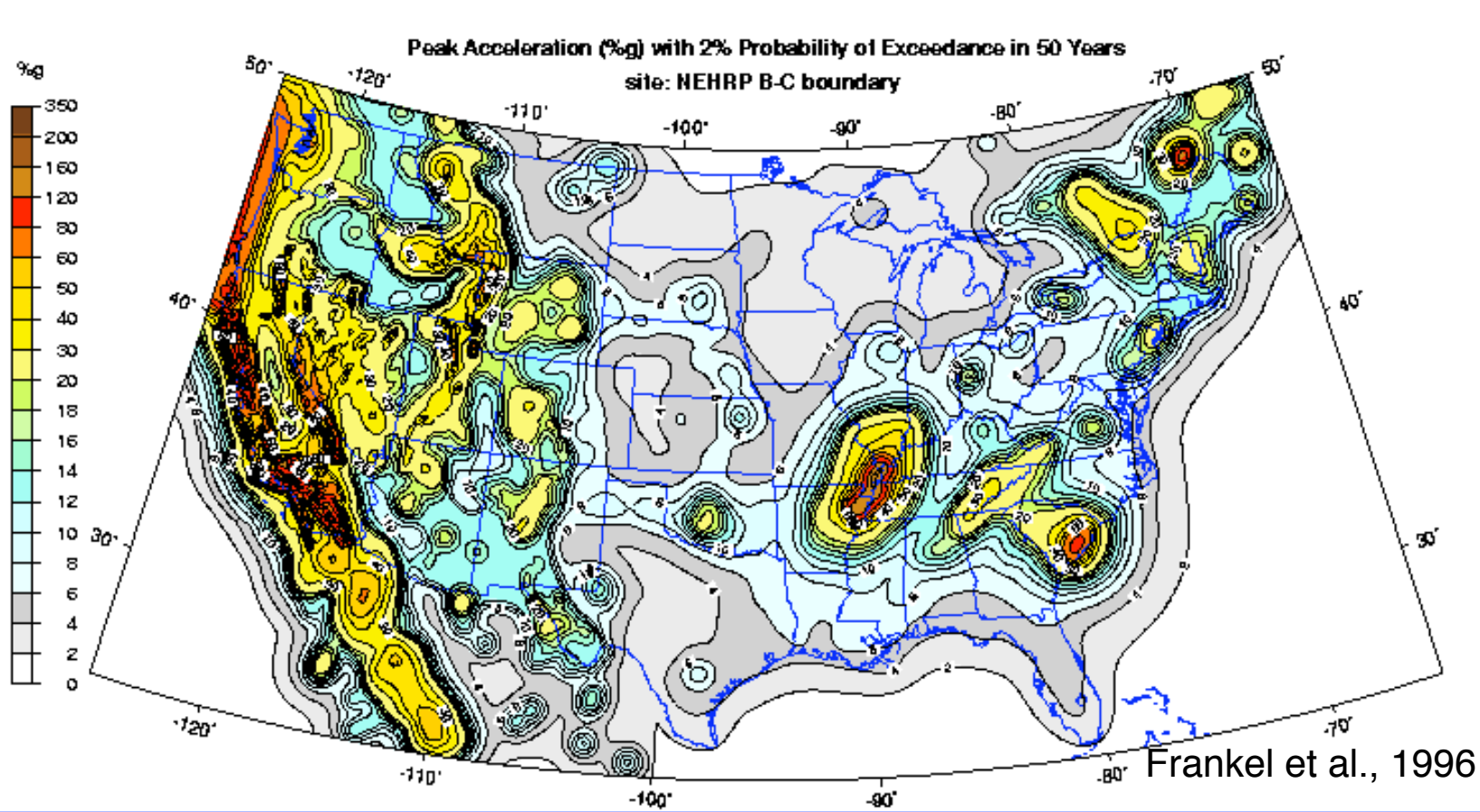
9. As hazardous as California?

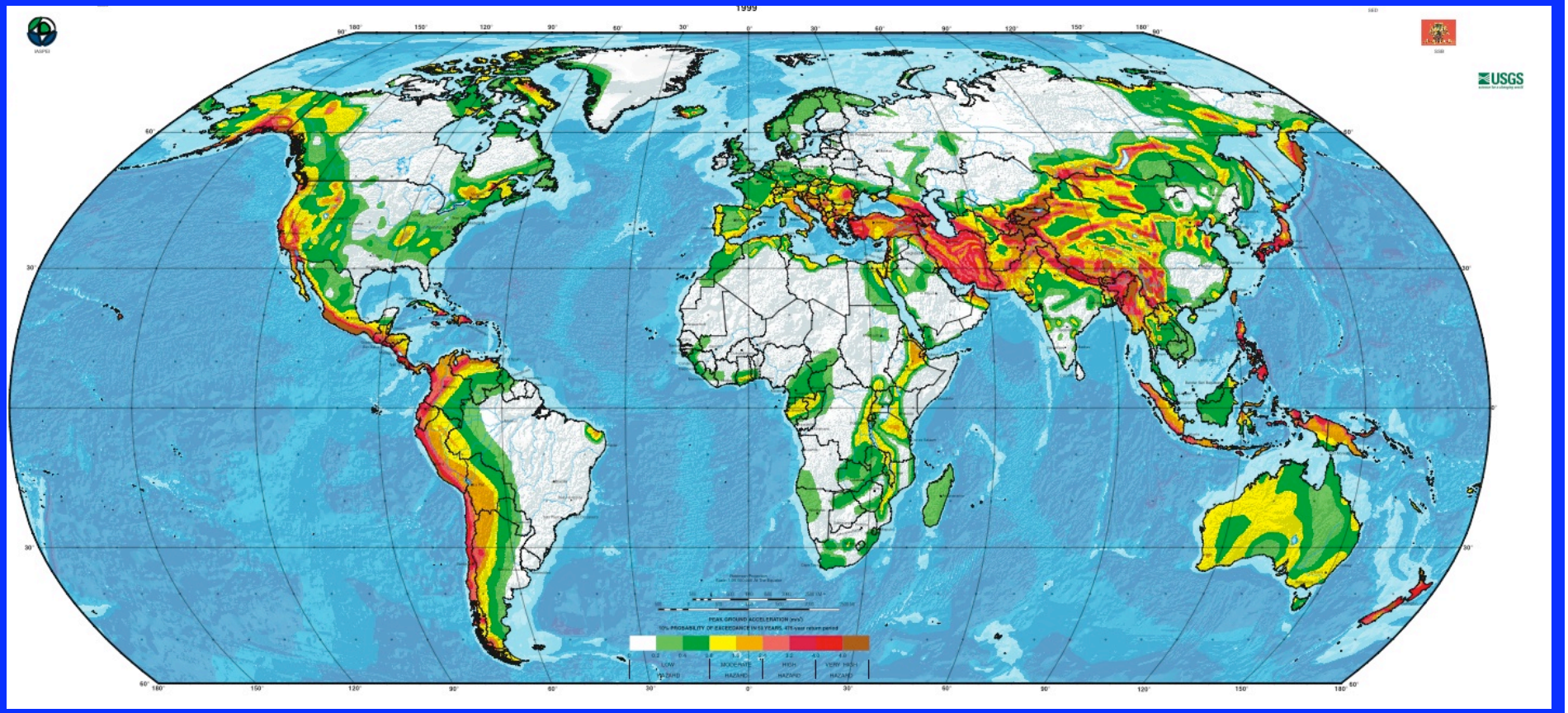
USGS/FEMA: Buildings should be built to same standards

