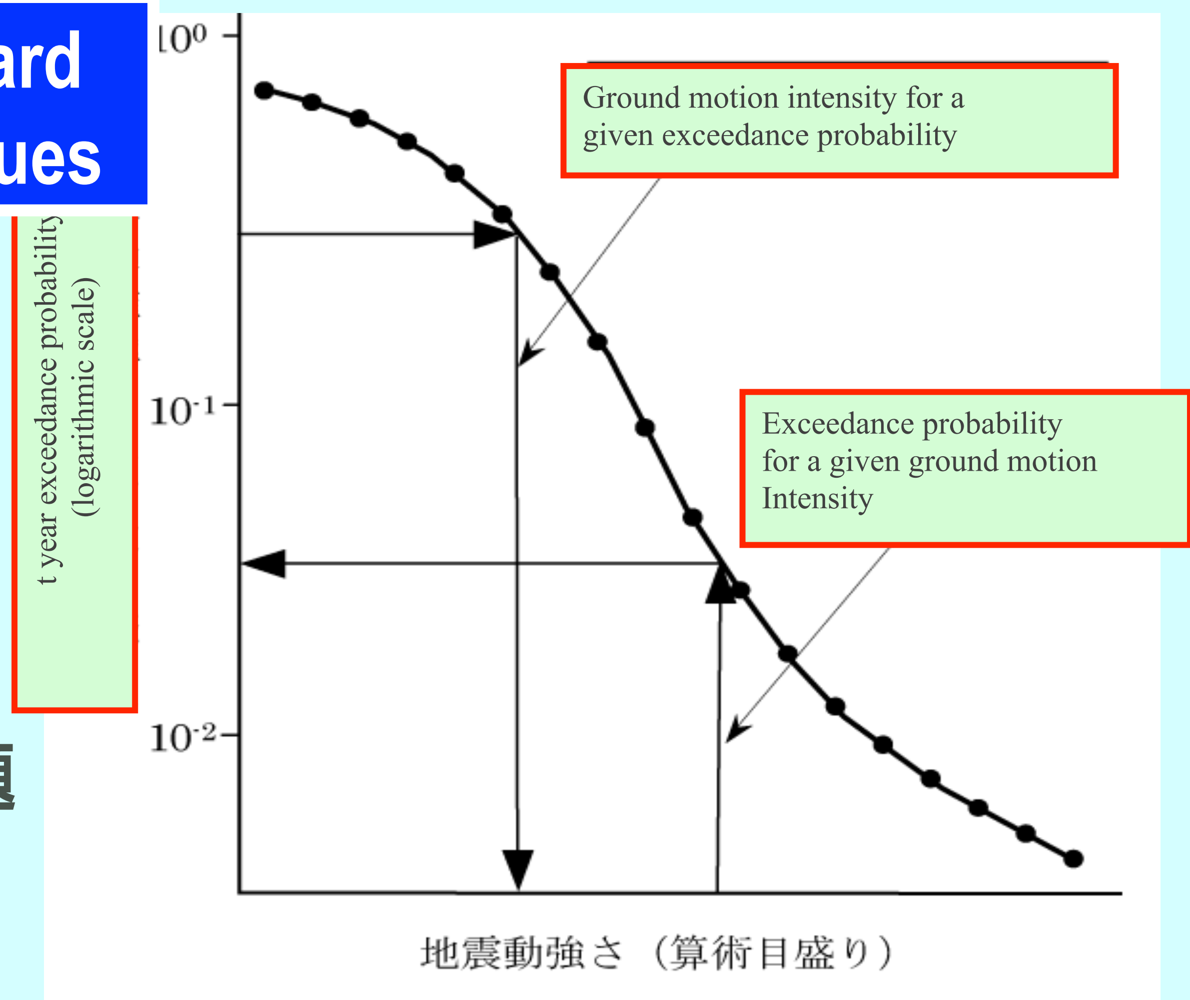
Probabilistic Seismic Hazard Assessment in general issues



確率地震予測評価之課題

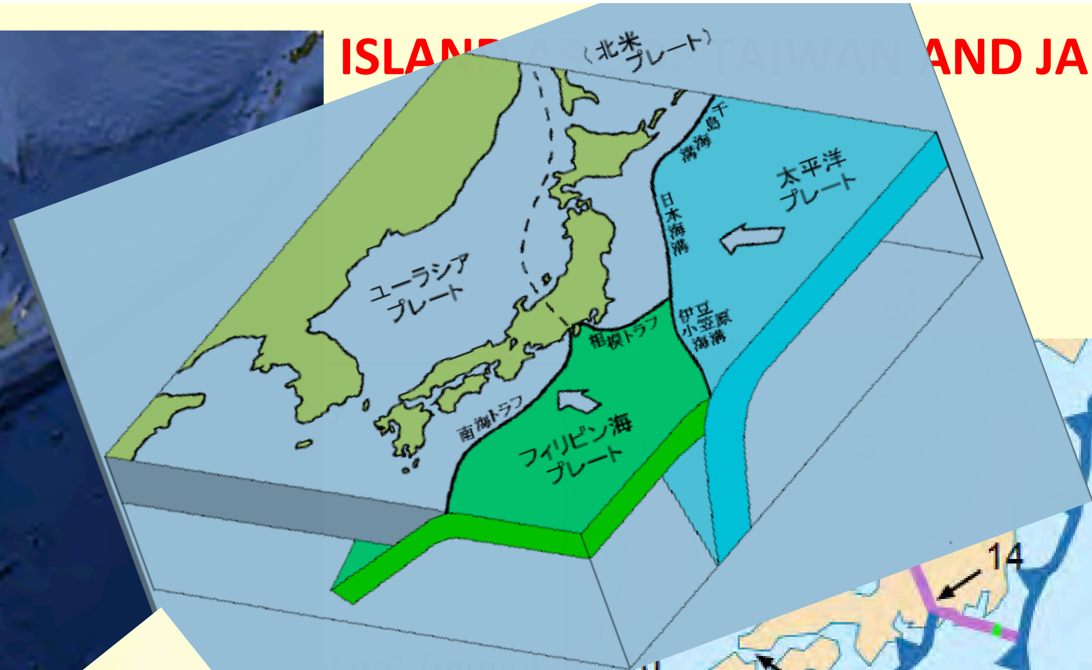
Ken XS Hao (郝憲生)　独立行政法人　防災科学技術研究所

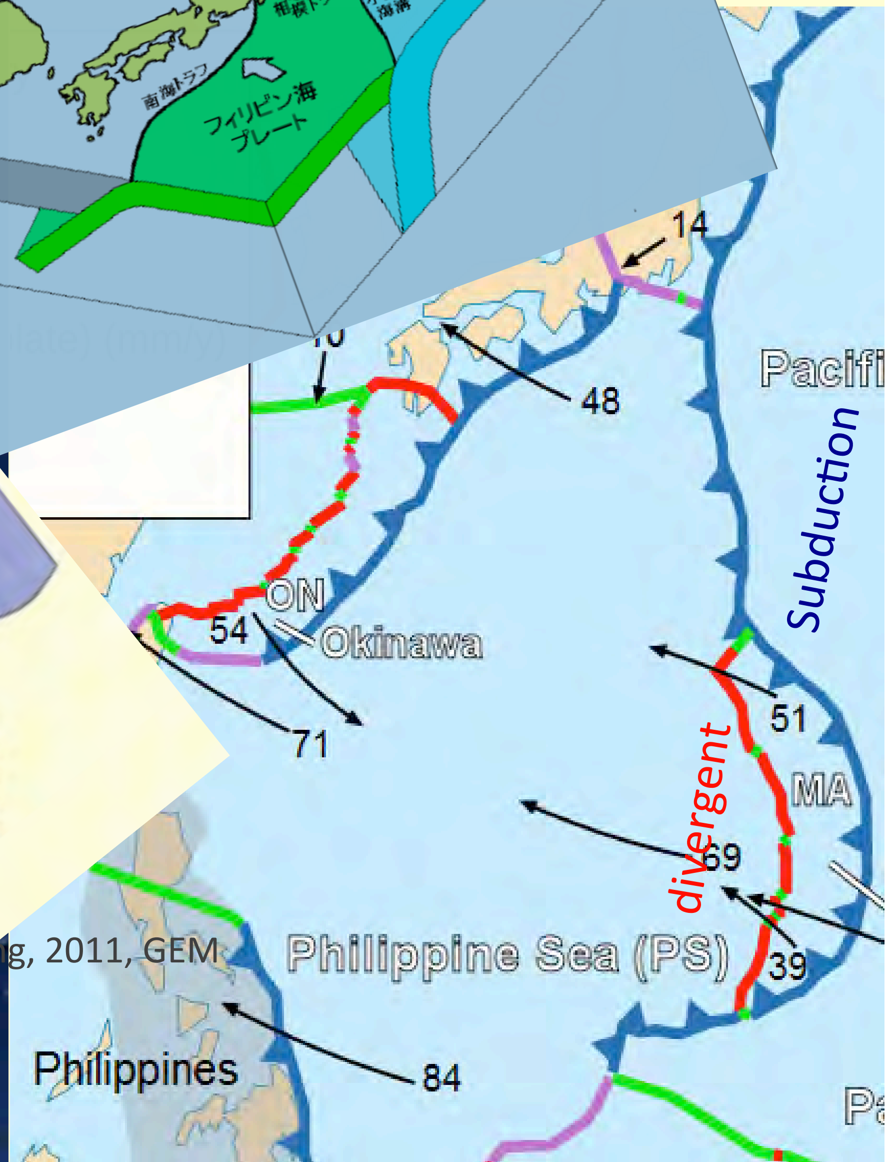
National Research Institute for Earth Science & Disaster Prevention

The big quakes might be considered “black swans”, for they are rare, had an extreme impact on society. But being rare is not the same as being an outlier that invalidates a particular probability model or overturns a methodology. Consequently, it is not obvious that our models and methods are in need of repair (Ellsworth, 2012).

- 1. Seismic activity in Island arc of Taiwan and Japan
- 2. Probabilistic Seismic Hazard Assessment
  - Modeling of Seismic Activity
  - Classification into 3 category
  - EQ without specified source faults
  - Uncertainty
  - Reality on East Japan
- 3. Cooperative works on PSHA
  - Historical records
  - Sharing EQ database
  - Person exchange

