

# ANALYSIS OF TSUNAMI HAZARD POTENTIAL USING TSUNAMI SIMULATION AT SUNDA STRAIT REGION

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## ABSTRACT

As a region in the line of trench, Sunda strait region have a very high probability to be attacked by earthquake and tsunami. To anticipate geological hazard were will occure in the future, especially by tsunami, we need to learn about hazard in this region. To determine tsunami hazard in this region, we use tsunami simulation for three tsunami source which have most high tsunami run up potential. Two tsunami sources parameters taken from the last tsunami occured at western and eastern part of sunda trench. One source placed along seismic gap for biggest earthquake which have possibility occurred. Tsunami wave distribution from tsunami simulation in observation point, will be the discussion materials to decide tsunami hazard level along coastal in both provinces at sunda strait.

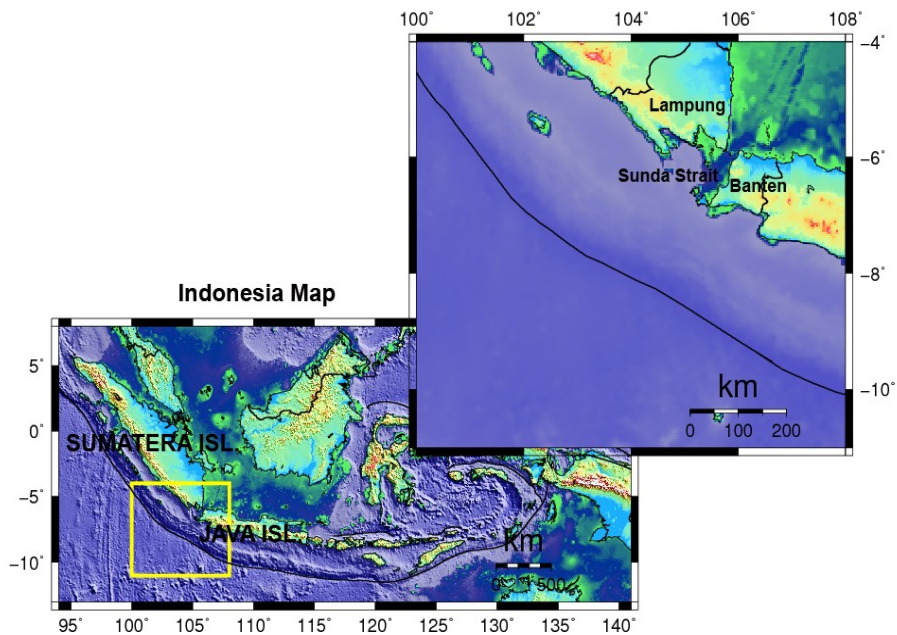
## INTRODUCTION

Sunda strait region including Lampung and Banten province is located at western part of Indonesia. Lampung province is most southern part of Sumatera Island and Banten province is most western part of Java Island, connected by Sunda strait (figure 1).

Tsunami is unpredicted event which almost always forgotten by people because its has long event period, but always cause disastrous social and environment effect. Because of that, analysis of tsunami hazard is very important, especially for regions which never or after long period not happen but have potential of being attacked.

Since tsunami Sumatera 2004 happened, tsunami prepardness and mitigation system become a big concern. For the purpose of preparing and improving tsunami awareness and mitigation system, this paper try studying about tsunami hazard potential at sunda strait region by using modelling tsunami generated by earthquake at seismic gap along Sunda trench around sunda strait with three different scenarios. Simulation result will be used to identify tsunami hazard level according to tsunami wave height attacking coastal areas.

## Location of Interest



*Fig 1. Location of Sunda strait and two provinces around Sunda strait is Lampung and Banten. It is located between Sumatera island and Java island. This povinces became very important because of its location as bridge between those two big islands.*

## TECTONIC AND SEISMICITY

Tectonic setting around interest area is divided in to three segment deformation pattern as seismogenic sources, that is Sumateran forearc region (western part of Sunda trench), offshore Java region (eastern part of Sunda trench) and Sunda strait region as single seismogenic source (*Lasitha et. al., 2006*) (figure 2).

