Tsunami Warning in Japan, and Tsunami Advisory for Northwest Pacific and Indian Ocean regions

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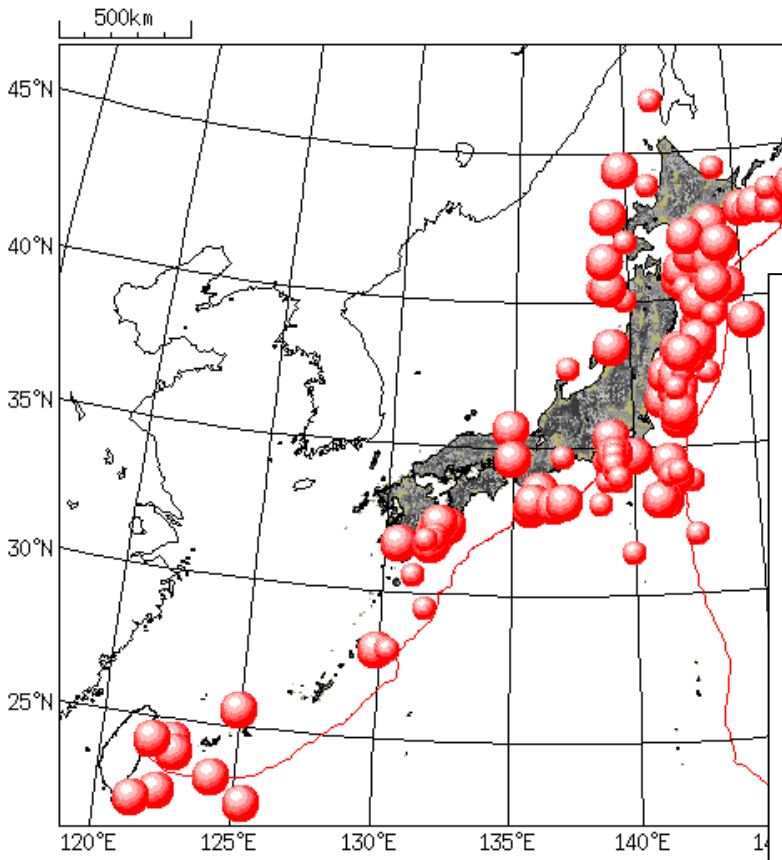
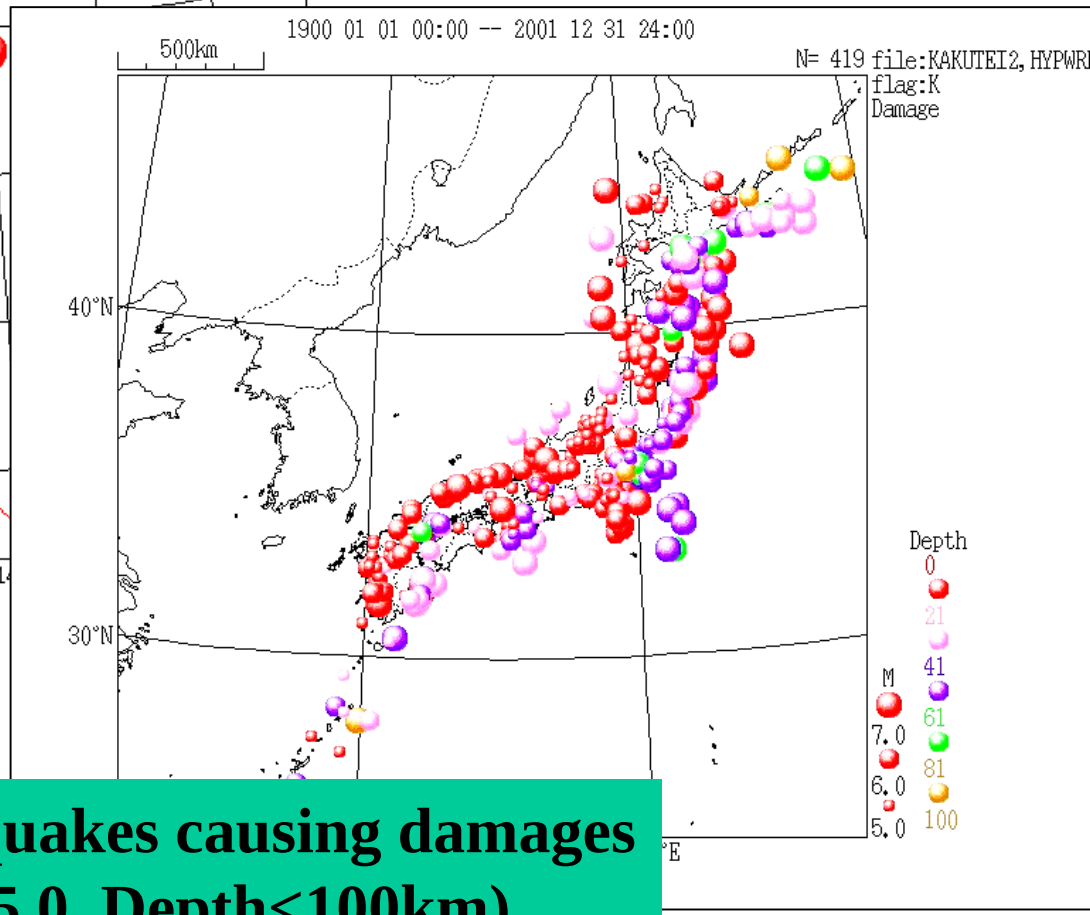
Japan Meteorological Agency (JMA)

Contents

- Tsunami Warning / Advisory in Japan
- International Contribution through Provision of Tsunami Bulletin
  - Northwest Pacific Tsunami Advisory
  - Interim Provision of Tsunami Watch Information for the Indian Ocean Countries

Distribution of Earthquakes Causing Tsunami (1896~2004) in Japan



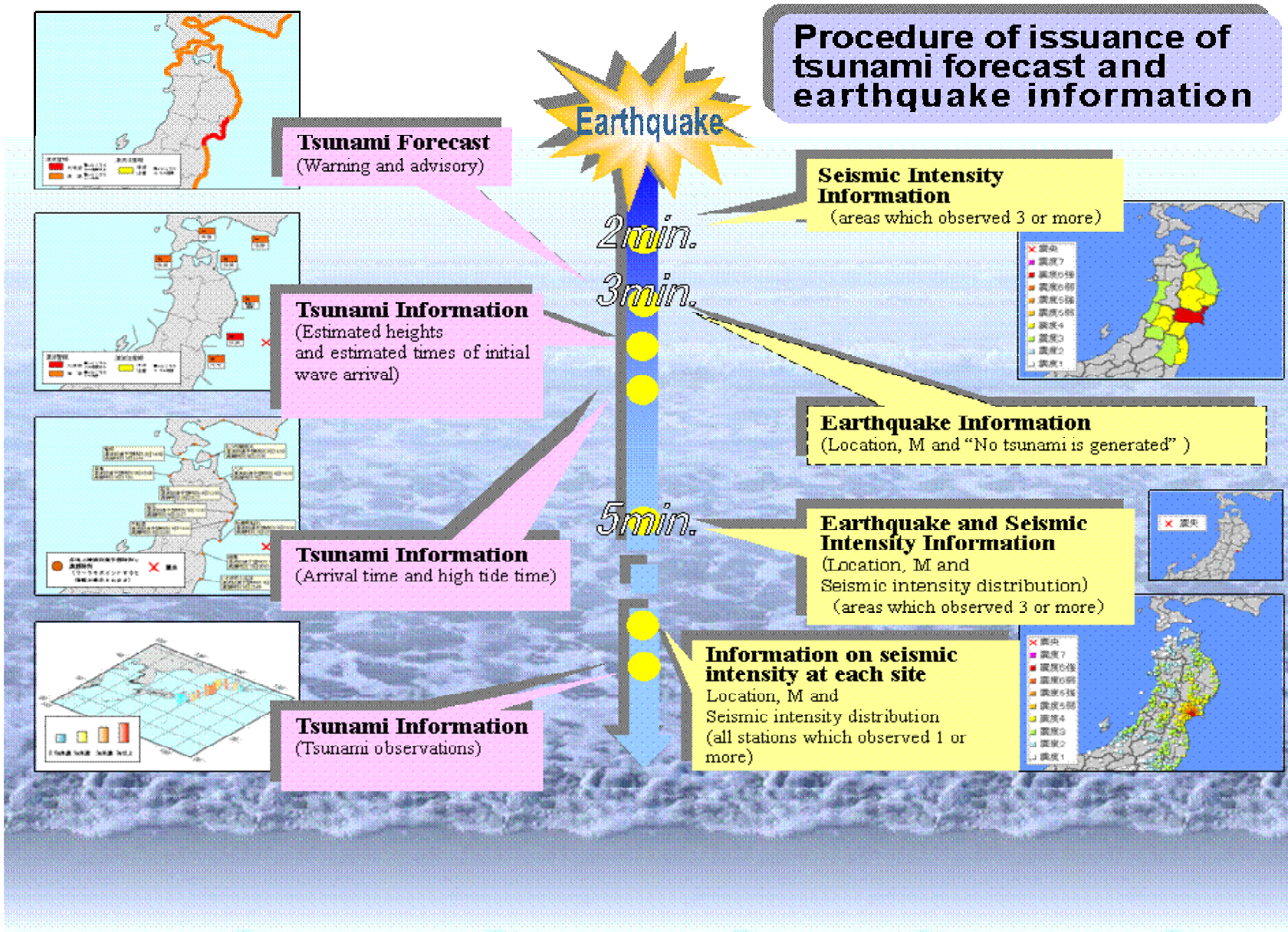


Distribution of Earthquakes causing damages (1900~2001, M>=5.0, Depth<100km)

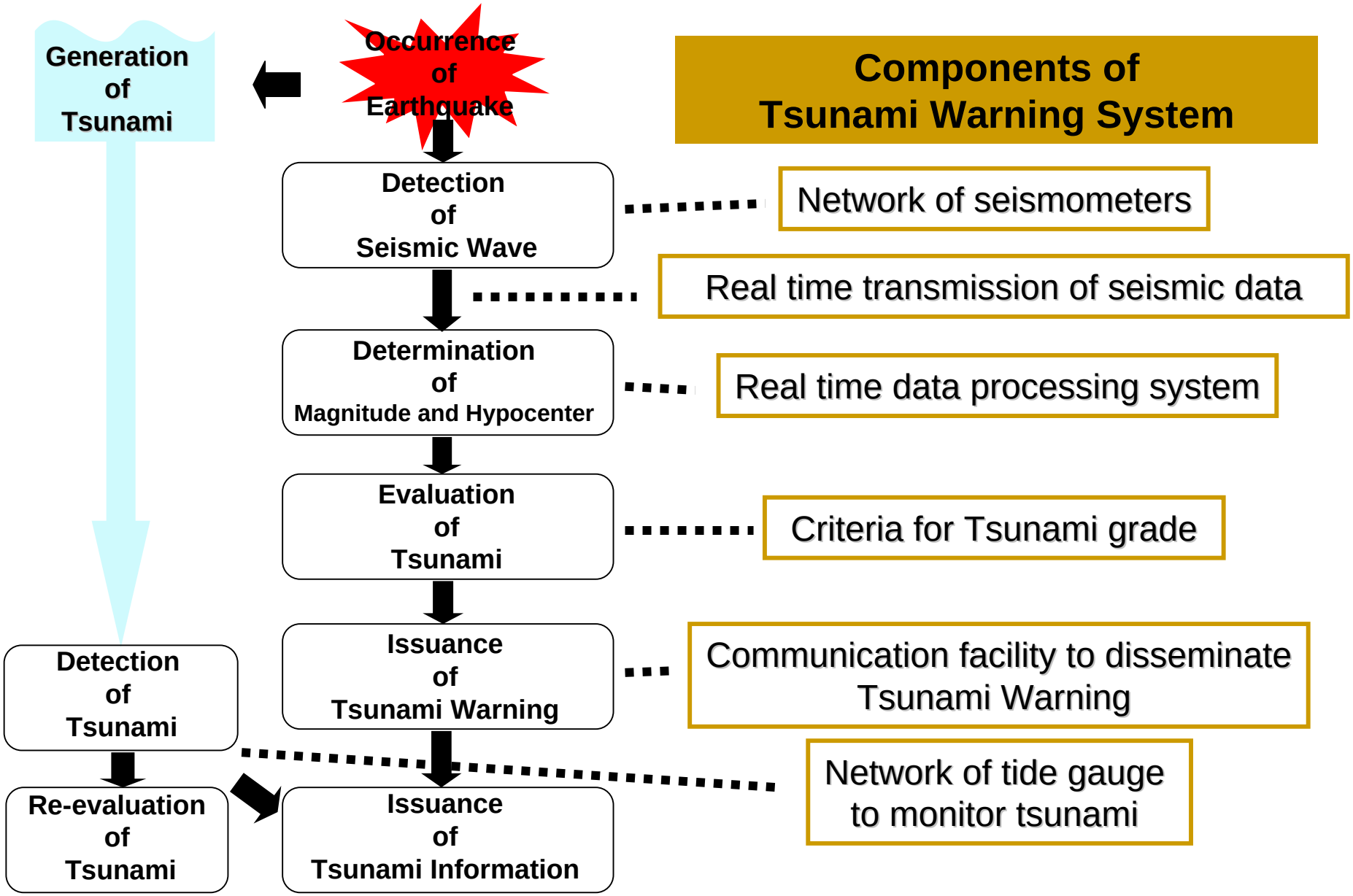
Okushiri, Japan, 1993 (Tsunami disaster)

