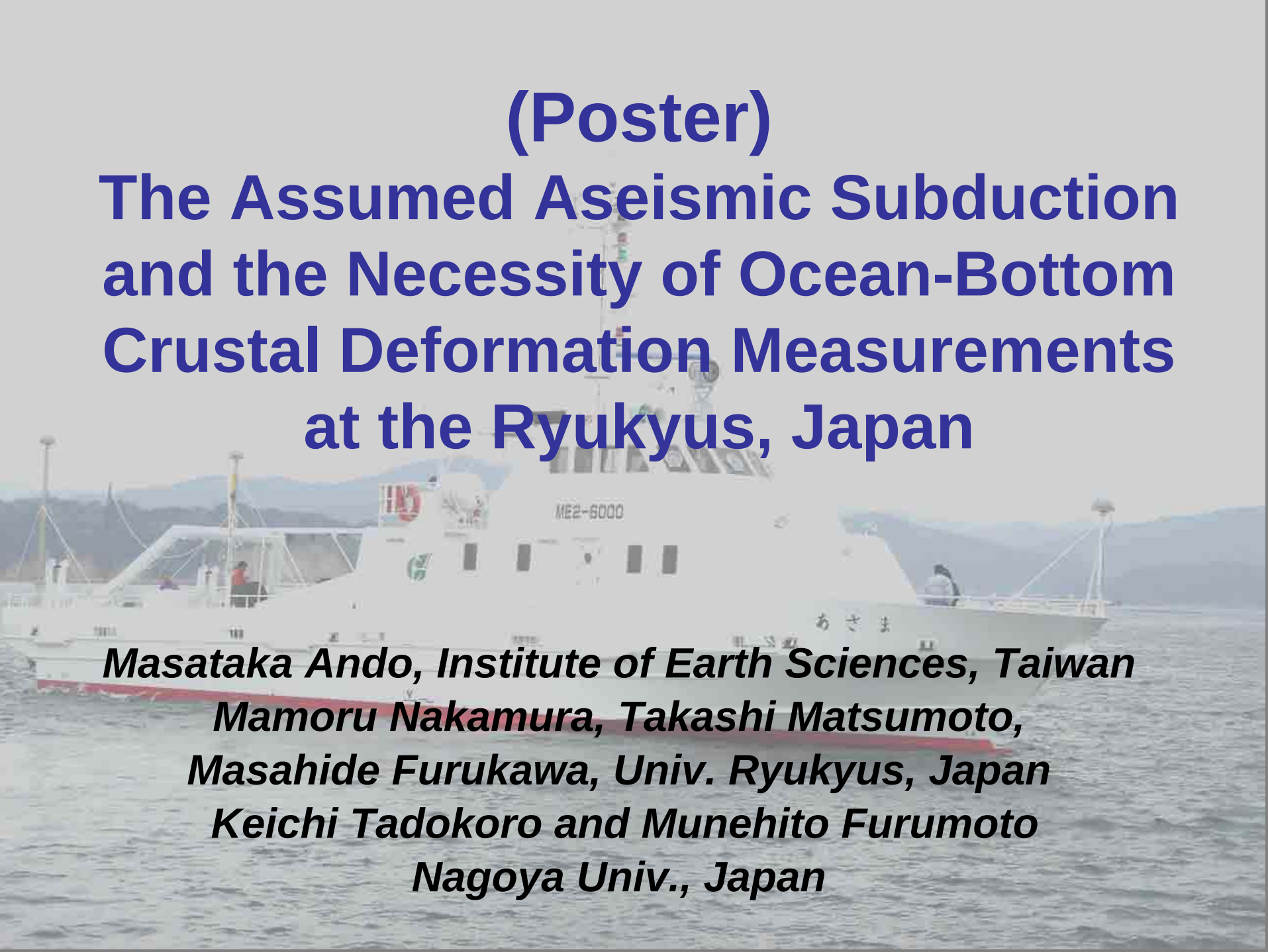
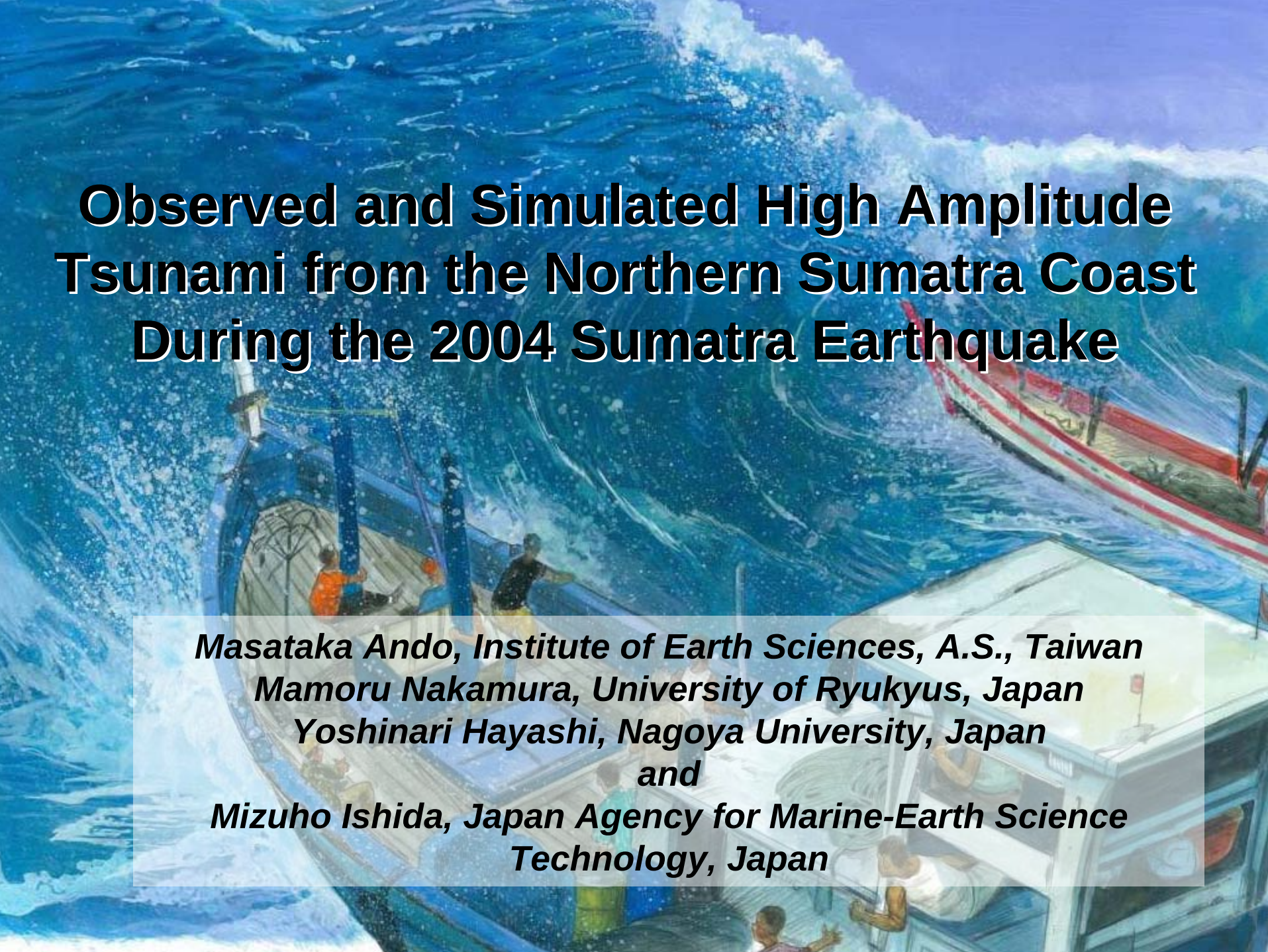
(Poster)

The Assumed Aseismic Subduction and the Necessity of Ocean-Bottom Crustal Deformation Measurements at the Ryukyus, Japan



Masataka Ando, Institute of Earth Sciences, Taiwan
Mamoru Nakamura, Takashi Matsumoto,
Masahide Furukawa, Univ. Ryukyus, Japan
Keichi Tadokoro and Munehito Furumoto
Nagoya Univ., Japan



Observed and Simulated High Amplitude Tsunami from the Northern Sumatra Coast During the 2004 Sumatra Earthquake

Masataka Ando, Institute of Earth Sciences, A.S., Taiwan
Mamoru Nakamura, University of Ryukyus, Japan
Yoshinari Hayashi, Nagoya University, Japan
and
Mizuho Ishida, Japan Agency for Marine-Earth Science Technology, Japan

