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## TSUNAMI EARLY WARNING SYSTEM IN JAPAN

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### GENERAL INFORMATION

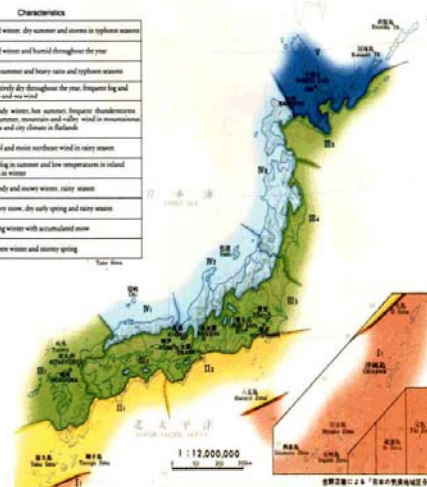
- Japan is an archipelago of 6,852 islands.
- Surrounded by the sea
- About 73 percent of Japan is forested, mountainous.
- habitable zones, mainly located in coastal areas are highly populated.
- Japan - one of the most populated countries in the world



## CLIMATE

- Clear-cut temperature changes between the four seasons
- The average winter temperature is 5.1 °C (41.2 °F)
- average summer temperature is 25.2 °C (77.4 °F).
- Rainey season begins in early May in Okinawa and gradually moves north until Hokkaido in late July.
- Late summer and early autumn - typhoons

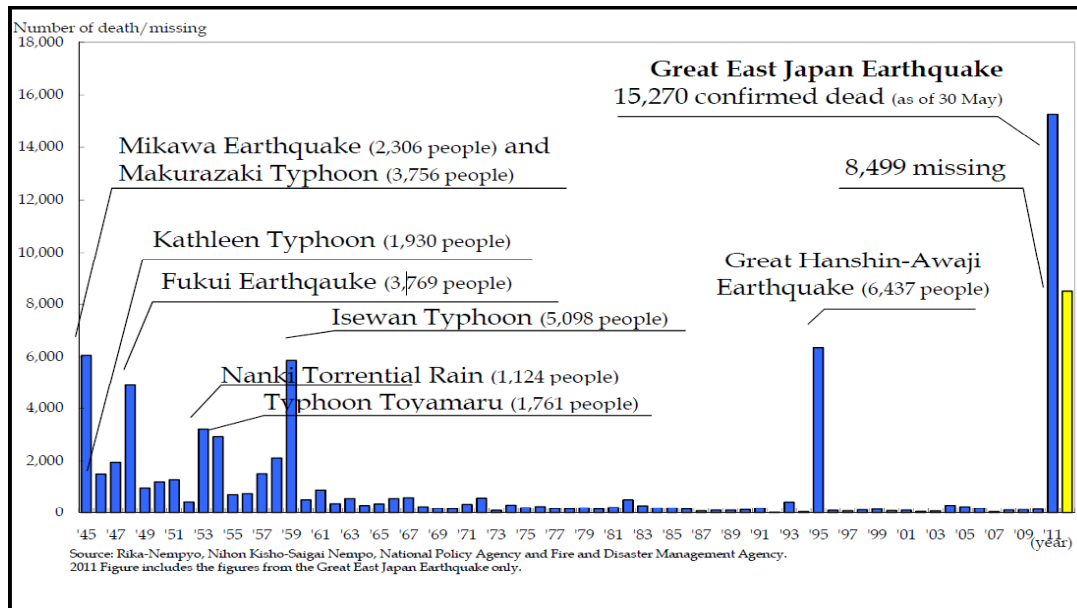
Climate Types	Characteristics
A, B, C	Mild winter, dry summer and storms in typhoon season
H <sub>1</sub> , H <sub>2</sub>	Mild winter and humid throughout the year
H <sub>3</sub>	Hot summer and heavy rain and typhoon season
H <sub>4</sub>	Relatively dry throughout the year, frequent fog and fog and sea mist
H <sub>5</sub>	Windy winter, hot summer, frequent thunderstorms in summer, moderate wind and fog, wind in mountainous area and city climate in Hokkaido
H <sub>6</sub>	Cool and moist northeast wind in rainy season
H <sub>7</sub>	Sea fog in summer and low temperature in inland area in winter
B <sub>1</sub>	Windy and snow winter, rainy season
B <sub>2</sub>	Heavy snow, dry early spring and rainy season
B <sub>3</sub>	Long winter with accumulated snow
V	Severe winter and sunny spring



