ΕΦΑΡΜΟΣΜΕΝΗ ΓΕΩΜΟΡΦΟΛΟΓΙΑ - ΧΑΡΤΟΓΡΑΦΗΣΗ

ΤΣΟΥΝΑΜΙ

Ο ΣΕΙΣΜΟΣ ΚΑΙ ΤΟ ΤΣΟΥΝΑΜΙ ΤΟΥ 2004 ΣΤΗΝ ΙΝΔΟΝΗΣΙΑ

ΤΣΟΥΝΑΜΙ

Τα **τσουνάμι** (ιαπωνικά: 津波, tsunami) είναι θαλάσσια φαινόμενα, που δημιουργούνται κατά την απότομη μετατόπιση μεγάλων ποσοτήτων νερού, σε ένα υδάτινο σχηματισμό, όπως ένας ωκεανός, μια θάλασσα,

μια λίμνη ή ένα φιόρδ.

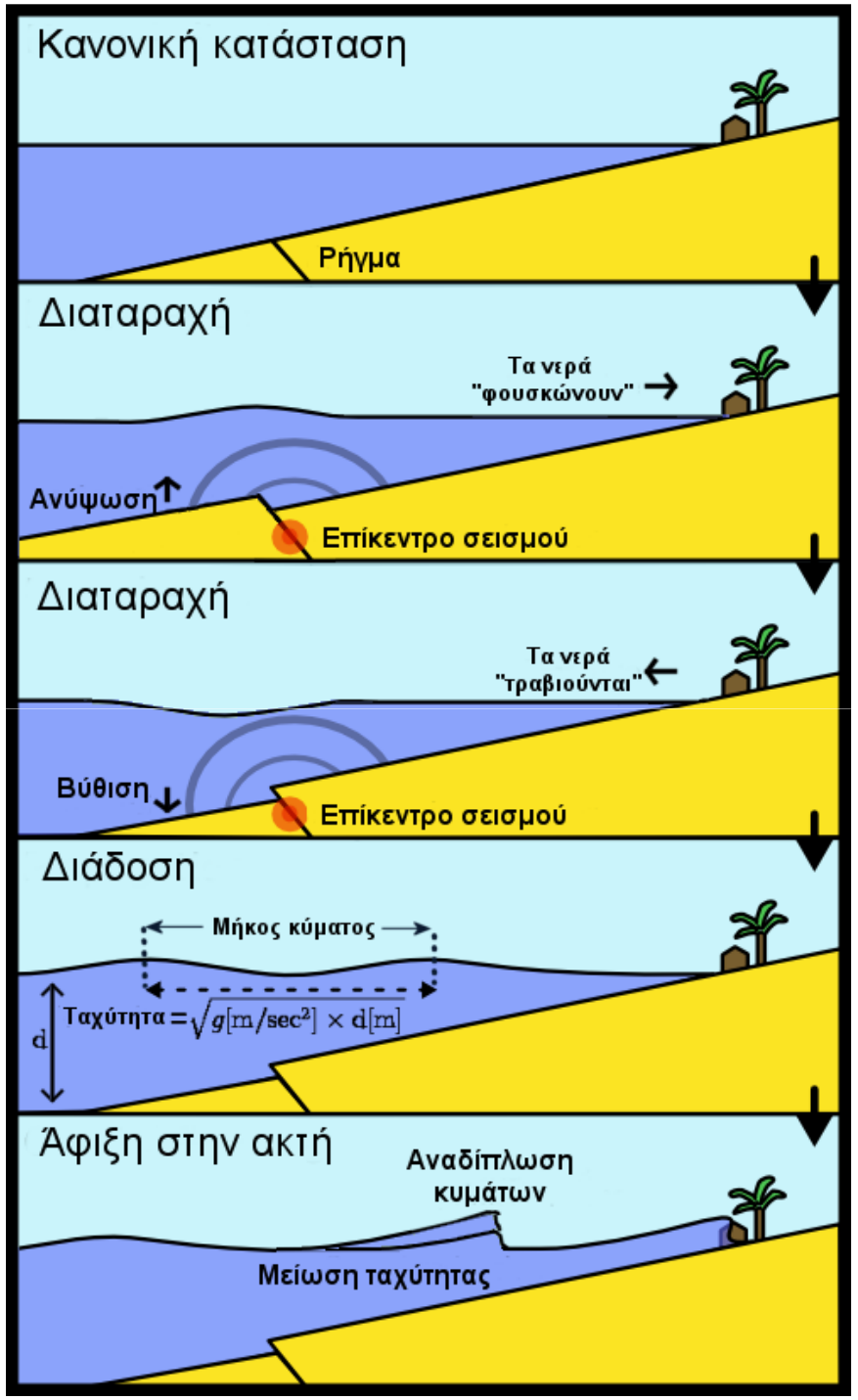
Το τσουνάμι εκδηλώνεται ως κύματα, τα οποία στα βαθιά νερά των ωκεανών (μέσο βάθος 4.500 μέτρα) οδεύουν με μέση ταχύτητα 756 km/ώρα

ΤΣΟΥΝΑΜΙ

Φτάνοντας τα κύματα αυτά σε ρηχά νερά χάνουν την ταχύτητά τους, έως και 20 φορές, αρχικά στο μπροστινό τους μέτωπο, αυτό που φτάνει πρώτο στα ρηχά, και έτσι το μήκος τους μικραίνει, καθώς το πίσω μέρος του κύματος ταξιδεύει ακόμη, με σχετικά μεγαλύτερη ταχύτητα.

Φτάνοντας στις ακτές το κύμα συμπιέζεται και κερδίζει σε ύψος, που είναι και ο λόγος για τον οποίο γίνεται καταστρεπτικό φθάνοντας στις ακτές, αφού το ύψος του διατηρείται και καθώς εισβάλλει στην ενδοχώρα.

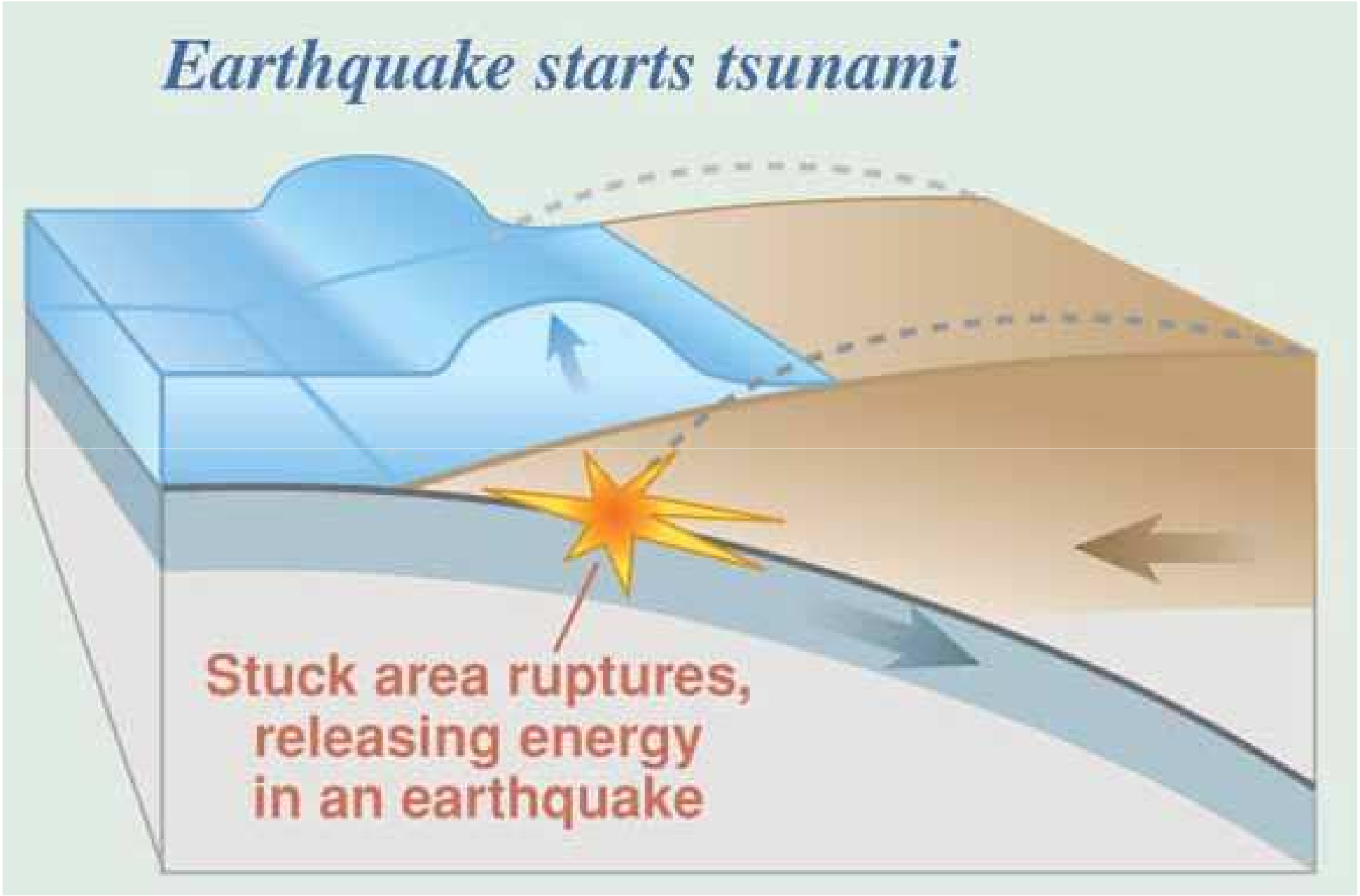
ΤΣΟΥΝΑΜΙ

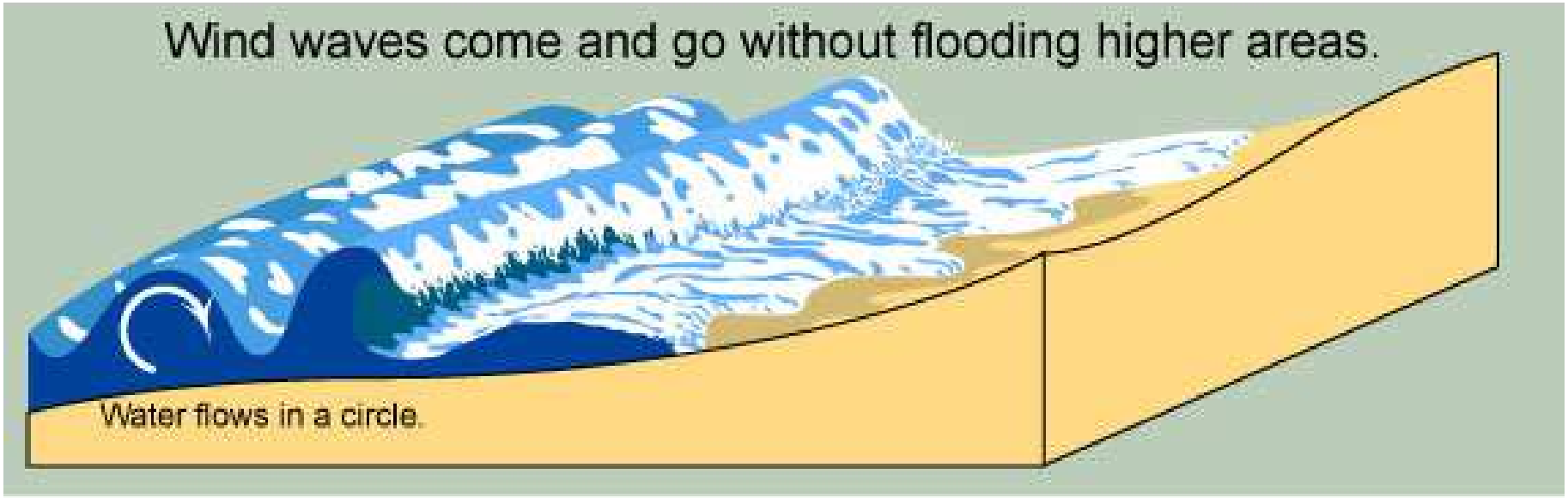

Κανονική κατάσταση
Ρήγμα
Διαταραχή
Τα νερά "φουσκώνουν"
Ανύψωση
Επίκεντρο σεισμού
Διαταραχή
Τα νερά "τραβιούνται"
Βύθιση
Επίκεντρο σεισμού
Διάδοση
Μήκος κύματος
Ταχύτητα = $\sqrt{g[\mathrm{m/sec^2}] \times \mathrm{d[m]}}$
d
Άφιξη στην ακτή
Αναδίπλωση κυμάτων
Μείωση ταχύτητας

