SIMULATION OF A WORST CASE TSUNAMI SCENARIO FROM THE MANILA TRENCH TO VIETNAM

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OUTLINE

- Earthquake -Tsunami Hazards in Vietnam
- Source modeling
- Simulation results
- Applications
- Conclusions

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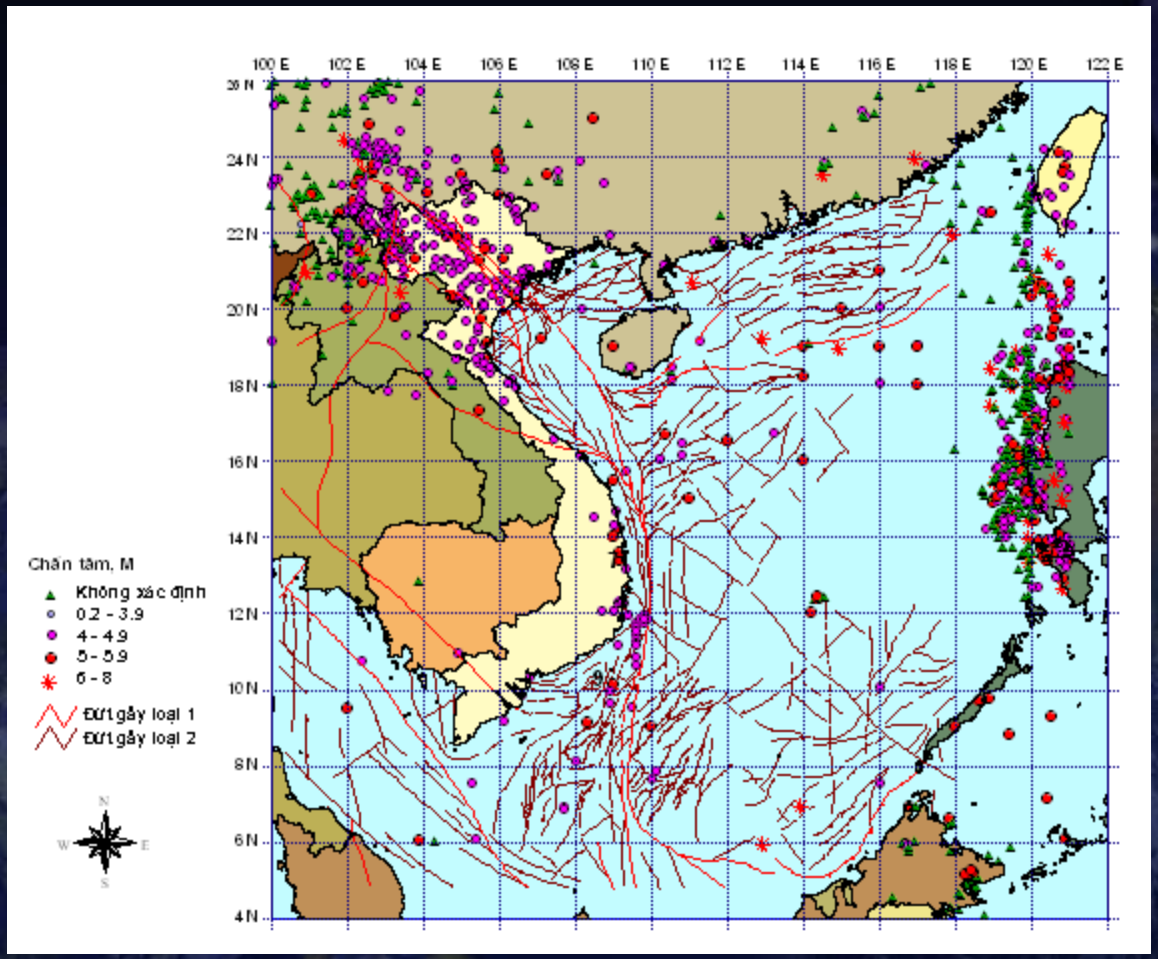
EARTHQUAKE – TSUNAMI HAZARDS



Seismotectonic map of Vietnam and adjacent sea areas

- The largest earthquakes in country: 3
  - -1 historical (in the 14th century)
  - - 2 recorded:
  - -Dien Bien 1935 (M=6.7) and Tuan Giao 1983 (M=6.8)
- Offshore volcanic earthquake 1923 (M=6.1).
- No records of historical tsunamis, no official data on damage and casualties

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EARTHQUAKE – TSUNAMI HAZARDS

Due to its location, the Vietnamese coast can hardly be affected by destructive tsunamis, originated in the central Pacific Ocean, from the sea of Japan and East China sea in northeast side and even from the mega subduction zones as the Sundaland and the Philippines.

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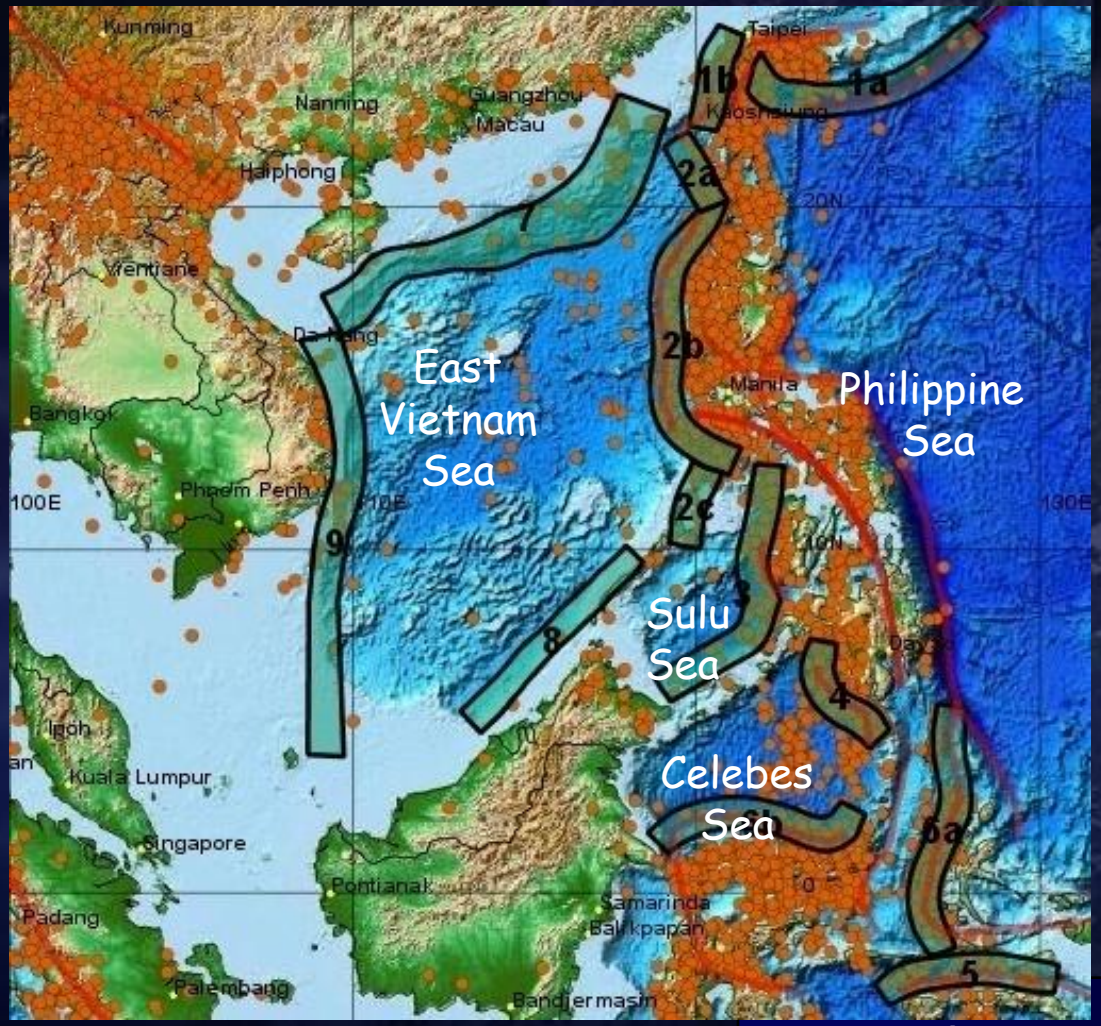
EARTHQUAKE – TSUNAMI HAZARDS

However, the tsunami threats might come from inside the East Vietnam sea.



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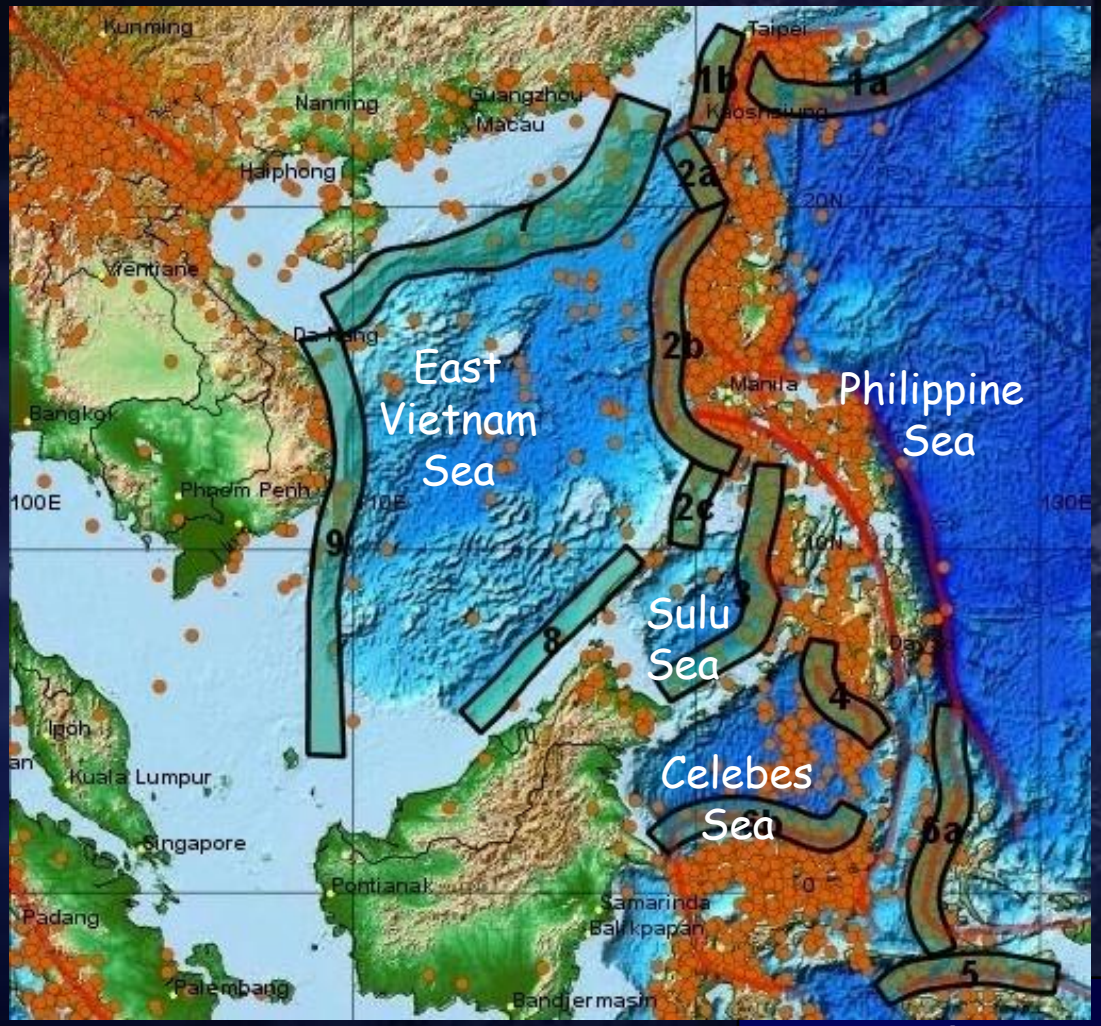
EARTHQUAKE – TSUNAMI HAZARDS

