Estimating earthquake source parameters from S-wave maximum amplitudes: Application to the 2019 Ridgecrest sequence

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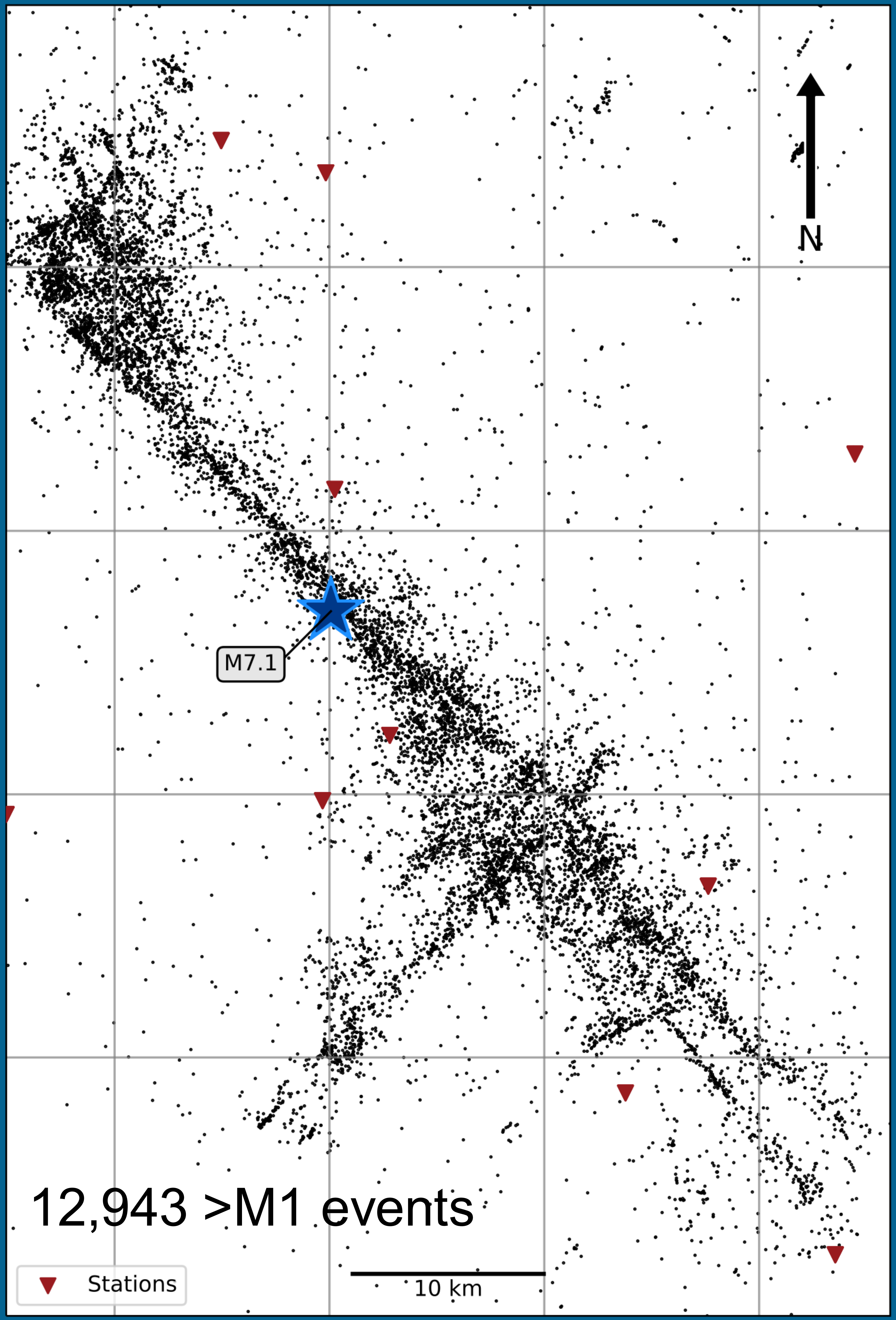
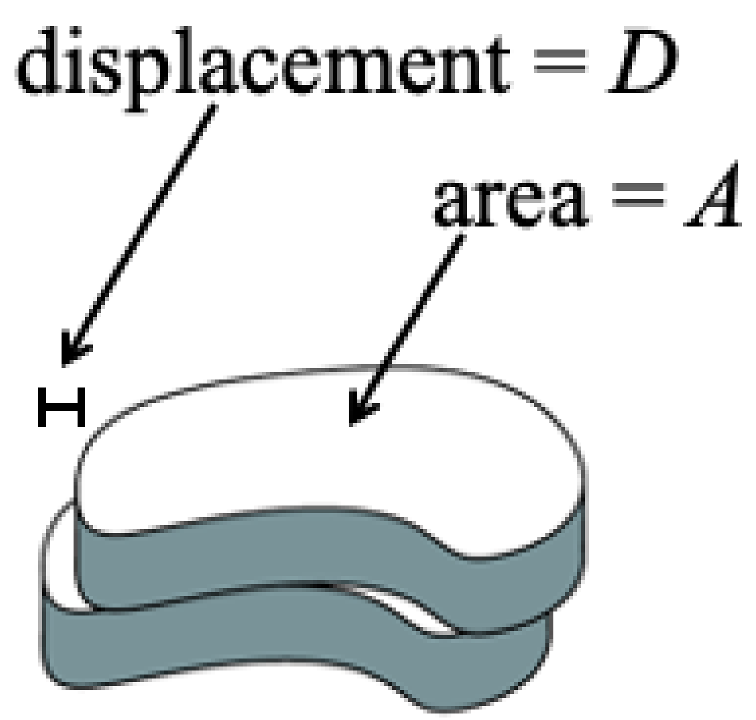


Two key source parameters have high variability

- **Moment** $M_0 = \mu A D$



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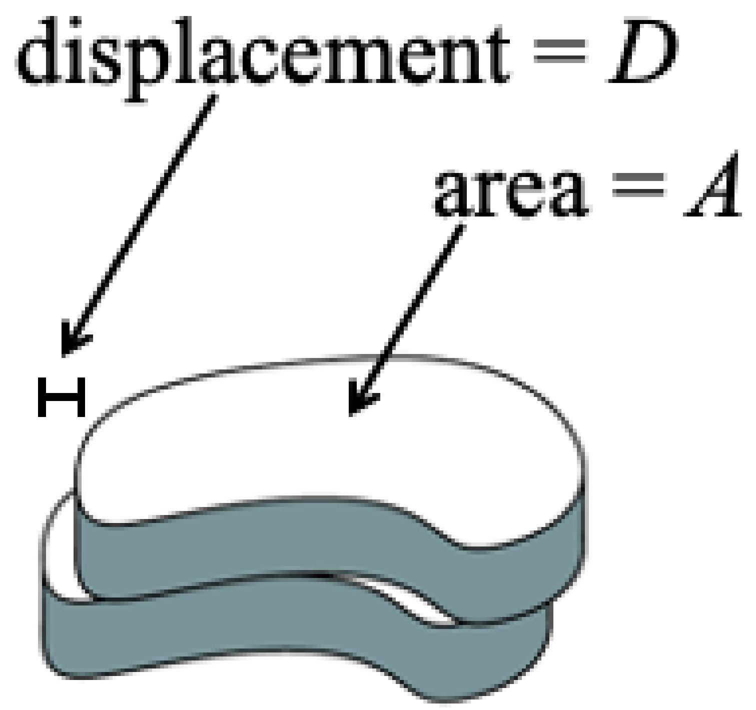
- Moment $M_0 = \mu AD$
- **Stress drop** $\Delta\sigma = \sigma_{final} - \sigma_{initial}$



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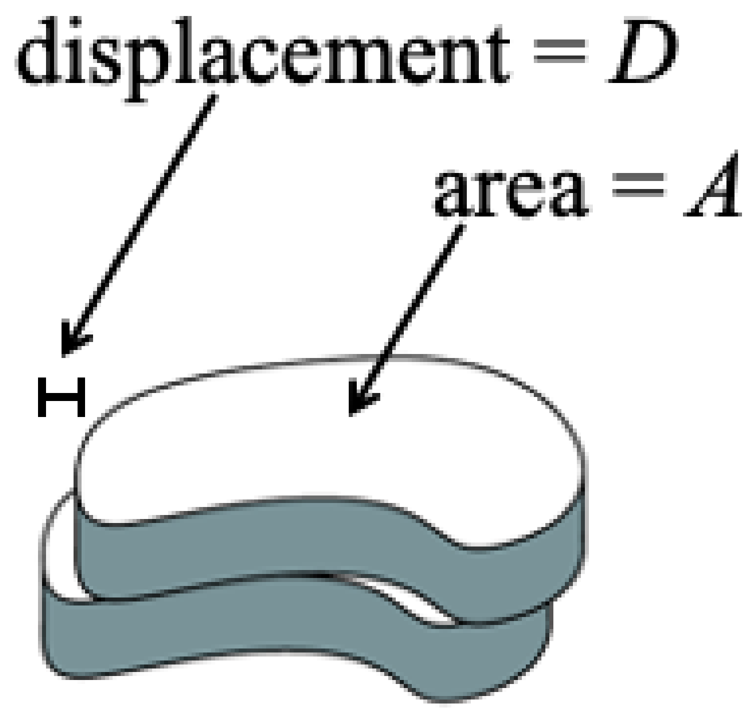
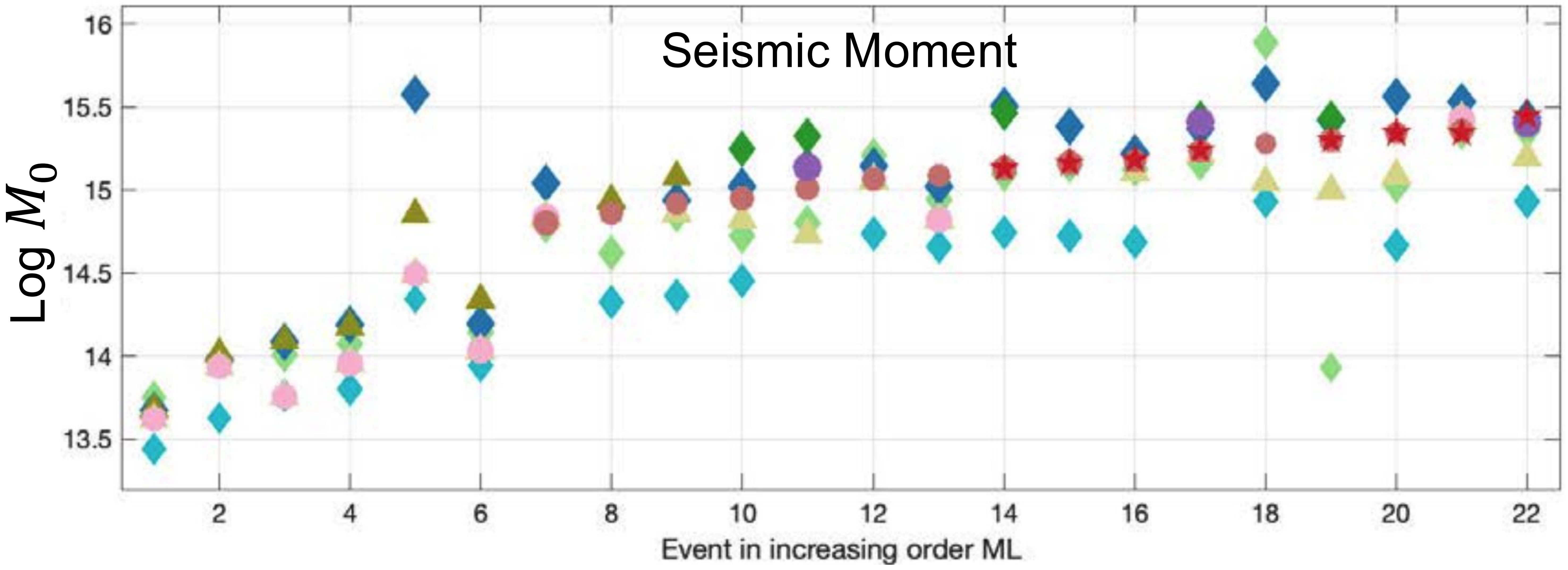


Different studies = different moment!



