The image cannot be displayed. Your computer may not have enough memory to open the image, or the image may have been corrupted. Restart your computer, and then open the file again. If the red x still appears, you may have to delete the image and then insert it again.

Dynamic Earth

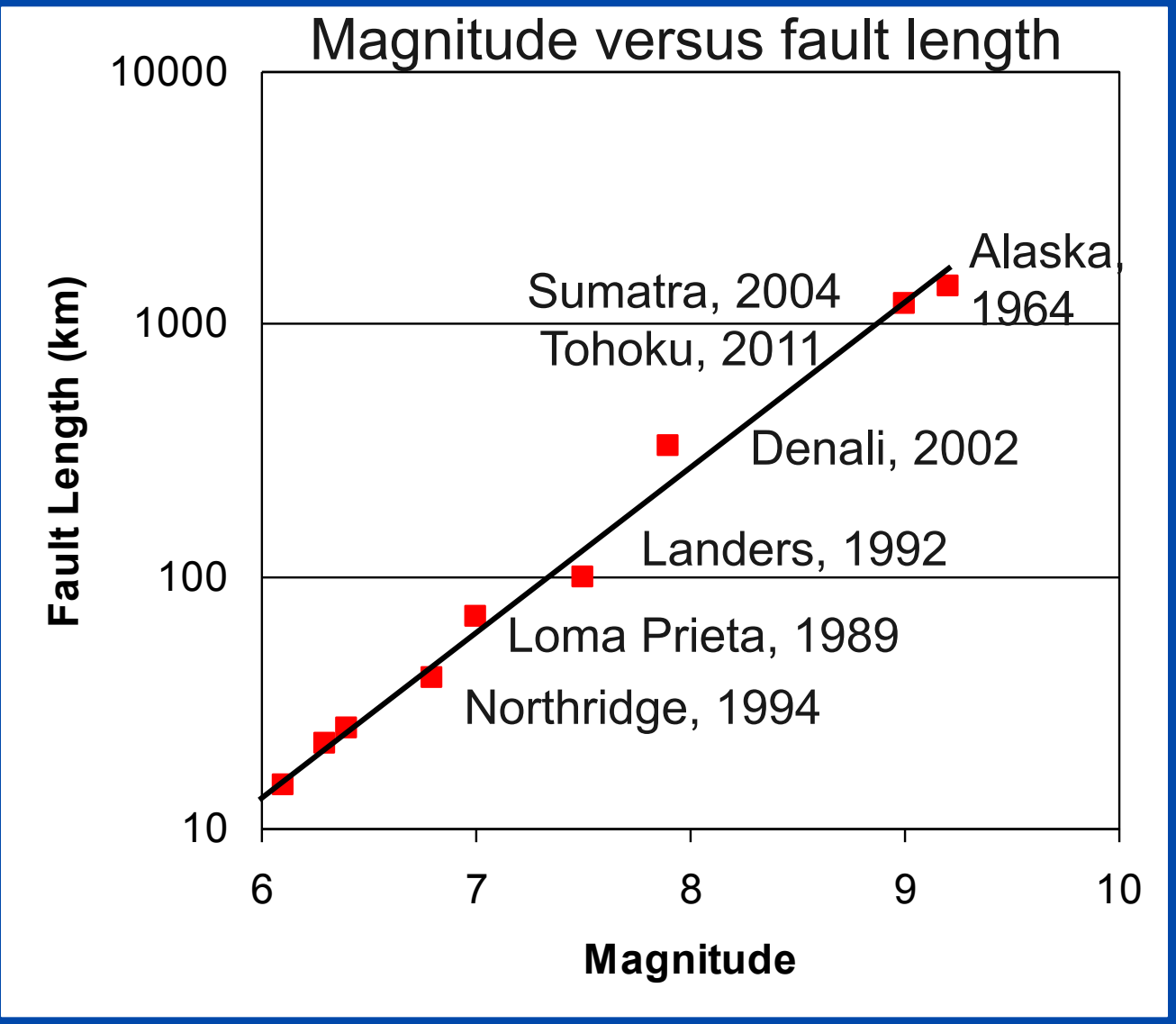
GG 101

Greg Moore

Tohoku Earthquake and Tsunamis

October 12, 2011

Earthquake magnitude is controlled by fault length (or area) that ruptures



Magnitude versus fault length (determined from aftershock zone length) for various earthquakes

Rule of Thumb

On average a magnitude X+1 earthquake has:

- 10 times greater peak amplitude of shaking than a magnitude X earthquake
- 3.2 longer length of fault and duration of slip
- 32 times greater energy and moment release

For example, this is how an M4 quake differs from an M3 quake

Earthquake Hazards – Building Collapse

Collapsed buildings: Dec. 7, 1988, Armenia, M6.9, ~25,000 people died

Collapsed buildings: January 17, 1995, Kobe, Japan, M6.9, depth ~5 km

Earthquake Hazards

Sichuan, 2008

Landslides

Building collapse

Earthquake Hazards

Kobe, 1995

Freeway collapse

Earthquake Hazards

Fires

- Displacements cause power and gas lines to break and ignite
- Hard to put out because water lines are often broken

Kobe, 1995

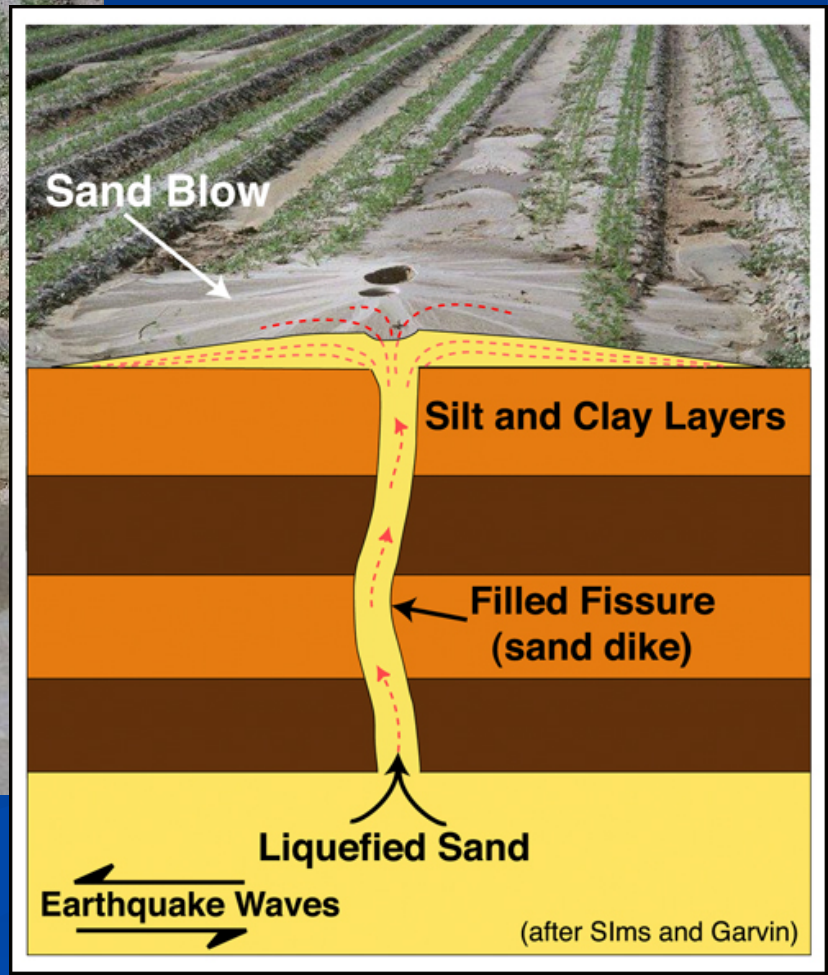
Loma Prieta, 1989

Northridge, 1994

Effects of Earthquakes

Liquefaction

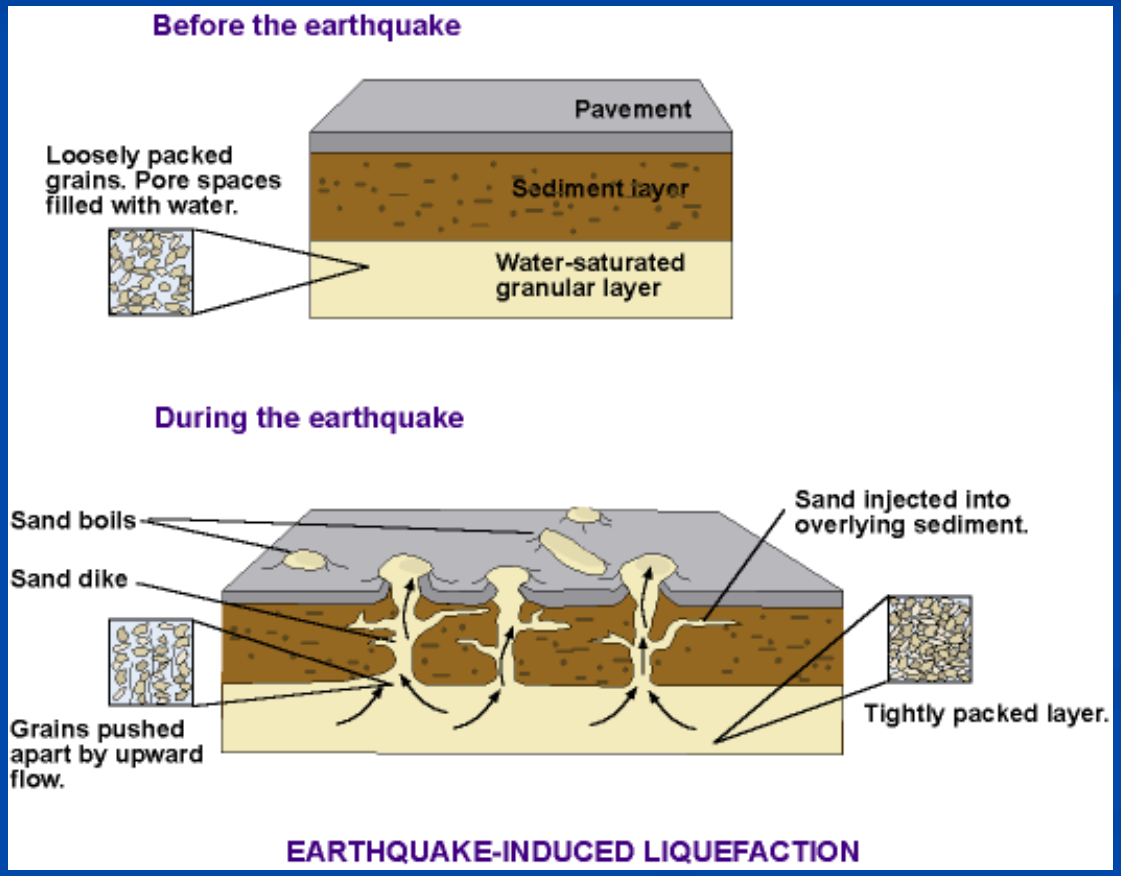
A near-surface layer of water-saturated sand changes rapidly from a solid to a liquid

