

Earthquake
Early
Warning

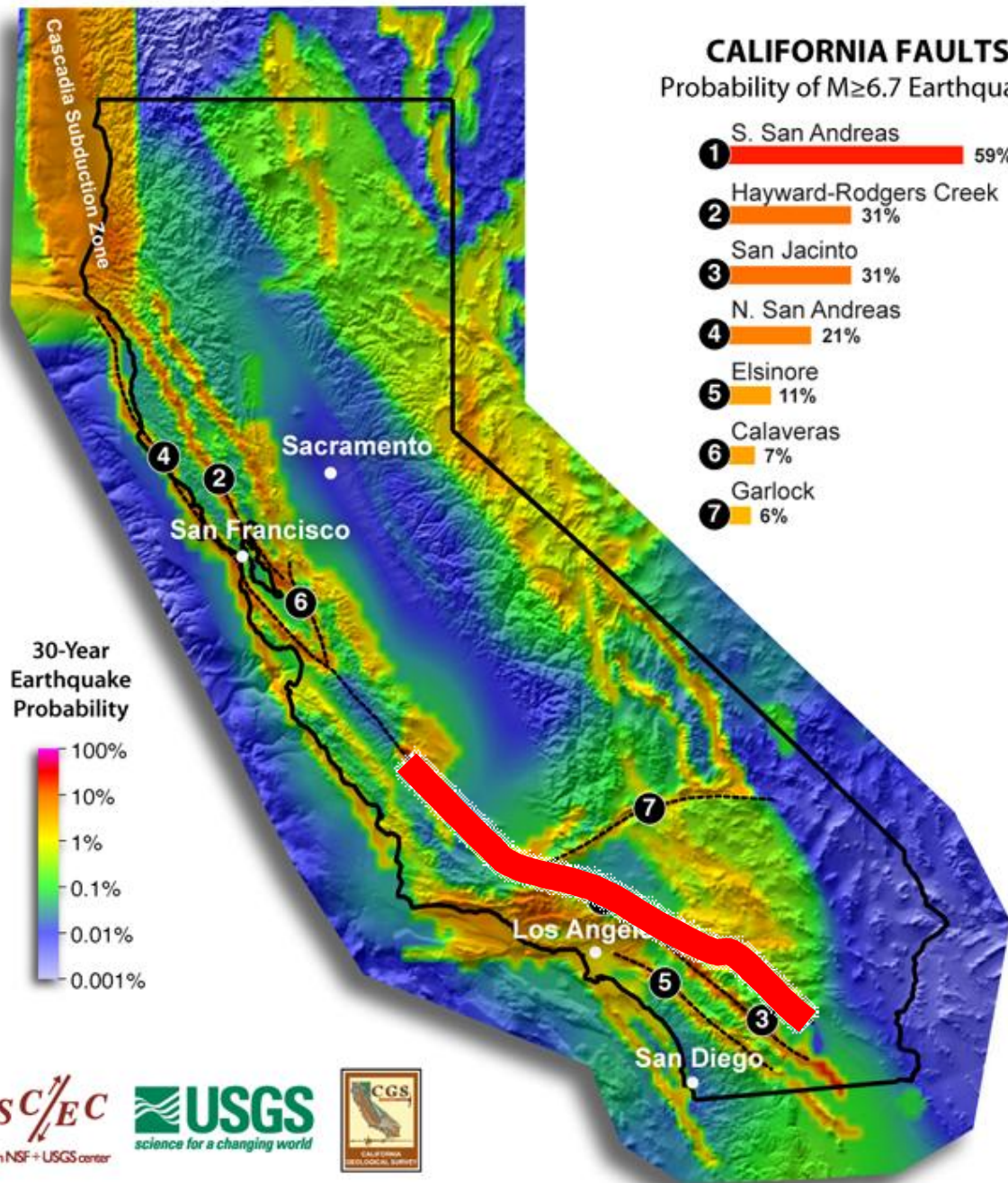
&

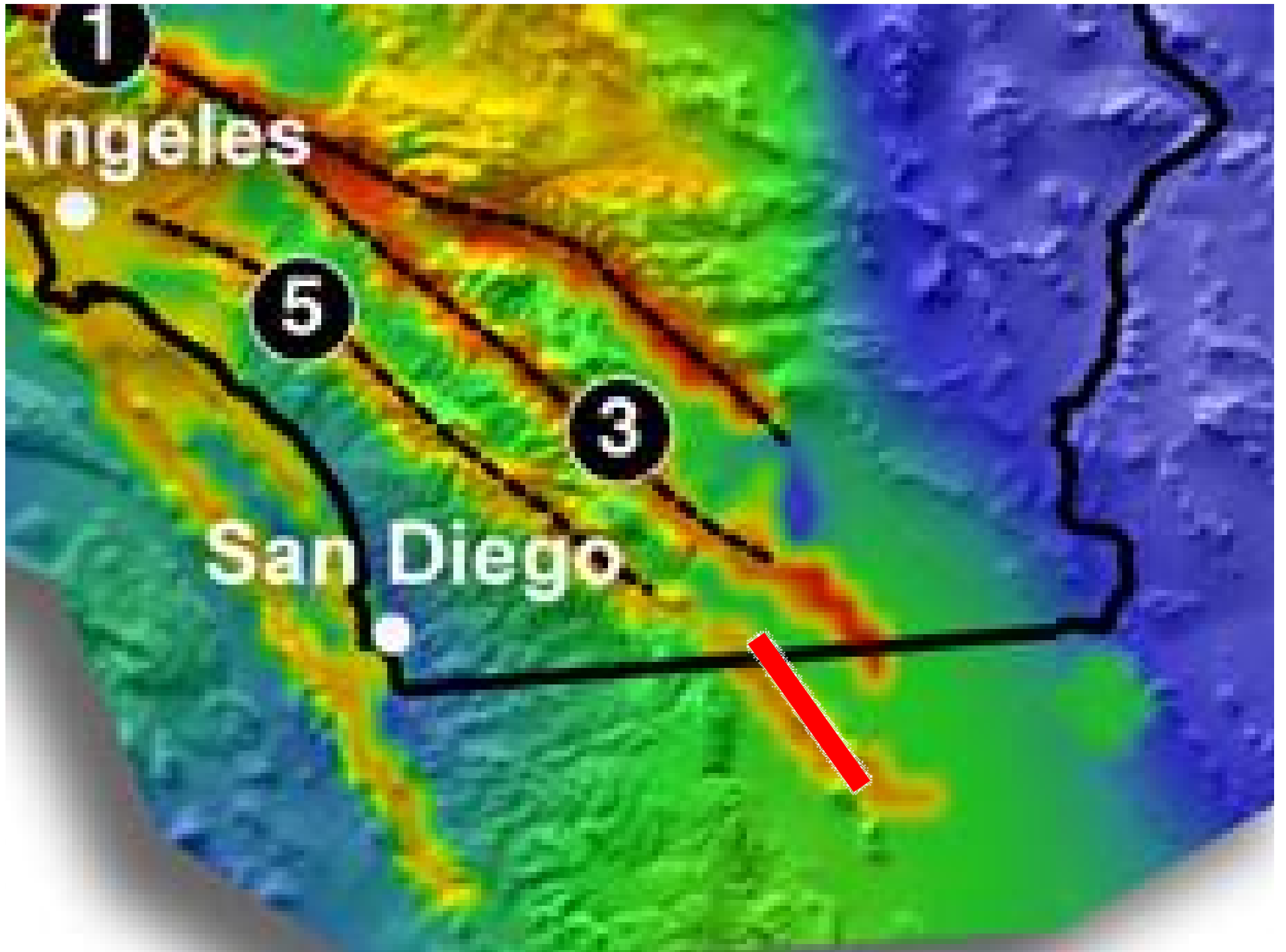
The Great
California
Shake
Out



an NSF + USGS center

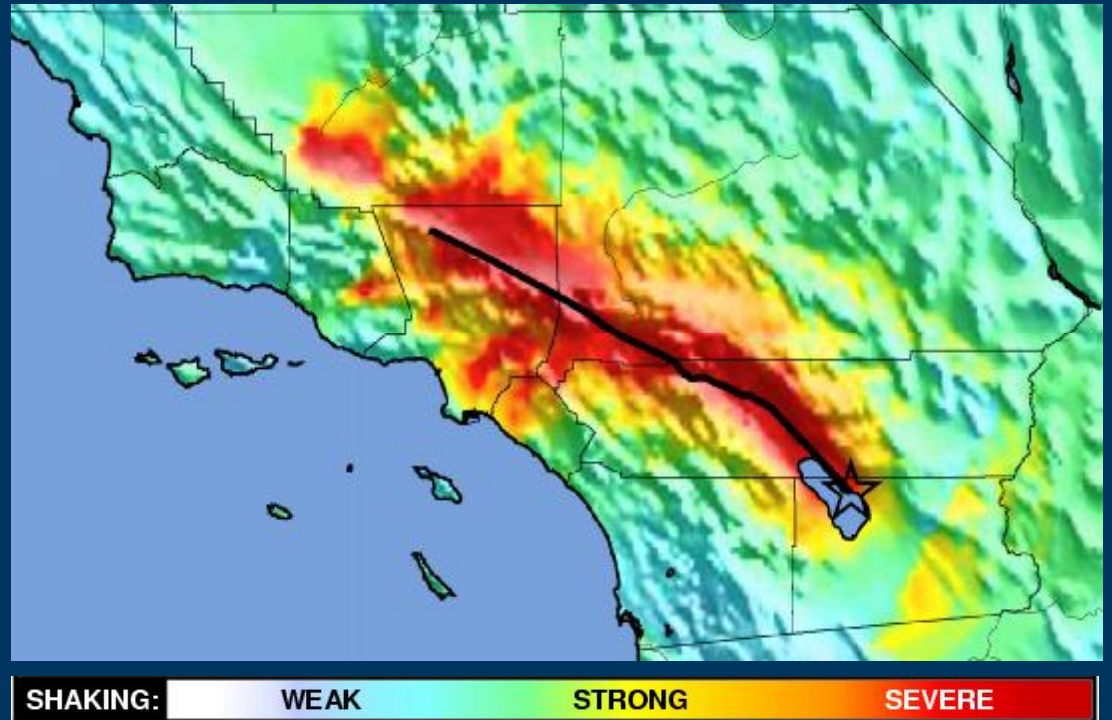
Mark Benthien
Southern California Earthquake Center



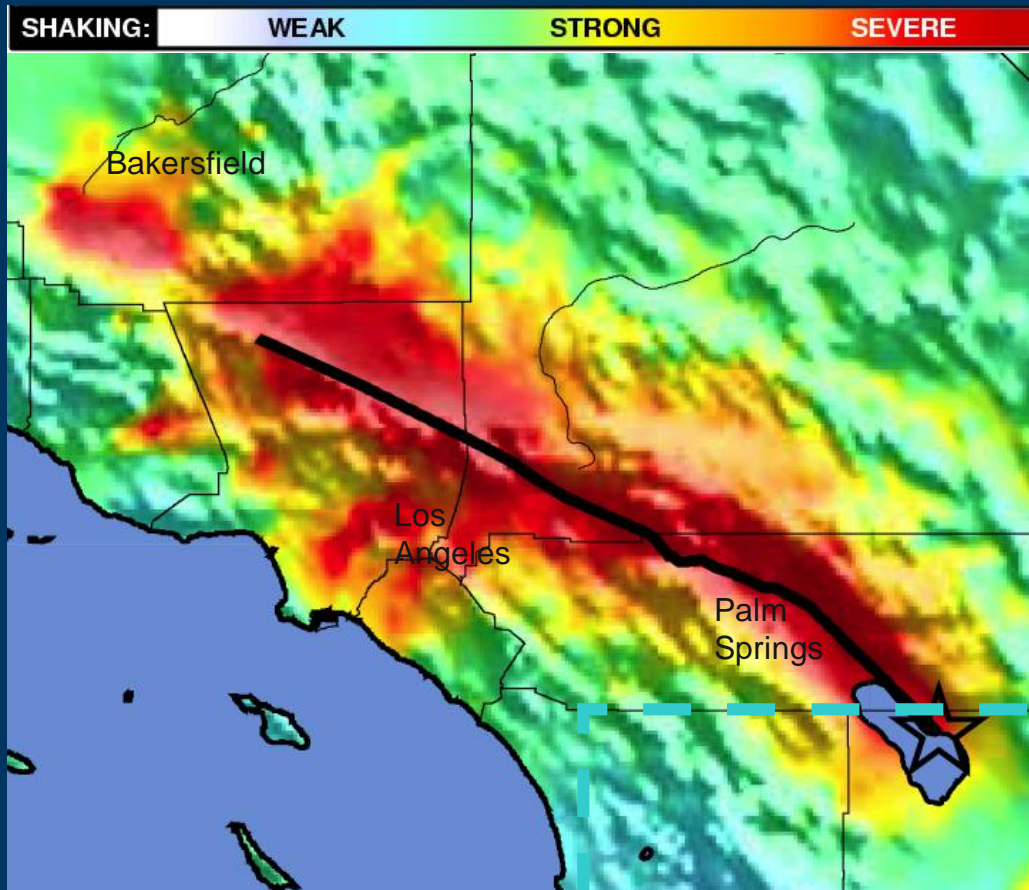


A Possible “Big One”

- Southernmost San Andreas
- 180 mile 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.

