CyberShake: bringing physics-based PSHA to central California

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CyberShake Computational Platform

CyberShake is an integrated collection of scientific software and middleware that performs 3D physics-based probabilistic seismic hazard analysis (PSHA).

The CyberShake platform populates a mesh with velocity information using UCVM, which serves as input to AWP-ODC-SGT, which generates Strain Green Tensors (SGTs). A catalog of earthquakes is produced by extending the UCERF 2 earthquake rupture forecast (ERF) by varying the hypocenter location and slip distribution. Seismic reciprocity is used to calculate synthetic seismograms for approximately 500,000 events per site. From these seismograms intensity measures (IMs), such as peak spectral acceleration and RotD100, are calculated, as well as duration metrics. IMs are combined with probabilities from the ERF into a PSHA curve for the site of interest. Hazard curves from hundreds of sites are combined into a hazard map for a region.

CyberShake produces a rich suite of layered data, from hazard maps all the way down to seismograms, illustrated below.

CyberShake Study 17.3

In 2017, we migrated CyberShake to Central California and performed a new CyberShake Study, 17.3. This study included:

- 408 new sites and 30 previous sites (below)
- 3D and 1D velocity models (at right)
- 1 Hz seismic velocity
- Minimum Vs = 900 m/s

Study 17.3 sites are depicted above, along with the Central California CyberShake region (pink) and the Southern California CyberShake region (black). Sites included:

- 310 sites on a regular 10 km grid (purple)
- 54 CISM stations (orange)
- 30 cities from USGS Gazetteer (pink)
- 4 PG&E pumping stations (cyan)
- 6 historic Spanish missions (blue)
- 4 OBS stations offshore (orange).

After the initial Study, we added 57 sites along the San Andreas (yellow) for better near-fault resolution.

Study 17.3 Performance

- 31 days wallclock time on OLCF Titan and NCSA Blue Waters
- Hazard estimates for 438 sites x 2 velocity models
- 15,581 jobs submitted
- 21.6 million core-hours burned
- Average of 1295 nodes, maximum of 5374.
- 1.1 PB of data generated
- 285 million two-component seismograms
- 42.7 billion intensity measures

Workflows

For Study 17.3, we ran end-to-end workflows on Titan for the first time, using a new Pegasus tool, rvGAHP. This enabled us to run automated workflows using remote job submission, despite Titan’s policies requiring two-factor authentication.