Single-Station Sigma Using NGA-West2 Data

Linda Al Atik
Resource Expert
GMPEs: \[ \ln \left( Y_{es} (T) \right) = \mu_{es} (M_e, F_e, R_{es}, Vs30_s, \ldots) + \delta_{es} \]

Bommer (2010)
Residual Components

\[ \delta_{es} = \delta B_e + \delta W_{es} \]

\( \delta B_e \) : Between-event (inter-event) residual for earthquake \( e \)

\( \delta W_{es} \) : Within-event (intra-event) residual at station \( s \) for earthquake \( e \)

\[ \sigma = \sqrt{\tau^2 + \phi^2} \]

\( \tau \) : Between-event standard deviation

\( \phi \) : Within-event standard deviation
Single-Station Sigma: Approach

- Given multiple recordings of GM at an individual site, $s$, allows estimating the systematic site effects, $\delta S^2 S_s$, and removing them from the GM variability: **Single-Station Sigma**

- $\delta S^2 S_s$ represents the systematic deviation of the observed amplification at this site from the median amplification predicted by the model
Single-Station Sigma: Approach (cont’d)

\[ \delta W S_{es} = \delta W_{es} - \delta S2S_s \]

- \( \delta S2S_s \): systematic deviation of the observed amplification at this site from the median amplification at this site predicted by the model.

- \( \phi_{SS} \): Single-station within-event standard deviation.

- \( \sigma_{SS} \): Single-station standard deviation

\[ \sigma_{SS} = \sqrt{\phi_{SS}^2 + \tau^2} \]
Application to PSHA

• Removing the site-to-site residual from the GM variability leads to a reduced aleatory variability

• **However**, the median GM at the SITE needs to be estimated:

\[
\ln(Y_{es}(T)) = \mu_{es}(M_{e}, R_{es}, T, ...) + \delta S 2S_{s} + \delta B_{e} + \delta WS_{es}
\]

If site-specific knowledge is limited, use of single-station sigma **SHOULD** be accompanied with an **INCREASE** in epistemic uncertainty.
## Terminology

<table>
<thead>
<tr>
<th>Ergodic</th>
<th>Partially Non-Ergodic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Within-event residual, $\delta W_{es}$</td>
<td>Single-station within-event residual, $\delta WS_{es} = \delta W_{es} - \delta S 2S_s$</td>
</tr>
<tr>
<td>Within-event standard deviation, $\phi$</td>
<td>Single-station within-event standard deviation, $\phi_{SS}$</td>
</tr>
<tr>
<td>Total standard deviation, $\sigma = \sqrt{\phi^2 + \tau^2}$</td>
<td>Single-station standard deviation, $\sigma_{SS} = \sqrt{\phi_{SS}^2 + \tau^2}$</td>
</tr>
</tbody>
</table>

Al Atik et al. (2010)
Data Needs

• Minimum of 5 recordings per earthquake in order to compute a reliable event term, $\delta B_e$

• Minimum of 5 recordings per site in order to compute the average site-to-site residual, $\delta S_2 S_s$
NGA-West2 Dataset

• CA SMM and global LM dataset:
  – 21,539 recordings from 600 eqks
  – 163 recordings with Sa = -999 eliminated
  – 3 recordings missing magnitude eliminated
  – 34 recordings missing distance measures eliminated
  – 12 recordings missing station info eliminated

21,327 recordings from 578 eqks at 4,096 stations
NGA-West2 Dataset with Periods
NGA-West2: Data Distribution

- CA: 15,264 recs
- Taiwan: 1,986 recs
- Japan: 1,946 recs
- China: 1,332 recs
- Italy: 333 recs
- NZ: 217 recs
- Other (Alaska, Iran, Greece, Turkey, ...): 249 recs

21,327 recordings from 578 eqks of 2.99 ≤ M ≤ 7.9
Total number of earthquakes: 578
408 earthquakes with 5 or more recordings
For events with minimum of 5 recordings:

Total number of stations: 4,012

838 stations have 5 recordings or more
399 stations have 10 recordings or more
Minimum of 5 recs per eqk and per station:

**15,592 recs from 364 eqks at 838 stations**

**Region** | **Nrecs**
---|---
CA | 13,162
Taiwan | 1,339
China | 1,076
Italy | 15
Minimum of 5 recs per eqk and per station:

15,592 recs from 364 eqks at 838 stations
Preliminary PhiSS Results: NGA-West2

Using preliminary AS13 within-event residuals:

– Minimum of 3 recs per eqk

– 15,619 recs from 326 eqks at 3,164 stations

<table>
<thead>
<tr>
<th>Region</th>
<th>Nrecs</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA</td>
<td>12,025</td>
</tr>
<tr>
<td>Japan</td>
<td>1,700</td>
</tr>
<tr>
<td>Taiwan</td>
<td>1,535</td>
</tr>
<tr>
<td>Italy</td>
<td>175</td>
</tr>
<tr>
<td>New Zealand</td>
<td>72</td>
</tr>
<tr>
<td>China</td>
<td>48</td>
</tr>
<tr>
<td>Iran + Turkey</td>
<td>43</td>
</tr>
<tr>
<td>Others</td>
<td>21</td>
</tr>
</tbody>
</table>
Total number of stations: 3,164
675 stations have 5 recordings or more
322 stations have 10 recordings or more
AS13 Dataset at PGA (cont’d)

Minimum of 5 recs per station: 11,188 recs

<table>
<thead>
<tr>
<th>Region</th>
<th>Nrecs</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA</td>
<td>10,123</td>
</tr>
<tr>
<td>Taiwan</td>
<td>1,049</td>
</tr>
<tr>
<td>Italy</td>
<td>16</td>
</tr>
</tbody>
</table>
AS13 Dataset at PGA (cont’d)

Minimum of 5 recs per station: 11,188 recs
Preliminary Results
CA PhiSS Preliminary Results

PGA

T 1 sec
Magnitude Dependence: CA

![PGA Graph]

![T 1.0 sec Graph]
Distance Dependence: CA

![Graph showing PGA and T 1.0 sec vs. Rrup (km)]
M-R Dependence: CA

**PGA**

- Data points for different magnitudes (M3 to 5, M5 to 6, M6 to 8) across varying Rrup (km) values.

**T 1.0 sec**

- Similar data points as PGA, but for T = 1.0 sec.
$V_{S30}$ Dependence: CA

PGA

T 1.0 sec
References (I)

