# Auxiliary material for "California foreshock sequences suggest aseismic triggering process"

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## 1. Methods

1. Location: The initial locations are obtained from a relocated catalog based on a 3D seismic velocity model and waveform cross-correlation [*Hauksson et al.*, 2012]. Most of the foreshocks are within similar event clusters, but the mainshocks lack waveform similarity and are located using phase picks alone. In the catalog, the Landers and Hector Mine mainshocks are much deeper than their foreshocks, which may due to different location methods. To obtain more reliable mainshock locations relative to foreshocks, we apply a STA/LTA auto-picker method [*Chen et al.*, 2011] to obtain differential arrival times between the mainshocks and foreshocks, which are then incorporated with differential times among the foreshocks to obtain relative locations for each foreshock-mainshock sequence

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[*Lin et al.*, 2007]. After relocation, the Landers and Hector Mine mainshock hypocenters are located within their foreshock clouds. For the El Mayor-Cucapah sequence, due to the lack of station coverage south of the US-Mexico bounder and reduced waveform similarity, only the Hauksson catalog locations are used.

2. Source spectra and stress drop: We obtain available waveforms from the Southern California Seismic Network (SCSN), as archived at the Southern California Earthquake Center (SCEC) data center. Individual source spectra and stress drop estimates are obtained with an iterative de-convolution and empirical Greens function method [*Shearer et al.*, 2006]. To directly compare the source spectra before and after the mainshock, we need to account for differences in corner frequency due to moment variations, which is done by shifting the source spectra along the $f^{-3}$ curve [*Prieto et al.*, 2004]. We then normalize the spectra to their low-frequency amplitude, and calculate an average for foreshocks and aftershocks respectively, estimating a standard error using a bootstrap approach.

