

CINQ ANS APRES SUMATRA :

Avons–Nous Gagné en Sagesse ?

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THE NEED FOR WISDOM

SUMATRA 2004

$H_0 + 01:30$



THAILAND

8000 deaths

$H_0 + 02:00$



SRI LANKA

31000 deaths

$H_0 + 02:00$



INDIA

11000 deaths

$H_0 + 06:30$



SOMALIA

300 deaths

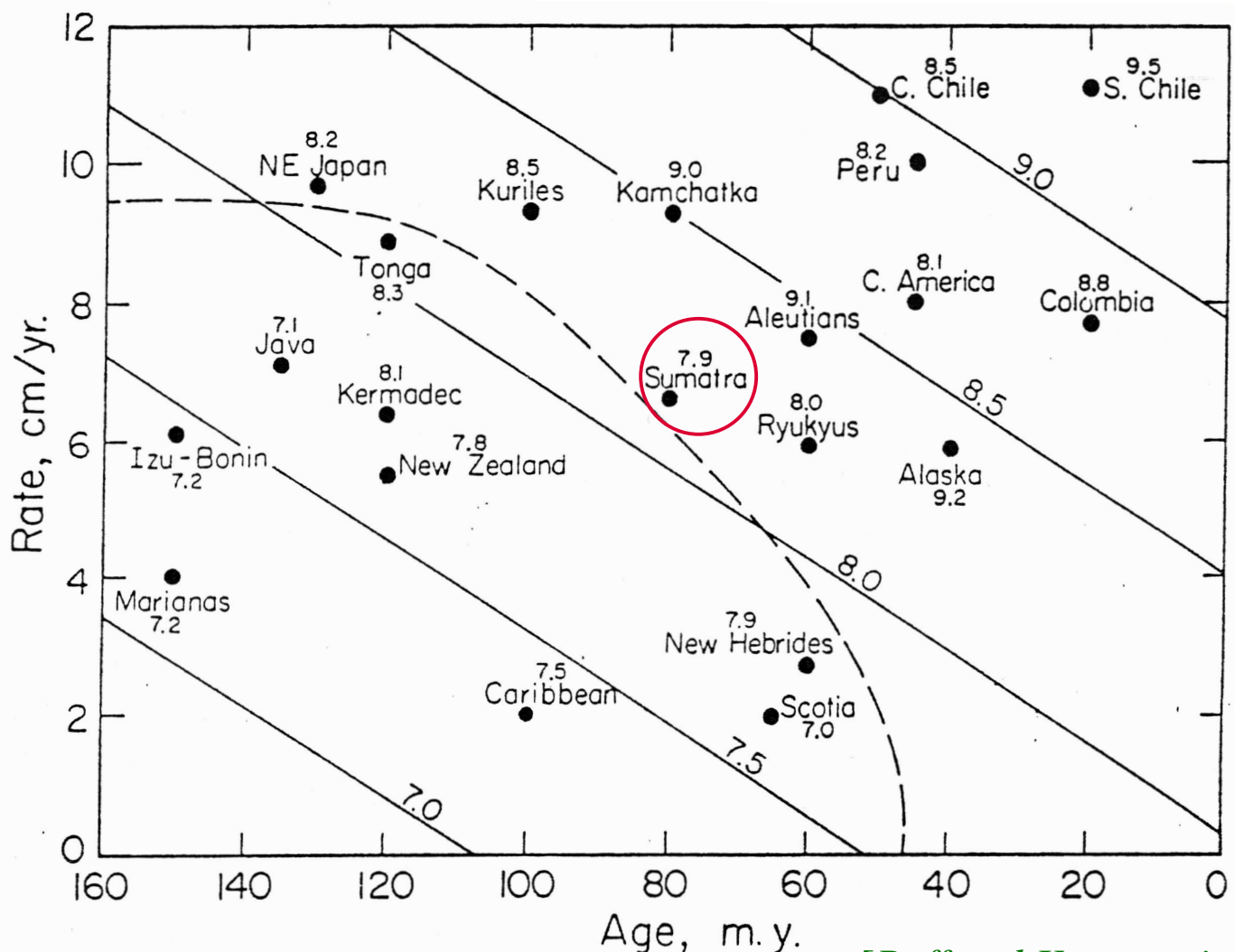
THE EARTHQUAKE OCCURRED WHERE A MEGA-EVENT *WAS NOT EXPECTED*

The 2004 [and 2005] Sumatra earthquake[s] violated
the concept of a

maximum expectable

subduction earthquake controlled by

plate age and convergence rate.



[Ruff and Kanamori, 1980]

Modern parameters: **> 55 Ma; 5 cm/yr**

Would predict Maximum **8.0–8.2 not ≥ 9 ...**

Could we get *WISER* ?

UPDATING THE RUFF-KANAMORI DIAGRAM

Over the past 25 years...



We have obtained new rates

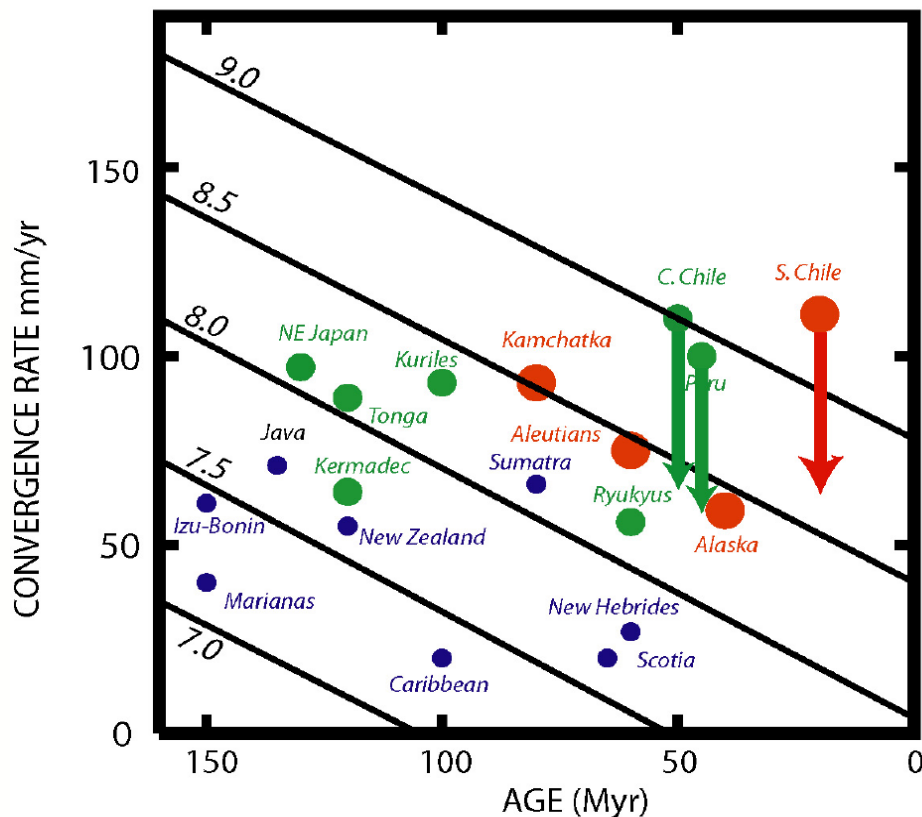
Examples: South Chile **70** mm/yr vs. 111

Tonga (20°S): **185** mm/yr vs. 89

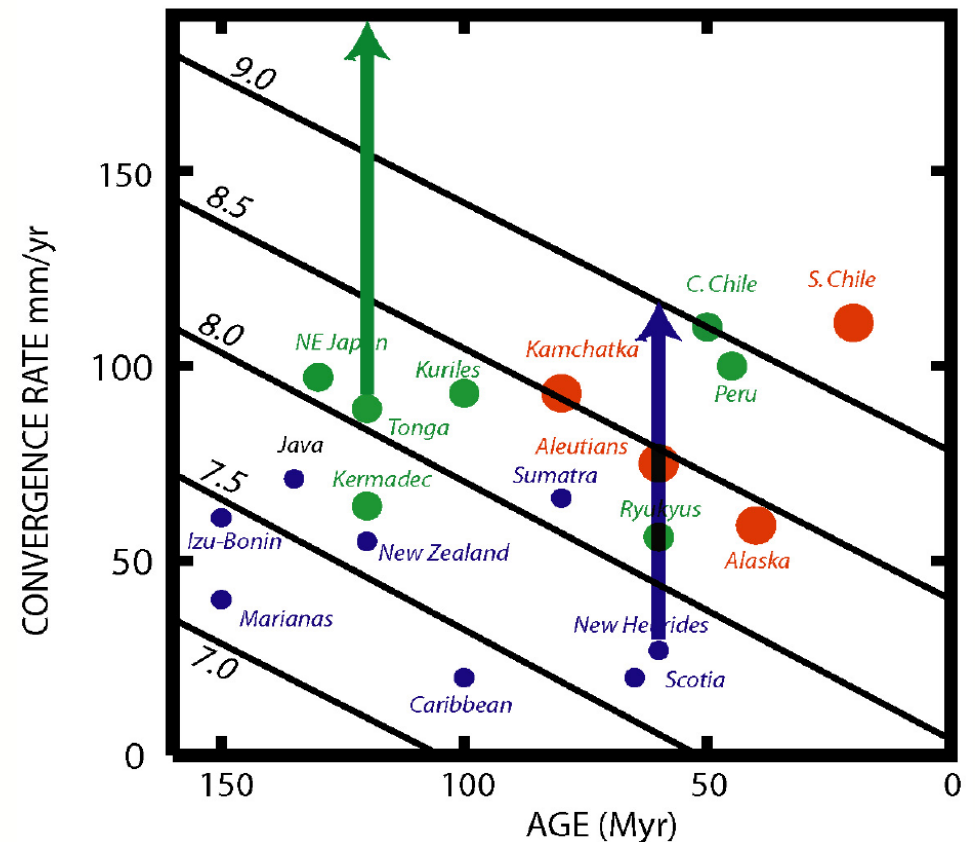
South Peru: **67** mm/yr vs. 100

Vanuatu: **103** mm/yr vs. 27

RUFF AND KANAMORI 1980



RUFF AND KANAMORI 1980



UPDATING THE RUFF-KANAMORI DIAGRAM (ctd.)

Over the past 25 years...

→ We have "discovered" new earthquakes

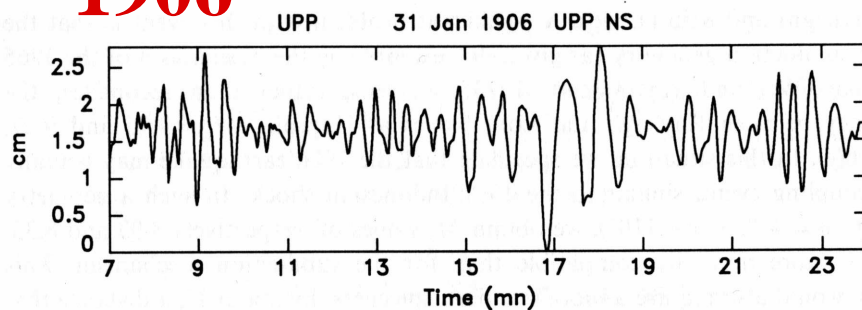
→ We have revised the size
of historical earthquakes

Examples: **Sumatra 2004 !**
Cascadia, 1700

Example: 1906 Colombia-Ecuador:

$$M_0 = 6 \times 10^{28} \text{ dyn-cm vs. } 2 \times 10^{29}$$

1906



1979

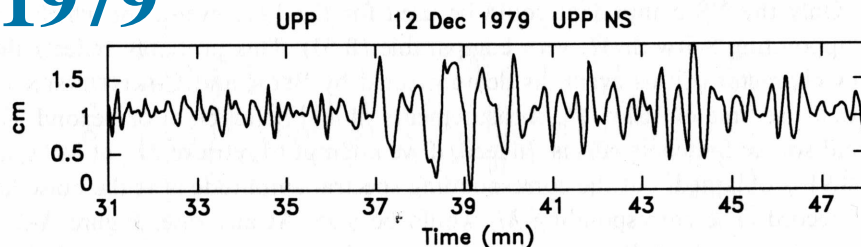
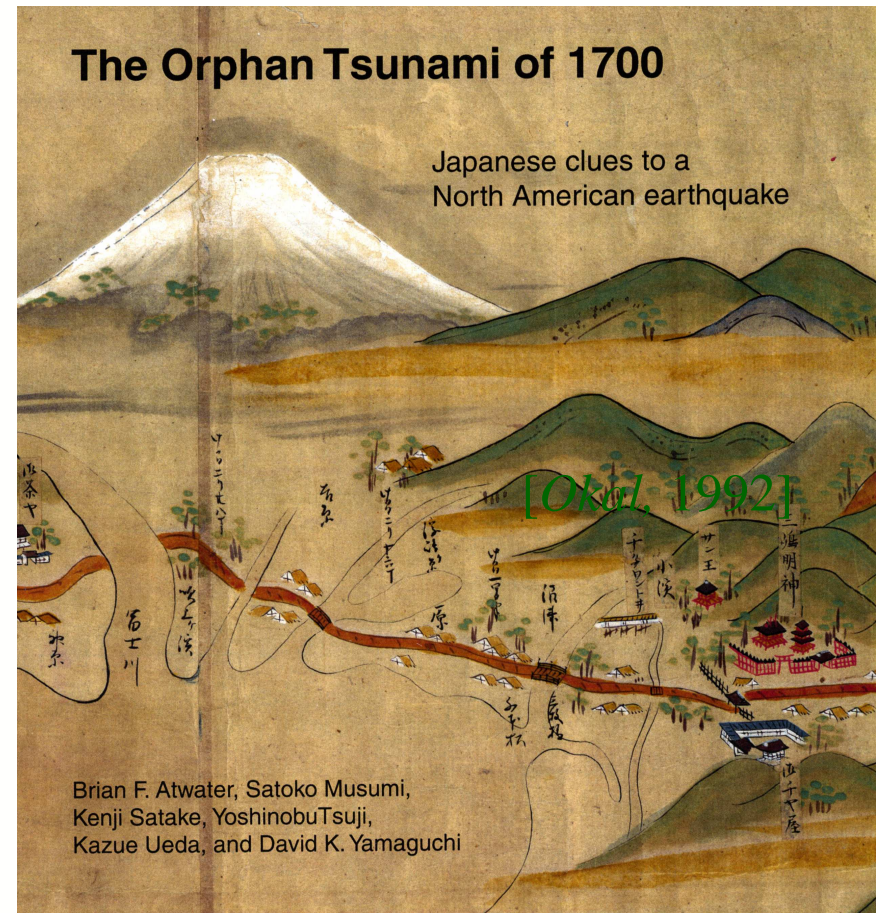


Figure A-1

Comparison of the Love wavetrains G_1 of the 1906 and 1979 Ecuador-Colombia earthquakes, as recorded on the NS component of the Uppsala Wiechert. The records are plotted on the same scale, with the abscissa offset so as to align the G_1 wavetrains, thus allowing a direct comparison of their relative sizes. Note that while the 1906 earthquake is undoubtedly the larger of the two, it cannot have a moment 10 times larger than the 1979 event.

