



東北大学

Tsunami disaster and impact due to the 2011 Tohoku earthquake

On 2011 July 02 , #6026 IUGG Union Sympo.

Fumihiko Imamura, Prof. Tsunami Eng, DCRC, Tohoku Univ.

- Mechanism of earthquake & tsunami in Pacific coast of Tohoku region
- Measured tsunami along the coast
- History of earthquakes and tsunamis in the region
- Countermeasure at Tsunami prone area
- City of Sendai, development, prevention work and
- <http://www.dcrc.tohoku.ac.jp/>

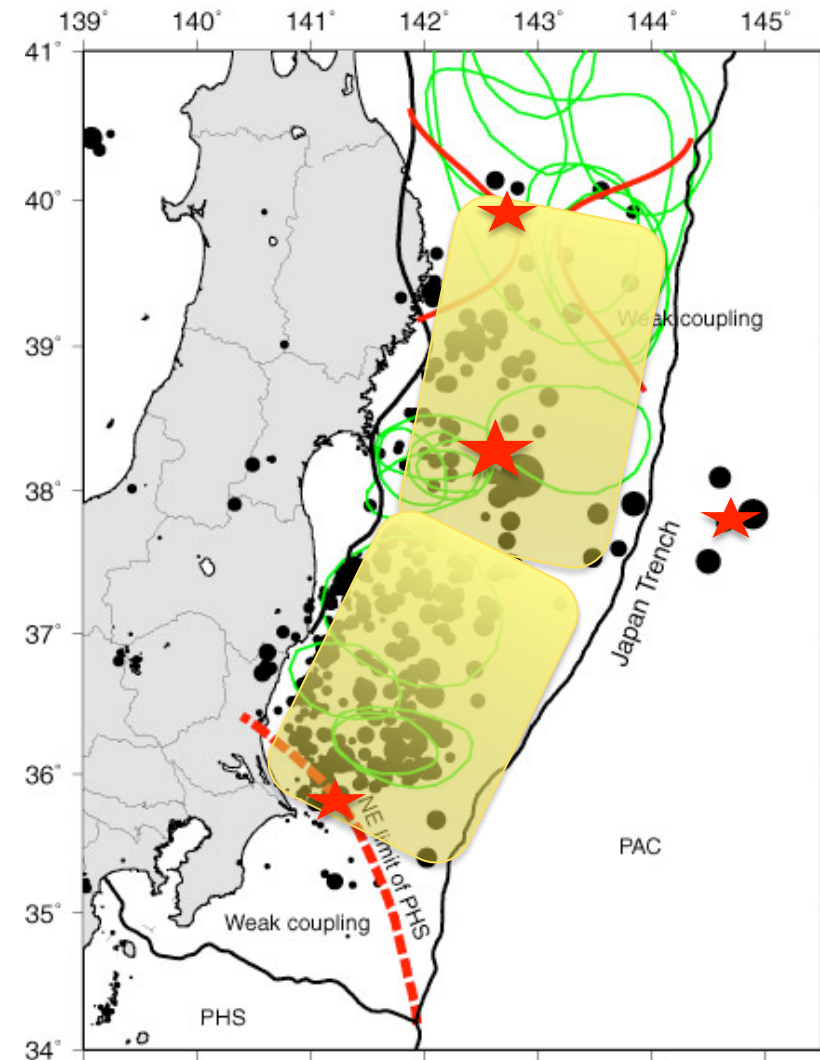


Summary of 2011 March Earthquake

- Time
 - 11 March 2011 at 14:46 JST (5:46 GMT)
- Type of earthquake:
 - Plate-boundary thrust-faulting in subduction area of Japan
- Hypocenter and depth:
 - region (38°N, 142°E), 24km depth
- 130km off the Pacific coast of Tohoku
- Magnitude:Mw9.0
- Damage:
 - The destruction of social infrastructure, housing and corporate facilities would cost between 16 and 25 trillion yen (Cabinet Office's estimate)
 - 23,000 death and missing, 140,000 cars damaged in Miyagi only²

