USGS
science for a changing world

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Earthquakes ★ Floods ★ Hurricanes ★ Landslides ★ Tsunamis ★ Volcanoes ★ Wildfires

Update on USGS Earthquake Hazards Program

ACEHR Meeting – Memphis

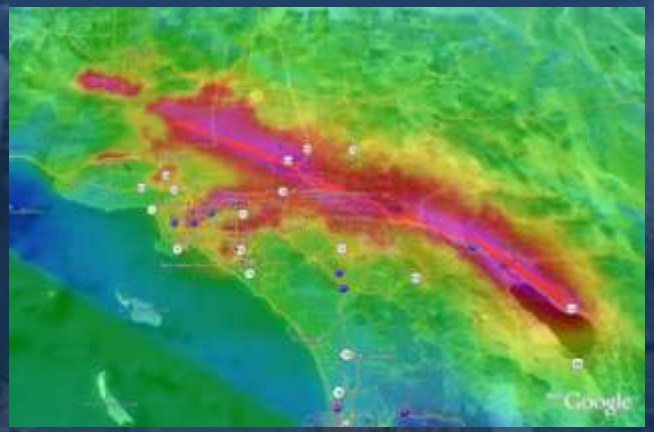
November 2010

U.S. Department of the Interior
U.S. Geological Survey

The USGS role in NEHRP

- Provide earthquake monitoring and notifications,
- Assess seismic hazards, and
- Conduct targeted research needed to reduce the risk from earthquake hazards nationwide.
- Work with NEHRP agencies and many other partners to support public awareness of earthquake hazards and impacts

USGS *National Earthquake Information Center*



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So many earthquakes… too many earthquakes?

USGS science for a changing world

News Release

April 14, 2010	Dr. Michael Blanpied	703-648-6696	mblanpied@usgs.gov
	Clarice Nassif Ransom	703-648-4299	cransom@usgs.gov

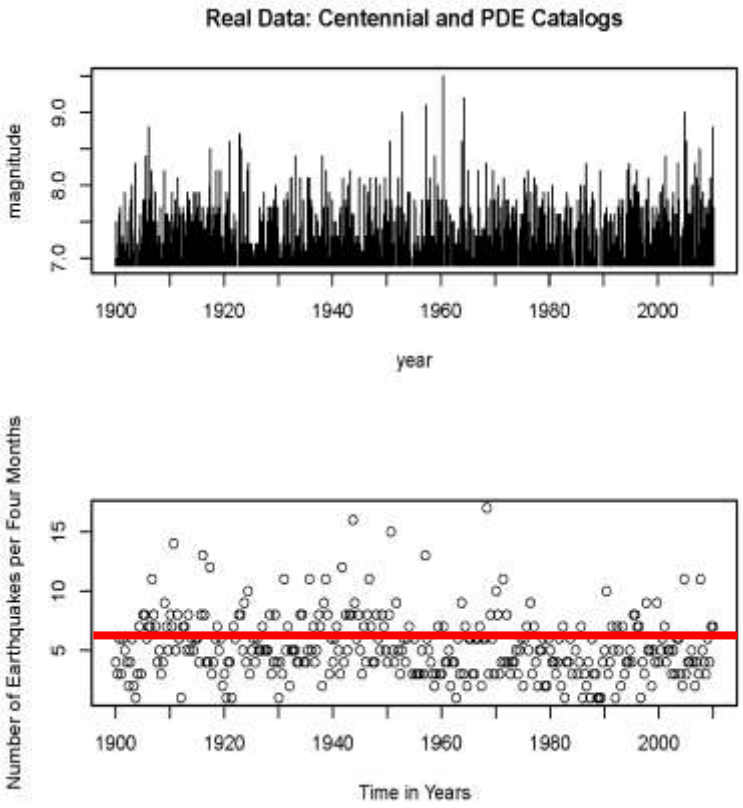
Is Recent Earthquake Activity Unusual? Scientists Say No.

SHARE

China's tragic magnitude 6.9 earthquake on April 13 and the recent devastating earthqua
many wondering if this earthquake activity is unusual.

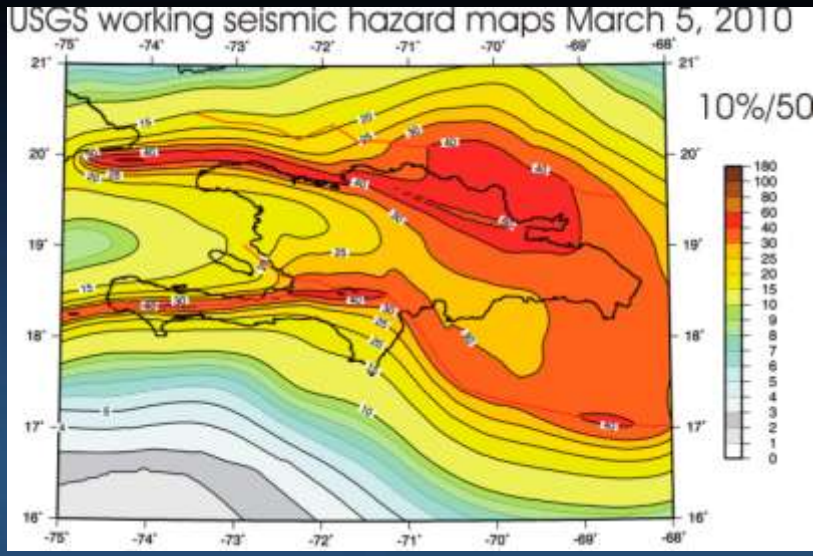
Scientists say 2010 is not showing signs of unusually high earthquake activity. Since 1900
earthquakes — the size that seismologists define as major — have occurred worldwide e
1986 and 1989, while 1943 had 32, with considerable variability from year to year.

With six major earthquakes striking in the first four months of this year, 2010 is well withi
2009, to April 14, 2010, there have been 18 major earthquakes, a number also well with



USGS/USAID Earthquake Disaster Assistance Team in Haiti

- Port au Prince Urban Seismic Network
  - Temporary deployment for site-response analysis
- Near-fault aftershock detection
- Modern seismic hazard assessment for rebuilding
- Investigations of fault rupture



USGS seismologist Doug Given and Haitian colleagues from Bureau of Mines and Energy installing station at school

Photo from Sue Hough, USGS

USGS Response to M8.8 Chile Earthquake

- Provided information to US Embassy
- Helped coordination between US science & engineering groups visiting Chile
- Loaned seismometers for aftershock recording
- Participated in Earthquake Engineering Research Institute investigation of damage
- Developed plans for future research collaboration

Due to modern codes, only one major structure collapsed (Concepcion).

PAGER: USGS rapid-response product

USGS

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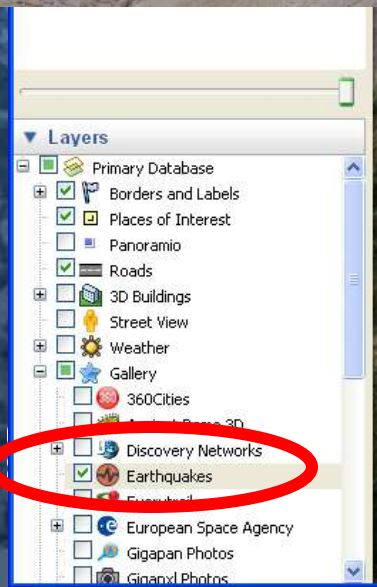
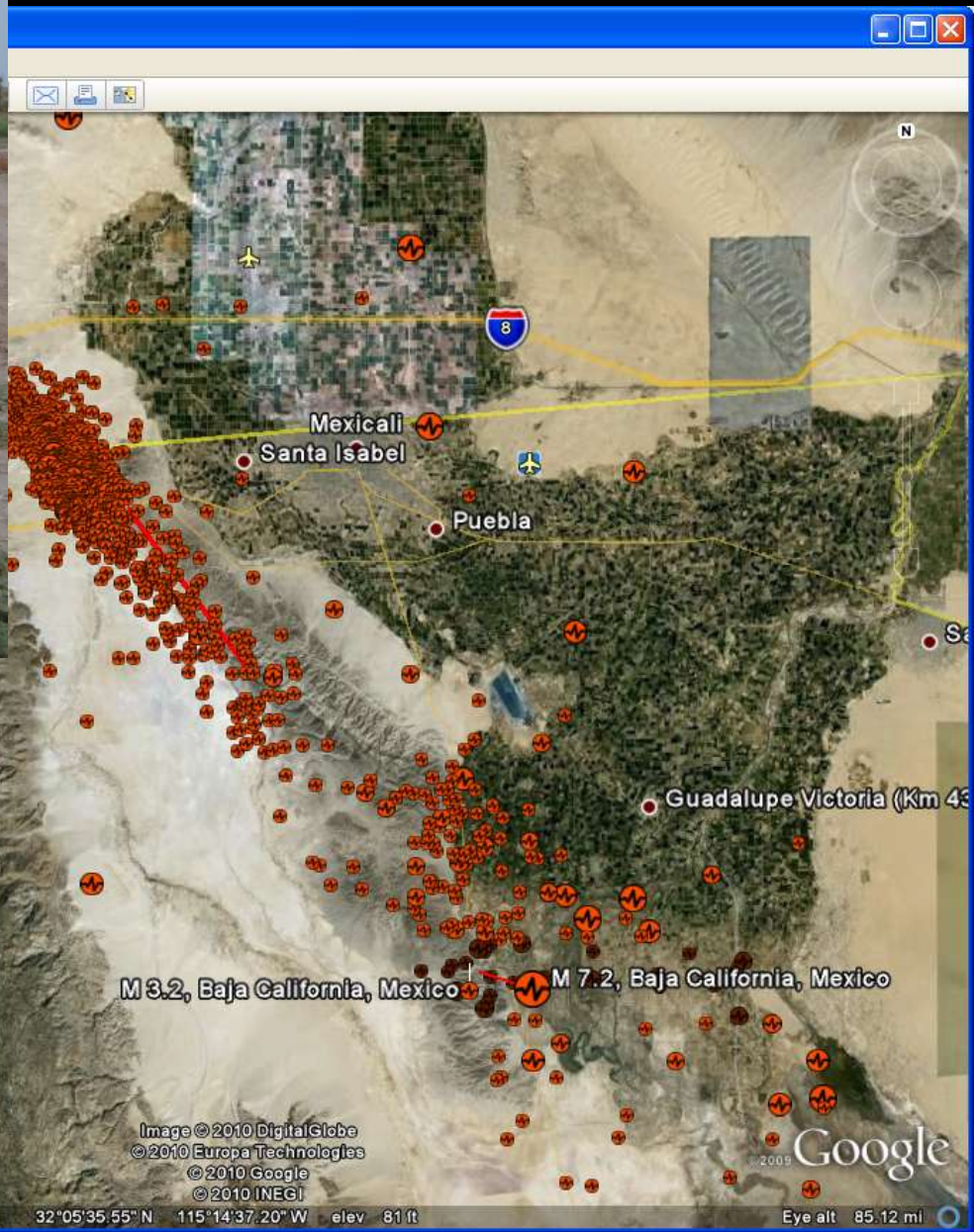
Magnitude-7.2, Northern Baja California 4/4/10





