Ben Brooks  
USGS  
Earthquake Science Center, Menlo Park

- 3:20 AM, Sunday 24 August
- West Napa Fault  
  Mw 6.0, 11.3 km depth
- 1898 M 6.3 near Mare Island
- 2000-09-03 M5.1 Yountville earthquake
- >> $100M damage
- Inter-agency response cooperation/coordination
“We’re a little ahead of the curve here in Northern California”
- South Park, Ep. 1002
EEW Performance

- Hypocentral Error: < ~ 3km
- Magnitude Error: < 0.2 within 11 s of origin
- Network approach: 4 stations required for alert
- 3 of 4 triggering stations would have been faster if upgraded
- Size of the “zone of no warning” is a choice based on alert thresholds.
- Variation in data transmission latency was from 0.27s (BK.CVS) to 2.62s (NC. NHC). If all stations had same latency as BK.CVS the alert could have been out in half the time.

source: Doug Given, Richard Allen
Ground Motion

Shorter duration of strong shaking at N016 compared to NHC is consistent with northward directivity.

Distinct pulses with separation in time **independent of distance from the rupture** suggest more source complexity (i.e., two asperities) than preliminary rupture models indicate.

source: Brad Aagaard
**Ground Motion**

<table>
<thead>
<tr>
<th>Location</th>
<th>PGA [g]</th>
<th>PGV [cm/s]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire station</td>
<td>45%</td>
<td>87</td>
</tr>
<tr>
<td>Main street Napa</td>
<td>64%</td>
<td>34</td>
</tr>
<tr>
<td>Carquinez bridge</td>
<td>98%</td>
<td>22</td>
</tr>
</tbody>
</table>

PGA shows small residuals/typical ground motions at close distances, implying a typical stress drop consistent with the NGAWest data (~5 MPa). N components larger (true at all periods), consistent with the directivity. At farther distances, attenuation in the napa/delta region is stronger than GMPEs predict. Might not be a big surprise, since the NGA west GMPEs are created with data that is sparser in NorCal than SoCal, so attenuation might be different.

Data from ShakeMap; ASK14=Abrahamson et al, 2014; BSSA14=Boore et al, 2014

**Source:** Annemarie Baltay
**Ground Motion**

Fire station
45%g PGA
87 cm/s PGV

Main street Napa
64%g PGA
34 cm/s PGV

Carquinez bridge
98%g PGA
22 cm/s PGV

The *psa1.0* second map shows strong attenuation to the north, but also a possible wave guide to the south along the older franklin/Southampton fault system. In both the PGA and *psa1.0* s map, and the distance vs PGA plot, you can see the few stations pointed out on the shake map with large ground motions.

**source: Annemarie Baltay**

Data from ShakeMap; ASK14=Abrahamson et al, 2014; BSSA14=Boore et al, 2014
Static displacements nearly double after first day

source: Fred Pollitz
InSAR: Cosmo-Skymed (x-band, ~3cm)

• Cosmo-Skymed: X (~3cm)
• Sentinel 1-A: C (~5cm)
• UAVSAR: L (~20 cm)

source: Andrea Donnellan
Finite Fault Models

West Napa Earthquake
Mw 6.0 (1.17e25 dyne cm) August 24, 2014

source: Bill Barnhart

source: Doug Dreger

source: Fred Pollitz, Jessica Murray
Triggered slip on Green Valley fault?

source: Ross Stein & Jian Lin
Surface Rupture

source: Dan Ponti

7 km

source: Dan Ponti

source: Tim Dawson

source: Tim Dawson
Pre-existing Scarp
- Napa Watershed Airborne Lidar; NCALM, 2003, 1 pt/m^2; see Open Topo
- New acquisition, DWR/CGS/USGS/PEER+GEER, 20 pr/m^2 – ask Hudnut

Ron Rubin, Tim Dawson (CGS) in the trench at Alston Park ~1 month prior: “I guess we’ll just have to wait for an earthquake to show us where the fault is”
Afterslip

source: Tim Dawson
Afterslip: Saintsbury Winery

8/24/2014

source: Dan Ponti

9/1/2014
Subsurface & Surface Slip Distribution

source: Morelan, Trexler, Brooks, Hudnut, Lienkamper, Barnhart
UAVSAR & Surface Rupture

Fault trace interpretation from Dan Ponti

source: Andrea Donnellan
Mobile Laser Scanning
Differential LiDAR – a new tool for mapping coseismic fault-zone deformation, Edwin Nissen (CSM), J Ramon Arrowsmith (ASU), Adrian Borsa (UCSD), Craig Glennie (Terrapoint), Alejandro Hinojosa-Corona (CICESE), Tadashi Maruyama (JAMSTEC), and Michael Oskin (UC Davis)

