Seismogenic sources and segmentation of a plate boundary fault: the dislocation modeling on a long-term geodetic dataset

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Abstract

The Longitudinal Valley (LV) is one of the major geologic sutures within collision zone of Taiwan, in which the Costal Range Fault (CRF) is the most active fault located in its eastern margin. The main goal of this study is to diagnose the geometry and behavior of the CRF by using the available geodetic database. Two available triangulation datasets measured from 1917 to 1921 and from 1976 to 1978 provide the crustal movements including both horizontal and vertical components in eastern Taiwan (Chen, 1984; Lee and Yu, 1987). According to the historical earthquake catalog of the past one hundred year, there is only one event large enough, the 1951 Hualien-Taitung Earthquake Sequence occurring in LV. We therefore assumed it is the major contributor to the ground slip recorded in the triangulation datasets.

This long-term geodetic result is composed of 60-year interseismic and the coseismic displacement of the CRF. We utilize the interseismic GPS records of 1992 to 1999 (Yu and Kuo, 2001) to estimate the possible interseismic horizontal component during the two geodetic occupations and then extract the coseismic one from the triangulation datasets. The values of parallel and perpendicular to the CRF are shown in Figures 1a and 1b. For the comparison, we plot the vertical component in Figure 1c. By the color-tone in Figure 1, the CRF can be divided into three segments from north to south. The northern segment is coseismically dominated by left-lateral strike slip (~3 m) with small convergence and uplift. The central segment shows the similar scale with the northern segment in strike-slip component, but relatively larger thrust component (~0.8 m). The behaviors of the northern and central segment are consistent with the observations of the strike-slip and oblique-slip during 1951 event (Hsu, 1962; Shyu et al., 2005). In the 1951 event, a huge vertical offset observed in the northern part of Yuli Fault (3~4 m), which is the only segment showed the vertical uplift over one meter (Shyu et al., 2007). Different from the other two segments, the southern segment shows about 1 m shortening and about 1.5

m left-lateral motion, but less uplift.

Based on the derived coseismic horizontal displacements, an initial fault model is suggested under the consideration of field investigation, interseismic slips, and available focal solutions. A best-fit fault model is yielded by using the dislocation simulation method (Fig. 2) (Okada, 1992; Wu et al., 2006). The modeled northern segment is characterized by a sense of pure sinistral strike-slip with an amount of ca. 4.9 m. The earthquake generated by this fault is supposed to be Mw 7.1. In the central segment, the best-fit slip shows oblique sense with strike and dip slips of 4.9 m and 5.5 m respectively. The net slip is 7.5 m that is equivalent to an earthquake of Mw 7.4. In the southern segment, the modeled slips of upper and lower fault planes are 5.5 m and 3.6 m with rakes of 65.0° and 27.9° respectively. Based on the extent and the slip of each fault plane, the total magnitude generated is about Mw 7.6 and the energy is about 30 times of 2003 Chengkung Earthquake. However, within the coverage of the southern segment we didn't find any record as such a big event between two triangulation occupations. There are only two earthquakes are relatively large. One is the M6.8 foreshock of the second main shock in November of 1951 (Cheng et al., 1996). It produced a surface rupture between Yuli and Chihshang and approximately 30 km in length. The field investigation documented a few ambiguous offsets which are much less than a meter (Shyu et al., 2007). Another one is a M7 earthquake happened in 1937. Unfortunately, there is no available report of the field investigation done after this earthquake. However, its epicenter is roughly at the same place of 2003 Mw6.8 Chengkung earthquake, which has been confirmed as the rupture event of the southern segment. In our opinion, the modeled huge amount on the southern segment is probably a cumulative result of more than one event. This characteristics differ from its northern two counterparts, representing they are decoupled geologically. Further, it may be related to why the southern segment of CRF interseismically creeps faster than its northern two counterparts.

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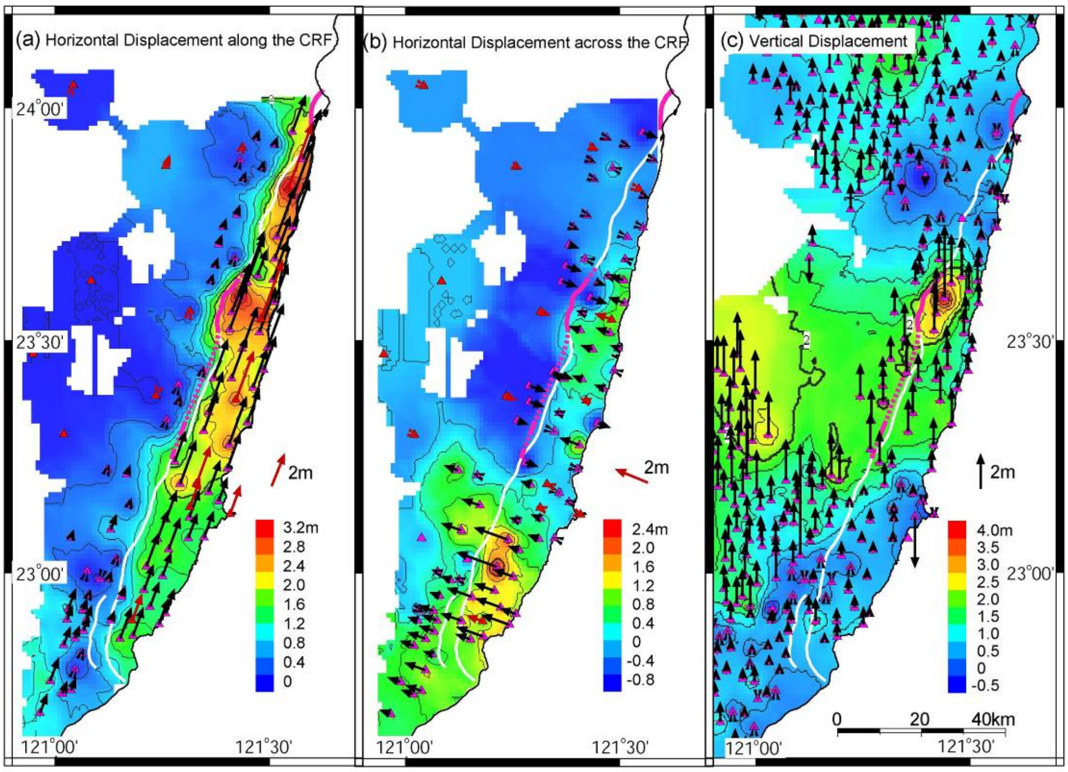

