Summary on the great East Japan earthquake and tsunami

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- Summary on the great East Japan earthquake
- Tsunami survey report
- Numerical simulations on tsunami （preliminary results）

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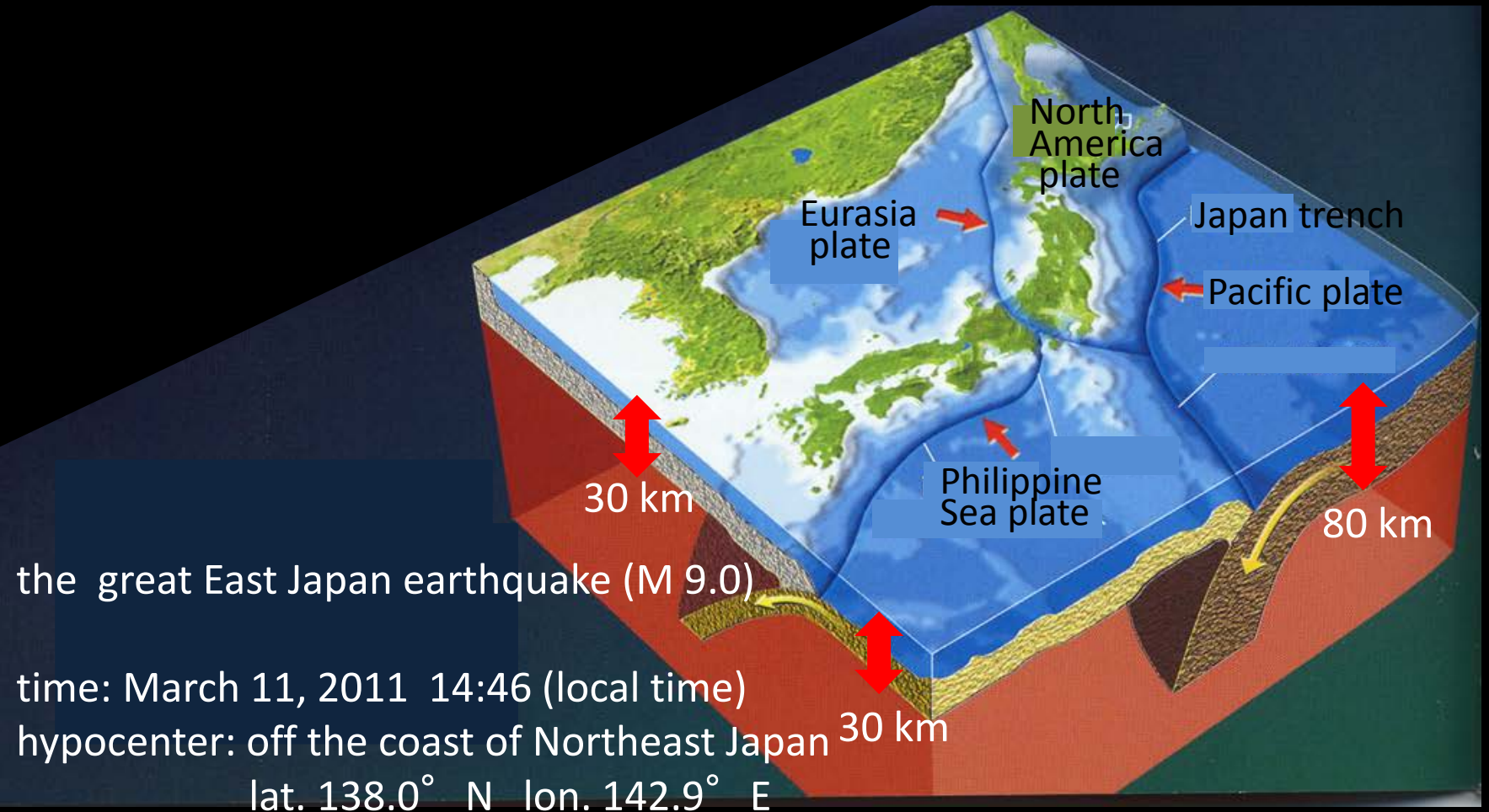
Oceanic and continental plates in and around the Japanese islands

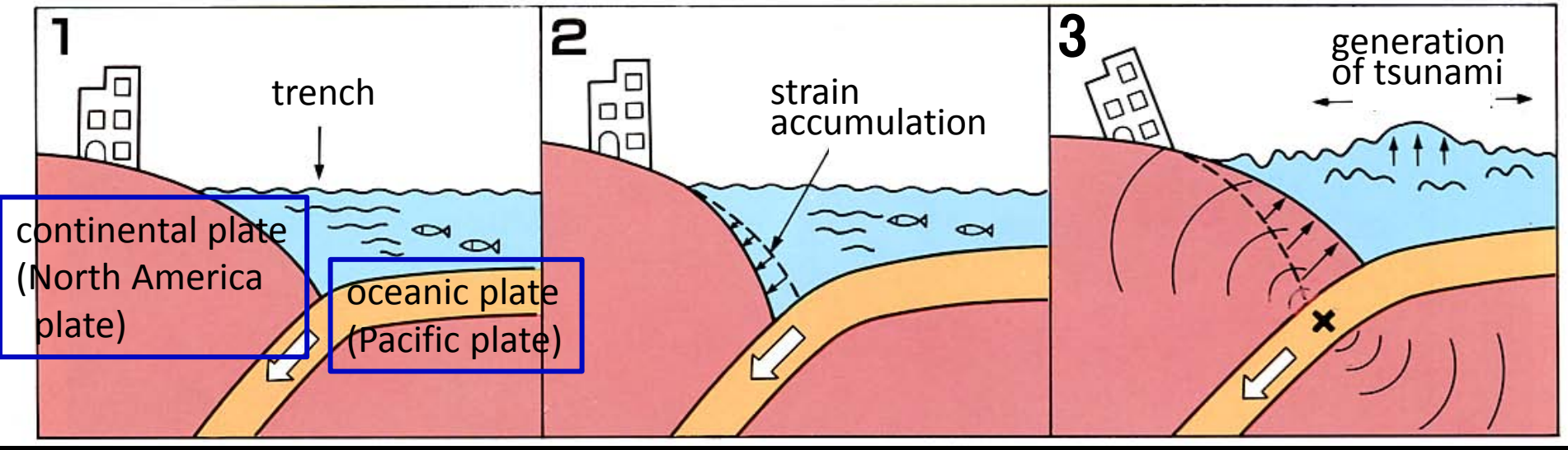


the great East Japan earthquake (M 9.0)

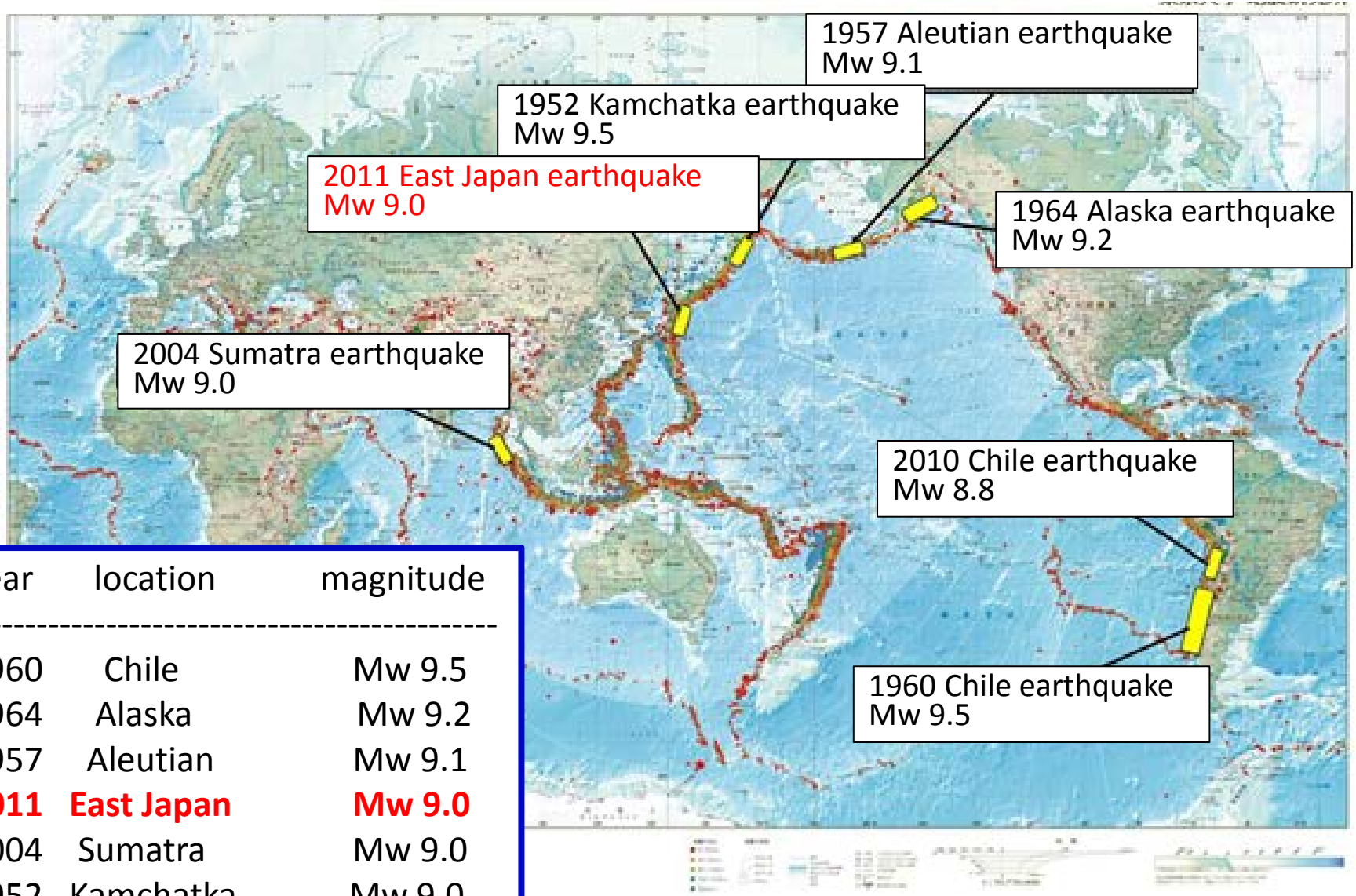
time: March 11, 2011 14:46 (local time)
hypocenter: off the coast of Northeast Japan
lat. 138.0° N lon. 142.9° E
depth 24 km
fault size: 450 km × 200 km

(modified from Shimazaki et al., 2002)

