Surface displacements around the geothermal power plant of Landau (Germany) during the 2013-2014 event

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ABSTRACT

Mid-2013 an uplift began centered on the geothermal power plant of the city of Landau (Germany) due to a leak in the reinjection well. The uplift has an extension at kilometer order (figure 1). The beginning (3 first months) was analyzed in previous studies (Heimlich et al., 2014; 2015). This uplift occurs until mid-March 2014, followed by a subsidence centered at the same location (figure 2). In this study, we present the observation and analyze of the surface displacements during the whole 2013-2014 period, including the subsidence after the power plant shutting down in March 2014. We also analyze the displacements at larger scale over the area of Landau. For that purpose, we process 60 Synthetic Aperture Radar (SAR) images from TerraSAR-X satellite, covering January 2013 to January 2015. We use StaMPS (Hooper et al., 2004) software with Persistent Scatterers (PS) method to obtain times series and velocity map. At 500 meters from the power plant location, the uplift reaches 4.5 cm. We can assume that the displacement is higher at the power plant location. But, on this place, the PS-InSAR results suffer of decorrelations due to the large displacement rate and to the vegetated areas surrounding the power plant. So it is difficult to quantify the full displacement in this area.

In order to better constrain our results, we analyze the leveling and GNSS results. There are 2 leveling acquisitions at some locations before the leak event, in 1993 and 2011. And regular measurements have been done between October 2013 and December 2014 (figure 3). The leveling measurements between 1993 and 2011 show a subsidence at centimeter level (0 to 2 cm) followed by an uplift until March 2014. The main displacement occurs near the power plant location. It reaches 11.2 cm between March 2014 and December 2014.

We analyze also the result of a GNSS station, located in the West-North of the city. The result shows that the city of Landau was first affected by a subsidence from 2004 to beginning 2008 then was affected by an uplift until end 2009. From 2010 to 2012 the vertical displacement is not significant. During 2012 until mid-2013, we observe a

subsidence, then an uplift until mid 2014 (end of the acquisition). The GNSS station vertical displacement is consistent with the displacement that affects the central part of the city of Landau. The combining of three geodetics tools provides better constrains to analyze the displacement.

We use a simple model, the Mogi model (Mogi, 1058) used in volcanology, to explain the surface displacement around the power plant location at the different periods of the surface deformation. During the uplift period, all inversion results give a deepness around 400-500 m. During the subsidence, the source deepness is at 50 on the beginning then at 300 meters.

In this study, we see the utility of geodesic tools to prevent and to analyze in space and time the surface displacements due to human activities. Our results highlight also the differential displacements that can be related to geological structures.

Figures

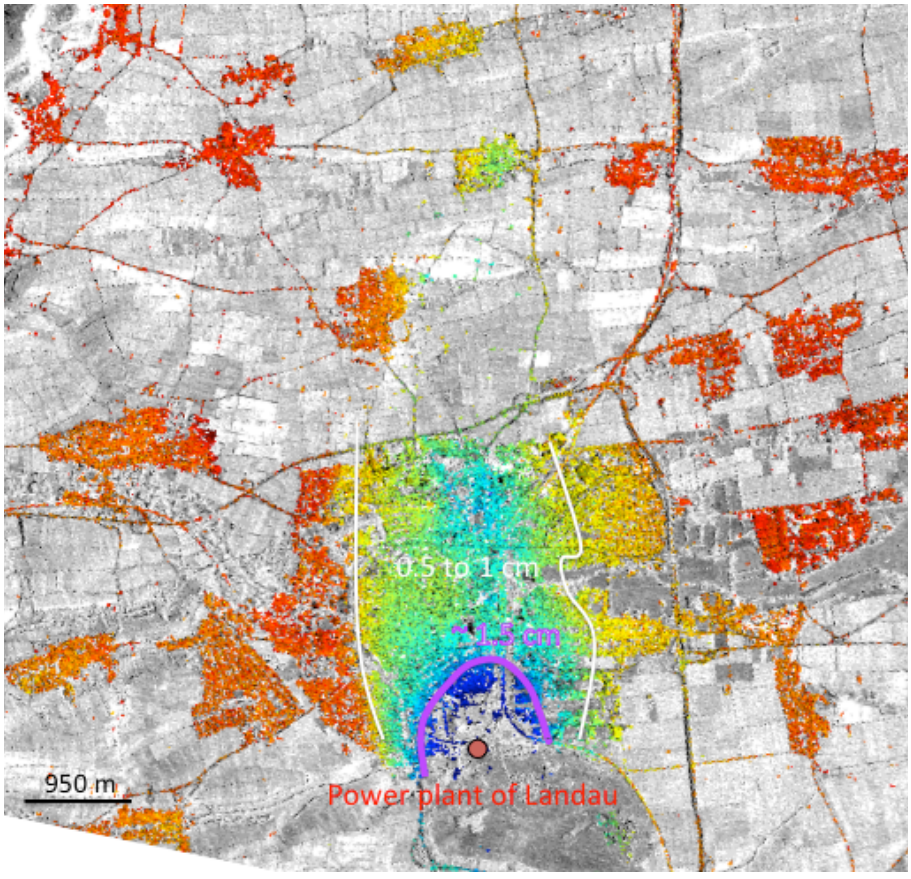

Figure 1: Surface displacements over Landau from January 2013 to January 2015 images. Red circle, power plant location. The scale exetend from zero (red) to (blue).

