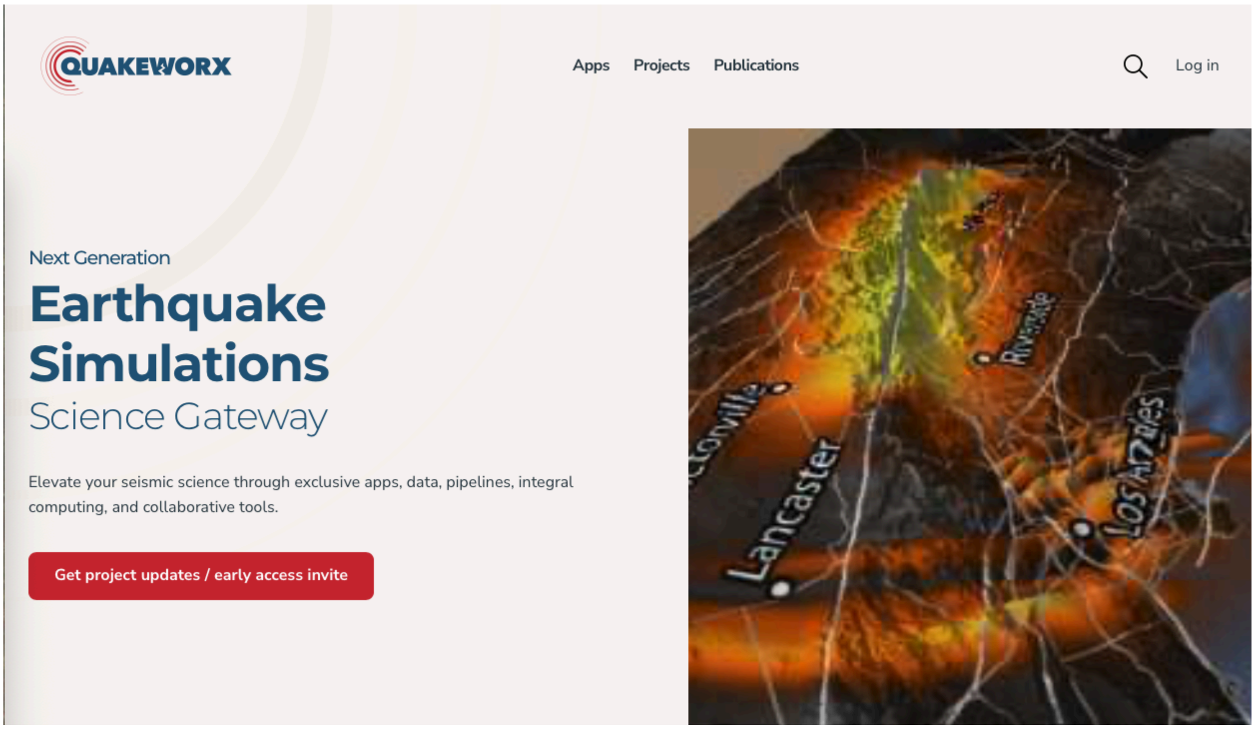
December 2025 Newsletter



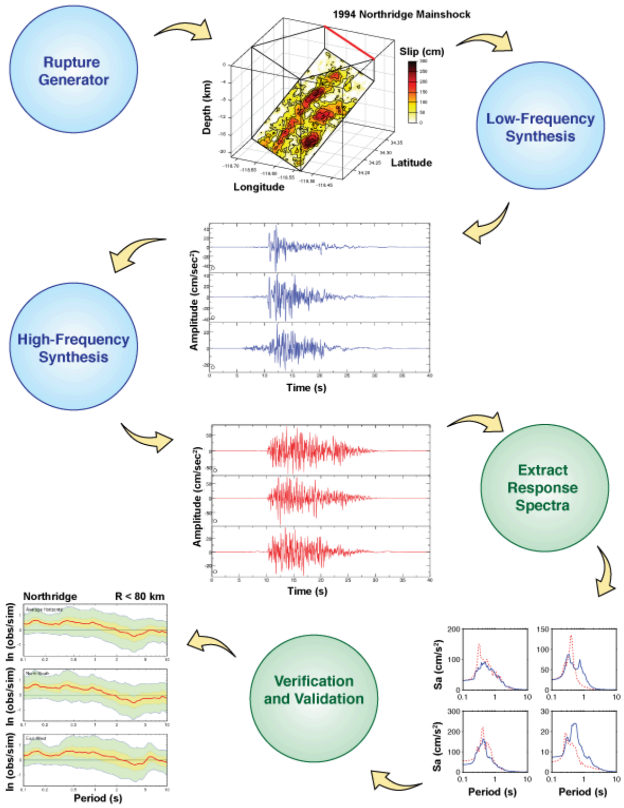
Dear Quakeworx community,

The Quakeworx science gateway has entered its **early-user phase**. A set of high-value computational applications is now available for the community to use. These tools were selected to cover key earthquake science workflows and test key platform capabilities. **We invite you to try** them out and provide feedback so we can **move the gateway toward full production**.

Applications available for exploration include:

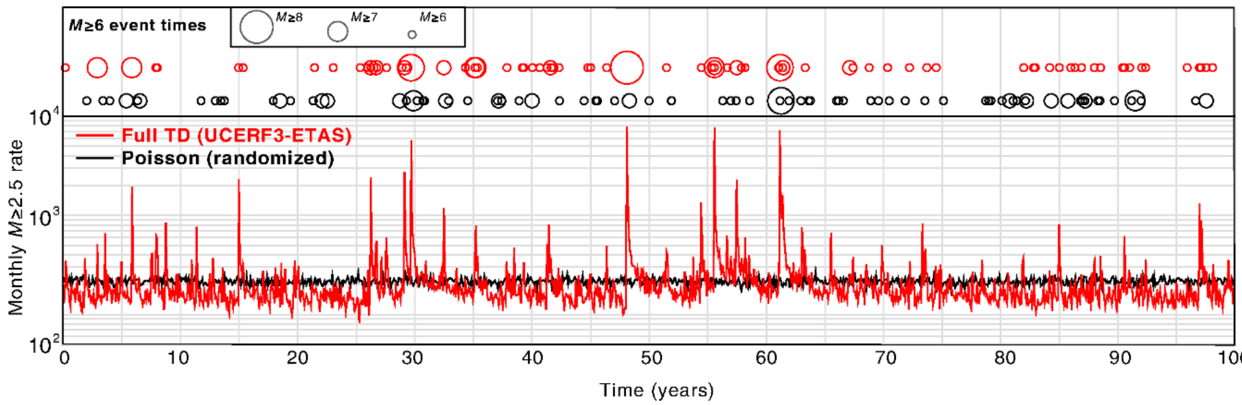
The Statewide California Earthquake Center's Broadband Platform (BBP) is now available on the [Quakeworx Science Gateway](). The BBP is a well-established open-source software system for simulating broadband (0–20+ Hz) ground motions for both historical and scenario earthquakes in regions including California, Eastern North America, and Japan. Through Quakeworx, users can now run BBP validation and scenario simulations directly from their web browser, without installing software or managing dependencies. The Quakeworx web application provides access to all current BBP validation events and allows users to upload custom source and station files for scenario runs. Researchers are invited to log in to the

[Quakeworx Gateway](), explore the Broadband Platform, and use it to advance their seismological studies. For additional information, please contact Fabio Silva at [fsilva@usc.edu.]()



A Broadband Platform workflow showing a simulation method consisting of a rupture generator, low- and high-frequency waveform synthesis, and two stages of post-processing. Modified from Maechling et al. (2015).

