Correction Factors for Peak Ground Acceleration Related to Site Conditions in Northeastern Taiwan

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Abstract

Using random vibration theory with the inputs of empirical parameters, the decay relationship of peak ground horizontal accelerations is obtained based on the analyses of recordings recorded from reference sites without evident site effects in Ilan area. Taking the estimates as references, the amplification factor of PGA for each site can be obtained by comparing with the historical observations. For shallow earthquakes, the average amplification factor is 1.21±0.57 for reference sites, but 1.95±0.88 for the others. However, the factors increase to 1.70±0.72 and 2.69±1.03, respectively, for deep earthquakes.

Introduction

The damage pattern, after the 1999 Chi-Chi earthquake (M_L 7.3) in Taiwan, indicates that local geological conditions are very important factors in the analysis of ground motion. In order to predict ground motions, this study was trying to establish a predictive relationship, which allows the estimation of the specific ground-motion parameter as a function of magnitude, distance from the source, and frequency. Then, a rapid way of obtaining the peak motions is to use random vibration theory proposed by Cartwright and Longuet-Higgins (1956). By comparing the observations to the predictive peak motion at reference sites, local site effect can be evaluated.

Data

Considering the possible various effects on ground motions due to source depth, thirty shallow earthquakes and nineteen deep ones (Fig. 1) referred by the Moho depth are analyzed. The data used in this study were collected in the period of 1994-2004 by the TSMIP network of the Central Weather Bureau. The free-field site conditions have been categorized into four classes, namely, B, C, D, and E based on the geologic and geomorphologic data (Lee *et al*., 2001). Only the accelerograms recorded at 28 rock sites (class B, see Fig. 2) in northeastern Taiwan are collected for deriving the reference peak ground accelerations in different distance and magnitude.

Method

Following the description of Raoof *et al*.(1999), the essence of this method is that the site and excitation effects are identical for both of the S waves and coda waves. Based on the results of the coda normalization method, the Q model of the S/Lg waves propagating through the crust will be inverted by giving an empirical geometrical spreading model (Sokolov *et al*., 2000). Using random vibration theory with the inputs of empirical parameters, the estimates of peak ground horizontal accelerations for moment magnitudes M_w= 4.5 to 7.0, respectively, are shown in Fig. 3. The result indicates that in practice, for a specified earthquake with a shallow focal depth, a predictive curve can be obtained by giving the moment magnitude of the event.

Summary

Taking the estimates as references, the amplification factor of PGA for each site can be obtained as shown in Fig. 4. For shallow earthquakes, the average amplification factor is 1.21±0.57 for reference sites, but 1.95±0.88 for the others. However, the factors increase to 1.70±0.72 and 2.69±1.03, respectively, for deep earthquakes. Based on these evaluations, the intensity map around the northeastern Taiwan can be empirically predicted just giving the location and the magnitude of an earthquake.

References

Cartwright, D. E. and M. S. Longuet-Higgins (1956). The statistical distribution of the maxima of a random function, *Proc. R. Soc. London*, **237**, 212-232.

Lee C. T., C. T. Cheng, C. W. Liao, and Y. B. Tsai (2001). Site classification of Taiwan free-field strong-motion program, *Bull. Seism. Soc. Am*., **91**, 1283-1297.

Raoof, M., R. B. Herrmann, and L. Malagnini (1999). Attenuation and excitation of three-component ground motion in Southern California, *Bull. Seism. Soc. Am*., **89**, 888-902.

Sokolov, V., C. H. Loh, and K. L. Wen (2000). Empirical model for estimating Fourier amplitude spectra of ground acceleration in Taiwan region, *Earthquake Engineering and Structural Dynamics*, **29**, 339-357.

