

The Great
California
**Shake
Out**[™]



ShakeOut, Tohoku & their Implications for Canada

Prof. Keith Porter
University of Colorado at Boulder
Principal, SPA Risk LLC

National Insurance Conference of Canada
Vancouver, 27 Sep 2011



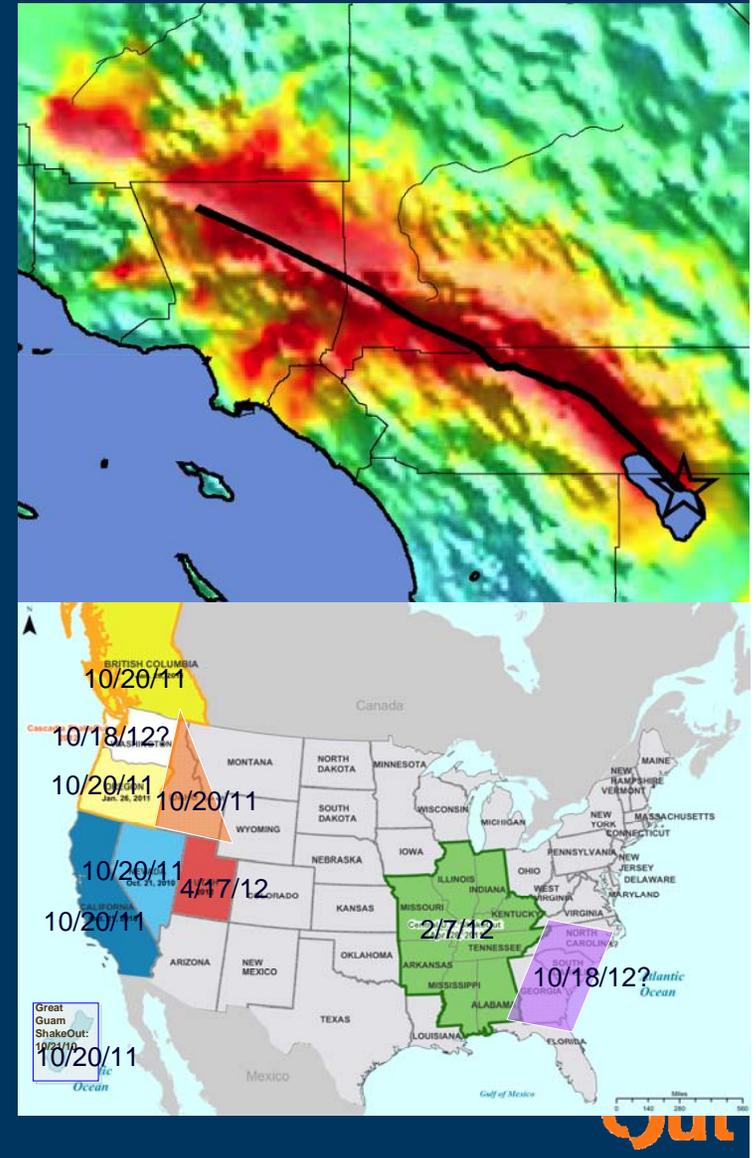
Earthquake Country **Alliance**
We're all in this together.

Overview

- In 2008, 300 scientists, engineers, etc., imagined a M7.8 SoCal earthquake, dubbed “ShakeOut”
- The event is realistic, overdue
- \$200B loss, 50,000 injured, 1,800 dead, 1600 fires
- 8 million Californians exercise the event annually
- Today:
 - How the ShakeOut was produced
 - How Tohoku is like Vancouver
 - Implications for Canada

What is a ShakeOut?

- A 2008 USGS-led scenario & exercise
- Now: a large likely earthquake imagined in granular detail
- Severe, not worst-case event
- Science-based, broad scope
- Multimedia education effort
- Diverse participation in same event, same time



All seeking to answer two questions

1. What could happen in a large, likely earthquake near me?
2. How can I prepare for it?

Multi Hazards Demonstration Project

- Demonstrate how science can improve community resiliency to natural hazards
- Multi-hazard: earthquakes, floods, tsunamis, wildfires, landslides...
- Stakeholder workshops set research priorities

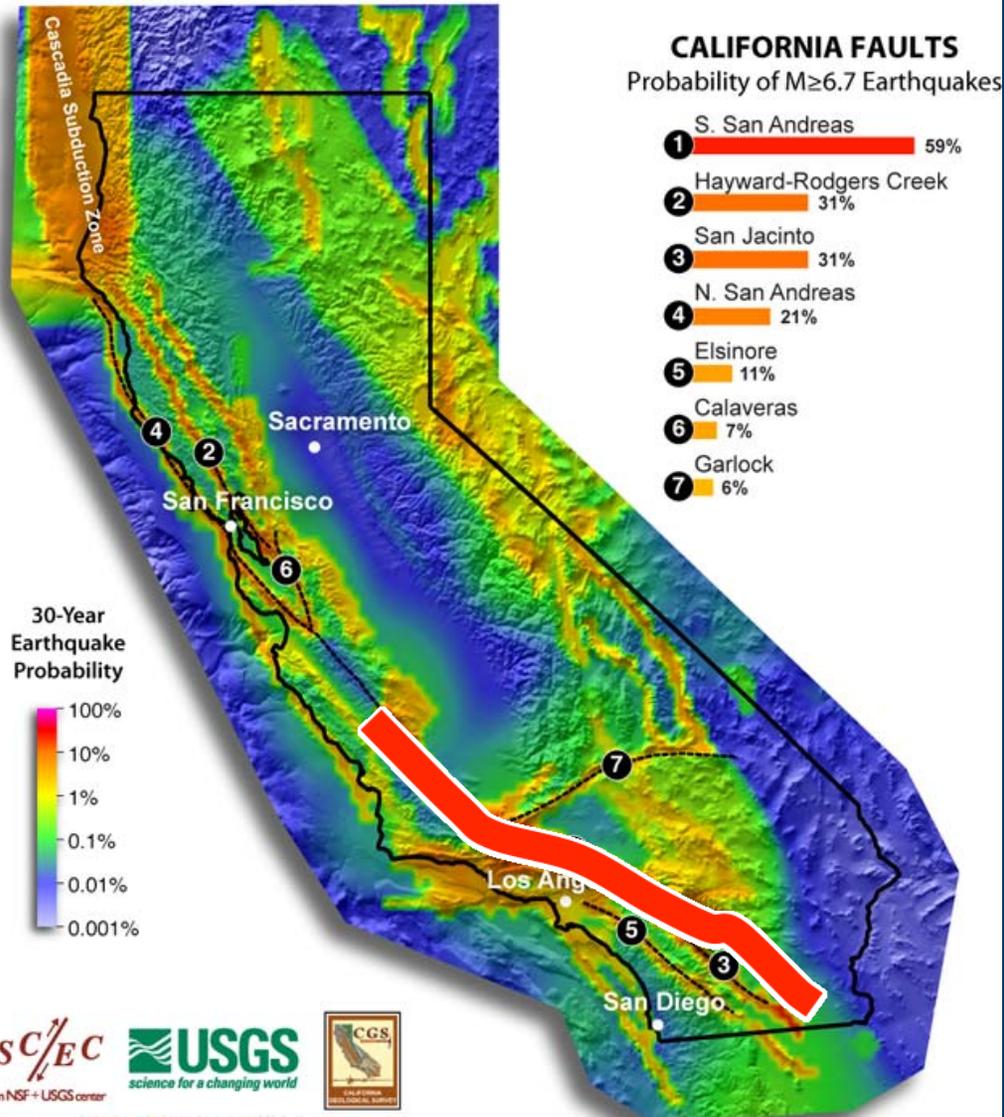


Why “science-based?”

- Population that sometimes needs better information
- Before: credible predictions of what the disaster will be to better prepare
- During: accurate information about what is happening, who is affected
- After: inform decisions on how to support response and recovery



Why a scenario?



Stakeholders
wanted it, with:

1 outcome

No probability

An earthquake
every resident,
business, and
government
agency should
be ready for

Shake
Out

ShakeOut developers



- Multi - agency
- USGS Multi-Hazards Demonstration Project (MHDP)

Lucy Jones, Chief Scientist
Dale Cox, Project Manager
Sue Perry, Staff Scientist

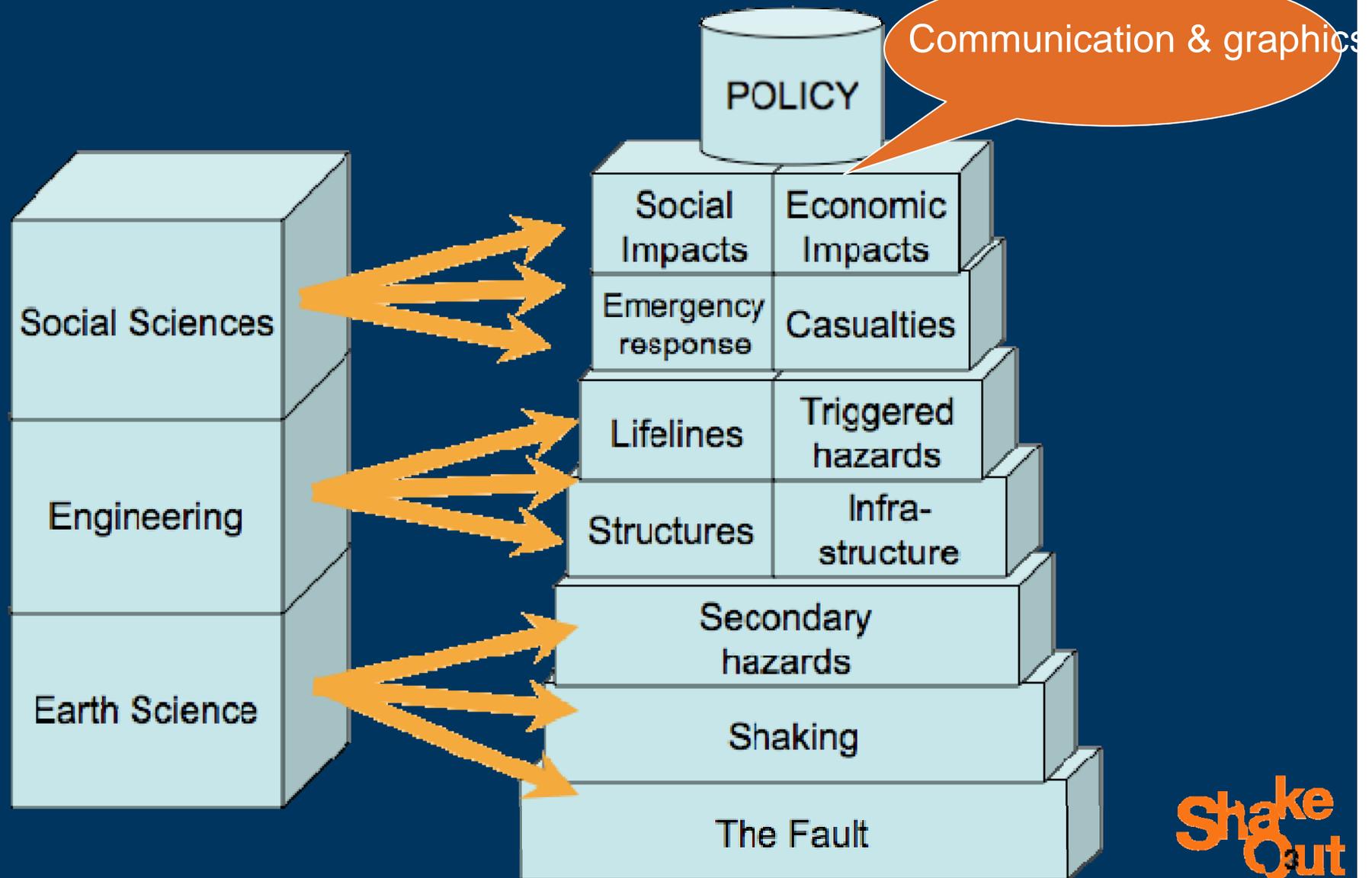
+290 other earth scientists, engineers, social scientists, emergency planners, utility operators...

