# CyberShake as a CISM ground motion prediction platform

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2016 SCEC Annual Meeting CISM Workshop
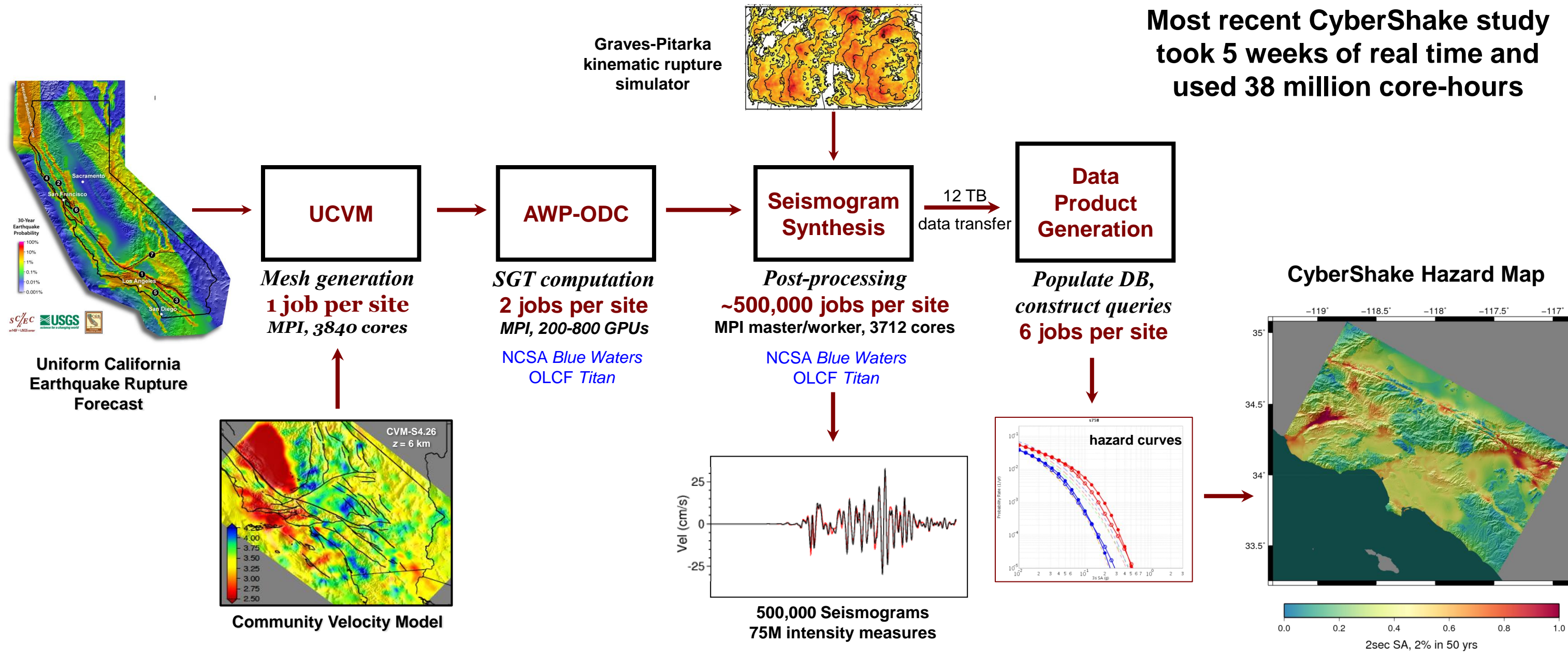September 11, 2016

CyberShake Overview

- 3D physics-based probabilistic seismic hazard analysis

- Uses seismic reciprocity to simulate seismograms from UCERF earthquake rupture forecast (distance<200 km)

- Hazard curves are created for individual locations in region of interest, interpolated for map

- Model produces 300M+ seismograms, 22B intensity measures

Earthquake forecast: UCERF2
Structural model: CVM-S4.26
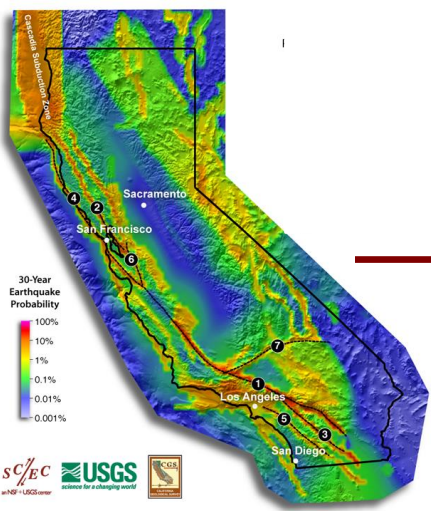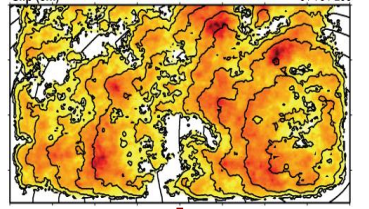
LA region

