THE ATTENUATION OF PEAK GROUND ACCELERATION

Hung-Chie Chiu and Shean-Der Ni

Institute of Earth sciences, Academia Sinica

ABSTRACT

The strong motion data recorded from the SMART-2 array and a temporary array deployed in south of Hualien were used in deriving the attenuation equation for the peak ground accelerations (PGA) in the Hualien area. During the deployment of SMART2 array, an earthquake of ML=6.7 occurred in the south of the array on 13 December 1990. At that time, only a few instruments had been installed.A temporary array was then deployed in the epicentral area four days after the main shock. This array accompanied by the SMART-2 array covered an area of roughly 400 square kilometers in Hualien as shown in Figure 1. Both arrays used the same instruments. Each station in the array included a 16-bit (resolution about 3.05x10^-5 g)three-channel recorder SSR-1, a triaxial force-balance accelerometer (FBA-23) with a natural frequency of 50 Hz and a damping ratio of 0.7 of critical,

Most of the data selected in this study come from the aftershock sequence of the 13 December 1990 Hualien earthquake. Some criteria were established in the selection of the data.First, the data are limited to shallow events (focal depth < 25 km). In fact, 90 percent of their focal depths are less than 6 km. Second, local events which triggered fewer than five stations are excluded to satisfy the requirement for statistical analysis.These events are mostly small events (ML<3.0) which are insignificant in the engineering application and likely to cause potential bias owing to non-triggered events. Third, a few events which had poor location quality are removed from the database. Under these criteria,about 1500 accelerograms from over 150earthquakes were included in this study. The location of these events are shown in Figure 2.

A nonlinear regression was introduced to derive the attenuation equation with the results being:

$$\ln[PHA] = 4.15 + 1.41 \times M_L - 2.37 \times \ln[R + 13.7]$$

$$\ln[PVA] = 2.46 + 1.34 \times M_L - 2.05 \times \ln[R + 10.3]$$

where PHA is the mean value of two horizontal peak accelerations,PVA represent the vertical peak acceleration, and ML, R are the local magnitude and epicentral distance. The attenuation coefficients for horizontal and vertical PGA

are 2.37 and 2.05 respectively.This indicates a higher attenuation rate in the Hualien area. The distance saturation terms, namely the last coefficients in the attenuation equations,were often defined as a magnitude-depended parameter for modulating the PGA attenuation at a distance close to the fault.However,it is demonstrated in this study that there is scarcely any relation to magnitude . Furthermore, a high inter-correlation among coefficientsis found in the regression analysis.

Since the attenuation of PVA was seldom studied in the past, the high-quality data also provide good opportunity to examine the attenuation of vertical acceleration.Comparisons of PVA and PHA attenuation curves are shown in Figure 3. In contrast to that of PHA, the PVA attenuation equation has a slightly smaller magnitude scaling coefficient, attenuation coefficient and saturation distance but a larger standard deviation. Overall, PVA has a similar attenuation mechanism to that of PHA.

Results of this studies different from previous works. Some of these differences may have come as a result ofinvestigating a different area and of the large improvement in the quality of SMART-2 data. Since observed data were limited to moderate earthquakes, more data is required, especially those data from large events and near-source, so as to clarify the near-source behavior of PGA.

Two earthquakes were selected to test this attenuation equation. The hypocenter of 8 August 1992 earthquake was located using three independent data sets(SMART-2 array, TTSN and CWB networks). The SMART-2 location is largely(about 15km)different from that of the other two. The attenuation relationships for the same data sets but different epicenters are shown in Figure 4.The epicentral distances based on the SMART-2 location seem to give a best fitting. The attenuation relationship for the event of 23 January 1993 is given in Figure 5. This earthquake triggered SMART-2 array, SMA-1 stations in eastern Taiwan and TSMIP instruments in Ilan and Taipei. Overall, the CWB location seems to have better fitting. However, if we carefully examine the data and divided them roughly into two groups(rock (solid symbol) and soil(open symbol) sites), the SMART-2 location still have better fitting. The data of rock site fit the M_L=5.6 curve well and the data of soil site have higher values which correspond to the Richter magnitude about 6.2.

