Current tsunami research activities in Vietnam

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Current research activities

- Previously, there were very few tsunami researches in Vietnam with almost no fund;

- After the Sumatra tsunami, significant researches about tsunami in Vietnam started: investigation about historic tsunami events, studying the characteristics of tsunamigenic earthquake in the South China Sea, evaluating tsunami risks, developing tsunami hazard maps, and establish the tsunami warning center.

Current research activities

- Study on the possibility of tsunami in Vietnam (VN Gov.);

- Tsunami hazard mapping project (VN Gov.);

- Tsunami risk evaluation and tsunami early warning system development project (NZ Gov.);

- Tsunami early warning center establishment

Tsunami risks at Vietnam coast

➢ There is no tsunami observation system in Vietnam, then no recorded data of tsunami exist.

➢ The tsunami events are mainly based on the memory of coastal residents. Almost all cases of tsunami events are confused with storm surge or wind waves.

➢ Sept., 1887, earthquake with magnitude of 7.0 caused small tsunami (the only historic record);

➢ Two important events: tsunami in Dien Chau (Nghe An Province, Year?), and tsunami in Nha Trang in 1923 due to Hon Tro volcanic eruption (the recorded material is missing)

➢ The results of the analysis of water level data at water level stations (4 obs per day) show no sign of tsunami attacking Vietnam coast.

Tsunami risk at Vietnam coast

➢ Primary research results of Paleotsunami (Cao Đình Triều, Ngô Thị Lư et al) show that in the past, there was huge tsunami attacking Vietnam coast;

➢ The time tsunami attacking Vietnam coast is 380 years, 610 years and 960 years ago. Thus the tsunami return period is about 310 years???;

➢ The maximum tsunami runup height could be 18m (????);

Tsunami attacking spots
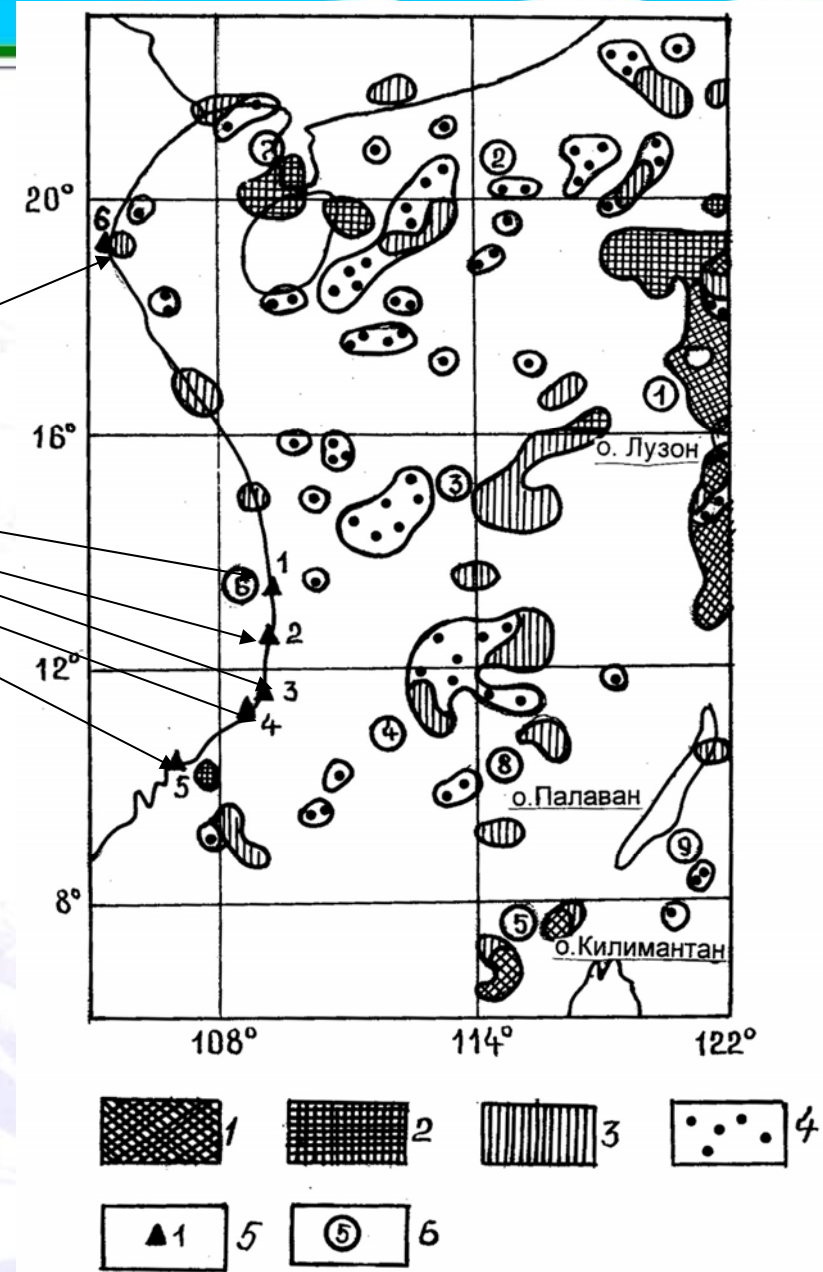
➢ However, the collected data were not reliable enough, and detailed studies are needed.

