Strong Motion Attenuation Relationship for PSHMs in Japan

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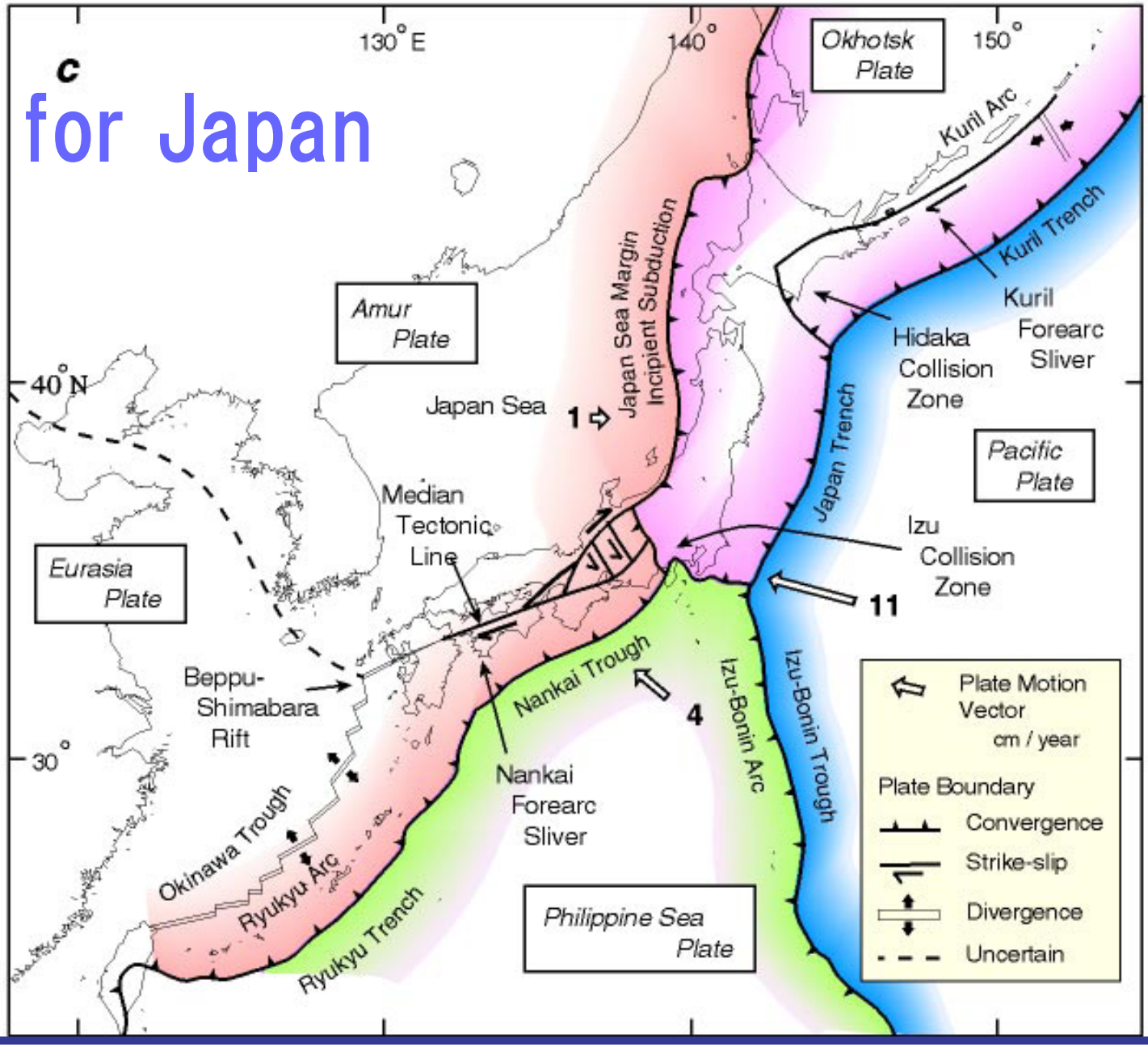
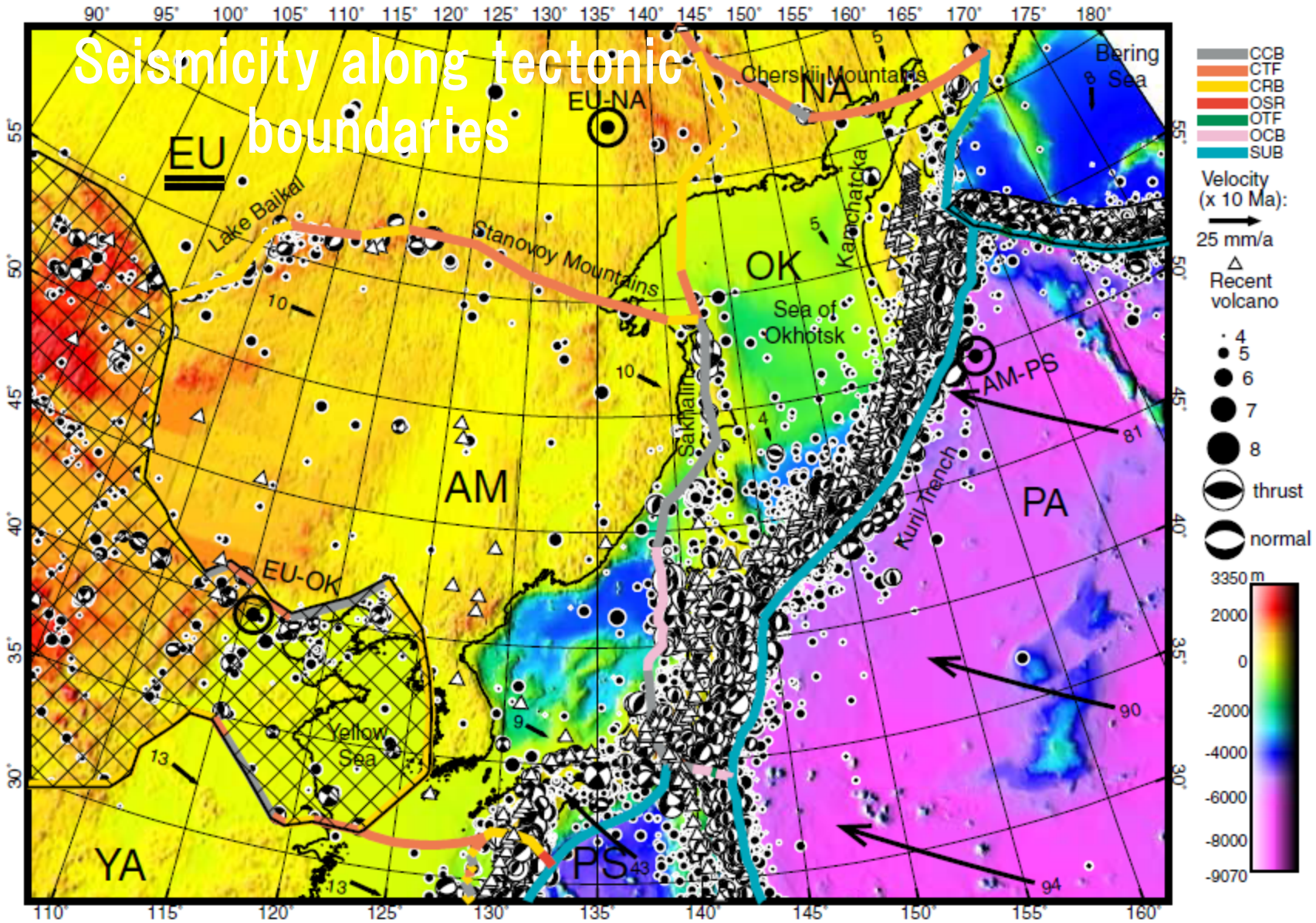
Outline

- Tectonics surrounding Japan
- Strong motion observation network
- GMPE for PSHMs in Japan
- Applicability to worldwide data
- About the 2011 Mw9.1 Tohoku earthquake
- Summary

Tectonics for Japan

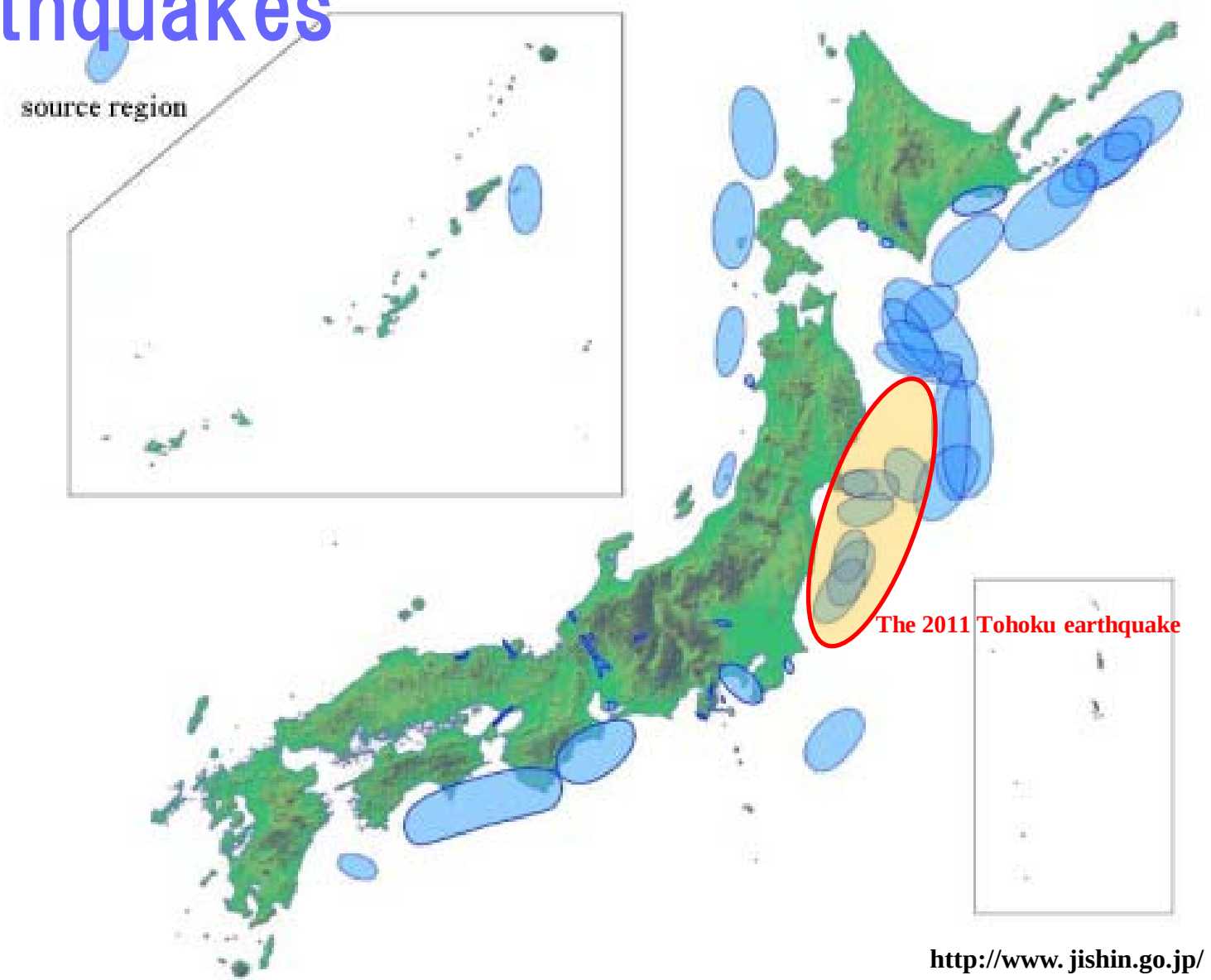


Taira (2001)



