Physics-Based PSHA:

RSQSim & CyberShake

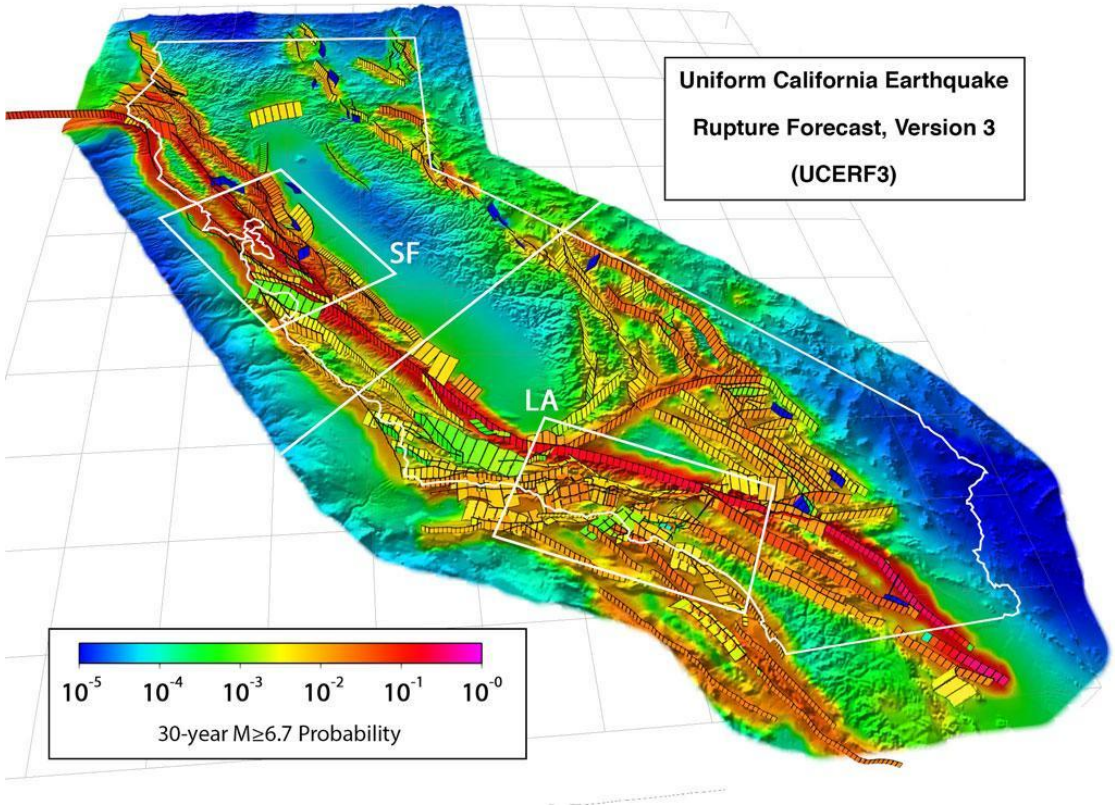
Kevin Milner

The Future of SCEC Computing

July 29, 2019

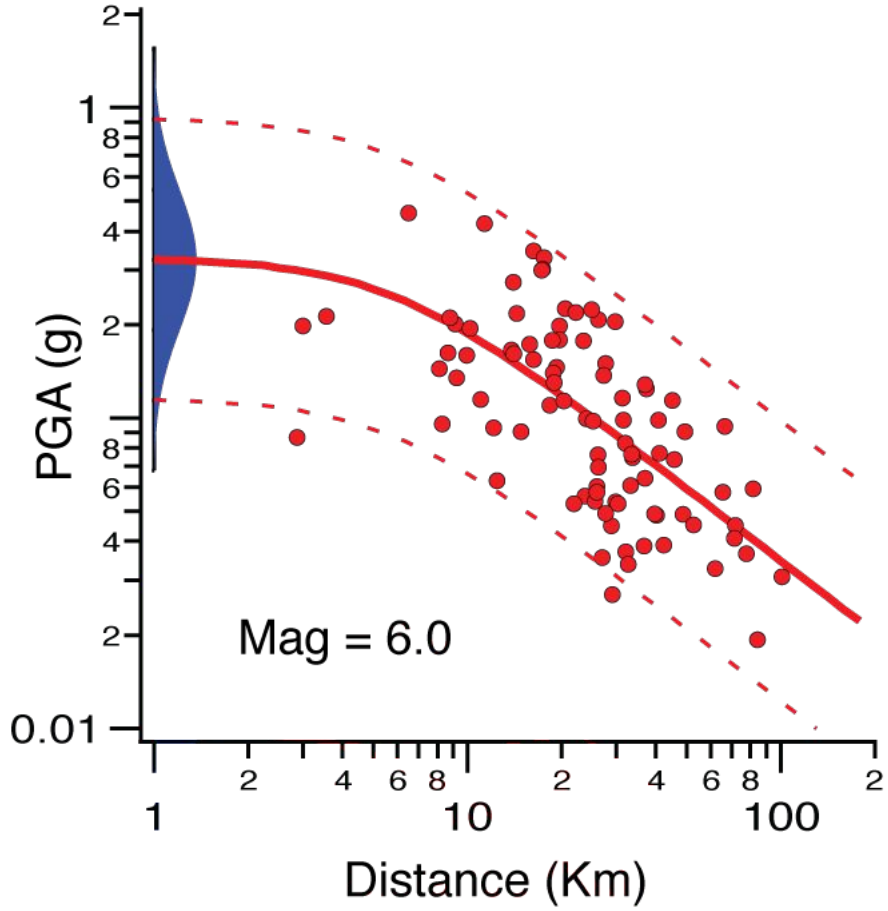
Traditional PSHA

Empirical Earthquake Rupture Forecast (ERF)



