



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

## **Tsunami Warning and Mitigation: Japan Experience**

# **JMA's Tsunami Warning Operations**



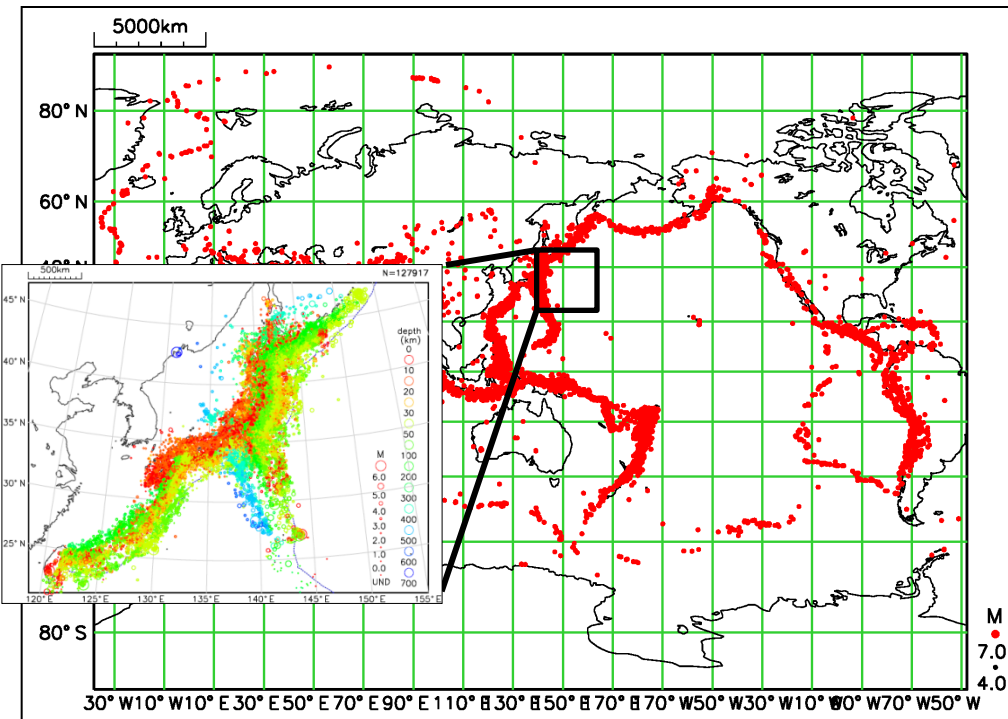
**Yasuo SEKITA**

**Director General, Seismology and Volcanology Department  
Japan Meteorological Agency (JMA)**

# Earthquakes and Tsunamis around Japan

## Disastrous tsunamis in Japan (1896 --)

|      |                                |         |
|------|--------------------------------|---------|
| 1896 | Meiji-Sanriku Earthquake       | Local   |
| 1923 | Great Kanto Earthquake         | Local   |
| 1933 | Showa-Sanriku Earthquake       | Local   |
| 1944 | Tonankai Earthquake            | Local   |
| 1946 | Nankai Earthquake              | Local   |
| 1960 | Great Chile Earthquake         | Distant |
| 1983 | Nihonkai Chubu Earthquake      | Local   |
| 1993 | Hokkaido Nansei-oki Earthquake | Local   |
| 2011 | Great East Japan Earthquake    | Local   |



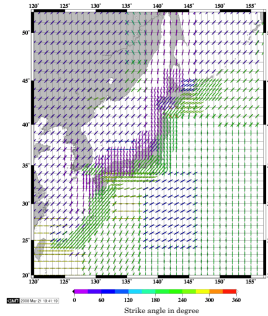
Hypocenter determined by JMA in 2010:  
about 128,000 (approx.350/day)

