Earthquake Engineering, Seismology, Corruption, Ignorance, and Poverty

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Despite a century of earthquake engineering, the last decade has been the worst ever in terms of the number of people killed by earthquakes - more than 650,000, with an order of magnitude more injured, and economic losses requiring reconstruction approaching half a trillion US$. Advances in earthquake resistance to structures have been accompanied by remarkable advances in our physical understanding of earthquakes, and our ability to identify regions where earthquake hazards are high. Given these advances in science, clearly something is missing in our attempts to reduce losses from earthquakes. Where is the disconnect between scientific knowledge and its application? I examine our current approaches to earthquakes as a global phenomenon in an attempt to identify areas where the best efforts of science and technology have failed. The three primary ingredients of our failure can be attributed to corruption, ignorance and poverty. Corruption is endemic to the human psyche, and is globally linked to poverty. In some countries it is worse than it should be, and it can be shown that more than 80% of deaths from earthquakes in the past 30 years have occurred in these countries. Ignorance is again linked to poverty, and an absence of access to education about earthquakes and constructional methods is responsible for many deaths from earthquakes that could be avoided. Finally, and perhaps most obviously, the world's poor do not have access to earthquake resistant buildings. This is not so much caused by the cost of safe building materials, but more often through their need to live in buildings constructed by corrupt or ignorant landlords. The most inexpensive remedy for all three of these ailments in society is education - in construction methods, and in simple explanations of the hazards and the history of earthquakes in their countries. Finally, it is clear that our current approach to seismic risk is such that it is aimed at risks that are either insured or central to the administration of our societies (Civic structures etc.). Most of the world's future deaths from earthquakes will thus continue to occur following the collapse of low income residential housing, constructed by contractors and residents ignorant of sound construction practices, and not protected by the application of national or international building codes.

European Science Foundation Conference

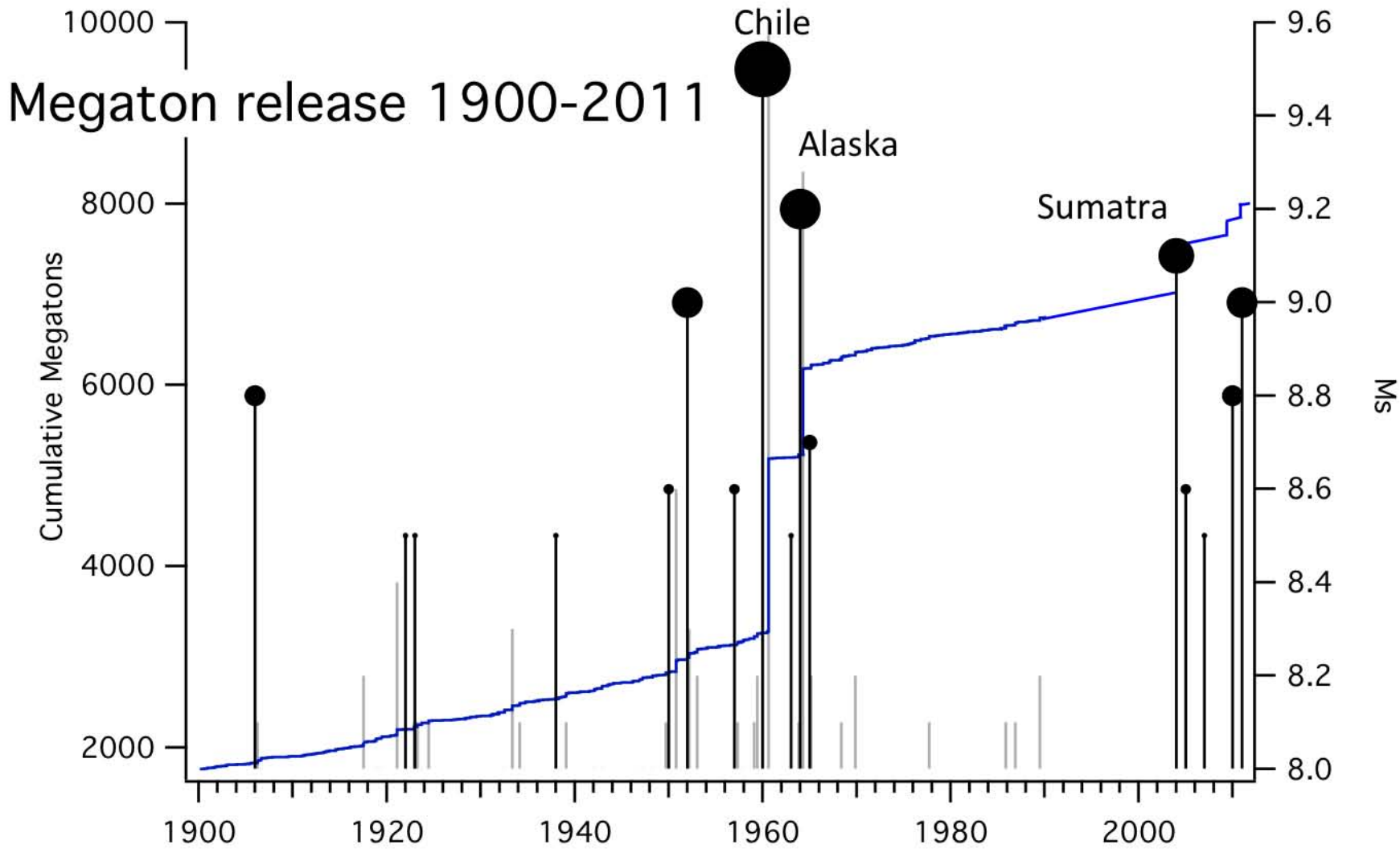
Understanding Extreme Geohazards: The Science of the Disaster Risk Management Cycle

November 28 to December 1, 2011, Sant Feliu de Guixols, Spain

Gutenberg/Richter energy released by earthquakes

$$e = 10^{1.5Mw+4.8} \text{ joules}$$

Magnitude	Megatons	deaths	earthquake
Mw=6.3	0.04	260	Canterbury NZ 2011
Mw=7.0	0.5	100k	Haiti 2010 (New Madrid 1811)
Mw=7.6	3.8	93k	Bhuj 2001 Kashmir 2005
Mw=8.0	15.1	85k	Wenchuan 2008
Mw=8.8	239	620	Chile 2010
Mw=9.1	477	25k	Japan 2011
Mw=9.2	951	212k	Indonesia/Andaman
Mw=9.5	2682	3k	Chile 1960



century average ≈ 80 megatons/year:

40% from Mw>8.5 earthquakes

OBSERVATION #1

80 Mt/year for 7 billion people is equivalent to
≈11 kg of TNT per person per year
Assuming that a stick of dynamite =1 lb

Earthquake energy release is equivalent to 2 sticks of dynamite per person per month

