



SCEC: What it is and How it Works

**Greg Beroza
(Deputy Director)**



an NSF+USGS center



The Risk Equation

$$\text{Risk} = \text{Probable Loss (lives \& dollars)} =$$

$$\text{Hazard} \times \text{Exposure} \times \text{Fragility} \div \text{Resiliency}$$



Faulting, shaking, landsliding, liquefaction



Extent & density of built environment



Structural & nonstructural vulnerability



Emergency response, insurance, CAT bonds

Earthquake Risk Reduction

- **Predict the Hazard**
 - Seismic hazard analysis
 - Earthquake prediction
 - Early warning
- **Manage the Exposure**
 - Hazard mapping
 - Land-use policies
- **Reduce the Fragility**
 - Building codes
 - Performance-based design
 - Retrofitting programs & mandates
 - Non-structural mitigation
- **Improve the Resilience**
 - Rapid emergency response
 - Insurance, catastrophe bonds
 - Long-term recovery planning

**Integrate tactics into a
system-level strategy for
risk reduction**

**Educate the public;
involve them in the
planning**

**What is SCEC and how
does it fit into this?**

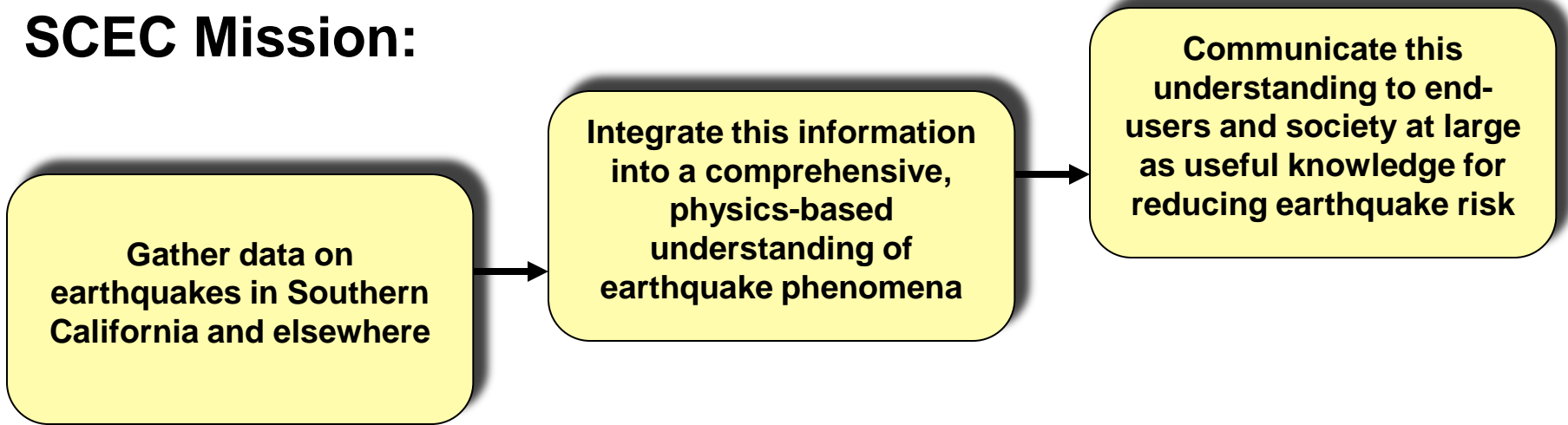


Southern California Earthquake Center



- *Large consortium of institutions* that coordinates earthquake research
- *Collaboratory* that uses advanced IT to synthesize and validate system-level models of earthquake processes
- *Open community of trust* that shares data, models, knowledge, and ideas
- *Reliable partner* that works with other organizations to promote earthquake resilience
- *International leader* that involves scientists from many countries

SCEC Mission:



SCEC is a Consortium of Institutions

Core Institutions (16)

California Institute of Technology
 Columbia University
 Harvard University
 Massachusetts Institute of Technology
 San Diego State University
 Stanford University
 U.S. Geological Survey, Golden
 U.S. Geological Survey, Menlo Park
 U.S. Geological Survey, Pasadena
 University of California, Los Angeles
 University of California, Riverside
 University of California, San Diego
 University of California, Santa Barbara
 University of California, Santa Cruz
 University of Nevada, Reno
 University of Southern California (lead)

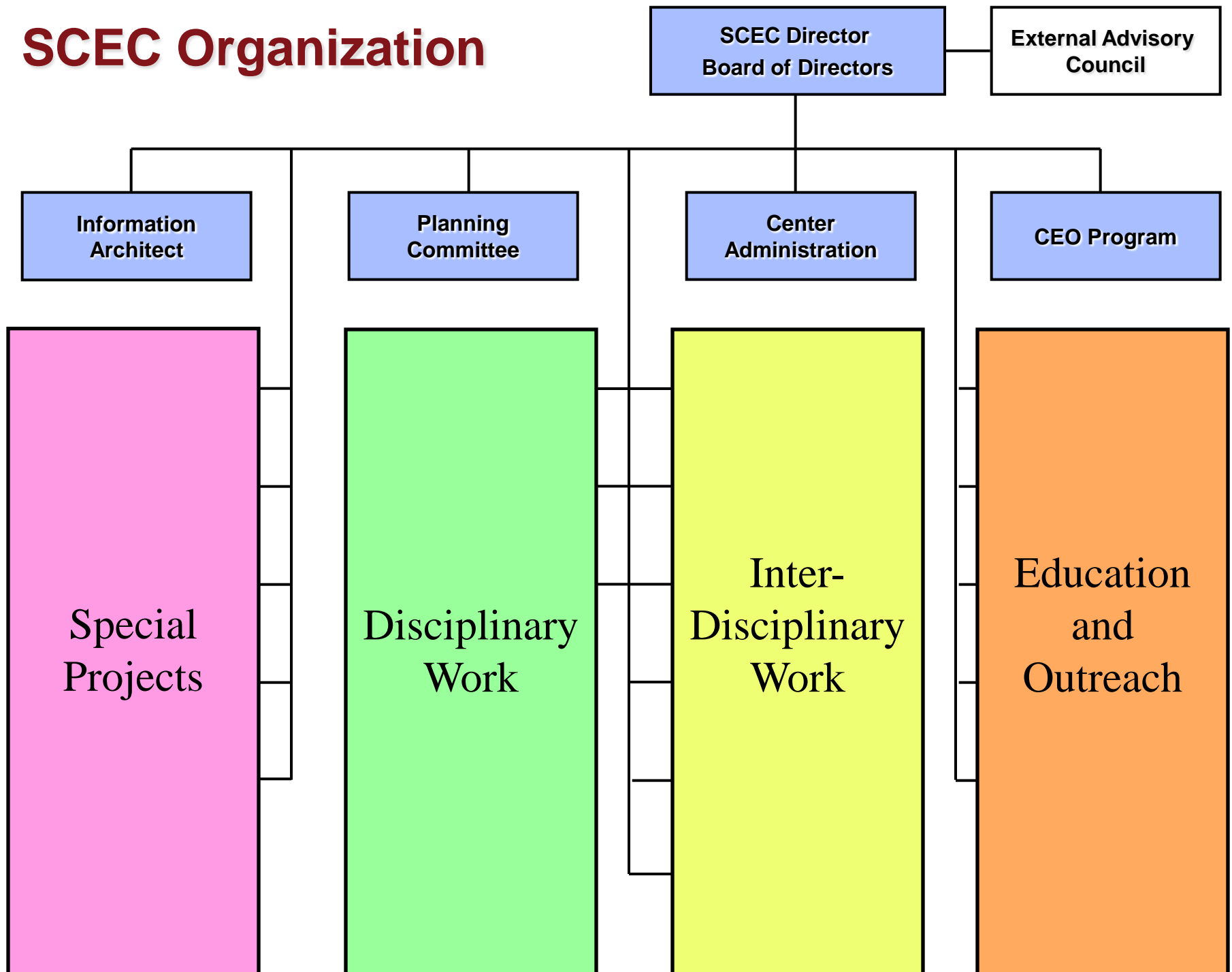
Participating Institutions (47)

