

Earthquake Early Warning in Japan

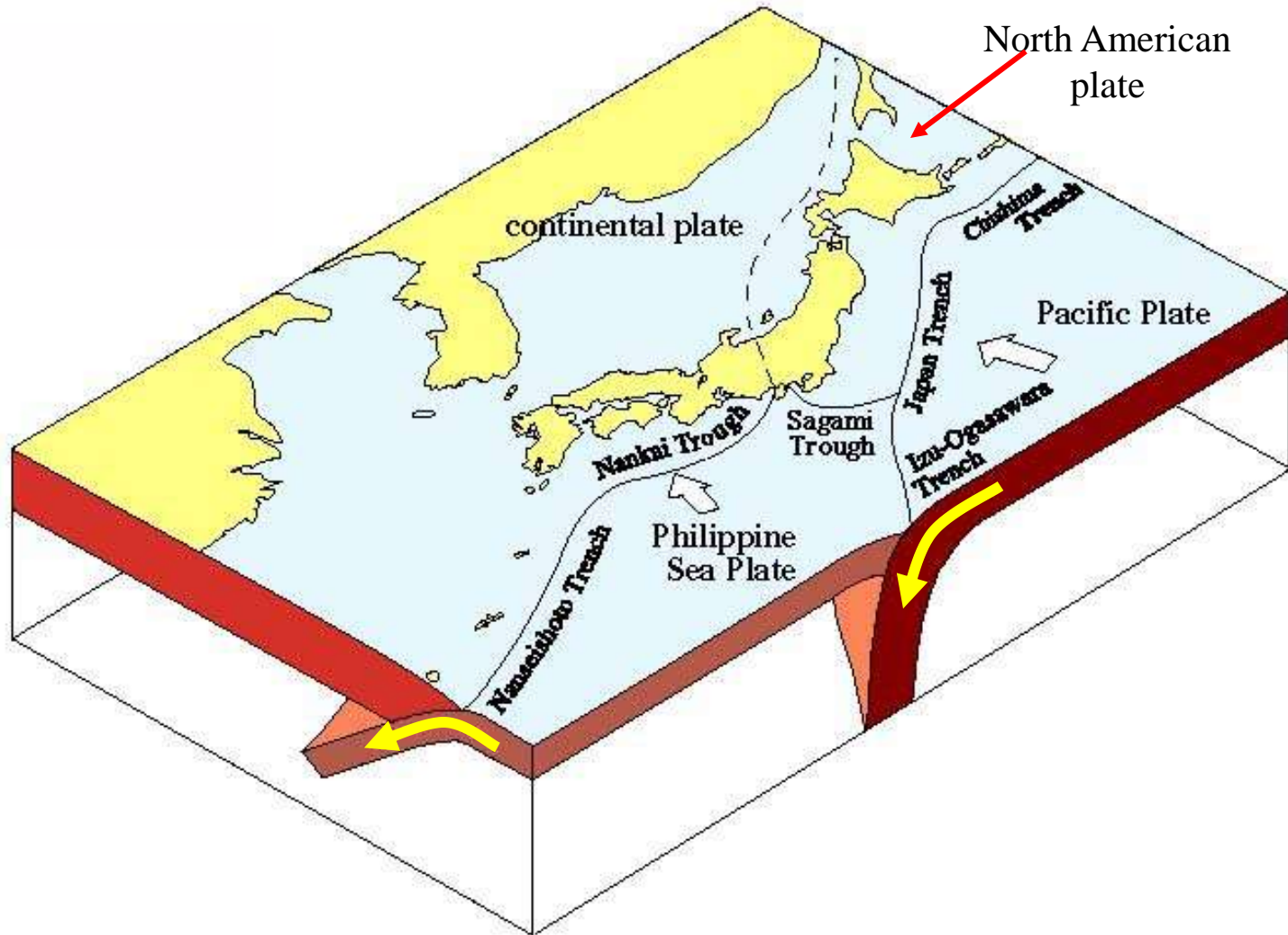
- Provision to the General Public and its Results -



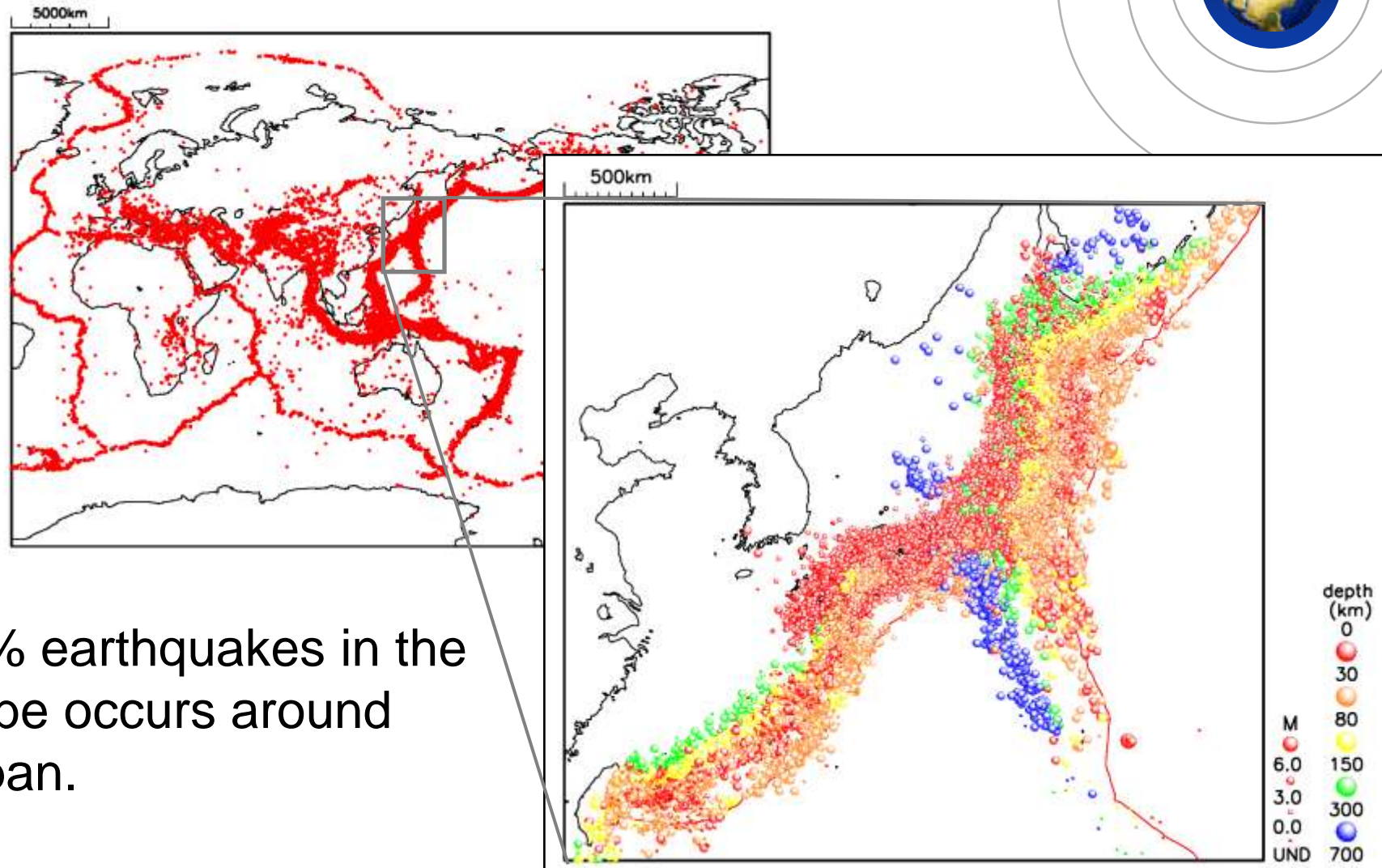
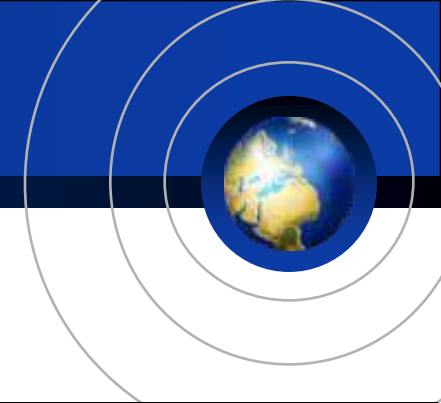
DOI, Keiji

Japan Meteorological Agency

Plate Tectonics around Japan



Seismicity in and around Japan 地震発生状況



10% earthquakes in the globe occurs around Japan.