Generation mechanism of a trench-type megathrust earthquake

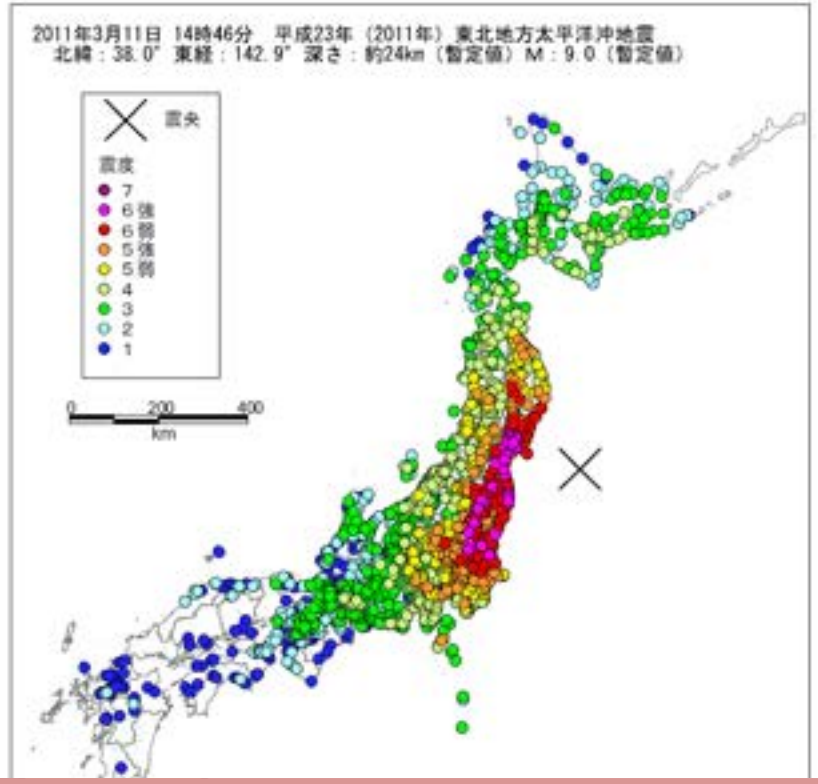


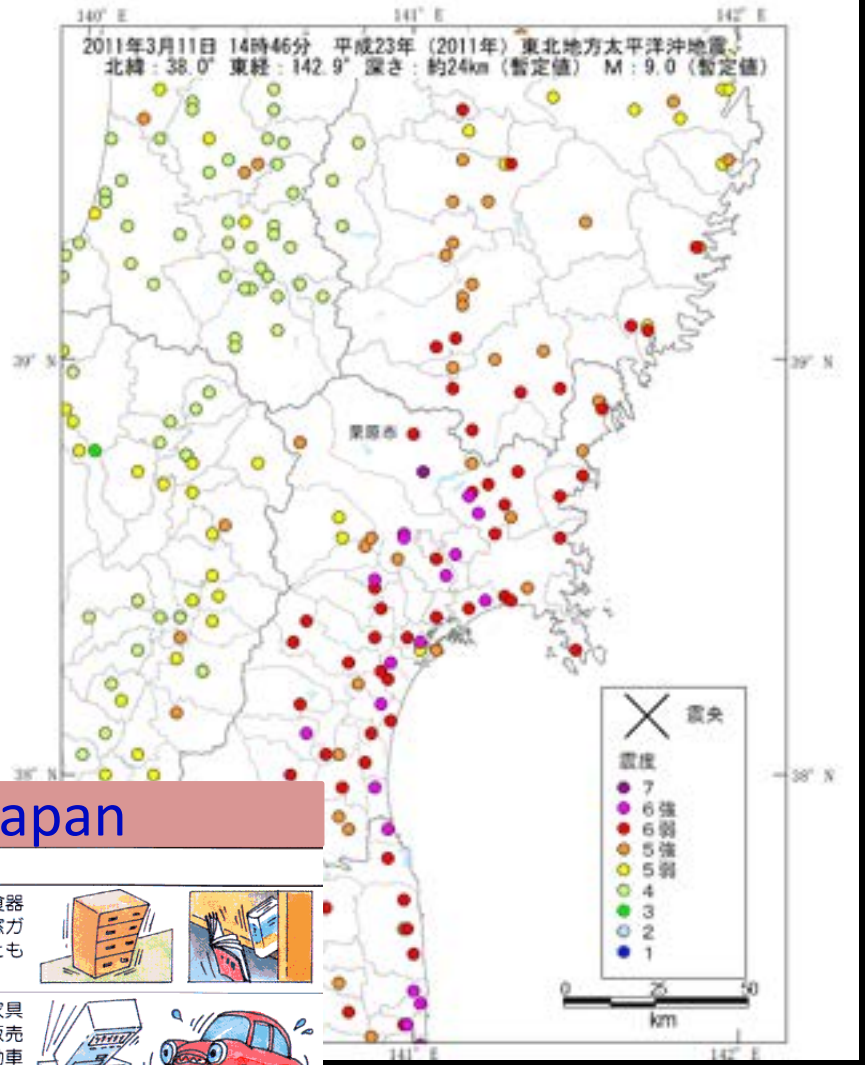
Trench-type great earthquakes ever recorded in the world



year	location	magnitude
1960	Chile	Mw 9.5
1964	Alaska	Mw 9.2
1957	Aleutian	Mw 9.1
2011	**East Japan**	**Mw 9.0**
2004	Sumatra	Mw 9.0
1952	Kamchatka	Mw 9.0

modified from ERI, Univ. of Tokyo





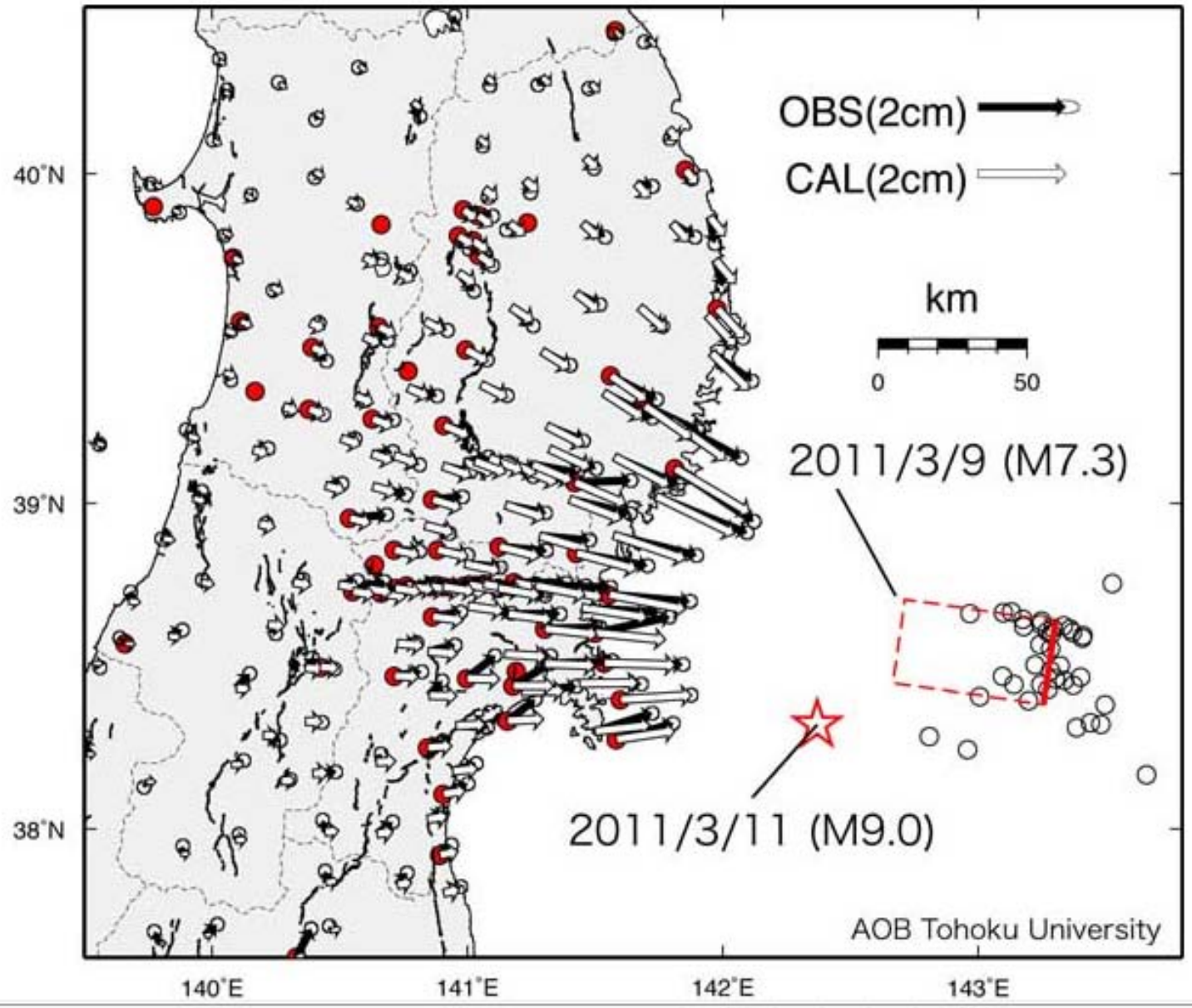
seismic intensity scale in Japan

（気象庁震度階級より作成）

0	人は揺れを感じない。	5 weak	家具が移動し、食器や本が落ちる。窓ガラスが割れることもある。
1	屋内にいる人の一部がわずかな揺れを感じる。	5 strong	タンスなど重い家具や、外では自動販売機が倒れる。自動車の運転は困難。
2	屋内にいる人の多くが揺れを感じる。つり下がっている電灯などがわずかに揺れる。	6 weak	立っていることが難しい。壁のタイルや窓ガラスが壊れ、壁に亀裂が入る。
3	屋内のほとんどの人が揺れを感じ、棚の食器が音をたてることがある。	6 strong	立っていられず、はわないと動くことができない。戸がはずれて飛ぶこともある。ブロック塀が崩れる。
4	眠っている人のほとんどが目を覚ます。部屋の不安定な置物が倒れる。歩行中の人も揺れを感じる。	7	自分の意思で行動ができない。大きな地割れや地すべり、山崩れが発生する。

[jma_s.05.avi](jma_s.05.avi)

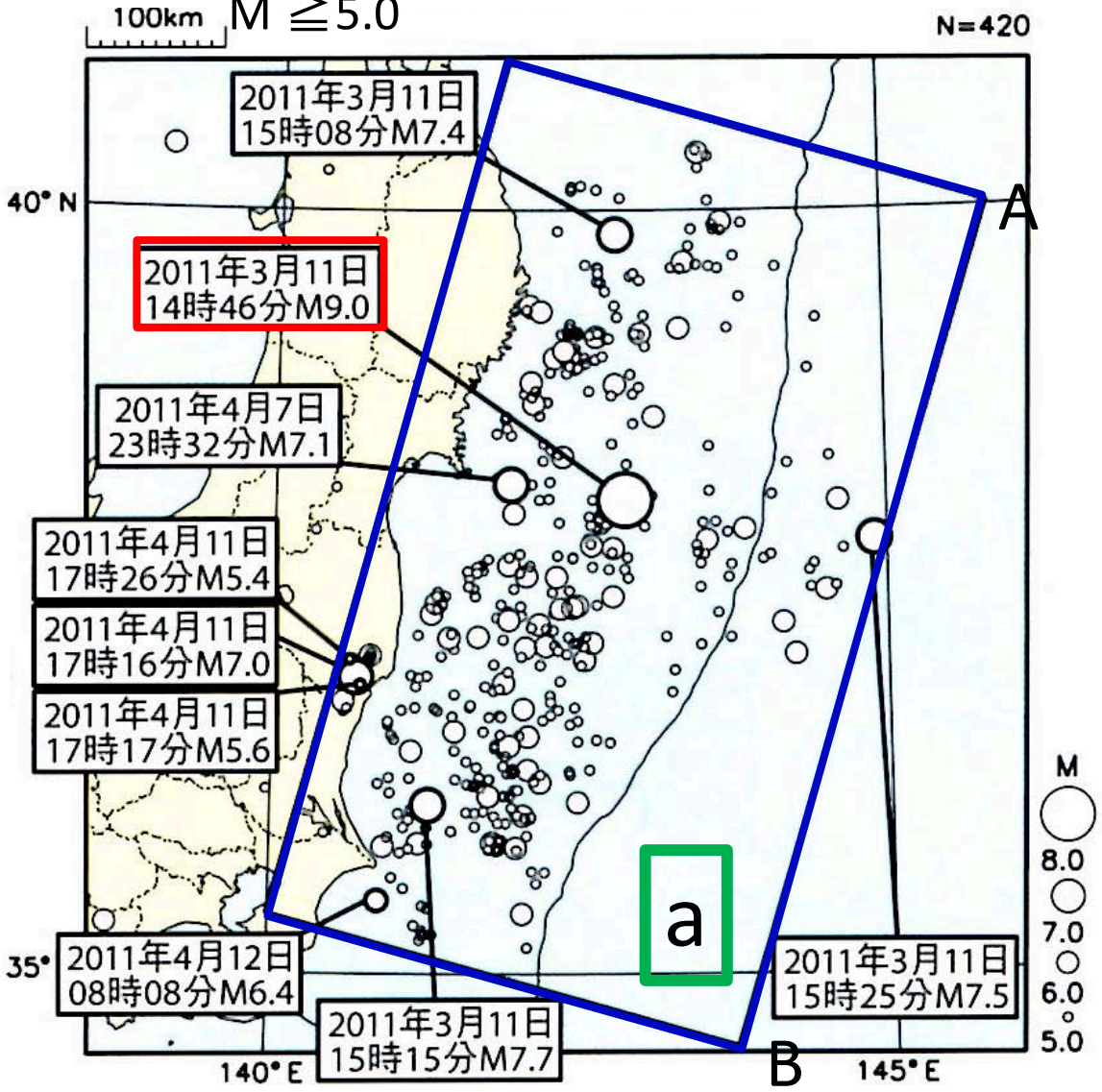
Spatial relation between the fault plane of the Sanriku-oki earthquake (March 9, 2011) and the epicenter of the great East Japan earthquake



