STRONG GROUND MOTION SIMULATION OF THE 1972 MANAGUA, NICARAGUA EARTHQUAKE BASED ON EMPIRICAL GREEN'S FUNCTION METHOD

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ABSTRACT

We simulated the strong motion record obtained at the Esso Refinery station from the 1972 Managua, Nicaragua earthquake using its aftershock record through the empirical Green's function method.

In order to obtain the best initial guess for the modeling, we carried out the hypocenter relocation through the modified joint hypocenter determination method using the phase data listed in the ISC seismic catalog.

Finally, we found out that the source model which best fitted to the observed waveform had two asperities. This asperity model fell on the trend of the empirical relation between the seismic moment and the strong motion generation area.

Keywords: Empirical Green's function, asperity, heterogeneous source model.

INTRODUCTION

One of the very useful outcome of the empirical Green's function method (EGFM) is that it provides the strong motion generator area, and this is almost equivalent to that of asperities which generates the earthquakes (Miyake et al. 2000), where asperities are defined as the areas with the highest stress drop. The location of the earthquake is very important in order to modelize in the best way possible. For this purpose, the modified joint hypocenter determination was used. This method allows correcting many hypocenter locations simultaneously taking into account station correction and a difference in trade off, and this is useful to reduce error in the location.

The main purpose of this study is to simulate the 1972 Managua earthquake. Simulation here should be understood as taking a time history best fit to that of a specified earthquake. This will be done by using the information of the National seismic network.

RELOCATION OF THE HYPOCENTER

Exact location facilitates the modeling of the fault parameters concerning the EGF method, because the more exact the location is, the better fit between the synthetic and the observed seismogram.
Here the analysis and method to obtain the relocation through the modified joint hypocenter determination is skipped. We are interested just present the results obtained in general way.

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Results

The results demonstrated that epicentral location was improved in comparison with the ISC result, but for the focal depth the results are unreliable because the error in the depth showed a trend to increase very illogically when the shallow faulting system present in Managua city is considered (Figure 1). Even when some of the events improve their relative locations, other events could not improve their relative locations because of bad picking of arrival times.

a)

b)