Main & After shocks

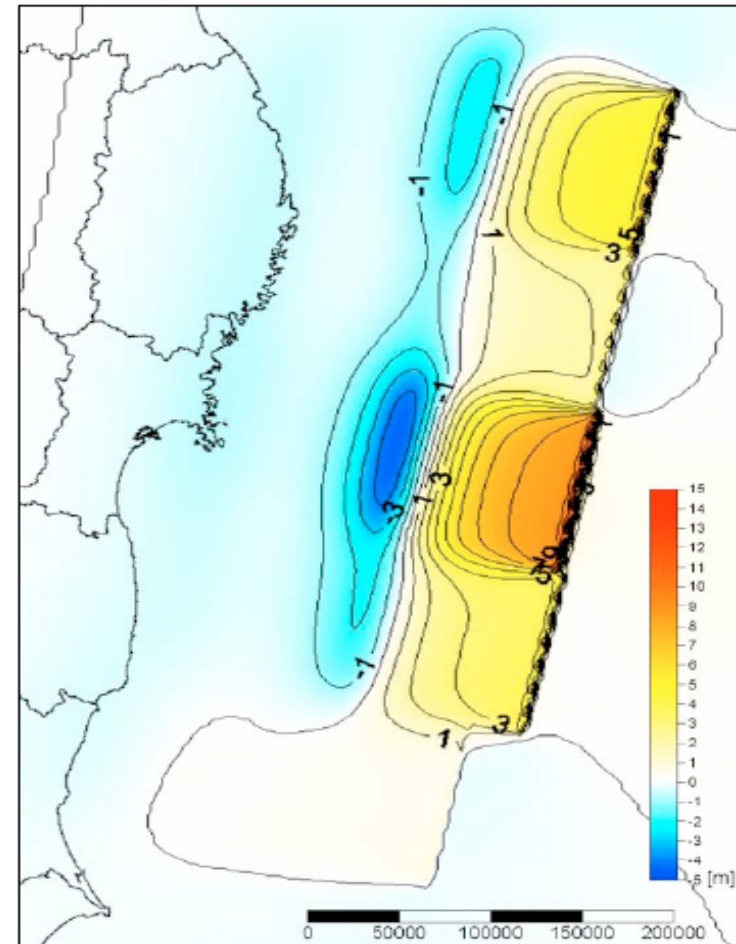
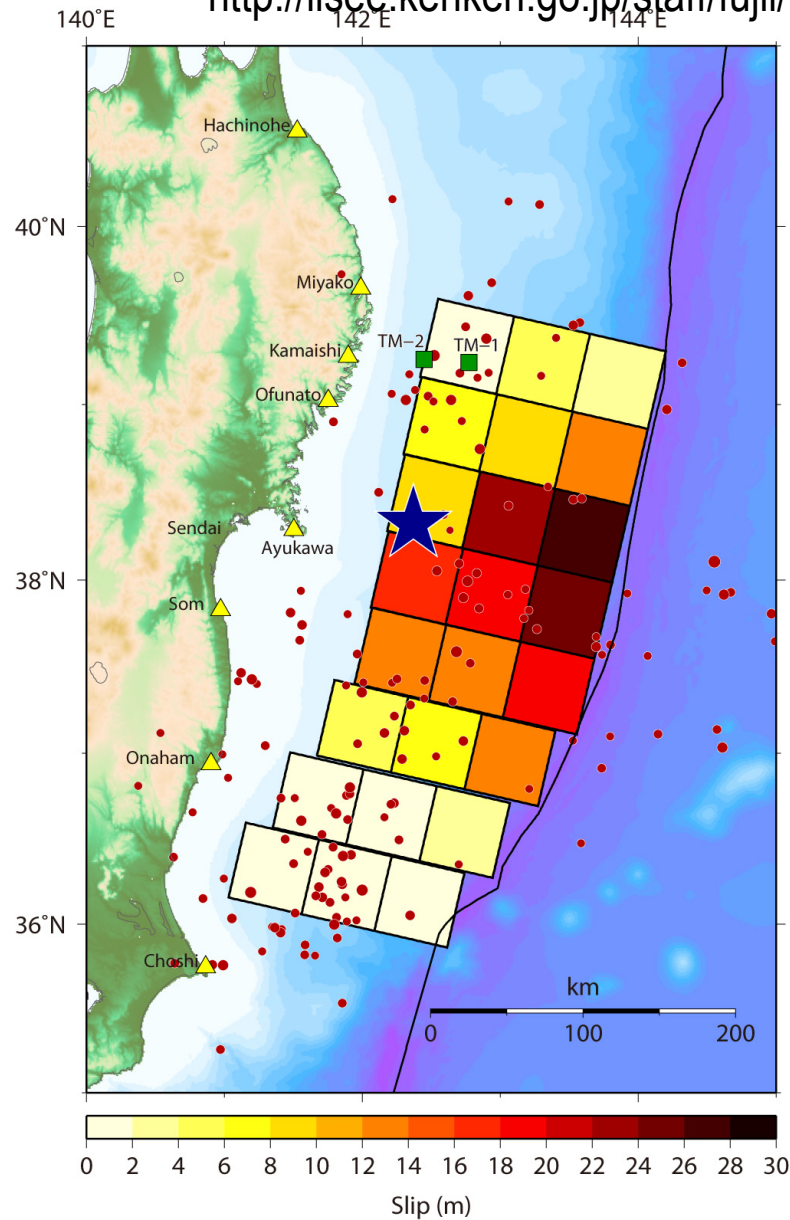
- Main = M9.0 (14:46)
500kmx200km size
- Maximum one in our history
 - Earthquakes follows
 - Sanriku M7.5(15:08)
 - Ibaragi M7.3(15:15),
 - Japan trench M7.4 (15:25)
- After Shockes
 - Fukushima, Ibaragi



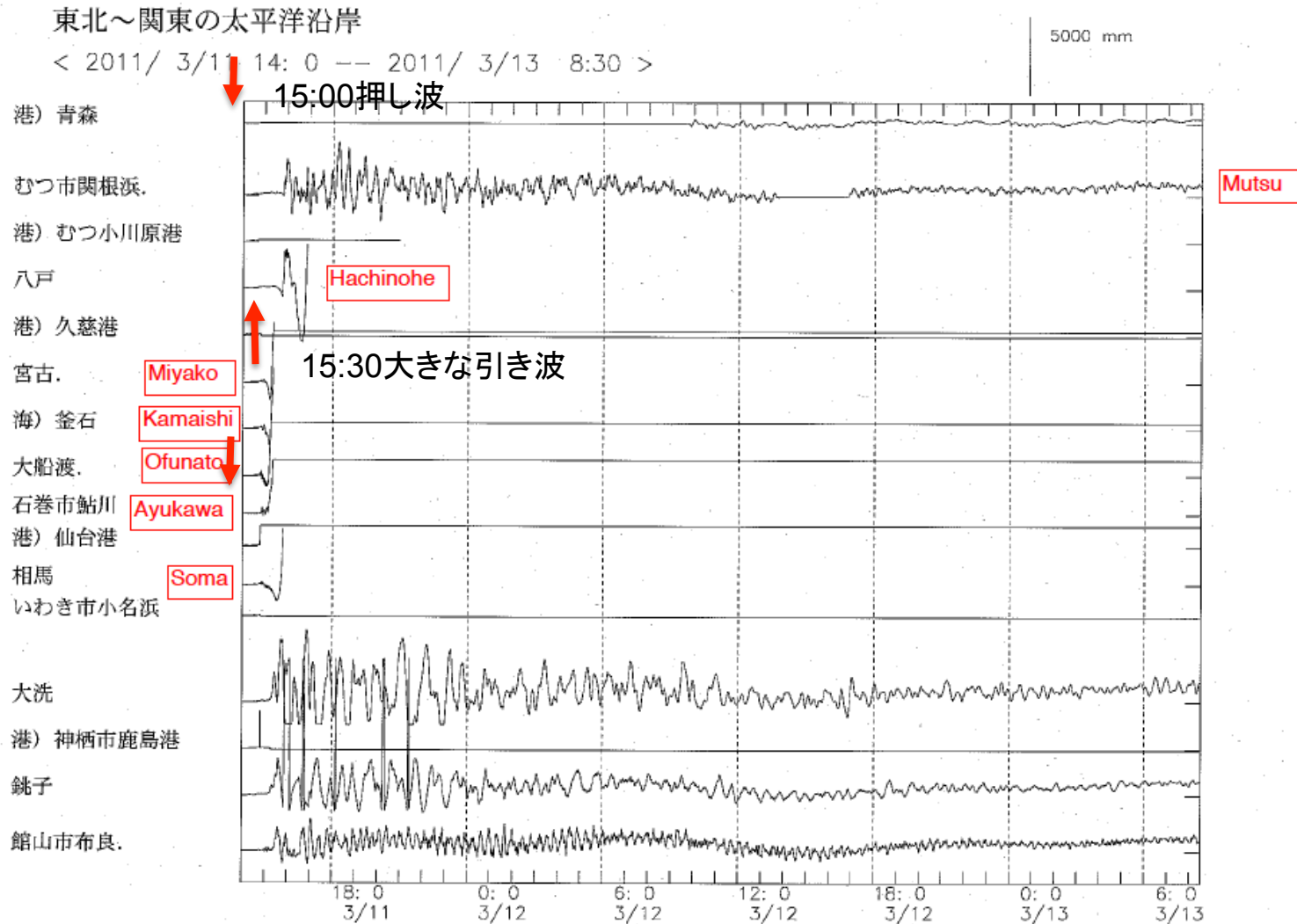
発生した地震と津波(断層モデル)

