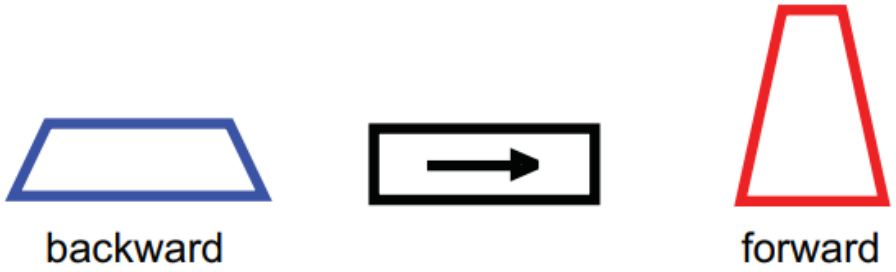
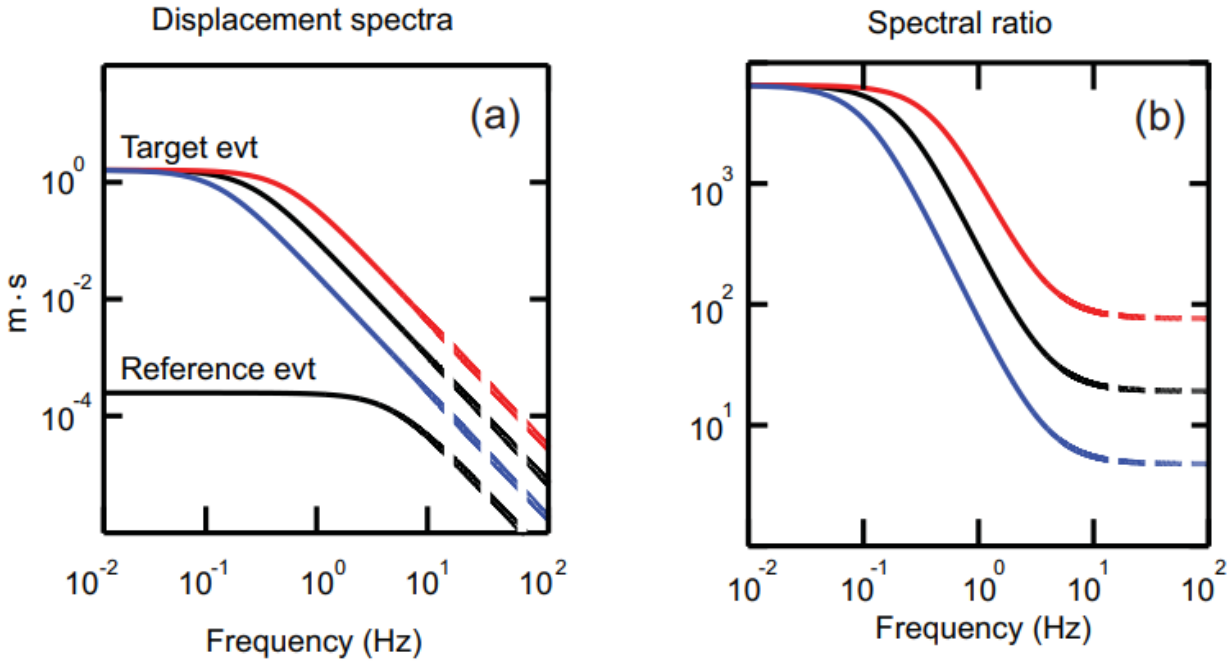
Source Spectrum

- 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)