## References

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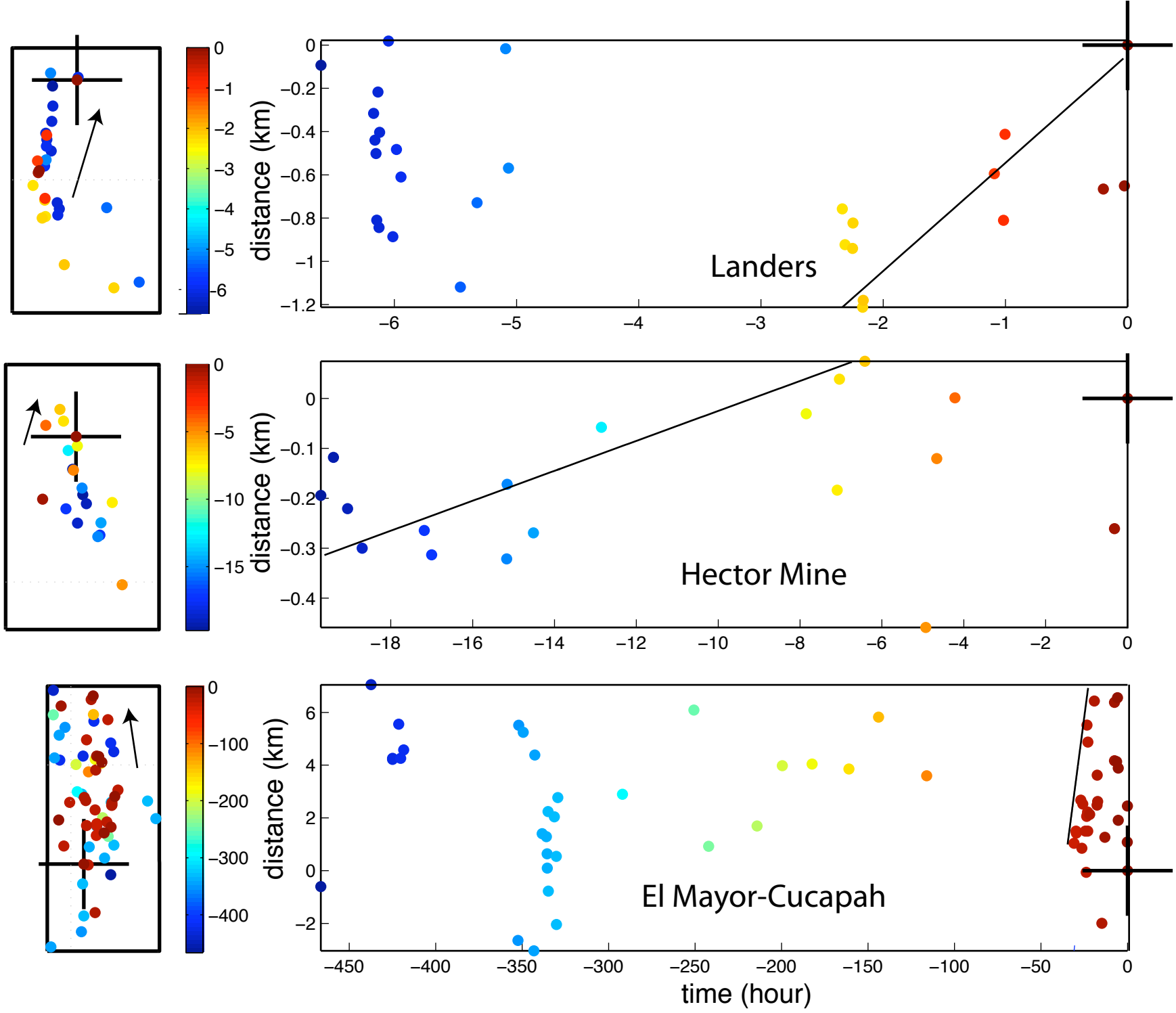
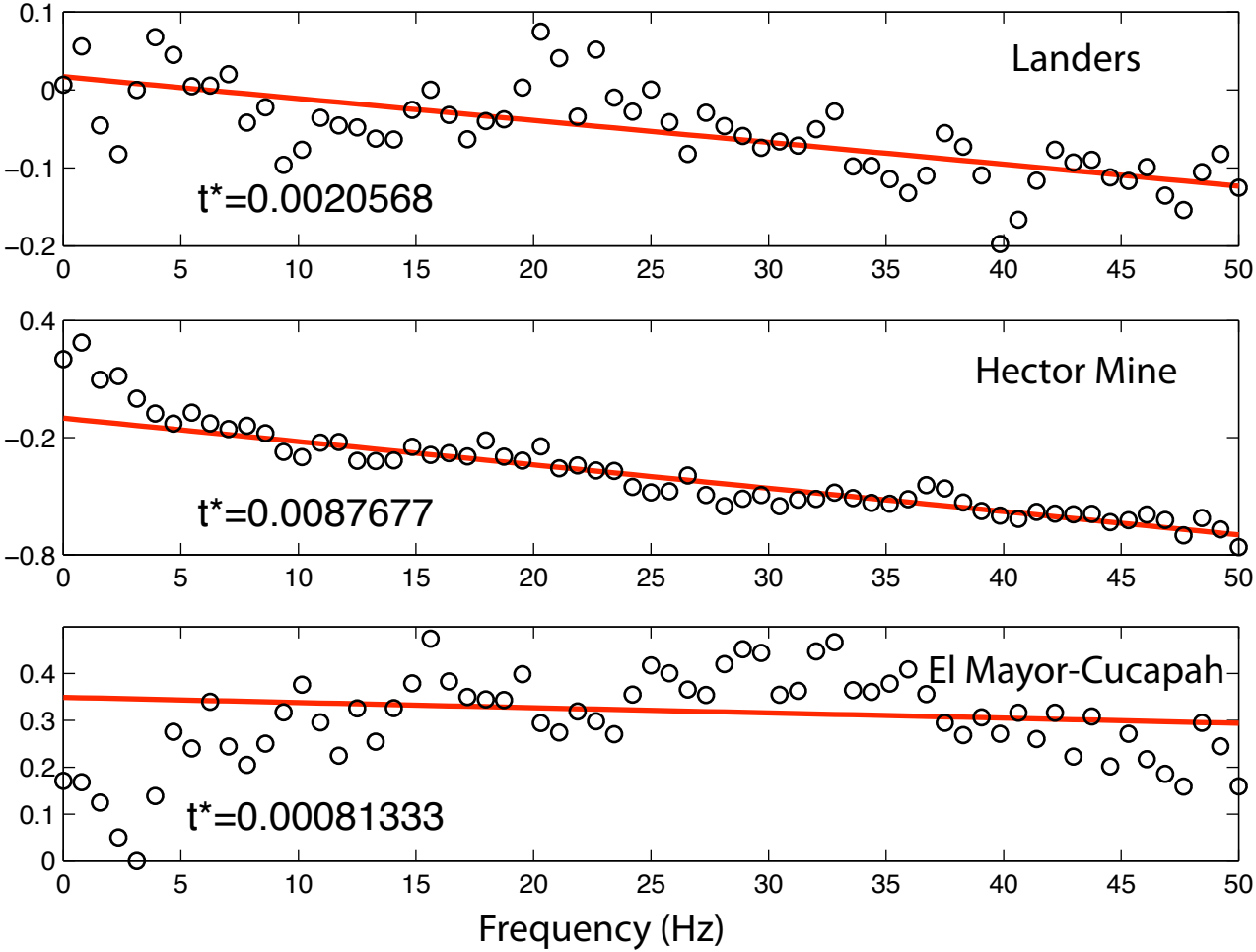
**Figure 1.** Detailed spatial-temporal distribution of foreshock sequences. Left column is the map view of seismicity, with events colored by occurrence times. Right column is the distance along best-fitting seismicity onset migration direction (black arrows) versus time. Black lines are the best-fitting migration velocity. Black + are mainshock locations.

