Literature Study of Tsunami Risk in SCS and its Adjacent Regions

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Outline

- Historical earthquakes and tsunamis
- Seismo-tectonic
- Tsunami risk evaluation
- Conclusion
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- **Historical earthquakes and tsunamis**
- **Seismo-tectonic**
- **Tsunami risk evaluation**
- **Conclusion**
Historical earthquakes

Shared Criterias
Region:
5° S-28° N, 105° E-128° E
Magnitude>=6.5

Merged Earthquake Database
393 events
1900 to 2015

National Geophysical Data Center
2150BC to 1900

National Earthquake Information Center
1900 to 2015

Global Historical Earthquake Archive
1000 to 1903
Historical earthquakes from 2150BC to 2015 (Mag>=6.5)
Historical tsunamis

Shared Criteria:
Region: 5° S-28° N, 105° E-128° E
Cause of tsunami: earthquake
Validity >=1

NGDC
2150BC to 2015
National Geophysical Data Center

Merged Tsunami Database
102 events

Tsunami Laboratory Novosibirsk
1628BC to 2015
Historical tsunamis caused by earthquake (2150BC-2015)
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Tectonic Setting

- Transition zone between Eurasian plate, Philippine Sea plate and Australian Plate.
- Different plates move relatively to each others.
- The western subduction system that consists Manila, Negros and Cotabato Trenches is induced by plate motion of the Philippine Sea plate.
- The Manila Trench and the north fault system have been in compression for long time with the Eurasian plate and Philippines plate.
Potential Tsunami Zones

8 tsunami potential zones can be divided in the SCS regions.

Potential Tsunami Zone in SCS

- An oceanic trench created by subduction of Sunda Plate under Philippine Mobile Belt
- Shallow earthquakes because of hot subduction
- The stress distribution of the north part is compressive-thrusting, the south region becomes very complex.
- Maximum magnitude predicted is 8.3-8.7 (north); 8.1-8.5 (central); 6.3-6.7 (south). (Phuong)
- Lower bound return periods of 30-120 years are found for Mw 7.6-8.2 (NGI)
Potential Tsunami Zone in SCS

- Boundary between the Indo-Asian geoblock and the South China Sea oceanic crust
  - NS direction
  - deep-seated
  - less active
  - Maximum magnitude predicted is 6.2-6.6

- Passive continental margin zone of Atlantic type
  - NE-SW or ENE-WSW
  - strike-slip type with some normal fault type
  - Maximum magnitude predicted is 6.6-7.0

- Located at where ancient collision tectonic zone of Nansha trough had stopped expanding
  - Northwest of the fault is a thrust fault zone
  - Maximum magnitude predicted is 6.4-6.5

- Located at the boundary of the Philippine Sea plate and the Eurasian plate
  - Less earthquakes than eastern
  - Maximum magnitude predicted is 6.8-7.2
Potential Tsunami Zone in Sulu Sea

- Short convergence zone along the western margin of the central Philippines
- North SS, south TS for CMT
- Maximum magnitude predicted is 8.0-8.4
Potential Tsunami Zone in Sulawesi Sea

- A short trench system located along the southwestern coast of Mindanao.
- TF and NF are parallel distributed along the trench.
- Maximum magnitude predicted is 8.1-8.5
- A lower return period of 60 years is found for a Mw7.9 earthquake.
Potential Tsunami Zone in Sulawesi Sea

- SEA triple junction (Pacific-Philippine, Indo-Australian Plates and the Sunda Block, Transform-Transform-Trench type, central part coinciding with Sulawesi)
- Maximum magnitude predicted is 6.6-7.0
- A lower bound return period of 30 years is found for Mw 7.9 earthquake.
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Lead Author: Thio (2007)
Method:
Use PTHA to compute the probabilistic tsunami wave heights in Southeast Asia.

Results/Conclusions:
- The map of peak tsunami wave height for return period of 475 years.
- Tsunami wave height hazard curves for different localities in Southeast Asia

Lead Author: Yingchun Liu (2007)
Method:
Use PFTH to determines the probability distribution of the waves excited by hypothetical earthquakes in South China sea.

Results/Conclusions:
- The probability for a scenario of a 2.0m wave hitting Hong Kong or Macau is around 10% for this century.
Deterministic tsunami hazard studies

Lead author: NGI (2009) (Norwegian Geotechnical Institute)

Method: Applied a “depth averaged three dimensional model” to simulate some “worst case” in the SCS.

Results/Conclusions:
- Coastlines on the western part of Luzon Island facing the earthquake sources of Manila Trench are subject to large maximum water levels of more than 10 m.
- Potential tsunami hazard induced by earthquakes of magnitudes smaller than 8.2 in Manila Trench are small and almost negligible to Vietnam.
- The coastlines along the Gulf of Thailand are not threatened by tsunamis originating from the Manila Trench.
Deterministic tsunami hazard studies

**Lead author:** Okal (2010)

**Method:** Present 14 scenarios of potential tsunamis in the South China Sea and its adjoining basins, the Sulu and Sulawesi Seas.