The UCERF3-ETAS (Third Uniform California Earthquake Rupture Forecast – Epidemic Type Aftershock Sequence) model is now available on the [Quakeworx Science Gateway](). UCERF3-ETAS is a prototype operational earthquake forecasting tool for California that combines the long-term UCERF3 time-dependent model with short-term aftershock probabilities to simulate sequences of earthquakes, including both observed and spontaneous events. Through Quakeworx, researchers can now configure and run UCERF3-ETAS simulations directly from their web browser to estimate aftershock probabilities following significant California earthquakes. This capability has recently been applied to events such as the March 2025 M4.1 Malibu and April 2025 M5.3 Julian earthquakes. A tutorial version of the application is also available for training and education. Researchers are invited to log in to the [Quakeworx Gateway]() to explore UCERF3-ETAS and use it to advance their studies of earthquake sequences and time-dependent hazards. For additional information, please contact Akash Bhatthal at bhatthal@usc.edu.

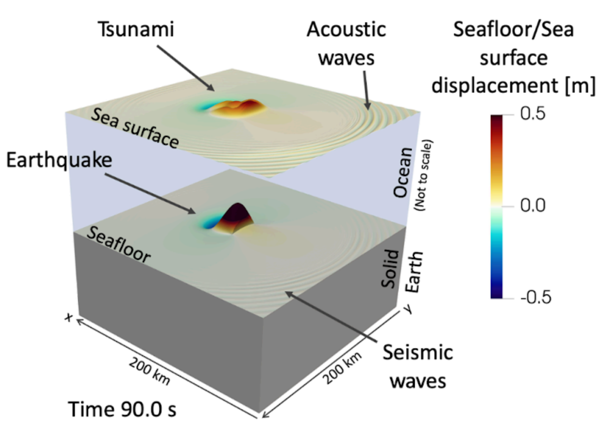


UCERF3-ETAS (red) simulates 100-yr statewide M≥6 events and monthly M≥2.5 rates, showing aftershock decay and clustering, unlike the time-independent Poisson model (black) which randomizes event times, thereby removing spatiotemporal clustering. From Field et al. (2012).

SeisSol (www.seissol.org**,** Gabriel et al., 2025) is an open-source software for the simulation of seismic, acoustic, and tsunami wave propagation and earthquake rupture dynamics, and is now available on the Quakeworx Science Gateway. The software utilizes the arbitrary high-order accurate derivative discontinuous Galerkin method (ADER-DG) to allow high-order accuracy in space and time. SeisSol supports complex 3D model geometries using tetrahedral meshes and handles various material models, including acoustic, elastic, viscoelastic, poroelastic, and viscoplastic rheologies. SeisSol is optimized for running on large-scale parallel computing architectures.

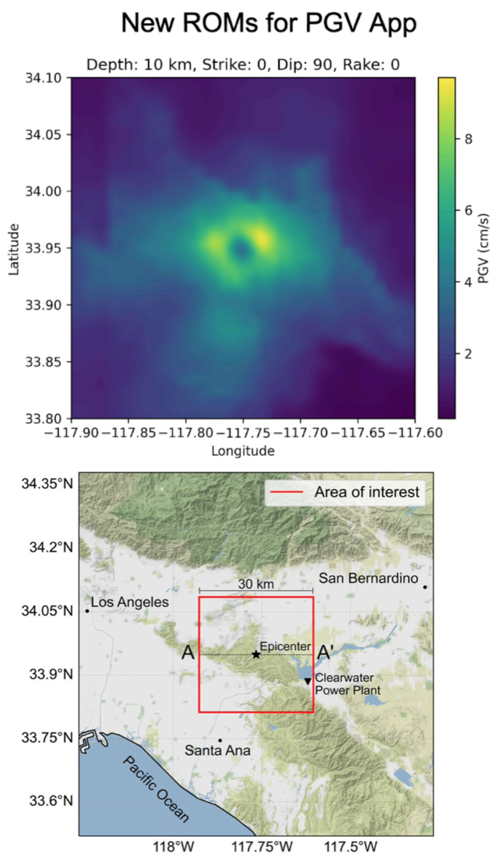
Researchers are invited to explore the new SeisSol earthquake-tsunami option within the SeisSol App to model earthquake-tsunami interaction. The 3D fully coupled models combine earthquake dynamic rupture and tsunami generation into a single simulation (e.g., Maeda & Furumura, 2013; Lotto & Dunham, 2015; Wilson & Ma, 2021, Abrahams et al., 2023), capturing 3D elastic, acoustic, and tsunami waves, including dispersion effects, simultaneously. We invite users to try two recently developed benchmark problems (https://doi.org/10.5281/zenodo.15389414, Kutschera et al., 2025), developed jointly by CRESCENT and SCEC/USGS.

