FAST DETERMINATION OF EARTHQUAKE MOMENT AND MAGNITUDE

B. S. Huang and F. T. Wu

Institute of Earth Sciences, Academia Sinica

ABSTRACT

Near real-time seismic source information of strong earthquakes may useful for timely earthquake information broadcast.The near real-time availability of seismic data from globally distributed seismic stations allows estimation of a point source moment tensor and rupture duration within a few hours after the earthquake(Ekstrom, 1992) and rupture directivity(Ammon et. al, 1993).However, existing techniques do not apply to source parameters determination from local network data. The basic difficulty is that the distribution of stations from which the P-wave first motion data are obtained is often inadequate to constrain two nodal planes. For offshore earthquakes near eastern Taiwan, the coverage of the P-wave first motion data from inland stations is rather insufficient to determine the source mechanism of theevents. However, strong motion records include not only arrival times but on-scale wave forms and are useful for determinating source parameters.

The aim of this study is to test the performance of rapid determination of the source mechanisms of earthquakes from local network (e.g., CWB telemetered weak and strong motion network)data only. We aim at decreasing the report time to several minutes after the event. The method proposed by Jost and Herrmann(1989)to determinate the moment tensors based on the fitness of the short-period SH-wave peak amplitudes was applied to match the three component wave forms of high quality near-source records. We hope to obtain the source mechanism from near-source strong motion data (" low gain channels ") recorded by single or a small number of well-calibrated stations with the source location determinated by network autometic epicenter determination.As a initial experiment,inversion has been applied to the strong motion seismograms recorded at Chengkung (CHK), a permanent station of Central Weather Bureau (CWB) in eastern Taiwan, of the earthquake of 1992 May 28(Origin time: 5/28/1992 23:19:35.6 GMT; ML =5.4; 23.15N,121.35E; depth=13.7). These records are interesting because the station is only about 5 km from the epicenter so that not only the far-field but alsonear-field displacements were clearly recorded. Figure 1 shows the acceleration records by Geotech A800 force balance accelerometer. The maximum acceleration

at this station was 215 gals. To prepare the waveform inversion, the N-S and E-W components were rotated into radial and transverse components.The displacement trace obtained from the acceleration record by time-domain integration with high pass filtering at 0.4 Hz to remove the baseline drift as shown in Figure 2. The far-field pulses and the near-field displacement (displacement between P and S) are clearly recorded. Since the distance to the hypocenter is very small (Δ = 4.76km,azimuth = 198.5° backazimuth = 18.5°), the arriving phases can be assumed as directly propagated from source and the near-field displacements should be considered. To reduce the high frequency scattering which is not included in synthetic wave forms, the data were band-pass filtering between 0.4 and 2.0 Hz frequency band and the same filtering was done on the theoretical Green's functions (Johnson, 1974) for the consist frequency content on waveform fit. Figure 3 compares the observations and synthetic seismograms computed by the source mechanism from the waveform inversion.Although , there are some later phases after S wave with small amplitudes on observed data, they cannot be fit using the half-space Green's functions. The overall observed and synthetic seismograms are in good agreement for each component. Figure 4 (a) shows the retrieved source mechanism obtained by the waveform inversion using the 3-component displacements of station CHK only. The best fit double-couple mechanism had the following parameters: for plane 1, strike= 280 ° dip=72° and slip=170° ; for plane 2, strike=14° ,dip=81° and slip=18° . The limited first P motion data identified from the Central Weather Bureau short-period network is also shown in Figure 4(a).Figure 4(b) shows the mechanism of this event as listed in the PDE (Preliminary Determination of Epicenters) , by using the global network, data with the CMT inversion method (Dziewonski et al. , 1981). The retrieved source mechanism is in agreement with the distribution of the few observed first P motion of short-period network data and similar to the CMT solution.The advantage of our method is the speed of the determination . Application of the method toward fast determination of source mechanisms of local strong earthquakes using acceleragrams from the presently available seismic stations.

REFERENCES

Ammon, C. J., A. A. Velasco, and T. Lay (1993). Rapid estimation of rupture directivity: application to the 1992 Landers (Ms = 7.4) and Cape Mendocino (Ms = 7.2), California earthquakes, Geophys. Res. Lett., 20, 97-100.

Dziewonski, A. M., T.-A. Chou, and J. H. Woodhouse (1981). Determination of earthquake source parameters from wave form data for studies of global and regional seismicity, J. Geophys. Res., 86, 2825-2852.

Ekstrom, G. (1992). Quick CMTs - What's the next step ?, 4th Annual IRIS Workshop, April, Sante Fe, NM.

Johnson, L. R.(1974). Green's function of Lamb's problem, Geophys. J. R. Astr. Soc., 37, 99-131.

Jost, M. L. and R. B. Herrmann (1989). A student's guide and review of moment tensors, Seism. Res. Lett., 60, 36-57.