# JMA's tsunami warning history

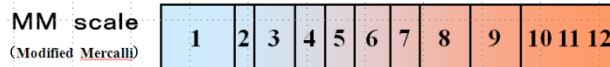
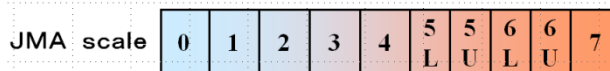
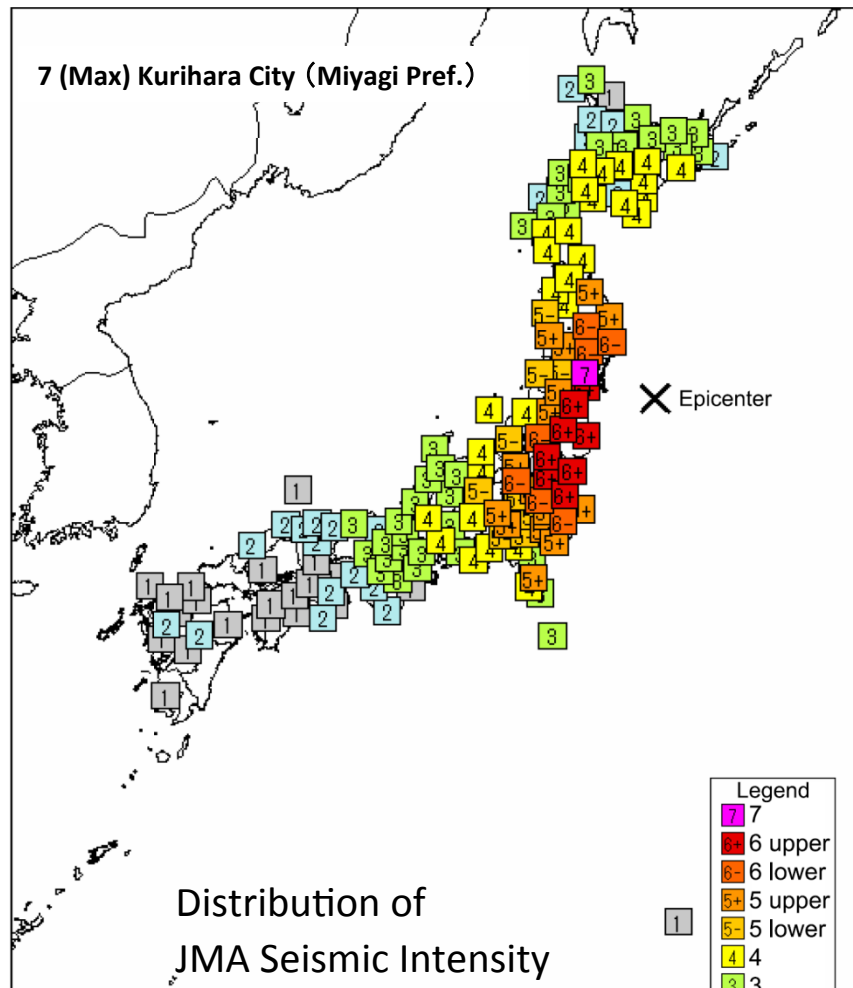
| Year | Events  | International Events                   |
|------|---|--|
| 1941 | Sendai local observatory started a local tsunami warning service.                               |  |
| 1949 | JMA started a nationwide tsunami warning service.   |  |
| 1960 |   | The Great Chilean Earthquake occurred. |
| 1962 | JMA established a procedure for the issuance of domestic tsunami warnings for distant tsunamis. |  |
| 1965 |   | ICG/ITSU was established.              |
| 1999 | A quantitative tsunami prediction system was introduced.  |  |
| 2005 | JMA established NWPTAC (the Northwest Pacific Tsunami Advisory Center).                         | ICG/ITSU was renamed ICG/PTWS          |
| 2011 | The Great East Japan Earthquake occurred.   |  |



