

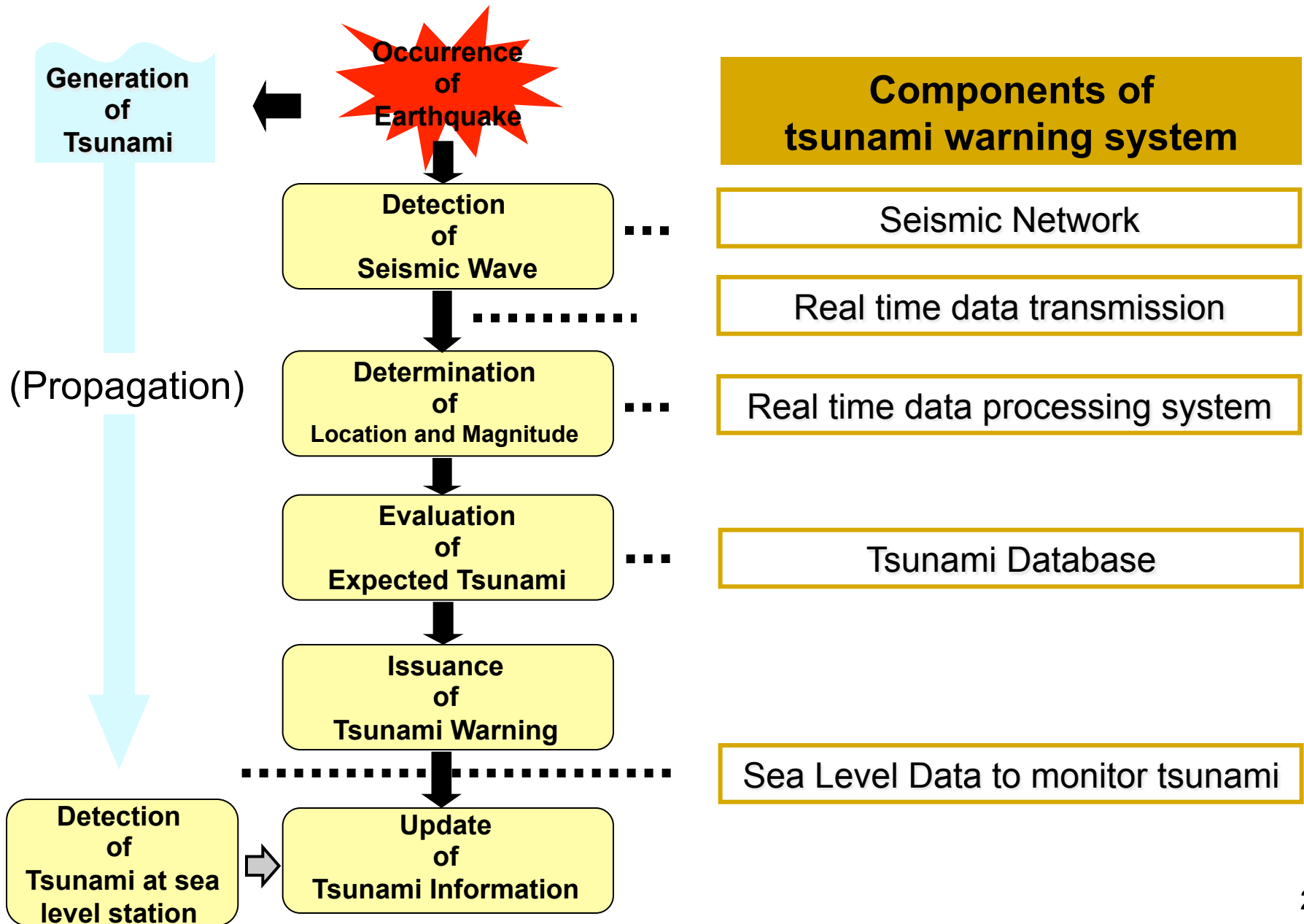


International Tsunami Symposium Commemorating
50th Anniversary of the Pacific Tsunami Warning and Mitigation System
20-21 April 2015, NOAA Inouye Regional Center, Ford Island, Oahu, Hawaii

Japan's Local Tsunami Warning

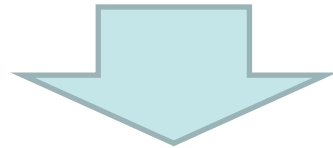
Tomoaki OZAKI
Japan Meteorological Agency

The principle of Tsunami Warning



Tsunamis can hit coasts within a very short time after an earthquake...

*Lesson: In 1993, large tsunamis hit coasts in **a few minutes** after the southwest off Hokkaido earthquake, which caused more than 200 deaths and missing.*