The epicenters used in deriving the attenuation curves were obtained from TTSN locations. Although the individual location of some of the earthquakes in this data base may have large errors, these attenuation curves still provide good prediction for PGA attenuation.

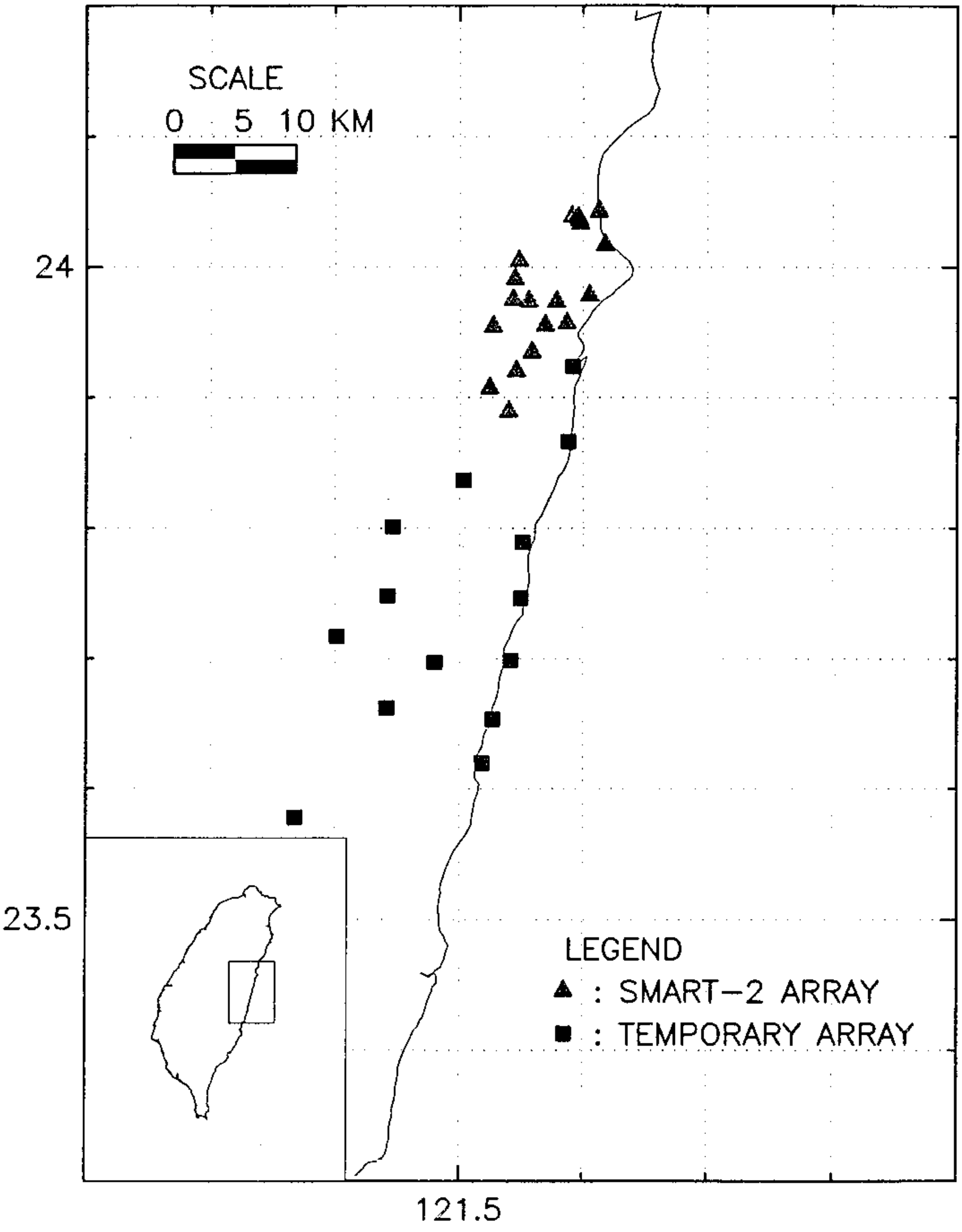

Figure 1. The locations of the SMART-2 array and temporary array stations.