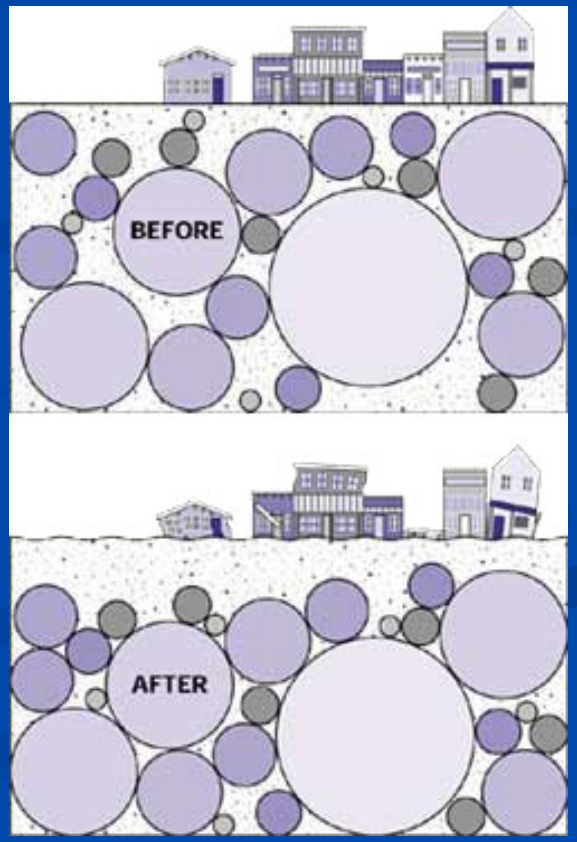


Effects of Earthquakes

Liquefaction

- A near-surface layer of water-saturated sand changes rapidly from a solid to a liquid
- Causes buildings to “float” in earth





Liquifaction in SF Marina District Loma Prieta quake

© 2012 Pearson Education, Inc.