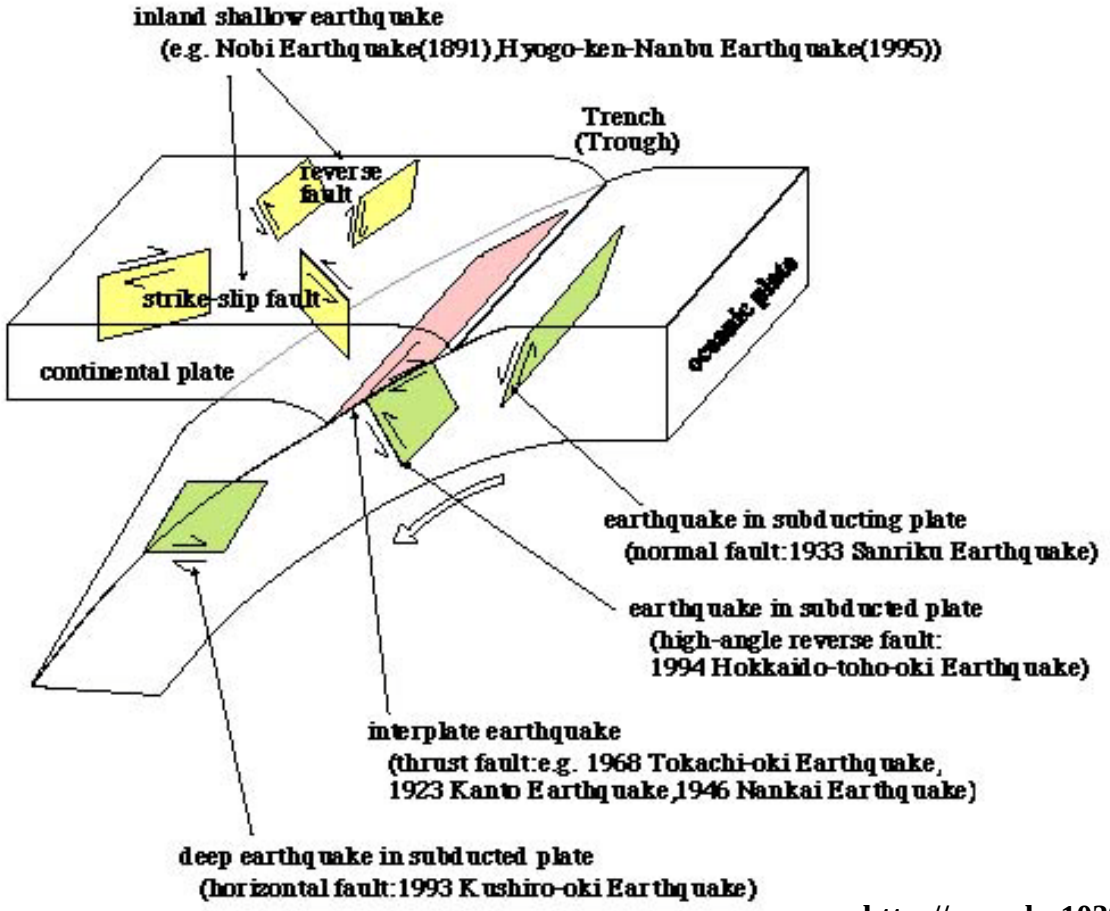
By Bird (2003)

Main earthquakes



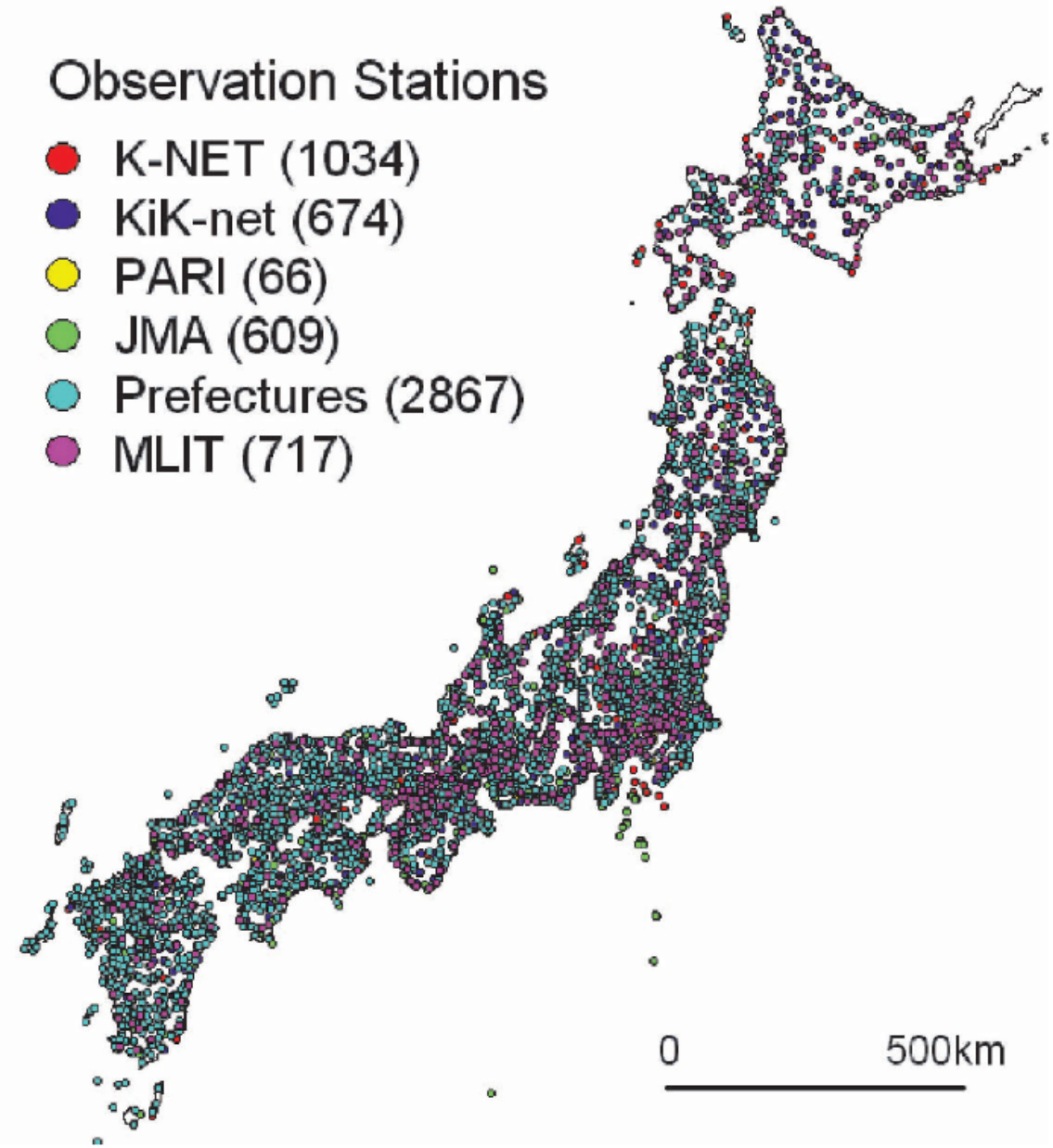
http://www. jishin.go.jp/

The types of earthquakes that occur in the Japanese archipelago and the surrounding area



http://www.hp1039.jishin.go.jp/eqchreng/f2-18.htm

Strong motion observation networks in Japan



After Midorikawa(2005)

Si and Midorikawa (1999) for PGV

Attenuation relation in Japan by Si and Midorikawa (1999)

$$\log PGV = 0.58M_w + 0.0038D + d - \log(X + 0.0028 \bullet 10^{0.5M_w}) - 0.002X - 1.29$$

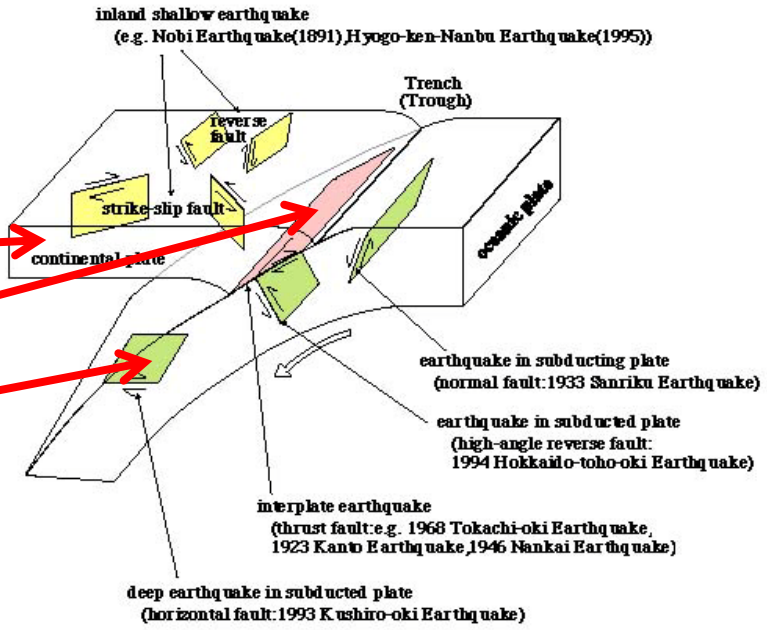
where X, M_w show fault distance, and moment magnitude, respectively. D is focal depth represented by the depth of the center of a fault plane. d shows is defined as bellow:

