

THE SEISMIC FUTURE OF CITIES

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Seismi-City

The perils of urban earthquakes

Seismology the study of earthquakes

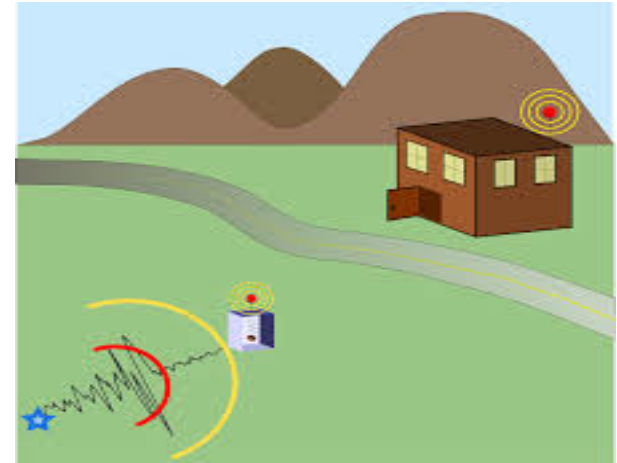
Four measures of failure:

1. We cannot predict earthquakes.
2. We can indicate precisely how badly your house will be shaken a few seconds before it happens
3. We can estimate the death-toll in a deadly earthquake within 30 minutes (weeks before ground crews confirm death toll)
4. We can guarantee that at least 25,000 people will die from earthquakes in the next decade.

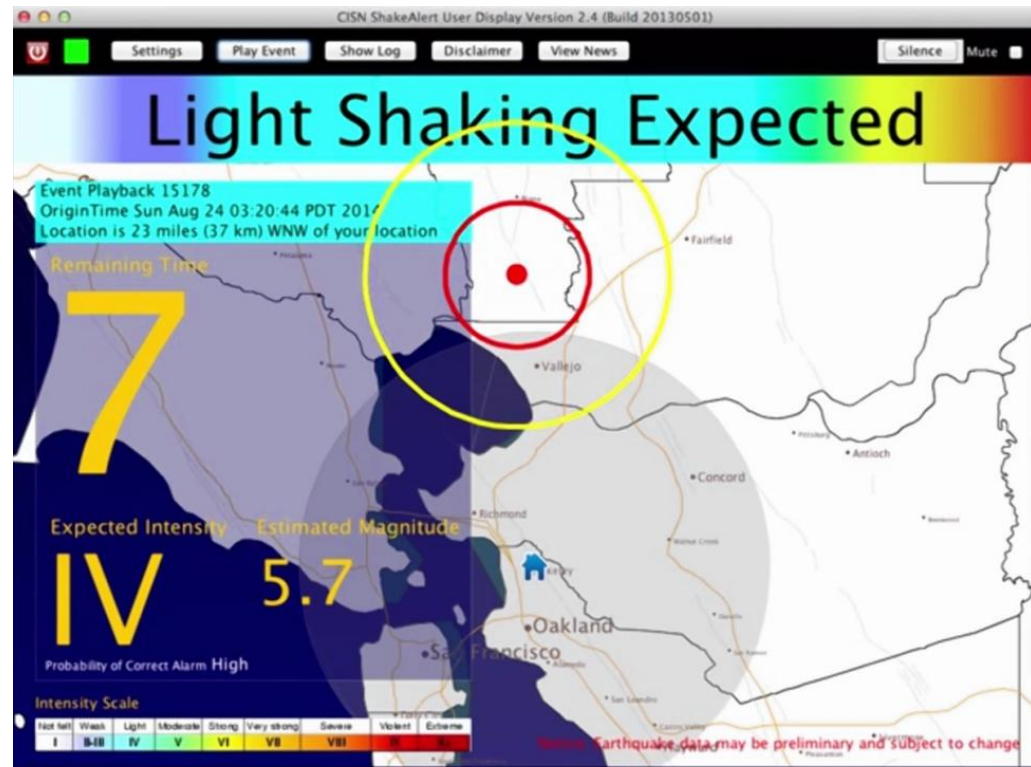
EARLY WARNING (Thunder follows lightning)

Elapsed time

- 0-1s Earthquake rupture occurs
- 2-3 s Magnitude and location determined by three seismometers
- 4s Radio alert broadcast
- 7s-70s Shaking occurs



7 second warning for recent NAPA earthquake



30 minute Prediction of Deaths in Earthquake (globally)

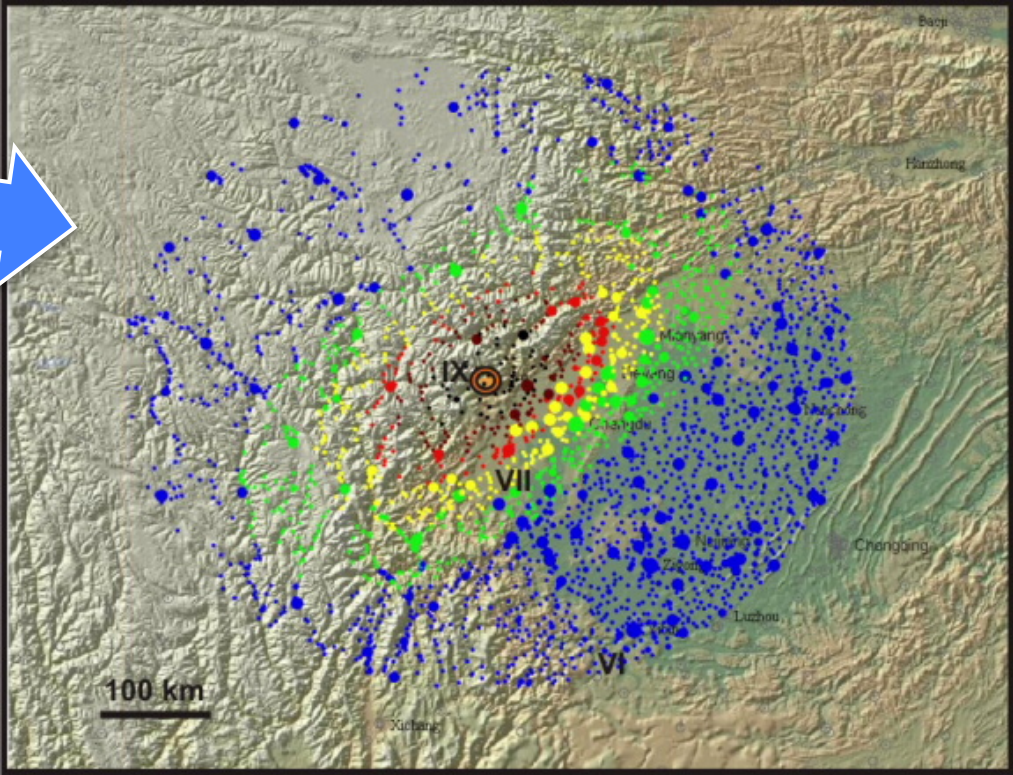
Elapsed time

- 0-2 minutes Earthquake rupture occurs
- 25 minutes Magnitude and location determined by global seismic network
- 30 minutes Shaking intensity predicted near epicenter
- 35 minutes Death-toll forecast
- 35 DAYS Death toll confirmed

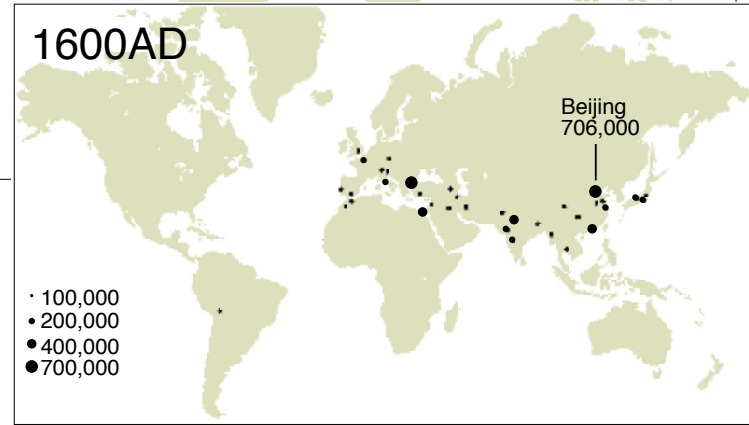
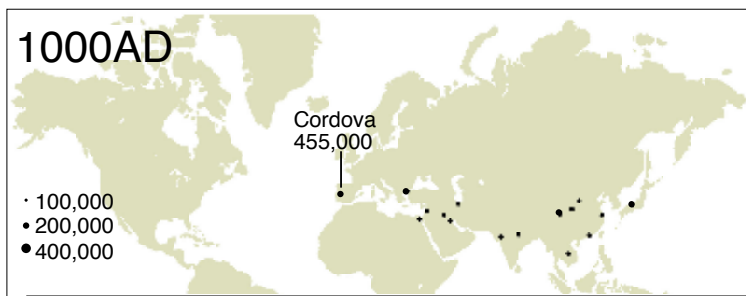
“Instantaneous” map of death and destruction Wenchuan
Predicted 40-100k
Actual 85k



12 May 06:28 Magnitude: M 7.9
WAPPMER May 13, 2008 02:06 pm
Fatalities Exp. min/max: 40000 / 100000



WAPPMER (Max Wyss) and USGS (Dave Wald) predict losses within minutes from seismograms



8,000 BC to 1700 AD

World population <500 million.

