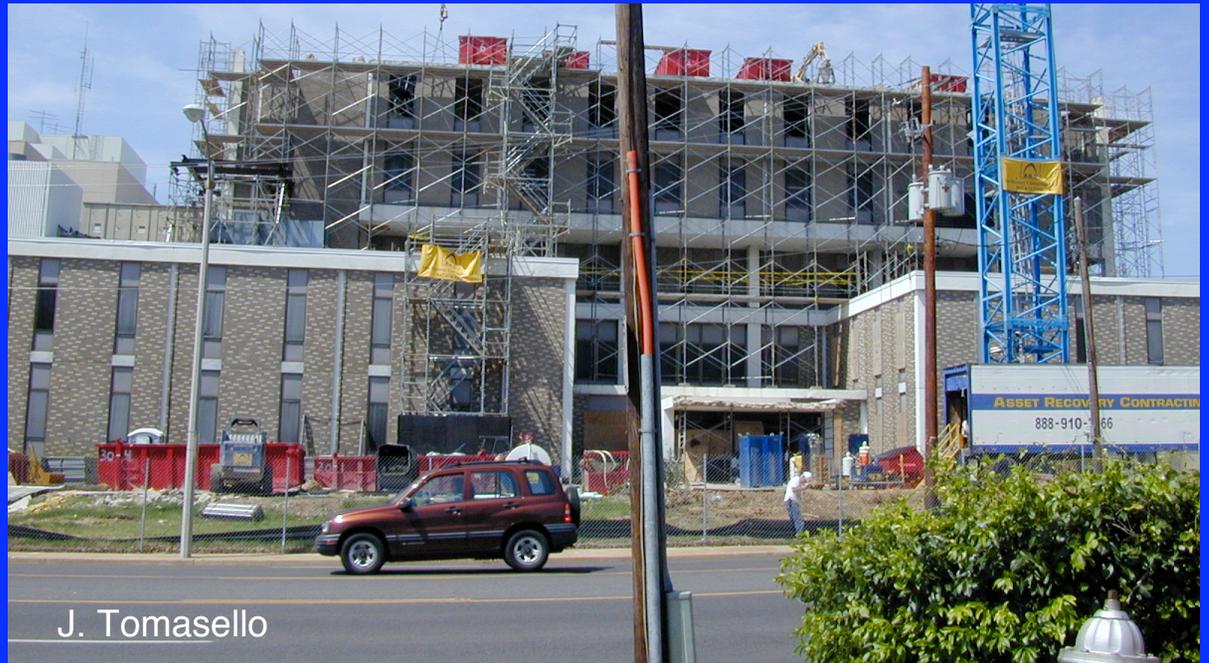


10. What to do?



\$100M retrofit of Memphis VA hospital, removing nine floors, bringing it to California standard

Such measures would cost \$billions over 100s of years

Is this a wise use of resources compared to alternatives that could do more good?

Activity 10.1: Assessing hazards and mitigation measures

- About 1 in 200 houses in the US has a fire each year
- Fires on average do about \$20,000 damage
- Should you install a \$2000 sprinkler system? Why or why not?



DAMAGE DEPENDS ON WHERE AND HOW WE BUILD

“Earthquakes don't kill people; buildings kill people.”