Before the Tsunami (1976) ***After (1993)***

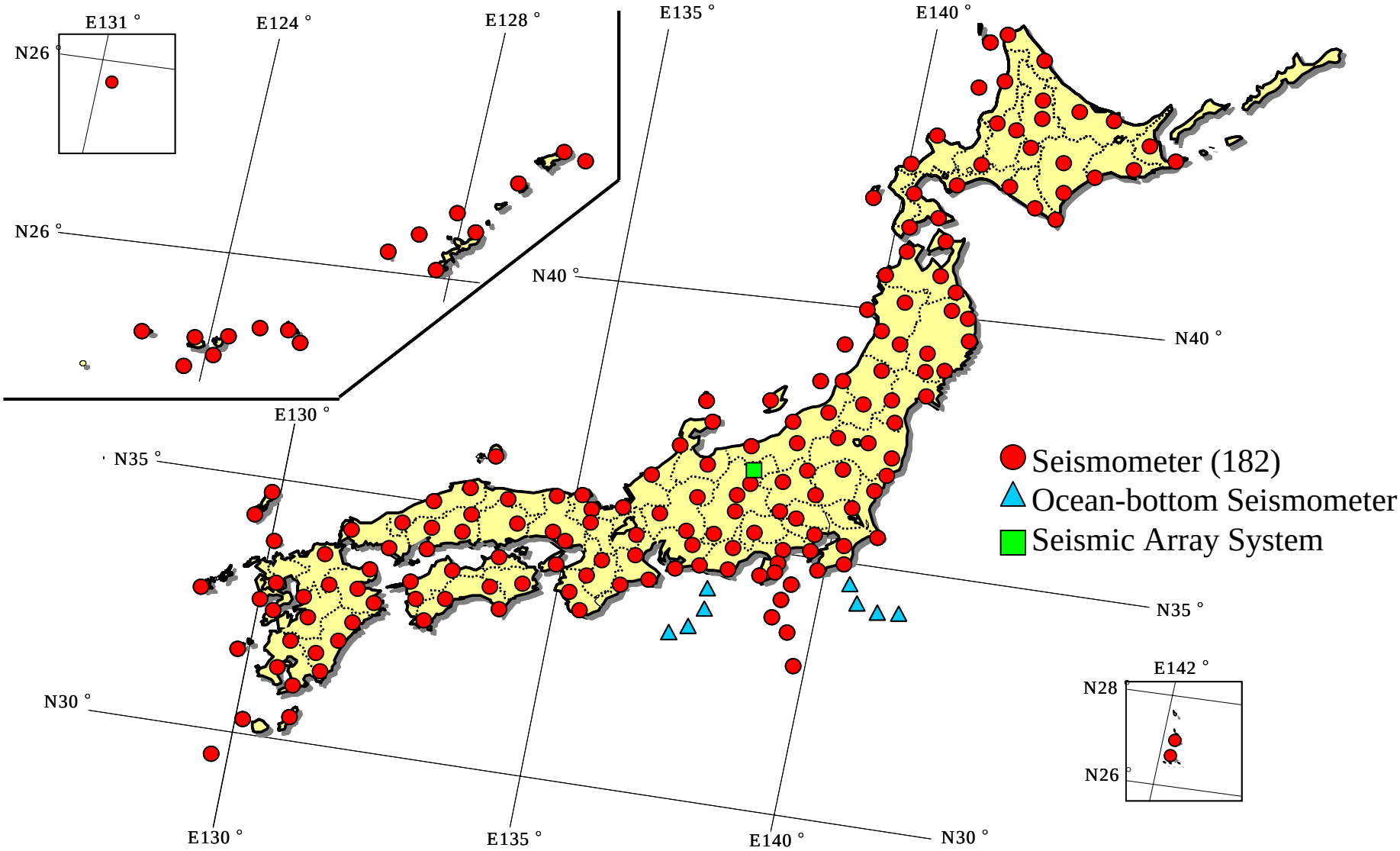
Tsunami Warning/Information Dissemination Sequence



Sequence and Components of Tsunami Warning System

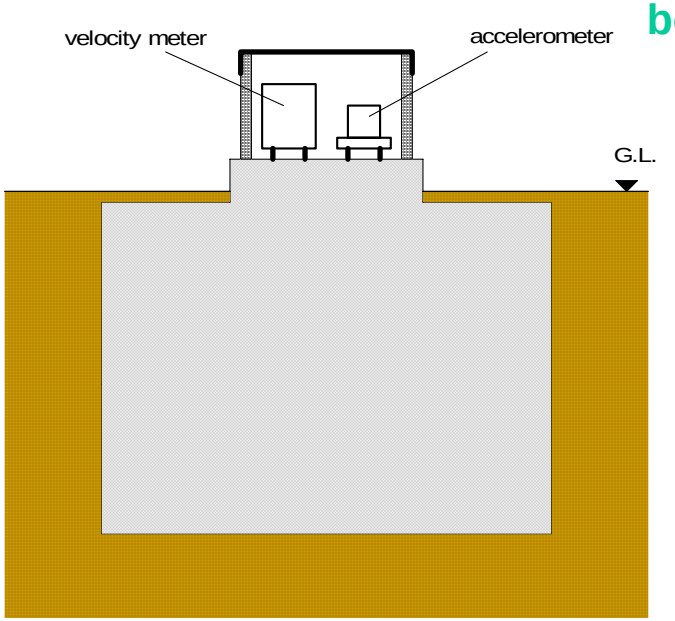


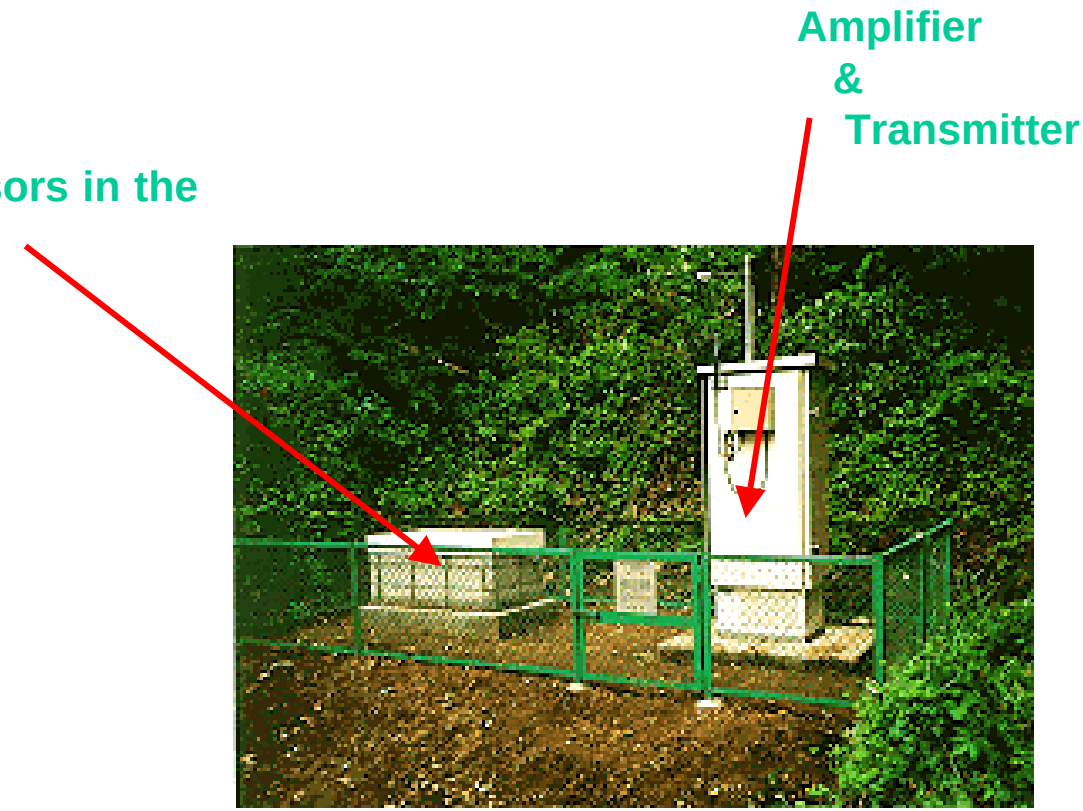
Seismic Network for Tsunami forecast



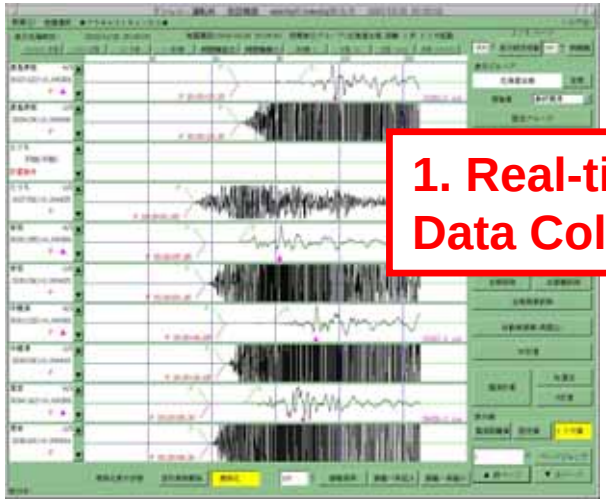
Seismometers used in JMA's Network

- **Velocity type seismometer with 3 components**
- **Strong motion accelerometer with 3 comp.**



