

SCEC/USGS Stress Drop Validation Technical Activity Group

Annemarie Baltay (USGS), Rachel Abercrombie (Boston U), Xiaowei Chen, Yihe Huang, Chen Ji, Peter Shearer, Daniel Trugman, Taka'aki Taira, Colin Pennington, Elizabeth Cochran, Dino Bindi, *Adrien Oth, Elisa Tinti, Camillo Pinilla-Ramos, Minkyung Son, Rebecca Harrington, Mariano Supino, Oliver Boyd, Olga-Jean Ktenidou, Ioannis Fountoulakis, Erion-Vasilis Pikoulis, Cliff Thurber, Hao Guo, Zhe Jia, Hongfeng Yang, Evan Hirakawa, Grace Parker, Sherry Nie, Taiga Morioka, Alex Marston, Francesca Burkett*

September 1, 2026

SCEC Annual Meeting, Palm Springs, California





Not just “Stress Drop”!

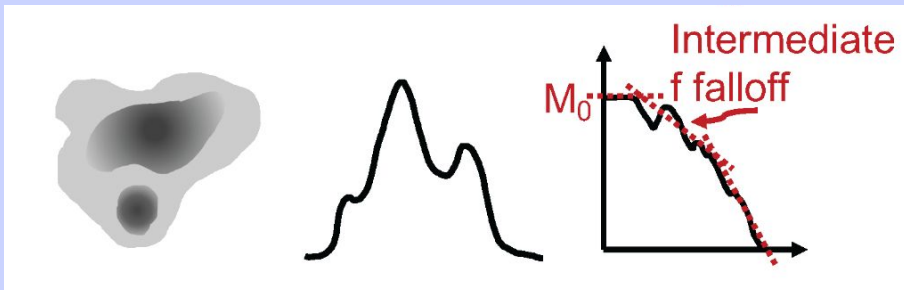
How to better characterise and quantify earthquake sources

What can we measure reliably?

What measurements do we need to answer science questions?

How can we best connect with ground motion modeling community?

1. Moment (or magnitude) - Lowest Frequency
2. Rupture area (or length) - Corner Frequency
3. Energy Radiated - Highest frequency





SCEC/USGS Stress Drop Validation TAG

Phase I: Quantified problem

First order problem: isolating source from path and site

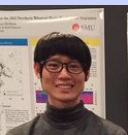
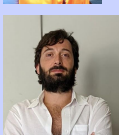
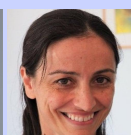
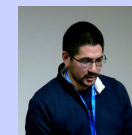
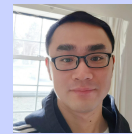
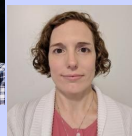
Brought Community together to work to solve it

Sparked method development to improve approaches

Found some consistent spatial variations common to all methods suggesting some REAL variation exists!

Phase II: Focus on improving quantification and characterisation of earthquake sources through 5 approaches:

global participation - Join us!





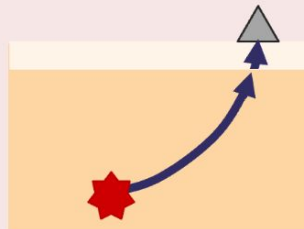
Seismogram = source * path * site

Simple Model
Assumptions

=



*

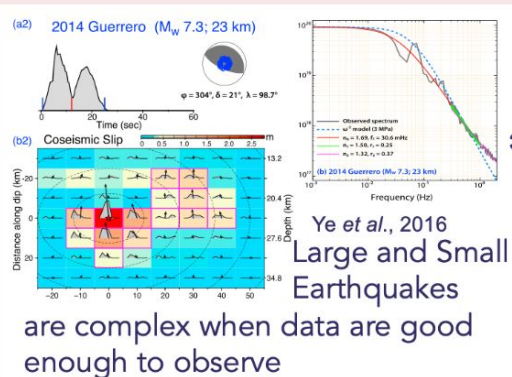


Site: Relative to reference site, often ignored, direct trade-off with source

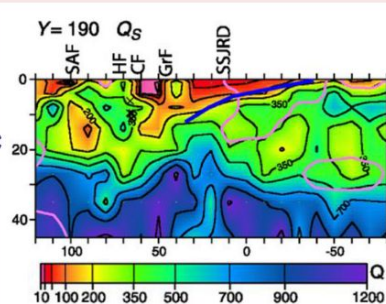
Path: 1D (or constant) attenuation structure, travel time dependent