## NATURAL HAZARDS IN JAPAN

- Geographical and climatologically vulnerable to disasters such as
  - Typhoon
  - Torrential Rain
  - Heavy Snow
  - Earthquake
  - Tsunami
  - Volcanic Eruptions
- Located in circum pacific (Ring of fire)
- Have the highest natural disaster risk in the developed world

# NATURAL HAZARDS IN JAPAN



# EARTHQUAKES AROUND JAPAN

- Earthquakes occur because of plate movement
- Japan is situated in a subduction zone
- Pacific plate and Philippine plate subduct (North American plate and Eurasian plate) several centimeters annually.
- These movement cause forces to act in various directions
- Extremely high seismic activity
- 1300 – 2000 earthquakes are felt per annum

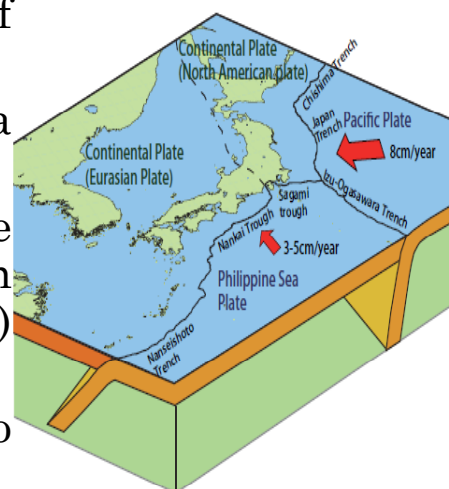
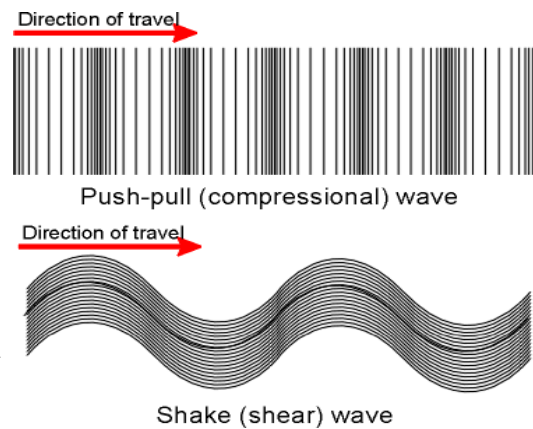


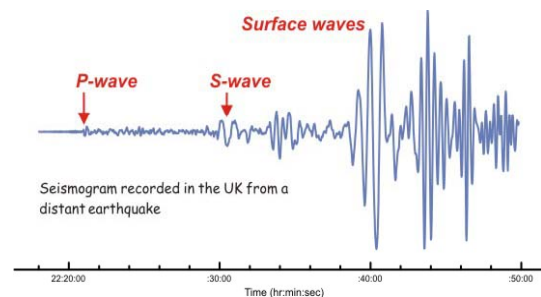
Plate Tectonics around Japan

## MEASURING EARTHQUAKE

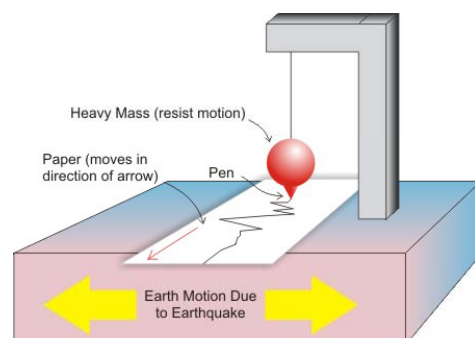
- Two types of waves are emitted by an earthquake
- P-Wave : first wave to arrive
  - Causes very little or no destruction
- S-Wave : travels slower than P-wave
  - Causes most damage such as the destruction of buildings and landslides



- efficient earthquake warning system – quickly detect the P-waves and issue a warning before the arrival of these s-waves



- A seismograph or seismometer is the measuring instrument that creates the seismogram.
- A seismogram is a record of the seismic waves from an earthquake.