How can we evaluate this argument?



Frankel et al., 1996

To design buildings, we try to predict the hazard defined as maximum shaking (acceleration) they'll face in some time period, which isn't easy



"A game of chance against nature of which we still don't know all the rules" (Lomnitz, 1989)

Activity 9.1: Fermi problem

Estimate answers using only orders of magnitude

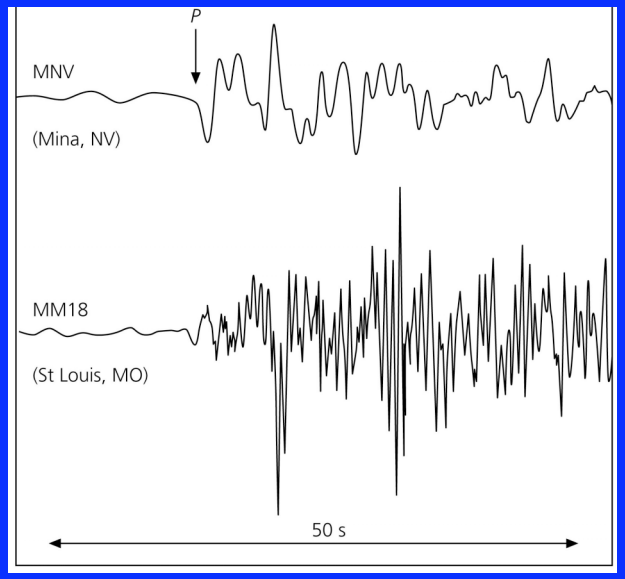
About much do Americans spend each year on Halloween?

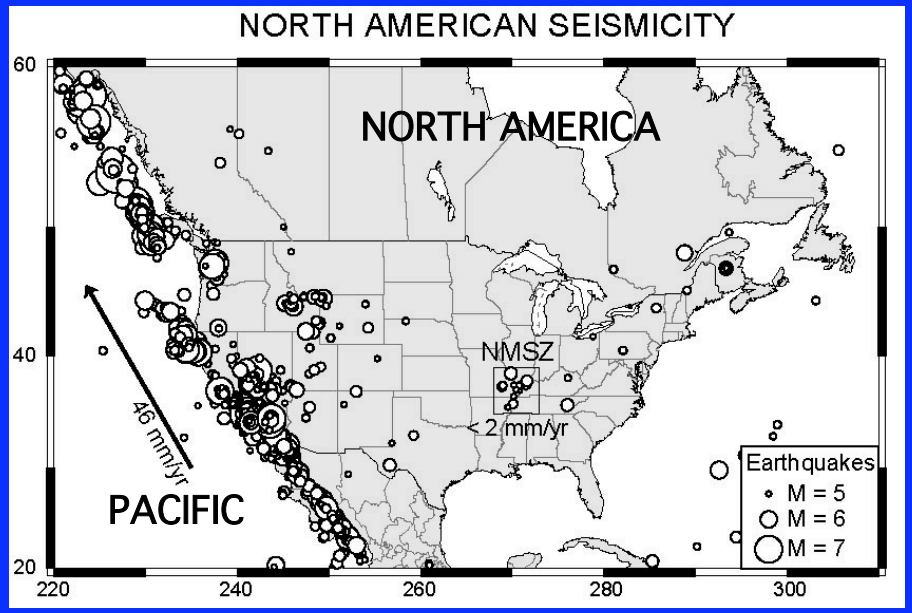
Expect New Madrid hazard much less than California

Seismicity 1/30-1/100 California rate, due to different motion rates

Seismic energy propagates better than in California (midwest M 6 about the same as western M7), so correct by 10x

Implication: Midwest hazard 3/3-1/10 California's





Earthquake hazard isn't a physical thing we measure. It's something we *define* and use computer programs to predict. Different assumptions produce very different maps.

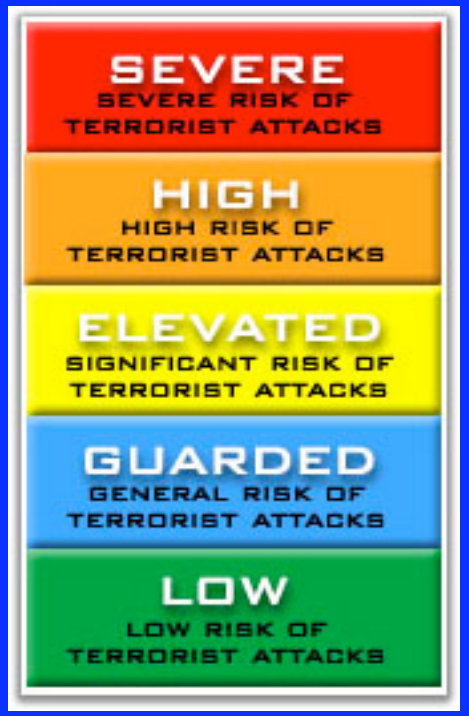
- ***What's the definition* of hazard (political, not scientific)**

