

Shallow Slow Earthquake Episodes Near the Trench Axis Off Costa Rica

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Additional Supporting Information (Files uploaded separately)

Data Set S1
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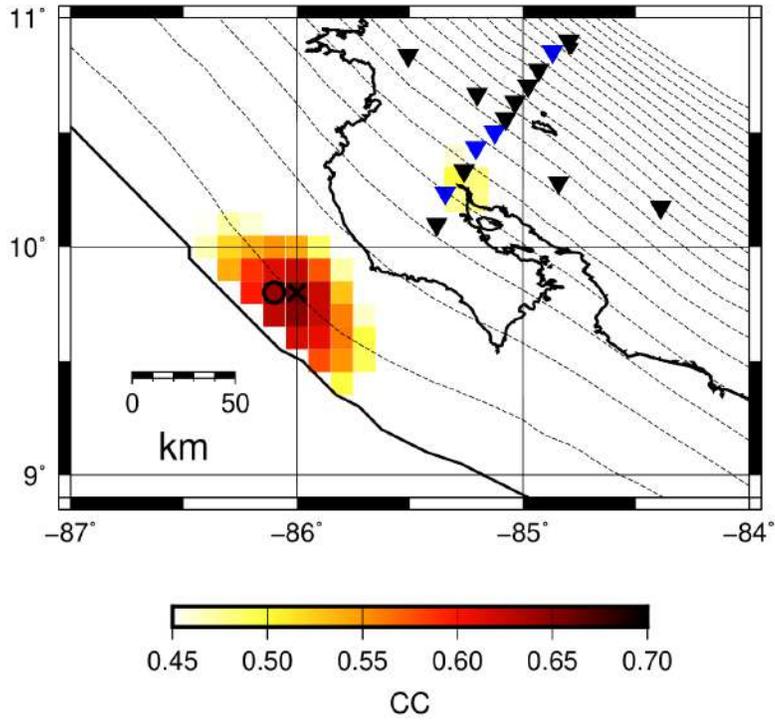
Introduction

This supporting information file includes four figures and one table. Figure S1 represents the comparison of distributions of epicenters and cross-correlation coefficient distributions when using only vertical component seismograms and both vertical and horizontal component seismograms. Figure S2 shows the differences in waveforms for different focal mechanism and depth cases. The examples of waveforms of a very low frequency earthquake and a non-VLFE signal are illustrated in Figure S3. Figure S4 presents the distribution of earthquakes used in the estimation of the quality factor and site amplification factors. Table S1 presents the physical parameters of each layer in the velocity structure model used for computing template waveforms.

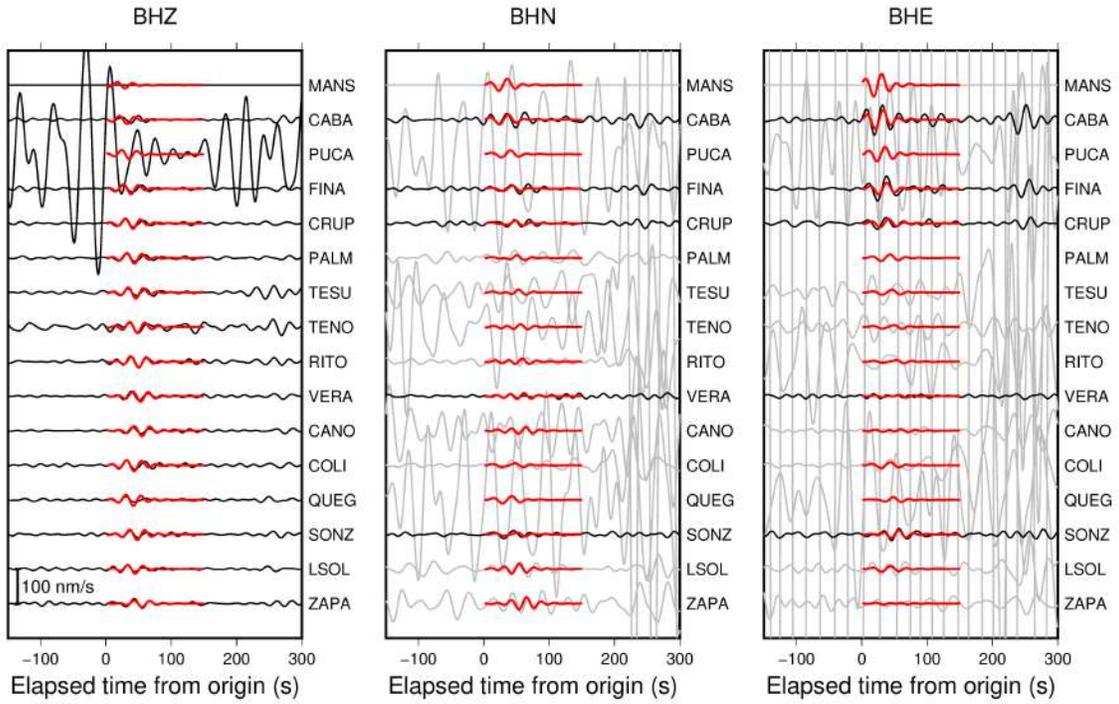
Additional Supporting Information includes the detected VLFE (Data Set S1) and tremor catalog (Data Set S2).