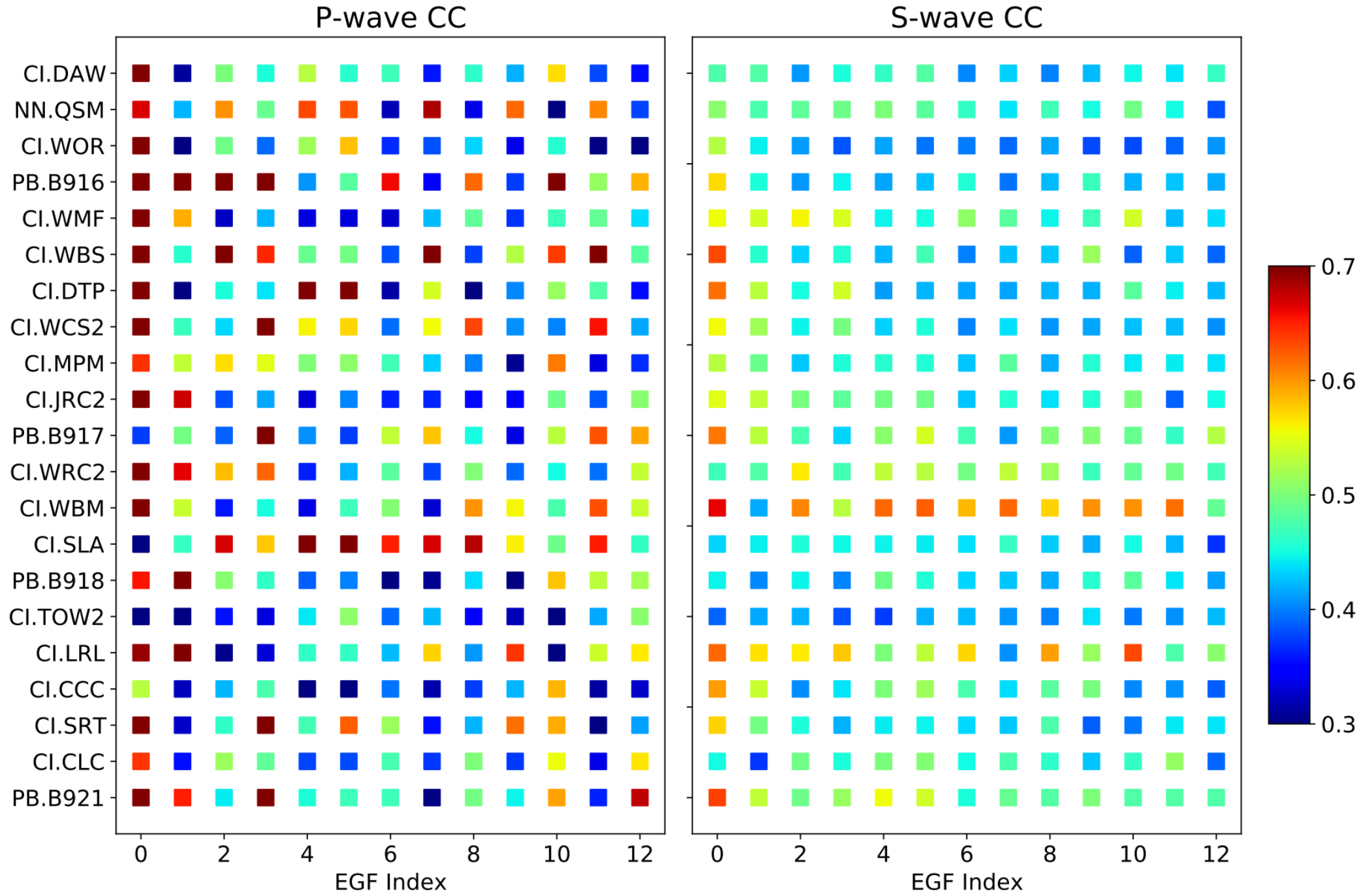
Calderoni et al., GJI 2015

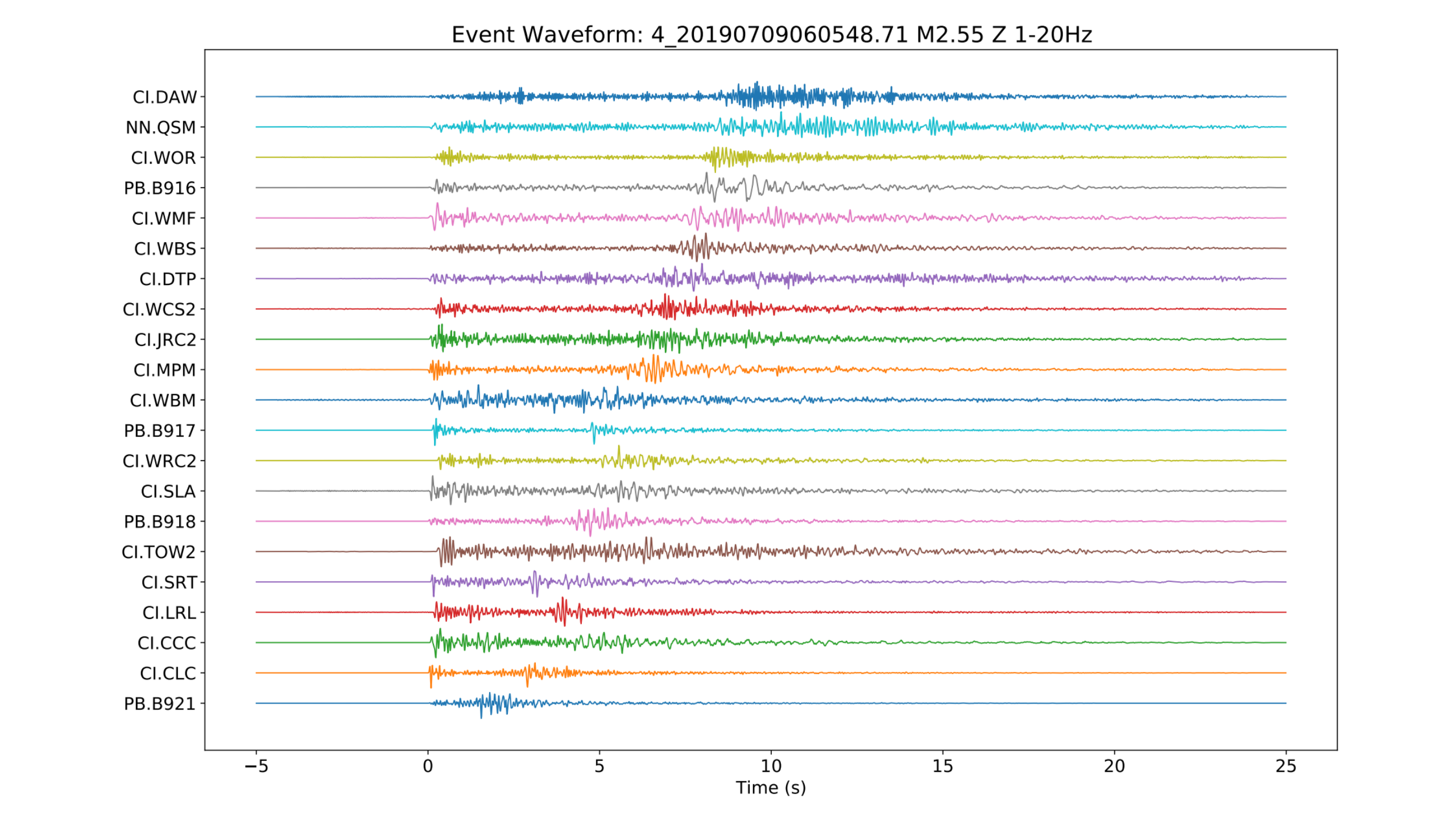
Source Spectrum

- 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

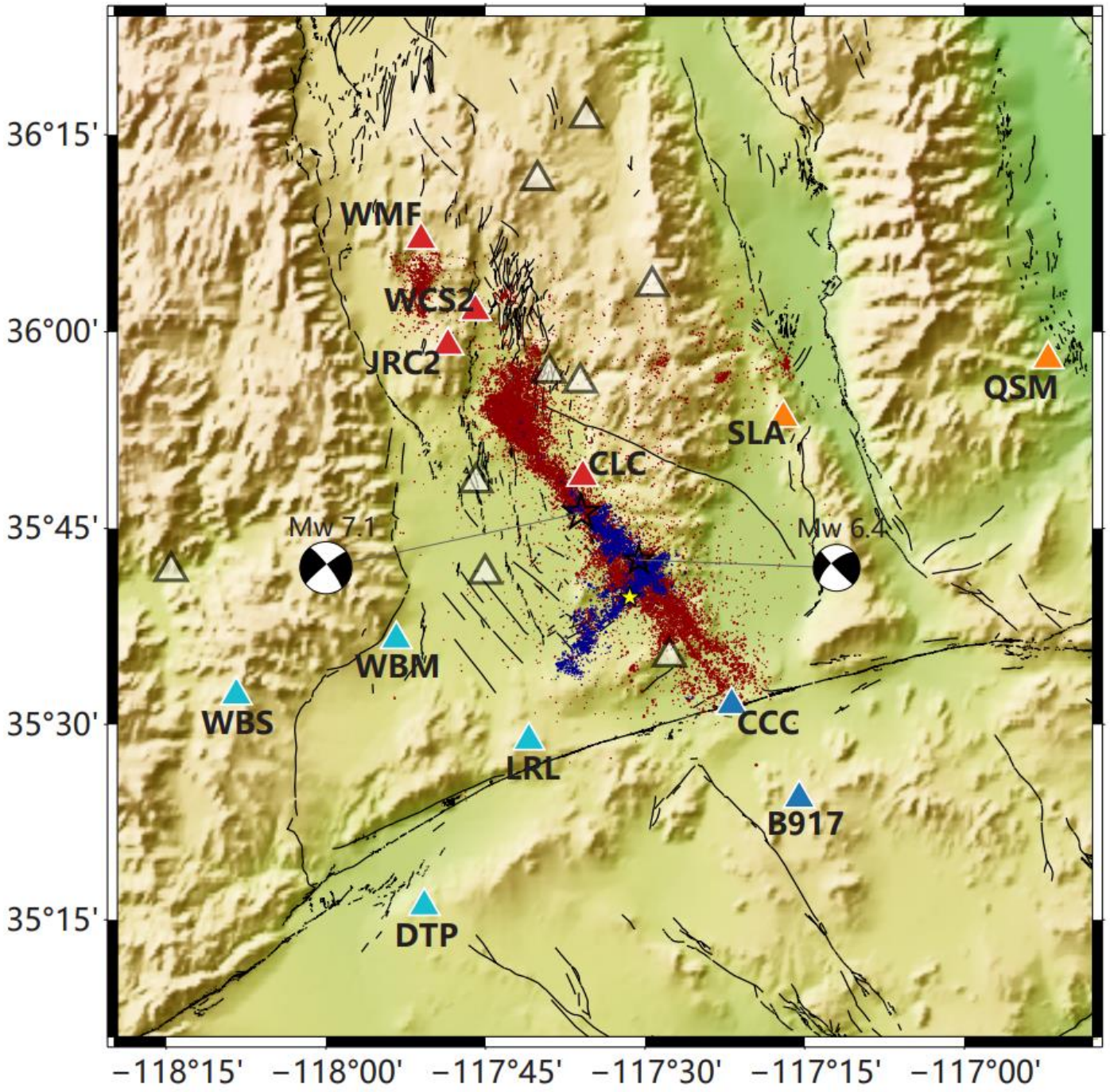
Input	**Operation**	**Output**	***Notes***
fctlg_all & fsta	*select_egf_loc.py*	fpha_egf_org	select EGF by time, location, & magnitude
fpha_tar & fpha_egf_org	*cut_events.py*	input/events_tar input/events_egf	cut raw data
fpha_egf_org & input/events_egf	*pick_events.py*	fpha_egf_org	refine original pick 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
CI.DAW
NN.QSM
CI.WOR
PB.B916
CI.WMF
CI.WBS
CI.DTP
CI.WCS2
CI.MPM
CI.JRC2
PB.B917
CI.WRC2
CI.WBM
CI.SLA
PB.B918
CI.TOW2
CI.LRL
CI.CCC
CI.SRT
CI.CLC
PB.B921
0
2
4
6
8
10
12
EGF Index
0.7
0.6
0.5
0.4
0.3


Event Waveform: 4_20190709060548.71 M2.55 Z 1-20Hz
CI.DAW
NN.QSM
CI.WOR
PB.B916
CI.WMF
CI.WBS
CI.DTP
CI.WCS2
CI.JRC2
CI.MPM
CI.WBM
PB.B917
CI.WRC2
CI.SLA
PB.B918
CI.TOW2
CI.SRT
CI.LRL
CI.CCC
CI.CLC
PB.B921
−5
0
5
10
15
20
25
Time (s)

