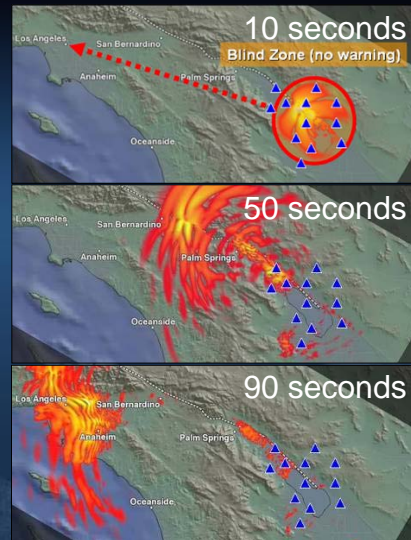


# ShakeAlert – Earthquake Early Warning

**Doug Given**

USGS, Pasadena

*Earthquake Program,  
Early Warning Coordinator*

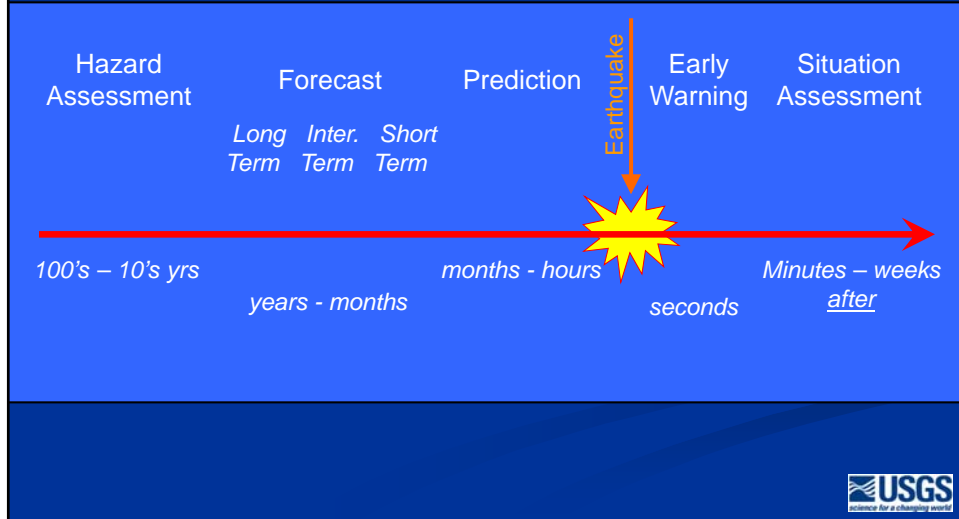


## USGS Earthquake Hazard Responsibilities

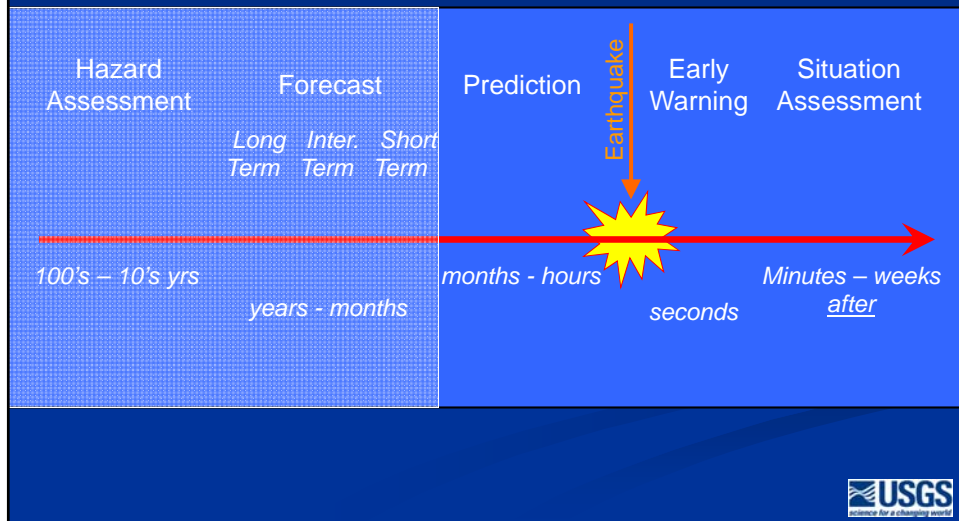
- **USGS** has the lead federal responsibility to provide notification and warnings for **earthquakes**, **volcanoes**, and **landslides**.  
(Stafford Act, P.L. 92-288)
- Pre-earthquake products  
- for planning and preparation
- Post-earthquake products  
- for situational awareness
- **Earthquake early warning** is a developing capability to reduce earthquake losses