2sec SA, 2% in 50 yrs
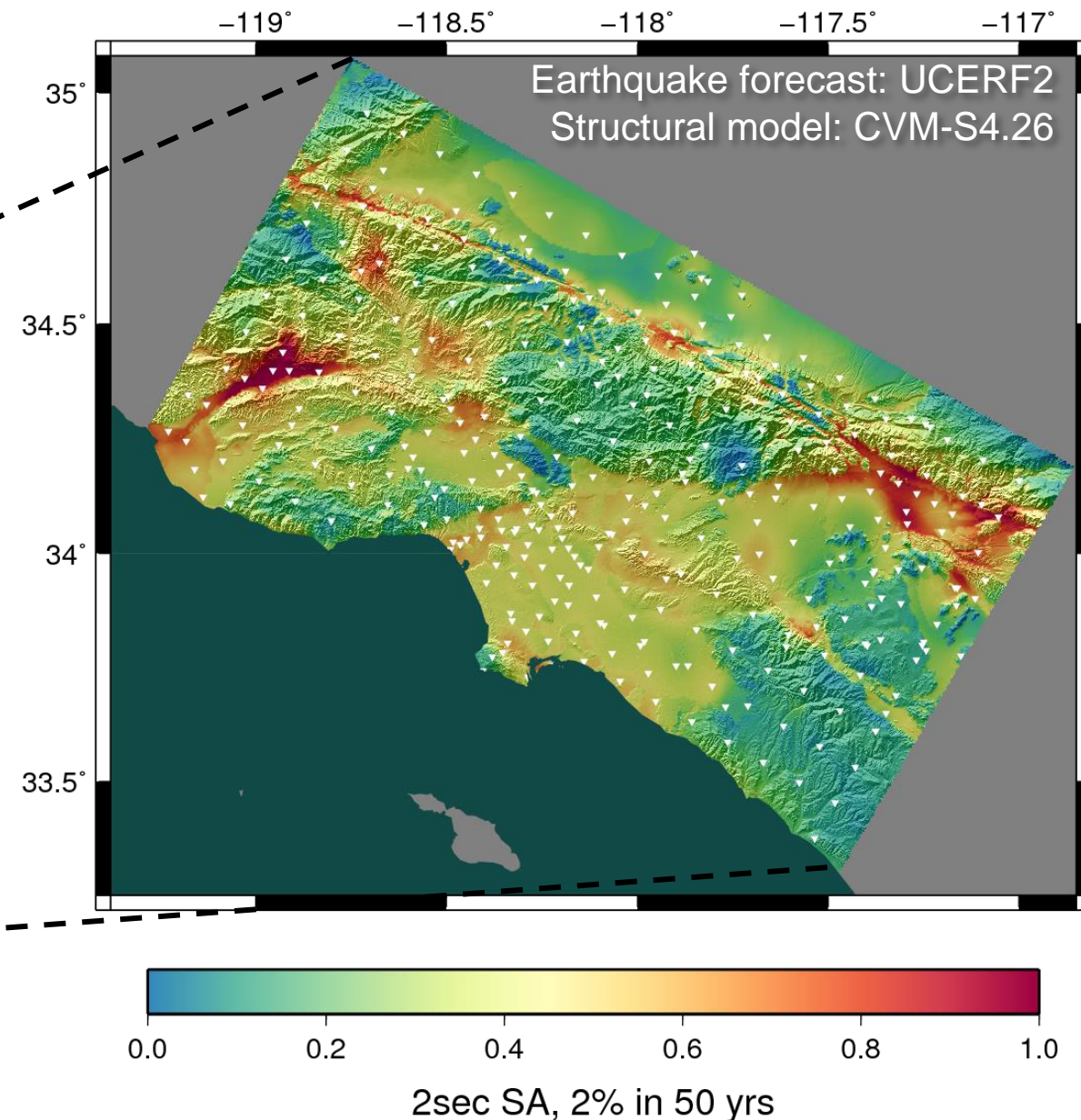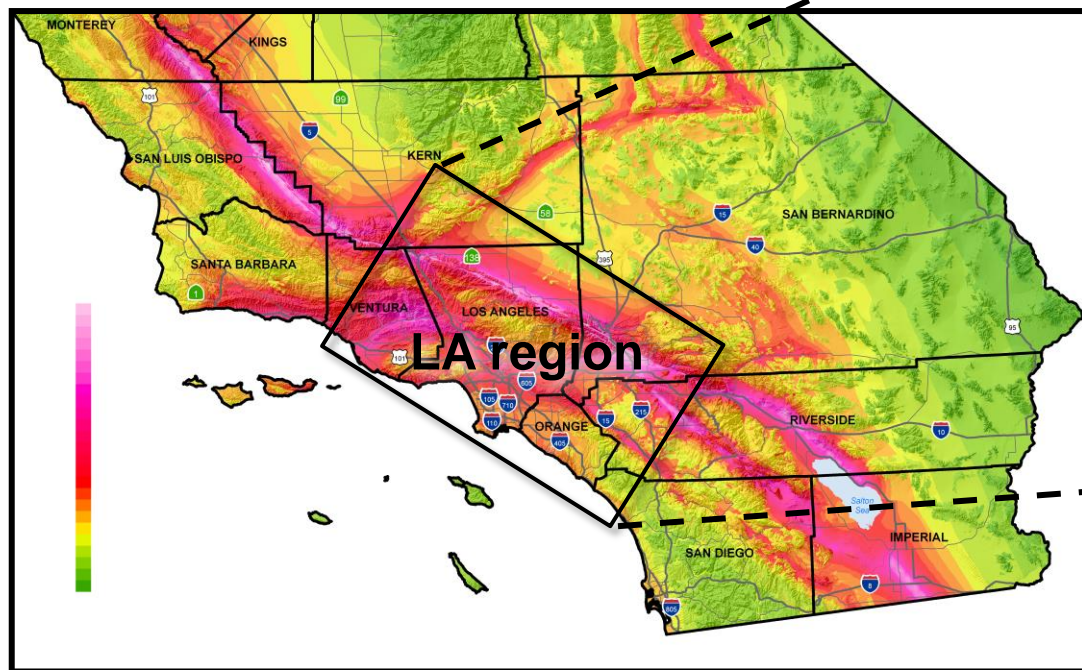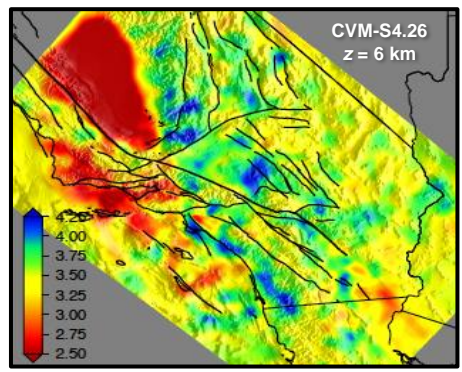
CyberShake Data Flow

