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Rupture process of the 2009 L'Aquila, central Italy, earthquake, from the separate and joint inversion of Strong Motion, GPS and DInSAR data.

A. Cirella, A. Piatanesi, E. Tinti, M. Chini, and M. Cocco
Istituto Nazionale di Geofisica e Vulcanologia, Rome, Italy (antonella.cirella@ingv.it)

In this study, we investigate the rupture history of the April 6th 2009 (Mw 6.1) L'Aquila normal faulting earthquake by using a nonlinear inversion of strong motion, GPS and DInSAR data. We use a two-stage non-linear inversion technique. During the first stage, an algorithm based on the heat-bath simulated annealing generates an ensemble of models that efficiently sample the good data-fitting regions of parameter space. In the second stage the algorithm performs a statistical analysis of the ensemble providing us the best-fitting model, the average model, the associated standard deviation and coefficient of variation. This technique, rather than simply looking at the best model, extracts the most stable features of the earthquake rupture that are consistent with the data and gives an estimate of the variability of each model parameter.

The application to the 2009 L'Aquila main-shock shows that both the separate and joint inversion solutions reveal a complex rupture process and a heterogeneous slip distribution. Slip is concentrated in two main asperities: a smaller shallow patch of slip located up-dip from the hypocenter and a second deeper and larger asperity located southeastward along strike direction.

The key feature of the source process emerging from our inverted models concerns the rupture history, which is characterized by two distinct stages. The first stage begins with rupture initiation and with a modest moment release lasting nearly 0.9 seconds, which is followed by a sharp increase in slip velocity and rupture speed located 2 km up-dip from the nucleation. During this first stage the rupture front propagated up-dip from the hypocenter at relatively high ($\sim$ 4.0 km/s), but still sub-shear, rupture velocity. The second stage starts nearly 2 seconds after nucleation and it is characterized by the along strike rupture propagation. The largest and deeper asperity fails during this stage of the rupture process. The rupture velocity is larger in the up-dip than in the along-strike direction. The up-dip and along-strike rupture propagation are separated in time and associated with a Mode II and a Mode III crack, respectively.

Our results show that the 2009 L'Aquila earthquake featured a very complex rupture, with strong spatial and temporal heterogeneities suggesting a strong frictional and/or structural control of the rupture process.