## SEISMIC INTENSITY AND MAGNITUDE

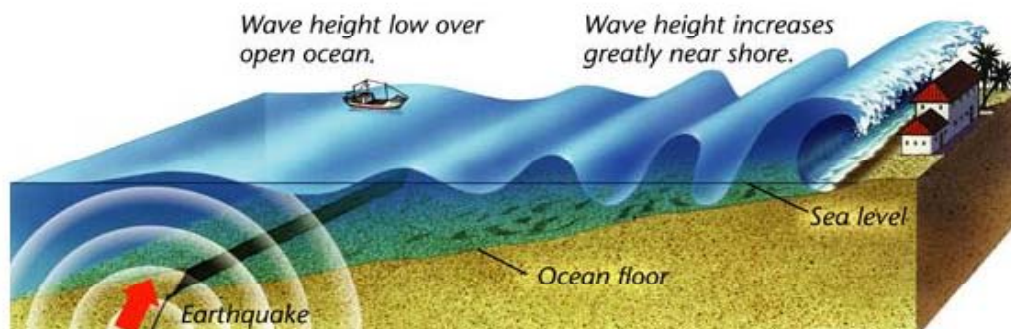
- Seismic intensity describes the scale of the ground motion at a particular location.
- Varies with the distance from the epicenter
- Magnitude is a numerical value that represents the scale of a fault slip underground
- Large earthquakes have high magnitude



## TSUNAMI

- Series of very long waves generated by rapid, large-scale disturbances of the sea
- Displacement of a large volume of water, generally from the raising or lowering of the seafloor caused by:
  - earthquakes
  - landslide
  - volcanic eruptions
  - explosions
  - meteorites

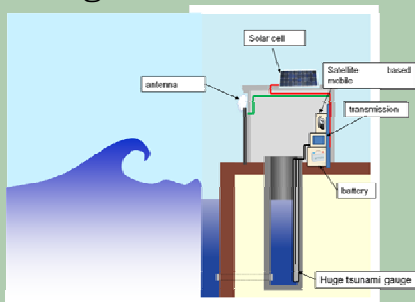
- Once a tsunami has been generated, its energy is distributed throughout the water column.
- waves travel outward on the surface of the ocean in all directions away from the source.
- The deeper the water, the greater the speed of tsunami waves is.
- But can pass under a ship in the ocean with those aboard the vessel hardly noticing
- As it reaches the shore it slows down the speed but increase the high



- The wave length and their period depend on the generating source and the dimension.
- Tsunamis arrive at a coastline as a series of successive crest and troughs.
- Tsunami wave smash into shore like a wall of water or move ashore as a fast moving flood or tide.
- Destroying everything in its path
- Tsunamis struck with devastating force and reach a high of 30 -50 meters.
- Tsunami run-up of more than 1 meter is dangerous due to the strong force
- Greater tsunamis move inland with debris and sometimes with massive fire
- Coasts and islands with steep fringes or surrounded by barrier reefs are safer than those with gradually rising fringes or those that are exposed to open ocean

# MEASURING TSUNAMI

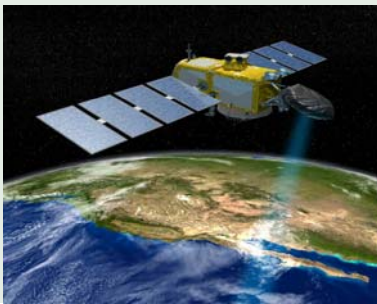
## Tide Gauge



## Open ocean buoy



## Satellite



## Costal Tsunami monitoring system



# INDIAN OCEAN TSUNAMI

- Earthquake of m 9.0 to the western coast of northern Sumatra
- Mega thrust – India plate and Burm tectonic plates
- Vertical displacement of the sea-floo generated the devastating tsunami
- 11 nations - complete surprise for the people living on the area – no early warning received
- Over 226,000 people are known to have lost their lives
- More than 1.5 million people were left homeless around the region





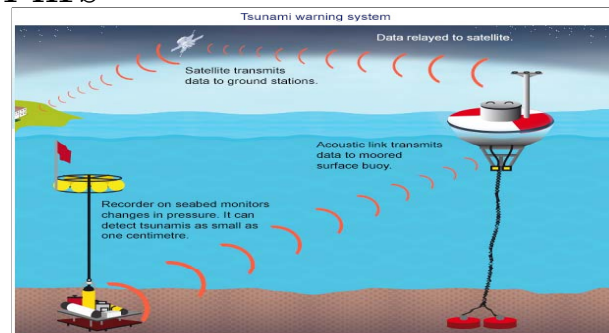
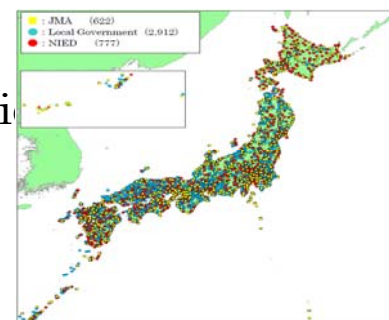
# GREAT EAST JAPAN EARTHQUAKE AND TSUNAMI