Spectral Ratio Calculation and Analysis

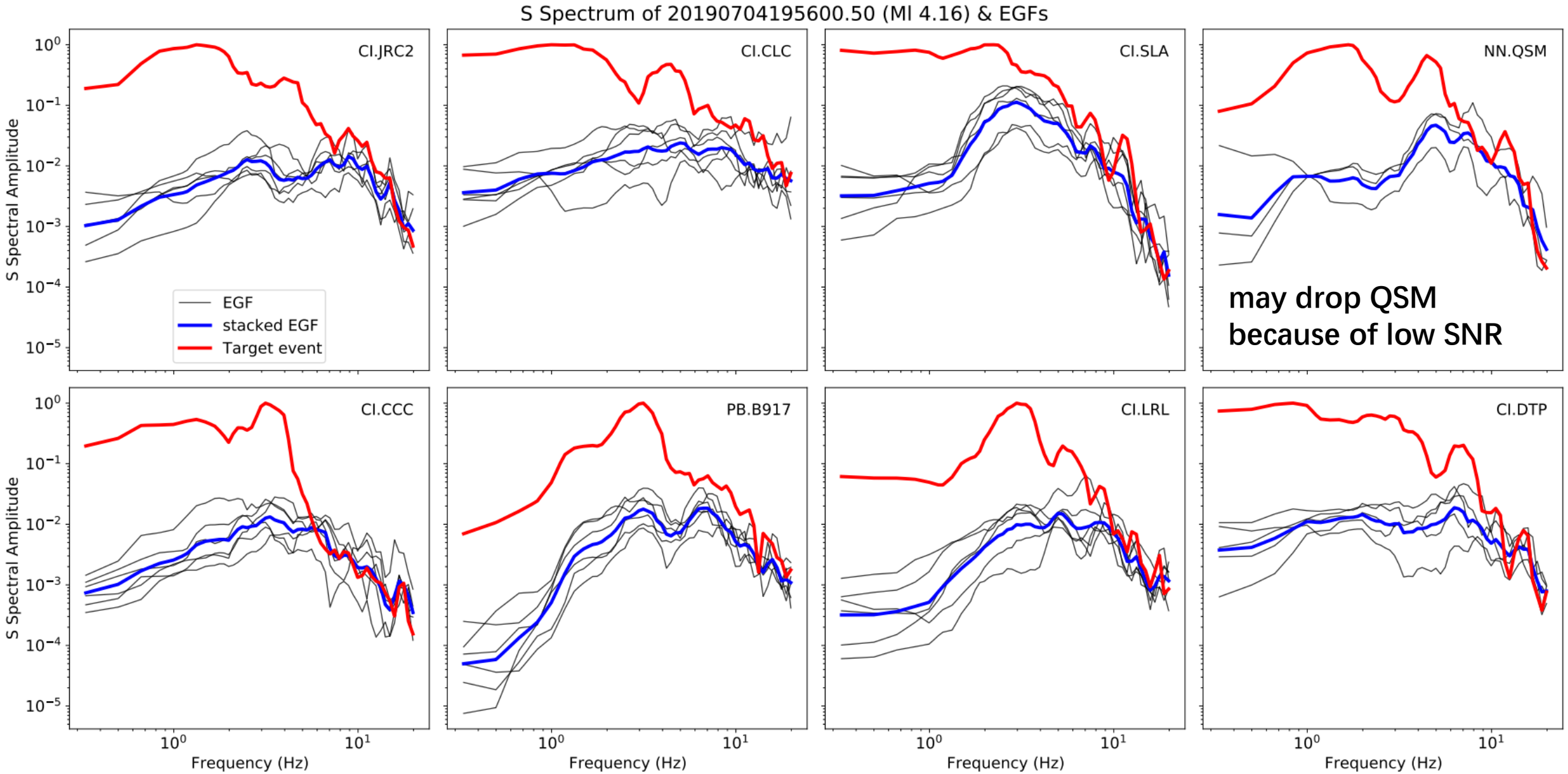
Input	**Operation**	**Output**	***Notes***
fpha_egf & fpha_tar	*plot_spec-s.py*	eg_spec-s_name.pdf	check the consistency between spectrum of EGFs
fpha_egf & fpha_tar	*plot_spec-ratio-compare.py*	eg_spec-ratio-compare_name.pdf	resolve rupture directivity first to determine the fault plane
fpha_egf & fpha_tar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

