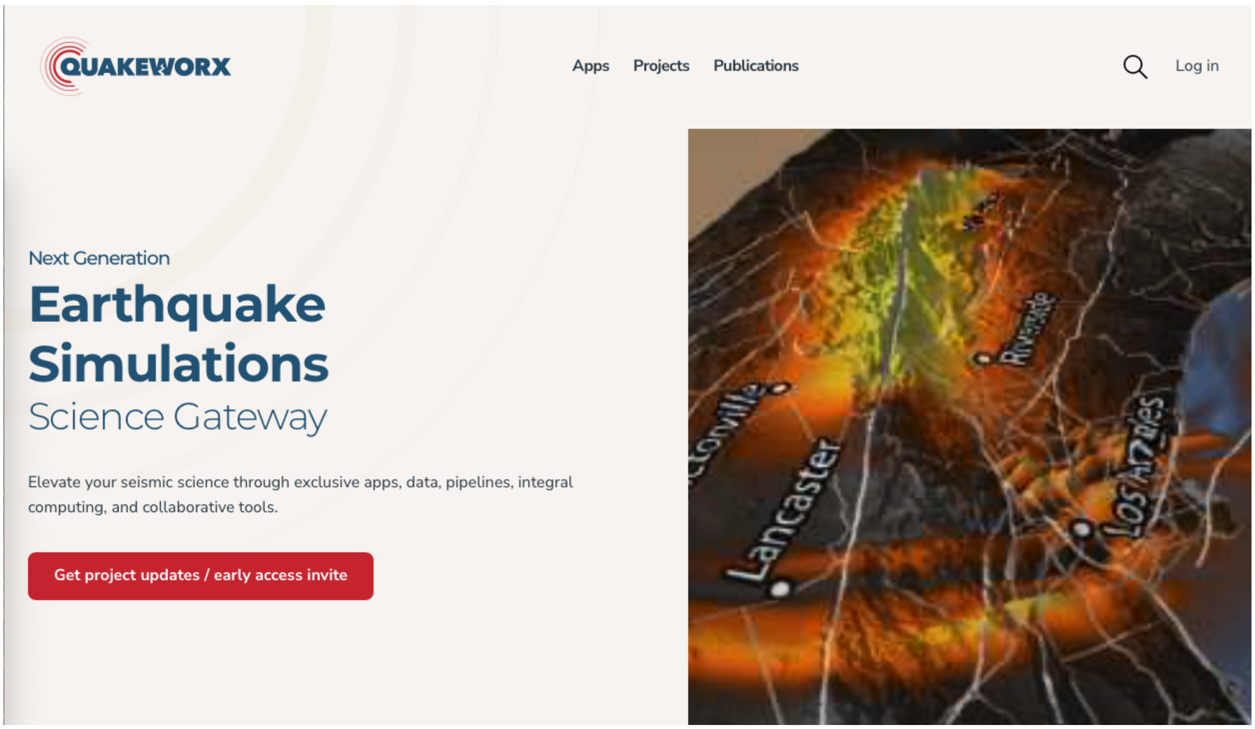
August 2026 Newsletter



Dear Quakeworx community,

We hope your Summer is going well, and we are pleased to share updates about new Apps, educational activities, the platform, recent publications, and other topics of interest.

The added Apps include RSQSim -- originally developed by Jim Dieterich and Keith Richards-Dinger that is widely used by the USGS, SCEC and other research groups – and other codes for simulations of earthquakes, seismic waves, and data analyses. We are in the process of developing additional Apps that will be described in the Quakeworx website when available, and the next newsletter. Several of our team members will be in the SCEC and AGU annual meetings and will be happy to discuss in person current and coming Quakeworx activities.