- Earthquake of m 9.0 to hypocenter at an underwater depth of approximately 30 km
- Pacific plate dive beneath the Eurasian plate releasing built up stress
- The countries stringent seismic building code and early warning prevented it from the worst case
- Powerful tsunami wave of 40.5 meters
- More than 18000 people died of the tsunami – drowning
- Tsunami caused level 7 meltdown of Fukushima Daiichi Nuclear power plant



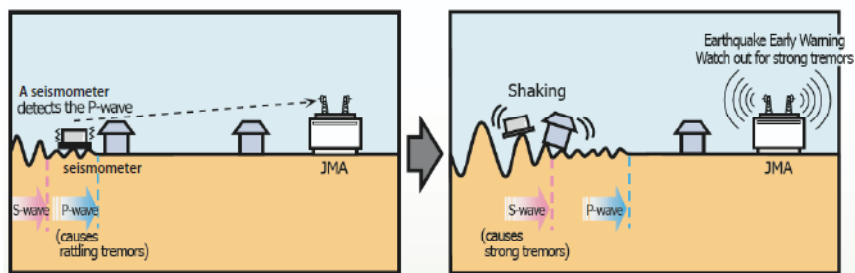
## DATA COLLECTION SYSTEM

- 180 seismographs and 600 seismic intensity meters for earthquake detection
- 110 sea level gauges
- Tsunami detection buoys
- Natural phenomena and weather conditions are monitored 24 hrs



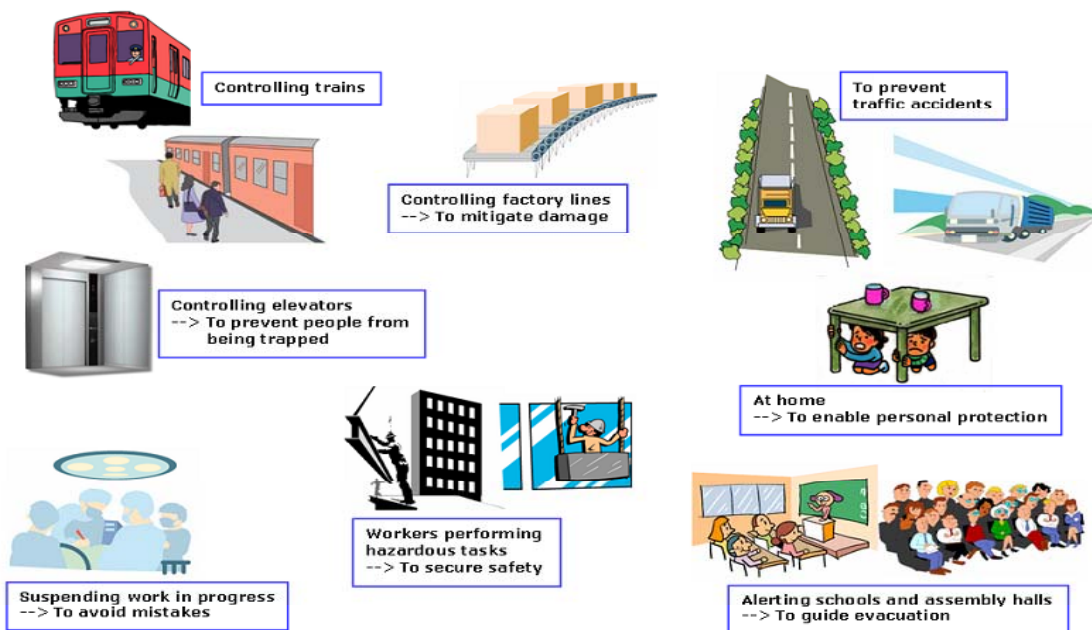
# EARTHQUAKE INFORMATION ISSUED BY JMA

- EEW are issued after an earthquake occurs
- There are no earthquake prediction technology
- Provides first announcement by detecting P-Waves
- Technology that forecasts from very weak shaking and communication technology for prompt dissemination are the key elements



Title	Content and Timing to be issued
<b>Seismic Intensity Information</b>	This information is issued within about two minutes from an earthquake to provide information on the regions where seismic intensity of 3 or more was observed. Each prefecture is divided into 2 or more regions.
<b>Earthquake Information</b>	The location and magnitude of an earthquake is determined within about three minutes. In case of no tsunamigenic earthquake, the message of "Tsunami is not expected" is added.
<b>Earthquake and Seismic Intensity Information</b>	This information indicates the location of the hypocenter, magnitude, and name of regions, cities, towns and villages in which intensity of 3 or more was observed.
<b>Information on seismic intensity at each site</b>	All stations which observed intensity of 1 or more, hypocenter location and magnitude of the earthquake are provided.
<b>Shake Map</b>	Just after an earthquake, the shaking-intensity map is prepared. This map is produced taking into account local geological conditions and observed seismic intensity
<b>Information on the number of earthquakes</b>	When earthquakes occur frequently in a same place called earthquake swarm, hourly/daily number of earthquakes is provided.

