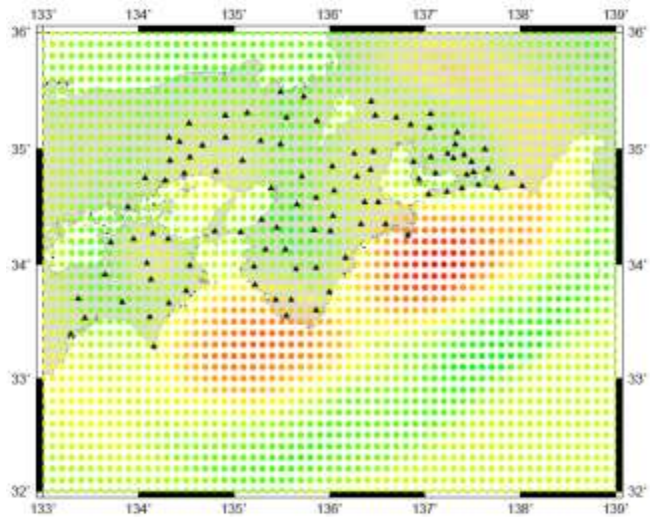
A Robust Method for Imaging Asperities of Large Earthquakes



Shunroku Yamamoto[1], Kimitoshi Ashiya[1],
Shinji Sato[1], Masahiro Korenaga[1], Shunta Noda[1],
Mitsuyuki Hoshiba[2] Kojiro Irikura[3],
and Yoshimitsu Fukushima[4]

1 Railway Technical Research Institute, 2 Meteorological Research Institute
3 Aichi Institute of Technology, 4 Shimizu Corp.

Outlines

1. Background of this study
2. Objective
3. Method
4. Analysis (blind test)
5. Conclusions

1. Background of this study

Earthquake Early Warning system (EEWs) became operation in 2007 in Japan

The EEWs in Japan provides…

1) hypocenter location
2) magnitude
3) origin time

We need…

1. More rapidness
2. More accuracy

1. Background of this study (cont.)

We are developing (applying…)

To have more rapidness, we need…

- More seismometers
- Faster data transmission
- Faster location algorithm
- Faster method to determine magnitude

To have more accuracy, we need…

- More proper parameters (method) to estimate strong-motion
- More underground information
- More information on seismic fault for very large earthquakes

home-seismometer (Horiuchi et al., 2007)

ocean bottom seismometer data (Wu et al., 2008)

tau-P (Allen and Kanamori, 2003)

seismic intensity magnitude (Yamamoto et al., 2007)

3-D Q structures (Wu et al., 2007)

near-source classification (Yamada and Heaton, 2007)

this study

2. Objective

1. To image asperities (≒centroid of intensity) of large earthquakes in real-time with high stability

2. To estimate accurate seismic intensity in an EEWs by using the asperity information

3. Method

Assumptions

1. The targets are very large (M>8) earthquakes

2. Seismic intensity is determined
by incoherent high-frequency waves
(=Waves from the most influential source region
for the site determine seismic intensity)