10 Section Leaders
Earthquake Computer Science
Ken Hudnut and Dan Ponti (USGS)
Engineering
David Seligson and Hope Seligson (MMI)

Public Health
Kim Shoaf (UCLA)
Disaster Sociology
Dennis Mileti (California Seismic Safety Commission)
Jim Goltz (Governor's Office of Emergency Services)
Disaster Economics
Anne Wein and Rich Bernknopf (USGS)



Building a scenario

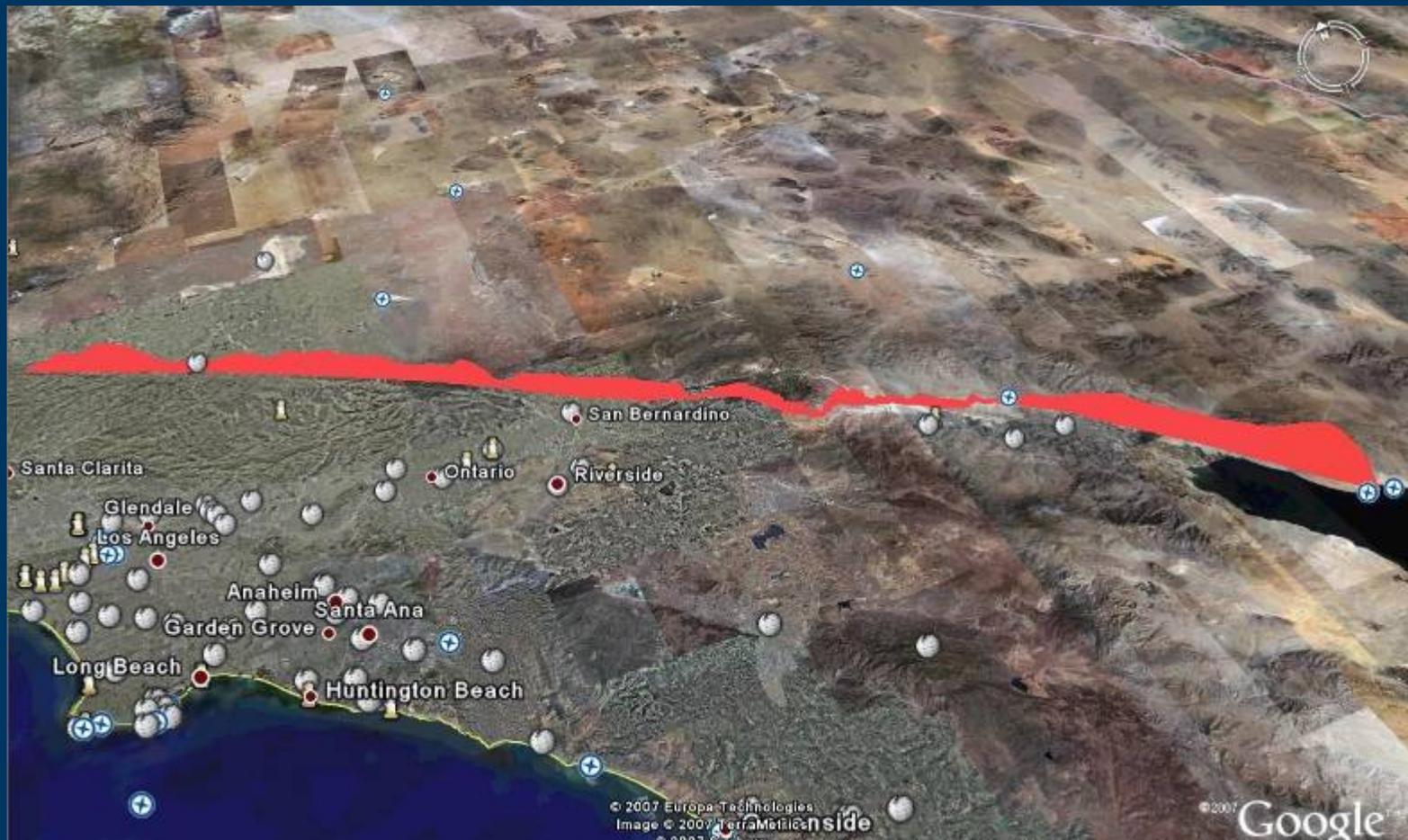


Earth sciences

150 yr return period; 300 yr since last rupture

Northridge 1994
over in 30 sec's

ShakeOut rupture unzips SE to NW, taking 90 seconds;
Shaking lasts >3 minutes in LA & Ventura



Shake
Out

Fault offset up to 13m

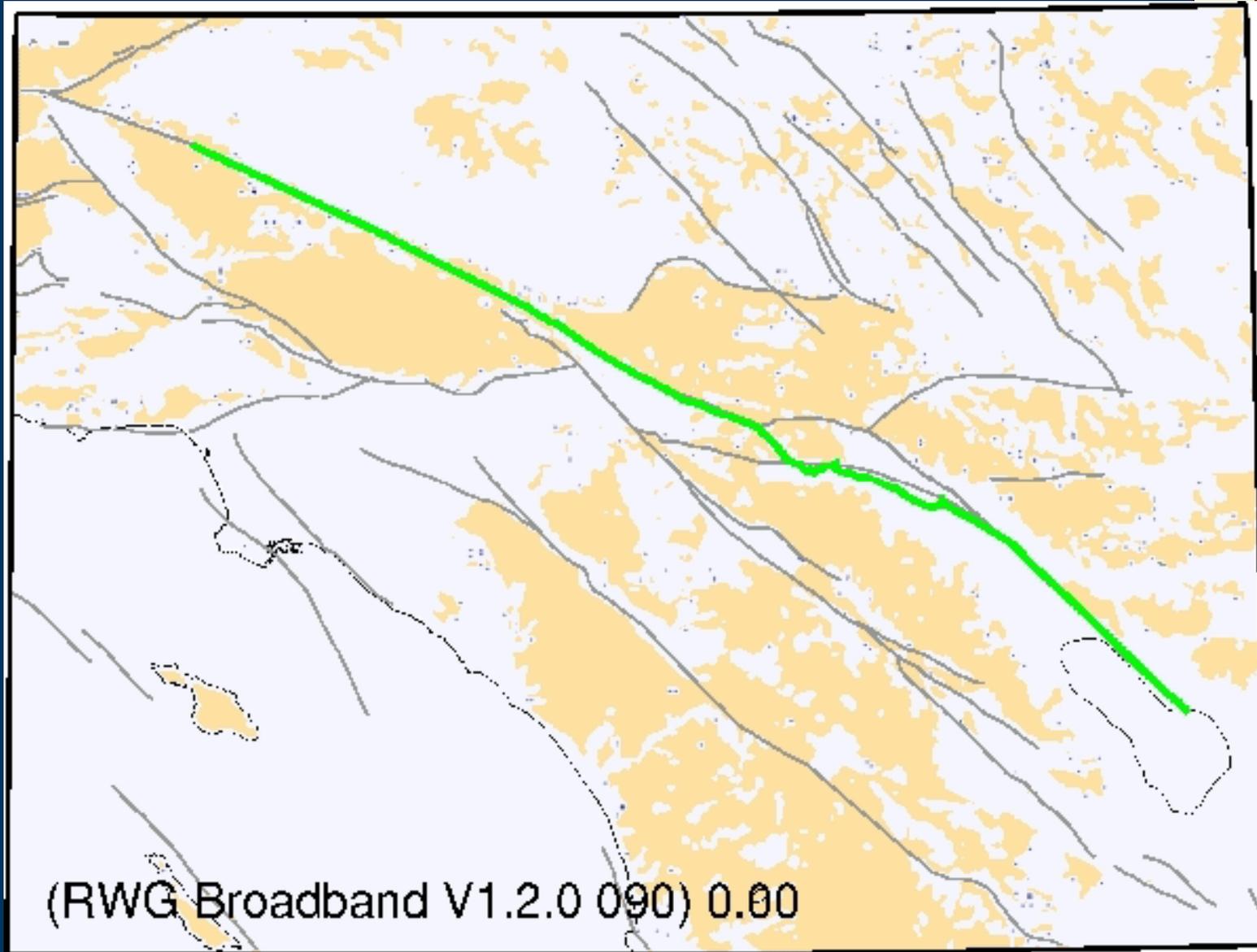


Landers, California M



Wairarapa fault, New Zealand - 1855 earthquake; ~18 meter (54 feet) right-lateral offset

Physics-based models of shaking



USGS center

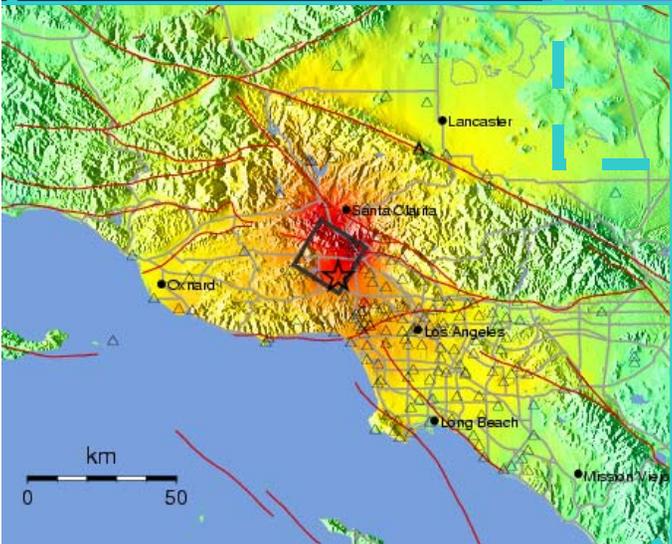
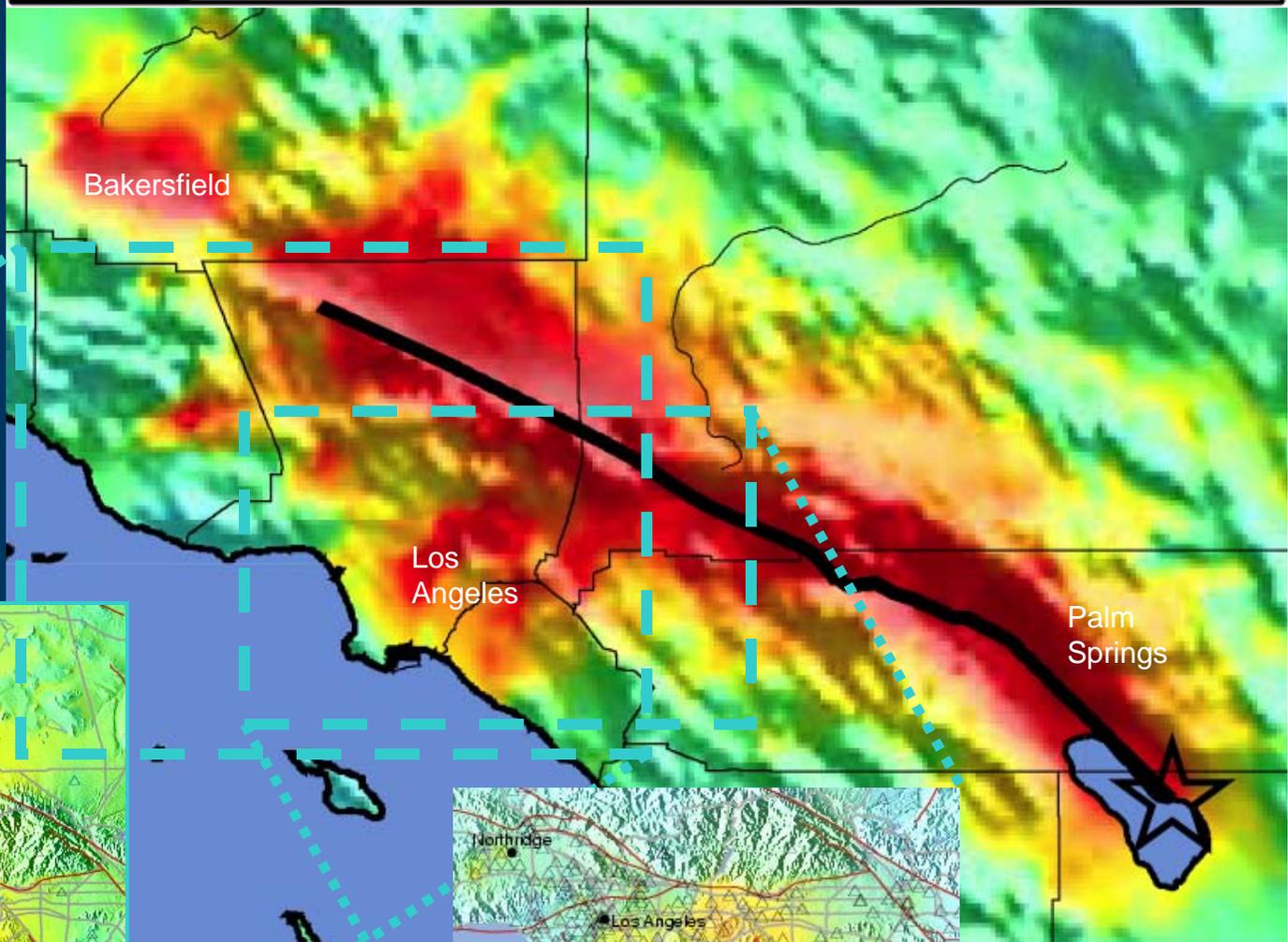
shake
Out

Shaking intensity (notice: no hot dog)

Compare with
2008 Northridge
earthquake:

- 50x smaller!
- Magnitude 6.7
- 57 deaths
- \$40 billion damage

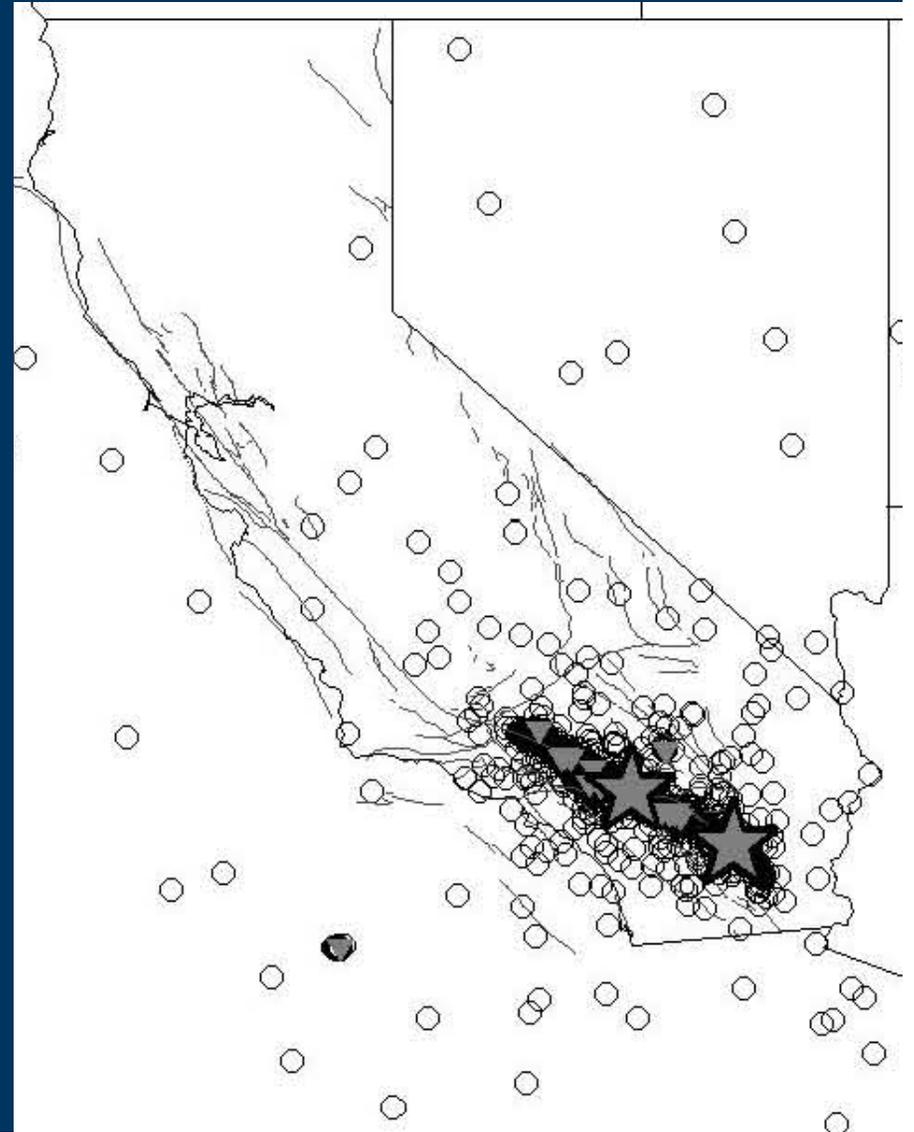
SHAKING: WEAK STRONG SEVERE



Shake Out

Aftershock sequence

- M7.2 on Cucamonga fault @ 16 hrs
- 10,000s more felt
- Aftershocks disrupt repairs
- Aggravate damage



Damage and loss

HAZUS-based building damage

- 300,000 significantly damaged (1 in 16)
- 45,000 complete losses (1%)
- Most dangerous: brick & older concrete
- Most numerous: wood
- Less dangerous: pre-1994 steel

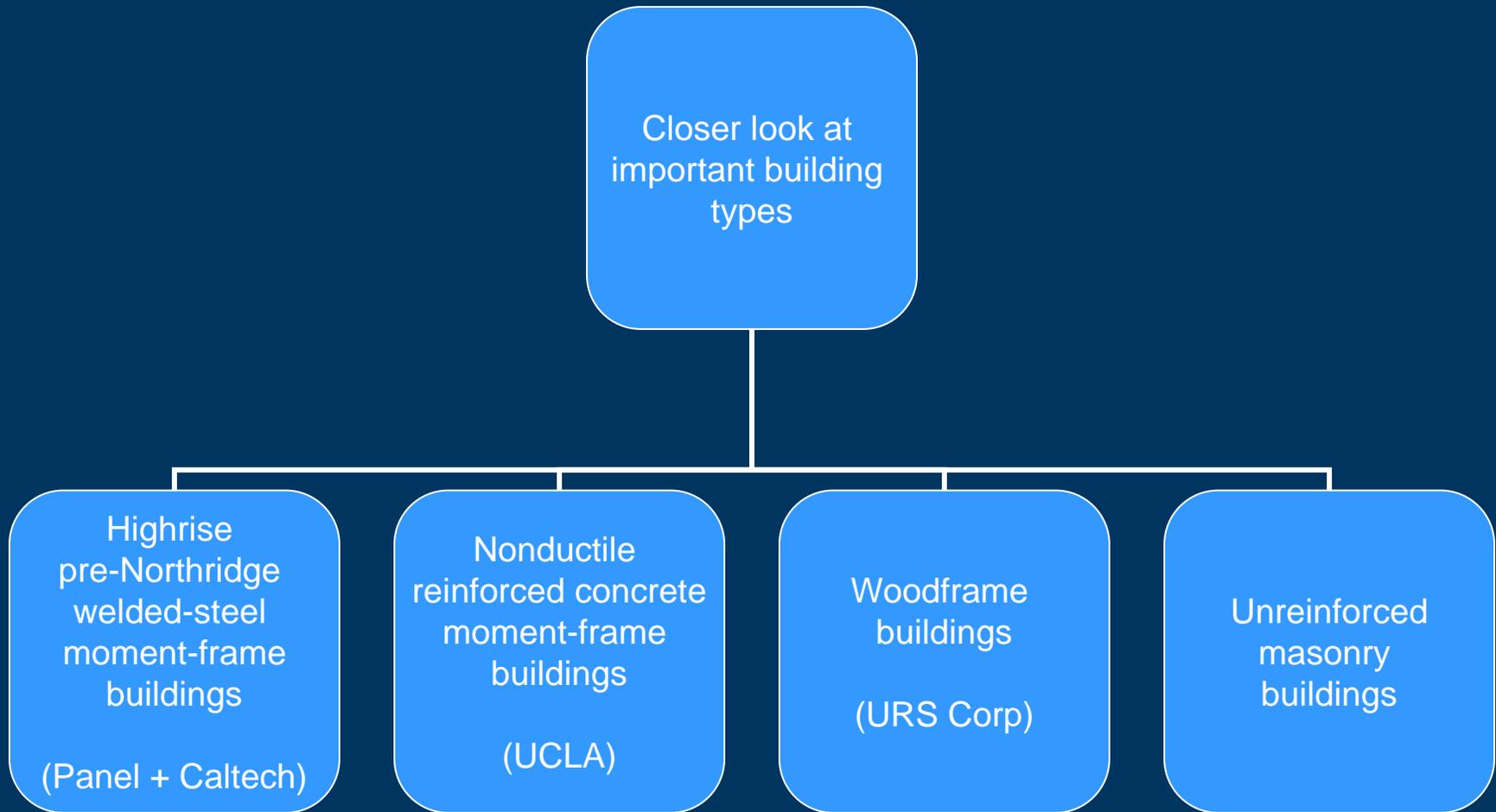


1933 Long Beach, CA



1994 Northridge CA

ShakeOut building focus studies

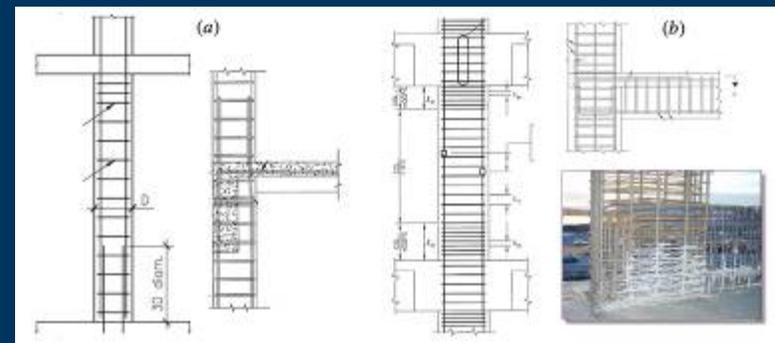


Older reinforced concrete

- Less rebar, can collapse
- Concrete construction has improved since 1970s
- Older buildings remain
 - 1000s of low- and midrise buildings of this type
 - 10s of highrise buildings of this type



1971 San Fernando



Older reinforced concrete

ShakeOut study by UCLA:

- 50 collapses
- 5,000 – 10,000 people in collapsed buildings
- 100 red tagged buildings



1994 Northridge



1995 Kobe

Woodframe buildings

- Most western US & Canadian housing
- Lots of past damage
- Common damage:
 - Foundation anchorage
 - Soft-story collapse
 - Brick chimneys & veneer
- Scenario: 175,000 significantly damaged (1 in 25)



1992 Mendocino



1989 M7.1
Loma Prieta

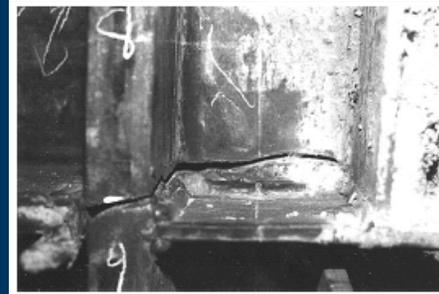


5/2/83
M6.5 Coalinga

**BC has a lot of these;
seismic code provisions
“largely nonexistent”**

Highrise steelframe buildings

- Connections fractured in 1994
- In Kobe (1995), 10s collapsed
- No US collapses, but ShakeOut is longer, stronger, and richer in damaging motion than 1994
- Cascadia event even more so
- 600+ buildings in study area



Caltech steelframe study

Sophisticated computer analyses

- 5 collapses of 11-15 stories, 250,000 sq ft
- 1,000 occupants each
- 10 red tags
- 20 yellow tags

Expert review:

- “The fact that there were no collapses in previous US earthquakes cannot be taken as evidence that there would not be collapses in this scenario. In fact, the possibility of some collapses is quite credible.”



Kobe, Japan 1995



Mexico City, 1985

Infrastructure damage



Electric power

10 experts from 5 agencies found:

- Immediate loss of power
- Collapse of high-tension towers, overhead transformers damaged
- Generating plants taken offline for inspection

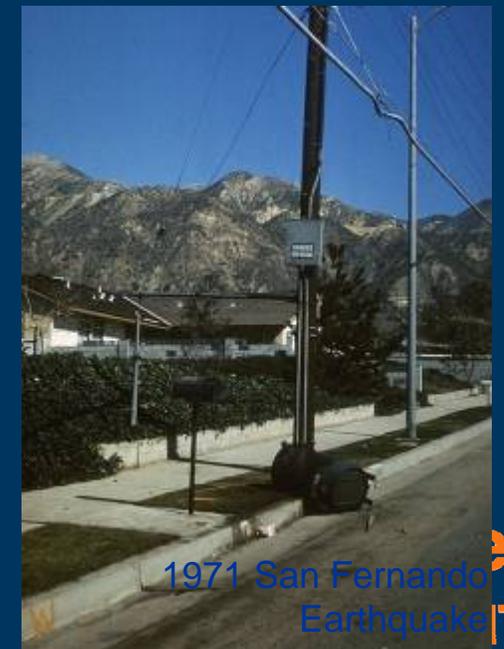
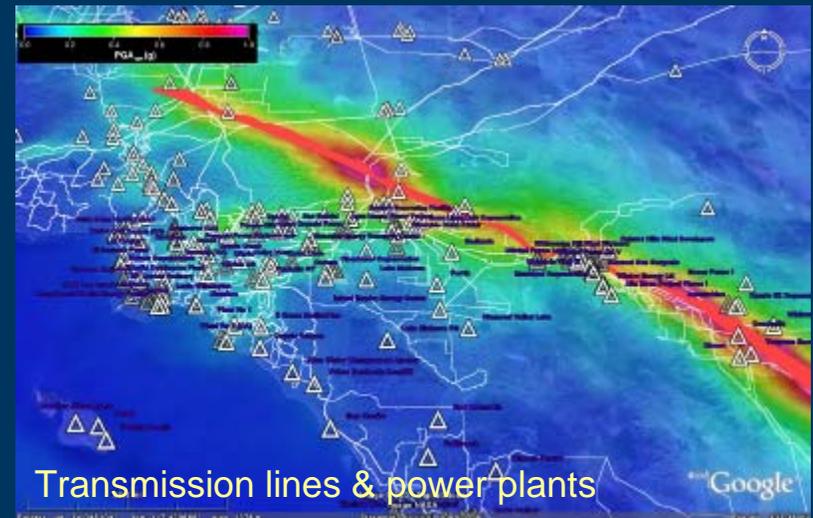
LA, Riverside, & San Bernardino Counties:

- 30-50% of service restored in 24 hrs
- 75-90% restored in 3 days
- ~100% restored within 1-4 months

5 other Counties:

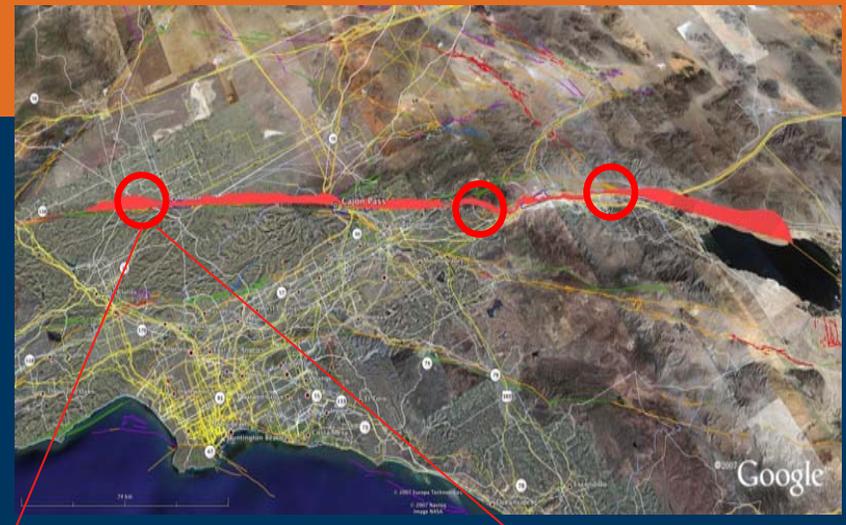
- 90% restored in 1-2 days

Utility participation was crucial to credibility, their buy-in, their awareness of lifeline interaction & limits of mutual aid

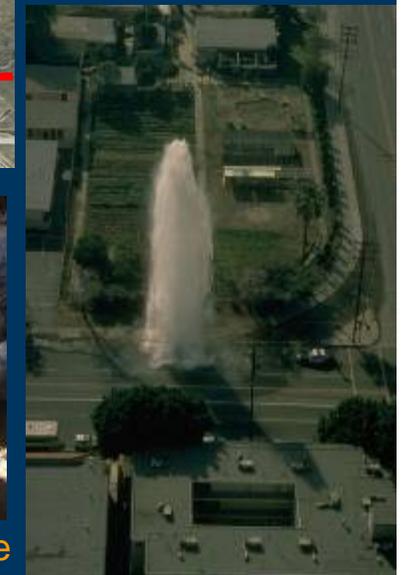


Water supply

- Aqueducts & tunnels cross the fault in several places
- Widespread landslide & liquefaction potential
- Older pipe very damageable
 - Some LA water & sewer pipe is 100+ yr old
- Water supply relies on power, pumps, tanks, and other equipment



1971 San Fernando Earthquake



1994 Northridge Earthquake

Water supply

Expert panel: 19 reps from 8 agencies

- ≤ 10 miles of fault: supply impaired up to 6 months
- In much of study area, 1/2 of customers lose service for up to 1 week
 - Loss of power, damage to pumps, tanks, etc.
- In 3 counties, 5% lose service for 1-8 weeks
- Renovation to aqueducts now underway
- Water agency staff now have desk at EOC

Deaths & injuries

Study by UCLA:

- 50,000 injured (to ERs)
- 1,800 killed
 - 900 in fires, 900 from shake
 - Vs. 8,300 injured, 33 killed in 1994 Northridge Earthquake
- Up to 2/3 of hospital beds unavailable in some counties



Evacuation of Sherra Cox, 1989 Loma Prieta earthquake



Olive View Medical Center
1971 San Fernando earthquake

Fire following earthquake

- 2 largest peacetime conflagrations: 1906 San Francisco, 1923 Tokyo. Why?
 - Numerous simultaneous ignitions
 - Degraded fire-resistive building features
 - Water supply impacts
 - Saturated communications & traffic
 - More fires than firefighting capabilities... *this is what leads to conflagrations*

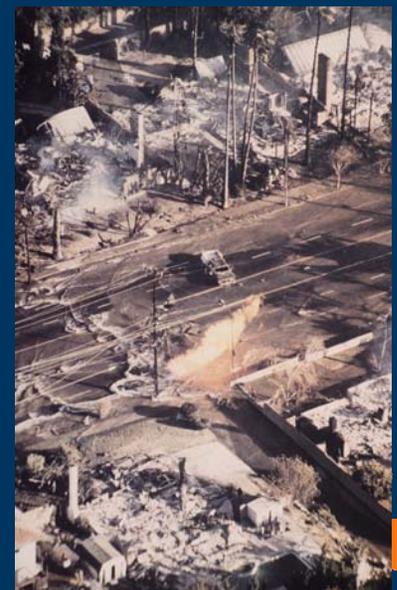


Fire following earthquake

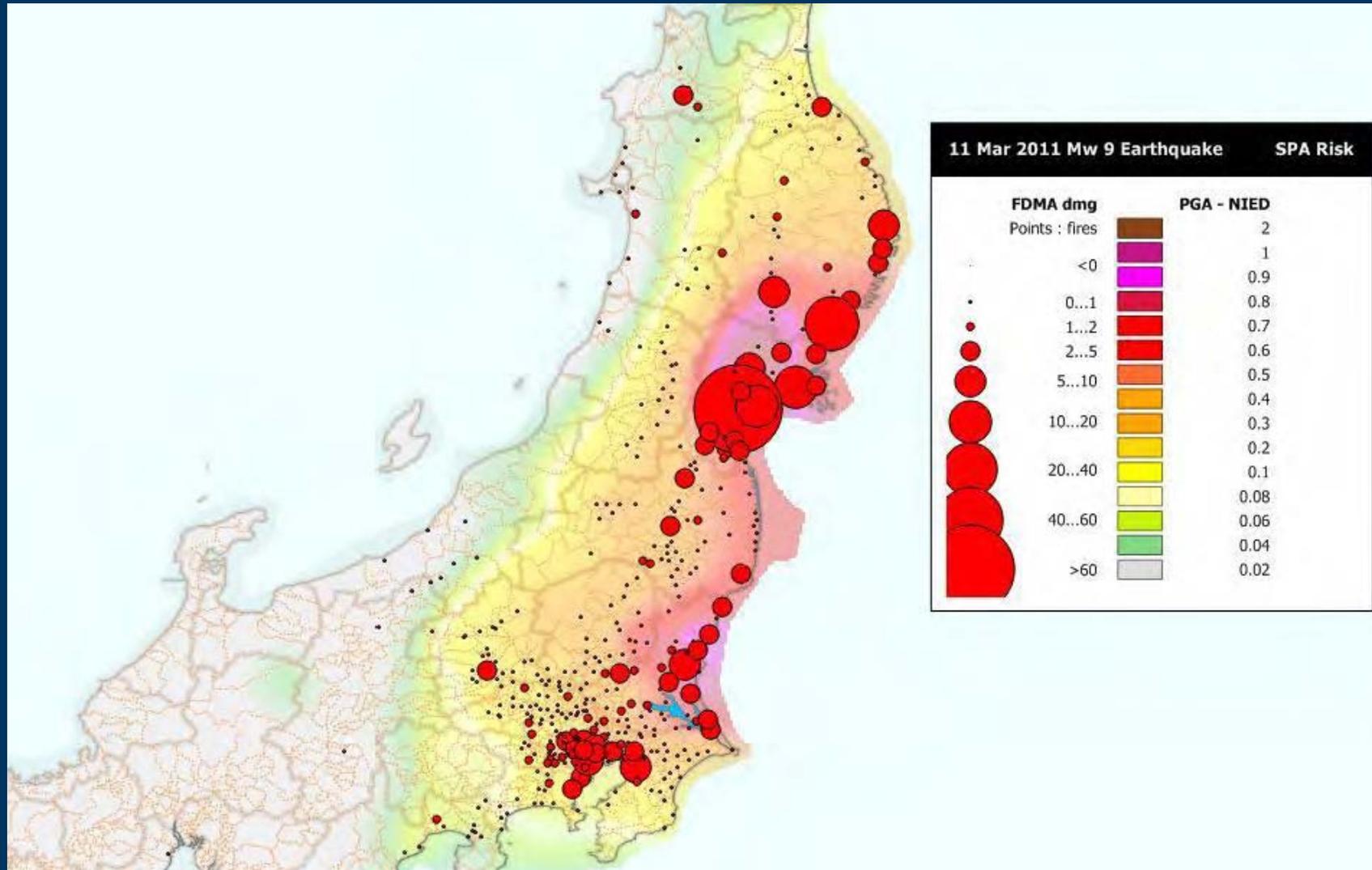
Scawthorn estimates:

- 1,600 ignitions requiring a fire engine
- 1,200 exceed capability of 1st engine
- 200M sq ft burn \approx 133,000 SFDs
- USD \$65B property loss + \$22B BI
- *Not worst case*
- Recommend new water supply system

Review by 4 fire officials: “Reasonable... if anything, a bit low.”



FFE has not gone away



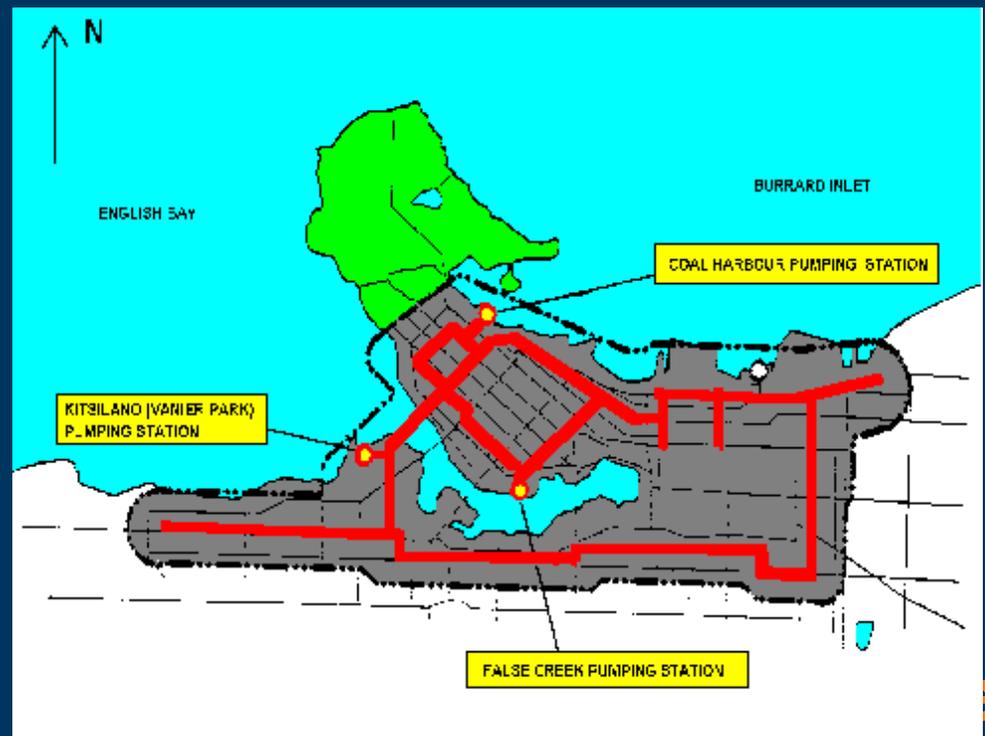
C Scawthorn 2011

Fire following earthquake in BC

- Concern since 1980s: dense fuel, liquefiable soil at water transmission lines, and earthquakes
- Vancouver Fire & Rescue built DFPS in 1990s

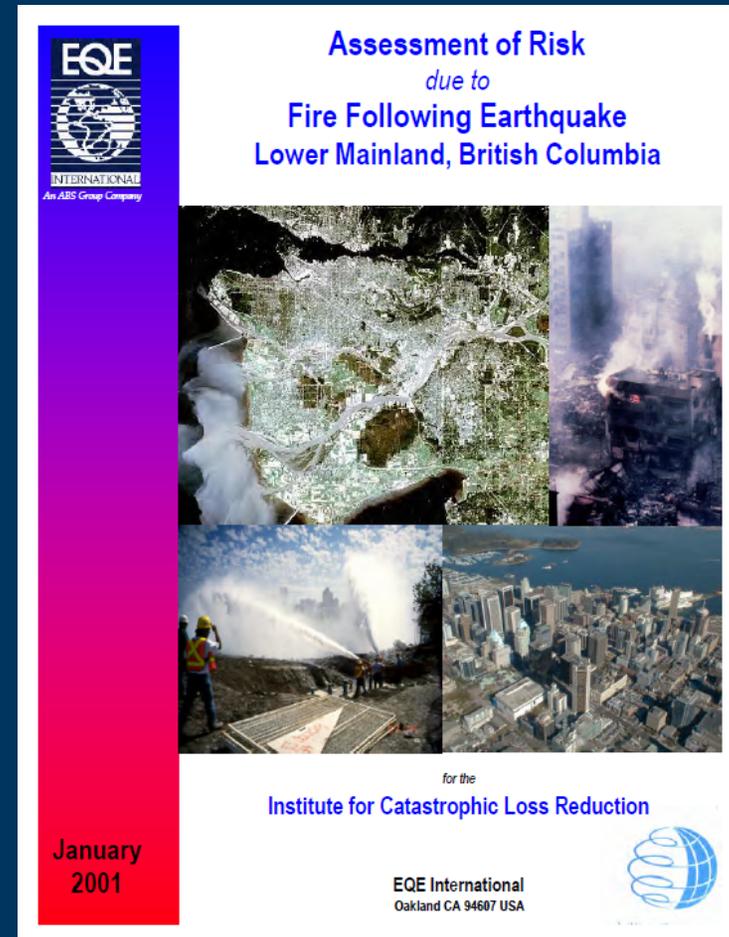


C Scawthorn 2011



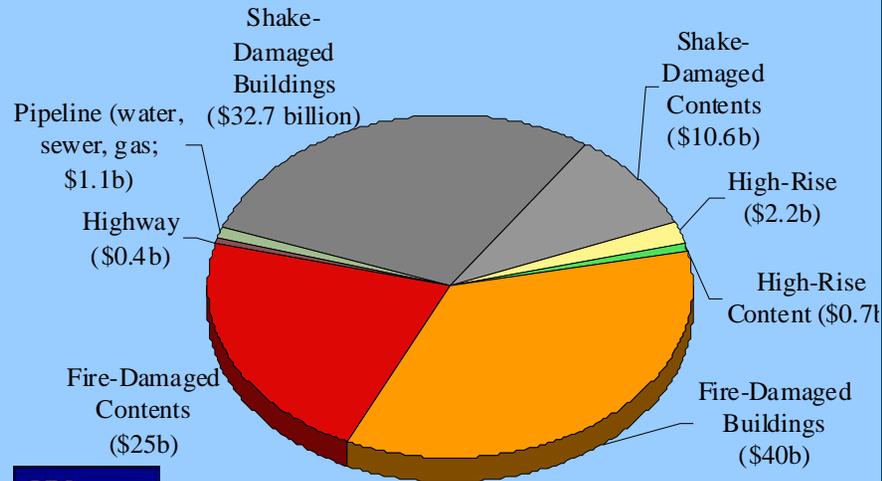
Fire following earthquake in BC

- ICLR under Kovacs
2001 EQE study:
 - 150 fires vs. 120 engines
 - 2001 CAD \$8.5B loss
- Somewhat out of date
 - Population growth
 - New ignition data



