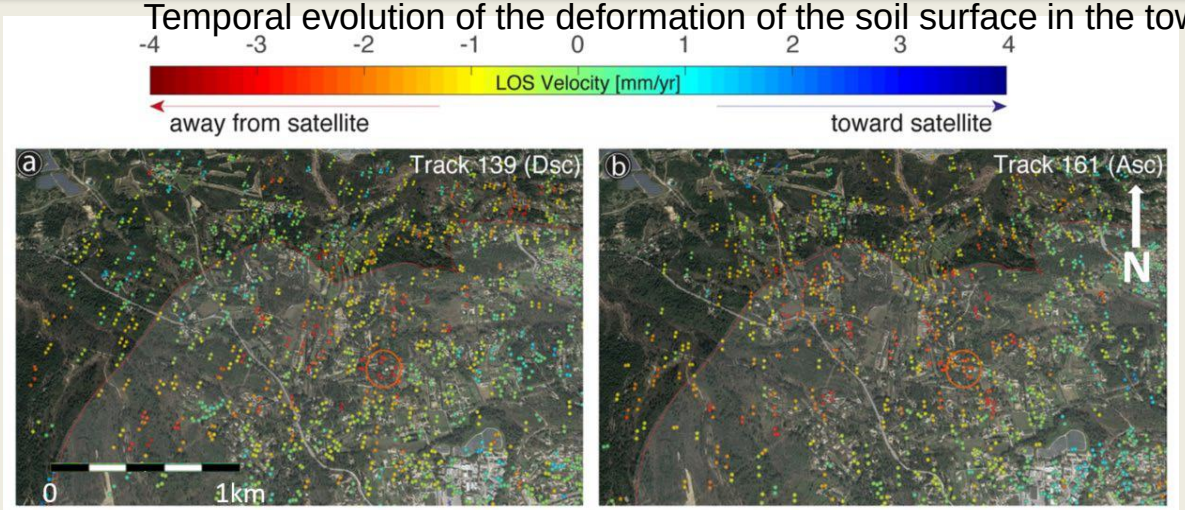
Method

In the framework of the Postminquake WP6, we used processing methods based on the Stanford Method for Persistent Scatterers InSAR package (StaMPS) (Hooper 2008) applied to process the series of Sentinel 1-A and 1-B Synthetic Aperture Radar (SAR) images. In the first processing (end 2014 - mid 2020) using directly the StaMPS package. For reason of efficiency (access to the data, platform processing), the second processing (April 2015-December 2022) has been carried out using the means of the SNAPPING service described below. BRGM received the support of the ESA NoR initiative (processing resources for GEP/SNAPPING use).

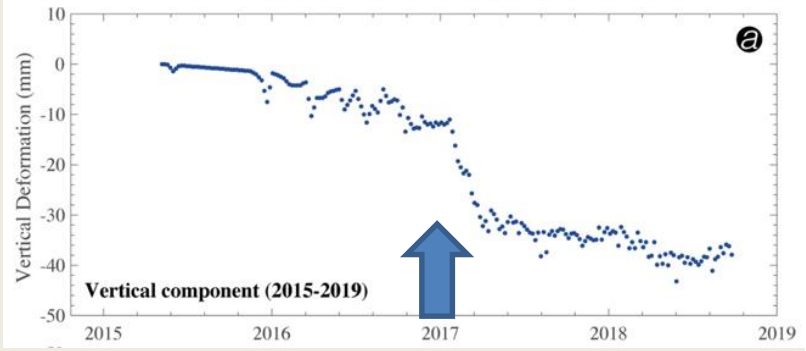
Zoom into Sauvaires slag heap : temporal evolution of the deformation of the soil surface

