

SCEC's Earthquake Rupture and Ground Motion Forecasting Capabilities



Xiaofeng Meng (SCEC)

OpenSHA/UCERF3-ETAS: Ned Field, Kevin Milner, Akash Bhatthal

Quakeworx: Yehuda Ben-Zion, Ahmed Elbanna, Alice-Agnes Gabriel, Fabio Silva, Chunhui Zhao, Evan Marschall

PyCSEP: Fabio Silva
and many more collaborators

September 1, 2026

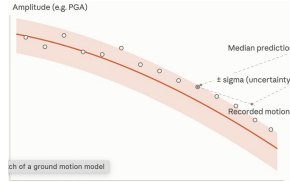
SCEC Annual Meeting, Palm Springs, California



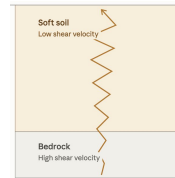
SCEC Capabilities

Ground Motion Forecast

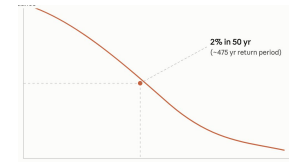
Ground Motion Model



Site response

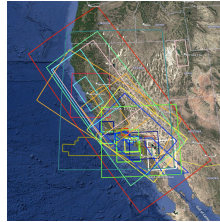


Hazard curve

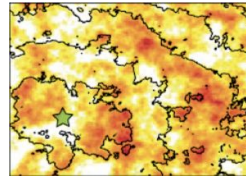


Physics-based Ground Motion Forecast

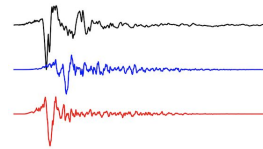
Velocity model



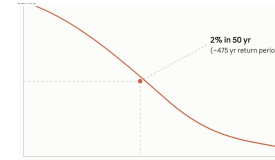
Kinematic/Dynamic rupture



Synthetic seismogram

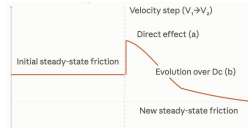
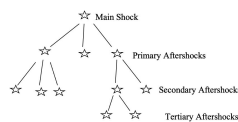


Hazard curve

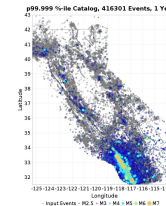


Seismicity / Earthquake Cycle Forecast

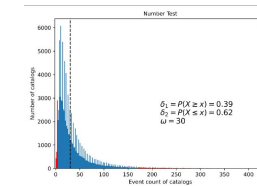
Statistical/Physics-based Model



Synthetic catalogs



Statistical evaluation



- A **Open**-source platform for **Seismic Hazard Analysis**
- It implements ERFs and combining them with ground motion models to compute hazard products
- It is used both on local workstations and in large-scale environments (e.g., HPC systems)
- A framework where any arbitrarily complex (e.g., physics based) SHA component can “plug in” for end-to-end SHA calculations

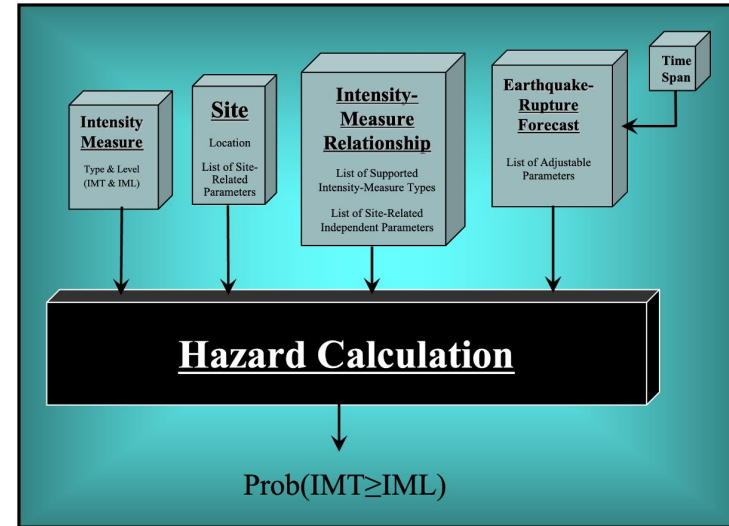


Figure from Ned Field



OpenSHA User Cases - Hazard Curves



1. Select Ground motion model (GMM), Intensity Measure (IM) and site locations

Gaussian Truncation:

