Regional Variation in Ground Motion based on the Comparison of GMPE and Global Ground Motion Dataset

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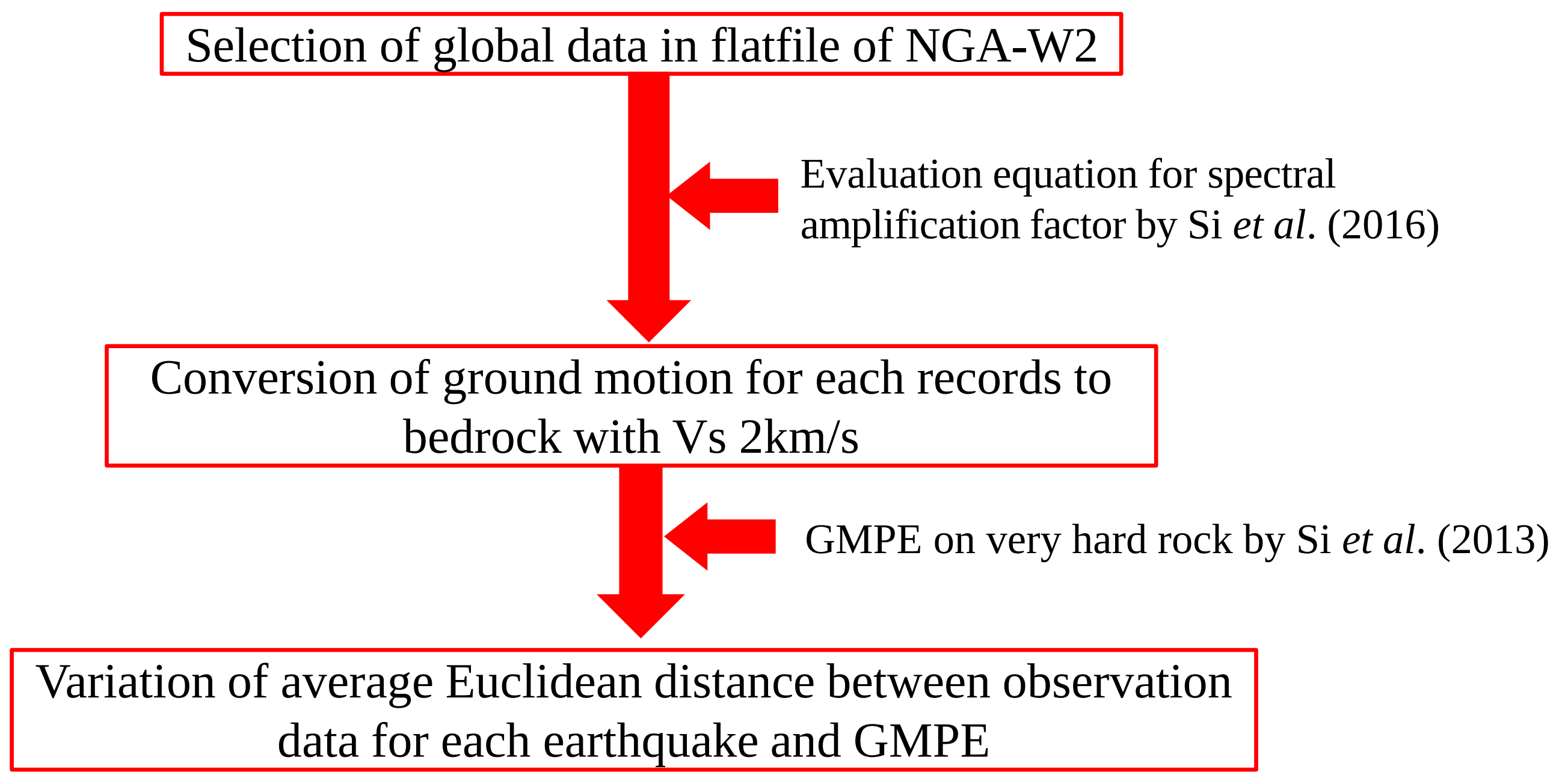
CONCEPT

