The Community Stress Drop Validation Study

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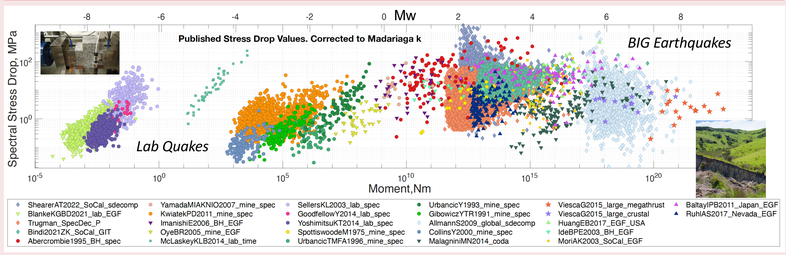
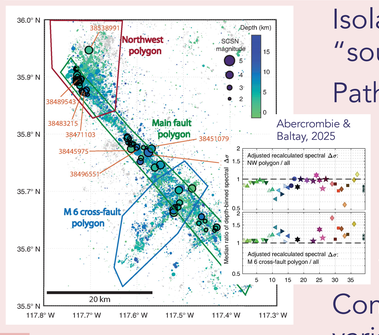
Phase I: Why are estimates of Stress Drop so controversial?

Baltay, Abercrombie, Chu, Taira 2024, *Seismica*



Published spectral stress drops show considerable variation and imply inconsistent dependence on depth and magnitude. These have very different implications for physical rupture models and ground motion prediction What are the causes of this large uncertainty and incompatible results?

TAG: Ridgecrest International Community Comparison of Methods



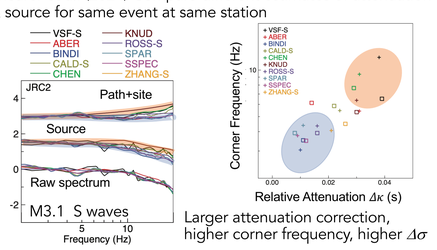
- Isolation of source is the "source" of the problem
- Path and site effects equivalent to magnitude and depth dependence.
- Need better ways of modeling to isolate source to resolve
- Consistent relative spatial variation

TAG: Start working together – Acknowledge, Quantify and Understand problem

BSSA Bulletin of the Seismological Society of America

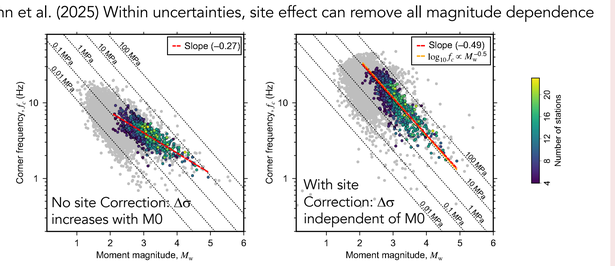
Special Issue: June 2025
Improving Measurements of Earthquake Source Parameters
+ Abercrombie & Baltay, *August 2025*

Shearer et al. (2024) Compare different estimates of attenuation & source for same event at same station



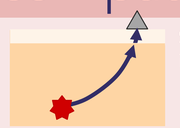
Larger attenuation correction, higher corner frequency, higher $\Delta\sigma$

Ahn et al. (2025) Within uncertainties, site effect can remove all magnitude dependence



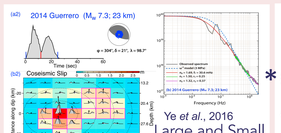
Seismogram = source * path * site

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

Real Earth Heterogeneity =



Large and Small Earthquakes are complex when data are good enough to observe

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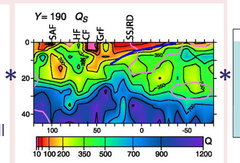

Attenuation heterogeneity along path

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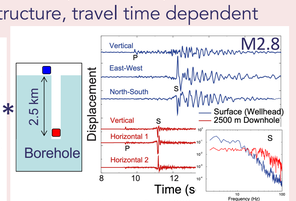


Abercrombie & Leary, GRL 1993; Abercrombie, JGR 1995; BSSA 1997

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

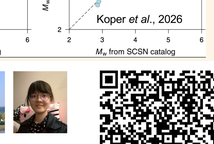
Next Generation Ground Motion Simulation, Validation, and Utilization (GM-SVU) in Seismic Hazard and Engineering Applications: A New SCEC TAG = **Community Stress Drop (TAG)** * **SCEC Community Earth Models (CEMs); SCEC Multi-scale Community Velocity Model TAG**