Slow city growth 1000-1600 AD

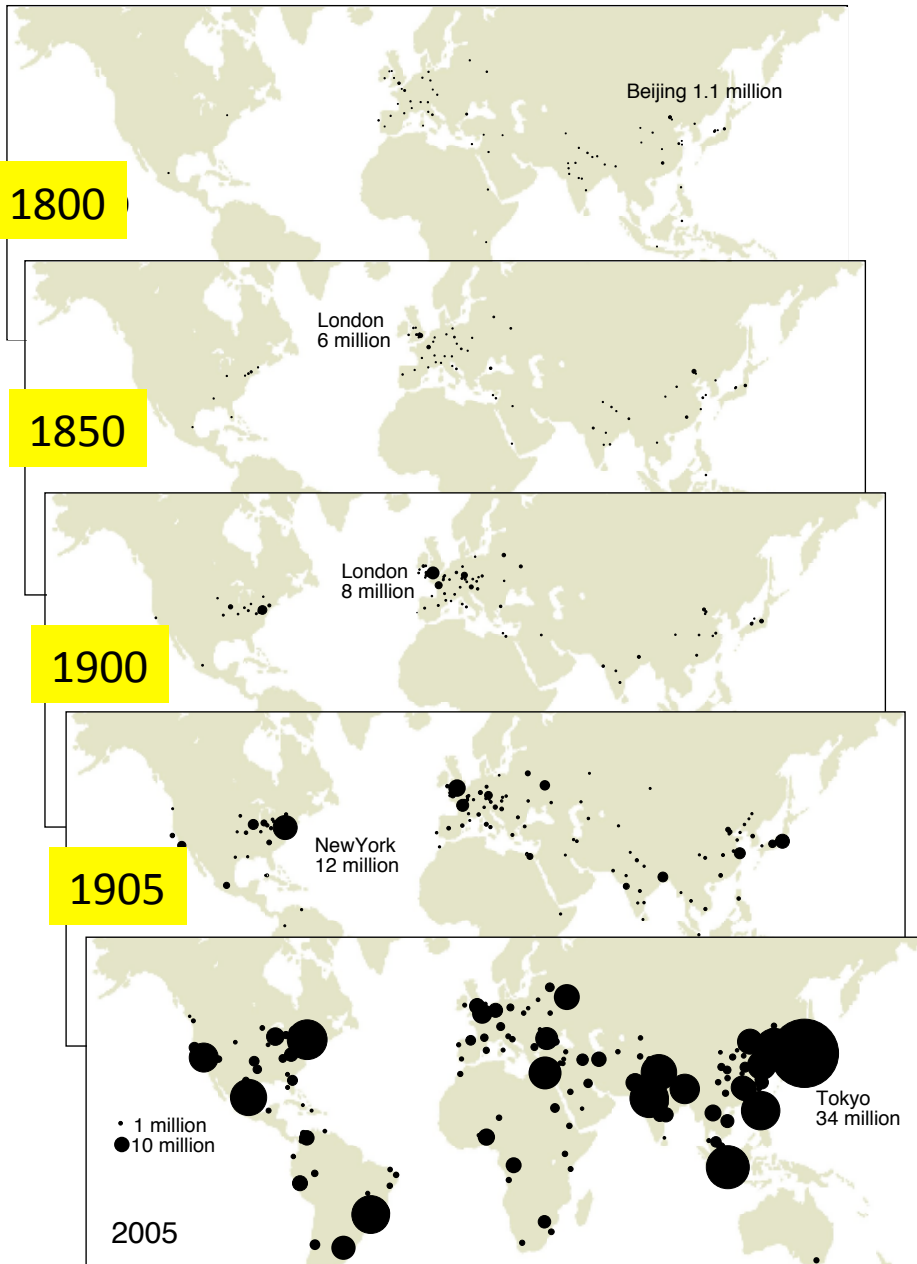
Max. City size 0.5-0.75 M

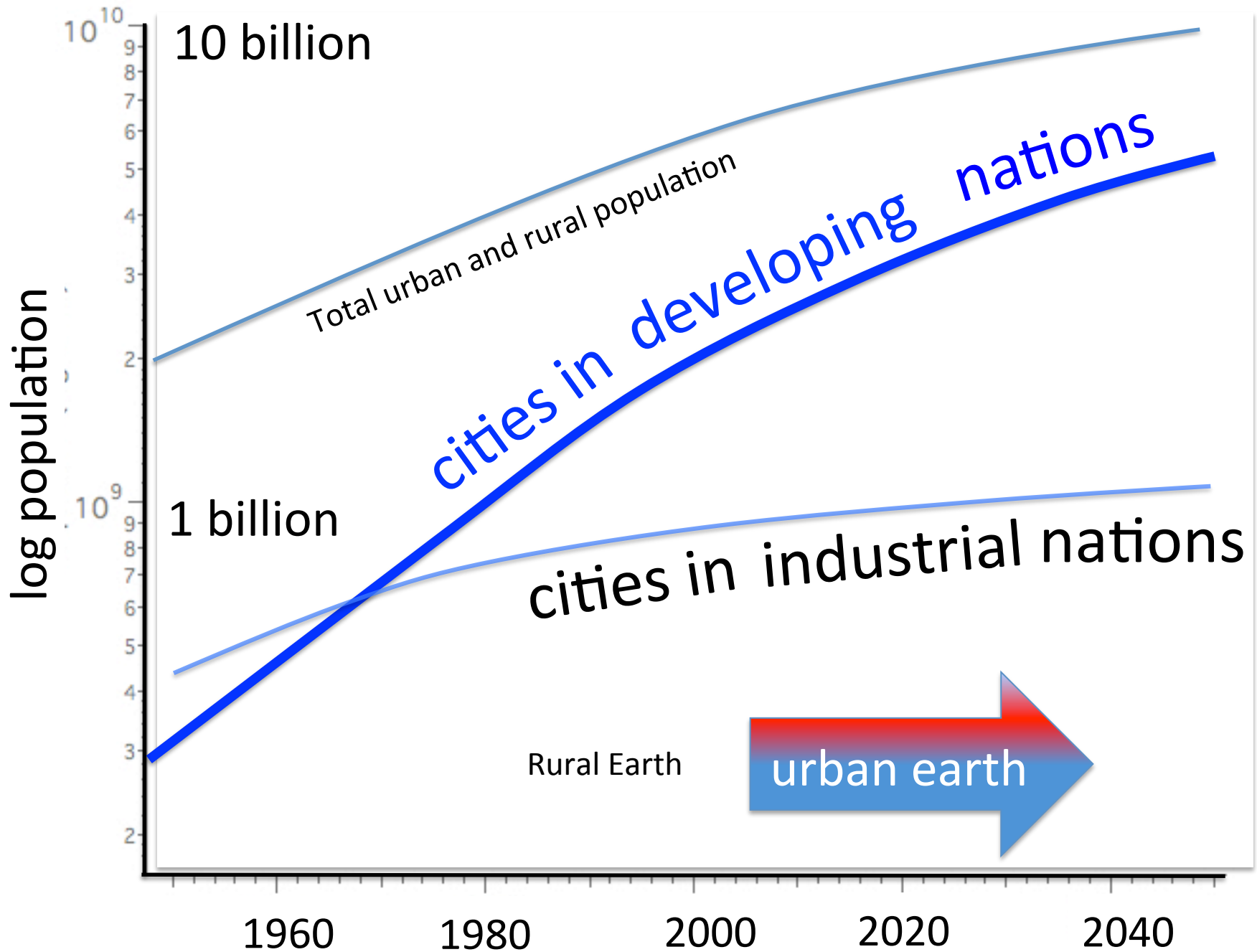
**cities a place
to die (mothers
die young, few
children survive)**

post 1800 medicine/sanitation

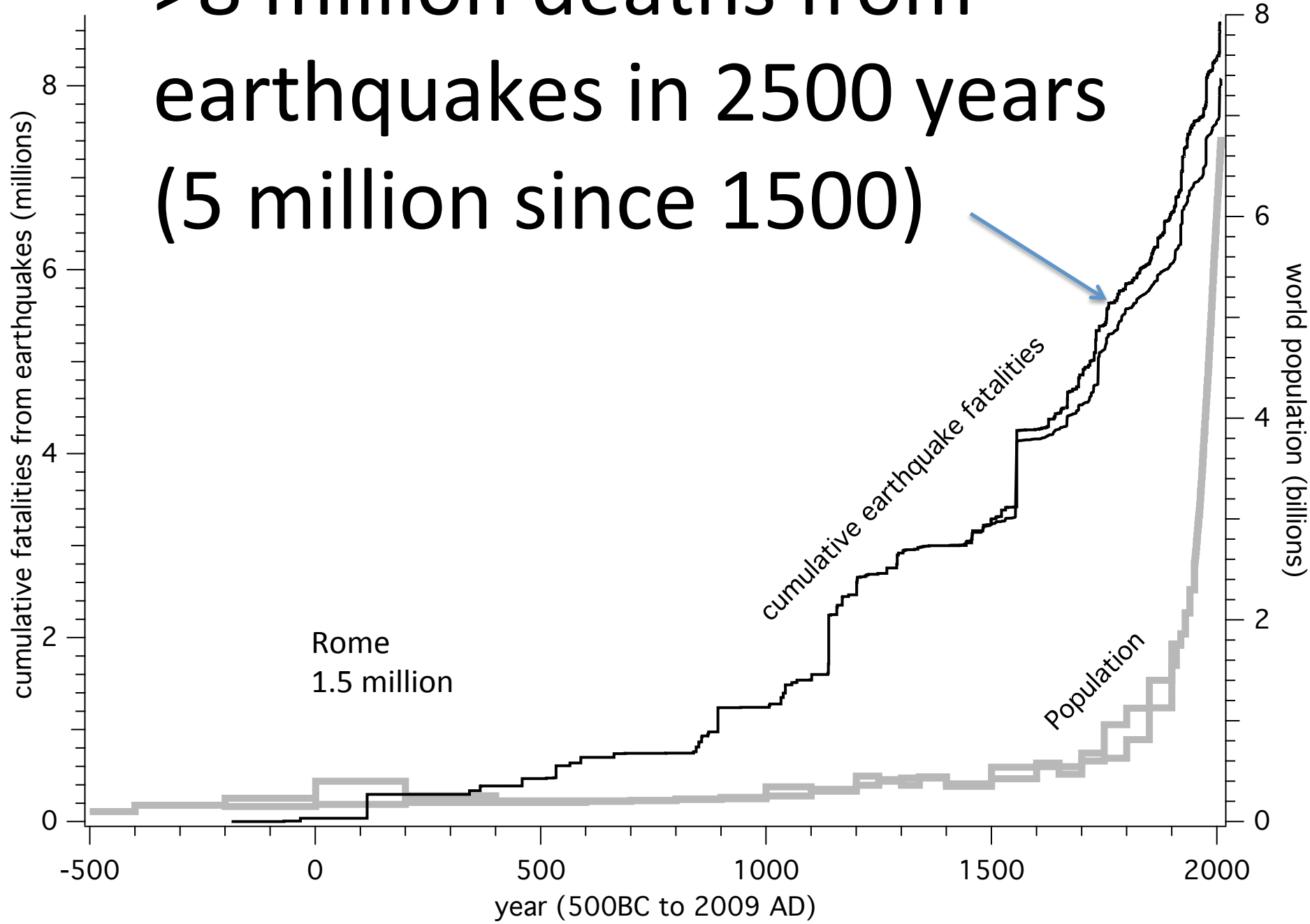
Cities now a place to live.

