Engineering Seismology and Seismic Hazard – 2019

Lecture 2

Earthquake Hazard and Risk

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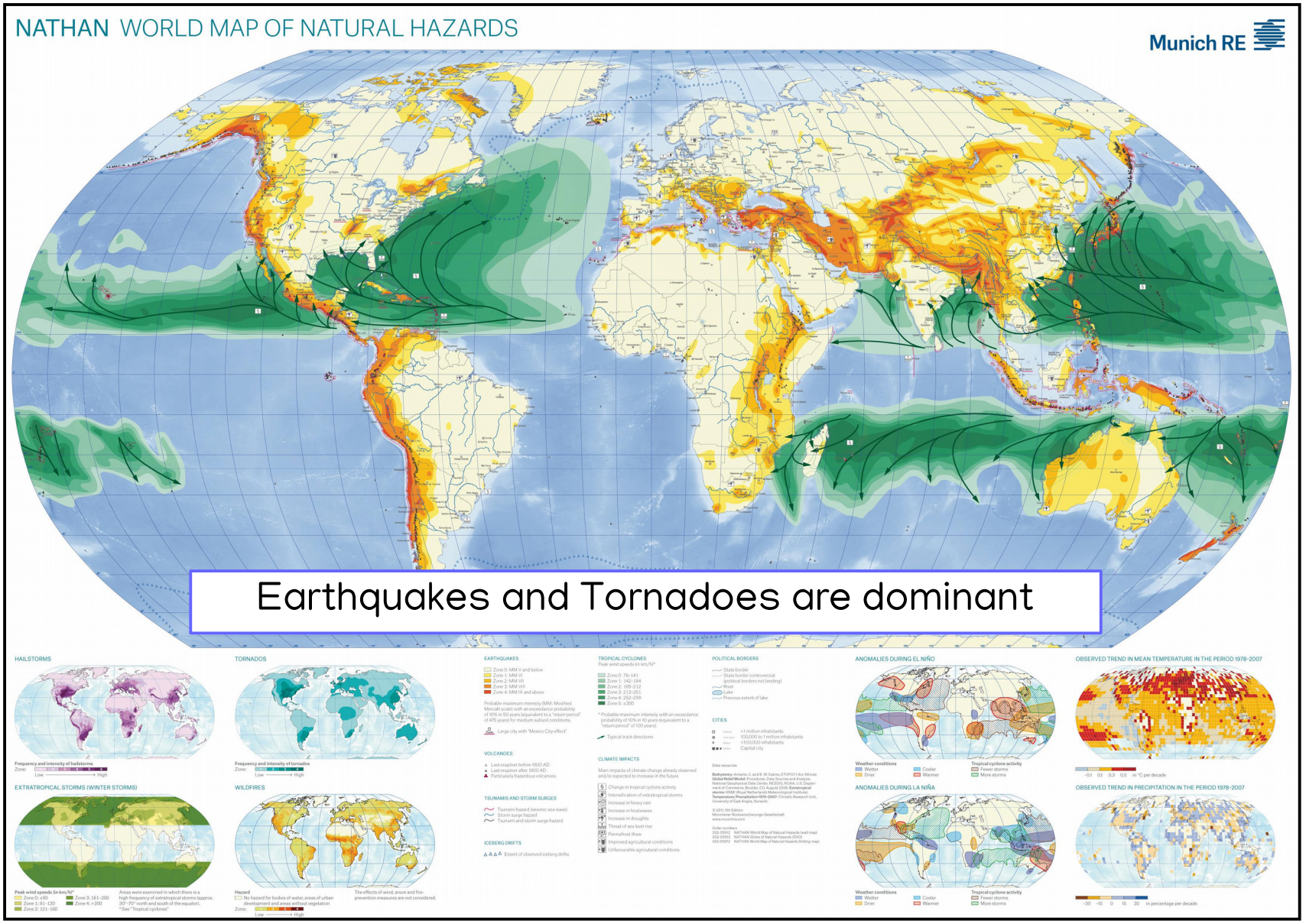
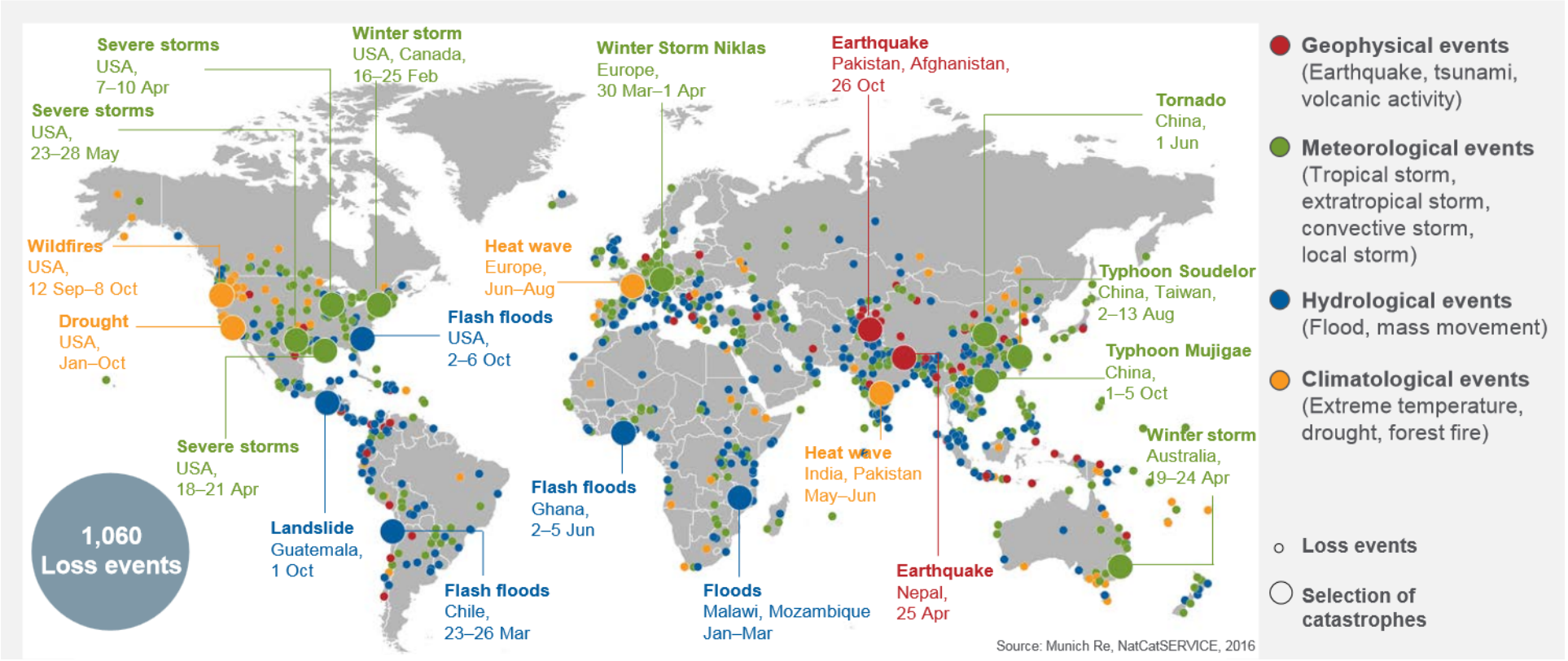
Natural Hazards



