

Automatic arrival time picking compared to manual picking (6)

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1. Introduction

Recent installation of many ocean bottom seismometers increases the number of P and S-wave arrival times to be measured. The number becomes more than the limit that we are able to conduct picking. We have started to develop an automatic system of hypocenter location which is able to locate hypocenter with accuracy compatible to manually picking. Our previous study introduced a method of using the evaluation equation composed of many parameters based on seismological knowledge about how to pick arrival times. We have showed that the method can pick reliable arrival times of P and S waves. We also have introduced the method of hypocenter location which is able to locate hypocenters even at a period of earthquake swarm. The method makes pseudo seismograms whose amplitude become large at P and S wave arrival times and locates hypocenter with applying the semblance technique to the pseudo seismograms. In this paper, we preset the accuracy of P and S wave picking by the automatic system.

2. Method

In general, the predominant frequency of S wave is lower than that of P wave. We added the data of time variations of predominant frequency for S wave picking. The predominant frequency is calculated by the similar manner of calculating τ_c , which is used widely to calculate magnitude in the EEW system. Firstly, we calculate differential and double differential of horizontal component observed seismograms as follows.

$$V(t) = (u(t) - u(t-dt)) / dt$$

$$A(t) = (u(t) - 2u(t-dt) + u(t+2dt)) / dt^2$$

Then we compute 0.1 second running mean of the absolute value of $V(t)$, and $A(t)$ and calculate the ratio of two running means. We get time variations in predominant frequency from the time change of the reciprocal value of the ratio, though it is required to multiply a constant value. We assume dt to be 0.02 seconds. We put values of time changes of predominant frequency in the evaluation equation, which is composed of many parameters showing characteristic of seismograms; correspond to the periods between the candidates of arrival times.

3. Results

1) Remarkable drop in predominant frequency are found in almost all seismographs at times of S wave arrivals, showing the effectiveness of its usage in the arrival time picking. Same drop is found at P wave arrivals but there are many cases of increase.

2) We copied all available continuous seismic waveform data in Japan for 24 hours on September 3, 2011, and computed hypocenter automatically. Our automatic system locates 1523 events and the number by JMA catalogue is 588 in the same period. The number of automatically picked P waves is 2.6 times larger than that of manually picking by JMA, and S wave 1.6 times larger.

3) We compared P and S wave arrival times picked automatically with those by manually picking. P and S wave time differences are 0.06 and 0.16 seconds, respectively. This value is close to the difference in a case when two operators conduct picking for the same data.

4) We compared origin times estimated by two closed stations both of which have P and S wave arrivals. We select all couple of two stations with station distance less than 30km and compared origin times estimated from P and S wave arrival times. The average origin time differences by the manually picked data and those by automatically are 0.26 and 0.27sec, respectively.

We can conclude from these comparisons that we already developed an automatic system compatible to manually picking.

Keywords: Hypocenter location, Automatic P and S wave picking, Evaluation equation, Semblance, Predominant frequency, compatible to manual picking