California-wide public preparedness drill

The Great California ShakeOut

October 21, 2010

OES California Governor's Office of Emergency Services

USGS

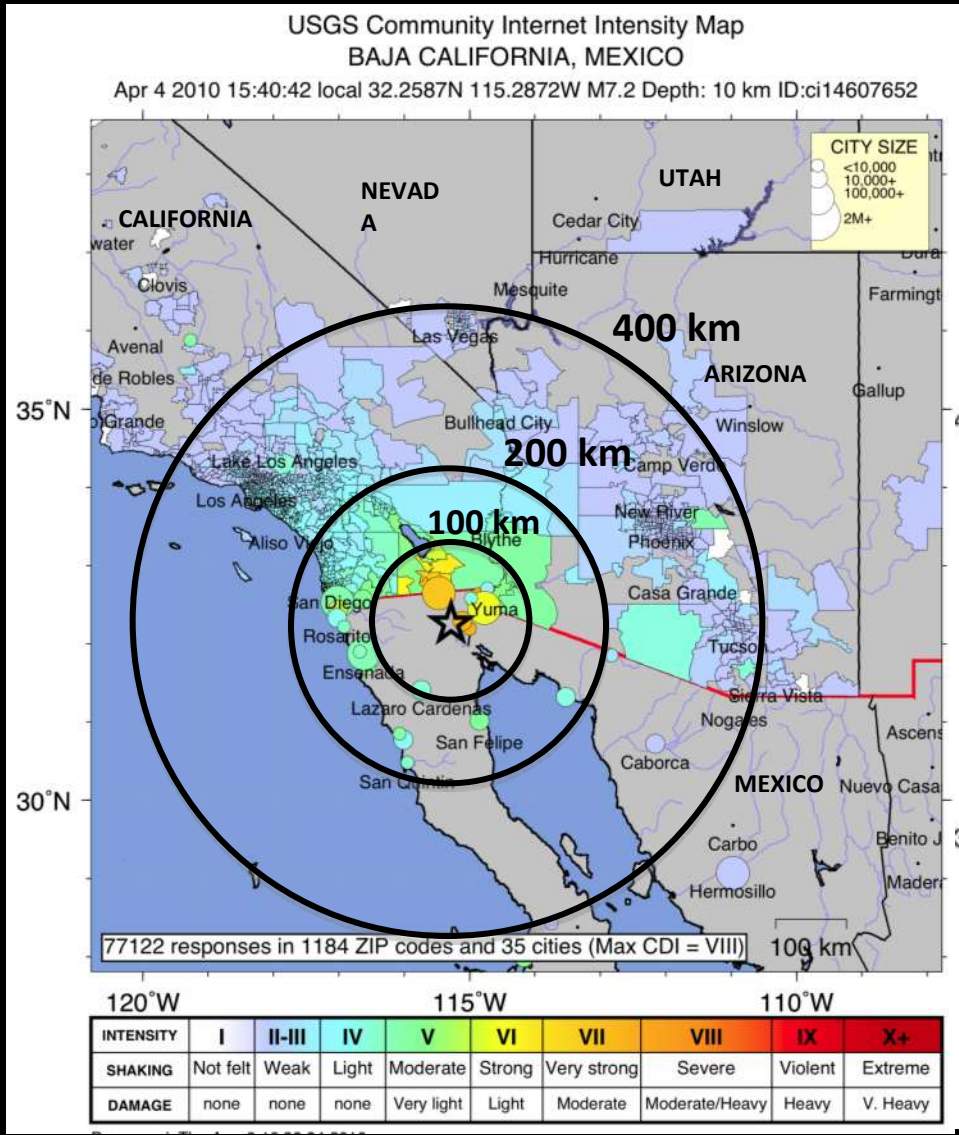
SCEC an NSF+USGS center

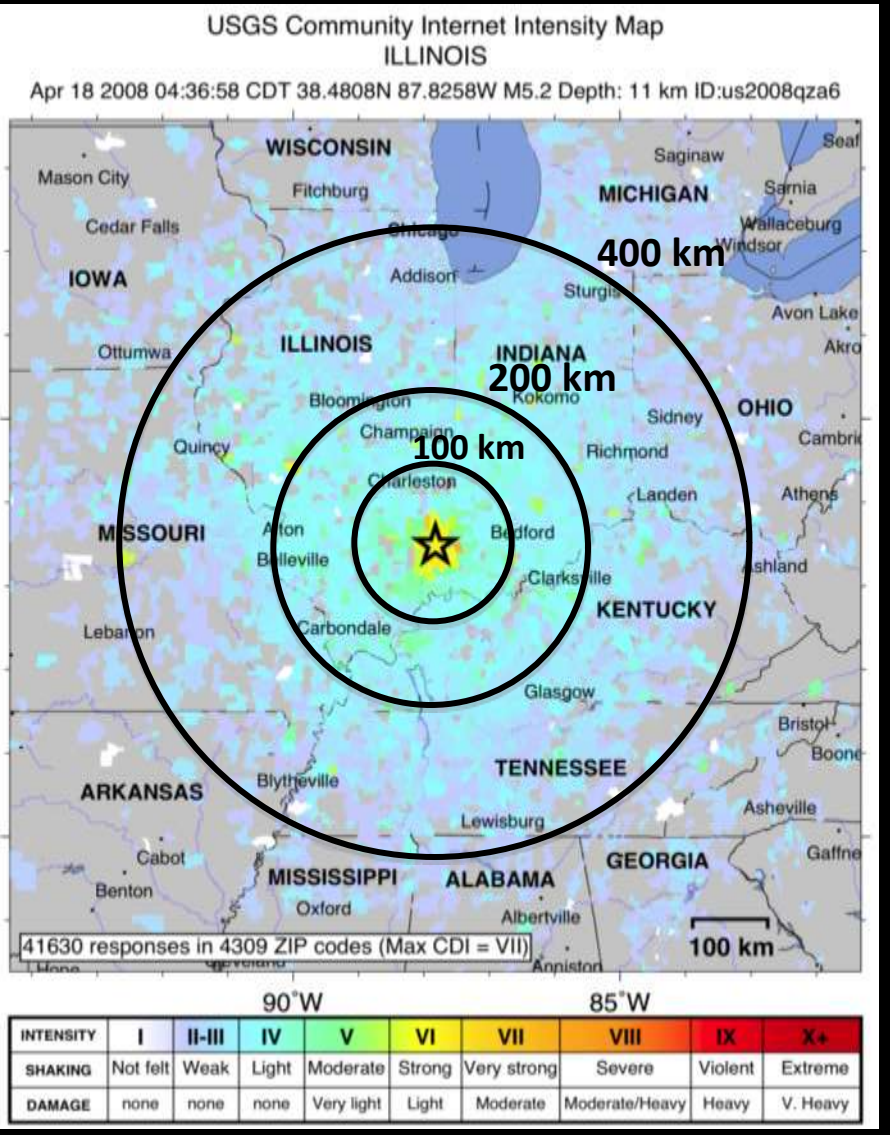
nehrp Earthquake Country Alliance *We're all in this together.*

FEMA

ShakeOut

Did You Feel It comparison: Baja and Illinois quakes





Magnitude 7.2

Magnitude 5.2

USGS

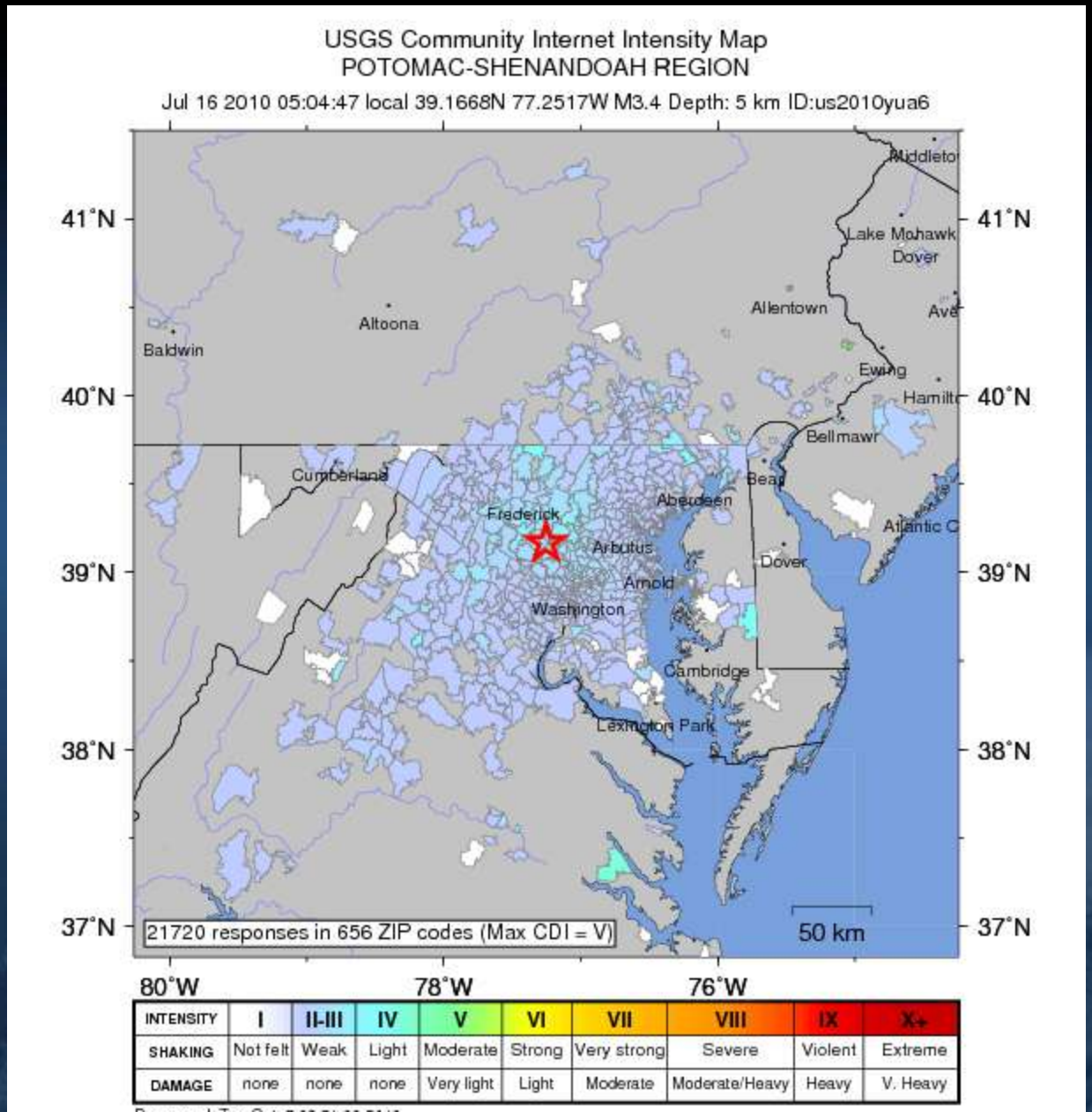
Figure courtesy of Dave Wald and Rob Williams, USGS

July's Great Gaithersburg Earthquake

Magnitude-3.6

Light shaking felt in six states and DC

(except by yours truly)



Scientific Earthquake Studies Advisory Committee 2008-09 report recommendations

1. Strongly recommends full funding of the ANSS at authorized levels and support for R&D on earthquake early warning systems.
2. Pleased to see USGS expand its multi-hazard initiative to the Pacific Northwest and encourages further expansion to include other high-risk areas of the Nation.
3. Imperative for the USGS to develop a comprehensive monitoring, analysis and research program to study the significance of episodic tremor and slip (ETS) events with respect to changes of earthquake probability.
4. Hiring and direct support is critical for the ability of USGS to fulfill its NEHRP responsibilities.

