Hazard and Risk Assessment

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President, SPA Risk
Outline

• Status of hazard data
  (earthquake, flood, hurricane…)
• Status of risk data
• Early Warning Systems (EWS)

What gets assessed, gets managed
- Peter Drucker (?)
Tropical Cyclone Data

Historical Hurricane Tracks
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Legend
- X Hurricane Category 1-2
- X Hurricane Category 3-5
- X Hurricane Category 4-5
- V Conventional Landfall Storm (Moving from water to land)
- X* Exiting or Inland Storm (Moving from land to water)

Direct Strike
Indirect Strike

Prior to 1970, some tracks during that period may not be exact. Some dates and times were changed in one source to match another. However, it is not clear which source had the correct time or date. From the original 16,539 storm features, over 3,000 were dropped or added as a result of the changes. Therefore, the storm features presented in this image should not be used for official forecasting purposes or for making any decisions about coastal hazards based on historical data.
NOAA Storm Prediction Data

Tornado Tracks

Hail
Hail (1955 - 2011)

Wind
Wind (1955 - 2011)

Click image above to get a larger image. Download wind.zip.
USGS Earthquake Data

PAGER - M 9.0 - NEAR THE EAST COAST OF HONSHU, JAPAN

Earthquake Shaking Alert Level: **RED**

Alert level does not include impacts from earthquake-related hazards such as tsunamis, landslides, fires or liquefaction.

- Event Id: US0001XGP
- Alert Version: 15
- Created: 22 weeks, 6 days after earthquake.
- FOR TSUNAMI INFORMATION, SEE: tsunami.noaa.gov

**Alert Information**

Red alert for shaking-related fatalities and economic losses. High casualties and extensive damage are probable and the disaster is likely widespread. Past red alerts have required a national or international response. Estimated economic losses are 0-1% GDP of Japan.

**Estimated Fatalities**

- 1% 12% 36% 37% 13% 2%

**Estimated Economic Losses**

- 1% 7% 24% 35% 32%
USGS Earthquake Hazards Data

Latitude: 37.77896  Longitude: -122.41920

Annual Frequency of Exceedence vs. Ground Motion (g)

- 10% PE in 50 yrs.
- 2% PE in 50 yrs.
Flood
Other hazards
Risk Analysis

$ Loss = (\text{\$ Value} \mid \text{\% Loss}) (\text{\% Loss} \mid \text{Event}) (\text{Event})$

<table>
<thead>
<tr>
<th>Risk</th>
<th>Exposure</th>
<th>Vulnerability</th>
<th>Hazard</th>
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Insurance maps:
- widely employed US urban areas, Civil War onwards.
- comprehensive source of Building Exposure information.
- However, in 1960s insurance underwriting shifted risk-based → statistical

Result:
- Major drop-off of insurance maps
- loss of exposure data
- decline in Fire Rating Bureaux / monitoring of fire protection.

1905 San Francisco Insurance Map – Sanborn Co. (Rumsey Collection)
Risk Analysis: Exposure (cont.)

- 1960s work at Travelers Insurance Company,
- 1970s at MIT, Stanford and Kyoto University (Japan) → portfolio risk modeling for natural catastrophes.

- Hazard work well grounded
- Building exposure often estimated based on census population
The situation remains largely true today:

- HAZUS default inventory is based on the Census of Population and Housing, 2000 and some other general sources which are **... a proxy for the general building stock**
- Local studies typically rely on tax assessor data:

  ~180,000 buildings
  >90% wood
Building Taxonomy

Wood Frame??
Risk Analysis: Vulnerability (i.e., damage data)

“data collection” anecdotal, not systematic – mostly un-geo-referenced photographs

few (partial) exceptions:
- McClure and Steinbrugge (1971)
- Eguchi et al (1994)

As a result, until recently:
- Earthquake vulnerability relations are expert opinion-based
- Flood vuln. relns. are largely statistical (NFIP / USACE data)
Exposure and Damage Data

Hurricane Sandy Predicted Flooding

Hurricane Sandy Actual Flooding

Credit: USACE / WNYC / http://animalnewyork.com/2012/see-how-nycs-predicted-flood-zones-compared-to-actual-flooding/

Figure 9.14 MTA subway flooding map for a category-1 hurricane based on surge heights listed in USACE (1995)

Note: Red symbols indicate definite flooding, blue ones potential flooding, the latter corresponding closely to the "overflow" segments in Figures 9.11–13. Green areas near the line tracks indicate locations of yards. Two yards along the Harlem River (upper left) are flooded, and so are facilities in Coney Island and Rockaway (bottom center and right). Source: MTA—NYCT, 2005, A. Cabrera (see Endnote 35)
Good News!