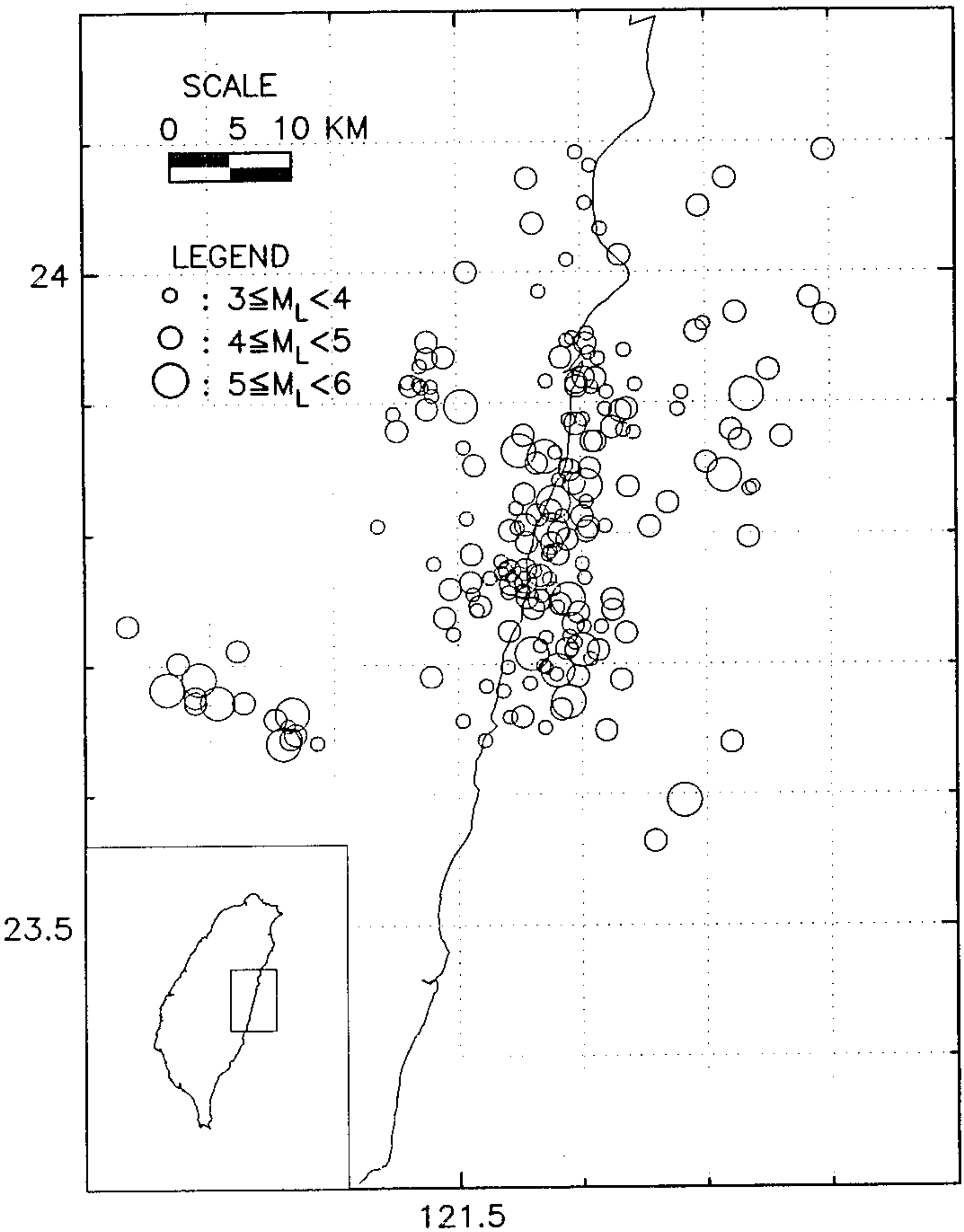

Figure 2. The epicenter map of 160 earthquakes used in regression analysis.