About 127,000 earthquakes occurred in 2008 including 2,000 felt earthquakes



Great Hanshin-Awaji Earthquake (1995)

Niigata Chuetsu Earthquake (2004)

Tsunami Disaster by the Southwest off Hokkaido Earthquake in 1993 (July 12, 1993, M7.8)

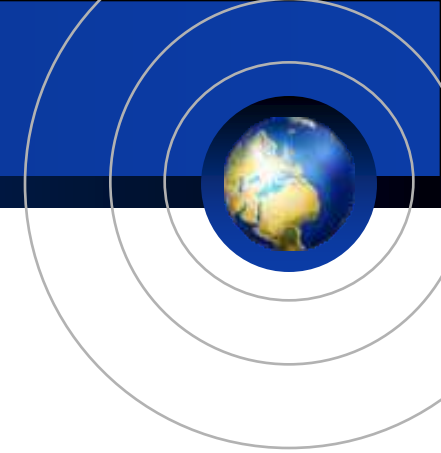


202 people killed ,28people missing

Eruption of Usu Volcano in 2000



JMA's Responsibilities



- Earthquake Early Warning
- Tsunami Warning / Information
- Earthquake Information
 - **Location, Magnitude, Seismic Intensity**
- Earthquake Prediction in the Tokai area
- Volcanic Warning / Information

Time Sequence to Issue Earthquake Information and Tsunami Warning

Earthquake Early Warning

Earthquake

Tsunami Warning

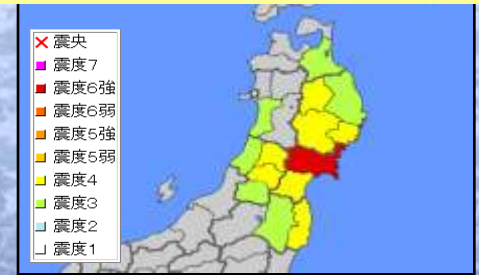


Seismic Intensity Information (Local area seismic intensity)

2min.

3min.

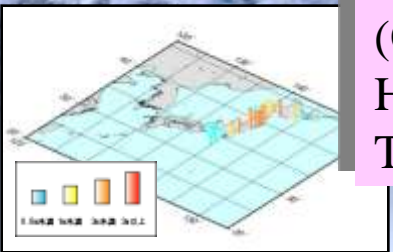
Tsunami Information (Estimated Tsunami Heights and Arrival Times)



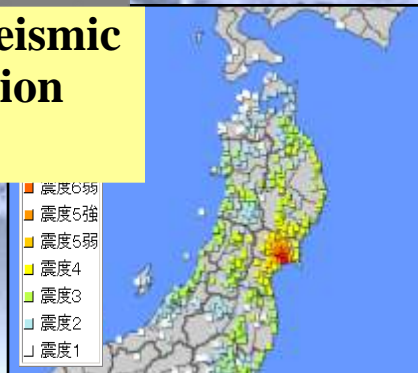
Earthquake Information (Hypocenter and Magnitude)

5min.

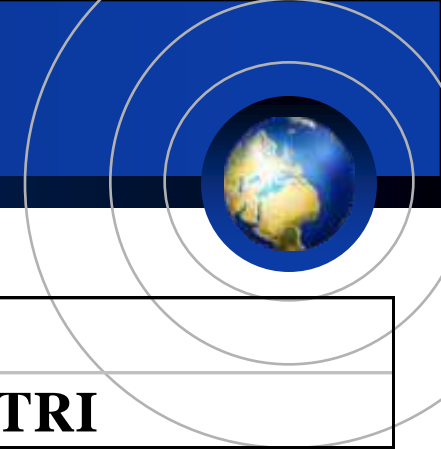
Tsunami Information (Observed Tsunami Heights and Arrival Times)



Earthquake and Seismic Intensity Information (Updated)



Chronology of Earthquake Early Warning's development and operation



| | |
|------------------|--|
| 2000- | Development of EEW technology |
| | B- Δ method was developed by JMA and RTRI |
| 2004.2.25 | Start of trial provision (For Kanto-Tokai-Nankai area) |
| 2005.3.28 | Expand of trial dissemination area (For Hokkaido-Tohoku area) |
| 2005.6 | Integrate of 'Not Yet Arrived Data Method' algorithm developed at National Research Institute for Earth Science and Disaster Prevention |
| 2006.3.31 | Expand of trial dissemination area (For whole country) |
| 2006.8.1 | Start provision for the limited online users |
| | familiarize general public about EEW |
| 2007.10.1 | Start provision for the general users through various media outlets such as TV and radio. |
| 2007.12.1 | The revision of the Meteorological Service Law |

Earthquake Early Warning System

Provision to public started on Oct. 1, 2007

Forecast / Warning started on Dec. 1, 2007

How to acquire EEW

Using TV, radio, local-governmental radio, cellular phone, etc.

EEW receivers, dedicated systems, etc. provided by private companies

Image of TV broadcast

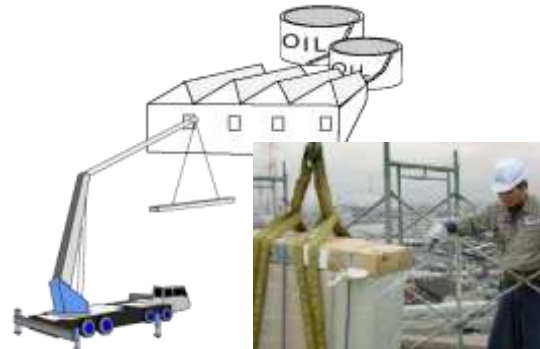
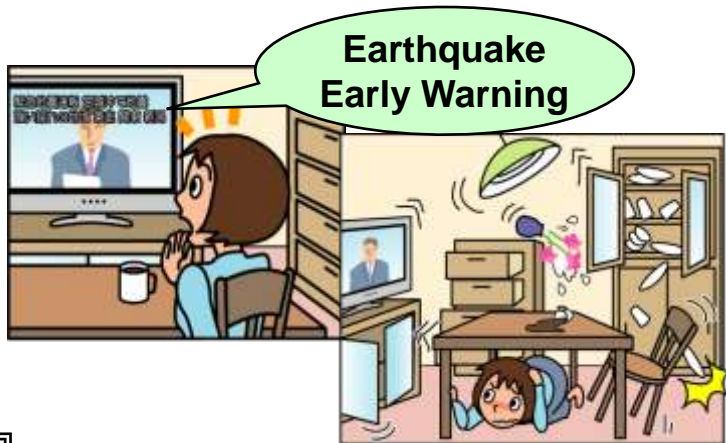


Areas where strong tremors (intensity 4 and up) may occur when the max. intensity is 5 lower and up.

Predicted earthquake intensity and the expected time of arrival in each point.

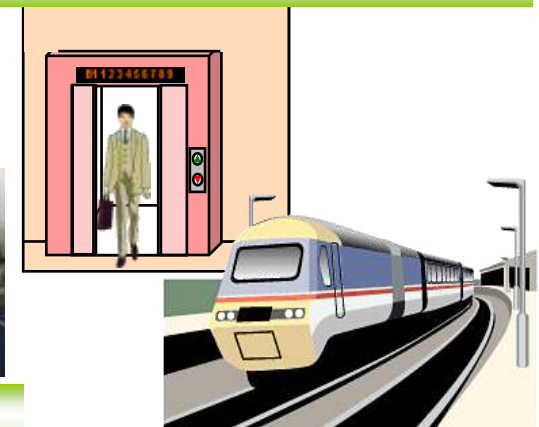
Example of Response to EEW

To enable personal protection at home

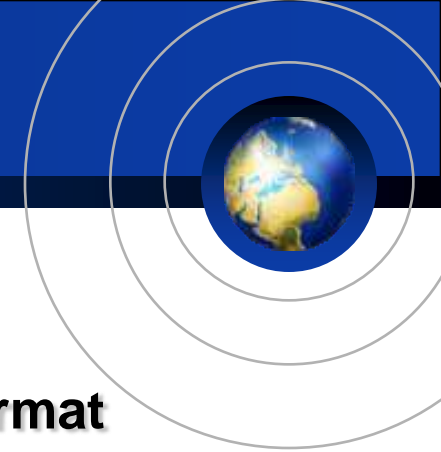


Line Control, Safety action

Controlling trains and Elevators



Ideas to establish EEW system



- **On-site data processing**

 - Estimating a source parameter, PGA, PGV

 - Data transmission using compressed data format

- **Estimation of source parameters**

 - Several methods being used for the source parameter estimation according to available data

- **Estimation of seismic ground motion**

 - Seismic Intensity being estimated for ground motion forecast

- **Provision of warning/forecast**

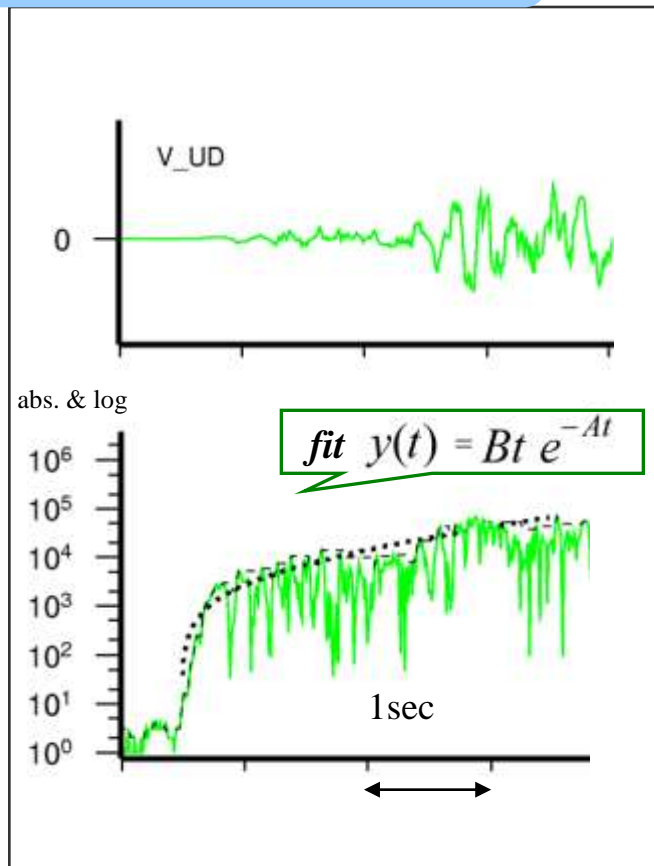
 - Provision of warning to the public through broadcasting media