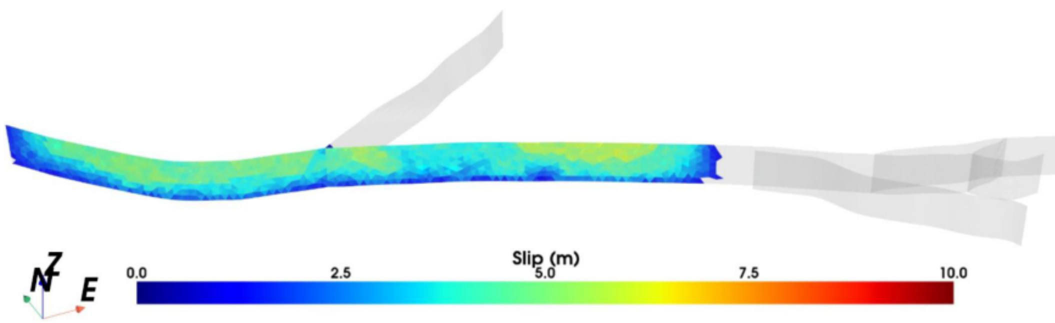
New Applications available for exploration

“RSQSim” App

RSQSim is a quasi-static 3D boundary element code used to model long-term earthquake cycles on fault systems (Dieterich, 1995; Dieterich & Richards-Dinger, 2010;

Richards-Dinger & Dieterich, 2012). Fault patches in RSQSim are governed by a rate-and-state friction law (Dieterich, 1979, 1981; Ruina, 1983; Linker & Dieterich, 1992) and the on-fault stressing rates are either calculated via a back-slip calculation given slip rates, or by explicit assignment. RSQSim utilizes a discrete element state framework that allows for analytical solutions for the timing of the next event and advances the entire system by the minimum time to failure across all elements in the fault model; this approach is very computationally efficient and removes the need for discrete time stepping. During events, RSQSim implements approximations of the elastodynamics by prescribing weakening to neighboring patches to represent the stress concentration at the rupture front which would be present in a fully dynamic model.

SIO PostDoc Evan Marschall led the development of the new RSQSim App. RSQSim is a useful tool for long-term earthquake simulations on a fault network and we are happy to make it available for a wider community via Quakeworx. In Quakeworx users are required to upload two files: an input file that gives on fault parameters (such as reference friction (μ*), critical weakening distance (D_c,), the rate-and-state coefficients *a* and *b*, etc.), and a fault mesh file which can either be discretized into rectangular or triangular elements. There are also optional files that can be uploaded if one would like to implement explicit shear and normal stressing rates on each element, rather than calculate them from a back-slip calculation. Recent applications include generating synthetic earthquake catalogs and 30-year rupture probabilities for faults of the eastern San Francisco Bay Area (Marschall et al., 2026 SCEC Annual Meeting).



Example of a Mw 7.66 event along the Southern San Andreas fault system from an RSQSim simulation run on Quakeworx.

OpenSHA App

OpenSHA version 26.8 introduces significant performance enhancements for seismic hazard analysis. A platform-wide upgrade to Java 21 leverages virtual threads to accelerate the concurrent processing of massive earthquake catalogs while reducing the overall memory footprint. This release officially moves the 2025 National Seismic Hazard Model for Puerto Rico and the U.S. Virgin Islands (NSHM25-PRVI) into production and expands site data integration with the new CONUS Basin and MUSCAL velocity models. To streamline deployment in upstream projects, OpenSHA is now natively hosted on Maven Central for developers, while users of OpenSHA desktop applications will benefit from a new built-in auto-updater that provides seamless, single-click updates.

“ROMs for PGV” and “San Andreas Scenario ROMs” Apps

Computer simulations can be used to predict the intensity of ground shaking caused by earthquakes, however such simulations require significant amounts of computing time to obtain accurate results, making them too slow for real-time systems or uncertainty quantification tasks. To overcome these challenges model-order reduction techniques, including reduced-order models (ROMs), have been successfully developed and applied to predict Peak Ground Velocity (PGVs, Rekoske et al, 2023) as well as time-dependent ground motions and synthetic seismograms (Rekoske et al., 2025).

The simplified models are fast enough to evaluate millions of synthetic earthquake scenarios on demand. The new “ROMs for PGV” Quakeworx App deploys the shakemap method and data described in Rekoske et al. (2023), and the new “San Andreas Scenario ROMs” App provides time-dependent 3D wavefield reduced-order models for San Andreas earthquake scenarios, both led by SIO PhD student John Rekoske, The underlying reduced-order modeling approach has recently been extended to CyberShake, using SeisSol simulations of the southern San Andreas fault, Rekoske et al. (2026) derive high-resolution, frequency-dependent site terms for 480,000 sites and estimate that reduced-order models can reduce the CyberShake time-to-solution by a factor of 336 for the entire earthquake rupture forecast.