**Results/Conclusions:**
- Simulated scenarios generally result in containment of the tsunamis to their original individual basin.
- Very shallow bathymetry dampens regional tsunamis propagating from the deeper basins in the eastern South China Sea and across the Straits of Makassar.
- Some shores of the southern Chinese mainland from the Taiwan straits to Hainan, Vietnam, and northern Borneo may feature far-field tsunami risk under some destructive tsunami around Luzon Trench.
Deterministic tsunami hazard studies

**Lead author:** Kusnowidjaja Megawati (2009)

**Method:** Presented an earthquake rupture model in Manila Trench with magnitude up to 9.0 constructed from seismic and geodetic data, together with hydrodynamic simulations of the potential tsunami with COMCOT.

**Results/Conclusions:**
- The western coast of Luzon Island is the hardest hit area with waves of more than 8 m. The south of Luzon Island is hit by waves of 4 m high.
- Southern China, including Hong Kong and Macau is exposed to tsunami waves of 6-8 m high. The western coast of Vietnam is struck by waves of 4-5 m, showing that it is not fully shielded by the Paracel Islands. Taiwan receives the impact of reflections from mainland China, and the central western coast appears to suffer waves of up to 3 m in height.
- The western coast of Borneo receives waves of 2-3 m, whereas the eastern coast of Malay Peninsula is hit by waves of up to 2 m. Singapore, on the southern tip of the Malay Peninsula, is well shielded and hardly affected.
Deterministic tsunami hazard studies

**Lead author:** Zhenhua Huang (2009)

**Method:** investigated the possible impact of an earthquake of magnitude 9.0 scenario rupture of Manila Trench on Singapore using COMCOT.

**Results/Conclusions:**
- It takes about 12 h for the tsunami waves generated at Manila Trench to arrive at Singapore coastal waters.
- The wave period of the tsunami wave is about 5 h.
- The maximum water level rise in Singapore water is about 0.8 m.
- The maximum velocity associated with the tsunami waves is about 0.5 m/s, which is not likely to have significant impact on the port operations in Singapore.
Deterministic tsunami hazard studies

Lead author: Anat Ruangrassamee (2009)

Method: Conducted the simulation of tsunamis in the Gulf of Thailand. Six cases of fault ruptures in the Manila trench are considered for earthquakes with magnitudes of 8.0, 8.5, and 9.0.

Results/Conclusions:
- Tsunamis reach the southernmost coast of Thailand in about 13 h and take about 6 h more to reach Bangkok.
- The Gulf of Thailand is affected by the diffraction of tsunamis around the southern part of Vietnam and Cambodia. The tsunami amplitude at the southernmost coastline is about 0.65 m for the Mw 9.0 earthquake.
- The current velocity in the Gulf of Thailand due to the Mw 9.0 earthquake is generally less than 0.2 m/s. The earthquake magnitude significantly affects current velocity.
Deterministic tsunami hazard studies

Lead author: Tso-Ren Wu (2009)

Method: Created a hypothetical earthquake tsunami scenario caused by seismic motion at Manila trench based on the faults parameters issued by USGS and the seismic record from Global CMT.

Results/Conclusions:

- The wave height along SW Taiwan varies from 4 m to 10 m.
- The tsunami wave also attacks the northeast of Taiwan. The wave height is able to reach 8 m.
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Conclusion

- Historical events in this area show that most earthquakes and tsunamis occur near the Manila Trench, the Negro Trench, the Cotabaco Trench and the Gorontalo Trench. Most destructive tsunamis occurred in Sulawesi Sea.

- 8 tsunami potential zones can be divided in the SCS regions. They are 1. west Taiwan, 2. Manila Trench, 3. The north of South China sea, 4. The west of South China sea, 5. The Northwest Borneo-Palawan, 6. The Sulu-Negros Trench, 7. The Cotabato Trench, 8. Gorontalo Trench. The zone 3, 4, 5 have little possibility to occur destructive tsunami.

- For Manila Trench, the maximum magnitude of the north part is 8.3-8.7, the maximum magnitude of the central part is 8.1-8.5, the maximum magnitude of the south part is 6.3-6.7. The lower bound return periods of 30-120 years are found for Mw 7.6-8.2 earthquakes.
Conclusion

- According to the PTHA and tsunami simulation in the area, Manila Trench is the most dangerous potential tsunami zone.

- Southern China, including Hong Kong and Macau and west of Philippines are mainly threatened by tsunami originating from the Manila Trench. Southern China, including Hong Kong and Macau is exposed to tsunami waves of 6-8 m high. The western coast of Luzon Island is the hardest hit area with waves of more than 8 m. When the magnitude is 9.0.

- Vietnam is threatened by Manila Trench when the earthquake magnitude is larger than 8.2. The western coast of Vietnam is struck by waves of 4-5 m, When the magnitude is 9.0.

- It takes about 13 h for the tsunami waves generated at Manila Trench to arrive at southernmost coast of Thailand and take about 6 h more to reach Bangkok. The tsunami amplitude at the southernmost coastline of the Gulf of Thailand is about 0.65 m for the Mw 9.0 earthquake at Manila Trench.

- It takes about 12 h for the tsunami waves generated at Manila Trench to arrive at Singapore coastal waters. The maximum water level rise in Singapore water is about 0.8 m.
Thank you

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