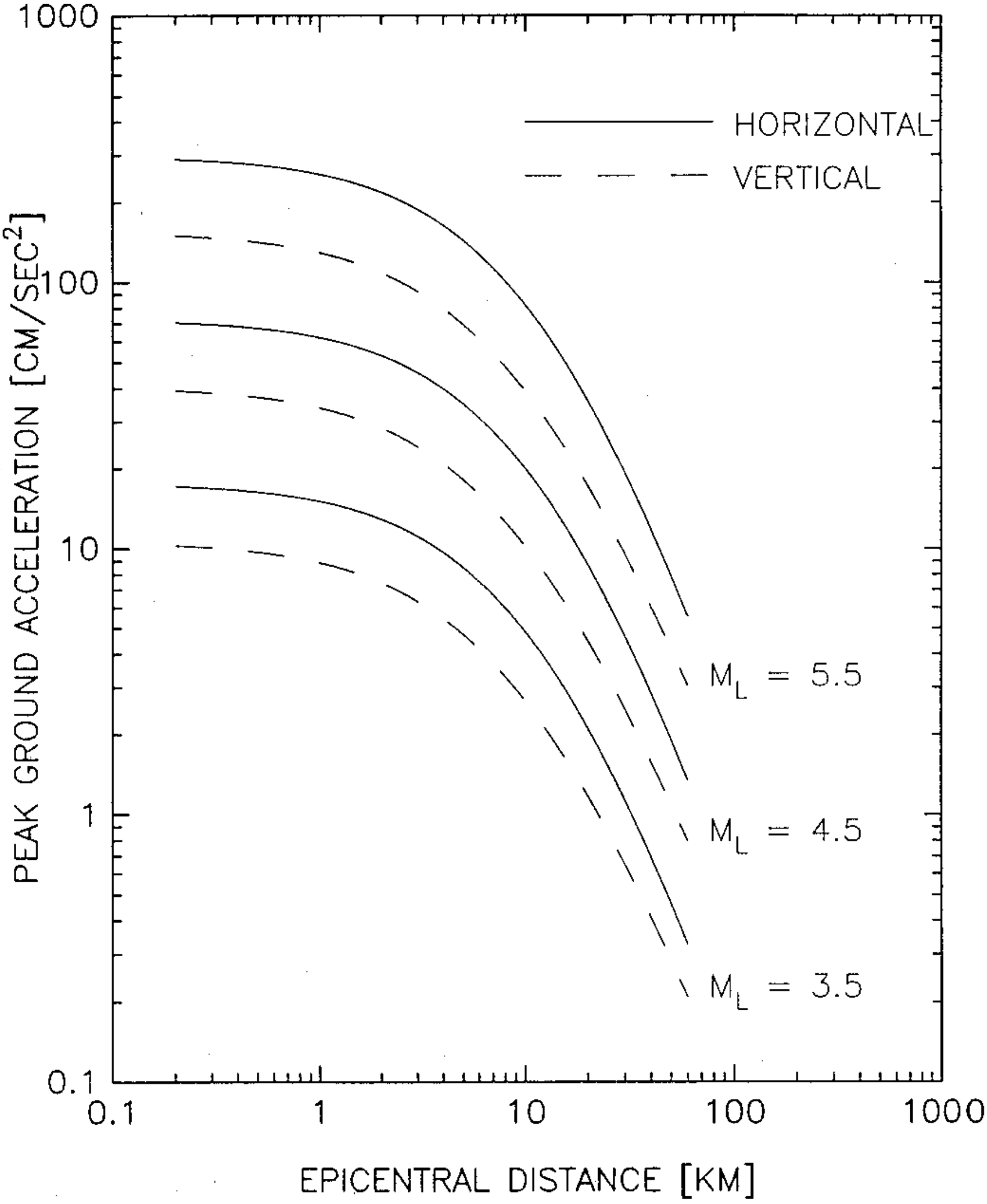

Figure 3. Attenuation curves for PVA(dash line) and PHA (solid line) for magnitude 3.5, 4.5 and 5.5.

