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JICA/JST/NIED Symposium

JMA tsunami warning improvement plan

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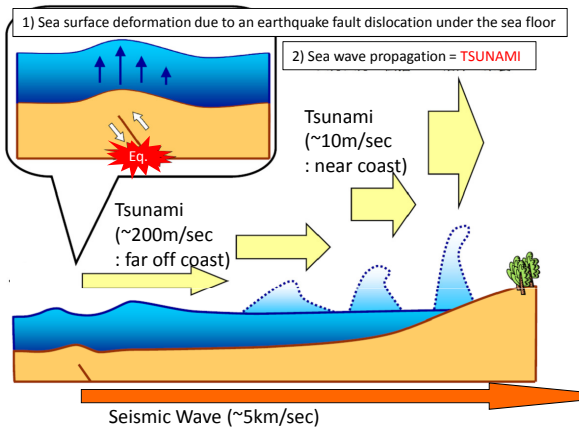
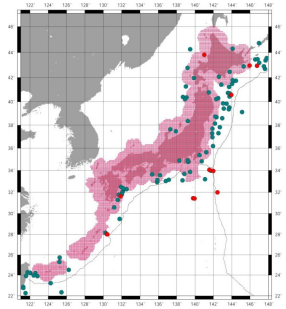
Technical Principle of Tsunami Warning





About 40% of near-Japan tsunamigenic earthquakes have caused tsunami that struck coast within 20 minutes.

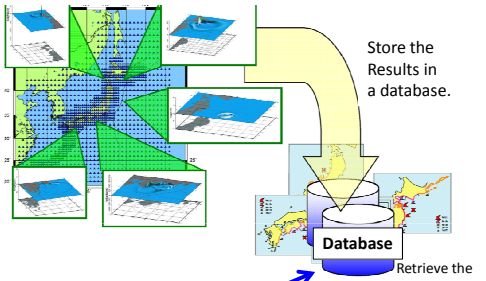
Prompt Tsunami Warning dissemination is essential to ensure max. time for evacuation, which can be realized only by taking advantage of propagation velocity difference between seismic and tsunami waves. Tsunami height can be forecast by the seismic wave analysis. -> Tsunami Warning

Warning should be updated with improved accuracy by using as many available seismic & sea level data as possible.

Tsunami Warning Dissemination

Establishment of Tsunami Simulation Database

Conduct Tsunami simulation for various epicenters, depths and magnitudes.

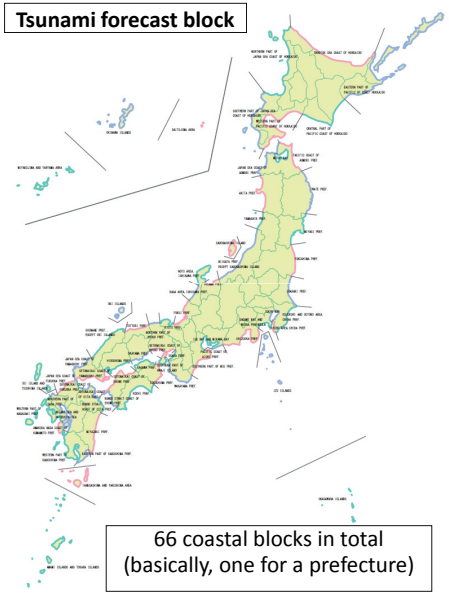


Quickly Estimated Hypocenter & Magnitude

Forecast Grade		Levels of Estimated Tsunami Amplitude
Warning	Major Tsunami	3 m, 4 m, 6 m, 8 m, 10 m or greater
	Tsunami	1 m, 2 m
Advisory		0.5 m

