


CyberShake Study 21.12: Say, what is that, anyway?

Scott Callaghan

From January 2022 staff slides...

SC/EC Christine Goulet

Work: Quite the start of the year!

- NSF Center proposal tasks in collaboration with several groups and people
- Submitted DOE allocation pre-proposal: accepted and full due on Feb. 22
- Submitted and obtained Director's allocation on Summit
- Working on Director's allocation on Theta
- Very productive workshop on post-EQ response
- Proposal reviews done
- Scott and Kevin completed CyberShake study  :)

Scott Callaghan

Work Highlights

- AGU (feels like so long ago)
- Finally migrated CyberShake to Github
- Completed CyberShake Study 21.12
 - Used 46% of world's #2 supercomputer

Kevin Milner

- Jordan go into grad school! ...at USC! ...in our department! ...and already started 3 weeks ago! Paleoclimate with Julien Emile-Geay
- Got up super early on Christmas morning and surprised my family!
- Threw an outdoor Christmas party before Omicron got out of hand
- Did a deep dive into the simulated annealing implementation and sped it up 6-40x (depending on problem size)
 - Can now reproduce UCERF3 inversions in minutes and handle much larger problems
- Collaborated with Scott to calculate an RSQSim-CyberShake hazard map for greater LA

CyberShake Study 21.12

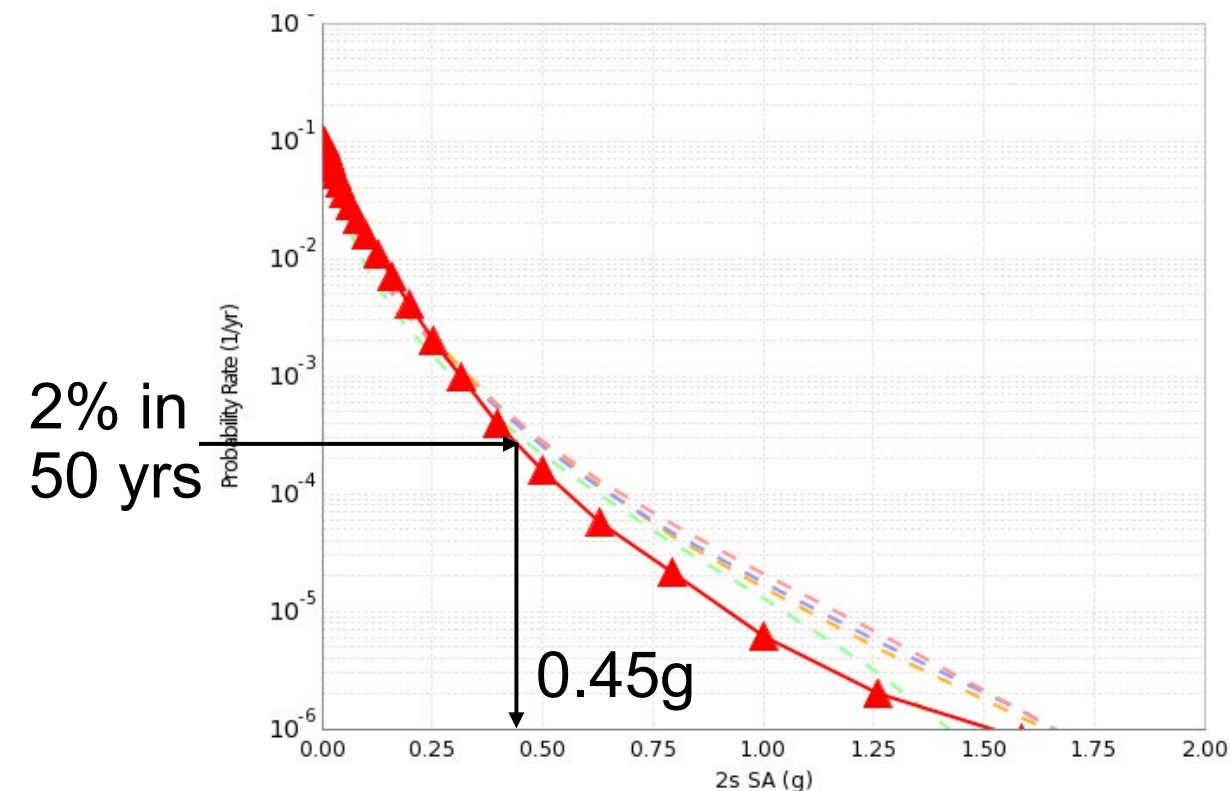
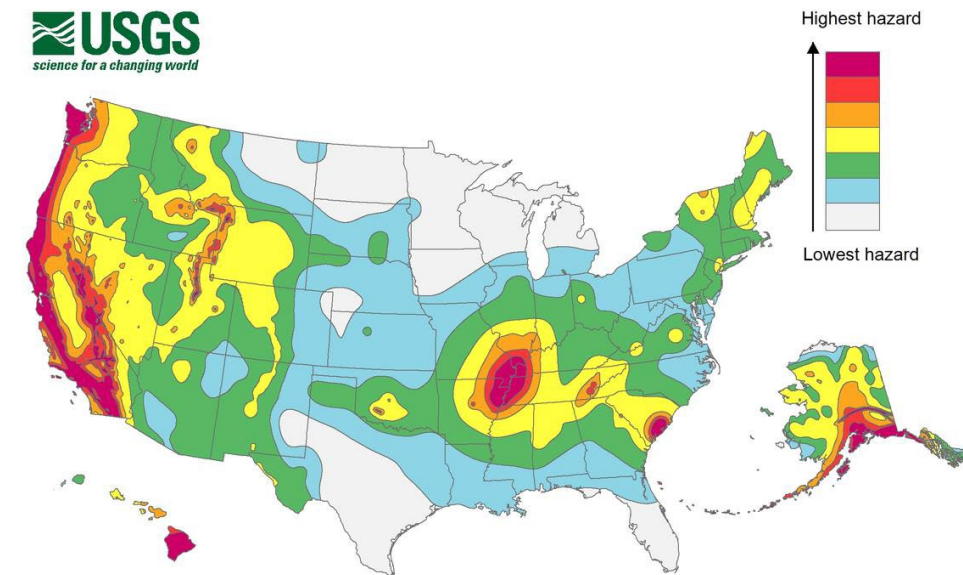
What is CyberShake?