The Orphan Tsunami of 1700

Japanese clues to a
North American earthquake

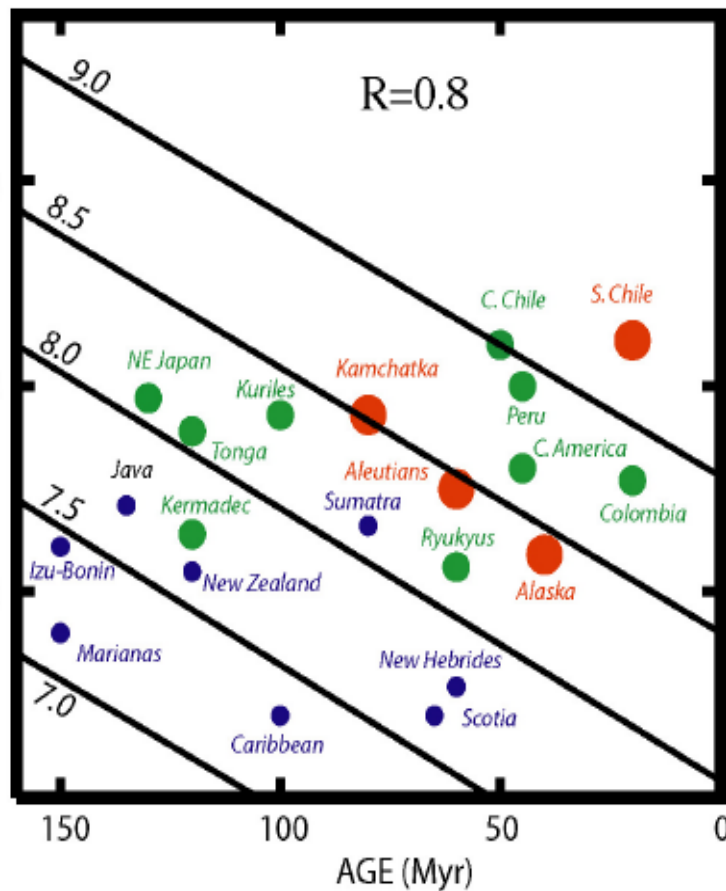


*embarrassingly so, in subduction zones supposedly
"safe" from mega-events !*

USING NEW RATES, AGES & MAGNITUDES

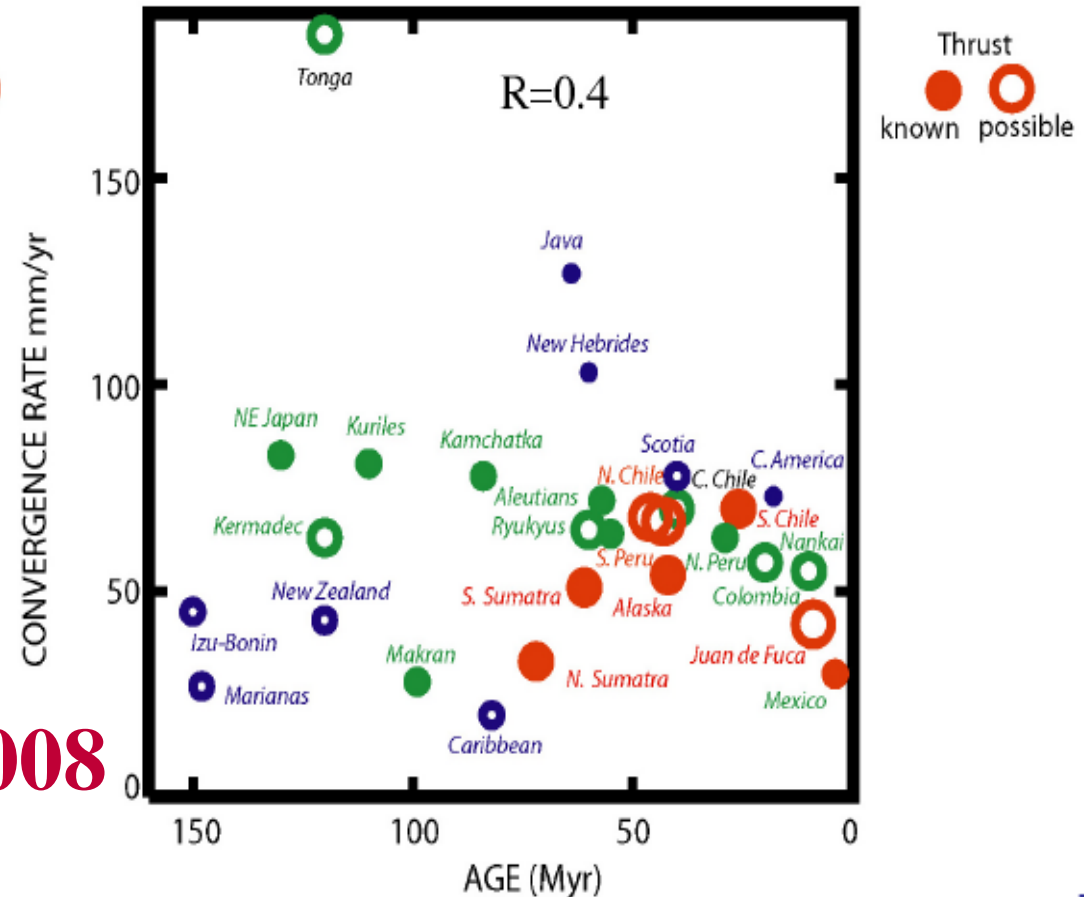
MUCH OF THE CORRELATION VANISHES

RUFF AND KANAMORI 1980



1980

2008



Correlation: 80%

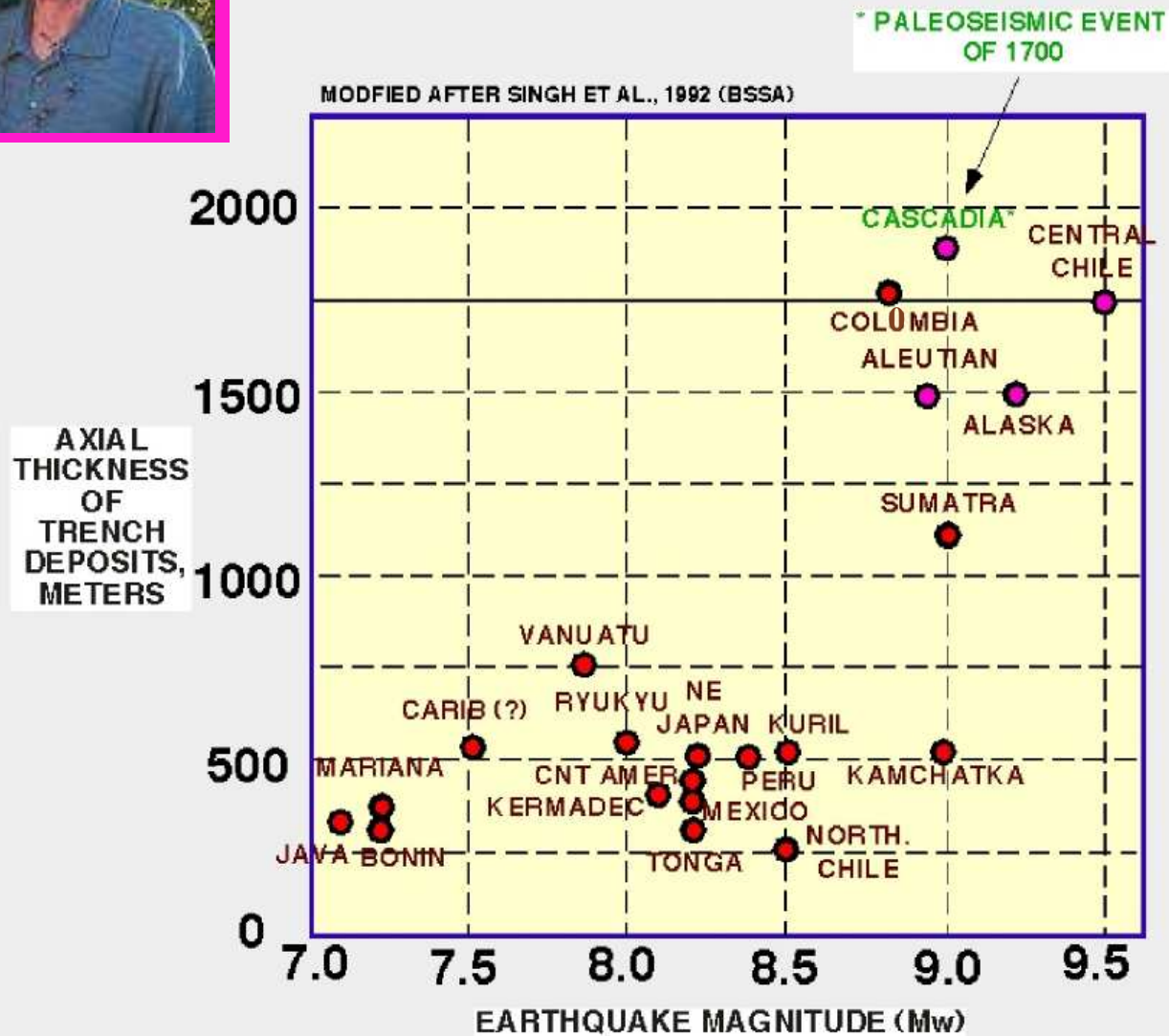
35%

Thick trench
sediments
lubricate interface
& allow rupture to
propagate long
distances, giving
 $M_w > 8.5$

Looks good, but



Another Suggestion [from D. Scholl] *in the Quest for WISDOM ?*



[D. Scholl, pers. comm., 2006, building on a suggestion by L.J. Ruff, 1985]

Thick trench
sediments
lubricate interface
& allow rupture to
propagate long
distances, giving
 $M_w > 8.5$

Looks good, but
easy to find
counterexamples

South Peru: 1868

$$M_w \approx 9.2$$

no sediments...

No. Chile Based on 1922

BUT 1877 ?