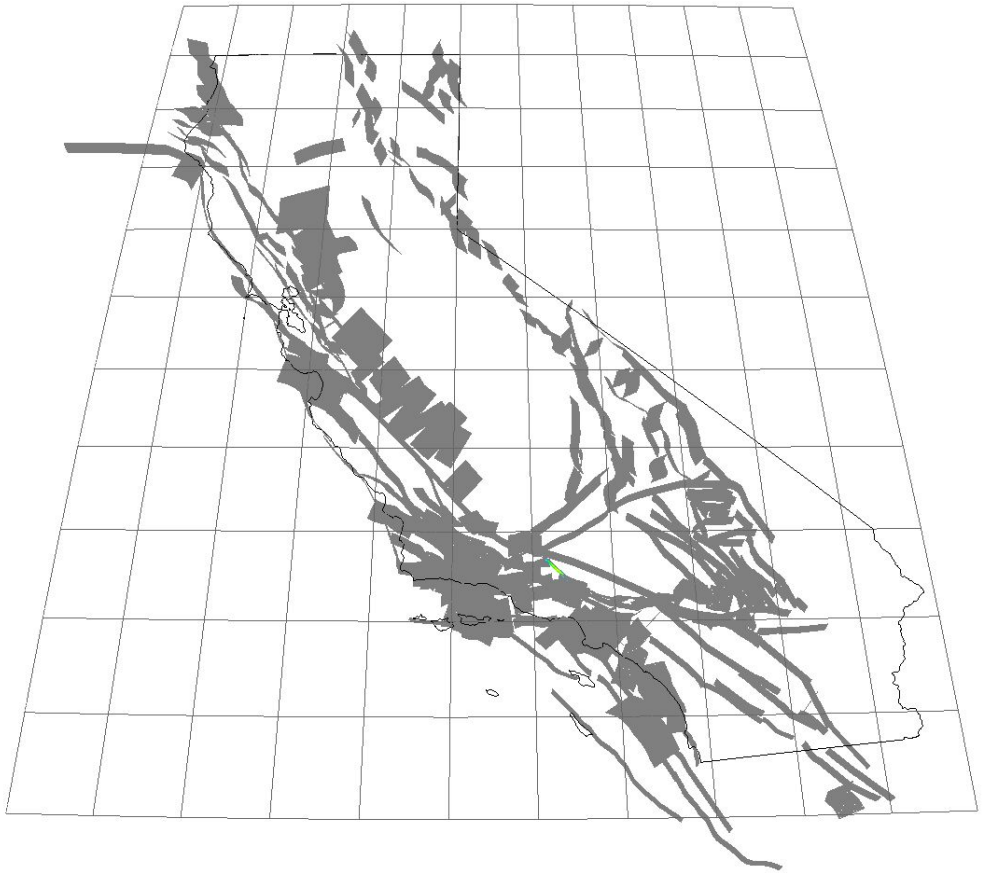
+

Empirical Ground Motion Models (GMMs)



A Different Approach: RSQSim

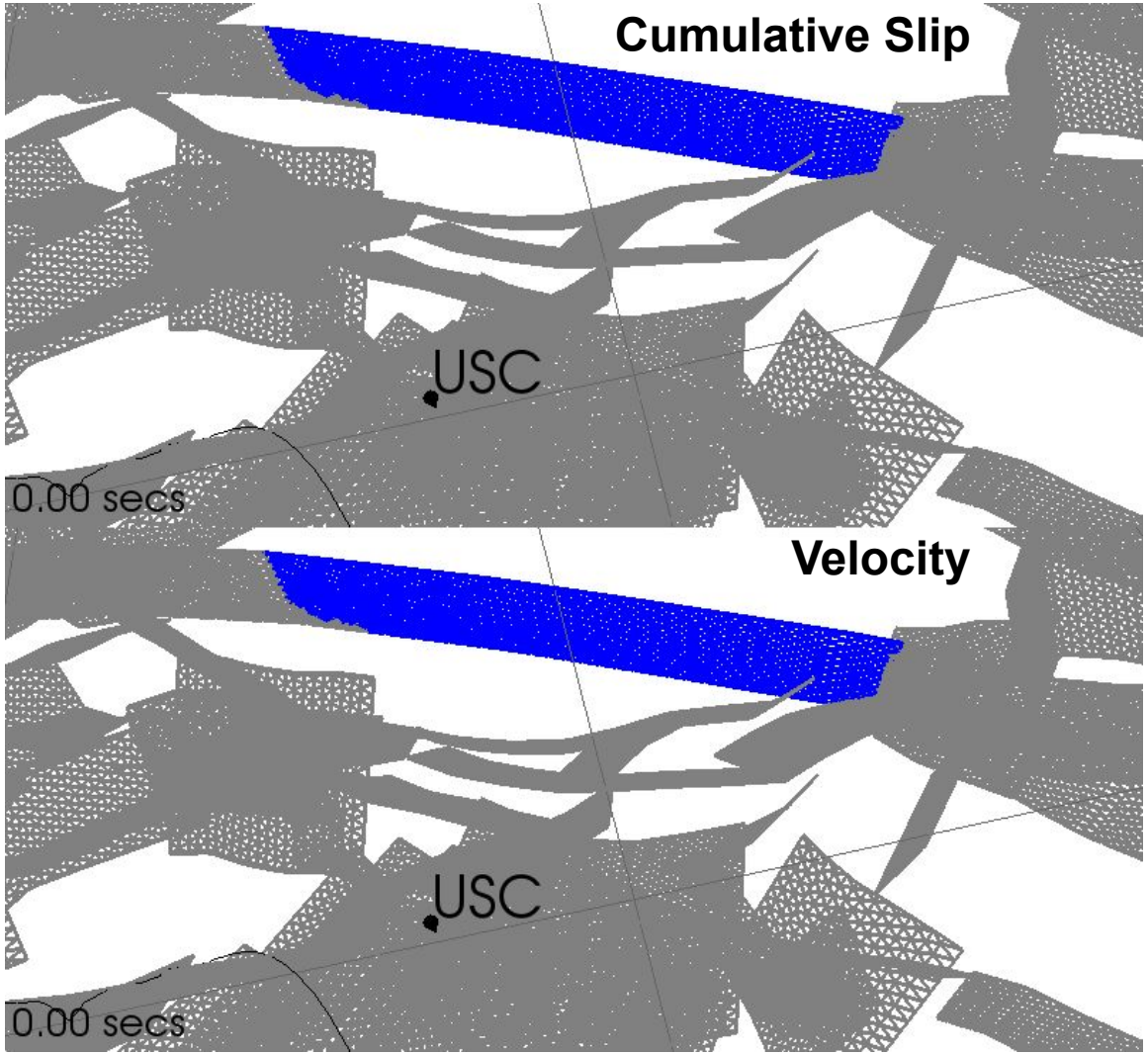
- **R**ate **S**tate earth**Q**uake **Sim**ulator
  - Richards-Dinger & Dieterich, 2012
- Physics-based multi-cycle simulator
  - Tectonic loading of faults by backslip approximation
  - Rupture nucleation by rate- and state-dependent friction
  - Dynamic overshoot
  - Stress transfer in homogeneous elastic halfspace
- No prescribed ruptures
- Synthetic catalogs of thousands to millions of years of earthquake sequences