**What's unique about
Study 21.12?**

Probabilistic Seismic Hazard Analysis (PSHA)

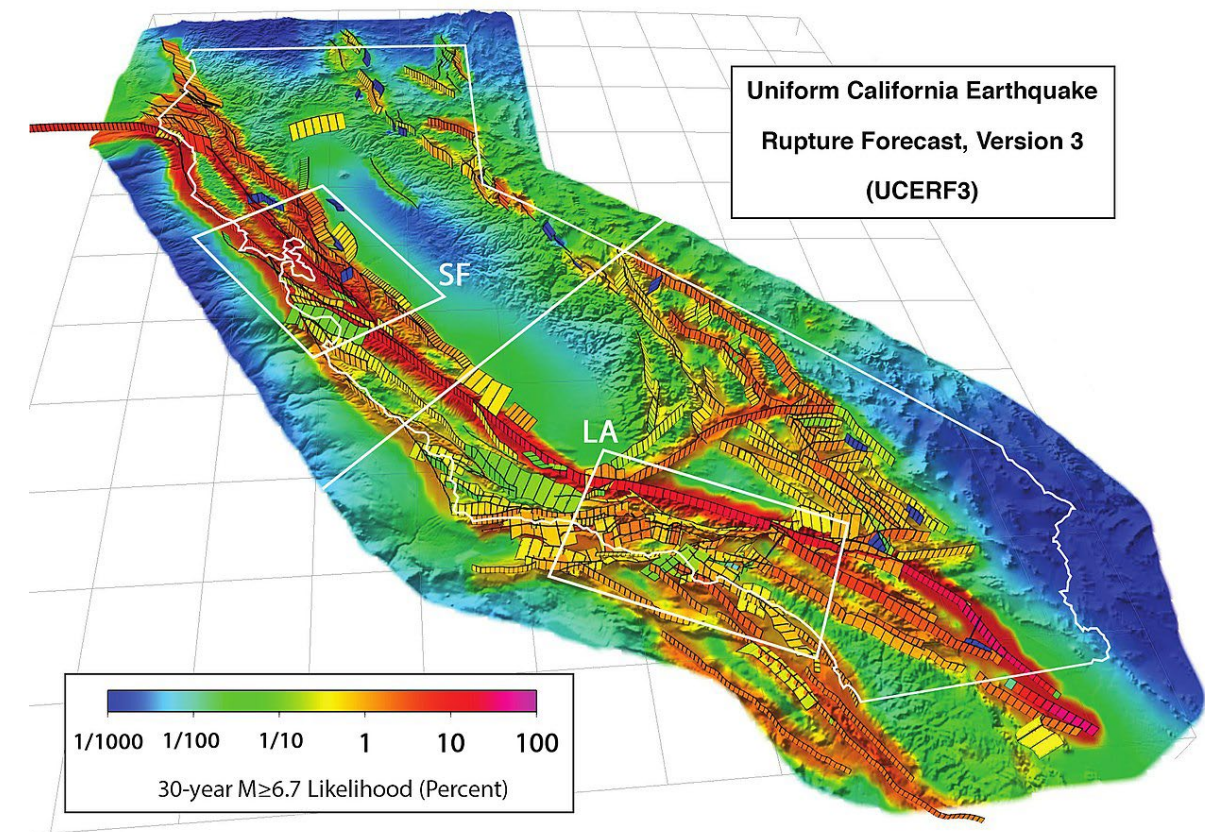
Quantifying hazard based on probabilities.

1. Pick a location.
2. Get a list of all possible earthquakes that might affect the site, along with their probabilities.
3. Calculate the amount of shaking each earthquake would cause at the site.
4. Combine the shaking values with the probabilities to produce a hazard curve.



Where do we get this list?

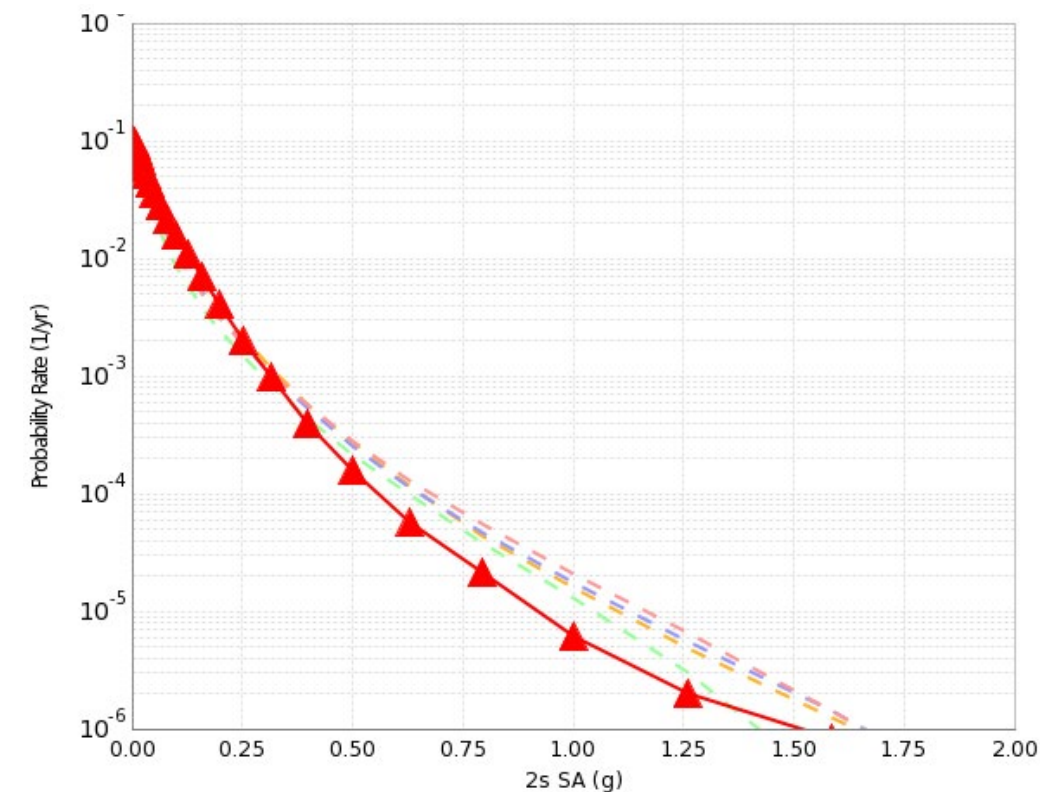
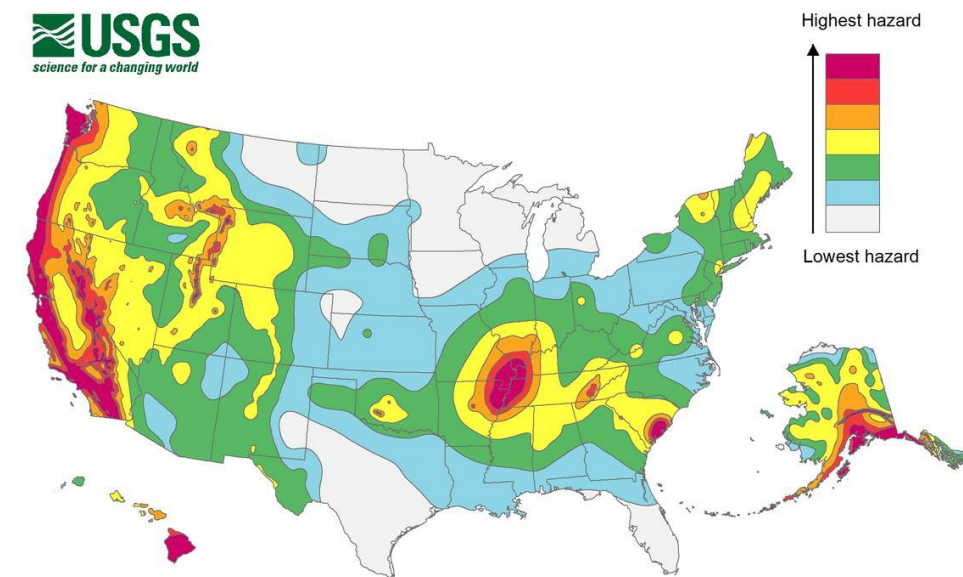
- Called an ‘earthquake rupture forecast’, or ERF
- Working Group on California Earthquake Probabilities produces ERFs
 - UCERF2 (2008), UCERF3 (2015), ask Kevin about UCERF4 😊
 - Derived from slip rates, event rates, deformation, other observables
- Alternatively, can run a physics-based earthquake simulator, like RSQSim
 - Simulates hundreds of thousands of years of California fault system
 - Use the generated earthquakes as an ERF
- Usually 50-600k earthquakes per site



