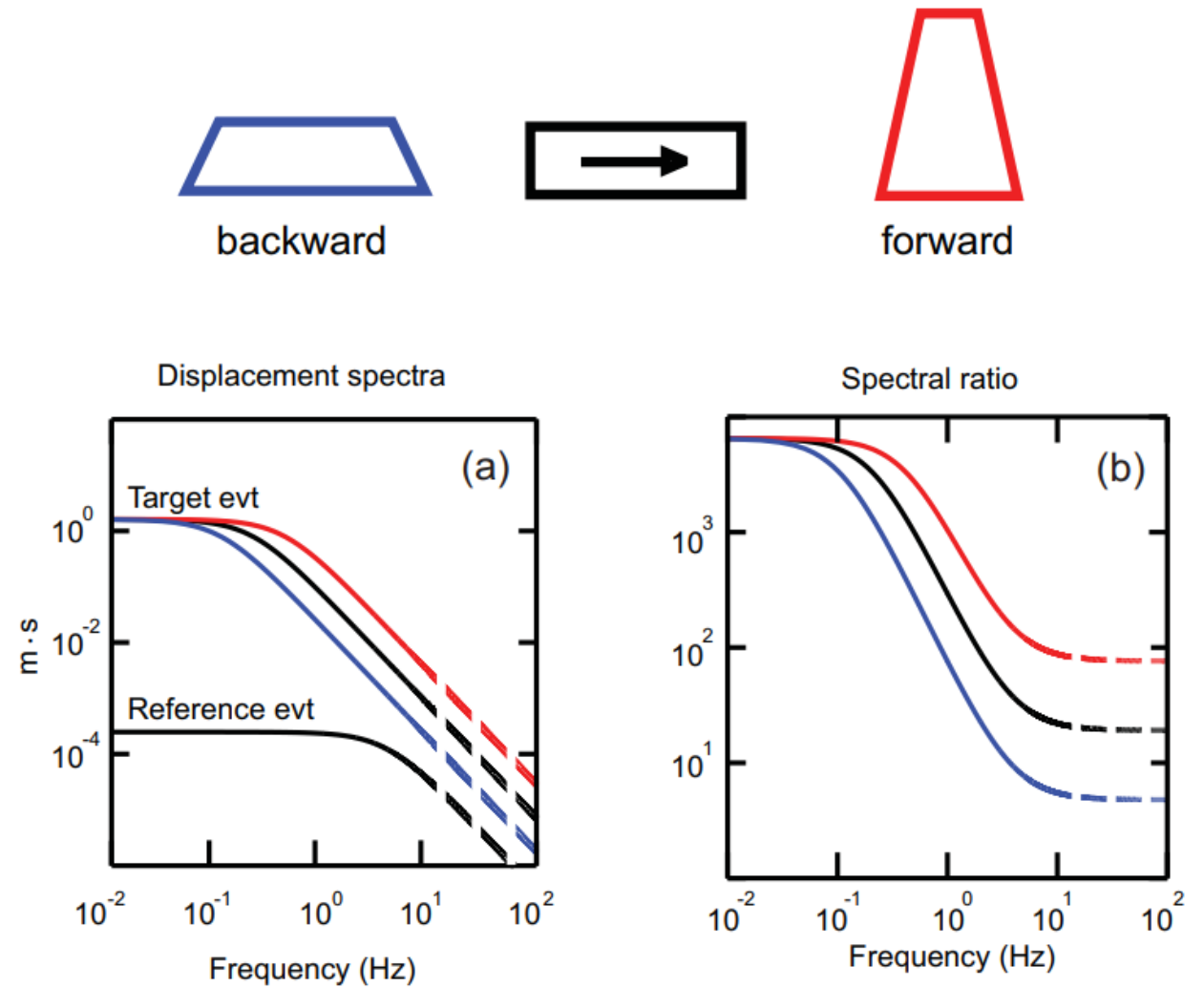# Spectral Ratio

- EGF-based spectral ratio contain information on the source parameters, e.g. stress drop, rupture area etc.

- Rupture directivity can be inferred from azimuthal variation of the corner frequency and high/low frequency component (e.g. Zhou et al 2022)


Calderoni et al., GJI 2015

Spectral Ratio

- Inputs
  - fpha_tar: phases for the target events
  - fctlg_all: catalog that contain all available events
  - fsta (station_eg.csv): station file
- Outputs
  - spectrum of target & EGFs
  - comparison of spectral ratio on different stations
  - stacked spectral ratio and estimated source parameters

