Geological and historical evidence of paleotsunami

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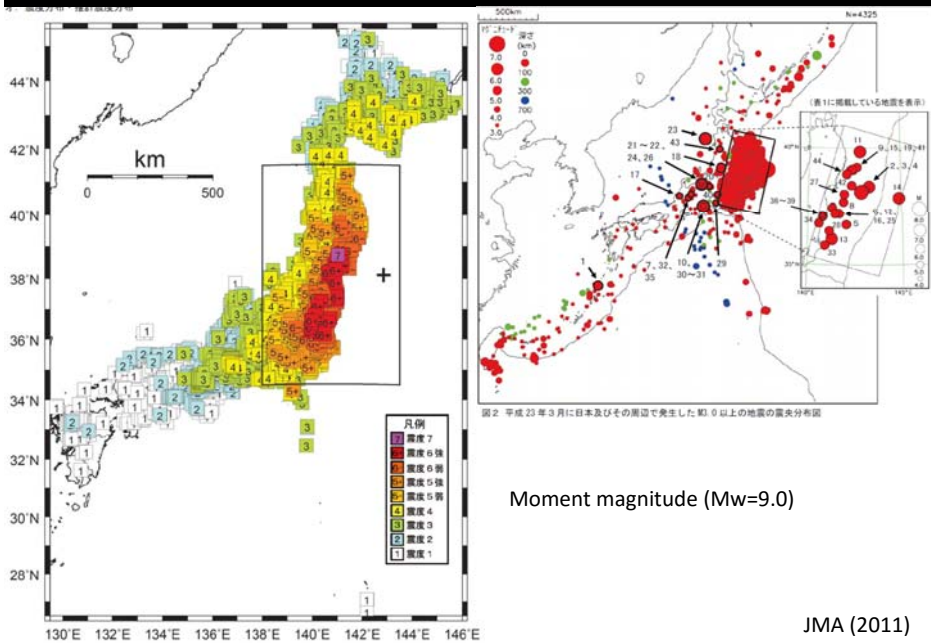
Geological evidence of paleotsunami in Tohoku

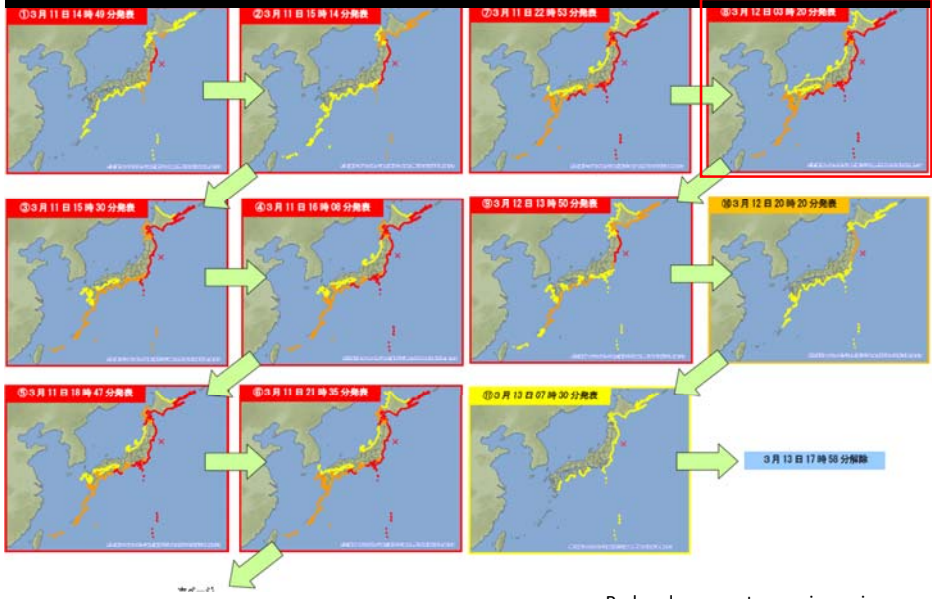
Mw=9.0 earthquake on 11 March 2011



Moment magnitude (Mw=9.0)

JMA (2011)