Most recent CyberShake study took 5 weeks of real time and used 38 million core-hours

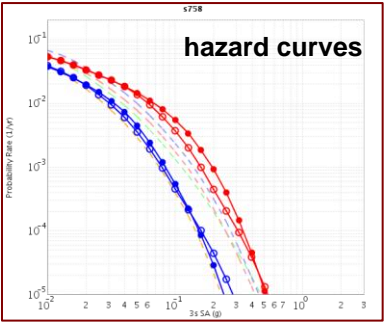**Graves-Pitarka kinematic rupture simulator**

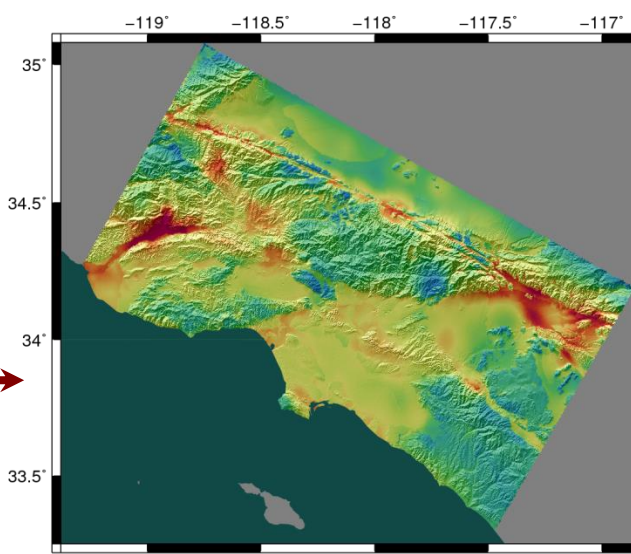**Uniform California Earthquake Rupture Forecast**