Real Earth
Heterogeneity

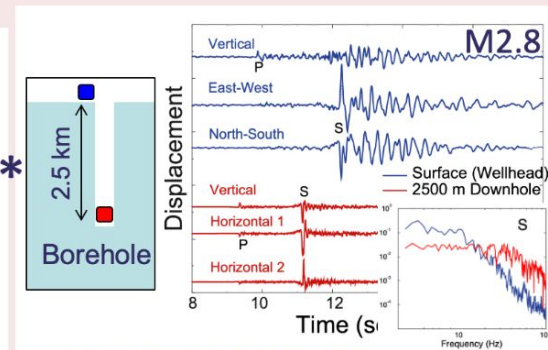
=



*



Attenuation heterogeneity along path



Abercrombie & Leary, GRL 1993;
Abercrombie, JGR 1995; BSSA 1997

Amplification and large attenuation in upper 100s-1000s m

Next Generation Ground
Motion Simulation,
Validation, and Utilization
(GM-SVU) in Seismic Hazard
and Engineering Applications: =
A New SCEC TAG

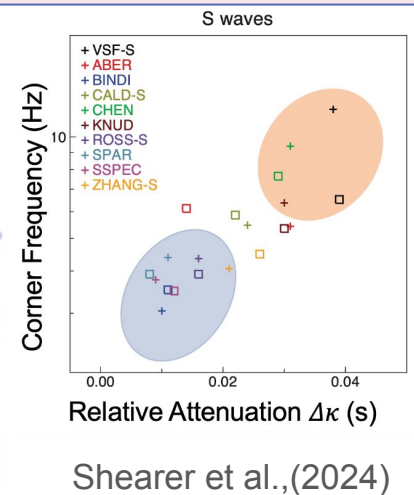
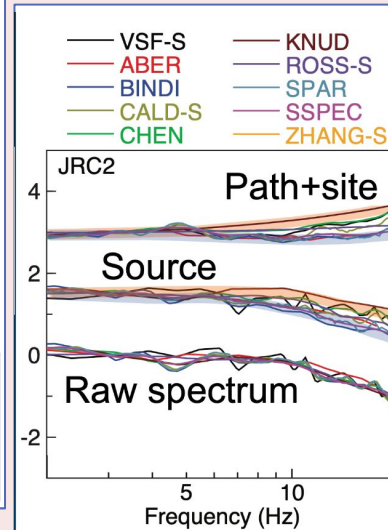
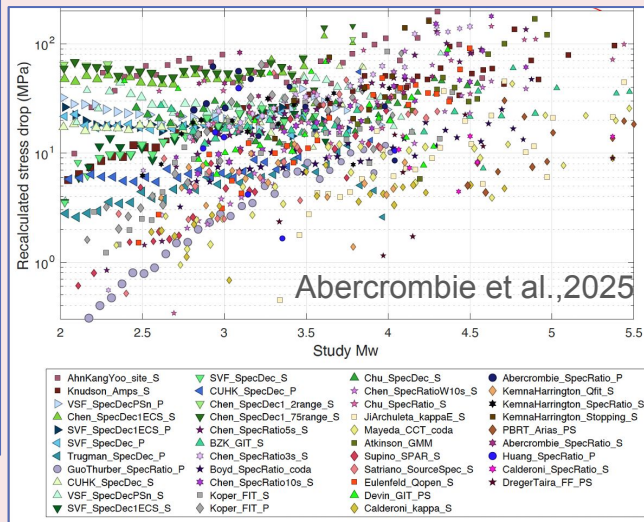
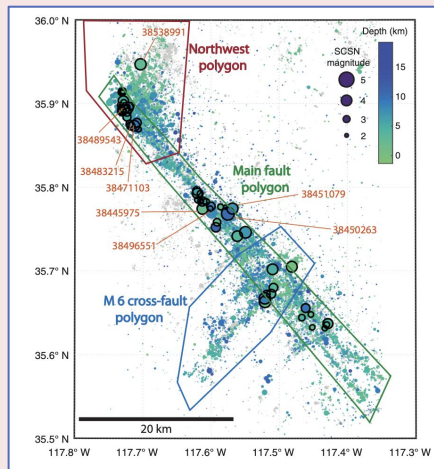
Community
Stress Drop (TAG) *

SCEC Community Earth Models
(CEMs); SCEC Multi-scale
Community Velocity Model TAG

* SEM: Shallow Earth Materials (TAG)



Phase I: Ridgecrest comparative experiment



BSSA

Bulletin of the
Seismological Society
of America

Improving Measurements of
Earthquake Source Parameters

Special Issue June 2025
42 papers!