Appalachian State University; Arizona State University; Boston University; Brown University; Cal-Poly, Pomona; Cal-State, Long Beach; Cal-State, Fullerton; Cal-State, Northridge; Cal-State, San Bernardino; California Geological Survey; Carnegie Mellon University; Case Western Reserve University; CICESE (Mexico); Disaster Prevention Research Institute, Kyoto University (Japan); ETH (Switzerland); Georgia Tech; Institute of Earth Sciences of Academia Sinica (Taiwan); Earthquake Research Institute, University of Tokyo (Japan); Institute of Geological and Nuclear Sciences (New Zealand); Jet Propulsion Laboratory; Los Alamos National Laboratory; Lawrence Livermore National Laboratory; National Chung Cheng University (Taiwan); National Taiwan University (Taiwan); National Central University (Taiwan); Ohio State University; Oregon State University; Perdue University; Rensselaer Polytechnic University; Texas A&M University; University of Arizona; UC, Berkeley; UC, Davis; UC, Irvine; University of British Columbia (Canada); University of Colorado; University of Massachusetts; University of Minnesota; University of Missouri-Columbia; University of North Carolina; University of Oklahoma; University of Oregon; University of Utah; University of Western Ontario (Canada); University of Wisconsin; URS Corporation; Utah State University; Woods Hole Oceanographic Institution

Rationale for the Collaboratory

- **SCEC is a virtual organization with the structure**
 - to coordinate an interdisciplinary, multi-institutional research program in earthquake system science
 - to sustain the web of organizational partnerships needed to translate basic research into useful knowledge
- **The SCEC collaboration achieves a deeper understanding of earthquake behavior more rapidly than would be feasible by individual researchers or institutions working alone**
 - **Southern California serves as a well-equipped natural laboratory for gaining new knowledge**

SCEC Organization



SCEC Organization

SCEC Director
Board of Directors

External Advisory
Council

Mary Lou Zoback	Chair, Risk Management Solutions
Jeffrey Freymueller	Chair-Designate, U. Alaska
Gail Atkinson	U. Western Ontario
Donna Eberhart-Phillips	UC Davis
John Filson	U.S. Geological Survey (Emeritus)
Jim Goltz	CalEMA
Steve Mahin	PEER
Anne Meltzer	Lehigh University
Denis Mileti	U. Colorado (Emeritus)
M. Meghan Miller	UNAVCO
Roger Bilham	U. of Colorado
John Vidale	U. Washington
Andrew Whittaker	U. Buffalo
Farzad Naeim	John A. Martin & Associates

External Advisory Council includes: earthquake scientists, earthquake engineers, social scientists emergency planners, reinsurance industry