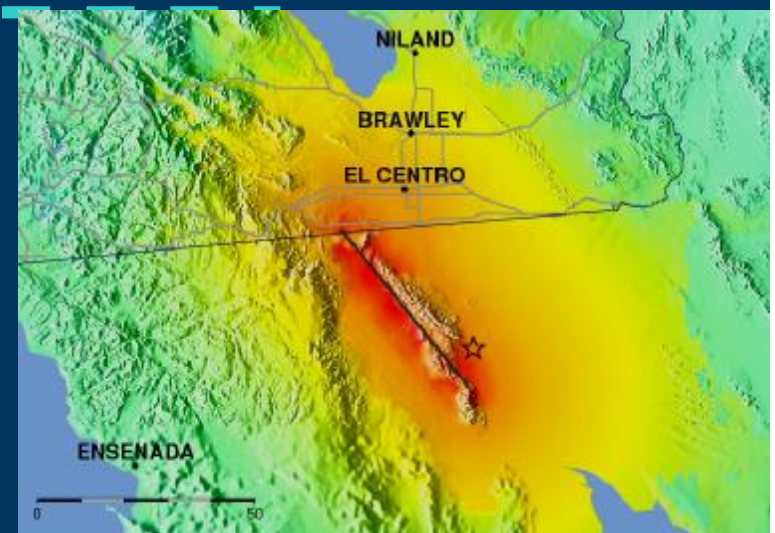


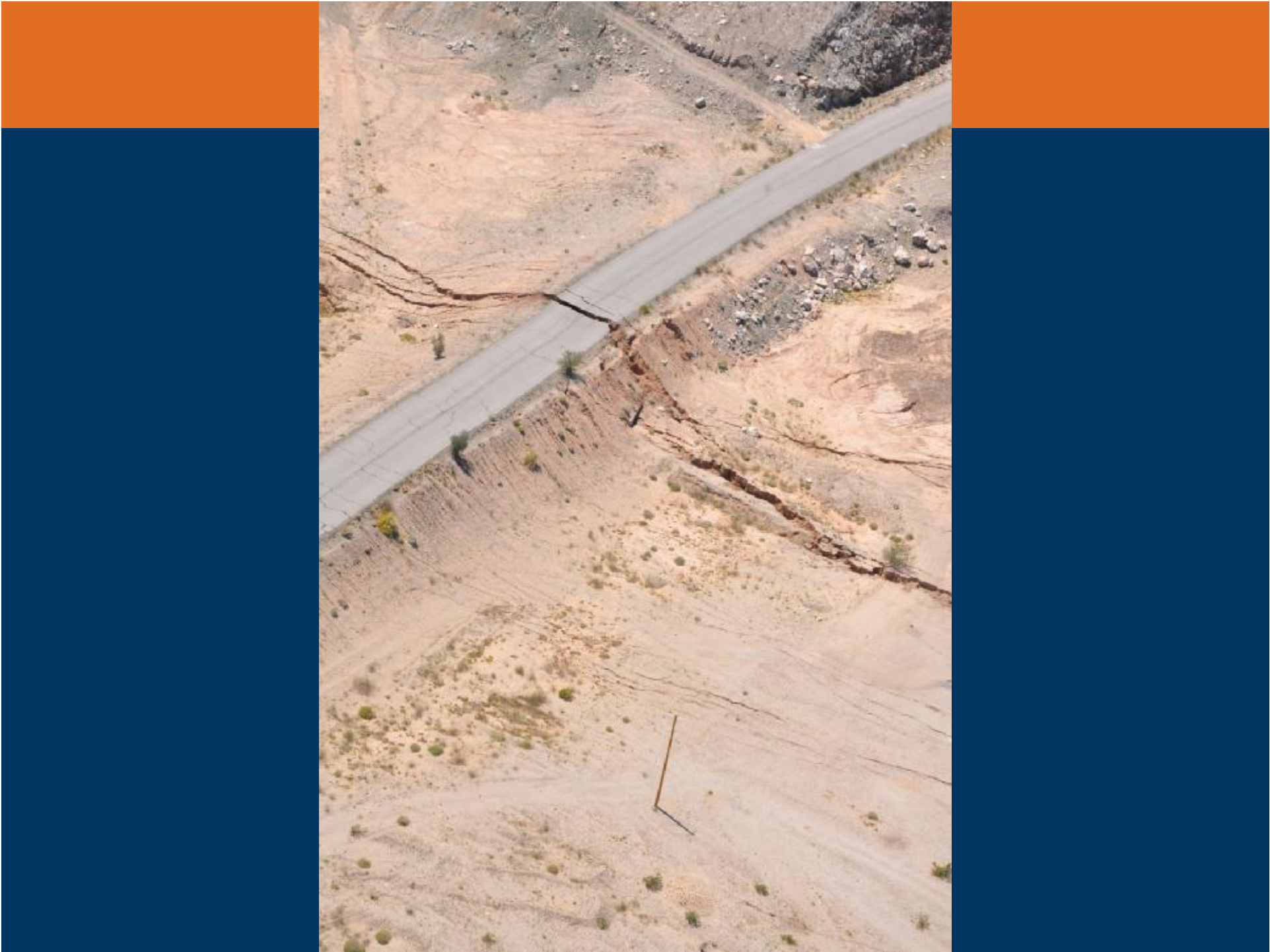
A not-so-big one (but biggest since '92)



Compare with
2010 Sierra El Mayor
earthquake:

- 8x smaller!
- Magnitude 7.2
- 2 deaths
- Damage being assessed



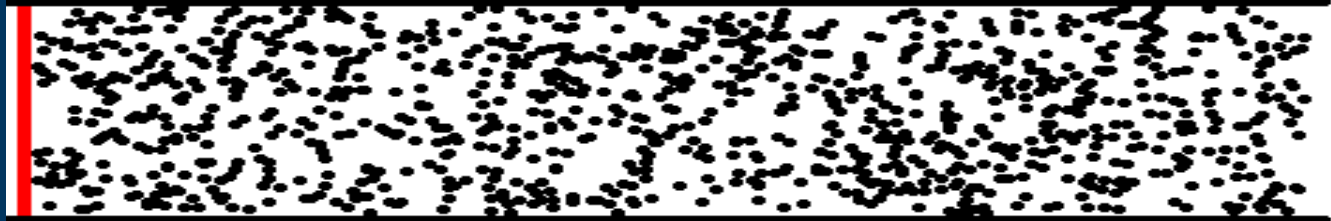




Earthquake Waves

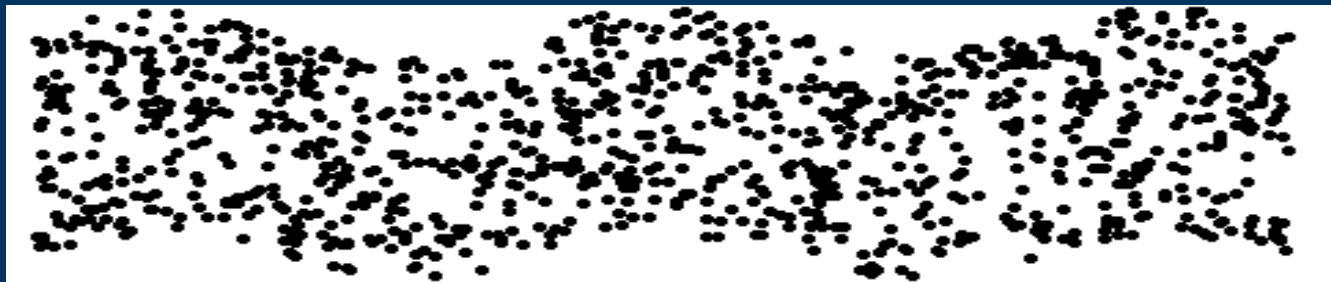
P-wave

~3.5 mi/sec



S-wave

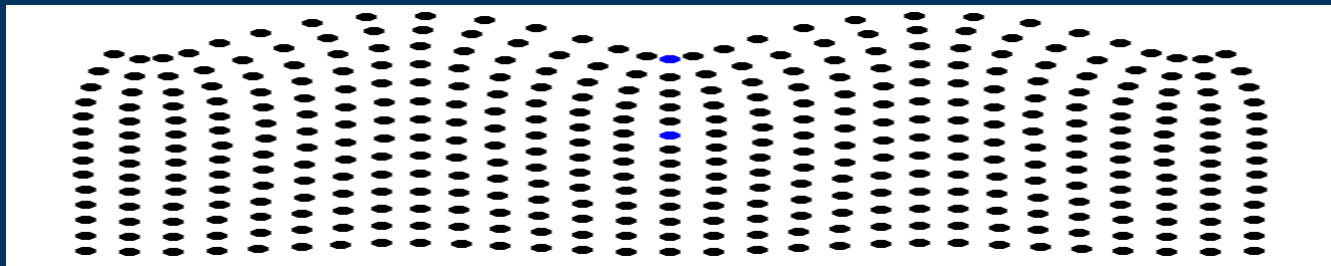
~2 mi/sec

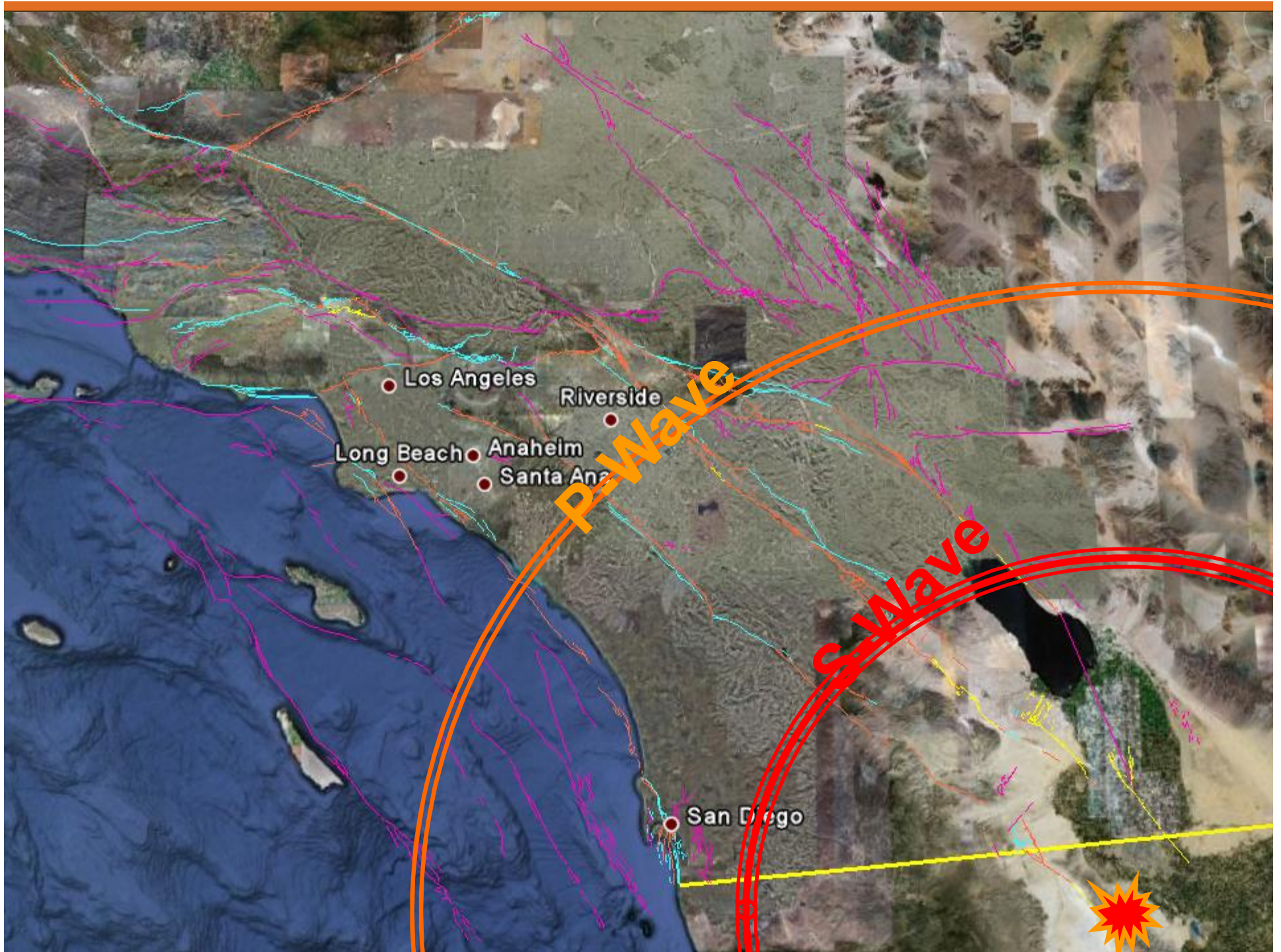


Surface wave

< 2 mi/sec

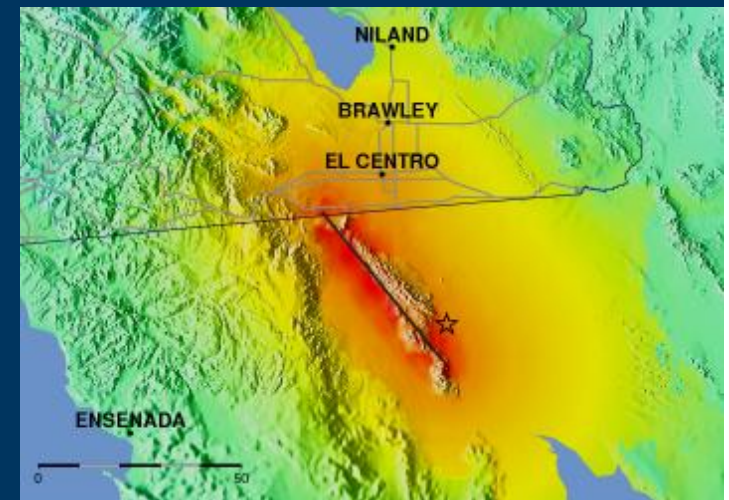
(Rayleigh)





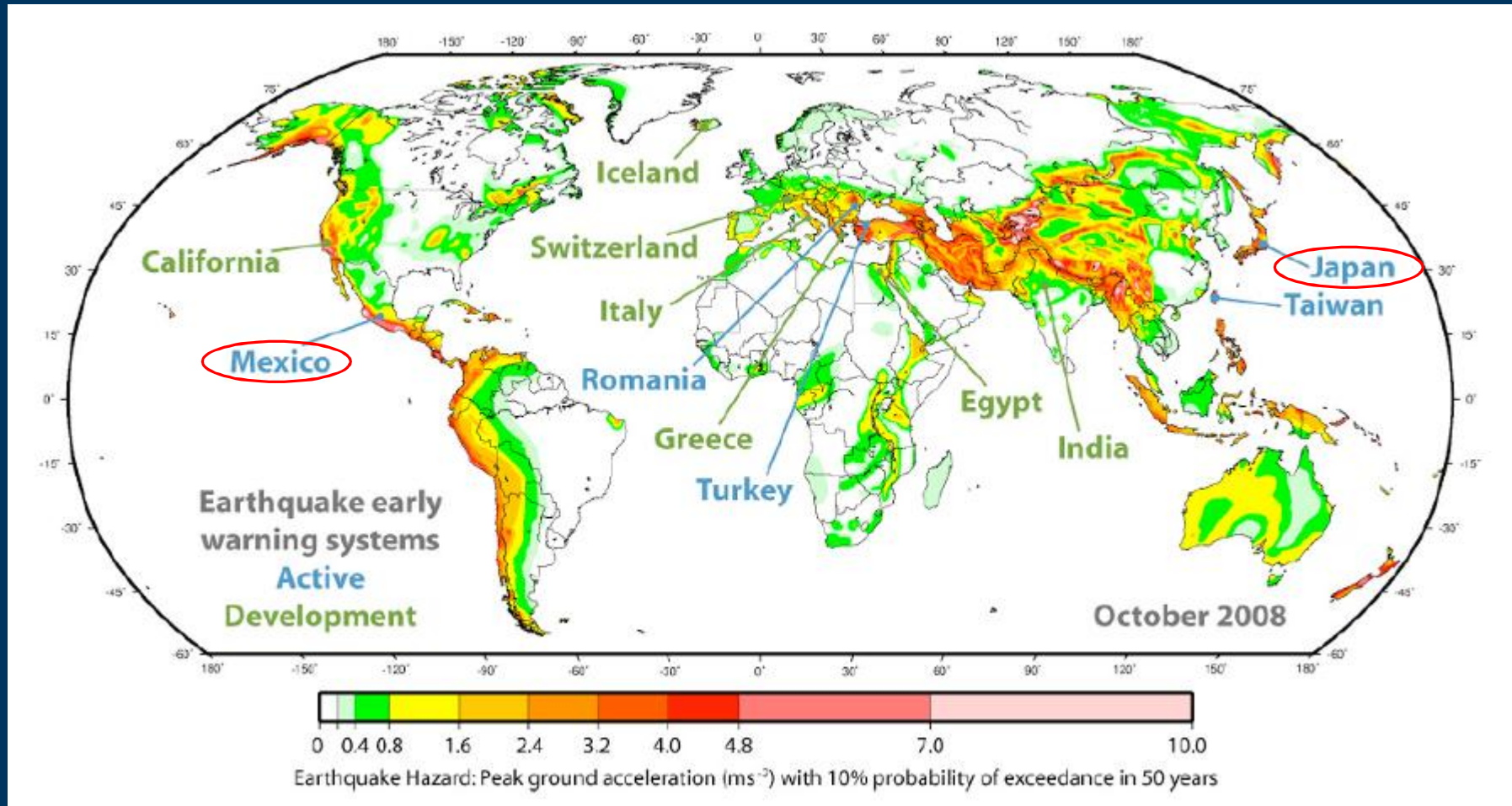
My Mobile Warning!

- Epicenter of the Sierra El Mayor earthquake was 80 miles from my father in San Diego (0:00)
- Shaking arrived in around 25 seconds (0:25)
- Shaking lasted about 20 seconds (0:45)
- My father then went to get his cell phone (!) and called me, which took approximately 60 seconds (1:45)
- P-wave arrived in LA but too small to notice (1:00)
- My phone rang 5 seconds before the S-wave began (1:50)



This is the basis behind “Earthquake Early Warning” (EEW)

Who's Doing EEW?



Public messages

Richard Allan, UCB

Mexico City EEW System



centro de instrumentación y registro sísmico a.c.

Imprimir Inicio Cerrar

BOLETÍN DEL SISTEMA DE ALERTA SÍSMICA (SAS)

Avisos Recientes

No.	Fecha	Hora Local	Tipo de Aviso
1	2009-10-29	22:10:29	Sin Alerta
2	2009-10-28	19:24:02	Sin Alerta
3	2009-10-24	16:04:51	Sin Alerta

Buscar Avisos Recientes

El **29 DE OCTUBRE DE 2009** a las **22:10:29** hrs. (hora local) el SAS detectó un sismo en **2** de sus **12** estaciones en Guerrero. El SAS **NO GENERÓ** señal de alerta porque la energía del sismo en desarrollo no superó los niveles de disparo preestablecidos. El epicentro del sismo detectado por el SAS (Fuente SSN) se indica en el mapa de abajo.



Alertas Recientes

No.	Fecha	Hora Local	Tipo de Alerta
1	2009-04-27	11:46:45	Preventiva
2	2009-03-27	02:48:32	Preventiva
3	2008-11-11	05:02:28	Preventiva