**Figure 2.** Spectral ratio of the empirical Greens function (EGF) before and after the mainshock. t* changes are relative to the pre-mainshock level. Red lines show the least-squares fit line (from 3 to 50 Hz); t* is then computed from the line slope.

**Figure 3.** Example of the original displacement spectra at station CDY on channel EHZ for the Hector Mine sequence. Foreshock spectra are shown in red, and aftershock spectra are shown in black. Spectra are shifted relative to the low frequency amplitude. The events are from the spatial-temporal window shown in Figure 3.


distance (km)
Landers
Hector Mine
El Mayor-Cucapah
time (hour)


Landers
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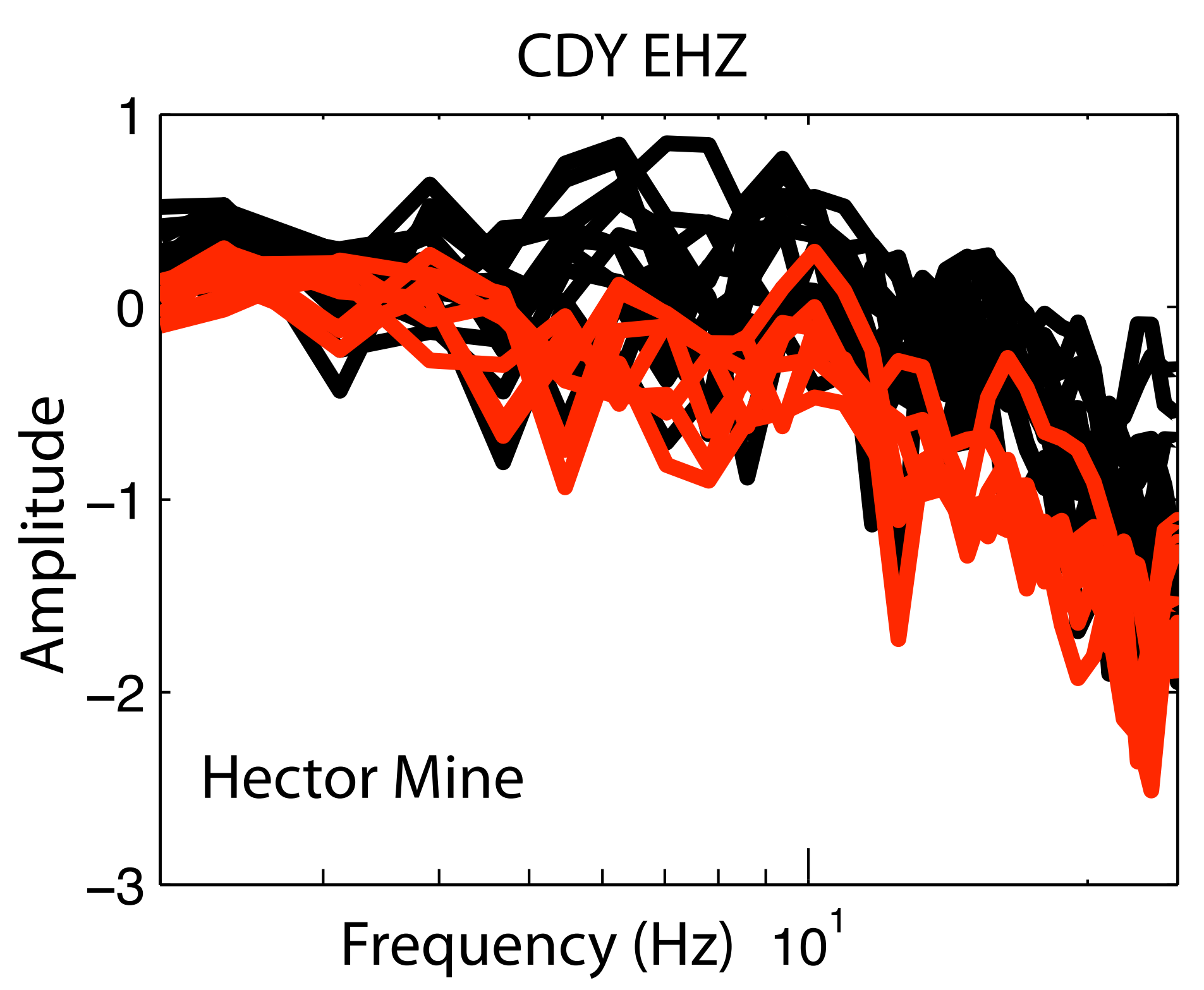
Hector Mine
t*=0.0087677
El Mayor-Cucapah
t*=0.00081333
Frequency (Hz)


CDY EHZ
1
0
−1
−2
−3
Amplitude
Hector Mine
Frequency (Hz)
10^1