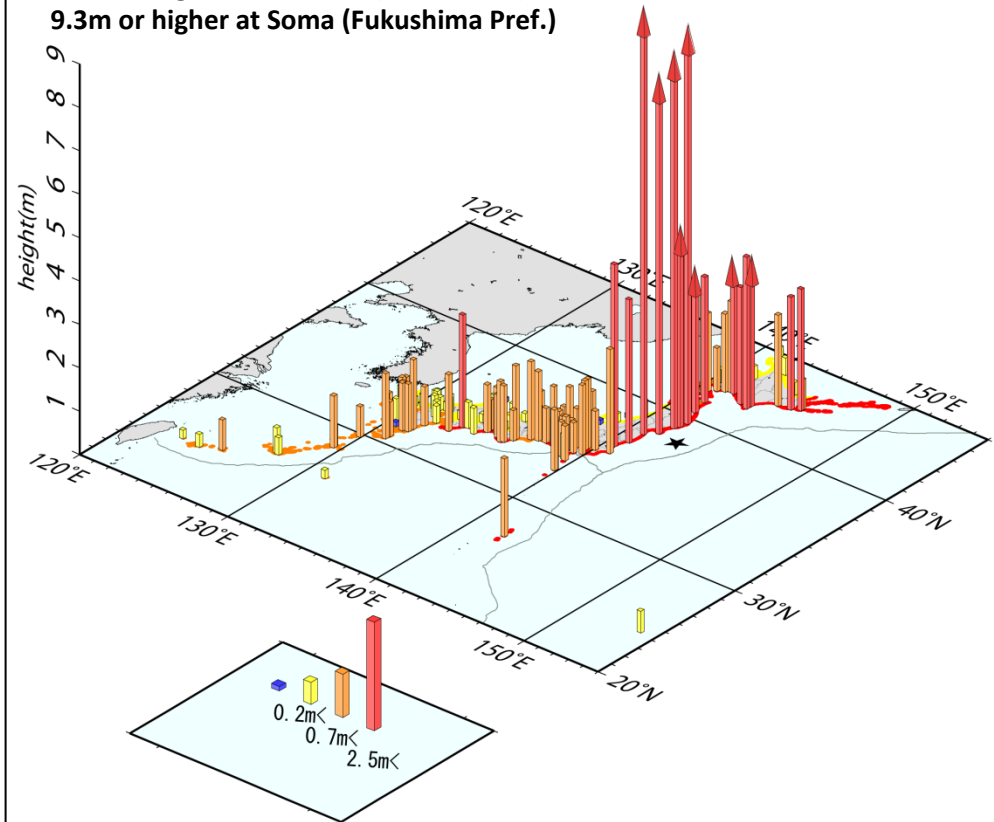
Chilean tsunami hit Japan (courtesy of Onagawa Education Board)



# Tsunami Warnings on March 11, 2011 and the improvements after the tsunami



8.5m or higher at Miyako (Iwate Pref.)  
8.0m or higher at Ofunato (Iwate Pref.)  
9.3m or higher at Soma (Fukushima Pref.)



Observed Tsunami  
(height)