- ***Where* and *when* will earthquakes occur?**

- **If they occur, then**

- ***How large*?**

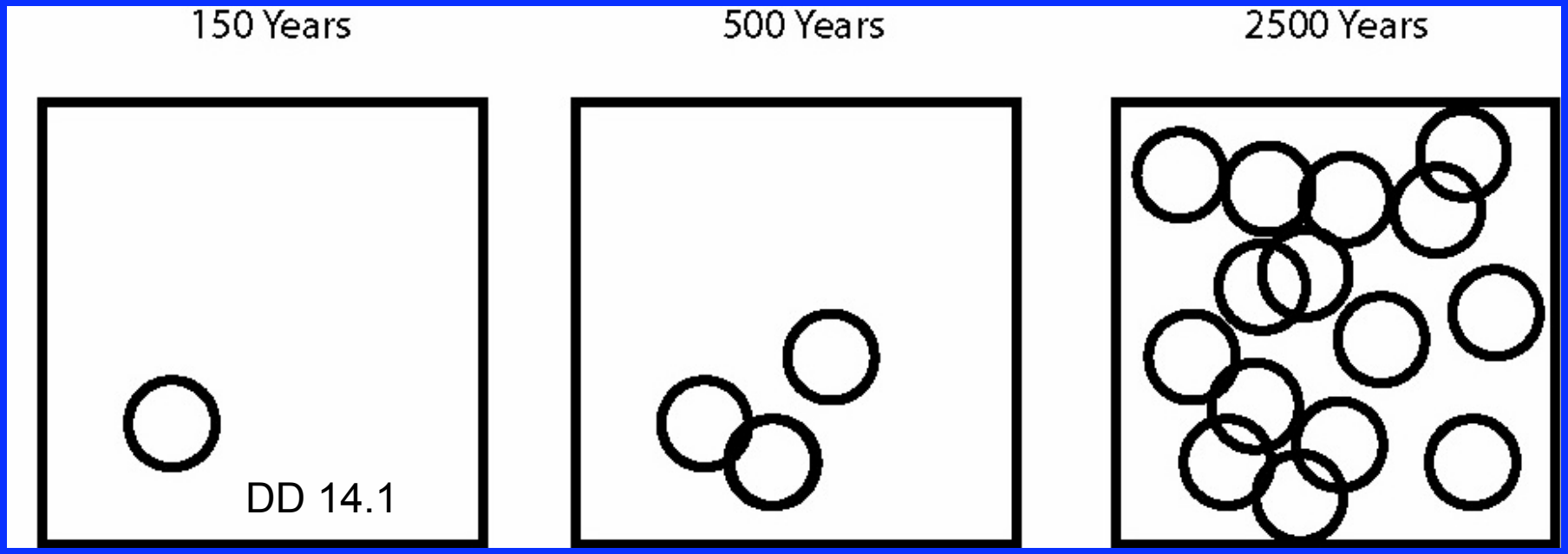
- ***How strong* will ground motion be?**



These aren't well understood, especially where large earthquakes are rare, so hazard estimates have considerable uncertainties

How can we assess these uncertainties?

Assume that an earthquake of a certain size will strike in a certain time and cause shaking within a certain area.



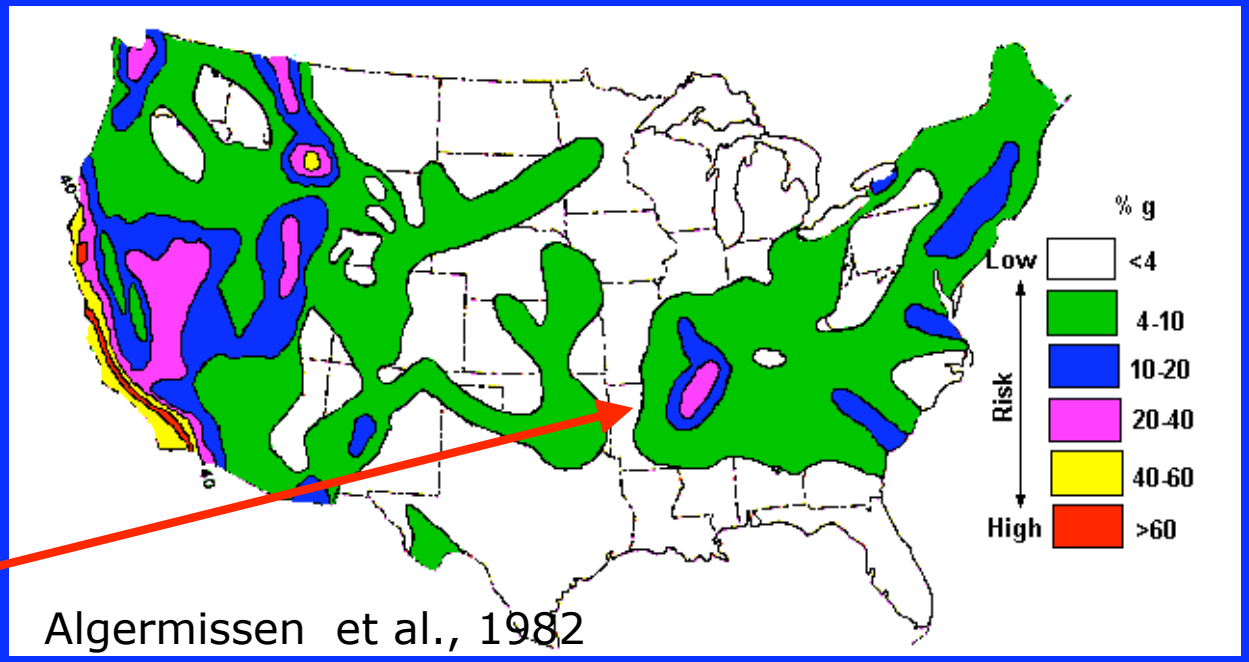
Strongly shaken areas MMI > VII for M 6

Include earthquakes of different magnitudes, assume some areas more likely to have earthquakes, and have stronger shaking close to the epicenter. Hazard at a given location is described by the maximum shaking due to earthquakes that is predicted to happen in a given period of time. Thus it increases for longer time windows / lower probabilities

