

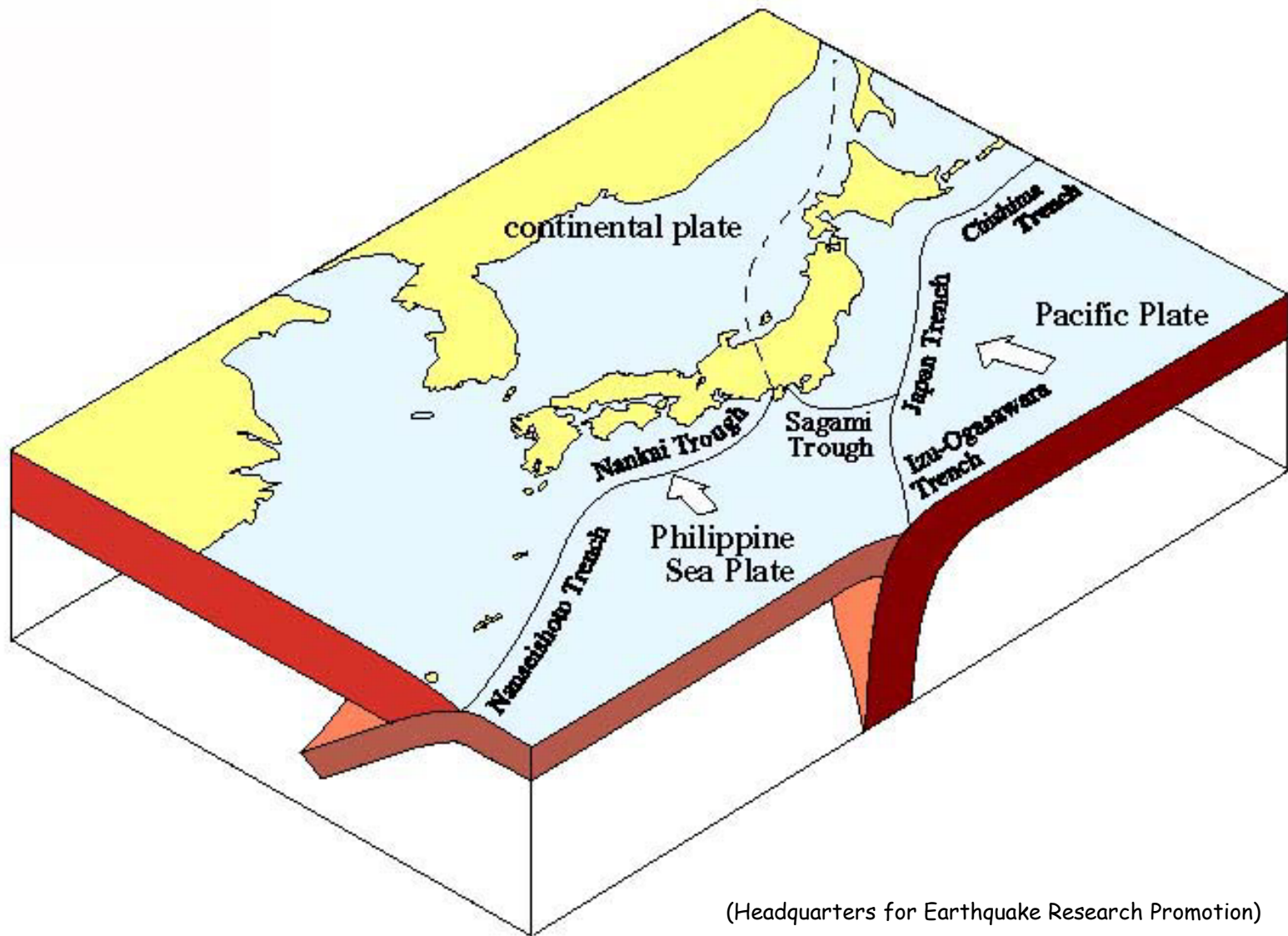
JMA Tsunami Warning Services

Tomoaki OZAKI

**Senior Coordinator for Tsunami Forecast Modeling
Japan Meteorological Agency**



Tectonic Setting of Japan



(Headquarters for Earthquake Research Promotion)

Time Sequence of Earthquake Information and Tsunami Warning in JMA

Earthquake

Earthquake Early Warning

Tsunami Warning

Seismic Intensity Information

Tsunami Information
(Estimated Tsunami Heights and Arrival Times)

1.5min.

2~3min.

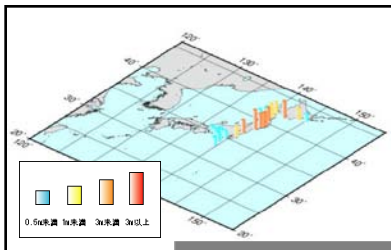
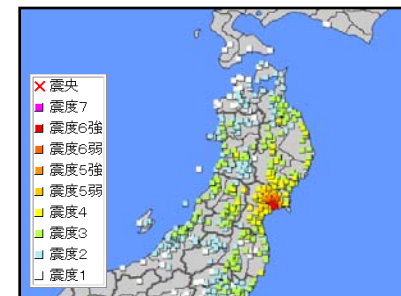
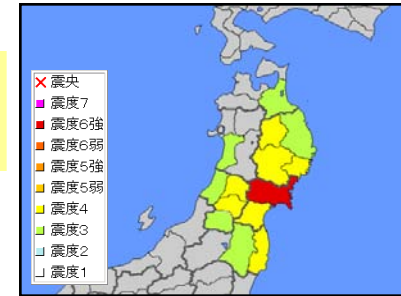
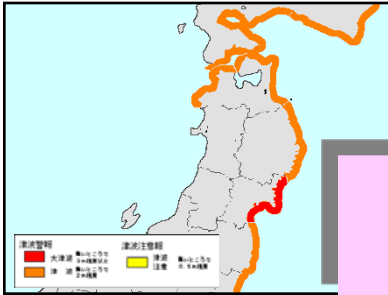
Earthquake Information
(Hypocenter and Magnitude)