 - Estimation of strong motion at a recipients site being served by forecasting company

Seismic Observation Network

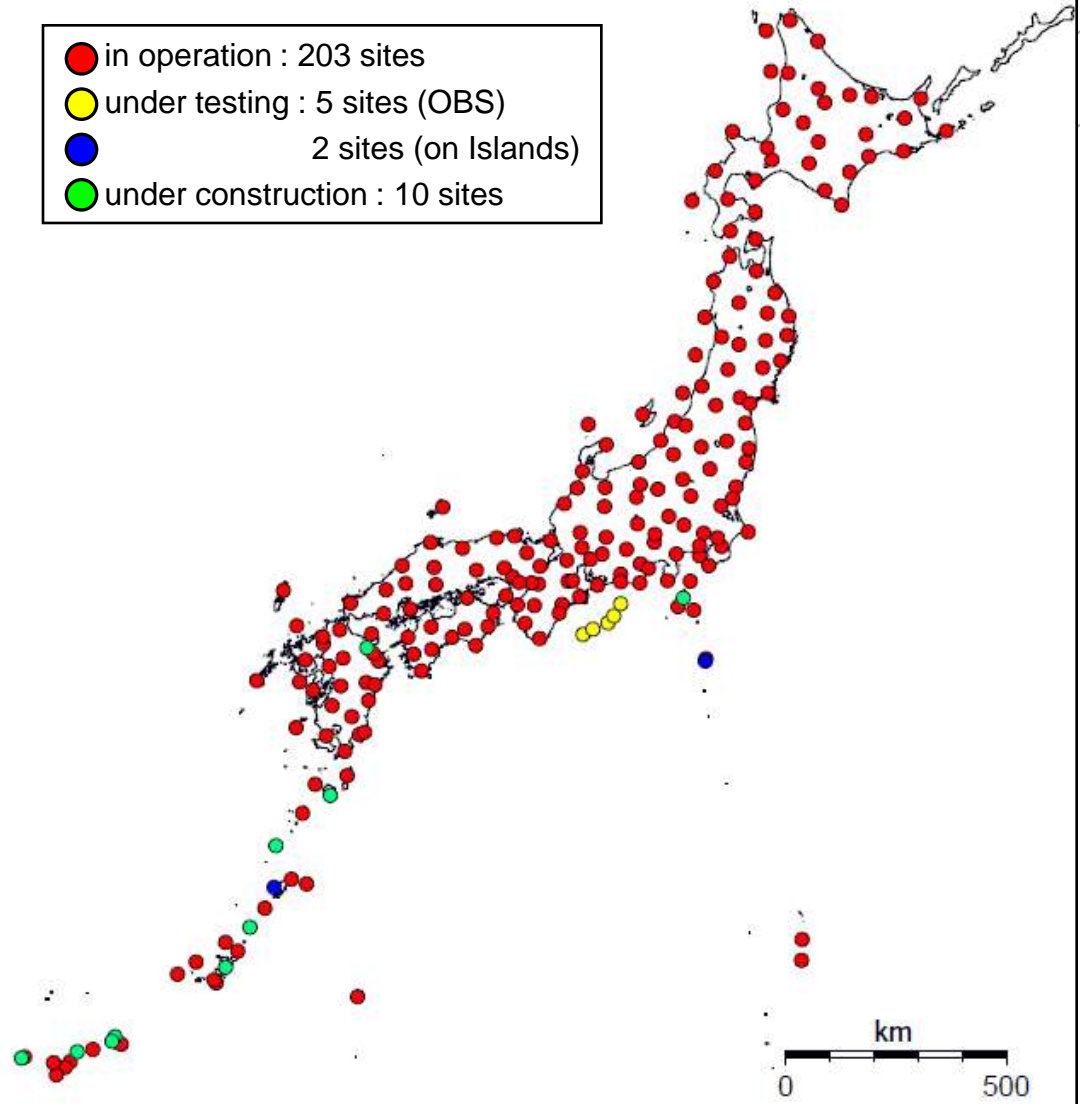


Single-Station Method (JMA-RTRI)



JMA's Seismic Stations

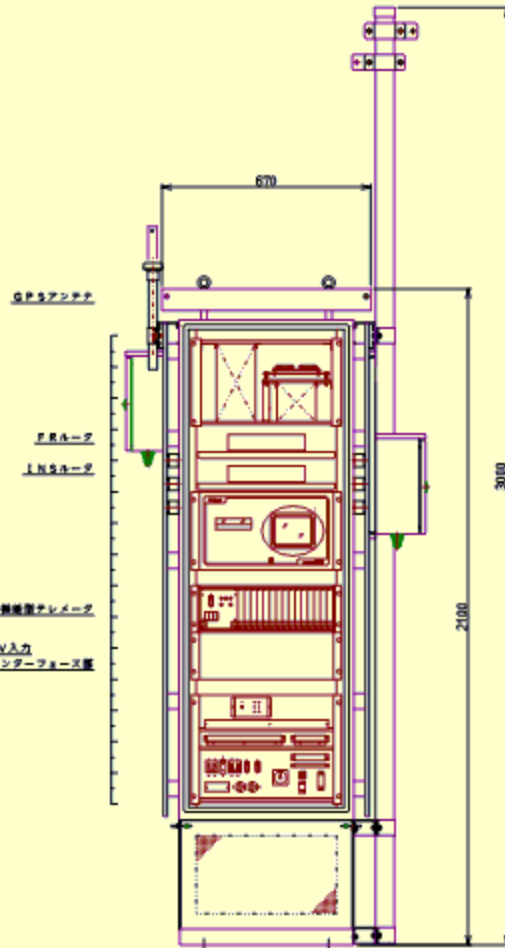
- in operation : 203 sites
- under testing : 5 sites (OBS)
- 2 sites (on Islands)
- under construction : 10 sites



Seismic Station



Sensor
left : accelerogram
middle : velocity



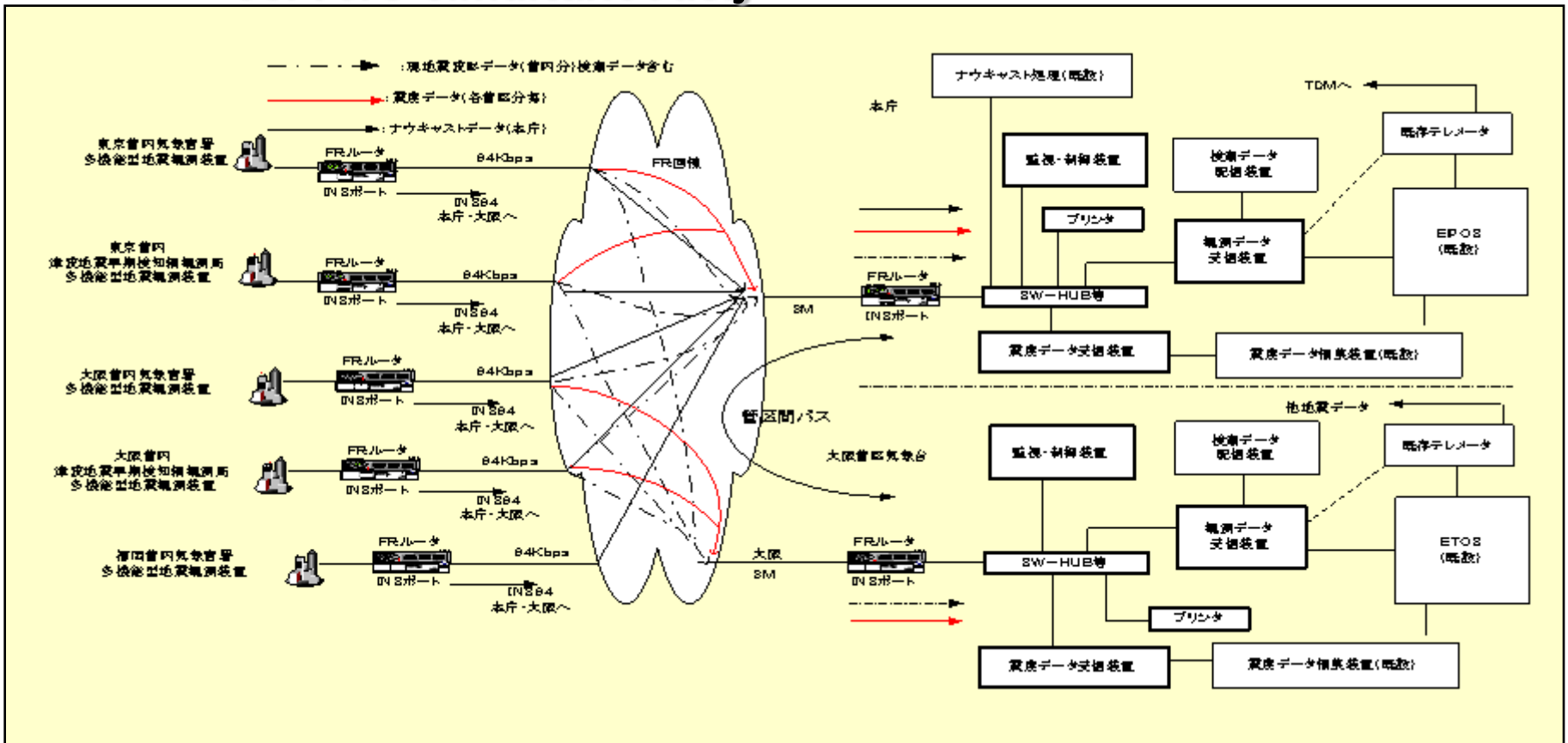
筐体内部

- Accelerogram and velocity meter
- Sampling with 100Hz・24Bit
- Time calibration by GPS clock
- On-site processing of seismic data
- Results are transmit to the Center with waveform data