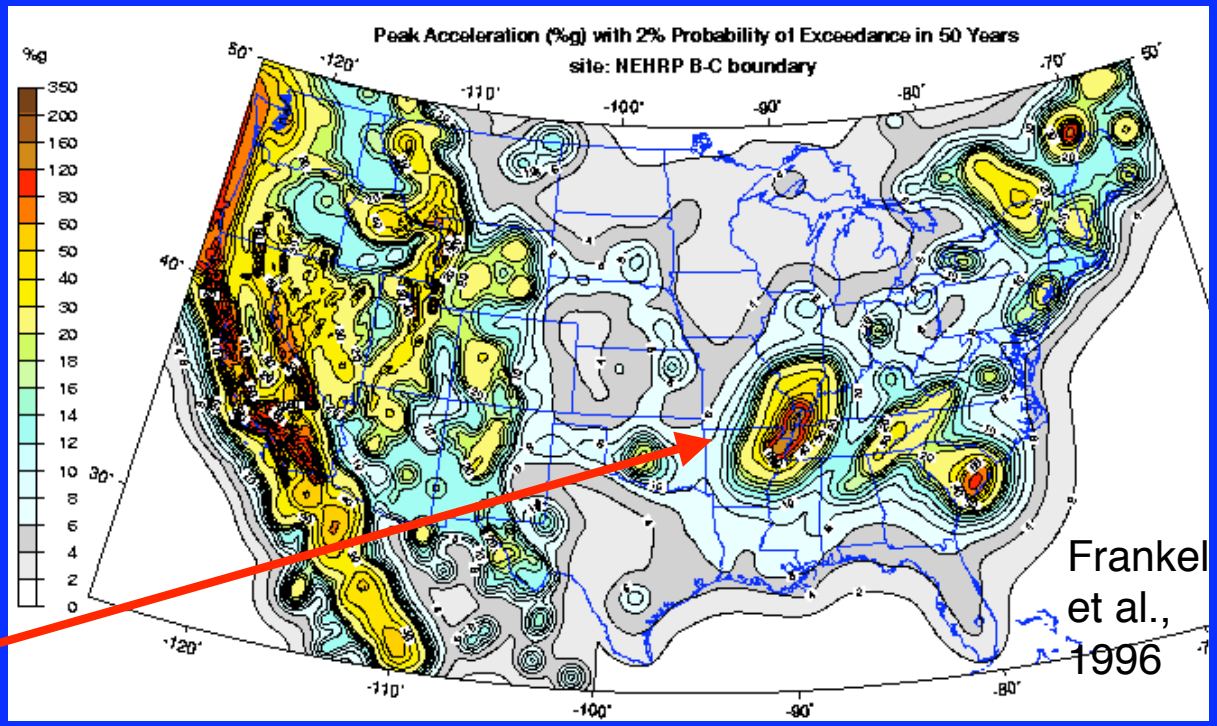
Hazard redefined with longer window

from maximum acceleration predicted at 10% probability in 50 yr (1/ 500 yr)

to much higher 2% in 50 yr (1/2500 yr)



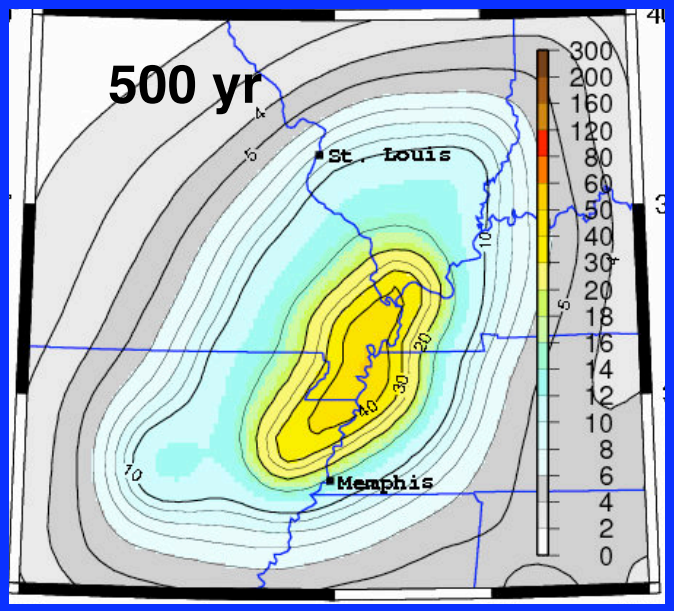
Algermissen et al., 1982



Frankel et al., 1996

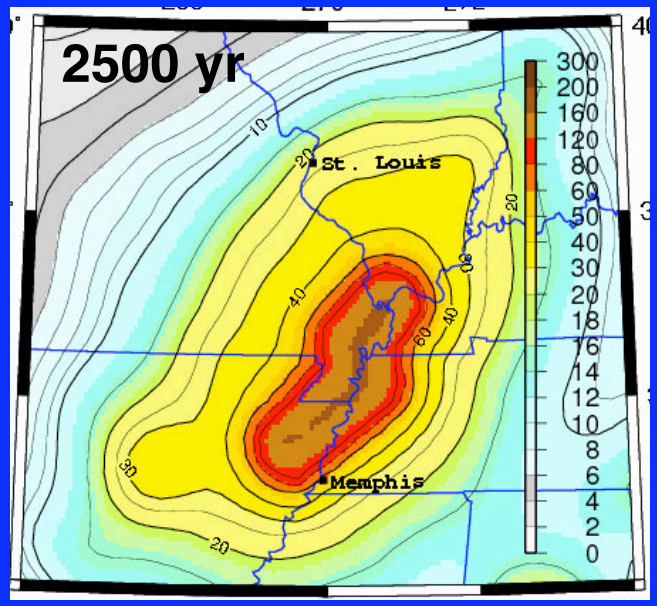
DD 14.1

New Madrid hazard higher than California results largely from redefining hazard as largest shaking expected every 2500 yr: Not so for 500 yr



400%

DD 14.3



Problem: buildings have typical life of 50-100 years

Predicted hazard depends on likely we assume that it is that big earthquakes like those of 1811-1812 will happen again “soon”

“The" probability of a large earthquake isn't something we know or even can know.

All we can do is estimate it by making various assumptions.

One big choice: we can assume the probability of a major earthquake is either

-constant with time (*time-independent*) or

-small after a large earthquake and then increases (*time-independent*).

Activity 9.2: Explain why you prefer time-independent or time-dependent probability to describe:

- Flipping coins: after three heads is tails more or less likely?

- Playing cards: after two aces are drawn is an ace more or less likely?

- Hurricanes: after a big storm hits an area, is one more or less likely to hit next year?

