IAEA ANSN / ISSC - REGIONAL WORKSHOP ON
"Volcanic, Seismic, and Tsunami Hazard Assessment Related to NPP Siting Activities and Requirements"
Jakarta, Indonesia, 13-17 June 2011

"Tsunami-Tsunami Hazard Assessment-Warning and Notification Systems"

Prof. Dr. Ahmet Cevdet YALCINER
INTERNATIONAL SEISMIC SAFETY CENTRE, NSNI/IAEA

IAEA
International Atomic Energy Agency

Lecture XX

IAEA ANSN / ISSC - REGIONAL WORKSHOP ON
"Volcanic, Seismic, and Tsunami Hazard Assessment Related to NPP Siting Activities and Requirements"
Jakarta, Indonesia, 13-17 June 2011

"Tsunamis from Source to Targets, Protection and Safety Measures"

Prof. Dr. Ahmet Cevdet YALCINER
INTERNATIONAL SEISMIC SAFETY CENTRE, NSNI/IAEA

IAEA
International Atomic Energy Agency

Lecture XX

- TSU: harbor
- NAMI: wave

津波 (つなみ)

- The word tsunami was regitered in all languages after Great Meiji Tsunami 1883.

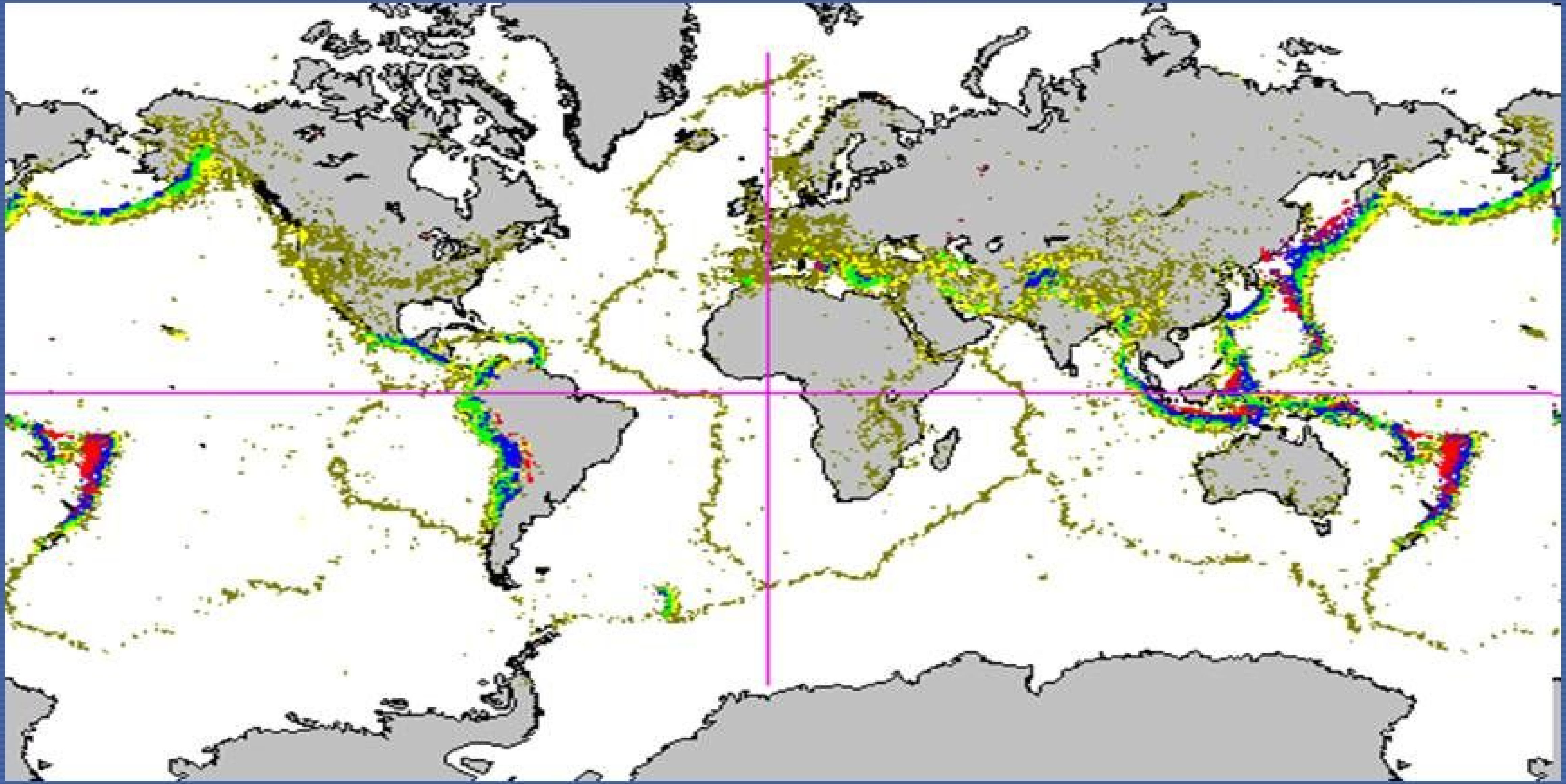
WHAT IS TSUNAMI?

A **tsunami** is a series of ocean waves of extremely long wave length and long period generated in a body of water by an impulsive disturbance that displaces the water.

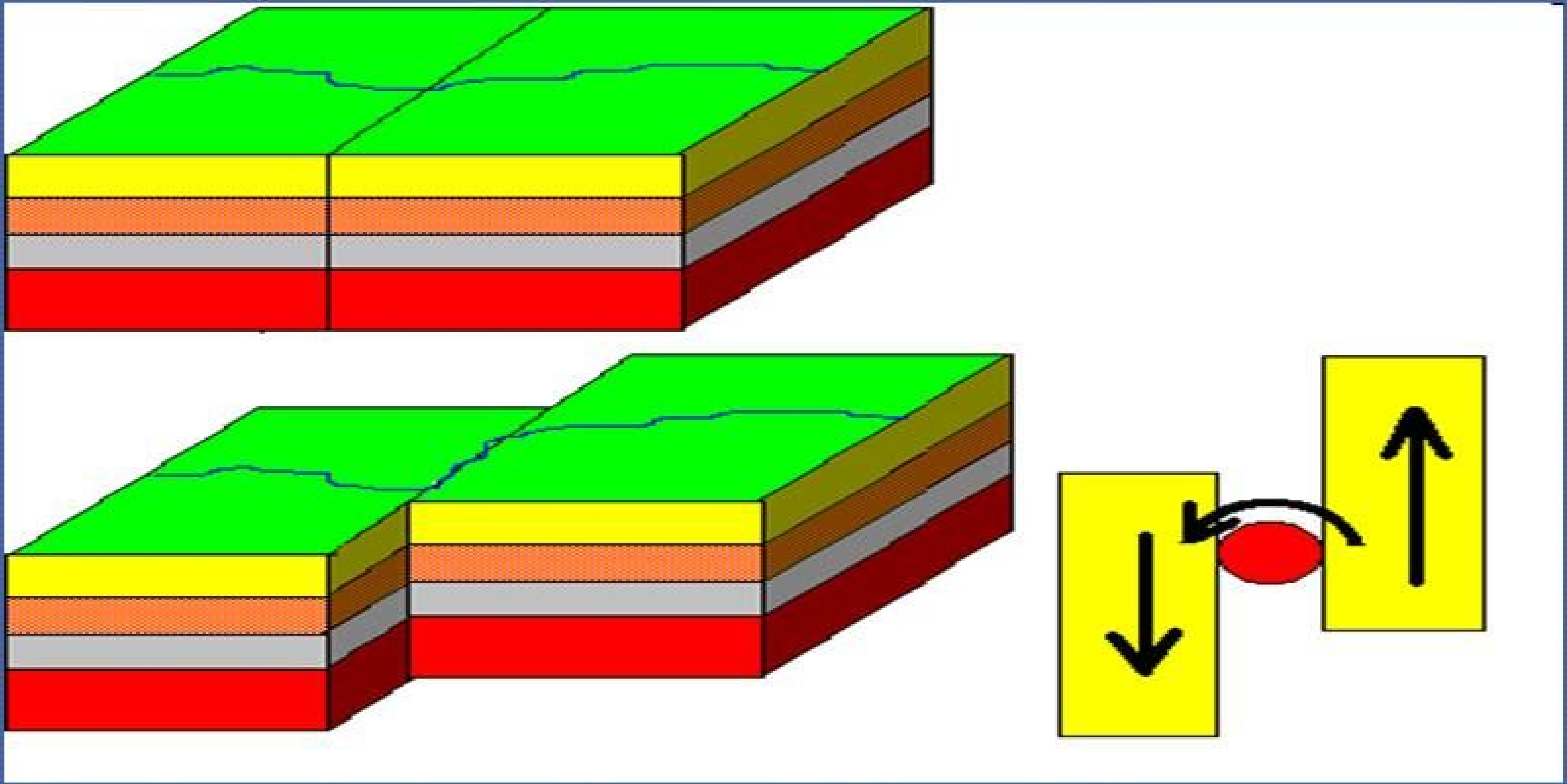
CAUSES OF TSUNAMI

- Impulses are:
- **Submarine Earthquakes**
- **Undersea Landslides**
- **Volcanoes**
- **Impacts of objects from outer space (such as meteorites, asteroids, and comets)**

EARTHQUAKE ZONES

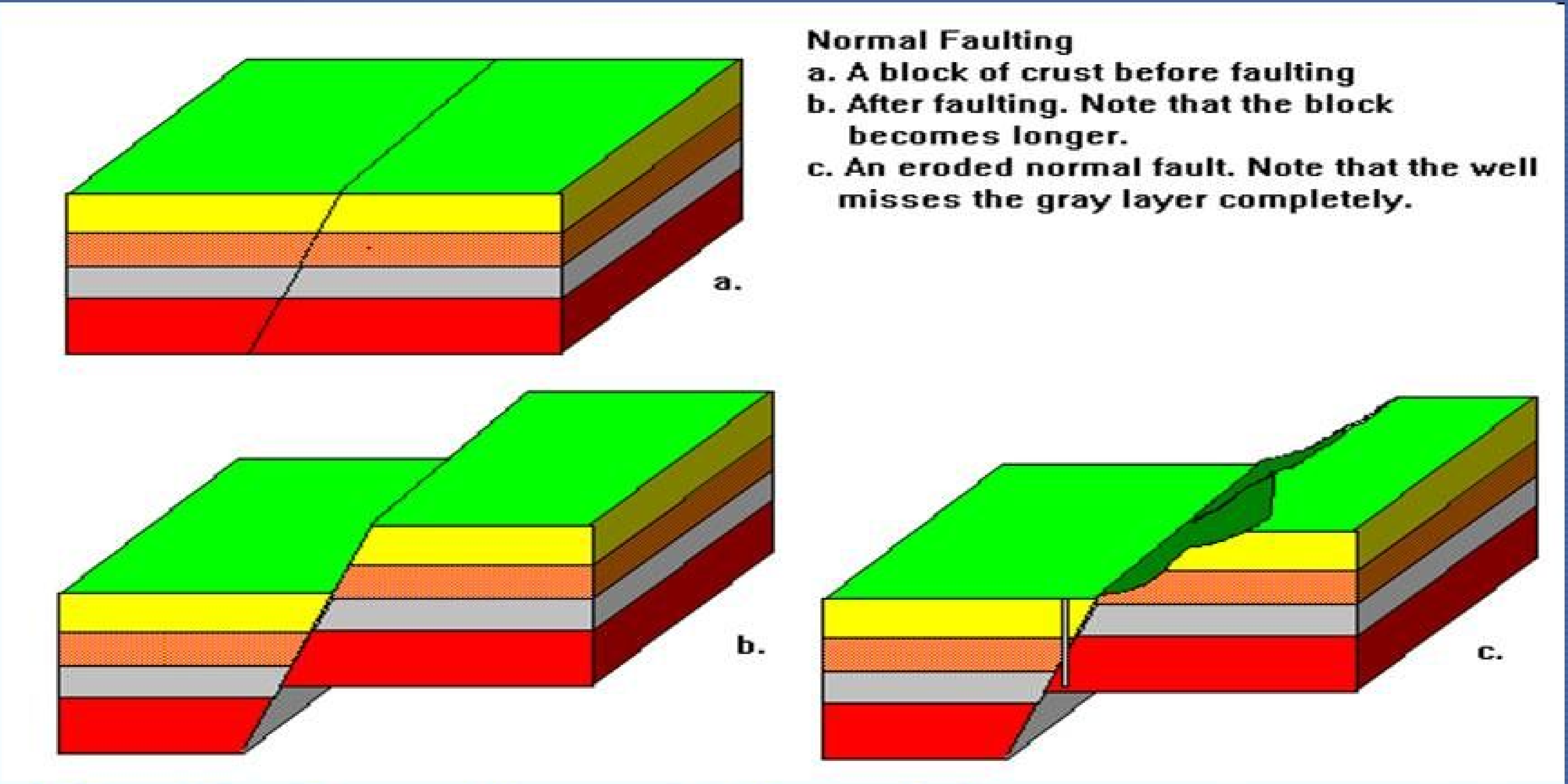


FAULTS: STRIKE SLIP



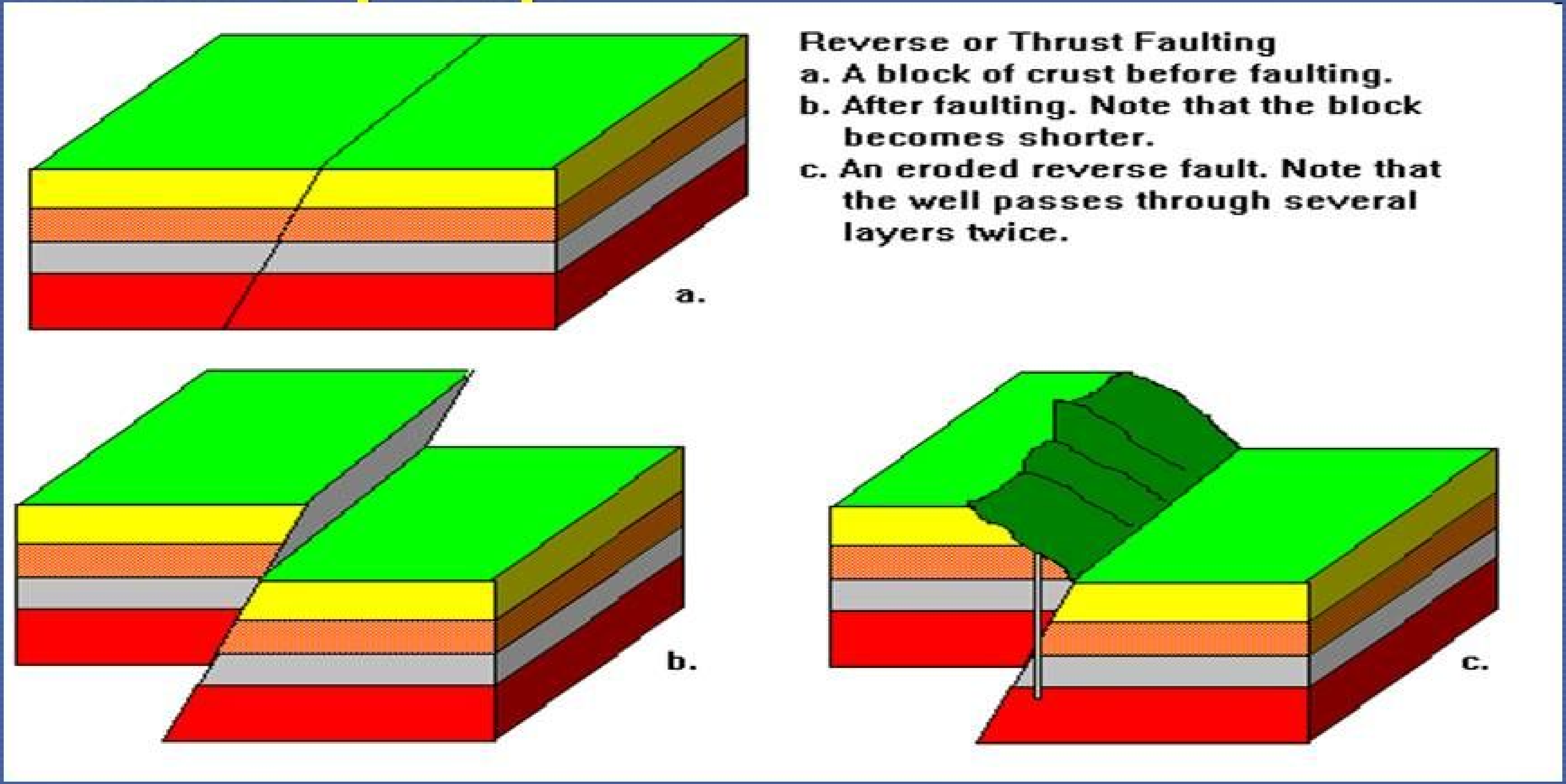
Horizontal motion of the plates

FAULTS: DIP SLIP



Vertical motion of the plates

Faults: Dip Slip



Vertical motion of the plates

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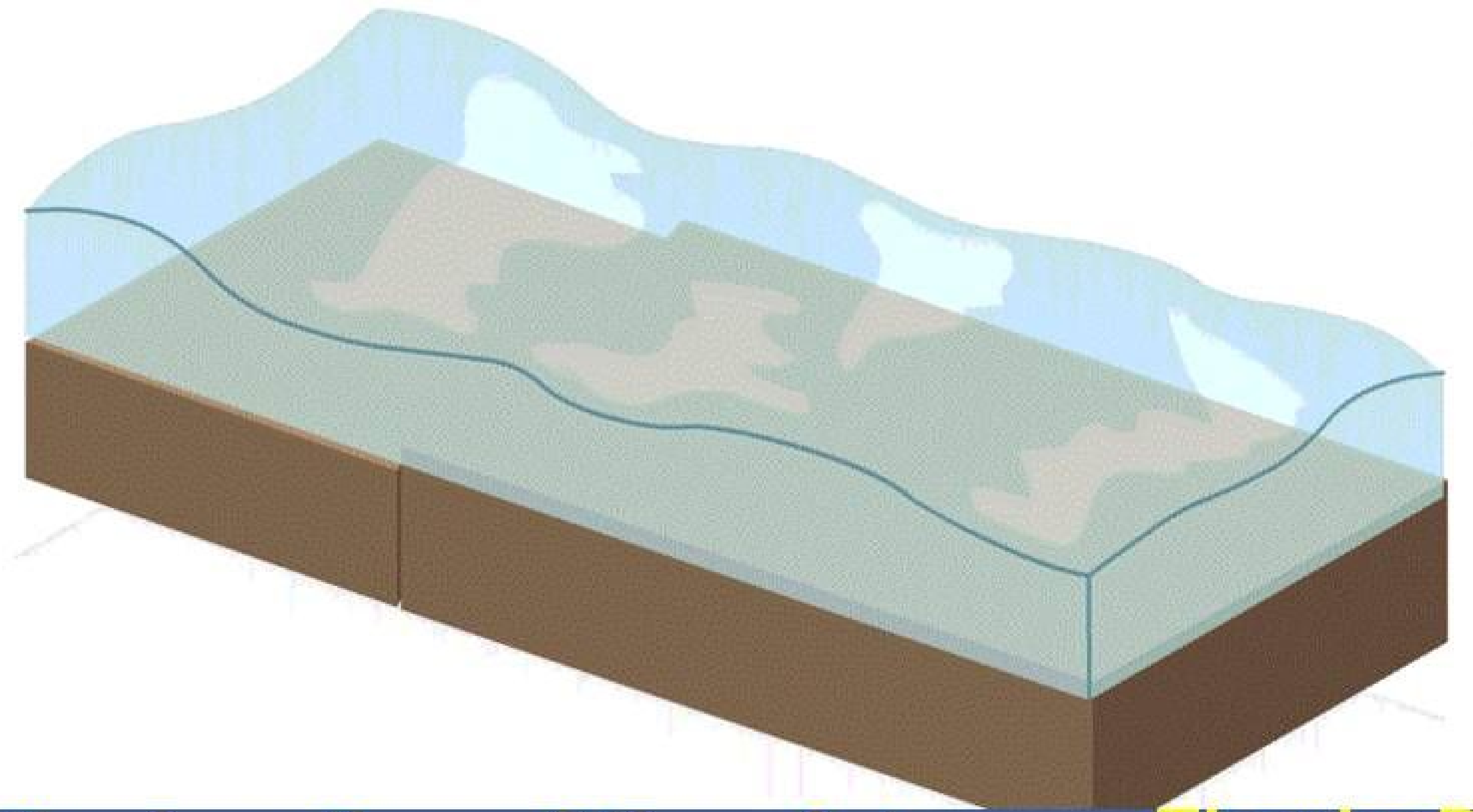
The tsunami formed when energy from the earthquake vertically jolted the seabed by several metres, displacing hundreds of cubic kilometres of water.



Vertical motion of the plates

Thanks Dr. Wattana (Thailand)

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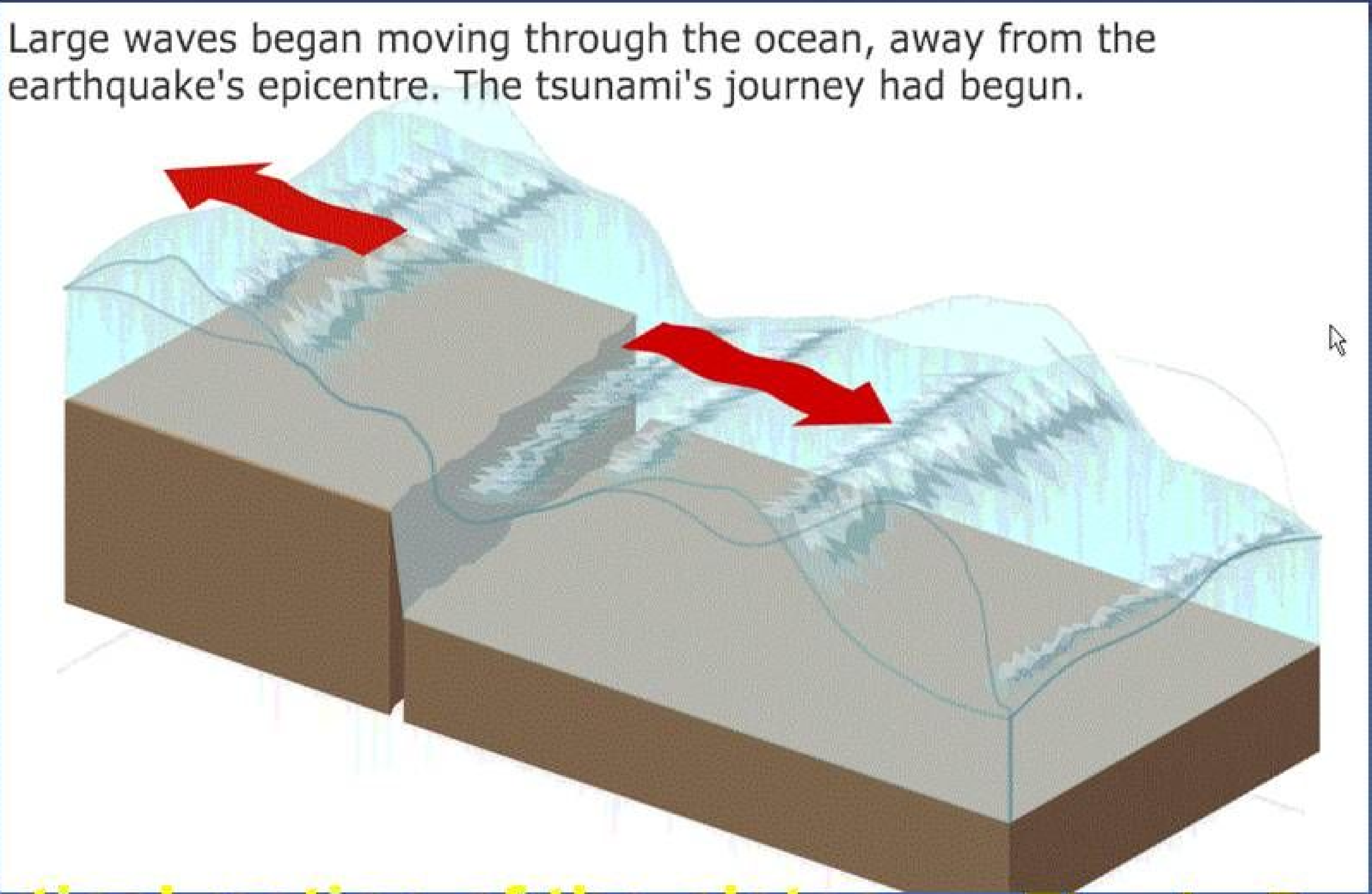
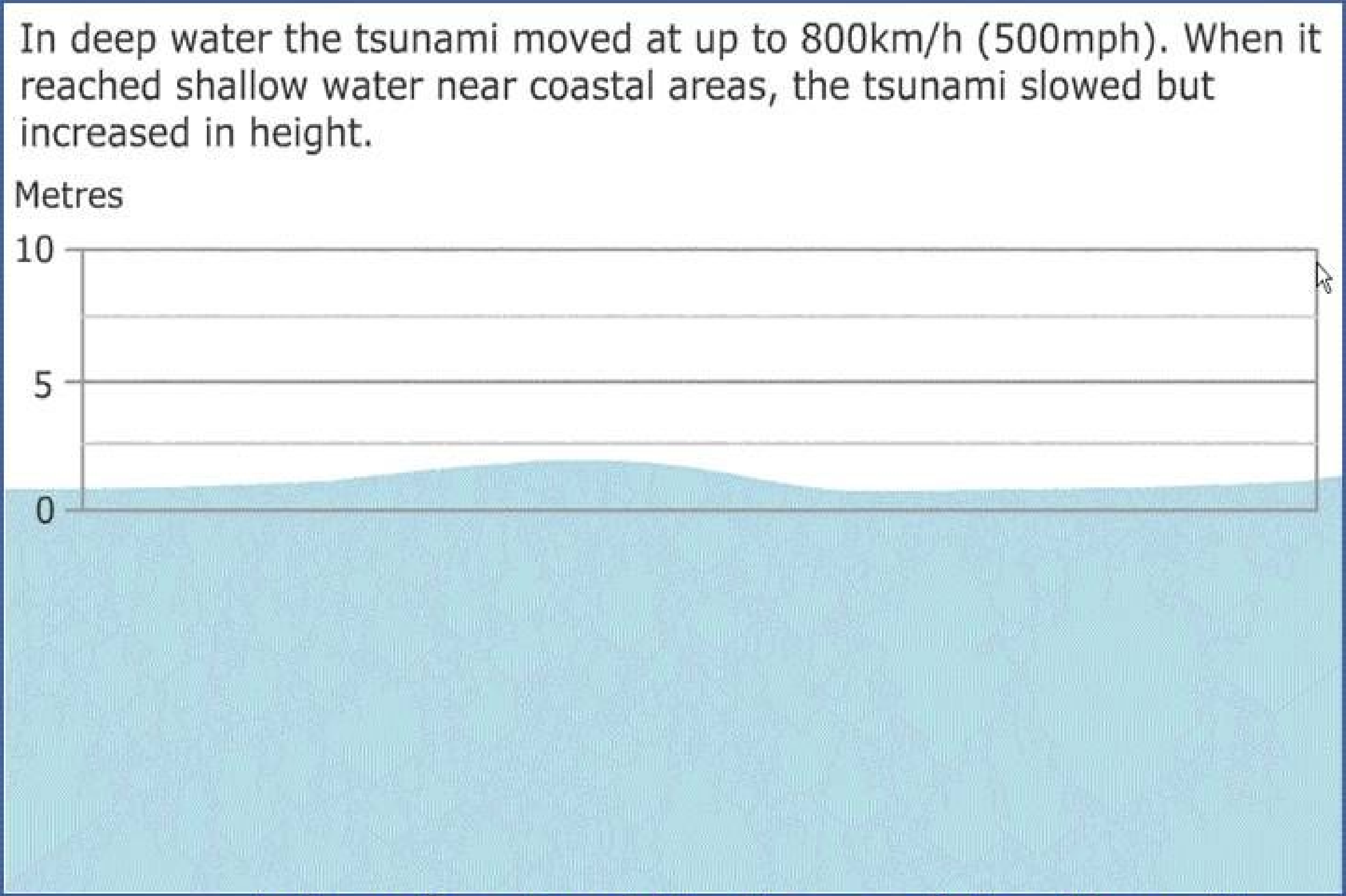


Vertical motion of the plates

Thanks Dr. Wattana (Thailand)

TSUNAMI AMPLIFICATION



Thanks Dr. Wattana (Thailand)

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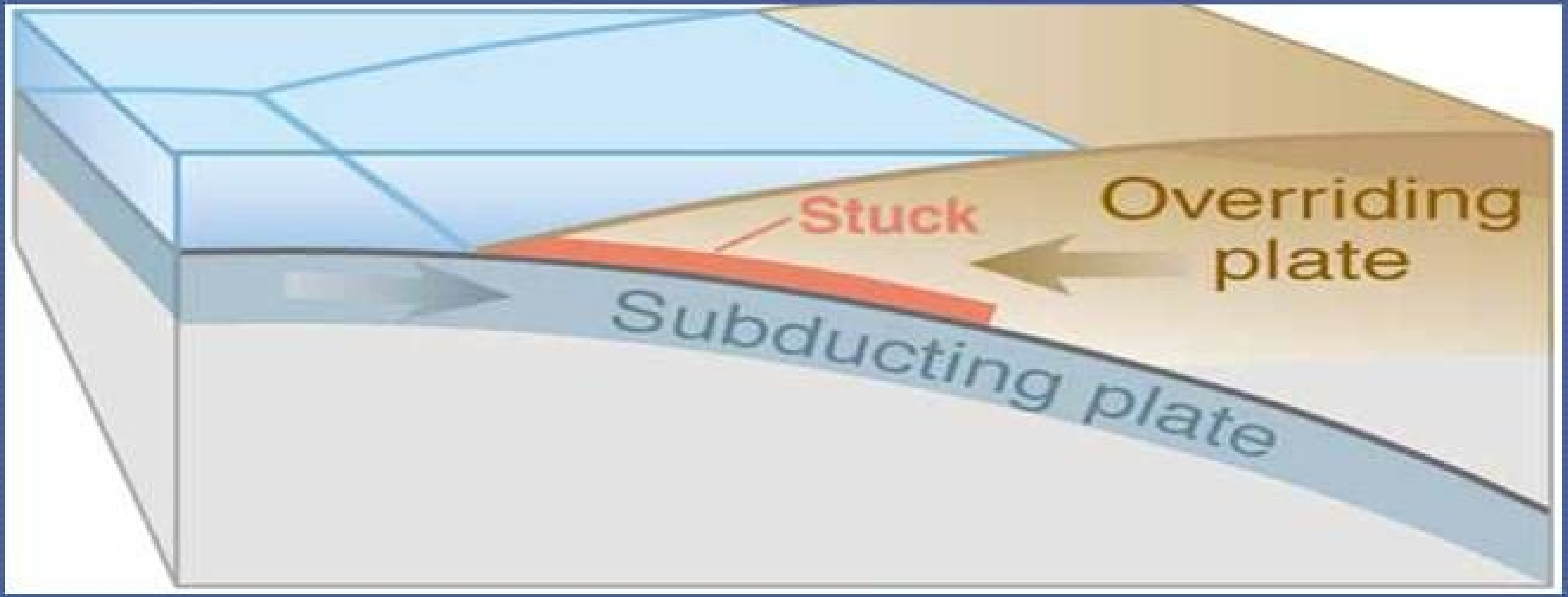
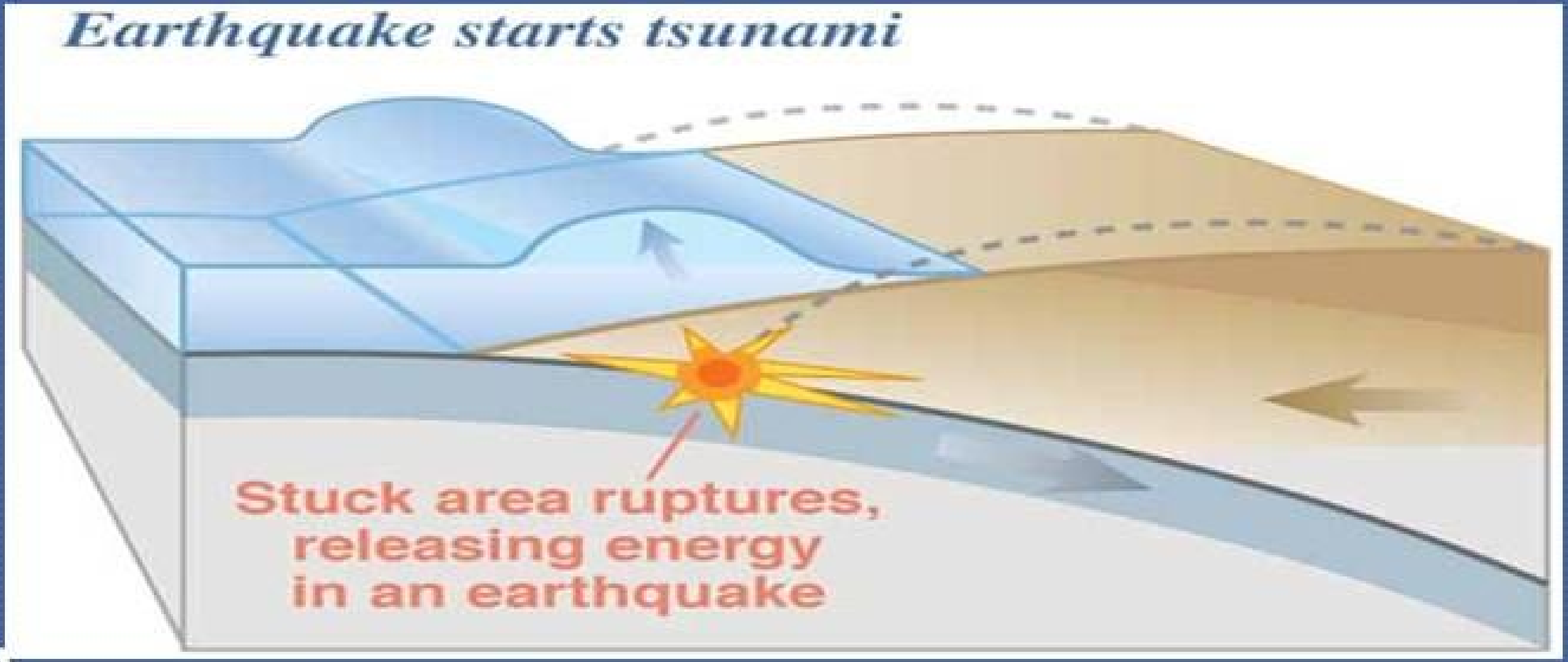

Stuck
Overriding
plate
Subducting plate


Earthquake starts tsunami
Stuck area ruptures,
releasing energy
in an earthquake

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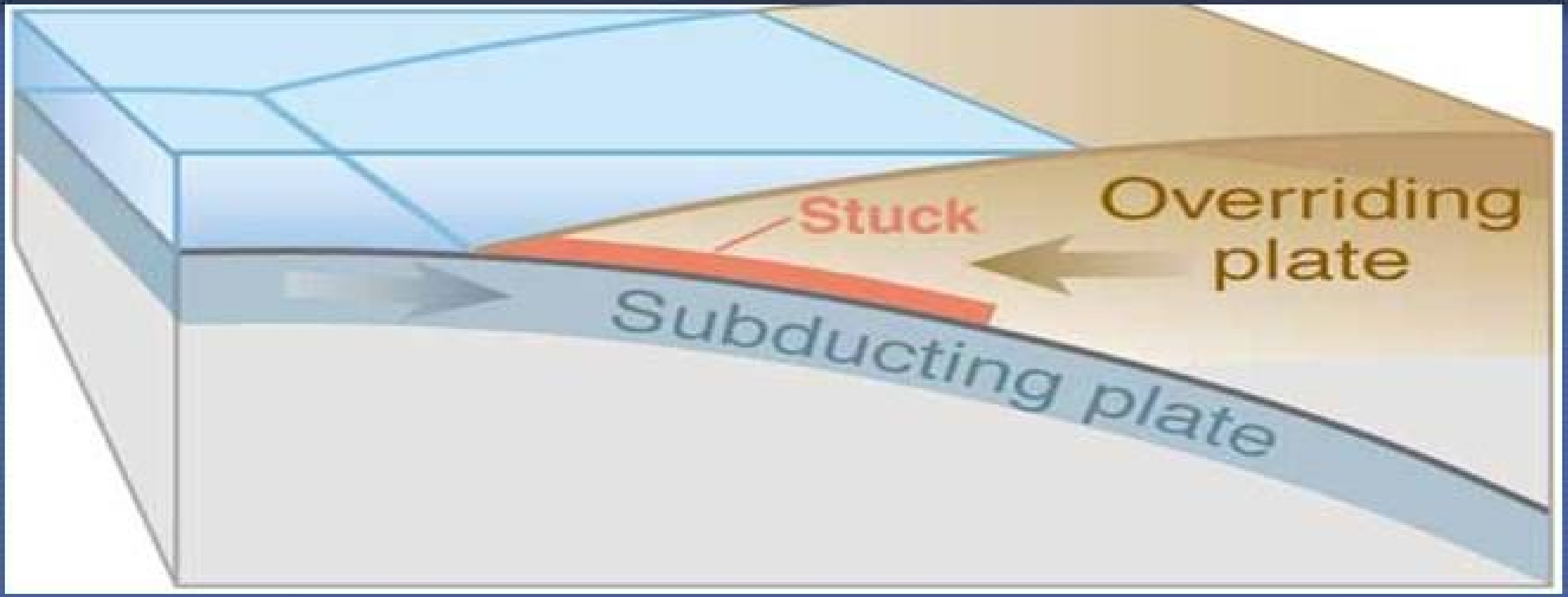
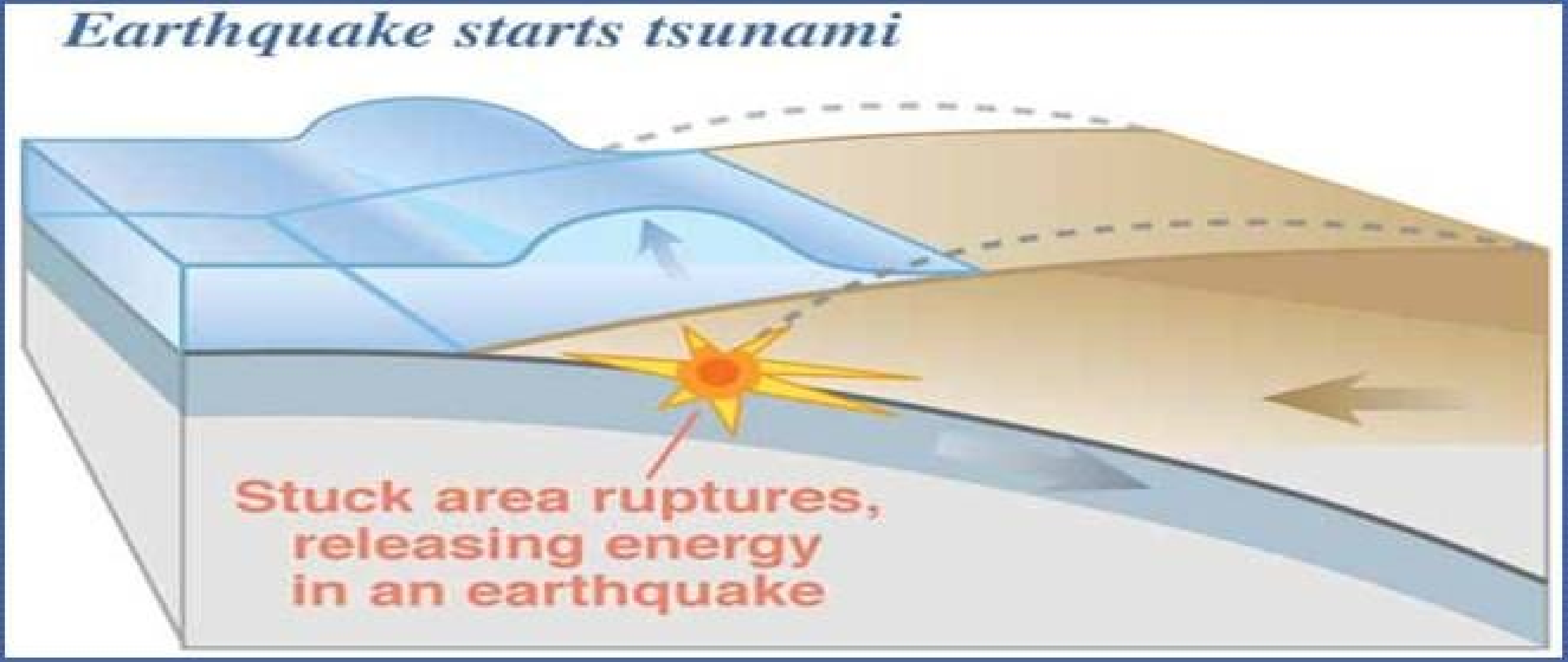