Disseminate the first warning in 3 minutes

Tsunami forecast block



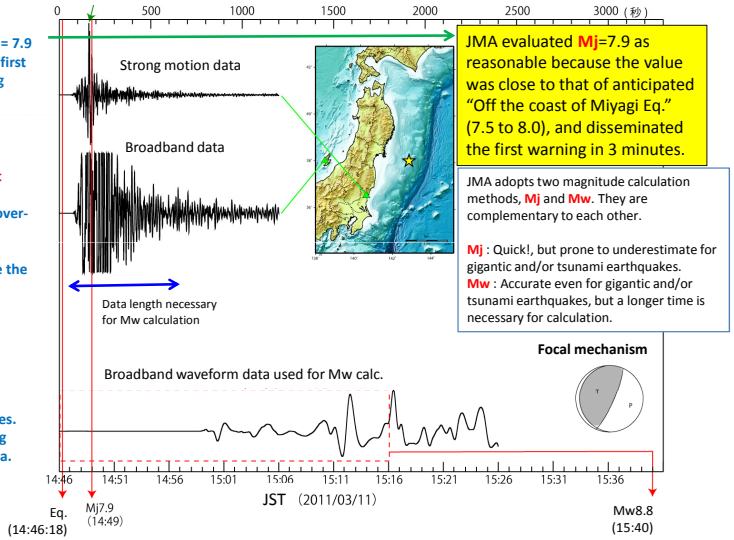
66 coastal blocks in total
(basically, one for a prefecture)

Magnitude estimation on 11th of March and its problem

Calculated Mj (JMA magnitude) = 7.9 in 3 minutes to disseminate the first tsunami warning by using strong motion data.

Failed to calculate Mw (Moment magnitude) automatically in 15 minutes due to waveform data over-scale for most of the domestic broadband seismometers, and consequently, could NOT update the warning.

Collected unsaturated oversea broadband waveform data, and calculated Mw = 8.8 in 54 minutes. That was too late for the warning update based on the seismic data.

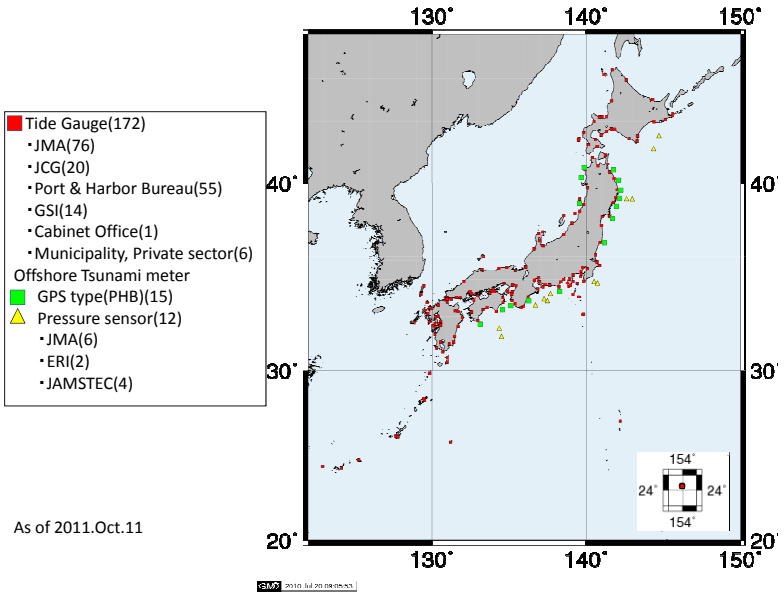


JMA evaluated Mj=7.9 as reasonable because the value was close to that of anticipated "Off the coast of Miyagi Eq." (7.5 to 8.0), and disseminated the first warning in 3 minutes.

JMA adopts two magnitude calculation methods, Mj and Mw. They are complementary to each other.

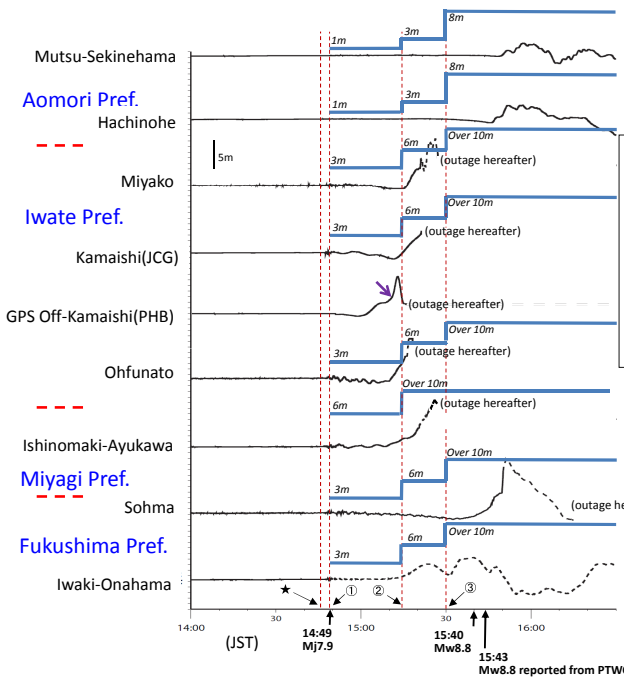
Mj : Quick!, but prone to underestimate for gigantic and/or tsunami earthquakes.
Mw : Accurate even for gigantic and/or tsunami earthquakes, but a longer time is necessary for calculation.