Tectonic Region:

Component:

Std Dev Type:

Set IMT

IMT:

SA Period (sec):

SA Damping (%):

Sites

1.	34.0, -118.0
2.	35.0, -118.0
3.	34.0, -110.5

Add Site Remove Site(s) Edit Site

Site Data Values

1.	AS Site Type: Deep-Soil
2.	Vs30: 260.0
3.	Depth 2.5 km/sec: 1.0
4.	Vs30 Type: Measured
5.	Depth 1.0 km/sec: 100.0

2. Select ERF

Set Forecast

Eqk Rup Forecast:

Mean UCERF3 Presets:

Background Seismicity:

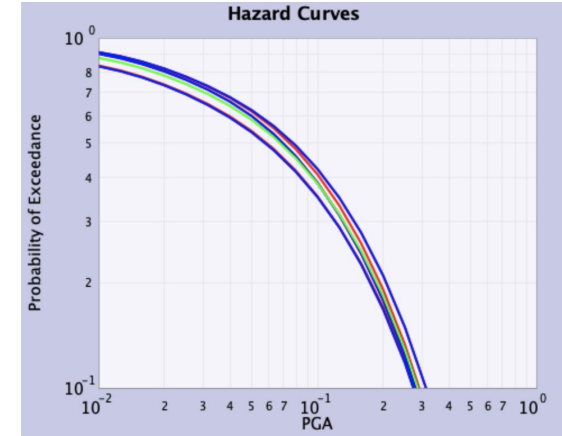
Treat Background Seismicity As:

Gridded Seismicity Settings:

Minimum Gridded Magnitude:

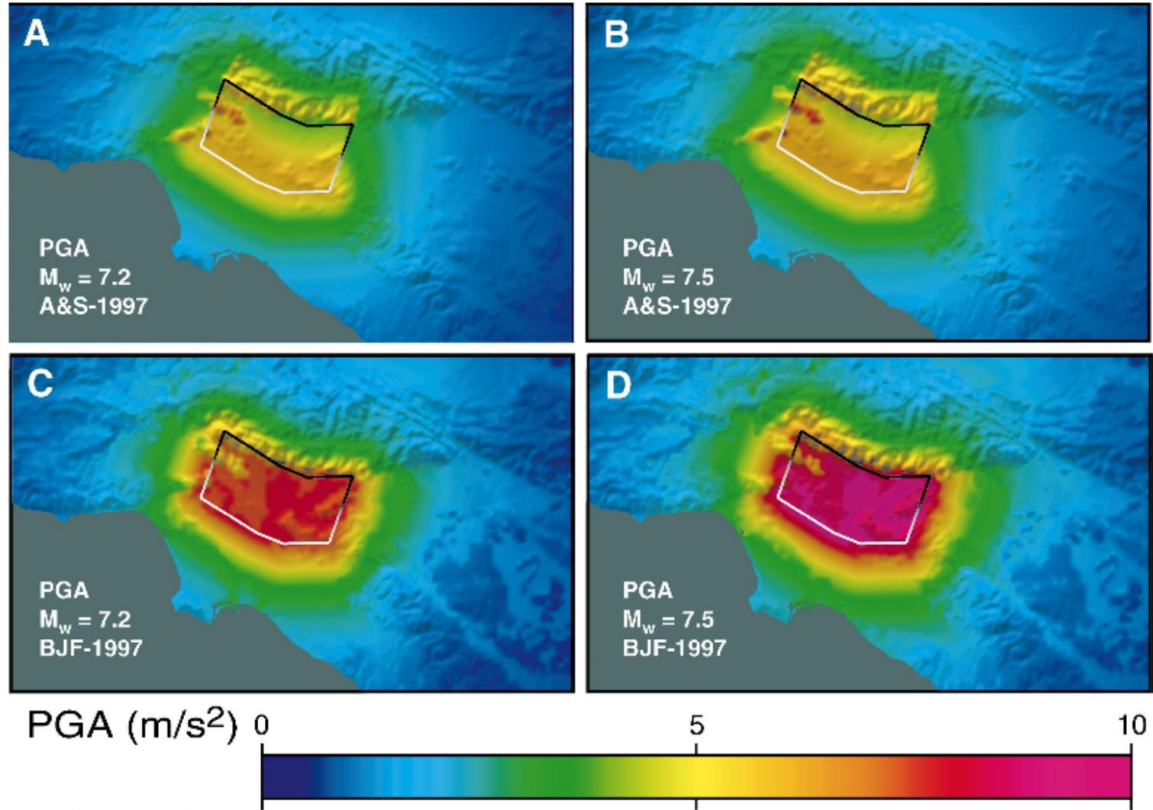
Minimum Finite Magnitude:

3. Results (plots and csv files)



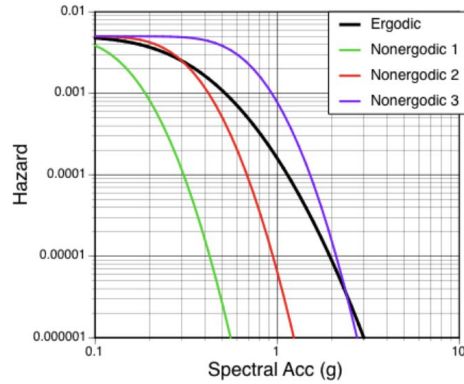
Figures from OpenSHA tutorials

1. Select GMM and IM
2. Define an earthquake rupture
(create a custom one or choose one from ERF)
3. Define a geographic region and site conditions



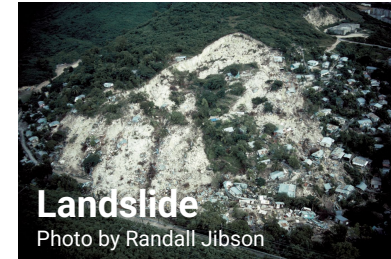
Figures from OpenSHA tutorials

OpenSHA Future Improvements

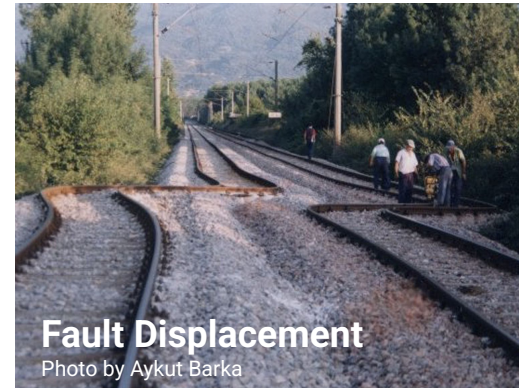
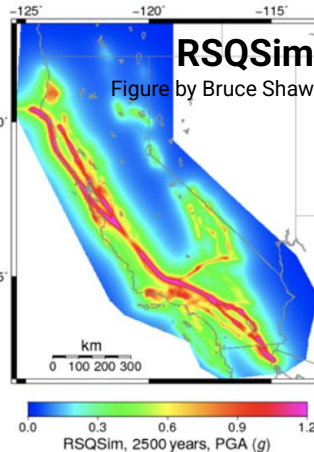
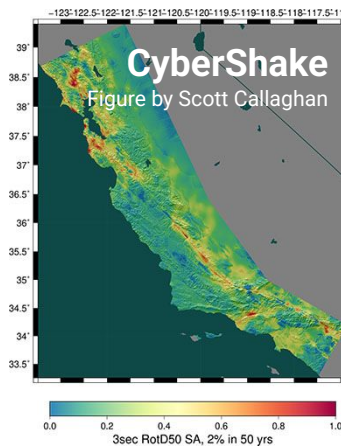


Non-ergodic seismic hazard analysis

Support hazard computations for



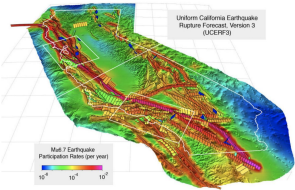
Integration of physics-based models



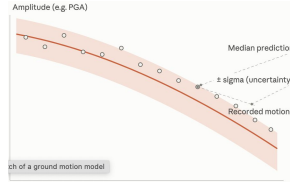


SCEC Capabilities

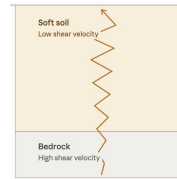
Earthquake Rupture Forecast (ERF)



