

Engineering Seismology and Seismic Hazard – 2019

Lecture 2

Earthquake Hazard and Risk

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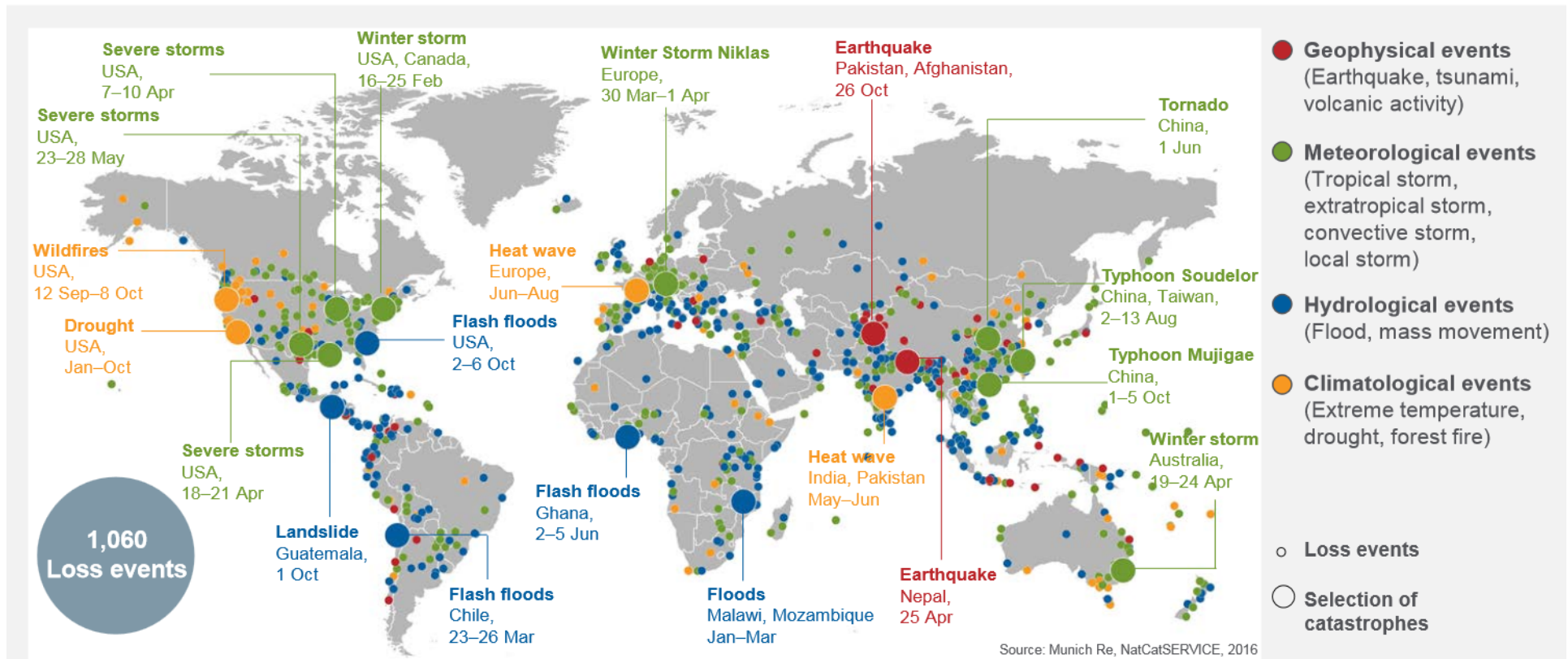
National Institute of Oceanography and Applied Geophysics (OGS)





Global Losses

Natural loss events worldwide 2015 Geographical overview



The United Nations estimates natural disasters and hazards in the past 20 years have affected four billion people, claiming 1.3 million lives, with a cost of around two trillion dollars in economic losses.

Earthquake Hazard

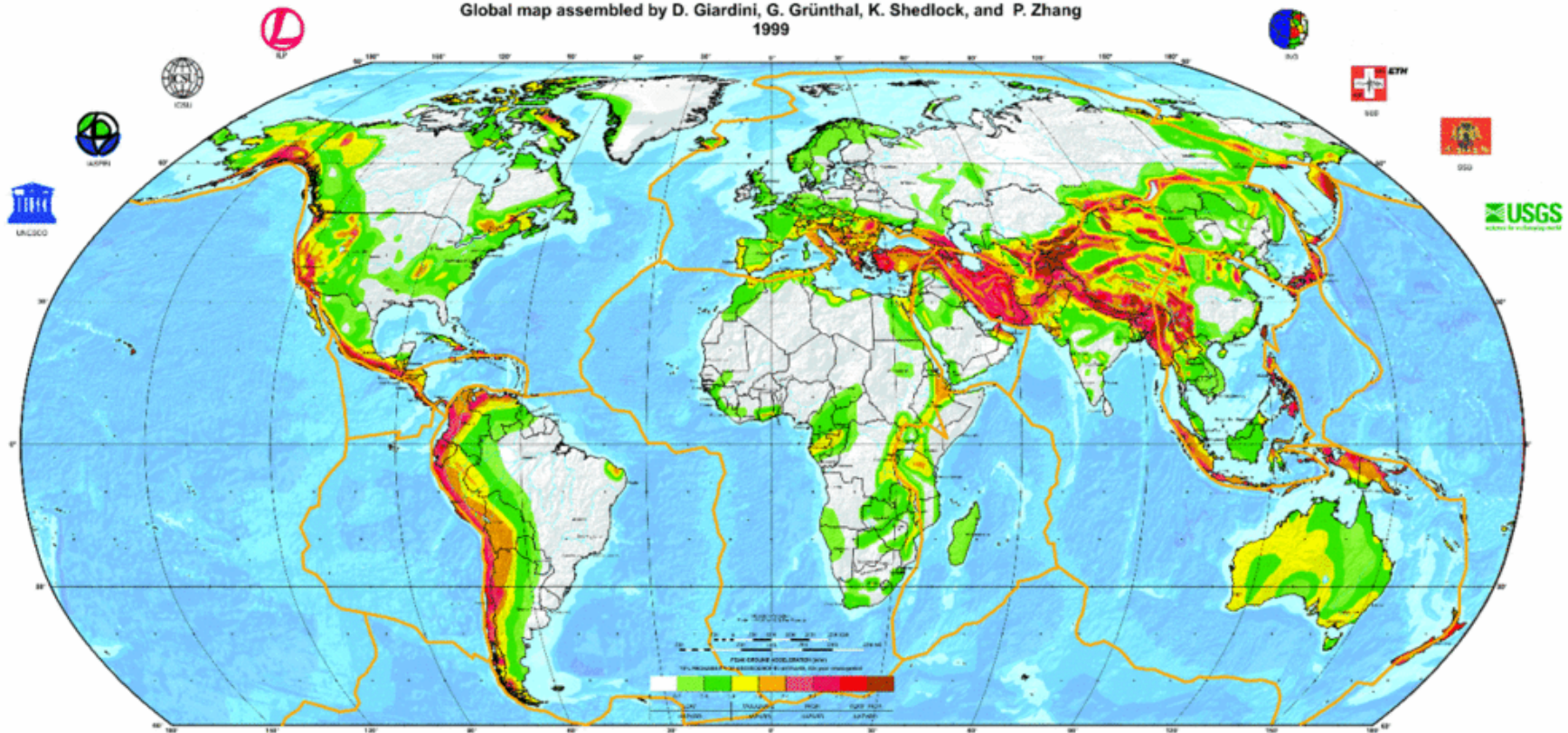
GLOBAL SEISMIC HAZARD MAP

Produced by the Global Seismic Hazard Assessment Program (GSHAP),
a demonstration project of the UN/International Decade of Natural Disaster Reduction, conducted by the
International Lithosphere Program.

