Geophysical Research Abstracts
Vol. 13, EGU2011-8777, 2011
EGU General Assembly 2011

Active fault analysis and tectonic setting assessment with SqueeSAR

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Surface deformation monitoring can provide evidence of fault activity at the ground surface. Geodetic measurements (Levelling campaigns, GPS permanent stations) and Satellite Radar Interferometry are the techniques most widely used to determine surface displacements. Whatever the surveying technique, the detection of millimetre level surface deformation is required. While differential synthetic aperture radar (DInSAR) data has been widely explored in a number of cases for detecting and analyzing surface faulting, especially in case of seismic events, few are the applications of Persistent Scatterer Interferometry (PSI) algorithms to tectonic studies. Permanent Scatterer Techinque (PSInSAR), introduced by POLIMI in the late nineties and subsequently improved by TRE, and the advanced second generation SqueeSAR analysis, search the radar image set for targets that consistently reflect radar signals throughout the entire dataset of images, exploiting both permanently scattering ground targets (PS, e.g. buildings, pipelines, linear structures, open outcrops etc.) and homogenous distributed scatterers (DS, e.g. homogeneous ground or scattered outcrops, uncultivated areas, debris covered areas). Thanks to the high density of measurement points, the millimetric accuracy of measurements, and the wide spatial coverage, the SqueeSAR technique is able to measure slow tectonic displacements and represents a useful tool to detect ground deformation related to crustal faulting over wide areas. The availability of long time-series archives of images also allows the reconstruction of the dynamic evolution of the displacement, which is extremely functional to model deformation fields and to evaluate seismic hazard. Applications of SqueeSAR analyses aimed at identifying displacements related to fault reactivation induced by hydrocarbon reservoir exploitation have been recently published. In this paper, a methodology to be used to extract information on surface deformation fields will be presented, but, rather than focusing on InSAR algorithms, “post-processing” activities will be highlighted, and some applications of active fault analysis and tectonic setting assessment are reported. The proposed methodology consist of: extraction of easting and vertical components by combining ascending and descending satellite data-sets, removal of systematic errors and calibration with in situ data, estimation of the gradient of the displacement field in order to highlight trends and anomalies and analysis of the temporal evolution of displacement values along representative cross sections. Moreover, the complementarities of InSAR results with GPS measurements will be demonstrated through the analysis of selected case studies, e.g. city of Tunis and the San Francisco Bay Area. Applications of fault identification, pre-seismic and post-seismic deformation setting analysis and silent slip events (e.g. Superstition Hills slip event of October 2006) demonstrate that the proposed methodology can help evaluate fault geometry, identify causative tectonic structures, support dynamic behaviour interpretation and assess hazard in areas exposed to high seismic risk.