



SCEC/USGS Community Stress Drop Validation Project



Rachel Abercrombie (Boston University)

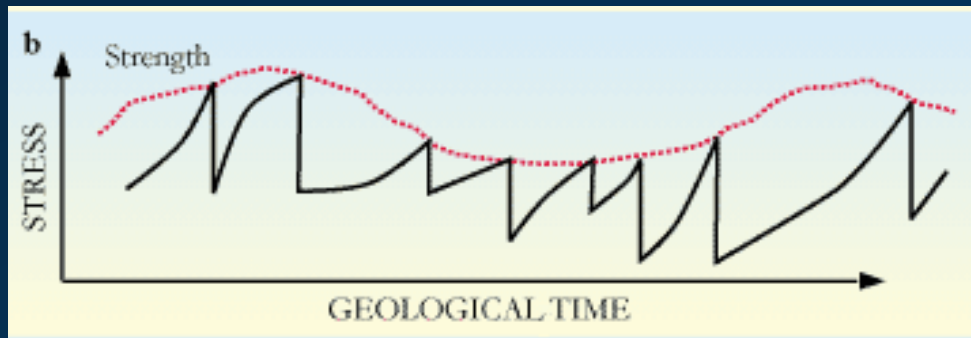


Annemarie Baltay (USGS)



with a LOT of help from many others

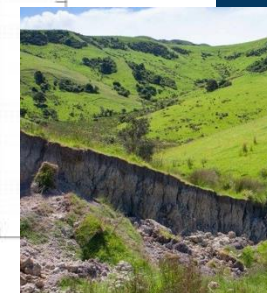
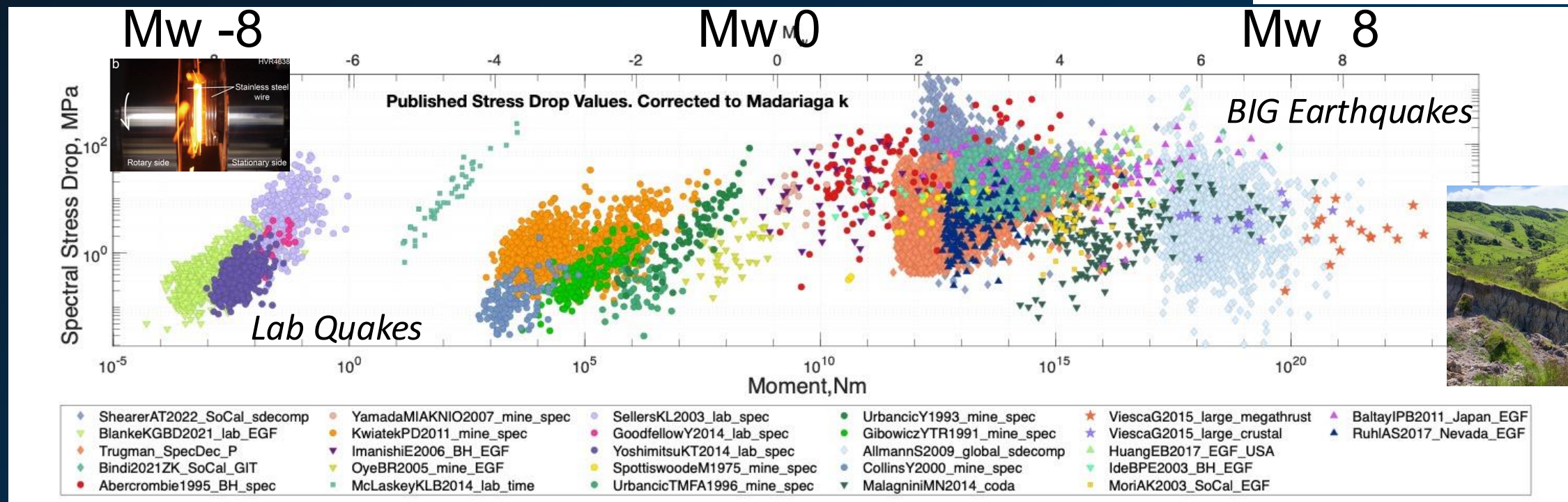
Aims: Improve reliability & precision of estimates of earthquake source parameters to place real constraints on rupture dynamics and ground motion prediction



Stress drop = stress released over fault as it slips is a commonly used parameter to characterize earthquakes

Constant Stress Drop Scaling?

Baltay *et al.*, Seismica 2024



Are different study methods comparable?

Self-similar process from lab to 100s km,
but strong trends in individual studies
Are scatter and trends real?
Or uncertainties?

Seismic Moment:

$$M_0 = \text{rigidity} \times \text{slip} \times \text{area}$$

$$\text{Stress Drop} \sim \text{strain} \sim \text{slip} / \sqrt{\text{area}}$$

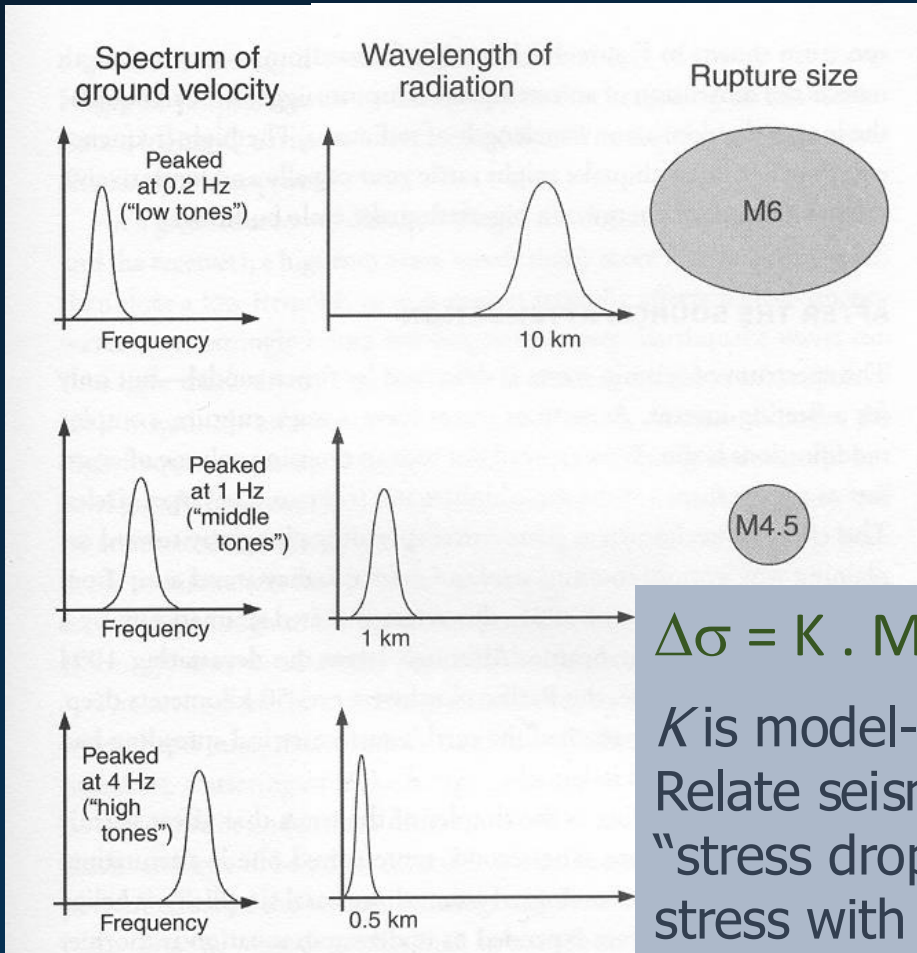
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Measurements from Frequency of Seismic Waves

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1960s and 1970s Aki, Brune, Kanamori, Madariaga etc.
(pre digital recording and big computers..)

Source spectrum has simple shape:



Peak in velocity spectrum
= corner frequency (f_c) in
displacement
 $\sim 1/\text{source dimension}$

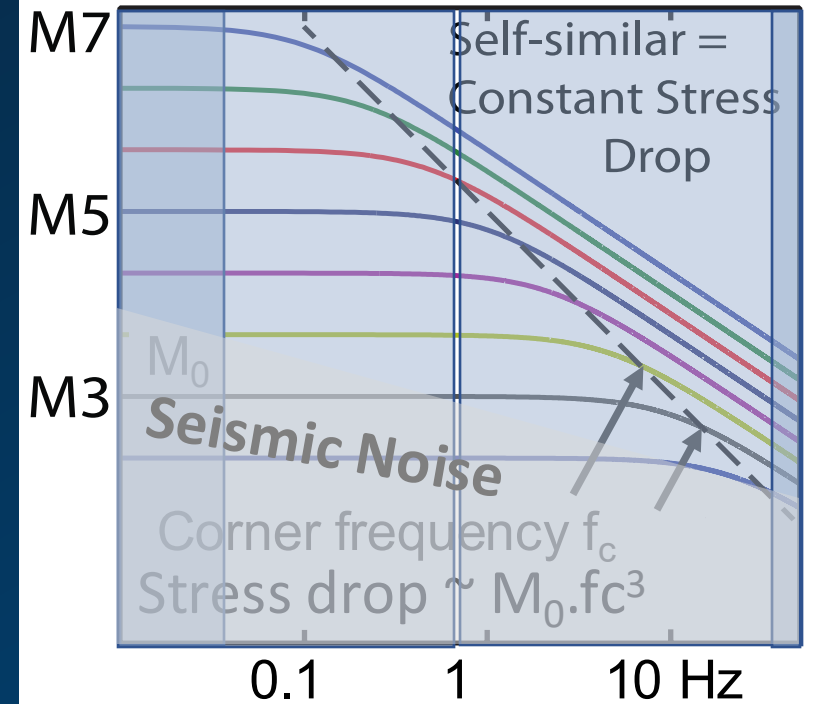
Brune Model:

$$n=2 \quad M_0(f) = \frac{M_0}{1 + \left(\frac{f}{f_c}\right)^n}$$

$$\Delta\sigma = K \cdot M_0 \cdot f_c^3$$

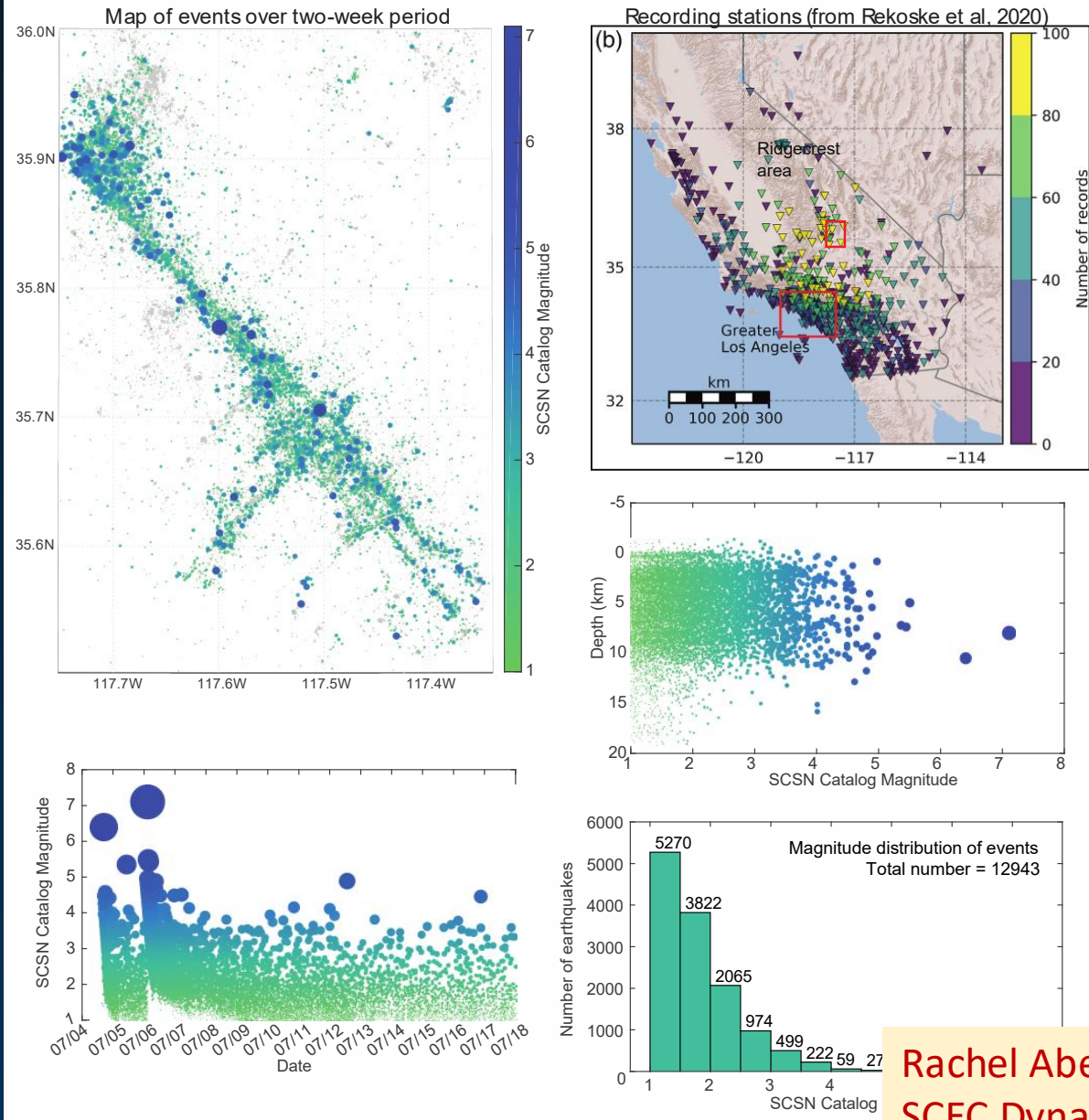
K is model-dependent.
Relate seismological
"stress drops" to real
stress with care!

Model Earthquake Spectra



Seismic Moment: $M_0 = \text{rigidity} \times \text{slip} \times \text{area}$
= Long period level

"Stress Drop" $\sim \text{strain} \sim \text{slip} / \sqrt{\text{area}}$

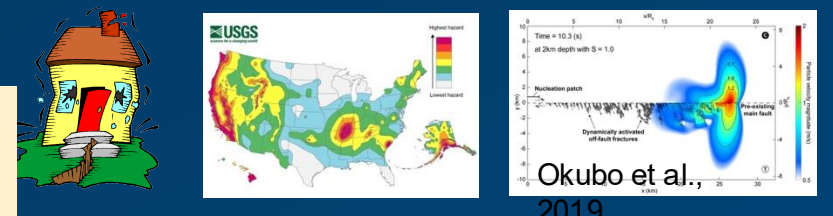


Annemarie Baltay (USGS)
Rachel Abercrombie (Boston University)
& Shanna Chu (USGS) & Taka'aki Taira (UCB)

Invite community to calculate & submit estimates of stress drop for a common data set
Compare & investigate differences
Recalculate & repeat

2 Weeks of 2019 Ridgecrest Sequence, California. Including mainshocks

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An Ongoing Community Effort. Come Join us



Results of first joint study published in June BSSA Special Issue

Informal zooms: Thursday 4 Dec 8 am & 3 pm (Pacific)
Virtual Workshop: 20 January 2026

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Introduction to the Special Section on Improving Measurements of Earthquake Source Parameters ✓

Annemarie Baltay; Rachel E. Abercrombie; Adrien Oth; Takahiko Uchide

Extract ▾

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Overview of the SCEC/USGS Community Stress Drop Validation Study Using the 2019 Ridgecrest Earthquake Sequence ✓

Rachel E. Abercrombie; Annemarie Baltay; Shanna Chu; Taka'aki Taira; Dino Bindi; Oliver S. Boyd; Xiaowei Chen; Elizabeth S. Cochran; Emma Devin; Douglas Dreger; William Ellsworth; Wenyuan Fan; Rebecca M. Harrington; Yihe Huang; Kilian B. Kemna; Meichen Liu; Adrien Oth; Grace A. Parker; Colin Pennington; Matteo Picozzi; Christine J. Ruhl; Peter Shearer; Daniele Spallarossa; Daniel Trugman; Ian Vandever; Qimin Wu; Clara Yoon; Ellen Yu; Gregory C. Beroza; Tom Eulenfeld; Trey Knudson; Kevin Mayeda; Paola Morasca; James S. Neely; Jorge Roman-Nieves; Claudio Satriano; Mariano Supino; William R. Walter; Ralph Archuleta; Gail Marie Atkinson; Giovanna Calderoni; Chen Ji; Hongfeng Yang; Jiewen Zhang

Abstract ▾

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Supplementary data

PDF

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**SCEC/USGS Community Stress Drop
Validation Project**
General Links 2025



<https://www.scec.org/events/2025-scec-stress-drop-workshop/>
[Join mailing list](#)

Study Description:

Baltay, A., Abercrombie, R., Chu, S., & Taira, T. (2024). The SCEC/USGS Community Stress Drop Validation Study Using the 2019 Ridgecrest Earthquake Sequence. *Seismica*, 3(1). doi: <https://doi.org/10.26443/seismica.v3i1.1009>

BSSA Special Issue on Improving Measurements of Earthquake Source Parameters:

(all papers referenced within the Introduction):

Baltay, A. S., R. E. Abercrombie, A. Oth and T. Uchide (2025) Introduction to the Special Issue on Improving Measurements of Earthquake Source Parameters, *Bull. Seismol. Soc. Am.*, doi: <https://doi.org/10.1785/0120250055>

Overview Paper:

Abercrombie, R. E., A. Baltay, S. Chu, T. Taira, D. Bindi, O. S. Boyd, X. Chen, E. S. Cochran, E. Devin, D. Dreger, W. Ellsworth, W. Fan, R. M. Harrington, Y. Huang, K. B. Kemna, M. Liu, M., A. Oth, G. A. Parker, C. Pennington, M. Picozzi, C. J. Ruhl, P. Shearer, D. Spallarossa, D. Trugman, I. Vandevent, Q. Wu, C. Yoon, E. Yu, G. C. Beroza, T. Eulenfeld, T. Knudson, K. Mayeda, P. Morasca, J. S. Neely, J. Roman-Nieves, C. Satriano, M. Supino, W. R. Walter, R. Archuleta, G. M. Atkinson, G. Calderoni, C. Ji, H. Yang and J. Zhang (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>

First Analysis of Combined Results:

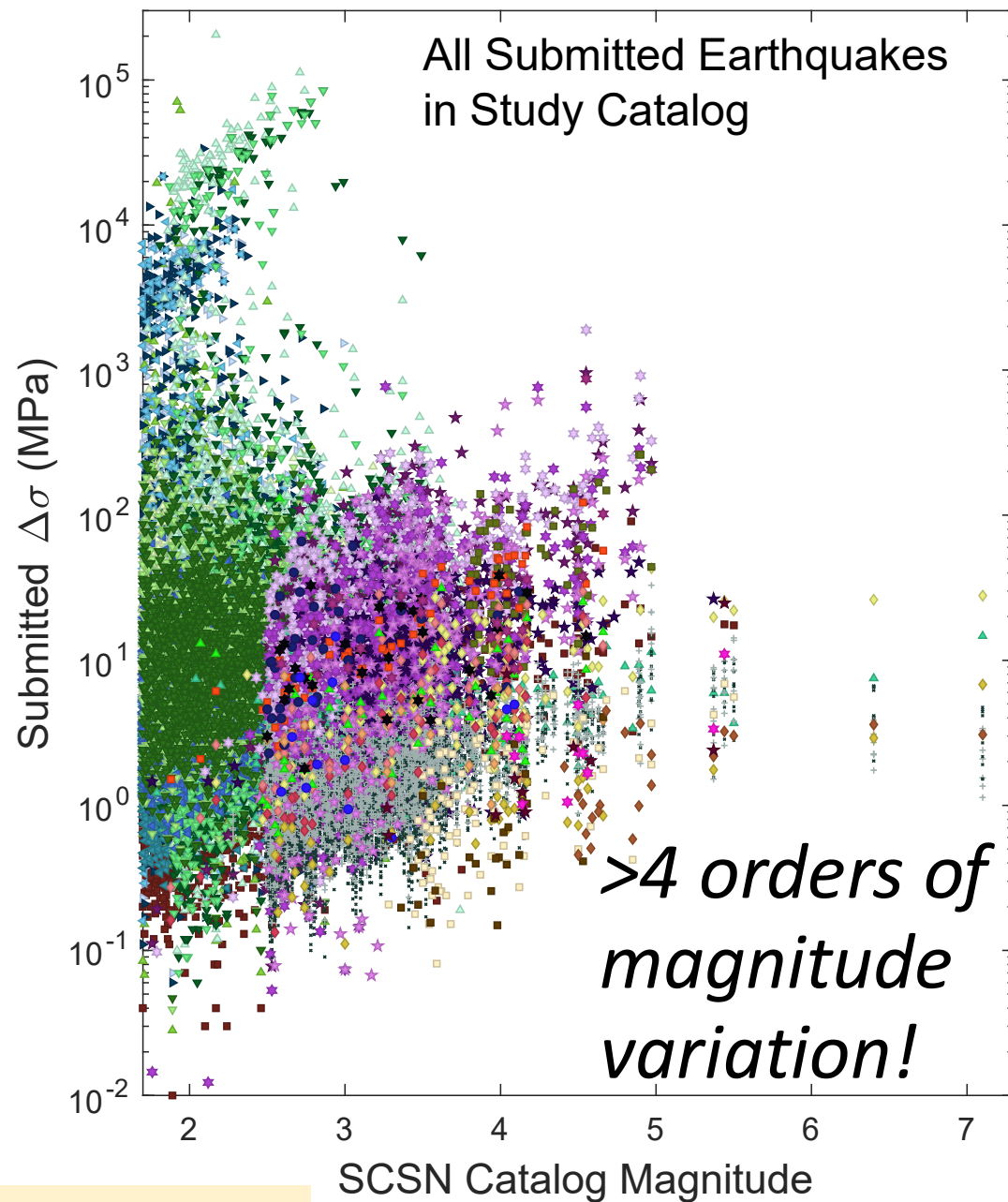
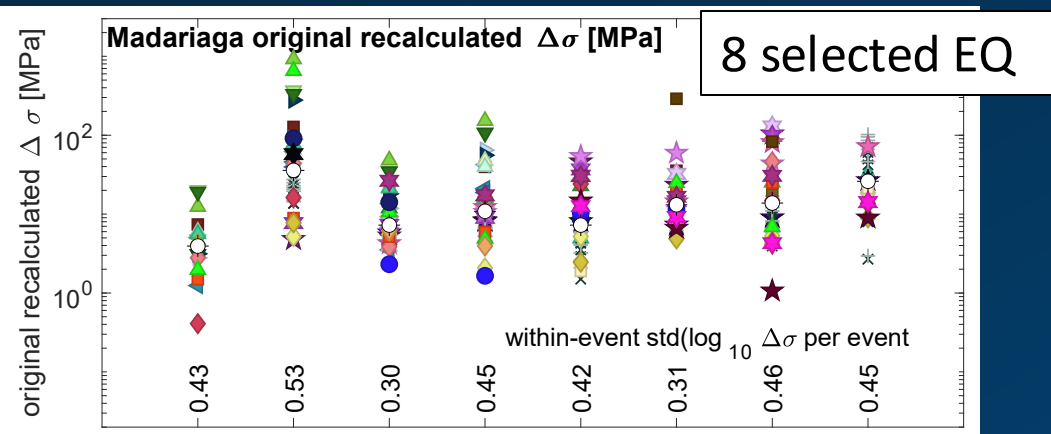
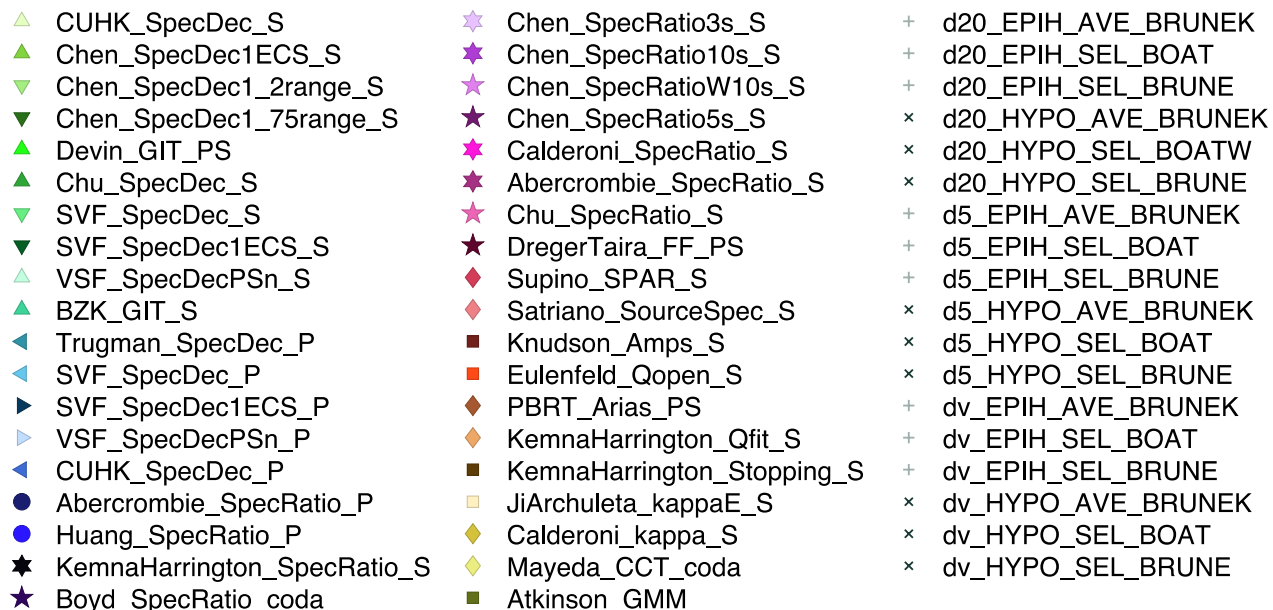
Abercrombie, R. E. and A. S. Baltay (2025), Magnitude, Depth, and Methodological Variations of Spectral Stress Drop Within the SCEC/USGS Community Stress Drop Validation Study Using the 2019 Ridgecrest Earthquake Sequence. *Bull. Seismol. Soc. Am.*. doi: <https://doi.org/10.1785/0120250056>

Download common waveform dataset:

<https://scedc.caltech.edu/data/stressdrop-ridgecrest.html>

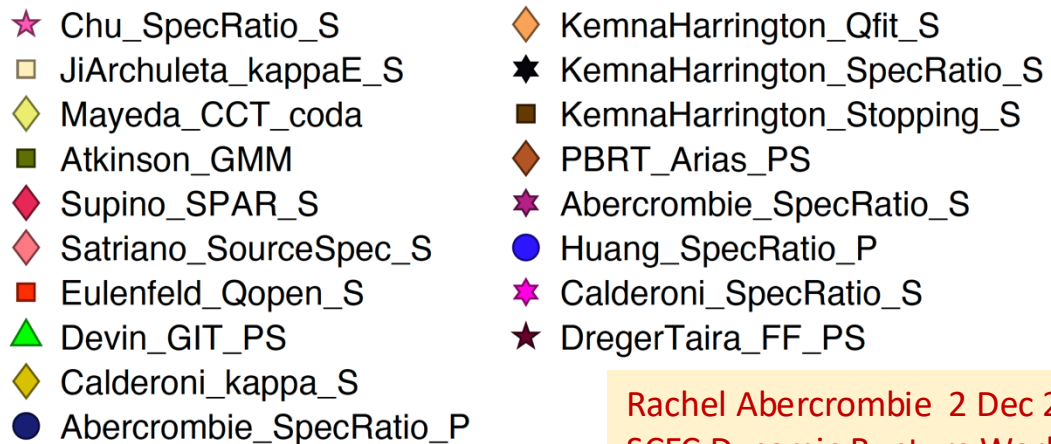
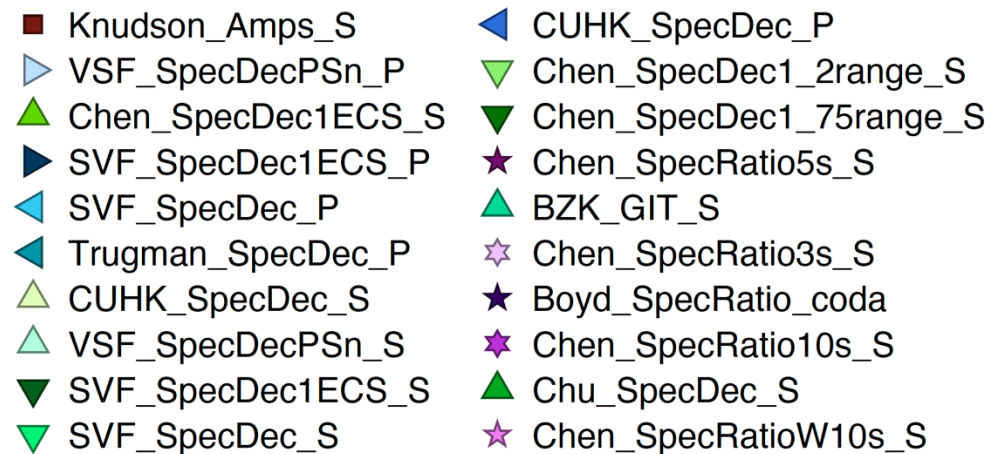
All submitted results to date: Abercrombie *et al.* 2025