Example of faults model for tsunami(Fujii&Satake,2011 &Tohoku Univ.)

http://iisee.kenken.go.jp/staff/fujii/OffTohokuPacific2011/tsunami_ja.html

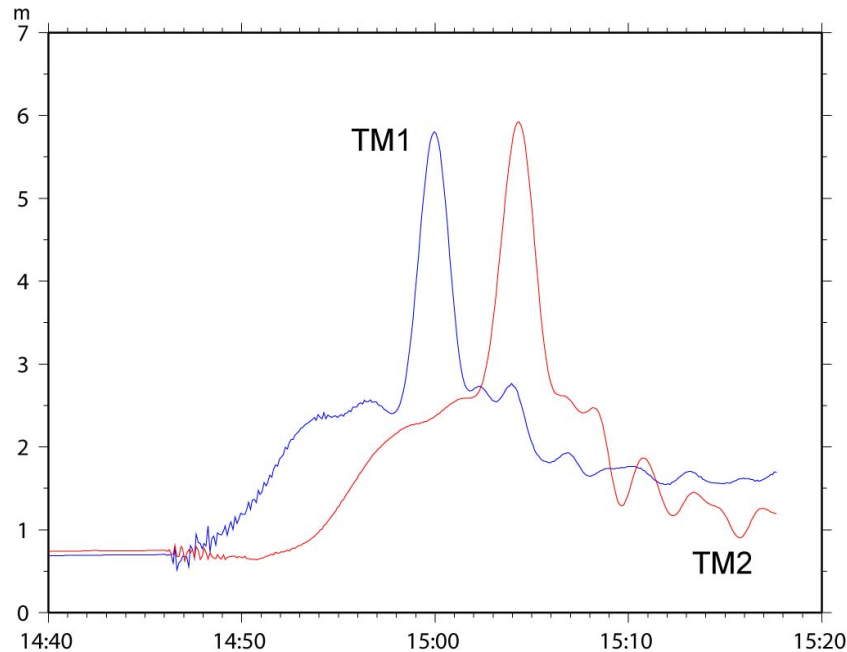


The tsunami measured at tidal stations (JMA) along the shore in Pacific ocean

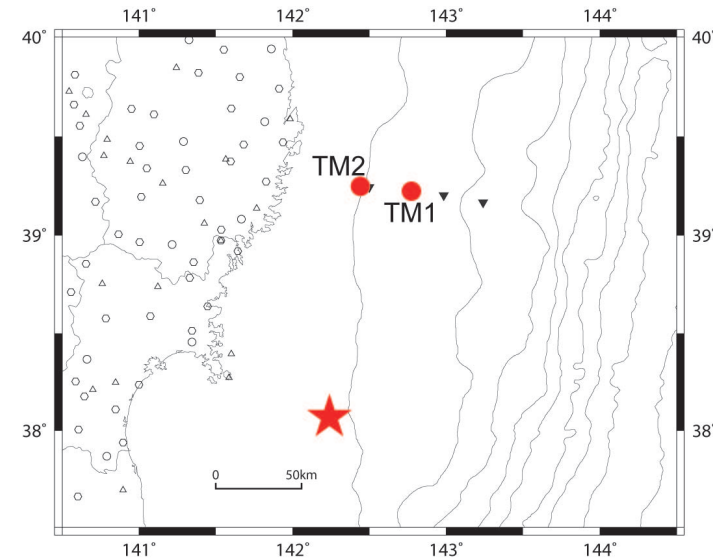


The tsunami observed by tsunami pressure gauge at the deep bottom

2011/3/11 14:40~15:20



TM1 (海溝寄り)では14時46分頃にP波が到達し、14時58分頃に約3.5mの津波(押し)が到達した。その4分後にTM2(陸寄り)ではほぼ同振幅の津波が観測された。