Earthquake and Seismic Intensity Information

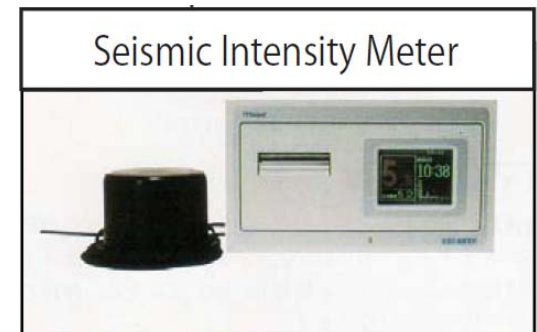
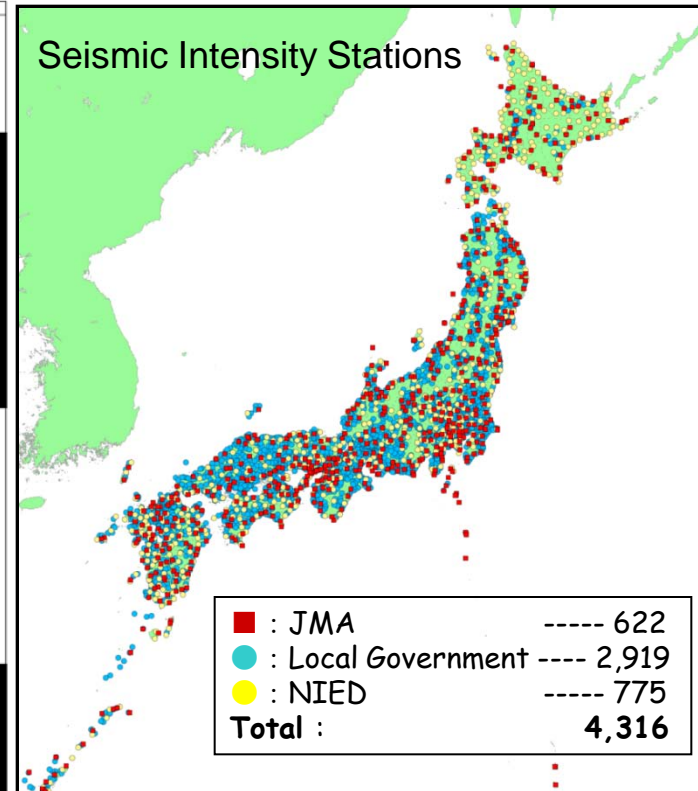
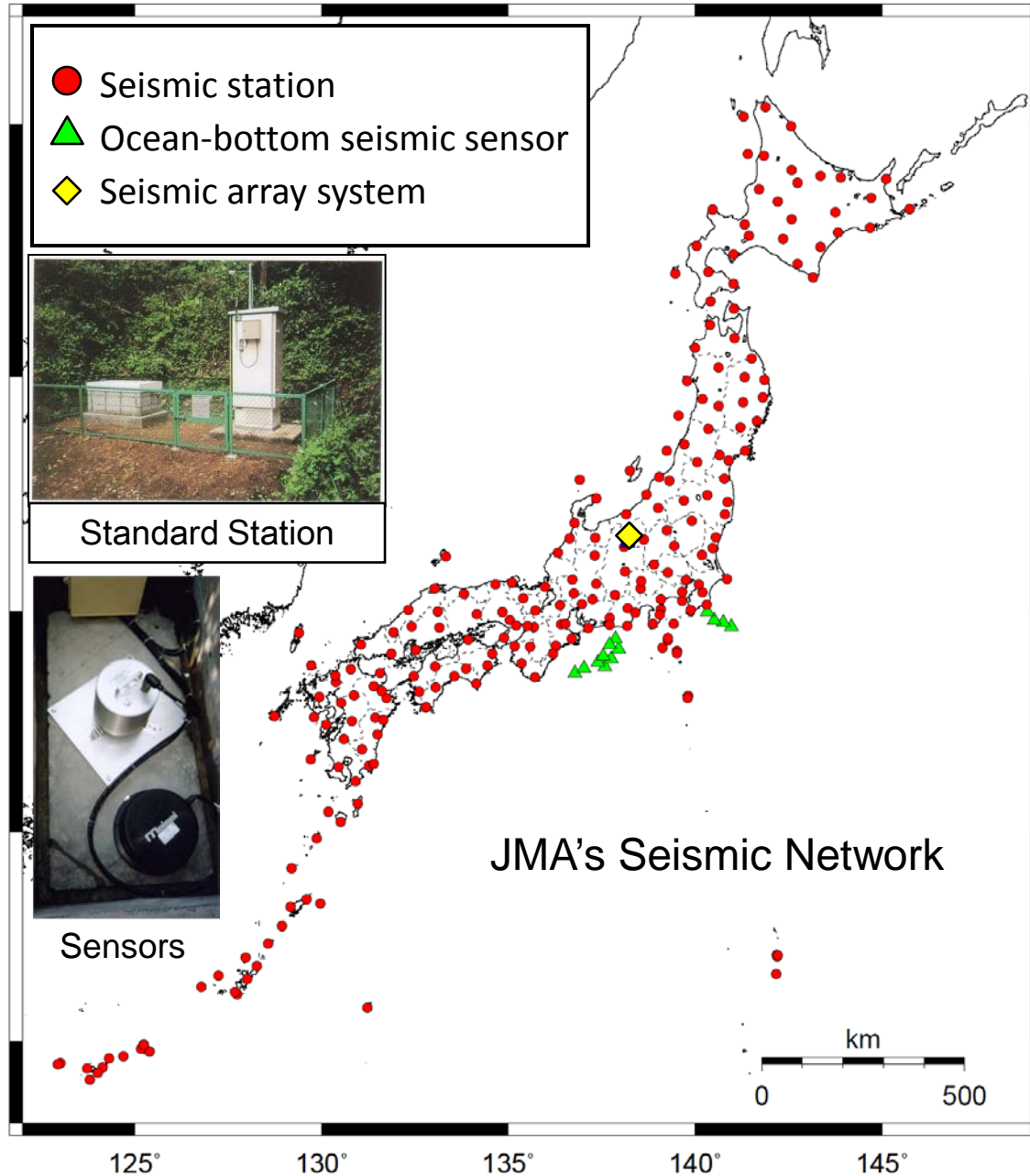
5min.

Tsunami Information
(Observed Tsunami Heights and Arrival Times)

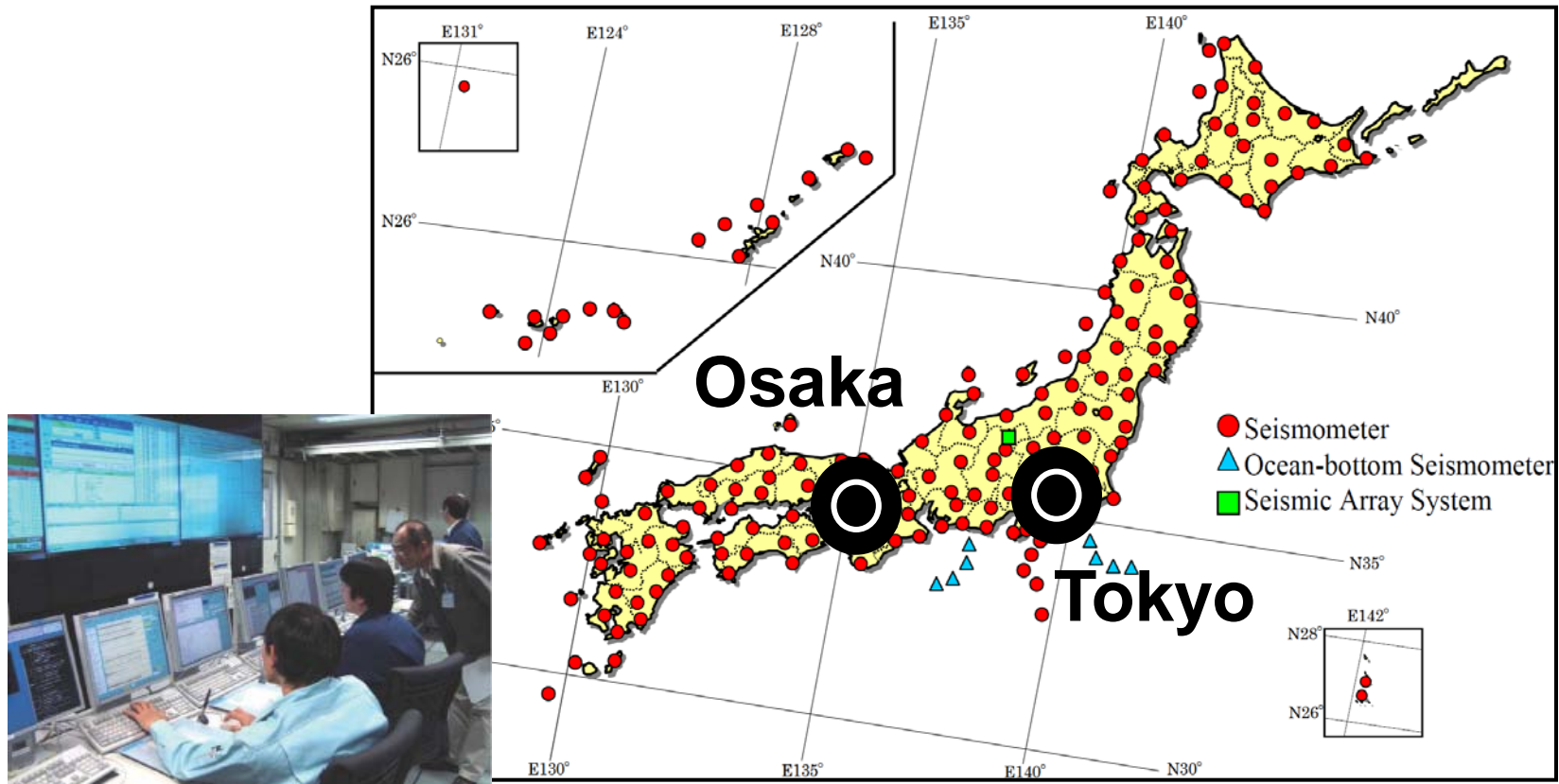
Seismic Intensity Information at each Site



Seismic Network in Japan



Earthquake Data Processing System



- To process seismological data, and make and issue earthquake and tsunami information, JMA developed EPOS (Earthquake Phenomena Observations System).
- EPOS is located in Tokyo and Osaka. Tokyo-EPOS and Osaka-EPOS work in parallel, and function as back-up system one another.