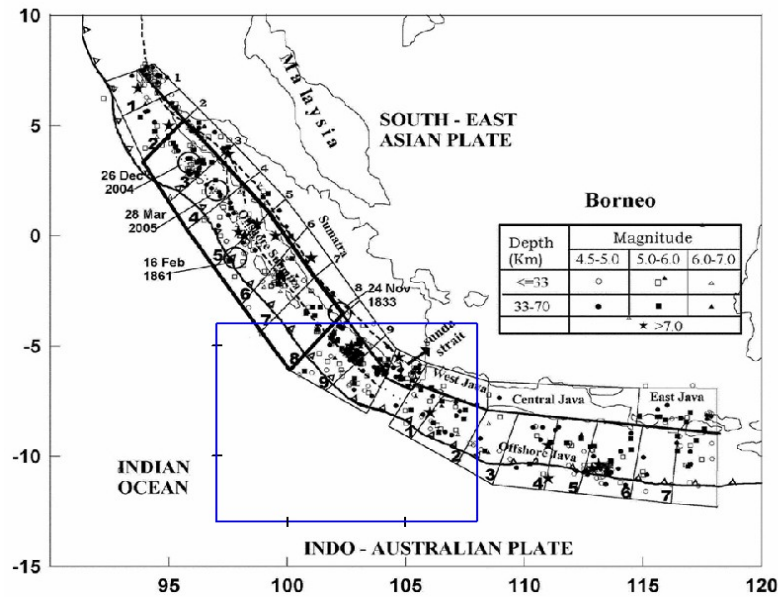


Fig 2. (Picture taken from Lashita et. al., 2006). Segment deformation pattern for Sumatra and Java. Blue box is observation area, which have three seismogenic sources are Sumateran forearc region, offshore Java region, and sunda strait region.

These three segments have their own different pattern for crustal deformation. Lashita et. al. observed that Sumateran forearc region has thrust-faulting mechanism. Deformation velocities indicate dominantly compression with higher compressional velocities around 19 mm/yr along N45° direction. Sunda strait region has strike-slip and normal faulting, with dextral slip of 13 mm/yr along N88°. And Java forearc region has thrust and strike-slip mechanism with deformation velocities dominant of compression (19mm/yr) in western part.

Based on earthquake database record (PDE Catalog) for 1973 – July 2007, at interest area indicate seismic gap which has a potential to generate earthquake and tsunami (fig 3).

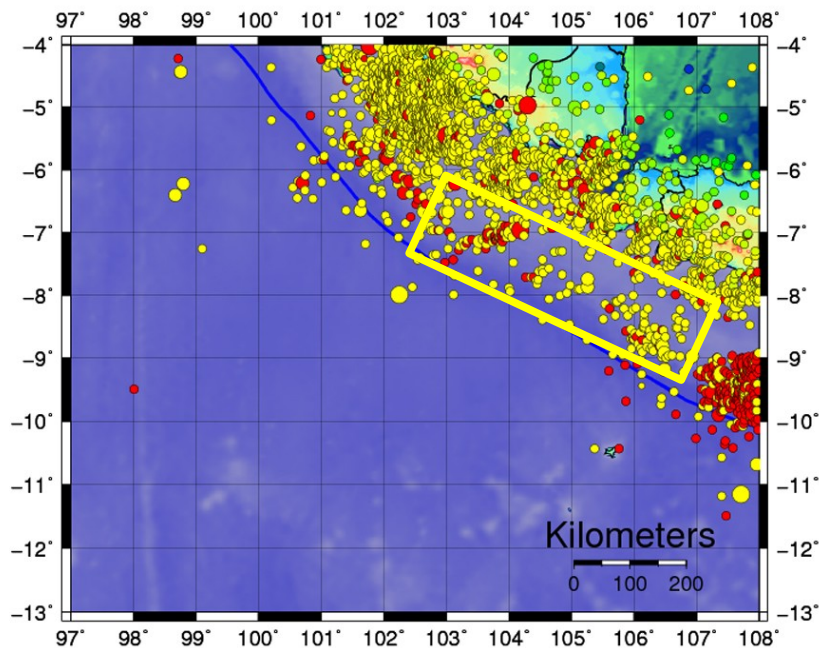


Figure 3. Seismic activity around interest area during period 1973 – 2007. Red dot showing shallow earthquakes with depth less than 70 km, yellow dot is earthquake with depth 70-300 km, and green is earthquake with depth more than 300 km.

