Using CyberShake 3D Ground Motion Simulation Workflows to Advance Central California PSHA

2017 SSA Annual Meeting
April 18, 2017

Scott Callaghan
Southern California Earthquake Center
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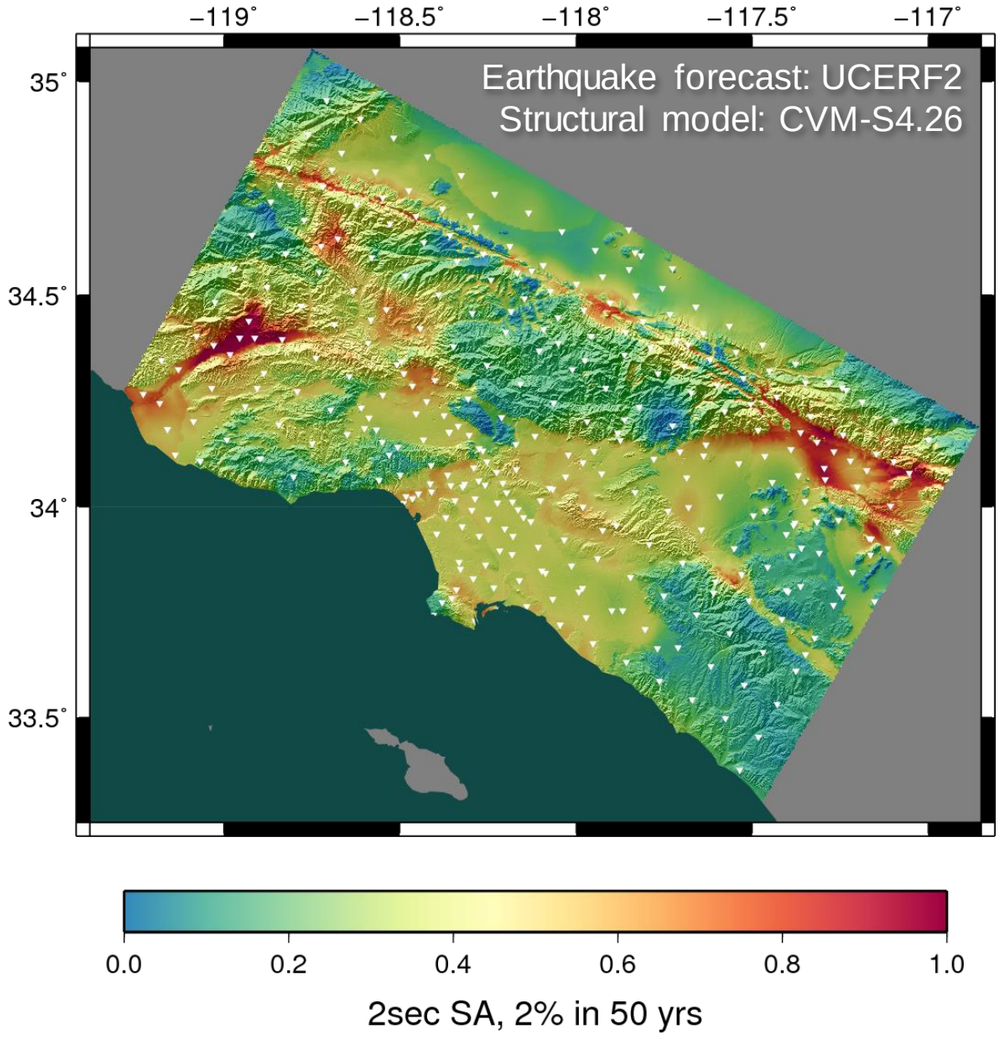
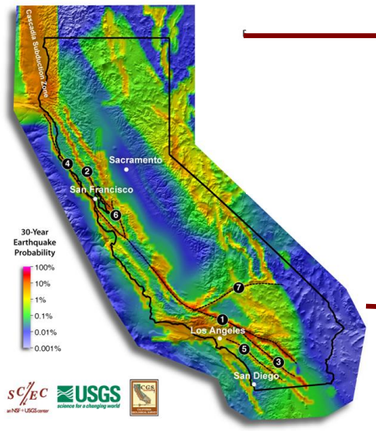
SCEC
an NSF+USGS center