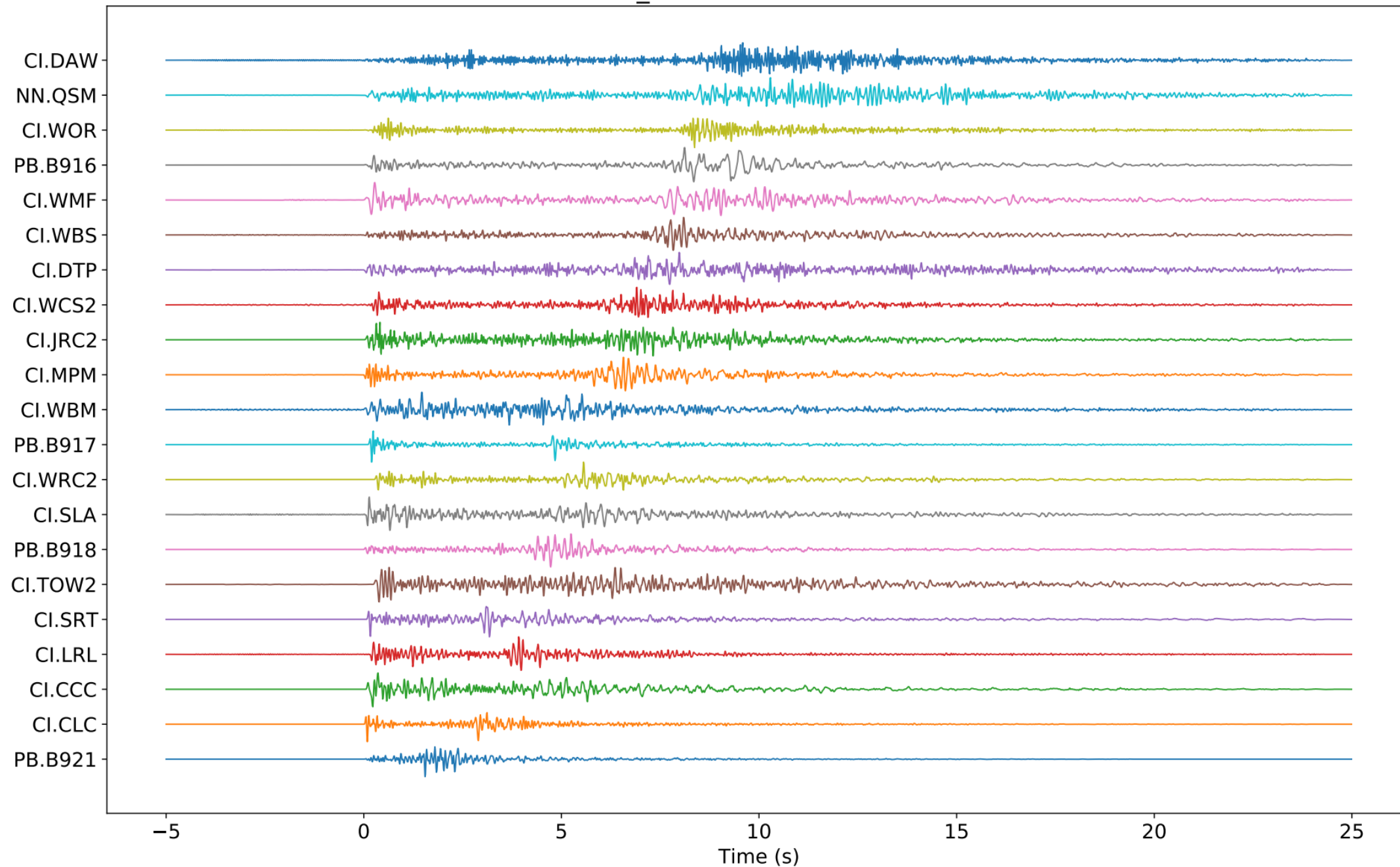| Input	Operation	Output	*Notes*
fctlg_all & fsta	*select_egf_loc.py*	fpha_egf_org	select EGF by time, location, & magnitude
fpha_tar & fpha_egf_org	*cut_events.py*	input/events_tar input/events_egf	cut raw data
fpha_egf_org & input/events_egf	*pick_events.py*	fpha_egf_org	refine original pick with STA/LTA
fpha_egf_org	*calc_egf-cc.py & plot_egf-cc.py*	eg_tar-egf.cc & eg_tar-egf-cc.pdf	
eg_tar-egf.cc	select_egf_cc.py	fpha_egf	select with CC (not strict criteria as well)
fpha_egf	*plot_waveform-events.py*	evid_name.pdf	inspect selected events

