

Uncertainty of anticipation of seismic intensities

-A study of fluctuation of anticipated seismic intensities by the method of current JMA Earthquake Early Warning –

JMA intensity

Mitsuyuki HOSHIBA, Kazuo OHTAKE, Kazuhiro IWAKIRI

(Meteorological Research Institute, Japan)

Tamotsu AKETAGAWA (Japan Meteorological Agency)

Hiromitsu NAKAMURA (National Research Institute for Earth Science and
Disaster Prevention, Japan)

Shunroku YAMAMOTO (Railway Technical Research Institute, Japan)

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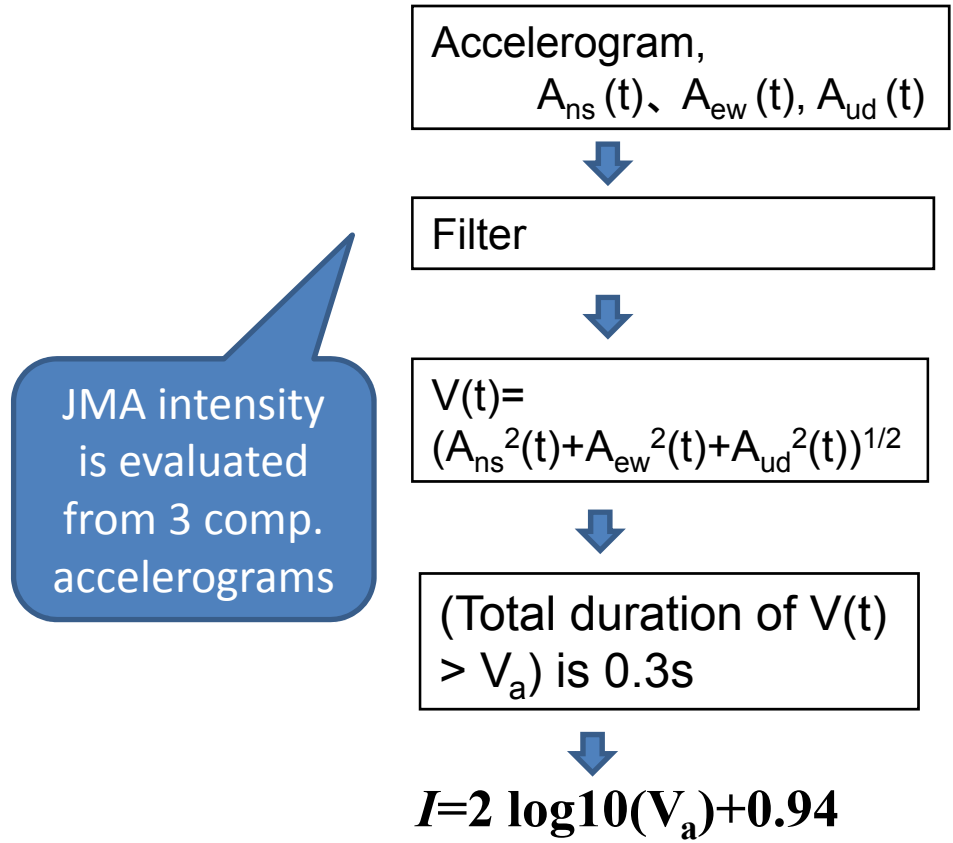
Anticipated Seismic Intensity = f (Source Factor, Path Factor, Site Factor)

At Present

- | |
|---|
| <p>○ Source Factor : 1 scalar (for example; Magnitude)</p> <p>○ Path Factor : Attenuation relation</p> <p>○ Site Factor : 1 scalar</p> |
|---|

Without consideration of spectrum contents *Meteorological Res. Inst., Japan*

JMA seismic Intensity



Approximate Relation between JMA Intensity scale and Modified Mercalli scale

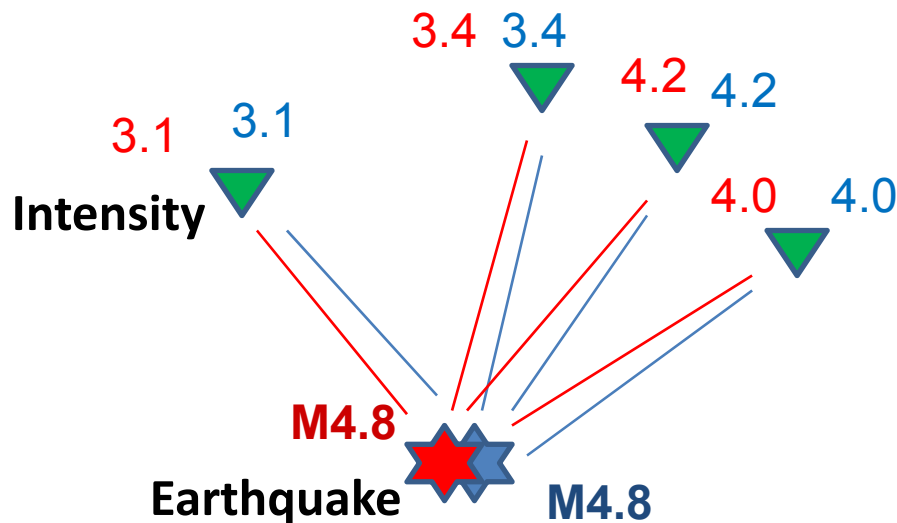
JMA	0	1	2	3	4	5 L	5 U	6 L	6 U	7
Modified Mercalli	1	2	3	4	5	6	7	8	9	10, 11, 12

Method for anticipation of Seismic Intensity used in JMA Earthquake Early Warning

1. Estimation of PGV from attenuation relation (Si and Midorikawa, 1999) using Magnitude, Hypo. Dist. and Depth
2. (PGV at surface)=(PGV at basement) \times site factor
3. JMA intensity= $2.68+1.72\log(\text{PGV at surface})$ \dots
Midorikawa et al, 1999