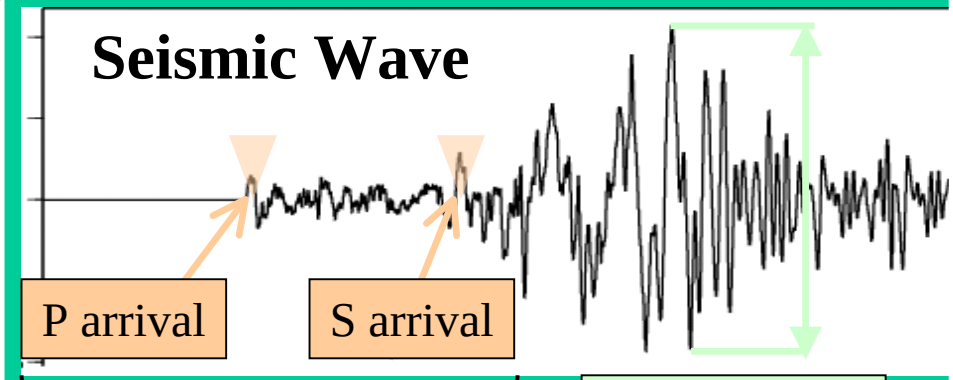


Determination of Magnitude and Hypocenter



1. Real-time Data Collection

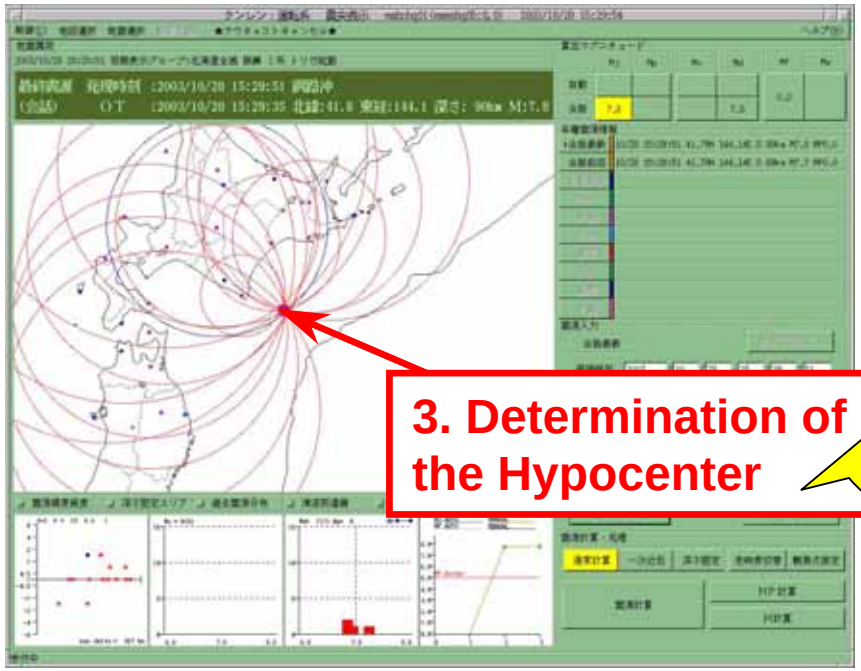
2. Read P/S Arrival Time and Maximum Amplitude



Maximum Amplitude

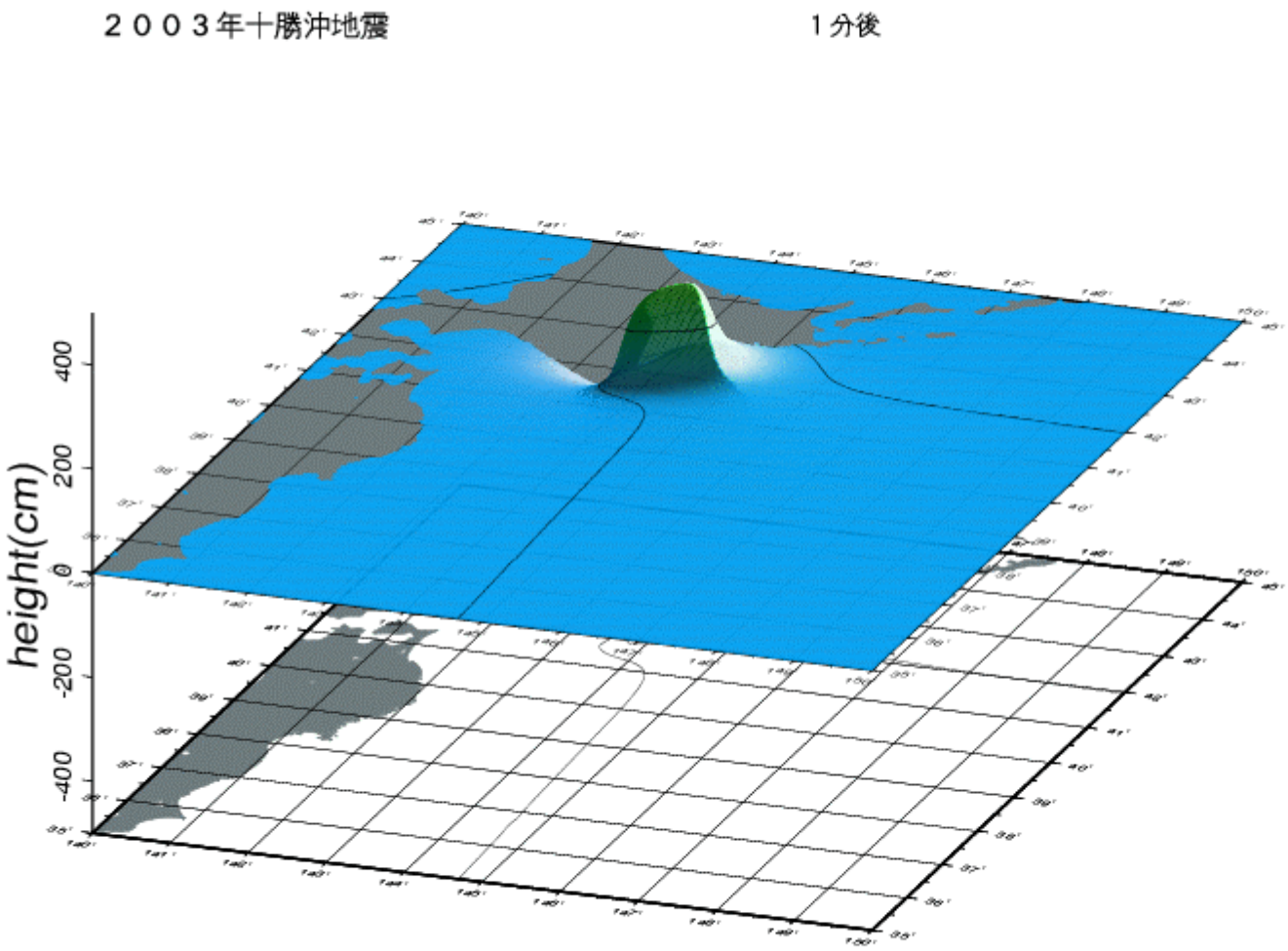
Hypocenter

Magnitude



3. Determination of the Hypocenter

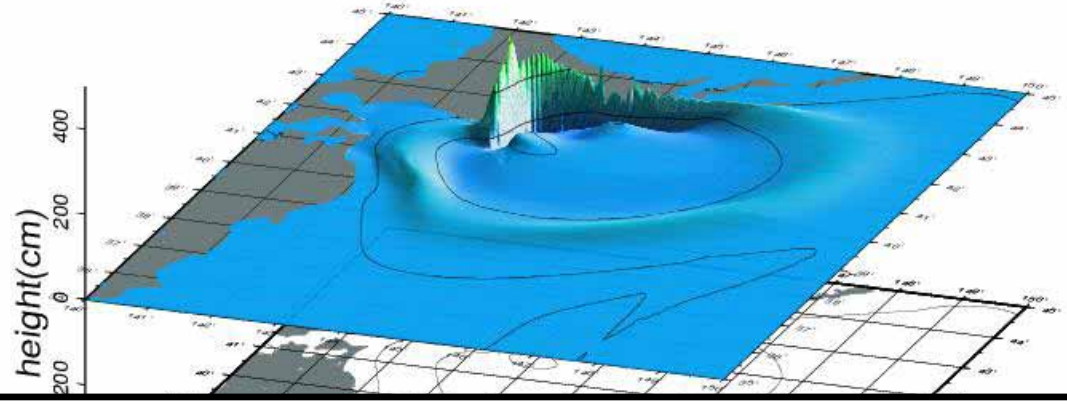
Example of Tsunami Simulation



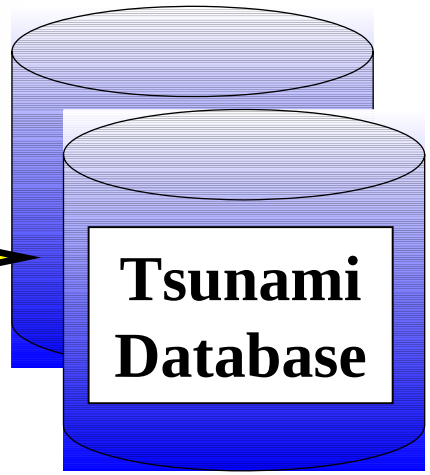
Numerical simulation technique is a very powerful tool for precise and detailed tsunami estimation.

Tsunami Forecast (1)

But... numerical simulation takes a long time. If we run the simulation after the occurrence of an earthquake, tsunami would arrive at coasts before tsunami warning is announced.



Computer simulation of tsunami generation and propagation is conducted IN ADVANCE.

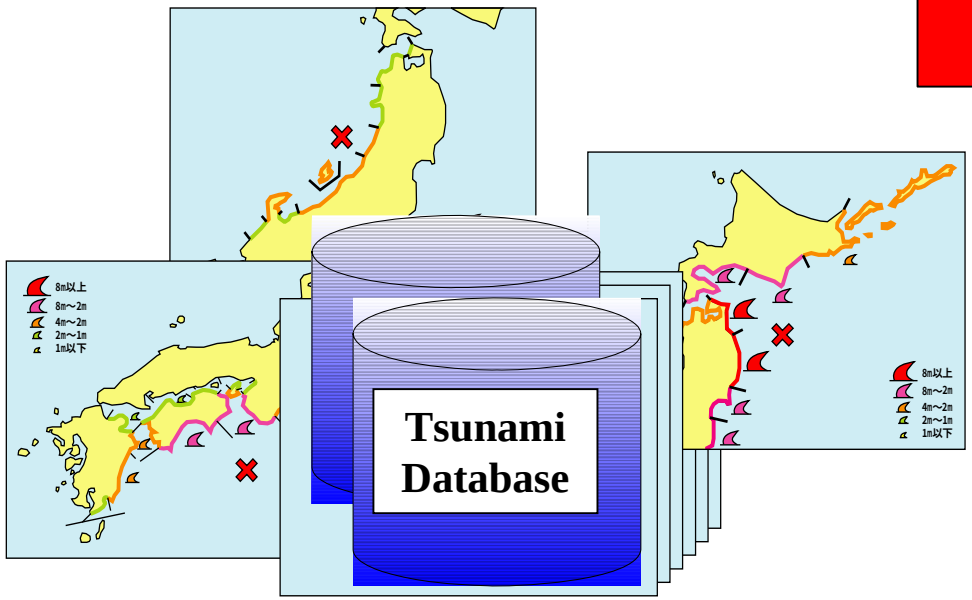


Scenarios of tsunami arrival time and amplitude corresponding to 100,000 different tsunamigenic earthquakes

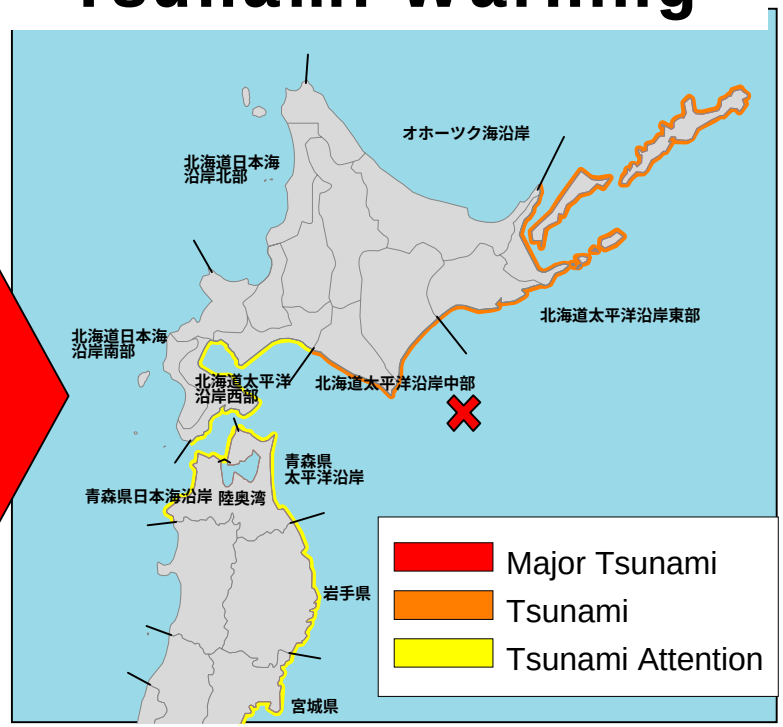
Tsunami Forecast (2)

Tsunami Forecast Operation

Referring to the determined location and magnitude of the earthquake, the system searches tsunami database and picks up the most appropriate scenario from the database.