Abercrombie and Baltay, SCEC, 2023

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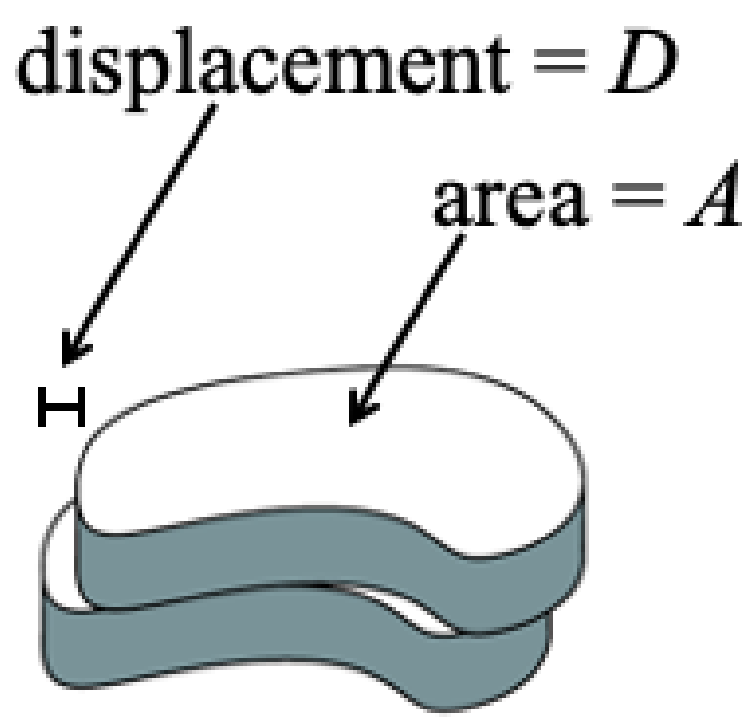

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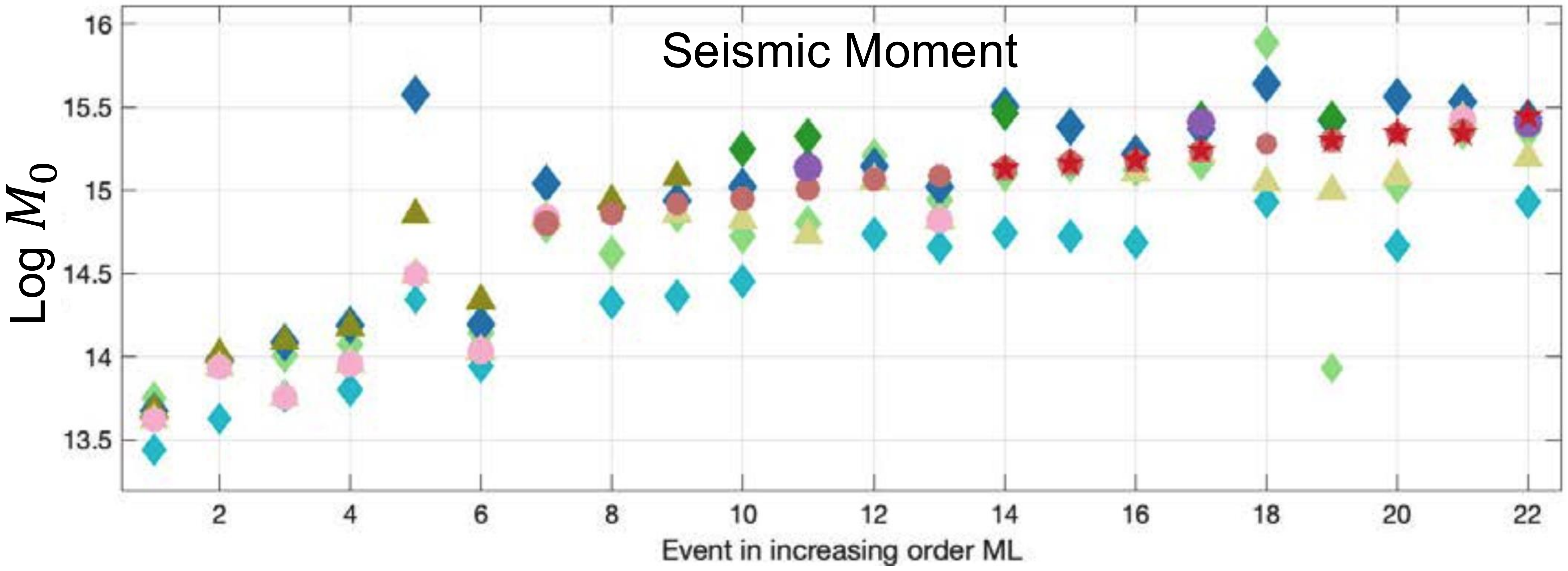

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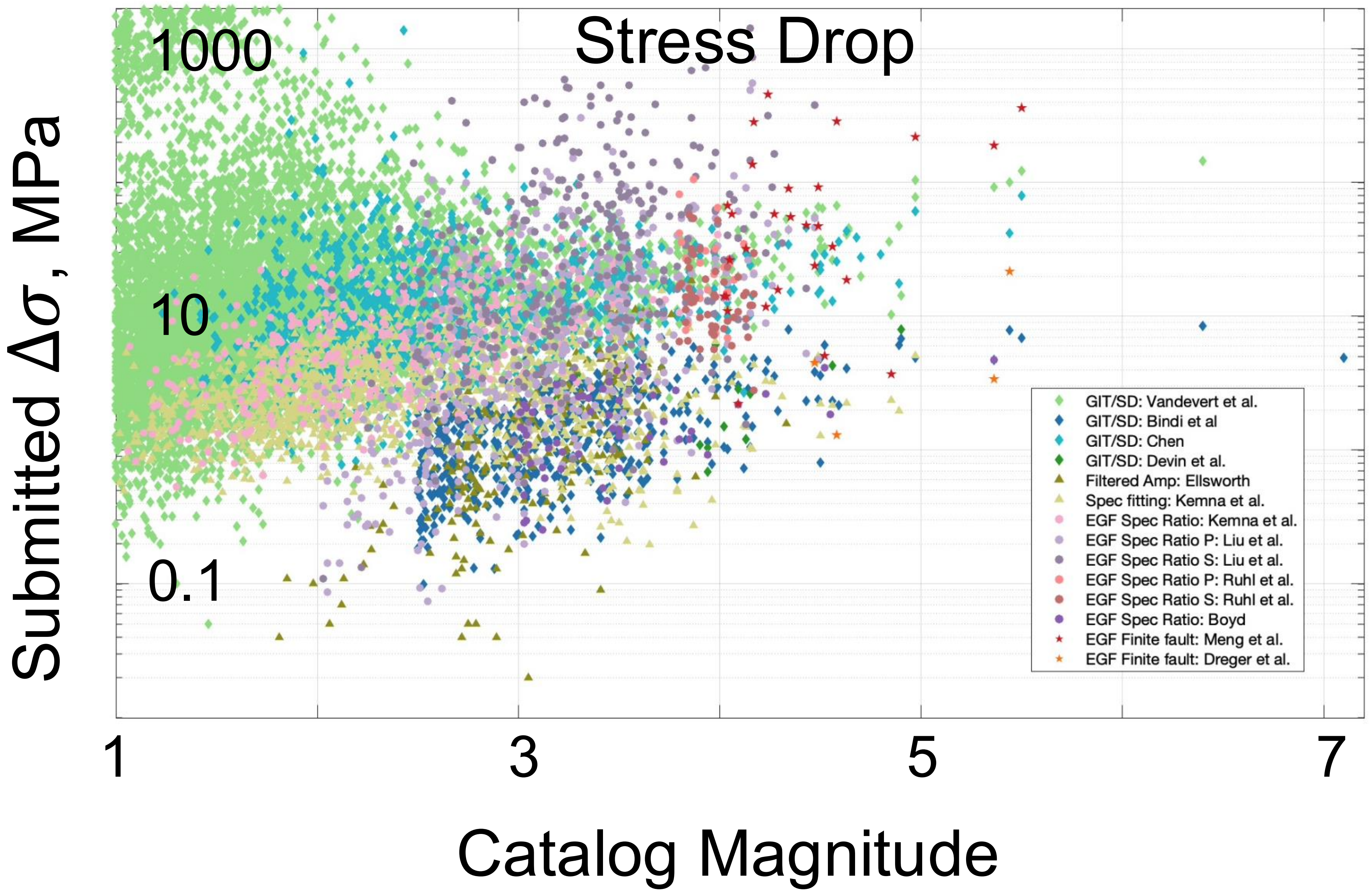

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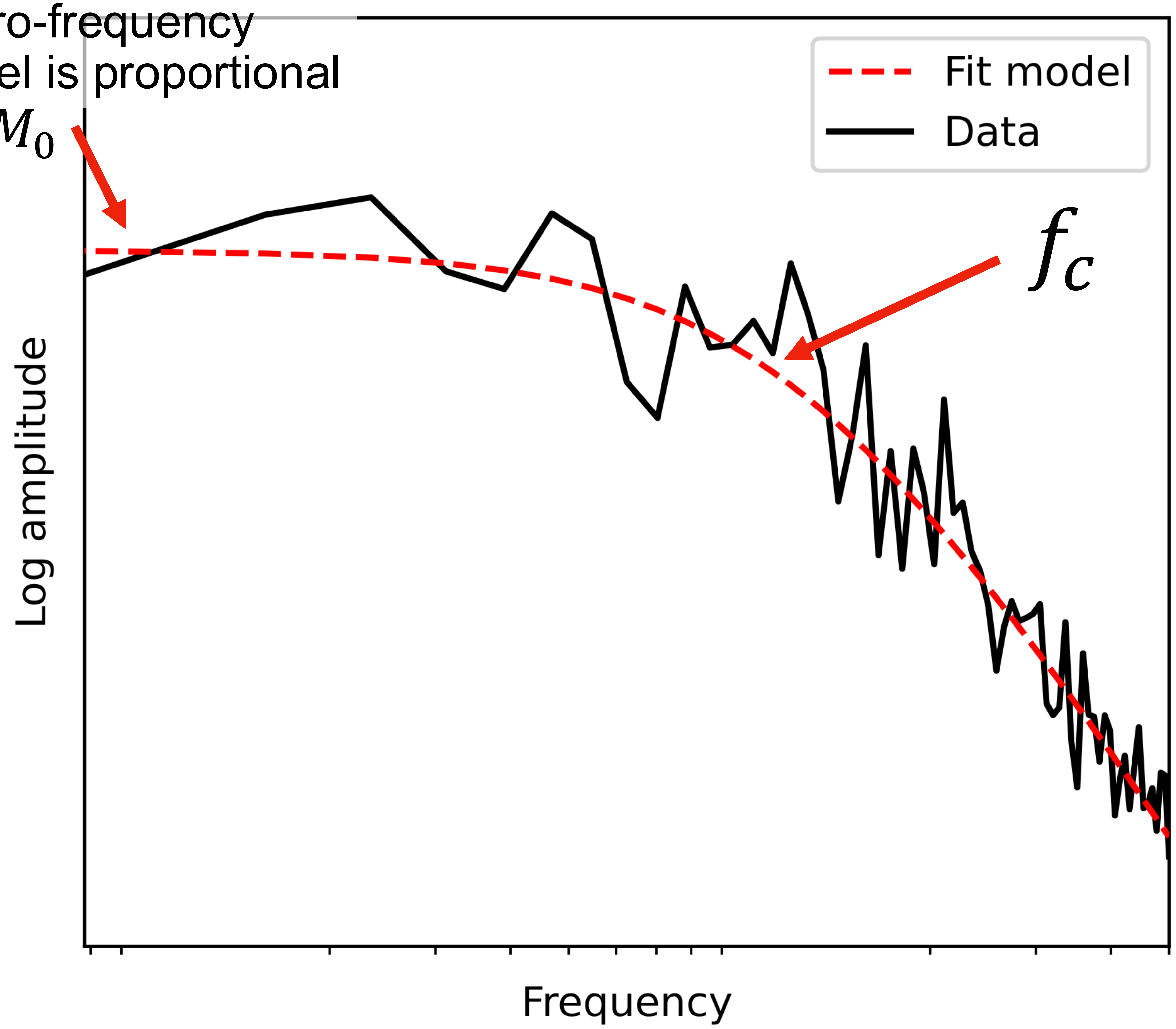
Stress drop from M_0 and f_c estimation