Buscar Alertas Recientes



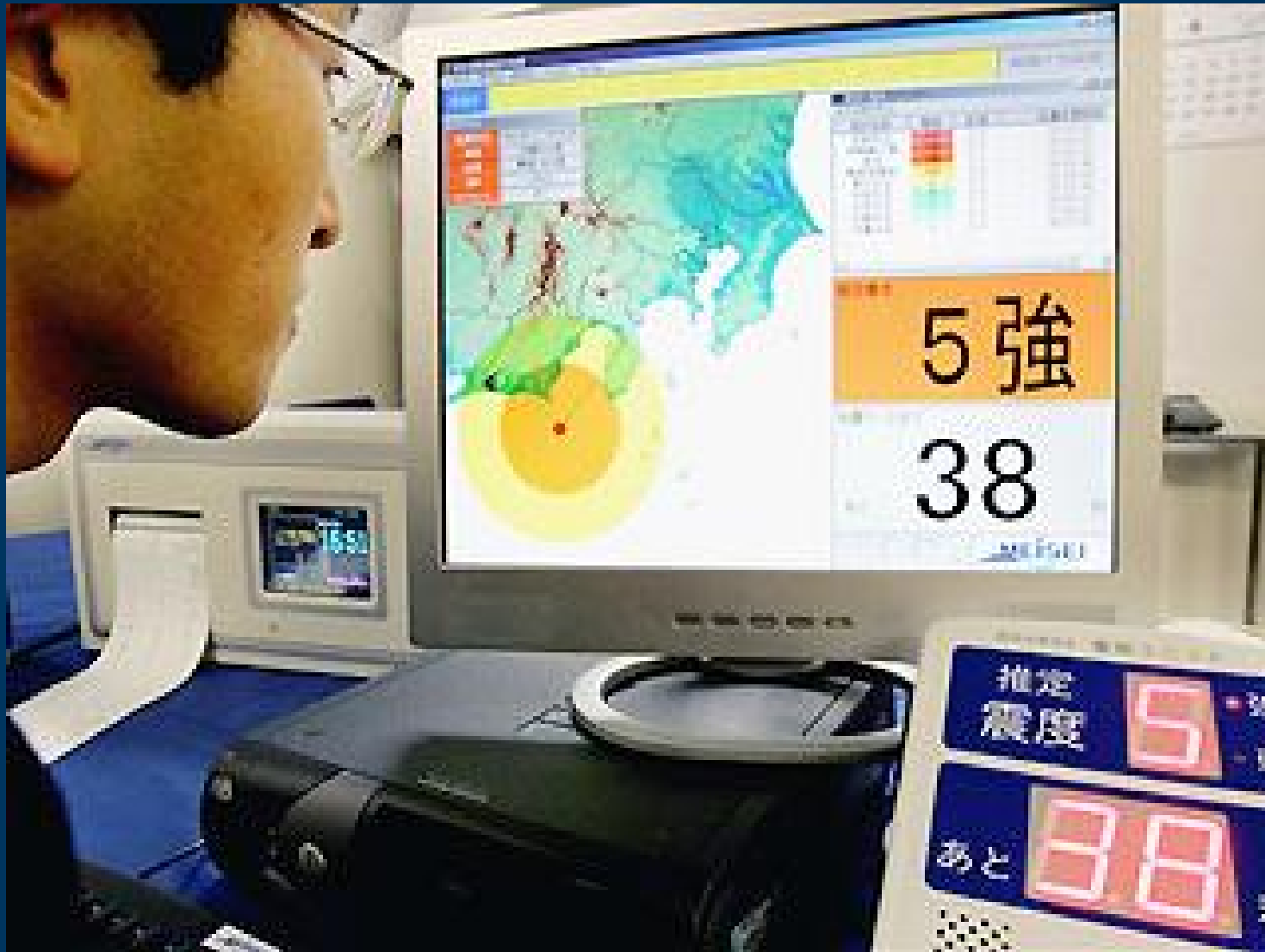
Mexico City

Estado de las Estaciones del SAS, Fecha: 2009-10-29 Hora: 22:10:29

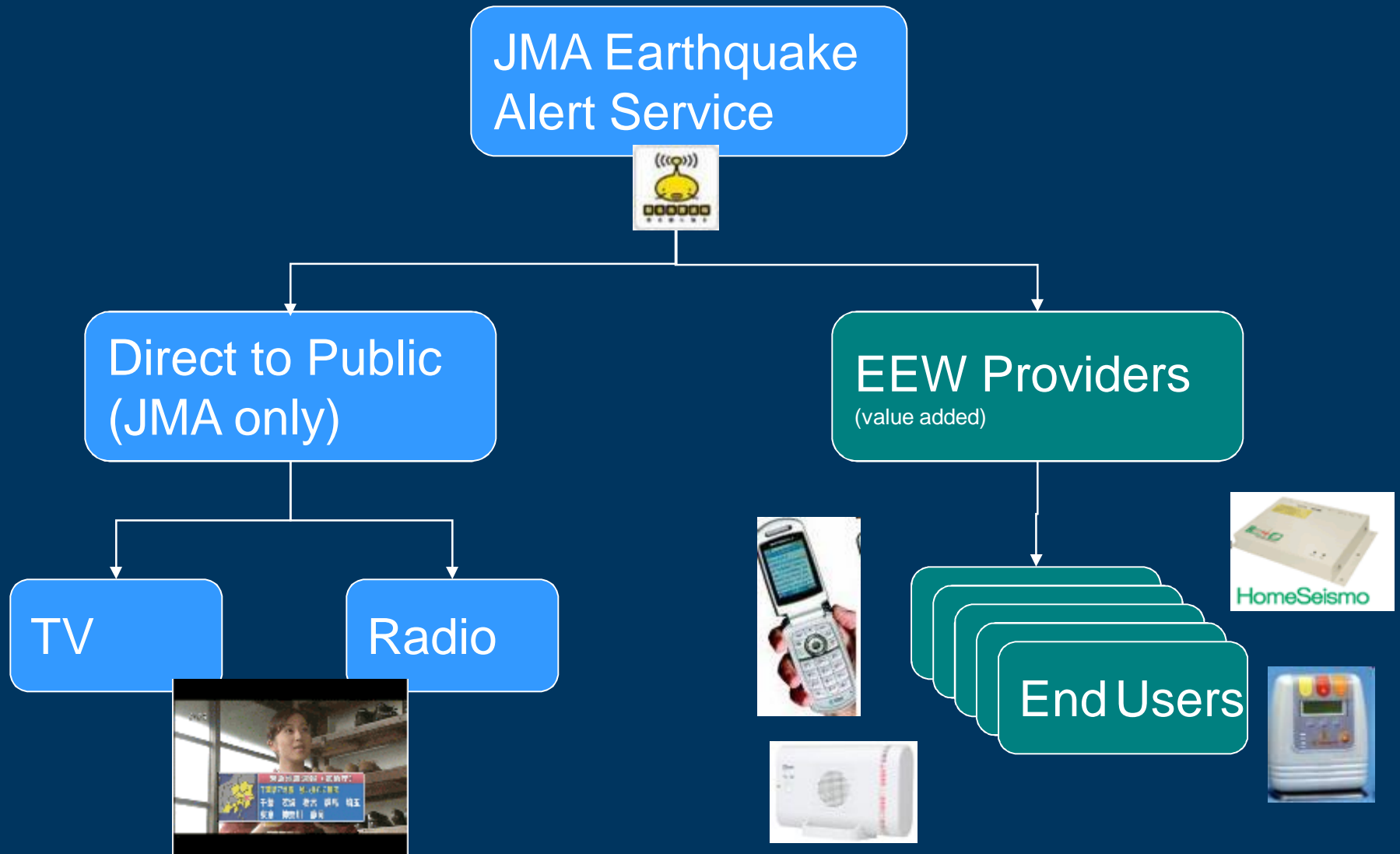
No.	Estación	Boletín	No.	Estación	Boletín	No.	Estación	Boletín
1	Papanoa	No Detectó	5	Pénjamo	No Detectó	9	Las Vigas	Detectó
2	El Veinte	No Detectó	6	El Jardín	No Detectó	10	El Carrizo	Detectó
3	Tetitlán	No Detectó	7	San Pedro	No Detectó	11	Marquelia	No Detectó
4	Cacalutla	No Detectó	8	El Cortés	No Detectó	12	Huehuetán	No Detectó

Japanese EEW System

Japan Meteorological Agency (JMA)



Japan Notification Structures



What about California?

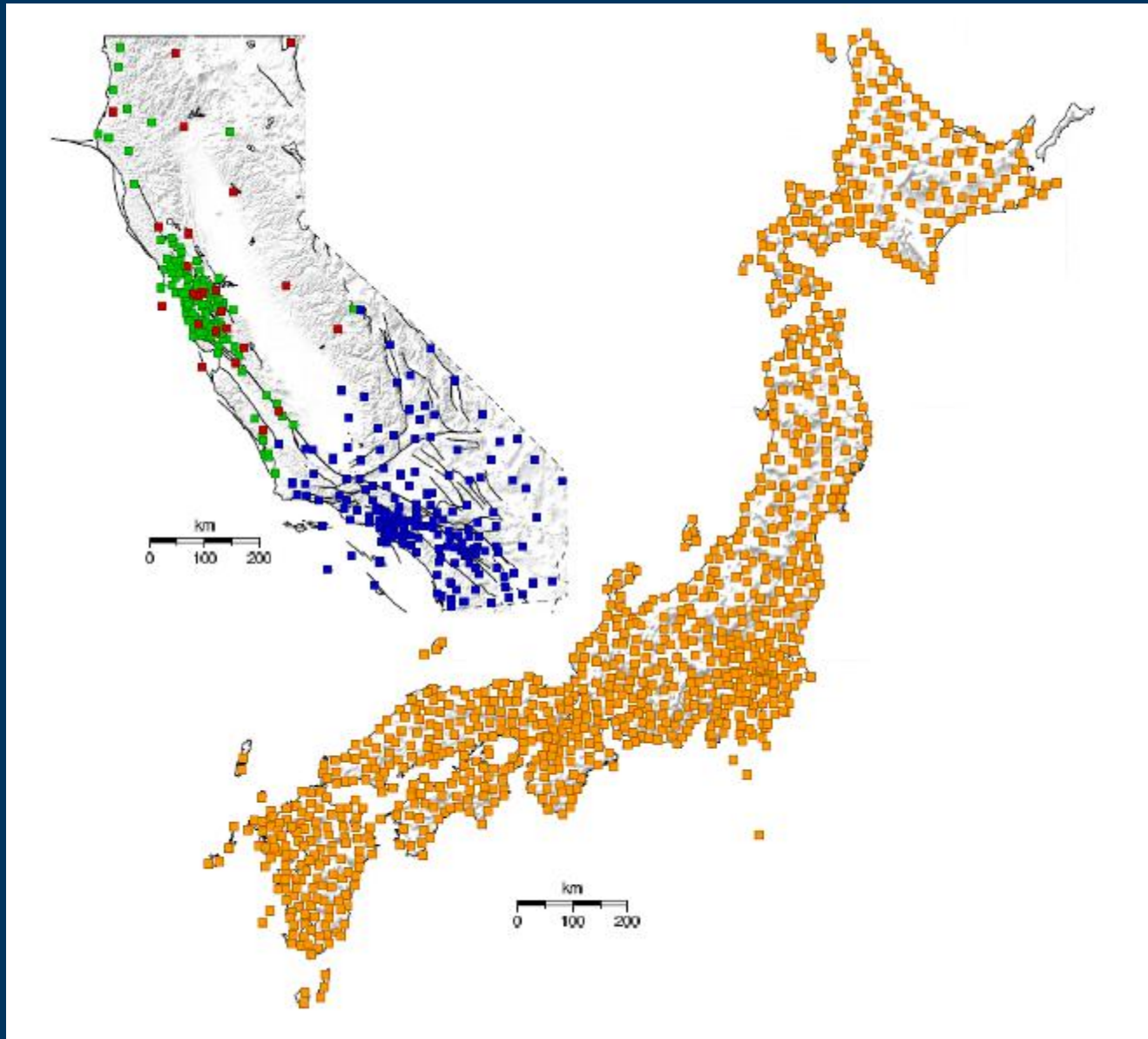
- EEW Development
 - Phase I: *(2006-2009 completed)*
 - Development & Testing of Algorithms
 - Phase II: *(2009-2012)*
 - Integration & Prototype Implementation



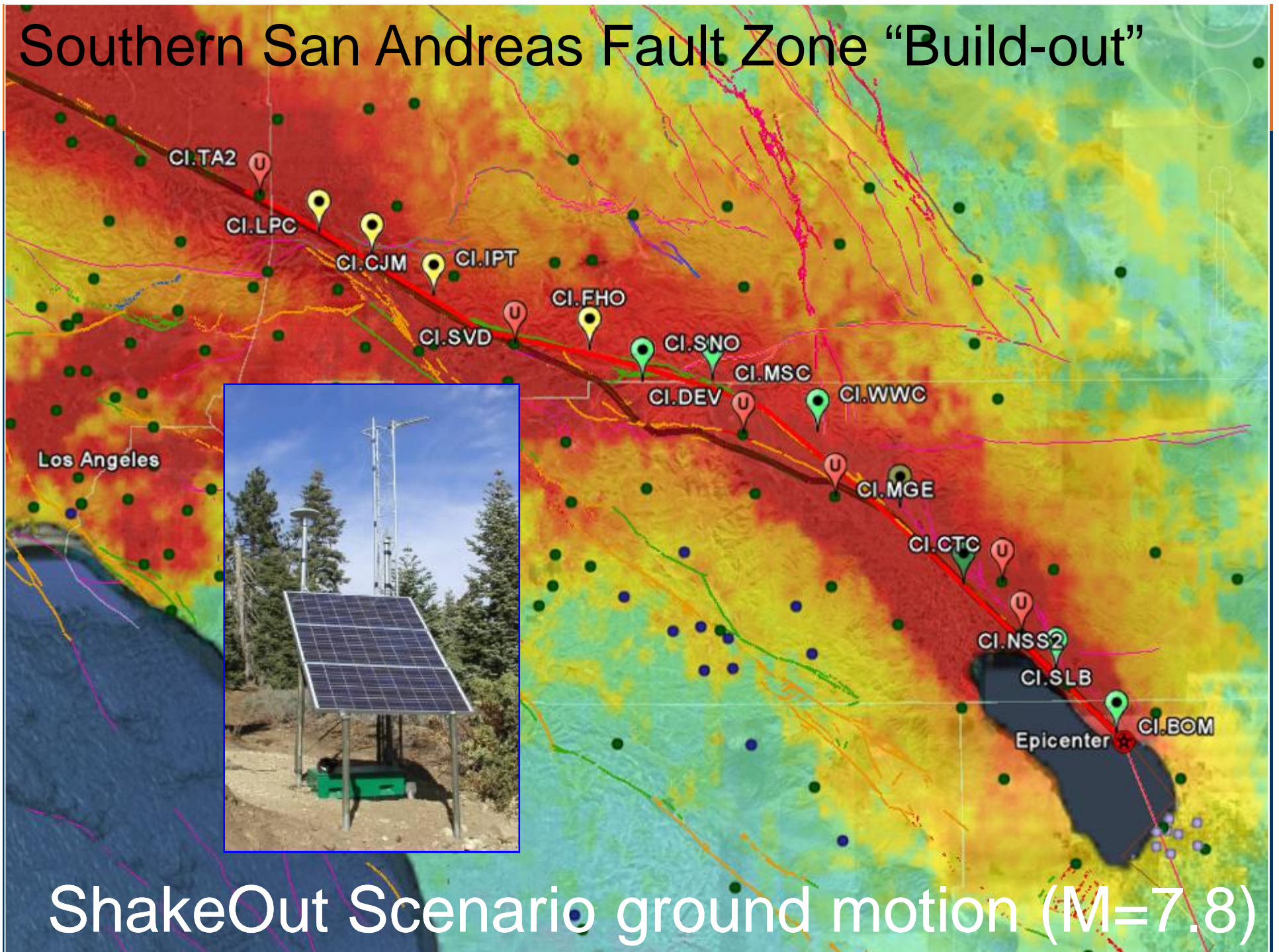
Requirements for EEW

- Closely spaced sensors near source areas
- Fast, reliable communication from field stations
- Fast, reliable algorithms
- Fast, reliable communication to users
- Automated response systems
- Well educated users

