New Ground Motion Prediction Equations for Saudi Arabia
（サウジアラビアにおける地震動予測式の開発）

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Damage to buildings and structures is the primary risk from earthquake ground shaking. In order to assess such risk at different locations, predicting ground shaking levels is the key factor in terms of both the seismic hazard model and the corresponding building code provisions for earthquake-resistant structures. Ground Motion Prediction Equations (GMPEs) play an important role. GMPEs are the empirical relationship based on observed data and provide mean and its associated uncertainty for predicting ground motion levels, depending on given earthquake magnitude, source-to-site distance, very shallow condition of the site, and so on. However, the differences of seismic attenuation and characteristics of earthquakes source in different regions are taken account into GMPEs. Therefore, the development of region-specific GMPEs are significantly important to assess ground shaking level the region of interest.

In this study, we developed new Ground Motion Prediction Equations (GMPEs) for Saudi Arabia using 2761 selected records of Peak Ground Acceleration (PGA) and Peak Ground Velocity (PGV) derived from the two horizontal components for 225 events of magnitude M_L 3.0 – 5.4, recorded at 77 recently deployed stations in the distance range from 1 km to 400 km (Fig. 1). New Arabian GMPEs are developed by employing a mixed effects regression model to modify the reference GMPEs of Boore et al. (2014) (referred to as BSSA14) which has been developed based on a large global dataset.

Saudi Arabia is surrounded by several active tectonic regions, such as extension in the Red Sea, left-lateral strike-slip motion along the Gulf of Aqaba as known Dead Sea Transform Fault (DSTF), and the continental collision zone in the Zagros mountain belt. These tectonic environments produce numerous earthquakes that present a significant hazard to Saudi Arabia. Also, more than 15 continental, intraplate volcanic fields, locally called as “harrats”, are spreading over more than 3,000 km from Yemen in the south through Saudi Arabia to Turkey in the north. Some of these volcanic fields are young and active, including Harrat Lunayyir where a seismic swarm consisting of 30,000 recorded earthquakes associated with dike intrusion occurred from April through June 2009 (Pallister et al., 2010). Along with historical evidence about volcanic activity accompanied by moderate to large earthquakes, this seismic swarm has caused the public in Saudi Arabia to recognize the risk of damage caused by a potential future volcanic eruption and associated large earthquakes around the volcanic fields in Saudi Arabia.

The main modification to the BSSA14 was the event residuals, which showed that PGAs recorded in Saudi Arabia have smaller magnitude scaling compared to the reference GMPEs, while PGV data shows similar scaling between the GMPEs. Furthermore, there is a clear difference in distance scaling for the Arabian GMPEs in comparison with the reference GMPEs. This difference is especially significant at large distances and is mainly due to lower anelastic attenuation in the crystalline crust of western Saudi Arabia. The site residuals incorporated into the analysis due to the lack of site response information, such as V_{S30} (time-averaged shear wave velocity of the top 30 m) are derived during the regression. The obtained site residuals seem to be a general agreement with the surface geologies and the site characteristics derived from H/V response spectral ratios. Our empirical data demonstrate that the GMPEs presented here are in good agreement with the observed earthquake ground motions in Saudi Arabia (Fig. 2).