Christchurch, NZ, 2011

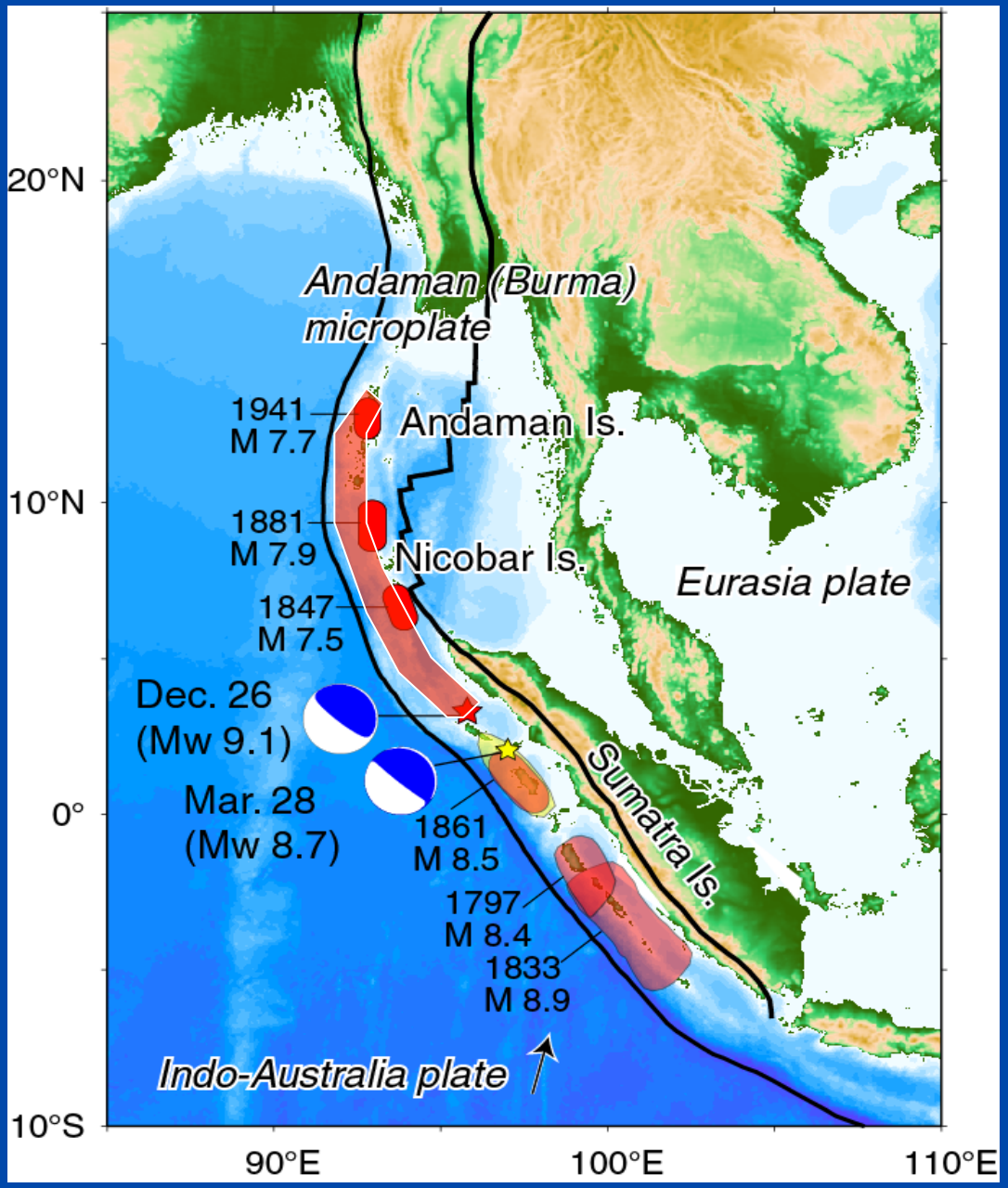
Earthquake Hazards

Tsunamis – effect wide areas

Indian Ocean, 2004

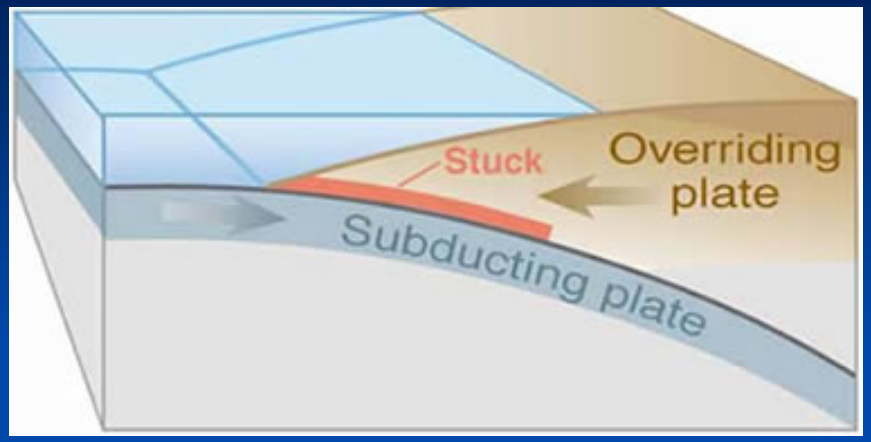
Tohoku, 2011

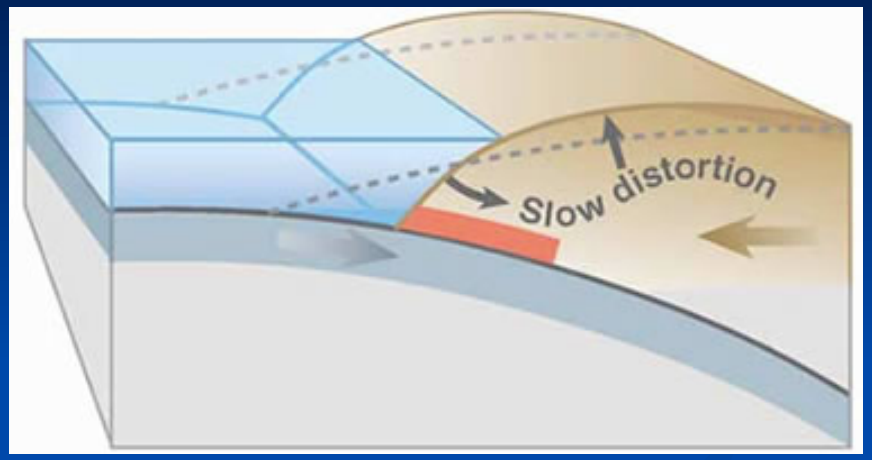
Segments of the Sumatra-Andaman Region

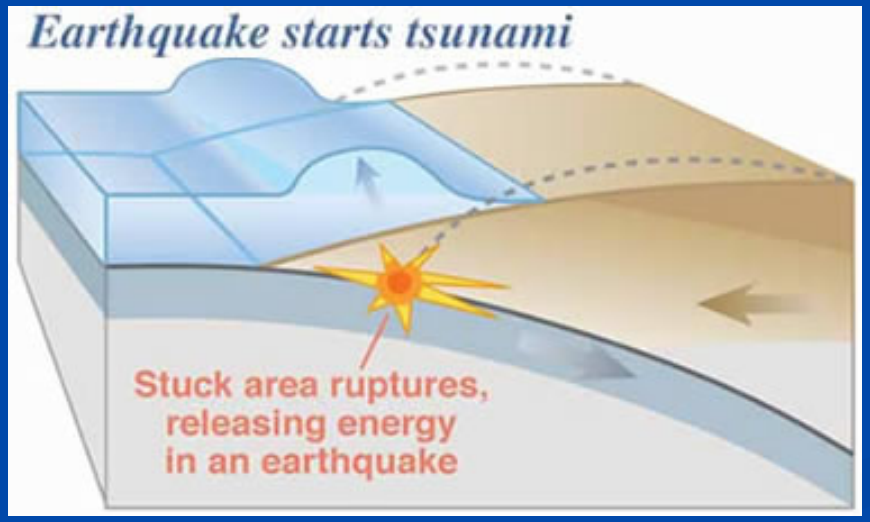


In December, 2004, multiple segments broke sequentially

Tsunami Generation







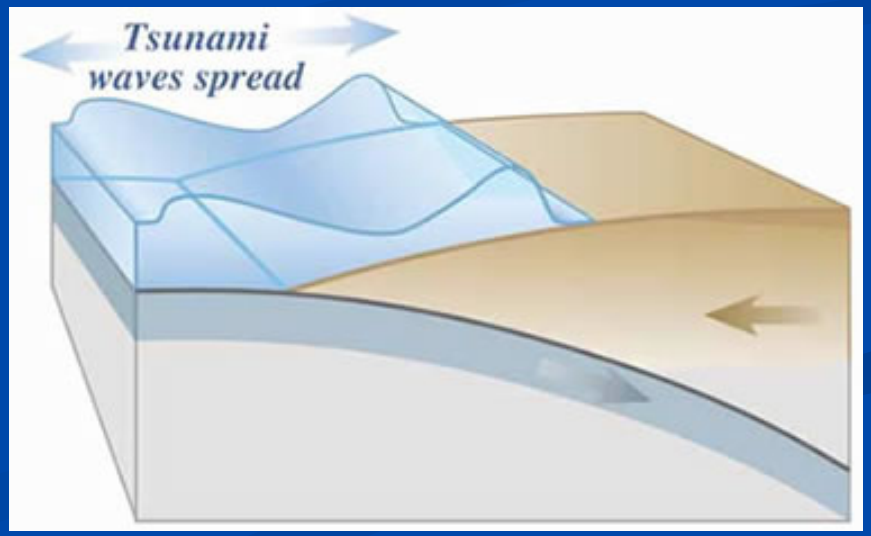
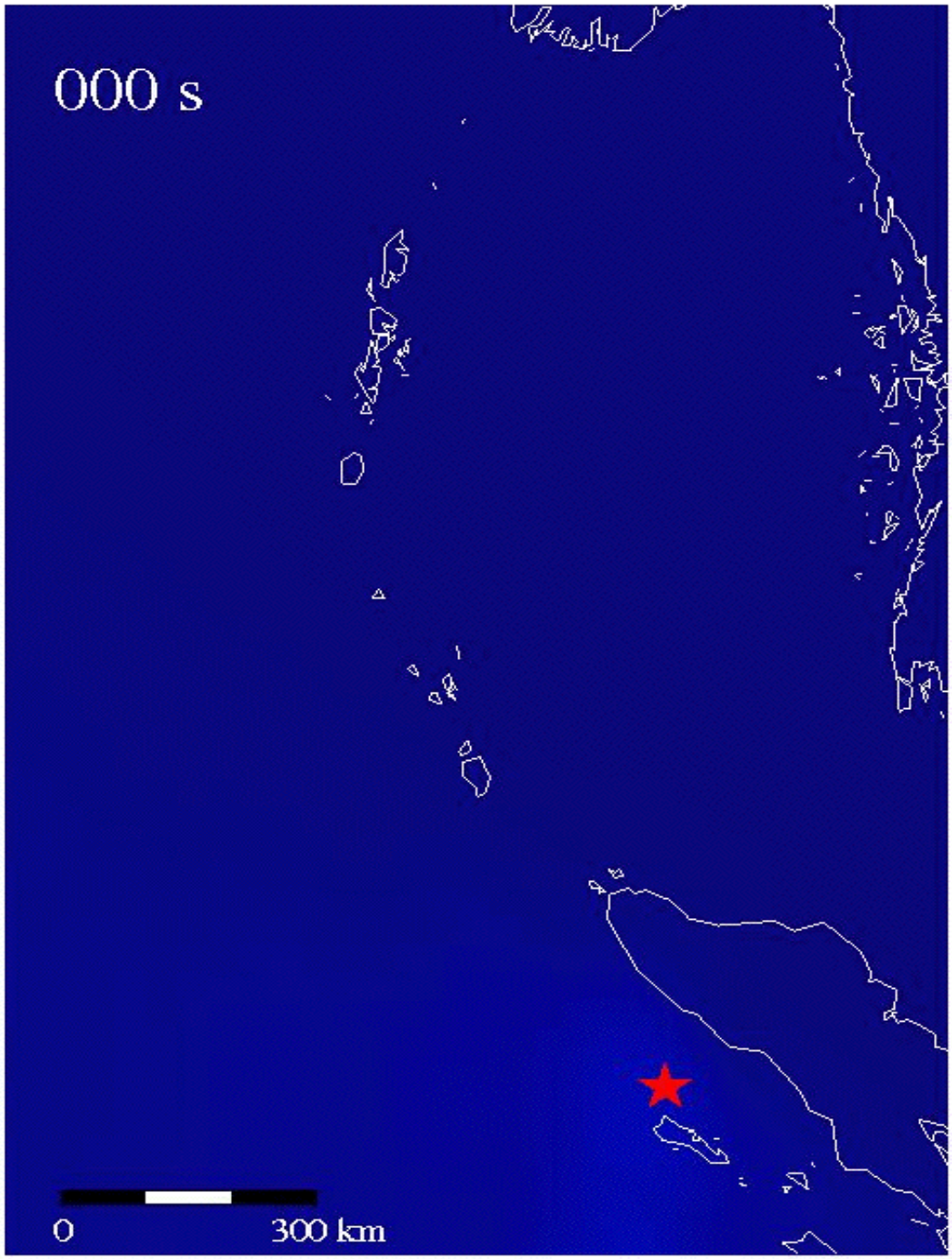
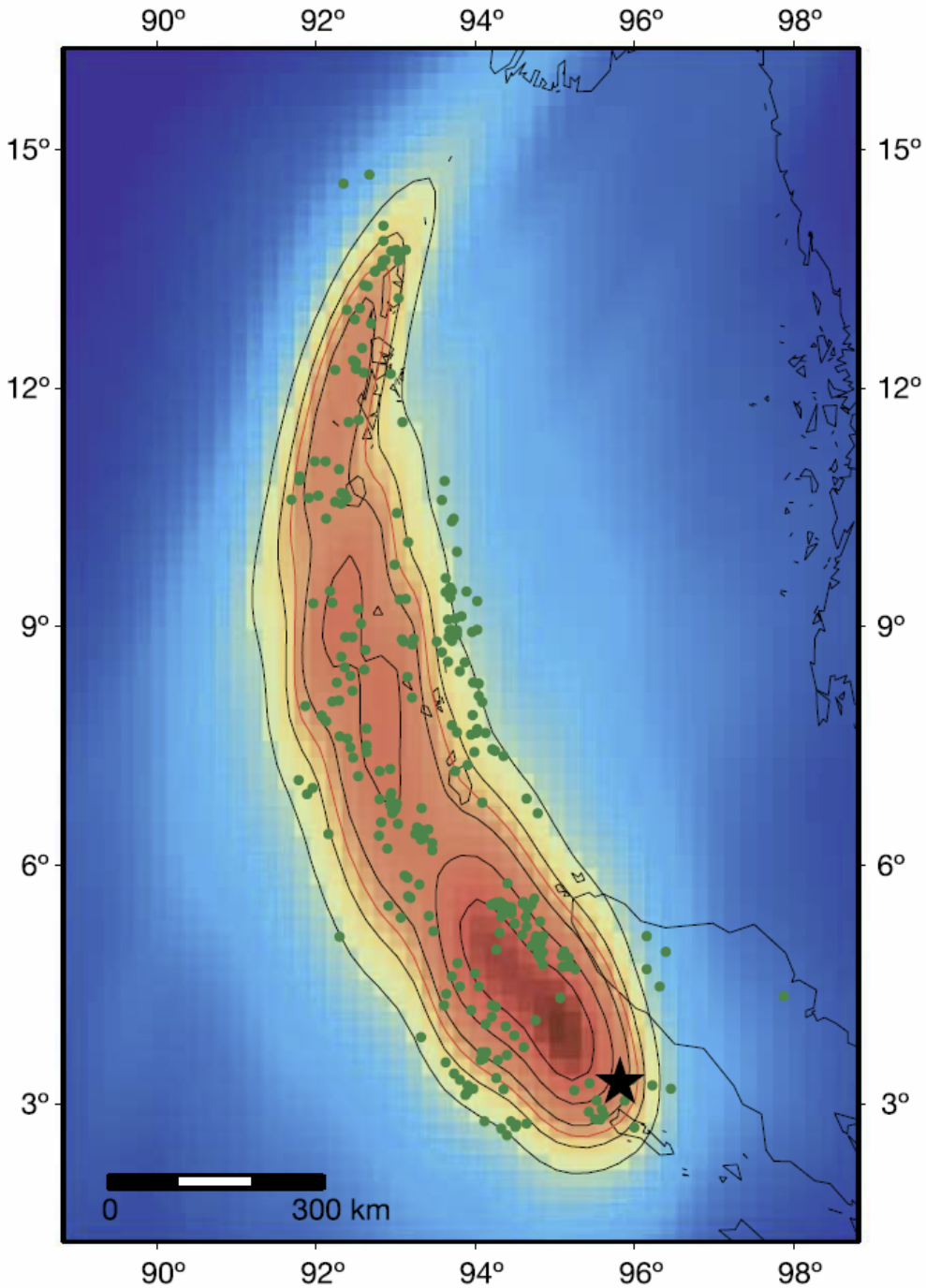


Figure from Geology.com

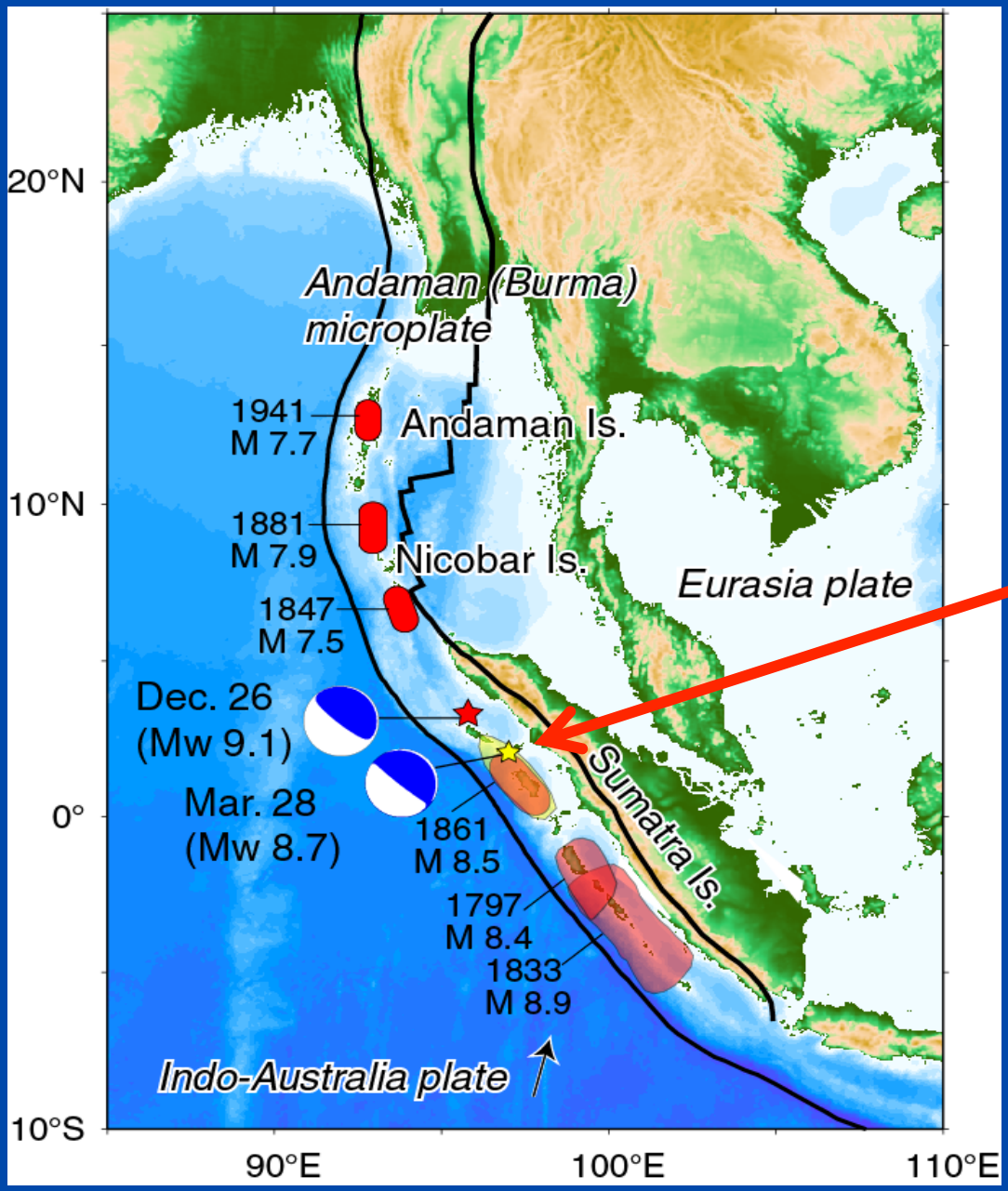


Propagation of the earthquake over 10 minutes



Cumulative radiated energy of 2004 Sumatra quake over 10 minutes

Earthquake Triggering



Clearly, the 2004 Sumatra quake triggered a quake on the adjacent segment in 2005