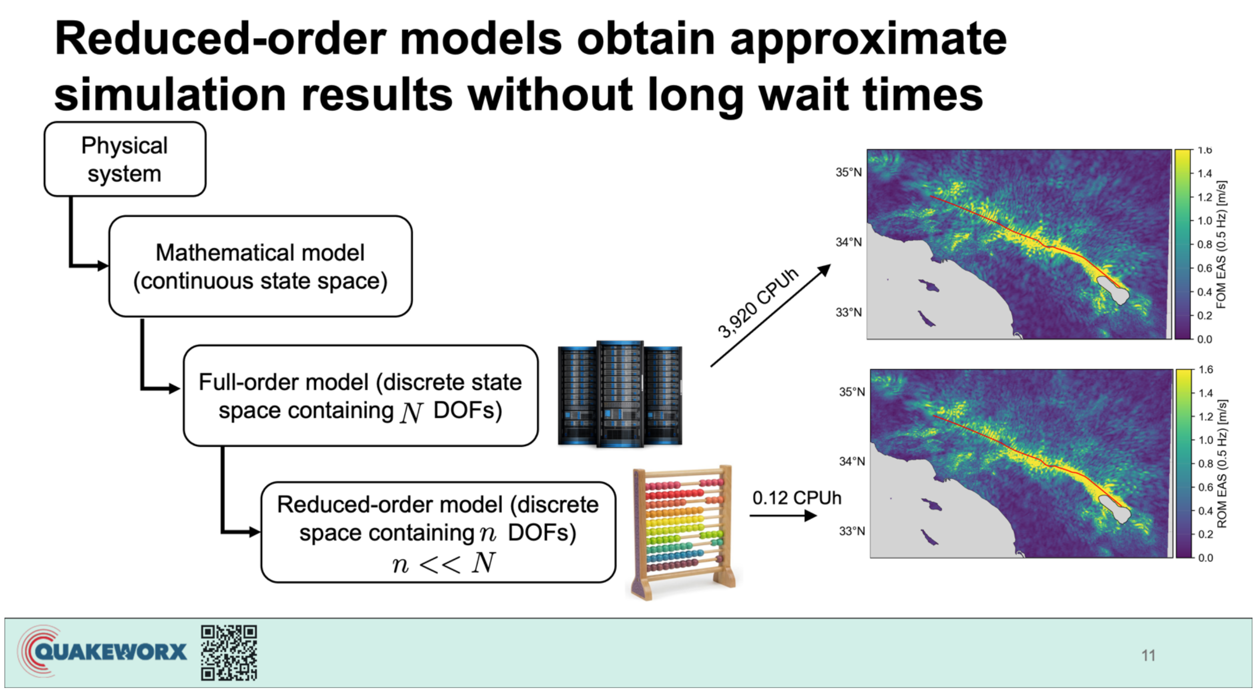


Illustration of the new “San Andreas Scenario ROMs” App using scientific machine learning and SeisSol simulations for rapid generation of physics-based shake maps (Rekoske et al., 2026)