Based on the analysis of tectonic feature and geodynamic characteristics of regional faults systems in the South East Asia, 9 source zones capable of generating tsunamis affecting Vietnamese coast were delineated in the South China Sea and adjacent sea areas.



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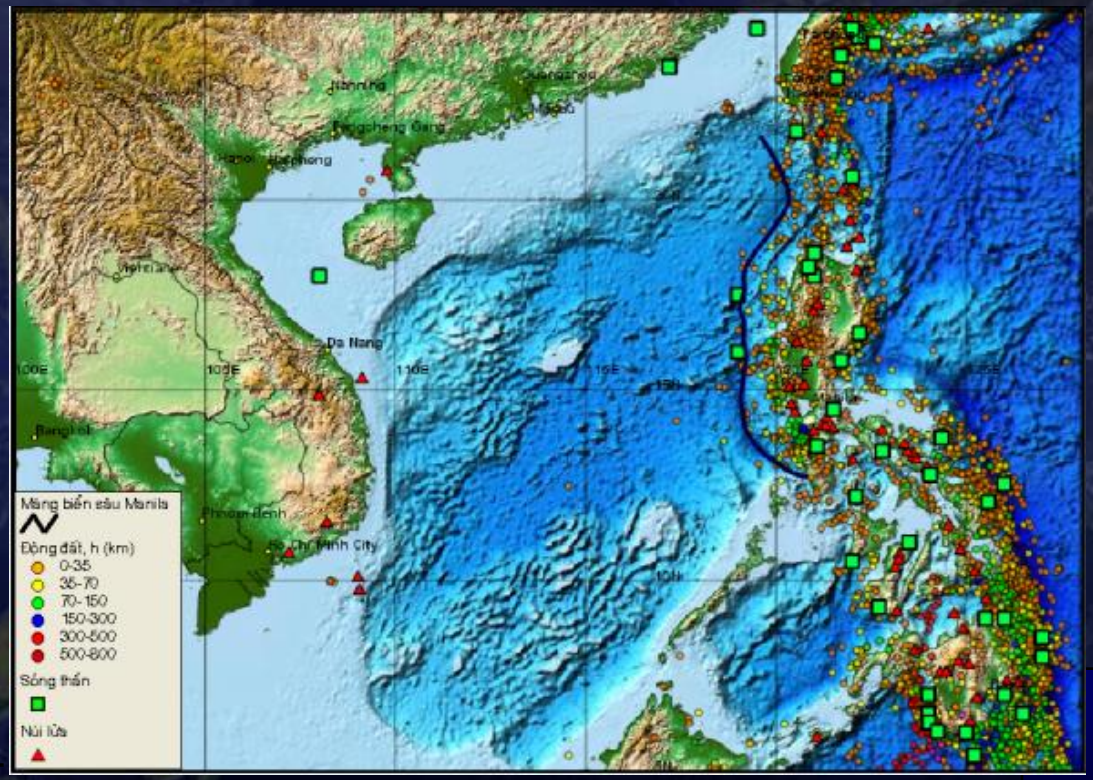
EARTHQUAKE – TSUNAMI HAZARDS

Among the tsunami source zones defined, the Manila Trench source, west of the Philippines is considered as the most dangerous for the Vietnamese coast. The recent research results show that the maximum expected earthquake magnitude for the Manila Trench source zone may reach to the value of Mw = 8.7, and it takes approximately 2 hours for a tsunami from this source zone to hit the Vietnamese coast at the earliest.



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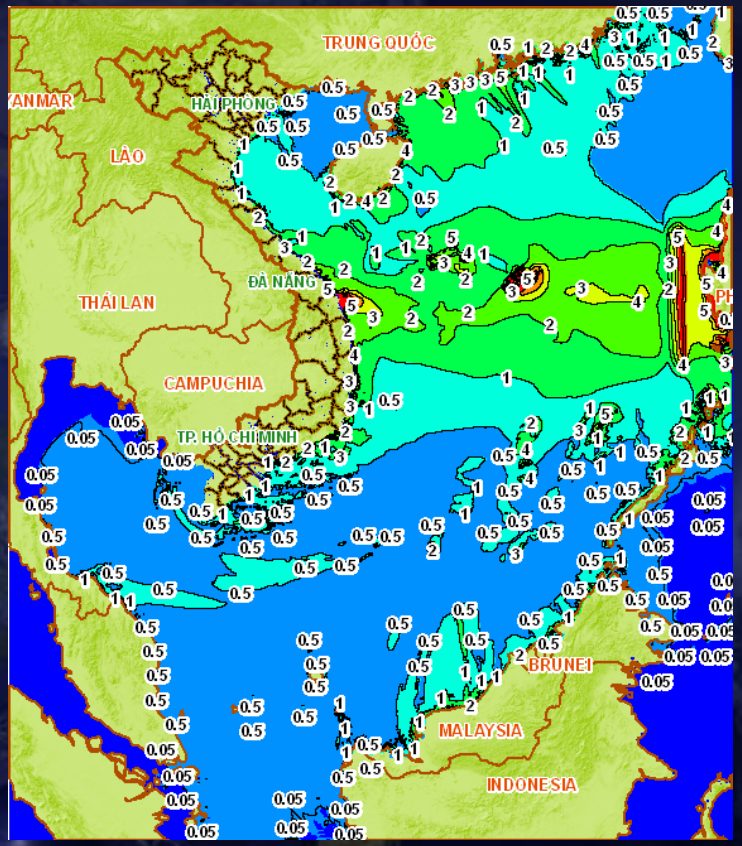
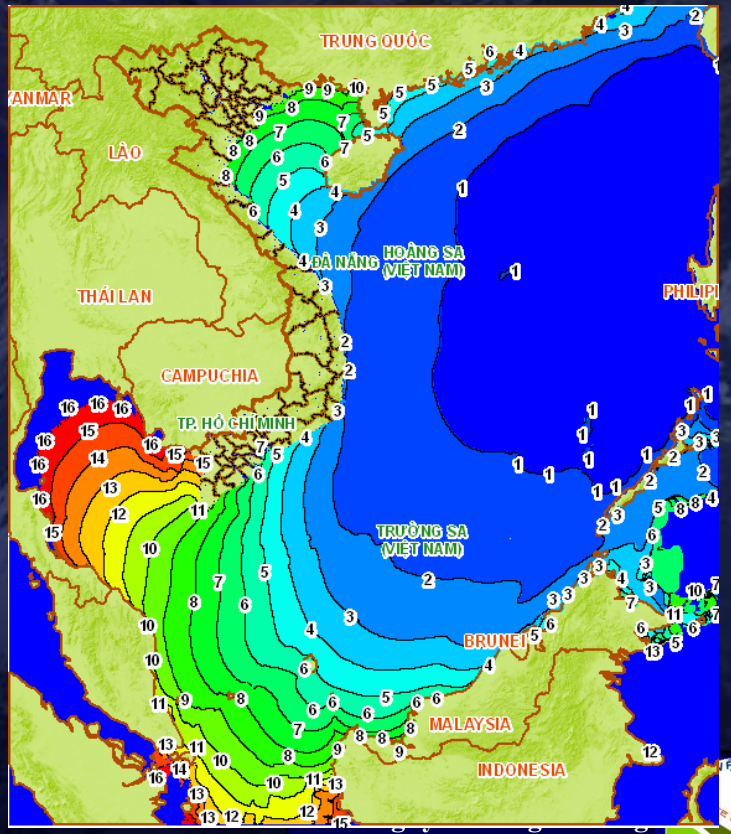
SOURCE MODELING

- Vu Thanh Ca et al (2008) calculated 25 tsunami scenarios generated in the South China sea in order to investigate the impact to the Vietnamese coasts.
- The MOST model and a two – segment source model were used for simulation.





SOURCE MODELING

- In this study, we create a worst-case scenario of tsunami earthquake excited by Manila Trench megathrust and assess the impact to the Vietnamese coast.
- The Manila Trend source is modified on the basis of published updated data and reasearch results in the region.