(a)

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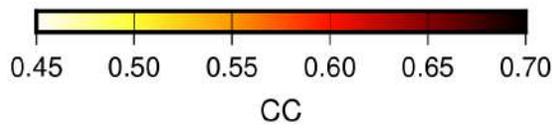
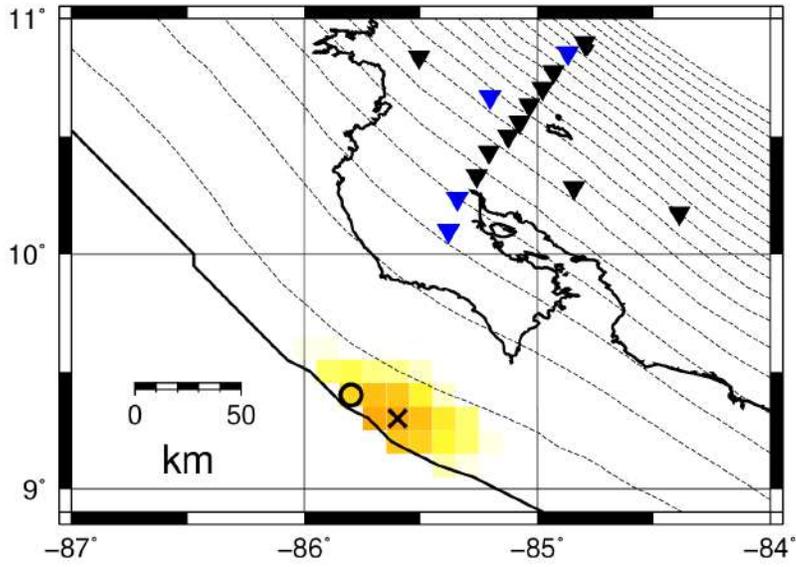


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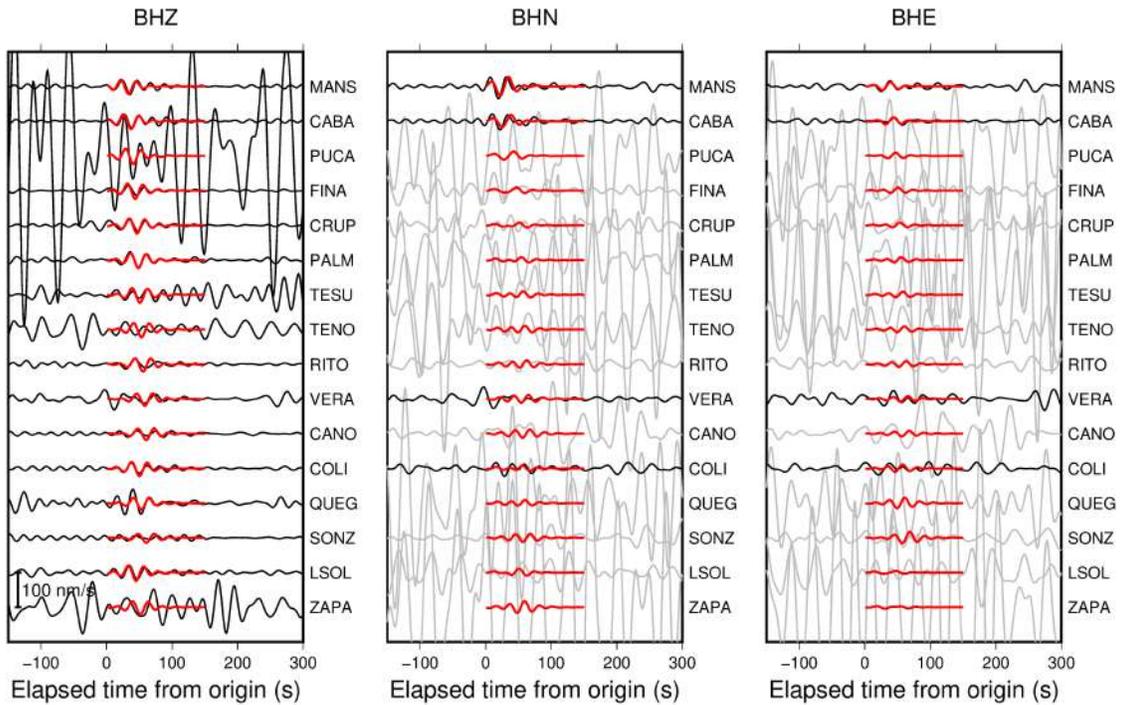


(b)

2005/08/10 02:59:06

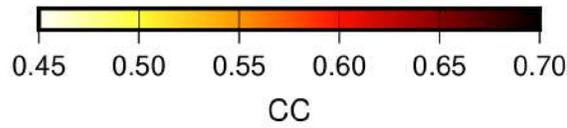
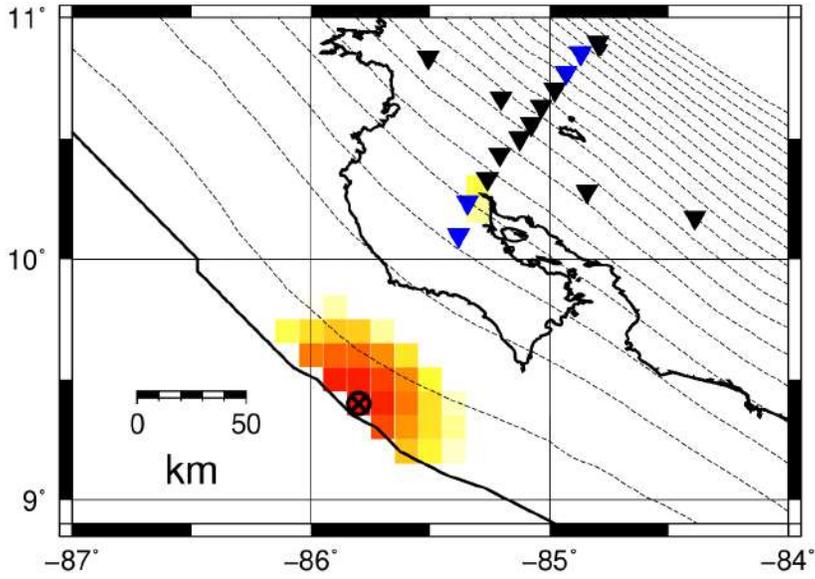


