Hypocenter Determination Using 3-D Velocity Structure

Masaki Nakamura[1]

[1] MRI

Japan Meteorological Agency (JMA) routinely determines hypocenter parameters by travel time tables calculated by spherical layered velocity structures (Ueno et al., 2002). However, there are various heterogeneities horizontally as well as vertically, e.g. subducting oceanic plates and magma chambers beneath volcanoes. Therefore, the hypocenter determination by layered velocity structures occasionally produces systematic biased residuals between theoretical travel times and observed ones. In the result, hypocenters are occasionally mislocated.

JMA has been developing the hypocenter determination method using a three dimensional (3-D) velocity structure for the future routine work (Nakamura et al., 2000). In this presentation, we report hypocenter distribution determined by P- and S-wave velocity structures beneath Japan obtained in Nakamura et al. (2003).

The velocity structures were obtained by applying the seismic tomography method proposed by Zhao et al. (1994). The grid interval was about 10km in the shallow areas of main 4 lands, and was about 30km in other areas. For the inversion, they explicitly defined the Conrad, the Moho and the upper boundary of the Pacific plate.

The hypocenter determination method was same to the conventional one, which uses a nonlinear least squares method. We evaluated theoretical travel times every time by the ray tracing method used in Zhao et al. (1994), which is hybrid one of Snell's law and pseudo bending (Um and Thurber, 1987).

Hypocenter distribution determined by the 3-D velocity structure has the following characteristics, compared to JMA's one. Hypocenter distribution off Sanriku, which is eastern part than 143E, shifts to the west several tens kilometers. Moreover, far east off Sanriku, hypocenters are similarly determined deeper than real ones because of bad station distribution. To break the situation, we propose to calculate hypocenters with constraint condition of hypocenter depth information. Mainshock and aftershock hypocenter distributions of 2000 Tottori-ken Seibu Earthquake are not so different each other, but 3-D one is shallower and smaller cluster. A distribution of mainshock occurred off Miyagi prefecture on 26 May 2003 and the aftershocks shifts to the west several kilometers and is smaller cluster. Moreover, a bend seen in a vertical cross section of JMA hypocenters is slighter, as mentioned in Sekine et al. (2003). Mainshock and aftershock hypocenter distribution of 2003 Tokachi Oki Earthquake is shallower and shifts to the north or the west about ten kilometers.

When we use a single Pentium4 (3.2Ghz), it takes less than 10 sec. to calculate a hypocenter for most of 128,186 events occurred in 2002, but takes more than 1 hour for 71 events, which have poor solutions or occurred near the Ogasawara Islands or the Kuril Islands. For those cases, it will take fewer times to calculate them by making the condition to terminate them softer. Moreover, if it takes less than 1 hour to calculate it in this circumstance, it will takes less than 1 minute by the near future advance of the CPU or by the parallel programming. Therefore, it will be practicable for the routine work.

References: Nakamura et al., 2000, Abstr. 2000 Japan Earth Planet. Sci. Joint Meeting, Sk-018.; Nakamura et al., 2003, Abstr. 2003 Japan Earth Planet. Sci. Joint Meeting, S053-P010.; Sekine et al., 2003, Programme Abstr. Seism. Soc. Japan 2003, Fall Meeting, P182; Ueno et al., 2002, Q. J. Seismol., 65, 123-134.; Um and Thurber, 1987, BSSA, 77, 972-986.;Zhao et al., 1994, JGR, 99, 22313-22329.