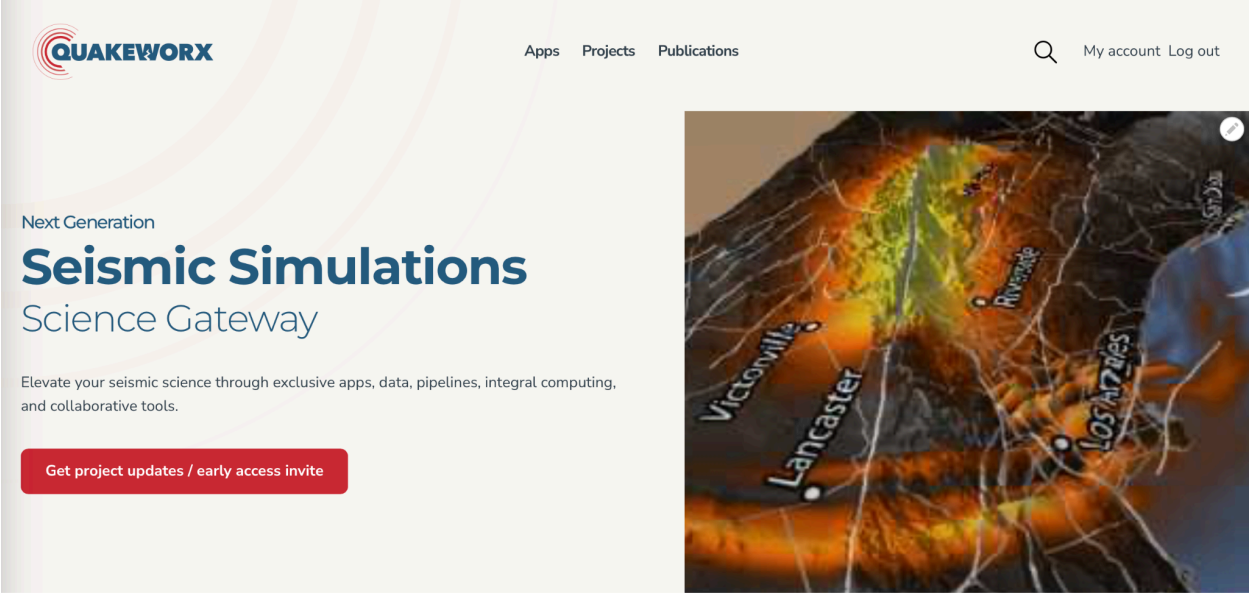
Dear Quakeworx community,



We are pleased to kick-off our Quakeworx newsletter with brief updates about recent and planned activities. The *Quakeworx* *Kick-Off Workshop*, held virtually from January 21-24, 2025, brought together over 65 researchers from 16 countries to learn how to access and run state-of-the-art earthquake simulation software through our *Quakeworx* *Science gateway* (**Figure 1**). The workshop consisted of lectures and hands-on exercises covering basic and technical aspects of several codes on dynamic rupture and seismicity. These include *SeisSol* - a dynamic rupture and wave propagation simulator, *Tandem* - a multi-cycle earthquake simulator, *MOOSE-Farms* - a fault and rupture mechanics simulator, *UCERF3-ETAS* - an epidemic type aftershock model for California, and *pyCSEP* - an earthquake forecast evaluation code. We received 162 applications, but because of the hands-on exercises the workshop was limited to 65 attendees, of which 92% were students or postdocs. All workshop material is available on the Quakeworx Workshop website, and recordings of all sessions are published on YouTube. Additional information on the workshop is available in the SCEC article. We are currently planning the next workshop and welcome your suggestions for topics to include. Please feel free to share this newsletter with others who may be interested in the Quakeworx Project. Community members can subscribe to the Quakeworx email list via a link on the main project website.