GFZ
POTSDAM

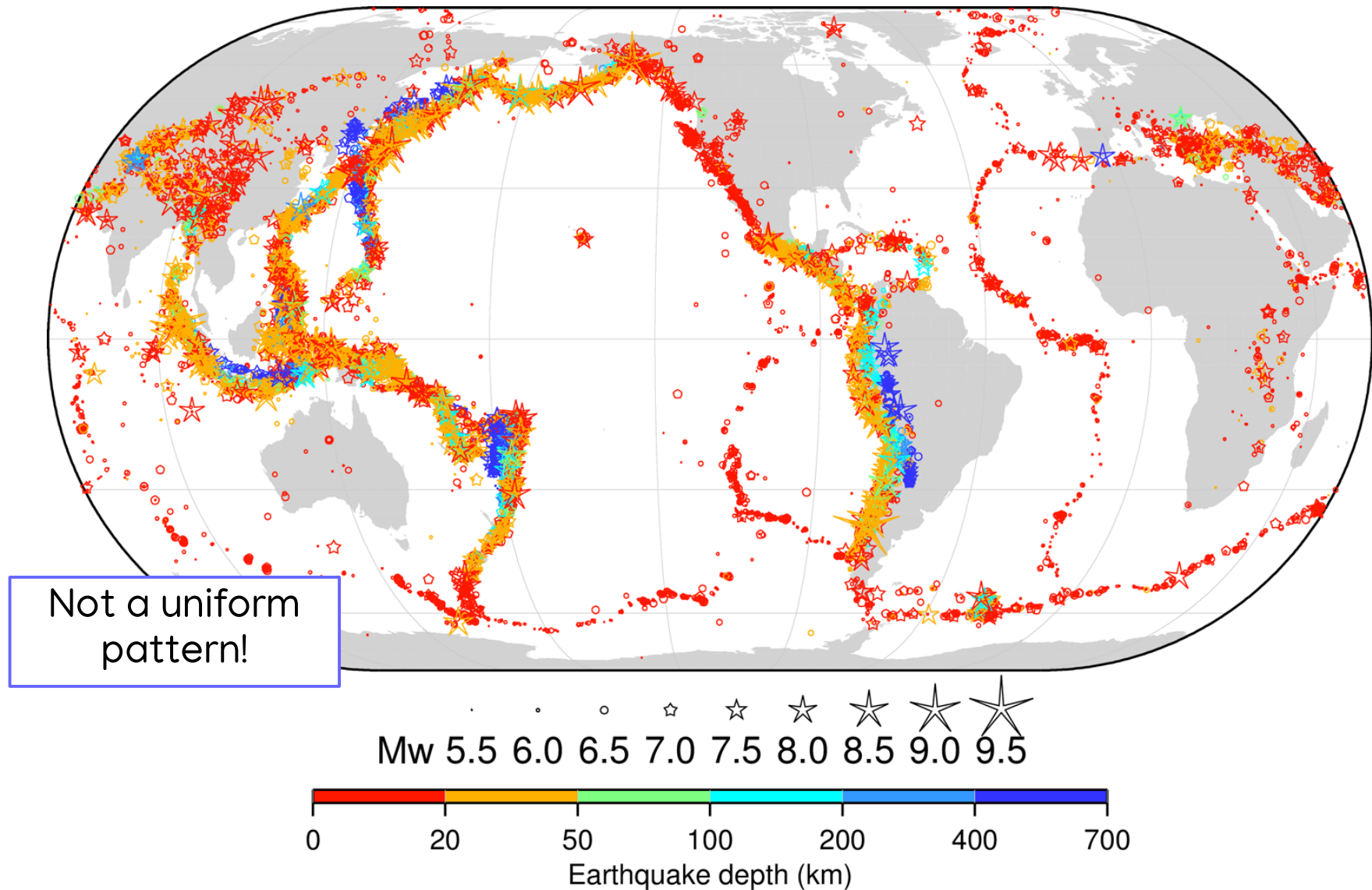
International Decade for Natural Disaster Reduction
IDNDR
1990 - 2000
Building a Culture of Prevention

Global map assembled by D. Giardini, G. Grünthal, K. Shedlock, and P. Zhang
1999



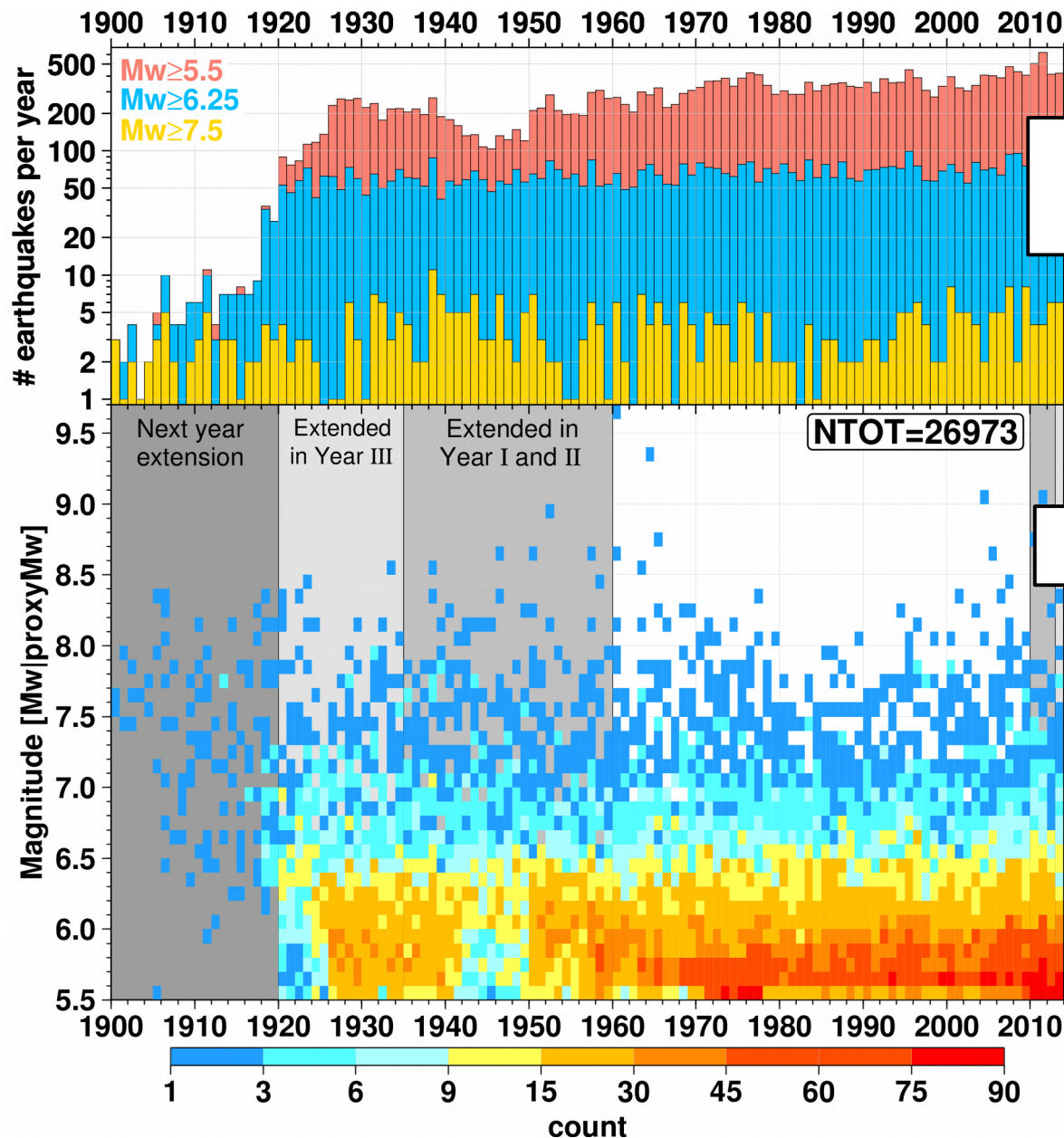
60% of the world population lives in countries with a significant seismic hazard