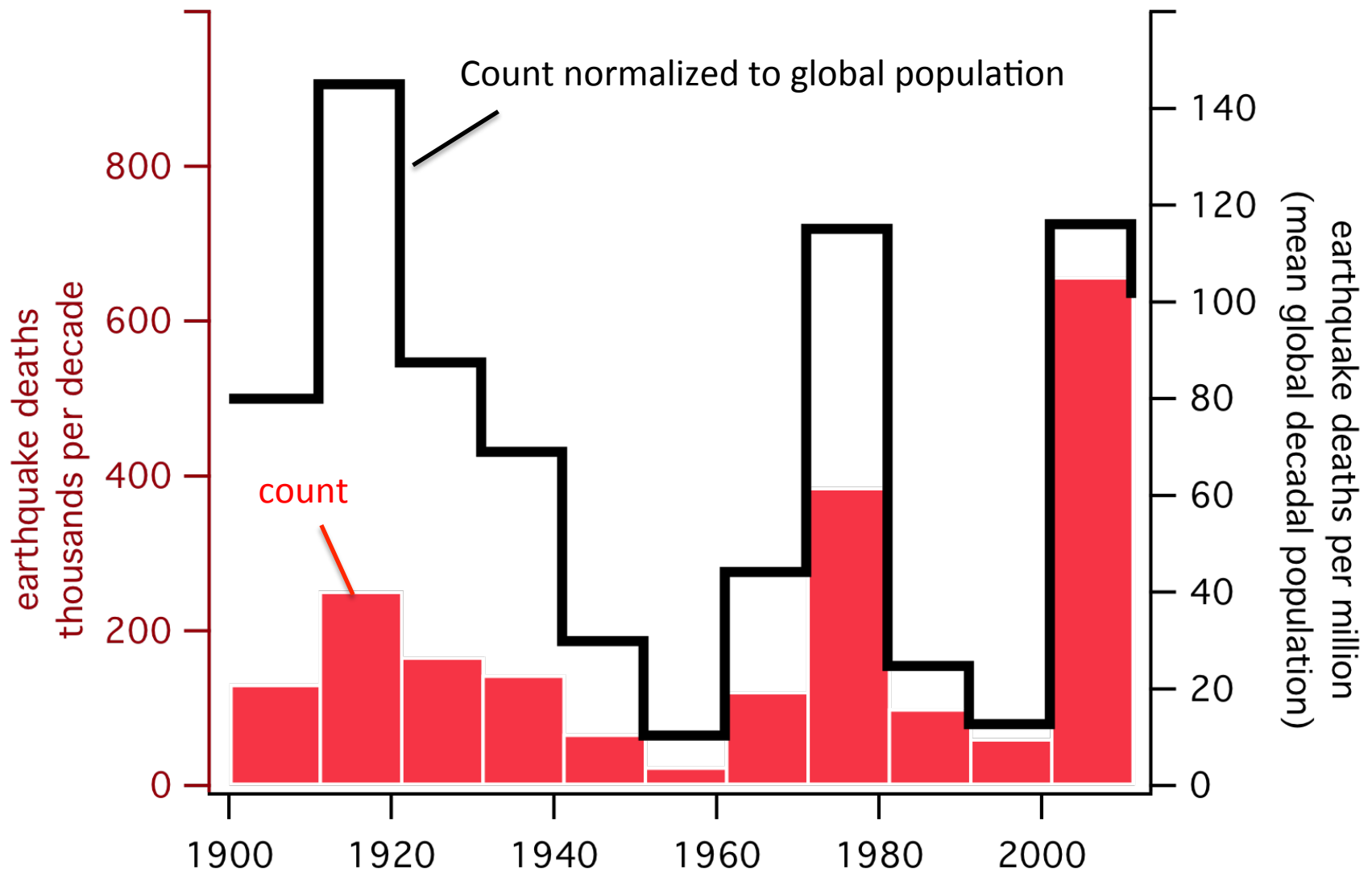
City size explodes in 20th
century.





>8 million deaths from earthquakes in 2500 years (5 million since 1500)





Earthquake deaths per decade since earthquake resistant construction was recognized in Italy/Japan/ US

The last 15 years are the worst on record (600,000 deaths)

16 Dec 1857 Mw=7.0 19,000 dead



Italy 1857 building collapse identified as cause of deaths in earthquakes.

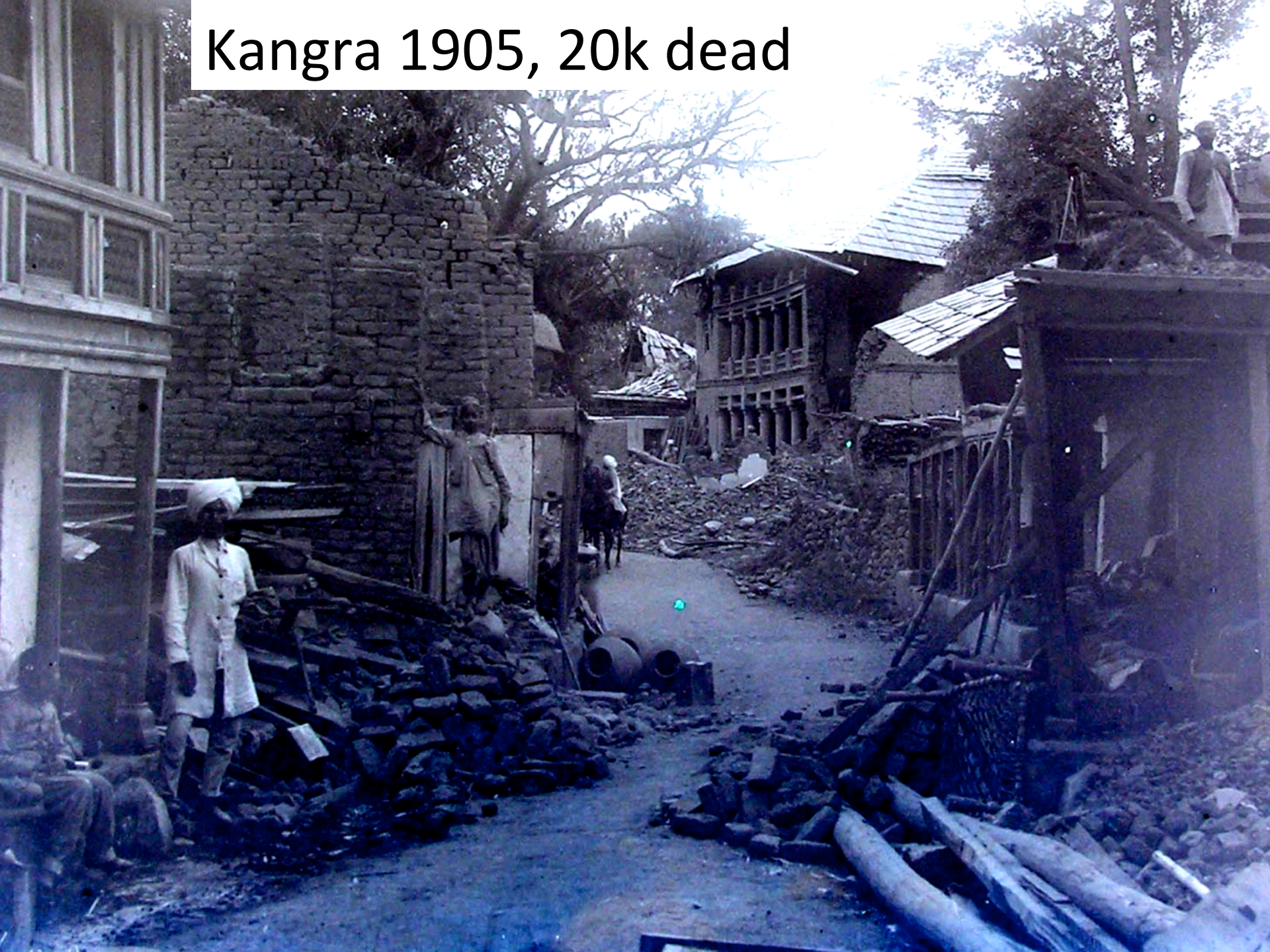
The fix- earthquake resistant construction

The eye is bewildered by "a city become an heap". Robert Mallett 1862.


*"Earthquakes don't kill people- buildings do"
Ambraseys 1972*



Kangra 1905, 20k dead



T
Tokyo 1923, 143 k dead

An aerial black and white photograph showing the aftermath of the 1923 Great Kanto Earthquake in Tokyo. A wide, multi-lane street runs diagonally from the bottom left towards the center. The surrounding urban area is almost entirely in ruins, with only skeletal remains of buildings and scattered debris visible. On the left side of the street, a large, multi-story building with a grid of windows and arched ground-floor openings stands partially intact. In the background, more buildings are visible, some appearing as dark silhouettes against a hazy sky. A small, dark letter 'T' is positioned in the upper right quadrant of the image.