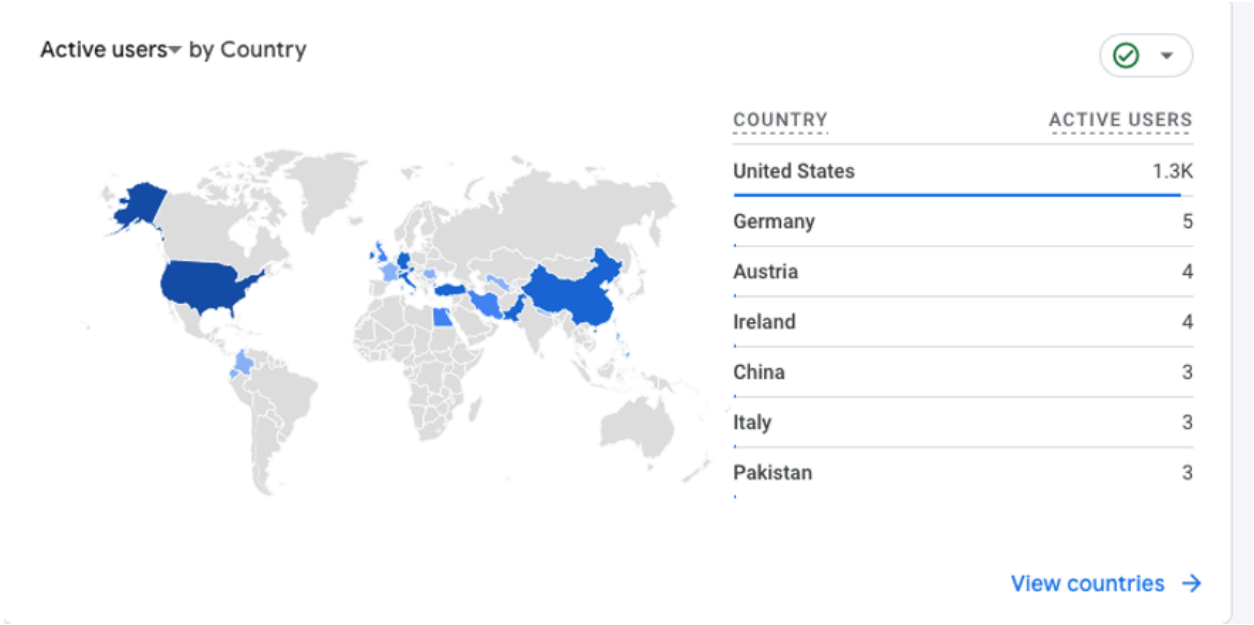


Figure 1: Google Analytics data for this year's Quakeworx Kick-off Workshop (held from January 21 to January 24, 2025) shows that the workshop website had over 1,300 active users from more than 10 different countries.

The *Quakeworx* gateway had several cyberinfrastructure developments and enhanced capabilities recently, including application management, an advanced user interface builder to support complex workflows, and improved job management. Significant updates were also made to the overall user interface. Ongoing work includes a complete revamp of the site's branding, integration of single sign-on (SSO), and migration of the underlying infrastructure from AWS to on-premises at SDSC to support and manage the gateway effectively. Work is also underway to extend the pool of HPC resources that can be used by the Quakeworx system.

Amit Chourasia, the Principal Investigator leading the cyberinfrastructure development of the Quakeworx gateway, has transitioned from the University of California San Diego to the University of California Los Angeles, where he now serves as Chief Research Data Architect at the Office of Advanced Research Computing. The administrative transfer of the project is currently in progress and Co-PI Alice Gabriel will continue leading the science thrust for the Quakeworx project at UCSD. This transition is anticipated to further widen the Quakeworx activities and foster new contributions and advancements emerging from UCLA.

In the coming weeks we plan to add to *Quakeworx* several additional features. These include an App on benchmarking simulations of dynamic rupture with off-fault brittle damage, an App on fully coupled earthquake-tsunami simulations with SeisSol, and the Broadband Platform (BBP) for simulations of ground motion to high frequencies. The BBP is a collection of open-source modules that can simulate broadband (0-25+ Hz) ground motions for earthquakes at regional scales, compare simulation results between methods, and validate simulation results against observations. The BBP contains multiple component-based ground motion methods that

implement rupture generators, low-frequency 1D deterministic wave propagation methods, high-frequency stochastic methods, and site-response modules.

In the second half of the year, we will introduce an App which enables rapid evaluation of “reduced-order models”, which allow for seismic wave propagation and shake maps on demand based on unsupervised dimensional reduction of complex forward models. We will also add an app for accelerating dynamic rupture simulations using Fourier Neural Operators.

In addition to Apps, we plan to include soon in the Quakeworx website “Earthquake Pages” with information on California earthquakes of interest (typically with magnitude > 3.5). The information shared for research purposes (not for broad outreach to the public and media) includes basic results distributed by the USGS, aftershock probabilities simulated with the UCERF-ETAS App on Quakeworx, 3D waveform simulations using the community velocity model for the area, and pre-event seismicity patterns.