ChiChi 1999, 6k

Izmit 1999. 19-30k

Duzce, 1999, 3k

Bhuj, 2001, 20k

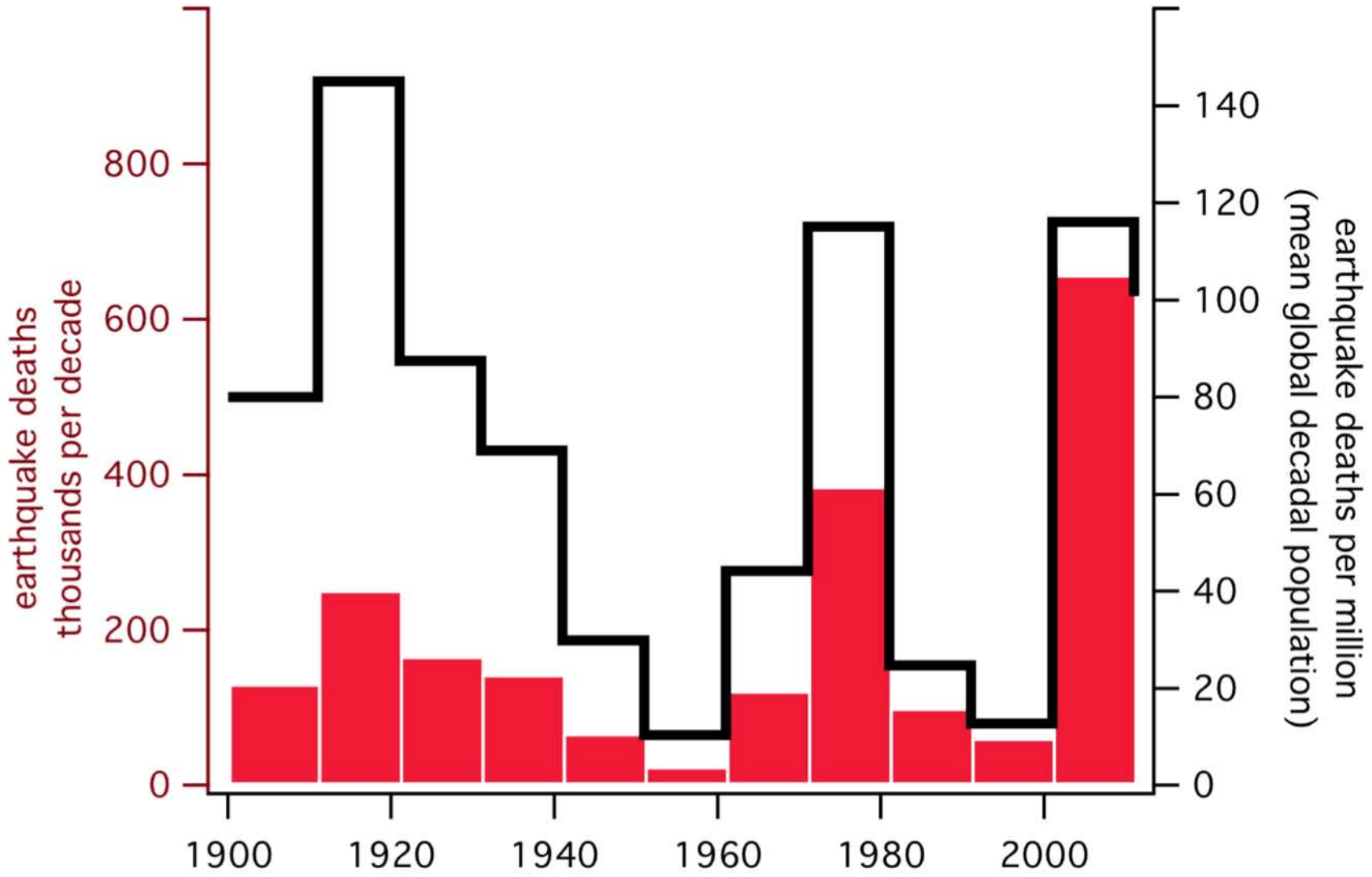
Sumatra/Andaman, 2001, 220k

Kashmir, 2005, 82k

Wenchuan, 2008, 85k

Haiti 2010, 100k

Honshu 2011, 26k

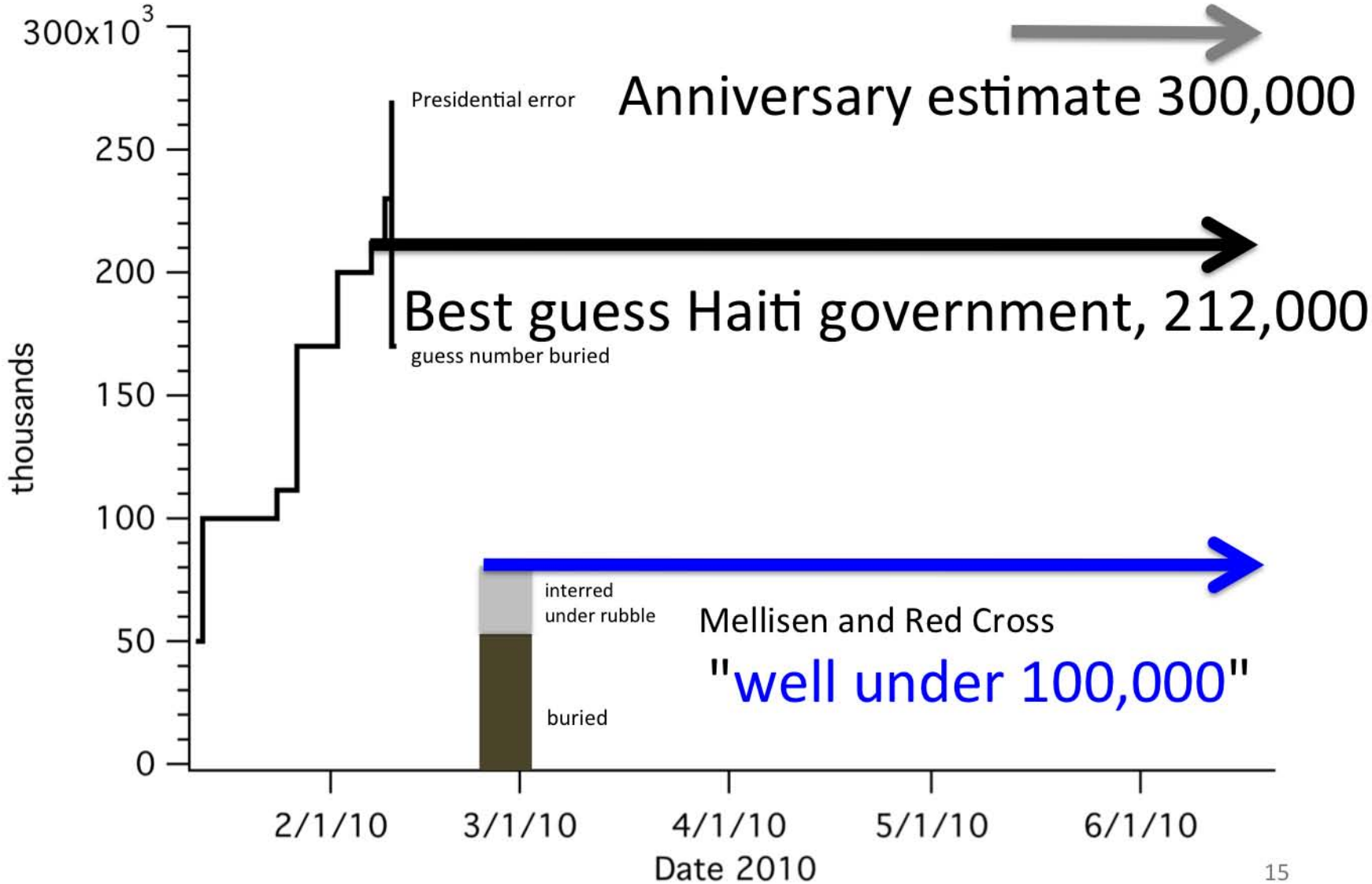


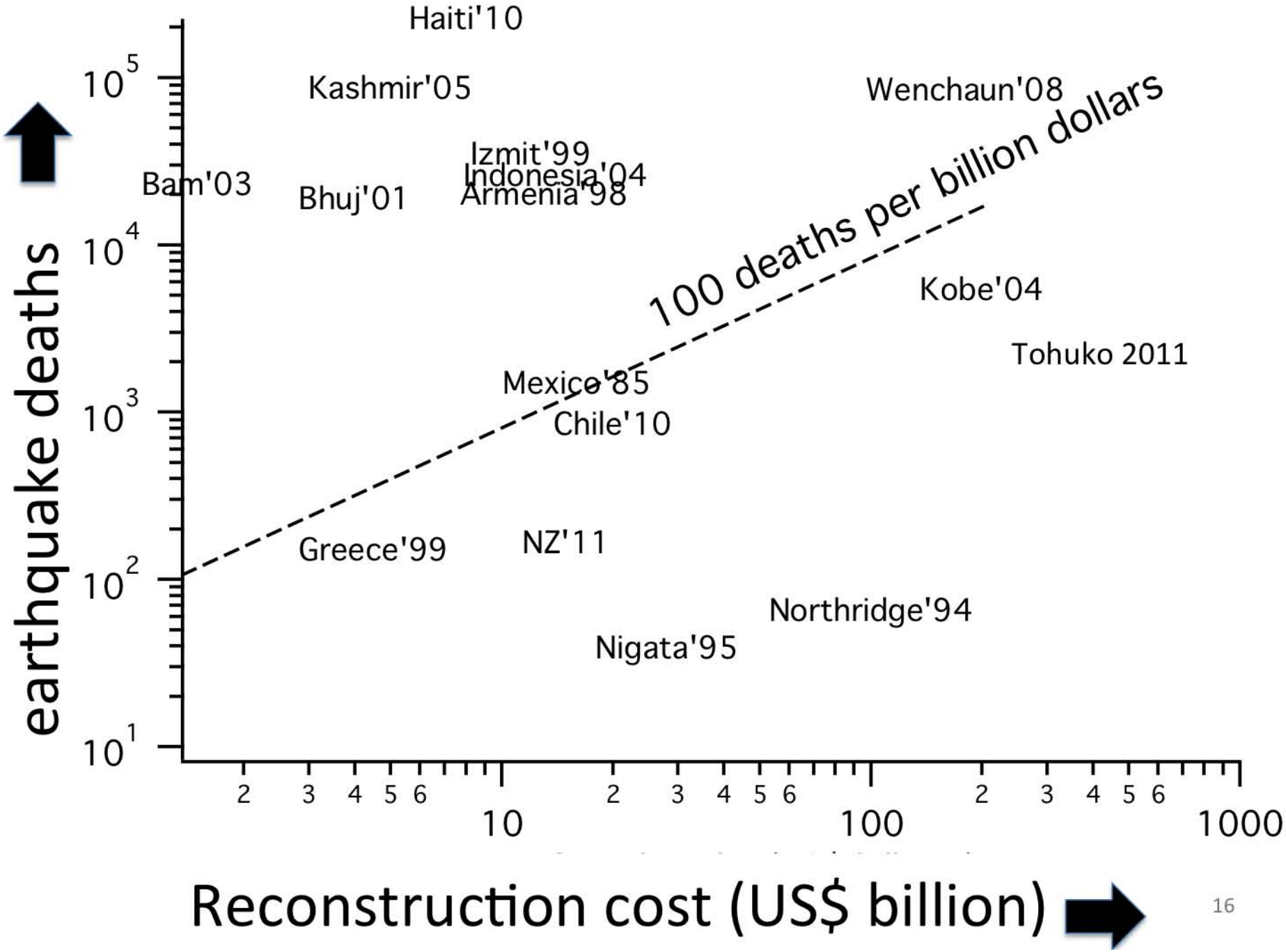
deaths per decade since earthquake resistance implemented

Ten years 600k deaths $400 billion

Haiti deathtoll 85k not 300k

from government reports and news media




Haiti'10
Kashmir'05
Wenchaun'08
Izmit'99
Indonesia'04
Armenia'98
Bam'03
Bhuj'01
100 deaths per billion dollars
Kobe'04
Tohuko 2011
Mexico'85
Chile'10
Greece'99
NZ'11
Northridge'94
Nigata'95
earthquake deaths
10^5
10^4
10^3
10^2
10^1
2 3 4 5 6
10
2 3 4 5 6
100
2 3 4 5 6
1000
Reconstruction cost (US$ billion)

OBSERVATION #2

Average cost earthquakes 1999-2011
= $35 billion/yr

≈ $5/person per year
i.e. earthquakes are surprisingly affordable.

However cost is mostly born by the industrial world
($50/person/year)

Obervation #3

LIFE IS WORTH HOW-MUCH?

From religion $∞ (Life is priceless etc)

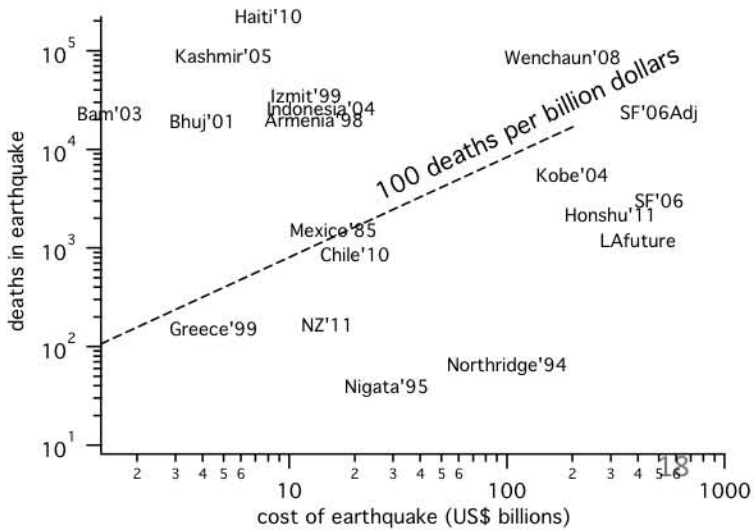
9/11 WTC $1.6 million/life

IPCC $6.1 million/life

Jack London "**Life**? Bah! It has no **value**.
Of cheap things it is the cheapest"
The Sea-Wolf 1904

from cost/death regression

1 death = $10 million



Earthquake arithmetic

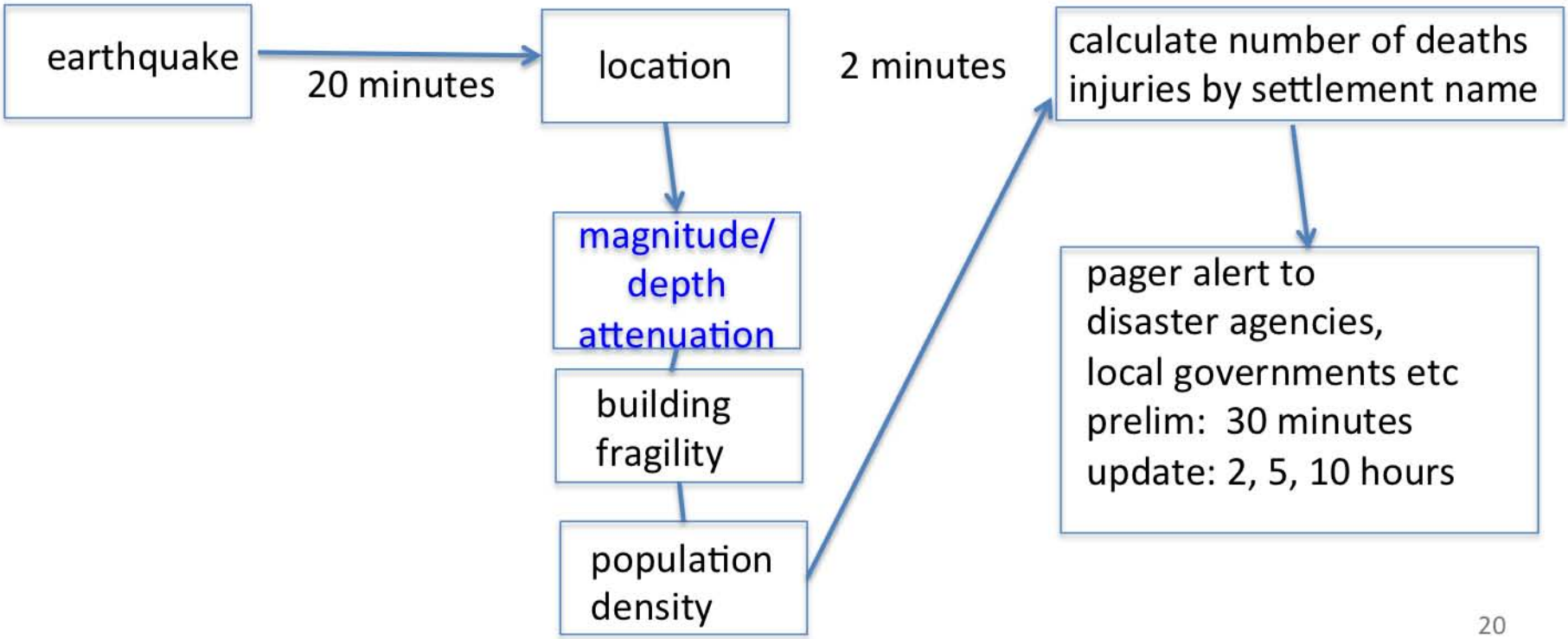
Energy per person 11±0.1kg TNT
Cost per person $7±$1

Value of human life $∞± $∞

Your chances of dying in an earthquake are 1 in a million.
Much higher in some countries

30 minutes: an appalling measure of failure by the seismic community

Deathtolls can be estimated in 30 minutes (WAPPMER/USGS)
Yet real deathtoll unknown for 5 days

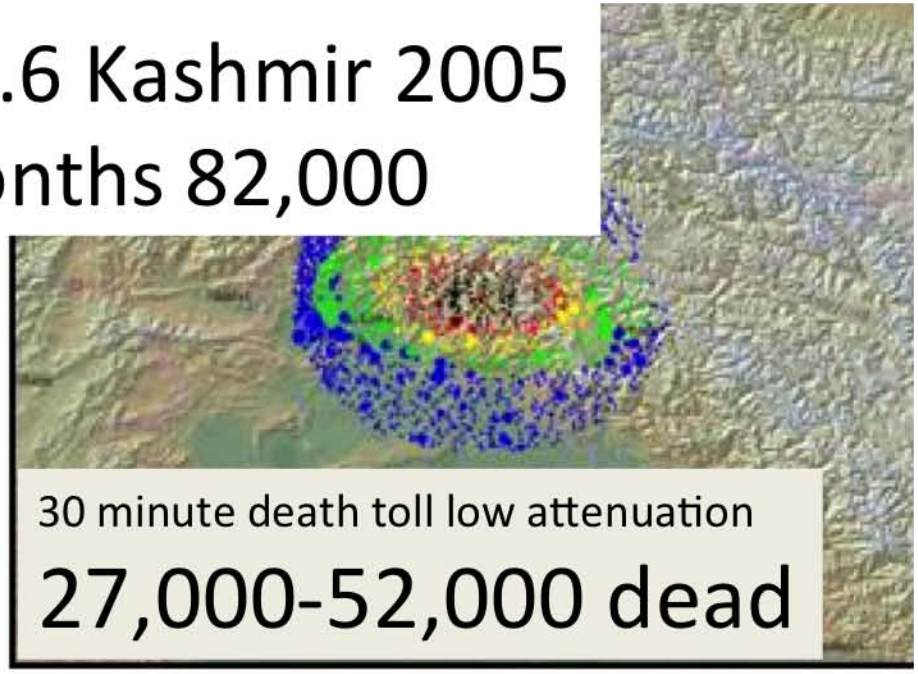


First 2 hours 20% of deaths: asphyxia from dust inhalation or chest compression, hypovolemic shock, or hypothermia.