3. Attenuation relation of seismic intensity
magnitude (MI) is applicable

4. Network data can be used in real-time

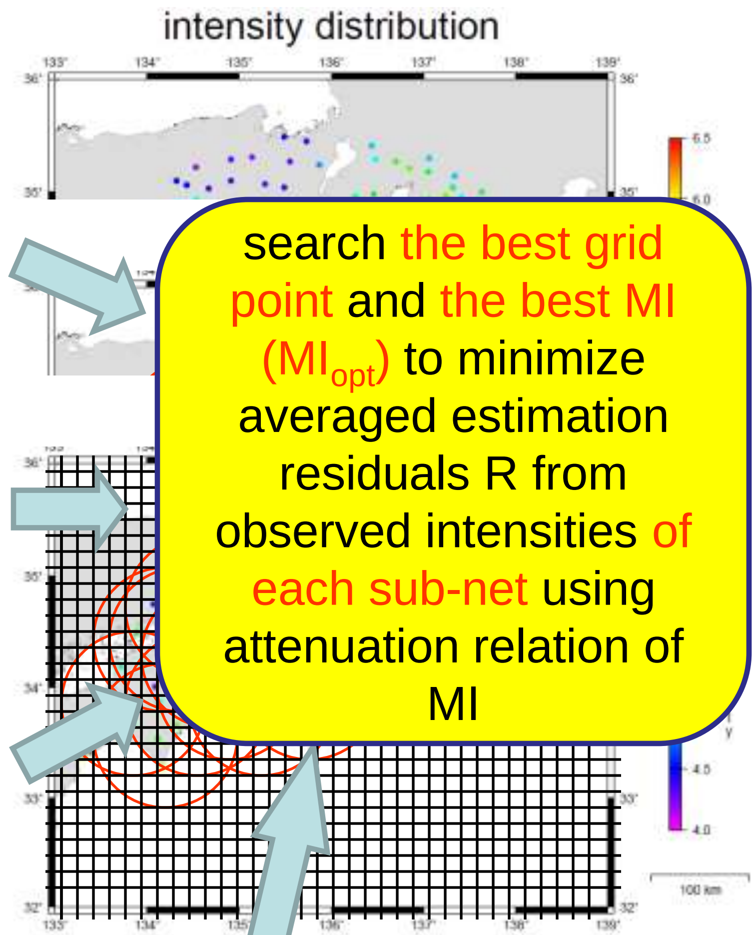
3. Method (cont.)

Original EEWs

- seismic waveforms
- locate hypocenter

Asperity imaging system

- calculate seismic intensity (I) at observed stations
- separate observed stations into neighboring groups(sub-net)
- set grid-points (candidates of asperity) around hypocenter



search the best grid point and the best MI (MI_{opt}) to minimize averaged estimation residuals R from observed intensities of each sub-net using attenuation relation of MI

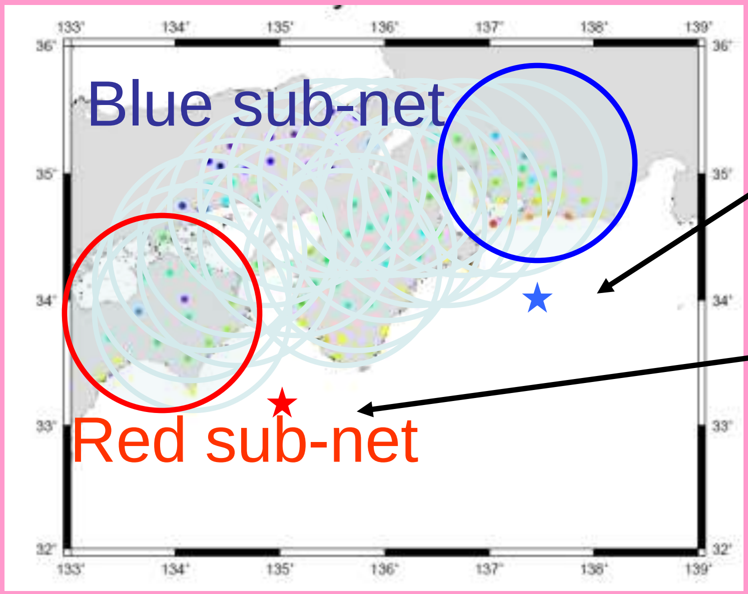
attenuation relation of MI (Yamamoto et al., 2007)

$$MI = I/2 + \log(r) + 0.012ts + 2.73$$

MI can be calculated from P or S-wave

3. Method (cont.)

What is the best grid point
and the best MI for each sub-net?



The best grid point and the best MI (MI_{opt}) to explain intensity distribution of the blue sub-net

The best grid point and the best MI (MI_{opt}) to explain intensity distribution of the red sub-net

Data of each sub-net determine the most influential source for the sub-net region.