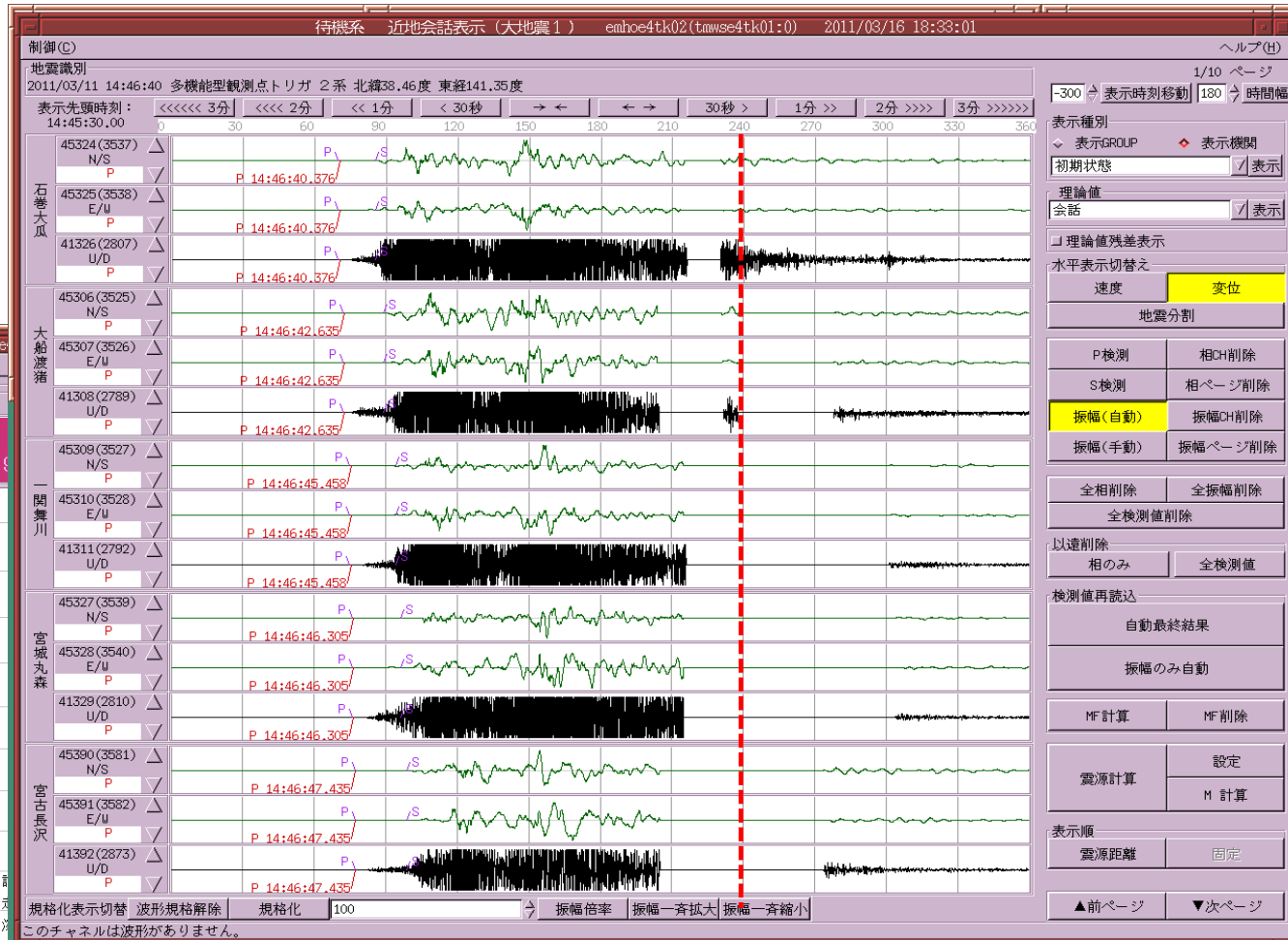


【JST】新機組 12時28分00秒
2012/09/09

大阪 東京
機組1 機組2

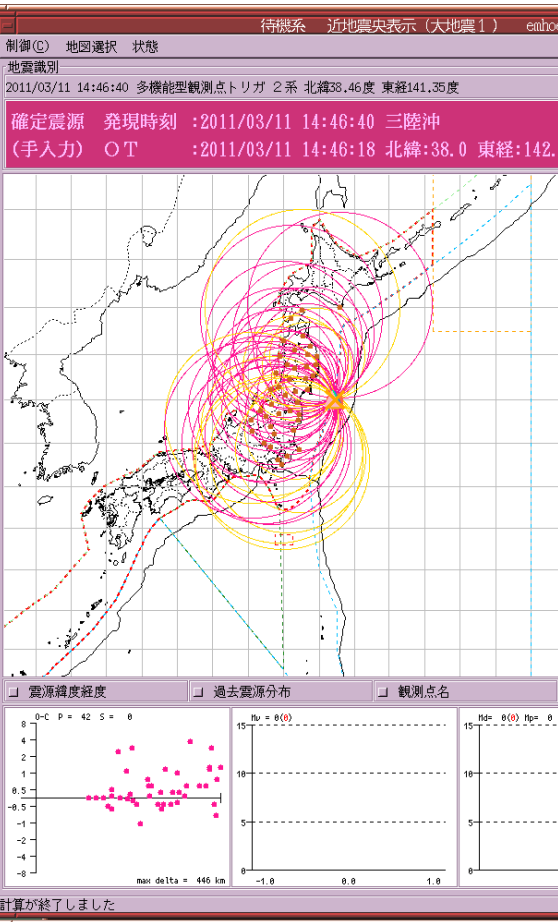
Determination of Hypocenter and Magnitude

The 2011 off the Pacific coast of Tohoku Earthquake



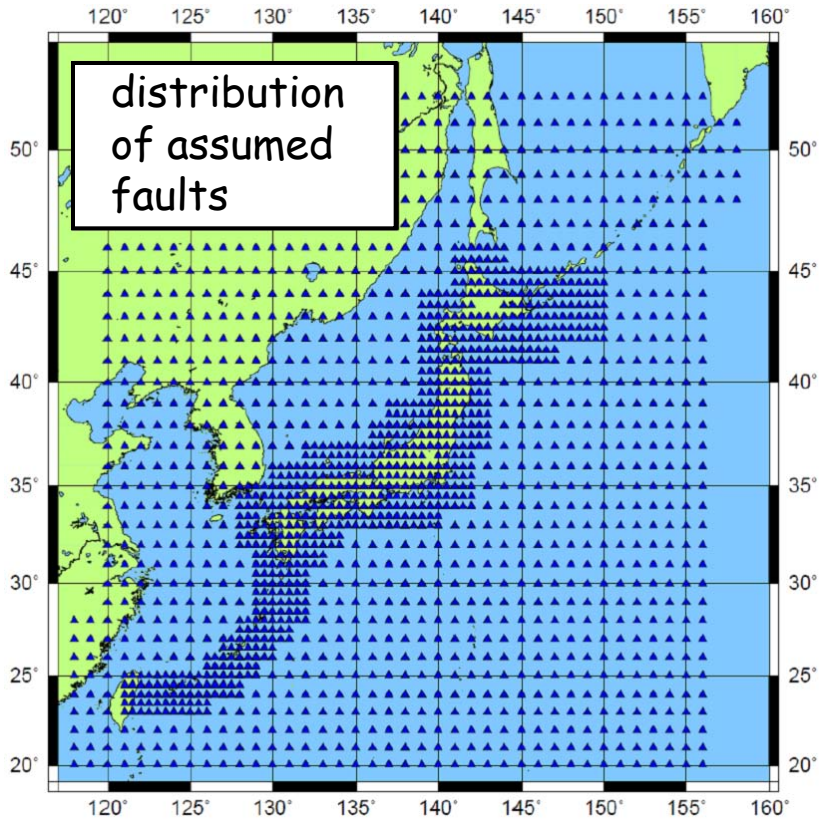
For each station :

- P-phase arrival time
- S-phase arrival time
- Maximum amplitude



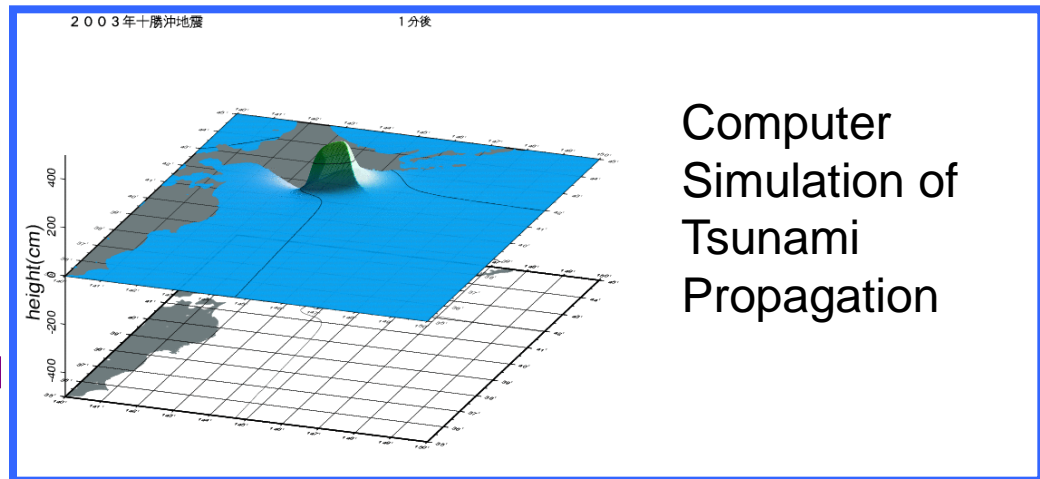
Database for Tsunami Warning

Preparation -- Create Tsunami Database



1,500 (horizontal direction)
× 6 (vertical direction, 0-100 km)
× 4 (magnitude) × some mechanism
= about **100,000** scenarios