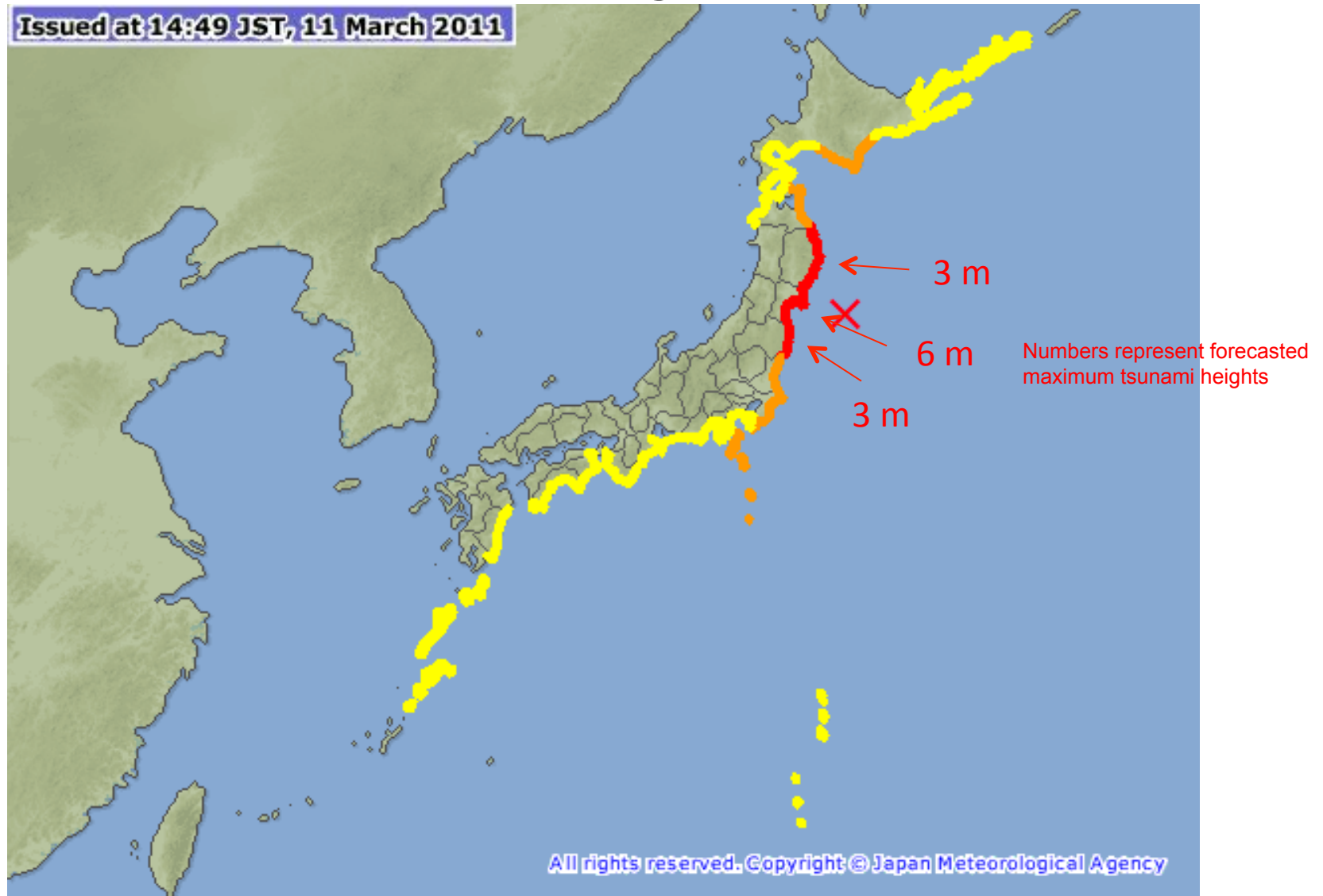
Date and Time: 11 March 2011 14:46 JST (05:46 UTC)





Magnitude: 9.0 (the largest earthquake recorded in Japan)

Hypocenter: N38.1, E142.9 Depth 24km  
(130km ESE off Ojika Peninsula)