3. Method (cont.)

Asperity imaging system 2

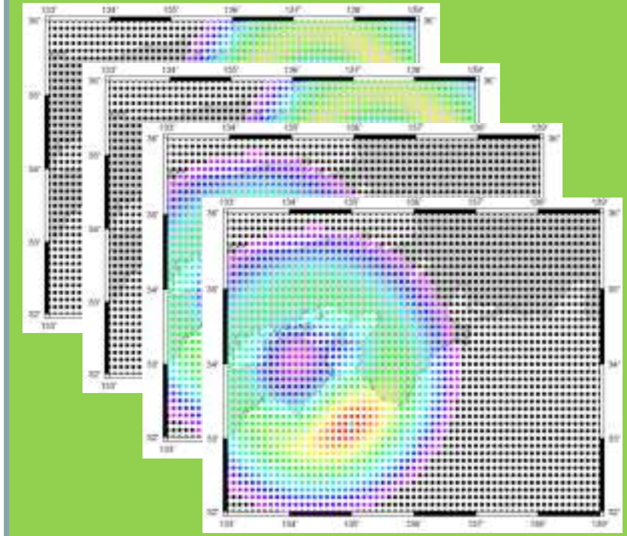
Plot R distribution for the sub-net j by constraining MI to be MI_{opt}.

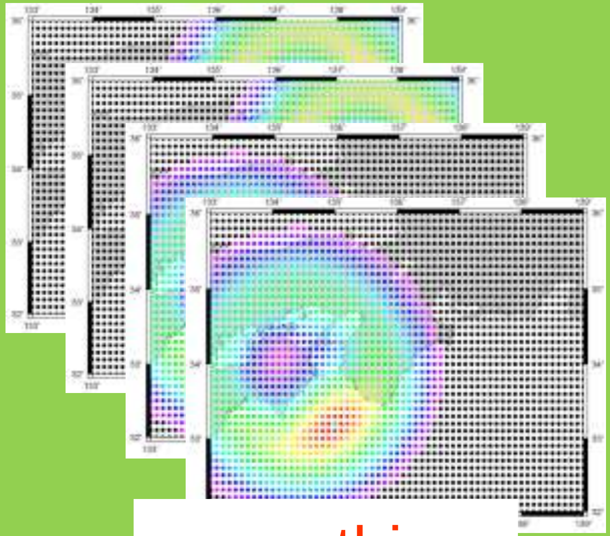
→

Smooth the raw *R* image by using other raw images of the neighboring sub-net analyses

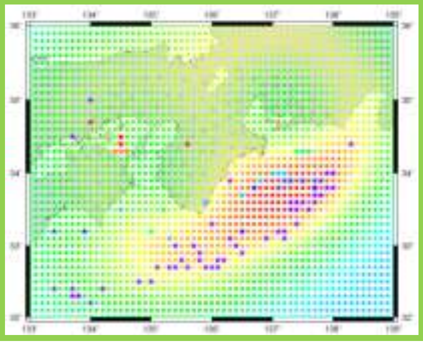
→

Pick the lowest R value at every grid point from all the smoothed R images and re-plot the final R distribution.