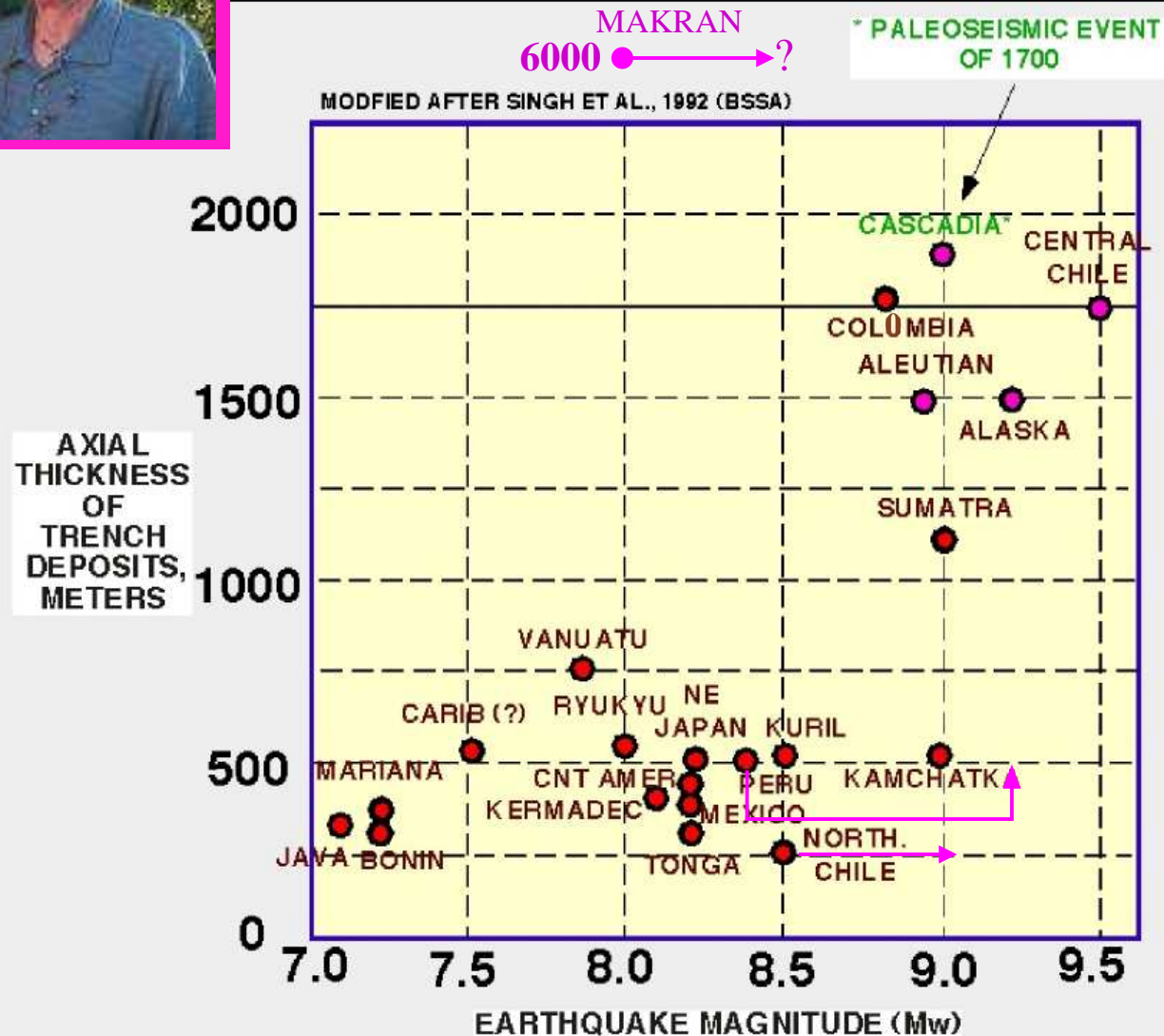
Makran

6000 m of sediments

Max **KNOWN** $M_w = 8$



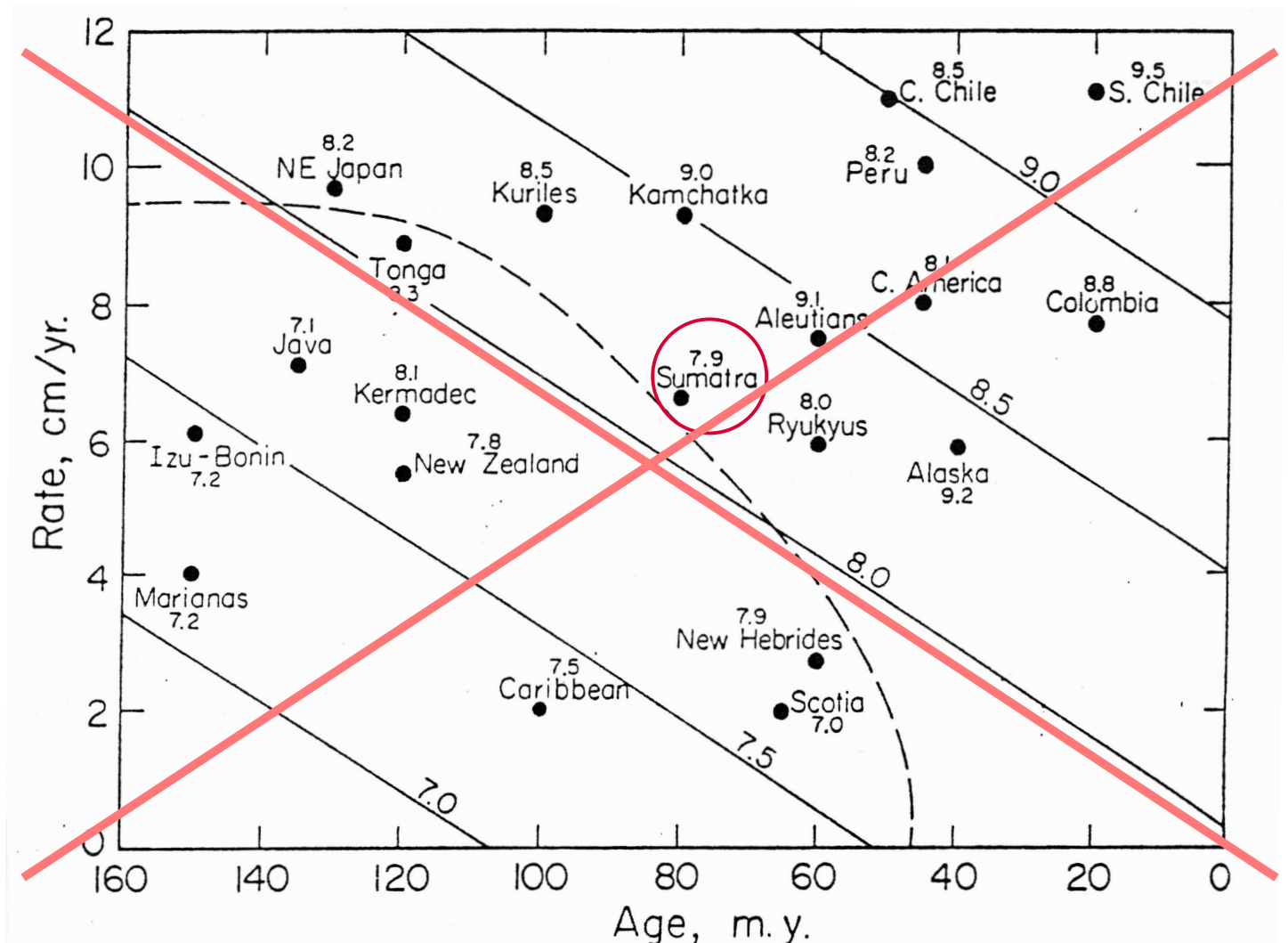
Another Suggestion [from D. Scholl] in the Quest for WISDOM ?



[D. Scholl, pers. comm., 2006, building on a suggestion by L.J. Ruff, 1985]

HARSH LESSON in TECTONICS from SUMATRA EVENT

Mega-earthquakes DO occur in unsuspected areas !



So, have we become...

Humbler : CERTAINLY

Wiser : ???

We still have not devised the better



**IN THE MEAN TIME, WE SHOULD CONSIDER
ALL LONG SUBDUCTION ZONES
AS POTENTIALLY MEGA-GENIC**

THE QUEST FOR A BETTER

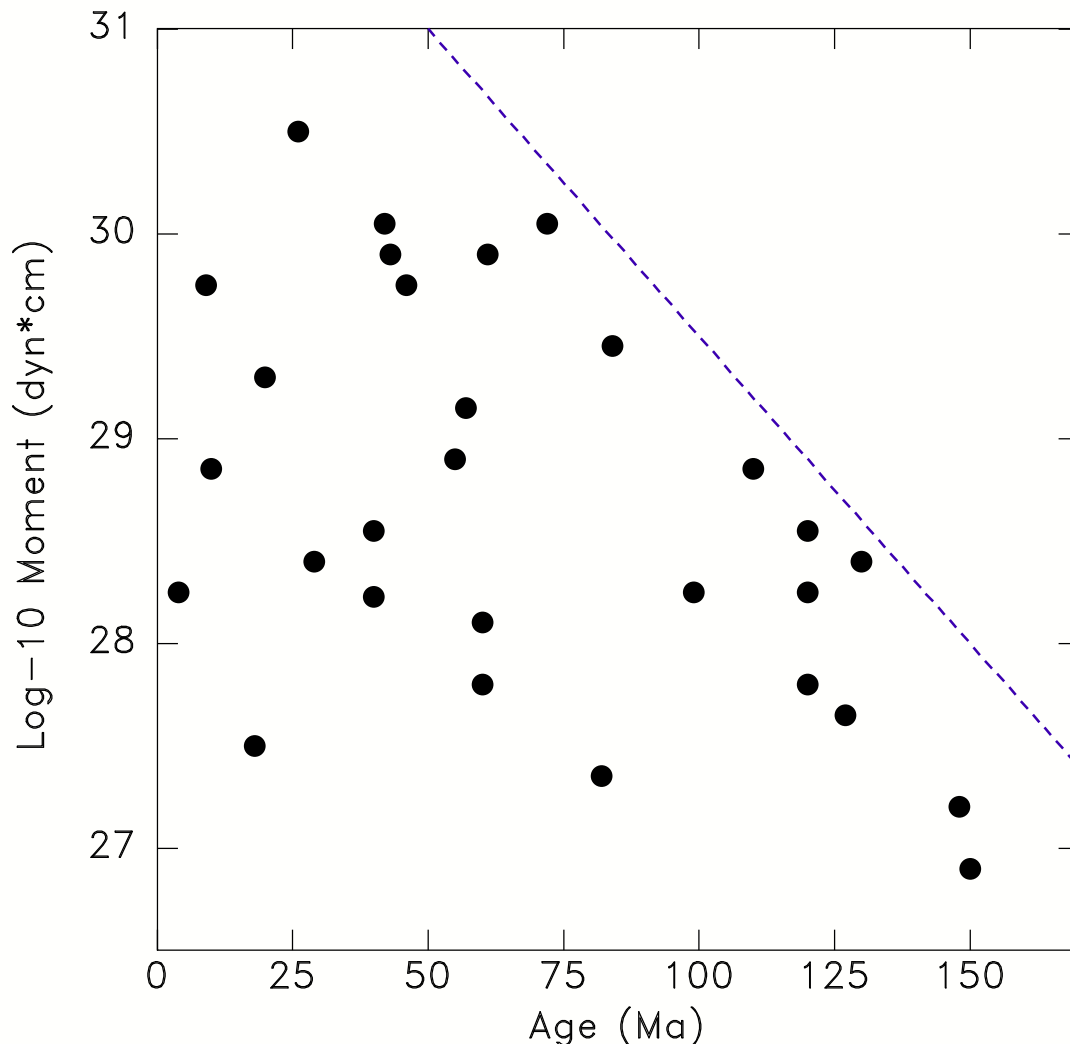


- One idea would be to throw out of the Kanamori-Ruff diagram all the contribution of *Rates*, keeping only *Ages*.

*This approach strongly suggests that
MEGA EVENTS EXIST ONLY IN YOUNG PLATES*

- Maximum moment could be given by

$$\log_{10} [M_0]_{\max} = 31 + 0.03 * (50 - A)$$

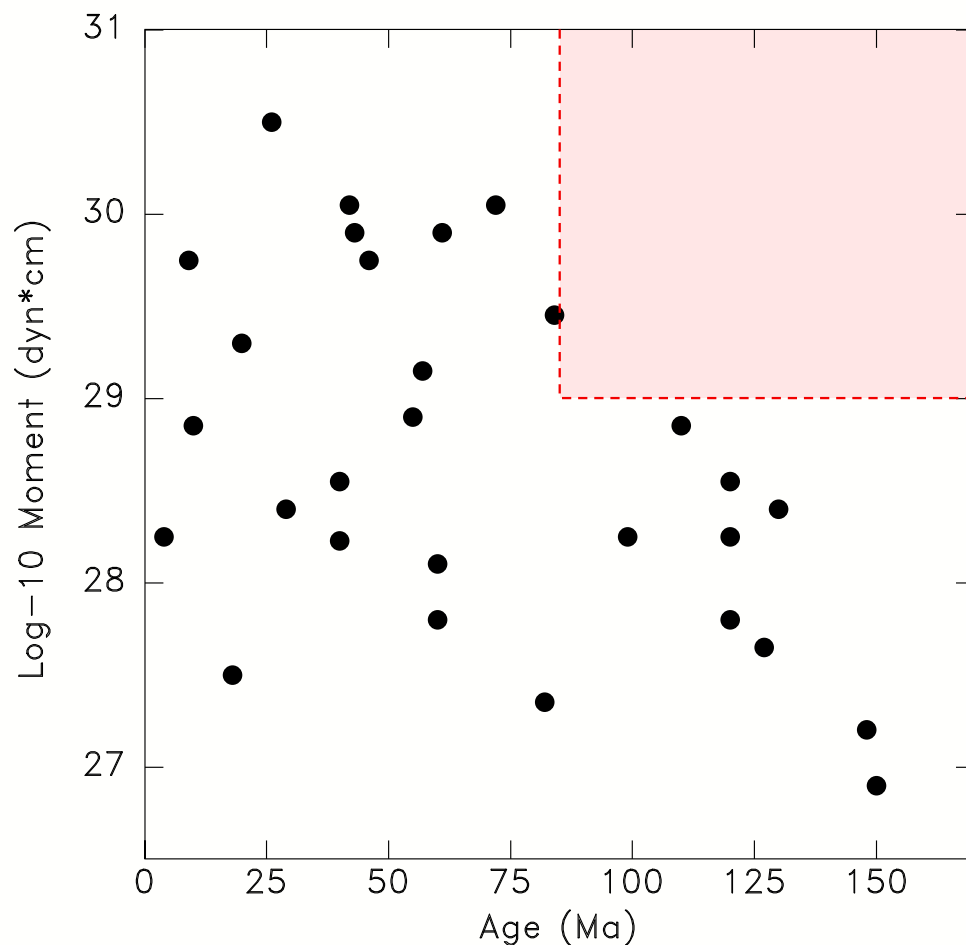


THE QUEST FOR A BETTER



→ Another interpretation of the same dataset could be that

*MEGA EVENTS ($M_0 > 10^{29}$ dyn*cm)
ARE LIMITED TO AGES LESS THAN 85 Ma*



→ *This suggests a kind of "wilting" age for the oceanic lithosphere, which after 85 Ma, cannot [pro-]create Mega-Earthquakes.*

~~εμμηνοπαυση~~

λιθοπαυση ?

- It is remarkable that this age (85 Ma) is also that beyond which the simple half-space thermal model no longer applies.

W Phase

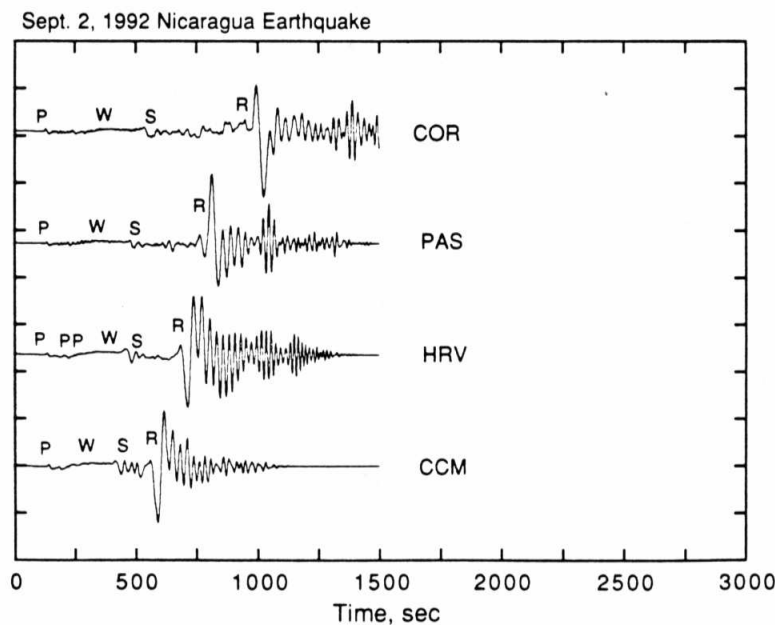
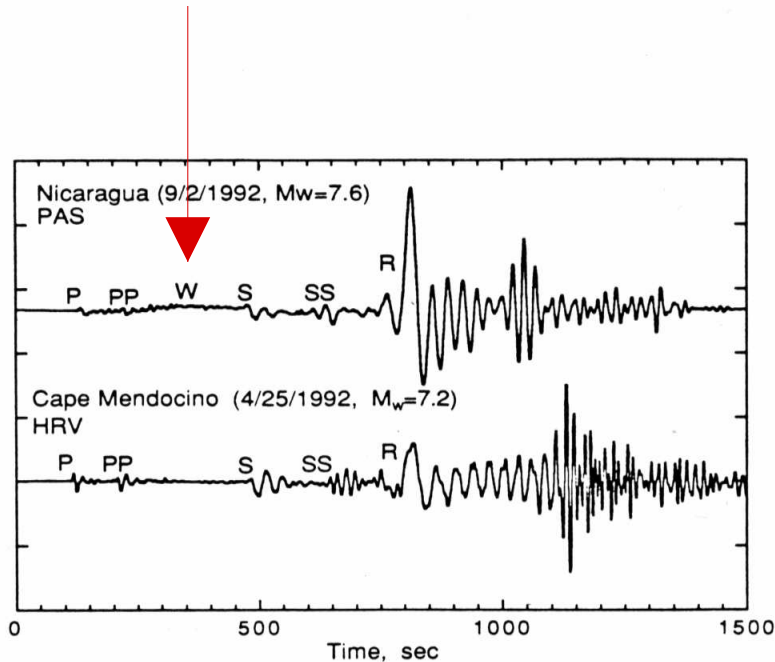
A +

W as in... ~~Whisky~~ **WISDOM**

*** *Dean's List* ***

[*Kanamori et al., 2008*]

Geophysical
Research
Letters



[*Kanamori, 1993*]

AUGUST 20, 1993

Volume 20 Number 16

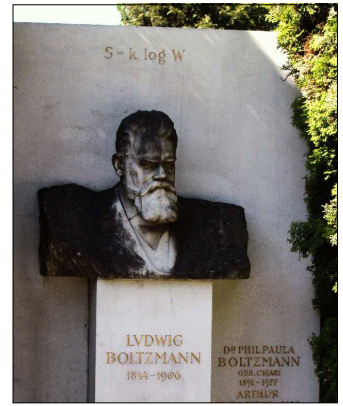
AMERICAN GEOPHYSICAL UNION

DEVELOPMENTS SINCE 2004

- Many meetings, committees, symposia, workshops, etc.