And there have been several more recent quakes farther south

Magnitude 8.9 NEAR THE EAST COAST OF HONSHU, JAPAN

Friday, March 11, 2011 at 05:46:23 UTC

Japan was struck by a magnitude 8.9 earthquake off its northeastern coast Friday. This is one of the largest earthquakes that Japan has ever experienced.

In downtown Tokyo, large buildings shook violently and there is severe flooding due to a tsunami generated by the earthquake.

Part of houses swallowed by tsunami burn in Sendai, Miyagi Prefecture (state) after Japan was struck by a strong earthquake off its northeastern coast Friday, March 11, 2011.

New York Times

Magnitude 8.9 NEAR THE EAST COAST OF HONSHU, JAPAN
Friday, March 11, 2011 at 05:46:23 UTC

Tsunami waves swept away houses and cars in northern Japan and pushed ships aground.

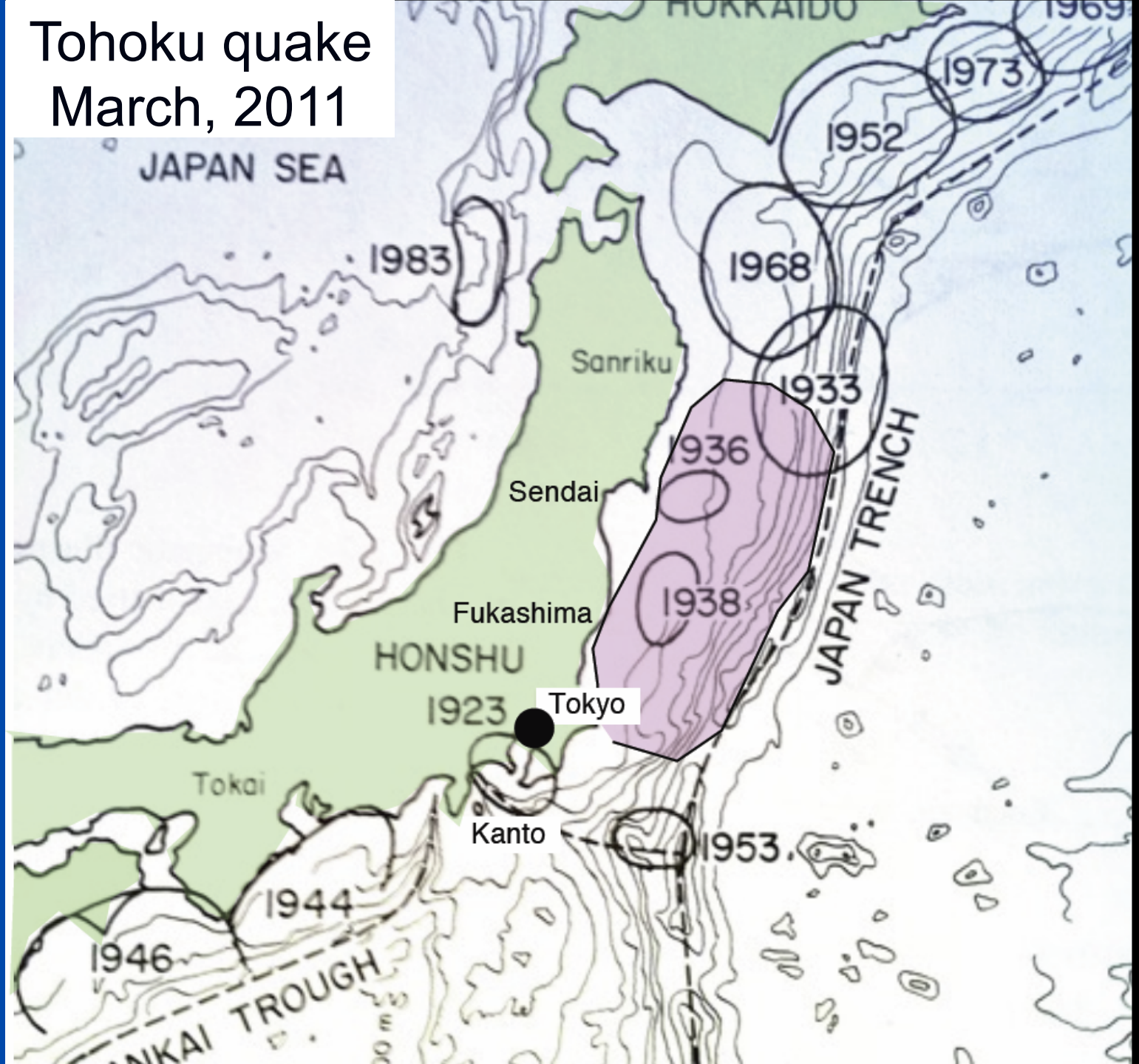
The tsunami waves traveled far inland, the wave of debris racing across the farmland, carrying boats and houses with it.

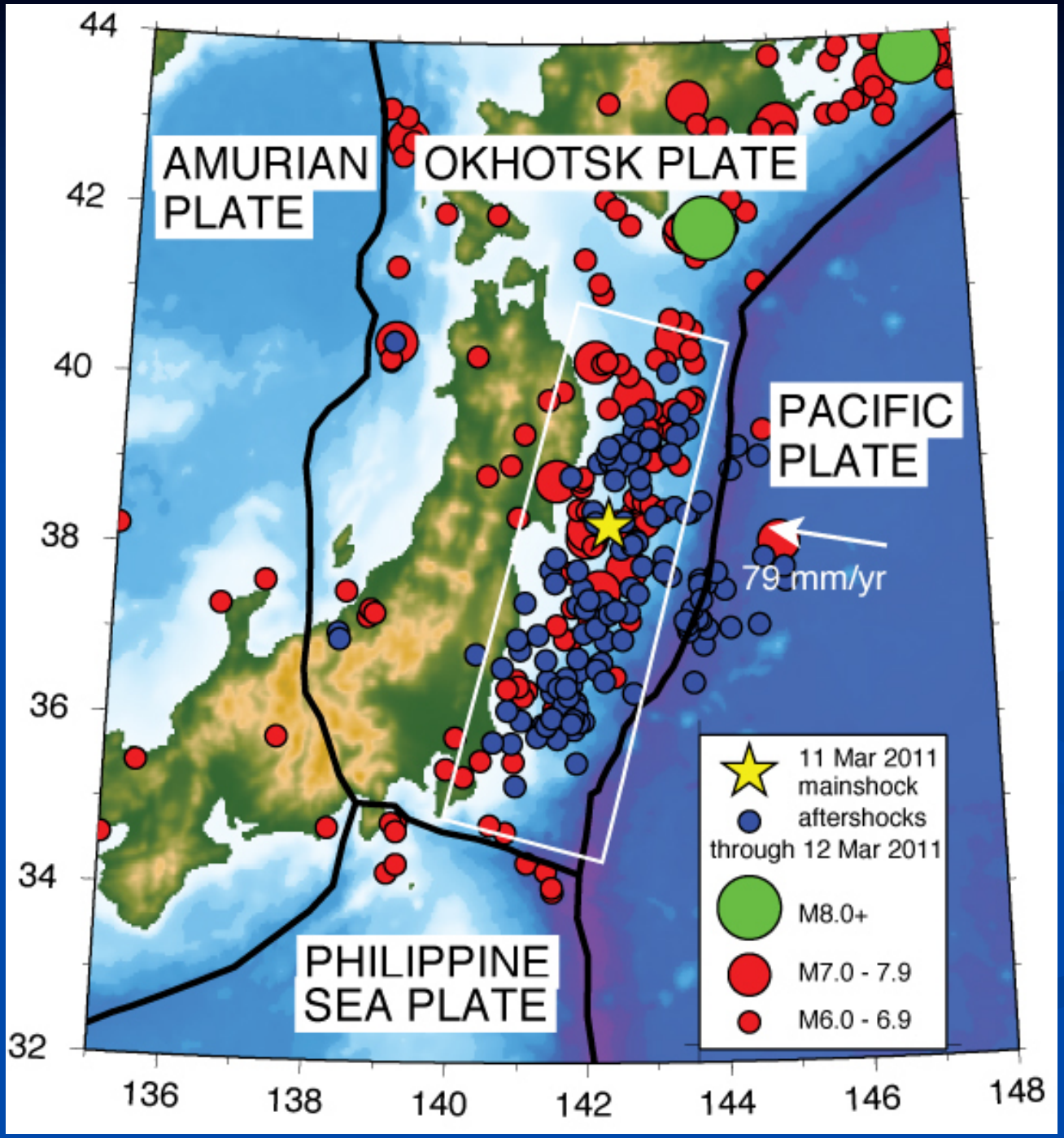
The tsunami, seen crashing into homes in Natori, Miyagi prefecture. *AP*