**1989 LOMA PRIETA, CALIFORNIA EARTHQUAKE:
M 7.1**

**Mile of two level freeway collapsed, crushing cars
& causing 42 deaths**

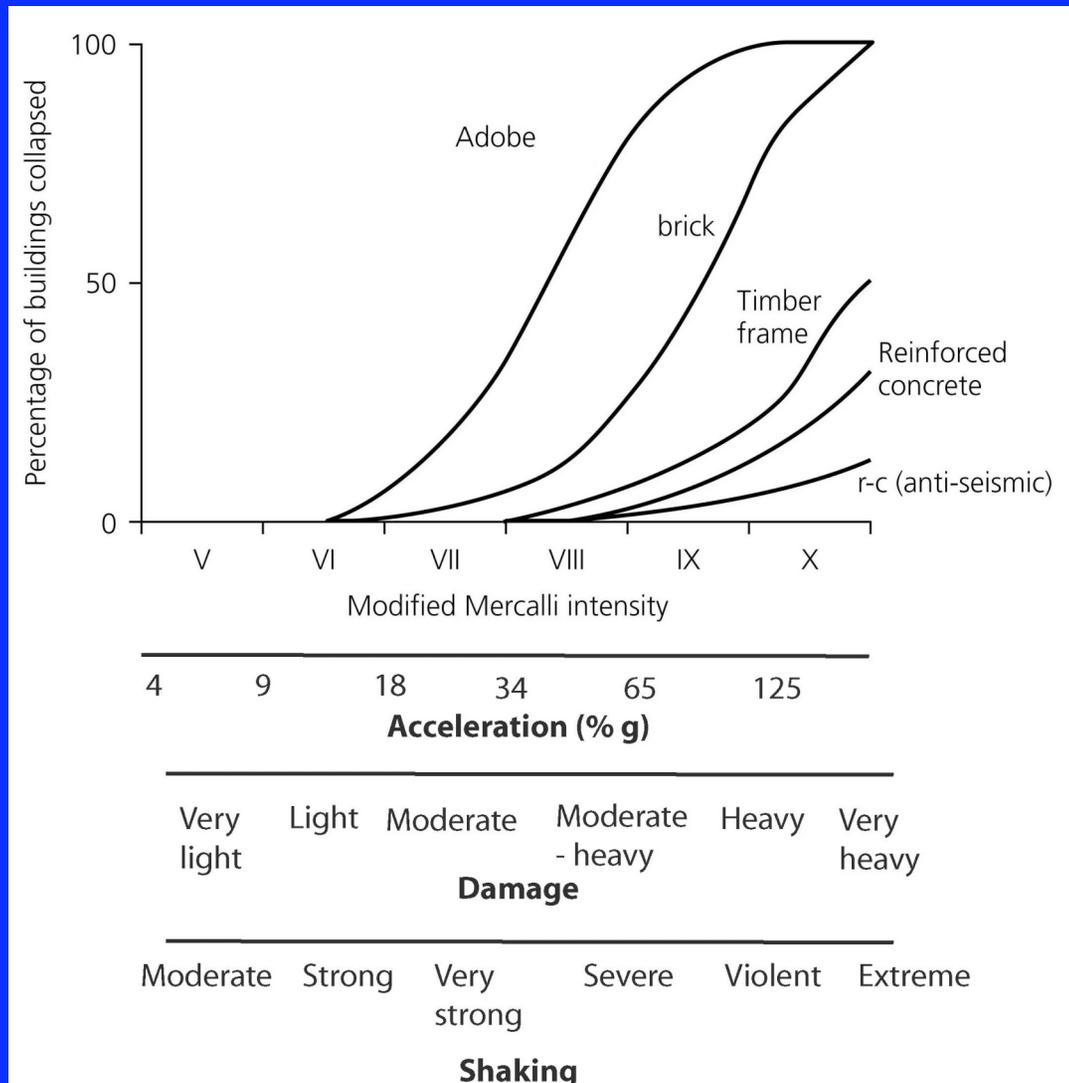
DAMAGE DEPENDS ON BUILDING TYPE

RESISTANT CONSTRUCTION REDUCES EARTHQUAKE RISKS



Pigs had it wrong

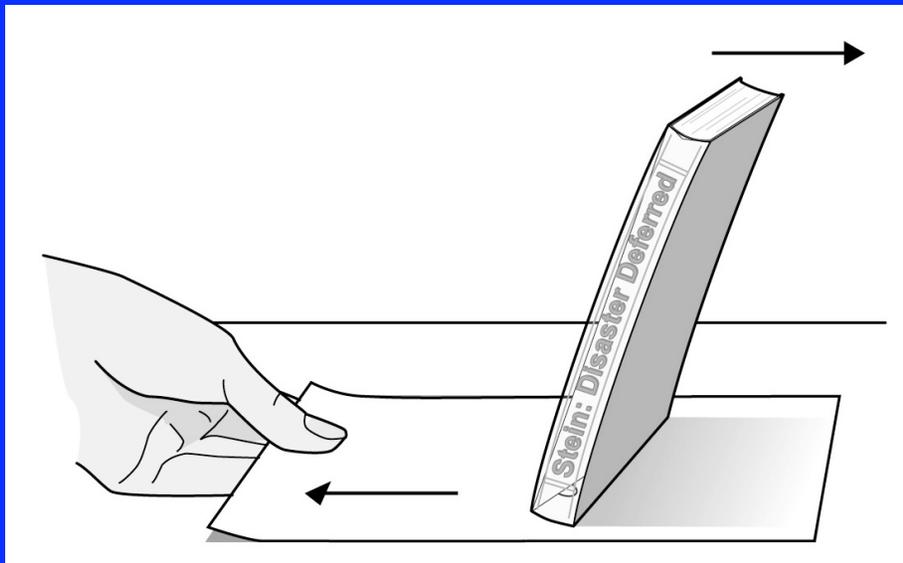
DD 15.5



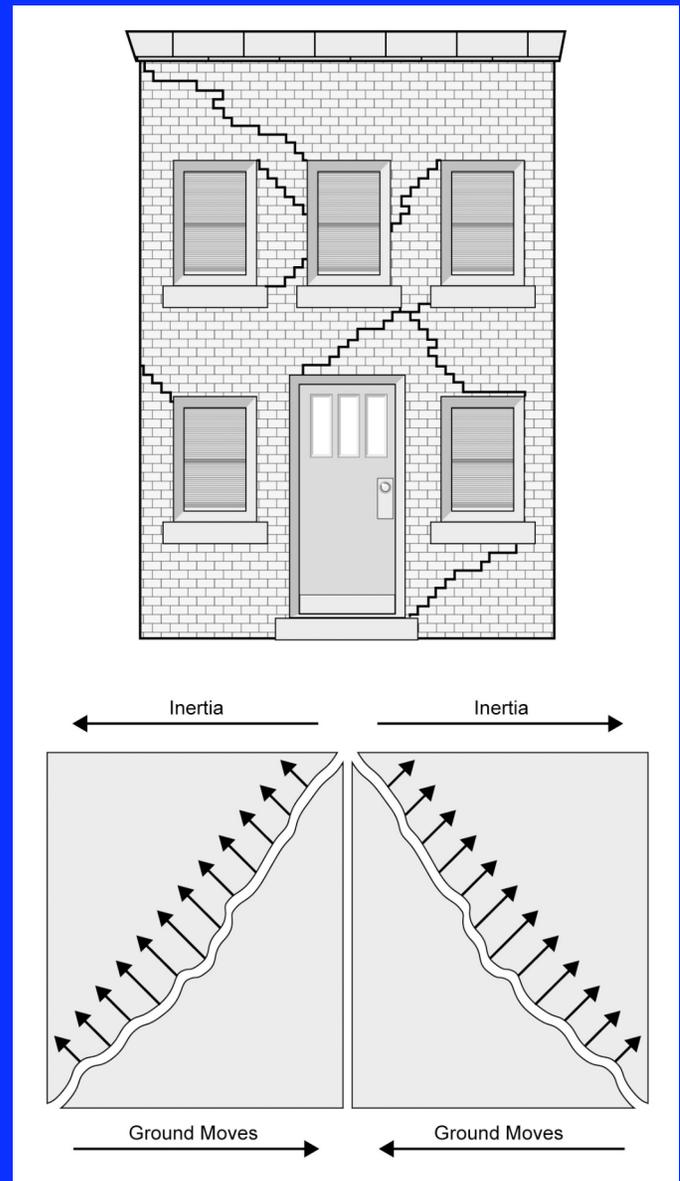
Why buildings fall down in earthquakes