http://www.aob.geophys.tohoku.ac.jp/info/topics/20110311_news/

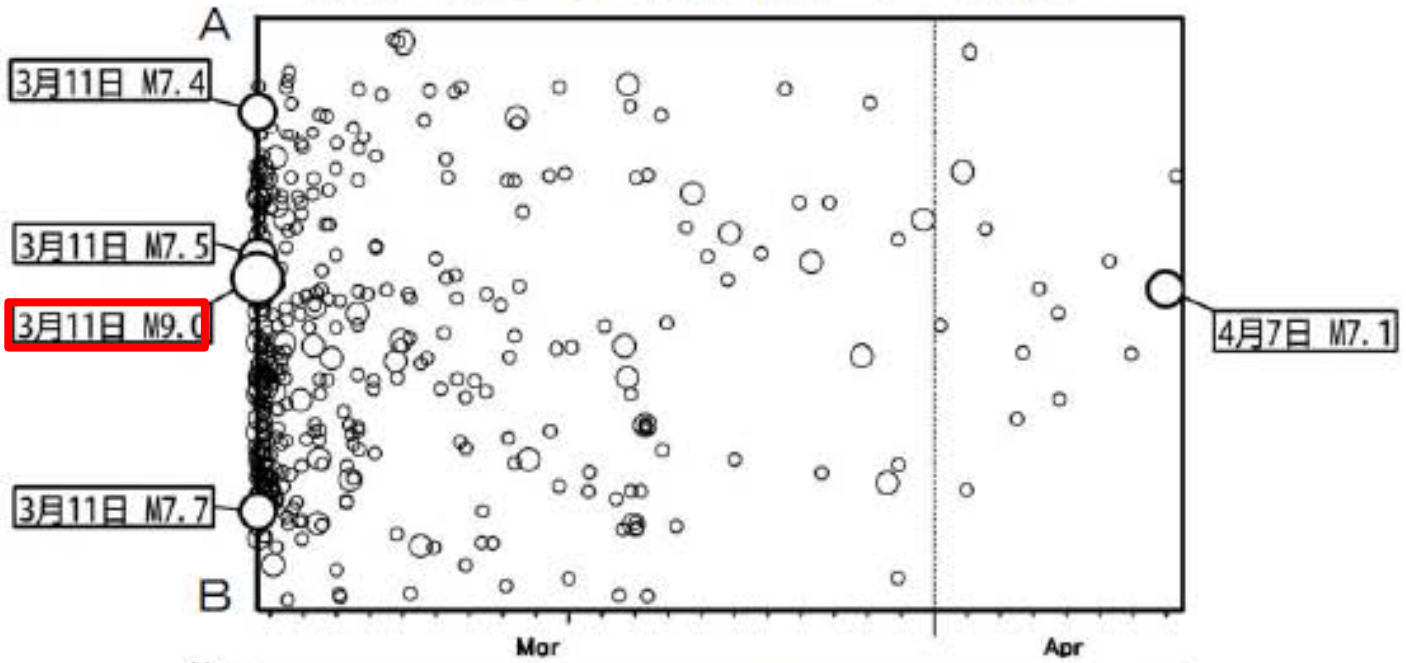
Aftershock distribution of the 2011 great East Japan earthquake

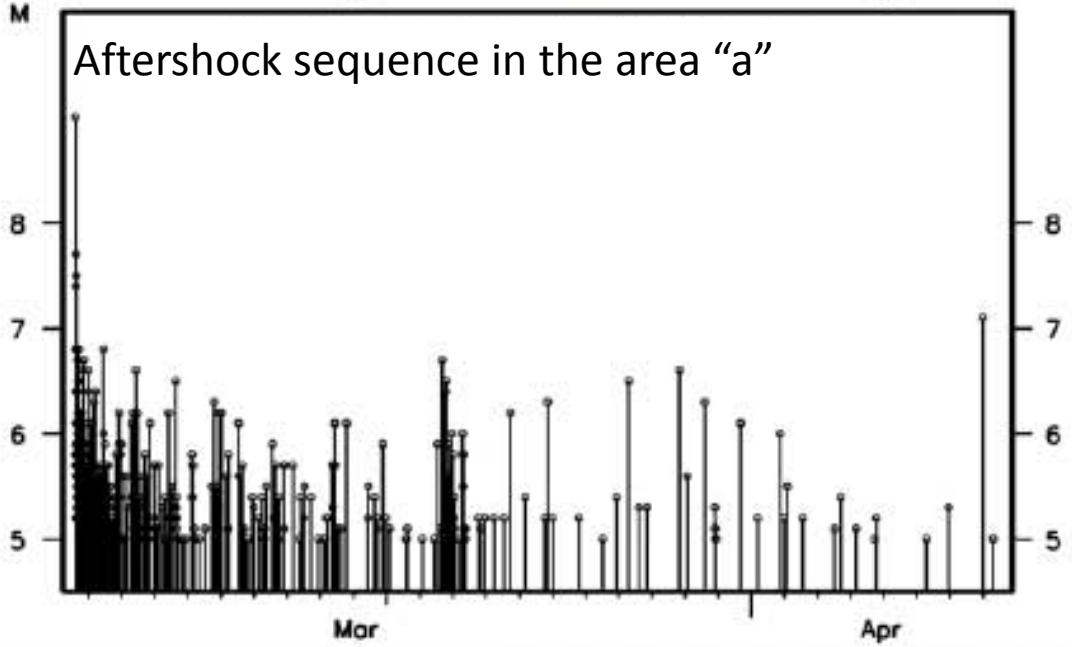
March 11, 2011 12:00－April 12 11:00
shallower than a depth of 90 km
M ≧5.0



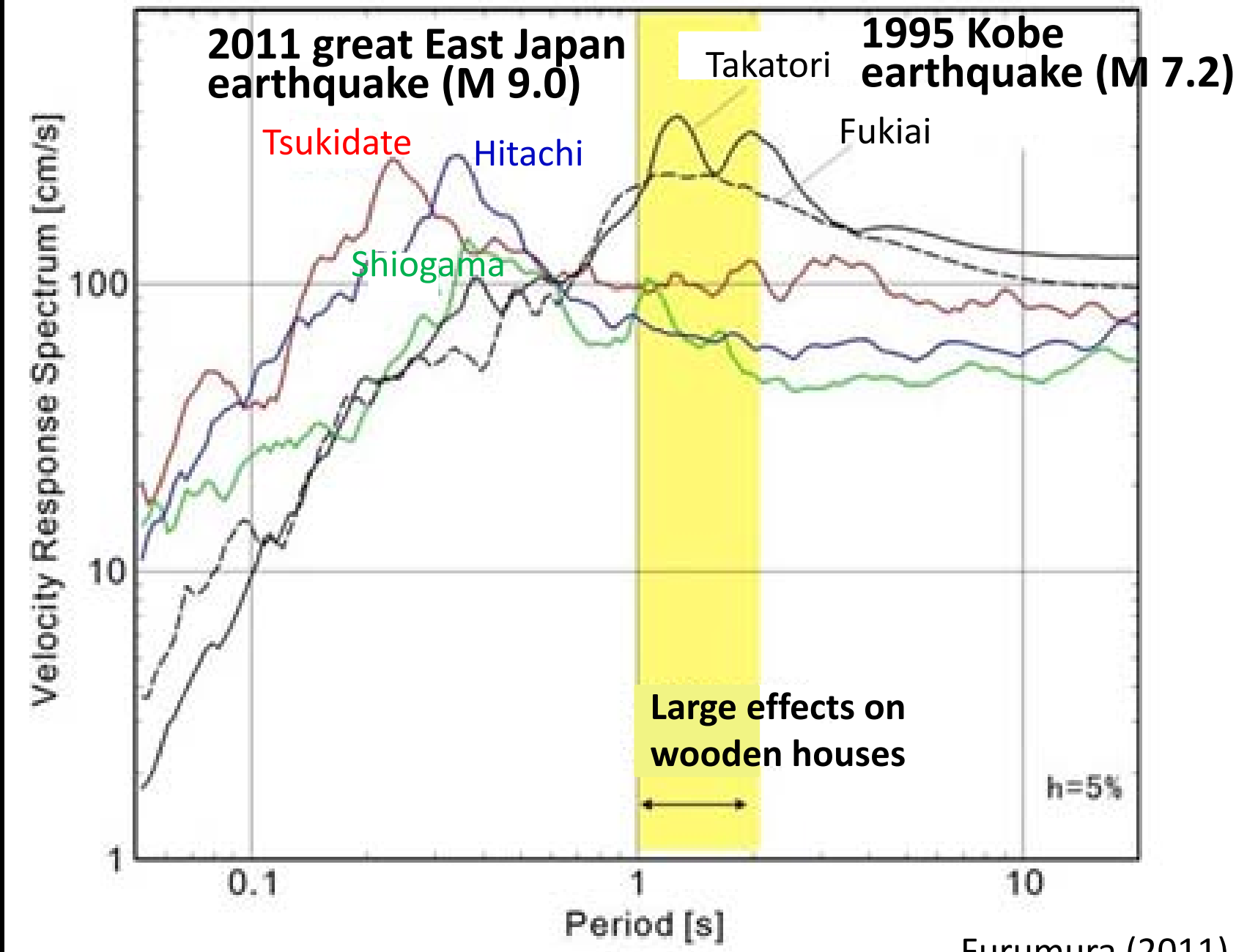
earthquake headquarter news（2011）

Space-time plot of aftershocks in the area “a” (A-B projection)





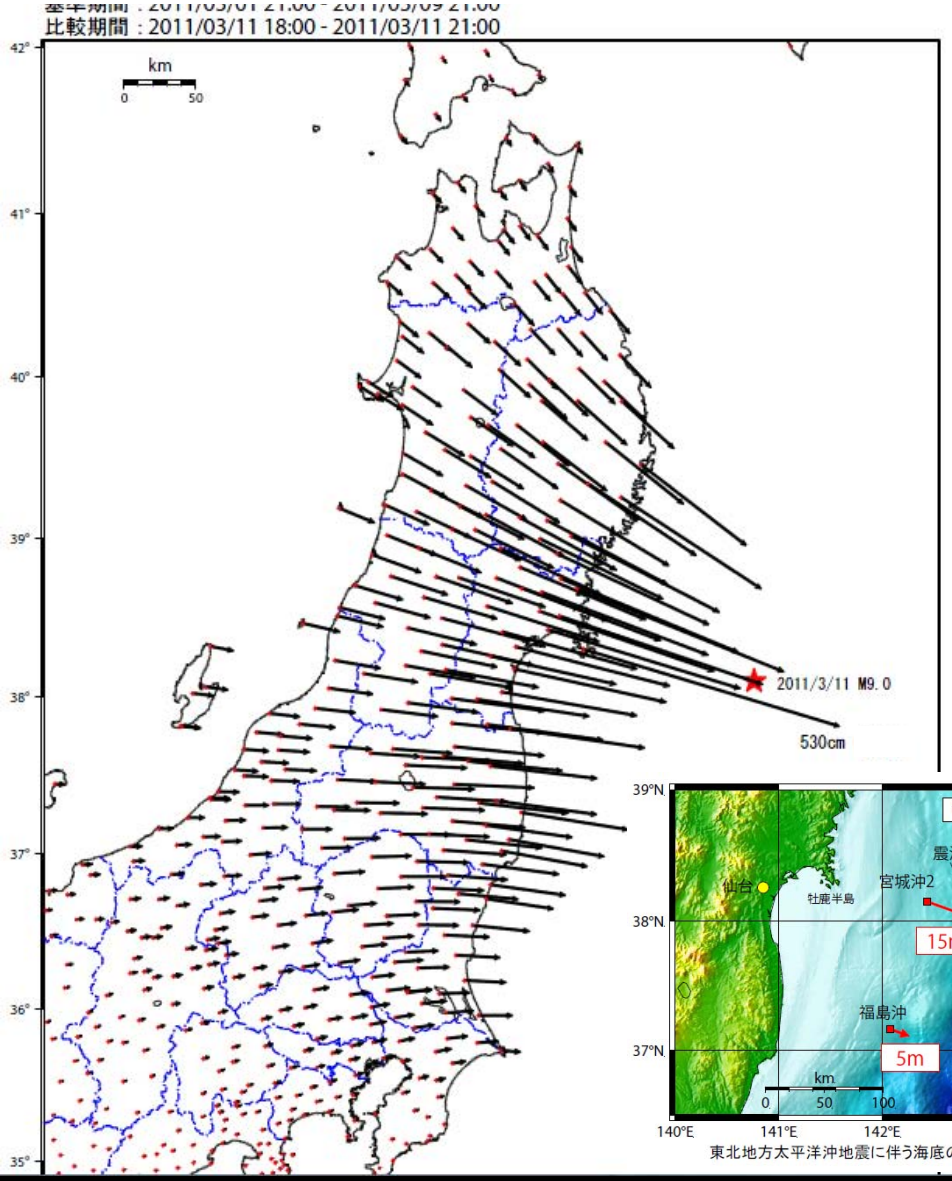
Japan Meteorological Agency



Furumura (2011)

