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BROADBAND STRONG GROUND MOTION MODELING WITH 1D DETERMINISTIC GREEN'S FUNCTIONS: MW5.5 AFTERSHOCK OF THE 2009 L'AQUILA, ITALY, EARTHQUAKE

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Broad-band simulation techniques are usually employed to simulate strong events (M > 6), because the ground motion close to the causative faults is mainly controlled by the complexity of the source mechanism and propagation effects at low frequencies. These techniques are rarely applied to reproduce moderate magnitude events, as the duration of the source is rather short and high-frequency site and propagation effects might dominate the records. Nevertheless, the broad-band modeling to a moderate magnitude event could be very attractive to investigate to what extent the ground motion is coherent with the source kinematics and 1D propagation and to evaluate the level of randomness of high-frequency due to site and near surface propagation.

In this work, we present an extensive study of the strongest aftershock (Mw 5.5 - 7th April 2009, 17:37 UTC, hypocentral depth 17 km) of the L'Aquila (central Italy) seismic sequence, based on low-frequency inversion and broadband simulation of about 30 strong-motion data recorded within 50 km from the epicenter.

Low-frequency strong-motion data (< 0.5), are used to invert centroid, fault plane solution, and slip distribution in terms of a single homogeneous slip patch with constant rupture propagation. The optimal solution provides a fault dimension of 6x6km, located at 15km depth, static stress drop of 1 MPa and a weak indication of bilateral rupture propagation. These features are used to setup a broadband (0-10Hz) composite source model with fractal number-size distribution of overlapping subsources to be adopted for modeling strong-ground motions at rock-site stations and stations for which 1D subsurface velocity profile is available. The propagation medium is modeled through full-wavefield deterministic 1D Green's functions in the whole frequency range.

The overall goodness of fit between simulated and observed waveforms obtained in this study suggests that the 1D Green's Function model can be adopted to generate broad-band seismic motion, keeping in mind some limitations. The modeling performs well in terms of peak values and, in case of rock stations, the strong-motions are correctly predicted even in terms of duration, suggesting that the dominant S wave group is composed of S waves multiples and weak scattered waves. As expected, the 1D Green's functions clearly fail in reproducing the duration and the energy content of the ground motion recorded at sedimentary basins, although the peak displacements are correctly predicted.

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To better evaluate the performance of broad-band modeling, we also carried out a careful analysis of S-wave group polarization at high frequencies (HF). This study revealed that while some stations retain the predominantly linear polarization in accordance with the 1D modeling, other stations show a peculiar mismatch. The latter is either expressed by random circular polarization or by polarization remaining linear but at different angle. We interpret these observations as a consequence of strongly depth-varying scattering crustal properties, being relatively weak at larger depths. In particular

- For deep events at rock stations with no site amplification, the 1D source linear HF polarization is preserved because the waves travel rather short path in the shallow scattering medium. Contrarily, for shallower events with longer path in the heterogeneous subsurface crust, the scattering "destroys" the linear polarization, resulting in observed circular random particle motion.
- At stations with strong site-effects associated with very heterogeneous subsurface structure, the linear polarization is "destroyed" in any case. In case of strong azimuthal dependence of the site-effects (associated perhaps with effectively anisotropic heterogeneous structure), the HF particle motion can be linearly polarized in accordance with the maximum amplification direction, irrespectively to the source radiation.