Building materials are strong in compression, but weaker in tension

Building materials are strong in compression, but weaker in tension

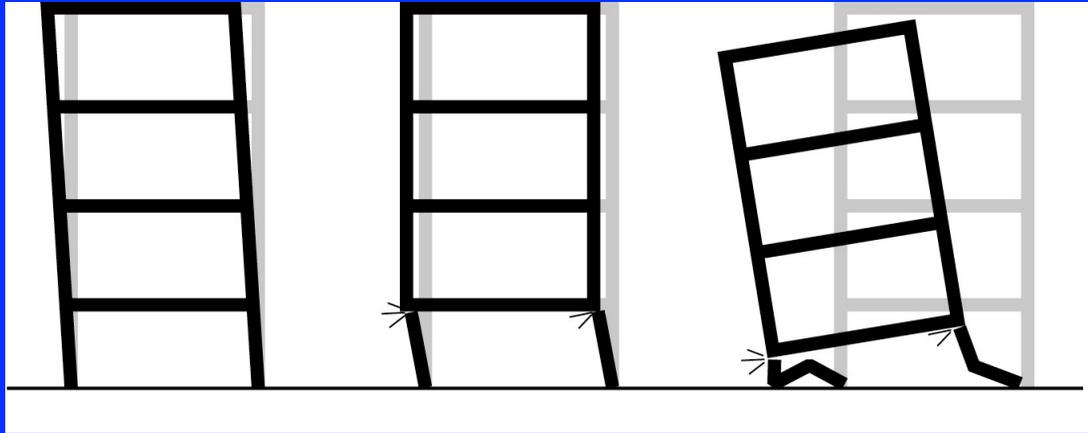


DD 15.1

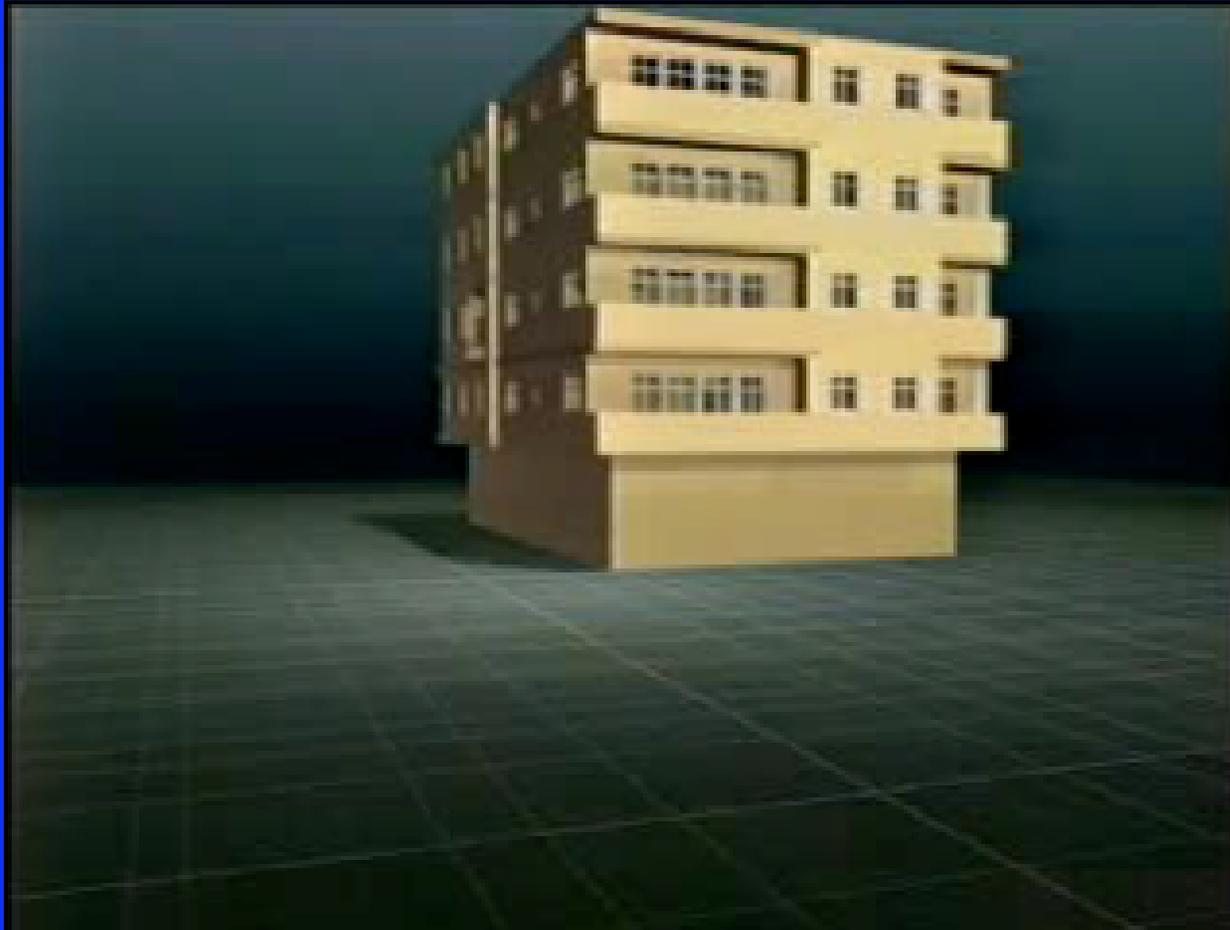


Unreinforced brick is vulnerable

Reinforced concrete buildings can collapse if columns fail



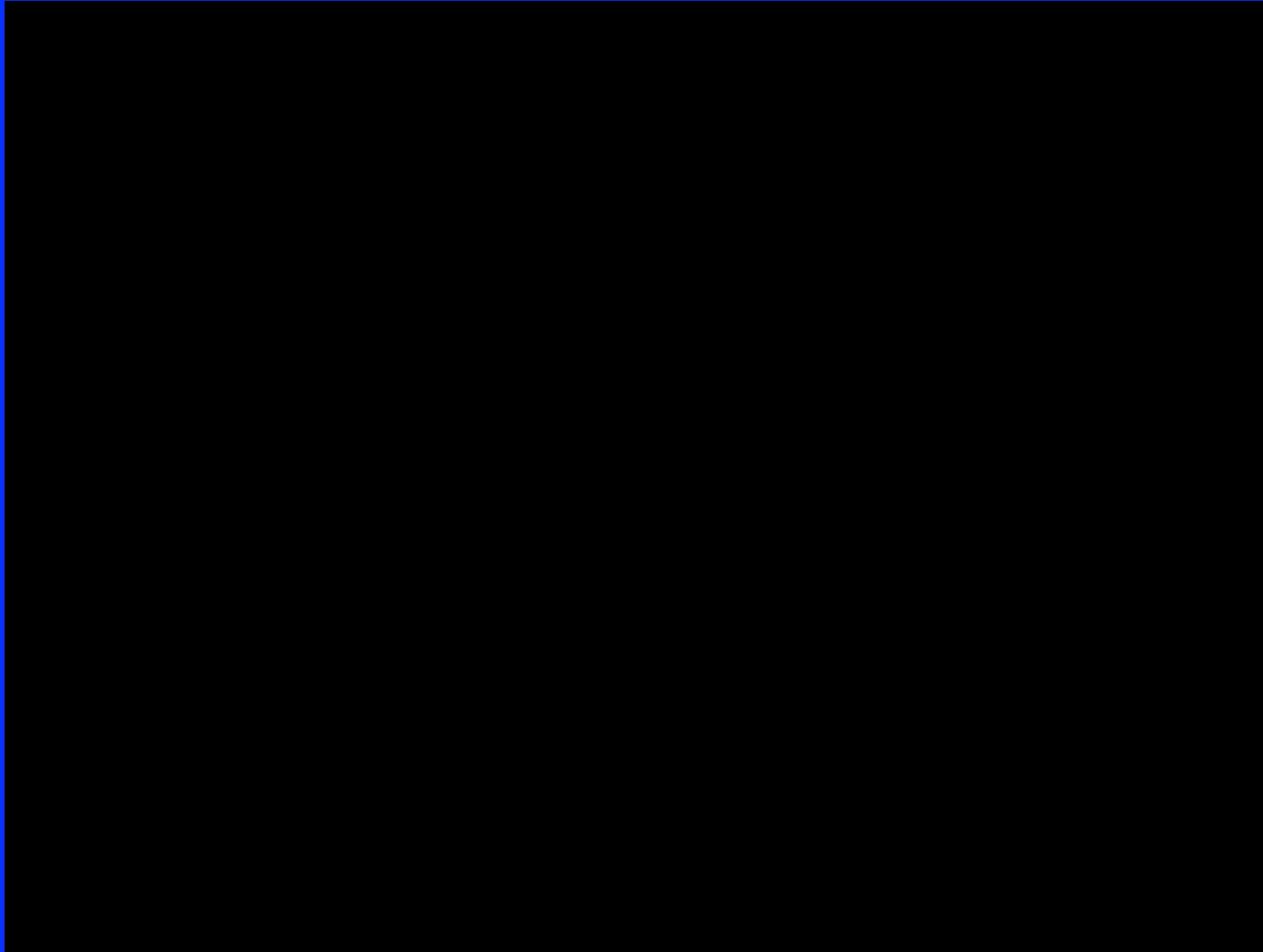
MODERN CONSTRUCTION WITHOUT SEISMIC STRENGTHENING: Concrete buildings