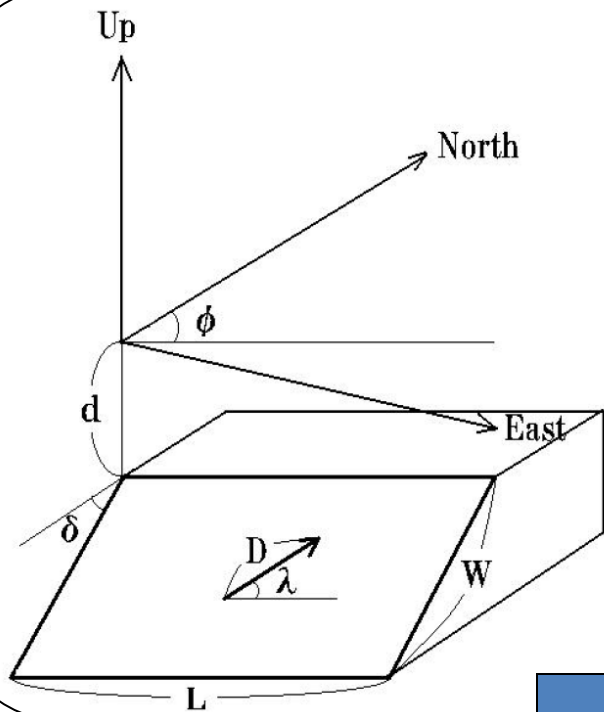
Calculate Crustal Movement for each Assumed Fault



Arrival Time
&
Height

Tsunami Database

Fault Parameter and Tsunami Source

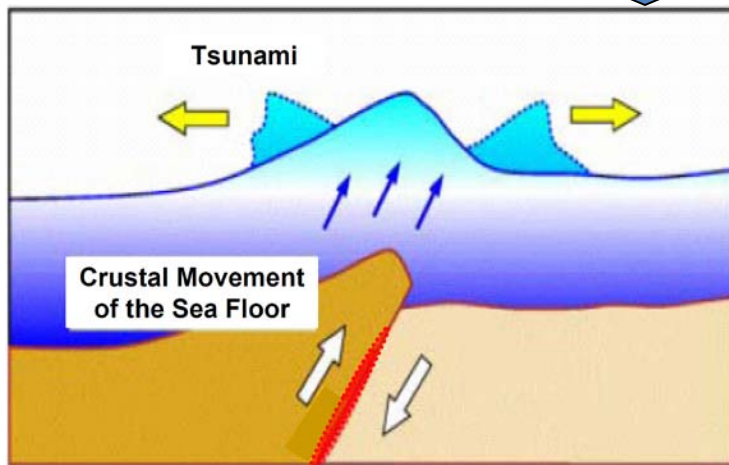
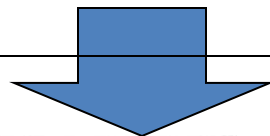


Fault model

- Reverse fault

- d: Depth ← given by epicenter
- L: Fault Length } given by scaling law
- W: Fault Width } $\log L = 0.5M - 1.9$ (M: magnitude)
- D: Slip Length } $W = L/2$
- ϕ : Strike Angle } $\log D = 0.5M - 3.2$
- δ : Dip Angle ← given in advance
- λ : Slip Angle ← 45degree (fixed)
- ← 90degree (fixed)

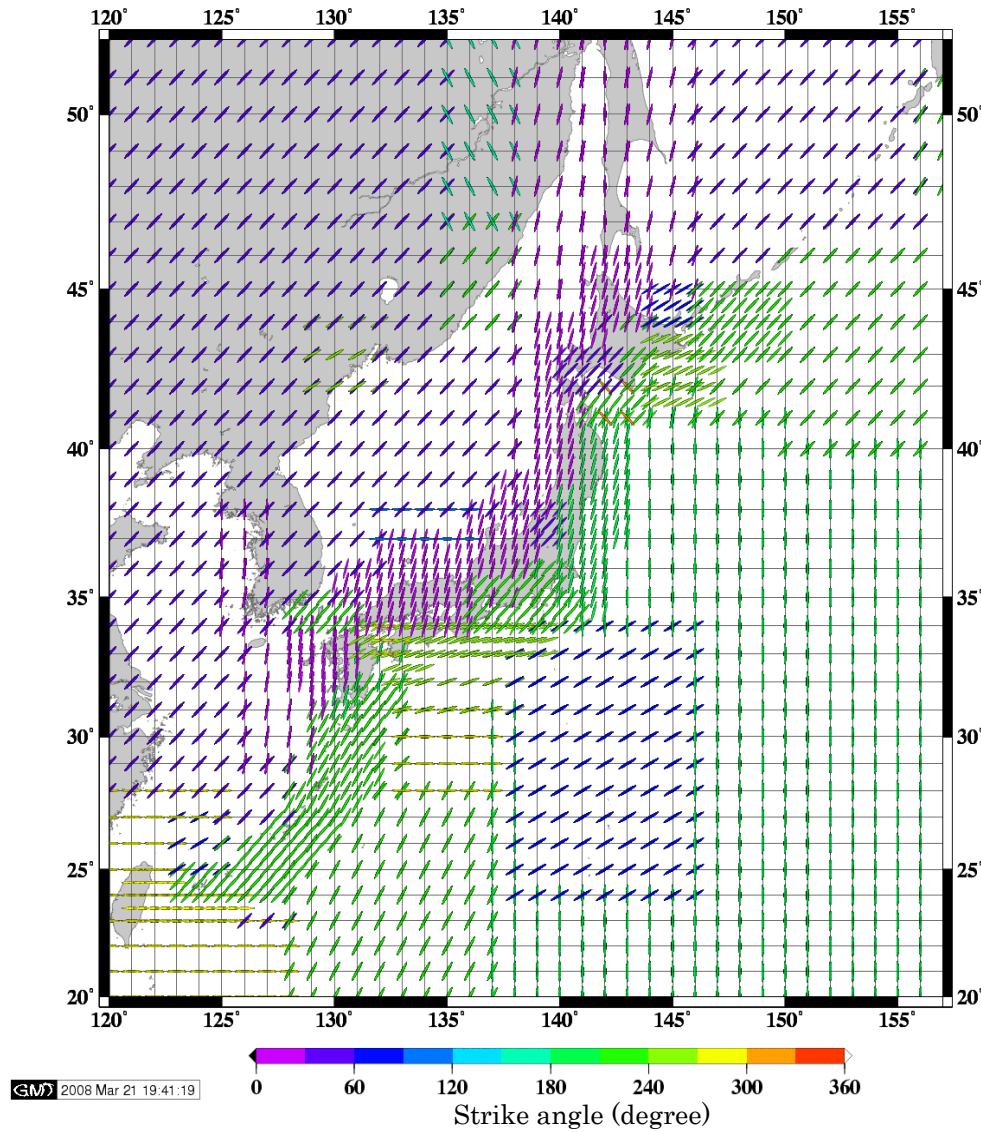
Dip angle is set which general tsunami most effectively.
 $\lambda = 0$ (strike-slip), 20 and 80 are also assumed.



Tsunami source

- Crustal deformation on the sea floor calculated by the elastic theory (Okada, 1985)
- Initial tsunami height distribution is assumed to be same shape as the sea floor deformation

Strike Angle (ϕ) of the Assumed Faults



Interpolation for Cases Far from the Shore

I. Simulation results for closest grid points are retrieved from the database

II. Interpolation is performed in magnitude and depth in logarithm scale for grid point A so that we obtain tsunami height. Same calculation is performed for grid points B, C and D.