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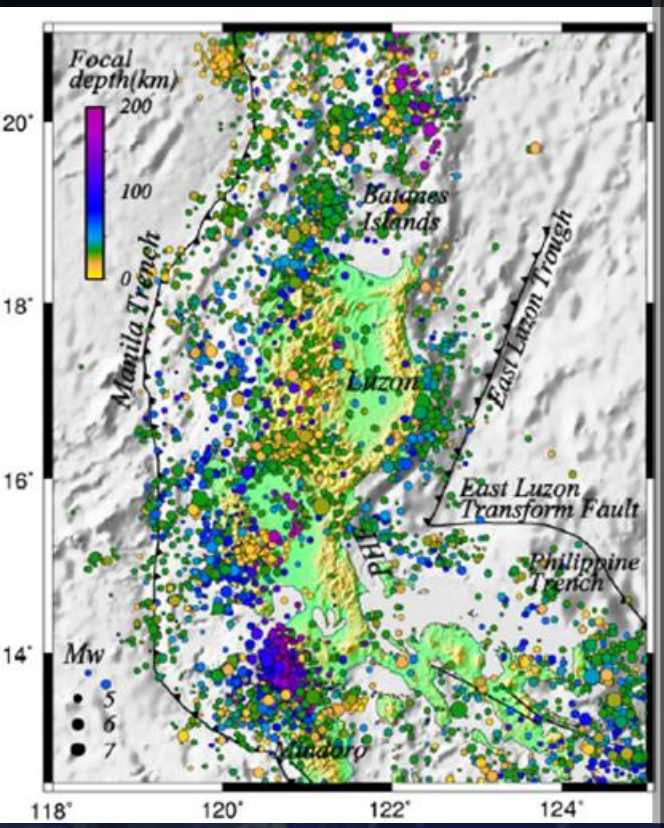
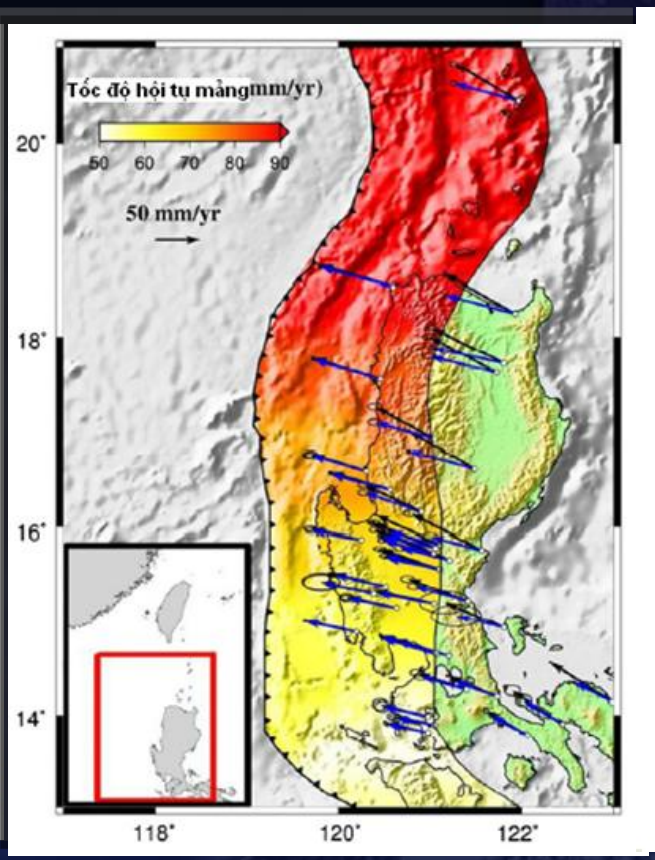
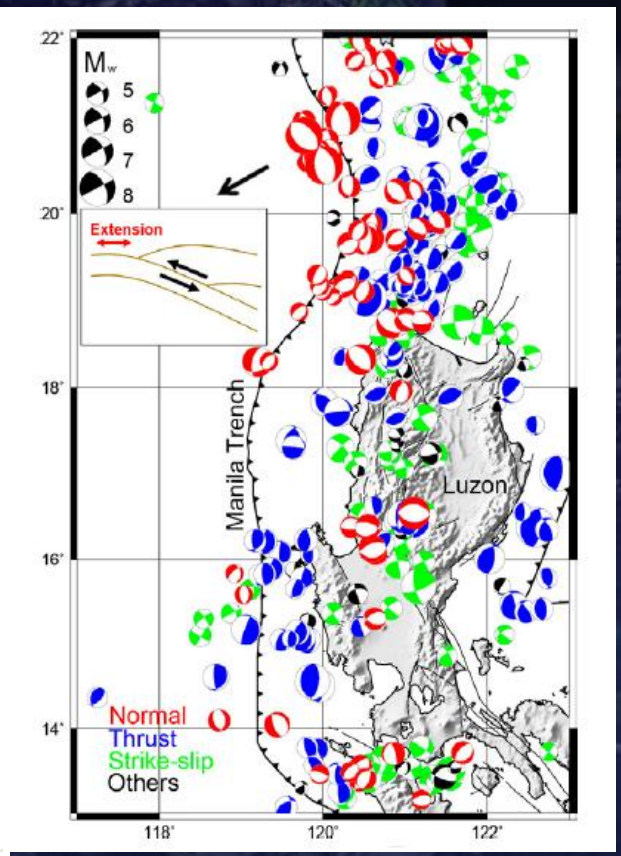
SOURCE MODELING







After Hsu et al (2012).

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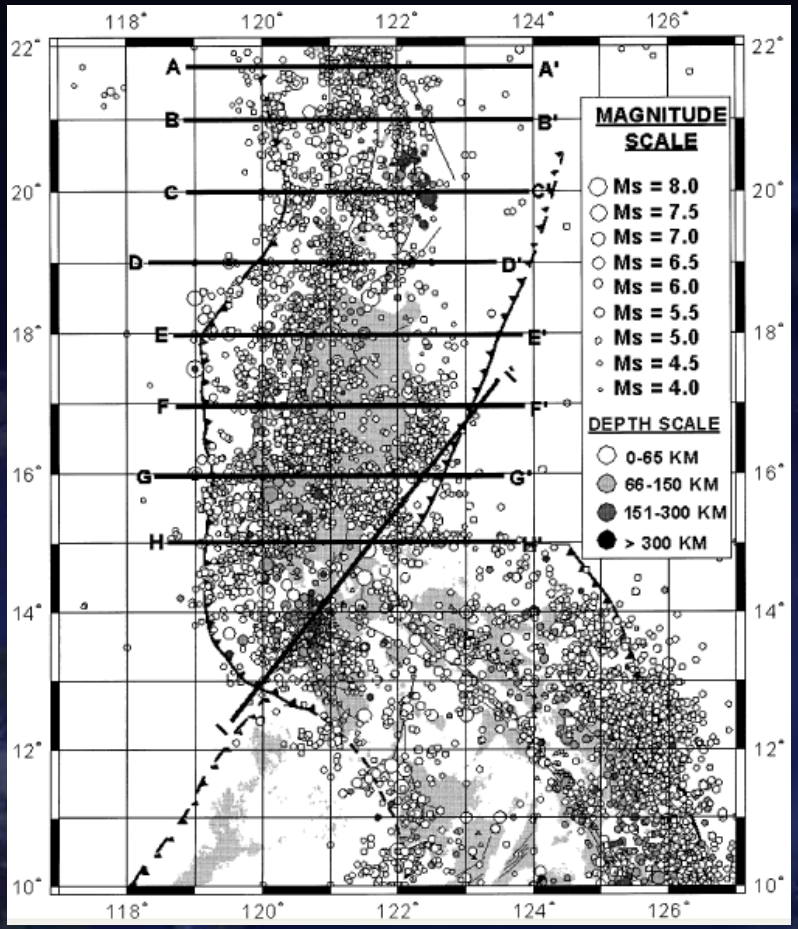
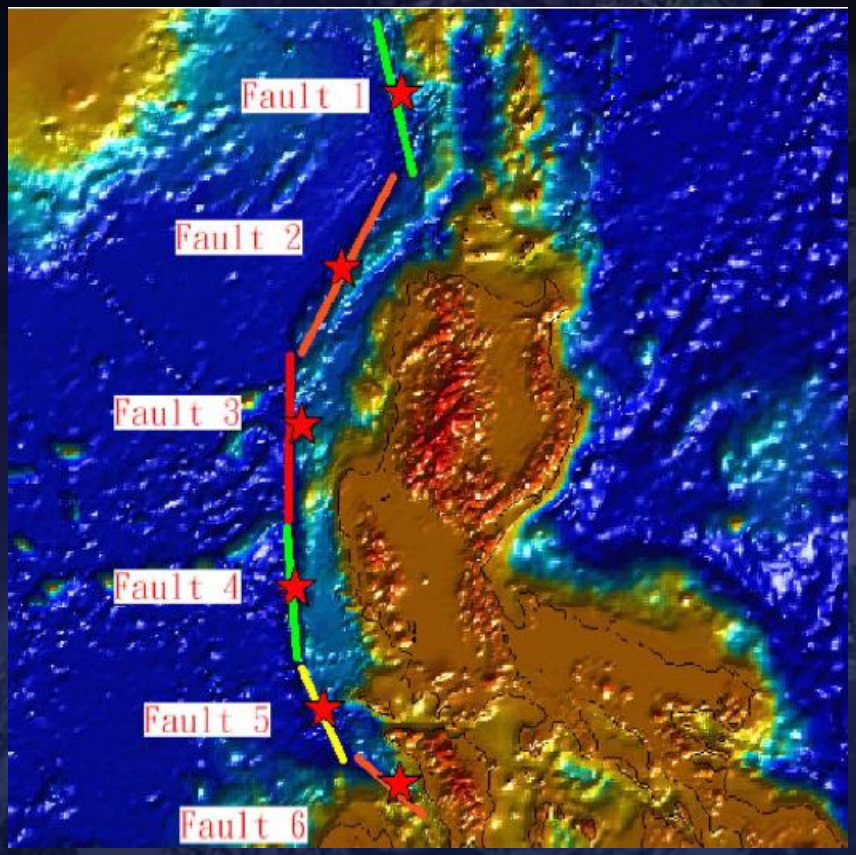
SOURCE MODELING



After Bautista et al (2001)



After Tso-Ren Wu et al (2009)

