Geophysical Research Abstracts, Vol. 9, 03890, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-03890
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Development of shakemap methodology based on Fourier amplitude spectra and its application for the case of Vrancea (Romania) earthquakes

V. Sokolov (1), F. Wenzel (1) and M. Boese (1)

Geophysical Institute of Karlsruhe University, Karlsruhe, Germany
(Vladimir.Sokolov@gpi.uni-karlsruhe.de / Fax +49 721 71173)

Shakemaps are generated within a few minutes on a routine basis for Southern California (Wald et al., 1999) by extrapolation ground motion parameters such as PGA, PGV, response spectra (RS), and computed intensity (CI) from observational sites equipped with accelerometers with distances in the range of kilometers to tens of kilometers between them. Extrapolation is based on empirical hard-rock attenuation relations, geological classification of the sites, and on empirical relations of ground motion amplification for a given geological class.

The Californian approach cannot be copied for many cases due to a lacking empirical strong motion data base and due to missing understanding of the relations between geological near-surface structure and ground motion amplification for PGA, PGV or CI.

We suggest the following approach based on Fourier amplitude spectrum (FAS) that can be used in most cases and that allows obtaining site-dependent assessment in terms of various ground motion parameters using a single model. First, source scaling and attenuation models for FAS are evaluated using recordings obtained on rock stations. Second, the site effect at non-rock stations is analyzed as ratios between the spectra of observed records and the obtained spectral models. Third, the generalized site amplification functions are constructed for typical soil conditions. Fourth, so-called “phantom” sites are introduced to cover areas with a lack of strong-motion stations. The site amplification functions are assigned to these sites regarding the typical site classification or results of modeling based on available geotechnical data. The site amplification factors may be evaluated for PGA, PGV, and RS as values, which are dependent on

magnitude and distance (i.e. frequency content and intensity), using stochastic simulation. Also, the site-dependent attenuation relations may be constructed to be used directly in Shakemap generation. The CI amplification factors or intensity attenuation models are evaluated using the proposed relationship between intensity and FAS. The developed ground-motion database will also provide a basis for early-warning system and for site-dependent deterministic and probabilistic seismic hazard assessment both in regional and urban scale.

The technique is applied for the case of intermediate-depth (70-140 km) earthquakes of the Vrancea (Romania) source zone, which produce the most significant seismic hazard to Romania, including the city of Bucharest, and its neighboring countries. We modeled ground motion parameters distribution for four major Vrancea earthquakes occurred during the last century, namely: November 10, 1940 (M = 7.7); March 4, 1977 (M = 7.4); August 30, 1986 (M = 7.2); and May 30, 1990 (M = 6.9). The theoretical data were compared with available macroseismic observations and instrumental data.