Global Losses

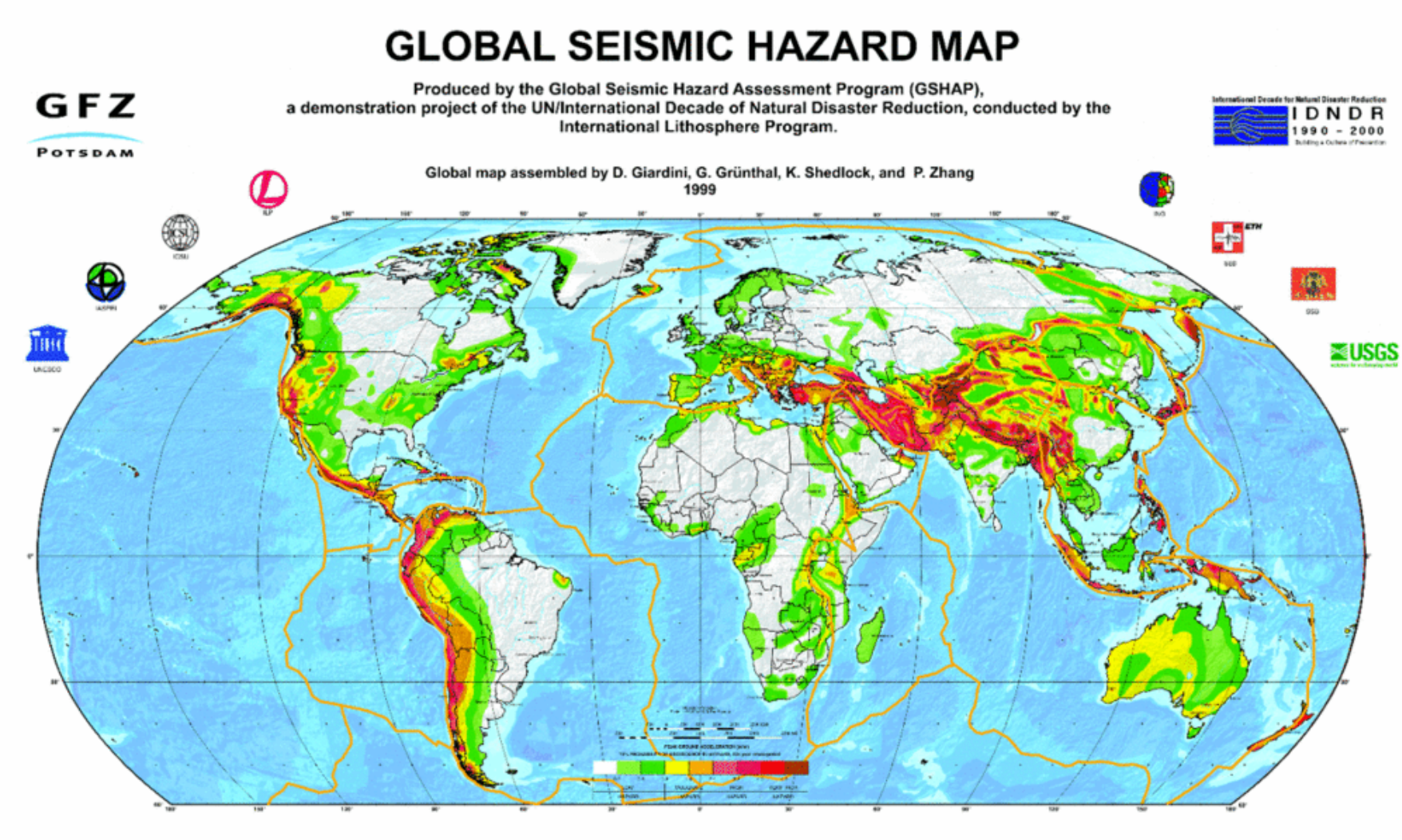
Natural loss events worldwide 2015
Geographical overview

Munich RE



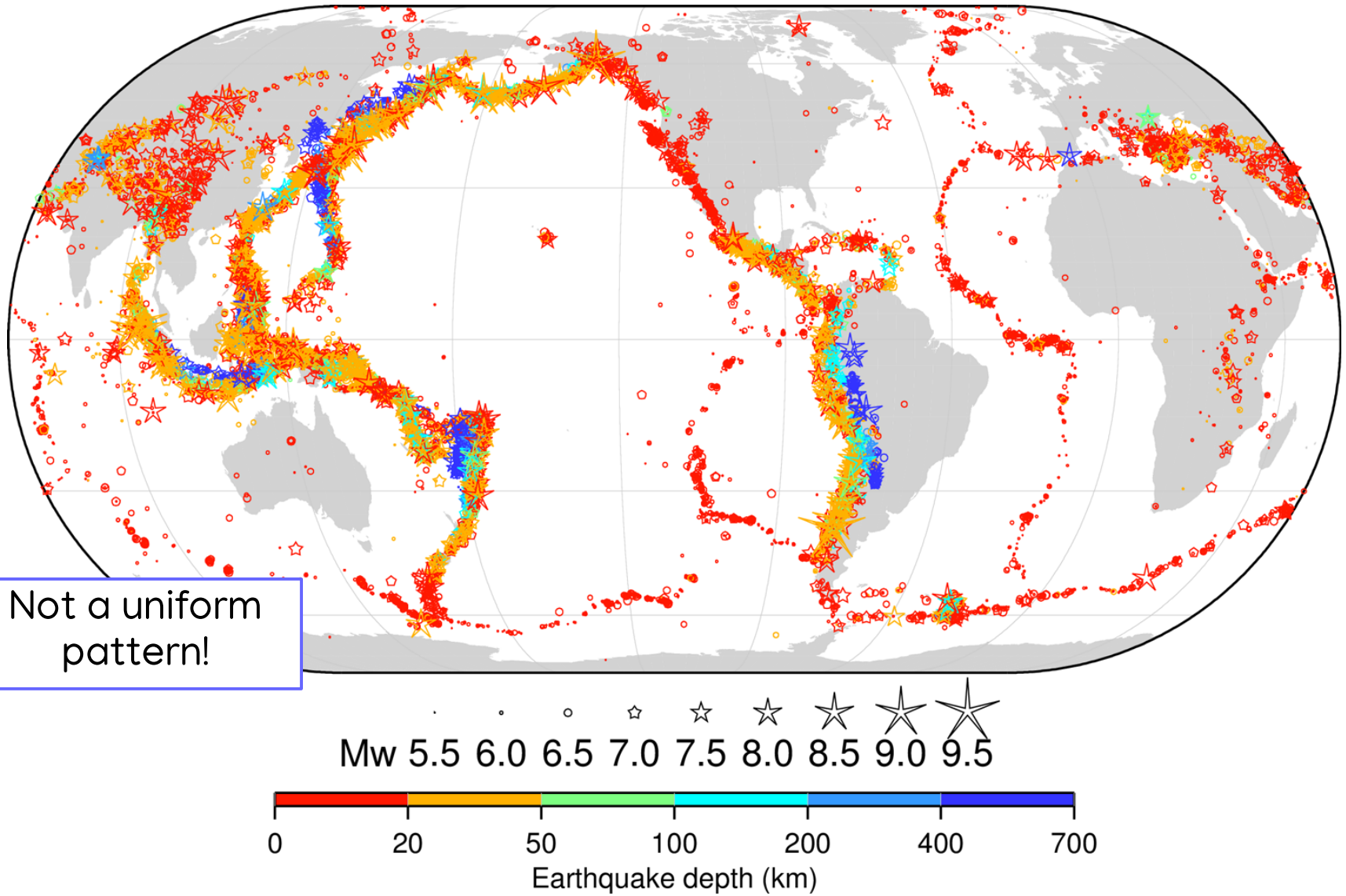
The United Nations estimates natural disasters and hazards in the past 20 years have affected four billion people, claiming 1.3 million lives, with a cost of around two trillion dollars in economic losses.