+ Abercrombie & Baltay (August 2025)



Phase II: 1. Synthetic Experiments



Validating observed data - don't know the CORRECT answer

Use synthetic seismograms and spectra enables method verification

Challenge: Design a series of synthetic community comparisons to test very different approaches, balancing simplistic, to investigate specific trade-offs, with complex to simulate the real earth

Start simple: Community fitting and comparing results each time.

Experimental Setup

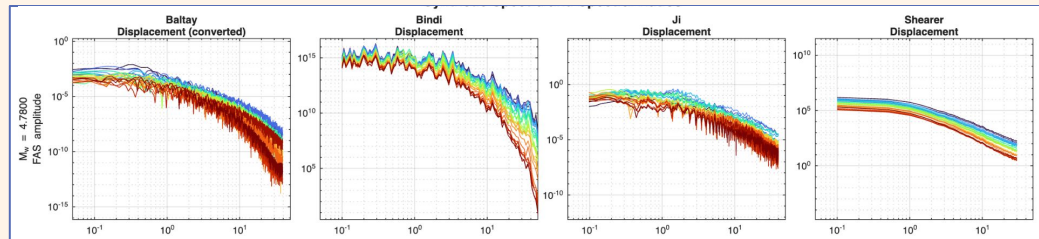
sources:

50 co-located earthquakes, M 1.5 - 6
random parameters (f_c , etc) set by developer

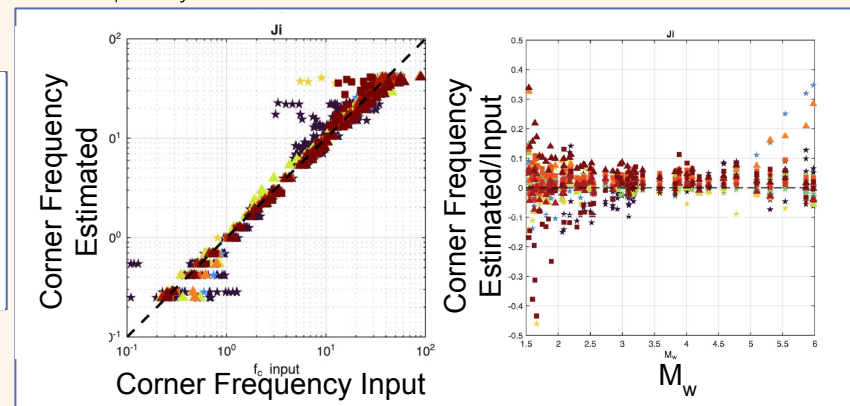


path: parameters (Q , etc) set by developer
different kinds of noise, complexity

sites: 25 stations
0 - 70km distance.
random parameters (V_{s30} , κ_0)
set by each developer

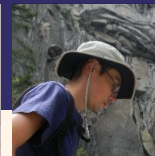


4 different ways of generating synthetics





2. Community Comparison: Bay Area Empirical Data set



Ridgecrest Study led to significant method development from community
Need to compare new approaches, are we converging?