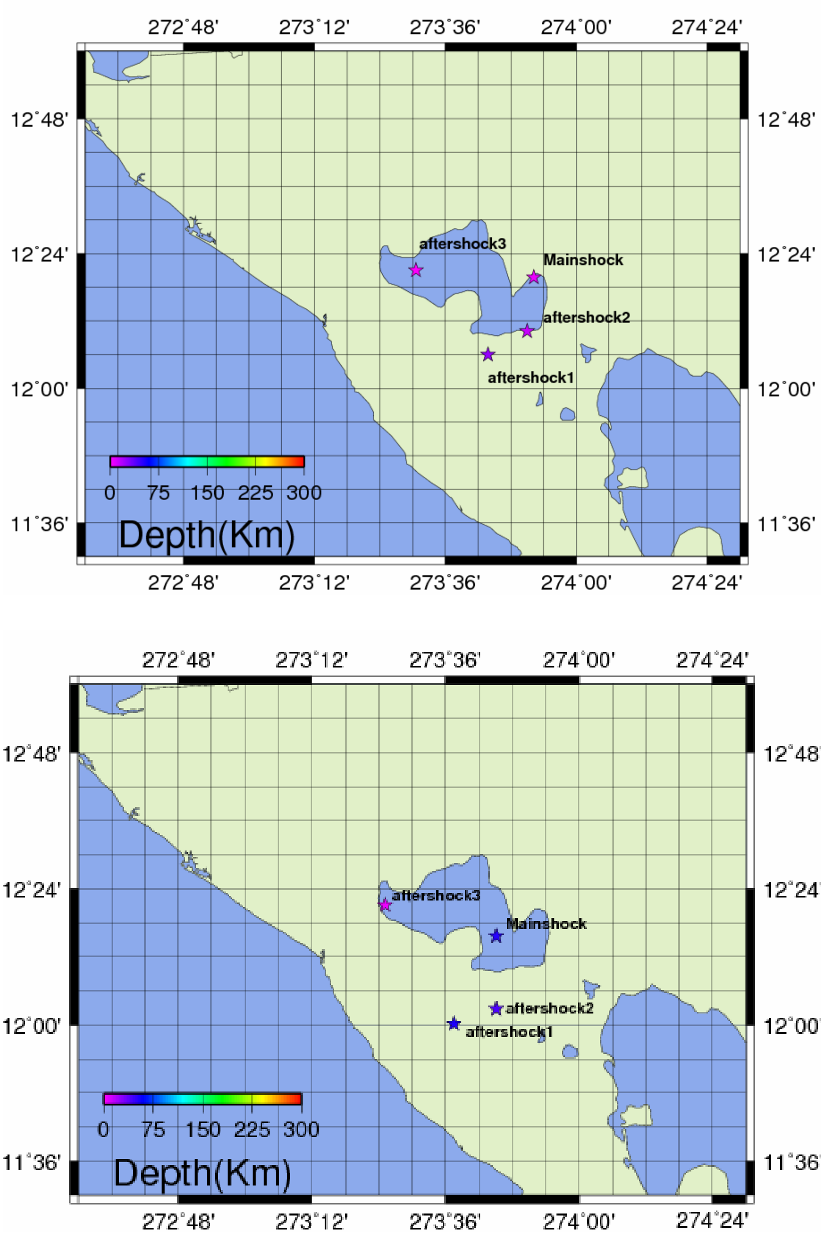


Figure 1 a) The epicenters given in the ISC catalog for the 1972 earthquakes.
b) The relocated epicenters obtained from the modified joint hypocenter method.

STRONG MOTION SYNTHESIS BY EMPIRICAL GREEN'S FUNCTION METHOD

Formulation of the empirical Green's function (EGF) is based on the simple fact that small events carry complete information about transfer properties of the medium between a given focal zone and station. Since small events are generated by small segment of the main fault, it represents an approximation of the impulse response.

The technique of the EGFM is based on the summation of the waveform of a small earthquake corrected by a slip time function. Each point of the synthetic seismogram is then corrected by the spatial dependence between the large event and the small event and after that a factor is applied to this result to take the stress drop difference between both events into account.

Data

The data used in this study was obtained from National Oceanic and atmospheric administration (NOAA).

Table 1 Parameters of the main and element event

Date	Time	Hypocenter location			Magnitude	Focal mechanism		
		Lat. (^{o}N)	Lon (^{o}E)	Depth (Km)		Strike	dip	Rake
23/12/1972	6:29:42.9	12.33	-86.13	5	6.2Ms	42	74	5
23/12/1972	7:19:49	12.17	-86.15	5	5.2Mb	25	80	5

Processing

Since there is no slip distribution studies for the 1972 Managua earthquake to identify the high slip areas, we assumed a strong motion generation area (SMGA) near the foci. We divided SMGA into 3x3 subfaults based on the above mentioned consideration.

Initially we carried out the fitting process assuming a single asperity model. However after several trials we found that the waveform for this model did not match the observed one even for the smaller residual. One of the source models for the single asperity source is shown in Figure 12b. Especially, two peaks in displacement trace or an impulsive wave at 8 second in velocity trace is impossible to replicate using single asperity model.

This revealed that such model could not fit the observed seismogram because the characteristics of the source should be dependent on a multiasperity model instead of a unique asperity. Then we decided to try a multiasperity model to simulate the observed record.

