Study on attenuation relations focused on near source region
-Evaluation of their applicability for earthquake early warning-

Kazuhiro Iwakiri, Mitsuyuki Hoshiba, and Kazuo Ohtake (Meteorological Research Institute, Tsukuba, Japan)

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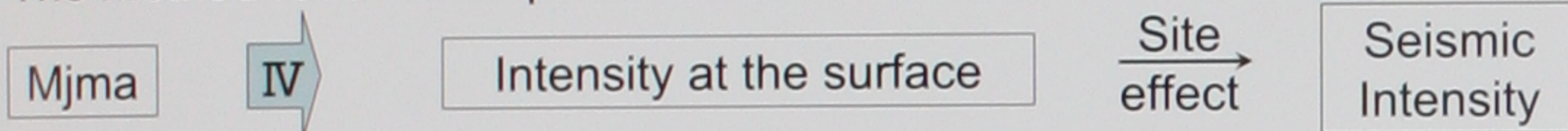2009.4.22 Poster No.15

1. Introduction

In the current earthquake early warning from Japan Meteorological Agency (JMA), the anticipation of seismic intensity is based on an empirical attenuation relation for peak ground velocity. This method uses Mw converted from Mjma by empirical relation, and seismic intensity converted from peak ground velocity by empirical relation. Therefore the predicted seismic intensity contains uncertainties of these two empirical relations. Using a seismic intensity empirical attenuation relation with Mjma, as these two empirical relations are not used, the improvement of prediction accuracy can be expected. In this study, we evaluated availability of the seismic intensity empirical attenuation relation within near source region with comparing the current EEW method from JMA.

The methods for the anticipation of seismic intensity

·The current EEW from JMA

Mjma → Ⅰ → Mw → Ⅱ → PGV at the basement → Site effect → PGV at the surface → Ⅲ → Seismic Intensity
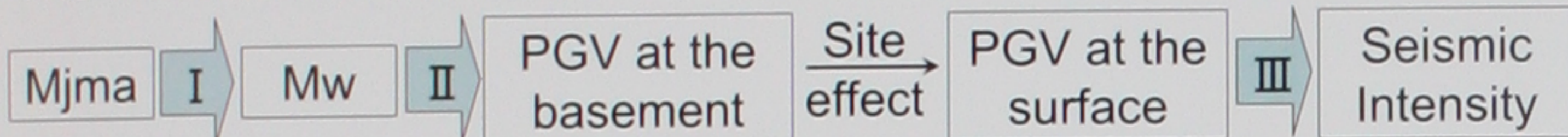
·The method reduced empirical relations

Mjma → Ⅳ → Intensity at the surface → Site effect → Seismic Intensity

The empirical relations : (Ⅰ) Utsu (1982); (Ⅱ) Si and Midorikawa (1999); (Ⅲ) Midorikawa et al. (1999); (Ⅳ) e.g., Matsusaki et al. (2005).