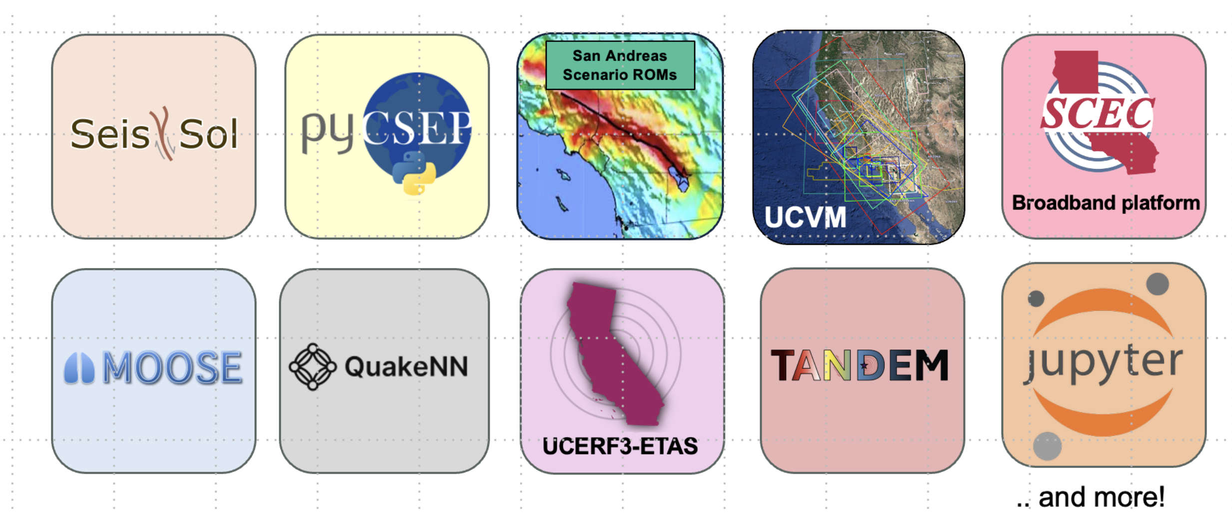
“UCVM” App

Under development is a Quakeworx app for the SCEC Unified Community Velocity Model (UCVM) software. This app will enable users to query UCVM on a variety of community velocity models and retrieve data products, such as site profiles, horizontal slices, and vertical cross-sections, to evaluate and compare velocity models.

SeisSol earthquake-tsunami

Advances in numerical modeling have enabled the coupling of 3D earthquake dynamic rupture and tsunami generation. However, with increased model complexity, there remains the need for community benchmark exercises to ensure that different numerical implementations yield consistent results for identical scenarios. Recently, two benchmark problems, developed jointly by CRESCENT and SCEC/USGS, extended a 3D shallowly dipping thrust faulting dynamic rupture problem including surface rupture (Harris et al., 2018) to tsunami generation and acoustic wave propagation (https://doi.org/10.5281/zenodo.15389414). Downscaled versions of “The Tsunami Problem Versions” TTPV1 and TTPV2 to model fully coupled earthquake dynamics and tsunami generation can be run through the SeisSol App on the Quakeworx Gateway. Following the corresponding SeisSol Training exercises (https://github.com/SeisSol/Training/tree/main/earthquake-tsunami), users can adapt these simulations and include e.g., receivers in the modeling domain. A newly developed Code Verification Platform for benchmark exercises based on Amazon Web Services allows users to upload a single file for quick comparison without authentication (Bachelot et al., 2026).

Quakeworx supports a range of earthquake simulation and visualization tools



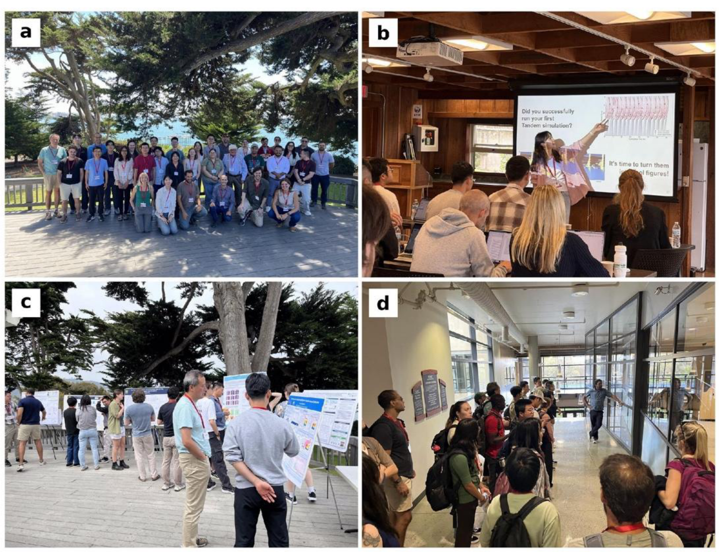
Visit Quakeworx for a full list of **Applications.** *Overview of Quakeworx Apps was presented by SIO PhD student John Rekoske at SSA 2026.*

Recent education activities include:

Tandem workshop

In June 2026, the SCEC Tandem Training Workshop brought 39 early-career researchers from 22 institutions across 8 countries to the Scripps Institution of Oceanography at UC San Diego for an intensive, hands-on introduction to physics-based earthquake-cycle modeling. Over two and a half days, participants learned about the state of the art in Sequences of Earthquakes and Aseismic Slip (SEAS) research through invited speakers and participant talks, and learned to design, mesh, run, and interpret SEAS simulations using Tandem, an open-source high-performance computing code. Tandem's Quakeworx implementation is described in a newly published paper in Seismological Research Letters (Gabriel et al., 2026).