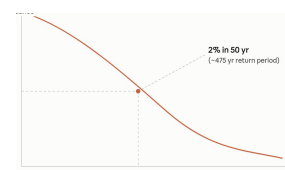
Ground Motion Model



Site response

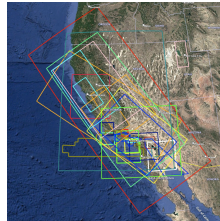


Hazard curve

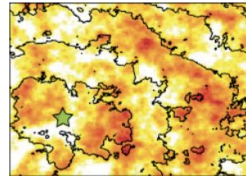


Hazard Forecast

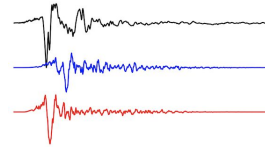
Velocity model



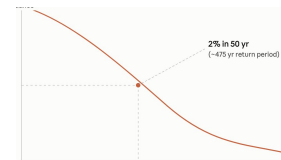
Kinematic/Dynamic rupture



Synthetic seismogram

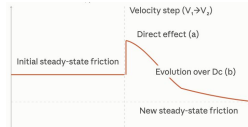
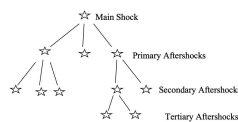


Hazard curve

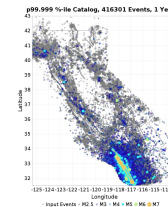


Physics-based Hazard Forecast

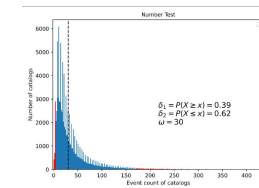
Statistical/Physics-based Model



Synthetic catalogs

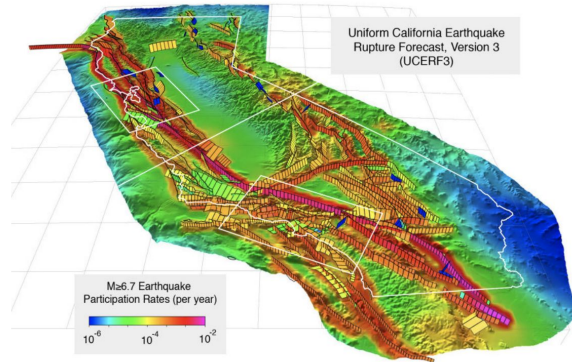


Statistical evaluation

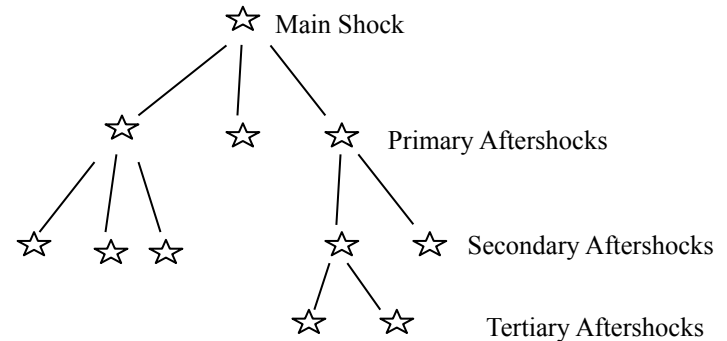


Seismicity / Earthquake Cycle Forecast

Uniform California Earthquake Rupture Forecast, Version 3 (UCERF3)



Epidemic Type Aftershock Sequence (ETAS)