Community Study Legend

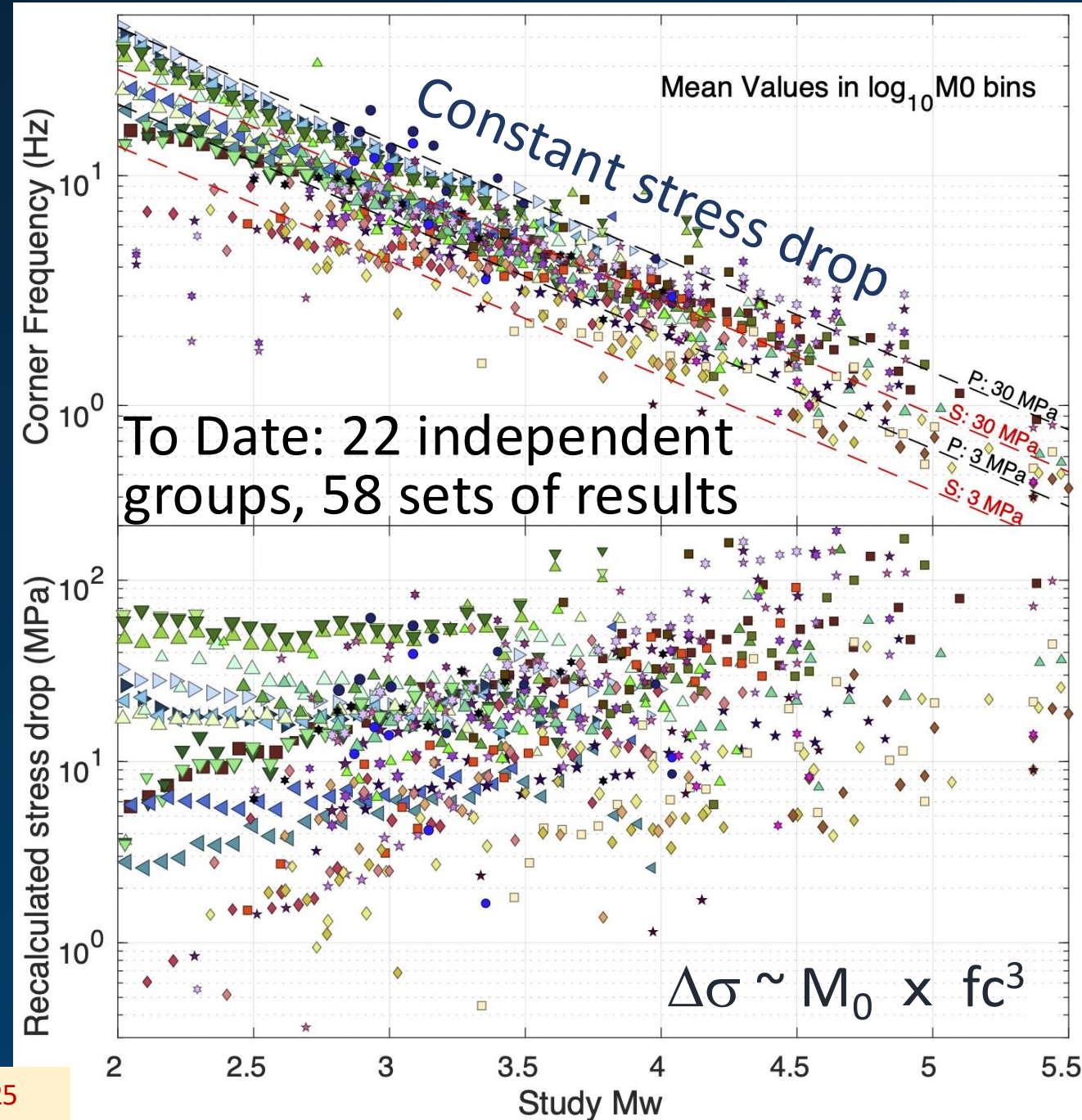


Abercrombie *et al.* (BSSA Special Issue 2025)

Running Means: Systematic and Random variation

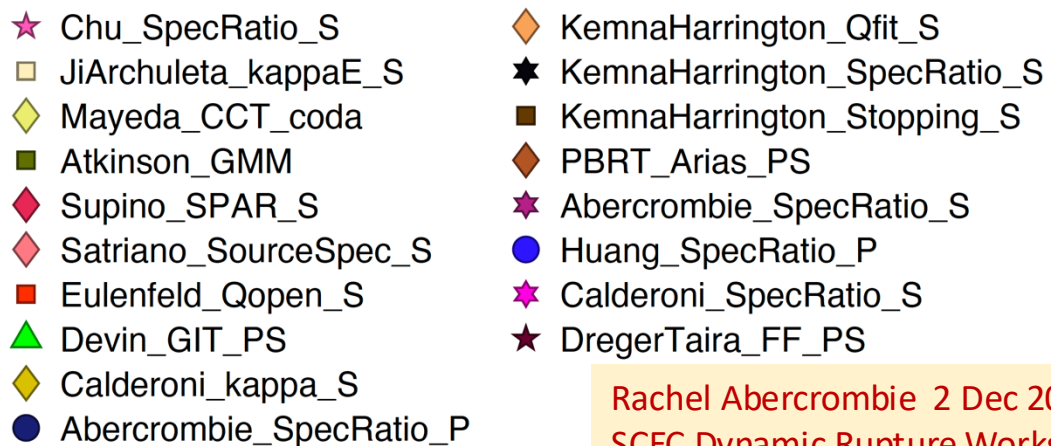
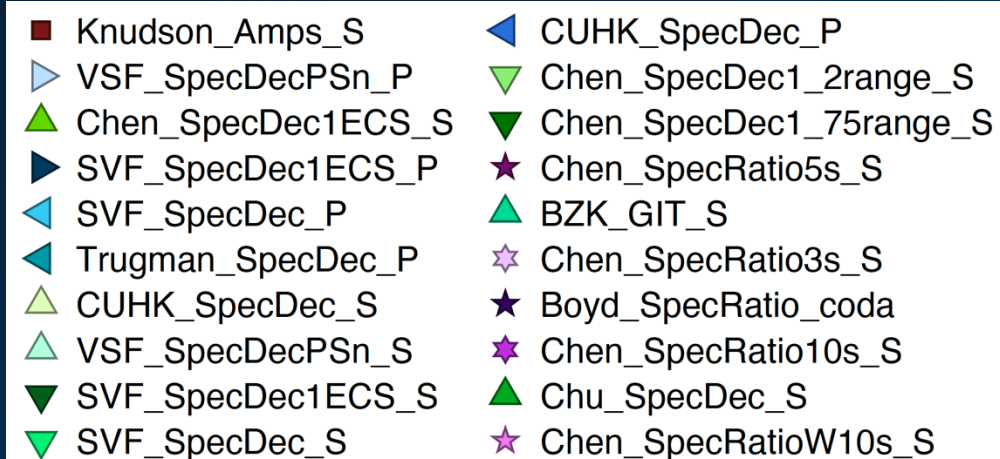


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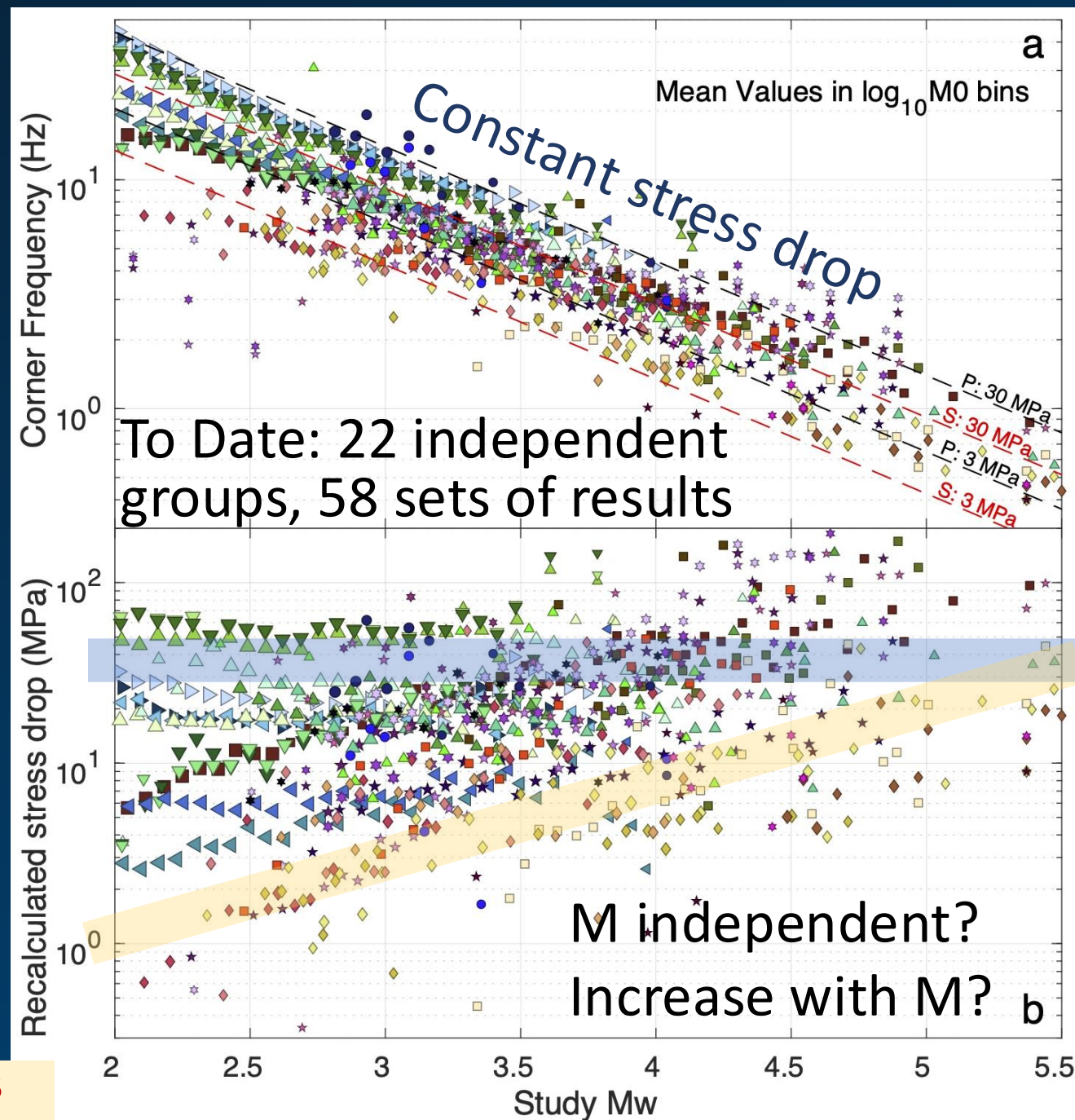


Abercrombie *et al.* (BSSA Special Issue 2025)

Running Means: Systematic and Random variation



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Abercrombie *et al.* (BSSA Special Issue 2025)

