High-frequency Simulations: Verification and Validation of the M5.1 La Habra, CA, earthquake

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Verification

» Correctness of the implementation of a simulation scheme

» Comparison of simulations with exact or alternative solutions

Validation

» Level of agreement between synthetics and actual data

» Comparison of simulations with observations
SCEC High-F simulation codes and collaboration history

**Finite Difference Method**

- AWP-ODC
- AWP-RWG

**Finite Element Method**

- Hercules

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2005–2006 **TeraShake**

- 0.5–1 Hz
- 500 m/s

2007–2008 **ShakeOut**

- Simulation, verification
- 0.5–1 Hz
- 500 m/s

2009–2018 **Chino Hills & La Habra**

- Simulation, validation, verification
- 2–4 Hz
- 200 m/s
The 2014 Mw 5.1 La Habra earthquake

- 3 codes
- $f_{\text{max}} = 4 \text{ Hz}$
- $V_{s\text{min}} = 500 \text{ m/s}$
- 300+ observations
Source models considered

Point source model

Finite fault model
Velocity models considered

Half-space model
- $V_s = 1$ km/s
- $V_p = 2$ km/s
- Density = 2.1 g/cm$^3$

1D layered model (BBP)
- $V_{s_{\text{min}}} = 0.5$ km/s

3D crustal structure (CVM-S4.26.M01)
- $V_{s_{\text{min}}} = 0.5$ km/s
Initial verification – Point source – 1D elastic

FUL 040°

Initial – 2 codes

2 months later – 2 codes

4 months later – 3 codes

6 months later – 3 codes
Initial verification – Point source – 1D elastic vs 1D anelastic

FUL 040°

Initial – elastic vs 2 months later – anelastic
Initial verification – Point source – 3D anelastic

FUL 040°

Initial – 2 codes

2 months later – 2 codes

4 months later – 3 codes

6 months later – 3 codes
Initial verification – Point source – 3D anelastic (cont.)

FUL 040°

8 months later – 3 codes

10 months later – 3 codes

12 months later – 3 codes
Latest results – Finite fault – 3D anelastic
Validation
Quantitative comparisons and goodness-of-Fit (GOF) methods

» Signal metrics
  › Anderson (2004)
Preliminary results – 2 codes – Point source – $f_{\text{max}} = 4$ Hz
Final remarks

» It takes time
» It requires careful attention to detail (interpretation of “standards”)
» It is preferable to have an independent party for (automated) comparisons
» Never underestimate the most basic level of modeling
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