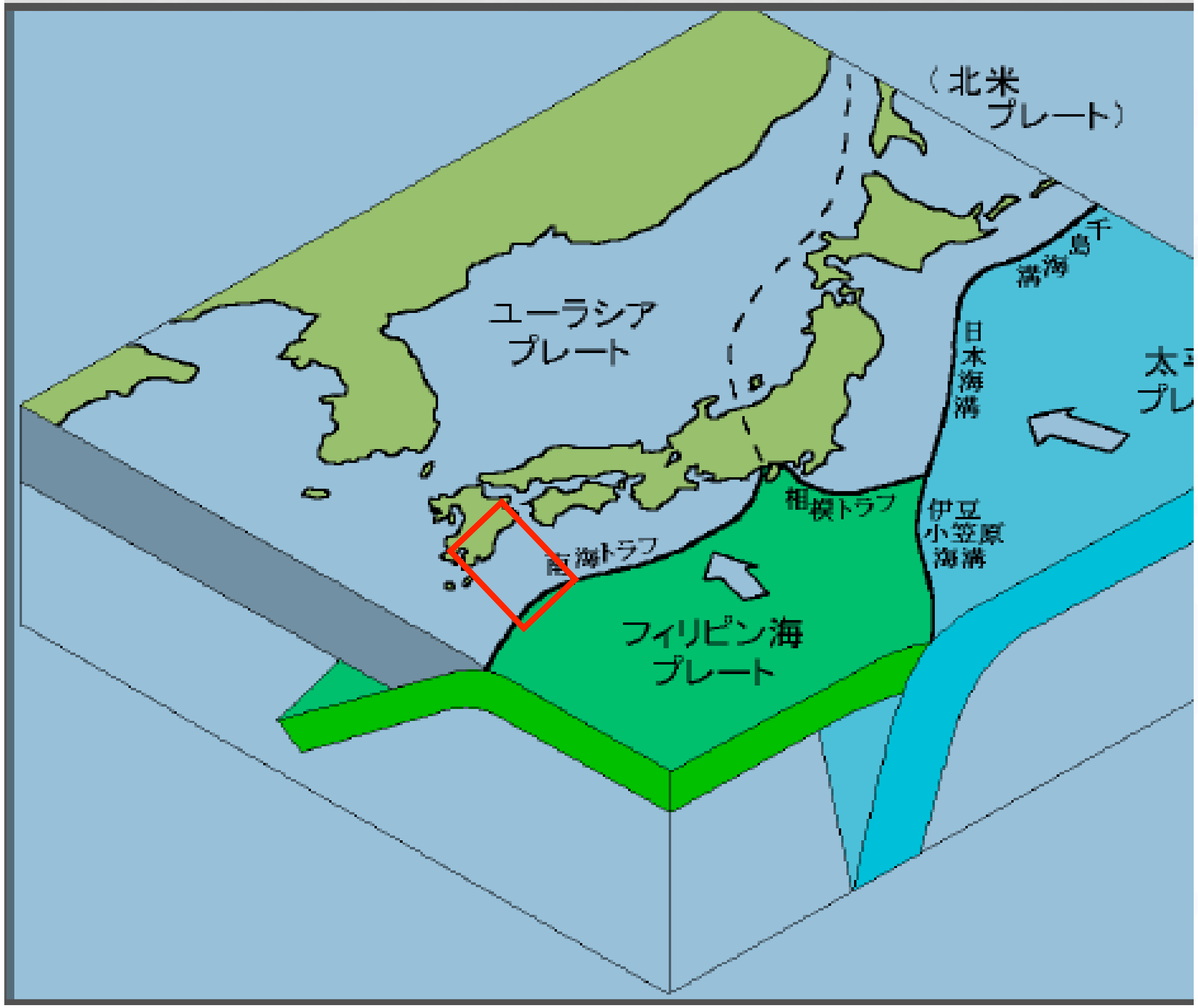
ISLAN … AND JAPAN

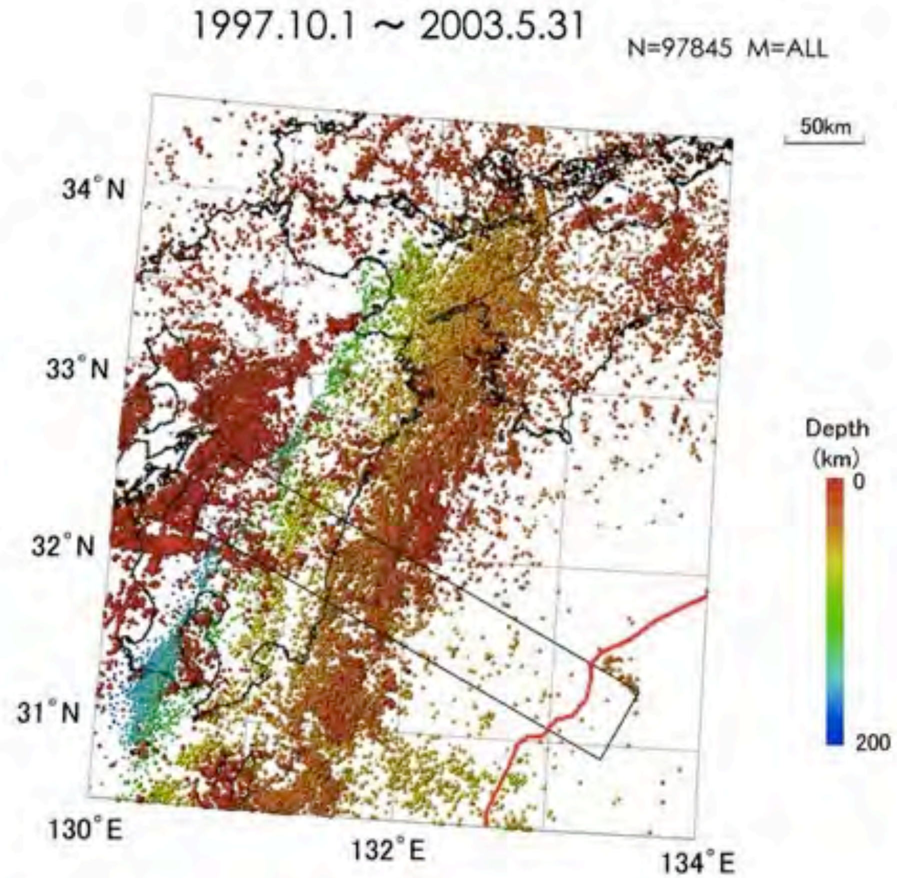




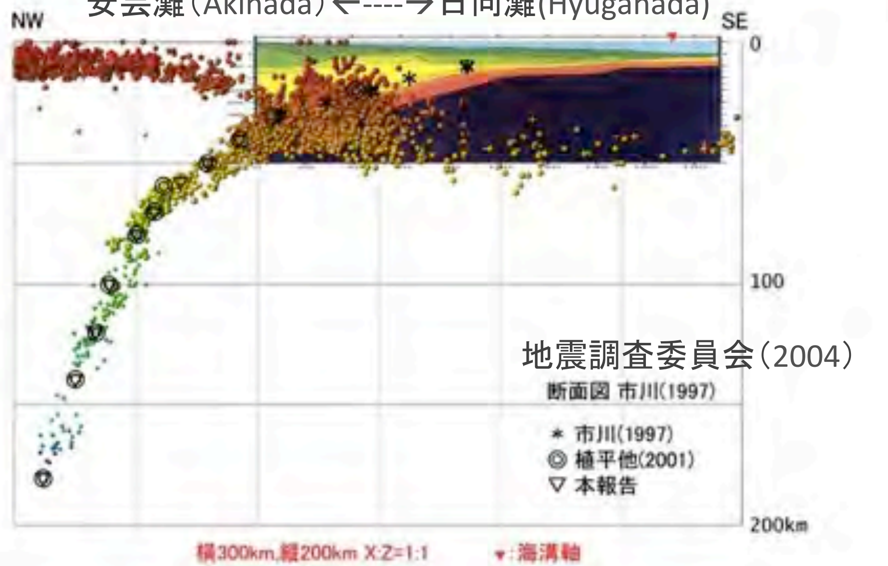
Ma Kuo-Fong, 2011, GEM

Four Plates of Eurasia, North American, Pacific and Philippines joined in Japan with 4,000 km of subduction zones



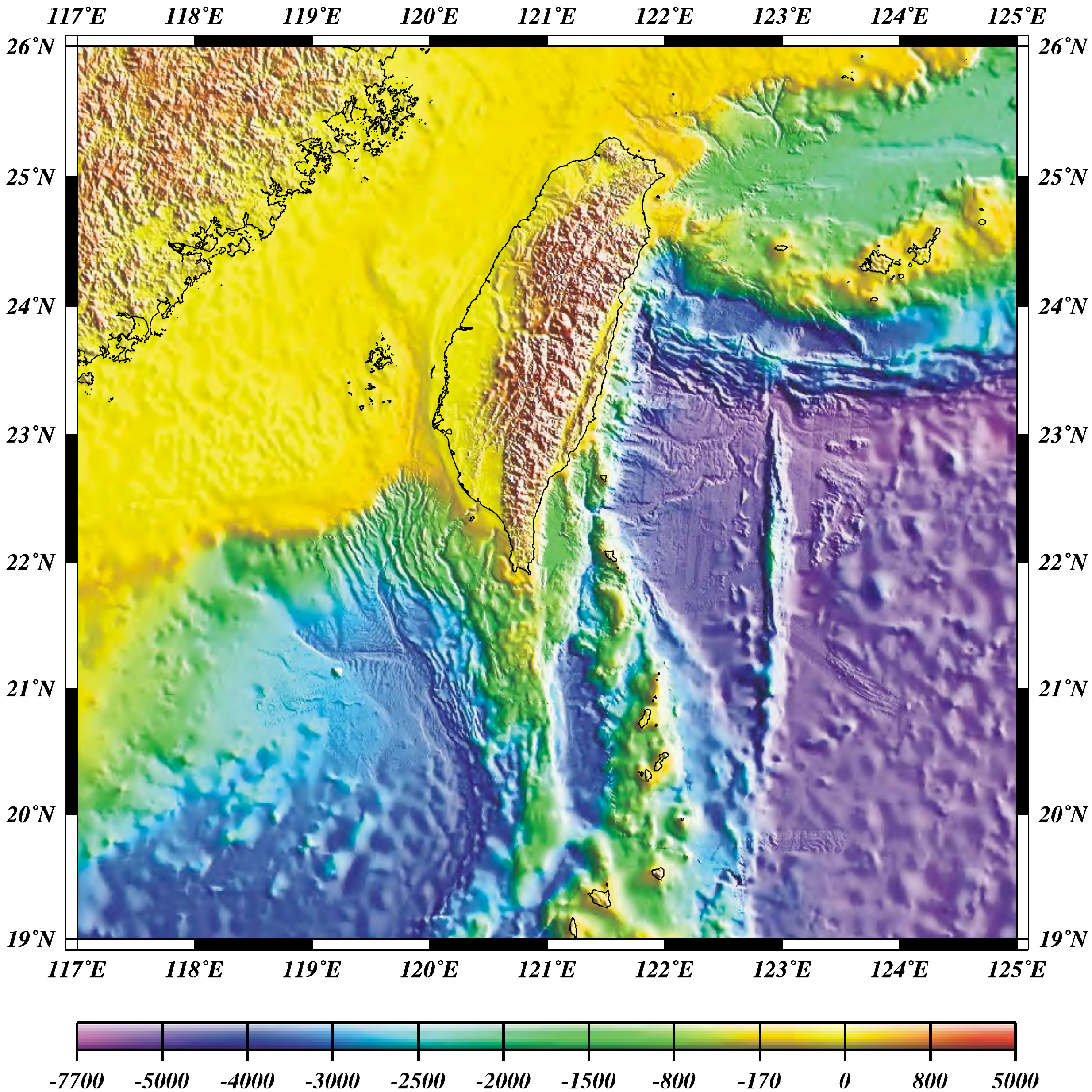


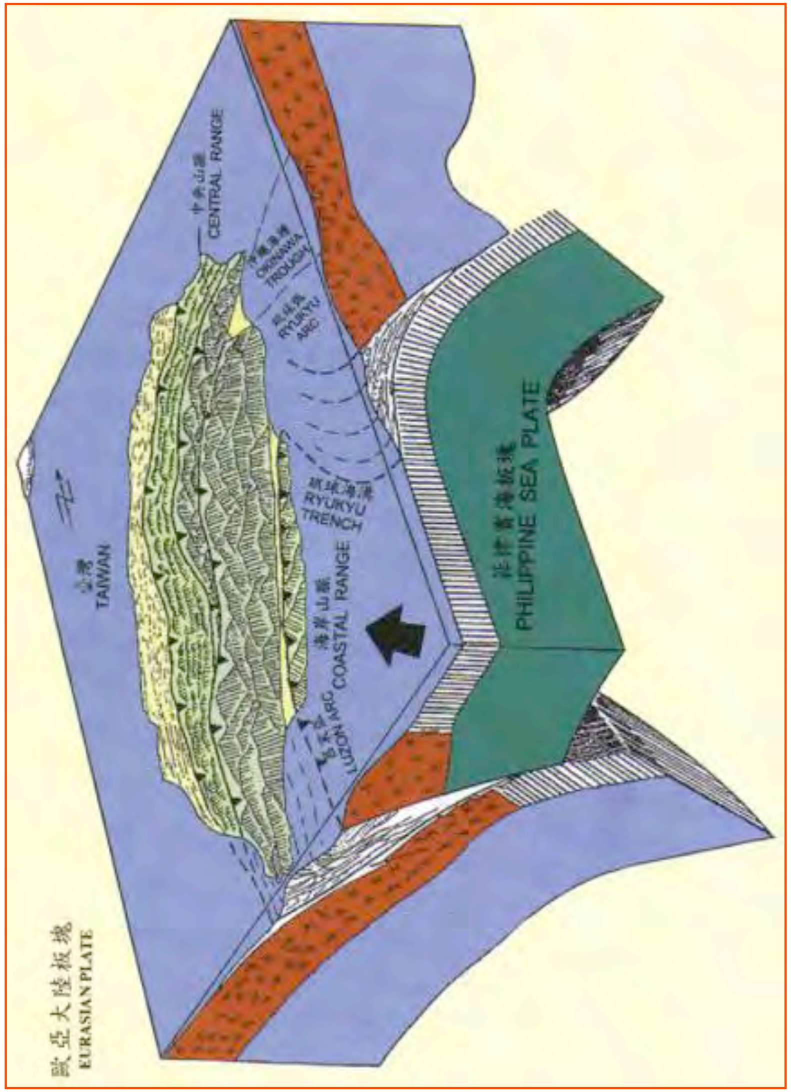
安芸灘（Akinada）←----→日向灘(Hyuganada)



地震調査委員会（2004）

Bathymetry and Tectonic Setting near Taiwan





Ma Kuo-Fong, 2011, GEM

2. Probabilistic Seismic Hazard Assessment

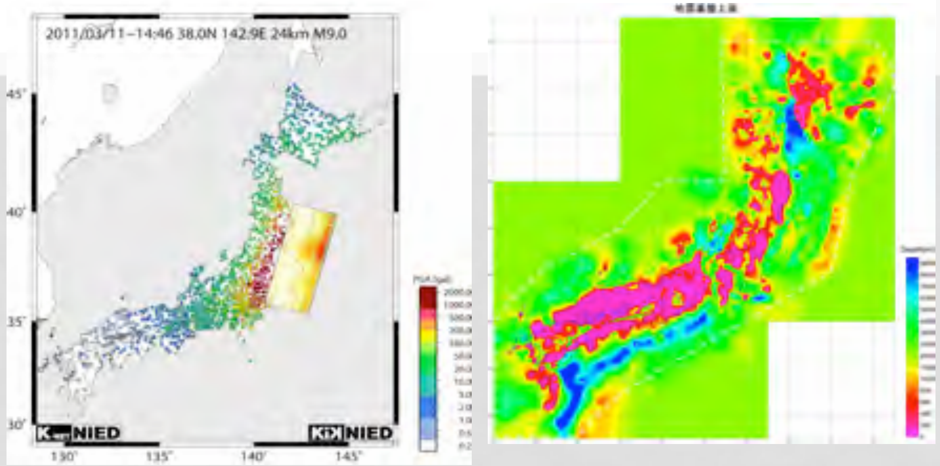
- Modeling of Seismic Activity
- Classification into 3 category
- EQ without specified source faults
- Uncertainty
- Reality on East Japan

National seismic hazard maps for Japan

Long term evaluation

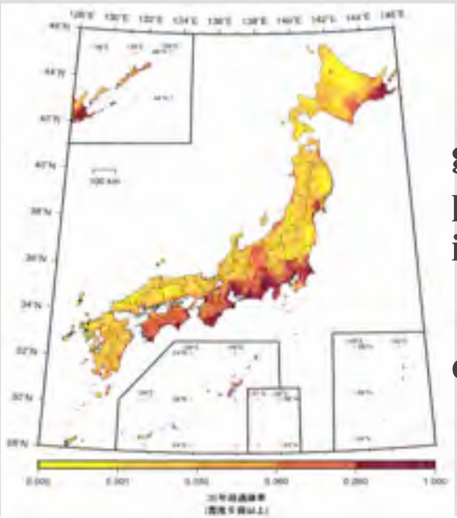
Probability of occurrence, magnitude, location

Strong-motion evaluation



Strong-motion, underground structure

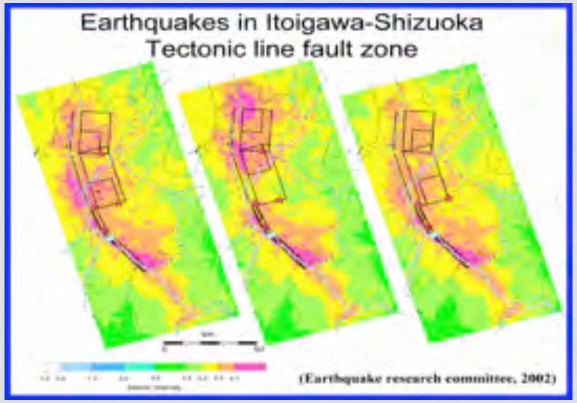
Probabilistic Seismic Hazard Maps



・Strong-motion intensity with a given probability, or the probability with a given intensity.

