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Rupture Process of the 2009 L'Aquila, Italy, Earthquake Inferred from Waveform Inversion of Strong Motion Data

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The L'Aquila, Central Italy, earthquake occurred on April 6, 2009 at 01:32:40 UTC time. This Mw 6.3 (Global CMT Project) event caused severe damages to the city of L'Aquila and surrounding villages of the Abruzzo region. Over 300 people were killed, about 1000 people were injured, and thousands of buildings were destroyed and damaged. The event was followed by a significant aftershock activity that extended over the length exceeding 30 km in NW-SE direction. According to the moment tensor solution, the earthquake was generated by a normal faulting on a fault system running parallel to the axis of the Apennine mountains. The aftershock distribution (Chiarabba et al., 2009) and the previous studies of the active faults in the area (e.g., Salvi et al., 2 003) suggest that the fault activated during the mainshock is a NW-SE oriented structure dipping to the SW. The updated epicenter location is reported by INGV, Rome to be 2 km away westwards from the city of L'Aquila.

The 2009 L'Aquila earthquake provided an unprecedented for a normal faulting event amount of seismological records. The mainshock and its aftershocks have been recorded by several local and regional seismic networks. The records from the Italian strong-motion network (RAN), operated by the Department of Civil Protection were integrated into the ITalian Accelerometric Archive (ITACA). A total of 56 three-component strong motion records were obtained within 280 km distance from the mainshock. Seismic stations located on the hanging wall of the causative fault displayed clear near-field signal with evident static displacements. The maximum PGA values ranging from 0.35 to 0.65 g (Ameri et al., 2009) were recorded at the near-fault stations (epicentral distance from 1.7 to 5.0 km) located on the hanging wall. These stations are also characterized by the vertical PGA values similar to the horizontal ones. Stations located on the foot wall of the fault recorded PGA values less than 0.15 g. It must also be mentioned that significant site effects were observed at some stations. Clear evidence of the site amplification were confirmed inside the area of the Aterno valley (e.g., AQK station).

In this study, we investigated rupture process of the L'Aquila earthquake by waveform inversion of near-field strong motion data from the ITACA database, using the method of Yoshida et al. (19 96). Based on the aftershock study (Chiarabba et al., 2009) and the teleseismic waveform inversion results (Poiata et al., 2009), we assumed that the rupture occurred on the southwest dipping fault plane with strike = 148 deg. and dip = 44 deg., and the fault dimensions of 25 km in length by 15 km in width. We used three component velocity records from the stations located within the distance of 55 km from the epicenter. To account for the geological complexity of the area, we determined a set of 1D stratified velocity models adapted for each of the station by the forward modeling of the aftershock records available from the ITACA database. The initial model was assumed based on the surface wave dispersion study by Herrmann and Malagnini (2009). The slip distribution of our best fit model shows a major asperity located about 18 km southeast from the hypocenter. The total seismic moment is Mo = 3.56 x 10**18 Nm and the optimal depth is found to be 8 km. We also determined the rupture velocity that minimizes the residuals between

observed and synthetic waveforms to be 1.9 km/s. The overall source duration is around 15 s.

The resultant source model and location of the main asperity fairly agree with the studies by other authors (Cirella et al., 2009, Atzori et al., 2009). It is also in a good correlation with the aftershock distribution (Chiarabba et al., 2009) and the observed coseismic surface breaks (Falcucci et al., 2009).

Keywords: rupture process, waveform inversion, normal fault, strong ground motion