Thanks to Didik, Putri, Nani and Aboy, Dept. Physics, Syiah Kuala Univ., Banda Ache, Sumatra


Tsu Nami
津 波
Harbor Wave

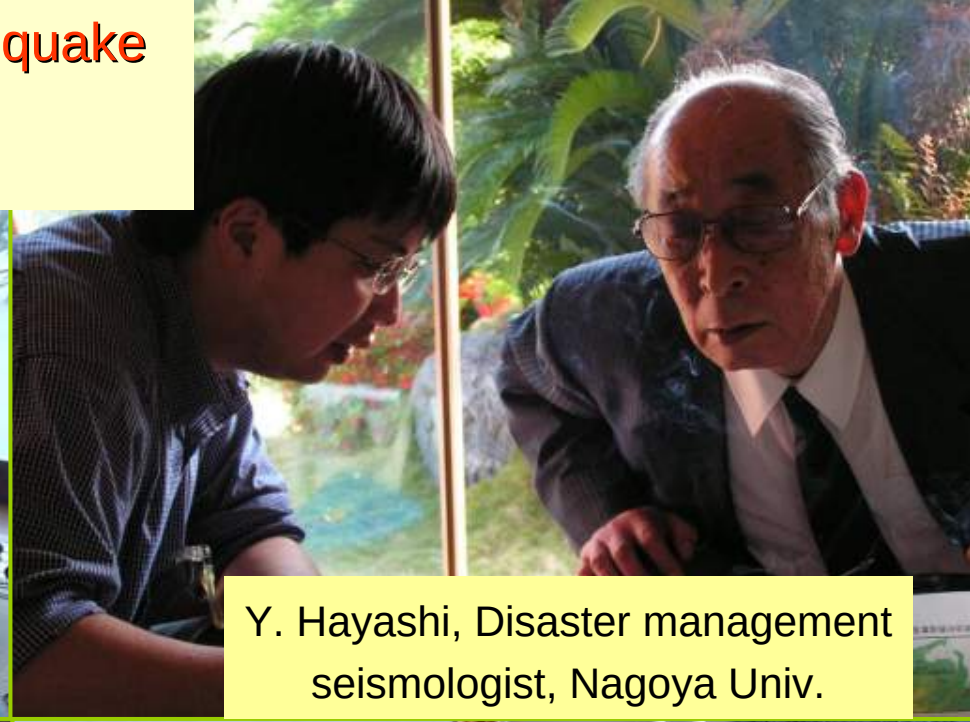
Origin of the word “Tsunami”

- A tsunami causes little or no visible effect to fishermen while fishing in the deep sea.
- Upon going back home, the fishermen found their villages devastated by the tsunami,
- Thus, they thought that the tsunami happened only in harbors and elsewhere close the shorelines.

Is this the same for the Sumatra tsunami?

Interviewing with victims of 1945 earthquake
Human behaviors in disasters
Y. Hayashi and R. Kimura

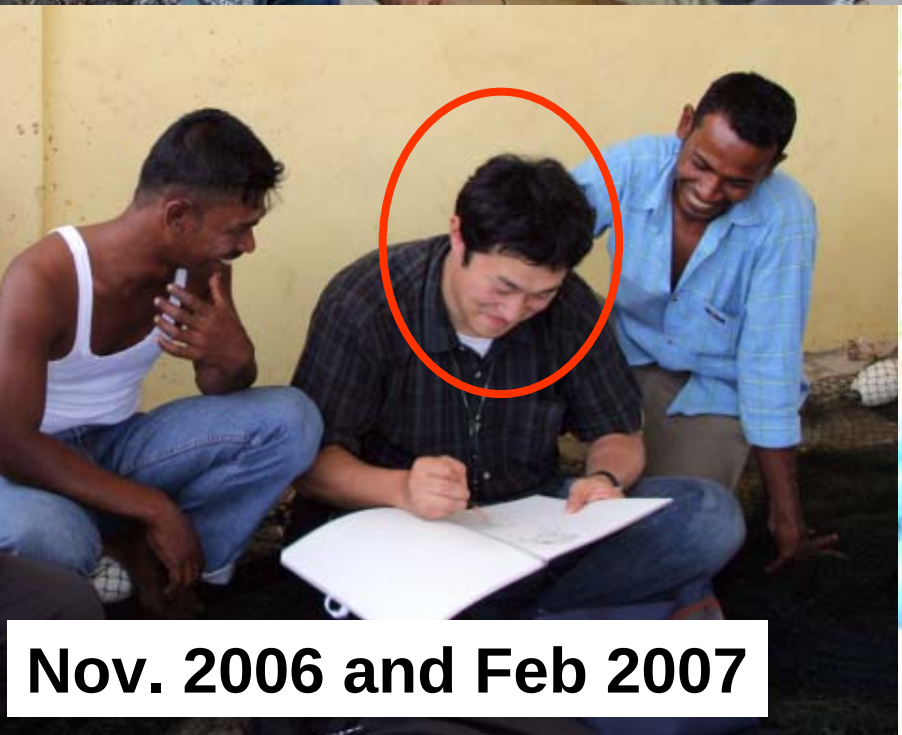
R. Kimura, Disaster management sociopsychologist, Nagoya Univ.