1923年9月1日東京大地震後情形

Tabas 1978 25k dead



ChiChi 1999 6k dead



Izmit 1999 20k dead



Duzce, Turkey 1999 1k dead



2003 Bam, Iran, 26k dead



Kashmir 2005 88k dead



Bhuj, India 2001, 20k dead



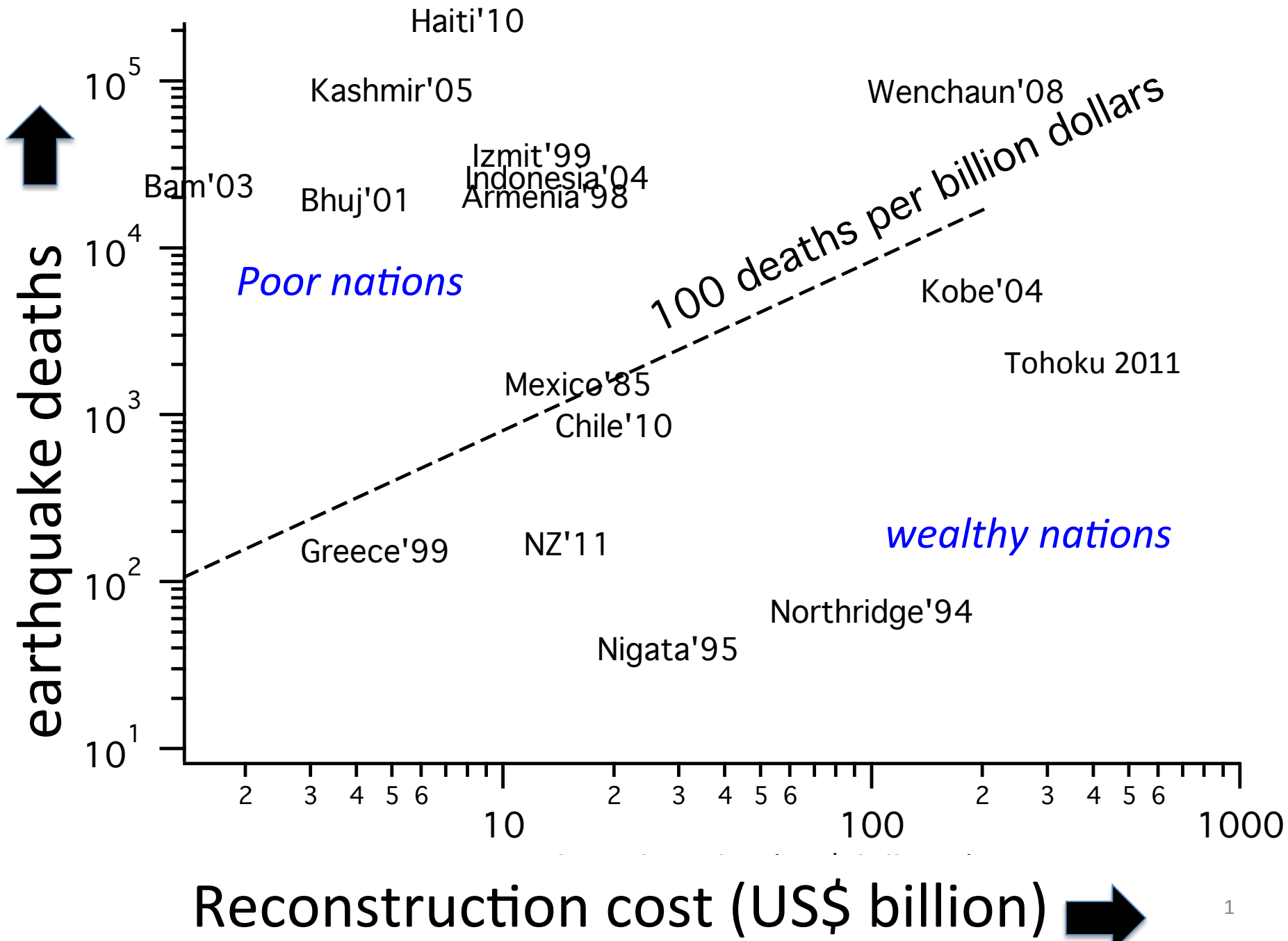
2008, Wenchuan, PRC, 85k dead



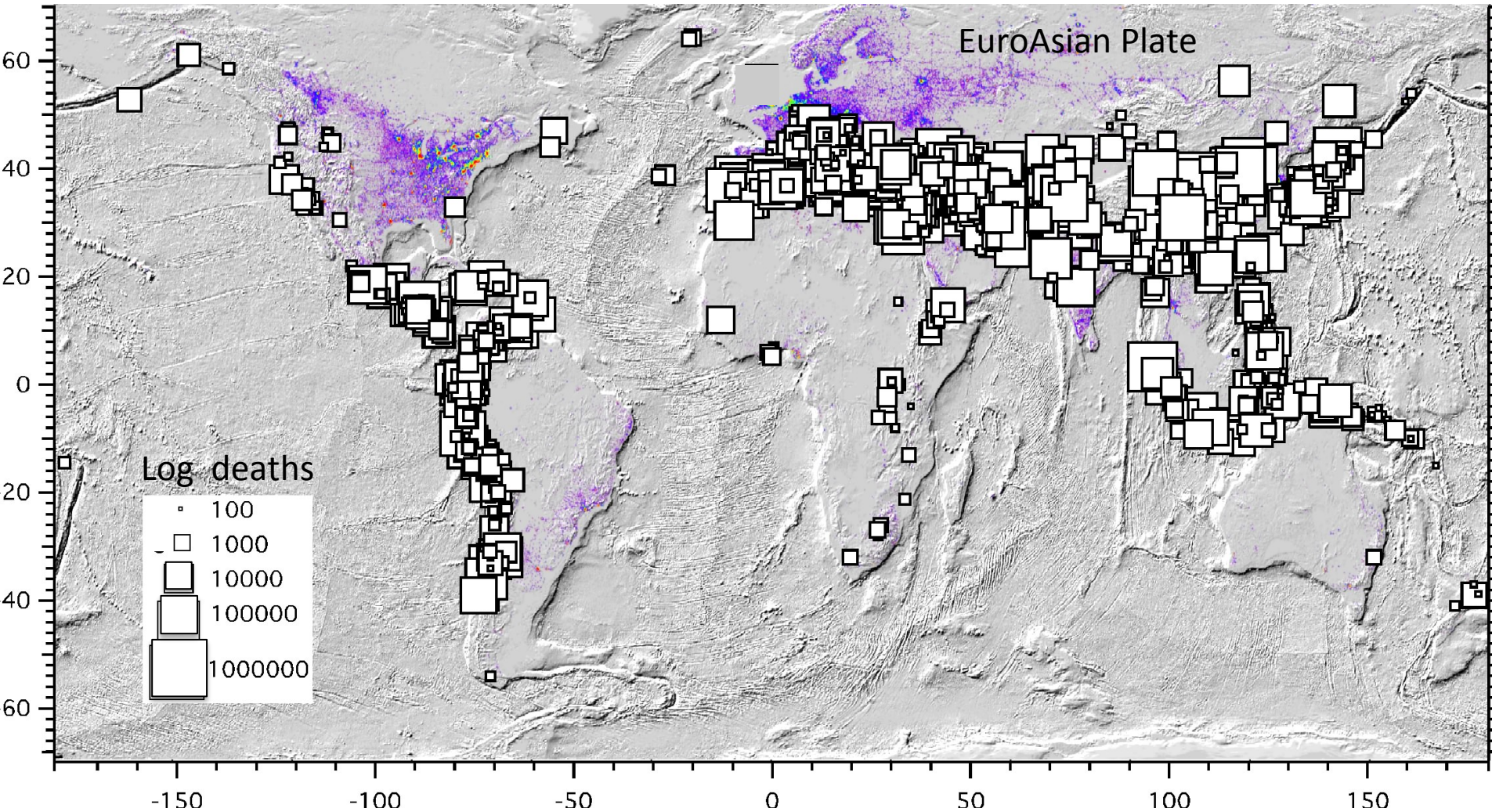
2010, Haiti, 85k dead



Cost vs. death-toll: the poor die- the rich pay

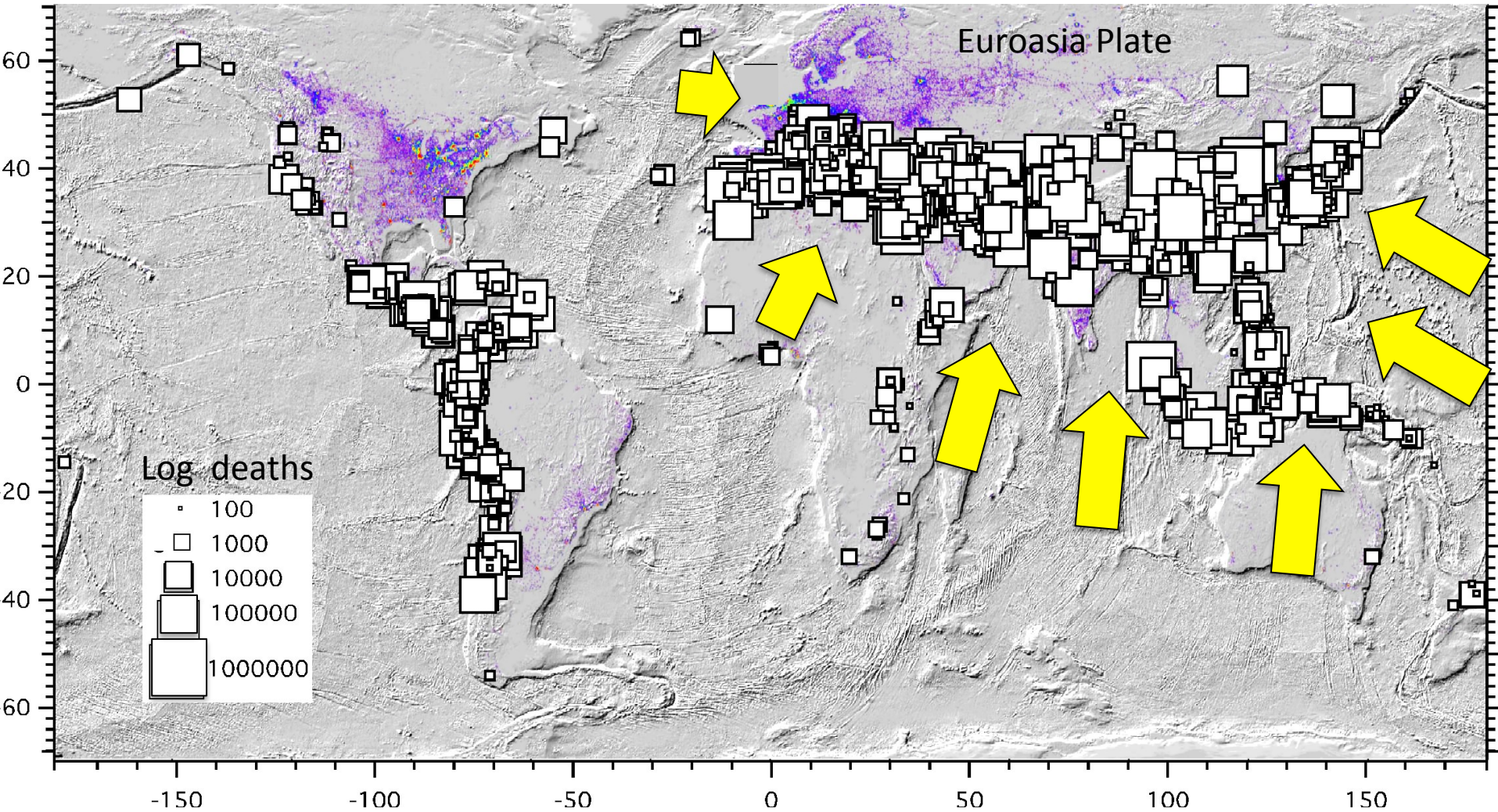


Deadliest earthquakes S. edge of EuroAsian plate



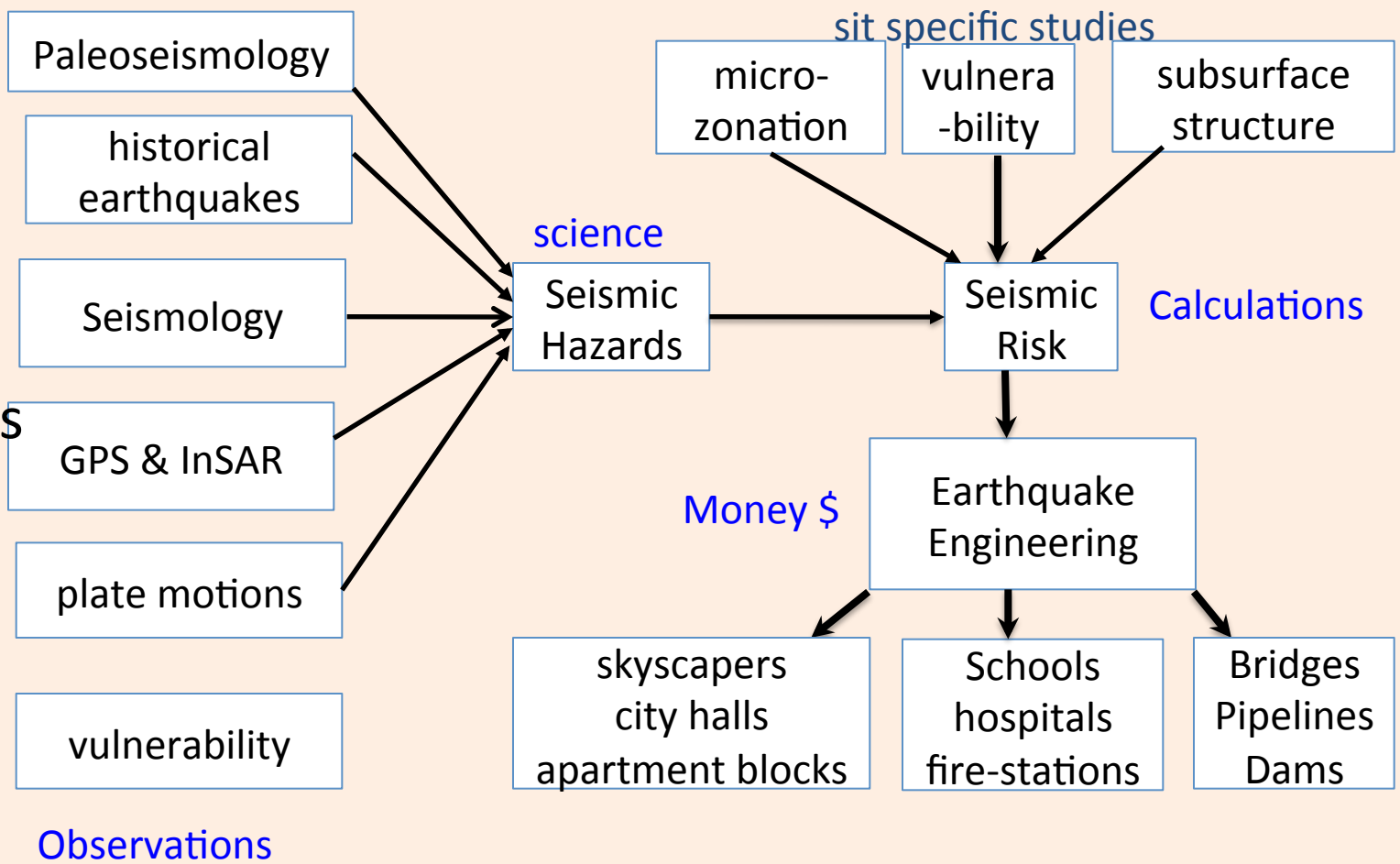
85% of all earthquake deaths in Alpine/