2. Data

Seismic intensity stations

Epicenter (N=45)
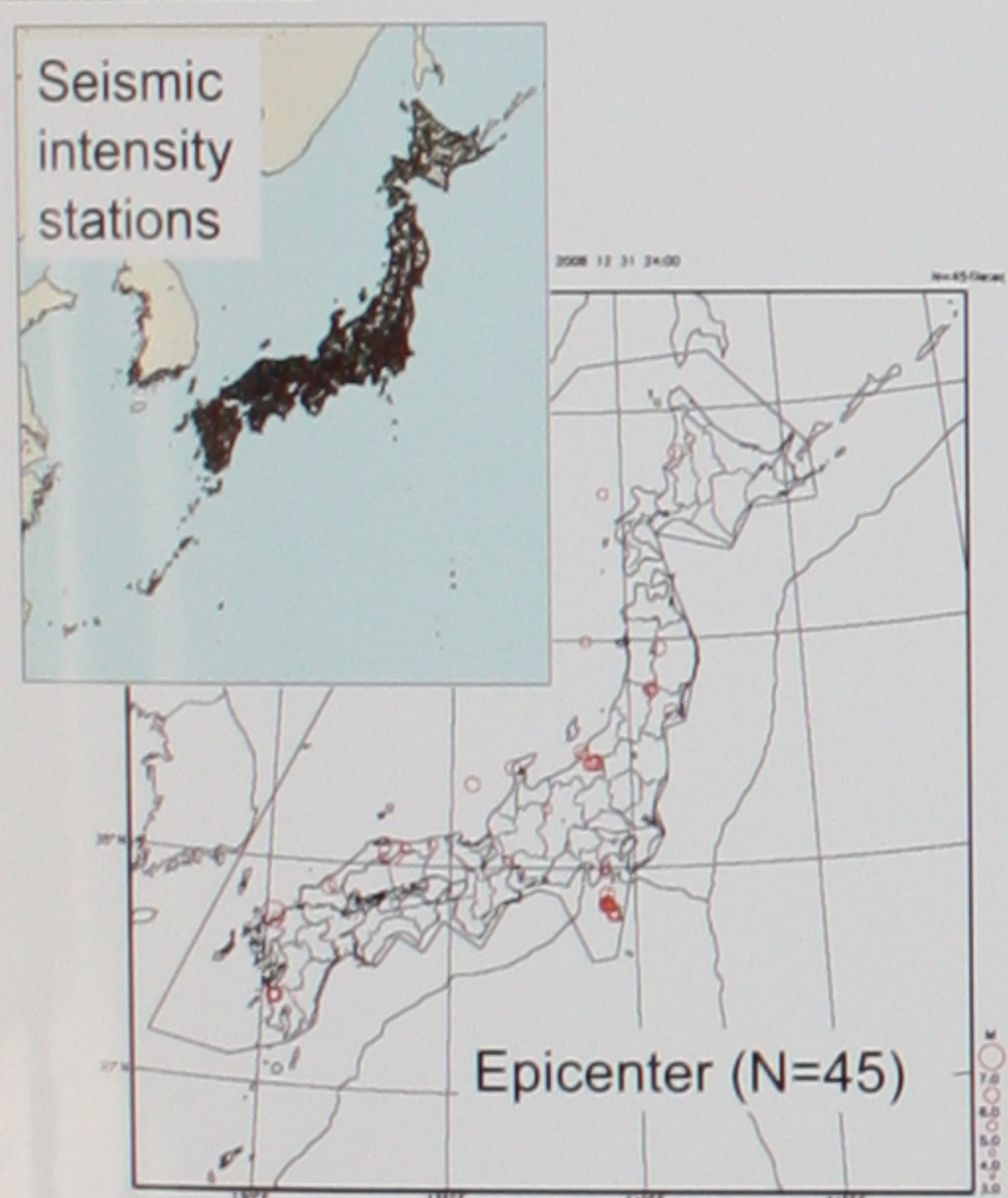
➤Earthquake:
· May 1996 – July 2008
· Mjma≧5.5
· Focal depth≦30km

