Earthquake Qualitative Impact Assessment (EQIA) and the Key Role of Eyewitnesses’ Observations

R. Bossu for the EMSC

LastQuake

www.emsc-csem.org
www.citizenseismology.eu
Euro-Med Seismological Center in a Few Words

- EMSC not for profit non-governmental organisation
- 85 institutes as members from 56 countries
- Back-up & redundancy to national services
- Information at Euro-Med & global scales
- One of the Top Global Earthquake Information Center
- Well Identified at Global Scale
  - Websites: 2m visits/month
  - LastQuake app: 200k users
  - Twitter quakebot: 40k users
How to Rapidly Evaluate EQ Impact?

Modelling
Fault geometry, slip distribution, directivity effects, wave propagation, site effects...

Dense RT Accelerometric Networks
Italy, California, Japan, Taiwan...
Complexity of Fault Rupture

Seismic Risk Assessment Tools

Ispra, 2017
Variability of Slip Distribution

Tohoku 2011
Observed Variability of Ground Motions

Records from KikNet (Japan), same mag, same distance, same soil conditions: $M_w=5.5$, $R=50\text{km}$, $V_{s30}=500-600\text{m/s}$
Even for the Same Earthquake

Recordings of the 2004 M\textsubscript{w} 6.0 Parkfield, California, Earthquake
Building Stock, Vulnerability & Occupation

- Building stock: poorly known
- Vulnerability: poorly known
- Occupation: time dependant
Salvador Earthquake 2001
Empirical Approaches

Jaiswal and Wald (2010)

Shaking Intensity (MMI)

Fatality rate
(fraction of people who would die)

10,000 people subjected to violent shaking

3,000 would die in Iran
400 would die in India
150 would die in Italy
40 would die in Indonesia
3 would die in California

Jaiswal and Wald (2010)
Earthquake Qualitative Impact Assessment

- At global scale for all crustal $M \geq 5$ (1,500/yr)
- In operation since 2007
- Calibration per country
- Real time automatic heads-up!
- Explore uncertainty domain
- $5 < M < 7$: Point source model
- $M > 7$: 2D-model
- 80% no impact confirmed within min (no exposure)

(Samardjieva & Badal, 2002)
Botswana M6.5 April 4 2016

PGA (g) | 0.3 | 0.25 | 0.20 | 0.15 | 0.10  
#       | 44  | 94   | 217  | 335  | 690   

Exposed Persons (most likely scenario)
Athens 1999, M5.9 143 Casualties

A: Final Loc

B: Alloc 10km

<table>
<thead>
<tr>
<th>PGA (g)</th>
<th>0.25</th>
<th>0.20</th>
<th>0.15</th>
<th>0.10</th>
</tr>
</thead>
<tbody>
<tr>
<td># (A/B)</td>
<td>1.3k/326k</td>
<td>30k/1.1M</td>
<td>0.13/2.1M</td>
<td>1.7/3.2 M</td>
</tr>
</tbody>
</table>

Exposed Persons (most likely scenario)
M>7 2D Model: 6 Scenarios

One rupture length
2 possible fault orientations
For each fault orientation
  – 2 unilateral rupture
  – 1 bilateral
LastQuake Smartphone App

• Questionnaires replaced by cartoons (Bossu et al. 2016)
• Best way to collect geolocated pics & videos
• Comments shared on Facebook, Twitter
• Notifications (push info rather than website visit)
200k LastQuake users Worldwide (100k one year ago)
Eyewitnesses are Real Time Seismometers!