UCVM

Mesh generation
1 job per site
MPI, 3840 cores

AWP-ODC

SGT computation
2 jobs per site
MPI, 200-800 GPUs

NCSA *Blue Waters*
OLCF *Titan*

Seismogram Synthesis

Post-processing
~500,000 jobs per site
MPI master/worker, 3712 cores

NCSA *Blue Waters*
OLCF *Titan*

12 TB data transfer

Data Product Generation

Populate DB, construct queries
6 jobs per site

Community Velocity Model
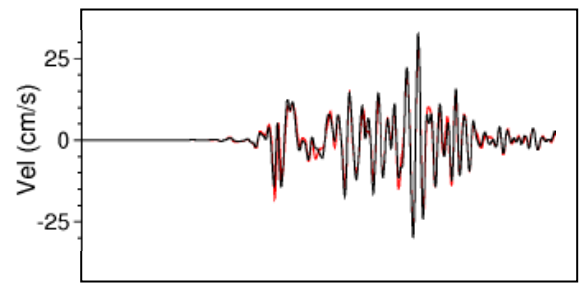
500,000 Seismograms
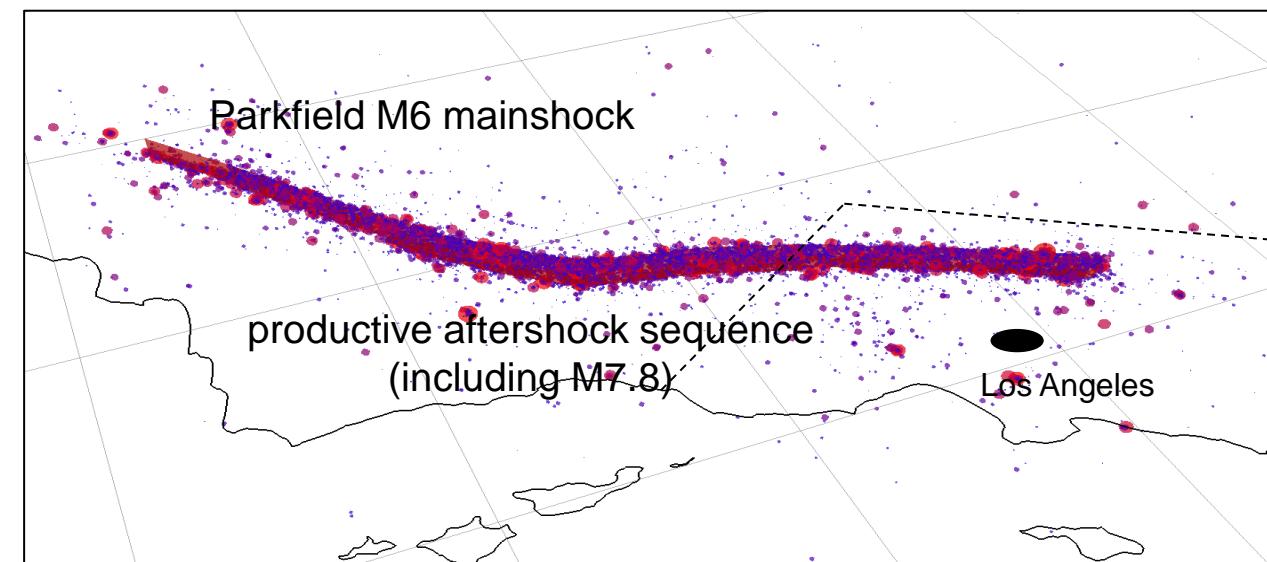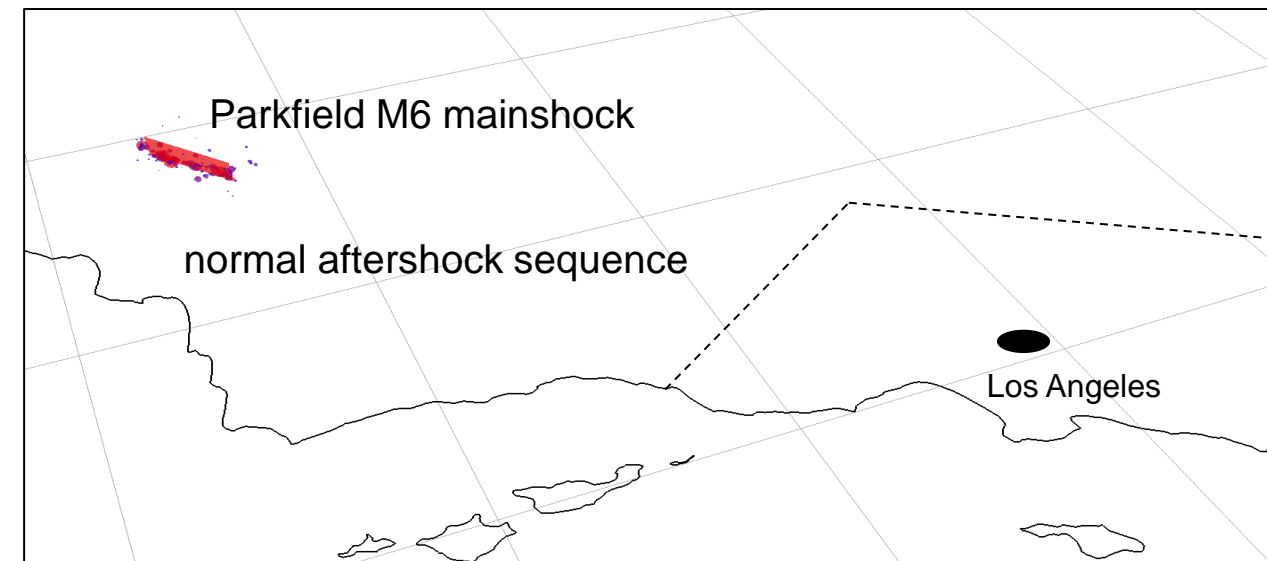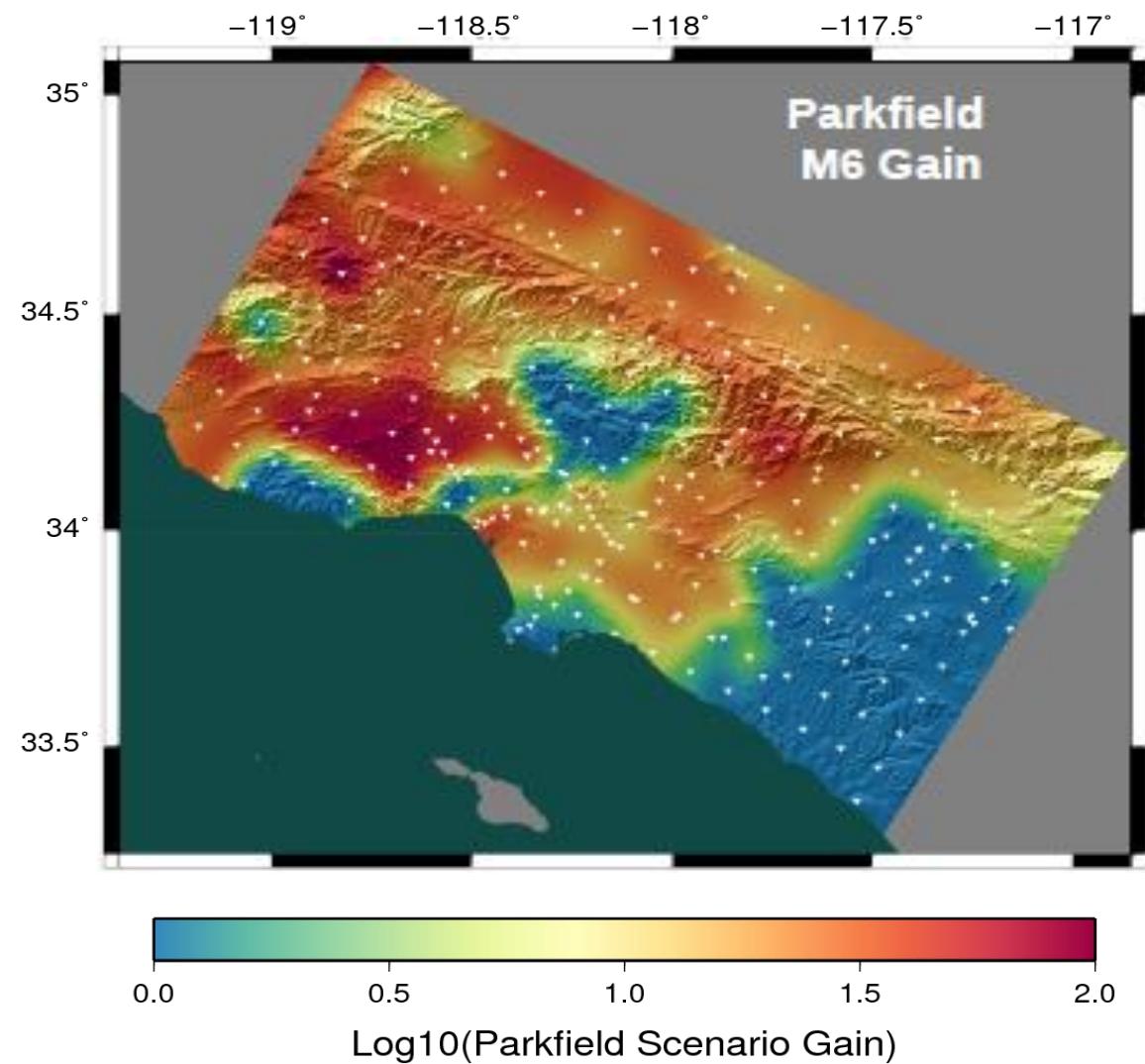**75M intensity measures**

hazard curves

CyberShake Hazard Map

2sec SA, 2% in 50 yrs

Forecasting with CyberShake

- Since 1B+ intensity measures are stored for each model, can quickly recompute with modified probabilities from UCERF or RSQSim