Historical data does not show that around interest area, tsunami generated by earthquake happened. Big earthquake which has occurred around this area is of magnitude 8.3 at western part of Sunda trench. Recently, some tsunamis which occurred at Sunda trench are 1994 East Java tsunami, 2004 Sumatera tsunami, and 2006 Java tsunami.

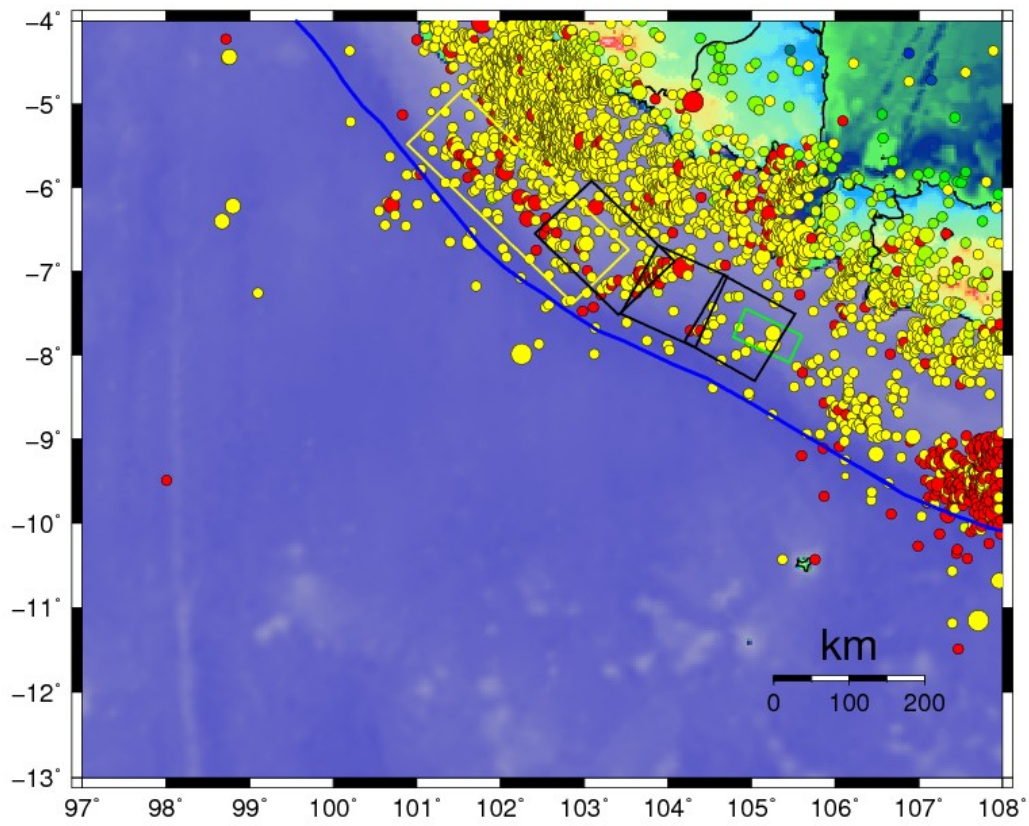
## DATA AND PROCESSING

Data set used in this paper is as follows : (i) Seismicity data for seeing earthquake history and determine earthquake activity, (ii) Fault parameter of each earthquake model for tsunami simulation. Seismicity data taken from PDE catalog around interest region during 1973-2007. Simulation include area for  $97^{\circ} - 108^{\circ}$  E and  $13^{\circ} - 4^{\circ}$  S, and for bathymetri using Etopo2 with accuracy 2 minute.

