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The Implementation of Detailed Site Effects into PSHA Using Ground Motion Simulations

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1 Introduction

In this study, uniform hazard spectrum (UHS) in Eastern Turkey, Erzincan is developed using stochastic ground motion simulations instead of ground motion prediction equation (GMPE). In the proposed approach, the stochastic earthquake catalog of the region is generated based on Monte Carlo simulation. Gutenberg-Richter recurrence relationship is adopted to derive the magnitude of each event in the catalog (Figure 2). Stochastic ground motion simulation methodology is applied to obtain the ground motion amplitudes. Annual exceedance rate of each ground motion amplitude is then calculated which leads to UHS of the region. Incorporation of detailed site effects in PSHA is one of the most important advantages of ground motion simulation techniques because GMPEs consider site categories such as rock and soil very roughly. Two alternative site amplification functions are used to model the site effects in PSHA (Figure 3). The first one is generic site amplification which is based on approximate quarter wavelength method. The second approach is theoretical site amplification which is derived considering detailed soil layers at each site (Figure 4). Theoretical site amplification leads to larger seismic hazard compared to generic site amplification for larger periods of UHS. It is possible to model soil nonlinearity in PSHA when a large input motion is applied at bedrock level in the second approach. Theoretical site amplification with soil nonlinearity produces considerably smaller seismic hazard than generic site amplification at short-period range.

1 PSHA based on ground motion simulation

(Azari et al., 2017)