# RESPONSE TO A EARTHQUAKE EARLY WARNING SYSTEM



## LIMITATIONS TO EEW

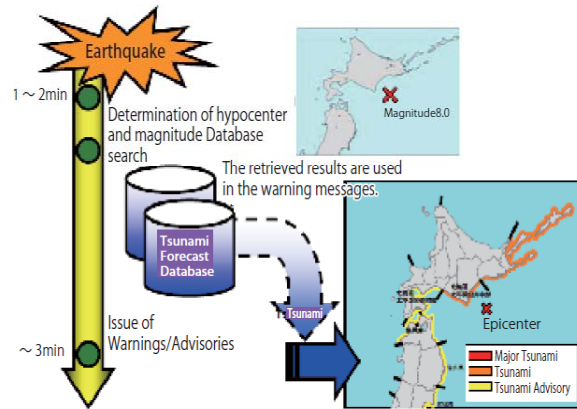
- Timing
- False alarm
- Magnitude estimation
- Seismic intensity estimation
  
- JMA continue improving the accuracy and timing of the EEW through joint research with the NIED

# TSUNAMI INFORMATION ISSUED BY JMA

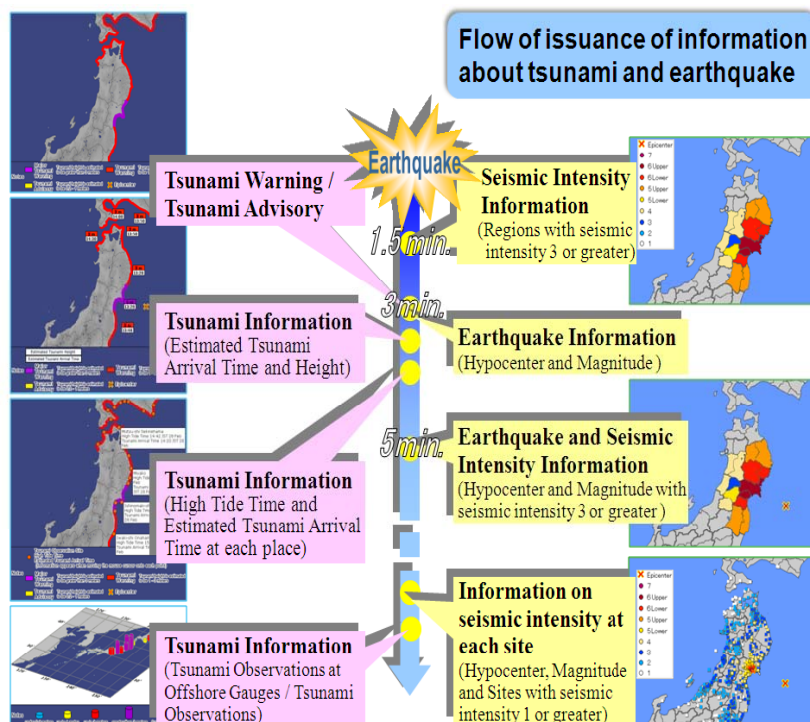
- Computer simulations of tsunamis with various magnitude and location are stored in a database

- When a large earthquake occurs the system calculates its hypocenter and magnitude searches the database, selects the closest matching result







- JMA Issues the warning or advisory



# FLOW OF INFORMATION ABOUT EARTHQUAKE AND TSUNAMI



# TSUNAMI WARNING AND ADVISORIES

	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>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>Get out of the water and leave coastal areas immediately. Do not engage in fishing or swimming activities until Advisories are cleared.</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> 

# TSUNAMI INFORMATION

Messages about tsunami	Indication
<b>Tsunami Information</b> (Estimated Tsunami Arrival Time and Height)	Estimated arrival times and heights of the tsunami for relevant tsunami forecast regions. * The estimated tsunami arrival time for each tsunami forecast region is the time at which it is expected to hit first in any part of that area. Hence, in some coastal regions, tsunamis may hit after the estimated time.
<b>Tsunami Information</b> (High Tide Time and Estimated Tsunami Arrival Time at each place)	The high tide times and estimated arrival times of the tsunami at selected points.
<b>Tsunami Information (*1)</b> (Tsunami Observations)	Arrival times and heights of the tsunami observed at tide gauges or tsunami meters.
<b>Tsunami Information (*2)</b> (Tsunami Observations at Offshore Gauges)	Tsunami arrival times and heights observed at offshore gauges, and related tsunami heights along the coast in the corresponding forecast region estimated from offshore observations.