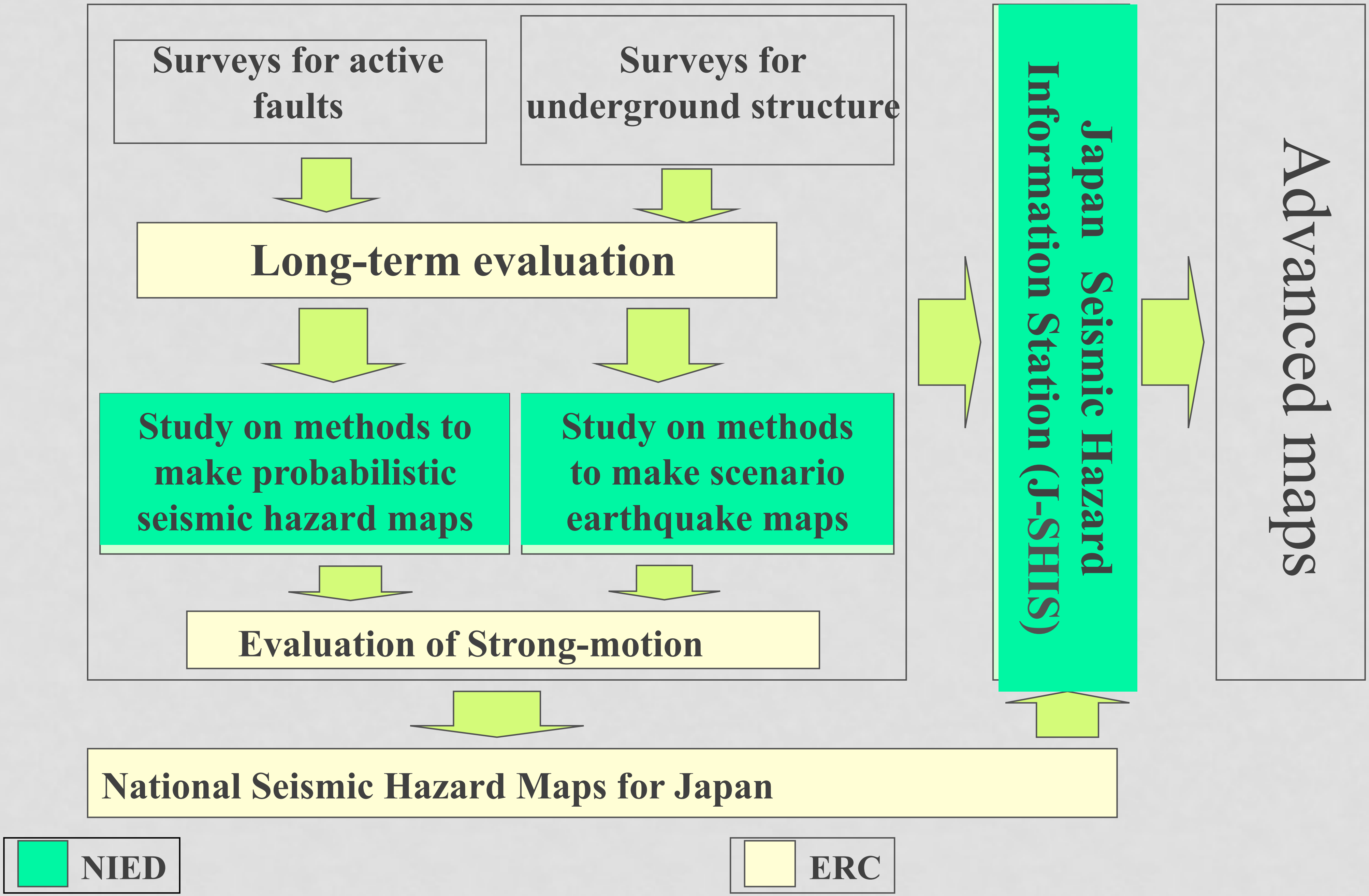
・Considering all possible earthquakes.

Scenario Earthquake Shaking Maps



・Strong-motion intensity around the fault for a specified earthquake.

System for the national seismic hazard mapping project



Technical reports on National Seismic Hazard Maps for Japan (2009)

http://www.j-shis.bosai.go.jp/en/downloads

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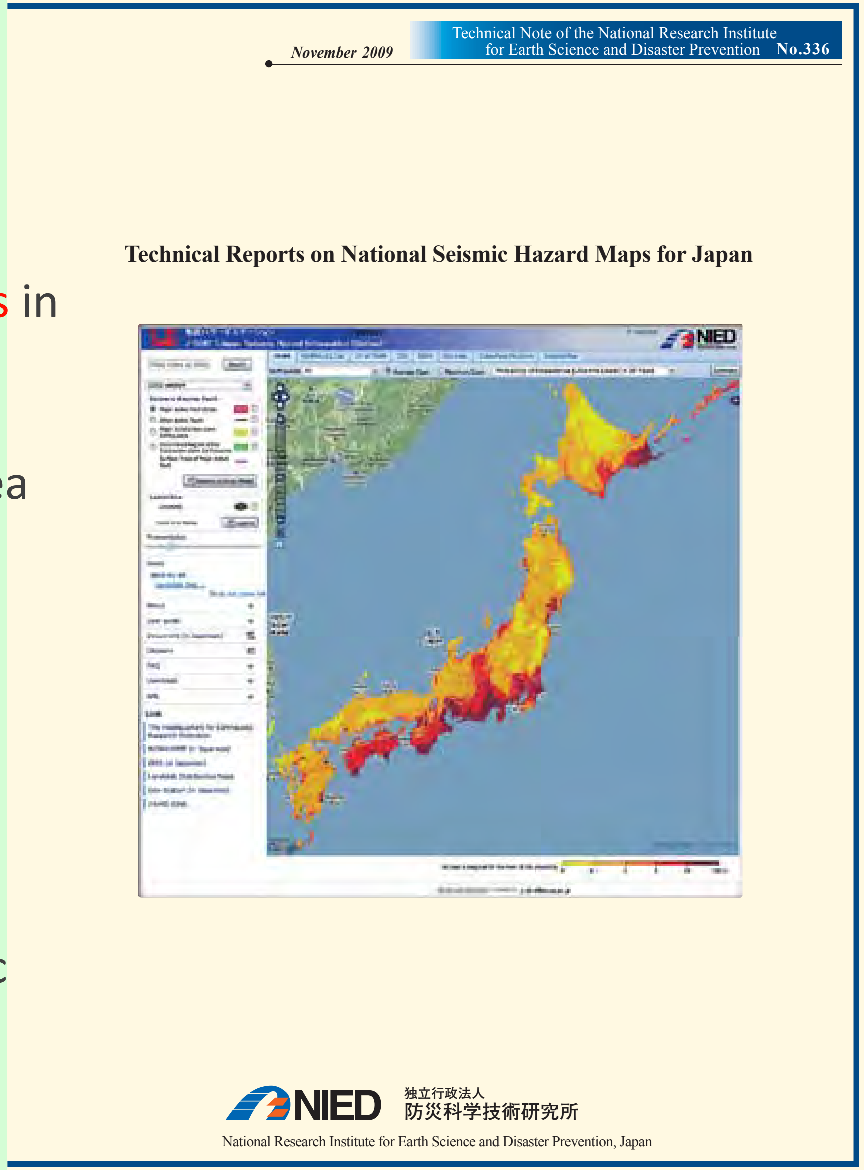

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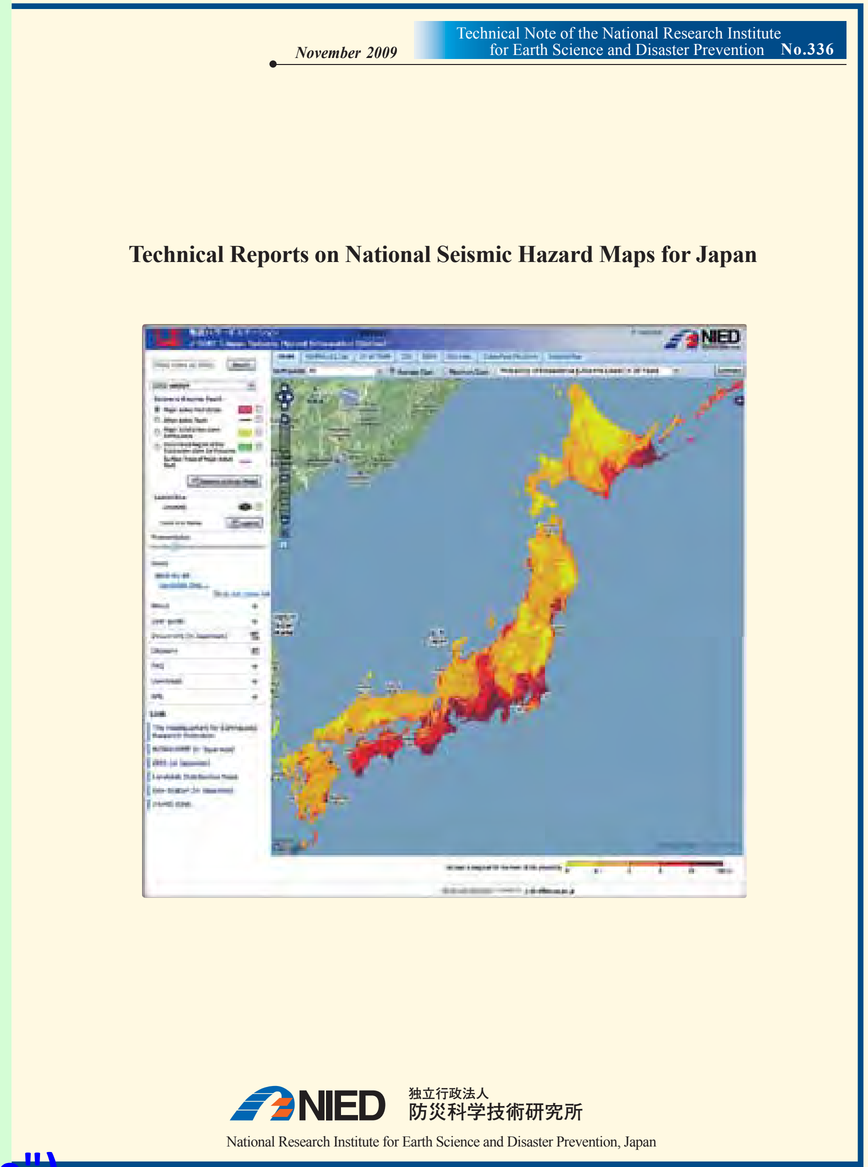
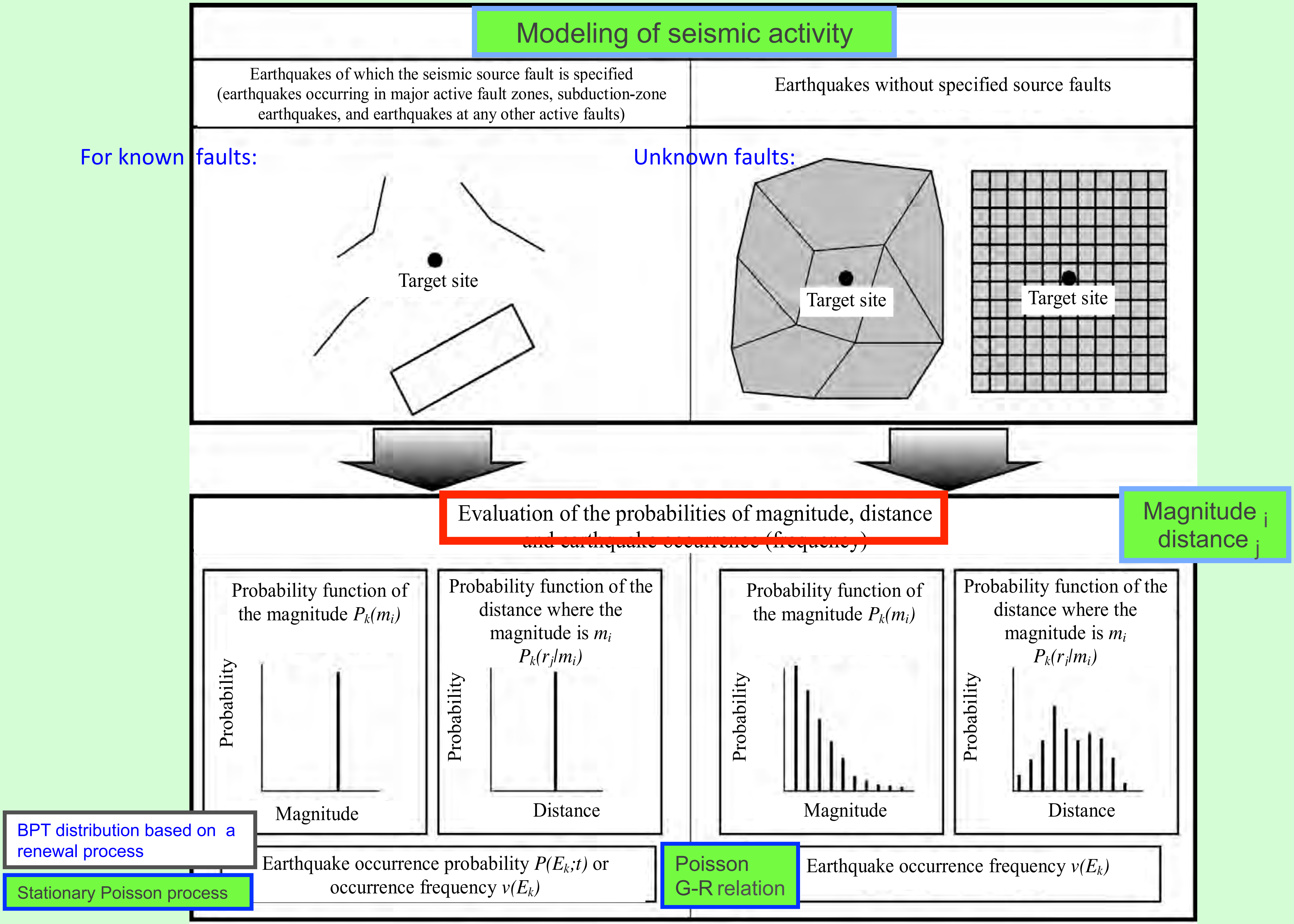
Technical reports on National Seismic Hazard Maps for Japan (2009)