Parkfield M6 Gain

Log10(Parkfield Scenario Gain)

Parkfield M6 mainshock

normal aftershock sequence

Los Angeles

Parkfield M6 mainshock

productive aftershock sequence
(including M7.8)

Los Angeles

CyberShake Central California

- Preparing to begin CyberShake study in Central California
  - 408 new locations, including CISN stations, cities, missions, PG&E pumping sites

- Using CCA-06 (tomographic inversion) velocity model and 1D derived model

- Proof-of-concept for CyberShake expansion into new regions
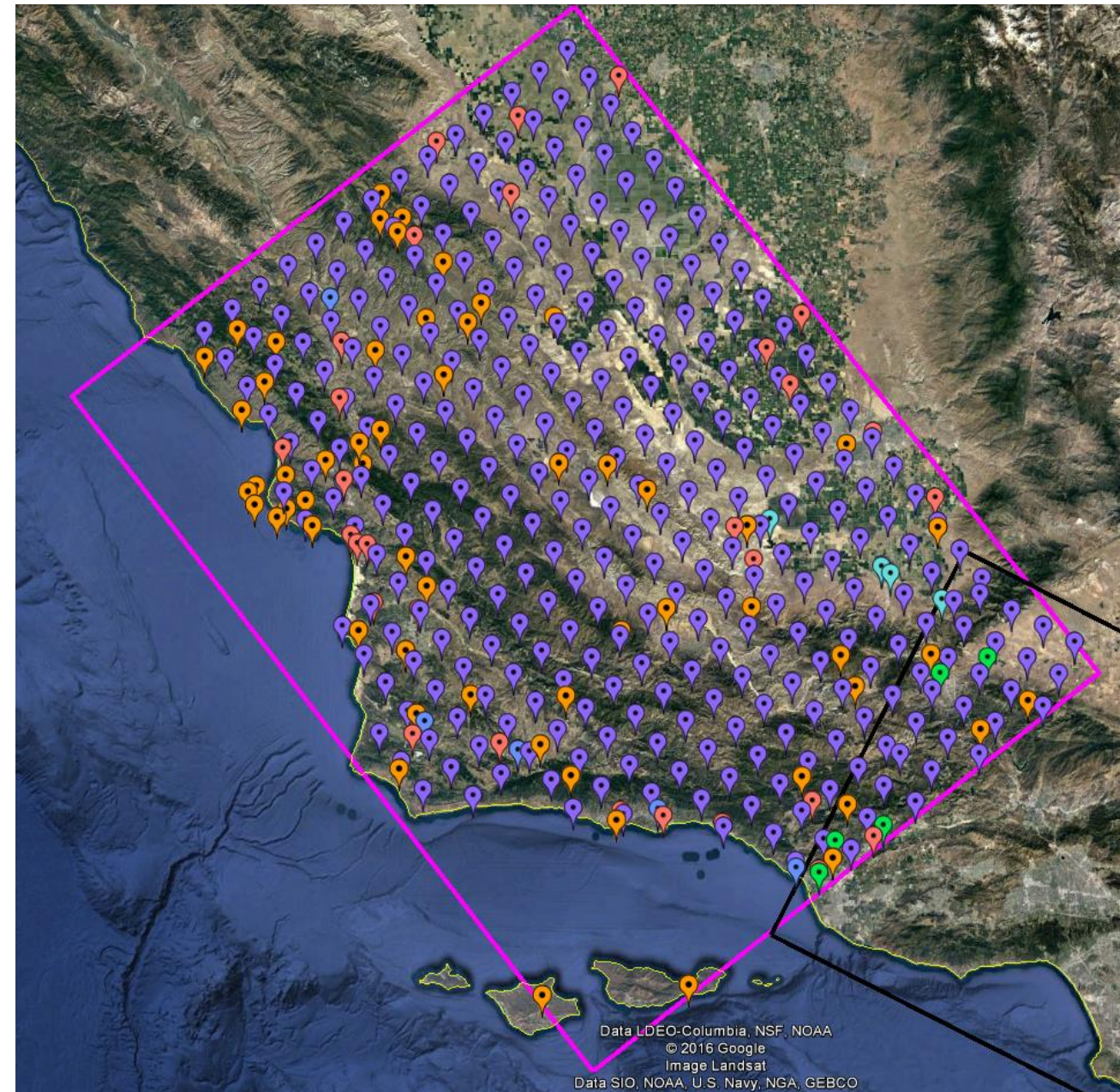
Challenges in CyberShake migration to UCERF 3