- For the probabilistic seismic hazard assessment in stable continental regions (SCR), since the lack of strong ground motion data, and thus the local ground motion prediction equation (GMPE), GMPEs developed in other regions are well used in PSHA. Thus, understanding the variation of ground motion for different regions is very important issue.
- In this study, in order to investigate the regional variation in strong ground motion, a GMPE developed by Si et al. (2013) based on Japanese data on bedrock with Vs larger than 2.0km/s are used. The GMPE are compared with the ground motion data from the well recorded earthquakes in the database of the PEER NGA-West2 project.

METHOD

- The method used in this study is shown in the flowchart.


Selection of global data in flatfile of NGA-W2

Evaluation equation for spectral amplification factor by Si *et al.* (2016)

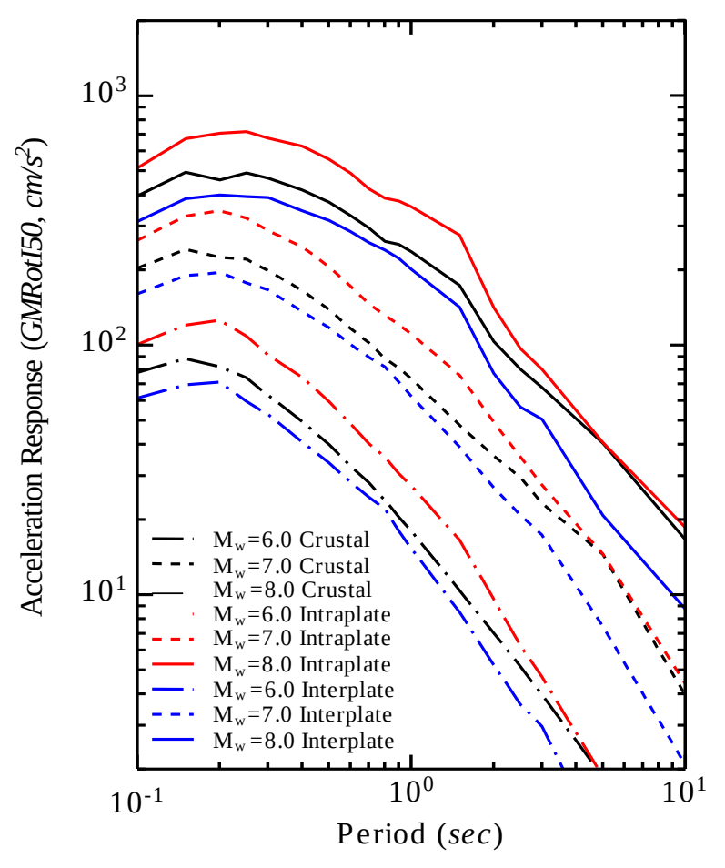
Conversion of ground motion for each records to bedrock with Vs 2km/s

GMPE on very hard rock by Si *et al.* (2013)

Variation of average Euclidean distance between observation data for each earthquake and GMPE

Summary of GMPE on bedrock by Si et al. (2013)

- The GMPEs are defined on very hard rock with Vs => 2km/s.
- Applicable up to Mw9.1 earthquakes, and crustal and subduction earthquakes.
- Different attenuation rate for shallow and deep earthquakes



GMPE by Si et al. (2013)

