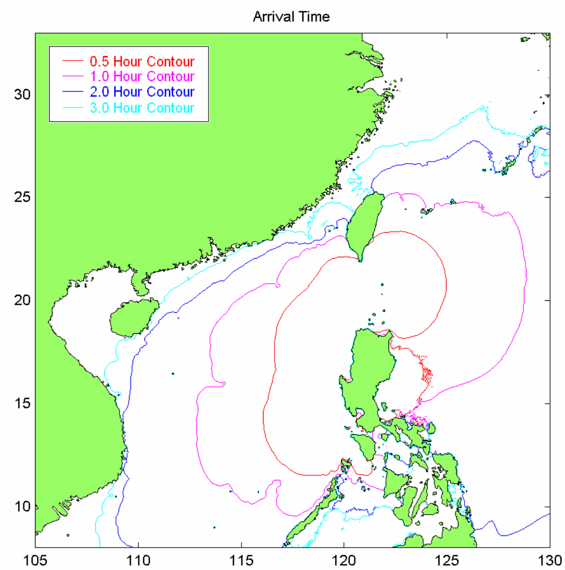
BOOK OF ABSTRACTS

2007 南中國海域海嘯預警與災害防治國際研討會摘要集

Date：5 ~ 6 December 2007 (Workshop)
7 December 2007 (Field Trip)

Venue：Institute of Earth Sciences, Academia Sinica, Taiwan (Workshop)
Center for Space and Remote Sensing Research, National Central University (Field Trip)
Tainan Hydraulics Laboratory, National Cheng Kung University (Field Trip)



Workshop on a System Approach for Tsunami Warning and Hazard Mitigation in the South China Sea Region

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2007 SCS TSUNAMI WORKSHOP

Introduction

The 2004 Sumatra-Andaman earthquake and Indian Ocean tsunami have highlighted inherent vulnerabilities of the world's coastal communities to extreme natural hazardous events. During the Indian Ocean tsunami, which lasted for only a few hours, nearly 300,000 people were killed and more than one million people were left homeless in more than 10 countries surrounding the Indian Ocean. Based on various reports, the total property damage is estimated over US$10 billion. Most of damage occurred because neither a tsunami warning system nor a simple communication network among the countries in the region was in place. Public education and coastal zone planning for tsunami hazard were also practically non-existent in the region.

After the 2004 Indian Ocean tsunami, many countries, including the United States, Japan, Germany and other European countries, have been working independently and collectively to develop tsunami warning systems for Indian Ocean region countries. To ensure the safety and protection of American lives and property from tsunami, the US government has also made plans to expand the U.S. tsunami detection and warning capabilities. The plan has committed more than $50 millions over the next several years to deploy 29 new deep ocean sensor systems in the Pacific Ocean rim and Caribbean Sea.

Recently the USGS issued a report assessing the potential risk as a tsunami source along the entire Pacific seduction zones. It identified the Manila (Luzon) trench as a high risk zone, where the Eurasian plate is actively subducting eastward underneath the Luzon volcanic arc on the Philippine Sea plate. Two other medium risk subduction zones in the neighboring area are also identified. Along the Ryukyu trench the Philippine Sea plate subducts northward beneath the Ryukyu Arc on the Eurasian plate, while along the North Sulawesi trench the Pacific-Philippine, Indo-Australian Plates and the Sunda Block meet. These subduction zones can also rupture and generate large tsunamis in the future that will have significant impacts on the countries in the South China Sea region.

It is clear that recent attention on tsunami hazard mitigation planning and early warning system development has been primarily focused on Indian Ocean, Pacific Ocean and Caribbean Sea. Potential devastating tsunami disasters in the South China Sea region have been overlooked. During the recent 2007 NUS-TMSI workshop on “Earthquake and Tsunami: From Source to Hazard” (http://et2007.org/), this concern was raised and discussed. The participants of the workshop supported the idea of forming a working group to initiate a study on a regional tsunami hazard mitigation plan and an early warning system in the South China Sea region.

2007 SCS TSUNAMI WORKSHOP

Objectives

To understand the fundamental processes for tsunami, one needs to address the generation mechanisms, the propagation characteristics and, finally their coastal effects. Therefore, strong interactions and collaborations among coastal physical oceanographers, geophysicists, and engineers are necessary. The objective of the workshop is to create such a forum.