Running Means: Systematic and Random variation

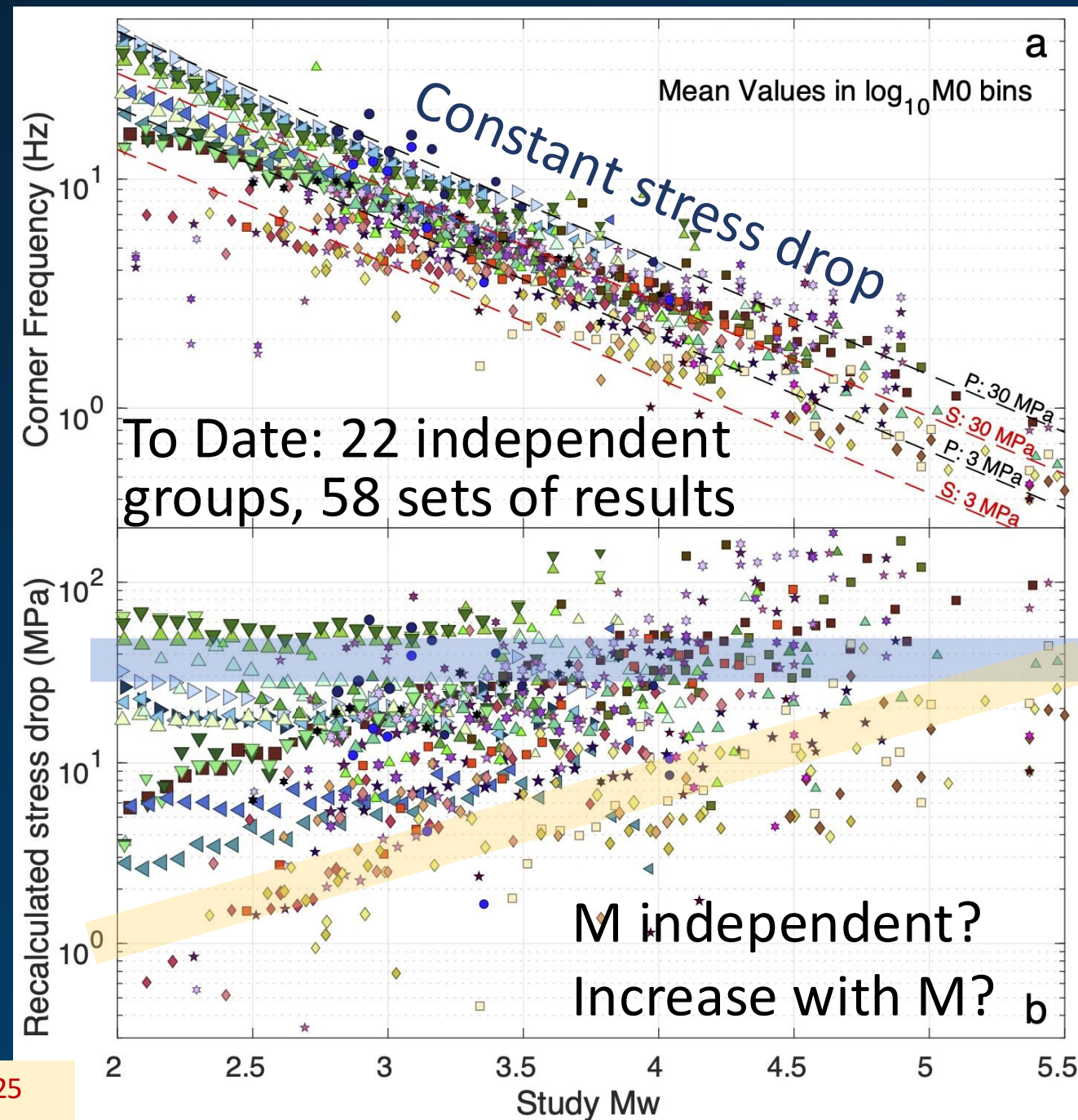
■ Knudson_Amps_S ▶ CUHK_SpecDec_P
▶ VSF_SpecDecPSn_P ▼ Chen_SpecDec1_2range_S
▲ Chen_SpecDec1ECS_S ▼ Chen_SpecDec1_75range_S
▶ SVF_SpecDec1ECS_P ★ Chen_SpecRatio5s_S

“Spectral” stress drop = estimate of stress drop from spectra.

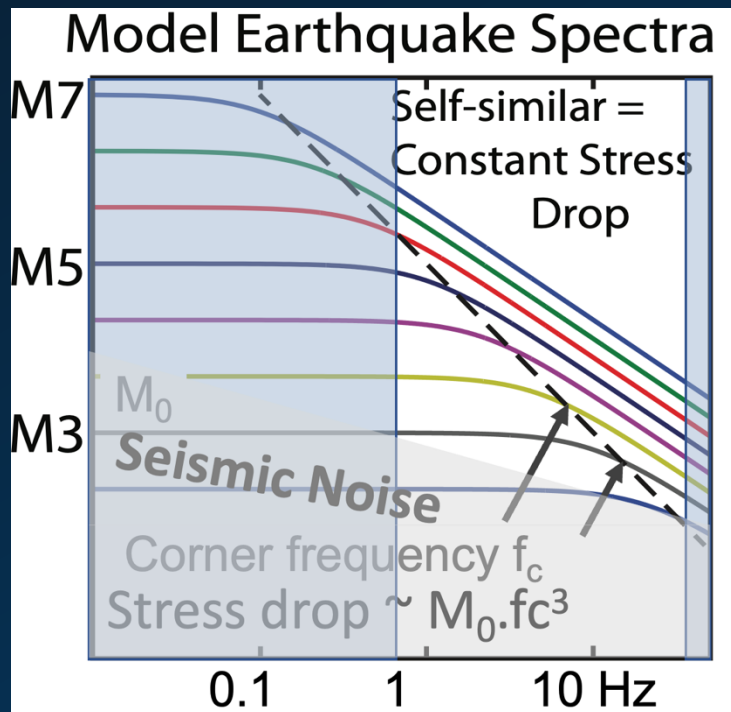
Be careful relating “spectral” stress drop to stress release in earthquake!

◆ Satriano_SourceSpec_S ● Huang_SpecRatio_P
■ Eulenfeld_Qopen_S ★ Calderoni_SpecRatio_S
▲ Devin_GIT_PS ★ DregerTaira_FF_PS
◆ Calderoni_kappa_S
● Abercrombie_SpecRatio_P

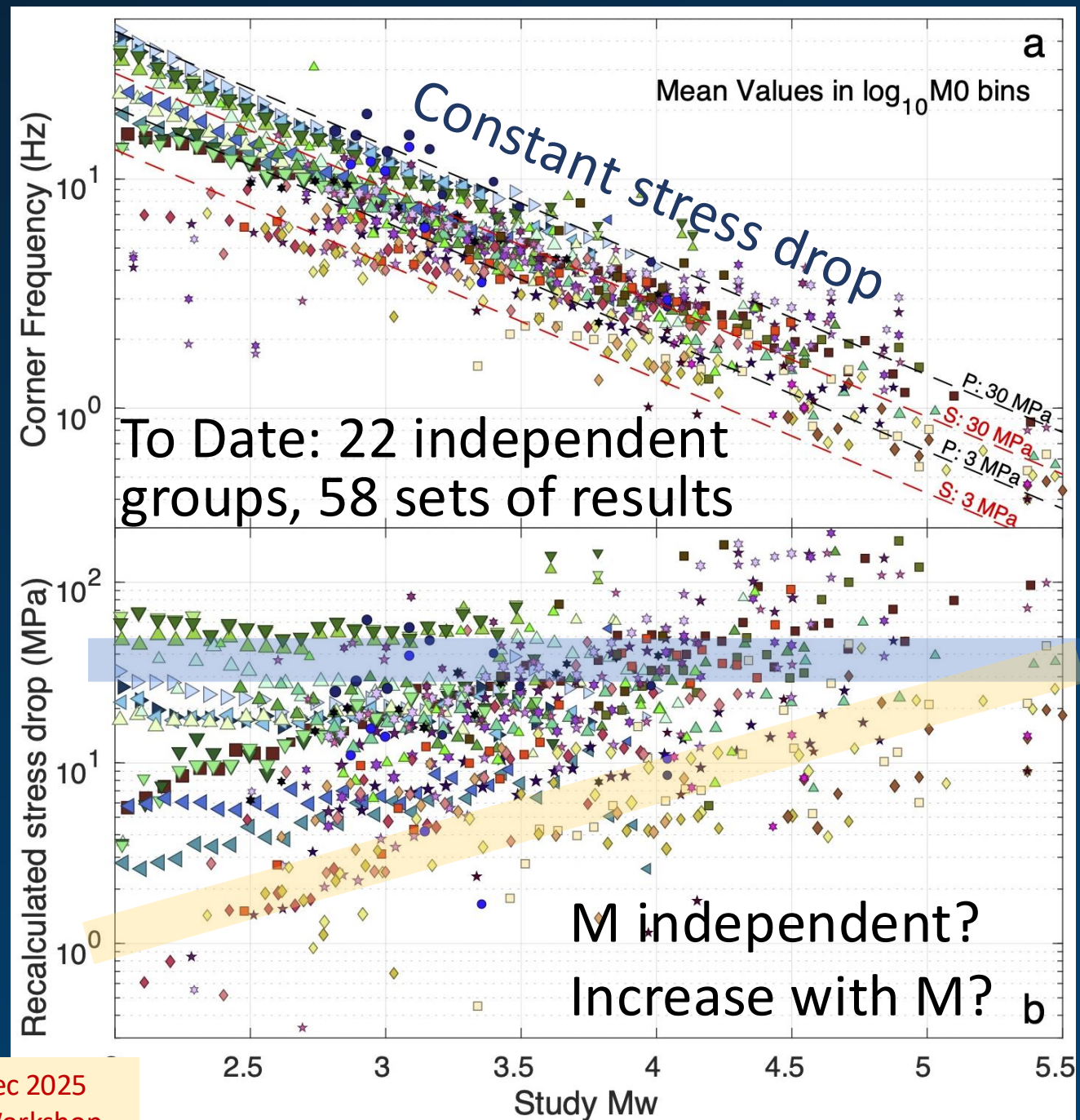
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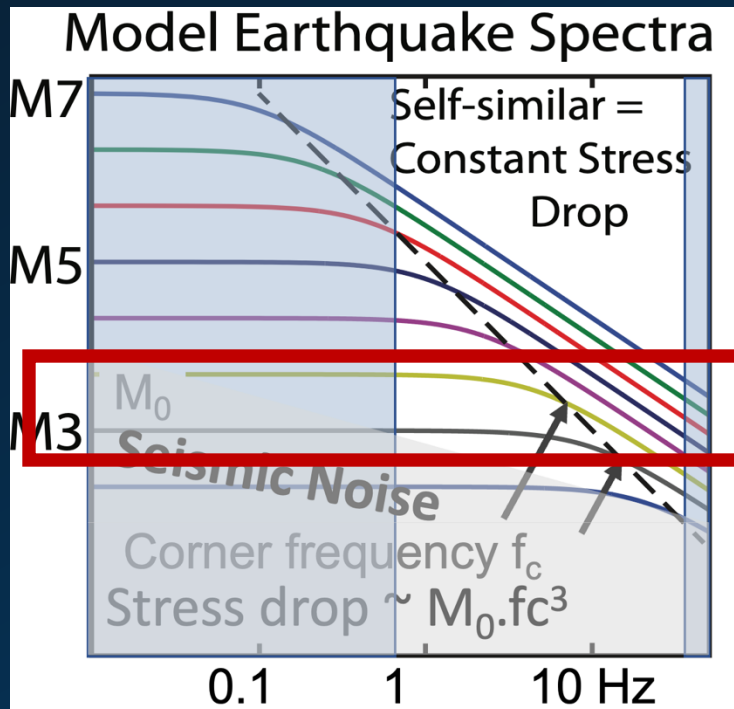
Abercrombie *et al.* (BSSA Special Issue 2025) Running Means: Systematic and Random variation