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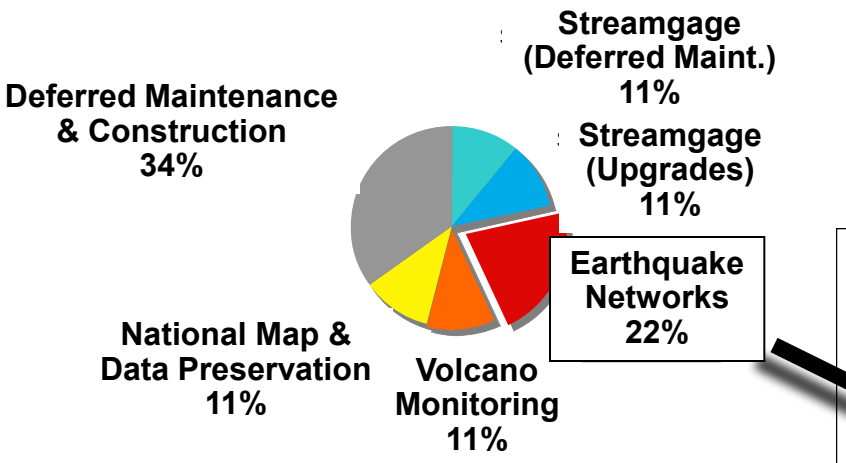
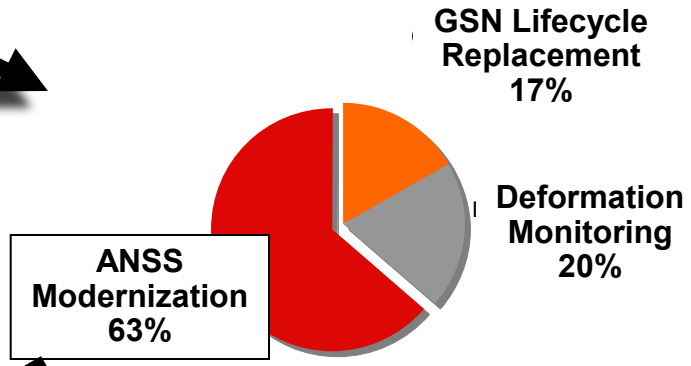
The full report is on the web at http://earthquake.usgs.gov/aboutus/sesac/

USGS spending plan for Recovery Act (ARRA) funding

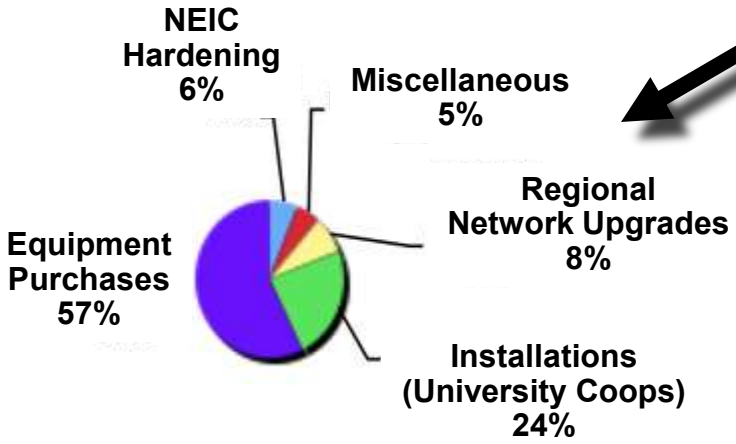
USGS Total: $140M



Earthquake Networks: $29.4M



ANSS Modernization: $19.2M



ARRA earthquake projects

- **$30 million obligated by Sept. 30th, 2010**
- **Currently ~60% of funds have been expended**
- **826 monitoring sites will be affected:**
  - **478 seismic stations to up upgraded to ANSS standards**
  - **148 new NetQuake instruments to be deployed**
  - **193 GPS stations to be upgraded**
  - **5 new GPS stations added in SF-Bay area**
  - **2 new strain monitoring sites (replacing two sites)**
- **All monitoring sites received a NEPA "Categorical Exclusion" (clearance)**
- **210 stations completed by Oct. 25**

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RECOVERY.GOV

ARRA – By Development Task

- Software developers at NEIC paid thru 2011
- Renovate and harden NEIC computer center
- Replace portable arrays (43 systems added)
- Upgrade CISN communications (microwave)
- Started geotechnical characterization of ANSS seismic station sites (400 sites)
- SAFOD remediation completed
- Initial LiDAR collection completed
- GSN “Next-Generation upgrades” will standardize the global network
  - $5M from NSF matched USGS contribution

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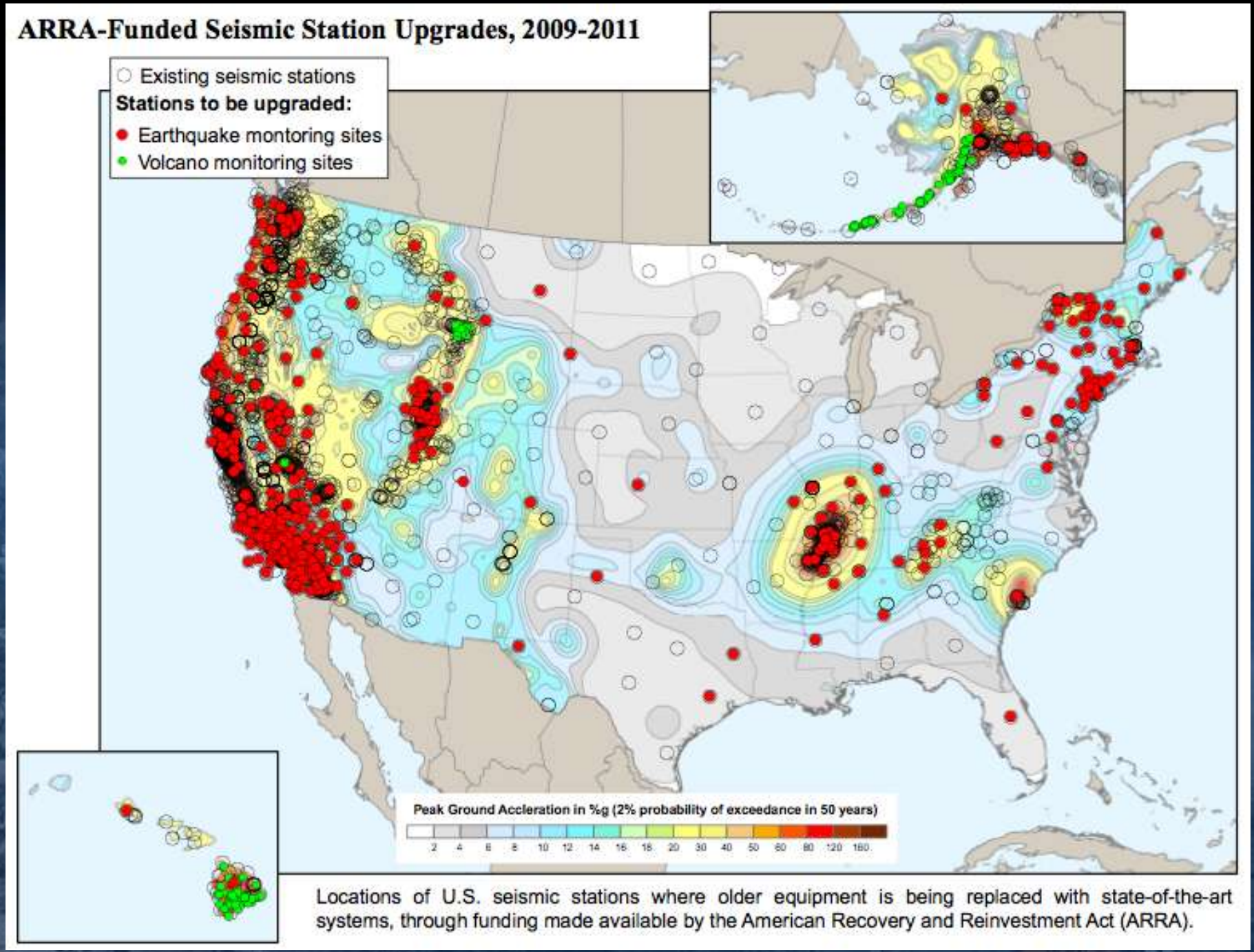
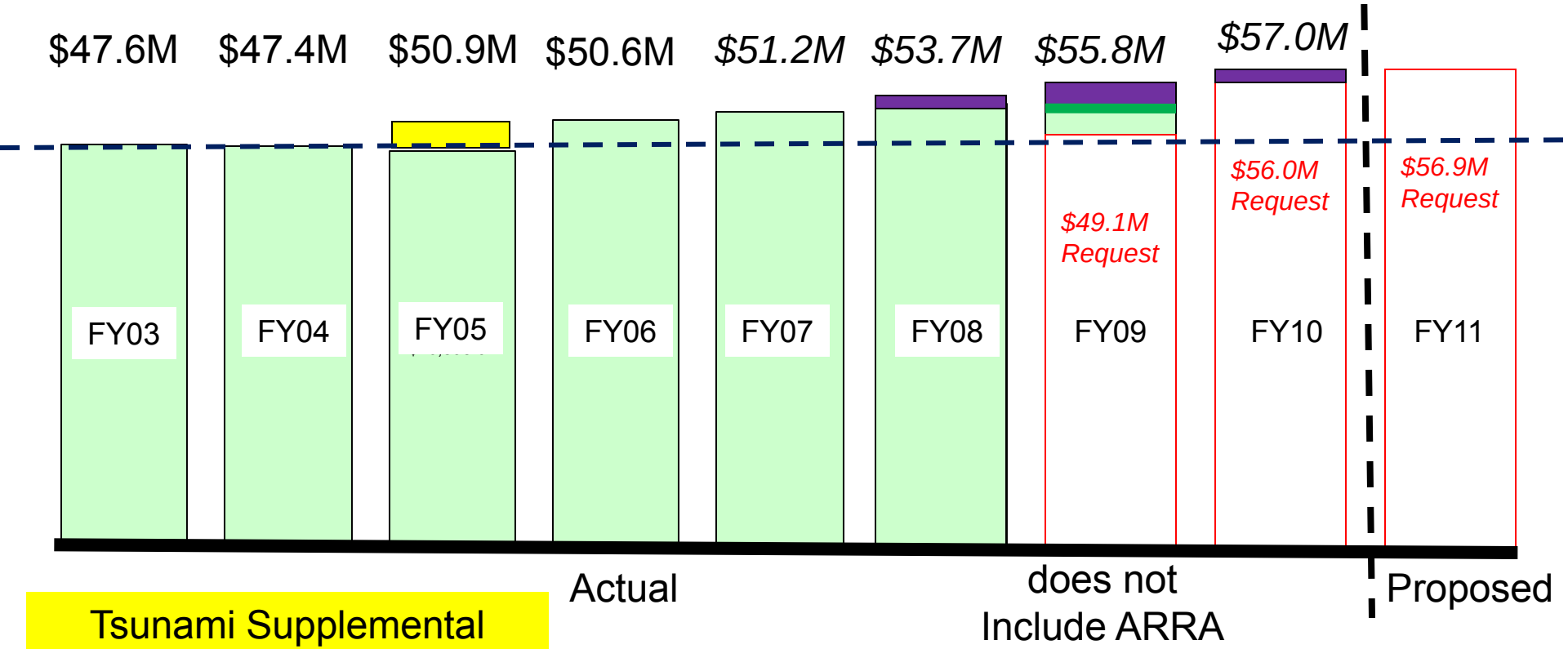
ARRA-Funded Seismic Station Upgrades, 2009-2011



Locations of U.S. seismic stations where older equipment is being replaced with state-of-the-art systems, through funding made available by the American Recovery and Reinvestment Act (ARRA).