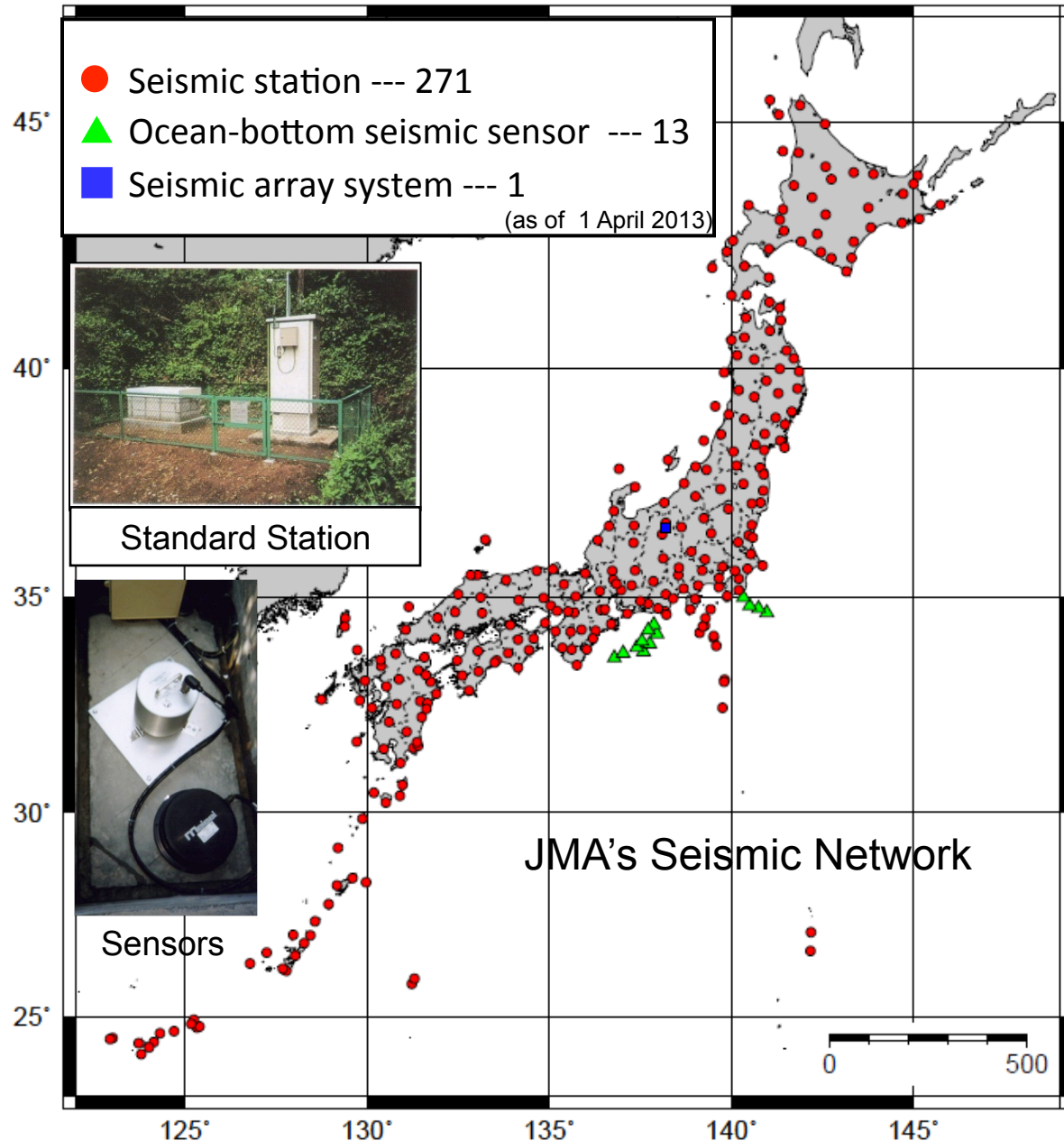
1.To be announced quickly

2. To be as simple as possible

1. To be Announced Quickly

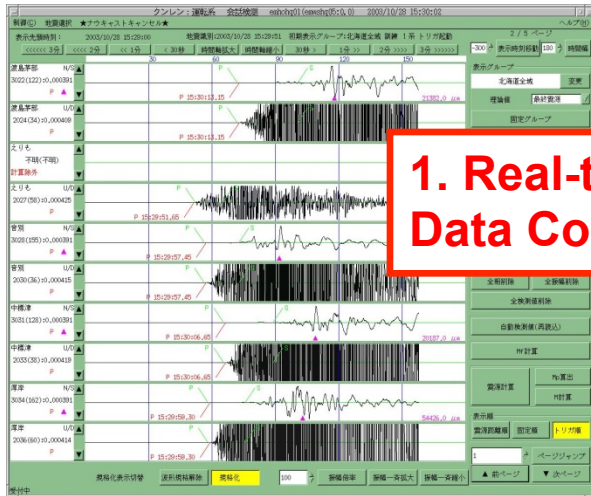
- **Real-time seismic monitoring**
- **Real-time data processing system**
- **Tsunami simulation database**
- **Uncertainties in the initial stage**

Real-time Seismic Monitoring



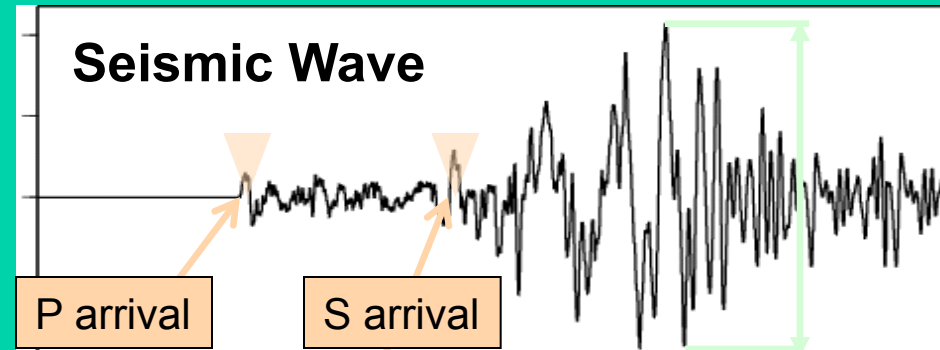
**Maintenance
of **reliable**
and **real-time**
seismometers
network is
indispensable**