Himalayan/ Indonesian/Pacific collision zone
(where we are now!)

Deadliest earthquakes S. edge of EuroAsian plate

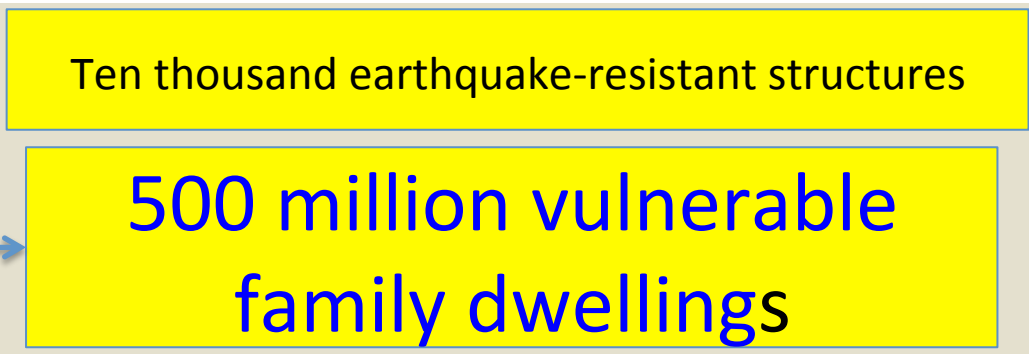


83% of all earthquake deaths in Alpine/
Himalayan/ Indonesian/Pacific collision zone
Mostly in $7.0 < M_w < 8.0$ earthquakes on land.

How we currently view future earthquakes

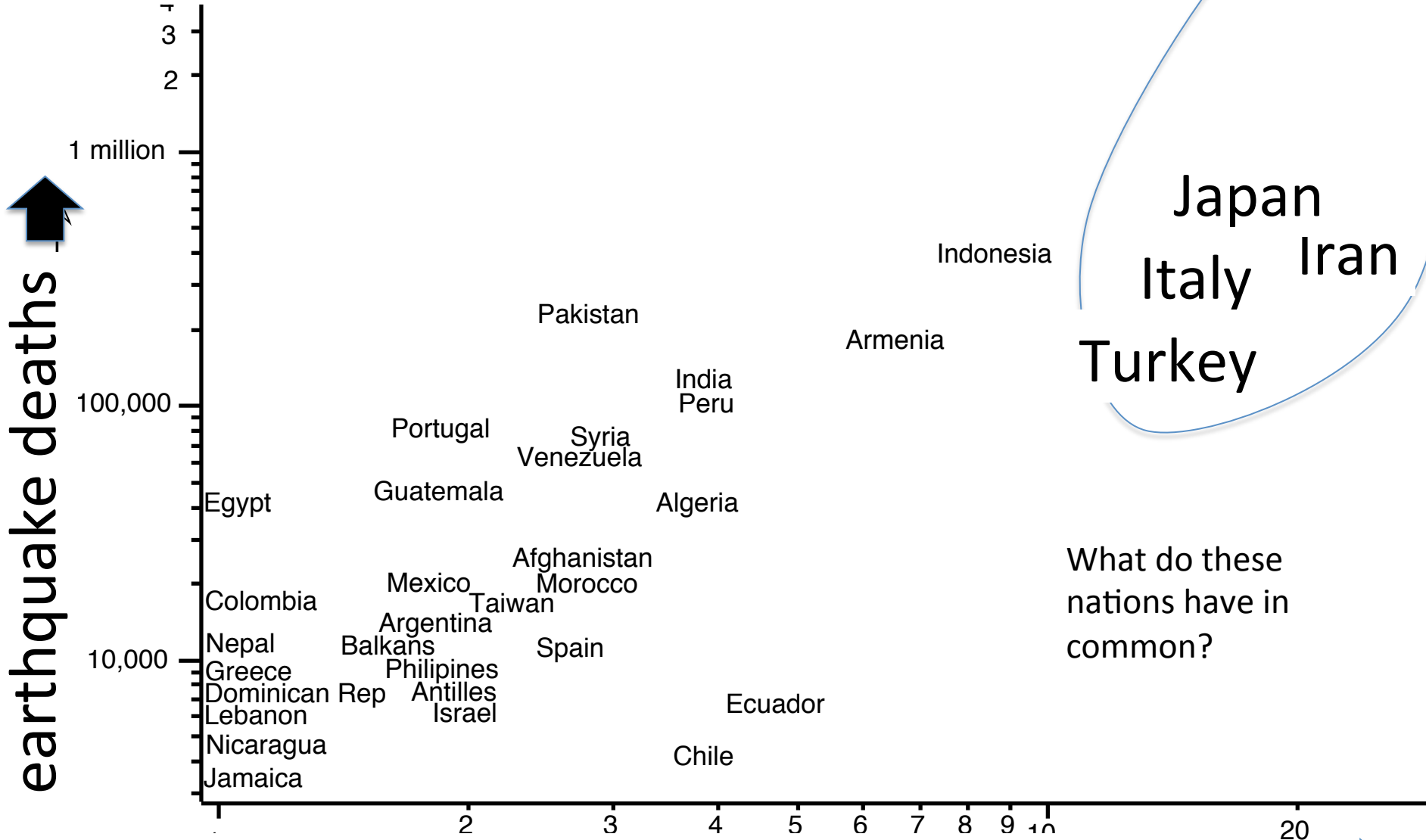


how future earthquakes view society



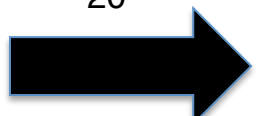
ie deaths from earthquakes (~50,000/year) will continue to rise

Most dangerous earthquake nations since 1500



What do these nations have in common?