Animation of 3,000 years of RSQSim ruptures in CA
(100 years per second)

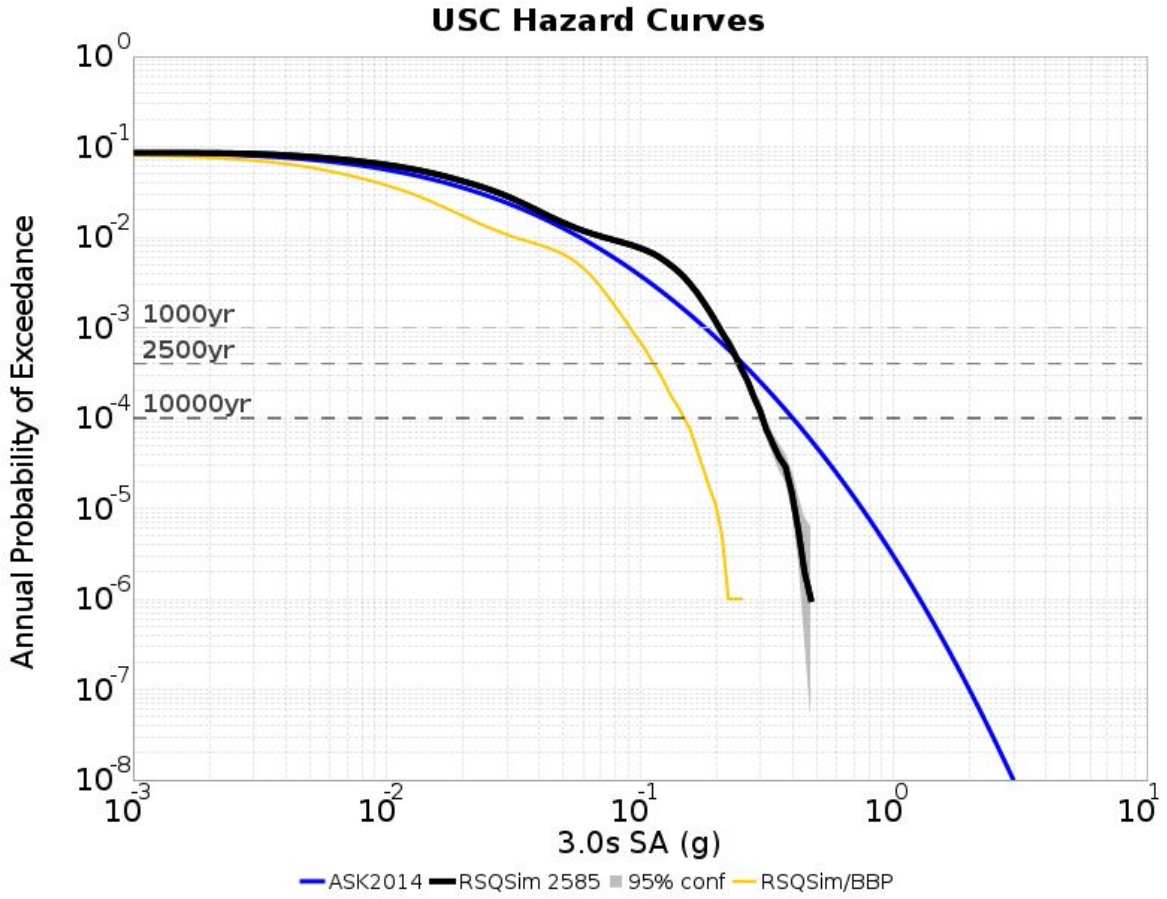
RSQSim Rupture Slip-Time Histories

- RSQSim provides full slip-time functions for all ruptures
  - Example (right): M7.5 on SAF Mojave
- Can be used directly as input to deterministic ground motion simulations
- Unlike kinematic rupture generators, no prescribed rupture properties