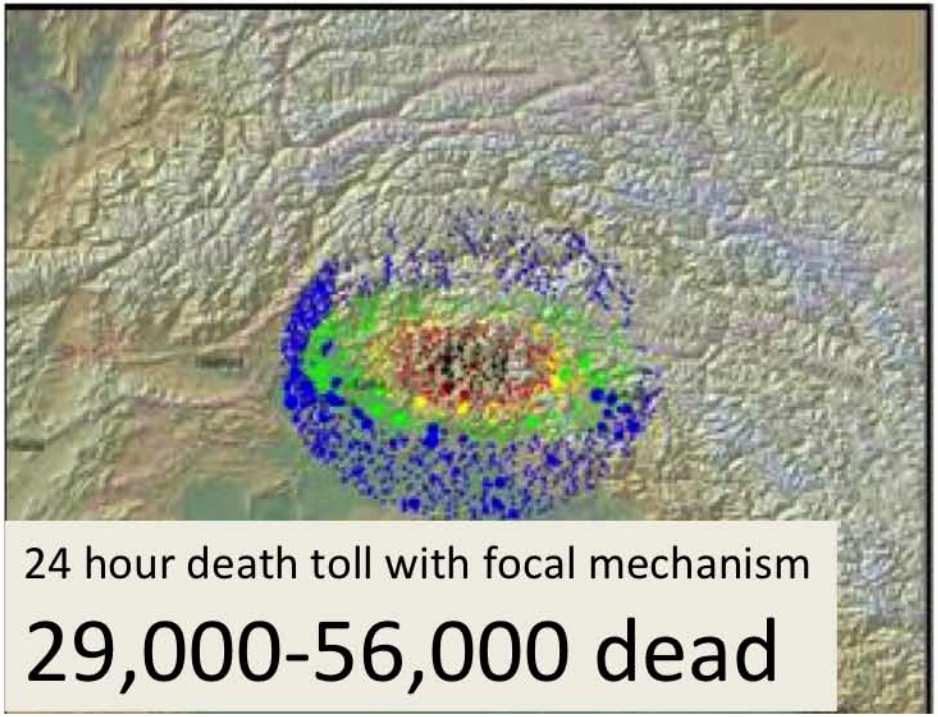
Days 1-3 80% of deaths

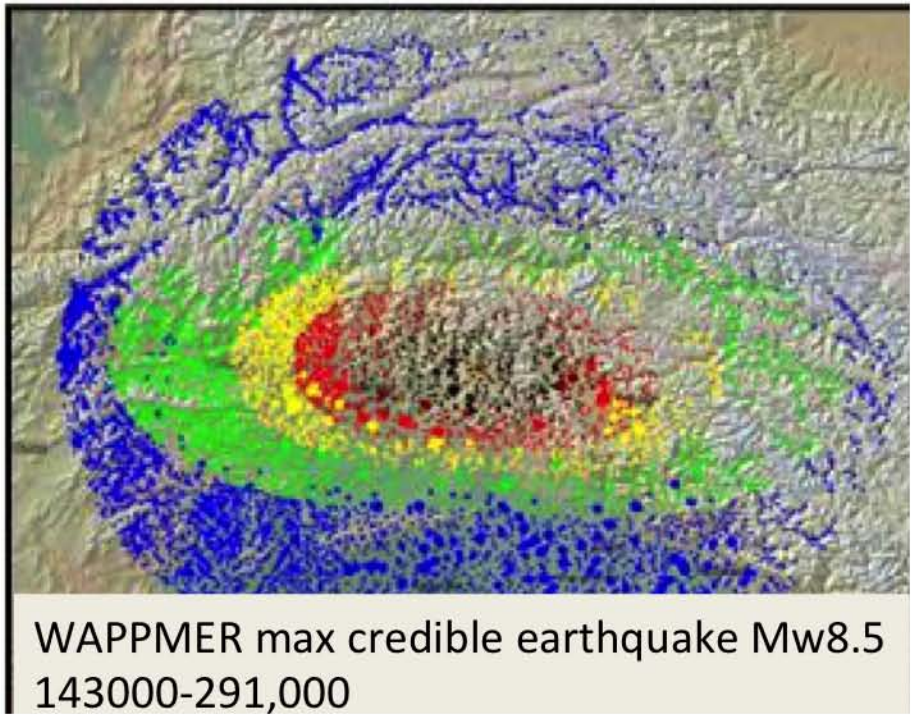
Delayed death occurs within days due to dehydration, hypothermia, hyperthermia, crush syndrome, wound infections, or postoperative sepsis.

Example earthquake Mw=7.6 Kashmir 2005 official death toll after 2 months 82,000

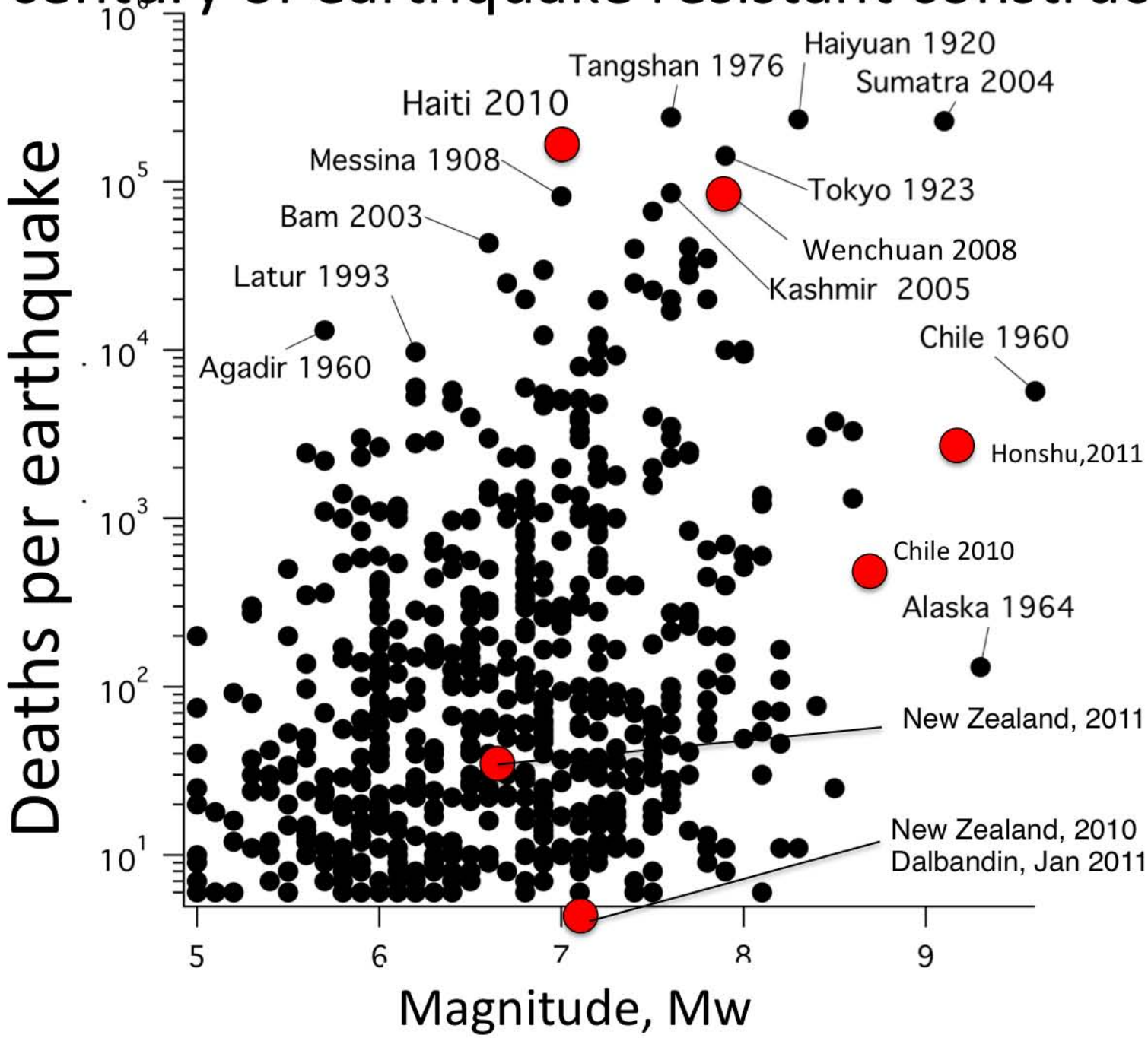


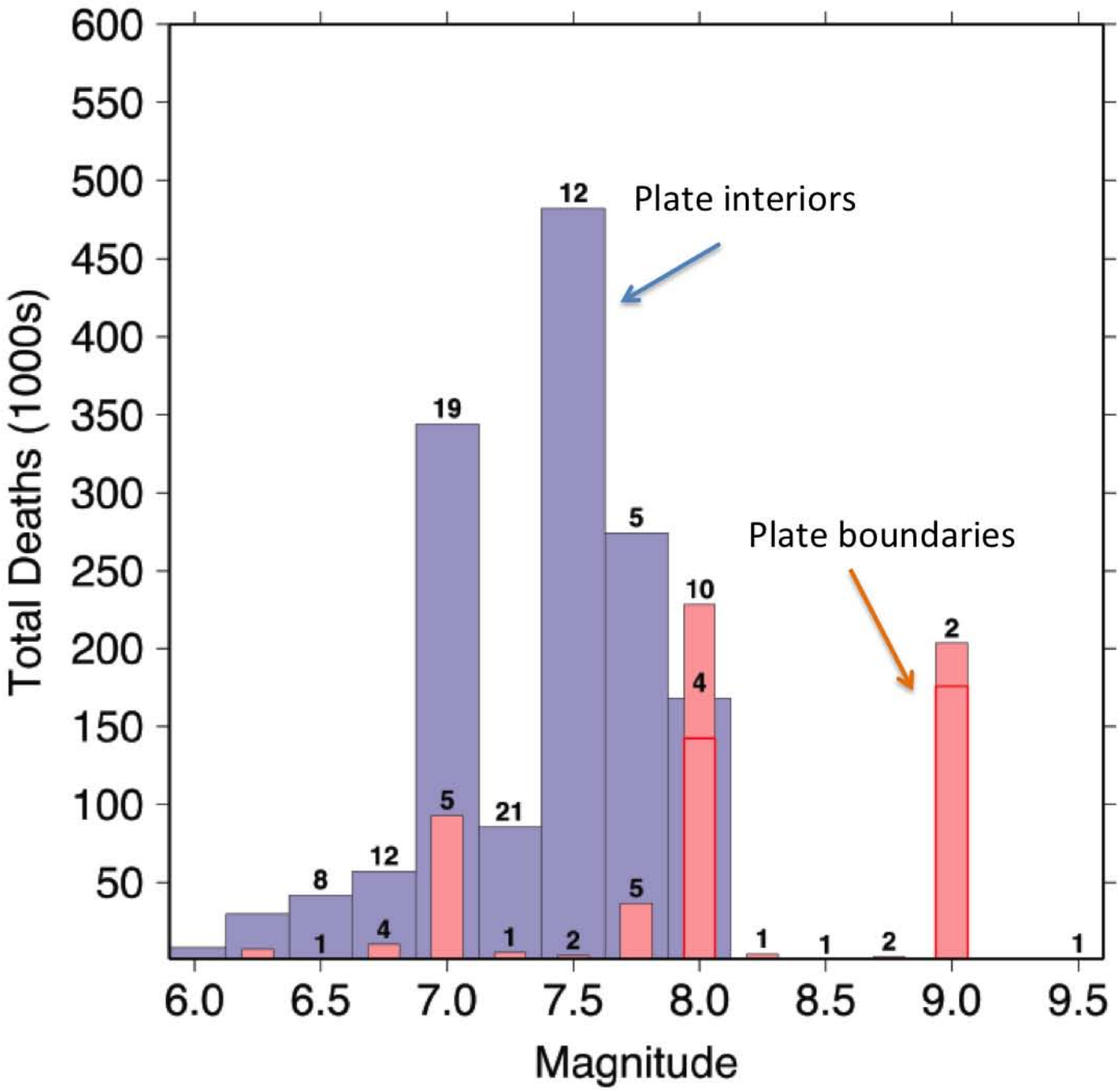
black =total destruction: blue=minor damage. 5 classes of building fragility, 6 classes of damage intensity