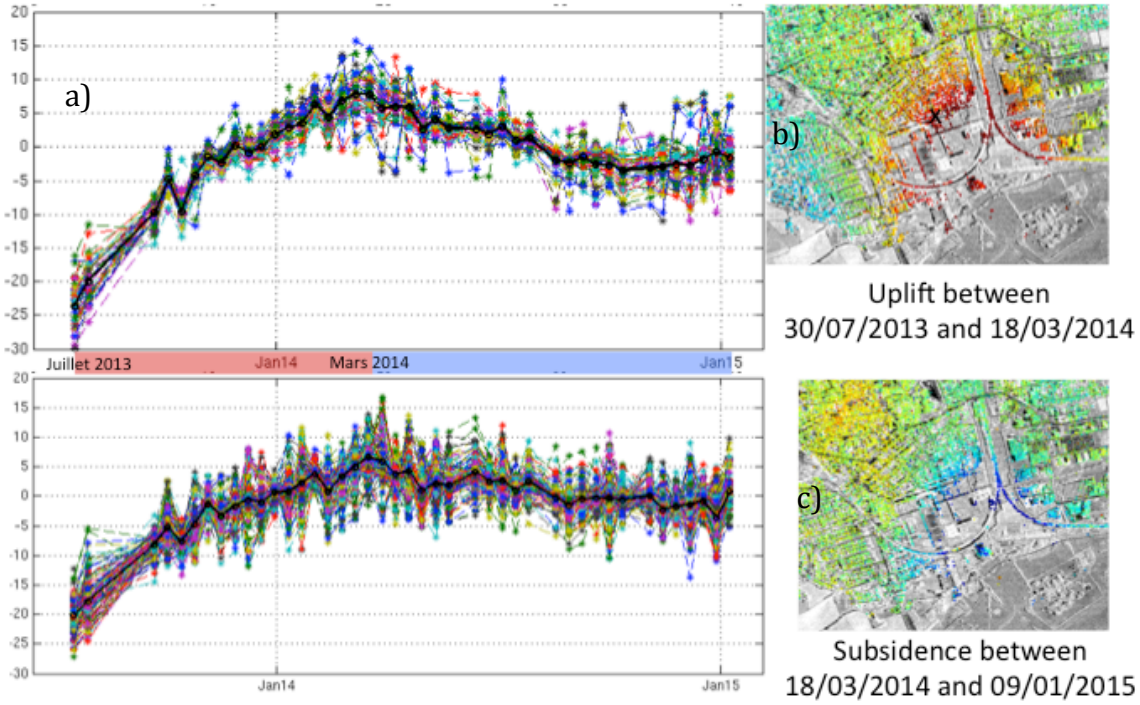

Figure 2: Surface displacements arround the power plant location. a) times series of surface displacements (in mm) ; b) uplift between July 2013 and March 2014 ; c) subsidence between March 2014 and January 2015.

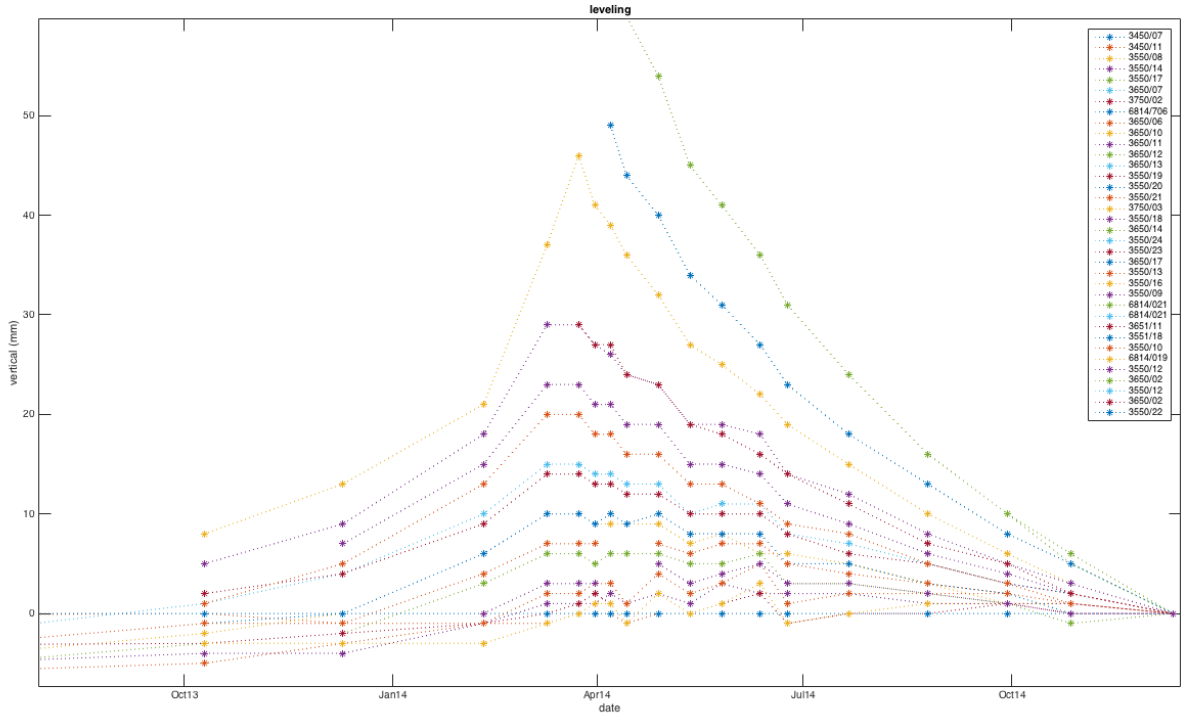

Figure 3 : Time series of vertical displacement (mm) from leveling data between October 2013 and December 2014.

References

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