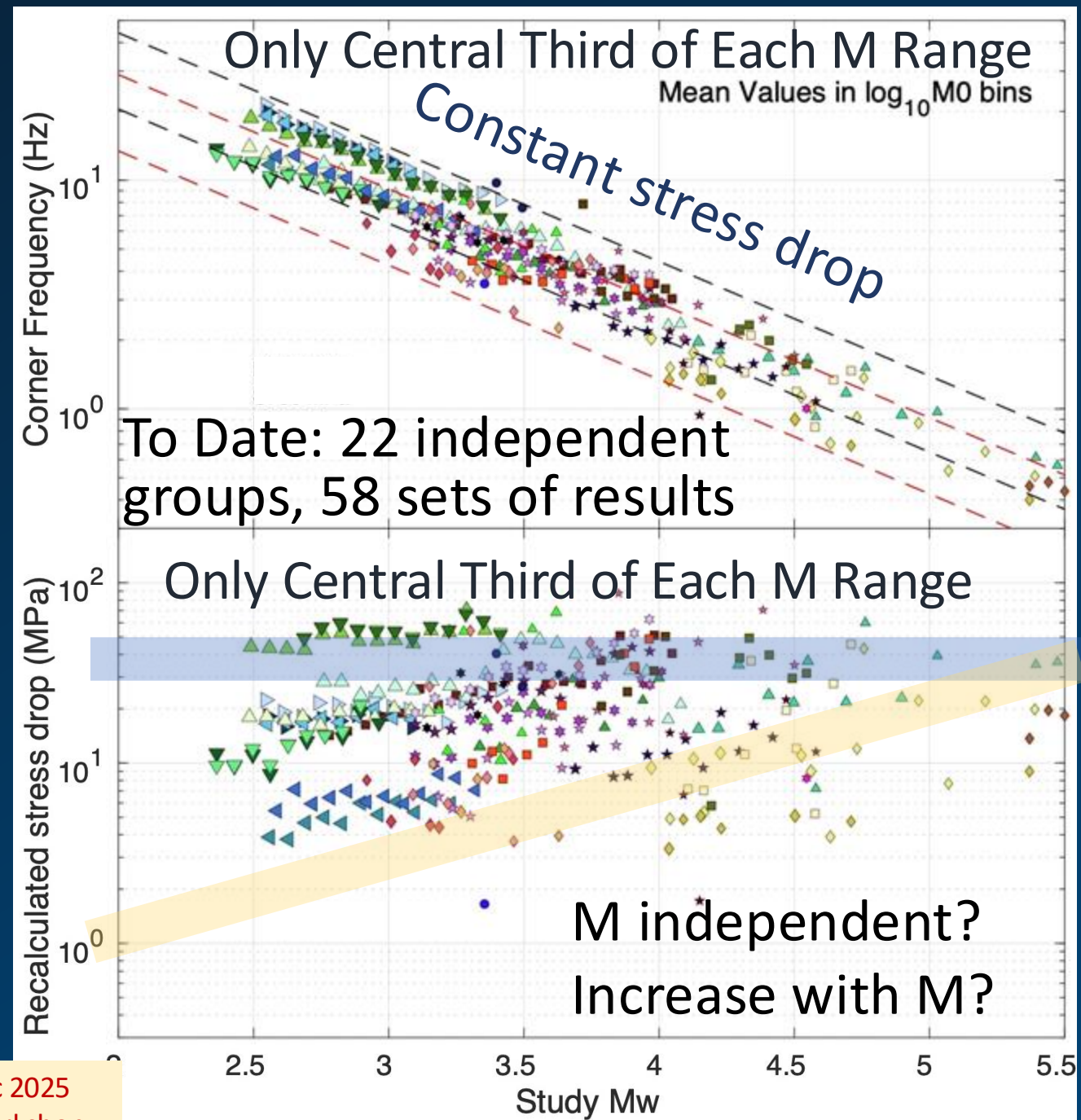
Many submissions include less well-constrained measurements



Abercrombie *et al.* (BSSA Special Issue 2025) Running Means: Systematic and Random variation



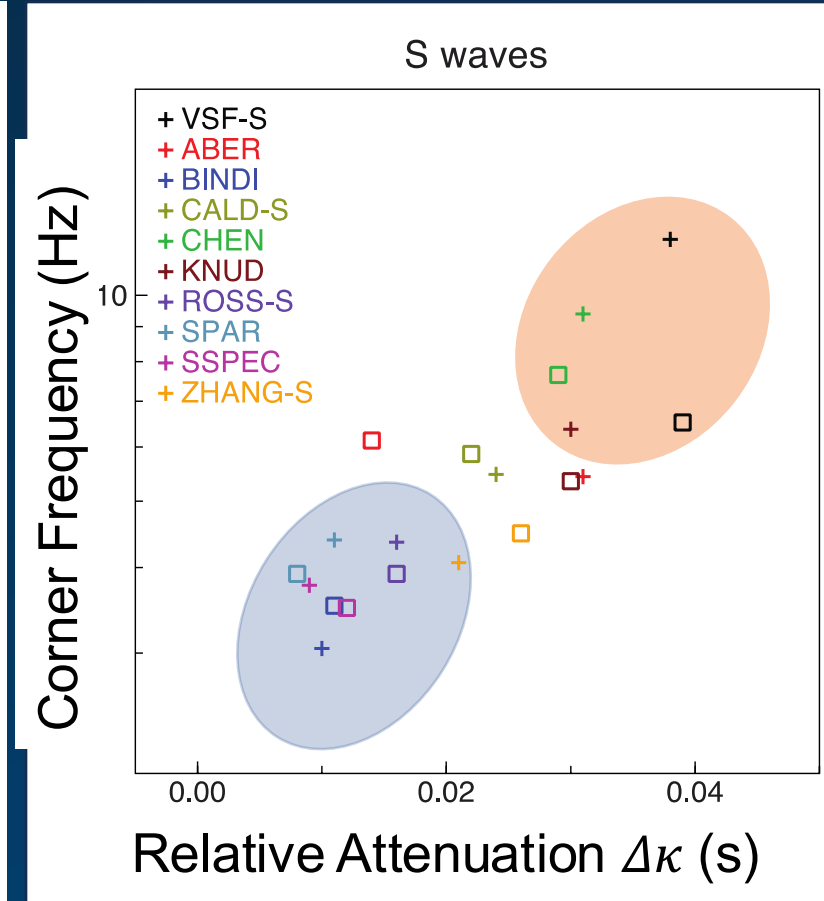
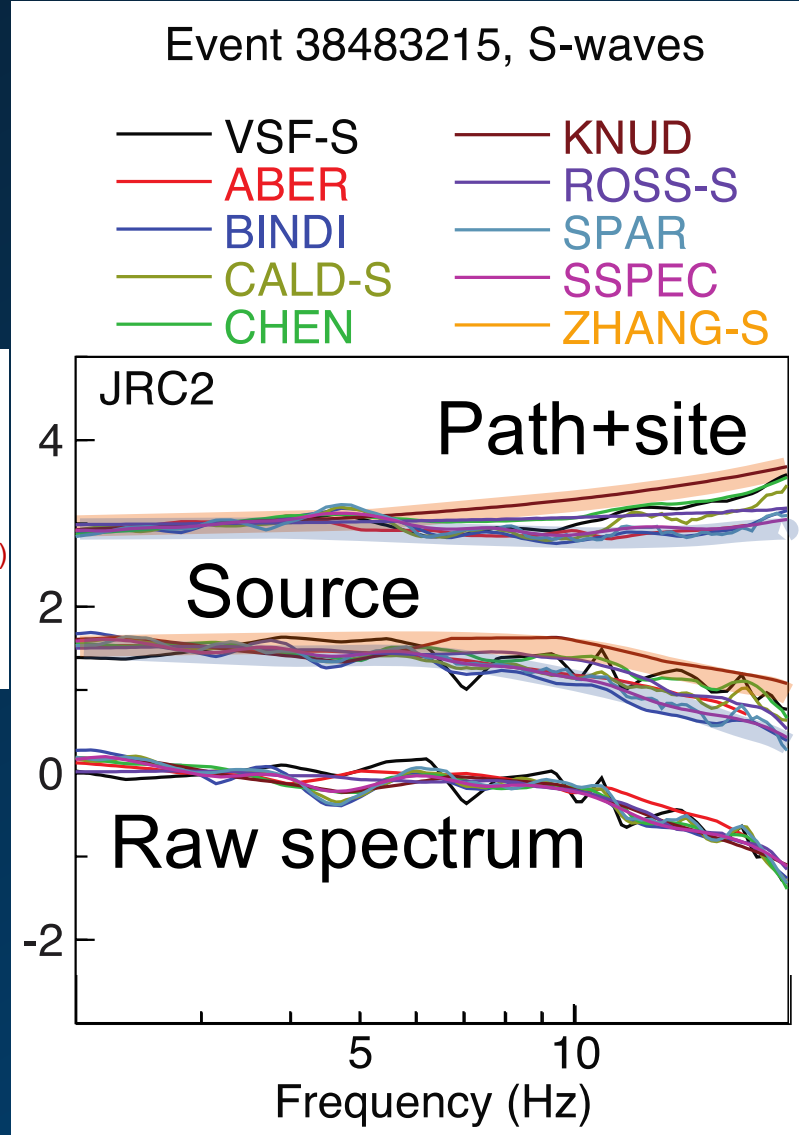
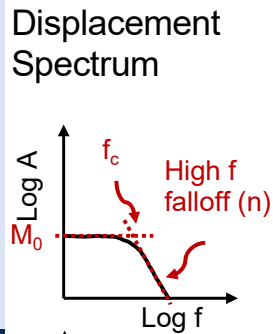
Select only BEST resolved events – f_c in middle of frequency range



Most differences from separation of source, path and site effects: Shearer *et al.*, 2024 BSSA Special Issue

Compare different estimates of attenuation & source for same event at same station

Frequency spectrum:
 $\text{recorded}(f) = \text{Source}(f) \times \text{Path}(f) \times \text{Site}(f)$



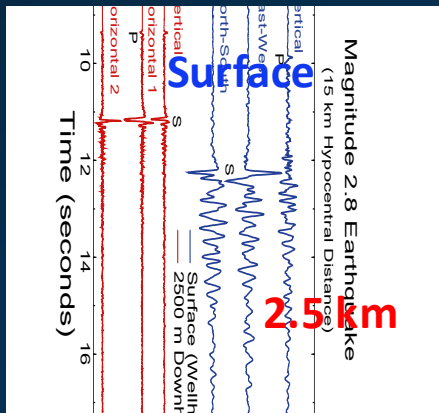
Larger attenuation correction,
higher corner frequency,
higher $\Delta\sigma$