\*1 Issuance of information based on tsunami observation

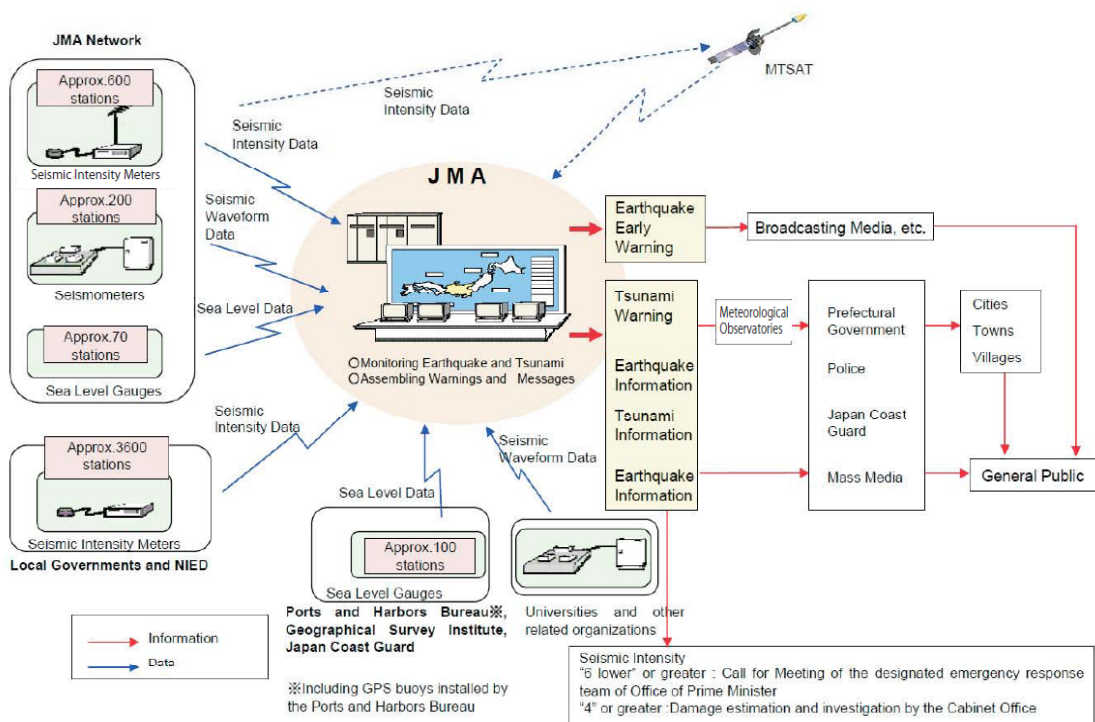
\*2 Issuance of information based on Tsunami Observation at off shore gauge

# TSUNAMI FORECAST

- After an earthquake occurs, if no damage is expected, JMA issues Tsunami Forecasts.