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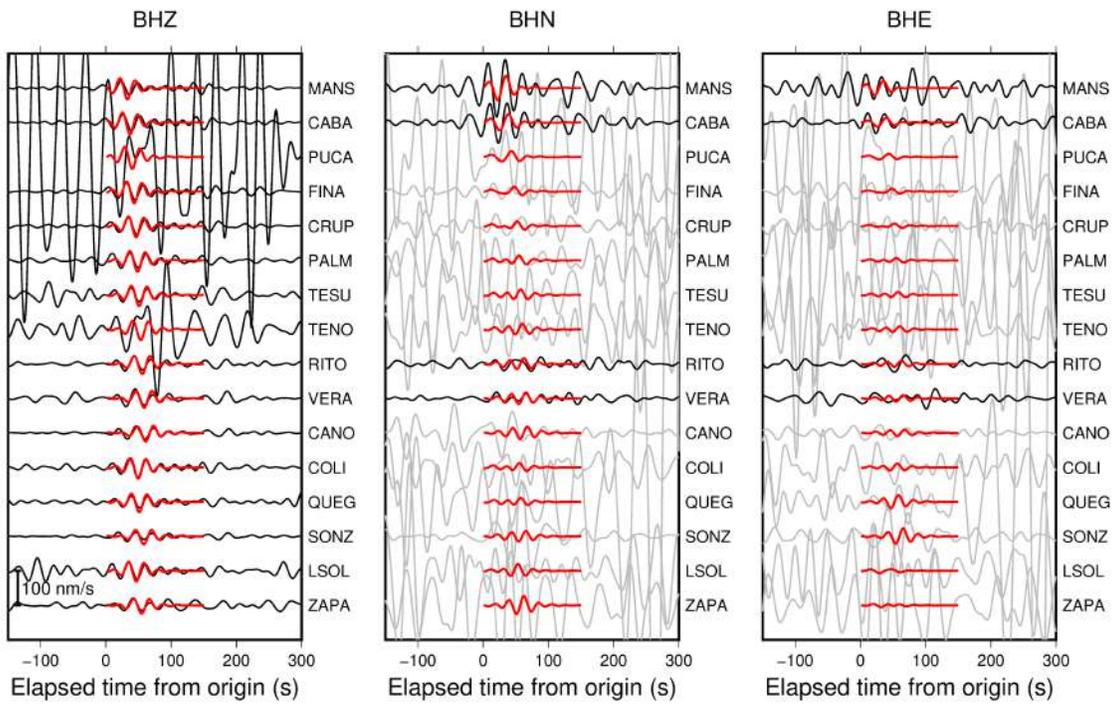


(c)

2005/08/10 03:53:47

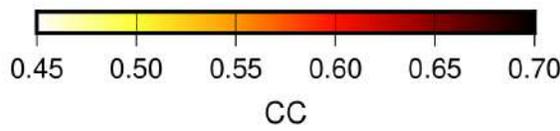
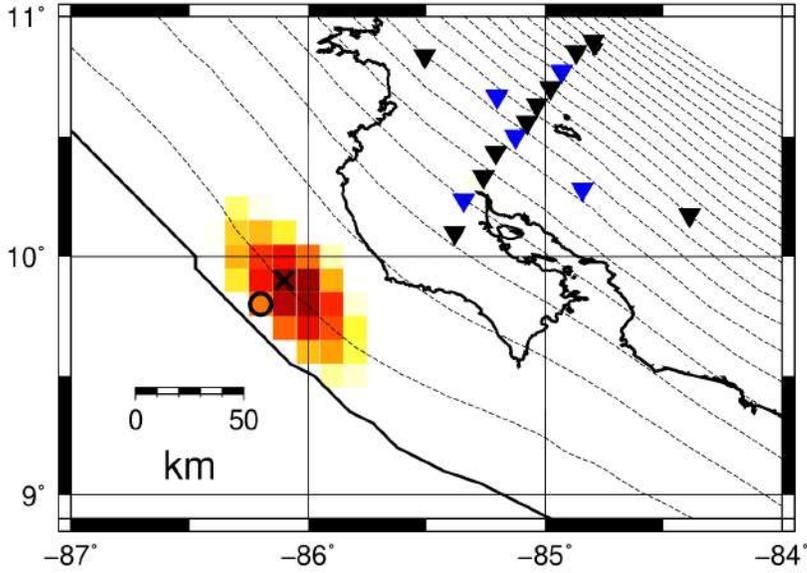


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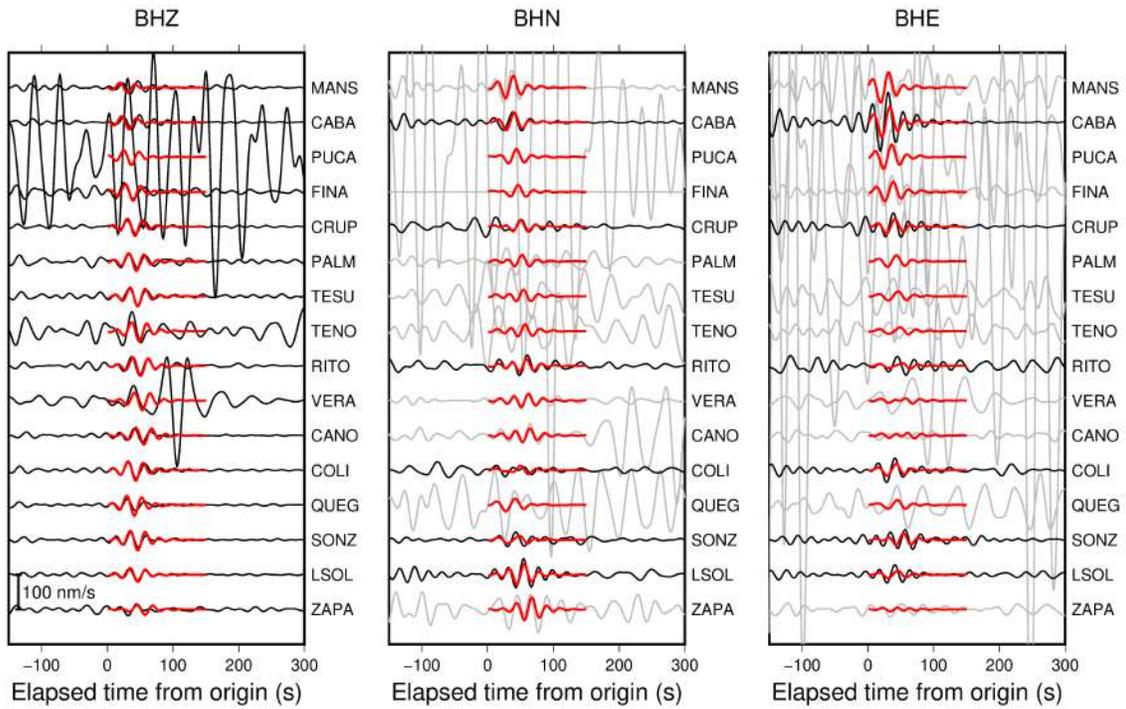