As a first step toward expanding our educational material, we will integrate Quakeworx into Alice Gabriel’s “Advanced Seismology” course this spring, alongside the development of additional teaching materials and interactive app usage.

Student/Postdoc Awards

Our student member Jeena Yun was awarded the Outstanding Student Presentation Award for the 2024 American Geophysical Union (AGU) Fall Meeting, presenting a poster on seismic cycle simulations with Tandem, an App available through Quakeworx (**Figure 2**). Jeena Yun also received the 2025 Paul Andrew Spudich Travel Grants from the Seismological Society of America (SSA), enabling her to represent the Quakeworx project in the International Joint Workshop on Slow-to-Fast Earthquakes in Japan in Fall 2025.

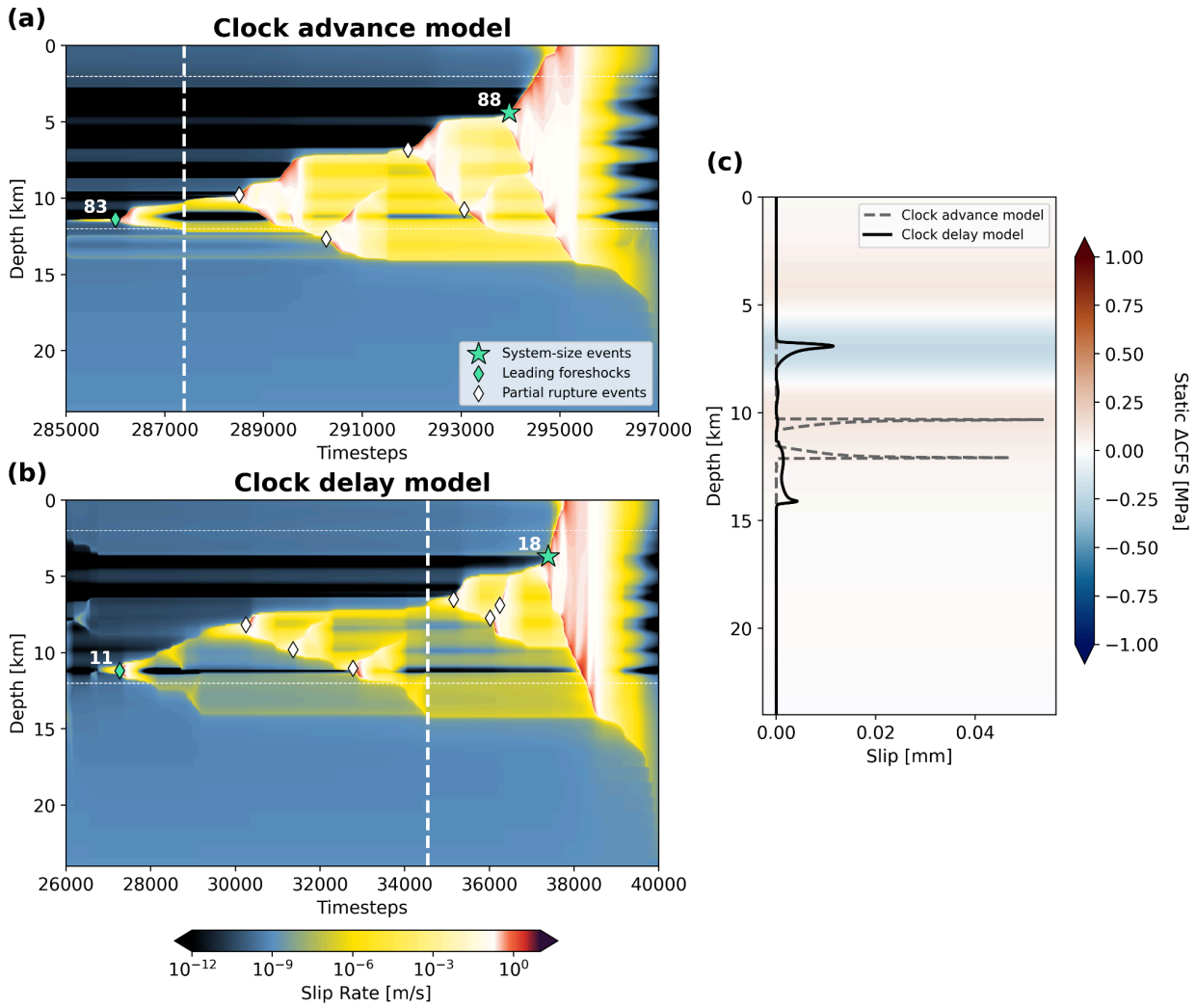


Figure 2: Results from Jeena Yun's work presented at the December 2024 AGU Fall Meeting combining dynamic rupture (*SeisSol*) and seismic cycle (*Tandem*) simulations to investigate mechanisms of delayed earthquake triggering. (a-b) Spatiotemporal evolution of slip rate for mainshock clock advance and delay models. The white dashed line indicates the dynamic perturbation period. (c) Net slip during the perturbation period for both models and static Coulomb stress changes (ΔCFS) vs. depth for both models. See Yun et al. (2024, 2025) for additional details.

Recent Quakeworx Papers and Preprints:

Preprints

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.*, in review, ArXiv preprint doi:arXiv:2503.21260

Niu, Z., A.-A. Gabriel, S. Wolf, T. Ulrich, V. Lyakhovsky, H. Igel (2025), "A Discontinuous Galerkin Method for Simulating 3D Seismic Wave Propagation in Nonlinear Rock Models:

Verification and Application to the 2015 Mw 7.8 Gorkha Earthquake", *J. Geophys. Res.*, in review, ArXiv preprint doi:arXiv:2502.09714

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.*, in review, Preprint April2025_small.pdf

Tainpakdipat, N., M. Abdelmeguid, C. Zhao, K. Azzizadenesheli, A. Elbanna, 2025. Fourier Neural Operators for Accelerating Earthquake Dynamic Rupture Simulations. *J. Geophys. Res.*, in review, ESSOAr preprint doi:10.22541/essoar.174526096.60853381/v1