A century of earthquake resistant construction



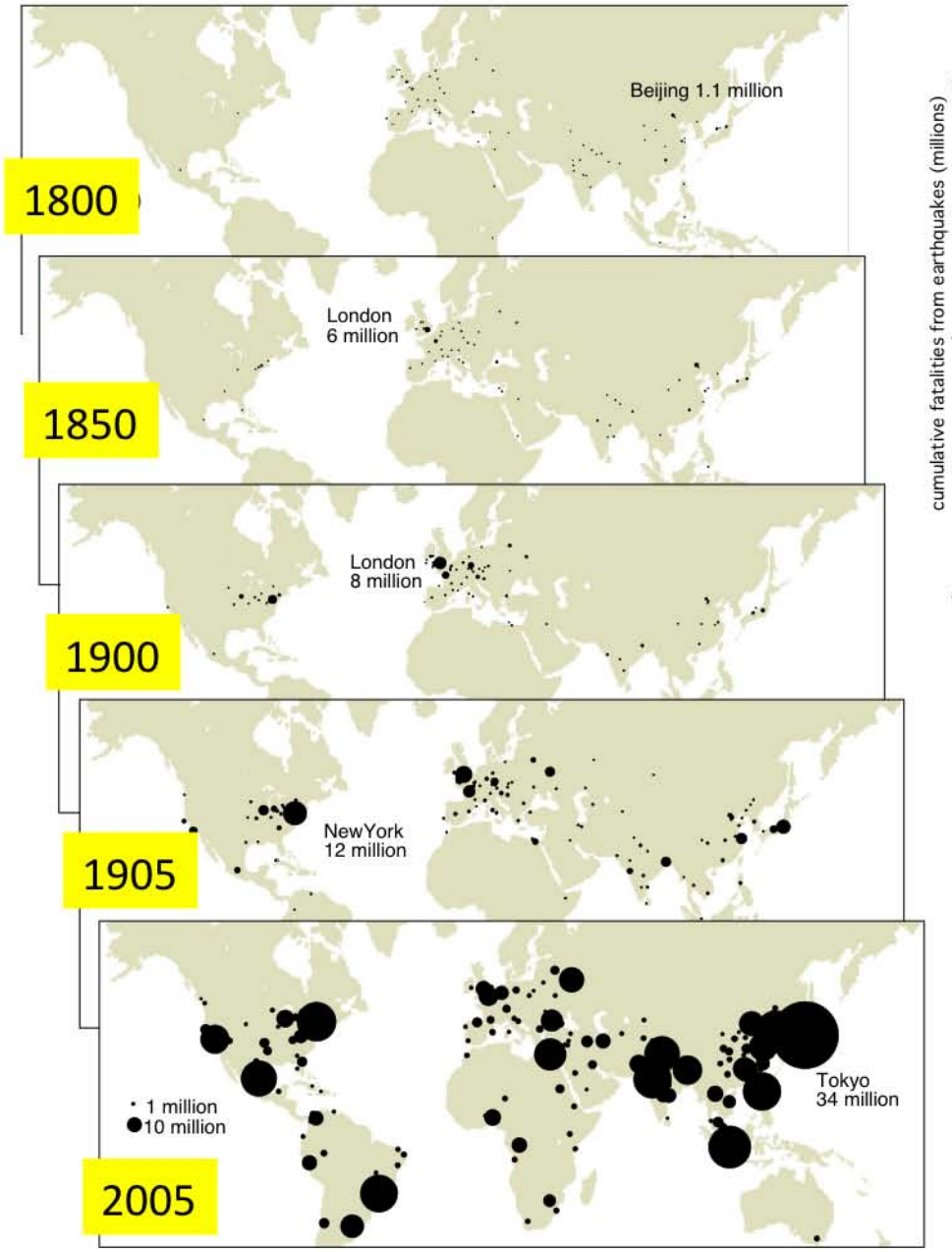


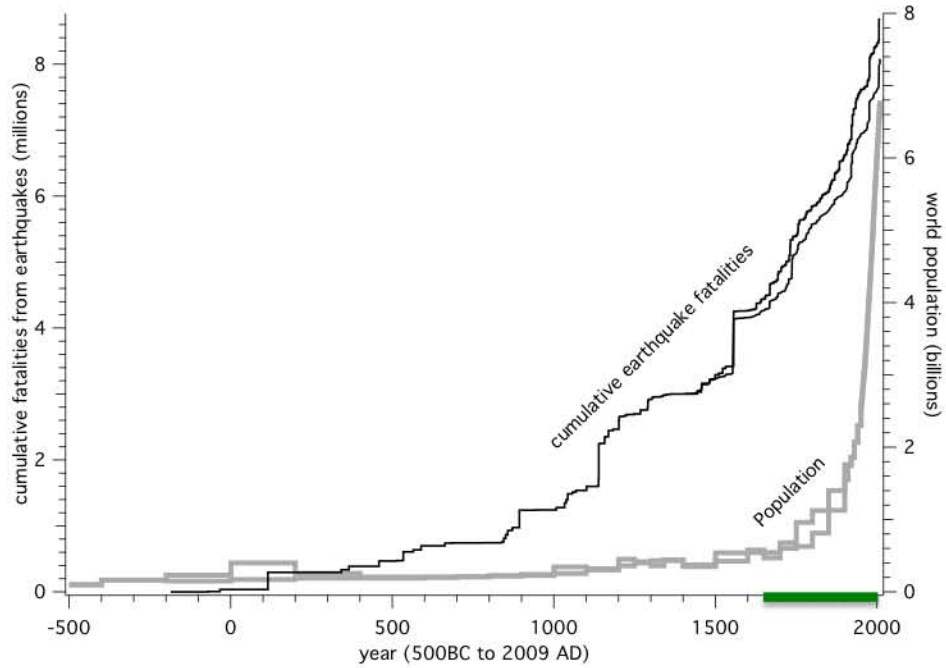
Most deaths from M<7.5 plate interior earthquakes.

Fewer deaths from much larger plate boundary earthquakes

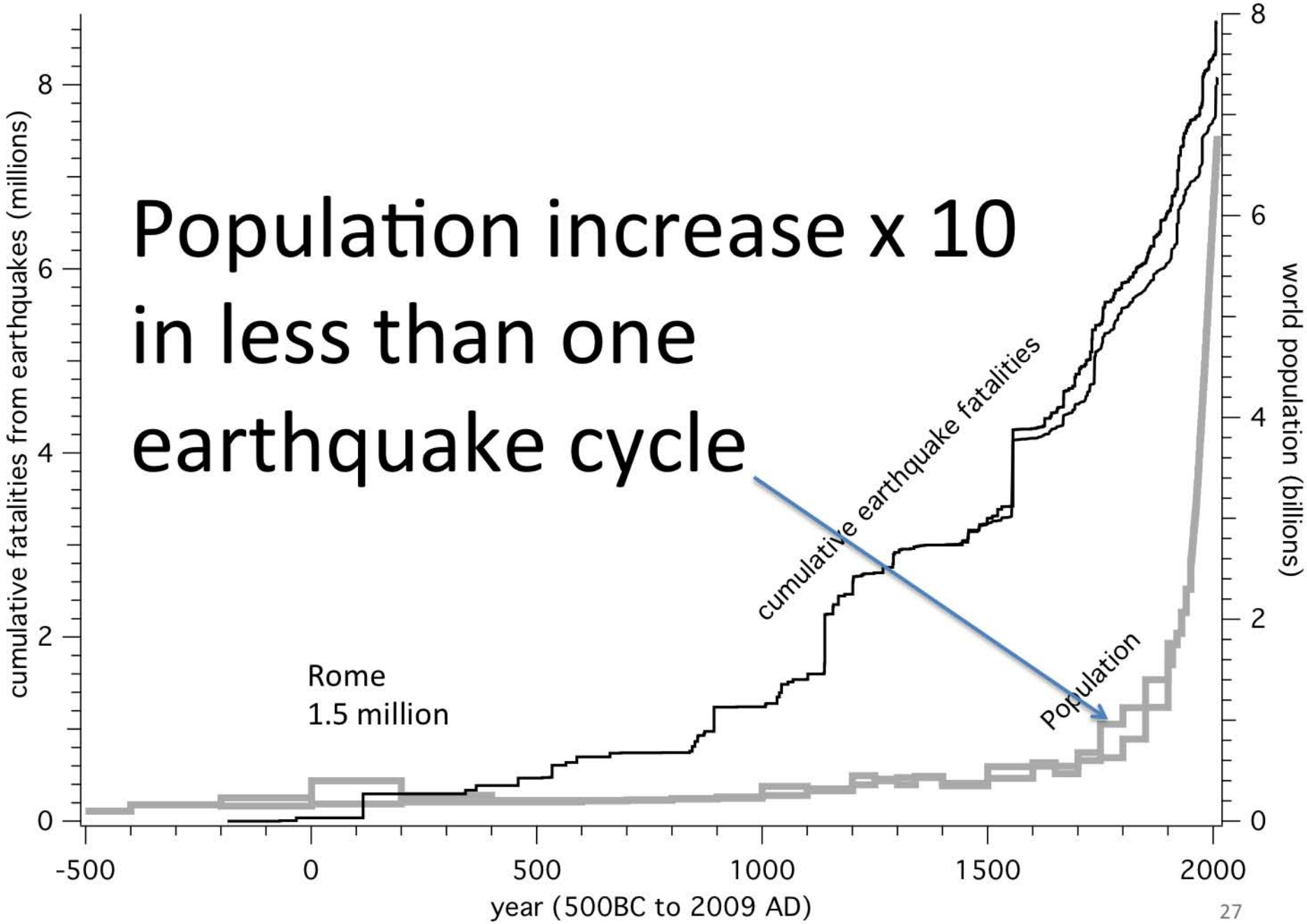
England and Jackson

the problem:
too many people in badly constructed buildings

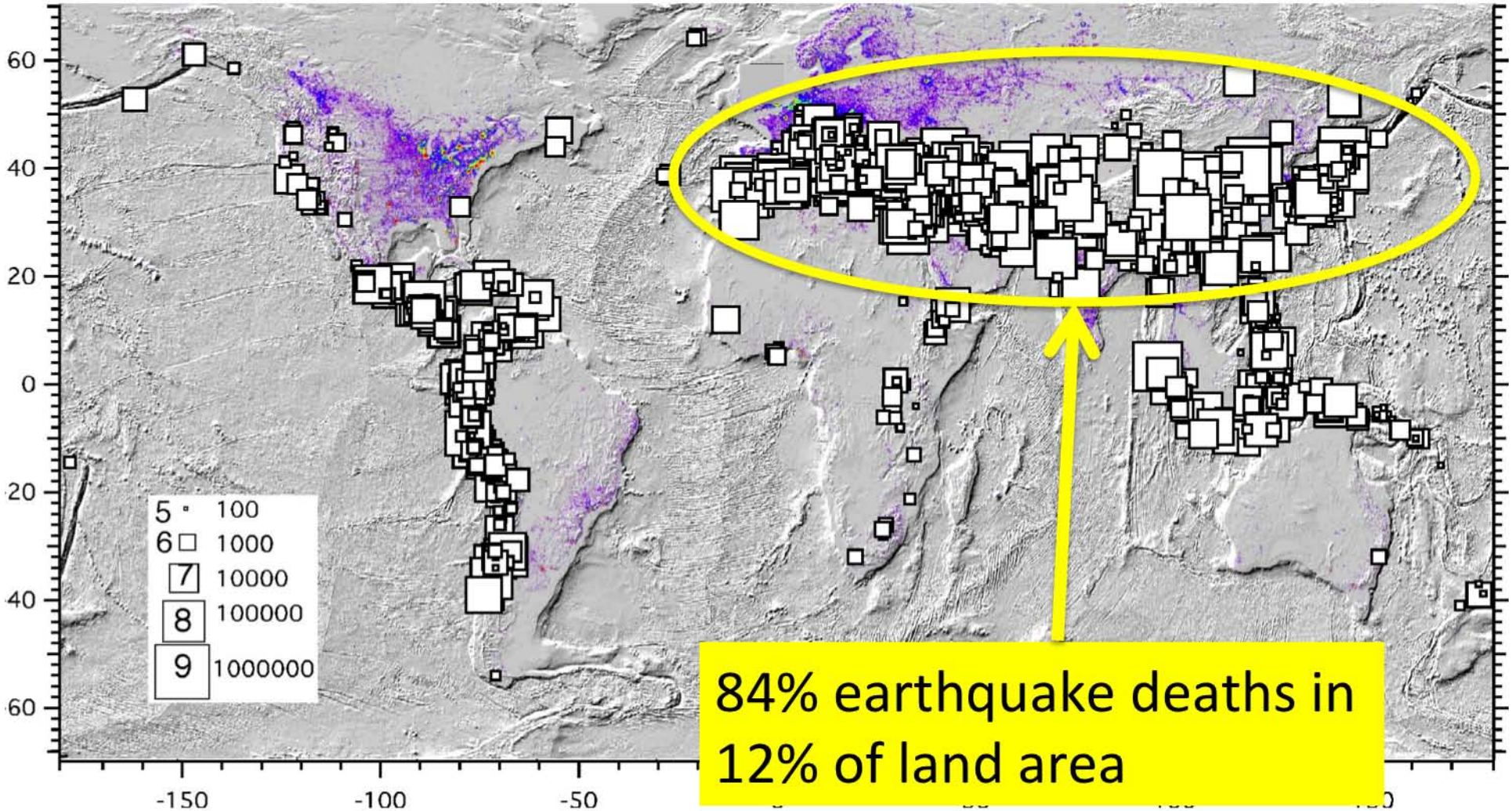




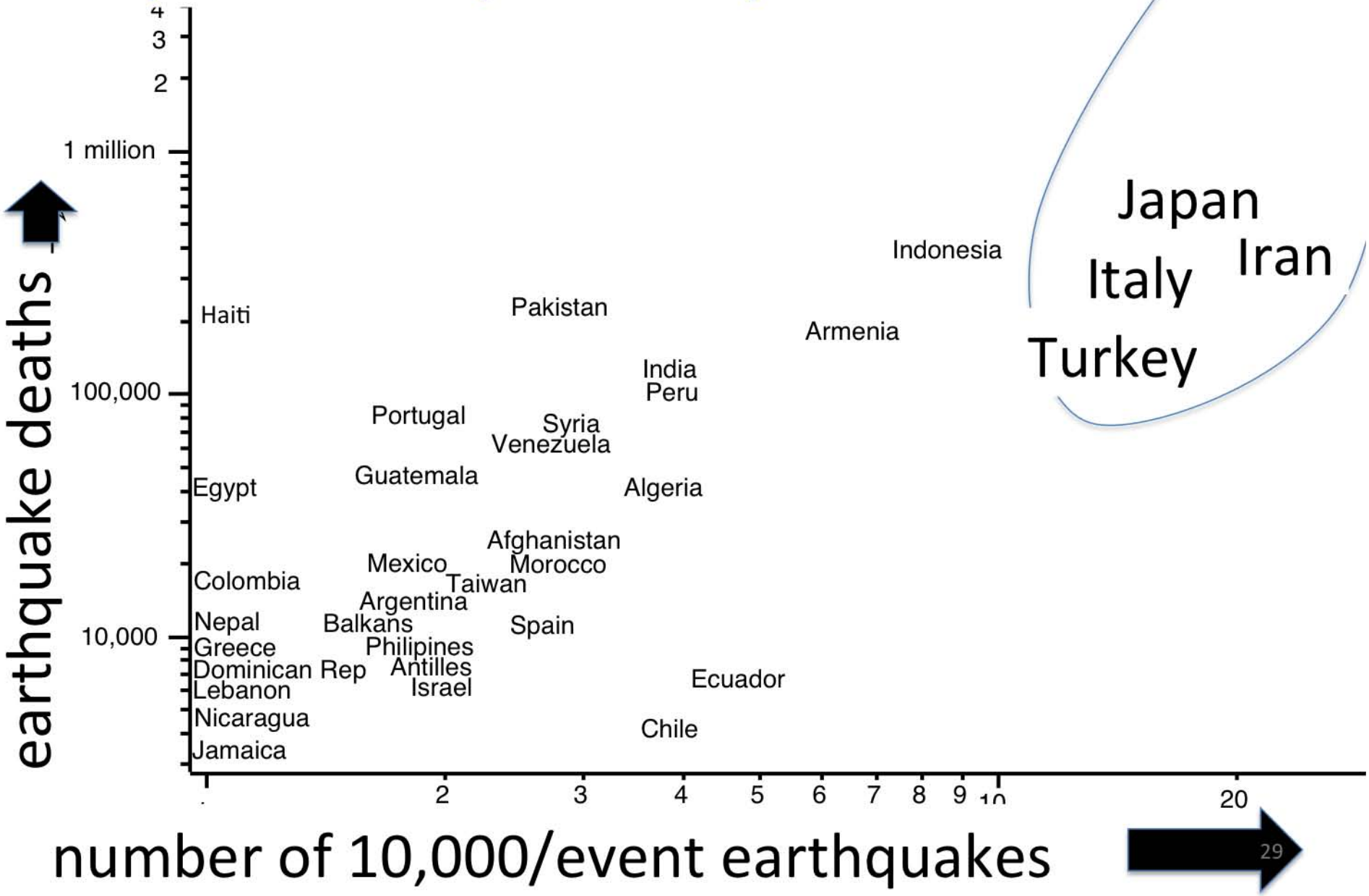
City size exploded after 1800
When cities became no longer
a place to die.


