2026 Workshop Report for SCEC Award 26018:
2026 SCEC Workshop Proposal: Community Stress Drop Validation Project

2026 SCEC Stress Drop Workshop: Phase II

August 20, 2026 In-Person Workshop at USGS Moffett Field, CA

https://www.scec.org/events/2026-community-stress-drop-validation-workshop-phase-ii/

Cover Figure: Group photo from in-person participants at the workshop at the USGS Moffett Field.

Submitted by Annemarie Baltay
and Rachel Abercrombie

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Amount Requested: $21,500
Category: Workshop Proposal
Conveners: Annemarie Baltay (USGS) and Rachel Abercrombie (Boston University)

Community Stress Drop Validation Project Overview

The Community Stress Drop Project is focused on understanding the nature and causes of discrepancies in earthquake spectral stress drop, as well as where random and physical variability arises, and effectively disseminating these results towards more effective collaboration with key users of earthquake stress drop. The importance and timeliness of this work is evidenced by the large, global attendance (> 100 people from 7 continents) at virtual workshops, regular attendance at informal zoom meetings, and well-supported Special Sessions at multiple AGU, SSA, JpGU and EGU meetings.

Stage 1 of the Community Project began in 2021 with the Ridgecrest Study (Baltay et al., 2024), in which we distributed a common dataset to be analyzed by the community. The PIs have continually coordinated and led the Project through workshop organization, Zoom meetups, distribution of datasets, and designing and coordinating benchmarks. To date, we have received results from 20+ unique research groups for the 2019 Ridgecrest Earthquake sequence, for a total of 56 submissions (Abercrombie et al., 2025). Throughout the study, Abercrombie, Baltay, Cochran, Shearer and others have performed meta-analysis to guide the group comparisons (e.g., Abercrombie and Baltay, 2025; Shearer et al., 2024; Cochran et al., 2024). The team spearheaded and guest edited a successful BSSA special issue on the topic with 46 included papers (Baltay et al., 2025).

The Community Stress Drop Validation Study was recently approved and funded by SCEC as a new Technical Activity Group in July 2026, which we are terming Phase II. Phase II highlights three scientific objectives to *1) improve ground motion modeling*; *2) benchmark new methods and datasets of spectral stress drop*; and, *3) inform earthquake physics.* These three scientific objectives will be met through the project work elements of Community Datasets (Ridgecrest, synthetics, and Bay Area); Community Individual Analysis on spectral stress drop and site response and attenuation; and Meta-Analysis to compare submitted stress drops and site response, connect community stress drops to ground motion, compare seismic moment and magnitude, and understanding physical fault parameters.

2026 Workshop

The *2026 SCEC Stress Drop Workshop: Phase II* was held on August 20, 2026 at the USGS Moffett Field, CA. The workshop was attended by 39 people, 7 of whom were virtual and 11 of whom were students. As always, we encouraged attendance and participation from students and early career researchers, as well as those in other fields who are interested in learning more or applying stress drop methods.

This workshop was designed to kick off two specific components of the TAG Phase II: the Bay Area empirical dataset, and the synthetic experiment. A key component of the TAG remains benchmarking and testing existing and emerging methods of isolating the source component of recorded seismograms and measuring source, propagation and site properties. To continue on this path and also continue to engage the community, we decided to develop a new empirical dataset. At the January 2026 virtual workshop, several regions for study were presented by community members, and the “San Francisco Bay Area” was voted the top choice. At this current August 2026 workshop, we wanted to select the specific region of the Bay Area to study and explore scientific aims.

Secondly, it has long been suggested that we should use synthetic or simulated ground motion data in order to verify our methods. Complex rupture simulations or kinematic ground motion models rely on observational estimates of stress release, or path attenuation and site effects, that are often derived from spectral or point source modelling of methods, of the type used by the stress drop community. The long term goals are to move towards using more realistic, complex synthetics to test methods on more realistic simulations, and improve understanding of how the seismic measurements relate to the stress on the fault. First we must start with a simple set up to understand where our methods differ, and improve and verify them against input values. We will then vary the input values and starting models and see how the methods compare, gradually adding different types of complexity in turn. Therefore, we started with very simple, point-source, co-located, spectra-only data.