Crustal deformation obtained by GPS associated with the main shock (M9.0)

horizontal component

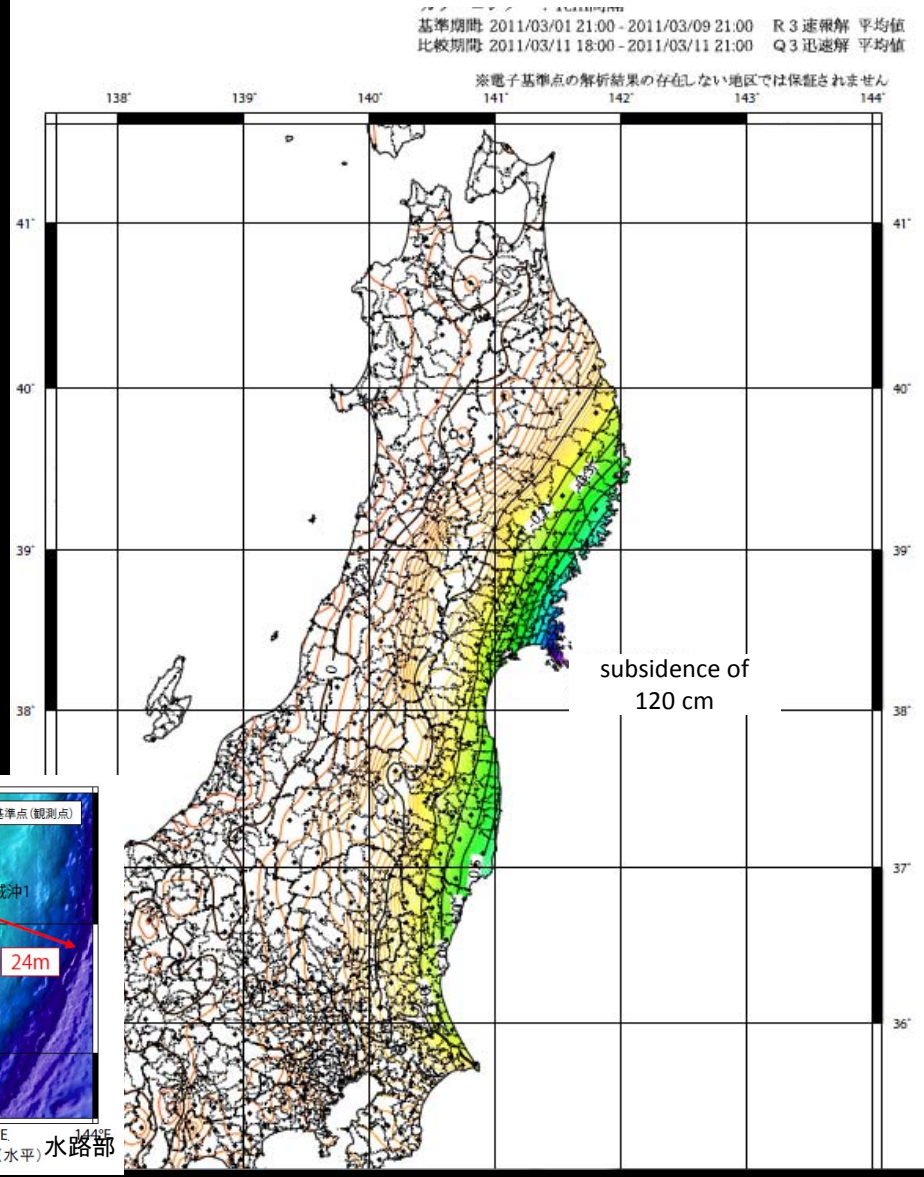


東北地方太平洋沖地震に伴う海底の動き（水平）

水路部

Crustal deformation obtained by GPS associated with the main shock (M9.0)

vertical component

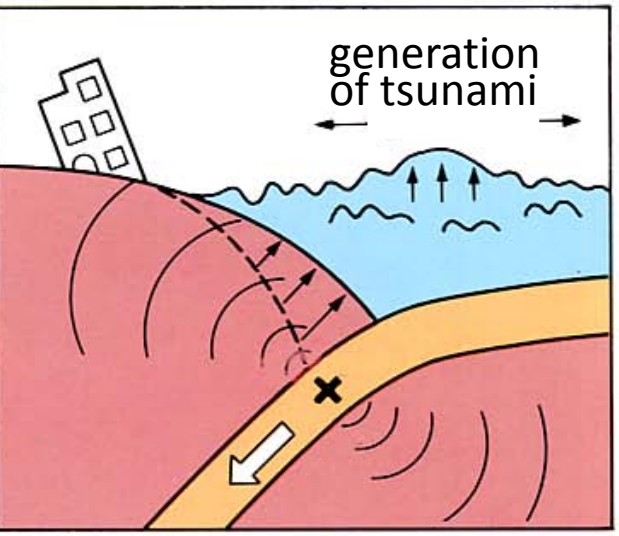


subsidence of 120 cm

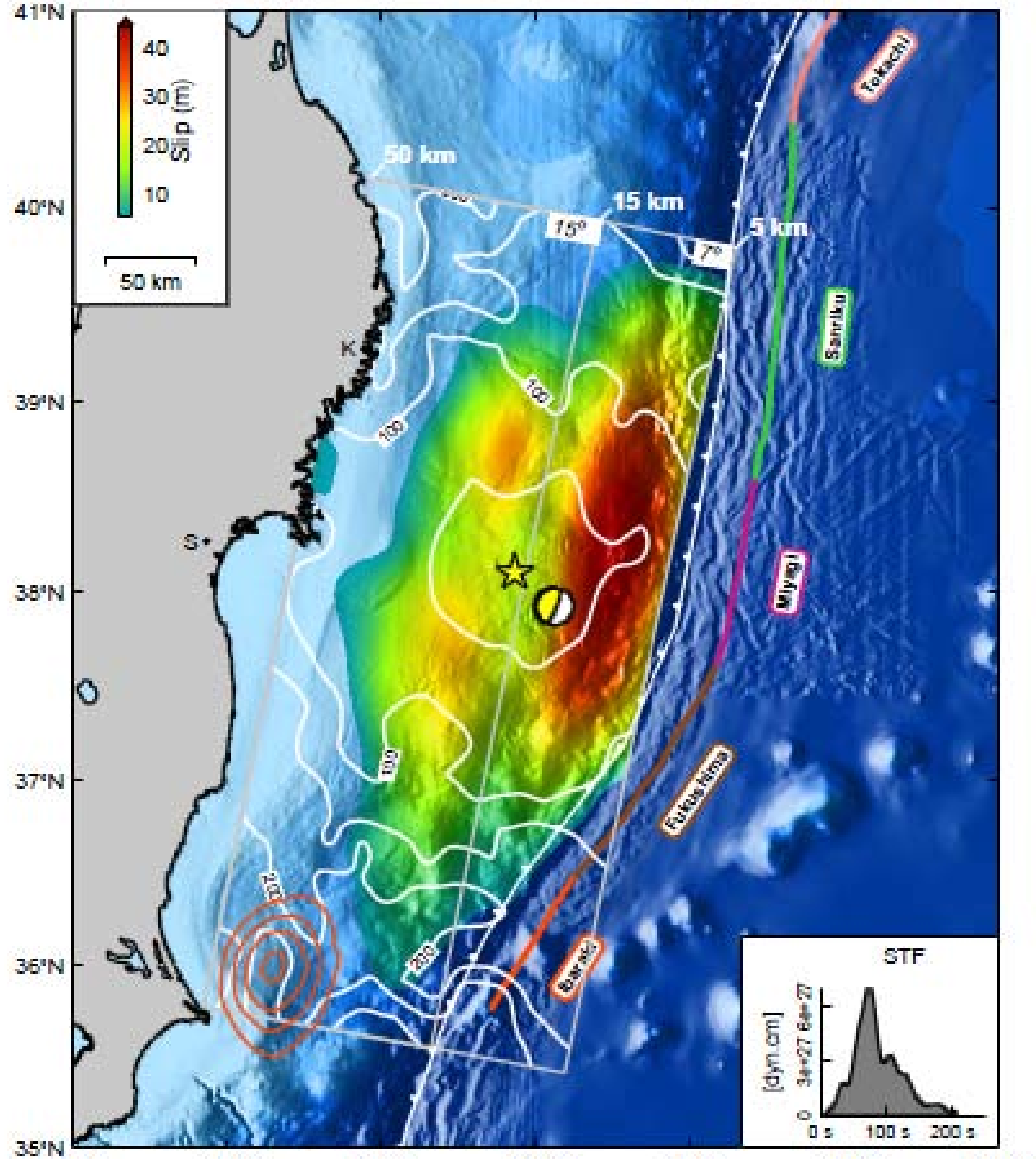
http://www.gsi.go.jp/common/000059672.pdf