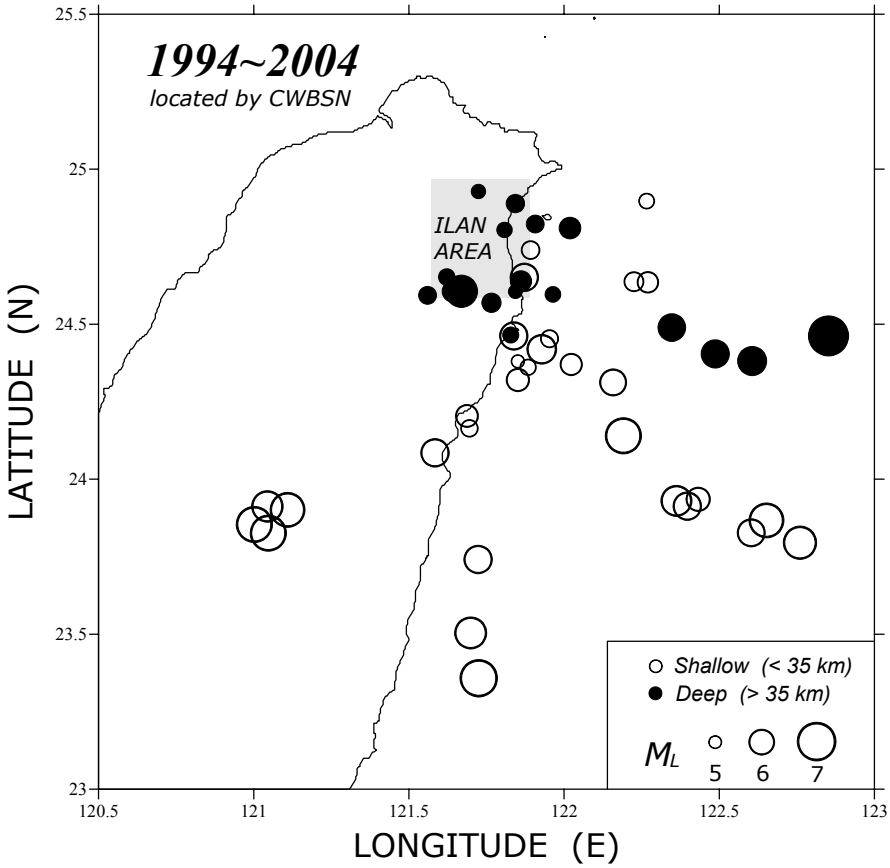

Figure 1. Epicenter locations of the shallow (open circles) and the deep (solid circles) earthquakes analyzed in this study. The diameter of circle is proportional to the local magnitude. The studied area is denoted as the shadowed zone.

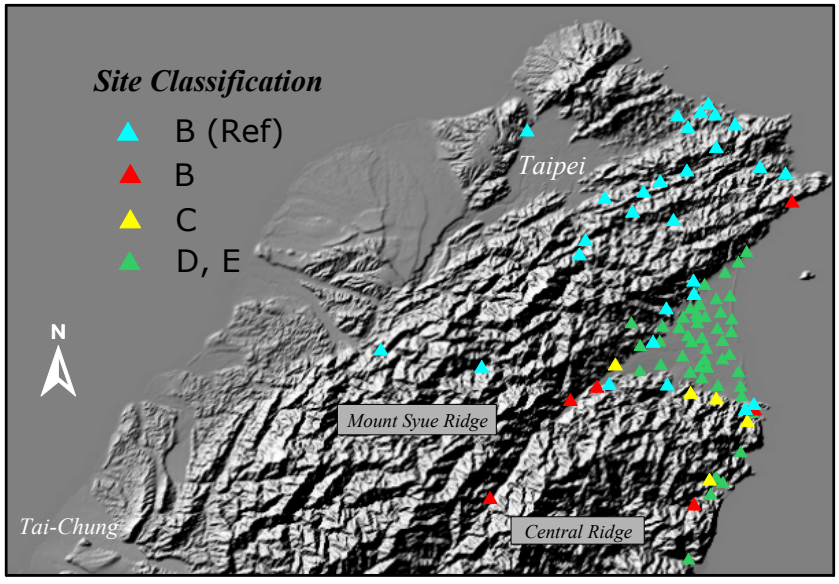

Figure 2. Locations of the free-field TSMN stations analyzed in this study. The denoting color of station is based on the site classification proposed by Lee *et al.* (2001). The reference stations are denoted in light blue.