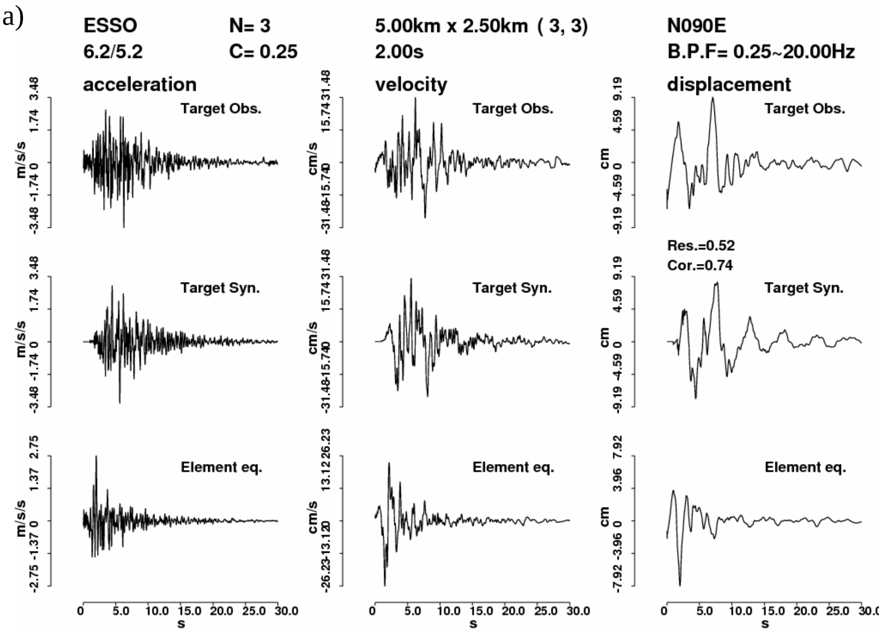
Results

The optimum fitting was decided by observing when the residual was minimized. Residuals values was evaluated for the rise time and rupture velocity. The result of the residuals comparison showed that for the rupture velocity the minimum varied rapidly. The values selected for the rupture velocity and the rise time are 2.1 Km/s and 2.0 seconds, respectively.

We finally obtained the waveform for the horizontal components (Figure 2).We found out that the amplitude in the EW component between the observed data and synthetic waveform has a good agreement, while in the SN component the amplitude of the synthetic waveform could not be well estimated. At least the synthetic one shows the peaks that correspond to the main event trace.

Source scaling properties of the simulated earthquake was compared with the empirical source scaling relationship for inland crustal earthquake proposed by Somerville et al. (1999) and Miyake et al. (2003). The comparison is based on the size of strong motion generation area estimated in this study and the seismic moment of the main event converted from the moment magnitude in ISC Bulletin.

a)



b)

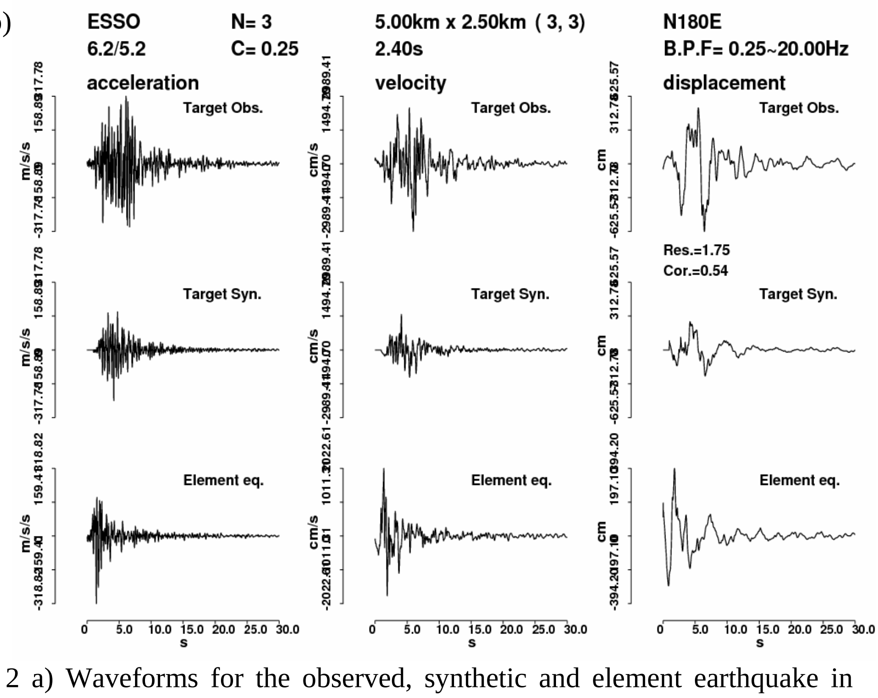


Figure 2 a) Waveforms for the observed, synthetic and element earthquake in EW. b) those of NS component.

DISCUSSION AND CONCLUSIONS

We attempted to obtain a good initial presumption for the start rupture point location. For this purpose, we relocated the hypocenter of the main shock and aftershock. Result showed that ISC catalog hypocenter locations were improved considering the aftershocks distributions area. Although due to the poor azimuthal coverage of available station and the lack of stations close to epicenter in the decade 70's, new locations could not approximate sufficiently as the area of aftershocks epicenters, this gave a general scheme of the main shock faulting model.

Then, we simulated the waveform of the 1972 Managua, Nicaragua earthquake. We found that the model with two asperities for the source showed a good fitting in the EW component but in the NS component the amplitude of the seismogram was underestimated. The reason of this underestimation could be the error of the hypocenter and the focal mechanism of the aftershock that controls the coefficients for the correction of the radiation pattern.