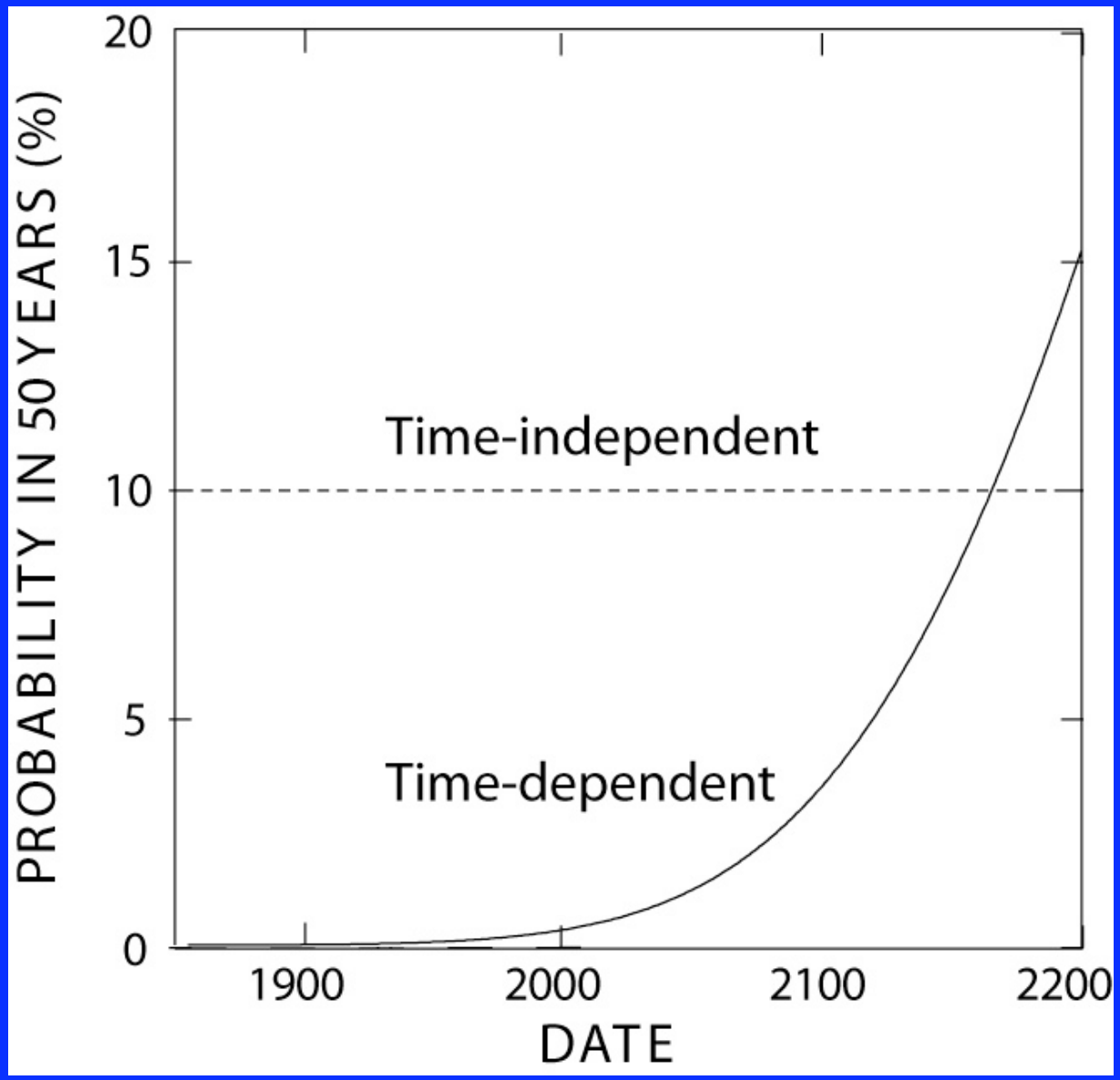
- Large earthquakes on a fault: does the probability depend on the time since the last?

If big New Madrid earthquakes occur on average 500 years apart

Time independent probability predicts the chance of one in the next 50 years is 50/500 or 10%

Time dependent probability predicts a much lower chance

Why?

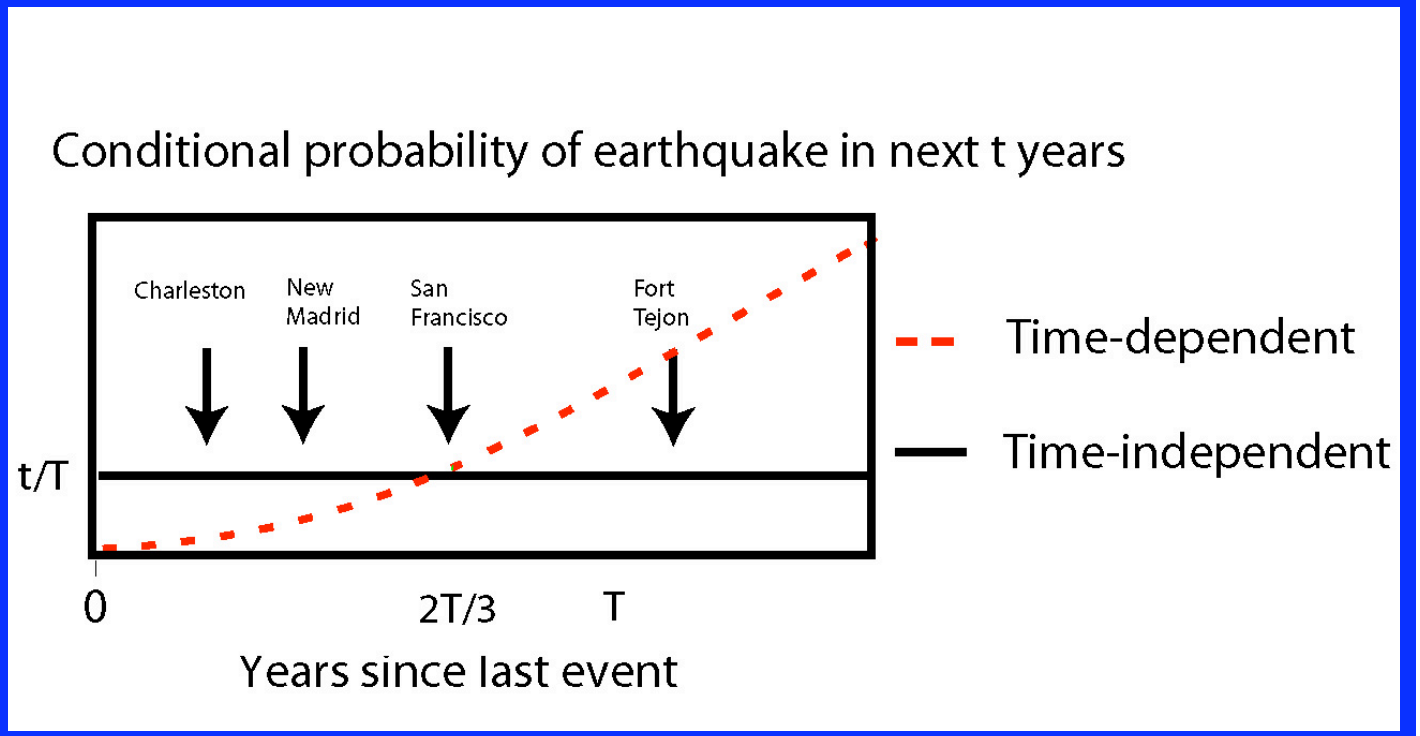


DD 14.4

Predicted hazard depends on time since last big earthquake and average time between them

