Introduction and geological settings

Los Humeros is one of the largest geothermal fields in Mexico connected to a caldera system that has been active from 5.48 Ma until recent. Production of the field started in the early 80’s. Since then more than 50 wells were drilled and the current operating capacity is ~66 MW (NREL, 2017).

We performed PS-InSAR (Persistent Scatterer by Synthetic Aperture Radar Interferometry) time-series analysis to resolve ongoing ground deformation. We used C-band Envisat ASAR images acquired between April 2003 and March 2007 (Figure 1). The LosHumeros geothermal field is located in a complex tectonic environment and influenced by Quaternary volcanism resulting in large-wavelength background movements. Our main goal was to isolate and identify local displacements due to geothermal exploration activities.

Interferometric Synthetic Aperture Radar data

PS-InSAR processing was performed on 13 Envisat images with descending orbits using the StaMPS method (Hooper et al, 2007). We selected a single master image based on criteria for perpendicular and temporal baselines: (Figure 3). During the processing the interferograms were investigated and the ones with no visible coherence and vegetation especially in the norther part of the study area induces low signal coherence (Figure 4).

Most parts of the study area are located at high altitudes with strong relief. As a result, the interferograms seem to be influenced by topography-related atmospheric phase delays. We corrected these artifacts based on a linear relationship between phase and elevation. We selected a region outside the geothermal field (Figure 5, black boxes) to estimate the topographic contribution and removed them from the interferograms.

Correction of the stratified tropospheric artifacts

The individual interferograms are of good quality with high coherence even on long time scales in the vicinity of the Los Humeros geothermal field. On the other hand, dense vegetation especially in the norther part of the study area induces low signal coherence (Figure 4).

The laggest subsidence is observed in the norther part of the field. The geothermal field is characterized by about 4-8 mm/year of surface subsidence. The laggest subsidence is observed in the norther part of the field. We correlate the deformation over the Los Humeros geothermal field with geothermal production and fluid flow and displacement along the main structures. We plan to extend the analysis with an inverse study to learn more about the geothermal field characteristics.

Concluding remarks:

- Interferograms are influenced by strong topography-related atmospheric signal which requires correction.
- The geothermal field is charaterized by about 4-8 mm/year of surface subsidence.
- The laggest subsidence is observed in the norther part of the field.
- We correlate the deformation over the Los Humeros geothermal field with geothermal production and fluid flow and displacement along the main structures.
- We plan to extend the analysis with an inverse study to learn more about the geothermal field characteristics.

Table 1. Acquisition dated of Envisat images used for processing. The details of the master image is in Figure 4.

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Figure 1. Map showing the location of the study area and the footprint of the SAR data (descending track 212).

Figure 2. Geologic map of the Los Humeros geothermal field and its surroundings, highlighting major faults, the caldera rims, and the location of the wells. Modified after Carrasco-Nunez et al. (2017).

Figure 3. Movement of a single PS point.

Figure 4. Phase-elevation plots of the 7th and 11th interferograms.

Figure 5. a: Elevation of the PS points. b: Deformation map showing the velocities in the satellite line of sight (LOS). Movements are relative to the mean of the whole area. Standard deviations are below 4 mm/year. Black rectangle highlights the region used for tropospheric correction.

Figure 6. Deformation map corrected for topography-related atmospheric phase delays.

Figure 7. Deformation map corrected for tropospheric contribution.

Figure 8. Interpolated deformation map over the geothermal field. Negative values indicate movement away from the satellite (=subsidence) and positive values indicate movement towards the satellite (=uplift).

Figure 9. Production/injection history during the period of InSAR monitoring.

Figure 10. Production/injection history during the period of InSAR monitoring.

Figure 10. Production/injection history during the period of InSAR monitoring.

Figure 11. Production/injection history during the period of InSAR monitoring.

Monitoring the geothermal field

The geothermal field is characterized by about 4-8 mm/year of surface subsidence. The laggest subsidence is observed in the norther part of the field. We correlate the deformation over the Los Humeros geothermal field with geothermal production and fluid flow and displacement along the main structures. We plan to extend the analysis with an inverse study to learn more about the geothermal field characteristics.

References