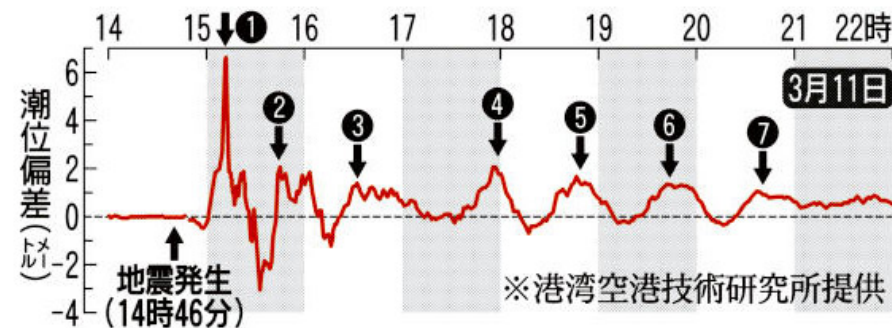


TM1 (海溝寄り)では11時45分頃にP波が到達し、その7分後に約7cmの津波(押し)が到達し、その4分後にTM2(陸寄り)では約10cmの津波が観測された。

東京大学地震研究所

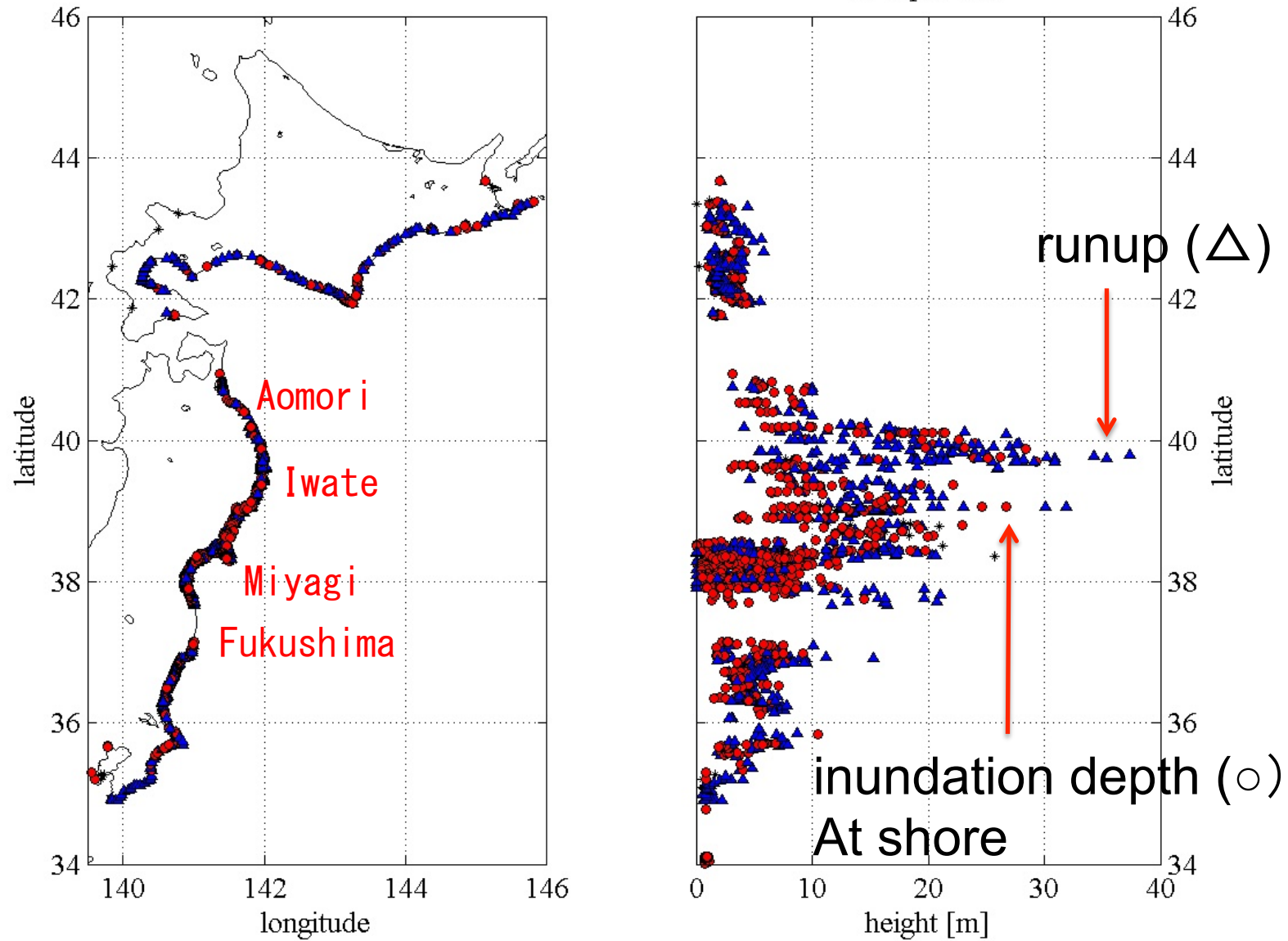


岩手県南部沖GPS波浪計でとらえた津波の波形



Tsunami runup (Δ) and inundation depth at shore ($\circ$) measured