P-wave CC
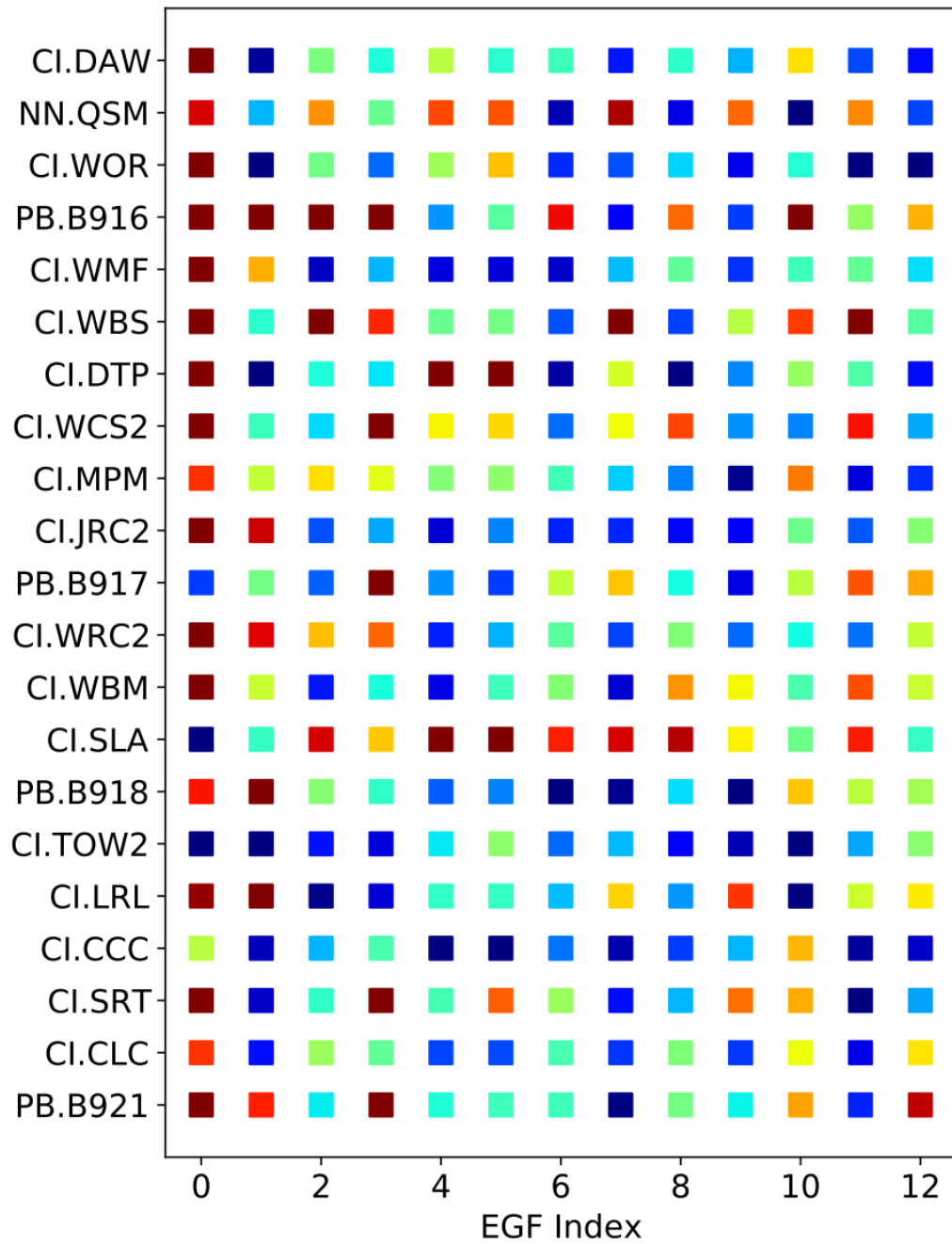
S-wave CC
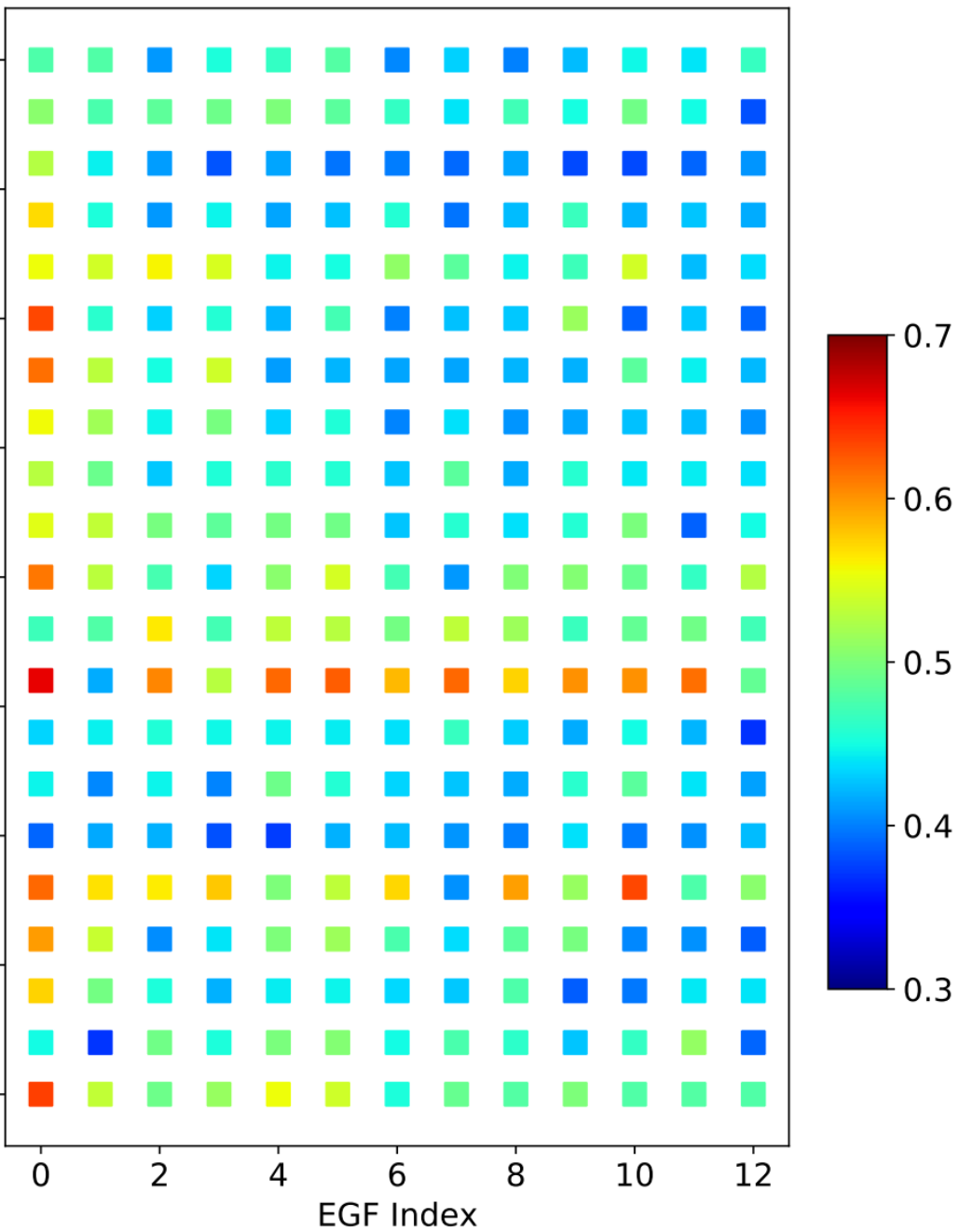
Event Waveform: 4_20190709060548.71 M2.55 Z 1-20Hz