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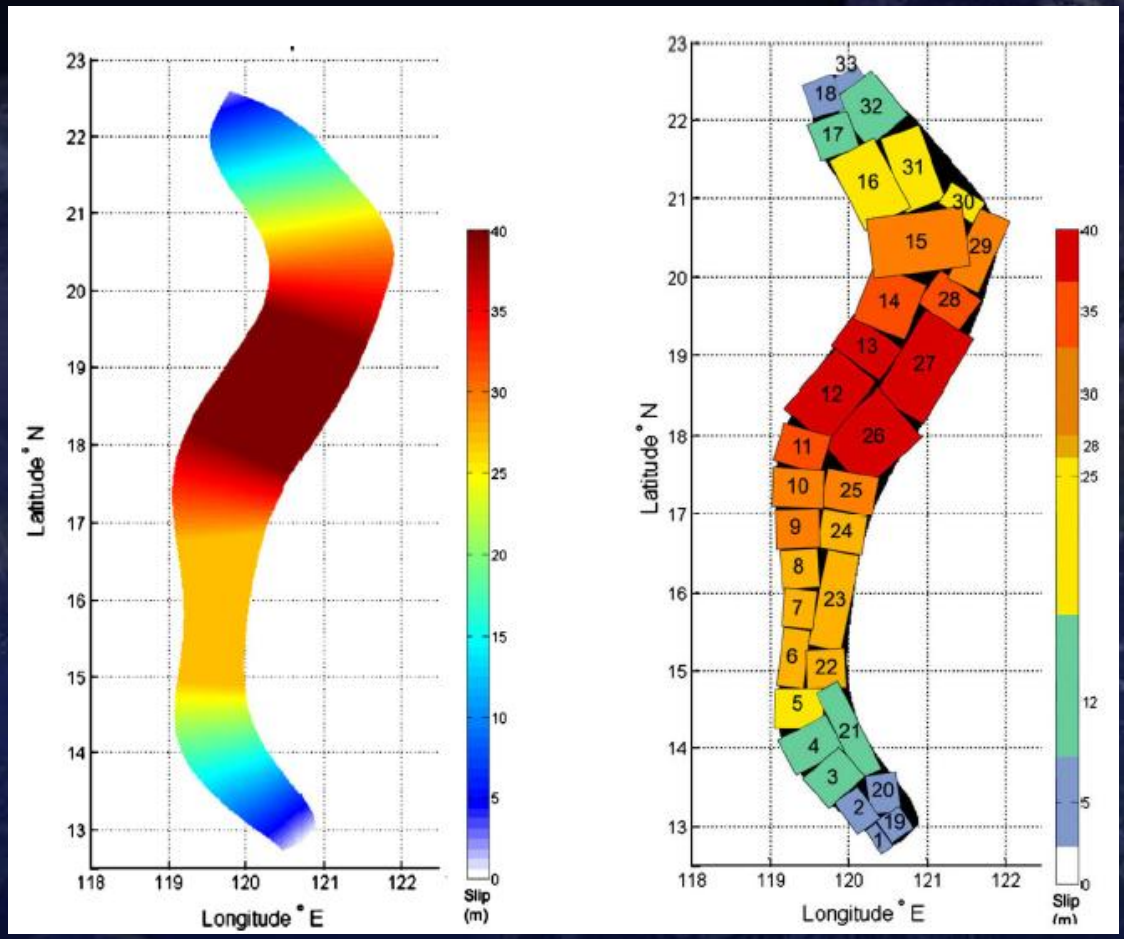
SOURCE MODELING



After Kusnowidjaja Megawati et al (2009)

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SOURCE MODELING

The Manila Trench worst case scenario's source model was created assuming a 6-segments fault zone which is capable for a M_w9.3 tsunami generating earthquake. Parameters of each segment is listed bellow.

Seg.	Long.	Lat.	Length (km)	Width (km)	Dislocation (m)	Depth (km)	Strike (deg.)	Dip (deg.)	Rake (deg.)
1	120.5	20.2	190	120	25	30	354	10	90
2	119.8	18.7	250	160	40	30	22	20	90
3	119.3	17.0	220	160	40	30	2	28	90
4	119.2	15.1	170	90	28	30	356	20	90
5	119.6	13.7	140	110	12	30	344	22	90
6	120.5	12.9	95	80	5	30	331	26	90

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SIMULATION

The numerical approach is applied to this study. The well validated open source code, COMCOT (Cornell Multi-grid Coupled Tsunami Model), is chosen to perform the simulation.

The COMCOT model is capable of solving both linear and nonlinear shallow water equations in the spherical and Cartesian coordinate systems. The nested grid system can provide tsunami simulations in both deep-water and near-shore coastal regions. The COMCOT model also provides the moving boundary algorithm to simulate the tsunami inundation (Philip L. –F. Liu et al, 1998).

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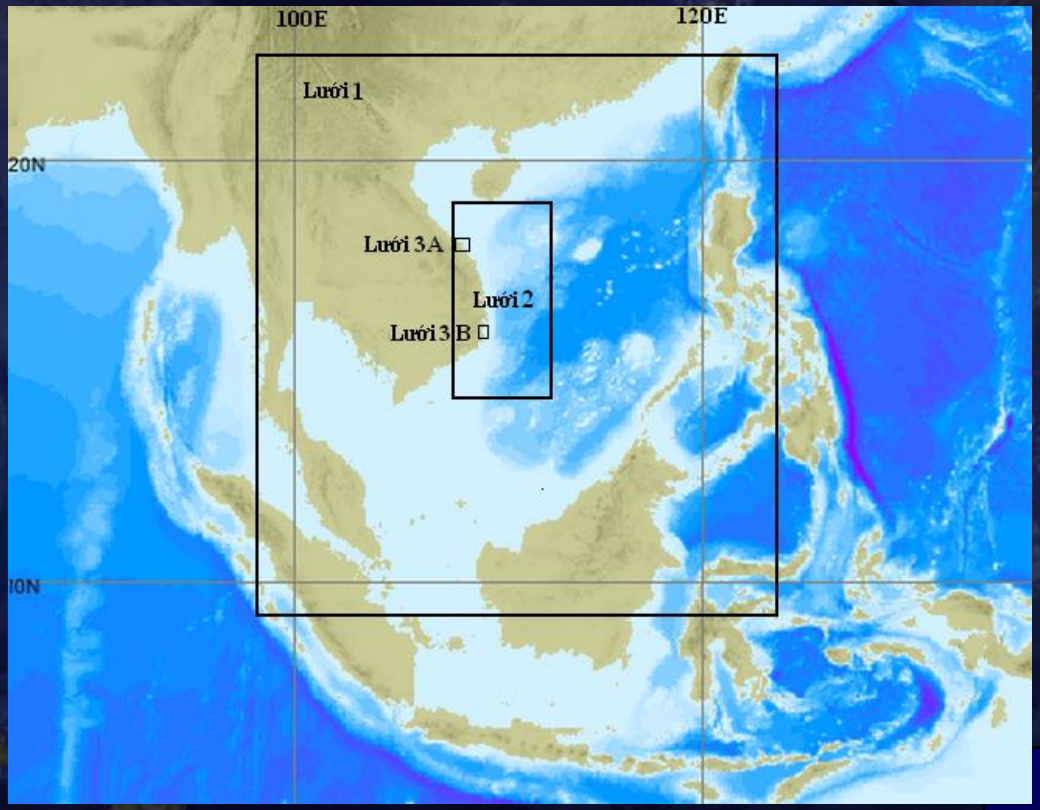
SIMULATION

To estimate the maximum wave heights at different places along the Vietnamese coast, four grid layers are adopted and referred as Grids 1, 2, 3A, and 3B. Finer grid layers, Grids 3A and 3B, are placed in the areas of the two coastal cities Da Nang and Nha Trang, respectively.



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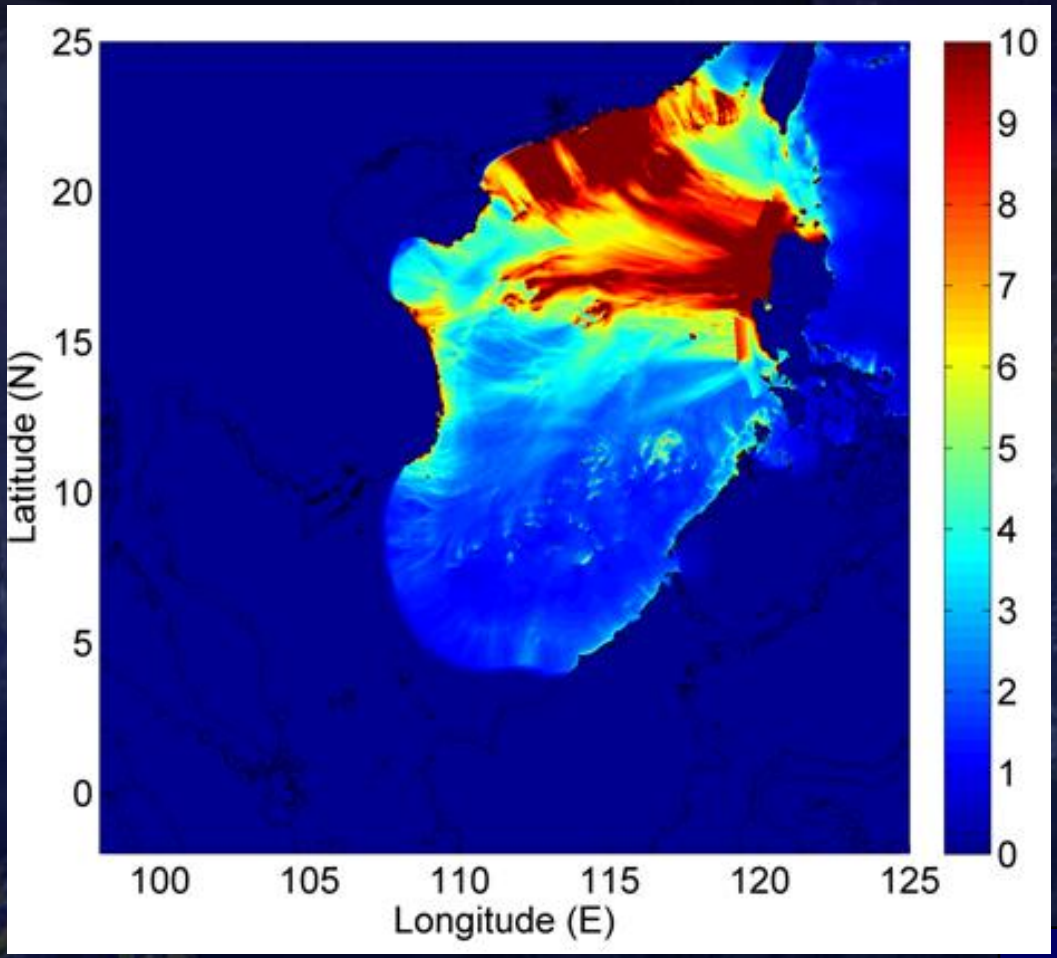
RESULTS AND APPLICATION