Fit a source model:

Zero-frequency level is proportional to M_0



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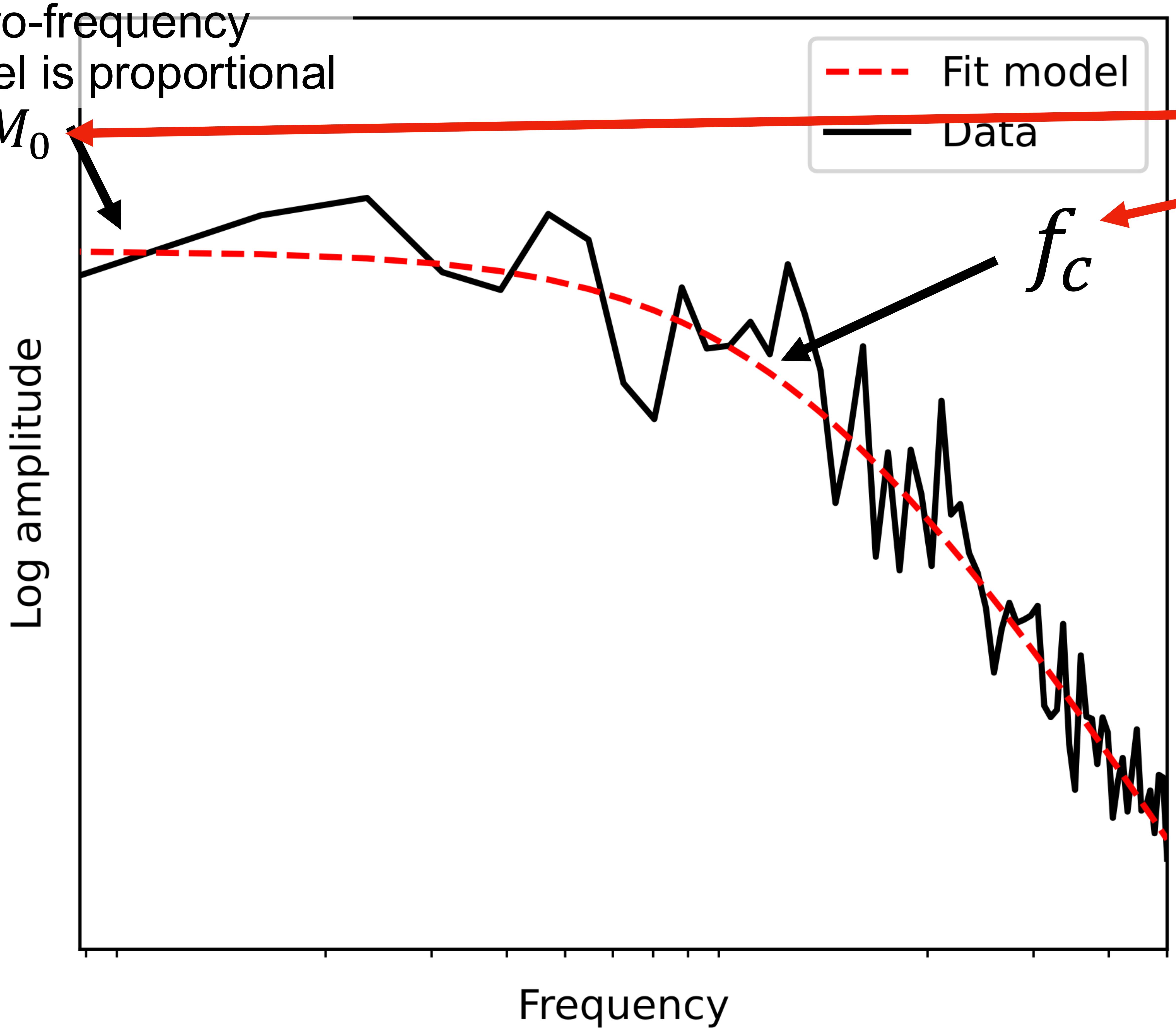

Tradeoffs, especially for low f_c

Stress drop from M_0 and f_c estimation

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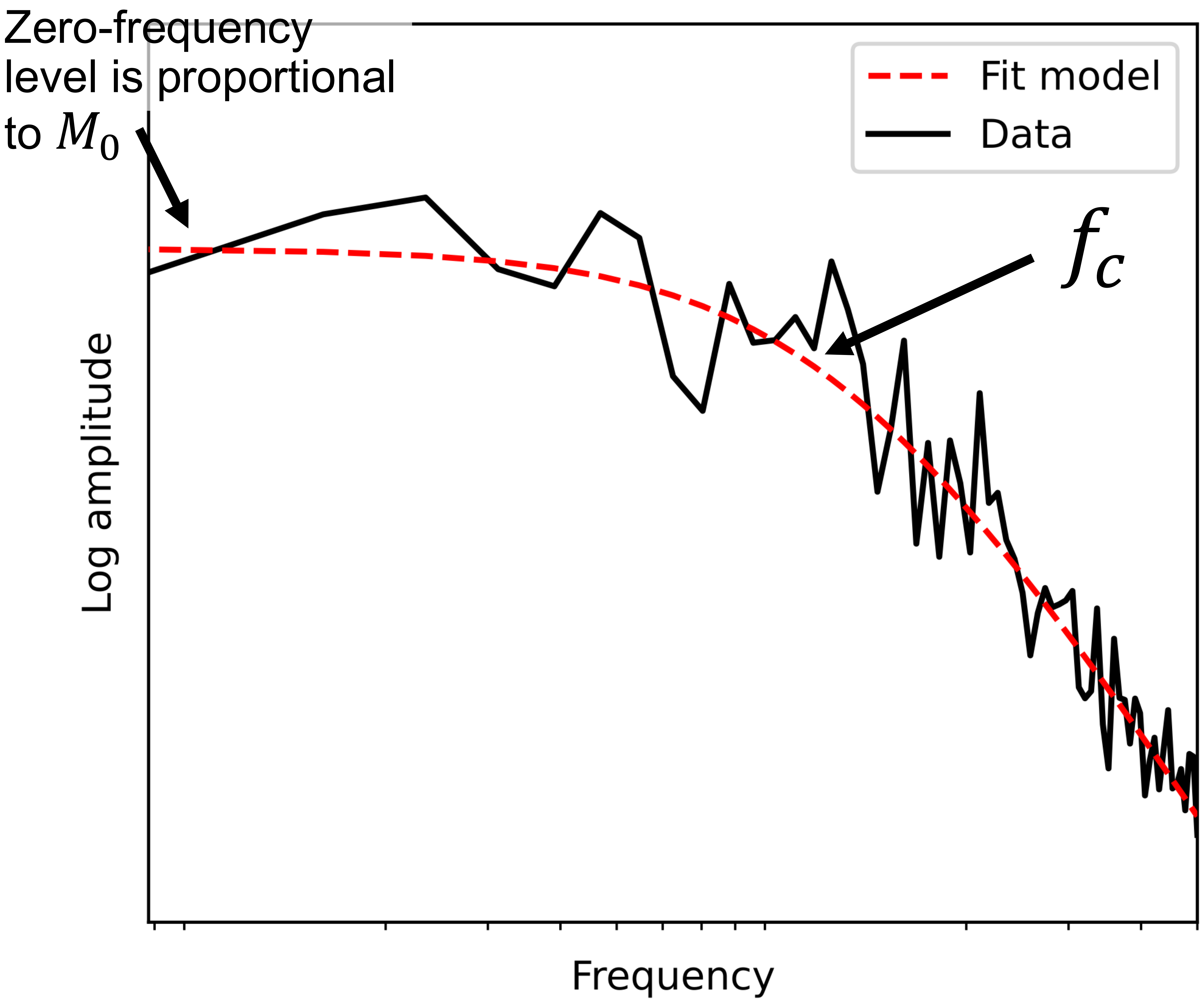


Estimate parameters:

$$\Delta\sigma = \frac{7}{16}\left(\frac{f_c}{k\beta}\right)^3 M_0$$

Ex. Brune stress

Isolating source spectra with spectral decomposition

Decompose the observed spectrum into parts to solve for **source spectra**:

Observed spectrum

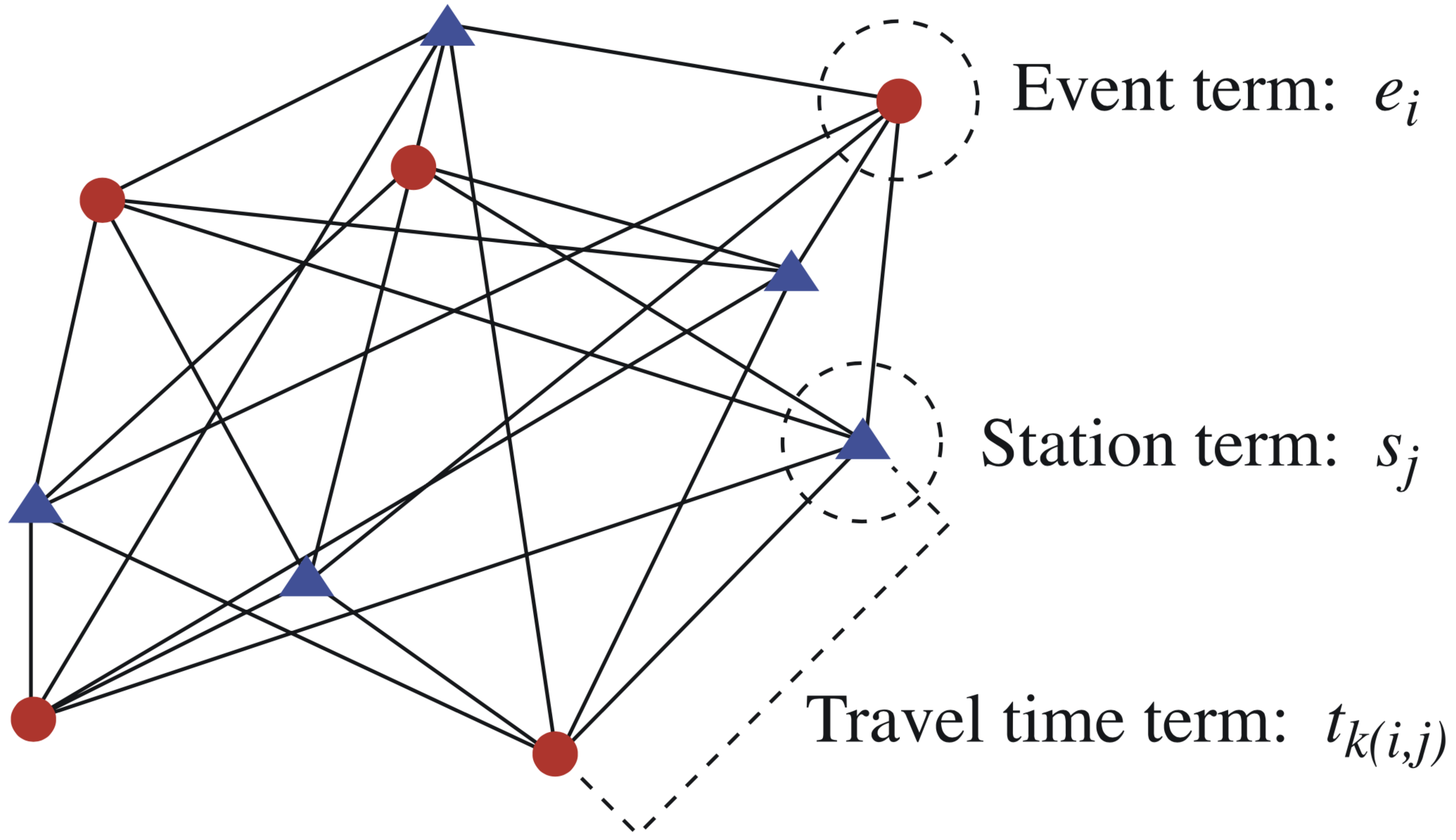
Station term

Residual

$$d_{ij} \approx e_i + s_j + t_{k(i,j)} + r_{i,j}$$

Event term (source spectrum)

Travel time term



Shearer et al., *JGR,* 2006; Shearer et al., *JGR,* 2022

Isolating source spectra with spectral decomposition

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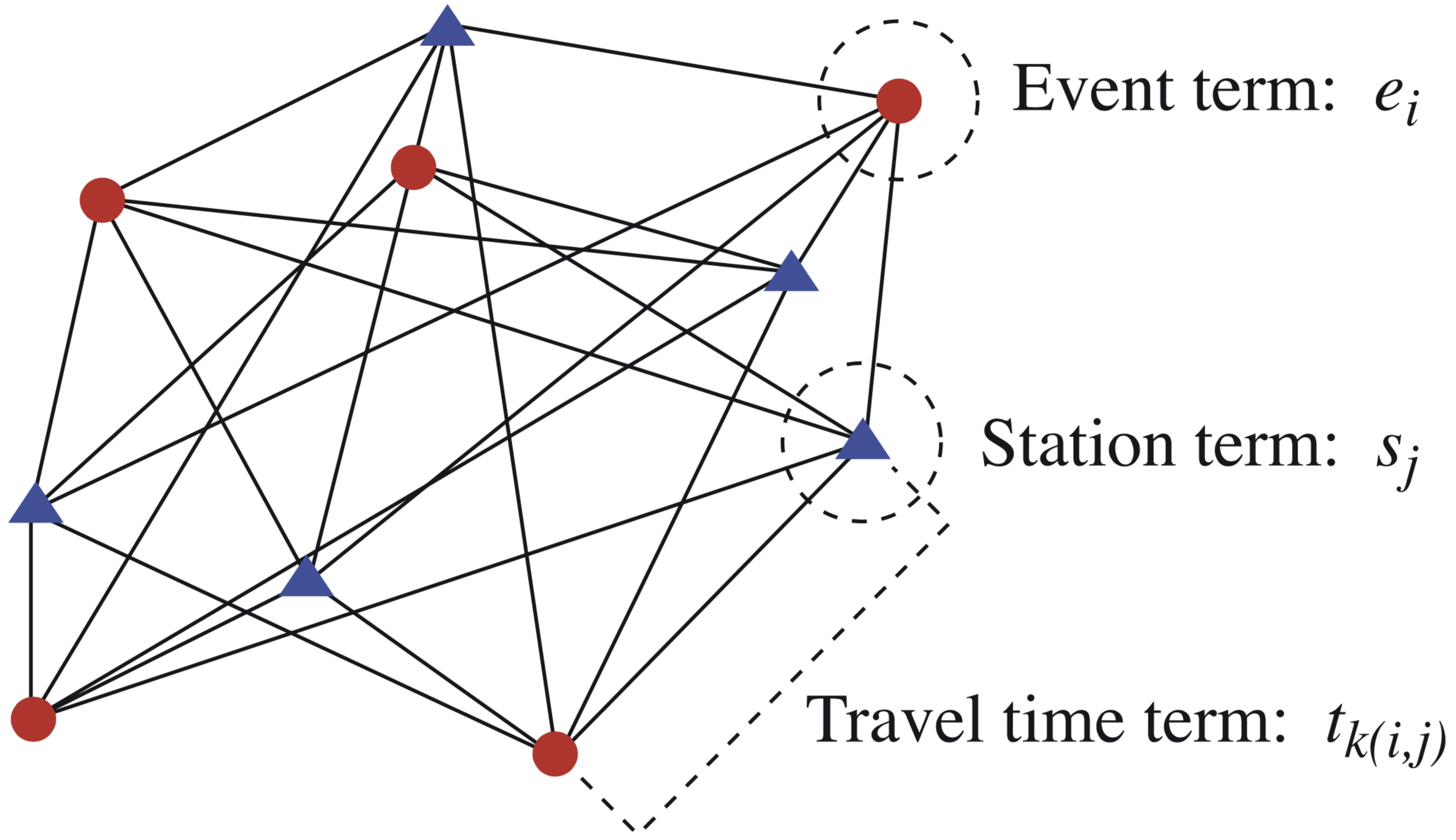
Invert following procedure in **Shearer et al.**, *JGR*, 2022



Shearer et al., *JGR*, 2006; Shearer et al., *JGR*, 2022

Motivation for this work

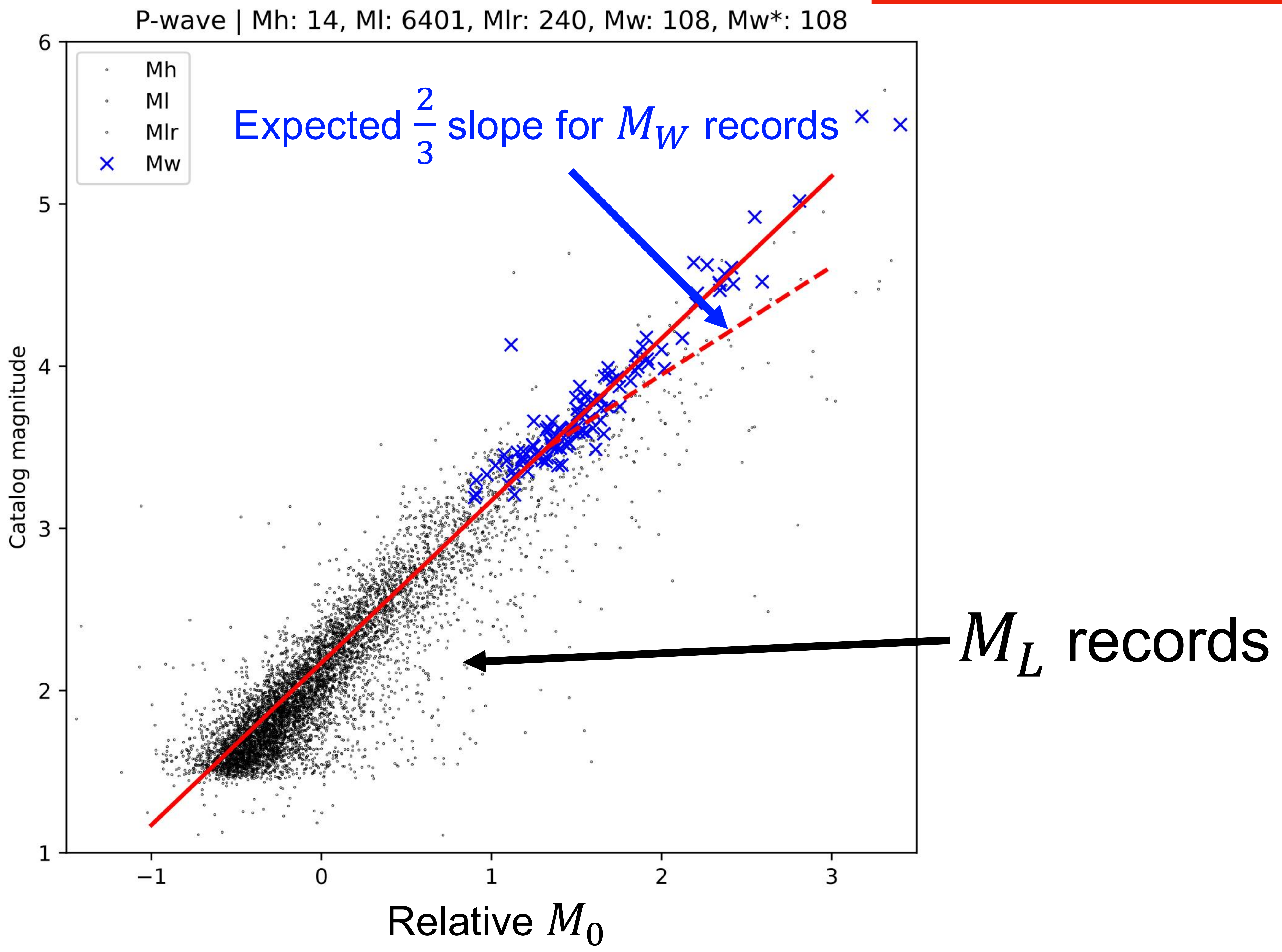
1. How can we improve the accuracy of seismic moment and corner frequency estimates?