Spectral Ratio Calculation and Analysis

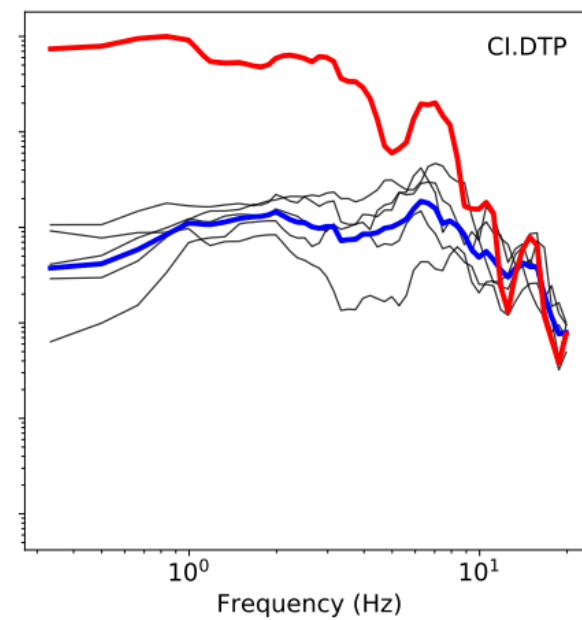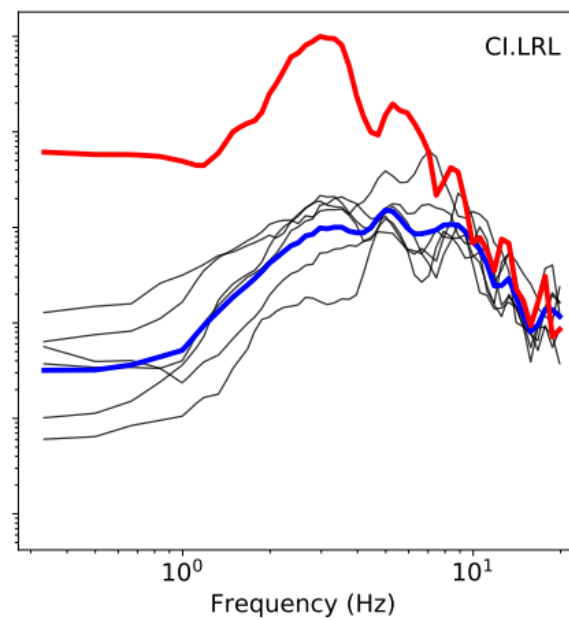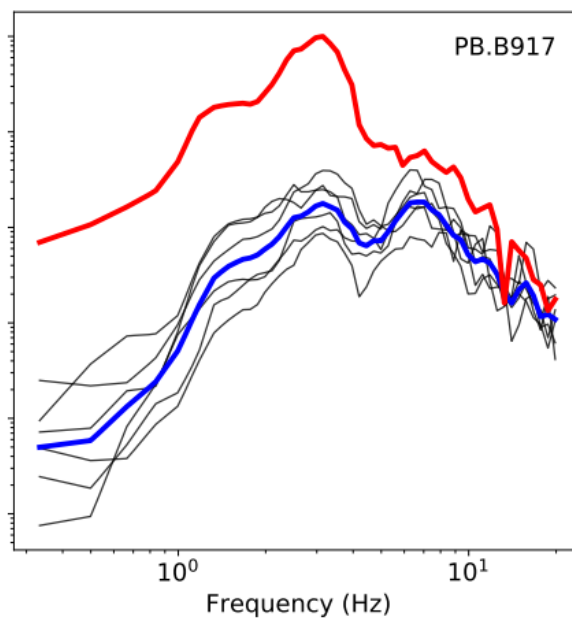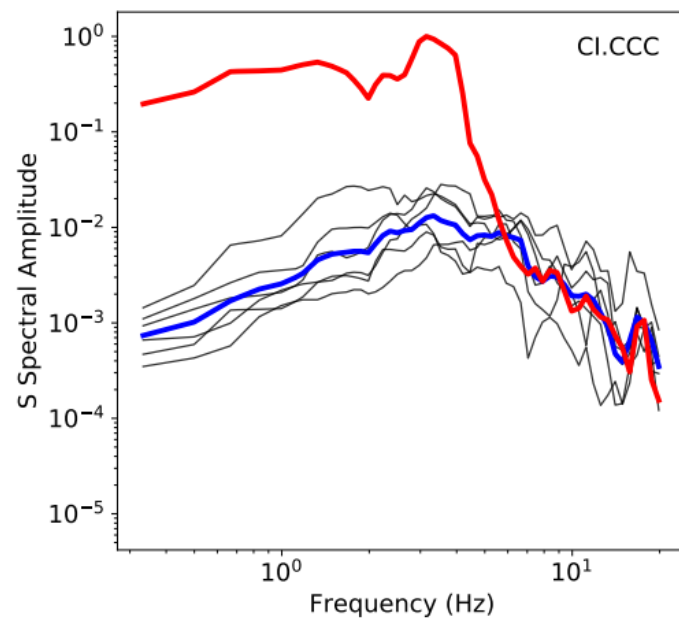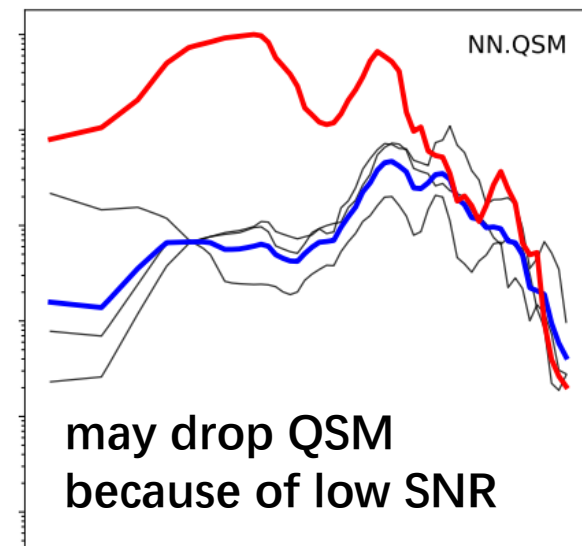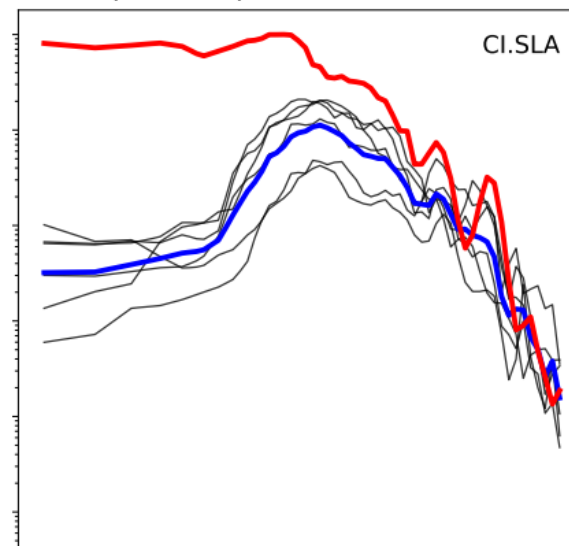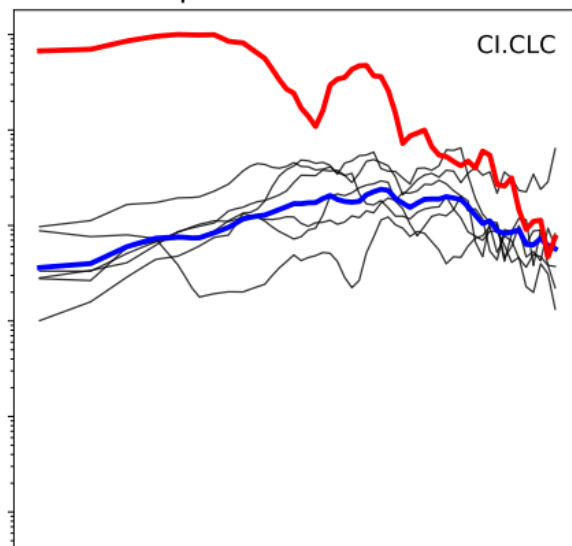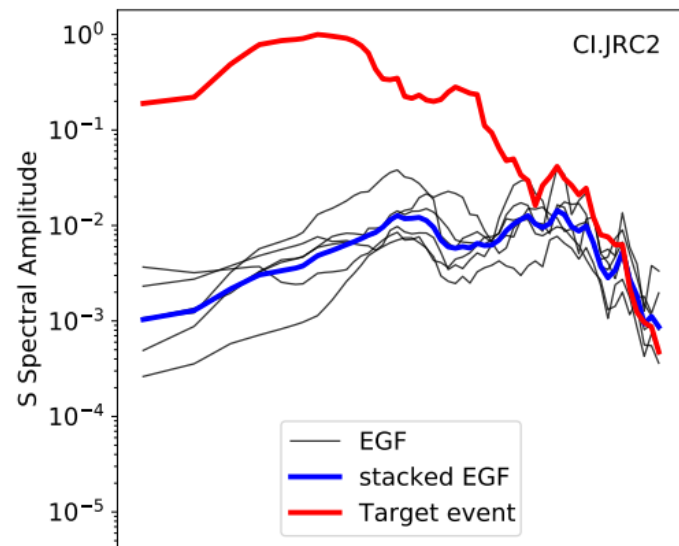| Input	Operation	Output	*Notes*
fpha_egf & fpha_tar	*plot_spec-s.py*	eg_spec-s_name.pdf	check the consistency between spectrum of EGFs