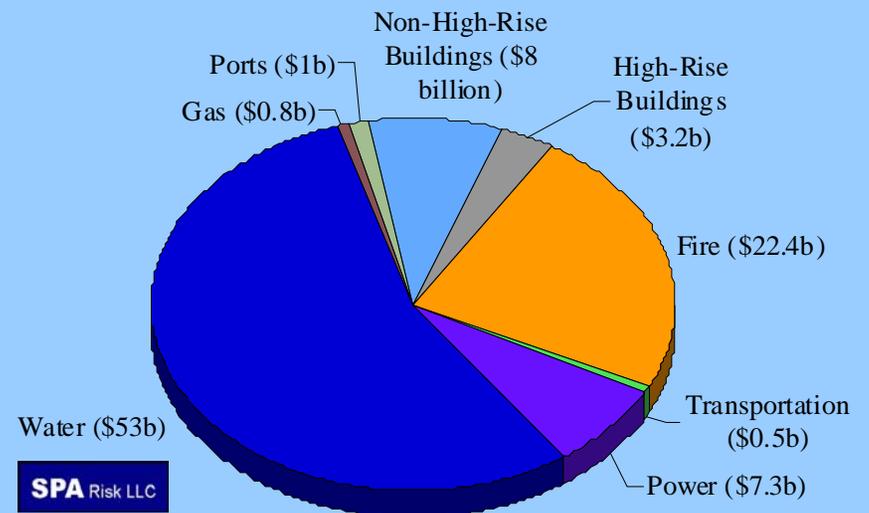
Monetary bottom line

Property Damage: \$113 billion



SPA Risk LLC

Business Interruption: \$96 billion



SPA Risk LLC

New model of emergency response

Organized and Spontaneous Response Summary					
Impact (2-5 Minutes)		30 Minutes		2 Hours	
Organized	<i>Spontaneous</i>	Organized	<i>Spontaneous</i>	Organized	<i>Spontaneous</i>
None.	<i>Escape fire.</i>	Begin to locate fires.	<i>Localized fires being fought with</i>	<u>Western Region</u> : Fire departments	<i>Small fires that were discovered early have been extinguished.</i>
		considered.	<i>such as fire extinguishers.</i>	within jurisdictional boundaries.	<i>Larger fires are either being fought by local departments</i>
				<u>Eastern Region</u> : Fire departments	
		transportation. (Fire departments cannot get equipment across fault rupture or disrupted roads.)			

Similar for 17 response functions



Great BC ShakeOut exercise

IBC and BC Earthquake Alliance

10:20 AM 20 Oct 2011



Great BC ShakeOut exercise

The Great British Columbia ShakeOut

Share the ShakeOut: Email | facebook | twitter

OTHER SHAKEOUTS

SEARCH: GO

Be a Part of the ShakeOut
Register Now!
Log In

Home
Overview
Resources
News and Events
Media Centre
Partners
Contact Us

GET READY TO SHAKEOUT!

At 10:20 a.m. on October 20, 2011, British Columbians will "Drop, Cover, and Hold On" in The Great British Columbia ShakeOut, the largest earthquake drill in Canadian history!

[Register](#) to participate and be counted!

Earlier this year, more than 470,000 people participated in the first BC ShakeOut. The drill will be on the third Thursday of October annually. ([Why October?](#))

Time to 2011 ShakeOut:
23 days 17:46:36

ANNOUNCEMENTS

[Who is Participating?](#)
In each district, area, and by category

[How to Participate](#)
Information for schools, businesses, organizations, government, families...

[ShakeOut Resources](#)
[Audio/Video broadcast](#), manuals, posters, web banners & more

[Participant E-mail Updates](#)

QUICK LINKS

[Order ShakeOut T-shirts](#)

[ShakeOut stories & photos](#)

What's happening in your district?:

[Frequently Asked Questions](#)

Original [California ShakeOut](#) website.

INTERACTIVE MAP

Over 230,000
Participants and Counting!

Click the map for details about each area

LEARN & PLAY

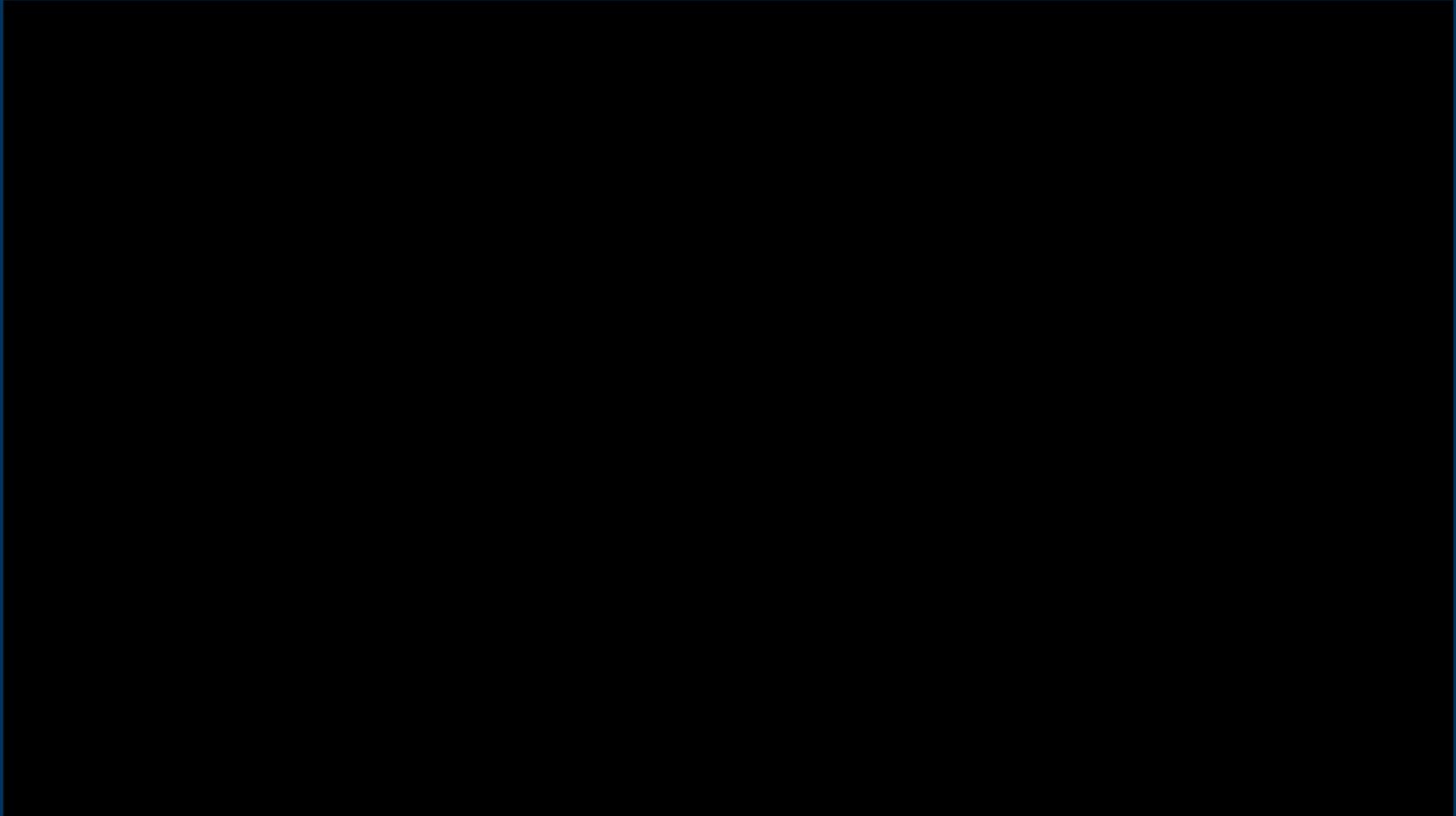
PLAY BEAT THE QUAKE

DROP! COVER! HOLD ON!

Home | Register | Overview | Resources | News & Events
Media Centre | Partners | Contact Us | Tell a Friend | Other ShakeOuts