# Tsunami Warnings/Advisories

Issued at 14:49 JST, 11 March 2011

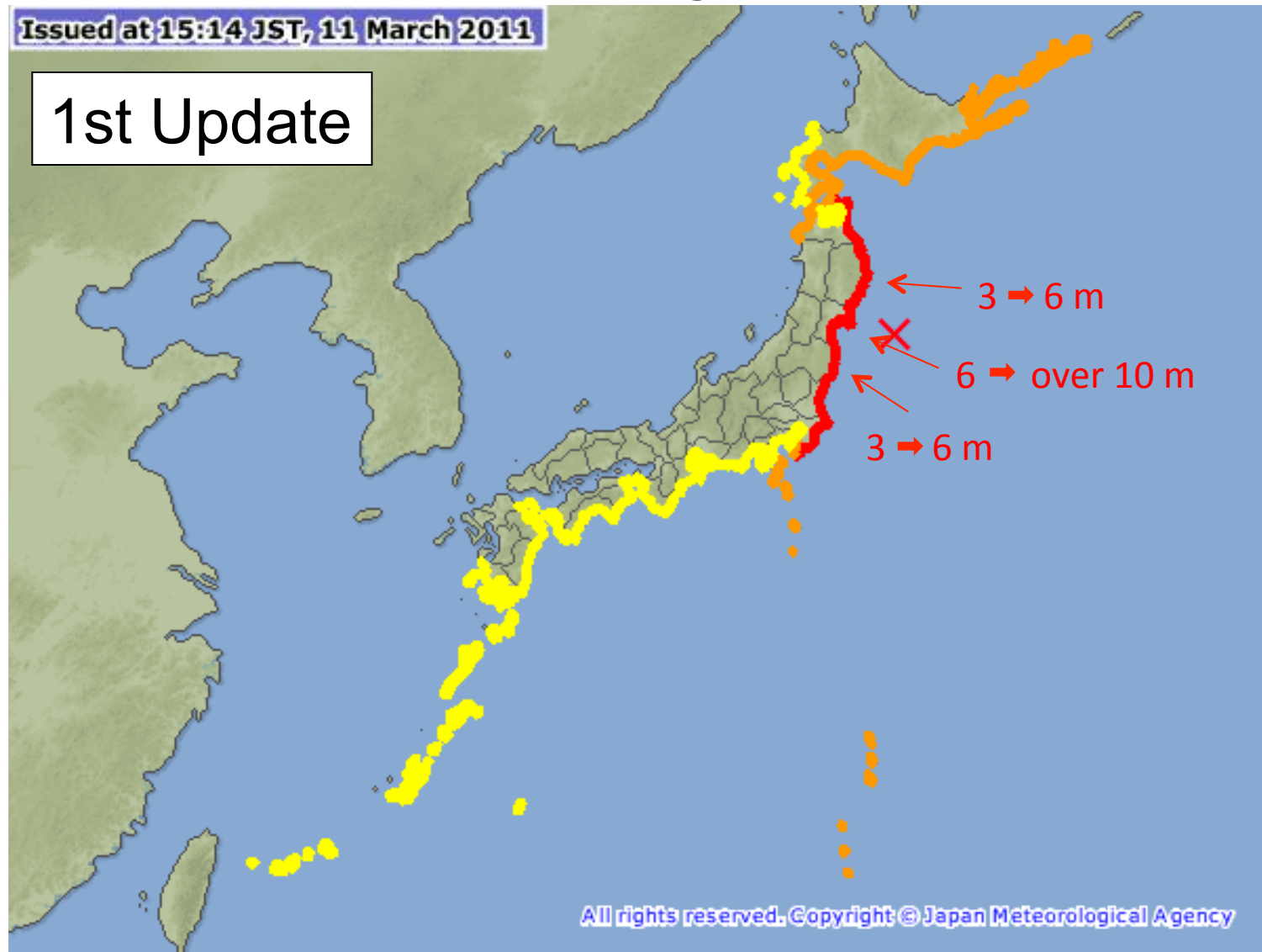


| Tsunami Warning |   | Tsunami Advisory                                   |   |
|-----------------|---|--|---|
| Notes           |  Major Tsunami | Tsunami height is estimated to be 3 meters or more |  Tsunami height is estimated to be about 0.5 meter |
|                 |  Tsunami       | Tsunami height is estimated to be up to 2 meters   |  Epicenter   |
|                 |   |  |   |





