Detecting low-frequency earthquakes within non-volcanic tremor in southern Taiwan triggered by the 2005 Mw8.6 Nias earthquake

Chi-Chia Tang,[1,2] Zhigang Peng,[2] Kevin Chao,[2] Chau-Huei Chen,[1] and Cheng-Horng Lin[3]

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[1] We use a matched filter technique to detect 41 low-frequency earthquakes (LFEs) within 700-s of triggered tremor signals in the Southern Central Range in Taiwan during the surface waves of the 2005 Mw8.6 Nias earthquake off the coast of northern Sumatra. The depth distributions of LFEs after double-difference relocations concentrate at the depth range of 12–38 km below the background seismicity and above the Moho depth inferred from receiver function studies. The locations of LFEs are close to the downward extension of the steep-dipping Chaochou-Lishan fault with only modestly high Vp/Vs ratios (1.75–1.85). Our observation indicates that at least portions of triggered tremor consists of many LFEs, similar to ambient tremor observed at other major plate boundary faults. **Citation:** Tang, C.-C., Z. Peng, K. Chao, C.-H. Chen, and C.-H. Lin (2010), Detecting low-frequency earthquakes within non-volcanic tremor in southern Taiwan triggered by the 2005 Mw8.6 Nias earthquake, *Geophys. Res. Lett.*, *37*, L16307, doi:10.1029/2010GL043918.

1. Introduction

[2] Deep “non-volcanic” tremor is a subtle seismic signal with long durations and no clear body wave arrivals observed away from volcanic regions [*Obara*, 2002]. Tremor often accompanies slow-slip events, and together they are termed “episodic tremor and slip” [*Rogers and Dragert*, 2003]. Tremor has been found at many places along the circum-pacific subduction zones and the transform plate boundary in California [*Rubinstein et al.*, 2010; *Peng and Gomberg*, 2010, and references therein]. Tremor appears to be highly stress sensitive, and can be triggered instantaneously by the passing surface waves [e.g., *Rubinstein et al.*, 2007; *Peng and Chao*, 2008; *Peng et al.*, 2009].

[3] Because of the lack of clear P- and S-wave arrivals in the near continuous tremor episodes, obtaining an accurate location of tremor, especially the depth, has been difficult [e.g., *Kao et al.*, 2009; *Rubinstein et al.*, 2010]. Recent studies have shown that tremor consists of many low-frequency earthquakes (LFEs) with weak P and S waves and deficient in high-frequency energy [*Shelly et al.*, 2007]. This provides a new approach for accurate tremor location, especially the depth [*Brown et al.*, 2008, 2009], and hence improves our knowledge of the underlying physical mechanism of tremor and LFE generation.

[4] In this study we apply the recently developed matched filter technique [*Gibbons and Ringdal*, 2006; *Shelly et al.*, 2007; *Brown et al.*, 2008, 2009; *Peng and Zhao*, 2009] to detect LFEs within tremor in Southern Taiwan triggered by the 28 March 2005 Mw8.6 Nias earthquake (Figure 1). This study is built upon our recent findings of tremor triggered by surface waves of large teleseismic events beneath the Central Range (CR) in Taiwan [*Peng and Chao*, 2008; K. Chao et al., Remote triggering of non-volcanic tremor around Taiwan, submitted to *Geophysical Journal International*, 2010]. The tremor triggered by the 2005 Nias earthquake is one of the most clearly recorded episodes (Figures 2 and S1) and hence is further studied here.[1]

2. Data and Method

[5] We examined waveform data during the passage of large-amplitude surface waves of the 2005 Mw8.6 Nias earthquake recorded by 4 stations in the Broadband Array in Taiwan for Seismology (BATS) and 9 short-period stations in the Central Weather Bureau Seismic Network (CWBSN) (Figure 1). The great circle distance and the back-azimuth to the BATS station TPUB are 3453 km and 231°, respectively. We first cut the data between 900 s and 1600 s after the occurrence time of the mainshock, removed the mean, re-sampled the data to 20 samples/s, and then applied a 2–8 Hz band-passed filter. The high-frequency tremor signal is coherent among many stations with the moveout close to that for the S waves (Figure 2a), and is in phase with the passing surface waves of the teleseismic event (Figure S1).

[6] Next we visually identified 11 LFEs within the entire 700-s of tremor bursts with relatively high signal-to-noise ratios (SNR) and clear P and S arrivals (Figure S2), and manually picked the P- and S-wave arrivals at nearby stations with high waveform similarities (Figure S3). Then we located them by a double-difference algorithm [*Waldhauser and Ellsworth*, 2000] according to the 1-D velocity model (Table S1) of central Taiwan [*Chen et al.*, 2001]. The same model has been used to locate tremor in our previous studies [*Peng and Chao*, 2008; K. Chao et al., submitted manuscript, 2010]. Next, we created an averaged 1-D model (Table S2) from the recent 3D velocity model of *Wu et al.* [2007] based on the box that bounds the initial location of the 11 LFEs (Figure S4). The 11 LFEs are relocated according to the new 1-D velocity model (Figures S5 and S6). Finally we calculated the theoretical S-wave

[1]Institute of Seismology, National Chung Cheng University, Min-Hsiung, Taiwan.
[2]School of Earth and Atmospheric Sciences, Georgia Institute of Technology, Atlanta, Georgia, USA.
[3]Institute of Earth Sciences, Academia Sinica, Taipei, Taiwan.

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