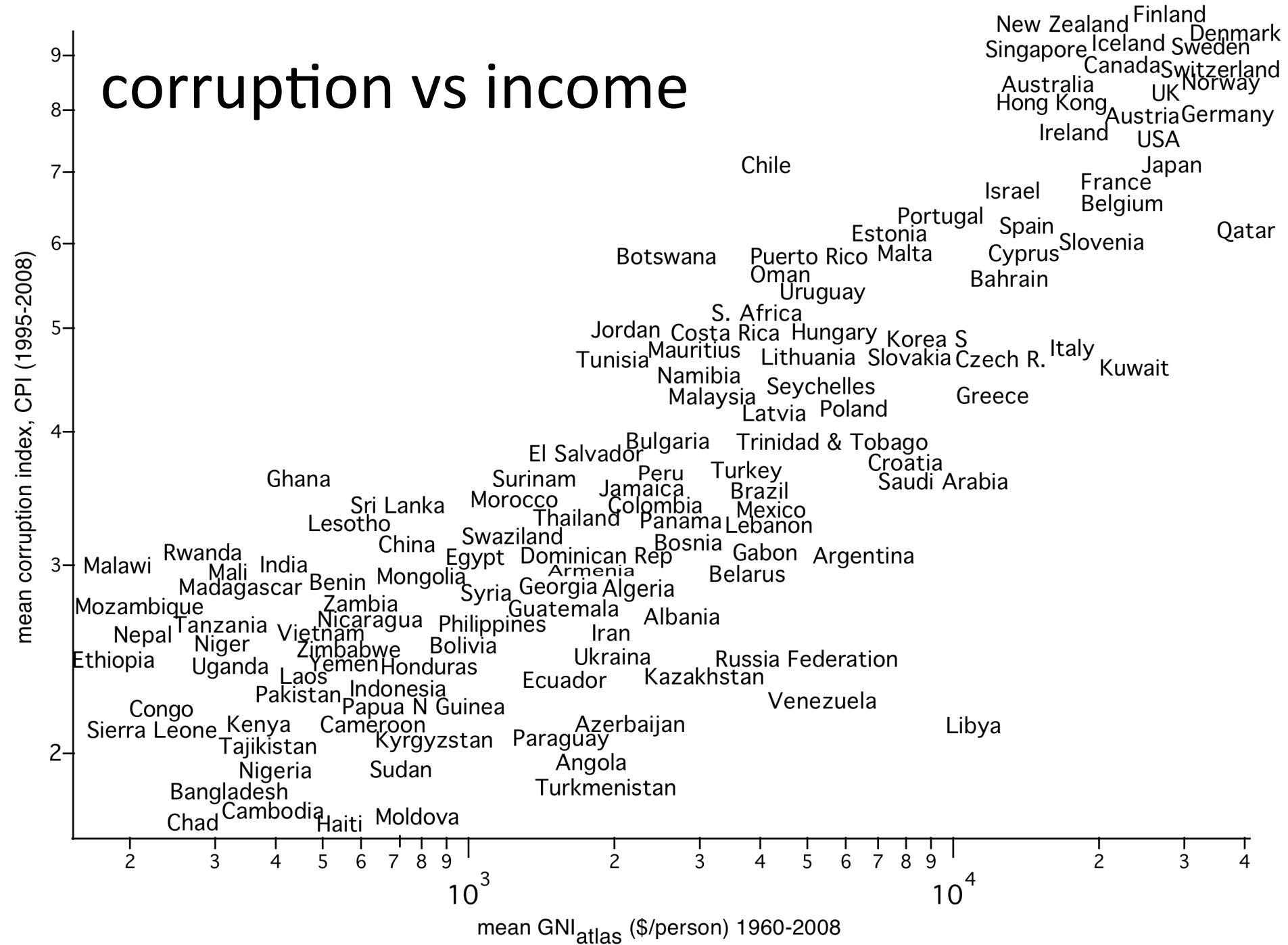
number of earthquakes with >3k death tolls



Corruption in the \$7,500 billion/year global construction Industry (Transparency International 2005).

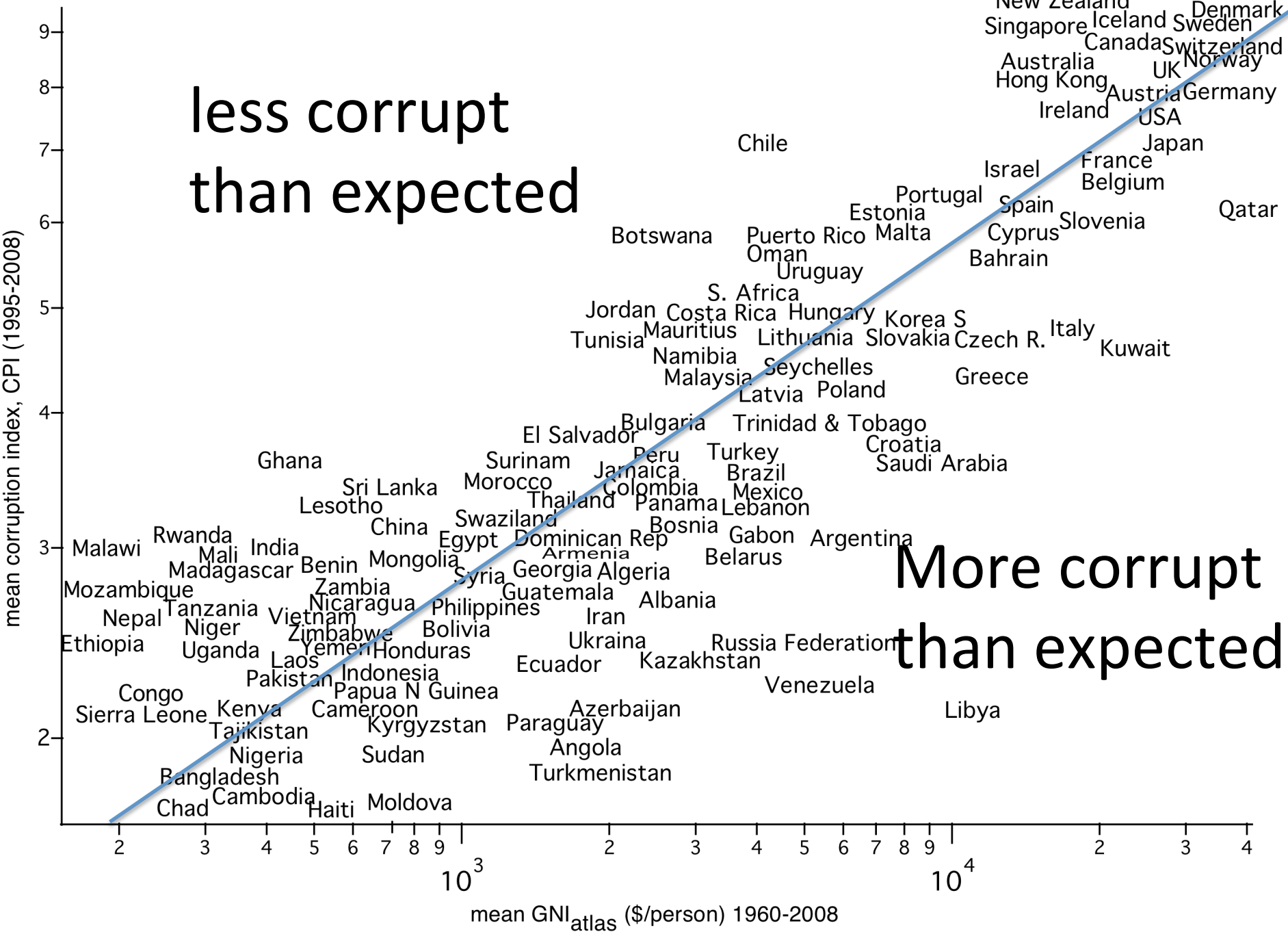
- greater than in any other sector of the global economy
- corrupt award of construction contracts (bribery & political pressure).
- corrupt issuance of approvals and permits.
- corrupt inspection process at all stages of construction
- shoddy work concealed by concrete, plaster and cladding.