A view of guests and participants of the workshop



$$S = k \cdot \log W$$



NOTE: A remarkable number of individuals self-appointed themselves as "Tsunami Experts" on 27 or 28 December 2004...

- Tsunami courses**

Given, mostly under UNESCO funding, to researchers and front-line technicians from developing countries

The Oostende course of June 2006



Australia, Indonesia, India, Madagascar, Oman, Mauritius, Seychelles, Germany, Kenya, Tanzania, Greece, Thailand, Sri Lanka, Somalia, Pakistan and Japan.



The Tehran course of May 2010

POST-SUMATRA: EXPANDING WARNING CENTERS

- *Immediately* (Early 2005)

PTWC chartered to cover Indian Ocean

ATWC given responsibility over Caribbean



- Australia establishes Tsunami Warning Center

Seismology detection at G.A. (Canberra)
Real-time Simulation at B.M. (Melbourne)

Operational, Late 2007 Cost: AUD 70 million



Image courtesy of Geoscience Australia



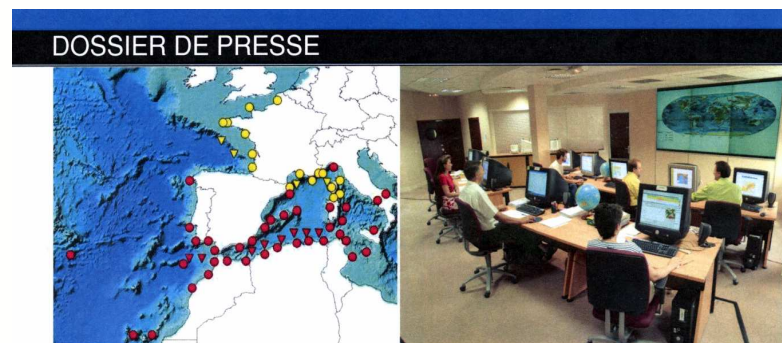
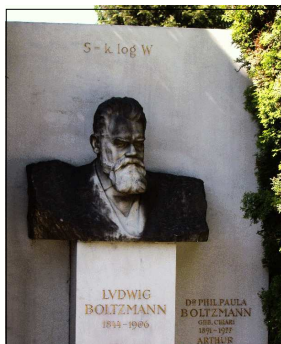
Image courtesy of the Bureau of Meteorology

- Indian Ocean
Nations keep meeting and discussing Regional Center
- Mediterranean and Atlantic Ocean
Nations keep meeting and discussing Regional Center

→ **2009: France embarks on building a Warning Center for NE Atlantic and Western Mediterranean;**
Operational ≈ 2012.



?



Création d'un Centre d'alerte aux tsunamis pour l'Atlantique nord-est et la Méditerranée occidentale

9 octobre 2009

\$ \$ \$ = WISDOM ? ?

TSUNAMI WARNING AND EDUCATION ACT

Public Law 109-424
109th Congress

An Act

Dec. 20, 2006
[H.R. 1674]

To authorize and strengthen the tsunami detection, forecast, warning, and mitigation program of the National Oceanic and Atmospheric Administration, to be carried out by the National Weather Service, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

Tsunami
Warning and
Education Act.
33 USC 3201
note.

SECTION 1. SHORT TITLE.

This Act may be cited as the "Tsunami Warning and Education Act".

SEC. 8. AUTHORIZATION OF APPROPRIATIONS.

There are authorized to be appropriated to the Administrator to carry out this Act—

(1) \$25,000,000 for fiscal year 2008, of which—

(A) not less than 27 percent of the amount appropriated shall be for the tsunami hazard mitigation program under section 5; and

(B) not less than 8 percent of the amount appropriated shall be for the tsunami research program under section 6;

(2) \$26,000,000 for fiscal year 2009, of which—

(A) not less than 27 percent of the amount appropriated shall be for the tsunami hazard mitigation program under section 5; and

(B) not less than 8 percent of the amount appropriated shall be for the tsunami research program under section 6;

(3) \$27,000,000 for fiscal year 2010, of which—

(A) not less than 27 percent of the amount appropriated shall be for the tsunami hazard mitigation program under section 5; and

(B) not less than 8 percent of the amount appropriated shall be for the tsunami research program under section 6;

(4) \$28,000,000 for fiscal year 2011, of which—

(A) not less than 27 percent of the amount appropriated shall be for the tsunami hazard mitigation program under section 5; and

(B) not less than 8 percent of the amount appropriated shall be for the tsunami research program under section 6; and

(5) \$29,000,000 for fiscal year 2012, of which—

(A) not less than 27 percent of the amount appropriated shall be for the tsunami hazard mitigation program under section 5; and

(B) not less than 8 percent of the amount appropriated shall be for the tsunami research program under section 6.

Approved December 20, 2006.

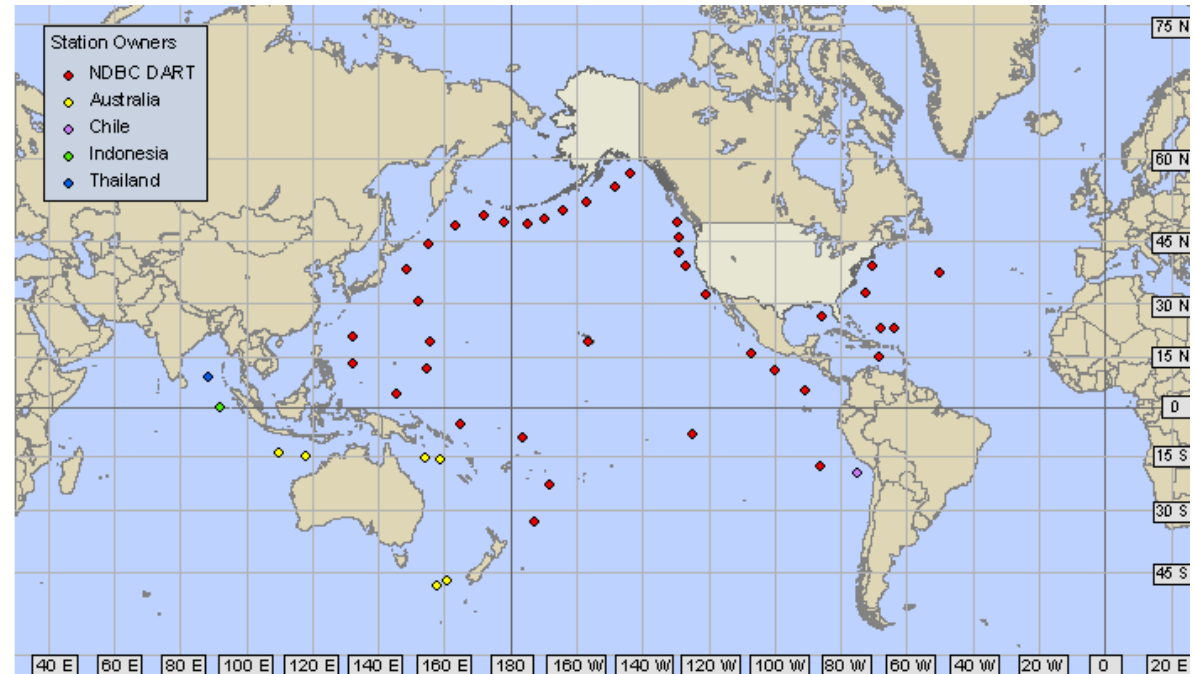
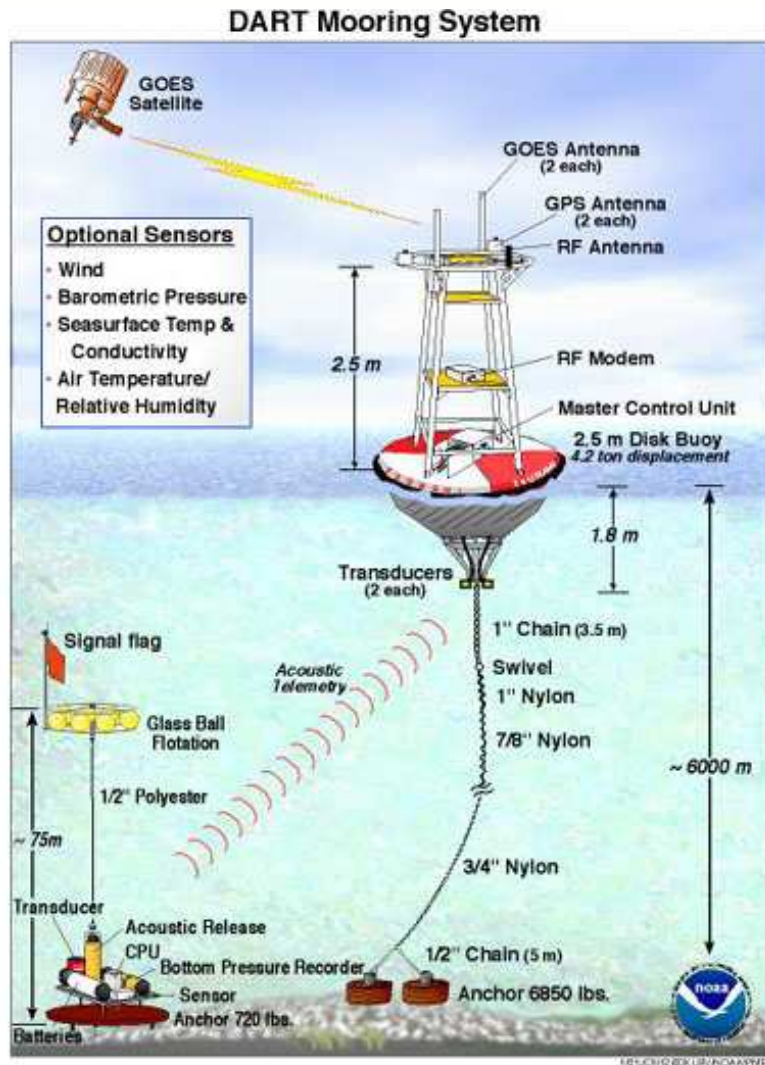
Total Appropriation: \$135 million over 5 years

DEVELOPMENTS SINCE 2004 (ctd.)

- Funded by PL 109-424: Enhancement of DART Buoy Network

2004: 6 instruments

2008: 39 instruments



Note: Maintenance Issues

→ During 2010 Chile event, critical buoys (and maregraphs) were out of commission

- Other systems deployed, many of them International
Seismic networks
DART clones
GPS networks

ON THE ROAD TO WISDOM... TSUNAMI DRILLS

Crescent City, California, 24 March 2010

~ 300 people responded out of several thousand....

- Excellent response from Law Enforcement, Civil Defense, *SCHOOLS*



- *Inertia from people in position of private responsibility (e.g., Motel Manager)*

TSUNAMI DRILL IS TODAY

Tsunami Evacuation Map
Crescent City, CA

Evacuation Zone Assembly Point
Safe Ground Evacuation Route

Here is the Crescent City evacuation map. To see maps for Smith River, Fort Dick and Klamath, go to co.del-norte.ca.us

The day to evacuate

By Nick Grube
Triplicate staff writer

A first-ever county-wide "live code" tsunami evacuation drill will take place this morning starting shortly after 10 a.m.

Local, state and federal agencies will participate in the drill, and officials are asking anyone who lives in a tsunami inundation zone, whether it's in Crescent City, Klamath, Fort Dick or Smith River, to take part as well.

"I think we're about ready," Del Norte County Emergency Services Manager Cindy Henderson said.

Tuesday, "As long as it's good weather I think we'll have a really good turnout."

The drill will begin when the National Weather Service activates the Emergency Alert System, sending a message to television stations, radio stations and National Oceanic and Atmospheric Administration weather radios, that states there is a tsunami warning in Del Norte, Humboldt and Mendocino Counties. This signal will also trigger tsunami sirens throughout the Del Norte County.

When people in inundation zones receive the notification, either through their televisions, radios or from the sirens, they are asked to voluntarily evacuate to designated safe zones within 10-15 minutes.

While Henderson said there will be checkpoints set up for people to help officials gauge the success of the evacuation drill, she

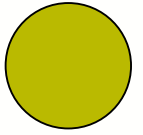
See DRILL, A3

POST-SUMATRA TSUNAMIS

Have We Become Wiser ?

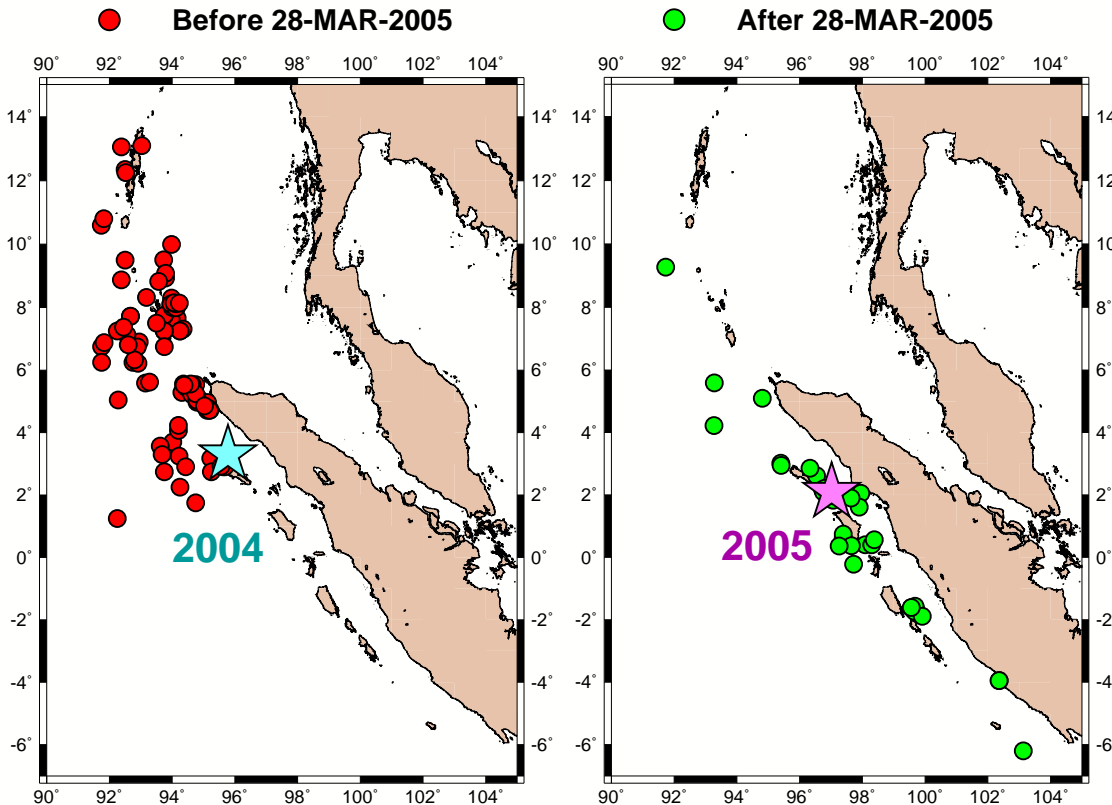
- We now examine significant tsunamis since 2004, from the standpoint of the performance of the warning centers, and of the response of the populations at risk.
- In this context, we assign to each event a **color-coded** report card, from *Gold* (Excellent) and *Green* (Very good) through *Olive* (Good), *Yellow* (Average), *Orange* (Mediocre), to *Red* (Bad) and *Black* (Disastrous).
- The report card is not directly a function of the death toll in the tsunami, but rather, reflects on the various components of its mitigation.