Real-time Data Processing System



1. Real-time Data Collection

2. Read P/S Arrival Time and Maximum Amplitude



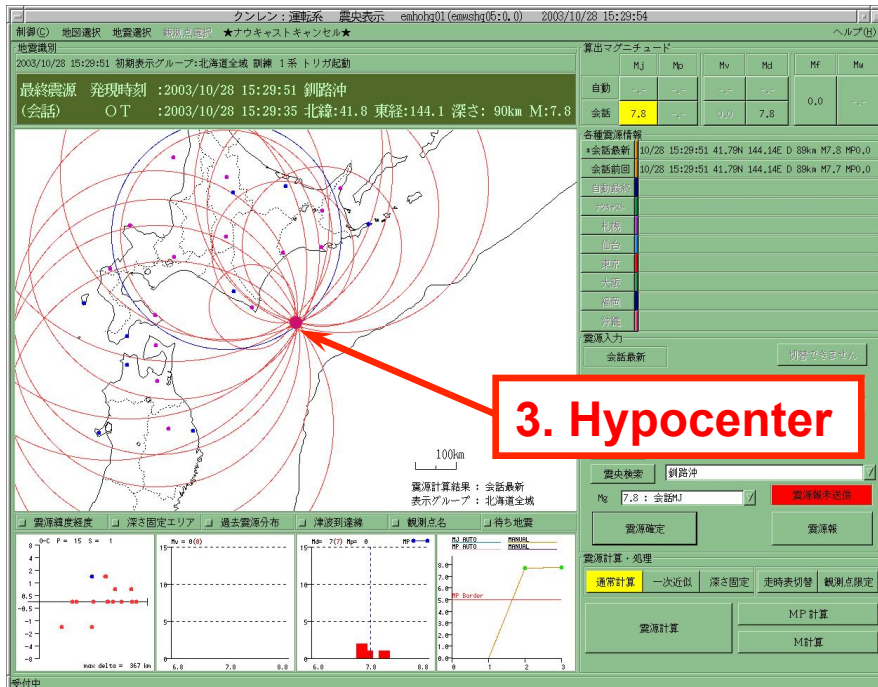
Seismic Wave

P arrival

S arrival

Maximum Amplitude

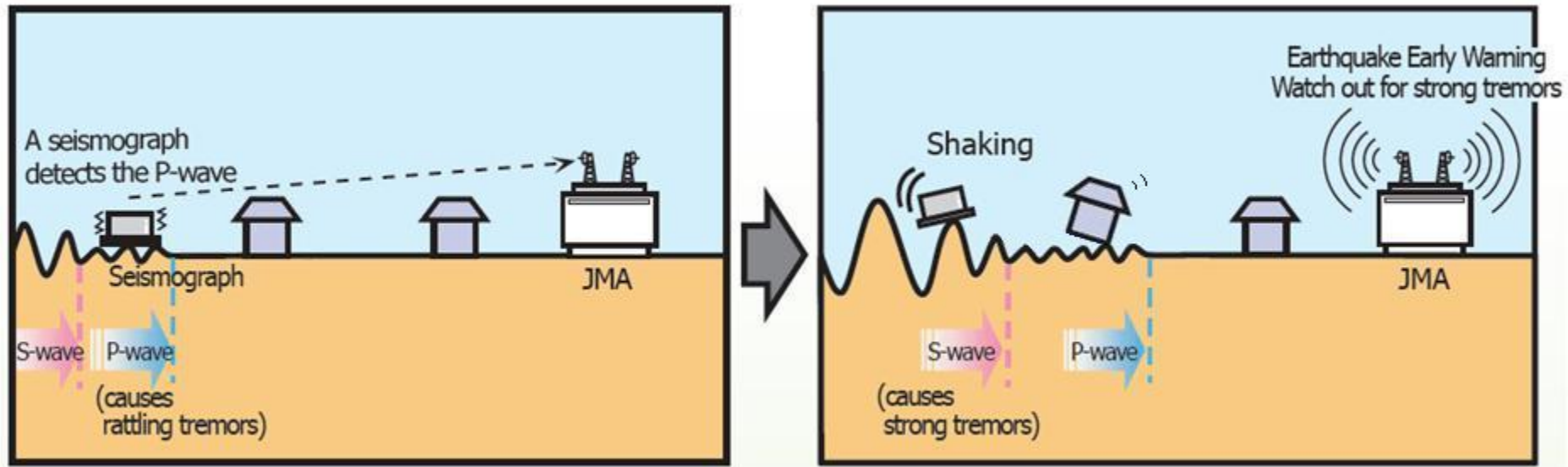
4. Magnitude



3. Hypocenter

Distance from the Hypocenter

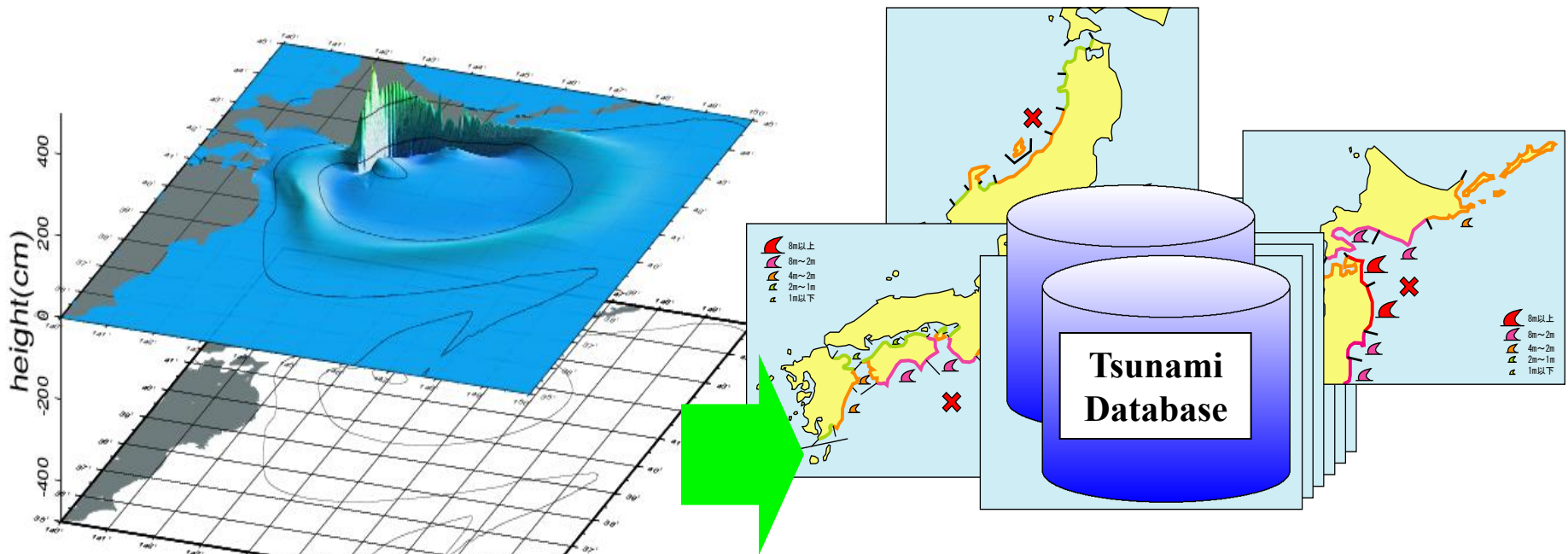
Real-time Data Processing System (Earthquake Early Warning)



1 The EEW system **automatically calculates an earthquake's hypocenter and magnitude from P-waves detected near the epicenter**, and then estimates the