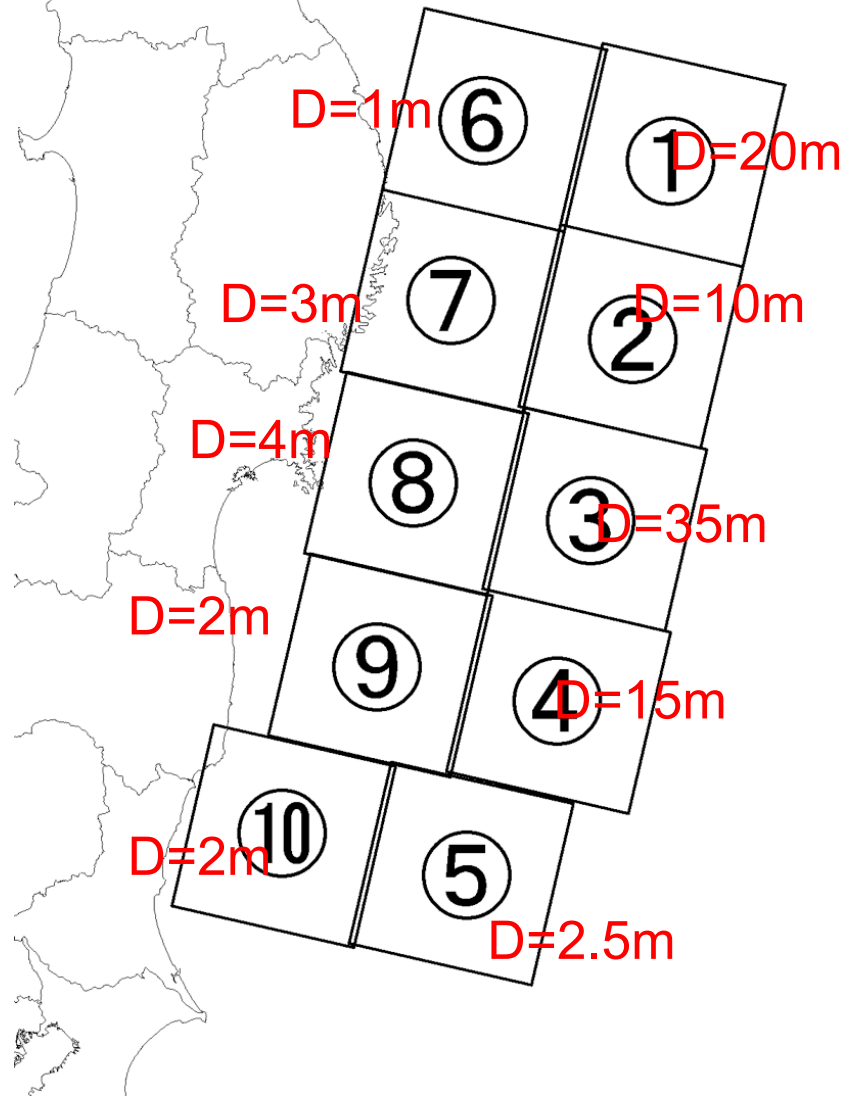
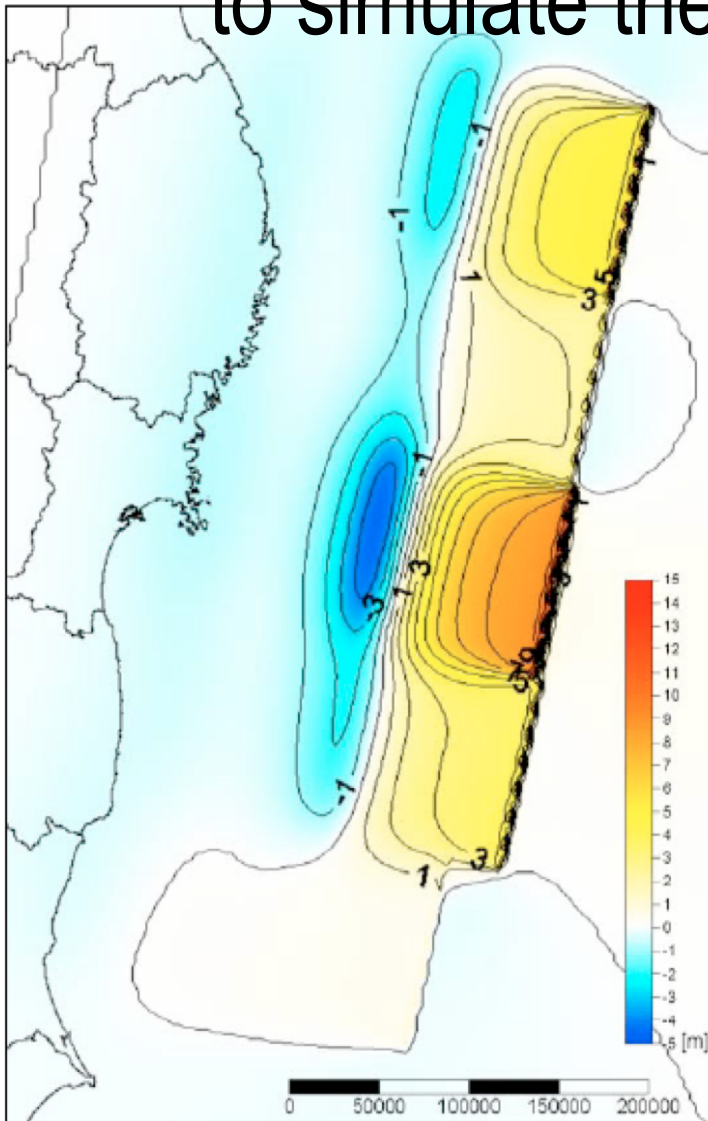
25-Apr-2011



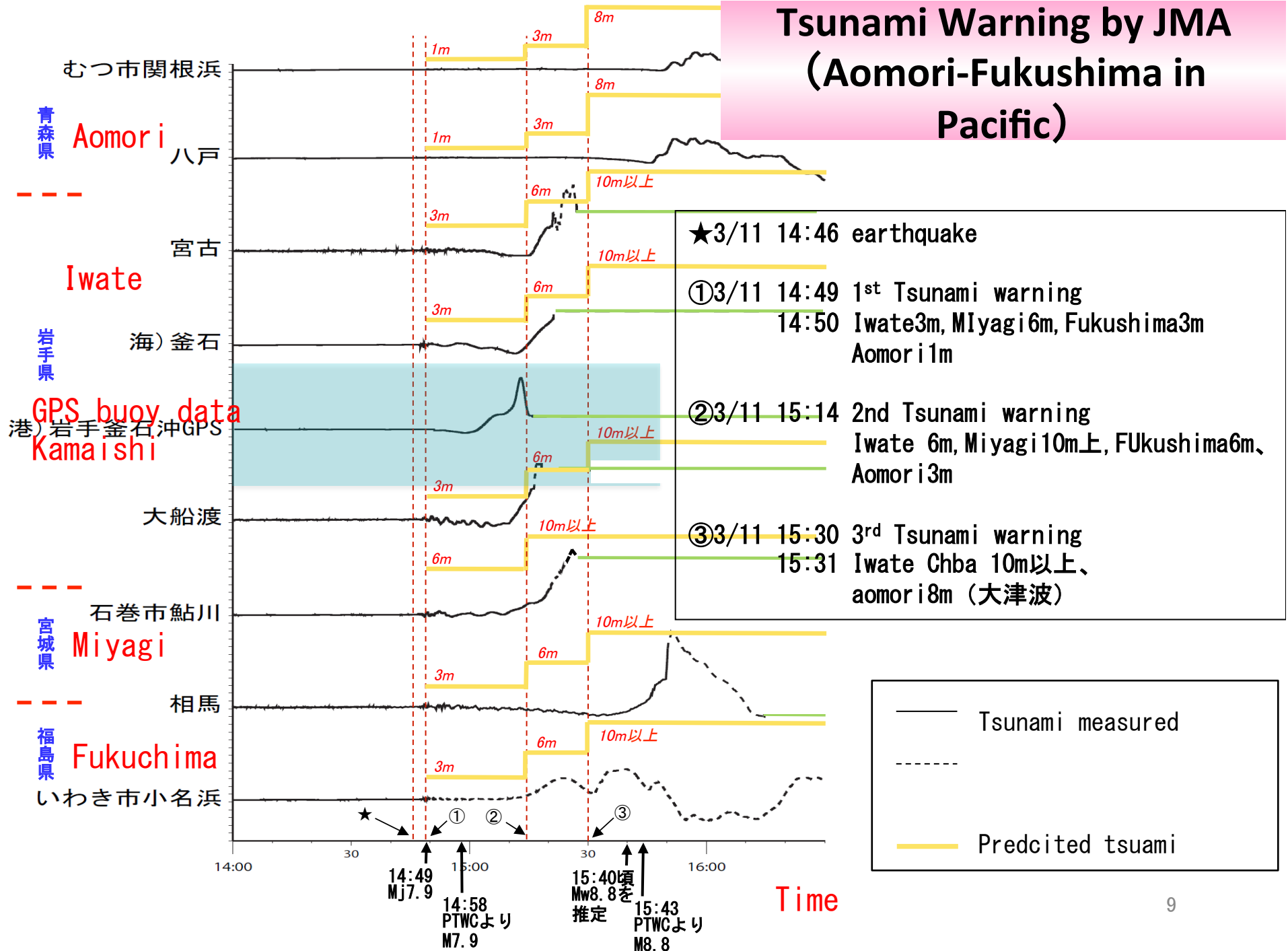
東北地方太平洋沖地震津波合同調査グループ <http://www.coastal.jp/ttjt/index.php?現地調査結果>