The overall scientific aims for the workshop were to develop the designs for the synthetic data tests through initial analysis of the first synthetic data, as well as select the optimal Bay Area empirical dataset. The workshop was designed to have lots of time for discussion between participants, and featured an in-person poster session to enable participants to showcase and discuss ongoing work on stress drop and related topics. 11 posters were displayed throughout the entire day.

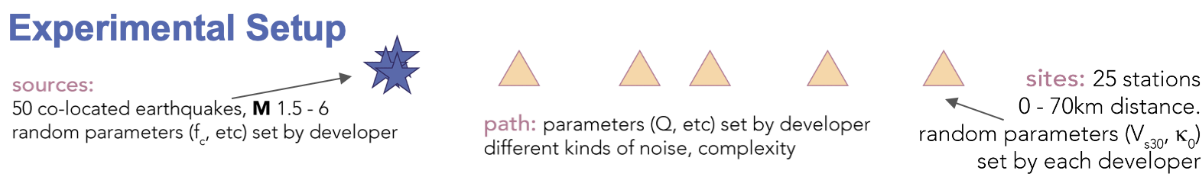

Figure 1. Synthetic experiment design set up. 50 co-located earthquakes of M1-6, recorded at 25 stations given only by their distance away from 1 to 70 km.

<u>Pre-Workshop: Synthetic Point-Source Data.</u> In order to meet the first goal of the workshop, to develop synthetic tests, we distributed an initial, simple set of synthetic data to the community on July 20, 2026, one month prior to the workshop. Four Developers (Baltay, Bindi, Ji and Shearer) each contributed a dataset of Fourier amplitude spectra for 50 co-located earthquakes of magnitude 1 to 6, recorded at 25 stations at distances of 1 to 70km (Figure 1). In discussions among the Developer group including Abercrombie leading up to the July 20 distribution date, it was decided that all four Developers would use the same magnitude and station distribution, but were free to vary other parameters related to their synthetic generation. However, all methods were similar, relatively simple point-source stochastic-type methods, that started by specifying a source spectral shape, and then added path and site effects (Figure 2). The details of the input parameters for each dataset were kept a secret, and the data was distributed to the entire community, through the Stress Drop Validation email list and Google Drive.

In response to this call, 18 unique individual researchers analyzed the spectral data and submitted estimates of corner frequency, moment, and site parameters such as k0, site amplification or t*, source and site spectra, and associated uncertainties. Baltay and Abercrombie rapidly harmonized the various submitted data and compared the estimated parameters to the true, input parameters, to be shown and discussed at the workshop.

Session I: Welcome and Introduction. Baltay welcomed everyone to the USGS Moffett Field and participants gave introductions. Abercrombie then gave an overview of the Stress Drop Validation TAG and the community work to date.