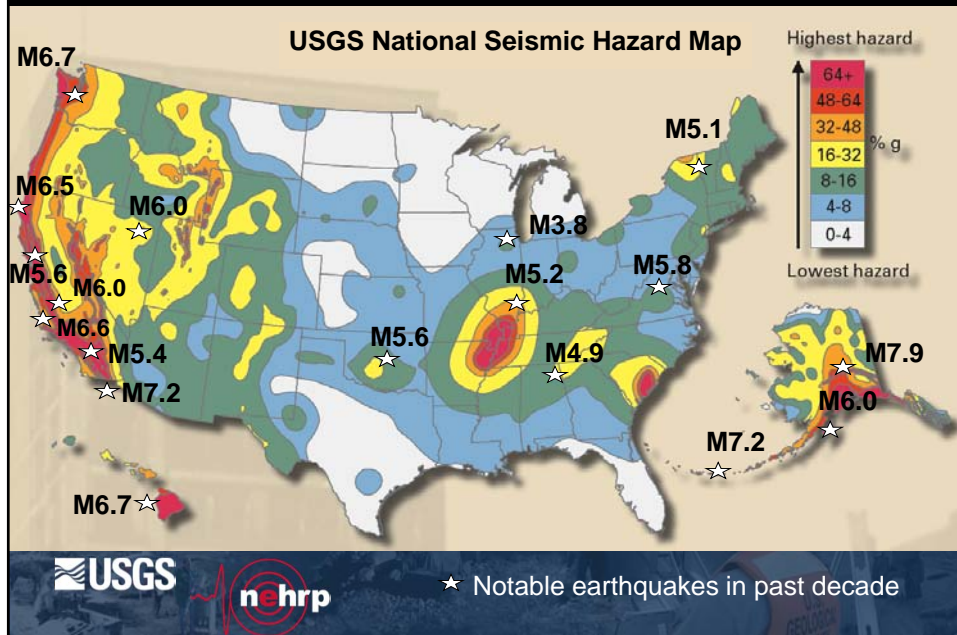
# Time Scales of Quake Information



# Time Scales of Quake Information



## National Hazard Map



## National Hazard Map: a Tool for Performance-Based Seismic Design

**INTERNATIONAL BUILDING CODE®**

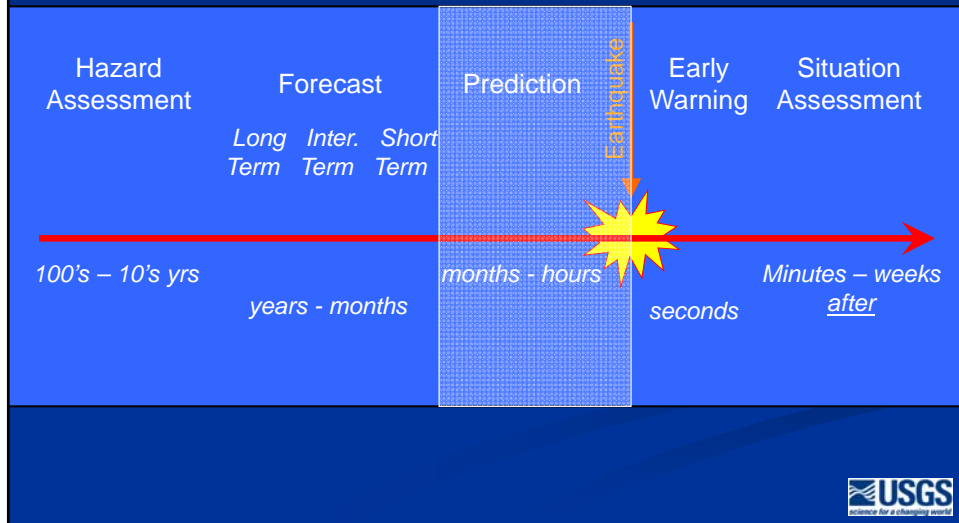
**2012**

**NEHRP Recommended Seismic Provisions**  
for New Buildings and Other Structures  
FEMA P-750 / 2009 Edition

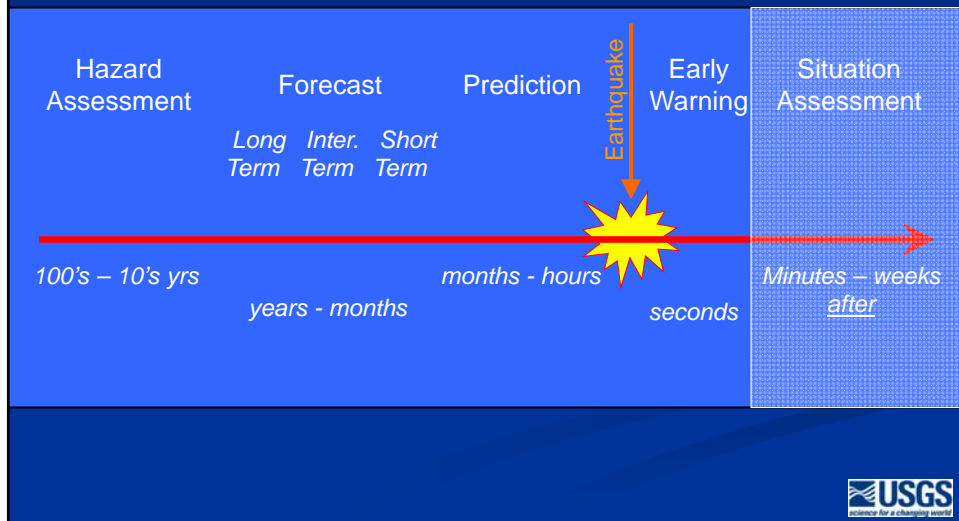
USGS nehrp

**Seismic element of NEHRP Provisions and Int'l Building Code are based on the USGS national seismic hazard map**

# Time Scales of Quake Information



# Time Scales of Quake Information



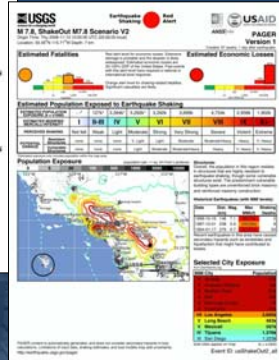


Map Version 1.0 (Downloaded 10/10/2007 08:00:00 PM PST)