Where do Earthquakes Occur?



90% most of the worlds seismicity occurs long the Ring of Fire

How often do Earthquakes occur?



Do earthquakes occur uniformly in time?

Why gaps in the record?

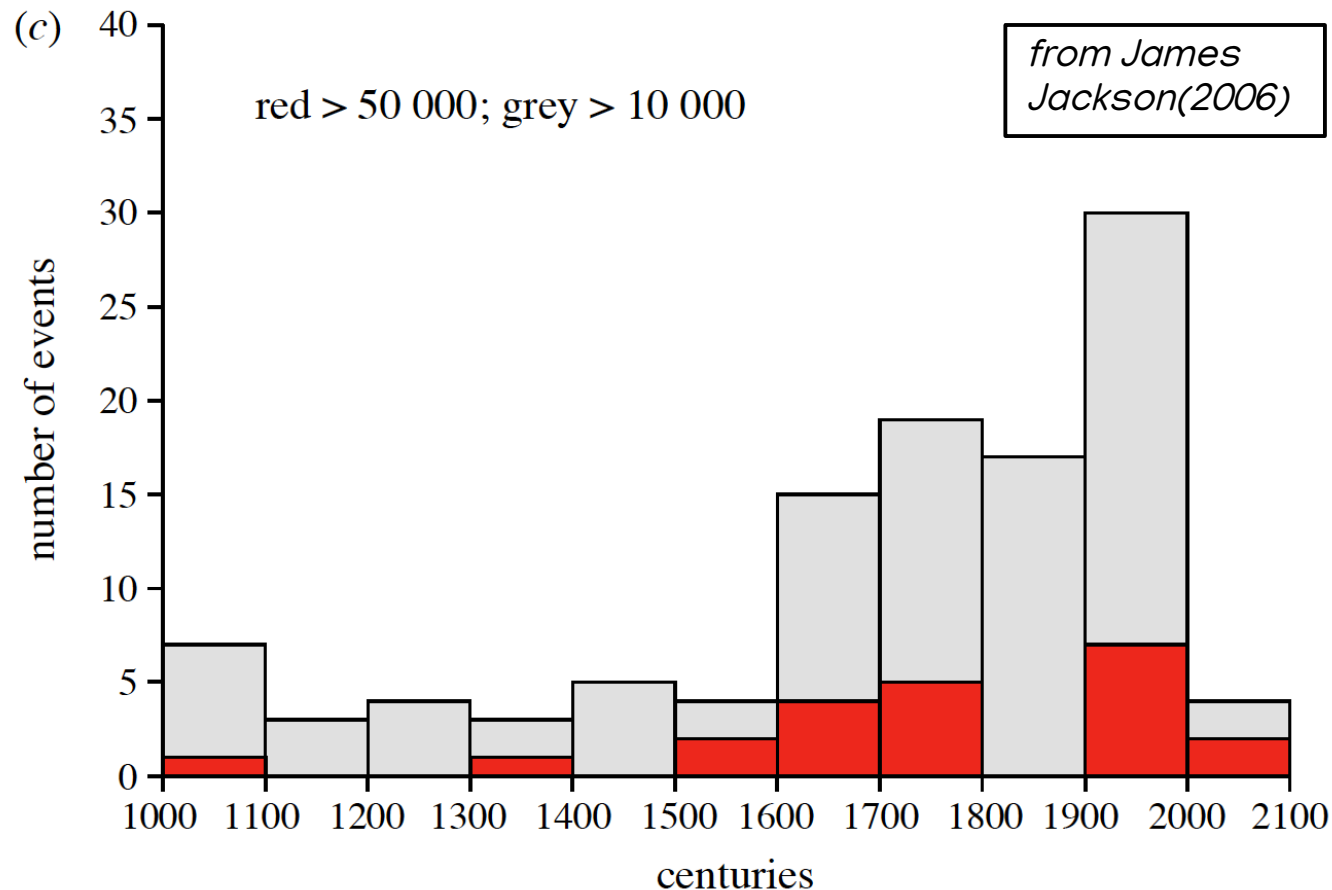
<http://www.isc.ac.uk/>

Occurrence in Numbers

Earthquakes occur actually quite often (more than we expect)
However, large magnitude earthquakes are rather infrequent.