Tohoku Univ. model Vers.1.0

to simulate the inundation and runup



Tsunami Warning by JMA (Aomori-Fukushima in Pacific)



Casualties

- The number of casualties continues to rise. The Government has confirmed 10,102 people have died. Still 17,053 missing on March 26. It has already exceeded that the 1995 Great Hanshin Awaji (Kobe) Earthquake.

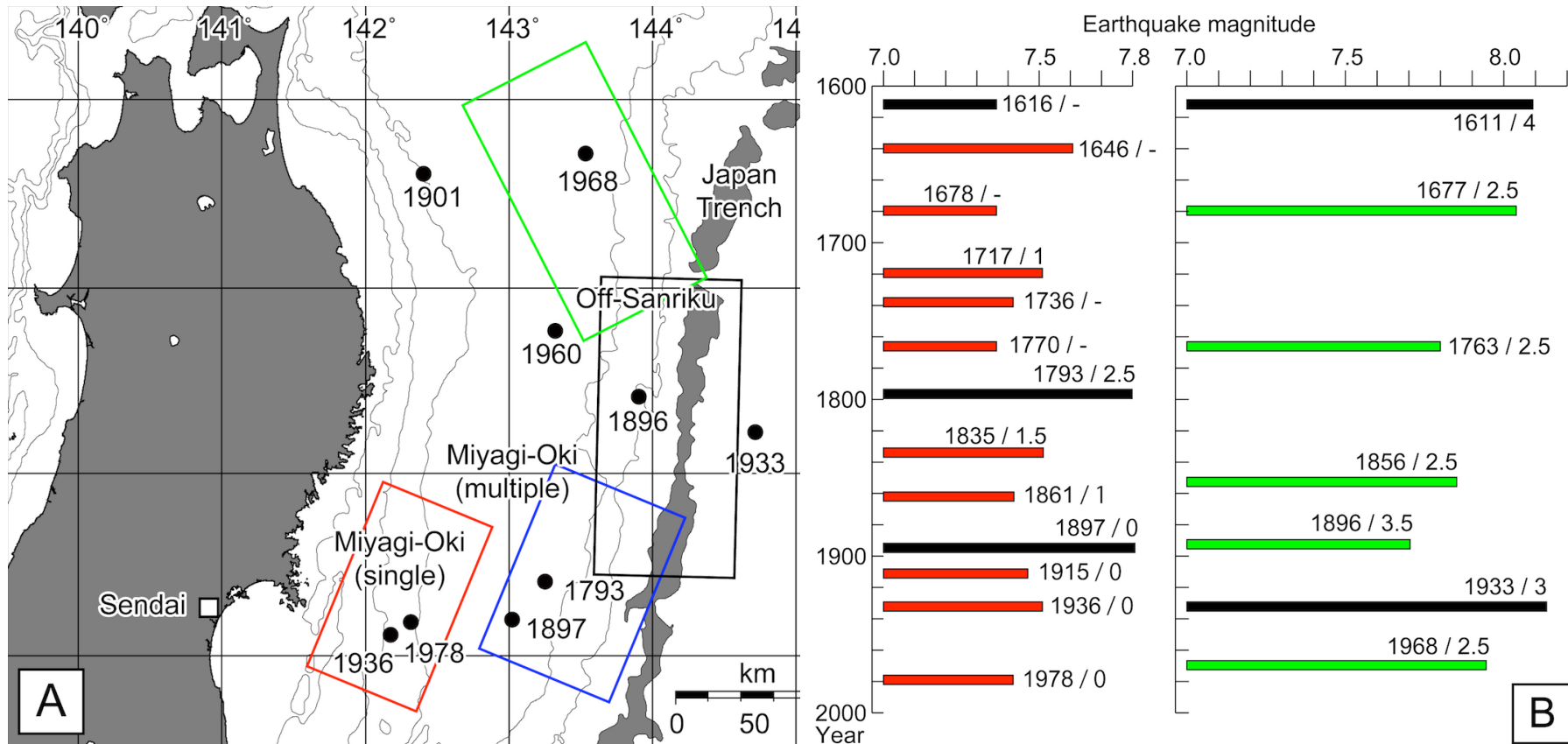
As of 8:00 am March 26 2011

Prefecture	Killed	Missing	Refugees
Iwate	3,092	4,878	43,728
Miyagi	6,097	6,237	86,927
Fukushima	855	5,934	86,308
Others	58	4	29,146
Total	10,102	17,053	246,109

Source: The Emergency Disaster Response Headquarters

=> 15,400 killed and 7,700 missing on 22 June ¹⁰

Historical tsunamis in Sanriku for 400 years



- T.Hatori, Distributions of Seismic Intensity and Tsunami of the 1793 Miyagi Oki Earthquake, Northeastern Japan, *Bulletin of Earthquake Research Institute, University of Tokyo*, **62**, 297-309 (1987).