According to this idea,

Two Earthquakes occurred at the same place with the same magnitude



At each site,

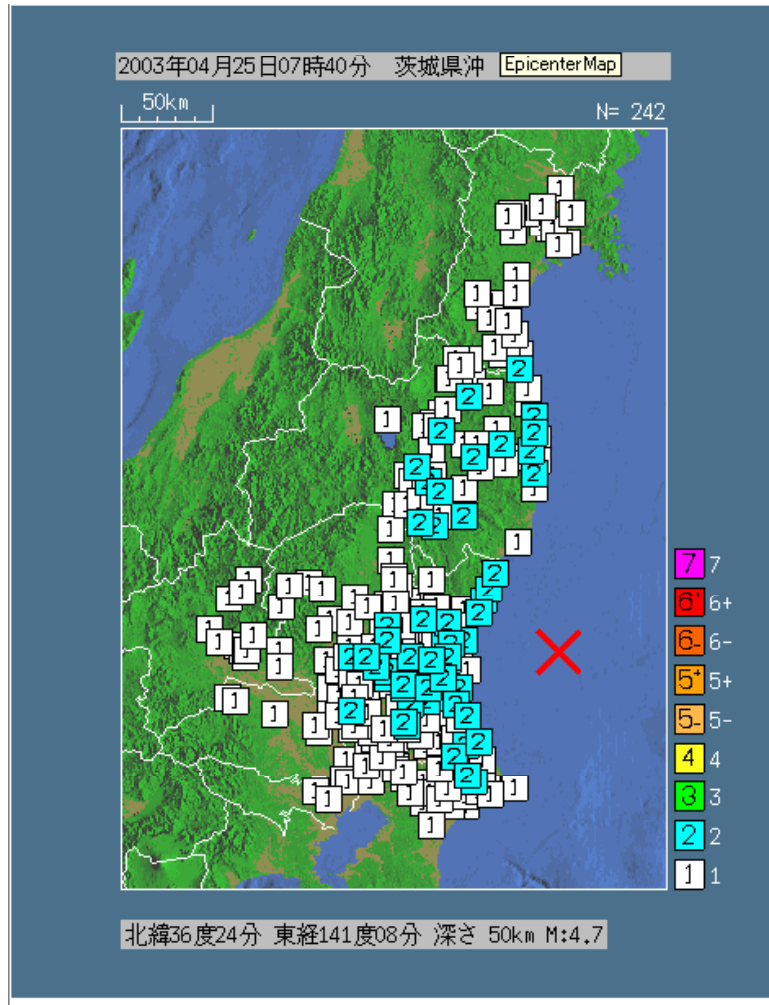
- paths are the same
- Site factors are the same

At each site, Intensities of the two earthquakes are expected to be the same!

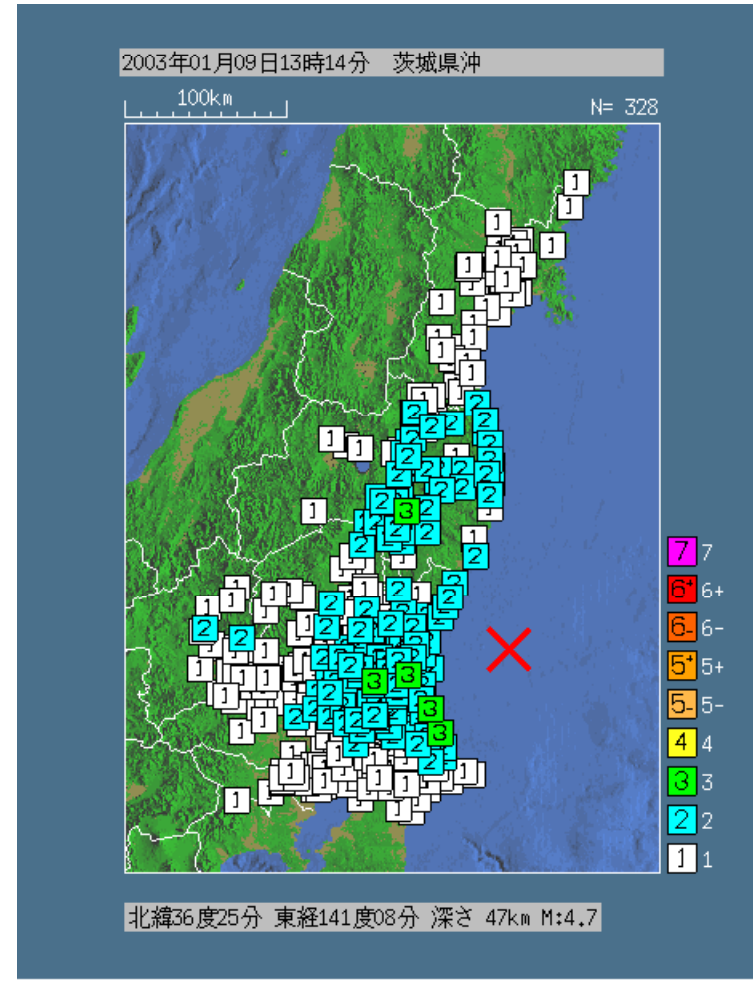


Really? or Not ?

In actual observation, even with the same magnitude ...

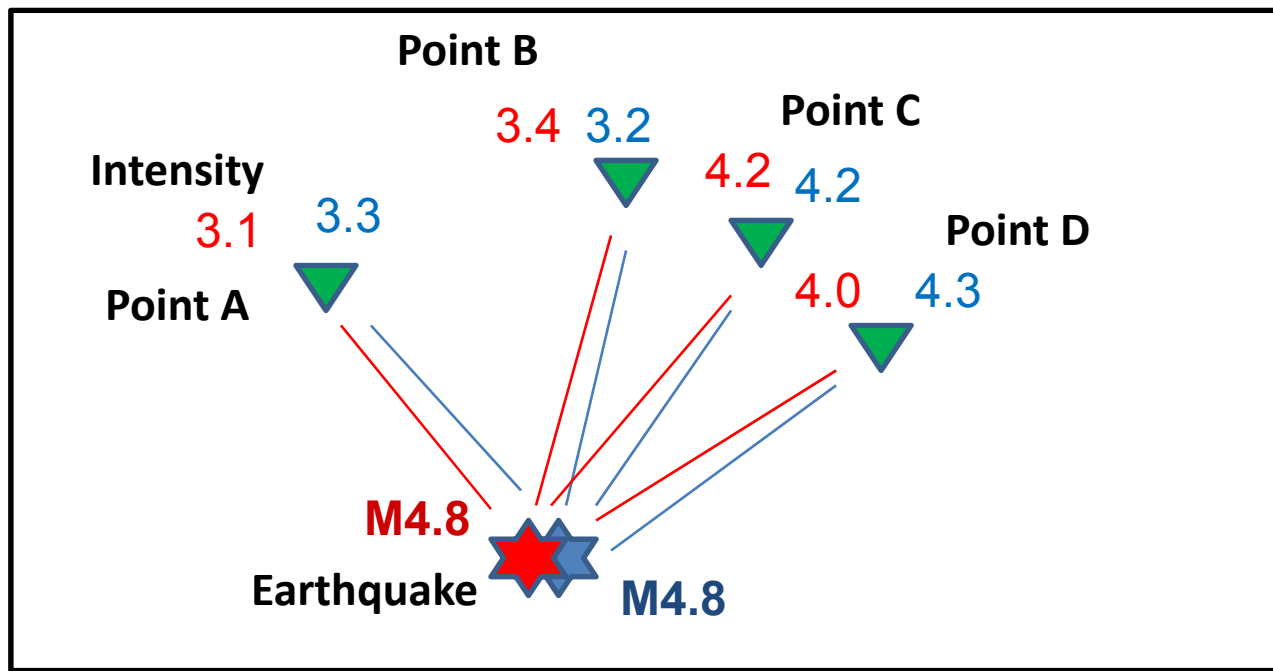


Even if the same magnitude,



Intensities are not always the same

From HP of JMA



How large fluctuation ?