Some Magnitude dependence of Spectral stress drop is artefact of missing site correction

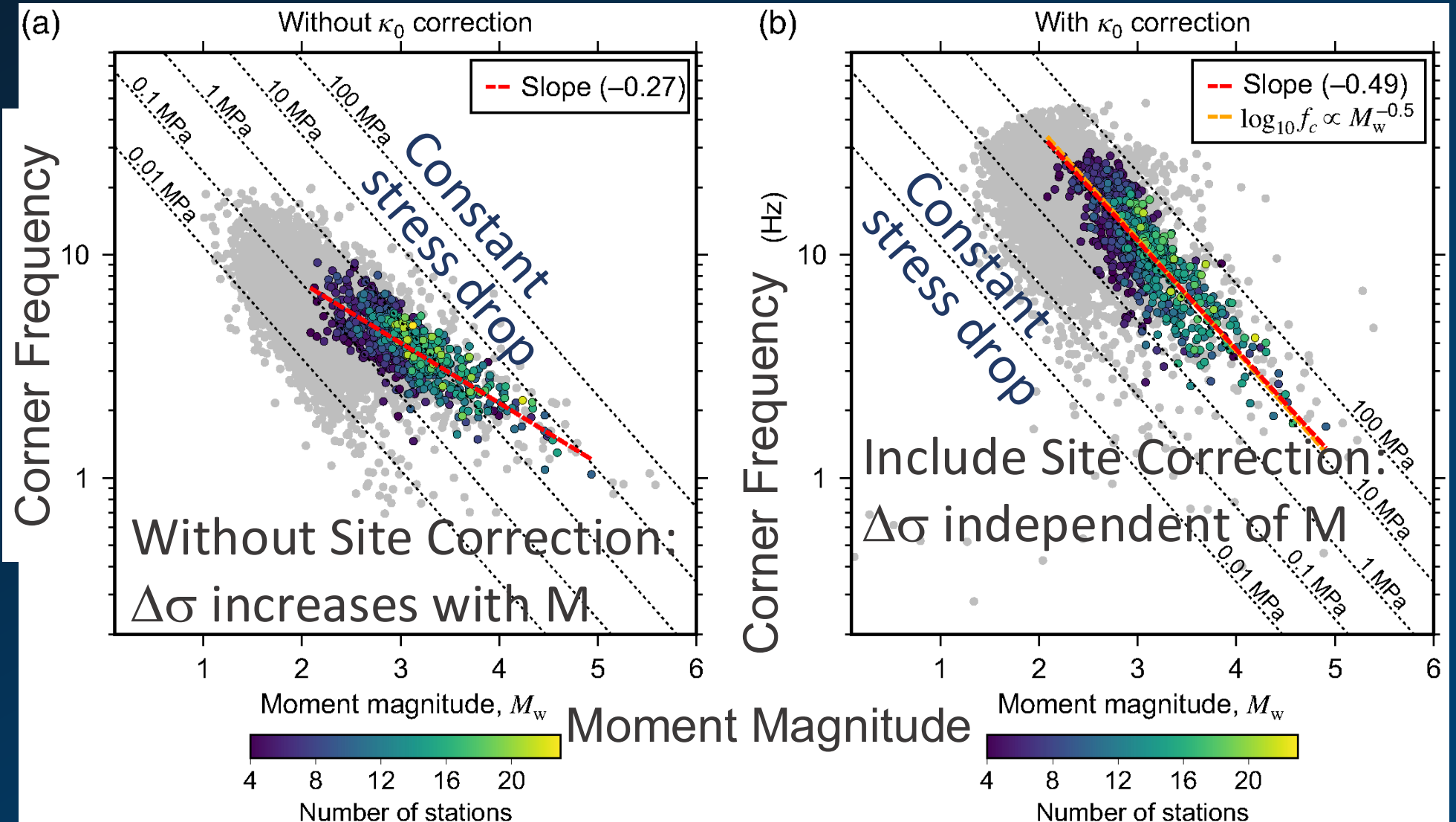
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Ridgecrest
Community
Study:
Ahn *et al*
(BSSA 2025)

Remember deep
borehole recording



Abercrombie 1995



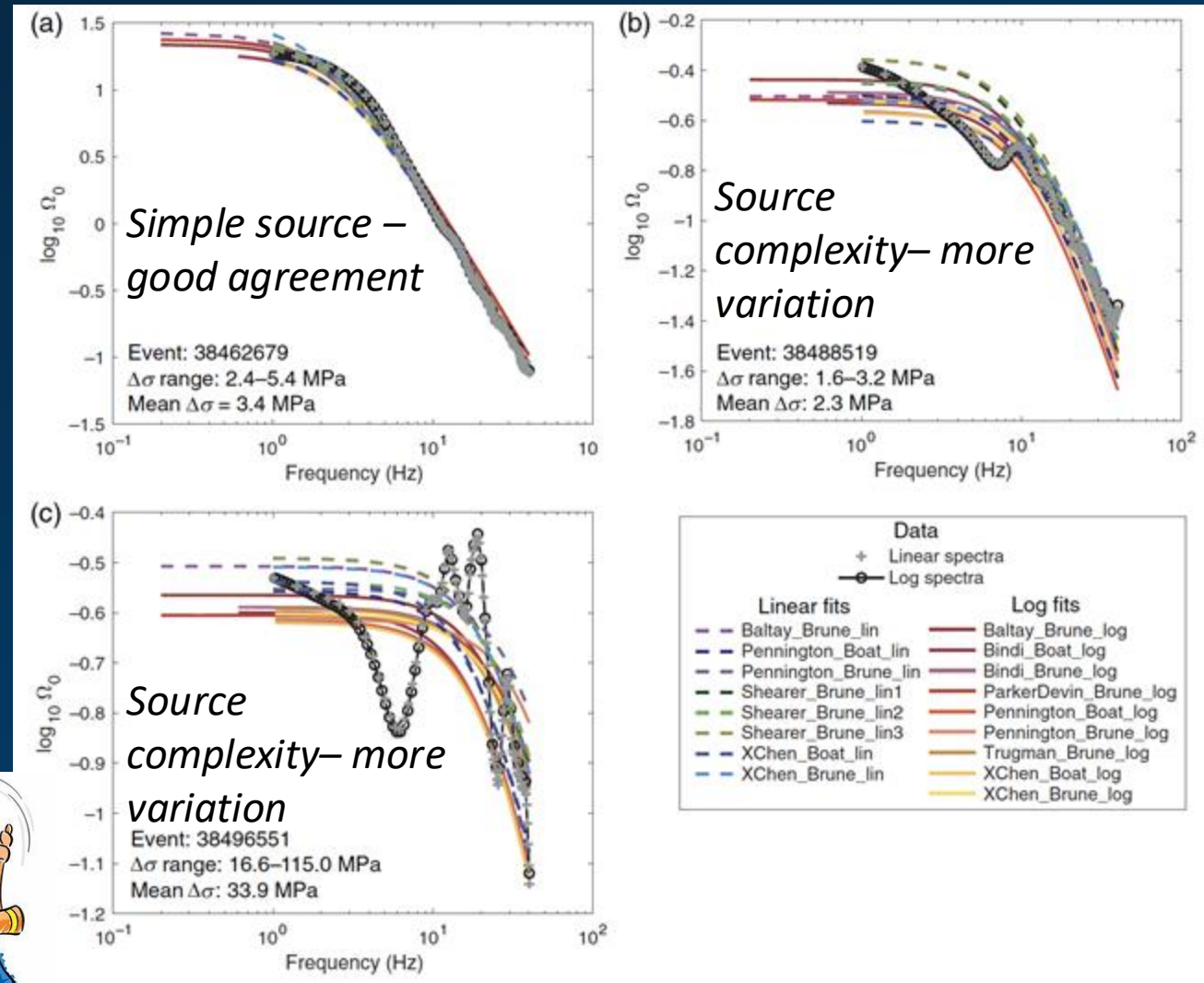
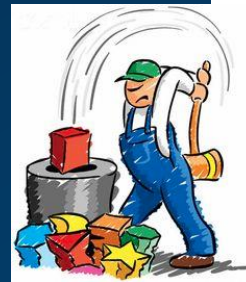
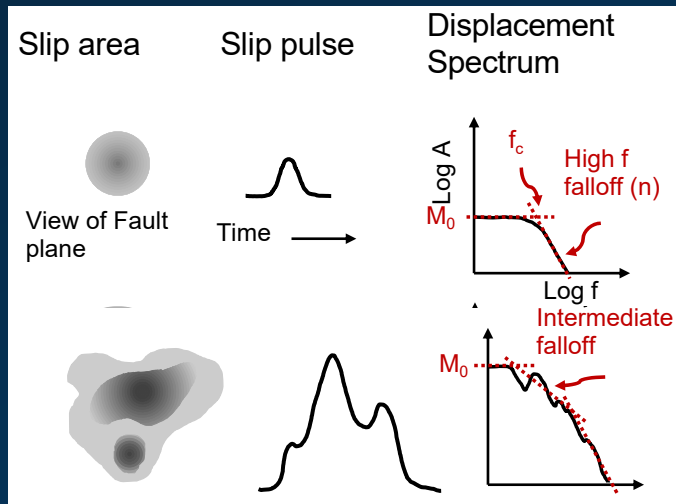
Source Complexity causes increased variability between Methods: Cochran *et al.* BSSA Special

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Assume “source” spectra are correct,
and compare fitting approaches