(d)

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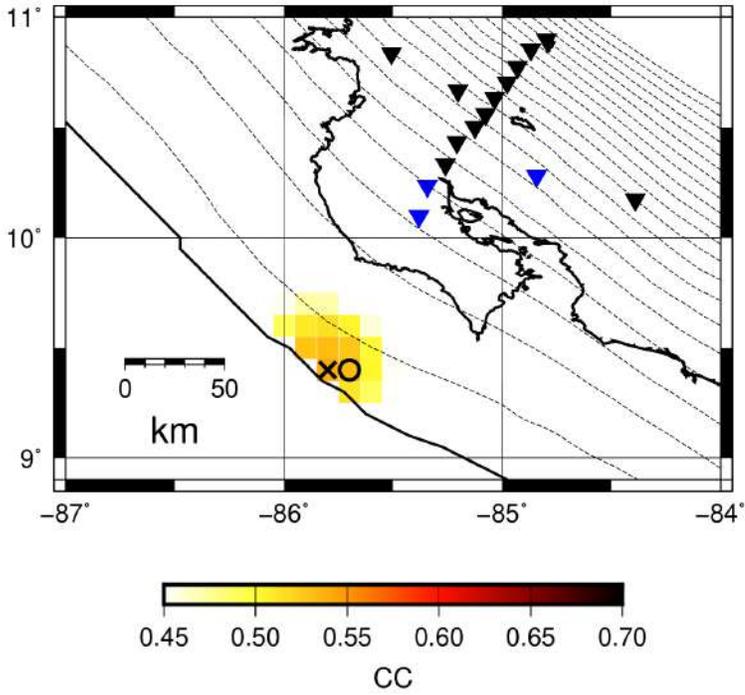


2005/08/12 05:14:33



(e)