Point A	3.1	—	3.3	=	-0.2
Point B	3.4	—	3.2	=	0.2
Point C	4.2	—	4.2	=	0.0
Point D	4.0	—	4.3	=	-0.3
...					



Investigated the distribution of fluctuation

Data

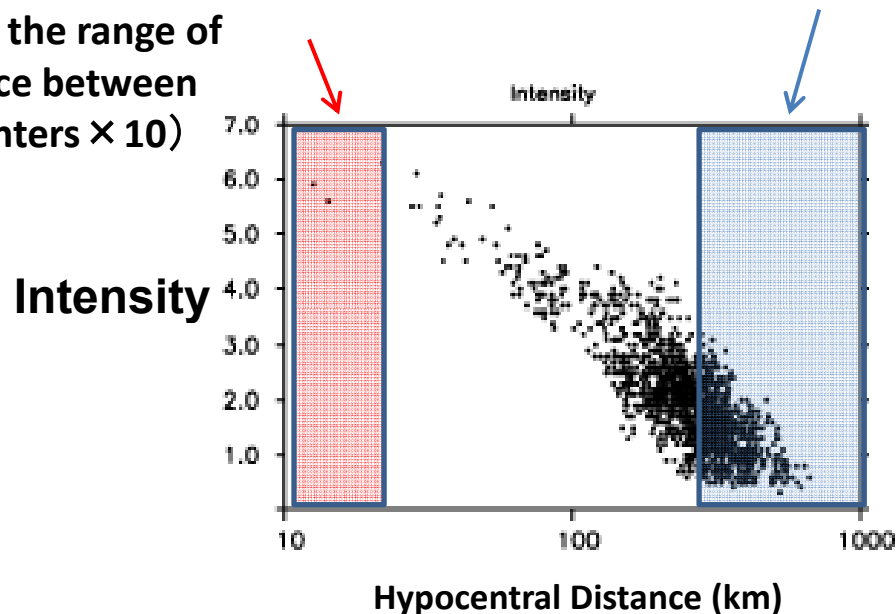
- Hypocenter and magnitude are from JMA unified catalogue
- Intensity observation by JMA, municipalities and NIED
- May, 1996 – July, 2007
- M3.5~5.5

Select of the earthquake pair

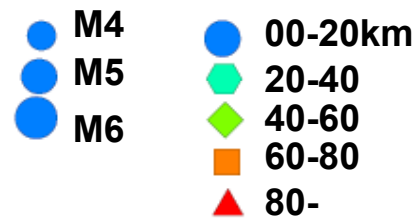
- Distance between those epicenters is less than 5km
- Difference of focal depth is less than 5km
- Having the same magnitude

Select of Intensity data

Exclude the range of
(distance between
hypocenters $\times 10$)