Tsunami Warning



Issuance of tsunami warning at each coastal region (66 regions in Japan) with the grade determined from estimated tsunami height.

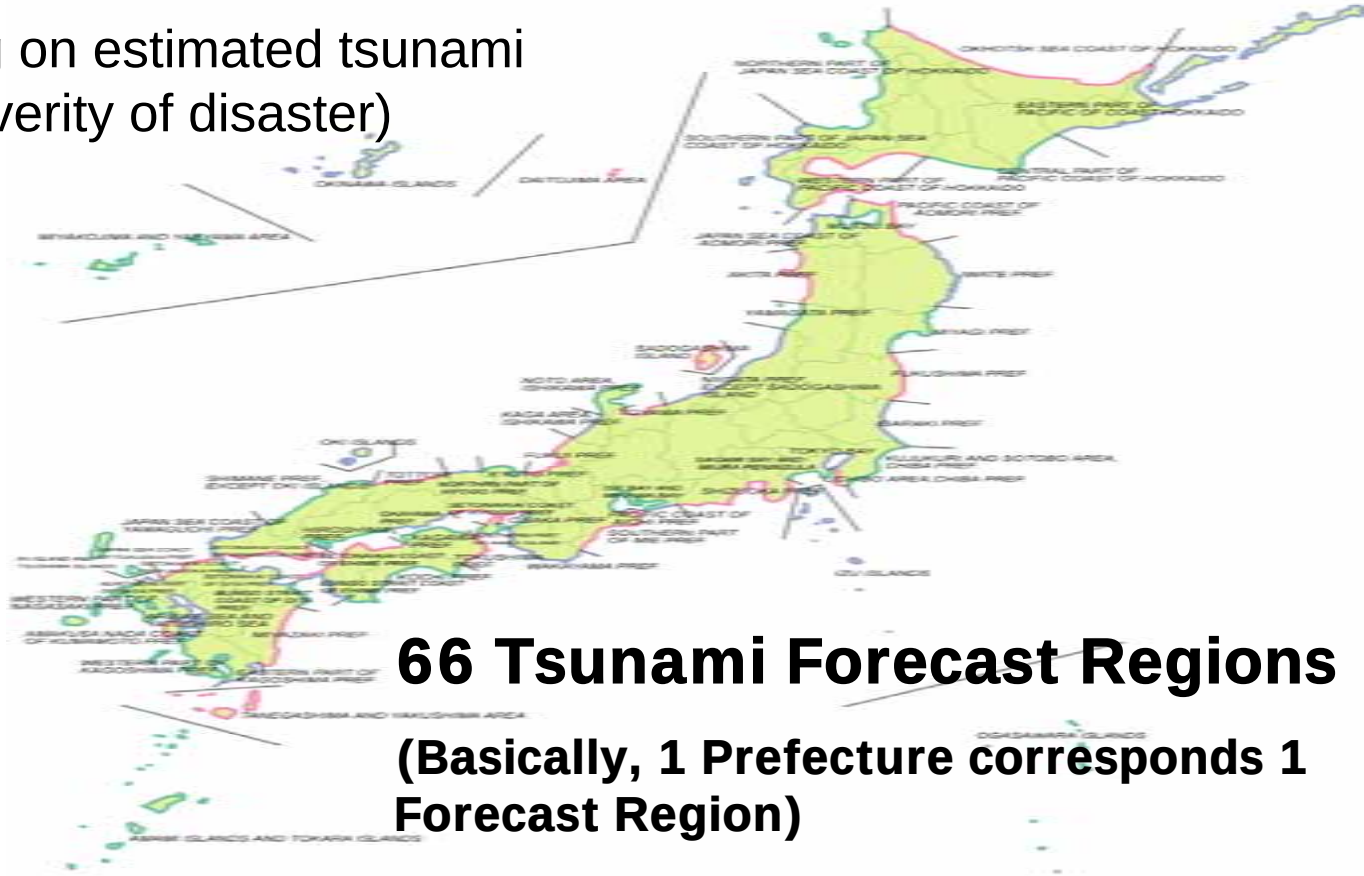
Tsunami Forecast (3)

Category		Estimated Tsunami Height to be shown in the Forecast Message
Tsunami Warning	Major Tsunami	"3m", "4m", "6m", "8m", "10m or higher"
	Tsunami	"1m", "2m"
Tsunami Advisory	Tsunami Attention	"0.5m"

People in Tsunami Hazard Zone (designated by municipalities) should evacuate

People on a beach, or swimming should go to a high place

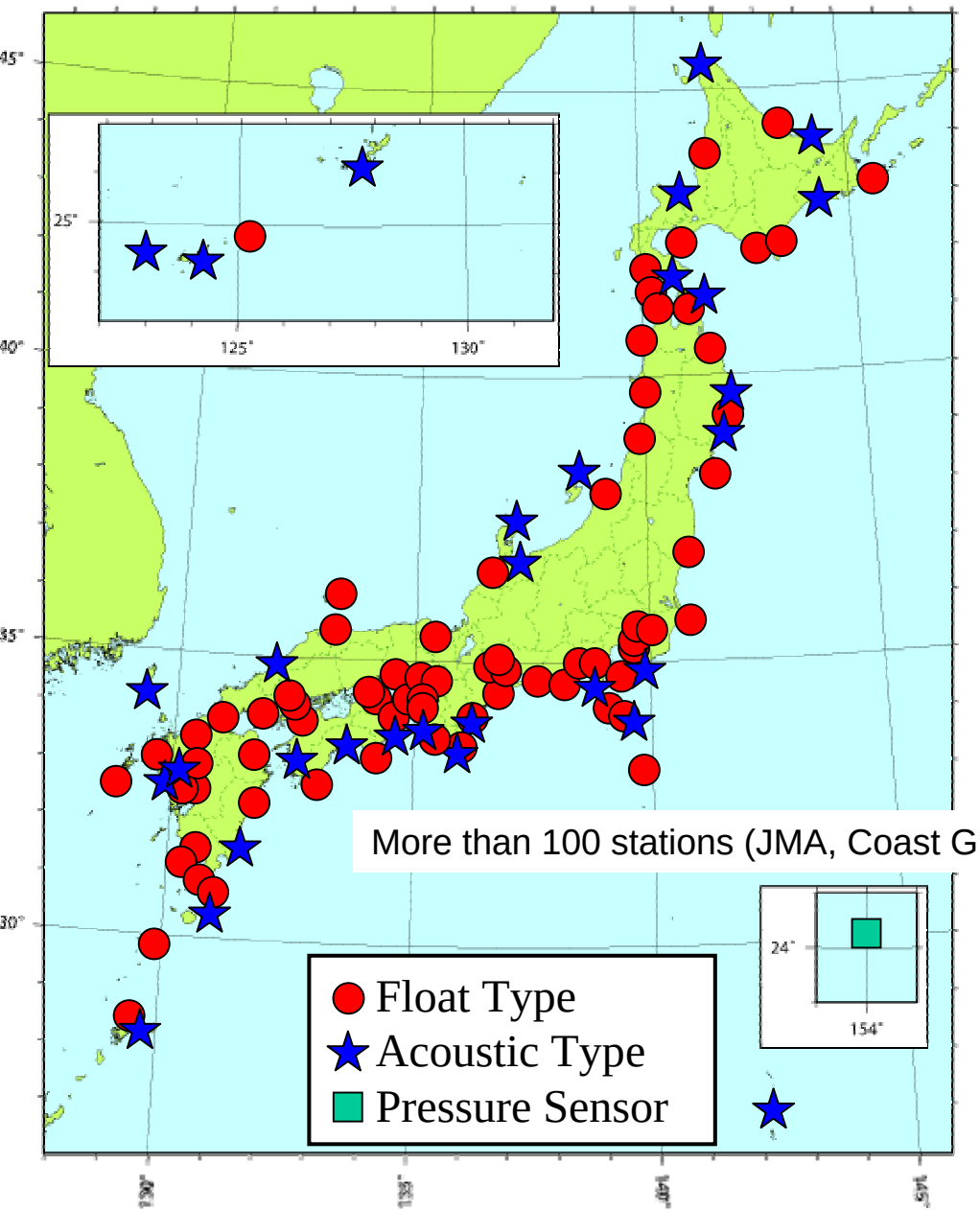
3 grades : depending on estimated tsunami height (severity of disaster)



66 Tsunami Forecast Regions

(Basically, 1 Prefecture corresponds 1 Forecast Region)

Tsunami Monitoring Network in Japan



More than 100 stations (JMA, Coast Guard, GSI, etc)

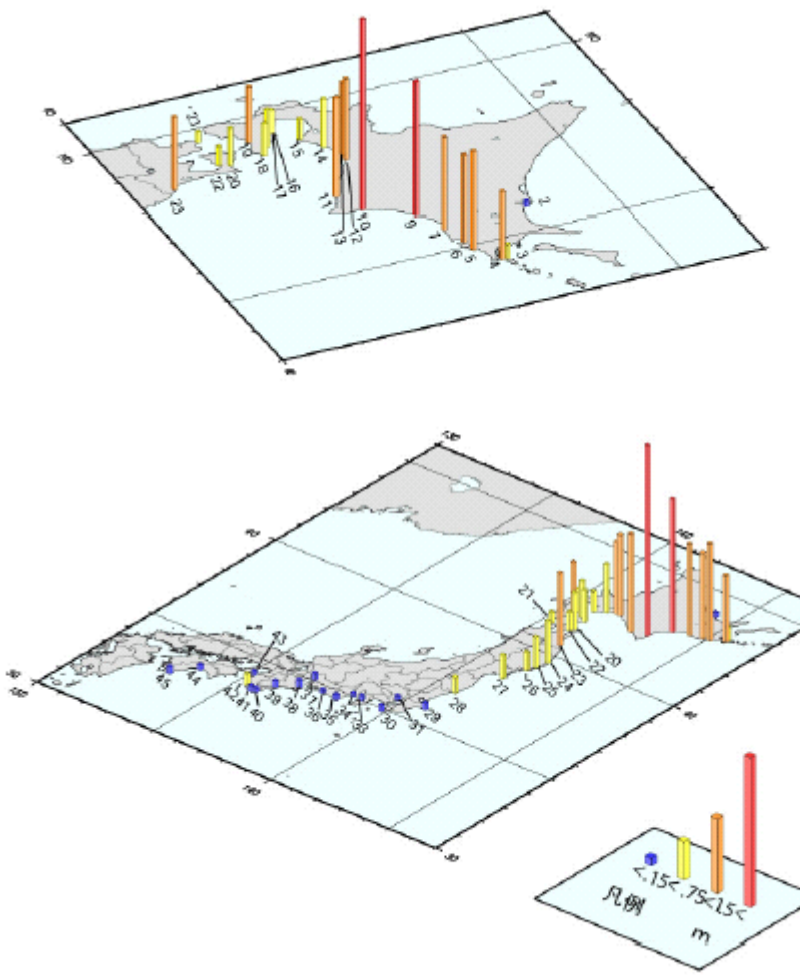
Tide Gauge (Float Type)