➢ The study on the tsunami risk in Vietnam is mainly based on the earthquake data in the South China Sea, especially that from the Manila Trench.

Tsunami risk at Vietnam coast

➢ Based on previous study, the earthquake in the Manila Trench can have the magnitude of more than 8.0.

➢ According to computational results, if an earthquake with the magnitude of 8.5, the tsunami height at the coast of Central Vietnam may be as high as 3 - 4m.

➢ The area with tsunami height of more than 1m, i.e. dangerous tsunami can be from Quang Binh to Binh Thuan.

➢ If the earthquake with such magnitude happens withour preparation, catastrophy can occurs.

The project of tsunami hazard mapping development in Vietnam
Introduction

- Project management: Ministry of Natural Resources and Environment of Vietnam

- Project execution: Vietnam institute of Meteorology, Hydrology and Environment (Marine and Ocean-Atmosphere Interaction Research Center)

Objectives of the project

➢ Study to develop tsunami hazard maps at the Vietnam coast for the preparedness and mitigation of tsunami hazards and provide scientific basics for the establishment of the tsunami early warning system.

Project contents

➢ Colect and process necessary data and materials;

➢ Literature review;

➢ Analysis the geologic and earthquake characteristics of the South China Sea floor;

➢ Apply numerical models for the generation of tsunami from earthquake, the propagation of tsunami in the South China Sea, and the inundation due to tsunami.

Project contents

➢ Establish the tsunami hazard maps in the South China Sea and at the coast of Vietnam;

➢ Propose alternatives for the evacuation and recommendation for the planning of the social and economic development of the coasts according to each tsunami scenarios;

➢ Establish WEB of the tsunami hazard maps in the IMHEN's page

Project outputs

➢ Data on the natural, economic and social conditions of Vietnamese coastal areas

➢ Data set on the topography, geology, earthquake and tsunami in Vietnam sea and at the Vietnamese coastal areas

➢ Tsunami hazard maps at the Vietnamese coast

Project outputs

➢ Alternatives for evacuation in the case of tsunami, and recommendations on the planning and socio – economic development at the Vietnamese coast;

➢ A webpage on the tsunami hazard maps and other relating materials;

➢ Project final report.

Project execution timing

➤ 30 months (June 2006 to December 2008).

Current results

- ➤ Tsunamigenic earthquake scenarios in the South China Sea;

- ➤ Numerical models for tsunami generation, propagation and inundation;

- ➤ Results of the computation of tsunami height and arrival time at Vietnam coast according to tsunami scenarios.

Tsunami earthquake scenarios for Vietnam coast

➤ The tsunami generation model: the Okada's double couple source model (1985, 1997).

➤ Determined 12 tsunamigenic earthquake scenarios with corresponding parameters:

Earthquake parameters

No.	M	λ (degree)	φ (degree)	L (km)	W (km)	h (km)	Dip angle δ (degree)	Slip angle β (degree)	Dip direction θ (degree)	Displ. length u_0 (m)
1	8.0	119.10	17.50	151	47	12	15	90	177	5.28
2	8.25	119.10	17.50	217	57	15	15	90	177	7.12
3	8.5	119.10	17.50	313	70	18	15	90	177	9.61
4	8.75	119.10	17.50	449	86	22	15	90	177	13.34
5	9.0	119.10	17.50	646	101	27	15	90	177	17.49
6	8.0	119.10	16.00	151	47	12	15	90	177	5.28
7	8.25	119.10	16.00	217	57	15	15	90	177	7.12
8	8.0	119.10	14.50	151	47	12	15	90	177	5.28
9	8.75	121.80	23.53	387	108	19	15	90	87	12.82
10	9.0	121.80	23.53	501	141	24	15	90	87	16.71
11	7.5	110.46	17.13	89	25	17	78	-45	57	2.97
12	7.5	108.52	16.91	89	25	17	78	-45	172	2.97