New SeisSol earthquake-tsunami App Type



The SeisSol earthquake-tsunami App type allows users to model earthquake-tsunami interaction. Illustrated is a very simple 3D fully coupled simulation output resembling the recent CRESCENT and SCEC/USGS earthquake-tsunami benchmark setup TTPV1, showing a vertically exaggerated view of how the seafloor is permanently displaced due to spontaneous earthquake dynamic rupture, and how acoustic waves and the tsunami propagate at the sea surface.

Scientific machine learning for generating instantaneous SeisSol shake maps: The Quakeworx gateway now features [a new application](#) to rapidly generate peak ground velocity maps in Southern California using Reduced-Order Models (ROMs, Rekoske et al., 2023). These are accurate approximations of maps that would ordinarily require hundreds of CPU hours to model 3D viscoelastic seismic wave propagation in a 3D Southern California velocity model with topography. Simply enter the earthquake depth and focal mechanism and in just a short moment the app will produce a PNG figure of the peak ground velocity. We encourage users to try out this new app.

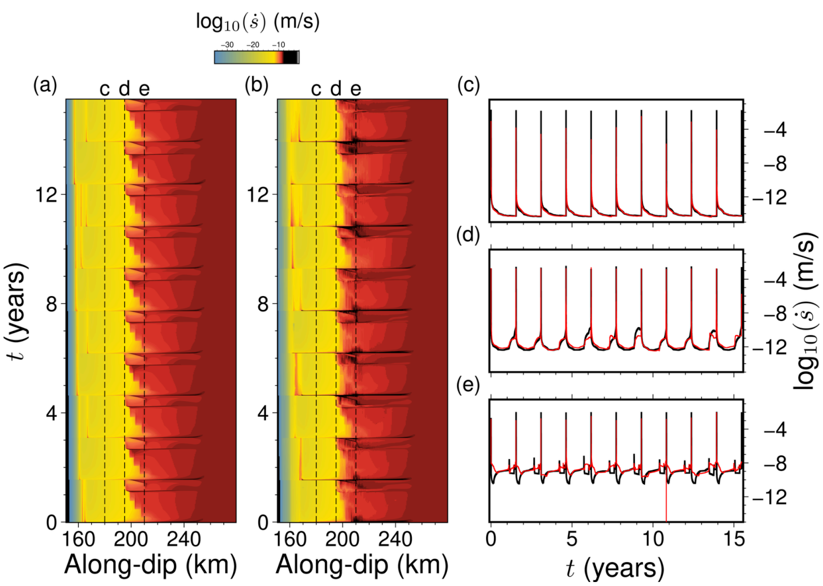


Example output of a peak ground velocity map which can be generated for Southern California with an arbitrary focal mechanism using the interpolated Proper Orthogonal Decomposition reduced-order mode via the "ROMs for PGV" App.

For additional information, please contact Alice-Agnes Gabriel algabriel@ucsd.edu.

Tandem (https://github.com/TEAR-ERC/tandem) is an open-source, high-performance computing (HPC) software for volumetric simulations of sequences of earthquakes and aseismic slip (SEAS) on complex fault systems in 2D and 3D. It is based on a symmetric interior penalty discontinuous Galerkin formulation, combining unstructured curvilinear tetrahedral/triangular meshes with high-order polynomial bases. This enables native representation of intersecting, branching, non-planar faults, heterogeneous material properties, and topography. The pre-defined fault interfaces obey the aging-law rate-and-state friction.