Bay Area: Hayward/Calaveras Region

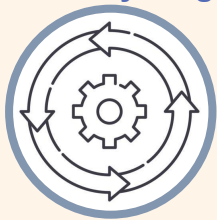
Selected by Community at August Workshop:

- High hazard w dense population
- Active seismicity w good station coverage
- High resolution velocity and Q models to test and improve source isolation
- Regional ground motion, site, and path studies for comparison
- Existing kinematic waveform simulation need improved source constraints

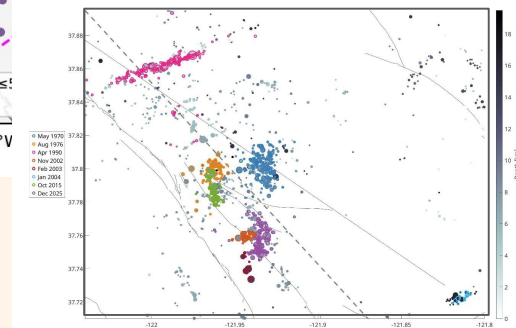
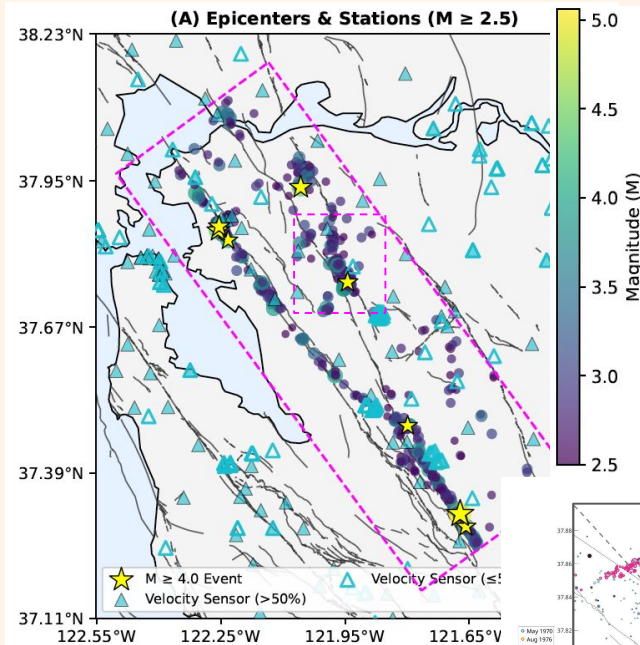
Scientific questions:

- Variety of fault locking behaviour
- Active san Ramon swarms

TAG 1 year goal: Compile dataset for distribution

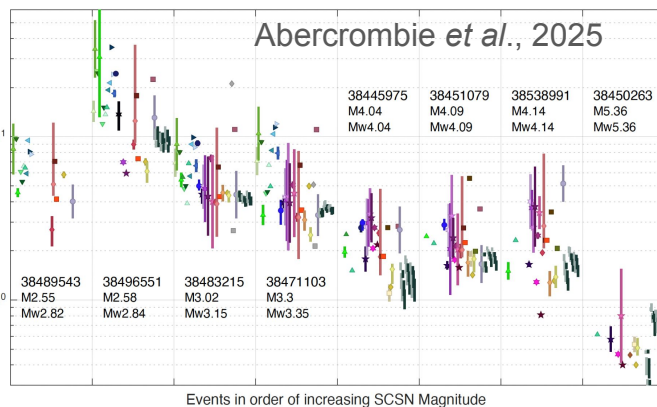
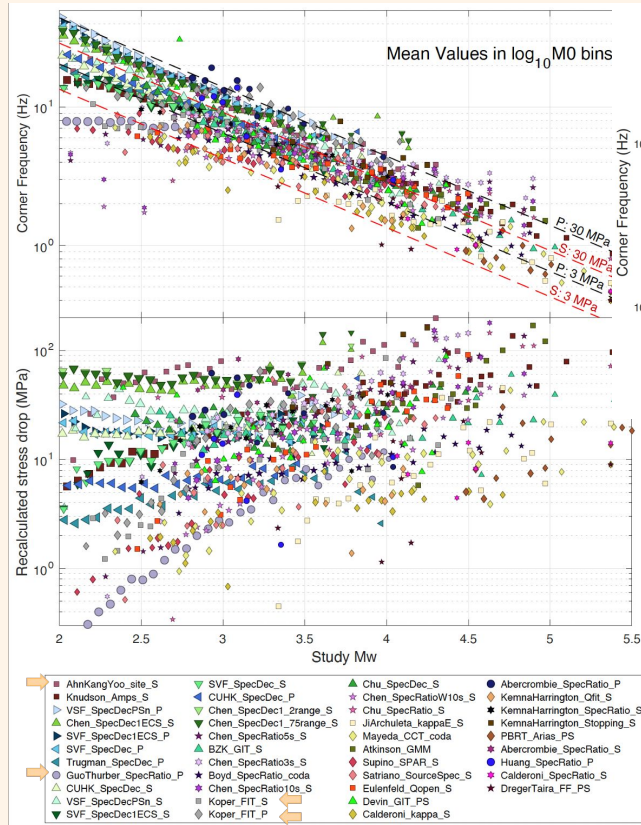


Compare, develop, compare, develop....