The specific objectives of the workshop include:

1. To review the on-going tsunami early warning program for Indian Ocean region.
2. To review the on-going tsunami research in the South China Sea region.
3. To discuss the future research and implementation plans for tsunami early warning system and coastal hazard mitigation programs in the South China Sea region.

2007 SCS TSUNAMI WORKSHOP

Board

Prof. Philip L.-F. Liu, Cornell University, USA

Prof. Chung-Pai Chang, National Central University, Taiwan

Prof. Po-Fe Chen, National Central University, Taiwan

Prof. Yue-Gau Chen, National Taiwan University, Taiwan

Prof. Shu-Kun Hsu, National Central University, Taiwan

Prof. Bor-Shouh Huang, Academia Sinica, Taiwan

Dr. Gwo-Shu Hwang, National Cheng Kung University, Taiwan

Prof. Hwung-Hweng Hwang, National Cheng Kung University, Taiwan

Dr. Zhao Li, Academia Sinica, Taiwan

Prof. Kuo-Fong Ma, National Central University, Taiwan

Prof. Wu-Ting Tsai, National Central University, Taiwan

Prof. Tso-Ren Wu, National Central University, Taiwan

Prof. Horng-Yuan Yen, National Central University, Taiwan

Staff

Ms. Shu-Jen Hsu

Mr. Li-Chun Hu

Ms. Mei Hui Chuang

Ms. Sharon Yao

Mr. Dong-Jeng He

Ms. Miao-Shan Wei

Ms. Shiue-Jen Huang

Ms. Chia Chen Chen

Ms. Feng-Yee Ho

2007 SCS TSUNAMI WORKSHOP

Committees (in alphabetic order)

Center for Space and Remote Sensing Research National Central University (Taiwan)

Chinese Geophysical Society (Taiwan)

Graduate Institute of Hydrological and Oceanic Sciences,National Central University (Taiwan)

Institute of Earth Sciences, Academia Sinica (Taiwan)

Research Center of Ocean Environment and Technology (Taiwan)

School of Civil and Environmental Engineering, Cornell University (USA)

2007 SCS TSUNAMI WORKSHOP

Financial Sponsors (in alphabetic order)

Academia Sinica (Taiwan)

College of Earth Sciences, National Central University (Taiwan)

Cornell University (U.S.A.)

Earth Science Research Promotion Center (Taiwan)

National Center for Ocean Research (Taiwan)

National Science Council (Taiwan)

Program (5 December 2007)

- 08:00 – 09:00 Registration
- 09:00 – 09:30 Welcome and opening remarks
  Prof. Bor-ming Jahn, Director, Institute of Earth Sciences, Academia Sinica, Taiwan
  Prof. Wing Ip, Vice President, National Central University, Taiwan
  Dr. Robert Y. Lai, Chairman, National Applied Research Laboratories, Taiwan
- 09:30 – 10:15 Present practice of tsunami warning system and hazard mitigation programs in Japan
  (Dr. Nobuo Shuto, Nihon University, Japan)
- 10:15 – 10:30 Coffee Break
- 10:30 – 11:15 Overview of on-going activities on tsunami warning systems and tsunami hazard mitigation in Indian Ocean and presentation of the framework for South China Sea Initiative
  (Prof.. P.L.L.-F. Liu, Cornell University, USA)
- 11:15 – 11:45 A review on the characteristics of Manila (Luzon) subduction zone and other potential tsunami generation source regions in the South China Sea
  (Prof. Shu-Kun Hsu, National Central University, Taiwan)
- 11:45 – 12:15 An overview of current tsunami research activities in Taiwan
  (Prof. Tso-ren Wu, National Central University)
- 12:15 – 13:30 Lunch
- 13:30 – 14:00 Current tsunami research activities in Philippines
  (Prof. Edanjarlo J. Marquez, Department of Physical Sciences and Mathematics, University of the Philippines-Manila)
- 14:00 – 14:30 On-going tsunami research in tsunami research group, Bandung Institute of Technology
  (Dr. Hamzah Latief, Bandung Institute of Technology, Indonesia)
- 14:30 – 15:00 Overview of Singapore tsunami research program
  (Dr. Pavel Tkalich, National University of Singapore, Singapore)