Sea Level Monitoring Stations (all are collected at JMA in realtime)



As of 2011.Oct.11

Tsunami Warning Updates (Aomori to Fukushima Pref.)



★3/11 14:46 Eq. Occurrence

①3/11 14:49 Tsunami Warning Dissemination
Iwate 3m, Miyagi 6m, Fukushima 3m (Major Tsunami),
Pacific coast of Aomori 1m (Tsunami)

②3/11 15:14 Tsunami Warning Update
Iwate 6m, Miyagi over10m, Fukushima 6m,
Pacific coast of Aomori 3m (Major Tsunami)

③3/11 15:30 Tsunami Warning Update
Iwate to Boso-peninsula over10m,
Pacific coast of Aomori 8m (Major Tsunami)

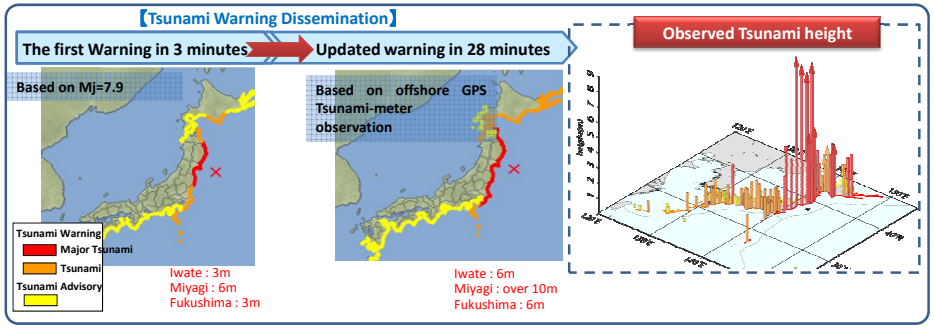
JMA updated Tsunami Warning NOT by earthquake magnitude estimation, but by observed tsunami heights at GPS Tsunami meters and tide gauges.

Monitored in realtime
Recovered data by on-site inspection
Forecast Tsunami height

Problems of Tsunami Warning for Off the Pacific Coast of Tohoku Eq.

【Tsunami Warning Dissemination】

The first Warning in 3 minutes → Updated warning in 28 minutes



Major Problems

Sub.-1 Underestimation of earthquake magnitude used in the first tsunami warning in 3 minutes.

Sub.-2 Announced tsunami height estimate "3m" led to delays in evacuation.

Sub.-3 Failure in the prompt earthquake magnitude examination by Mw due to over-scale of domestic broadband seismometers, and insufficient warning update technology by using offshore Tsunami-meter (Pressure sensors data more offshore than GPS-type could not be used for the update) .

Sub.-4 Announced tsunami height observation "the initial wave height 0.2m" led to delays/interruptions in evacuation.

Investigated measures for Tsunami Warning improvement, in cooperation with intelligent persons, municipalities, broadcasting companies and other relevant organizations.