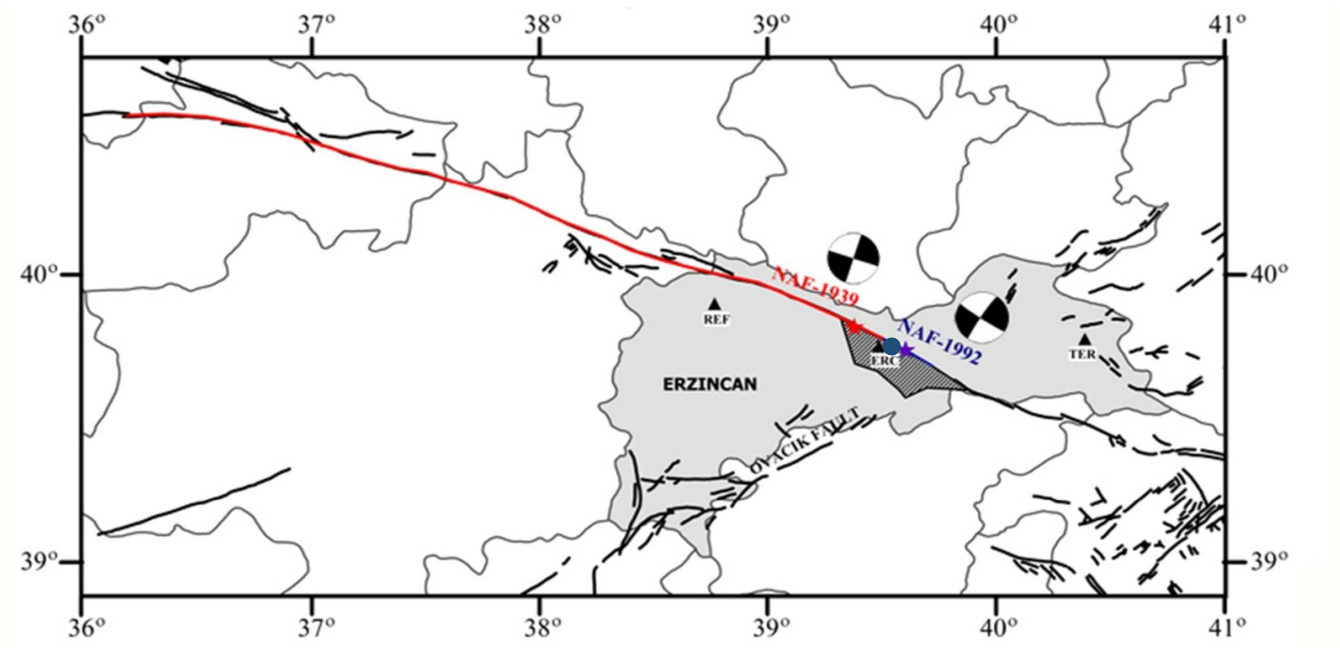

Fig. 1: Regional map showing the epicenters, rupture zones and the mechanisms of the 1939 and 1992 earthquakes (epicenters are indicated with stars) and strong ground motion stations that recorded 1992 Erzincan earthquake are indicated with triangles The site, which is used in this study, is indicated with solid blue circle.

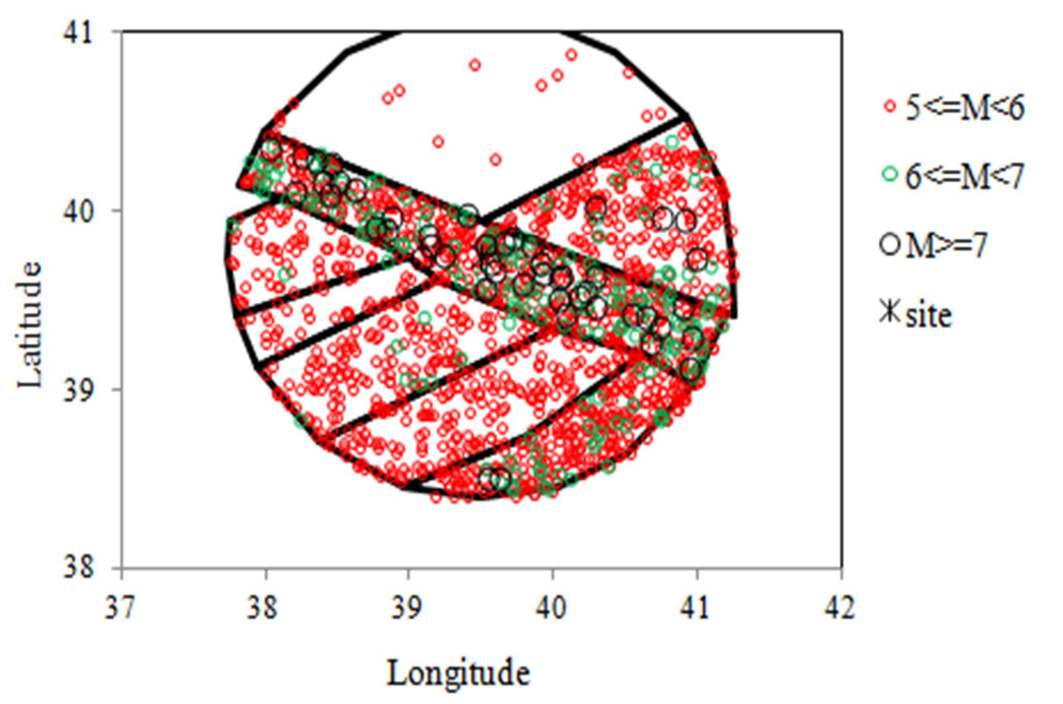

Fig. 2: Distribution of events in 3000-year stochastic earthquake catalog inside the effective area (a circle of radius 150 km around the site). Monte Carlo Simulation method is used to distribute the events temporally and spatially. Gutenberg-Richter recurrence model is used to sample the magnitudes. Seismic zones are adopted from Deniz (2006).

- For faults: Stochastic finite fault model based on dynamic corner frequency (Motazedian and Atkinson, 2005).
- For areal sources: Stochastic point source model (Boore, 2003).
- Ground motion simulation parameters are adopted from Askan et al. (2013).