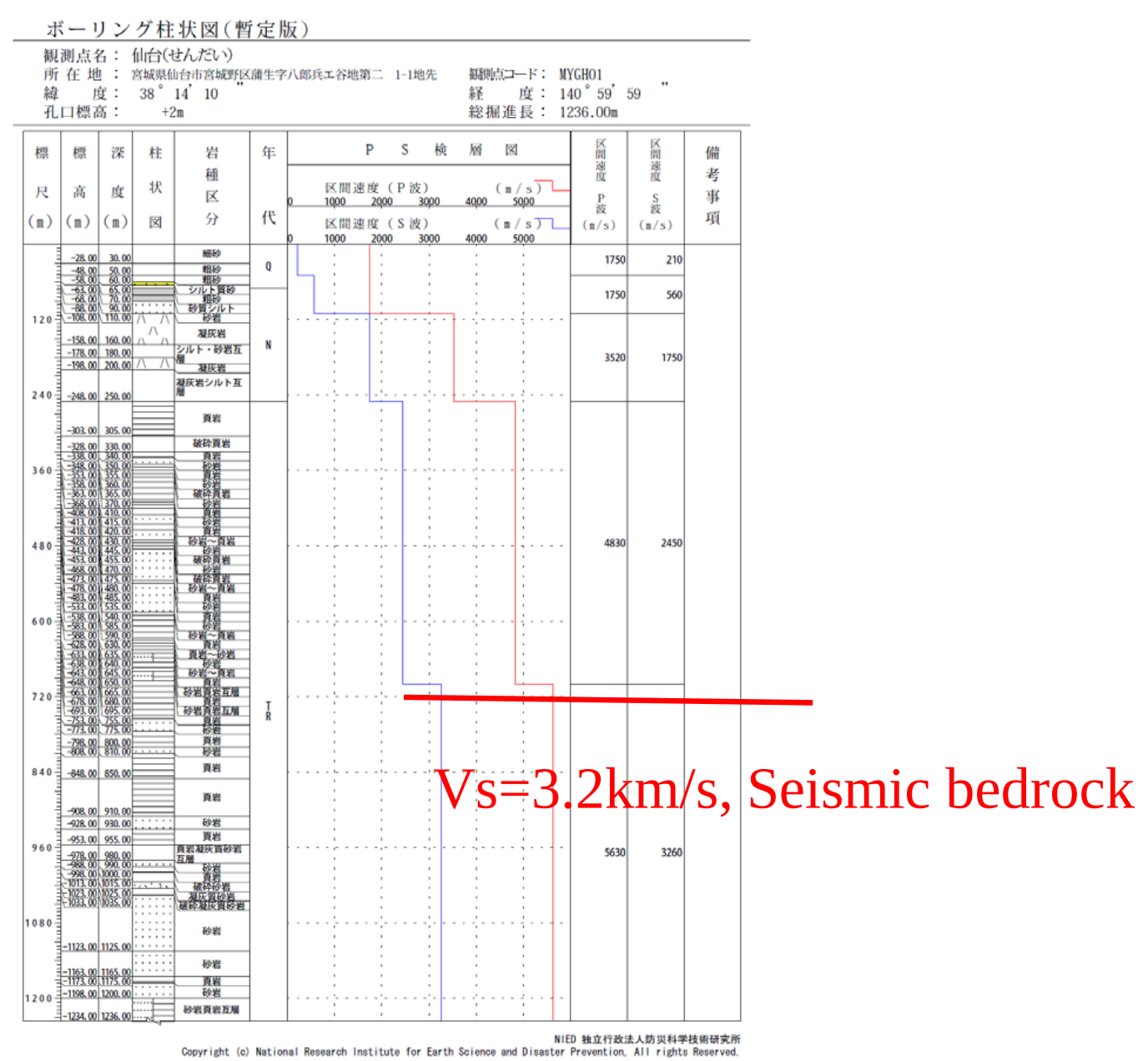
$$\log SA(T) = b(T) + g(X) - k(T)X + \varepsilon(T)$$

$$g(X) = \begin{cases} -\log(X + C(T)); D \le 30km\,or\,D > 30km \,\&\, X < 1.7D \\ 0.6\log(1.7D + C(T)) - 1.6\log(X + C(T)); D > 30km \,\&\, X \ge 1.7D \end{cases}$$