USGS

40,000 in California. 8,000 schools, including 239 in Los Angeles. Downtown Los Angeles has about 500.

RETROFIT FOR SEISMIC STRENGTHENING



USGS

Problem: retrofit cost close to that of razing building & starting over. \$20-50 B needed for California hospital retrofits!

How Risky Are Older Concrete Buildings?

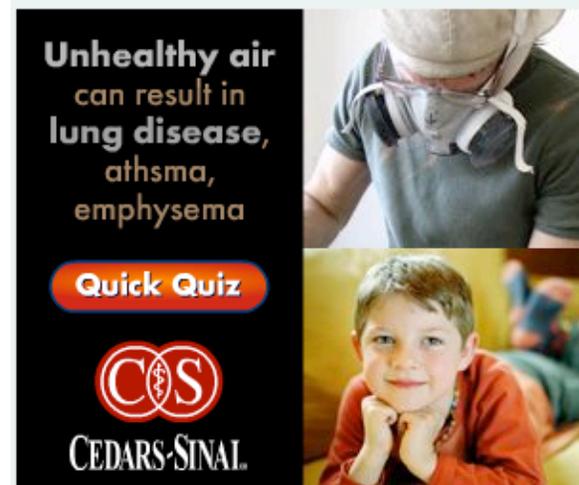
- State officials say many should be retrofitted for quakes. Others say cost would outweigh benefit.

By Sharon Bernstein, Times Staff Writer

Tens of thousands of older concrete buildings across California represent the state's largest remaining risk of serious damage in a major earthquake, seismic safety officials say.

Constructed as department stores, schools, parking structures and office buildings from the 1930s through the early 1970s, these buildings typically consist of large, open lower stories held up by unreinforced or poorly reinforced concrete pillars.

ADVERTISEMENT



Unhealthy air
can result in
lung disease,
athsma,
emphysema

Quick Quiz

CEDARS-SINAL

After several collapsed in the 1971 San Fernando earthquake, seismic safety codes were upgraded to require that any new concrete buildings be better constructed. Many seismic experts say preexisting structures — known as non-ductile concrete buildings — need to be retrofitted to bring them up to current standards.

"It's well recognized within the earthquake professional community that many California non-ductile concrete buildings are at unacceptable risk of collapse in moderately strong shaking," said Thomas Heaton, professor of engineering seismology at Caltech.

Because many of the older concrete buildings tend to be filled during the day with office workers, schoolchildren or people parking their cars, the death and injury toll from an earthquake that caused several of the structures to collapse could be staggering, said Heaton.

But building owners and business organizations have long fought efforts to require retrofits, arguing that the risk is overstated. And they say that in some cases, the cost of retrofits comes close to that of razing a building and starting over. Neither the state nor local governments have required that the structures be reinforced.

"If you're going to use a 'sky is falling' scenario, then maybe you can justify" a retrofit requirement, said Carol Schatz, president of the Central City Assn. "But if you're going to put a bunch of commercial property owners out of business in the process, what have you accomplished?"

Property owners and business associations opposed a proposal last year by City Councilmen Greig Smith and Alex Padilla to count the number of unreinforced concrete buildings in Los Angeles. The measure didn't make it out of a council committee.

Earthquake provisions in building code involve tricky balance:

Too weak lowers cost but increases risk

Too strong imposes unneeded costs (typically 5-10%, can be more) & uses resources that could be better used otherwise

Too strong can produce less safety because older buildings won't be replaced if too expensive

Builders (including cities & states) won't follow ones whose costs exceed benefits

THOUGHT EXPERIMENT: TRADEOFF

Your district is about to build a new school building.

The more seismic safety you want, the more it will cost.

You have to decide how much of the construction budget to put into safety. Spending more makes you better off in a future large earthquake. However, you're worse off in the intervening years, because that money isn't available for office and class space, equipment, etc.

Deciding what to do involves cost-benefit analysis. You try to estimate the maximum shaking expected during the building's life, and the level of damage you will accept.

You consider a range of scenarios involving different costs for safety and different benefits in damage reduction.

You weigh these, accepting that your estimates for the future have considerable uncertainties, and somehow decide on a balance between cost and benefit.

THIS PROCESS, WHICH SOCIETY FACES IN PREPARING FOR EARTHQUAKES, ILLUSTRATES TWO PRINCIPLES:

“There's no free lunch”

Resources used for one goal aren't available for another. This is easy to see in the public sector, where there are direct tradeoffs. Funds spent strengthening schools aren't available to hire teachers, upgrading hospitals may mean covering fewer uninsured (~\$1 K/yr), stronger bridges may result in hiring fewer police and fire fighters (~\$50 K/yr), etc...