Principle policy to investigate how to improve Tsunami Warning

1 Early Warning and Update

・Disseminate the first warning as soon as possible. (as before)

・Update the warning with improved accuracy by using as many available seismic & sea level data as possible. (as before)

・Consider a possibility that updated warnings can not reach to residents due to power or communication link failure. → <u>The first warning is important!</u>

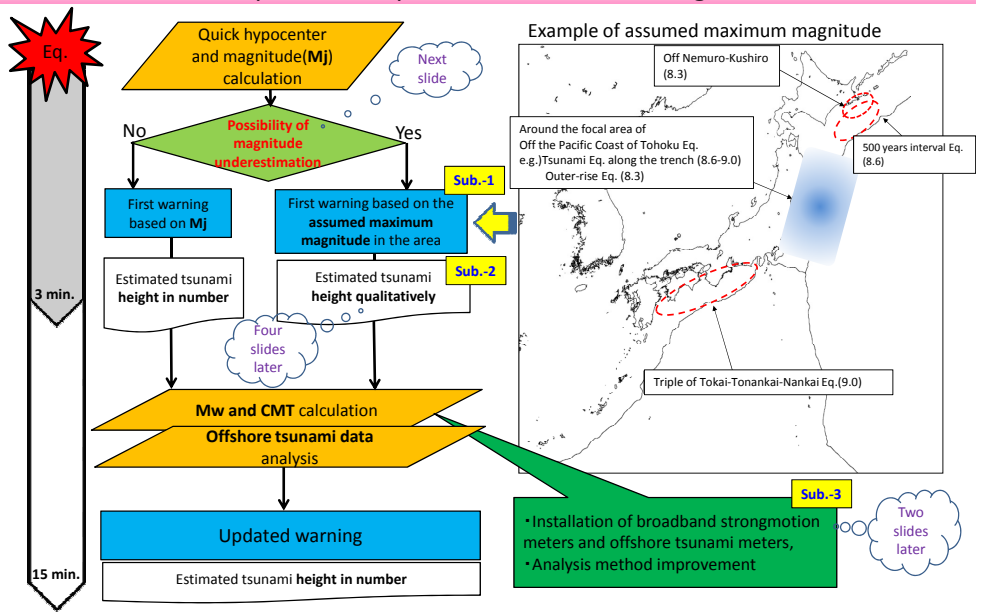
2 Safe Side Warning

Transmit the worst possible case within an uncertainty of tsunami height estimate due to an uncertainty of initial tsunami source estimate.

Enable to disseminate proper tsunami warning even to very rare gigantic earthquakes, while making public relations activities on the importance of "self-protection" (run to a high place when you feel a strong shaking near a coast without confirming JMA's warning!).

At the same time, improve the accuracy of warning for frequent M<8 earthquake to get reliance of residents on the warning.

General flow of planned improved Tsunami Warning Dissemination

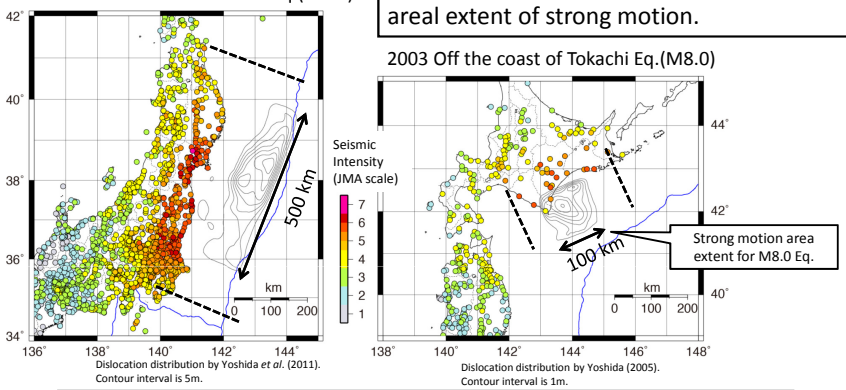


Example of monitoring method to recognize earthquake magnitude underestimation

2011 Off the Pacific Coast of Tohoku Eq.(M9.0)

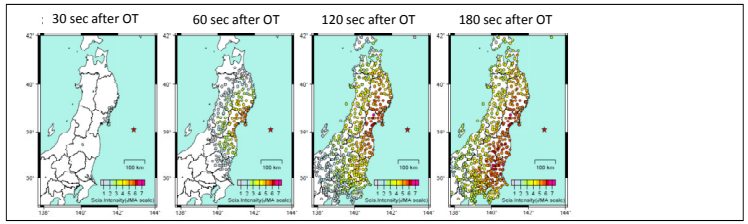
Rough estimation of magnitude by referring to areal extent of strong motion.

