2012 SCEC Project Report

#12155: Continued Development of OpenSHA in Support of Operational Earthquake Forecasting, Hazard Assessment, and Loss Modeling

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Proposal Categories: (A) Data Gathering and Products
(B) Integration and Theory

Science Objectives: 2b, 2e, 2a, 6b, 6e

Special Projects: (A) WGCEP

Abstract

Major achievements were made in loss modeling integration with OpenSHA, including calculating expected annualized losses (EALs) for a proxy to the CEA residential catalog and every branch of the UCERF2 logic tree (Figure 1), showing the influence of each logic tree choice to the overall EAL. Interfaces with HAZUS were also improved allowing users to analyze OpenSHA generated hazard and scenario shakemaps with HAZUS. Visualization capabilities were also improved, including a new SCEC-VDO plugin framework and Earthquake Simulator result visualization tools. On the technical side, the UCERF3 inversion framework was finalized and optimized (1000x speedup over original algorithm), and interfaces with high performance computing resources were streamlined. The 2008 NSHMP results were also replicated in OpenSHA as a cross-validation exercise.

Technical Report

Scientific and implementation advances:

- Calculated expected annualized losses (EALs) for a proxy to the CEA residential catalog for each branch of the UCERF2 logic tree and each NGA relationship. Keith Porter used these results to create tornado diagrams for the purpose of trimming the UCERF2 logic tree (Poter 2012, SRL, in press). See Figure 1 below.

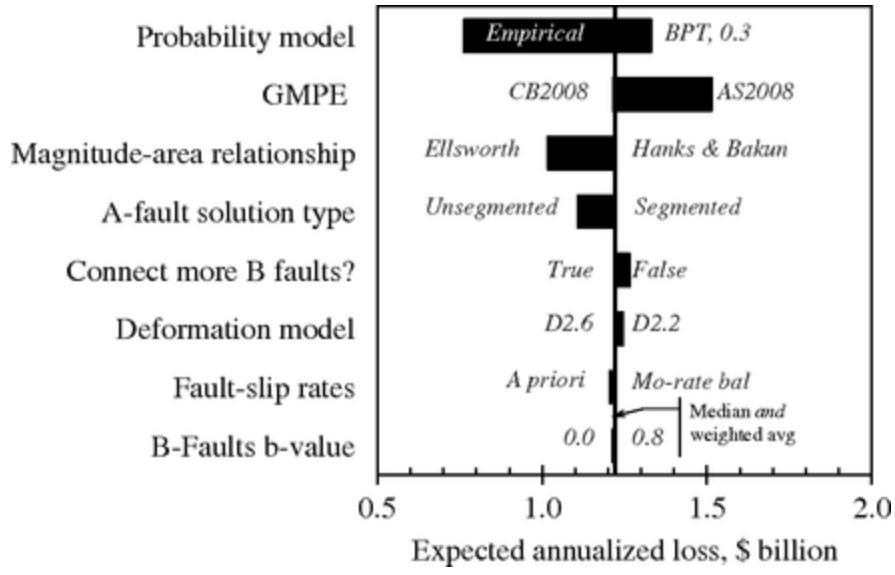

Figure 1
Tornado diagram from Porter et al 2012, Figure 7, showing effect of each UCERF2 logic tree br on expected annualized loss (EAL) for a proxy to the CEA residential catalog.

- Continued access to CyberShake's 3D-waveform-based hazard data set. This included the ability to plot CyberShake 1.x results such as hazard curves, maps, and disaggregation (collaborators: Phil Maechling, Rob Graves, and Thomas Jordan).
- Improved PSHA loss interface with HAZUS including development of a parallel version which uses high performance computing to quickly calculate large datasets (collaborator: Hope Seligson).
- Created comprehensive suite of visualization tools for exploring UCERF3 results, both within OpenSHA and SCEC-VDO.
- Created analysis and visualization capabilities for results coming out of the SCEC Physics-Based Simulator Working Group, specifically looking at medium term time dependence in Southern California.
- Replicated the 2008 NSHMP for peak ground Acceleration (PGA) and 5Hz and 1Hz spectral accelerations (SA) at 2% in 50 year and 10% in 50 year return periods.
- Implemented a risk targeted ground motion (RTGM) calculator to provide ground motion values recommended by the current Building Seismic Safety Commission (BSSC)

Technical advances:

- Continued improvement of the SCEC-VDO platform, including plugins for visualising UCERF3 components.
- Dramatically improved efficiency of UCERF3 inversion, up to 1000x using efficient sparse matrix calculations and memory management (reducing array copy operations).
- Developed framework for representing logic trees, calculating weights, and looping of suites of UCERF3 inversions.
- Improved high performance computing capabilities, allowing for easy parallelization within OpenSHA by implementing a few abstract methods. This has been used to parallelize UCERF3 plot generation/analysis as well as hazard and loss calculations.
- Improved code quality and usability, especially with respect to Earthquake Rupture Forecast objects & Parameter framework
- Improved thread safety and efficiency of distance calculations, dramatically reducing hazard computation time with UCERF3.

Intellectual Merit

UCERF3 and other models implemented in OpenSHA have ended up posing some of our most profound and practically important scientific questions. For example, it has been shown that the elastic-rebound methodology used by WGCEP 2003 and 2007 is not self consistent, forcing us to consider the process more deeply. Another example is the implementation of spatiotemporal clustering, which seems to require elastic rebound to work properly (something that was not previously

appreciated), and that sub-regions of the state need to more closely adhere to a Gutenberg-Richter distribution (otherwise one gets never-ending aftershock sequences). A final example is the difference between a multi-fault ruptures and a neighboring fault being quickly triggered as a separate event; we don't presently know the answer.

Broader Impacts

The UCERF2 loss calculations and tree trimming exercise is applicable to anyone wanting to use UCERF2, especially loss modeling organizations. OpenSHA is a tool used by the community, and various improvements and bugfixes were in direct response to user reported issues/suggestions. The UCERF3 inversion framework developed will serve as the basis for the UCERF3 hazard model which, upon release, will be high impact and used for 2014 National Seismic Hazard Maps and future building codes.