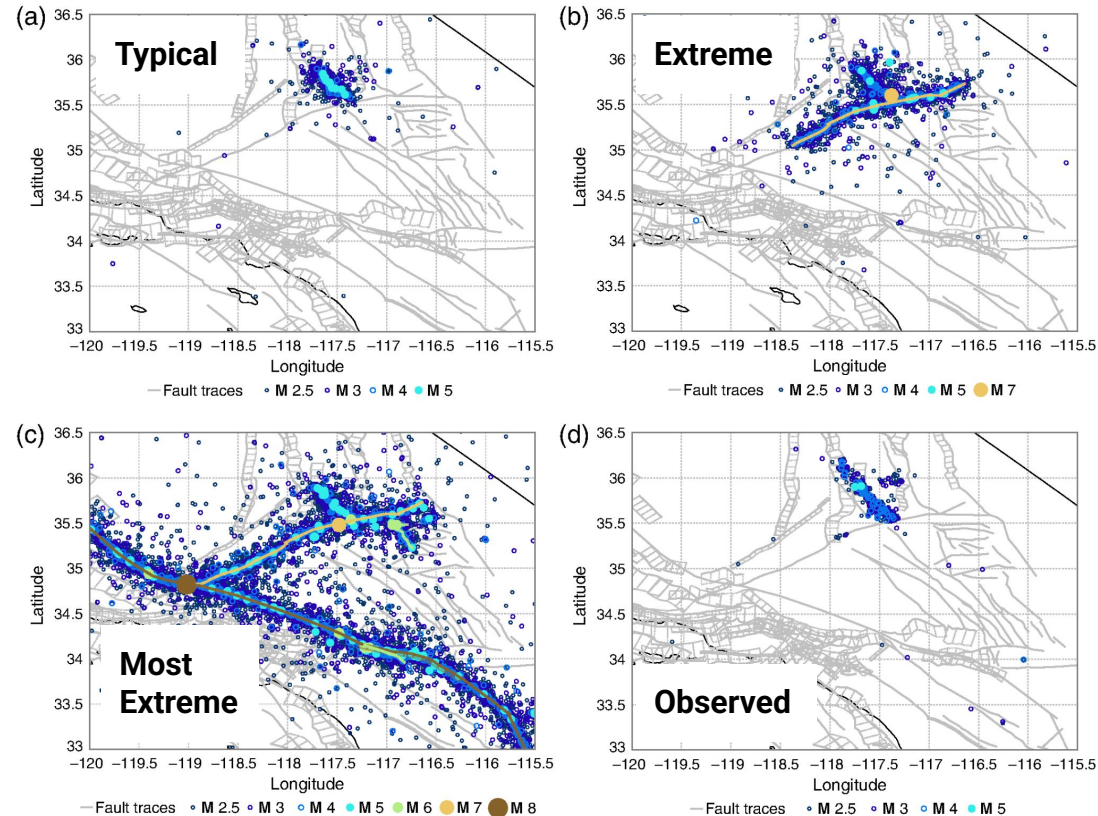
UCERF3-ETAS simulates time-dependent clustered seismicity from days to hundreds of years

- Inputs can include:
 - Historical catalog
 - Scenario events
 - Trigger ruptures, either on or between UCERF3 faults
- Outputs are suites of synthetic seismicity catalogs

Figures from Kevin Milner

Aftershock Sequence Forecasting

2019 M7.1 Ridgecrest
sequence example

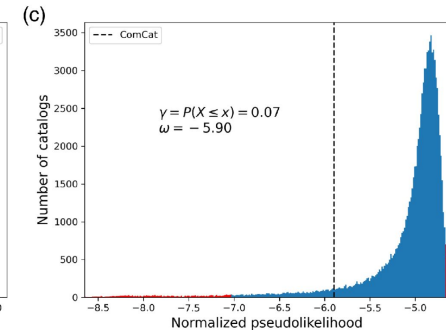
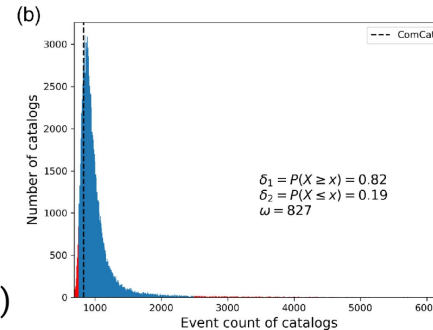
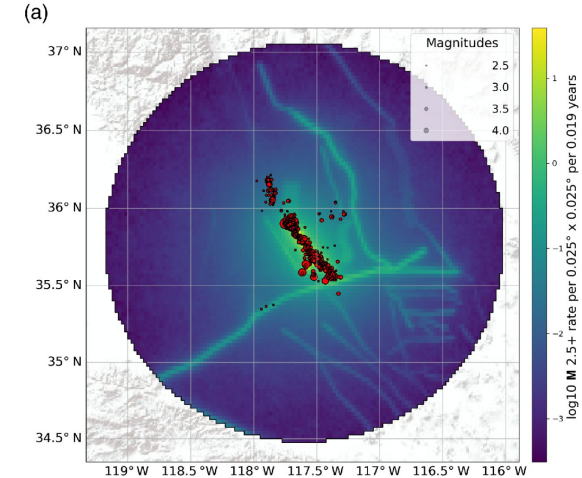


Figures from Kevin Milner

The Collaboratory for the Study of Earthquake Predictability (CSEP)

pyCSEP provides open-source implementations of useful tools for evaluating earthquake forecasts with real data