To our friends at the USGS:
REF TEK employees thank you for your orders
REFRACTION TECHNOLOGY INC.
1600 TENTH STREET

Recent Earthquake Hazards Program funding history and FY11 proposed request



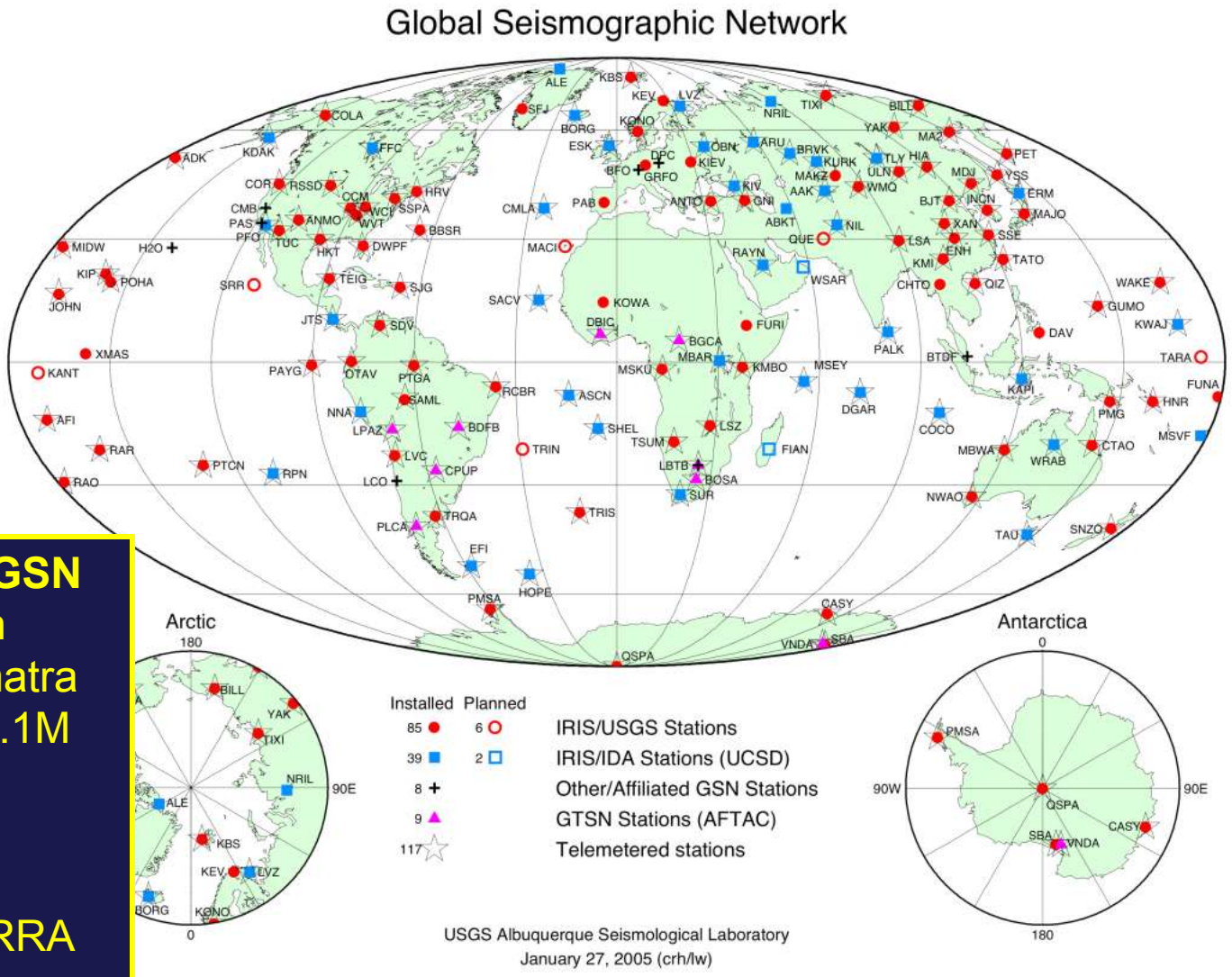
Tsunami Supplemental (became part of base in FY06)

Congressional adds for Multi-Hazards Initiative

Arkansas earmark

FY10 House mark added $1M above request for "critically needed LIDAR and other seismological studies of areas with high earthquake risk and community danger."

Global Seismographic Network



USGS Funding for GSN

FY 2005: $3.4 million

FY 2005 post-Sumatra supplemental: +$4.1M

FY 2006: $3.9M

FY 2007: $3.9M

FY 2008: $4.4M

FY 2009: $5.5M + ARRA

FY 2010: $5.8M

FY 2011: $5.4M (request)

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IRIS

GSN

Taking the multi-hazard initiative on the road in FY11: Pacific Northwest and Alaska

- **Southern California Multi-Hazards Demonstration Project (+$1.7M)**
  - Earthquake Hazards Program for early warning and operational earthquake forecasting (+1M)
  - Mineral Resources, Ecosystem, and Geography programs for economic, environmental and ecosystem impact analysis (+$0.7M)
- **Pacific Northwest (+$0.9M)**
  - EHP for Netquake deployment and EM training on USGS products (+$0.4M)
  - Volcano Hazards Program for improved forecasting of volcanic events, implementing National Volcano Early Warning System (+$0.5M)
- **Alaska (+$1.1M)**
  - EHP for assessing tsunami-generating earthquake sources (+$0.4M)
  - High-threat volcano monitoring (+$0.7M)
- **Add volcano quake detection role to NEIC 24/7 operations (+$0.3M)**

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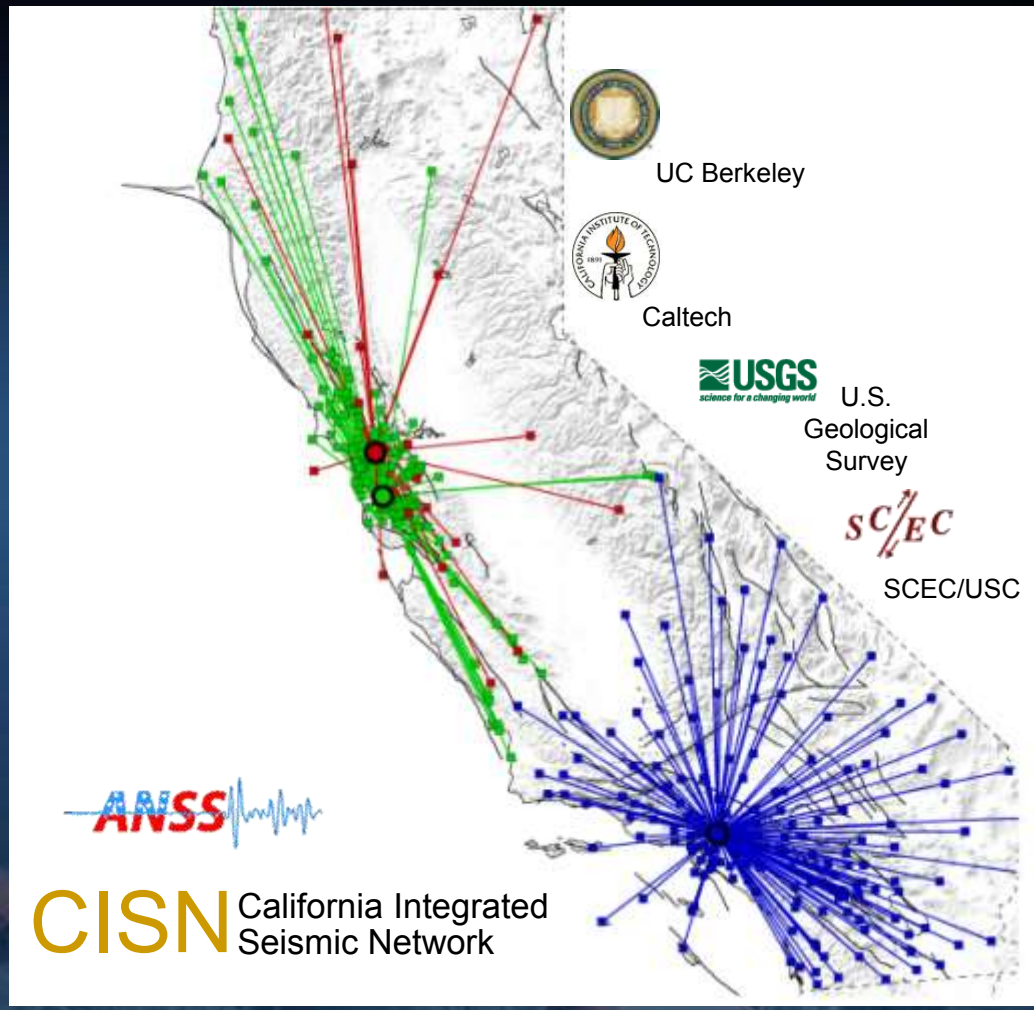
Earthquake early warning – getting ahead of strong ground shaking

- USGS/CISN Phase I (2007-2009) cooperative agreement supported algorithm testing
- Phase II (2010-2012) supports prototype development and identifies test users
- ARRA funding used to reduce datalogger delays
- EEW requirements:
  - -- rapid earthquake detection
  - -- early magnitude estimation
  - -- ground shaking prediction
  - -- robust monitoring networks
  - -- well-defined user community



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US/Japan Earthquake Research Panel

- 8th bi-annual meeting held in Nagaoka, Japan
- Support from NSF and USGS enabled participation of early-career scientists
- Pleased to have Jack Hayes there to compare with UJNR Wind and Seismic Effects panel
- Topics included
  - early warning,
  - episodic tremor and slip,
  - recurrence,
  - hazard assessment, and
  - recent events

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Situational awareness available in 20 minutes

Prompt
Assessment of
Global
Earthquakes
for
Response

Rapidly estimated that over 2 million people were exposed to violent shaking

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USAID FROM THE AMERICAN PEOPLE

M 7.0, HAITI REGION

Origin Time: Tue 2010-01-12 21:53:10 UTC
Location: 18.46°N 72.53°W Depth: 13 km

PAGER
Version 8
Created: 1 day, 20 hours after earthquake

Estimated Population Exposed to Earthquake Shaking

ESTIMATED POPULATION EXPOSURE (k = x1000)		- -*	- -*	5,887k*	7,261k	1,049k	571k	314k	2,246k	332k
ESTIMATED MODIFIED MERCALLI INTENSITY		I	II-III	IV	V	VI	VII	VIII	IX	X+
PERCEIVED SHAKING		Not felt	Weak	Light	Moderate	Strong	Very Strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	Resistant Structures	none	none	none	V. Light	Light	Moderate	Moderate/Heavy	Heavy	V. Heavy
	Vulnerable Structures	none	none	none	Light	Moderate	Moderate/Heavy	Heavy	V. Heavy	V. Heavy

*Estimated exposure only includes population within the map area.