fpha_egf & fpha_tar	*plot_spec-ratio-compare.py*	eg_spec-ratio-compare_name.pdf	resolve rupture directivity first to determine the fault plane
fpha_egf & fpha_tar	*plot_spec-ratio-stack.py*	eg_spec-ratio-stack_name.pdf	use fault-normal stations to estimate source parameters
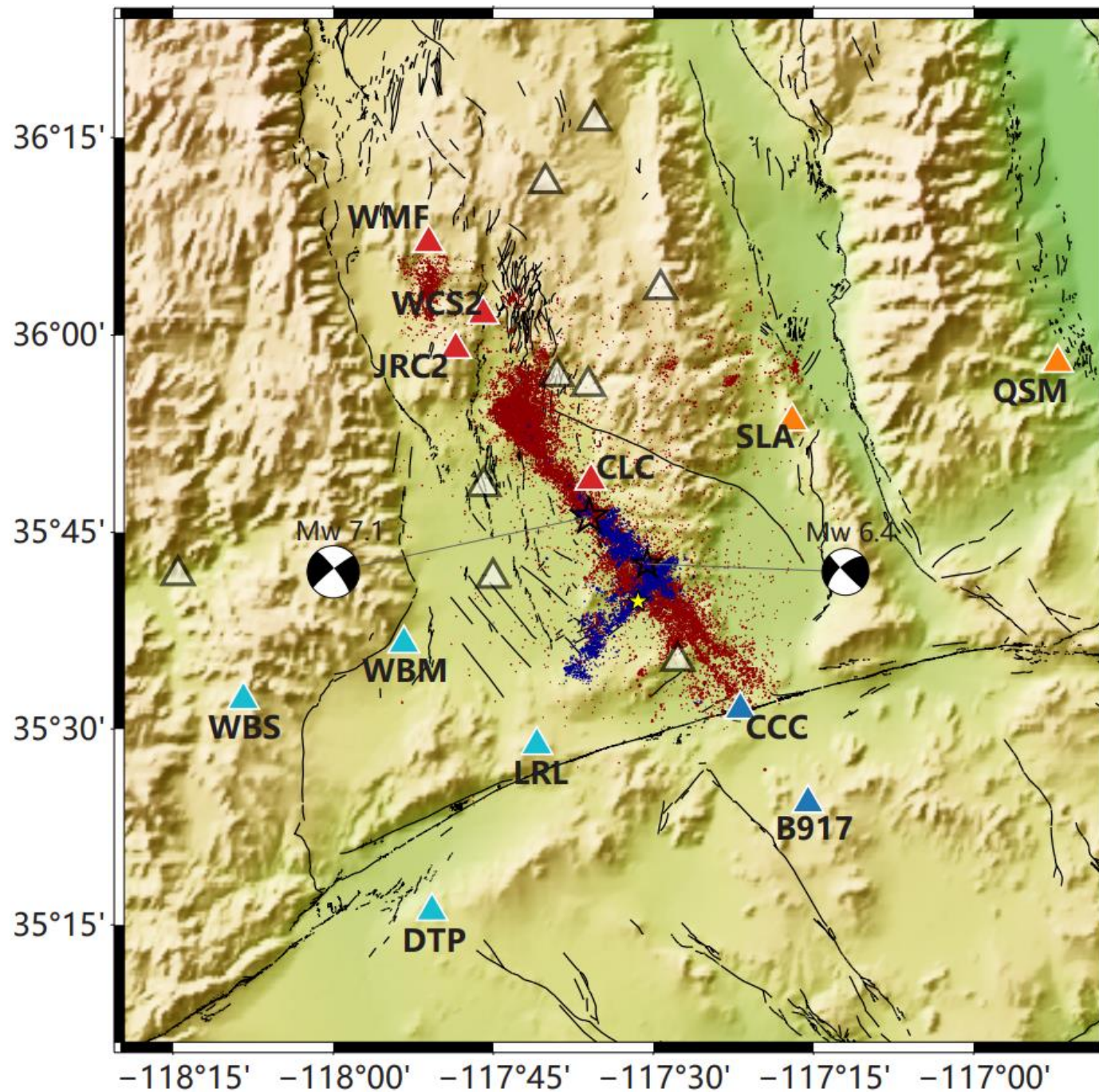
Aftershocks show two fault trends, thus two possible rupture directivity exists