Station	Lat (N)	Long (W)	Depth (km)	Mag	Station	Lat (N)	Long (W)	Depth (km)	Mag	Station	Lat (N)	Long (W)	Depth (km)	Mag
San Jacinto	33.5	116.5	1.0	2.5	San Gabriel	34.5	116.5	1.0	2.5	San Andreas	35.5	116.5	1.0	2.5
San Bernardino	34.0	117.0	1.0	2.5	San Jose	34.5	117.0	1.0	2.5	San Juan	35.0	117.0	1.0	2.5
San Luis	35.0	117.5	1.0	2.5	San Marcos	35.5	117.5	1.0	2.5	San Ramon	36.0	117.5	1.0	2.5

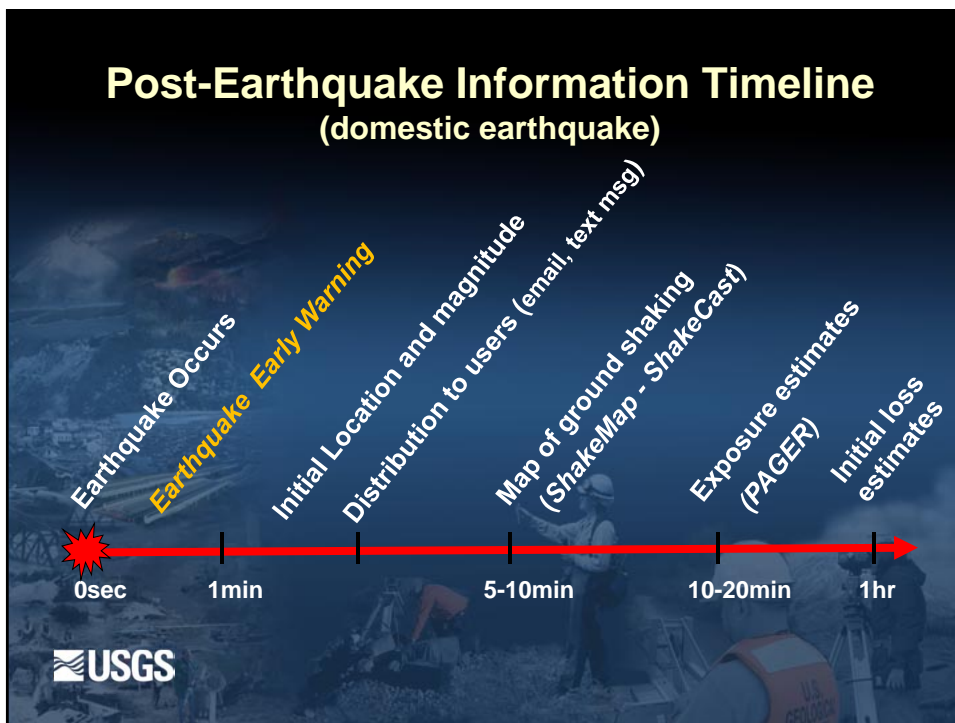
[illegible]

# Prompt Assessment of Global Earthquakes for Response



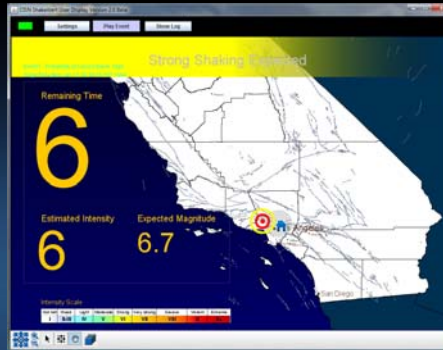
A timeline diagram showing the sequence of events following an earthquake. The timeline is a red arrow pointing right, with markers at 0sec, 1min, 5-10min, 10-20min, and 1hr. The background is a dark, grainy image of an earthquake scene with people in hard hats.