2. How can we obtain consistent moment and stress drop estimates using both P-waves and S-waves?

Challenges in estimating M_0 using spectral decomposition

P-wave SD

$$M_W = \frac{2}{3}\left[\log_{10} M_0 - 9.1\right]$$



Challenges in estimating M_0 using spectral decomposition

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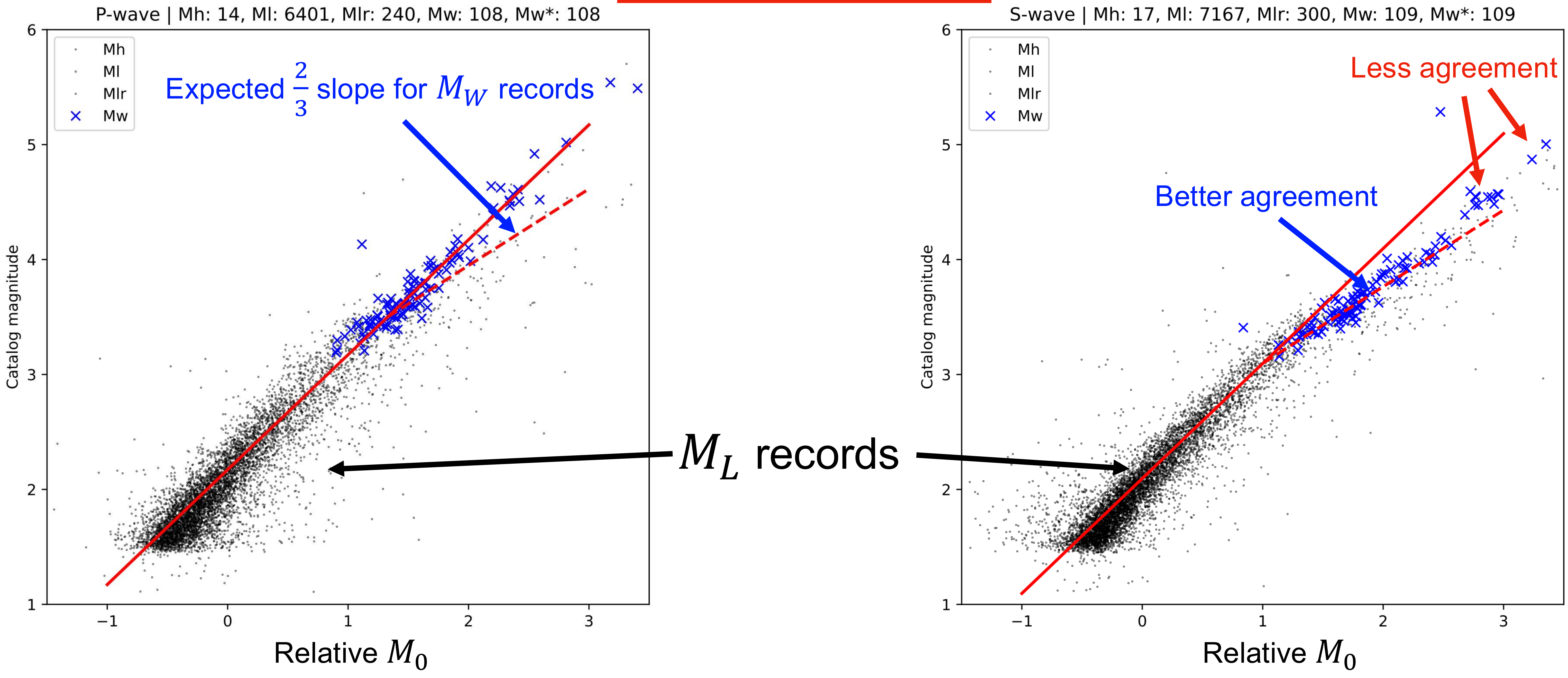
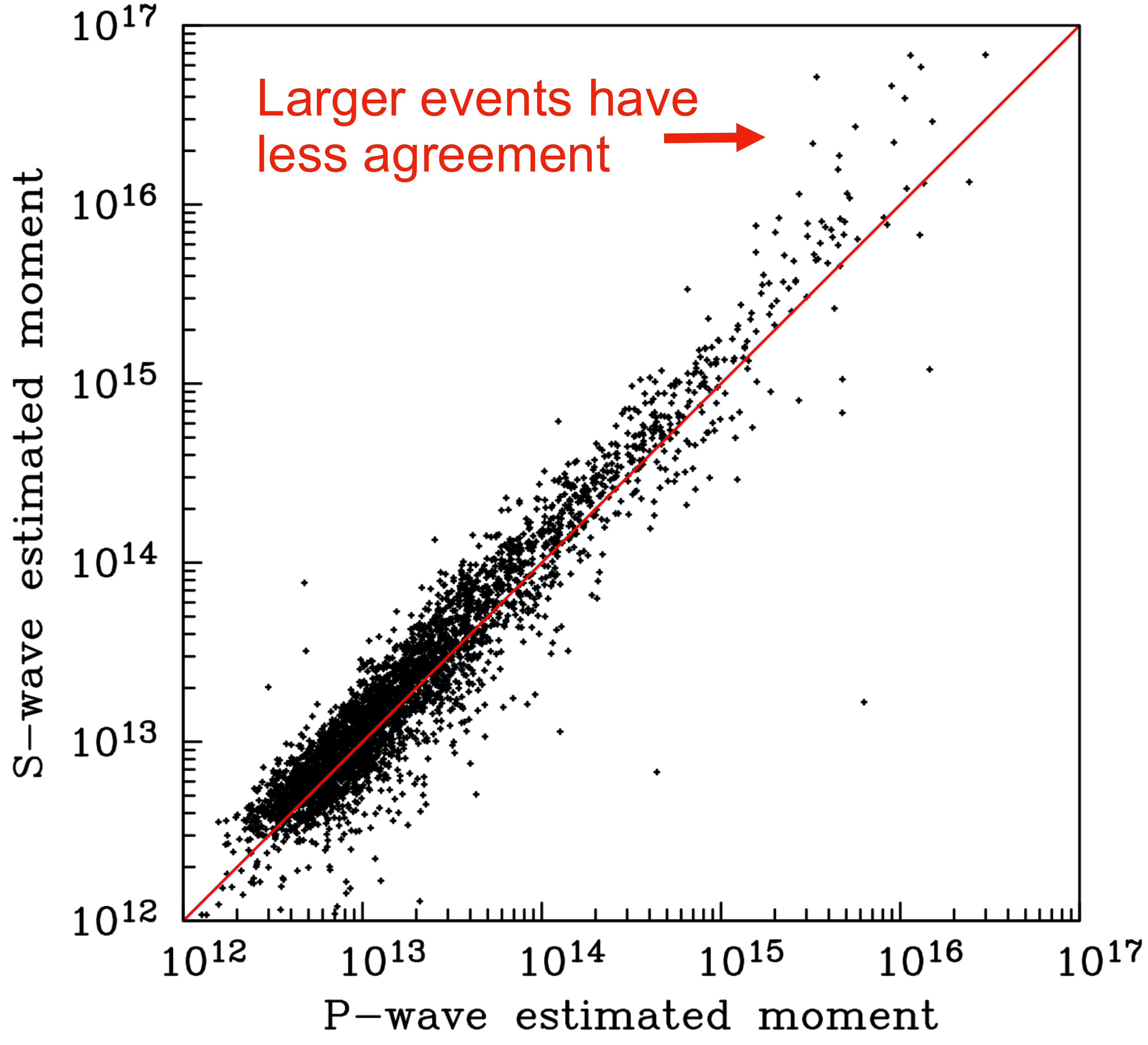
P-wave SD

S-wave SD



P- and S-wave spectral decomposition comparison

Moment comparison



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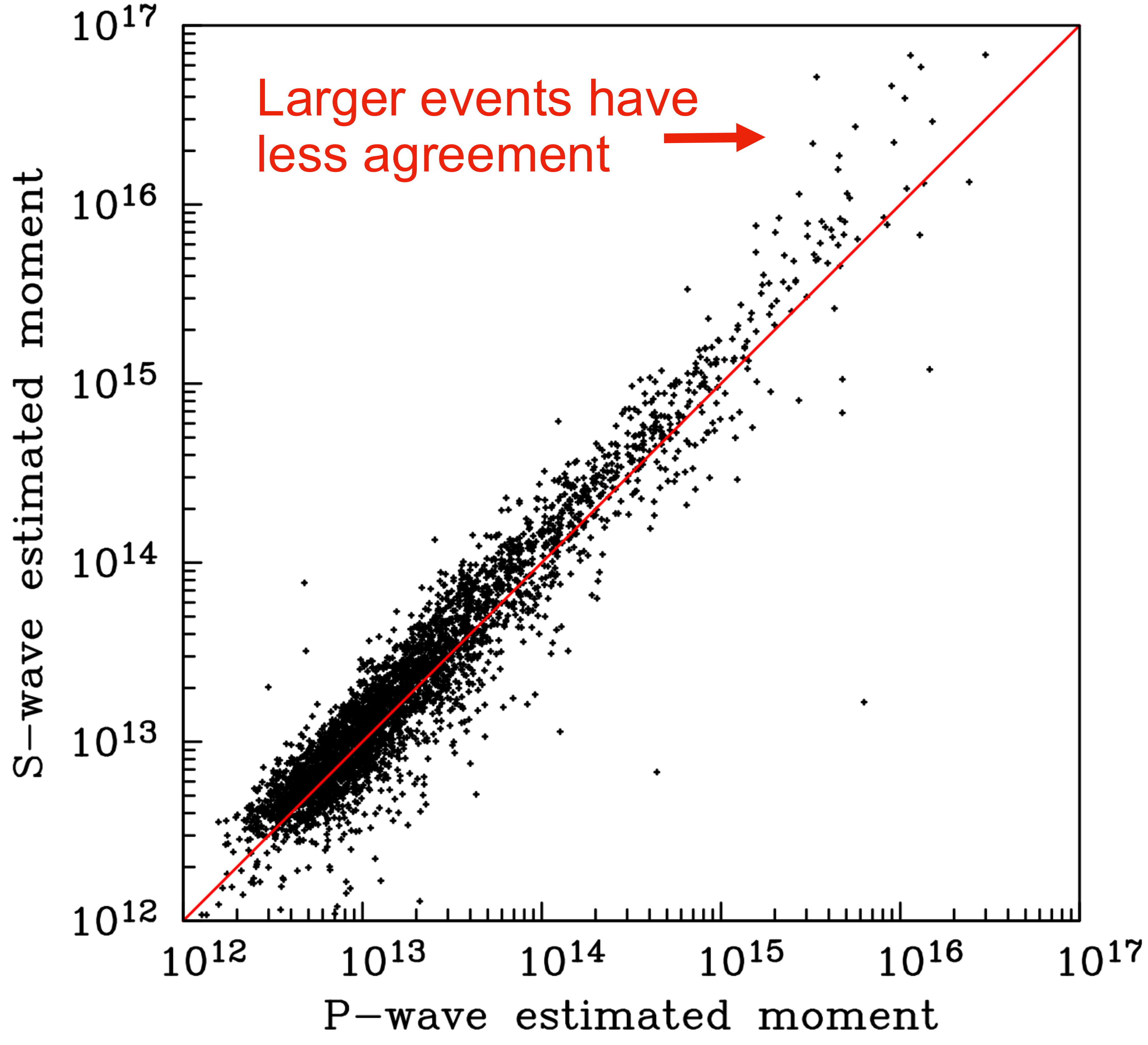
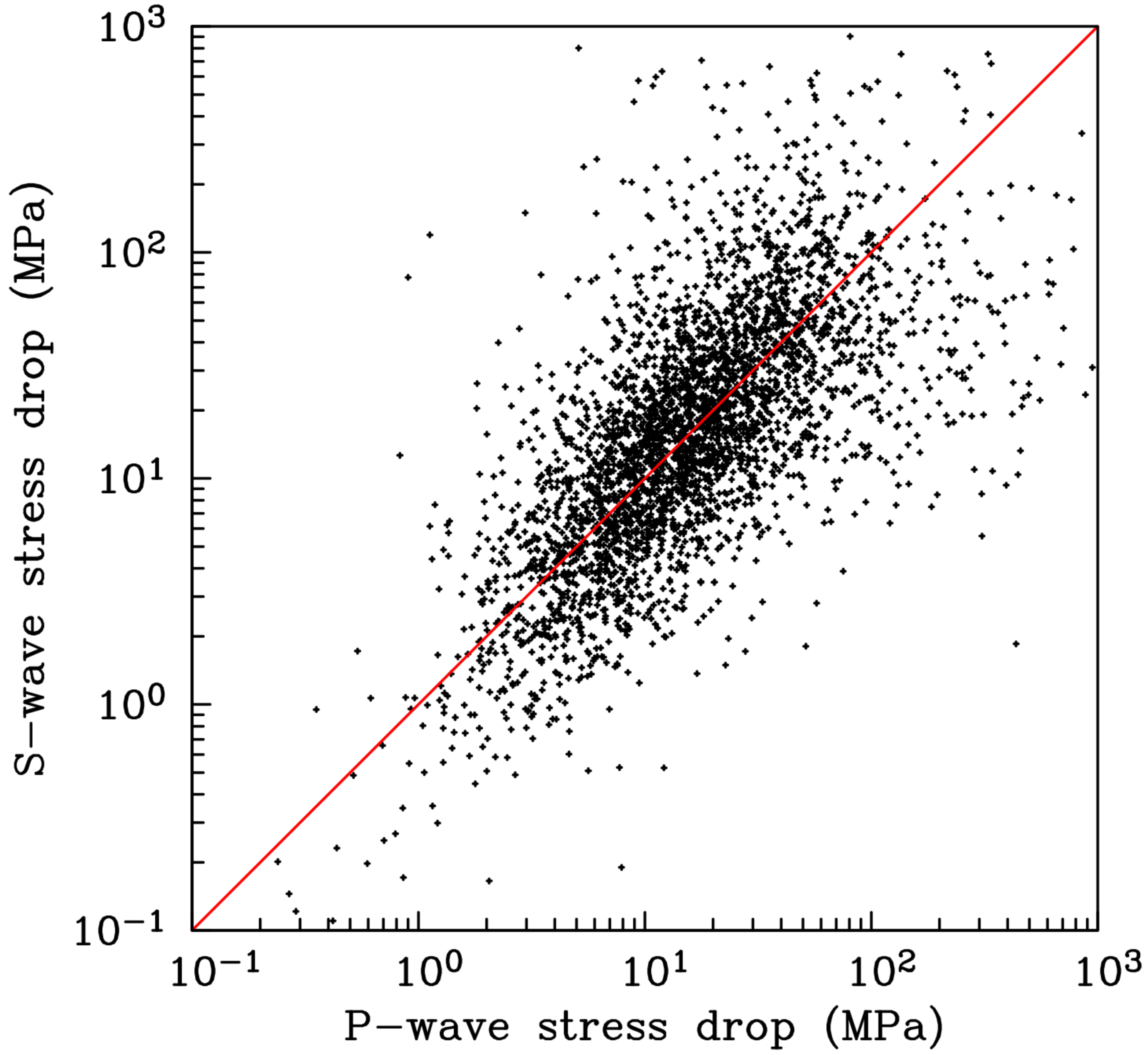