To determine tsunami hazard potential, only using tsunami simulation program based on simulation program from Nakamura (1996). This simulation used 3 sintetic fault model, (1) 2 scenario representating the last tsunami that happened at both part of Sunda strait, and (2) 1 scenario which representating fault for each part of trench. Fault parameter used for each scenarios refering to worst possibility which could happen.

	Model 1	Model 2	Model 3		
			Segment 1	Segment 2	Segment 3
Length (km)	300	80	150	100	100
Width (km)	100	40	100	100	100
Depth (km)	10	6	10	10	10
Strike ( $^{\circ}$ )	135	113	135	115	120
Dip ( $^{\circ}$ )	15	83	15	15	15
Slip (m)	10	6	10	10	10
Mw	8.5	7.7	8.5		
Center Fault Coordinat	102.24 -6.04	105.27 -7.78	103.25 -6.67	104.10 -7.29	104.88 -7.67

*Table 1. Fault parameters for each scenarios used for tsunami simulation. Model 1 is fault parameter representating 1833 Sumatera tsunami, model 2 representating 2006 Java Tsunami, and model 3 representating big earthquake which could happen with scenario idea adapted from 2004 sumatera tsunami.*



*Figure 4. Fault location for tsunami simulation explained by table 1. Yellow box is fault model 1, green box is model 2 and black box is fault model 3.*

## RESULT AND DISCUSSION

Simulation result showed that distribution of tsunami wave height along Lampung and Banten coast has the same trend for 3 kind tsunami scenario. Calculation of tsunami height distribution for each scenarios is showed in figure 5 – 7 and table 2 below.