- 0sec:** Earthquake Occurs (marked with a red starburst icon)
- Between 0sec and 1min:** Earthquake Early Warning
- Between 1min and 5-10min:** Initial Location and magnitude
- Between 5-10min and 10-20min:** Distribution to users (email, text msg)
- Between 10-20min and 1hr:** Map of ground shaking (ShakeMap - ShakeCast)
- Between 1hr and 1hr:** Exposure estimates (PAGER)
- At 1hr:** Initial loss estimates

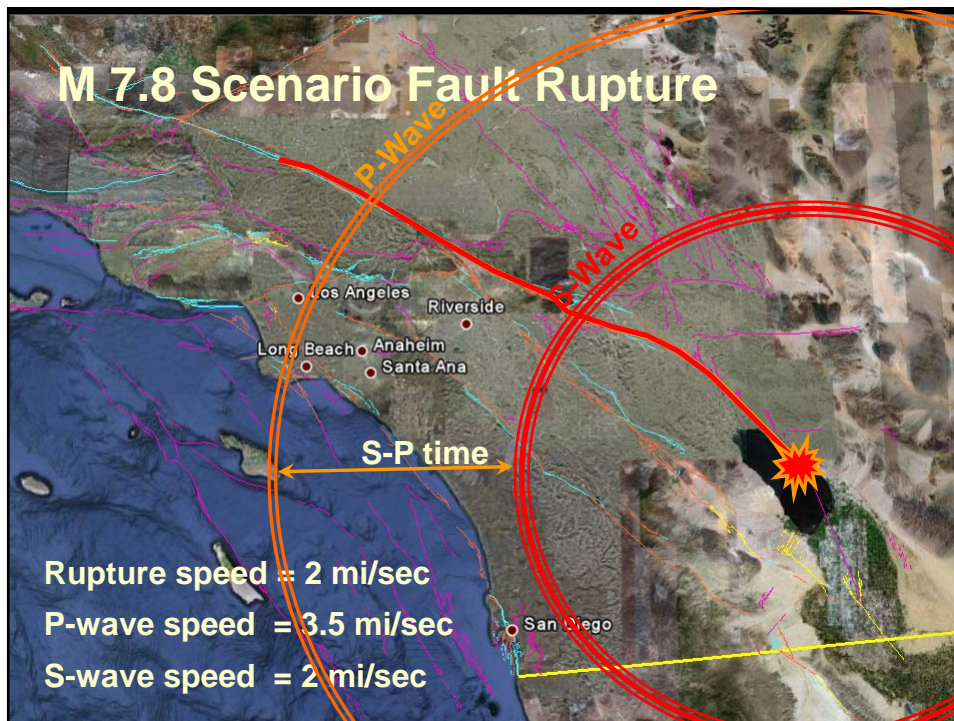


## ShakeAlert: Earthquake Early Warning

USGS and its partners are developing an EEW system for the U.S.



## M 7.8 Scenario Fault Rupture

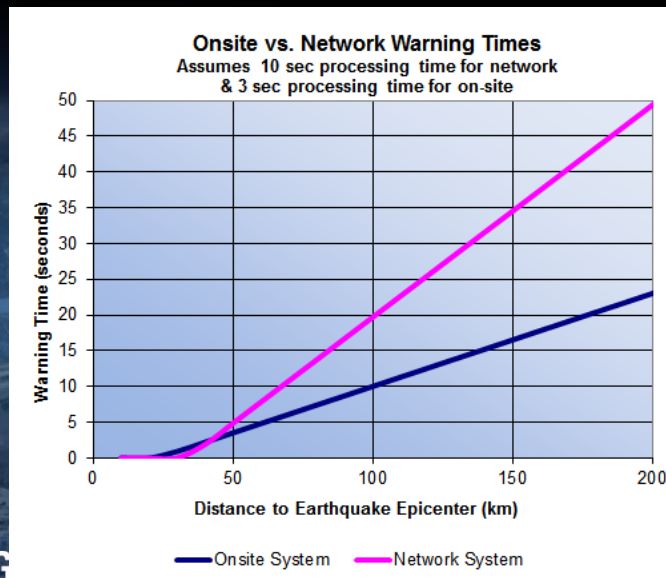


## Two Types of EEW

- **On-site EEW**
  - Local sensor
  - Shorter warning time
  - S-P time
  - Simple, low cost
  - Less reliable
- **Network EEW**
  - Sensors near source
  - Longer warning time
  - S-wave travel time
  - More complex
  - More reliable