- ## Many more ruptures
  - About 25x compared to UCERF 2

- ## Statewide ruptures
  - Mendocino to Bombay Beach has a (low) probability

- ## More complex ruptures
  - Multi-segment
  - Fault-to-fault jumps

Low ▬▬▬▬▬ High
Participation Rates M ≥6.7
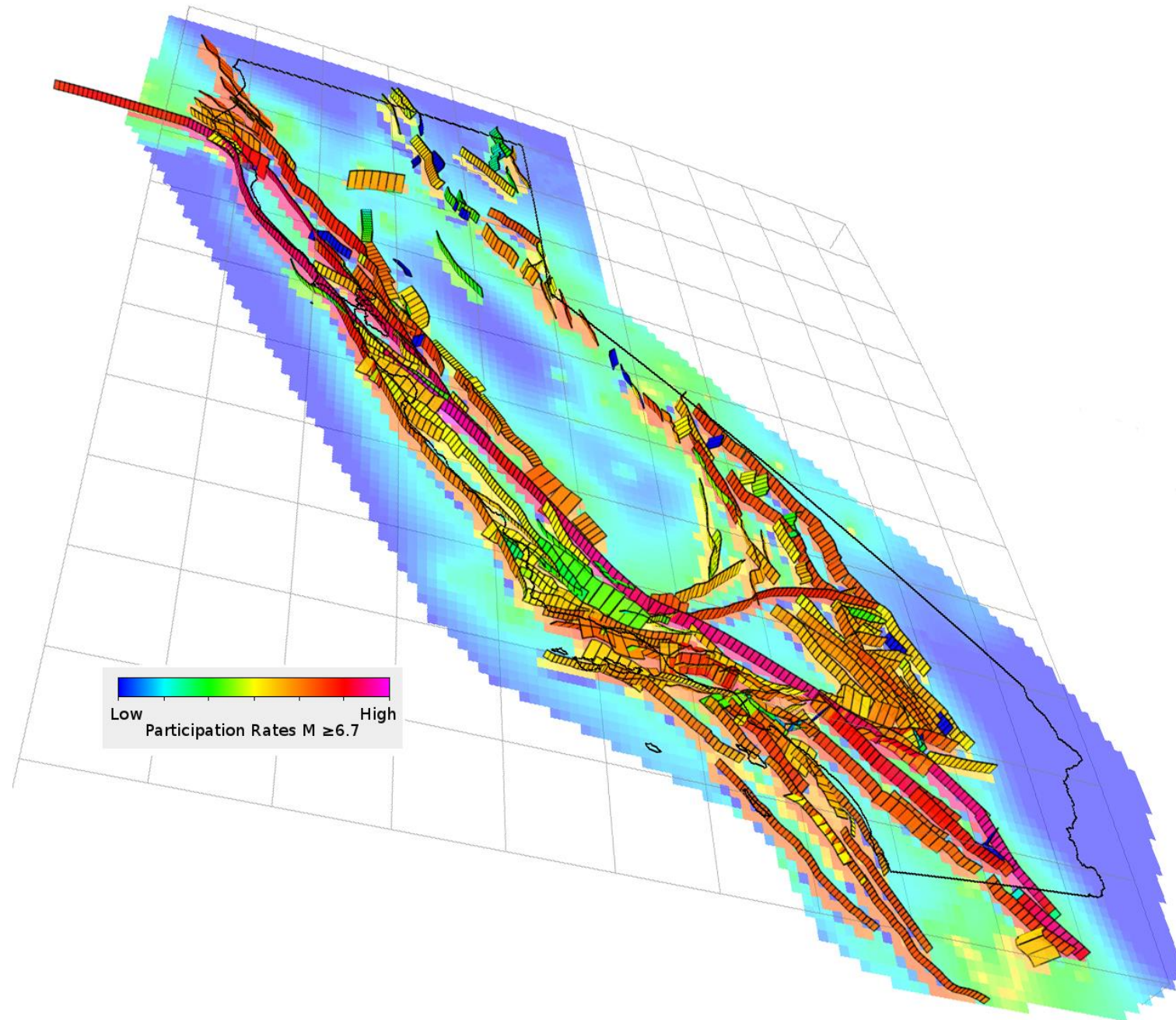
Possible UCERF 3 solutions