Stuck
Overriding plate
Subducting plate


Earthquake starts tsunami
Stuck area ruptures, releasing energy in an earthquake

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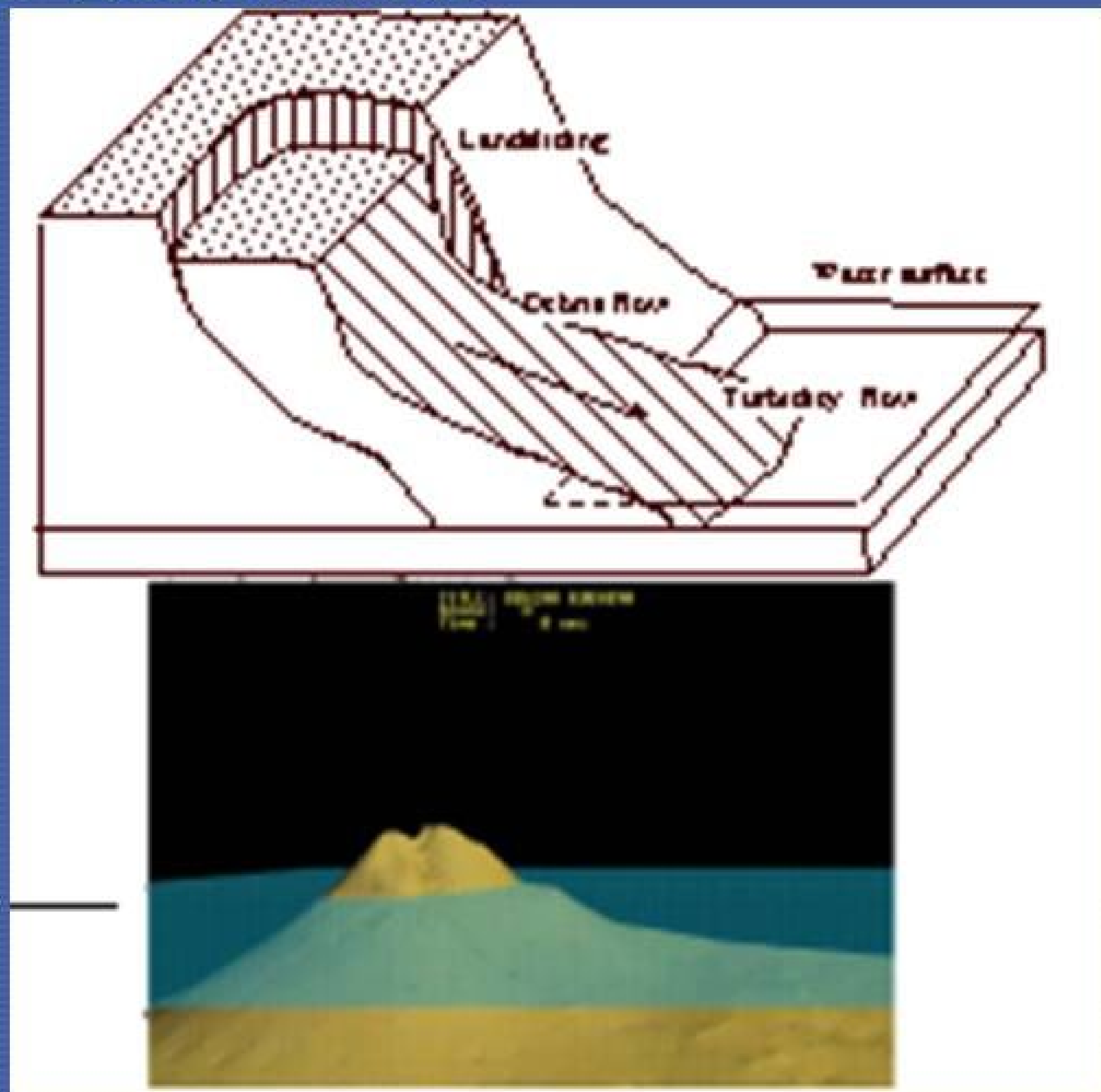
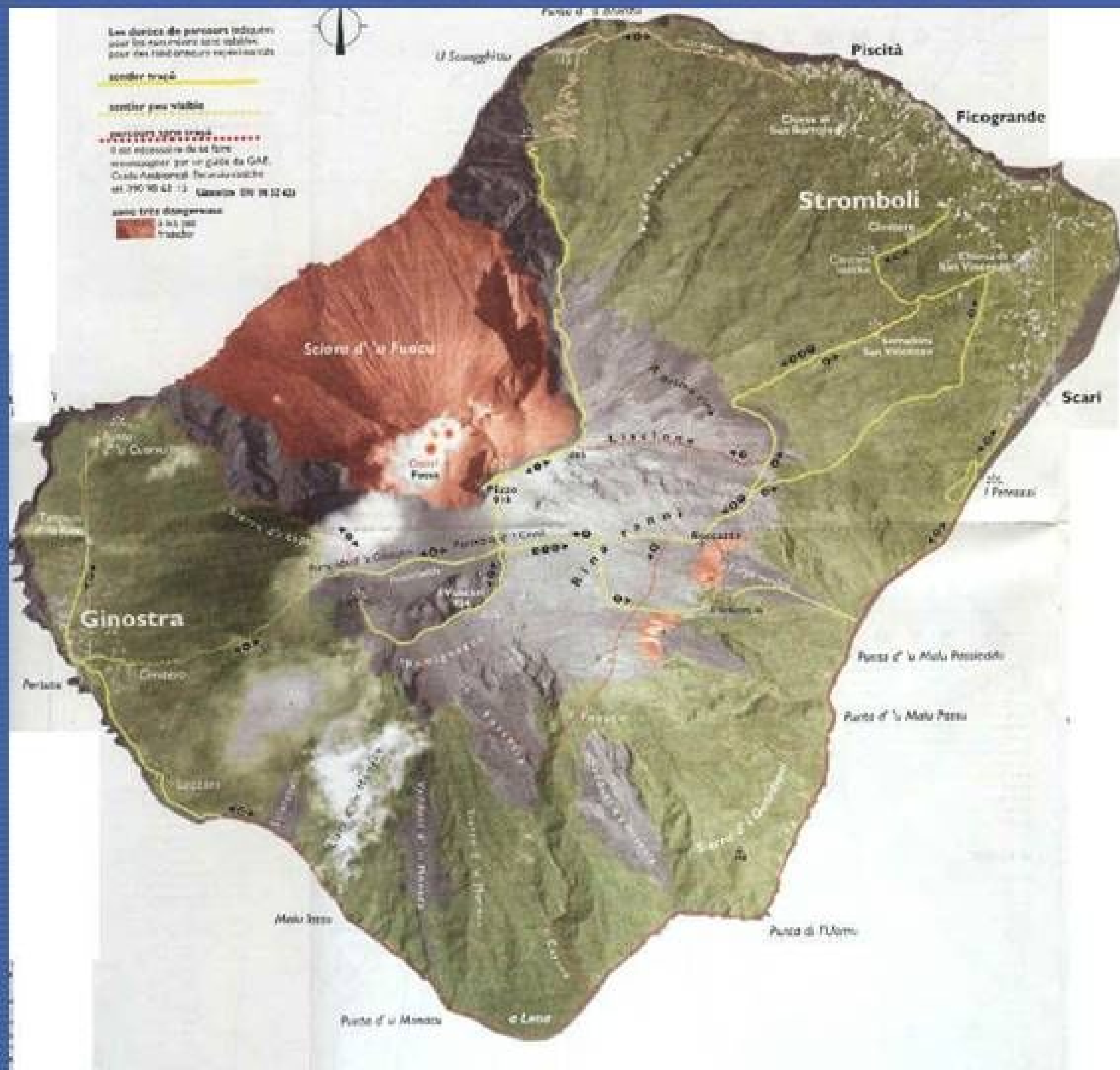
Submarine Landslide



Stromboli Eruption and Associated Submarine and Subareial Landslide

Stromboli Eruption and Associated Submarine and Subareial Landslide

Stromboli Eruption and Associated Submarine and Subareial Landslide



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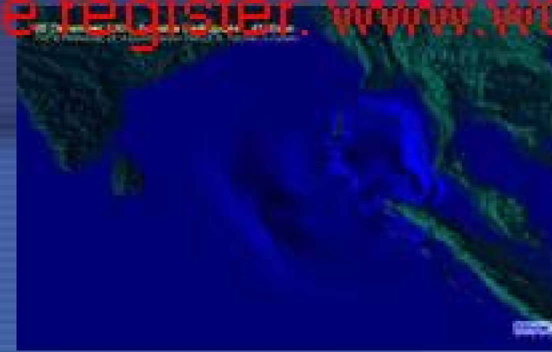
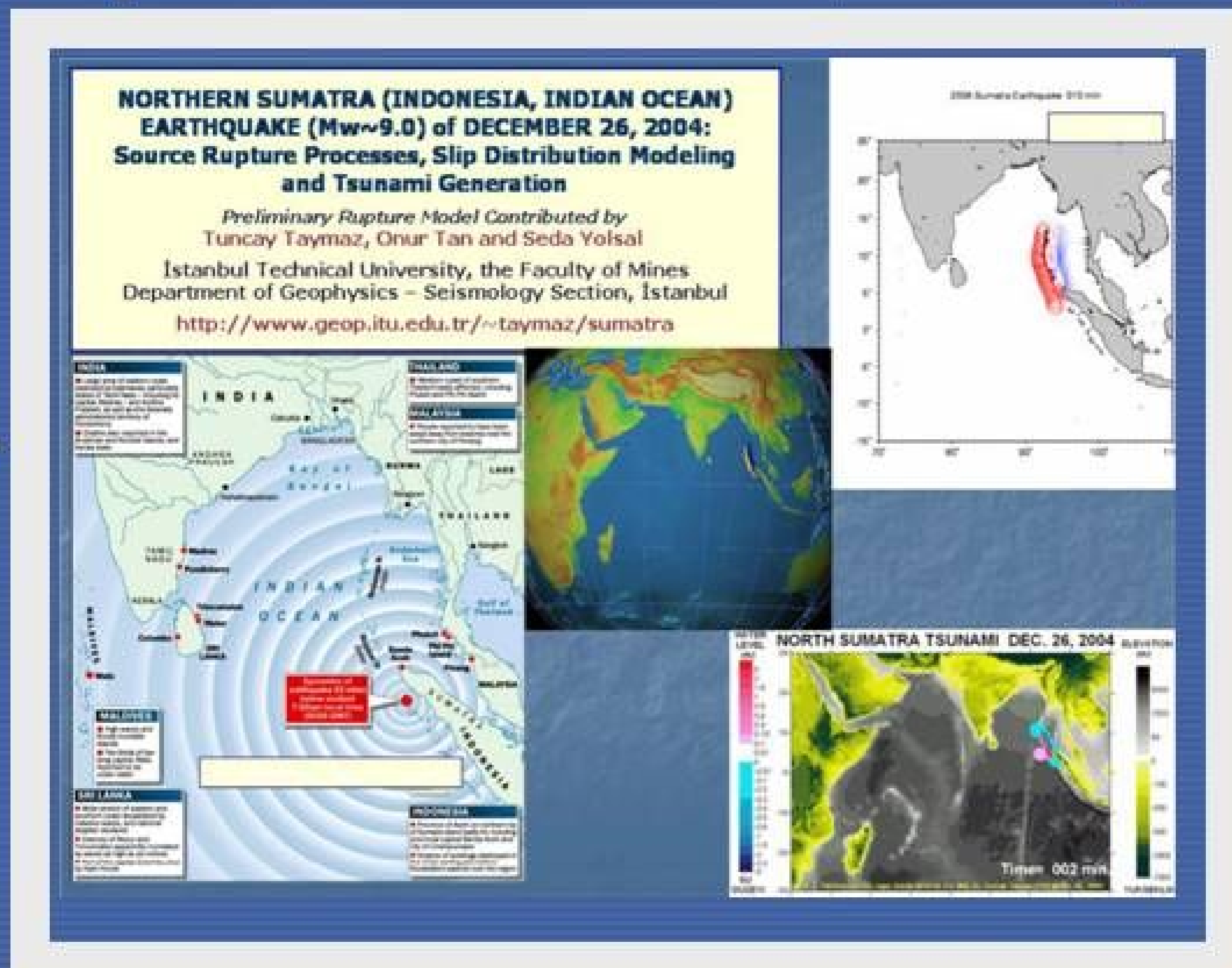


? ?

BEFORE



AFTER

? DATE MARK ?

Dec. 26, 2004

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There are mainly two types of tsunami effects:

1) Indirect Effect: The resonance of the enclosed basins

2) Direct Effect: very extensive and disastrous impact

→ wave elevations and flow velocity are main parameters causing damage !!!

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- The amplification of tsunami amplitudes at coasts and resulting strong flow velocities are main cause of impact by tsunami waves.

TSUNAMIS CAN:

1) drag the whole structures
or their units at land or vessels in the sea,

2) damage the buildings with accumulated shoreline debris carried on the advancing wave fronts,

TSUNAMIS CAN:

3) undercut foundations and pilings with erosion caused by the receding waves,

4) overturn structures by suction of receding or thrust of advancing waves.

Importance of Hydrodynamic Parameters

- Maximum positive amplitude ➡ important for several coastal regions.
- Maximum current velocity ➡ important for scour, erosion, deposition and debris drag.
- Hydrodynamic load ➡ an instantaneous value during inundation depending on water velocity and flow depth. Since current velocity and flow depth are changing independently, the maximum value of hydrodynamic load also varies with time.
- Maximum negative amplitude ➡ essential for the ships and boats at shallow region since water depth decreases.
- Flow depth ➡ another governing parameter for hydrodynamic load.

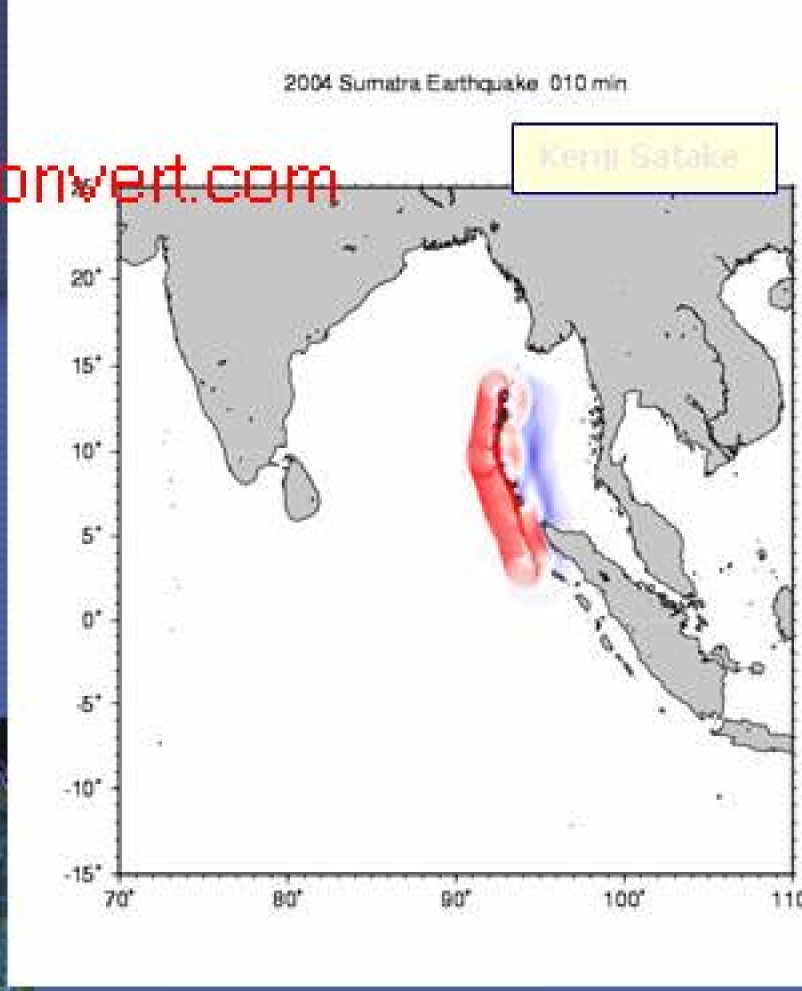
NORTHERN SUMATRA (INDONESIA, INDIAN OCEAN) EARTHQUAKE (Mw: 9.0) of DECEMBER 26, 2004: Source Rupture Processes, Slip Distribution Modeling and Tsunami Generation

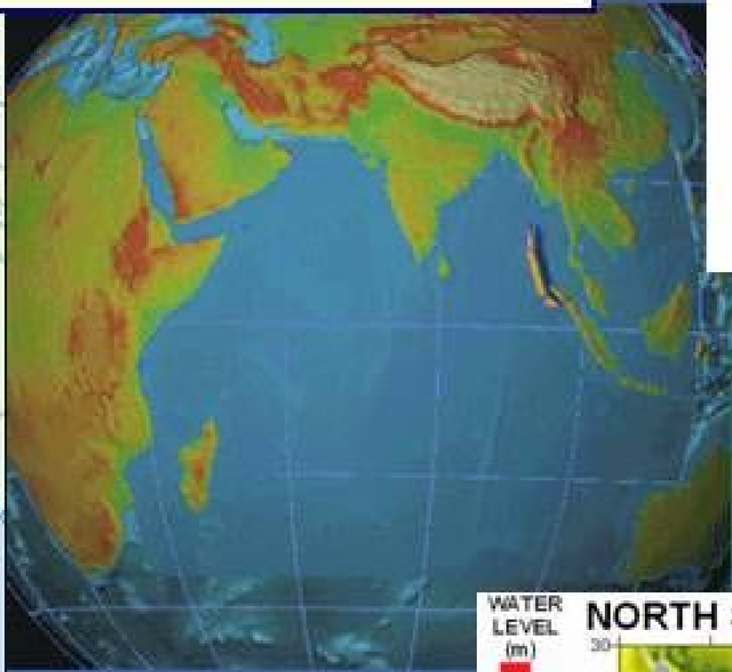
Preliminary Rupture Model Contributed by

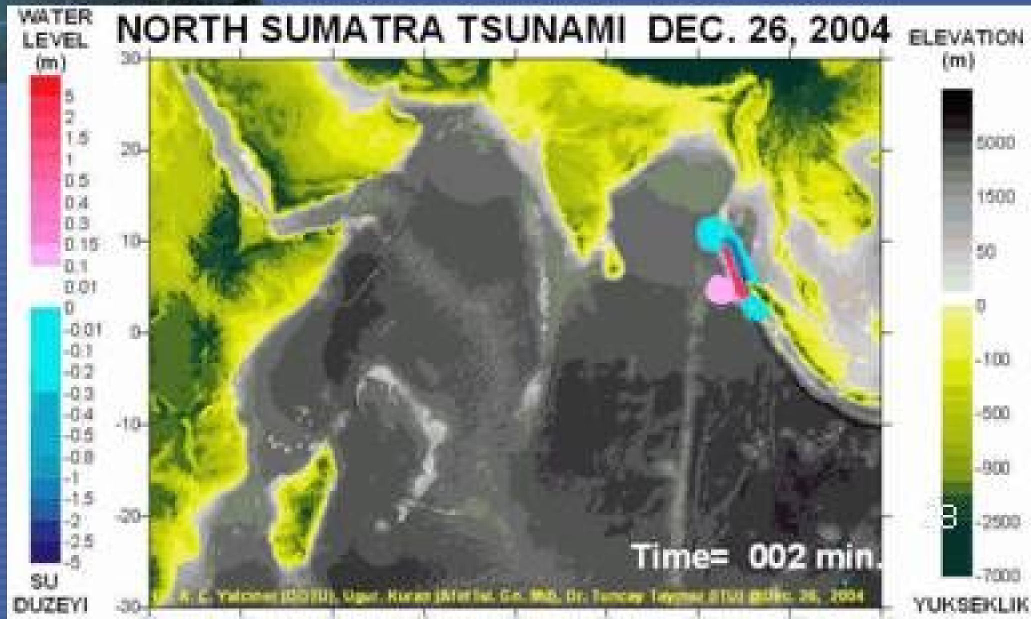
Tuncay Taymaz, Onur Tan and Seda Yolsal

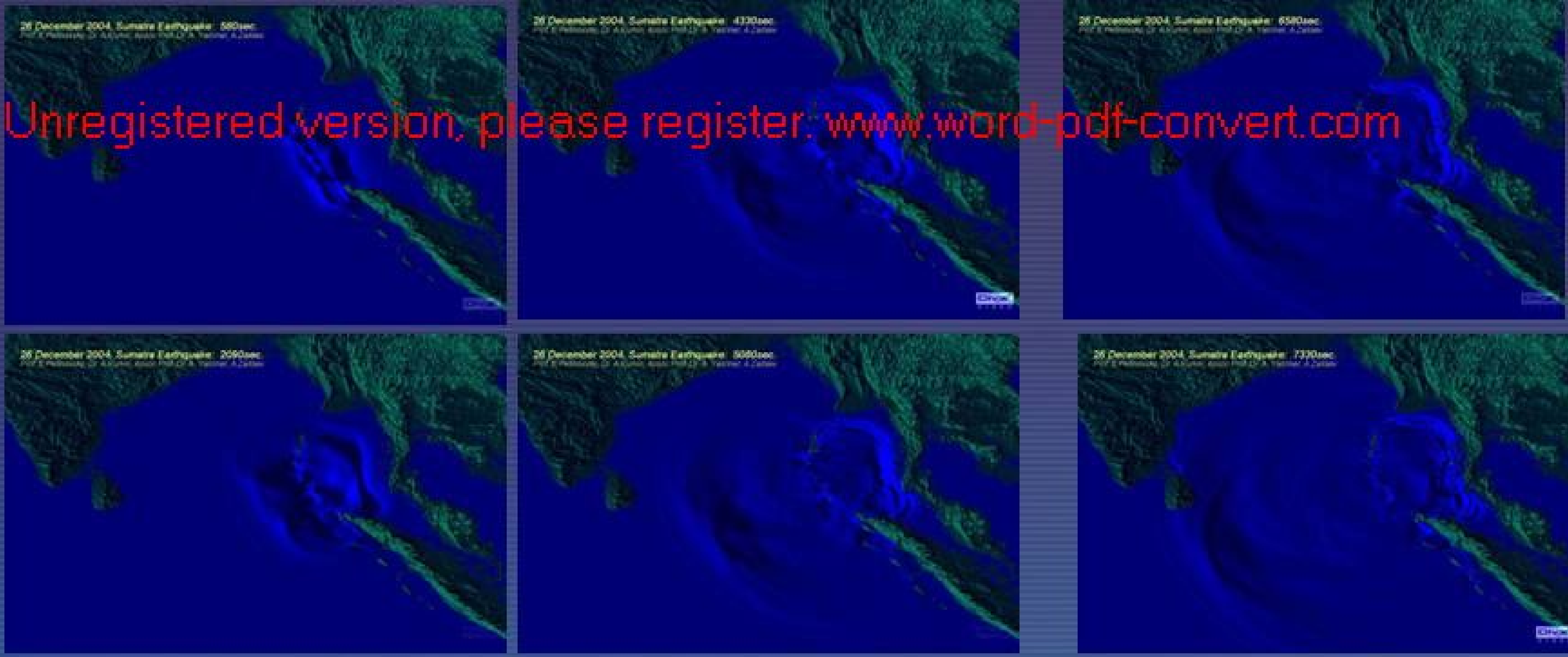
İstanbul Technical University, the Faculty of Mines
Department of Geophysics – Seismology Section, İstanbul

http://www.geop.itu.edu.tr/~taymaz/sumatra








26 December 2004, Sumatra Earthquake: 580sec.
26 December 2004, Sumatra Earthquake: 4330sec.
26 December 2004, Sumatra Earthquake: 6580sec.
26 December 2004, Sumatra Earthquake: 2090sec.
26 December 2004, Sumatra Earthquake: 5080sec.
26 December 2004, Sumatra Earthquake: 7330sec.


Location: Kuala Tadu (South of Meulaboh)
Eyewitness Mr. Jurmadi (30yr fisherman) watched on top of a Coconut Tree
Eyewitness Mr. Maswandi (30yr fisherman) watched on boat from offshore
04° 07.740" N 96° 07.738" E

Medan City (East of Sumatra)

December 26, 2004 Indian Ocean Tsunami Deposits at Medan coast (East of Sumatra)

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Inundation of December 26, 2004 Indian Ocean Tsunami at Meulaboh Coast
(East of Sumatra)

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Mud deposits drifted by December 26, 2004 Indian Ocean Tsunami at Meulaboh (5 km from shore at East of Sumatra)

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Destruction by December 26, 2004 Indian Ocean Tsunami at Meulaboh coast (East of Sumatra)

Scour near building by dragged by December 26, 2004 Indian Ocean Tsunami at Simeulue Island (West coast)

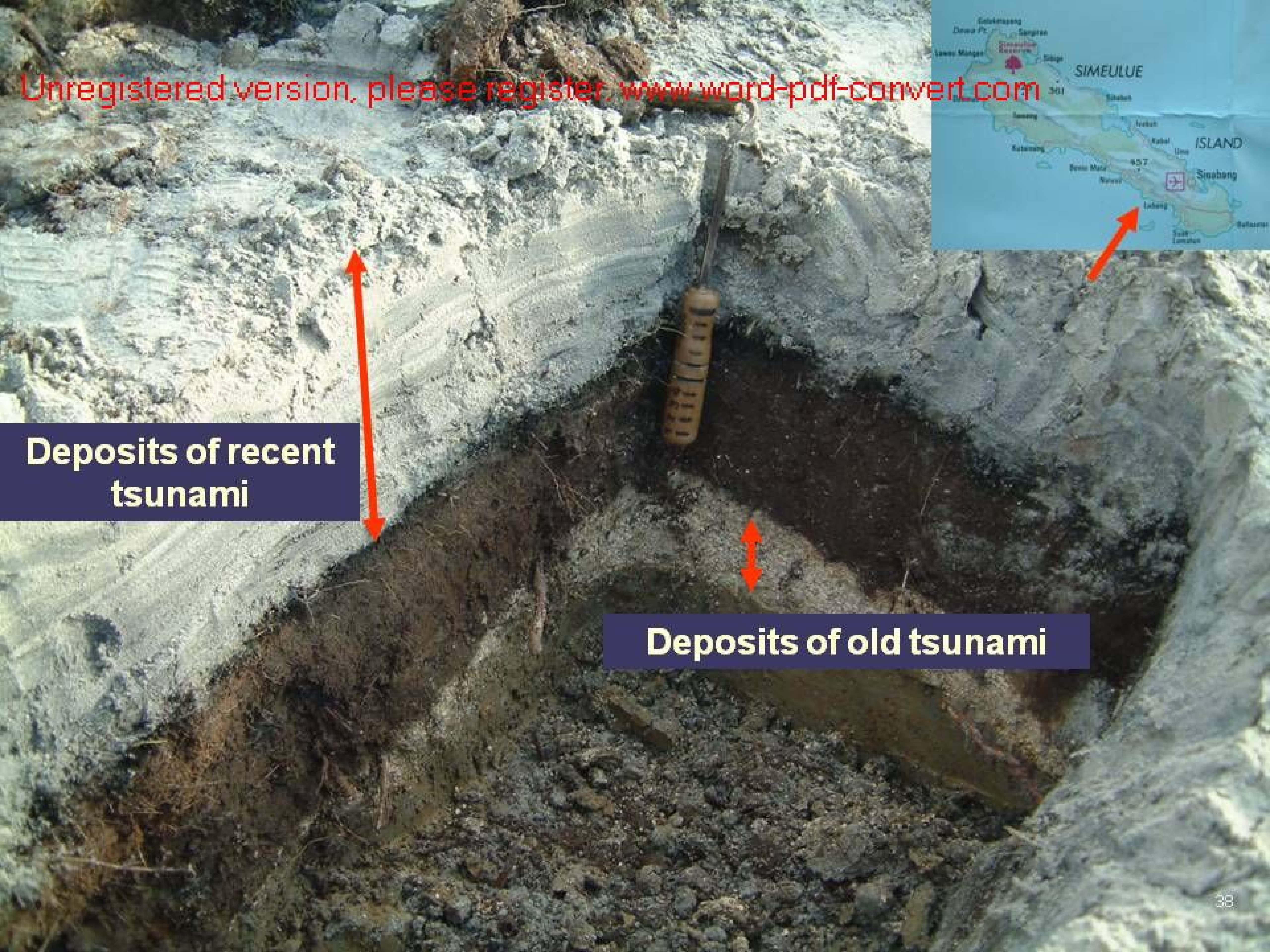
Location of Medan city (West of Sumatra Island)


Bridge moved 45 cm by the wave
Wave direction
Forceon the bridge by Tsunami at
Medan coast (East of Sumatra)
03° 57.930" N 96° 18.576" E

Tsunami Deposits

Method to detect "old" tsunamis

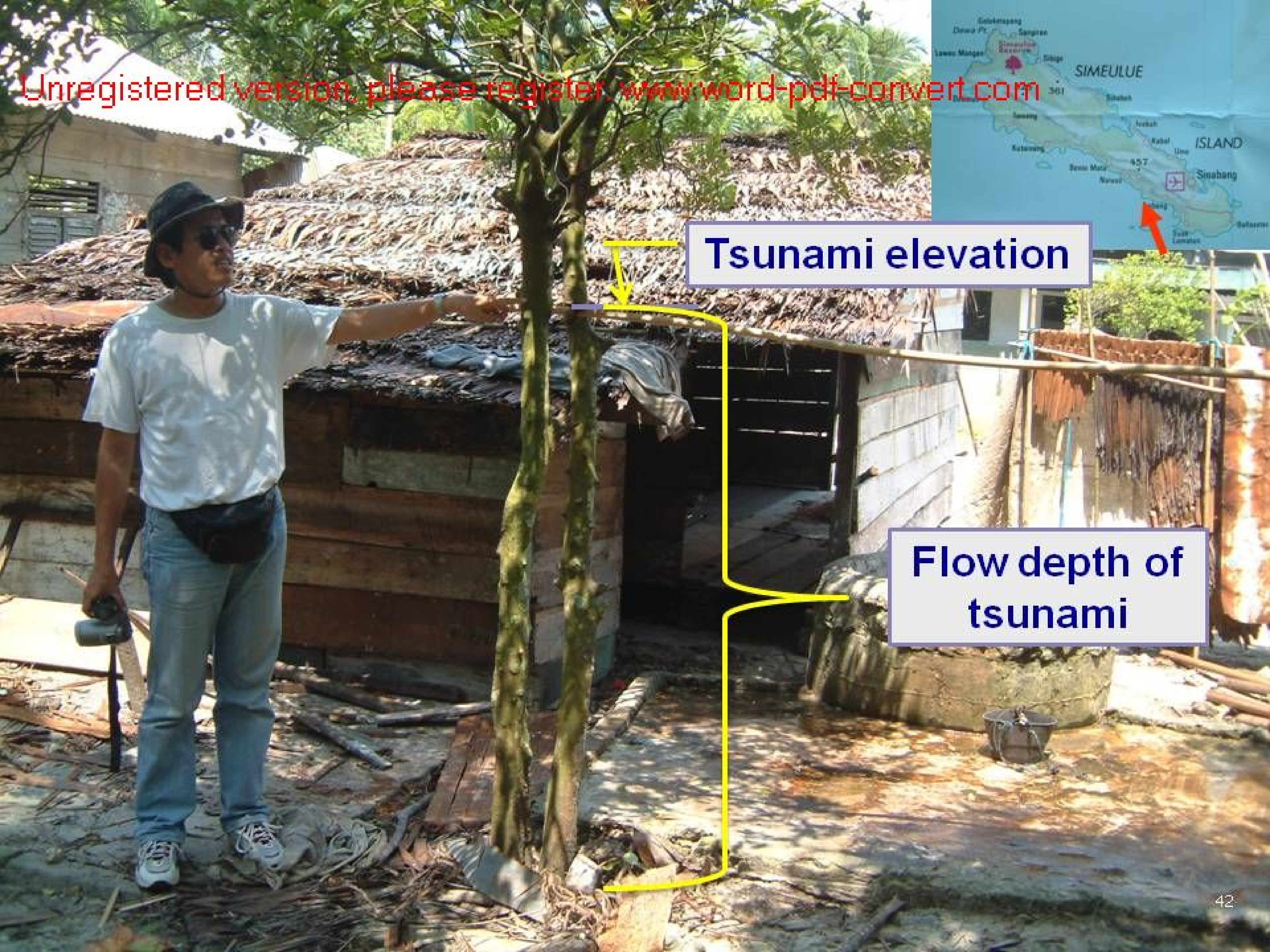
Size of sand particles is smaller atthe top of the layer


SIMEULUE
ISLAND
Sinabang
Deposits of recent tsunami
Deposits of old tsunami

Deposits of recent tsunami


SIMEULUE
ISLAND
361
457
Sinabang
Deposits of
recent tsunami


SIMEULUE
ISLAND
Sinabang
361
457
Deposits of recent tsunami
Deposits of marine shells


Tsunami elevation
Flow depth of tsunami
SIMEULUE
ISLAND
Sinabang

KNOWLEDGE MEANS LIFE

- Simeulue Island is at 50 km south of tsunami source with ~80 000 population.
- Loss of life is 8 in December 26, 2004
- They experienced a tsunami in 1907 after an earthquake. They called it "Smong".
- Smong means the invasion of sea after earthquake
- They always escape from the shore after the earthquake considering that Smong comes
- They did the same after December 26 2004 event and survived

TSUNAMI = Smong

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Paleotsunami deposits found under the recent tsunami deposits in Busung

DECEMBER 26, 2004 INDIAN OCEAN TSUNA

FIELD SURVEY AT NORTH OF SUMATRA ISLA

Prasetya (Indonesia), Rahman Hidayat (Indonesia), Brian McAdoo (USA) have performed the field survey in bo along coasts of Medan, Meulaboh cities, and Simeulue island which are located North of Sumatera with the inv UNESCO IOC and also invaluable logistic and administrative supports by Indonesian Government, Ministry of Fi and Indonesian Army. The Russian survey team Victor Kaistrenko (leader) and Nadia, Yuri, Andrey Zaitsev, participated and contributed the survey in Simeulue island and Medan.

ITST
INTERNATIONAL TSUNAMI SURVEY TEAM
FOR
DEC. 26 '04 ACEH - SUMUT TSUNAMI
JANUARY 2005

MAIN PAGE

EARTHQUAKE

TSUNAMI SIMULATION

SURVEY (JAN. 20-31, 2005)

RELATED LINKS

SPONSOR
UNESCO-IOC

SUPPORTERS

FULL REPORT OF FIELD SURVEY

ACKNOWLEDGEMENTS

Survey performed by
Ahmet Cevdet Yalciner, Dogan Perincek, Sukru Ersoy
Gegar S Prasetya, Rahman Hidayat, Brian McAdoo

SURVEY PHOTO GALLERY

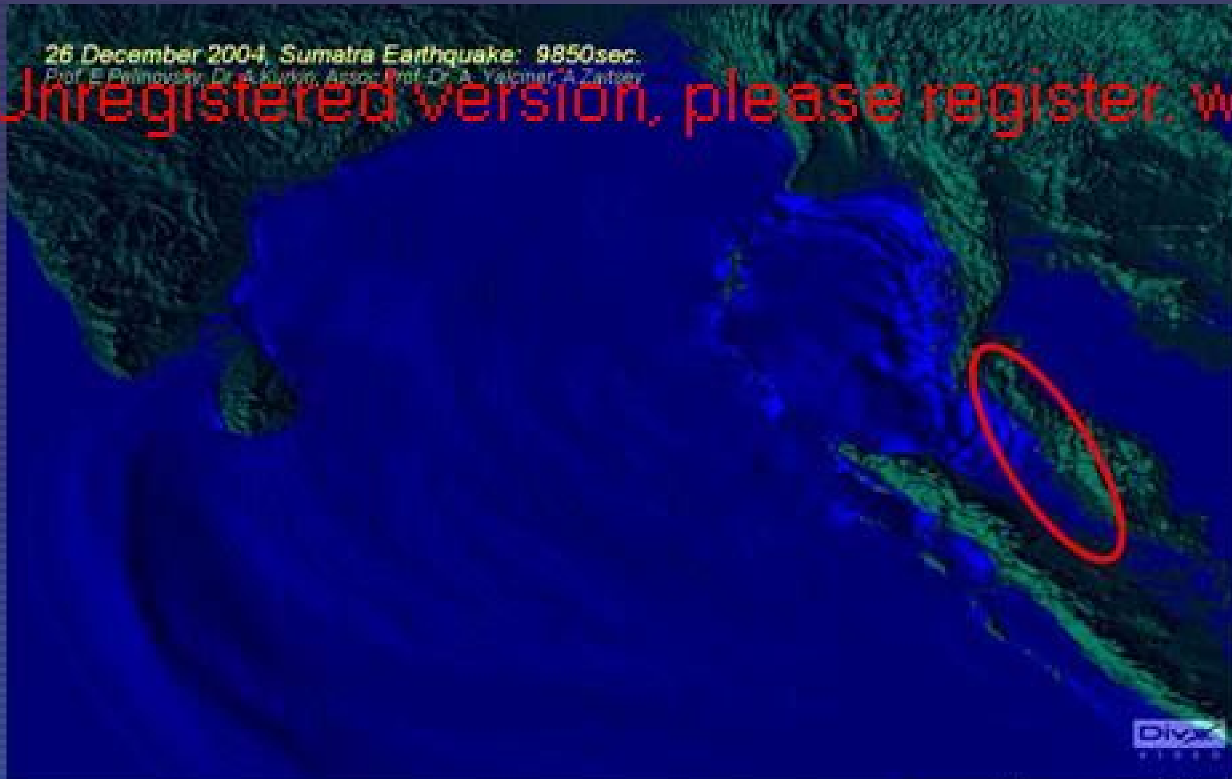
Site Prepared by Research Assistants: CEREN OZER & HULYA KARAKUS

UNESCO IOC POST TSUNAMI FIELD SURVEY SUMATRA

January 15-30, 2005 Medan, Simeulue and Meulaboh

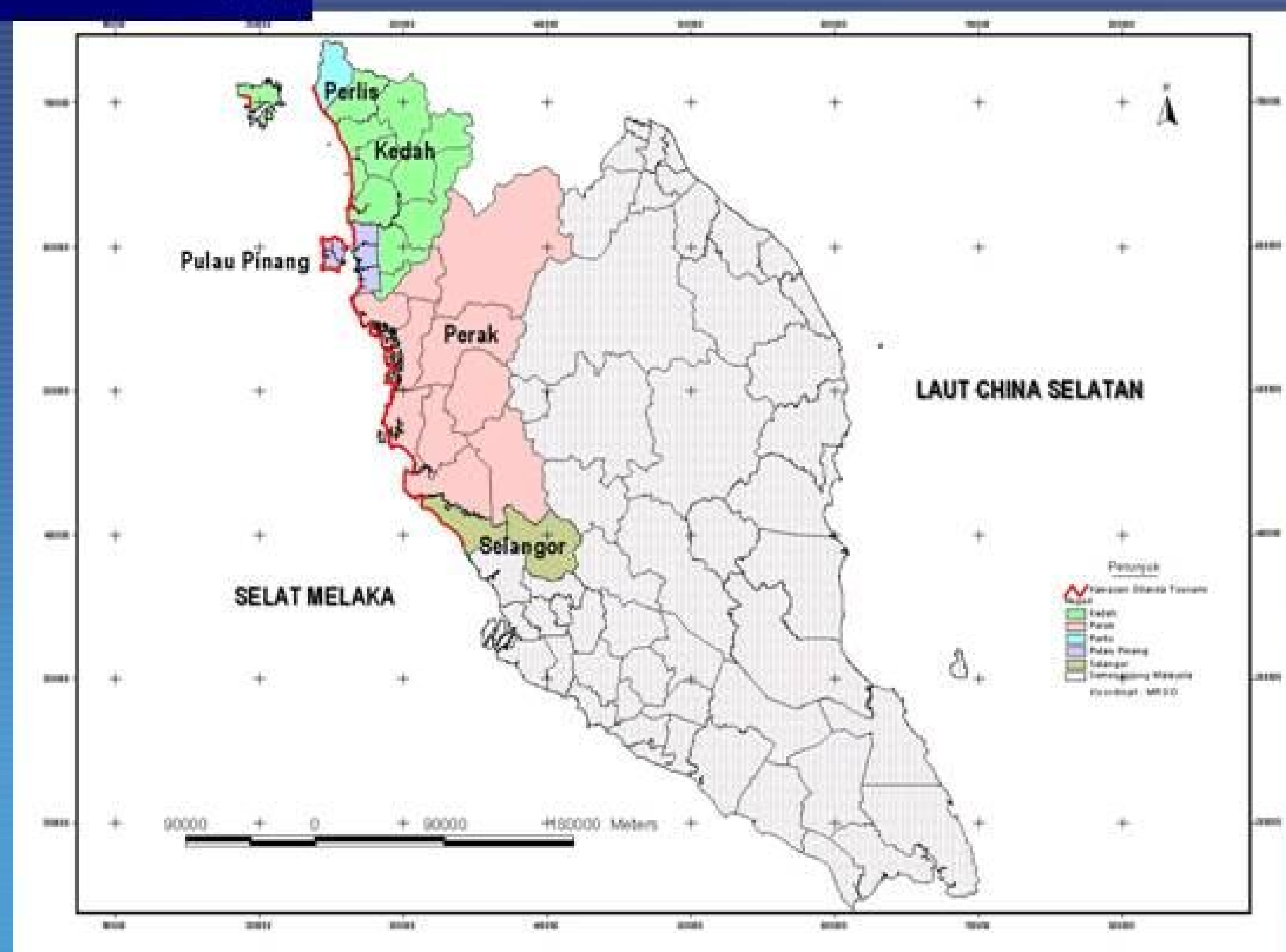
IAEA

http://yalciner.ce.metu.edu.tr/sumatra/survey



Tsunami Effects in Malaysia

Langkhawi, Penang Kedah



Pasir Panjang beach where there was the border barrier behind the beach to prevent evacuation. The people could not escape from shore and 27 casualities at this location <u>because of no evacuation route</u>.

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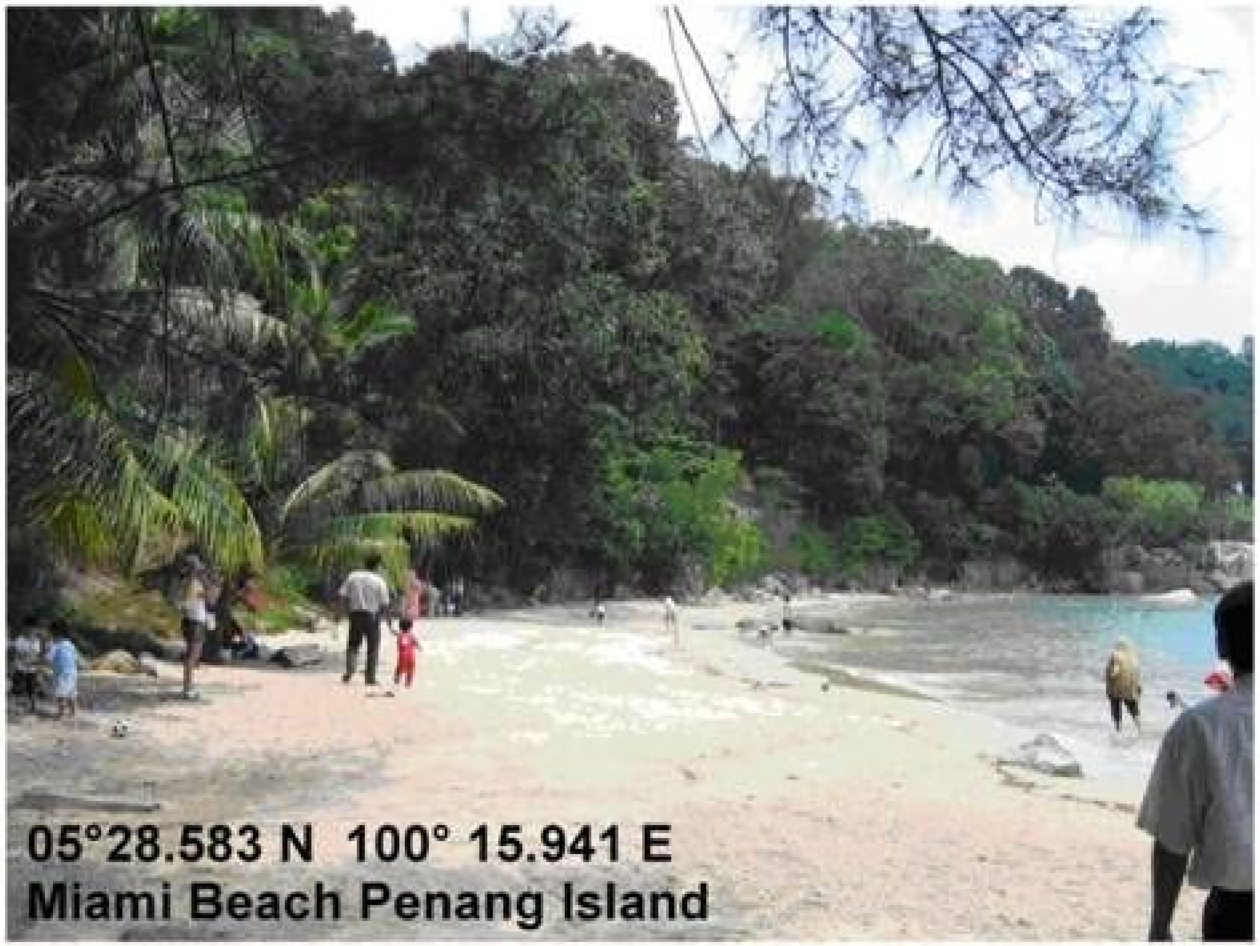

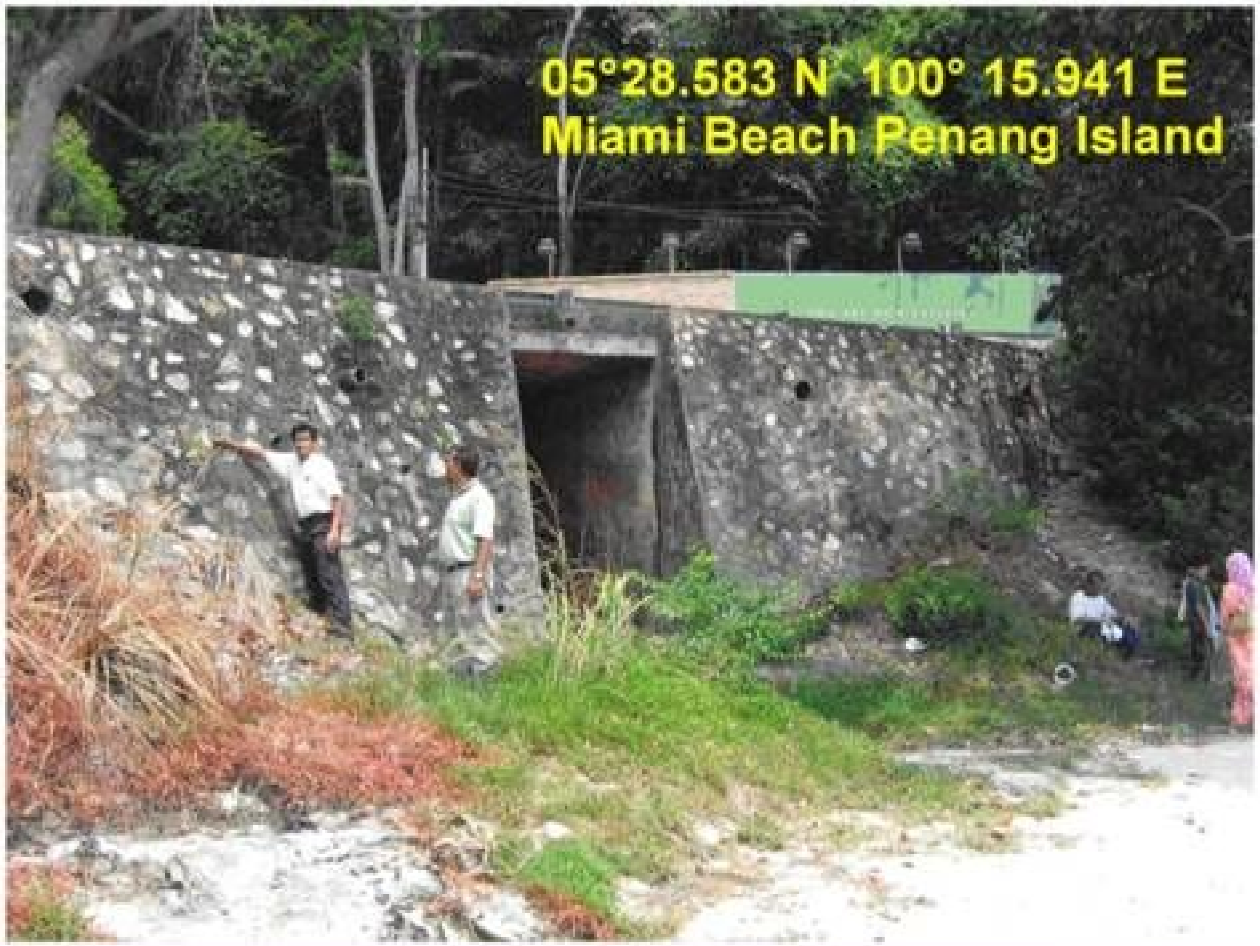

Miami Beach in Penang where there is highway to prevent access to evacuate. The people could not escape from the shore and 23 casualities at this location only <u>because of no evacuation route</u>.