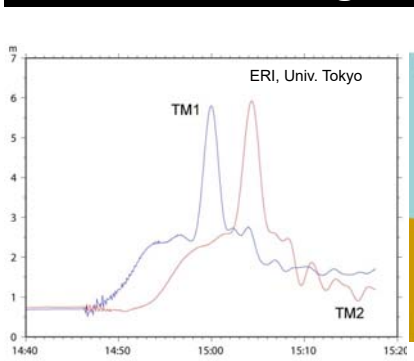
Tsunami warning issued on 11 March 2011

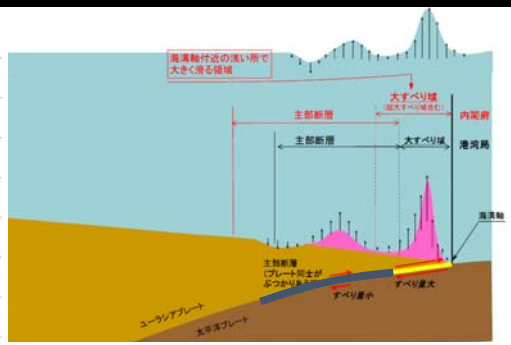


JMA (2011)

Red and orange: tsunami warning
Yellow: attention

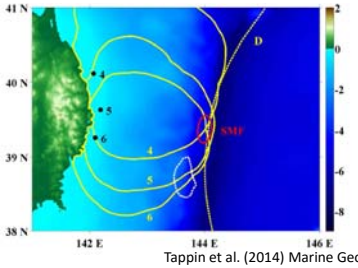
Tsunami generation mechanism





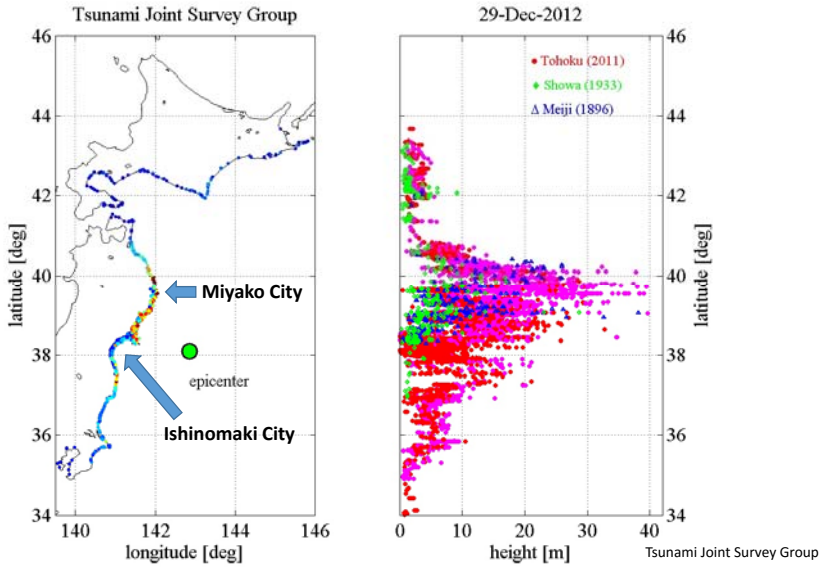
http://www.mikawa.pa.cbr.mlit.go.jp/topics/img/press/kinuura4/06.siryou3.pdf

- Extremely large slip along the shallow plate boundary (near trench axis) (e.g., Satake et al., 2011).
- Submarine landslide(s) was the additional source of tsunami at Sanriku coast (Tappin et al., 2014)?