Recently (i.e., 2012) many jurisdictions are compiling detailed building databases, which is a critical step in assessing exposure and vulnerability to natural disasters. Figure 3.1 illustrates the exposure-weighted damage state contribution by inundation depth, showing how different building materials react under varying degrees of flooding. This information is crucial for risk management and mitigation planning.

Figure 3.1. Exposure-weighted damage state contribution by inundation depth.
Risk Analysis: Computation

- US in 1980s emerged as center of innovation
- Global insurance industry is served by RMS, AIR, EQECAT…

Gov. Wilson Puts Cost of Earthquake In Los Angeles as High as $30 Billion

By Thomas R. King
And Rhonda L. Huddle

Staff Reporters of The Wall Street Journal

LOS ANGELES – California disaster authorities said damages from Monday’s earthquake “conservatively” could range from $15 billion to $30 billion, an estimate far higher than most experts had suggested.

If damages reach the higher end of the first official estimate, from Gov. Pete Wilson’s office, they would approach the $30 billion cost of Hurricane Andrew, the 1992 disaster in Florida and Louisiana that ranks as the nation’s costliest so far.

The staggering California estimate, coming even as a sense of normalcy began to return despite the continuing aftershocks here, was contained in an appeal by Gov. Wilson to President Clinton. The president toured the quake-hit region yesterday and conducted a town meeting in Burbank, just southeast of the temblor’s Northridge epicenter in the San Fernando Valley.

The state damage estimate was based on a computer model devised by EQE International Inc., a San Francisco consulting firm. EQE, in a separate statement, estimated overall damages at $15.5 billion, the lower end of the state’s range. Of the local, residential damages was estimated to be $8.8 billion, with commercial damage $3.7 billion, industrial damage $1.5 billion, and the rest in other damages, EQE said. It estimated insured losses at $1.5 billion to $1.9 billion.

Kevin Eckery, the governor’s deputy press secretary, said the upper end of the range came from the state Office of Emergency Services, which has long experience in calculating disaster costs. He said the range is “a very, very rough estimate.”

EQE’s model relies on such factors as known fault lines and the seismic history of the region but doesn’t reflect actual inspection.

In his plea, Gov. Wilson asked President Clinton to follow the precedent established after Hurricane Andrew and Hawaii’s 1992 Hurricane Iniki. In those disasters, he said, 90% of the public assistance costs were covered by federal disaster aid.

Without full funding, state and local governments would be required to pay 25% of the costs.

Santa Monica Freeway measured the inward acceleration of the roadbed at 1.3 times the force of gravity. Such forces, a she said, are comparable to the acceleration experienced by fighter pilots making violent maneuvers.

The violence of the quake could prompt many owners of plants, shopping centers and other commercial buildings to invest in upgrading facilities to better withstand such forces. Since earthquake insurance rates are expected to continue to rise, some businesses may find such long-term investments more economical.

1994 Northridge Earthquake – Scawthorn et al, EQE
Risk Analysis: Computation

Storm Surge: SLOSH (Hazard only)
Flood: HEC RAS…(Hazard, no default exposure data…)

Multi-Hazard: HAZUS-MH ✔

- Flood, Earthquake, Hurricane, ….tsunami
- Many excellent attributes: Free, default exposure data….
- However:
  - Dated – most development stopped about 2004
  - Black Box – inflexible, bug response not nimble…
    (note: FEMA now committed to Open Source)
  - Proprietary / expensive software host (ArcGIS)
HAZUS had a 10 year lead on loss estimation

Next Generation HAZUS badly needed!
A word on EWSs

Flood ✓

Tropical Cyclone / Hurricane ✓

Tsunami
• In the Pacific since 1946 ✓
• In the Indian Ocean, since 2004
• Atlantic, some DARTs
• Mediterranean?

Earthquake
• Japan, Mexico, Turkey ✓
• USA?
Earthquake EWS - Needed Research

What to do given an EEWS?

\( f \) (event, occupants, building structure / furnishings)

• When is shelter seeking prudent?
• What is the optimum shelter seeking?
  • Flee the building?
  • Stay inside (under a table?)
  • ....
• Post each building accordingly?
• Occupant training?
• Real-time instructions / announcements?
Summary

• Knowledge: **Hazard < Built Environment**
  
  *What Nature does    What we do*

• Knowledge Access: **Hazard >> Built Environment**

• by the way, Why?
  
  • Hazard agencies: *USGS, NOAA, NWS, USACE…*
  • Built Environment agencies: *

• Recent (IT) advances (eg, building footprint datasets) may soon result in a real paradigm shift in natural hazards risk management

• HAZUS needs to catch up, not just be maintained on a starvation diet

• EEWS urgently needed in California, PNW (!!)

• EEWS needs techno-societal complementary research