Geophysical Research Abstracts
Vol. 12, EGU2010-10934, 2010
EGU General Assembly 2010

Fault Geometry, Co-Seismic and Post-Seismic Slip Distribution of the April 6, L'Aquila Earthquake Imaged From Inversion of GPS Data

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On April 6, 2009, the city of L'Aquila was struck by a Mw 6.3 earthquake that killed 307 people, causing severe destruction and ground cracks in a wide area around the epicenter. Four days before the main shock 5 GPS stations have been installed at geodetic points belonging to the Central Apennine GEOdetic NETwork, to integrate the existing continuous GPS stations operating around the L'Aquila basin. All these stations directly measured the co-seismic displacement and a significant early post-seismic deformation. Within 1-2 days from the main-shock other 6 GPS units have been installed, later reaching a total amount of 42 geodetic points reoccupied, allowing us to reach unprecedent details of the co-seismic deformation field for a "moderate" normal faulting earthquake. We use rectangular, uniform-slip dislocations embedded in a elastic, homogeneous and isotropic half-space and a constrained, non-linear optimization algorithm, to solve for the best fit rectangular dislocation geometry and fault slip distribution. We find that the optimal fault geometry is a 12.5 long plane, N138°E striking, 50.6° SW-ward dipping and extending between 0.8 and 13.1 km depths, corresponding to the Paganica fault, in agreement with other geodetic and geological data. We invert for the distribution of co-seismic slip adopting an extended fault plane, covering the entire along-strike aftershocks distribution, while imposing non-negativity and boundary constraints, and adopting a finite difference approximation of the Laplacian operator to apply smoothing on the slip distribution between adjacent patches. We found a very good anti correlation in the distribution of aftershocks and co-seismic slip, with a larger slip patch located between 4 and 7 km depth, SW of Paganaica, and a maximum slip of about 1.10 m, corresponding to a total seismic moment release of 2.61e+18 (Nm), and a Mw = 6.27. Position time series of GPS stations show significant post-seismic displacements, with largest amplitudes in the epicentral area, even if post-seismic transients are evident also at greater distances. We model the post-seismic signal as a logarithmic function, estimating a time decay constant value for each GPS station, and invert for both time-dependent and cumulative post-seismic slip. We found a good correspondence between after-slip and aftershocks distributions along the main fault that ruptured during the mainshock, displaying afterslip to occur between 4 and 10 km depth. Model residuals, however, require a certain amount of after-slip to occur on the deeper portion of the Monti della Laga fault plane, north of the Paganica fault, which is in good agreement with the distribution of aftershocks on this secondary fault plane, illuminating a complex post-seismic distribution of the deformation.