Magnitude	Description	Number in 1 Year	One Quake Every
8+	Great	< 1	1--2 years
7.0–7.9	Major	17	every 20days
6.0–6.9	Large	135	3 days
5.0–5.9	Strong	1320	9 hours
4.0–4.9	Moderate	13000	90 minutes
3.0–3.9	Mild	130000	11 minutes
2.0–2.9	Small	1300000	2 minutes

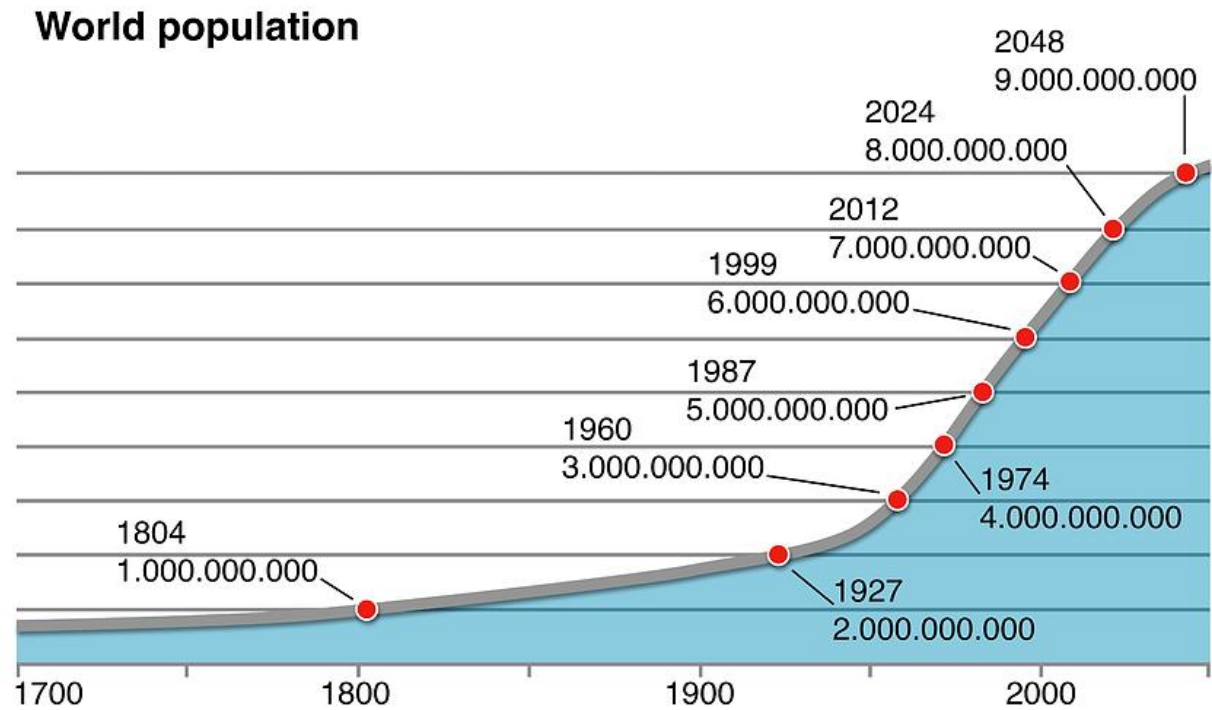
Impact of Earthquakes over Time



Histogram of the number of earthquakes killing more than 10000 (grey) or 50000 (red) people per century.

World population growth

“The global population distribution is changing rapidly as underdeveloped nations continue to grow most rapidly in cities that are preferentially located in seismically hazardous regions.” (Bilham, 2004, Allan et al 2007).



Increased population: **increased earthquake risk**

Consequences:

- Number of people killed in earthquakes continues to rise in poorer nations
- Cost of earthquakes continues to rise for rich nations

Destructive Earthquakes



	YEAR	LOCATION	MAGNITUDE	ESTIMATED DEATH TOLL
1	1976	Tangshan, China	7.5	255,000
2	1920	Gansu, China	8.6	200,000
3	1927	Qinghai, China	7.9	200,000
4	1923	Kanto, Japan	7.9	143,000
5	1948	Turkmenistan	7.3	110,000
6	1908	Messina, Italy	7.2	70,000
7	1932	Gansu, China	7.6	70,000
8	1970	Peru	7.9	66,000
9	1990	Iran	7.7	40,000
10	1935	Quetta, Pakistan	7.5	30,000

SOURCES: United States Geological Survey, Associated Press

THE WASHINGTON POST

However, earthquakes of similar size (and energy) do not often produce comparable effects and consequences

Earthquake Risk Controlling Factors

Earthquake Risk

=

Seismic Hazard * Vulnerability * Exposure

Natural:

- Strength of Earthquake
- Distance from earthquake epicentre
- Earthquake depth
- Ground type (Soft Soil)
- Duration

Anthropic:

- Population density
- Quality of building construction and design
- Level of development
- Level of population preparedness
- Time of disaster

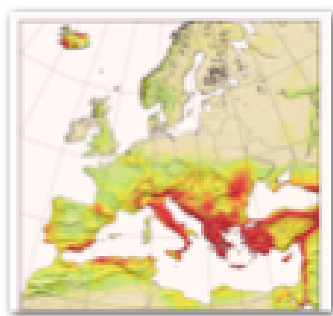
To Remember!

"Earthquakes don't kill people, collapsed buildings do so"