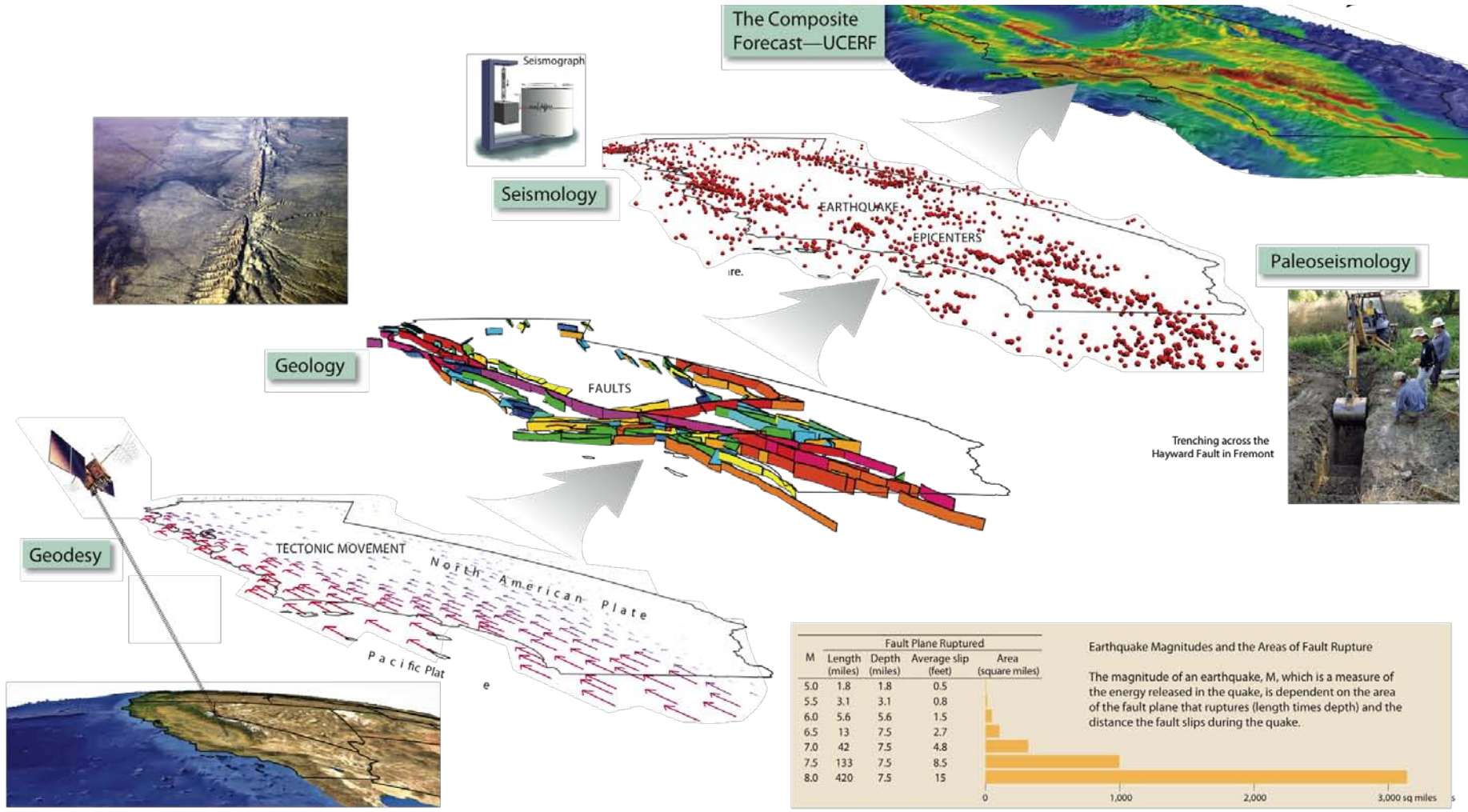


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UCERF Special Project

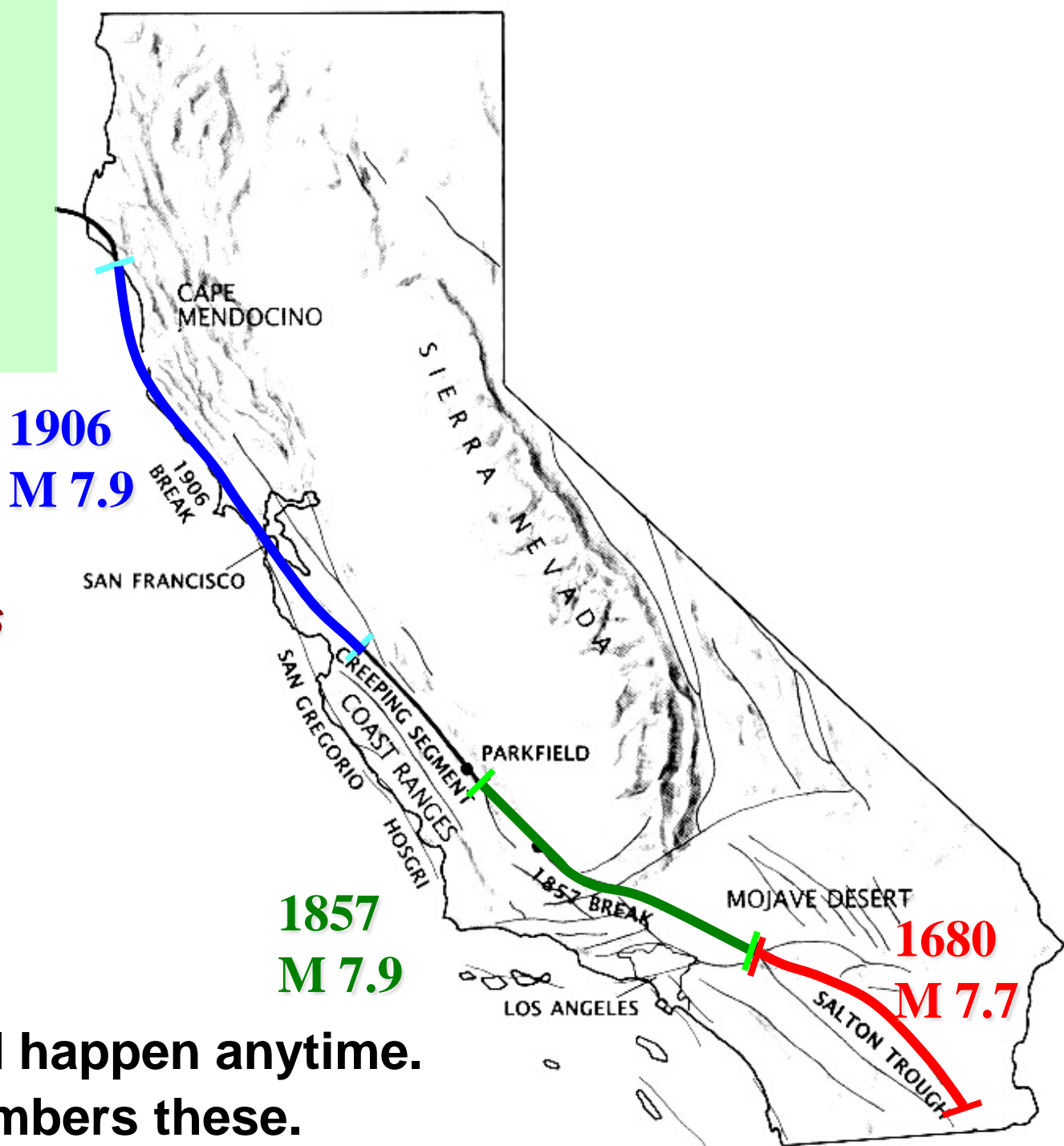


Best available science: used to set insurance rates, national hazard maps

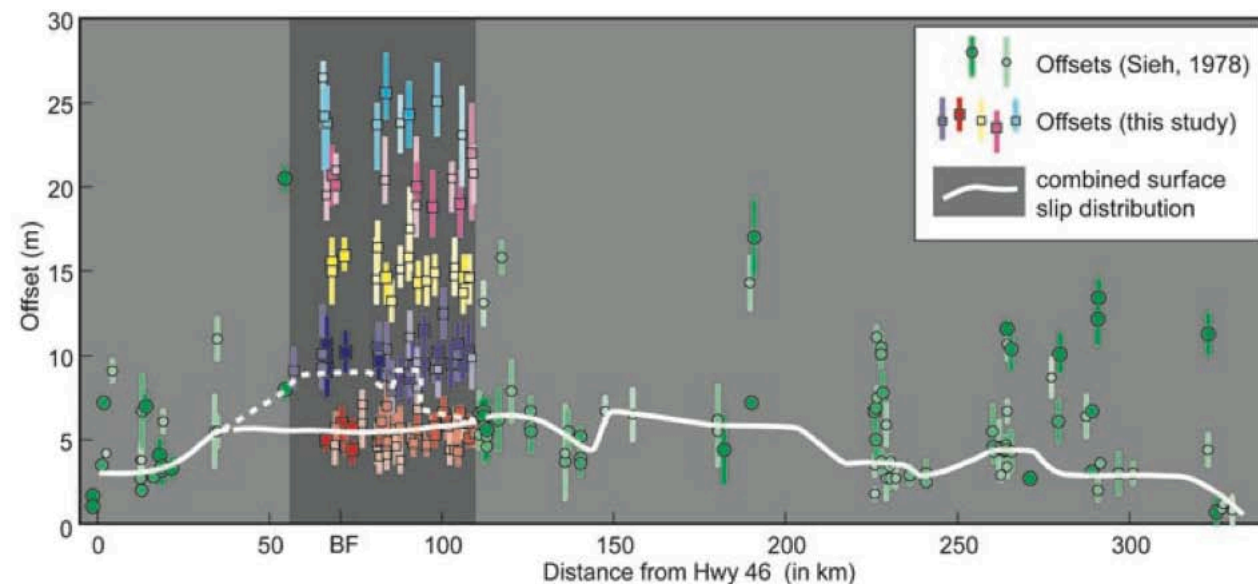
Multi-Disciplinary Science: Understanding the San Andreas

*Large earthquakes
recur on the San
Andreas fault
every 150-200
years.*

**Next big one could happen anytime.
No one alive remembers these.**

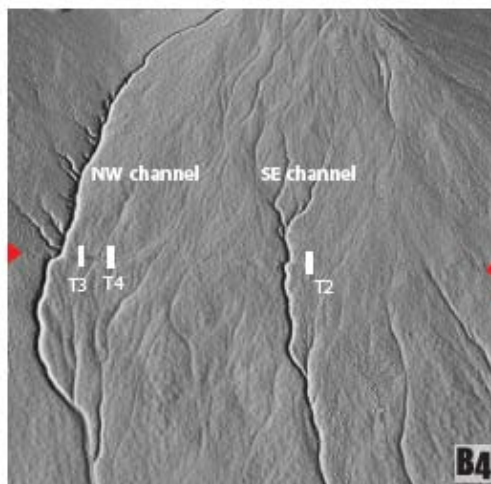


New Understanding of 1857 Earthquake



Zielke et al. (2010)

Earthquake
likelihood higher
than we thought it
was last year.