Earthquake Hazard



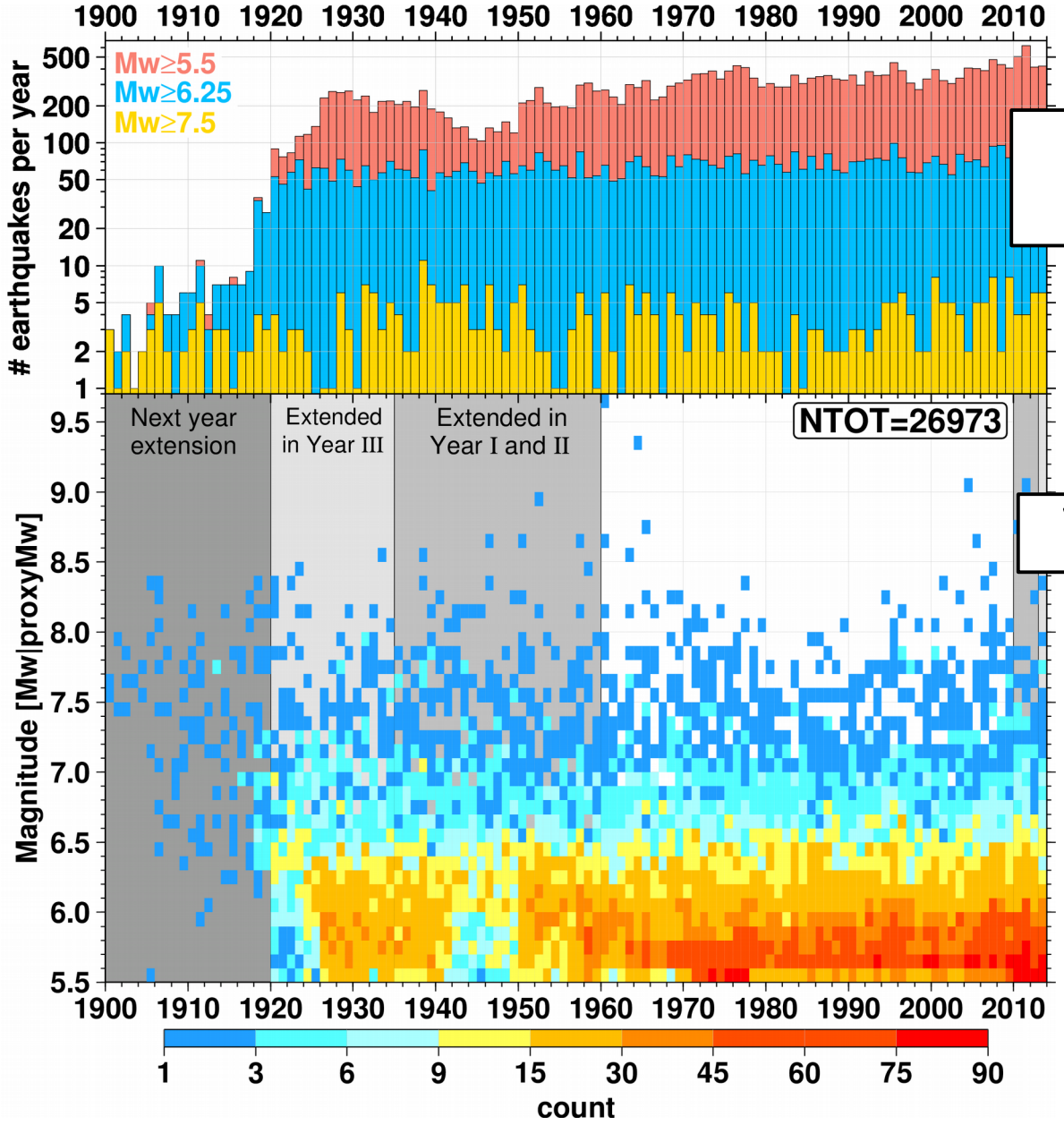
60% of the world population lives in countries with a significant seismic hazard

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?