2005/08/18 01:36:28



2005/08/18 01:36:28

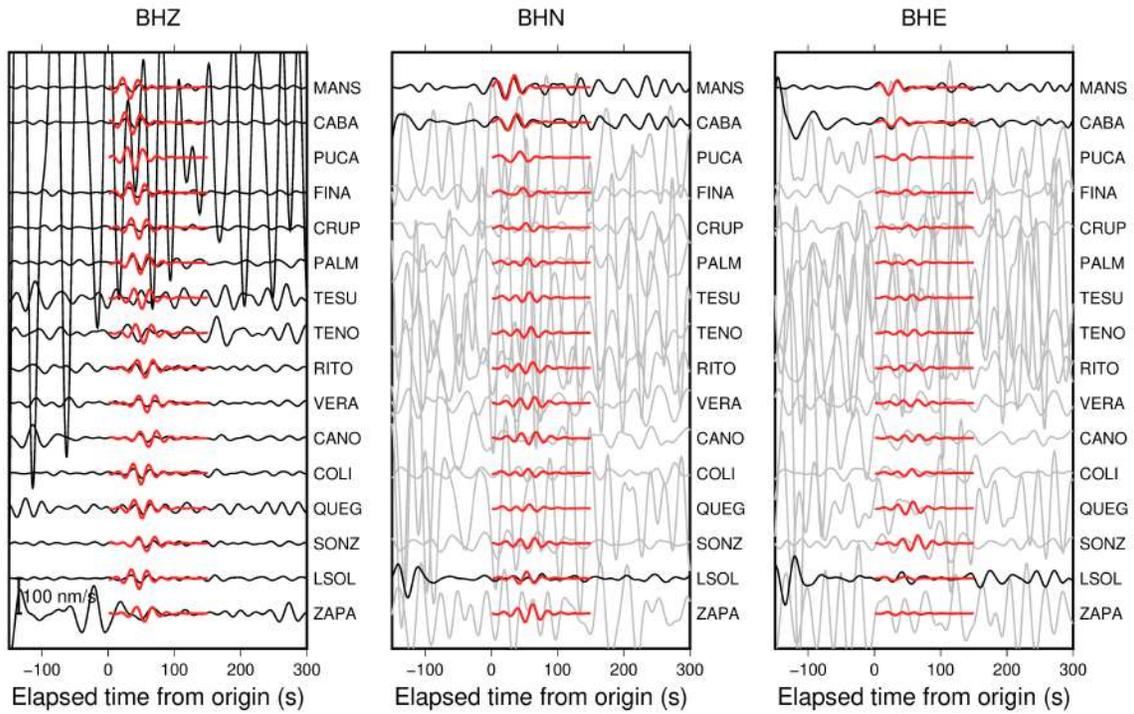
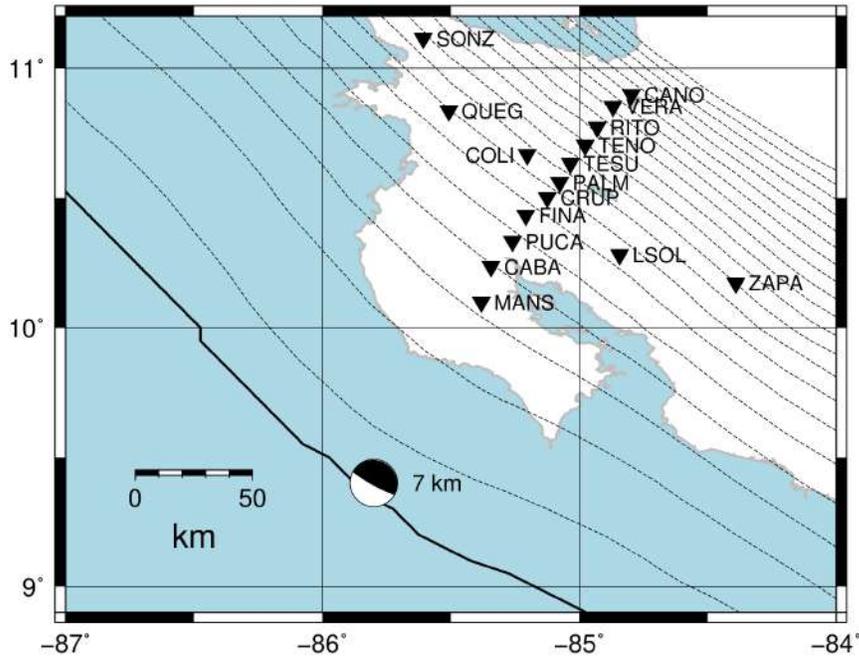
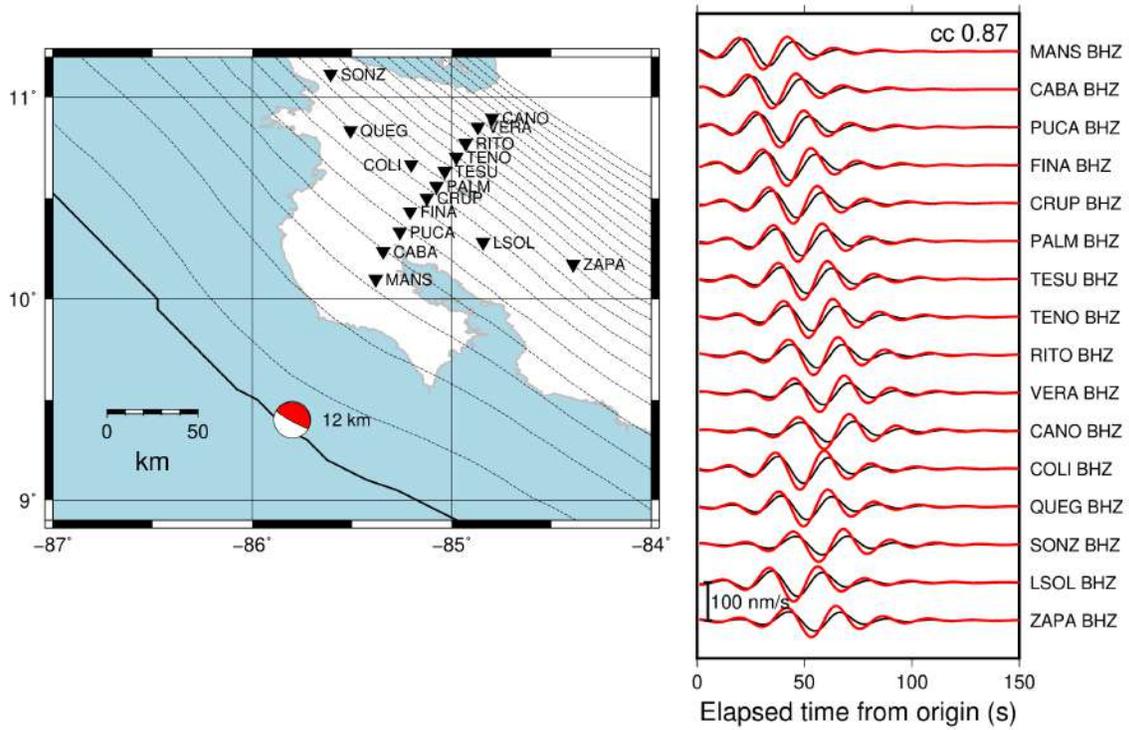


Figure S1. Comparison of epicenters and cross-correlation coefficient (CC) distributions when using three components. Color scales in the maps show CC distributions when three components are used. For horizontal component seismograms, we only used waveforms with lower noise levels (black lines) and did not use waveforms with high noise levels (gray lines). Waveforms are band-pass filtered in the frequency range of 0.02–0.05 Hz. Circles and cross marks in the maps are epicenters when using only vertical component seismograms and both vertical and horizontal component seismograms, respectively. Blue and black inverted triangles in the maps are stations whose three components and only the vertical component seismograms are used for locating very low frequency earthquakes (VLFs), respectively. Black line and dashed contours in maps are the same as in Figure 1.