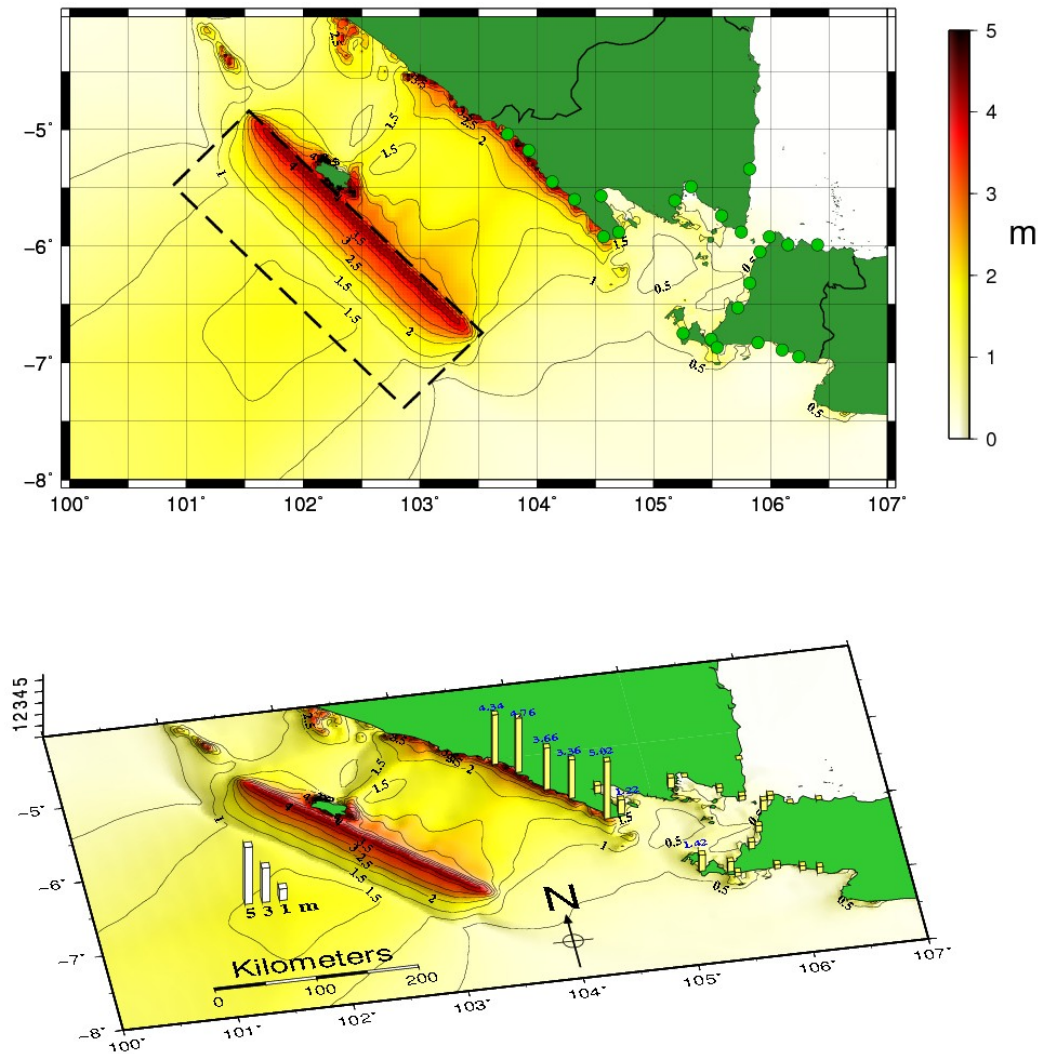


Figure 5. Distribution of maximum tsunami height (up) and maximum wave height arrive at observation point along coastal area (down), for simulation of model 1. Very high wave attack southern part of Lampung coast