Numerical model for the tsunami propagation in the South China Sea

➤ Based on MOST(Tito & Gonzalez, 1997)

$$\frac{\partial \eta}{\partial t} + \frac{1}{R\cos\phi}\left[\frac{\partial(ud)}{\partial \lambda} + \frac{\partial(vd\cos\phi)}{\partial \phi}\right] = 0$$

$$\frac{\partial u}{\partial t} + \frac{u}{R\cos\phi}\frac{\partial u}{\partial \lambda} + \frac{v}{R}\frac{\partial u}{\partial \phi} + \frac{g}{R\cos\phi}\frac{\partial h}{\partial \lambda} = \frac{g}{R\cos\phi}\frac{\partial d}{\partial \lambda} + fv$$

$$\frac{\partial v}{\partial t} + \frac{u}{R\cos\phi}\frac{\partial v}{\partial \lambda} + \frac{v}{R}\frac{\partial v}{\partial \phi} + \frac{g}{R}\frac{\partial h}{\partial \phi} = \frac{g}{R}\frac{\partial d}{\partial \phi} - fu$$

Numerical modeling

➢ Discretization schme: Finite volume methods with geological coordinate;

➢ The computed results by the model are used as the boundary conditions for tsunami inundation computation on Vietnam coast.
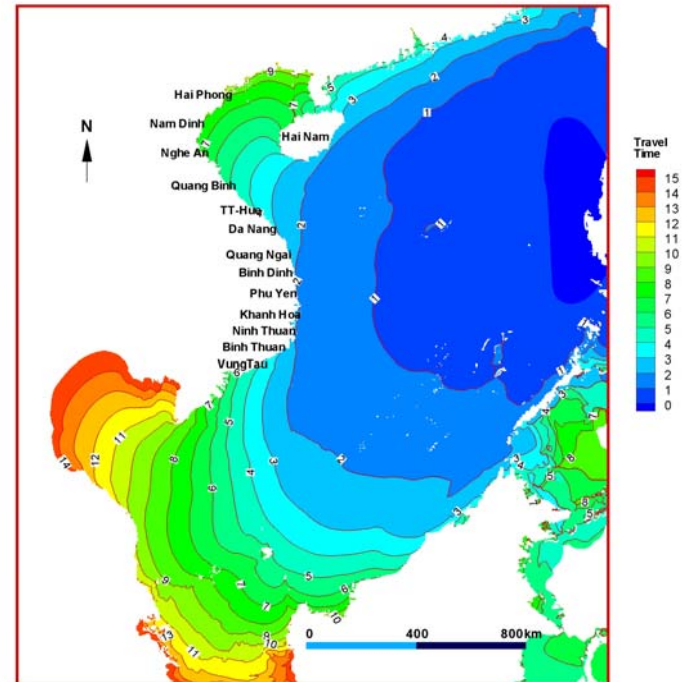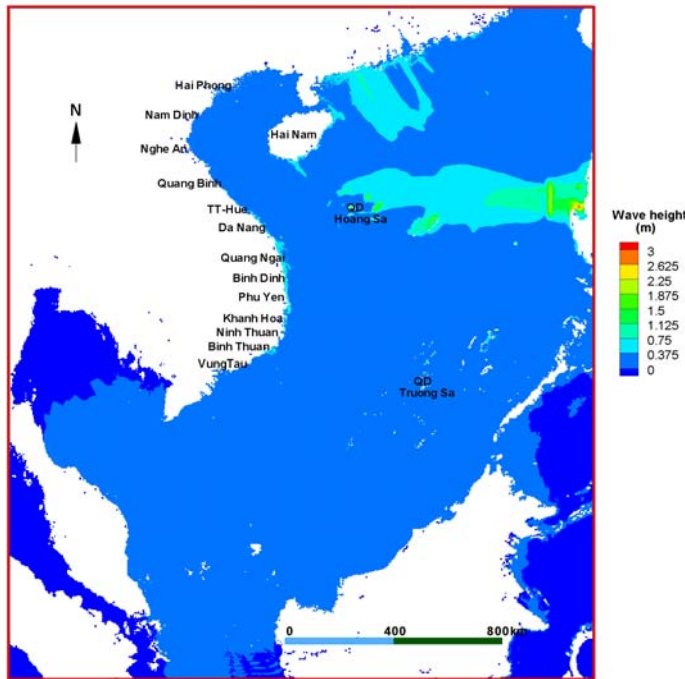
Results of tsunami computation at the Vietnam coast