Tide Gauge (Acoustic Type)

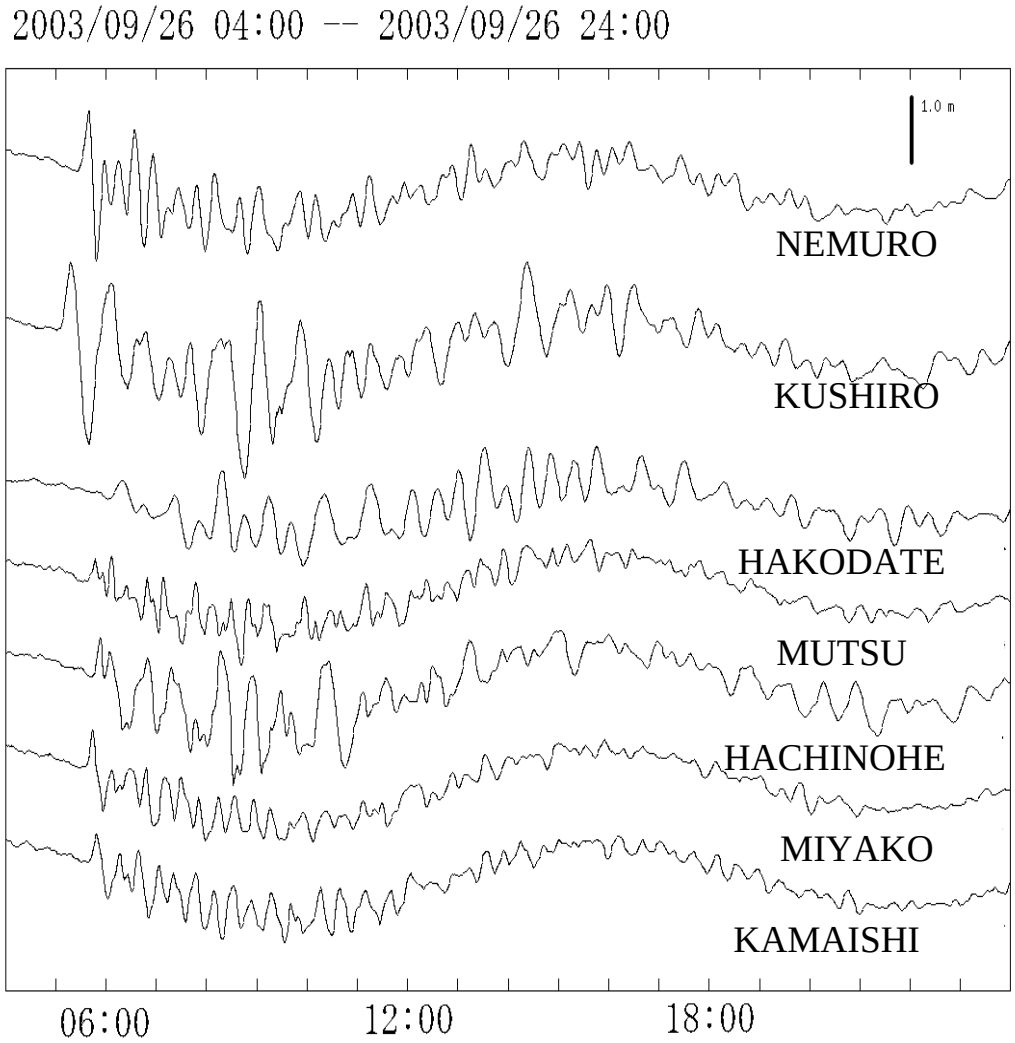
Huge Tsunami Gauge

Pressure Sensor on Sea Floor

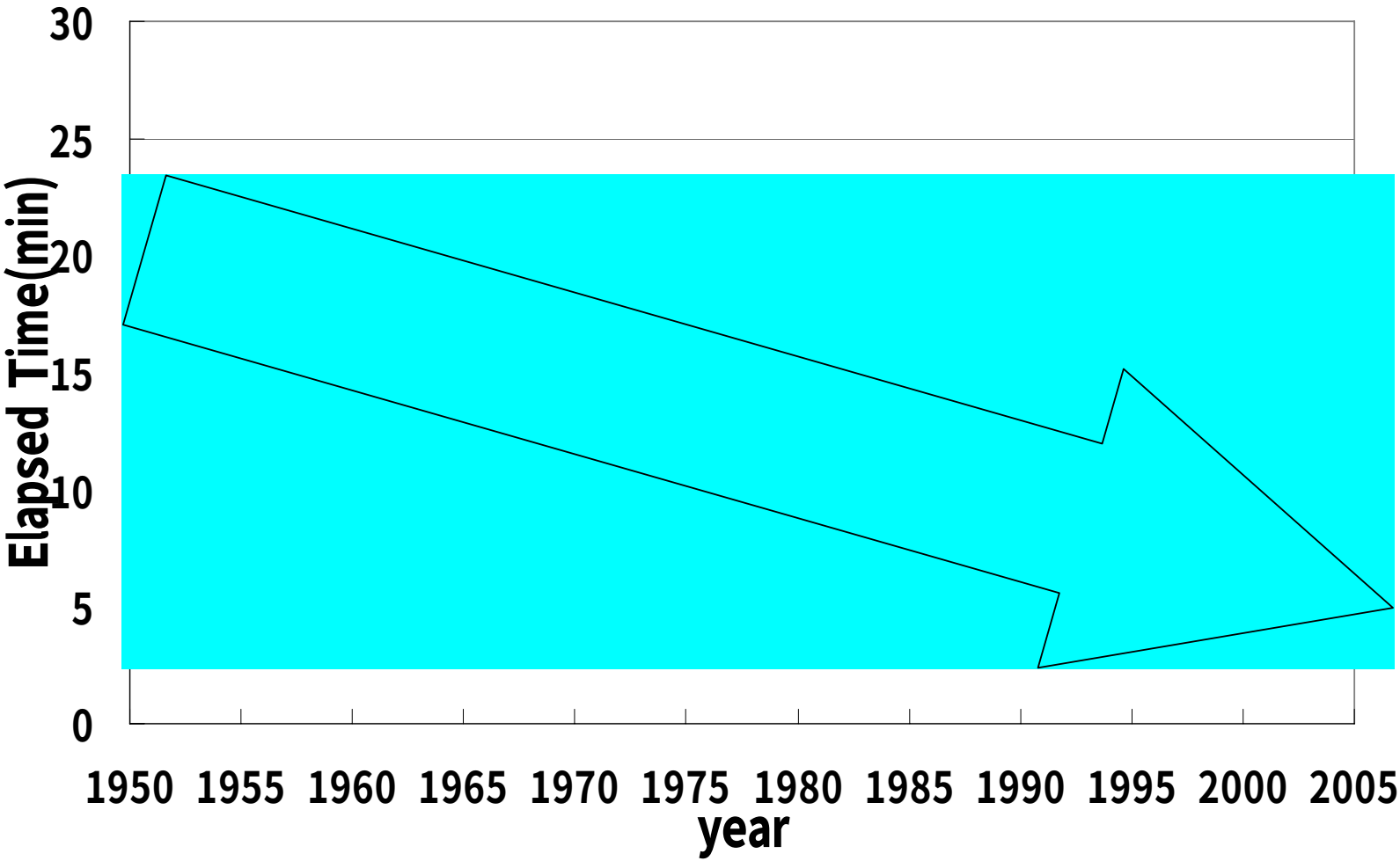
Tsunami heights observed by tide gauge



第 2.2.1 図　検潮記録による津波の最大の高さ（図中の番号は第 2.2.1 表の番号に対応す



Elapsed Time for Tsunami Warning (for local Earthquakes)



Earthquakes for which tsunami warning/advisory were issued (1999- : After the introduction of numerical simulation method)

Date	Epicenter	Magnitude	Tsunami warning/advisory	Maximum observed tsunami amplitude at tidal stations
18 Dec 2001	Near Ryukyu-Islands	7.3	Advisory	12cm
26 Mar 2002	Near Ryukyu-Islands	7.0	Warning (Tsunami)	6cm
31 Mar 2002	Near Taiwan	7.0	Warning (Tsunami)	12cm
26 Sep 2003	Off the south coast of Hokkaido (Tokachi-oki)	8.0	Warning (Tsunami)	255cm
31 Oct 2003	Off the east coast of Tohoku-District	6.8	Advisory	34cm
5 Sep 2004	Off the south coast of Central Honshu	7.1	Advisory	63cm
5 Sep 2004	Off the south coast of Central Honshu	7.4	Warning (Tsunami)	93cm
29 Nov 2004	Off the south coast of Hokkaido	7.1	Advisory	12cm
19 Jan 2005	Off the south coast of Kanto-District	6.8	Advisory	39cm
16 Aug 2005	Off the east coast of Tohoku-District	7.2	Advisory	13cm
15 Nov 2005	Off the east coast of Tohoku-District	7.2	Advisory	42cm
15 Nov 2006	Kuril Islands	7.9	Warning (Tsunami)	84cm

(No warnings/advisories were issued for distant earthquakes in this period)

Dissemination and Utilization of Tsunami Forecast and Earthquake Information

Dissemination of Tsunami Warning and Earthquake Information

satellite

JMA as the National Center

Dedicated telephone line

Central Government

Local Governments

Police, Fire offices

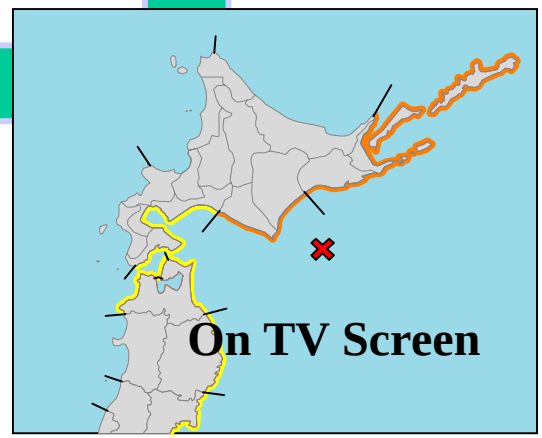
TV broadcasting

Radio Stations

Etc.