The Tandem App is available on [Quakeworx]() and provides three options: "autoTandem: simple 2D planar fault setup"; "Tandem 2D"; and "Tandem 3D". "Tandem 2D", "Tandem 3D" provide a general interface to execute two-dimensional, or three-dimensional SEAS models. In these app options users are required to upload all mesh files and input files for a Tandem simulation. The Tandem app option "autoTandem: simple 2D planar fault setup" offers a lower barrier to entry by providing users with a simplified 2D seismic cycle model scenario and automating many modeling steps, including mesh and input file generation. Users are free to alter a small number of physical parameters, such as dip angle, normal stress, and frictional property distributions via the launch page. This app type enables new and novice users to explore SEAS models without requiring meshing tools, scripting interfaces, or an understanding of Tandem's input file configuration.



Comparisons between a 2D Tandem simulation of Cascadia slow slip events, with a scientific machine learning surrogate reduced order model (ROM) described in Magen et al (2025). (a) Slip rate as a function of time and along-dip distance obtained using Tandem. The locked portion of the subduction interface is not shown. (b) Slip rate obtained from the ROM. (c)-(e) Time histories of slip rate at specific observation points along the fault, marked by dashed lines in panels (a) and (b), with Tandem results shown in black and ROM results in red.

Other updates:

We are in the process of requesting additional HPC resources that will allow users to run jobs on Quakeworx apps. Our new ACCESS Discover allocation, several times larger than our current allocation, will support our growing user base, future workshops, and expanding Quakeworx to additional computational backend systems.

Ahmed Elbanna moved from the department of Civil and Environmental Engineering in UIUC to the department of Earth Science at USC to become the Director of the StateWide California Earthquake Center (SCEC) starting 1/1/2026. He will remain closely involved with Quakeworx and help to coordinate the project activities with those of SCEC.

We congratulate Alice Gabriel and the SeisSol group for receiving the **2025 Gordon Bell Prize** as part of a team led by Stefan Henneking and Omar Ghattas at UT Austin. The team developed a real-time tsunami forecasting approach using an advanced “digital twin” framework that reduces what would normally require 50 years of supercomputing time to less than a second. This has the potential to dramatically improve early warning systems for coastal communities near earthquake and tsunami-prone regions.

Upcoming webinar: Amit Chourasia will be presenting a talk on the Quakeworx Science Gateway at the Science Gateway Center of Excellence on January 15, 2026. See abstract and registration information.

References:

Abrahams, L. S., Krenz, L., Dunham, E. M., Gabriel, A.-A., & Saito, T. (2023). Comparison of methods for coupled earthquake and tsunami modelling. Geophysical Journal International, 234(1), 404–426. DOI: 10.1093/gji/ggad053

Field, Edward & Milner, Kevin & Hardebeck, Jeanne & Page, Morgan & Elst, Nicholas & Jordan, Thomas & Michael, Andrew & Shaw, Bruce & Werner, Maximilian. (2017). A Spatiotemporal Clustering Model for the Third Uniform California Earthquake Rupture Forecast (UCERF3‐ETAS): Toward an Operational Earthquake Forecast. Bulletin of the Seismological Society of America. 107(3):1049. DOI: 10.1785/0120160173

Gabriel, A.-A., Kurapati, V., Niu, Z., Schliwa, N., Schneller, D., Ulrich, T., Dorozhinskii, R., Krenz, L., Uphoff, C., Wolf, S., Breuer, A., Heinecke, A., Pelties, C., Rettenberger, S., Wollherr, S., & Bader, M. (2025). SeisSol. Zenodo. DOI: 10.5281/zenodo.4672483

Kutschera, F., Gabriel, A.-A., & Dunham, E. M. (2025). CRESCENT Tsunami Benchmark (TTPV1 and TTPV2): 3D fully coupled earthquake dynamic rupture and tsunami benchmarks with varying bathymetric complexity. Zenodo. DOI: 10.5281/zenodo.15389414

Lotto, G. C., & Dunham, E. M. (2015). High-order finite difference modeling of tsunami generation in a compressible ocean from offshore earthquakes. Computational Geosciences, 19(2), 327–340. DOI: 10.1007/S10596-015-9472-0

Maechling, P. J., F. Silva, S. Callaghan, and T. H. Jordan (2015). SCEC Broadband Platform: System Architecture and Software Implementation, Seismol. Res. Lett., 86, no. 1, doi: 10.1785/0220140125.