- 15:00 – 15:15 Coffee Break
- 15:15 – 15:45 Tsunami research in Malaysia post Andaman 2004 tsunami: A country overview
  (Prof. Hock Lye Koh, Universiti Sains Malaysia, Malaysia)
- 15:45 – 16:15 The effect of tsunamis generated in Manila trench on the South China Sea and the Gulf of Thailand
  (Prof. Anat Ruangrassamee, Chulalongkorn University, Thailand)
- 16:15 – 16:45 Current tsunami research activities in Vietnam
  (Prof. Vu Thanh Ca, Institute of Meteorology and Hydrology, Vietnam)
- 16:45 – 17:15 Current tsunami research activities in China
  (Prof. Hua Liu, Shanghai Jiao-Tong University, China)

- 17:15 – 18:15 General discussions

Program (6 December 2007)

- 08:30 – 08:50 Long-term earthquake potential modeling around Sunda Arc: A case study of Sumatra plate margin (Dr. Wahyu Triyoso, Bandung Institute of Technology, Indonesia)
- 08:50 – 09:10 Tsunami source mechanisms in the Philippine archipelago (Dr. Cala Dimalanta, University of the Philippines, Philippines)
- 09:10 – 09:30 The subduction zones of Ryukyu, Manila and Philippine Trenches: Tsunamigenic or Nontsunamigenic? The necessity of Ocean-Bottom crustal deformation and GPS measurements (Dr. M. Ando, Academia Sinica, Taiwan)
- 09:30 – 09:50 Fault mechanism and essential fault parameters for predicting tsunami generation in South China Sea (Prof. S-H Chew, National University of Singapore, Singapore)
- 09:50 – 10:10 Review of seismic network activities in the Manila-taiwan subduction zone (Prof. P.F.Chen, National Central University, Taiwan)
- 10:10 – 10:30 Possible future reupture scenarios of the Manlia trench (Prof. K. Megawati, Nanyang Technological University, Singapore)
- 10:30 – 10:45 Tsunami Hazard near Taiwan and implications for rheological stratification under Taiwan (Prof. D. A. Yuen, University of Minnesota, UAS)
- 10:45 – 11:00 Coffee break
- 11:00 – 11:20 Numerical Simulation of Tsunami propagation and Inundation on the West-Coast of South China Sea (Prof. Phung D. Hieu, Hanoi University of Science, Vietnam)
- 11:20 – 11:40 Modeling of tsunami run-up and inundation in Singapore (Prof. Z. Huang, Nanyang Technological University, Singapore)
- 11:40 – 12:00 Tsunami runup and inundation simulation in Malaysia including the role of mangroves (Ms. Su Yean The, Universiti Sains Malaysia, Malaysia)

- 12:00 – 12:20 A numerical model for tsunami runup calculation (Prof. Vu Thanh Ca, Institute of Meteorology and Hydrology, Vietnam)

- 12:20 – 13:30 Lunch

- 13:30 – 13:50 Taiwan seismic network status and plans for seismic monitoring cooperation with countries surrounding the South China Sea
(Dr. Bor-Shouh Huang, Academia Sinica, Taiwan)

- 13:50 – 14:10 Construction of the marine earthquake and tsunami monitoring stations
(Dr. Yuanqing Zhu, Earthquake Administration of Shanghai Municipality, China)

- 14:10 – 14:30 Current initiatives on the development of tsunami early warning systems in the South China Sea region
(Dr. Bart Bautista, Philippine Institute of Volcanology and Seismology, Philippines)

- 14:30 – 14:50 The roles and responsibilities of the Institute of Geophysics (IGP) in tsunami research, and early warnings for Vietnam
(Dr. B.C. Que, iGP, Vietnam)

- 14:50 – 15:10 Effect of sea-dikes on tsunami run-up
(Dr. K.S. Hwang, National Cheng Kung University, Taiwan)

- 15:10 – 15:30 Simulating mangrove succession and recovery after tsunami
(Ms. Su Yean The, Universiti Sains Malaysia, Malaysia)

- 15:30 – 15:45 Coffee Break

- 15:45 – 17:00 General discussion on the future plans for SCS initiatives

Program (7 December 2007)---Field Trip

There will be a field trip to visit the facilities at the Center for Space and Remote Sensing at National Central University, Jhongli, and the Tainan Hydraulic Laboratory at National Cheng Kung University, Tainan.