intensity of expected ground shaking (seismic intensity) at numerous locations in cities, towns and villages.

2 An EEW message is provided in **a few seconds to a few tens of seconds before S-waves, or strong tremors, start.**

Tsunami Simulation Database (1)

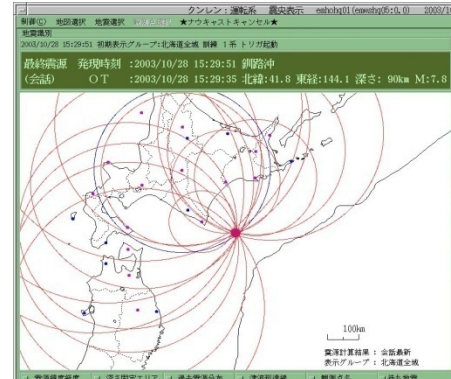


Scenarios of tsunami arrival time and height according to more than 100,000 different tsunamigenic earthquakes

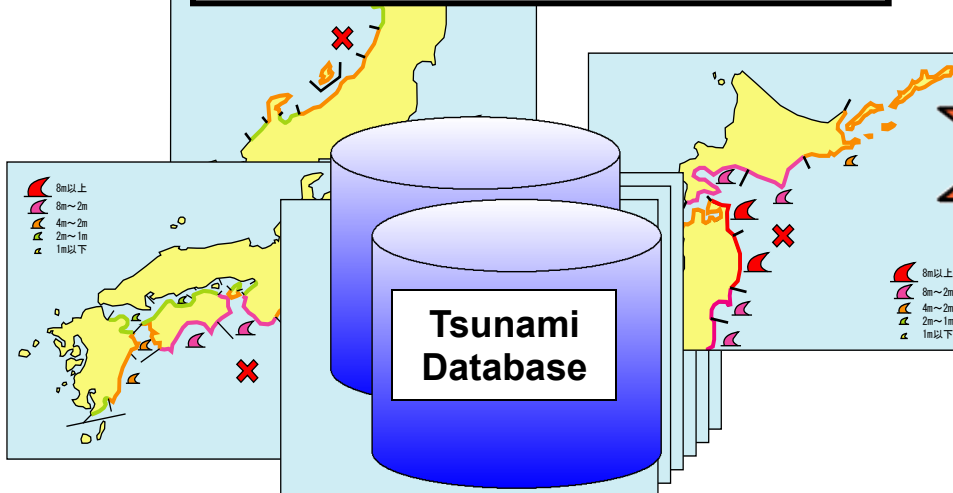
Computer simulation of tsunami generation and propagation is conducted in advance.

Tsunami Simulation Database (2)