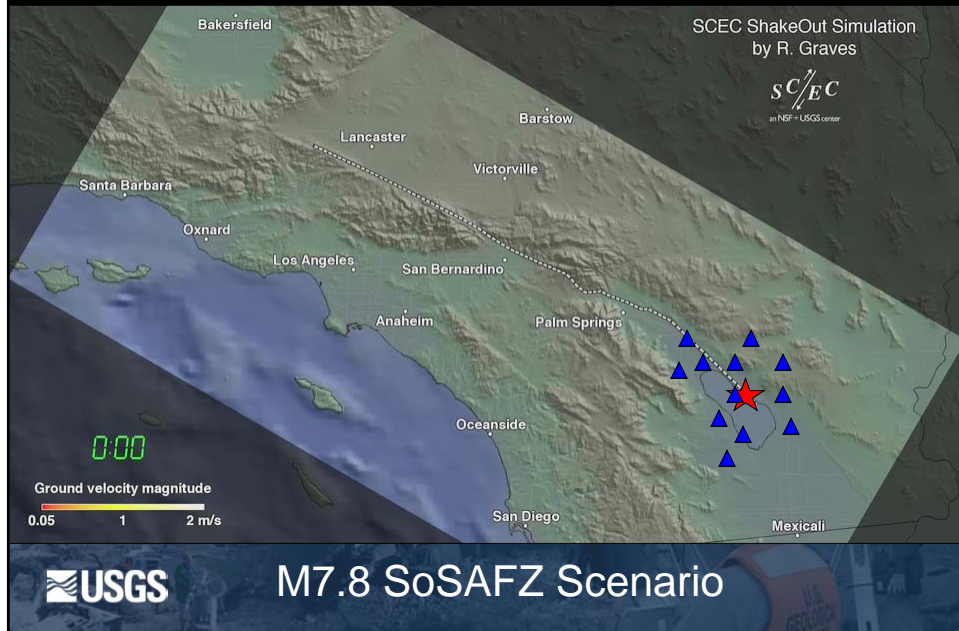


## Summary of Estimated Warning Time

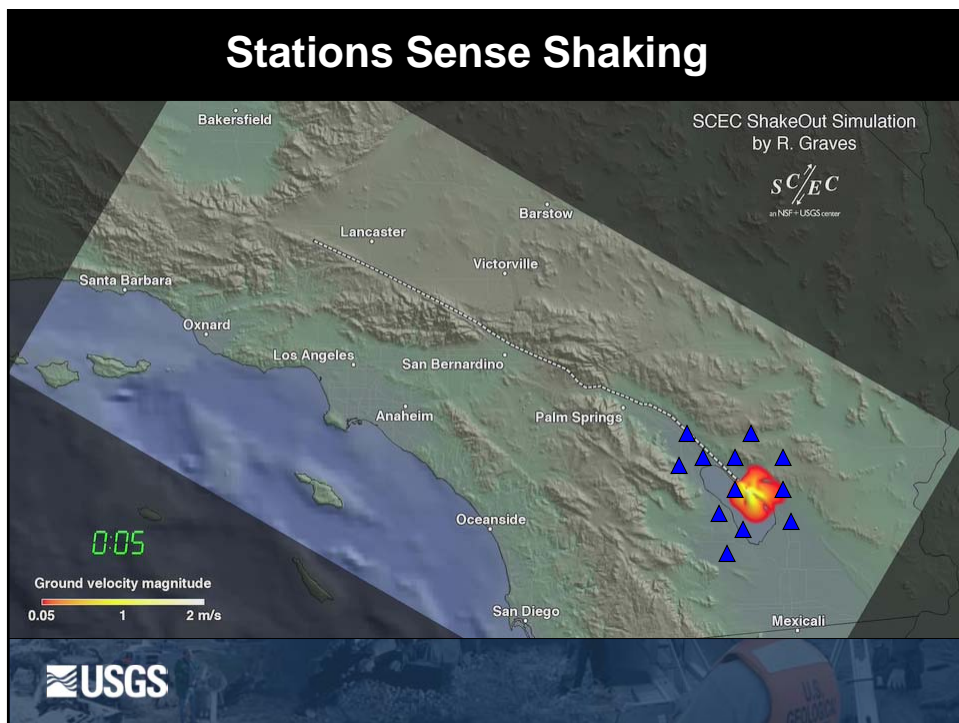




## Earthquake Begins



## Stations Sense Shaking