d=

0.0 for crustal

-0.02 for inter-plate

0.12 for intra-plate

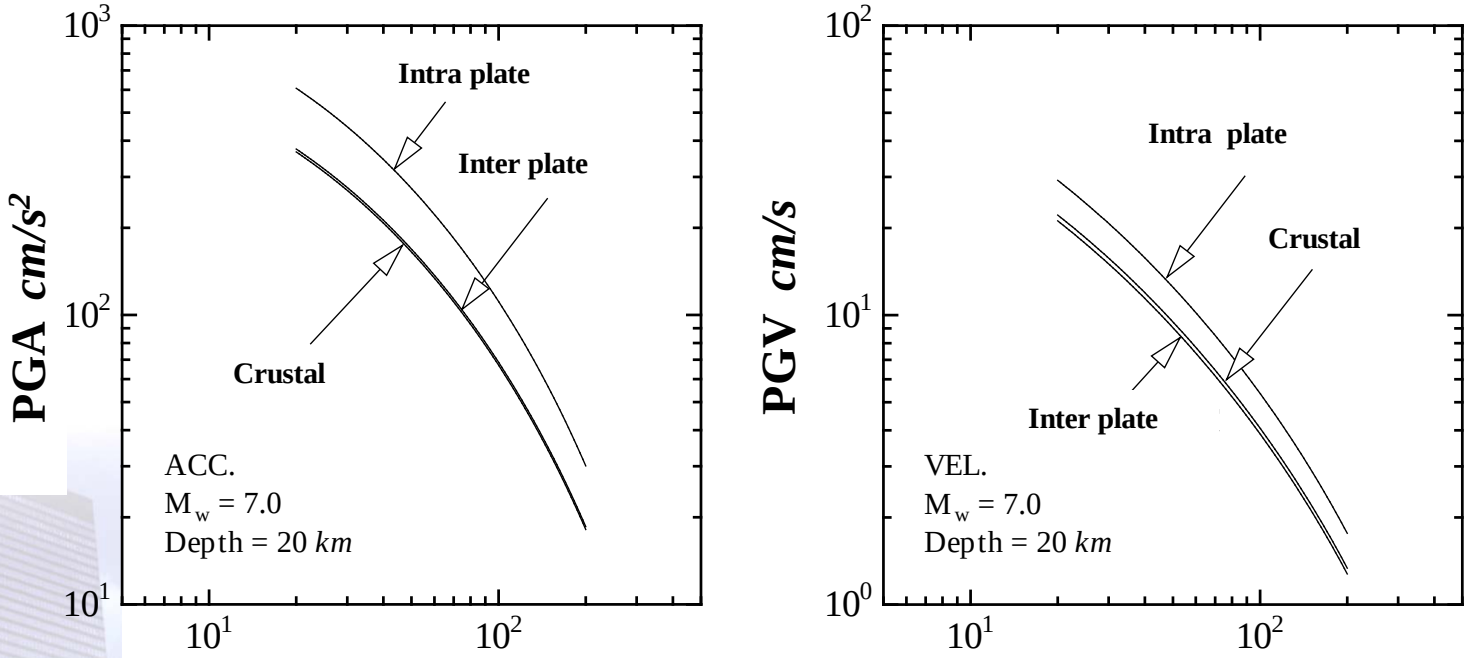


Si and Midorikawa (1999) is defined on stiff ground with Vs30=600m/s

http://www.hp1039.jishin.go.jp/eqchreng/f2-18.htm

Effects of earthquake type

Attenuation relation in Japan by Si and Midorikawa (1999)

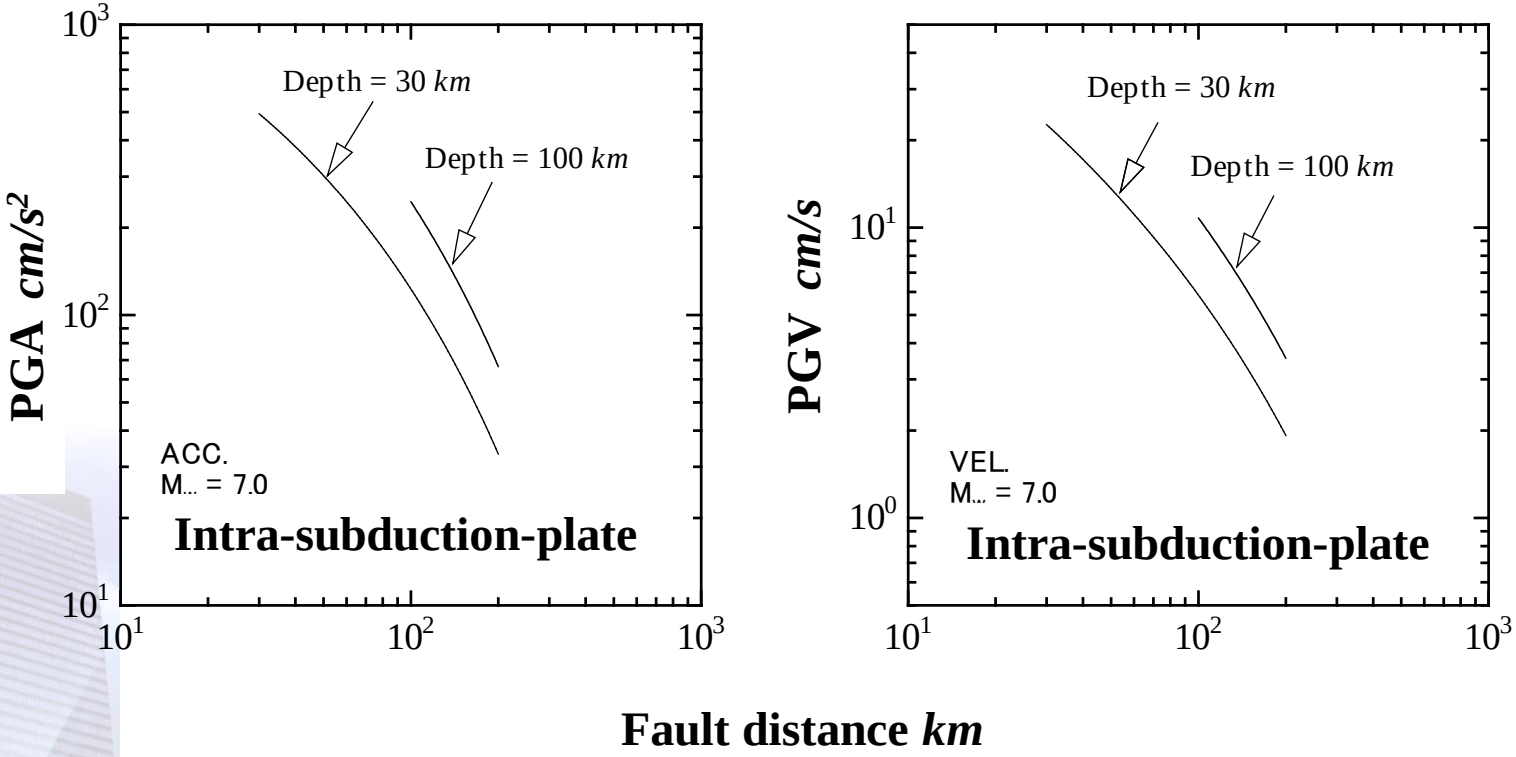


Fault distance *km*

Evaluating the effects on strong motion by the earthquakes with different tectonic setting, applicable to near source area

Effects of focus depth

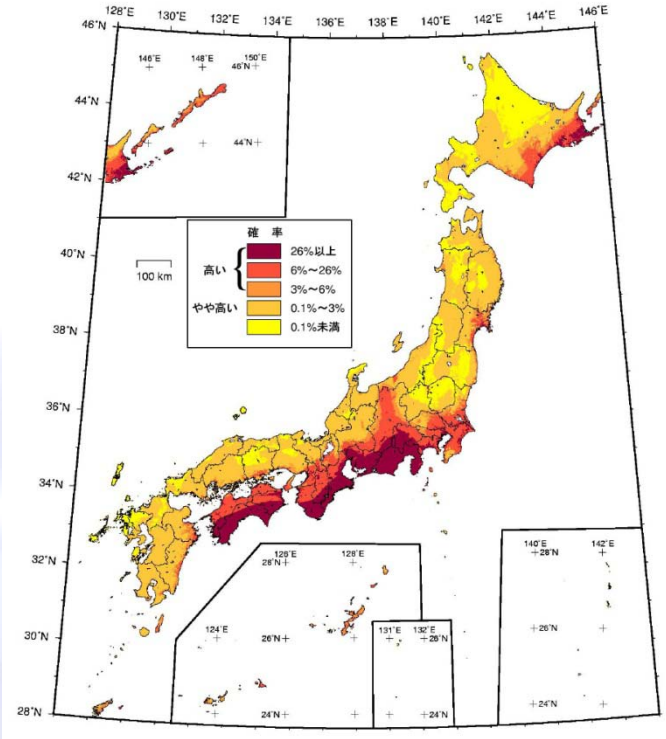
Attenuation relation in Japan by Si and Midorikawa (1999)



Evaluating the effects of focus depth and site effects on strong ground motion

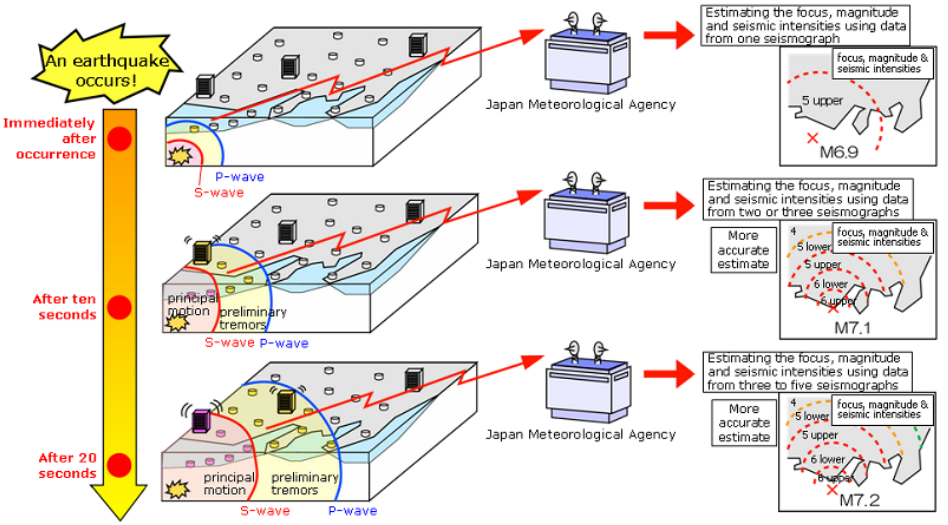
Main Application of Si and Midorikawa(1999)