➤Seismic intensity station:
K-NET, JMA and Local government

We used seismic intensity data within 100km from fault plane or Hypocenter. Nine earthquakes were used shortest distance to the fault plane. Mw was from the CMT catalog of JMA.
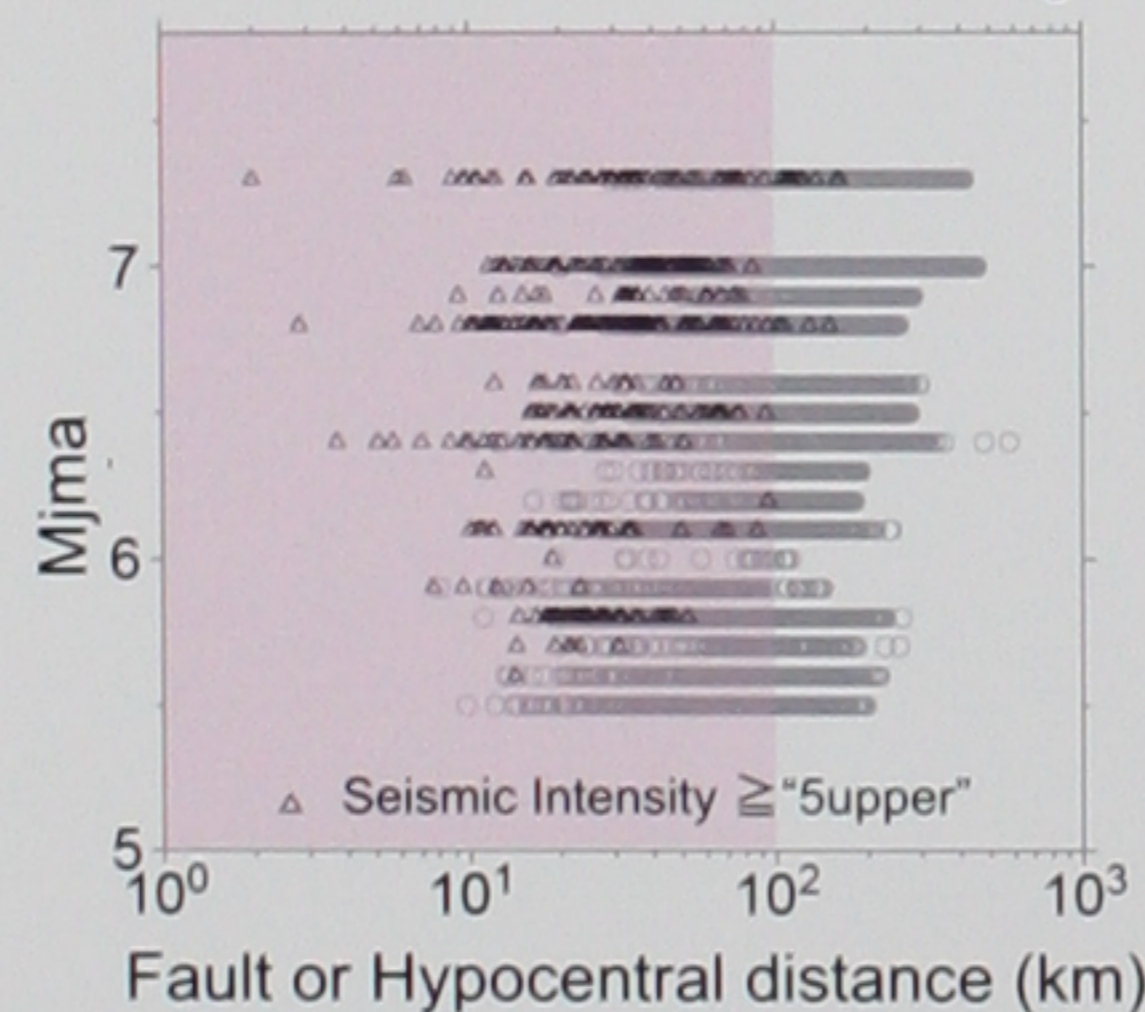
3. Method

We adopted Morikawa et al. (2007) and Matsusaki et al. (2006) as a seismic intensity empirical attenuation relation. The amplification factor of stations was not applied to the anticipation. We focused on the distance dependencies of seismic intensity residual (Io-Ic).

➤ Si and Midorikawa (1999) which is the current EEW method from JMA

$$\log(PGV_{600}) = 0.58\,Mw + 0.0038\,D - 1.29 - \log(x + 0.0028 \cdot 10^{0.5Mw}) - 0.002\,x$$

Seismic intensity ← PGV_{600} by empirical method of Midorikawa et al. (1999) or Fujimoto and Midorikawa (2005), amplification factor was not applied in this study.