Shake
Out

Emphasis on personal safety



ShakeOut vs. cat models

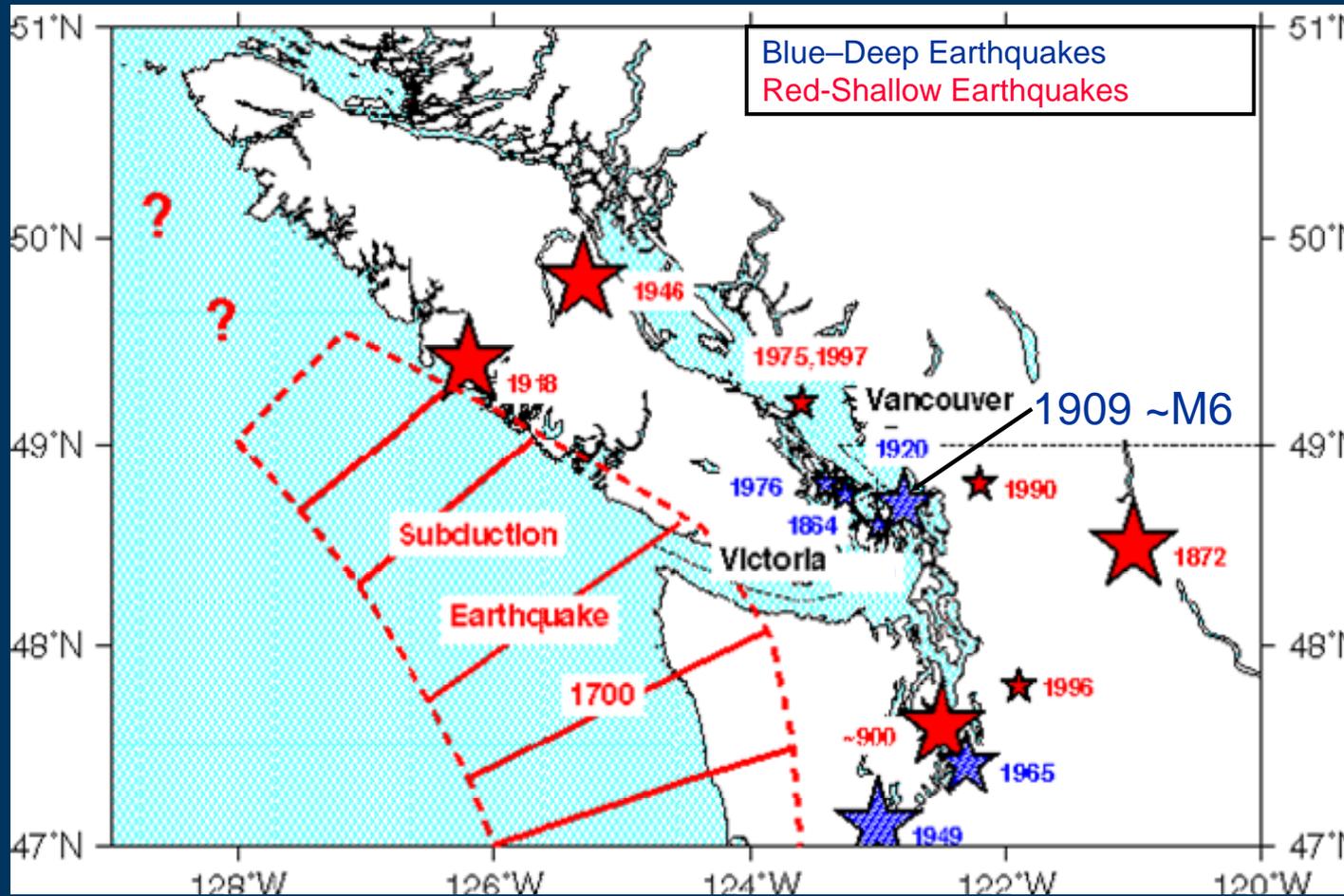
ShakeOut

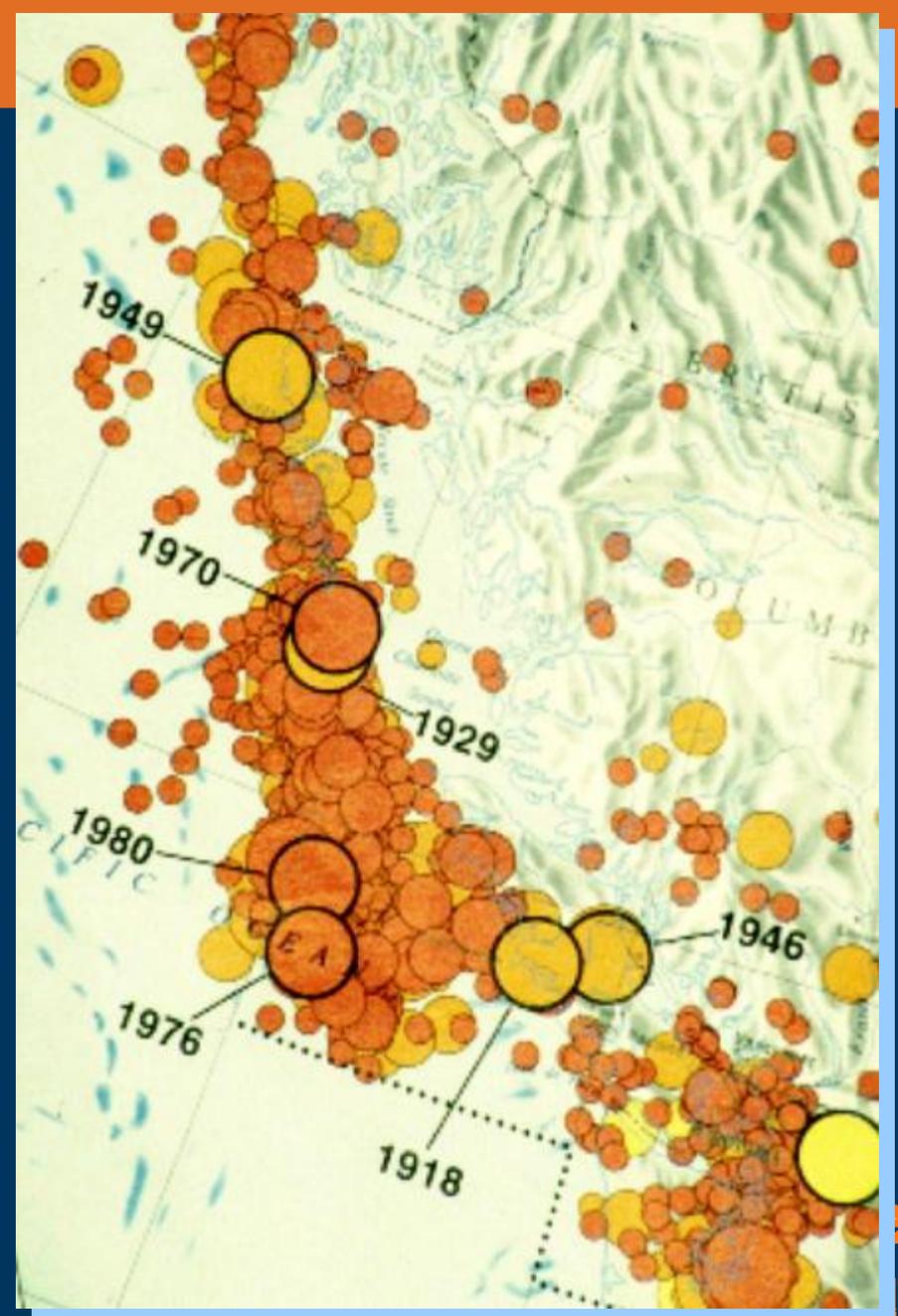
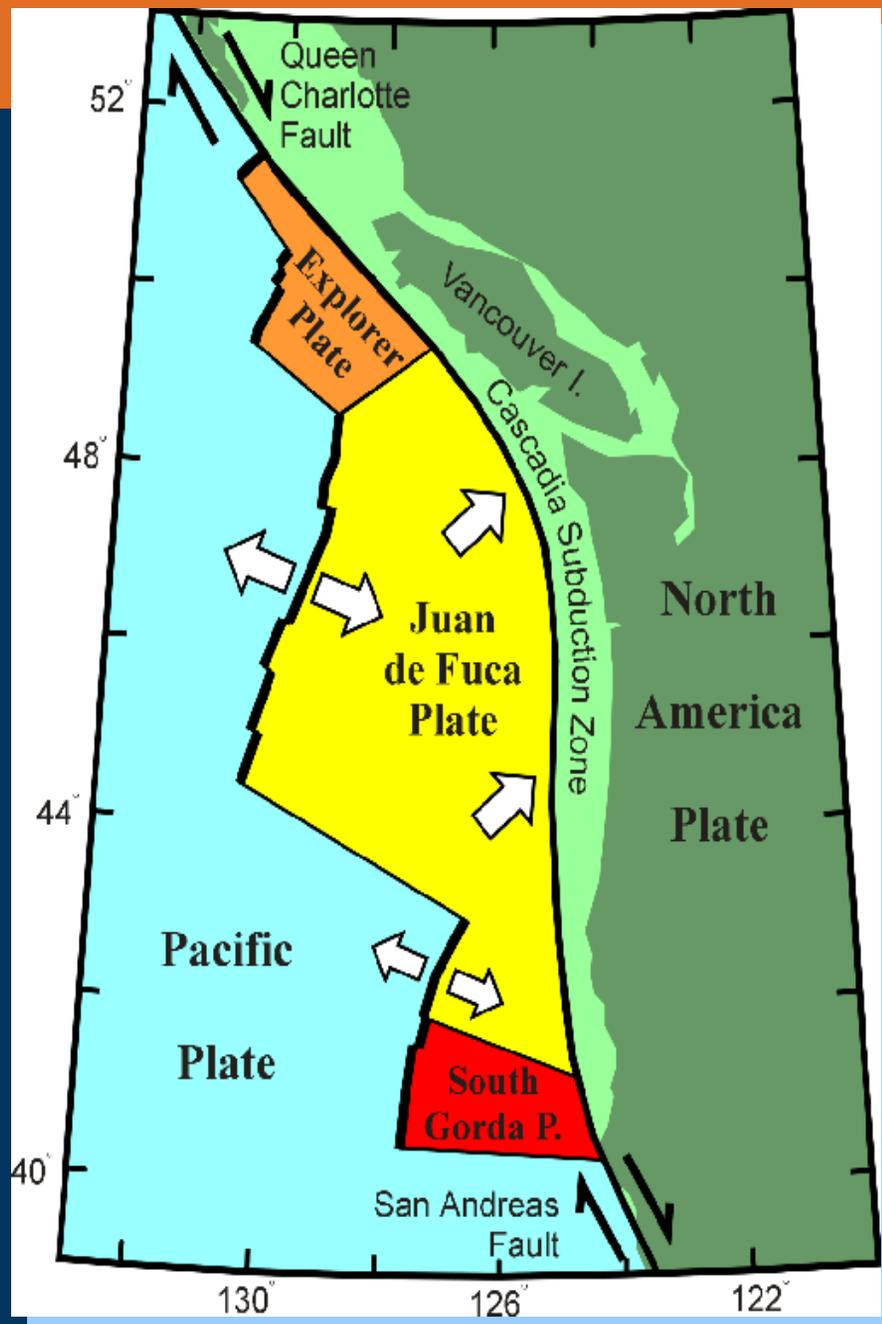
- Depth
- Physical detail
- Local conditions
- 100s of specialists
- Filtered models
- Planning, mitigation

Cat risk software

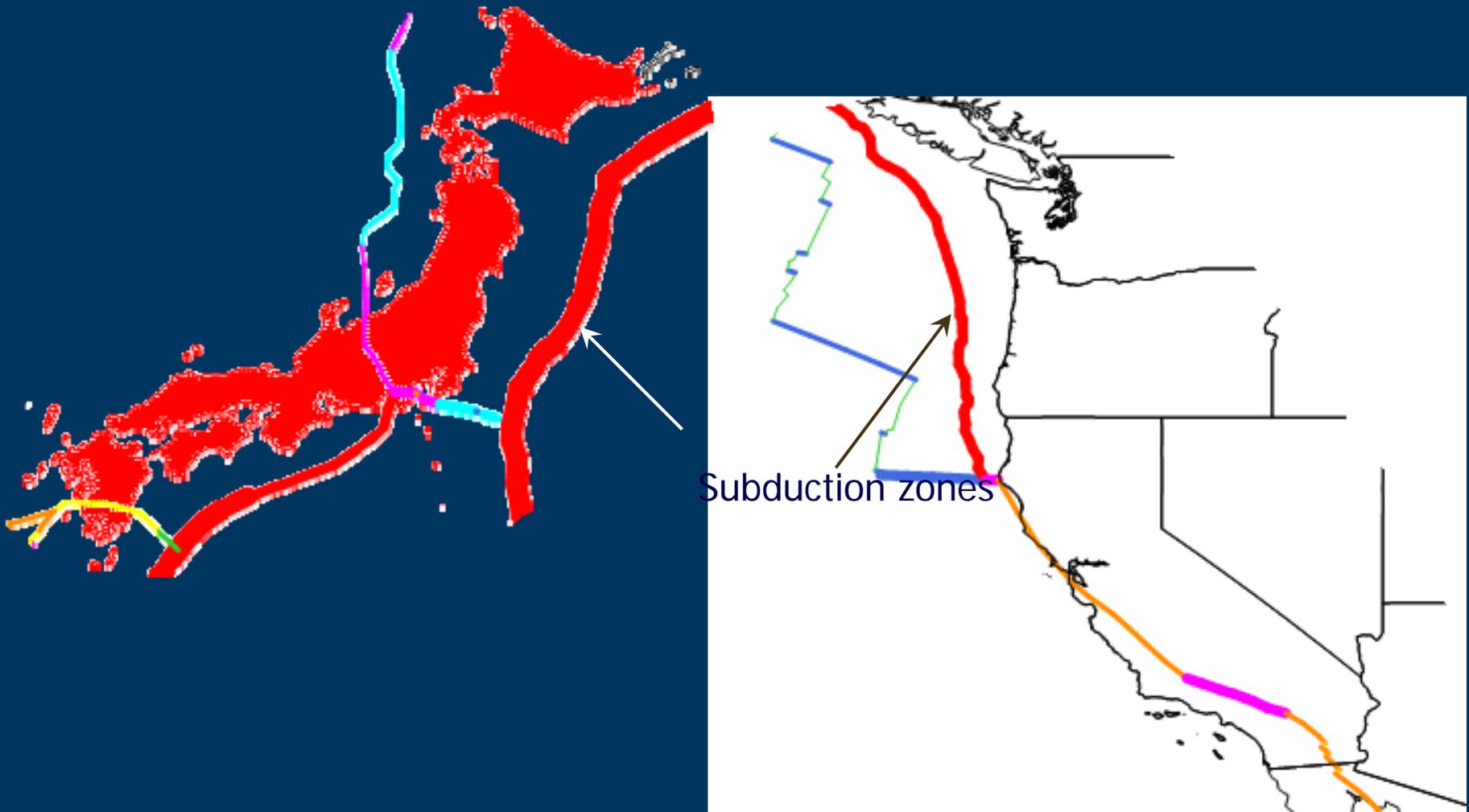
- Probabilistic breadth
- Financial risk
- General application
- 10s of modelers
- Encode models
- Risk transfer

Some notable nearby earthquakes





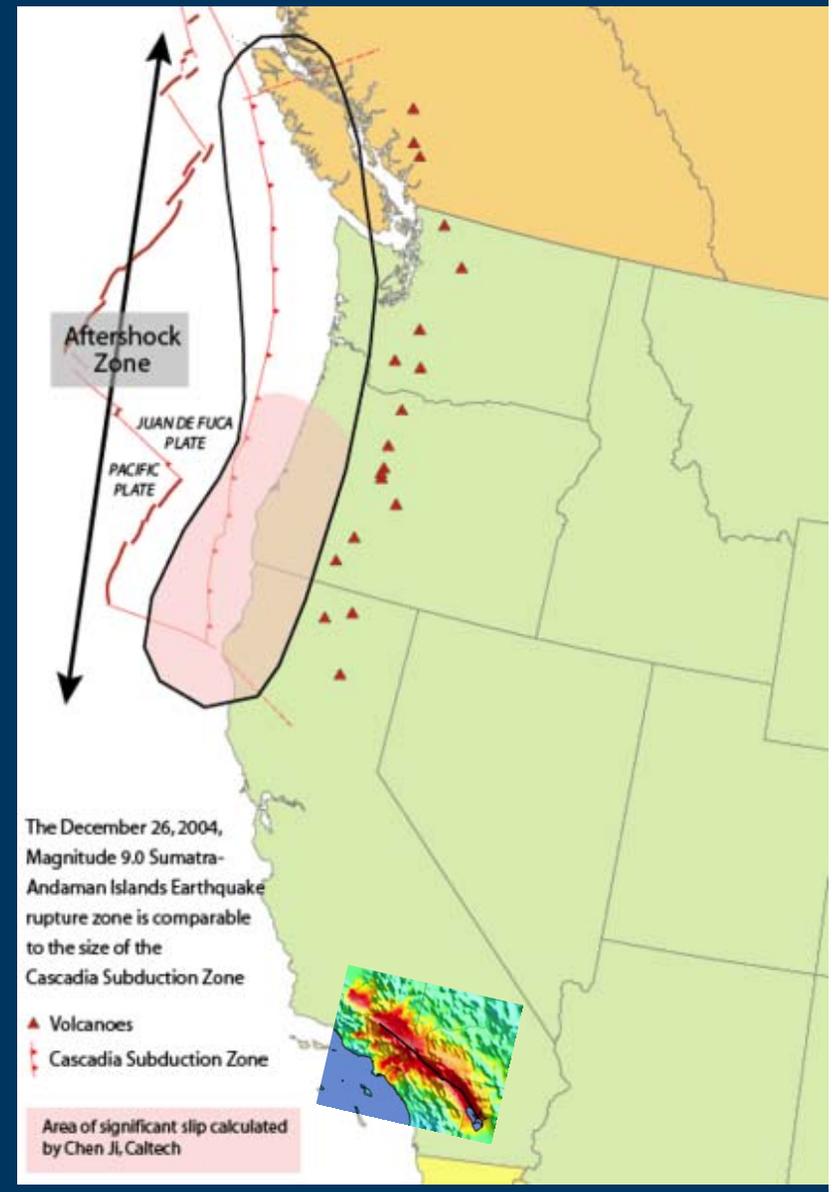
Tohoku: sneak preview of Cascadia



Bird, P., 2003. An updated digital model of plate boundaries. *Geochem. Geophys. Geosyst.*, 4, pp. 1027-1079