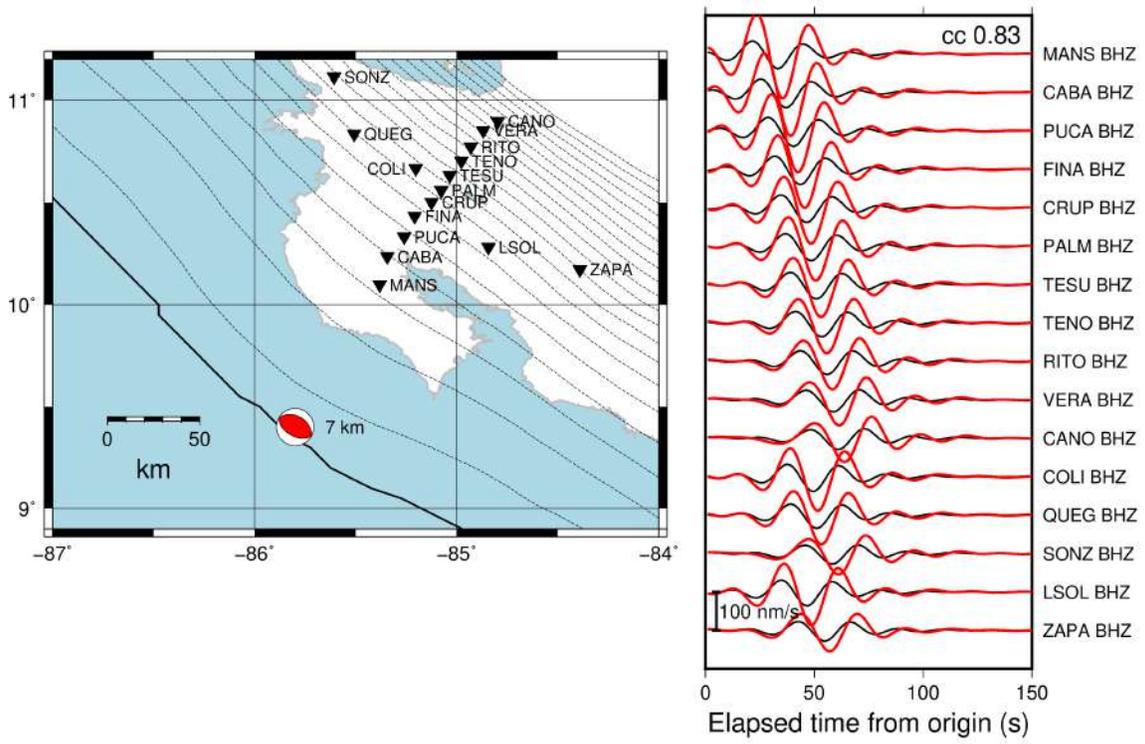
(a)