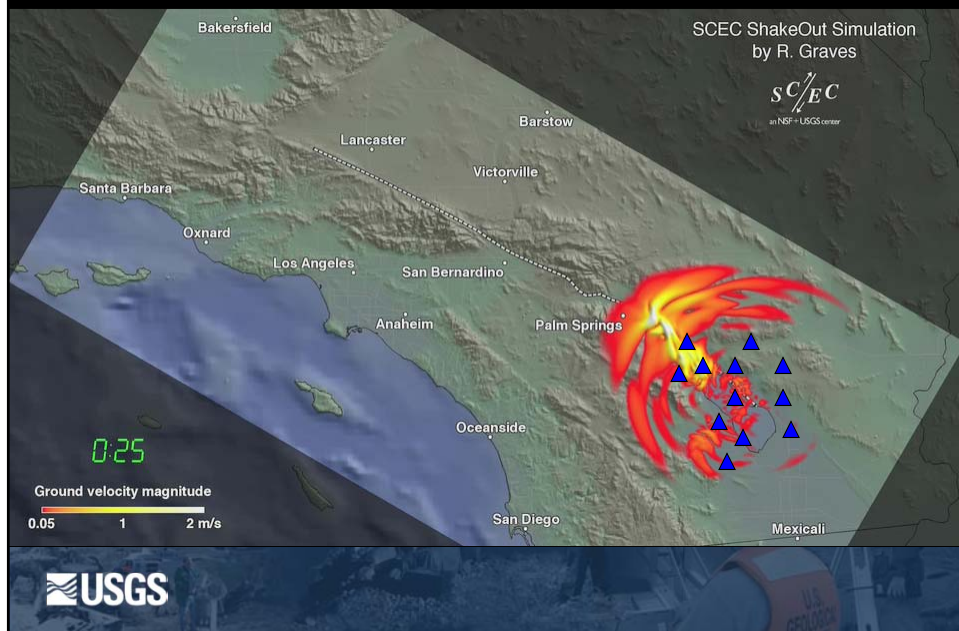




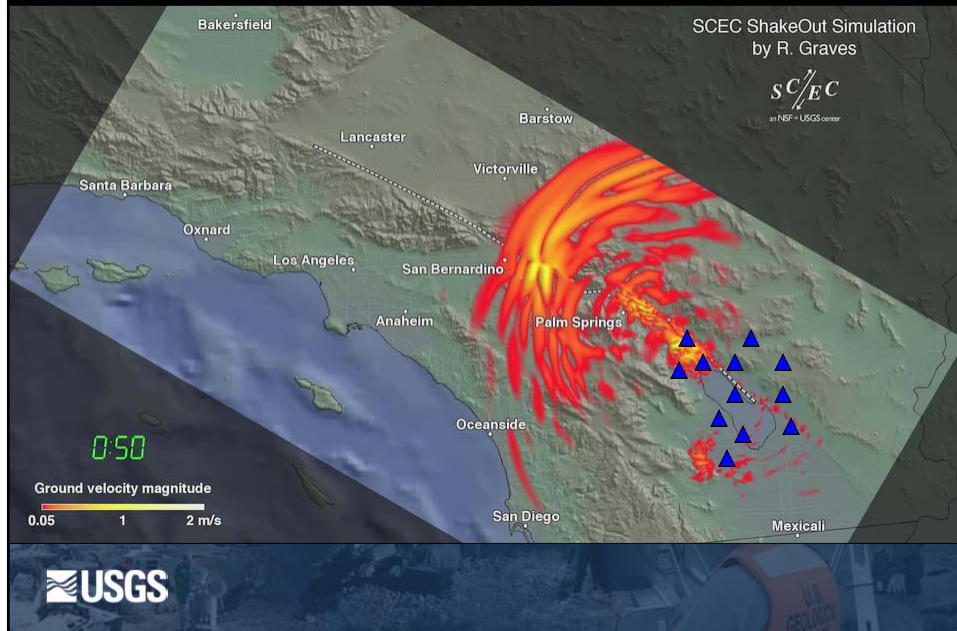
## Warning Issued



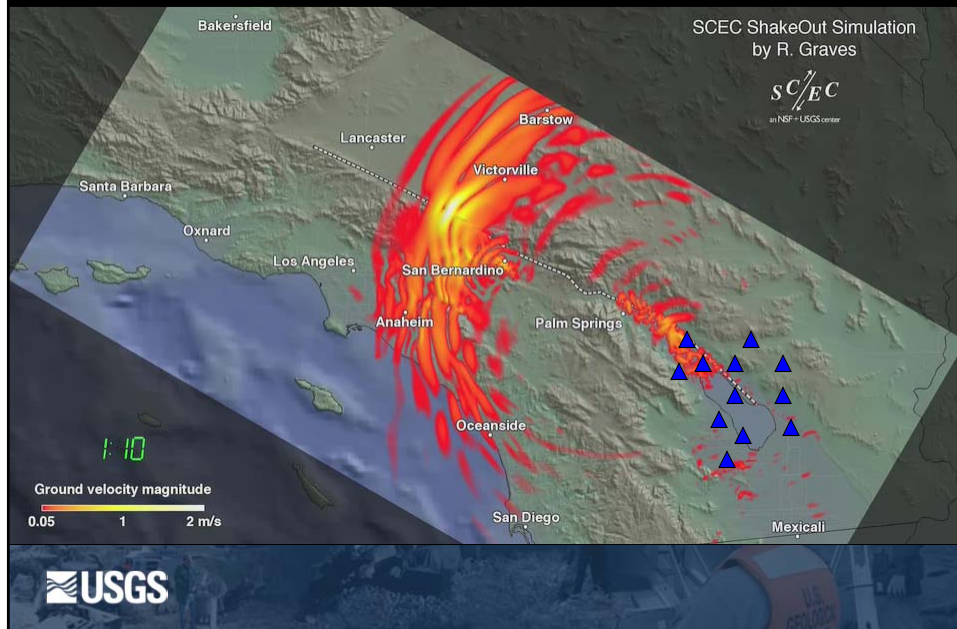
## Strong Shaking Arrives – Palm