Basin Effects in Simulated and Observed Ground Motions for Southern California

Chukwuebuka C. Nweke, Jonathan P. Stewart
Civil and Environmental Engineering Department
UCLA

Presented at the National Earthquake Conference,
Sheraton San Diego and Marina; 03/06/2020
Funding and Collaborators

• SCEC Award #181376
• Complimentary support from:
  – USGS Award # G17AP00018
• Collaborators:
  – Prof. Jonathan Stewart (P.I.) and Prof. Scott Brandenberg (Co-P.I.)
  – Pengfei Wang (UCLA Ph.D. student)
  – Rob Graves (USGS), Christine Goulet (SCEC), Phil Maechling (SCEC), Kevin Milner (SCEC), Scott Callaghan (SCEC)
Motivation

• Seismic Hazards
Motivation

- Basin effects (site amplification)
Empirical Modeling

- Earthquake ground motion “physics”

Mean Prediction of Intensity Measure = Earthquake source/event Term + Wave-propagation path Term + Local site effects Term + error
Empirical Modeling

Mean Prediction of Intensity Measure = Earthquake source/event Term + Wave-propagation path + \textbf{Local site effects} + error Term

\[
\begin{align*}
\delta Z_x & = z_x - \bar{z}_x \\
\delta Z_x & > 0 \\
\delta Z_x & < 0
\end{align*}
\]
Simulation Models

- Use multiple base models to create a mesh within which waves are propagated
Objectives

- Effectiveness of 3D simulations at predicting basin response
  - Simulations and Empirical estimates of amplification are different!!!
  - Are the absolute levels of amplification of one preferred over the other?
  - How does the level of amplification change relative to changes in basin depth differential?
Region of Study: Earthquake Events Map

Basin Label:
- Imperial Valley Basin (IVB)
- Los Angeles Basin (LAB)
- Morongo Basin (MB)
- San Bernardino-Chino Basin (SBCB)
- San Fernando Basin (SFB)
- San Gabriel Basin (SGB)
- Ventura Basin (VB)
Basin Categorization
<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Criteria</th>
<th>Category ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basin</td>
<td>Site location in basin interior</td>
<td>Basin width in short direction &gt; 3 km</td>
<td>3</td>
</tr>
<tr>
<td>Basin Edge</td>
<td>Along basin margin</td>
<td>Within 300m of basin edge*</td>
<td>2</td>
</tr>
<tr>
<td>Valley</td>
<td>“Small” sedimentary structure</td>
<td>Valley width in the short direction &lt; 3 km</td>
<td>1</td>
</tr>
<tr>
<td>Mountain-Hill</td>
<td>Sites without significant sediments, generally having topographic relief</td>
<td>Generally identified on basis of appreciable gradients and/or irregular morphology</td>
<td>0</td>
</tr>
</tbody>
</table>

* Basin edge defined visually from break in slope (topographic feature)
Simulation Domain Overview (Event and Stations)

EQID - pw_108; M4.43; 2014

EQID - 1002; M5.39; 2008

EQID - 1011; M4.7; 2009

EQID - 1036; M4.24; 2001

EQID - 151; M5.28; 1994

EQID - 1113; M3.99; 2008

EQID - 55; M5.19; 1980

EQID - pw_102; M5.09; 2014

EQID - 1042; M4.42; 2000

EQID - 114; M5.27; 1987

EQID - 1002; M5.39; 2008

EQID - 1005; M5.06; 2008

EQID - 170; M4.92; 2003

EQID - 1019; M4.66; 2007

EQID - 1005; M5.06; 2008

EQID - 114; M5.27; 1987

EQID - 1005; M5.06; 2008

EQID - 170; M4.92; 2003

EQID - 1113; M3.99; 2008

EQID - 55; M5.19; 1980

EQID - pw_102; M5.09; 2014
Both for the case of observed and simulated earthquake data:

- **STEP 1**: Compute ground motion intensities at locations of interest for all earthquakes in chosen catalogue.
- **STEP 2**: Perform residuals analysis.
- **STEP 3**: Partition residuals into event and site terms.
- **STEP 4**: Look at trends of site terms with respect to basin parameters.

\[
W_{ij} = R_{ij} - h_E, i
\]

Within-event residual

Event term (between-event residual)

\[
W_{ij} = s_i + e_{ij}
\]

Represents mean misfit from GMM

Trends across site groups indicate systematic effects

Scope Overview
Mean of Site terms
Site Term vs. Basin Depth Differential

Similar Trends!!!
Conclusions

• Physics-based earthquake simulation estimates of ground motion and empirical show similar scaling features with basin depth parameters.
• The De-amplification for shallow basin depths in the original NGA-West2 model is primarily from the valley sites, while the amplification for deeper basin depths is primarily from basin sites.
• The next objective is to validate the overall levels of amplifications in simulations data to properly compare it to amplifications in empirical data.
Questions???