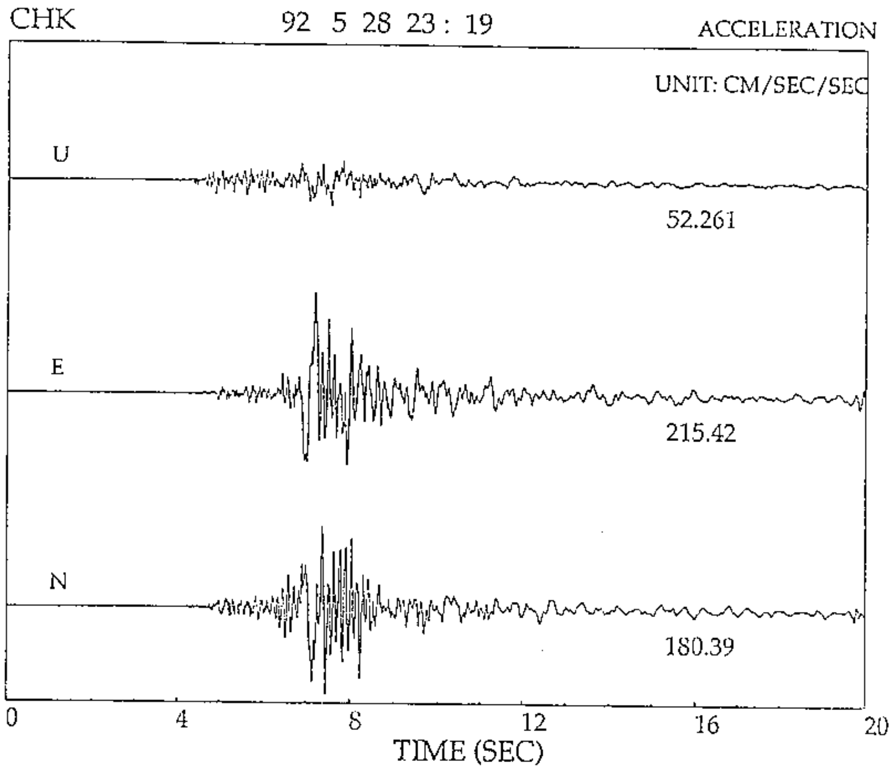

Figure 1. Vertical (U, positive to up), east-west (E, positive to east) and north-south (N, positive to north) component acceleration seismograms recorded at CHK for the event on May 28, 1992. The numbers on each right end are the peak values of each components.

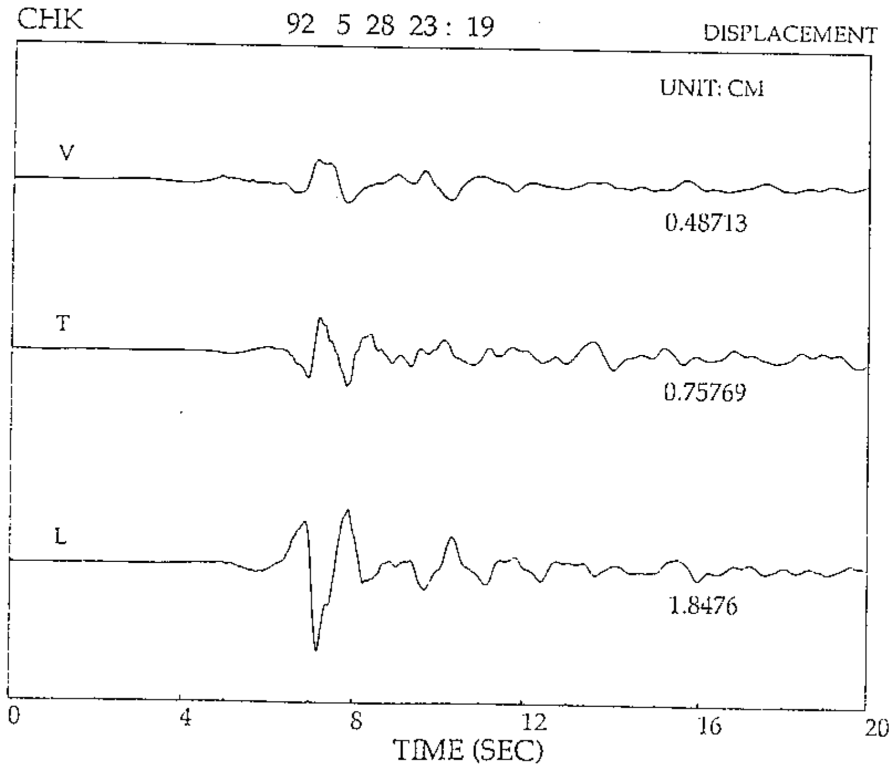

Figure 2. The integrated displacement seismograms of May 28, 1992 event recorded at CHK from the acceleration seismograms (Figure 1). Each traces highpass filtered upper 0.4 Hz frequency. The seismograms indicated as V, R and T are vertical, radial, and transverse components.