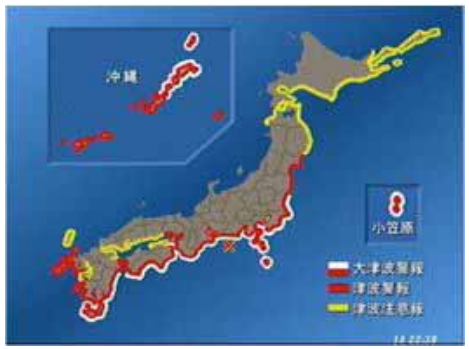
Loud Speakers Sirens

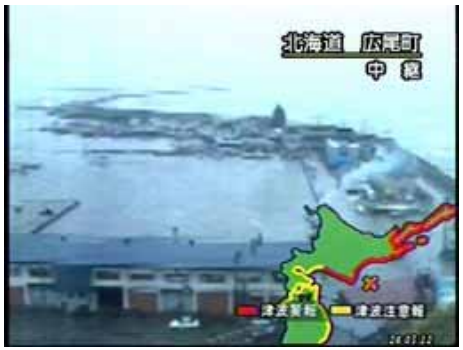
Residents in coastal areas at risk



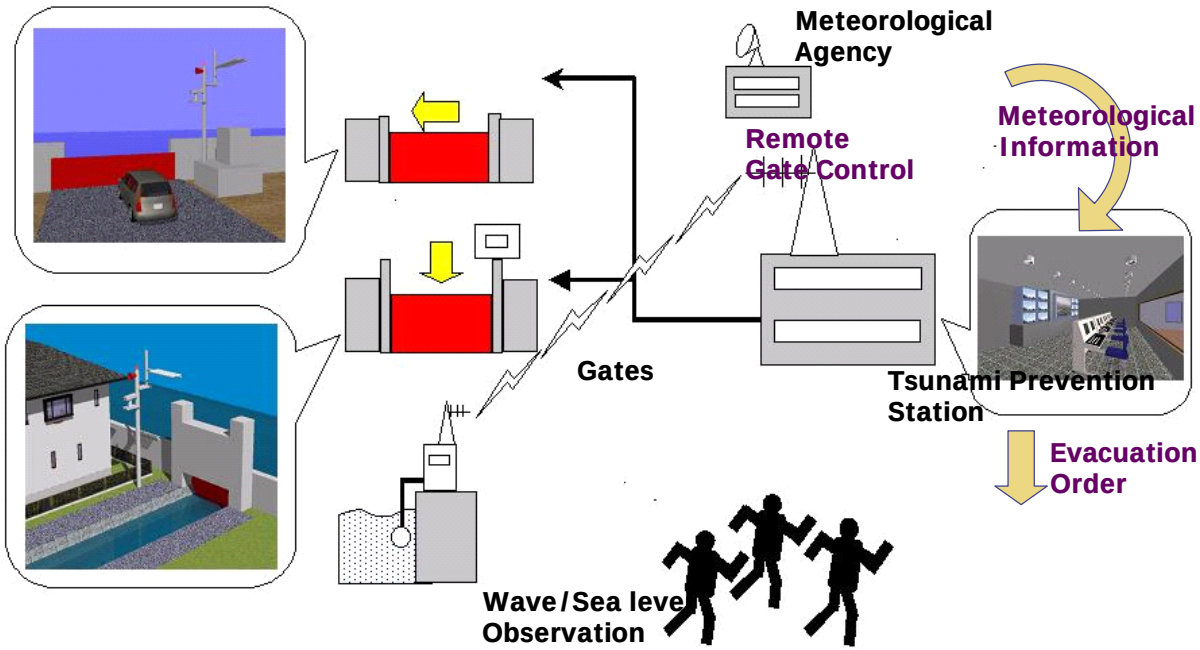
TV Broadcasting in Japan

When an Earthquake Occurs…..





Remote Control of Water Gates



Coastal area is dangerous when tsunami is coming. Remote control system of water gates enables operators to close gates safely.

◯Gate

◯Control Center

Shizuoka Pref.

Northwest Pacific Tsunami Advisory Center

1960 Chile Earthquake and Tsunami

Tsunami Propagation

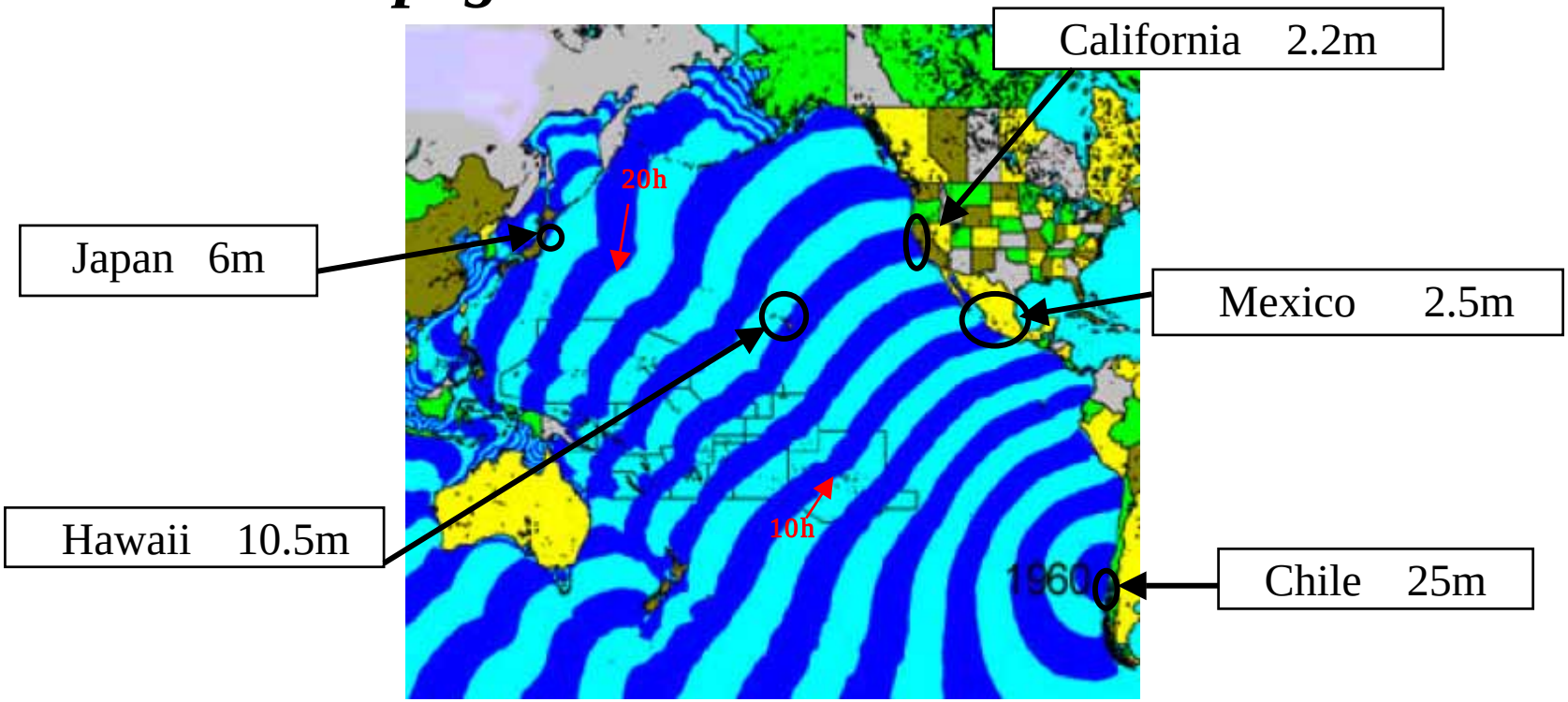
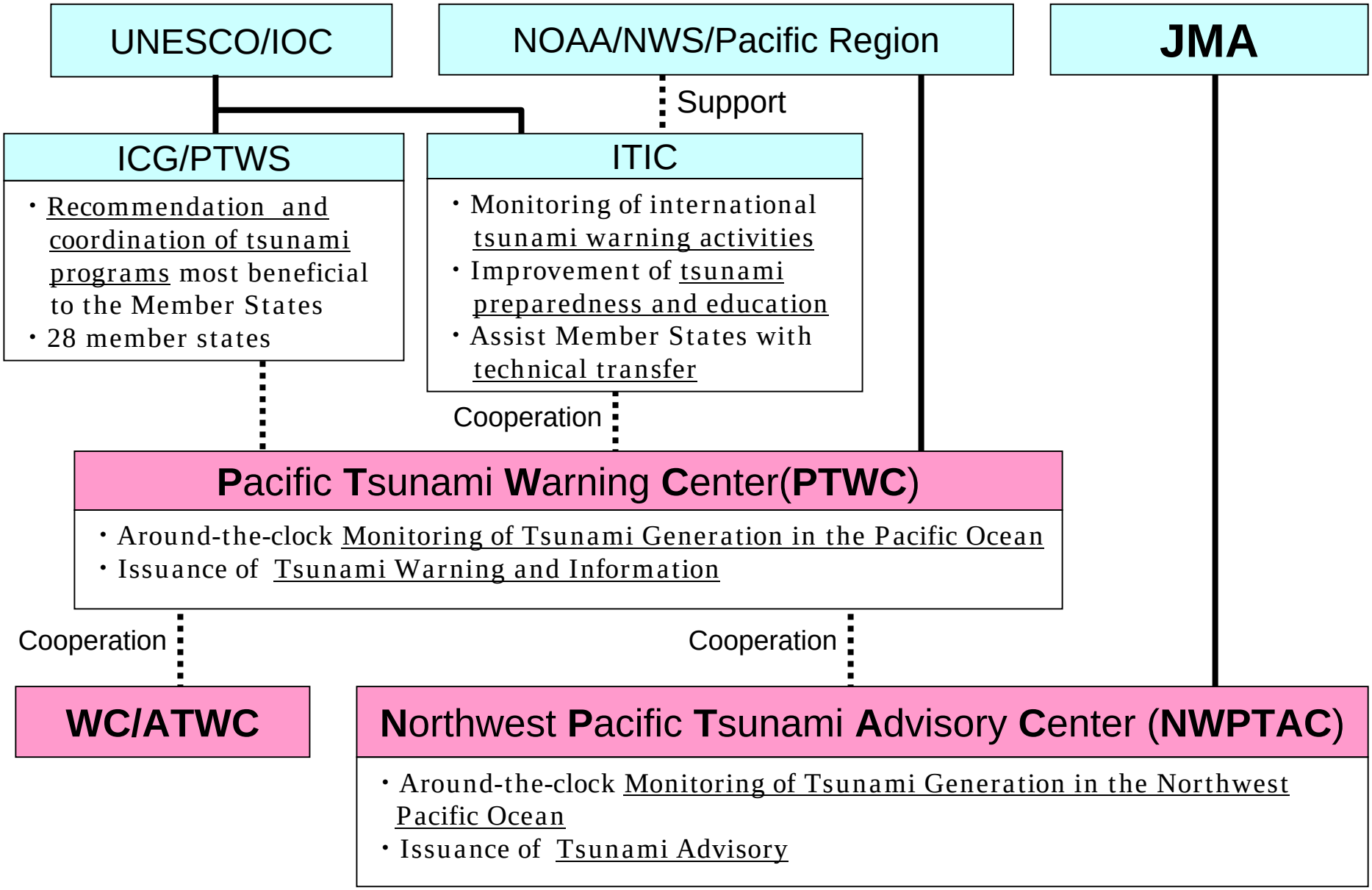


Fig.2 Tsunami propagation diagram and tsunami heights

Missing and Death :
142 (in Japan)
61 (in Hawaii)
about 6000 (in the world)

With this earthquake as a turning point, ICG/ITSU (now, renamed as ICG/PTWS) was organized under UNESCO/IOC

Organizations of Pacific Tsunami Warning System



Northwest Pacific Tsunami Advisory Center

Japanese Seismic Network

Global Seismic Network

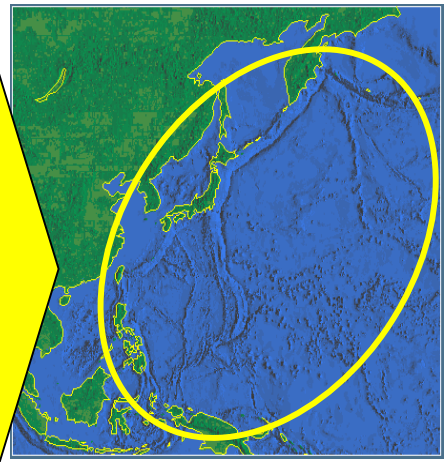
JMA Headquarters

Analysis of seismic data and estimation of arrival time and height of tsunami generated by earthquakes in the Northwest Pacific Area

Northwest Pacific Tsunami Advisory

- Origin Time
- Hypocenter
- Magnitude (>=6.5)
- Estimated arrival time and height of tsunami

