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A method to select EGF by using waveform similarity analysis: an application for modelling the 24 of November 2004 Salo' earthquake (northern Italy, Ml 5.2).

M. Massa (1), G. Ameri (1), F. Pacor (1), P. Augliera (1) and R. Castro (2)

(1) Istituto Nazionale di Geofisica e Vulcanologia, Sezione di Milano (INGV-MI), via Bassini, 15, 20133 Milano, Italy (2) Centro de Investigation Cientifica y de Education Superior de Ensenada (CICESE), Division Ciencias de la Tierra, Departemento de Sismologia, 22860, Baja California, Mexico (massa@mi.ingv.it)

The aim of this study is to obtain synthetic ground velocity and acceleration waveforms consistent with those observed during the M5.2 Salò earthquake. This event shocked Northern Italy on 24 of November 2004 and generated a large amount of damage and losses (about 300 million euros). We made ground-motion simulations using the empirical Green's functions method (EGF) (Hartzell, 1978 and Irikura, 1986). A simple and effective technique for predicting earthquake's time series at a site in a broad frequency band including effects related to propagation path and site amplification. The main aspect of the paper is focused on an alternative approach to estimate potential EGF on the basis of a waveforms similarity analysis. The proposed method allow us to implement the simulations by using as Green's functions only events that present very similar waveforms with respect to the target event, and consequently the same focal mechanism and propagation pattern. Such events, defined doublets (or multiplets), represent different rupture episodes that are surely related to the same source. This approach has been tested considering a seismic sequence recorded at the bedrock that occurred on October 2006, and was located 20 km west of the M5.2 event. The event of October 2006 is characterized by a main-shock of Ml 3.8 and 9 aftershocks ($1.3<Ml<2.4$) with relative epicentral inter-distances spanning from about 0.5 km to 2.5 km. Considering this swarm, a normalized cross-correlation approach has been applied: the correlation matrices have been calculated using for each event 3s of sig-

nal, starting both from P and S-phase onset and filtered in the range 1-10 Hz. In order to recognize earthquake families (multiplets) present in the swarm, and to overcome the limit of the difference in magnitude between the events, the bridging technique has been applied (Ferretti et al., 2005). The procedure allow to detect 1 multiplet including the target event (Ml 3.8) and 3 aftershocks. Applying the EGF technique and by using the 3 aftershocks was possible to reproduce the target event obtaining both in time and in frequency domain a high degree of agreement between observed and synthetic data. The test has been concluded by simulating the 3.8 event also for a site characterized by local amplification effect in the frequencies range 2-6 Hz. In this step the sensitivity of simulations to the input parameters used in the code (rise time, stress drop, rupture velocity, etc...) was also carefully evaluated. The improvement with respect to select the EGF only on the basis of routine location are shown and discussed in order to strengthen the idea that choosing the EGF by a waveforms analysis is of primary importance, in particular when records to calibrate the source parameters used in the simulations are not available. Finally the same analysis has been applied to the sequence related to the 24 of November 2004 Salò earthquake characterized by 187 aftershocks with magnitude up to 2.8. Because the absence of near field data related to the 5.2 earthquake (the receiver installed in near field are saturated) the analysis has been computed in two different steps: first by cross-correlating only the aftershocks recorded in near field by both fixed and temporary stations and then by applying the same analysis including in the matrices only the mainshock and the bigger aftershocks recorded by stations installed in far field. The similarity recognized by considering the first seconds of P-phases related to the main-shock and an aftershock of Ml 2.7 at a station installed 70 km east to the epicentral area, allow us to use the same aftershock as EGF to simulate the main-shock also in the epicentral area. The obtained synthetic waveforms are compared with empirical attenuation relationships and with the results from deterministic ground shaking scenarios obtained for the same event (Pessina et al., 2006).