A New Method of Estimating Epicentral Distance and Magnitude for Early Earthquake Detection: (2) Application of JMA data

Shin'ya Tsukada[1], Toshikazu Odaka[1], Kimitoshi Ashiya[1], Shinji Sato[1], Kazuo Ohtake[2], Daisuke Nozaka[3]

[1] RTRI, [2] JMA, [3] SVD, JMA

We deal with the application of a new method to seismograms observed by Japan Meteorological Agency in estimating earthquake magnitude and epicentral distance from initial P phase observed at a single seismic station. From curve fitting of a simple function (y = bt exp(-at)) to initial P phases, we find a negative correlation between parameter "b" and epicentral distances within almost 200km. We think it may be possible to estimate magnitude and epicentral distance from parameter "a" (or maximum amplitude of initial phase) and "b" in a very short time (2 - 5 seconds).

1) Introduction

Many ideas have been demonstrated for earthquake warning system based on initial motion of a single seismic station. For example, Mp calculation for tsunami warning by JMA, UrEDAS to stop railway, systems to stop elevator and computer systems before the arrival of principal motion are the practical systems.

However so far the study of the principle for estimating epicentral distance and magnitude for a short time has not been made enough. Moreover, recent development of "real time seismology" is mainly concerned about the determination of hypocenter, source mechanism, fracture process and strong motion forecast.

In this paper we apply our new technique of estimating epicentral distance and magnitude in a short time to Japan Meteorological Agency data set.

2) Application to Japan Meteorological Agency data set

We select 14 earthquakes observed by Japan Meteorological Agency from Oct. 1994 to Oct. 1996 which show no bias in the magnitude, depth and location. Data include Earthquake off Eastern Hokkaido (Mj8.1), Far off Sanriku Earthquake (Mj7.5) and The Southern Hyogo Prefecture Earthquake. All stations have three-component 1Hz velocity seismographs. All waveform data are digitized with 100 samples per second and a 20 bit dynamic range.

The procedure of the analysis is as follows,

(1) The offset is removed from time series data.

(2) The envelope is defined for the absolute values of the data.

(3) The standard deviation of amplitudes in the noise part is calculated. P wave arrival is detected by an excess in amplitude by a given quantify (e.g. five times of the standard deviation).

(4) To fit a function [y = bt exp(-at)] to envelop waveform. Coefficients "a" and "b" are obtained by applying the least squares method to data of n seconds duration (n is 0.5-5).

We investigate the relation between these parameter "a", "b", epicentral distances and magnitudes. Similar analysis is made for acceleration seismograms which are obtained by differentiating velocity waveforms.

3) Result and discussion

Results are as follows,

(1) For earthquakes with magnitude more than 4, a negative correlation is seen between log "b" and epicentral distances within almost 200 km. This relation does not depend on magnitudes. Epicentral distances can be roughly estimated by this relation.

(2) For the case where the amplitude keeps growing "a" becomes negative. For earthquakes with small magnitudes, "a" becomes positive and the envelop has a maximum at t = 1/a.

(3) Both velocity and accelaration waveforms show similar tendency in the behavior of "a" and "b". Once we obtain an epicentral distance from "b", we can estimate an earthquake magnitude in a very short time (2-5 seconds) using

M=A log Amax + B f(b) + C,

where Amax is a maximum amplitude and f(b) is some function, for example, log b.

Other important conclusion is that the noise reduction is comparatively easy because we assume a specific waveform a priori and unusual waveforms can be identified easily. Moreover , it is easy to distinguish small near-field earthquakes and deep earthquakes from others because those earthquakes are characterized by small "a".