Geospatial Information Authority of Japan

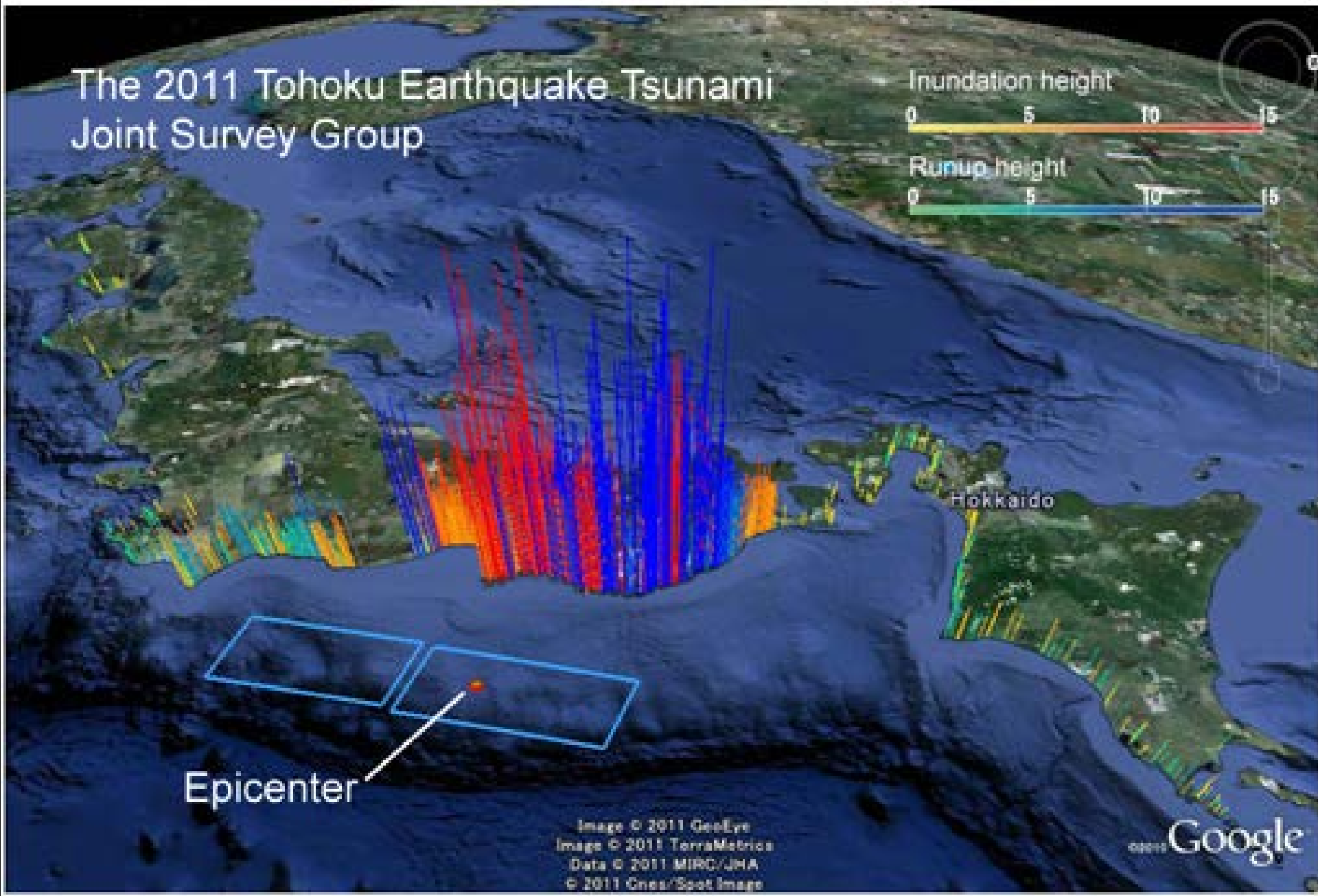
GPS+ teleseismic



Simons et al. (2011)

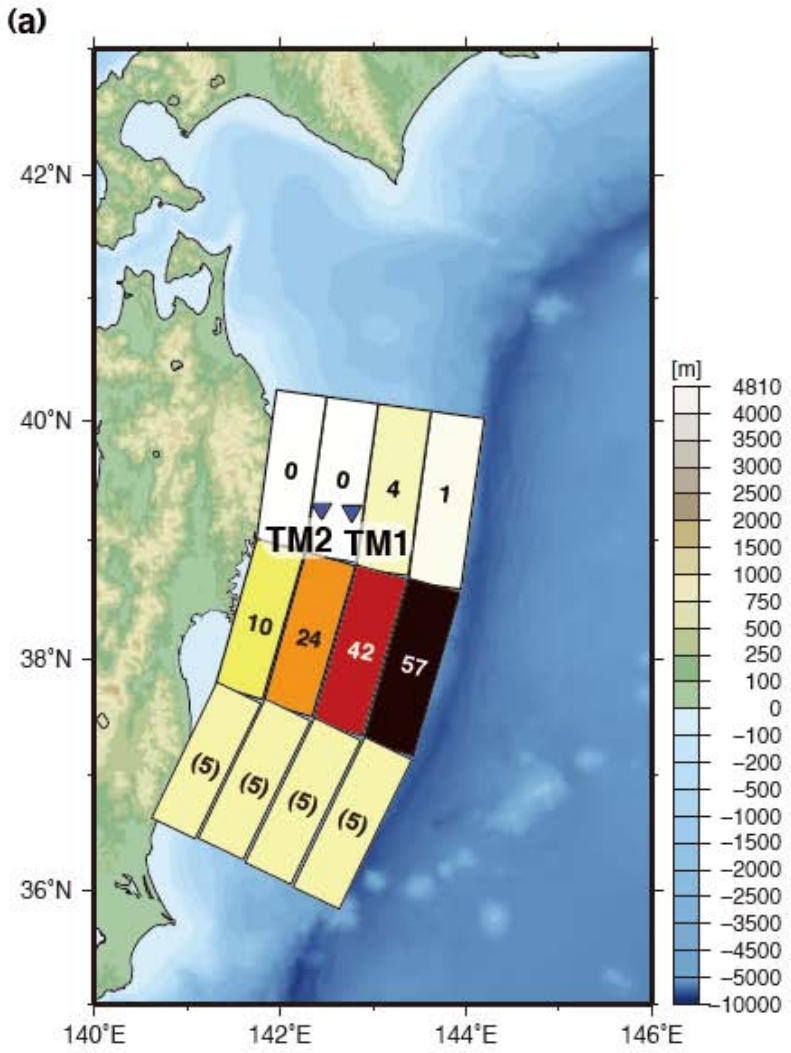


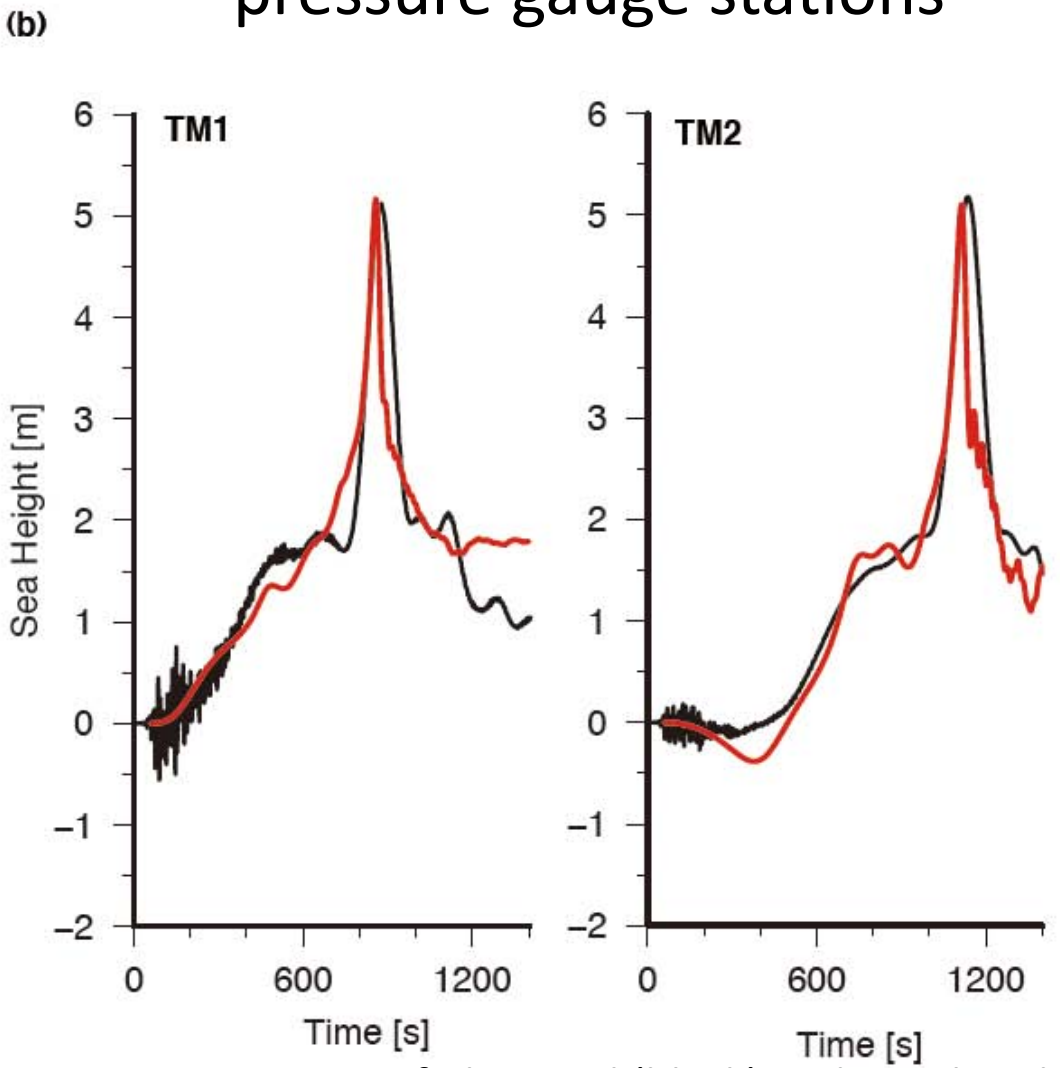
Spatial distribution of observed tsunami height



Estimated slip distribution in meters for each subfault

Tsunami waves recorded at offshore ocean bottom pressure gauge stations

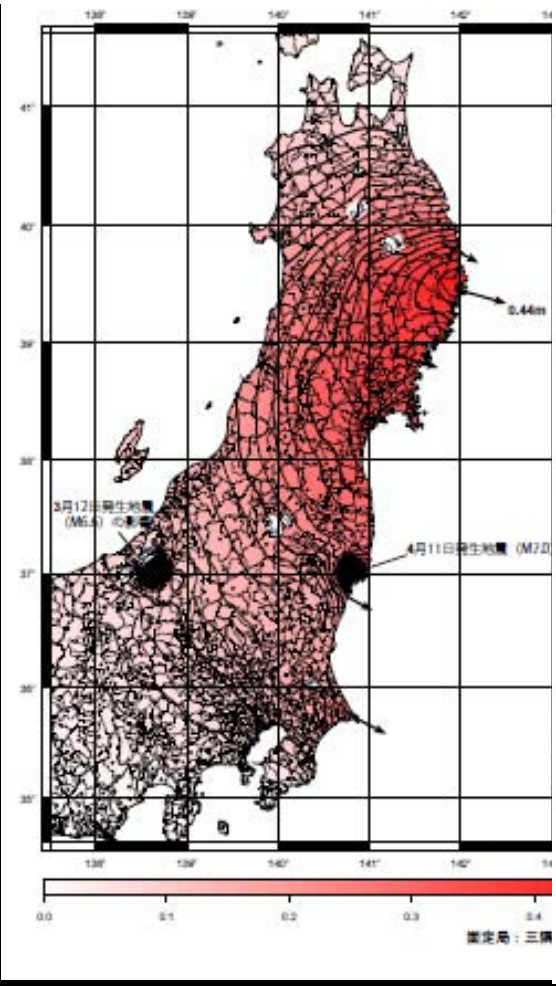




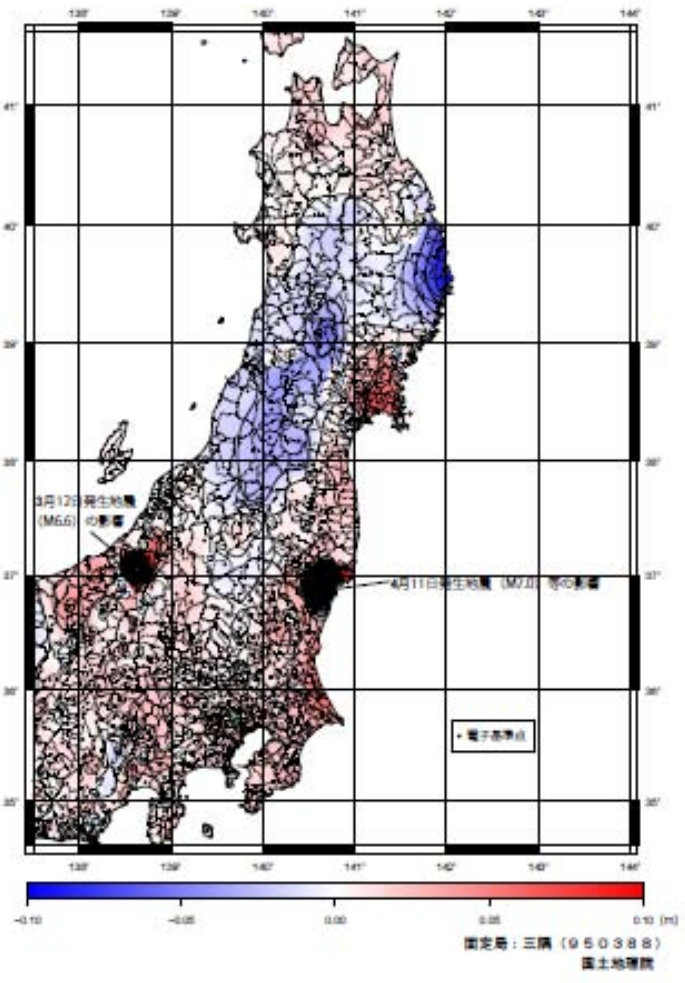
Maeda et al. (2011)

Comparison of observed (black) and simulated (red) tsunami traces at stations TM1 and TM2.