2003 Off the coast of Tokachi Eq.(M8.0)



Dislocation distribution by Yoshida *et al.* (2011). Contour interval is 5m.

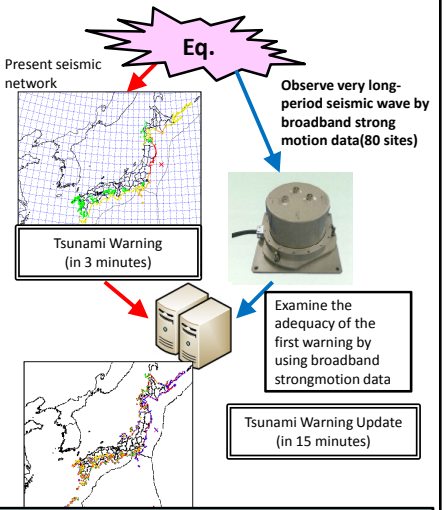
Dislocation distribution by Yoshida (2005). Contour interval is 1m.



by MRI

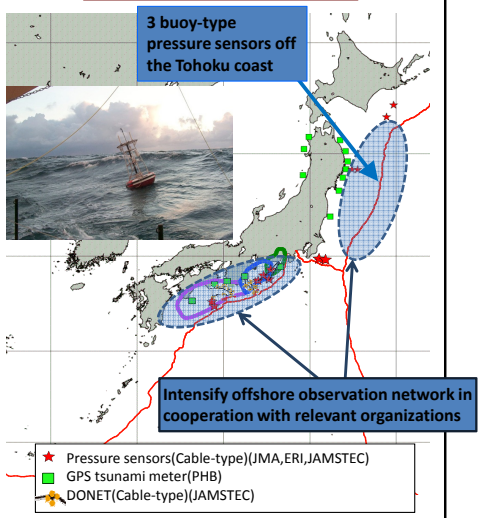
Deployment of broadband strongmotion meter & offshore tsunami meter

Domestic Broadband Strongmotion meter



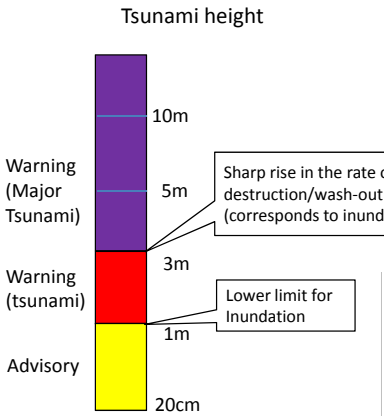
Ensure Tsunami Warning update in 15 minutes based on the accurate estimation of magnitude even for gigantic earthquake.

Offshore Tsunami meter



Ensure prompt update of Tsunami Warning with improved accuracy based on offshore sea level data.

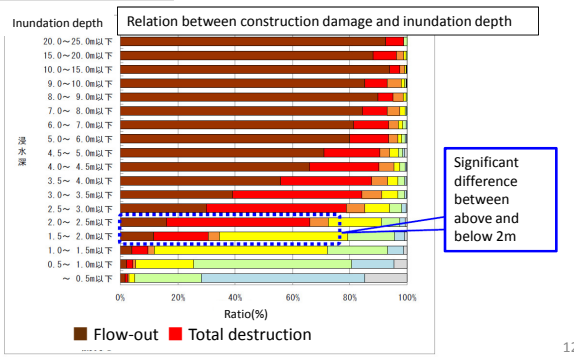
Examination of tsunami warning/advisory criteria and levels of estimated tsunami height



Points to be considered

1)Technical issue
Scatter of tsunami height(estimated & observed) around mean value (higher, the larger)
2)Difference in disaster severity
3)Feasibility of multiple levels of evacuation

→Reduce the number of levels from 8 to 5.



