Monitoring Strong Motion in Cascadia

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Cascadia: 3 kinds of quakes

- Subduction zone earthquakes (1700)
- Crustal earthquakes (1872)
Topics

1) Why monitor strong motions?
   a) Structural monitoring
   b) Research and model validation
   c) Earthquake early warning (EEW)
   d) Earthquake Impacts (ShakeMap, ShakeCast, etc.)

2) Who monitors strong motions in Cascadia?

3) Future trends
Why monitor strong motion?

- Structural Monitoring
- Research and model validation
- Earthquake Early Warning
- Earthquake Impacts (ShakeMap, ShakeCast, etc.)
Why monitor strong motion?

- Structural Monitoring
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- Earthquake Early Warning
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*e.g., Seismic Hazard Assessments*

Frankel et al., 2007
Why monitor strong motion?

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ShakeAlert EQ Detection Times (seconds after O.T.)
Why monitor strong motion?

- Structural Monitoring
- Research and model validation
- Earthquake Early Warning
- Earthquake Impacts (ShakeMap, ShakeCast, etc.)

ShakeMap used: 68 Stations within 450 km

COSMOS VDC holds: 95 stations within 355 km

TODAY: > 400 Class-A strong motion stations
Topics

1) Why monitor strong motions?

2) Who monitors strong motions in Cascadia?
   a) PNSN/ANSS
   b) USGS National Strong Motion Program
   c) Other USGS
   d) Municipalities, and others?

3) Future trends
Who monitors strong ground motion in Cascadia?

– PNSN/ANSS: operator & aggregator (UW, UO, USGS)
  • Continuous streaming network
  • Triggered “NetQuakes” stations
  • Contributed data (real-time and triggered)

– USGS
  • NSMP (for: USACE, Tacoma, Seattle, ODOT, USDVA, USN, GSA)
  • Frankel USA: Triggered network for hazard studies.
  • USNSN: USGS “backbone” stations
  • Seattle Liquefaction Array: also with UW, UCSB/NEES
  • Assembled event datasets

– Tacoma (?), Portland (?)
Some Tools of the Trade

- Broad-Band Seismometer
- Accelerometer

Noisy Urban Site
Categorizing SM Stations in OR & WA

<table>
<thead>
<tr>
<th>Setting</th>
<th>Continuous</th>
<th>Triggered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free-field + “reference”</td>
<td>186 (558) PNSN</td>
<td>43 (~129) NP</td>
</tr>
<tr>
<td>Structural</td>
<td>0? (0?)</td>
<td>43 (619) NP</td>
</tr>
<tr>
<td>TOTAL</td>
<td>~ 411 (~1723)</td>
<td></td>
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<table>
<thead>
<tr>
<th>Purpose</th>
<th>Number</th>
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<tbody>
<tr>
<td>Regional Monitoring</td>
<td>382 (ff+nq+us+nsmp+fusa)</td>
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<tr>
<td>Earthquake Early Warning</td>
<td>186</td>
</tr>
<tr>
<td>Geotechnical</td>
<td>2</td>
</tr>
<tr>
<td>Hanford site</td>
<td>~ 7</td>
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<tr>
<td>Bridges/Overpasses</td>
<td>9</td>
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<tr>
<td>Structures</td>
<td>10</td>
</tr>
<tr>
<td>Dams</td>
<td>~ 25</td>
</tr>
</tbody>
</table>
Station Map(s)

Real-time
Continuous

red=100 sps
purple=200 sps
Station Map(s)

Real-time Continuous + NetQuakes

red=100 sps
purple=200 sps
yellow=200 sps
triggered NQ
Station Map(s)

Real-time
Continuous +
NetQuakes +
“Contributed”

red=100 sps
purple=200 sps
yellow=200 sps
triggered NQ
green =
contributed
Seattle and Portland

• Seattle
  - red = 100 sps
  - purple = 200 sps
  - yellow = 200 sps
  - triggered NQ
  - green = contributed
  - blue = NSMP

• Portland
CA(lifornia) and CA(nada)

Strong Motion Seismographs in Western Canada
Topics

1) Why monitor strong motions?
2) Who monitors strong motions in Cascadia?
3) Future trends
   a) Class “C” sensors
   b) Novel and emerging transducer technology
   c) Non-inertial sensors and techniques
   d) Portable networks
Trending: The Future

• Class C Sensors (trade quality for quantity)
  – QuakeCatcher *et al.*, (how to integrate?)
  – SmartPhones
  – IOT (Amazon Echo, others)
• Novel transducers (classical inertial sensors)
• Non-inertial sensors: fiber for structures and geotech
• Portable arrays
The Future (is here)

Quake Catcher Net

Smart Phone

• “Class C” Sensors

IOT (Internet Of Things)
The Future (is here)

- Inertial sensors with novel transducers

Laser optical interferometer: Silicon Audio

MEMS electric tunneling: Lumedyne

Quartz-piezometer frequency counting: Paroscientific
The Future (is here)

- Non-Inertial sensors and techniques
  - Distributed Acoustic Sensing (Fiberoptic cable strain): Silixa
  - High Sample Rate GPS (GNSS)
  - Rotational accelerations (& tilts)
RAPID (NSF Rapid Response Research)

Next-generation tools
• laser scanning equipment
• **seismic instruments**
• mobile devices for social surveys
• mixed-media recording
• drones outfitted with cameras
• sensors that can measure damage at the centimeter scale
• assistance to teams that can deploy in the aftermath of a disaster anywhere around the world.
• training to communities who wish to conduct post-disaster investigations themselves, as well as assess the social costs of disasters.

Courtesy: Joe Wartman
Concluding thoughts

Processing Centers.

Data Archives.