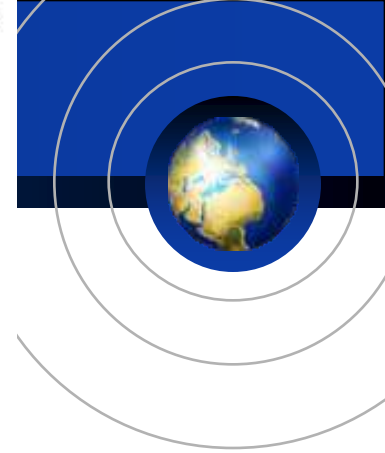
Transmission of seismic data



- Compressed data are transmitted through digital communication network every 1 second
- Results of on-site processing are forwarded to the servers simultaneously



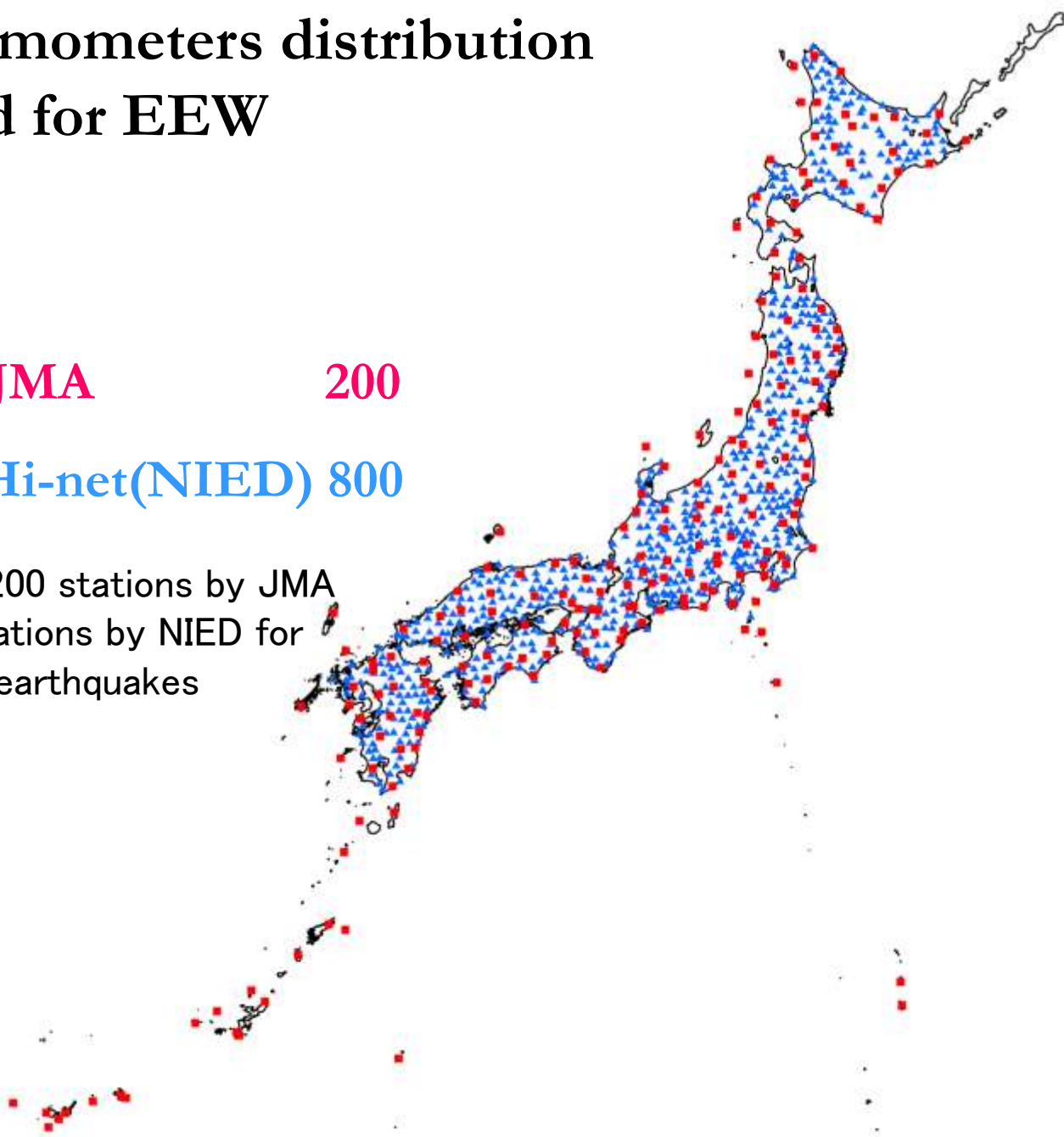
Seismometers distribution used for EEW



■ JMA 200

▲ Hi-net(NIED) 800

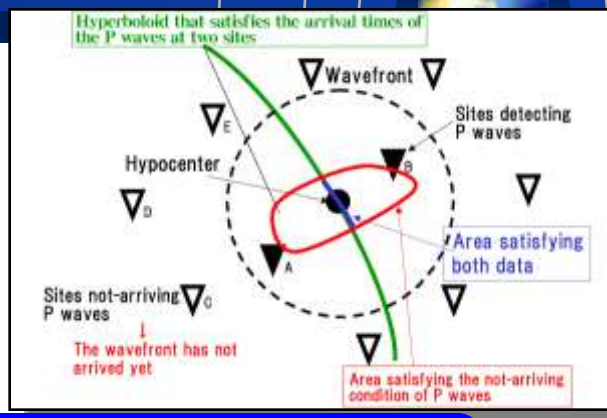
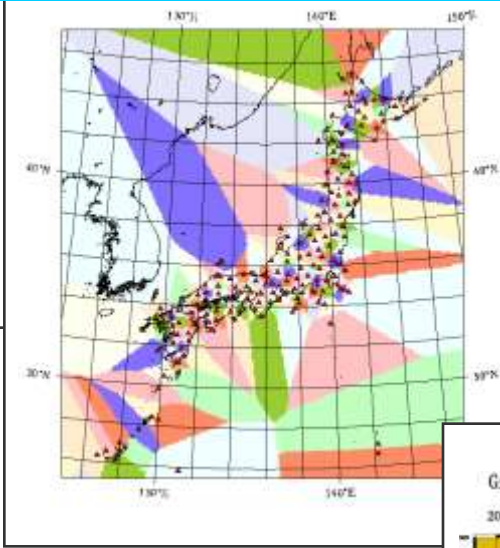
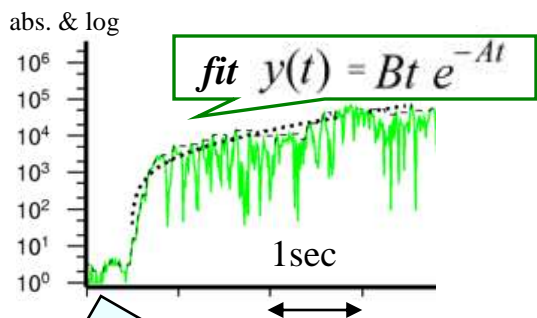
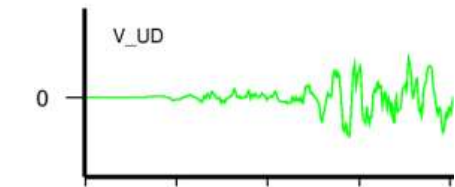
Data from 200 stations by JMA
with 800 stations by NIED for
location of earthquakes



Single-Station Method (JMA-RTRI)

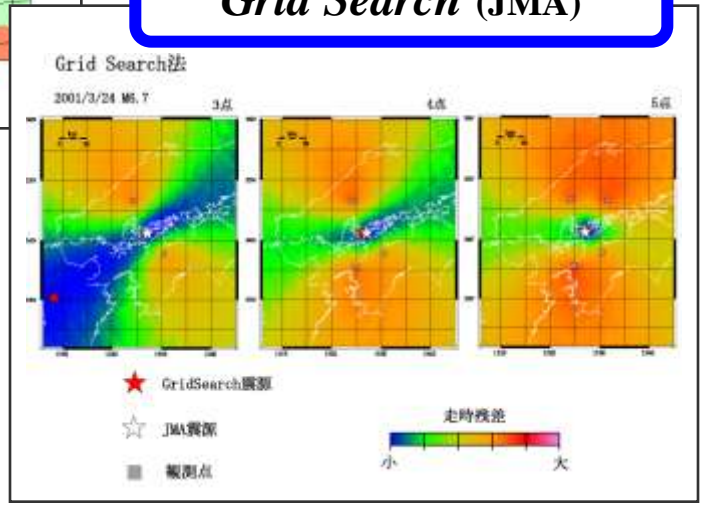
Method of hypocenter estimation

Network Method - Territory (JMA)