- Grid-based probabilistic earthquake forecast
- Catalog-based probabilistic earthquake forecast (e.g., UCERF3-ETAS)
- Number test
- Spatial test
- Magnitude test
- Pseudolikelihood test



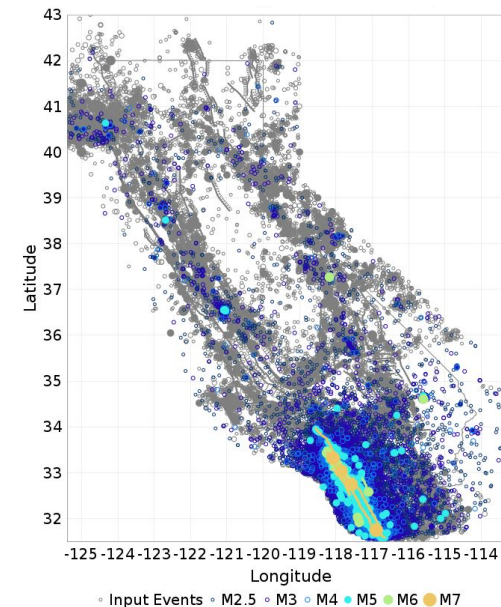
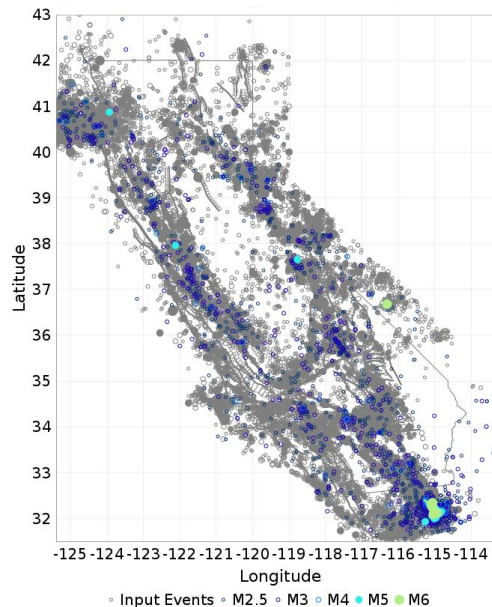
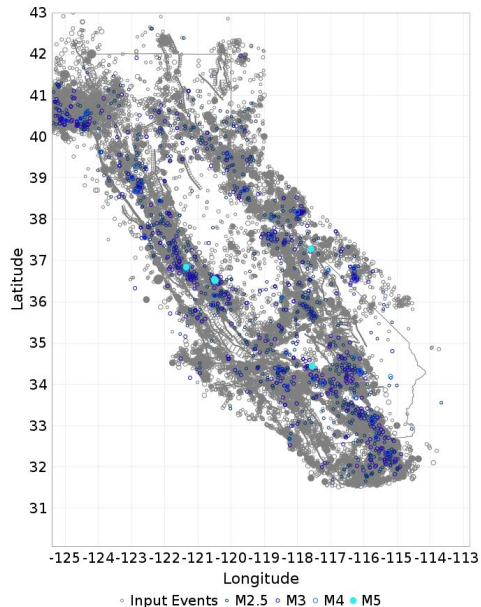
Savran et al., (2020)