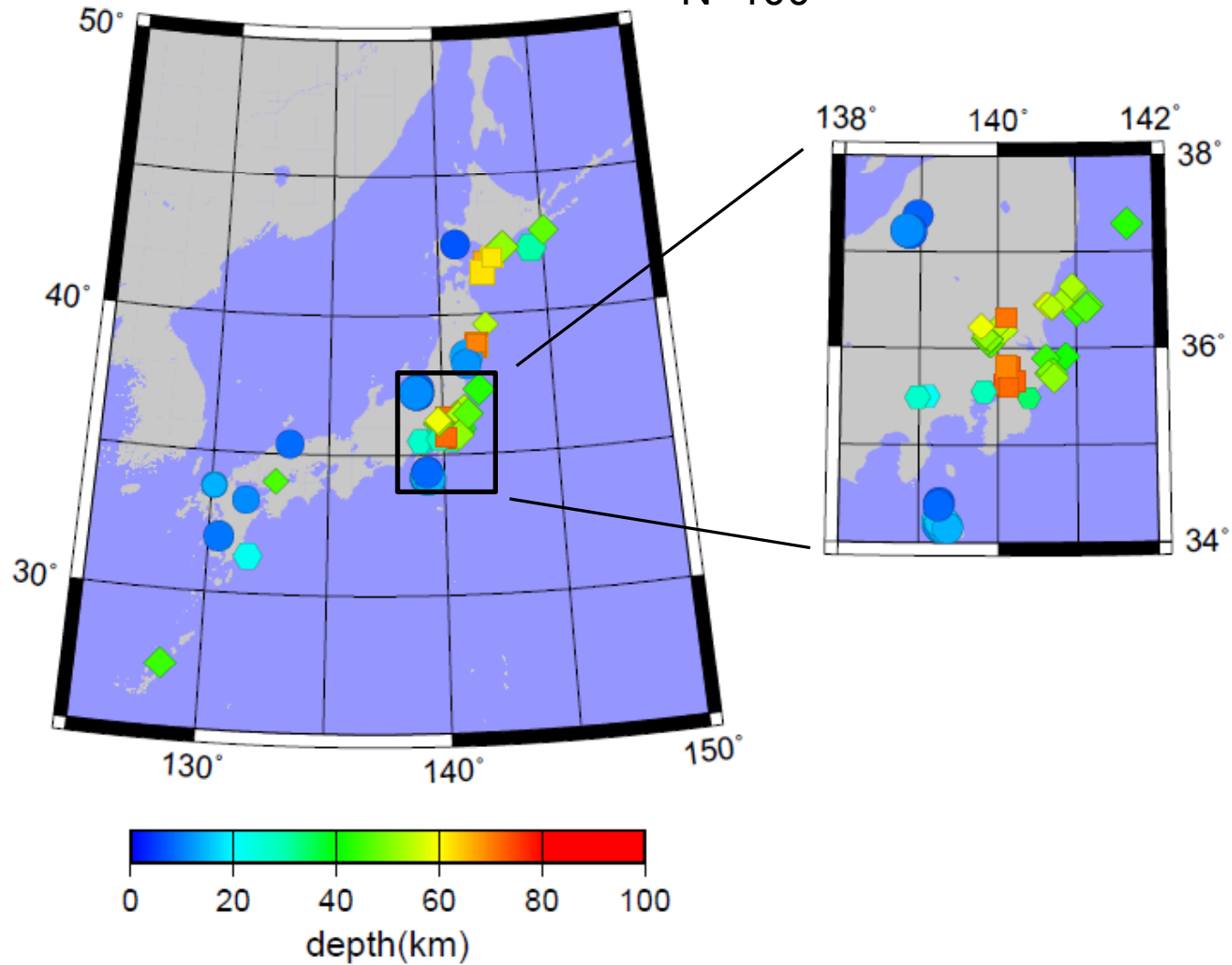


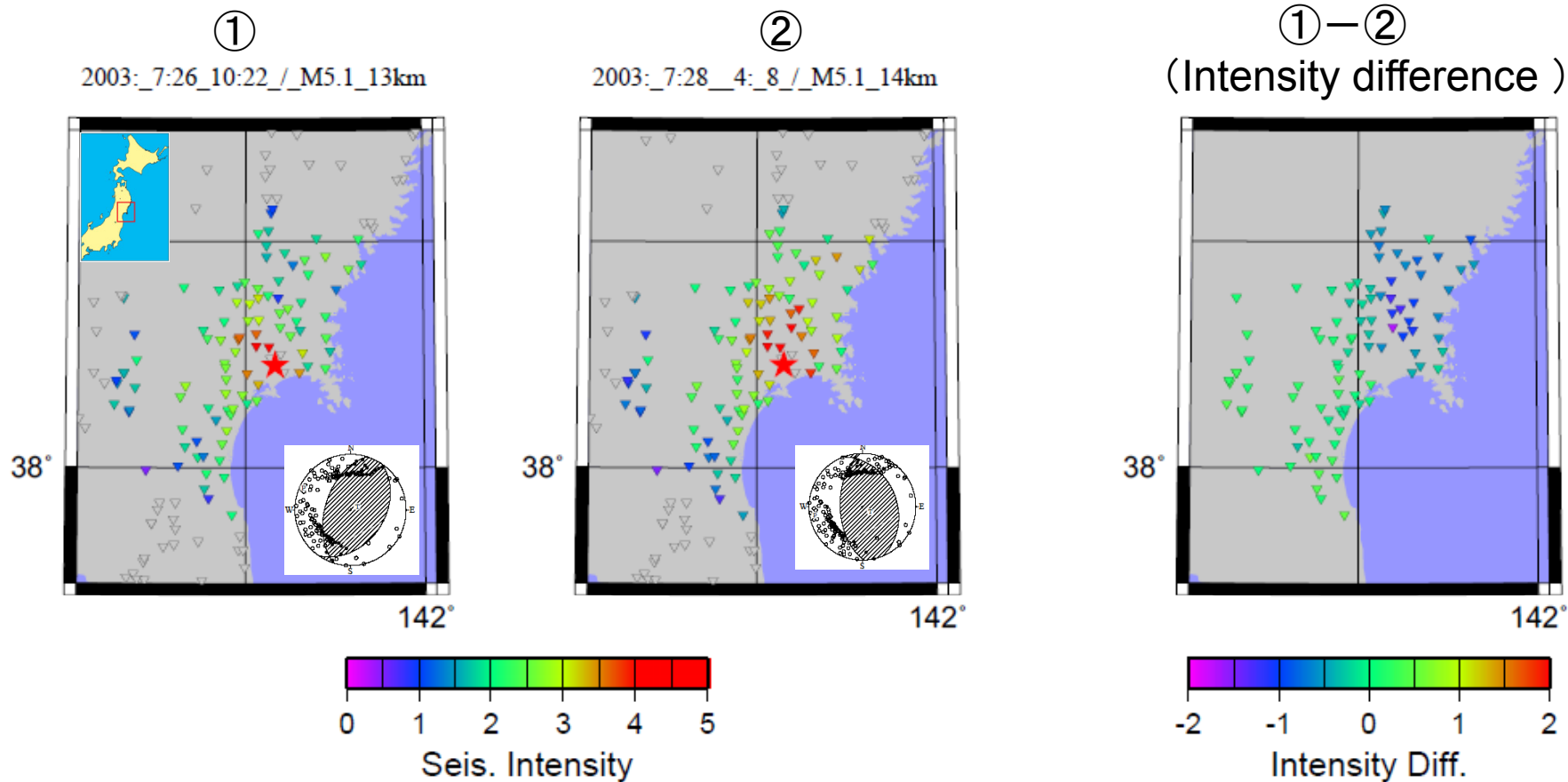
Exclude the range of
hypocentral distance at
which seismic intensity is
observed to be less than
0.6



- Same magnitude
- distance is less than 5km
- Focal depth difference is less than 5km
- Intensities are observed commonly more than 10 stations

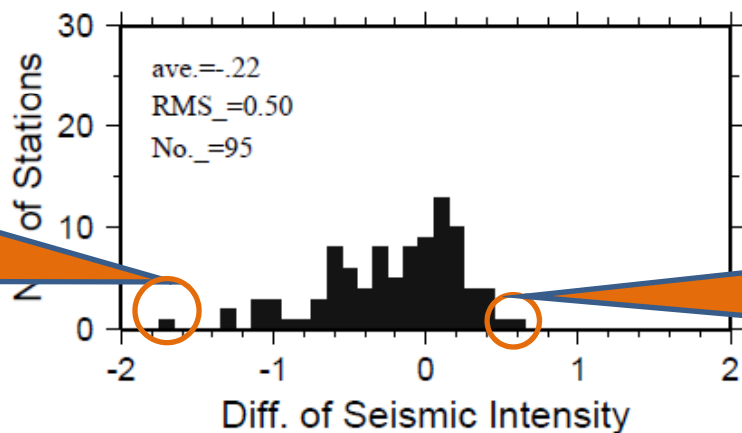
N=100





Distribution of Intensities

At this station, Intensity of earthquake ② is larger than ① by 1.7



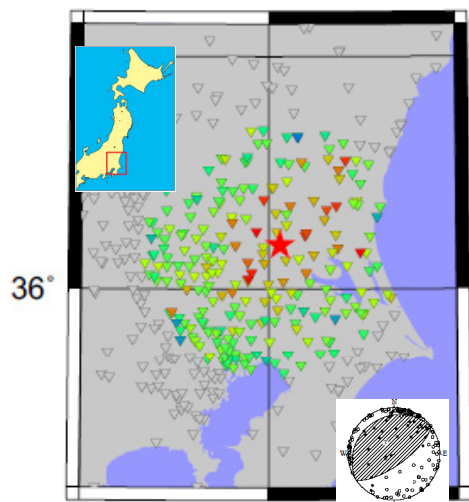
RMS: 0.50

Extent of uncertainty even when the earthquake occurred adjacently with the same magnitude

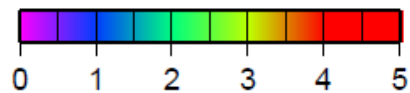
Intensity of earthquake ① is larger than ② by 0.6