Station Density: CA vs. Japan



Southern San Andreas Fault Zone "Build-out"



ShakeOut Scenario ground motion (M=7.8)

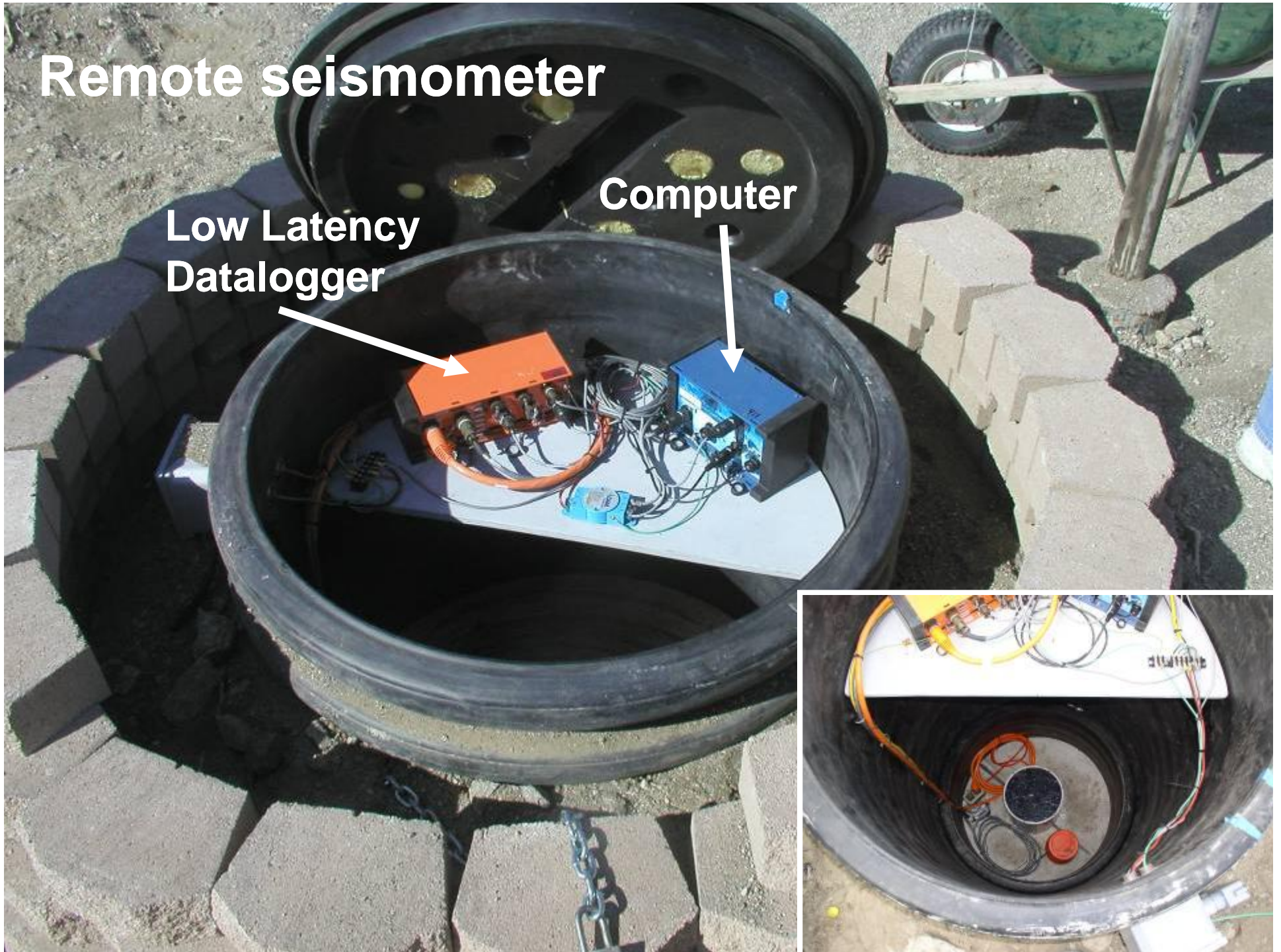
Requirements for EEW

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Remote seismometer

Low Latency
Datalogger

Computer



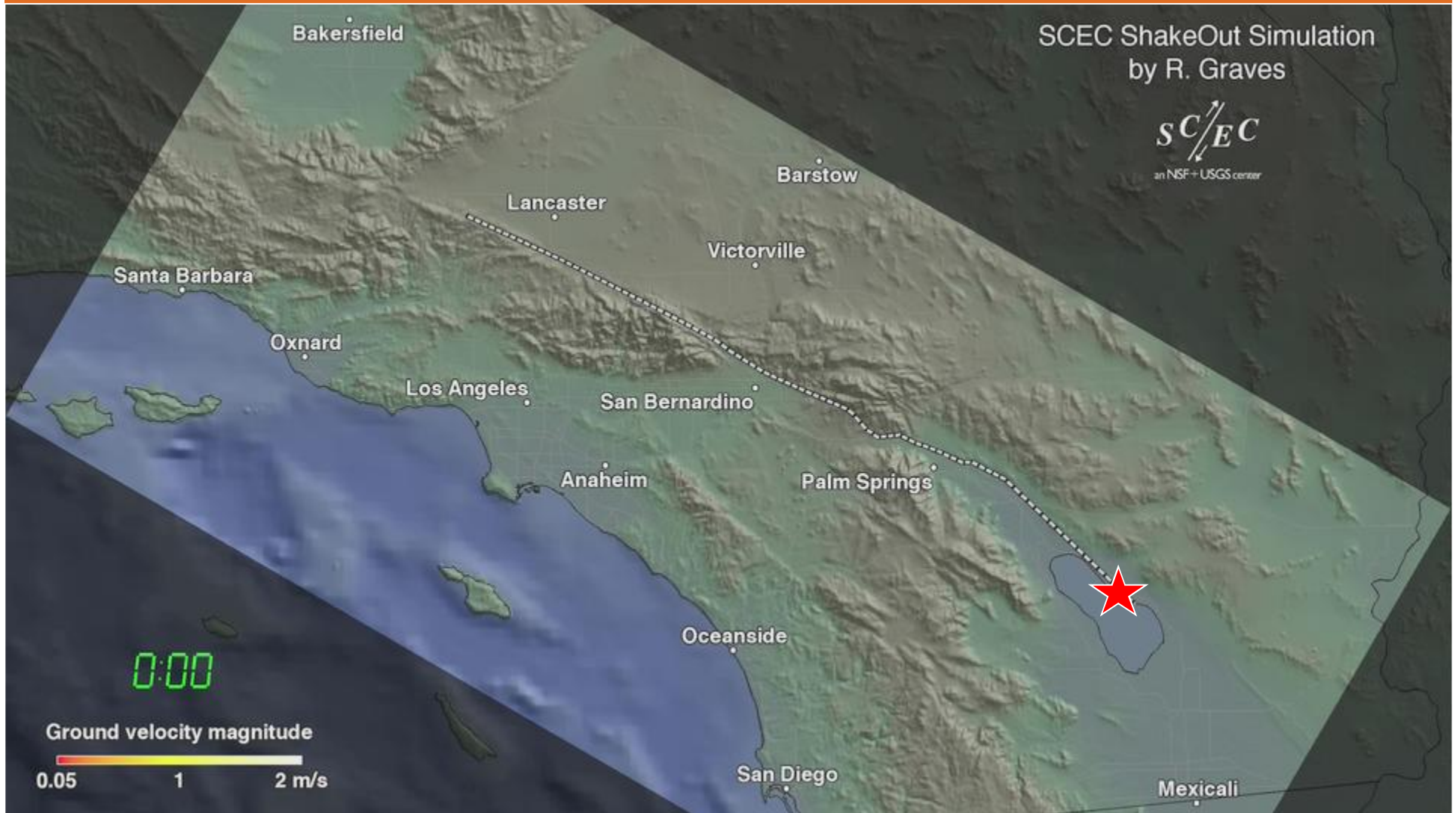
Fast, Diverse Data Telemetry



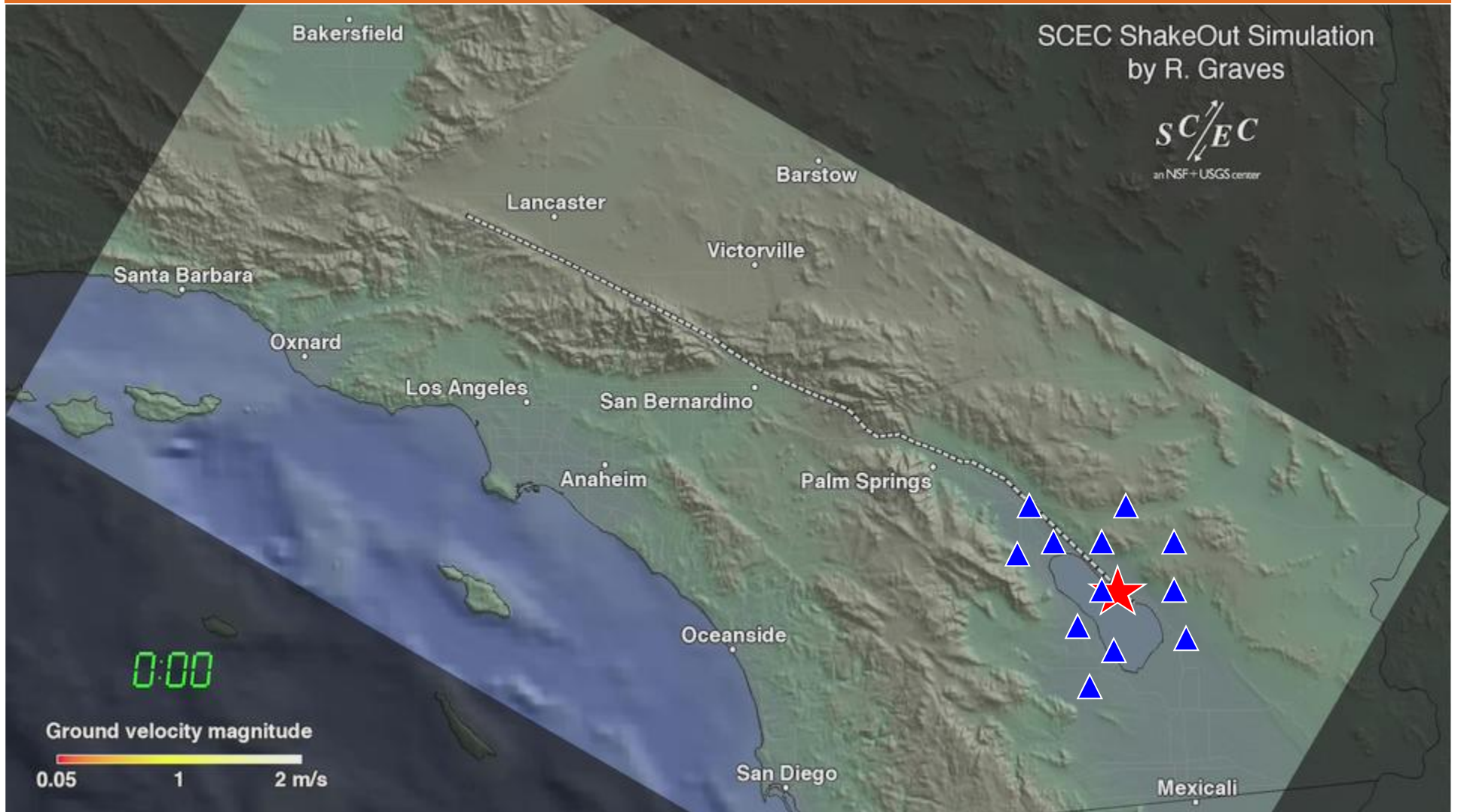
Requirements for EEW

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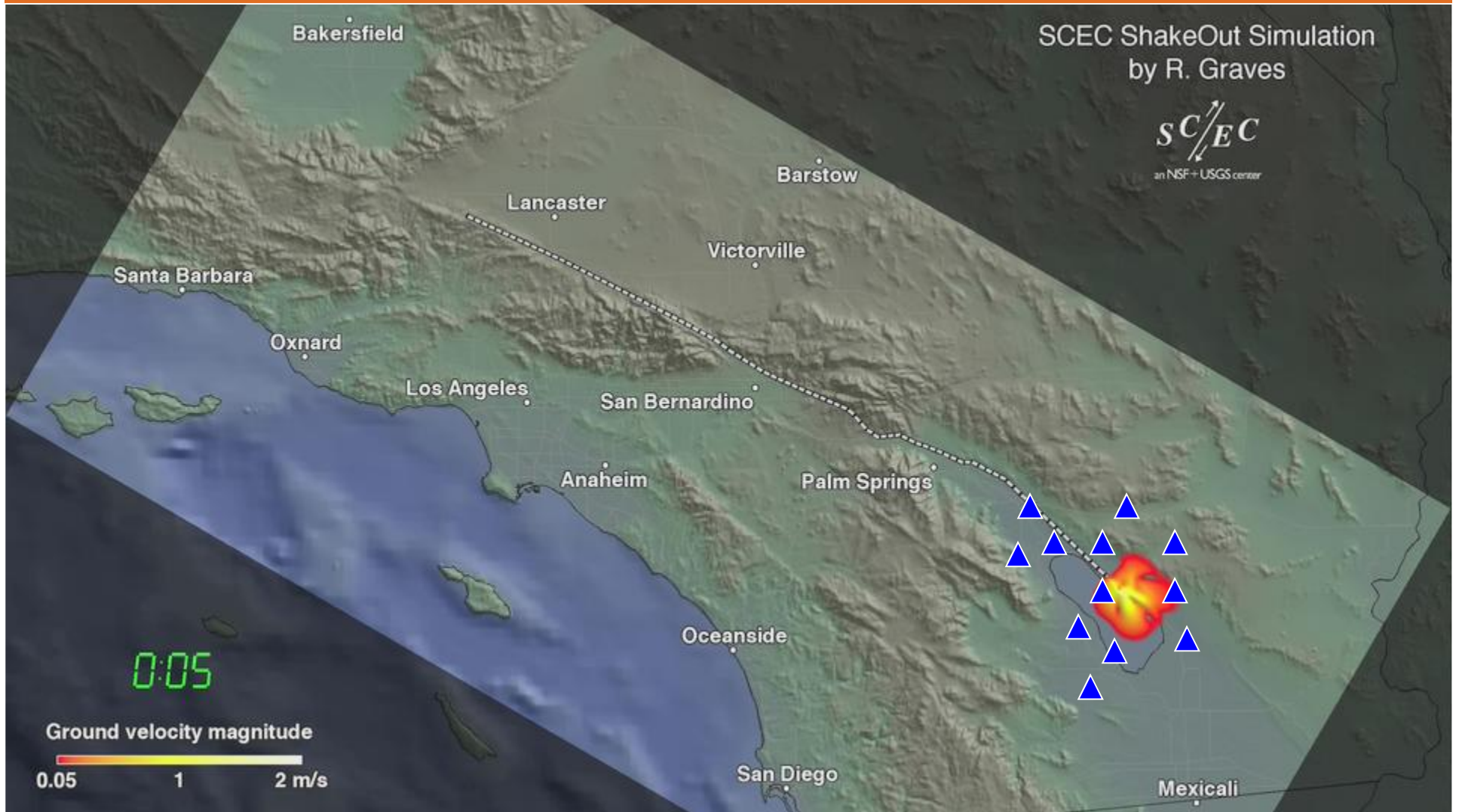
Southern San Andreas M=7.8 (Scenario)