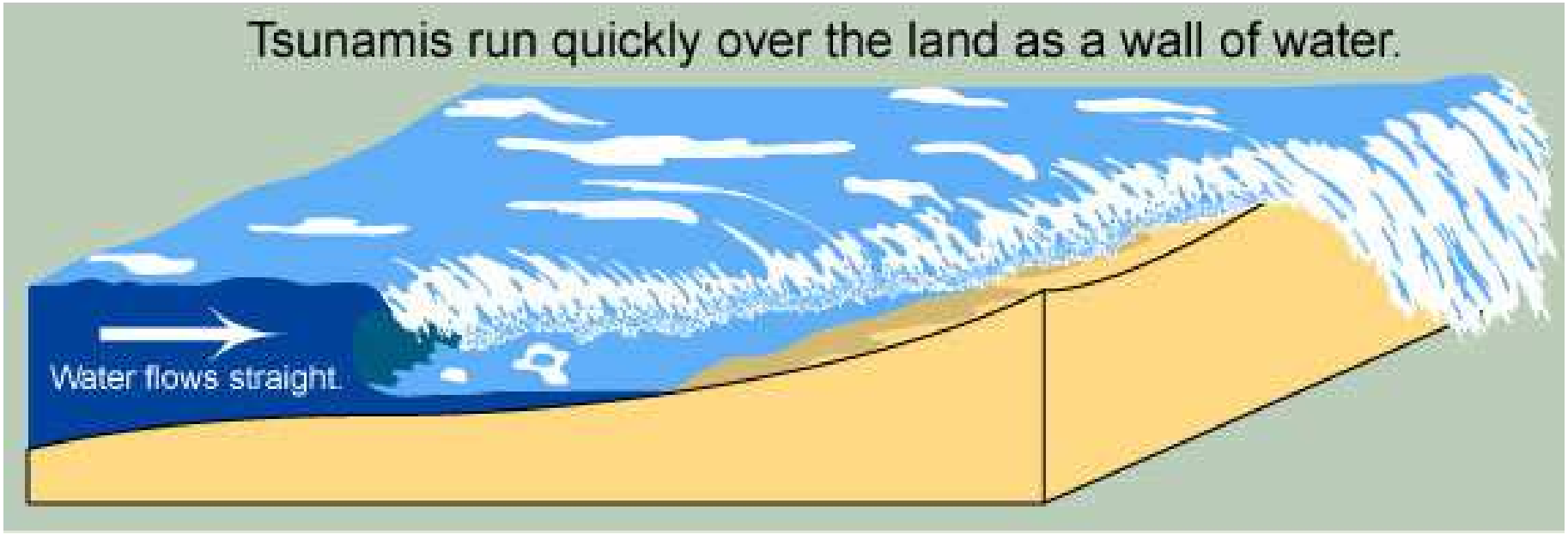
ΤΣΟΥΝΑΜΙ

Η αρχική απότομη μετατόπιση του νερού, που προκαλεί τη γένεση ενός τσουνάμι, μπορεί να είναι αποτέλεσμα σεισμού κυρίως υποθαλάσσιου, που προκαλεί κατακόρυφη ανάταξη του βυθού, παραθαλάσσιας κατάρρευσης βουνοπλαγιάς ή ηφαιστείου υποθαλάσσιας ηφαιστειακής έκρηξης ή κατολίσθησης, καθώς και πτώσης ικανού μεγέθους ουράνιου σώματος στη θάλασσα.

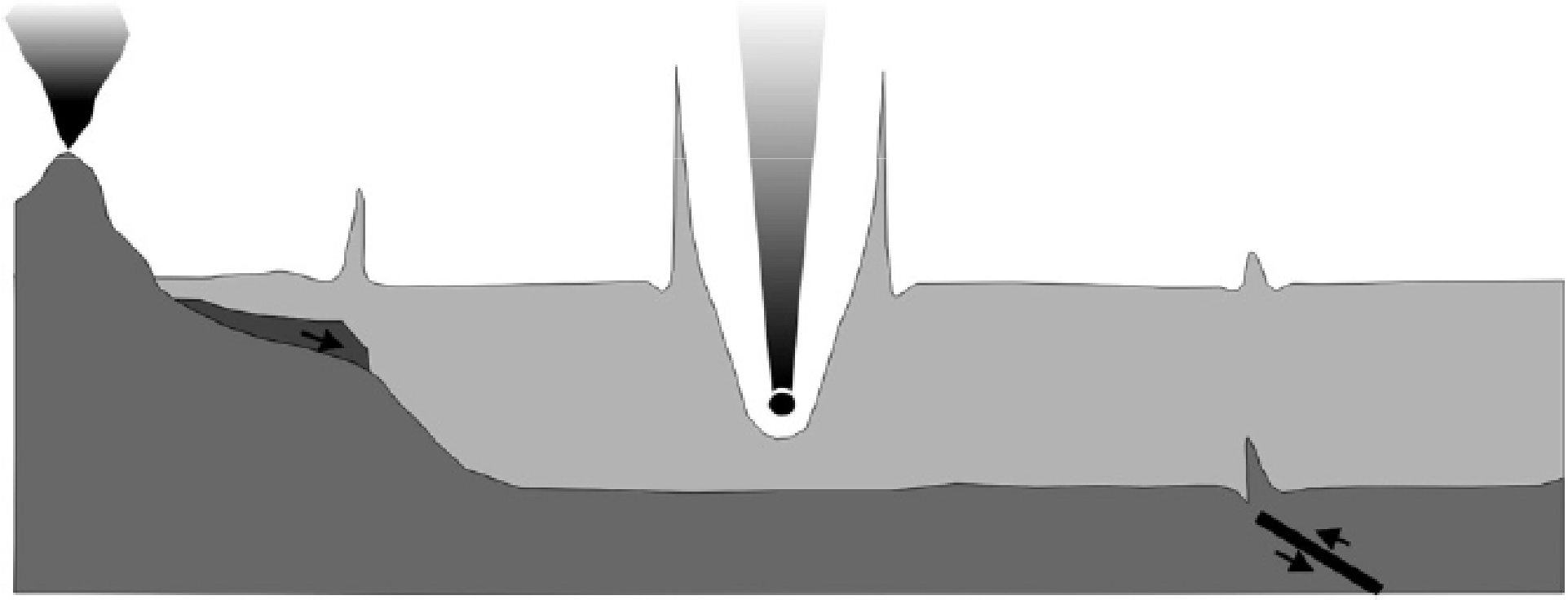
Ενώ σε βαθιά νερά το τσουνάμι, λόγω των χαρακτηριστικών του εκεί, δεν θεωρείται σοβαρός κίνδυνος για τις πλέουσες κατασκευές, φτάνοντας στις ακτές έχει ιδιαίτερα καταστρεπτικές συνέπειες.


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

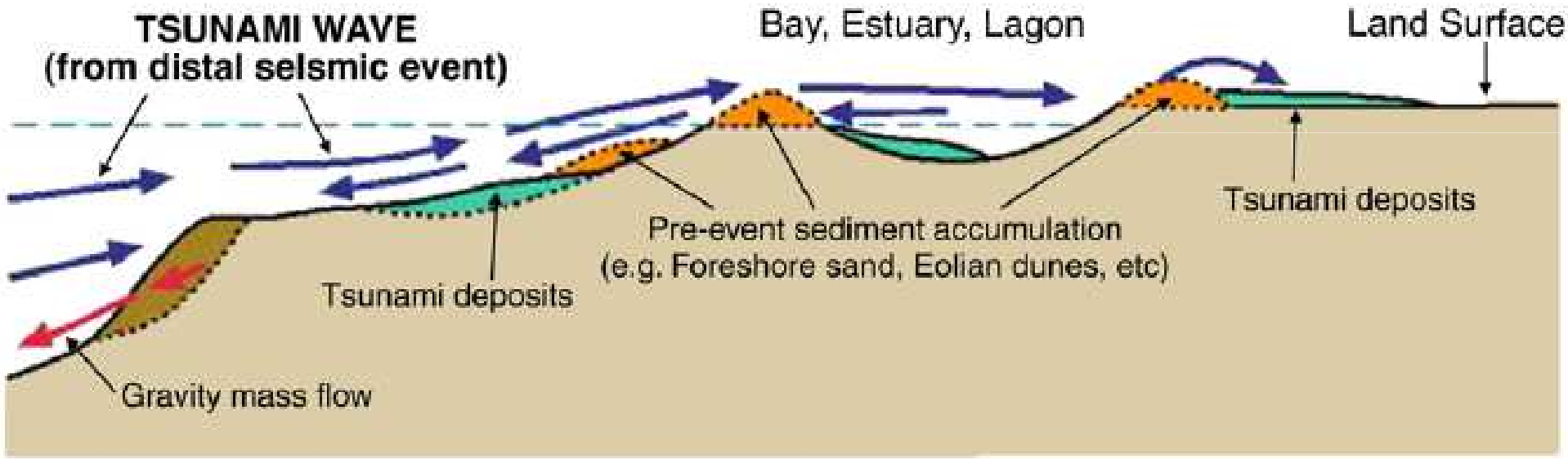

Wind waves come and go without flooding higher areas.
Water flows in a circle.


Tsunamis run quickly over the land as a wall of water.
Water flows straight.

Μηχανισμός δημιουργίας



Μηχανισμός μεταφοράς ιζημάτων



ΑΠΟΘΕΣΕΙΣ ΤΣΟΥΝΑΜΙ

- Αναμόχλευση ιζημάτων και δομές απόσυρσης
- Αποθέσεις τσουνάμι και διείσδυση πλημμυρικών ροών
- Αποθέσεις ογκολίθων