①

2000: 4:10_ 6:30 / M4.8_55km



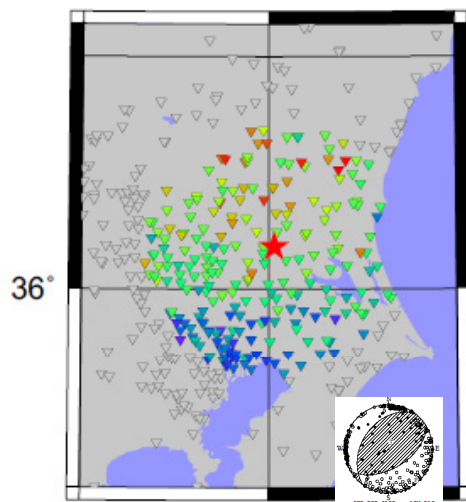
140°



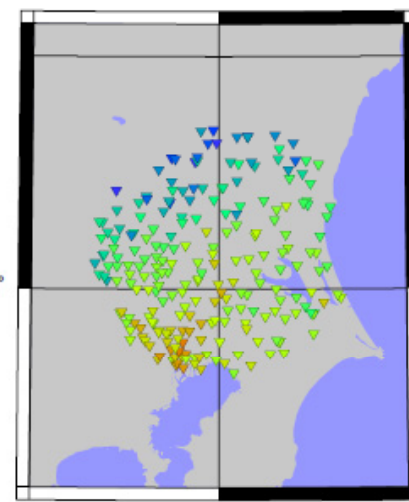
Seis. Intensity

②

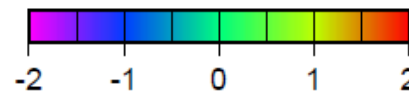
2005:12:28_18:46 / M4.8_53km



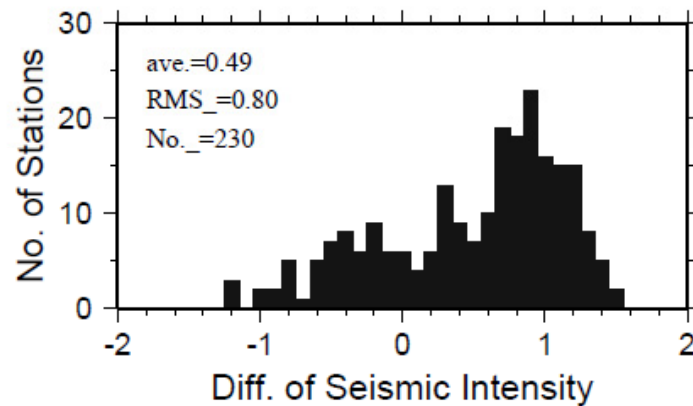
140°



140°



Intensity Diff.

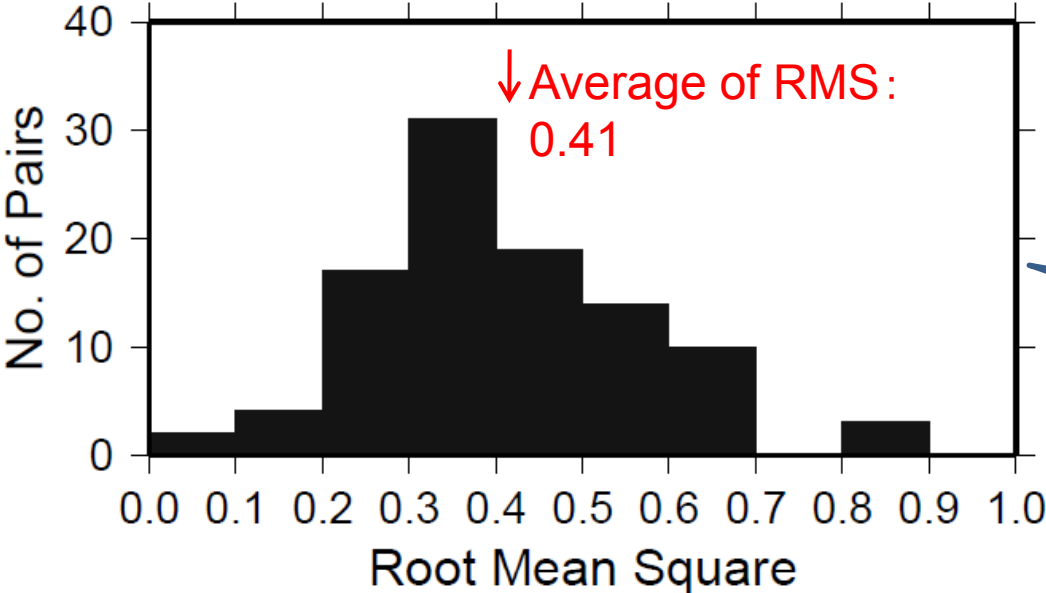


Distribution of
Intensity difference
RMS: 0.80

- Same magnitude
- distance is less than 5km
Focal depth difference is less than 5km
- Intensities are observed commonly more than 10 stations

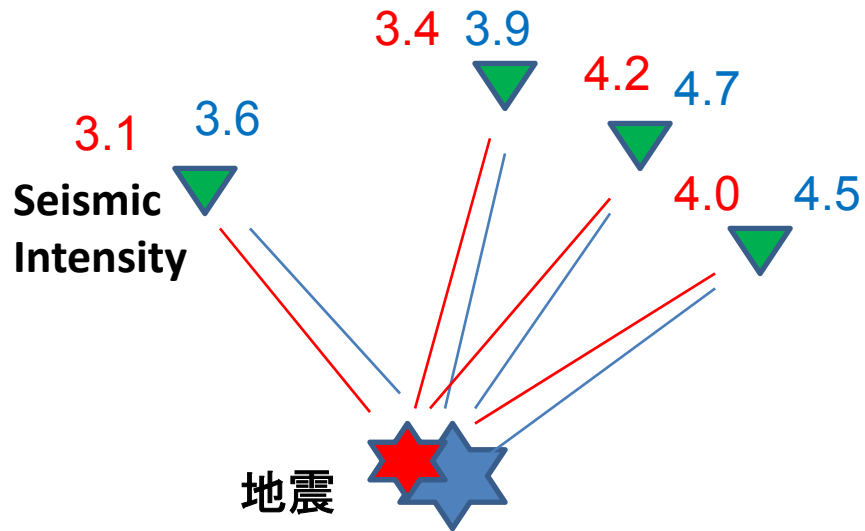
Histogram of RMS of Intensity Difference

N=100



Extent of uncertainty of intensity even when the magnitude, path and site are the same