Modeling of seismic activity
Earthquakes of which the seismic source fault is specified (earthquakes occurring in major active fault zones, subduction-zone earthquakes, and earthquakes at any other active faults)
Earthquakes without specified source faults
For known faults:
Unknown faults:
Target site
Target site
Target site
Evaluation of the probabilities of magnitude, distance and earthquake occurrence (frequency)
Magnitude $_i$
distance $_j$
Probability function of the magnitude $P_k(m_i)$
Probability
Magnitude
Probability function of the distance where the magnitude is m_i $P_k(r_j|m_i)$
Probability
Distance
Probability function of the magnitude $P_k(m_i)$
Probability
Magnitude
Probability function of the distance where the magnitude is m_i $P_k(r_j|m_i)$
Probability
Distance
BPT distribution based on a renewal process
Stationary Poisson process
Earthquake occurrence probability $P(E_k;t)$ or occurrence frequency $v(E_k)$
Poisson
G-R relation
Earthquake occurrence frequency $v(E_k)$

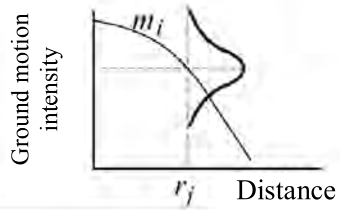
Technical reports on National Seismic Hazard Maps for Japan (2009)

Magnitude $_i$
distance $_j$
earthquake $_k$

Probability distribution of ground motion intensity

Probability that the ground motion intensity exceeds level y where the magnitude is m_i and the distance is r_j

$$P(Y>y \mid m_i, r_j)$$



Exceedance Prob. of an intensity level **P(Y > y|E$_k$)**

Probability that the ground motion intensity exceeds a certain level where earthquake k has occurred

$$P(Y>y \mid E_k) = \sum_i \sum_j P(Y>y \mid m_i, r_j) P_k(m_i) P_k(r_j \mid m_i)$$

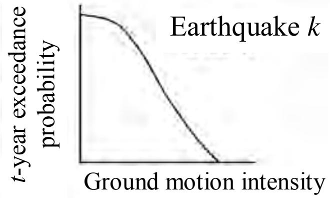
Hazard curve for each earthquake

Probability that the ground motion intensity exceeds a certain level within t years as a result of the target earthquake (earthquake cluster) k

$$P_k(Y>y;t) = P(E_k;t)\, P(Y>y \mid E_k)$$

or

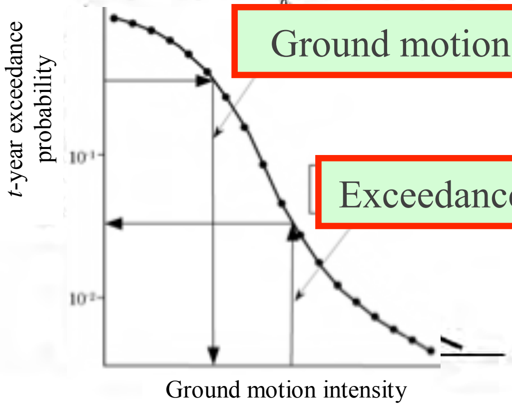
$$P_k(Y>y;t) = 1 - \exp\{-\nu(E_k)\, P(Y>y \mid E_k)\, t\}$$



Prob. for each earthquake
P(Y > y)= P(E$_k$) P(Y > y|E$_k$)

Hazard curve integrating the results for all earthquakes

$$P(Y>y;t) = 1 - \prod_k \{1 - P_k(Y>y;t)\}$$



Prob. for all Eqs **E$_k$**
P(Y > y)=1-Π[1- P(Yi > y)]

Ground motion intensity for a given exceedance probability

Exceedance probability for a given ground motion Intensity

Classification into Earthquake category

EQ **category I**

EQ **category II**

EQ **category III**

Characteristic Subduction-zone Earthquakes

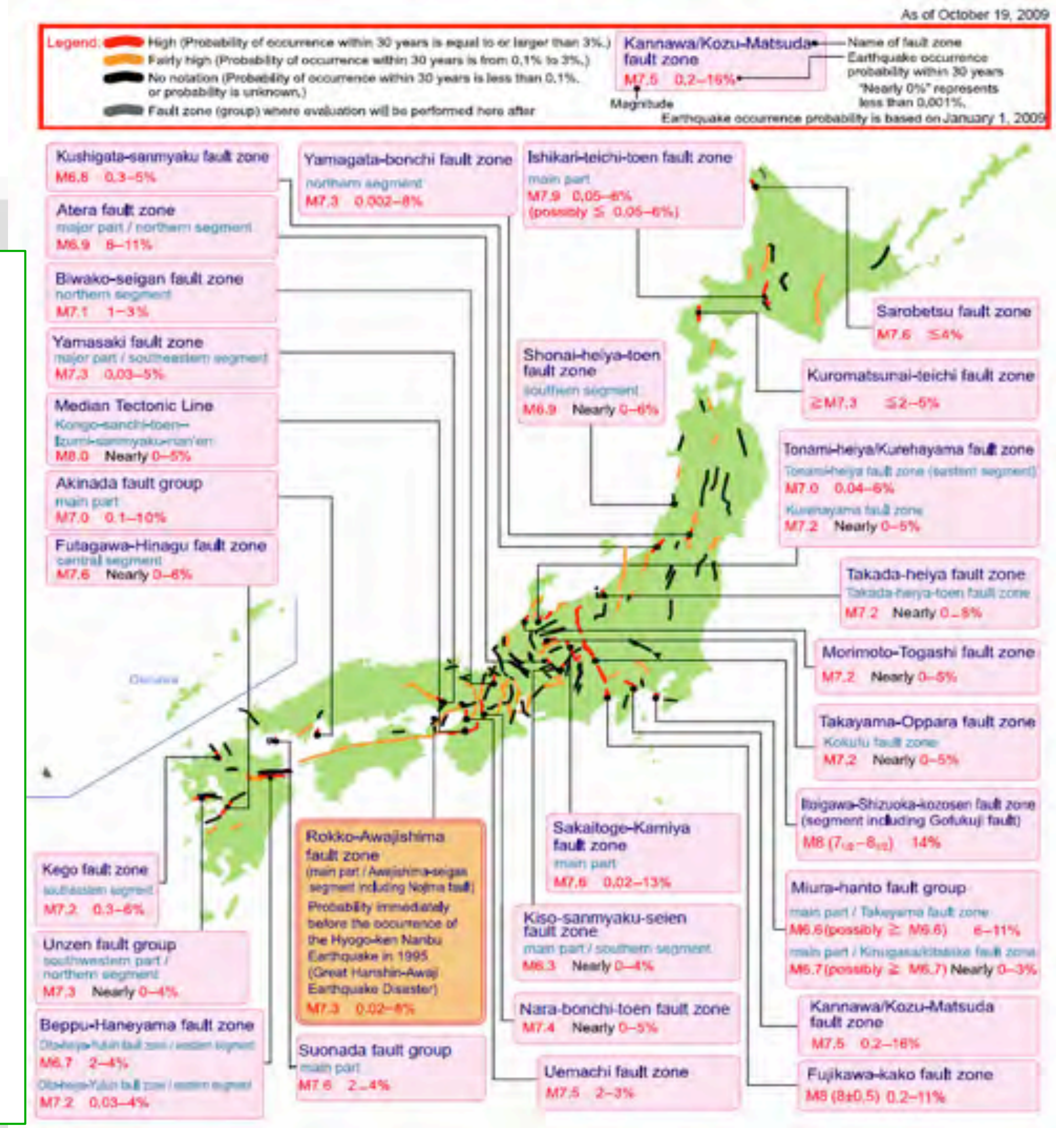
Fused Subduction-zone Earthquakes

Crustal Earthquakes

3.3.3 Earthquakes occurring on Active faults

EQ **category III**

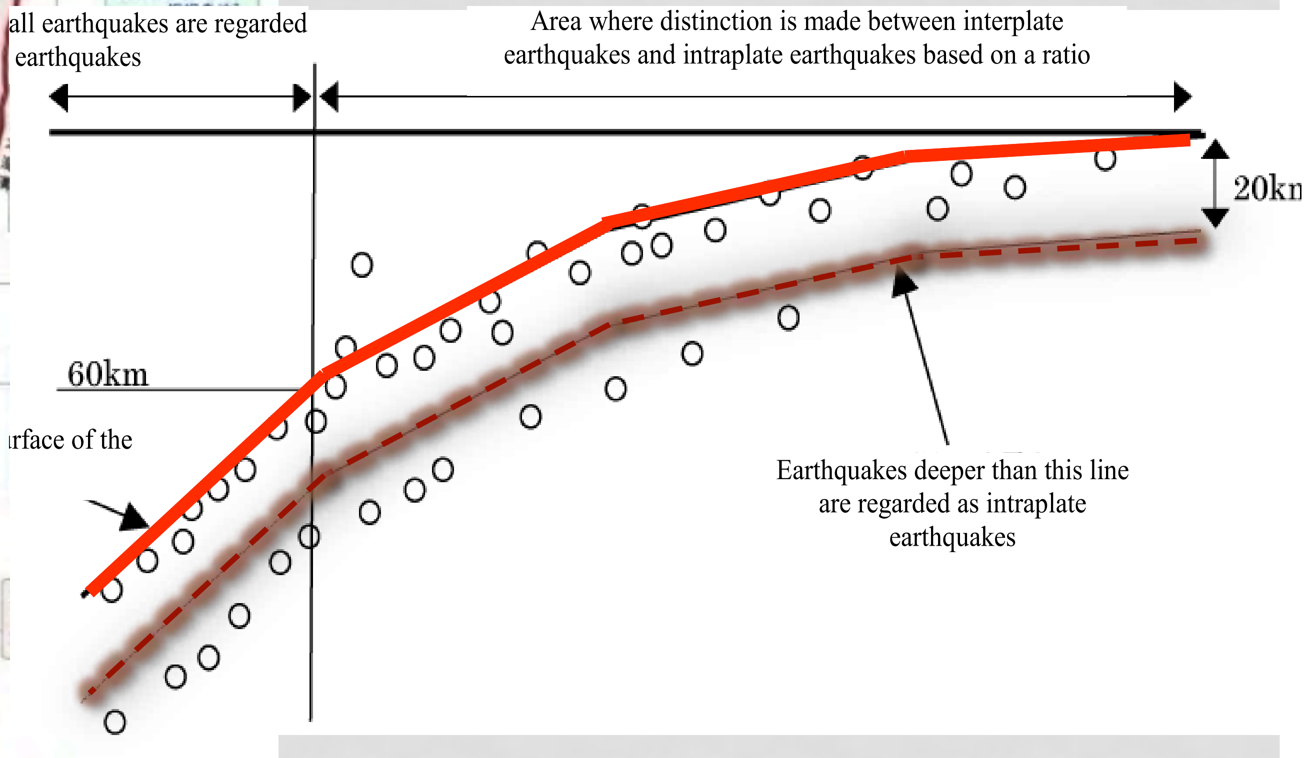
- Determination of the earthquake occurrence probability
- R (year) : Mean recurrence interval
- $R = D / S * 1000$
- Where, D (m) = displacement per event;
- S (mm/year)= average slip rate
- $\log R = \log L / S + 1.9$
- Where, fault length L
- $\log L = 0.6\,M - 2.9$; (Matsuda, 1975)
- $\log D = 0.6\,M - 4.0$;
- For the unknown of average slip rate,
- activity levels are grouped as
- Class A: 1 mm/y
- Class B: 0.25 mm/y
- Class C: 0.047 mm/y



EQ category II

3.3.4 Earthquakes without specified source faults

- The Earthquake Occurrence Ratio
- R = between Interplate and intraplate



3.4.3-8 Idea of distinguishing between interplate earthquakes and intraplate earthquakes (SLTE/SESGM, ERC, 20