Springs



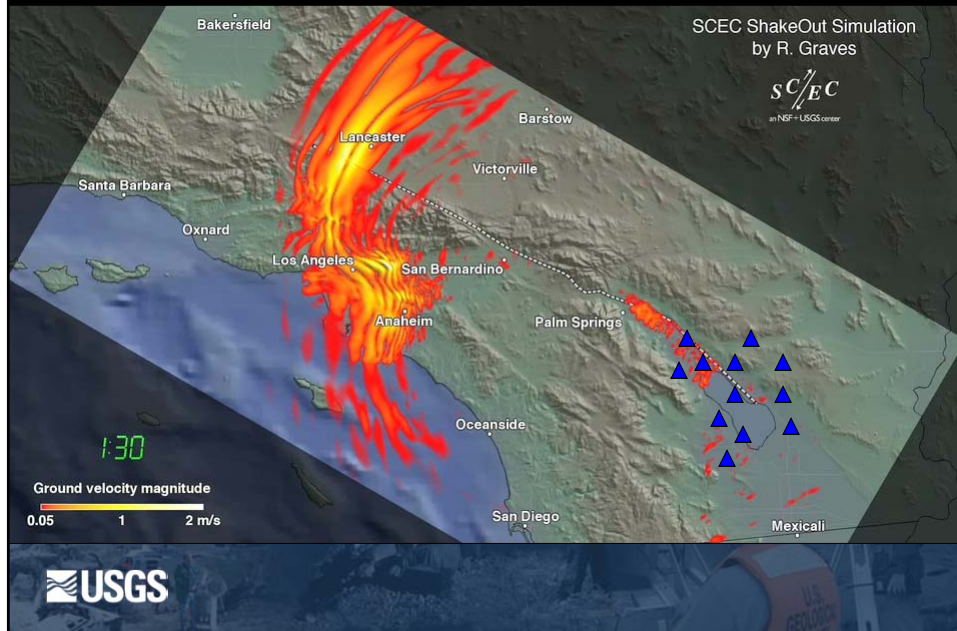
## Strong Shaking Arrives – San Bernardino



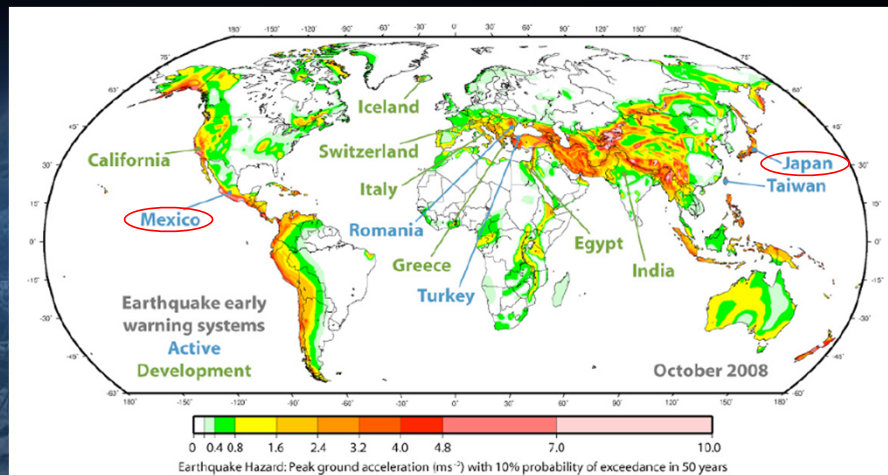
## Strong Shaking Arrives – Orange Co.



