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# A hypocenter determination method with travel time difference between observation points

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A hypocenter determination problem from observed seismic wave data has been one of the most important issues for seismology. In the hypocenter determination process, model errors originated from earth model uncertainty should be most important, because it is well recognized that errors due to uncertainty of velocity structure model can severely bias the result in the hypocenter determination. Considerable efforts were made to obtain more precise velocity structure, and then accuracy of hypocenter determination has been improved. However, we never obtain the true velocity structure model, and never calculate a theoretical travel time with the true velocity structure model. So in this study, we developed new hypocenter determination method so as to mitigate the model errors due to uncertainty of velocity structure model.

In general, the model errors correlate with not only location of hypocenter but also location of observation point. Taking the difference between the observation equations for a pair of observed points, we mitigate the effect of the model error. First, we constructed an observation equation for each station with the model error term, obtained an equation for location of hypocenter by taking the difference between the observation equations for a pair of observed points, and then determined location of hypocenter using the difference equation. The model error correlations among observation points should be mitigate in the difference equation.

We first made a synthetic test to compare the new formulation with the traditional formulation. We computed the synthetic travel time with 2.5 D structure model, and then determined location of hypocenter with simplified layered structure model. The results show that the estimation errors significantly mitigated under the new formulation. We next applied the new formulation to the JMA unified data of aftershocks of the 2004 Mid-Niigata prefecture earthquake, and to travel time observed MeSO-net in aftershocks of the 2010 northeast Chiba prefecture earthquake. From distribution of the 2004 Mid-Niigata prefecture earthquake, the fault plane dipping into southeastward was confirmed. This fault plane is not identified in JMA catalogue and relocation with HypoDD, though same observation data was used. And, from distribution of the 2010 northeast Chiba earthquake, it is revealed that reverse fault earthquakes are focused near plate boundary, whereas other earthquakes are located inside of subducting slab, deeper than plate boundary.