Nepal M5.6, May 2015

Crowdsourced detections faster than seismic ones in 95% cases

Fastest so far 14s with app traffic analysis
Felt reports M5.3 Jan 18  T0 + 1 min

0 reports
Felt reports M5.3 Jan 18  T0 + 2 min

13 reports
Felt reports M5.3 Jan 18  T0 + 3 min

109 reports
Felt reports M5.3 Jan 18  T0 + 4 min

233 reports
Felt reports M5.3 Jan 18 T0 + 5 min

329 reports
Felt reports M5.3 Jan 18 T0 + 6 min

394 reports
Felt reports M5.3 Jan 18  T0 + 7 min

444 reports

Seismic Risk Assessment Tools  Ispra, 2017
Felt reports M5.3 Jan 18  T0 + 8 min

489 reports
Felt reports M5.3 Jan 18 T0 + 9 min

522 reports
Felt reports M5.3 Jan 18  T0 + 10 min

554 reports
Social Networks: Twitter

- Many comments shared with us @LastQuake

- Kaikoura:
  - Broken glasses in Wellington
Ispra, 2017
Seismic Risk Assessment Tools
M 7.8 Kaikoura

Seismic Risk Assessment Tools

Ispra, 2017
Comments for M4.9 Oklahoma Nov. 7 2016

- **Cushing (4 km SW of epicenter):**
  - Sounded like an explosion. Power went out, me and my dogs and cat freaking out. So many broken dishes, glass everywhere. cracking in the walls. Cabinets and drawers flung open. The jolt was so hard it pull in screws out of my table and the wood top hit the floor and the top to the toilet jumped off and broke. This is the worst one I have ever felt.

- **Cushing (7 km SE of epicenter):**
  - I was standing up, it almost knocked me down. pitching deck of a ship! Yes! Still picking up things knocked off walls and shelves!
Heavy damage in Kathmandu: At least, tens of thousands of casualties, and up to 100 000!
Eyewitnesses Hitting EMSC Website!

M 7.8 Nepal
2015-04-25 11:56:26 +0545 NPT

New visitors to the EMSC website
Regional audience (at least one visit in the last 12 months)
P wave
S wave
Epicenter

Updated on 2015/04/30 11:59:05 UTC
Nepal 2015: 100+ Validated Geolocated Pics
## Interpretation of Website Traffic Patterns

<table>
<thead>
<tr>
<th>Time Evolution of the number of visitors</th>
<th>Non-exclusive conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Graph" /></td>
<td>Not felt, or severe loss of Internet connectivity, or significant widespread damage, or severe perception of danger</td>
</tr>
<tr>
<td><img src="image2" alt="Graph" /></td>
<td>Felt and no significant loss of Internet connectivity and no significant damage</td>
</tr>
<tr>
<td><img src="image3" alt="Graph" /></td>
<td>Felt and, local or temporary, loss of Internet connectivity, or locally significant damage or, locally severe perception of danger</td>
</tr>
<tr>
<td><img src="image4" alt="Graph" /></td>
<td>Felt and, local or temporary, loss of Internet connectivity, or locally or widespread significant damage or, locally or widespread severe perception of danger</td>
</tr>
<tr>
<td><img src="image5" alt="Graph" /></td>
<td>Significant loss of Internet connectivity, or significant damage, or severe perception of danger</td>
</tr>
</tbody>
</table>

### Seismic Risk Assessment Tools

- **Website Traffic**
  - Patterns
  - Time Evolution
  - Non-exclusive conclusions

- **Ispra, 2017**
Doughnut Shape: Potential Damaged Area

Seismic Risk Assessment Tools

Ispra, 2017
Concluding Remarks

• **Rapid Impact Assessment of Global EQ intrinsically uncertain:**
  - Individual accident (e.g. Molise, 2002, Bingol, 2003, Christchurch 2011)
  - M6 close to a city (L’Aquila 2009; Athens 1999)
  - Difficulty to model large (M>7) earthquake,
  - Variability of ground motion,
  - Presence of foreshock (Kuamoto 2016),
  - Wind speed (Tokyo scenario)
  - Indirect effects
  
  - …

• **EQIA offers real-time heads-up for global earthquakes:**
  - 80% of cases: no damage confirmed
  - Uncertainty estimates

• **In-situ information essential to exclude scenario and reduce uncertainties (within 1 to 3h)**
6.7 millions App Launches since Jan. 2016

THANK YOU!

Seismic Risk Assessment Tools

Ispra, 2017