Tsunami Countermeasures

- **Structures;** sea wall, break water, dike, controlling forest, started in 1930's and 1960 after Chilean tsunami
- **Non-structures;** Tsunami warning, Evacuation building, Education and awareness, monuments

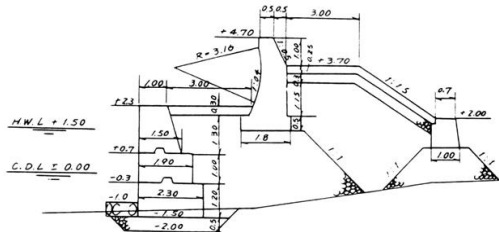


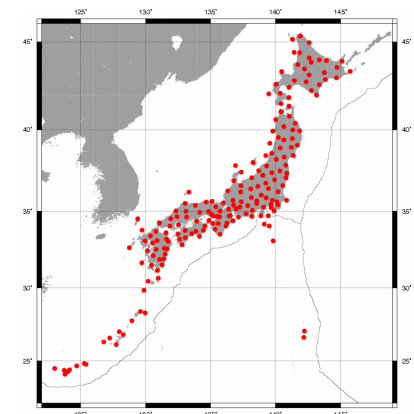
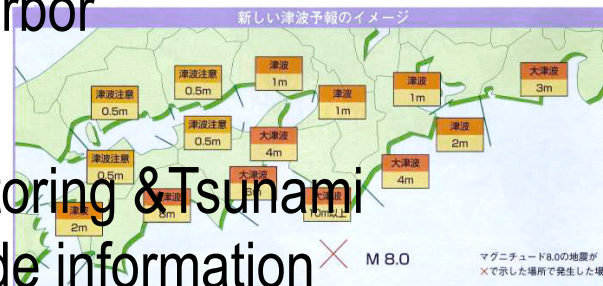
Fig. 2. Dual purpose structure (composite type tsunami wall).



Photo 2. Typical fishing village, (Ryoishi), on the Sanriku coast.

Sea wall protecting the fishery harbor

JMA Earthq.&Tsunami monitoring &Tsunami
Forecasting system to provide information



Tsunami Disasters

- Huge amount of inundation (443km²)+ destructive wave force
- Direct and in-direct tsunami damages
- Floating of debris, ships, cars and tanks
- Fires by attack of ships, sea water, houses
- Change of topography and Geometry due to erosion and deposition

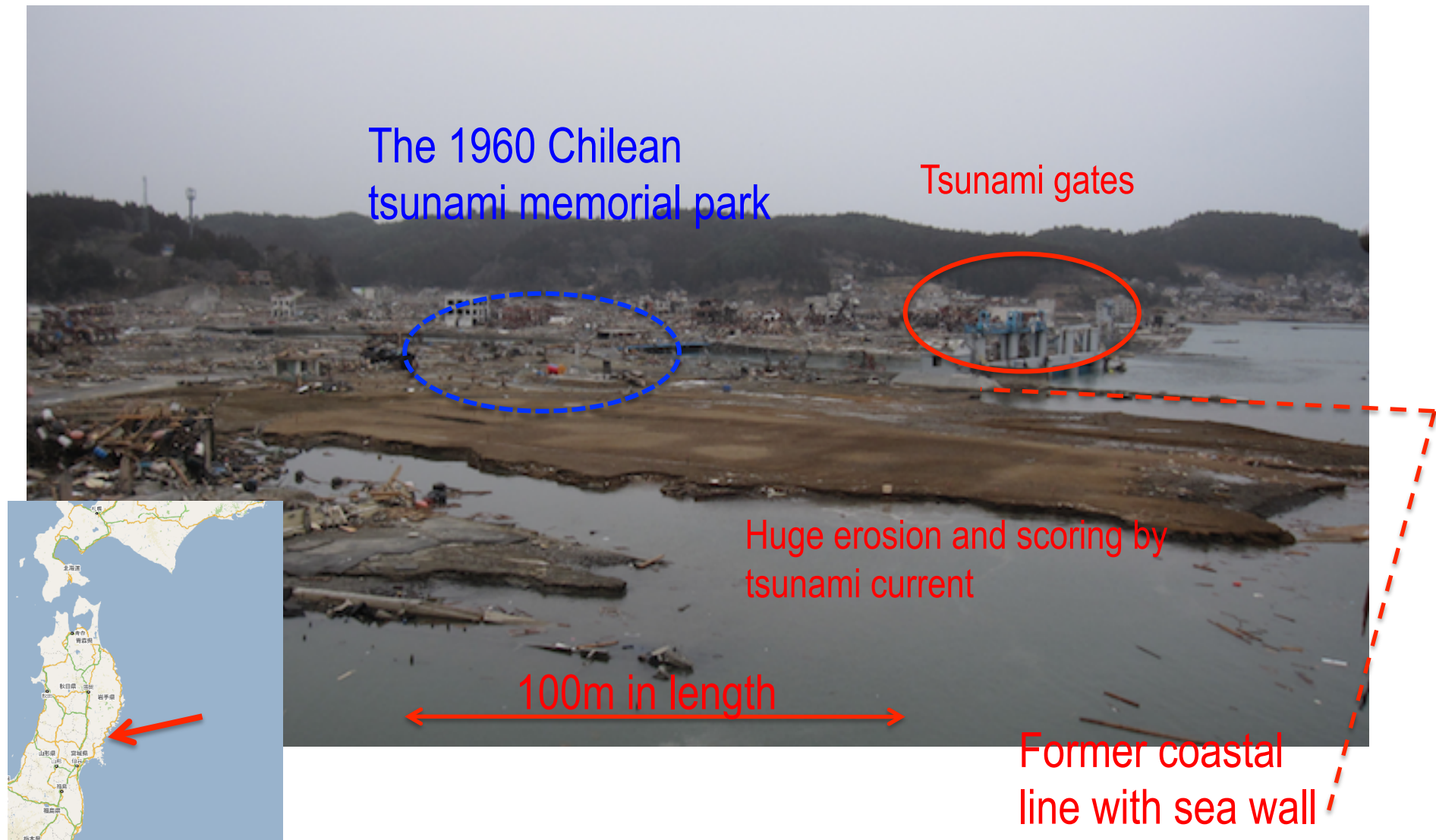
Ships and fire at Kesennuma



Destruction on community at Sendai



Change topography, erosion, destruction on the gates and sea wall at Minami-Sanriku, Miyagi