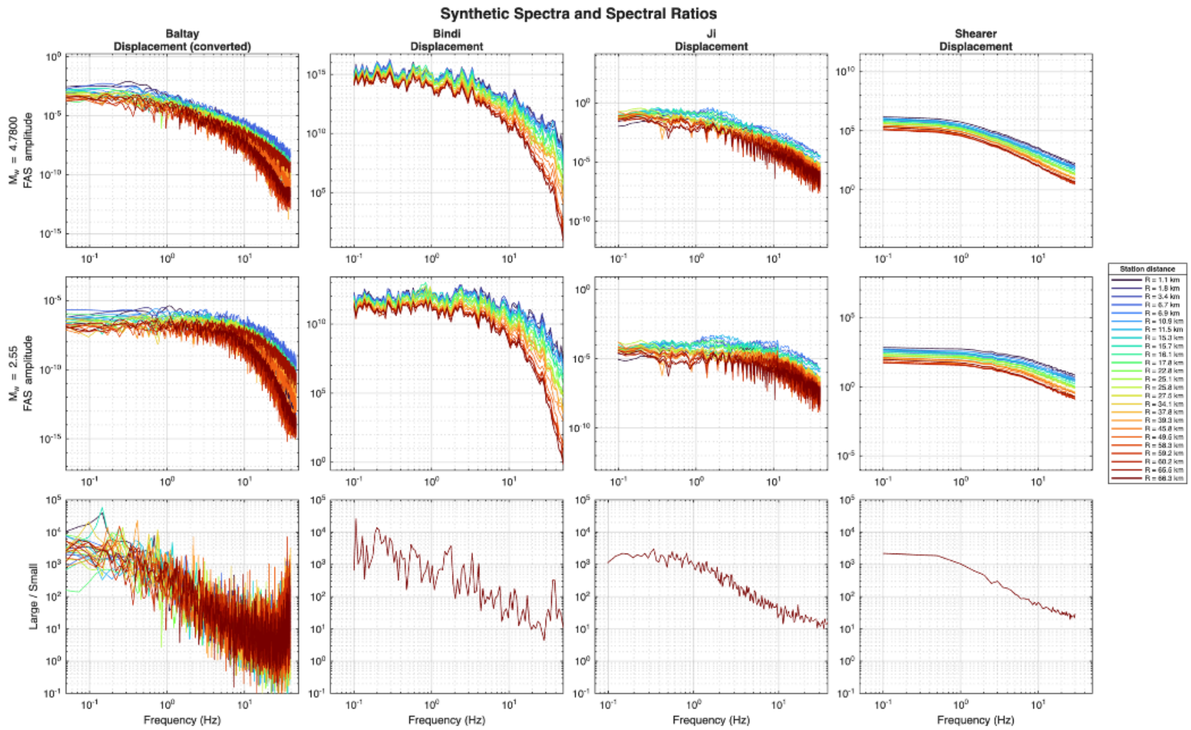

Figure 2. Example earthquakes for the four sets of synthetic, point-source, stochastic spectral data. Each column is one dataset, generated by Annemarie Baltay (left column), Dino Bindi (second column), Chen Ji (third column) and Peter Shearer (right column). (Top row) Displacement spectra for an M4.78 earthquake and (middle row) M2.55, and (bottom row) the ratio between the two, with station distance in color. Note that for all but the Baltay data, there is no site-to-site variability and the ratios of the two earthquakes plot on top of each other for all stations.

Session II: Synthetic Data Exercise. Session II focused on discussing the development of the current synthetic data, methods used by the Contributors for the current experiment, comparison of results, and discussion of next steps. Baltay first mentioned that the motivations for this current, simplistic experiment are to perform more rigorous verification of methods on data with inputs that are consistent with how the community considers them, i.e., spectral corner frequency. We will then increase the complexity of the synthetic data to consider tradeoffs and uncertainties in how different methods can separate source, site, and path effects, identifying the effects of heterogeneity in each part, using multiple, carefully designed synthetic experiments.

Baltay unveiled the input parameters from the four dataset Developers and then compared the submitted estimates to those known values. A wide ranging discussion ensued, focusing on decisions that various Contributors made that got them closer or farther from the true results, and how that reflected decisions the dataset Developers made. For example, Shearer decided not to use *n=2* for the high-frequency spectral falloff, and rather randomly varied the falloff rate between *n=1.6* and *n=1.8* for different events. This caused many Contributors to get the wrong answers for the Shearer data (Figure 3, right), as most Contributors assumed or fixed *n=2*. However, a few Contributors tried varying *n* or assumed it was *<2*, and they were more successful in recovering the true corner frequencies. Contributors were most easily able to recover the correct input values for the Ji dataset, which was determined to be because the variability in the stress drop and site parameters was low. On the other hand, the Baltay dataset was the only one with varying site randomness and was perhaps more difficult to model. It was instructive to see how much the method of constructing the synthetic spectra, and the types of randomness added affected the results.

We discussed how to describe and include various sources of complexity, noise, and randomness, and the difference between them. We also discussed the next steps for slowly increasing complexity and noise in more synthetic datasets. As a result we have a community-informed plan for moving forward with the next stages of the synthetic experiments.

