USGS Update

Advisory Committee for Earthquake Hazard Reduction

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U.S. Geological Survey

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High visibility for earthquake science

- Wenchuan, China, 2008
- Haiti, Jan. 2010
- Maule, Chile, Feb. 2010
- Baja Calif., Apr. 2010
- Christchurch, Feb. 2011
- Tohoku, Japan, 2011
- Mineral, Virginia, 2011

and several smaller but significant induced earthquakes!
Very High Public Exposure

- More than 500 million EHP web pages delivered by USGS in each of the past two years
- Growth of earthquake (ENS) notification subscriptions to over 350,000 and counting
- Congressional hearings and special events on tsunami, induced earthquakes, quake warning systems
- Presidential and National Level earthquake response exercises
Great ShakeOut earthquake drills help people in homes, schools, and workplaces to learn what to do in an earthquake and provide an opportunity for everyone to improve their over all preparedness. For your family, your co-workers and millions of others will be better prepared for the next earthquake in your region! As of today, there are over 13.2 million people participating in ShakeOut 2012, including over 8.7 million people, on October 18th.

To register or learn more, click a ShakeOut region map or detailed information.
2013 Research & Development Efforts

• National Seismic Hazard Maps
  – Incorporation of California dynamic earthquake probabilities (UCERF-3) and geodetic strain data

• Earthquake Early Warning Prototype

• Induced Seismicity Research
  – Part of broader USGS-DOE-EPA hydrofracturing initiative

• Eastern U.S. earthquake research (unfunded)

• Aftershock Probability Forecasts (OEF)
NEO Assessments Results for USGS Natural Hazards Mission Area

**OSTP National Earth Observation System Assessment 2012**

Thousands of Earth observing systems and activities were reviewed by “subject matter experts” from federal agencies.

Major USGS systems ranked highly in the NEO impact assessment, both for the Disasters and the Space Weather Societal Benefit Areas.

The ANSS Ranked 37th and in the top 100 systems having the highest impact across all benefit areas.

The Global Seismographic Network ranked as the highest impact system in the “solid earth” portion of the Disasters SBA.

The USGS Geomagnetic Observatory network ranked second in impact, among dozens of space weather observation systems.

The highest impact system, by far, was GPS.
ANSS Update

Growth of ANSS Stations Since Inception

Number of ANSS Stations

Fiscal Year

Annual Funding ($M)

16.0

8.0

USGS
ANSS – Recent Developments

• Increasing subscribers and usage
• New Product: TED – Tweet Earthquake Dispatch
  – Test Service: TEDect (Twitter monitor)
• High interest in earthquake early warning
• Redesigned Web Pages, Catalog server
• New Mobile Earthquake Information App.
• Building Instrumentation
  – Expanded VA hospital instrumentation
  – One Rincon Tower cooperation
Tweet Earthquake Dispatch and Twitter Event Detections

• @USGSted distributes alerts for quakes with magnitudes of $\geq 5.5$

• Tweets contain a size estimate, location, origin time, and link to the event webpage.

• They also include the frequency of tweets in a region surrounding the event that contain the word “earthquake” or its equivalent in several languages.

• NEIC analysts also get an early indication of a significant quake – often before the system locates it!
Recent Earthquake Response: Maine M4.0
Oct 16, 2012

40 sec. – TEDect alert
3 mins. – initial solution
10 min. – reviewed solution
11 min. – ShakeMap
12 min. – PAGER “Green” impact assessment
ShakeAlert Earthquake Early Warning

Status today:
Demonstration system

Next three years:
Demonstration ➔ Prototype
Made possible thanks to a public-private-foundation partnerships

Receiving alerts today:
• 50 research scientists
• Google.org
• BART
• Metrolink
• Amgen
• SoCal Edison
• CalEMA
• SF DEM
• L.A. City
• L.A. County
• UC Berkeley OEP
• more...
One Rincon Tower –
A Joint USGS-CGS
Structure Instrumentation Project

64 stories – 641 ft.
Concrete core construction
72 channels of real-time strong motion
Automated damage detection analysis
In collaboration with the U.S. Department of Veterans Affairs (VA), the National Strong Motion Project has recently installed sophisticated seismic systems that will monitor the structural integrity of hospital buildings during earthquake shaking. The new systems have been installed at more than 20 VA medical campuses across the country. These monitoring systems, which combine sensitive accelerometers and real-time computer calculations, are capable of determining the structural health of each structure rapidly after an event, helping to ensure the safety of patients and staff.
USGS Induced Seismicity Project

• Statistical analyses of induced seismicity – Leader: Justin Rubinstein

• Hydrologic/geomechanical model studies – Leader: Steve Hickman

• Hazard and risk from induced earthquakes – Leader: Tom Hanks

• Geophysical framework of induced earthquake sites – Leader: Walter Mooney
Hydrofracking and Induced Seismicity

- Below a few kilometers depth, the Earth’s crust is everywhere stressed.

- The Earth’s crust is full of faults, both old and new.

- The fracking itself typically releases very little seismic energy.

- But, in many cases, the gas production comes with large volumes of formation water (brine), which must be treated or disposed of responsibly.
Earthquakes and Fracking
Investigation of Observed Seismicity in the Horn River Basin
BC Oil and Gas Commission - August 2012

Figure 8: Cumulative microseismic plot for Kiwiga, coloured dots indicate contained micro-seismicity events caused by tensile and shear failure of intact shale. Trail of coloured dots suggest reopening or movement of pre-existing fault. Generalized stratigraphic column to right.

“The seismicity observed and reported by NRCan in the Horn River Basin between April 2009 and December 2011 was induced by fault movement resulting from injection of fluids during hydraulic fracturing.”