$$k(T) = 0.003, T \le 0.3s$$
$$= 0.002, T \ge 0.6s$$

$$C(T) = 0.0055 \cdot 10^{0.5M_w}, T \le 0.3s$$
$$= 0.0028 \cdot 10^{0.5M_w}, T \ge 0.6s$$

$$b(T) = \begin{cases} a_1(T)M_w + \sum d_i(T)S_i + h(T)D + e(T) + \varepsilon_1(T) \\ Mw < 8.3\,if\,T < 2s\,or\,M < 7.5\,if\,T \ge 2s \\ a_2(T)M_w + \sum d_i(T)S_i + h(T)D + e(T) + \varepsilon_2(T) \\ Mw \ge 8.3\,if\,T < 2s\,or\,M \ge 7.5\,if\,T \ge 2s \end{cases}$$


Vs=3.2km/s, Seismic bedrock

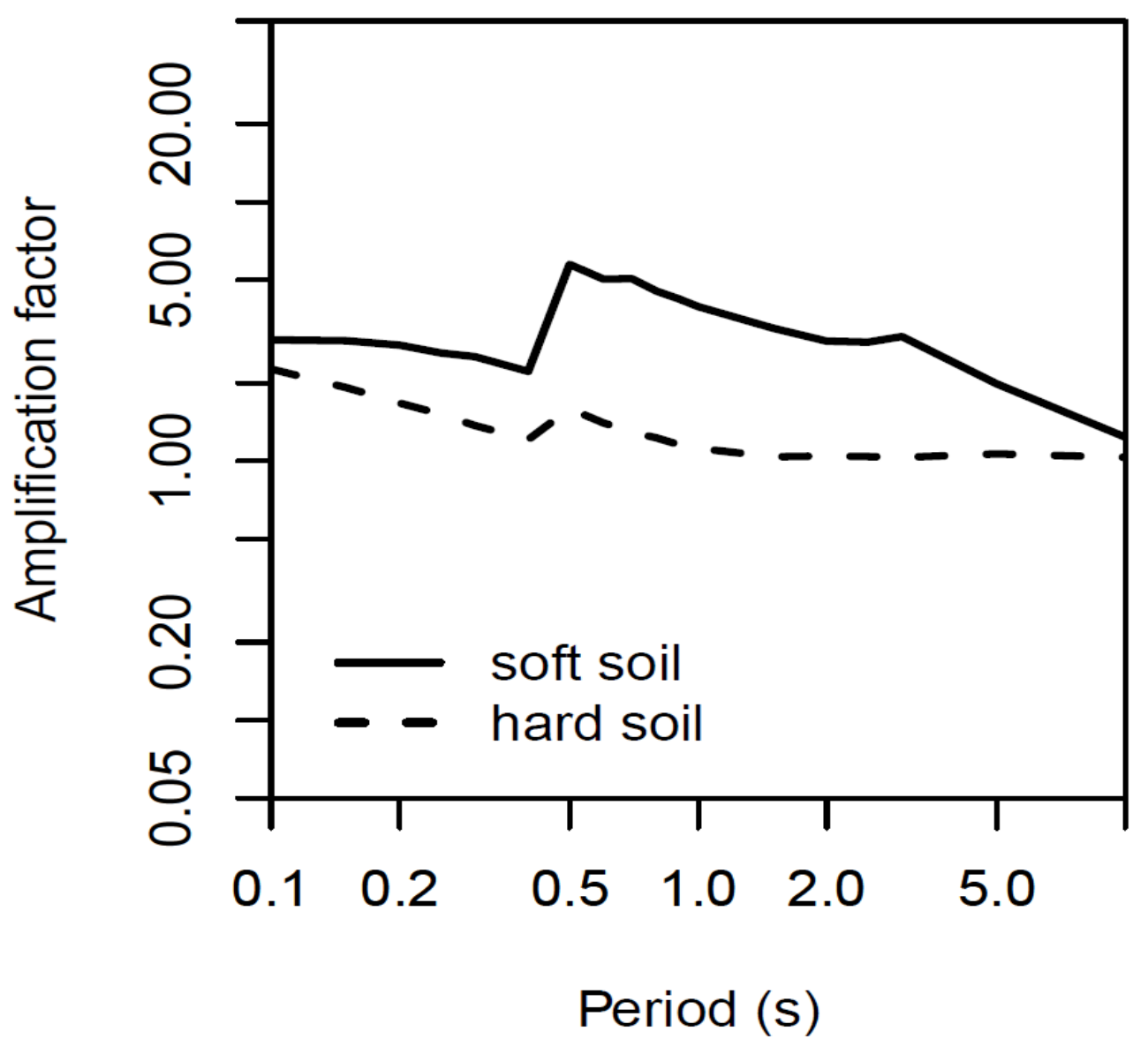
Example of data on hard rock layer station