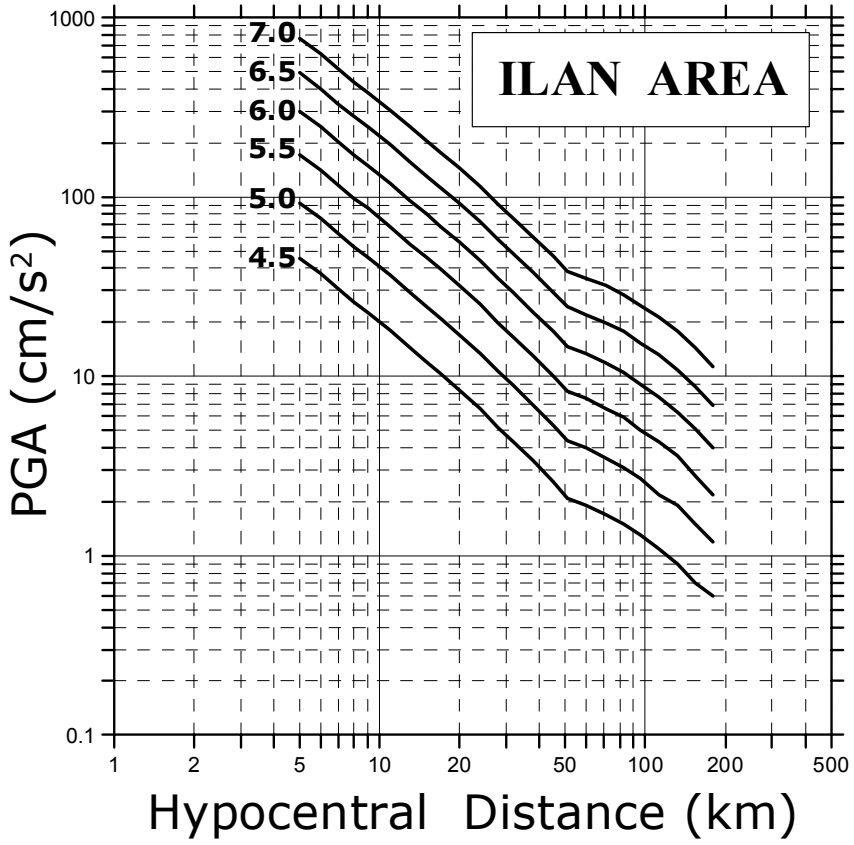

Figure 3. Modeled attenuation curves of peak ground horizontal accelerations in Ilan area for the moment magnitudes ranging from 4.5 to 7.0, respectively.

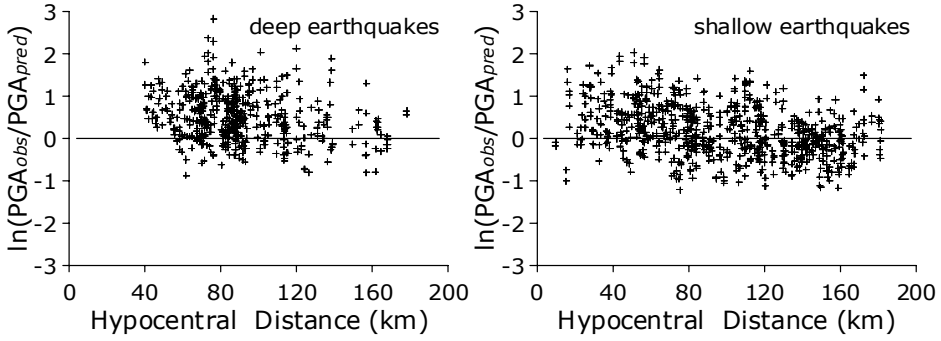

Figure 4. Comparisons between the modeled PGA and the observed PGA for data recorded from deep earthquakes and shallow earthquakes respectively.