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Spatio-temporal evolution of anthropogenic deformation around Cerro Prieto geothermal field in the Mexicali Valley, B.C., Mexico, between 1993 and 2009 from DInSAR and leveling.

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Land subsidence is an environmental hazard which could be caused by withdrawal of large amounts of fluid from beneath the earth's surface. Land subsidence is an issue in several geothermal fields worldwide (e.g., Geysers, USA (Mossop and Segall, 1997), Wairakei–Tauhara, New Zealand (Allis et al., 2009)).
Cerro Prieto geothermal field (CPGF), located in the Mexicali Valley, northwest Mexico, is the oldest and largest Mexican geothermal field in operation and has been producing electricity since 1973. The large amount of geothermal fluids extracted to supply steam to the power plants has resulted in considerable deformation in and around the field (e.g. Glowacka et al., 1996, 1999; Carnec and Fabriol, 1999; Sarychikhina et al., 2011). The deformation includes land subsidence and related ground fissuring and faulting. These phenomena have produced severe damages to the local infrastructure such as roads, irrigation canals and other facilities.
Detection of land subsidence and monitoring of the spatial and temporal changes of its pattern and magnitude can provide important information about the dynamics of this process and controlling geological structures. The technique of Differential Synthetic Aperture Radar Interferometry (DInSAR) has been demonstrated to be a very effective technique for measuring ground deformation.
This study presents an application of DInSAR interferogram stacking technique to investigate the land subsidence in the Mexicali Valley near CPGF. C-band ENVISAR ASAR images acquired between 2003 and 2009 from the ascending (track 306, frame 639) and descending track (track 84, frame 2961), obtained from the European Space Agency (ESA), as part of ESA CAT-1 project (ID - C1P3508), were used. Gamma ISP and DIFF/GEO software packages were used to calculate differential interferograms from SLC data and for differential interferograms stacking (Wegmüller and Werner, 1997). Eight average annual deformation rate maps were generated for 2005 (descending track), 2006 (ascending and descending tracks), 2007 (ascending and descending tracks), 2008 (ascending and descending tracks) and 2009 (ascending track). Since here we attempt to present results of only aseismic character the annual deformation rate for 2006 and 2008 were not included in the analysis because of presenting strong co-seismic deformation signals. The low number of images available for 2006 was also the factor for exclusion. The similar subsidence pattern and rate with maximum of ∼20 cm/yr is observed in all analyzed deformation rate maps.
In order to evaluate the spatio-temporal evolution of anthropogenic deformation in the study area, the published data from precise leveling surveys from 1994-1997 and 1997-2006 periods (Glowacka et al., 1999; Glowacka et al., 2006) and DInSAR data from ERS 1/2 acquired in 1993-1997 period (Carnec and Fabriol, 1999; Hanssen, 2001) were analyzed. Changes in subsidence rate with time and migration of zone of maximum subsidence were observed. The role of the deep fluid extraction in subsidence pattern and rate changes is discussed.