Summary of evaluation equation for spectral amplification factor by Si et al. (2016)

- Amplification factor are directly calculated from the ratio of surface records of borehole records removed the effects of surface layers.
- Not only the Vs30, sediment depth also used as parameter accounting for long period amplification factor.

$$R_H = (1 - a\,(1 - V_{S30}RT)^{b})\,(c + dH) \qquad (0.6s \leqq T \leqq 5s) \quad (2\text{-}1)$$
$$= 1 - a\,(1 - V_{S30}RT)^{b} \qquad (\text{otherwise})$$
$$R_V = 1 - a'\,(1 - V_{P30}RT)^{b'} \qquad (T \leqq 0.5s) \qquad (2\text{-}2)$$
$$= (1 - a'\,(1 - V_{P30}RT)^{b'})(c' + d'H) \qquad (0.5s \leqq T \leqq 0.6s)$$
$$= c' + d'H \qquad (0.6s \leqq T \leqq 2.0s)$$
$$= 1.0 \qquad (T \geq 2.0s)$$

where, R_H, R_V is the amplification factor for horizontal and vertical PGA, PGV and GMRotI50, respectively.

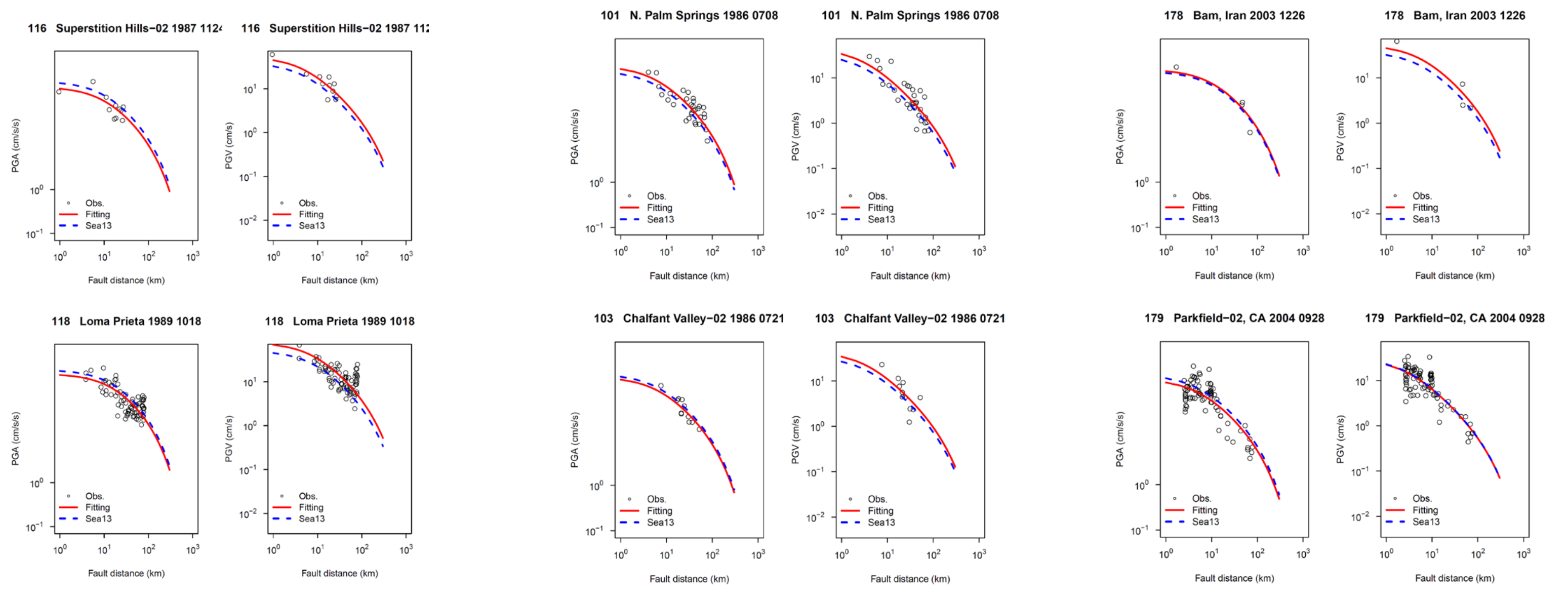


Estimated spectral amplification factosr for soft soil (V_{S30}=0.3 km/s, V_{Sbed}=2.0 km/s, H=1.0 km) and hard soil (V_{S30}=0.6 km/s, V_{Sbed}=2.0 km/s, H=0.1 km)

Acknowledgments: We thank PEER for providing data of flatfile for NGA-W2.