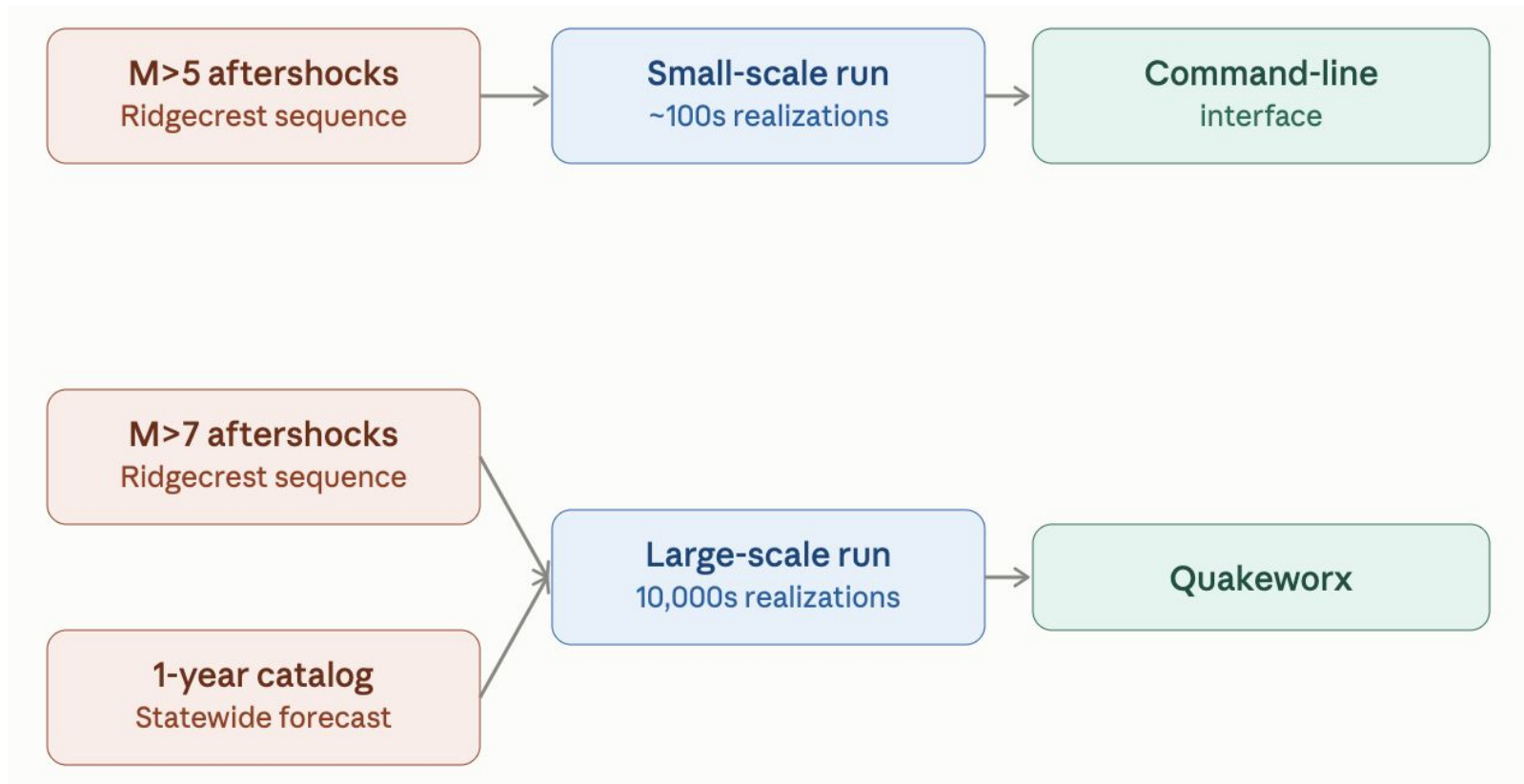
Used to create realistic statewide synthetic catalogs

Figures from Kevin Milner

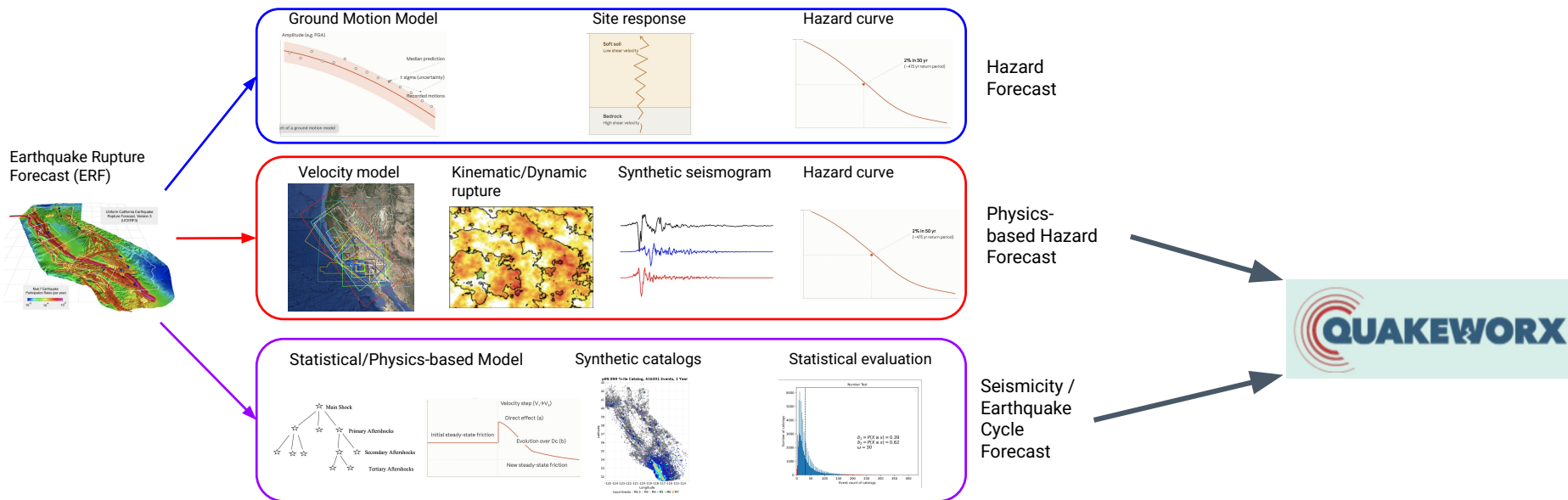
- 100k realizations of the next 1 year of seismicity
- 1k realizations of the next 500 years to look at behavior over multiple seismic cycles