Two Earthquakes occurred at the same place ~~with the same magnitude~~

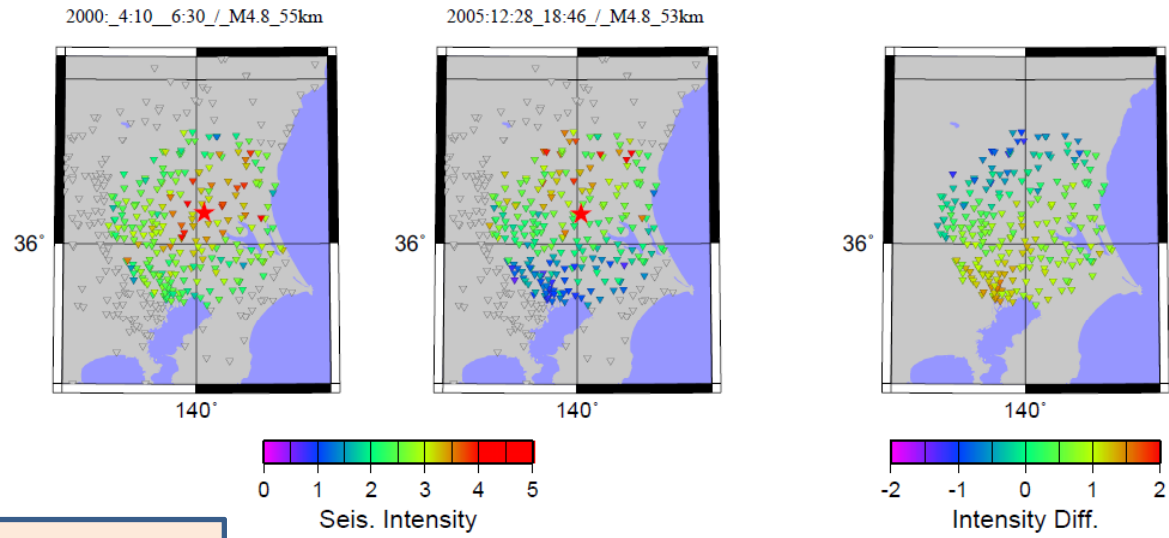


- At each site,
- paths are the same
 - Site factors are the same

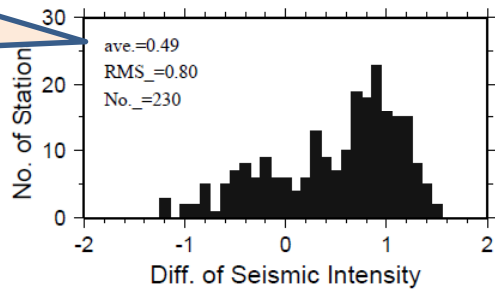
Difference of
At each site, Intensities of the two earthquakes are expected to be the same!



Really? or Not ?



AVE.=0.49
RMS=0.80
No._=230

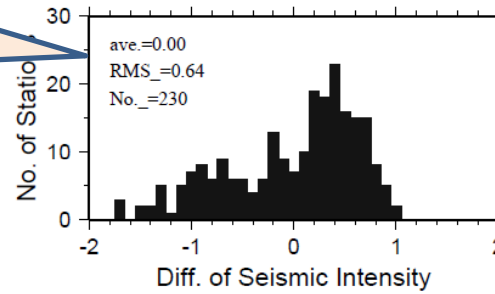


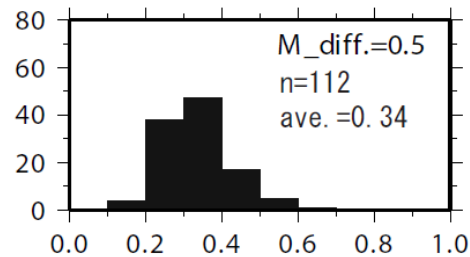
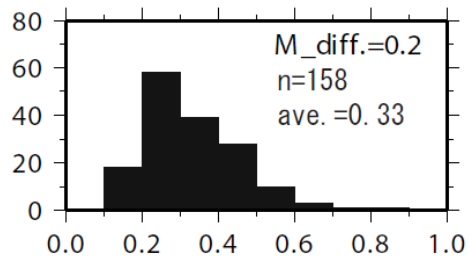
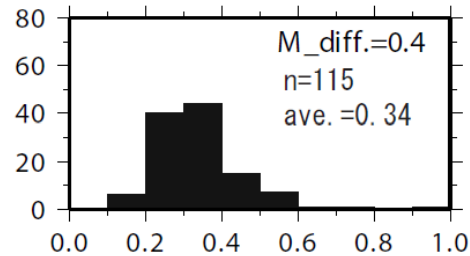
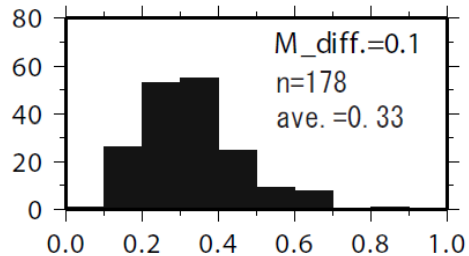
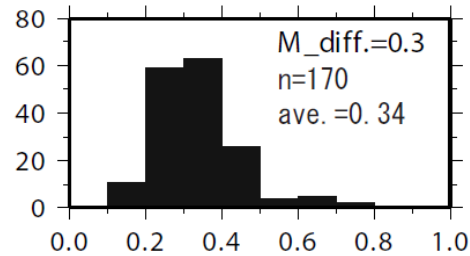
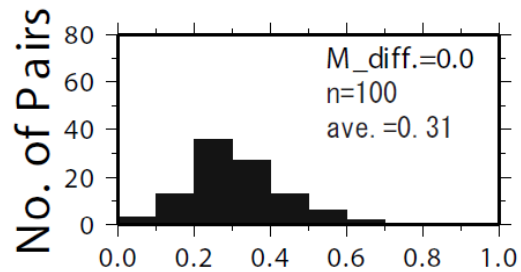
Removing
Inter-event
residual