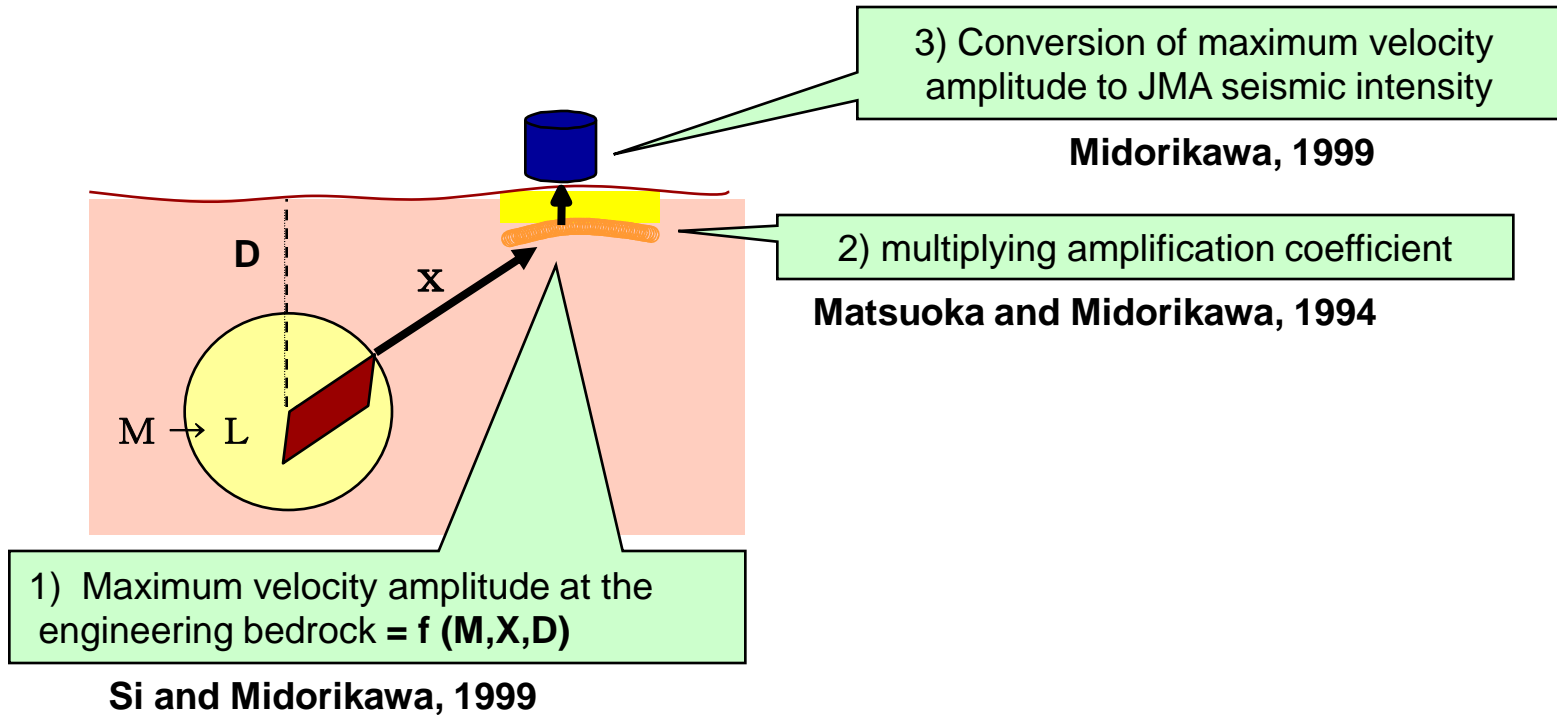
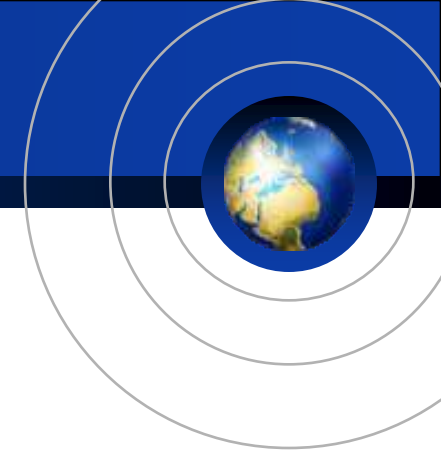
Network Method -Not Yet Arrived Data (NIED)

Network Method - Grid Search (JMA)

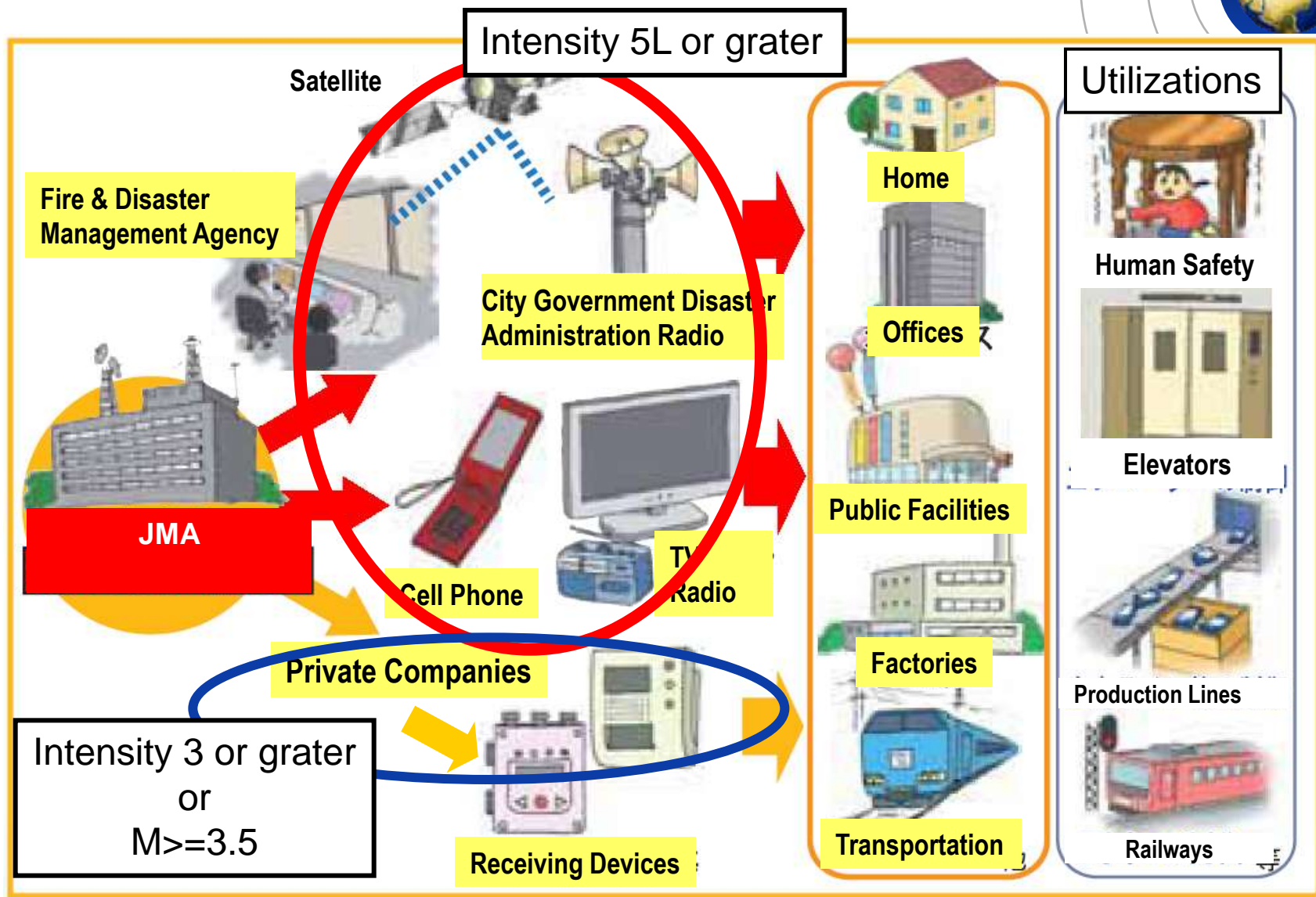


RTRI : Railway Technical Research Institute
NIED : National Research Institute for Earth Science and Disaster Prevention