Stress drop comparison



Estimating spectra using maximum amplitudes in the time domain

Compute spectra using the following:

Estimating spectra using maximum amplitudes in the time domain

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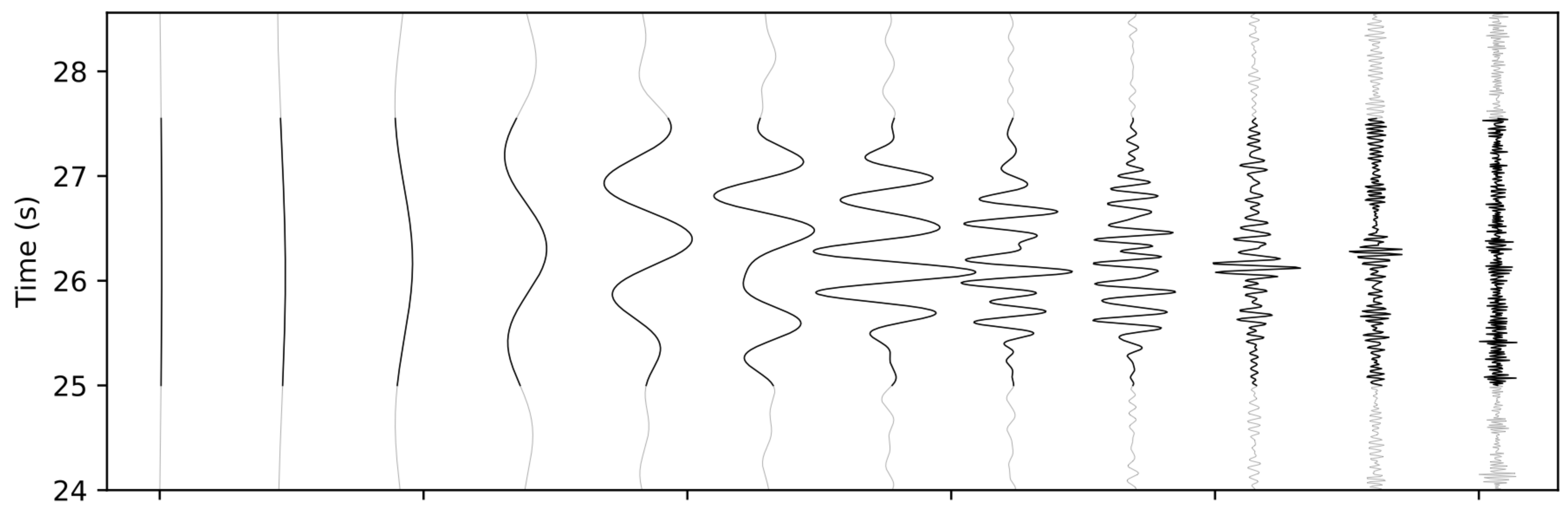
1. Filter **entire** seismogram using many different narrow bandpass filters separately



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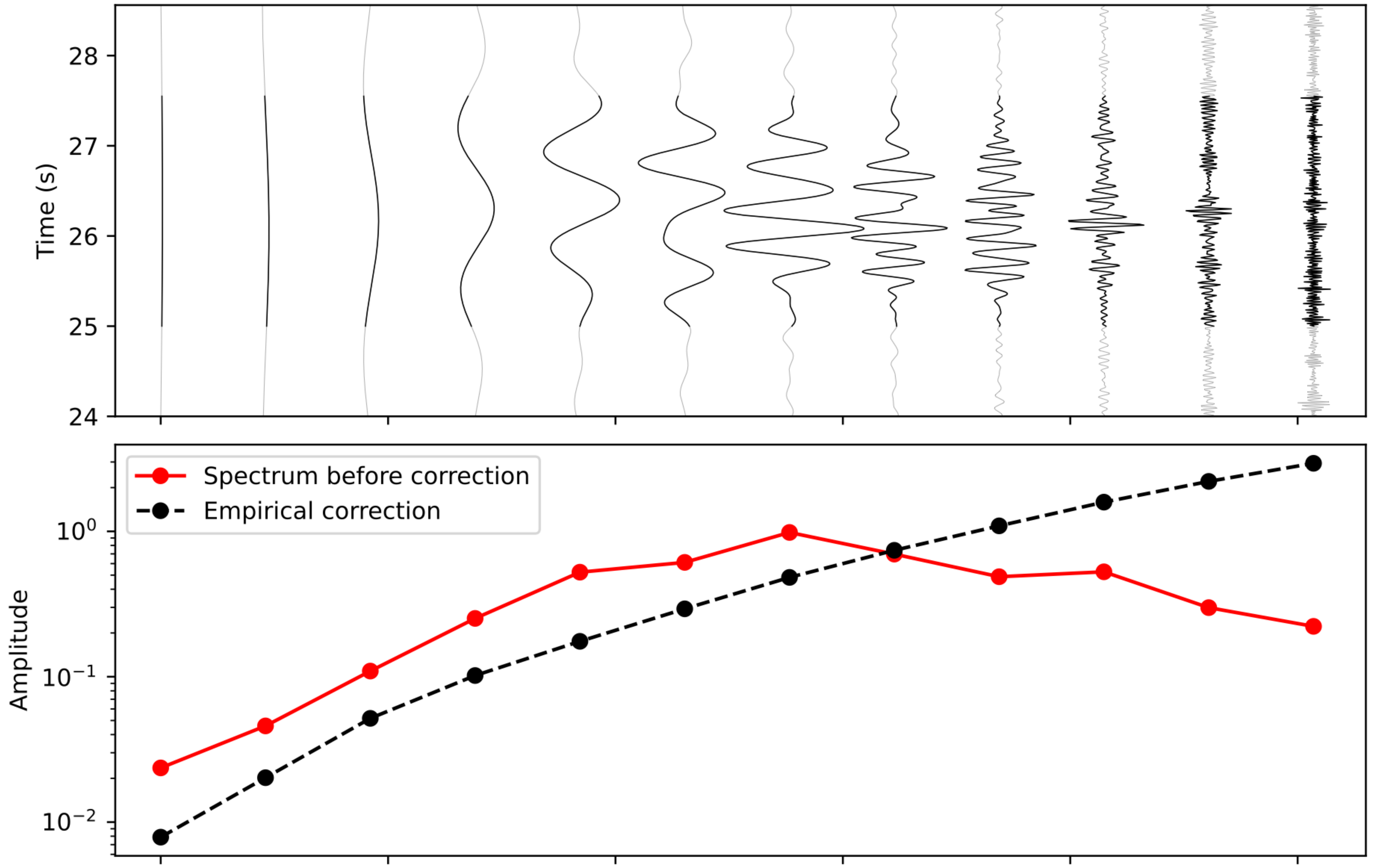

Estimating spectra using maximum amplitudes in the time domain

Compute spectra using the following:

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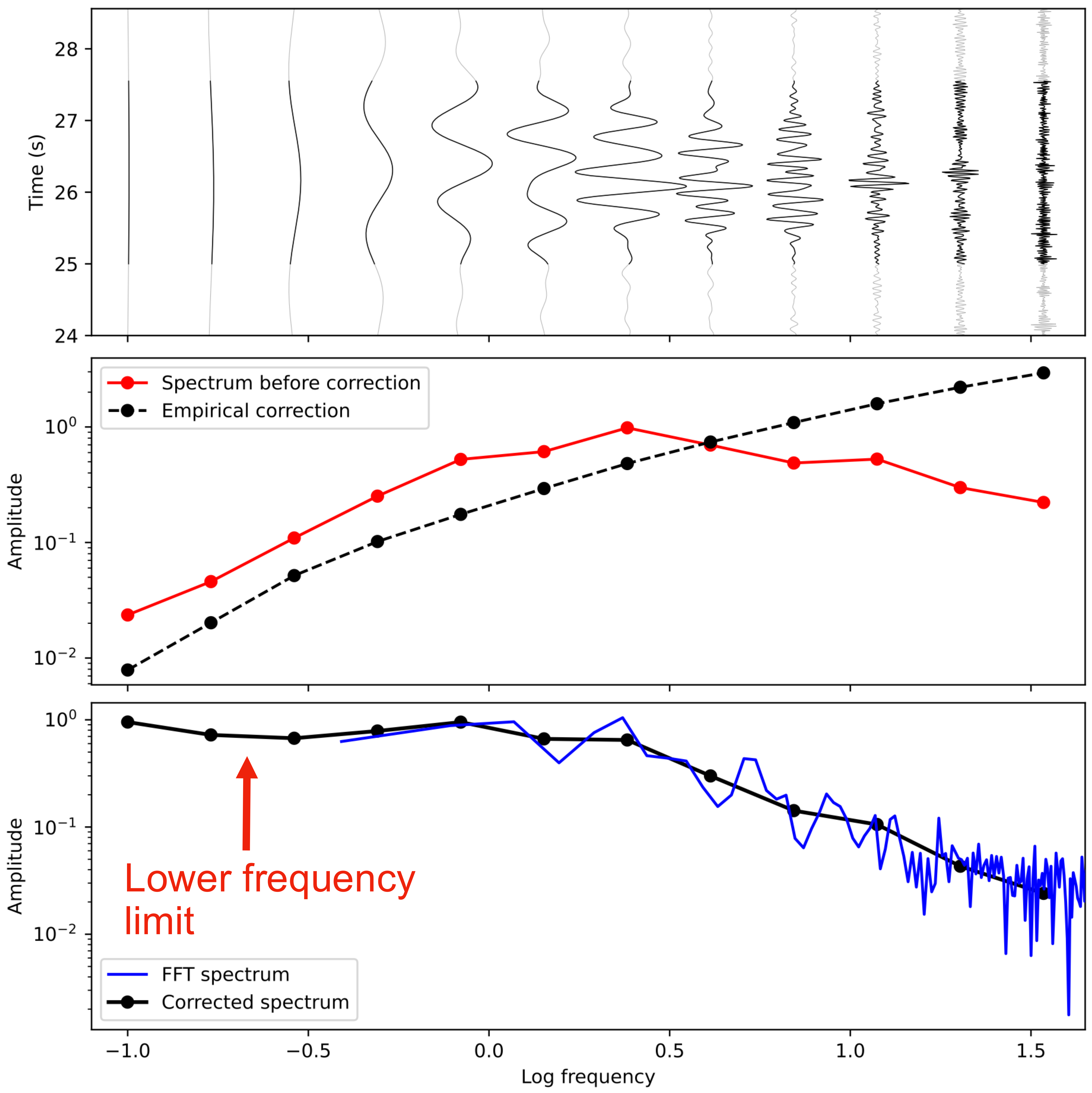
2. Compute the maximum amplitude inside the time window of interest

3. Assemble a spectrum from these maximum amplitudes and correct for passband width



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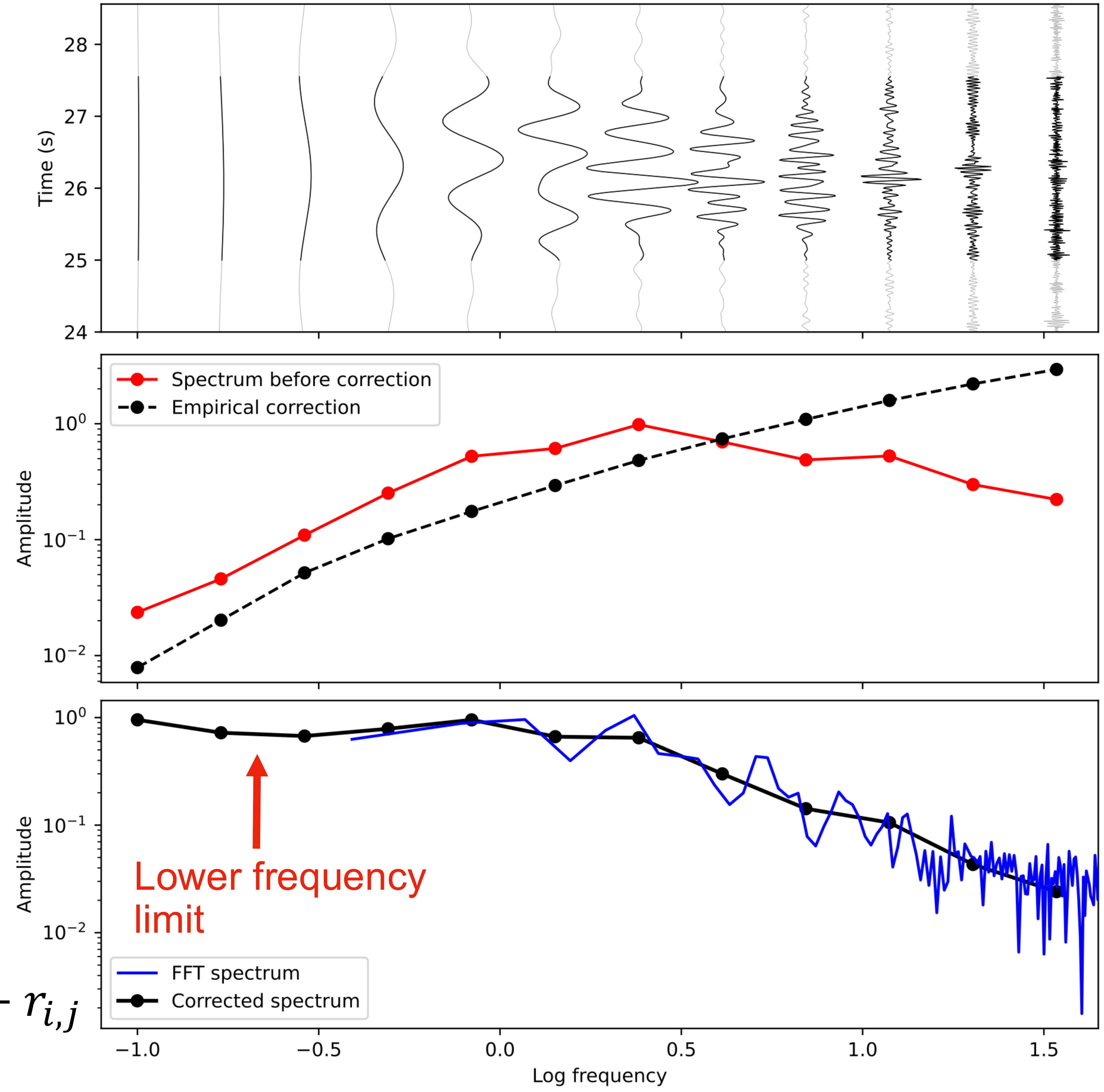
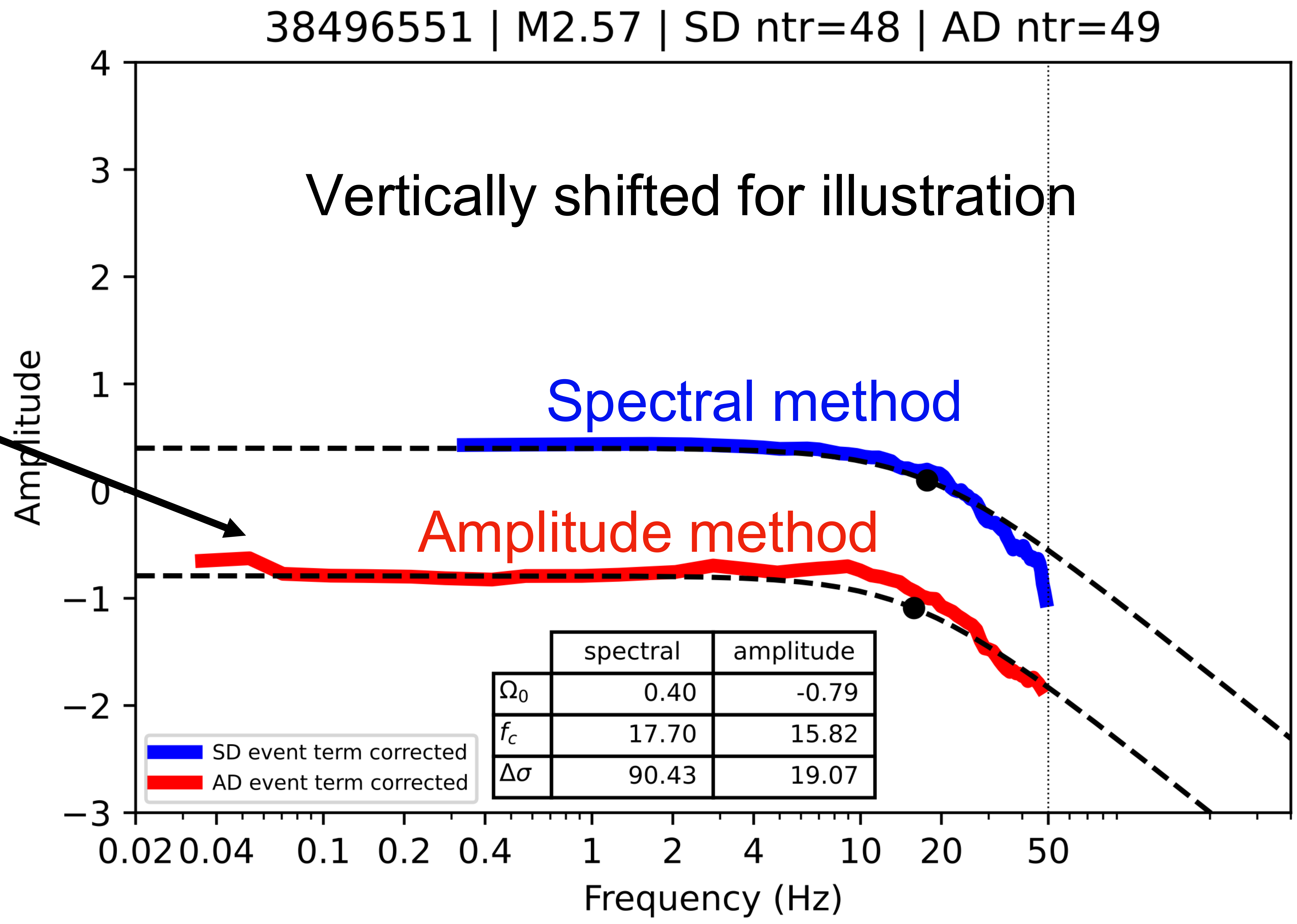