including Tanjung, Krui, Banjar Nagari, Kota Jawa, and Balingbing coast, with higher wave attacking Balingbing coast is 5.02 m. Higher wave hit Banten at Ujungkulon with 1.42 m.

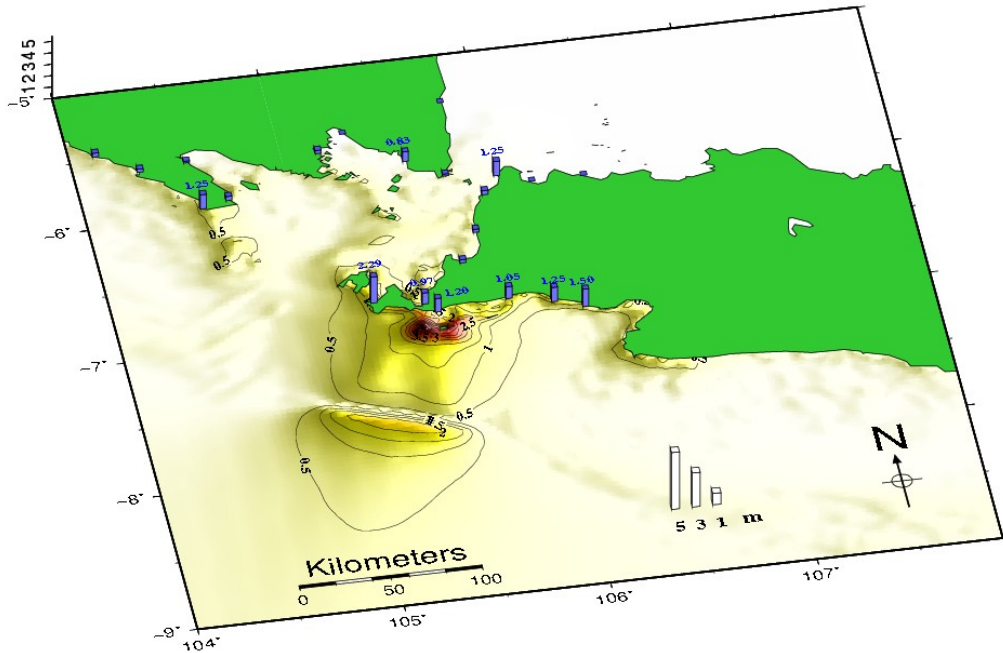
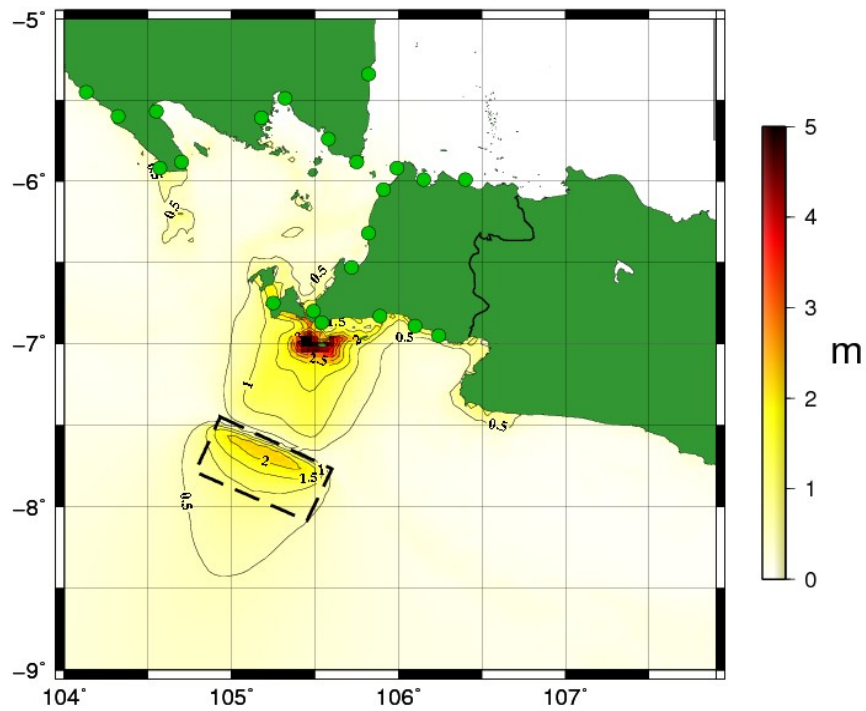