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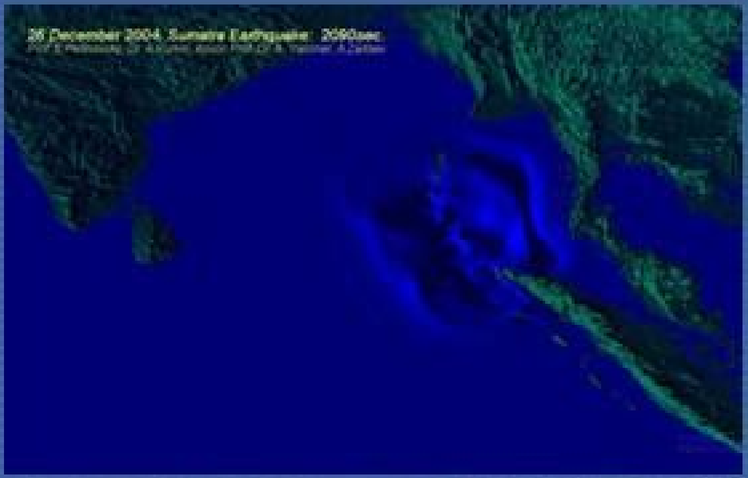
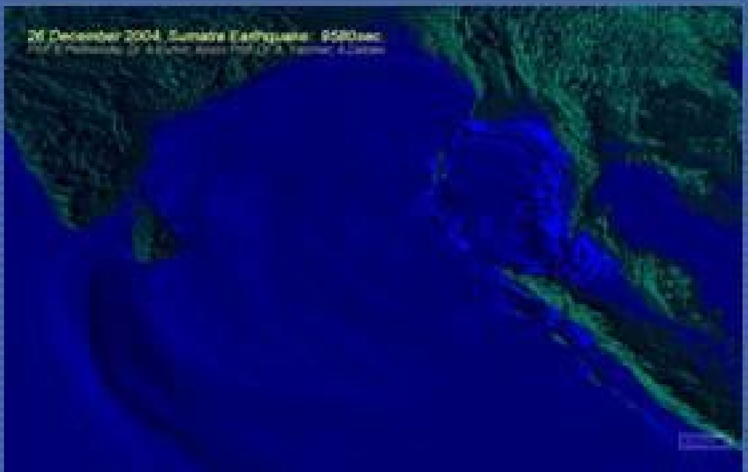
The protection wall and land vegetation n Kampung Tepi Sungai and the level of the water rise.

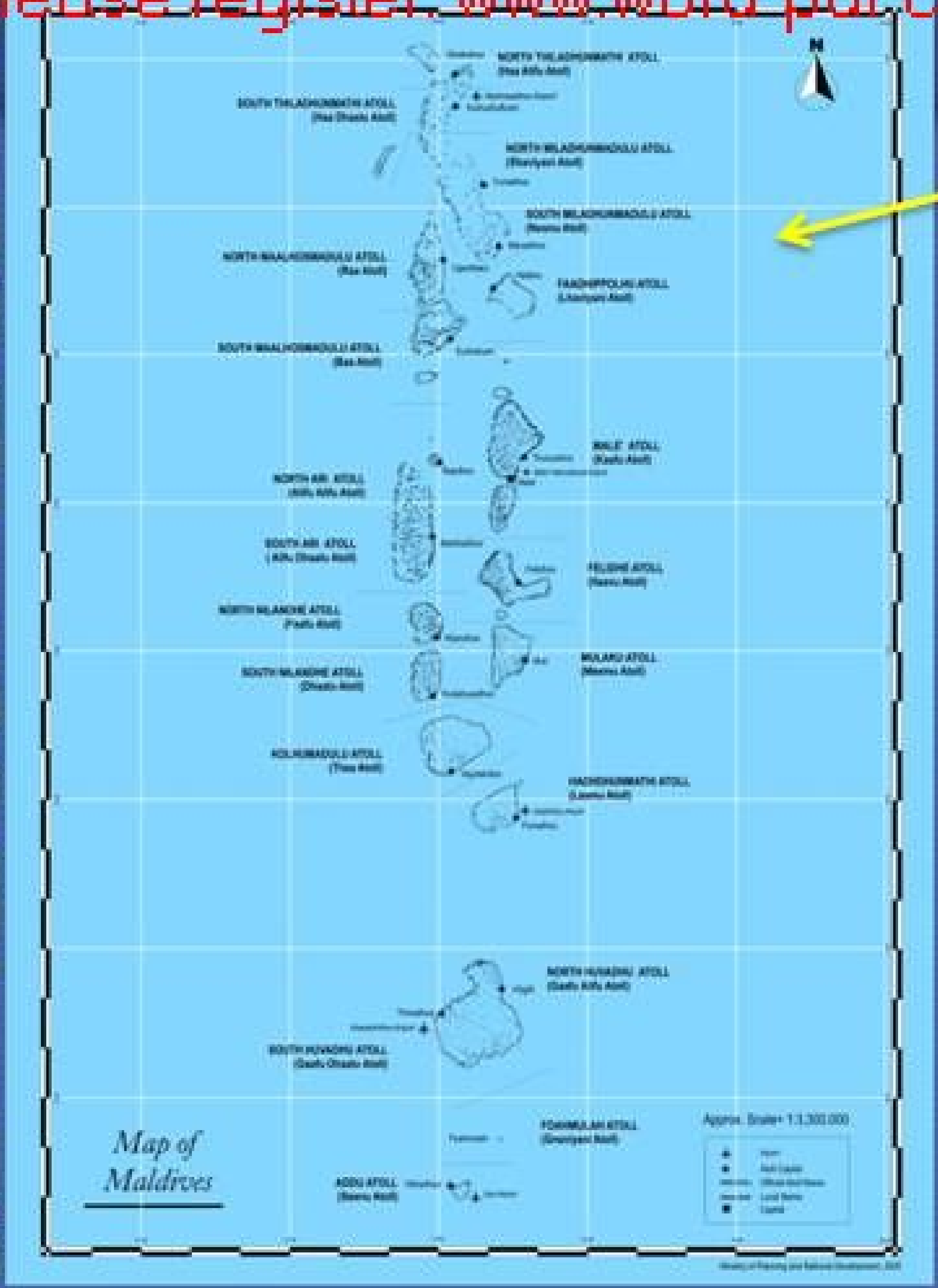
There was no damage and casualty behind this location <u>because of the coastal protection</u>.

(Note: 11 casualties and damages occured 50m to the North of this point where there is no coastal protection.

MALDIVES







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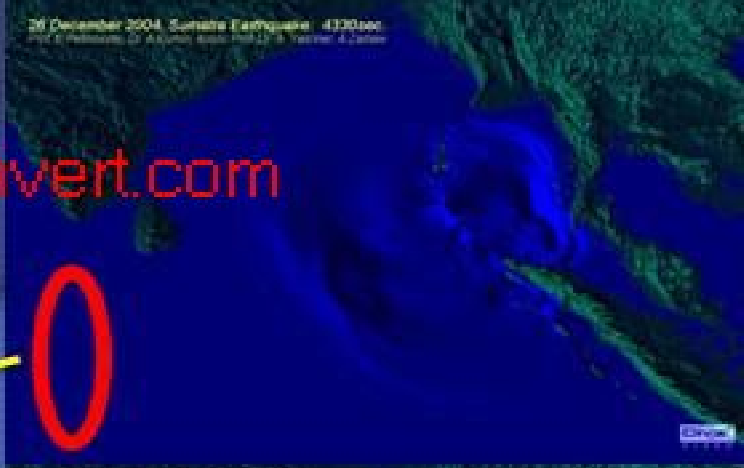

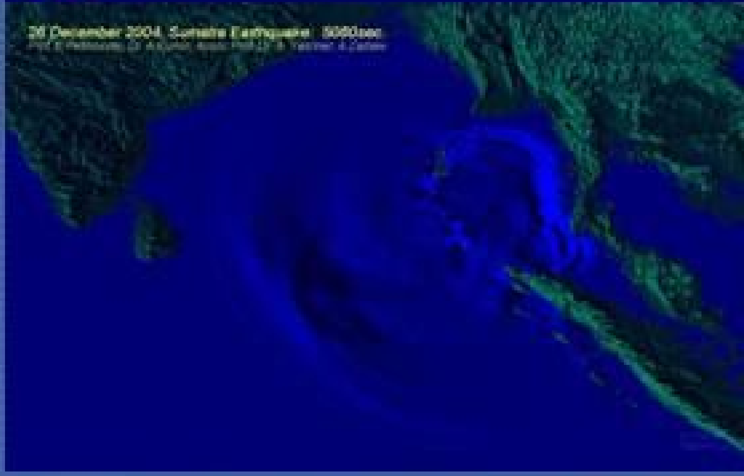

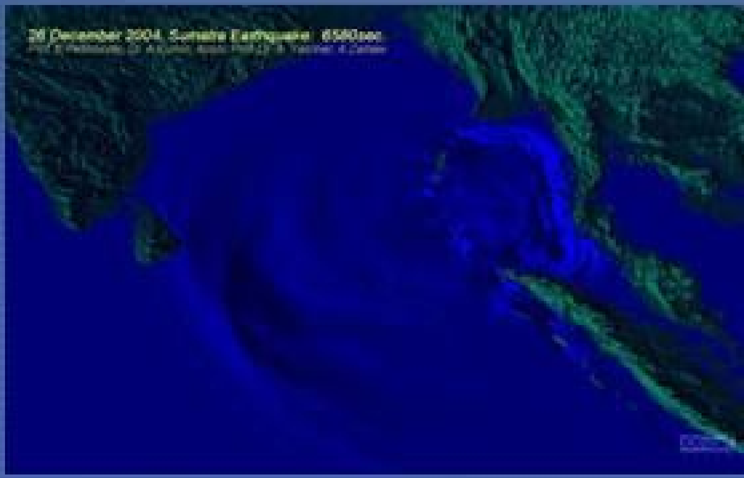

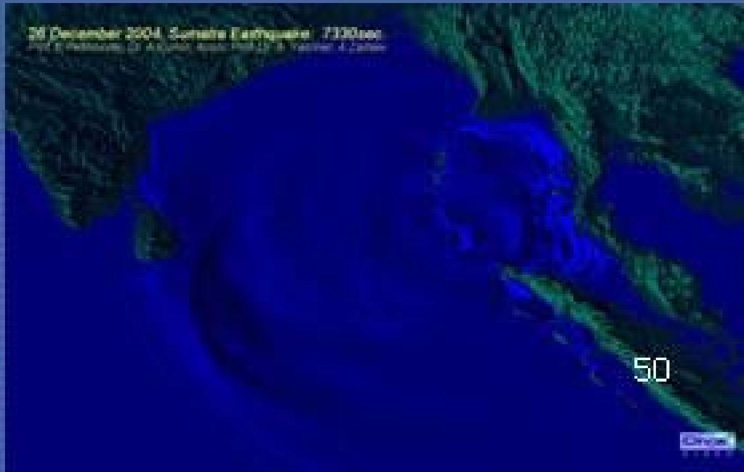

Tsunami effects after 3000 km propagation


Maldives


Maldives


Tsunami Damages in Maldives

Debris and Tsunami Damages in Maldives

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Tsunami Behavior in Maldives

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Scour

Roundwood blocks from Indonesia to Maldives

IAEA ANSN / ISSC - REGIONAL WORKSHOP ON
"Volcanic, Seismic, and Tsunami Hazard Assessment Related to NPP Siting Activities and Requirements"
Jakarta, Indonesia, 13-17 June 2011

"DAMAGE INVESTIGATION & HAZARD ASSESSMENT IN JAPAN"

Prof. Dr. Ahmet Cevdet YALCINER
INTERNATIONAL SEISMIC SAFETY CENTRE, NSNI/IAEA

IAEA
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Lecture XX

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- METU
- Tohoku University (Profs. Shuto, Imamura and Koshimura)
- Bogazici University

Prof. Dr. Ahmet Cevdet Yalciner

Dr. Anawat Suprassi
Thailand

Öcal Necmioğlu
Turkey

Erick Mas
Peru

Nikos Kaligeris
Greece

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MEGA TSUNAMIS IN JAPAN

- 869 JOGAN TSUNAMI
- 1611 KEICHO TSUNAMI
- 1896 MEIJI TSUNAMI
- 1933 RIYORI TSUNAMI
- 1960 SHIZUKAWA TSUNAMI (CHILE EARTHQUAKE)

RYORI-MINATO AFTER THE 1896 MEIJI TSUNAMI

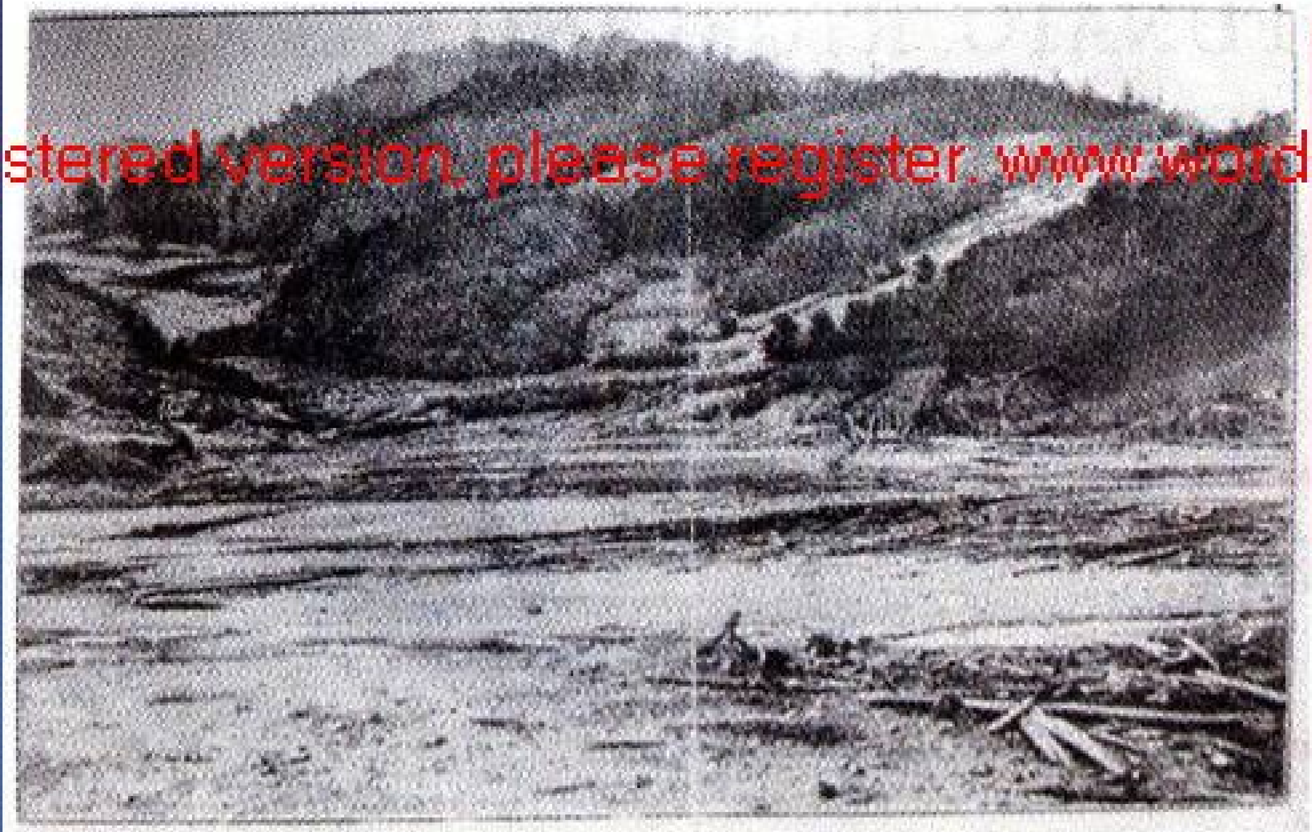

Photo by Igi.

Fuzoku Gaho

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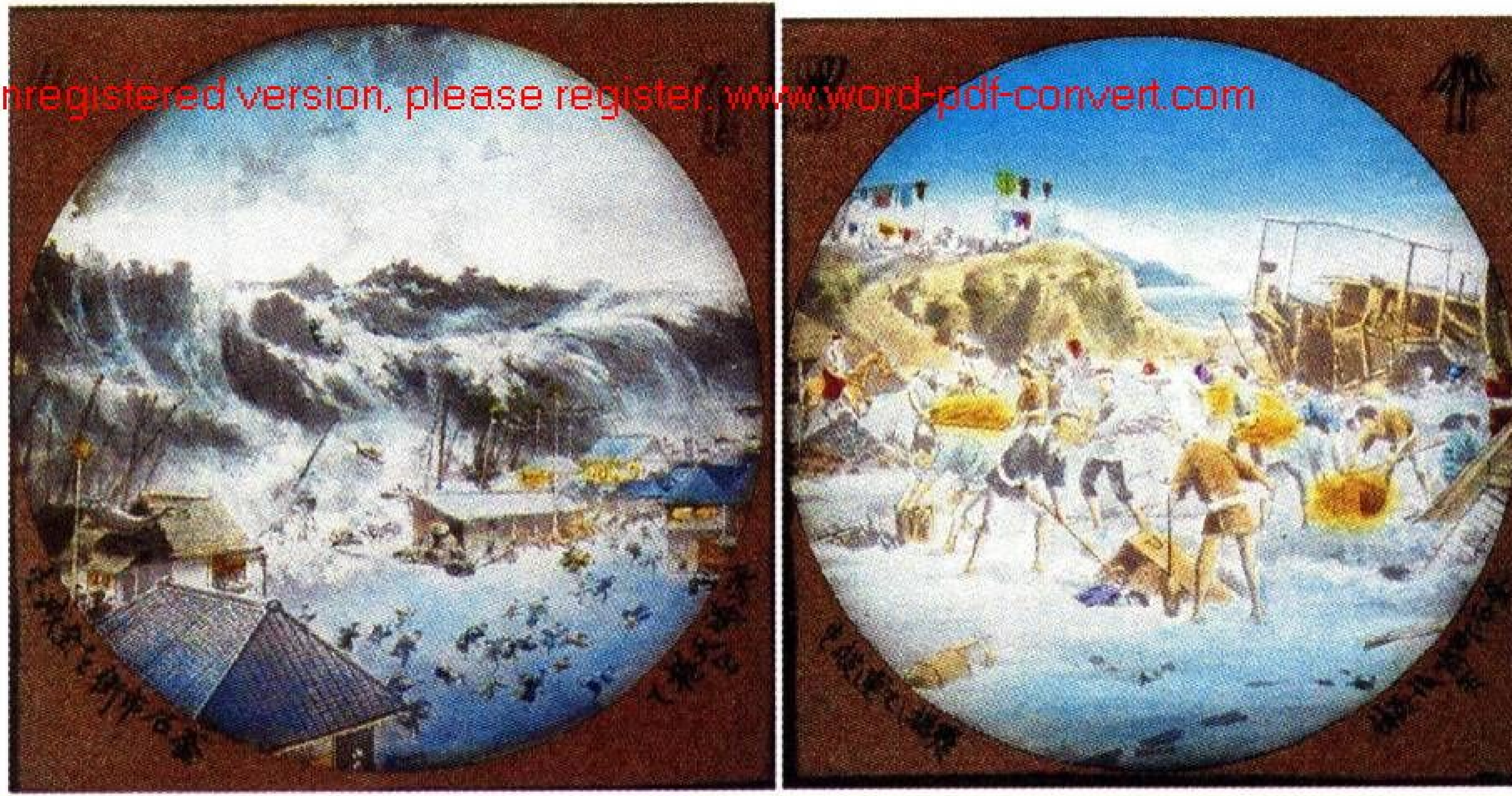
From field guide, 3rd International Tsunami Field Symposium, April, 2010, Tohoku University, Sendai

Trip leaders: Nobuo Shuto, Fumihiko Imamura



Pictures sold after

1896 tsunami - On right, people recovering bodies and debris from sand.

From field guide, 3rd International Tsunami Field Symposium, April, 2010, Tohoku University, Sendai

Trip leaders: Nobuo Shuto, Fumihiko Imamura

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Ryori-Shirahama in 1933 shows the limit of control forest.

(Report.) [B. E. R. I., Suppl. Vol. I. Pl. CLXXIV.]

Fig 309. Ryori Sirahama. Lower part of "Sagi" woods was cut down by attacks of tsunami. (Photo by Y. Otaka, May 7.)

寫眞第五十一　綾里村白濱。澤の右岸傾斜面にある徑約 30 cm の樹木が上流側に折れてゐる。

Pine trees of 30 cm diameter were all cut off, upstream. Inundation was estimated over 10 m.

From field guide, 3rd International Tsunami Field Symposium, April, 2010, Tohoku University, Sendai

Trip leaders: Nobuo Shuto, Fumihiko Imamura

IAEA

From field guide, 3rd International Tsunami Field Symposium,
April, 2010, Tohoku University, Sendai
Trip leaders: Nobuo Shuto, Fumihiko Imamura

Source Process of the 2011 Off the Pacific Coast of Tohoku earthquake based on Strong Ground Motions (Preliminary)

National Research Institute for Earth Science and Disaster Prevention

NIED

Eartquake Magnitude= 9.0

EQ Epicenter= 142.4° E, 38.3° N

Fault Lenght= 510 km

Fault Width= 210 km

Focal Depth= 32 km

Fault Displacement= 29 m

○ Fault Model

- Strike：195 degrees
- Dip：13 degrees
- Size：510km×210km

○ Results

- M_0：3.28×10^{23}Nm (Mw8.9)
- Largest slip：23m

This is a preliminary result and it will be updated

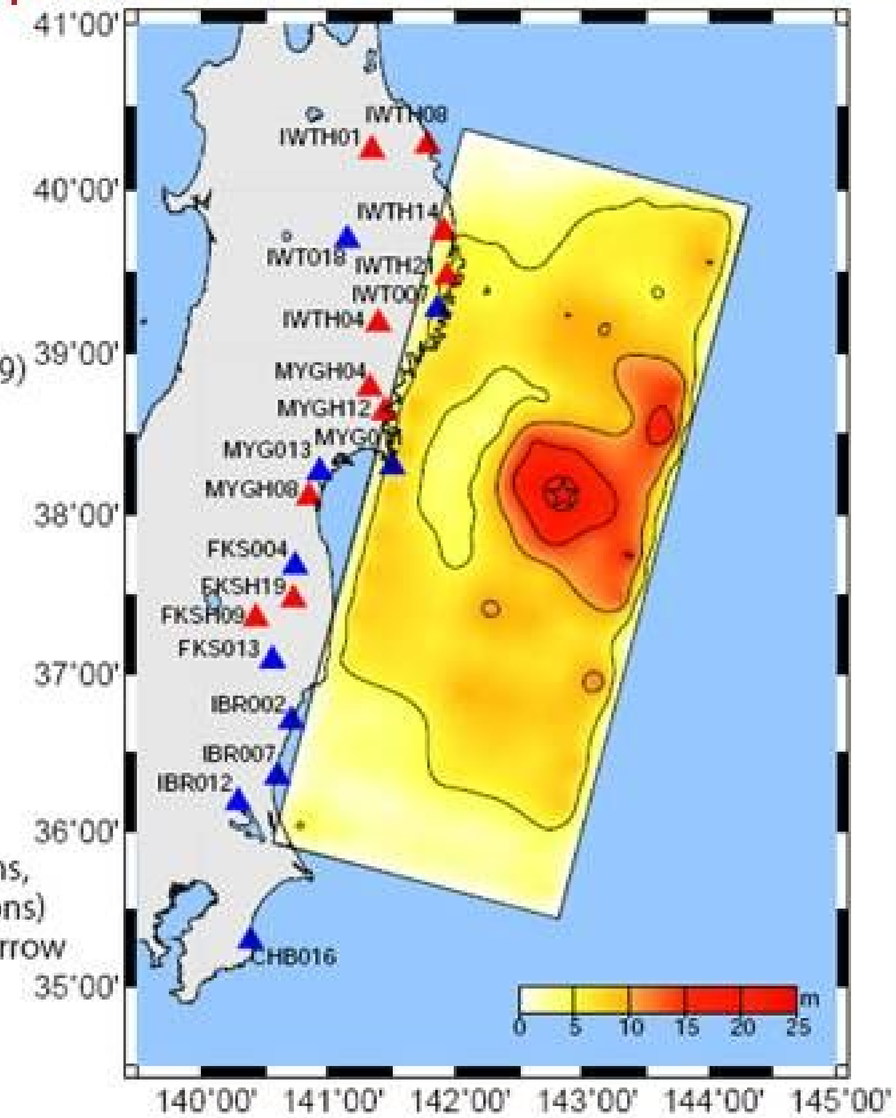

Figure 1：Stations used for inversion (Red: K-NET stations, Blue: KiK-net borehole stations) and slip distribution. A red arrow displays the epicenter.

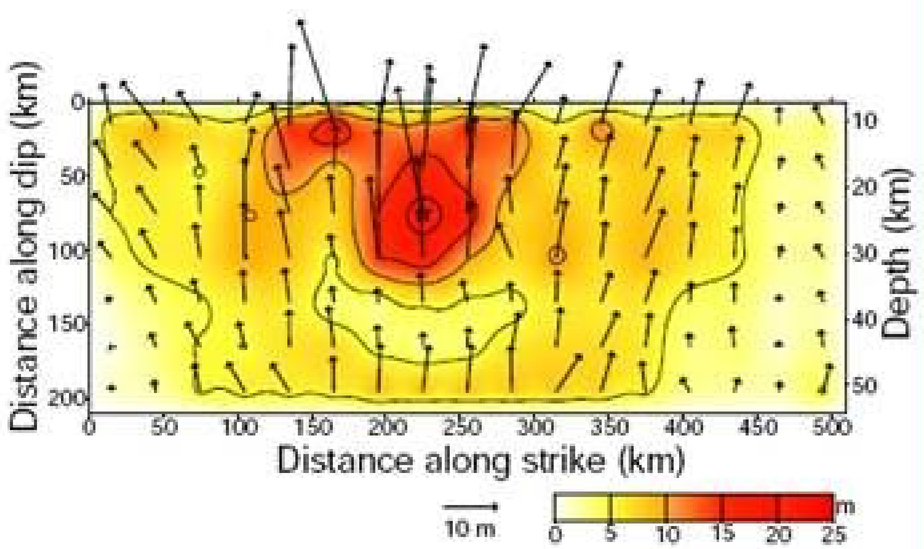

Figure 2：Slip distribution. Contour lines of slip every 5 m are displayed. The arrows show the slip directions and amplitudes of the hanging wall.

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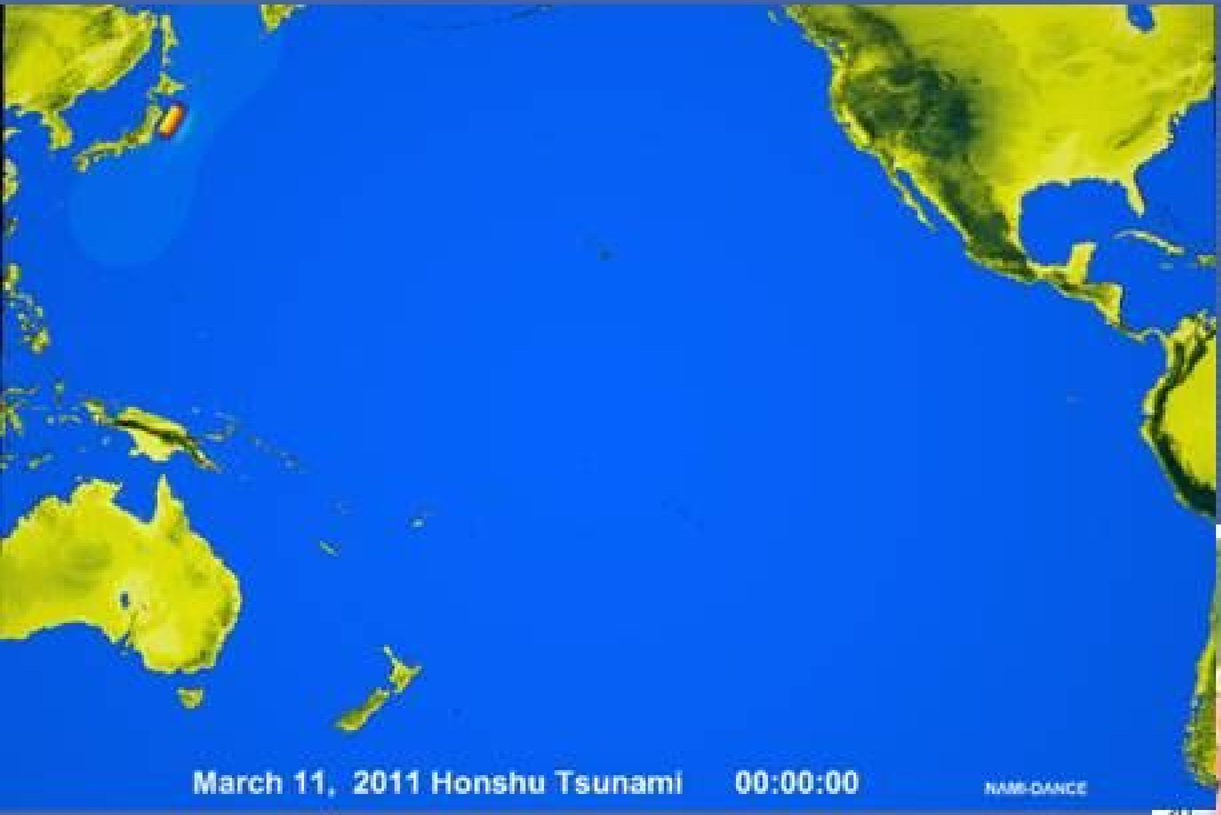
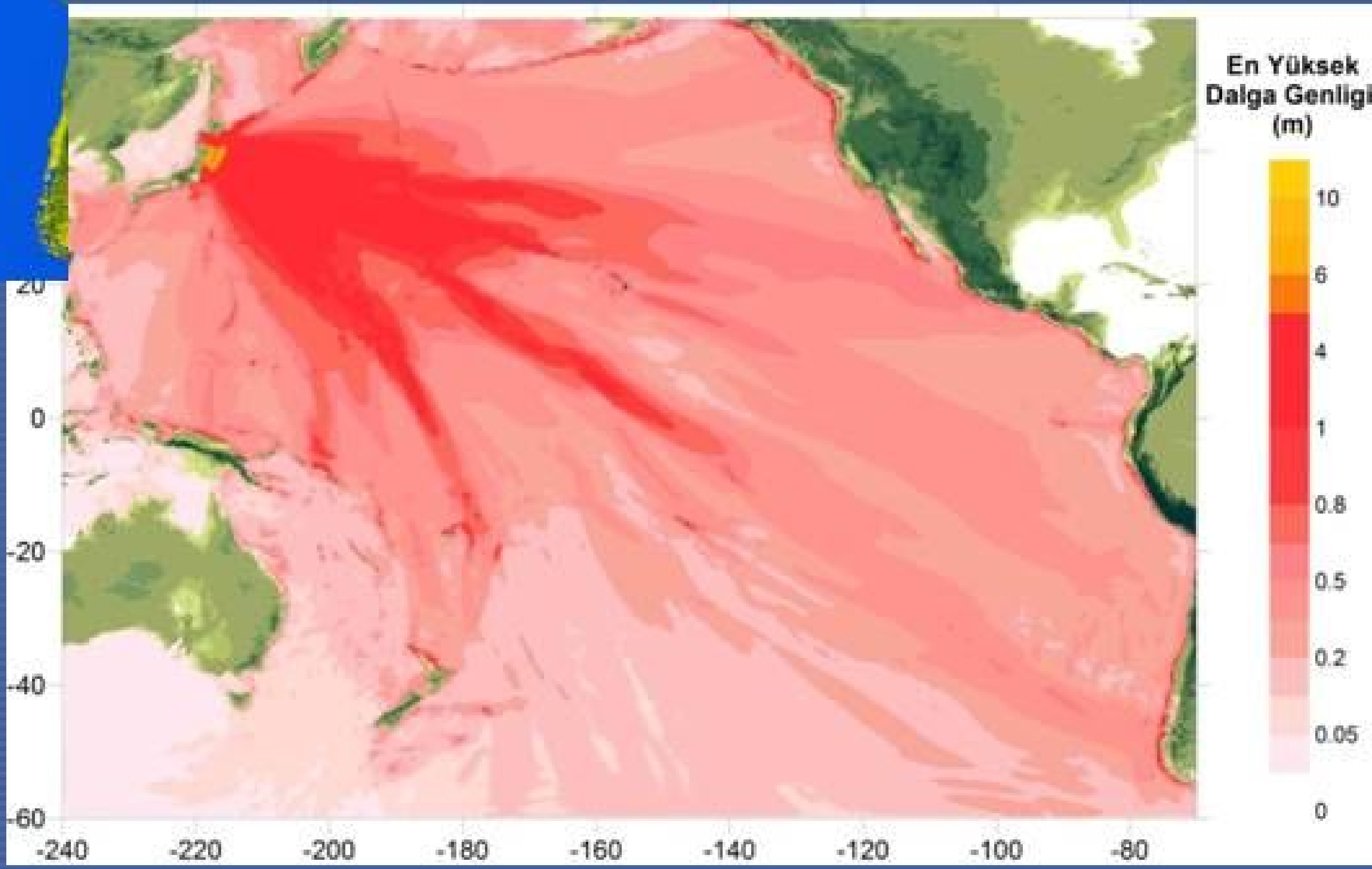
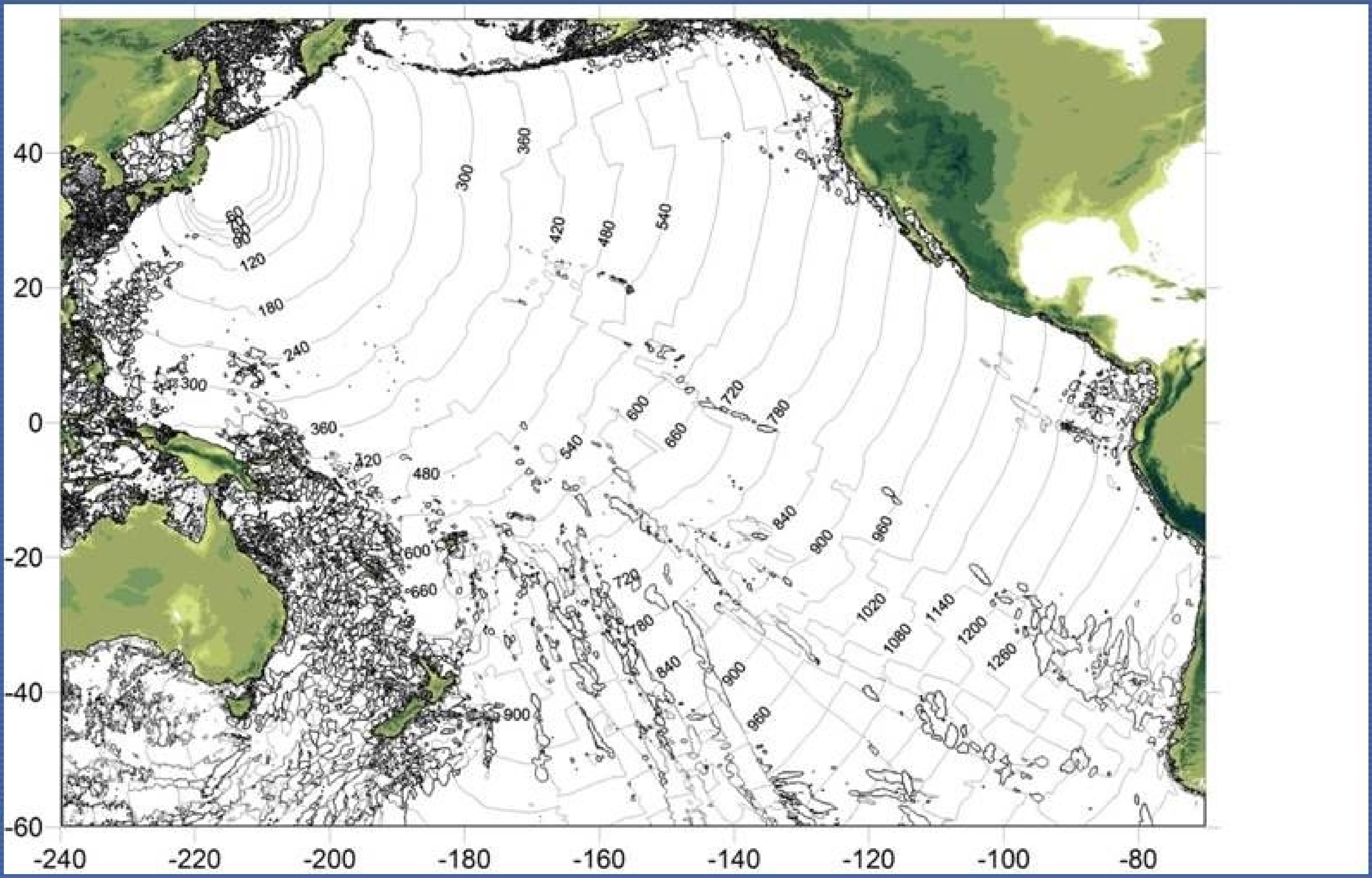