“There's no such thing as other people's money”

Costs are ultimately borne by society as a whole. Imposing costs on the private sector affects everyone via reduced economic activity (firms don't build or build elsewhere), job loss (or reduced growth), and resulting reduction in tax revenue and thus social services.

Editorial 5/29: Gauging risk along New Madrid fault

May 29, 2003

DON'T EXPECT state and local governments to follow Washington's lead at the Memphis Veterans Medical Center, which is undergoing a \$100 million retrofit to protect the building against the potential threat of an earthquake along the New Madrid fault.

Unlike the federal government, local governments are required to balance their budgets, and expenditures of that size would be difficult to justify. Still, the project - as well as devastating seismic events recently in Algeria and Turkey - illustrate the importance of earthquake risk assessment to residents of the Mid-South.

Editorial 9/01: Crucial decision nearson building code

September 1, 2003

A NEW, MORE stringent building code in Memphis and elsewhere in the New Madrid fault zone might not pay off soon. The proposed new guidelines, however, would require an investment in additional reinforcement of new structures that could save an inestimable number of lives, in the immediate or distant future.

Memphis Mayor Willie Herenton and Shelby County Mayor A C Wharton are among local elected officials and builders who suggest further study before the enactment of seismic provisions in the proposed International Building Code of 2003. Mayors from across West Tennessee have joined an effort to generate more information about the costs and benefits of the provisions, which surely would be useful in this important decision-making process.

Advertisement

As Wharton notes, dollars that are applied to protection against earthquakes could otherwise be spent on education or health care. Supporting tough new seismic guidelines is a difficult stand for elected officials who must answer to taxpayers for costs that could discourage development, increase pressure to raise taxes and make less money available for public services that produce immediate and tangible results.

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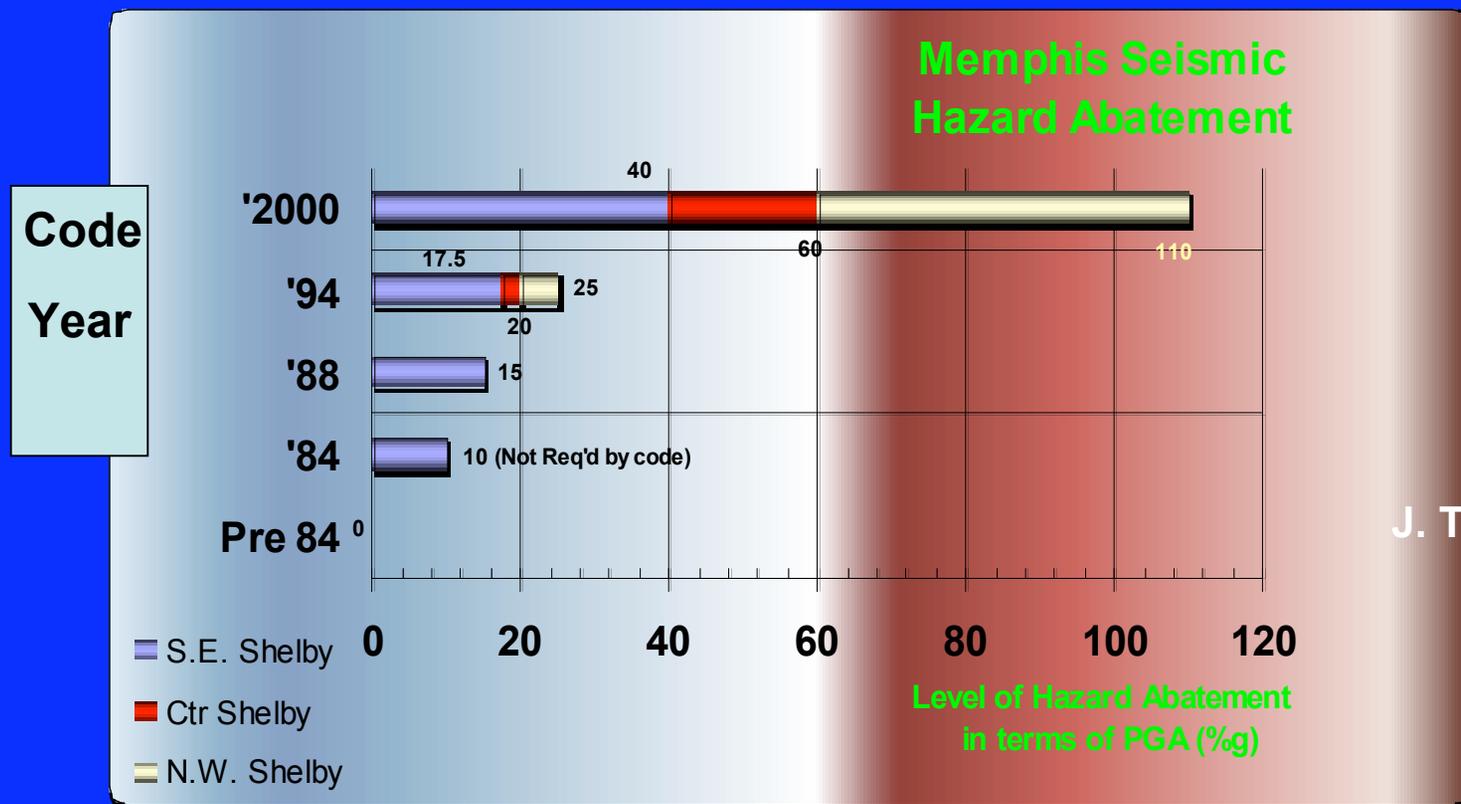
SHOULD MEMPHIS BUILDINGS MEET CALIFORNIA STANDARD?

New building code IBC 2000, urged by FEMA, would raise to California level

Essentially no analysis of costs & benefits of new code

Initial estimates suggest cost likely to exceed benefits

Detailed study needed to see if justified



INITIAL COST/BENEFIT ESTIMATES: MEMPHIS

I: Present value: FEMA estimate of annual earthquake loss for Memphis area (\$17 million/yr), only part of which would be eliminated by new code ~ 1% of annual construction costs (\$2 B).

II: Life-of-building: Use FEMA estimate to infer annual fractional loss in building value from earthquakes. If loss halved by new code, than over 50 yr code saves 1% of building value.

Seismic mitigation cost increase for new buildings with IBC 2000 is about 5% or more, so probably wouldn't make sense.

Similar results likely from sophisticated study including variations in structures, increase in earthquake resistance with time as more structures meet code, interest rates, retrofits, disruption costs, etc.