Hazards Assessment



Maximum free-surface elevation on Grid 1

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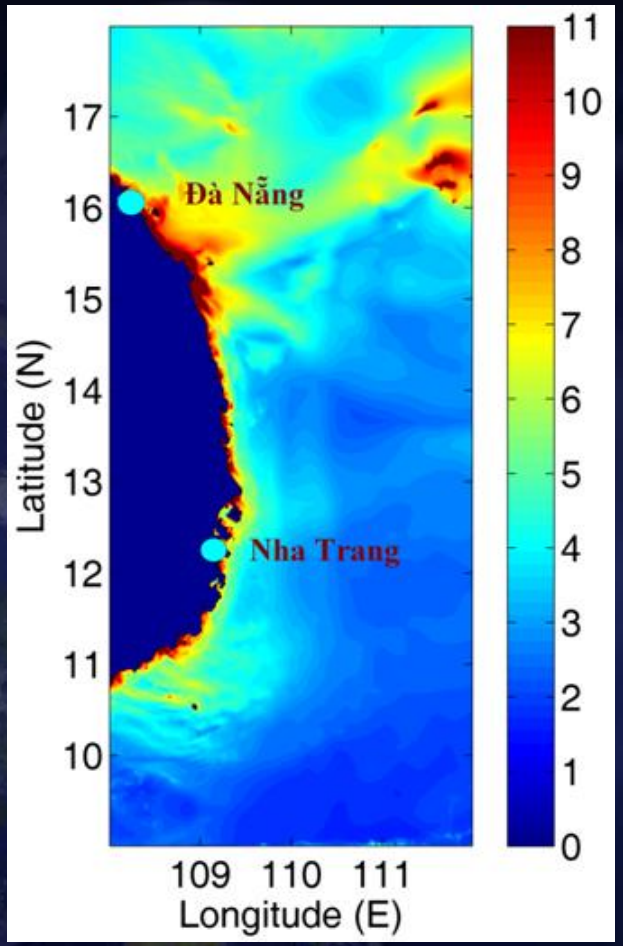
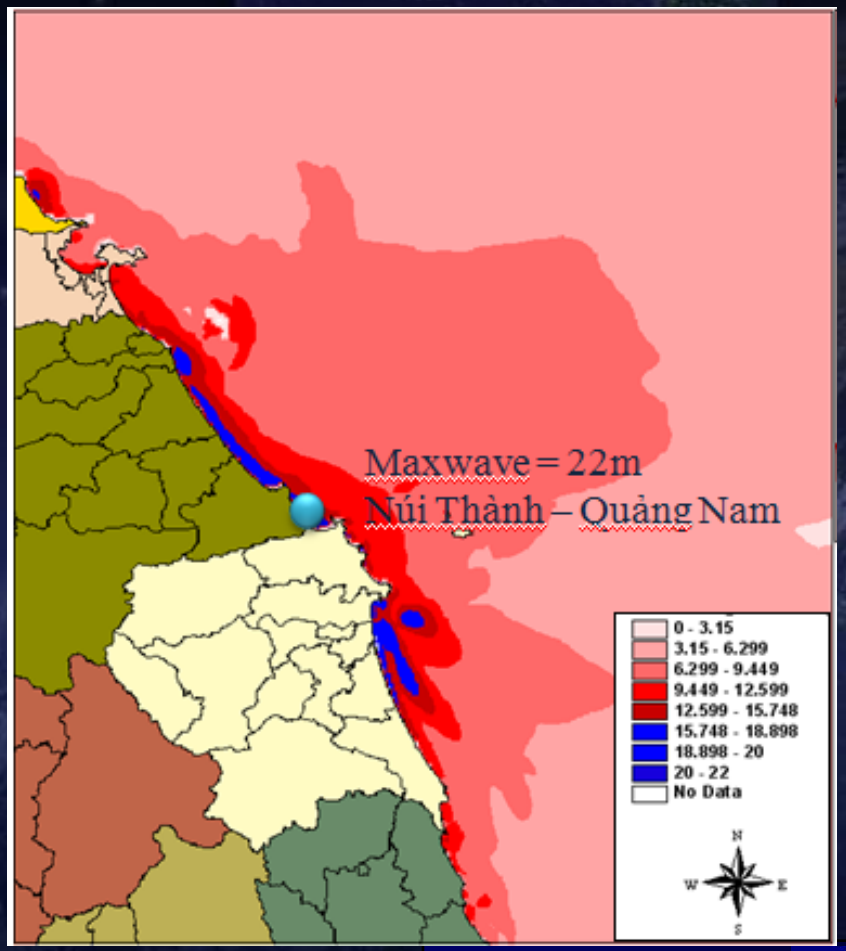
RESULTS AND APPLICATION

Hazards Assessment





Maximum free-surface elevation on Grid 2 (Central Vietnam coast)

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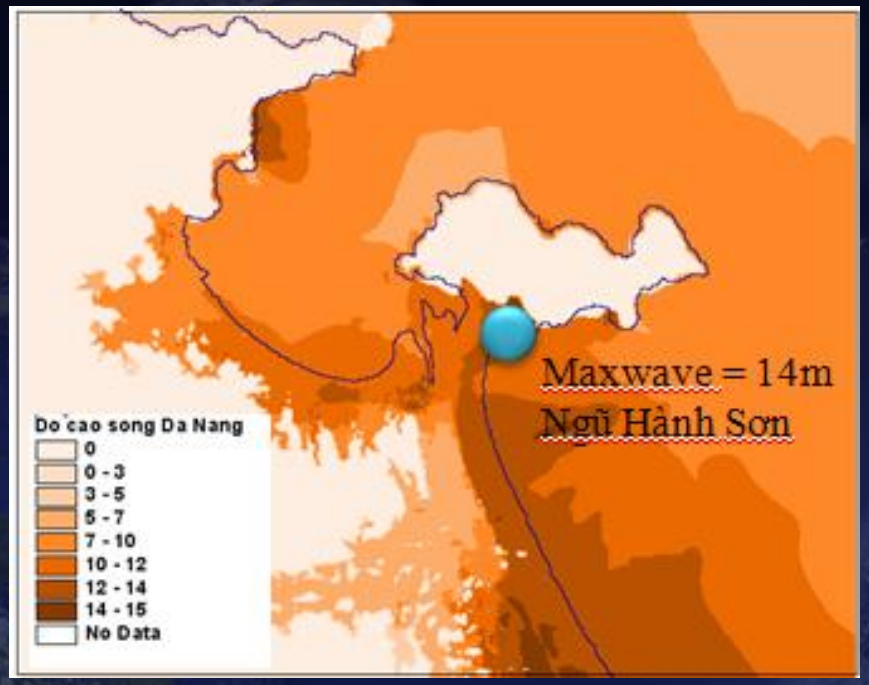
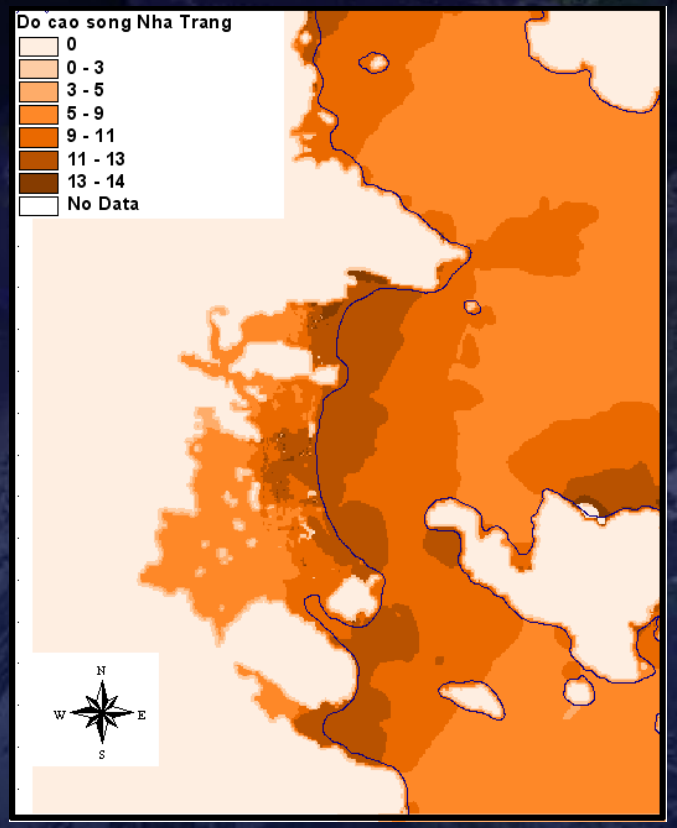
RESULTS AND APPLICATION

Hazards Assessment





Wave heights maps calculated for Da Nang city (left) and Nha Trang city (right)

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RESULTS AND APPLICATION

Hazards Assessment

Sea level station	Long	Lat
Hòn Dáu_Hải Phòng	106.818300	20.665300
Giao Thủy_Nam Định	106.559000	20.158600
Cửa Lò – Nghệ An	105.756000	18.824500
Đồng Hới – Quảng Bình	106.668000	17.479900
Đà Nẵng	108.250000	16.075000
Hội An	108.432000	15.877900
Núi Thành – Quảng Nam	108.800000	15.488600
Nghĩa An – Quảng Ngãi	108.920000	15.118900
Quy Nhơn 2	109.303000	13.774900
Tuy Hòa	109.379000	13.083200
Nha Trang	109.198500	12.239400
Ninh Thuận	109.027000	11.410000
Vũng Tầu (Mũi Nghinh Phong)	107.083800	10.319700
Cà Mau	104.850000	8.545000

Location of the sea level stations along the coast

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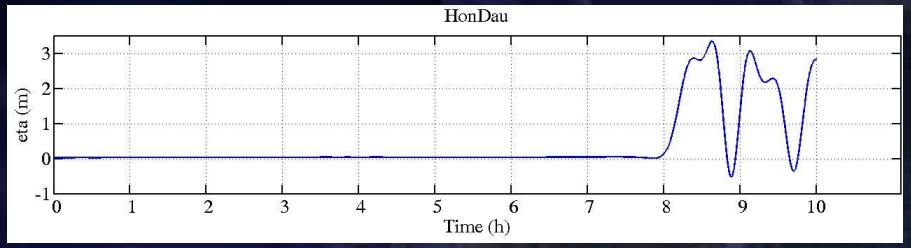
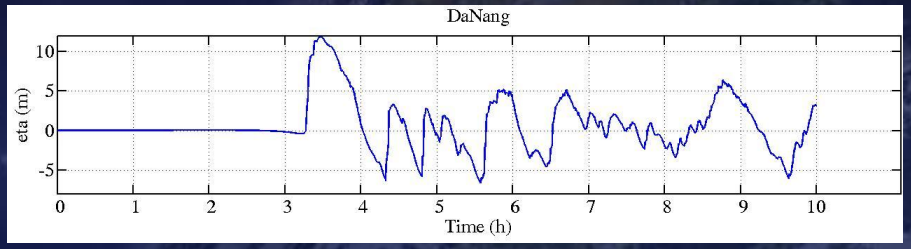
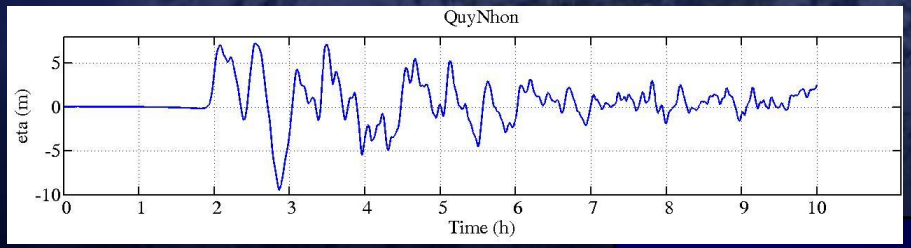
RESULTS AND APPLICATION