# Tsunami Warnings/Advisories

Issued at 15:14 JST, 11 March 2011

1st Update



All rights reserved. Copyright © Japan Meteorological Agency

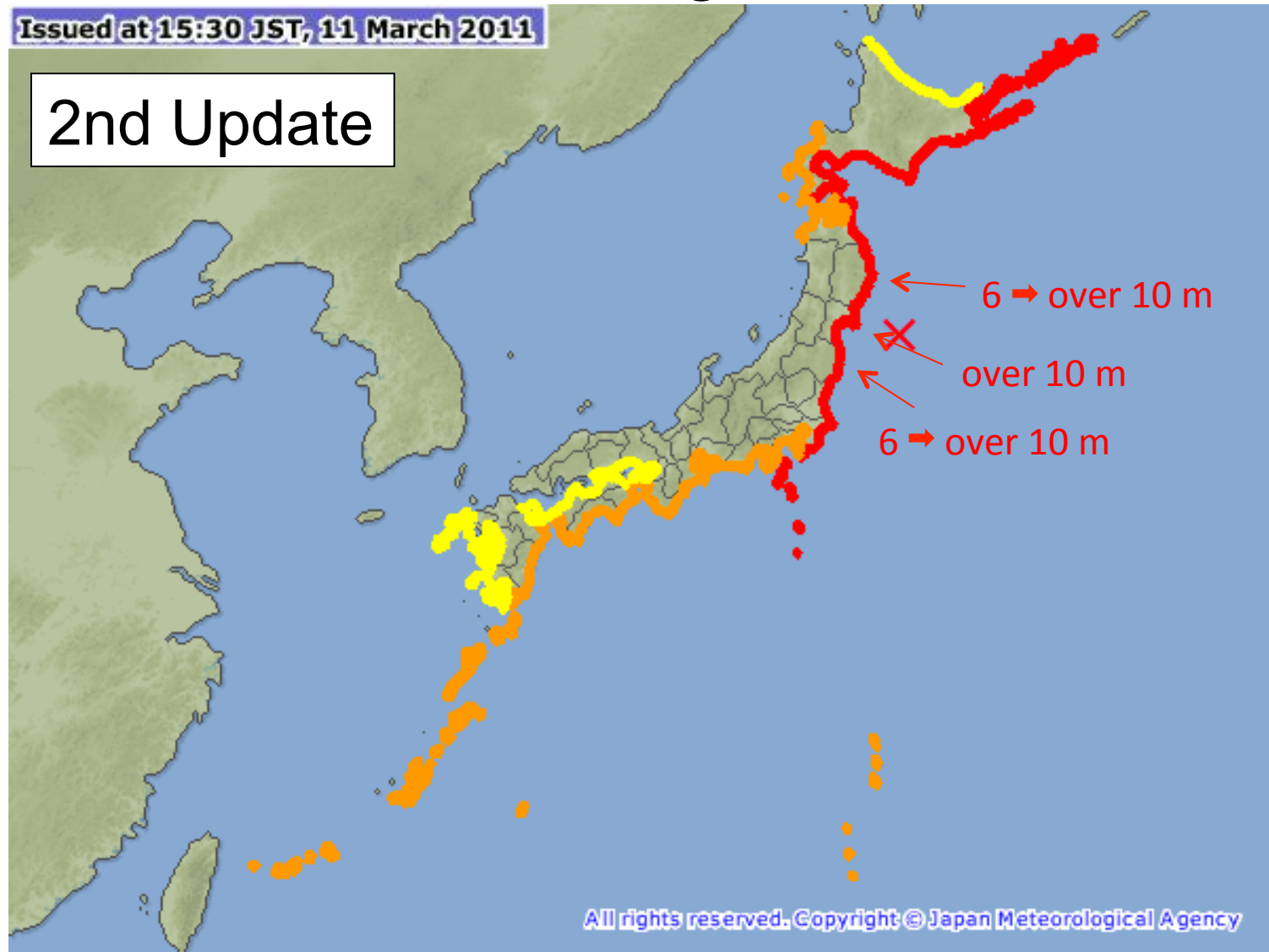
| Tsunami Warning |   | Tsunami Advisory                                   |   |
|-----------------|---|--|---|
| Notes           |  Major Tsunami | Tsunami height is estimated to be 3 meters or more |  Tsunami height is estimated to be about 0.5 meter |
|                 |  Tsunami       | Tsunami height is estimated to be up to 2 meters   |  Epicenter   |
|                 |   |  |   |







# Tsunami Warnings/Advisories

Issued at 15:30 JST, 11 March 2011

2nd Update



| Tsunami Warning |   | Tsunami Advisory                                   |   |
|-----------------|---|--|---|
| Notes           |  Major Tsunami | Tsunami height is estimated to be 3 meters or more |  Tsunami height is estimated to be about 0.5 meter |
|                 |  Tsunami       | Tsunami height is estimated to be up to 2 meters   |  Epicenter   |
|                 |   |  |   |