Quakeworx was central to the training, with participants using the science gateway to run Tandem simulations on the Expanse supercomputer without having to compile Tandem or secure HPC allocations. Participants were given full access, and they continue to use the gateway to advance their own research after the workshop. Participant feedback was enthusiastic, and many left ready to bring Quakeworx into their own research, extending the reach of accessible, HPC-emempowered SEAS modeling to a new generation of scientists.



2026 SCEC Tandem Training Workshop at the Scripps Institution of Oceanography and touring the San Diego Supercomputer Center

SeisSol workshop

In celebration of 20 years of SeisSol, a user workshop, training and hackathon brought together 63 participants on June 11 & 12, 2026. Over these two days, scientific talks and keynote presentations at the Leibniz Supercomputing Centre in Garching, Germany, highlighted two decades of computational innovation in SeisSol alongside ten years of ExaHyPE. Participants explored state-of-the-art advancements in high-order discontinuous Galerkin methods for hyperbolic PDE systems, learning to configure, run, and interpret simulations of earthquake dynamic rupture and seismic wave propagation using these open-source codes. Science and training presentations are made available online: https://www.geo-inquire.eu/dissemination/workshops/seissol.

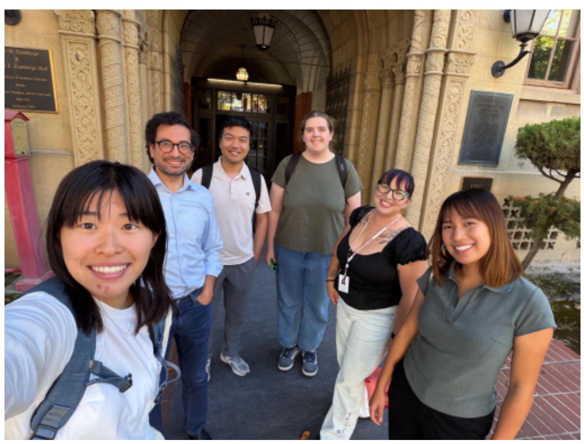
The Quakeworx science gateway enabled attendees to run SeisSol simulations on the Expanse supercomputer without needing to handle code compilation or apply for independent HPC allocations. Participants received allocated computational resources from SDSC, facilitating participants to apply these tools directly to their own project workflows during the hackathon and beyond. Attendees left the workshop ready to use the Quakeworx gateway for future research and education.

2026 Joint SeisSol & ExaHyPE User Workshop, Training and Hackathon at the Leibniz Supercomputing Centre in Garching, Germany (https://cheese2.eu/news/flagship-codes-seissol-and-exahype-celebrate-20-and-10-years-of-computational-innovation-in-cheese-training)

SCEC Interns training on Earthquake Scenarios

This summer, between June 8 and July 31, SCEC hosted four SURE interns—Clare Ip of Dartmouth College, Ashley Seeman of San Diego State University, Tomoka Yanao of Princeton University, and Laura Garnet-Jones of UCLA—to support ShakeOut Scenario 2.0 research using the Quakeworx science gateway. From June 8 through July 31, the interns received training in Quakeworx, OpenSHA, SCEC Community Velocity Models, the Broadband Platform, high-performance computing, and earthquake physics. They then applied these tools to physics-based simulations of a potential magnitude 7.8 earthquake on the southern San Andreas Fault.

Using SeisSol (Gabriel et al., 2025) (Gabriel et al., 2025) on the Expanse supercomputer through Quakeworx, the team tested dynamic rupture scenarios that incorporated updated SCEC fault, velocity, stress, and thermal models. The simulations explored how fault geometry, stress conditions, and shallow frictional behavior influence rupture propagation and ground shaking, including strong northward directivity and pronounced shaking in the Los Angeles Basin. The results will inform the next phase of ShakeOut Scenario 2.0, and the associated models and data products are planned for open release through Quakeworx to support future research, education, and resilience planning.



The 2026 SCEC Summer Interns with Drs. Chunhui Zhao and Ahmed Elbanna

Science Gateway Platform

Quakeworx continued its early-user phase over the past several months, providing valuable experience that has driven improvements to application workflows, usability, security, platform stability, and integration with HPC resources.