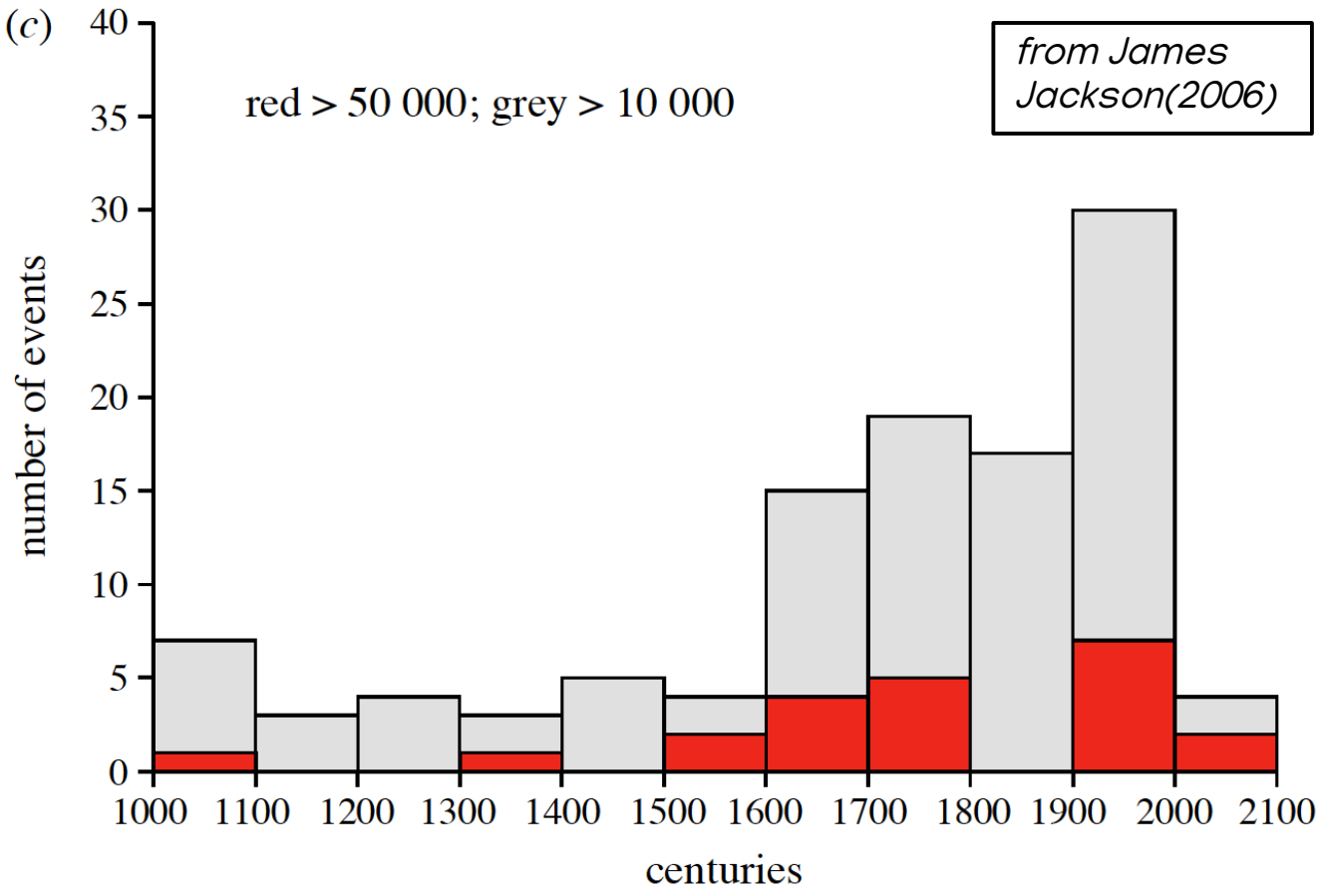
http://www.isc.ac.uk/

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

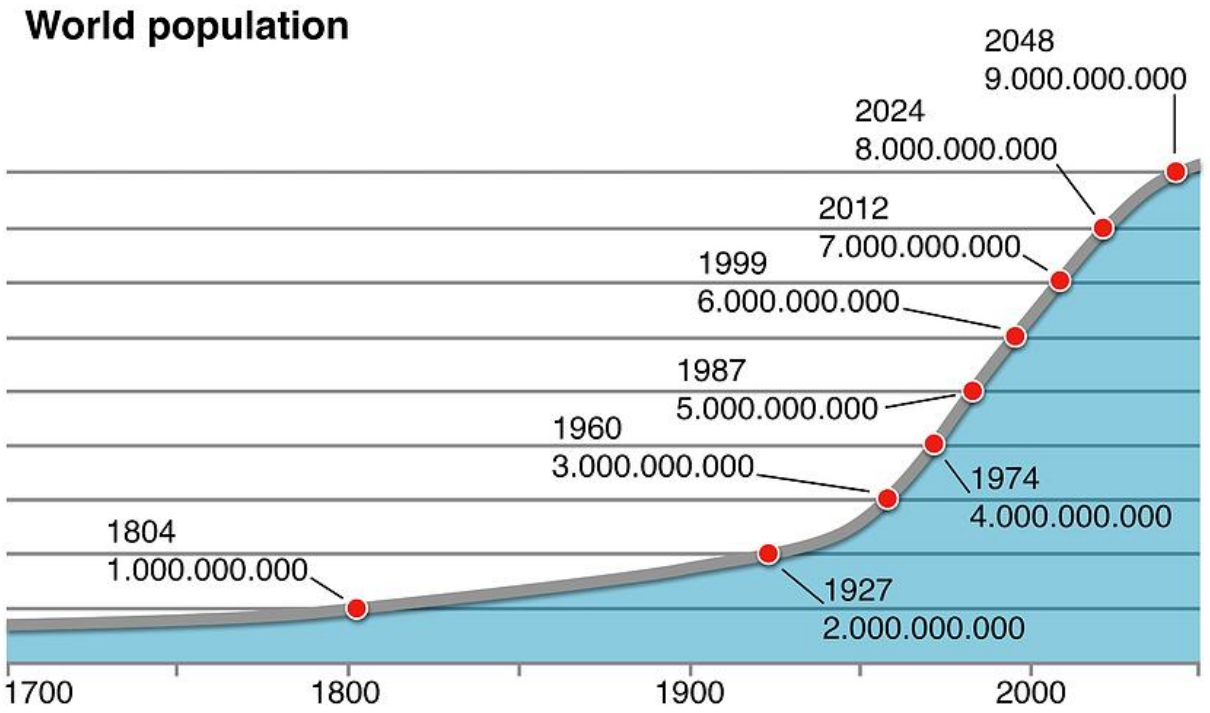
Impact of Earthquakes over Time



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

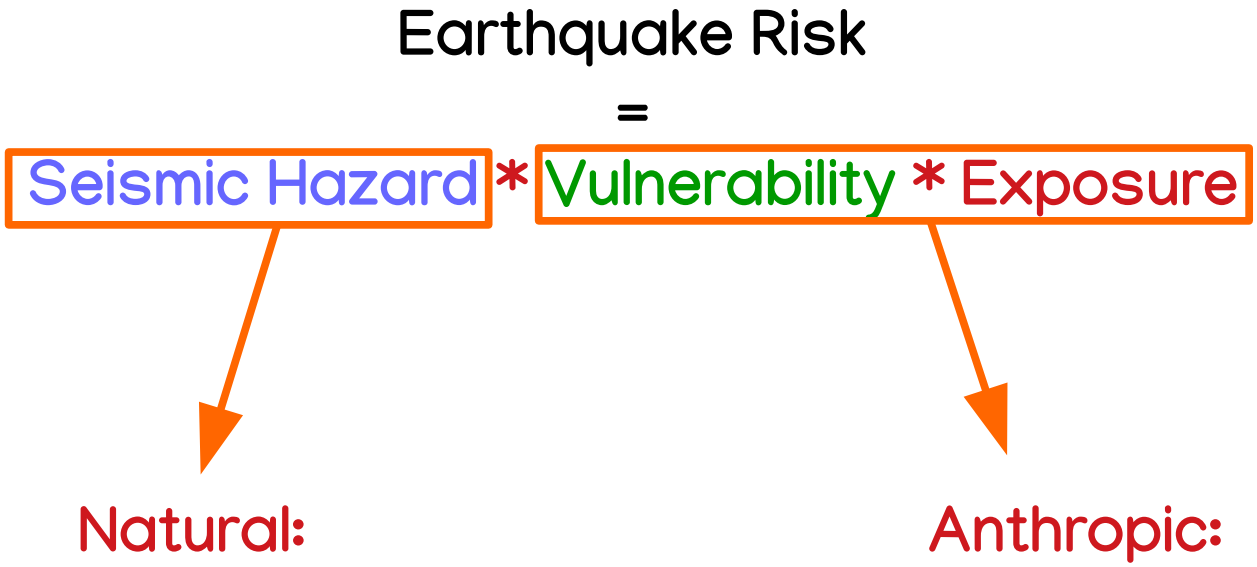
Destructive Earthquakes

	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



Natural:

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

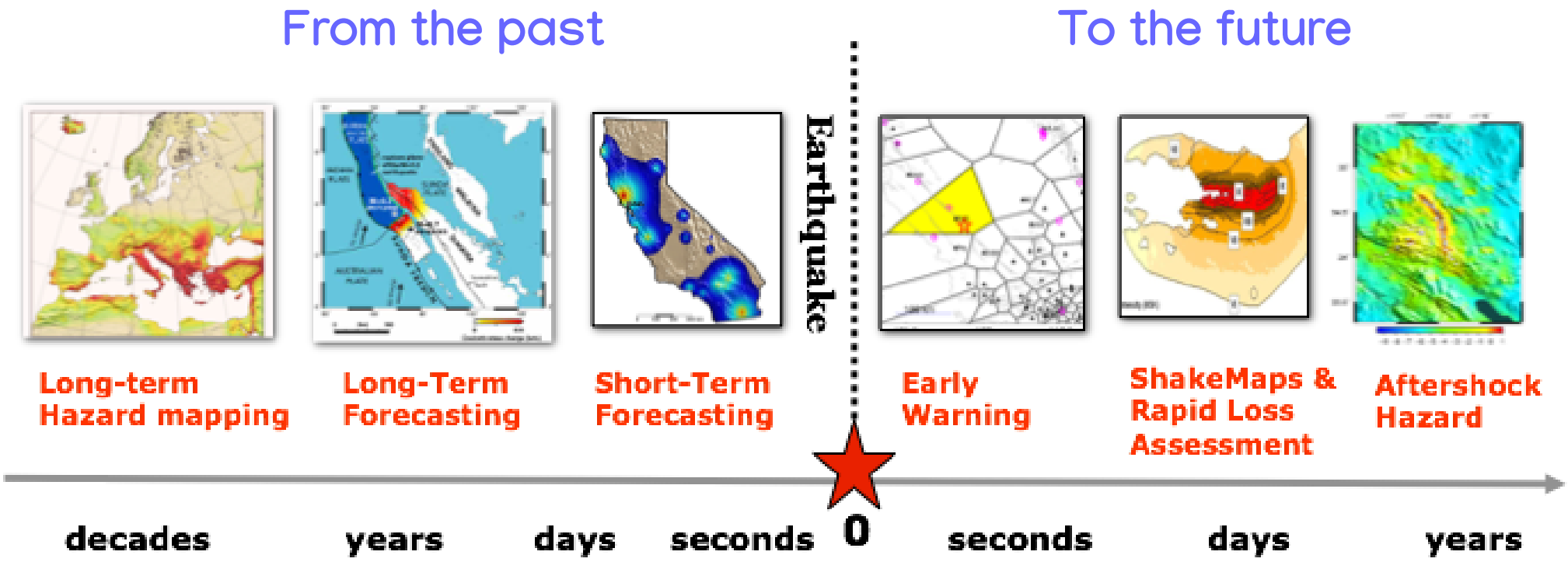
Anthropic:

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

To Remember!