Probabilistic Seismic Hazard Analysis (PSHA)

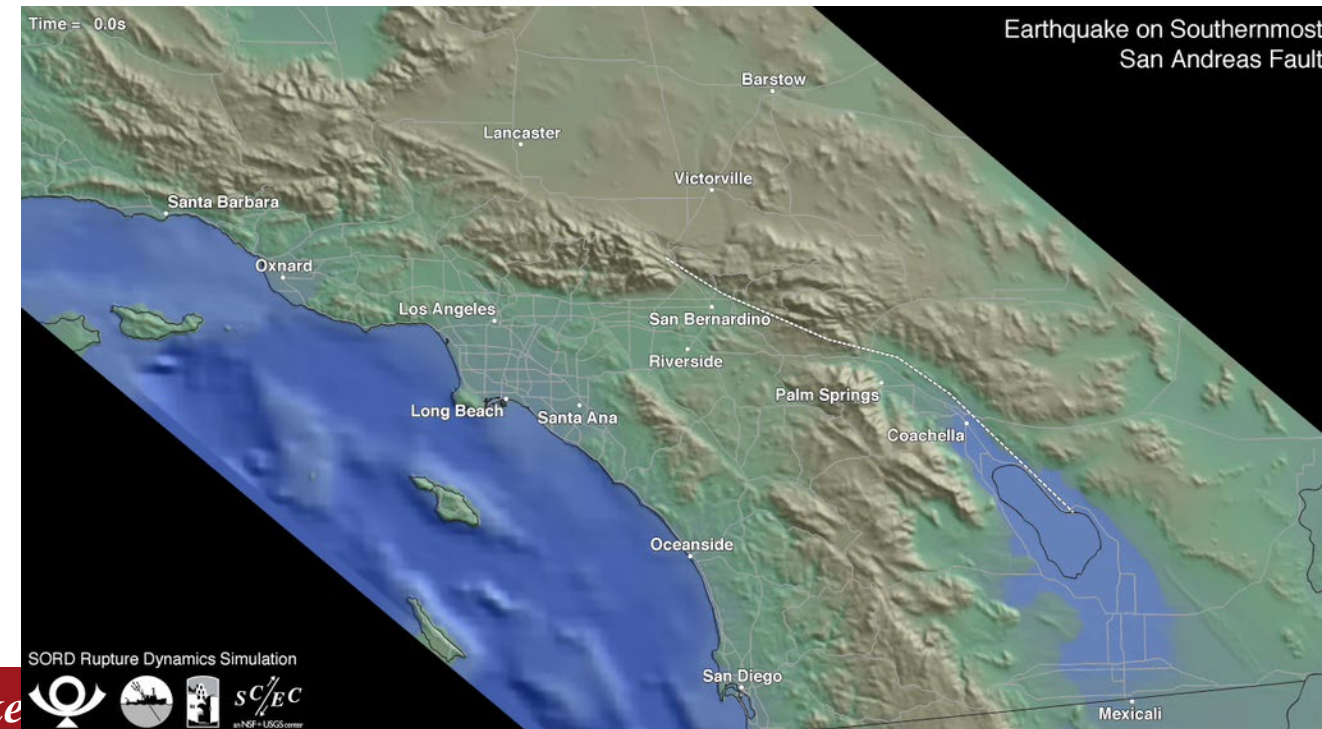
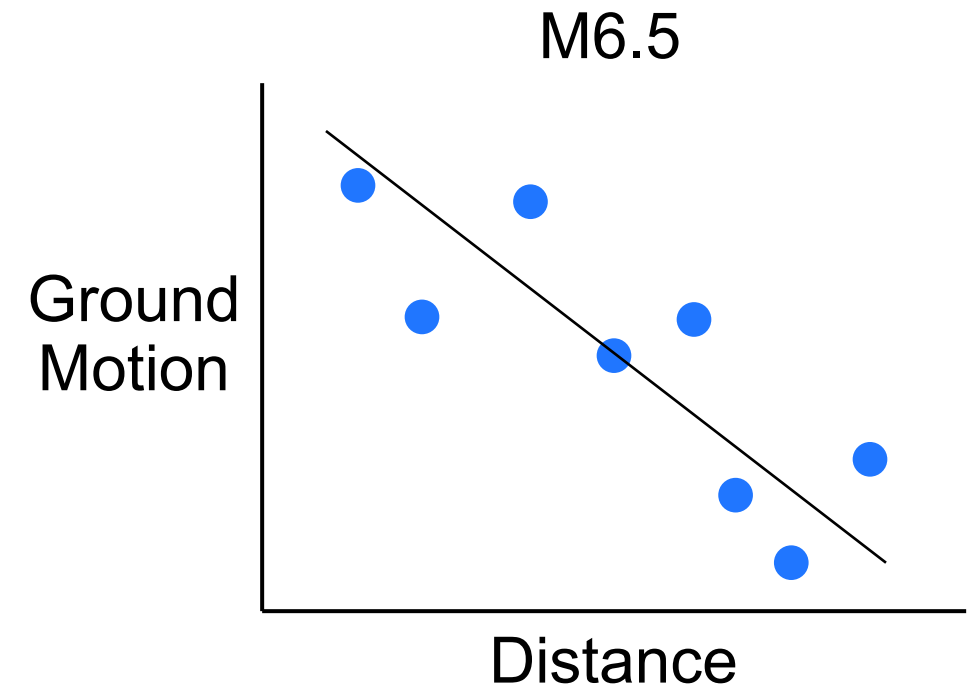
Quantifying hazard based on probabilities.