- **Faster application launch:** Application cards now provide launch options directly from the application catalog, reducing the steps required to start applications.
- **Improved file management:** New file management widgets allow users to select and reuse existing files when configuring and launching applications, simplifying workflows that use data already available in the computing environment.
- **Cleaner job management:** User interface improvements allow users to hide jobs that are no longer relevant, making job listings easier to navigate and allowing users to focus on current work.
- **More secure interactive sessions:** Jupyter notebook sessions now use token-based access instead of passwords, providing more secure yet seamless access to interactive computing sessions.
- **Expanded HPC integration:** We completed a test integration with TACC's Stampede3 cluster, extending workflow validation across additional national HPC resources.
- **Security and stability:** We incorporated additional security, reliability, and stability improvements across the platform to strengthen application access and improve the robustness of services and workflows.

The OneSciencePlace (OSP) platform that powers Quakeworx continues to gain adoption. The project recently received a new NSF award to develop and deploy the Interactive Discovery Laboratory (iDLab) across five advanced computing centers and two cloud providers. iDLab will provide a consistent catalog of interactive applications for researchers, educators, and students, along with a unified data system across all sites. Visit the project website for more information and to get involved.

Event Pages

The SCEC Event Pages system is undergoing a major architectural overhaul to improve rapid-response capabilities, security, and extensibility. Moving away from the legacy PHP framework, the new system consolidates page generation logic directly into Java and shifts the workflow to new Quakeworx applications, including "Generate Event" and "Event Publisher." This modernized pipeline securely stages preliminary event reports and UCERF3-ETAS results in private repositories until authorized users choose to publish them to GitHub Pages. This transition not only simplifies the generation process but also allows researchers to manually customize published HTML pages without losing their changes upon regeneration.

Computational resources

Quakeworx simulations are supported by an NSF ACCESS Discover allocation, which provides computational resources on any system in the NSF ACCESS ecosystem. The *Expanse* system at the San Diego Supercomputing Center provides the computational infrastructure for the majority of Quakeworx applications, and we are currently adding support for *Stampede3* at the Texas Advanced Computing Center, which will increase Quakeworx throughput and make possible additional applications which require different architectures.

Recent Quakeworx-related Publications

Journal papers

Bachelot, L., Kutschera, F., Barall, M., Erickson, B.A., Dunham, E.M., Gabriel, A.A., Harris, R., Ma, S., Thomas, A.M. and Zhang, W., 2026. CRESCENT Earthquake Dynamic Rupture, Earthquake Cycle, and Tsunami Code Verification Platform. *Seismica*, doi: 10.26443/seismica.v5i2.2716

Gabriel, A.A., Karki, P., Magen, Y., Oryan, B., Ulrich, T., Yun, J. and May, D.A., 2026. Tandem: An Open-Source High-Performance Computing Volumetric Software to Model Sequences of Earthquakes and Aseismic Slip Across Complex Fault Systems, *Seismological Research Letters*, doi:10.1785/0220250436.

Niu, Z., Kruse, M., Seelinger, L., Schliwa, N., Igel, H. and Gabriel, A.A., 2026. Constraining On- and Off-Fault Nonlinear Dynamic Rupture Parameters via Hierarchical Bayesian Inversion for the 2019 Mw 7.1 Ridgecrest Earthquake. *Earth and Planetary Science Letters*, doi: 10.1016/j.epsl.2026.120061.

Rekoske, J. M. Scott Callaghan, Kevin R. Milner, Dave A. May, and Alice-Agnes Gabriel, 2026. Efficient physics-informed ground motion simulations with reduced-order models: CyberShake implications and high resolution site terms for Southern San Andreas Fault earthquakes. *Bulletin of the Seismological Society of America*, doi:10.1785/0120260021.

Zhao, C., Y. Ben-Zion, and A. Elbanna, 2026. Depth Dependent Fault Zone Damage in 3D Simulations of Dynamic Rupture on a frictional fault with brittle Damage Breakage Rheology in the bulk (to be submitted)

Yeh, T.-Y., Y. Ben-Zion, and K. B. Olsen, 2026. Multi-Scale P and S Seismic Velocity Models of California and Western Nevada, *J. Geophys. Res.*, in review.