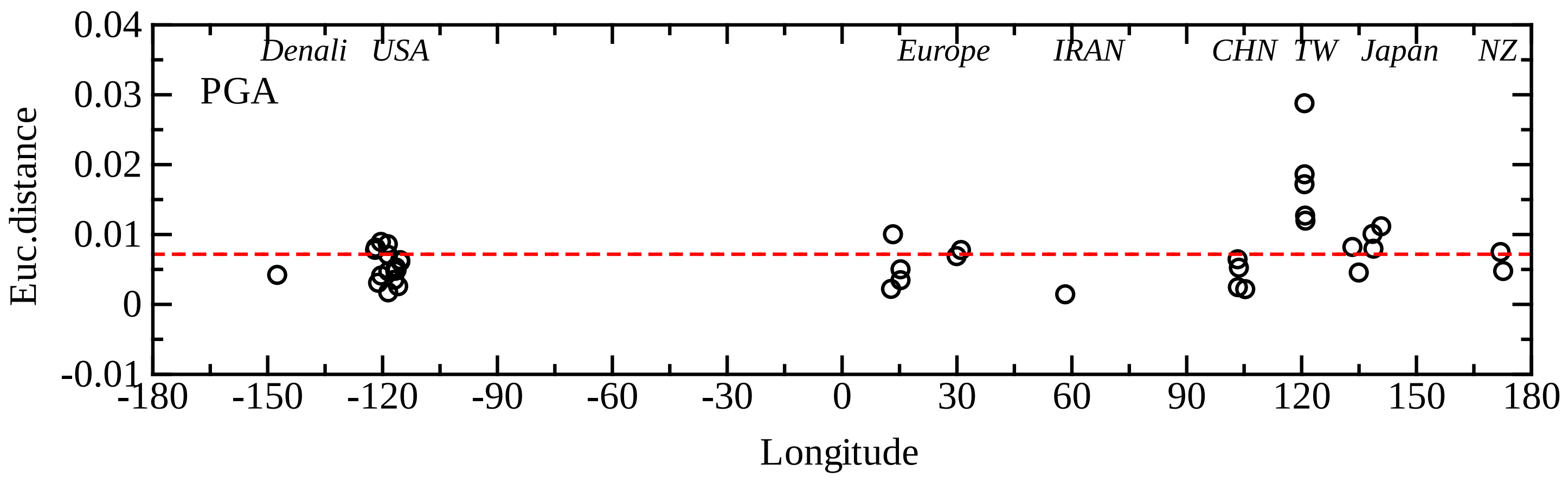
Results

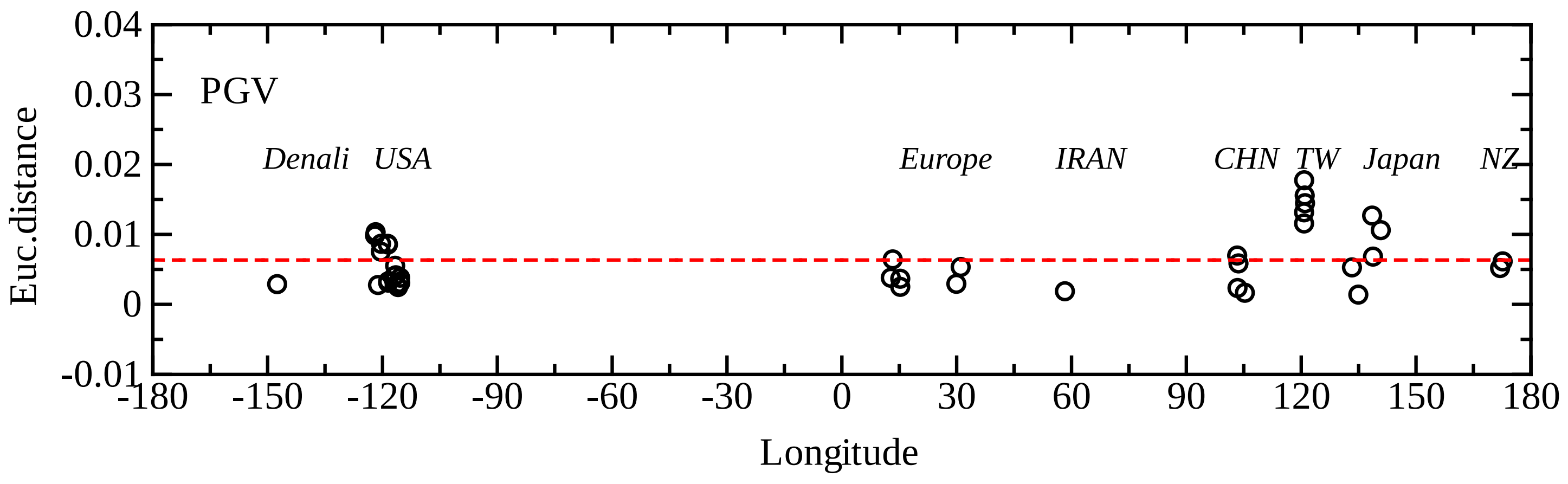
- All observation data are converted to bedrock based on the methods by Si e (2016).
- Euclidean distane defined as follows: Euc_r = SQRT (sum(Obs-Pred)^2)/n
- Target earthquakes are from
- Examples of comparison between observation data and GMPE are shown several earthquakes.