ΣΕΙΣΜΟΣ ΣΟΥΜΑΤΡΑΣ

Μέγεθος: 9.0 R

Ημέρα: Κυριακή,
26 Δεκεμβρίου 2004
Ωρα: 00:58:53 (UTC)
Τοπική ώρα: 7:58:53 AM

Συντεταγμένες:
3.316°N, 95.854°E

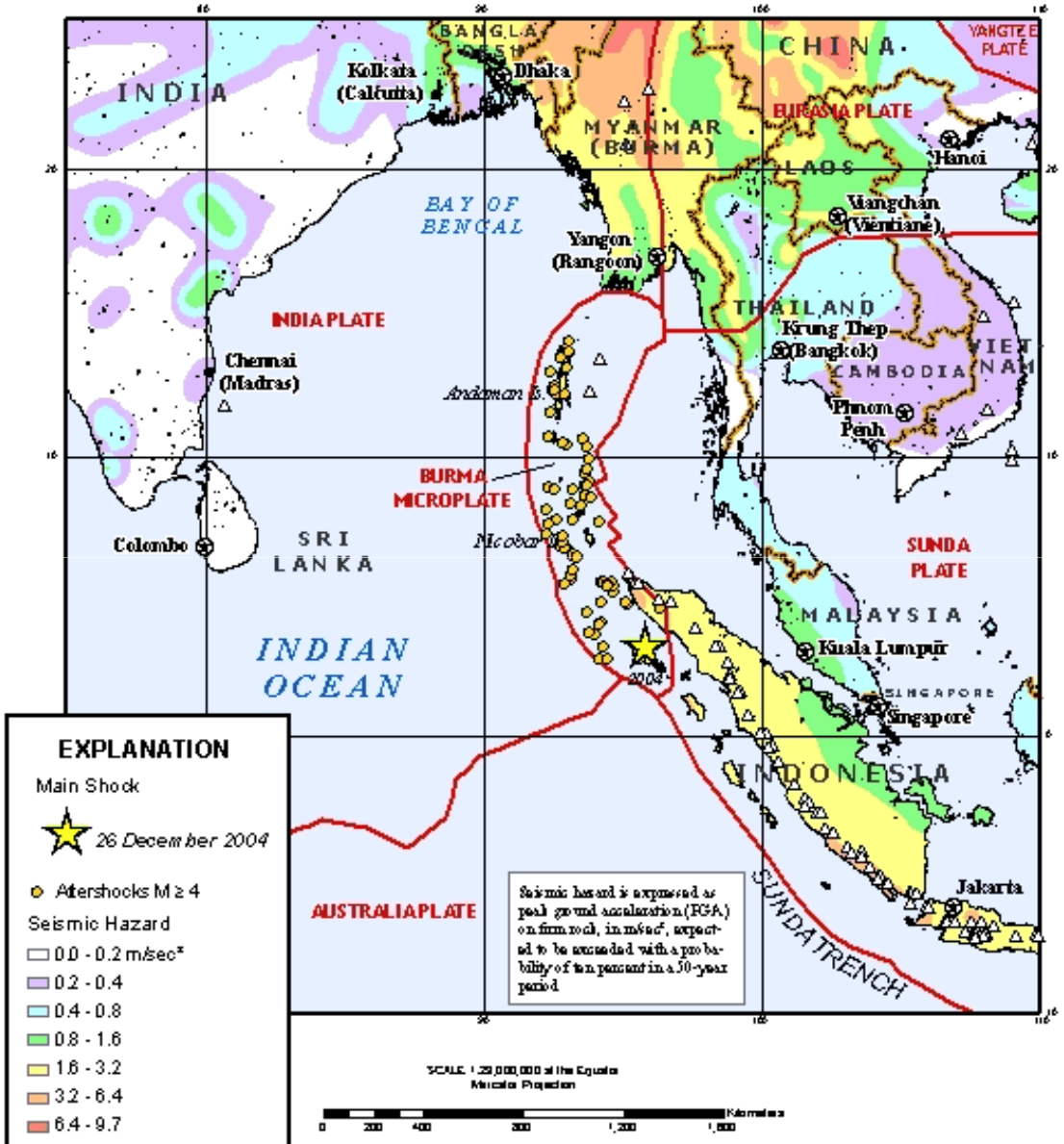
Βάθος εστίας: 30 km

Τεκτονικό καθεστώς

- Βύθιση της Αυστραλο-ινδικής πλάκας κάτω από την πλάκα της ΝΑ Ασίας 55-60 mm/yr

Northeast Indian Ocean Region
Seismicity 1900 - 2002, M ≥ 6

Northeast Indian Ocean Region
Generalized Seismic Hazard

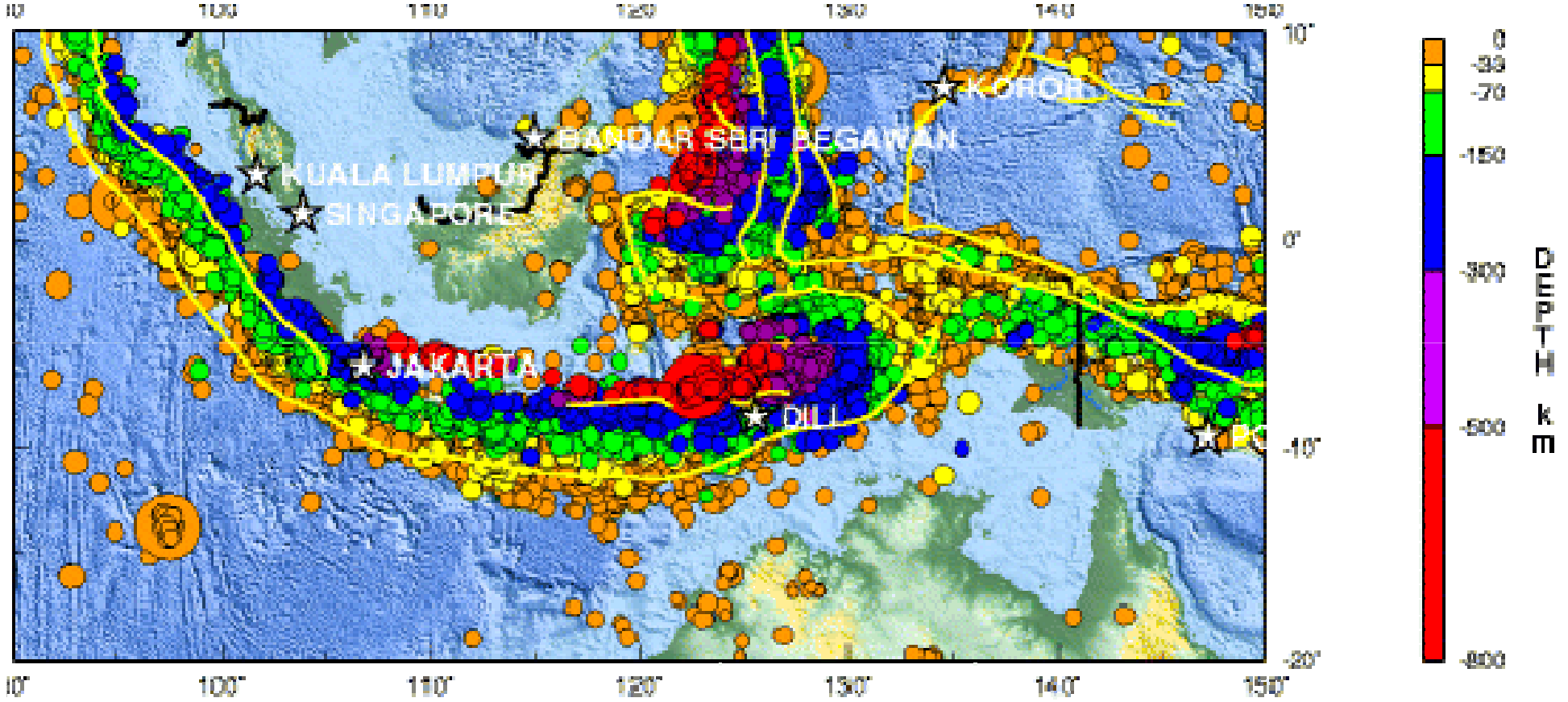


Χαρακτηριστικά σεισμού

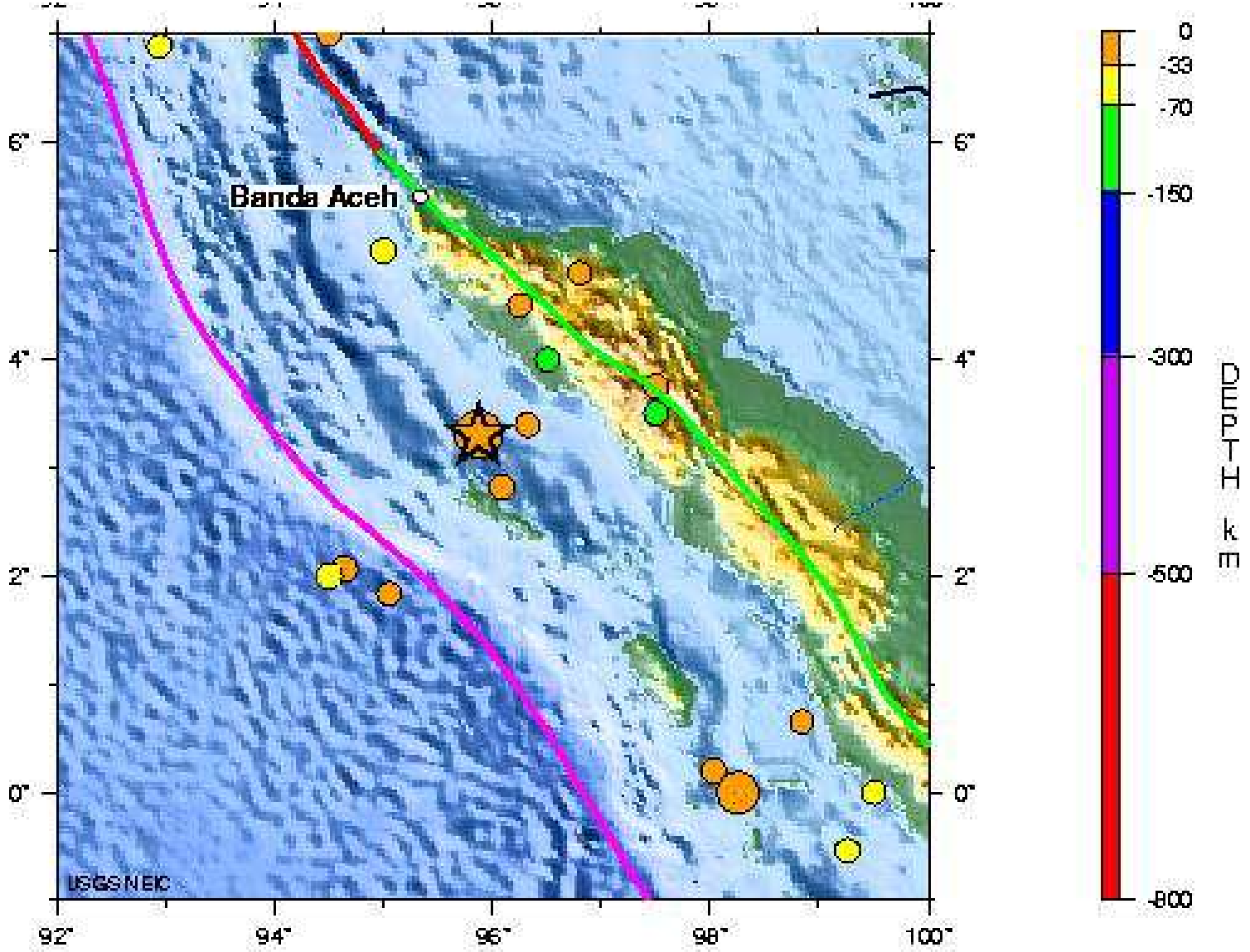
- Μήκος ρήγματος 1200-1300 km
- Ολίσθηση στο νότιο τμήμα : 400km
- Μέγιστη μετατόπιση στην εστία : 20 m
- Μέγιστη μετατόπιση του πυθμένα στο επίκεντρο: 10 m
- Ενέργεια που απελευθερώθηκε από τη δόνηση: 475,000 kilotons (475 megatons) TNT, ισοδύναμο 23,000 βόμβες Hiroshima

Σεισμικότητα περιοχής

YEAR	Magnitude 5.5 & larger events.	Magnitude 5.0 & larger events.	Magnitude 4.5 & larger events.
1995	2	7	35
1996	2	9	36
1997	2	11	37
1998	1	8	38
1999	3	11	34
2000	5	12	44
2001	4	9	36
2002	11	25	91
2003	6	20	64
2004	4	14	67



Seismicity of Indonesia, 1990 - 2000



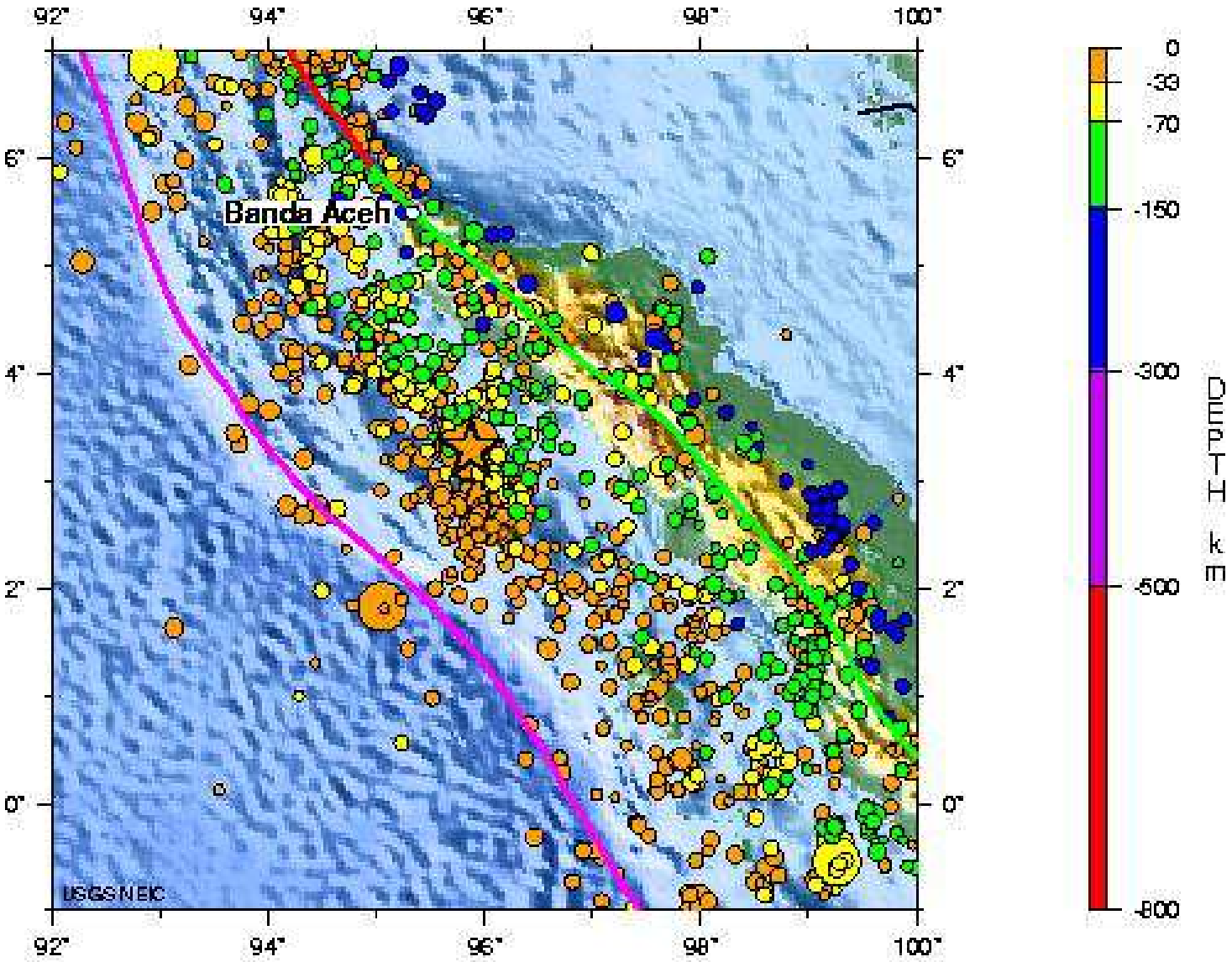
OFF THE WEST COAST OF NORTHERN SUMATRA

2004 12 26 00:58:53 UTC 3.30N 95.87E Depth: 30 km, Magnitude: 9.0

Magnitude 7 and Greater Earthquakes Since 1900

Major Tectonic Boundaries: Subduction Zones - purple, Ridges - red and Transform Faults - green