Determined Epicenter

Epicenter A
Epicenter B
Epicenter C
Epicenter D

Depth	Magnitude			
	6.2	6.8	7.4	8.0
0km	0.02	0.18	0.38	0.88
20km	0.02	0.11	0.38	0.88
40km	0.01	0.09	0.38	0.88
60km	0.01	0.07	0.30	0.88
80km	0.01	0.04	0.22	0.88
100km	0.01	0.03	0.17	0.74

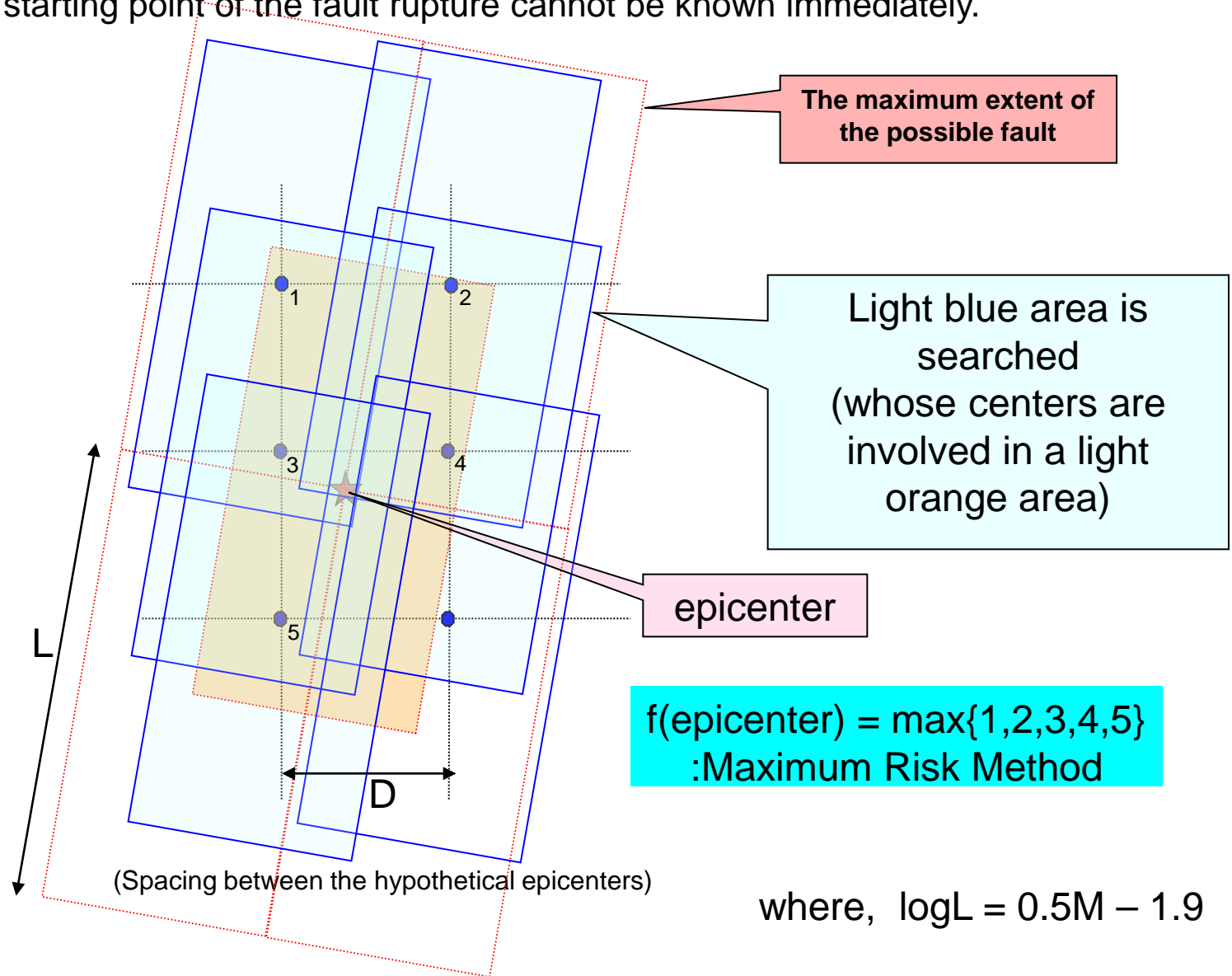
III. Interpolation is performed among closest points so that we obtain tsunami height for the determined epicenter.

Estimation of arrival time ---> choose the severest (earliest) case

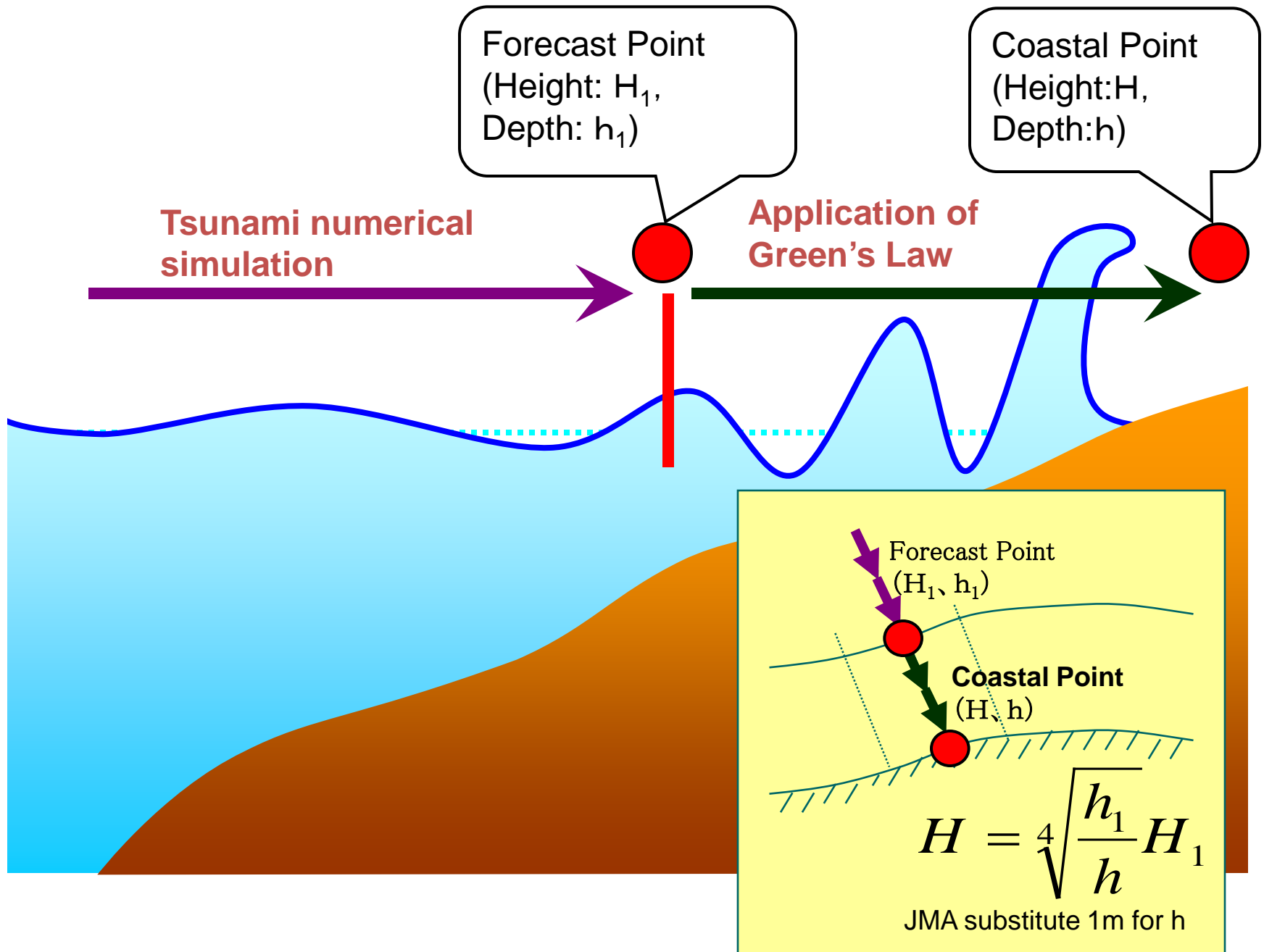
Maximum Risk Method for Cases Close to the Shore

Maximum risk method is used in case epicenter is near the coast.