Tappin et al. (2014) Marine Geology

2011 Tohoku-oki tsunami heights

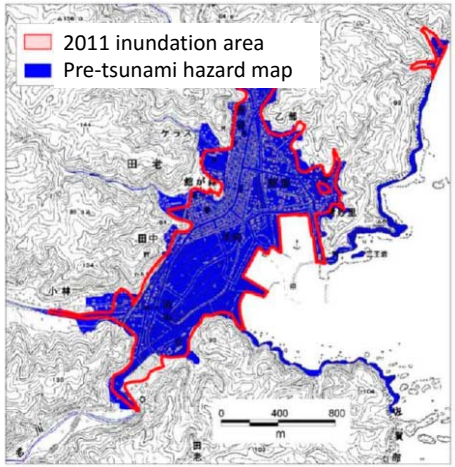


Tsunami Joint Survey Group

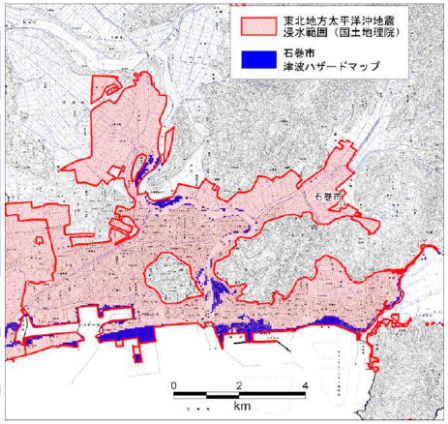
Very high run-up, but northern people experienced similar size of tsunamis past 120 years.

Pre-2011 tsunami risk assessment

Tsunami hazard map and 2011 inundation area at Miyako City, Iwate Prefecture



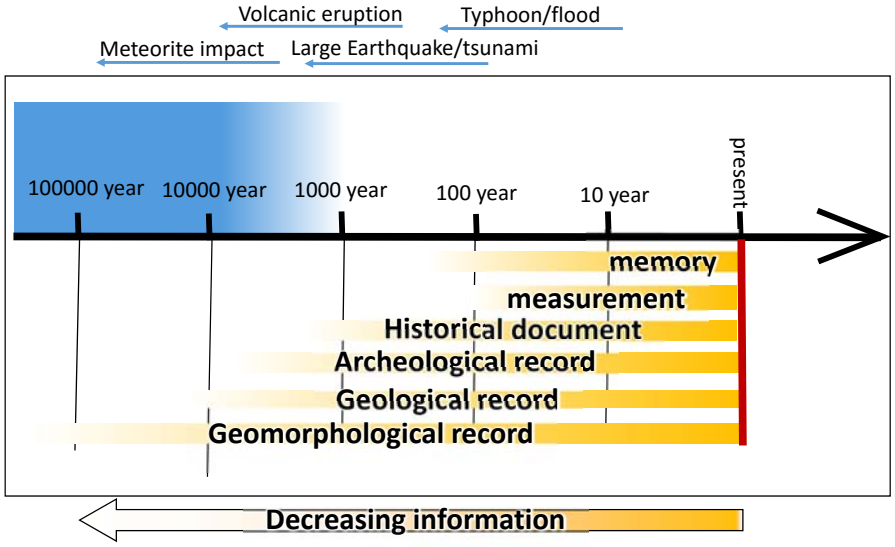
Tsunami hazard map and 2011 inundation area at Ishinomaki City, Miyagi Prefecture



Modified after CDMC (2011)

Large difference of the tsunami hazard maps in areas prepared before the 2011 event

How to know past hazard/disaster?

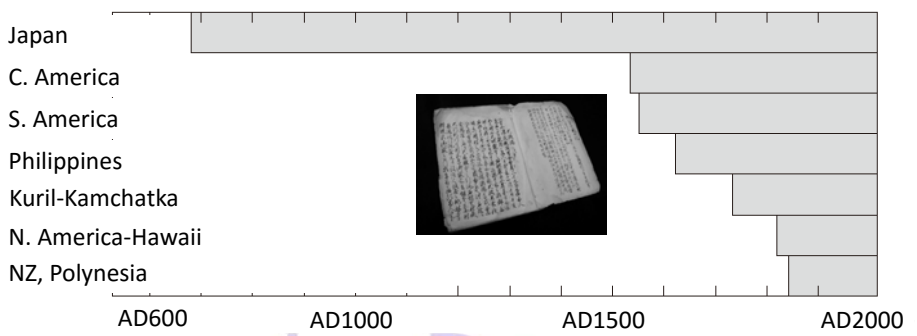


Modified after J. Komatsubara

Evidence of paleotsunami decreases to the past

Historical record

Historical documents describe detail of earthquake and tsunami and consequent damages.



Modified after report by B. Jaffe

Some countries have legend and/or oral tradition of tsunamis.