Population increase x 10
in less than one
earthquake cycle
cumulative fatalities from earthquakes (millions)
world population (billions)
cumulative earthquake fatalities
Population
Rome
1.5 million
year (500BC to 2009 AD)
-500
0
500
1000
1500
2000
0
2
4
6
8

1000 years of earthquake deaths

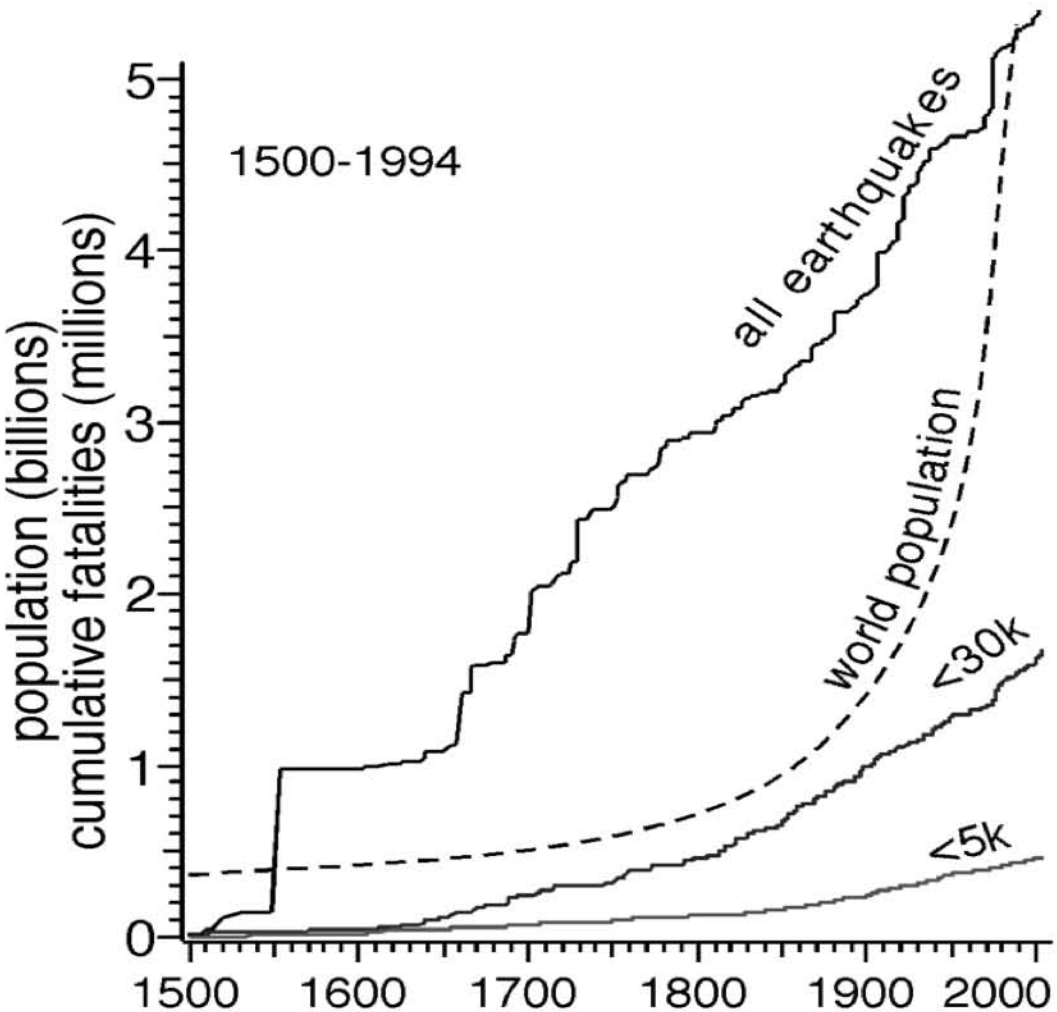


earthquake deaths per country since 1500



the future

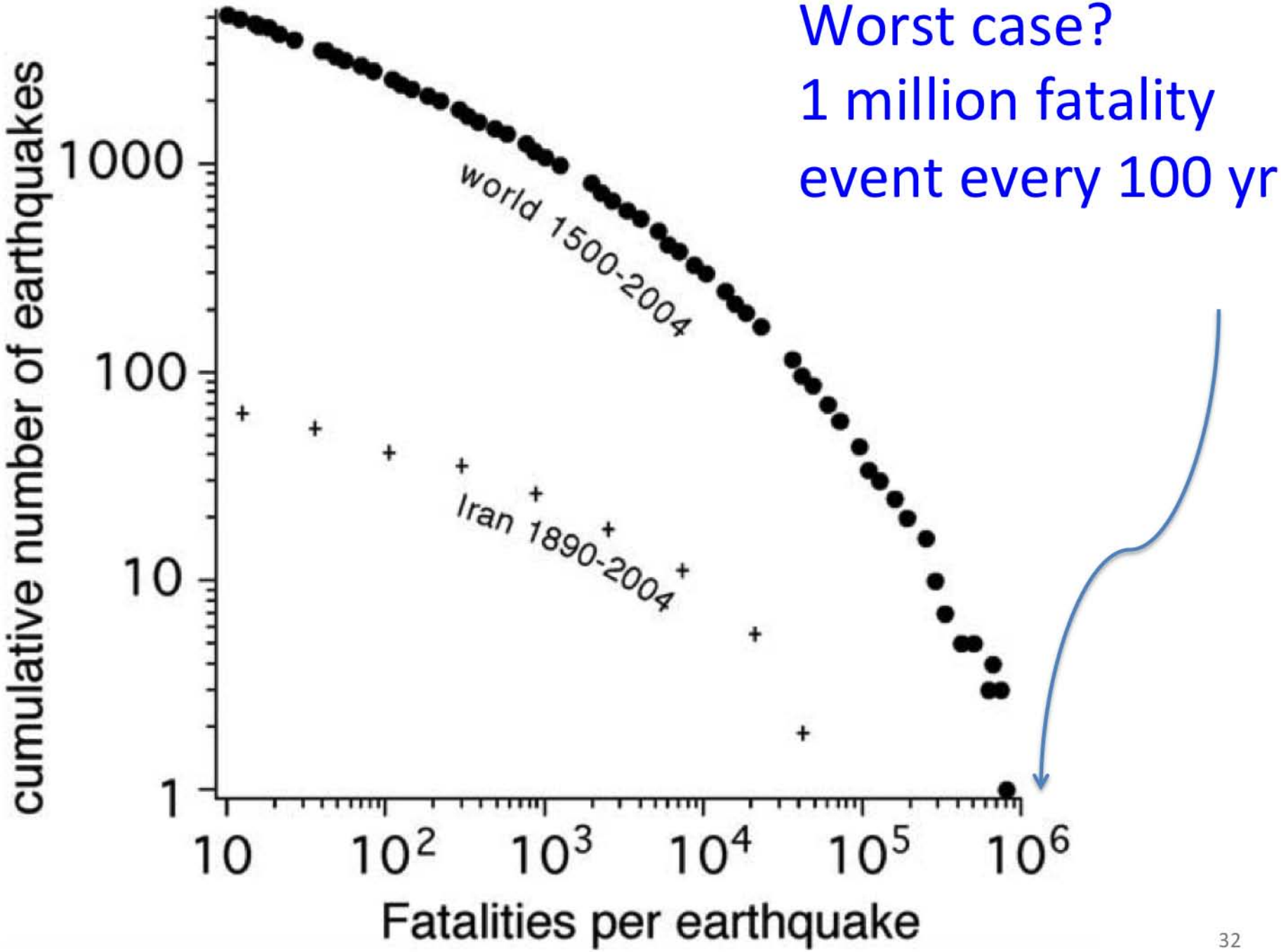
Historical deathcasts too conservative.....



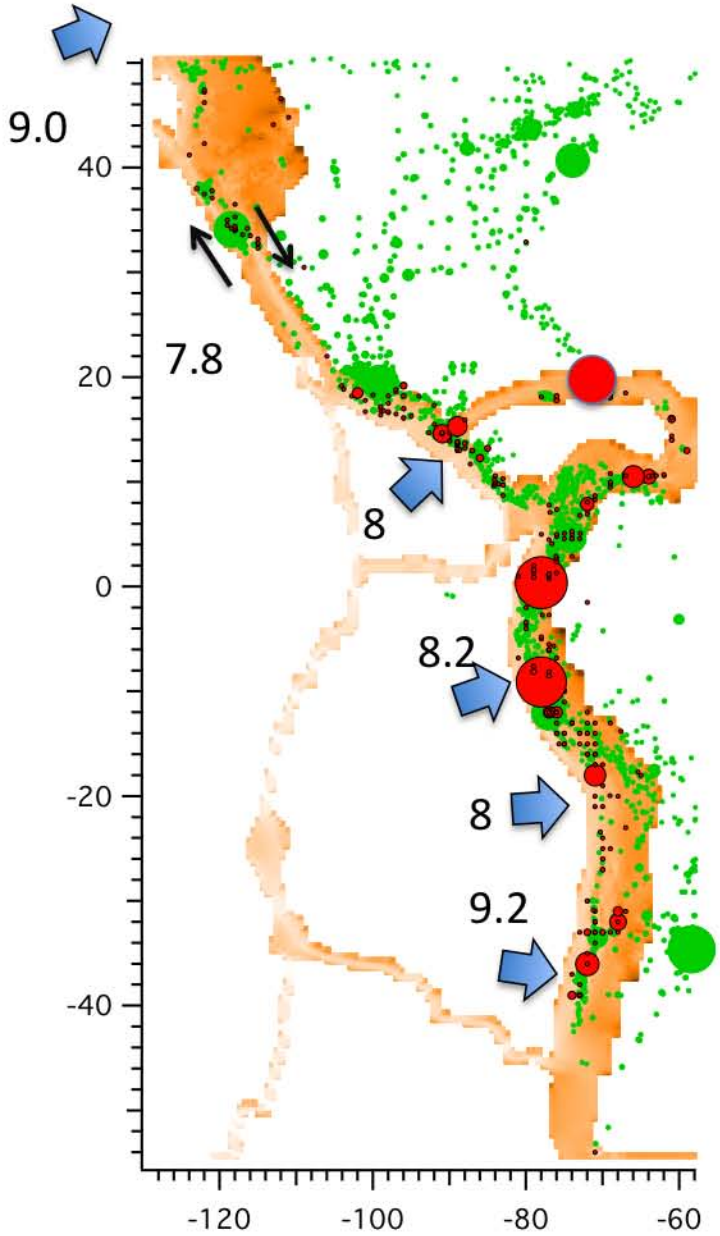
1985<50k/yr predicted
2011 60k/yr actual

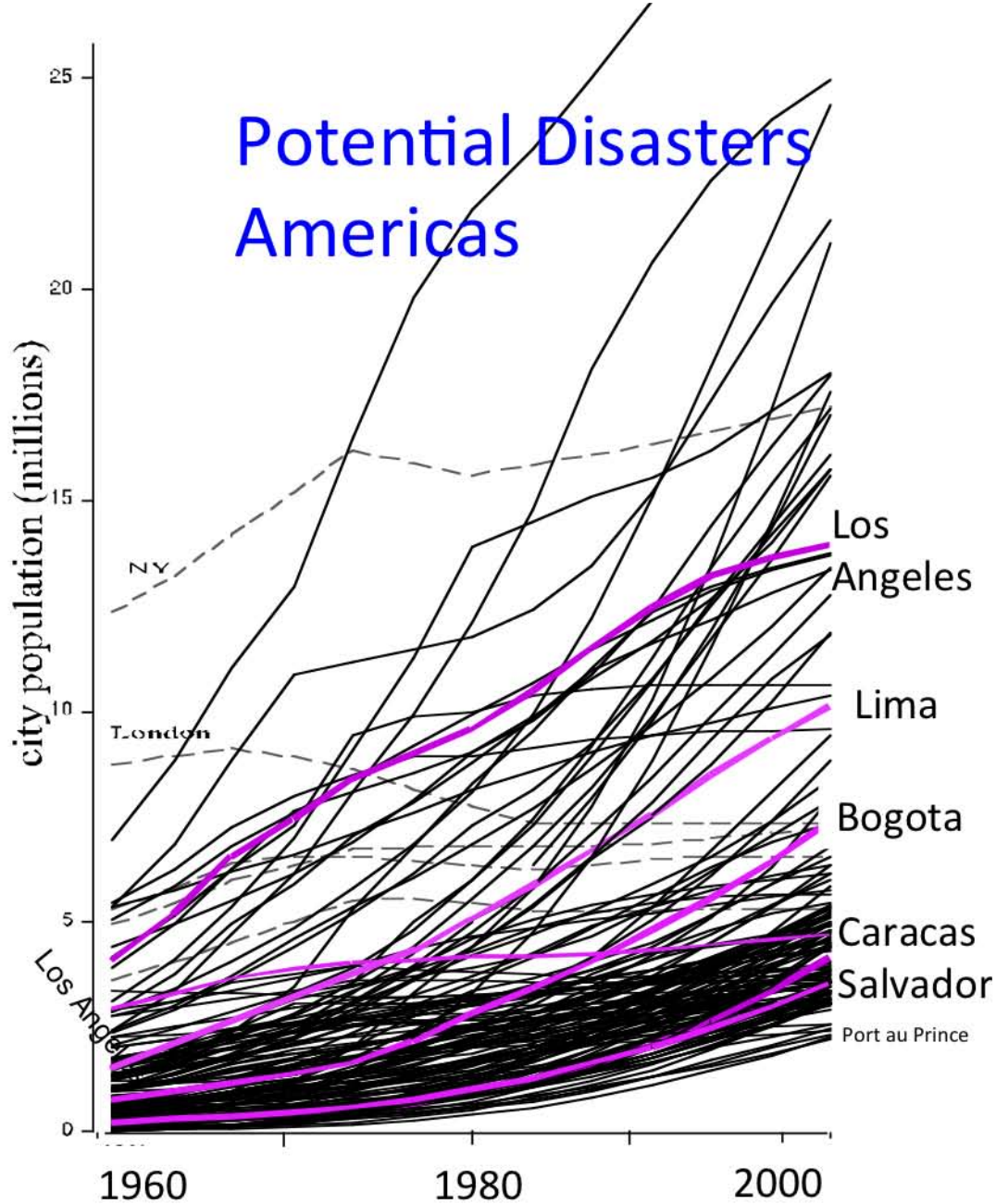
1985 9k/yr predicted
12k/yr 2011 actual

1985 5k/yr predicted
7k/yr 2011 actual


Worst case?
1 million fatality
event every 100 yr
world 1500-2004
Iran 1890-2004
cumulative number of earthquakes
1000
100
10
1
10
10^2
10^3
10^4
10^5
10^6
Fatalities per earthquake