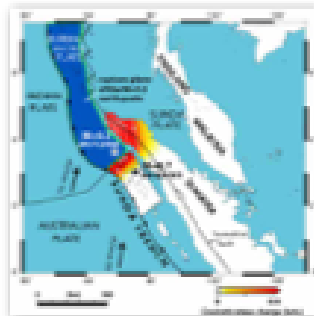
Hazard Mitigation Strategies

From the past

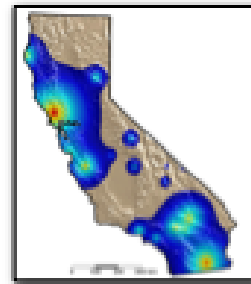
To the future



**Long-term
Hazard mapping**

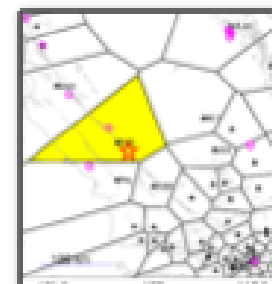


**Long-Term
Forecasting**



**Short-Term
Forecasting**

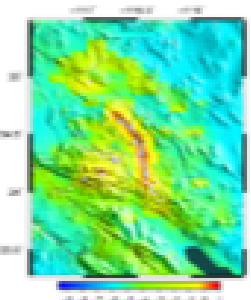
Earthquake



**Early
Warning**



**ShakeMaps &
Rapid Loss
Assessment**



**Aftershock
Hazard**

decades

years

days

seconds

0

seconds

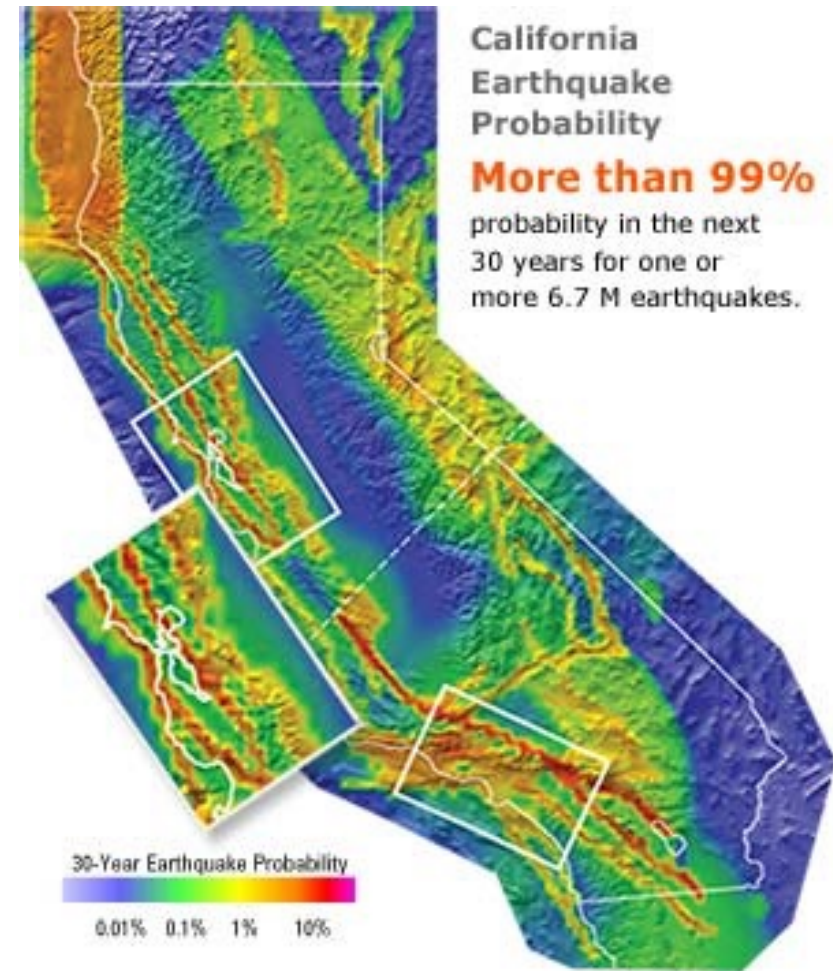
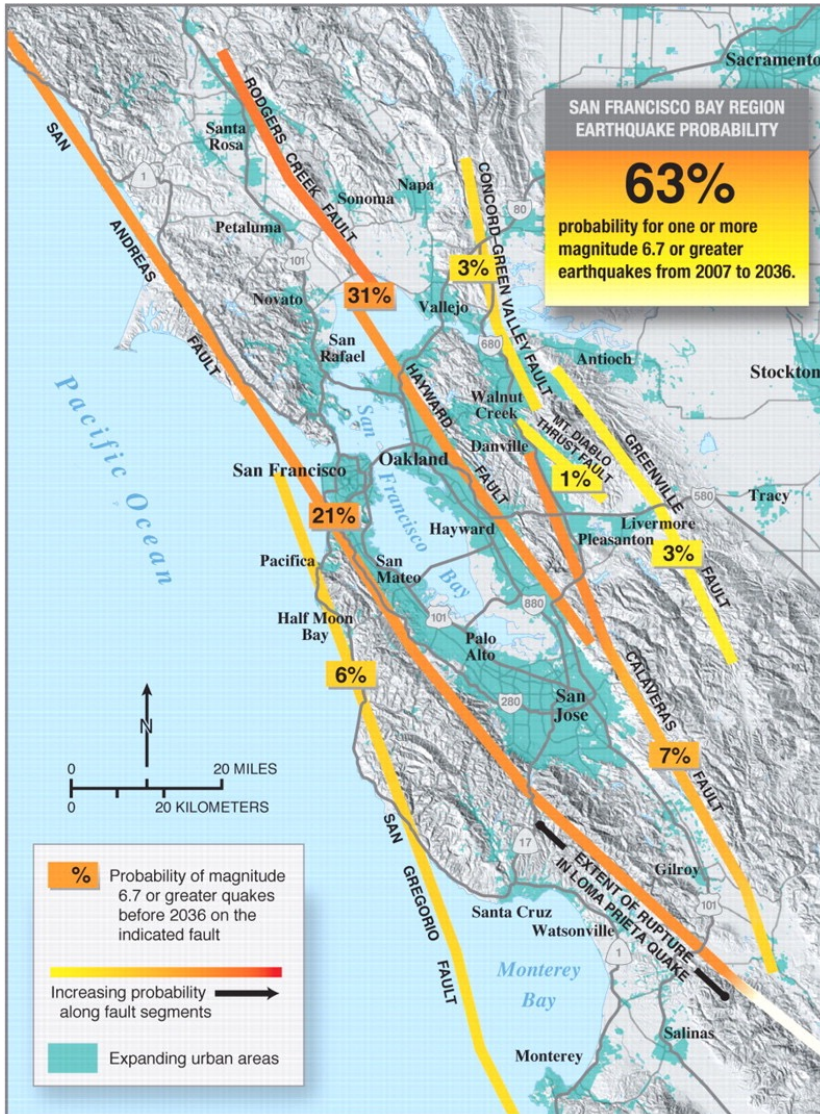
days

years

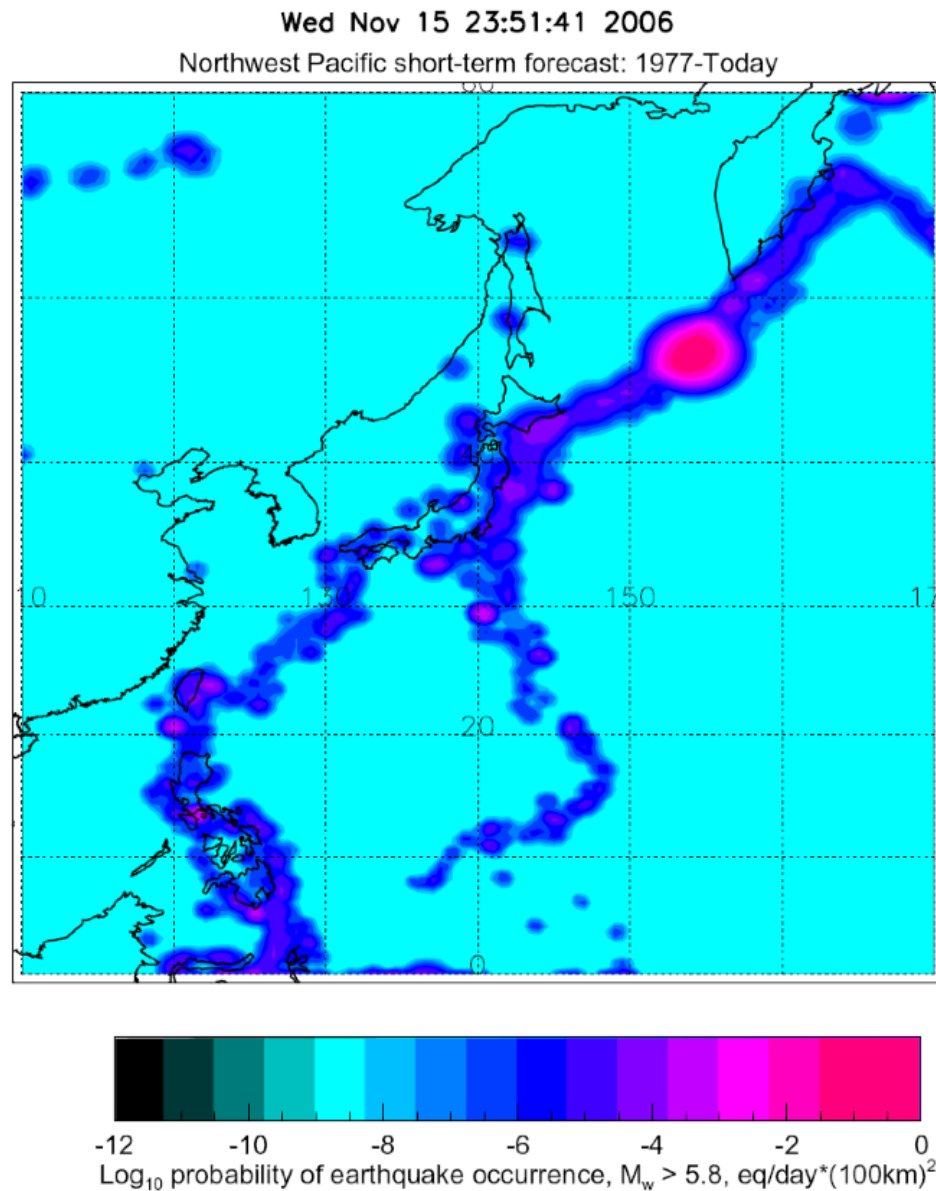
TO REMEMBER: Earthquakes cannot be predicted (so far)!