CyberShake Overview

- 3D physics-based probabilistic seismic hazard analysis
- Uses reciprocity-based approach to simulate seismograms from UCERF earthquake rupture forecast (<200 km)
- Intensity measures extracted from seismograms
- Hazard curves created for individual locations in region of interest, interpolated for map
- Engineers using CyberShake results to inform ground motion predictions
  - UGMS Committee: “Use of 3-D Physics-Based Numerical Simulations in the Development of Long Period Ground-Motion Maps for Los Angeles”, Thursday at 4:15

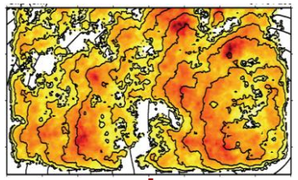


CyberShake Data Flow



Uniform California Earthquake Rupture Forecast

Graves-Pitarka kinematic rupture generator



UCVM (poster 84)

Mesh generation
1 job per site
MPI, 1500-4000 cores

AWP-ODC

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

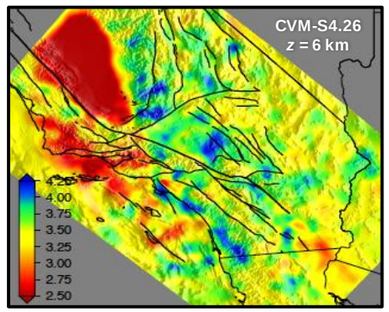
Seismogram Synthesis

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

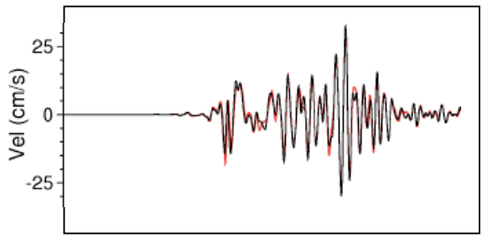
12 TB
data transfer

Data Product Generation

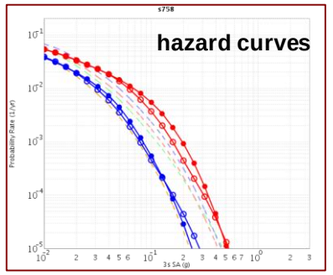
Populate DB, construct queries
6 jobs per site