Tuesday, September 9, 2014 (14:00)

The recent surge in airborne laser scanning in California and elsewhere provides high-resolution topographic baselines against which future, post-earthquake LiDAR datasets can be compared, equipping us with a powerful new tool for mapping coseismic rupture-zone deformation. Here, we showcase its rich potential using synthetic datasets derived from the southern California "B4" survey and real examples from earthquakes in Baja California and Japan to illustrate. Point-cloud differencing procedures based on the Iterative Closest Point algorithm or on cross-correlation techniques can determine the surface deformation field in 3 dimensions, complimenting conventional InSAR and pixel-tracking techniques which measure line-of-sight and horizontal displacement components only. A further advantage is that differential LiDAR retains coherence in the presence of steep displacement gradients, such as close to surface ruptures, and it is therefore well-suited for probing the slip distribution and mechanical properties of the shallow part of the fault zone. Challenges include the treatment of vegetation and the reliance on older, "legacy" LiDAR datasets – third party surveys which were not optimized for earthquake studies and for which important data acquisition and processing metrics may be unavailable. The 4 April 2010 El Mayor-Cucapah (Mexico) earthquake was the first complete rupture with both pre- and post-event LiDAR coverage, and its resultant 3-D displacement field is used to explore whether significant slip occurred on low-angle detachment faults, as has been postulated by some field geologists. The 11 April 2011 Fukushima-Hamadori (Japan) normal-faulting earthquake is the second such example, and was studied with support from the Virtual Institute for the Study of Earthquake Systems (VISES), a joint initiative between SCEC and the Earthquake Research Institute and Disaster Prevention Research Institute of Japan. Here, coherent differential LiDAR displacements within the interior part of the fault zone are used to help bridge a critical observational gap between surface faulting offsets (observed in the field) and slip occurring at depths of a few kilometers (inferred from InSAR modeling). Near-fault displacements and rotations are consistent with decreased primary fault slip at very shallow depths of a few 10s of meters, possibly accounting for the large, along-strike heterogeneity in field measurements of surface offset.
Structure From Motion

source: Mike Oskin

source: Kate Scharer
Relocations with tomoDD (Zhang and Thurber, 2003): 3D velocity model (Hardebeck et al., 2007) + relative relocation.

Black lines: projection of planes fit to locations, OADC algorithm (Ouillon et al., 2008).

Black line: plane intersection.
Aftershock Relocation

source: David Shelly
While the one-week aftershock counts for the South Napa event are relatively low, there is a fair amount of variability even among just the N. CA mainshocks.

Magnitude distributions (left) show relatively similar b-values among the N. CA earthquakes, which are low compared to the S. CA earthquakes.

<table>
<thead>
<tr>
<th>Event</th>
<th>M</th>
<th>N(M≥1.8)</th>
<th>N(M≥4)</th>
<th>Mmaxaft</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014 South Napa</td>
<td>6</td>
<td>70</td>
<td>0</td>
<td>3.9</td>
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<tr>
<td>2004 Parkfield</td>
<td>6</td>
<td>243</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>1984 Morgan Hill</td>
<td>6.2</td>
<td>102</td>
<td>0</td>
<td>3.85</td>
</tr>
<tr>
<td>1980 Livermore Valley</td>
<td>5.8</td>
<td>300</td>
<td>7</td>
<td>5.4</td>
</tr>
<tr>
<td>1979 Coyote Lake</td>
<td>5.8</td>
<td>77</td>
<td>2</td>
<td>4.3</td>
</tr>
<tr>
<td>2000 Yountville</td>
<td>5</td>
<td>9</td>
<td>0</td>
<td>2.57</td>
</tr>
<tr>
<td>1992 Joshua Tree</td>
<td>6.1</td>
<td>1880</td>
<td>9</td>
<td>4.47</td>
</tr>
<tr>
<td>1986 Palm Springs</td>
<td>5.7</td>
<td>1153</td>
<td>6</td>
<td>4.3</td>
</tr>
</tbody>
</table>

- 1947 Manix: ML 6.5, 6km rupture; shallow
- 1975 Galway Lake; ML 5.0 6.8 km rupture, 5.8km depth
- 1987 Elmore Ranch; Mw 6.2, 10 km rupture, 10.6km

source: Andrea Llenos, David Schwartz
Coulomb Grape Stress

source: Andy Lutz