Long-Term Forecasting

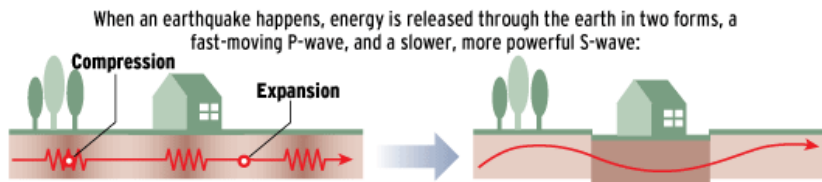
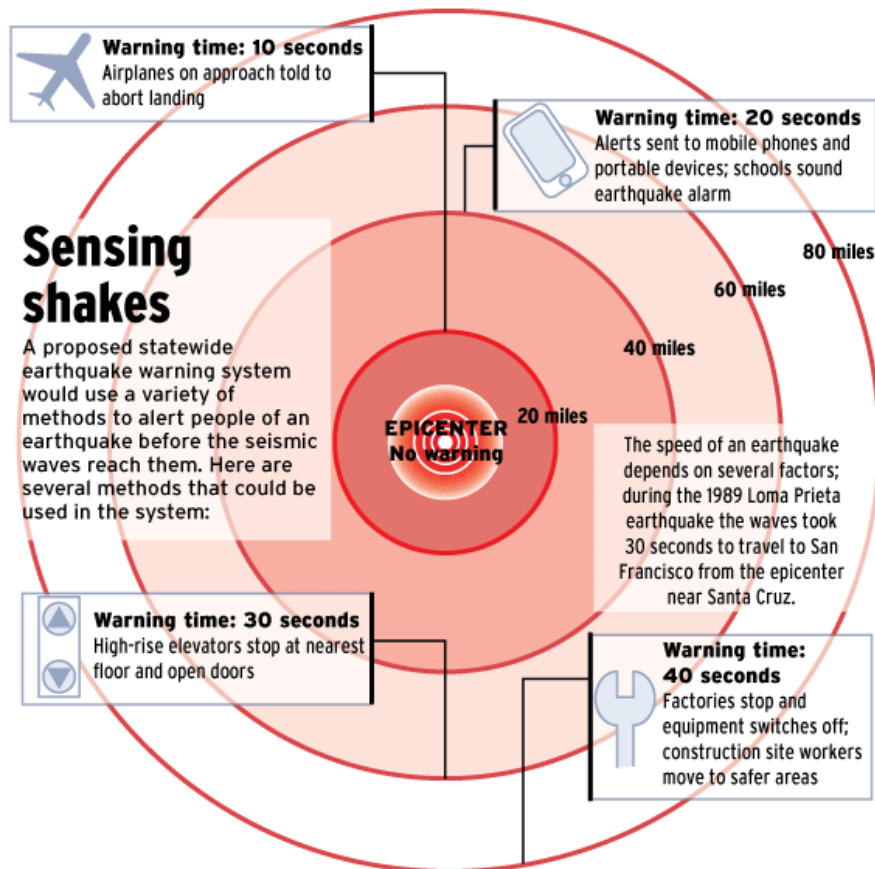


Short-Term Forecast



Forecast one day after
the recent (2006/11/15)
M8.3 Kuril Islands
earthquake.

Early Warning Systems

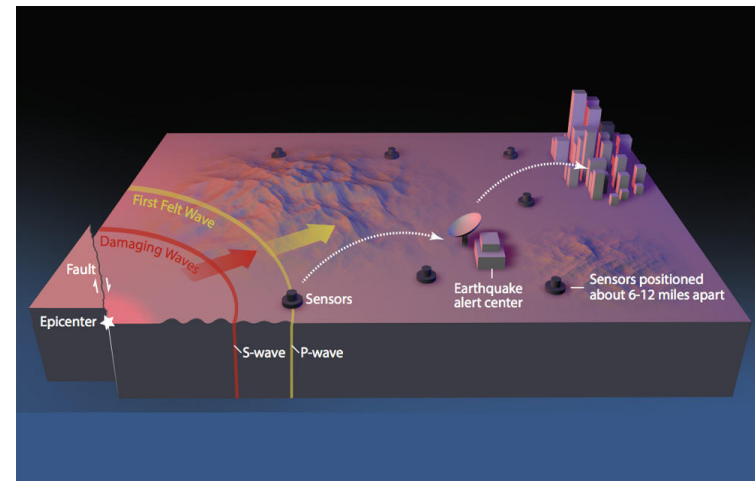


A P- (or compressional) wave compresses and expands the earth as it moves. P-waves move fast, but don't cause much damage.

An S- (or shear) wave physically moves the earth like an ocean wave as it moves. S-waves carry more of the quake's energy.