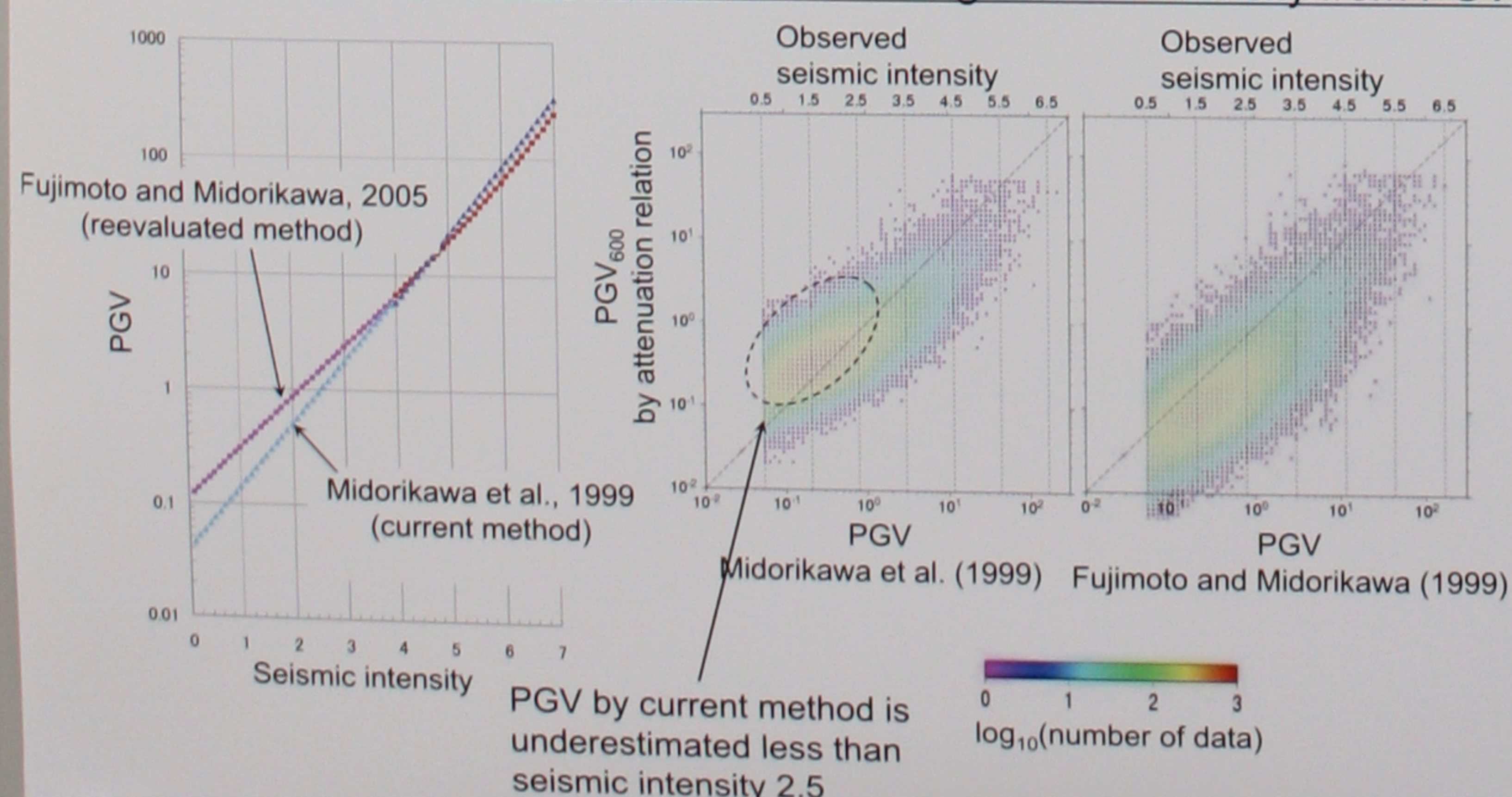➤Morikawa et al.(2007) for shallow events (focal depth<30km)

Seismic intensity = $2(0.63\,Mw - 0.0018\,x - \log(x + 0.003 \cdot 10^{0.5Mw}) - 0.24)$

➤Matsusaki et al.(2006)

Seismic intensity = $1.36\,Mjma - 4.03\log(x + 0.00675 \cdot 10^{0.5Mjma}) + 0.0155\,D + 2.05$

where Mw: moment magnitude, Mjma:JMA magnitude, x:distance from fault plane, and D: focal depth.

Characteristic of empirical methods for estimating seismic intensity from PGV

Fujimoto and Midorikawa, 2005 (reevaluated method)

Midorikawa et al., 1999 (current method)

Observed seismic intensity

PGV Midorikawa et al. (1999)

PGV Fujimoto and Midorikawa (1999)

PGV by current method is underestimated less than seismic intensity 2.5

$\log_{10}$(number of data)

4. Analysis and Results

The Io-Ic derived by Morikawa et al. (2007) and Si and Midorikawa (1999) had the distance dependencies. When the distance dependency of Io-Ic exists, it leads to inappropriate influence when estimating the empirical site amplification. Morikawa et al. (2007) and Matsusaki et al. (2006) had about the same RMS of Io-Ic for all data. Matsusaki et al. (2006) had constant Io-Ic with distance, and it was available for earthquakes which do not hold good for the empirical relation of Utsu (1982) for the case that Mj is much larger than Mw.

