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Chronicle of a disaster foretold

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Voila (Trilogy International), Trimble, Inc.
Graph R. Bilham

The diagram illustrates the relationship between earthquake magnitude (Mw) and deaths per earthquake. Points representing specific earthquakes are plotted, with notable events such as Haiti 2010, Messina 1908, Tokyo 1923, and Chile 1960. The graph shows a scatter plot with a logarithmic scale for deaths per earthquake, ranging from 10 to 10^6, and magnitude ranging from 5 to 9.
Geodetic monitoring with GPS: tracking the earth’s crust in motion (millimeters per year...!)

Episodic GPS measurement site, Jacmel, Haiti

Continuous GPS measurement site, Port-au-Prince, Haiti
Simple math:
- Slip deficit accumulates at 7 mm/yr
- Last release 250 years ago (M7.5 earthquake)
- $250 \times 7 = 1.75 \text{ m}$
- If sudden fault slip of 1.75 m = M7.2

Each arrow represents the direction and speed of motion of a geodetic point – notice that Hispaniola is sheared at ~20 mm/yr.

(1998-2008 = 10 years of efforts => long-term observations are key)
Rapid scientific response is essential = “crime scene investigation”
Available information:

– Previous large earthquakes (only past 250 years known!)
– Geodetic measurements (sparse)
– Very limited seismological monitoring (no seismic network in Haiti...
• Sources (potential seismic faults) + rate of seismic energy accumulation (form GPS) + nature of soil (amplification of seismic waves) => first seismic hazard map.
• Hazard level similar to San Andreas fault in California.
• Other earthquakes are likely:
  – On same fault.
  – On other faults in Haiti/Dominican Republic (North DR particular concern).
• Seismic hazard map = guide for earthquake-safe designs.
• Other earthquakes are likely on other faults in the Caribbean (the 100 km rule...) and Central America.

• Some of these faults have tsunamogenic potential (Puerto Rico, Lesser Antilles)

• The “other” north American plate boundary: vastly understudied.
Earthquakes in the Caribbean are less common than hurricanes...

...but when they hit an unprepared country they are devastating.

<table>
<thead>
<tr>
<th>Hazard</th>
<th>GDP affected</th>
<th>People affected</th>
<th>Fatalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004 hurricane Jeanne</td>
<td>7%</td>
<td>300 000</td>
<td>5 000</td>
</tr>
<tr>
<td>2007 hurricanes Dean+Noel</td>
<td>2%</td>
<td>194 000</td>
<td>330</td>
</tr>
<tr>
<td>2008 hurricanes FGH</td>
<td>15%</td>
<td>1 000 000</td>
<td>800</td>
</tr>
<tr>
<td>2010 earthquake</td>
<td>120%</td>
<td>2 000 000</td>
<td>217 000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>3 494 000</strong></td>
<td><strong>223 100</strong></td>
</tr>
</tbody>
</table>

Source PDNA, 2010
Concluding remarks

• Reconstruction with sustainable seismic safety built-in:
  – Short-term: buildings, infrastructures, individual houses.
  – Long term: build science, communicate, educate – capacity building.

=> Not only build better, but build better prepared.

• Risk reduction must start together with reconstruction – shift emphasis from disaster management only to disaster + risk.

• We cannot (should not) do it all for Haiti – one should (1) train their next generation of scientists, (2) help build a sustainable risk reduction strategy for Haiti – multilateral effort.

• “Science works” – but scientific efforts in Caribbean not up to the challenge: wake up call for Caribbean and central America, need to be proactive with science + capacity building projects.