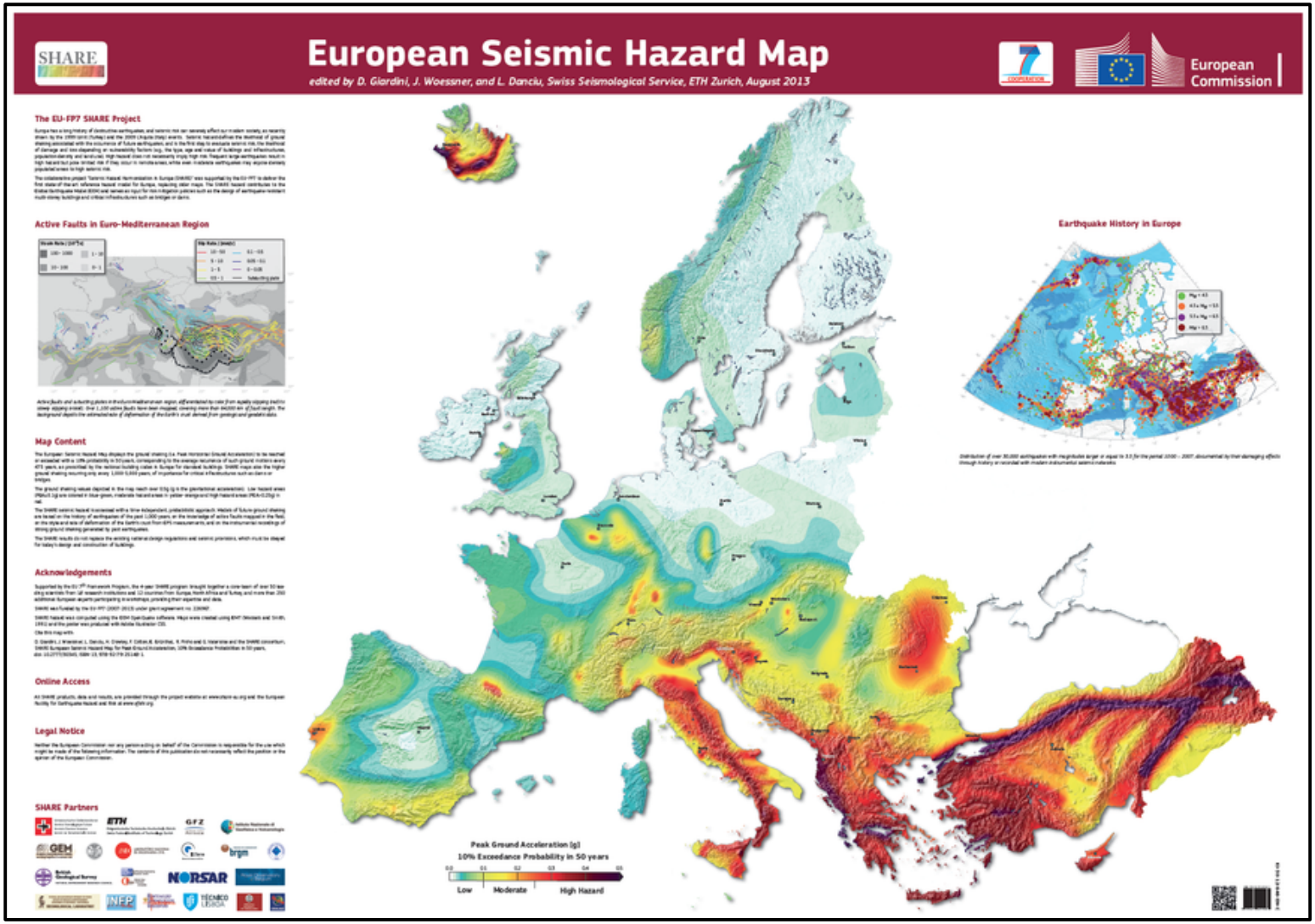
"Earthquakes don't kill people, collapsed buildings do so"

Hazard Mitigation Strategies

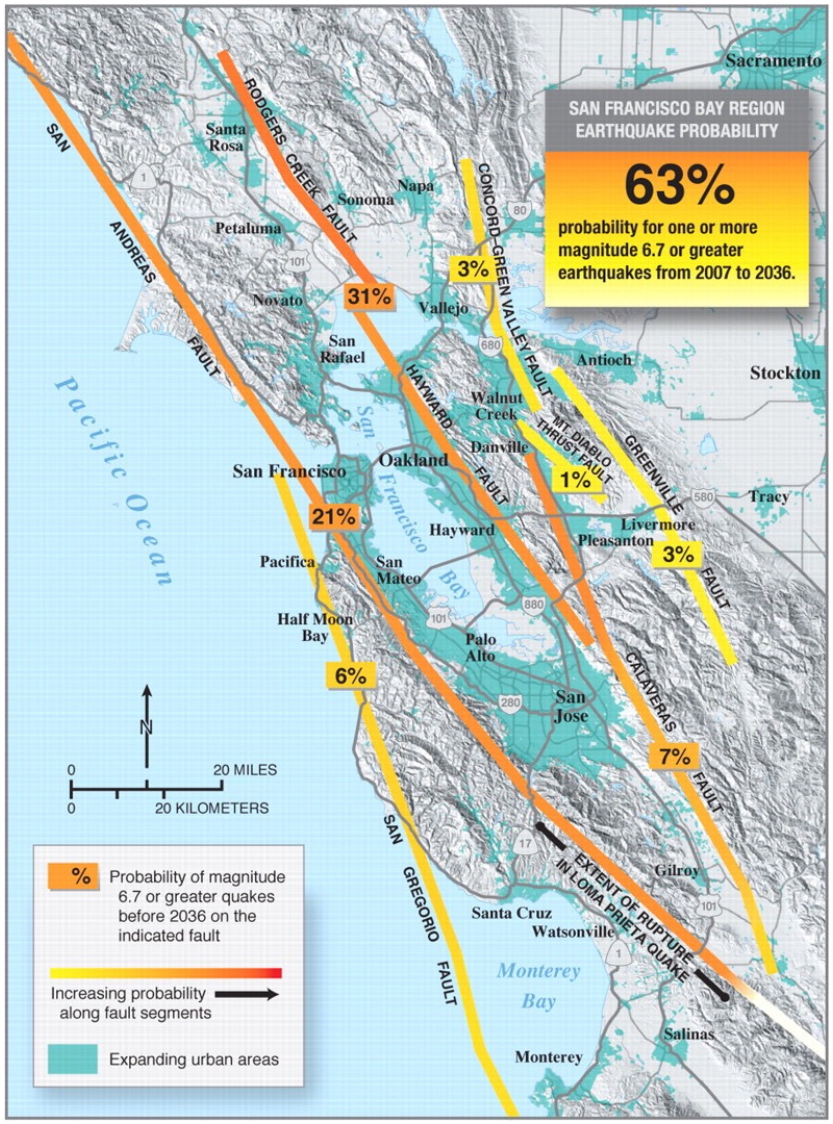


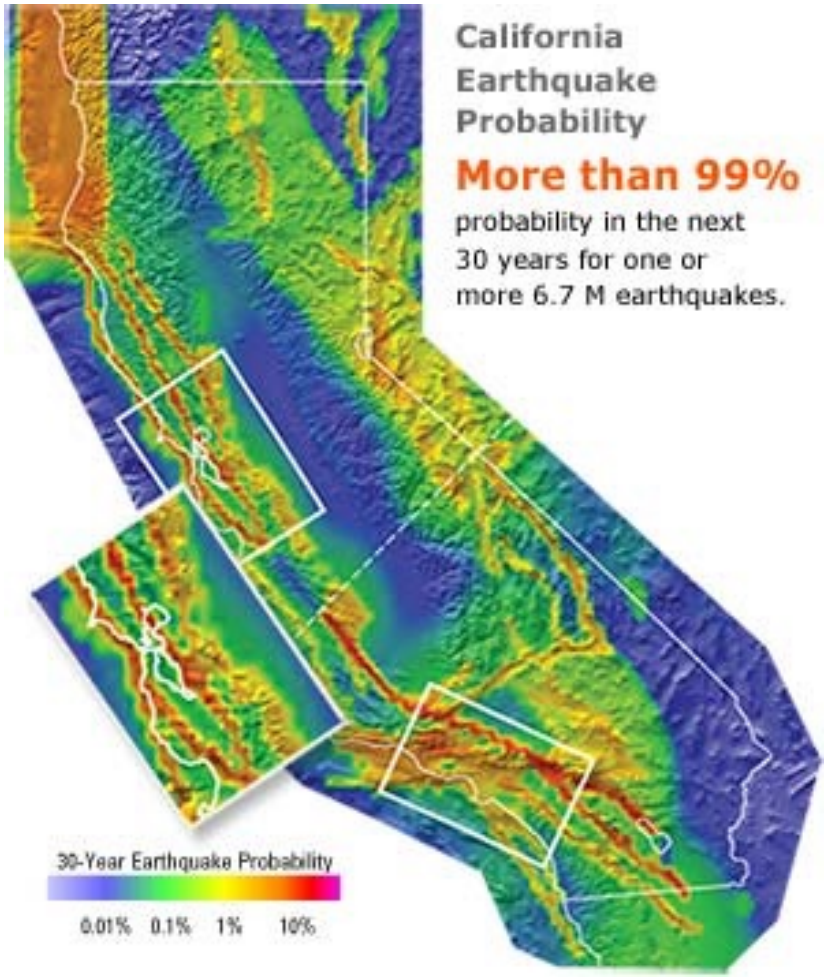
TO REMEMBER: Earthquakes cannot be predicted (so far)!