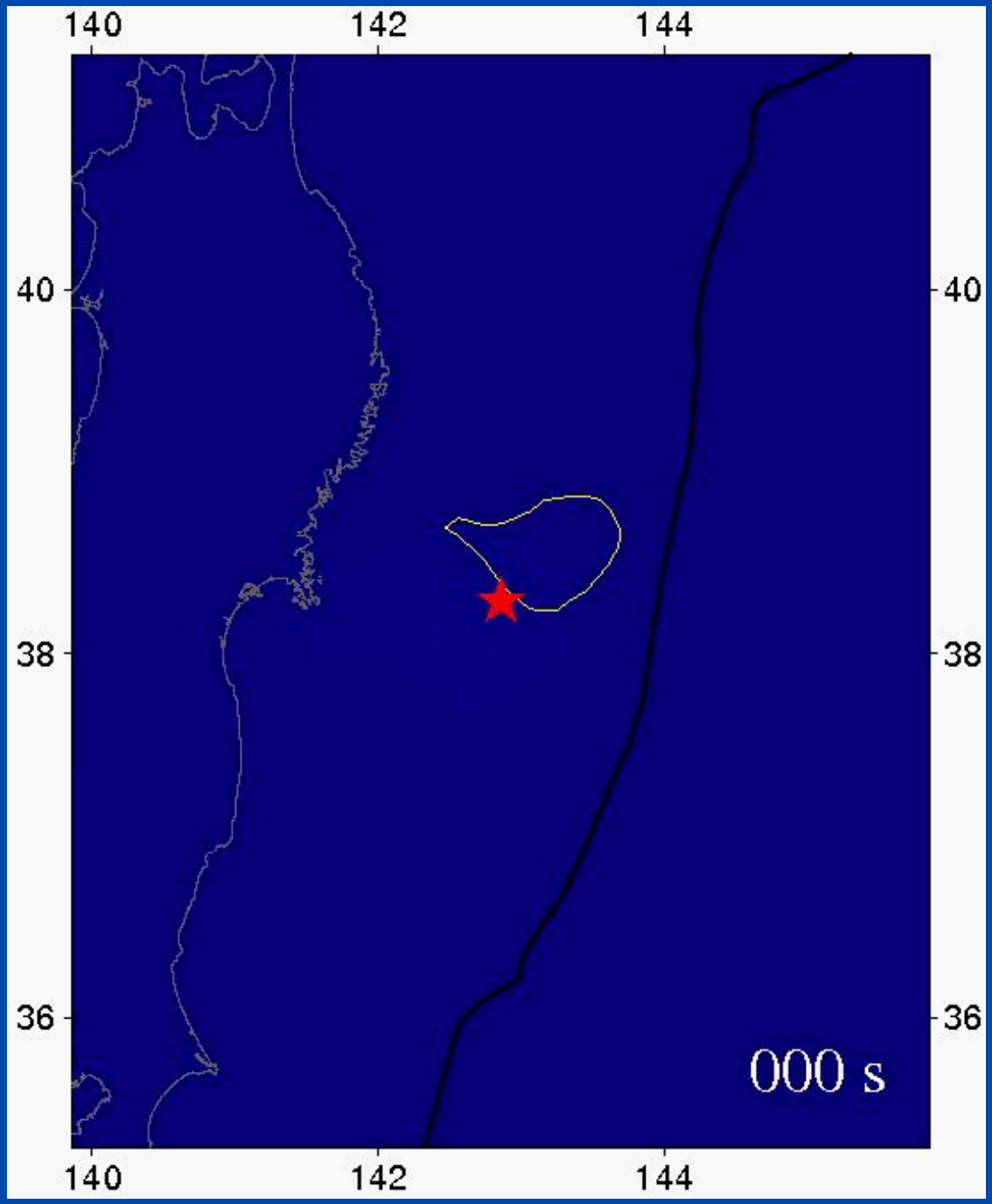
Houses were washed away by tsunami in Sendai, Miyagi Prefecture in eastern Japan, after Japan was struck by a magnitude 8.9 earthquake off the northeastern coast.

New York Times

Tohoku quake March, 2011




AMURIAN PLATE
OKHOTSK PLATE
PACIFIC PLATE
PHILIPPINE SEA PLATE
79 mm/yr
11 Mar 2011 mainshock
aftershocks through 12 Mar 2011
M8.0+
M7.0 - 7.9
M6.0 - 6.9
44
42
40
38
36
34
32
136
138
140
142
144
146
148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36
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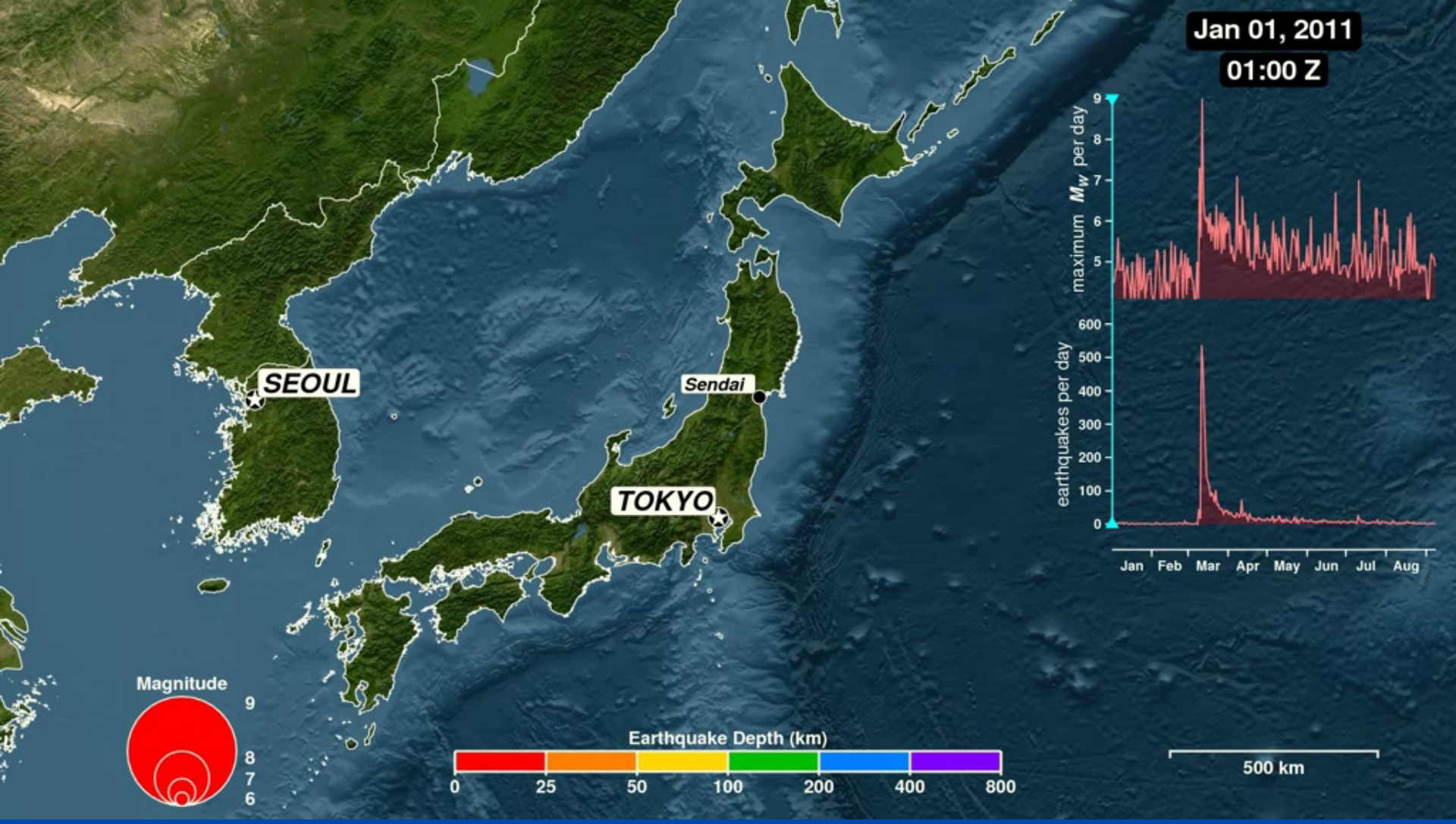
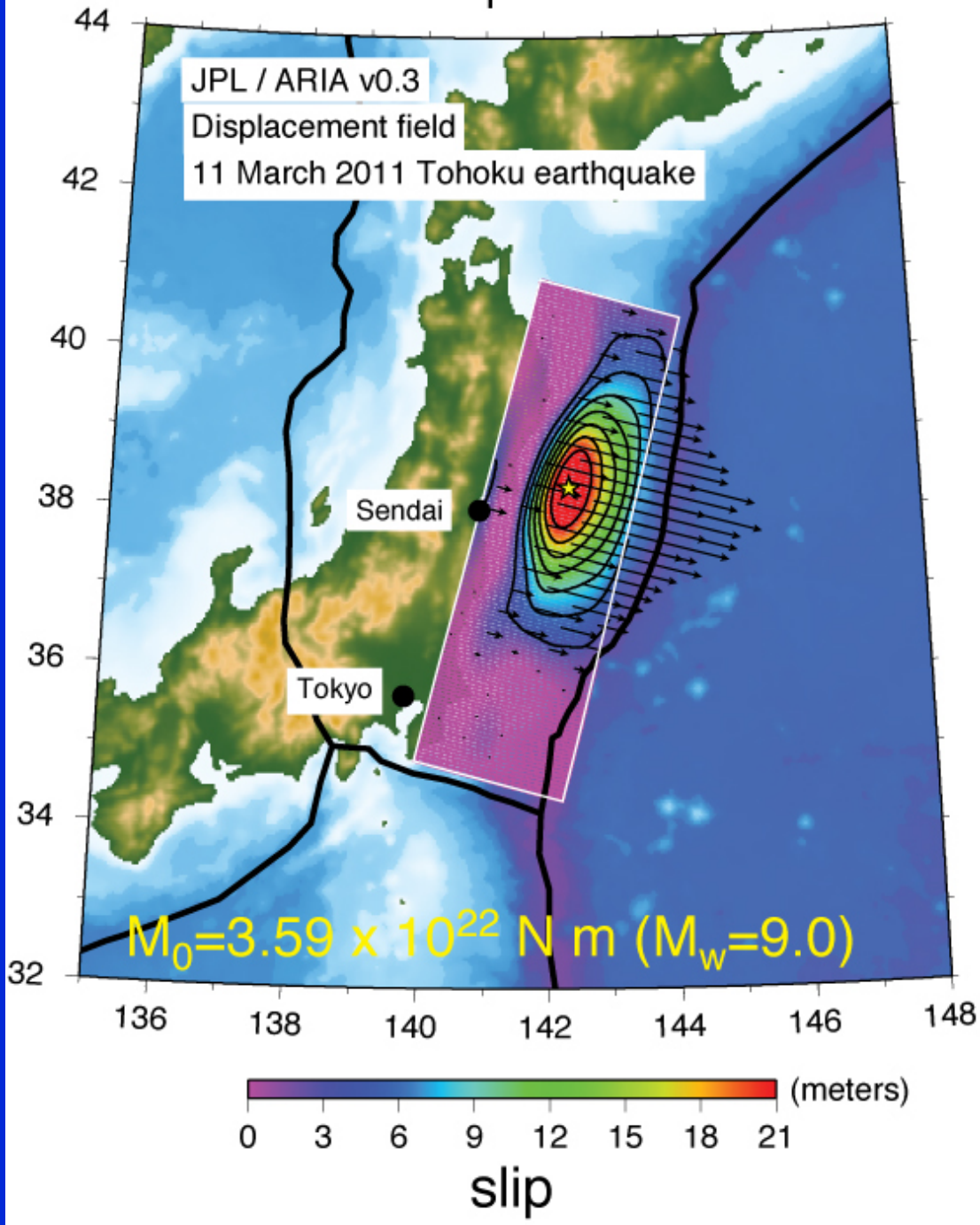
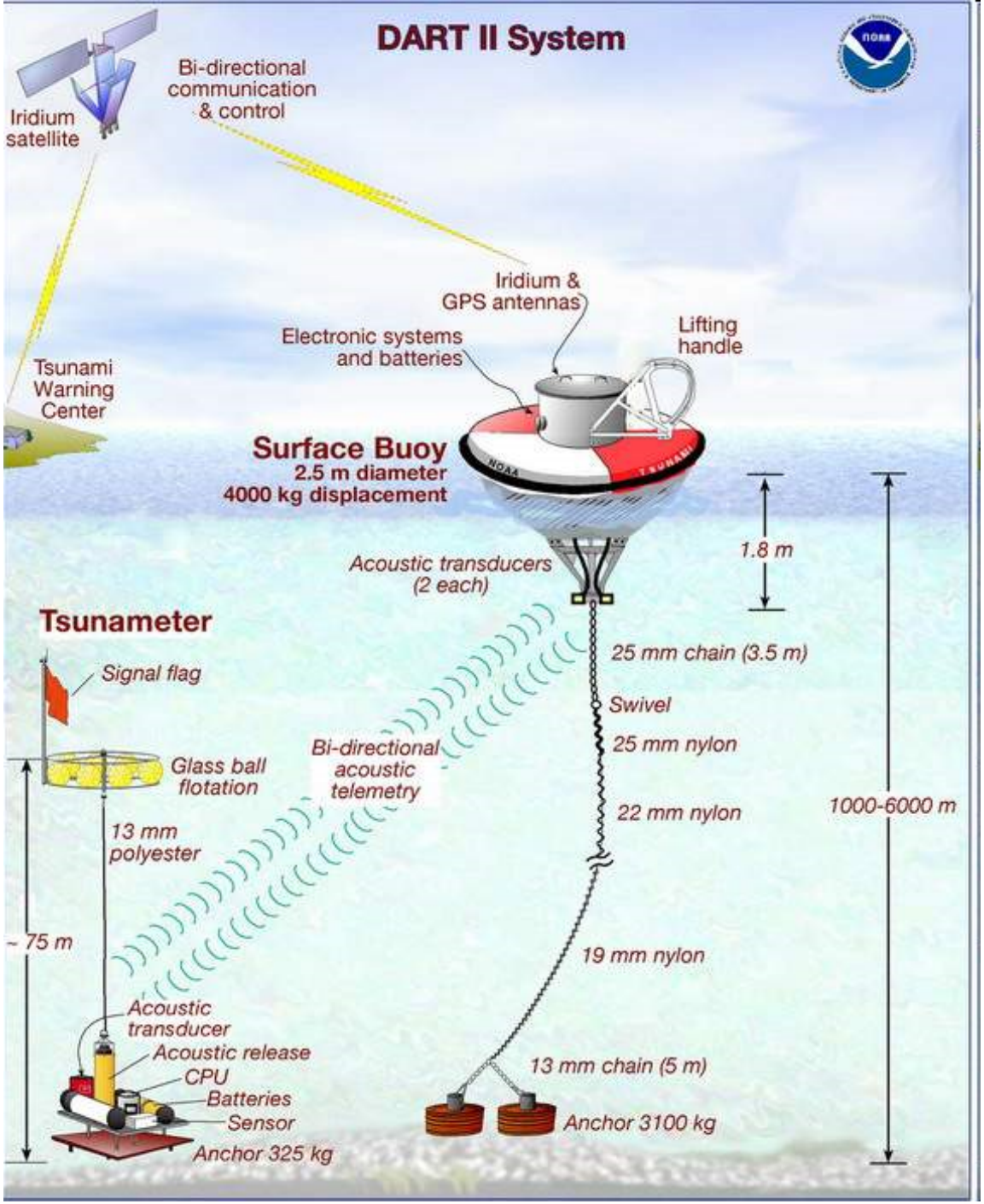
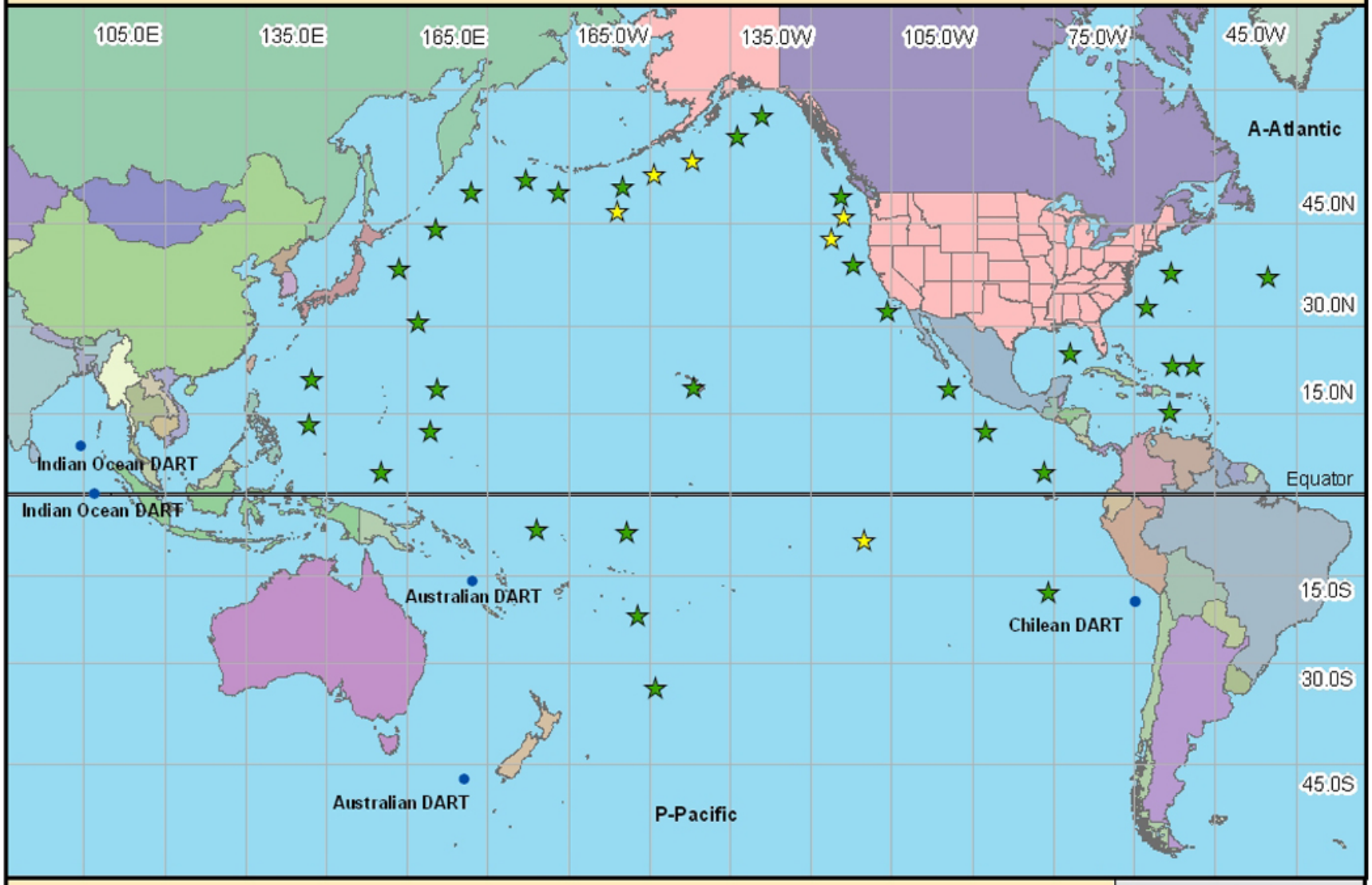