Deviation of source from simple
model causes large variation
between approaches

Small and Large earthquakes are more
complex than a simple circular source model



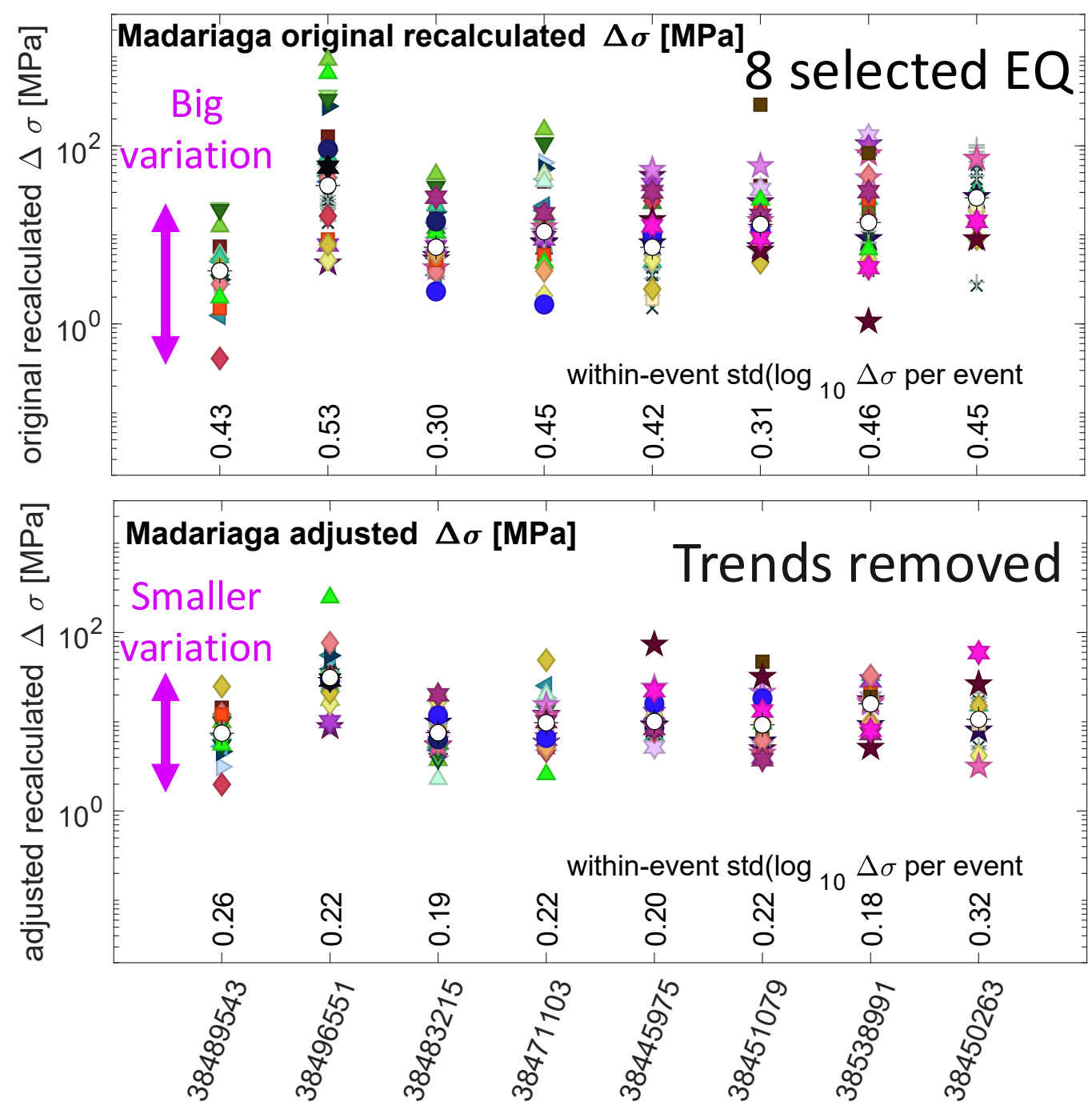
Relative variation in spectral stress drop is potentially resolvable

Abercrombie & Baltay, (2025)

Calculate and Remove
systematic differences
between methods

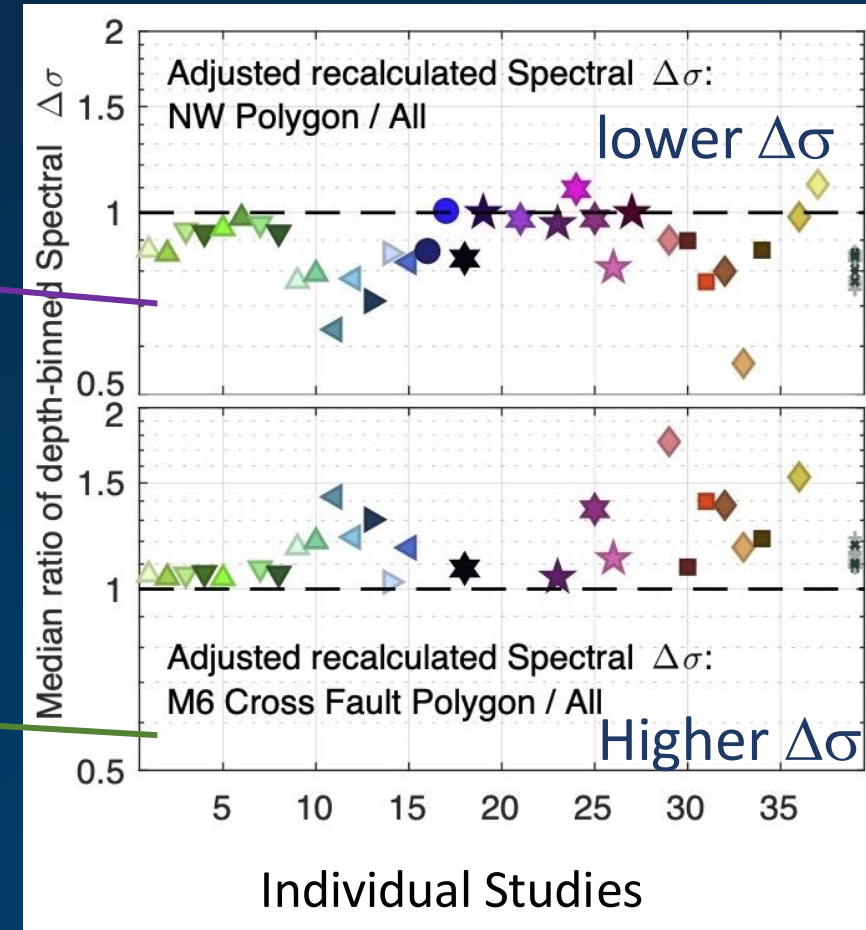
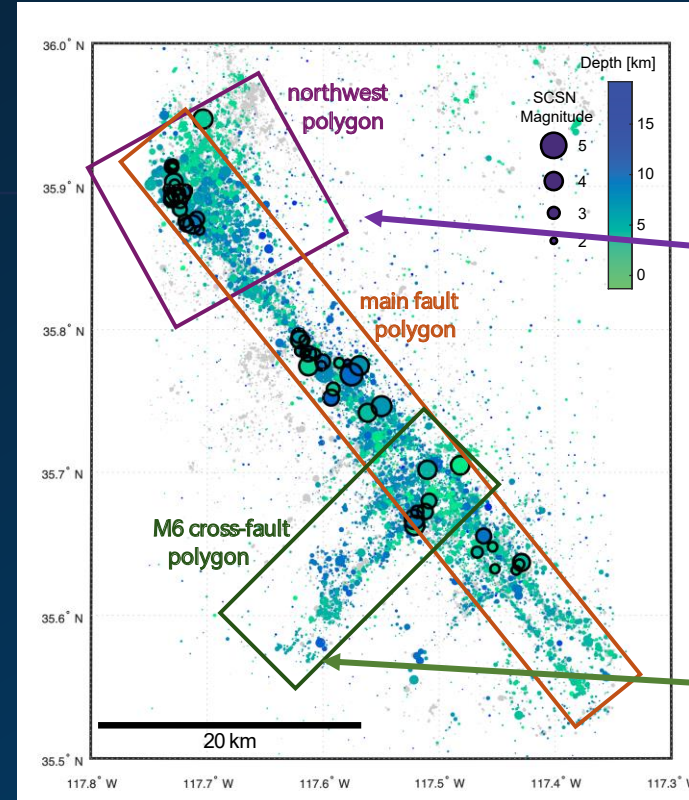
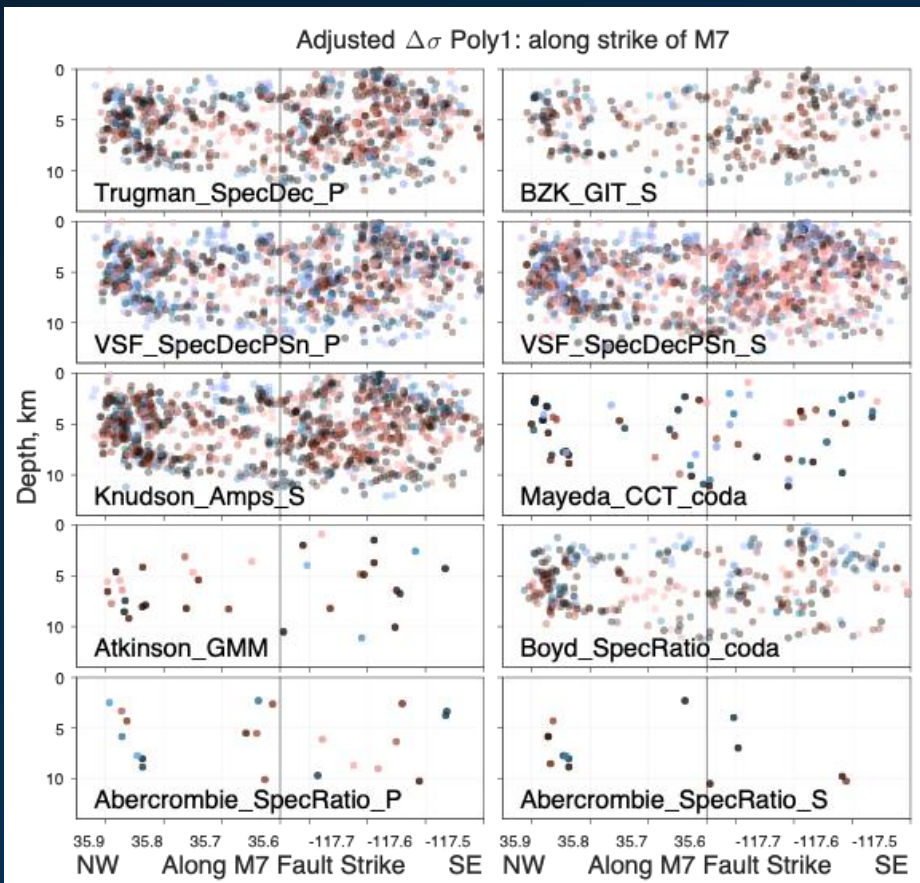
→ decreased variation
- reveals relative variation

8 Selected EQ: M2.5-5.5



Spatial Variation: Some Relative Consistency!

Cross Section: $\Delta\sigma$ variation in 10 individual studies



Small scale heterogeneity dominates

Abercrombie & Baltay, (2025)



SCEC/USGS Community Stress Drop Validation Project



First Stage Published in BSSA:

- Identified problems
- Ongoing collaboration & method developments



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Plans for 2026 and beyond:

- LOI for SCEC Themed Activity Group submitted
- Goals include:
 - Use synthetics to isolate effects of source/path separation
 - test revised methods on new common data set
 - develop better methods for source complexity