National wide hazard map



After NIED

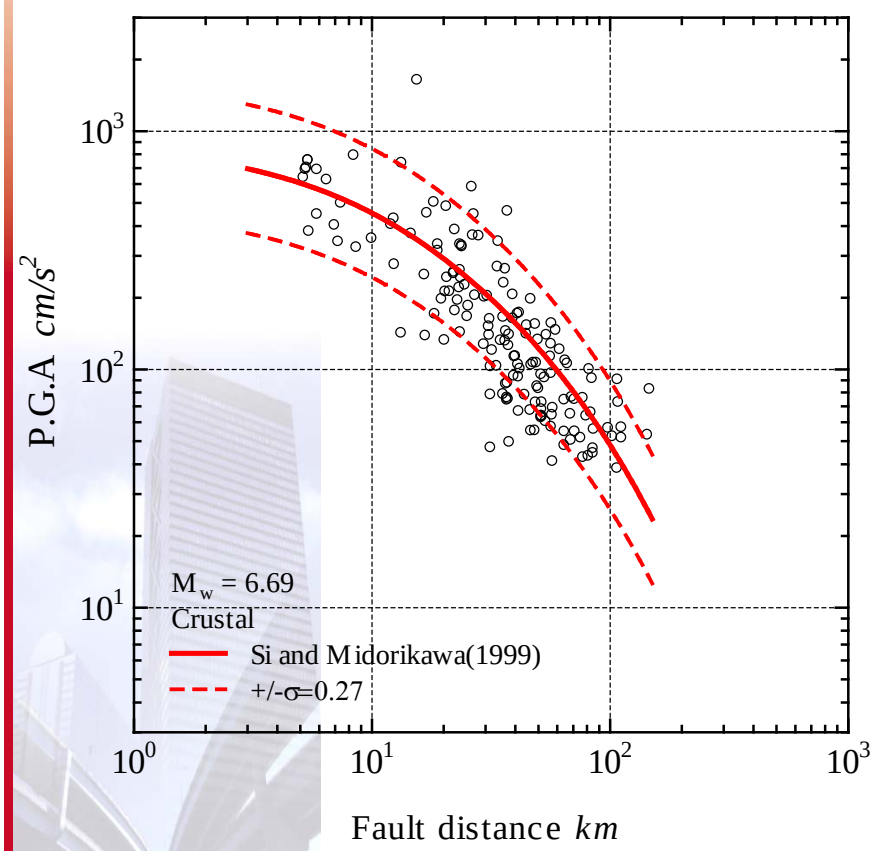
Earthquake Early Warning

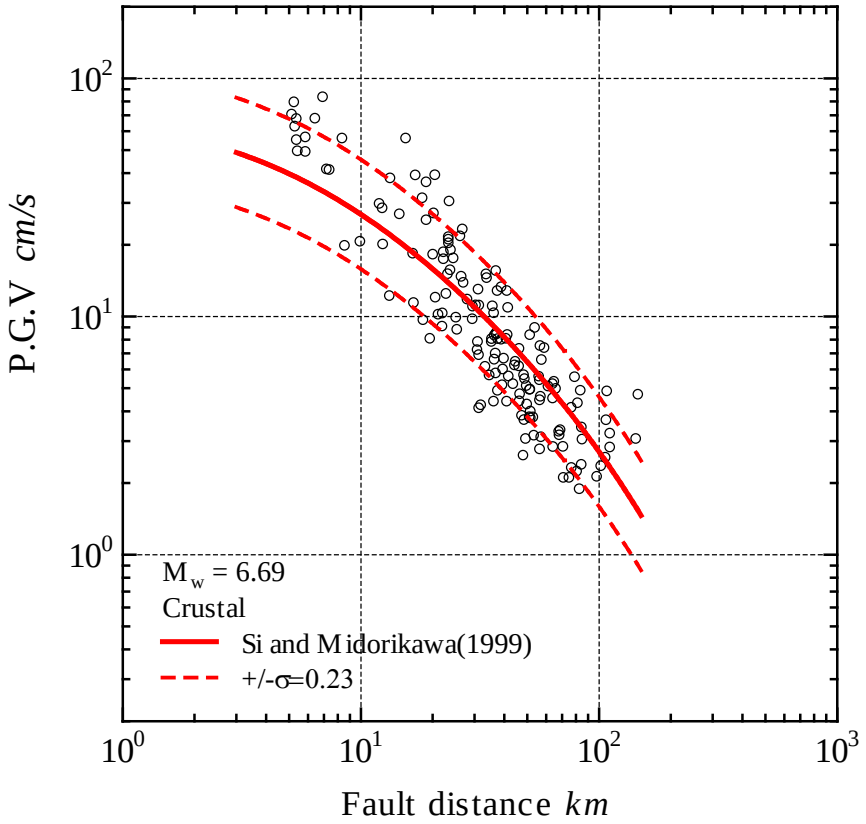


After JMA

Applicability of the GMPE in Japan to the earthquakes in the world 1

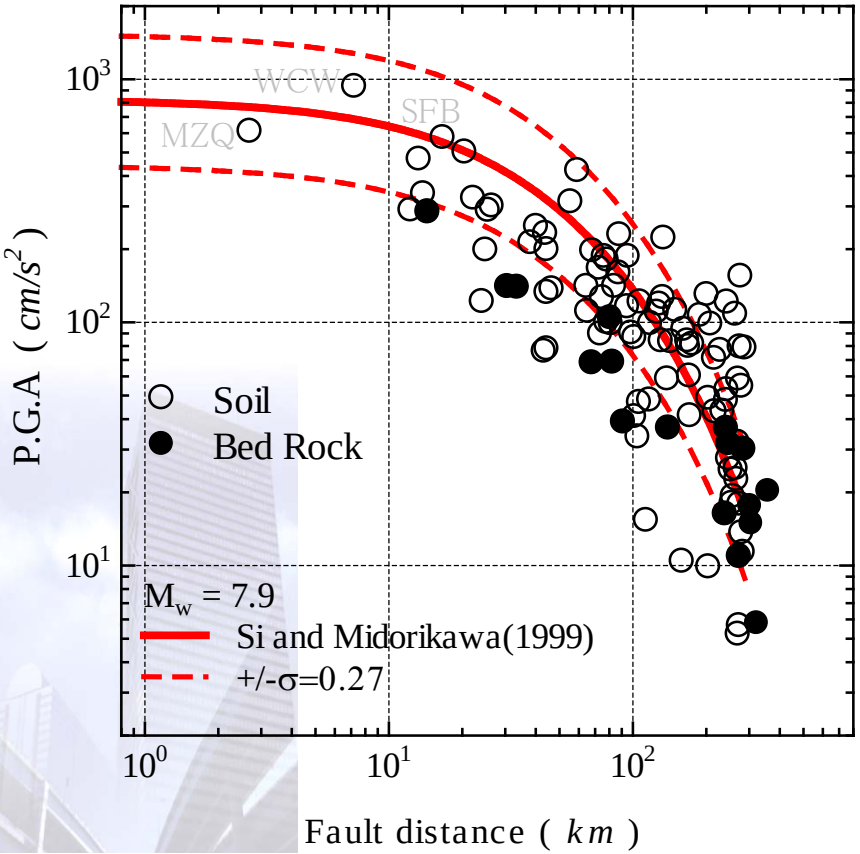
Crustal event: The 1994 Mw6.7 Northridge , California earthquake