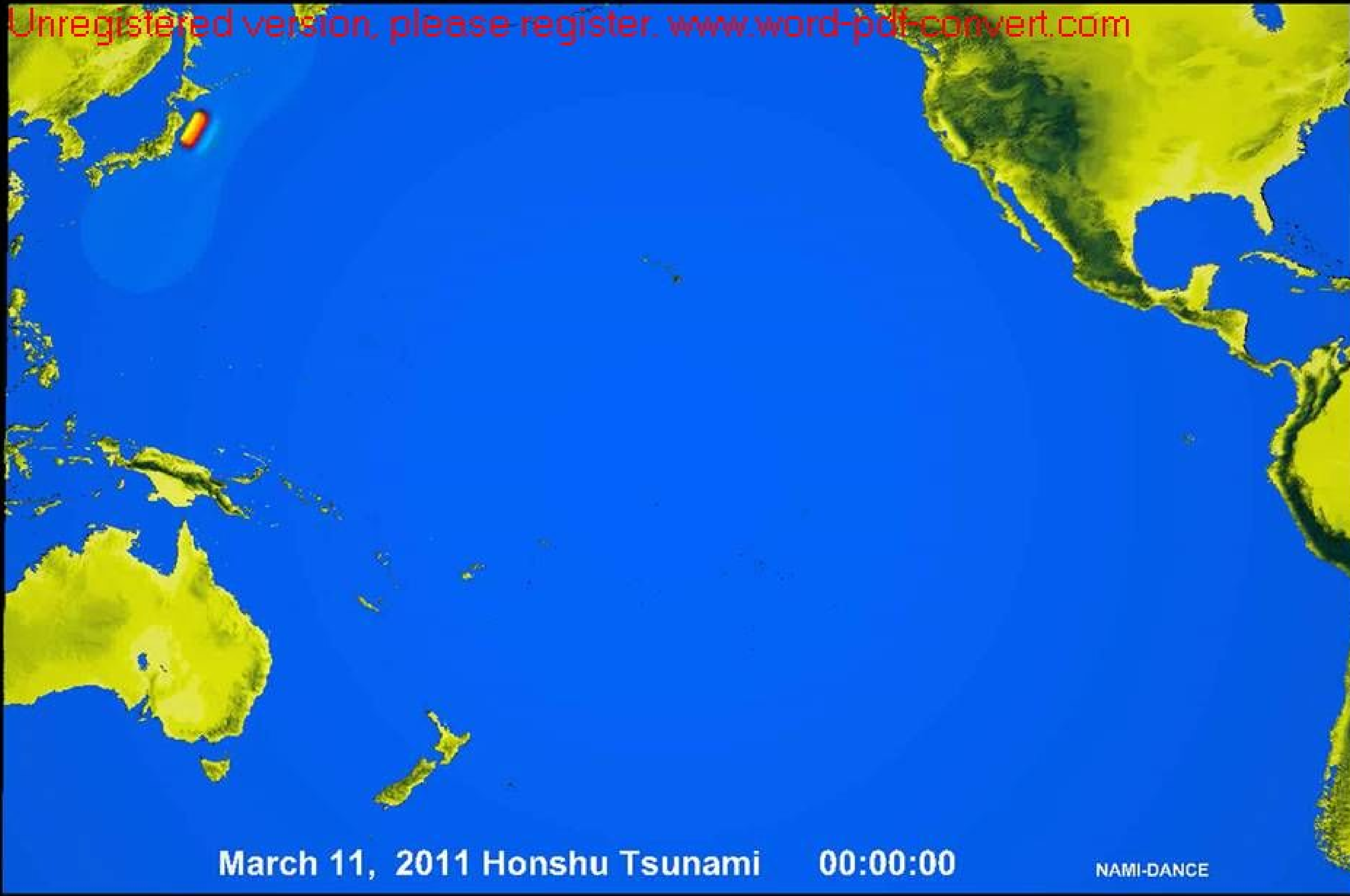
First Wave

Energy Distribution Map

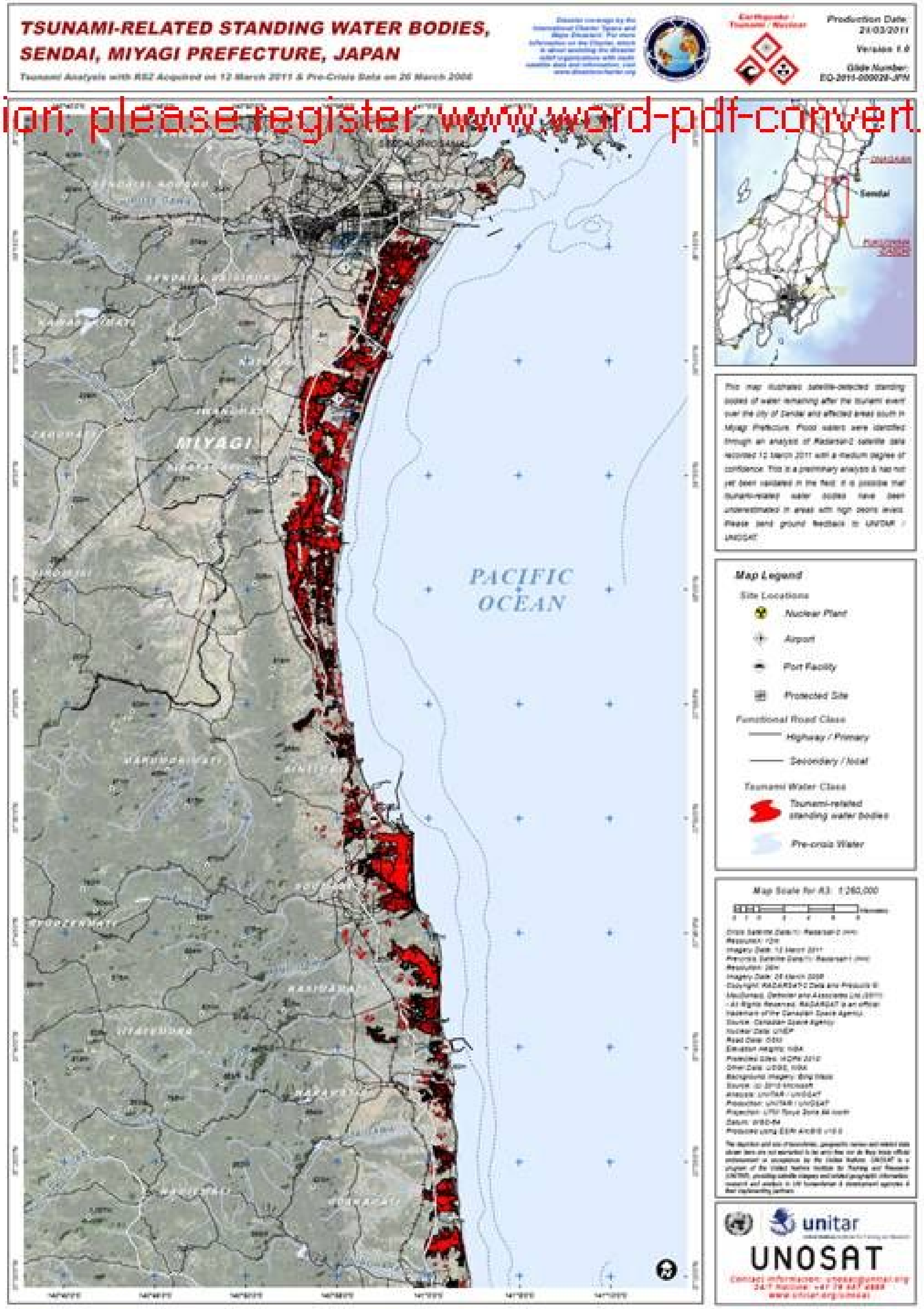


Distribution Time of Maximum Wave



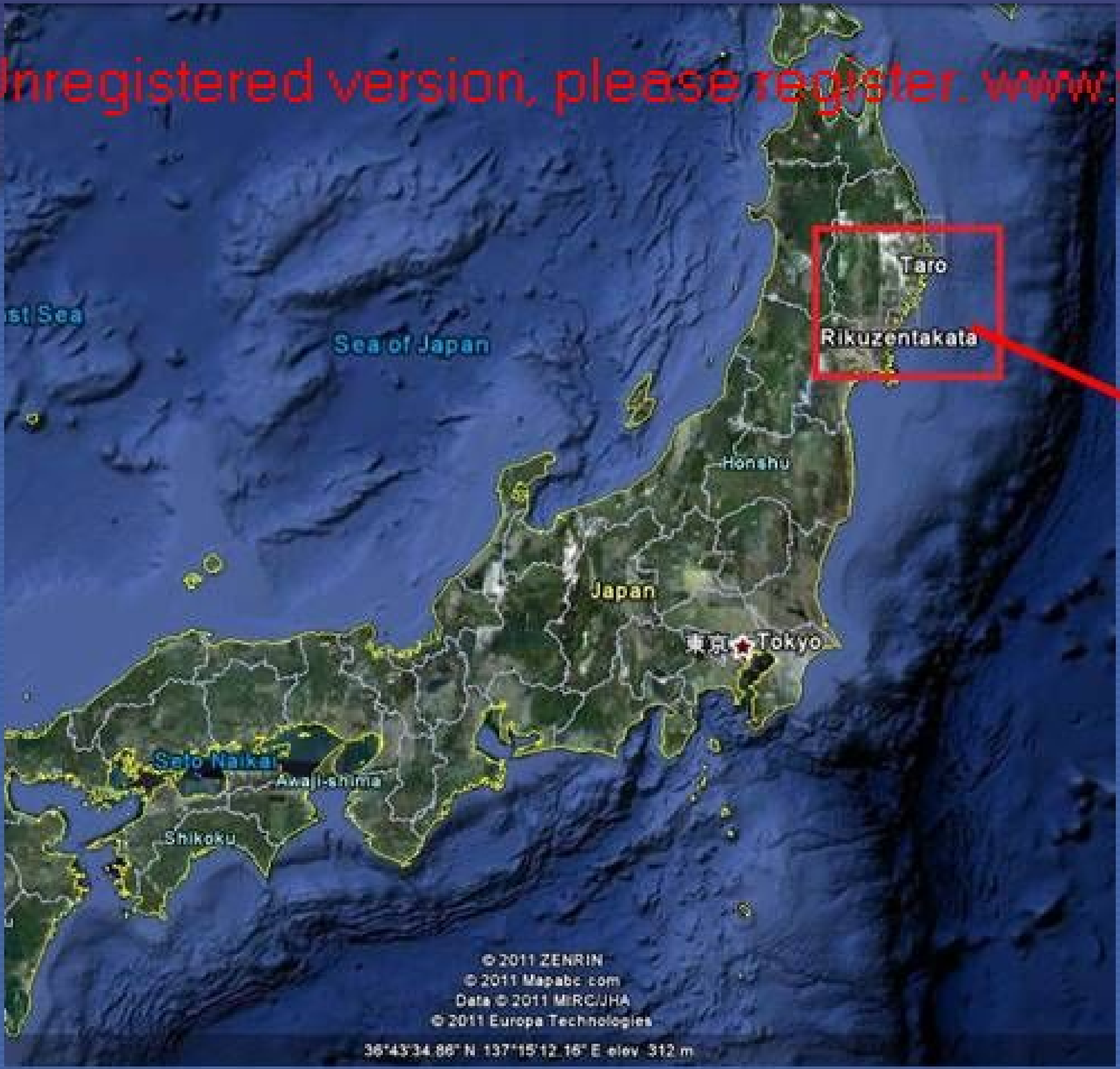

March 11, 2011 Honshu Tsunami
00:00:00
NAMI-DANCE

Close up Simulation



TSUNAMI-RELATED STANDING WATER BODIES, SENDAI, MIYAGI PREFECTURE, JAPAN
Tsunami Analysis with RS2 Acquired on 12 March 2011 & Pre-Crisis Data on 26 March 2006
Production Date: 21/03/2011
Version 1.0
Glide Number: EQ-2011-000028-JPN
Sendai
MIYAGI
PACIFIC OCEAN
This map illustrates satellite-detected standing bodies of water remaining after the tsunami event over the city of Sendai and affected areas south in Miyagi Prefecture. Flood waters were identified through an analysis of Radarsat-2 satellite data recorded 12 March 2011 with a medium degree of confidence. This is a preliminary analysis & has not yet been validated in the field. It is possible that tsunami-related water bodies have been underestimated in areas with high debris levels. Please send ground feedback to UNITAR / UNOSAT.
Map Legend
Site Locations
Nuclear Plant
Airport
Port Facility
Protected Site
Functional Road Class
Highway / Primary
Secondary / local
Tsunami Water Class
Tsunami-related standing water bodies
Pre-crisis Water
Map Scale for A3: 1:260,000
unitar
UNOSAT

IAEA

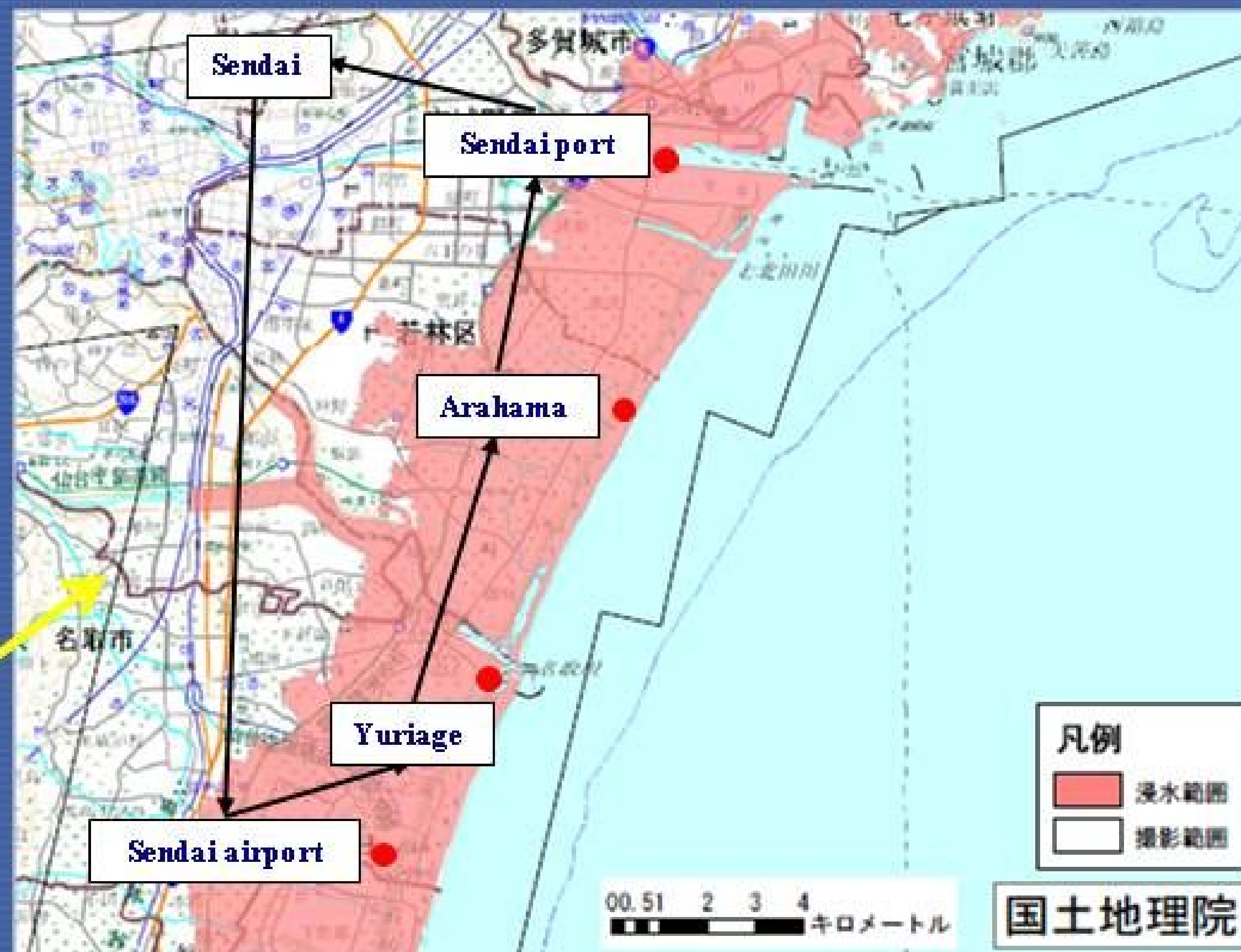


30 May-3 June 2011
Investigations after Great East Japan Earthquake and Tsunami

IAEA

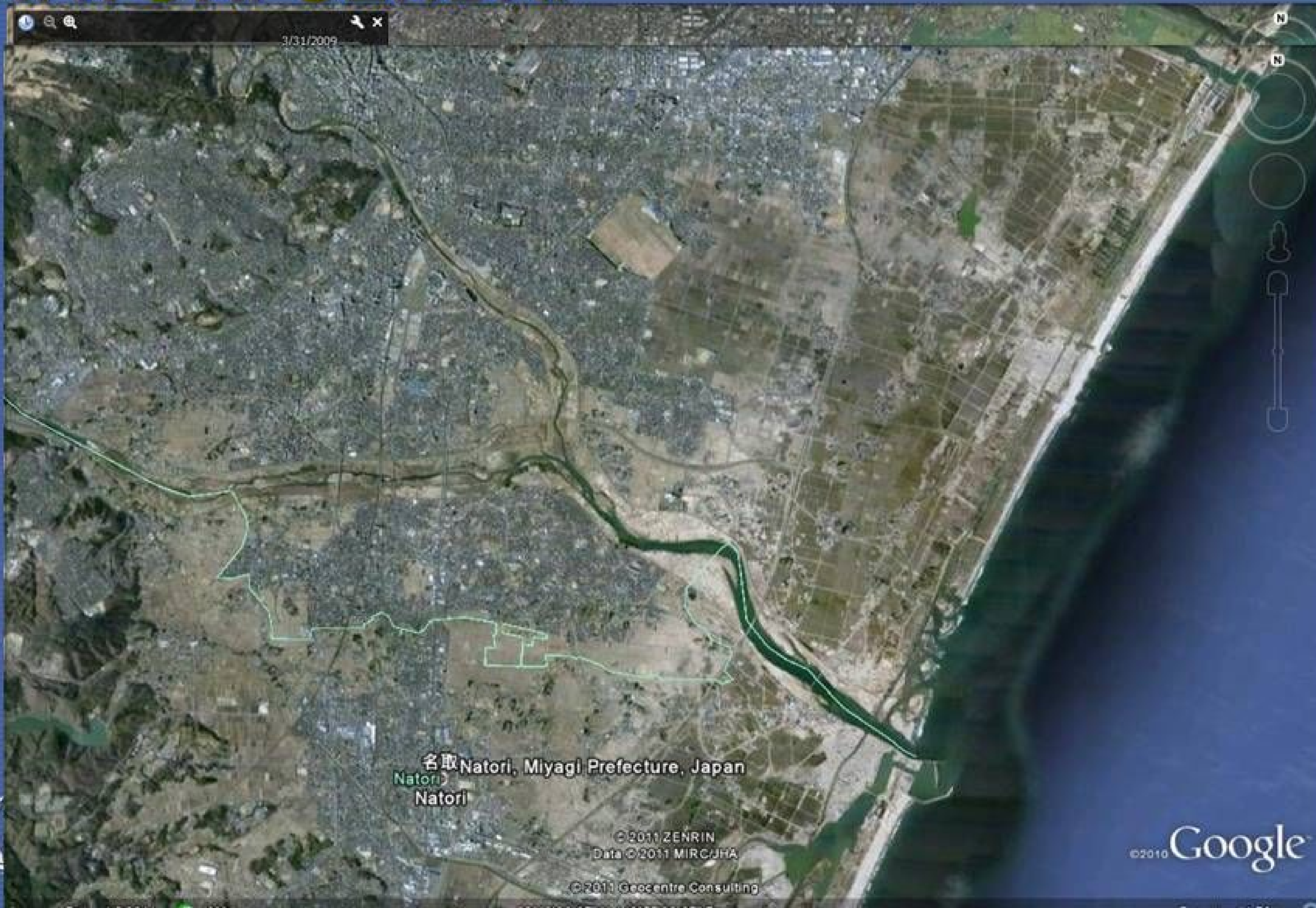
SENDAI


Kesennuma,
yagi Prefecture, Japonya
Sendai


Sendai
Sendai port
Arahama
Yuriage
Sendai airport
多賀城市
若林区
名取市
凡例
浸水範囲
撮影範囲
0 0.5 1 2 3 4 キロメートル
国土地理院

IAEA

NATORI-SENDAI



IAEA

ARAHAMA-SENDAI



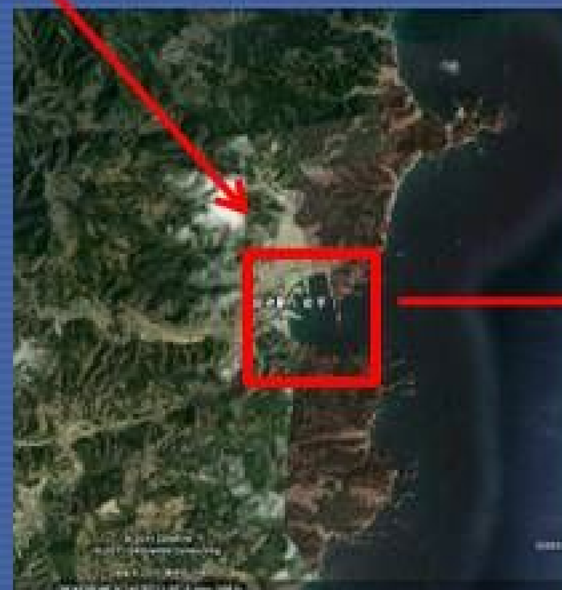

IAEA

ARAHAMA-SENDAI


Morioka
Taro
Miyako
Yamada
Otsuchi
Kitakami
Kamaishi
Ofunato
Rikuzentakata
Ichinoseki
Kesennuma
Mt Togenokami
Mt Aomatsuba
Iwate
岩手県
Mt Hayachine
早池峰山
Mt Yakushi
薬師岳
Tachimaru
Pass
立丸峠
Miyako
宮古市
Miyako Bay
宮古湾
Mt Junijin
十二神山
Hanamaki
花巻市
Funakoshi
Bay
船越湾
Tono
遠野市
Mt Rokko-Ushi
六角牛山
Kitakami
北上市
Kitakami
River
北上川
Kamaishi
釜石市
Kamaishi
Bay
釜石湾
Mt Goyo
五葉山
Oshu
奥州市
Ofunato
大船渡市
Mt Hikami
氷上山
Rikuzentakata
陸前高田市
Mt Murone
室根山
Ichinoseki
一関市
Kesennuma
気仙沼市
Karakuwa
Peninsula
唐桑半島

IAEA


Taro
Yamada
Otsuchi
Kamaishi
Ofunato
Rikuzentakata
Kesennuma 気仙沼



IAEA

TARO


© 2011 ZENRIN
©2010 Google
© 2011 Geocentre Consulting
39°43'57.64" N 141°58'09.55" E elev 3 m
Eye alt 1.61 km

IAEA

TARO

IAEA

1896 MEGA MEIJI TSUNAMI - TARO

MİYAKO

IAEA


Yamada
Otsuchi
Kamaishi
Ofunato
Rikuzentakata
Kesennuma

IAEA

MIYAKO


Motomachi 本町
1丁目
宮古Miyako, Iwate Prefecture, Japan
Miyako
© 2011 ZENRIN
©2010 Google
© 2011 Geocentre Consulting
Imagery Date: 4/1/2011
2004
39°38'29.54" N 141°57'27.15" E elev 5 m
Eye alt 657 m

MIYAKO City Hall Camera

IAEA

MIYAKO

IAEA


Miyako
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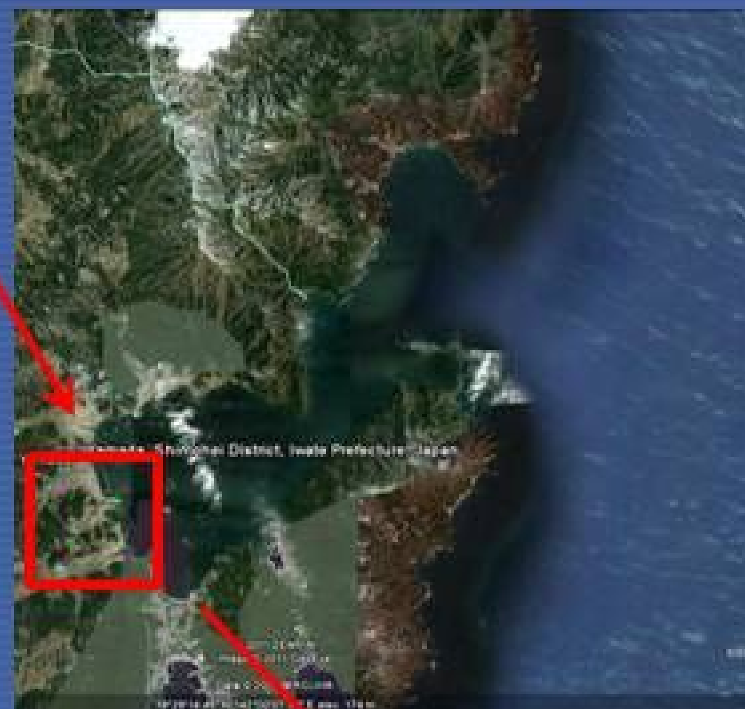
© 2011 ZENRIN
Google

MIYAKO


550m →
宮古漁協ビル
津波避難場所
Evacuate to higher ground!

YAMADA

IAEA



IAEA

IAEA

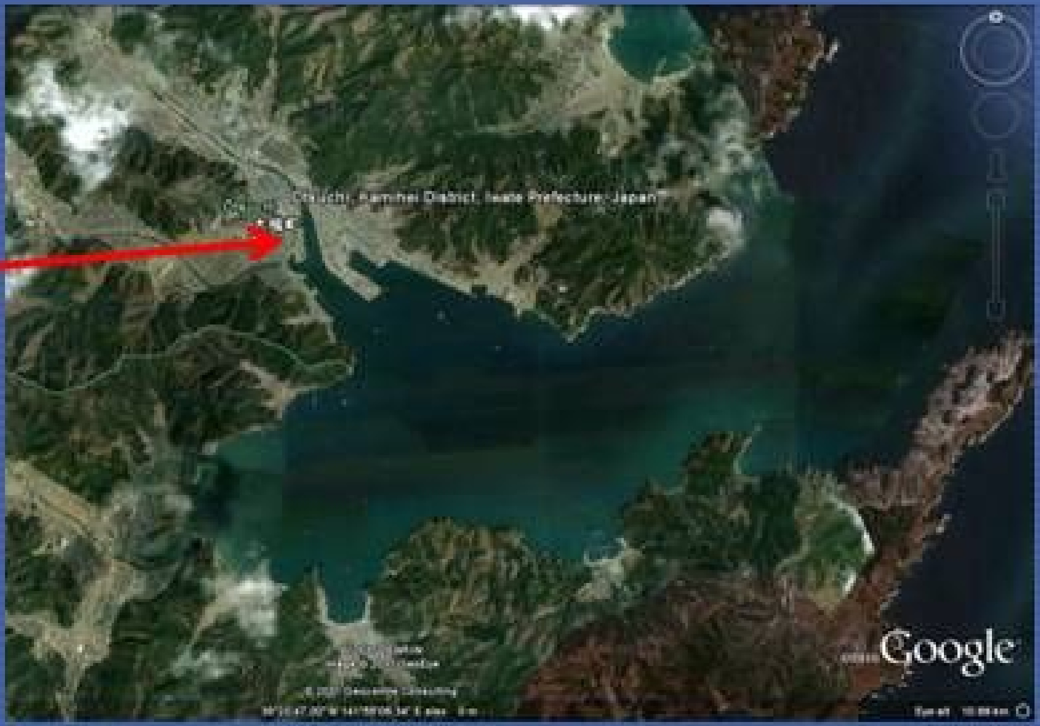
Yamada


4/1/2011
2011
山田町
Yamada, Shimohei District, Iwate Prefecture, Japan
Yamada
© 2011 ZENRIN
© 2011 Geocentre Consulting
©2010 Googl
4/1/2011
2005
39°28'02.36" N 141°57'16.33" E elev 0 m
Eye alt

IAEA

Yamada

OTSUCHI



IAEA

IAEA

OTSUCHI

IAEA

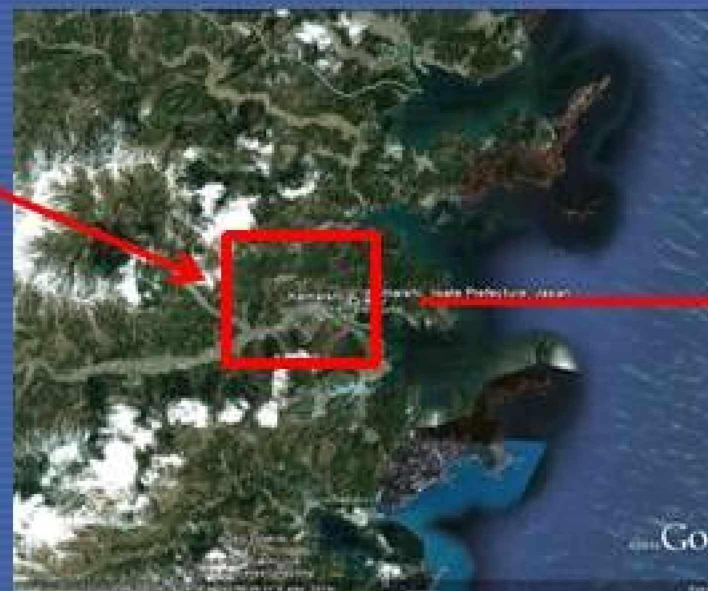
OTSUCHI

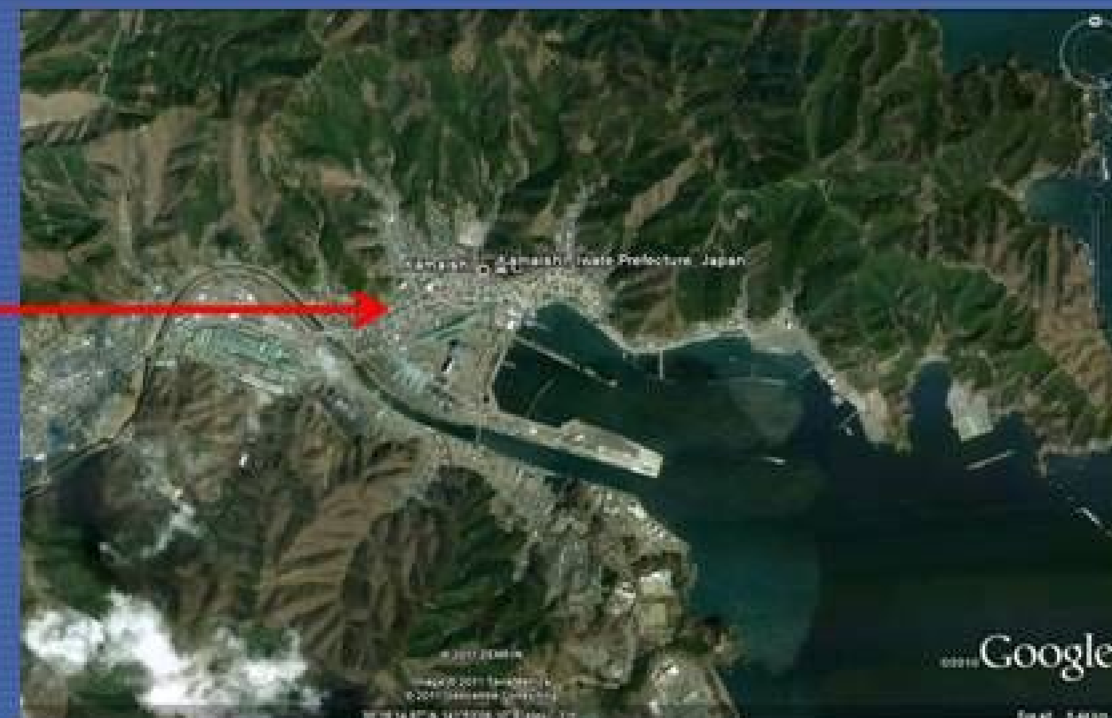





KAMAISHI


Taro
Yamada
Otsuchi
Kamaishi
Ofunato
Rikuzentakata
Kesennuma 気仙沼


Google


Kamaishi, Iwate Prefecture, Japan
Google

IAEA

KAMAISHI

KAMAISHI

Video footage

IAEA

KAMAISHI

OFUNATO


Taro
Yamada
Otsuchi
Kamaishi
Ofunato
Rikuzentakata
Kesennuma

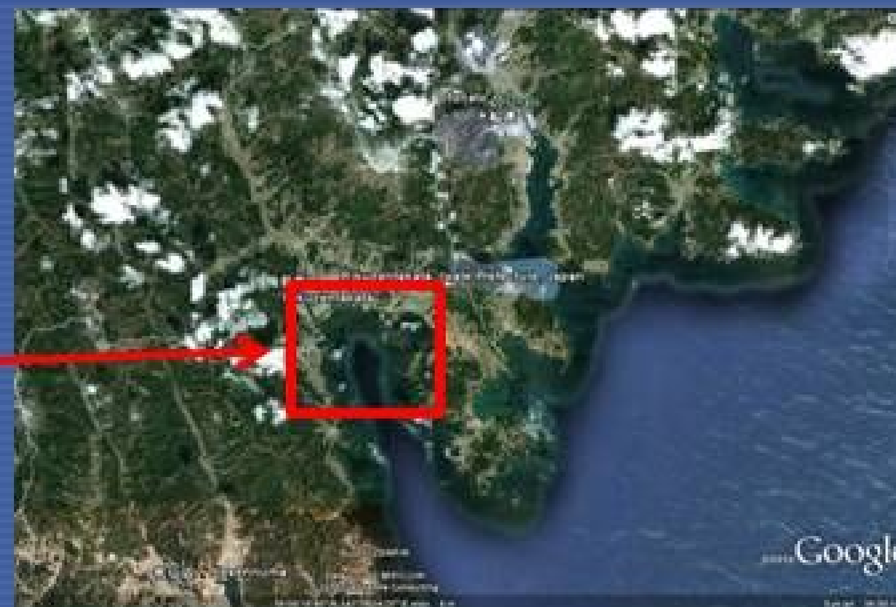

Oofunato
View
開口部201.7m
北堤243.7m
南堤291m

IAEA

OFUNATO

OFUNATO

RIKUZENTAKATA



IAEA

2010

IAEA

RIKUZENTAKATA

IAEA

PALM TREES

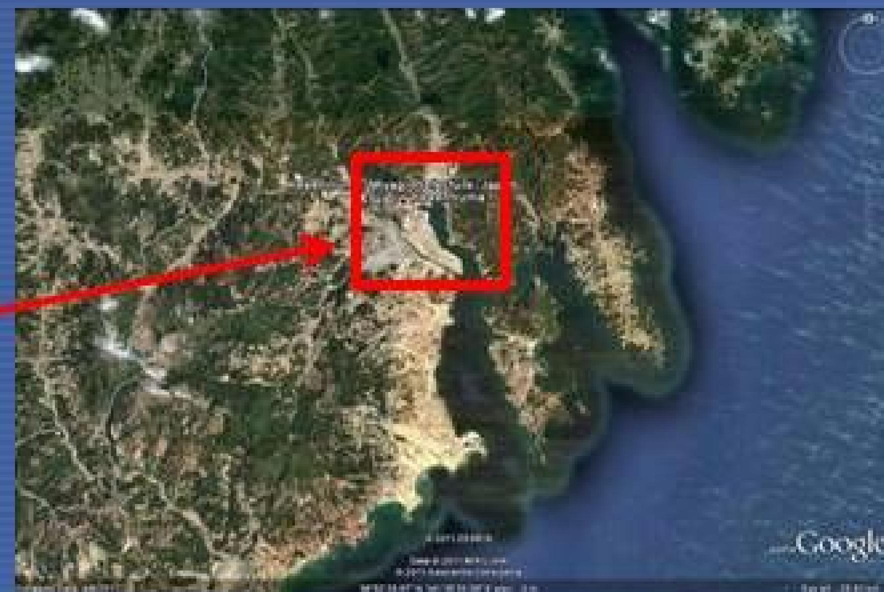
Rikuzentakata – 1896 Great MeijiTsunami

IAEA

IAEA

RIKUZENTAKATA

KESENNUMA

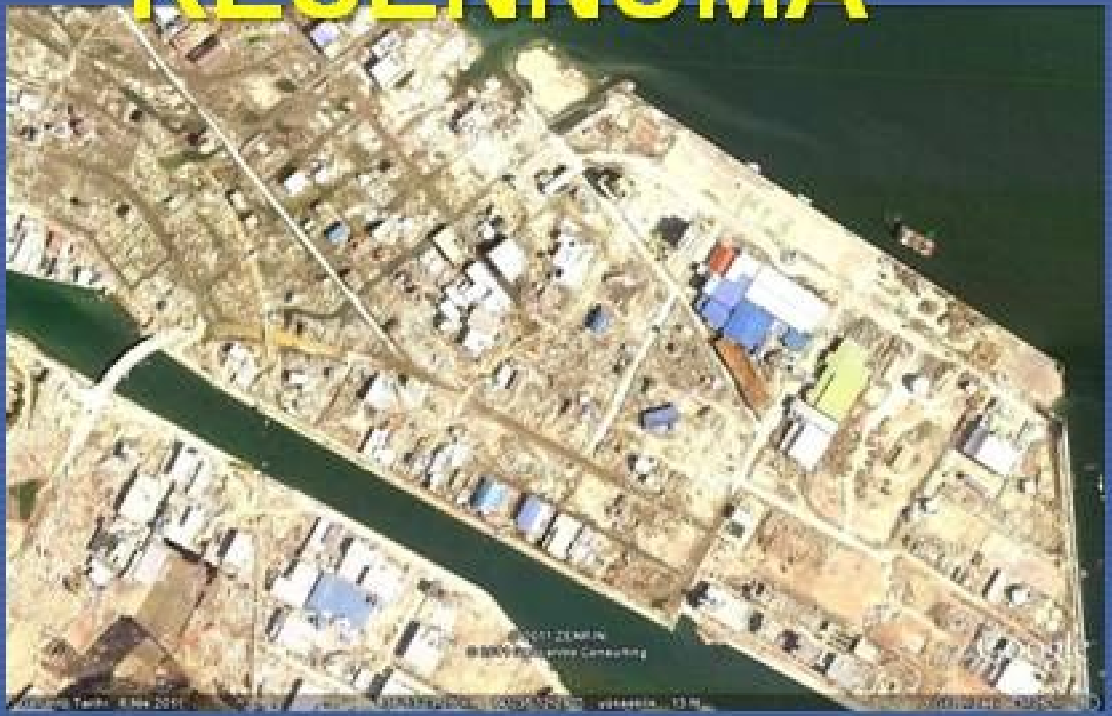


IAEA

13 MART 2011

IAEA

KESENNUMA



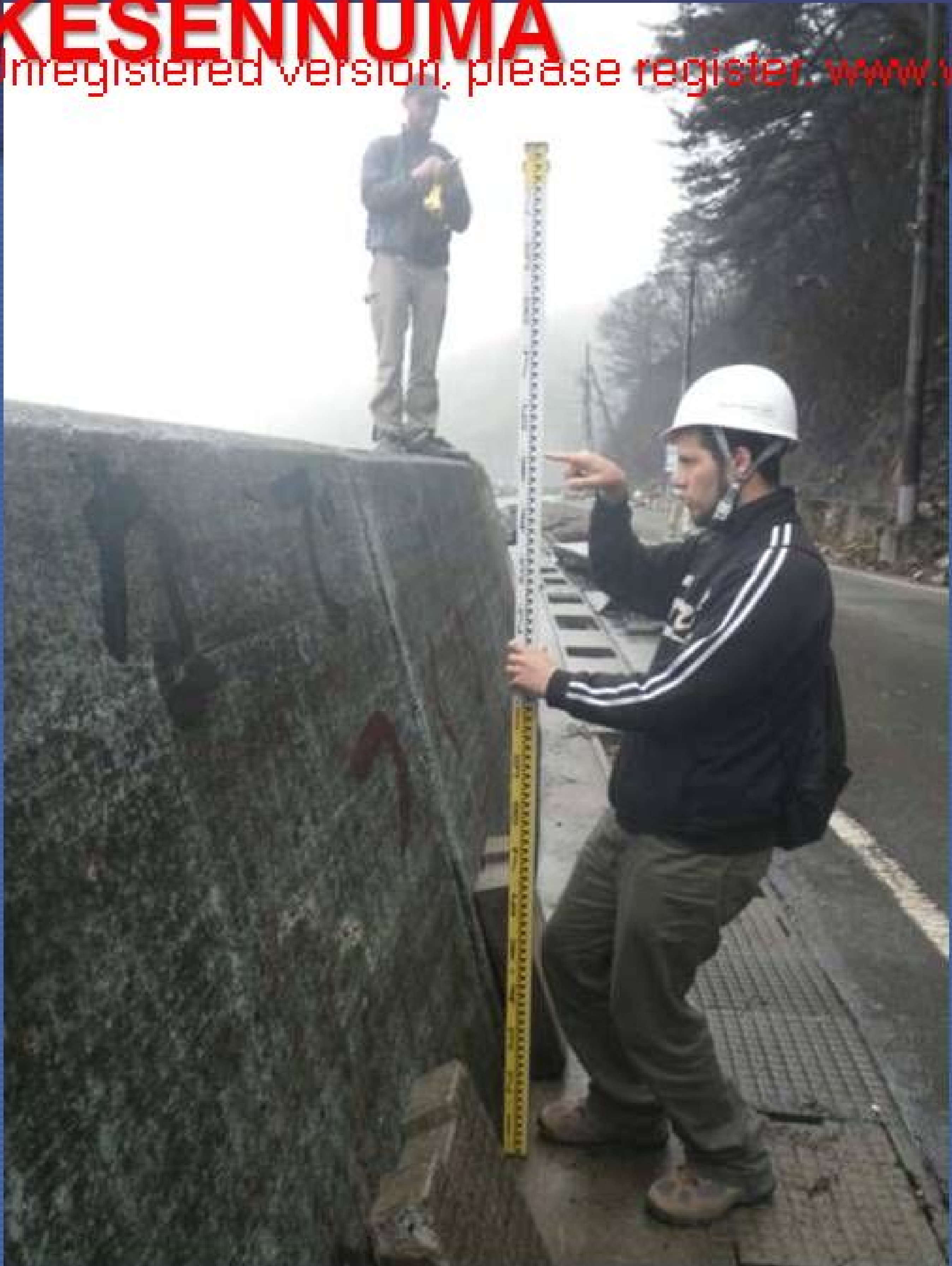
IAEA

KESENNUMA

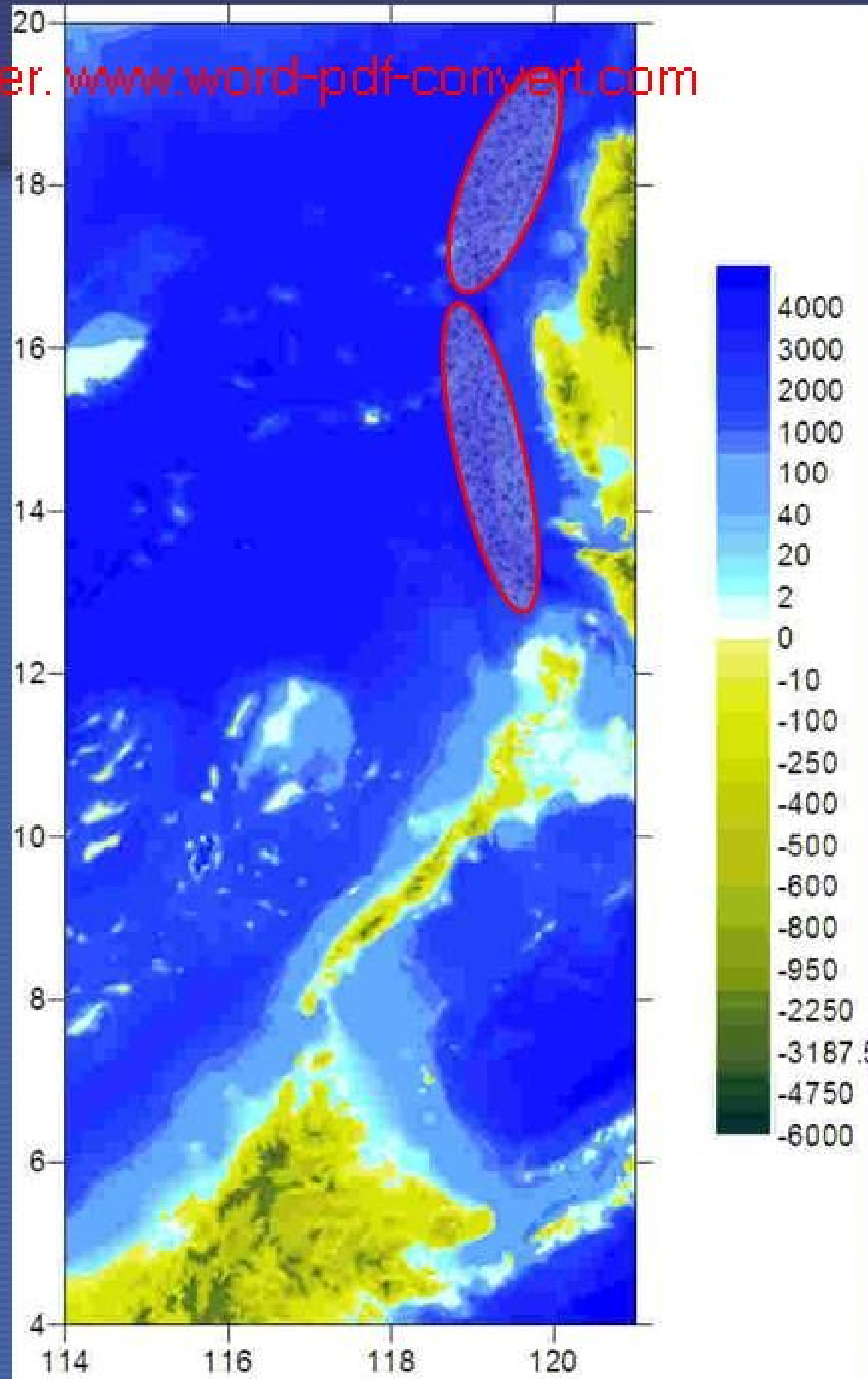




KESENNUMA

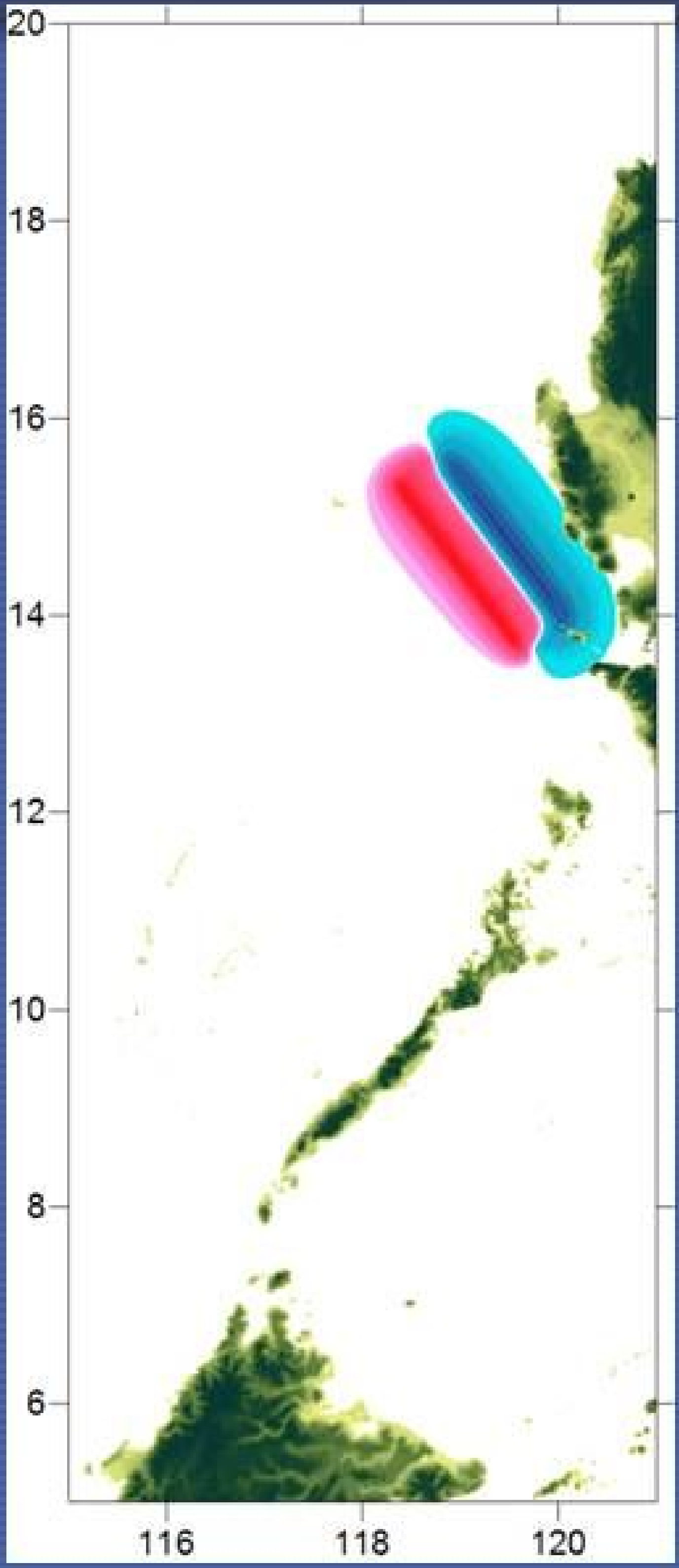


- A case Study from
- South China Sea


20
18
16
14
12
10
8
6
4
114
116
118
120
4000
3000
2000
1000
100
40
20
2
0
-10
-100
-250
-400
-500
-600
-800
-950
-2250
-3187.5
-4750
-6000