• 07:30 – 08:00	On board
• 09:30 – 11:00	Visiting the Center for Space and Remote Sensing (CSRS) at National Central University
• 11:00 – 11:30	On board
• 15:30 – 17:30	Visiting the Tainan Hydraulic Laboratory at National Cheng Kung University

Abstracts of Speeches

Present Practice of Tsunami Warning System and Hazard Mitigation Programs in Japan

Nobuo Shuto

Institute of Earth Sciences, Academia Sinica, Taiwan

Abstract

In 1941, a tsunami warning organization was founded for the Sanriku coast. A forecasting chart empirically obtained was used for judgment. It took about 20 minutes to obtain seismic data and judge. Then the information was transmitted to coastal residents by radio and telephone.

The Meteorological Business Act enacted in 1952 required to establish the tsunami warning system for all coasts of Japan, divided into 18 tsunami forecasting areas. The former chart for Sanriku coast was improved and used until 1999. The manual analysis of seismic data took at least 17 minutes before transmission of tsunami warning.

In order to speed up, a Local Automated Data Editing and Switching System (L-ADESS) was introduced in 1980. Data of seismographs were sent through dedicated lines via manual input and reading, and then evaluated by computer, shortening the forecasting process to 10 minutes.

The Earthquake Phenomena Observation System (EPOS) introduced in 1987 and the Earthquake Observation System (ETOS) introduced in 1993 shortened tsunami forecasting time of 7 minutes, by automating all the process.

In 1993, JMA switched form the use of S-wave to that of P-wave. The time needed for tsunami forecasting was shortened to 3-5 minutes.

In 1999, the quantitative tsunami forecasting began, based upon numerical simulation for 100,000 cases. The tsunami forecasting areas was increased from 18 to 66.

Since October 2006, the NOWCAST Earthquake Information System in JMA made it possible to issue the forecasting within 2 minutes. Then residents can receive the forecasting immediately on TV and via other means such as the meteorological satellite if a dedicated receiver is set.

All the tsunami countermeasures have been carried out as the post-event countermeasure until 1976 when the importance of the pre-event preparedness was officially recommended. In 1983, a Guideline on Comprehensive Disaster Prevention Countermeasures in Tsunami-prone Areas was worked out by a cooperation of the River Bureau, Ministry of construction and Fishery Agency, Ministry of Agriculture.

In 1997, including other 5 agencies, 7 government offices that concerned with tsunami disaster prevention policies agreed to Guidance on Reinforcement of Tsunami Disaster Prevention Countermeasures in Local Disaster Prevention Planning. This is a revised version of the former Guideline.

The planned tsunami is the larger one of the largest past tsunami and the possible tsunami caused by the largest earthquake that can be supposed to occur based on present knowledge and science.

The Central Disaster Management Council announces earthquake and tsunamis thus estimated as the standard force to be prepared for, especially after the 2004 Indian Ocean Tsunami.

Three factors, defense structures (hard-ware), tsunami resistant town development, and defense systems (soft-ware) are to be combined.

Sea walls, tsunami breakwaters, and tsunami gates are defense structures.

The essential measure in tsunami resistant town development is the land-use regulation. The movement of residence to high tsunami-free ground is the most recommendable. If a building is in the tsunami-risk area, the building should be tsunami-resistant, that is, reinforced concrete building.

The main points of the defense system are improvement in tsunami forecasting and warning, evacuation based on this information, disaster prevention training in response to tsunamis, and disaster prevention education to make people aware of tsunamis and what to do in the event of tsunami.

Part I: Review on the activities in establishing Indian Ocean Tsunami Warning systems

Part II: An Introduction of the South China Sea Initiative

Philip L.-F. Liu

School of Civil and Environmental Engineering, Cornell University, Ithaca, NY 14853

and

Graduate Institute of Hydrological and Oceanic SciencesNational Central University, Jhongli, Taiwan

Abstract

In the first part of this talk we will review the on-going activities in establishing the Indian Ocean Warning systems. We will examine the necessary steps to be taken in order to establish such systems.

In the second part of the talk we will discuss the need to investigate the potential tsunami hazards in the South China Sea (SCS) region. The general seismological and geographical conditions in the SCS region will be discussed. The objectives of the SCS initiative will be presented. Finally, the specific goals of the workshop will be briefly outlined.