Geological evidence of paleotsunami

Major objectives of the paleo-tsunami research are

- estimation of the long-term tsunami recurrence interval.
- estimation of the inundation area, flow height, and magnitude of earthquake.

for the tsunami risk assessments.

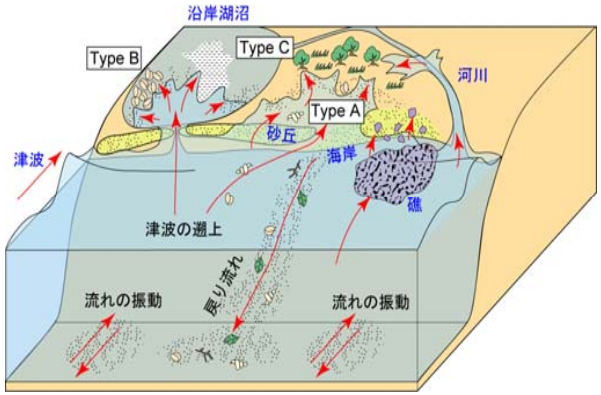
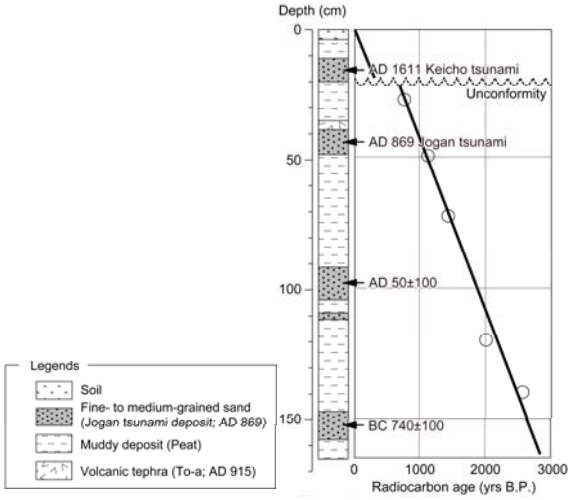


Image of the tsunami sediment transportation (Sugawara et al., 2008)

Tsunami recurrence estimated from tsunami deposit in Sendai



Minoura and Nakaya (1991), Sugawara et al. (2012)

Few hundred to thousand years interval.

Estimating magnitude of the AD869 Jogan earthquake

Distribution limit of sand deposit (>0.5 cm)

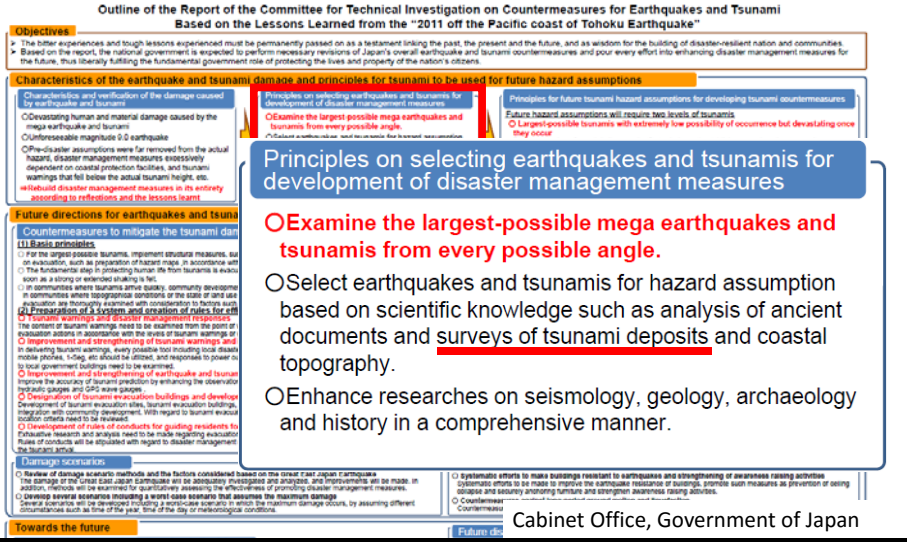
Courtesy: Daisuke Sugawara

Mw>8.4

It was not considered in the hazard map before the 2011 event

- Tsunami inundated at least 3-4 km from the paleo-shoreline (e.g. Abe et al., 1990).
- Few hundred to thousand years recurrence interval (e.g. Minoura and Nakaya, 1991).