Yun, J., A.-A. Gabriel, D.A. May, and Y. Fialko, 2024. Controls of Dynamic and Static Stress Changes and Aseismic Slip on Delayed Earthquake Triggering: Application to the 2019 Ridgecrest Earthquake Sequence, *J. Geophys. Res.*, in review, EarthArxiv preprint doi:10.31223/X55983,

Yun, J., A.-A. Gabriel, D.A. May, and Y. Fialko, 2025. Effects of Stress and Friction Heterogeneity on Spatiotemporal Complexity of Seismic and Aseismic Slip on Strike-Slip Faults, *J. Geophys. Res.*, in review, EarthArxiv preprint doi:10.31223/X52X57.

Published and in press:

Denolle M., et al. (2025). "Training the Next Generation of Seismologists: Delivering Research-Grade Software Education for Cloud and HPC Computing through Diverse Training Modalities", Seismological Research Letters, in press, preprint: doi:arXiv:2409.19147

Wolf, S., A.-A. Gabriel, M. Galis, P. Moczo, D. Gregor, M. Bader, "3D wave propagation and earthquake dynamic rupture simulations in complex poroelastic media", Geophysical Journal International, in press, preprint: doi:10.31223/X55M52

Palgunadi, K. H., A.-A. Gabriel, D.I. Garagash, T. Ulrich, N. Schliwa, P.M. Mai (2025), "Ground Motion Characteristics of Cascading Earthquakes in a Multiscale Fracture Network", Bulletin of the Seismological Society of America, in press, preprint: doi:10.48550/arXiv.2412.15416,

Glehman, Y., A.-A. Gabriel, T. Ulrich, M.D. Ramos, Y. Huang, E.O. Lindsey (2025). “Partial ruptures governed by the complex interplay between geodetic slip deficit, rigidity, and pore fluid pressure in 3D Cascadia dynamic rupture simulations“, Seismica, in press, preprint: doi:10.31223/X5GH66

Mosconi F.,, E. Tinti, E. Casarotti, A.-A. Gabriel, A.P. Rinaldo, L. Dal Zilio, M. Cocco (2025). "Modeling the 3D dynamic rupture of microearthquakes induced by fluid injection", Journal of Geophysical Research: Solid Earth, 130, e2024JB029621, doi:10.1029/2024JB029621

Yen, M.-H., E. Türker, T. Ulrich, M. Marchandon, A.-A. Gabriel, F. Cotton (2025). "An analysis of directivity pulses using empirical data and dynamic rupture simulations of the 2023 Kahramanmaras earthquake doublet", Earthquake Spectra, doi:10.1177/87552930241305012

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.*, in press. preprint-May-2025.pdf