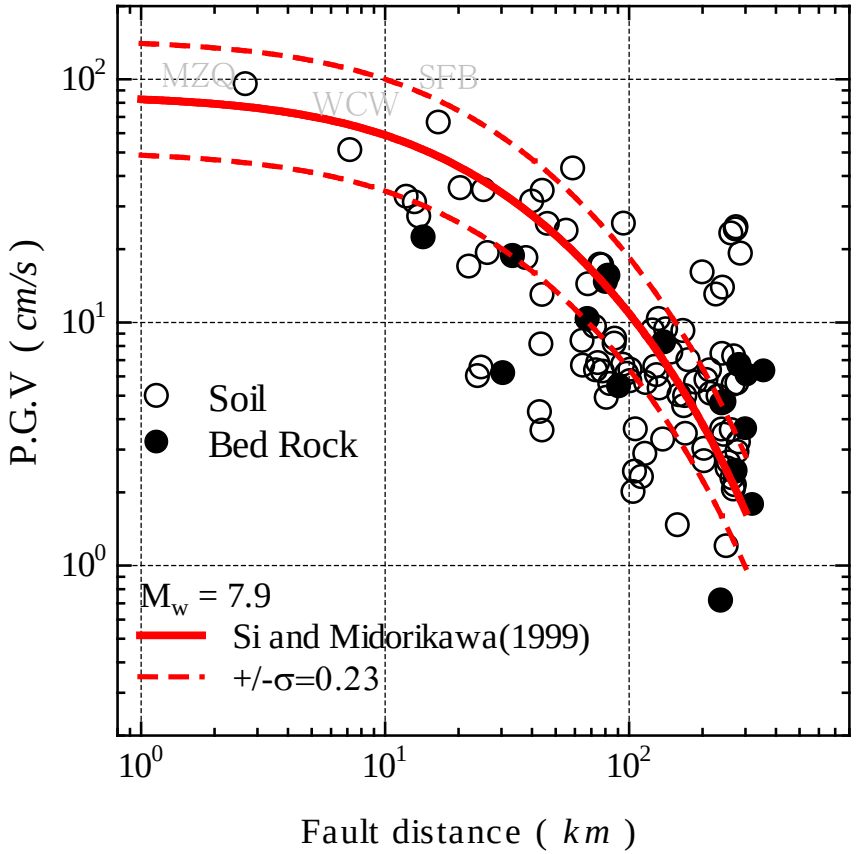




Applicability of the GMPE in Japan to the earthquakes in the world 2

Crustal event: The 2008 Mw7.9 Great Wenchuan, Sichuan, China

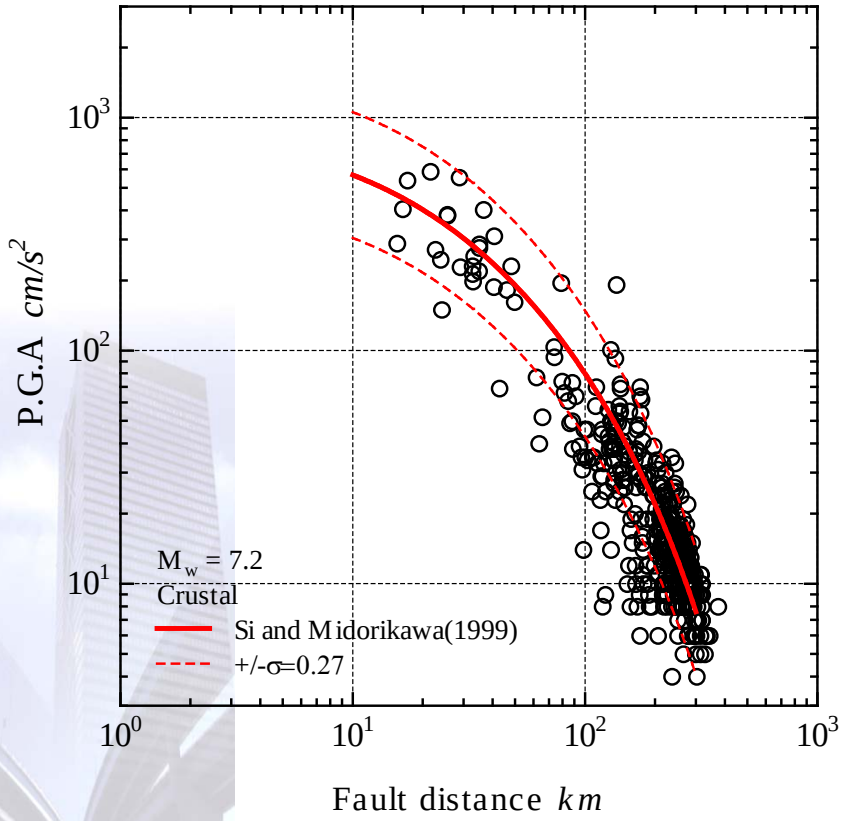




Applicability of the GMPE in Japan to the earthquakes in the world 3

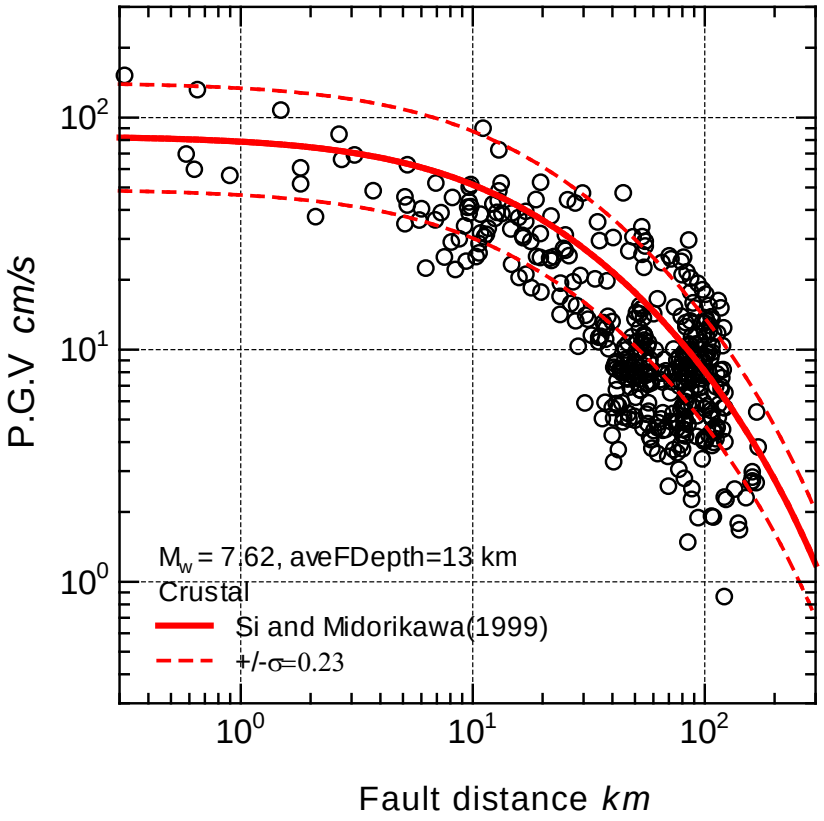
Crustal event:

The 2010 Mw7.2 BAJA CALIFORNIA, MEXICO

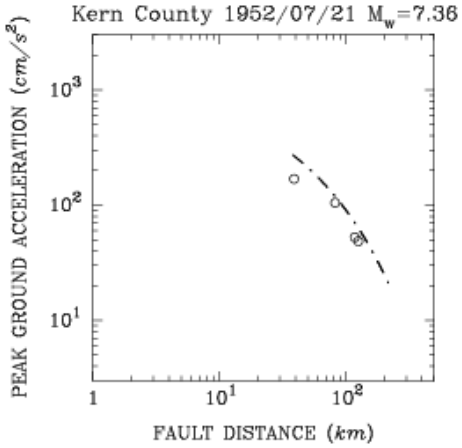


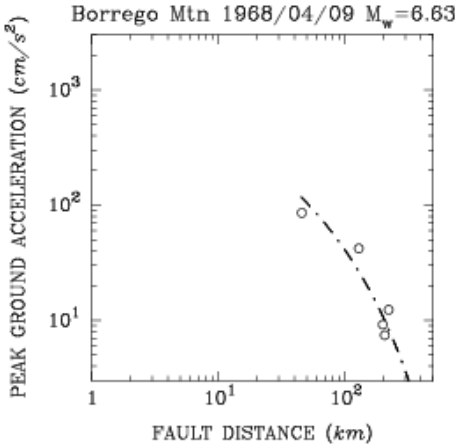
Crustal event:

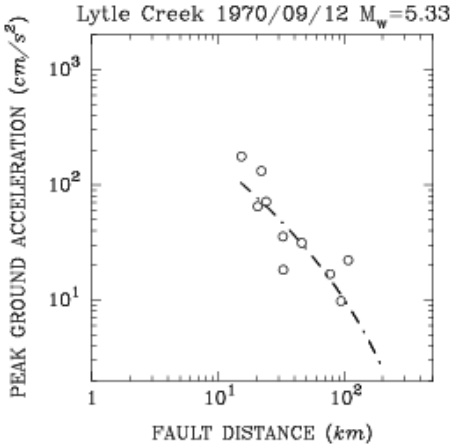
The 1999 Mw7.62 Chi-Chi earthquake

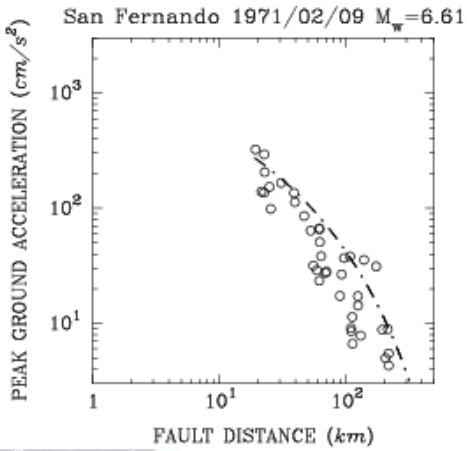


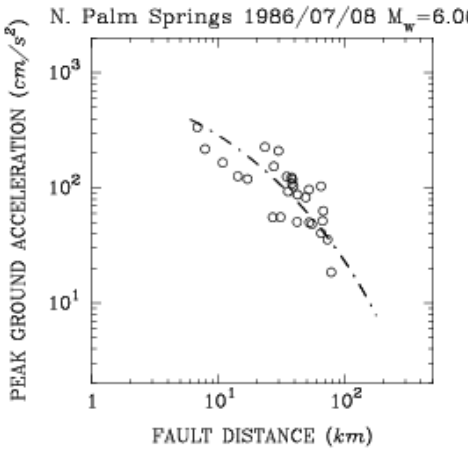
Applicability of the GMPE in Japan to the earthquakes in the world: NGA-PGA