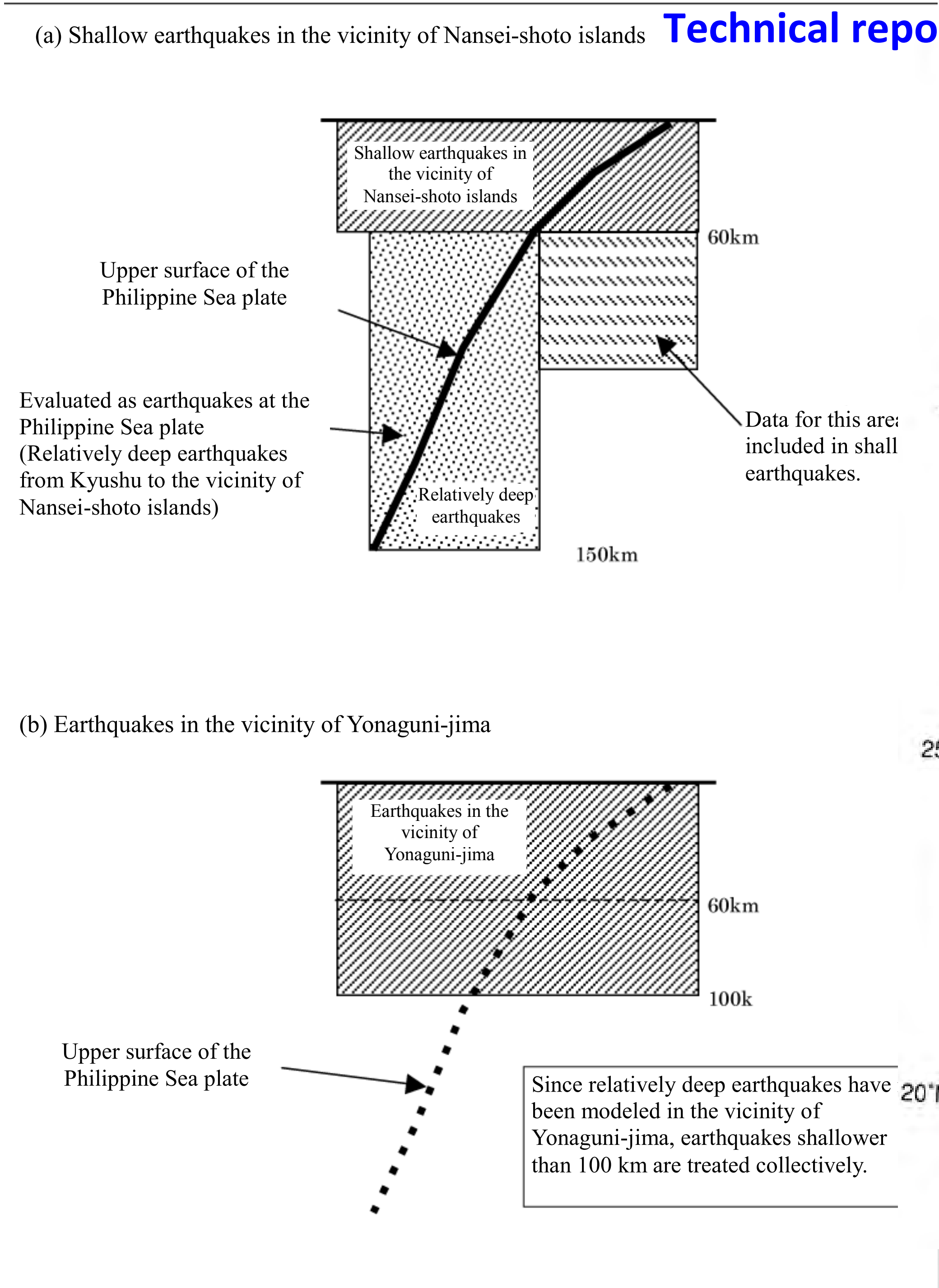


Figure 3.3.4.9-1 Target earthquakes of earthquakes without specified source faults in the vicinity of Nanse

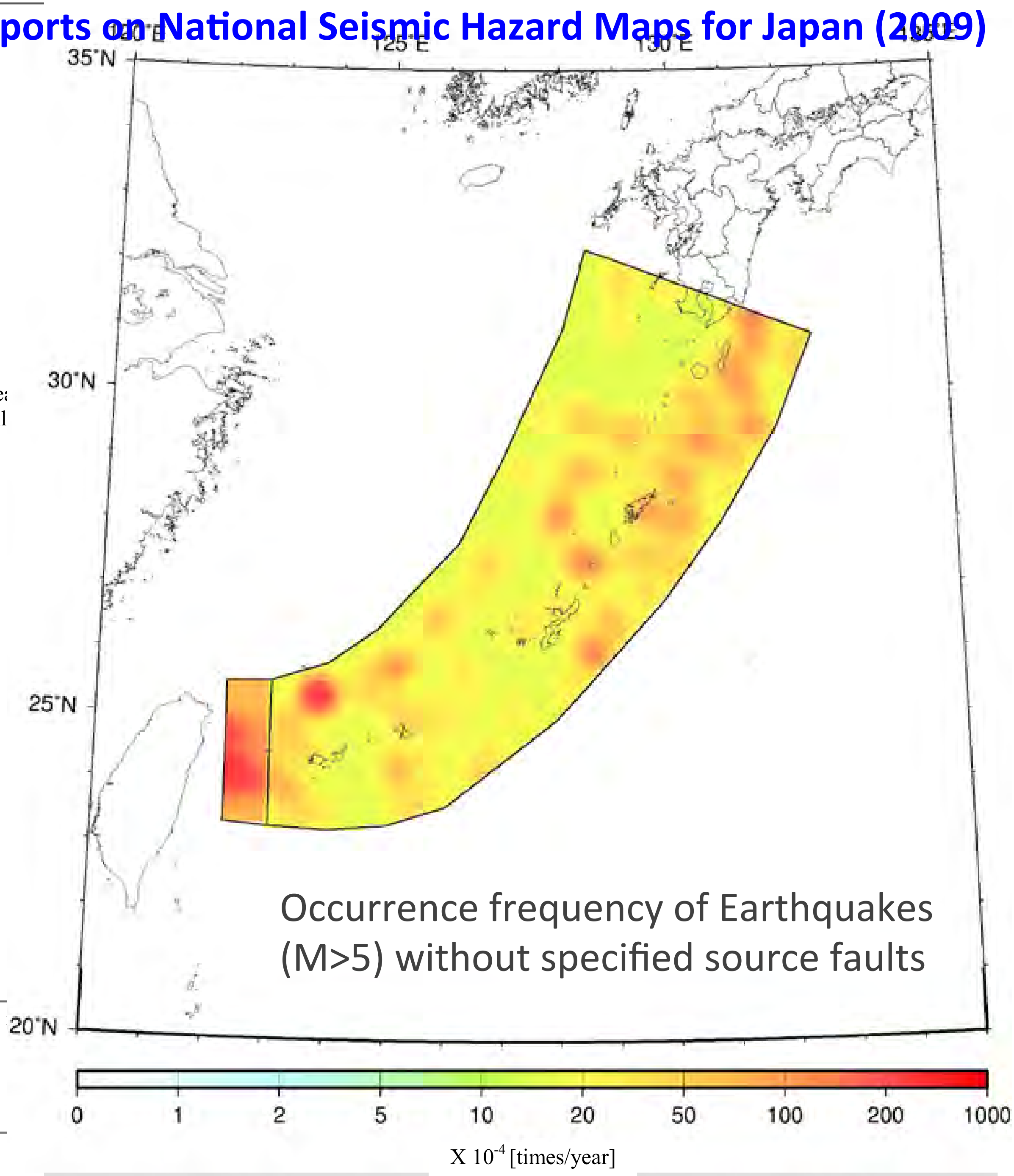
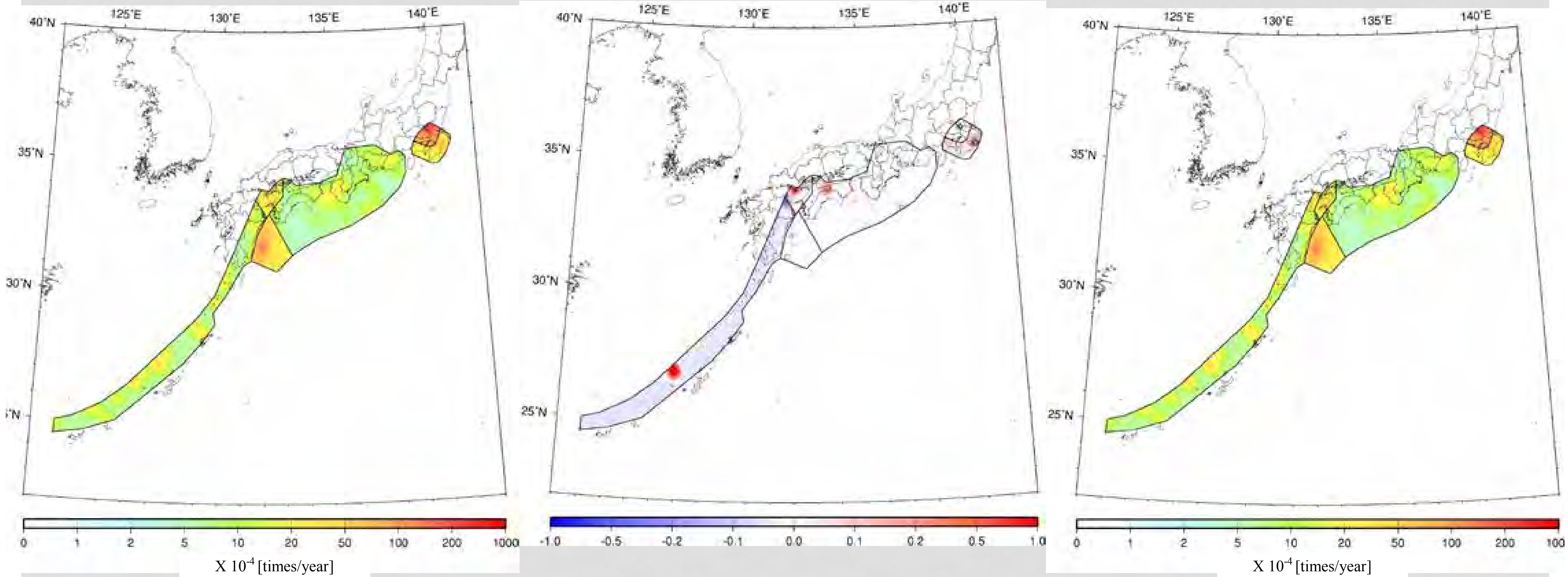


Figure 3.3.4.9-5 Occurrence frequency of earthquakes without specified source faults in the vicinity of Nansei-shoto islands (per 0.1-degree square, *M*5.0 or more)



2009 version (data: - Dec. 2007)

Rate of change = (2009-2008)/2008

2008 version (data: - Dec. 2006)

Figure 3.3.4.10-2 Occurrence frequency of earthquakes without specified source faults in the Philippine Sea plate (Total for interplate and intraplate earthquakes)

Uncertainty: U = Ur_+Uk

1. Ur: Aleatory (Random) Uncertainty

- Time of EQ occurrence
- Location of EQ occurrence
- Source properties (e.g. M) of EQ occurrence
- Ground motion at a site
- Given the median value of motion
- Inner Source parameters, fault rupture process(e.g., direction of rupture 震源の微視的)

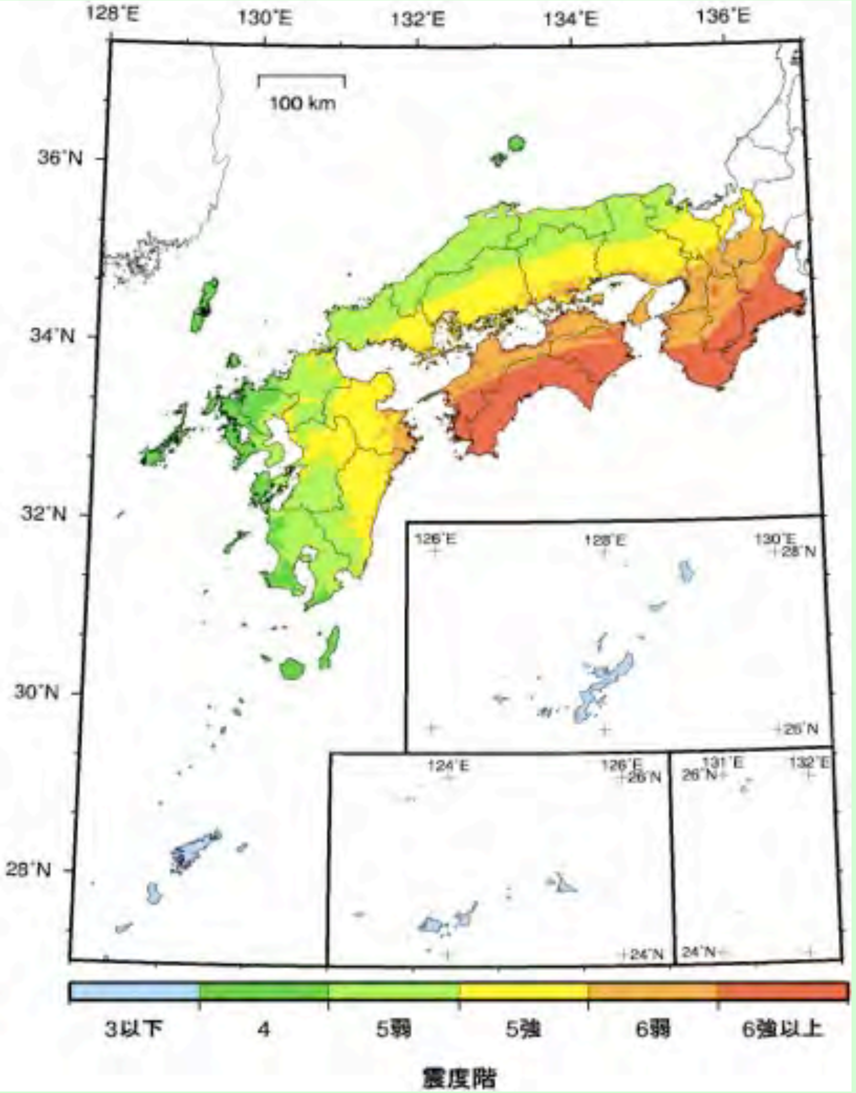
2. Uk: Epistemic (Knowledge) Uncertainty 情報不足->不確定性

- Geometry of seismotectonic and seismo-genic zones
- Distributions describing source parameters