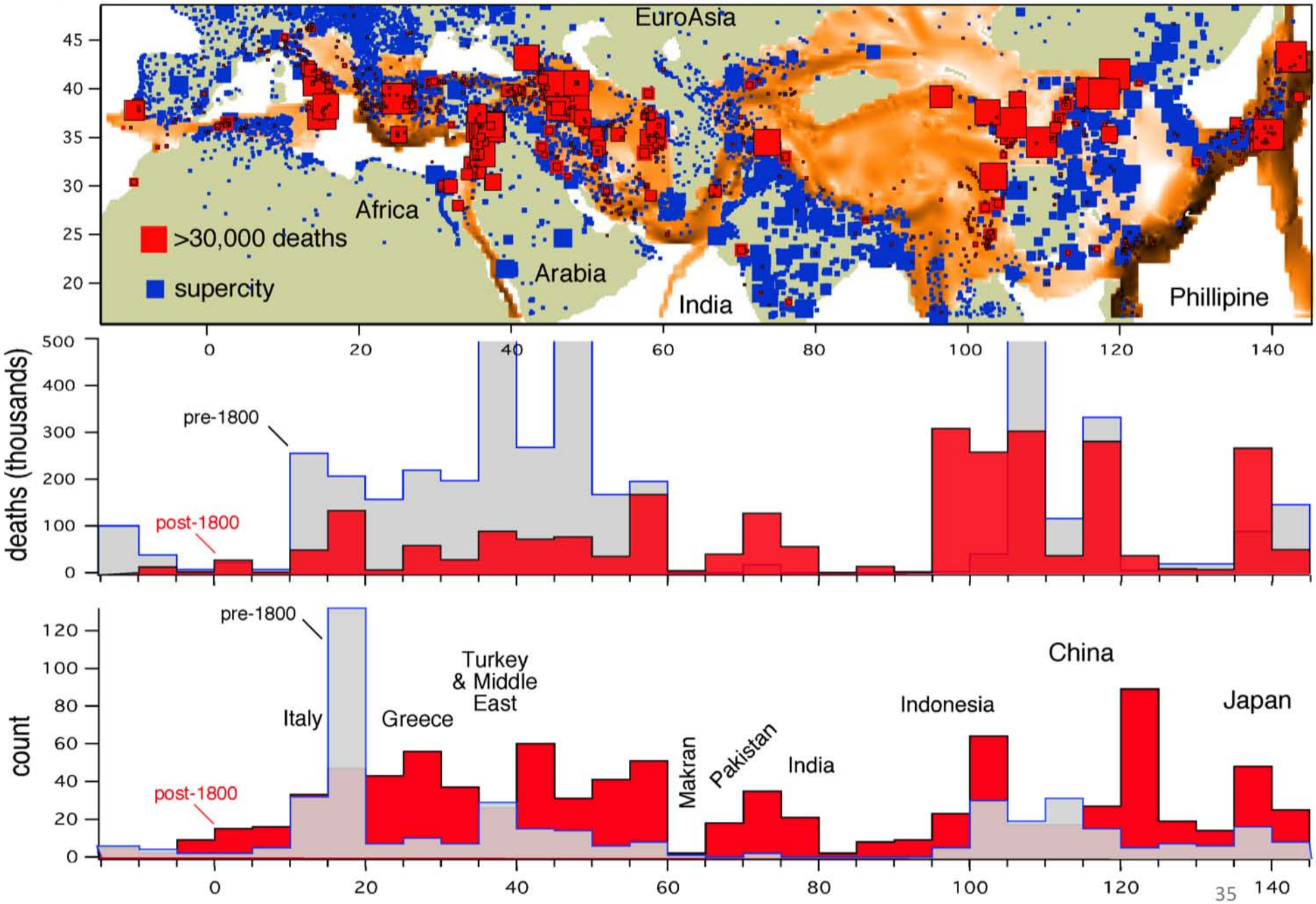
Naming names



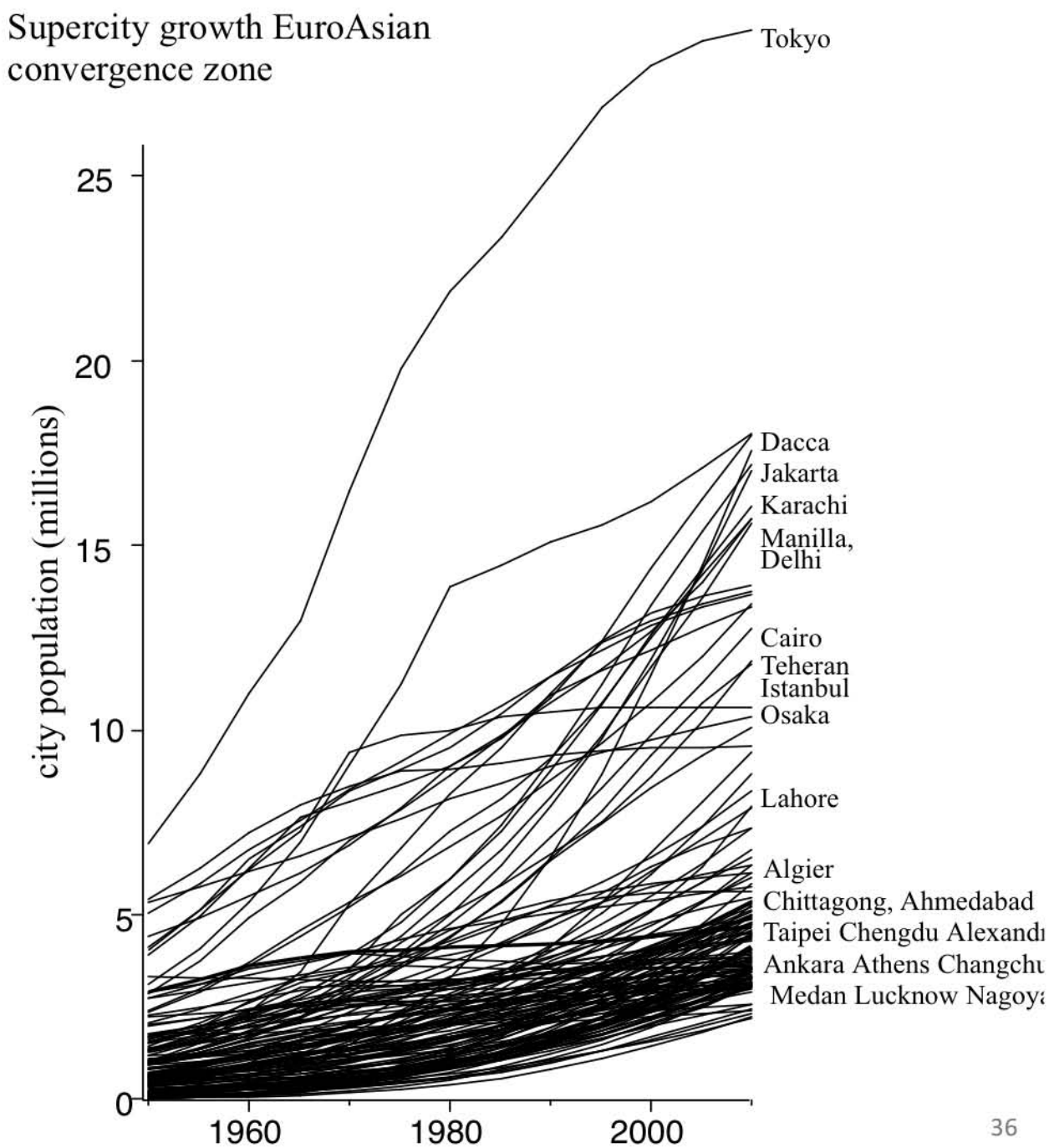


red=fatal earthquakes, green =cities

southern margin of EuroAsian plate: 85% of all fatalities from earthquakes



Potential Disasters EuroAsia



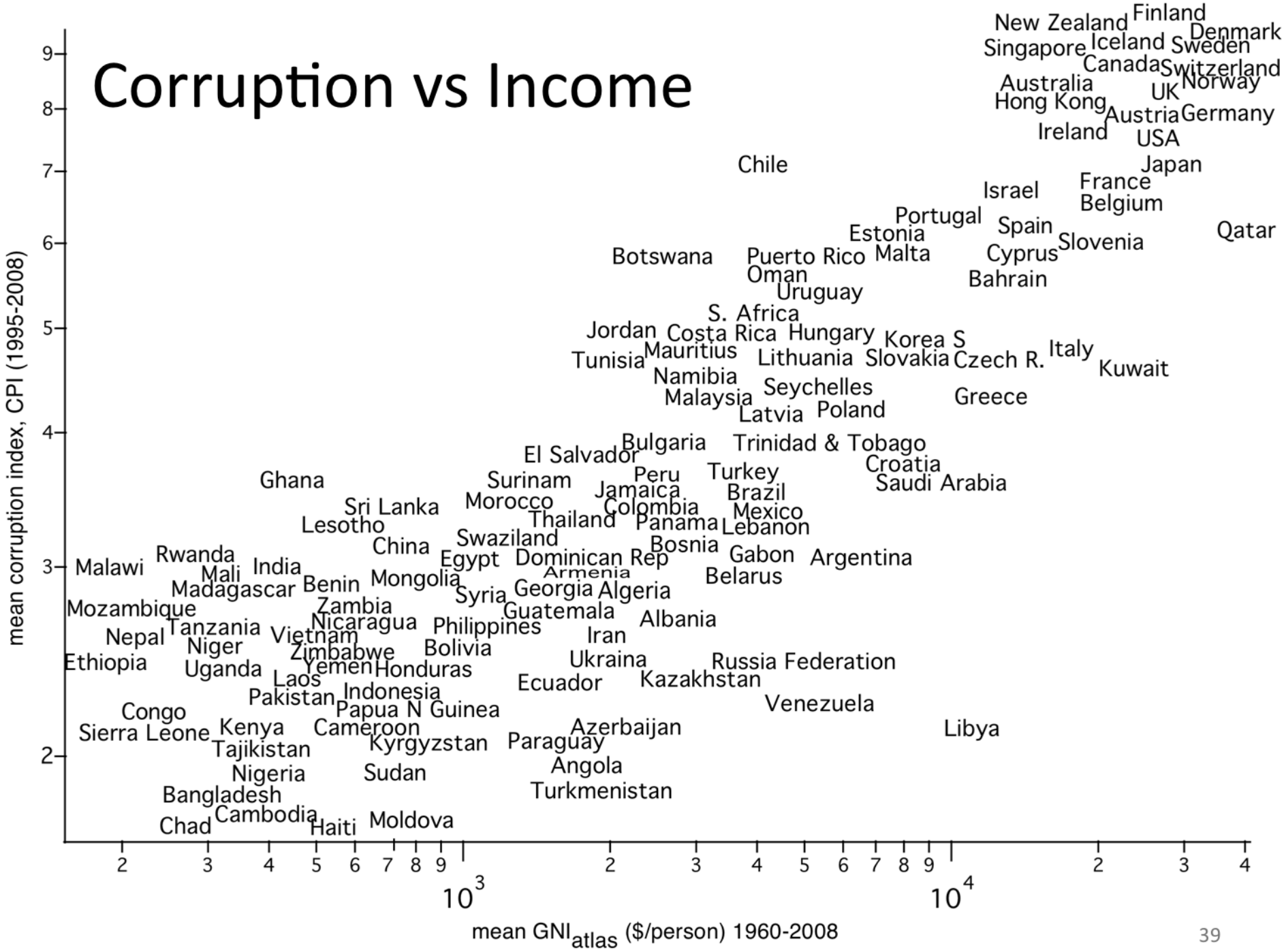
Corruption

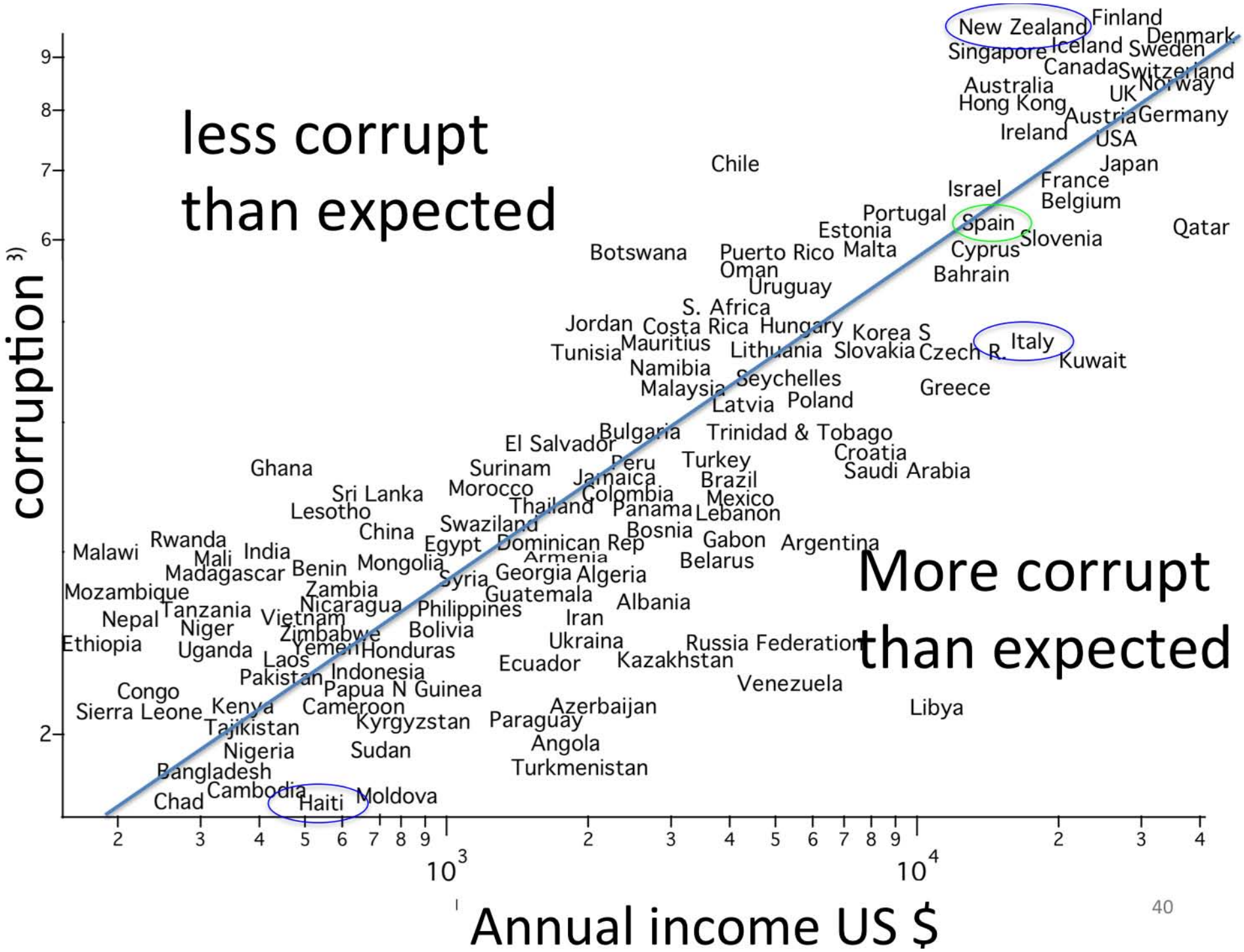
global construction Industry $7,500 billion/year Corruption responsible for numerous deaths

(Transparency International 2005).

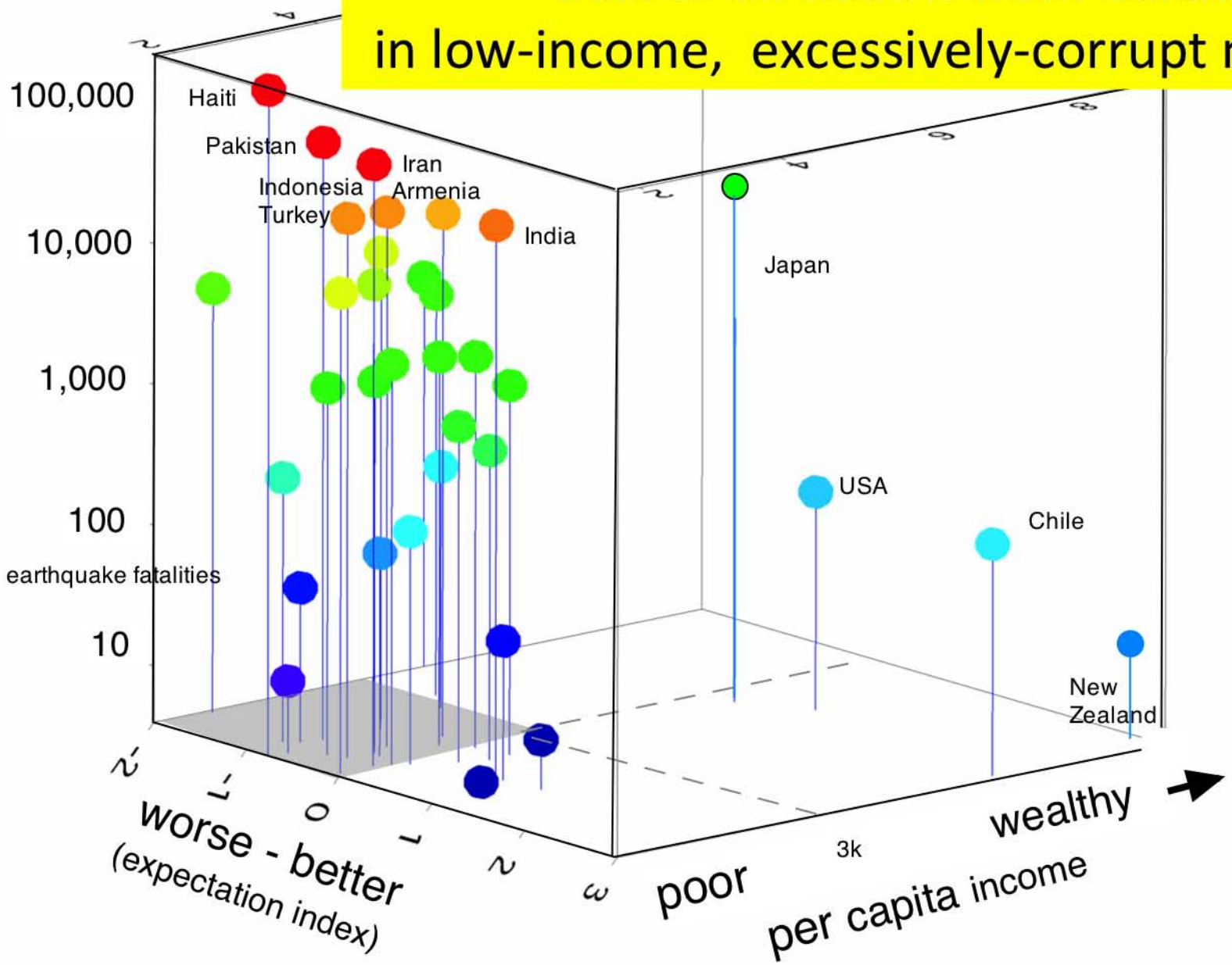
- corrupt award of contracts (bribery & political pressure).
- corrupt issuance of approvals and permits.
- corrupt inspection processes
- shoddy work irreversibly concealed by concrete, plaster....
- COVER UP is a construction industry term!!

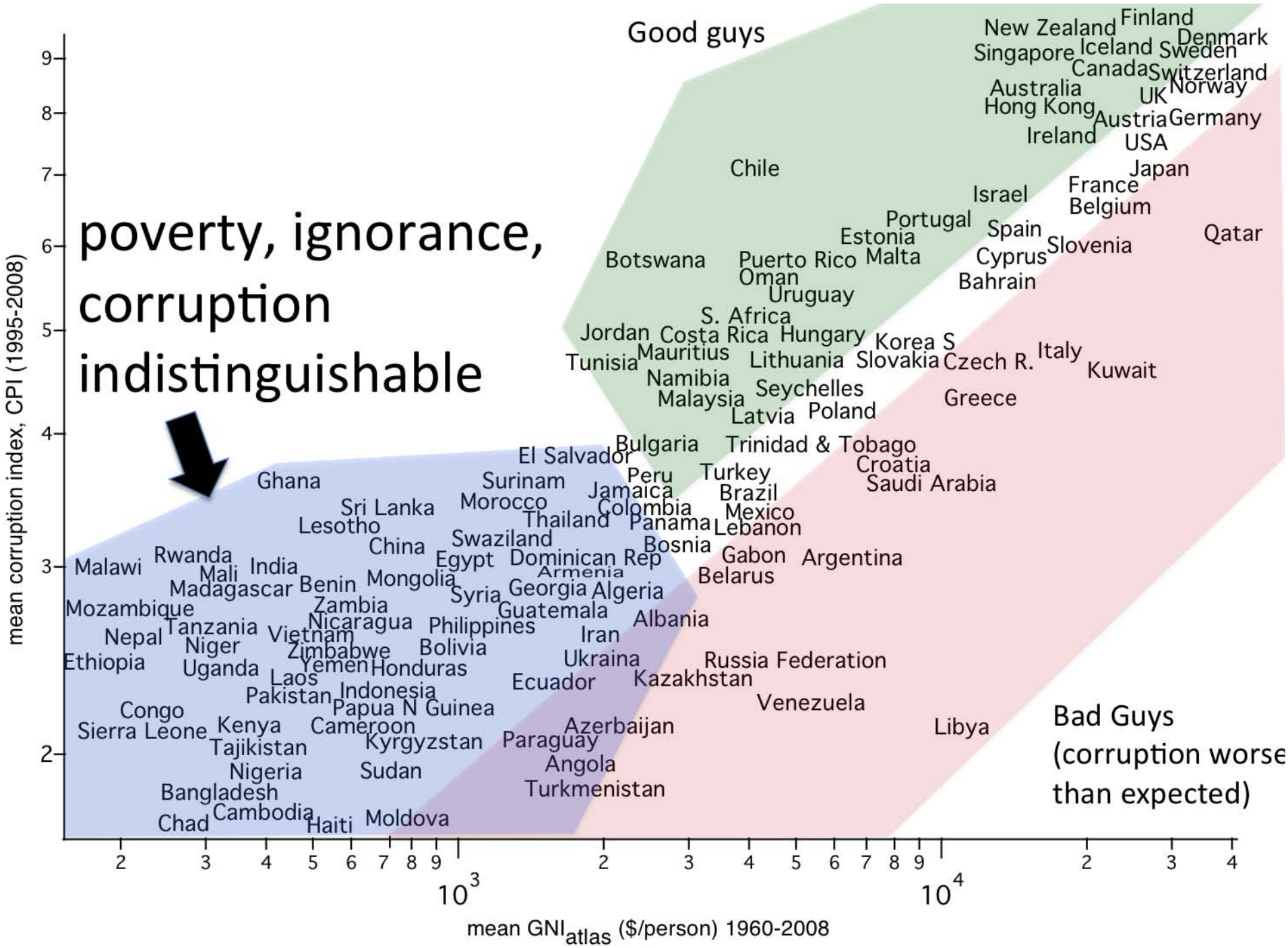
Corruption vs Income



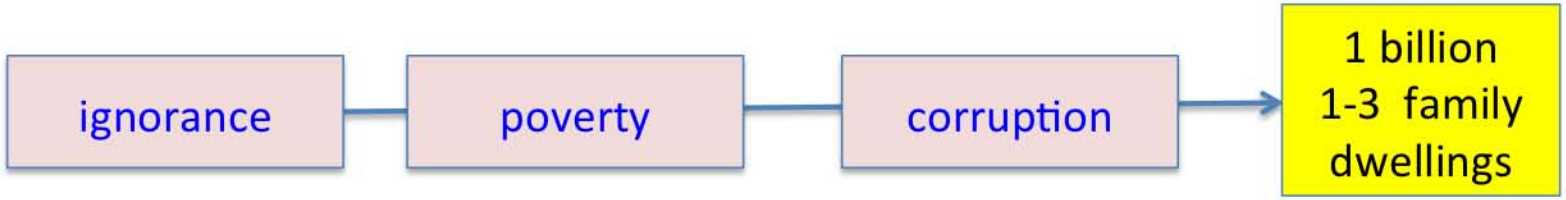

less corrupt than expected
More corrupt than expected
corruption
Annual income US $
New Zealand
Finland
Denmark
Singapore
Iceland
Sweden
Canada
Switzerland
Australia
Norway
UK
Hong Kong
Austria