- Avoid performing 3D simulations of all ruptures

  – Downsampling: map rate from distant ruptures onto closer ruptures

    • Reduces rupture set by 75%

  – Grow UCERF 3 ruptures in terms of magnitude, not fault segments

    • Reduces rupture set by 87%

    • Shows promise; more tweaking required

  – 1D modeling

    • Use 1D Green's functions for distant events

- Move to rupture generator capable of handling complex ruptures

Right: Downsampling test: original (black), downsampled (blue), excluded (green)

SBSM GMPE Curves
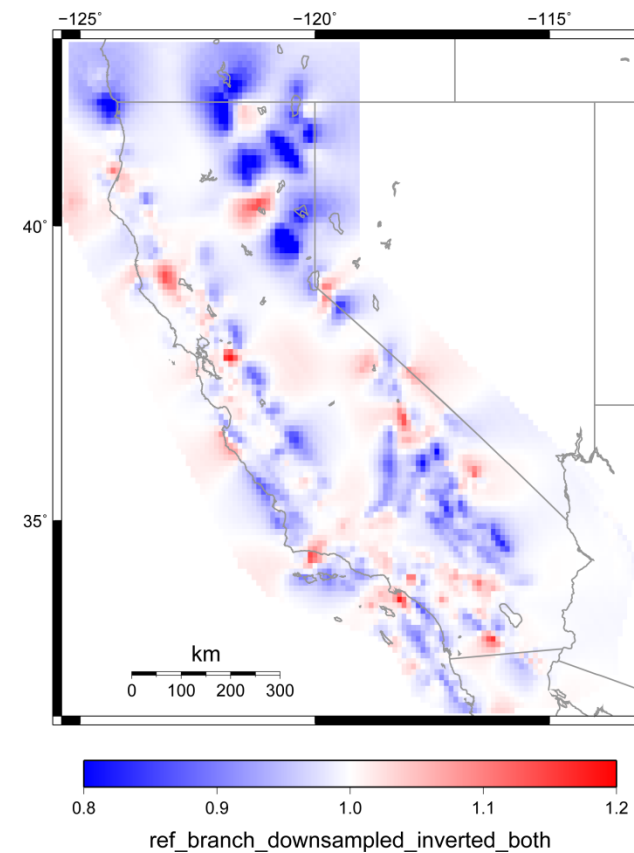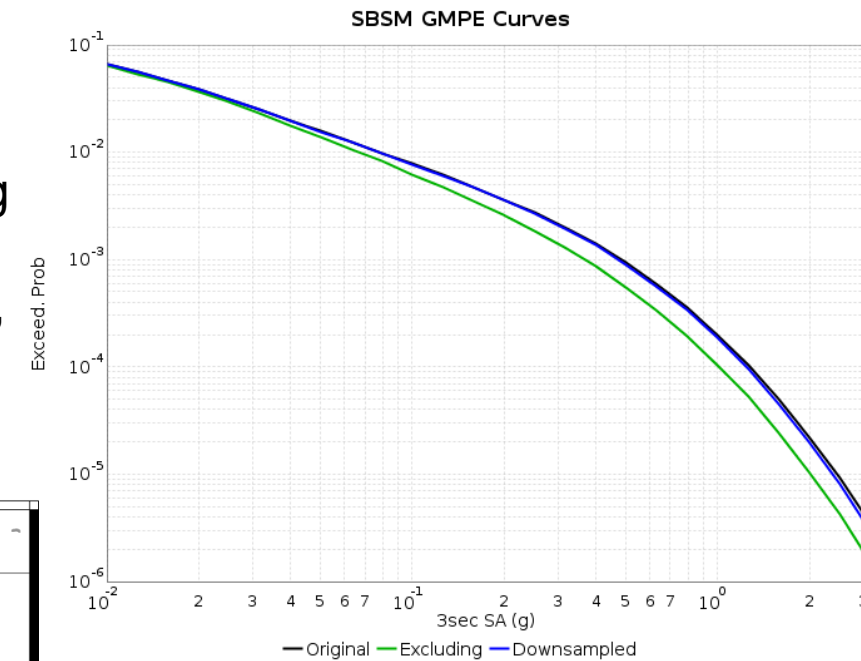
Left: Ratio of 2% in 50 yr PGA, downsampled/original

ref_branch_downsampled_inverted_both

Future CyberShake Plans

- Short-term:
  - Central California Study

- Medium-term:
  - Migration to UCERF 3
  - Expansion to other regions (Bay Area?)
  - Increase in maximum frequency from 1 Hz

- Long-term:
  - Migration to RSQSim as ERF
  - Transition from reciprocity to forward simulation