2004 Sumatra Earthquake and Tsunami Versus Cascadia Subduction Zone Models

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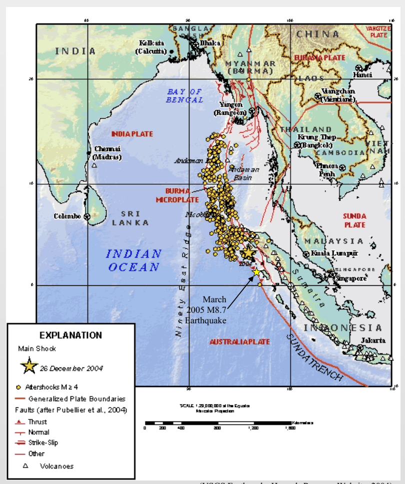
Abstract

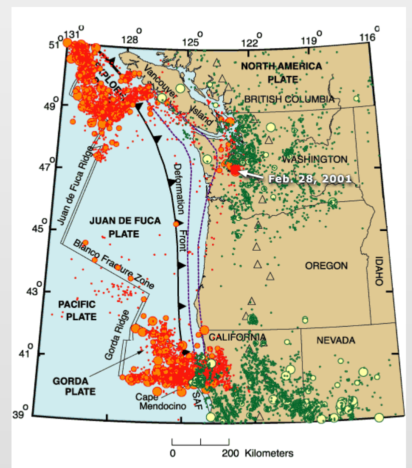
On December 26, 2004, a devastating earthquake initiated off the western coast of Sumatra, Indonesia, and propagated roughly 1200 km to the north. This earthquake created seismic and tsunami waves that affected people who live around the entire Indian Ocean region. The Sumatra-Nicobar-Andaman Earthquake (Sumatra Earthquake) had a moment magnitude of Mw9 (or possibly higher), making it one of the largest earthquakes ever recorded. The most severe damage occurred in low-lying coastal regions of Indonesia, Thailand, Sri Lanka and India. The tsunami destroyed much of what lay in its path and resulted in an international human tragedy with an estimated one-quarter million deaths or more. This poster compares the 2004 Sumatra earthquake and tsunami with the Cascadia Subduction Zone. Comparisons between plate tectonic settings, recent earthquakes, probabilistic ground motions, and damage and loss (actual for Sumatra versus projected for Cascadia) are provided. There is a section on damage patterns noted in Thailand. It concludes with some of the lessons learned from the 2004 Sumatra earthquake and tsunami and future science and policy actions items. Findings indicate that structures and lifelines should require modern engineering design and construction, including tsunami-resistant buildings (at least for more important structures), tsunami education for communities, and regional tsunami warning systems.

I. Sumatra Earthquake Versus Cascadia Subduction Zone



(USGS Earthquake Hazards Program Website, 2004)

Indian Ocean Subduction Zone Setting and Recent Earthquakes



(USGS Earthquake Hazards Program Website, 2004)

Cascadia Subduction Zone Setting and Recent Earthquakes

Sumatra Earthquake Statistics

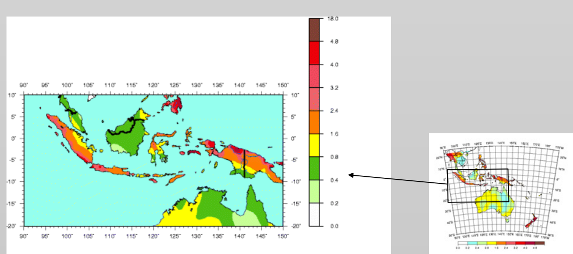
Date: 2004 December 26 00:58:53 UTC
Frequency: Every few hundred years
Magnitude: M_w9.0 (or possibly 9.3)
Length of Shaking: ~7-10 mins
Type: Subduction Zone (India Plate>Burma Plate)
Rate of Movement: ~6 cm/yr
Rupture Length: ~1200 km fault rupture
Tsunamis: local ~30 m; distant ~11m

(Park and Others, 2005, Stein and Okal, 2005, and USGS Earthquake Hazards Program Website, 2005)

Cascadia Earthquake Summary Statistics

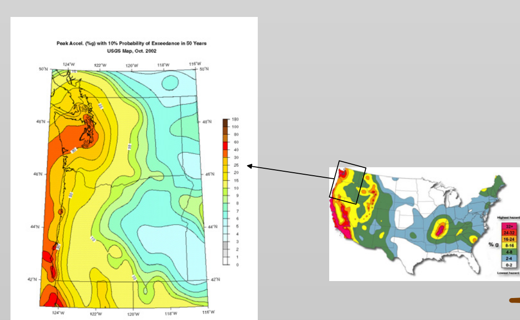
Date: TBA (last earthquake January 26, 1700)
Frequency: 10%-15% chance in 50 years
Magnitude: M_w8.5-9.0
Length of Shaking: Estimate of 5 minutes +
Type: Subduction Zone (Juan De Fuca Plate>North American Plate)
Rate of Movement: ~4cm/yr
Rupture Length: ~1000 km
Tsunamis: Offshore thrust creates local and distant

(Clague and others, 2000)



(Global Seismic Hazard Assessment Program Website, 2004)

Peak Ground Acceleration (m/s^2) with a 10% Probability of Exceedance in 50


(Frankel, A. and others, 2002)

Peak Ground Acceleration (%g) with a 10% Probability of Exceedance in 50

Sumatra Earthquake Damage and Losses Statistics

Fatalities: ~100,000 in Sumatra (~300,000 Global)
Estimated Losses: Untold billions
Displaced Population: ~425,000 in Sumatra (~1.1 million Global)

(USGS Earthquake Hazards Program Website, 2004)

Cascadia Earthquake Damage and Losses Statistics

Fatalities: ~5,000 in Oregon (Global unknown)
Estimated Losses: ~$12 billion in buildings in Oregon
Displaced Population: ~17,000 in Oregon (Global unknown)

(Wang, 1999)

II. Damage Patterns Noted from the Sumatra Earthquake

A) Extensive scouring and erosion from tsunami wave forces exacerbated by debris laden receding waters


(Wang, 2005)


(Wang, 2005)

B) Structures that allow water to flow through generally performed better


(Wang, 2005)


(Wang, 2005)

(Wang, 2005)

C) Protection from tsunamis, even as minimal as this sea-wall, generally had less landward damage

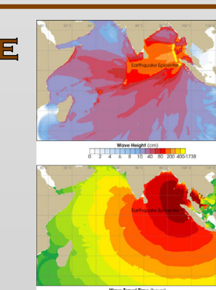
(Wang, 2005)

(Wang, 2005)

D) Local and distant tsunamis were both destructive. Run up heights and inundation distances were, in places, surprisingly extensive

III. Lessons Learned from Sumatra Earthquake

- Global scale disasters are getting bigger and more expensive
- Strong ground shaking for ~5+ minutes
- Coseismic subsidence ~2 m
- Damaging near field (local) and distant tsunamis
- Education was not part of the culture in communities within tsunami zones
- Tsunami design was not included in building code
- Regional tsunami warning system was needed


(NASA Earth Observatory Natural Hazards Website, 2004)

IV. Science and Policy Actions Needed

- Need more scientific studies and understanding of the hazards, including damage and loss studies
- Apply the science to public policy such as: including tsunami design in the building code and incorporating education into the culture of communities within tsunami inundation zones
- Government to community level support of comprehensive mitigation programs and modern engineering design and construction
- Perform pre-disaster mitigation of emergency facilities, schools, and infrastructure


(Priest, 2000)

Tsunami inundation map and aerial photo of Newport, OR

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