1. Pick a location.
2. Get a list of all possible earthquakes that might affect this location, along with their probabilities.
3. Calculate the amount of shaking each earthquake would cause at your site.
4. Combine the shaking values with the probabilities to produce a hazard curve.



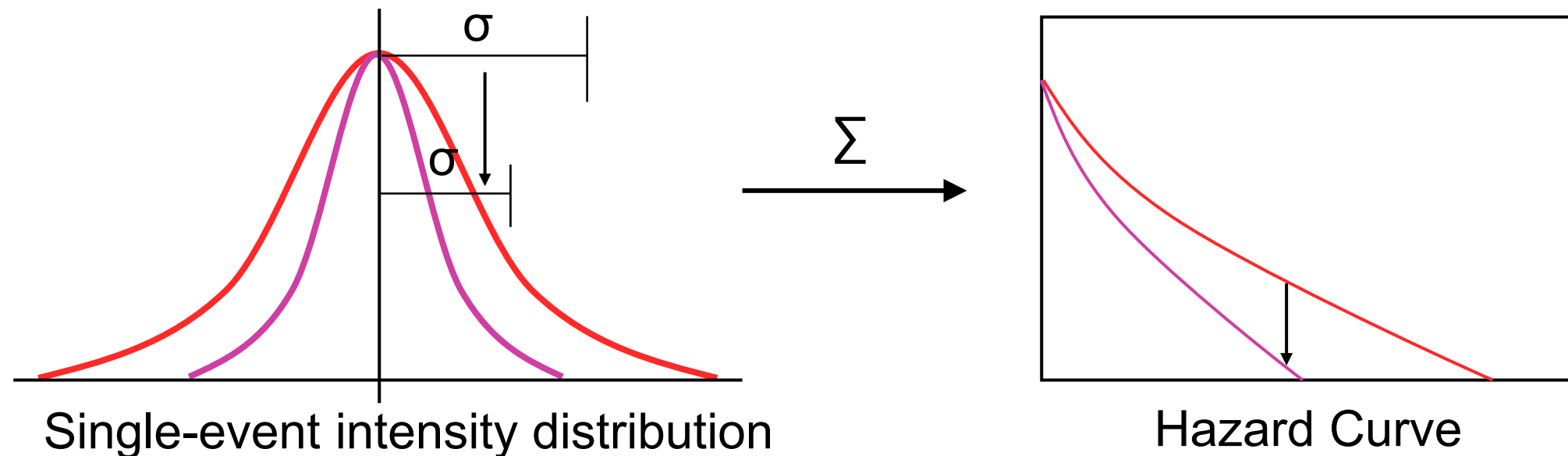
Calculating Intensities

- One way is to use ground motion prediction equations (GMPEs).
 - Regressions on historic earthquake data
 - Very quick to calculate
 - Only able to capture simpler effects
- CyberShake uses a “physics-based” approach
 - Performs wave propagation simulations
 - Captures complex physics
 - Requires supercomputers



Is CyberShake worth it?

- Overall goal is to reduce hazard uncertainty
- GMPEs deliver a mean + standard deviation. Larger deviations translate into higher hazard curves, requiring stronger buildings.



- With CyberShake, we hope to be able to model additional physics to reduce uncertainty.
 - For example, perhaps differences in ground structure which are rolled into ‘uncertainty’ in GMPEs can be modeled in CyberShake.

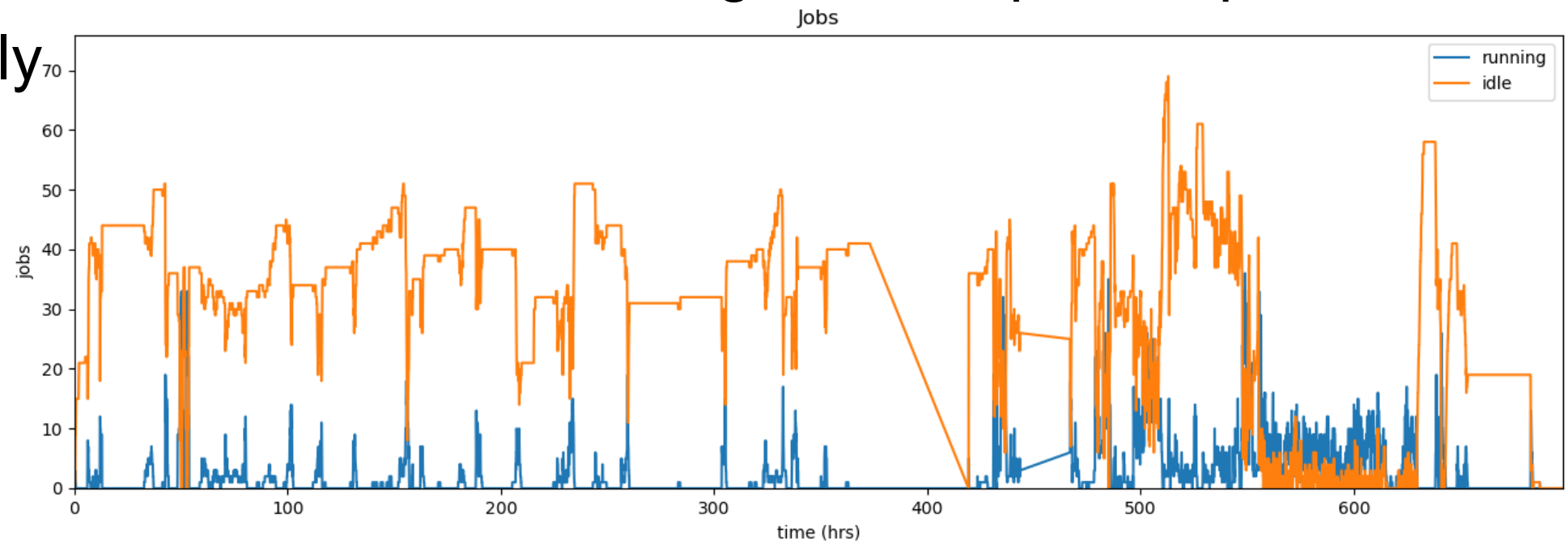
Workflow Tools

- CyberShake manages many jobs and files

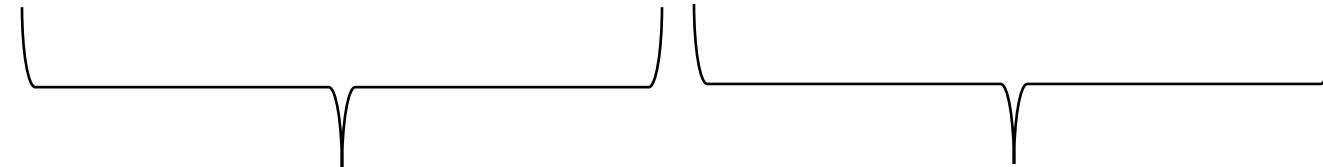
- 16,000 software executions
- 103 million files