Typical
→
 Extreme





- A web-based cyberinfrastructure for the community to run and contribute advanced computational tools
- It curates a suite of state-of-the-art earthquake modeling codes, runnable via a web browser or command line





Quakeworx Web Portal



1. Select an app

All apps

List of apps available on this site.
About Apps and Jobs: Apps are software applications that are configured to be executed on a predefined compute system. Launching an App creates a Job that stores its configuration and state.

App type: Search:

UCERF3 ETAS
BATCH APP / EXECUTABLE
UCERF3 ETAS
ver: 069a27e
system: Expense service
UCERF3 ETAS Application

UCERF3 ETAS
BATCH APP / EXECUTABLE
UCERF3 ETAS Tutorial
ver: 069a27e
system: Expense service
UCERF3 ETAS Application

2. Define parameters

UCERF3-ETAS Parameters

Please specify the following UCERF3-ETAS parameters

Event id ^{*}

ComCat event ID, can be extracted from the USGS event page URL

Number of simulations ^{*}

Number of simulated catalogs to generate. More catalogs result in longer runtime but better statistics, especially for rare events.

Days before ^{*}

The number of days of seismicity to include before the specified event (foreshocks).

3. Set up computing environment

Please specify the computing environment for this application

Job name ^{*}

Specify a name for this job

System ^{*}

The system to run this app on.

Batch Logical Queue ^{*}

The batch logical queue to run this app on.

Allocation ^{*}

The allocation ID to use for running this app.

▼ Job resources
Specify the job resources for this app

Number of nodes ^{*}

The number of nodes to use for running this app.

Cores per node ^{*}

The number of cores to use per node.

Memory (MB) ^{*}

The amount of memory to use for running this app.

Max runtime (minutes) ^{*}

The maximum amount of time to run this app.

4. Outputs

③

- filebrowser.db
- ospjob_proxy_info.txt (158 B)
- outputs (56 KB)
 - config.json (1.92 KB)
 - config_input_plots (56 KB)
 - index.html (129.17 KB)
 - index.pdf (6.28 MB)
 - markdown.css (16.22 KB)
 - opensha-all.jar (10118 MB)
 - ospjob.log (309.96 KB)
 - plots (147.5 KB)
 - README.md (73.97 KB)
 - results (110.5 KB)
 - results_complete.bin (745.35 KB)
 - results_m5_preserve_chain.bin (17.98 KB)
 - tapisjob.out (1.86 KB)
 - tapisjob.sh (2.47 KB)
- tapisjob.env (1.4 KB)
- tapisjob.sh (2.47 KB)

Figures from Akash Batthal

Physics-based Ground Motion Forecast

Broadband Platform

SeisSol

Moose-FARMS

Reduced-Order Models (ROMs)

Seismicity / Earthquake Cycle Forecast



UCERF3-ETAS

TANDEM

RSQSim

HFQsim

Community Model

Unified Community Velocity Model (UCVM)

Earthquake Forecast Evaluation





Guiding Principles

- 1. Develop a range of open-source tools to forecast ruptures, aftershocks, and seismic hazard, based on best available science**
- 2. Reduce technical barrier and accelerate scientific discovery**
- 3. Support scientific research, operational aftershock forecasting during major sequences, engineering applications, and catastrophe risk models used in the insurance sector**