USGS National Earthquake Information Center



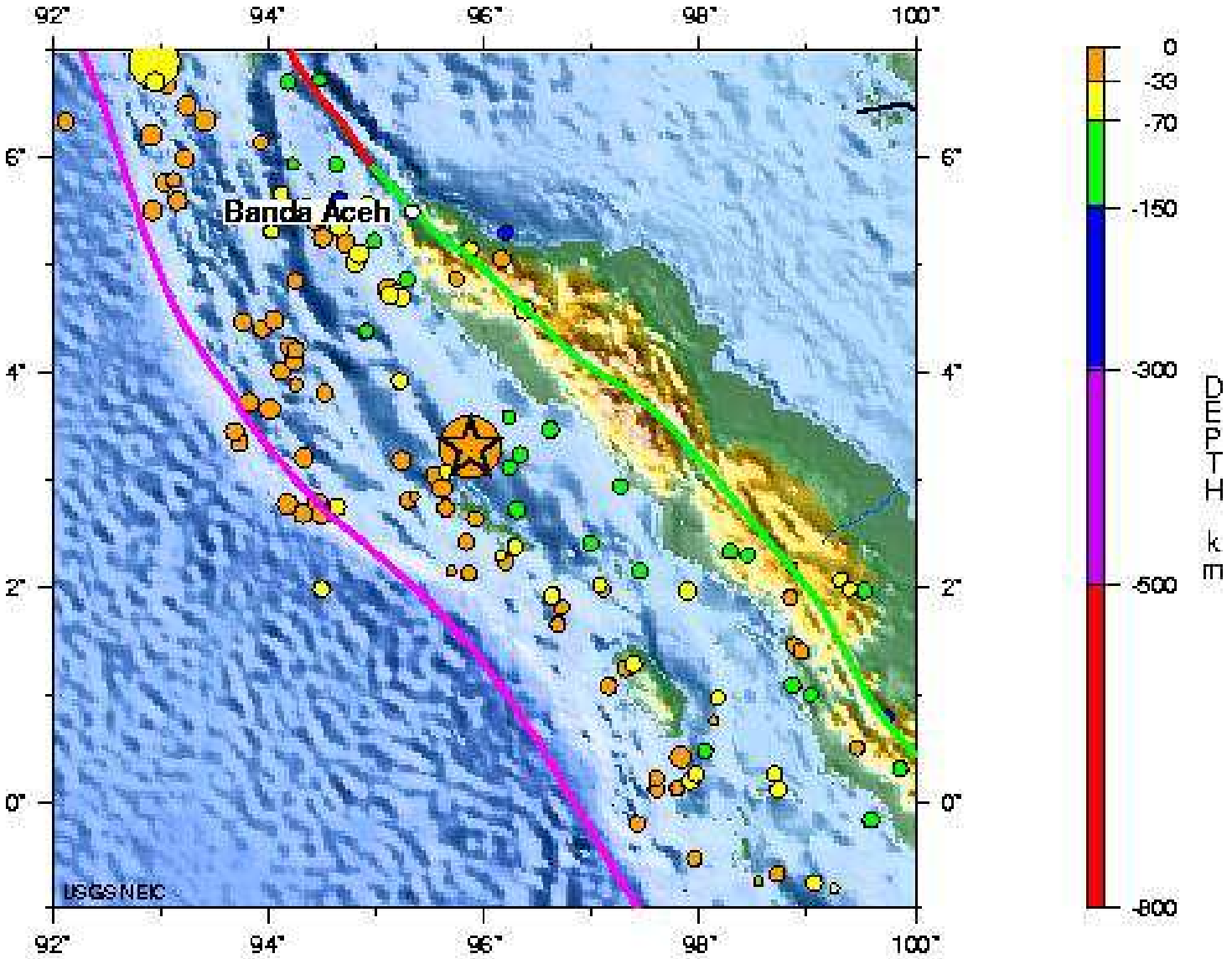
OFF THE WEST COAST OF NORTHERN SUMATRA

2004 12 26 00:58:53 UTC 3.30N 95.87E Depth: 30 km, Magnitude: 9.0

Seismicity 1990 to Present

Major Tectonic Boundaries: Subduction Zones -purple, Ridges -red and Transform Faults -green

USGS National Earthquake Information Center



OFF THE WEST COAST OF NORTHERN SUMATRA

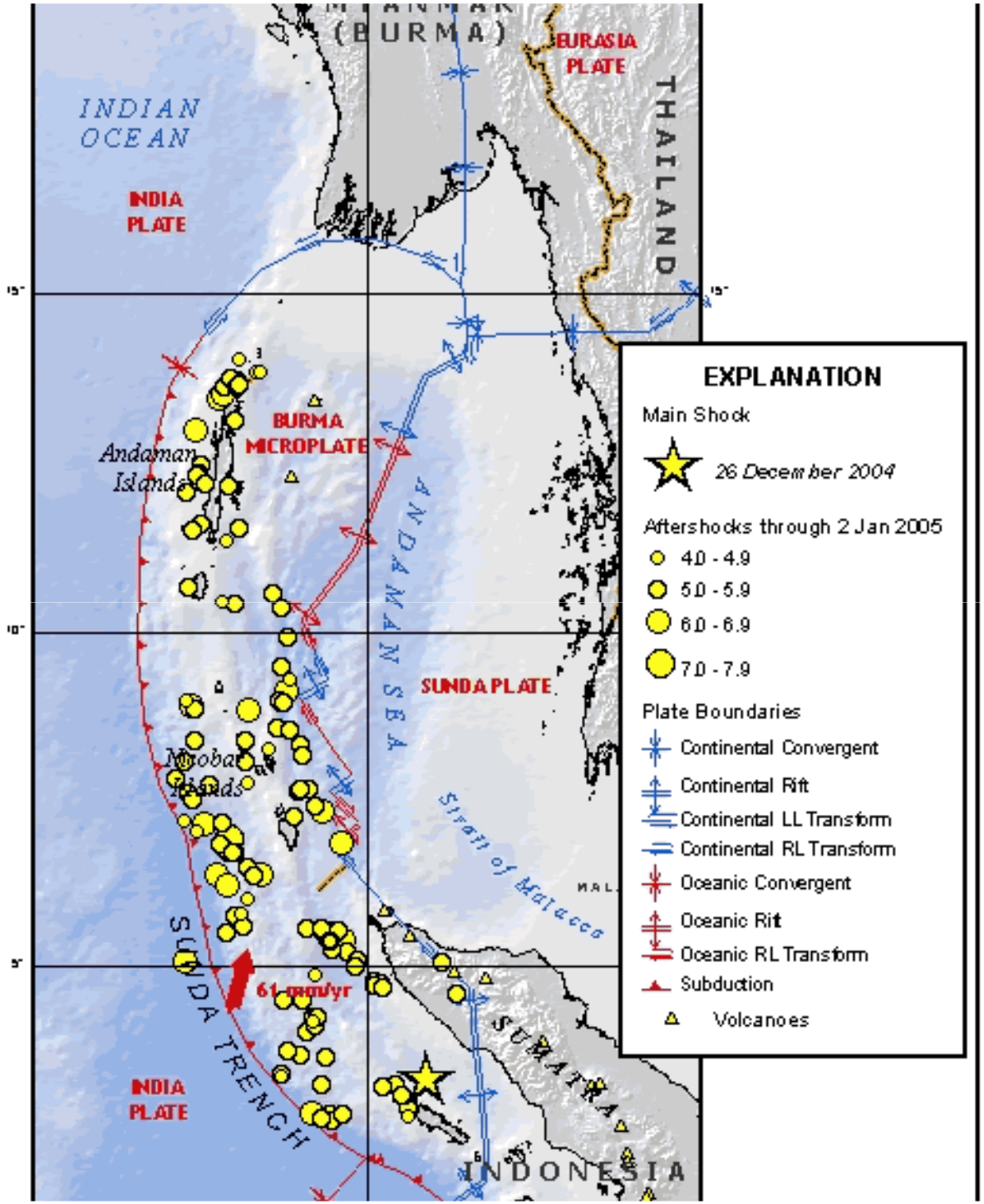
2004 12 26 00:58:53 UTC 3.30N 95.87E Depth: 30 km, Magnitude: 9.0

Seismicity in 2004

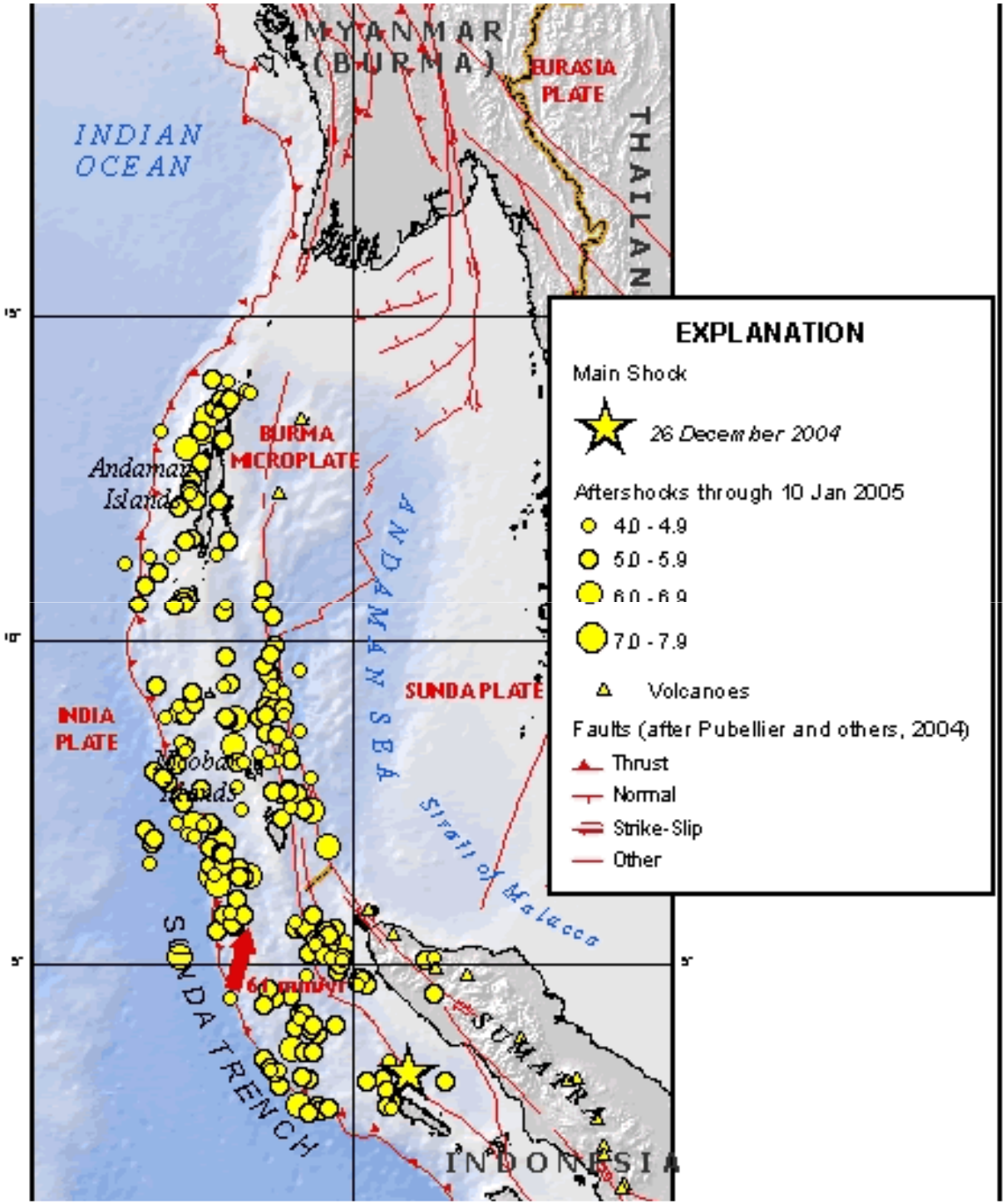
Major Tectonic Boundaries: Subduction Zones - purple, Ridges - red and Transform Faults - green