Seismic Intensity Estimation



Dissemination of EEW



An actual example



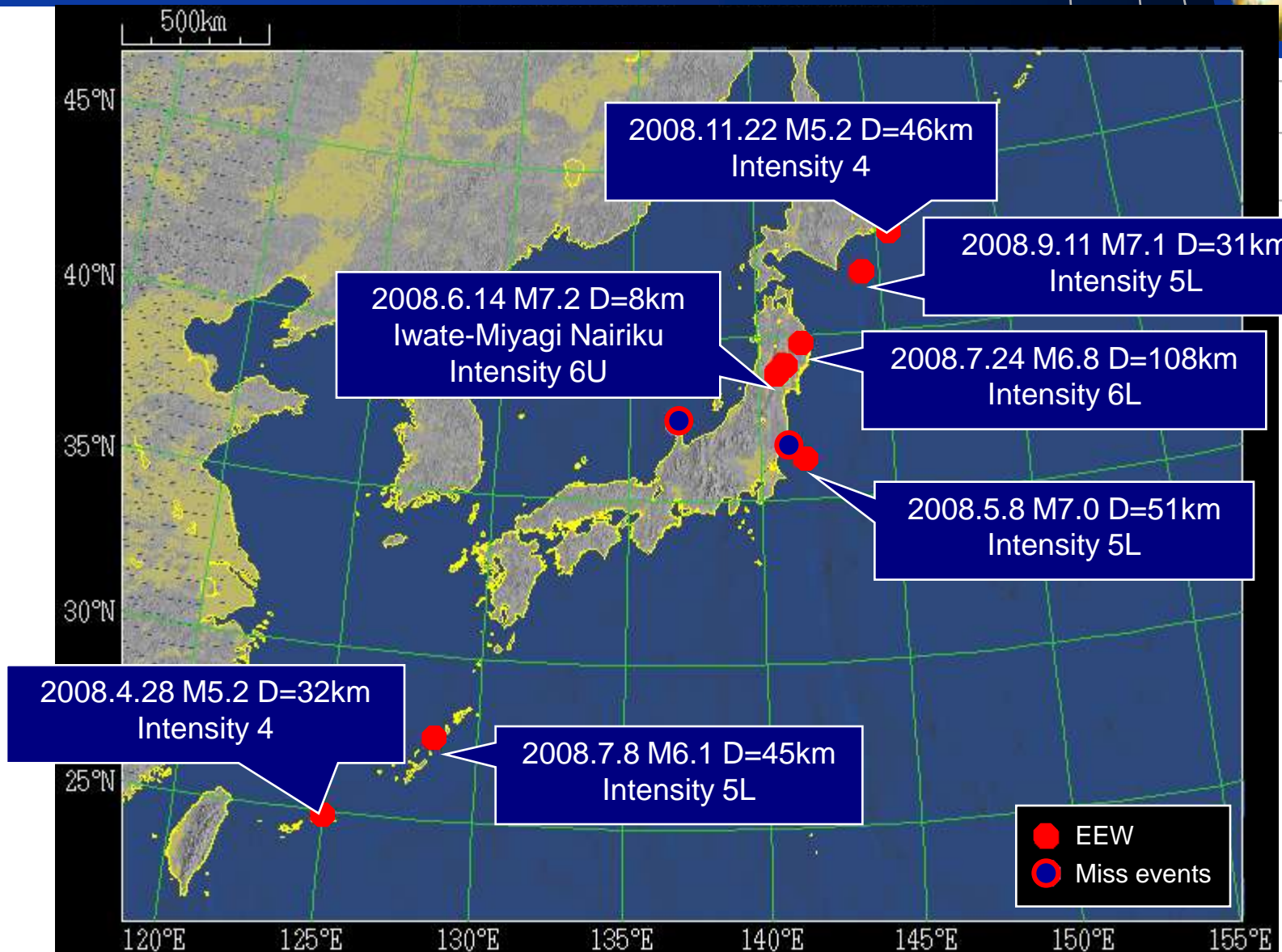
Drill



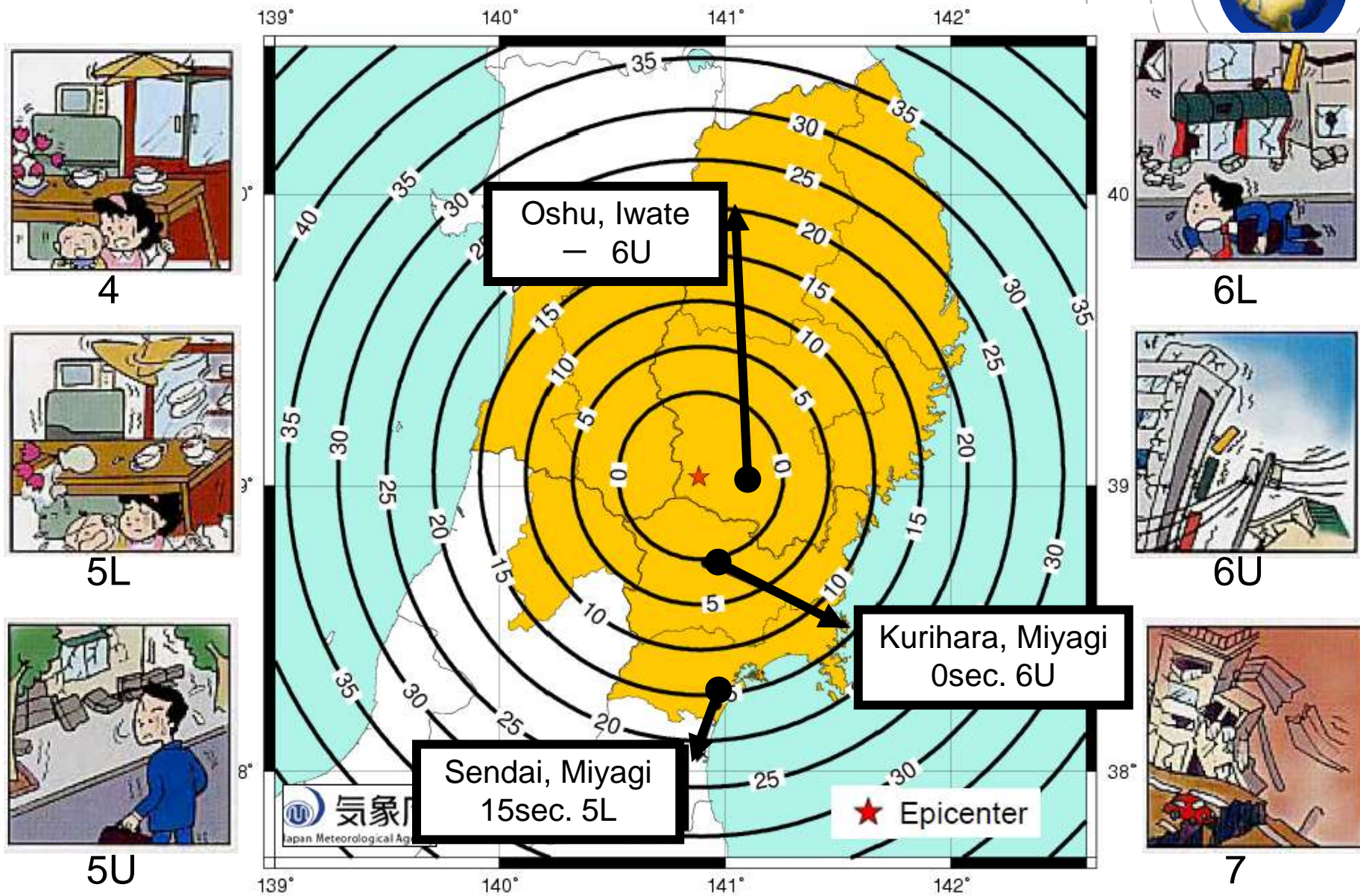
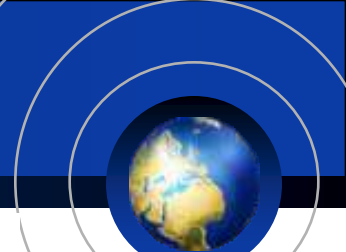
A drill at an elementary school

A scene of 2nd Grade pupils at Hirata Elementary School in Kamaishi, Iwate, participating in a drill on 4th July 2008 huddling under their desk after receiving EEW through City Government Disaster Administration Radio.

Case study : all cases of EEW to the public



Iwate-Miyagi Nairiku Earthquake (2008/6/14 8:43 M7.2)



Iwate-Miyagi Nairiku Earthquake (2008/6/14 8:43 M7.2)



detection time of a
seismic wave

08:43:50.7

| | issue time | elapse time from the detection (in second) | latitude (degree) | longitude (degree) | depth | M | estimated maximum intensity |
|------|------------|--|----------------------|-----------------------|-------|-----|-----------------------------------|
| 1st | 08:43:54.2 | 3.5 | 38.9 | 141.1 | 10km | 5.7 | 5Lower |
| 2nd | 08:43:55.2 | 4.5 | 39.1 | 141.0 | 10km | 6.1 | 5Upper |
| 3rd | 08:43:56.1 | 5.4 | 39.0 | 140.9 | 10km | 6.2 | 5Upper |
| 4th | 08:43:56.8 | 6.1 | 39.0 | 140.9 | 10km | 6.3 | 5Upper |
| 5th | 08:43:59.1 | 8.4 | 39.0 | 140.9 | 10km | 6.7 | 6Upper |
| 6th | 08:44:02.1 | 11.4 | 39.0 | 140.9 | 10km | 6.7 | 6Upper |
| 7th | 08:44:13.1 | 22.4 | 39.0 | 140.9 | 10km | 6.9 | 6Upper |
| 8th | 08:44:21.1 | 30.4 | 39.0 | 140.9 | 10km | 7.0 | 6Upper |
| 9th | 08:44:42.1 | 51.4 | 39.0 | 140.9 | 10km | 7.0 | 6Upper |
| 10th | 08:44:53.6 | 62.9 | 39.0 | 140.9 | 10km | 7.0 | 6Upper |