NIAS (Sumatra), 28 MAR 2005, $M_0 = 1.0 \times 10^{29}$ dyn*cm



Would be Largest Event since 1965 Rat Island, but for 2004 Sumatra earthquake...

**28-MAR-2005 (SUMATRA-II) EARTHQUAKE PREDICTED ON THE BASIS
of STRESS TRANSFER by McCLOSKEY *et al.* [Nature, 17 MAR 2005].**



In the far field, general warning issued throughout Indian Ocean Basin, followed by [night-time] evacuation.

At least 10 people killed in Sri Lanka and 6 in Madagascar during evacuation

YET, NO DETECTABLE FAR-FIELD TSUNAMI... WHY ?

- Local tsunami with significant damage and run-up to 8 m

Only 8 local fatalities



Residents were

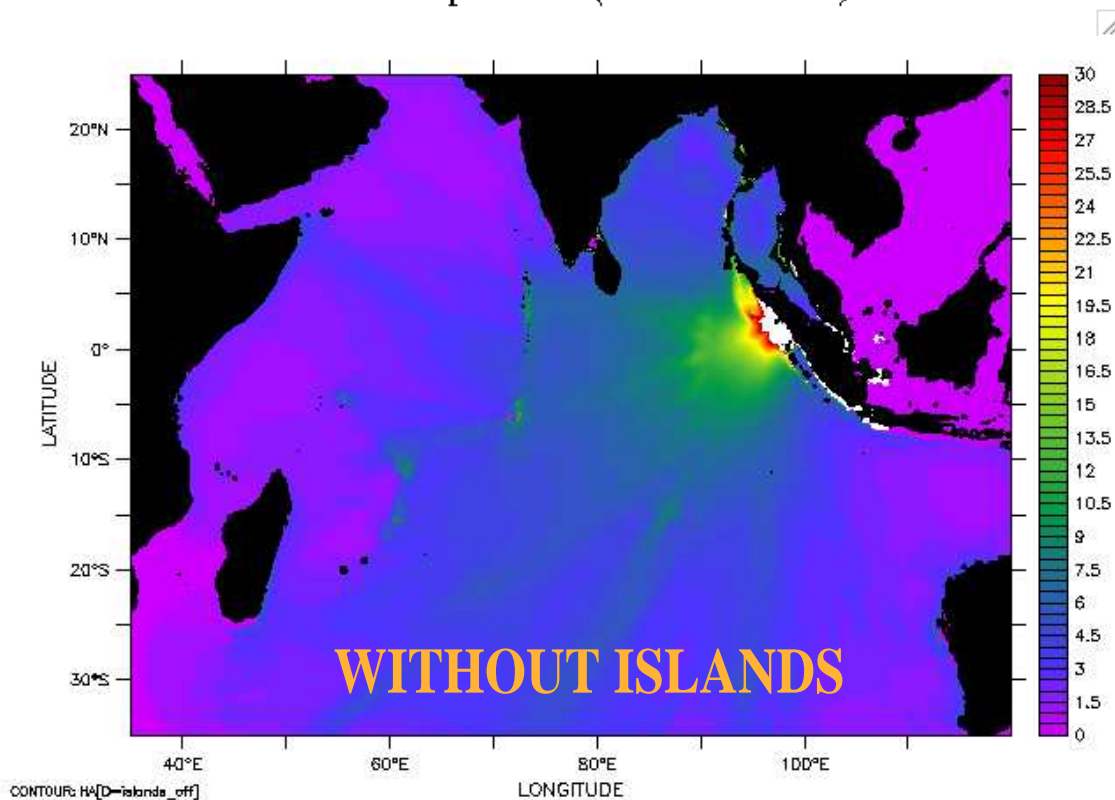
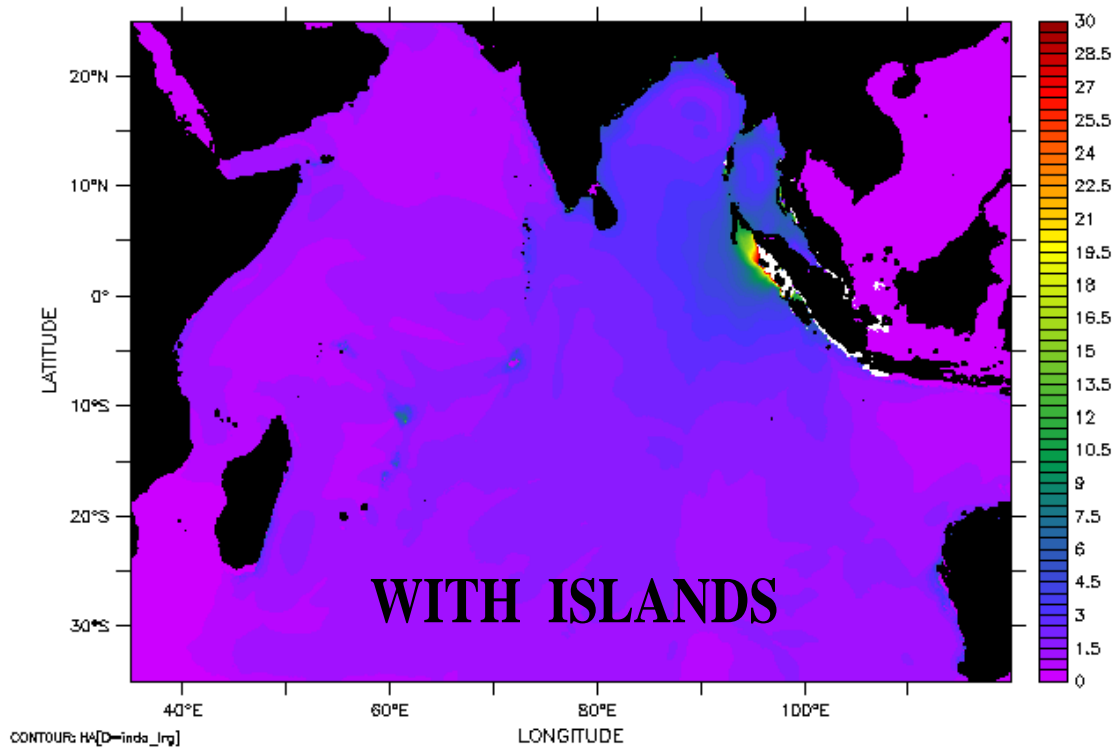
- * *Educated through ancestral tradition (SMONG)*
- * *Sensitized to tsunami by 2004 Sumatra event*
- * *[Temporarily] relocated to higher ground following Sumatra disaster*

WHY NO FAR-FIELD TSUNAMI on 28-MAR-2005 ?

Source area has much shallower bathymetry, including large islands

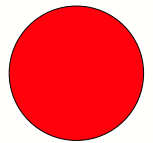
Green's Law [1837]: Amplitude Falters when Transitioning to Deep Water.

Compare simulations



[Synolakis and Arcas, 2005]

JAVA, 17-JUL-2006

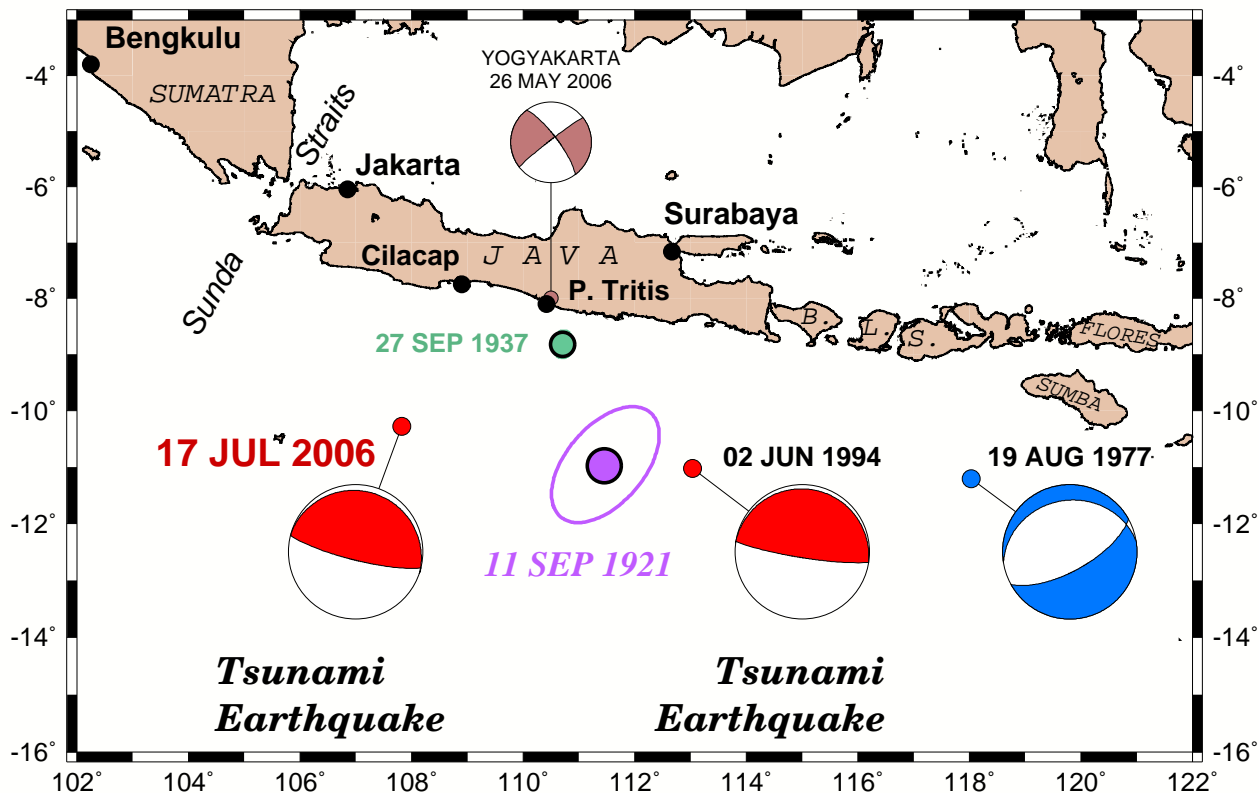


$$M_0 = 4.6 \times 10^{27} \text{ dyn*cm} \quad \text{Slow event, } \Theta = -6.13$$

Typical "Tsunami Earthquake"; — 700 killed by tsunami

Carbon copy of 1994 event, 600 km to the East

T.E. : Event whose tsunami is stronger than suggested by its seismic magnitudes [Kanamori, 1972].



This event suggests that *"tsunami earthquakes"* could feature a regional character.

Question: Does this exclude the danger of a subduction mega-thrust earthquake in Java ?

- * What is the role of the 1921 shock (contrary to the T.E.s, strongly felt, but with benign tsunami)?



17-JUL-2006 JAVA TSUNAMI

Warning and Arrival Timeline (GMT)

08:19 H_0

08:20 BMG (Indonesia): Notes "**non-typical earthquake**"

08:36 PTWC : Watch for Indonesia and Australia

" EVALUATION

A DESTRUCTIVE WIDESPREAD TSUNAMI THREAT
**DOES NOT EXIST BASED ON HISTORICAL
EARTHQUAKE AND TSUNAMI DATA. "**

08:40 *Tsunami arrives at Pangandaran, **Second wave reaches 5 m***

08:46 JMA : Tsunami watch for all Sunda Islands

08:49 – 09:14 : *Tsunami reaches all Southern coast of Java*
Run-up to 21 m; 700 casualties

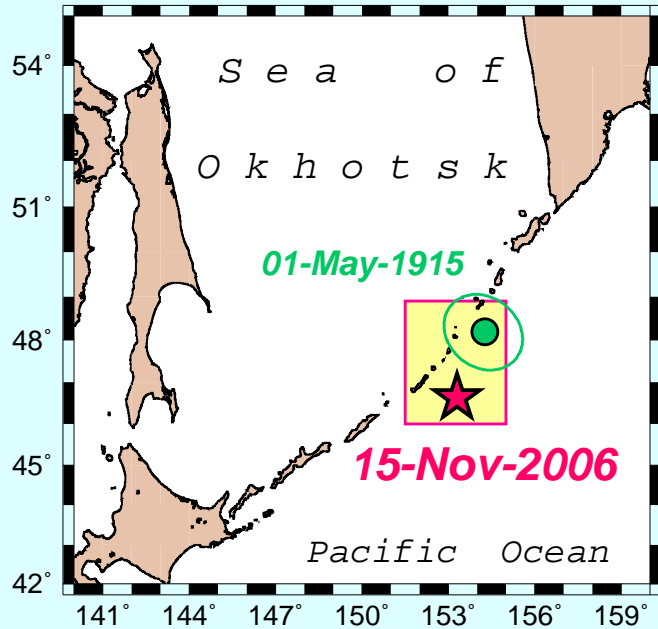
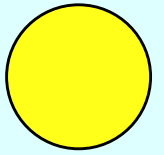
VERDICT:

Despite Recognition of anomalous character by BMG and history of "Tsunami Earthquake" in the region in 1994, **no Warning issued !**

*No data available from New Networks
(Seismic and GPS)...*



SIMUSHIR (Central Kuril Is.) – 15 NOVEMBER 2006



$$M_0 = 3.5 \times 10^{28} \text{ dyn*cm}$$

First large earthquake in the Central Kurils since 1915.