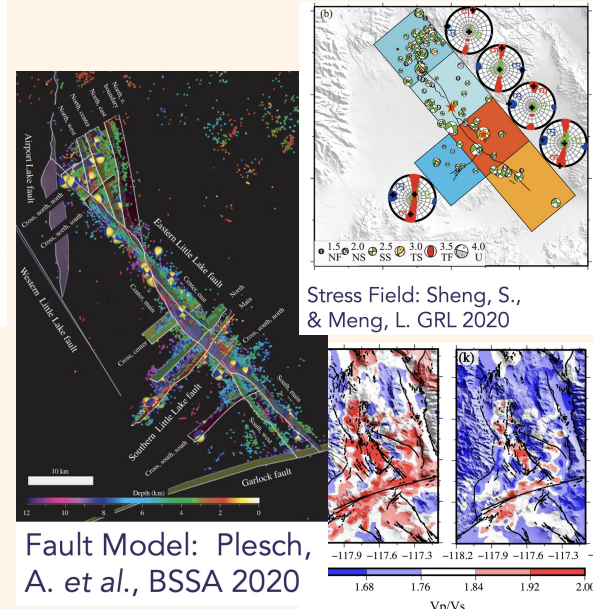


3: Ridgecrest Sequence - Benchmark and beyond



New submissions (→) welcome,
and continually accepted.
Contact Rachel or Annemarie

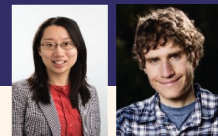
Compare spatial variations in stress
drop results with recent & ongoing
imaging to improve understanding of the
stress field, and with high-frequency ground
motion for non-ergodic models





4: Site terms

5: Magnitudes and moments

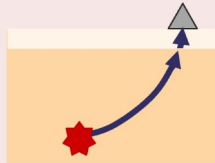


Simple Model
Assumptions

=

Circular source

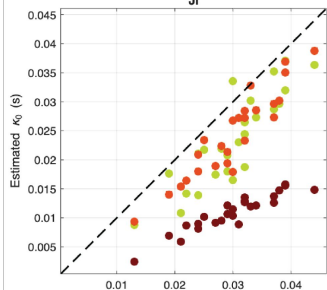
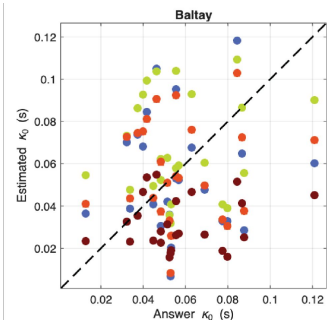
*



Site: Relative to reference site, often ignored, direct trade-off with source

Path: 1D (or constant) attenuation structure, travel time dependent

κ_0 Estimated

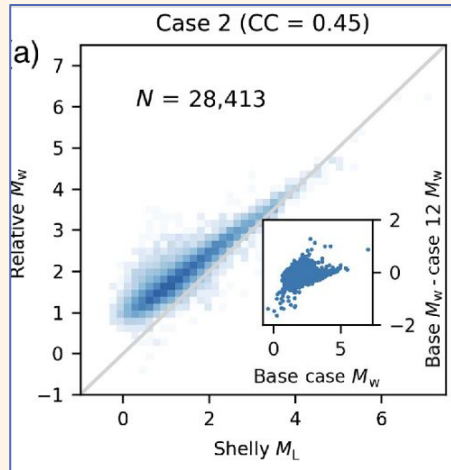


κ_0 Input

Study site terms/response and κ_0 to clarify trade-offs between source, and path/site amplification and attenuation.