corruption vs income

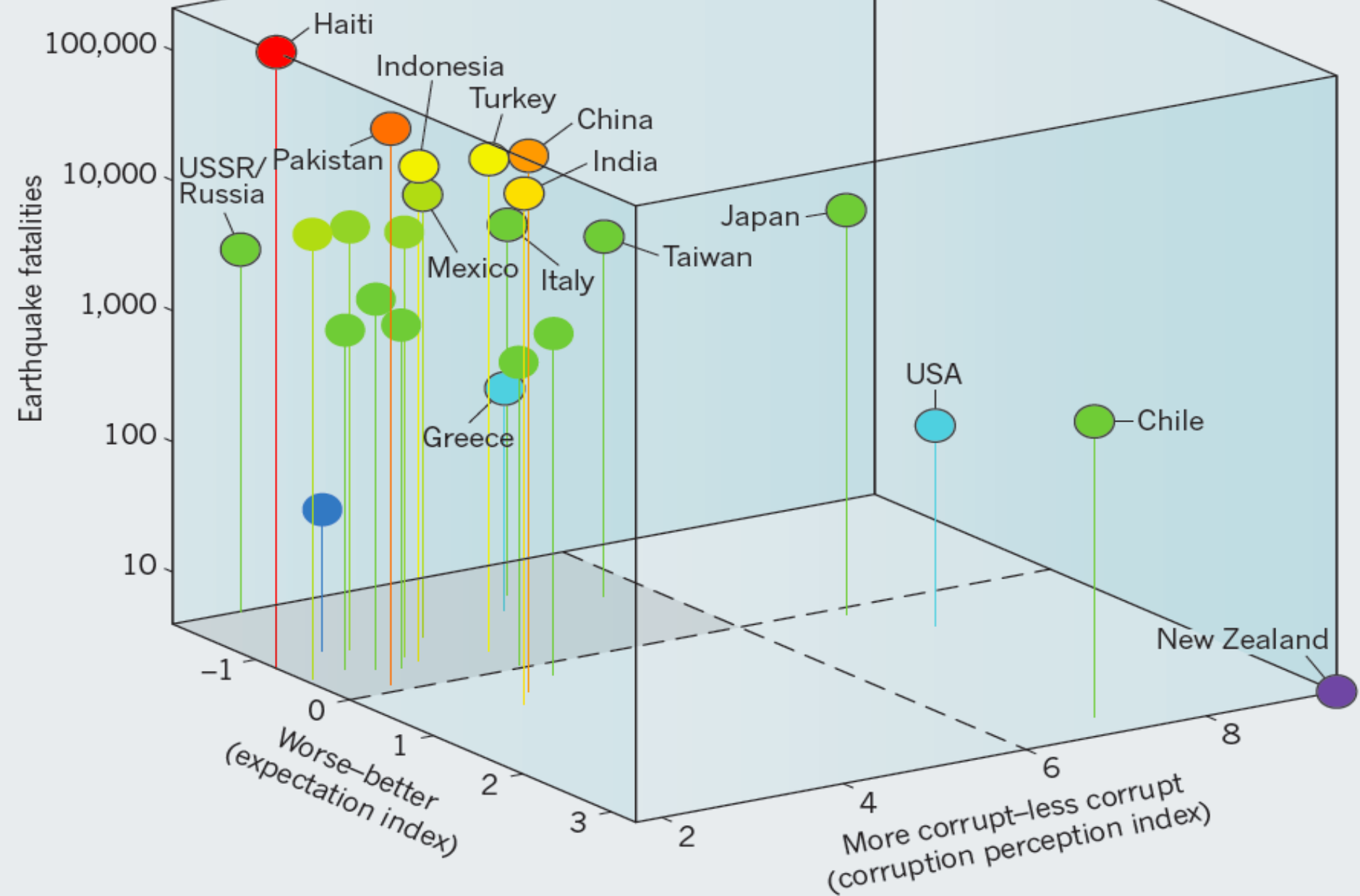


less corrupt
than expected

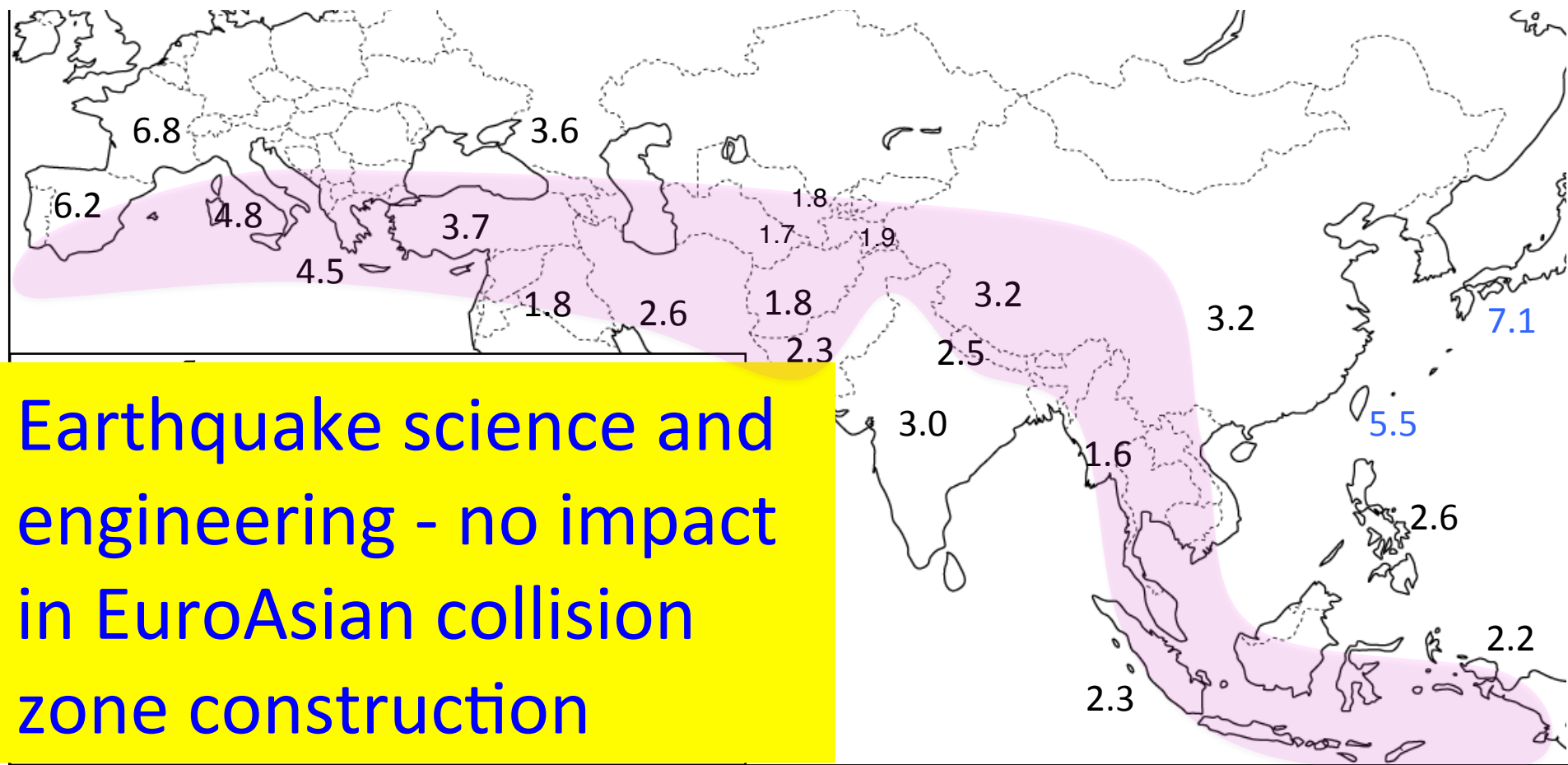
More corrupt
than expected



83% of all deaths from earthquakes in the past 30 years in low-income corrupt nations



Wealthy nations = strong buildings
Poor nations = ignorance, corruption
and weak buildings



CPI Corruption Index (numbers) declines eastward

- The world's poor often rent or construct weak dwellings
- Corruption costs the world >15% more – earthquake resistance costs only 10%

Is there a fix?

Yes-education

Conclusions

Hidden societal factors within the structure of societies act to thwart the best intentions of seismologists and engineers.

Cities in S. Asia are unexpectedly fragile

- 1. ignorant construction**
- 2. codes circumvented- earthquake resistance low priority**
- 3. rampant bribery to maximize profits**

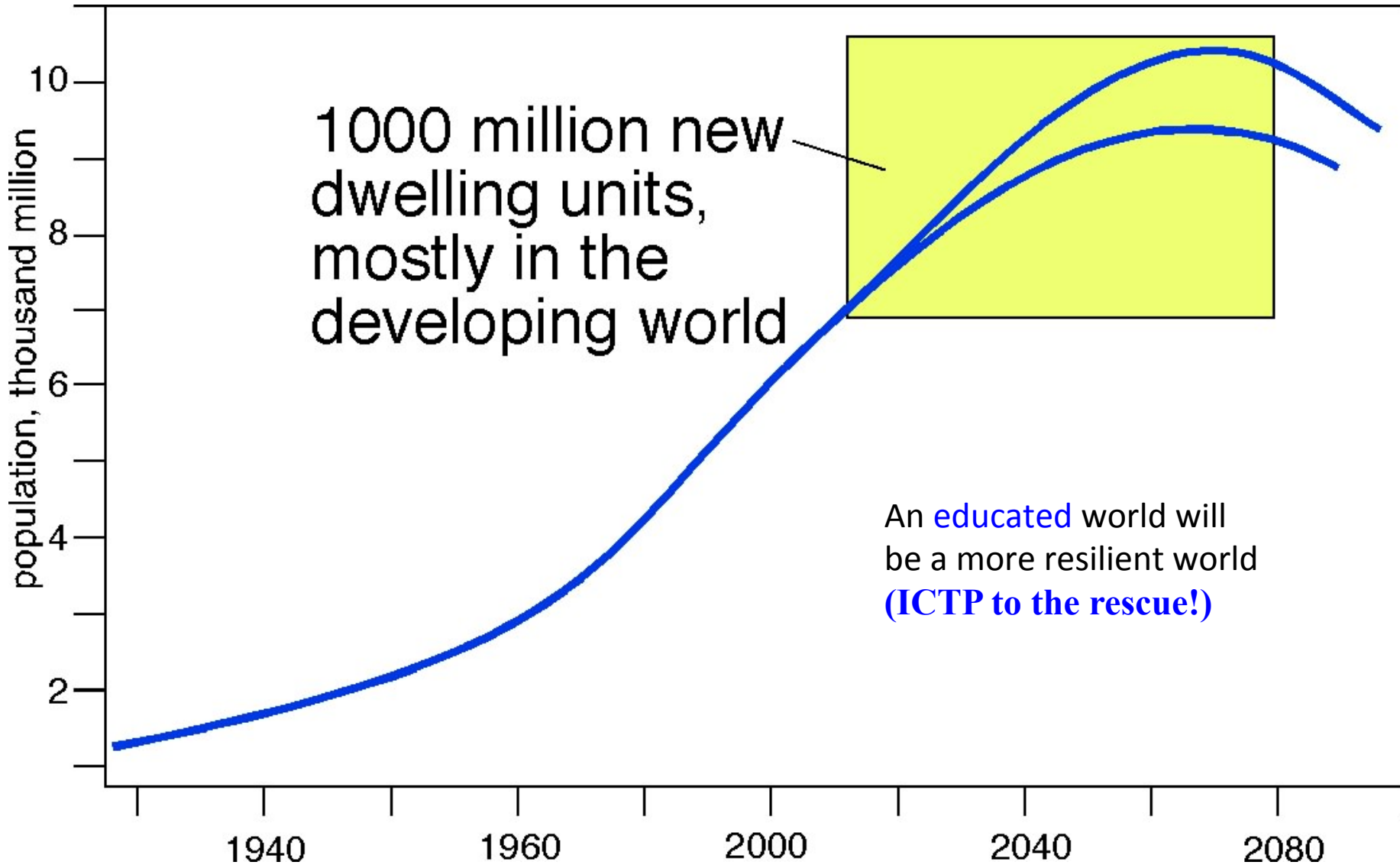
urban and rural poor especially vulnerable.