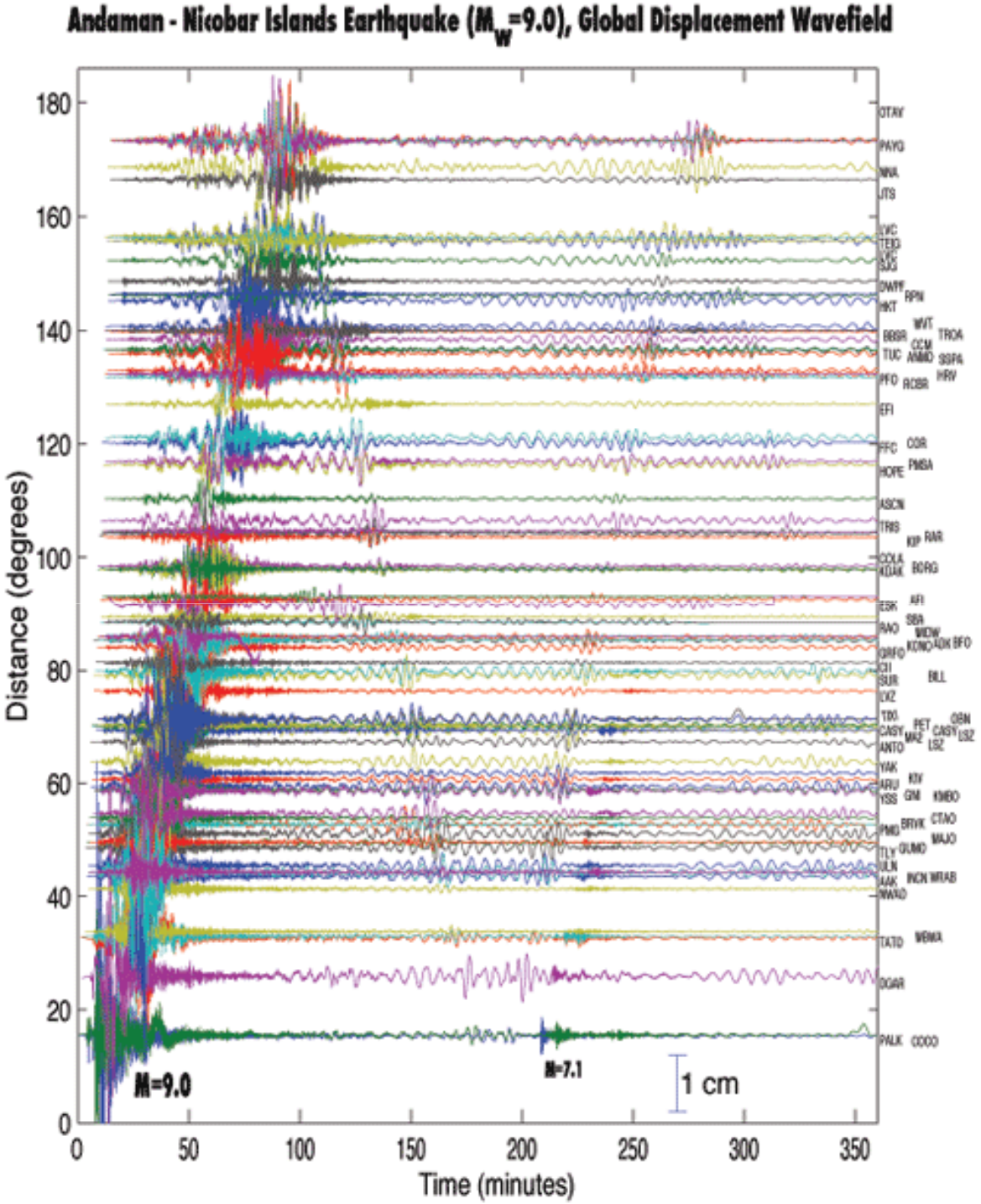
USGS National Earthquake Information Center

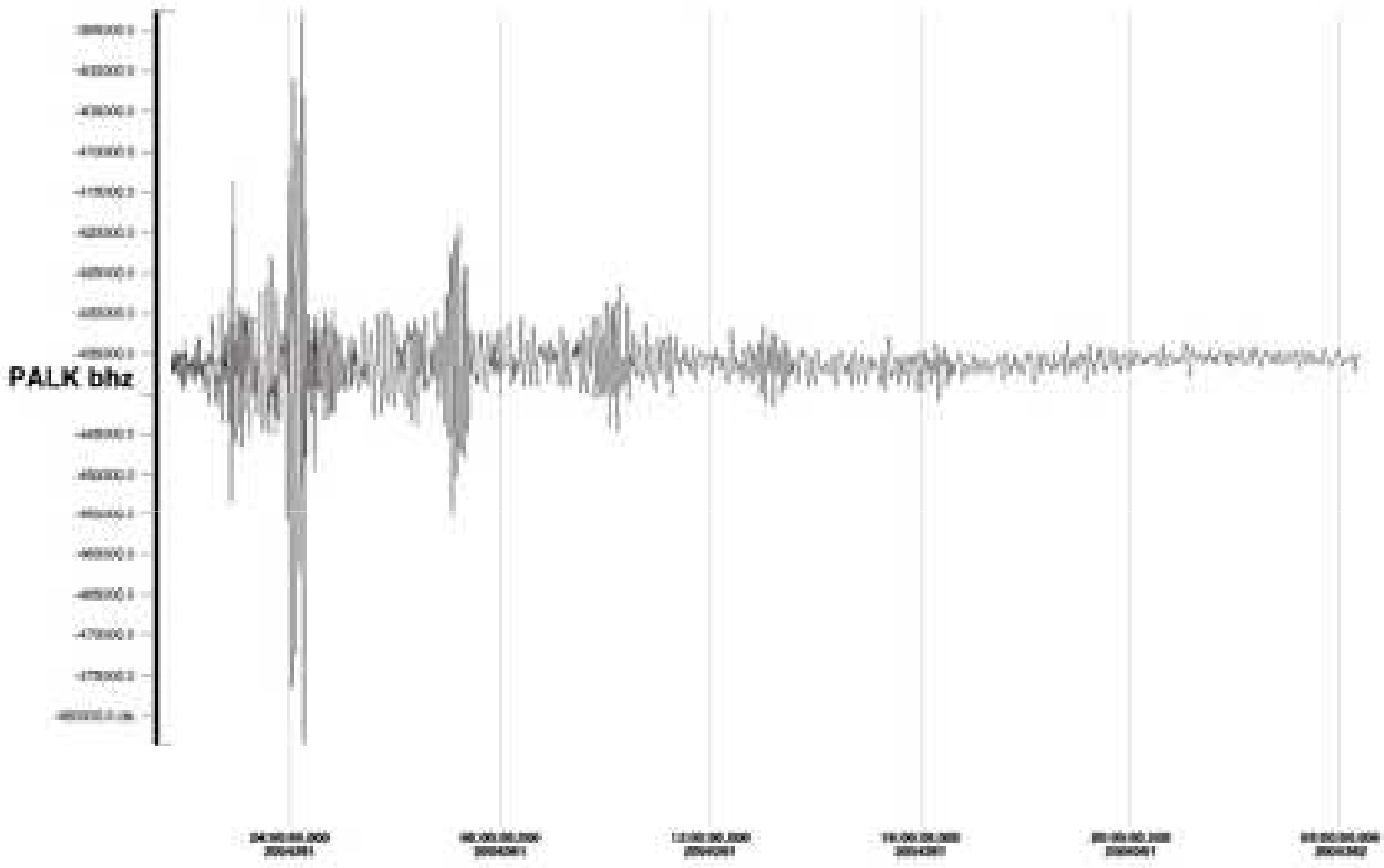
Χάρτης
Μετασεισμών
2-1-2005



Χάρτης
Μετασεισμών
10-1-2005

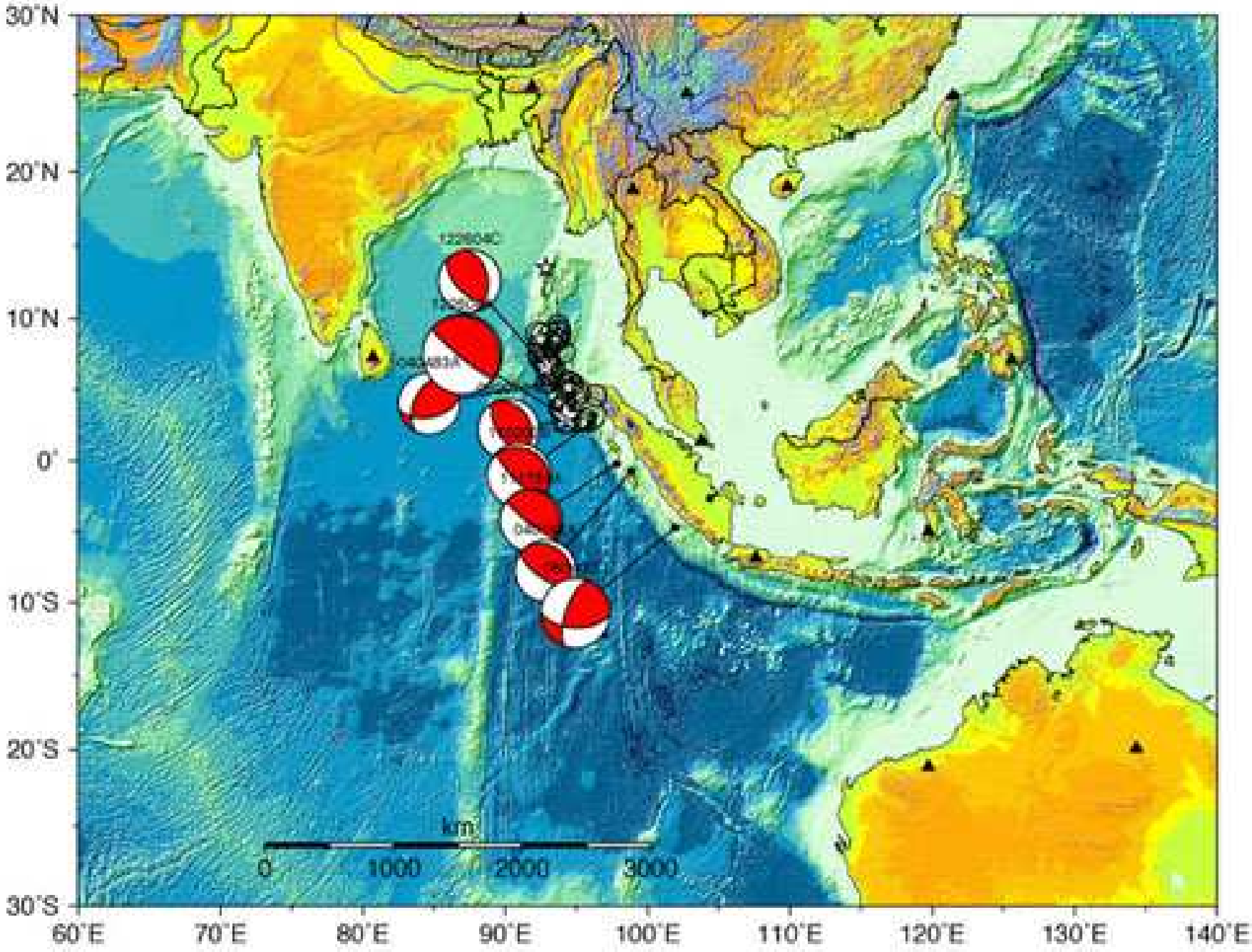



Andaman - Nicobar Islands Earthquake (M_w=9.0), Global Displacement Wavefield
Distance (degrees)
Time (minutes)
0
20
40
60
80
100
120
140
160
180
0
50
100
150
200
250
300
350
M=9.0
M=7.1
1 cm
OTAV
PAYG
WVA
JTS
LVC
TEIG
SUG
DWPF
RPN
HKT
WVT
BBSR
TROA
CCM
TUC
ANMO
SSPA
PFO
RCBR
HRV
EFI
FFC
CSR
HOPE
PMSA
ASCN
TRIS
KIP
RAR
COLA
KDAK
BORG
EGK
AFI
SBA
RAO
WMOK
KONO
ADK
BFO
GRFO
CII
SUR
BILL
LKZ
TDO
CASY
PET
MAZ
OBN
CASY
LSZ
ANTO
YAK
KIV
ARU
GNI
KMBO
YSS
PMG
BRVK
CTAO
TLY
GUMO
MAJO
ULN
AAK
INCN
WRAB
WAKO
TATO
WBMA
DGAR
PALK
COCO