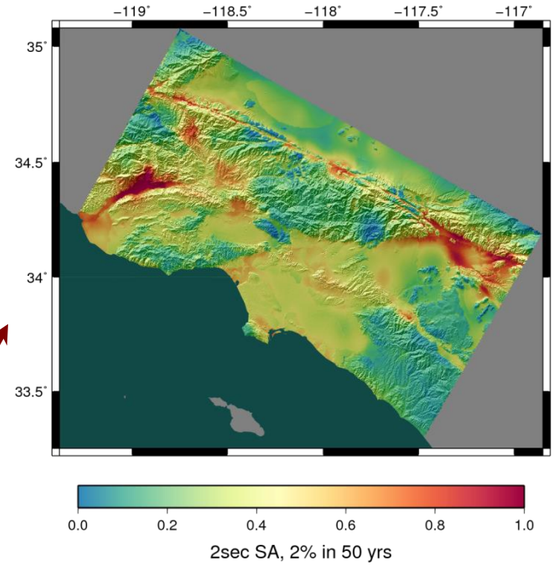
Community Velocity Model



500,000 Seismograms
75M intensity measures



CyberShake Hazard Map

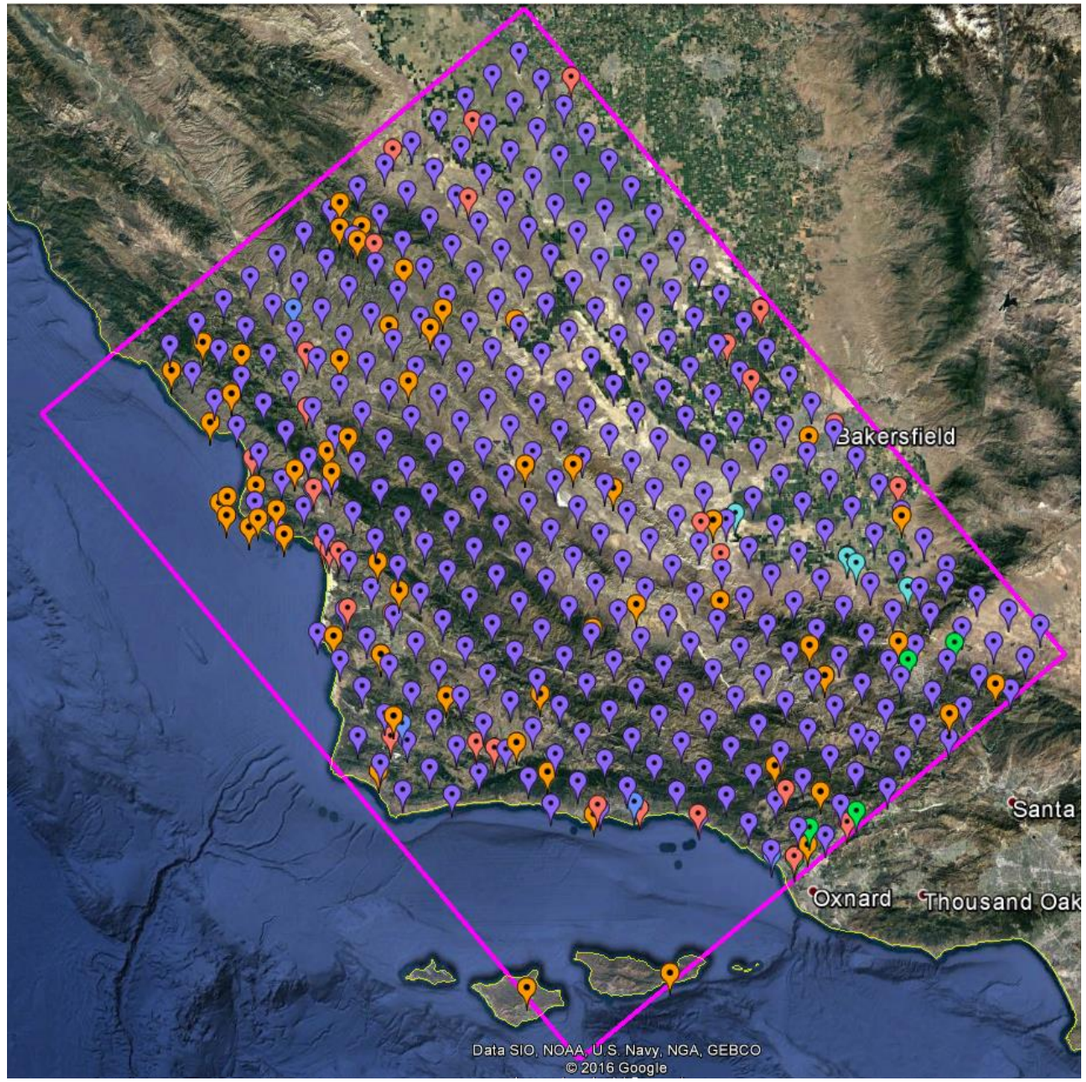


CyberShake Workflows

- Use scientific workflow tools to orchestrate CyberShake calculations
  - Pegasus, HTCondor, Globus
  - Use tools to write description of workflow with files and dependencies
  - Tools then manage real-time execution of workflow
- Automation
  - Supports running thousands of jobs over days or weeks
- Data management
  - Files are automatically staged in and out as needed
- Resource provisioning
  - From workflow host, can submit jobs to multiple remote resources
- Enabled SCEC to scale CyberShake since 2007