Relationships between residual (Io-Ic) and fault or hypocentral distance

Si and Midorikawa(1999) + Midorikawa et al.(1999)
Si and Midorikawa(1999) + Fujimoto and Midorikawa(2005)
Morikawa et al.(2007)
Matsusaki et al.(2006)

Fault or Hypocentral distance (km)
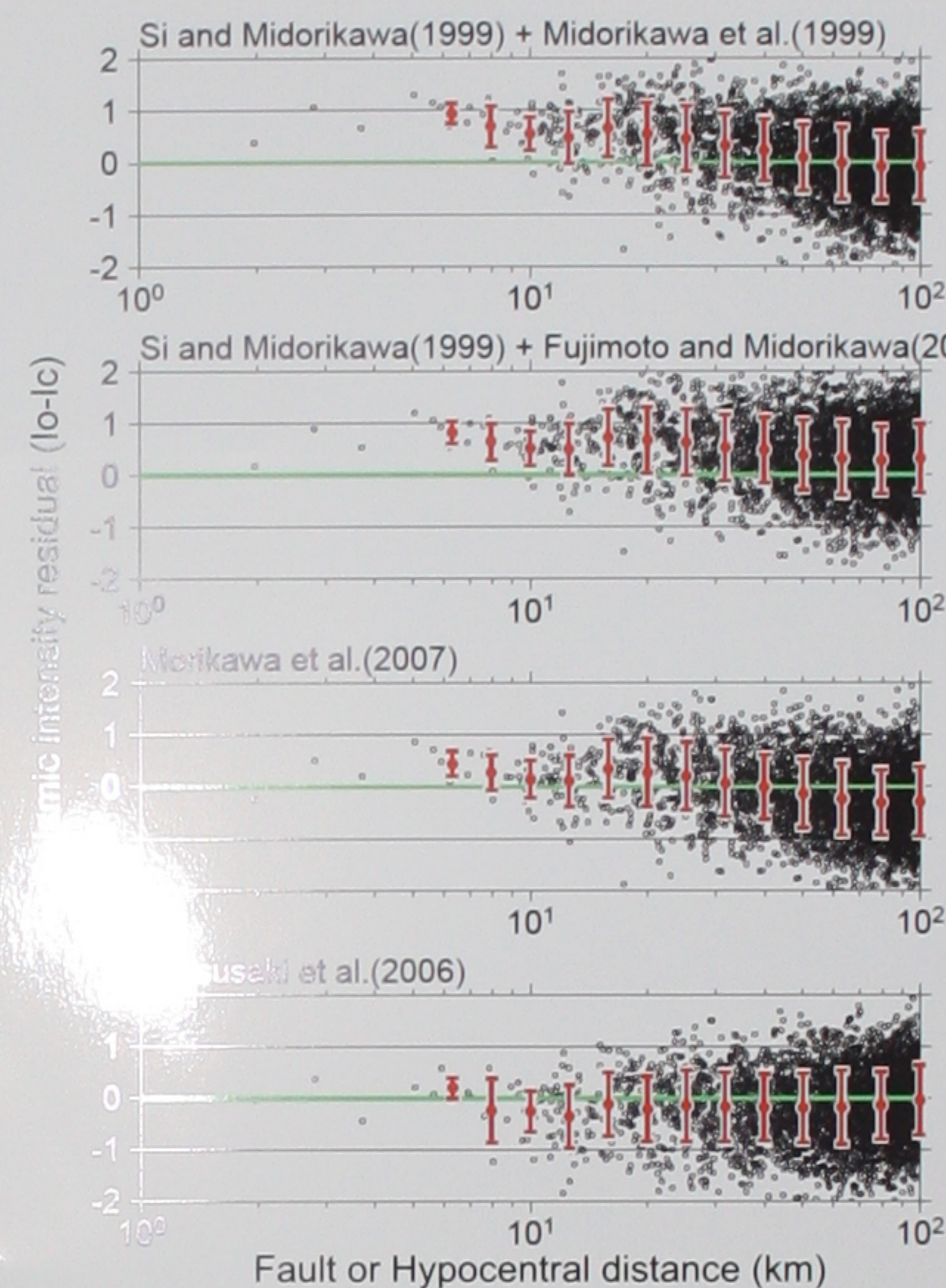
These relations had the distance dependencies for Io-Ic.