*estimated with a
single station

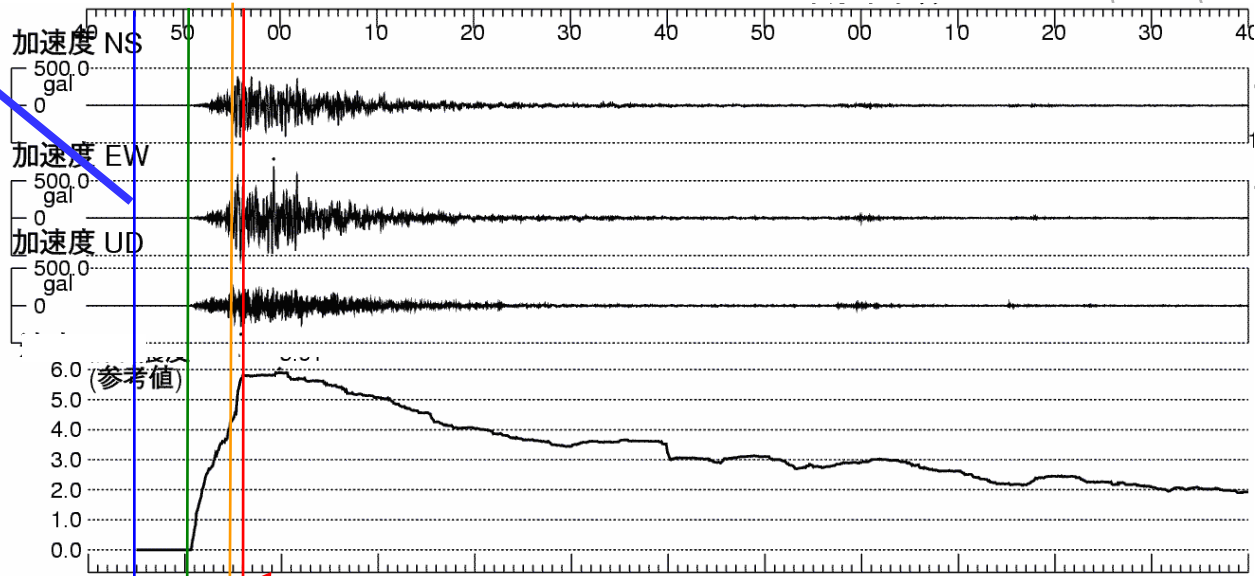
Iwate-Miyagi Nairiku Earthquake (2008/6/14 8:43 M7.2)



Origin time

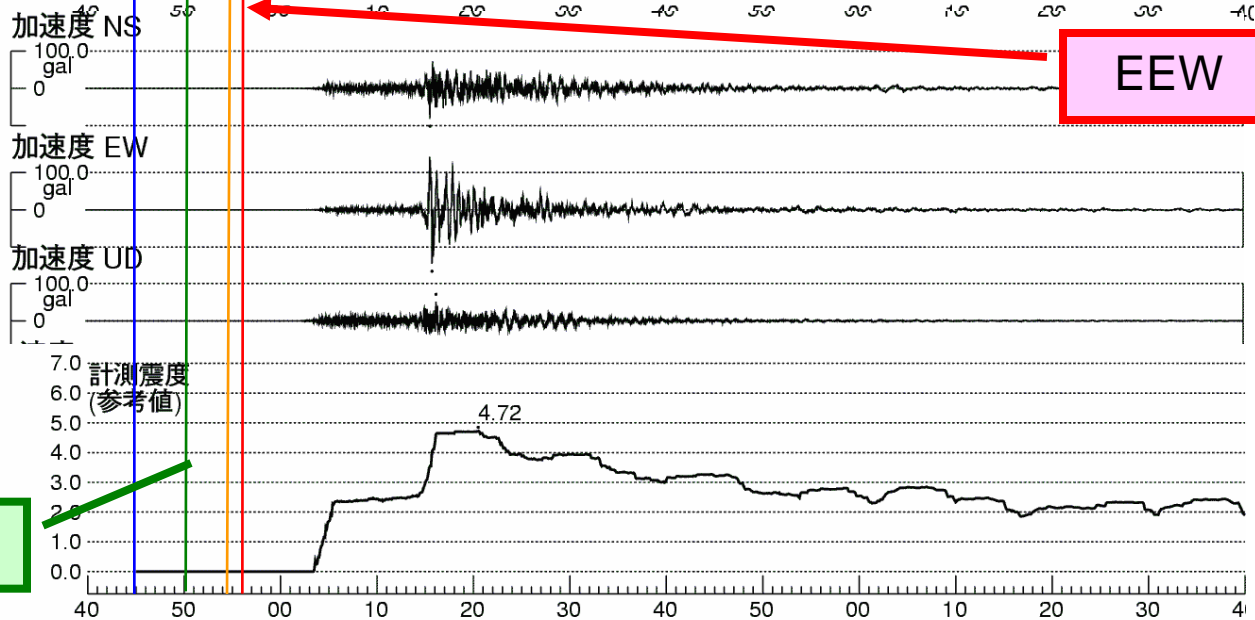
Kurihara
Kurikoma
(6L)

Delta:
24.9km



Sendai A.P.
(5L)

Delta:
99.6km



Detection time

Iwate-Miyagi Nairiku Earthquake (2008/6/14 8:43 M7.2)



★ epicenter

Home

Slowing down in driving a car

Controlling factory systems

Junior High School

Controlling elevators

Announcement in the factory

Office

Announcement in the office room

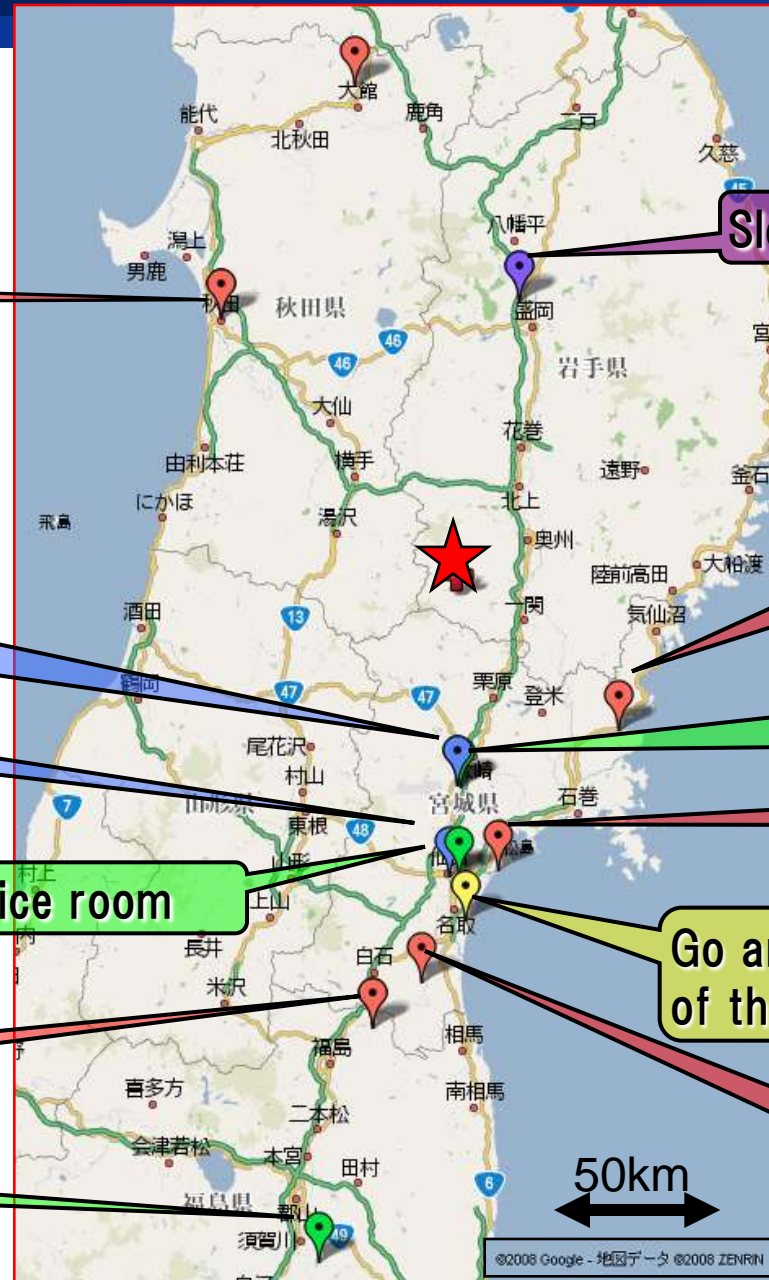
Go around from Control tower of the Airport