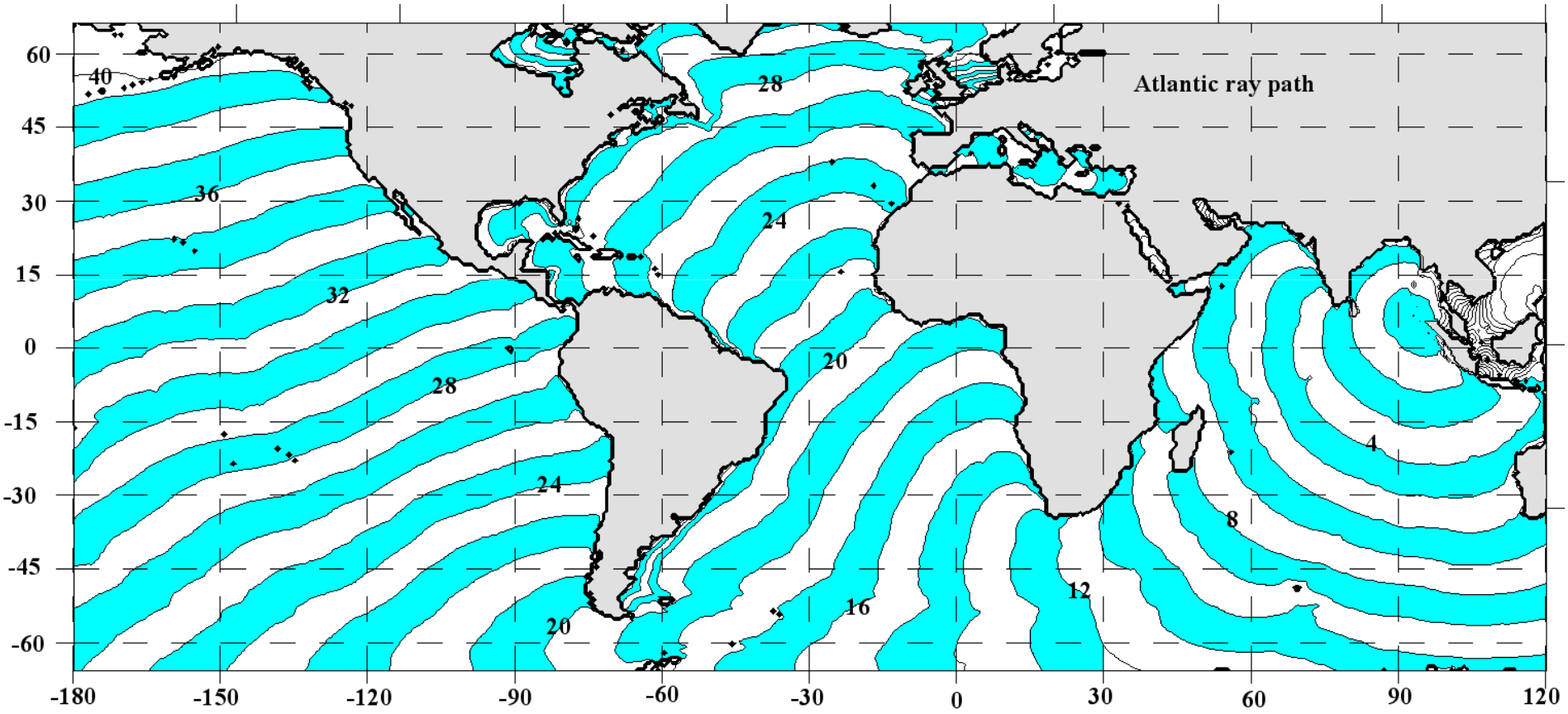


Filter: 0.005 LP, Amp: Auto
BRTT dbpick: palk /scr/day/pdavis/palk_lp.pv pdavis Tue Jan 4 13:02:21 2005

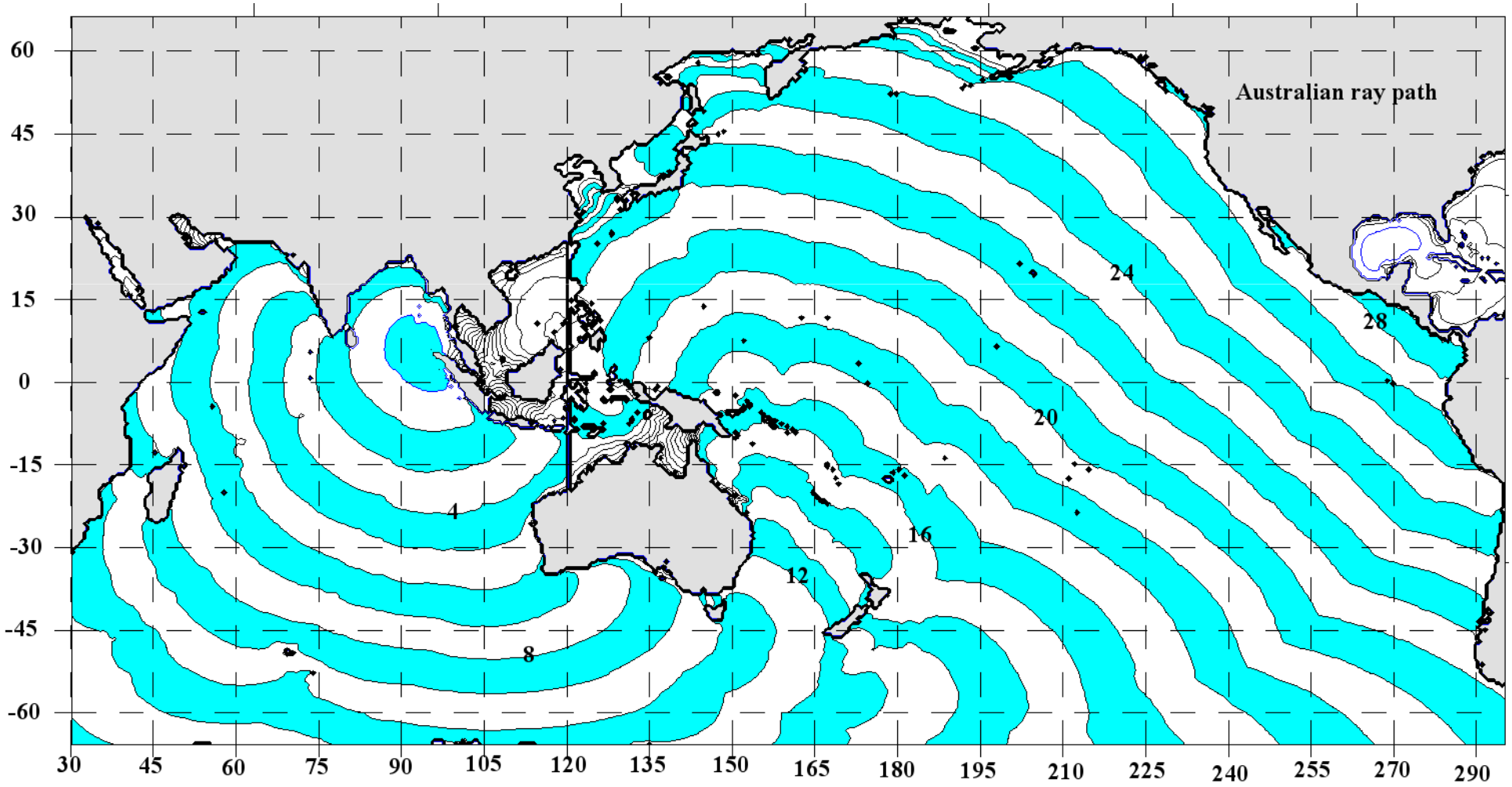
Mw 9.0 Earthquake on 12/26/2004 Off West Coast of Northern Sumatra