Jan 01, 2011
01:00 Z
maximum M_w per day
9
8
7
6
5
earthquakes per day
600
500
400
300
200
100
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
SEOUL
Sendai
TOKYO
Magnitude
9
8
7
6
Earthquake Depth (km)
0
25
50
100
200
400
800
500 km

GPS Slip Model



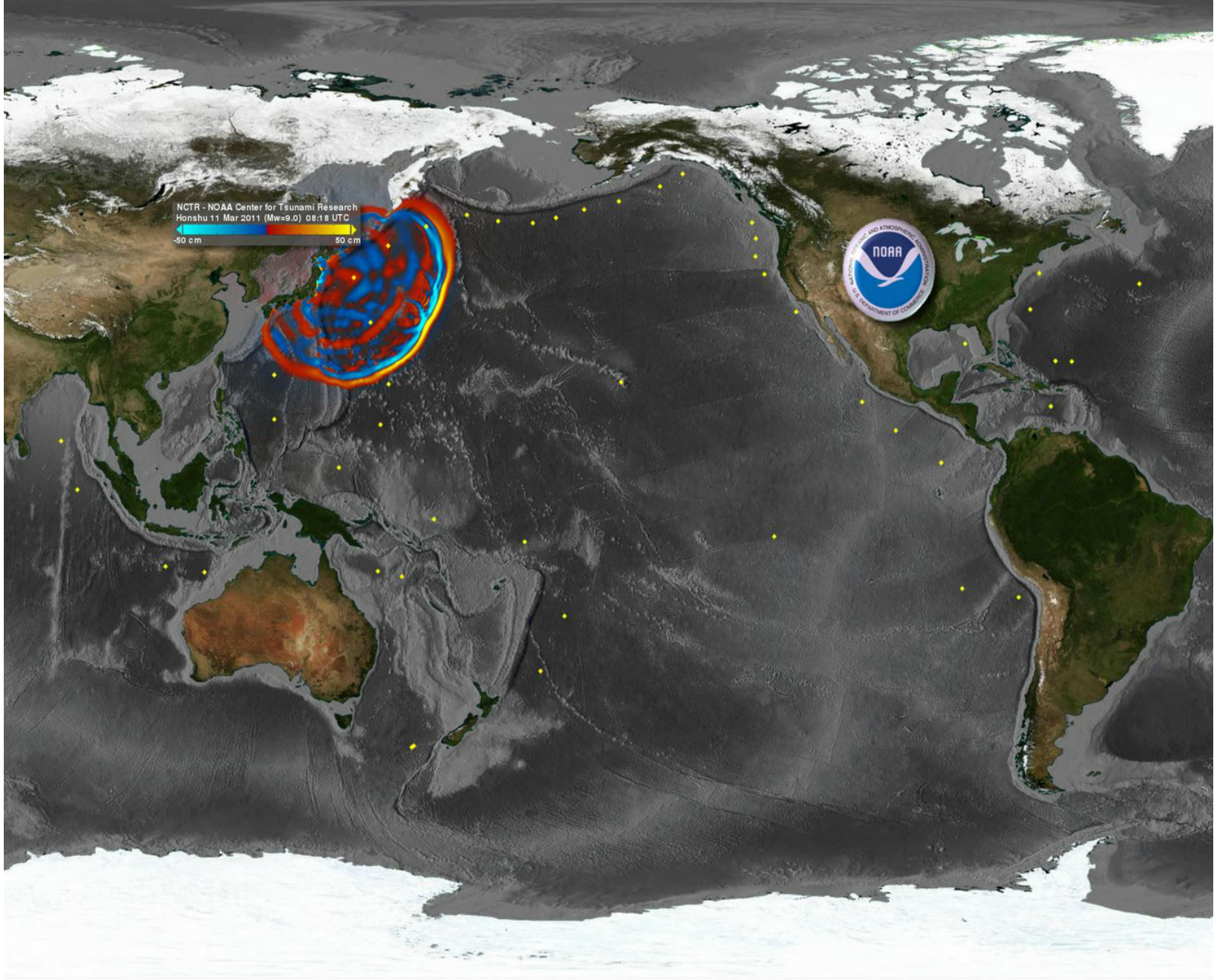

DART II System
Iridium satellite
Bi-directional communication & control
Tsunami Warning Center
Iridium & GPS antennas
Electronic systems and batteries
Lifting handle
Surface Buoy
2.5 m diameter
4000 kg displacement
NOAA
TSUNAMI
1.8 m
Acoustic transducers (2 each)
Tsunameter
Signal flag
Glass ball flotation
Bi-directional acoustic telemetry
13 mm polyester
~ 75 m
Acoustic transducer
Acoustic release
CPU
Batteries
Sensor
Anchor 325 kg
25 mm chain (3.5 m)
Swivel
25 mm nylon
22 mm nylon
19 mm nylon
13 mm chain (5 m)
Anchor 3100 kg
1000-6000 m