Population Exposure

population per ~1 sq. km from Landscan

Selected City Exposure

MMI	City	Population
X	Grand Goave	5k
IX	Port-au-Prince	1,235k
IX	Carrefour	442k
IX	Petionville	108k
IX	Delmas 73	383k
IX	Croix des Bouquets	9k
VI	Miragoane	6k
V	Verrettes	49k
III	Santo Domingo	2,202k
III	Guantanamo	273k

bold cities appear on map (k = x1000)

Shaking Intensity

MMI

How the Chilean earthquake would have looked using new version of PAGER

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Earthquake Shaking — Red Alert

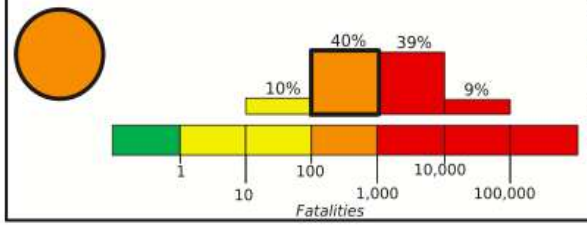
GSN · USAID FROM THE AMERICAN PEOPLE · ANSS

M 8.8, OFFSHORE MAULE, CHILE

Origin Time: Sat 2010-02-27 06:34:14 UTC (02:34:14 local)
Location: 35.85°S 72.72°W Depth: 35 km
FOR TSUNAMI INFORMATION, SEE: tsunami.noaa.gov

PAGER Version 3
Created: 3 hours, 10 minutes after earthquake

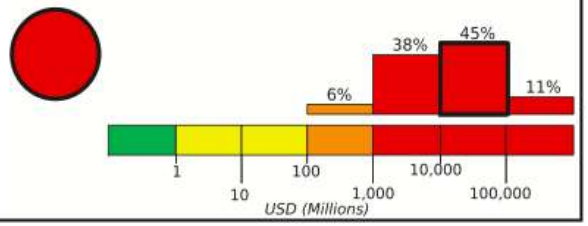
Estimated Fatalities



Red alert level for economic losses. Extensive damage is probable and the disaster is likely widespread. Estimated economic losses are 3-20% GDP of Chile. Past events with this alert level have required a national or international level response.

Orange alert level for shaking-related fatalities. Significant casualties are likely.

Estimated Economic Losses



Estimated Population Exposed to Earthquake Shaking

ESTIMATED POPULATION EXPOSURE (k = x1000)		- -*	- -*	487k*	2,147k*	3,657k	6,405k	3,083k	0	0
ESTIMATED MODIFIED MERCALLI INTENSITY		I	II-III	IV	V	VI	VII	VIII	IX	X+
PERCEIVED SHAKING		Not felt	Weak	Light	Moderate	Strong	Very Strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	Resistant Structures	none	none	none	V. Light	Light	Moderate	Moderate/Heavy	Heavy	V. Heavy
	Vulnerable Structures	none	none	none	Light	Moderate	Moderate/Heavy	Heavy	V. Heavy	V. Heavy

*Estimated exposure only includes population within the map area.

Three red alerts; three very different outcomes for fatalities

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Summary Alert: Red

USAID FROM THE AMERICAN PEOPLE

M 7.0, HAITI REGION

Origin Time: Tue 2010-01-12 21:53:10 UTC (16:53:10 local)

Location: 18.45°N 72.57°W Depth: 13 km

PAGER Version 1

Created: 1 month, 2 weeks after earthquake

Estimated Fatalities

Red alert for fatalities and economic losses. High casualties and widespread damage are likely and the disaster is potentially widespread. Past red alerts have required a national or international response.

Estimated Economic Losses

Estimated Population Exposed to Earthquake

ESTIMATED POPULATION EXPOSURE (k = x1000)		- -*	50k*	7,272k*	6,149k
ESTIMATED MODIFIED MERCALLI INTENSITY		I	II-III	IV	V
PERCEIVED SHAKING		Not felt	Weak	Light	Moderate
POTENTIAL DAMAGE	Resistant Structures	none	none	none	V. Light
	Vulnerable Structures	none	none	none	Light

*Estimated exposure only includes population within the map area.

Population Exposure

population per ~1 s

0 5 50 100 500 1000

75°W 74°W 73°W 72°W 71°W

Guantanamo

Port-au-Prince

VI

V

This information was automatically generated.

http://earthquake.usgs.gov/pager

USGS science for a changing world

Summary Alert: Red

USAID FROM THE AMERICAN PEOPLE

M 7.0, SOUTH ISLAND OF NEW ZEALAND

Origin Time: Fri 2010-09-03 16:35:46 UTC (04:35:46 local)

Location: 43.53°S 172.12°E Depth: 5 km

PAGER Version 5

Created: 7 hours, 10 minutes after earthquake

Estimated Fatalities

Red alert level for economic losses. Extensive damage is likely and the disaster is potentially widespread. Estimated economic losses are 1-10% GDP of New Zealand. Past events with this alert level have required a national or international level response.

Green alert level for fatalities. There is a low likelihood of casualties.

Estimated Economic Losses

Estimated Population Exposed to Earthquake Shaking

ESTIMATED POPULATION EXPOSURE (k = x1000)		- -*	147*	91k*	111
ESTIMATED MODIFIED MERCALLI INTENSITY		I	II-III	IV	V
PERCEIVED SHAKING		Not felt	Weak	Light	Moder
POTENTIAL DAMAGE	Resistant Structures	none	none	none	V. Lig
	Vulnerable Structures	none	none	none	Ligh

*Estimated exposure only includes population within the map area.

Population Exposure

population

0 5 50 100 500 1000

170°E 171°E 172°E 173°E

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Earthquake Shaking: Red Alert

USAID FROM THE AMERICAN PEOPLE

GSN ANSS

M 8.8, OFFSHORE MAULE, CHILE

Origin Time: Sat 2010-02-27 06:34:14 UTC (02:34:14 local)

Location: 35.85°S 72.72°W Depth: 35 km

FOR TSUNAMI INFORMATION, SEE: tsunami.noaa.gov

PAGER Version 3

Created: 3 hours, 10 minutes after earthquake

Estimated Fatalities

Red alert level for economic losses. Extensive damage is probable and the disaster is likely widespread. Estimated economic losses are 3-20% GDP of Chile. Past events with this alert level have required a national or international level response.

Orange alert level for shaking-related fatalities. Significant casualties are likely.

Estimated Economic Losses

Estimated Population Exposed to Earthquake Shaking

ESTIMATED POPULATION EXPOSURE (k = x1000)		- -*	- -*	487k*	2,147k*	3,657k	6,405k	3,083k	0	0
ESTIMATED MODIFIED MERCALLI INTENSITY		I	II-III	IV	V	VI	VII	VIII	IX	X+
PERCEIVED SHAKING		Not felt	Weak	Light	Moderate	Strong	Very Strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	Resistant Structures	none	none	none	V. Light	Light	Moderate	Moderate/Heavy	Heavy	V. Heavy
	Vulnerable Structures	none	none	none	Light	Moderate	Moderate/Heavy	Heavy	V. Heavy	V. Heavy

*Estimated exposure only includes population within the map area.

Population Exposure

population per ~1 sq. km from Landscan

0 5 50 100 500 1000 5000 10000

77°W 75°W 73°W 71°W 69°W

San Felipe

Valparaíso

Santiago

San Bernardo

33°S

Structures:

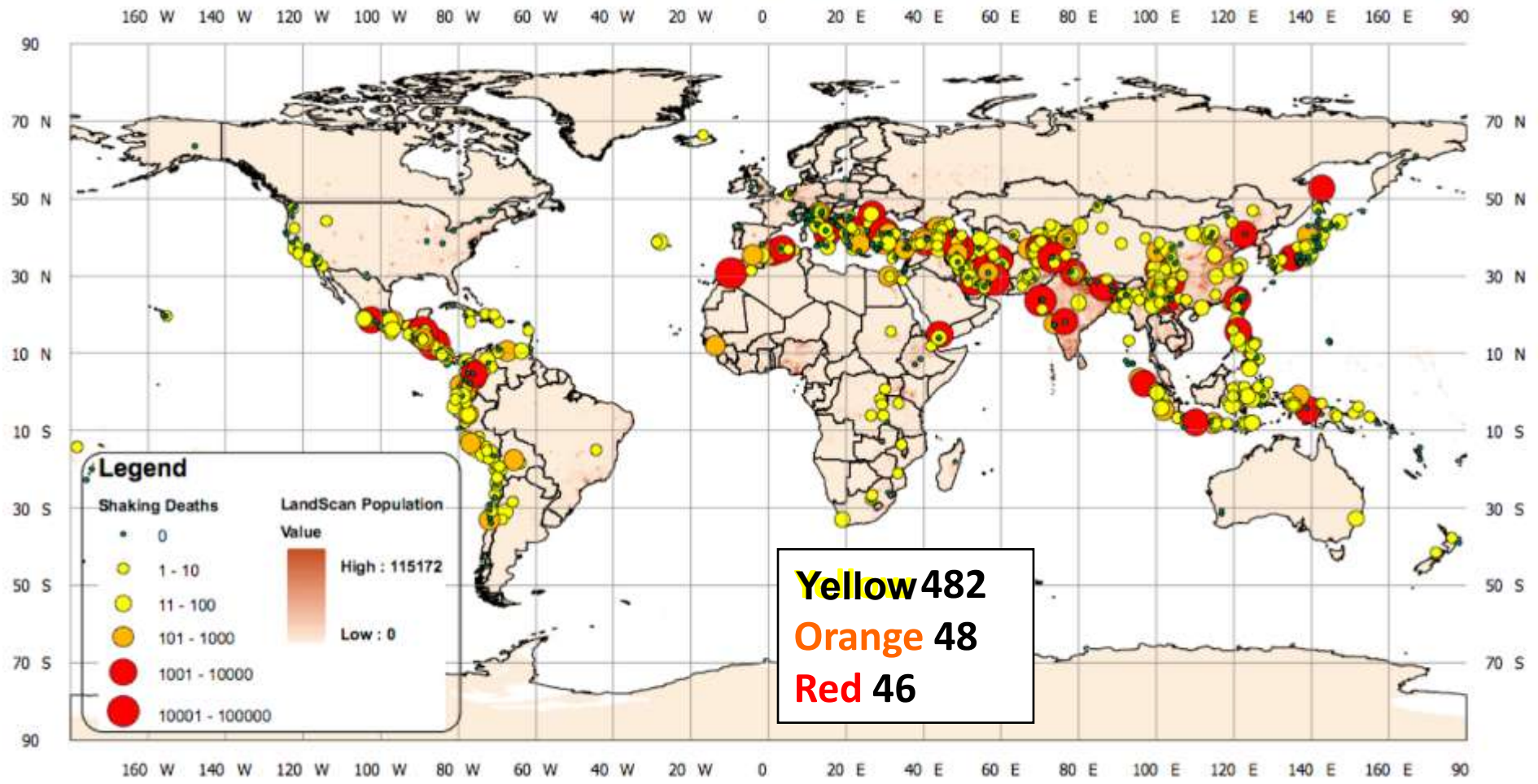
Overall, the population in this region resides in structures that are resistant to earthquake shaking, though some vulnerable structures exist. The predominant vulnerable building types are low-rise reinforced/confined masonry and adobe block construction.