31 earthquakes largest Mw 3.6
A by-product of the fracking operation is “produced water” (natural brine and fracking flowback).
Disposal of Fluids from Fracking

Wastewater (brine) injection depths are usually deep, in rocks naturally stressed with faults capable of generating earthquakes.

Wastewater well

Fracking well

Well is turned horizontal

Marcellus Shale

deep injection may trigger earthquakes due to stress relief on faults
Recent USGS Activities

• Interagency Agreement with the EPA – reported results of three studies concerning earthquake risk due to injection of wastewater at depth. Special focus in the Raton Basin of S. Colorado

• Mid-continent seismicity increase, starting in 2001, caused mostly by deep injection of wastewater from oil and gas production

• Paradox Valley (CO) brine disposal (BLM monitoring)

• Monitoring at sites of induced quakes in Arkansas, Colorado, Ohio

• Desert Peak (NV) EGS project – injected water to establish hydraulic connection from injection well to production well
How do induced earthquakes affect hazard maps, and therefore building codes?

USGS National Seismic Hazard Map
Peak Acceleration with 10% Chance of Exceedance in 50 years
Magnitude 4 and Larger Earthquakes
2008 - 2011
Rate of Earthquakes in the Midcontinent

Cumulative Number of Earthquakes
M >= 3

Earthquake Count

0 200 400 600 800

Year

Rate of Earthquakes in the Midcontinent

Cumulative Number of Earthquakes
M >= 3

Mid-Continent M>=3.0 Seismicity 1970–1979
205 EQs
20.5 EQs/yr

21 events/year
### Tectonic or Induced?

Eleven recent earthquakes of public concern

<table>
<thead>
<tr>
<th>Date</th>
<th>Location</th>
<th>$M_w$</th>
</tr>
</thead>
<tbody>
<tr>
<td>8/23/2011</td>
<td>Mineral, VA</td>
<td>5.8</td>
</tr>
<tr>
<td>11/6/2011</td>
<td>Prague, OK</td>
<td>5.6</td>
</tr>
<tr>
<td>8/26/2012</td>
<td>Brawley, CA</td>
<td>5.5</td>
</tr>
<tr>
<td>8/23/2011</td>
<td>Trinidad, CO</td>
<td>5.3</td>
</tr>
<tr>
<td>10/20/2011</td>
<td>Fashing, TX</td>
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<tr>
<td>5/17/2012</td>
<td>Timpson, TX</td>
<td>4.8</td>
</tr>
<tr>
<td>2/27/2011</td>
<td>Guy, AR</td>
<td>4.7</td>
</tr>
<tr>
<td>9/11/2011</td>
<td>Cogdell, TX</td>
<td>4.3</td>
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<tr>
<td>12/31/2011</td>
<td>Youngstown, OH</td>
<td>4.0</td>
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<tr>
<td>5/19/2011</td>
<td>Horn River Basin, BC</td>
<td>3.6</td>
</tr>
<tr>
<td>6/24/2012</td>
<td>Cleburne, TX</td>
<td>3.5</td>
</tr>
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Rate of Earthquakes in the Midcontinent
Rate of Earthquakes in the Midcontinent

Cumulative Number of Earthquakes
$M \geq 3$

- 21 events/year
- 31 events/year
- 151 events/year

[Graph showing the cumulative number of earthquakes in the Midcontinent over time.]
Rate of Earthquakes in the Midcontinent

Sources of extra earthquakes in 2010 and 2011

506 $M \geq 3$ Earthquakes in the Midcontinent 2001 – 2011

- **Guy, Arkansas**: N = 56
- **Oklahoma**: N = 112
- **Raton Basin**: N = 93
- **Remainder of Midcontinent**: N = 245

Expected Number = 234
Maximum Seismic Moment vs. Injected Volume

\[ M_0(\text{max}) = G \Delta V \]

wd = waste disposal  
egs = enhanced geothermal  
frak = fracking

A. McGarr, in prep.
2004-2010: Congressional Interest and Funding

- FY04: $47.4M
- FY05: $50.9M
- FY06: $50.6M
- FY07: $51.2M
- FY08: $53.7M
- FY09: $55.8M* (Request of $49.1M)
- FY10: $57.0M

* FY09 also received $25M in ARRA funding

- Tsunami Supplemental
- Congressional adds for Multi-Hazards Initiative
- Arkansas earmark for network
2010-2012: Contributing to deficit reduction

• Program funding down $2.5M (-5%) since 2010
  – Reduced allocations to all internal projects, across-the-board in 2012
  – reduced grant and network funding (ANSS)

• House of Representatives, Committee on Appropriations has recommended 2013 funding at $44M (20% reduction from 2012)
  – Proposed new funding level is below 1978 levels – which is, before there was a NEHRP
Budget Breakdown by Major Activity (2012)

Total 2012 budget $60.4M

Amount distributed externally, $14M (grants, seismic networks, geodetic networks, SCEC and other coops).

GSN amount, $5.5M is 60% of total network operational costs (NSF provides $3.5M).
Five 2013 Budget Scenarios

• President’s Budget & Senate Mark - $58.9M
  – Initiatives to Eastern U.S., Induced Seismicity and Early Warning

• Continuing Resolution at ~FY12 level

• Mission Area Planning Budget - $53.2M
  – 2% below 2012; Detailed planning in place for this scenario

• Sequestration Budget – $49.8 (-8.2%)

• House Committee Mark – $44.0M
What if? House Committee Mark - $44M

- Elimination of research grants
- Elimination of some regional seismic networks; reductions in others
- Reductions in research coops
- End early warning development
- Consider ending 24x7 ops.
- Loss of non-permanent staff, including postdocs