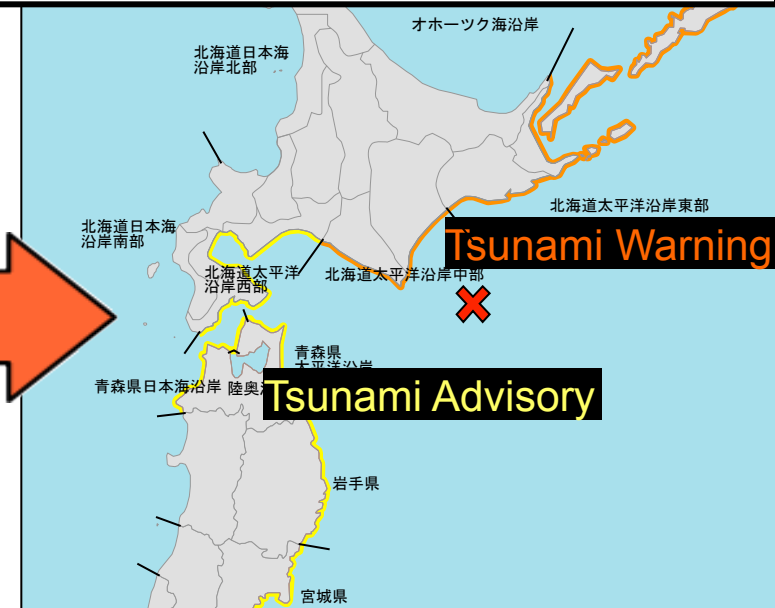
**Determined Magnitude
And Hypocenter**



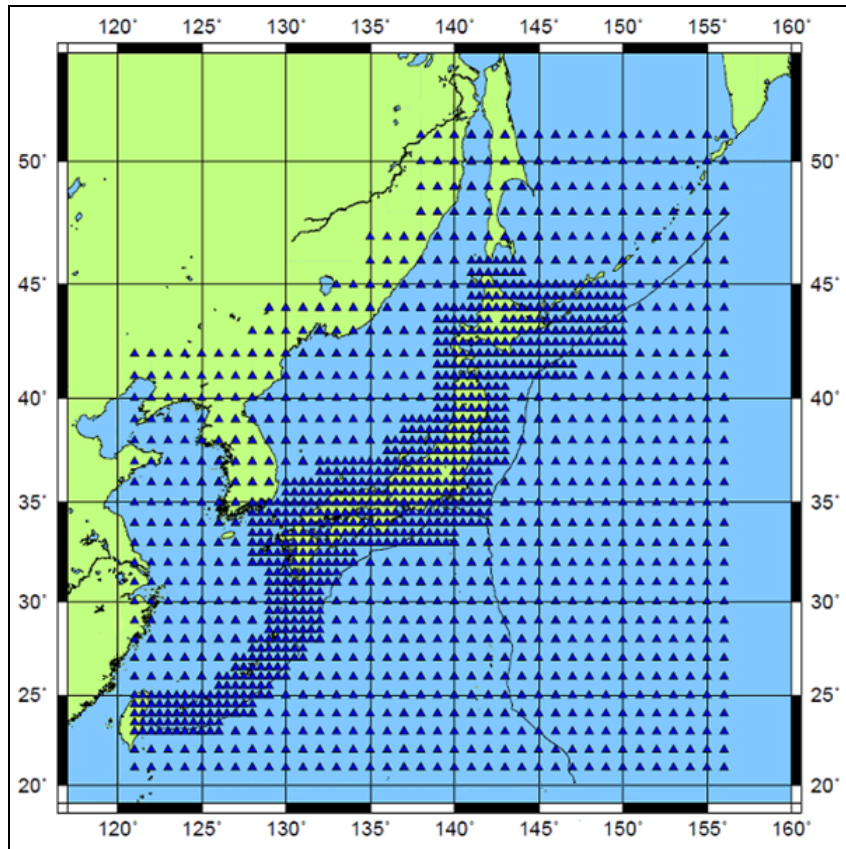
**Search tsunami database
and pick up the most
appropriate scenario
from database**



Issuance of tsunami warning



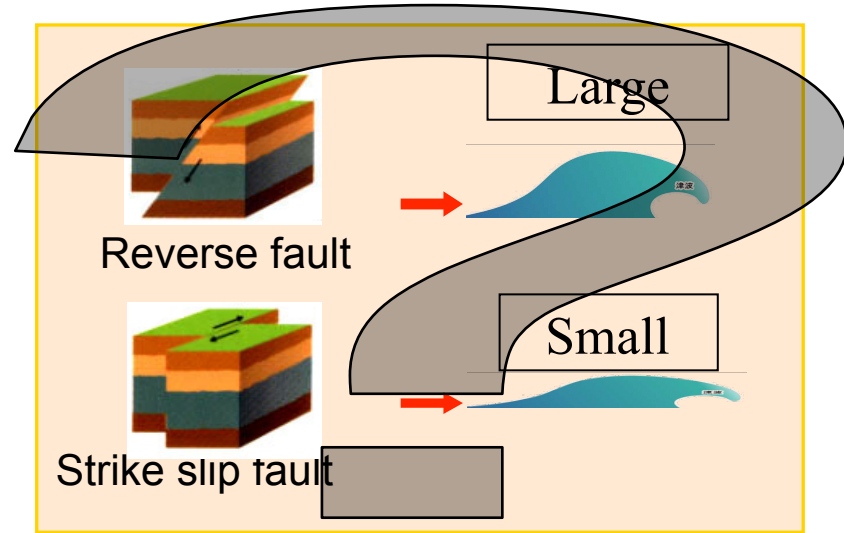
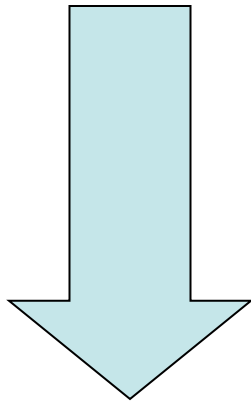
Tsunami simulation database (3) Assumed faults



Local tsunami simulation database

- More than 100,000 cases
- 0.5deg interval (around Japan)
1.0deg interval (other areas)
- 4 cases of magnitude (M8.0, M7.4, M6.8, M6.2)
- 6 cases of depth
(0km, 20km, 40km, 60km, 80km, 100km)

The hypocenter and magnitude are determined first.



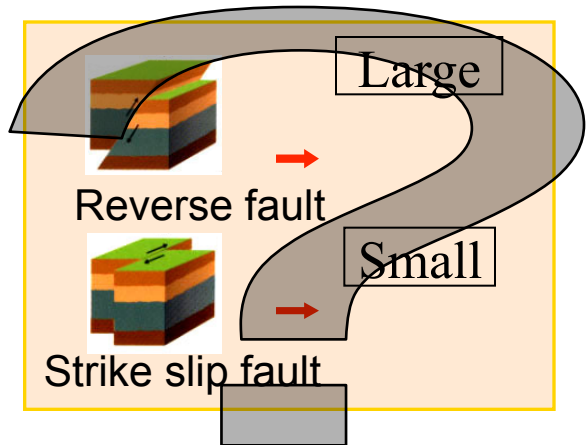
The first warning is **based only on the **hypocenter and magnitude**.**

The worst case scenario is adopted.

