II－48 Parametric Study Of The Source Model For The 2004 Indian Ocean Tsunami

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1. Introduction

At 00:58:50 (UTC) on 26th December 2004 an earthquake occurred along the Sunda Trench, where the India plate begins its subduction under Sunda plate. The magnitude was established by USGS as 9.3 and the epicenter was located at 3.3°N, 95.8°E. The earthquake generated a mega tsunami with tsunami magnitude estimated as 9.1 [Abe, 2005] and a maximum run-up of 48.8m [Choi et al., 2005] recorded at Banda Aceh, Indonesia.

2. Tsunami Numerical Model

The tsunami numerical model is based on the linear shallow water theory in a spherical coordinate system, with a staggered leap-frog scheme [Goto et al., 1997]. We used a spatial grid size of 2 min and time step of 3 sec and the calculations were made for 6 hours as computation time. The bathymetry data is 2-minute Gridded Global Relief data (ETOPO2) [National Geophysical Data Center, 2005].

3. Review of Previous Studies

The initial sea surface displacement [Okada, 1985] of the tsunami was calculated with the fault parameters summarized in Table 1.

TABLE 1: Fault Parameters from Koshimuara et el., 2005

Parameters	South Subfault	North Subfault
Origin of the fault	94.8°E, 2.5°N	92.0°E, 6.5°N
Length (km)	500	400
Width (km)	150	150
Dislocation (m)	11	11
Strike	329°	358°
Dip	15°	15°
Slip	90°	90°
Depth (km)	10	10

Figure 1 shows the tsunami front approximately 2 hours after the earthquake occurred and the observations made by Jason-1. This satellite measured the tsunami heights [Gower, 2005] along its 109 track and it was the first time to obtain tsunami data measurements by a satellite. Such spatial distribution of a tsunami is important to know the propagation process as well as the tsunami source. Figure 2 represents the latitudinal comparison between the model and measured tsunami heights. The latitude range varies from 4.5 °S to 20°N. We can see that there is a good agreement in terms of the tsunami front propagating to northern and southern directions. However, at the interval 0° to 5°N the results are not so good. This result suggests us that the initial source in the south part is well reproduced and trans-oceanic propagation model is also accurate since the first wave of the tsunami is correct.

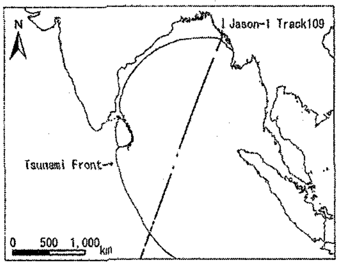

Figure 1: Snapshot of the tsunami approximately 2 hours after the earthquake occurred. Also in the figure is represented the water level measured by the satellite Jason-1 [Koshimura et al, 2005].

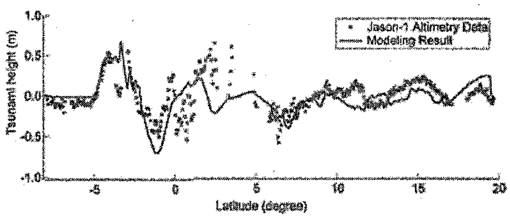

Figure 2: Comparison of the measured and calculated water level history, at the path of Jason-1 [Koshimura et al., 2005].

While Jason-1 measurements allow us a study in deep ocean, tide gauge stations provide a coastal study. From the several tide gauge stations distributed around the Indian Ocean (about 26), the best agreement was found at Sibolga tide gauge station. The observation sampling time is 10 min and the result of the calculation and observation is presented in Figure 3. The good result obtained in Sibolga also suggests that the south subfault (table 1) is well reproduced.

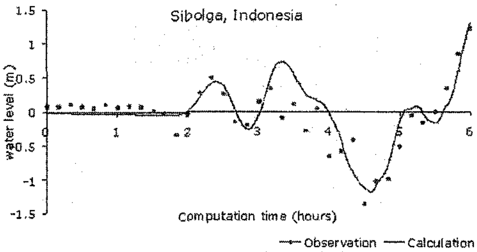

Figure 3: Comparison of the measured and calculated tsunami height at the Sibolga tide gauge station.