Long-Term Hazard Assessment

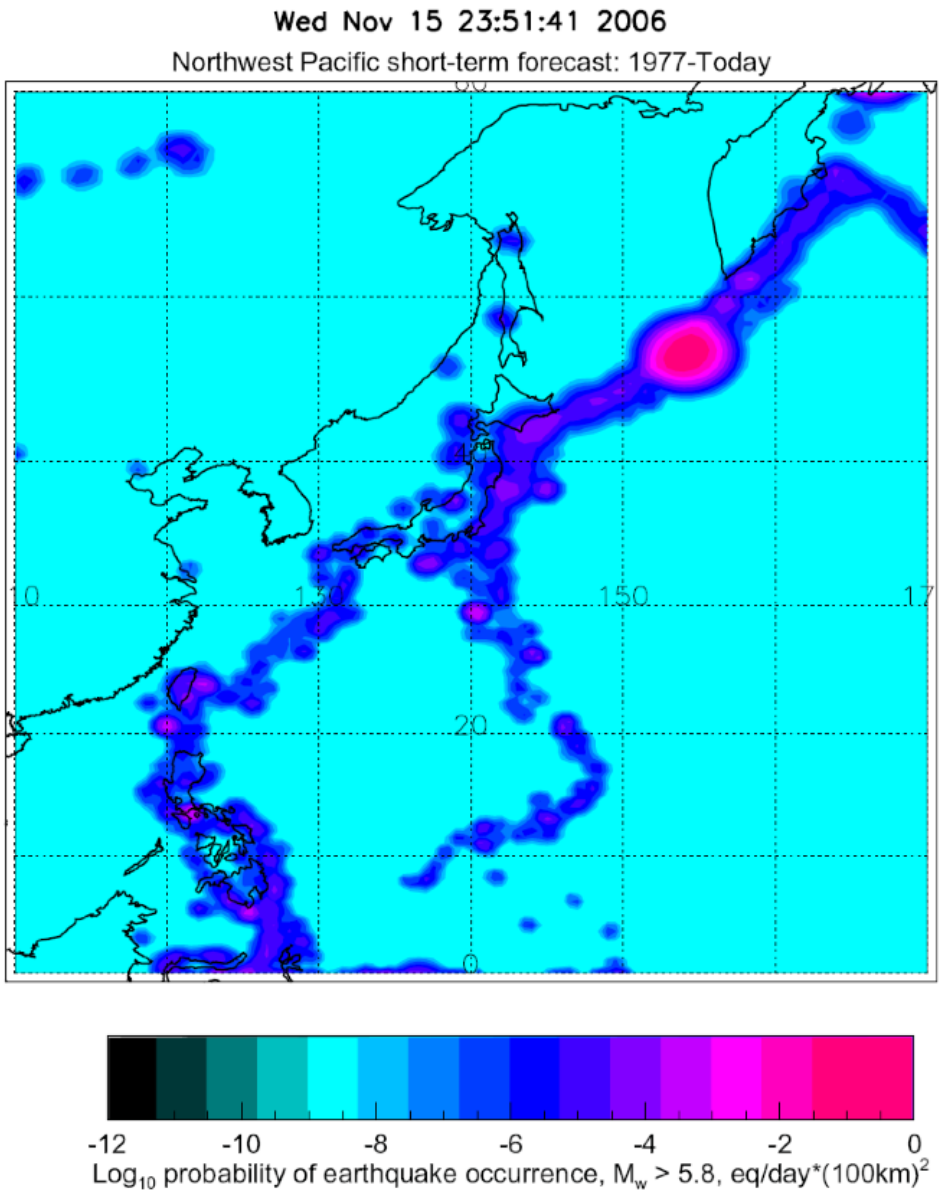


Long-Term Forecasting



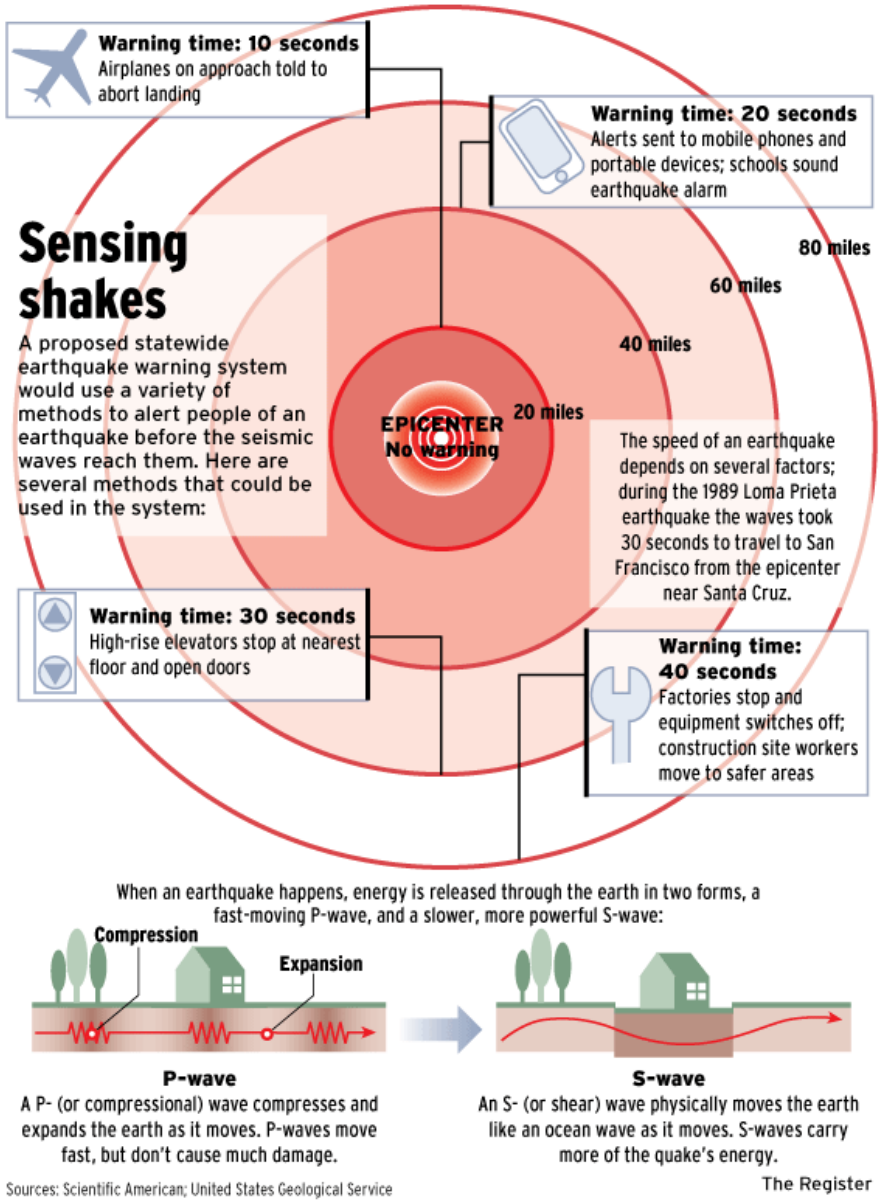


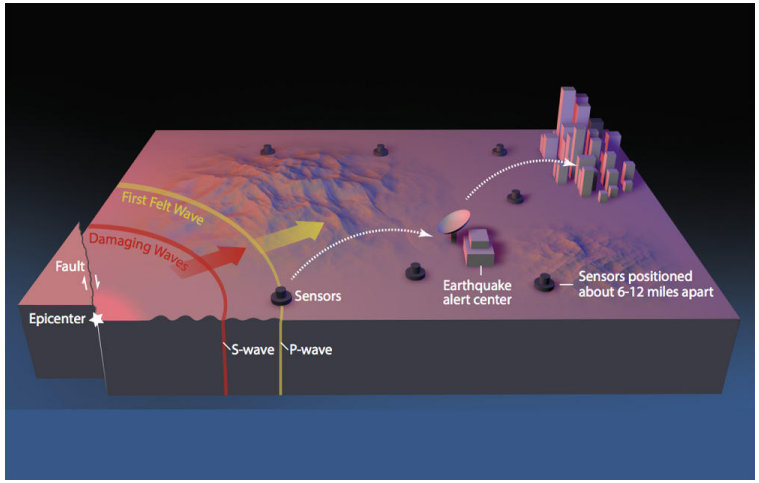
Short-Term Forecast

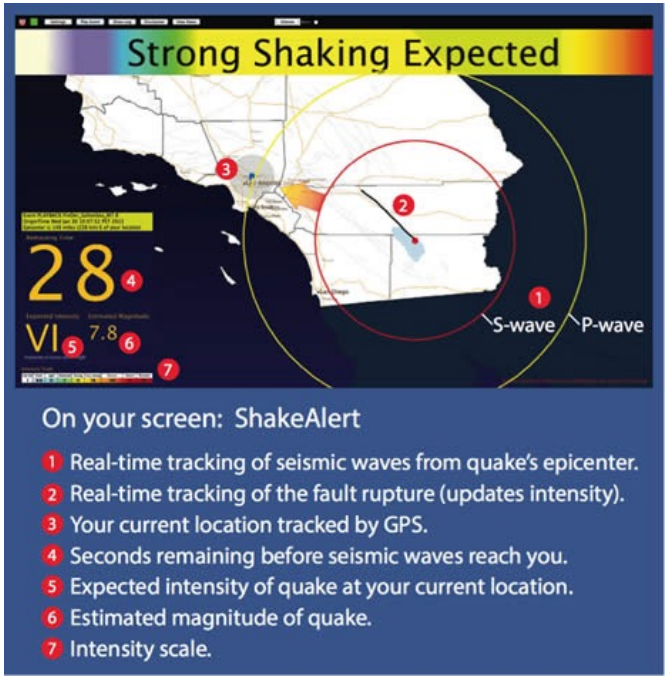