Y. Hayashi, Disaster management seismologist, Nagoya Univ.

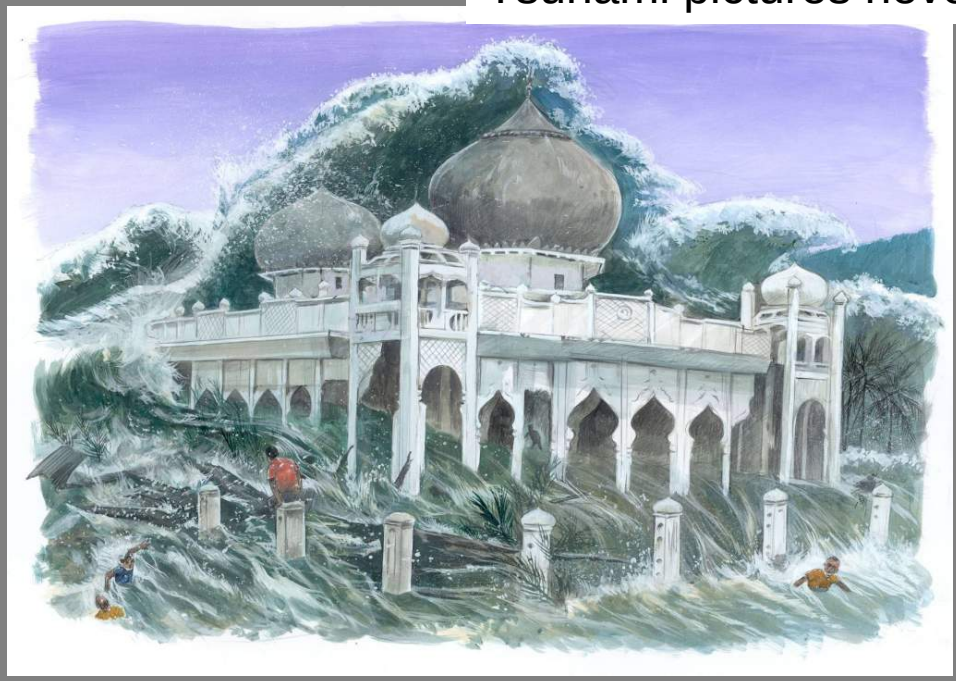
T. Banno
Japanese-style painter

T. Fujita
Japanese-style painter



Nov. 2006 and Feb 2007

Tsunami pictures never taken by cameras

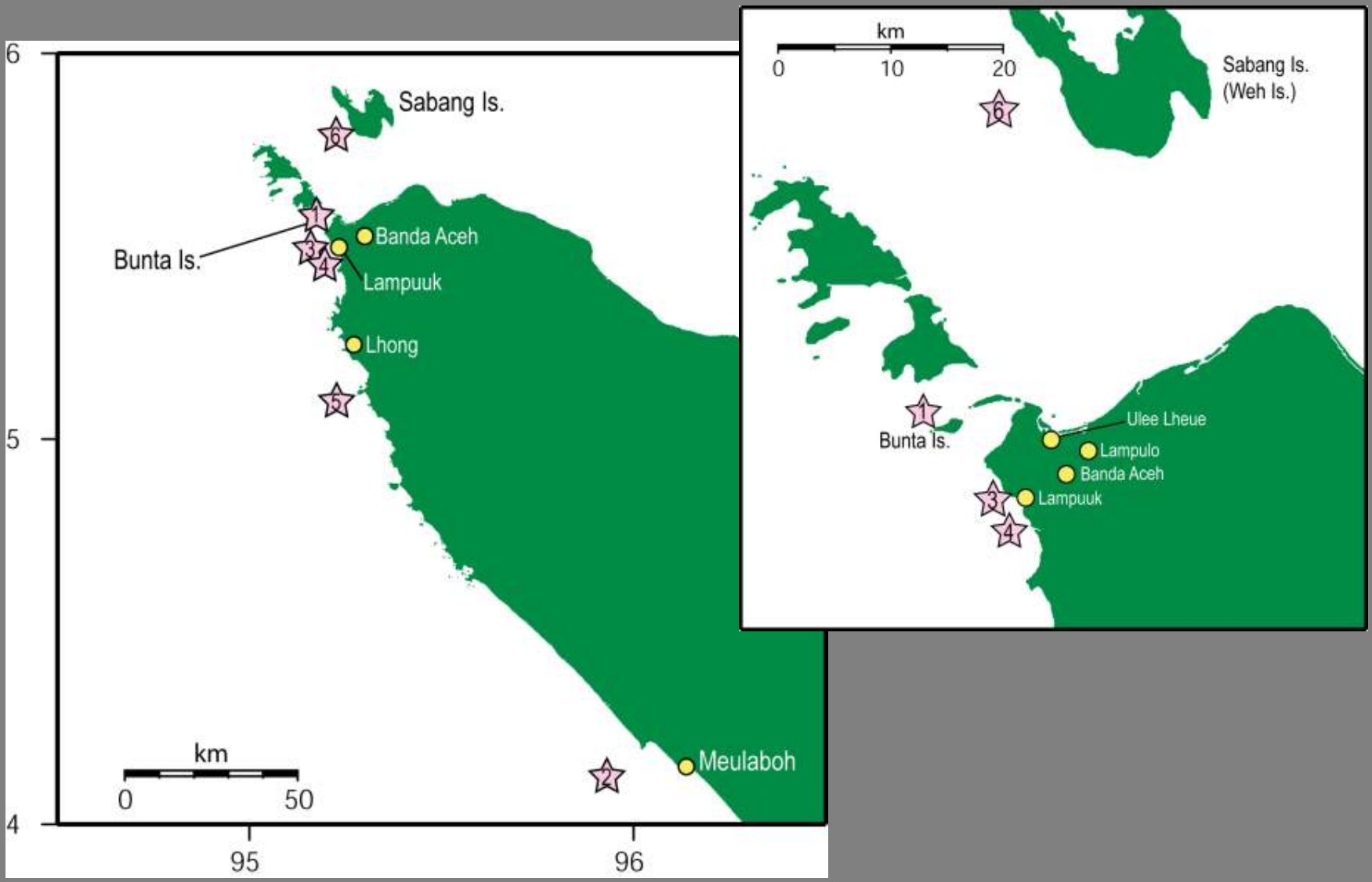


by T. Fujita

Fishermen onboard 0.5 to 20 km off the west coast of the northern Sumatra encountered large waves on 26 Dec. 2004.

Nov. 2006 and Feb 2007

Offshore sites where the interviewed fishermen encountered the tsunami off Banda Ache



Mr. Nasuri (35), a cook of 21-crew boat

- They were a group of four boats with 20 to 24 crew members.
- They fished *alfonsino* and *tuna*.
- The earthquake occurred when they were about 1.5km offshore.
- Since he was cooking inside of the boat, he did not feel any shaking

Witnessed by Mr. Nasuri (1)

- Then, he saw a wave of 10m or higher about 1km ahead.
- The boat tried to changed its direction and encountered the first wave obliquely.
- However, it was overturned by the second wave. The other three boats were likewise overturned.
- The waves were ordinary in color (blue).

Witnessed by Mr. Nasuri (2)

- He swam and held onto a fish box.
- He was too tired to swim anymore. He drifted towards the land and southwards along the coastline.
- After then, a boat near the shore came and rescued him and other 16 men.
- Among the rescued fishermen, 12 persons were from his group. In total, there were 3 fishermen missing, and 18 survivors.
- He was rescued probably 3 hours after the boat overturned.


by T. Fujita

大型漁船1隻と小型漁船4隻で漁をしているときに津波に遭遇した。大型船は船首の向きを変えられず、陸にぶつかって壊れてしまった。

絵　藤田哲也

Mr. Ali Hasym (51), a fisherman

- At the time of the earthquake, he was engaged in fishing.
- It was 20 hours since he left the harbor at noon of December 25.
- It was about 3 hours ride by his boat of an estimated speed of 3km/h.
- Based on the speed of the boat, he was about 9 km off the shore

Witnessed by Mr. Ali Hasym (1)

- He first noticed the shaking when saw the small puddle of water inside the boat trembled.
- He also noted that the seawater outside on the boat was bubbling even though the boat was not moving.
- He remembered that the sea was quiet and the weather was fine that morning.
- The shaking continued for about 10 to 15 minutes.
- Then, heard sounds like "*Bonn*" 5 times.

Witnessed by Mr. Ali Hasym (2)

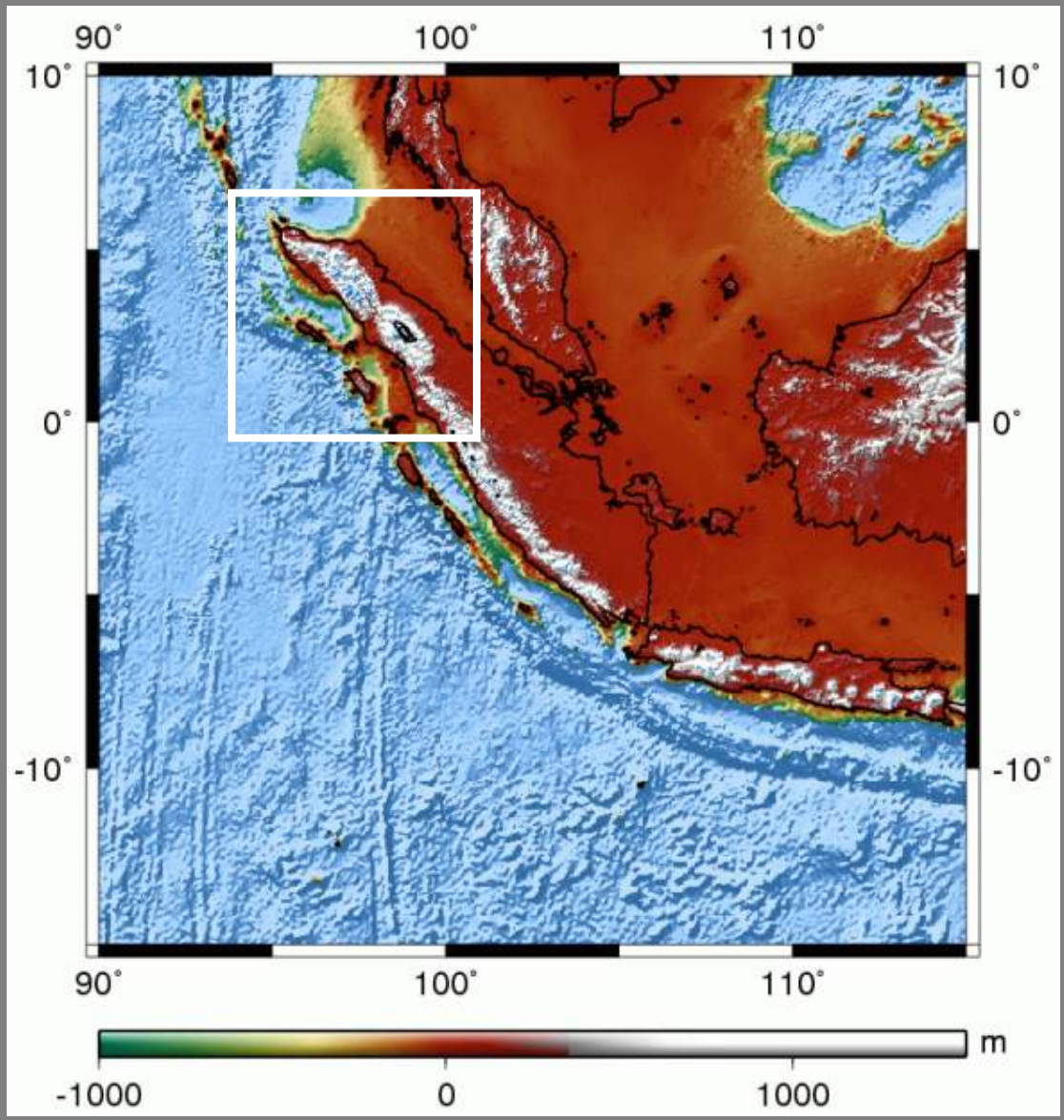
- Subsequently, the first wave could be seen at a distance but did not approach towards his direction.
- The wave was 30m high and more than 1km wide. Then, the second wave came and moved his boat up and down in an instant and passed through towards Lhoong.
- After the wave passed, he returned to his fishing work but fish was never caught although he extended his fishing line up to 130m long (usually 40m).