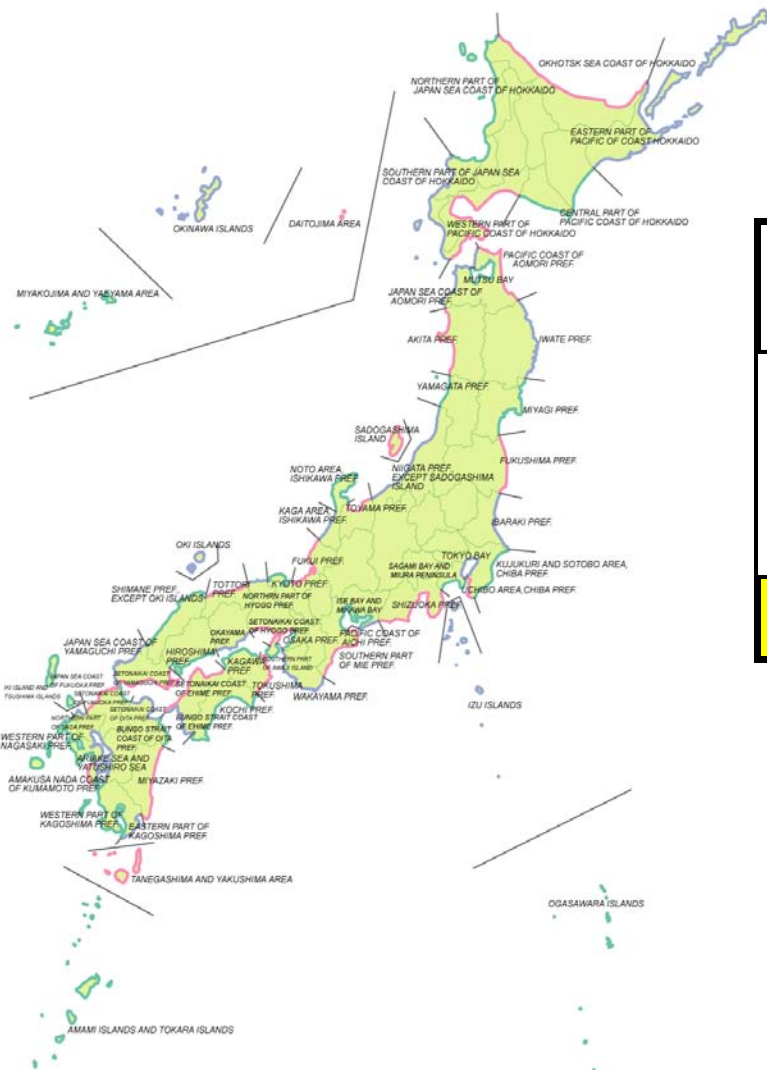
It is because starting point of the fault rupture cannot be known immediately.



Estimation of Tsunami Height at the Coast



Tsunami Warning Classification



Type of Tsunami Bulletin		Estimated Tsunami Height
Tsunami Warning	Major Tsunami	"3m", "4m", "6m", "8m", "over 10m"
	Tsunami	"1m", "2m"
Tsunami Advisory		"0.5m"

66 Regional Blocks for Tsunami Warning/Advisory

Tsunami Monitoring Network in Japan

■ : Tide Gauges(on the coast)	-- 172
JMA (77), Others(95)	
■ : GPS Buoy	-- 12
▲ : Tsunameter	-- 12
JMA (6), ERI (2), JAMSTEC (4)	
Total:	-- 196
Tsunameter data is under evaluation (12/05/2011)	

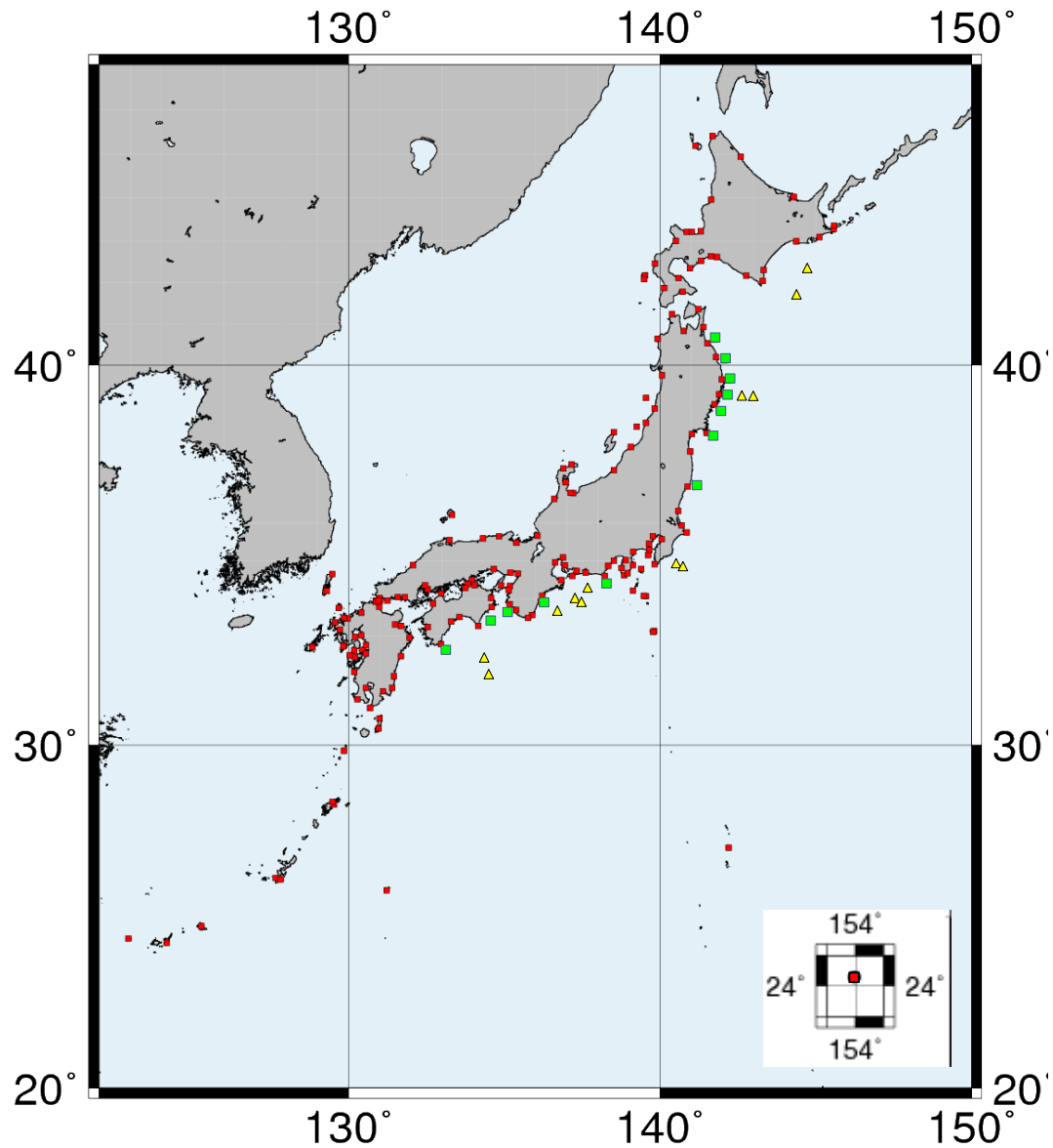
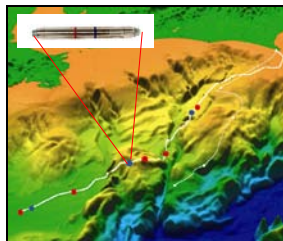