Germany
Ireland
USA
Chile
Japan
France
Israel
Belgium
Portugal
Spain
Qatar
Estonia
Slovenia
Botswana
Puerto Rico
Malta
Cyprus
Oman
Bahrain
Uruguay
S. Africa
Jordan
Costa Rica
Hungary
Korea S
Italy
Tunisia
Mauritius
Lithuania
Slovakia
Czech R.
Kuwait
Namibia
Seychelles
Malaysia
Greece
Latvia
Poland
Bulgaria
Trinidad & Tobago
El Salvador
Croatia
Peru
Turkey
Ghana
Surinam
Saudi Arabia
Jamaica
Brazil
Sri Lanka
Morocco
Colombia
Mexico
Lesotho
Thailand
Panama
Lebanon
Swaziland
China
Bosnia
Rwanda
Egypt
Dominican Rep
Gabon
Argentina
Malawi
India
Mali
Armenia
Belarus
Madagascar
Benin
Mongolia
Syria
Georgia
Algeria
Mozambique
Zambia
Guatemala
Nicaragua
Albania
Tanzania
Philippines
Nepal
Vietnam
Iran
Niger
Zimbabwe
Bolivia
Ethiopia
Ukraina
Russia Federation
Uganda
Yemen
Honduras
Laos
Ecuador
Kazakhstan
Pakistan
Indonesia
Venezuela
Papua N Guinea
Congo
Kenya
Cameroon
Azerbaijan
Libya
Sierra Leone
Kyrgyzstan
Paraguay
Tajikistan
Angola
Nigeria
Sudan
Turkmenistan
Bangladesh
Cambodia
Chad
Haiti
Moldova
9
8
7
6
2
2
3
4
5
6
7
8
9
10^3
2
3
4
5
6
7
8
9
10^4
2
3
4