Tectonics and potential tsunamis of the Manila Trench

Shu-Kun Hsu and Chia-Yen Ku

Institute of Geophysics, National Central University, Taiwan

Abstract

The Philippine Sea Plate overrides the Eurasian Plate along the east-dipping Manila Trench. From south to north, the plate convergence gradually evolves from normal subduction of the South China Sea lithosphere to initial collision of the Taiwan orogen. The subduction-related earthquakes become diffusive close to Taiwan; the accretionary prism is dramatically wider toward Taiwan. The subducted slab of the South China Sea change significantly the dipping angles from the south to north. The major reason for the changing dipping angles is associated the heterogeneous characters of the seabed. For instance, in the latitude of the Luzon island, the fossil mid-ocean ridge is subducting eastward. The subducting asperities may cause significant tsunami-earthquakes. To understand the plate convergent features of this subduction-collision transition zone, we have analyzed twelve seismic reflection profiles across the Manila Trench between Luzon and Taiwan. The results show that the basement of northern South China Sea basin generally dips toward east and south. The northern Manila Trench accumulates more trench-fill sediments in the south than in the north. Structural analysis shows that the subducting crust in the northern Manila Trench area can be characterized by three distinctive zones: a normal fault zone (NFZ), a proto-thrust zone (PTZ) and a thrust zone (TZ). The NFZ is defined by the distribution of numerous normal faults in the top or upper portion of the subducting crust. The normal faults are gradually buried by trench-fill sediments when they are closer to the deep trench. It is suggested that normal fault may take place at the location where the crust starts to bend and induces gravity sliding of the upper sedimentary layers. Some buried normal faults could be reactivated to blind thrust faults because of stronger plate convergence near the accretionary prism. The PTZ is located between the NFZ and the frontal thrust of the accretionary prism; it contains blind thrust faults or folds instead of thrust faults**.** The successive distribution of the crustal structures of normal faults, blind-thrust and thrust faults at the trench area suggests that the blind thrust faults develop along the location of pre-existing normal faults. The brittle deformation occurs at the lower part of the sedimentary layers because of stronger compaction and less water there; eventually blind thrust faults may propagate upward and become thrust faults at the seabed.

An Overview of Current Tsunami Research in Taiwan

Tso-Ren Wu

Graduate Institute of Hydrological and Oceanic Sciences, National Central University, Taiwan

Abstract

Owing to the complex plate boundaries, Taiwan area tends to have frequent under-water earthquakes and thus tsunami waves are generated. The most devastating tsunami occurred about 140 years ago in Keelung which locates on the northern tip of Taiwan Island. Based on the historical documents, the wave height was estimated to be 7.5 m. However, due to the infrequent occurrence of tsunamis and the special topography around Taiwan, there was no severe tsunami hazard in the past century and tsunami research is not ranked at the first place in Taiwan.

Mainly after the 2004 South Asian Tsunami, even though tsunami has infrequent occurrence, it is clear that tsunami still happens and researchers have called attention to this potential destructive hazard. In this presentation, the speaker is going to summarize the recent tsunami research development in Taiwan, including the tsunami monitoring, tsunami modeling, tsunami hazard mitigation, and historical tsunamis in Taiwan. At the end, the speaker will present the recent research results on modeling the pair-earthquake generated tsunami in Taiwan on December 26, 2006. The result is obtained by solving a numerical model which combined the elastic dislocation theory (Okada, 1985), scaling laws (Geller, 1976), and COMCOT nonlinear shallow-water-wave model (Liu et al., 1998). The results are compared with the tidal gauge data. Comments are addressed on the potential tsunami hazard.

Current tsunami research activities in Philippines

Graciano Yumul, Jr.[1,2], Carla Dimalanta[1] and Bart Bautista[3]

[1] Department of Science and Technology, Bicutan, Taguig, Philippines

[2]National Institute of Geological Sciences, University of the Philippines, Diliman, Quezon City, Philippines

[3]Philippine Institute of Volcanology and Seismology – Department of Science and Technology, UP Campus, Diliman, Quezon City, Philippines

Abstract

In the wake of the Asian 2004 tsunami, archipelagic countries like the Philippines have intensified their efforts towards the assessment and mitigation of tsunamis and related risks. In the Philippines, the Tsunami Hazard Assessment and Mitigation Program (THAMP) began in 2001 with an assessment of tsunami hazards all over the country. The activities included the assessment of historical data, survey of areas previously affected by tsunamis, studies of tsunami deposits and assessment of tsunami safety structures for the communities. Computations and modeling the occurrence of a possible tsunami with the Manila Trench as its source are being undertaken. Similar tsunami simulations were carried out for Mindanao with the southern portion of the Philippine Trench as the earthquake generator. This gave interesting results in terms of tsunami arrival times and estimates of damage to communities that may be impacted by the tsunami.