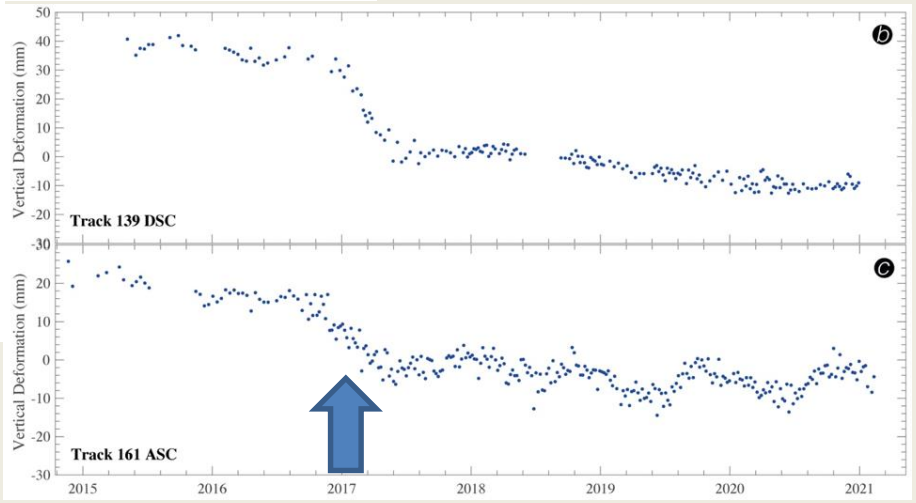


Temporal evolution of the deformation of the soil surface in the town of Fuveau



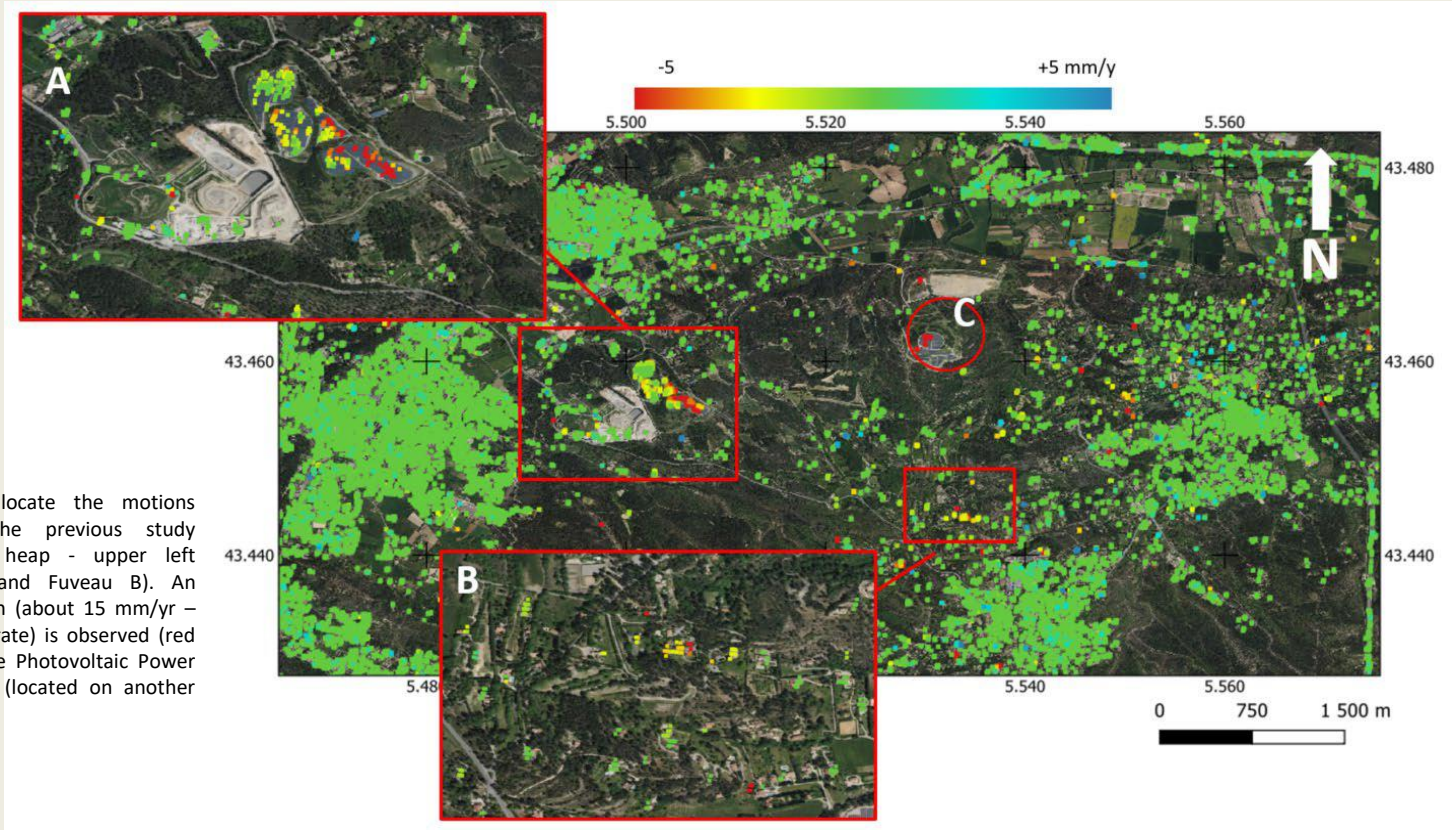
Average ground surface displacement velocities (Dec 2014 – July 2020) in line of sight (LOS) direction obtained from a descending orbit T139 (a) and an ascending orbit T161 (b) observed in the town of Fuveau.