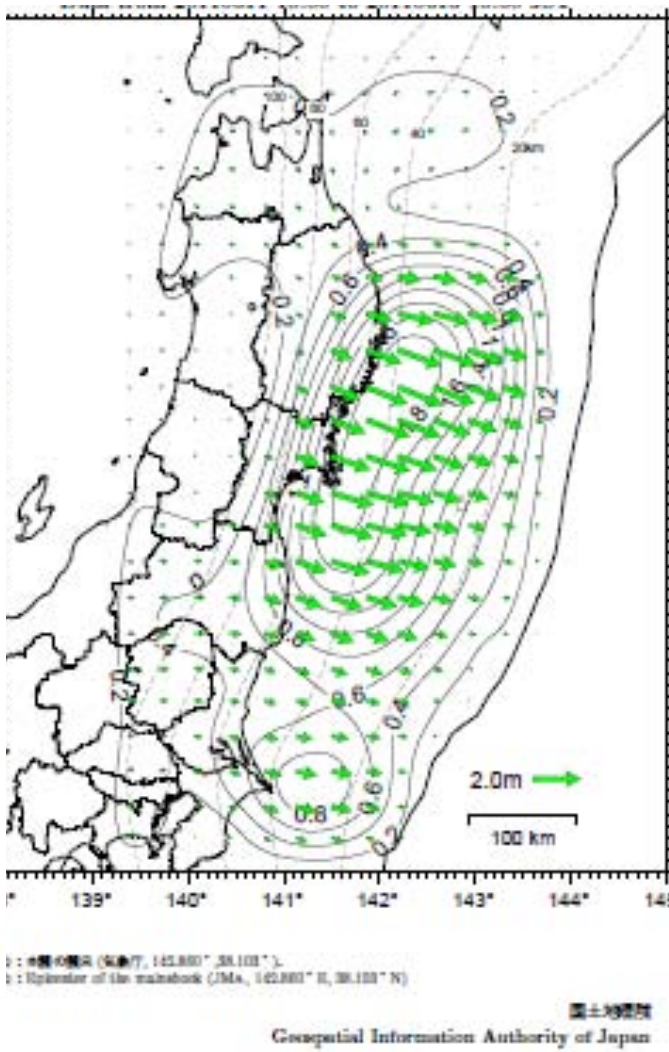
Horizontal movement obtained by GPS for three months following the main shock



Vertical movement obtained by GPS for three months following the main shock



Estimated slip distribution on the plate interface for three months following the main shock



Geospatial Information Authority of Japan

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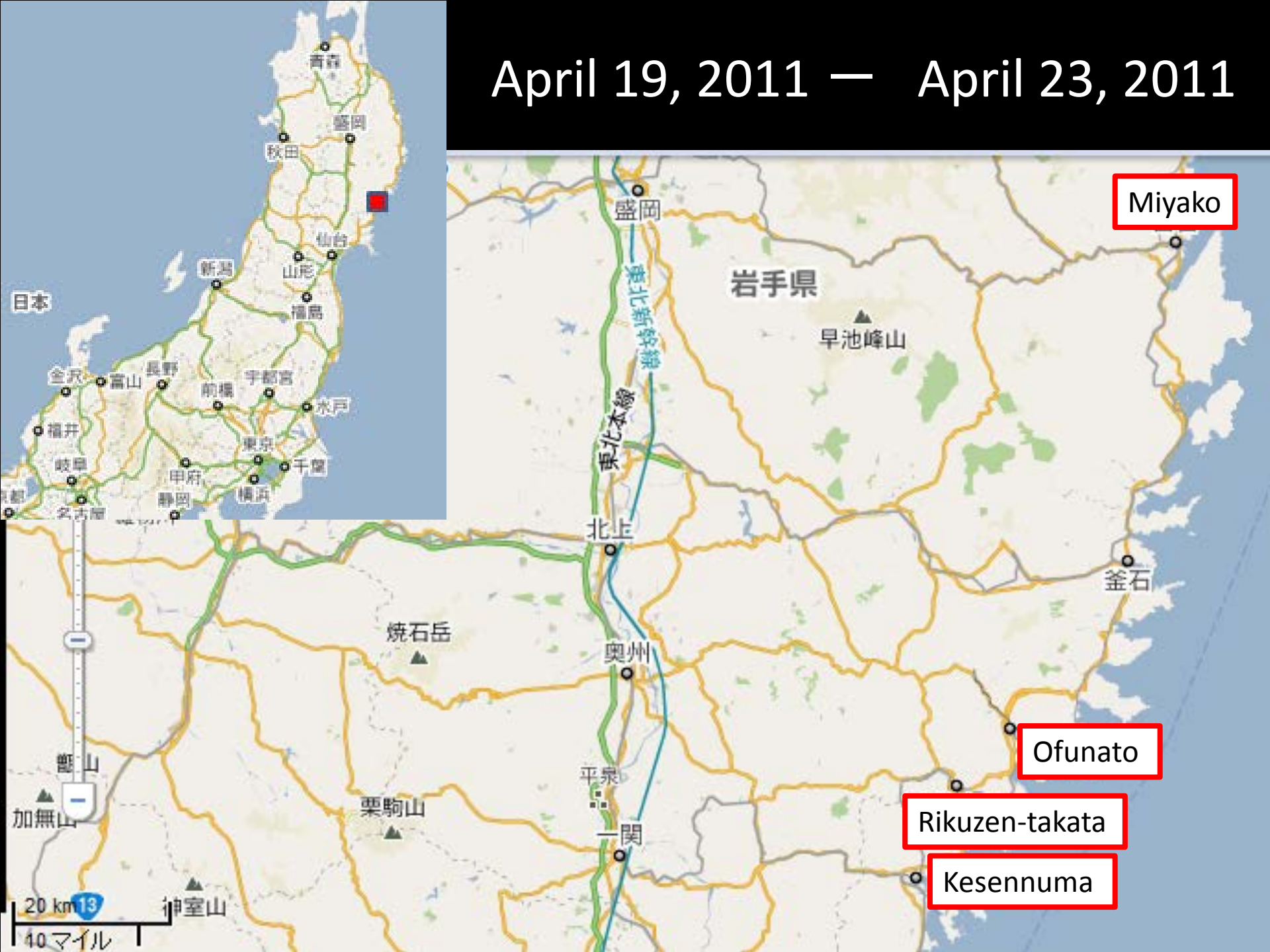

April 19, 2011 — April 23, 2011
Miyako
Ofunato
Rikuzen-takata
Kesennuma
盛岡
岩手県
早池峰山
北上
釜石
奥州
焼石岳
栗駒山
一関
平泉
日本
青森
秋田
仙台
新潟
山形
福島
金沢
富山
長野
前橋
宇都宮
水戸
福井
岐阜
東京
千葉
甲府
横浜
静岡
名古屋
20 km
40 マイル