Earthquake Begins



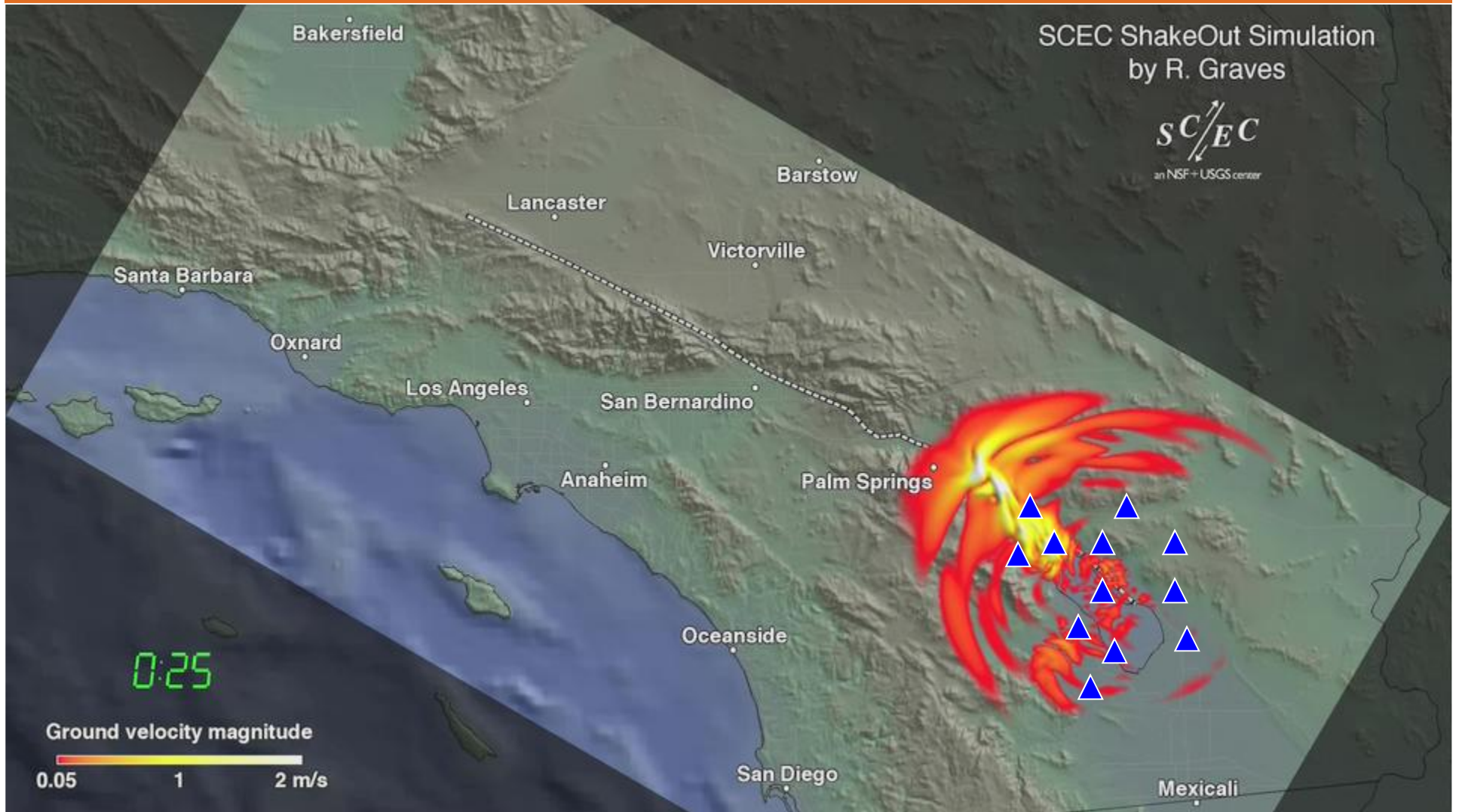
Stations Sense Shaking



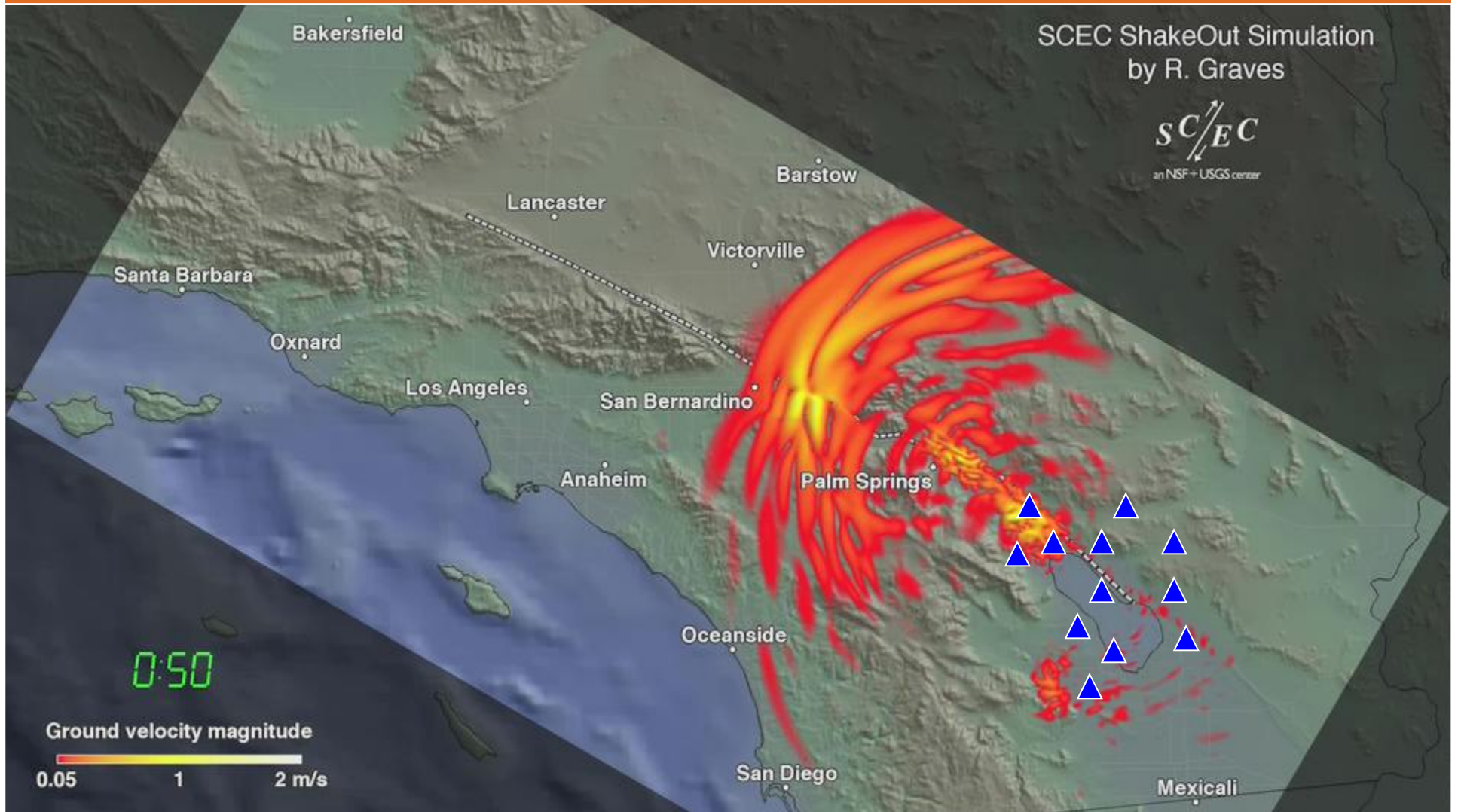
Warning Issued



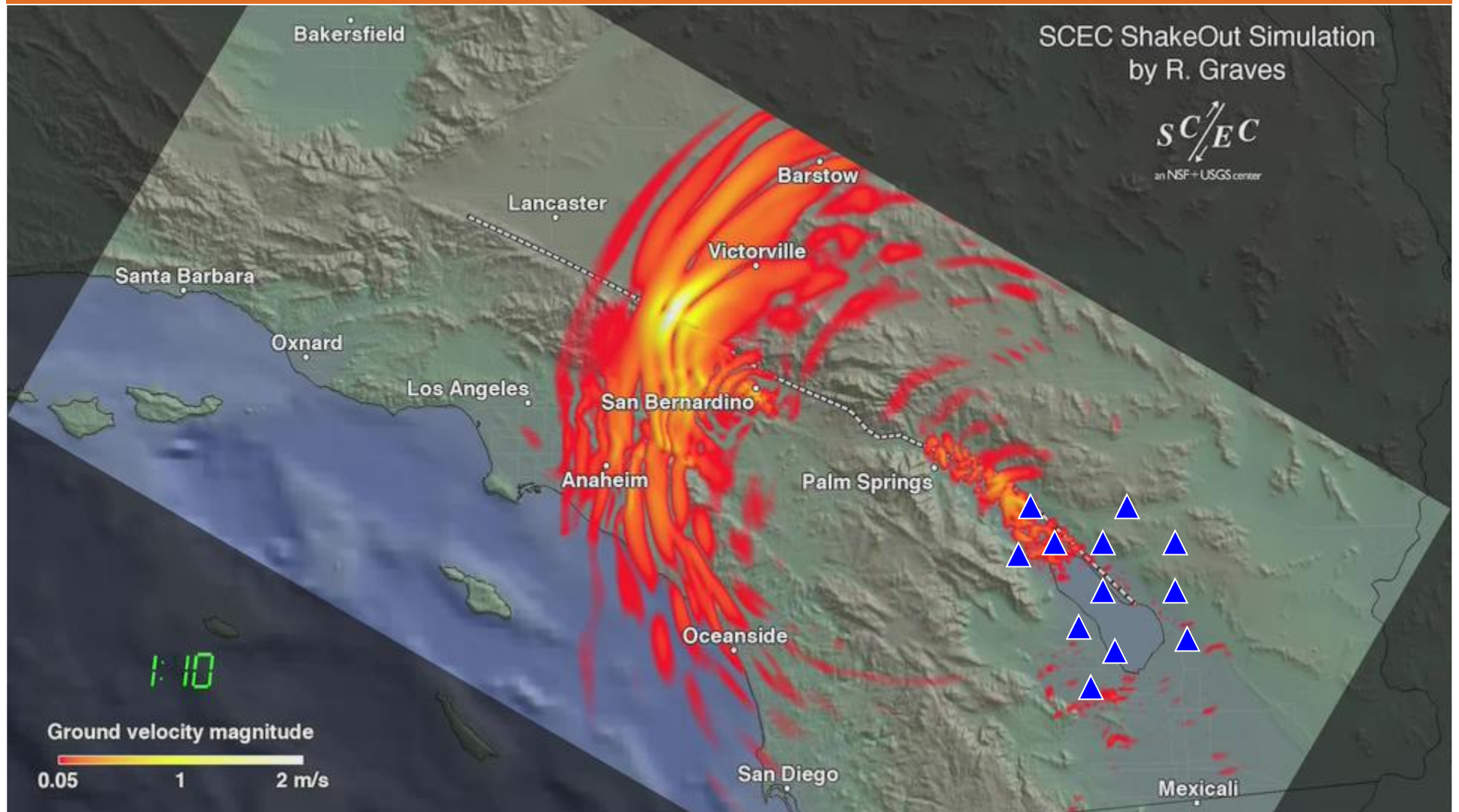
Strong Shaking Arrives



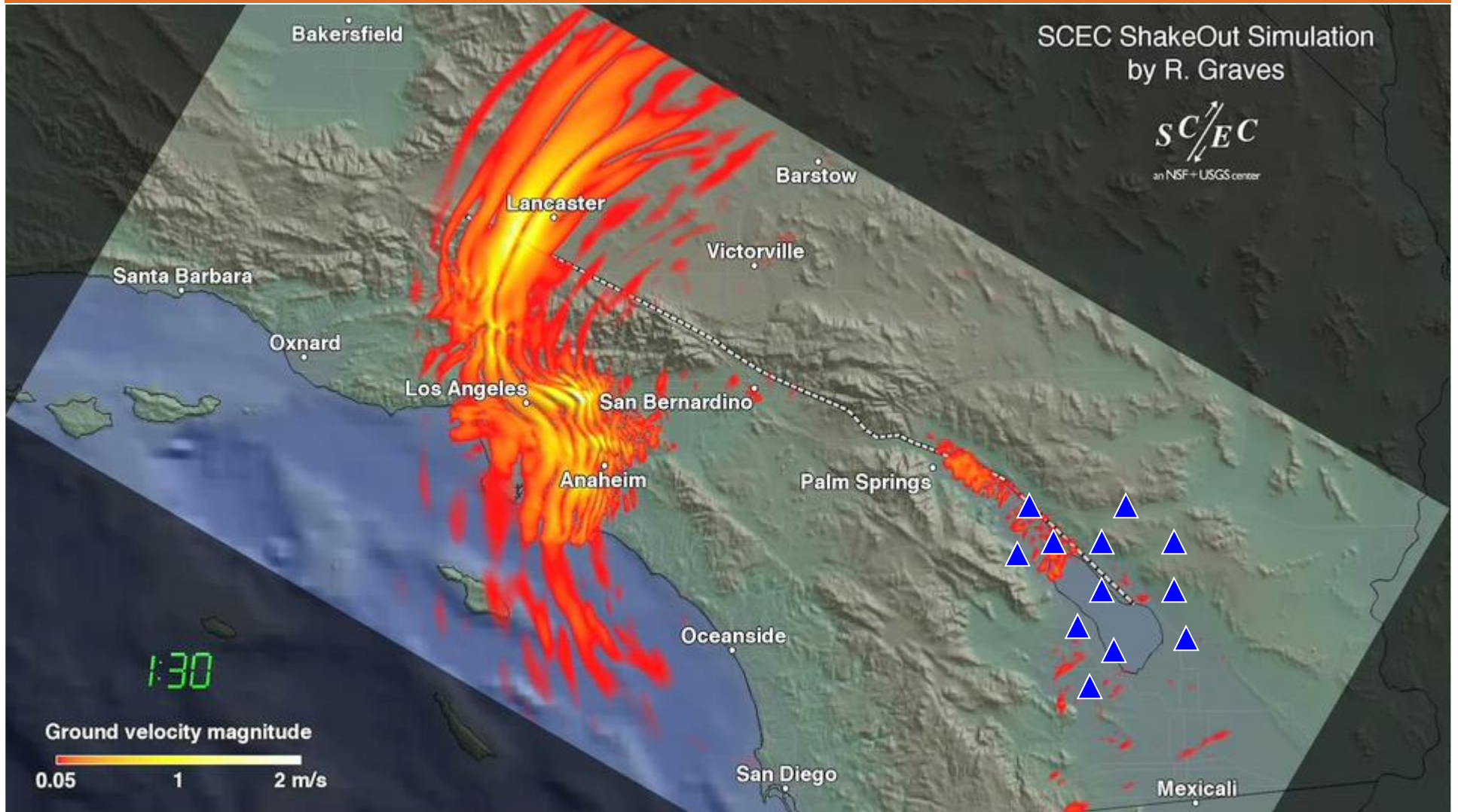
Strong Shaking Arrives...



Strong Shaking Arrives...



Strong Shaking Arrives...



EEW System Limitations

- Always a trade off between speed and accuracy
- Mistakes
 - False alarms - alarm but no quake (noise, equipment failure)
 - Bad alarms - miscalculated location or magnitude
 - Missed alarms - damaging quake, no alarm
- “Blind spot” – near the epicenter
- “So what?” zone – too far for damage



Requirements for EEW

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- Fast, reliable communication from field stations
- Fast, reliable detection algorithms
- Fast, reliable communication to users
- Automated response systems
- Well educated users

Rapid Mass Notification

- **Too slow....**
 - E-mail
 - Instant messaging
 - RSS
 - SMS (text messages)
 - Custom IP apps
 - Reverse 911



Rapid Mass Notification

- Possibilities
 - EAS via TV and radio
 - Air raid sirens