⬇
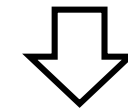
Compare **spectral ratio** on two sets of stations: along Fault_1 (NE) & along Fault_2 (NW) → the direction with more significant contrast indicate the ruptured fault

S Spectrum of 20190704195600.50 (Ml 4.16) & EGFs

may drop QSM
because of low SNR

(a) Comparison Along Fault 1

(b) Comparison Along Fault 2

NW
SE
Stacked
Stacked of (b)

NE
SW
Stacked
Stacked of (a)

S Spectral Ratio

Frequency (Hz)

Not along Fault 1
1. consistent spectral ratio
2. more low-frequency component

Rupture to SW
1. higher contrast in f_c
2. more high-frequency component
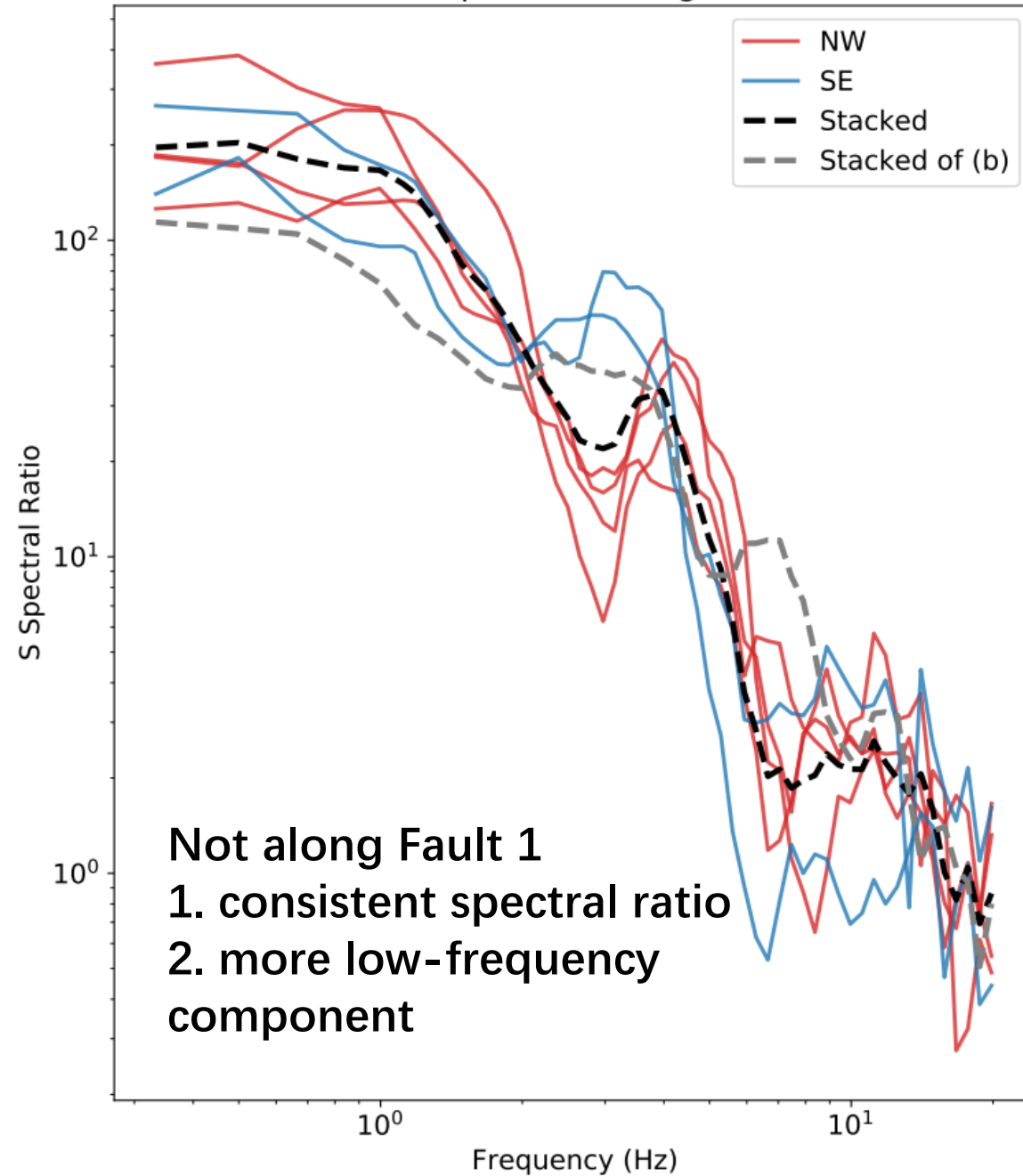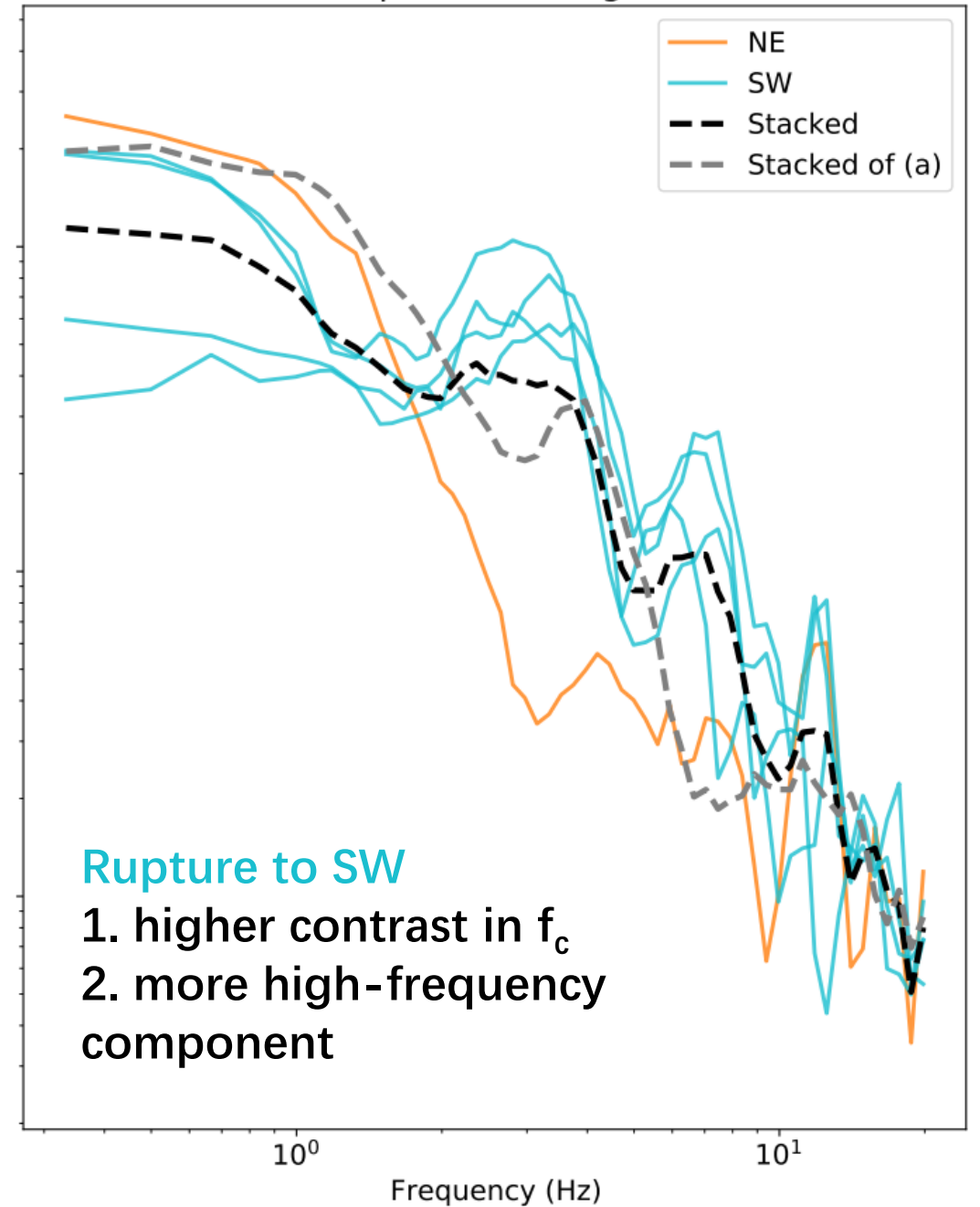
Stacked Spectral Ratio: 20190704195600.50 (Ml 4.16)