Historical Earthquakes (with MMI levels):

Date	Dist.	Mag.	Max MMI	Shaking Deaths

USGS

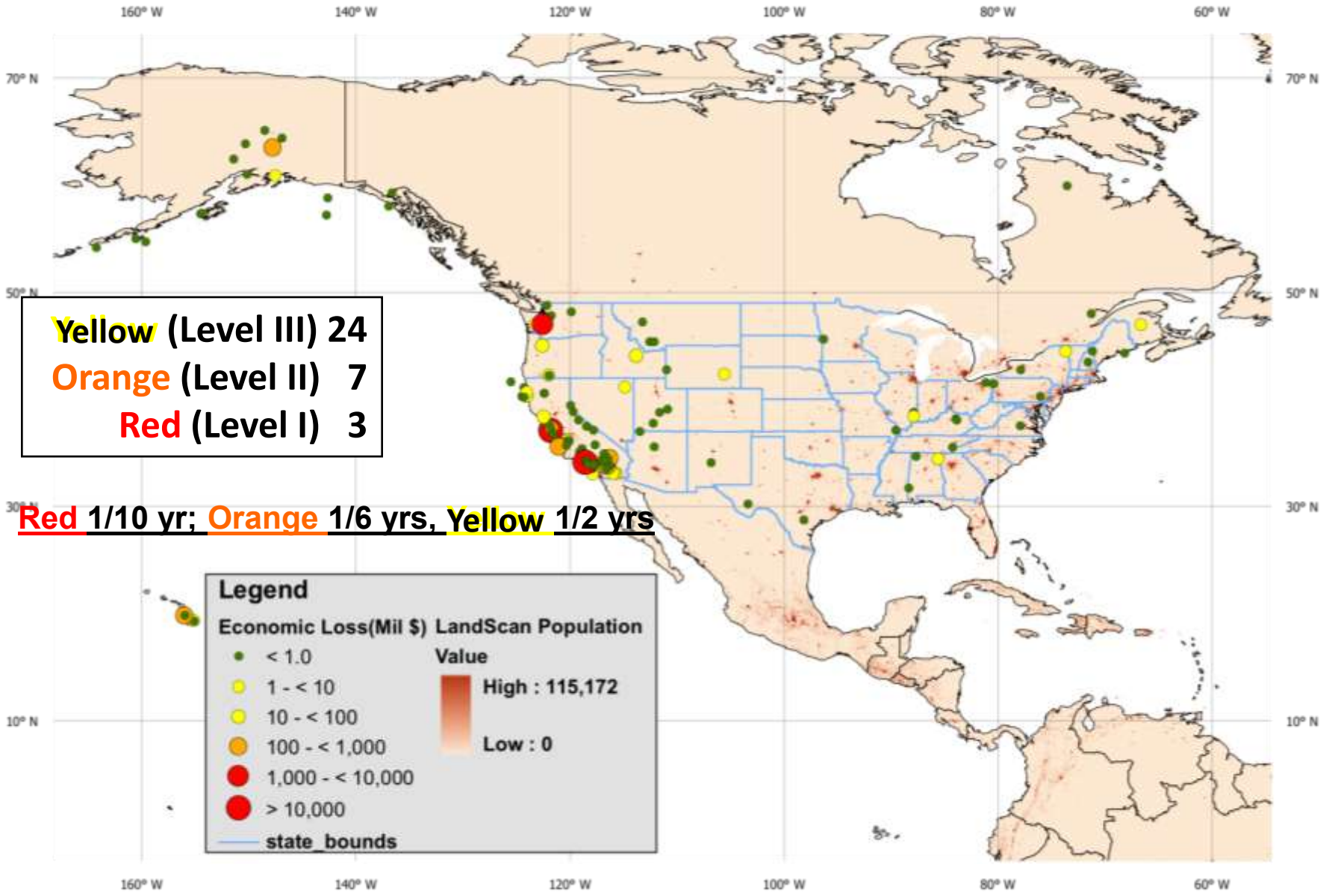
Global Fatality-based alerts over the past 40 years



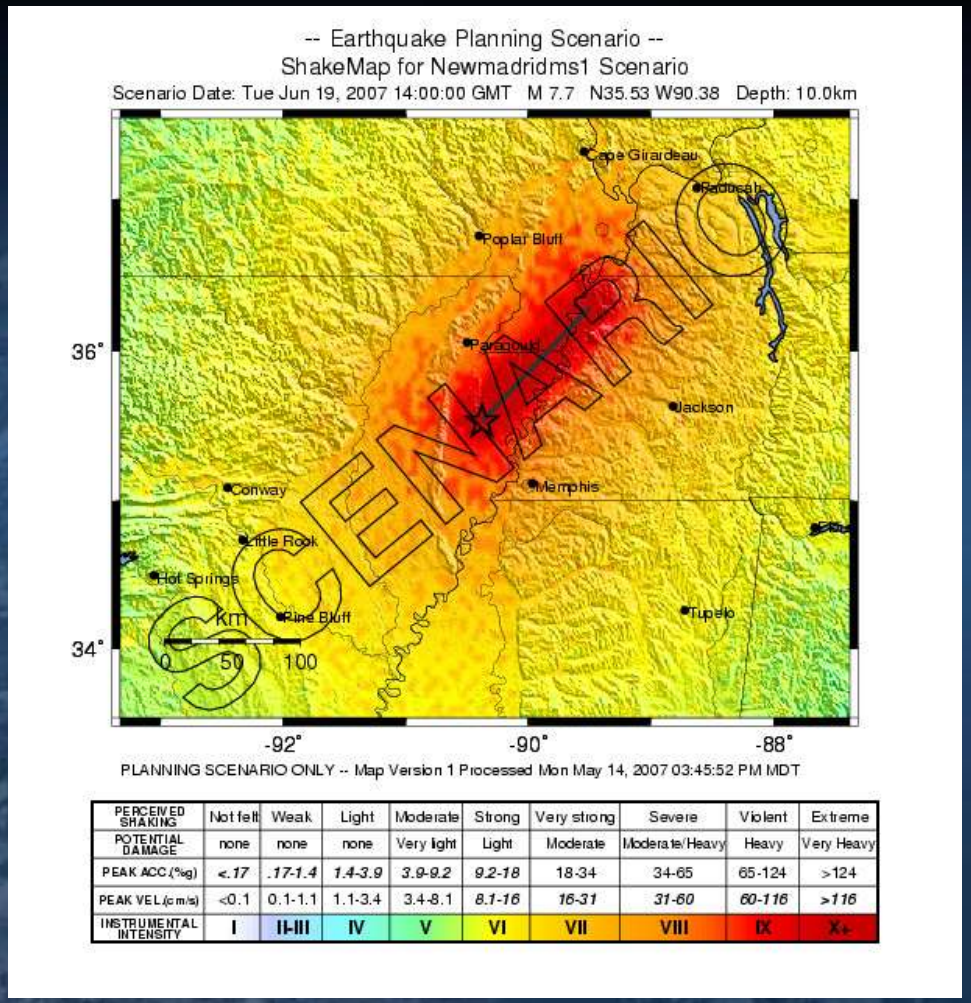
Map of fatality-based alert levels that would be triggered given the observed fatalities for events over the past forty years. The legend provides the fatality threshold for color-coded alert level. There would have been about 5,000 green, 490 yellow, 51 orange, and 48 red alerts (**approximately 12 yellow, 1-2 orange, and 1-2 red alerts per year**).

US $-Loss-based Activation Levels (past 40 years)

(From comparison of past losses, aid & response)

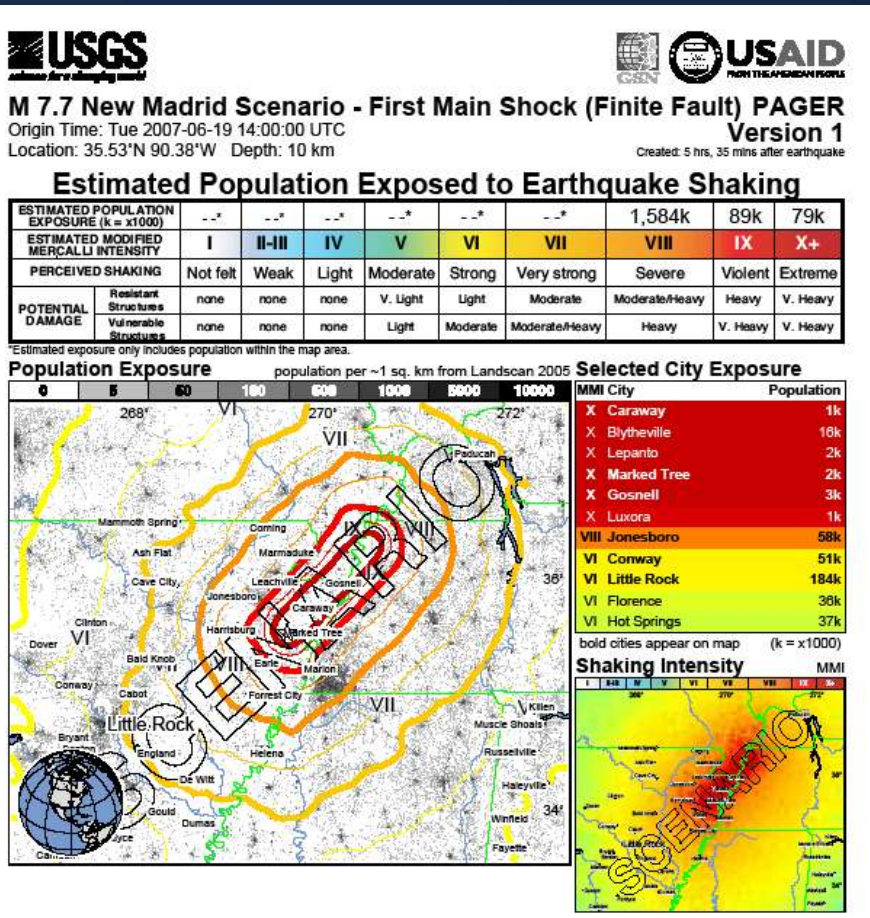


FEMA National Level Exercise 2011
Based on New Madrid earthquake



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Scenario ShakeMap and PAGER prepared for SONS07 emergency response exercise