Countries in Northwest Pacific Ocean

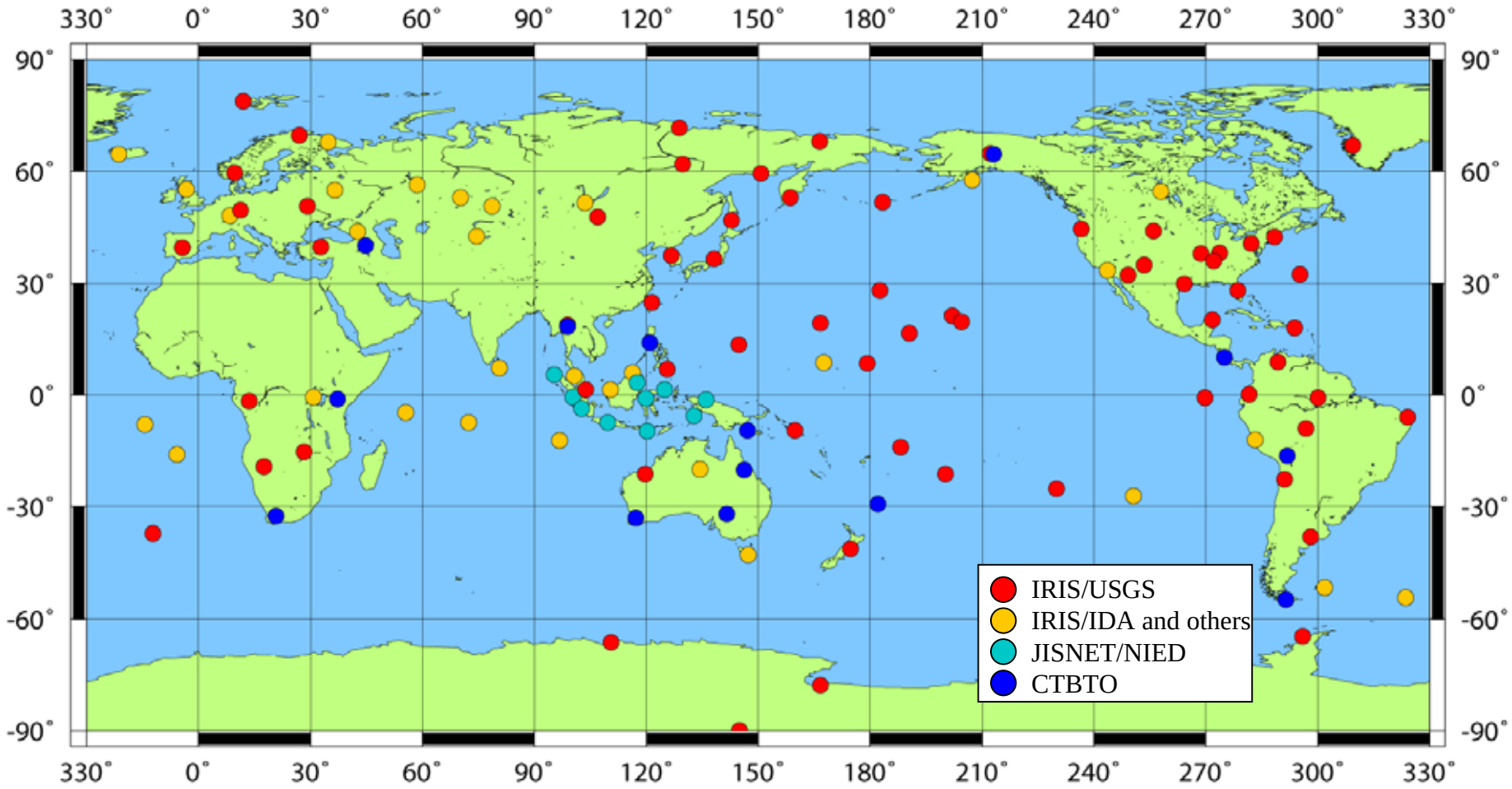


Inform using the Global Telecommunication System of WMO, E-mail and/or Facsimile

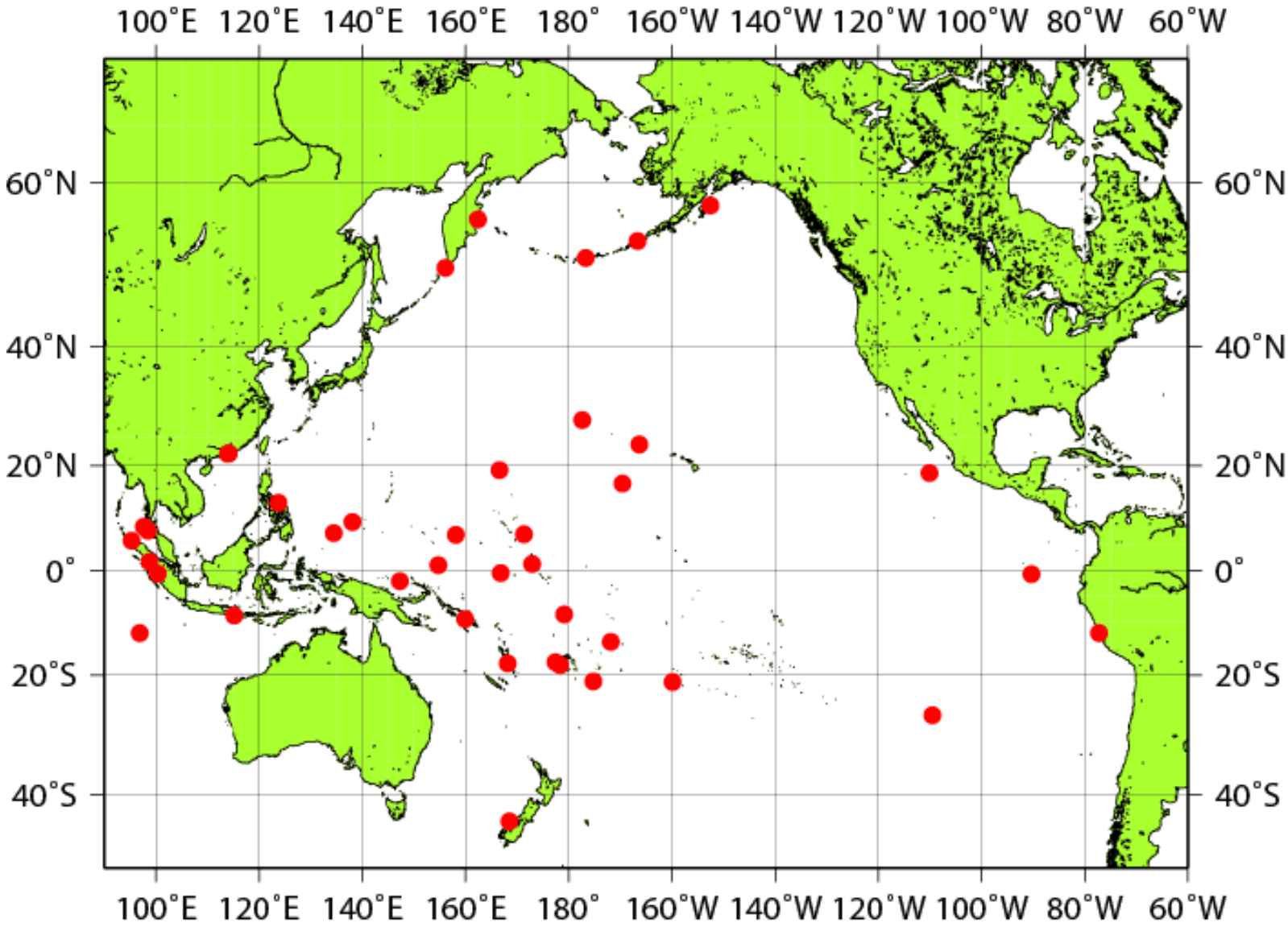
Information Exchange
- Magnitude
- Hypocenter
- Tsunami Information

Pacific Tsunami Warning Center (PTWC)

Seismic stations that NWPTAC uses for hypocenter determination



Sea Level Stations in the Pacific Ocean



collected using meteorological satellite from each country.

Example of Northwest Pacific Tsunami Advisory

TSUNAMI BULLETIN NUMBER 002
ISSUED BY NWPTAC(JMA)
ISSUED AT 2309Z 14 NOV 2005

HYPOCENTRAL PARAMETERS
ORIGIN TIME:2138Z 14 NOV 2005
PRELIMINARY EPICENTER:LAT38.0NORTH LON145.0EAST
OFF EAST COAST OF HONSHU, JAPAN
JAPAN - KURIL ISLANDS - KAMCHATKA PENINSULA
MAG:6.9(MJMA)

Earthquake Information

EVALUATION
THERE IS A VERY SMALL POSSIBILITY OF A DESTRUCTIVE LOCAL TSUNAMI

Potential of Tsunami

NO TSUNAMI WITH A HEIGHT OF 0.5 METER OR OVER IS EXPECTED
AT ANY POINT

Estimated Tsunami Height

MEASURMENTS OR REPORTS ON TSUNAMI
LOCATION COORDINATES ARRIVAL TIME HEIGHT
MIYAKO 39.6N 142.0E
MAXIMUM TSUNAMI WAVE 2231Z 14 NOV 0.2M
MAXIMUM TSUNAMI WAVE HEIGHT -- HALF OF HEIGHT FROM THE TROUGH
TO THE CREST

Tsunami Observation

THIS WILL BE THE FINAL INFORMATION UNLESS THERE ARE CHANGES ABOUT THE
POTENTIAL OF TSUNAMI GENERATION BY RE-EVALUATION OF THE EARTHQUAKE OR
THERE ARE REPORTS ON TSUNAMI OBSERVATIONS

Interim Provision of Tsunami Watch Information for the Indian Ocean Countries

Motivation for Interim Provision of Tsunami Watch Information

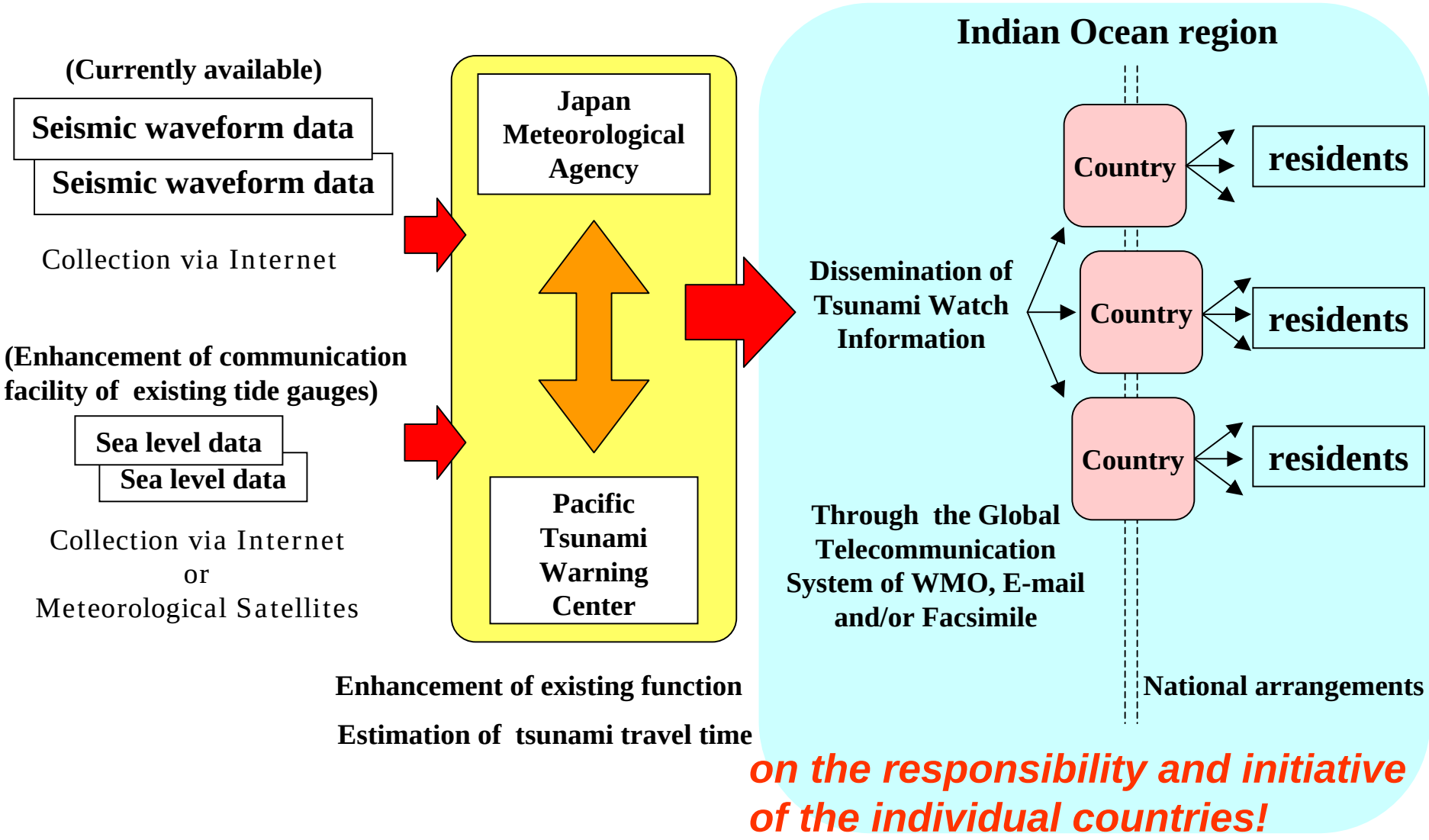
26 Dec 2004 SUMATRA-ANDAMAN ISLANDS EARTHQUAKE