Garapu、Rambeu、Tandok were fished before the tsunami

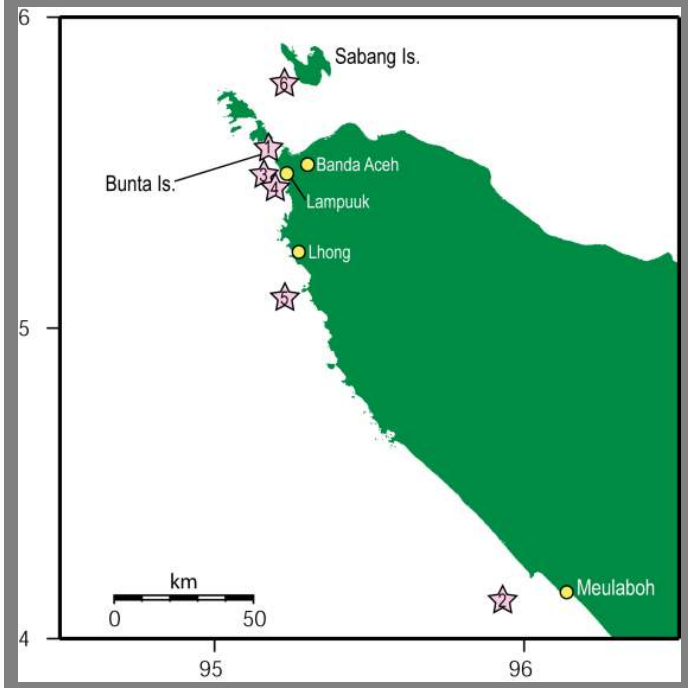
Depth <50m

1. Living at depths **20-30m to 50-60 m at most**, since they feed on small fishes that live on coral reefs.
2. Like **rocky seabed or coral reefs** where they hide.

Bathymetry of NE Indian Ocean

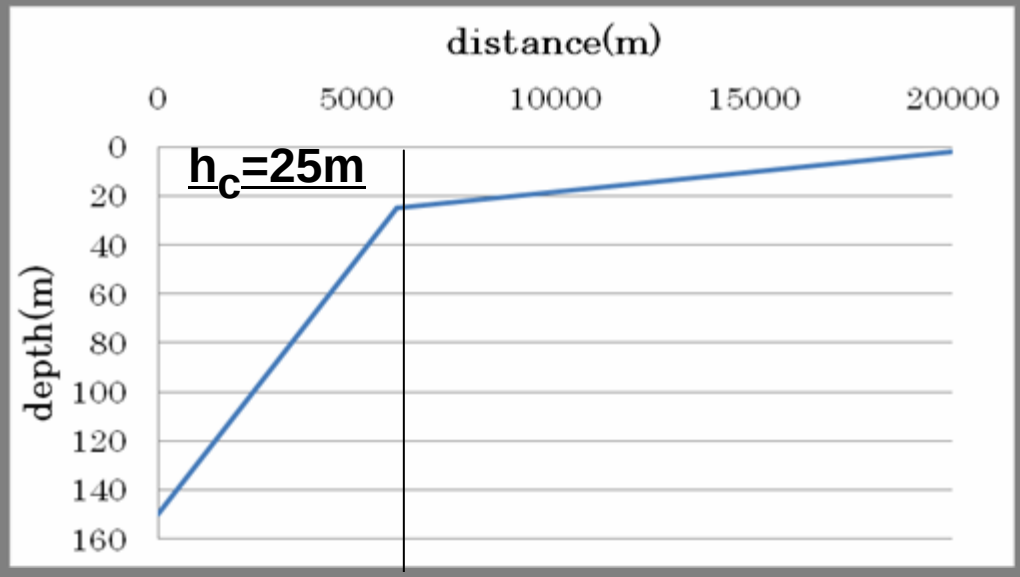


Offshore sites where the fishermen_interviewees encountered the large waves

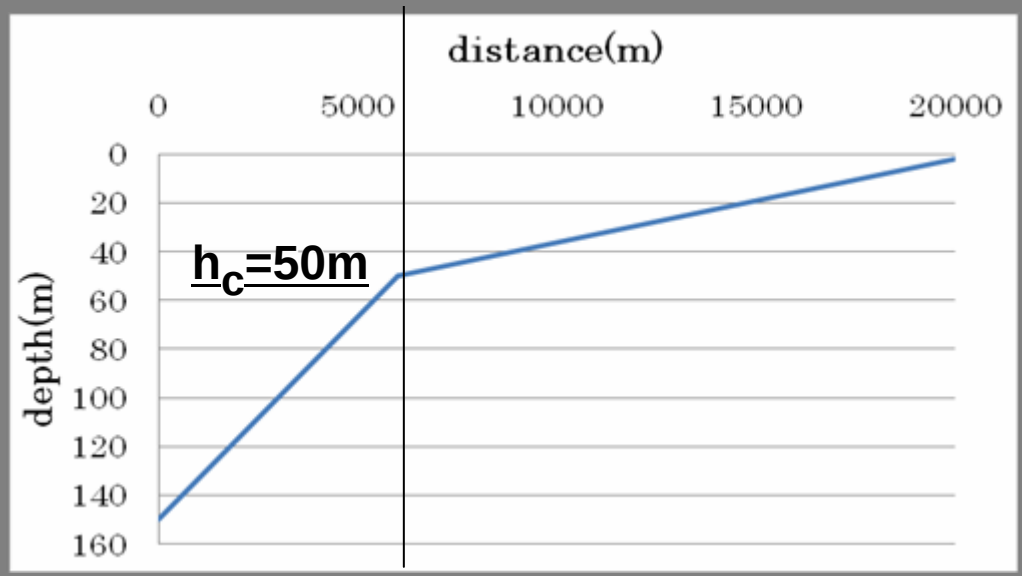


Shallow bathymetry (h<150m)

Model 1



Model 2



Tsunami simulation

1. Depth >= 150m ⟶ 2-D linear longwave equation

$$\frac{\partial \eta}{\partial t}+\frac{\partial Q_x}{\partial x}+\frac{\partial Q_y}{\partial y}=0$$

$$\frac{\partial Q_x}{\partial t}+gh\frac{\partial \eta}{\partial x}=0 \qquad \frac{\partial Q_y}{\partial t}+gh\frac{\partial \eta}{\partial y}=0$$

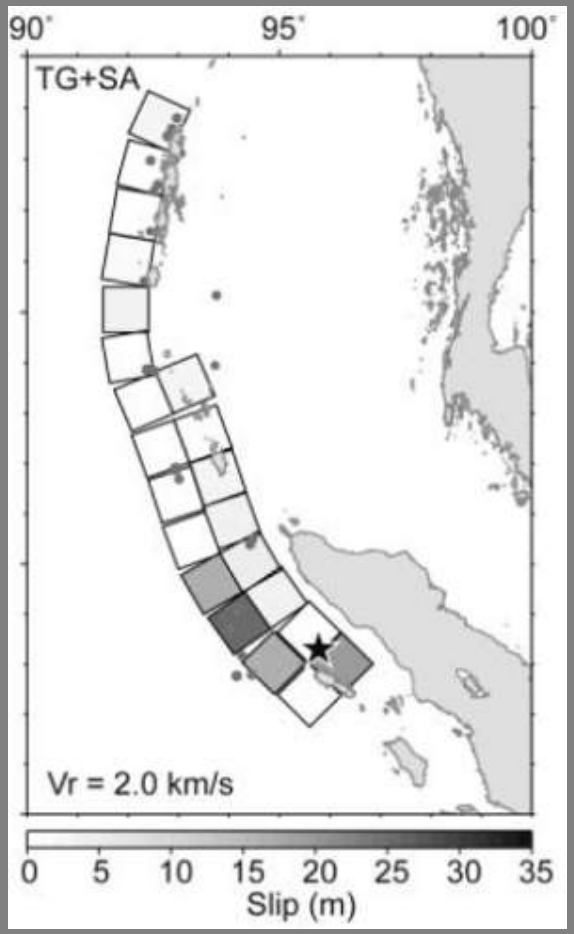
2. Depth < 150m ⟶ 1-D nonlinear dispersive equation