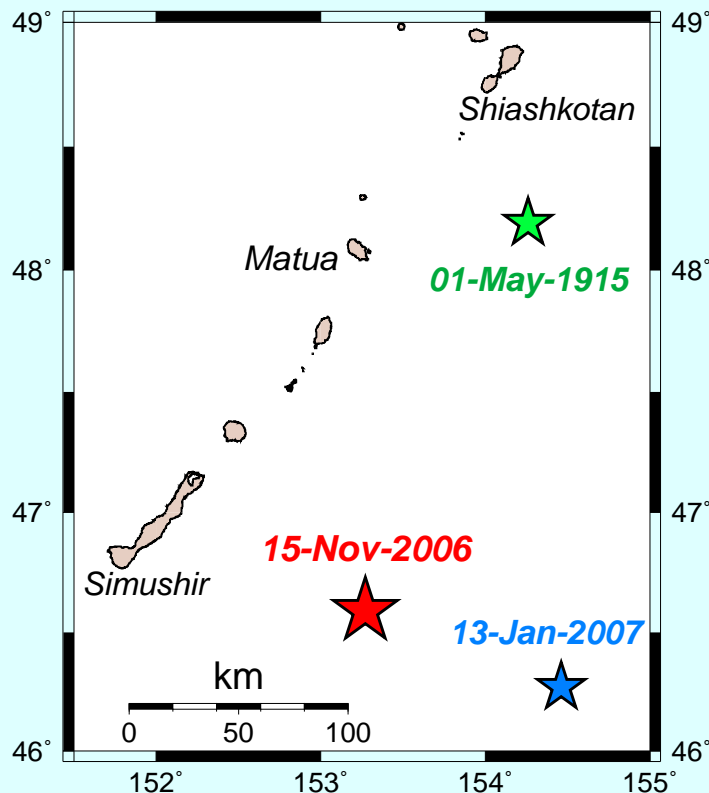
The event is not *slow*, but may be *delayed* (as for Peru, 2001).

Local effects surveyed in Summer, 2007.



[courtesy J. Bourgeois and M. Nikula, U. Wash.]

**Matua I.
(12 km long)**



Run-up reaches 10 m in Simushir (Dushnaya Bay) and up to **15–20 m on Matua.**

The latter figures are higher than expected, and could result from local topography (bays, cliffs) or localized landslides.

Fortunately, these islands are presently unpopulated (even by bears...).



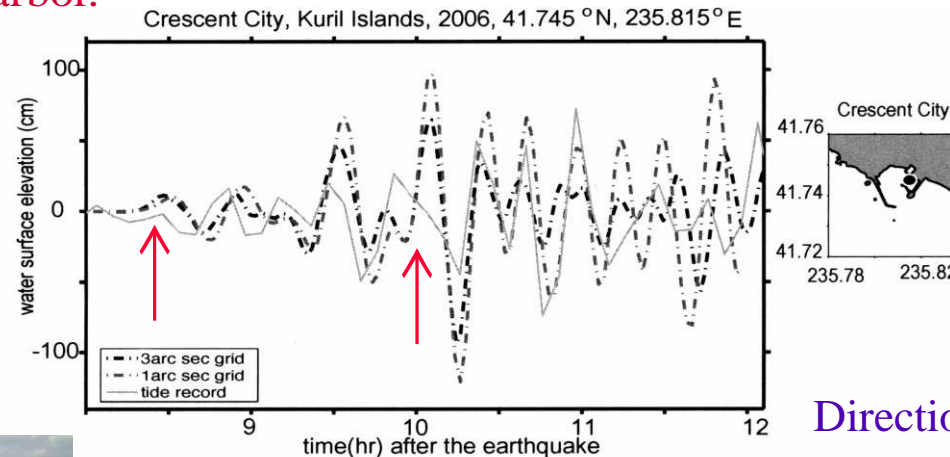
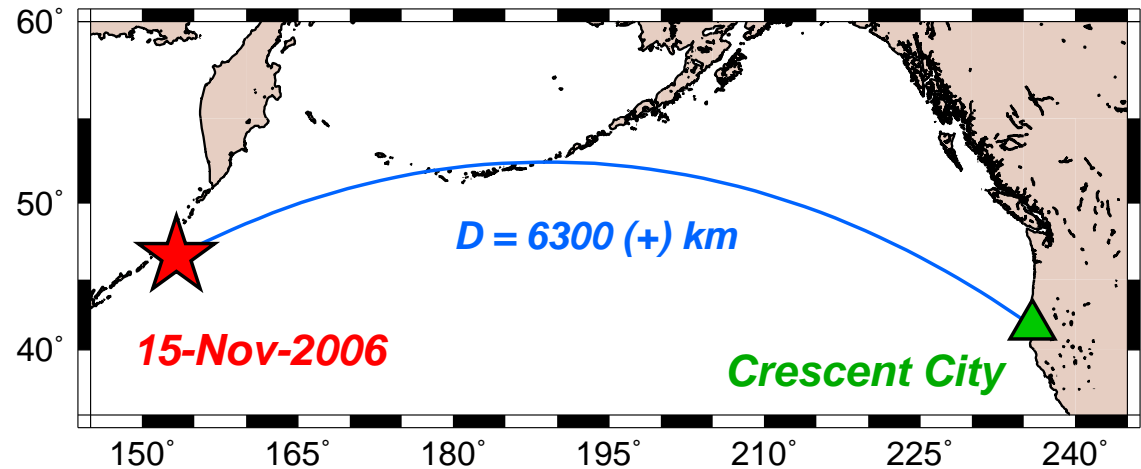
*Tsunami watermarks
on Matua*



2006 KURIL TSUNAMI DID SIGNIFICANT DAMAGE

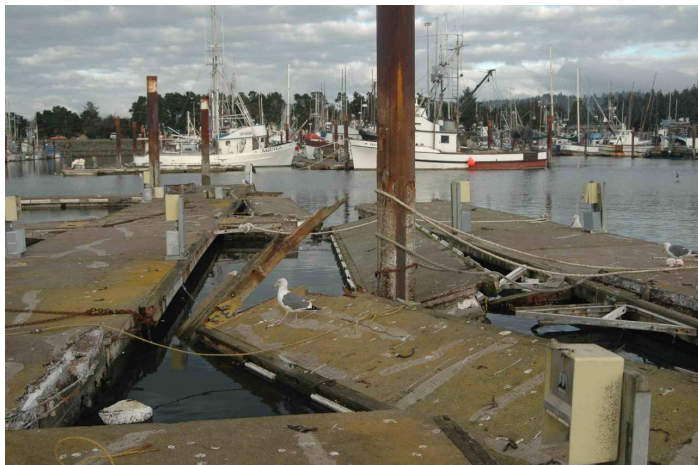
in CRESCENT CITY, California

- Harbor struck 8.5 hours after seismic O.T.
- Damage up to US\$ 9 million.
- Wave height reached 1.7 m (pk-to-pk) on local tide gauge
- Damage resulting from (i) beaming of some tsunami energy towards Northern California; (ii) non-linear amplification by bay and harbor.



[Dengler et al., 2008; 2009]

Damage to docks in harbor

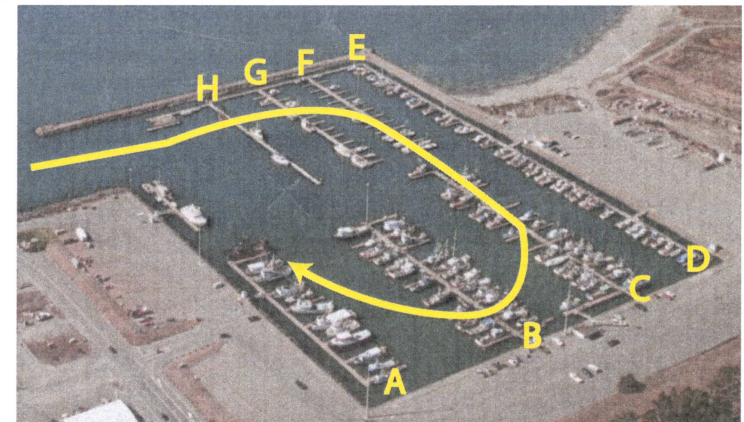


Tidal gauge record

[Uslu, 2007]

Docks H, G, F
severely damaged

Direction of flow into harbor



15-NOV-2006 KURIL Is. TSUNAMI

Warning and Arrival Timeline (GMT)

11:14 H_0

11:30 *PTWC* : Warning for Russia and Japan

11:31 *ATWC*: No warning for US West Coast

12:13 *ATWC* : Tsunami watch for Alaska
Repeats No Watch of Warning for US West Coast

12:14 *PTWC* : Tsunami watch for Pacific Basin

12:46 to 14:09 *ATWC*: Repeats No watch or Warning for US West Coast

14:41 *ATWC* : Tsunami watch canceled for Alaska

14:58 *PTWC* : Tsunami watch canceled for Pacific Basin

17:20 *Tsunami arrives in Hawaii;*
Minor local damage; one swimmer hurt

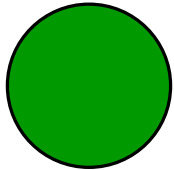
19:35 *Tsunami arrives in Crescent City*

21:30 *Largest waves hit Crescent City;*
Severe damage to
Small Boat Harbor

VERDICT:



SOLOMON Is., 01-APR-2007

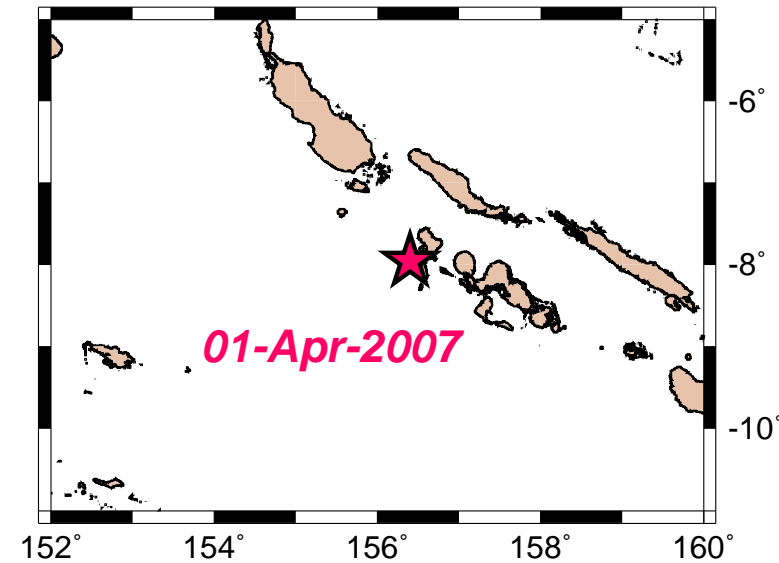


[The Miracle ?]

$$M_0 = 1.6 \times 10^{28} \text{ dyn*cm}$$

[Fritz & Kalligeris, 2007]

Local Tsunami, resulting in significant damage on several islands



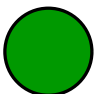
More than 6000 houses destroyed; **Only 52 dead or missing**



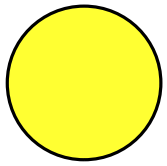
The community apparently had the reflex of *Self-Evacuation*

(probably conditioned by the memory of strong waves during a volcano-seismic swarm in the 1950s ?)

NOTE SIMILAR RESULTS on 03-JAN-2010



PISCO, Peru, 15 AUG 2007, $M_0 = 1.1 \times 10^{28}$ dyn*cm



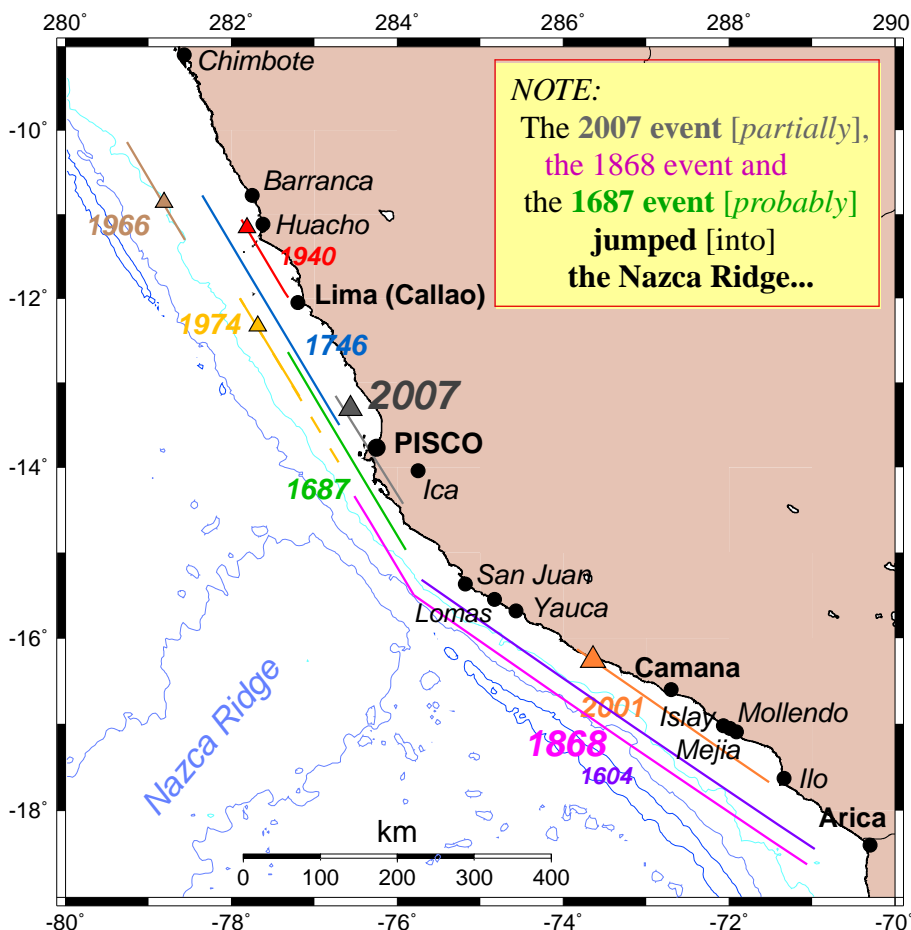
- Damaging Earthquake, which destroyed the city of Pisco (514 dead)
- Yet, much smaller than previous events in Central Peru (1687, 1746)
- Significant local tsunami with run-up of 5 m, locally 8–10 m
- Most shore locations successfully evacuated through community-based program using "sergeants" directing residents to shelters built out of harm's way.