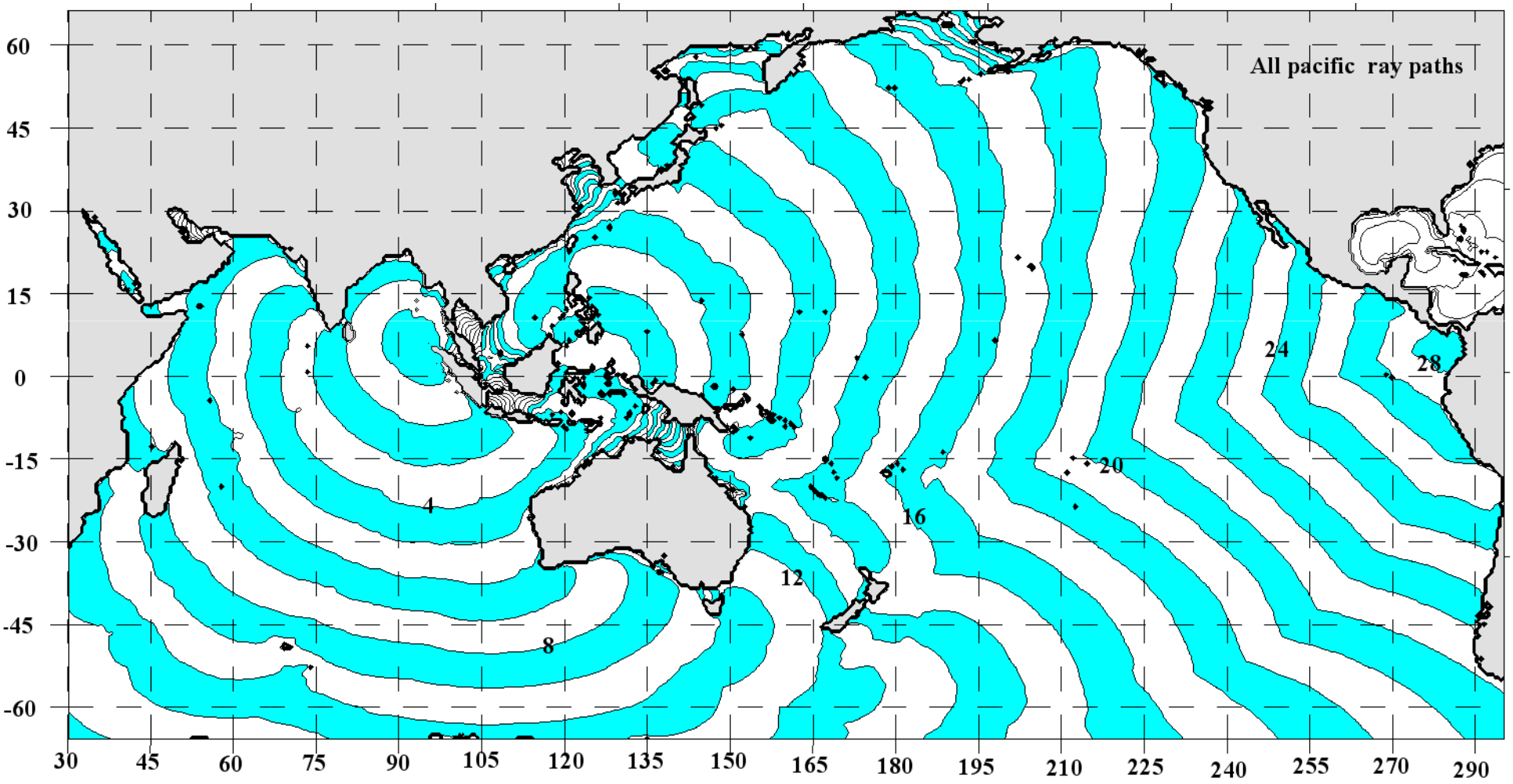
Η διάδοση του κύματος



Διάδοση στην Αυστραλία

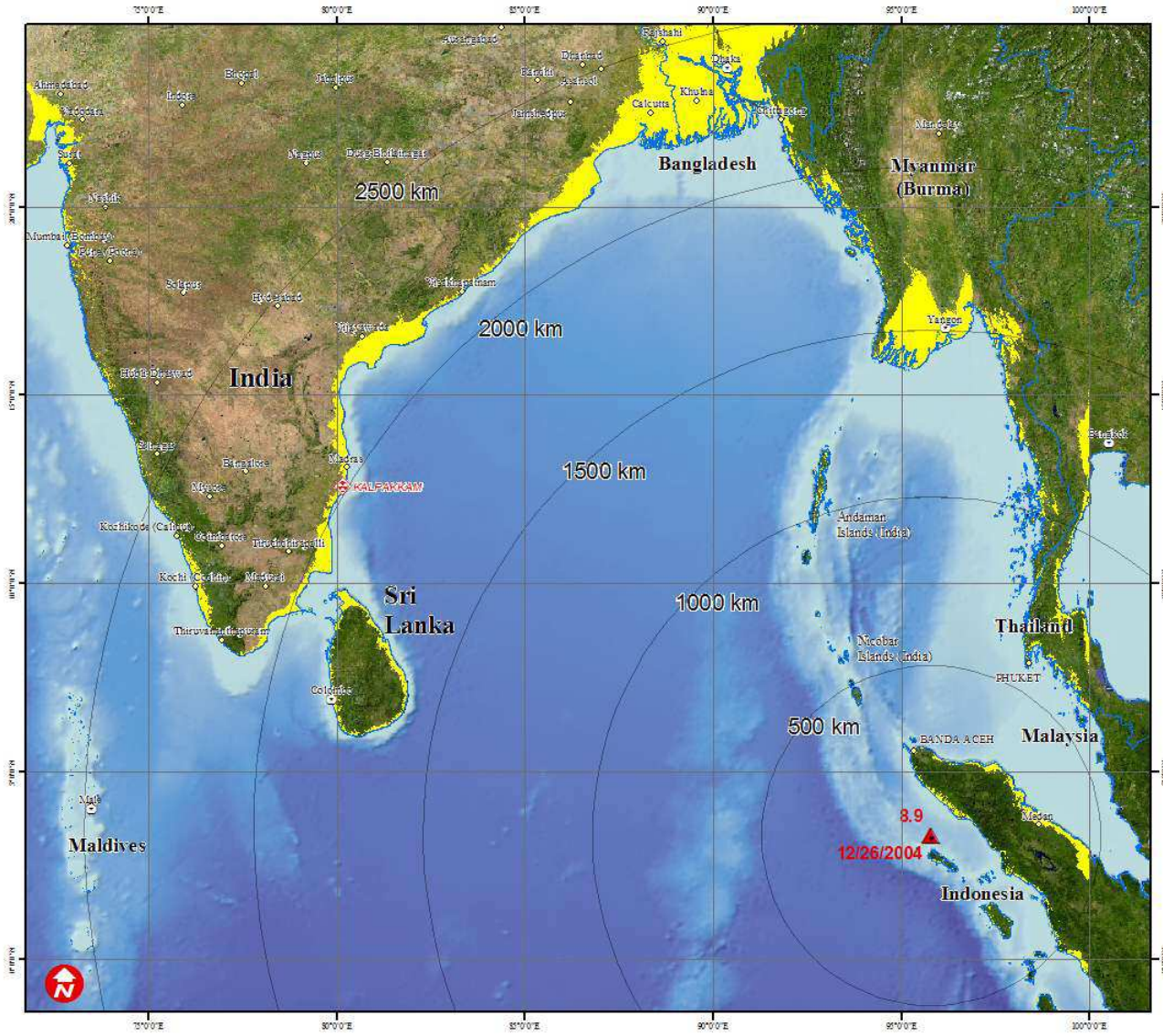


Διάδοση στον Ειρηνικό



ΤΟ ΚΥΜΑ : Παλαιότερα γεγονότα

- 1. 1797: Σεισμός 8.4 – Κεντρικό τμήμα Δυτικής Sumatra. Padang – πάνω από 300 θύματα.
- 2. 1833: Σεισμός 8.7 – Νότια ακτή Δυτικής Sumatra. Εκατοντάδες Θύματα.
- 3. 1843: Ενα tsunami κτυπησε την ακτή του νησιού Nias Εκατοντάδες Θύματα.
- 4. 1861: Σεισμός 8.5 Δυτικής Sumatra. Χιλιάδες Θύματα.
- 5. 1881: Σεισμός 7.9 Νησιά Andaman – Tsunami 1 m
- 6. 1883: Ηφαιστειακή εκρηξη Krakatau. 36.000 Θύματα Java - Sumatra.
- 7. 1941: Σεισμός ~7.7 Νησιά Adaman Φήμες για Tsunami . Δεν υπάρχουν καταγραφές.



Regional Map of Tsunami-Affected Areas

28 December 2004

This map illustrates coastal areas under 20 meters in elevation, as shown in bright yellow. This low-lying coastal zone is not a direct indication of areas affected by the 26 December 04 Tsunami--only those areas which may have suffered damage. For example, although Bangladesh is almost entirely under 20m in elevation, extensive swamps and limited settlements along the coast resulted in few casualties.

- Capital
- Large Town
- Epicenter
- Nuclear Power Plant
- International Border
- Elevation under 20m

Disaster Type: Tsunami
Disaster Date: 26 December 2004
Data Source: GLCF, NASA, USGS
Sensors: Modis-Terra mosaic
Elevation Data: SRTM30/ETOPO2
Resolution: 1km
Scale: 1:12,000,000 for A3 Prints
Datum: WGS-84
Projection: Geographic coordinates
Map Produced: 28 December 2004

This map was produced for the UNOSAT project headed by UNITAR and executed by UNOPS. UNOSAT is a UN-private consortium providing satellite imagery and related geographic information to UN humanitarian and development agencies, and their implementing partners. Please see www.unosat.org for additional information.

The International Charter on Space and Major Disasters aims at providing a unified system of space data acquisition and delivery to those affected by natural or man-made disasters through authorized users. Since 1 July 2003 the Charter is available to support the UN with satellite imagery. Please contact the UN Office for Outer Space Affairs for further information (oosa@unvienna.org).

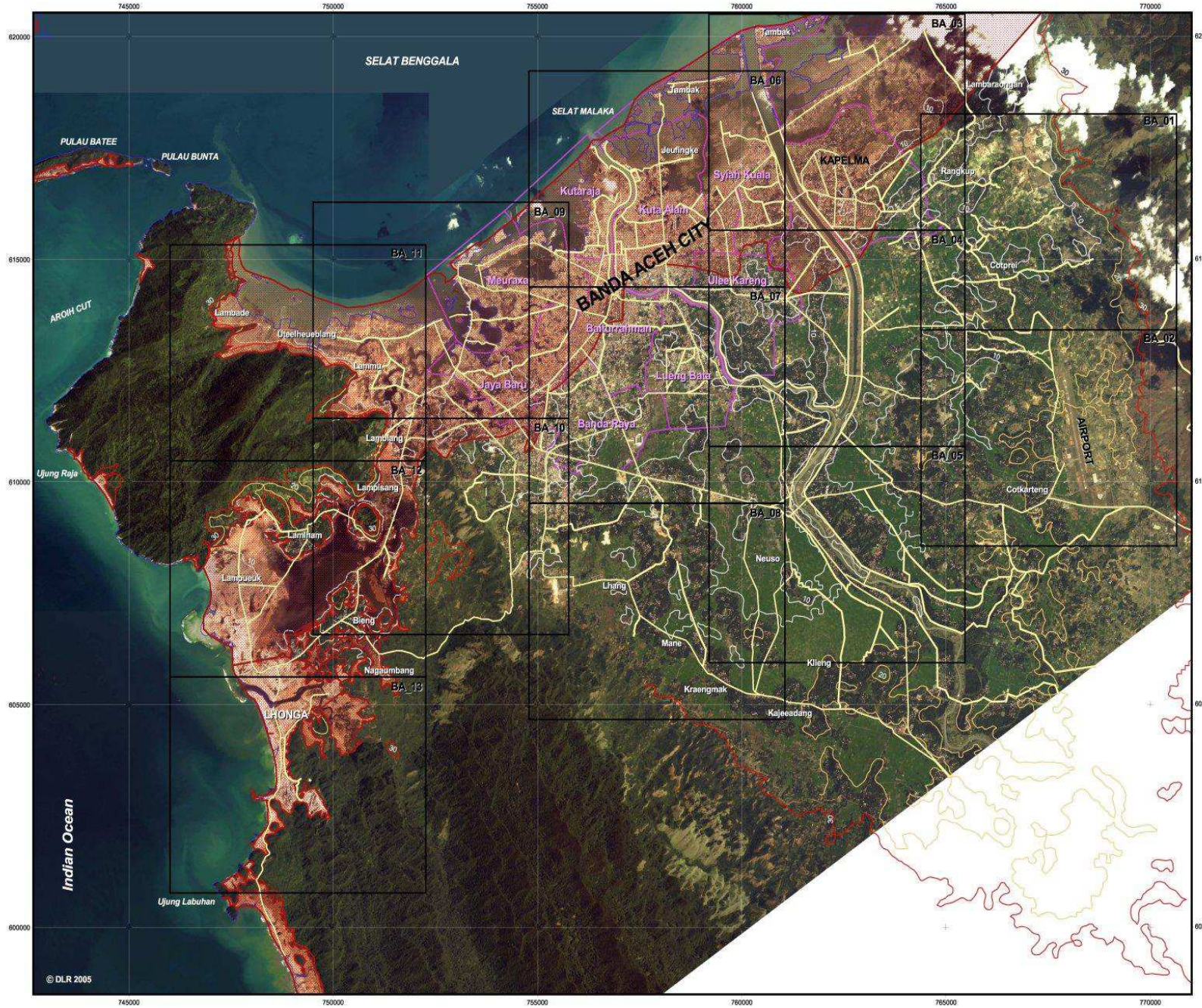
UNOSAT satellite imagery for all

ΔΟΡΥΦΟΡΙΚΕΣ ΕΙΚΟΝΕΣ QUICKBIRD

- Περιοχή: Βόρεια Σουμάτρα
- Πόλη: Aceh

INDONESIA/SUMATRA - Banda Aceh Region

1 : 45.000

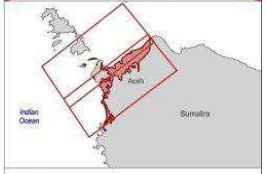


Center for Satellite based Crisis Information

- Emergency Mapping & Disaster Monitoring -

German Remote Sensing Data Center
German Aerospace Center

DLR



QUICKBIRD imagery of January 02, 2005

Legend

Banda Aceh city, road network and river

Coastline - forest area damaged area in red

Damaged area (red outline) contour and shore line

Airport, agriculture, contour lines (yellow: 20m)

Interpretation

This satellite map displays the area of Banda Aceh, Sumatra / Indonesia at a scale of 1:45.000. It shows an overview of the area struck by the tsunami flood wave of 26th December 2004. The map was derived from high resolution satellite imagery taken on 2nd January, 2005. It indicates that the seafront of the city of Aceh was extremely hit. Detailed analysis of the damage area shows, that 49 km² or 80% of the built-up city area (61 km²) were totally destroyed or extremely damaged. Furthermore the map indicates where the high resolution 1:10.000 map sheets were derived.

Scale

0 1000 2000 3000 4000 m

1 : 45.000

Projection: UTM Zone 46 N
Spheroid: WGS84
Datum: WGS 84

N

Data Source

QUICKBIRD © DIGITALGLOBE 2005 - 2005/01/02 provided by JRC 2005

Landsat imagery from: Global Land Cover Facility
Base maps (50k) from: East View Cartographic

Processing / Analysis

Image processing and analysis by DLR

- image enhancement by DLR-DFD
- geocorrecting base maps by DLR-IMF
- road network and damaged areas derived from Quickbird imagery by DLR-DFD
- SRTM-DEM processing by DLR-DFD

Map created December 29, 2004 by ZKI@DLR.DE updated with new satellite imagery January 5, 2004 (Version 03)

Joint Tsunami relief mapping by DLR and JRC in the framework of RESPOND

EUROPEAN COMMISSION Joint Research Centre

RESPOND

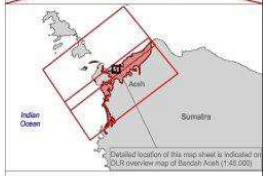
INDONESIA/SUMATRA - Banda Aceh Region - Map 6

1 : 10.000

Center for Satellite based Crisis Information
- Emergency Mapping & Disaster Monitoring -

German Remote Sensing Data Center
German Aerospace Center

DLR



QUICKBIRD imagery of January 02, 2005

Legend

Banda Aceh city, road network and river

Coastline - forest area damaged area in red

Damaged area (red outline) contour and shore line

Airport, agriculture, contour lines (yellow: 20m)

Interpretation

This satellite map displays the area of Banda Aceh, Sumatra / Indonesia at a scale of 1:10.000. It shows an overview of the area struck by the tsunami flood wave of 26th December 2004. The map was derived from high resolution satellite imagery taken on 2nd January, 2005. It indicates that the seafront of the city of Aceh was extremely hit. Detailed analysis of the damage area shows, that 49 km² or 80% of the built-up city area (61 km²) were totally destroyed or extremely damaged. The corresponding 1:45.000 overview map indicates where this high resolution 1:10.000 map sheet is located.

Scale

0 250 500 750 m

1 : 10.000

N

Projection: UTM Zone 46 N
Spheroid: WGS84
Datum: WGS 84

Data Source

QUICKBIRD © DIGITALGLOBE 2005 - 2005/01/02 provided by JRC 2005

Landsat imagery from: Global Land Cover Facility
Base maps (50k) from: East View Cartographic

Processing / Analysis

Image processing and analysis by DLR

- image enhancement by DLR-DFD
- geocorrecting base maps by DLR-IMF
- road network and damaged areas derived from Quickbird imagery by DLR-DFD
- SRTM-DEM processing by DLR-DFD

Map created January 05, 2004 by ZKI@DLR.DE

Joint Tsunami relief mapping by DLR and JRC in the framework of RESPOND

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

RESPOND

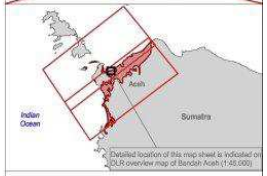
INDONESIA/SUMATRA - Banda Aceh Region - Map 9

1 : 10.000

Center for Satellite based Crisis Information
- Emergency Mapping & Disaster Monitoring -

German Remote Sensing Data Center
German Aerospace Center

DLR



QUICKBIRD imagery of January 02, 2005

Legend

Banda Aceh city, road network and river

Coastline - forest area damaged area in red

Damaged area (red outline) contour and shore line

Airport, agriculture, contour lines (yellow: 20m)

Interpretation

This satellite map displays the area of Banda Aceh, Sumatra / Indonesia at a scale of 1:10.000. It shows an overview of the area struck by the tsunami flood wave of 26th December 2004. The map was derived from high resolution satellite imagery taken on 2nd January, 2005. It indicates that the seafront of the city of Aceh was extremely hit. Detailed analysis of the damage area shows, that 49 km² or 80% of the built-up city area (61 km²) were totally destroyed or extremely damaged. The corresponding 1:45.000 overview map indicates where this high resolution 1:10.000 map sheet is located.