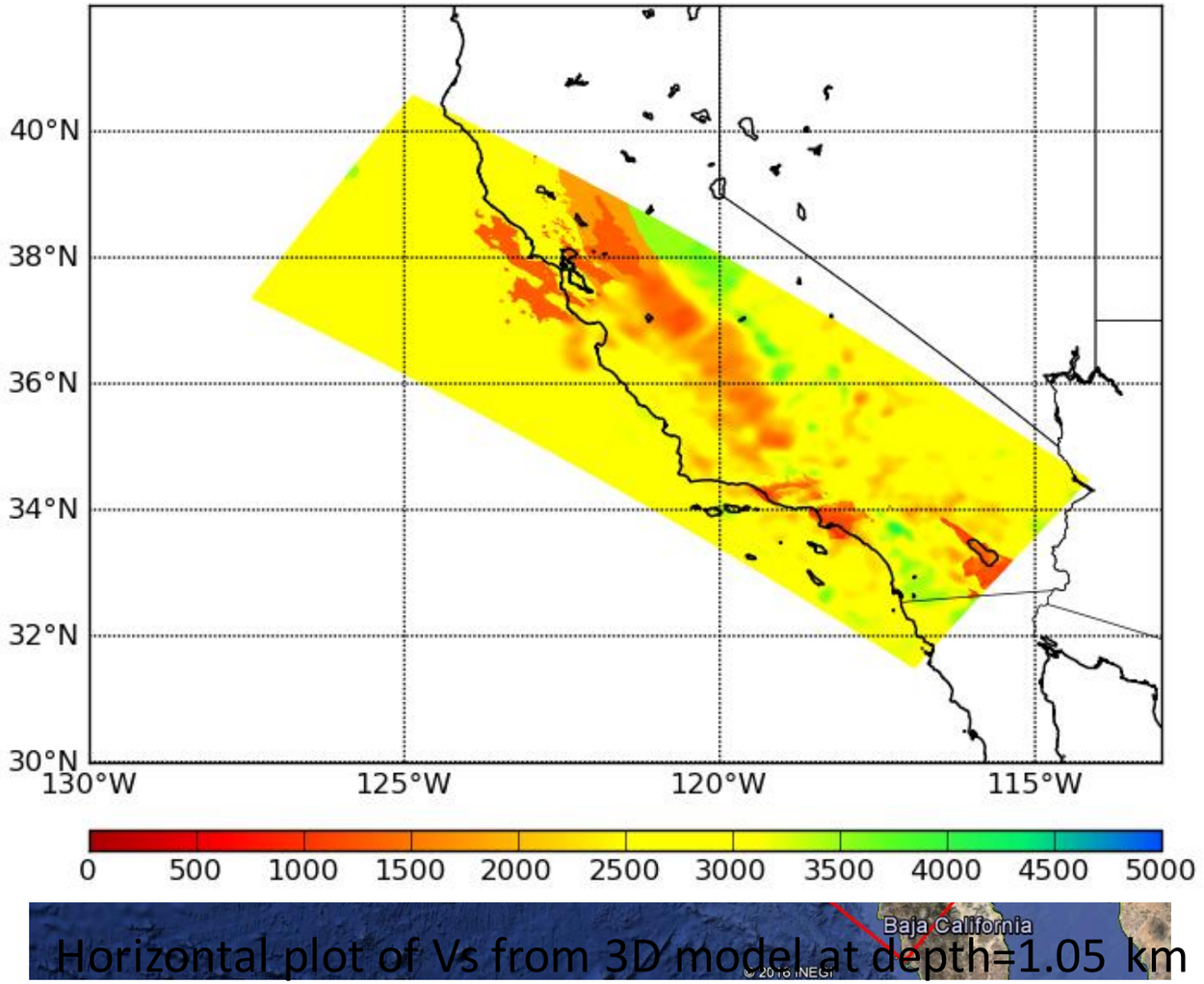
CyberShake Central California

- Proof-of-concept for expanding CyberShake to new regions
- Maximum frequency of 1 Hz
- Twice the size of CyberShake Southern California
- 438 locations
  - CISN stations
  - PG&E pumping sites
  - Cities from USGS Gazetteer
  - Historic missions
  - Regular grid for interpolation