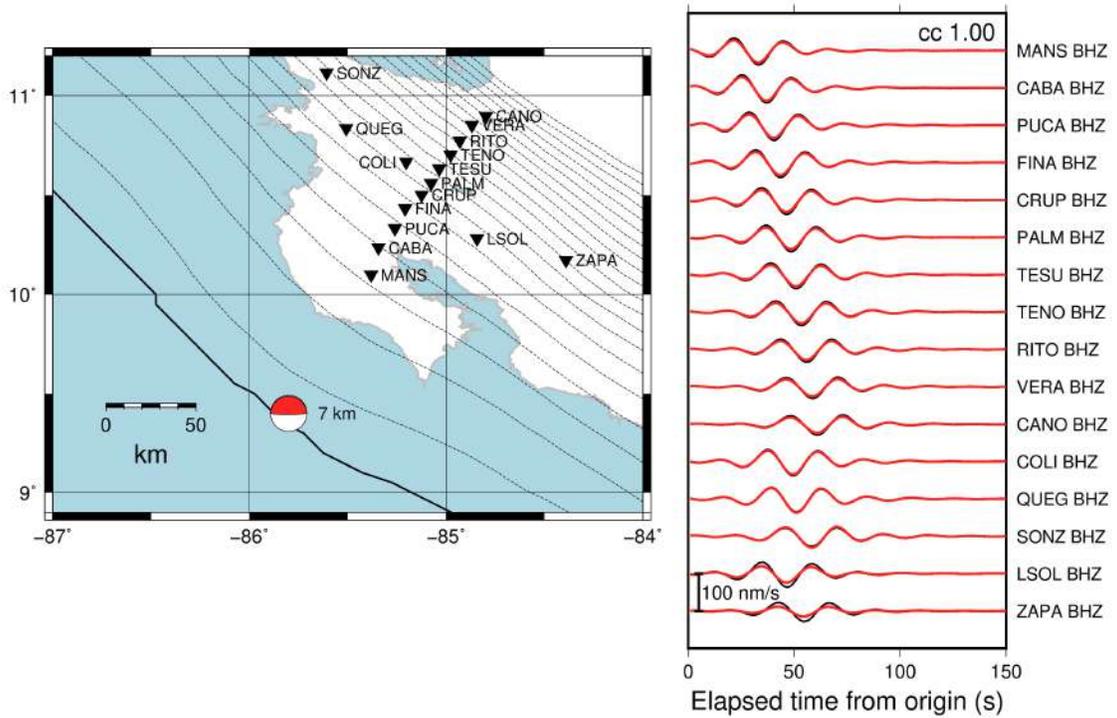
(b) Case A: depth 12 km



(c) Case B: dip 40°



(d) Case C: strike 270°



(e) Case D: strike slip

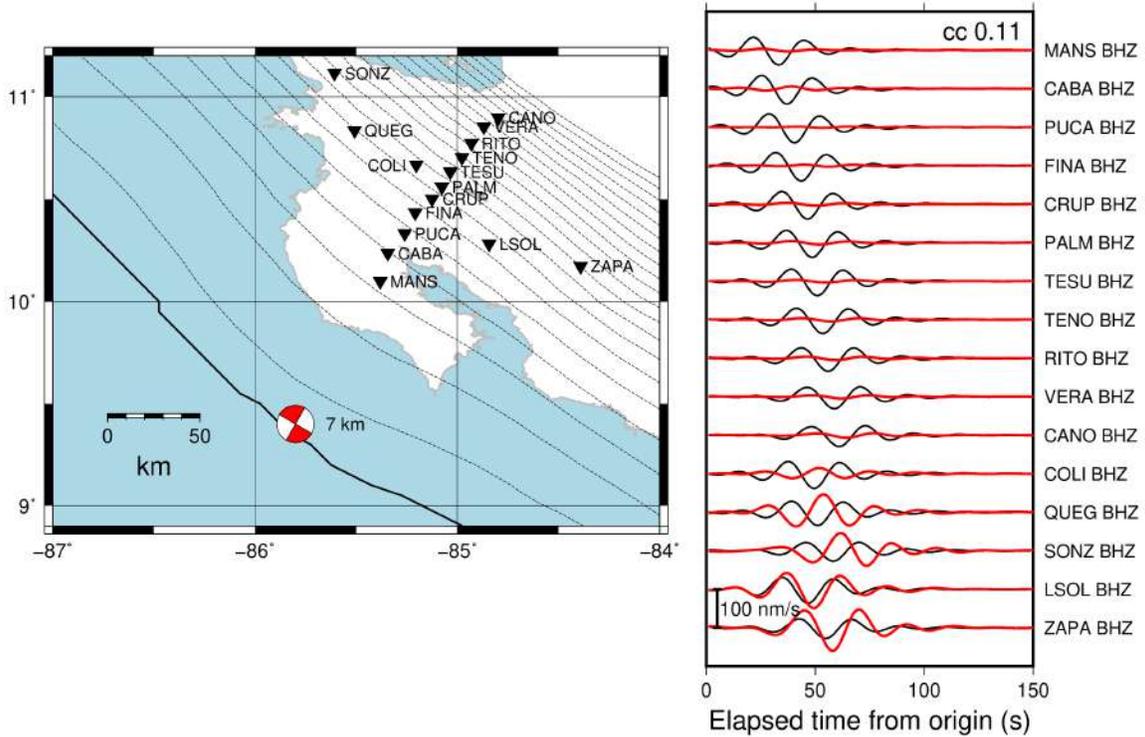


Figure S2. Comparison of waveforms in the frequency range of 0.02–0.05 Hz for different focal mechanism sources. (a) Focal mechanism and depth which are consistent with the geometry of the plate boundary; thrust type with a depth of 7 km, a strike of 299°, and a dip of 6°. (b) Case A: a focal mechanism whose depth is 5 km deeper than the plate boundary. (c) Case B: a focal mechanism whose slip is higher angle than the geometry of the plate boundary. (d) Case C: a focal mechanism whose strike changes in 30° from the geometry of the plate boundary. (e) Case D: a focal mechanism with a strike slip. Black and red lines are waveforms of focal mechanisms of (a) and (b-e), respectively. CCs between black and red waveforms are shown above the waveforms. Inverted triangles, black line, and dashed contours in maps are the same as in Figure 1.

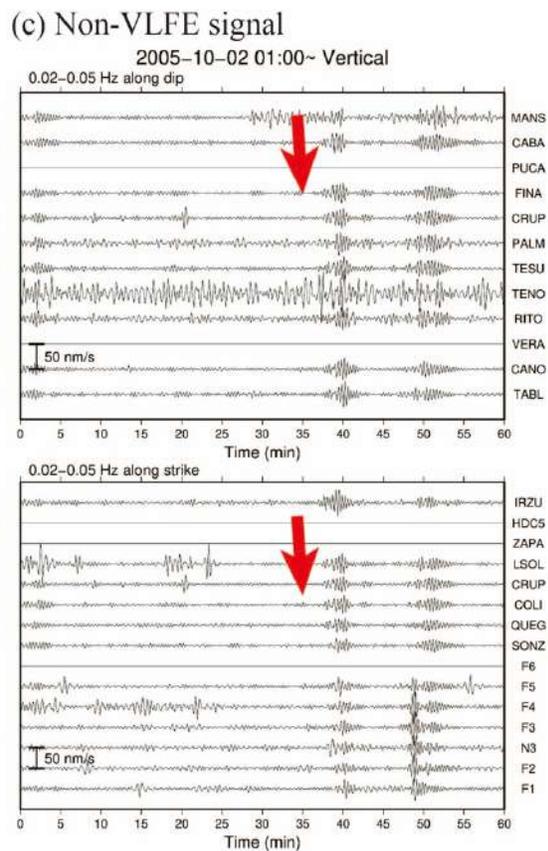
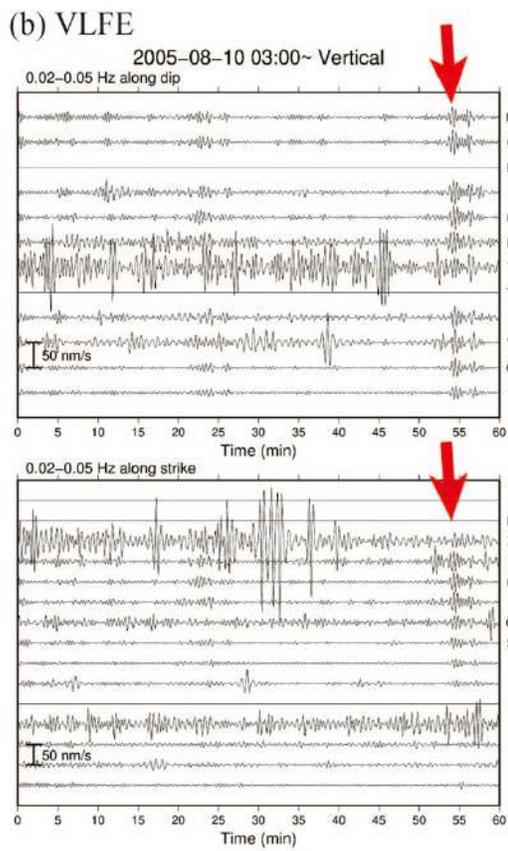
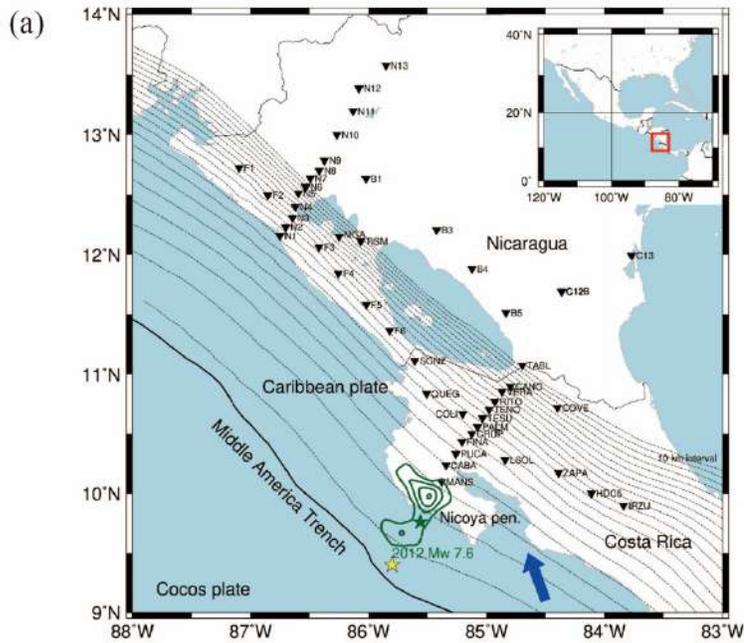