When the distance dependency of Io-Ic exists, it leads to inappropriate influence when estimating the empirical site amplification.

Matsusaki et al. (2006) had constant Io-Ic with distance

The solid circle and the vertical bar show an average residual of a sectioned area and the range of ± standard deviation, respectively.
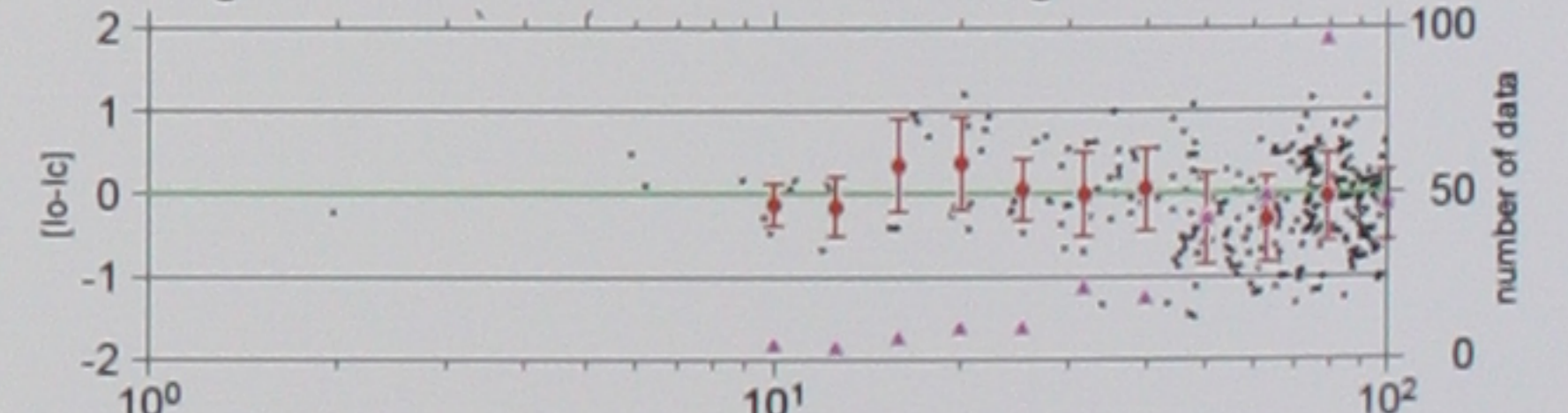
The anticipation of seismic intensity for earthquakes which do not hold good for the empirical relation
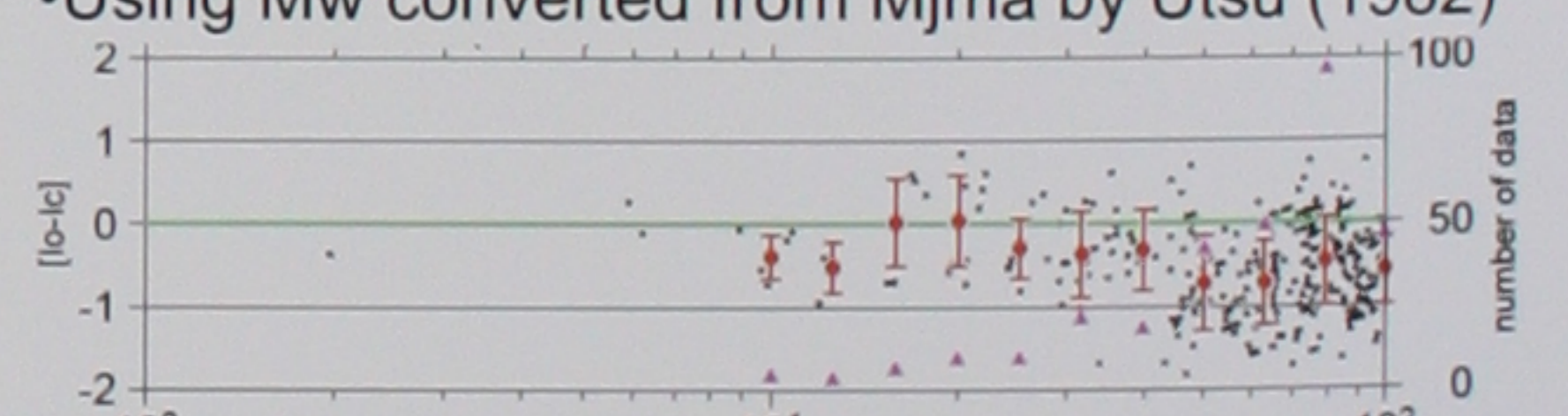