Some comparative statistics

Tohoku	SoCal	Cascadia
M9.0	M7.8	M9.0
63x (600M Hiroshima bombs)	1x energy	63x energy
	Probability in 2012: 0.7%	Probability in 2012: 0.3%
19,845 killed or missing	Maybe 1,800 killed of 20M	10M people affected
\$650B loss	\$213B loss	



10 Lessons for a Canadian ShakeOut Scenario from the Great California ShakeOut

1. Get to the point

Widespread Strong Ground Shaking
+ Shaking of Long Duration + Landslides =

300,000 buildings significantly damaged – 1 in 16

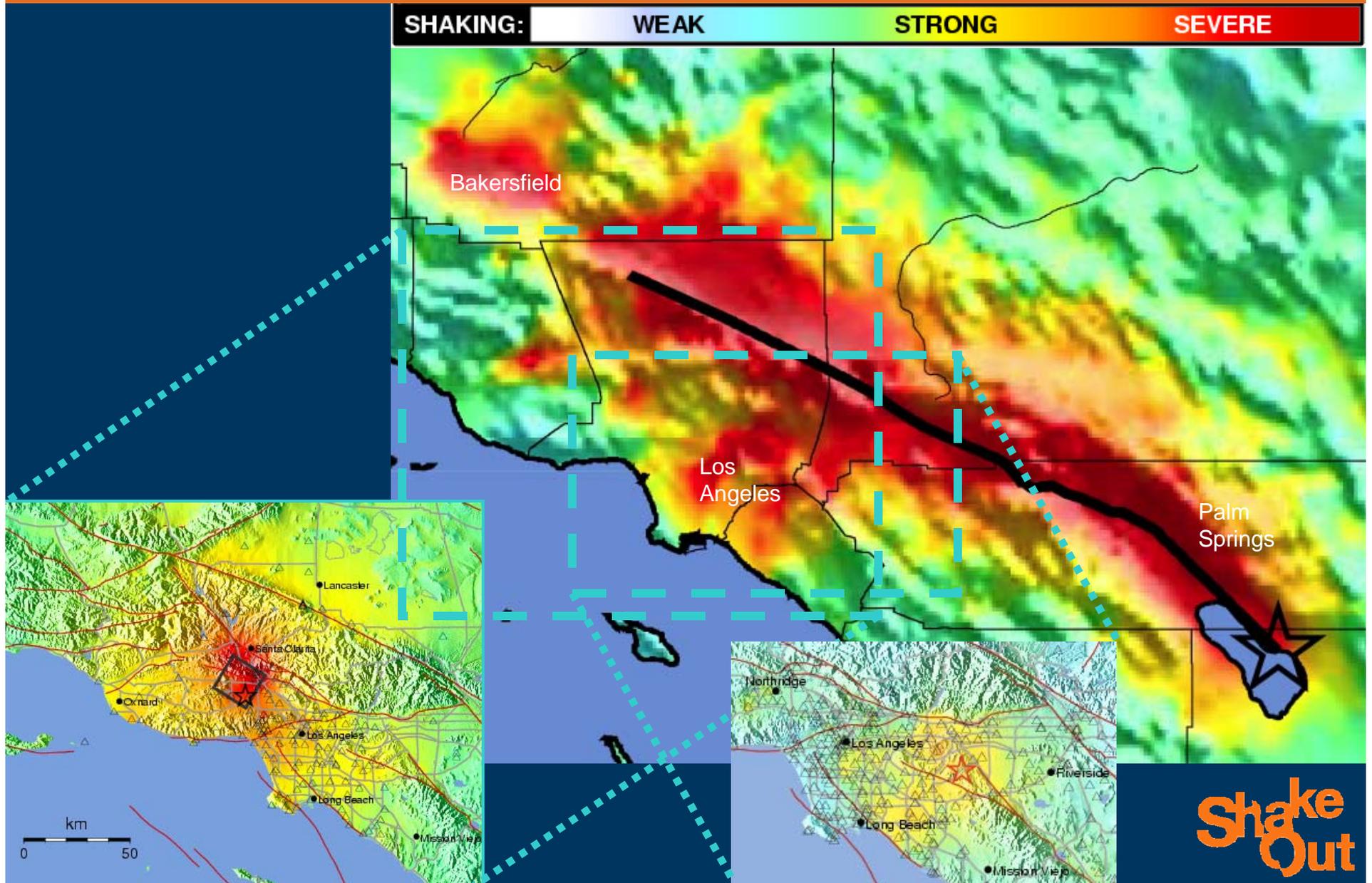
1,600 fires requiring response; **1,200** large fires

\$213 billion damages

255,000 displaced persons – 1 in 60

53,000 injuries, **1,800** deaths

2. Relate to experience



2. Relate to experience



1989 Loma Prieta



1989 San Francisco



1971 San Fernando



5/2/83 M6.5 Coalinga



1994 Northridge CA



1933 Long Beach

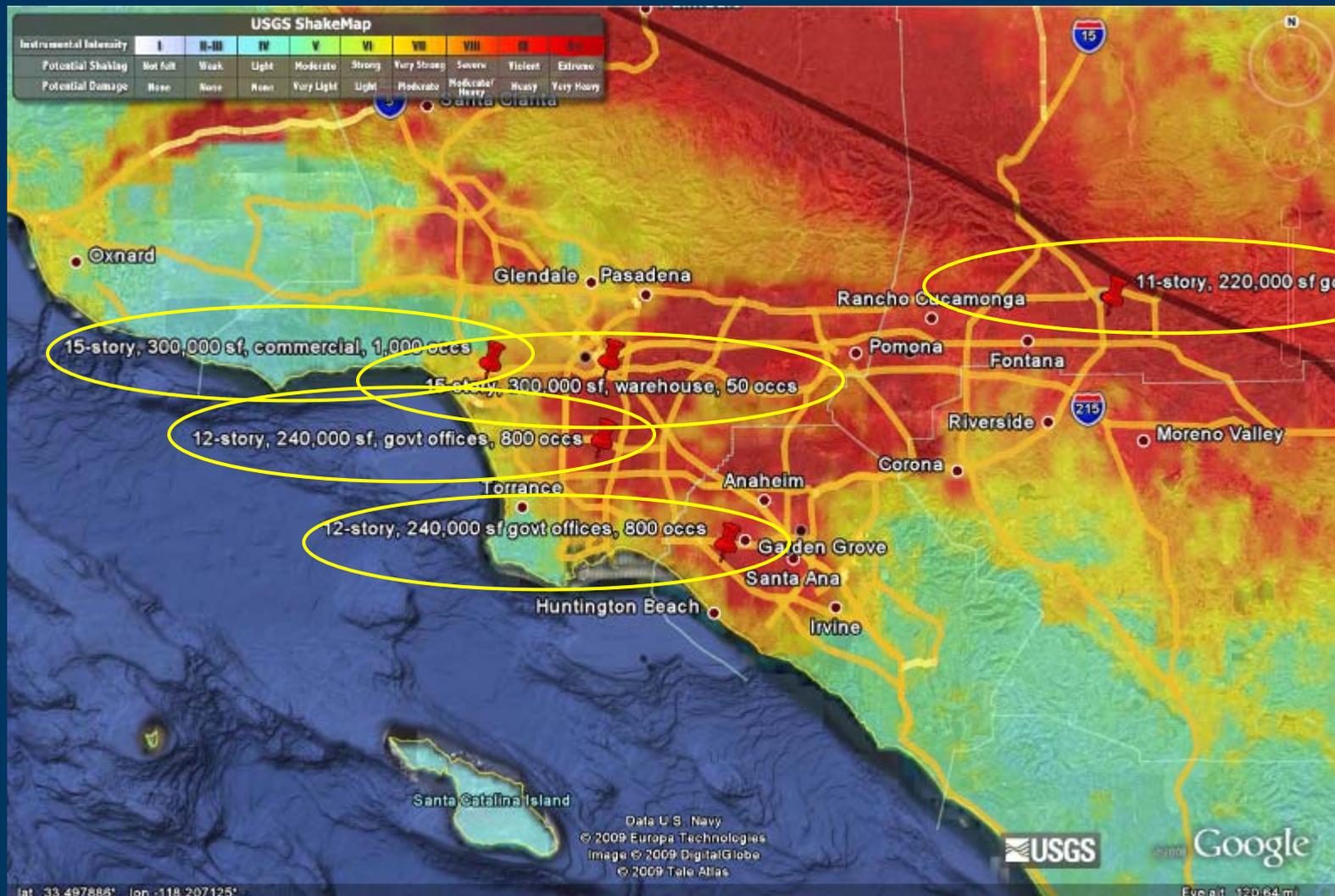
3. Avoid sensationalism

- Five highrise steelframe buildings collapse
- *Steel frame is safer than other types*



4. Avoid probability

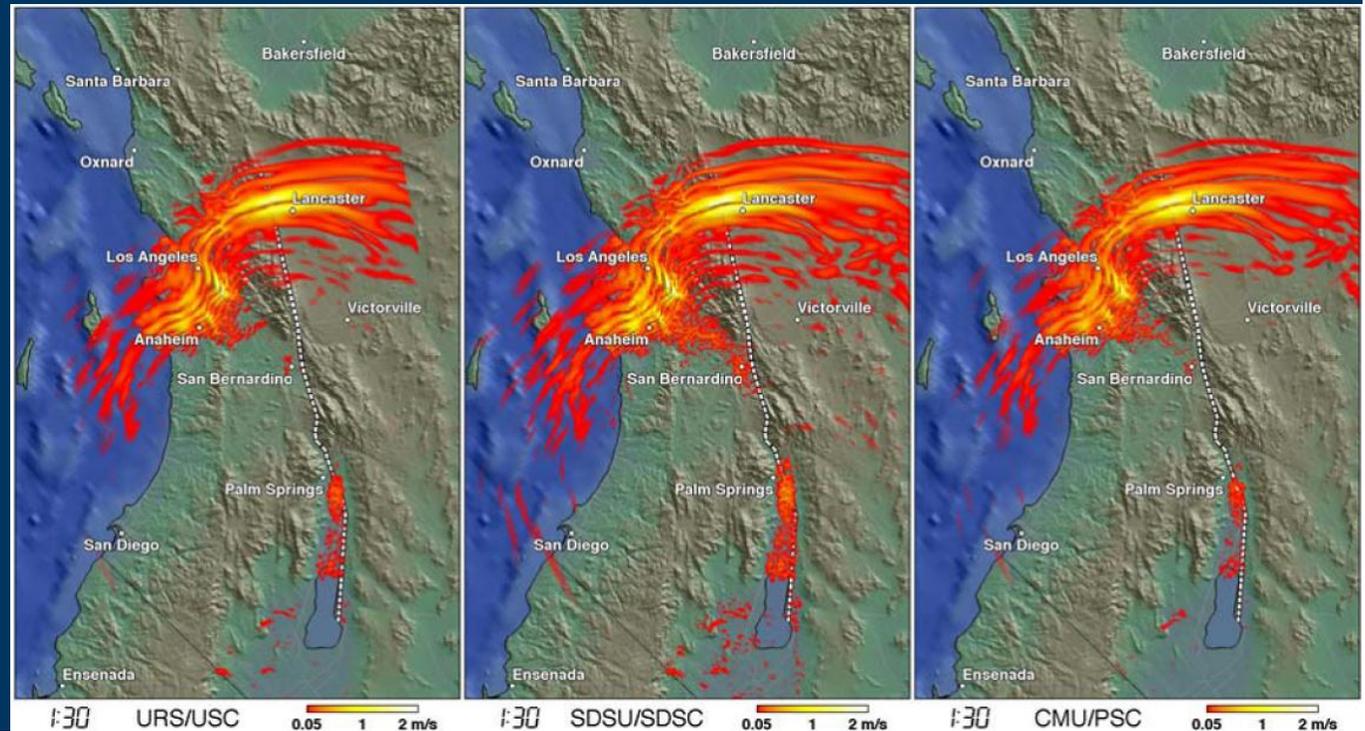
“Not if but when; could be tomorrow”