90% of all deaths from earthquakes in low-income, excessively-corrupt nations




Good guys
poverty, ignorance, corruption indistinguishable
Bad Guys (corruption worse than expected)
New Zealand
Finland
Denmark
Singapore
Iceland
Sweden
Canada
Switzerland
Australia
Norway
UK
Hong Kong
Austria
Germany
Ireland
USA
Chile
Japan
France
Israel
Belgium
Portugal
Spain
Qatar
Estonia
Slovenia
Botswana
Puerto Rico
Malta
Cyprus
Oman
Bahrain
Uruguay
S. Africa
Jordan
Costa Rica
Hungary
Korea S
Italy
Mauritius
Tunisia
Lithuania
Slovakia
Czech R.
Kuwait
Namibia
Seychelles
Malaysia
Greece
Latvia
Poland
Bulgaria
Trinidad & Tobago
El Salvador
Croatia
Peru
Turkey
Saudi Arabia
Ghana
Surinam
Jamaica
Brazil
Morocco
Sri Lanka
Colombia
Mexico
Thailand
Panama
Lesotho
Lebanon
Swaziland
China
Bosnia
Rwanda
Egypt
Dominican Rep
Gabon
Argentina
Malawi
India
Mali
Armenia
Mongolia
Belarus
Madagascar
Benin
Syria
Georgia
Algeria
Mozambique
Zambia
Guatemala
Nicaragua
Albania
Tanzania
Philippines
Nepal
Vietnam
Iran
Niger
Zimbabwe
Bolivia
Ethiopia
Ukraina
Russia Federation
Yemen
Honduras
Uganda
Laos
Ecuador
Kazakhstan
Pakistan
Indonesia
Venezuela
Papua N Guinea
Congo
Kenya
Cameroon
Azerbaijan
Libya
Sierra Leone
Tajikistan
Kyrgyzstan
Paraguay
Nigeria
Sudan
Angola
Bangladesh
Turkmenistan
Cambodia
Chad
Haiti
Moldova
mean corruption index, CPI (1995-2008)
mean GNI atlas ($/person) 1960-2008
10^3
10^4

future earthquakes will target civilization's weaknesses



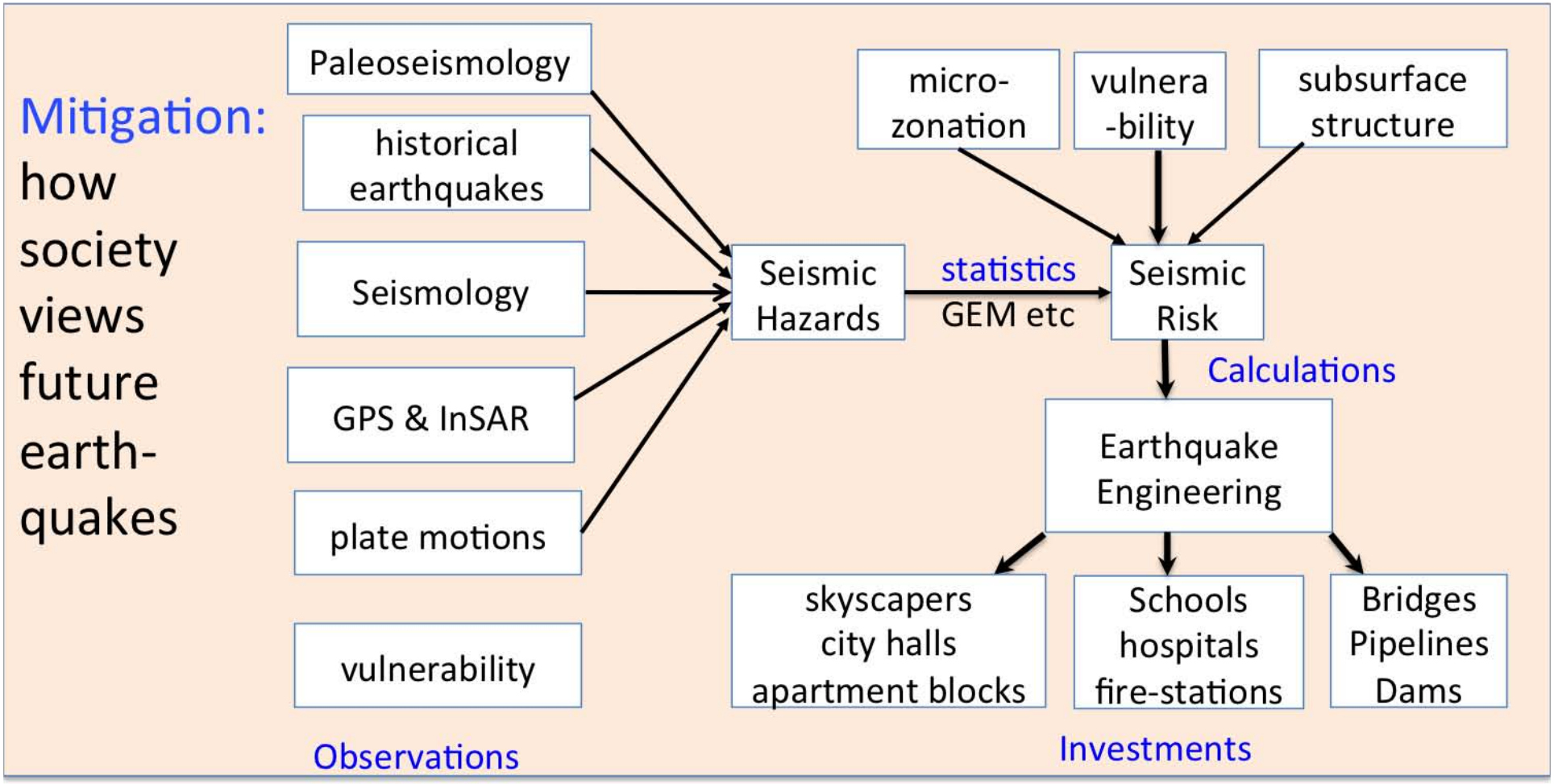
The fix.....

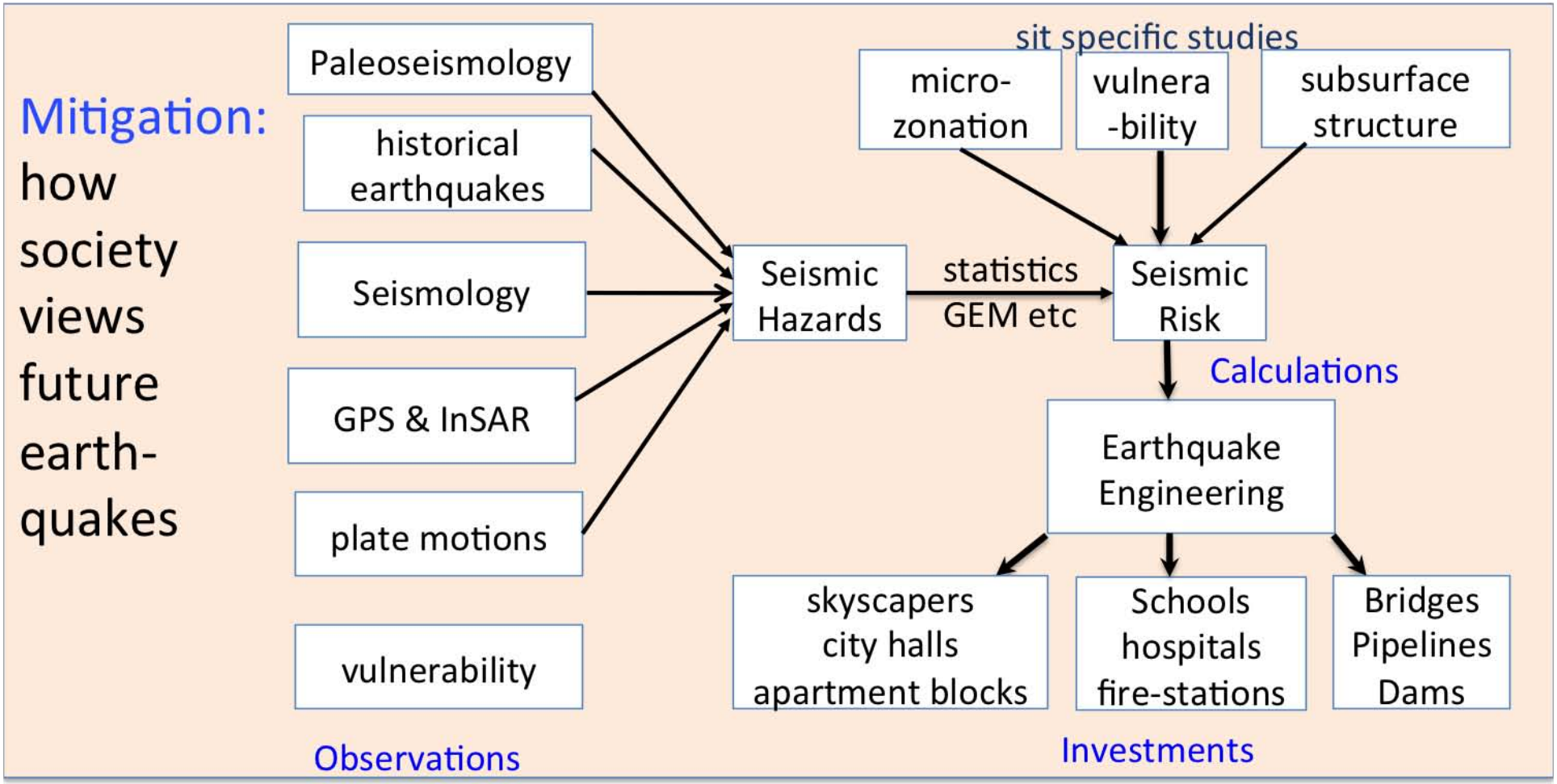
for ignorance = education

for poverty = education

for corruption = education

Earthquake risk assessments are not for everyone


Mitigation:
how
society
views
future
earth-
quakes
Paleoseismology
historical earthquakes
Seismology
GPS & InSAR
plate motions
vulnerability
Observations
Seismic Hazards
statistics
GEM etc
micro-zonation
vulnera-bility
subsurface structure
Seismic Risk
Calculations
Earthquake Engineering
skyscapers
city halls
apartment blocks
Schools
hospitals
fire-stations
Bridges
Pipelines
Dams
Investments



Disaster:

how future earthquakes view society

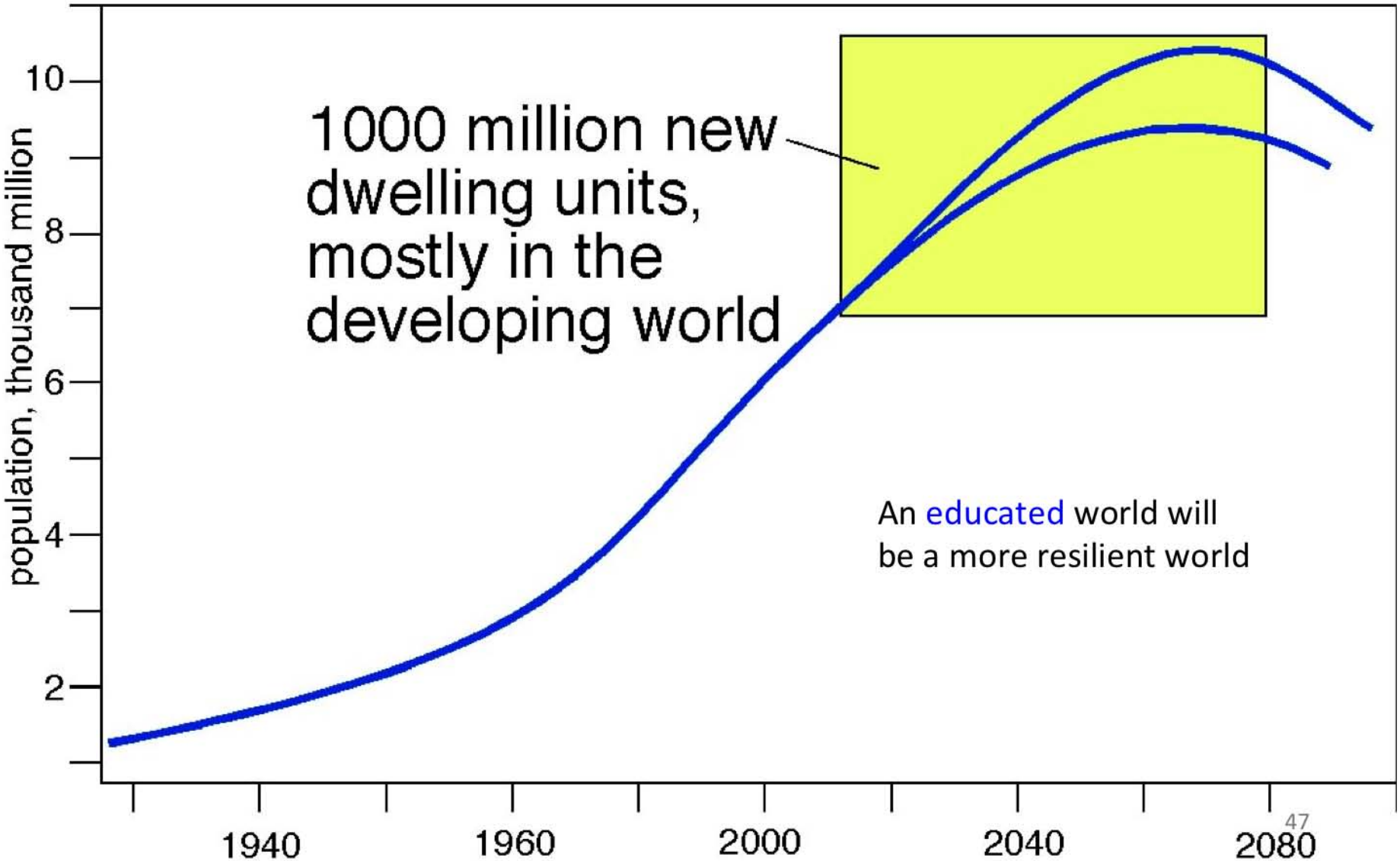
invulnerable: civic structures

vulnerable:

1 billion 1-3 family dwellings

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

Let's be optimistic



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