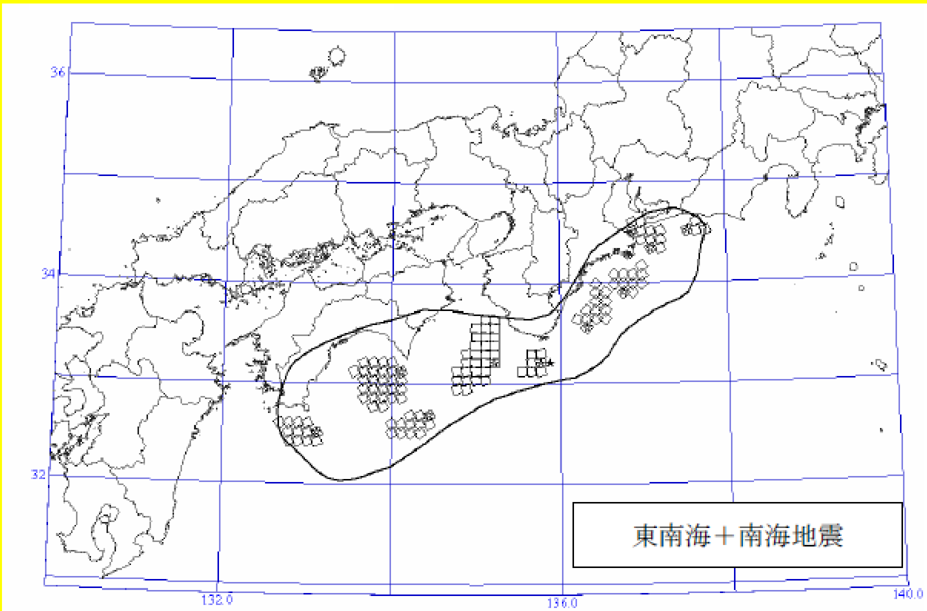


smoothing



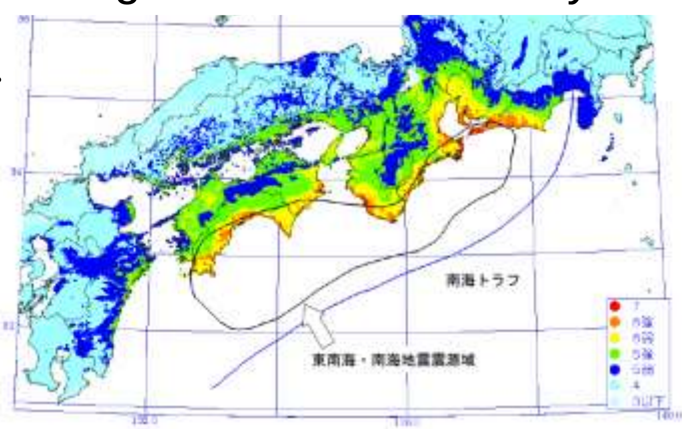
picking the lowest R

4. Blind test (data)



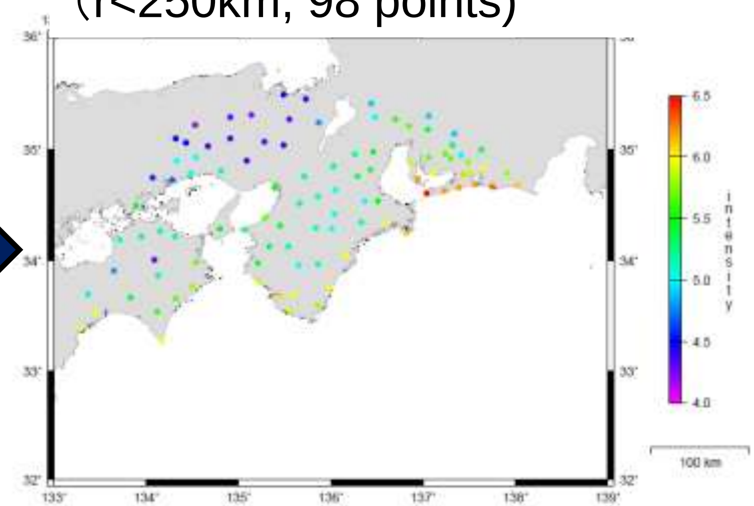
A target fault model for the future Nankai-Tonankai earthquake by the Central Disaster Prevention Council of Japan (CDPC)

Strong motion simulation by CDPC



Intensity data for this study

Pickup seismic intensities at 98 KiK-net stations (r<250km, 98 points)



4. Blind test (condition)

amplification factor ← from the digital national land information of Japan

grid-point ← 0.1 degree as a horizontal interval (depth is fixed to 25km)