We obtained, as final model for the source, a two-asperity source which looks like it was superimposed (Figure 3). We think that the explanation of the incapability of determining the boundaries between the asperities is related to the size of the element earthquake. The 3X3 mesh due to the size of the used aftershock was so rough that the asperities could not be clearly separated. This aftershock was the only possible choice for us.

The parameters of the model indicate that the south-west part of the fault was ruptured first then about 7 seconds later the north-east part. The fault area is almost filled with asperities except the sub fault at north-east bottom. The stress parameters for the first and second asperity are estimated around 0.38 and 0.25 respectively. The comparison between the results of this study and that about scaling of the strong motion generation area to seismic moment for crustal earthquakes (Somerville et al. 1999; Miyake et al. 2003) seems to be in good agreement.

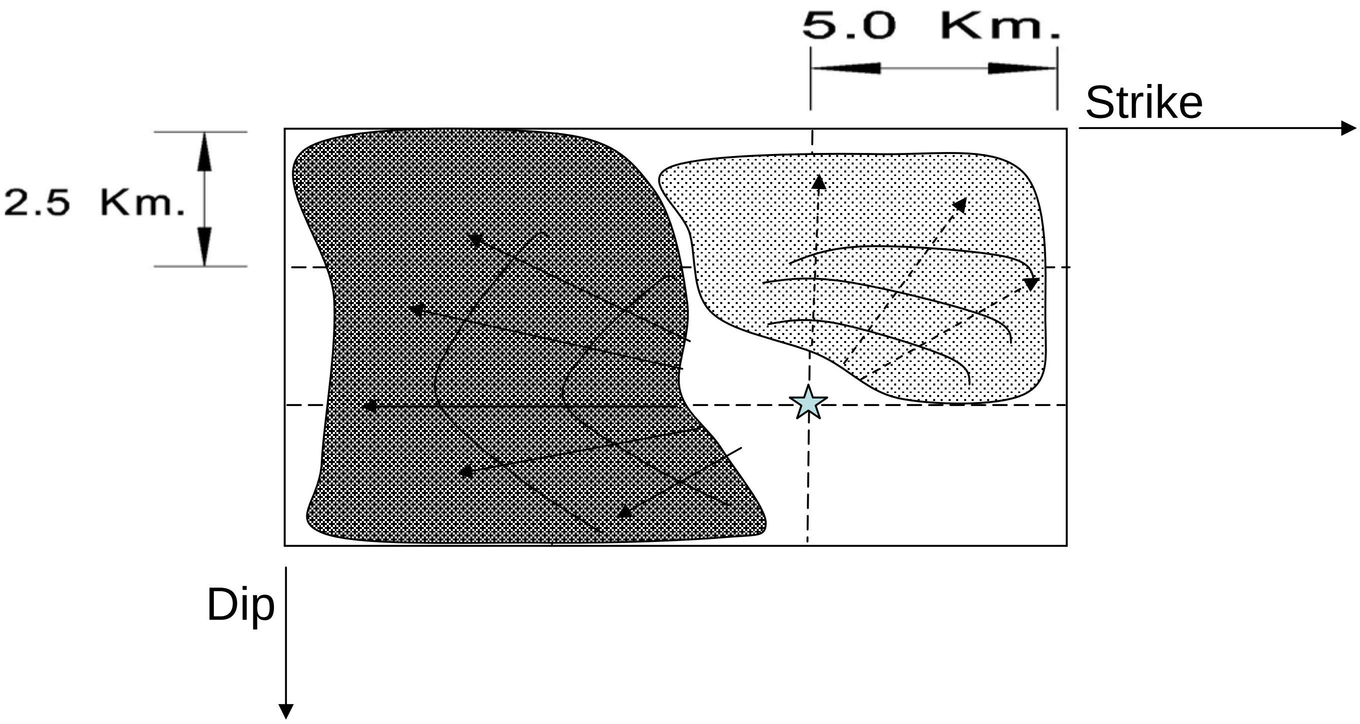


Figure 3 Sketch of the final source model for the 1972 Managua Earthquake.

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A FORTRAN code of Empirical Green's Function Method that was downloaded from (http://www.eri.u-tokyo.ac.jp/hiroe/egfm/) was used for strong motion synthesis. I appreciate the authors: Prof. K. Irikura and Dr. H. Miyake. Re-coding was done by Dr. T. Yokoi to adopt it with multi-asperity cases.

ViewWave software coded by Dr. T. Kashima was used to analyze the strong motion records; this is available at (http://iisee.kenken.go.jp/staff/kashima/viewwave.html).

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