Central California Velocity Models

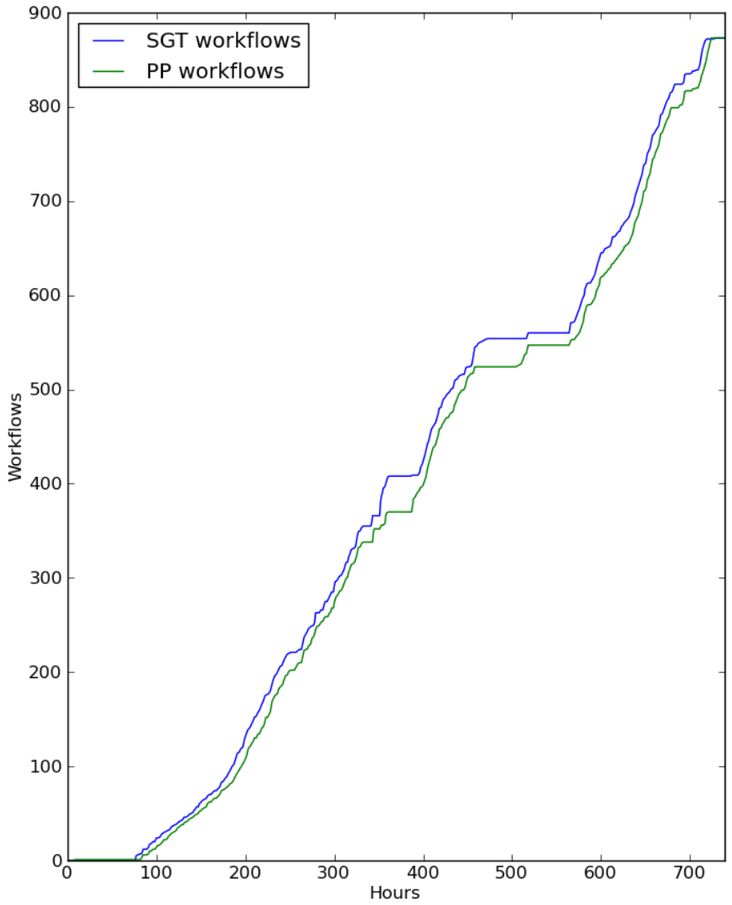
- 3D model
  - Simulation volumes too large for single velocity model (white)
    1. CCA-06 (Central CA, tomographic inversion, blue)
    2. CVM-S4.26 (Southern CA, tomographic inversion, red)
    3. USGS Bay Area (green)
  - Smoothing applied along model interfaces
- 1D model
  - Averaged CCA-06 over land



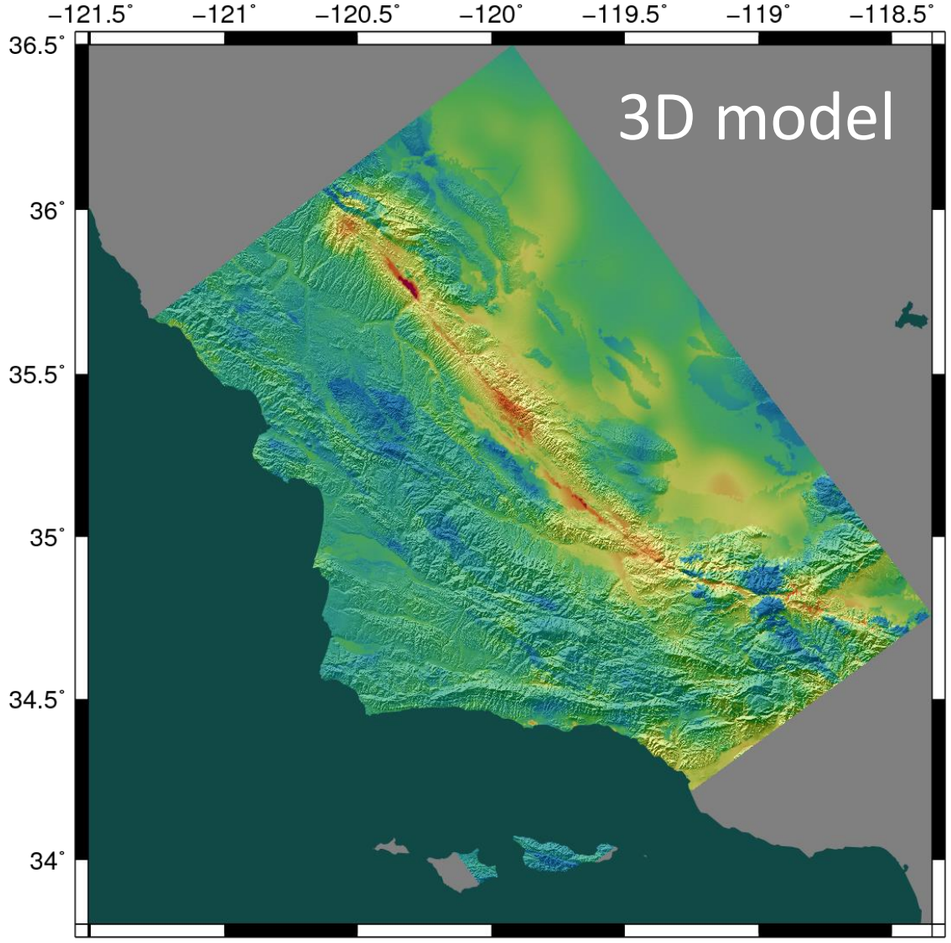
Horizontal plot of Vs from 3D model at depth=1.05 km