---not of interest to the global insurance business.

A $M_w \geq 7$ earthquake close to a city of 12 million could cause 1 million fatalities

**The fix for 1-3 is education!
(ICTP to the rescue!)**

the seismic future of cities?



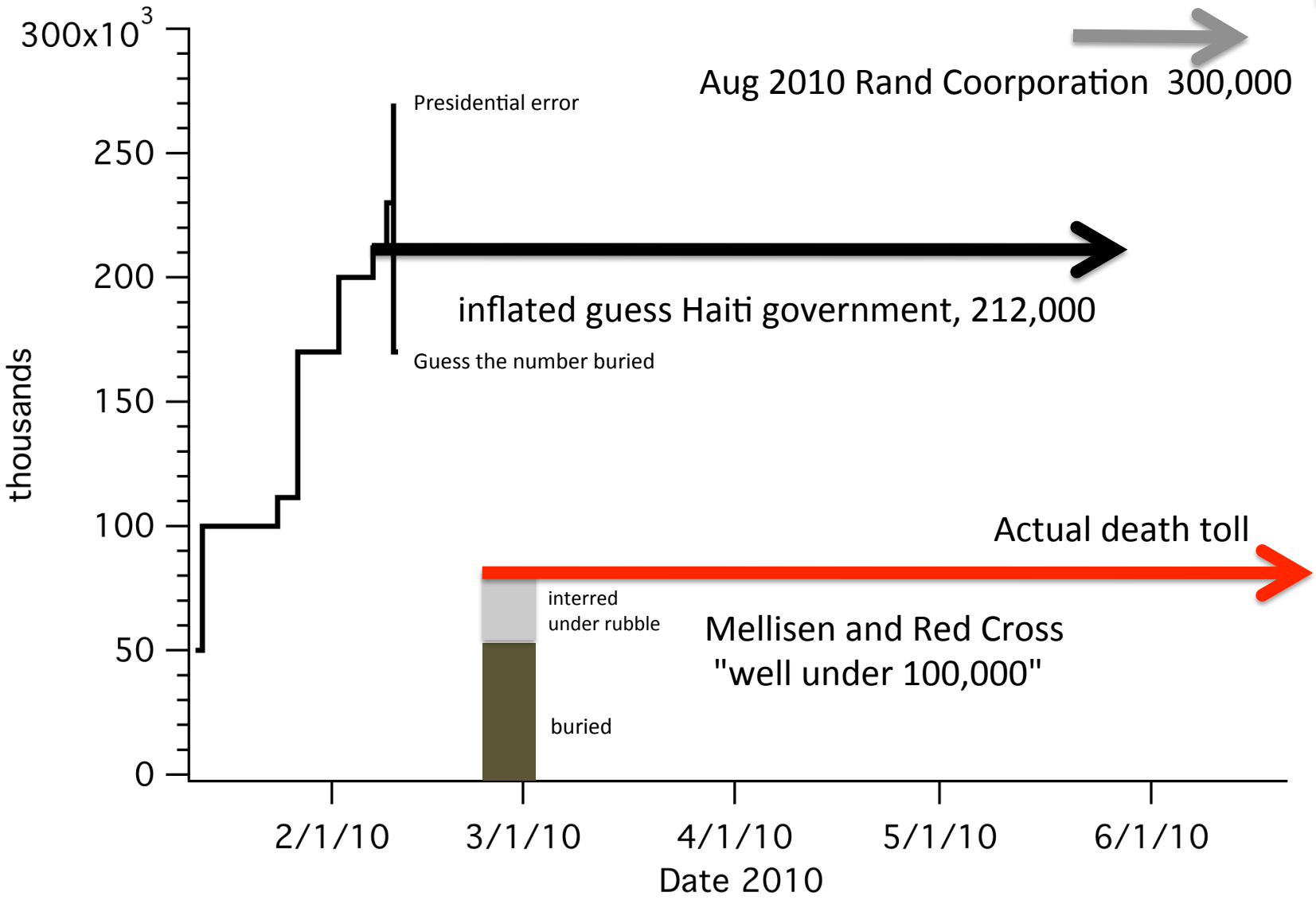
the Haiti Death toll: double counts & guesses

from government reports and news media

31600

12 Jan 2011 anniversary count

Aug 2010 Rand Corporation 300,000



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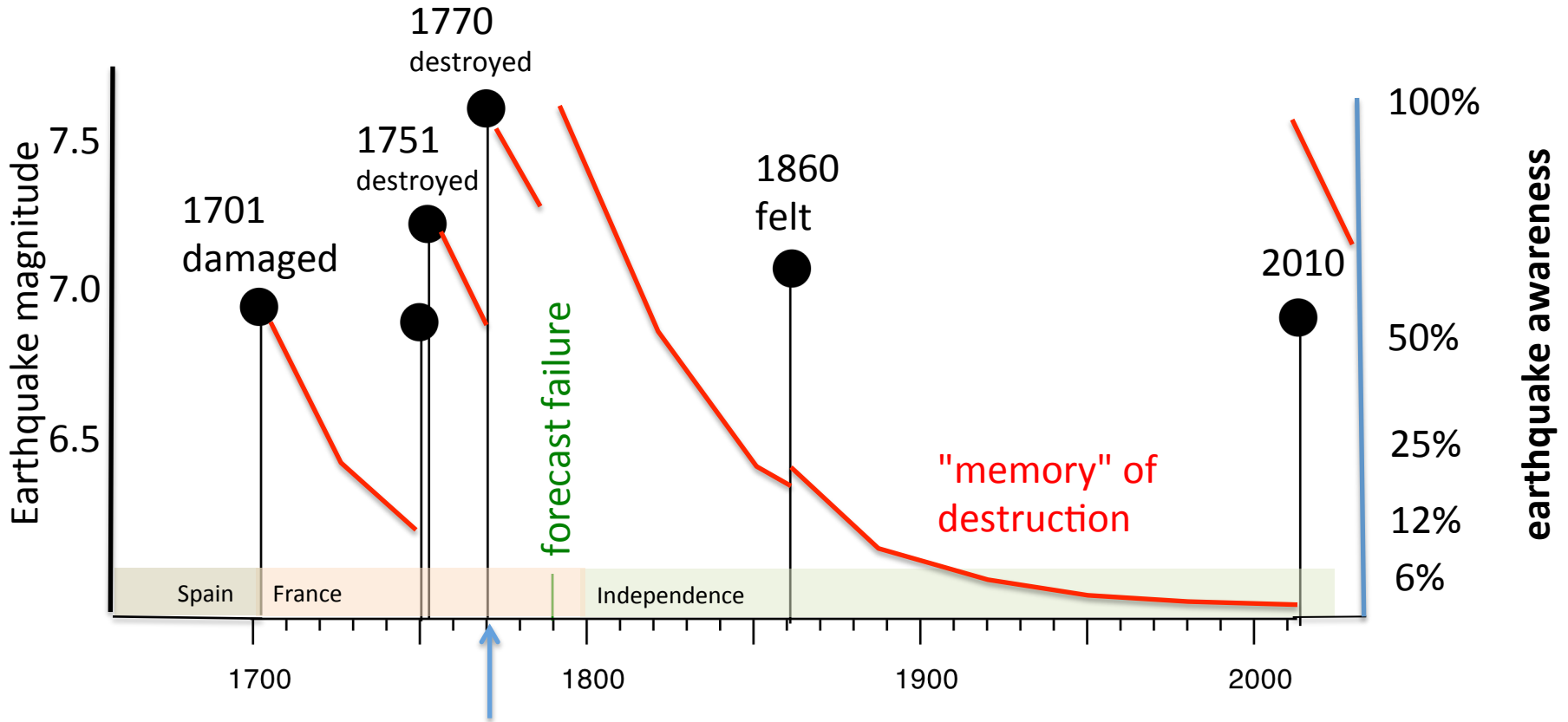
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1770 Haiti Building Code:

Wooden re-construction mandated.

No masonry walls higher than 60 cm.

No adobe unless plank-lined within.

No perimeter walls higher than 1 m, hedges OK.

"the low buildings of Port au Prince, gave the new city an aspect entirely different from the old city"

30 yr half-life earthquake awareness: Port au Prince, Haiti

"Villagers remember the lessons of the last earthquake with a half-life of 1.5 generations" Ambraseys 1976