• *EXCEPT...*

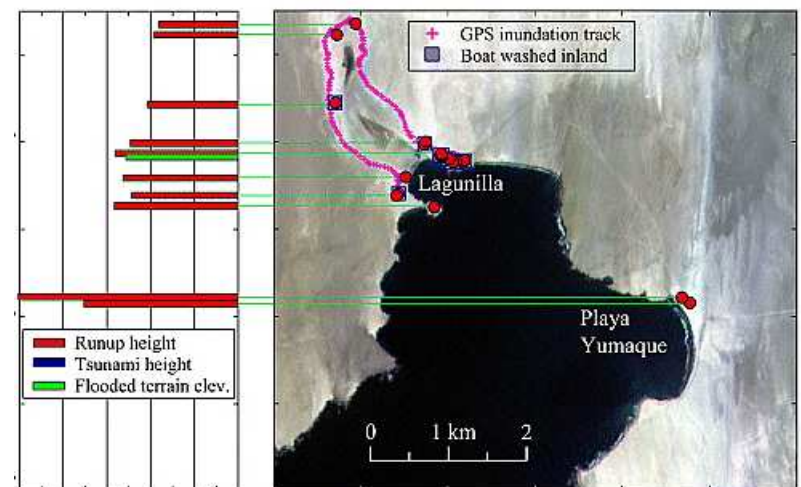
in **Lagunilla** (Southern coast of Paracas Peninsula), where tsunami ran up to 10 m, penetrating 1 km inland and **killing 3 people**.



[Fritz et al., 2008]



NOTE:
The 2007 event [partially],
the 1868 event and
the 1687 event [probably]
jumped [into]
the Nazca Ridge...



This omission in an otherwise successful program is unexplained and unacceptable.

12 SEP 2007 BENGKULU (I)



$$M_0 = 6.7 \times 10^{28} \text{ dyn*cm}$$

*[Then] Third-largest event ever in the Global CMT catalogue
[after Sumatra 2004 and Nias 2005]*

- Yet,
- Relatively low death toll (25 killed by earthquake)
 - Relatively small tsunami

Recorded on maregraph at maximum 1 m in Padang
15 cm on Cocos Islands (1100 km)
Negligible elsewhere

Tsunami damage contained in near field

NO TSUNAMI DEATHS ...

Event Earns a Gold Star !



BENGKULU, 12 SEP 2007 SURVEY HIGHLIGHTS



LAIS



Tsunami Flow
Direction

~2.0 m, 80 m inundation

Large debris scattered
across beach and into
forest



South of
AIR RAMI

Houses Moved by Tsunami



Post- Tsunami Survey reveals that

***POPULATION SELF-EVACUATED
UPON
FEELING EARTHQUAKE,***

**thus preventing CASUALTIES despite
significant damage by tsunami**

***WILL POPULATION BE AS WISE
IN NEXT (BIG PADANG) EVENT ??***

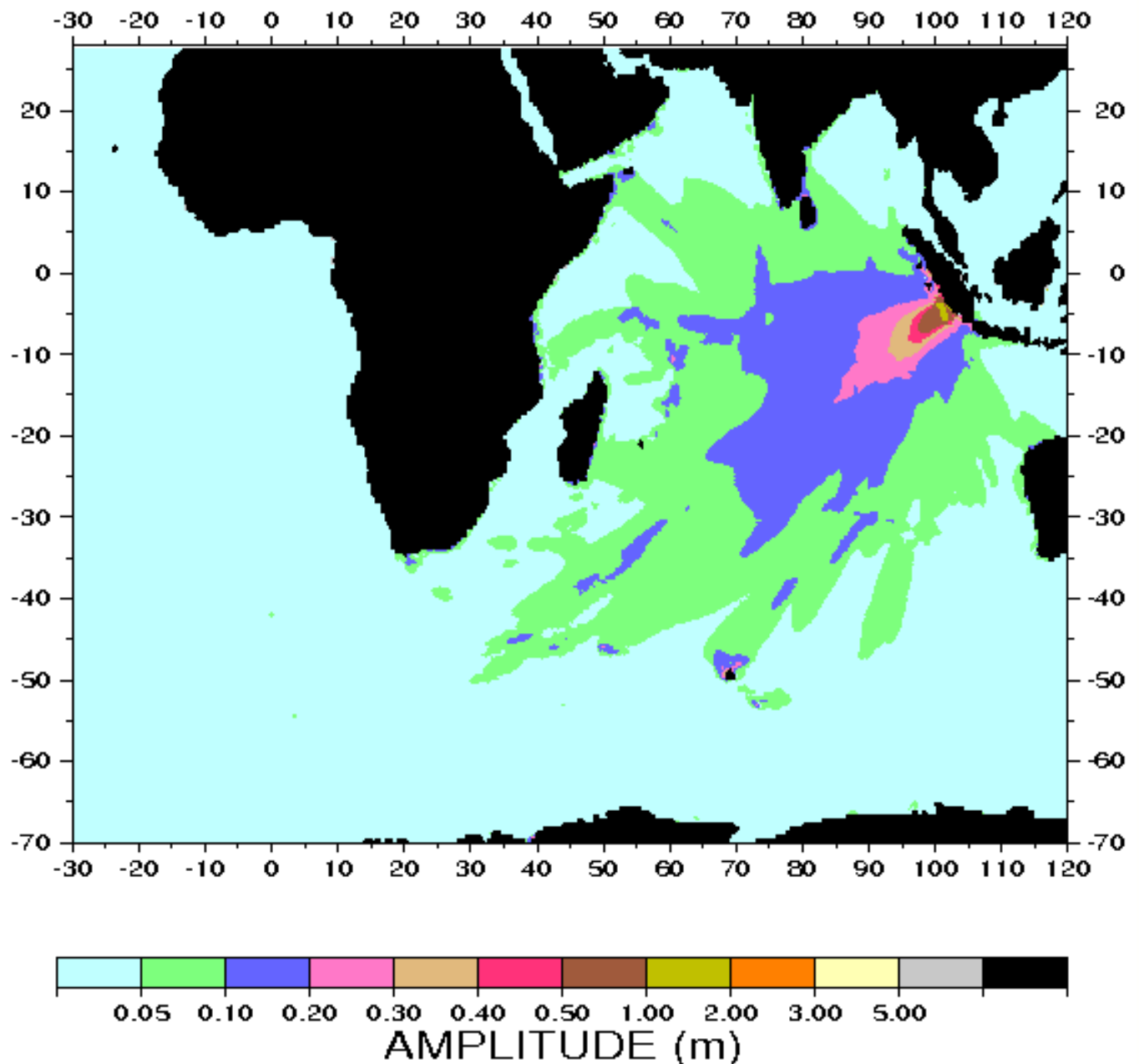
Event Earns a Gold Star !

12 SEP 2007; Bengkulu (I)

REAL-TIME SIMULATION and CUSTOMIZED WARNING

(Emile A. Okal)

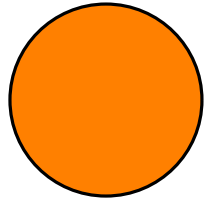
Based on an early estimate of M_0 (using the **Improved M_m** mantle magnitude algorithm), a tsunami simulation was performed in real-time, and the attached map of maximum expectable amplitude on the high seas forwarded to Dr. Chris J. Hartnady (Umvoto, Cape Town), who forwarded it to local S.A. civil defense authorities.



It was received in South Africa at 16:18 GMT (18:18 local time), 4.5 hours before the tsunami reached Port Elizabeth.

SAMOA, 29 SEP 2009

$$M_0 = 1.8 \times 10^{28} \text{ dyn*cm}$$



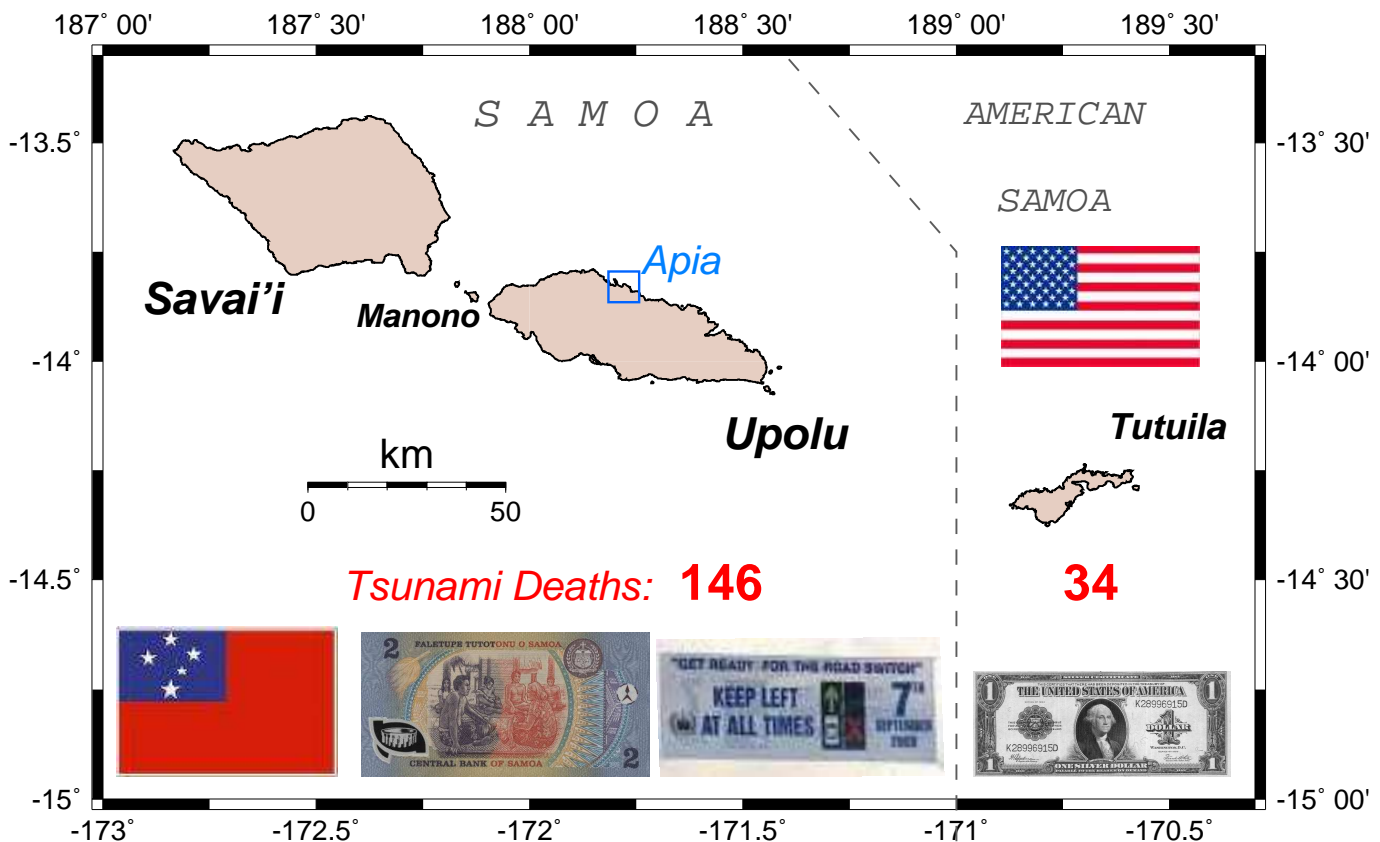
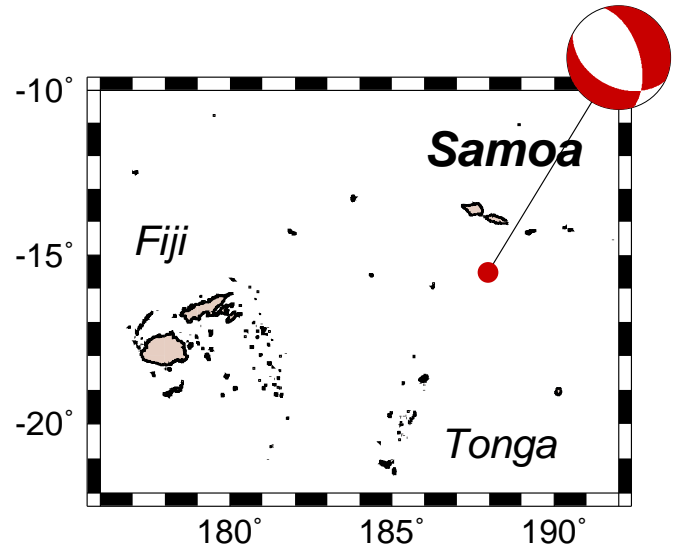
- First tsunami to cause substantial damage and many deaths **(34)** on U.S. soil (American Samoa) in **45 years**.

- Outer Rise Normal Faulting Event with probable predecessor in 1917.

- \$200 million damage (est.)

- 189 total deaths** in Samoa, American Samoa, Tonga.

29 SEP 2009



Epicenter 250 km to the South

Population: 179,000

Area: Savai'i: 1708 km² Upolu: 1125 km²

60,000

Tutuila: 200 km²

SAMOA, 2009: *Survey Results in American Samoa*

- Run-up to 17m in Poloa
- North Coast bays significantly affected (run-up to 12 m)
- Pago Pago harbor amplified waves (run-up to 9 m)



→ "Only"
34 fatalities

Thanks to :

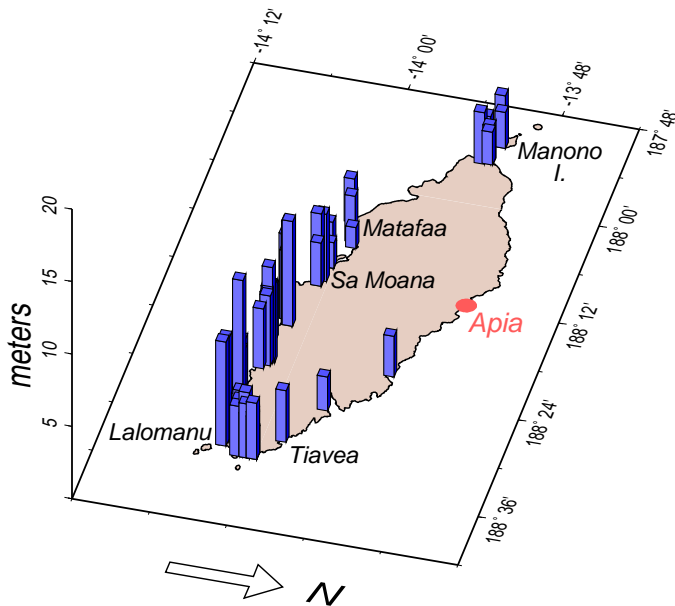
- * Signage Program
- * Self – Evacuation
- * Community–based Evacuation