$$\frac{\partial \eta}{\partial t}+\frac{\partial Q}{\partial x}=0$$

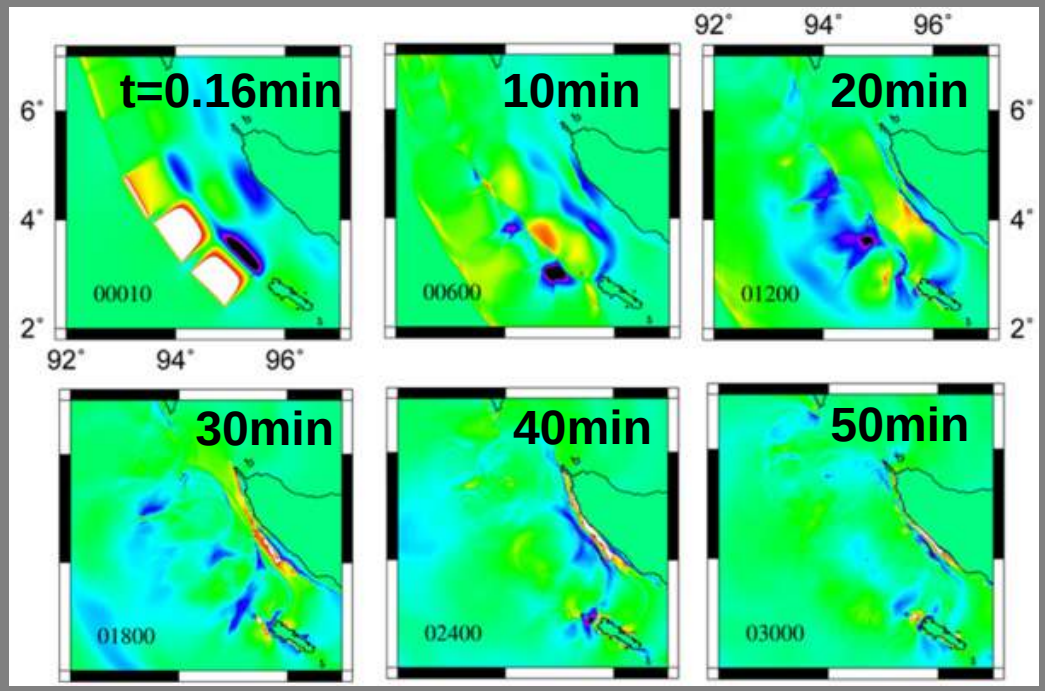
$$\frac{\partial Q}{\partial t}+\frac{\partial}{\partial x}\left[\frac{Q^2}{D}\right]+gD\frac{\partial \eta}{\partial x}+\frac{gn^2}{D^{7/3}}M|M|=\frac{2}{5}h^2\frac{\partial^3 Q}{\partial t \partial x^2}+\frac{1}{15}gh^3\frac{\partial^3 \eta}{\partial x^3}$$

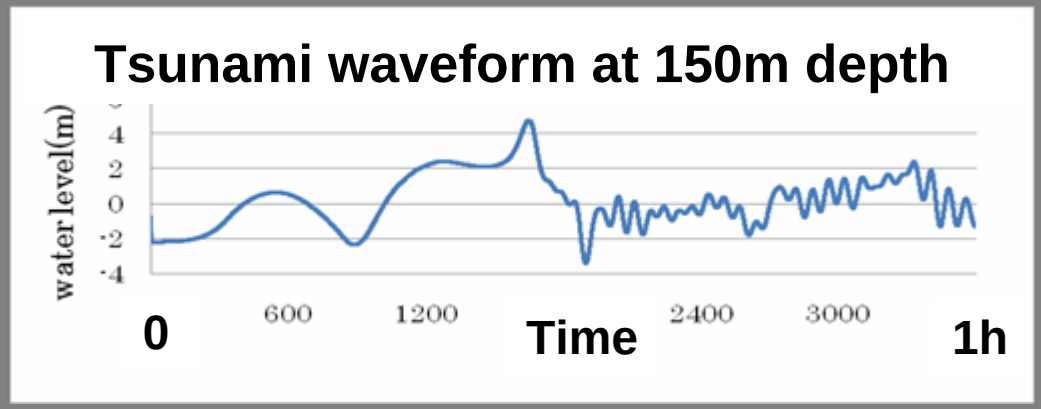
Q :Water flux	*η :Water height*
h :Still water depth	*g :Acceleration of gravity*
D :Total water depth (η+h)	*n: Coefficient of bottom friction*

Tsunami simulation based on linear longwave equation for h>=150m



(Fujii and Satake, 2007)