Improvements in Warning & Information Statement

○ Warning/Advisory criteria and levels of estimated tsunami height

Upper bound of each level

In case of possible magnitude underestimation

Sub.-2

present

Forecast Grade		Levels of Estimated Tsunami Amplitude
Warning	Major Tsunami	3 m, 4 m, 6 m, 8 m, 10 m or greater
	Tsunami	1 m, 2 m
Advisory		0.5 m

Improved

Levels of estimated Tsunami height	Expression In Number	Expression Qualitative
10m < H	Over 10m	Huge
5m < H <= 10m	10m	Huge
3m < H <= 5m	5m	Huge
1m < H <= 3m	3m	High
20cm <= H <= 1m	1m	(---)

○ Tsunami observation information

Sub.-4

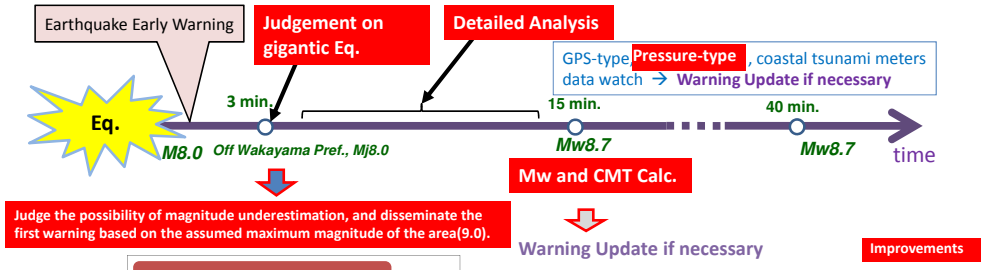
・Report the arrival time and initial polarity of tsunami, because the fact that “tsunami has arrived” is important to urge residents to evacuate.

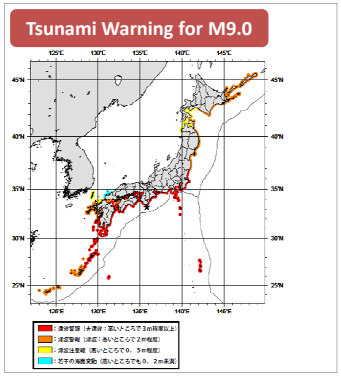
・Report the height of tsunami **only after** the height grows larger than the criteria height of one grade below the presently valid warning/advisory. (i.e. 1m when the Major Tsunami is valid)
While the height is smaller than the threshold above, expression is just “now observing”, not to give residents an underestimating threat.

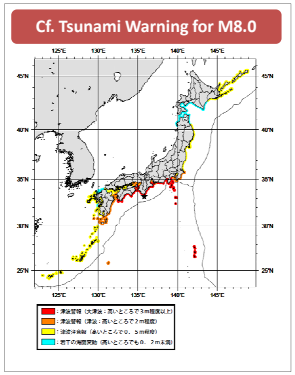
○ Information on the offshore tsunami observation

Establish a new information on the offshore tsunami observation(independently issued from coastal observation information) to emphasize its importance.

Scenario of Tsunami Warning for a huge Eq. anticipated along the Nankai-trough after the improvement







Other important issues

1) Closer link between Tsunami Warning and Hazard Map

2) Secure warning/information transmission route to residents at risk
→ cooperation with telecommunication companies and municipalities

3) Education on Tsunami Disaster Mitigation
・“Self-Protection” is the basis!
・Physical properties of Tsunami
Strikes repeatedly, initial wave is not always the biggest, etc.
・Philosophy of the “Tsunami Warning”
Its meaning(How severe the disaster will be)
Not just a forecast, but transmits the worst possible case within an uncertainty
(Show reasons why an estimation has an uncertainty)
Updated with improved accuracy

<< Summary >>

○ The First Warning
・Disseminate in 3 minutes.
・In case a possibility of magnitude(Mj) underestimation is recognized, the first warning is disseminated based on the assumed maximum magnitude of the area, and estimated tsunami height is mentioned just qualitatively as an emergency message.

○ Warning Update
・To secure the update of the first warning in 15 minutes based on Mw(& CMT), broadband strongmotion meters are deployed.
・For earlier and more accurate update of the warning, offshore tsunami meters are deployed in cooperation with relevant organizations.
・Develop/Improve seismic and sea-level data analysis method for warning update.

○ Warning/Information statements
・Reduce the number of levels of estimated tsunami height from 8 to 5, considering the scatter of tsunami height, and for closer linkage of warning to Hazard Map.
・Observed tsunami height is NOT reported in number while the height is small, not to give underestimating threat to residents.

○ Disaster Mitigation Education
・Education and Public relations activity are very important for more effective disaster mitigation.