No Tsunami Warning
if a big tsunami were generated again

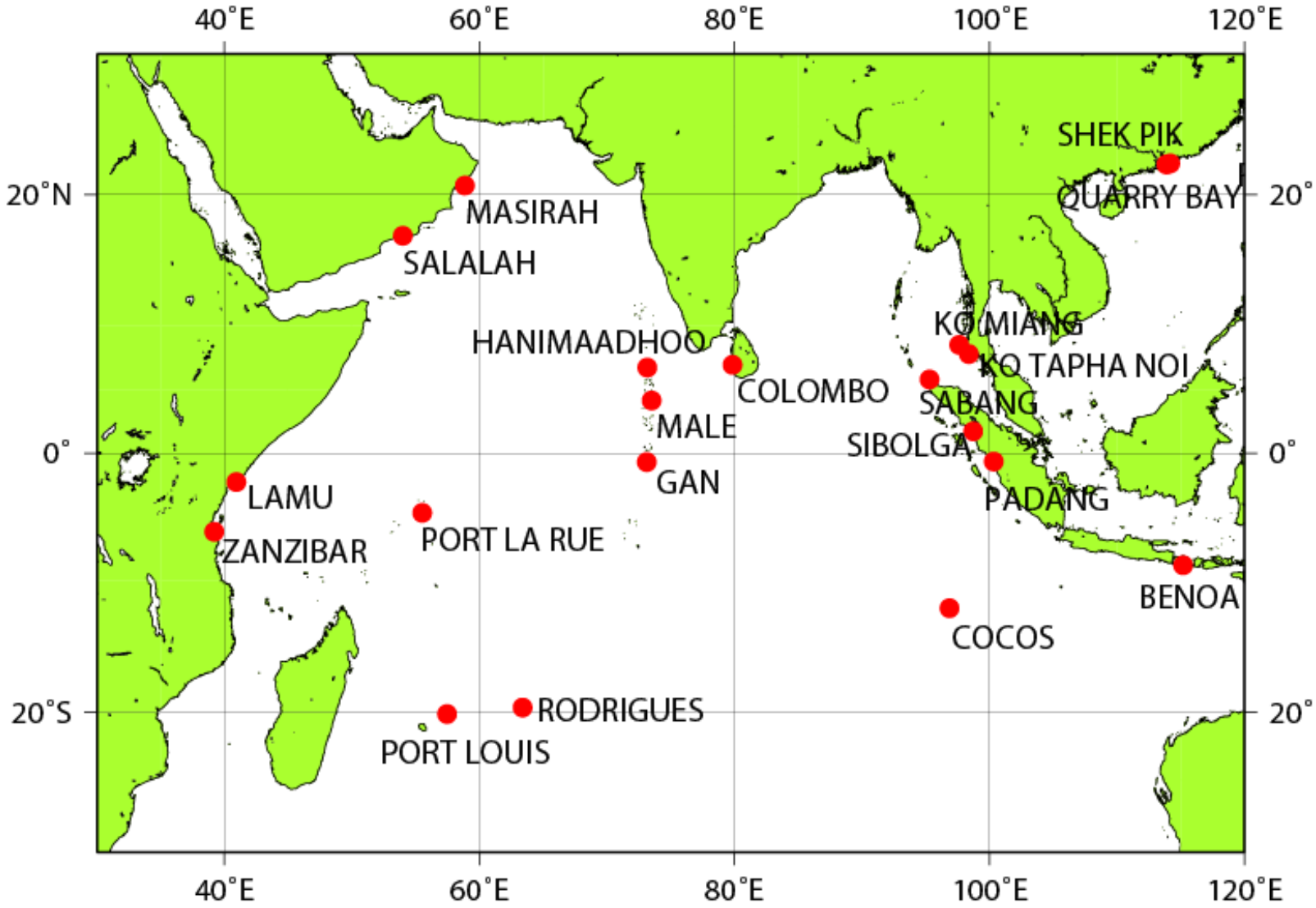
Need an Emergency Measure

Interim Provision of Tsunami Watch Information

Tsunami Watch Information should be Regarded as a Reference for Taking Preventive Measure against Possible Tsunamis on the Responsibility and Initiative of the Individual Countries



Sea Level Stations in the Indian Ocean



As of April 14 2006

Example of Tsunami Watch Information

TSUNAMI BULLETIN NUMBER NUMBER 001

ISSUED BY THE JAPAN METEOROLOGICAL AGENCY (JMA)

ISSUED AT 1602 24 JUL 2005 (UTC)

... A LOCAL TSUNAMI WATCH IS IN EFFECT ...

1.EARTHQUAKE INFORMATION

ORIGIN TIME : 1542 24 JUL 2005 (UTC)

COORDINATES : 8.7 NORTH 92.1 EAST

LOCATION : NICOBAR ISLANDS, INDIA, REGION

MAGNITUDE : 7.3

Earthquake Information

2.EVALUATION

THERE IS A POSSIBILITY OF A DESTRUCTIVE LOCAL TSUNAMI

IN THE INDIAN OCEAN.

Potential of Tsunami

3.ESTIMATED TSUNAMI TRAVEL TIME

ONE HOUR OR LESS

INDIA:

ALL COASTS OF ANDAMAN AND NICOBAR ISLANDS

INDONESIA:

INDIAN OCEAN COAST OF SUMATRA

MALACCA COAST OF SUMATRA

Estimated Tsunami Travel Time

Tsunami Watch Information Recipient Countries

International Tsunami Advisory Issued from JMA

Northwest Pacific Tsunami Advisory

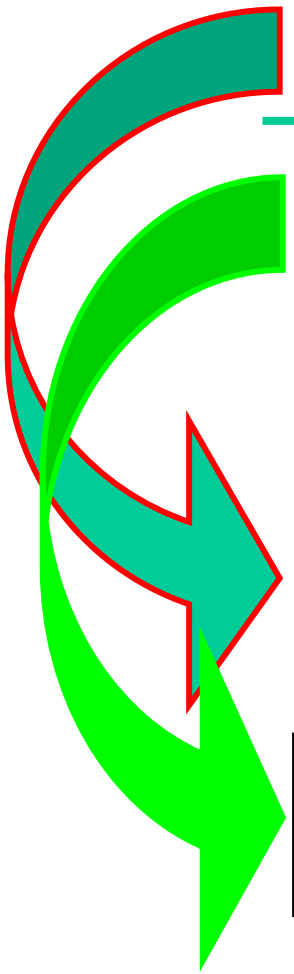
	Issued Time	Origin Time	Latitude	Longitude	M	Tsunami Evaluation	Remark
1	2005/08/16 02:55	02:46	38.1N	142.4E	6.8	Very Small Possibility of Local Tsunami	
2	2005/09/09 07:56	07:27	04.6S	153.3E	7.3	Possibility of Local Tsunami	
3	2005/10/15 16:03	15:51	25.3N	123.4E	6.5	No Tsunami	Depth: 182km
4	2005/11/14 21:50	21:38	38.0N	145.0E	6.9	Very Small Possibility of Local Tsunami	Miyako 0.2m Announced
5	2006/05/28 03:36	03:12	05.7S	151.3E	6.7	Very Small Possibility of Local Tsunami	
6	2006/08/24 22:18	21:50	51.2N	157.7E	6.5	Very Small Possibility of Local Tsunami	
7	2006/09/01 10:40	10:18	06.7S	155.4E	6.9	Very Small Possibility of Local Tsunami	
8	2006/09/30 18:03	17:50	46.4N	153.9E	6.8	Very Small Possibility of Local Tsunami	
9	2006/10/01 09:20	09:05	47.1N	153.3E	6.5	Very Small Possibility of Local Tsunami	
10	2006/10/17 01:45	01:25	05.9S	151.0E	6.8	Very Small Possibility of Local Tsunami	
11	2006/10/23 21:29	21:17	29.7N	142.2E	6.8	Very Small Possibility of Local Tsunami	
12	2006/11/07 18:01	17:39	06.6S	151.2E	6.6	Very Small Possibility of Local Tsunami	
13	2006/11/15 11:30	11:14	46.6N	153.6E	8.1	Possibility of Ocean-wide Tsunami	Kushiro 0.2m, Miyako 0.2m, Choshi 0.1m, Chichijima 0.5m and Port Vila 0.1m Announced
14	2006/12/26 12:33	12:26	21.7N	120.4E	6.9	Very Small Possibility of Local Tsunami	
15	2006/12/26 12:42	12:34	21.8N	120.6E	7.2	Possibility of Local Tsunami	

Tsunami Watch Information for the Indian Ocean

	Issued Time	Origin Time	Latitude	Longitude	M	Tsunami Evaluation	Remark
1	2005/04/10 10:56	10:29	01.1S	099.4E	6.8	Very Small Possibility of Local Tsunami	
2	2005/04/16 16:59	16:38	01.9N	097.8E	6.5	Very Small Possibility of Local Tsunami	
3	2005/04/28 14:30	14:07	02.2N	096.9E	6.6	Very Small Possibility of Local Tsunami	
4	2005/05/14 05:32	05:05	00.7N	098.7E	6.8	Very Small Possibility of Local Tsunami	
5	2005/05/19 02:15	01:54	02.0N	097.0E	6.6	Very Small Possibility of Local Tsunami	
6	2005/07/05 02:15	01:52	01.9N	097.0E	6.7	Very Small Possibility of Local Tsunami	
7	2005/07/24 16:02	15:42	08.7N	092.1E	7.3	Possibility of Local Tsunami	
8	2005/11/19 14:32	14:10	03.0N	096.5E	6.5	Very Small Possibility of Local Tsunami	
9	2006/02/22 22:50	22:19	21.0S	033.3E	7.2	No Tsunami	Land Area
10	2006/05/16 15:50	15:28	00.1N	097.0E	6.9	Very Small Possibility of Local Tsunami	
11	2006/07/17 08:46	08:19	09.3S	107.3E	7.2	Possibility of Local Tsunami	Benoa 0.2m and Rodorigues 0.4m Announced
12	2006/12/30 08:57	08:31	13.3N	051.5E	6.5	Very Small Possibility of Local Tsunami	

Summary (Domestic Service)

Provision of
Earthquake Information
and Tsunami Warning



Time, location, magnitude, seismic intensity

Height and arrival time based on numerical simulation modeling database

Summary (International)

- **Using data from many countries, and organizations.**
- **International Contribution through Provision of Tsunami Bulletin**
  - Northwest Pacific Tsunami Advisory
    - Since March 2005
  - Interim Provision of Tsunami Watch Information for the Indian Ocean
    - Since March, 2005

Thank you very much.