Geophysical Research Abstracts
Vol. 16, EGU2014-7028-2, 2014
EGU General Assembly 2014

3D Faulting Numerical Model Related To 2009 L'Aquila Earthquake Based On DInSAR Observations

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We investigate the surface displacements in the area affected by the April 6, 2009 L'Aquila earthquake (Central Italy) through an advanced 3D numerical modeling approach, by exploiting DInSAR deformation velocity maps based on ENVISAT (Ascending and Descending orbits) and COSMO-SkyMed data (Ascending orbit). We benefited from the available geological and geophysical information to investigate the impact of known buried structures on the modulation of the observed ground deformation field; in this context we implemented the a priori information in a Finite Element (FE) Environment considering a structural mechanical physical approach. The performed analysis demonstrate that the displacement pattern associated with the Mw 6.3 main-shock event is consistent with the activation of several fault segments of the Paganica fault.

In particular, we analyzed the seismic events in a structural mechanical context under the plane stress mode approximation to solve for the retrieved displacements. We defined the sub-domain setting of the 3D FEM model using the information derived from the CROOP M-15 seismic line. We assumed stationarity and linear elasticity of the involved materials by considering a solution of classical equilibrium mechanical equations. We evolved our model through two stages: the model compacted under the weight of the rock successions (gravity loading) until it reached a stable equilibrium. At the second stage (co-seismic), where the stresses were released through a slip along the faults, by using an optimization procedure we retrieved: (i) the active seismogenic structures responsible for the observed ground deformation, (ii) the effects of the different mechanical constraints on the ground deformation pattern and (iii) the spatial distribution of the retrieved stress field.

We evaluated the boundary setting best fit configuration responsible for the observed ground deformation. To this aim, we first generated several forward structural mechanical models, obtained through the activation of different structural segments; then, we compared the synthetic (related to the performed forward model) and the measured ground deformation fields, in order to select the minimum RMS solution. We search for the best model results using an optimization algorithm based on the genetic algorithm, providing an accurate spatial characterization of ground deformation.

Our results improve kinematic solutions for the Paganica fault and allow identification of additional fault segments that have contributed to the observed complex ground deformation pattern. The FEM-based methodology is applicable to other seismic areas where the complexity of buried structures plays a fundamental role on the associated surface deformation pattern.