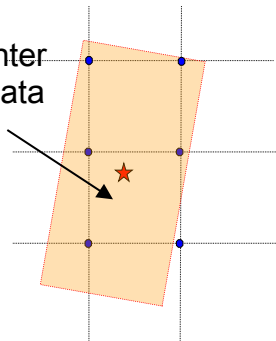
Uncertainties in the initial stage (2)

For the disaster prevention use, worst case scenarios are assumed.

Uncertainties

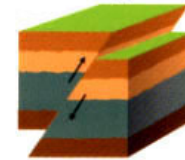


An obtained hypocenter
from seismological data
analysis



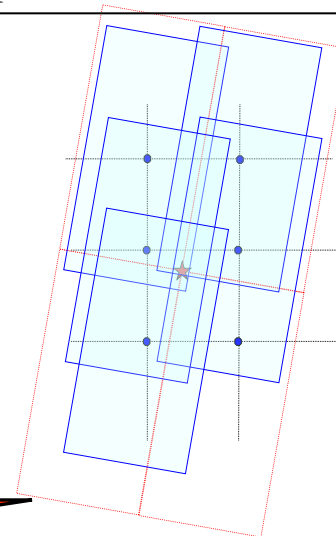
Worst Case

The most tsunamigenic case is assumed.



Reverse fault at an dip
angle of 45 deg.

All possible faults are picked up.



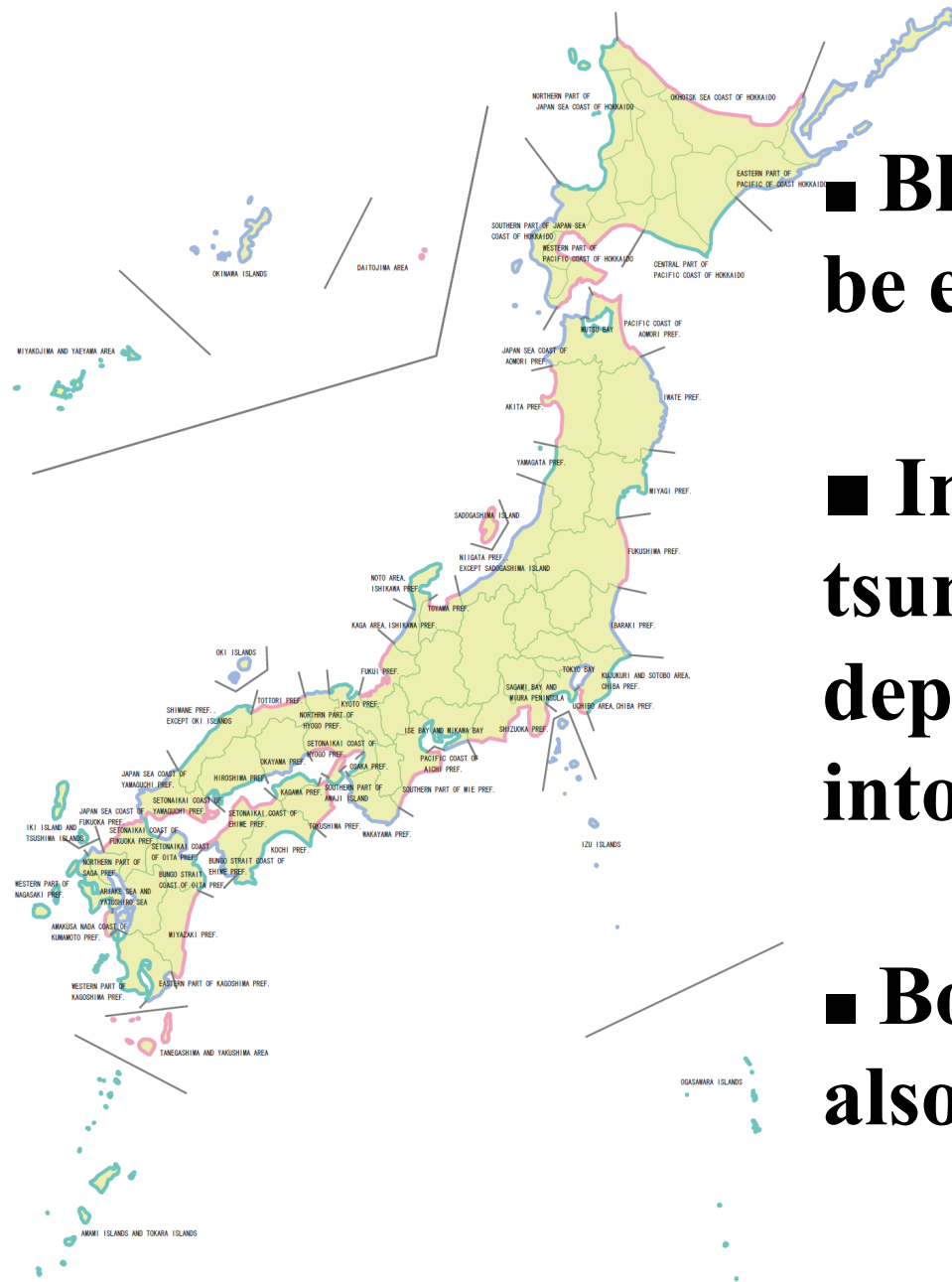
All faults containing
the location of a
hypocenter are
picked up.

Early tsunami warnings have to be overestimated for safety.

