A Preliminary Ground-Motion Model Using NGA-Subduction Database

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Acknowledgements

Supports of the following agencies are gratefully appreciated:

- FM Global
- USGS
- Caltrans
- PG&E
Acknowledgements:

31 researchers and practitioners who worked hard on various pieces of the project
Introduction: As part of NGA-Subduction program

- A comprehensive database of ground motions recorded in subduction zones is developed
- Teams of ground motion modelers are working to develop GMMs using the NGA-Sub database
Selection of a subset of NGA-Sub database

- $M > 4$; $R_{\text{RUP}} > 0$; $V_{\text{S30}} > 0$; $Z_{\text{HYP}} > 0$; $\text{PGA} > 0$
- Dip > 0; rake is provided
- Multiple event flag = 1
- Sensor depth 2m
- Geomatrix 1st letter = F
- Visual quality flag = 2;9
- $R_{\text{RUP}} < R_{\text{max}}$
- Number of stations per event $\geq 5$
- distance ratio $R_{\text{large}}/R_{\text{small}} > 3$
Our selected database

**NGA-Sub database overall**
- 71,343 records, 1,880 events, 6,421 stations

**Our selected data**
- 12,666 records, 158 events, 3,756 stations

**Our selected data in regions: (records, events, stations)**
- Alaska: 860, 37, 220
- Cascadia: 797, 11, 436
- Central America & Mexico: 162, 7, 158
- **Japan: 8391, 44, 1743**
- New Zealand: 248, 9, 166
- South America: 949, 46, 393
- Taiwan: 1259, 4, 640
Examples maps of data
Regions

- 7 broad geographical regions
  - Alaska, Cascadia, Central America and Mexico,
  - Japan, New Zealand, South America, Taiwan

- 12 subregions ("zones"), based on age of the slab and fault thickness
  - Aleutian, Alaska, Cascadia,
  - Central_America_S, Central_America_N, Japan_Pac, Japan_Phi,
  - New_Zealand_S, New_Zealand_N, South_America_N,
  - South_America_S, Taiwan
The GMM (or GMPE)

\[ Y = \theta_1 + f_{mag}(M, m_b) + f_{geom}(R_{RUP}) + f_{attn}(R_{RUP}) + f_{slab} + f_{depth}(Z_{HYP}) + f_{site} \]

Plus pages of more equations!

Magnitude scaling
Different for Interface and slab
For slab: Different for each zone

Distance scaling is different for interface and slab events

Anelastic attenuation
Is regionalized
The GMM (or GMPE)

\[ Y = \theta_1 + f_{\text{mag}}(M, m_b) + f_{\text{geom}}(R_{\text{RUP}}) + f_{\text{attn}}(R_{\text{RUP}}) \\
- f_{\text{slab}} + f_{\text{depth}}(Z_{\text{HYP}}) + f_{\text{site}} \]

Plus pages of more equations!

Constant term is regionalized
Slab events can have different ground-motions than interface events
Vs30 scaling is regionalized
Regionalization

✓ Constant term
✓ Anelastic attenuation
✓ $V_{s30}$ scaling
✓ Magnitude scaling of slabs (based on slab thickness)

✓ Additionally, as a reference, we have a “Global” model
Break in Magnitude Scaling for In-Slab Events (Courtesy of UCSB team)

<table>
<thead>
<tr>
<th>Subduction Zone</th>
<th>Saturation Magnitude</th>
<th>Fault Maximum Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aleutian</td>
<td>7.95</td>
<td>53</td>
</tr>
<tr>
<td>Alaska</td>
<td>7.2</td>
<td>22.5</td>
</tr>
<tr>
<td>Cascadia</td>
<td>7.2</td>
<td>22</td>
</tr>
<tr>
<td>Central America South</td>
<td>7.6</td>
<td>36</td>
</tr>
<tr>
<td>Central America North</td>
<td>7.4</td>
<td>28</td>
</tr>
<tr>
<td>Japan Pacific</td>
<td>7.65</td>
<td>38.5</td>
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<tr>
<td>Japan Philippines</td>
<td>7.55</td>
<td>36</td>
</tr>
<tr>
<td>New Zealand North</td>
<td>7.6</td>
<td>37.5</td>
</tr>
<tr>
<td>New Zealand South</td>
<td>7.4</td>
<td>30.5</td>
</tr>
<tr>
<td>South America North</td>
<td>7.3</td>
<td>25</td>
</tr>
<tr>
<td>South America South</td>
<td>7.25</td>
<td>24</td>
</tr>
<tr>
<td>Taiwan</td>
<td>7.7</td>
<td>42</td>
</tr>
</tbody>
</table>
Break in magnitude scaling for slabs needs to be regionalized.
Magnitude scaling of Global model (no regionalization), and BC-Hydro model
Event terms for PGA for **Global** model

- **Maule**
- **Tohoku**

Legend:
- Alaska
- Cascadia
- CentralAmerica&Mexico
- Japan
- NewZealand
- SouthAmerica
- Taiwan
Event terms for PGA for **Global** model; Cascadia events marked
Event terms for PGA for **Regionalized model**
Event terms for **regionalized** model: Interface vs Slab events
Interface magnitude scaling for Japan

\[ R_{RUP} = 100 \]
\[ V_{S30} = 760 \]
\[ Z_{HYP} = 20 \]

Legend:
- Global model
- Regionalized model
Interface magnitude scaling for South America

![Graph showing interface magnitude scaling for South America](image)
Slab magnitude scaling for Cascadia

\[ \text{PGA} = \begin{cases} \text{global model} \\ \text{regionalized model} \end{cases} \]

- \( R_{\text{RUP}} = 100 \)
- \( V_{S30} = 760 \)
- \( Z_{\text{HYP}} = 20 \)
- \( \text{Intraslab} \)
Distance scaling: Global model & BCHydro

\[ M = 7 \]
\[ V_{S30} = 760 \]
\[ Z_{HYP} = 20 \]
Summary

- We have both regionalized and global models

- Regionalization is for:
  - Constant term
  - Anelastic attenuation
  - $V_{s30}$ scaling
  - Magnitude scaling of slabs (based on slab thickness)

- Tentative decision for Cascadia:
  - Interface: Use global model for Interface
  - Slab: Use “average” of magnitude scaling of all regions

- Between-event standard deviation is smaller in regionalized versus global model:
  - Preliminary Regional model Tau = 0.54; Global model Tau = 0.63

- Models will be released in September 2018
THANK YOU!