4. Extension of the northern subfault

The south subfault gives generally good results however the north subfault is not well constrain. In order to evaluate the extension length of the northern subfault, we performed tests with 4 different lengths, shown in table 2. In this study we focus on the east part of the northern subfault, Thailand. The location of the stations is represented in Figure 4 and the sampling time for the 7 stations is 1 min [Siripong, et al., 2005]. The fault parameters are the same as shown in table 1, except for the length of the north subfault, which it varies from 150 km to 500km.

TABLE 2: Tested lengths of the northen subfault

Model	North Subfault length
Model 1	150 km
Model 2	300 km
Koshimura et al., 2005	400 km
Model 3	450 km
Model 4	500 km

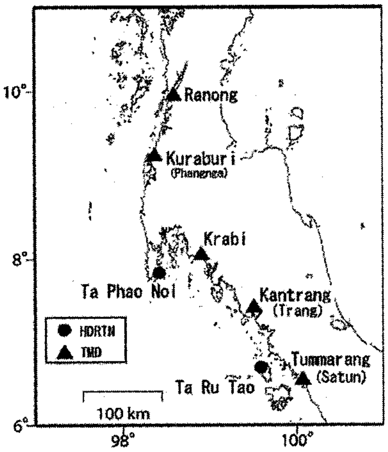

Figure 4: Location of the tide gauge stations in Thailand [http://www.eri.u-tokyo.ac.jp/tsunami/thai_records/].

From the comparison of tsunami travel time difference between the observation and calculation (T_{o-c}) for the different models (Table 3) we can see that it increases as the northern fault length increases. T_{o-c} is only 2 min for the stations below the 8°N: Ta Phao Noi, Krabi, Kantrang, Ta Ru Tao and Tummarang. On the other hand, T_{o-c} increases 16 min at Ranong and 8 min at Kuraburi.

TABLE 3: Travel time difference between observation and calculation for the 7 stations, and to the 5 models.

Station	T_{o-c} (min)				
	Model 1	Model 2	Koshimura et al., 2005	Model 3	Model 4
Ranong	9	18	22	24	25
Kuraburi	29	35	37	37	37
Ta Phao Noi	11	12	13	13	13
Krabi	32	33	33	33	34
Kantrang	70	71	71	72	72
Ta Ru Tao	-13	-12	-12	-11	-11
Tummarang	68	69	69	69	70

Besides the travel time, the waveform also changes and the most significant differences were also obtained in Ranong and Kuraburi. The 2 extreme cases are shown is figure 5 (Model 1) and figure 6 (model 4).

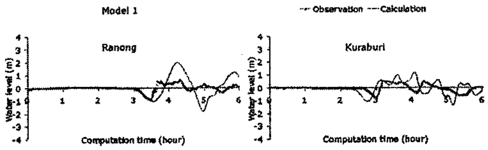

Figure 5: Comparison of the measured and calculated tsunami height at the Ranong and Kuraburi tide gauge stations, for the model1.

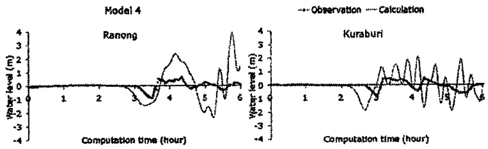

Figure 6: Comparison of the measured and calculated tsunami height at the Ranong and Kuraburi tide gauge stations, for the model4.

5. Summary

Due to geographical distribution of the fault mechanism and the location of Thailand stations, only those stations which are located above 7.85°N are affected by the changes in the north subfault length: Ranong and Kuraburi. This difference is obtained in the T_{o-c} and also in the waveforms. Therefore, future parametric studies sould focus only at Ranong and Kuraburi; also, the stations located at the west part of the fault should be taking in consideration.

The 2 min grid size is quite coarse, so in future studies a finer grid size (for ex., 1 min) should be used.

Parametric studies are very important in order to understand the correlation between the fault parameters, travel time and tsunami heights. These can be extrapolated to other events, such as historical tsunamis, where the information is rather scarce.

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