Fig 1 Tsunami height according to scenario 1 (earthquake M=8 at Manila Trench)

• Fig 2. Tsunami propagation time from the source (hours)
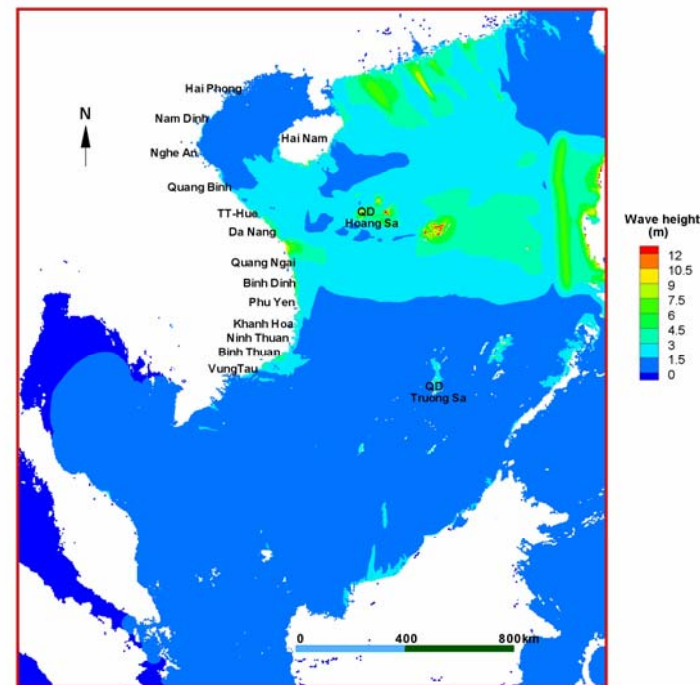
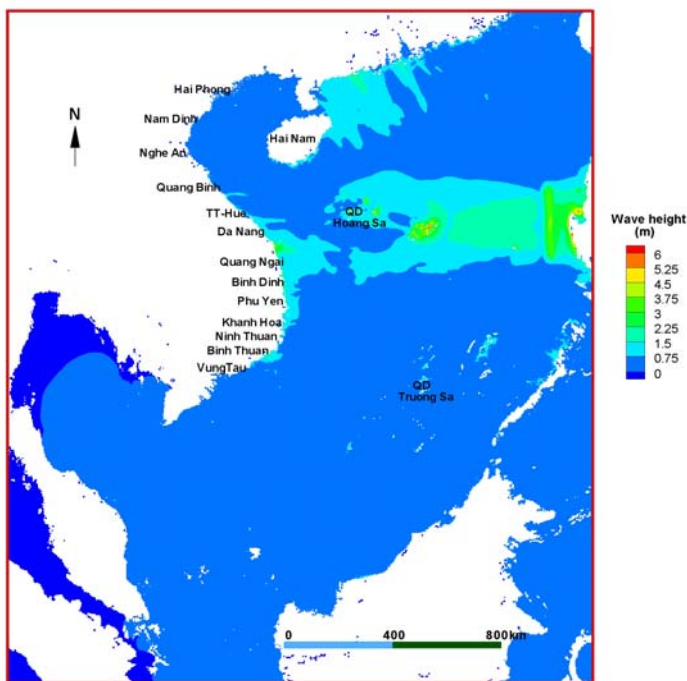# Results of tsunami computation at the Vietnam coast

Fig 3 Tsunami height according to scenario 3 (earthquake M=8.5 at Manila Trench)

Fig 4 Tsunami height according to scenario 5(earthquake M=9 at Manila Trench)