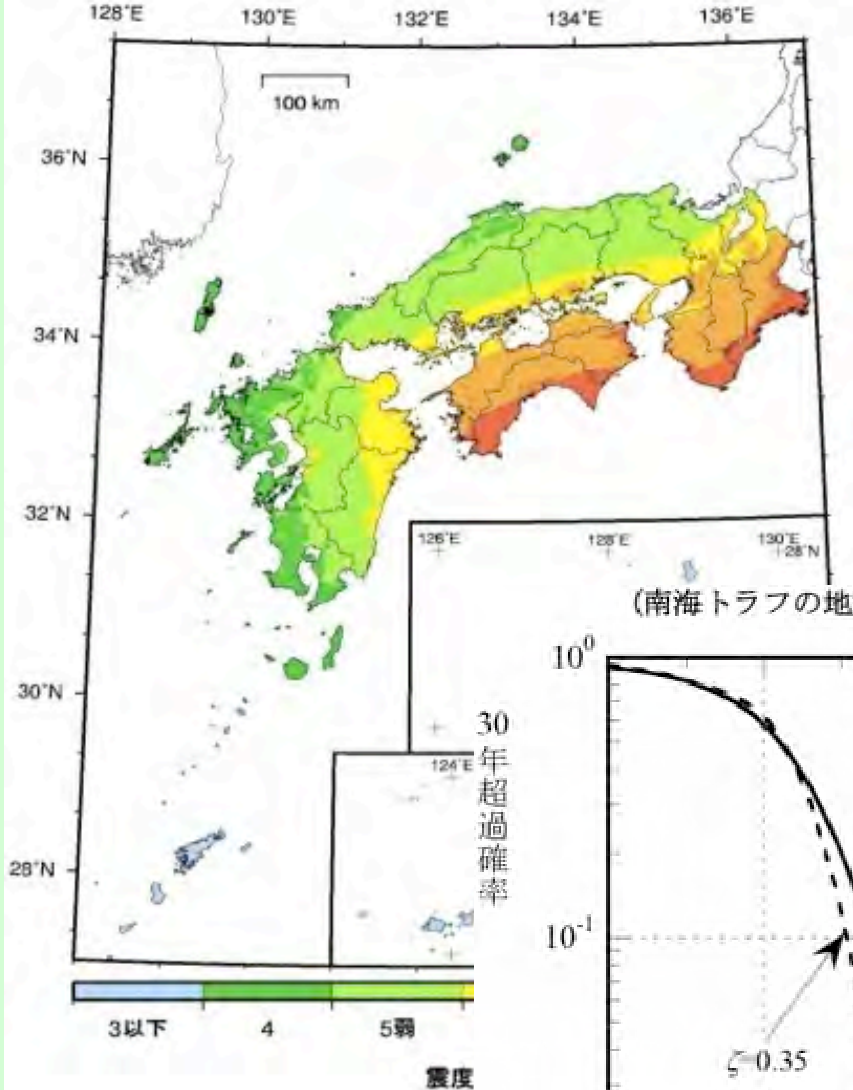
  (e.g., rate, b value, maximum M)
- Median value of ground motion given the source properties
- Limits on ground shaking

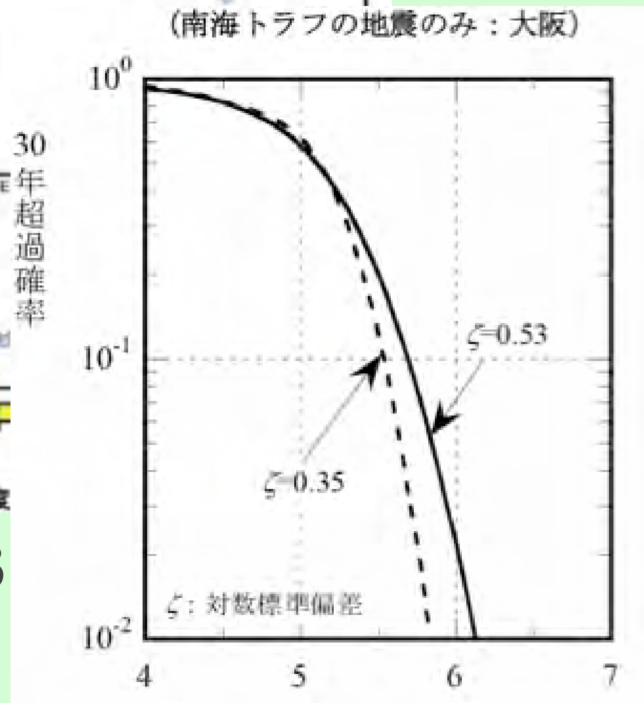
Common logarithm standard deviation σ

σ = 0.23

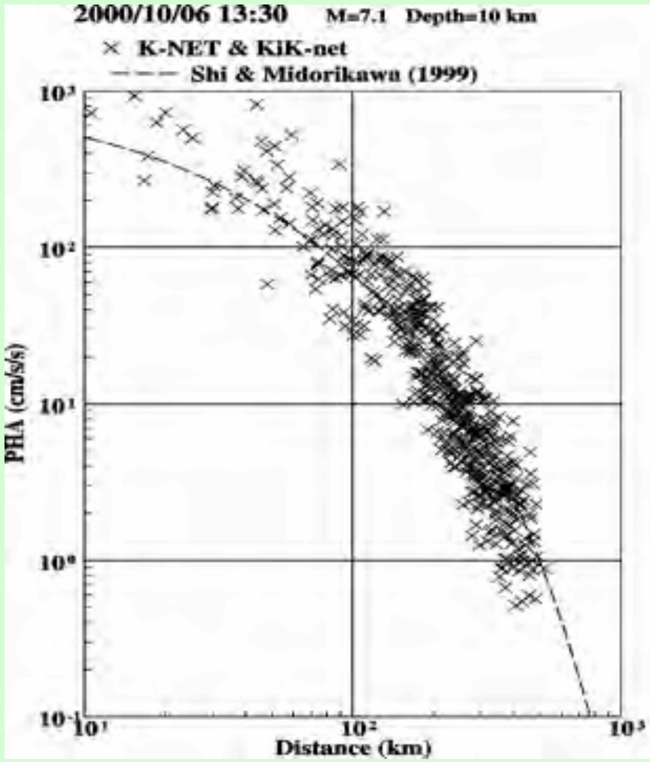


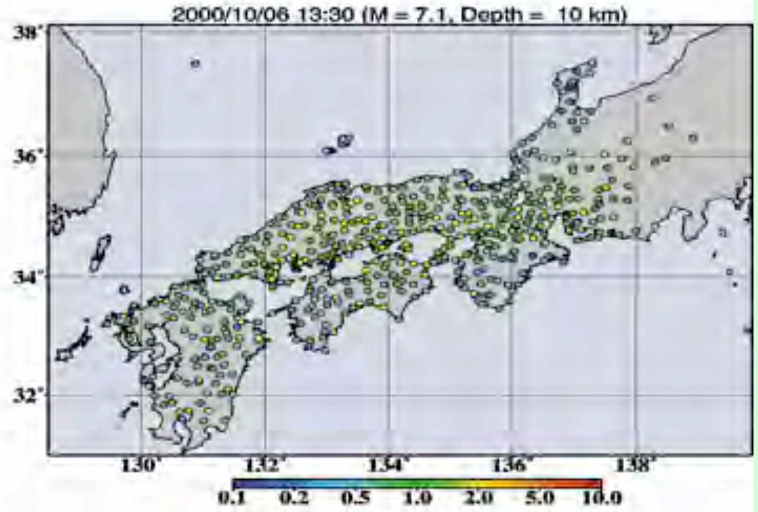
σ = 0.15





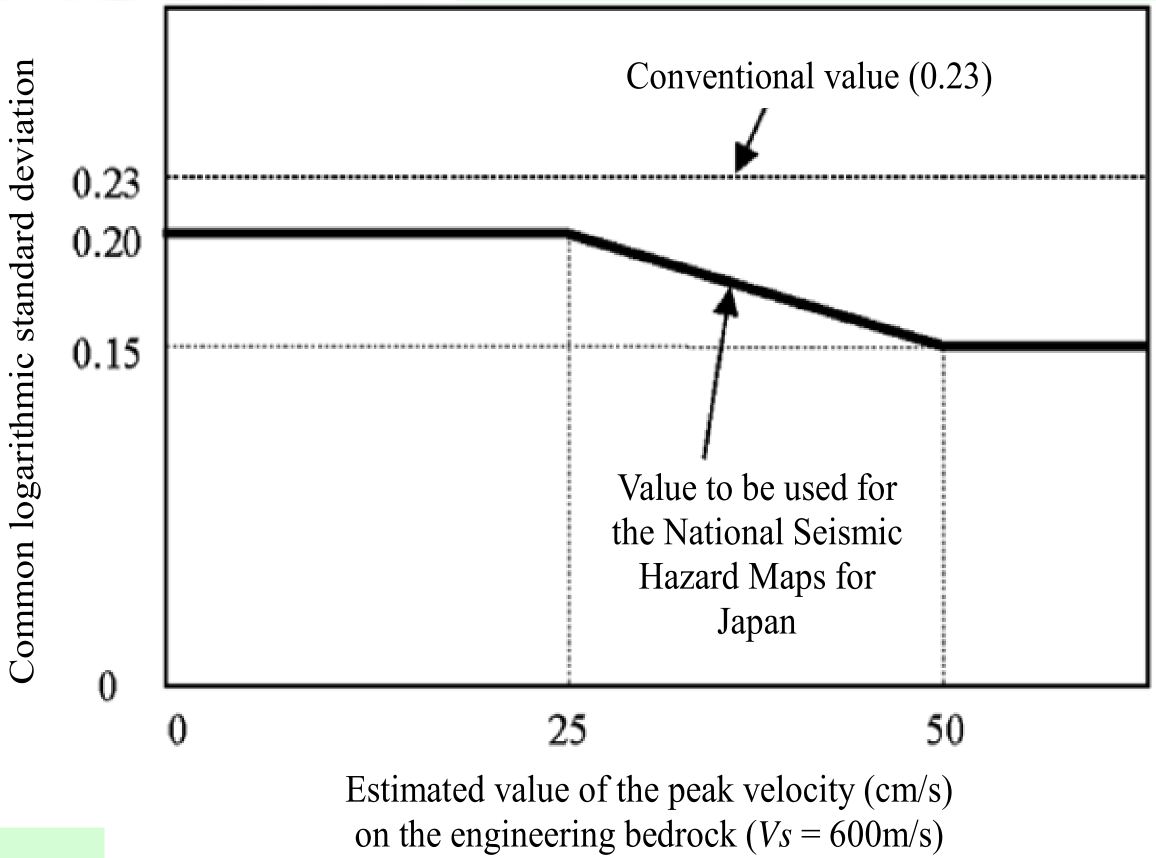
Seismic intensity in 3% exceedance probability within 3





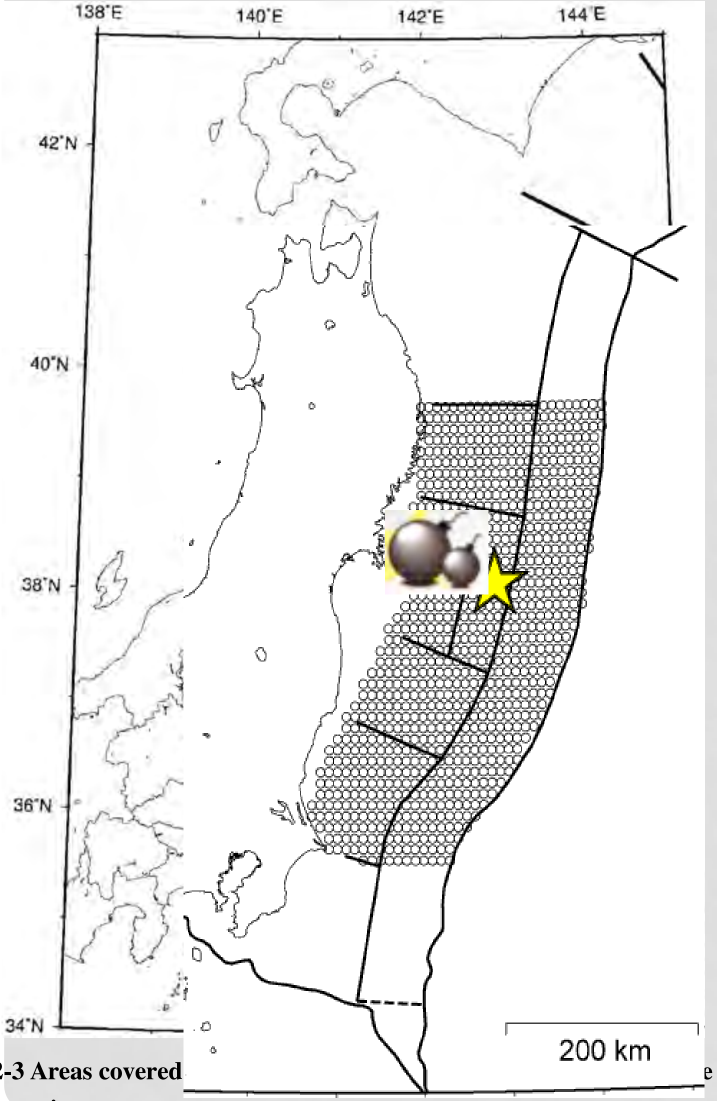
Random phenomenon (Aleatory uncertainty) was considered in hazard curve calculation

Reduce uncertainty by using variance σ depending on Velocity amplitudes



3.3.2 Subduction-zone Earthquakes

We did pointed out that a M7.4 to 8.0 earthquake in Miyagi-ken-Oki, area A, with probability of 99%, would be occur within 30 years.



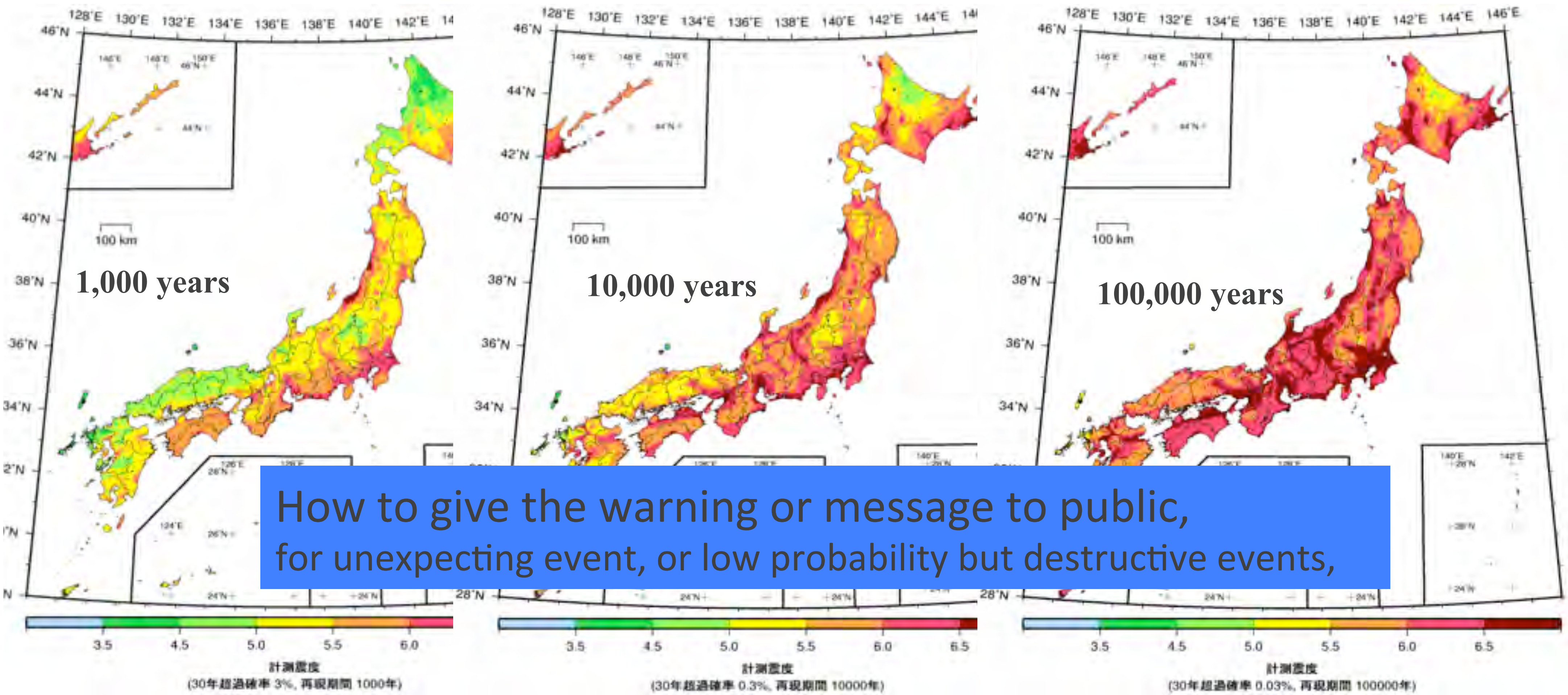
A: Miyagi-ken-Oki
B: Northern Sanriku-Oki
C: Close to the offshore trenches in the Northern Sanriku-Oki to Boso-Oki regions
D: Central Sanriku-Oki
E: Close to the offshore trenches in Southern Sanriku-Oki
F: Fukushima-ken-Oki
G: Ibaraki-ken-Oki

However, the ruptures trigged areas A, E, D, F, G and C simultaneously, over a region of 500km x 200km, which was far beyond our considerations.