**This was the optimal response  
possible with the system used at the time  
in terms of science and technology**

**However, death and missing reached 20,000**

**Based on lessons learned from the disaster,  
JMA improved its tsunami warning operations**








# Improvements in tsunami warning operations

## Broadband Strong Motion Meter

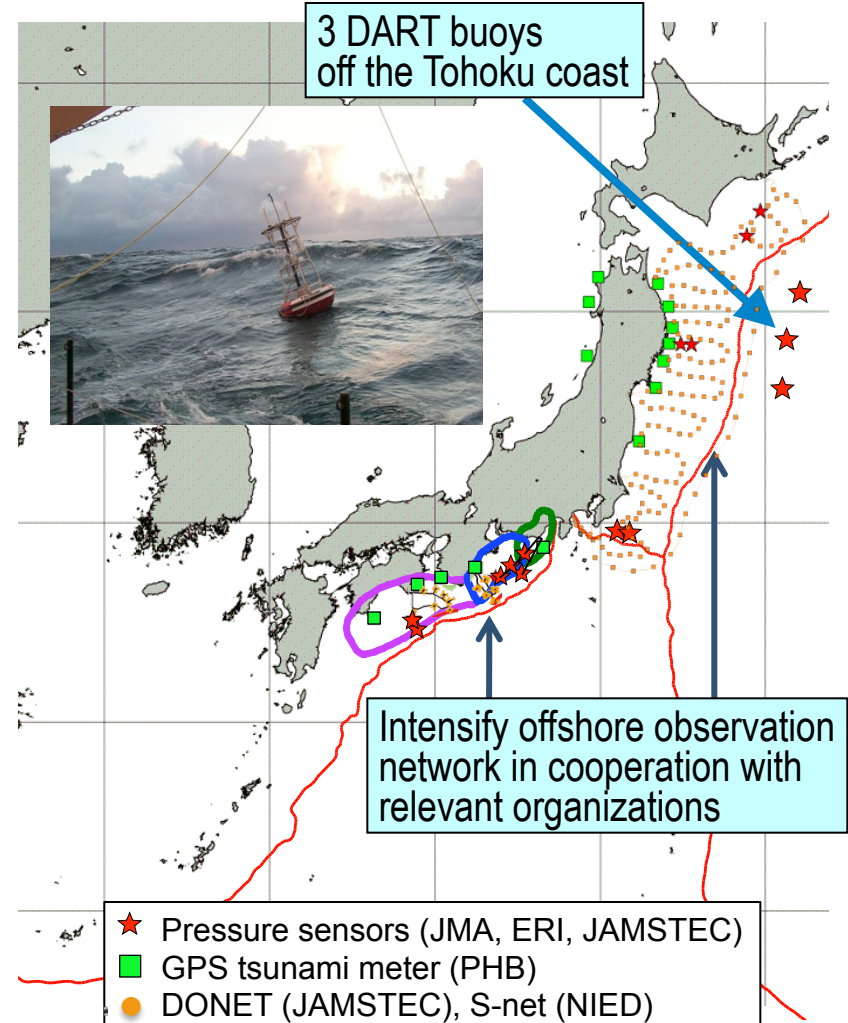


Observe very long-period seismic wave by broadband strong motion data (80 sites)

## Qualitative expression

|                       | Estimated maximum tsunami height |                      | Action to be taken   | Expected damage   |
|-----------------------|----------------------------------|----------------------|--|---|
|                       | Quantitative expression          | For huge earthquakes |  |   |
| Major Tsunami Warning | over 10 m<br>(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<br>(5m < height ≤ 10m)       |                      |  |   |
|                       | 5m<br>(3m < height ≤ 5m)         |                      |  |   |
| Tsunami Warning       | 3m<br>(1m < height ≤ 3m)         | High                 | <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>Toyokorocho (2003)</p>  |   |
| Tsunami Advisory      | 1m<br>(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>    |

## Offshore Tsunami Meter



# **Lessons learned in relation to tsunami warning services from the 2011 Great East Japan Earthquake and measures taken**

## **Issues from which lessons were learned**

- 1. The earthquake magnitude used in the first tsunami warning was underestimated.**



**Underestimation of tsunami heights in initial information misled people.**

- 2. Low values for observed tsunami heights also misled people.**

## **Measures taken (since March 7 2013)**

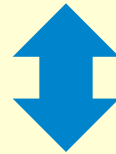
- 1. If a risk of magnitude underestimation on the  $M_{jma}$  scale is recognized, the initial warning is based on the maximum magnitude assumable for the area and expected tsunami heights are expressed qualitatively to communicate the potential scale of the pending emergency.**
- 2. Observed tsunami heights are NOT reported numerically when the amplitude is small so that residents do not underestimate the potential threat.**