Grant-Ludwig et al. (2010)

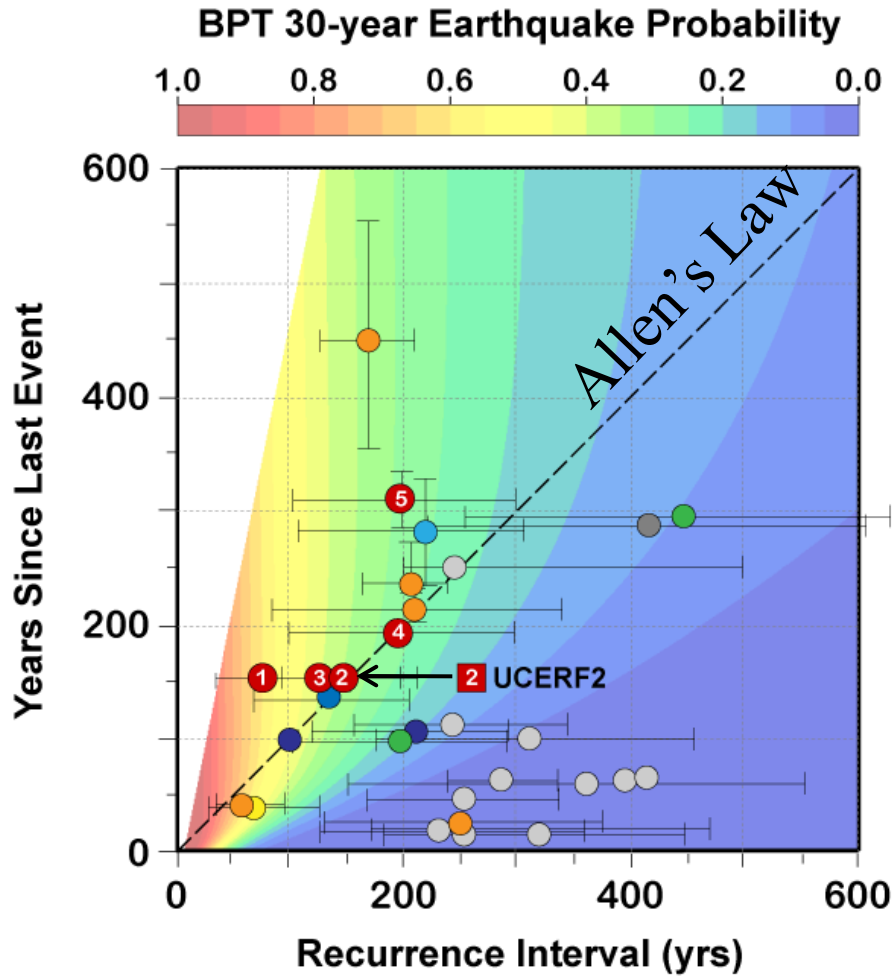
Dates

- A 1857
- B 1640-1840
- C 1510-1640
- D 1510-1640
- E 1465-1525
- F 1345-1430
- G 1280-1340

**7 EQs in
< 600 yrs**



Southern San Andreas Fault System “Locked and Loaded”

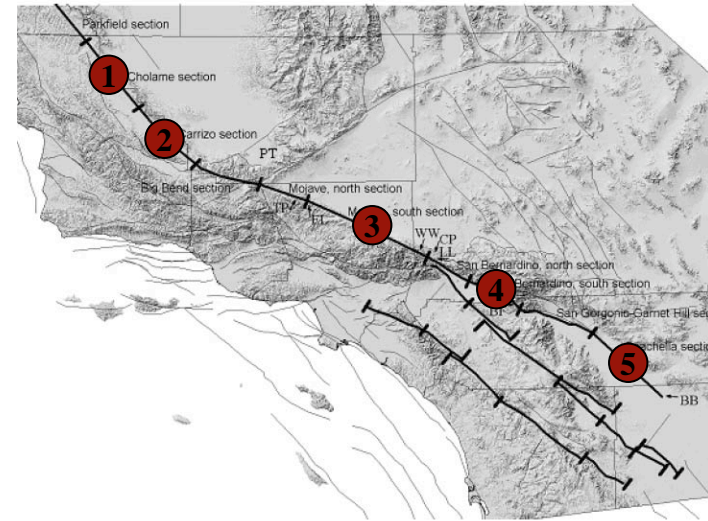


Southern CA

- sSAF
- 1 Cholame
- 2 Carrizo
- 3 Mojave
- 4 San Bernardino
- 5 Coachella
- SJF
- IF
- E-WF

Northern CA

- nSAF
- sHF
- RCF
- New Zealand AF
- Turkey NAF



How will the San Andreas Rupture?

How is fault slip accommodated?

One big earthquake or a series of earthquakes?

Can we reconcile geodetic/geologic slip rates?

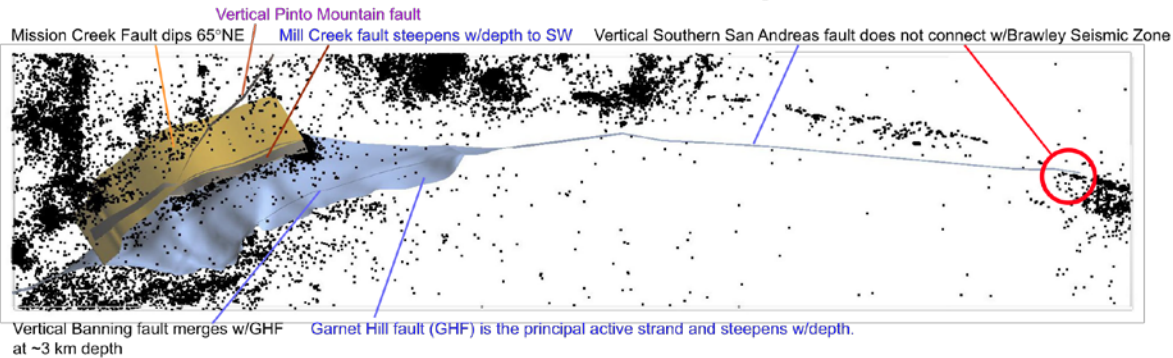
Slip on San Andreas vs. San Jacinto Faults?

Is throughgoing rupture possible?

