A 1D Velocity Model of Northern Thailand: Preliminary results

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1. INTRODUCTION

Thailand is in the low seismicity area as it is far for the plate boundary. Most earthquakes were occurred in the northern and western parts of Thailand, Myanmar, Laos, and Sumatra Andaman subduction zone. The earthquakes in the country and adjacent areas within latitude 2N˚-25N˚ and longitude 92E˚-110E˚ are mainly monitored by the Thai Meteorological Department (TMD). The earthquake location was calculated by using a global velocity model IASP91[3]. The earthquake location mainly depends on the accuracy of predicted travel-times and crust and mantle velocity structure [2]. Therefore, an appropriate regional velocity model was required to improve the earthquake location accuracy. In this study, the 1D seismic velocity model was obtained by using travel-times data for earthquakes in the northern Thailand and adjacent areas. The 6 different initial models, IASP91 [3], AK135 [4], MM_1D [9], Crust 1.0 [6], AsCRUST-08 [1], and P-wave Velocity model in northern part of Thailand [8] were used to find a 1D velocity model.

2. METHODOLOGY

In this study, we used the earthquakes event data (2014-2022) and P- and S-arrival times from TMD catalogue. The earthquake events were selected by using similar criteria as work of [9]: (1) the earthquake is recorded by a minimum of 8 stations, (2) the root mean square (rms) travel-time residuals are less than 2.0 s, and (3) the maximum azimuthal gap is 170˚. In total, 156 earthquakes were passed the criteria. The VELEST program [5] was used to obtain the 1D seismic velocity model. The P- and S-arrival time dataset and appropriate initial model are essential input [9]. The 6 initial velocity models were used. The first initial model is IASP91 model. The IASP91 velocity model was used to find an appropriated number of layers and thicknesses. Since VELEST does not automatically adjust layer thickness, the appropriate layering of the model must be found by a trial-and-error process. Thus, the calculation of a Minimum 1-D model normally starts with finding an appropriate model layering [5]. The grid size 1 km, 2 km, 3 km, 5 km, 2 layers crust (upper and lower crust) and 3 layers crust (upper, middle, and lower crust) models were tested. The 2 km grid size of IASP91 model that has minimum rms errors of selected earthquake locations was used in this study and for the other initial models. The second velocity model is AK135 model. The AK135 velocity model was discretized into 2 km depth and adjust the Moho to 32 km. The third initial model is MM_1D model. [9] developed a minimum 1D velocity model for Myanmar region. [8] propose the P-wave velocity model derived from receiver function. The average P-wave velocity was used to construct the initial model. The fifth model is AsCrust-08 model. [1] proposed a new crustal model for central and southern Asia. The last velocity model is Crust 1.0 model. [6] proposed the Crust 1.0 model. In this study, the P-wave velocity cross section of Crust 1.0 model from latitude 15˚N, longitude 95˚E to latitude 23˚N, longitude 102˚E was averaged for each depth and become 1D model. For all 6 initial model, the 2 km grid size with 32 km Moho depth were used to adjust initial model. If any model does not have the velocity model below Moho, mantle velocities from the AK135 were then used to the depth 200 km. The additional 50 random initial models were tested to find the best velocity model. For each depth, the P-wave velocity was randomly modified within the range of ±10%. The inverted models with the travel-time rms residuals less than 10% were then accepted. The final velocity models for each set of initial models are obtained by averaging the accepted model. After the 6 final models were obtained, HYPOCENTER was used to assess the inversion result and to select the best model. The best model has the minimum rms travel-time residuals.

3. RESULTS

The 6 initial models were used to obtain 1D velocity model. After testing the layer thickness and Moho depth of IASP91 model, the different grid size and different Moho depth resulting different inverted model. The 2 km grid size with the 32 km Moho depth show the minimum error and were then used to apply for all 6 initial model. For each initial model, the additional 50 random initial models were used to obtain the inverted model. After testing 306 different initial models, the MM_1D (Figure 1c) and P-wave (Figure 1d) models produce the best results. We chose the final model from P-wave model as the best model because this model shows less travel-time rms residual and major and minor axis of epicenter ellipse errors from HYPOCENTER program. This model will be referred as NTh1D model. The station corrections for P-wave travel times (Figure 2) represent the difference between observed and calculated travel-time where the late and early observed arrival was show as positive and negative values, respectively.

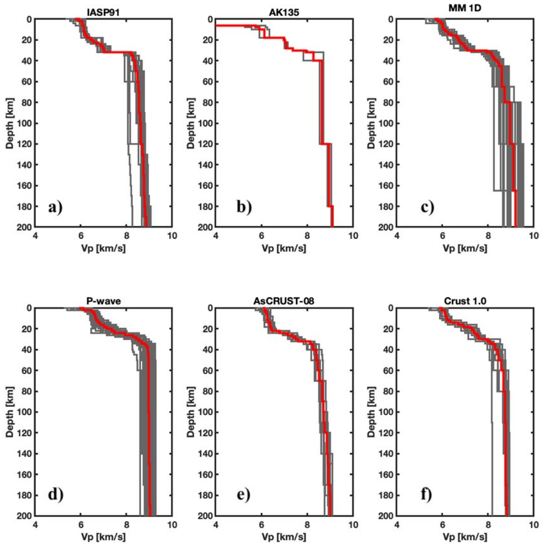

Figure 1 shows the accepted final models (travel-time rms residuals less than 10%) in grey line and the average final model in red from the initial model of a) IASP91 [3], b) AK135 [4], c) MM_1D [9], d) P-wave Velocity model in northern part of Thailand [8], e) AsCRUST-08 [1], and f) Crust 1.0 [6].

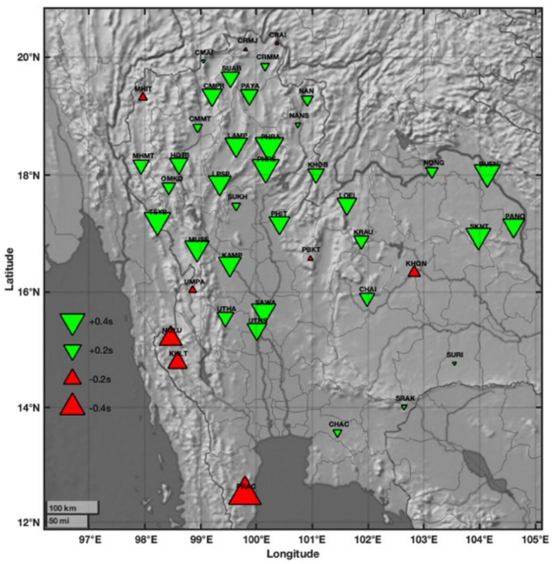

Figure 2. shows P-wave travel-time corrections obtained from VELEST program of the final model. Green reverse triangle and red triangle show station position and size represent the positive corrections and negative corrections, respectively.

4. CONCLUSIONS

The 6 initial models were tested to obtain the best 1D velocity model, called NTh1D model, to improve earthquake location in the northern part of Thailand. After testing the layer thickness of IASP91 model, the 2 km grid size and 32 km crustal thickness of the northern Thailand show the also show the minimum error. The NTh1D model shows more accurate hypocenter solution compare with original IASP91 and other models tested in this study. The station corrections were also reported to produced better earthquake locations. Additional data, seismic stations and initial models can be used to improve the 1D velocity model. The 3D velocity model is also great to earthquake location improvement.

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