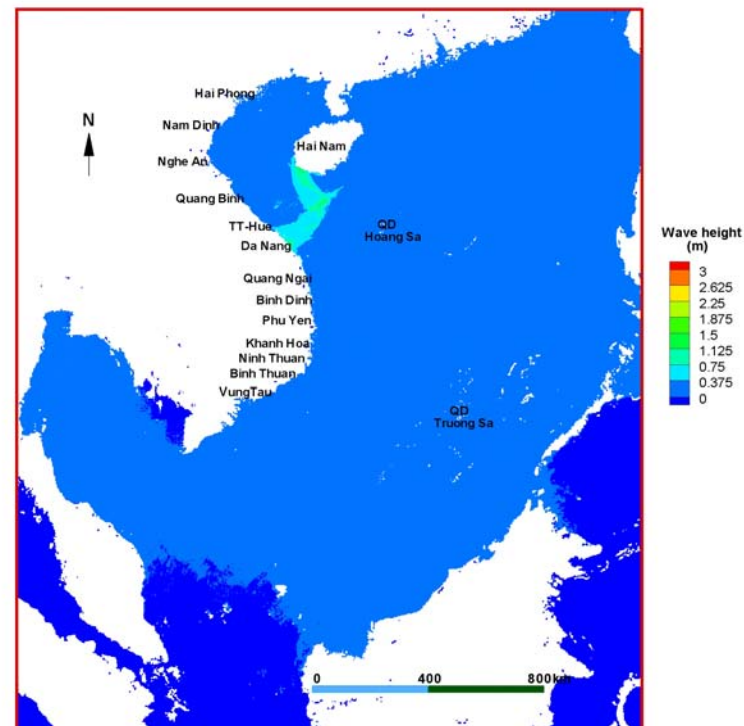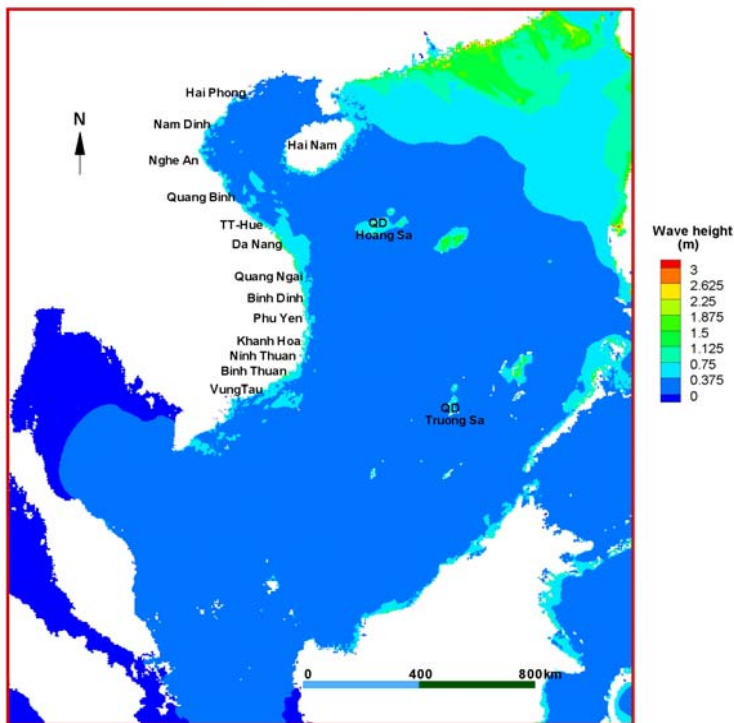# Results of tsunami computation at the Vietnam coast

Fig 4 Tsunami height according to scenario 10 (earthquake M=9.0 at Ryukyu Trench)

Fig 4 Tsunami height according to scenario 11 (earthquake M=7.5 south of Hainan)

Conclusion

➢ The risk of tsunami at Vietnam coast is small;

➢ Results of computation show that the most dangerous earthquakes are that with magnitude of greater than 8 in the Manila Trench;

➢ The possible strongest earthquake in the Manila Trench have the magnitude of 8.5. Thus, tsunami risk at Vietnam coast exists;

➢ An earthquake with the magnitude of 9 in Ryukyu Trench and earthquake with magnitude of 7.5 at south Hainan island may cause significant tsunami at Vietnam coast;

Conclusion

➢ The establishment of the tsunami warning center with tsunami hazard map in Vietnam is necessary.

Thank you