Source parameters and location

Epicenter of fault axis	119.64°E 13.6 ° N
Length of fault (km)	240
Strike angle (deg)	325
Width of fault (km)	60
Focal depth (km)	10
Dip angle (deg)	10
Slip angle (deg)	110
Displacement (m)	10
Height of initial wave (m)	5.6
Maximum positive amplitude (m)	3.6
Maximum negative amplitude (m)	-2.0



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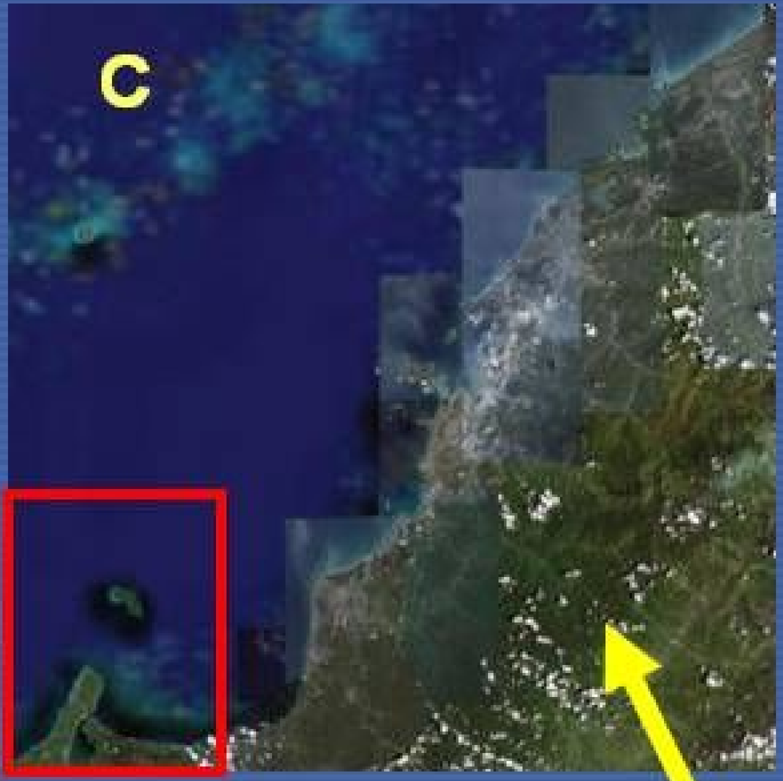
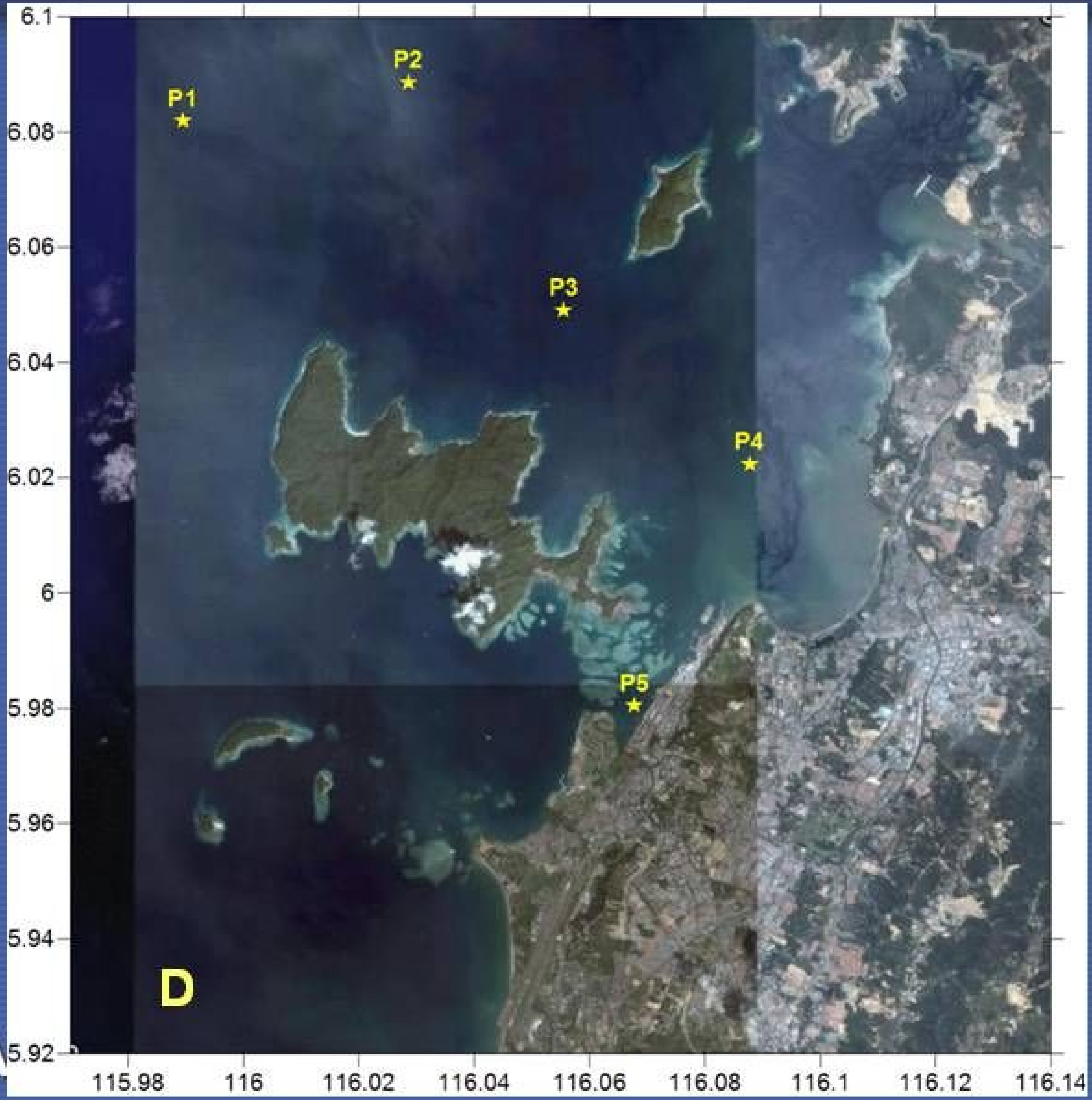
B


C


D

Gauge locations



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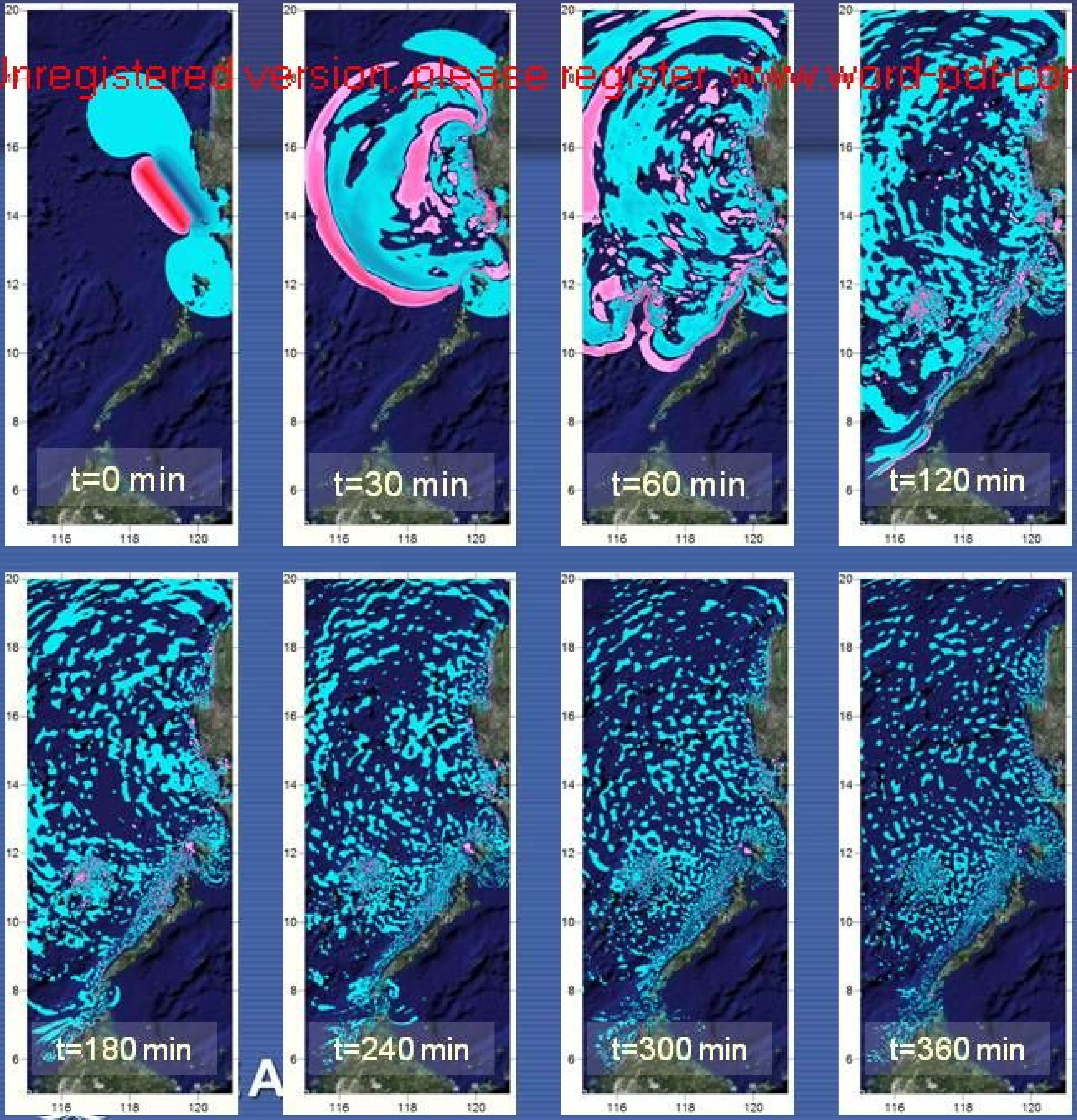
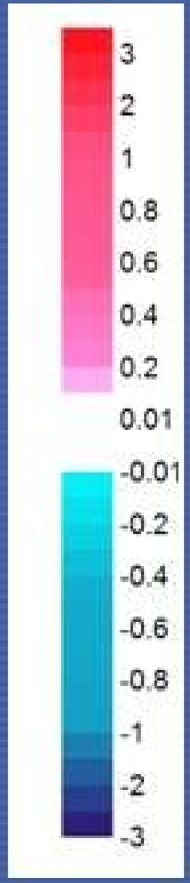