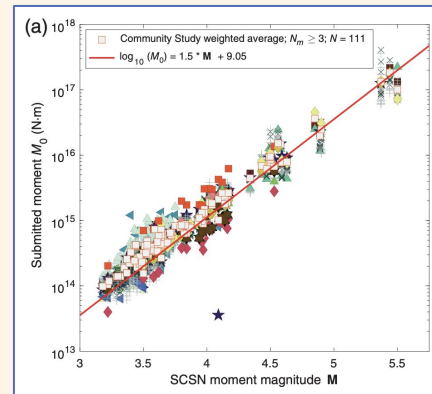
Ambiguity in correcting for near-surface effects was identified as a major source of discrepancies in the original Ridgecrest comparative study.

Work with near-surface, site response, velocity TAGs



Relative magnitude method
Gabel and Huang (2025)

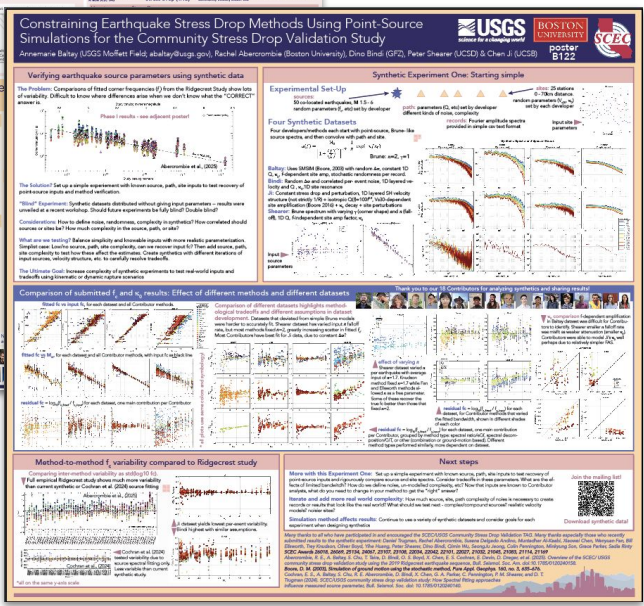
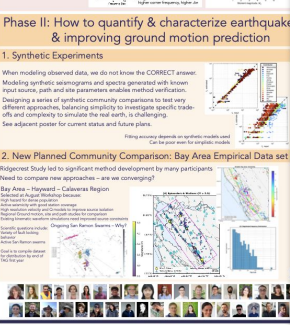
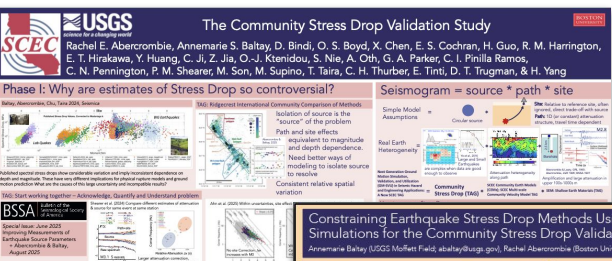
Moment directly trades off with f_c in fitting, need self-consistent techniques for moment and magnitudes, test on resultant stress drop estimates. Also important for GMM.



Community M_0 estimates from Ridgecrest
Baltay and Abercrombie (2025)

Come see the posters

Join us!



Group B, Seismology

#118 The Community Stress Drop Validation Study

Rachel E. Abercrombie, Annemarie S. Baltay, Dino Bindi, Oliver S. Boyd, Xiaowei Chen, Elizabeth S. Cochran, Hao Guo, Rebecca M. Harrington, Evan T. Hirakawa, Yihe Huang, Chen Ji, Zhe Jia, Olga-Joan Ktenidou, Shiyong Nie, Adrien Oth, Grace A. Parker, Camilo Ignacio Pinilla Ramos, Colin N. Pennington, Peter M. Shearer, Minkyung Son, Mariano Supino, Taka'aki Taira, Clifford H. Thurber, Elisa Tinti, Daniel T. Trugman, & Hongfeng Yang

#120 Constraining earthquake stress drop methods using point-source simulations for the Community Stress Drop Validation Study

Annemarie S. Baltay, Rachel E. Abercrombie, Dino Bindi, Peter M. Shearer, & Chen Ji

#122 Using a Ground-Motion Modeling Framework to Fit Stress Drops for the SCEC Community Stress Drop Validation TAG Synthetic Exercise

Grace A. Parker