Subsidence consistent with timing of seismic swarm

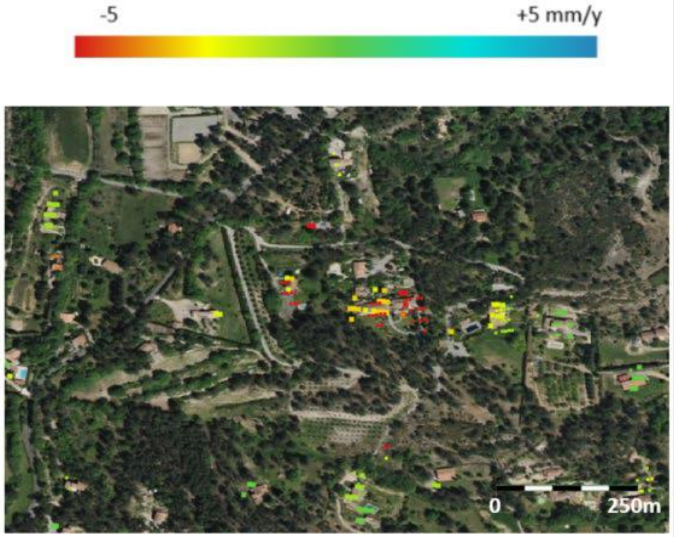
Second processing 2015-2022 : SNAPPING tools (Snaps + Stamps, ESA)



Zoomed areas locate the motions identified in the previous study (Sauvaires slag heap - upper left rectangle A - and Fuveau B). An additional motion (about 15 mm/yr – nearly constant rate) is observed (red circle - C) on the Photovoltaic Power plant of Fuveau (located on another slag heap).

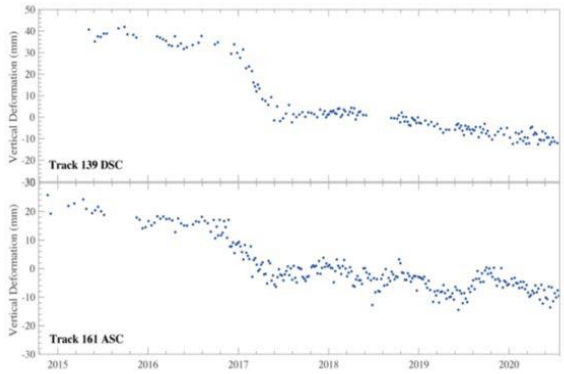
Average line-of-sight (LOS) ground deformation velocities (April 2015 – December 2022) obtained from descending orbit T139 on the identified PS. Negative speeds (red) represent movement of the ground away from the satellite (for example subsidence) and positive speeds (blue) represent movement towards the satellite (for example uplift).