Figure 6. Distribution of maximum tsunami height (up) and maximum wave height arrive at observation point along coastal area (down), for simulation of model 2. High wave attack southern part of Banten coast including Cikaung, Ujungkulon, Tanjung Sadang, Muara Binuangeun, Cihara, and Bayah coast, with higher wave attacking Ujungkulon coast is 2.29 m and higher wave hit Lampung is 1.25 at Balingbing coast.

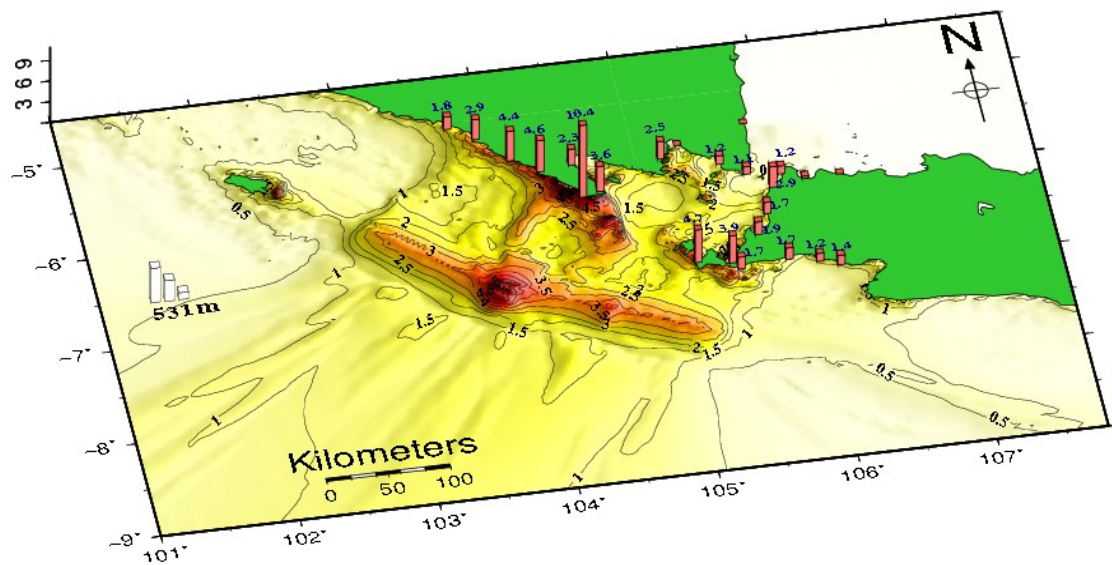
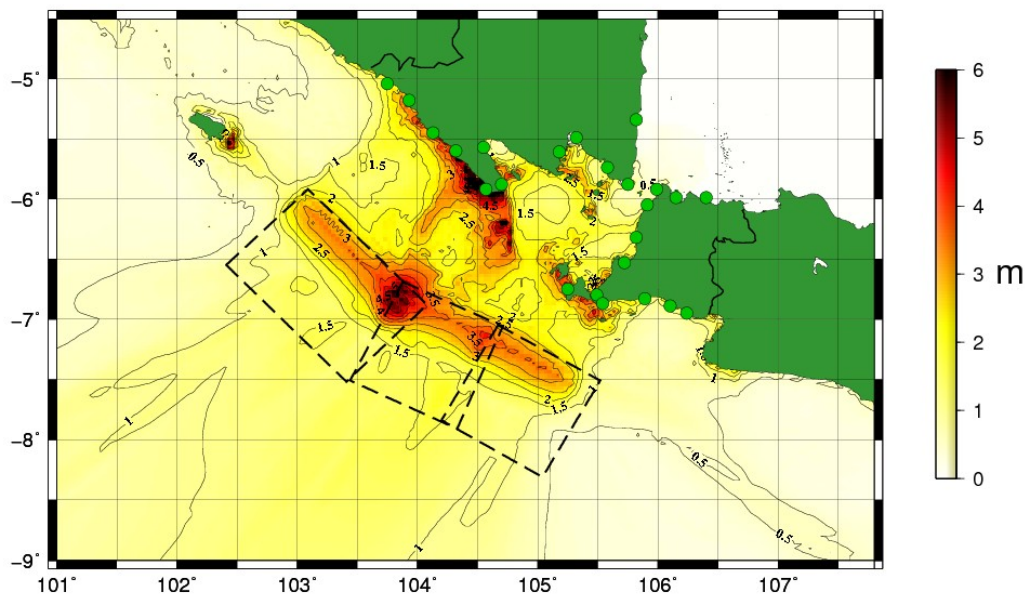


Figure 7. Distribution of maximum tsunami height (up) and maximum wave height arrive at observation point along coastal area, for simulation of model 3. Very high wave attack Lampung province along southern coast from Tanjung until Padang Cernan, higher wave attack Balingbing coast is 10.4 m, while attacks Banten along western and southern coast with higher wave at Ujungkulon and Cikaung is 4.7 m and 3.9 m respectively.

Name of Location	Max Wave Height (m)		
	Scene 1	Scene 2	Scene 3
Tanjung	4.340	0.140	1.840
Krui	4.760	0.260	2.900
Banjar Nagari	3.660	0.310	4.350
Kota Jawa	3.360	0.270	4.580
Balingbing	5.020	1.250	10.410
Tampang	1.220	0.350	3.610
Betung	0.670	0.160	2.330
Padang Cernan	0.860	0.280	2.510
Panjang	0.000	0.000	0.000
Kalianda	0.380	0.830	1.230
Bakauheni	0.380	0.170	1.100
Labuhan Maringgai	0.000	0.000	0.000
Ujungkulon	1.420	2.290	4.700
Cikaung	0.870	0.970	3.940
Citeureup	0.600	0.260	1.850
Carita	0.540	0.300	1.660
Anyer	0.900	0.370	2.960
Merak	0.420	1.250	1.180
Banten Bay	0.004	0.000	0.275
Tenara	0.007	0.000	0.017
Tanjung Sadang	0.350	1.200	1.700
Muara Binuangeun	0.380	1.050	1.670
Cihara	0.400	1.250	1.160
Bayah	0.530	1.500	1.380

Tabel 2. Maksimum tsunami wave height attack each observation point along coastal of Lampung and Banten provinces.