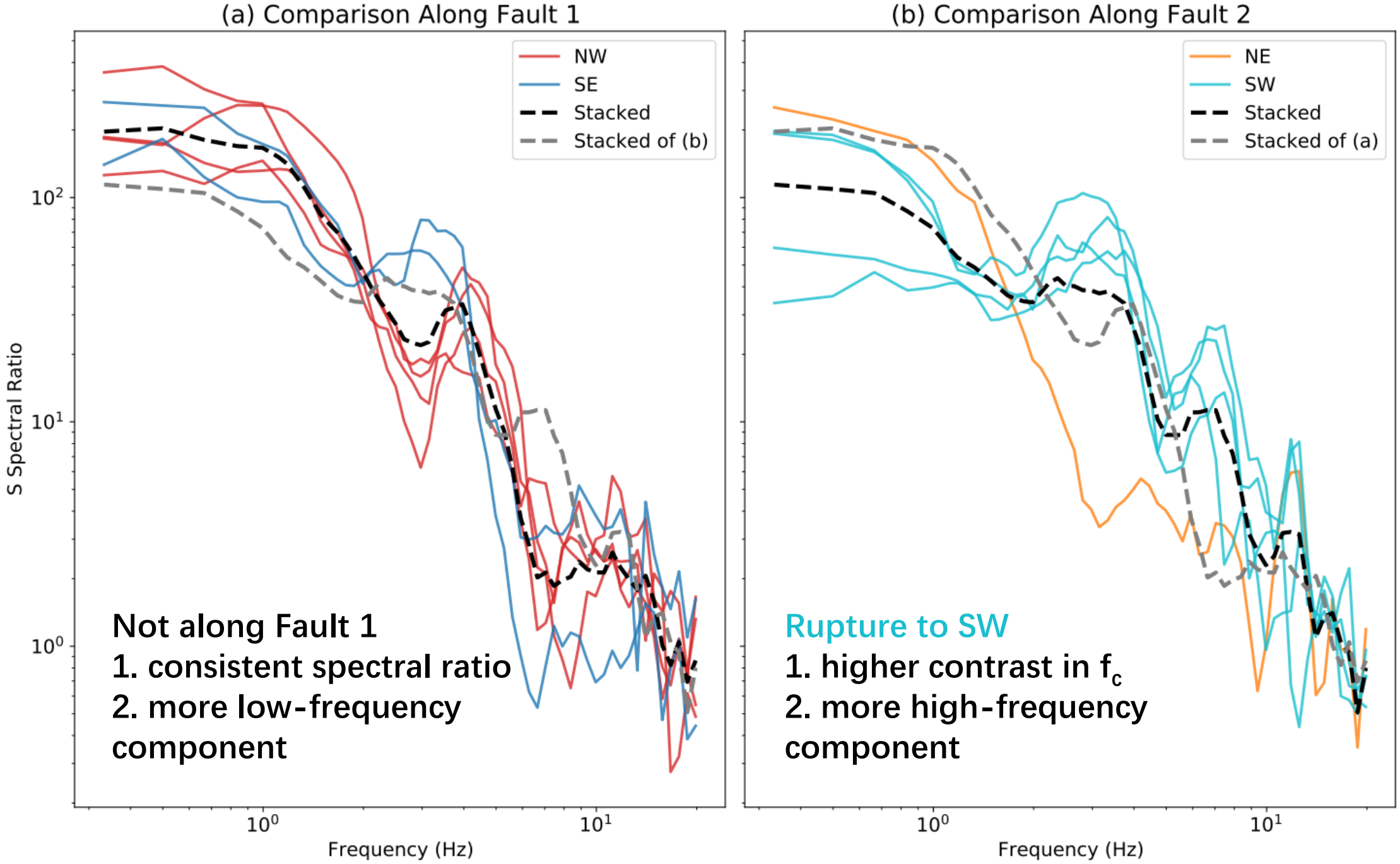


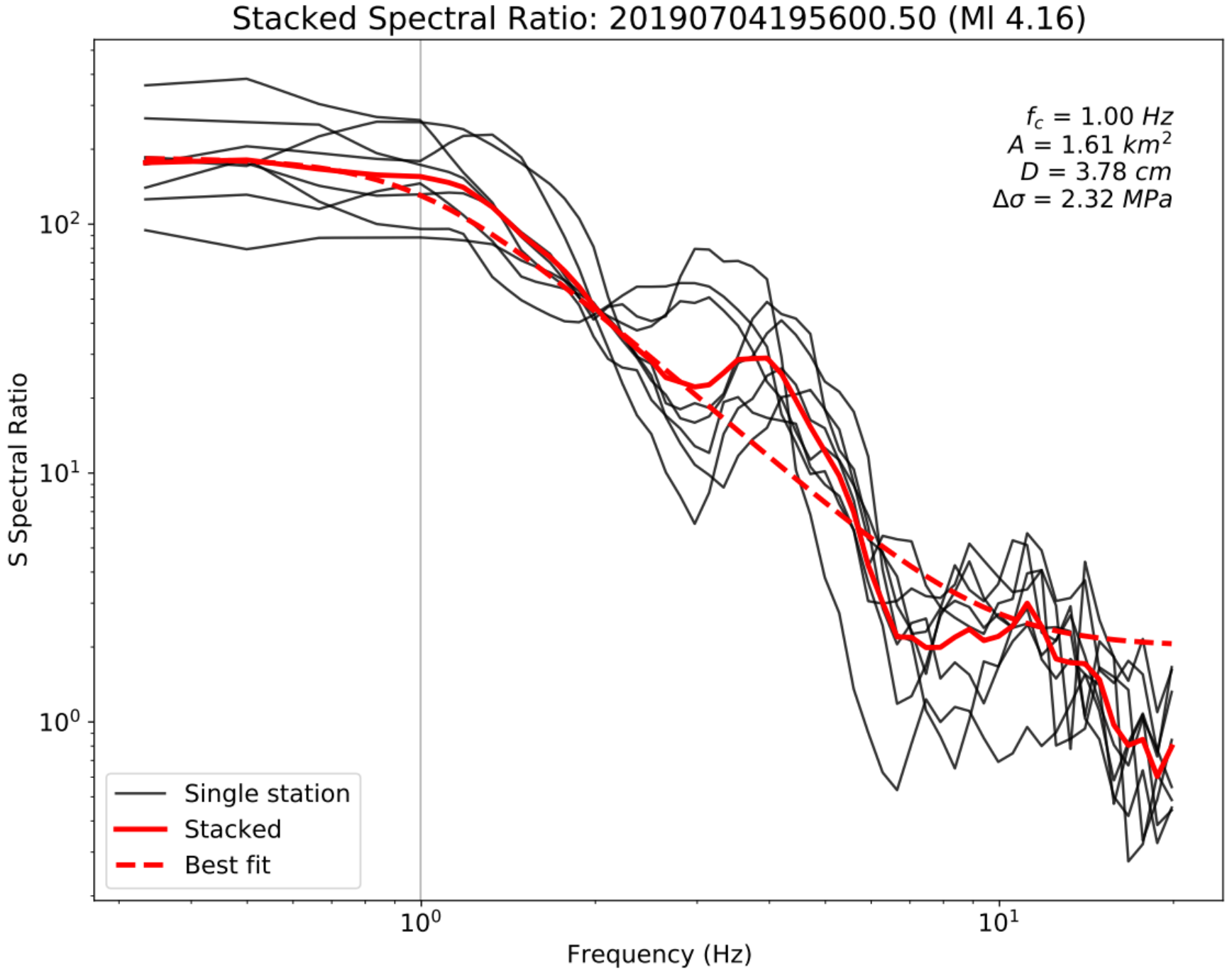
Aftershocks show two fault trends, thus two possible rupture directivity exists

⇩

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
CI.JRC2
CI.CLC
CI.SLA
NN.QSM
CI.CCC
PB.B917
CI.LRL
CI.DTP
EGF
stacked EGF
Target event
may drop QSM
because of low SNR
S Spectral Amplitude
Frequency (Hz)


(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
10^2
10^1
10^0
10^0
10^1
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
10^2
10^1
10^0
Single station
Stacked
Best fit
10^0
10^1
Frequency (Hz)

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 M w 7.1 Hector Mine, California, Earthquake. *Journal of Geophysical Research: Solid Earth*, *124*(2), 1569-1582. https://doi.org/10.1029/2018JB016383
- **Zhou, Y.**, C. Ren, A. Ghosh, H. Meng, L. Fang, H. Yue, S. Zhou, & Y. Su (2022, under review). Seismological Characterization of the 2021 Yangbi Foreshock-Mainshock Sequence, Yunnan, China: More than a Triggered Cascade. *Journal of Geophysical Research: Solid Earth*