Upcoming Quakeworx Conference Presentations and Related Events

Quakeworx will be represented at the 2026 SCEC Annual Meeting (Palm Springs, August 30 - September 2) and at the AGU Annual Meeting 2026 (San Francisco, December 7-11), with team abstracts recently submitted to both meetings. UCLA team members Benjamin Winjum and Amit Chourasia will present an overview of recent Quakeworx developments at the SCEC Annual meeting. SIO PhD student Fabian Kutschera will present the Quakeworx science gateway in an invited presentation at AGU.

- Chourasia, A., Youn, C., Silva, F., Oryan, B., Zhao, C., Yun, J., Tainpakdipat, N., Kutschera, F., Bhatthal, A., Marschall, E. O., Serafini, F., Winjum, B. J., Ronquillo, J., Maechling, P. J., May, D. A., Elbanna, A. E., Gabriel, A., & Ben-Zion, Y. (2026, 08). Quakeworx: A Community Science Gateway for Earthquake Research, Education, and Cybertraining. Poster Presentation at 2026 SCEC Annual Meeting.

- Kutschera, F., Chourasia, A., Youn, C., Silva, F., Oryan, B., Zhao, C., Yun, J., Tainpakdipat, N., Bhatthal, A., Marschall, E., Rekoske, J., Serafini, F., Winjum, B., Ronquillo, J., Maechling, P. J., May, D. A., Elbanna, A. E., Gabriel, A. & Ben-Zion Y. (2026, 12). Quakeworx: A Community Science Gateway for Earthquake Research, Education, and Cybertraining. Invited Presentation at 2026 AGU Annual Meeting.

- Online tutorial: Deploying Research and Education Apps on ACCESS and NAIRR Resources with iDLab and OneSciencePlace. View agenda and registration information.

References:

Dieterich, J. H. (1979). Modeling of rock friction: 1. Experimental results and constitutive equations. Journal of Geophysical Research: Solid Earth, 84(B5), 2161–2168. https://doi.org/10.1029/JB084iB05p02161

Dieterich, J. H. (1981). Constitutive Properties of Faults With Simulated Gouge. In Mechanical Behavior of Crustal Rocks (pp. 103–120). American Geophysical Union (AGU). https://doi.org/10.1029/GM024p0103

Dieterich, J. H. (1995). Earthquake simulations with time-dependent nucleation and long-range interactions. Nonlinear Processes in Geophysics, 2(3/4), 109–120. https://doi.org/10.5194/npg-2-109-1995

Dieterich, J. H., & Richards-Dinger, K. B. (2010). Earthquake recurrence in simulated fault systems. Pure and Applied Geophysics, 167(8), 1087-1104.

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 (all versions) [Computer software]. Zenodo. https://doi.org/10.5281/zenodo.4672483

Harris, R. A., Aagaard, B., Barall, M., Ma, S., Roten, D., Olsen, K., Duan, B., Liu, D., Luo, B., Bai, K., Ampuero, J. P., Kaneko, Y., Gabriel, A. A., Duru, K., Ulrich, T., Wollherr, S., Shi, Z., Dunham, E., Bydlon, S., … Dalguer, L. (2018). A suite of exercises for verifying dynamic earthquake rupture codes. Seismological Research Letters, 89(3), 1146–1162. https://doi.org/10.1785/0220170222

Linker, M. F., & Dieterich, J. H. (1992). Effects of variable normal stress on rock friction: Observations and constitutive equations. Journal of Geophysical Research: Solid Earth, 97(B4), 4923–4940. https://doi.org/10.1029/92JB00017

Marschall, E., Gabriel, A.A., Shaw, B., Yun, J., Kottke, A., Donahue, J. and Oskin, M., 2026. Fault Connectivity Controls Synthetic Earthquake Catalogs and 30-Year Rupture Probabilities in RSQSim Simulations of the Eastern San Francisco Bay Area. 2026 SCEC Annual Meeting and AGU Annual Meeting 2026.

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

Rekoske, J., D.A. May, A.-A. Gabriel (2025). "Reduced-order modeling for complex 3D seismic wave propagation", Geophysical Journal International, 241, 526–548, doi:10.1093/gji/ggaf049

Richards‐Dinger, K., & Dieterich, J. H. (2012). RSQSim Earthquake Simulator. Seismological Research Letters, 83(6), 983–990. https://doi.org/10.1785/0220120105

Ruina, A. (1983). Slip instability and state variable friction laws. Journal of Geophysical Research: Solid Earth, 88(B12), 10359–10370. https://doi.org/10.1029/JB088iB12p10359