Time dependent lower until ~2/3 mean recurrence

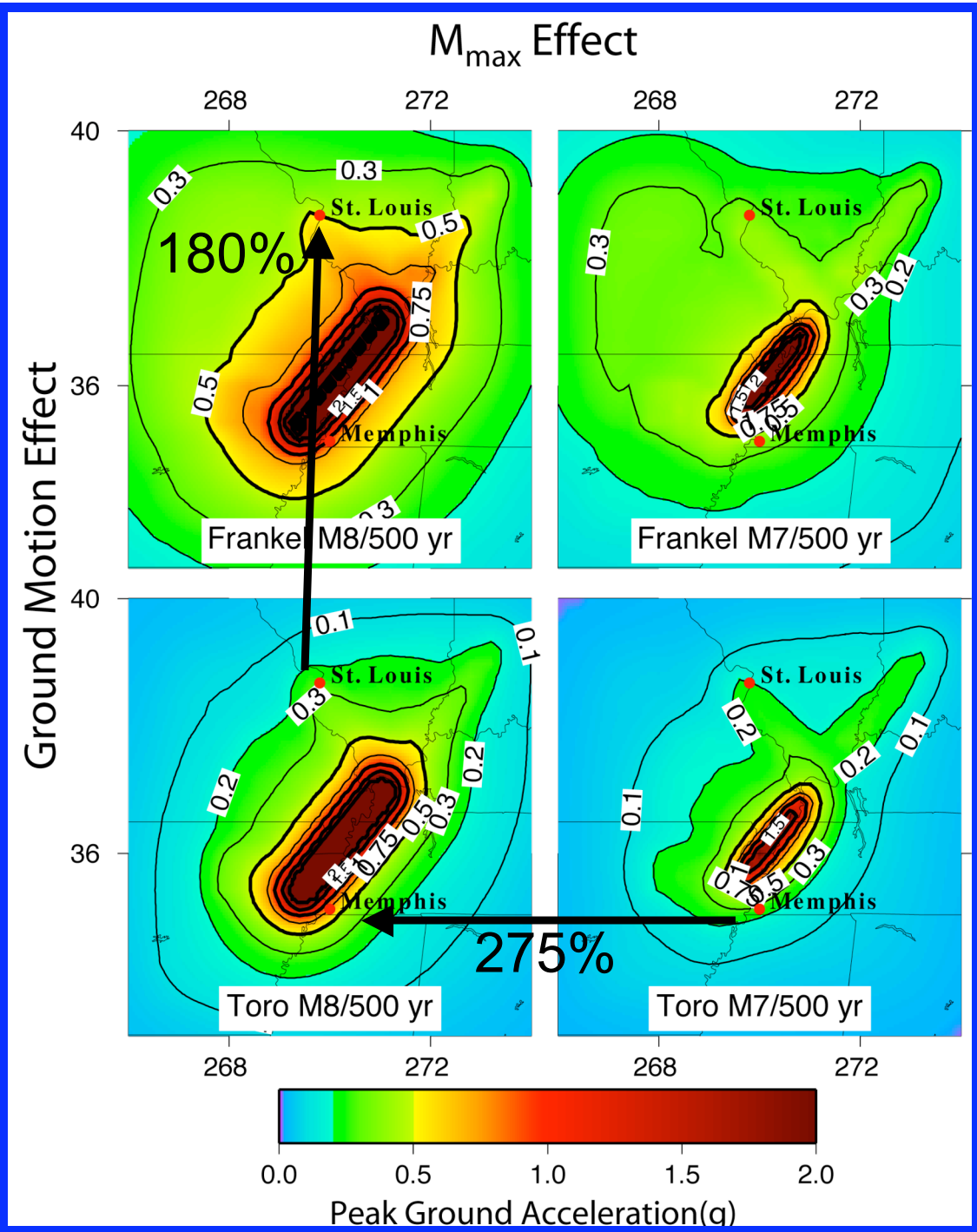
New Madrid in mid-cycle so USGS time independent assumption predicts higher hazard