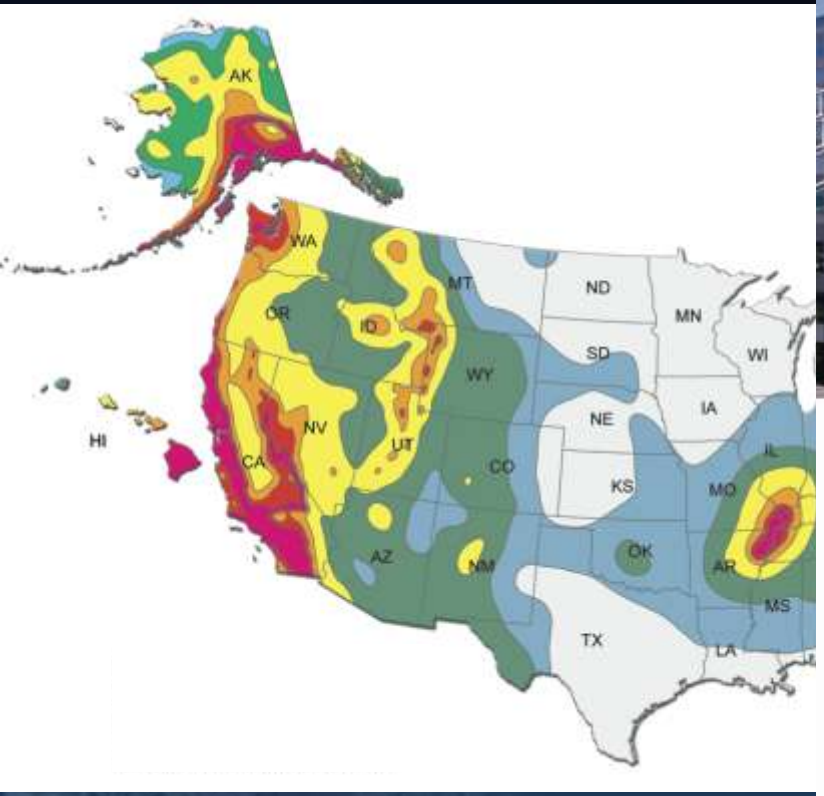
Opportunity: Basis for FEMA Activation Levels*

Alert Level & Color	FEMA's Activation Level	Estimated Losses ($M)	Number of Alerts per year
Red	Level I	> 1,000 ($1B)	0.1 (1/10 yrs)
Orange	Level II	100 – 1,000	0.2 (1/5 yrs)
Yellow	Level III	1-100 ($1M)	0.5 (1/2 yrs)
Green	No Activation (or Standby)	< 1	1 - 2

*Based on past losses, FEMA response activities & inferred response levels

USGS nehrp

The heart of NEHRP: Translating USGS national hazard maps into model building codes



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

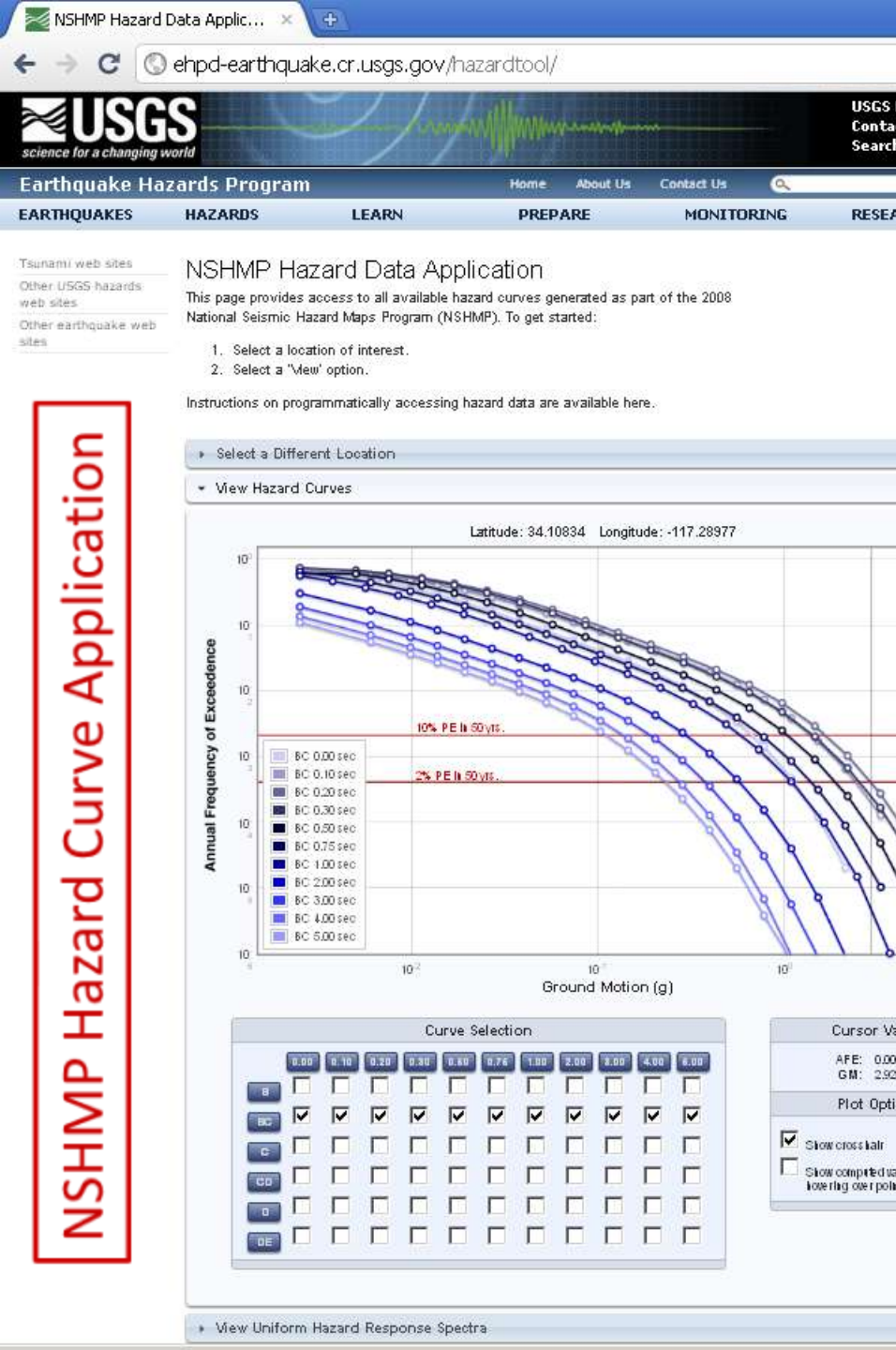
FEMA

nehrp

USGS nehrp

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

NSHMP Hazard Curve Application



- Being shaped to meet needs of FEMA-funded **ATC-58** "Guidelines for Seismic Performance Assessment of Buildings."
- Delivers **hazard curves** and **uniform-hazard spectra** for user-specified locations.
- Includes site soil classifications B, C, C-D (boundary), D, & D-E *in addition to* B-C (v_{S30}=760).
- Includes structural vibration periods T = 0, 0.1, 0.3, 0.5, 0.75, 2.0, 3.0, 4.0, & 5.0 *in addition to* 0.2 and 1.0 seconds.
- Will eventually interpolate and/or compute curves/spectra "on-the-fly" for user-specified T & v_{S30}.

2008 Interactive Deaggreg...

https://geohazards.usgs.gov/deaggint/2008/

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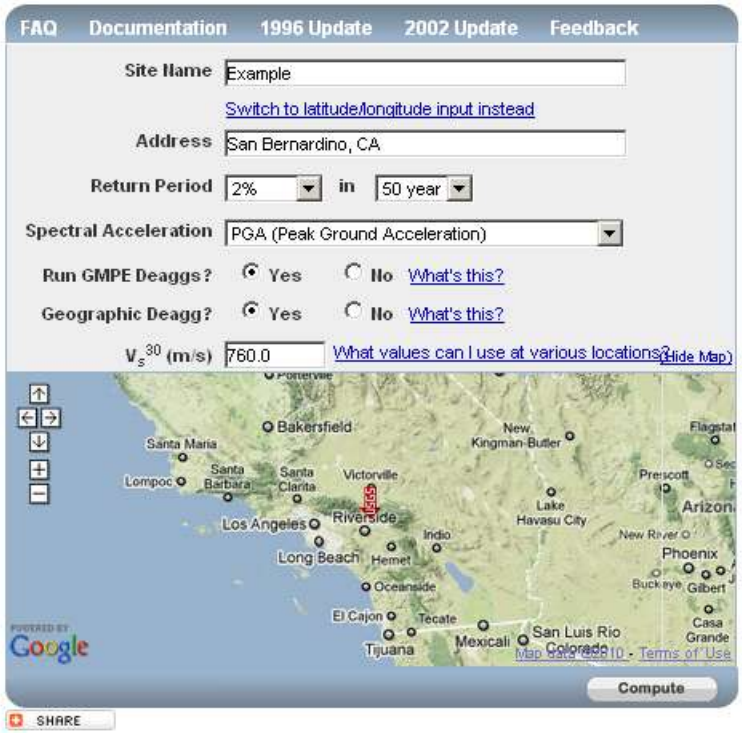
NSHMP Deaggregation App

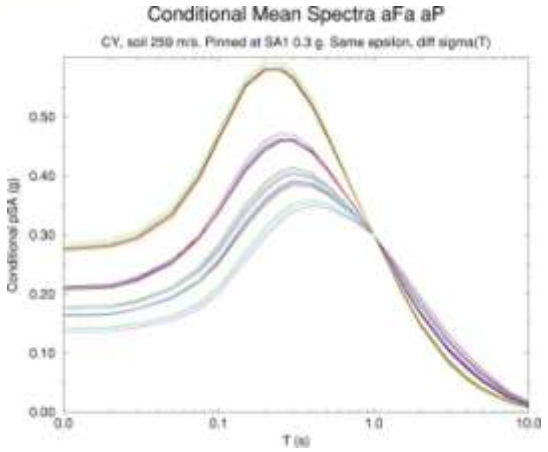
2008 Interactive Deaggregations (Beta)

This is a preliminary version of the 2008 NSHMP PSHA Interactive Deaggregation web site. In this initial release, the 2008–update source and attenuation models of the NSHMP (Petersen and others, 2008) are used with just one exception. For the New Madrid Seismic Zone (NMSZ), the deaggregation source model is set up for the "unclustered" event branches only. These unclustered New Madrid sources are given full weight (90% weight to the 500 year mean recurrence models; 10% weight to the 1000–year mean recurrence models) whereas in the 2008 NSHMP PSHA they are only given 50% weight. Clustered–source models receive the other 50% weight in 2008 NSHMP PSHA. This is a temporary difference. The interactive deaggregation will include the NMSZ clustered–source models when a few software checkups are completed.

