Hypocenter Determination of Volcanic Earthquakes in Consideration with Various Velocity Structure of Stations

Masaki Nakahashi[1]; Hideki Iino[1]; Jun Funasaki[1]; Tamio Oikawa[1]; Masahiro Koya[1]; Shinobu Andou[1]; Tetsuya Yamamoto[2]; Akimichi Takagi[2]

[1] Sapporo District Meteorological Observatory; [2] MRI

1. Background and purpose of the study

In routine hypocenter determination of volcanic earthquake, JMA is employing homogeneous velocity model or single 1D bedding structure model considered to be most suitable for each volcano. So the hypocenter may have a certain error caused by heterogeneity of the velocity structure. Consideration for 3D velocity structure is necessary for further improvement of location accuracy. However, information about 3D velocity structure is limited and insufficient for most volcanoes. On behalf of 3D velocity models, as a simplified method in hypocenter determination, we are trying to introduce travel-time tables that are made in consideration with differences in velocity structure of stations.

2. Velocity structure of Usu volcano

We selected Usu volcano for this study since surface geology of Usu volcano was well documented by boring survey (Yahata, 2002) and 3D velocity structure based on the explosion seismic experiment was reported by Onizawa (2002). JMA is using 1D velocity model based on the result of Onizawa (2002) in routine hypocenter determination at Usu volcano.

3.Procedures

We took following procedures in the study.

A: Prepare the data set of observed arrival times of 133 hypocenters (observed by all 5 stations in Usu volcano from Sep.2003 to Nov.2005).

B: Estimate the structure beneath each station. We estimated type of rocks and their thickness beneath each station from the result reported by Yahata (2002) and assigned P-wave velocity (Vp) and ratio of P-wave and S-wave velocity (Vp/Vs) to each layer. Then we made 100 sets of travel-time tables by gradually changing velocity structures beneath the stations (e.g. applying 10 Vp and Vp/Vs values).

C: Make travel-time tables based on the velocity structure set in B with 500m grid spacing (2km in usual). We changed travel-time table data mesh to make the influence of the heterogeneity clear.

D: Modify the hypocenter calculation program so as to include travel-time tables for stations and to correct the altitude.

E: Re-calculate and evaluate the distribution of hypocenter.

4.Results

First, we modified the travel time calculation and hypocenter determination program by changing travel-time table data mesh from 2km to 500m. However, this modification rather increased scattering of focal depth and we interpreted it is due to the difference in treatment of differentials in the equation of hypocenter determination. Therefore we considered it is necessary for accurate hypocenter determination to set correct velocity structure.

Second, we modified travel time calculation and hypocenter determination program to correct the altitude of the stations. Mean focal depth became shallower about 300m, that is the mean altitude of the stations.

Next we tested 100 sets of travel-time tables in hypocenter determination. The best fit result which showed minimum travel time residual and standard deviation was obtained when we assumed velocity Vp=2.2(km/s) and Vp/Vs=2.1 for surface layer.

Furthermore, we calculated travel time residual for each station according to hypocenter distance and focal depth to reduce errors caused by the heterogeneity of velocity structure near hypocenter or lay path. Then we subtracted the residual from each travel-time table. Comparison of the result of the present study and those by JMA routine hypocenter determination shows that mean focal depth became about 500m shallower and hypocenters significantly concentrated in horizontal, showing the effect of improvement hypocenter determination technique.