Current initiatives of the Philippine Institute of Volcanology and Seismology (PHIVOLCS), the focal agency for tsunami-related activities, are focused on nation-wide tsunami hazard mapping to determine tsunami arrival times and areas that will be inundated. In terms of far field tsunami monitoring and warning, the Philippines is a member of the Pacific Tsunami Warning System (PTWC) of the Intergovernmental Oceanographic Commission of UNESCO. It is also a recipient of earthquake and tsunami advisories from the newly established Northwest Pacific Tsunami Advisory Center (NWPTAC) of the Japan Meteorological Agency. These take care of possible far field tsunami events that may impact the eastern seaboard of the Philippines. For local tsunami detection, a 10-station tsunami detection network is also being put into place by PHIVOLCS using locally fabricated wet sensors. The first station was recently completed in Lubang Island, Oriental Mindoro. The institute has also recently improved its seismic monitoring network. There are now 64 stations that are digitally recording and 30 of these stations are being received at the central station in near real-time. Efforts to enhance its capability for rapid tsunami warning have been initiated through a collaborative project with the Advanced Science and Technology Institute (ASTI) of the Department of Science and Technology (DOST). This collaborative project aims to develop rapid mass alerting systems such as cell phone-triggered sirens or public address systems. Since local tsunamis have very short lead times, Community-based Tsunami Early Warning Systems (CBTEWS) are also currently being organized by PHIVOLCS and the Office of Civil Defense (OCD) in selected tsunami prone communities. Intensive information and education campaigns and tsunami evacuation planning and conduct of actual tsunami drills are also being done as part of the capacity building of communities for CBTEWS.

Current Tsunami Research Activities in Indonesia

"On going tsunami research in Tsunami Research Group, Bandung Institute of Technology "

Hamzah Latief[1,2) , Haris Sunendar[2)] and Aditya R. Gusman[2)]

[1)]Department of Oceanography, Faculty of Earth Sciences and Mineral Technology

Bandung Institute of Technology, Jalan Ganesha 10 Bandung 40132

[2)]Tsunami Research Group, Center for Coastal and Ocean Development

Bandung Institute of Technology, Jalan Ganesha 10 Bandung 40132

Abstract

Last three years, there are 3 tsunamis occurred in Indonesia. The first one is the catastrophic Indian Ocean tsunami of December 26, 2004 with maximum tsunami height more than 30 meters at western part of Banda Aceh caused nearly 283,000 deaths and affected the Asian and African countries surrounding the Indian Ocean. . The second one is the small Nias tsunami occurred on March 28, 2005 and the third one is the moderate West Java tsunami occurred on July 17, 2006 killed more than 600 people.

These events triggered a number of initiatives to mitigate tsunami-related events. Several on going researches in Tsunami Research Group, Bandung Institute of Technology (TRG-ITB), Indonesia such as:

- reviewing historical tsunami and updating tsunami catalog (web base),
- reconstructing all Indonesian tsunami events (at least 110 events) by using mathematical models
- preparing hazard map for the cities which have big potential attacked by tsunami
- implementing a soft protection strategy by analyzing an effectiveness of forests to reduce tsunami
- developing pre-calculate tsunami database as part of Indonesian TEWS, and
- public educations, tsunami drill, training and seminar.

One of a real implementation is **The Database of Pre-calculated Tsunami Model in Indonesia** as part of Indonesian TEWS which is developed by Tsunami Research Group, Bandung Institute of Technology (TRG-BIT), Indonesia, collaborated with Ministry of Research and Technology (MRT), Indonesia, Meteorology and Geophysics Agency (MGA), Indonesia, and the Japanese Government through JICA and JMA will be described. This database will be installed at MGA as part of Indonesian TEWS (see **Fig. 1**)