$f_c = 1.00\ Hz$
$A = 1.61\ km^2$
$D = 3.78\ cm$
$\Delta\sigma = 2.32\ MPa$

S Spectral Ratio

Frequency (Hz)

Single station
Stacked
Best fit
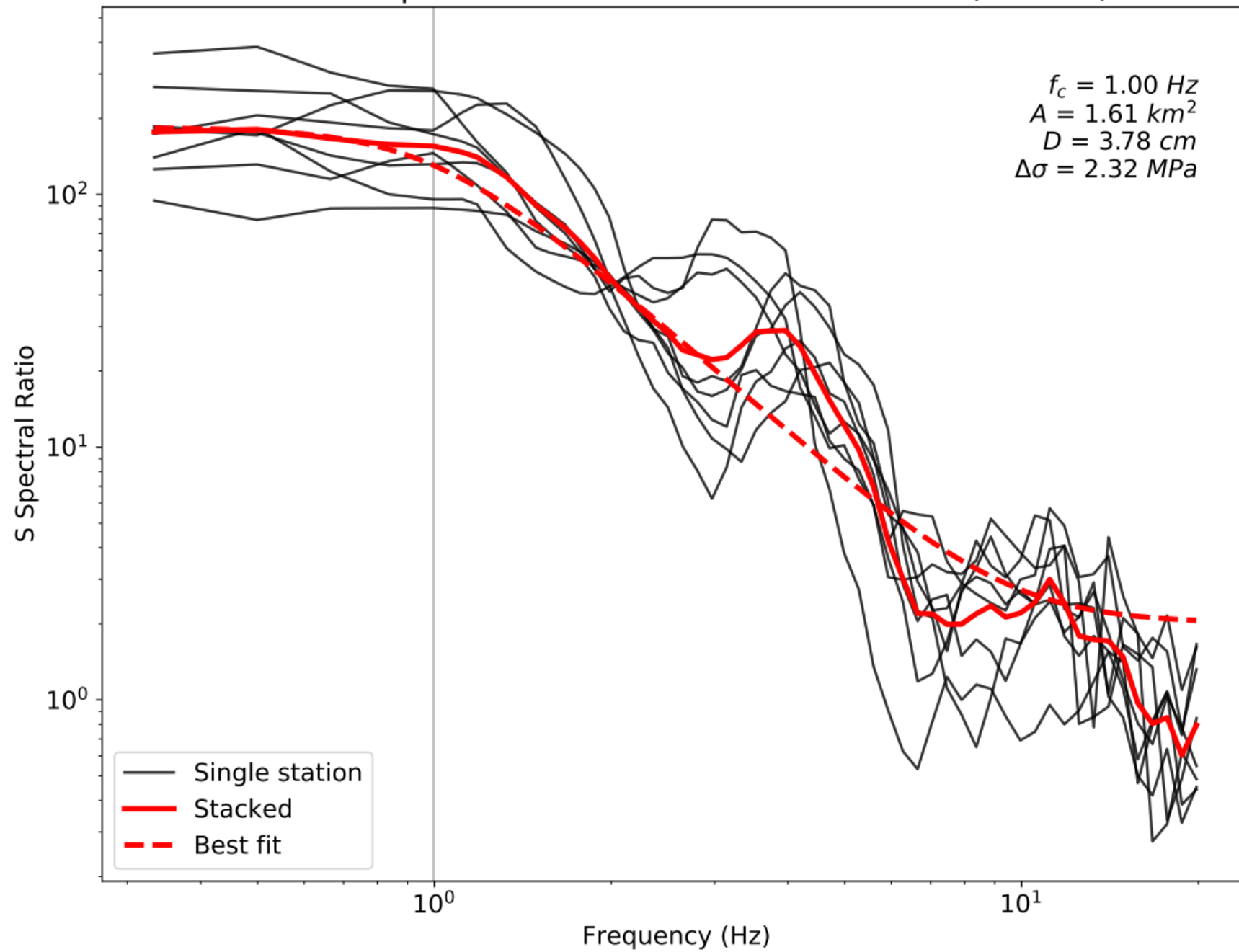
References

- Calderoni, G., Rovelli, A., Ben-Zion, Y., & Di Giovambattista, R. (2015). Along-strike rupture directivity of earthquakes of the 2009 L'Aquila, central Italy, seismic sequence. *Geophysical Journal International*, *203*(1), 399-415. https://doi.org/10.1093/gji/ggv275

- Yoon, C. E., Yoshimitsu, N., Ellsworth, W. L., & Beroza, G. C. (2019). Foreshocks and mainshock nucleation of the 1999 Mw 7.1 Hector Mine, California, Earthquake. *Journal of Geophysical Research: Solid Earth*, *124*(2), 1569-1582. https://doi.org/10.1029/2018JB016383

- **Zhou, Y.**, Ren, C., Ghosh, A., Meng, H., Fang, L., Yue, H., et al. (2022). Seismological characterization of the 2021 Yangbi foreshock-mainshock sequence, Yunnan, China: More than a triggered cascade. *Journal of Geophysical Research: Solid Earth*, 127, e2022JB024534. https://doi.org/10.1029/2022JB024534