Forecast one day after the recent (2006/11/15) M8.3 Kuril Islands earthquake.

Early Warning Systems

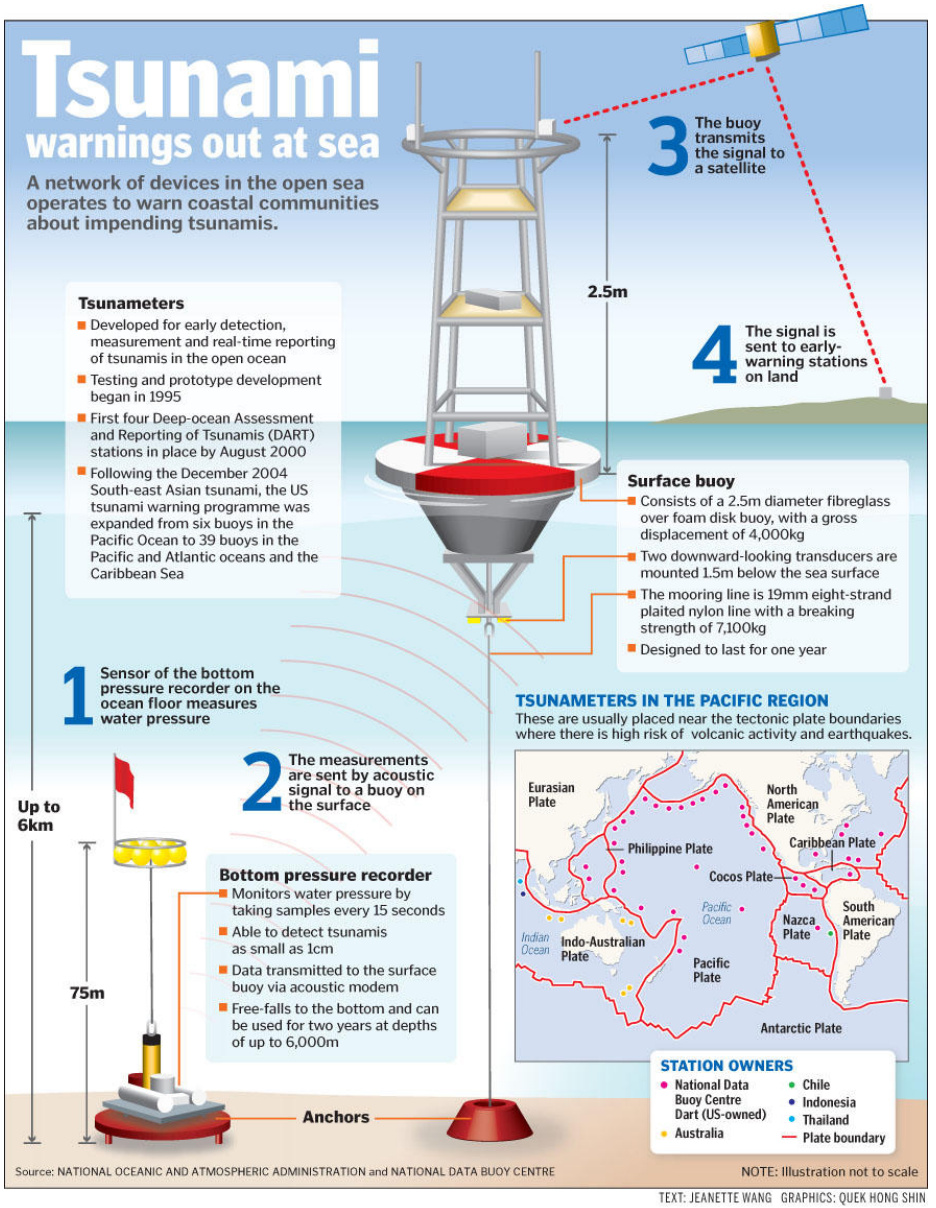






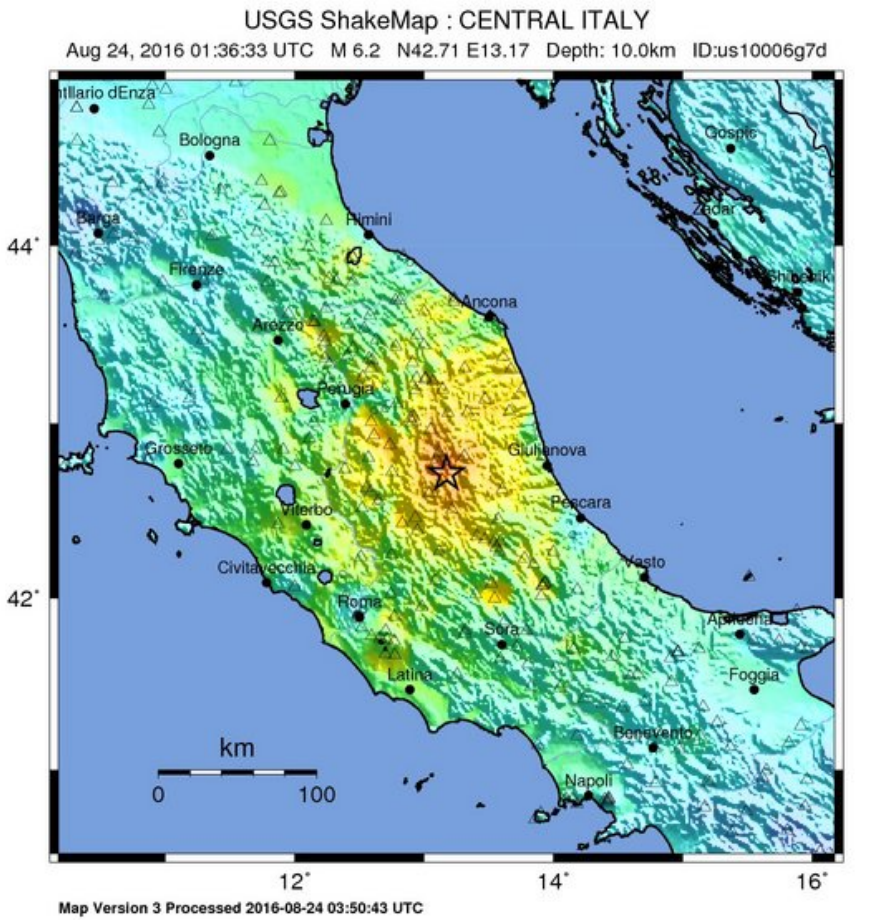
Early Warning Systems

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.