Maeda, T., & Furumura, T. (2013). FDM Simulation of Seismic Waves, Ocean Acoustic Waves, and Tsunamis Based on Tsunami-Coupled Equations of Motion. Pure and Applied Geophysics, 170(1), 109–127. DOI: 10.1007/s00024-011-0430-z

Rekoske, J. M., Gabriel, A. A., & May, D. A. (2023). Instantaneous physics‐based ground motion maps using reduced‐order modeling. Journal of Geophysical Research: Solid Earth, 128(8), e2023JB026975.

Wilson, A., & Ma, S. (2021). Wedge Plasticity and Fully Coupled Simulations of Dynamic Rupture and Tsunami in the Cascadia Subduction Zone. Journal of Geophysical Research: Solid Earth, 126(7), e2020JB021627. DOI: 10.1029/2020JB021627

Student/Postdoc updates:

Fabian Kutschera will present a poster about the new 3D fully coupled earthquake-tsunami benchmarks at AGU in Session T43E. A downscaled and simplified version of these benchmarks is already available in the Quakeworx gateway as part of the SeisSol App, ready for everyone to explore. Jeena Yun will present a poster about the Tandem software at AGU, in Session S33B.

Selected 2025 Quakeworx Papers and Preprints:

Gabriel, A.-A., P. Karki, Y. Magen, B. Oryan, T. Ulrich, J. Yun, D.A. May, "Tandem: An Open-Source High-Performance Computing Volumetric Software to Model Sequences of Earthquakes and Aseismic Slip Across Complex Fault Systems", EarthArxiv preprint. https://doi.org/10.31223/X5V75G

Magen, Y., May, D., and Gabriel, A.-A., 2025. Reduced-order modelling of Cascadia's slow slip cycles. EarthArXiv preprint. https://doi.org/10.31223/x5qt7v

Niu, Z., A.-A. Gabriel and Y. Ben-Zion, 2025. Delayed dynamic triggering and enhanced high-frequency seismic radiation due to brittle rock damage in 3D multi-fault rupture simulations, *J. Geophys. Res.*, *130*, e2025JB031632. doi: 10.1029/2025JB031632.

Schliwa, N., A.-A. Gabriel and Y. Ben-Zion, 2025. Shallow fault zone structure affects rupture dynamics and ground motions of the 2019 Ridgecrest sequence to regional distances, *J. Geophys. Res.*, *130*, e2025JB031194, doi: 10.1029/2025JB031194.

Yun, J., Gabriel, A.A., May, D.A. and Fialko, Y., 2025. Controls of dynamic and static stress changes and aseismic slip on delayed earthquake triggering: Application to the 2019 Ridgecrest earthquake sequence. *Journal of Geophysical Research: Solid Earth*, *130*(12), p.e2025JB031271.

Yun, J., Gabriel, A.A., May, D.A. and Fialko, Y., 2025. Effects of stress and friction heterogeneity on spatiotemporal complexity of seismic and aseismic slip on strike-slip faults. *Journal of Geophysical Research: Solid Earth*, *130*(12), p.e2025JB031270.

Zhou, X. and Y. Ben-Zion, 2025. A Simulator of Earthquakes and aseismic slip on a Heterogeneous strike-slip Fault (HFQsim) with static/kinetic friction and temperature-dependent creep, J. Geophys. Res., 130, e2024JB030680, doi: 10.1029/2024JB030680.