2 Site amplification functions

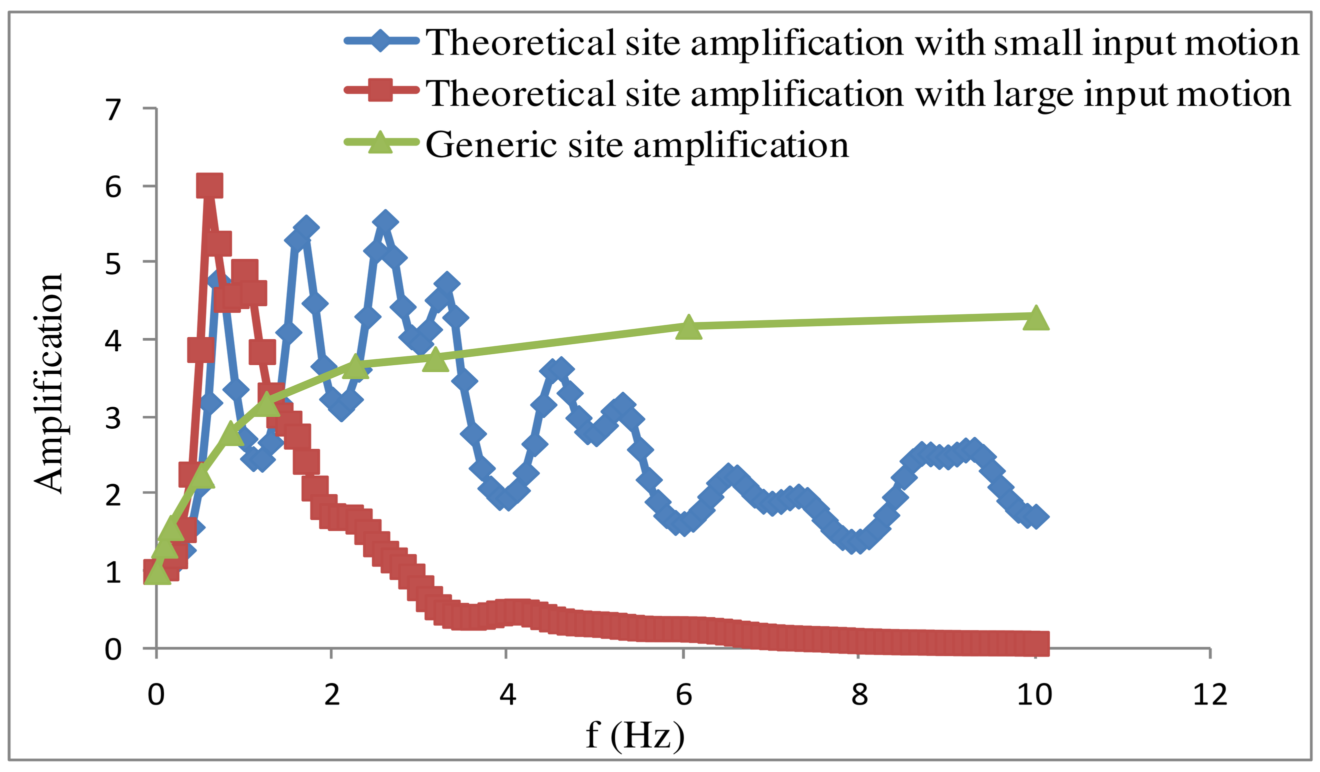

Fig. 3: Comparison of two alternative site amplification functions used in this study. Generic site amplification model is based on approximate quarter wavelength method (Boore and Joyner, 1997). Theoretical site amplification is based on transfer function which is obtained from regional soil properties. Smaller amplifications are observed for larger frequencies in the case of large input motion at bedrock (Soil nonlinearity).