Nursery

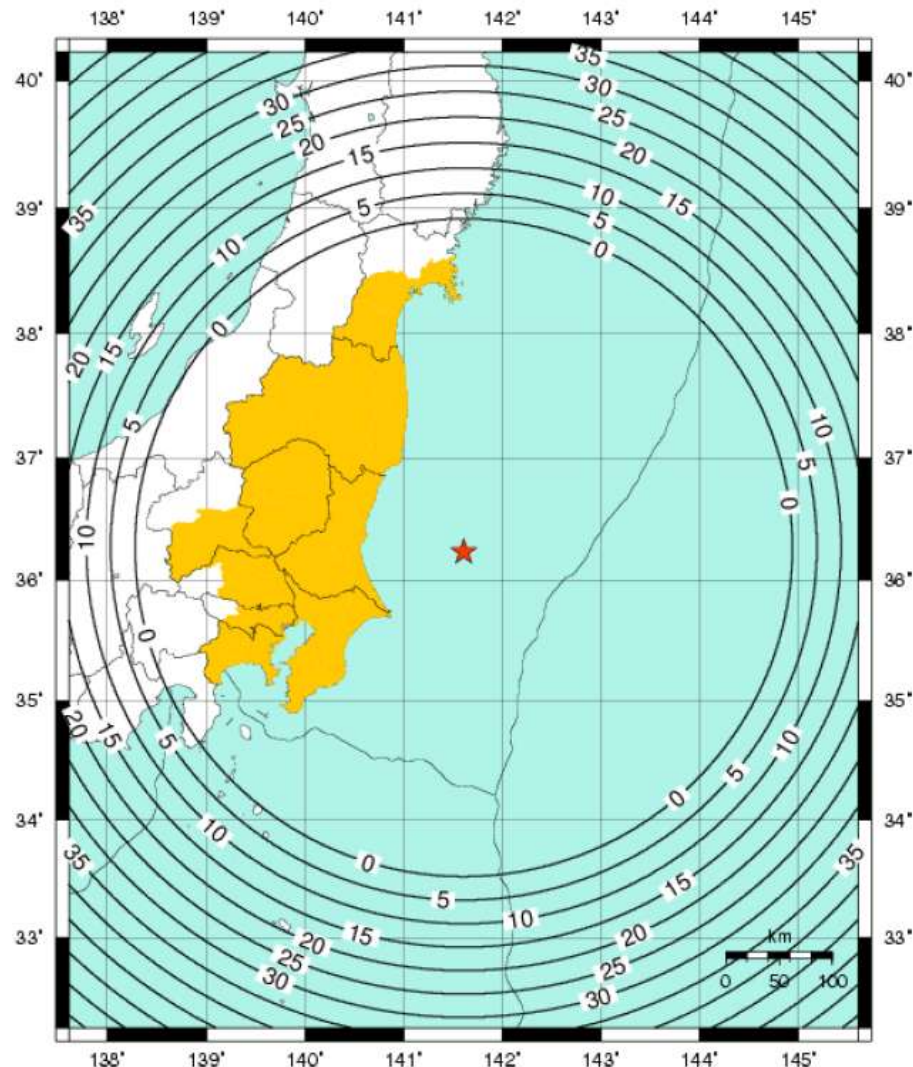
Announcement



Kindergarten

50km

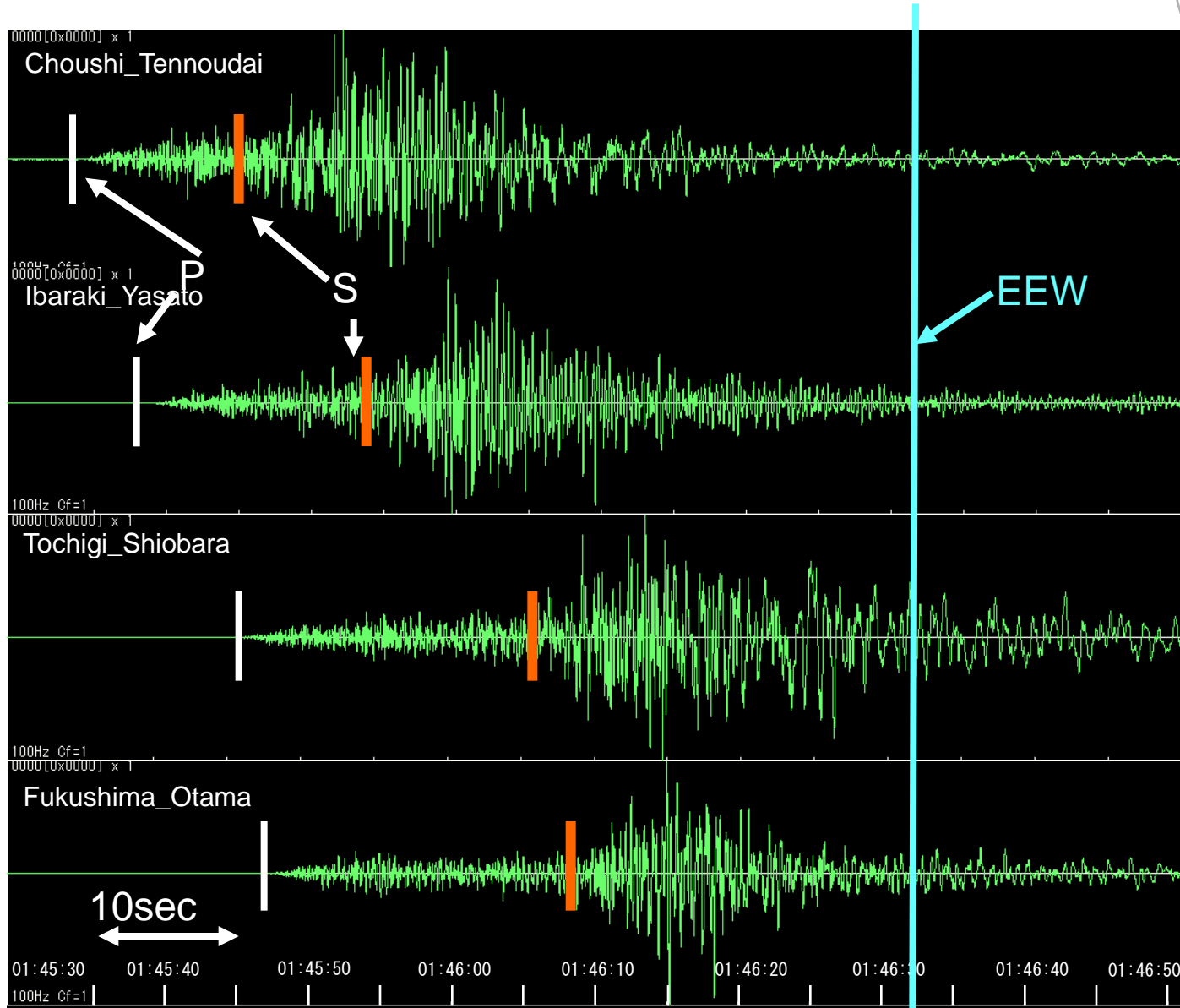
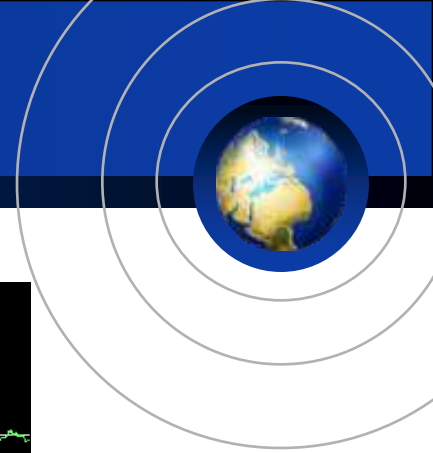


Off Ibaraki Earthquake (2008/5/8 M7.0)

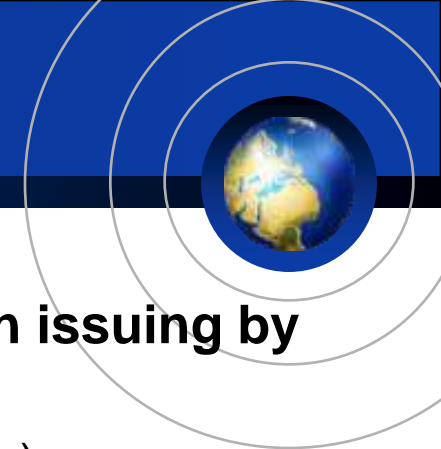


 一般向け緊急地震速報を発表した地域  : 震源

Off Ibaraki Earthquake (2008/5/8 M7.0)



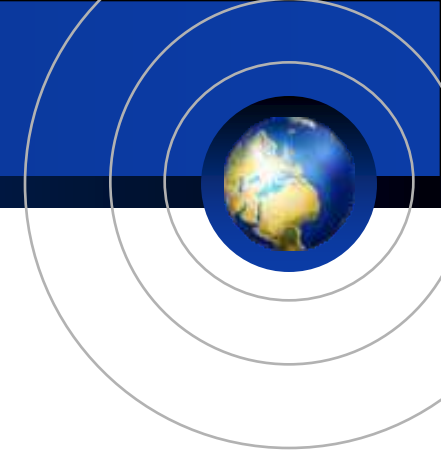
SUMMARY



- **Seismic Information and Tsunami Warning has been issuing by JMA.**
 - Dense seismic network (seismic station + communication)
 - Sophisticated processing system
 - Various dissemination way
- **Environment to accept EEW being prepared**
- **Technical development of the hypocenter estimation method using fewer seismic data**
- **Collaboration with related government/non-government organizations**
 - Promotion of EEW utilization
 - Technical limitation
 - Drill



- **Source and ground motion estimation method for M8 class earthquake**
 - Can we estimate a magnitude during rapture is going?
 - How do we consider effects of asperities size and seismic waves directivity in ground motion estimation?
- **Revision of the attenuation relationship between epicentral distance and PGV**
 - Taking into account 3D structure of crust
- **Forecast of long period ground motion**



Thank you for your attention.