0.171 (Utsu, 1982)
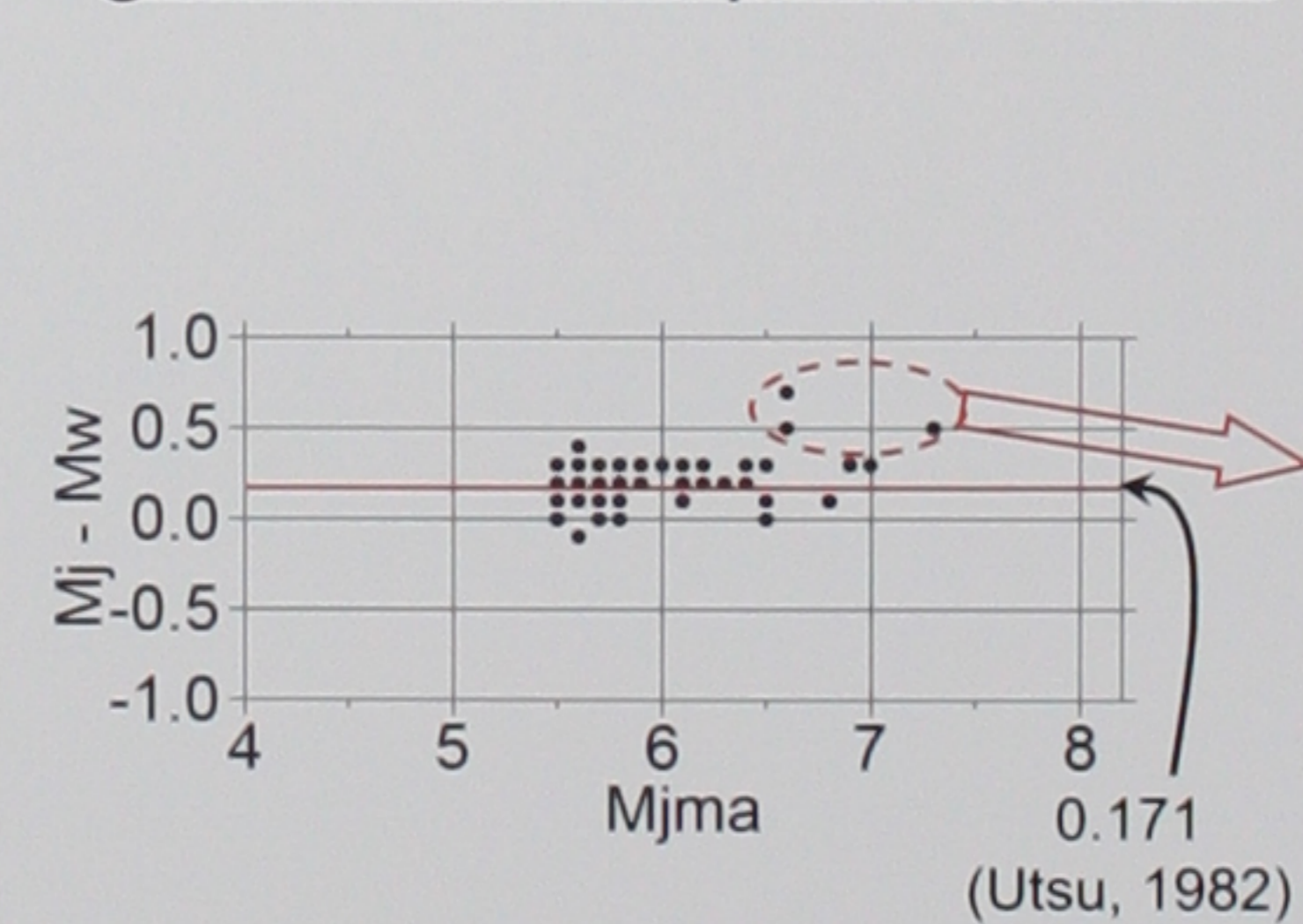
The anticipation of seismic intensity that used directly Mw or Mj was higher accuracy than using the empirical relation between Mw and Mjma.