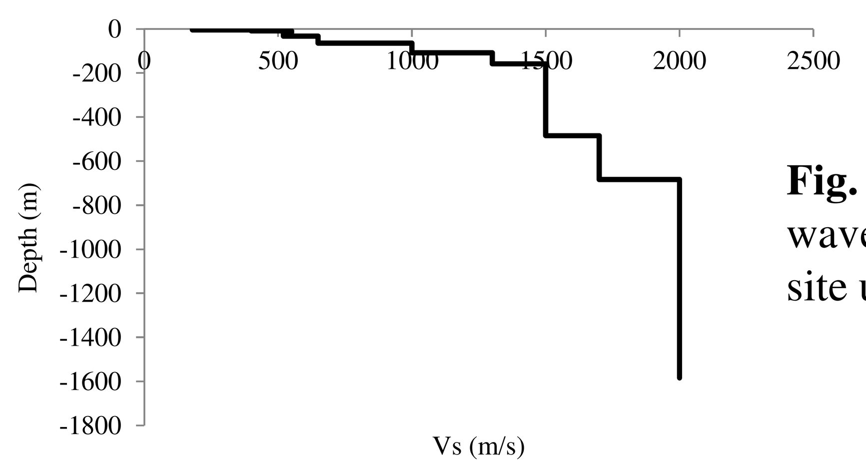

Fig. 4: One-dimensional shear wave velocity versus depth at the site under study (V_{s30}=350 m/s)

3 Results

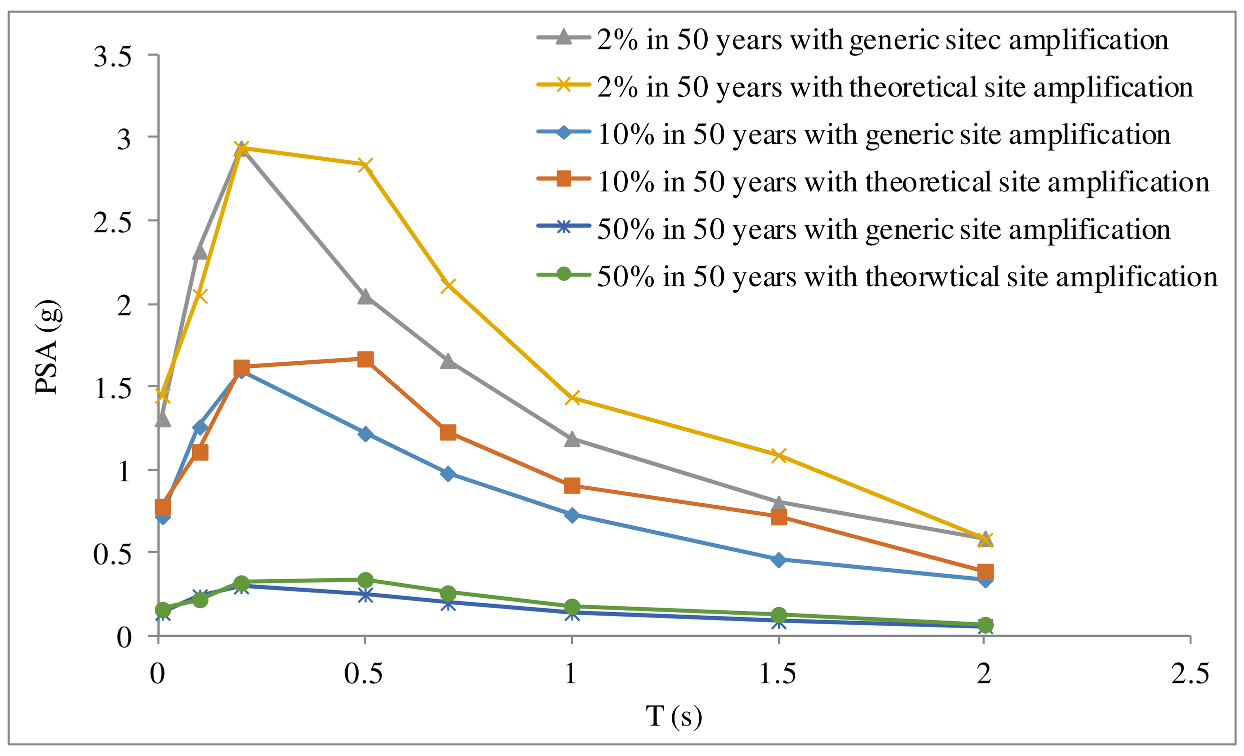

Fig. 5: Comparison of UHS's from generic and theoretical site amplification <u>without soil nonlinearity</u>. The theoretical site amplification leads to larger seismic hazard for periods larger than 0.3 seconds.