After a lunch and poster break and Session III, we returned to our Session II discussion and heard from various Contributors who analyzed the synthetic data. Several Contributors presented slides explaining the challenges and approaches they took to estimate spectral parameters using these datasets.

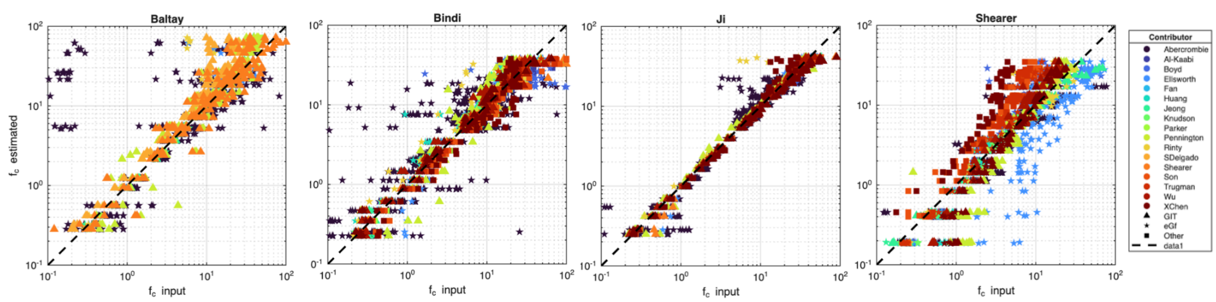

Figure 3. Submitted estimated corner frequencies (f_c) from 17 participants given in different colors, classifying the spectral $f_c$fmethods into three general categories of Generalized Inversion Technique (GIT/Spectral Decomposition, triangles); Empirical Green's Function technique (eGf; Spectral Ratios, stars); and other (squares) which are amplitude based or combination methods. Each dataset compared separately, given in the four panels.

<u>Session III: San Francisco Bay Area Empirical Dataset</u>. Led by Taka'aki Taira, Session III looked a several options for regions within the Bay Area for focus. Elizabeth Cochran presented three regions (Figure 4): 1) The Hayward-Berkeley-northern Calaveras region; 2) San Ramon area, which recently experienced an intense swarm; and, 3) the southern Calaveras-San Andreas Fault region. Sarah Minson then added some detail regarding the ongoing work in the San Ramon region.

As a group, it was decided that the Hayward-Berkeley-Calaveras region would be used, and extended slightly to the north to include the 2014 South Napa earthquake (seen by the orange dot on Figure 4-right). Taira agreed to process and create the dataset. The first step, to be completed in the next few months, is to check that there are sufficient recent data for the different approaches used by different community members. Assuming that is fine, the dataset will be created and distributed at the 2027 January Virtual Workshop.