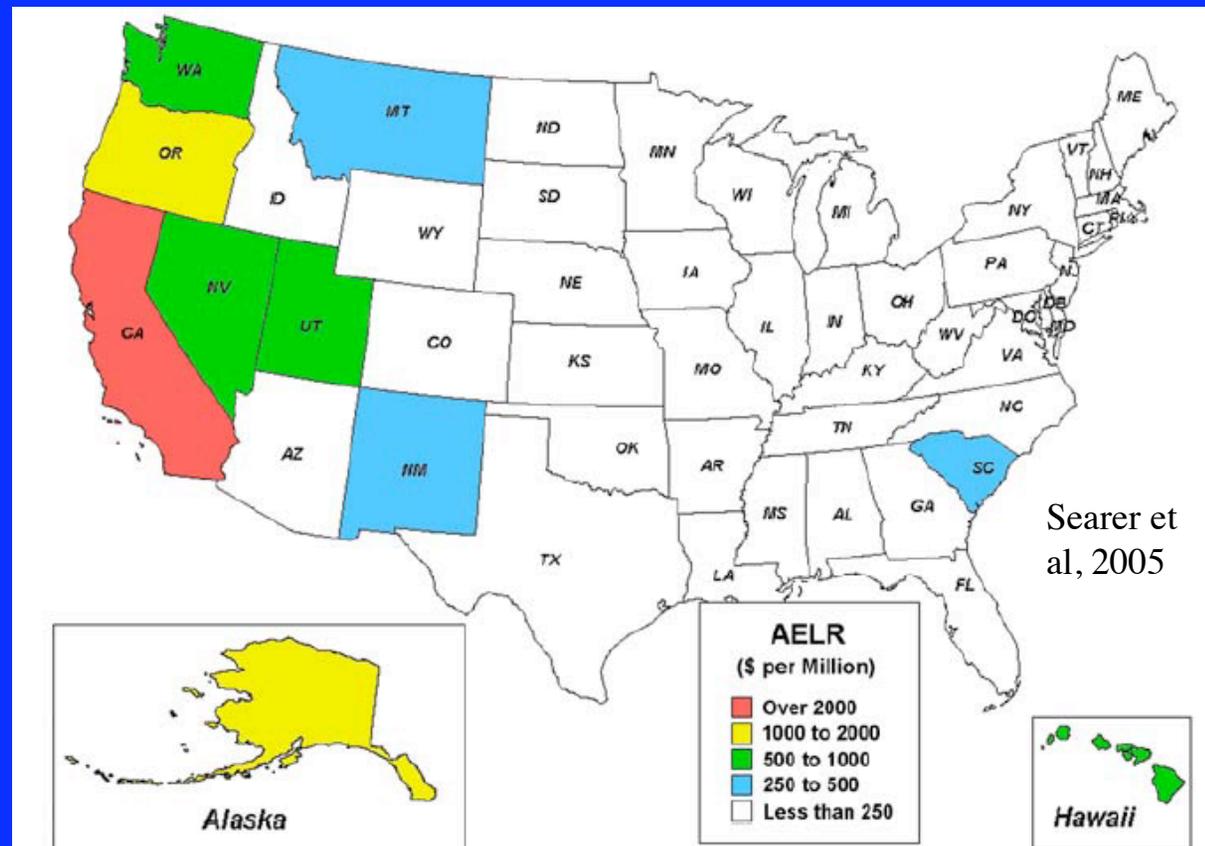
More mitigation becomes cost-effective if technology lowers costs, or benefits increase via improved understanding of earthquake probabilities or (?) large earthquake probability increases with time

BUILDING RISK COMPARISON

Estimate **annual earthquake loss ratio (AELR)**, ratio of annualized earthquake loss to the replacement cost of all buildings in the area.

Memphis and St. Louis values ~1/5 - 1/10 of those for San Francisco and Los Angeles. Memphis 32nd among major U.S. cities; St. Louis 34th.

Since ratios are equivalent to the fractional risk of building damage, estimate predicts **NMSZ buildings 5-10 times less likely to be damaged during their lives than ones in California.**



Activity 10.2: Talking to your students

Your students are hearing scary things about earthquake danger to your community. How would describe the danger to them?

SUGGESTIONS:

Tone down hype

Government warns of "catastrophic" U.S. quake

Thu, Nov 20 2008

By [Carey Gillam](#)

KANSAS CITY, Missouri (Reuters) - People in a vast seismic zone in the southern and midwestern United States would face catastrophic damage if a major earthquake struck there and should ensure that builders keep that risk in mind, a government report said on Thursday.

The Federal Emergency Management Agency said if earthquakes strike in what geologists define as the New Madrid Seismic Zone, they would cause "the highest economic losses due to a natural disaster in the United States."

FEMA predicted a large earthquake would cause "widespread and catastrophic physical damage" across Alabama, Arkansas, Illinois, Indiana, Kentucky, Mississippi, Missouri and Tennessee -- home to some 44 million people.

Instead of using the bicentennial to scare people,
promote public understanding and careful thought