DART LOCATIONS
March 2008



MIRS GIS GROUP

yellow - Original
green - U.S. Expansion
blue - International

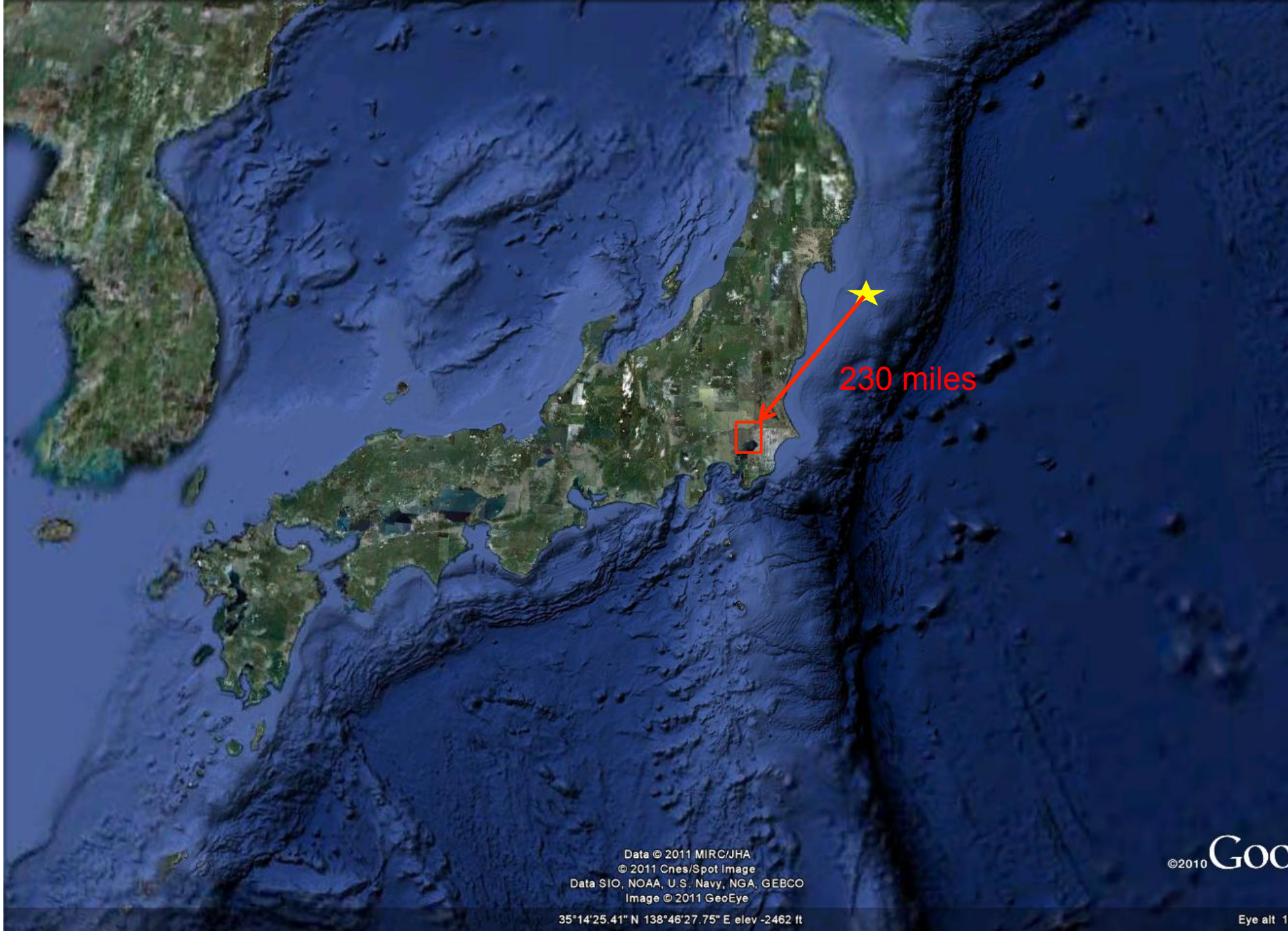

NCTR - NOAA Center for Tsunami Research
Honshu 11 Mar 2011 (Mw=9.0) 08:18 UTC
-50 cm
50 cm
NOAA

Disaster–Tsunami–

Tsunami attacked near the coast line near the Sendai Airport

Tsunami Video

http://www.youtube.com/watch?v=5-zfCBCq-8I&feature=relmfu

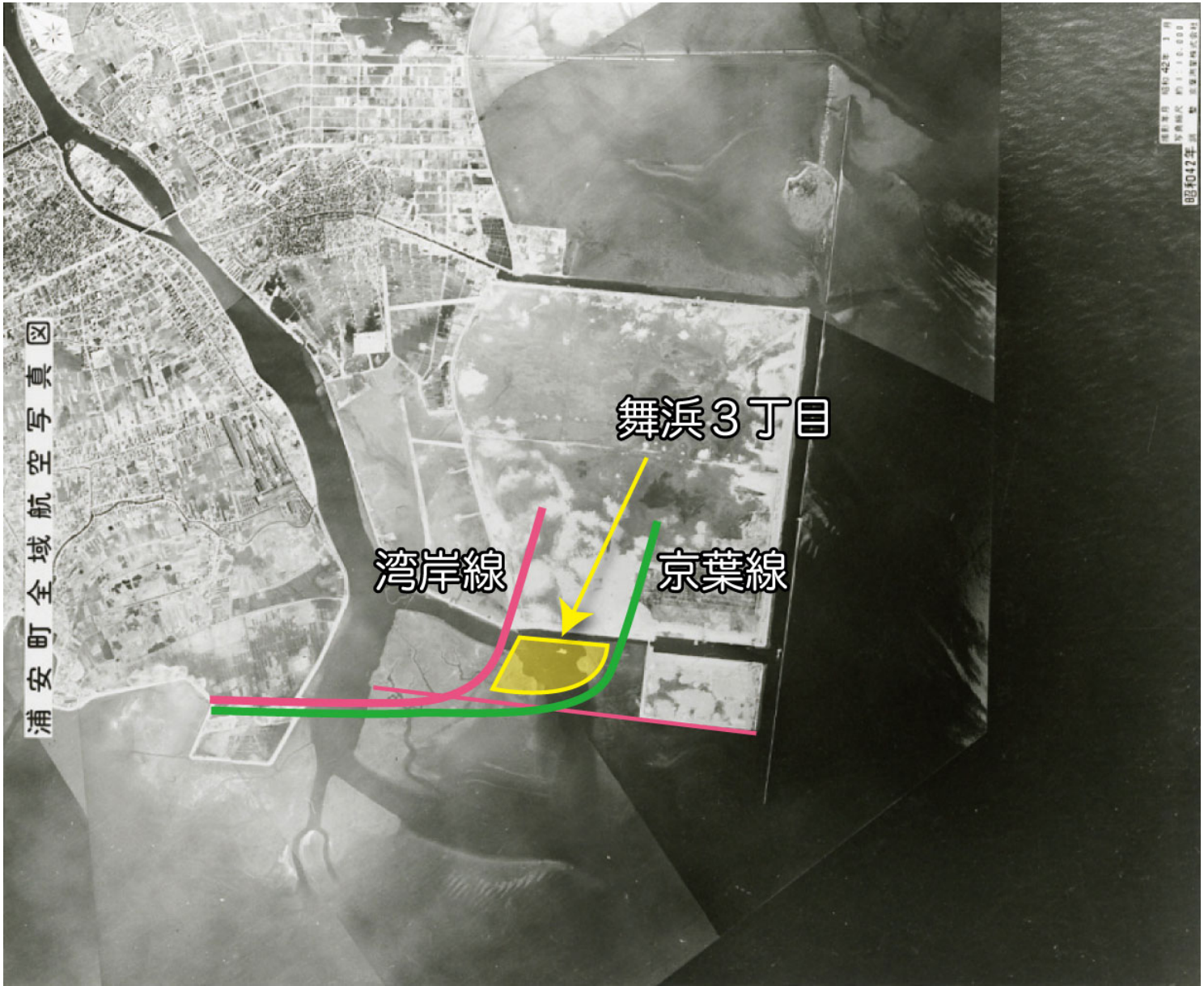

230 miles
Data © 2011 MIRC/JHA
© 2011 Cnes/Spot Image
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2011 GeoEye
35°14'25.41" N 138°46'27.75" E elev -2462 ft
©2010 Goo
Eye alt 1

N
Image © 2011 GeoEye
Image © 2011 DigitalGlobe
©2010 Google
Imagery Date: 3/30/2011
35°39'16.31" N 139°54'54.00" E elev 28 ft
Eye alt 26.69 mi