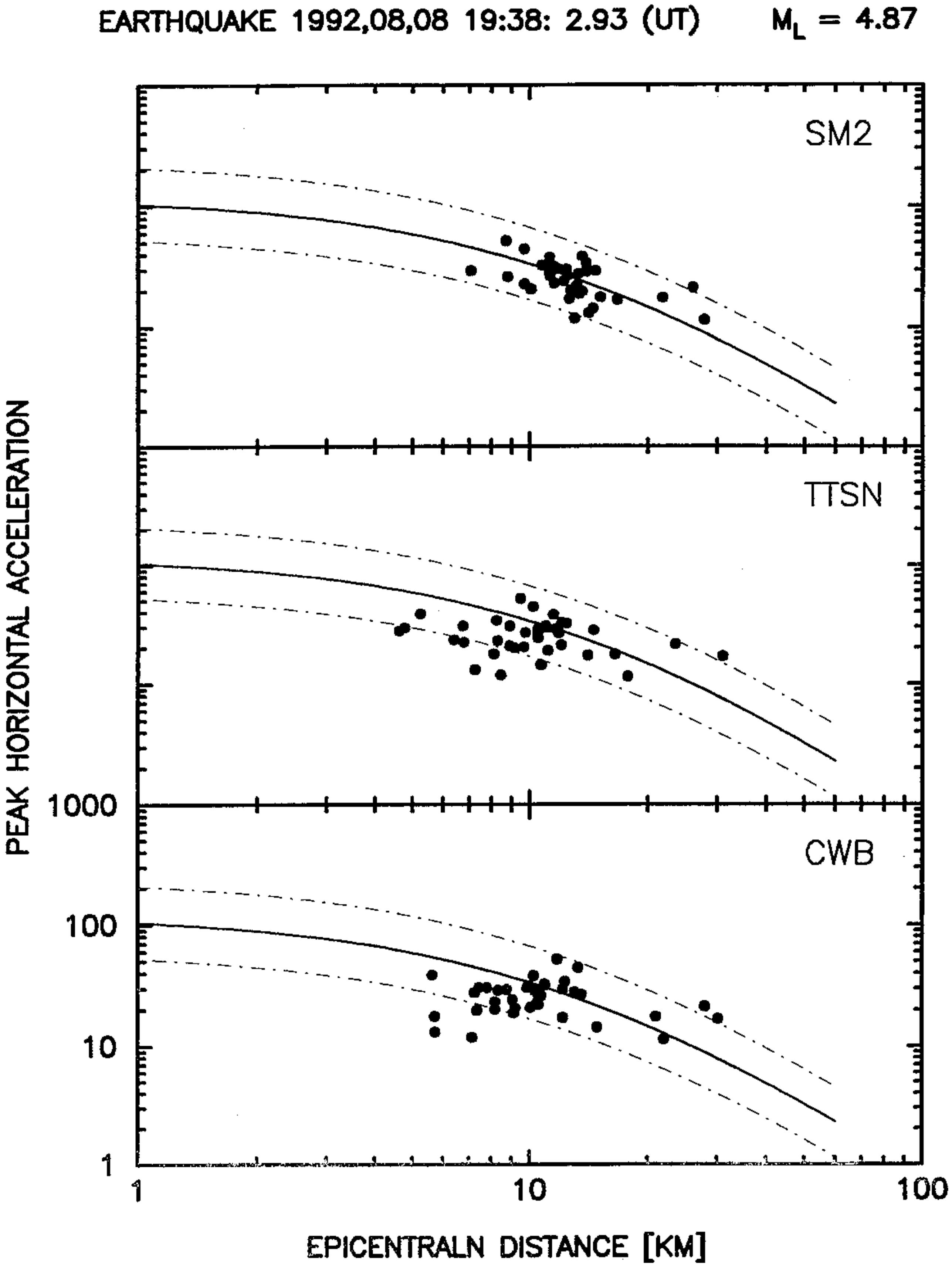

Figure 4. Attenuation curve for a ML=4.87 earthquake (solid line), one standard error bound (dot-dash line) and the mean horizontal acceleration of 8 August 1992 eathquake. Three plots in this figure have the same database but different epicenters which estimated independently from SMART-2 (top), TTSN (middle) and CWB (botom) data sets.