Sources: Scientific American; United States Geological Service

The Register

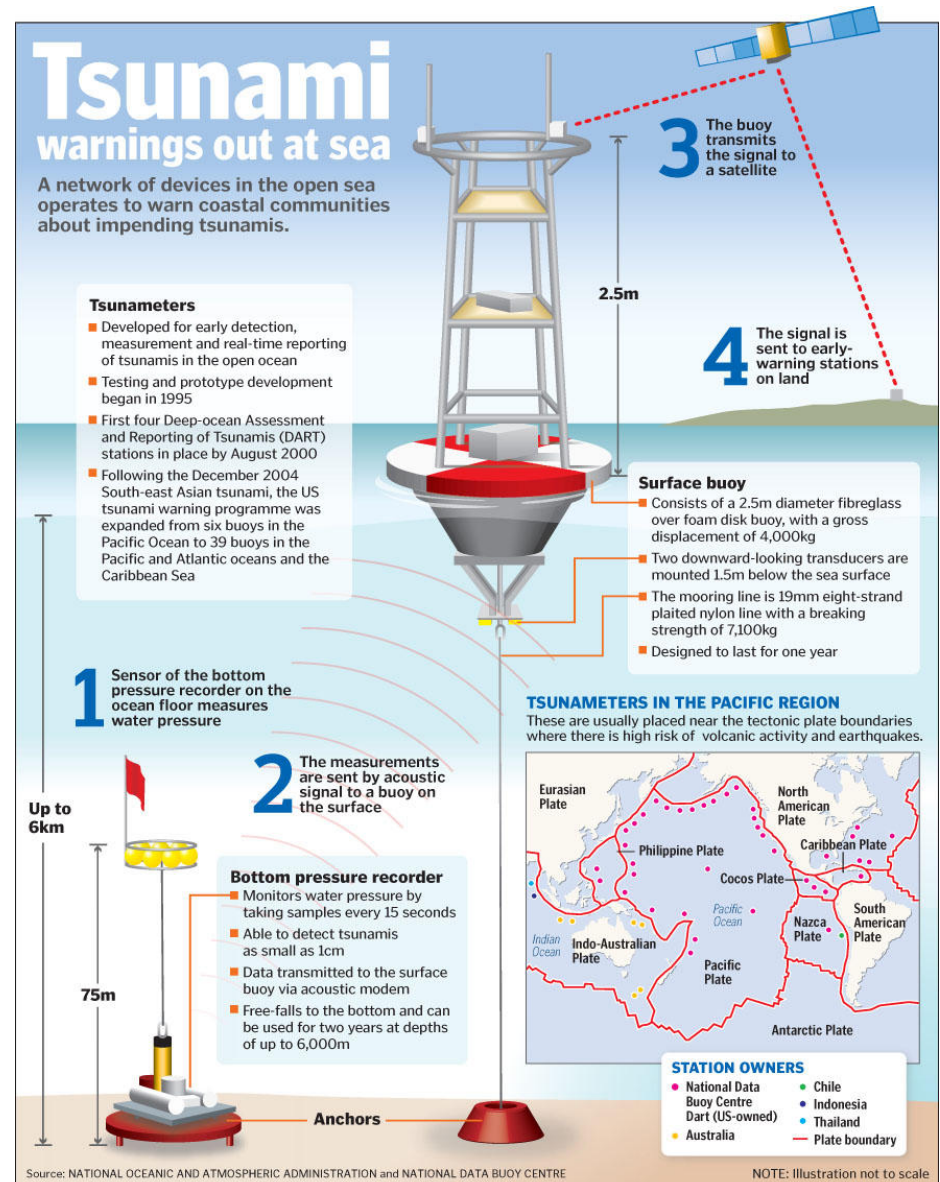


On your screen: ShakeAlert

- 1 Real-time tracking of seismic waves from quake's epicenter.
- 2 Real-time tracking of the fault rupture (updates intensity).
- 3 Your current location tracked by GPS.
- 4 Seconds remaining before seismic waves reach you.
- 5 Expected intensity of quake at your current location.
- 6 Estimated magnitude of quake.
- 7 Intensity scale.

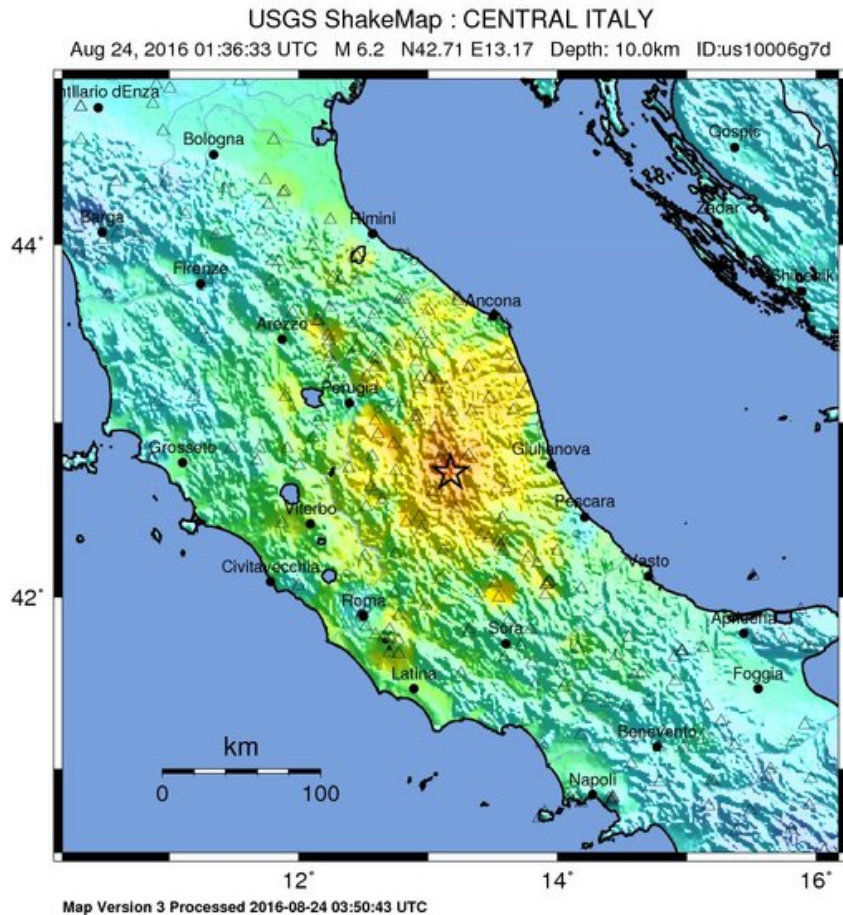
Early Warning Systems

The most difficult situations arise in areas located close to active offshore faults, where tsunamis arrive so quickly that there is no time for a warning.