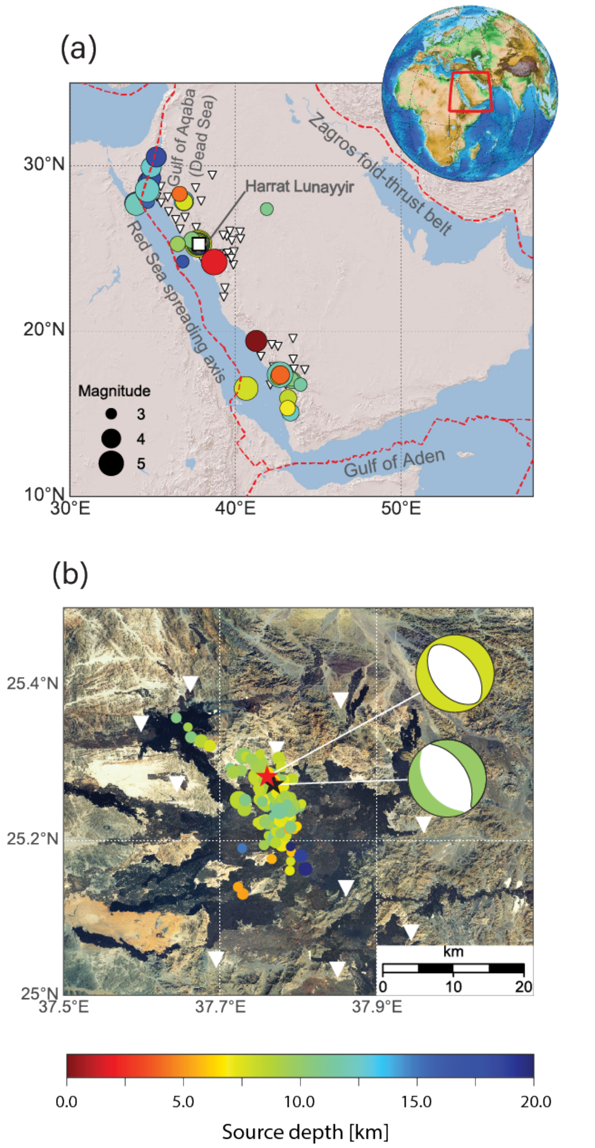

Fig. 1. (a) The hypocentral distribution of 225 events used in this study with colors representing source depth. Red dashed lines show the plate boundaries. The white square shows the location of Harrat Lunayyir. (b) The hypocentral distribution in the area of 2009 Harrat Lunayyir seismic swarm used in this study. The mainshock (M_L 5.39) and second largest events (M_L 5.18) during this swarm are shown as red and black stars, with corresponding focal mechanisms (Global CMT solution). The inverse white triangles are the stations used in this analysis.

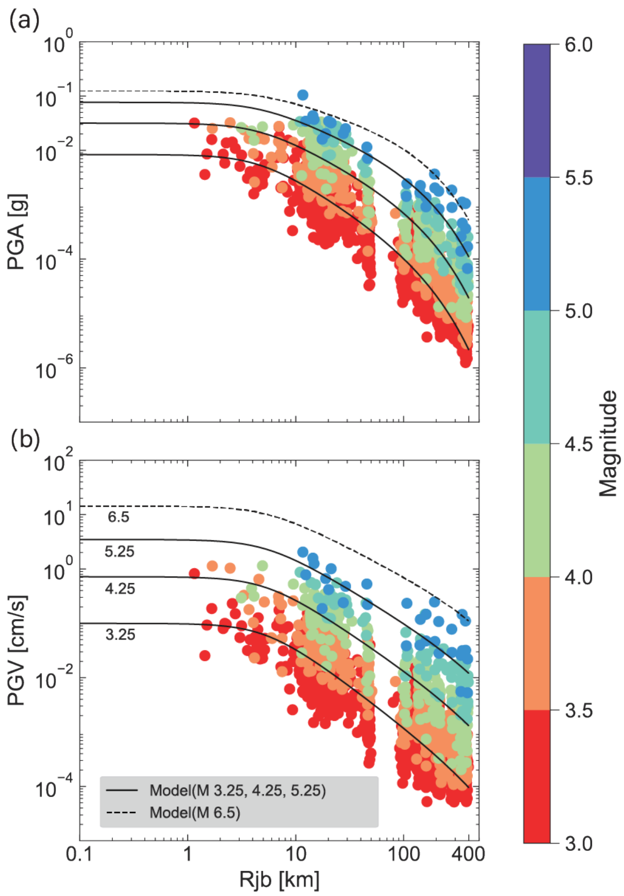

Fig. 2. The Arabian GMPEs are compared with observed data of normal fault events with the color corresponding to magnitude with respect to distance for (a) PGA and (b) PGV. The black lines display the modified GMPEs in the case of (solid) M_L 3.25, 4.25, 5.25, and (dashed) M_L 6.5 earthquakes.

References:

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