A GROUND-MOTION MODEL USING NGA-SUBDUCTION DATABASE

Y. Bozorgnia\textsuperscript{1,2}, K.W. Campbell\textsuperscript{3}, N. Gregor\textsuperscript{4}, N. Kuehn\textsuperscript{2}

ABSTRACT

This paper provides an overview of new ground-motion models (GMMs) developed by the authors (listed alphabetically) applicable to worldwide Interface and Intraslab subduction events. We used a comprehensive database developed under the NGA-Sub research program to develop two GMMs for subduction events: (a) a global “base” model that does not account for regionalization and (b) a model that accounts for different ground-motion scaling characteristics for selected regions. The GMMs are appropriate for predicting PGA, PGV, and 5%-damped pseudo-spectral acceleration over a period range of 0.01 to 10 sec.

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\textbf{Introduction}

The Next Generation Attenuation (NGA) projects are a series of research initiatives to develop databases and ground-motion models (GMMs) for various tectonic regimes employing the latest available data and state-of-the-art methodologies and knowledge in seismic hazard. The latest in this research program is NGA-Sub with a focus on subduction events. In this program, a comprehensive database of ground motions recorded in worldwide subduction events has been developed. The database includes over 214,000 individual ground-motion components recorded during worldwide Interface and Intraslab subduction events (Kishida et al., 2018 \cite{1}). The authors of this paper have selected a subset of the database for the analysis and development of a GMM as presented in the following sections.

\textbf{Selected Database}

Following an investigation of all the data in the database, we selected a subset of data that we believed to be appropriate for the development of our GMM. Our selection criteria are as follows:

\begin{itemize}
  \item [✓] Moment magnitude, $M > 4$
\end{itemize}

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✓ Closest distance to the fault rupture, $R_{RUP} > 0$
✓ Time-average shear-wave velocity in the top 30-m of the site, $V_{S30} > 0$
✓ Hypocentral depth, $Z_{HYP} > 0$
✓ Rupture-plane dip angle larger than zero
✓ Rupture-plane rake angle not equal to -999 or -888 (i.e., should be known)
✓ Multiple event flag not equal to 1
✓ Interface and Intraslab flag equal to 0, 1, or 5 (i.e., should be known)
✓ Sensor depth < 2m (i.e., exclude down-hole recordings)
✓ Exclude “Geomatrix” 1st letter equal to F (i.e., located in tunnels or below ground)
✓ Visual quality flag not equal to 2 or 9 (i.e., exclude “late S-trigger” and “do not use” cases)
✓ Exclude records with PGA < 0 (i.e., should be known)
✓ Number of records per event $\geq 5$
✓ $R_{RUP} <$ the minimum of $R_{max}$ (limit of complete recording) or 1000 km
✓ Events with a ratio of the largest to smallest distance ($R_{\text{largest}} / R_{\text{smallest}} > 3$

These selection criteria resulted in the subset data listed in Table 1.

<table>
<thead>
<tr>
<th>Source region</th>
<th># of 3-component recordings</th>
<th># of events</th>
<th># of stations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alaska</td>
<td>406</td>
<td>10</td>
<td>183</td>
</tr>
<tr>
<td>Cascadia</td>
<td>729</td>
<td>11</td>
<td>410</td>
</tr>
<tr>
<td>Central America &amp; Mexico</td>
<td>163</td>
<td>7</td>
<td>156</td>
</tr>
<tr>
<td>Japan</td>
<td>12850</td>
<td>56</td>
<td>1867</td>
</tr>
<tr>
<td>New Zealand</td>
<td>248</td>
<td>9</td>
<td>166</td>
</tr>
<tr>
<td>South America</td>
<td>573</td>
<td>34</td>
<td>277</td>
</tr>
<tr>
<td>Taiwan</td>
<td>2066</td>
<td>17</td>
<td>663</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>17,035</strong></td>
<td><strong>144</strong></td>
<td><strong>3,722</strong></td>
</tr>
</tbody>
</table>

**Ground Motion Models**

We investigated the selected database, as listed above, and developed two GMMs:

1. A global “base” model that has no regionalization.
2. A partially non-ergodic model with a regionalized constant term regionalized coefficients controlling the scaling with $V_{S30}$ and anelastic attenuation.

Model 1 is used when we do not have enough reliable data in a region. Model 2 is used for regions with enough reliable data in those regions to provide a robust GMM. Model 2 is used for the following regions:

✓ Alaska
✓ Central America & Mexico
✓ Japan
Example tentative results for Central America and Mexico are presented in Figures 1 and 2.

**Figure 1.** PGA magnitude scaling for the Central America and Mexico region for an Interface event at a rupture distance of 100 km and a hypocentral depth of 20 km. In this figure, the thick pink line is the BC Hydro model [2], the solid black line is our global “base” model, the solid thin pink line is our regionalized median model, and the dashed lines are the 5% and 95% confidence intervals of the posterior distribution of the median predictions.

**Figure 2.** PGA distance scaling for the Central America and Mexico region for a magnitude 6.0 Interface event with a hypocentral depth of 20 km. In this figure, the solid thick pink line is the BC Hydro model [2], the solid black line is our global “base” model, the solid thin pink line is our regionalized median model, and the dashed lines are the 5% and 95% confidence limits of the posterior distribution of the median predictions.
Concluding Remarks

We have used a subset of the comprehensive NGA-Sub database to develop two ground-motion models for subduction events: (a) a global “base” model and (b) a regionalized model with the following regions: Alaska, Central America & Mexico, Japan, New Zealand, South America, and Taiwan. $V_{S30}$ scaling, anelastic attenuation, and event terms were regionalized for these regions. For regions without sufficient data, we recommend using the global model.

Acknowledgements

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References