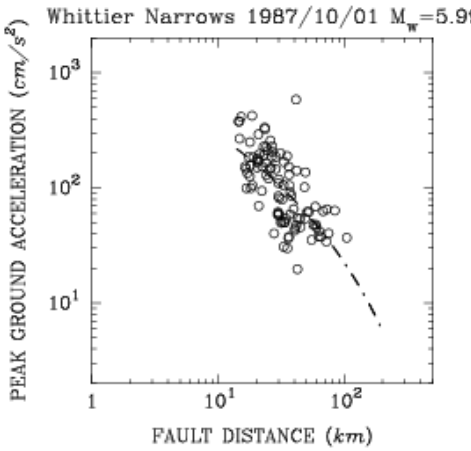




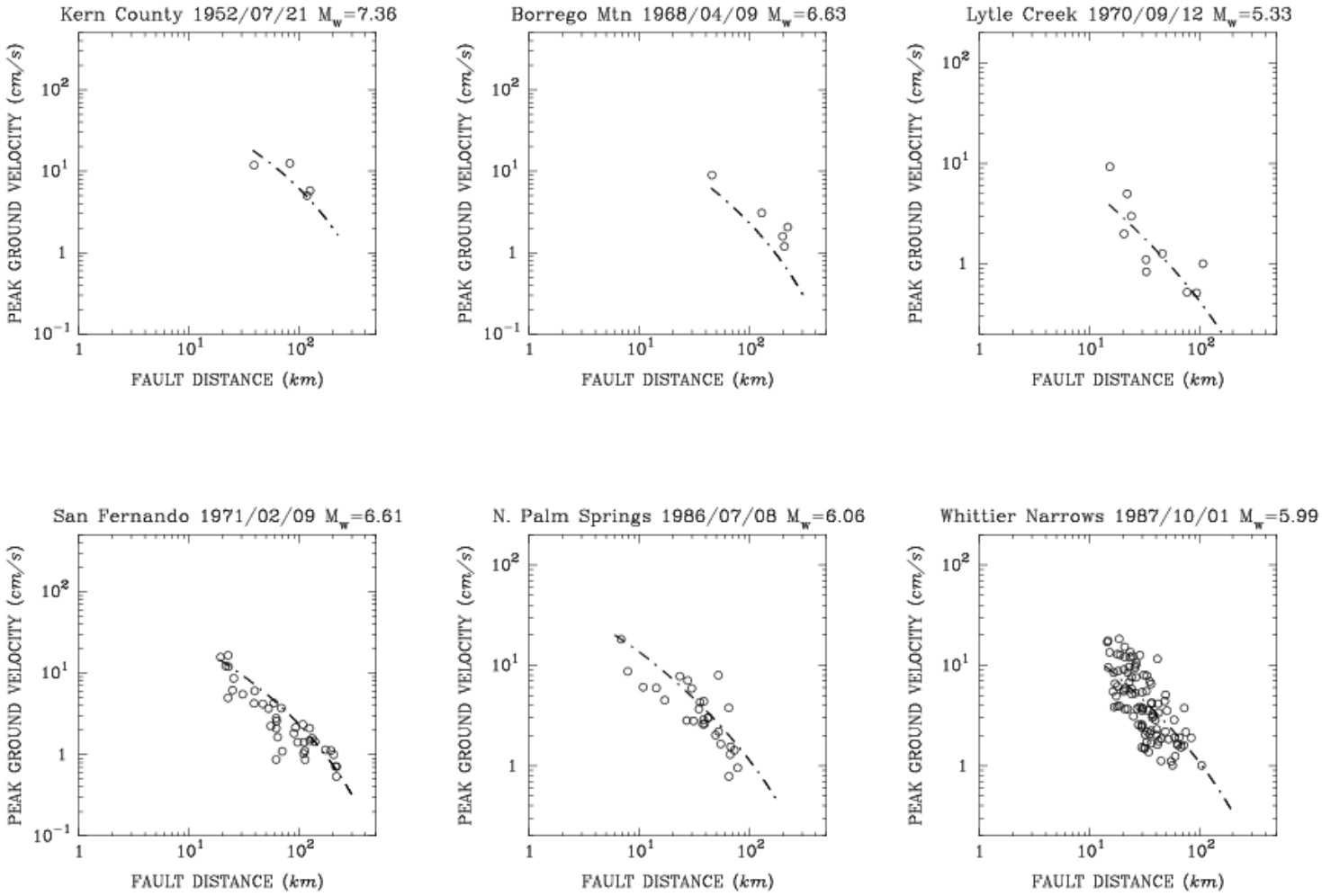




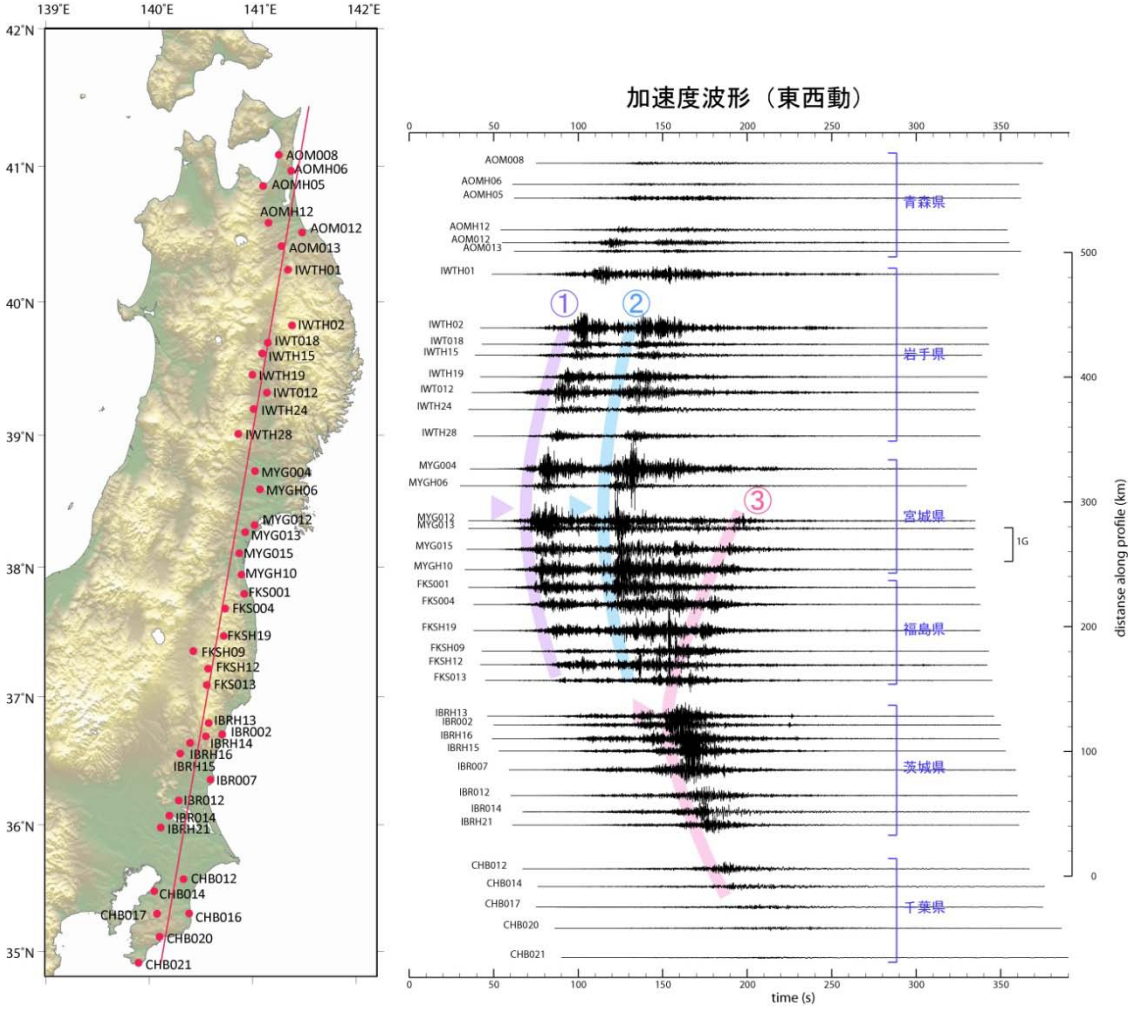




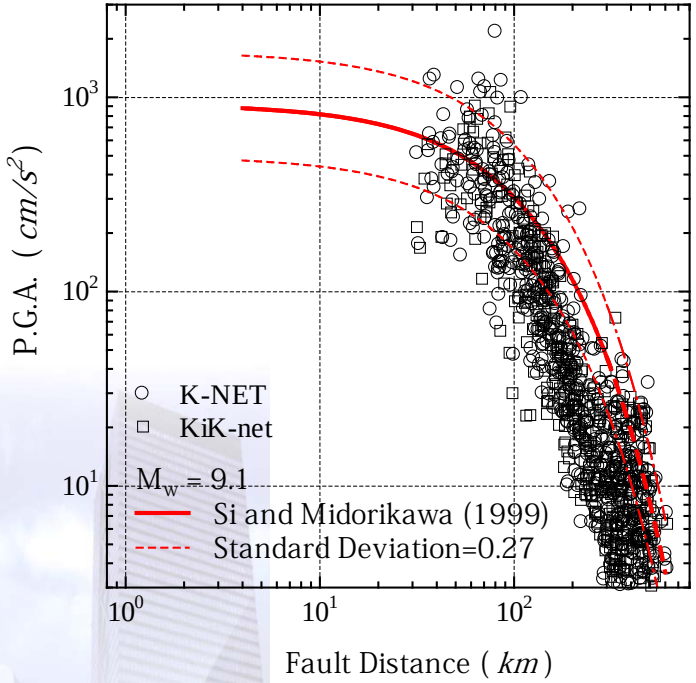
Applicability of the GMPE in Japan to the earthquakes in the world: NGA-PGV

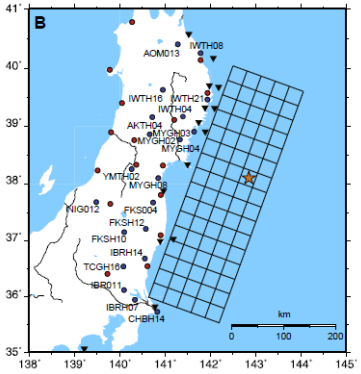


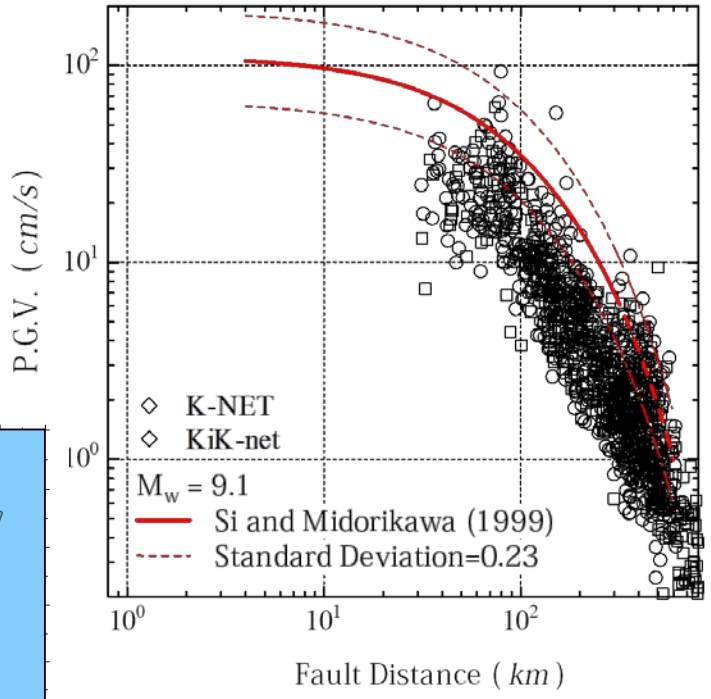
Strong motion recorded during the 2011 Mw9.1 Tohoku earthquake



PGA&PGV for the 2011 Tohoku earthquake







Koketsu et al. (2011)

Si, H., Kuyuk, H. S., Koketsu, K. & Miyake, M. Attenuation characteristics of peak ground motion during the 2011 Tohoku, Japan, earthquake, Seismol. Res. Lett. 82, 460 (2011)

Comments by Boore (2011)

http://www.daveboore.com/daves_notes/comparisons_of_ground_motions_from_the_m_9_tohoku_earthquake_with_gmpes_v1.4.pdf