DD 14.5

PREDICTED HAZARD ALSO DEPENDS ON

- Assumed maximum magnitude of largest events
- Assumed ground motion model



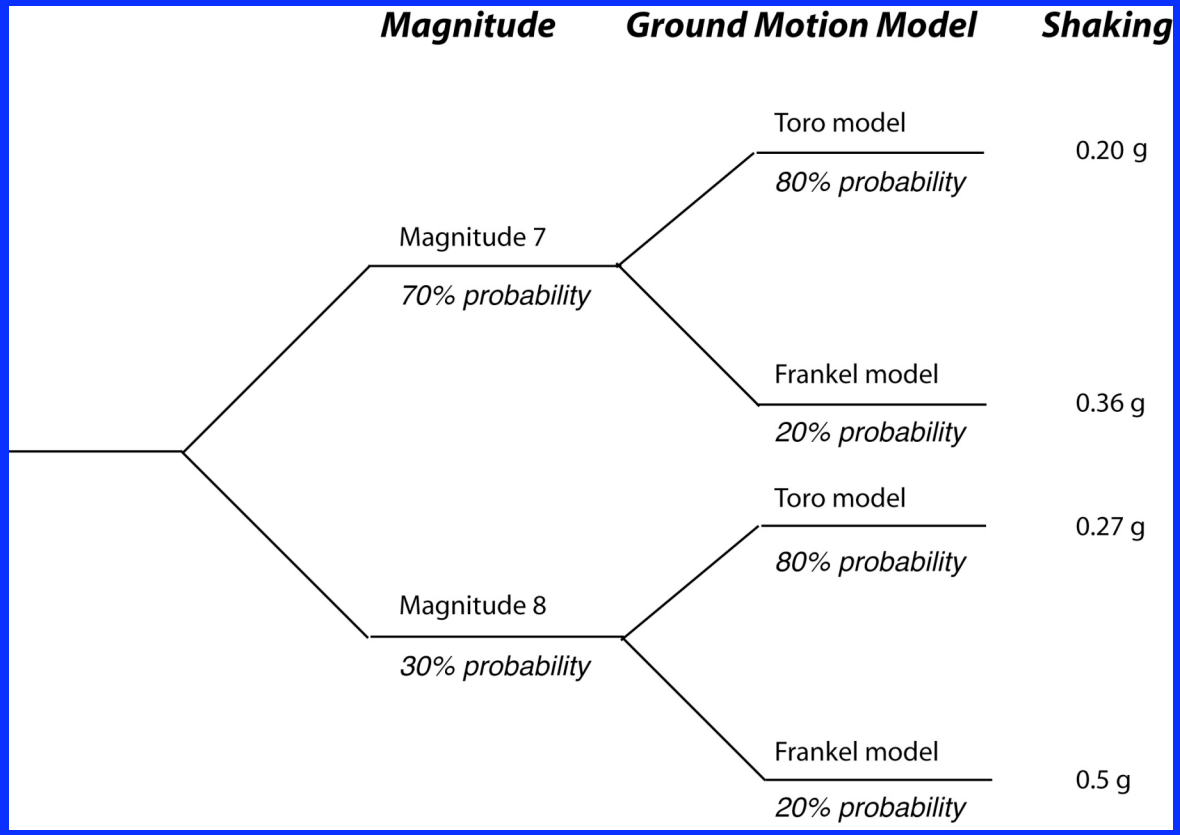
DD 14.6

Combine models using “logic tree”