- We use workflow tools (Pegasus, HTCondor) to help with all this
 - Describes the software steps, their inputs, and their outputs
 - Transfers files between workflow server, USC storage, and supercomputer
 - Execute jobs automatically
 - Restarts jobs if they fail
- One workflow per site



CyberShake Study 21.12

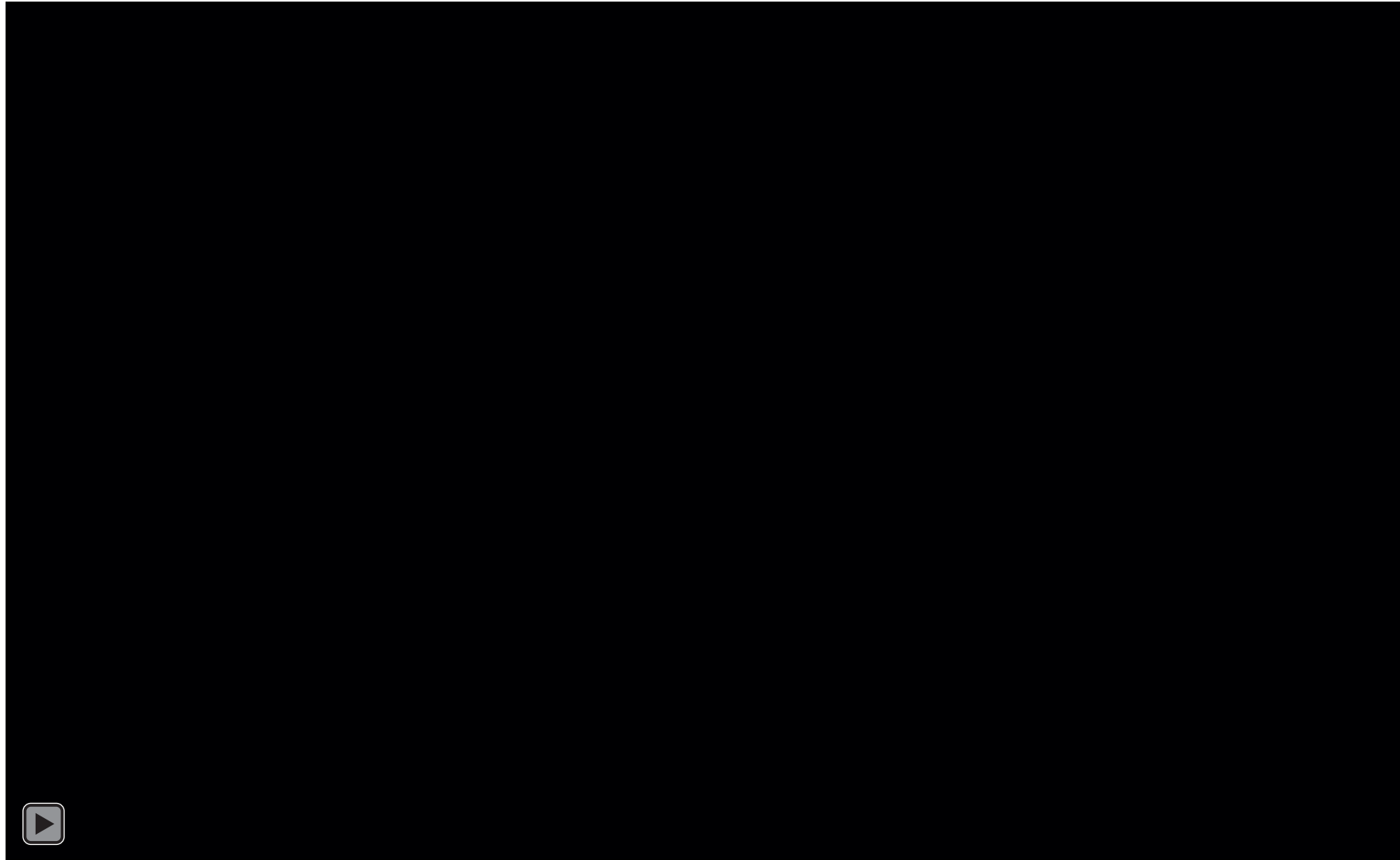


What is CyberShake?

What's unique about
Study 21.12?

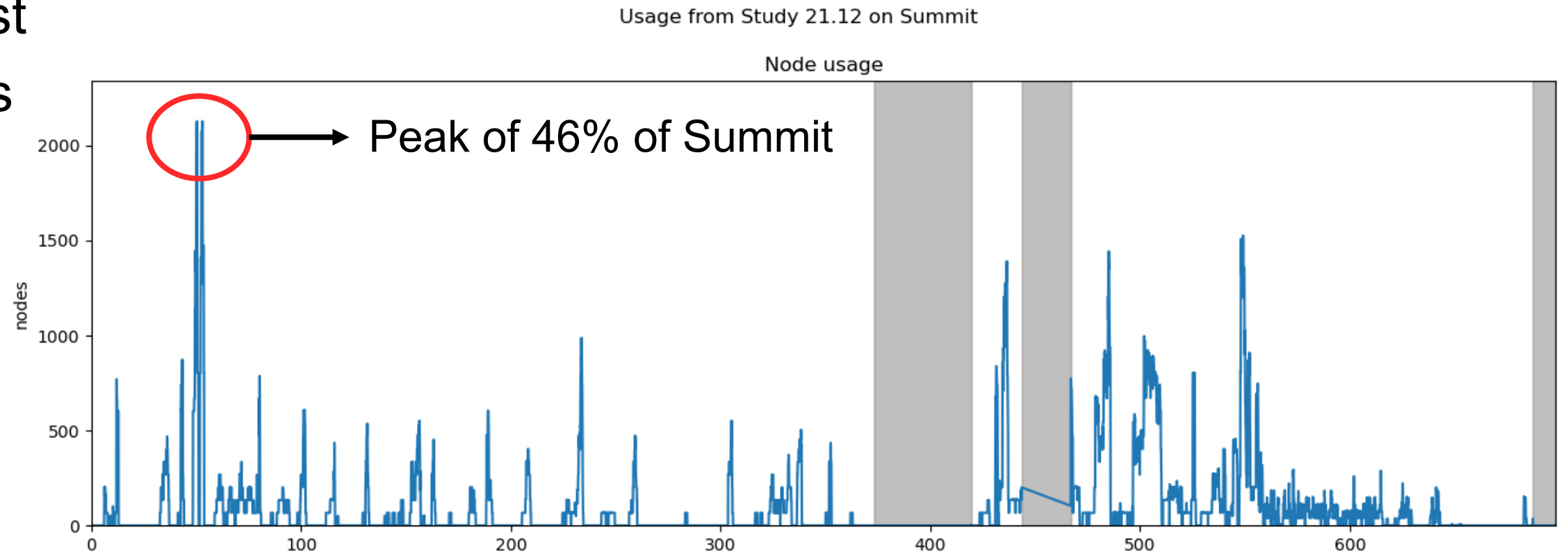
What's special about this study, scientifically?