Water surface elevations at times 0, 30, 60, 120, 180, 240, 300 and 360 minutes

B-Domain

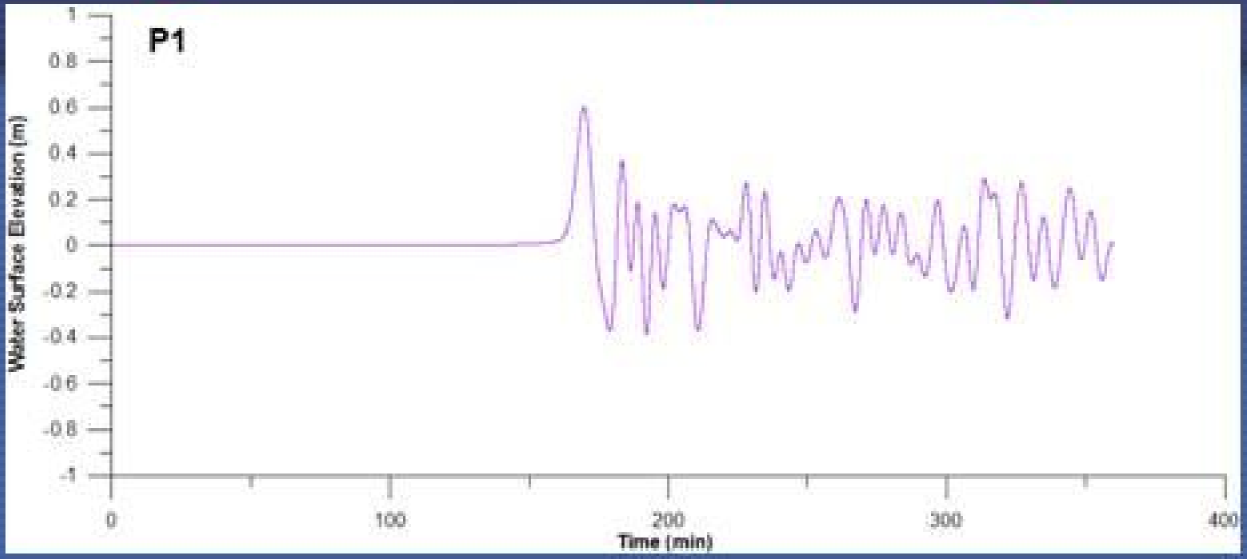
- Color scale

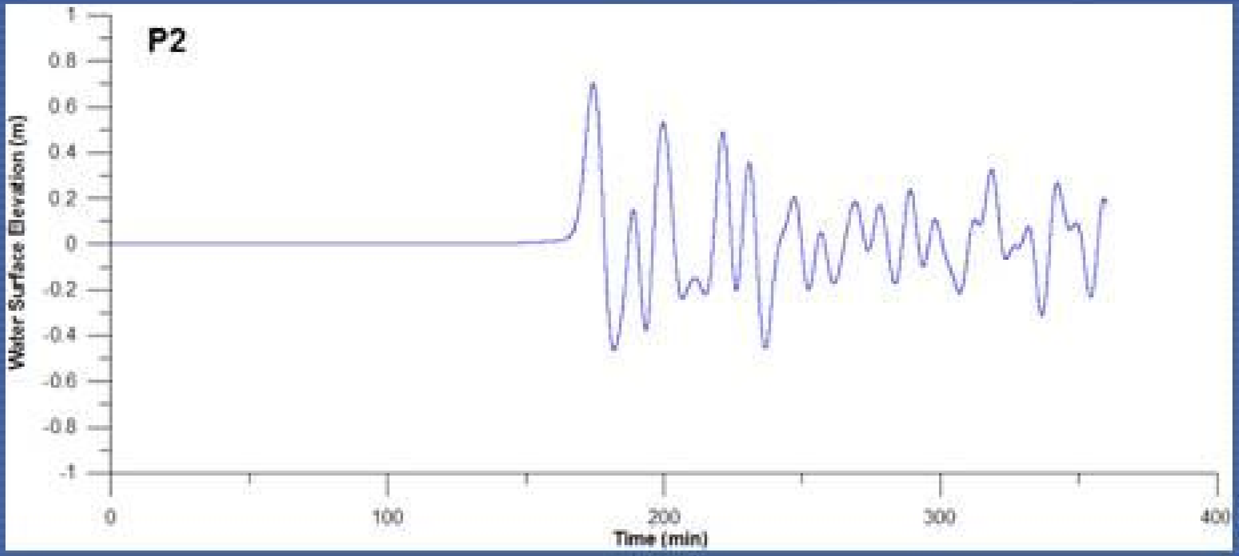


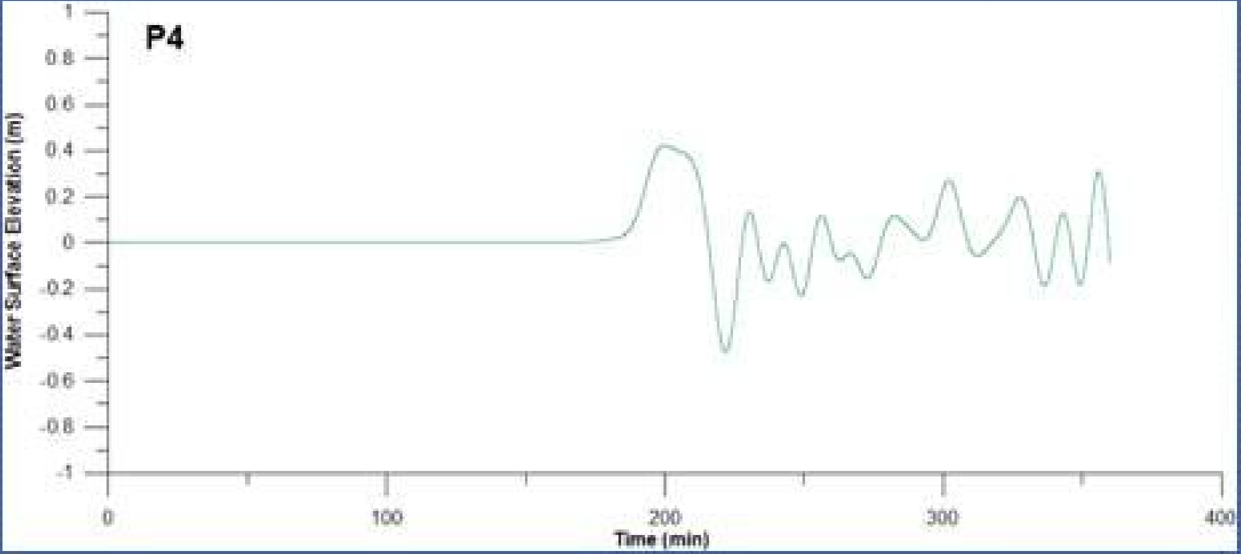
IAEA

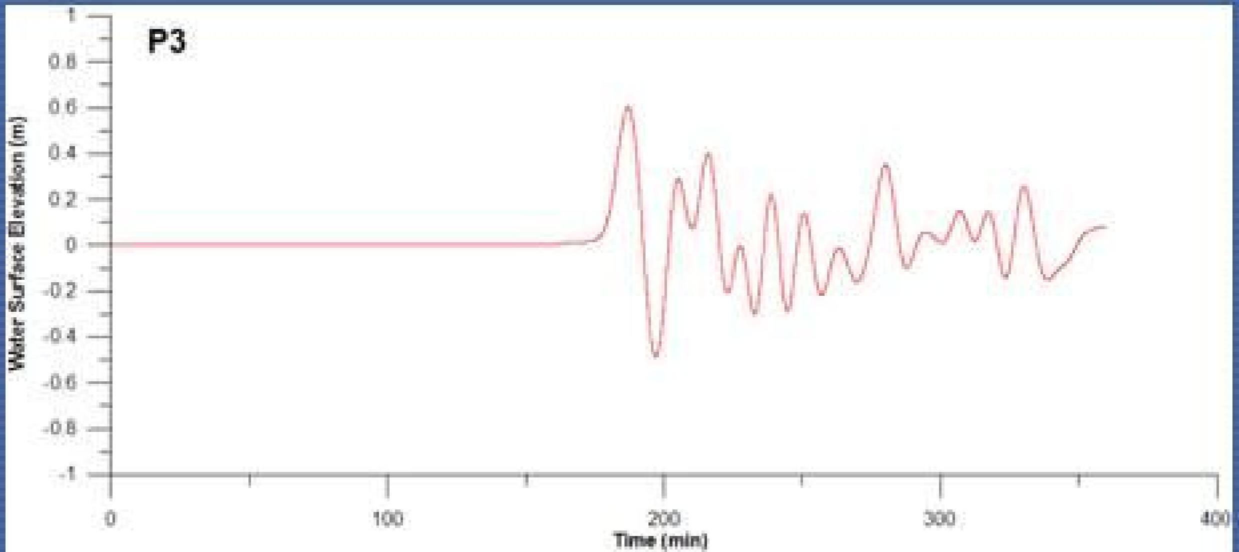
IAEA

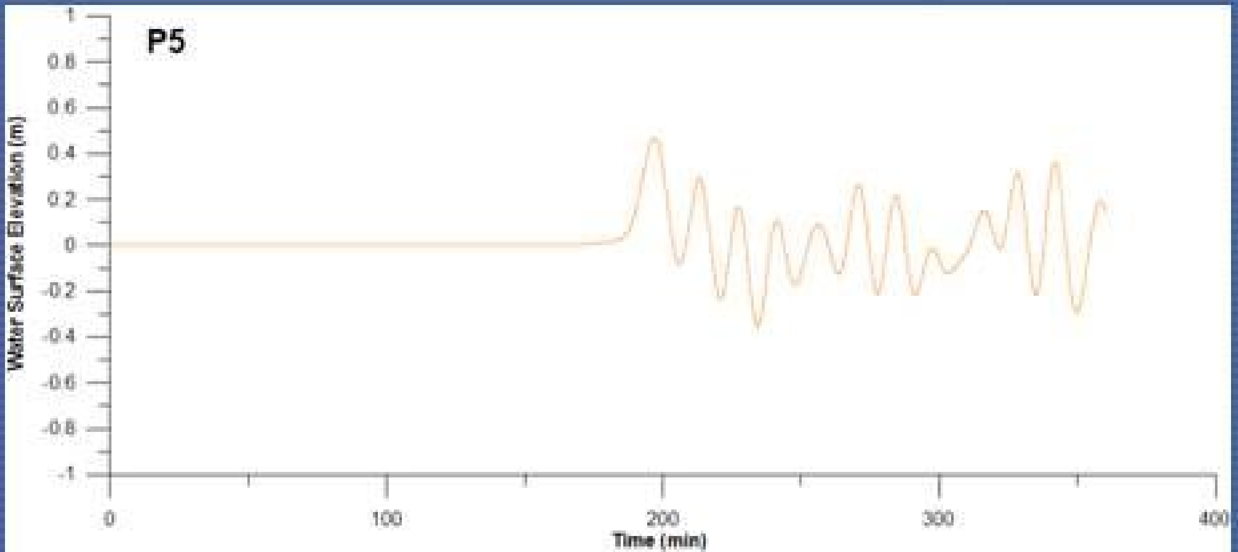
Time histories, B domain



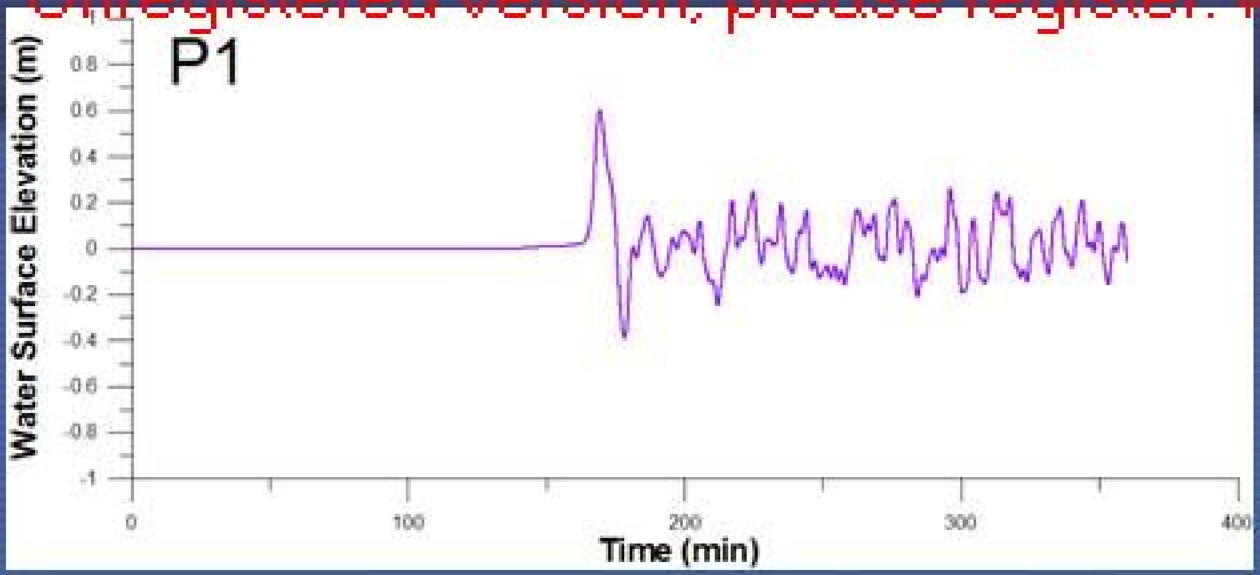


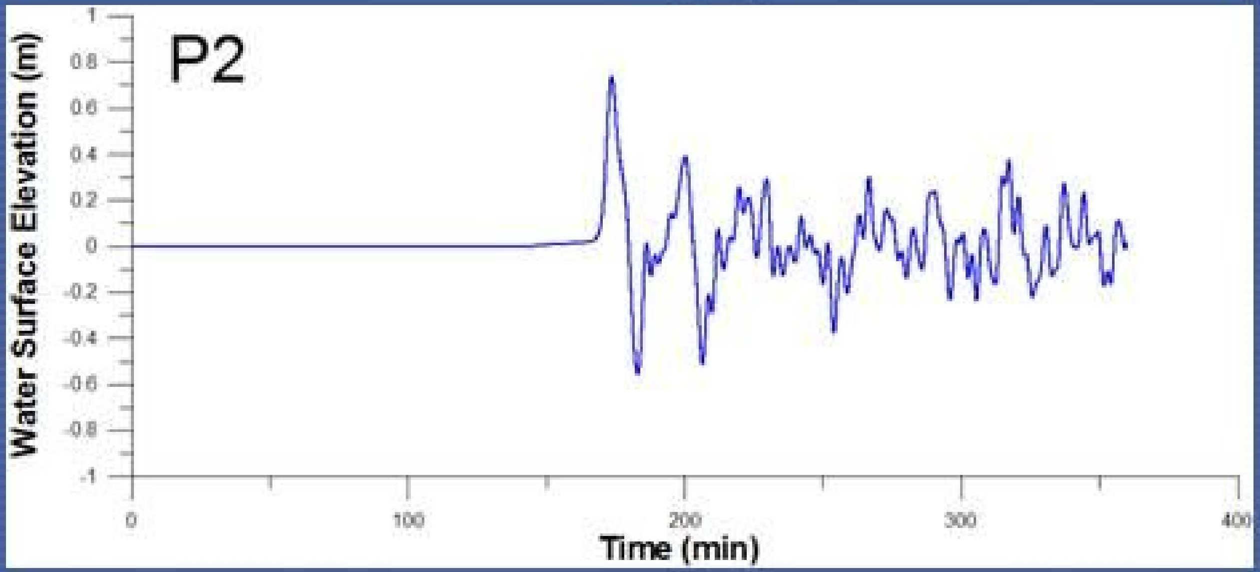


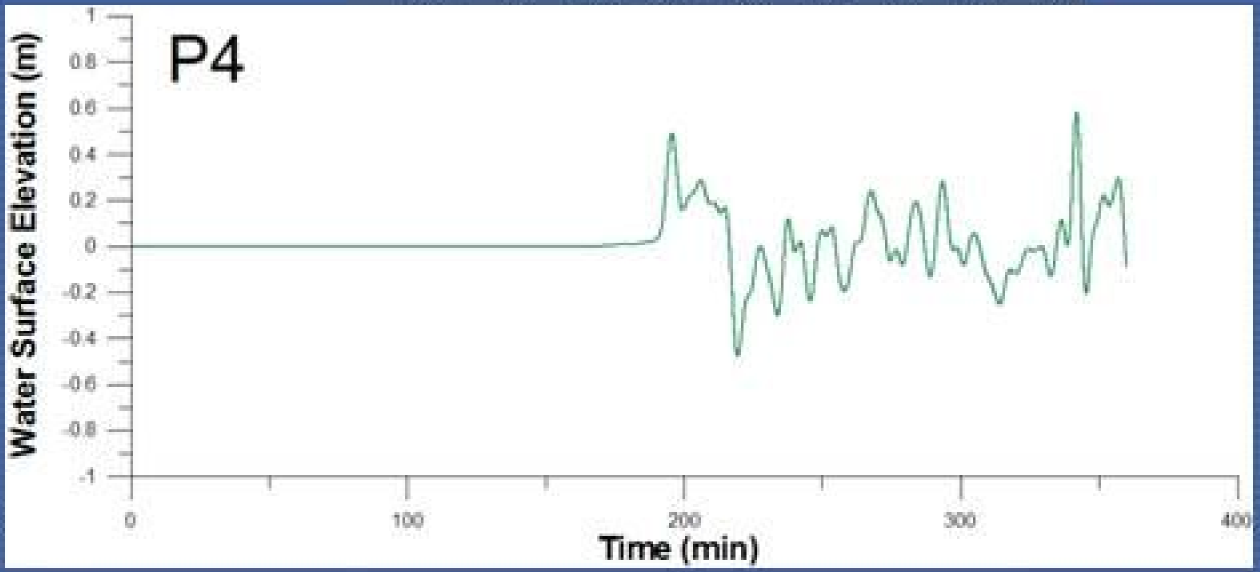


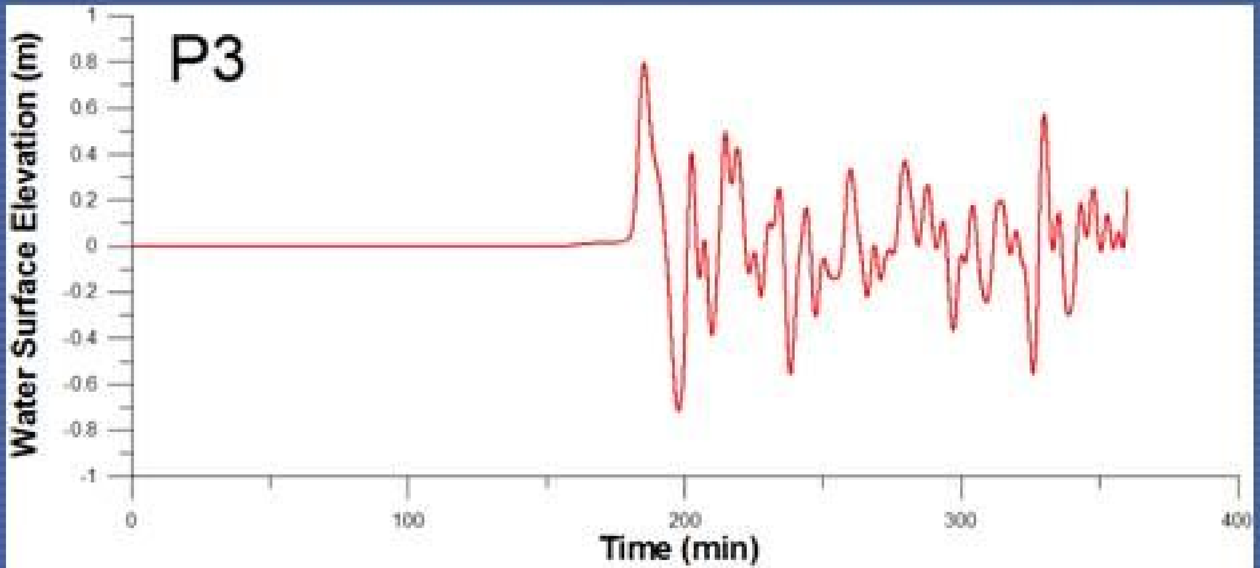


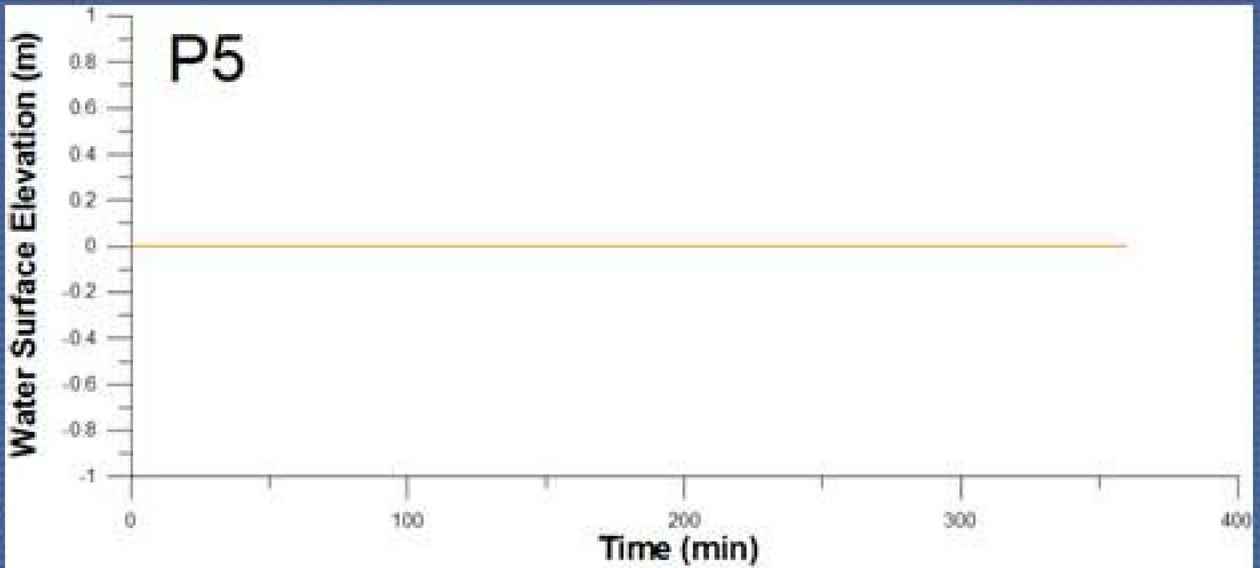
Time histories C domain



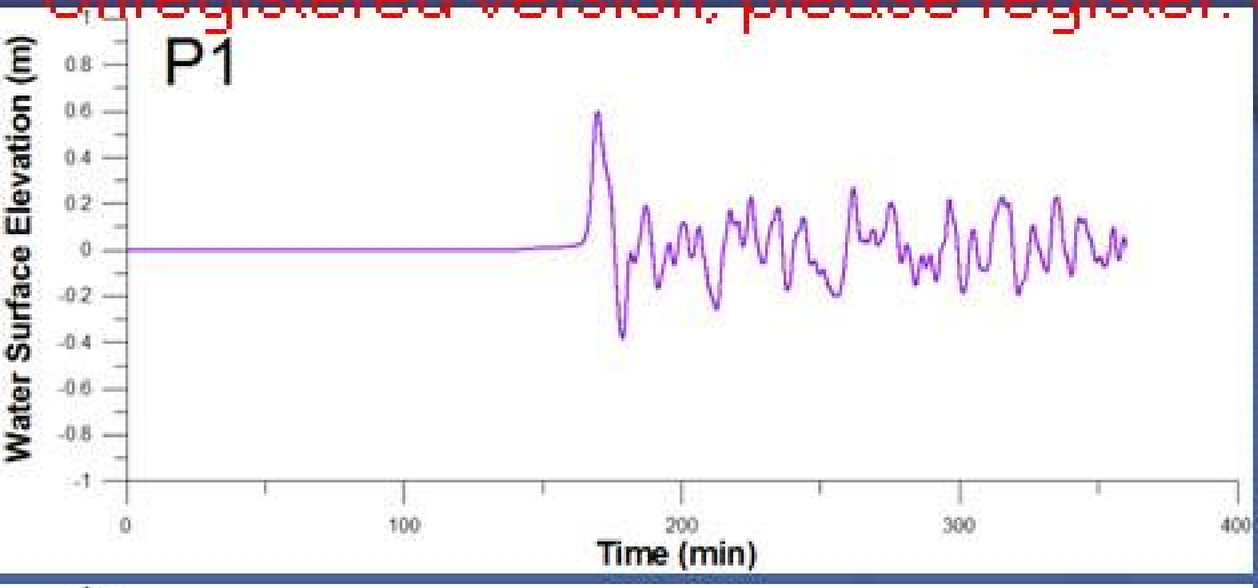


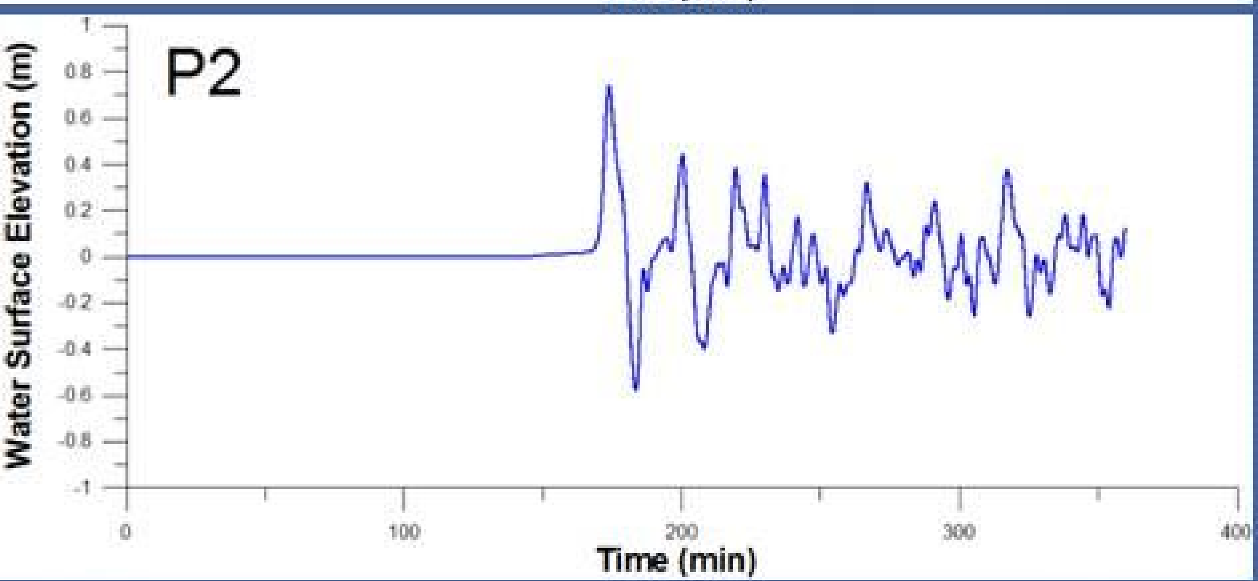


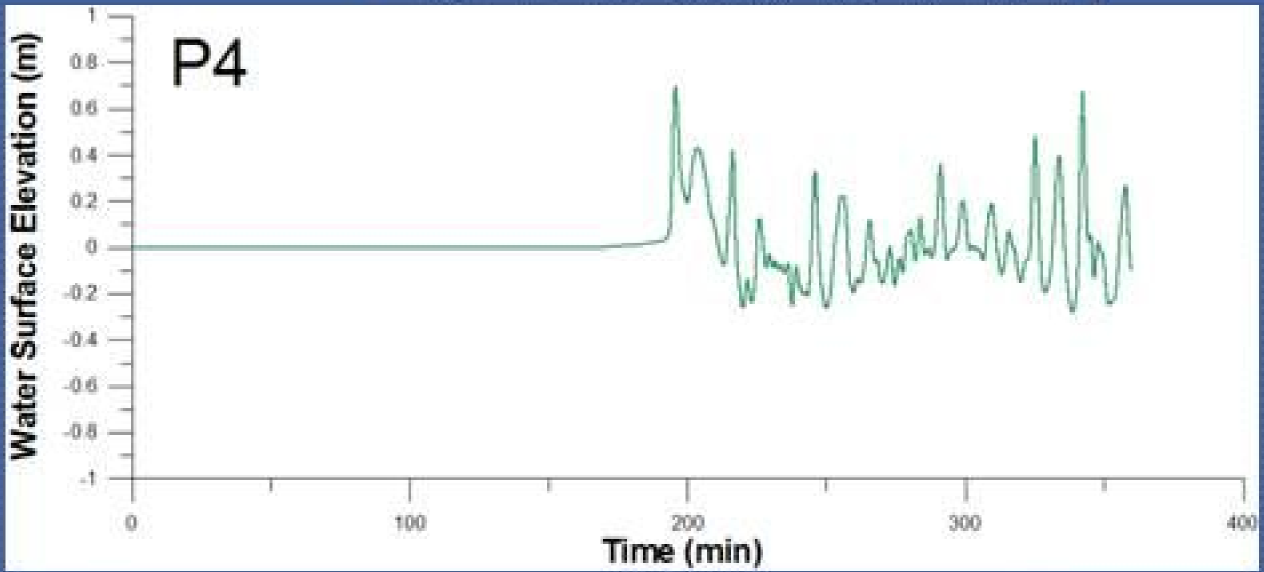


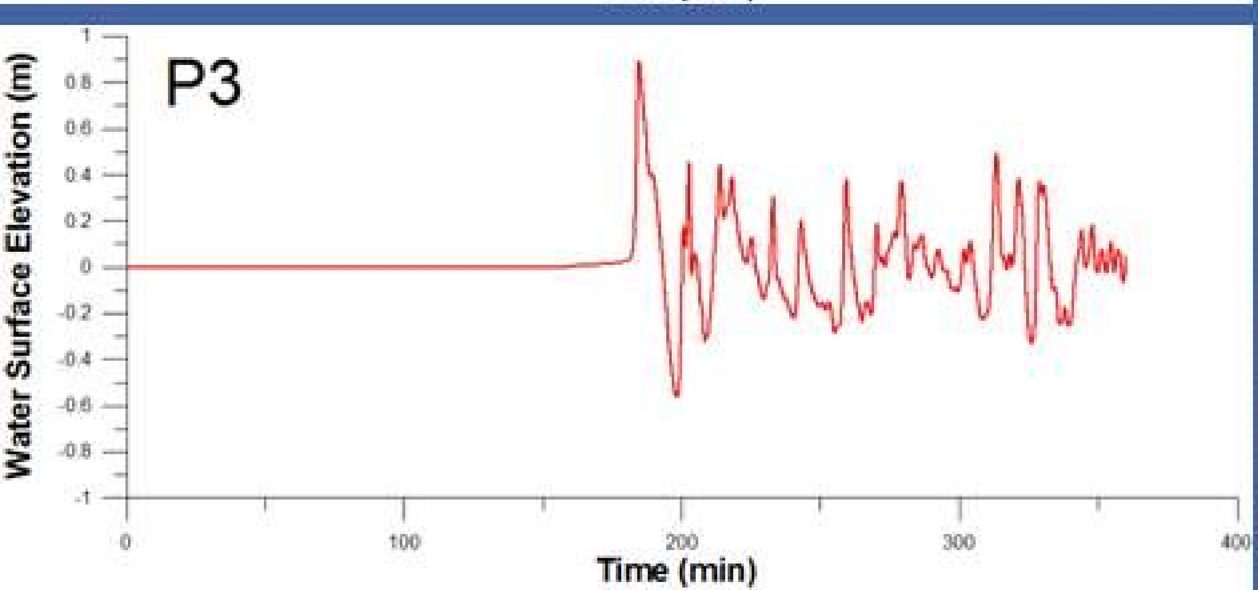


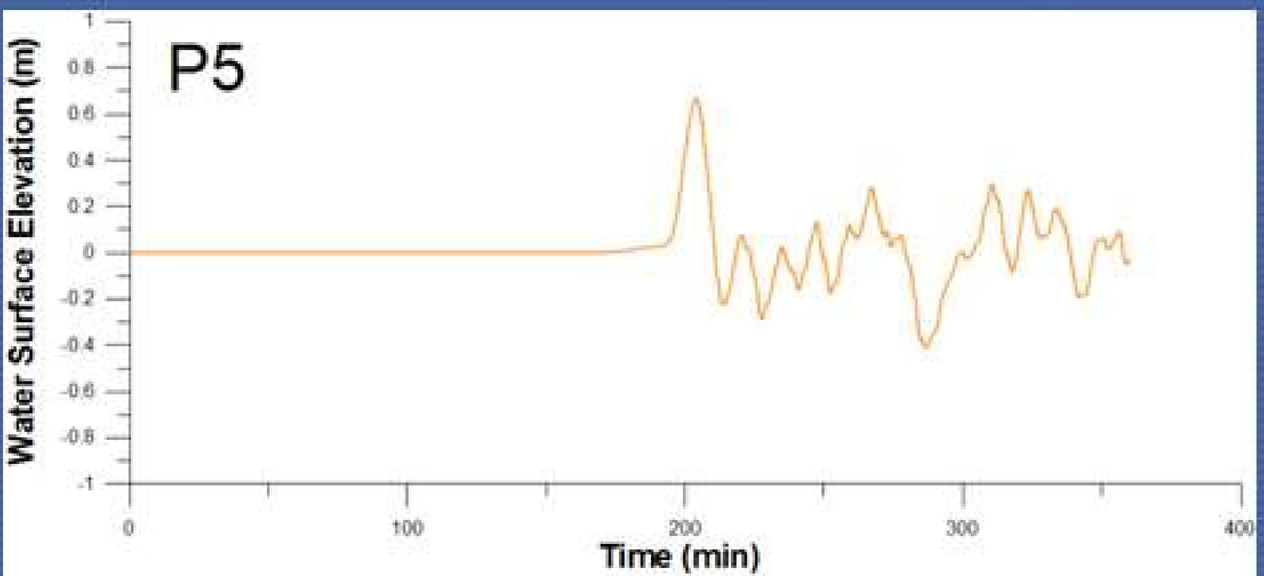
Time histories D domain



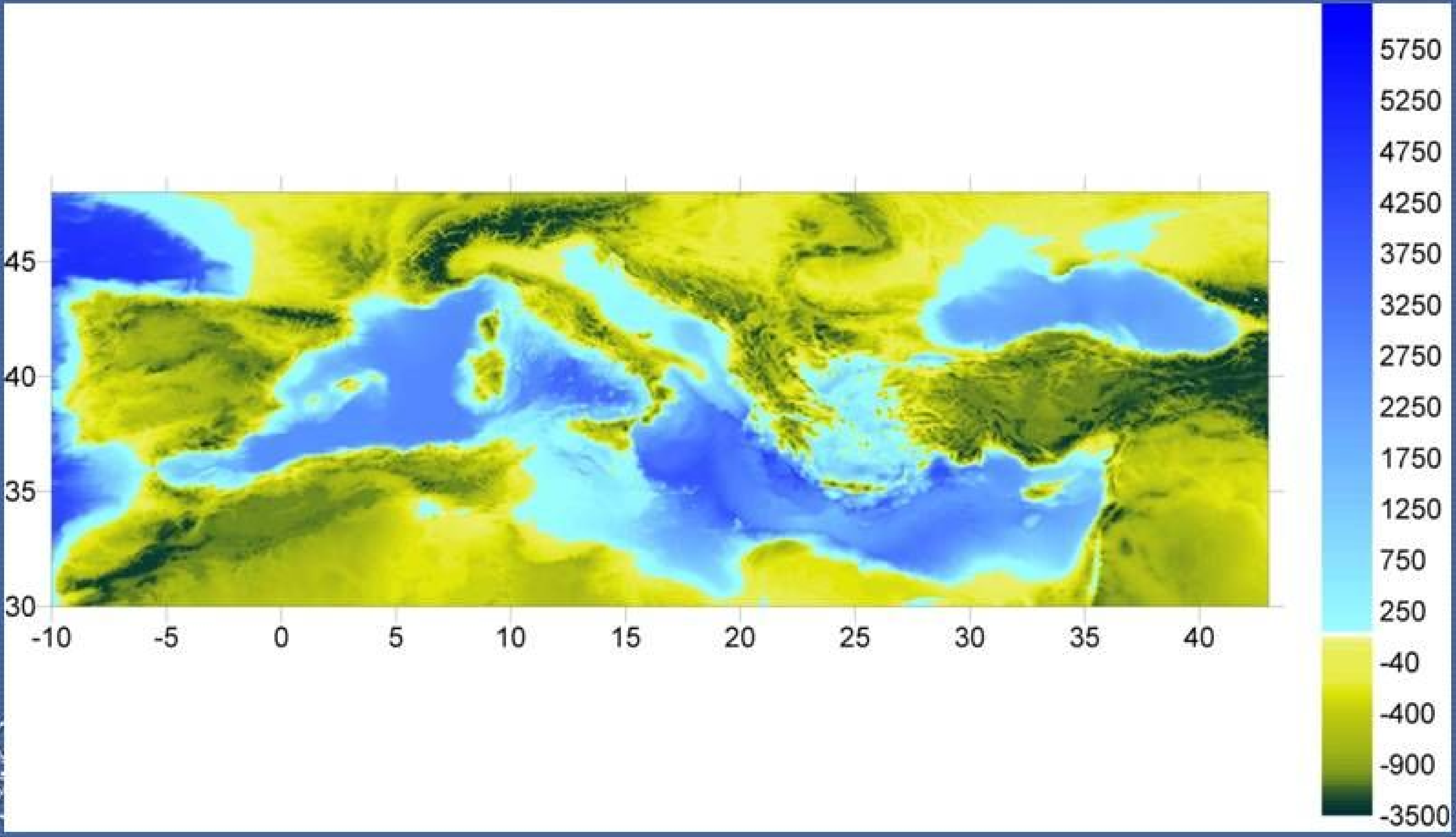






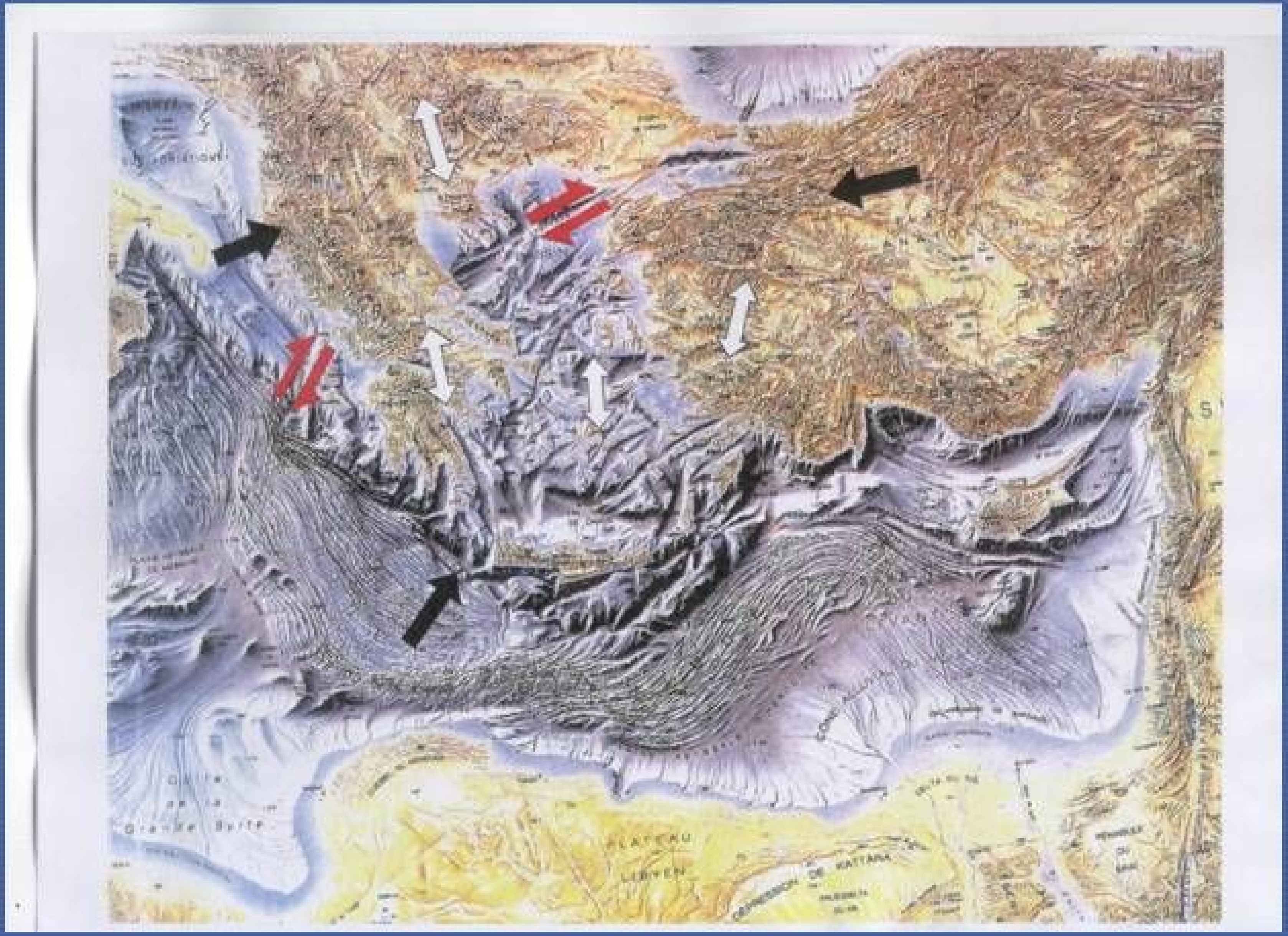


MEDITERRANEAN



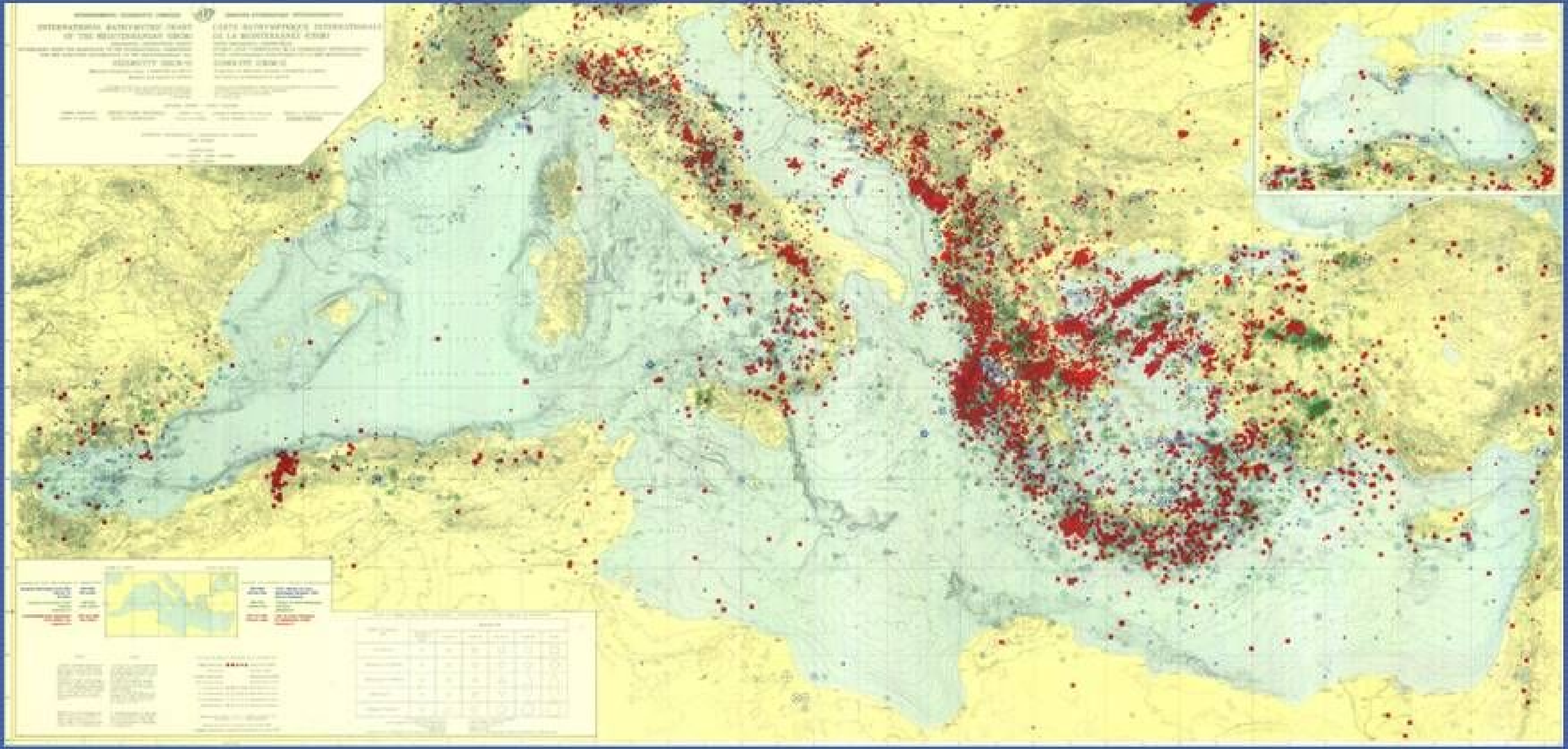
IAEA

PLATE TECTONICS IN MEDITERRANEA



IAEA

IAEA



Kaynak: IOC UNESCO

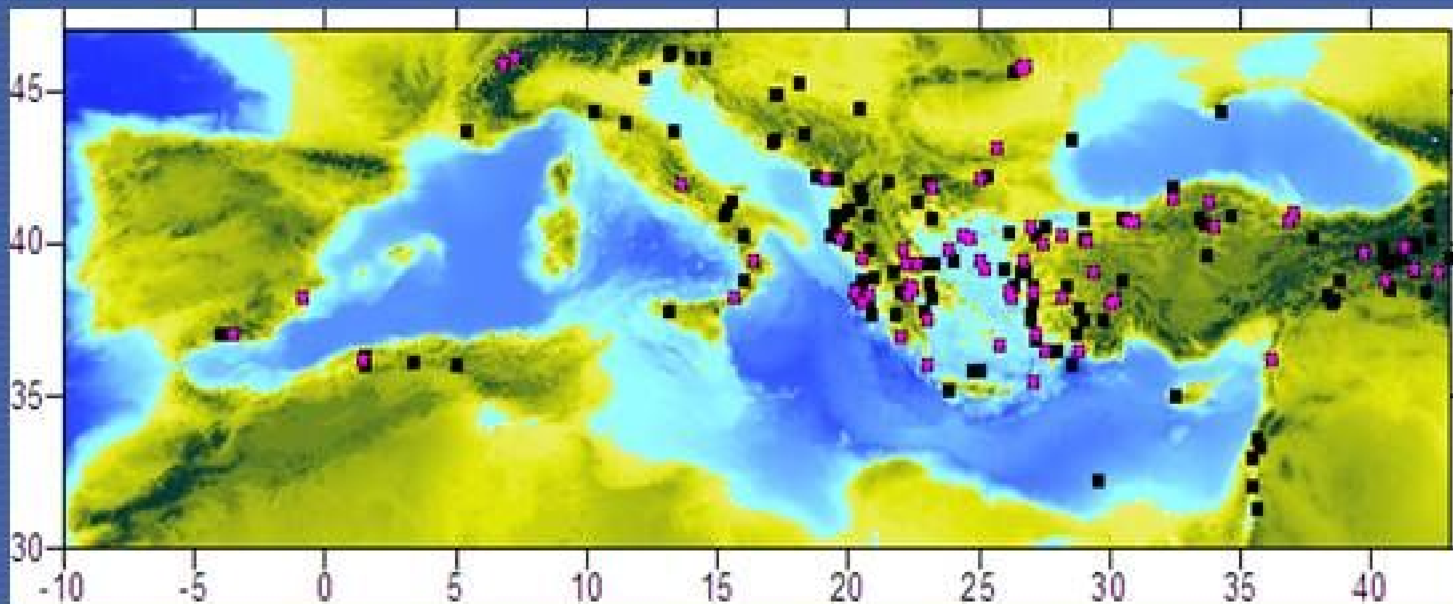
E-W : 3900 km N-S : 1600 km

Area: 4 000 000 km ^{2}

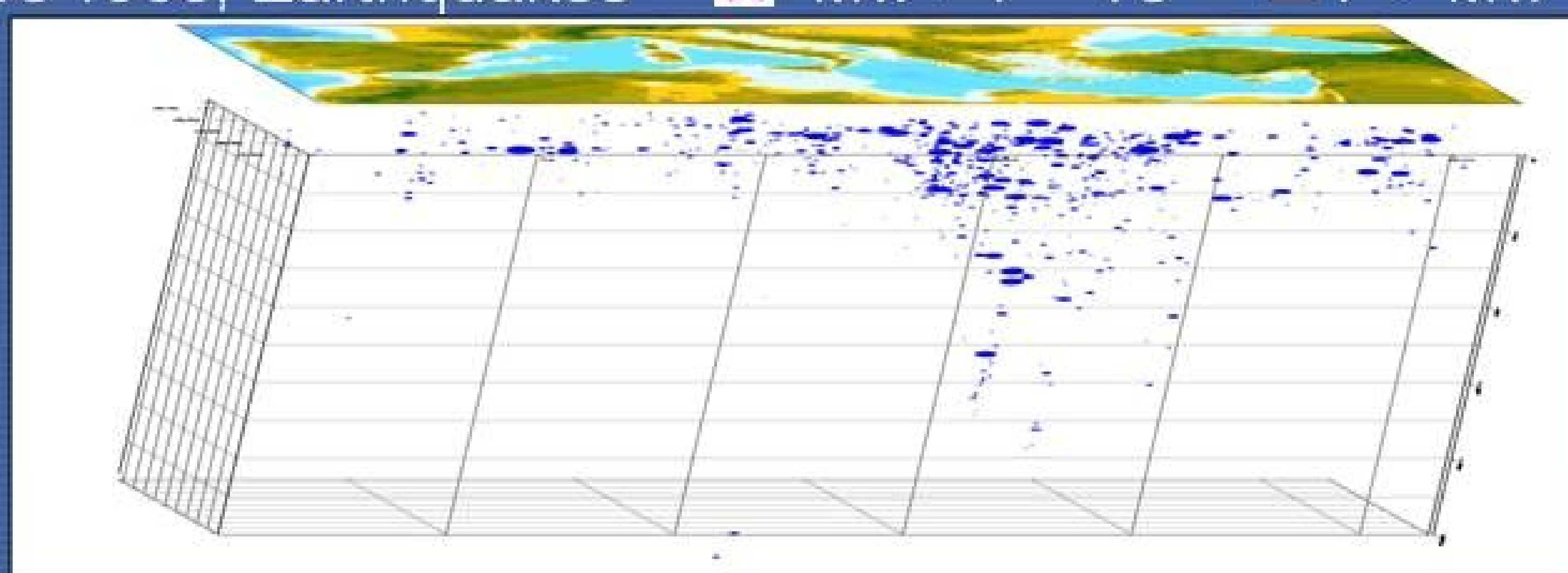
Max Depth: 4400 m

IAEA

IAEA



Since 1960, Earthquakes ★ Mw > 7 ve ■ 7 > Mw >6



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Source: National Earthquake Information Center - NEIC

EARTHQUAKES (1900-2002) SOUTH KYRETIA RHODES DALAMAN ARC

DEPREM BÜYÜKLÜĞÜ	DEPREM SAYISI	TSUNAMİ SAYISI
(7.1 -)	6	1
(6.1 - 7.0)	45	2
(5.0 - 6.0)	352	2
TOPLAM	**403**	**5**

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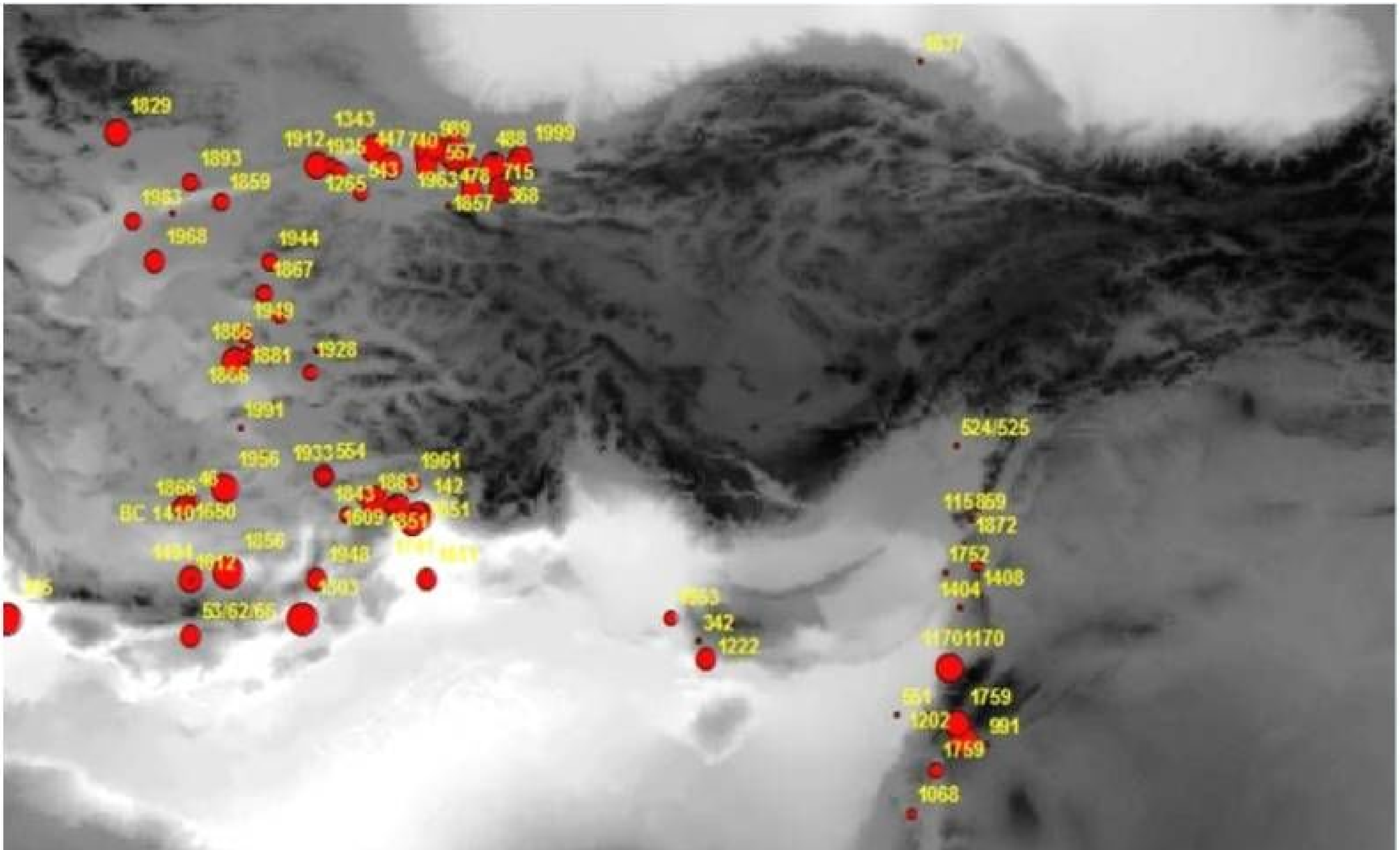

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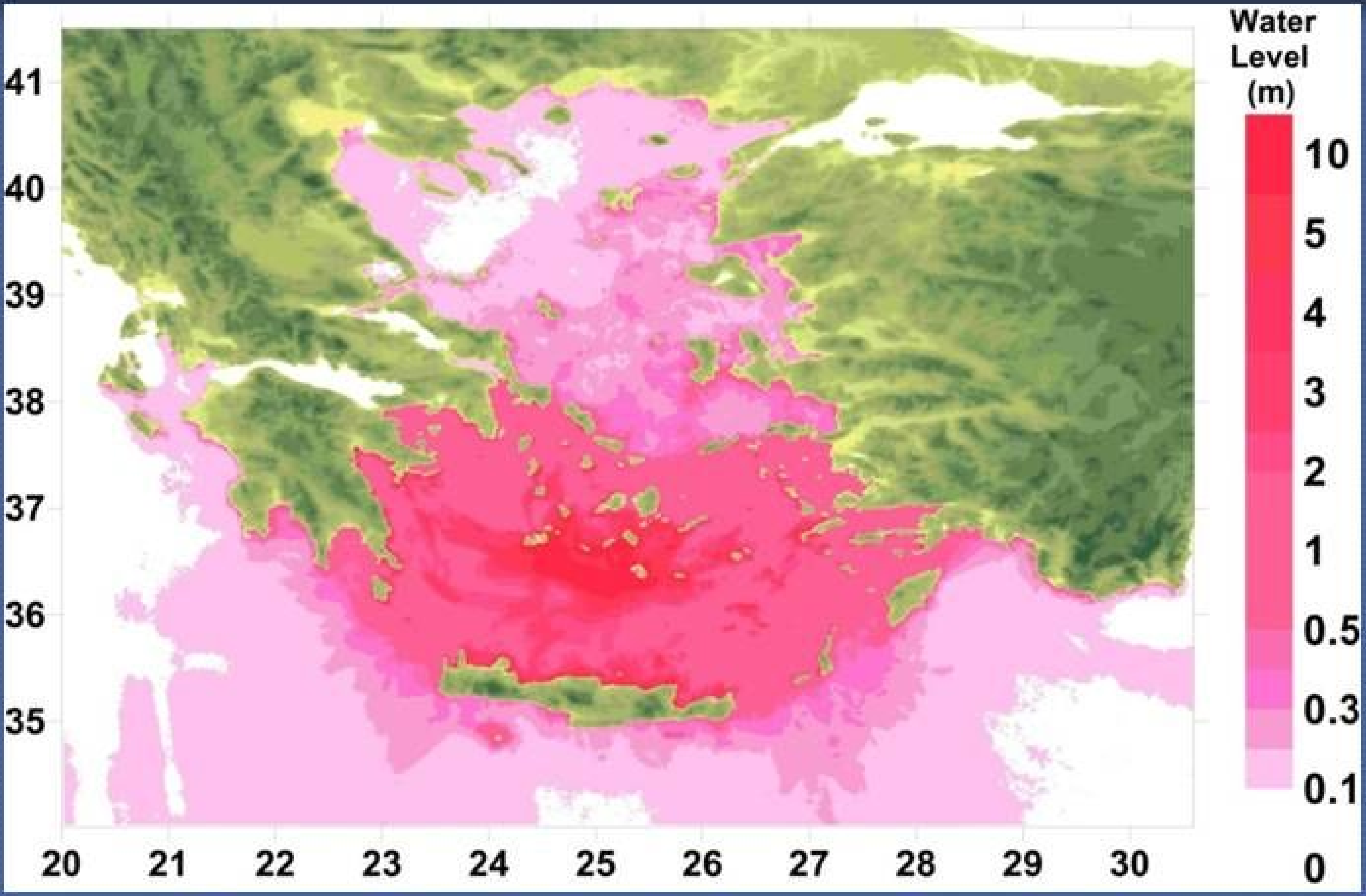
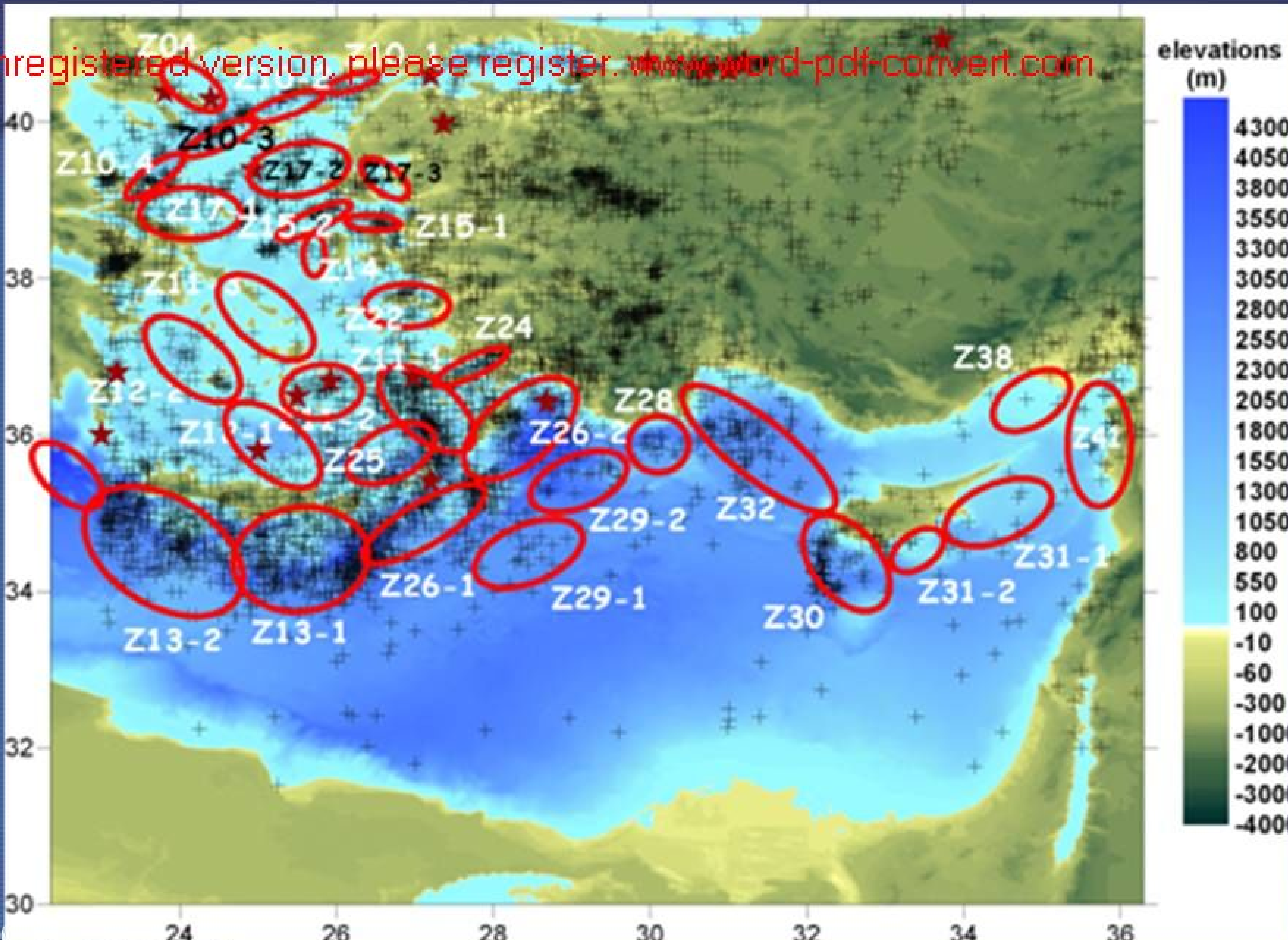
Historical Tsunamis in Eastern Mediterranean


00:00:00

IAEA



Energy Distribution in Aegean Sea after 4 hours simulations
(Grid: 900m, Faults lenght: 300km, Fault width: 10km)



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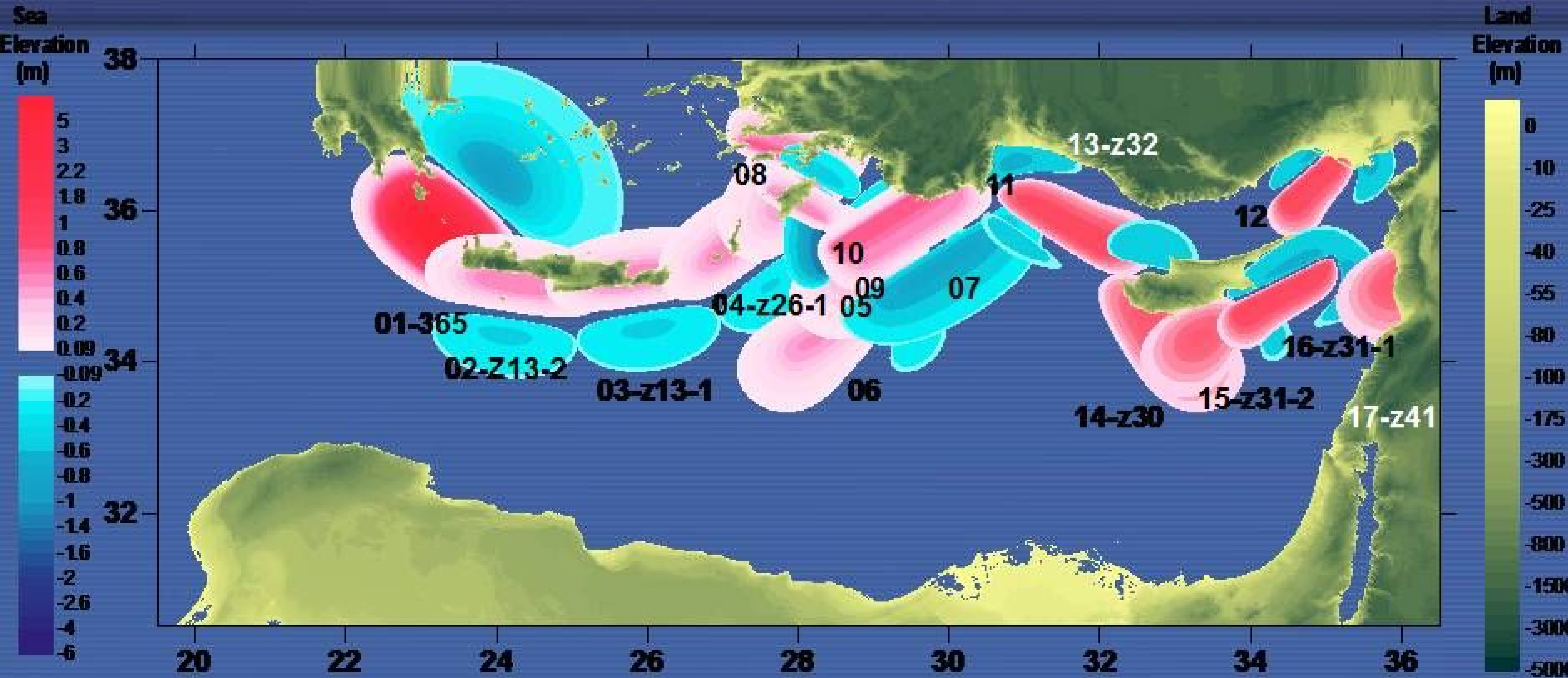
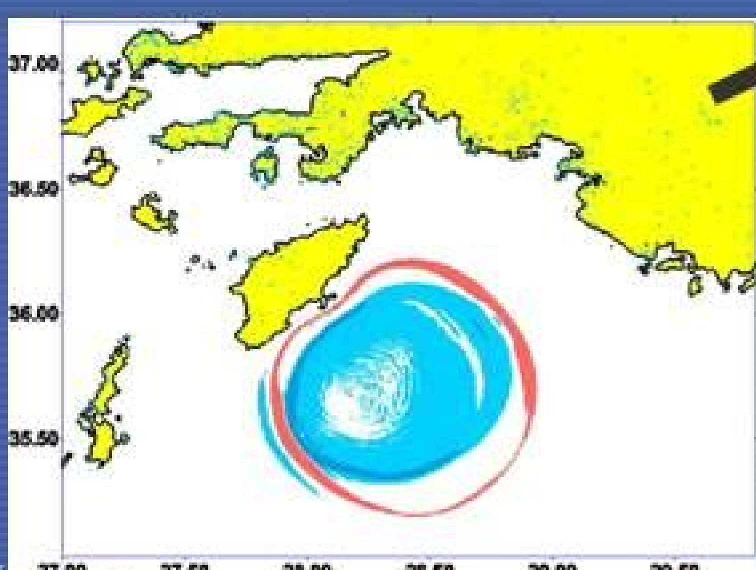
Middle East Technical University, Civil Engineering Dept.,
Ocean Engineering Research Center, Ankara TURKEY


Sea Elevation (m)
5
3
2.2
1.8
1
0.8
0.6
0.4
0.2
0.09
-0.09
-0.2
-0.4
-0.6
-0.8
-1
-1.4
-1.6
-2
-2.6
-4
-6
Land Elevation (m)
0
-10
-25
-40
-55
-80
-100
-175
-300
-500
-800
-1500
-3000
-5000
38
36
34
32
20
22
24
26
28
30
32
34
36
01-365
02-Z13-2
03-z13-1
04-z26-1
05
06
07
08
09
10
11
12
13-z32
14-z30
15-z31-2
16-z31-1
17-z41

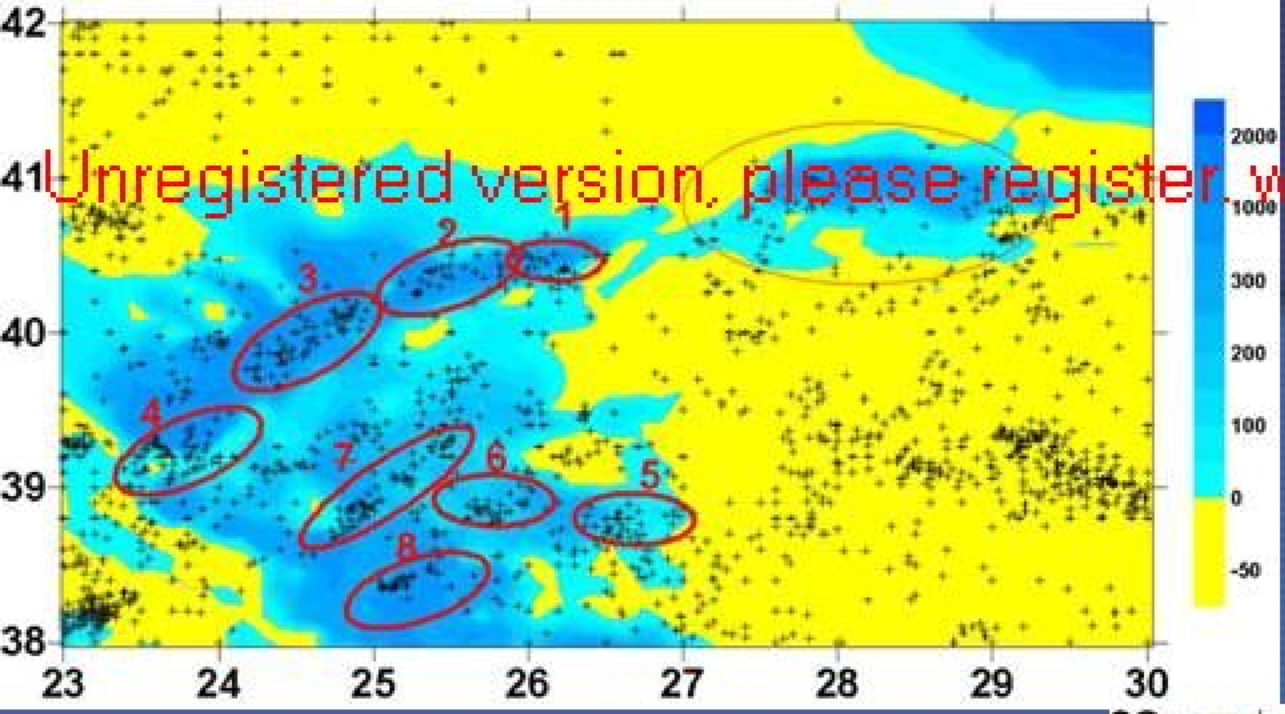
Dalaman

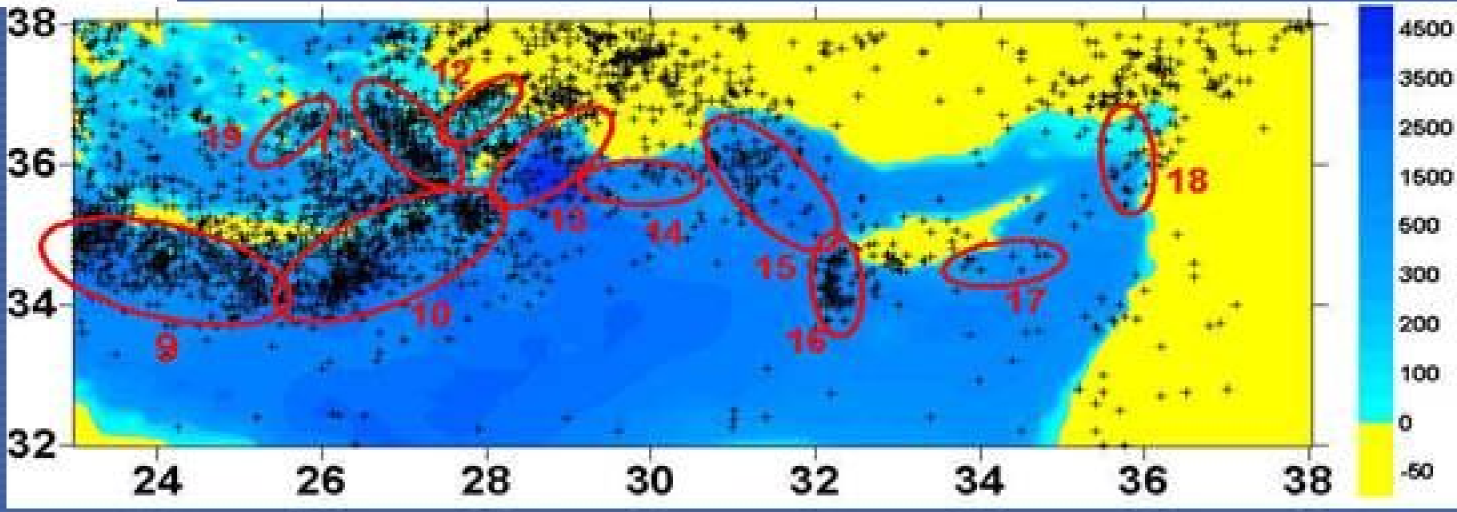
IAEA


DALAMAN
41
39
38
37
36
35
21
22
23
24
25
27
28
29


37.00
36.50
36.00
35.50
27.00
27.50
28.00
28.50
29.00
29.50

IAEA





- ✓ 4000 years earthquakes
- ✓ 100 years measurements
- ✓ Historical data

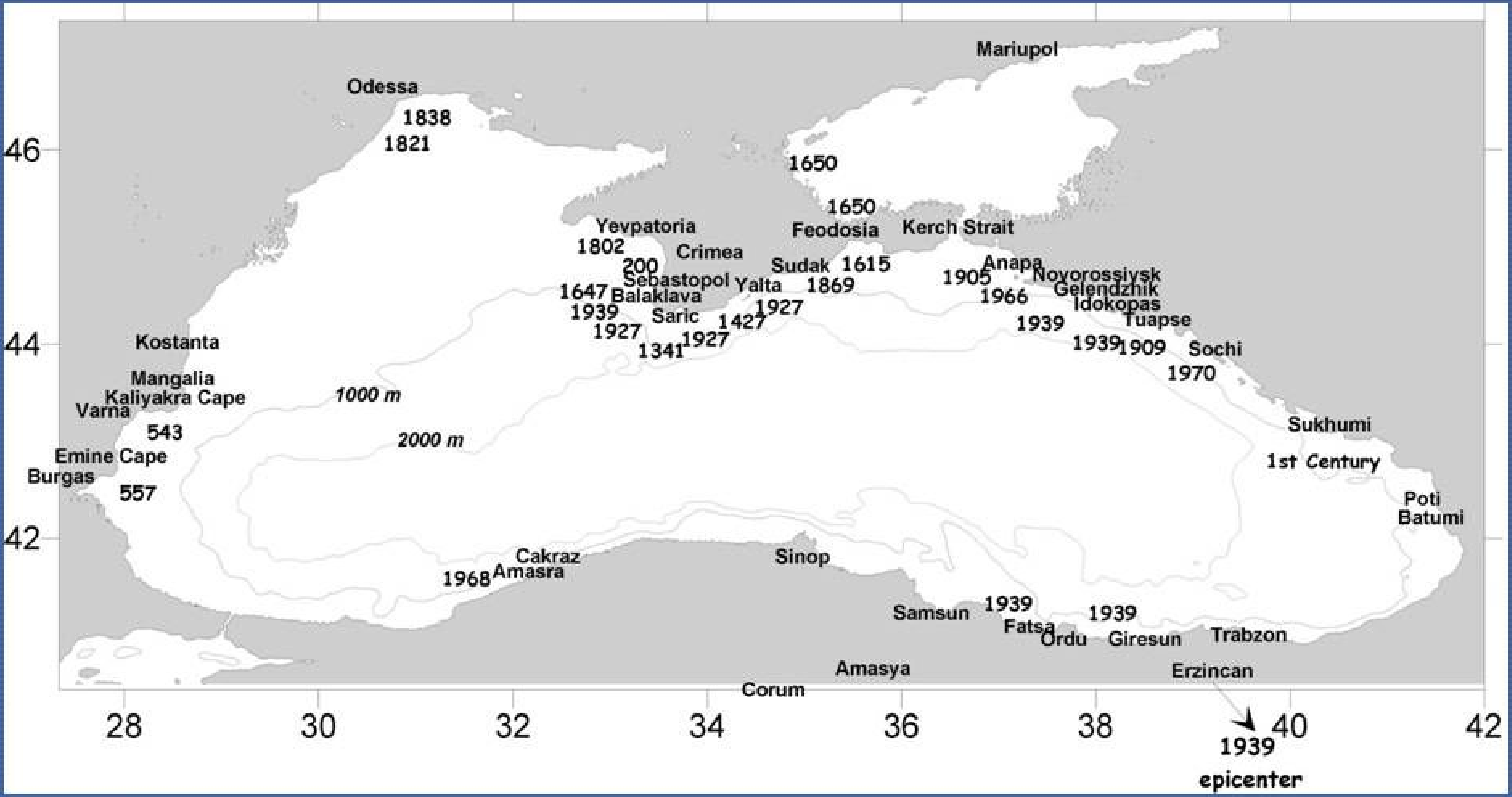
IAEA

Orta Doğu Teknik Üniversitesi,İnşaat Mühendisliği Bölümü
Deniz Mühendisliği Araştırma Merkezi, Ankara TÜRKİYE