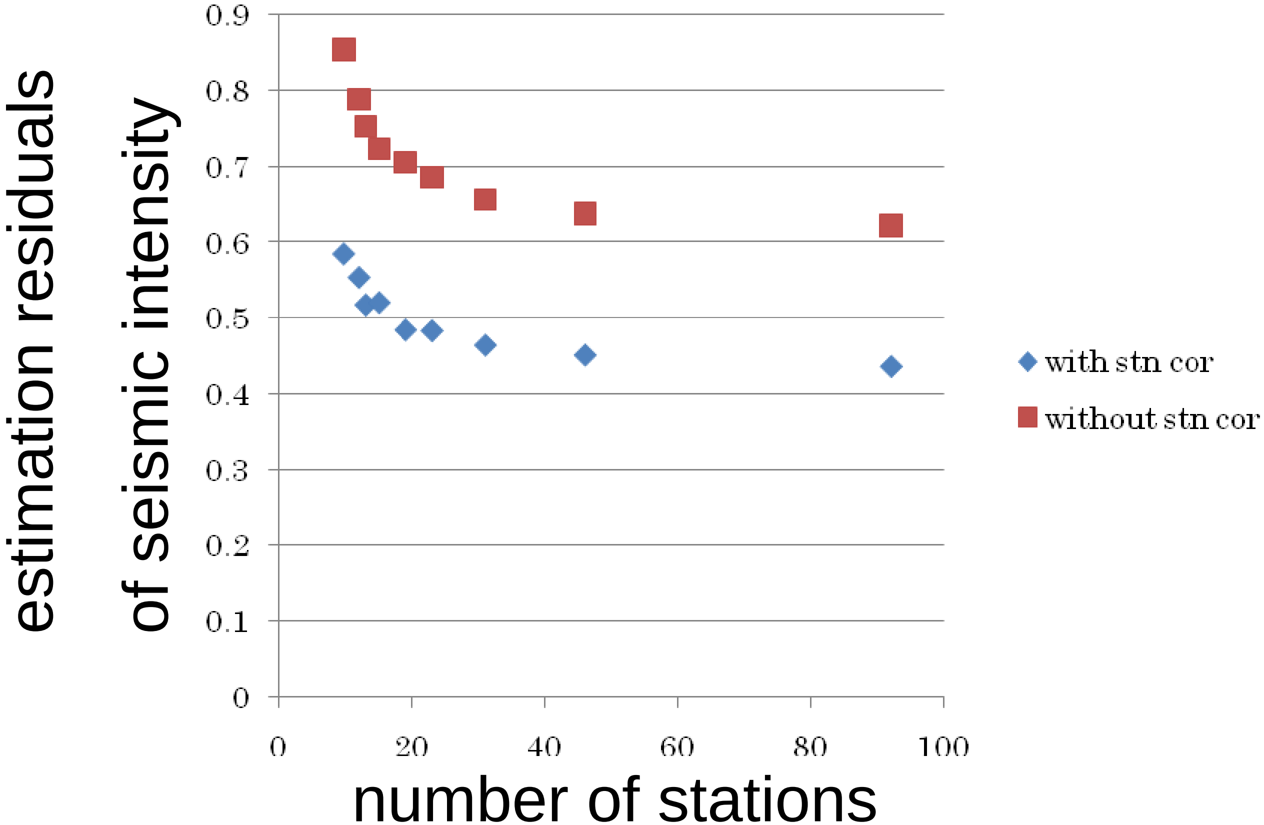
Sub-net consists of 15 neighboring stations

Maximum value of MIp is set to be 7.6
←Seismic intensity is saturated

Possible estimation residuals?

