The Distance Scaling of Crustal and Subduction Earthquakes in Japan

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Abstract

The observed ground-motions (GM) from shallow crustal, subduction interface and intraslab earthquakes indicate that separate ground motion models (GMM) should be developed for these earthquake classes. In Japan, earthquakes from these classes frequently occur and Japanese Seismological Agency provides abundant number of waveforms. Due to Japanese complicated seismic features, during the model development, one of the most difficult steps is defining the distance scaling terms which are composed of geometrical spreading (GS), anelastic attenuation and volcanic back/fore-arc components. This study investigates the differences in geometrical spreading term between earthquake classes.

Database

The Dawood et al. (2016) database is used. The minimum number of records per events and stations are 50 and 10, respectively. The total number of events and records are 380 and 36833, respectively.

Site Class | Number of stations | Number of recordings | Number of events | Number of recordings |
---|---|---|---|---|
NEHRP E | 13 | 818 | 41 | 3922 |
NEHRP D | 62 | 11766 | 64 | 5855 |
NEHRP B | 321 | 20438 | 23 | 2055 |
Crustal Normal | 36 | 2817 | 59 | 5913 |
Crustal Reverse | 15 | 1152 | 15 | 1152 |
Intra-slab Strike-Slip | 35 | 15139 | 145 | 15119 |
Intra-slab Reverse | 224 | 53 | 4524 |
Crustal Strike-Slip | 226 | 19 | 1997 |
Crustal | 227 | 51 | 4914 |
Neighboring East Coast of Honshu | 228 | 210 | 21792 |
Near S. Coast of Honshu | 229 | 2 | 475 |
Near S. Coast of Honshu | 230 | 12 | 1134 |
Western Honshu | 231 | 16 | 1218 |
Near S. Coast of Western Honshu | 233 | 8 | 844 |
Kyushu | 235 | 4 | 304 |
Shikoku | 236 | 5 | 304 |

Functional Form

General functional form

\[
\ln(GMIM) = \left[ a_1 + a_2(M_s - 6.79) + a_3F_p + a_4F_a \right] + \left[ a_5 \ln\left(\frac{R_{rup}}{R_0}\right) + a_6 \ln\left(\frac{\min(V_s,1000)}{V_{REF}}\right) + a_7 e^{\sigma} \right]
\]

Event-specific functional form

\[
\ln(GMIM) = b_1 + b_2(M_s - 6.79) + b_3\ln\left(\frac{R_{rup}}{R_0}\right) + b_4\ln\left(\frac{\min(V_s,1000)}{V_{REF}}\right) + b_5 e^{\sigma}
\]

Regression

Regressions are performed via Program R (Bates, 2010; Bates et al. 2013).

Conclusion

- The Dawood et al. (2016) database is used to investigate the regional differences in terms of Flinn-Engdahl regions.
- The site scaling is independent of distance limits.
- Although the trends are quite similar, the intraslab earthquakes produces lower site amplifications.
- Except in mid period range, crustal and interface earthquakes leads similar site amplifications.
- The distance limits play a considerable importance in distance scaling.
- The GS rates are very different for earthquake classes.
- It is observed that interface earthquakes attenuates slower than other two classes. For subduction earthquakes which occurred in Hokkaido and Near East Coast of Honshu regions show very different attenuation characteristics. Similarly the shallow crustal earthquakes in Near East Coast of Honshu region attenuate faster than other regions.

References