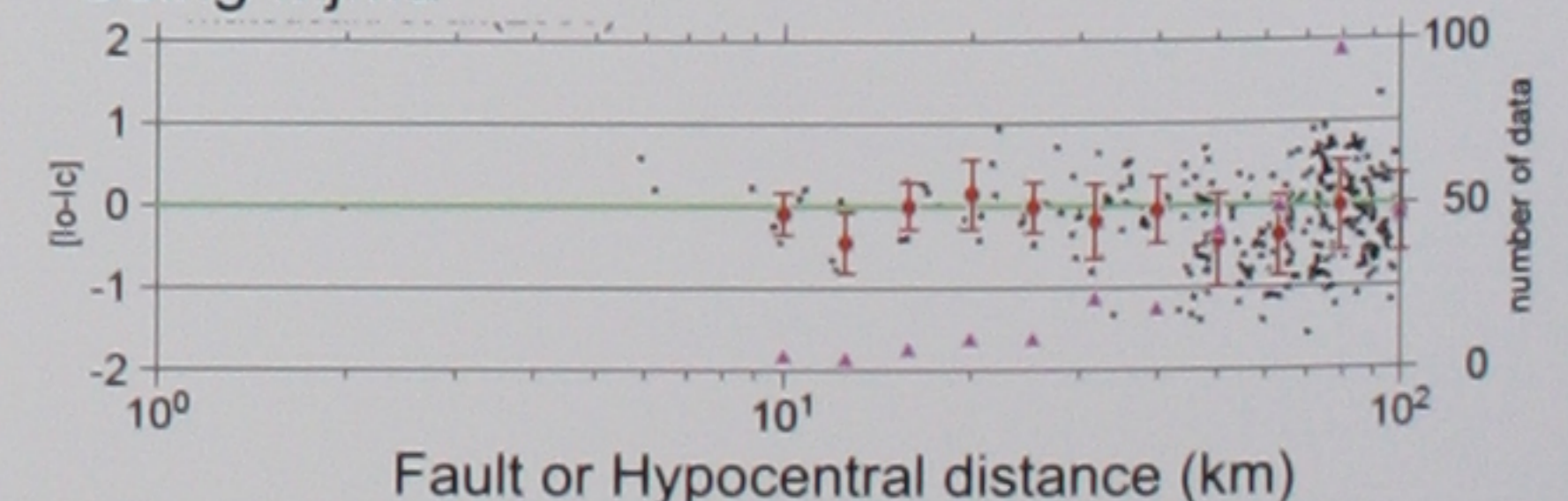➤Morikawa et al.(2007)
·Using Mw from the CMT catalog of JMA
·Using Mw converted from Mjma by Utsu (1982)

➤Matsusaki et al.(2006)
·Using Mjma

Fault or Hypocentral distance (km)

5. Conclusion

We evaluated availability of the several empirical attenuation relations using seismic intensity data within near source region of inland shallow earthquakes (Mjma≧5.5). The anticipation of seismic intensity in current EEW from JMA had the distance dependences as it uses the empirical relation between seismic intensity and PGV. The anticipation that used directly Mw or Mj was higher accuracy than using the empirical relation between Mw and Mjma. Using a seismic intensity empirical attenuation relation with Mjma, its anticipated seismic intensity didn't have the distance dependences. As this result leads to appropriate influence when estimating the empirical site amplification, improvement of prediction accuracy by its method can be expected compared with current EEW method.

Reference

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Utsu, T. (1982) Relationships between earthquake magnitude scales (in Japanese), Bull. Eqrthq. Res. Inst., 57, 465-497.

Matsusaki, S., Y. Hisada, and Y. Fukushima (2006), Attenuation relation of JMA seismic intensity applicable to near source region (in Japanese), J. Struct. Constr. Eng.,Trans. Archit. Inst. Jpn., 604, 201-208.

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