4. Blind test (condition)

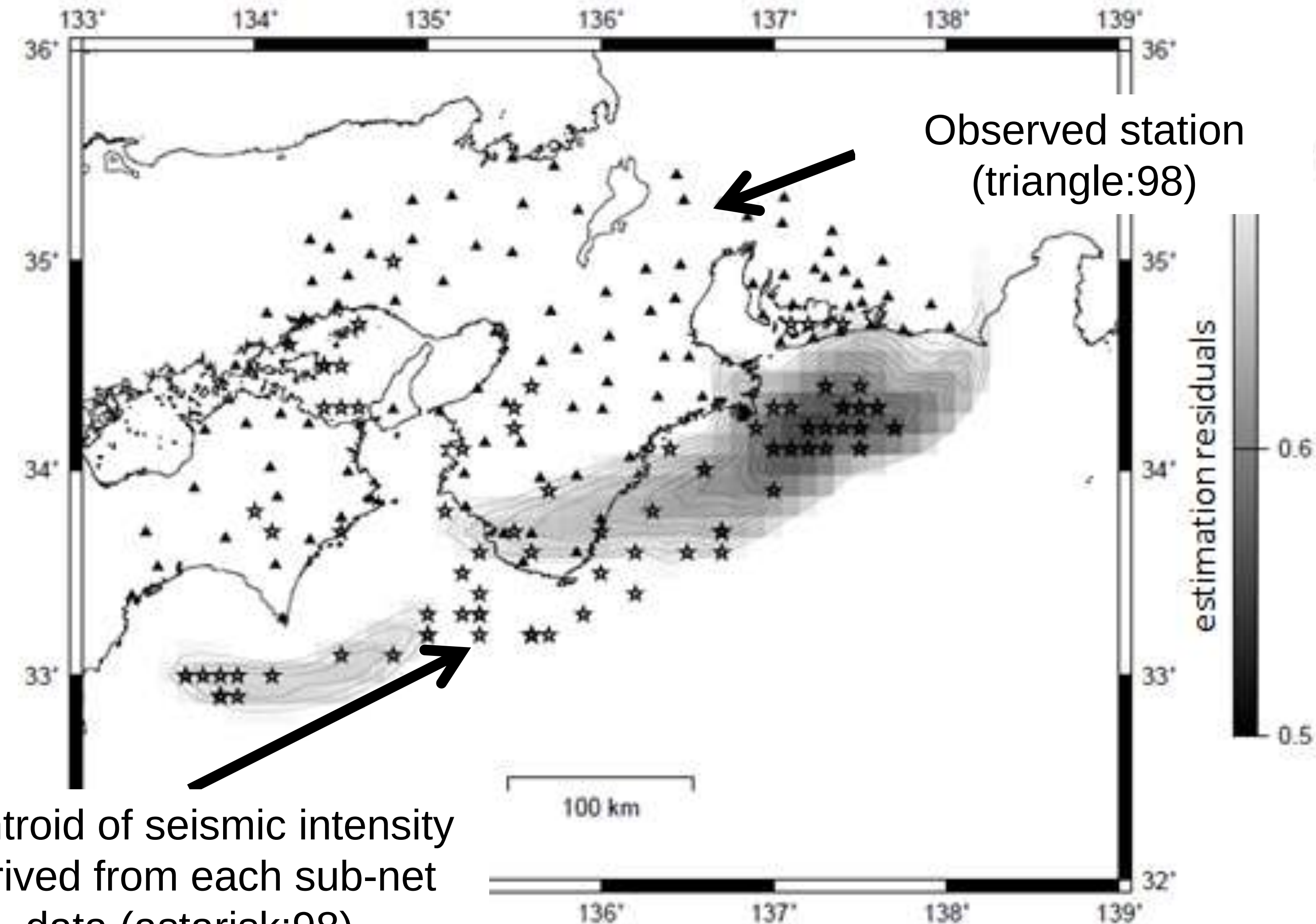
Possible estimation residuals calculated from observed Hi-net data



Estimation residuals of less than 0.7 are possible values for real asperities for 15-station sub-net

