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Source Complexity of the 2009 L'Aquila, Italy, earthquake retrieved from the joint inversion of strong motion, GPS and DInSAR data – Evidence for a Reological Control on Rupture Mechanics

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The 2009 L'Aquila earthquake (Mw 6.3) occurred in the Central Apennines (Italy) on April 6th at the 01:32 UTC and caused nearly 300 casualties and heavy damages in the L'Aquila town and in several villages nearby. The main shock ruptured a normal fault striking along the Apennine axis and dipping at nearly 50° to the SW. The identification of the fault geometry of the L'Aquila main shock relies on the aftershock pattern, the interferometric data, the GPS displacements as well as the induced surface breakages. The earthquake provided an unprecedented data set of seismograms and geodetic data for a moderate-magnitude normal faulting event.

In this study, we investigate the source process of the L'Aquila main shock by using a nonlinear joint inversion of strong motion, GPS and DInSAR data. The imaged rupture history is heterogeneous and characterized by rupture acceleration and directivity effects, which are stable features of the inverted models.

The inferred slip distribution is characterized by two main asperities; a small shallow slip patch located up-dip the hypocenter and a large and deeper patch located southeastward. The rupture velocity is larger in the up-dip than in the along-strike direction. This difference can be partially accounted by the local crustal structure, which is characterized by a high body-wave velocity layer above the hypocenter (9.46 km) and lower velocities below. The latter velocity seems to have affected the along strike propagation, since the largest slip patch is located at depths between 9 and 14 km. The imaged slip distribution correlates well with the on-fault aftershock pattern as well as with mapped surface breakages. The rupture history is also consistent with the large PGA values recorded at L'Aquila that is located right above the hypocenter.

Our results show that the L'Aquila earthquake featured a very complex rupture history, with strong spatial and temporal heterogeneities suggesting a strong reological control of the rupture process.