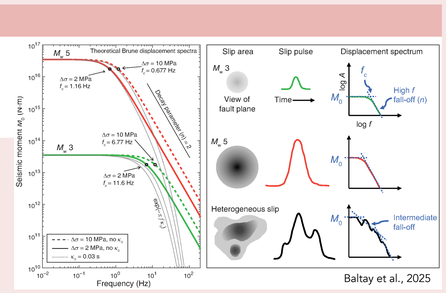
∗ **SEM: Shallow Earth Materials (TAG)**

How to measure Stress Drop

First isolate Source:
Stress release ∝ strain ∝ slip/ √area
rupture radius ∝ rupture duration (from source pulse), or
1/ corner frequency (from source spectrum)
Combine with moment (∝ area × slip) to get stress release

In Practice, a Balance:
-Trade-offs between inversion terms.
-Level of complexity in models with limits of data to constrain variables





Baltay et al., 2025

Phase II: How to quantify & characterize earthquake source observations for understanding rupture physics & improving ground motion prediction

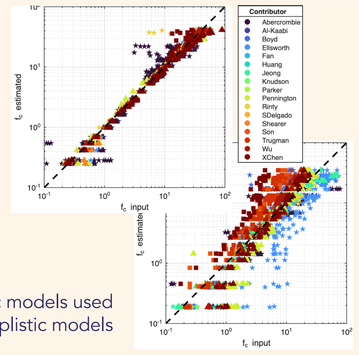
1. Synthetic Experiments

When modeling observed data, we do not know the CORRECT answer.

Modeling synthetic seismograms and spectra generated with known input source, path and site parameters enables method verification.

Designing a series of synthetic community comparisons to test very different approaches, balancing simplicity to investigate specific trade-offs and complexity to simulate the real earth, is challenging.

See adjacent poster for current status and future plans.



Fitting accuracy depends on synthetic models used
Can be poor even for simplistic models

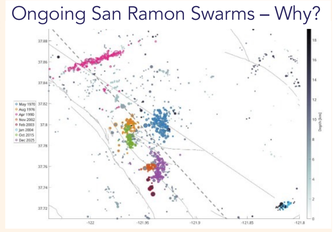
2. New Planned Community Comparison: Bay Area Empirical Data set

Ridgecrest Study led to significant method development by many participants

Need to compare new approaches – are we converging?

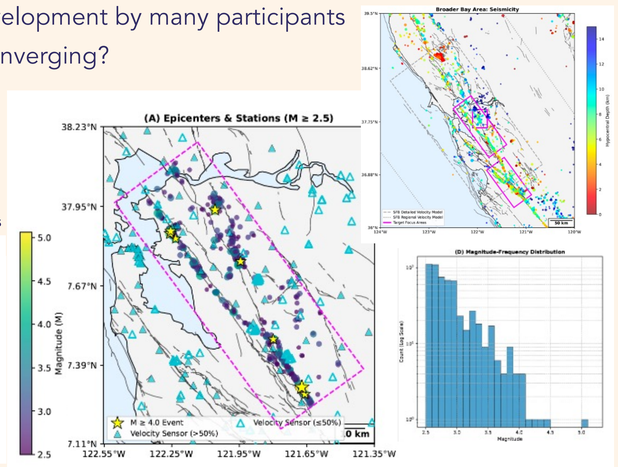
Bay Area – Hayward – Calaveras Region
Selected at August Workshop because:
High hazard for dense population
Active seismicity with good station coverage
High resolution velocity and Q models to improve source isolation
Regional Ground motion, site and path studies for comparison
Existing kinematic waveform simulations need improved source constraints

Ongoing San Ramon Swarms – Why?