MAKE POLICY OPENLY

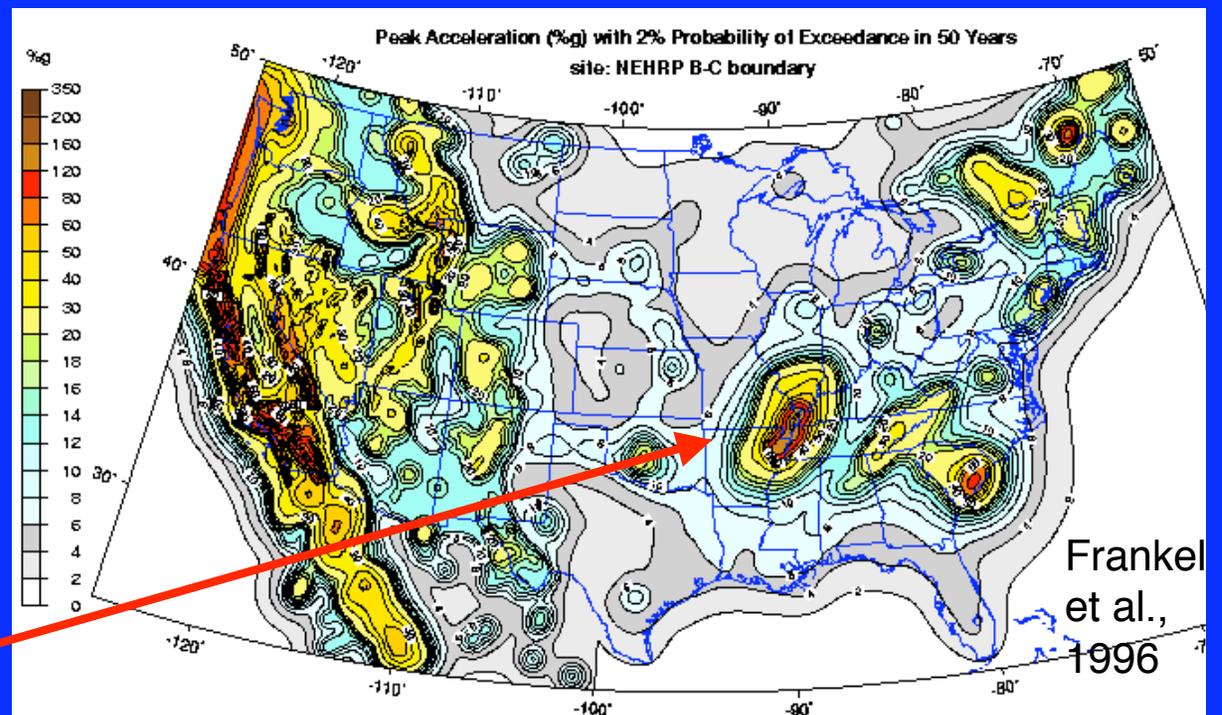
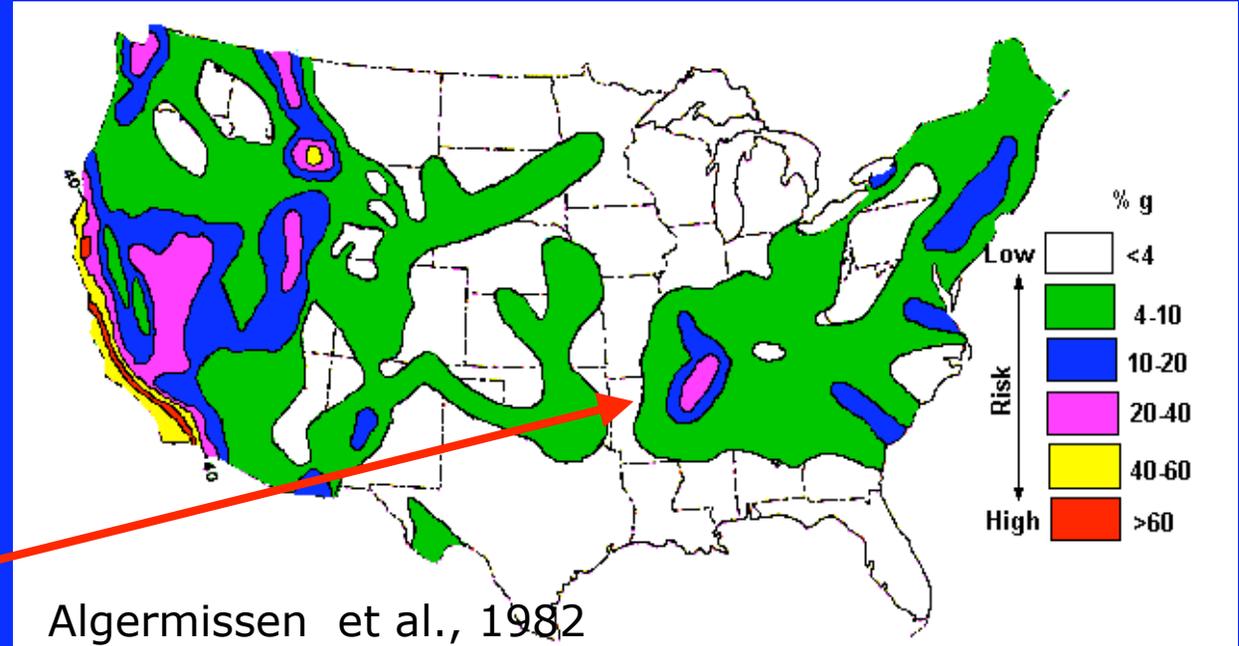
Use what we know about earthquake hazards and recurrence to **help society decide how much to accept in additional costs to reduce both the direct and indirect costs of future earthquakes.**

Need detailed analysis, which we don't have yet, of costs and benefits of various policies.

Strategy chosen shouldn't be bureaucratic decision imposed from above, but made openly through democratic process on the community level - *where costs and benefits of the policy accrue.*

Crucial economic and societal issues should be explored before a decision.

For example, redefining hazard that made New Madrid as hazardous as California should have been carefully analyzed, given enormous cost implications.



2500 YEAR HAZARD DEFINITION should be discussed carefully, given huge cost

Risk of major damage to typical building during 50 yr life much lower (1/5-1/10) in NMSZ than California

2500 yr predictions *larger and more uncertain* than over 500 yr (10% probability in 50 yr) used previously, in Europe, and for other natural hazards (floods, etc).

IBC 2000 code does not use 2500 yr throughout California, because in some places predicted shaking was so high as to require significant strengthening over present codes

Don't know if/where 2500 yr criterion is cost-effective (probably not for ordinary structures, maybe for long-lived or critical ones - nuclear plant)

MAKE POLICY THOUGHTFULLY

Hazard could be reduced by strengthening building codes, so the issue is how to balance this benefit with alternative uses of resources (flu shots, defibrillators, highway upgrades, etc.) that might save more lives for less.

Estimated cost to save life (in U.S.) varies in other applications:

~\$50 K highway improvements

~\$100 K medical screening

~\$5 M auto tire pressure sensors

Different strategies likely make sense in different areas within the U.S. and elsewhere, depending on earthquake risk, current building codes, and alternative demands for resources.

Don't rush to get the wrong answer as fast as possible

Because major earthquakes in a given area are infrequent on human timescale, we generally have time to formulate strategy carefully (no need to rush to the wrong answer)

Time can also help on both the cost and benefit sides.

As older buildings are replaced by ones meeting newer standards, a community's overall earthquake resistance increases. Similarly, even in situations where retrofitting structures isn't cost-effective, setting higher standards for new ones may be.

Technological advances can make additional mitigation cheaper and hence more cost-effective.

Eventually, if our understanding of earthquake probabilities becomes sufficient to confidently identify how large earthquake probabilities vary with time, construction standards could be adjusted accordingly where appropriate.

Sunday, 03/27/05

TennCare, budget fates hang on hearing

By ANITA WADHWANI
Staff Writer

Gov. Phil Bredesen cleared a big hurdle last week when the federal government approved many of his planned cuts to TennCare.

