Development of the NGA-East Ground Motion Characterization (GMC) Model

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http://peer.berkeley.edu/ngaeast/
The NGA-East Project

*A science AND a SSHAC Level 3 projects* to develop GMC model:

- GMMs/GMPEs
  - Median
  - Standard Deviation (aleatory variability)
- Logic trees (epistemic uncertainty)
- For:
  - Average horizontal ground motions (PGA, PGV and 5%-damped PSA for $f=0.1-100$Hz)
  - Hard rock sites ($V_{s30}=3,000$ m/s, kappa=6 ms) located up to 1,500 km
  - Future earthquakes in CENA ($M_4.0-8.2$)
- Capture the CBR of the TDI
The NGA-East Challenge: developing GMC model with limited data

NGA-East database: uniformly processed 9,500 record pairs/triplets from 70 earthquake events.
Capturing the CBR of the TDI in median ground motions

- Issue: many GMMs exist, but they may not sample the ground-motion space adequately
  - Redundant models? Confirmatory models?
  - Missing models?

![Graph showing 5 Hz PSA, M=5, 7](attachment:graph.png)
Capturing the CBR of the TDI in median ground motions

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  - Missing models?

- NGA-East approach: treat epistemic uncertainty as a continuous distribution in GM space
  - Goal is to *try to* select discrete mutually exclusive and completely exhaustive (MECE) GMMs representing the range in ground motions
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- Issue: many GMMs exist, but they may not sample the ground-motion space adequately
  - Redundant models?
  - Missing models?
- NGA-East approach: treat epistemic uncertainty as a continuous distribution in GM space
  - Goal is to try to select discrete mutually exclusive and completely exhaustive (MECE) GMMs representing the range in ground motions
- Populate the continuous distribution with *lots* of GMMs, re-discretize into a manageable number of GMMs that better represent the space
NGA-East approach to median GMs

- 1. Develop a suite of seed GMMs
- 2. Develop parameters for continuous distributions of GMMs
- 3. Sample 10,000 GMMs, visualize the ground-motion space
- 4. Re-discretize the ground-motion space, select representative GMMs
- 5. Assign weights
Median Ground Motions

Difficult to aggregate trends for various $M$, $R$ pairs. Solution: Use high-dimension visualization tools - **Sammon’s Maps** aggregate all the info in 2D

**M-scaling**

**R-scaling**
Median Ground Motions

- Sample new GMMs (10,000)
- Each resulting GMM is a vector of ground-motion values (374 dimensions)
- Project seeds and samples on Sammon’s map
Median Ground Motions

Sample Sammon’s map space using ellipse with 17 cells

Center = 10%

Body = 75%

Range = 95%
Sample result

- 17 GMMs, each representing one cell
Standard deviation

- Model developed for partitioned residuals
  - Phi, Phi_{s2s}, Phi_{ss}, Tau
- Partitioned standard deviation terms using the NGA-East database
- Considered models from data-rich regions (NGA-West2, Japan) to extrapolate models to larger magnitude
- Evaluated the models and assigned weights
- Products are
  - Sigma (ergodic) and Sigma_{ss} (single-station)
GMC model summary

Median and standard deviation models applicable to CENA, $M_{4-8.2}$, $R_{RUP}$ up to 1,500 km

- CBR of the TDI in medians: 17 GMMs per frequency, provided in tables of $M$, $R$ (no equations) for each PSA frequency, PGA and PGV

- Adjustments for the Gulf Coast region

- CBR of the TDI in standard deviation models: includes $\Phi$, $\Phi_{SS}$, $\tau$ with uncertainty branches
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