- RSQSim earthquake simulator as source of ERF
- Kevin and Bruce Shaw generated 715,000 years of California earthquakes
- Builds on Kevin's paper (presented at 10/20 staff meeting)
- Entire Southern California hazard map (335 sites)
- First fully physics-based PSHA model



What's special about this study, technically?

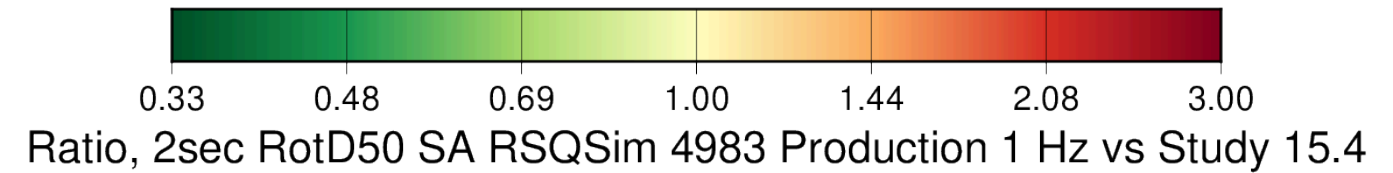
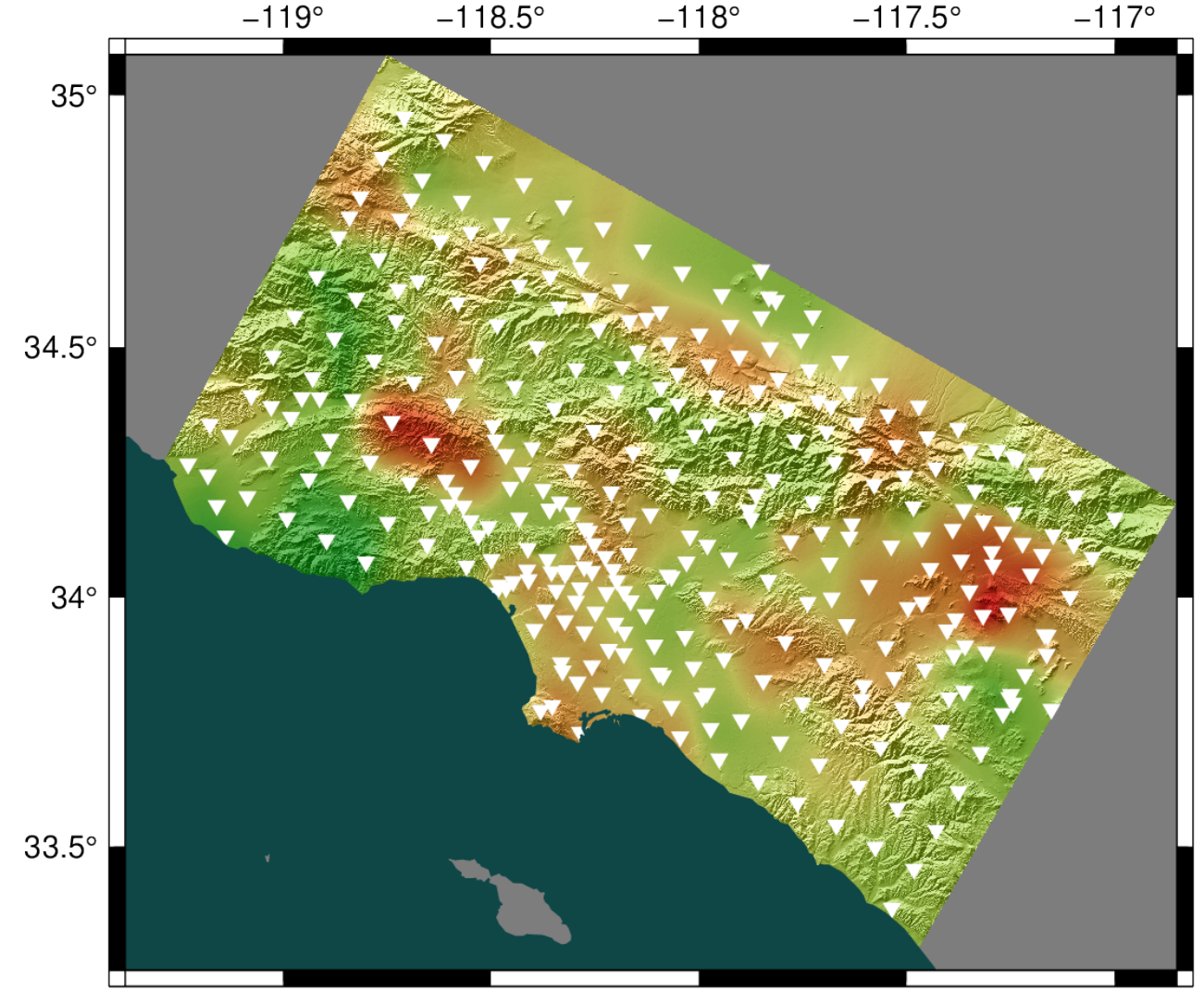
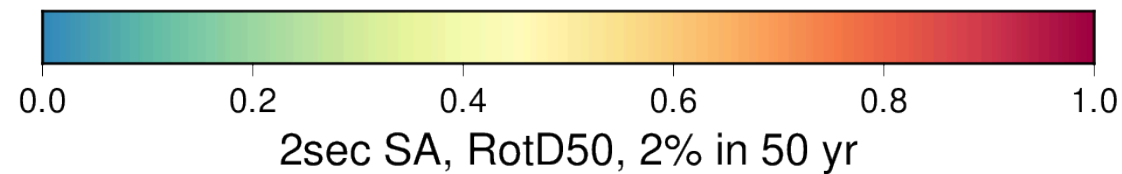
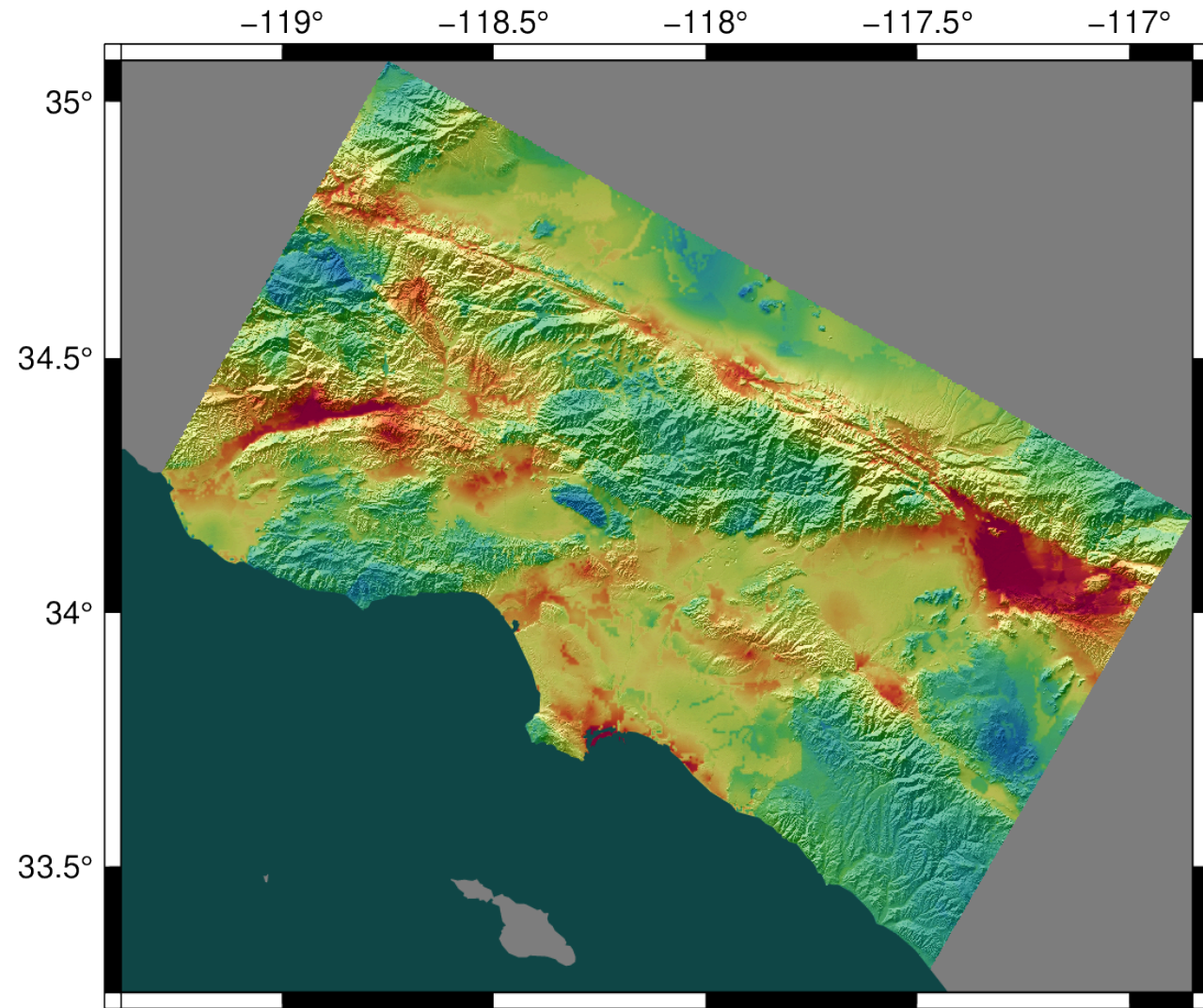
- In summer 2021, moved our workflow server to USC CARC
 - Many issues to resolve (storage, firewall, permissions, etc.)
 - First CyberShake study with new server
- First study to use the Summit supercomputer at Oak Ridge
 - #2 on Top500 list
 - 70,000 node-hrs