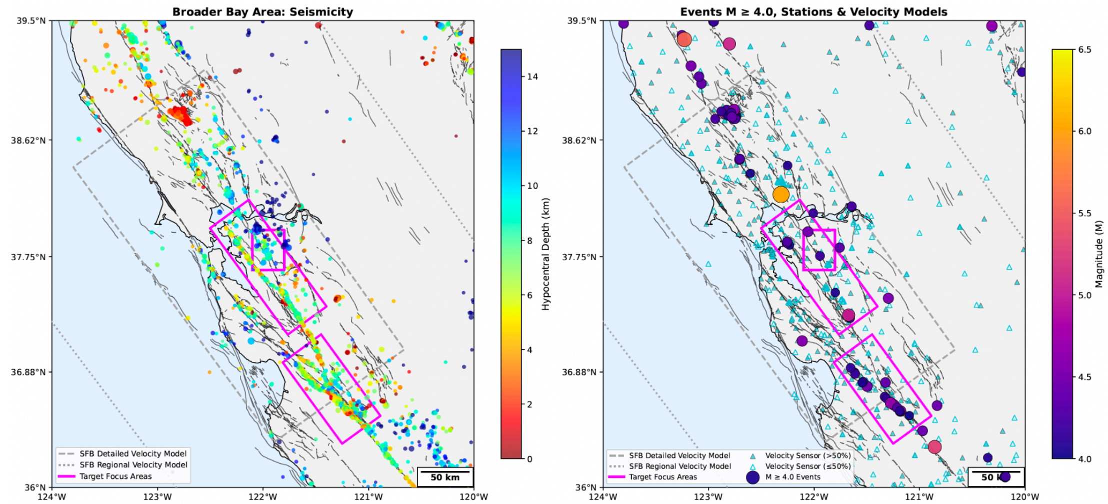

Figure 4. San Francisco Bay Area seismicity by depth (left) and magnitude (right). Dashed grey boxes are the extent of the SFVCM velocity model, and three pink boxes show potential Bay Area focus regions: Hayward-Berkeley-Calaveras, San Ramon area, and southern San Andreas Fault-Calaveras region.

Workshop Outcomes and Next Directions for the Community

The workshop was very successful in that we ended with several concrete directions., which were decided upon in the last part of the workshop during the recap discussion.

<u>Synthetic data and experiments:</u>

- Contributors and new researchers are encouraged to continue to analyze current Experiment One: What are the effects of limited bandwidth? Now that inputs are known contributors can investigate what would need to be changed to get the “true” values.
- Think about how we define noise, un-modelled complexity, randomness, etc.
- Continue to perform meta-analysis on this data to understand trends in different analysts, tradeoffs in source and site parameters, and other features.
- Compare source and site spectra between Contributor analysts.
- Create multiple datasets of increased complexity: complex/compound sources; more complex and realistic velocity models; noisier sites.
- Consider how much source, site, path complexity or noise is necessary to create records or results that look like the real world?
- Simulation method affects results: Continue to use a variety of synthetic datasets and consider goals for each experiment when designing synthetics.

<u>Bay Area Dataset:</u>

- Test and confirm the Hayward-Berkeley-Calaveras + Napa + San Ramon region.
- Goal is to distribute the data at the January 2027 virtual workshop.

<u>Community building:</u>

- Hold a virtual Zoom in mid-October to update the entire community on results and plans.
- Continue with discussion-based meetings and workshops, following the post-workshop survey in which many people cited “group discussions” as being an element that contributed most to their learning experience.

References

Abercrombie, R. E., A. Baltay, S. Chu, T. Taira, D. Bindi, O. S. Boyd, X. Chen, E. S. Cochran, E. Devin, D. Dreger, et al. (2025). Overview of the SCEC/USGS community stress drop validation study using the 2019 Ridgecrest earthquake sequence. Bull. Seismol. Soc. Am. https://doi.org/10.1785/0120240158.

Abercrombie, R. E., and A. S. Baltay (2025). Magnitude, depth, and methodological variations of spectral stress drop within the SCEC/USGS community stress drop validation study using the 2019 Ridgecrest earthquake sequence. Bull. Seismol. Soc. Am., 115(6), 2741–2768.

Baltay, A., R. E. Abercrombie, S. Chu, and T. Taira (2024). The SCEC/USGS community stress drop validation study using the 2019 Ridgecrest earthquake sequence. Seismica, 3(1). https://doi.org/10.26443/seismica.v3i1.1009.

Baltay, A., R. E. Abercrombie, A. Oth, and T. Uchide (2025). Introduction to the special section on improving measurements of earthquake source parameters. Bull. Seismol. Soc. Am., 115(3), 723–733. https://doi.org/10.1785/0120250055.

Cochran, E. S., Baltay, A., Chu, S., Abercrombie, R. E., Bindi, D., Chen, X., Parker, G. A., Pennington, C., Shearer, P. M., & Trugman, D. T. (2024). SCEC/USGS Community Stress Drop Validation Study: How spectral fitting approaches influence measured source parameters. Bull. Seismol. Soc. Am.