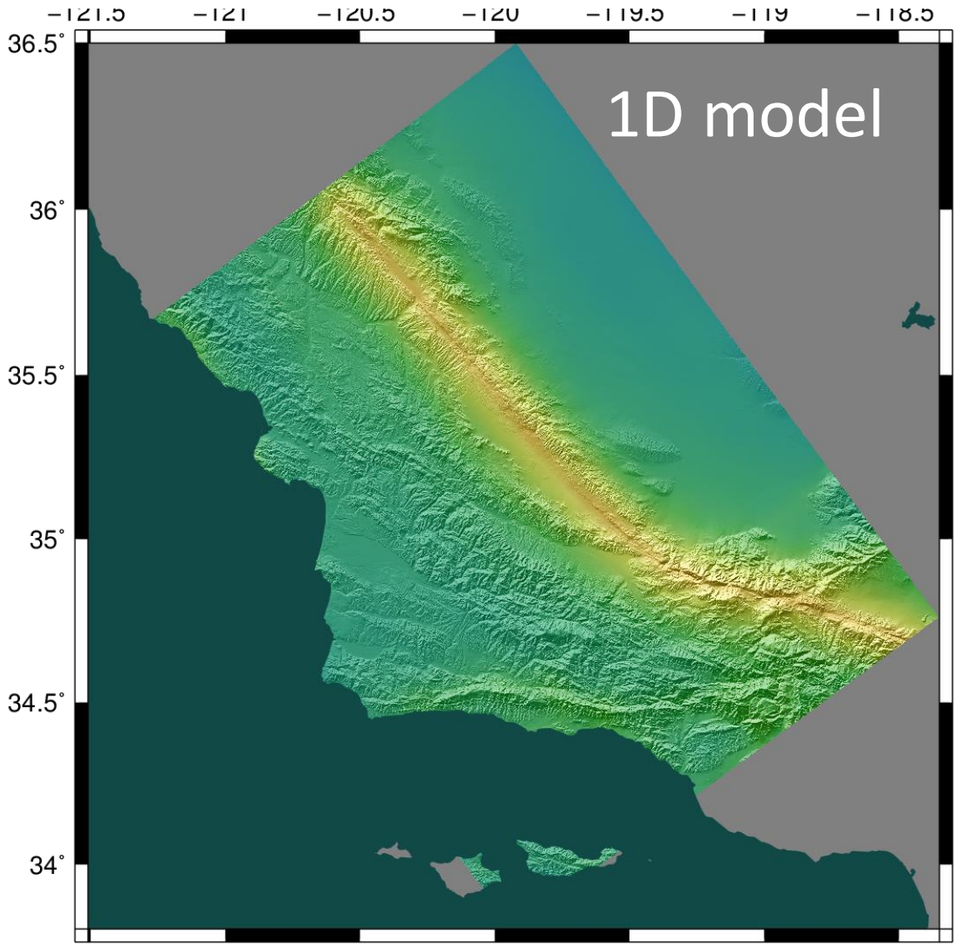
CyberShake Study 17.3

- Calculations for 2 velocity models for each of 438 sites
- Averaged 1295 nodes (CPU + GPU) for 31 days, maximum of 5374
  - 900,000 node-hours consumed (21.6M core-hours)
- Used OLCF Titan and NCSA Blue Waters
  - Workflow tools scheduled 15,581 jobs to both systems
  - Transferred 308 TB of intermediate data between the two systems
- Generated 285 million two-component seismograms
  - 43 billion intensity measures
- Workflow tools managed 777 TB of data
  - 10.7 TB of output data automatically staged back for archival storage