  - Stress drop, hypocenter, roughness, etc, dependent on global frictional parameters and state of stress at nucleation

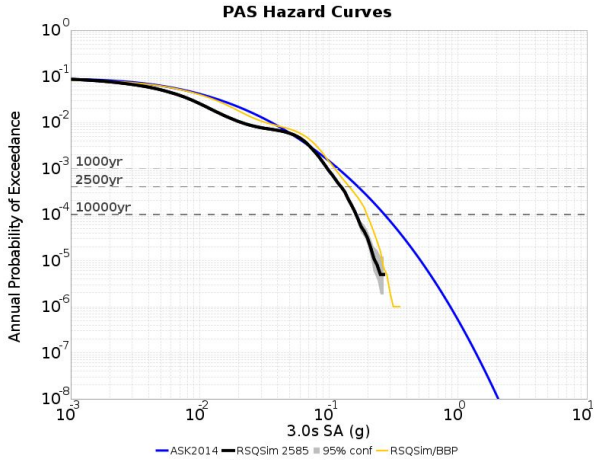


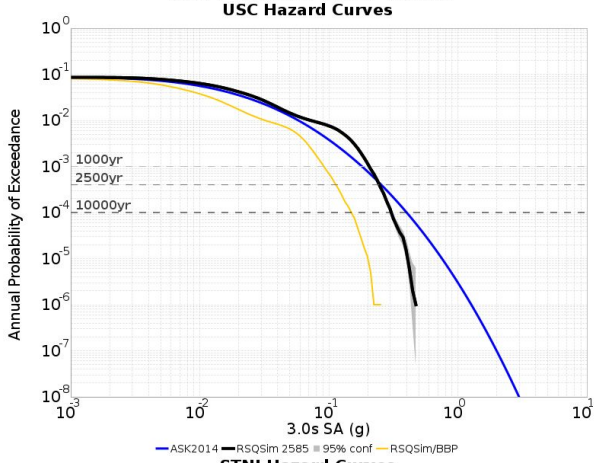
RSQSim/CyberShake Hazard Curves

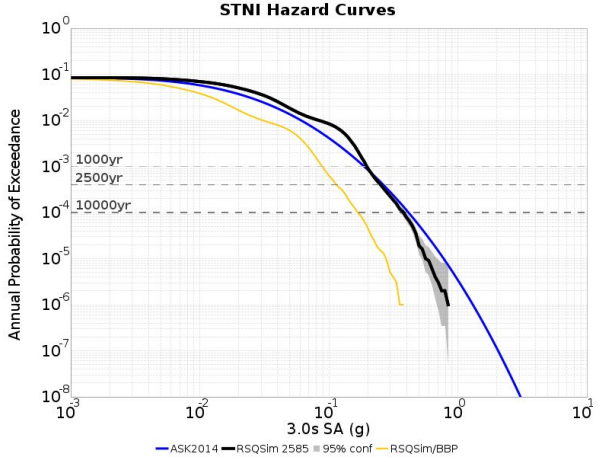
- Full hazard curves
  - **Black: RSQSim/CyberShake (3-D)**
  - **Blue: RSQSim/GMM (ASK 2014)**
  - **Orange: RSQSim/BBP (1-D)**
- Simulation curves are less smooth than empirical GMMs
  - Due to less variability for individual sources

