Geophysical Research Abstracts
Vol. 12, EGU2010-5124-2, 2010
EGU General Assembly 2010

Rupture process of the 2009 L'Aquila, Italy, earthquake inferred from inversions of teleseismic and strong motion datasets

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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) event caused large damages to the city of L'Aquila and surrounding villages of the Abruzzi region.

A detailed study of the source process of this event is essential in understanding the observed macrosesmic effects and the relation between the causative fault and the aftershock activity. The use of the seismological datasets recorded at different distance range is expected to give supplementary information on the rupture process offering a more stable and detailed image of the source area, while each of the teleseismic and strong motion data carries information on different period ranges of the process at the source. In this study we developed a rupture model for the L'Aquila event by analyzing the teleseismic waveform data of IRIS-DMC and near-field strong motion records from the Italian Strong Motion Network (RAN). We also examined what details of the rupture history can be deduced from the teleseismic data alone, the strong motion data alone, and the combined teleseismic and strong motion data sets.

At first, we estimated the general pattern of the source rupture area and determined the hypocentral depth, by performing the moment tensor analysis as well as the source inversion of broadband teleseismic records using the methods developed by Kikuchi and Kanamori (1982, 1991), Kikuchi et al. (2003) and Yoshida et al. (1996). Based on the aftershock study (Chiarabba et al., 2009) we assumed that the rupture occurred on the SW dipping fault plane with the dimensions of 25 km in length by 15 km in width. We also assumed strike = 148 deg. and dip = 44 deg., based on the residuals of the point source analysis and the aftershock distribution. The optimal depth that maximizes the waveform fit was found to be 6 km. The total seismic moment corresponds to Mo = 3.10 x 10**18 Nm. The inverted slip model shows one main asperity located in the upper shallow part of the fault close to the hypocenter, and a rupture extension towards the southeast.

We further performed a waveform inversion of near-field strong motion data from ITACA database using the method of Yoshida et al. (1996) and fault parameters from the teleseismic waveform inversion. We used three component velocity records from the stations located within the distance of 55 km from the epicenter. The velocity structure for each of the stations is approximated by a 1D model adjusted by the forward modeling of the aftershocks records available from the ITACA database. The slip distribution of our best model shows a major asperity located about 18 km SE from the hypocenter. The total seismic moment corresponds to Mo = 3.5610 x 10**18 Nm and the optimal depth is found to be 8 km. We also determined the average rupture velocity that minimizes the residuals between observed and synthetic waveforms to be 1.9 km/s.

The resulted source model, location of the main asperity, in generally agrees well with the studies by other authors (Cirella et al., 2009, Atzori et al., 2009). However, the slip distributions obtained from the inversion of the teleseismic and the strong motion datasets are largely different. We further investigated the possible explanation of this difference by performing the forward modeling of the teleseismic data using the source model from the strong motion inversion and the joint inversion of the teleseismic and the strong motion datasets. The results of these analysis as well as the details on the origin of the differences in the teleseismic and strong motion models will be presented in the meeting.