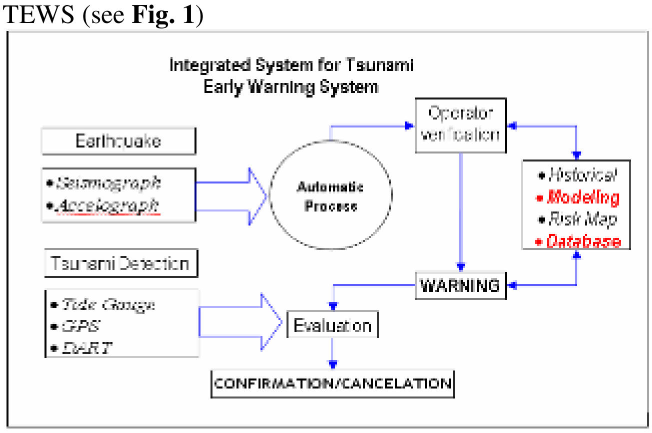

Fig. 1 Integrated tsunami early warning system (MGA)

The database is developed base on the Japan Meteorological Agency (JMA) scheme, by calculating the Indonesian region which is around 220.000 scenarios of earthquakes as hypothetic tsunami sources with varies coordinates (latitude and longitude), depth, and moment magnitude, base on the tectonic setting and their seismisities (see **Fig. 2**) to find wave heights and arrival times for each scenario along the coastal area.

If a real earthquake occurred at the undersea and has potential generate tsunami, so the engine automatically retrieves 16 sets file of the pre-calculated tsunami at surrounding

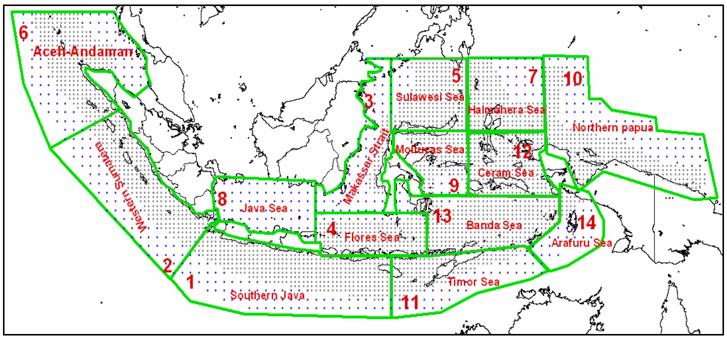

Fig. 2 Hypothetic sources distribution for Indonesian region (gray dot with interval 20 arc-mnts and blue dot with interval 40 arc mnt)

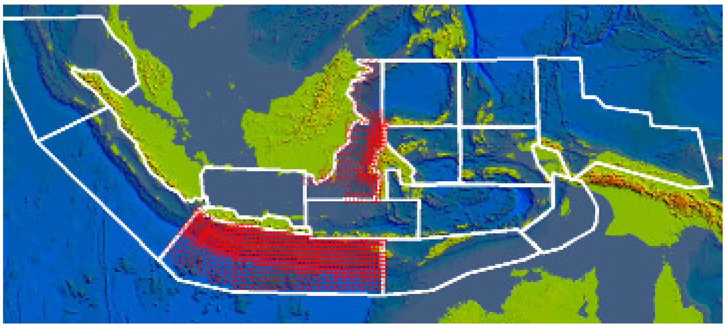

Fig. 3 Distribution of Faults with their dimension of 80km x 40km

the real source from the database. Those files are interpolated respect to the proportional location. To simulate the whole region, we need to design the works strategies by divide the region into several sub-regions with considering number simulations and resources. The region is divided in to 13 sub regions (see **Fig. 2**) and the work schedule is designed for 3 years, started from 2006 up to 2008. The sub-region -1 (Southern Jawa and Bali and -3 (Makassar Strait) have simu-lated with faults distribution and their orientation is shown in **Fig.3**.

Simulation samples of travel times and tsunami heights at the Southern of Java and Bali Islands and in the Makassar Strait are shown in **Fig. 4&5** and **Fig. 6&7** respectively.