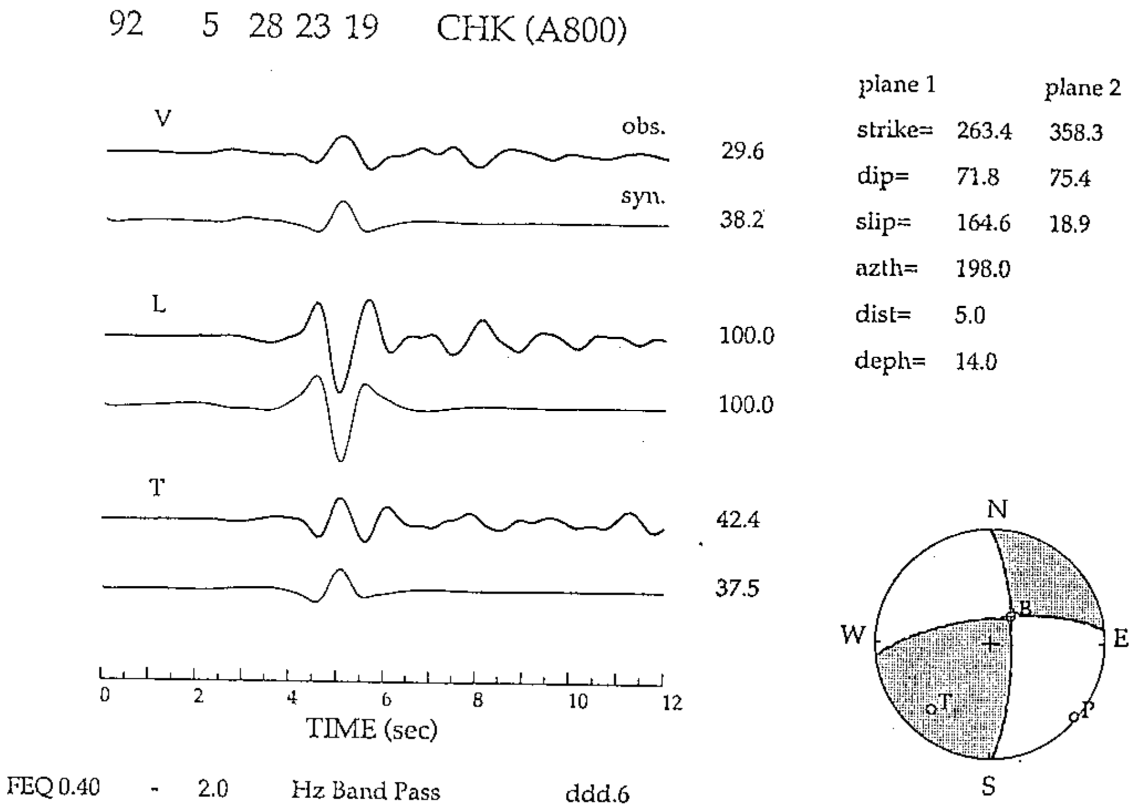

Figure 3. Comparison of observed and inverted synthetic seismograms for the May 28, 1992 event observed at CHK.

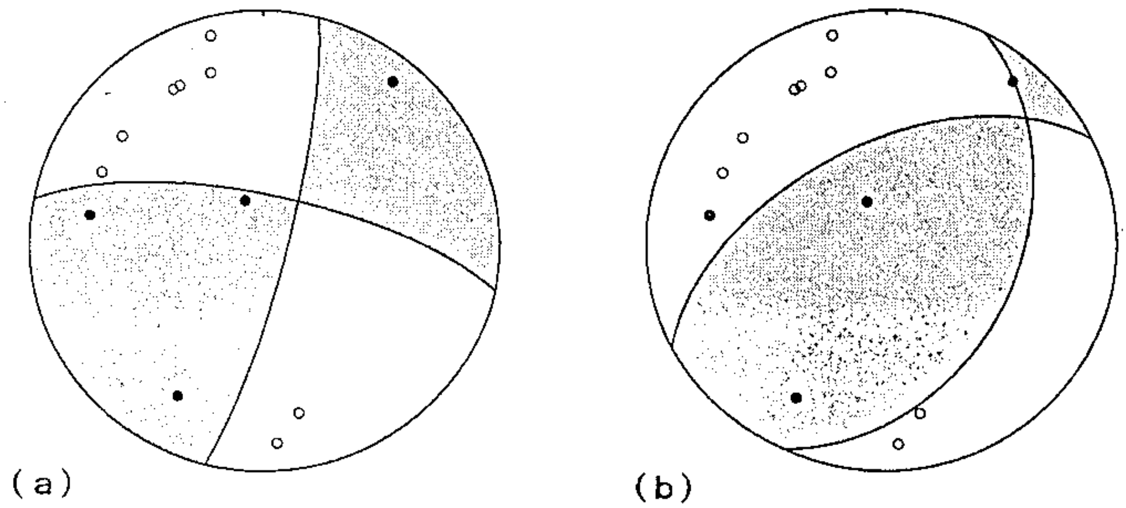

Figure 4. Comparison of the focal mechanisms of (a) single station moment tensor inversion (this study) for the May 28, 1992 event, (b) CMT solution. The open, dilatation, and solid, compression, circles are the first P motion plots observed from CWB short-period instruments (Cheng, personal communication).