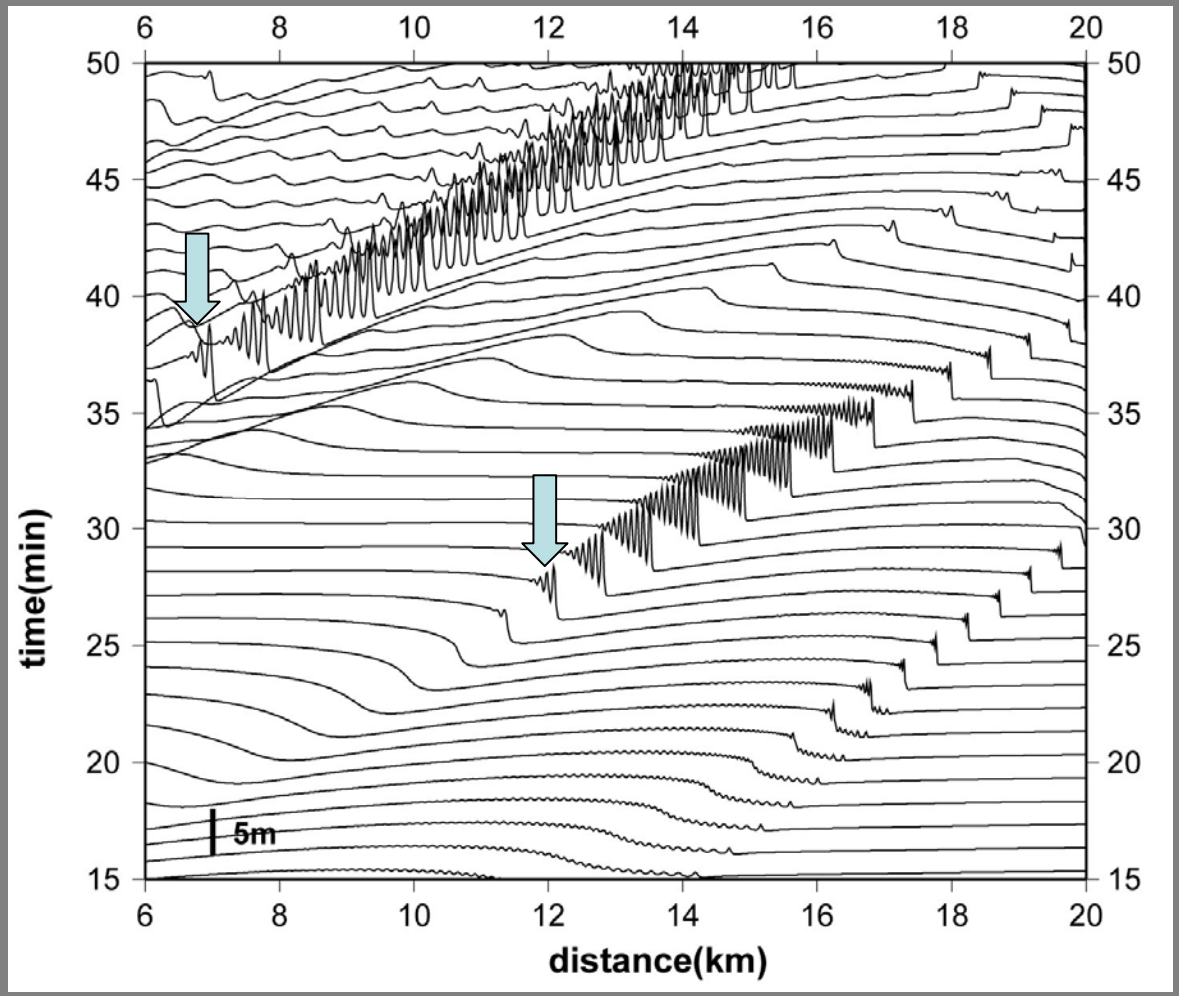




Tsunami waveform for Model 1

Depth=25m

0m

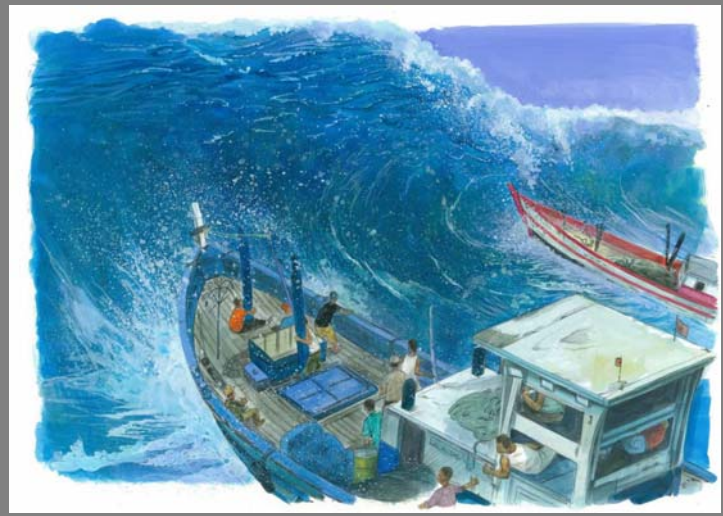


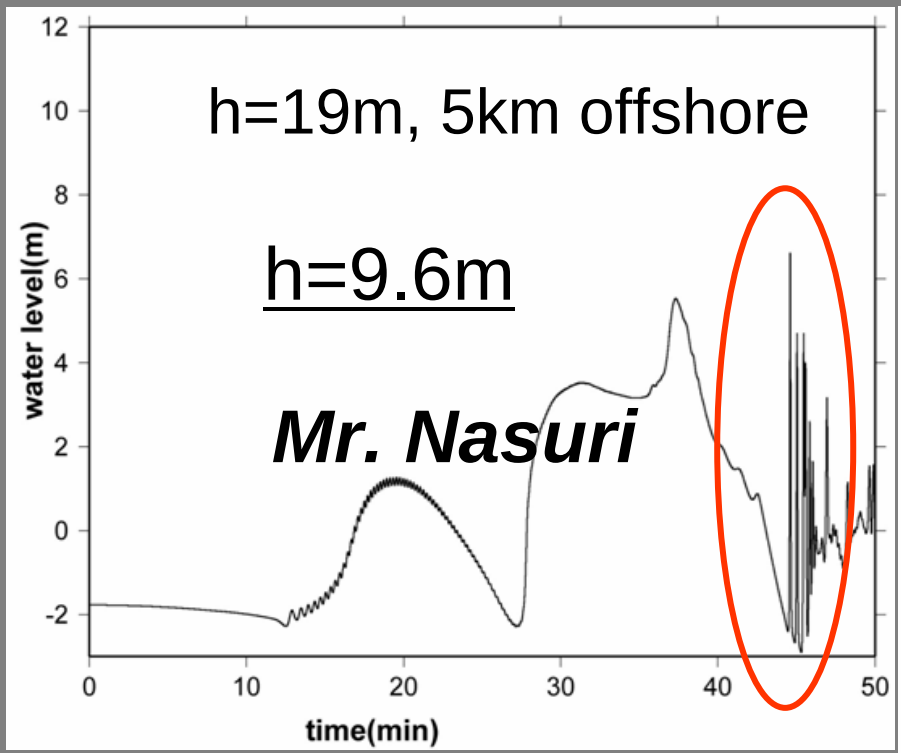
Δ t=0.05s
Δ x=10m

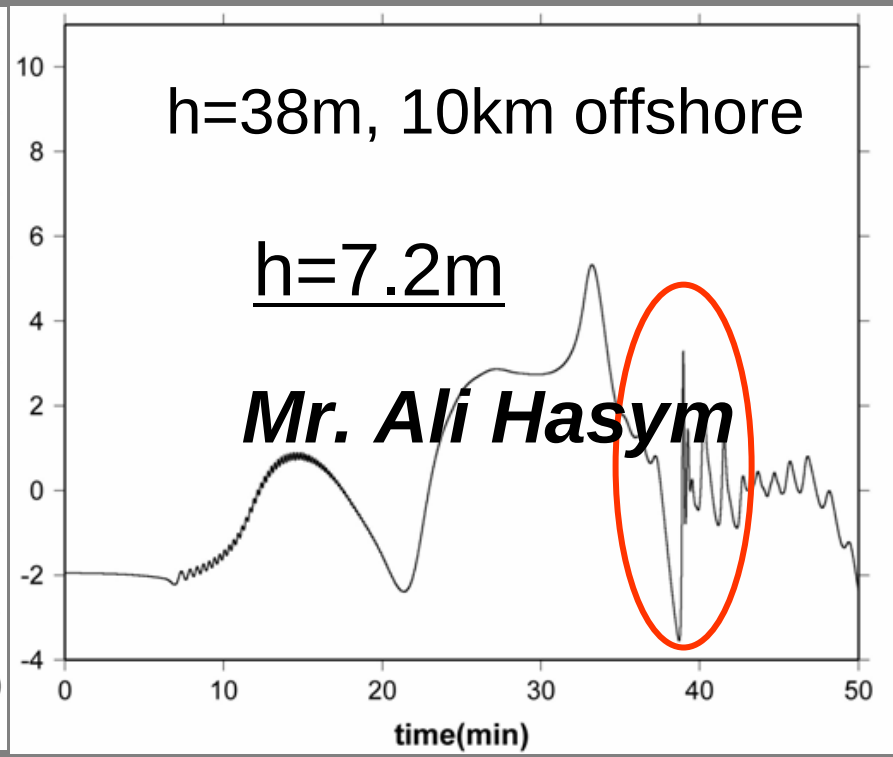
Time, min

Distance, km

Model 2 (h_c=50m)