Hazards Assessment







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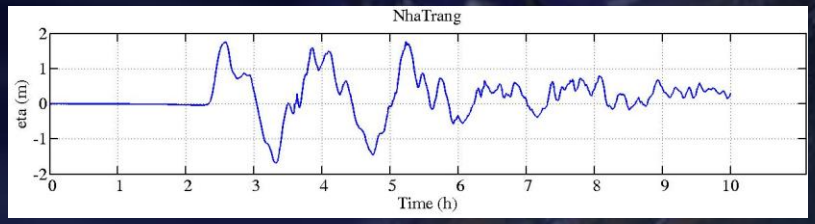
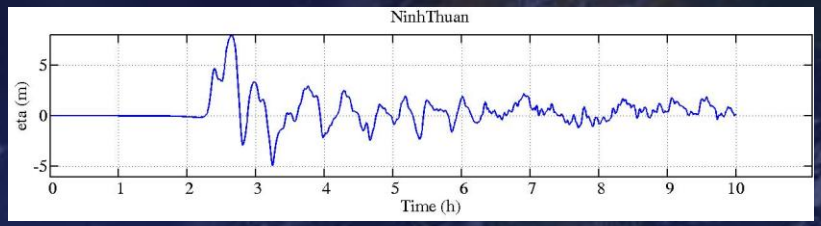
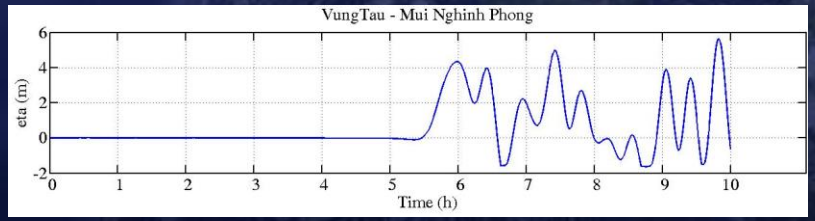
RESULTS AND APPLICATION

Hazards Assessment







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RESULTS AND APPLICATION

Database Development

A field trip was organized to collect data on built-environment and population in Nha Trang city.

Phiếu điều tra số:

PHIẾU ĐIỀU TRA , KHẢO SÁT
TRONG KHUÔN KHỔ ĐỀ TÀI "ĐÁNH GIÁ RỦI RO ĐỘNG ĐẤT CHO TP NHA TRANG"

Ngày điều tra:
Điều tra viên:

Tên công trình hoặc cụm công trình :
Mã bản đồ GIS: **Mã khu vực:**
Địa chỉ (Ghi rõ số nhà , phố , **phường** , quận hoặc tỏ , xã , huyện ...):

A. ĐẶC ĐIỂM CHUNG :
1. **Chủ đầu tư :**
2. **Chủ sử dụng :**
3. **Mục đích sử dụng và số lượng người sử dụng trong ngày** (Đánh dấu x cho loại phù hợp và ước lượng số người từ nhỏ nhất đến lớn nhất) :

- Nhà ở	☐	Số người từ ..... đến .....
- Thương mại	☐	Số người từ ..... đến .....
- Nhà ở và thương mại	☐	Số người từ ..... đến .....
- Văn phòng	☐	Số người từ ..... đến .....
- Sản xuất	☐	Số người từ ..... đến .....
- Trường học,hội trường	☐	Số người từ ..... đến .....
- Công trình quốc gia	☐	Số người từ ..... đến .....
- Dịch vụ khẩn cấp	☐	Số người từ ..... đến .....
- CT lịch sử,văn hóa	☐	Số người từ ..... đến .....
- Mục đích khác	☐	Số người từ ..... đến .....

4. **Thời kỳ xây dựng công trình :**
Trước 1960 ☐ Từ 1960 – 1975 ☐
Từ 1975 - 1990 ☐ Sau 1990 ☐

5. **Mức độ thiết kế kháng chấn**
Không ☐ Mức độ yếu ☐ Mức độ trung bình ☐ Mức độ cao ☐

B. QUI MÔ CÔNG TRÌNH :
1. Số tầng : Chiều cao tầng (m) :
2. Mặt bằng công trình : Có bản vẽ hoặc phác thảo kích thước chính
3. Diện tích xây dựng (m^2) :
4. Diện tích chiếm đất (m^2) :
5. Tổng diện tích công trình (m^2) :

C. KẾT CẤU CÔNG TRÌNH : (Đánh dấu x vào loại phù hợp)
Nền móng :
- Móng gạch, đá ☐
- Móng BTCT ☐
- Cọc BTCT ☐
- Cọc khoan nhồi : ☐

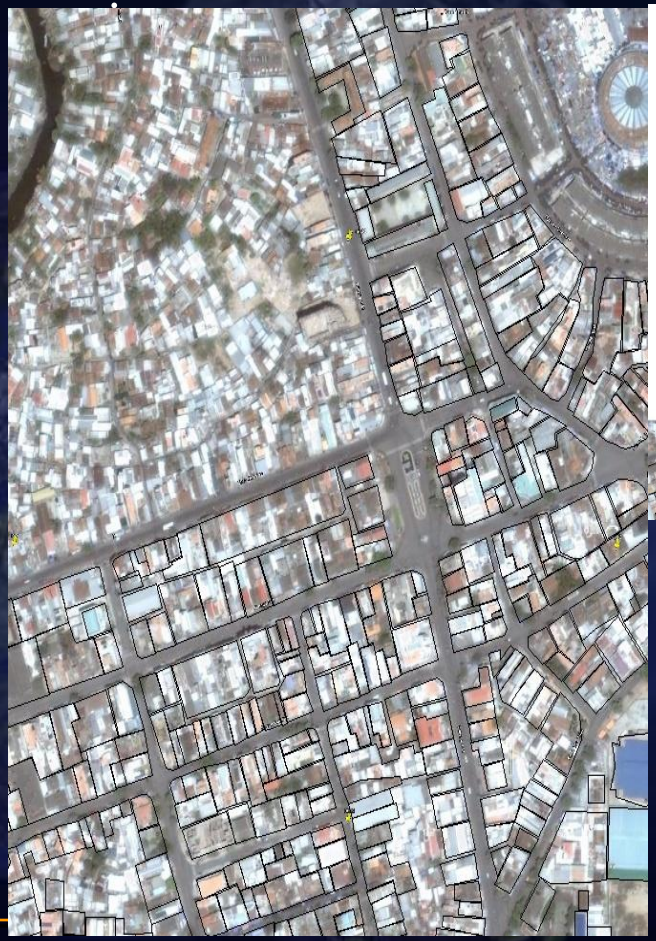
RESULTS AND APPLICATION

Database Development

RESULTS AND APPLICATION

Database Development

Head-up digitizing the building layer of the Nha Trang city using Google Earth



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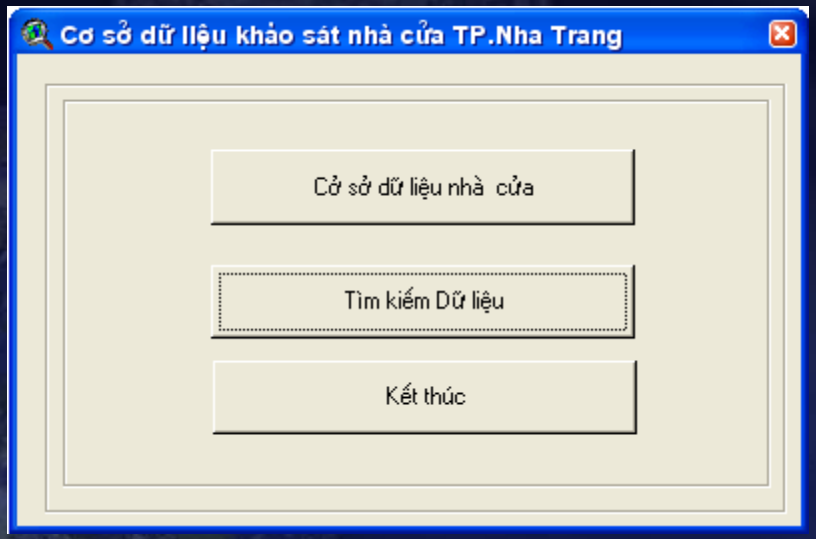
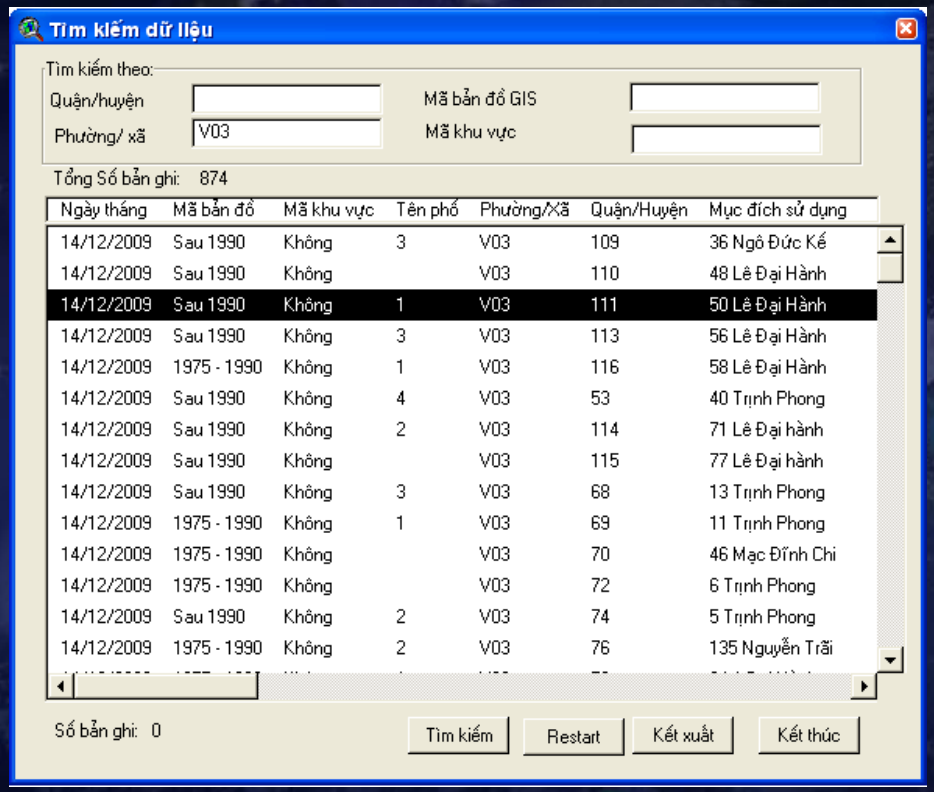
RESULTS AND APPLICATION

