USGS 2023 National Seismic Hazard Map – Key Updates and Their Implications on the Insurance Industry

Nilesh Shome  Model Development, Moody’s Insurance
Outline

• Overview of 2023 USGS Update
• Impact at important cities across the US
  • AAL change for key cities using a simplified methodology
  • Uncertainty in AAL for California portfolios
• Key questions and challenges of implementing the updates
• Q&A

“Nearly 75% of the U.S. could experience potentially damaging earthquakes and intense ground shaking, putting hundreds of millions of people at risk”

“37 U.S. states have experienced earthquakes exceeding magnitude 5 during the last 200 years, highlighting a long history of seismic activity across this country”
- USGS
Location Details for Loss Calculations

Location-level analysis
- 160 FEMA sites across the US
- Uniform NEHRP CD site conditions (Vs30=365 m/s)
- HAZUS vulnerability functions
- Modern Wood Frame Res Bldg
  - Bldg coverage only
- Simplified AAL calculations
- HAZUS approach (FEMA-366)
- Reasonable approach for estimating loss change

Portfolio Analysis
- 20km uniform grid in California
- Loss aggregation based on population
- Uniform NEHRP B/C site conditions (Vs30=760 m/s)
- Review of loss change for entire California, North CA, South CA, Bay Area, and LA region.
- Wood Frame residential buildings
2475-Year Hazard Map: Sa(0.2s) for NEHRP B/C Site Conditions (Vs30=760m/s)

Hazard Map

Difference Map


MOODY'S
Summary of 2023 USGS Update

- Earthquake Rupture Forecast (ERF): Source characteristics and event rate
- Ground-Motion Model: Rock ground motion
  - Active region – WUS
  - Stable region – CEUS
  - Subduction – Interface and inslab
- Soil and basin amplification
Change in Hazard and AAL: FEMA Sites

- Significant increase in hazard in CEUS, and smaller increase in CA
  - Hazard is low in CEUS, but high CA
  - Variability of change is high in WUS and CEUS

- AAL change is about 1.5-3x higher than hazard change
  - AAL change pattern is similar to hazard change
  - Large increase in CEUS, moderate increase in CA and small increase in WUS and PNW.
Change in Hazard and AAL: FEMA Sites

- Range of location-level AAL change for each region
- HAZUS functions for modern WF
- Soil CD site conditions
- HAZUS/FEMA AAL calculations

- Similar loss change pattern for MR and HR steel buildings

Range of Hazard and AAL Change (16-84 percentile) for Low-Rise Wood-Frame Buildings between 2023 and 2018 Models

475-Year Hazard Change:
- -5 to +20%
- -5 to +15%
- -30 to +50%
- +10 to +55%

AAL Change:
- 0 to +35%
- -10 to +25%
- -40 to +80%
- +5 to +95%
Perspective on the New Jersey Earthquake

Earthquake details
- Magnitude: 4.8
- Date: April 5th, 2024
- Number of M4.5 or greater earthquakes since 1960: 7 (USGS)

Impact summary
- Max intensity: MMI VI (Califon city)
- 2023 USGS Hazard
- 475-year hazard: MMI VI (strong shaking and light damage)
- 2475-year hazard: MMI VIII (severe shaking and moderate to heavy damage)
- Loss Cost (2023): $0.05-0.10 per $1000

Source: USGS and NY Times
Source Char and ERF

Main components

• Fault-based seismicity
• Off-fault/background seismicity

• Earthquake risk in CA is governed by fault-based seismicity

• Hazard generally increase near the newly added faults.

• Slip rates are well constrained at the locations of geologic studies
  • Constrain deformation
  • Low hazard uncertainty

• Paeloseismic event rate constrain
  • Reduces uncertainty and bias

The USGS 2023 Conterminous US Time-Independent Earthquake Rupture Forecast, Field EH, et al., BSSA (2024)
Hazard and AAL Change for Well Distributed Portfolio in CA

- Portfolio: 20km uniform grid in CA, pop-based exposure, modern residential Wood buildings, and Soil B/C site conditions for Time-independent rates

- Significant site-to-site variation in hazard and loss results
  - Range of hazard change is high in North and Bay Area
  - Range of AAL change is quite similar for all the portfolios

- Loss change is significantly higher than hazard change
  - (Weighted) avg loss change is 2-4x higher than hazard change
ERF Logic-Tree: Model-to-Model Uncertainty

- Logic-tree branches captures model-to-model (epistemic) uncertainty
- Deformation model is the biggest driver of change in USGS23 update
  - Geologic slip-rate constraints
  - GPS data – 2 models and lower weight

Percentage change in PGA hazard for each branch from the average branch solutions

The USGS 2023 Conterminous US Time-Independent Earthquake Rupture Forecast, Field EH, et al., BSSA (2024)
Goodness-of-Fit of The Deformation Models

- Slip-rates from model and observed compares well
- New models – Evans and Pollitz - give higher preference to the GPS data, introducing higher scatter in the results
- New models has low weight (=10%)
- Modeled average slip rates compare well with the observed
Hazard and AAL Difference for a Well Distributed Portfolio in CA

- Calculates the difference in the hazard and AAL between each of the logic-tree branches and the average for each site
- Range of difference in hazard is small, but higher for AAL, especially for Evans and Pollitz models
- Large number outliers for Evans and Pollitz model
- Small difference for statewide portfolios (wt average)
  - -5 to +5% for hazard, and -10 to +10% for AAL
Summary and Next Steps

- Significant changes in hazard, mostly increasing, result in large increase in AAL.
- Results shown are useful for planning of the work on model evaluation and implementation efforts, not intended for decision making.
- Next steps:
  - Implement the USGS model
  - Carry out sensitivity studies of different modeling assumptions on the loss results
  - Identify key issues that require further research before model adoption
    - New Madrid cluster, use of total rate including aftershocks, Gulf and Atlantic basin amplification model, etc.
  - Develop efficient solutions for day-to-day loss analysis work and underwriting
    - USGS can provide stochastic set for loss calculations (intermediate output from hazard tool), but that would require significant computation resources.
  - Time-dependent (TD) model

2475-Year Hazard Map: $\text{Sa}(0.2\text{s})$ for NEHRP B/C Site Conditions ($V_{s30}=760\text{m/s}$)
Thank you

Nilesh Shome
Senior Director, Moody’s
→ Nilesh.Shome@moodys.com