Tsunami Scenario in Eastern Mediterranean
0sec.
Pelinovsky, Kurkin, Zaytsev, Yalciner
Animated by NAMI DANCE ver 1.0

IAEA

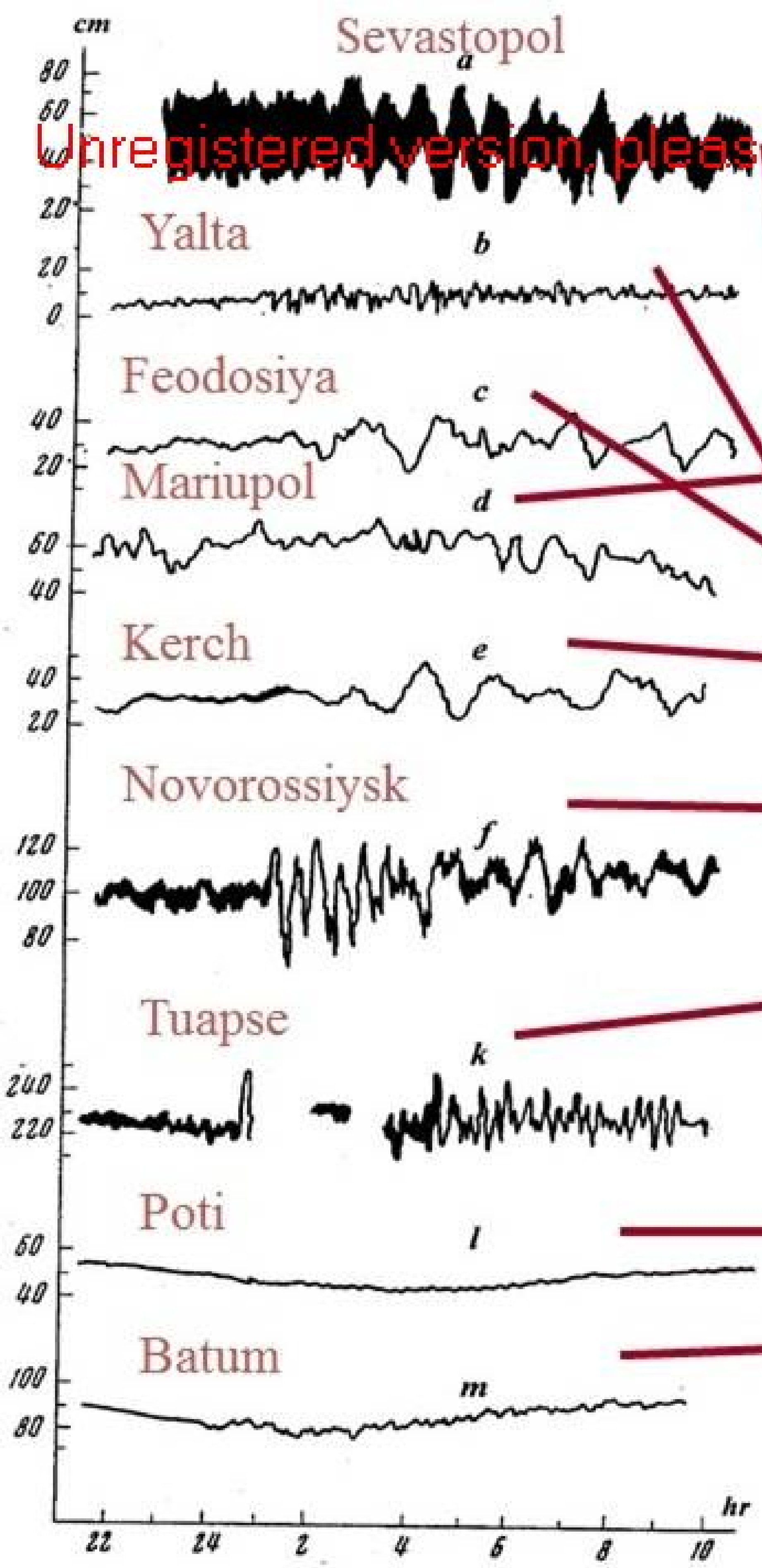
BLACK SEA



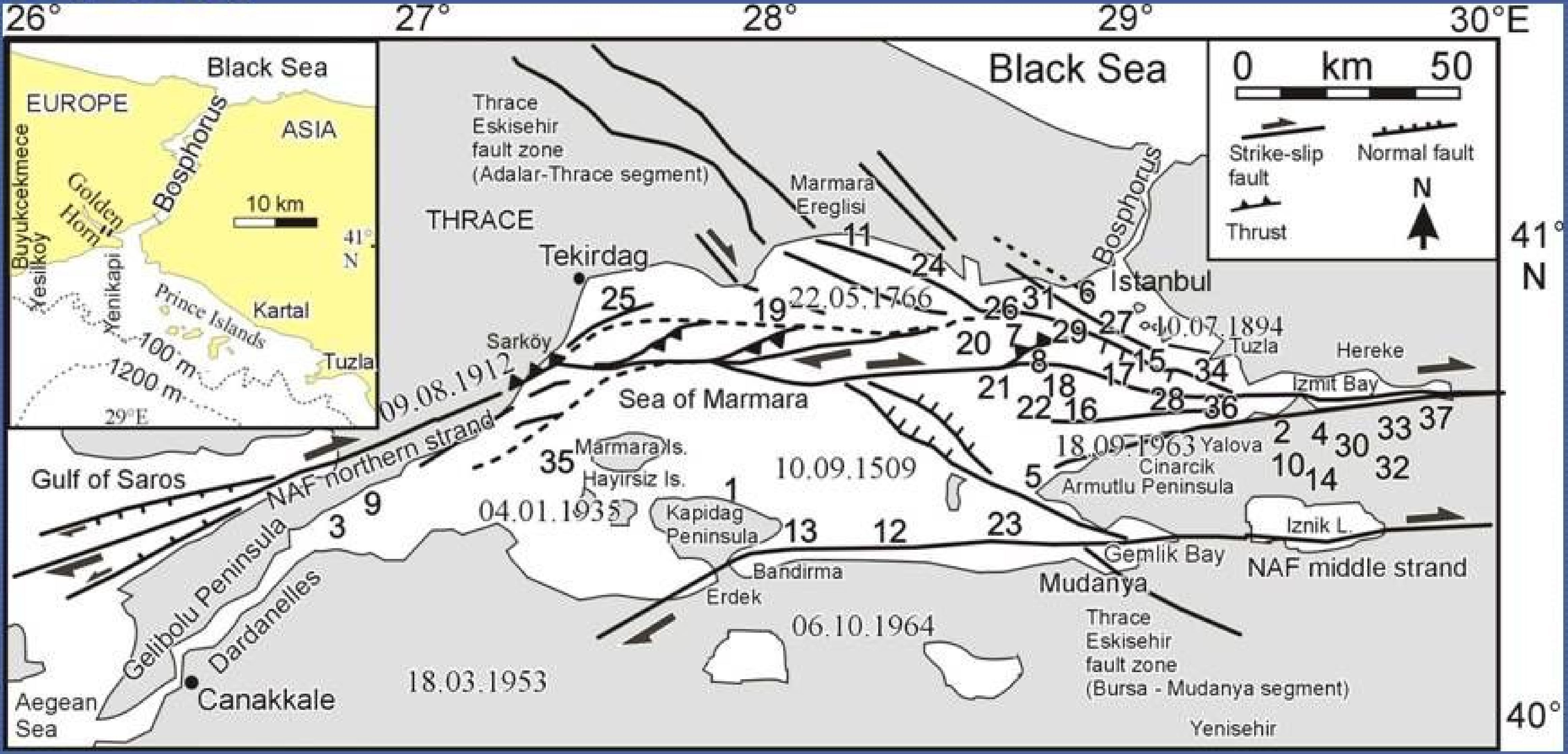
Erzincan, 26 Aralık 1939 Mw = 8 Fatsa, Yalta, Sivastopol,

Novorossiysk…. Richter, (1958)

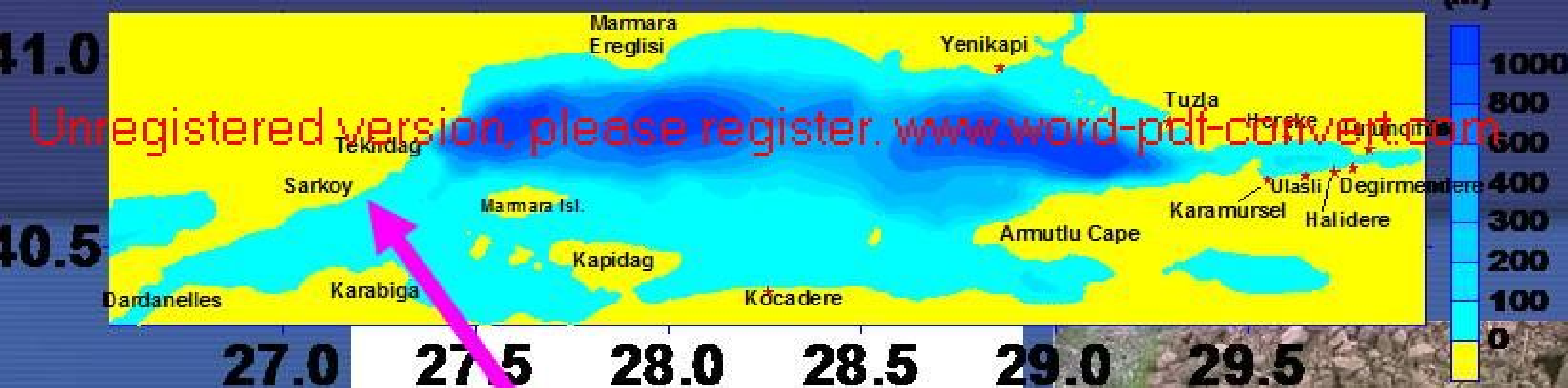
1939 LONG DISTANCE WAVE MOVEMENT



TSUNAMIS IN MEDITERRANEAN IN THE HISTORY



IAEA


Marmara
Ereglisi
Yenikapi
Tuzla
Hereke
Tekirdag
Sarkoy
Marmara Isl.
Ulasli
Degirmendere
Karamursel
Halidere
Armutlu Cape
Kapidag
Dardanelles
Karabiga
Kocadere
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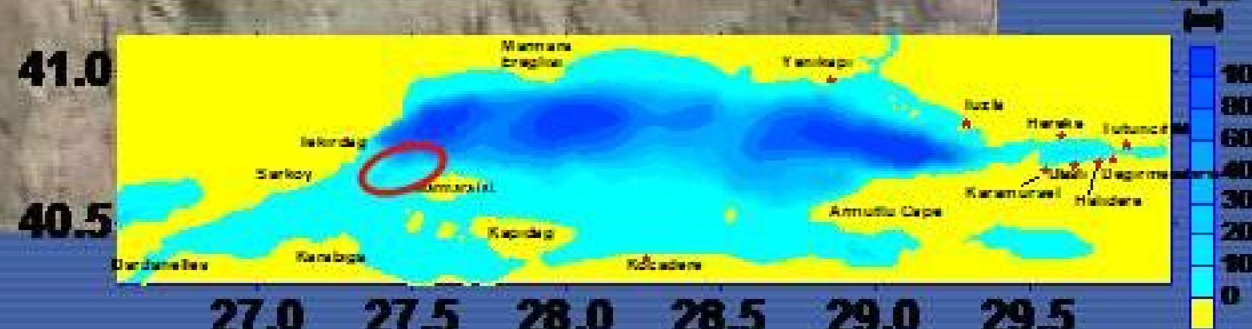
SEA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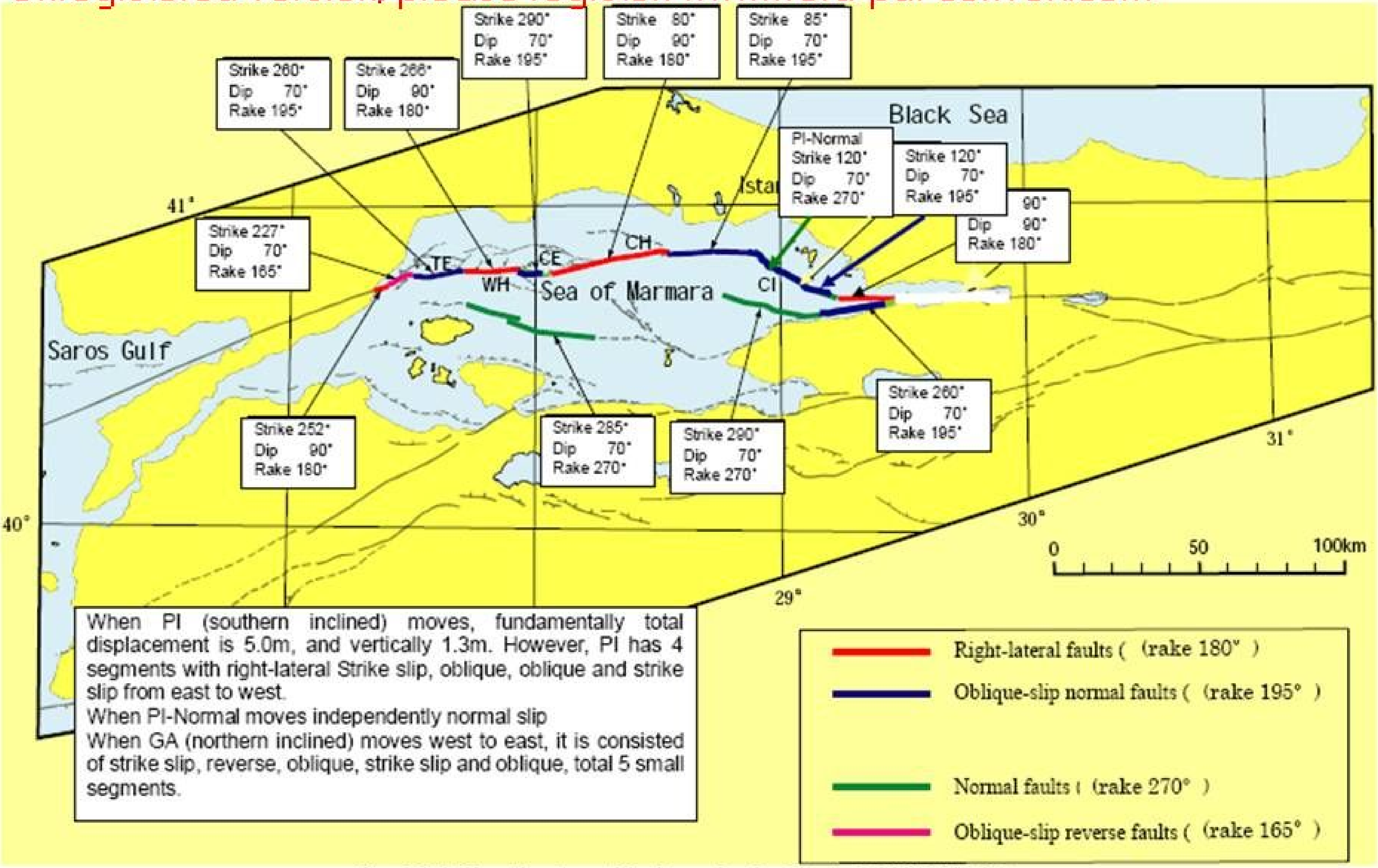
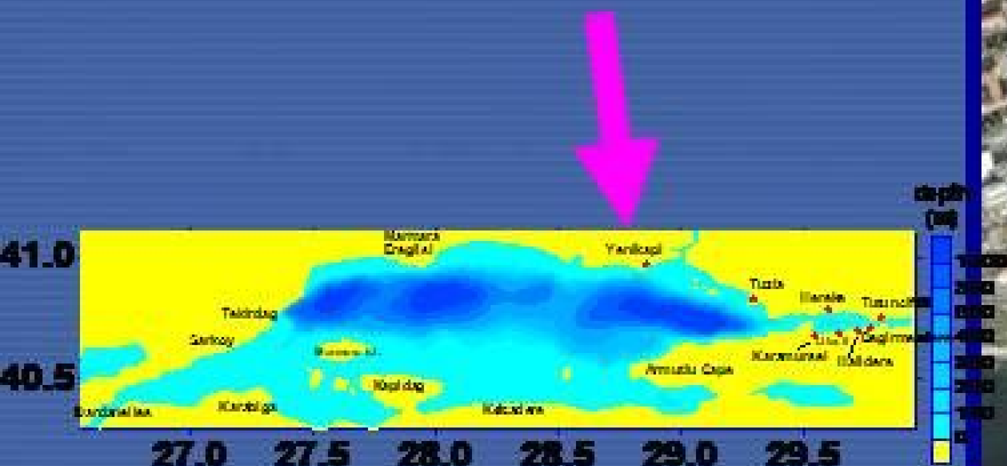


Fig. 5-3-2 Classification of faults and rake (Revised 2007 Feb. 07)

ISTANBUL- Yenikapi



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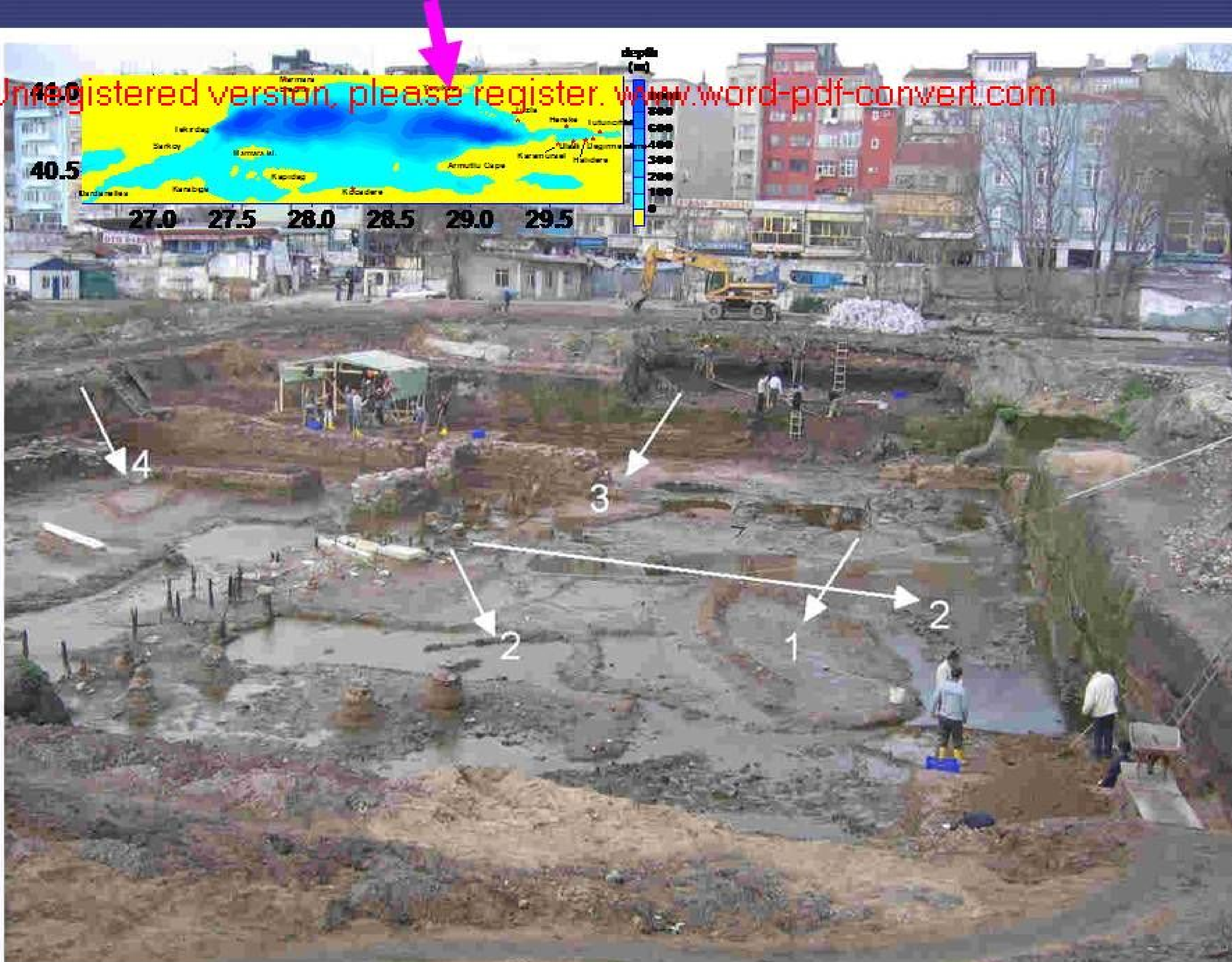
40.5
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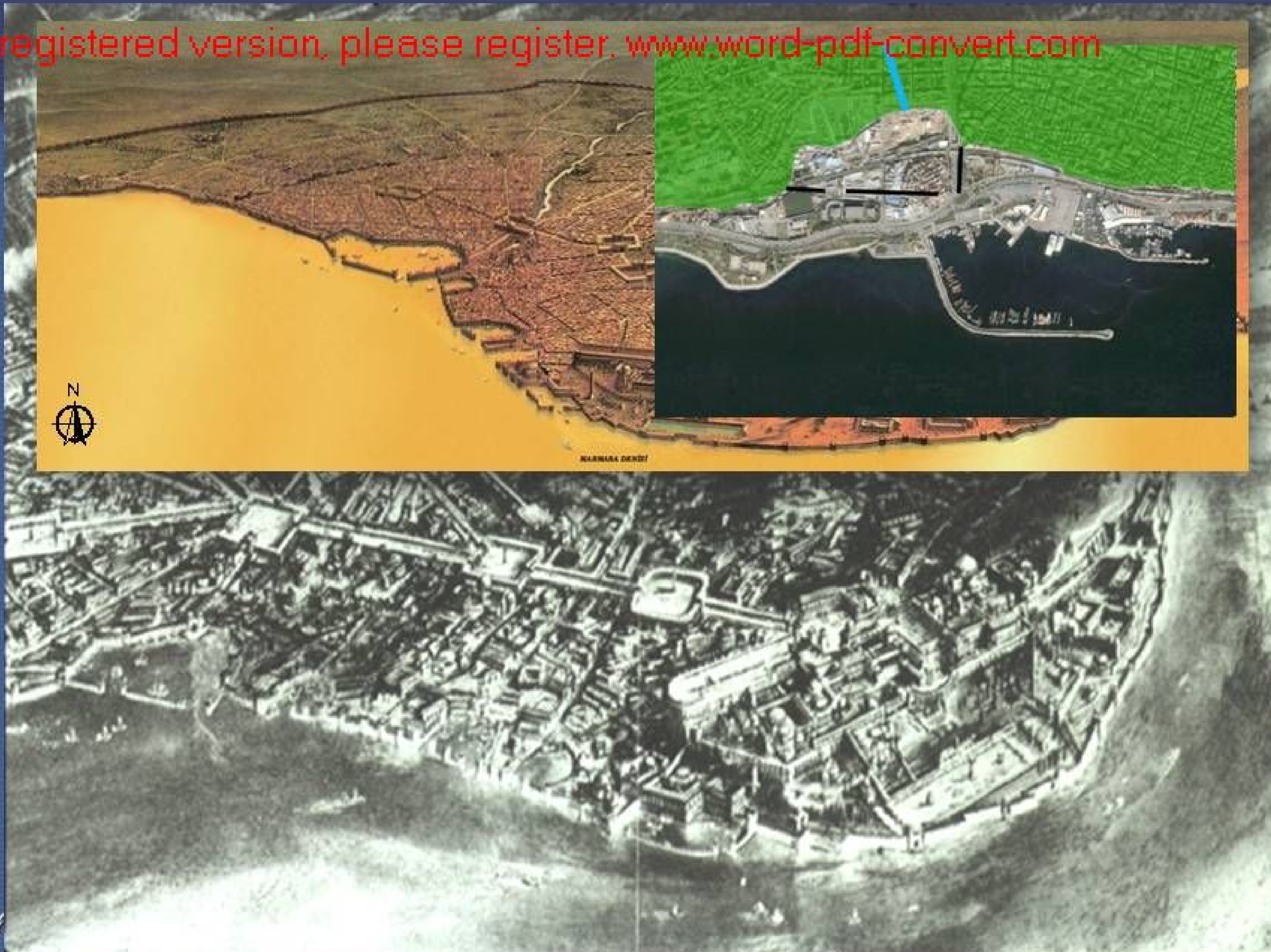
1


989 Tsunami ?
1010 earthquake ?


34 Shipwreck


N
MARMARA DENİZİ


00:00:00
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TSUNAMI HAZARD ASSESSMENT

- Long narrow bays
- Breakwaters
- Ports
- Aquaculture
- Sea walls
- Structure types (wooden, conrete, RC etc.)
- Structure and street layout
- Rivers
- Low elevation coastal plains
- Preparadness and Mitigation

International Atomic Energy Agency

Thank you for your attention

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yalciner@metu.edu.tr

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Yamada
Otsuchi
Kamaishi
Ofunato
Rikuzentakata
Kesennuma 気仙沼

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Kamaishi
Ofunato
Rikuzentakata
Kesennuma

RIKUZENTAKATA
11 MARCH 2011

Rikuzentakata – 11 March 2011


BBC

SENDAI KIYILARI

11 March 2011

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BBC
LIVE
BREAKING NEWS
NHK WORLD
TSUNAMI HITS

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Rikuzentakata

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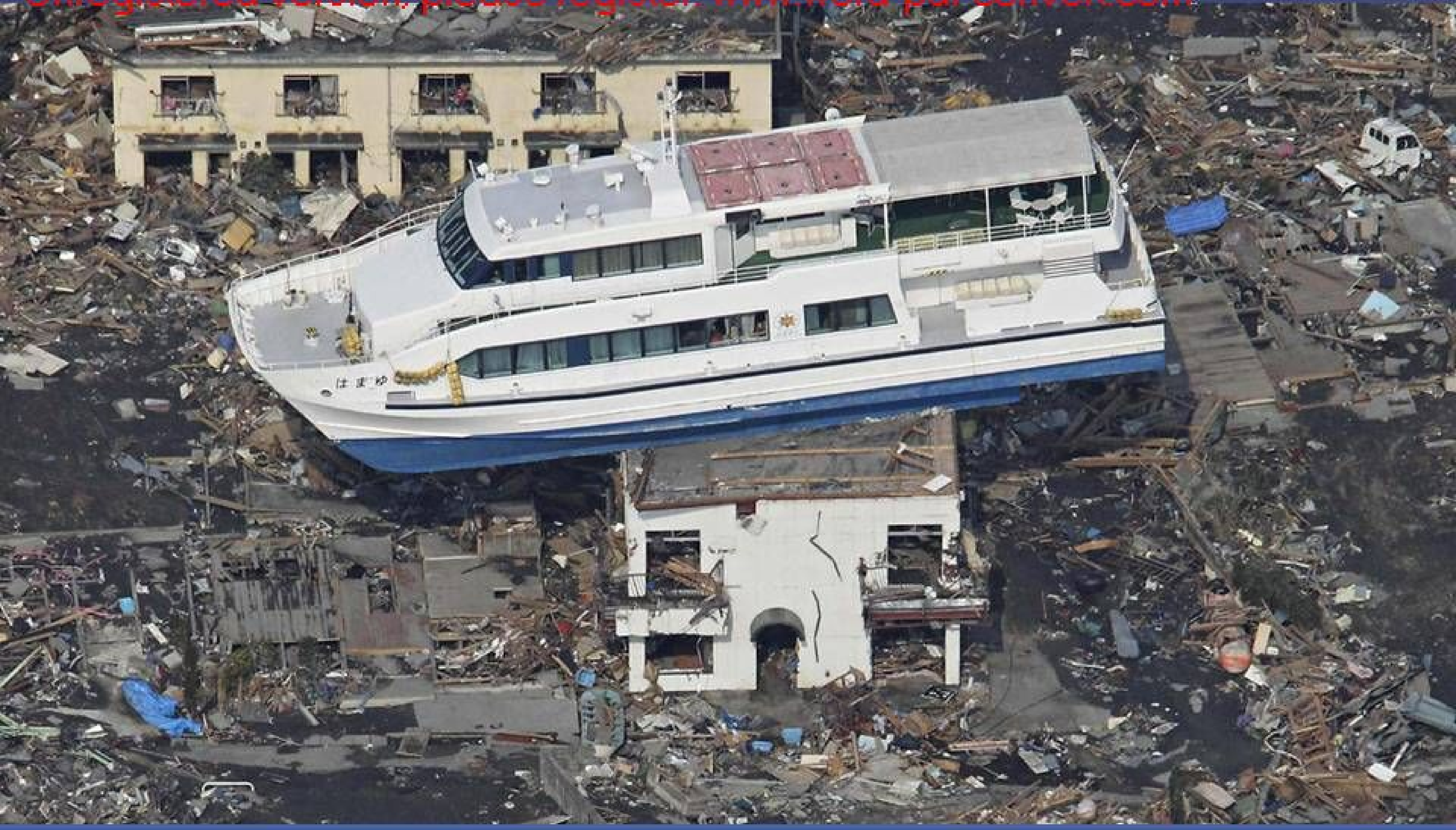
Oganawa



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Otsuchi

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Miyagi

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Sendai Airport

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Sendai

IAEA

Miyako

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Sendai Limanı

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Iwaki

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Miyagi

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Sendai Airport

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Sukagawa

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Natori


ÆON SUPERCENTER
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OTHER REGIONS

Assyrians, Chaldeans, Hebrews, Hittites, Akkadians, Etruscans, Minoans, Mycenaeans, Egyptians, Mesopotamians, Babylonians, Sumerians, Nubians, Persians, Phonecians, Vencians, Genoans, Arabs, Greeks, Romans, Ottomans

Civilizations

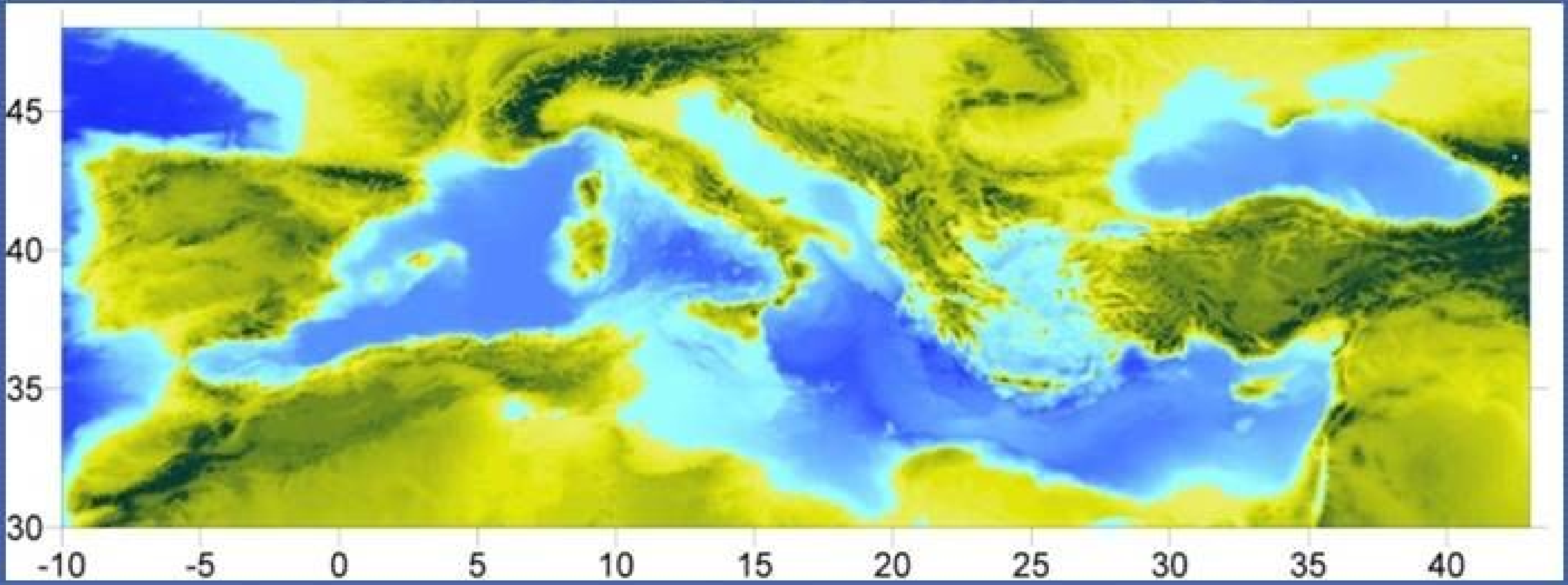
Plato, Socrates, Hammurabi, Aristotle, Alexander, Ceasar, Cleopatra, Augustus

Philosofers

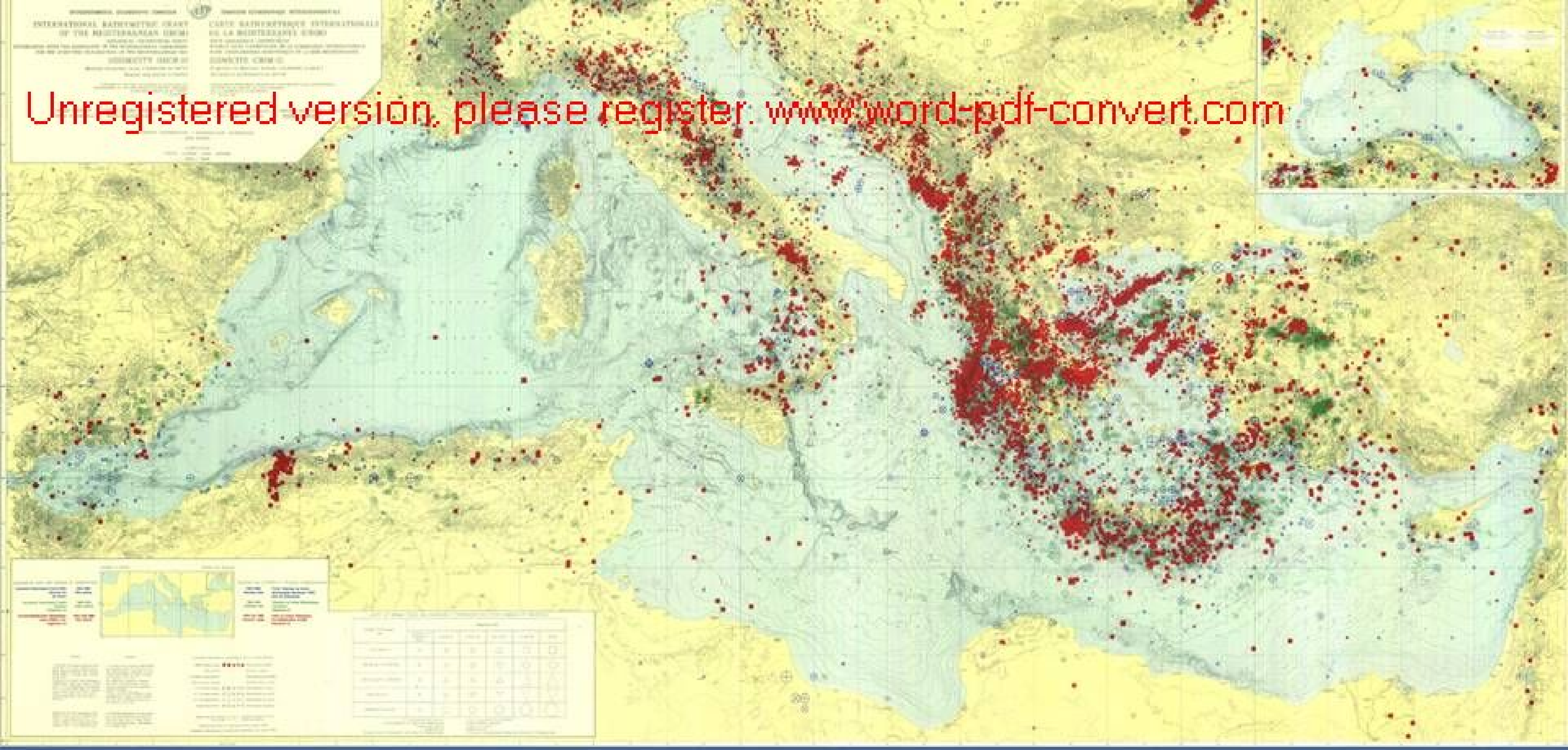
Pharaohs, Emperors, Kings, Queens and Sultans

Governors

WAR AND PEACE, OLIVE, GRAPE, DATE, SUN, BEACH, BREEZE



CULTURE, ARCHAEOLOGY, ART, MUSIC, THEATER, LANGUAGE, PHILOSOPHY, OLYMPICS, POLITICS, DEMOCRACY, HUMANITY



Map from IOC UNESCO

MEDITERRANEAN SEA

E-W 3900 km S-N 1600 km max

4 000 000 km^2

Depth max. 4400 m

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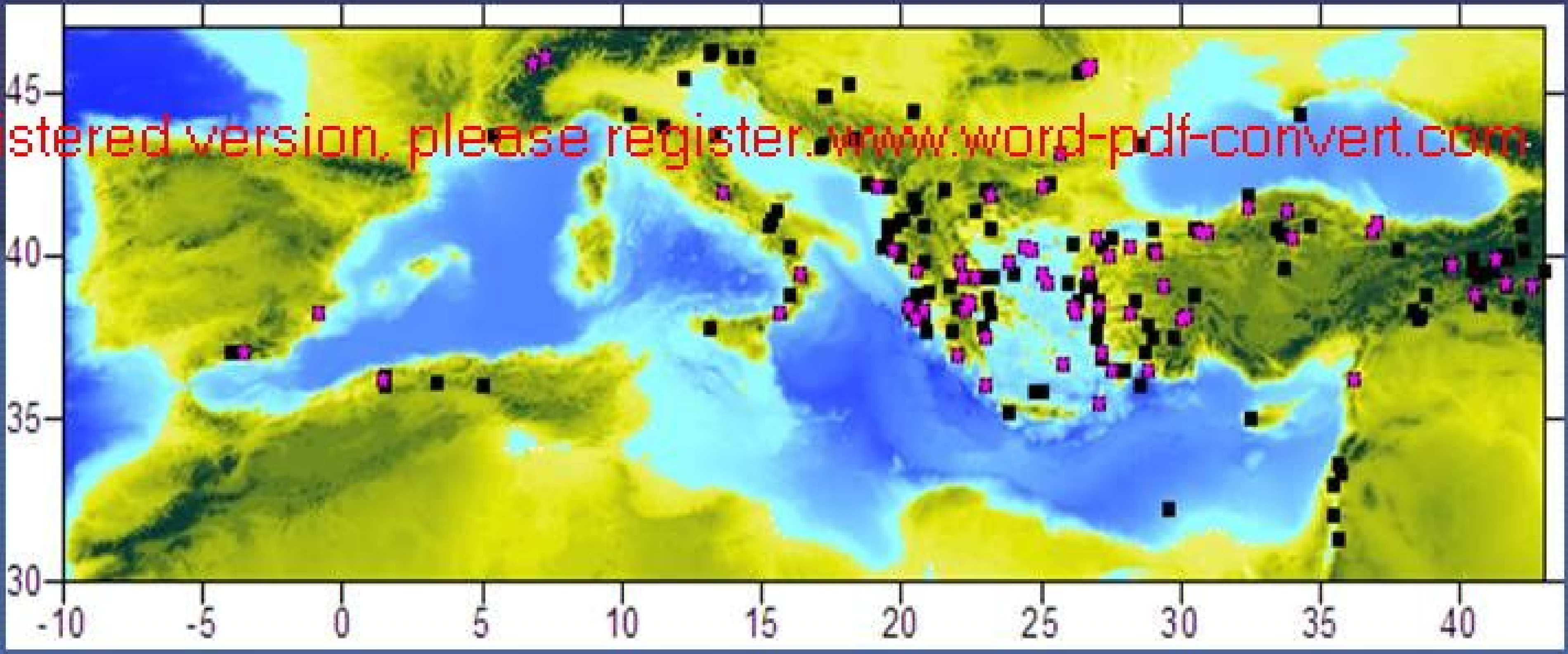
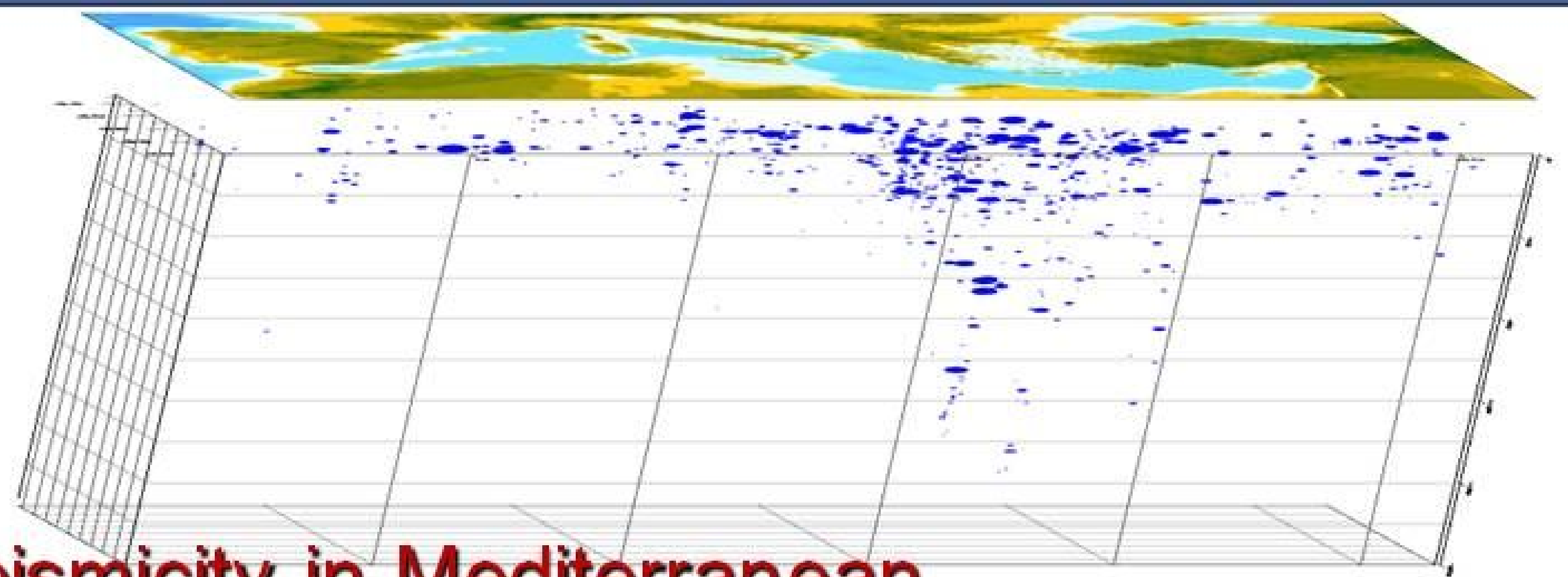