Database Development

Create a GIS building inventory database for the study area





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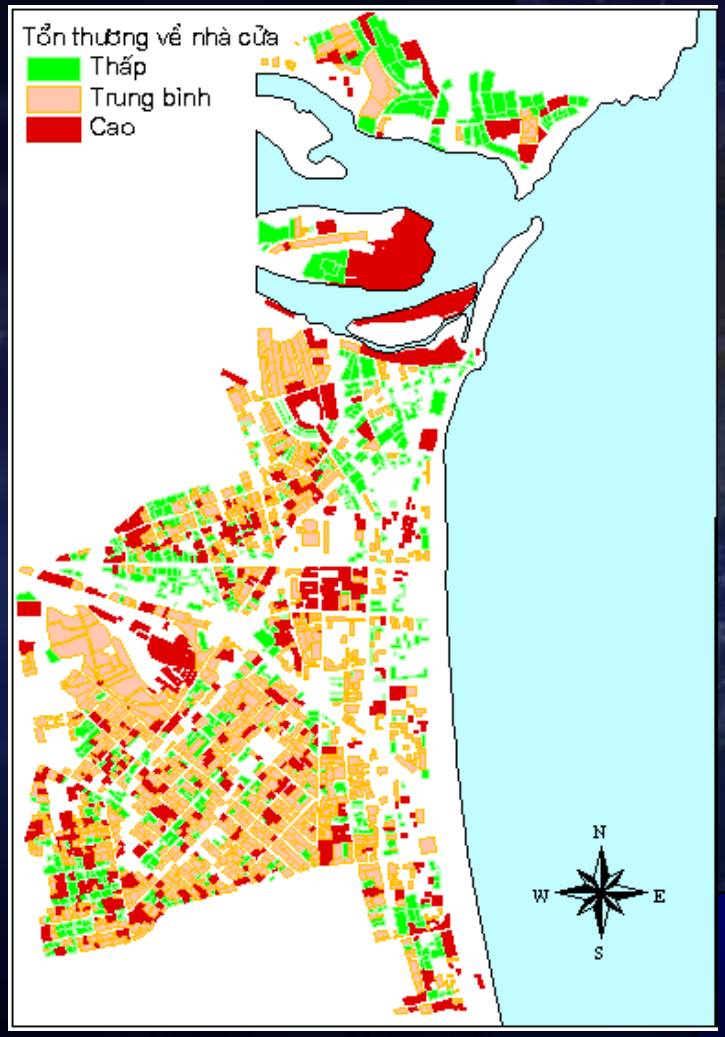
RESULTS AND APPLICATION

Vulnerability and Risk Assessment

Built Environment vulnerability map of Nha Trang city



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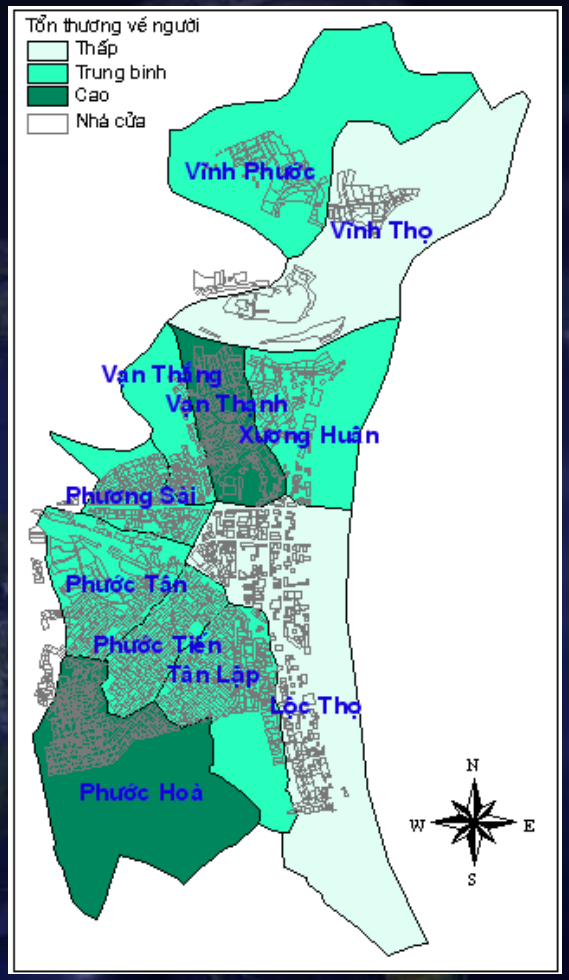
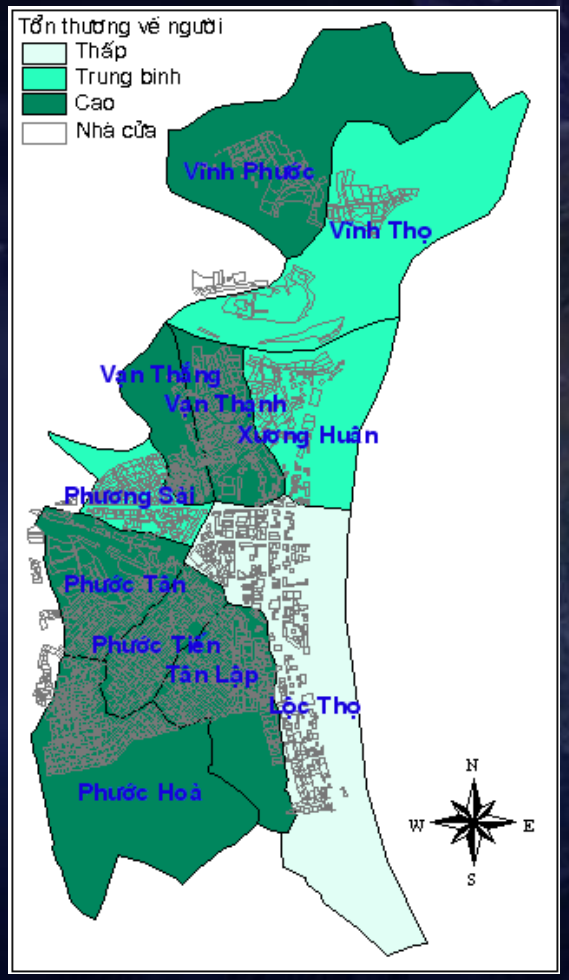
RESULTS AND APPLICATION

Vulnerability and Risk Assessment





Population vulnerability map of Nha Trang:

during day time and night time

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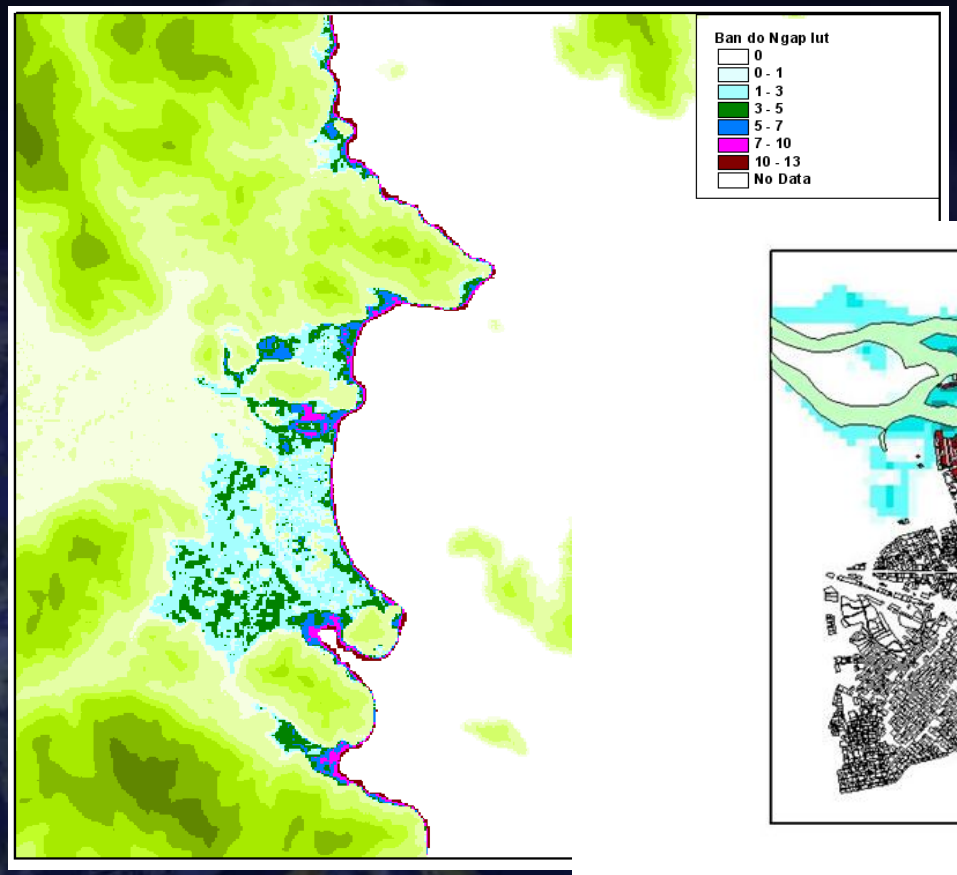
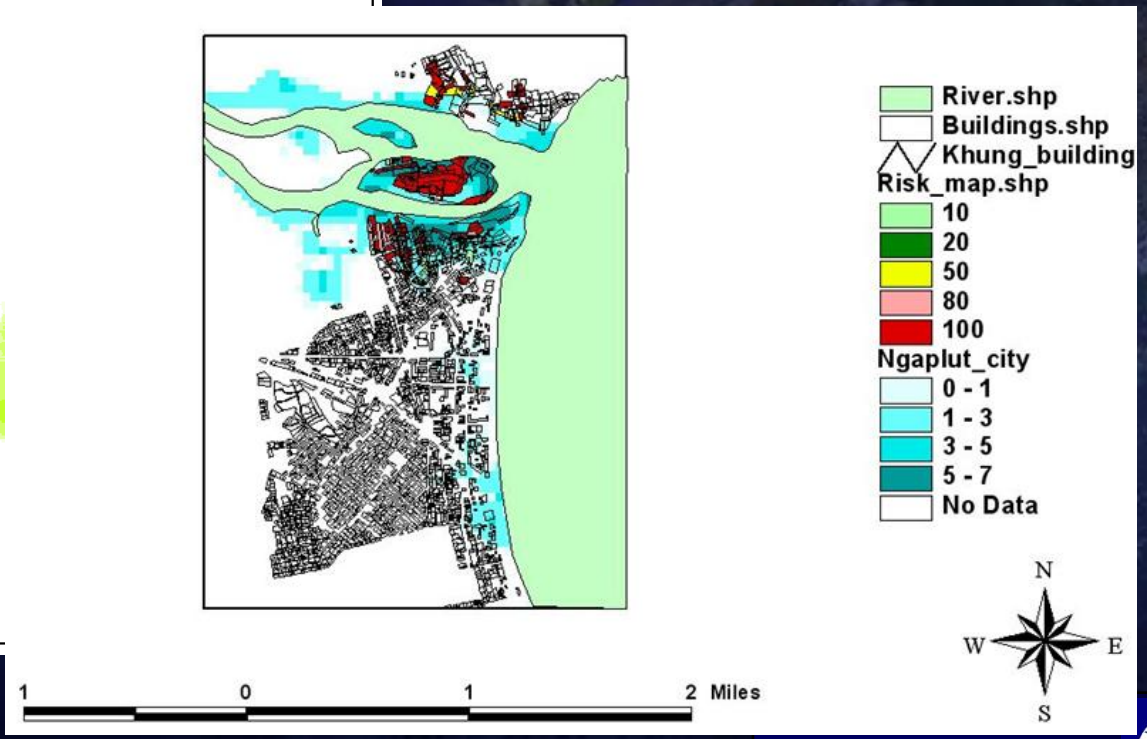
RESULTS AND APPLICATION