But the state may still be months away from actually dropping people from the rolls, and continuing financial uncertainty for the program could put a big squeeze on the rest of the state budget.

Federal overseers gave the governor permission last week to cut 323,000 people from TennCare — a move expected to save state taxpayers as much as \$350 million next year. TennCare officials are still awaiting word on whether they can impose medical and prescription caps on the 396,000 adults remaining on TennCare — which could save another \$225 million next year.

**Hence seismic mitigation costs in Memphis area - \$20-200 M/yr
(1-10% new construction cost) + any retrofits - could insure
20,000 - 200,000 people and save some lives that way**

Tricky tradeoff here

There's increasing recognition of the need to make policy more rationally. The challenge, summarized by a joint project of Brookings Institution and American Enterprise Institute is that

“The direct costs of federal environmental, health, and safety regulations are probably on the order of \$200 billion annually, or about the size of all federal domestic, nondefense discretionary spending. The benefits of those regulations are even less certain. Evidence suggests that some recent regulations would pass a benefit-cost test while others would not.”

DISCUSS UNCERTAINTIES FULLY

We know a lot less than we'd like about earthquake recurrence and hazards. Although we hope to do better, we don't know if we can, given the complexity shown by long earthquake records and the growing suspicion that earthquake occurrence has a large random component.

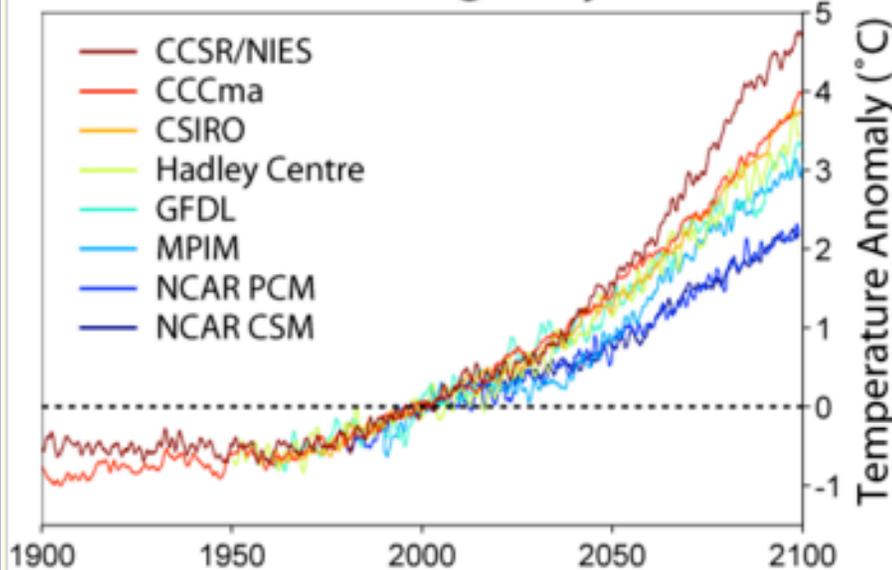
We don't know whether to view earthquake recurrence as time-dependent or independent, or even whether earthquakes are less likely in recently active areas. Hopefully on some time scale, perhaps a few hundred years, we will have made and tested forecasts adequately to have reasonable confidence in them.

Until then, we should explain what we know and what we don't.

There's no harm in discussing the limits of what we know. Individuals and society make decisions given uncertainty: we buy life insurance and decide how much to spend on safety features in cars. Business and political leaders consider risks in deciding whether and how to invest. We help ourselves by explaining what we don't know, since we want public funds to learn more.

Global warming predictions present uncertainties

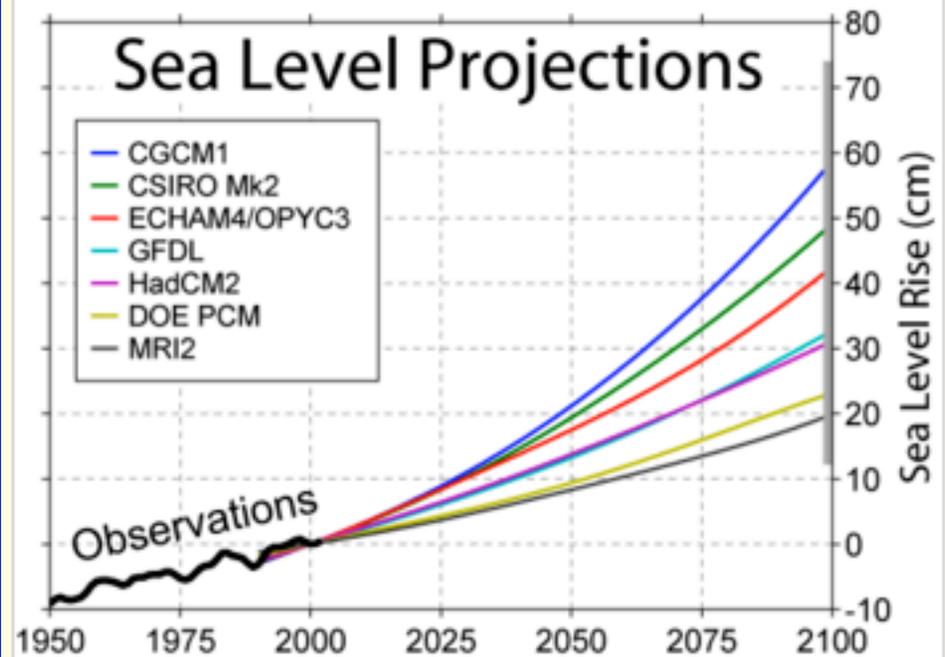
Global Warming Projections



The different predictions of global mean [temperature](#) change obtained from 8 different [climate models](#) under the [SRES A2](#) emissions scenario (one which assumes no significant action to combat greenhouse gas emissions).



Sea Level Projections



The predicted change in global mean [sea level](#) in a range of climate models following a business as usual emissions scenario (IS92a). The grey bar at 2100 indicates the full uncertainty range.



KEEP THUMBS OFF THE SCALE

Estimates biased toward high ("conservative") values distort policy decisions by favoring seismic safety over other resource uses.

Don't want poor education in earthquake-safe schools, or to turn away patients from earthquake-safe hospitals

Need careful balance

An analogy might be the tendency during the Cold War to overestimate Soviet military power, leaving the U.S. with enormous military strength but diverting resources from health, education, and other societal goals.

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September 1, 2003

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KEEP LEARNING

Seismology

GPS

Geology

Modeling

New data and ideas should lead to better science & hazard assessments