ake
Out

5. Involve everyone; emphasize consensus

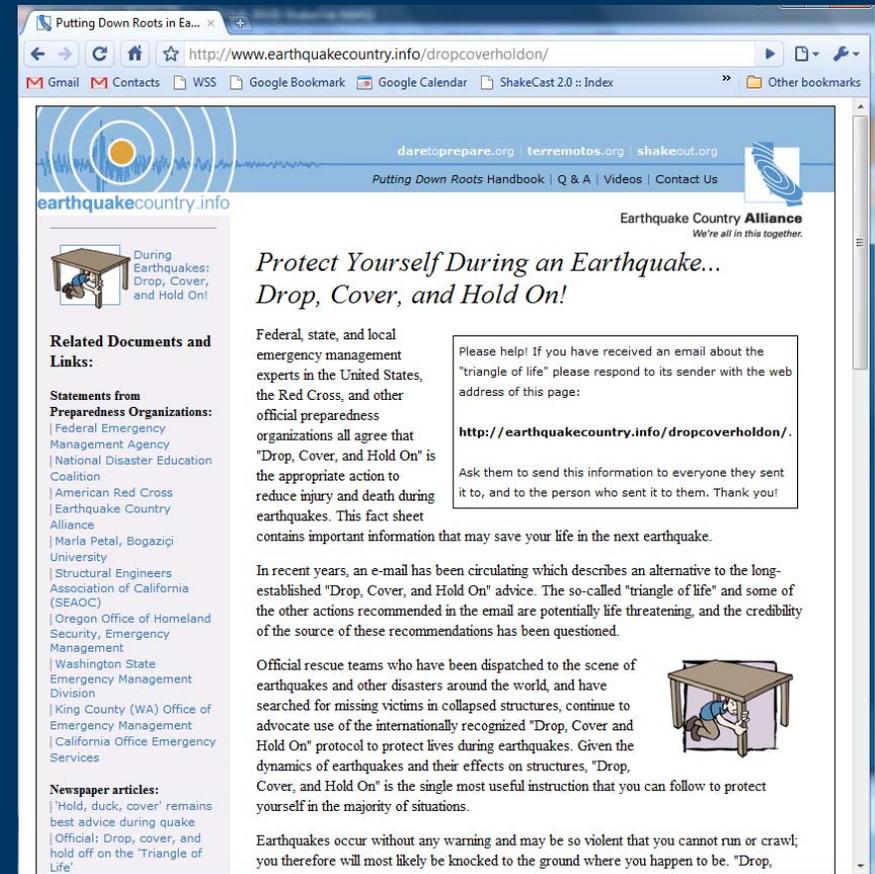
- Parallel studies, cross-compared
- Validation by thought leaders for controversial results
- Multiple agencies, NGOs, contributed to, endorsed & promoted the scenario



Hudnut et al.,
Suess et al., Raleigh

6. Confront misinformation

- E.g., “Triangle of life”
- Explain wrong assumptions:
 - Buildings don’t always collapse
 - Large heavy objects move
 - Occupants can’t always anticipate where voids are
 - Can’t always move there
- Cite authorities who rebut the misinformation
 - Cal OES, USGS, American Red Cross, Snopes.com, etc.



Putting Down Roots in Ea... x

http://www.earthquakecountry.info/dropcoverholdon/

Gmail Contacts WSS Google Bookmark Google Calendar ShakeCast 2.0 :: Index Other bookmarks

daretoprepare.org | terremotos.org | shakeout.org

earthquakecountry.info

Putting Down Roots Handbook | Q & A | Videos | Contact Us

Earthquake Country Alliance
We're all in this together.

**Protect Yourself During an Earthquake...
Drop, Cover, and Hold On!**

During Earthquakes:
Drop, Cover,
and Hold On!

Related Documents and Links:

Statements from Preparedness Organizations:

- | Federal Emergency Management Agency
- | National Disaster Education Coalition
- | American Red Cross
- | Earthquake Country Alliance
- | Marla Petal, Bogazici University
- | Structural Engineers Association of California (SEAOC)
- | Oregon Office of Homeland Security, Emergency Management
- | Washington State Emergency Management Division
- | King County (WA) Office of Emergency Management
- | California Office Emergency Services

Newspaper articles:

- | 'Hold, duck, cover' remains best advice during quake
- | Official: Drop, cover, and hold off on the "Triangle of Life"

Federal, state, and local emergency management experts in the United States, the Red Cross, and other official preparedness organizations all agree that "Drop, Cover, and Hold On" is the appropriate action to reduce injury and death during earthquakes. This fact sheet contains important information that may save your life in the next earthquake.

Please help! If you have received an email about the "triangle of life" please respond to its sender with the web address of this page:

<http://earthquakecountry.info/dropcoverholdon/>

Ask them to send this information to everyone they sent it to, and to the person who sent it to them. Thank you!

In recent years, an e-mail has been circulating which describes an alternative to the long-established "Drop, Cover, and Hold On" advice. The so-called "triangle of life" and some of the other actions recommended in the email are potentially life threatening, and the credibility of the source of these recommendations has been questioned.

Official rescue teams who have been dispatched to the scene of earthquakes and other disasters around the world, and have searched for missing victims in collapsed structures, continue to advocate use of the internationally recognized "Drop, Cover and Hold On" protocol to protect lives during earthquakes. Given the dynamics of earthquakes and their effects on structures, "Drop, Cover, and Hold On" is the single most useful instruction that you can follow to protect yourself in the majority of situations.

Earthquakes occur without any warning and may be so violent that you cannot run or crawl; you therefore will most likely be knocked to the ground where you happen to be. "Drop,



7. Acknowledge limitations

- Best earth science, but science evolves
- Lots of unknowns, e.g., about the building stock
- Panels judged many impacts w/o calculations
- Computer models simplify & extrapolate
- Reduces attacks and identifies areas needing more study

8. Temper lectures with activities

- Up-to-date info & drill scripts
- “Learn what else you can do, be counted as a participant, and ask others to register with you!”
- Participants create their own activities, e.g., LAUSD
 - Duck, cover & hold on
 - Building safety inspection drills
 - Executive communication

The Great Southern California ShakeOut
November 12–16, 2008

The Great Southern California ShakeOut is a week-long series of special events organized to inspire Southern Californians to get ready for big earthquakes, and to prevent disasters from becoming catastrophes.

PARTICIPATE IN THE SHAKEOUT DRILL
Thurs, Nov. 13, 2008, 10 a.m.
Join in the country's largest-ever earthquake preparedness exercise—the Great Southern California ShakeOut Drill. [Registration](#) is free and open to everyone.

[Register Now](#)

Now take the next step—[go beyond the Drill.](#)

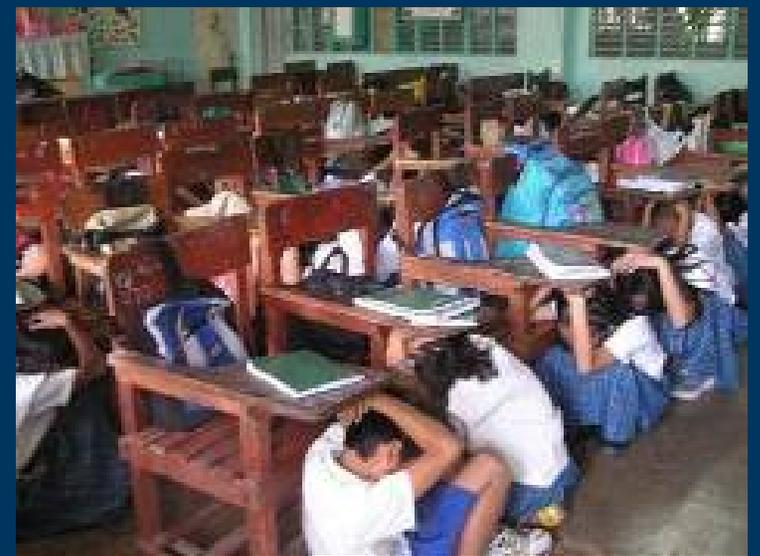
[BECOME A SPONSOR](#)

ShakeOut is organized by THE EARTHQUAKE COUNTRY ALLIANCE. A public-private partnership of leading earthquake professionals, emergency managers, government agencies, businesses and community leaders. The goals of the Alliance are to educate communities on earthquake safety and recovery, increase awareness and preparedness, improve response and recovery planning and reduce losses in future earthquakes.

[For more info click here](#)

CALENDAR OF EVENTS NOVEMBER 2008

12 Wednesday	13 Thursday	14 Friday	15 Saturday	16 Sunday
International Earthquake Policy Conference November 12				
	The ShakeOut Drill November 13			
	Golden Guardian Emergency Response Exercise November 13-19			
		Los Angeles Earthquake: Get		



9. Defend in depth

Scawthorn fire study

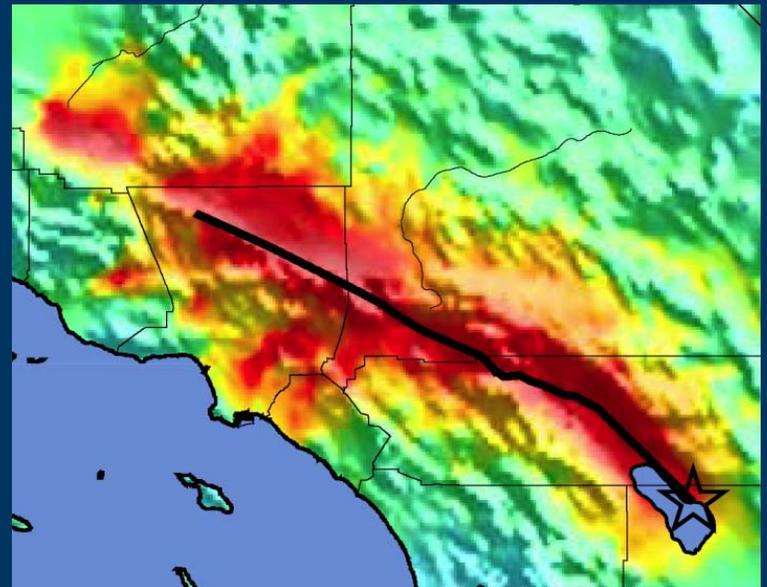
- Frightening losses, costly mitigation
- Reviewed by state & local fire officials

Caltech highrise study

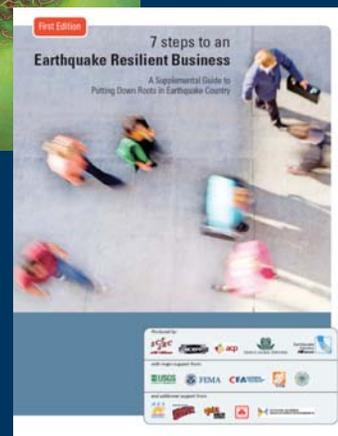
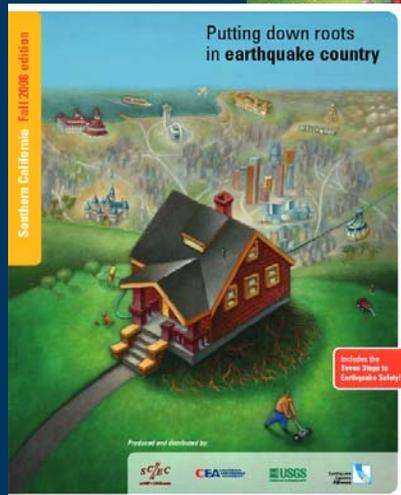
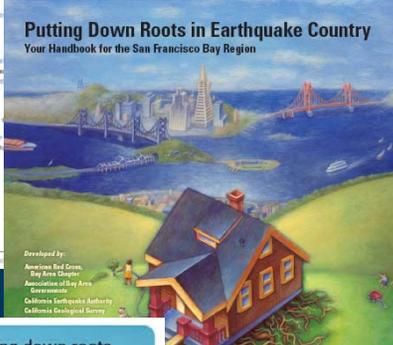
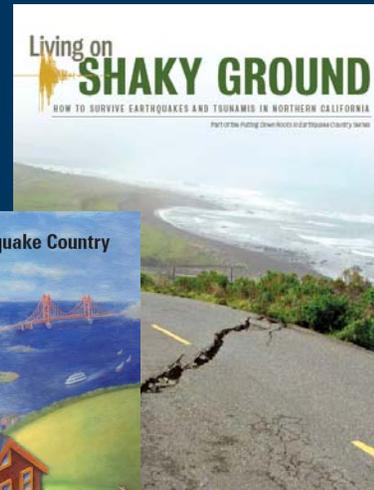
- Evokes 9/11
- Leading structural engineers agreed about collapse potential, provided advice about relative risk

ShakeMap

- 4 physics-based models largely agree
- Engineers tried to question it, could not argue with 100 seismologists



10. Offer engaging, useful resources



- Websites
- Journal articles
- YouTube videos
- Reports & brief abstracts
- Briefings & speakers' bureau
- Multiple languages
- K-12 educational kits
- *Beat the Quake* online game
- Twitter feeds

Bottom Line for BC & SoCal

What we do now,
before the disaster,
will determine
what our lives are like
after

Questions?