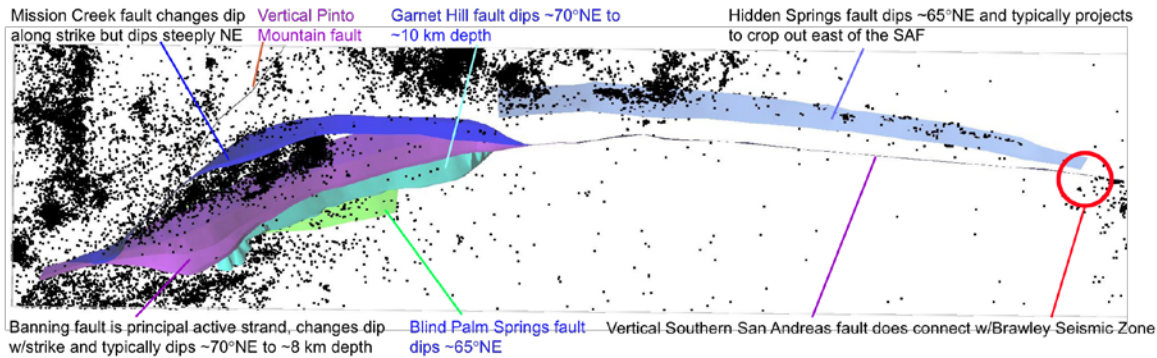
How strong will the shaking be?

SCEC's Multi-disciplinary approach is key to answering these questions.

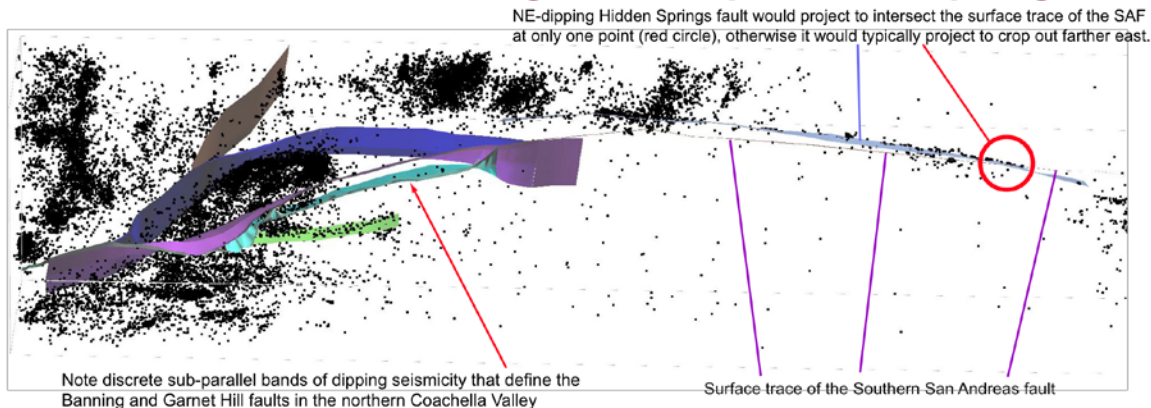
Current SCEC CFM 3.0 Fault Representations



Revised Alternative SCEC CFM Fault Representations



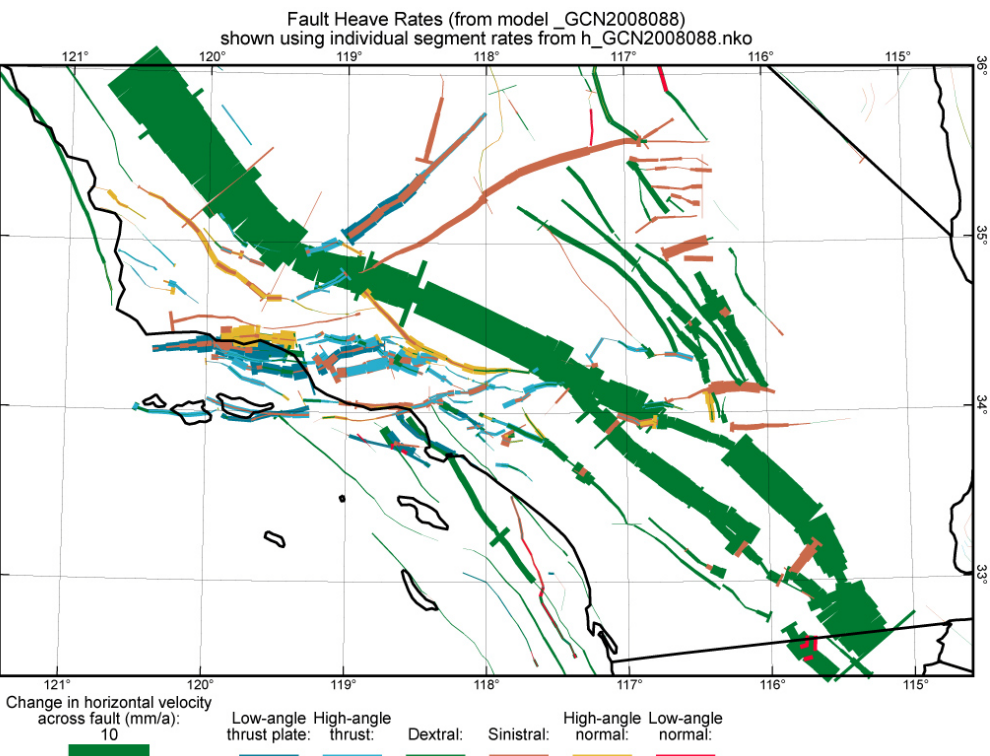
Revised CFM Faults Looking Down-dip Hidden Springs Fault



Seismology

Fault geometries informed by precise earthquake locations.

Nicholson (2009)