The maximum M was underestimated.

.2-3 Areas covered e and earthquakes in the Sanriku-Oki to Boso-Oki regions.

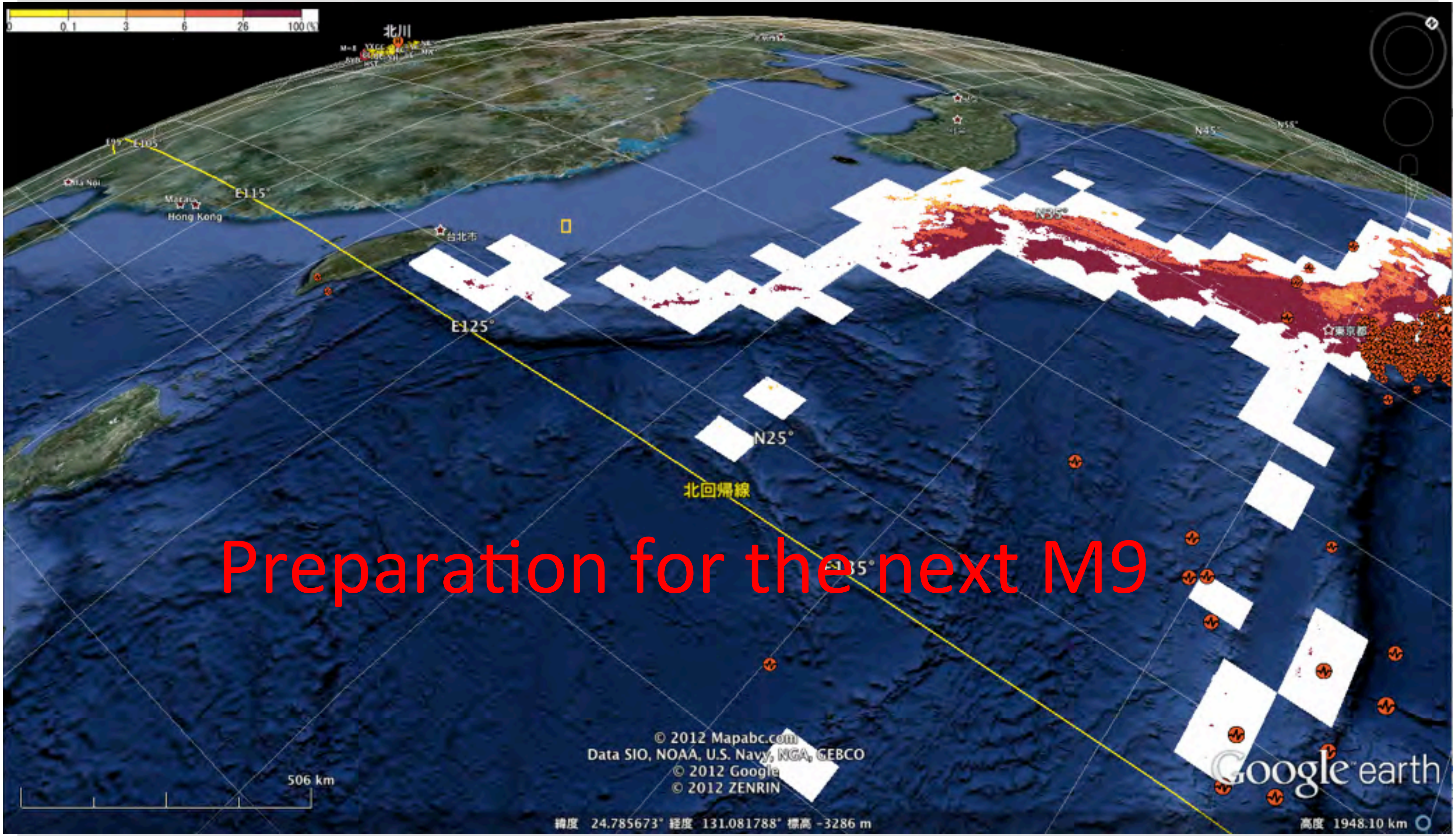
Strong-motion maps considering **low-probability** earthquakes



How to give the warning or message to public,
for unexpecting event, or low probability but destructive events,

Major earthquakes on active faults and subduction zone with low-probability.

Regarding the PSHA for low probability, at presen it is insufficient to evaluate the uncertainty for low probability of M8-class earthquakes and it is necessary to improve techniques for them.



Preparation for the next M9

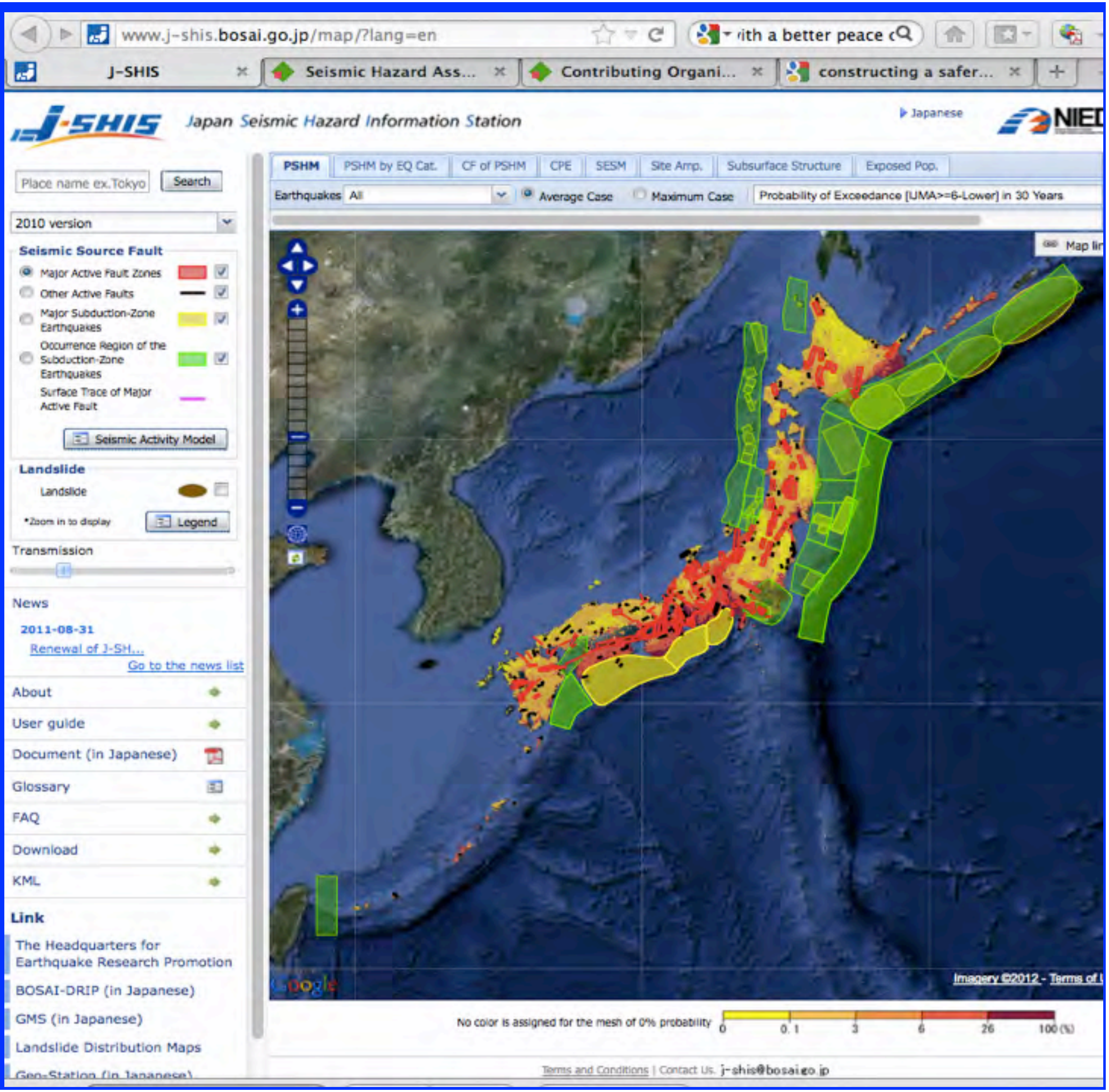
3. Cooperative works on PSHA

- Historical records
- Sharing EQ database
- Person exchange

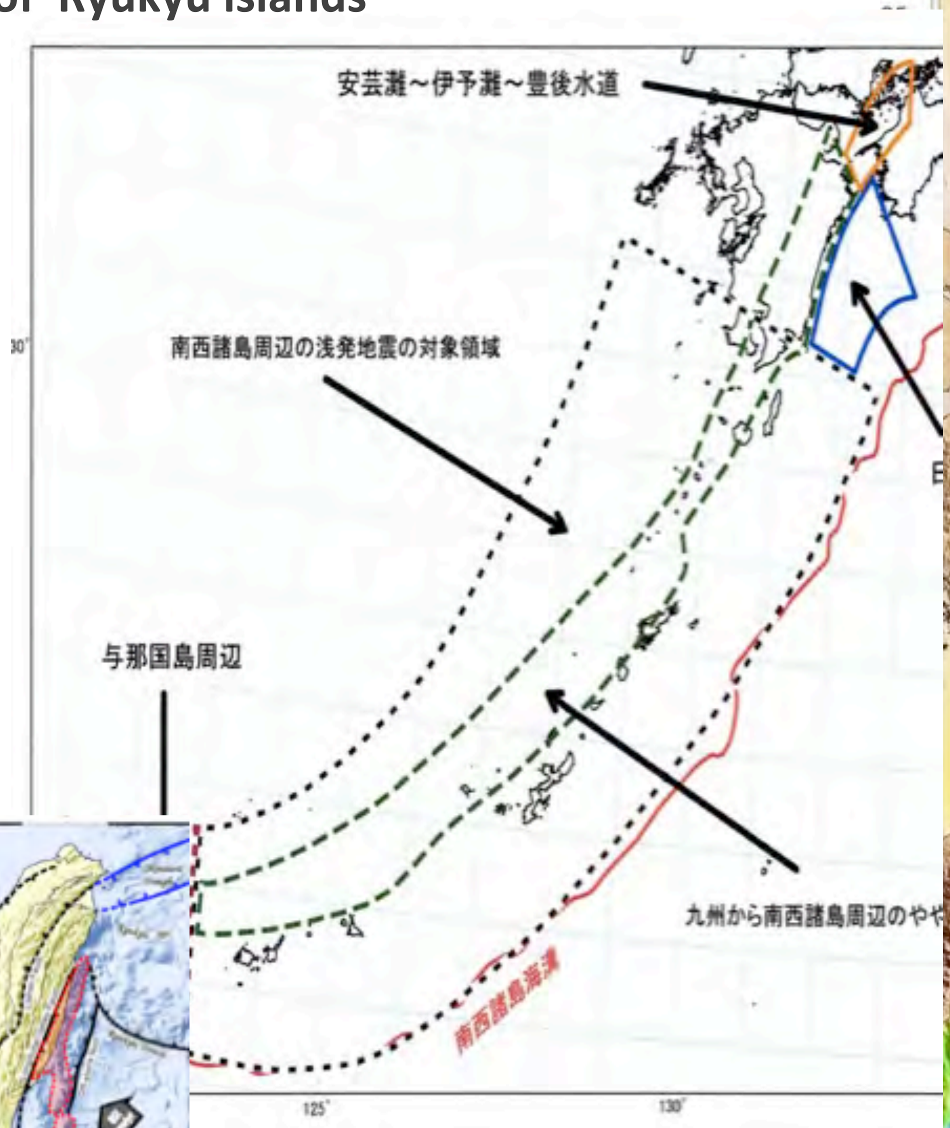
What lessons we have learnt from the Tohuku earthquake?

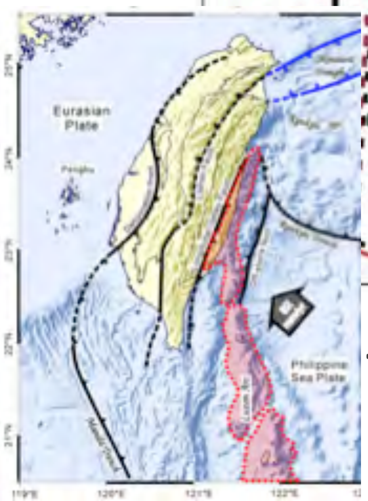
"The borderless world of Science" → enabling knowledge and data exchange each others.