Scientific questions include:
Variety of fault locking behavior
Active San Ramon swarms

Goal is to compile dataset for distribution by end of TAG first year



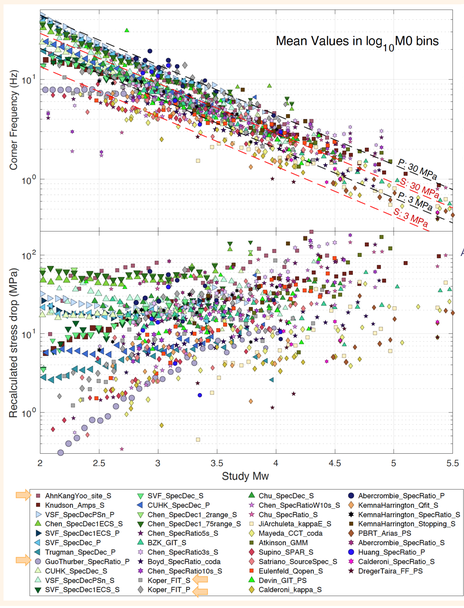
Working as a Community to Develop and Refine Methods & New Approaches

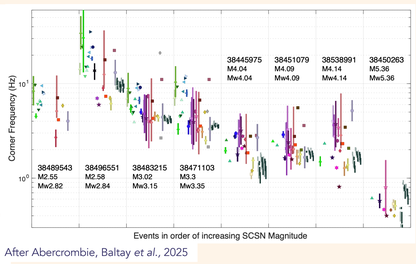
1. Testing and validating with Synthetic waveforms
2. Testing and validating with San Francisco Bay Area Data set
3. Using Ridgecrest as Benchmark for new approaches

Focus on smaller M which provide spatial and temporal resolution

Come Join Us

3. Ridgecrest: A benchmark for comparison, and further meta-analysis



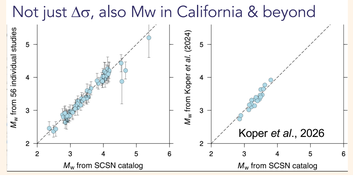


After Abercrombie, Baltay *et al.*, 2025

Ongoing Studies using Ridgecrest results (Abercrombie, Baltay et al., 2025) as a Benchmark to test methods

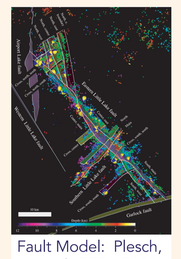
Including:
Koper, K. D. et al. *BSSA* 2024
https://doi.org/10.1785/0120230307
Guo, H., & Thurber, C. H. *Abstract* S44A-03.
Koper, K. D. et al. SRL2026
doi: https://doi.org/10.1785/0220260173
Astra, I. M. K. A. & Hawthorne, EGU 2025, https://doi.org/10.5194/egusphere-egu25-20124, 2025.

Not just $\Delta\sigma$, also Mw in California & beyond

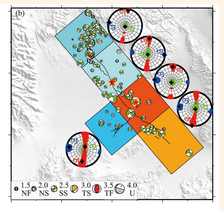


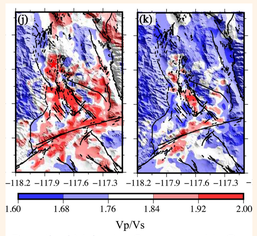
New submissions (➡) welcome and are continually accepted. Contact Rachel (rea@bu.edu) or Annemarie

The spatial variations in Ridgecrest stress drop results can be compared with recent and ongoing imaging to improve understanding of the stress field

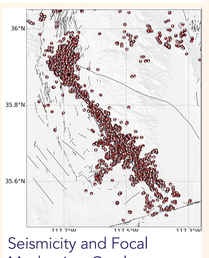


Fault Model: Plesch, A. *et al.*, BSSA 2020

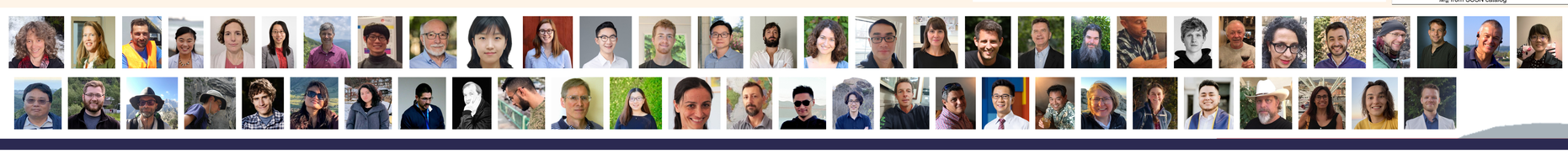




Detailed Velocity Structure: Li, G., & Ben-Zion, Y., JGR 2024



Seismicity and Focal Mechanism Catalog: Atterholt, J. *et al.* GJI 2025



Come and Join us!! Joining the mailing list will keep you posted, without any commitment.