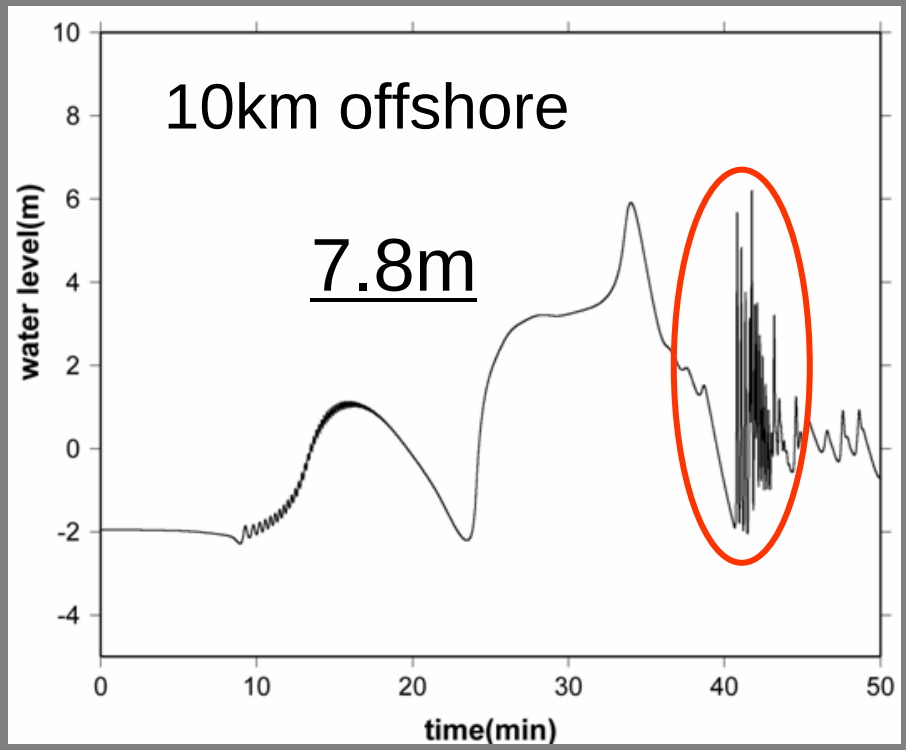




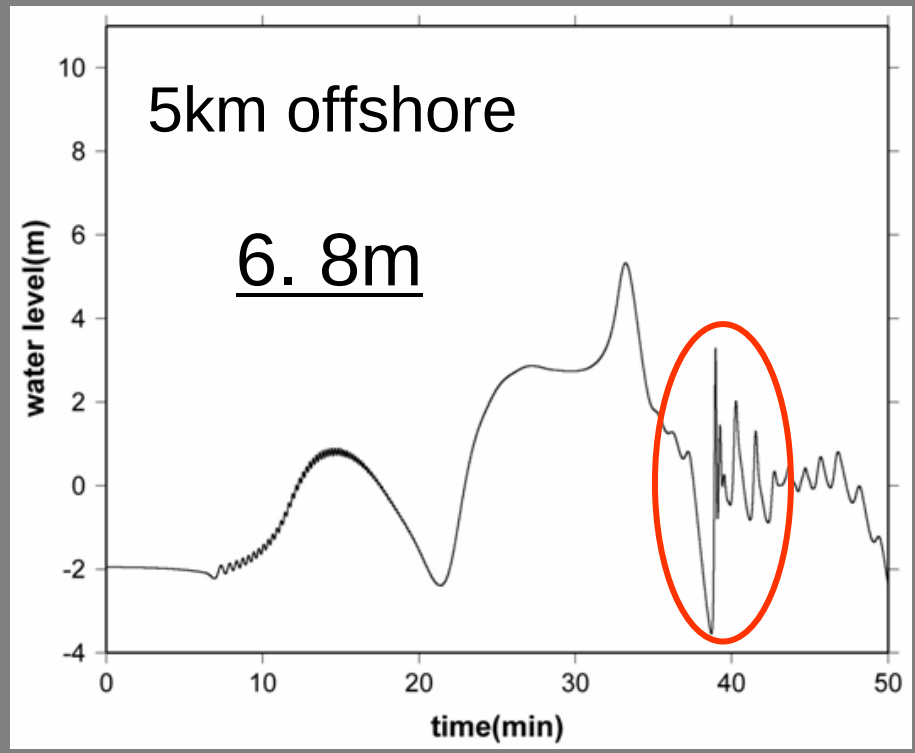


Depth at 18m

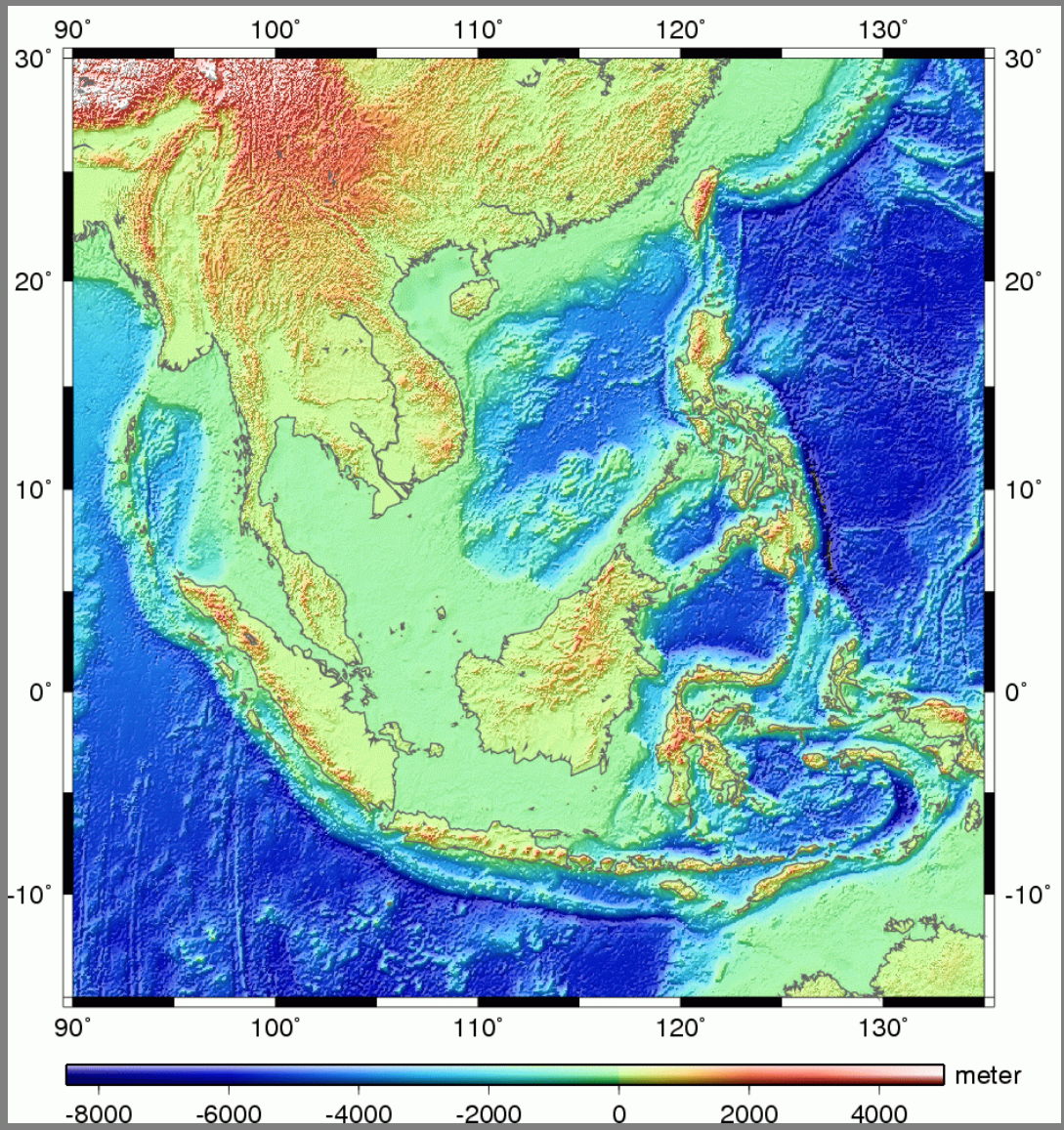
Model 1 (h_c=25m)



Model 2 (h_c=50m)

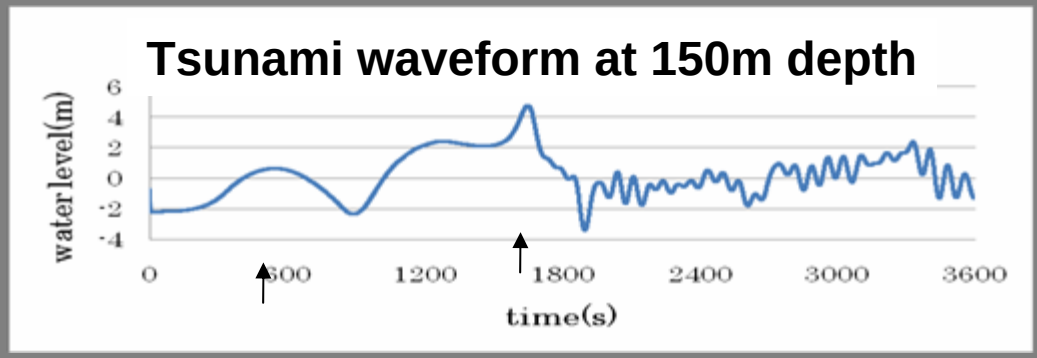


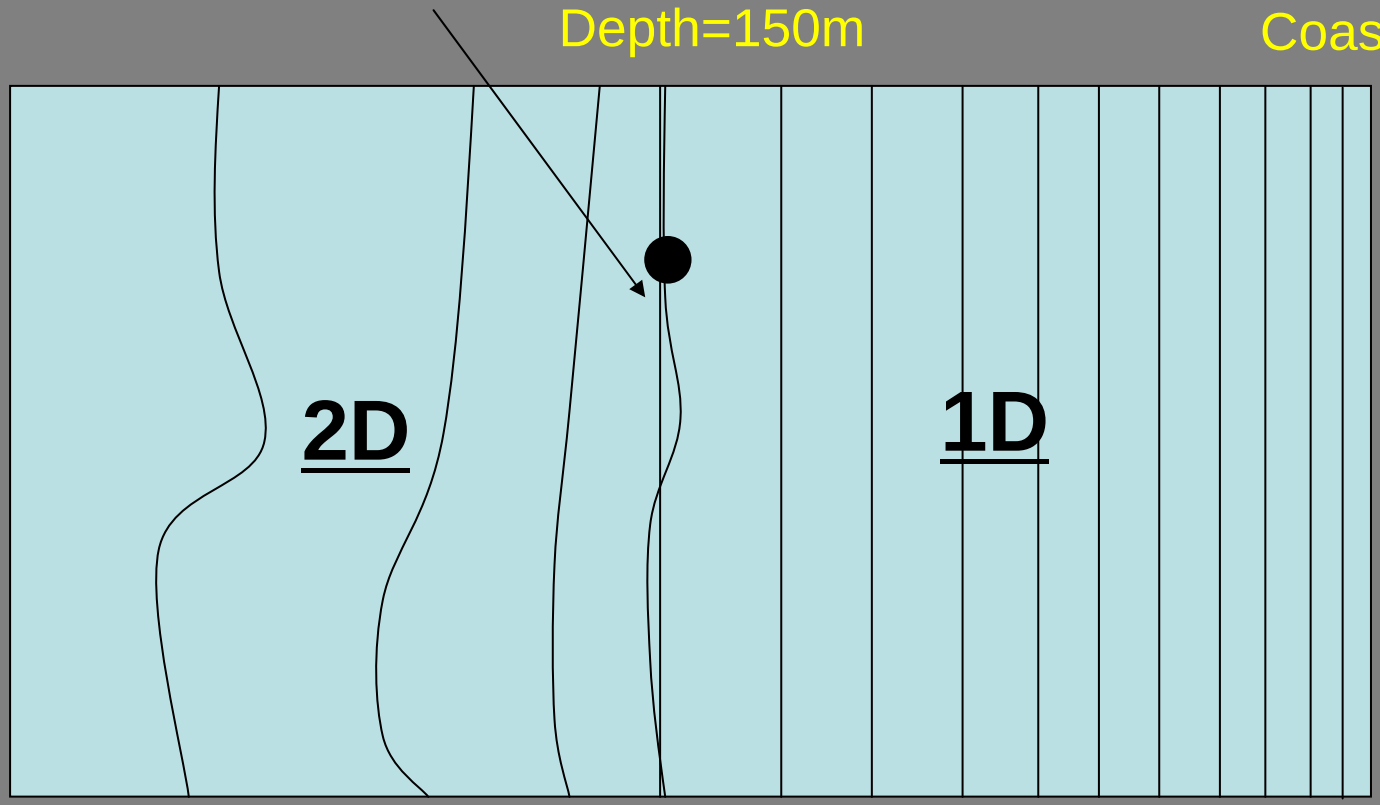
Soliton waves are likely to occur on continental shelves in South China Sea