 - Broadcast cellular (not yet in US)
 - IP redistributers



Requirements for EEW

- Closely spaced sensors near source areas
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Potential Prototype Users...

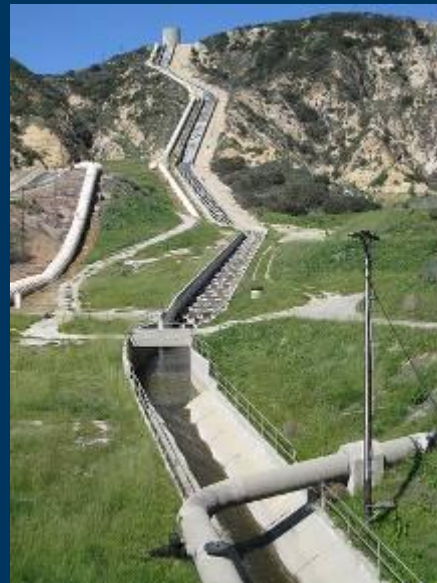
- BART



- BNSF



- LADWP



- Schools



Requirements for EEW

- Closely spaced sensors near source areas
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- Fast, reliable algorithms
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What can people do with a short warning?

- Drop, cover, and hold on
- Move from hazardous areas
- Stop driving
- Stop manufacturing



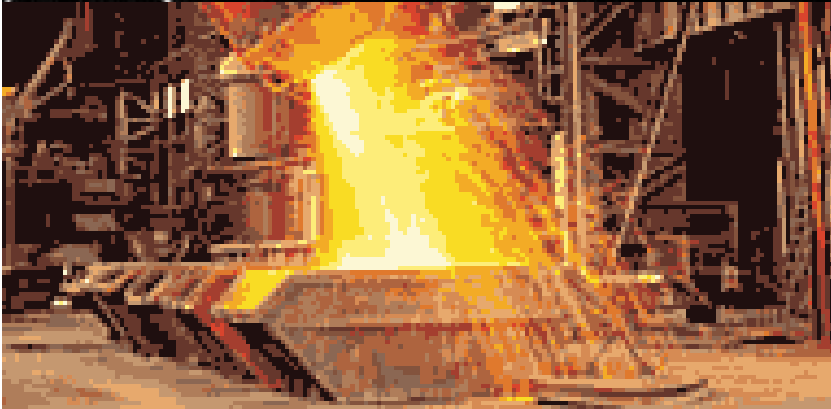


Photo : Veronique Vial © 2006 Cirque du Soleil Inc.

Earthquake Early Warning Issues

- No time for seeking additional information
- No personal confirmation possible (no equivalent to storm clouds)
- Past earthquakes may not have needed protective response (at their location- may not believe action is necessary)
- People must be educated and trained about the proper protective action in advance

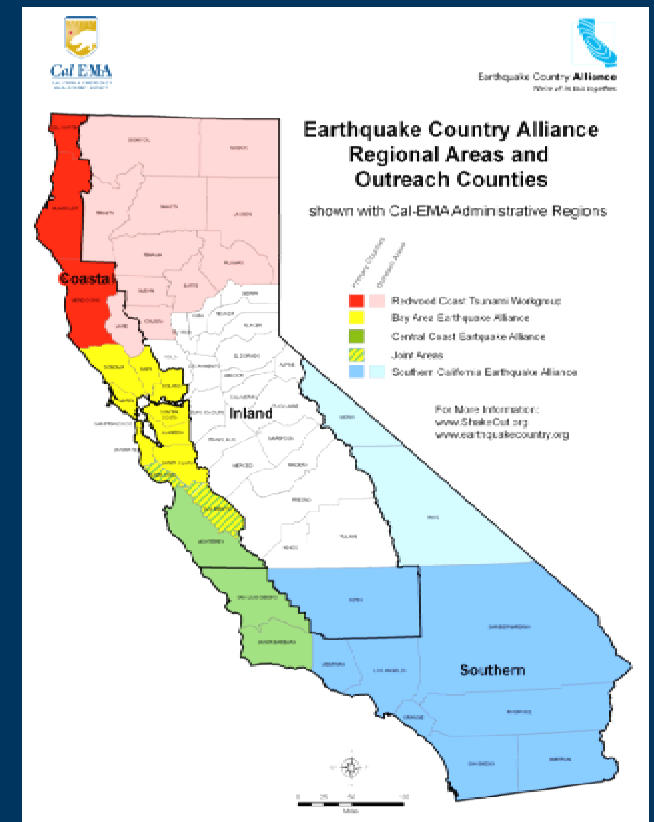
EEW is coming. We need to get ready!