Subduction zones → Crossing border connect the world



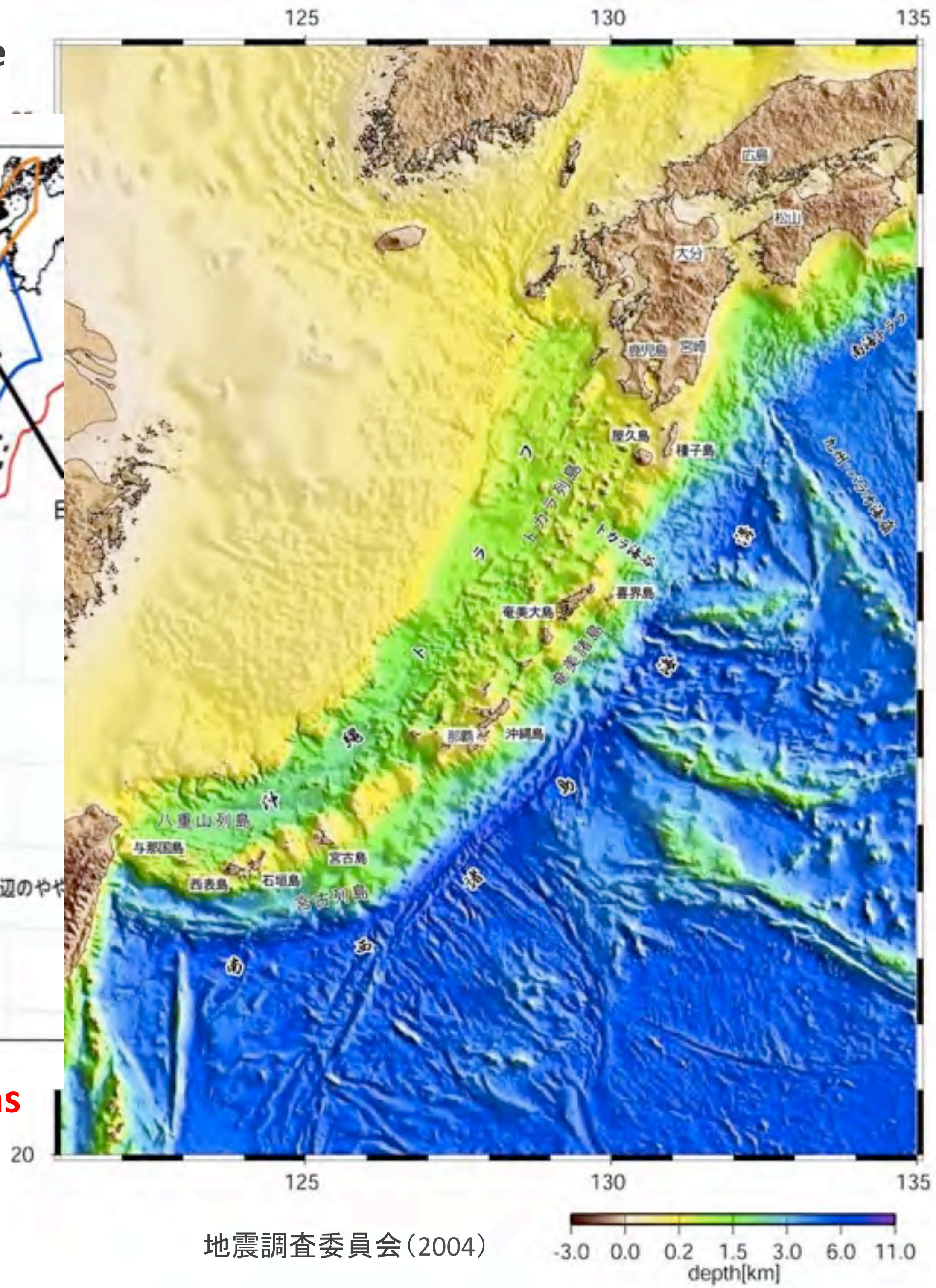
Earthquakes without specified source faults in the vicinity of Ryukyu islands





-> **Earthquake occurrence regions**

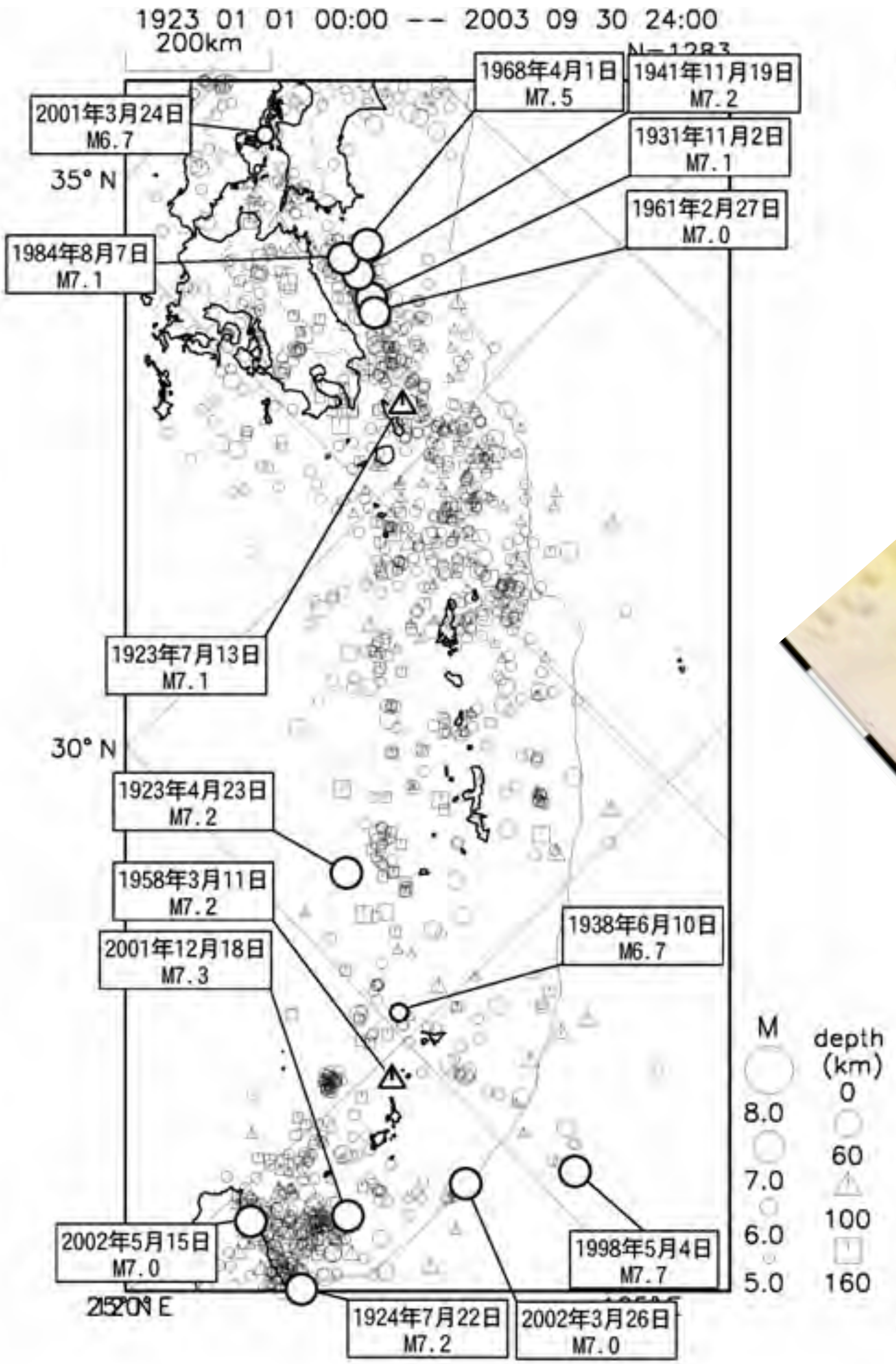
W.-J. Huang, et al, 2010

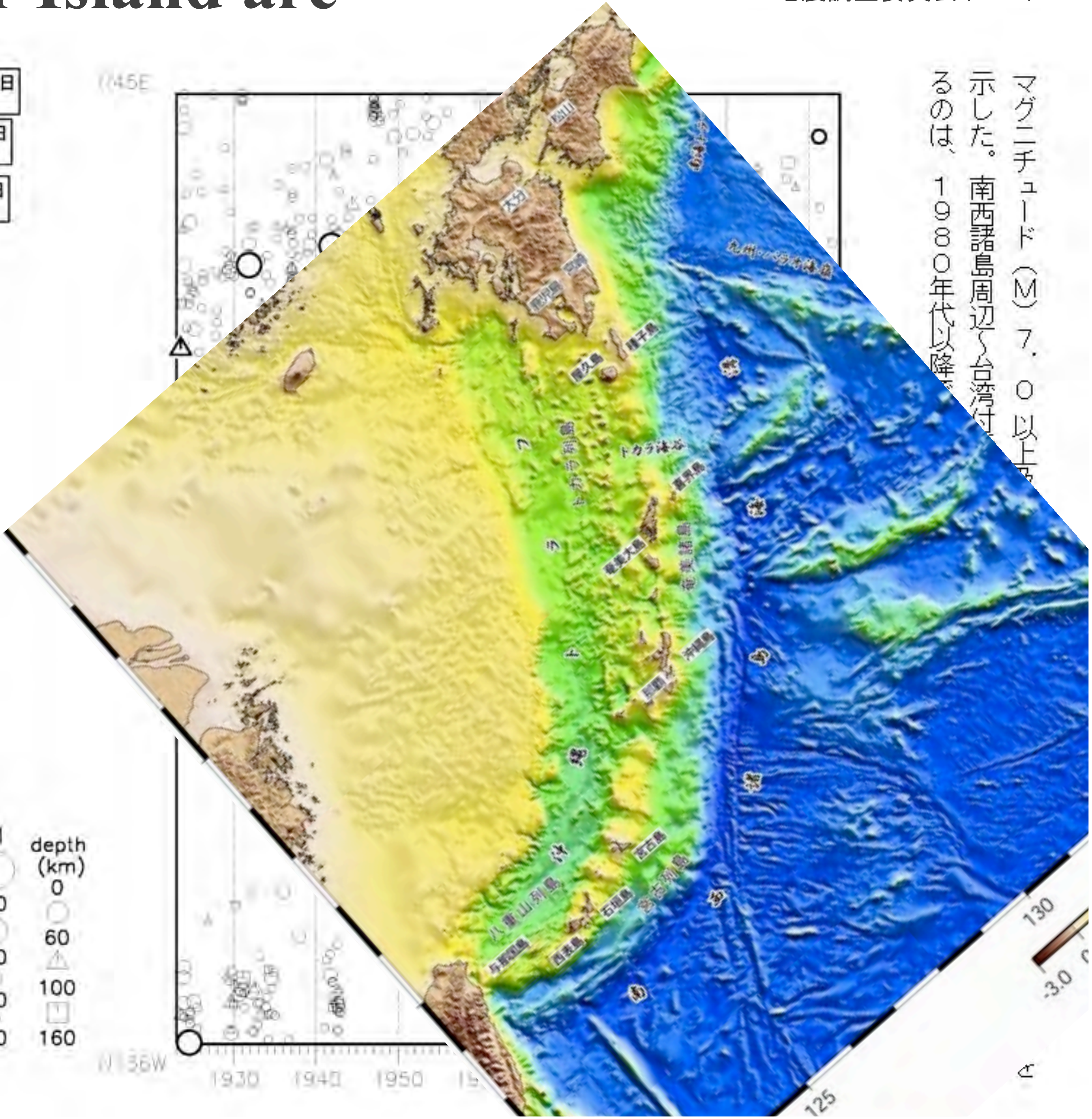


地震調査委員会（2004）

Subduction zones for Island arc

地震調査委員会(2004)





New Release →

www.j-shis.bosai.go.jp/intl/cjk

International Cooperation

→

Trilateral cooperative program enabling knowledge data exchange

Approved and supported by each individual counties

→ SHA for Next Generation

→ Welcome to Cooperation with TEM


J-SHIS | Seismic Hazard Asses... | Seismic Hazard Asses...

SEISMIC HAZARD ASSESSMENT FOR THE NEXT GENERATION MAP

Japan-China-Korea Cooperative Research Projects supported by JST-MOST-NRF

Constructing a safe and secure society

Over 90% of natural disasters have occurred in Asia and millions of people have lost their lives and homes by the recent earthquakes, tsunami and natural disasters. Earthquake prediction is not available in short-term, however, Probabilistic Seismic Hazard Assessment (PSHA) in long-term is considered as a scientific way to define earthquake area/zones and to guide urban planning and engineering management.

• • •

A strategic cooperative program (2010-2013) of "Seismic Hazard Assessment for the Next Generation Map" was finally selected after individual examinations by committees of MOST, NRF and JST, in China, Korea and Japan, respectively. The goal of this strategic project is to improve the PSHA methodology for the next generation maps in the three counties. To achieve this goal, the following approaches are planned:

1. to review the data and the methodologies adopted in the current PSHA maps of the three countries and evaluate if there is anything to be improved or added in each of the countries;
2. to compare the data and the methodologies with the state of the art technology and see if anything could be accepted for the next generation maps;
3. to develop a procedure to establish ground motion attenuation relationships for the maps;
4. to combine the probabilistic seismic hazard assessment and the deterministic approach of scenario earthquake for potential large earthquake and to prepare an example map for each country.

• • •

This site is a communication forum to deal with theories, methodologies, data and related issues. We encourage people from all of over world to exchange their own experiences and individual methods.

Activities

1st Annual meeting
Hosted by HIT in Harbin, China on Nov 25-30, 2011.

2nd Annual meeting
Will be hosted by KIGAM in Korea, 2012.

3rd Annual meeting
Will be hosted by NIED in Japan, 2013.

Links

Japan Seismic Hazard Information Station J-SHIS

哈爾濱工業大學 NIED KIGAM

Home | The 1st Annual Meeting | The 2nd Annual Meeting | The 3rd Annual Meeting | Links