Urayasu Village: 1946

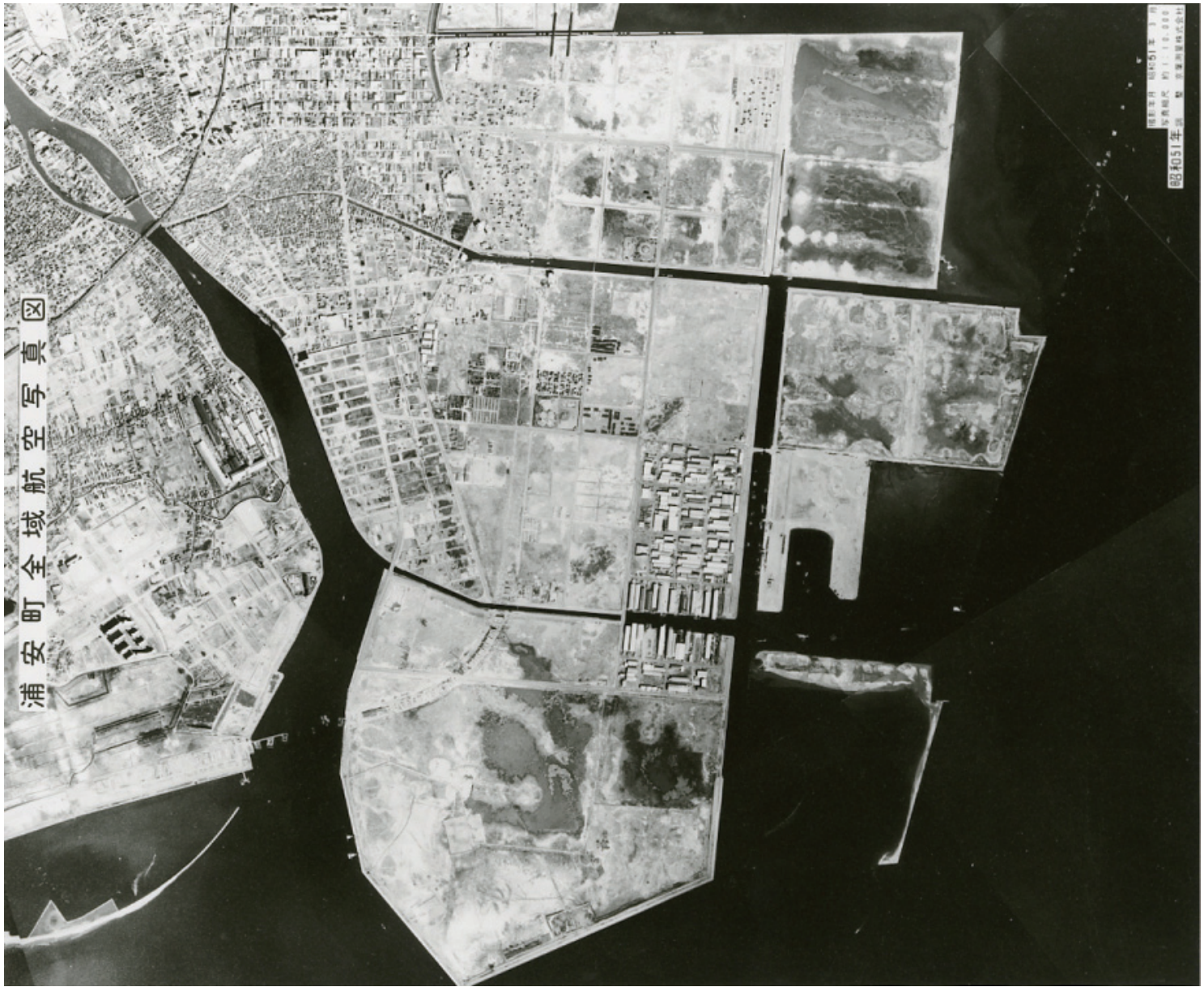
浦安市の資料より

Uraysu City: 1967



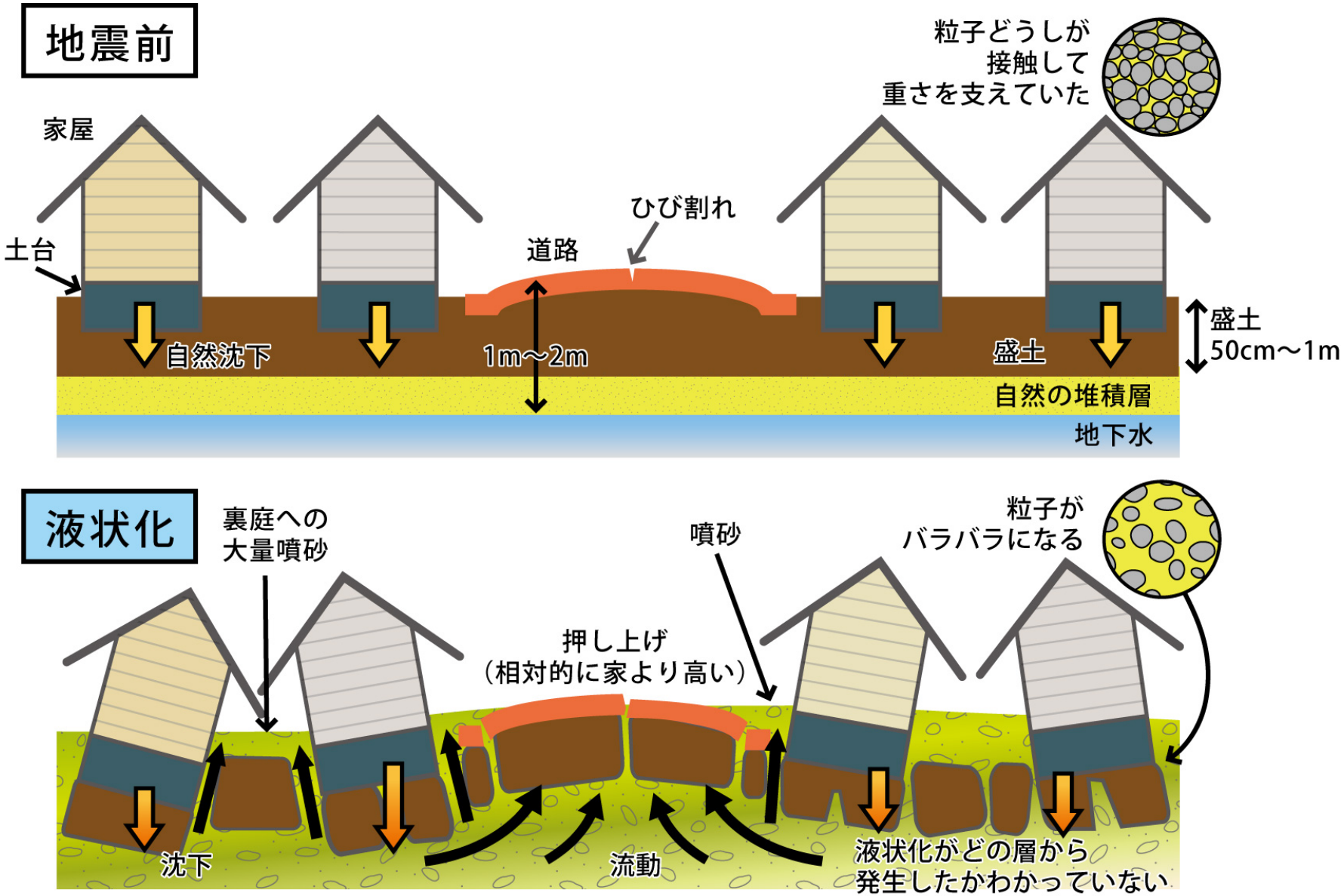
Uraysu City: 1973

Urayasu City : 1976

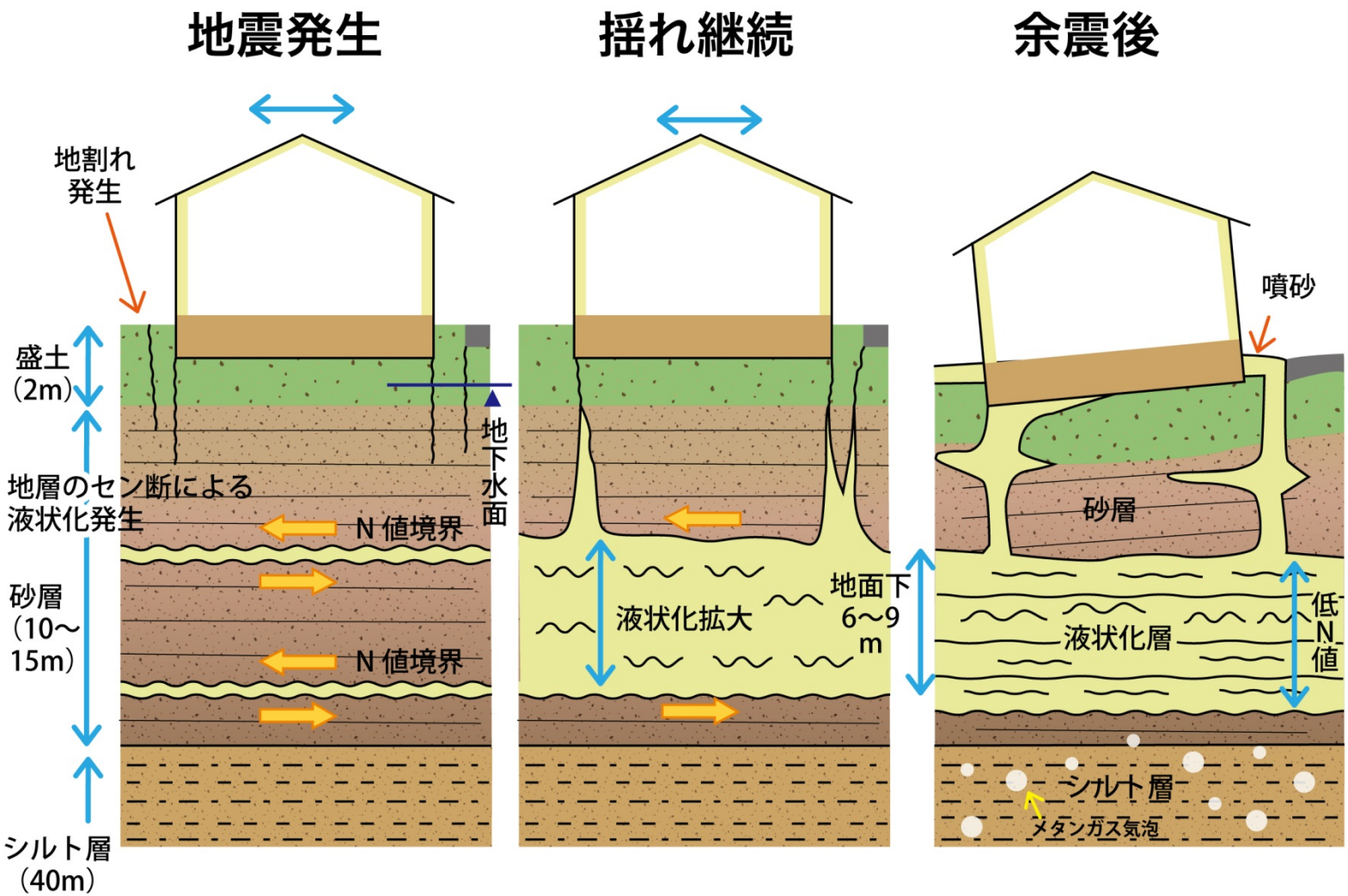


Maihama Town, Urayasu: March 12th

Sand Volcanoes, Urayasu



傾きや液状化層の分布は極端に示してある

平 朝彦原図

A Model of Liquefaction and House Damage