Miyako

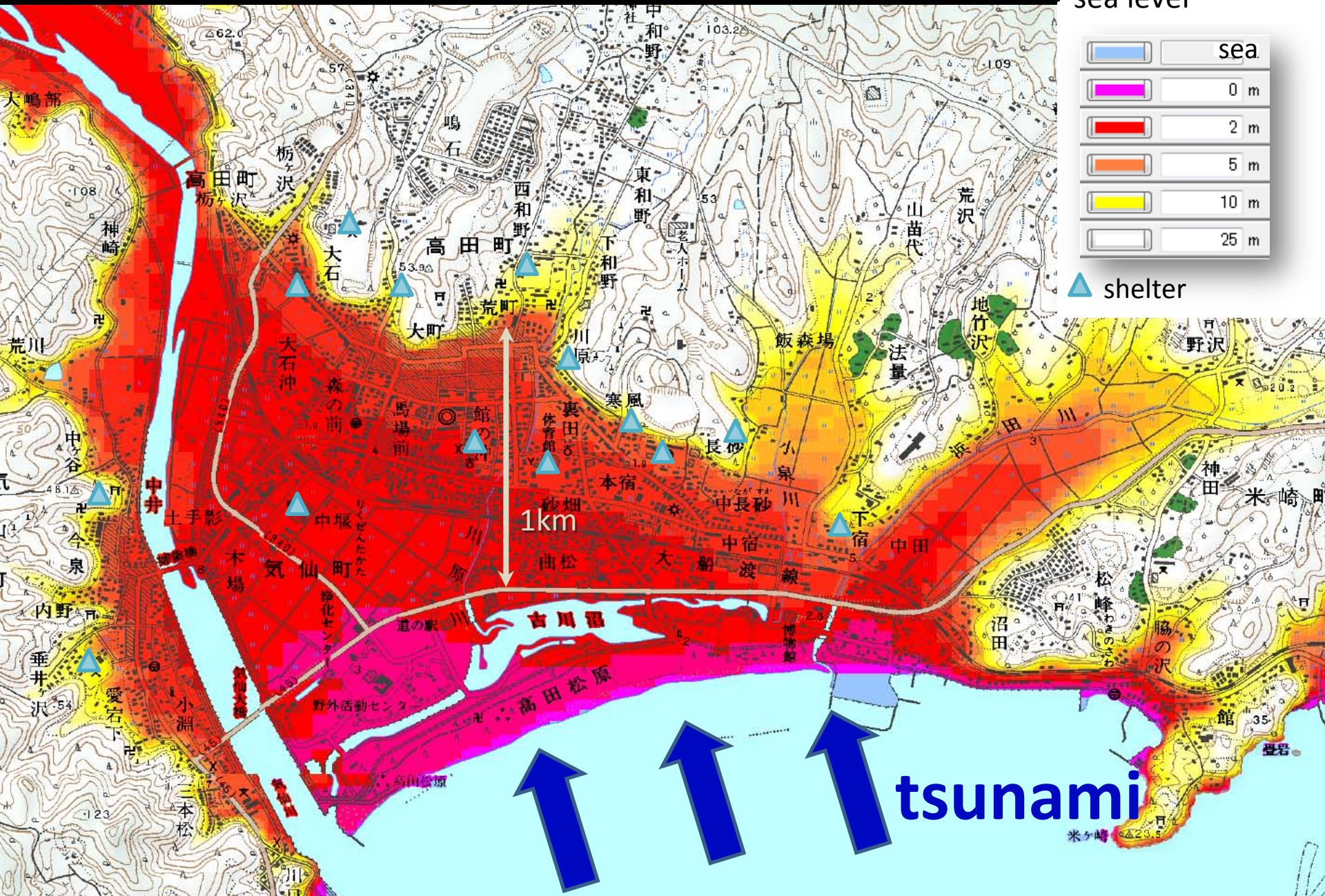
VIDEO

Miyako City Office

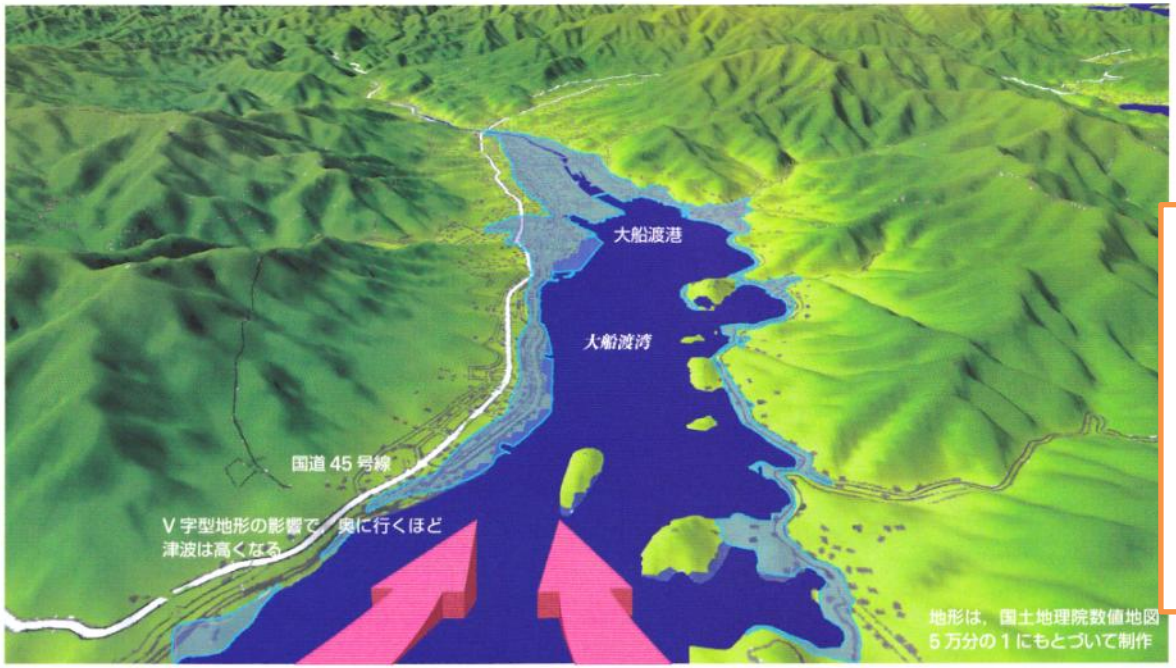
tsunami protective wall

Rikuzen-takata

Land height above sea level in Rikuzen-takata



In general, behavior of tsunami at a V-shaped bay is ・・



奥に行くほどせまい地形が波を高くした —— リアス式海岸「大船渡」

東北地方太平洋沖地震で大きな被害を受けた大船渡市（大船渡港付近）を南側上空からのぞんだイメージである。湾の両側に山がせまり，奥に行くほど湾がせまくなる地形になっていることがよくわかる。大船渡湾では地震発生から 29 分後に津波の観測器（検潮計）の針が振り切れた。その後，気象庁による現地調査で 11.8 メートルの波高が確認されている。水色の領域は浸水域。

（Newton, June, 2011）

Tsunami concentration takes place at the bottom of a V-shaped bay, and tsunami is amplified

Serious damage caused by the tsunami is considered to have occurred at the bottom of the V-shaped bay

deeply indented coastline (V-shaped bays)

Ryori
tsunami inundation height = 16.6m
tsunami run-up height = 23.82m

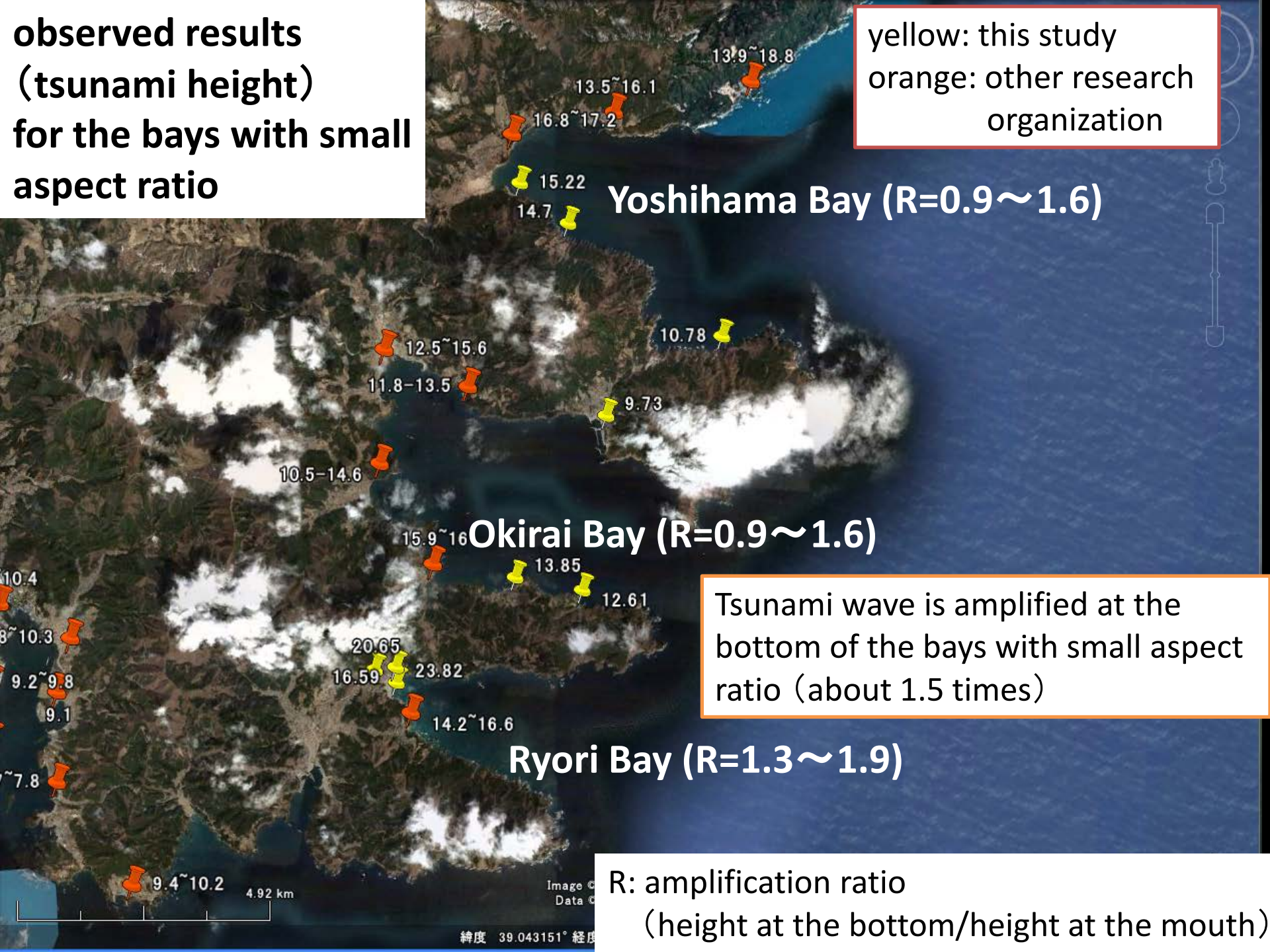
on-site tsunami height survey

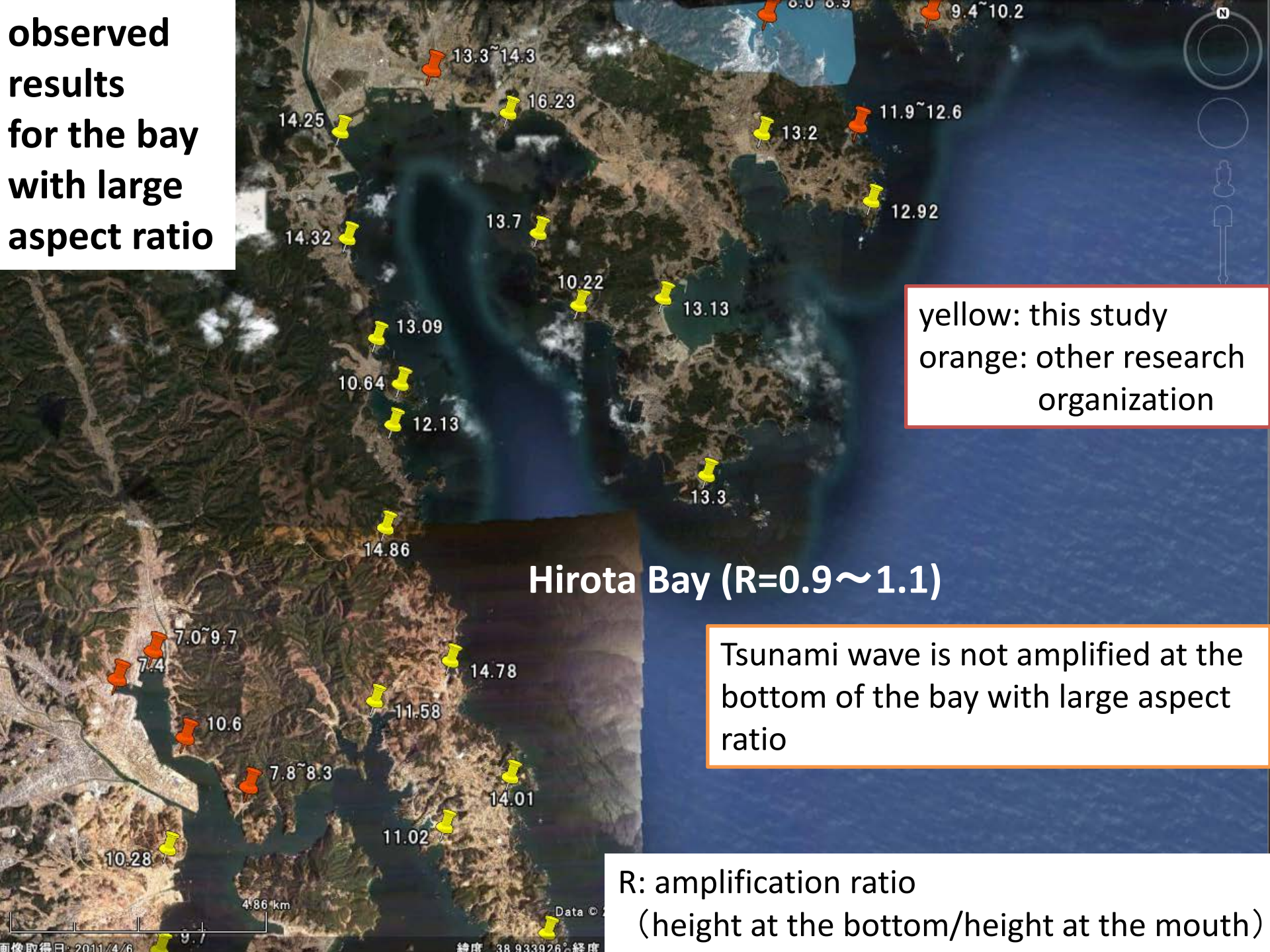
April 20, 2011 — April 23, 2011

Shoichi Yoshioka Kobe Univ.
Mamoru Nakamura Ryukyu Univ.
Kazuomi Hirakawa Hokkaido Univ.
Yuka Nishikawa Taiwan Univ.