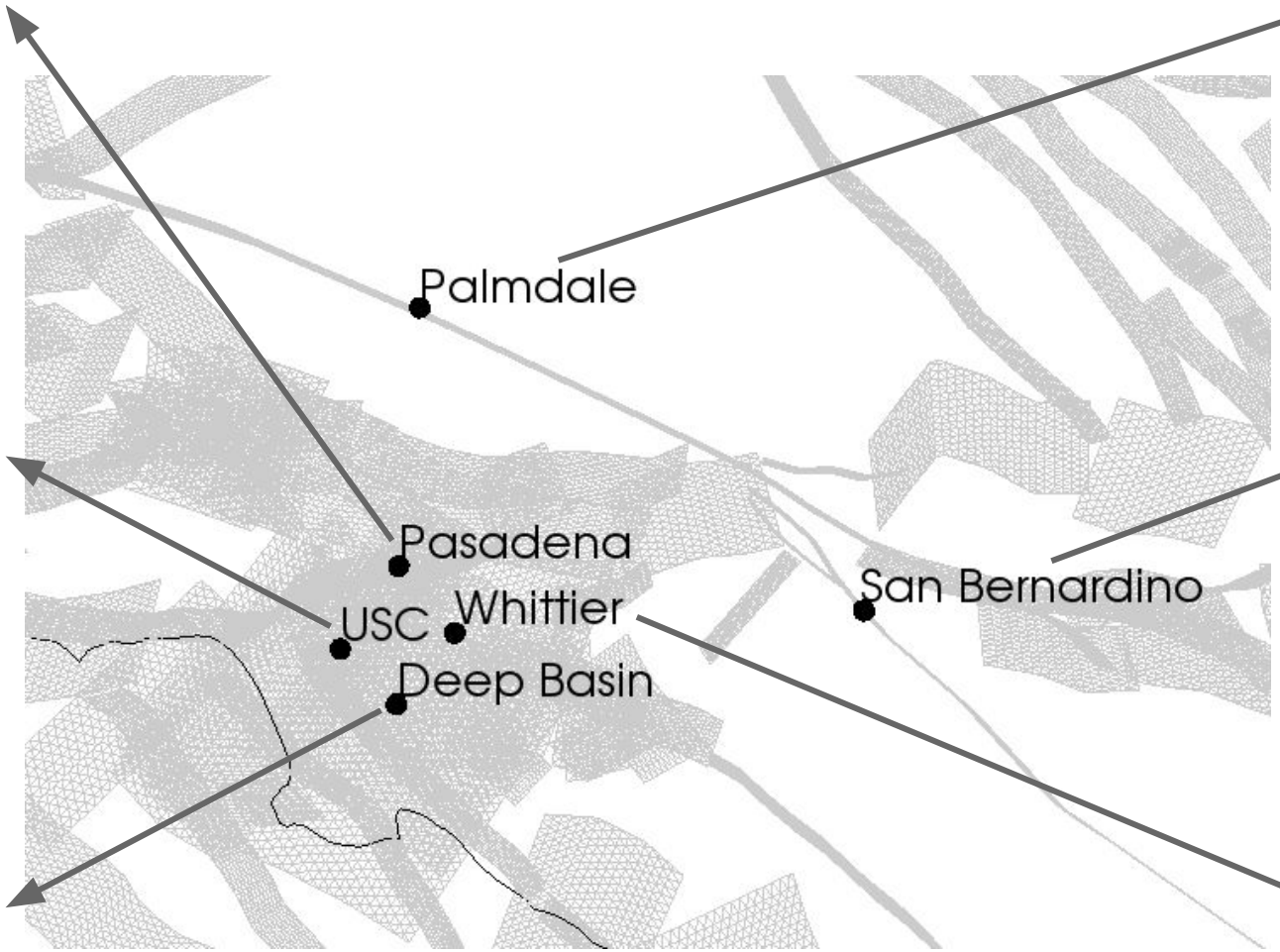


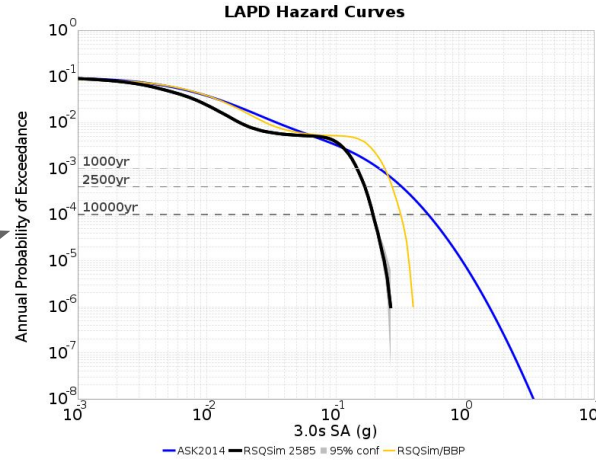
More Hazard Curves

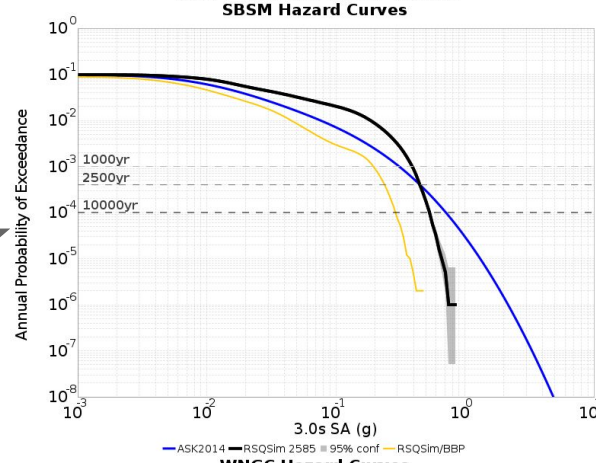


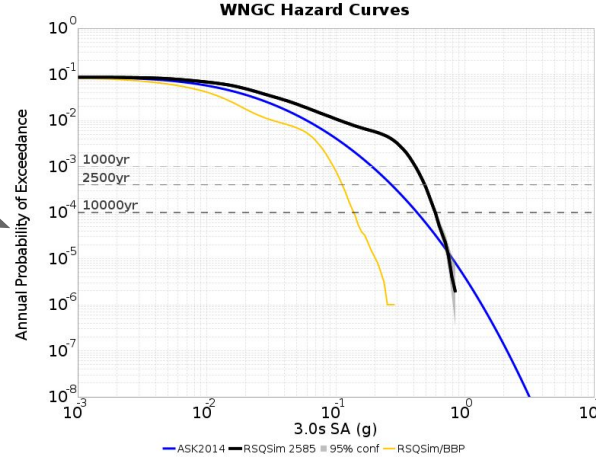












Computational Requirements and Next Steps

- Significant computing resources needed for both RSQSim catalog simulation and CyberShake ground motion calculation
  - RSQSim requirements depend on element size, catalog length, and parameterization
- Initial 1hz Los Angeles CyberShake-RSQSim hazard map planned for 2020
- If RSQSim becomes a branch on the UCERF4 logic tree, will need to generate production suite of long catalogs for different fault and deformation models, RSQSim parameterizations
  - Statewide CyberShake-UCERF4-RSQSim hazard map?

SCEC

AN NSF+USGS CENTER

Southern California Earthquake Center