Results depend weights assumed for different models

Depend on what map maker thinks is going on

No objective way to decide,and we won’t know for thousands of years

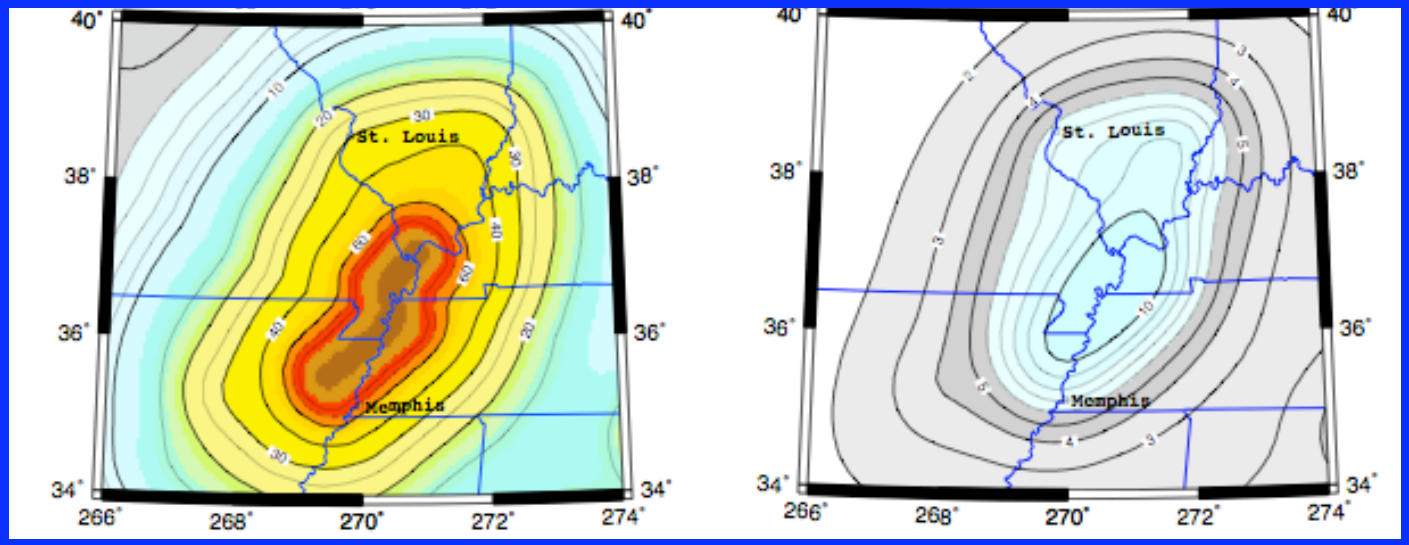


DD 14.7

Assume from GPS no M7 on the way

Hazard from quakes up to M ~ 6.7

~ 1/10 that of USGS prediction



DD 14.8

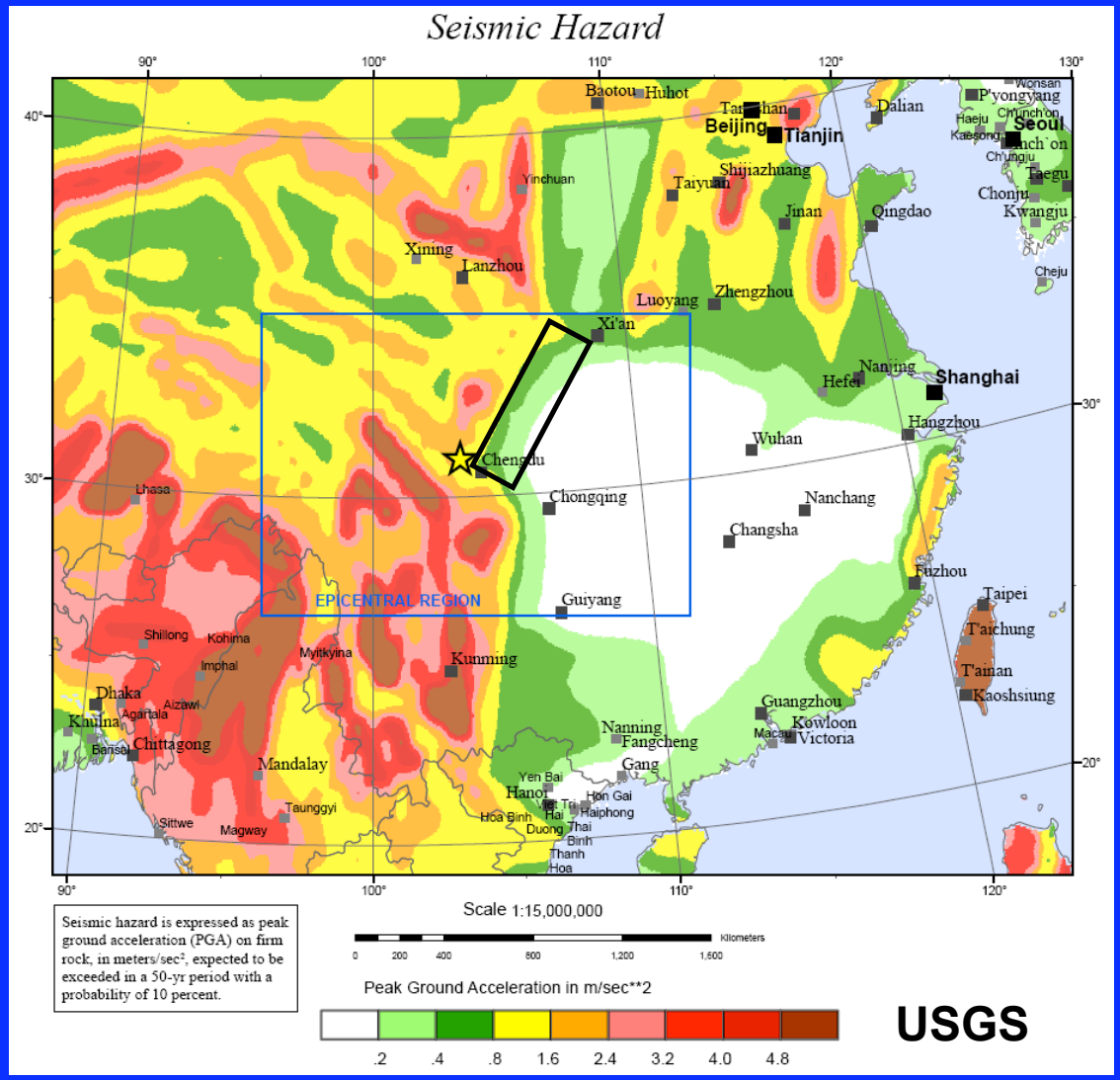
USGS, 2500 yr,
assumes M 7 coming

GPS, 500 yr, assumes
no M 7 coming

Agrees with order of magnitude estimate from motion rates

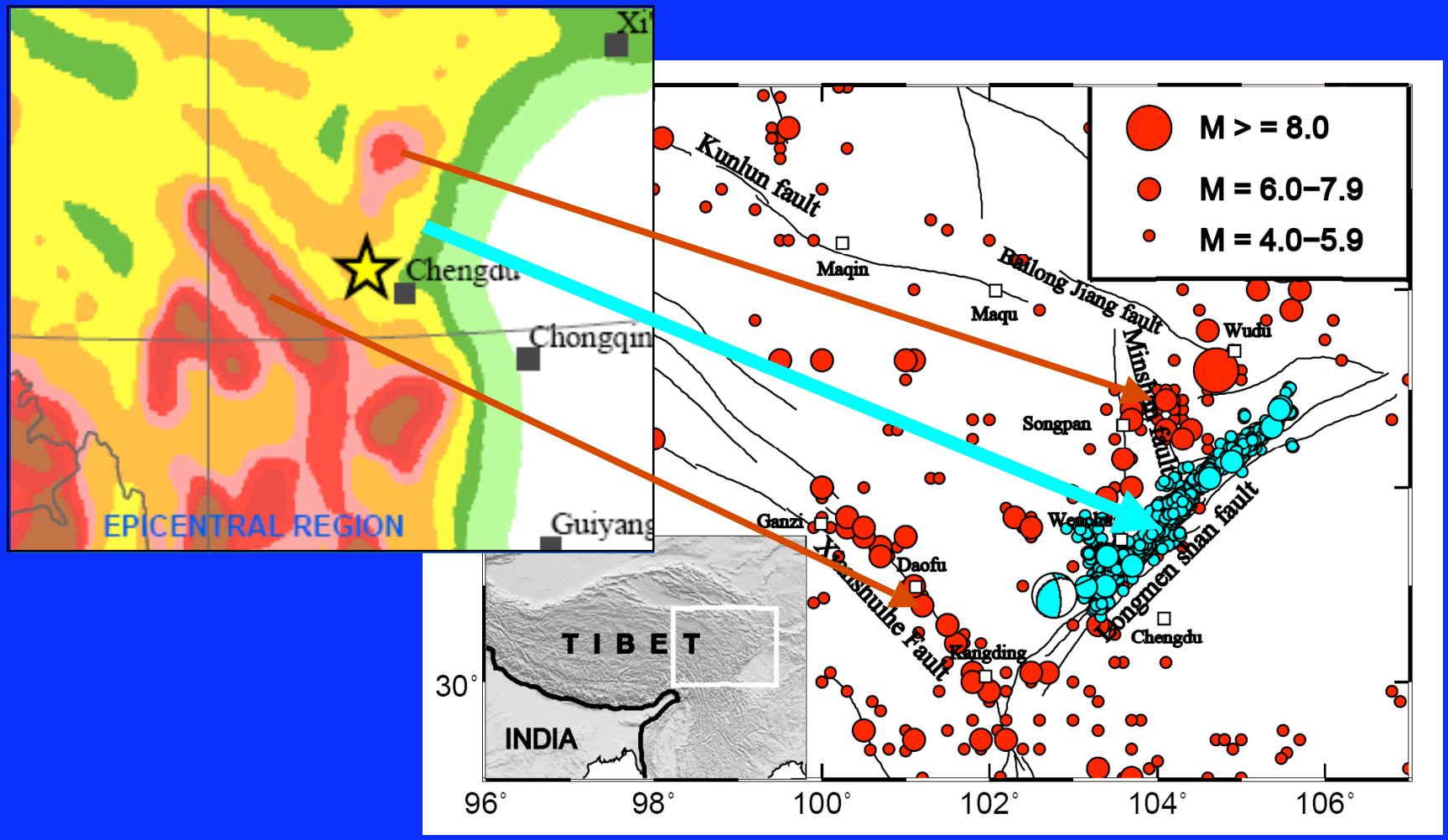
Even less if faults turn on and off!

2008 Wenchuan earthquake (Mw 7.9) was not expected: map showed low hazard



Hazard map ignored variability - assumed steady state - relied on lack of recent seismicity

Didn't use GPS data



- Earthquakes prior to the 2008 Wenchuan event
- Aftershocks of the Wenchuan event delineating the rupture zone

Neglecting variability is like ‘Whack-a-mole’ - you wait for the mole to come up where it went down, but it’s likely to pop up somewhere else.