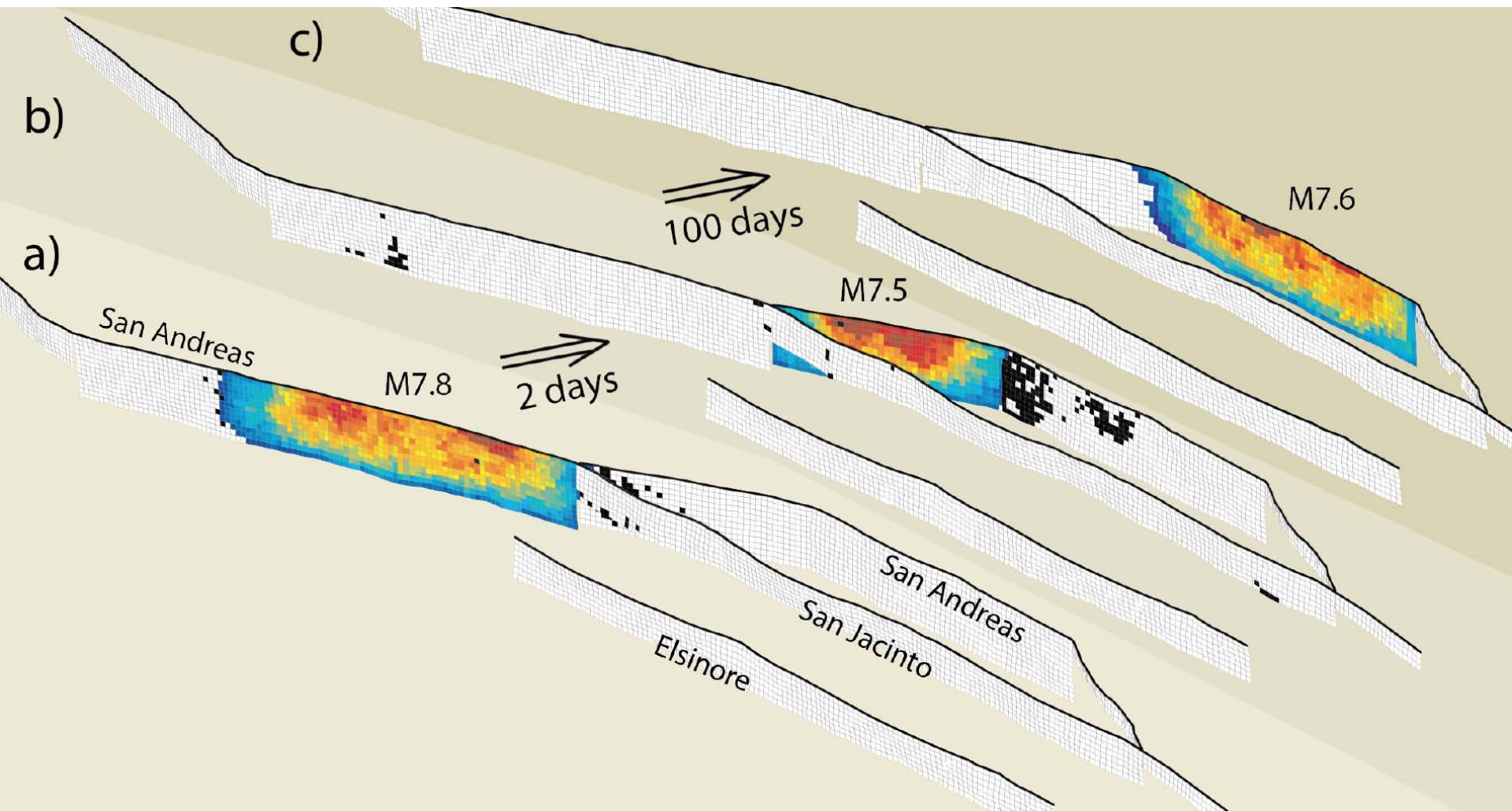
Geodetic Fault Slip Rates

(Bird, 2009)

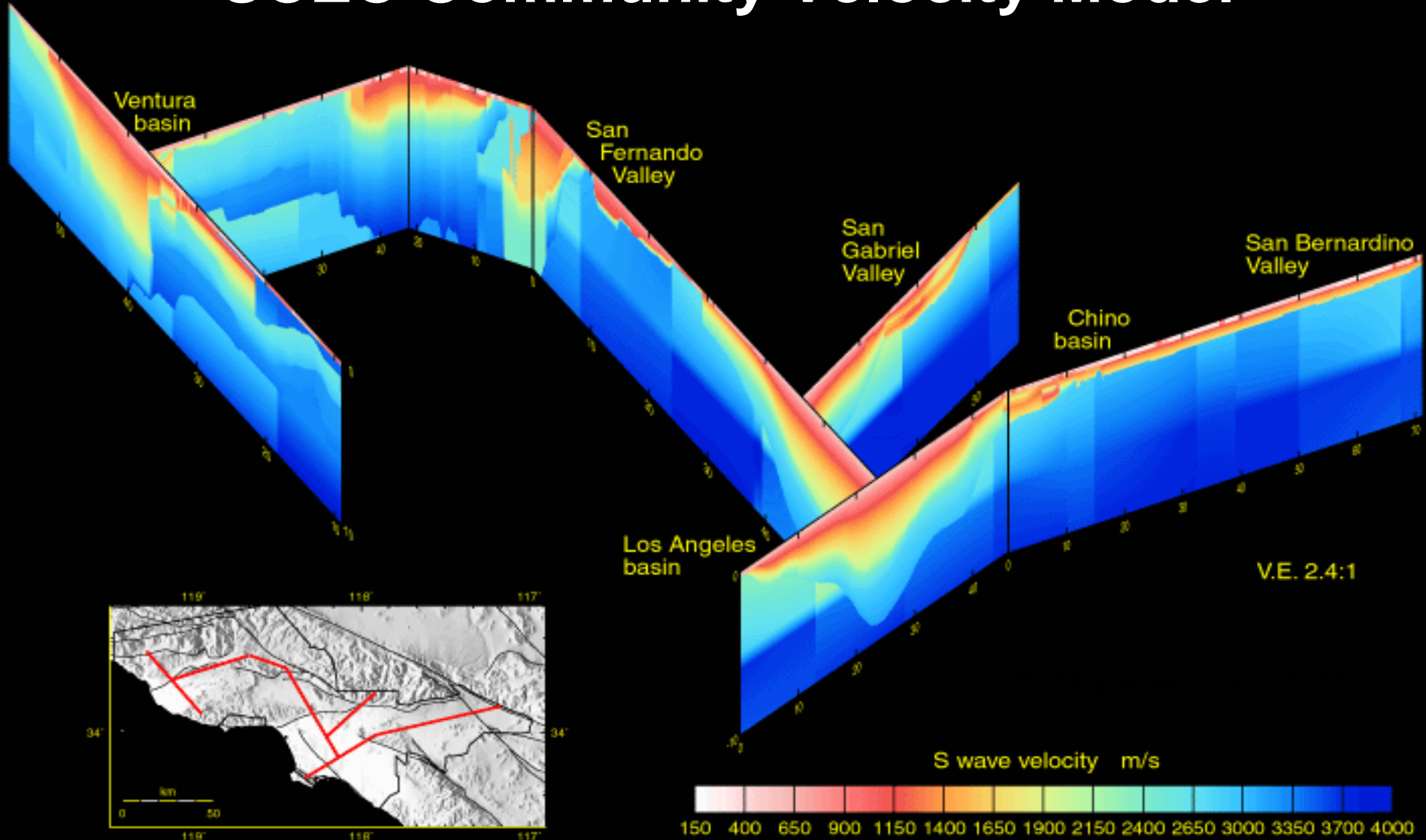
Includes geologic and stress direction data.

Allows for distributed deformation.

Southern San Andreas Simulation



SCEC Community Velocity Model





Simulations of Shaking from a Large Southern San Andreas Fault Earthquake



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**Integrate tactics into a
system-level strategy for
risk reduction**

**Educate the public;
involve them in the
planning**

... but how?

The Great
Southern California

Shake Out

November 12–16, 2008

Get Ready to ShakeOut!



an NSF + USGS center



Earthquake Country **Alliance**

We're all in this together.