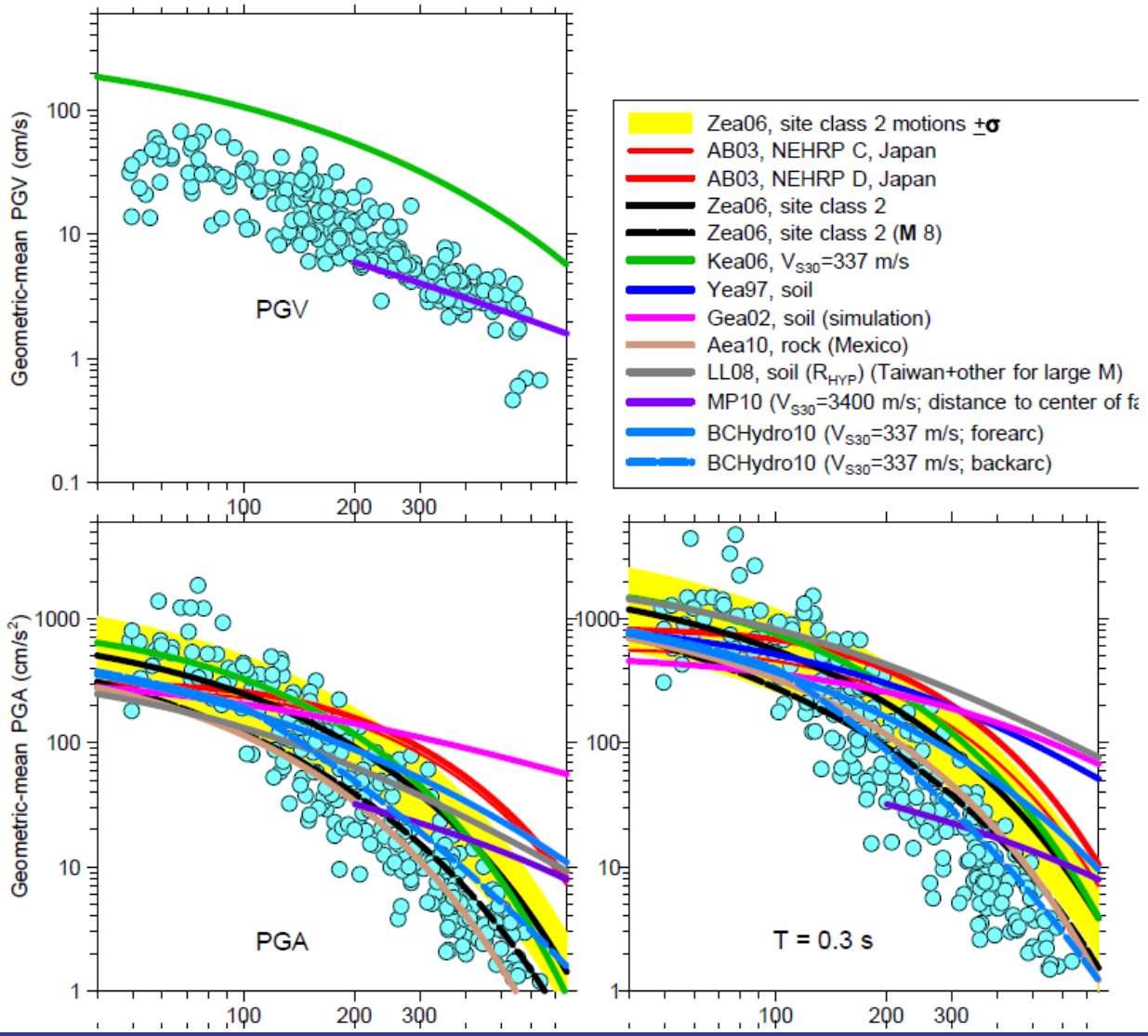
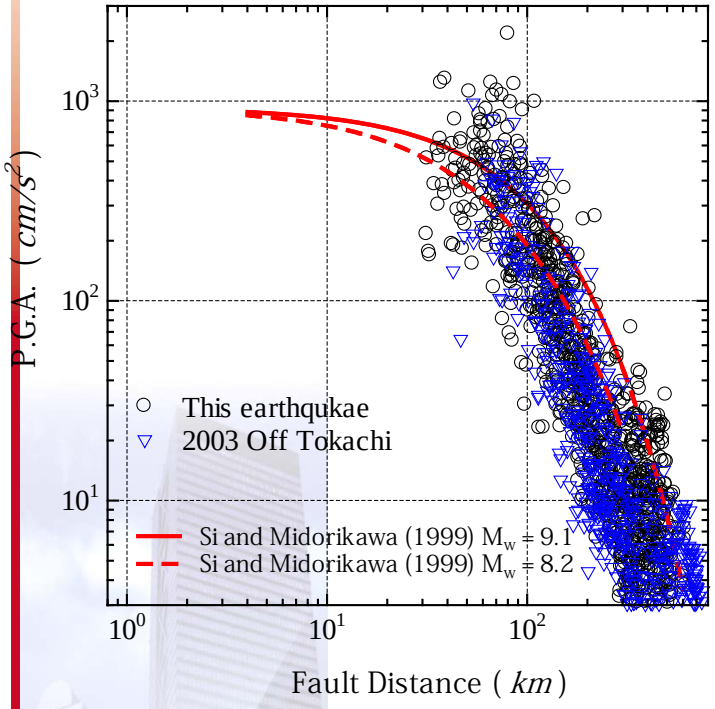
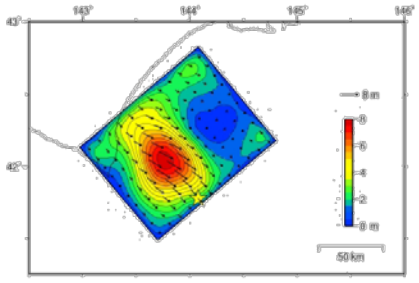


Figure 2. Observed and predicted ground motions (see text for definitions of the GMPE abbreviations). The yellow band corresponds to minus and plus one standard deviation in predicted values for the Zea06 GMPEs for *S 30 V of 345 m/s (because Zea06 uses discrete site* classes, the motions are the same as for *S 30 V of 586 m/s, because their site class 2 ranges from* 300 to 600 m/s).

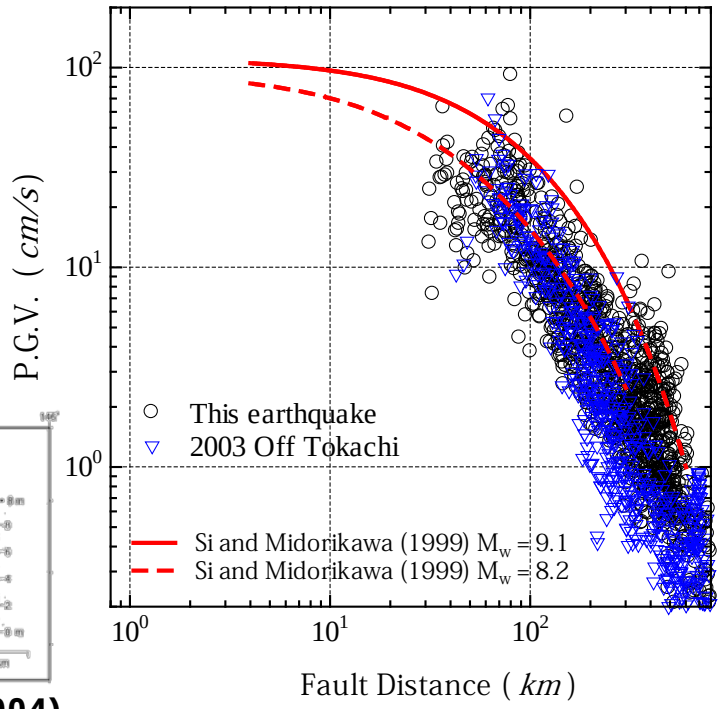
Figure 4. Similar to Figure 2, adding LL08, Aea10, MP10 GMPEs, and BCHydro10, and showing soil sites only for GMPEs (except for Aea10 and MP10, which are only for rock).

Comparison of Peak motions for the 2011 Mw9.1 Tohoku and the 2003 Mw8.3 Tokachi-oki earthquake



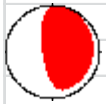


Koketsu et al. (2004)



Si, H., Kuyuk, H. S., Koketsu, K. & Miyake, M. Attenuation characteristics of peak ground motion during the 2011 Tohoku, Japan, earthquake, Seismol. Res. Lett. 82, 460 (2011)

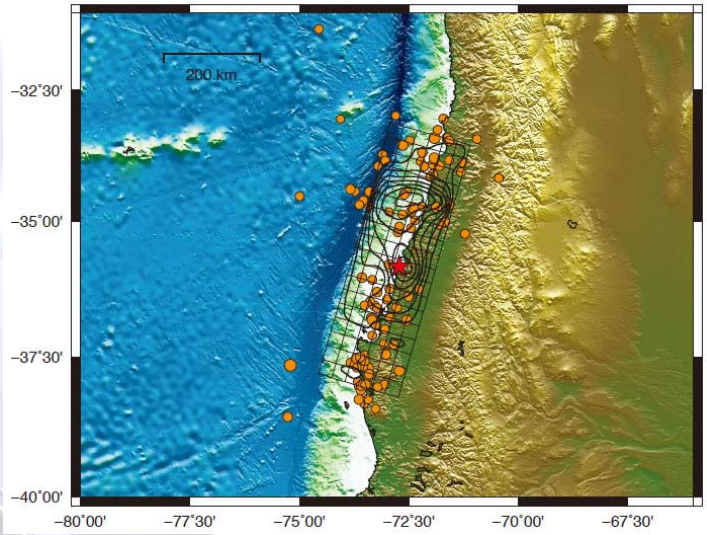
2010 Chile and 2001 Peru earthqauke

201002270634A NEAR COAST OF CENTRAL CH

Date: 2010/ 2/27 Centroid Time: 6:35:14.5 GMT
Lat= -35.98 Lon= -73.15
Depth= 23.2 Half duration=60.0
Centroid time minus hypocenter time: 58.9
Moment Tensor: Expo=29 1.040 -0.039 -1.000 0.304 -1.520 -0.119
Mw = 8.8 mb = 0.0 Ms = 8.3 Scalar Moment = 1.86e+29
Fault plane: strike=19 dip=18 slip=116
Fault plane: strike=172 dip=74 slip=82

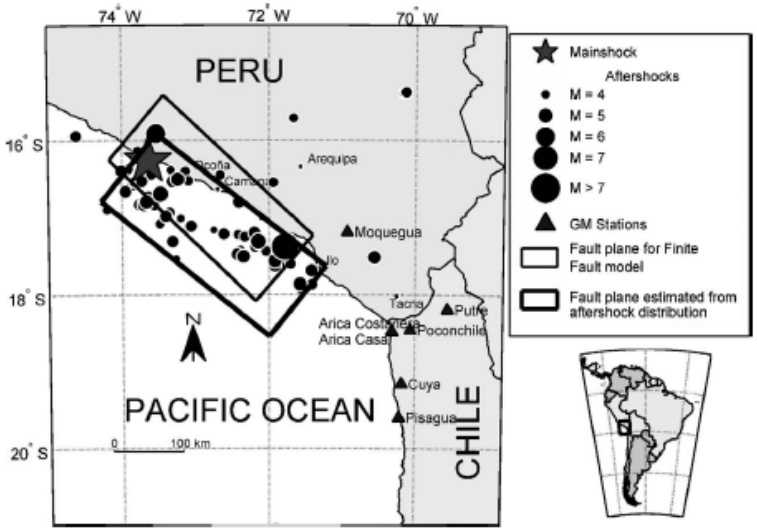
062301E NEAR COAST OF PERU

Date: 2001/ 6/23 Centroid Time: 20:34:23.3 GMT
Lat= -17.28 Lon= -72.71
Depth= 29.6 Half duration=43.2
Centroid time minus hypocenter time: 69.2
Moment Tensor: Expo=28 2.245 -0.547 -1.698 1.339 -3.728 1.444
Mw = 8.4 mb = 6.7 Ms = 8.2 Scalar Moment = 4.67e+28
Fault plane: strike=310 dip=18 slip=63
Fault plane: strike=159 dip=74 slip=98