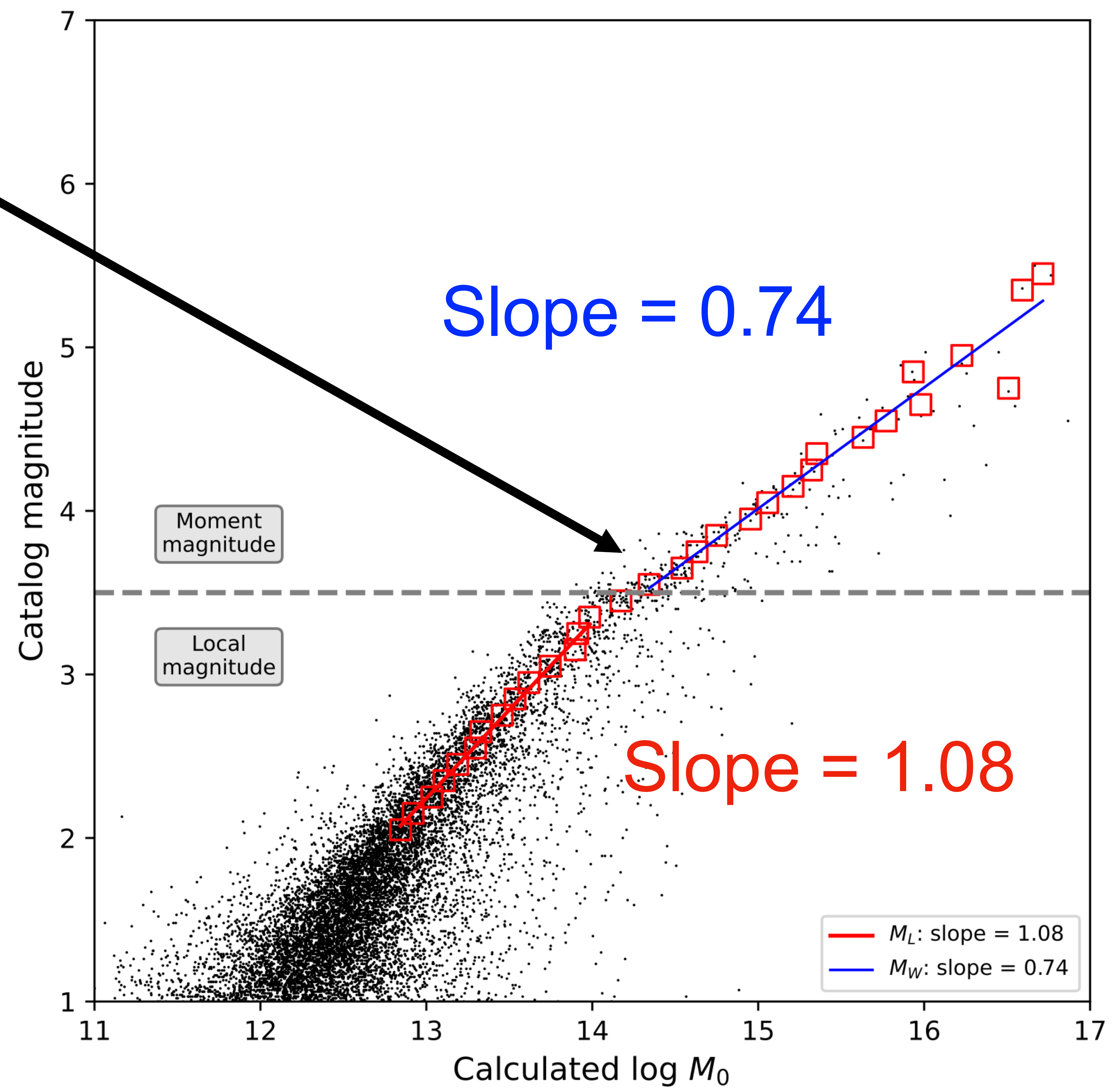
Reliable spectrum with lower low-frequency limit

Real earthquake example, lower low-frequency limit



Amplitude decomposition improves M_0 estimates

- Theoretical change in slope is apparent, though not exactly 2/3



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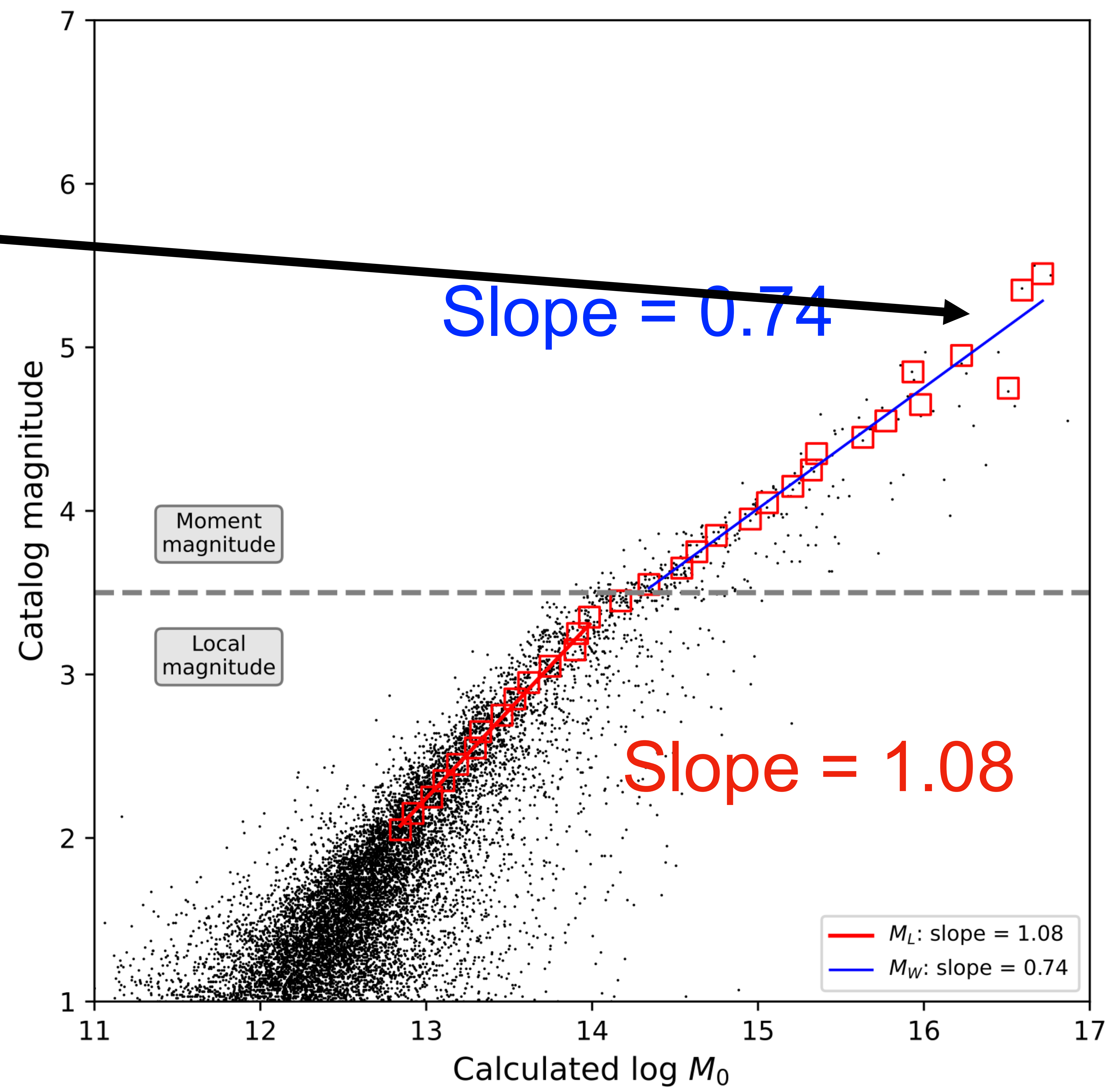
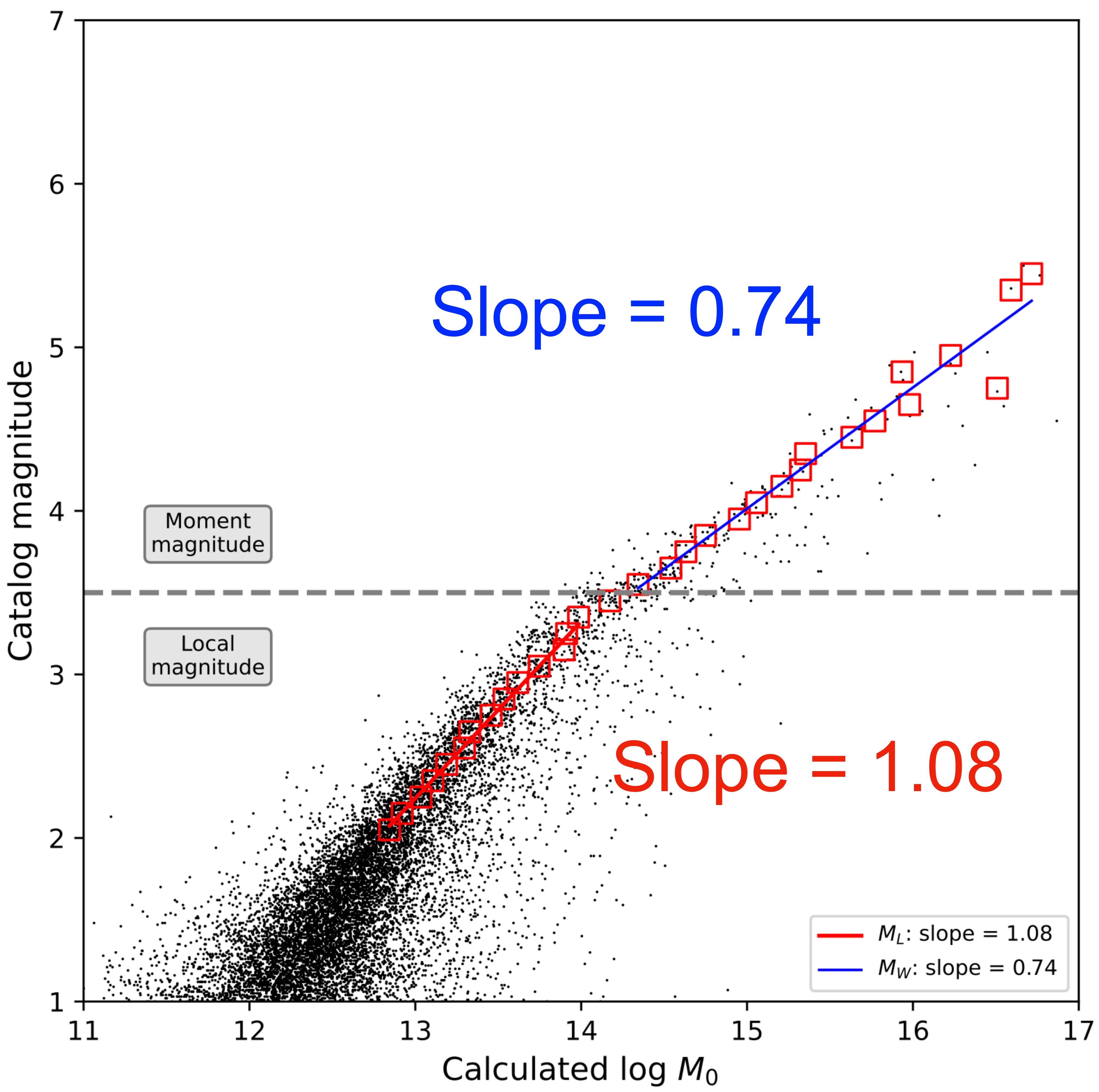


Amplitude decomposition improves M_0 estimates

- Theoretical change in slope is apparent, though not exactly 2/3
- Larger moment magnitude events follow this trend
- Lower frequency limit = higher accuracy in M_0 estimation



Conclusion

- Amplitude method is reliable to lower frequencies than spectral decomposition
- Good moment agreement between methods so far, possibly better estimation with amplitude method
- We are adjusting methods to get better consistency between P-wave and S-wave spectral decomposition, and S-wave amplitude decomposition to reduce source parameter uncertainty

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References

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- Shearer, P. M., Abercrombie, R. E., & Trugman, D. T. (2022). Improved stress drop estimates for M 1.5 to 4 earthquakes in southern California from 1996 to 2019. Journal of Geophysical Research: Solid Earth, 127(7).
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