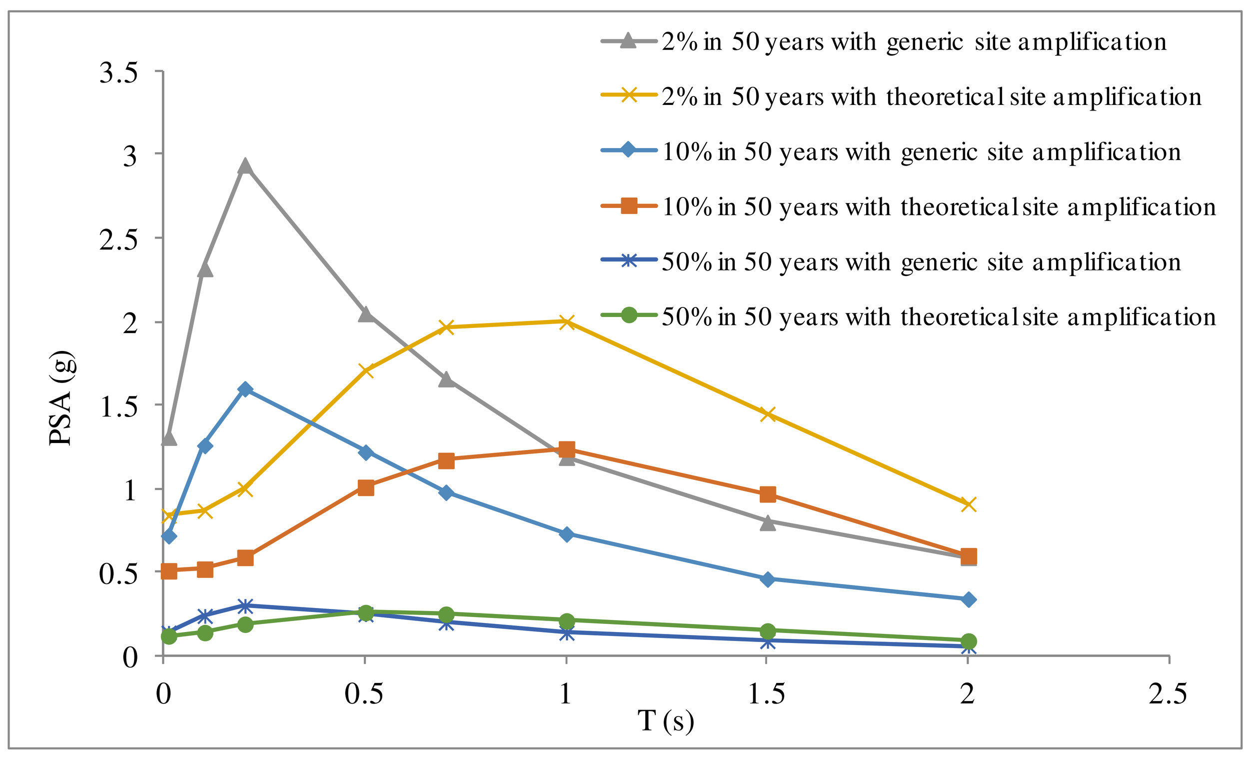

Fig. 6: Comparison of UHS's from generic and theoretical site amplification <u>with soil nonlinearity</u>. The theoretical site amplification leads to considerably smaller seismic hazard for periods smaller than 0.5 seconds.

4 Discussion

Use of ground motion simulations has the advantage of implementing detailed site effects in PSHA in a straightforward manner. The effect of complex regional and local site amplification is observed to be significant on seismic hazard results especially for large periods (>0.3s). The effect of soil nonlinearity is observed to be considerable at short periods (<0.5s). This detailed site effect is generally neglected or approximated in classical GMPE-based PSHA studies.

References

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