Global CMT



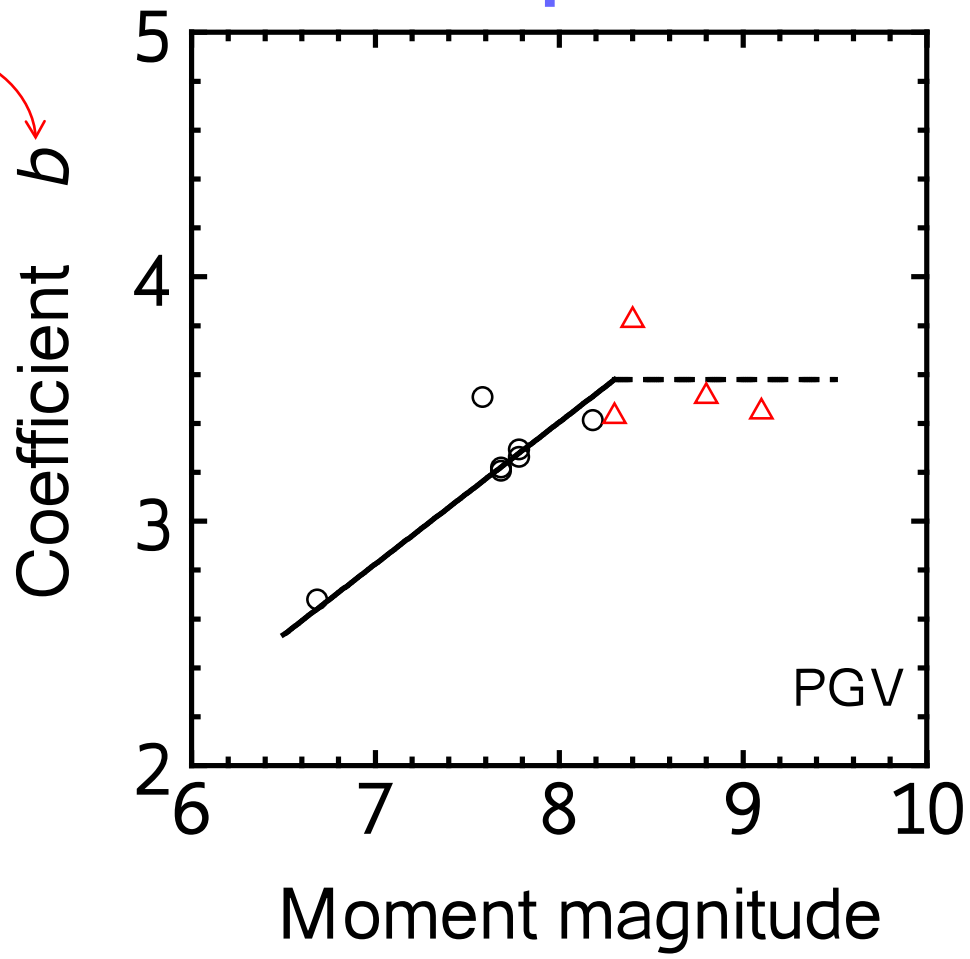
Poiata et al. (2010)



Boroschek et al. (2010)

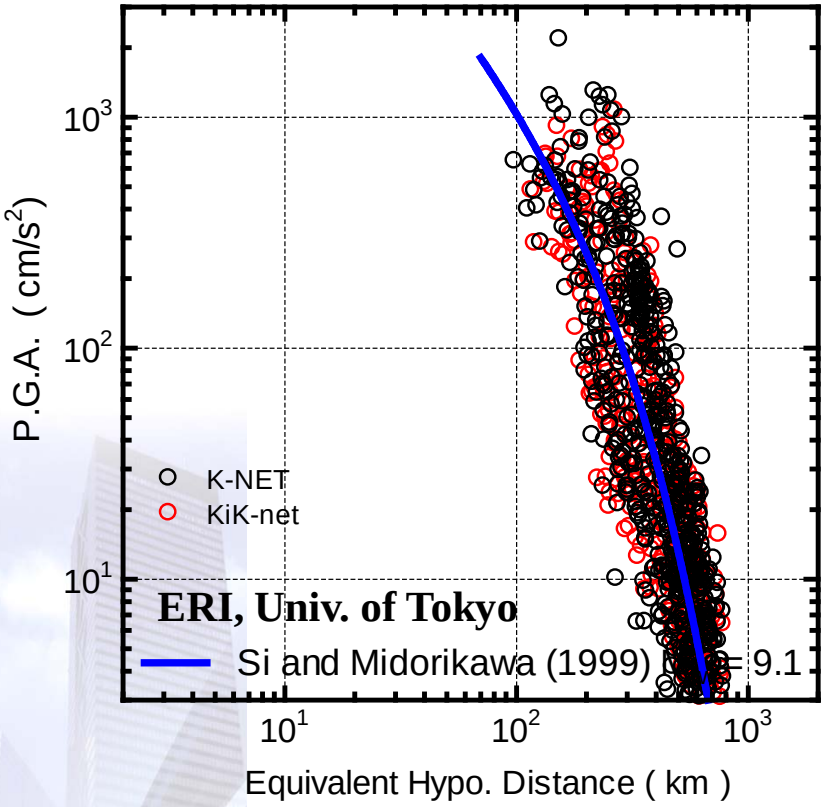
Application of GMPE for Mw9 Mega-thrust earthquakes

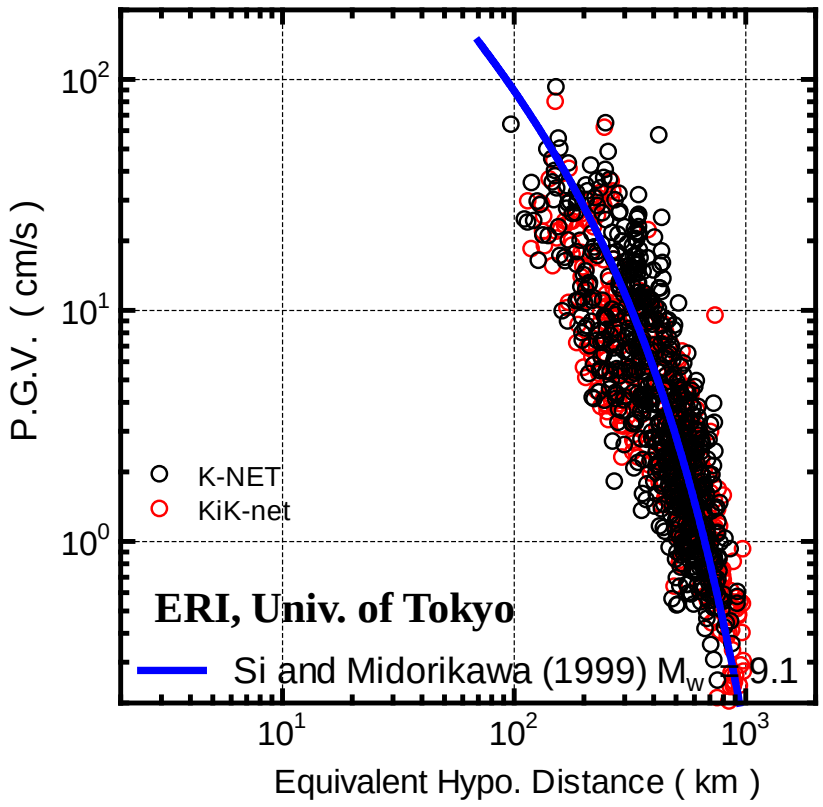
$$\log A = b - \log(X + c) - kX$$



Si, H., Koketsu, K. & Miyake, M, Midorikawa S. Attenuation Characteristics of Peak Ground Motions from Giant Earthquakes - The 2011 Tohoku Earthquake and Other Giant Earthquakes -, Fall meeting of SSJ (2011)

Strong motion for the 2011 Tohoku earthquake (when using Equivalent Hypo. Distance)





- Using the slip model by Koketsu et al. (2011)

Si and Midorikawa (1999) for PGV using Ehd

Attenuation relation in Japan by Si and Midorikawa (1999)

$$\log PGV = 0.58M_w + 0.0031D + d - \log X_{eq} - 0.002X - 1.25$$

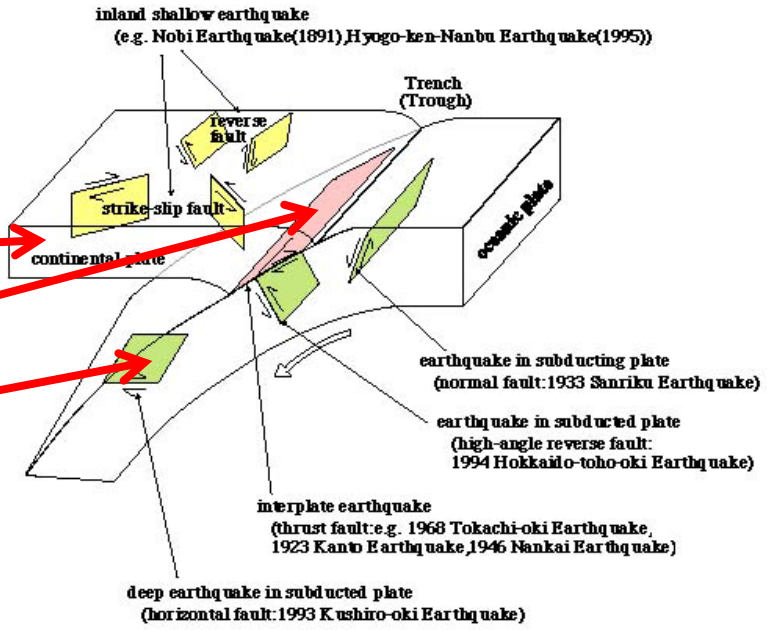
where X, M_w show EHD, and moment magnitude, respectively. D is focal depth represented by the depth of the center of a fault plane. d shows is defined as bellow:

d=

0.0 for crustal

0.06 for inter-plate

0.16 for intra-plate

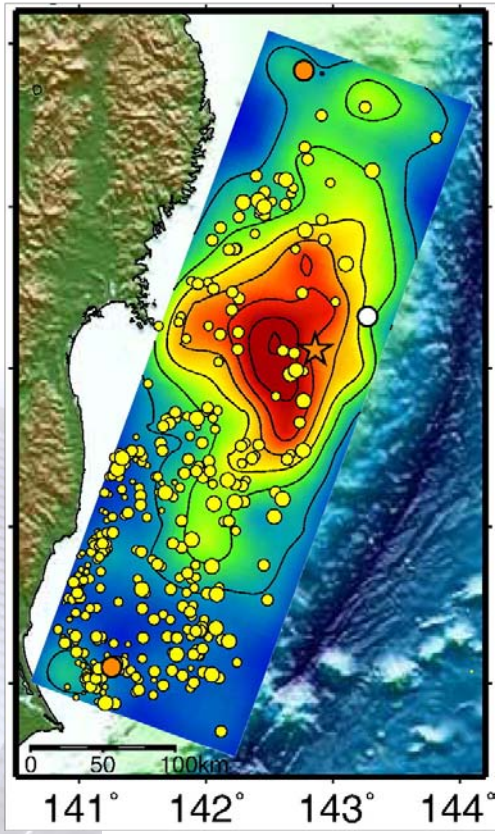


Si and Midorikawa (1999) is defined on stiff ground with Vs30=600m/s

http://www.hp1039.jishin.go.jp/eqchreng/f2-18.htm

Calculation of Ehd

Slip model by Koketsu et al.(2011)



Definition of Ehd

$$X_{eq} = \sqrt{\frac{\sum M_i^2}{\sum \frac{M_i^2}{X_i^2}}}$$

Summary

- Attenuation model for PSHMs in Japan also can be applied to the strong motion data world wide
- When using closest distance to the fault plane, additional saturation for M should me considered in an attenuation model. Fortunately, this saturation has been considered in the hazard map in Japan.
- the attenuation model using equivalent hypo. distance seems can be applied to a Mw9 mega-thrust earthquake.

FIN

Thank you !