RAPID DETERMINATION OF MOMENT MAGNITUDE FROM THE NEAR-FIELD SPECTRA: APPLICATION TO THE APRIL 6 2009, L’AQUILA SEISMIC SEQUENCE

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Abstract
On April 6th 2009, a magnitude Mw=6.1 earthquake struck the Abruzzi region in central Italy. Despite its moderate size, the earthquake caused more than 300 fatalities and partially destroyed the city of L’Aquila and many villages in its surroundings. The main shock was preceded by an earthquake swarm that started at the end of 2008, and, by the end of November 2009, more than 16,000 aftershocks with M> 0.5 have been recorded by the INGV seismic network. Current advances in data transmission and communication yield high quality broadband velocity and strong motion waveforms in near real-time. These data allow for the rapid characterization of earthquake sources in terms of fault geometry, focal depth and seismic moment. Delouis et al. (2009) have developed a methodology for rapid determination of moment magnitude from the near-fields spectra. In this study we test this methodology on the L’Aquila sequence earthquakes for which we have already computed the time domain moment tensor solutions (TDMT, Scognamiglio et al., 2010).

Methodology

MWSYNTH (Delouis et al., 2009) proceeds in 4 steps. With the first 2 steps a synthetic database is pre computed. Steps 3 and 4 correspond to the processing of the real data and to the actual computing of Mw for the earthquake of interest. Steps 3 and 4 can be implemented in real time.

Step 1: Compute synthetic seismograms for various fault orientations (9 different focal mechanisms), epicentral distances between 1 and 300 km, and magnitude between 2 and 8, using simple rectangular finite source models. Synthetics are computed for a 1D layered earth model with the discrete wave number method of Bouchon, (1981).

Step 2: Compute the displacement spectra of the synthetic seismograms of step 1, for various highpass filtering, retrieve the spectral level at low frequency (maximum amplitude on the spectra), and average over the different fault orientations. Store the average spectral levels as a function of Mw, hypocentral distance, and filtering (pre-computed tables of spectral levels).

Step 3: Establish the optimal highpass filtering for the real data, compute spectra of the filtered displacement, retrieve spectral levels at low frequency, and compare them with the averaged synthetic spectral levels of step 2.

Step 4: Compute Mw for each seismic station by interpolating spectral levels of real data among the pre-stored synthetic values. The final Mw is the average of the moment magnitudes of the individual stations.

Results

Rapid Mw - Tdmt Mw

Each star corresponds to a seismic station used to evaluate the Rapid Mw. The stars dimension is proportional to the weight applied in the computation.

Stations contributing to the Mw computation

For each station, we have evaluated the average +/- 1 standard deviation of the difference between all the rapid-Mw computed by the station and the relative tdm-Mw. The Map shows the overall behavior of the 70 stations that have mainly contribute to the 62 magnitude estimation.