4. Blind test (result)

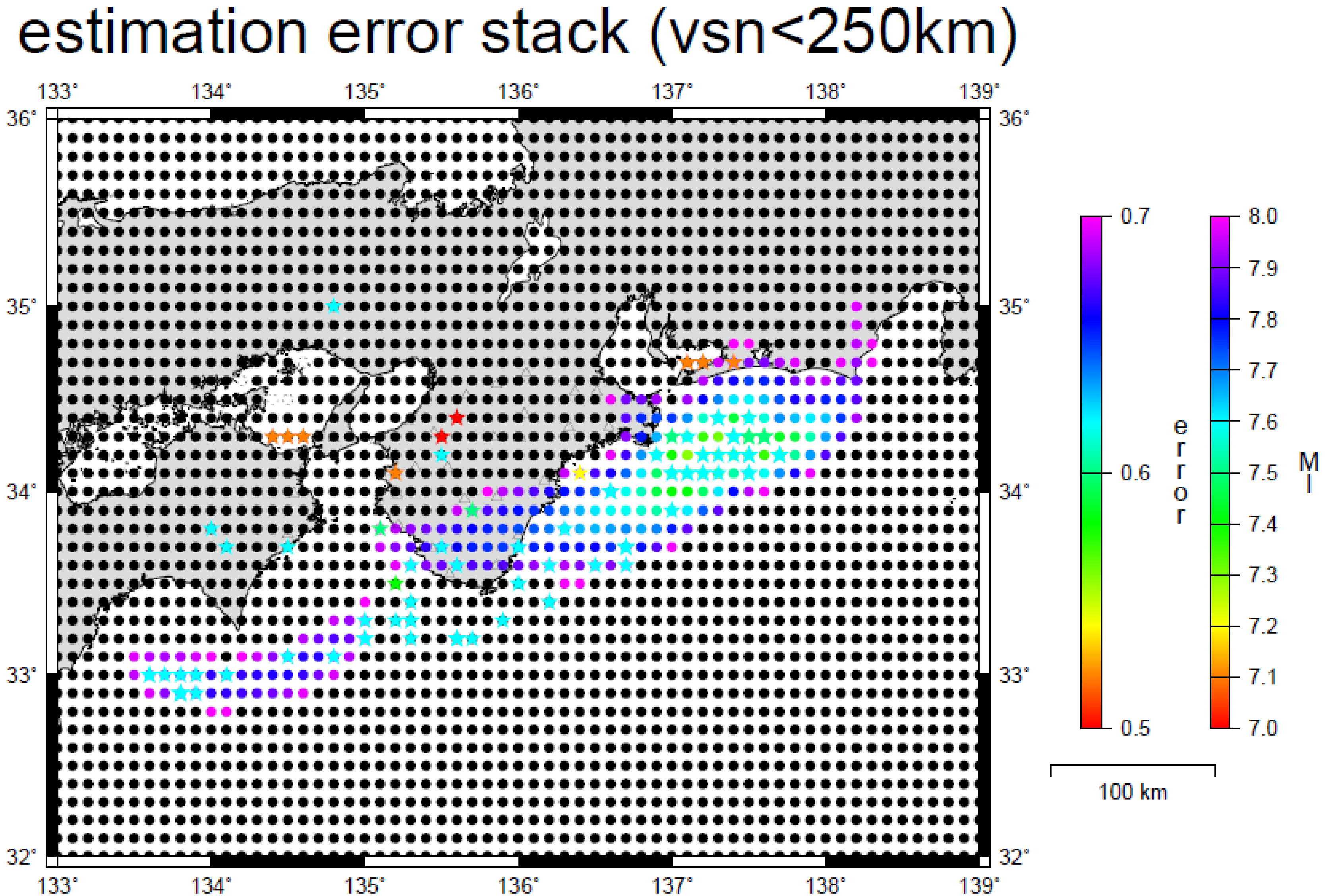
98 stations (r<250km), 98 sub-nets



Observed station (triangle:98)

