SCEC Perspective on Simulation Validation in SCEC5

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SCEC ground-motion simulation platforms

Seismic band

- mantle waves
- crustal waves
- basin waves
- strongly scattered waves

Earthquake engineering band
- tanks, tall buildings
- short buildings, houses
- stiff structures, NPPs, equipment

SCEC simulation computations

**BroadBand Platform**
- 1D Deterministic
- Stochastic

**CyberShake**
- 3D Deterministic

**BroadBand CyberShake**
- 3D Deterministic CyberShake

**High-F**
- 3D Deterministic

Development and production software (runs on clusters and PCs)

Complete physics-based PSHA (runs on HPC)

Physics-based development for new physics (runs on HPC and clusters)
Key lessons learned – past validations

Need transparent validation for forward simulations for source, wave propagation, site effects!
Validation objective and process needs to consistent with application.

- Requires non-modelers to run the codes, tie-in to versioned code.
- Need clear documentation of fixed and optimized parameters from modelers for each region (M-A scaling, stress drop/parameter, etc.)
- Need source description that is consistent between methods, or defined as part of the rules.
- Need to allow for randomization of parameters (source realizations, hypocenter locations, etc.)
- Need to validate against many events
- Make all validation metrics computation and plots part of processing pipeline.
Ingredients for ground motion simulations

Earthquake Rupture Forecast (e.g. UCERF) + Source model + Velocity model + Wave propagation code + Site response code = Seismograms and intensity measures
Validation of CVMs

- Validate against waveforms not used in model inversion/model development
- Use of optimized source ok

Validation of CVM-S4.26 synthetics against data from the 03/28/14 La Habra Earthquake (M5.1) \( f \leq 0.2 \text{ Hz} \)

Lee et al. (2014)
Validation of velocity models


![Map and Graph Illustrations]

<table>
<thead>
<tr>
<th>Model</th>
<th>Mean FS</th>
</tr>
</thead>
<tbody>
<tr>
<td>S4.26</td>
<td>4.87</td>
</tr>
<tr>
<td>S4</td>
<td>4.75</td>
</tr>
<tr>
<td>H+GTL</td>
<td>4.82</td>
</tr>
<tr>
<td>H</td>
<td>4.60</td>
</tr>
</tbody>
</table>

Event X (335)

Score Distribution for CVM-S4, CVM-S4.26, CVM-H, and CVM-H+GTL
Validation of ground motions (qualitative)

- Validation of ground motions – from the source to the surface
  - Visual/qualitative assessment of waveforms, Husid plots, FAS plots
  - Validation performed with “forward sims” in mind
  - Multiple realizations, can span various geometries/areas, hypocenter location, slip displacement and velocity distributions

```
SIMULATED
Vs30 = 863 m/s

RECORDED
Vs30 = 822 m/s
```
Validation of ground motions (quantitative)

- Part A – Against recorded events - think “forward” sims
  - Not tuned for a specific event – provide regional rules
  - Provide randomization of parameters
  - Aggregate evaluation over multiple events
  - Benefit to compare performance of sims relative to GMPEs

GOF Comparison between LOMAP and simulation 10000021
R < 85 km

RotD50
Validation of ground motions (quantitative)

- Part A – Against recorded events - think “forward” sims
  - Not tuned for a specific event – provide regional rules
  - Provide randomization of parameters
  - Aggregate evaluation over multiple events
  - Benefit to compare performance of sims relative to GMPEs

![Graph showing comparison of simulated and recorded ground motions]
Validation of ground motions (quantitative)

- Part B – against GMPEs
  - Is “validation” only for range of M, R at which the GMPEs are well constrained
  - Allows evaluation of model centering in a global sense
Validation of ground motions (quantitative)

- Part B – against GMPEs
  - Is “validation” only for range of M, R at which the GMPEs are well constrained
  - Allows evaluation of model centering in a global sense
  - Need to understand differences that may be due to parameterization (3D model Vs. basin depth proxies)
Validations in SCEC5

- On-going collaboration with users (engineers)
  - EEII, GMSV-like groups
  - Develop validation metrics
  - Implement pass/no pass gauntlets
- Integration of platform-specific tools on all relevant platforms