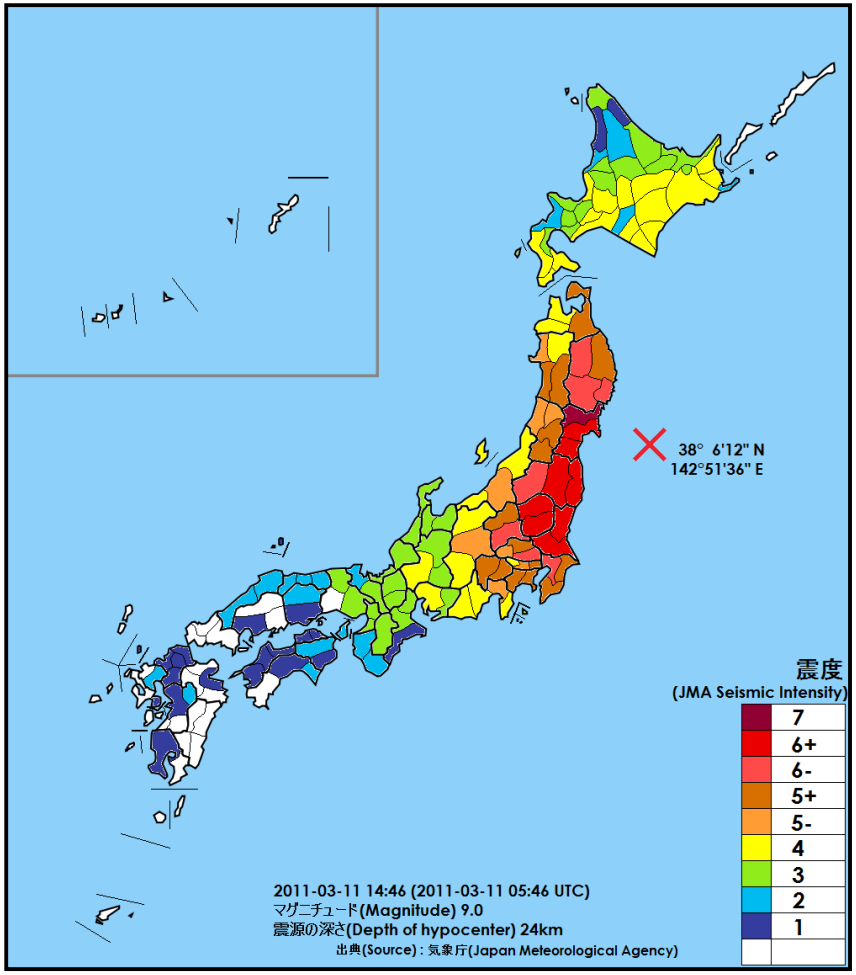
Shake Maps

2016 Norcia Earthquake, Italy



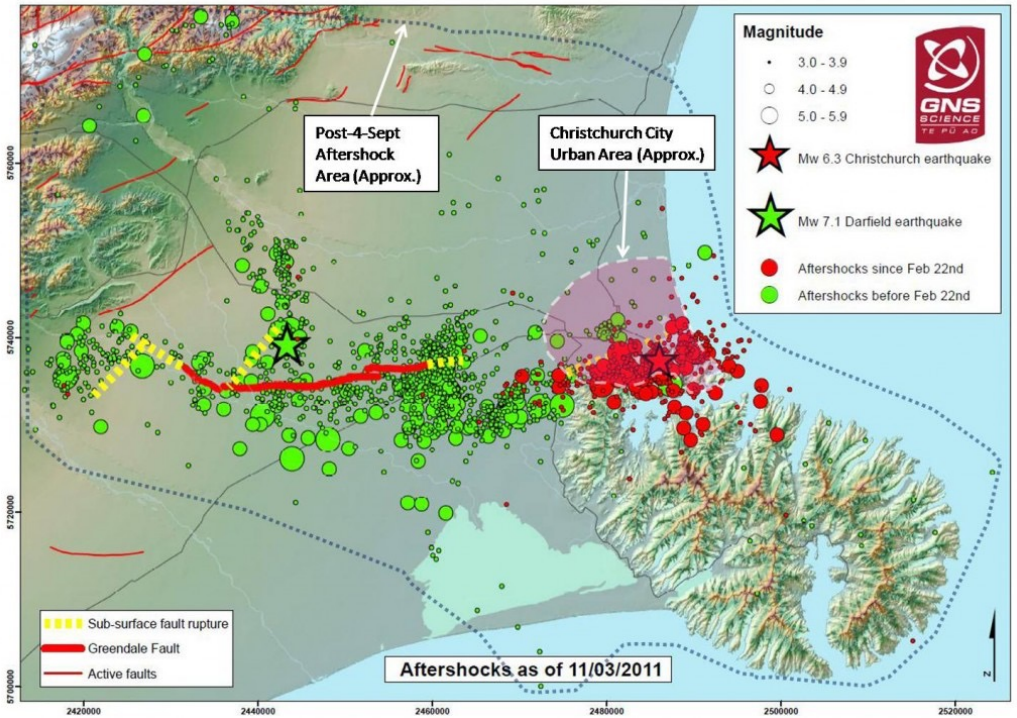
PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Mod./Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<0.06	0.2	0.8	2.0	4.8	12	29	70	>171
PEAK VEL.(cm/s)	*<0.02*	*0.08*	*0.3*	*0.9*	*2.4*	*6.4*	*17*	*45*	*>120*
INSTRUMENTAL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

Scale based upon Faenza and Michelini, 2010, 2011

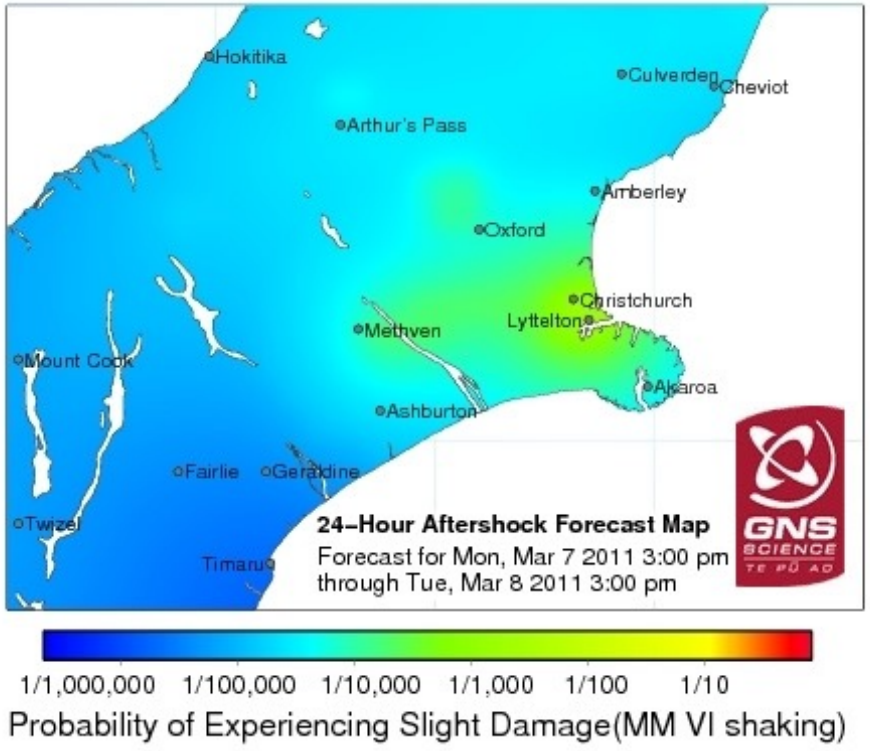


2011 Tohoku Earthquake, Japan

Aftershock Hazard



2011 Christchurch Earthquake, New Zealand



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:

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