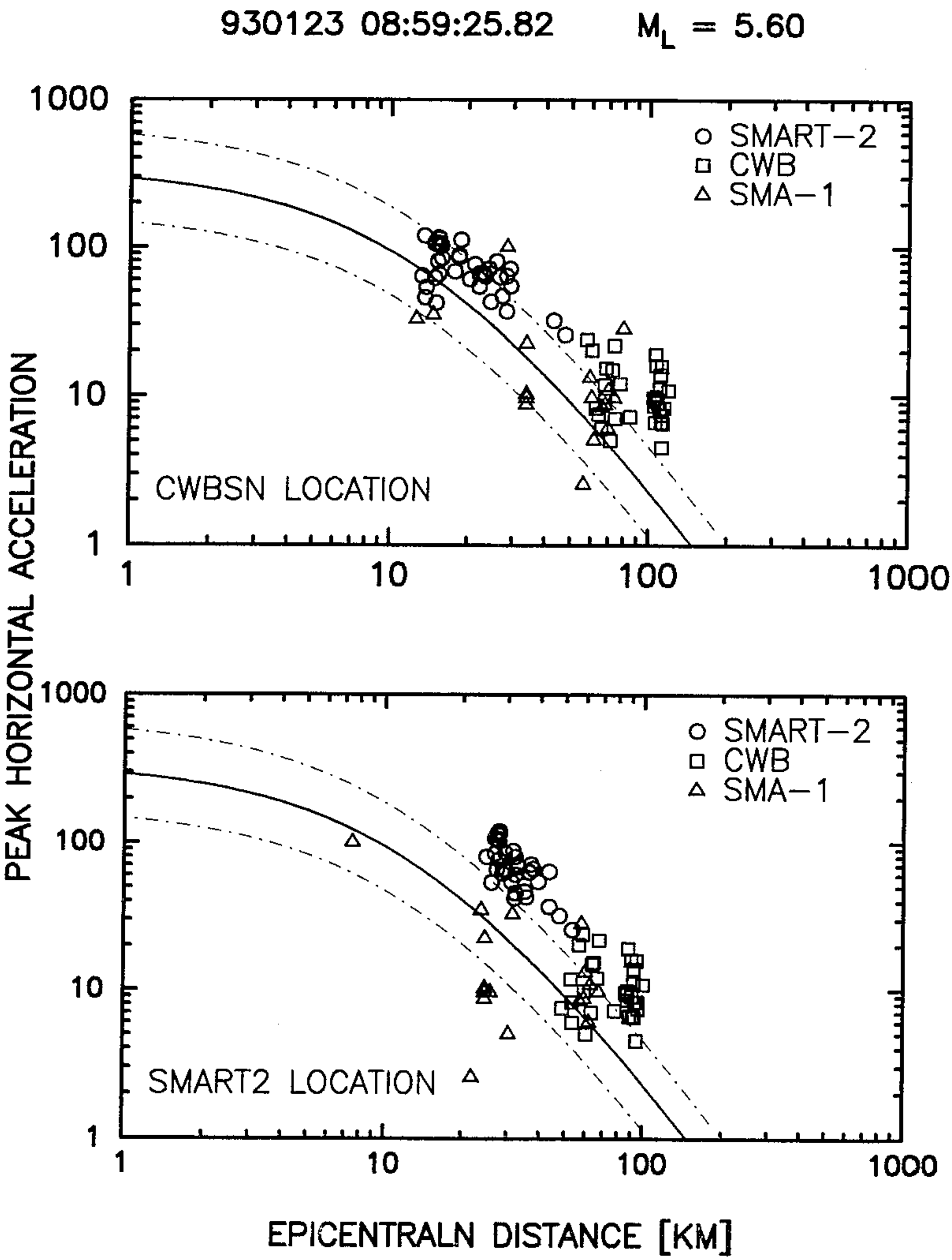

Figure 5. The attenuation relationships for the 23 January 1993 earthquake registered 5.6 in Richter Local Magnitude Scale. Three types(SMART-2, SMA-1 and CWB(TSMIP)) were included in this data set. Both the plots have same data set but different epicenters which estimated from CWB(top) and SMART-2(botom) data.