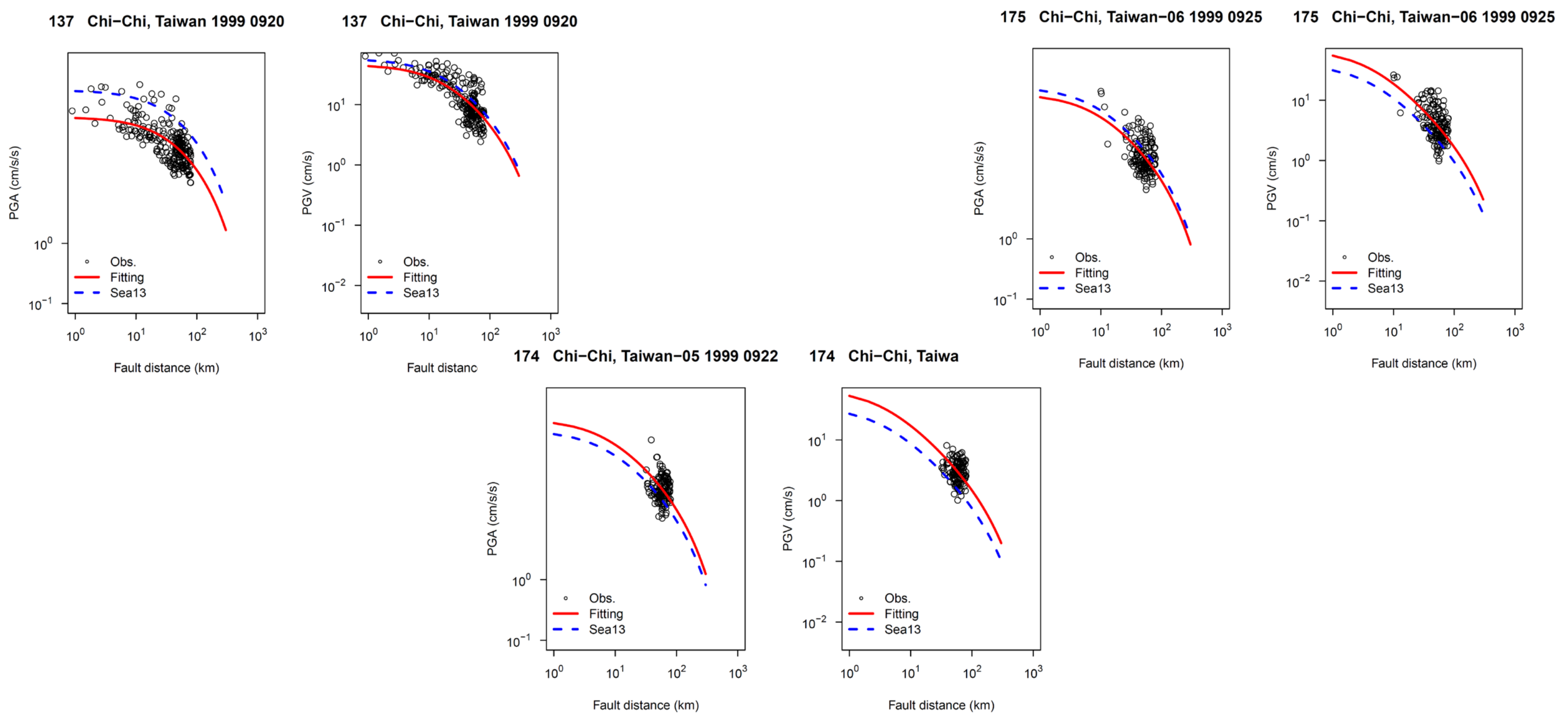


compared the observations and the predictions for the 1989 Loma Prieta, 1986 Chalfant Valley, and 2004 Parkfield earthquakes.

Results for the Euclidean distance







Confirmation of the comparison of observation and prediction for mainshock and two aftershocks for the 1999 Chi-Chi earthquake.
PGA for mainshock is significantly different from the prediction by GMPE

CONCLUSION

・We use GMPE model on bedrock and the evaluation equation for spectral amplification factor developed in Japan to discuss the regional variation of ground motion, based on the database of NGA W2 flatfile.

・By limiting data to near-field ones and removing site effects from data prior to the analysis, we focus on the source characteristics.

・We introduce a parameter of Euclidean distance to represent difference between data and model.

・The results show the variation of Euclidean distance are generally consistent world wide, but with different calculation method for Euclidean distance, Taiwan data show different behavior.

References: Boore, D.M., Watson-Lamprey, J., and Abrahamson, N. A. (2006), Bull. Seismol. Soc. Am., 96, 1502-1511; Si, H., Midorikawa, S., Tsutsumi, H., Wu, C., Masatsuki, T. and Noda A., (2013), Proceedings of CUEE, March 1-2, 2013, Tokyo, Japan.; Si, H., Tsutsumi, Masatsuki, T. and Noda A., (2016), Proceedings of 5ESG, 15-18, 2016, Taipei.