Earthquake Country Alliance



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

- New statewide effort to:
 - Bring together earthquake education and preparedness experts and advocates
 - Develop materials and activities with consistent messaging
 - Coordinate the ShakeOut
- Mission is to foster a culture of earthquake and tsunami readiness in California
- www.earthquakecountry.org



Key Preparedness Actions

At home, work, and school:

- Practice “Drop, Cover, and Hold On”



- Secure Your Space

- Top heavy furniture
- Water heaters
- TVs & electronics
- Vulnerable structures
- Etc.



- Store More Water

- 1 gallon per person per day for at least 3 days and *ideally* for 2 weeks



- Have a Fire Extinguisher(s)

- Everyone must know proper use

ShakeOut Goals

- Participation of millions of people
 - The ShakeOut is our chance to practice how to protect ourselves during earthquakes, and to get prepared at work, school, and home.
 - Earthquake Country Alliance Associates develop local efforts
 - Register at www.ShakeOut.org/register
- Shift the culture in California about earthquakes
 - Get people talking with each other about earthquakes and preparedness
 - Come together around a common vision for a resilient California
- Significant increase in earthquake readiness at all levels
 - Family, community, school, business, and government readiness

Key ShakeOut Components

- Multi-level *ShakeOut Drill Manuals* for key groups
- School drill resources, take home materials, class curricula
- *ECA Associates* throughout the state (250+ and growing)
- *ECA EPIcenter* partners (Museums, libraries, parks, and other venues)
- Presentations by speaker's bureaus
- *Preparedness Now* movie (So. Cal.)
- *Drill Broadcasts* (audio and video 2-minute narrated instructions with sound effects, in English and Spanish)
- Radio, TV, and print advertising and PSAs (supported by sponsors)
- Comprehensive news media resources and coordination

Resources for people and organizations to participate in the drill, to get prepared, and to share the ShakeOut

2008: The Great Southern California ShakeOut

- November 12-16, 2008
- A week of special events to inspire southern Californians to get ready for big earthquakes
- Regional earthquake drill on Nov. 13
- **5.47 million participants:** schools, businesses, communities, governments, families....
- Goal was to get people talking... and then to take action!



Shake
Out



2009: The Great California ShakeOut!

- October 15, 2009
- **Statewide** earthquake drill for all residents, businesses, schools, organizations... everyone!
- **6.9 million participated**
- Now will be annual, on the third Thursday of October
- Learn more at ShakeOut.org





Be a Part of the ShakeOut
Register Now!
Log in

Home

The Drill

Why Participate?

News and Events

Resources

ShakeOut Partners

Contact Us

PARTICIPANTS

The following agreed to be listed on this website when they registered. If you have registered, use the access code sent to you to return and update your information (and give permission for us to list you here).

PARTICIPANTS (2009) FOR SAN DIEGO COUNTY: SCHOOLS/DISTRICTS

Select a county...

There are 53 schools/districts registered in [San Diego County](#) for ShakeOut 2009, with a total of 366949 participants.

The following registrants agreed to be listed on this website when they registered. [View all groups.](#)

Only districts that have registered are listed in bold.

No district listed:

- [Bonita Learning Academy](#), Chula Vista
- [CDA Finney](#), San Diego
- [Christ Church Day School](#), Coronado
- [Escondido Christian Preschool](#), Escondido
- [Escondido Christian Preschool](#), Escondido
- [Faith Lutheran Church & Schools](#), Vista
- [Fallbrook Presbyterian Preschool](#), Fallbrook
- [Fletcher Hills Presbyterian Preschool](#), El Cajon
- [Horizon Elementary School](#), San Diego
- [Immanuel Lutheran Children's Learning Center](#), Oceanside
- [Incarnation Lutheran Preschool](#), Poway
- [Light and Life Christian](#), Escondido
- [Maranatha Christian Schools](#), San Diego
- [Mira Mesa Christian School](#), San Diego
- [Montessori Discovery School](#), Santee
- [Mountain Peak Charter School](#), Vista
- [San Carlos United Methodist Preschool](#), San Diego
- [St. Michael Academy](#), San Diego
- [Tecate Christian School](#), Tecate
- [Tecate Christian School](#), Tecate
- [Borrego Springs Unified](#), borrego springs
- [Cajon Valley Union School District](#), El Cajon
- [Carlsbad Unified School District](#), Carlsbad
- [Chula Vista Elementary School District](#), Chula Vista
- [Mae Feaster Elementary Charter School](#), Chula Vista
- [Dehesa School District](#), El Cajon
- Dioocese of San Diego
 - [Saint John the Evangelist School](#), Encinitas
 - [St Martin of Tours Academy](#), La Mesa
 - [St. Pius X School](#), Chula Vista
- [Encinitas Union School District](#), Encinitas
- [Escondido Union School District](#), Escondido
- [Grossmont Union High School District](#), La Mesa
- [Jamul-Duizura Union School District](#), Jamul
- Julian Union Elementary School District
 - [Julian Charter School Pine Valley Academy](#), Pine Valley
- [Lemon Grove School District](#), Lemon Grove
- Mountain Empire Unified School District
 - [Clover Flat Elementary School](#), Boulevard
- na
 - [Santa Sophia Academy Preschool](#), Spring Valley
- [National School District](#), National City
- [El Toyon School](#), National City

ShakeOut Flyers, Web Banners, etc.

Get Ready to Shake Out.

10.15.09
Register Now at www.shakeout.org

The Great California **Shake Out**



Shake Out The Great California ShakeOut
April 15th - October 15th 2009

Businesses
Get Ready to ShakeOut

Individuals and Families
Get Ready to ShakeOut

Register Today at ShakeOut.org

Drop! Cover! Hold On!

What will YOU be doing at 10:15 a.m. on **THURSDAY OCTOBER 15, 2009?**

The Great California **Shake Out!!**

Drop, Cover and Hold On!

Learn more at Shakeout.org

Shake Out. October 15, 2009

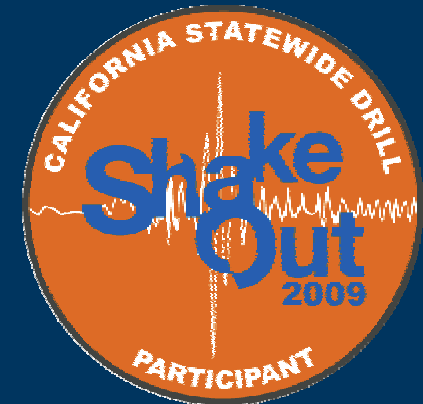
Don't Freak Out.

The Great California **Shake Out**

www.shakeout.org

Putting down roots in earthquake country

Drop! Cover! Hold On!



Join Us **October 15, 2009**
for the Largest Earthquake Drill in U.S. History.

Register Now at www.shakeout.org

The Great California **Shake Out**

www.dropcoverholdon.org



Protect Yourself. Spread The Word.



Earthquake Country Alliance
We're all in this together

earthquakecountry.info



PLAY BEAT THE QUAKE

Test your earthquake knowledge and skill right now!

VERSION ESPAÑOL



Protégete. Divulga La Palabra.



Earthquake Country Alliance
We're all affected by earthquakes

www.terremotos.org



DERROTA EL TEMBLOR

¡Pon a prueba tu conocimiento de terremotos y habilidad ahora mismo!

ENGLISH VERSION

Facebook.com/greatshakeout

The Great California ShakeOut

Wall Info Photos Discussions Events +

What's on your mind?

Attach: Share

The Great California ShakeOut We want your feedback! As a ShakeOut participant in 2009, we sent an email with a link to a survey about your preparedness, what you did in your drill, and how you think we can improve the 2010 ShakeOut. If you did not receive the email, please visit <http://www.surveymonkey.com/s/SV2HZ7F>.

Thank you for your participation and commitment to earthquake safety!

2009 ShakeOut Survey
www.surveymonkey.com
Thank you for helping us learn more about the October 15th, 2009 Great California ShakeOut! Learning about your experiences may help improve disaster preparedness throughout California. Findings from this survey will be posted on the ShakeOut website at www.shakeout.org. ...

January 24 at 11:38am · Comment · Like · Share

3 people like this.

Benandrew Briggs I am a certified CERT in our County but our County is not listed for this very important event...can you email me information that i can present to my CERT hierarchy so that awareness can be heightened? you have my email already...
January 28 at 2:49pm · Delete · Report

Write a comment...

The Great California ShakeOut There are many things you can do to reduce losses from happening in your home and community. The preparedness theme for ShakeOut 2010 is "Secure Your Space" —strap furniture and large appliances to walls, secure electronics and other objects, and much more. Learn how at: daretoprepare.org.
January 24 at 11:34am · Comment · Unlike

You, Lori Dengler, Kathleen Springer and 3 others like this.

Write a comment...

The Great California ShakeOut January 21st was the 9 month date to the...

Frequent posts about ShakeOut milestones, preparedness recommendations, and other info, with community interaction

Twitter.com/shakeout

The screenshot shows the Twitter profile for California ShakeOut. At the top is a banner with the Twitter logo and a 'Join today!' button. Below the banner is the profile information: Name: California ShakeOut, Location: California, Web: http://ShakeOut.org, Bio: The Official Twitter of the Great California ShakeOut, the largest earthquake drill ever! Statistics: 624 following, 787 followers, 45 listed. The main content is a list of tweets, including one about a survey and another about the 2010 ShakeOut Drill.

Hey there! **ShakeOut** is using Twitter. Twitter is a free service that lets you keep in touch with people through the exchange of quick, frequent answers to one simple question: What's happening? **Join today** to start receiving ShakeOut's tweets. [Join today!](#)

ShakeOut

We want your feedback! As a ShakeOut participant in 2009, we sent an email with a link to a survey about your... <http://bit.ly/5jUXWI>

11:10 AM Jan 24th From Facebook

There are many things you can do to reduce losses from happening in your home and community. The preparedness theme... <http://bit.ly/4GmKb1>

11:34 AM Jan 24th From Facebook

January 21st was the 9 month date to the 2010 ShakeOut Drill on October 21, at 10:21 a.m, and registration on the... <http://bit.ly/4vcCKC>

11:53 AM Jan 24th From Facebook

Our thoughts are with the good people of Haiti and relief and rescue workers this week. <http://bit.ly/6azcRy>

10:14 AM Jan 14th From Facebook

The Vial of L.I.F.E. (Lifesaving Information For Emergencies) is a program which allows you to provide medical... <http://bit.ly/3i51rj>

8:18 AM Nov 3rd, 2009 from Facebook

Check out the USGS earthquake map for the US to see the latest events you can click on. <http://bit.ly/4vckKb1>

Name California ShakeOut
Location California
Web <http://ShakeOut.org>
Bio The Official Twitter of the Great California ShakeOut, the largest earthquake drill ever!

624 787 45
following followers listed

Tweets 234

Following

RSS feed of ShakeOut's tweets

234 tweets in 2009

Tweets about ShakeOut milestones, preparedness recommendations, etc.

Key is re-tweets

Registrations by Category

K-12 School participants	5,010,000
Colleges/College Districts/University participants	998,000
Business participants	233,000
Other organizational participants	295,000
Local government agencies/offices/etc. participants	253,000
State agencies/offices/etc. participants	31,000
Federal agencies/offices participants	63,000
Individual/family participants	16,000







2010 ShakeOut:

October 21, 10:21 a.m.

2011 and Beyond

- Central U.S. states are planning a ShakeOut drill in April 2011 (as part of Bicentennial of New Madrid earthquakes)
- British Columbia planning a ShakeOut drill in January 2011
- Washington, Oregon, Utah, and Alaska also interested
- Other countries also planning ShakeOut drills: New Zealand, Turkey, and India

Thank you!

Mark Benthien
benthien@usc.edu
213-926-1683