Shearer, P. M., I. Vandevert, W. Fan, R. E. Abercrombie, D. Bindi, G. Calderoni, X. Chen, W. L. Ellsworth, R. M. Harrington, Y. Huang, T. C. Knudson, M. Rossbach, C. Satriano, M. Supino, D. T. Trugman, and J. Zhang (2024). Earthquake source spectra estimates vary widely for two Ridgecrest aftershocks because of differences in attenuation corrections. Bulletin of the Seismological Society of America, 115(3), 777–791. https://doi.org/10.1785/0120240134

Appendix 1: August 20, 2026 Workshop Agenda

August 20, 2026

All times below Pacific Daylight Time (UTC -7)

08:30 - 09:00	Coffee, donuts, fruit	
09:00 - 09:30	**Session I: Welcome and Introduction**	Annemarie Baltay / Rachel Abercrombie
09:30 - 10:15	**Session II: Synthetic data exercise** *We will first discuss the current mini-community experiment on the simplistic synthetic data, including goals, comparative results, invited lightning talks from those who analyzed the data, and an open discussion. Then we will discuss future goals for creating a larger, more realistic or complex synthetic experiment.*	
	Introduction, experimental setup and goals for the current experiment, and comparative results	Annemarie Baltay
	Lightning talks presented by those who analyzed the current synthetics	All
10:15 - 10:30	**Break**	
10:30 - 12:00	Discussion of current results, and forward discussion for designing the next stages of the synthetic experiment	All
12:00 - 14:00	**Lunch and Poster Session**	

	Catered lunch followed by poster session and casual discussion. Posters encouraged on similar or related topics.	
14:00 - 16:00	**Session III: San Francisco Bay Area Empirical Dataset** *We will hear from several researchers with interest and experience in Bay Area data and uses, and then discuss what dataset to use. The goal for this session is to define the science targets as well as a region (box) and time frame for the next empirical dataset. We will also consider designing the synthetic data to match the catalog and station distribution from this Bay Area dataset.*	Taka'aki Taira Elizabeth Cochran Sarah Minson
16:00 - 16:15	**Break**	
16:15 - 17:30	Wrap up discussion, looking forward, future TAG plans	All
18:00	**Dinner in downtown Mountain View (not hosted)**	

Appendix 2: August 20, 2026 Workshop Participants - 39 total

** Remote attendance*

Last Name	First Name	Organization
Abercrombie	Rachel	Boston University
Al-Kaabi	Muntadher	Saint Louis University
Baltay	Annemarie	US Geological Survey
Beeler	Nick	US Geological Survey
Bonhoff	Marco	GFZ
* Boyd	Oliver	US Geological Survey
Burkett	Francesca	University of Michigan
Chen	Xiaowei	Texas A&M University
* Cochran	Elizabeth	US Geological Survey
Delgado Andino	Susana	University of Memphis, CERI
Elbanna	Ahmed	USC/SCEC
Ellsworth	Bill	Stanford University
Fan	Wenyuan	University of California, San Diego
Harris	Ruth	US Geological Survey
Hearn	Elizabeth	US Geological Survey
Hirakawa	Evan	US Geological Survey
* Huang	Kaiteng	University of Science and Technology of China
* Huang	Yihe	University of Michigan, Ann Arbor
Hutchings	Sean	Sandia National Laboratories

Jeong	SeongJu	New Mexico Institute of Mining and Technology
Ji	Chen	University of California, Santa Barbara
Kilgore	Brian	US Geological Survey
Knudson	Trey	Stanford University
Marcou	Savvas	Berkeley Seismology Lab
Marston	Alex	University of California, Santa Barbara
* Minson	Sarah	US Geological Survey
Murphy	Alex	
Olawoyin	Victor	Boston College
Parker	Grace	US Geological Survey
Pennington	Colin	Lawrence Livermore National Laboratory
Pollitz	Fred	US Geological Survey
* Rinty	Sadia Marium	University of Memphis
Shearer	Peter	University of California, San Diego
Skoumal	Rob	US Geological Survey
* Son	Minkyung	Korea Institute of Geoscience and Mineral Resources
Taira	Taka'aki	University of California, Berkeley
van der Elst	Nicholas	US Geological Survey
Walter	Bill	Lawrence Livermore National Laboratory
Wu	Qimin	Lettis Consultants International, Inc.