Scale

0 250 500 750 m

1 : 10.000

Projection: UTM Zone 46 N
Spheroid: WGS84
Datum: WGS 84

N

Data Source

QUICKBIRD © DIGITALGLOBE 2005 - 2005/01/02 provided by JRC 2005

Landsat imagery from: Global Land Cover Facility
Base maps (50k) from: East View Cartographic

Processing / Analysis

Image processing and analysis by DLR

- image enhancement by DLR-DFD
- geocorrecting base maps by DLR-IMF
- road network and damaged areas derived from Quickbird imagery by DLR-DFD
- SRTM-DEM processing by DLR-DFD

Map created January 05, 2004 by ZKI@DLR.DE

Joint Tsunami relief mapping by DLR and JRC in the framework of RESPOND

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

RESPOND

ΔΟΡΥΦΟΡΙΚΕΣ ΕΙΚΟΝΕΣ IKONOS

- Περιοχή 1: Σουμάτρα
- Περιοχή 2 : Ταϊλάνδη

Sumatra

Aceh

Sumatra
Aceh

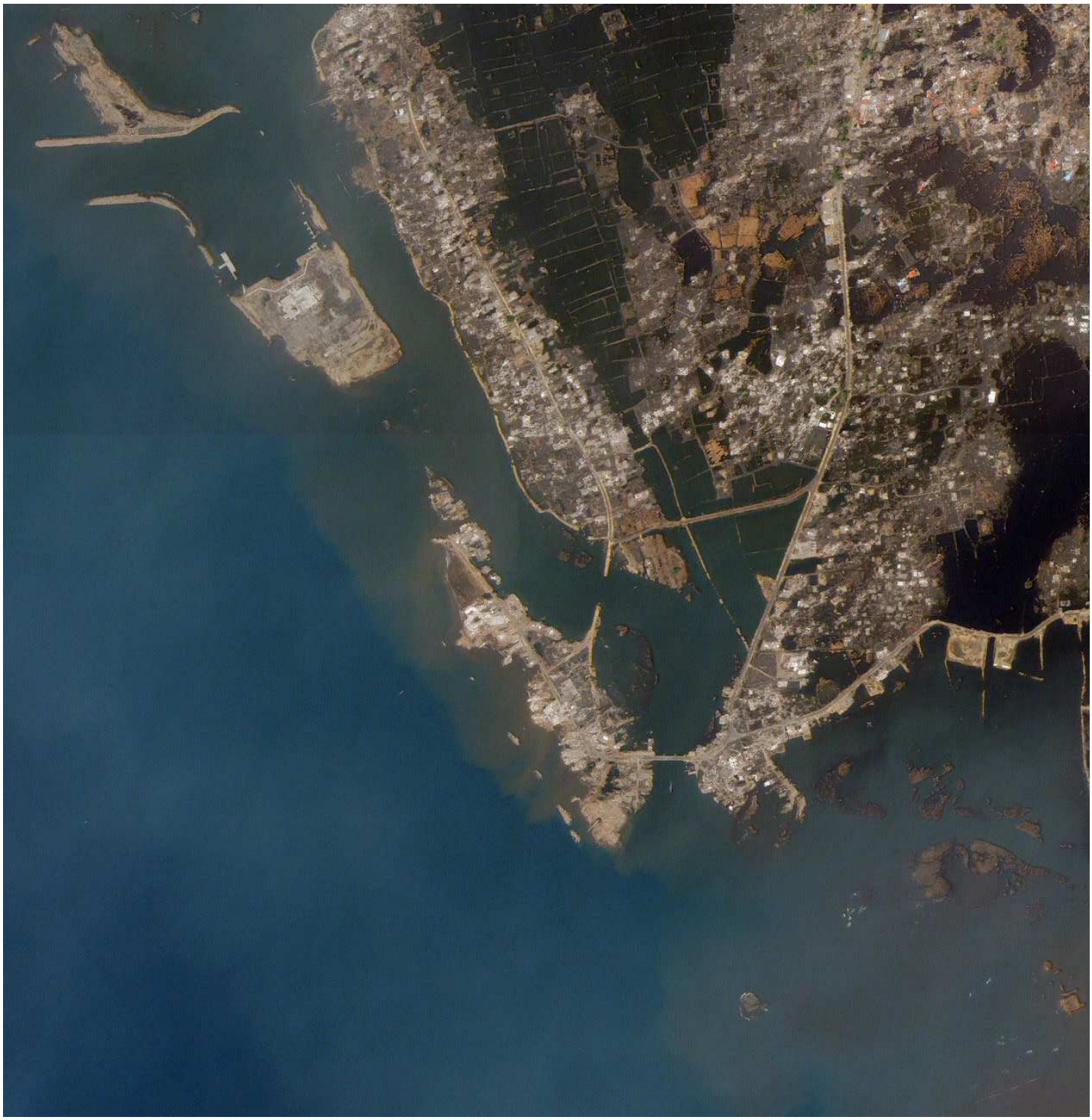
1

Sumatra
Aceh

2

Sumatra
Aceh

3



Sumatra
Aceh

4

Sumatra
Aceh

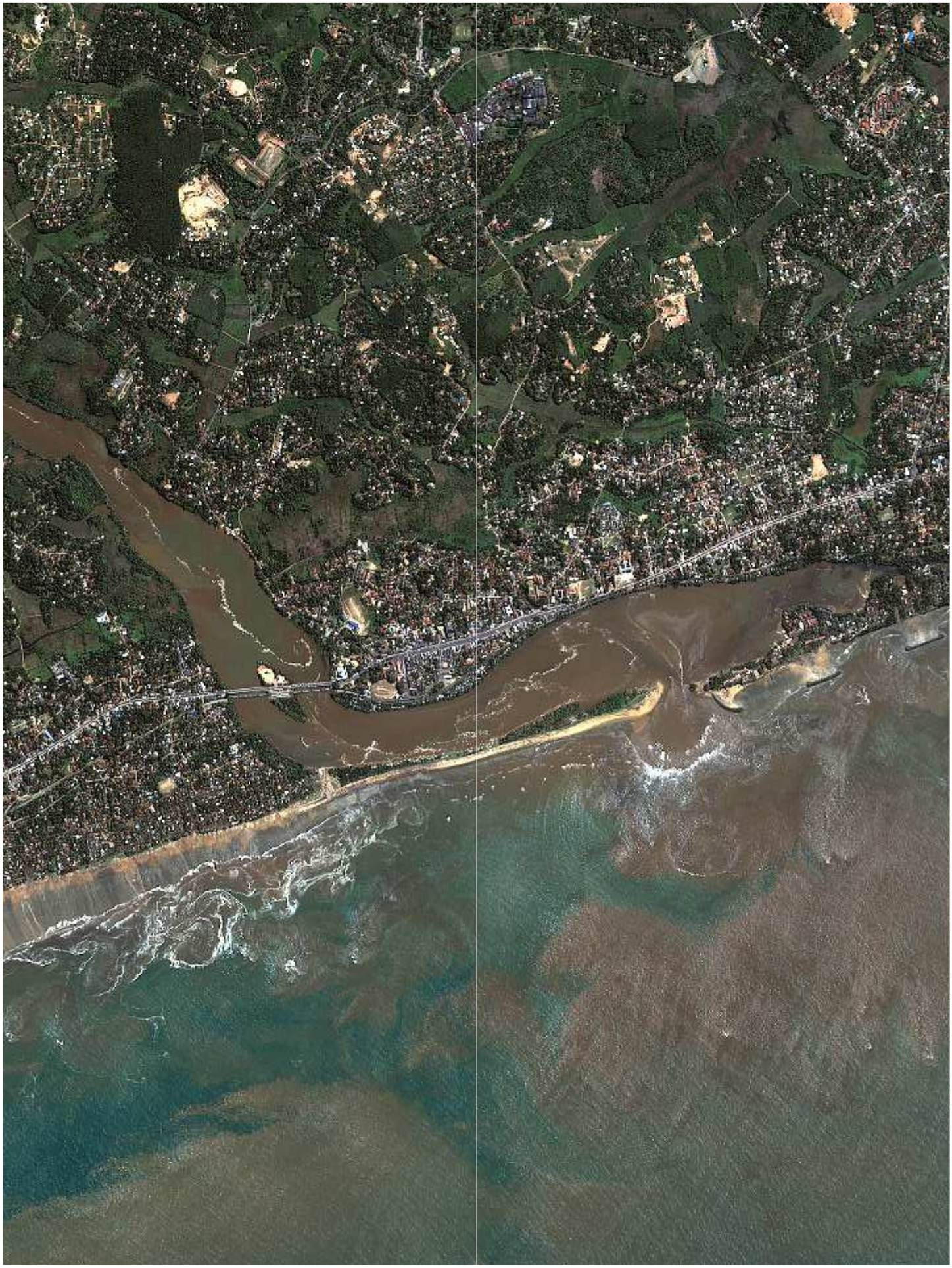
5

Thailand
Khao Lak

Πριν την έλευση του κύματος

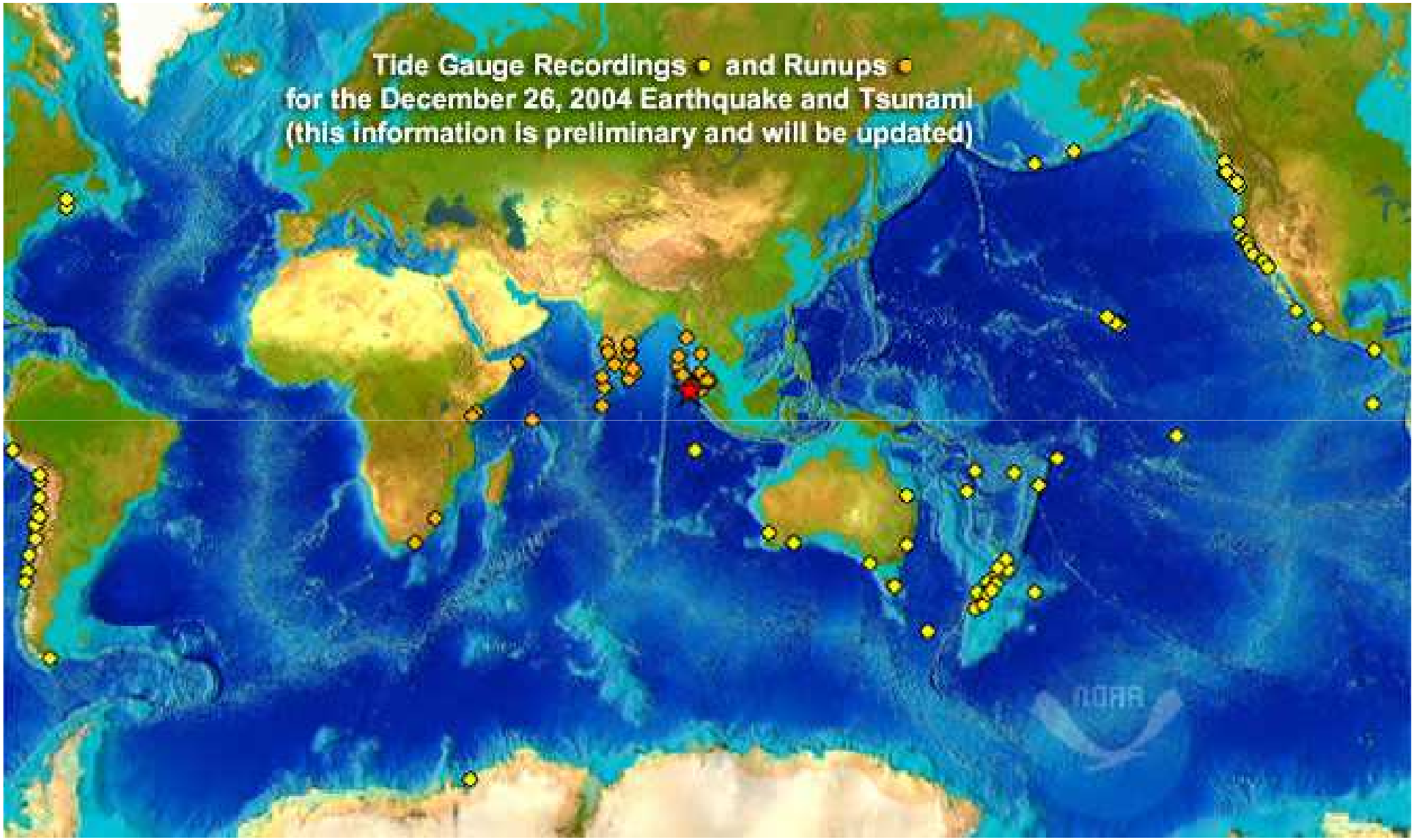
Μετά την επέλαση του κυματος

Η πρόσκρουση του κύματος



Agence France-Presse

Tourists try to rush to safety before the tsunami hit the Hat Rai Lay Beach in Thailand. The water had receded before the deadly wave struck.


Tide Gauge Recordings • and Runups •
for the December 26, 2004 Earthquake and Tsunami
(this information is preliminary and will be updated)
NOAA