New policy for the tsunami risk assessment


Outline of the Report of the Committee for Technical Investigation on Countermeasures for Earthquakes and Tsunami Based on the Lessons Learned from the "2011 off the Pacific coast of Tohoku Earthquake"

Objectives

Characteristics of the earthquake and tsunami damage and principles for tsunami to be used for future hazard assumptions

Future directions for earthquakes and tsuna

Towards the future

Principles on selecting earthquakes and tsunamis for development of disaster management measures

○Examine the largest-possible mega earthquakes and tsunamis from every possible angle.

○Select earthquakes and tsunamis for hazard assumption based on scientific knowledge such as analysis of ancient documents and surveys of tsunami deposits and coastal topography.

○Enhance researches on seismology, geology, archaeology and history in a comprehensive manner.

Cabinet Office, Government of Japan

The Japanese government made a new guideline for tsunami disaster prevention plans in December 2011, and recommended that local governments prepare for the "**maximum possible earthquakes and tsunamis**".

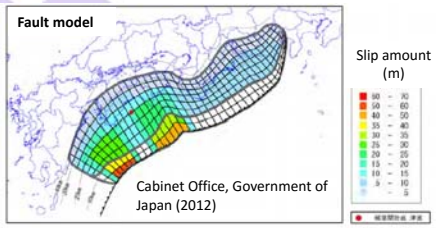
Maximum possible…. How large and how to estimate?

Historical and geological evidence tell us approximate return period and size of the rupture area of the fault.

- ✓ Magnitude of each seismic event is uncertain.
- ✓ Geological and historical researches take long time…
- ✓ Tsunami may not be generated only by the fault rapture (e.g. submarine landslide).

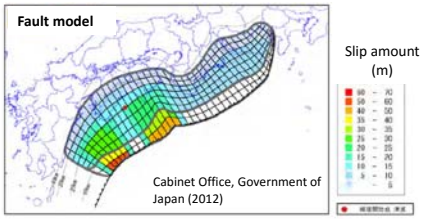
Nankai Trough

- ➢ Many big cities (Osaka, Nagoya, Tokyo)
- ➢ 1300 years historical record
- ➢ 100-200 years interval of large event
- ➢ 1707 event was the largest (Mw=8.6~8.7)
- ➢ Many geological evidence



In 2012, national government reported Mw=9.1 earthquake as the possible maximum event along the Nankai Trough. Tsunami run-up height will be approx. 30 m in maximum. Human and economic losses will be 320,000 peoples and 220 trillion JPY (Asahi newspaper).

Maximum possible…. How large and how to estimate?

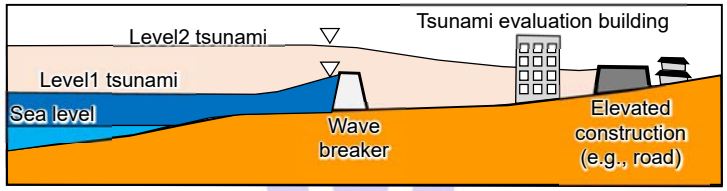


1. "The slip amounts were estimated based on the knowledge of 2004 Sumatra earthquake, 2010 Chilean earthquake, and 2011 Tohoku earthquake (CDMC, 2012)".

2. "It is very difficult to estimate the recurrence interval or timing of occurrence of this maximum possible earthquake and tsunami (CDMC, 2012)".

1. **Do local governments need to prepare for such event?**
2. **Is this really the maximum? Overestimation or underestimation?**

Post-2011 policy for the tsunami countermeasure



- ➢ **Level 1 tsunami**: One that occurs frequently every few tens of years to a hundred or more years. The estimated tsunami height is the basis for construction of shore protection facilities.
- ➢ **Level 2 tsunami**: One that occurs with an extremely low frequency, but generating severe damage once it occurs. Shore protection facilities are probably insufficient to protect against a tsunami of this size. Saving human life is, therefore, the top priority, and hence so an awareness campaign including disaster education is highly recommended.

Goto et al. (2014) Episodes