Pre-determined Items

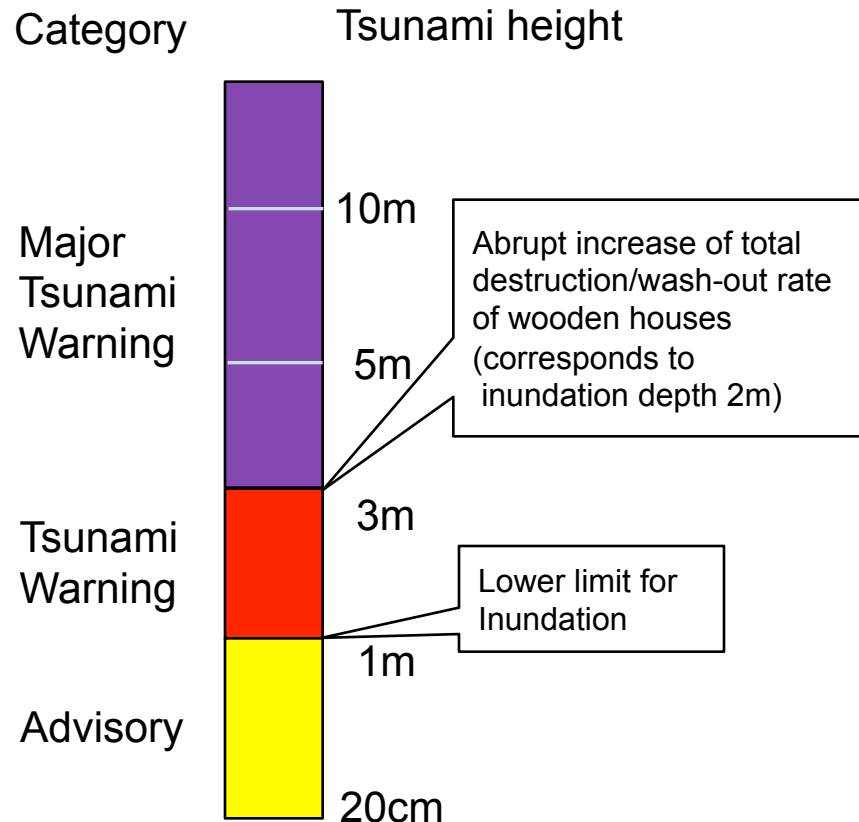
- **Tsunami warning coastal blocks**
- **Warning categories**
(Tsunami “warning” and “advisory”)
- **Contents of the warning text**
(categorized warning and quantitative forecast)

Tsunami warning coastal blocks



- Block names are defined to be easily recognized.
- In determining the blocks, tsunami height deference depending on areas is taken into account.
- Borders of prefectures are also taken into account.

Warning Categories



Levels of estimated Tsunami Height	Expression	
	In Number	Qualitative
$10\text{m} < \text{Amp.}$	Over 10m	Huge
$5\text{m} < \text{Amp.} \leq 10\text{m}$	10m	Huge
$3\text{m} < \text{Amp.} \leq 5\text{m}$	5m	Huge
$1\text{m} < \text{Amp.} \leq 3\text{m}$	3m	High
$20\text{cm} \leq \text{Amp.} \leq 1\text{m}$	1m	(---)

Contents of the warning text

Categories

Tsunami Warning
(Estimated Tsunami Arrival Time and Height)
Issued by the Japan Meteorological Agency (JMA)
Issued at 0457 26 SEP 2003 (JST)

"Major Tsunami"

Central Part of Pacific Coast of Hokkaido

0500 5m

"TSUNAMI"

Eastern Part of Pacific Coast of Hokkaido

0500 3m

"Tsunami Advisory"

Western Part of Pacific Coast of Hokkaido

0520 1m

Japan Sea Coast of Aomori Pref.

0550 1m

Pacific Coast of Aomori Pref.

0510 1m

Iwate Pref.