Temporal evolution of the deformation of the soil surface in the town of Fuveau

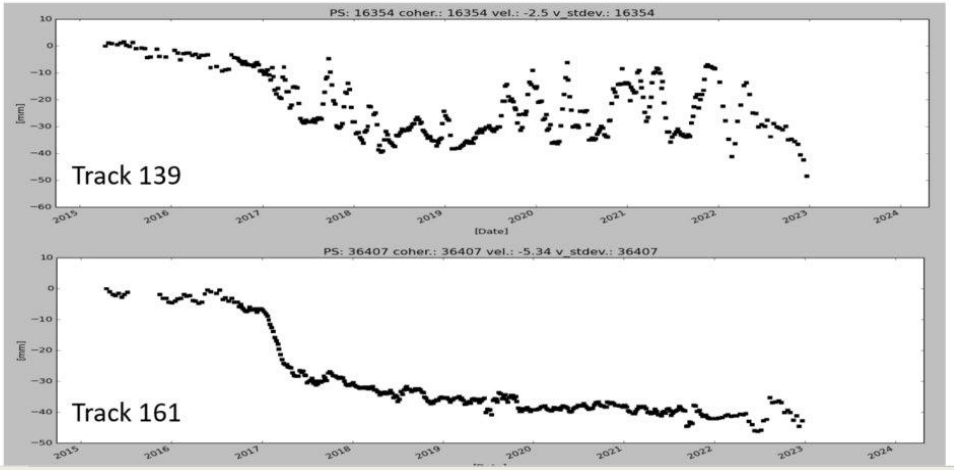


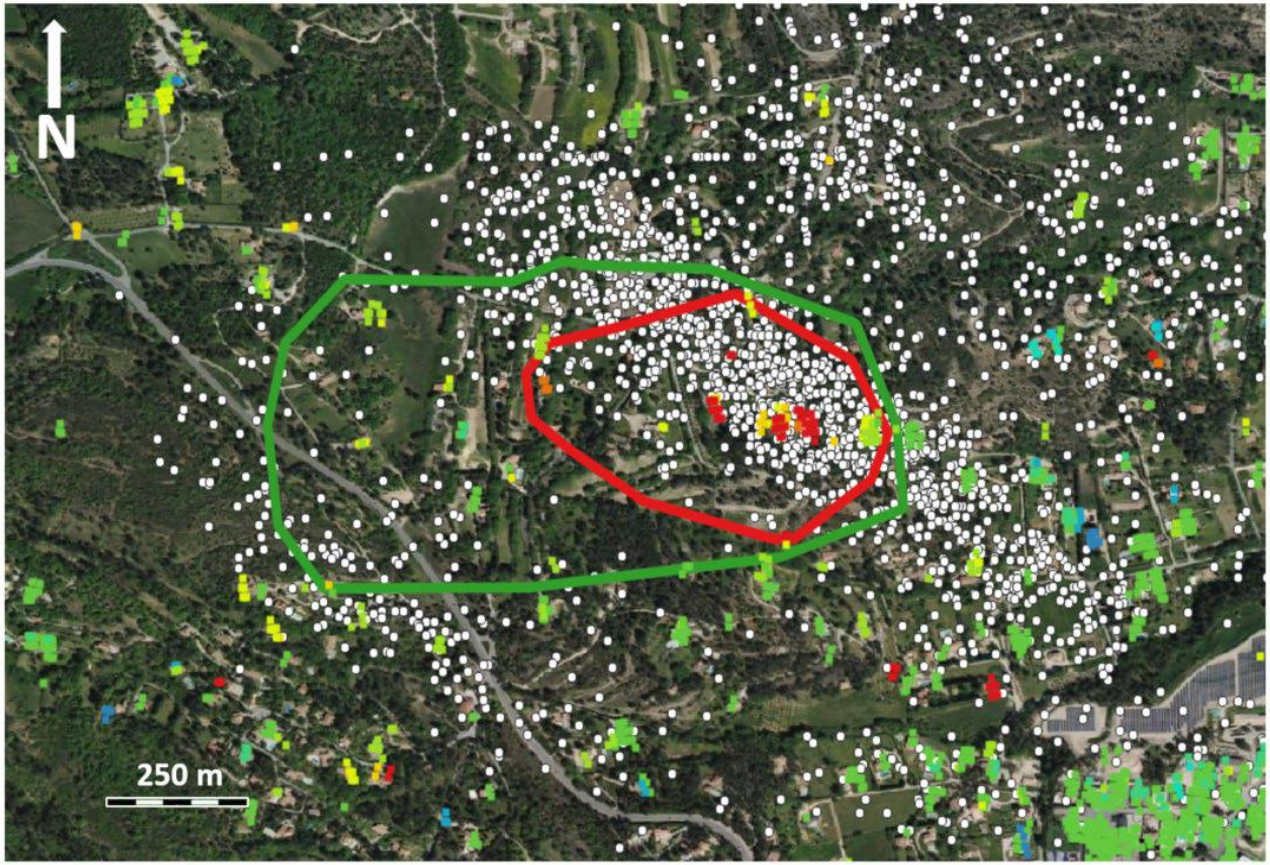
Average ground surface displacement/velocities in line of sight (LOS) direction obtained both from a descending orbit T139 and an ascending orbit T161, for better location of the phenomenon observed in the town of Fuveau