Population **educated** and *Well prepared*

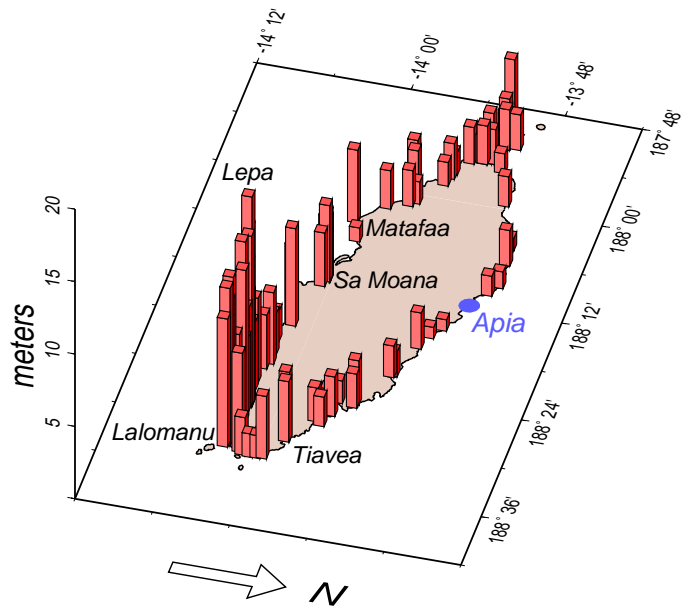


SAMOA, 2009: *Survey Results in Samoa (Upolu)*

Flow Depth



Run - Up



DEVASTATION AT LALOMANU

Run-up reached 11.4 meters, and inundation 250 m

- Run-up to **14.4 m** in Lepa
- Two villages eradicated
- North Coast
(with Capital, Apia)
largely spared



The village was totally eradicated, with **61 fatalities**

- **Higher Death Toll (146) than on Tutuila**

SAMOA 2009: Evacuation on UPOLU

- The population of Upolu was reasonably *aware* of the tsunami danger, despite the lack of ancestral memory.
- Evacuation *drills* had been conducted at *a number of* villages, but not everywhere.
- *No signage program on Upolu*



- In several areas, evacuation was hampered (with respect to Tutuila) by the need to travel longer distances, due to flatter terrain.
- Congestion trapped several victims in their cars.
- *The recent road switch could have instilled in the population the unfortunate perception of vehicles as a panacea to natural hazards.*

SAMOA 2009: *Results from Northern Tonga*

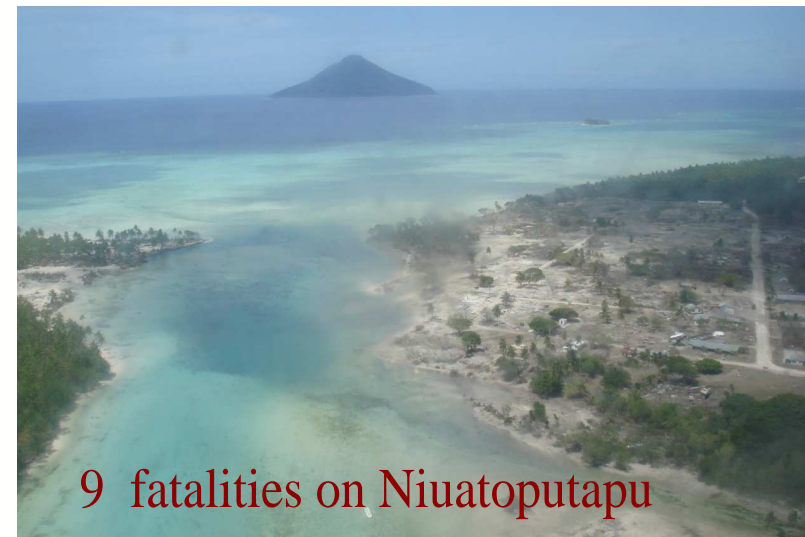
- Wave height to 16 m on East and South Beaches, Niuatoputapu



- Run-up to 22 m on Tafahi

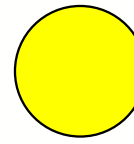


- Villages given relative protection by reef



- Most residents self-evacuated upon feeling the earthquake, *BUT...*
- Seven out of nine victims in pick-up truck driving parallel to coastline*

MAULE, Chile, 27 FEB 2010



- More than 200 victims killed by tsunami in Concepción and Constitución.

**Majority of population along Chilean coast self-evacuated, but
Many trapped camping on island in Rio Maule**

What could have been done better ? Note middle of the night

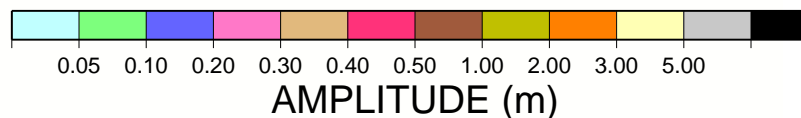
→ No local warning while tsunami took 34 minutes to reach Valparaíso.

- **Juan Fernandez Islands — at least 16 killed or missing. Run-up to 15 m.**

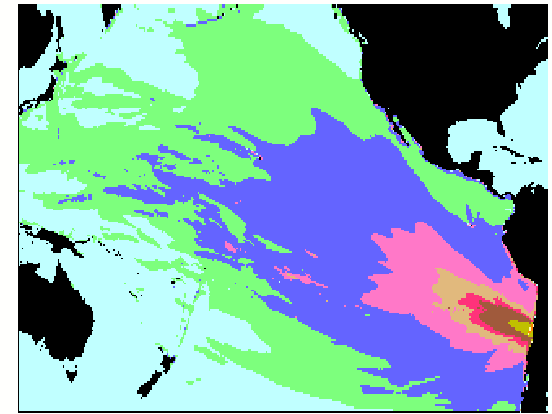
**Propagation time ~ 1 hour
No warning whatsoever**

- Transoceanic simulations largely correct, showing tsunami lobe between Hawaii and Tahiti, and accurately forecasting deep-water amplitudes (20 to 30 cm).
- Evacuations erred on side of caution, but largely successful. Run-up to 4 m in the Marquesas; no victims; only one boat sunk
- Lack of coordination between PMEL and PTWC
Conflicting reports from PTWC and ATWC
Several ocean sensors down
Erratic response in California

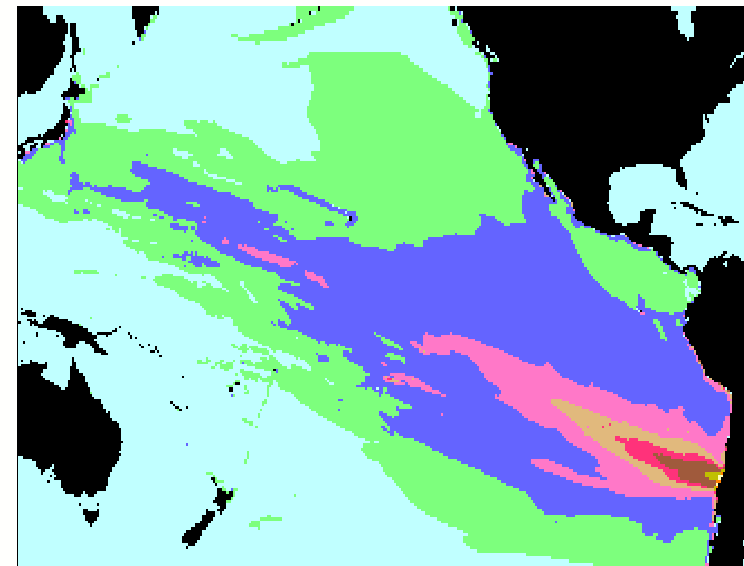
Bottom line: *YELLOW*



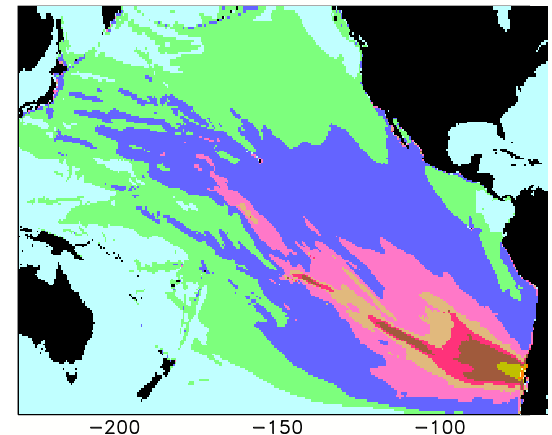
NORTHERN SOURCE



MAULE 27 FEB 2010



SOUTHERN SOURCE



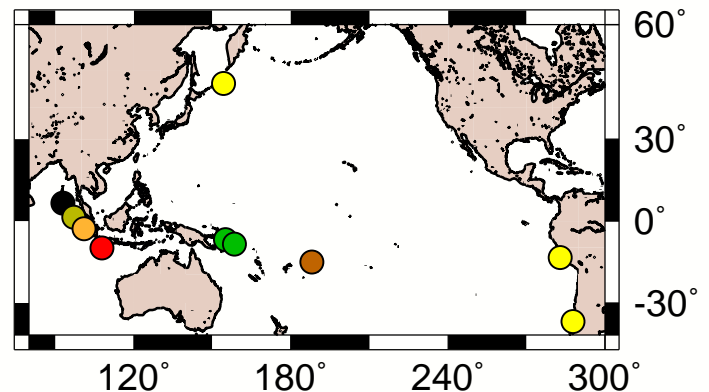
CONCLUSION: *Post-Sumatra: WISER ?*

- A "Mixed Bag", with **no evident trends**

- Still, stresses the value of Education

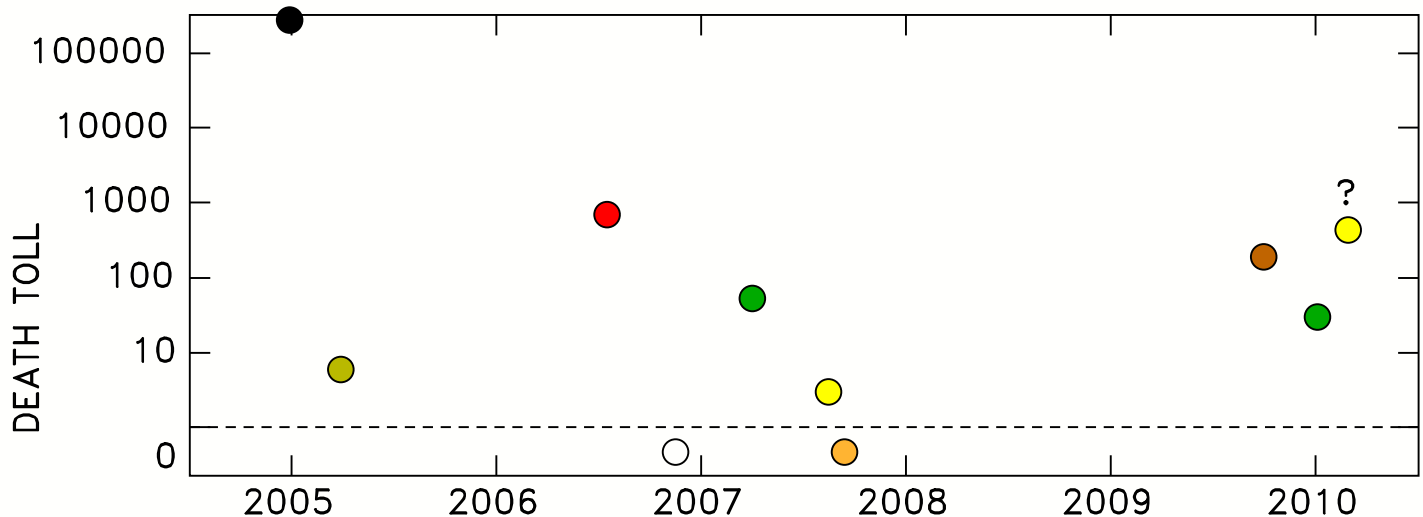
- *Indonesia: A Special Case*

One country, diverse results

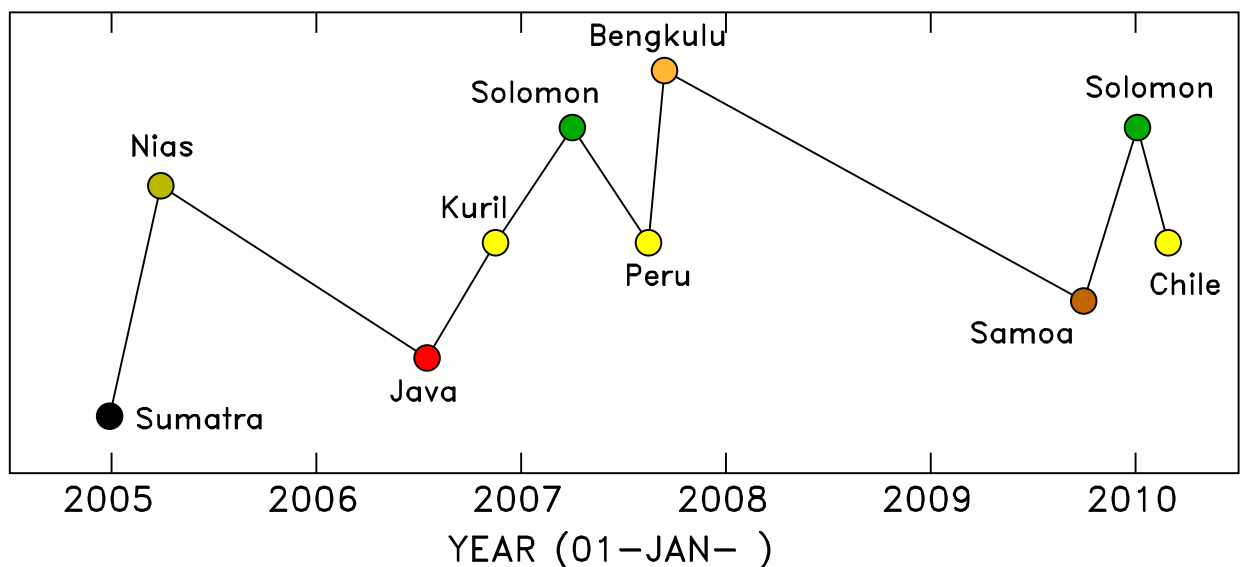


→ *Brace yourself for Padang, 20xx ...*

POST-SUMATRA TSUNAMI DEATHS



Gold
Green
Olive
Yellow
Orange
Red
Black



FINAL LESSONS

EDUCATION WORKS



C. Ruscher, Vanuatu, November 1999.

- The Moken people of the Surin Islands
- Little 10-year old English girl in Phuket
- Professor C.H. Chapman in Sri Lanka
- Japanese tourists in high-rise hotels

→ *Post-Sumatra Successes*: Nias (SMONG); Solomon (2 ×); Peru; Bengkulu; Maule [partially]

EDUCATION is NEEDED !



**DO NOT EXPLORE
EXPOSED BEACHES !!**



Sumatra Tsunami, Madagascar, 26 Dec. 2004

RUN TO SAFETY ON HIGHER GROUND !!

La Science est l'Asymptote de la Vérité



Victor Hugo