Rikuzen-takata (Horota Bay)
tsunami inundation height = 14.3m

observed results （tsunami height） for the bays with small aspect ratio




observed results for the bay with large aspect ratio
13.3~14.3
16.23
14.25
9.4~10.2
11.9~12.6
13.2
12.92
13.7
14.32
10.22
13.13
13.09
10.64
12.13
13.3
14.86
Hirota Bay (R=0.9～1.1)
yellow: this study
orange: other research organization
Tsunami wave is not amplified at the bottom of the bay with large aspect ratio
7.0~9.7
7.4
14.78
11.58
10.6
7.8~8.3
14.01
11.02
10.28
R: amplification ratio
（height at the bottom/height at the mouth）

Summary on observed results of tsunami height

- On-site survey at Ofunato, Rikuzen-takata, and Kesennuma
  —maximum height：Ryori（23.82m）

- Amplification ratio of tsunami in the bays（height at the bottom/height at the mouth）for the 2011 great East Japan earthquake
  – Bays with small aspect ratio：
    0.9—1.9・・・・same or amplified at the bottom
  – Bays with large aspect ratio：
    0.7—1.0・・・・no amplification at the bottom

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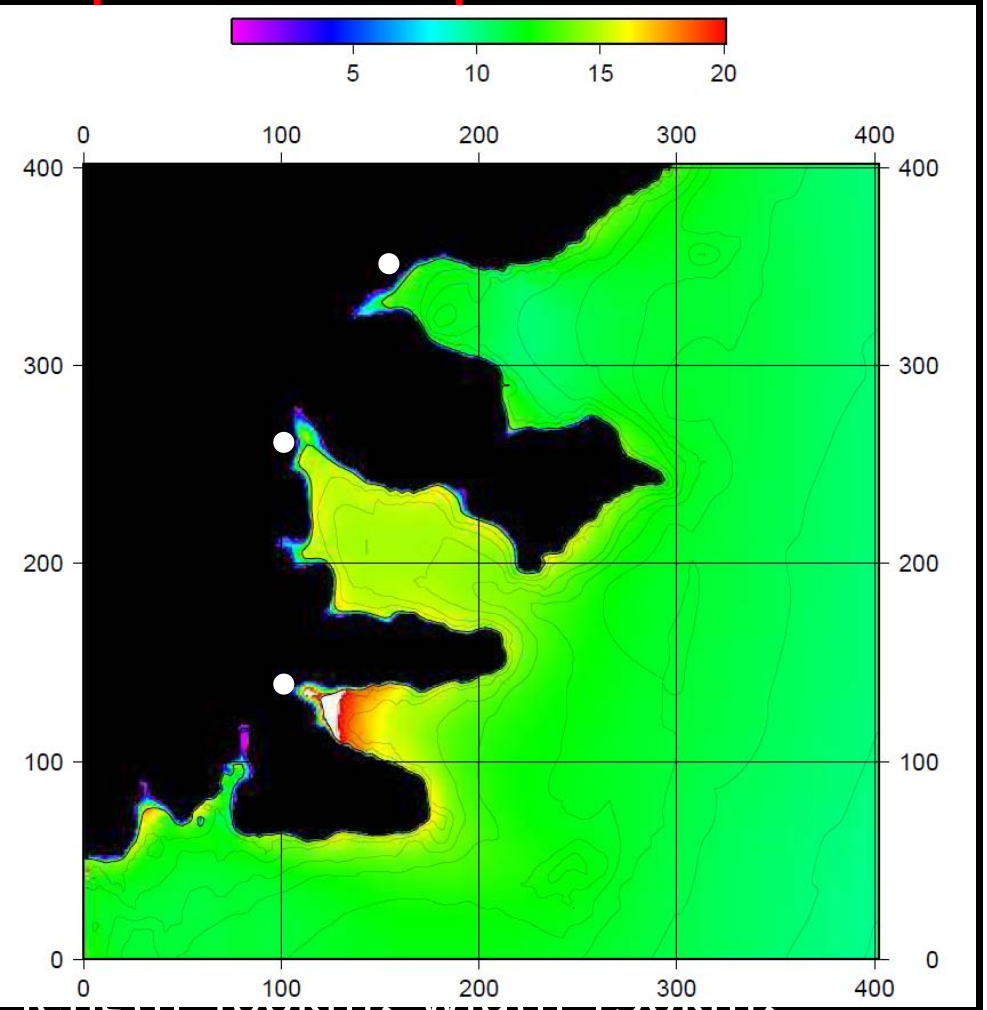
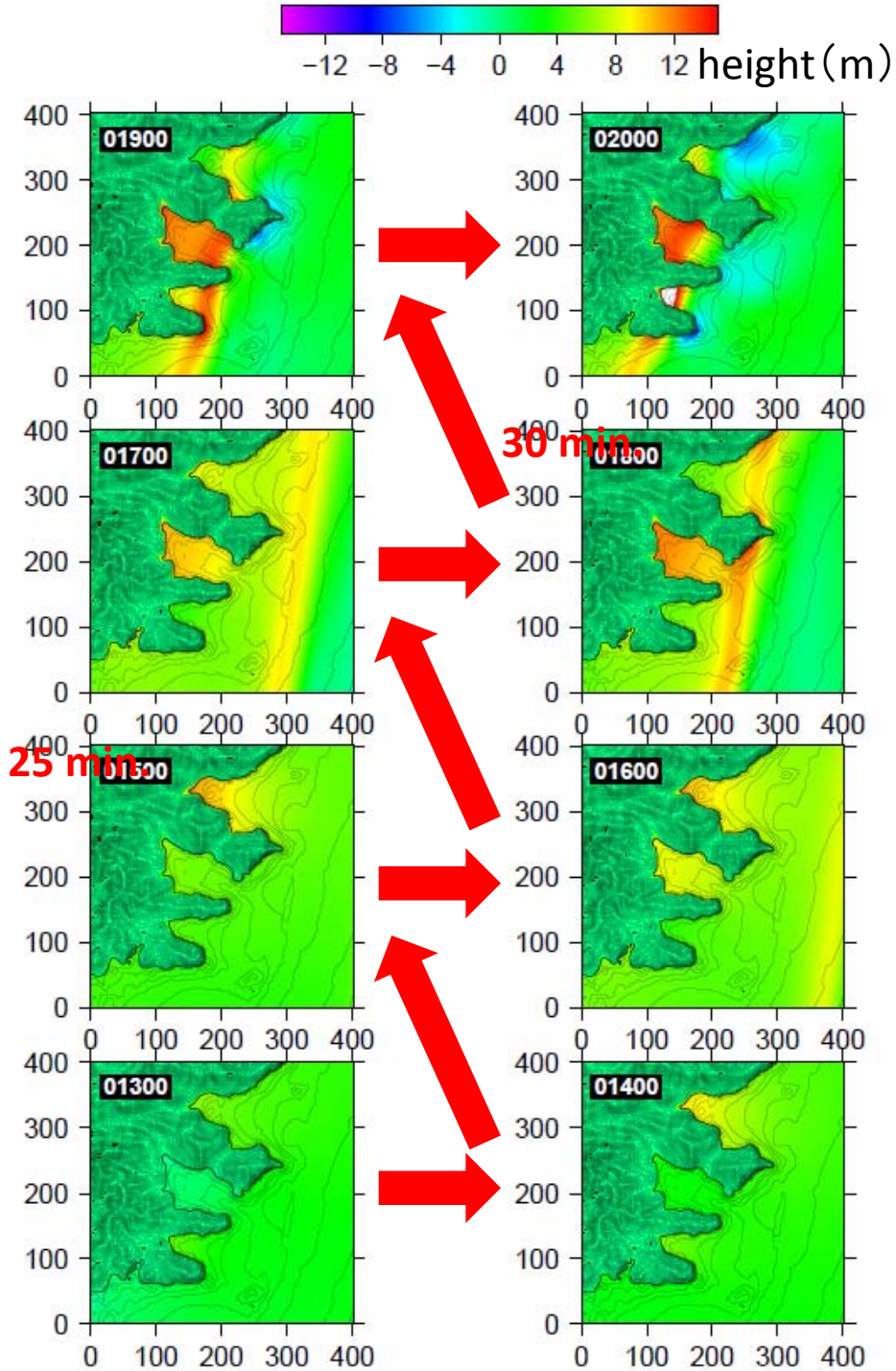
fault size: 500 km × 250 km　slip: 17 m

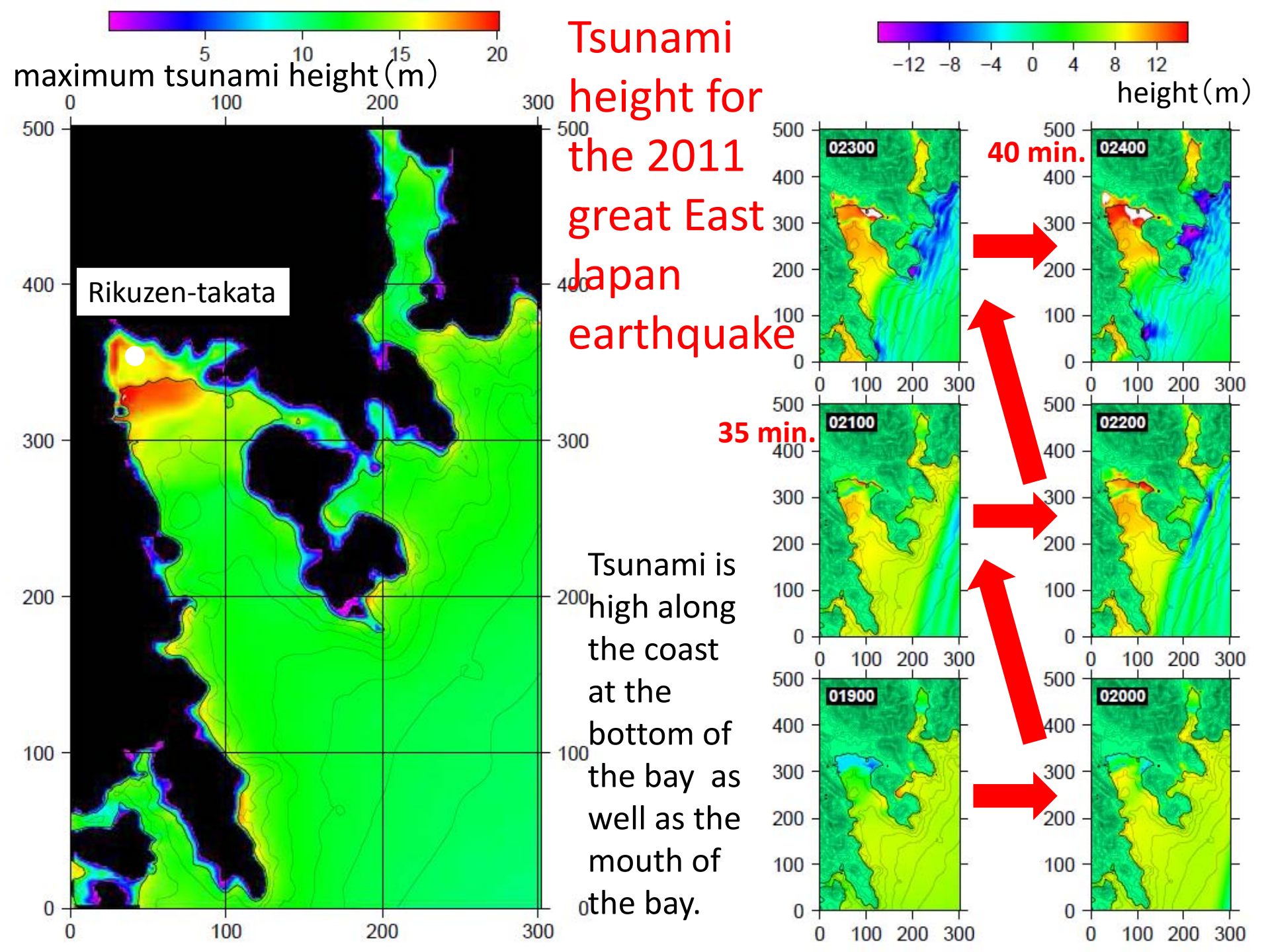
Maeda and Furumura（2011）

the 2011 great East Japan earthquake



amount of slip 15m
referred from Fujii et al. (2011) and Maeda et al. (2011)




maximum tsunami height (m)
5
10
15
20
Rikuzen-takata
Tsunami height for the 2011 great East Japan earthquake
height (m)
−12
−8
−4
0
4
8
12
02300
40 min.
02400
02100
35 min.
02200
01900
02000
Tsunami is high along the coast at the bottom of the bay as well as the mouth of the bay.

Tsunami height in the bays with small aspect ratio

- Tsunami is amplified at the bottom of the Ryori Bay
- Variation of tsunami height at the mouth and bottom of the bay is small for the Yoshihama and the Okirai Bays
- Tsunami might be high at the Ryori Bay due to geographical features prone to collect tsunami effectively

Tsunami height in the bays with large aspect ratio

- Tsunami height at the bottom is almost the same as that at the mouth

Thank you very much for your attention