Tide Gauges

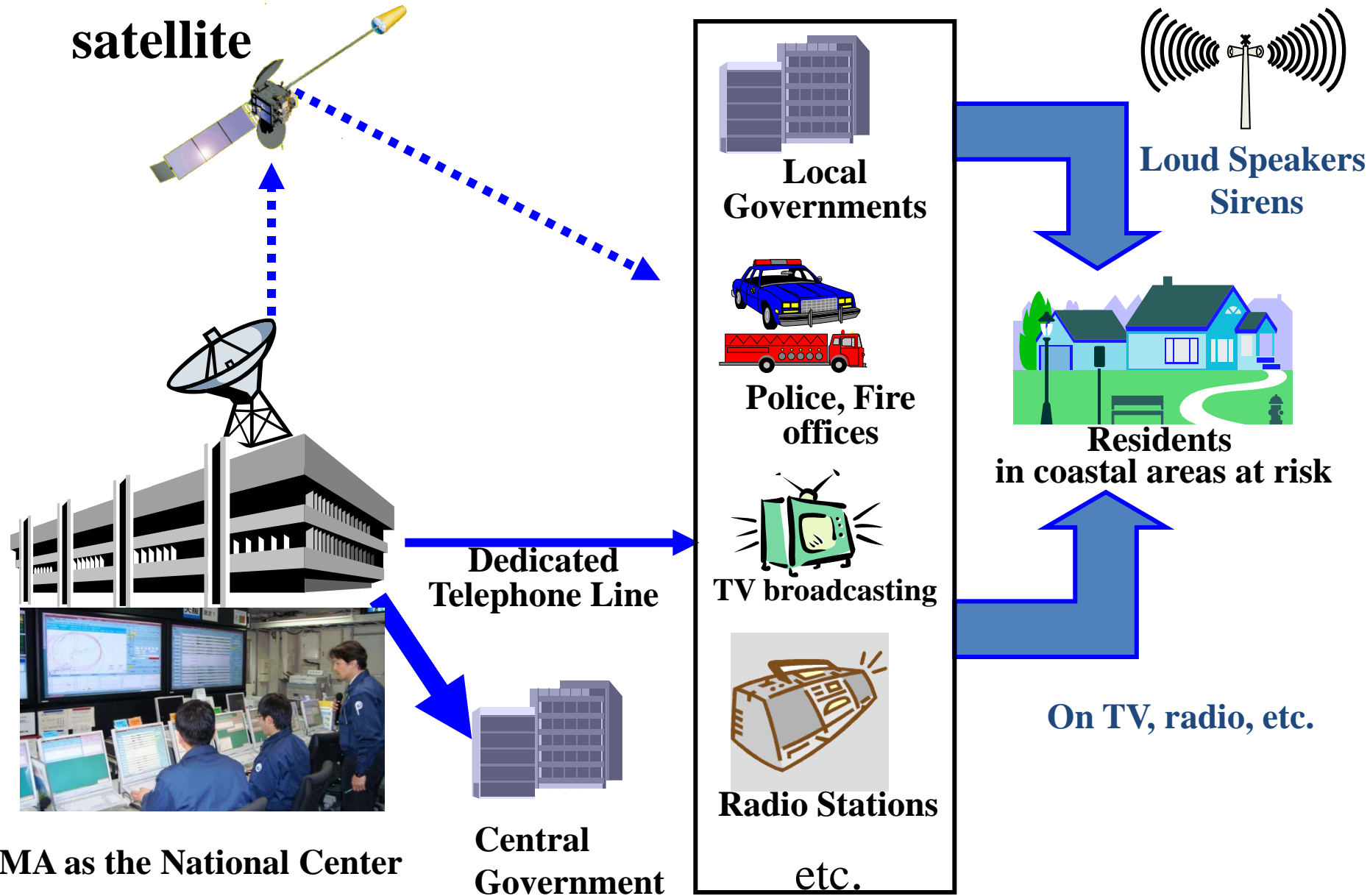
GPS Buoy



Tsunameter

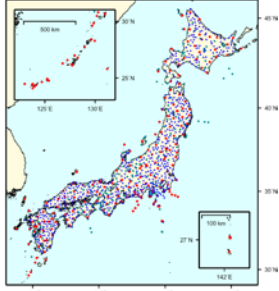


Dissemination of Tsunami Warning and Earthquake Information

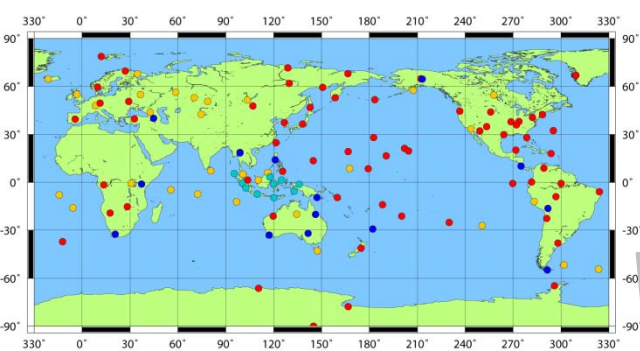


Provision of Tsunami Bulletins to countries around the Northwest Pacific and the Indian Ocean

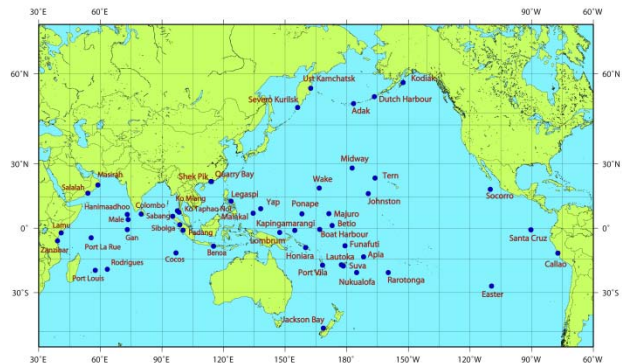
Japanese Seismic Network



Global Seismic Network



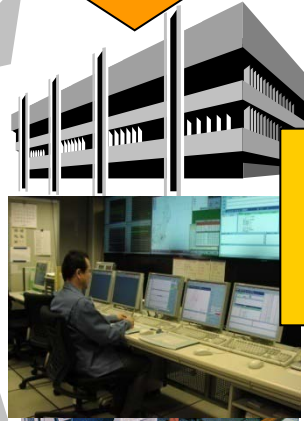
Sea Level Stations



Pacific Tsunami Warning Center (PTWC)



Information Exchange

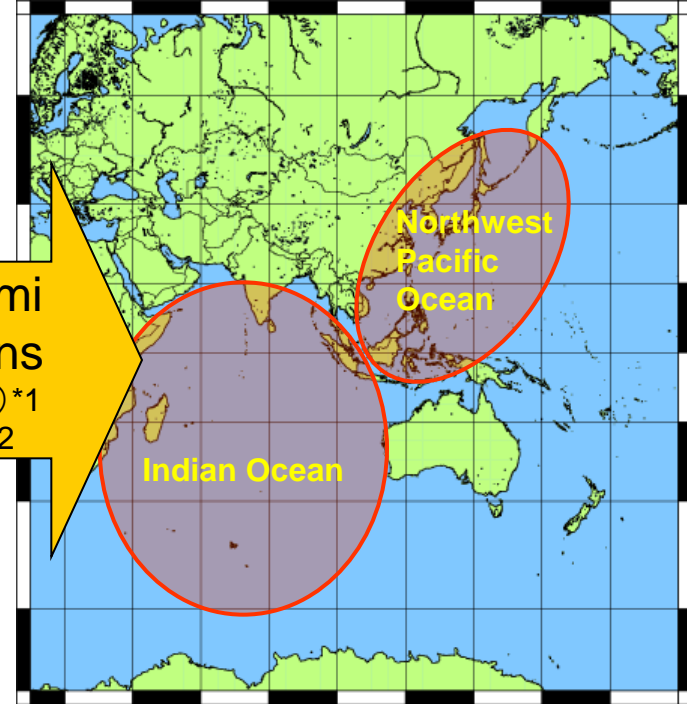


JMA

Data

Data

Tsunami Bulletins
(NWPTA)*1
(TWI)*2



Analysis

- Hypocenter
- Magnitude
- Evaluation of Tsunamigenic Potential
- Tsunami Observation etc.

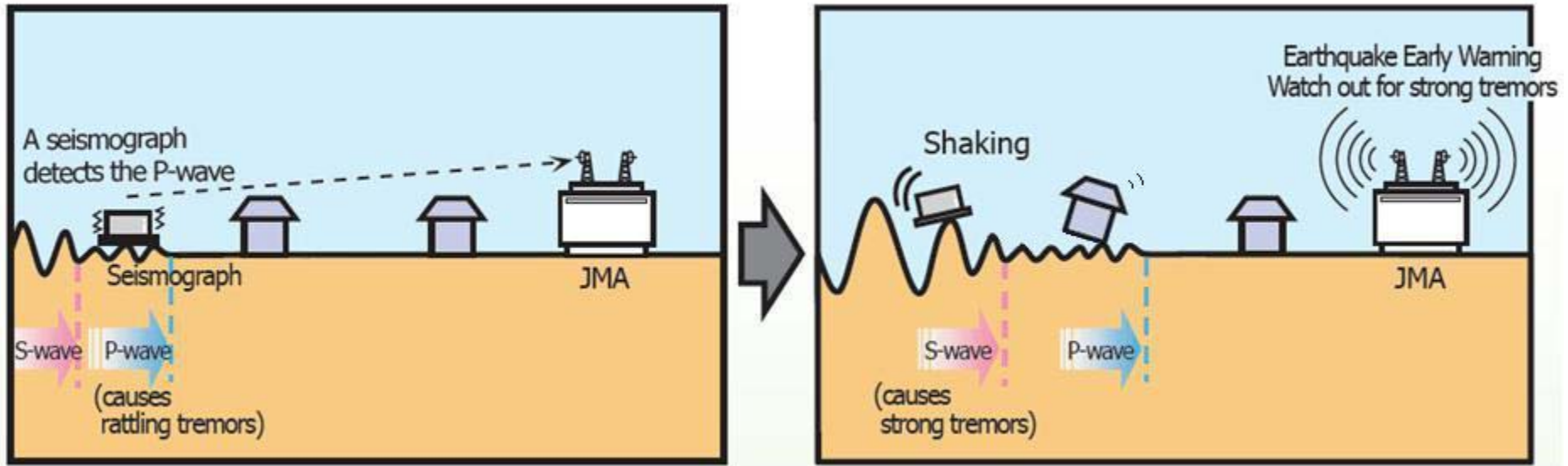
Contribute to the mitigation of tsunami disasters of countries around the Northwest Pacific and the Indian Oceans

*1) NWPTA: Northwest Pacific Tsunami Advisory

*2) TWI: Tsunami Watch Information for the Indian Ocean

EEW

Concept of Earthquake Early Warning (EEW)



① The EEW System automatically calculates the earthquake epicenter and magnitude from the P-waves detected near the epicenter, then estimates the strengths of following ground shaking (seismic intensities) at numbers of cities, towns and villages.