Developers of the ShakeOut Scenario

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

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

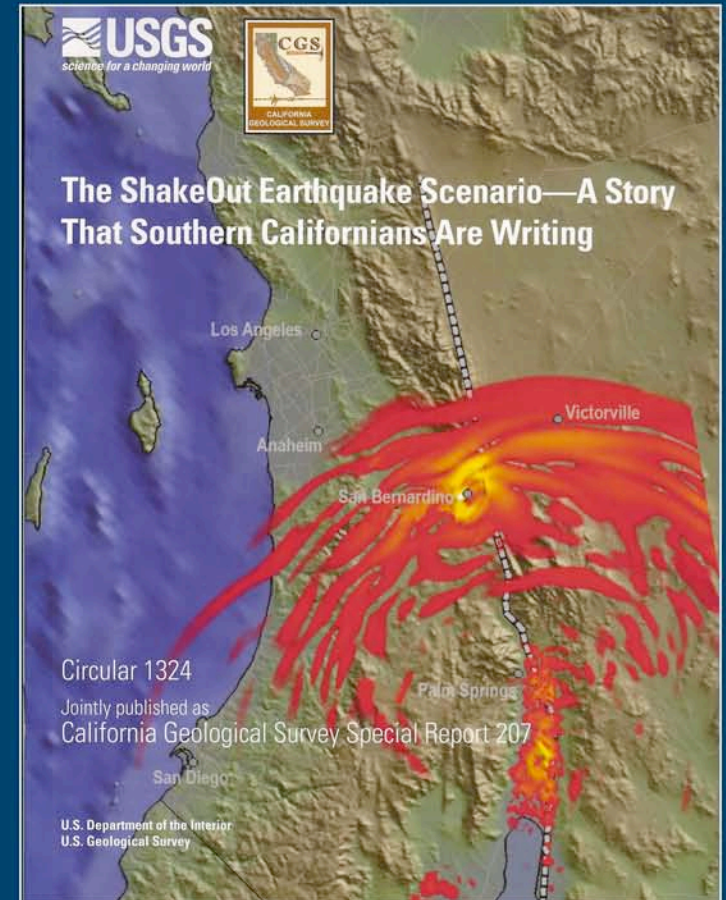
- **SCEC Simulation Group**

- Rob Graves, URS
- Kim Olsen & Steve Day, SDSU
- Jacobo Bielak, CMU
- Tom Jordan & Phil Maechling, USC

- **Scenario Study Sections**

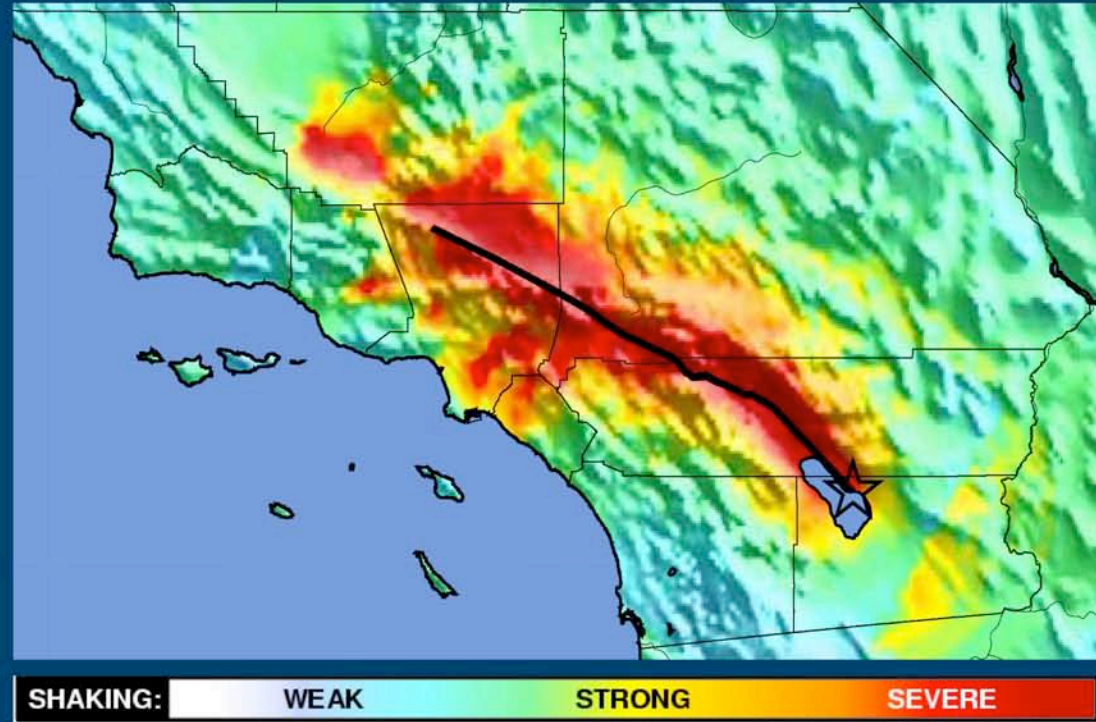
- Earth and Computer Science
 - Ken Hudnut, USGS
 - Dan Ponti, USGS
 - Mike Reichle, CGS
- Engineering
 - Keith Porter, EERI
 - Hope Seligson, MMI Engineering
- Public Health
 - Kim Shoaf, UCLA
- Disaster Sociology
 - Dennis Mileti, Seismic Safety Commission
 - Jim Goltz, Governor's Office of Emergency Services
- Disaster Economics
 - Anne Wein, USGS
 - Richard Bernknopf, USGS

- **More than 300 Panelists, Experts, Special Studies**



A Possible “Big One”

- Southernmost San Andreas
- 300 km (180 mi) rupture
- Magnitude 7.8
- 100 seconds of fault rupture
- Shaking for over 2 minutes in many places
- Dr. Lucy Jones (USGS) led many scientists, engineers, and others to create a realistic **scenario** of what will happen.



ShakeOut Scenario “Disaster Equation”

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

300,000 buildings significantly damaged

Widespread infrastructure damage

\$213 billion in damage and business loss

270,000 displaced persons

50,000 injuries

1,800 deaths

Building Damage

- 300,000 significantly damaged (1 in 16)
 - repairs cost at least 10% of replacement cost
- 45,000 complete losses (1% of all buildings)
- Unreinforced masonry (most dangerous)
 - 300+ complete collapses
 - most near the fault will be destroyed
 - Retrofitting will save lives
- Older concrete buildings (almost as dangerous)
 - 50 collapses
 - 100 red tagged buildings
 - 5,000 – 10,000 people in collapsed buildings (most survive)
- Pre-1994 Steelframe buildings (at risk, but less dangerous)
 - High rises will receive intense long-period shaking
 - Scenario assumes 5 collapses (not necessarily complete collapse)
 - 10 red tags
 - 11-15 stories, up to 1,000 occupants each
- Woodframe buildings (most numerous)
 - 175,000 wood buildings significantly damaged (1 in 25)