## Strong Shaking Arrives – Los Angeles



## Who's Doing EEW?



Public messages



Richard Allan, UCB



## Mexico City Early Warning System (SAS)



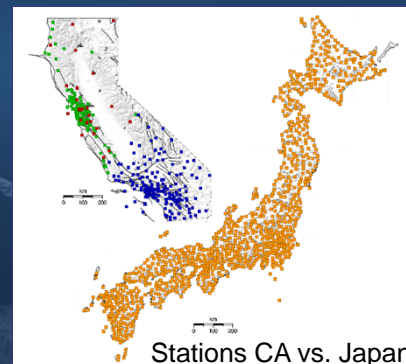
## SAS Radio Receiver



<http://www.cires.org.mx/>

## Japanese EEW system

- Spent \$500M on EEW after the M7.2 1995 Kobe earthquake killed 6,400
- Public warnings since Nov. 2007



## Stations CA vs. Japan



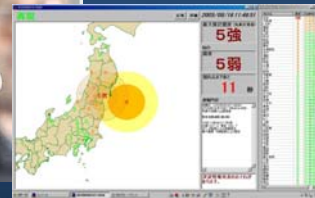
## Japan: Communicating the warning

- TV and radio announcements
  - 124 of 127 TV stations (98%)
  - 41 AM, 35 FM radio (75%)
- J-Alert messages
  - 226 municipalities receive the warnings
  - 102 announce them with public address systems
- Cell phones
  - 3 companies (Docomo, AU, Softbank)
  - 52 million can receive them (47%)
- Dedicated providers serve
  - power plants
  - factories
  - schools
  - hospitals
  - shopping malls



earthquake location  
and hazard

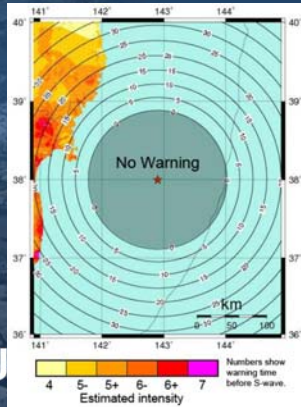
estimated shaking in  
your area



# Tohoku M9.0 – EEW Alert

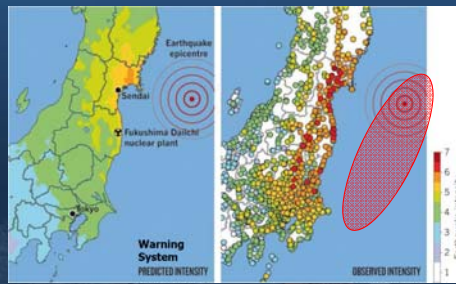
## The good:

- Alert was sent in ~9 sec
- Millions of people got 5 – 40 sec warning



## The not-so-good:

- JMA underestimated
  - magnitude (8.1)
  - intensity
  - area affected
  - missed aftershocks



# EEW Development in the U.S.

## USGS Funded Research & Development

### Phase I (2007-2009) \$750k

- Develop and test three approaches (algorithms)

### Phase II (2010-2012) \$1.25M

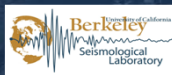
- Create *demonstration system* and partner with test users

### Phase III (2012-2015) ??

- Implementation

### ARRA funding (2010-2011)

- ~\$20M to modernize stations nationally & speed up data



## EEW Development in the U.S.



### Moore Funded Research

2012-2014 \$6M

- Continue research and development of algorithms
- Build *prototype system*
- Include Cascadia (U.W.)



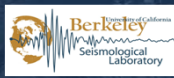
### Evolutionary Implementation

→ Research & Development

→ Demonstration

→ Prototype

→ Operation



## What's needed?

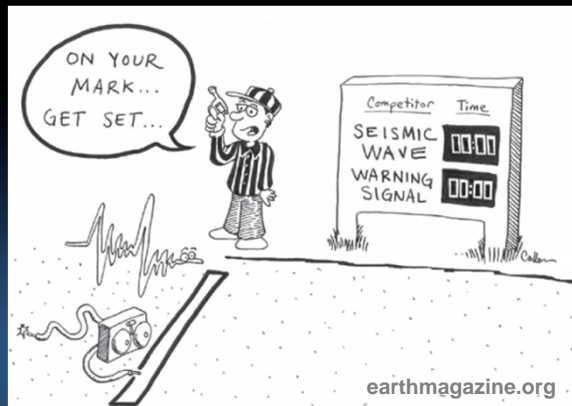
- Additional seismic sensors (leverage existing networks)
- Robust, resilient data communications
- Continued R&D – finite faults, GPS
- Staff and organization dedicated to EEW
- Standards & testing
- Multiple, robust notification methods
- Education and training

*Estimated cost of a California system:*

- \$15-20M/yr for 5 years to build it
- \$5-10M/yr to operate



Thank You



*Doug Given*

*Earthquake Early Warning Coordinator,  
USGS Earthquake Hazards Program*