← Shift by 0.49

Estimate the
RMS for each
pair of
earthquake

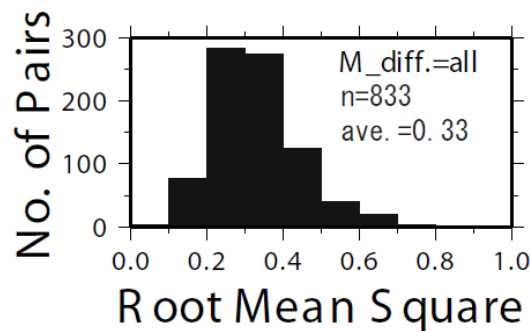
AVE.=0.00
RMS=0.64
No._=230





Root Mean S square

Root Mean S square



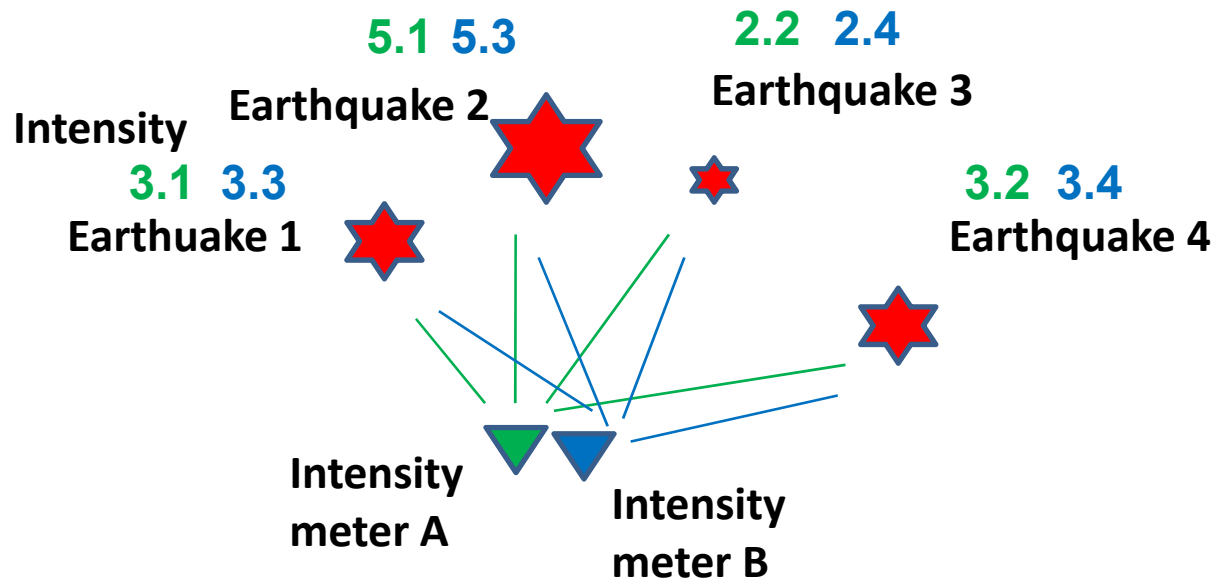
Root Mean S square

Magnitude is used as source factor

Average of RMS : 0.41 → 0.33

Average of Intensity difference is used as source factor

Two Seismic Intensity meters located adjacently



When Hypocentral distance is much larger than the distance between the 2 intensity meters

For each earthquake

- Source factor is same
- path is same

For each earthquake, difference of intensity is expected to be the same



Really? or Not ?

Data

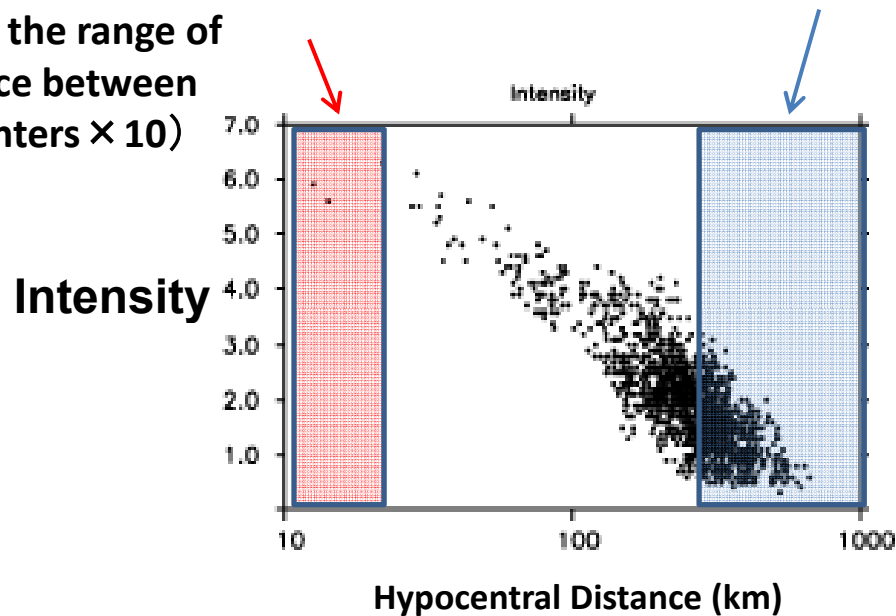
- Hypocenter and magnitude are from JMA unified catalogue
- Intensity observation by JMA, municipalities and NIED
- May, 1996 – July, 2007
- M3.5~5.5

Select of the pair of seismic intensity meter

- Distance between those intensity meters is less than 5km

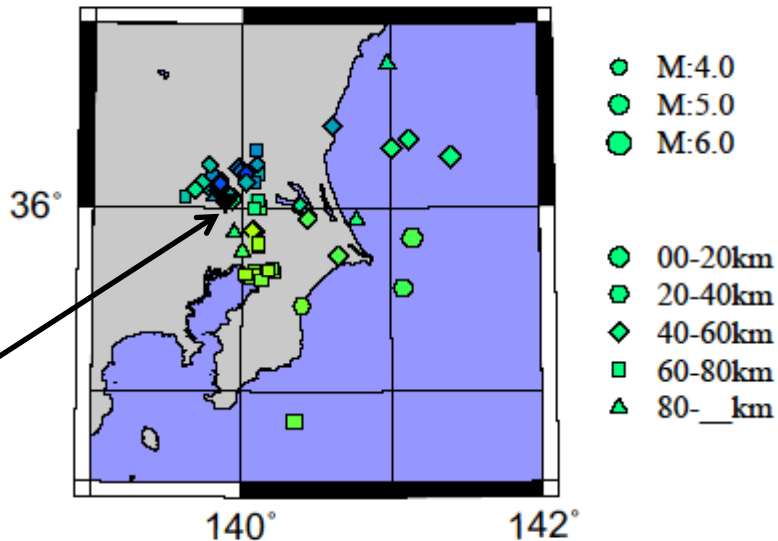
Select of Intensity data

Exclude the range of
(distance between
hypocenters $\times 10$)

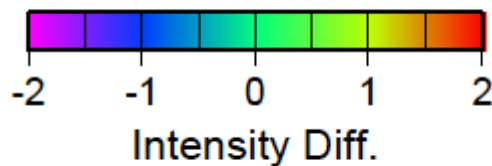


Exclude the range of
hypocentral distance at
which seismic intensity is
observed to be less than
0.6

Two Intensity meters



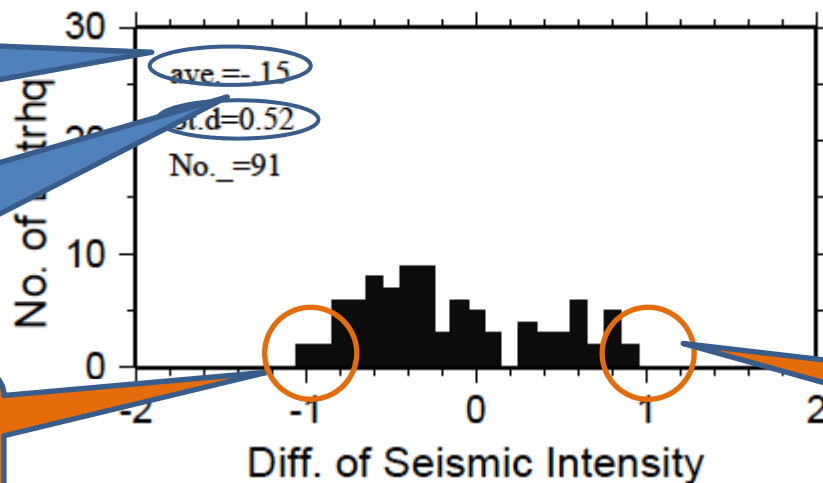
Distance between intensity meters : 0.9km