Figure S3. (a) Map of stations of TUCAN network in Costa Rica and Nicaragua. Inverted triangles, black line, and dashed contours in maps are the same as in Figure 1. (b) An example of waveforms of a VLFE in the frequency range of 0.02–0.05 Hz for an event with a time of origin 03:53:47 (UTC), August 10, 2005. The epicenter of this VLFE is shown by a yellow star in (a). (c) An example of a non-VLFE signal which was discarded by the beamforming analysis described in Section 2.3. The direction of this signal is shown by a blue arrow in (a). Amplitudes of noisy stations are set as zero.

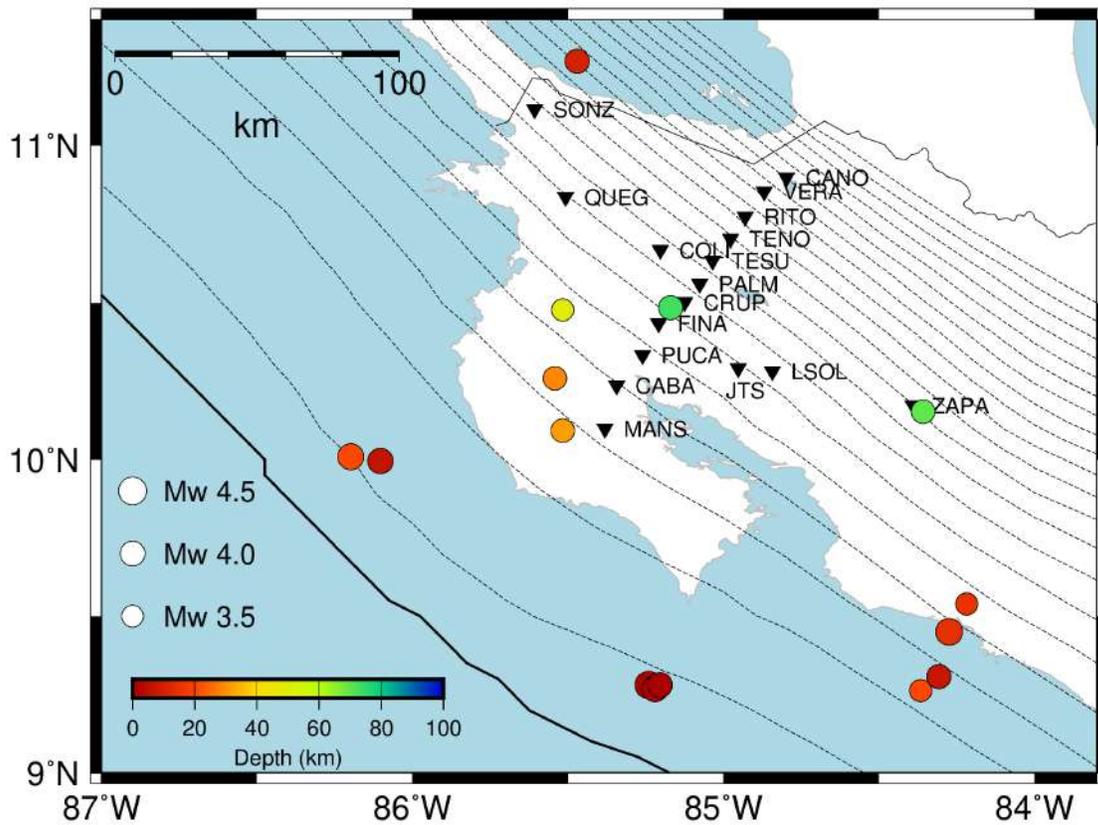


Figure S4. Distribution of earthquakes used in the estimation of the quality factor and site amplification factors. Inverted triangles, black line, and dashed contours are the same as in Figure 1.

Table S1. Physical parameters of each layer in the velocity structure model used for computing template waveforms.

	V_p (km/s)	V_s (km/s)	ρ (kg/m ³)	Q_p	Q_s
Air	0.0	0.0	1	10 ¹⁰	10 ¹⁰
Sea water	1.5	0.0	1,040	10 ⁶	10 ⁶
Upper sediments	2.2	0.8	2,000	260	150
Middle sediments	3.9	2.1	2,400	680	400
Lower sediments	5.1	2.9	2,600	680	400
Upper crust	5.5	3.1	2,600	680	400
Middle crust	6.5	3.7	2,800	680	400
Lower crust	7.0	4.0	3,000	680	400
Oceanic crust layer 2	5.0	2.9	2,500	340	200
Oceanic crust layer 2	6.7	3.9	2,800	510	300
Mantle	8.1	4.7	3,200	850	500

Data Set S1. List of detected VLFs. First column: year, second column: month, third column: day, fourth column: hour, fifth column: minute, sixth column: second, seventh column: longitude, eighth column: latitude, ninth column: depth (km), and tenth column: magnitude, eleventh column: duration (s). Times are described in UTC.

Data Set S2. List of energy rates of tremors accompanied by VLFs. First column: year, second column: month, third column: day, fourth column: hour, fifth column: minute, sixth column: second, seventh column: longitude, eighth column: latitude, ninth column: depth (km), and tenth column: energy rate (J/s). Times are described in UTC.