Vulnerability and Risk Assessment



Inundation map

Risk map



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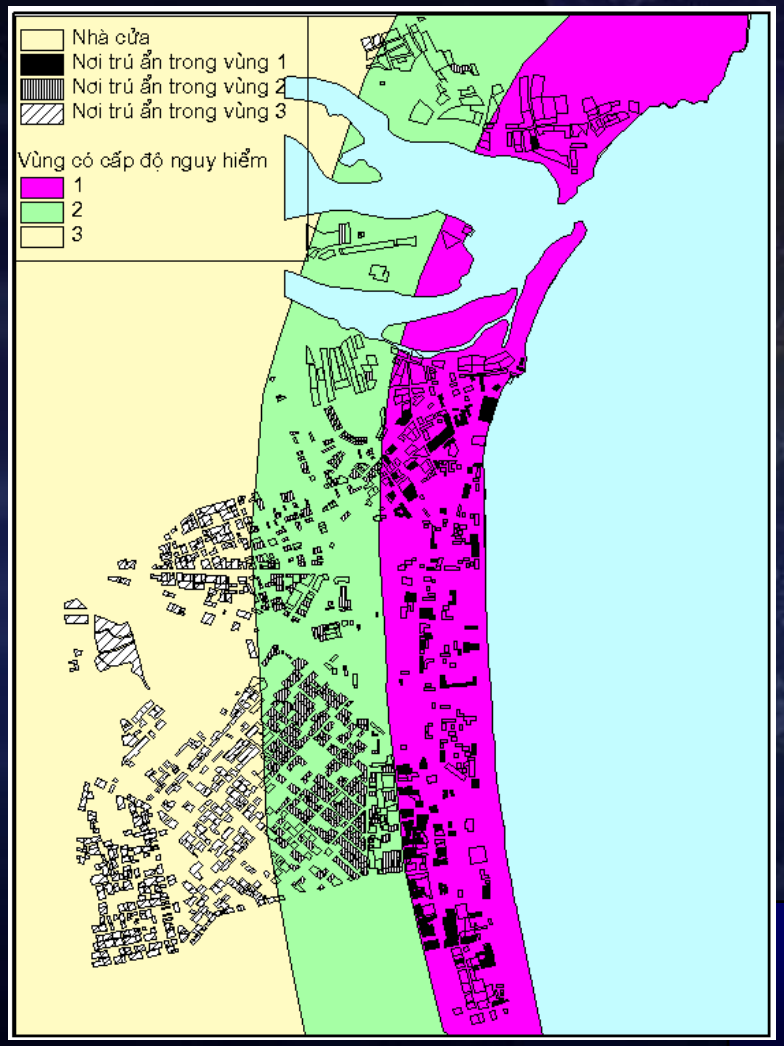
RESULTS AND APPLICATION

Response and evacuation Planning

Tsunami shelters map for Nha Trang city



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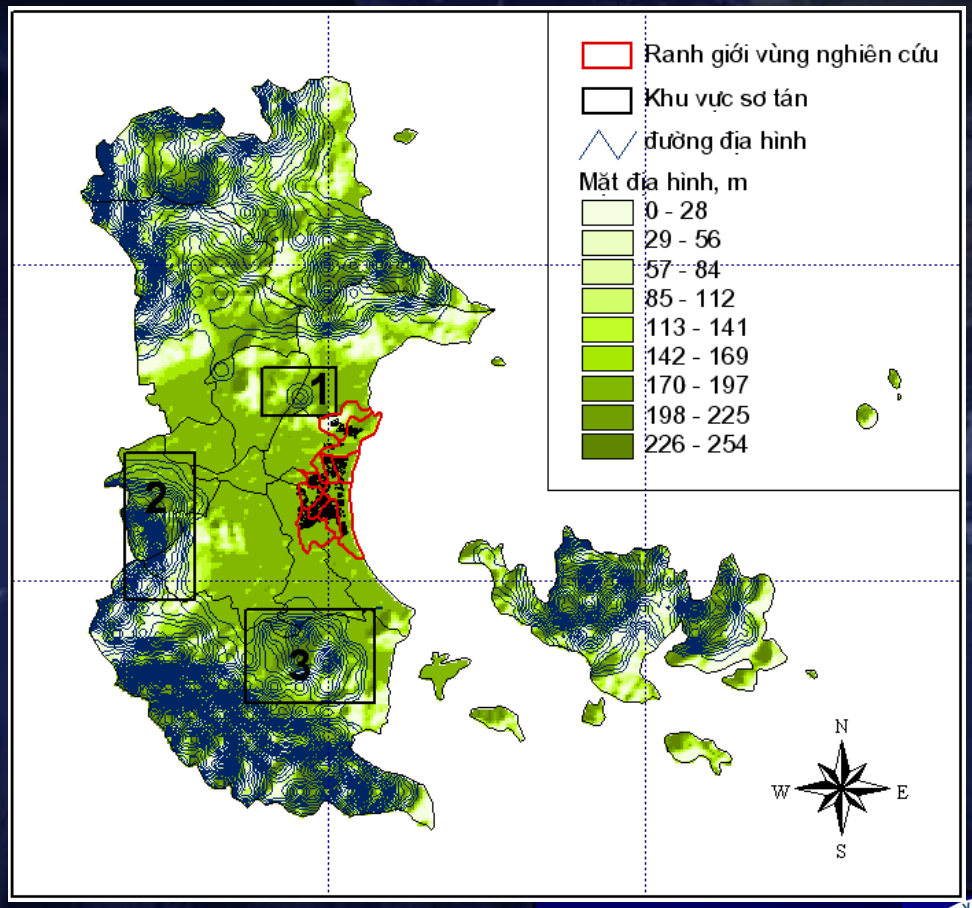
RESULTS AND APPLICATION

Response and evacuation Planning

Map of tsunami evacuation zones



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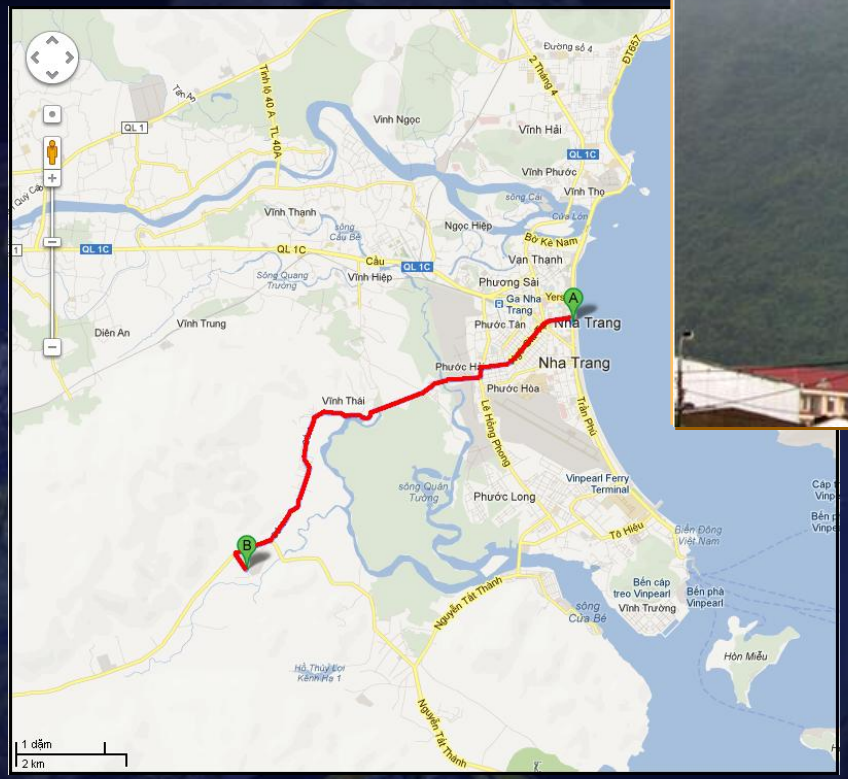
RESULTS AND APPLICATION

Response and evacuation Planning



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CONCLUSIONS

In this study, we create a worst-case scenario of tsunami earthquake excited by Manila Trench mega-thrust and assess the impact to the Vietnamese coast. The source parameters are defined based on the models proposed by Tso-Ren Wu et al (2009) and Megawati K. et al (2009). The earthquake magnitude, Mw, is assumed to be 9.3 generated on the Manila Trench. The tsunami propagation and inundation were numerically computed by using the COMCOT open source code.

We focus the discussion in Central Vietnam coastal regions, and carefully describe the maximum tsunami wave heights around two coastal cities, Da Nang and Nha Trang. In Central Vietnam coast, the maximum tsunami wave high of 22 m is observed at the coast of Quang Ngai province. The maximum wave height is 14 m recorded at the coast of Da Nang city and is 12 m at the coast of Nha Trang city. It might be concluded that the tsunami hazards from Manila Trench source are devastating to Vietnamese coast, especially to the Central Vietnam coast.

The simulation results can be used for the tsunami hazards/risk assessment as well as warning and response purposes for the coastal zones of the coutry.

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SIMULATION OF A WORST CASE TSUNAMI SCENARIO FROM THE MANILA TRENCH TO VIETNAM

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THANK YOU !

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