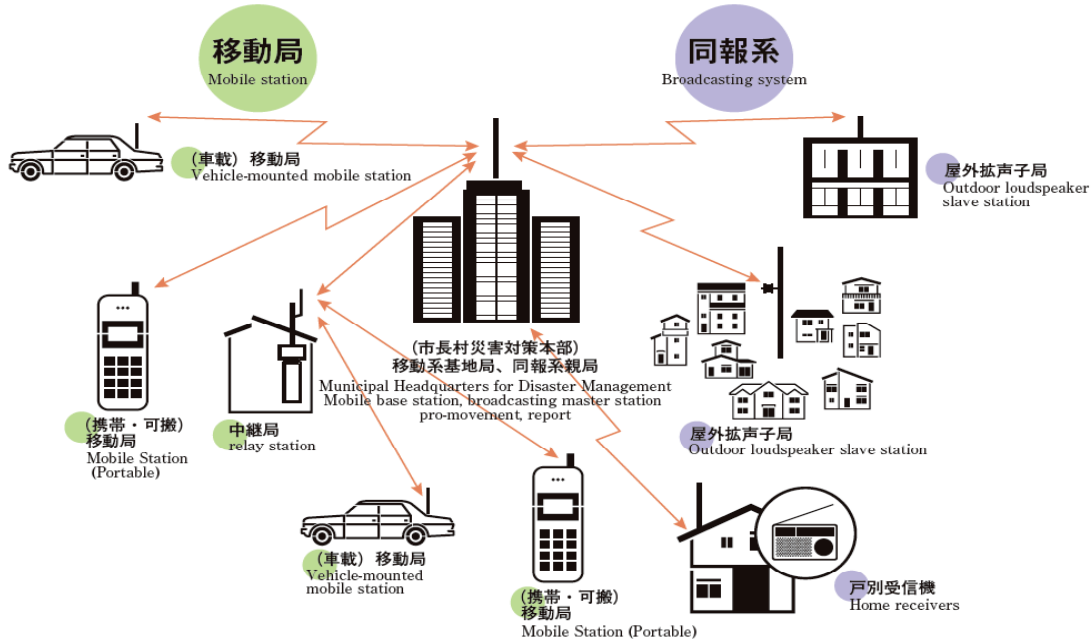
Forecasted sea level changes	Message
No tsunami is expected	"No tsunami is expected." (To be included in Earthquake Information.)
Tsunami height less than 0.2 meters is expected	No damage is expected because sea level changes will be less than 0.2 m, and no special action is needed.
Slight sea level changes are expected to continue after Tsunami Warnings/advisories are cleared	Particular attention is needed when fishing, swimming or engaging in other marine activities because tsunami-related sea level changes have been observed and may continue for a while.

