The Science of Earthquake Forecasts

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**SCEC Mission Statement**

- **Gather data** on earthquakes in Southern California and elsewhere

- **Integrate information** into a comprehensive, physics-based understanding of earthquake phenomena

- **Communicate understanding** to end-users and society at large as useful knowledge for reducing earthquake risk and improving community resilience
SCEC Participation and Growth

- ~600 attendees
- ~300 posters
- 160 first-time attendees
- 285 students & post-docs
- 18 core institutions
- 57 participating institutions
  - 44 domestic
  - 13 international
Ingredients for Ground Motion Computations

1. Earthquake rupture forecasts (ERFs)
   - detailed representation of fault geometry
   - rupture models that capture the complexities of dynamic fault failure

2. 3D models of geologic structure
   - large-scale crustal heterogeneity
   - sedimentary basin structure
   - geotechnical layer based on $V_{S30}$

3. Calculation of wave propagation and attenuation
   - efficient anelastic wave propagation codes
   - nonlinear models of near-surface response
In 2016, more than 55 million people were registered to participate in ShakeOut drills

2016 ShakeOut Earthquake Drills

2016 Official ShakeOut Regions
28 Regions worldwide
22 U.S. regions spanning 51 states & territories
70 additional countries with independent registrations (individuals, schools, etc.)

Participation History (worldwide)
2016: 55.9 million (+ major drills in MX, PH, etc.)
2015: 43.8 million (+ TX, IA, LA, NE, global growth)
2014: 26.5 million (+ NM, KS, FL, Quebec, Yukon, more)
2013: 25.0 million (+ Southeast, Northeast, MT, WY, CO)
2012: 19.5 million (+ Japan, New Zealand, UT, WA, AZ)
2011: 12.5 million (+ Central US, BC, OR)
2010: 8.0 million (+ Nevada and Guam)
2009: 6.9 million (+ Northern California)
2008: 5.4 million (Southern California)

Key Facts
• Participants practice “Drop, Cover, and Hold On” and other aspects of their emergency plans.
• Register at www.ShakeOut.org
Core product #1
Community geophysical models

- Fault surfaces
- Stress, strain rate
- Paleoseismic earthquake history
- Surface deformation
- 3D Vp, Vs, density structure
- Rheology – viscosity, plasticity, strength
- Temperature, Composition
and the science they require and enable
Core product #2

Using product #1 to reduce hazard uncertainty (enabling safety and savings)

After Wang & Jordan, 2014
**SCEC HPC Allocations**

- **Commercial cloud price of 2017 allocations ~ $20M**

*Phil Maechling*

*Christine Goulet*
Latest faulting model – UCERF3

- Uniform California earthquake rupture model.
- **In LA**, an M6 every 10 years,
- An M7 every 61 years, and
- An M7.5 every 100 years.
- Across state, an M6 every year, an M7 every 10 years, and an M7.5 every 50 years.
USC vs Cal vs Stanford vs UW hazard

- USC (UCLA) 100%
- UCB & Stanford 130%,
- UW 65%,
- Doesn’t count soil amplification
  - Most campuses variable
- 10% exceedance in 50 years
  - 0.2s period (5 Hz) spectral acceleration
  - % of g (gravity)
  - INSIDE typical small building, which amplifies
**UO vs UA vs UU vs CU hazard**

- OSU & UO about 30% g
- U Utah 40% - Wasatch Fault
- WSU, UA, UColorado, & ASU ~10% g
- Short period acceleration
  - % of g, gravity, in typical building
- 10% chance of exceedance in 50 years
- 2% in 50 years is most often used for buildings, and longer period motions for big structures.

2/23/18
Next – Time-dependent hazard maps

UCERF3-TI
- Time-independent, incorporated into 2014 National Seismic Hazard Map

UCERF3-TD
- Long-term time-dependent, based on a Reid renewal statistics

UCERF3-ETAS
- Short-term time-dependent, based on Omori-Utsu statistics (ETAS model)

Field et al. (2014, 2015, 2017)

M7 event on the Mojave section of the San Andreas Fault
Challenges

Geology is not yet well enough known.

Stretching to move north, capturing higher frequencies.

Near-surface softening, liquefaction in strong shaking.

We’d love to know which faults will go next (but don’t).

Best methods are still beyond our best computers.