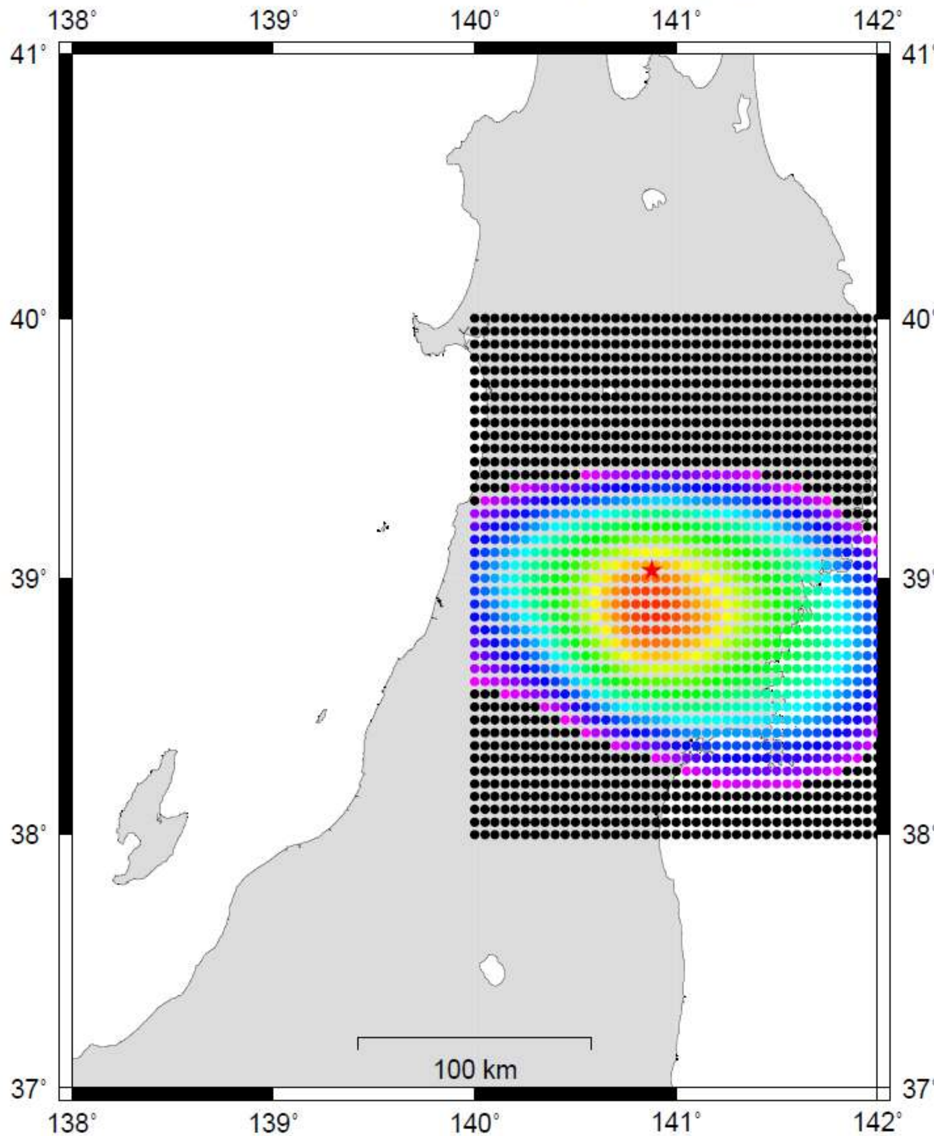
Centroid of seismic intensity derived from each sub-net data (astarisk:98)

4. Blind test (result)



Centroid of seismic intensity derived from each sub-net data (astarisk:98)

2008 Iwate Miyagi Eq (M=7.2)

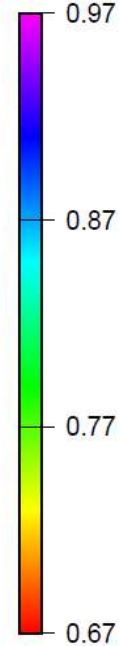


Residual distribution of seismic intensity

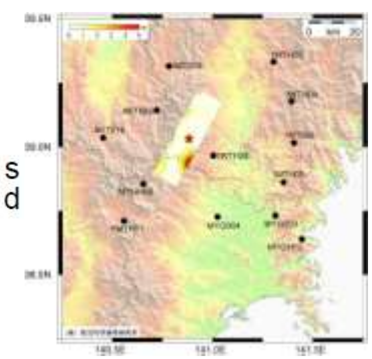
100 intensity data of K-NET are used

Sub-net consists of

15 stations



s
d



Suzuki et al.
（2008）

5. Conclusions

1. We develop a robust method to image asperity areas (centroid of seismic intensity) for large earthquake

2. Seismic intensities at sites are calculated by the asperity location obtained above.

3. This method could be very effective for the next-generation EEWs