Figure1. (a) Horizontal coseismic displacements parallel to the CRF. (b) Horizontal coseismic displacements perpendicular to the CRF. (c) Total vertical displacements between 1914 and 1979 (Chen, 1984). Red line: The surface ruptures of the 1951 Hualien-Taitung Earthquake Sequence; White line: the Costal Range Fault.

Table1. Parameters of best-fit Fault Model by dislocation algorithm

Left Bottom Point			Strike	Dip	Length km	Width km	Strike slip cm	Dip slip cm	Total slip Cm	M
Long. (°E)	Lat. (°N)	Depth km								
121.462	23.685	1	24	55	42.00	10.00	490.2	0.0	490.2	7.1
121.307	23.270	1	16	55	42.00	22.19	494.0	552.0	740.8	7.5
121.132	22.848	2	20	60	45.00	18.48	230.8	496.1	547.2	7.4
121.216	22.820	18	20	45	45.00	25.00	320.6	170.1	363.0	7.3

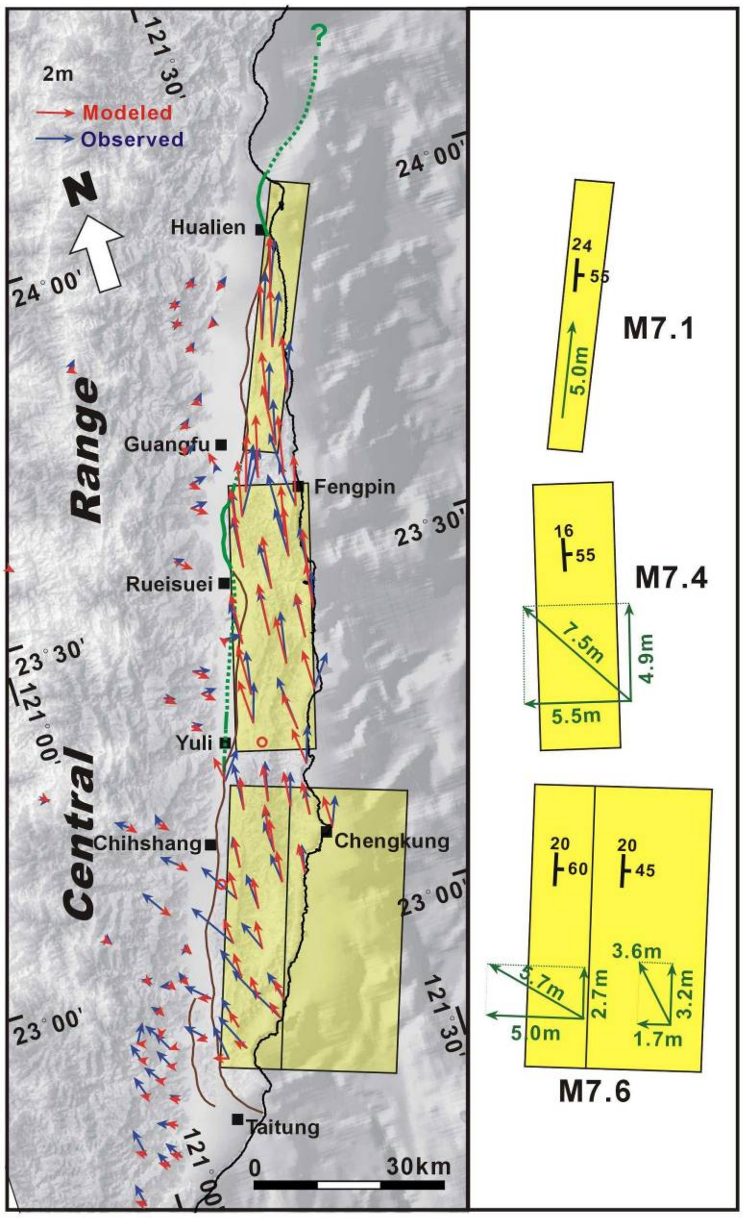

Figure2. The best-fit fault model is shown in yellow rectangles. Their related parameters are described in the right. The observed (in blue) and modeled (in red) displacements are shown for comparison.