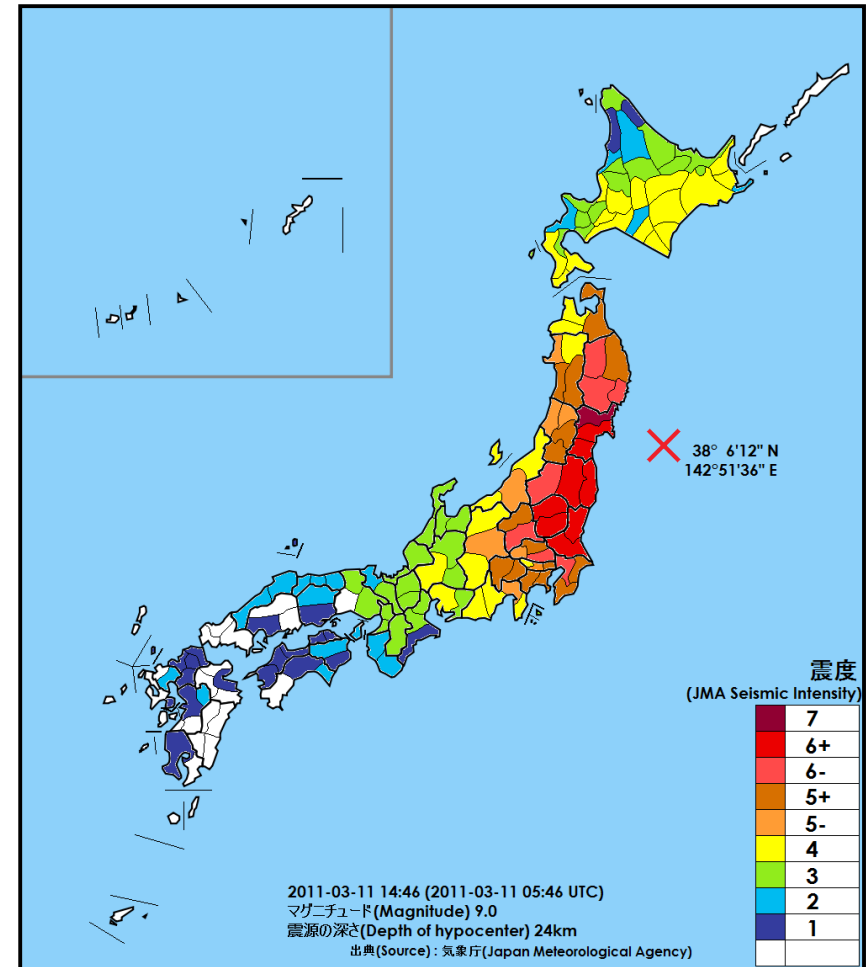
Shake Maps

2016 Norcia Earthquake, Italy



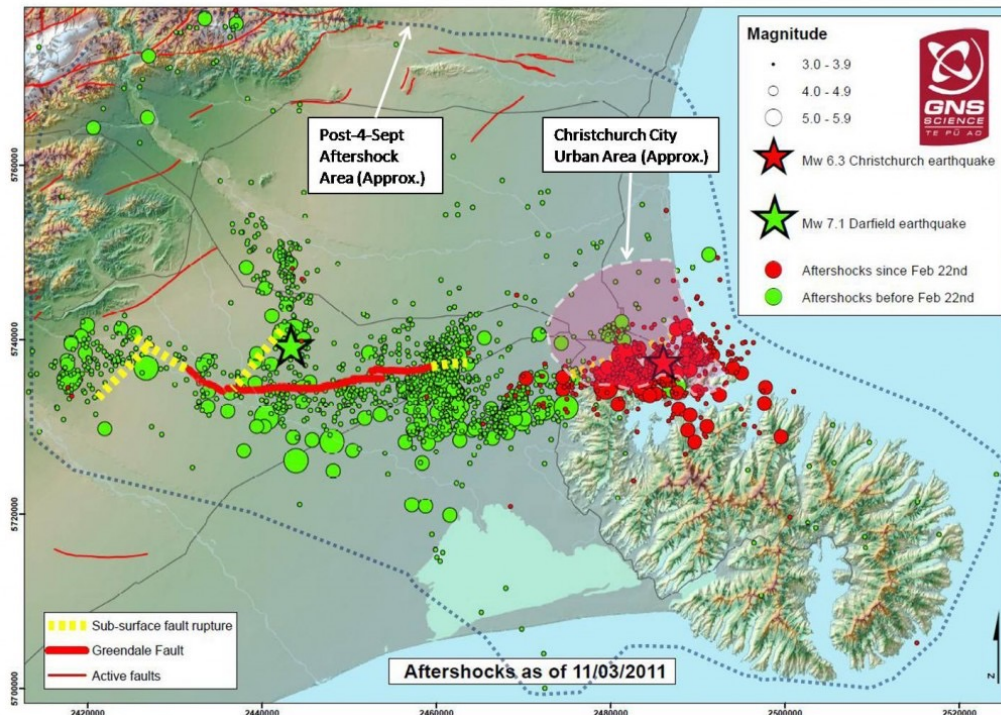
PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Mod./Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<0.06	0.2	0.8	2.0	4.8	12	29	70	>171
PEAK VEL.(cm/s)	<0.02	0.08	0.3	0.9	2.4	6.4	17	45	>120
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Scale based upon Faenza and Michelini, 2010, 2011

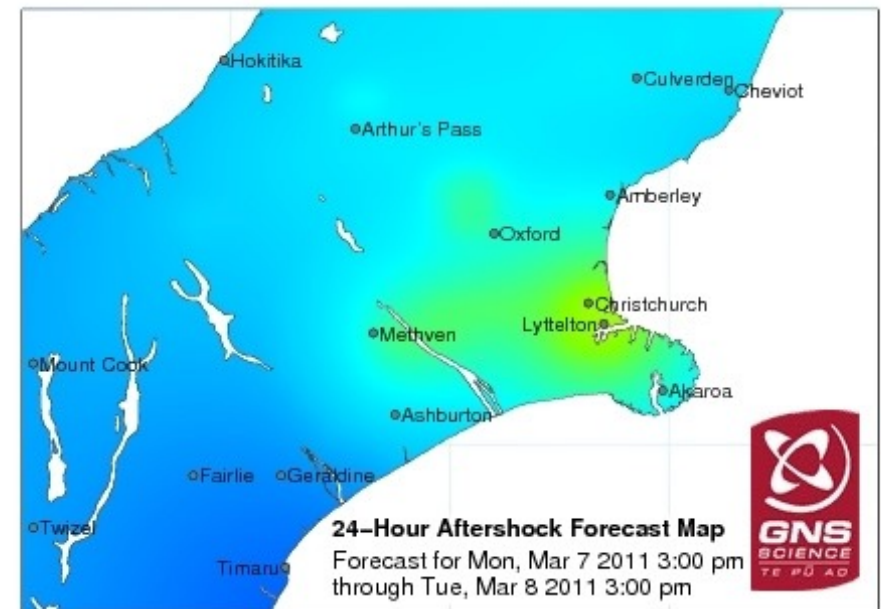


2011 Tohoku Earthquake, Japan

Aftershock Hazard



2011 Christchurch Earthquake, New Zealand



1/1,000,000 1/100,000 1/10,000 1/1,000 1/100 1/10
Probability of Experiencing Slight Damage(MM VI shaking)

Course Message

Earthquake is a complex phenomenon and no hazard mitigation strategy can be put in place without an appropriate understanding of its generation and propagation mechanism.

Therefore, the course will focus on the main theoretical and applicative aspects of seismology, with the goal of providing you with the necessary knowledge to critically and independently handle the most common problems in the seismic engineering practice.

However, since our scientific comprehension of the earthquake phenomenon is “relatively” limited, we will particularly focus on the concept of **uncertainty** and the way this is handled in seismic hazard analysis...

Resources

These lectures wouldn't have been available without the contribution of many people and the numerous resources from textbooks and online material (see attached file for a complete list)

A special acknowledgment (and a personal thanks) goes to the following people for their supporting material:

Dr. Dario Slejko – OGS, Trieste, Italy

Dr. Laurentiu Danciu – Swiss Seismological Service, ETH, Zurich, Switzerland

Dr. Donat Faeh – Swiss Seismological Service, ETH, Zurich, Switzerland

Dr. Elisa Zuccolo – EUCENTRE Pavia

Dr. John Douglas

Dr. Dave Boore