**Education and public awareness are very important for more effective disaster mitigation**

# Advantage of JMA's operations

- positive side of Tsunami Warnings on March 11

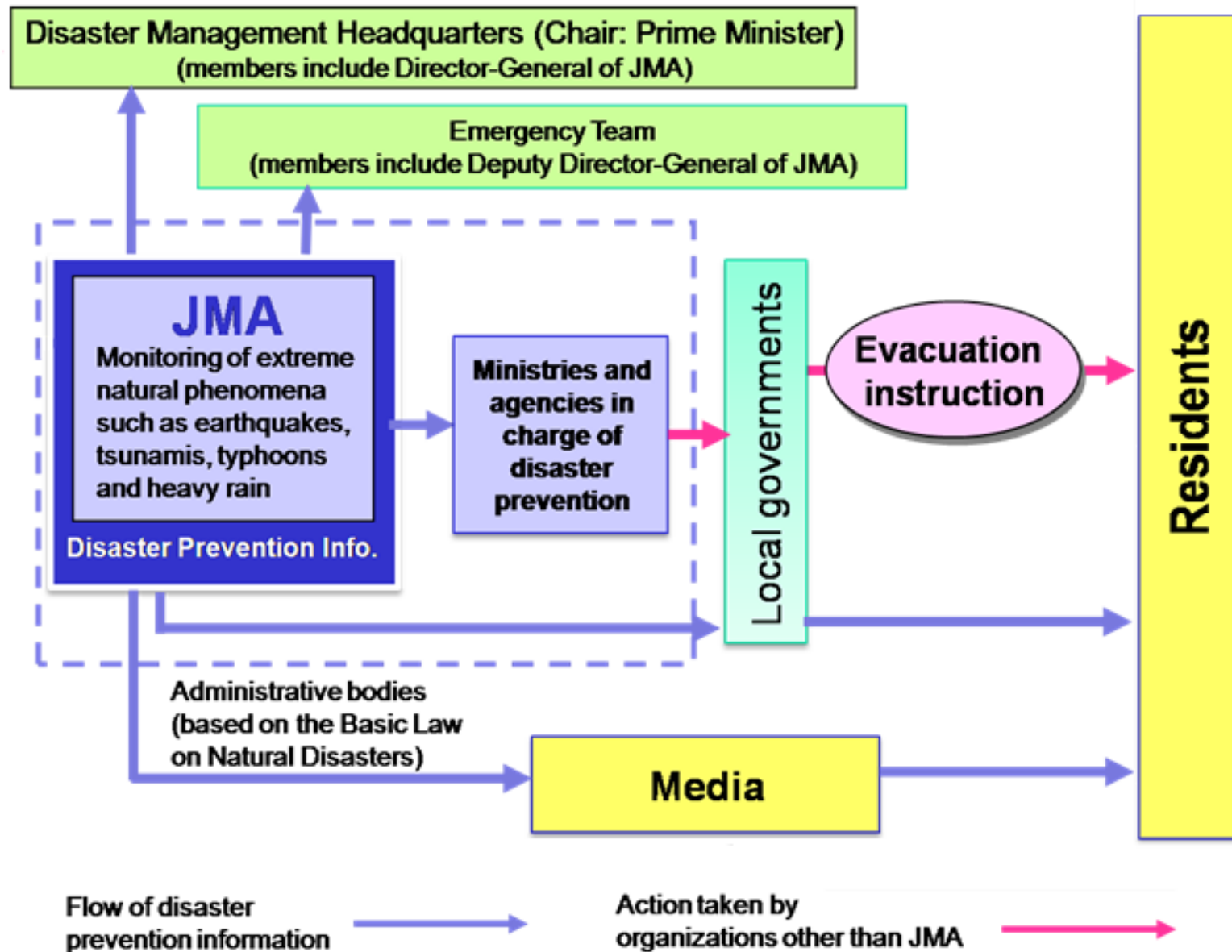
**JMA's staff managed to issue initial Tsunami Warnings within around 3 minutes after the earthquake occurrence, in a strongly shaken operation room.**



**Mega tsunamis are relatively rare.**

- **JMA issues earthquake information every day**  
(~ 2,000 felt earthquakes/year; 5 times if imperceptible quakes are included)
- **JMA conducts periodic drills for large earthquakes and tsunamis based on various scenarios.**
- **JMA engages in multi-hazard operations covering the whole process,**  
*observations → data analyses → forecasts → warning issuances → cancellations*  
**therefore, it can make a professional decision in timely and appropriate manner putting all factors together**

# Disaster prevention operation schemes and JMA's role



## **Suggestion towards the reduction of the potential risk and impact of mega disasters**

**Including daily exercise in the SOP (Standard Operating Procedure)  
of relevant disaster management organizations (ideally as a real duty)**



**Proper operations even at a sudden huge disaster occurrence  
e.g. the Great East Japan Earthquake in 2011**

**Thank you**