Destruction on the coastal villages and rail at Higashi Mastushima, Miyagi



Sendai city

岩沼市
Iwanuma city

阿武隈川

亘理大橋

river

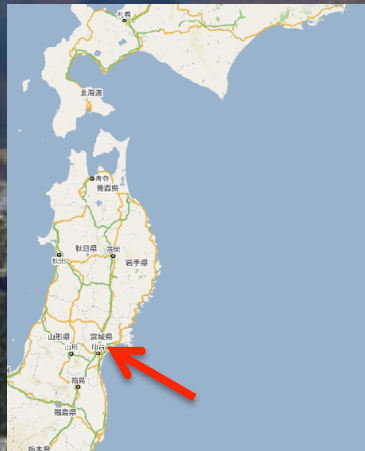
亘理町

Canals

Control forest

Sea wall

Mr.DATE伊達政宗,
Samurai at 1601,
developed Sendai city and
surround area,
constructing Canals and
planting control forest
to mitigate storm and tsunamis



多重の防護ライン

貞山堀Canals

防潮林Control forest

防潮堤Sea wall

Tsunami Evacuation Building (School 4F)

4km内陸には、
浪分神社が存在(元禄16年,
1702)建立



「その後あるとき**大波**があり・・・大波を南北に二分して・・・浪分大明神と呼ばれるようになった」

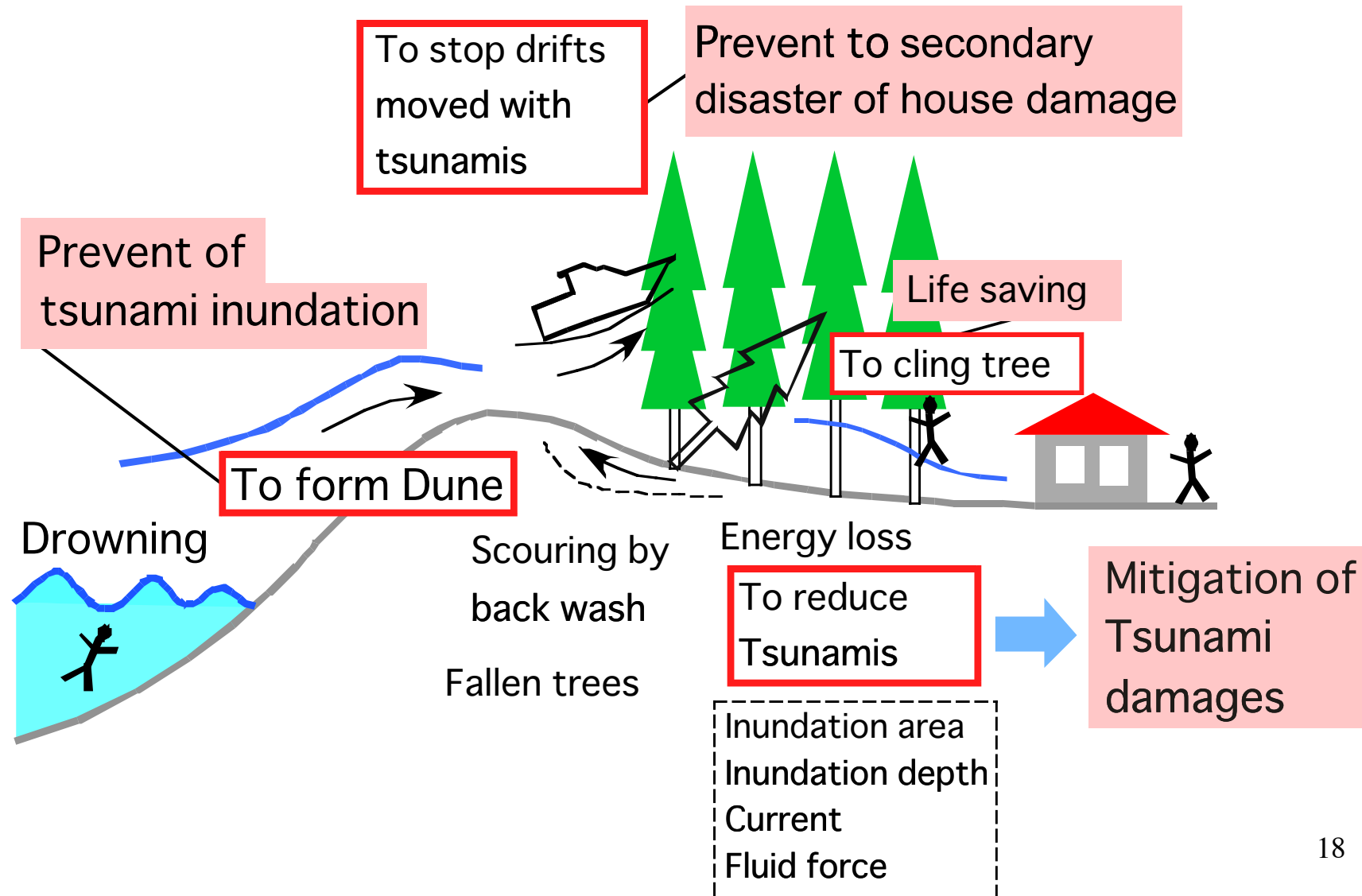


鉄筋コンクリート建物への
構造的被害無し

Around 90 % houses washed away



Several functions of coastal forest in Japan (Harada & Imamura, 2003)



Our Plan on Research

- Rapid and proper recovery and re-construction for long term - safety
- Observation and documentation of the tragedy with several viewpoints; natural, social and human sciences
- Identify the mechanism of earthquake and tsunami specially in the northern Sanriku
- Evaluation of the past countermeasures to identify the issues to solve the problems and develop

Thank you for your attention

Knowing risk
Reducing risk &
Living at risk