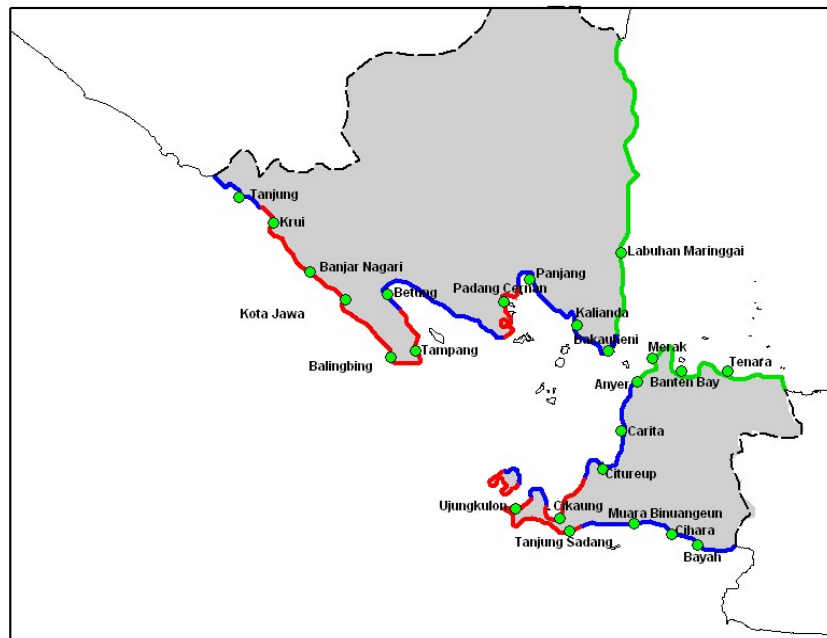


Figure 8. Tsunami hazard potential map at coastal area according to distribution of tsunami wave height from 3 scenarios tsunami simulation. Red line showing areas with high potential attacked by tsunami, blue line is medium potential, and green line is low potential to be attacked by tsunami wave.

Simulation result showed that some regions have tsunami wave height which is always high for each fault model, such as Balingbing coast and Ujungkulon. From wave distribution, tsunami hazard area is divided to three different level, that is high, medium and low potential.

High potential (red line) is areas with tsunami wave height at coastal more than 2 meters for 2 scenario or more and identified by high tsunami wave height from each scenario. This area including coastal from Krui until Betung, around Padang Cernan coast, Tanjung Sadang coast, Ujungkulon, and Cikaung.

Medium potential (blue line) is areas with tsunami wave height around 0.5 – 2 meters and identified by low increasing wave along coastal areas, including Tanjung coast to north, coastal area between Betung and Padang Cernan, Panjang, Kalianda and Bakauheni coast, northern part of Ujungkulon, Citeureup until Anyer beach, and eastern part from Tanjung Sadang until Bayah coast.

Low potency (green line) is areas with tsunami height less than 0.5 meters and identified by very low wave along coastal, that is along coastal on north part of Lampung and Banten.

Existence of small islands and low bathymetry around coastal areas also make some effect for coastal area behind and beside its. Small island or low bathymetry becomes barrier for coastal behind the island but become wave reflector for coastal beside. This can be seen at coastal between Tampang and Betung, Padang Cernan, western part of Ujungkulon and Tanjung Sadang.

## CONCLUSION

In order to define tsunami mitigation system, studying about tsunami hazard potential using tsunami simulation modelling, is one alternative could be used. Fault parameters to be used should be appropriate with tectonic and seismic activity on observation areas. Condition chosen for tsunami simulation is scenarios for earthquakes which happen on seismic gap. Tsunami wave height distribution is used to determine tsunami hazard areas. Maximum tsunami heights and also high potential of hazard is areas in front of tsunami sources. Tsunami wave height which attack coastal areas is affected by bathymetric condition and existences of small islands around coastal areas. Very high potential hazard identified around Balingbing and Ujungkulon coast at southern part of Banten and Lampung, and lowest potential is around Labuhan Maringgai, Banten Bay and Tenara coast at northern part of Lampung and Banten.

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