The Distance Scaling of Crustal and Subduction Earthquakes in Japan

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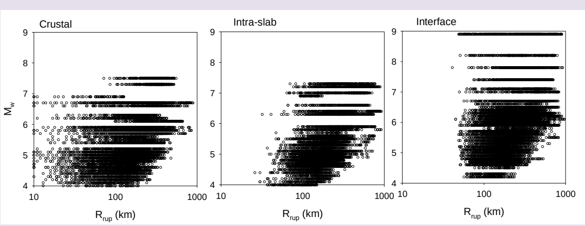
Abstract

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
NEHRP E	13	818
NEHRP D	162	11766
NEHRP C	321	20438
NEHRP B	52	3811
	Number of events	Number of recordings
Crustal Normal	41	3922
Crustal Reverse	61	5855
Crustal Strike-Slip	23	2035
Intra-slab Normal	36	2817
Intra-slab Reverse	59	5913
Intra-slab Strike-Slip	15	1152
Interface	145	15139
Flinn-Engdahl Regions	Number of events	Number of recordings
224|HOKKAIDO	53	4524
226|NEAR WEST COAST OF HONSHU	19	1897
227|EASTERN HONSHU	51	4341
228|NEAR EAST COAST OF HONSHU	210	21792
229|OFF EAST COAST OF HONSHU	2	475
230|NEAR S. COAST OF HONSHU	12	1134
232|WESTERN HONSHU	16	1218
233|NEAR S. COAST OF WESTERN HONSHU	8	844
235|KYUSHU	4	304
236|SHIKOKU	5	304



Functional Form

General functional form

$$\ln(GMIM) = \left\{ \begin{array}{l} a_1 + a_{2,3}(M_w - 6.75) + a_4 F_N + a_5 F_R + [a_6 + a_7(M_W - 6.75)]\ln(\sqrt{R_{rup}^2 + R_0^2}) + \\ a_8\sqrt{R_{rup}^2 + R_0^2} + F_{forearc} + F_{backarc} + a_9 \ln\left[\frac{\min(V_{S30},1000)}{V_{REF}}\right] + \varepsilon\sigma \end{array} \right\}$$

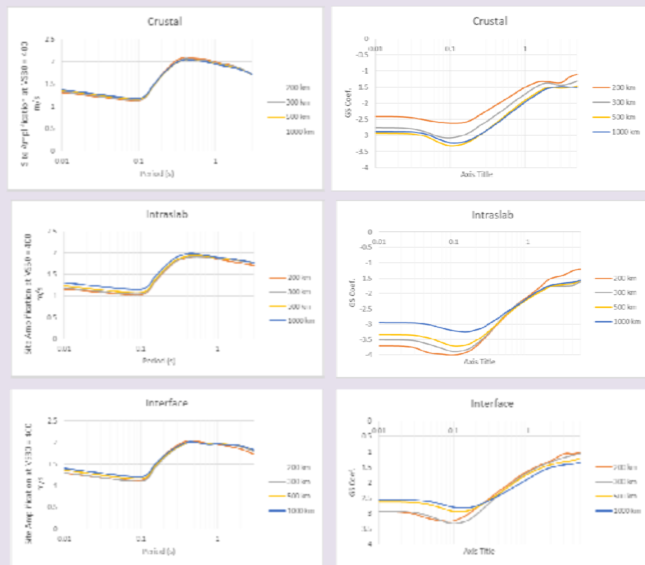
$$R_0 = 10 * \exp[0.4 * (M - 4)]$$

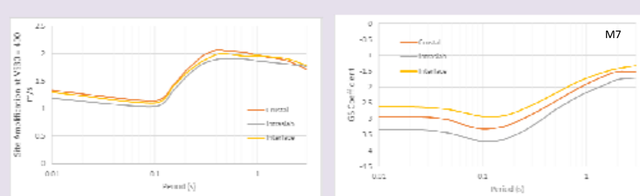
Event-specific functional form

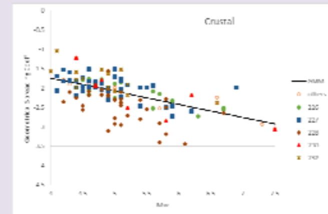
$$\ln(GMIM) = b_1 + b_2 \ln(\sqrt{R_{rup}^2 + R_0^2}) + a_8\sqrt{R_{rup}^2 + R_0^2} + a_9 \ln\left[\frac{\min(V_{S30},1000)}{V_{REF}}\right] + \varepsilon\sigma$$

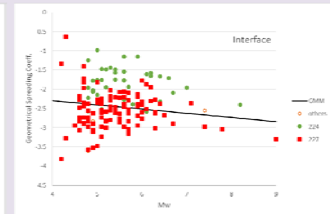
Regression

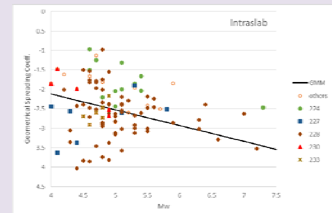
Regressions are performed via Program R (Bates , 2010; Bates et al. 2013).











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 earthqukes 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

- Bates, D. M. (2010). lme4: Mixed-effects modeling with R—Draft Chapters, R-forge, http://lme4.r-forge.r-project.org/book/ (last accessed March 2017).
- Bates, D. M., M. Maechler, and B. Bolker (2013). lme4: Linear mixedeffects models using S4 classes, R Manual, http://CRAN.R-project.org/package=lme4 (last accessed March 2014).
- Dawood, H.M., et al., A Flatfile for the KiK-net Database Processed Using an Automated Protocol. Earthquake Spectra, 2016. 32(2): p. 1281-1302.