0510 1m

Miyagi

Fukush

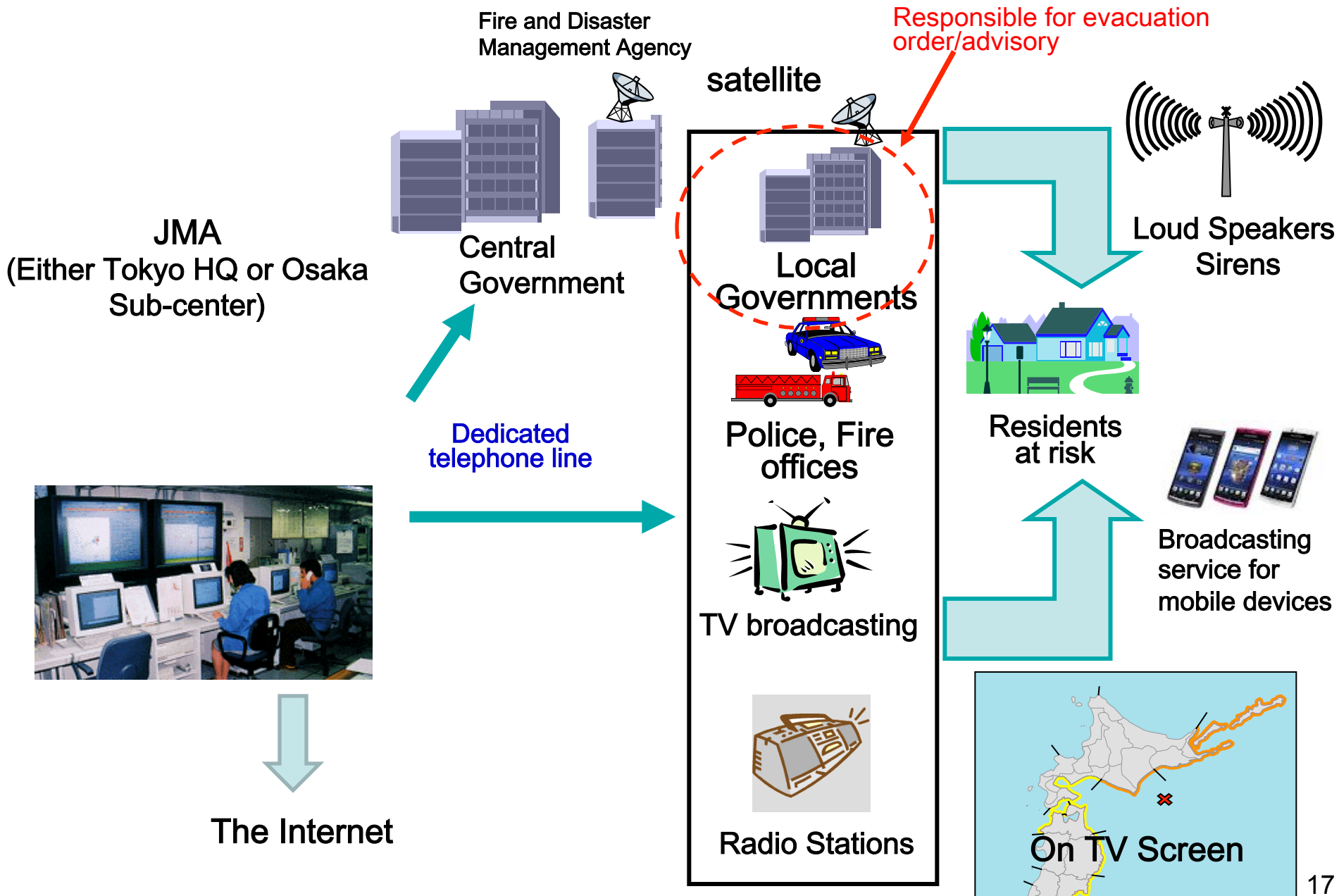
Estimated tsunami
arrival time and height

0530 1m

0600 1m







Coastal Blocks

Dissemination of Warning/Information



Tsunami Warning/Advisory categories and actions to be taken

Tsunami Warning/Advisory categories and action to be taken

	Estimated maximum tsunami height		Action to be taken	Expected damage
	Quantitative expression	For huge earthquakes		
Major Tsunami Warning	over 10 m (10m < height)	Huge	<p>Evacuate from coastal or river areas immediately to safer places such as high ground or a tsunami evacuation building.</p> <p>Tsunami waves are expected to hit repeatedly. Do not leave the evacuation location until Tsunami Warnings are cleared.</p> <p>Keep evacuating to higher and higher ground wherever possible!</p>  <p>Educational video "Escape the Tsunami" (JMA)</p>	<p>Wooden structures are expected to be completely destroyed and/or washed away; anybody exposed will be caught in tsunami currents.</p>  <p>(Most wooden structures washed away due to the tsunami in 2011)</p>
	10m (5m < height ≤ 10m)			
	5m (3m < height ≤ 5m)			
Tsunami Warning	3m (1m < height ≤ 3m)	High	 <p>Educational video "Escape the Tsunami" (JMA)</p>	<p>Tsunami waves will hit, causing damage to low-lying areas. Buildings will be flooded and anybody exposed will be caught in tsunami currents.</p>  <p>Toyokoro-cho (2003)</p>
Tsunami Advisory	1m (20cm ≤ height ≤ 1m)	(N/A)	<p>Get out of the water and leave coastal areas immediately. Do not engage in fishing or swimming activities until Advisories are cleared.</p> 	<p>Anybody exposed will be caught in a strong tsunami currents in the sea. Fish farming facilities will be washed away and small vessels may capsize.</p> 

- Tsunamis may hit before warnings are issued if the source region is near the coast. Be sure to evacuate when shaking occurs.
- Tsunami heights may exceed estimations due to coastal topography and other factors in some regions. Evacuate to higher ground.
- Tsunami Forecasts (Slight Sea Level Change) are issued if the estimated tsunami height is less than 20 cm and no damage is expected, or if slight sea level changes are expected after Tsunami Advisories are cleared.

The earthquake magnitude used in the first tsunami warning was underestimated, and underestimation of tsunami heights in initial information misled people.



e.g. Magnitude based on long period components of seismic waves

Countermeasure
(since March 7 2013)

If a risk of magnitude underestimation on the Mjma scale is recognized, the initial warning is based on the maximum magnitude assumable for the area and expected tsunami heights are expressed qualitatively to communicate the potential scale of the pending emergency.

Performance of JMA local tsunami warning/advisory

Tsunami warning/advisory issuance for local events and tsunami observations (2012-)

Date (JST)	Source	Event Time	Issuance Time	M used for tsunami forecast	Category	Observed maximum tsunami height
Mar.14, 2012	Off Sanriku	6:08pm	6:12pm	6.8	Advisory	21cm
Dec.7, 2012	Off Sanriku	5:18pm	5:22pm	7.3	Warning	98cm
Oct.26, 2013	Off Fukushima	2:10am	2:14am	6.8, 7.1	Advisory	36cm
Jul.12, 2014	Off Fukushima	4:22am	4:26am	6.8	Advisory	17cm
Feb.17, 2015	Off Sanriku	8:06am	8:09am	6.9	Advisory	27cm

- All warnings and advisories were issued within three to four minutes after the earthquake occurrence.
- In all cases, tsunamis were observed as predicted. During this period, there was no false alert.

Leave coastal areas immediately and evacuate to a safe place if strong shaking or weak but long-lasting slow shaking is felt.



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Thank you

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