Average: -0.15
Difference of site factor

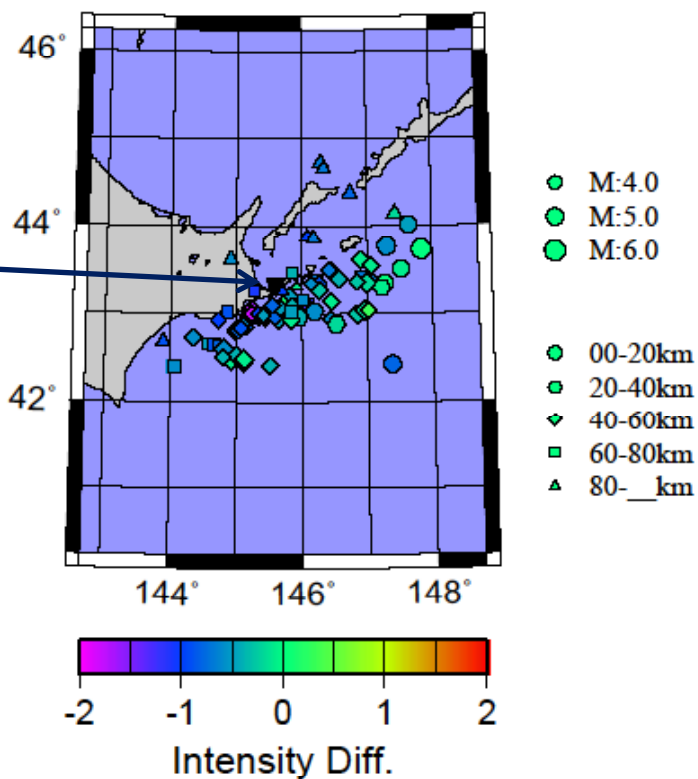
Standard deviation : 0.52
Fluctuation of seismic intensity

Intensity meter B is larger than A by 1.0



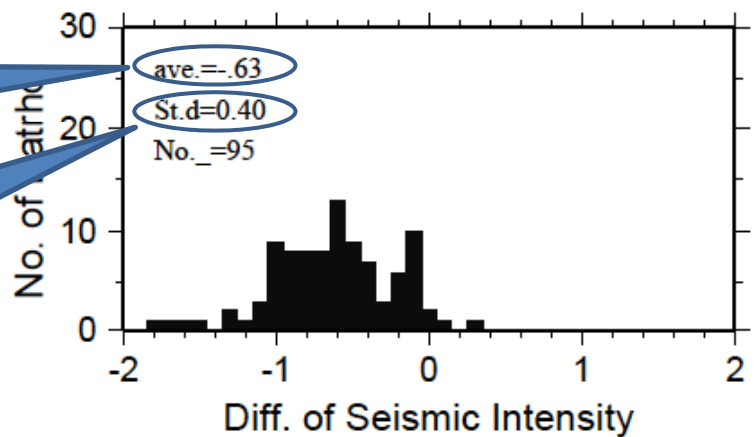
Intensity meter A is larger than B by 0.9

Distance
between Intensity
meters : 1.0km



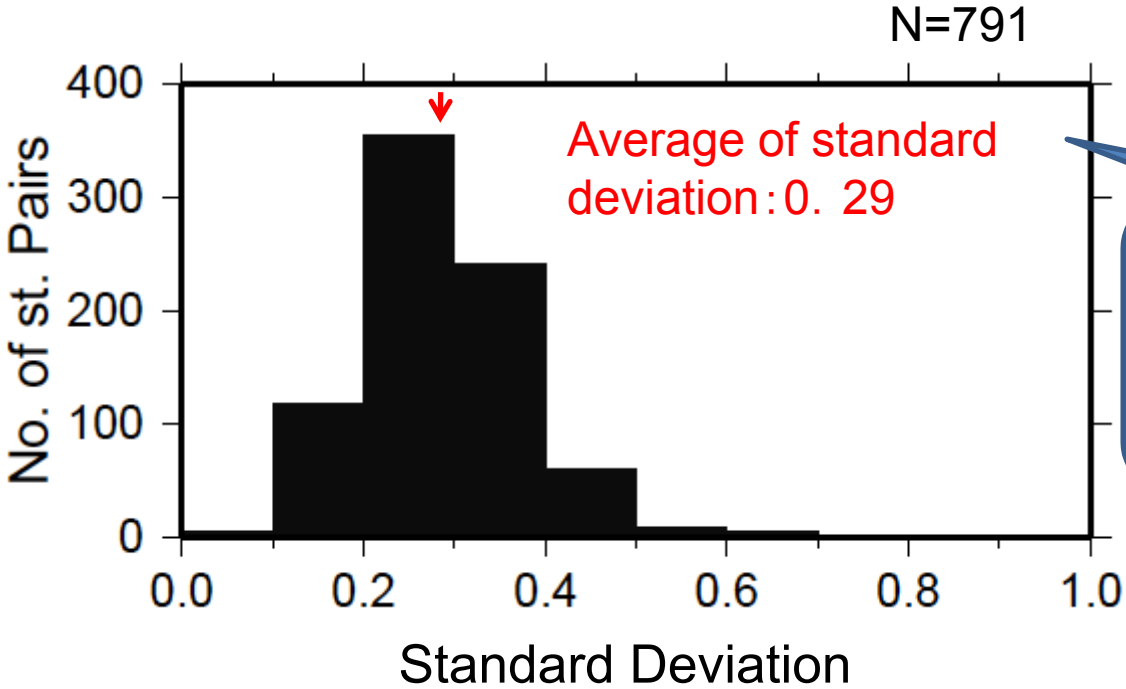
Average : -0.63
Difference of site
factor

Standard
deviation : 0.40
Fluctuation of
seismic intensity



- distance is less than 5km
- Intensities are observed commonly more than 10 stations

Histogram of standard deviation of intensity difference



Extent of uncertainty even when the sites located adjacently

Extent of uncertainty in anticipation of seismic intensity

Uncertainty in anticipation of seismic intensity when Source factor is represented by 1 scalar

Uncertainty (RMS) in case of same magnitude, same path, and same site $0.41 / \sqrt{2} = 0.29$



For source factor, Seismic intensity is used instead of magnitude $0.33 / \sqrt{2} = 0.23$



Uncertainty in anticipation of seismic intensity when Site factor is represented by 1 scalar

Uncertainty in case of same source, same path, and same site $0.29 / \sqrt{2} = 0.21$



In addition to these, uncertainty due to the attenuation relation should be considered