Referenced empirical ground-motion model for Eastern North America

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Introduction

- Development of GMPEs in ENA
  - Simulation-based method (Atkinson and Boore, 1995, 2006)
  - Hybrid empirical method (Campbell, 2003)
  - Referenced empirical method (Atkinson, 2008)

- Referenced Empirical Method
  - Proposed by Atkinson (2008): compare ENA motions to western GMPEs to derive empirical adjustment factors
  - Updated by Atkinson and Boore (2011) using the updated reference model.
Introduction

- Update ENA referenced empirical model based on NGA-West2 GMPE Models
  - NGA-West2 has better dataset at small-to-moderate magnitudes, leading to more robust characterization of east vs. west in common magnitude range
  - Reference WNA equation is Boore, Stewart, Seyhan and Atkinson, 2014 (denoted BSSA14)
  - Any of the NGA-West2 equations could be used with relatively similar results, although the BSSA14 GMPE is especially convenient as all of its necessary input parameters are available for the ENA database
  - It is well constrained at low magnitudes (M>3.5) and large distances R≤400 km, making comparisons to ENA data robust.

ENA Database

Gulf Coast data removed from the database due to different attenuation trend
Resources: NGA-East, Seismotoolbox website, Southern Ontario Database
Method

- Input: Observed ENA horizontal ground-motion parameters: PGA, PGV, and 5%-damped PSA at frequencies from 0.1 to 20 Hz.
- Input: Equivalent WNA ground-motion parameters for the same M, R and $V_{S30}$ using the reference model (BSSA14) (unspecified faulting mechanism)

$$\log(\text{Residuals}) = \log(\text{Observed (ENA)}/\text{Predicted (WNA)})$$

$$\log(\text{Residuals}) = F(f, r)$$

- $F$: Defined functional form as a function of frequency and distance.
Method

☐ Functional form ($F_{ENA}$):

Equation 1:

\[
\log(F_{ENA}(f))_{ij} = C_{1}(f) + C_{2}(f)(R_{jb})_{ij} + C_{3}(f) \max(0, \log(\min((R_{jb})_{ij}, 150)/50)) + \eta(f)_{i} + \epsilon(f)_{ij}
\]

- $C_{1}(f)$: Adjusts the overall level of the BSSA14 model
- $C_{2}(f)$: Models regional differences in anelastic attenuation
- $C_{3}(f)$: Adjusts the shape of the reference GMPEs
- $\eta(f)_{i}$: Random event term,
- $\epsilon(f)_{ij}$: Represents within-event residual

☐ Mixed effects regression of residuals according to Abrahamson and Youngs (1992)

Residuals (ENA relative to BSSA14):

Similar Residuals Trends in Central and East
Residuals (whole ENA database):

Simulated ground-motion parameters of Atkinson et al., (2014)

Within-event Residuals $\varepsilon$:
Within-event Residuals $\varepsilon$ vs. $V_{S30}$:

Between-event Residuals $\eta$:
GMPEs Comparison, M4, $V_{S30} = 760$ m/sec:

GMPEs Comparison, M5, $V_{S30} = 760$ m/sec:
GMPEs Comparison, $M7, V_{S30} = 760$ m/sec:

Response Spectra Comparison, $V_{S30} = 760$ m/sec:
Using another reference GMPE?

Using Another Reference GMPE?, $V_{S30} = 760$ m/sec
Model Applicability:

- BSSA14 limitations are transferred to HA14
  - $0 \leq R_{jb} \leq 400$ km
  - M3 to M8.5
  - Originally developed for $V_{S30} = 760$ m/sec
  - $150 \leq V_{S30} \leq 1500$ m/sec
  - Magnitude scaling of BSSA14
  - Close-distance scaling of BSSA14
  - No source depth-dependency considered

Conclusions:

- Update the former Referenced GMPE Model for ENA (A08')
- Similar residuals trends for East and Central regions
- Empirical adjustment factors are similar to the simulation-based adjustment factors.
- At close distances ($\leq 50$ km), residuals tend to be insignificant except at high frequencies (>5Hz);
- As distance increases, the residuals gradually increase, presumably due to the slower attenuation rate at regional distances in ENA compared to that in active regions
- Similar attenuation shape to the A06' model, greater saturation effect compared to A06'
- Similar adjustment factors to the other NGA-West2 GMPEs

Thank you!