② An EEW is provided a few seconds to a few tens of seconds before the S-wave or strong tremor arrival.

※ Strong tremors may hit areas close to the earthquake focus at the same time as the Earthquake Early Warning.

Seismic Intensity Information

JMA Seismic Intensity Scale

0



1



2



3



4



5 lower



5 upper



6 lower



6 upper



7



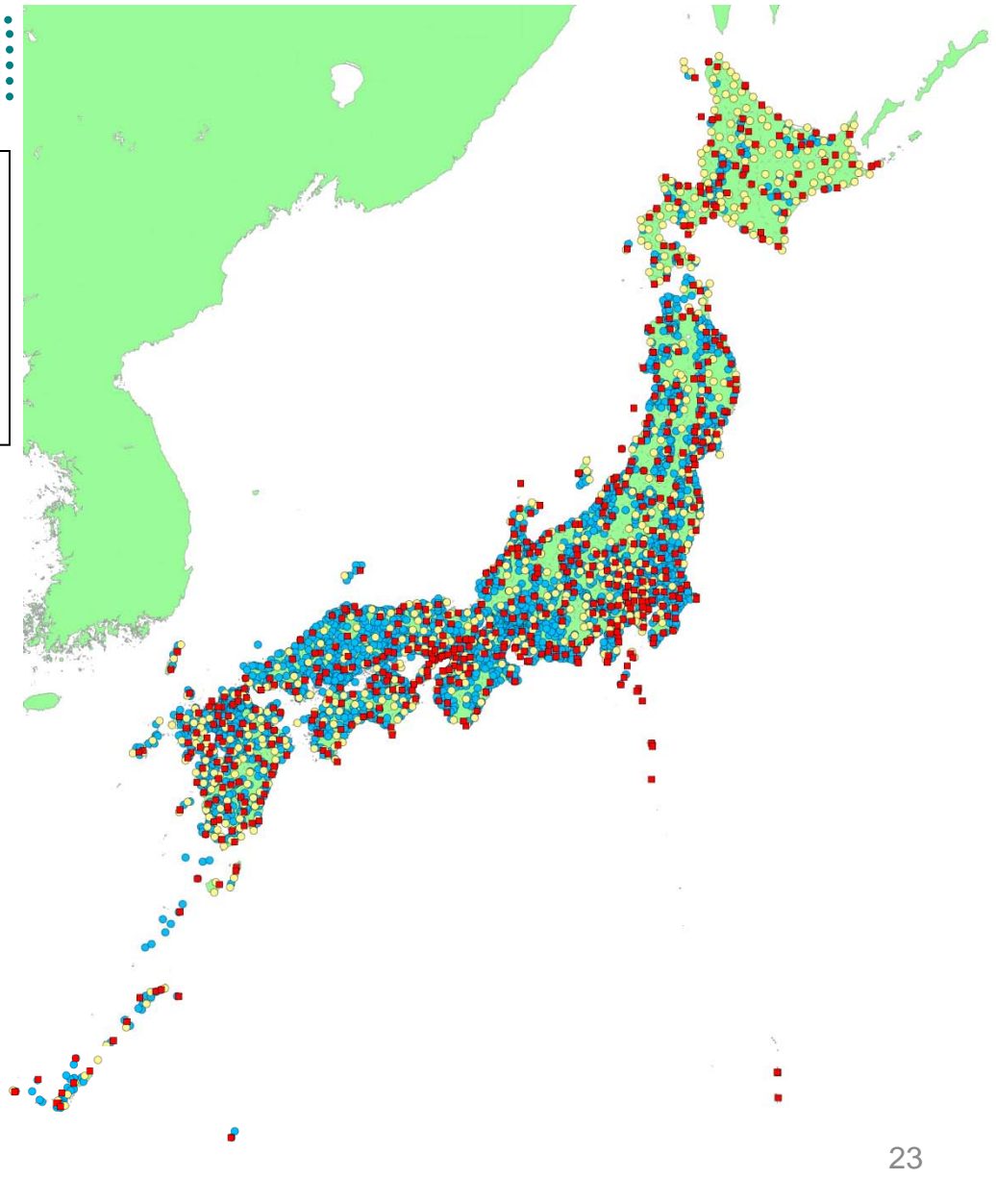
Seismic Intensity (1)

Network of Seismic Intensity Meter

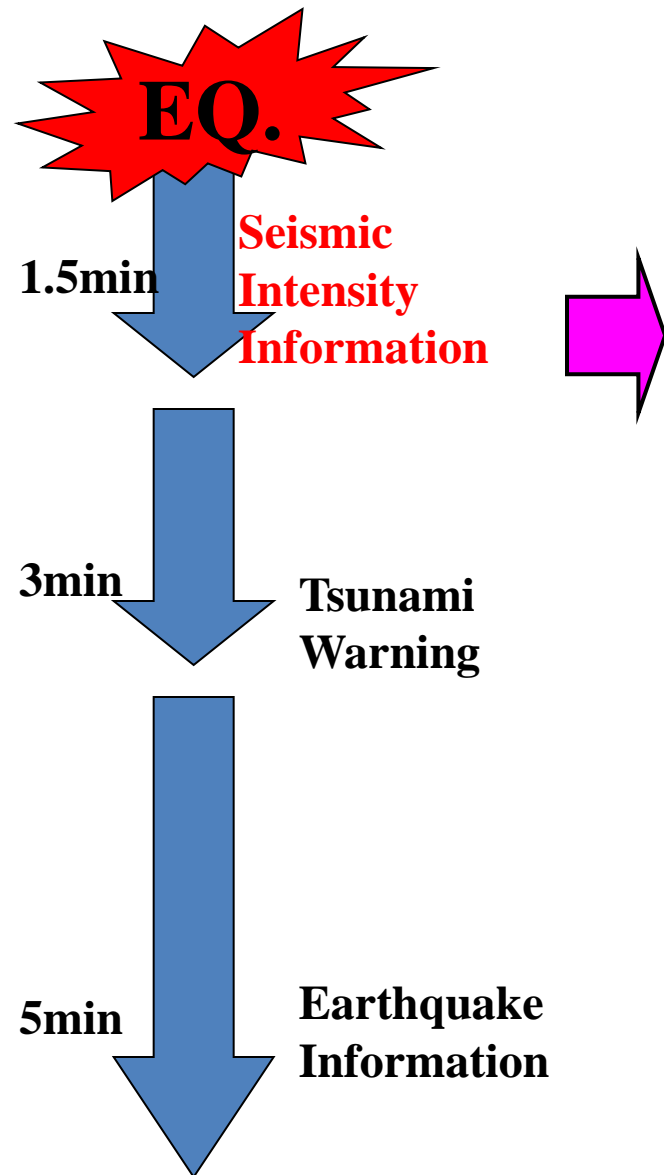
■ : JMA	-- 628
● : Local Government	-- 2,844
● : NIED	-- 778
Total:	4,250
(2010/07/01)	



Seismic Intensity Meter



Emergency Operation Triggered by Seismic Intensity Information



Cabinet Secretariat

6lower → Call of an urgent gathering team



Cabinet Office

4 → Estimation of damages



Ministry of Defense

5lower → Investigation of damages



Japan Coast Guard

5lower → Investigation of damages



Metropolitan Police Department, Fire and Disaster Management Agency

4 → Investigation of damages



NHK a broadcasting company



3 ↓
Announcement by TV or Radio

Shake Map

The Iwate-Miyagi Nairiku Earthquake in 2008 M:7.2 Depth : 8km

Distribution of Seismic Intensity
(observed point data)

Distribution of Seismic Intensity
(plane value estimated from observed data)