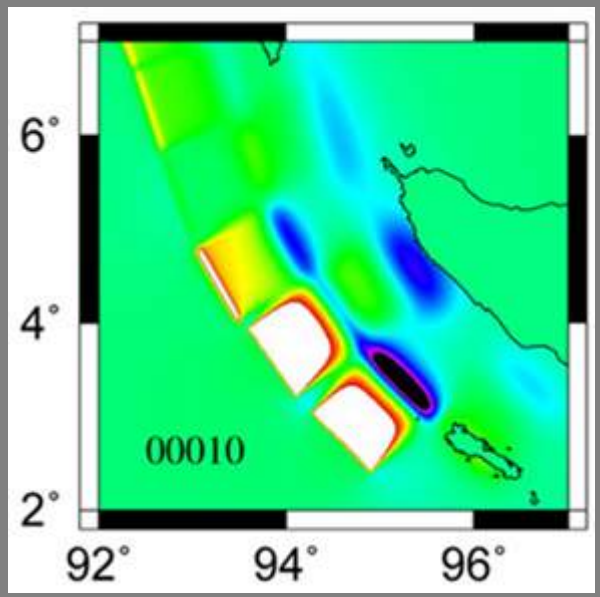
Summary

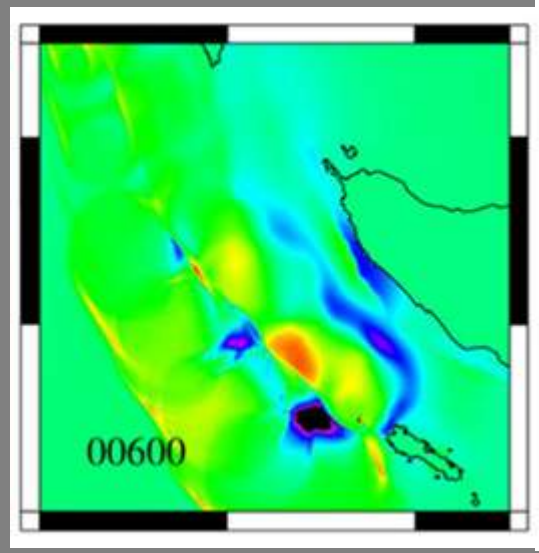
- **Fishermen onboard 0.5 to 20 km off the west coast of northern Sumatra when the tsunami occurred were interviewed.**
- **At depths 20-30m, the nonlinear dispersive equation generates short-period soliton waves of 7-10m height on the steeply uprising waves.**
- **Shallow gentle-slope sea are potentially vulnerable to damage of large soliton waves when tsunamis strike.**

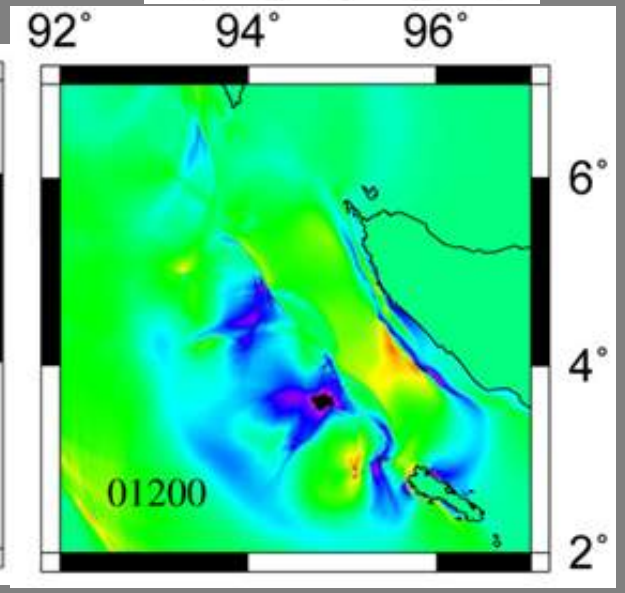

Tsunami waveform at 150m depth
water level(m)
6
4
2
0
-2
-4
0
600
1200
1800
2400
3000
3600
time(s)

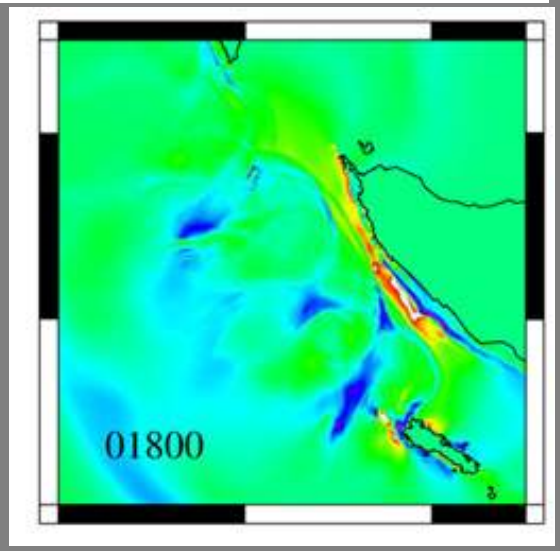

Depth=150m
Coast
2D
1D

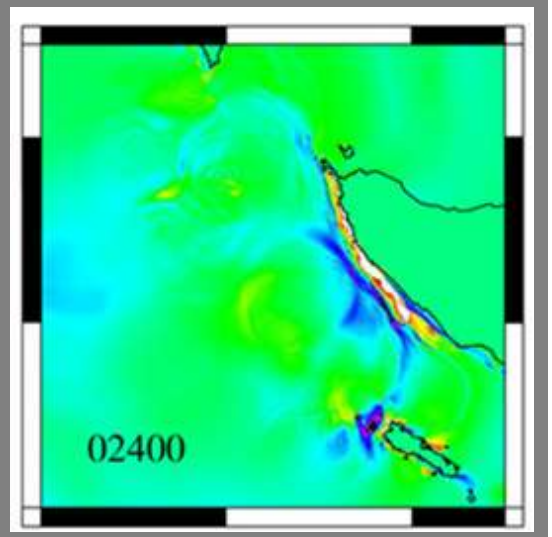
Tsunami wave height (0-40min)

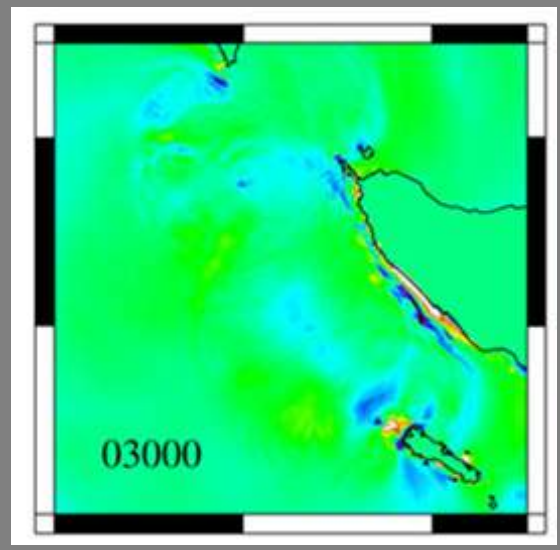












Fault model by Fujii and Satake (2007)