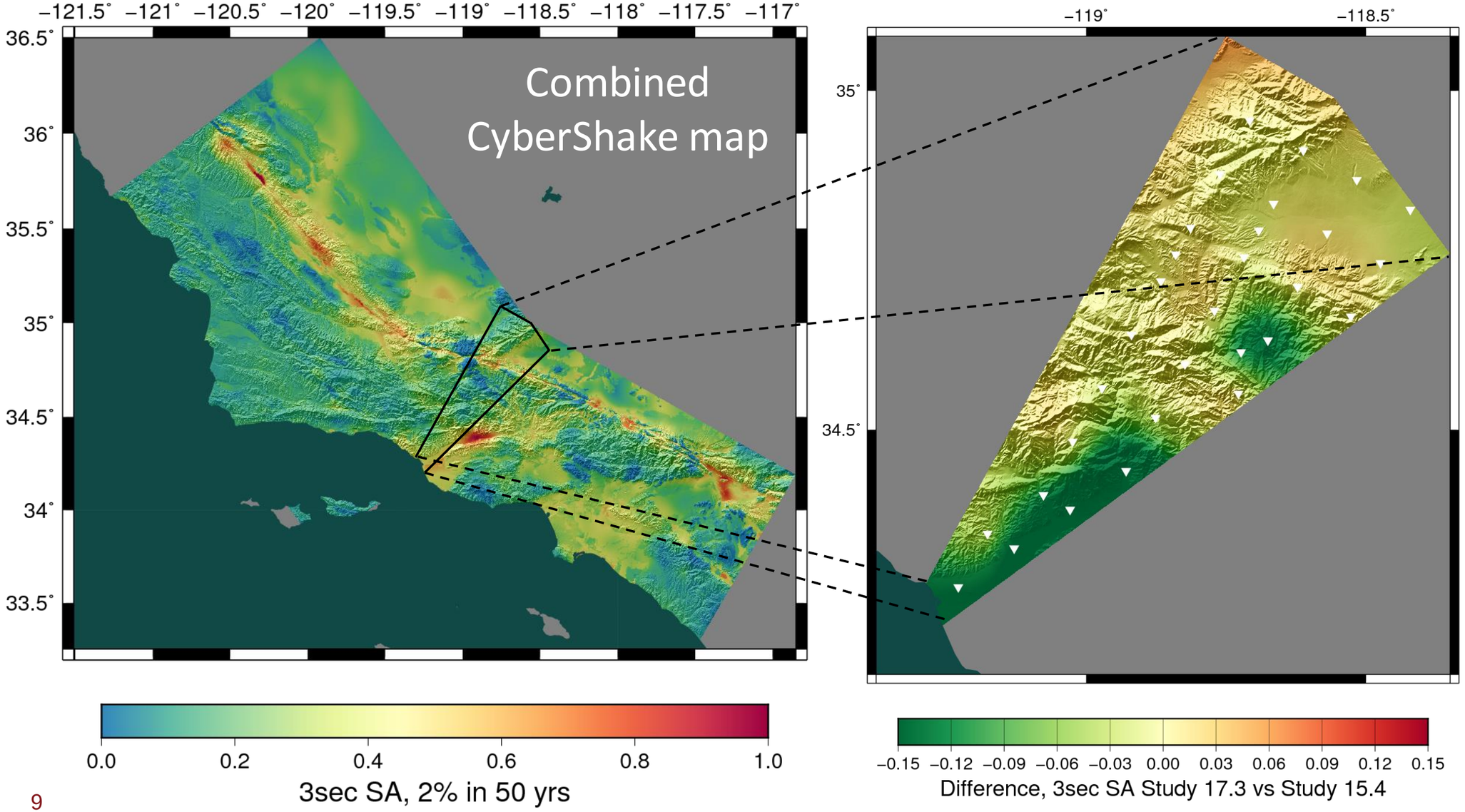


CyberShake Study 17.3 Results: Velocity Model Comparison





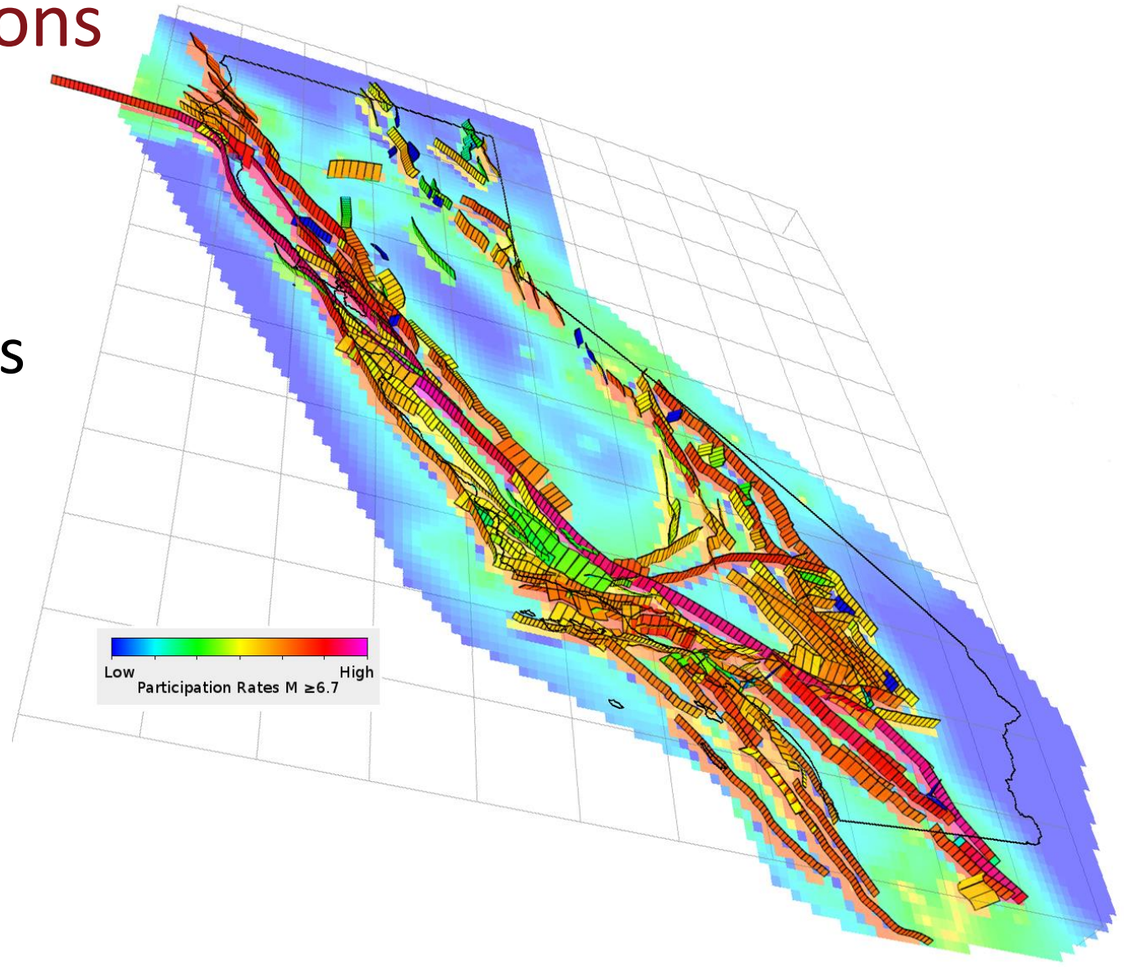
CyberShake Study 17.3 Results: CCA and LA



- Central CA results typically lower than LA results
- Likely due to lack of GTL and higher Vs min (500 m/s for LA, 900 m/s for CCA)

CyberShake Future Directions

- Continue to run CyberShake in new regions
  - Bay Area?
- Integrate UCERF 3 ruptures
  - Must reduce rupture set for 3D simulations
- Increase maximum frequency
  - Must include additional physics
    - Frequency-dependent Q
    - Velocity model heterogeneities
    - Non-linear effects?



Questions?

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ISI
Information Sciences Institute

XSEDE
Extreme Science and Engineering Discovery Environment

USGS
science for a changing world

SDSC
SAN DIEGO SUPERCOMPUTER CENTER

TACC

National Science Foundation

NCSA

OAK RIDGE National Laboratory | OAK RIDGE LEADERSHIP COMPUTING FACILITY

Pegasus

USC GRID