# DATA AND INFORMATION SHARING SYSTEM



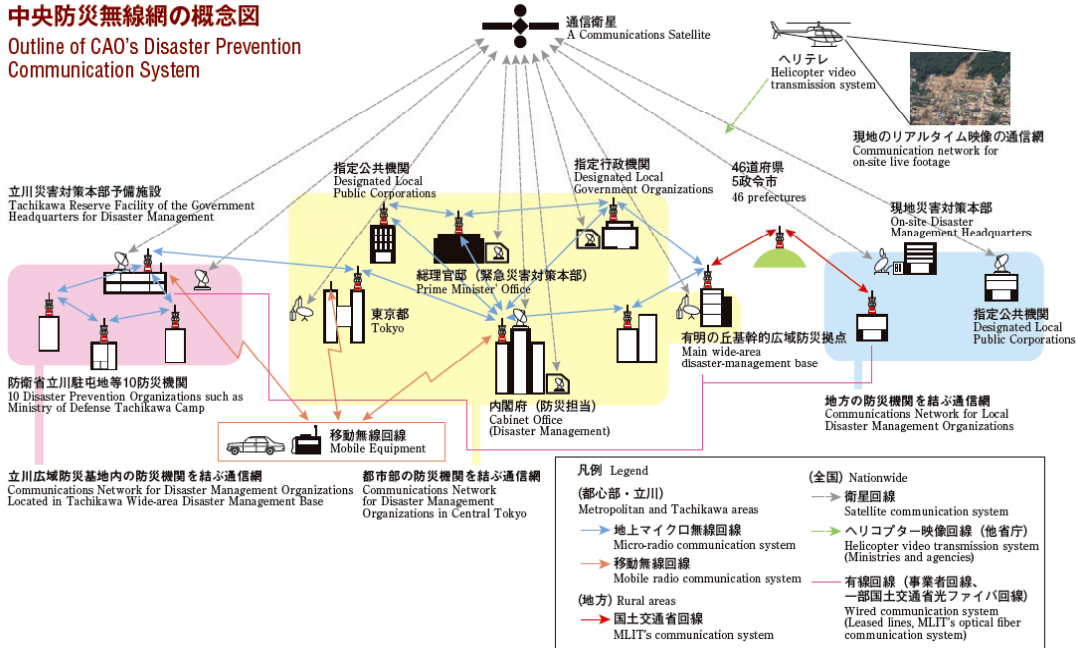
# EARLY WARNING SYSTEM

## 早期警戒体制の概念図 Outline of Early Warning Systems

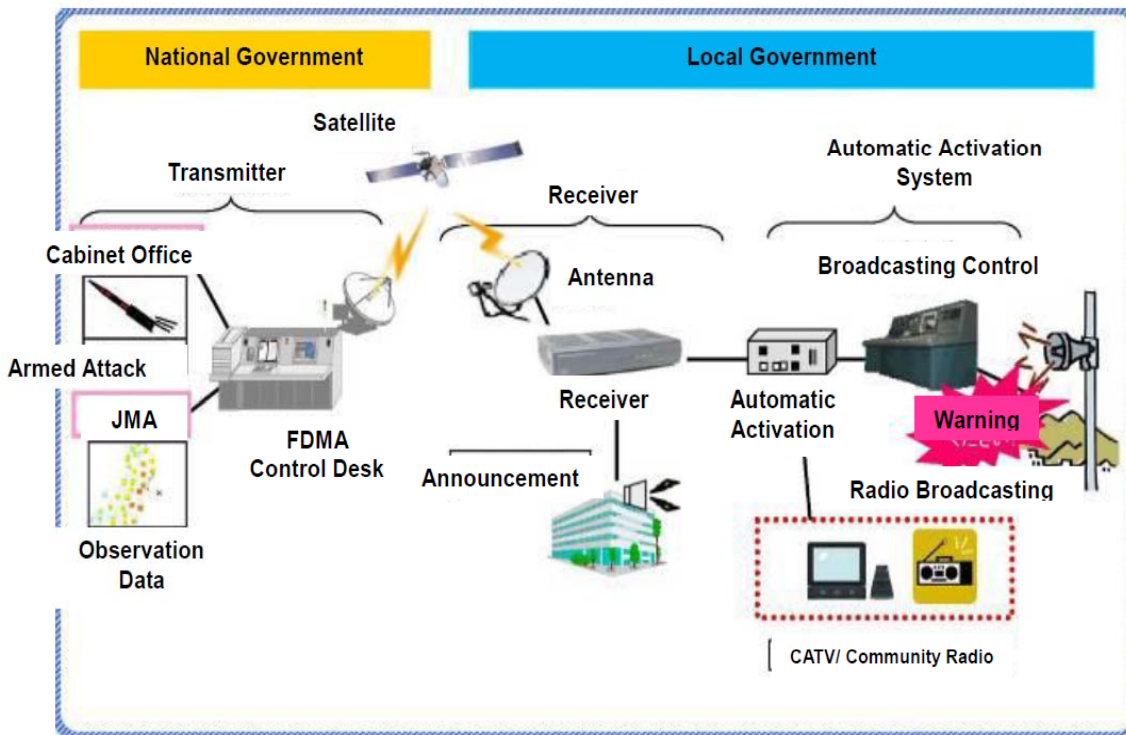


# CENTRAL DISASTER PREVENTION RADIO NETWORK

## 中央防災無線網の概念図 Outline of CAO's Disaster Prevention Communication System

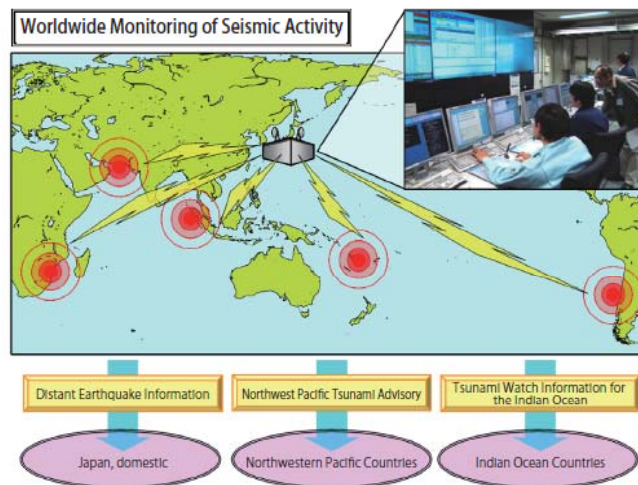


# J-ALERT SYSTEM



## DISTANCE EARTHQUAKE INFORMATION AND INTERNATIONAL TSUNAMI ADVISORIES

- JMA monitors seismic activity around the world
- When a large earthquake occurs near Japan, pacific region or Indian ocean, JMA provides international tsunami advisories to the countries
- Used for tsunami warning and evacuation orders.





## RECOMMENDATIONS WHEN DEVELOPING AN EARLY WARNING SYSTEM

- **Link with community-based activities**
- **Start with low-cost systems**
- **Conduct Communication drills**
- **Understand the limitations of technology**
- **Guidelines for quick decision making**
- **Understand communities' coping mechanisms**
- **Establish uninterrupted systems**
- **Ensure services are available 24/7**



THANK YOU