A



B

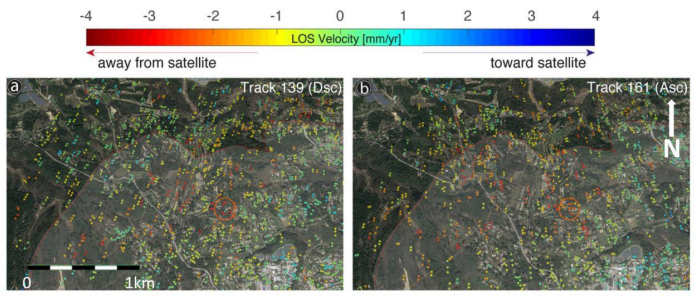


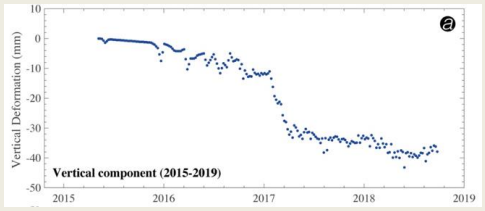


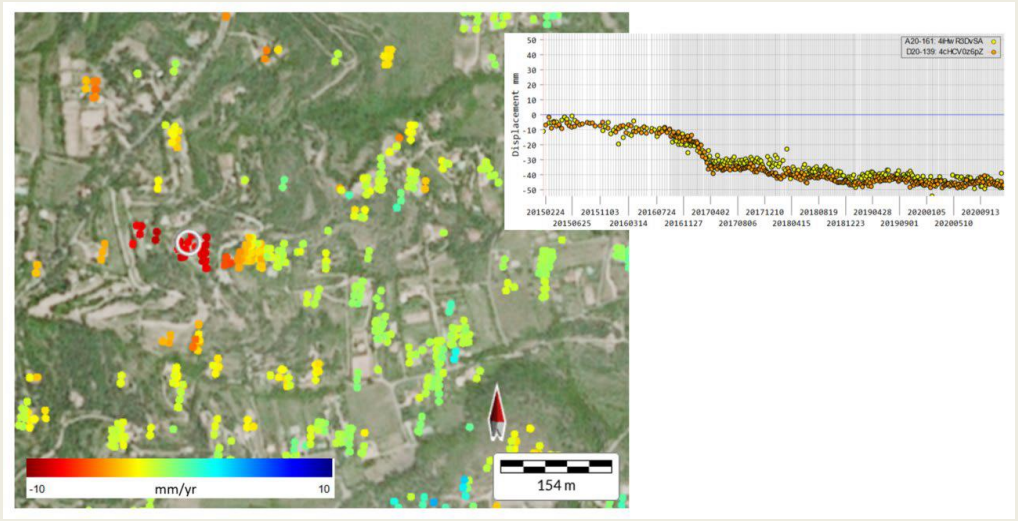
PS (SNAPPING) results overlaid with locations of the 2017 seismic swarm (white dots) (Dominique et al., 2021). In red, contour of PS of which Time Series exhibit clear subsidence starting last quarter of 2016 and ending mid 2017. In green, contour of PS for which the motion is less reliably (lower motion value, inconsistency between neighbours points) detected.

Discussion, conclusions & comparison with EGMS InSAR

In the framework of the WP6 of PostMinQuake we processed Sentinel-1 data (between end 2014 and end 2022) on the area of Gardanne (Bassin Houiller de Provence) in order to detect ground surface motion related to post-mining.
The area is globally stable but we observe a small subsidence (about 2 cm) on the sector of Fuveau concomitant with a seismicity event which occurred from the end of 2016 to the first quarter of 2017. The seismicity event is induced by a drop in the water table that occurred in the last quarter of 2016 (as reported by Dominique et al. 2022). SAR interferometry therefore captured the ground surface consequences of the phenomenon initially observed from seismic means. This study confirms the value of Persistent Scatterers interferometry for analyzing post-mining motion.
In addition, a comparison with the new EGMS (European Ground Motion Service) showed that this service can provide very similar observations. That opens up perspectives for such applications at a wide variety of similar sites in Europe.







Thank you

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