Seismic–hazard deaggregations are available for the following spectral periods anywhere in the conterminous U.S: 0.0 s (PGA), 0.1 s, 0.2 s, 0.3 s, 0.5 s, 1.0 s, and 2.0 s. This is the same set of periods that has been available at the USGS interactive deaggregation web sites since 1996 (for sites in the conterminous United States).

In the western US, long–period seismic–hazard deaggregations at 3.0 s, 4.0 s, and 5.0 s are also available at this web site. More...





- Also being shaped/revised to meet needs of **ATC-58** Guidelines.
- Adding output of **Conditional Mean Spectrum** (for seismogram selection) that is fully-consistent with USGS-NSHMP hazard & deaggregation computations.
- Assimilating **banded deaggregation** for user-specified ground motion ranges.

U.S. Seismic "DesignMaps" ...

https://geohazards.usgs.gov/secure/designmaps/us/application.php

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Upcoming U.S. Design Code Preview
- Web Application
- Batch Mode
- Min/Max for Regions

Seismic Design for Engineers
- Buildings
- Bridges

Seismic Hazards

Design Maps App

U.S. Seismic "DesignMaps" Web Application

Caution: If you need earthquake ground motion values for *present* building codes, e.g. from the 2009/2006/2003/2000 International Building/Residential Code (IBC/IRC) or the 2005/2002/1998 ASCE-7 Standard, **do not use this application**; instead use the Java Ground Motion Parameter Calculator. The application below currently only outputs values from the 2009 NEHRP Provisions and 2010 ASCE-7 Standard, which will be incorporated into *future* building codes via the 2012 IBC/IRC.

For batch mode, click here

Report Title (Optional)
This will appear at the top the generated report.
Example

Building Code Reference Document
Ask your local building official if you need help selecting this.
2010 ASCE 7 Standard

Site Soil Classification
This is not automatically selected based on site location.
Site Class D – "Stiff Soil" (Default)

Site Address
Enter a street address, cross street, or other canonical location.
San Bernardino, CA

Enter a latitude and longitude instead

Compute Values

SHARE

References to non-U.S. Department of the Interior (DOI) products do not constitute an endorsement by the DOI. By viewing the Google Maps API on this web site the user agrees to these Terms of Service set forth by Google.

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- Hazards
- Learn
- Prepare
- Monitoring
- Research

LANDSLIDES
- Research
- Advisories
- Monitoring
- Landslide Events
- State & Local Info
- Learning & Education

GEOMAGNETISM

http://earthquake.usgs.gov/designmaps/usapp/

- Will add ground motions from **ASCE 31/41 Standard** (performance-based design for existing buildings).
- Those ground motions are currently being updated with help from USGS-NSHMP.
- **Risk-targeted ground motions** developed for ASCE 7 Standard (new buildings) *established an explicit performance objective* (1%-in-50yr collapse risk).

President Obama today named 85 researchers as recipients of the Presidential Early Career Awards for Scientists and Engineers, the highest honor bestowed by the United States government on science and engineering professionals in the early stages of their independent research careers.

Including…

Department of the Interior

Jeanne L. Hardebeck, U.S. Geological Survey

Nicolas Luco, U.S. Geological Survey

Pamela L. Nagler, U.S. Geological Survey

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Facing Tomorrow's Challenges – USGS Science in the Decade 2007-2017

Understanding Ecosystems and Predicting Ecosystem Change

Climate Variability and Change

Energy and Minerals for America's Future

A National Hazards, Risk, and Resilience Assessment Program

The Role of Environment and Wildlife in Human Health

A Water Census of the United States

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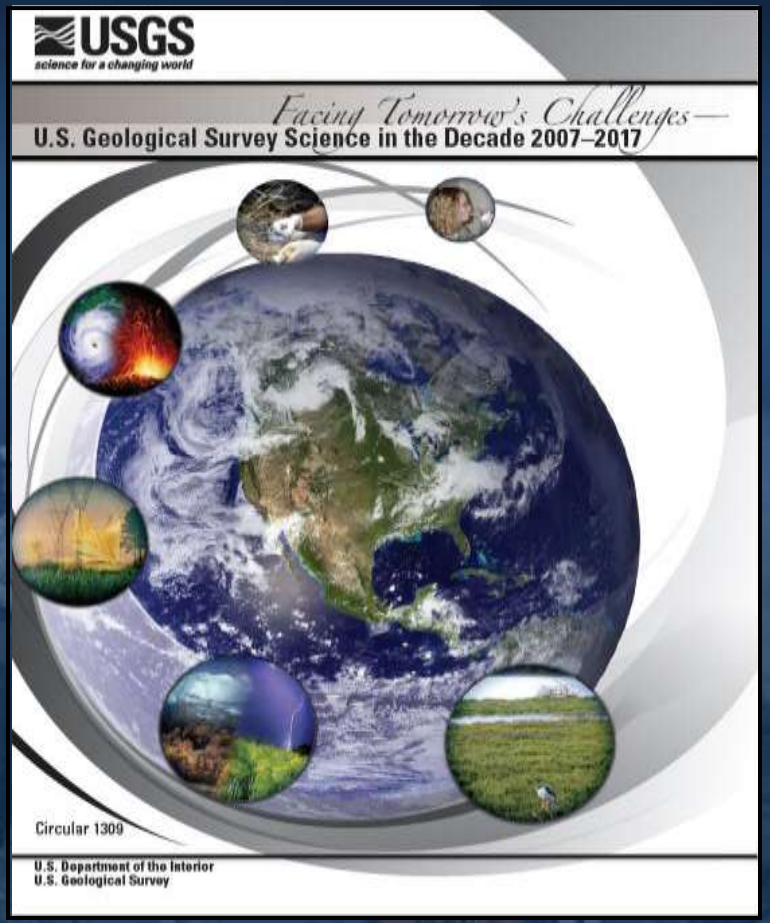


Aligning the USGS leadership structure with the science strategy

- Demonstrate that USGS science is focused on issues that concern society
- Enhance opportunities to increase the level of Federal and non-Federal investment in science
- Unite and integrate the capabilities of the USGS

Climate and Land-Use Change
Core Science Systems
Ecosystems
Energy, Minerals, and Environmental Health
Natural Hazards
Water

USGS

USGS Natural Hazards Mission Area

Coastal & Marine Geology Program

Earthquake Hazards Program

Geomagnetism Program

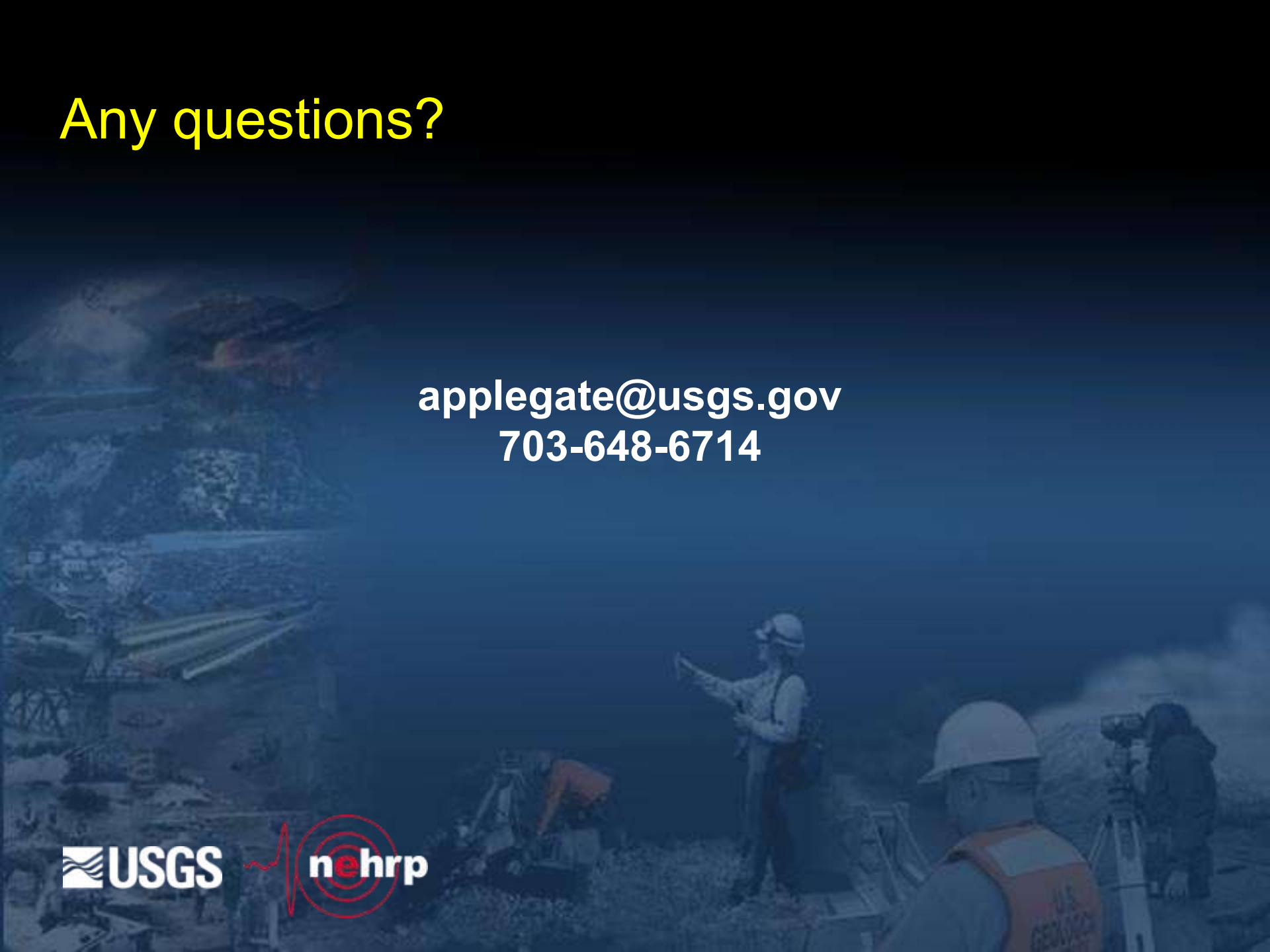
Global Seismographic Network

Landslide Hazards Program

Volcano Hazards Program

- Plus wildfire, hurricane and flood coordination
- Plus follow-on to Multi-Hazards Demonstration Project
- Next step: Establish science strategy planning teams to deliver 10-year plan to implement the bureau science strategy

USGS

Any questions?

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703-648-6714