Results, 2 sec

Study 21.12

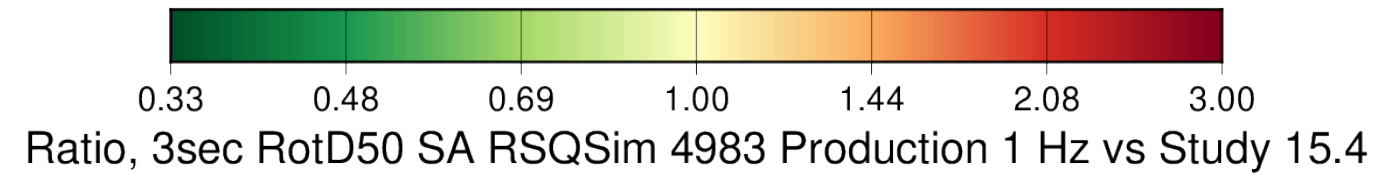
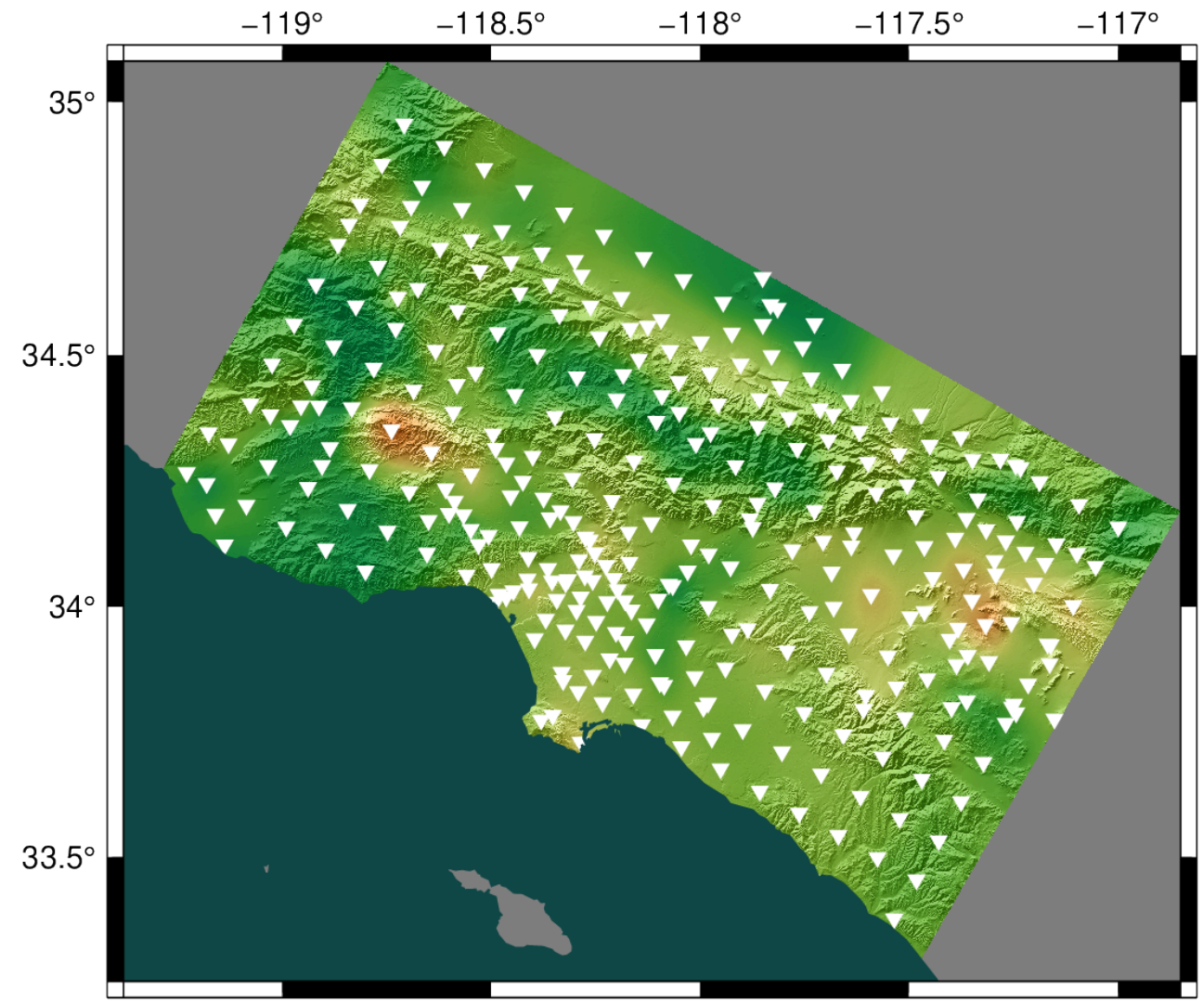
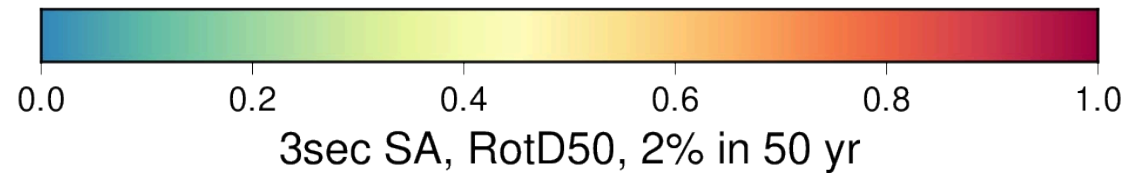
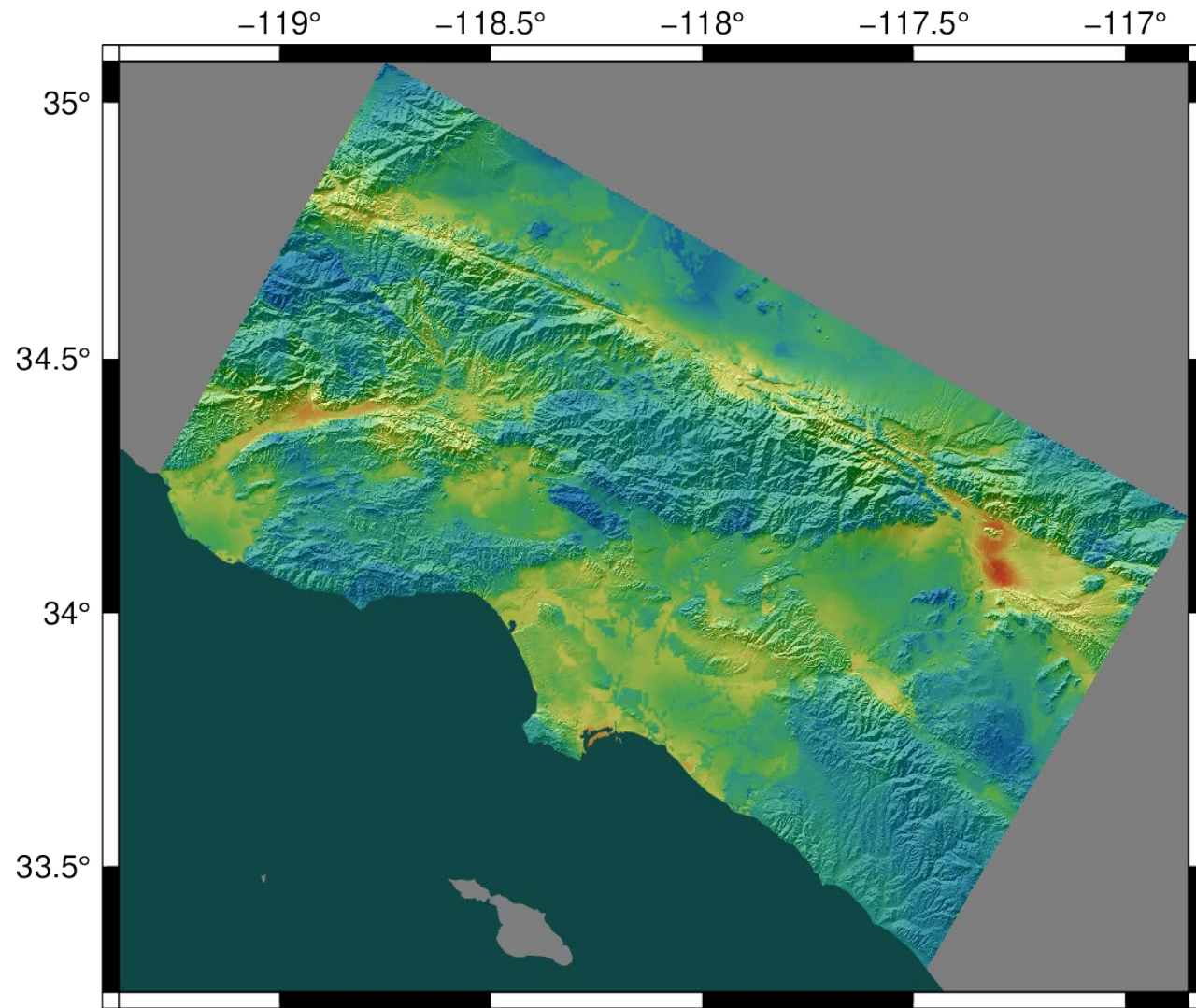
Ratio of Study 21.12 to UCERF2 CyberShake



Results, 3 sec

Study 21.12

Ratio of Study 21.12 to UCERF2 CyberShake



Now you know!