1994 Northridge CA



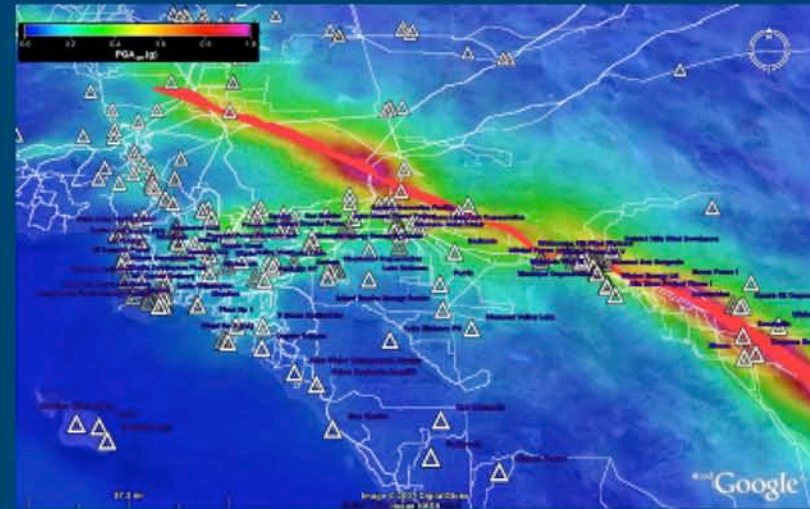
1992 M7.1 Mendocino



Kobe, Japan 1995

Lifeline Disruptions

- Water system damage is critical
 - Many homes and businesses without water for 1 week...
 - ... some for as long as 6 months
- Electricity and gas outages widespread
 - Even in hardest hit areas, 90% of service restored in days
- Phone systems overwhelmed
 - Cell towers unregulated so damaged
 - Fault offsets internet lines
 - All service out for first day; most restored within 2 weeks



Transmission lines & power plants



1971 San Fernando Earthquake

A National Economic Disaster



Los Angeles Total Truck Flows (1998)

Deaths and Injuries

- 50,000 injured (requiring emergency rooms)
 - Many non-functional hospitals due to structural or non-structural damage
 - Up to 2/3 of hospital beds unavailable in some counties
- 1,800 killed
 - 900 from fires
 - 900 from shake-related building and transportation damage
 - Compare to Northridge earthquake:
 - 8,300 injured
 - 57 killed



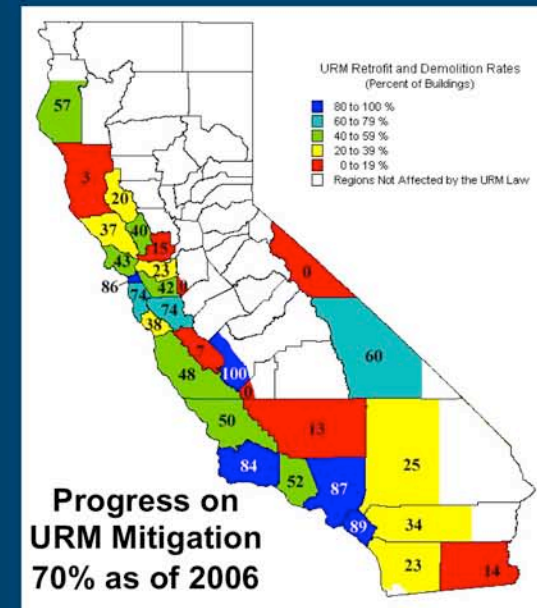
*Evacuation of Sherra Cox,
1989 Loma Prieta earthquake*



*Olive View Medical Center
1971 San Fernando earthquake*

Why it is not even worse

- Protections in the Built Environment
 - Inherently rugged construction
 - Steadily improving building codes
 - Highly trained, licensed engineers & contractors
 - Good code enforcement
- Mitigation Works
 - Enormous effort to upgrade highway bridges
 - Extensive work by electric power utilities
- Planning/Legislation
 - The Field Act
 - Unreinforced Masonry (URM) retrofit laws
- Not the Worst Case
 - Not the biggest or most urban-centric earthquake
 - No Santa Ana winds



The Great Southern California ShakeOut

- November 12-16, 2008
 - Week of special events to inspire SoCal to get ready for a Big One
- Region-wide earthquake drill Nov. 13
 - > 5 million of participants
- LA International Earthquake Conference
- “Get Ready Rally” in downtown L.A.
- Hundreds of community events
- Concurrent statewide “Golden Guardian” emergency response exercise
 - Largest ever



Shake
Out



ShakeOut Goals

- Participation of at least 5 million people in the ShakeOut Drill
 - School, Business, and Community Organization recruitment efforts will have several million people participate
 - Everyone is encouraged to “spread the word” to promote people participating in the ShakeOut!
- Shift the culture in southern California about earthquakes
 - We must all take greater responsibility for readiness
 - We all need to talk about earthquakes and preparedness more often
- Significant increase in earthquake readiness at all levels

What Leads to People Getting Prepared?

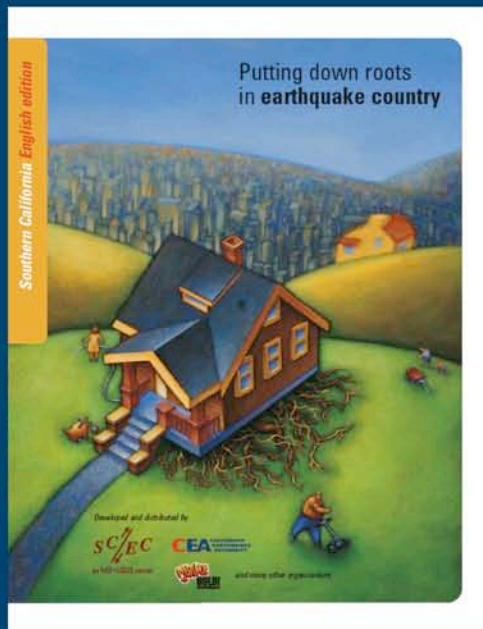
- They see and hear consistent, frequent, multi-media, and multi-source information about what to do to be prepared
 - “Sell” earthquake preparedness like Coca Cola sells Coke.
- They see others like themselves getting prepared
 - “Monkey See, Monkey Do”
- They talk about preparedness with people they know
 - And then think it’s their idea.

More Readiness Information



The screenshot shows the 'Dare to Prepare' website. The main heading is 'Dare to Prepare'. Below it, there is a section titled 'Secure Your Space!' with a sub-heading 'Other Resources'. A sidebar on the left contains 'Campaign Overview', 'Secure Your Space!', 'Other Resources', 'Calendar', 'News', and 'Contact Us'. The main content area includes a quote: 'Acknowledging that "Shift Happens," the main message of the Dare to Prepare campaign is that if you "Secure Your Space" you can protect yourself, your family, and your property. Secure your space by strapping top-heavy furniture and appliances to walls, adding latches to kitchen cabinets, and securing TVs and other heavy objects that can topple and cause serious injuries. Homes and other buildings should be retrofitted if necessary. These and other actions will greatly reduce your risk of damage or injury, and limit your need for community resources after the next earthquake.' There is also a 'Featured News Items' section with several news snippets.

- www.DareToPrepare.org
- www.Terremotos.org
- Dropcoverholdon.org
 - Play "Beat the Quake"
- *Putting Down Roots in Earthquake Country*



- 32-page handbook
- Includes "Seven Steps to Earthquake Safety"
- Online to read, download, or order free printed copies