EQ's Since 1610 Mw > 7 7 > Mw >6

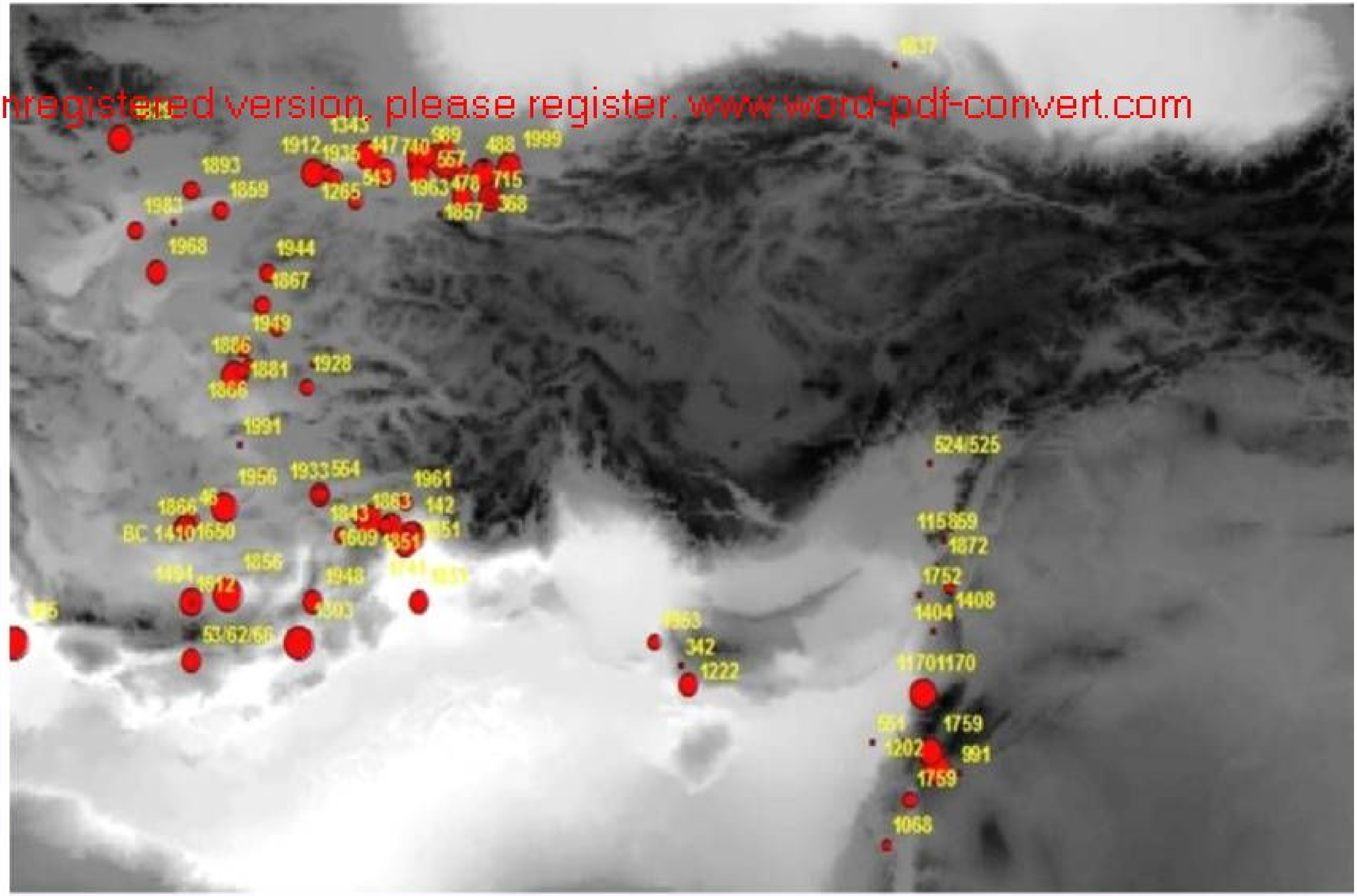


Seismicity in Mediterranean

Data Source, National Earthquake Information Center - NEIC

EARTHQUAKES AND TSUNAMIS IN THE MEDITERRANEAN REGION

- Earthquakes for over 4000 years
- Instrumental seismicity for over 100 years
- Many important cities in the middle east were destroyed by earthquakes



The locations of the tsunami events in the Eastern Mediterranean Sea

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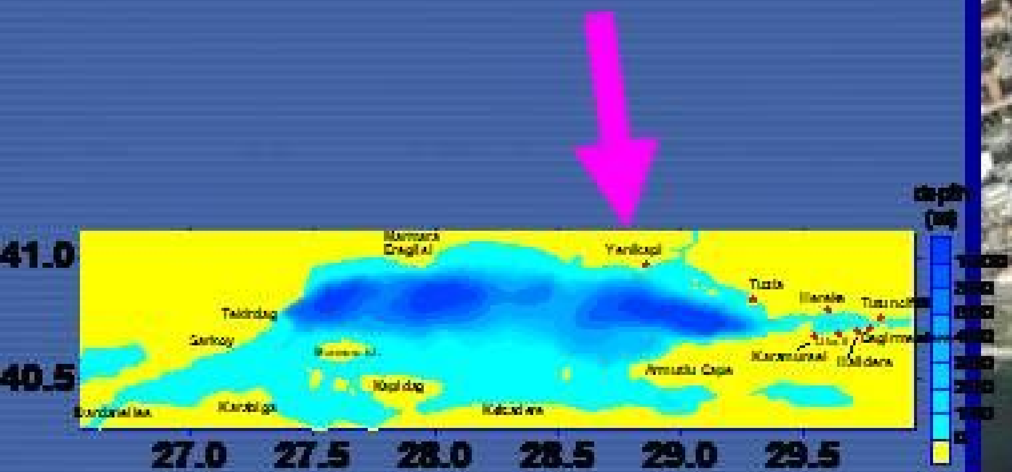

SHIP WRECKS IN THEODOSIUS HARBOR ISTANBUL

IAEA


Constantinople, 330–413
cistern
extent of city under Constantine, 330
extent of city under Theodosius II, 413
Golden Horn
column of the Goths
Greek Acropolis
wall of Theodosius II, 413
wall of Constantine, 330
Lycus
Church of the Holy Apostles
aqueduct of Valens
mese
forum Tauri
column of Constantine
Church of Haghia Eirene
Church of Haghia Sophia
Augusteum
arch of Theodosius
forum Bovis
forum of Arcadius
forum of Constantine
Hippodrome
harbour of Theodosius
Imperial palace
Propontis
Sea of Marmara
N
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100 m
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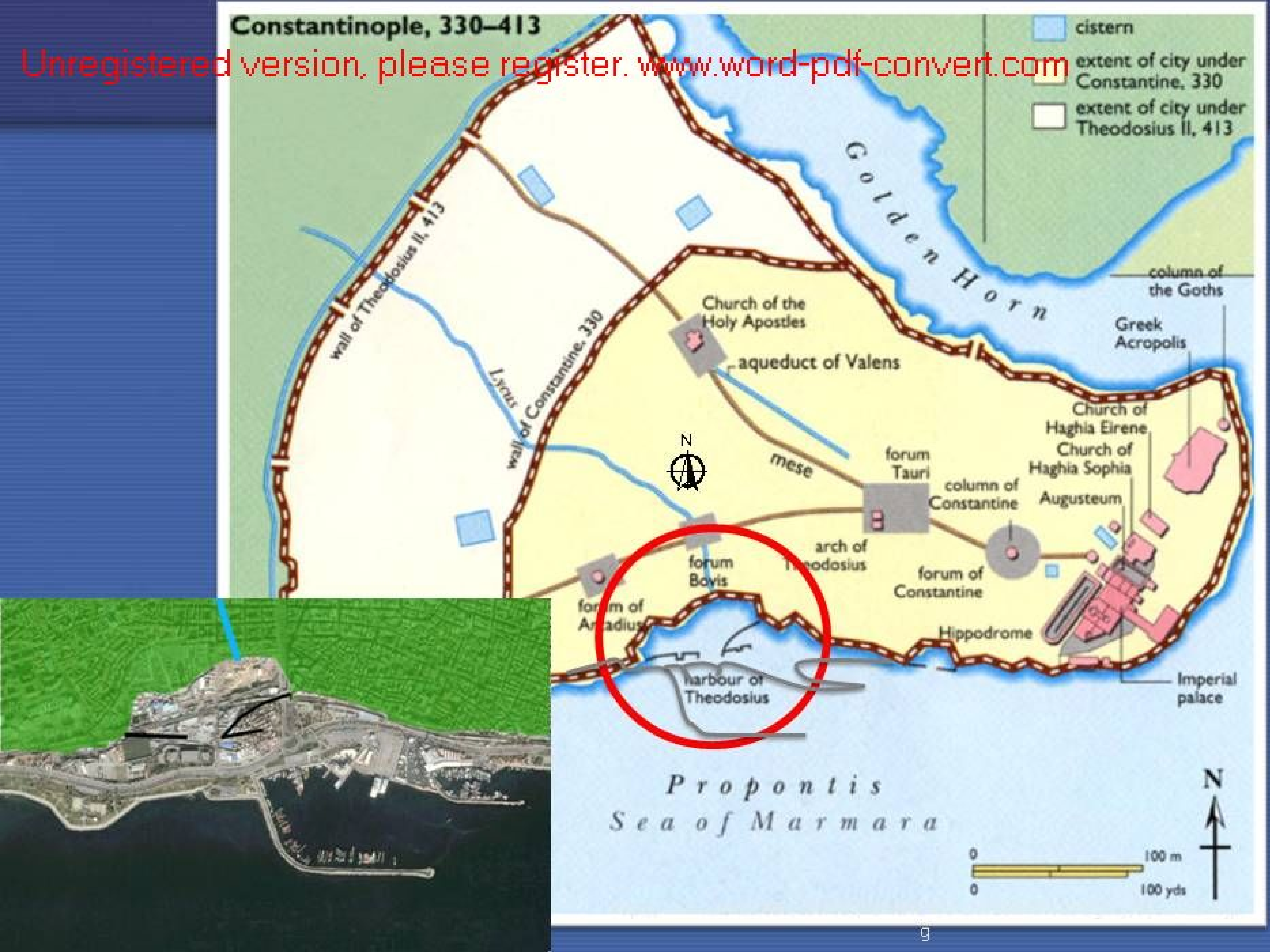
Constantinople, 330–413
cistern
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column of the Goths
Greek Acropolis
Church of the Holy Apostles
aqueduct of Valens
wall of Theodosius II, 413
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Lycus
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Church of Haghia Sophia
Augusteum
arch of Theodosius
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forum of Constantine
forum of Arcadius
Hippodrome
harbour of Theodosius
Imperial palace
Propontis
Sea of Marmara
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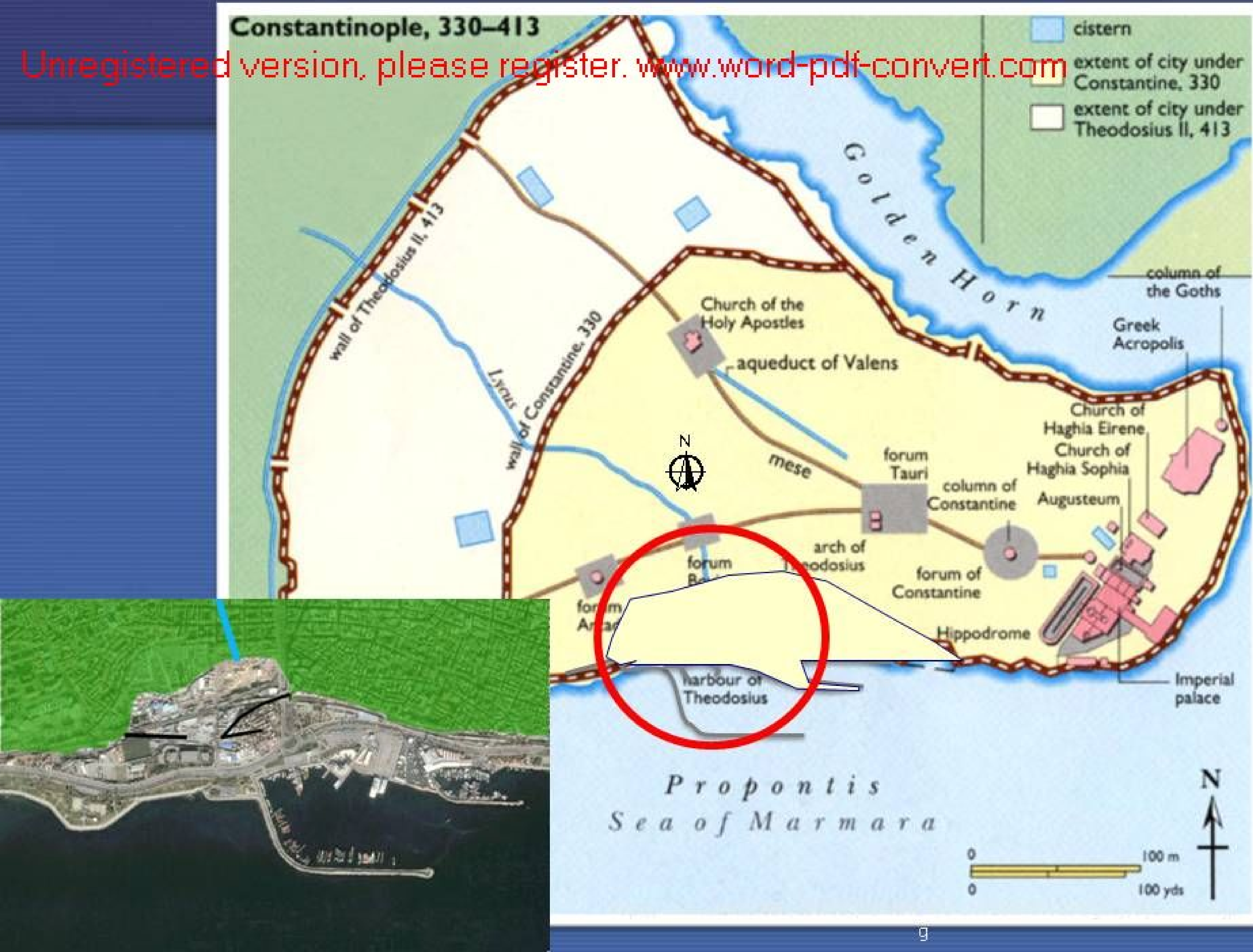
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arch of Theodosius
forum of Constantine
Hippodrome
Imperial palace
harbour of Theodosius
Propontis
Sea of Marmara
0
100 m
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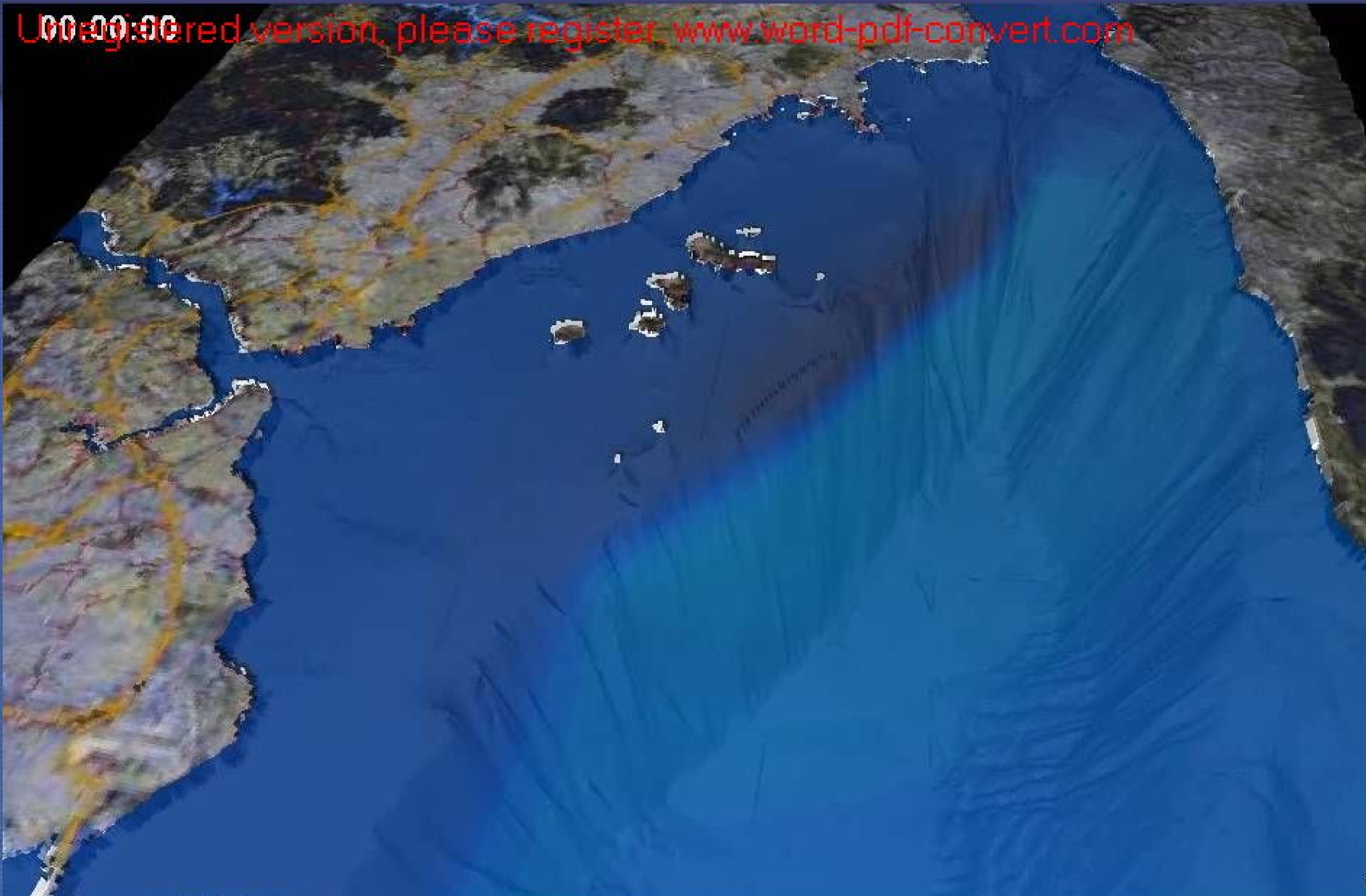
100 yds
N


Year 1000+-20 AD
Prof. Dr. Cemal Pulak
Texas A&M
Was it a storm or a tsunami ?


Piles of harbor structures


Ship wrecks



Tsunami Propagation in Marmara Sea

IN EASTERN MEDITERRANEAN

Since 1498:

90 tsunamis

Since 1610:

67 Earthquakes (Mw > 7)

133 Earthquakes (7>Mw>6)

<u>365 Tsunami</u>

is the strongest known tsunami

in Eastern Mediterranaean

July 21, 365 event

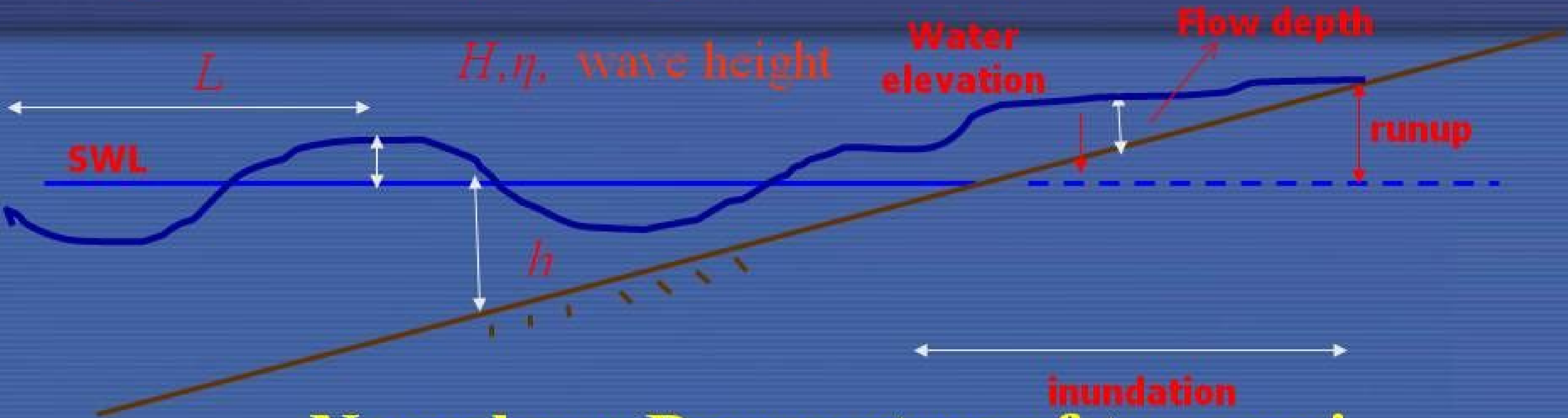
UNDERSTANDING OF TSUNAMIS BY NUMERICAL MODELING

- Mathematical description of the problem with initial and boundary conditions and with proper approximations and assumptions

- Solutions of the governing equations with different techniques

- Simulation

- Analysis



Nearshore Parameters of tsunami

Height	$H = \eta$
Length	L
Local water depth	h
Duration/period	T

Specific Terms:

Run-up: Vertical height a wave reaches above a reference sea level as it washes ashore.

Wave height: Vertical measurement of the wave before it reaches shore.

Flow Depth: Depth of the flow in inundation zone

Inundation distance: Horizontal distance a tsunami reaches landward from shoreline.

UNDERSTANDING OF TSUNAMIS BY NUMERICAL MODELING

- Simulation and Interpretation of computed parameters
- Visualization by computational tools
- Assessment of tsunami impact in inundation zone
- Developing mitigation strategies
- Using them for training and educational purposes

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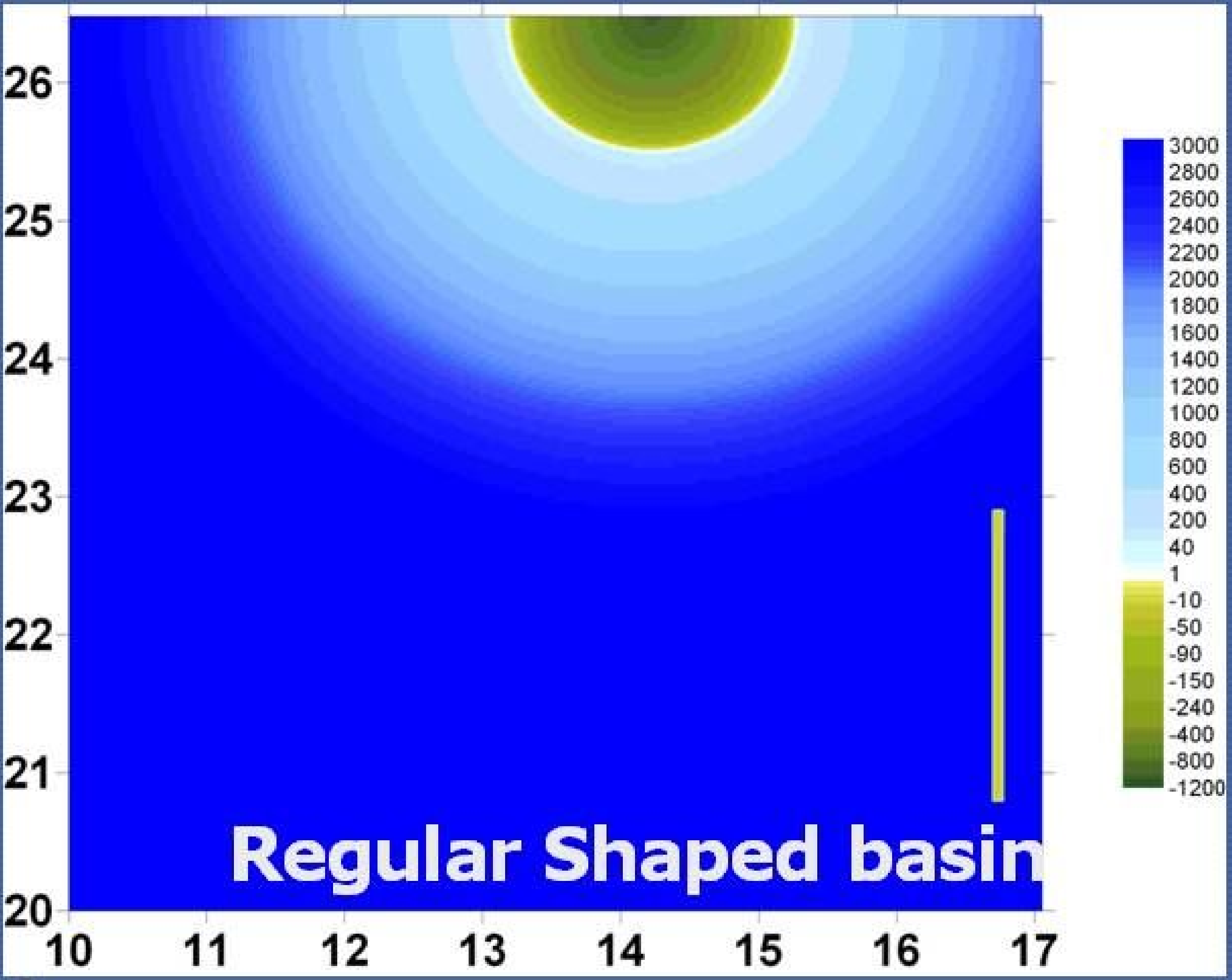
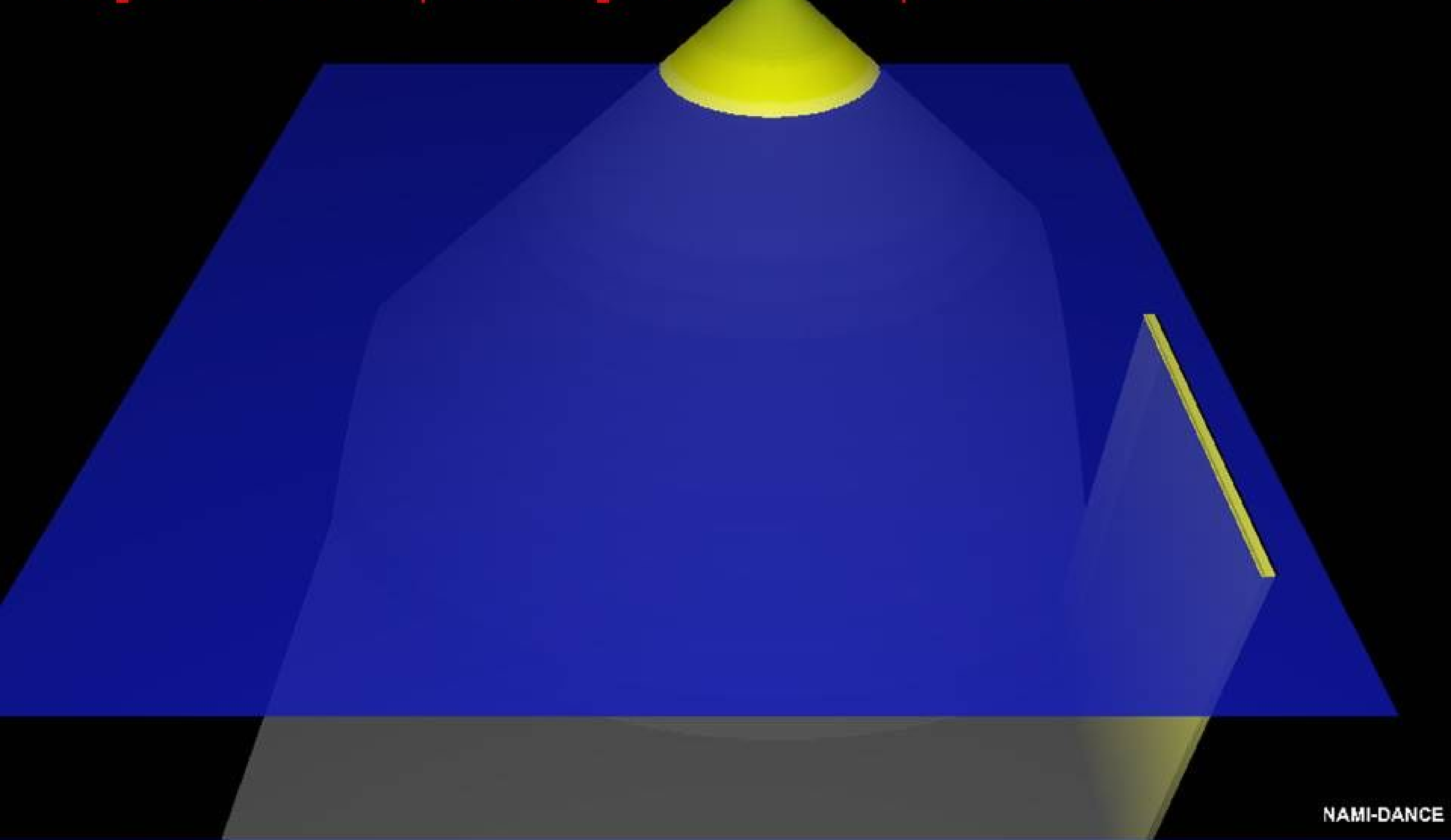
- A model is **scientifically qualified** if it computes the results **accurately**.
- A model is **operationally qualified** if it computes the results **faster.**

HISTORY OF NUMERICAL MODELING

- The TUNAMI code consists of;
- TUNAMI-N1 (Tohoku University's Numerical Analysis Model for Investigation of Near-field Tsunamis, No.1) (linear theory with constant grids),
- TUNAMI-N2 (linear theory in deep sea, shallow-water theory in shallow sea and runup on land with constant grids),
- TUNAMI-N3 (linear theory with varying grids),
- TUNAMI-F1 (linear theory for propagation in the ocean in the spherical co-ordinates) and
- TUNAMI-F2 (linear theory for propagation in the ocean and nonlinear theory at coastal waters).
- JNES Code

MODELING EXAMPLE

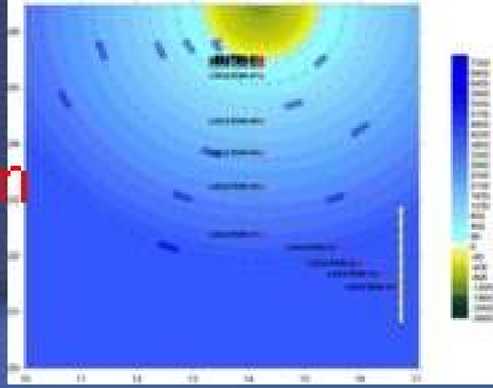


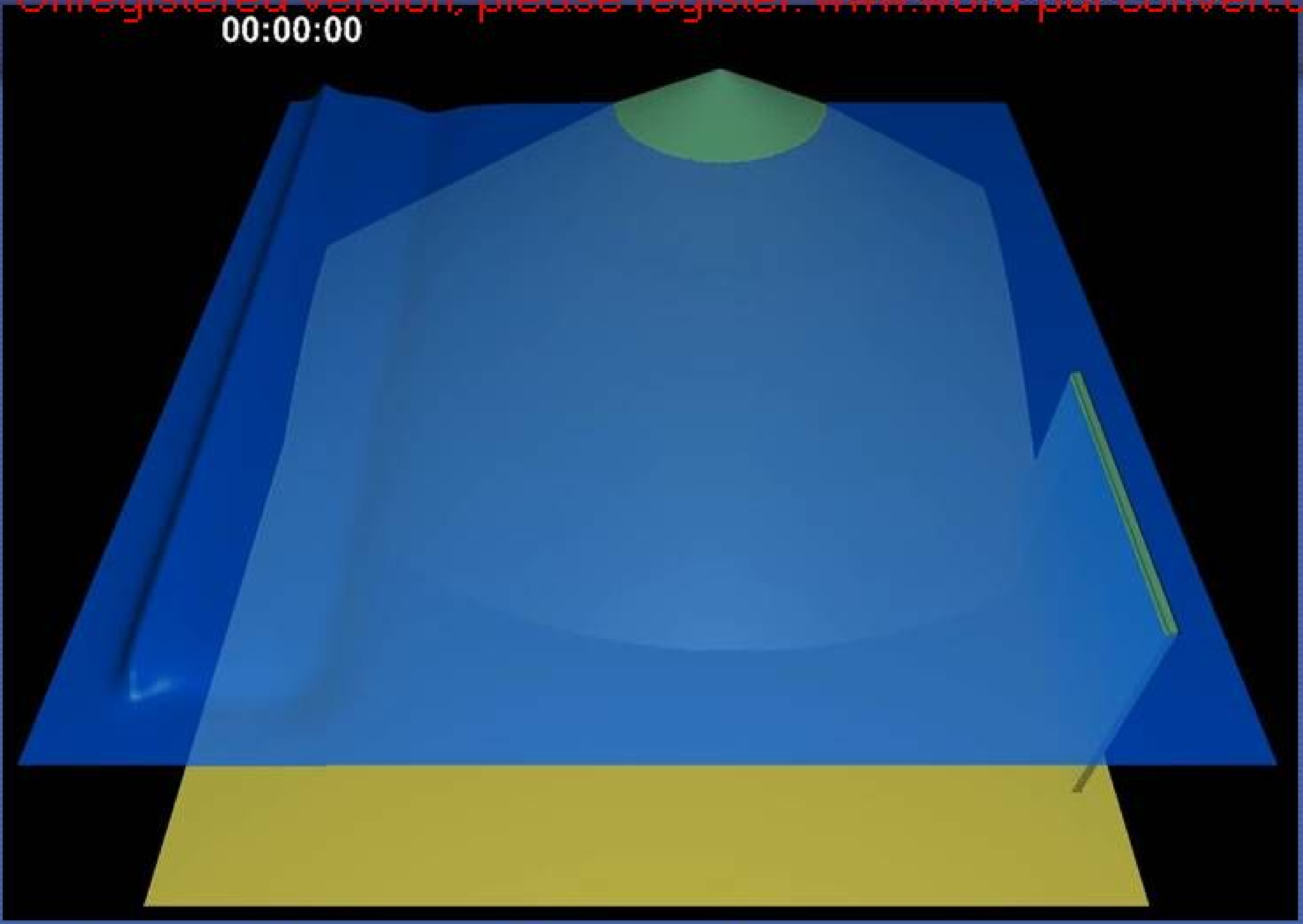


Prof.Dr. Ahmet Cevdet Yalciner
Middle East Tecnical University,
Department of Civil Engineering, Ocean Engineering Research Center
Phone: +90 312 210 54 38 E-mail: yalciner @metu.edu.tr

METU Department of Civil Engineering
Ocean Engineering Research Center
Ankara Turkey

Split Amplification Transformation





Reflection

Tsunami model

NAMI DANCE

Developed from TUNAMI N2

Generation Propagation

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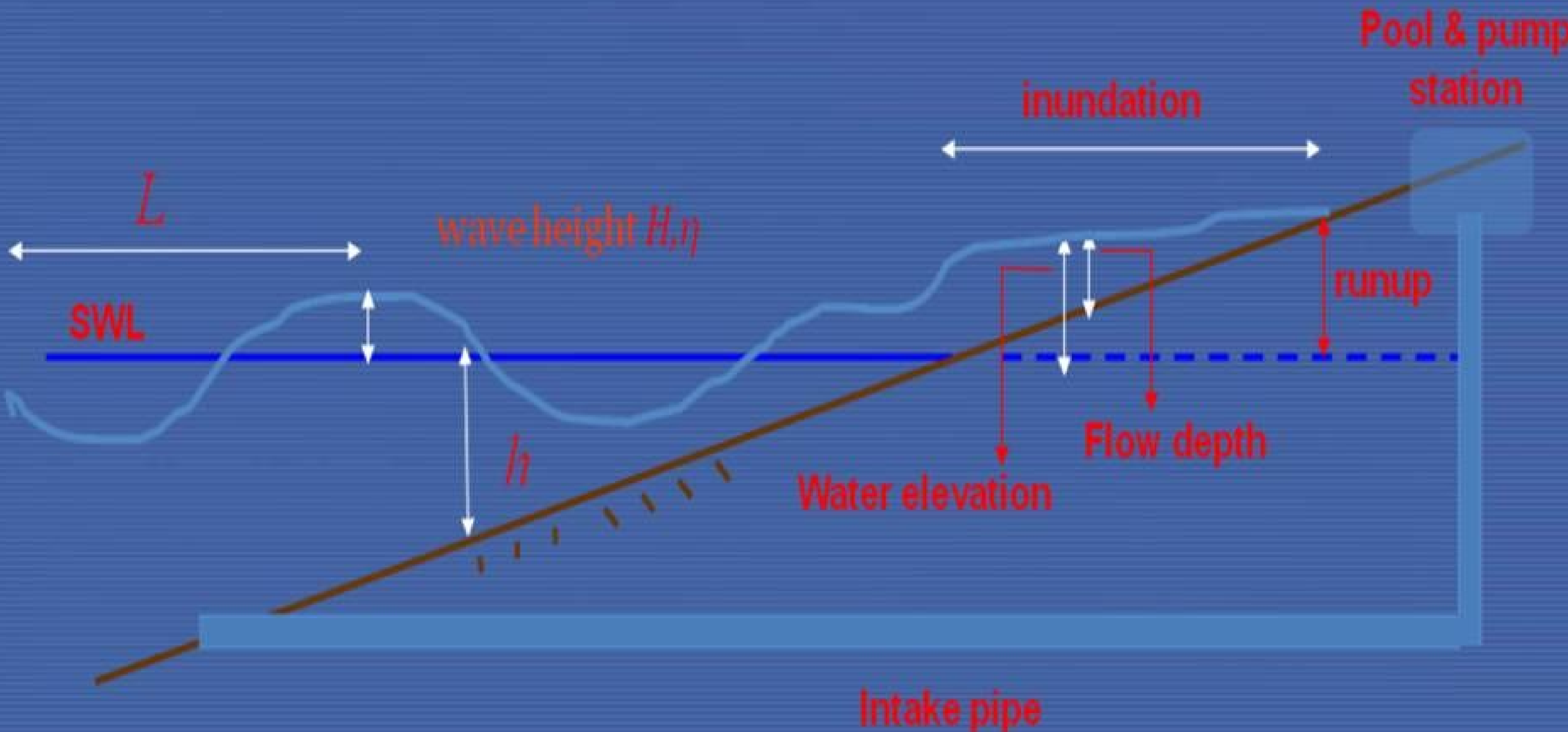
TSUNAMIS AND SENSITIVE STRUCTURES

- Power Plants (Nuclear, Thermal ..)
- Oil Terminals and Pipelines
- Passenger Terminals
- Fishery terminals and Small Craft Harbors
- Commercial Ports
- Waterfront Megacities

TSUNAMIS AND NPP SITES



TSUNAMIS AND NPP SITES

WE CAN NOT AVOID THE NPP FROM THE MARINE AREAS (FROM THE MARINE DISASTERS)

HOW CAN A TSUNAMI EFFECT AN NPP

PENETRATING THROUGH THE INTAKE PIPE AND DAMAGING THE PUMP STATION

DAMAGING THE INTAKE AND DISCHARGE STRUCTURES

DAMAGING THE SHORE PROTECTION STRUCTURES, COASTAL FACILITIES AND OTHER STRUCTURES AT THE SITE

EROSION AND DEPOSITION AT THE NEARSHORE AREA AND PREVENT/DISCONTINUE THE FLOW SYSTEM FROM INTAKE TO DISCHARGE

ASSESSMENT OF TSUNAMIS FROM SOURCE TO TARGET

TSUNAMIS AND NPP SITES

SUMMARY SHEET

HOW CAN A TSUNAMI EFFECT AN NPP

What and where are the tsunami source areas ?
What are the bathymetry topography resolution ?

For each Simulated source FOCUS ON NPP site

What are the arrival times of tsunamis from these sources to NPP ?

What are the level of runup and inundation at NPP sites ?

What are the level of rundown and sea withdrawal at NPP sites ?

What may be the shoreline velocities ?

What may be the level of erosion and deposition at the NPP sites?

HYDRODYNAMIC PARAMETERS

- Tsunami effect in the inundation zone is directly related to
  1) maximum positive amplitude
  2) maximum current velocity
  3) hydrodynamic load
  4) maximum negative amplitude
  5) flow depth

TSUNAMIS EFFECTS IN NPP SITES

Water Level Rise and Fall

Water inundation and damage on vessels at marine facilities

Strong Currents

Damage on vessels at marine facilities

Forces

Damage on the structures

Sea water withdraw and drawdown

Can make the cooling water intake mouth be idle during withdrawal. Hence the cooling system can temporarily be disconnected from the sea.

TSUNAMIS EFFECTS IN NPP SITES

Scouring

Near the structures

Debris and debris flow

Eroded sand, mud and dispatched material are mixed with the water and cause higher density of the flowing water. Hence, the drag and impact force exerted by the tsunami becomes much stronger than expected.

TSUNAMIS EFFECTS IN NPP SITES

Water Level Rise and Fall

Water inundation and damage on vessels at marine facilities

Strong Currents

Damage on vessels at marine facilities

Forces during tsunami

Damage on the structures

Sea water withdraw and drawdown

Can make the cooling water intake mouth be idle during withdrawal. Hence the cooling system can temporarily be disconnected from the sea.

TSUNAMIS EFFECTS IN NPP SITES

Morphological changes (Erosion and Deposition)

Big shear forces at the sea floor cause deposition and erosion. Eroded material is carried out and deposited at the locations where the energy of flow becomes insufficient, such as near marine structures and/or at the location of intake mouth. The unexpected deposition may cause problem of operating the marine utilities, or stuck the intake mouth.

TSUNAMIS EFFECTS IN NPP SITES

Dynamic water pressure

Short time water level change and strong current can cause the additional dynamic pressure at the shallow region. Due to excess dynamic pressure, sea water can more easily penetrate through the intake pipe of NPPs and inundates the pumping station and also damages the electrical control units. The dynamic effect of the water pressure can damage the structure and its components connected to intake pipe.

Resonant oscillations and seiches

Even small tsunamis may trigger resonance and cause seiches inside the enclosed basins.

TSUNAMIS EFFECTS IN NPP SITES

Close collaboration and experience sharing at international level for

JNES-IAEA EBP Activities

- ✓Training Programs
- ✓Expert meetings
- ✓Development of guidelines
- ✓Development of assessment methods
- ✓Development of mitigation strategies

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IAEA SAFETY REPORT ‘ INVESTIGATION & NUMERICAL MODELING ON TSUNAMI HAZARD ASSESSMENT FOR NUCLEAR POWER PLANT SITES

- Ahmet C. Yalciner & Ceren Ozer & Hulya Karakus
- Ocean Engineering Research Center,
- Department of Civil Engineering,
- METU, Ankara/Turkey

- Presented in Workshop on Tsunami Hazard Assessment and Computer Code Application,
- IAEA-KEPRI, June 23-27, 2008

- And now in the finalization stage

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MEETING AGENDA OF ANTALYA MEETING

1. Feedback from the users on JNES Code for convenience
2. Reporting Format

Comments and feedback on JNES Code

- Small reflection from outer open boundaries
- More powerful post processor
- Better matching of depths at same points in nested domains
- Dispersion, friction, viscosity effects
- Iteration limit control may be necessary
- More user friend interface with graphic support for new users (GUI)
- Improved fault rupture input (segmented and as time dependent)
- Spectral Analysis of the outputs
- More info in the manual
- Transition from global to local coordinates

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DEVELOPMENTS

March 2009 (Antalya Meeting) organized by METu and TAEK

Modeling Issues

- Catalogue and literature survey on the historical tsunamis
- Determination/development of bathymetry/topography data
- Obtaining or developing the land use plan/map of NPP site in GIS
- Determination of the near and far field tsunami sources
- Computing the tsunami source parameters from estimated rupture characteristics and/or landslide characteristics
- Performing test runs and applications to Benchmark Problems
- Determination of study domain(s) for modeling
- Simulation and computation of all necessary tsunami parameters
- Inundation Mapping
- Interpretation of the results
- Plotting, animations and visualizations from source to NPP
- Developing data and specific information for NPP authorities

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DEVELOPMENTS

June 2009 after Antalya Meeting)

Comments and feedback on Modeling

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ACHIEVEMENTS BY JNES AND IAEA

- International collaborations
- The assesment of tsunamis and their possible effects on the sensitive structures
- Developments of Safety Guides for better and safer design of sensitive structures against tsunamis
- Because knowledge is life

GOALS

- Recent technologies
- Innovations
- Design techniques
- Close collaboration
- Safer Structures for better life standards for future of humanity and confidence

ACKNOWLEDGEMENTS

All efforts behind this presentation are supported by

- IAEA
- JNES
- NISA
- NIIT
- TEPCO
- METU
- TAEK
- European Union Project TRANSFER (Tsunami Risk and Strategies for European Region) granted by the CEC, contract n. 037058, FP6-2005-Global-4
- TUBITAK – RFBR Turkey-Russia Joint Research Grant 108Y227
- Istanbul Metropolitan municipality and Fethiye Municipality

International Atomic Energy Agency

Thank you for your attention

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