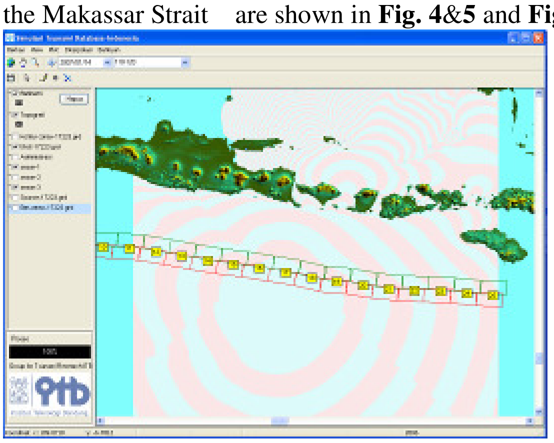

Fig 4. Travel time at the where the sources at the Southern Bali

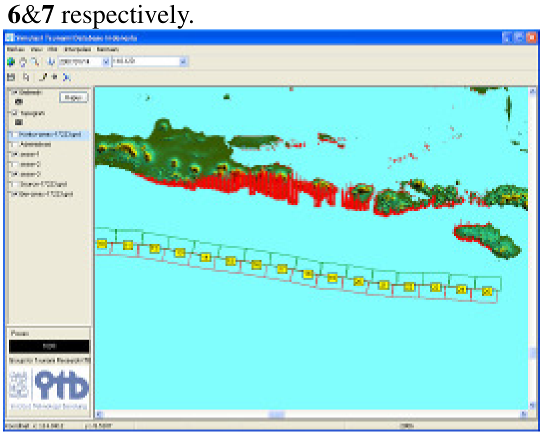

Fig. 5 Tsunami heights along the coast with tsunami sources at the Southern Bali

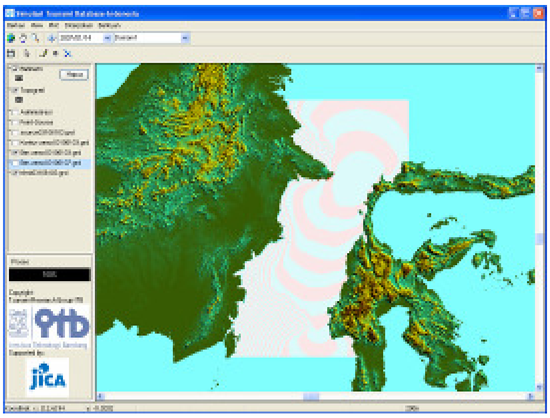

Fig. 6. Travel time for scenario 03017223 (Makassar Strait)

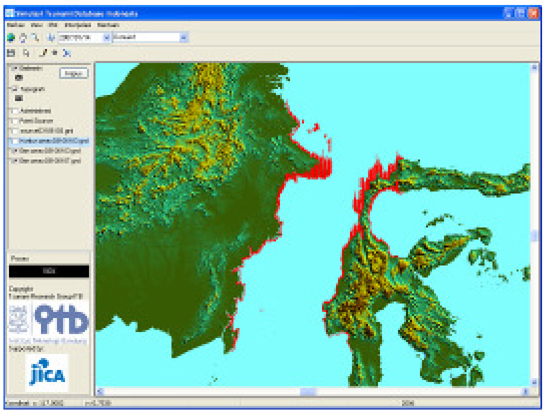

Fig. 7 Tsunami height along the coast for scenario 03017223 (Makassar Strait)

Keywords: Tsunami, mitigation, hazard map, tsunami modeling, database, TEWS

Overview of Singapore Tsunami Research Program

Pavel Tkalich, Chan Eng Soon

National University of Singapore

Abstract

The Indian Ocean tsunami event (2004) triggered coordinated efforts of affected coastal nations to deal with tsunami problems. Holistic socio-technological infrastructure has to be built, with key tasks including advanced sensors, reliable communication networks, fast predictive algorithms, early warning systems, and educational outreach. This paper highlights the key features of prediction capabilities under development in Singapore in support of the early warning system. The Project is sponsored by National Environmental Agency and will be operational in the Meteorological Service Division. It is executed by a combined team of National University of Singapore and Nanyang Technological University.

Research directions in the Project are grouped tentatively into three areas: (1) characterization of potential tsunamigenic sources, such as earthquakes and landslides; (2) accurate modeling of tsunami wave propagation and run-up; and (3) development of operational tsunami forecast capabilities. The early warning procedure will rely on the historical and domain knowledge data, as well as operational information derived from the regional and global sensor networks, including seismic stations and deepwater buoys. A hybrid system comprising process-based and data-driven models, backed by high performance computing, will eventually be implemented to advice instantaneously on the likely scenarios in the future events.

Tsunami Research in Malaysia Post Andaman 2004 Tsunami:

A Country Overview

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Abstract

Previously perceived as safe from the hazards of tsunami, Malaysia faced a rude awakening by the 26 December 2004 tsunami. Since the event, Malaysia has started an active initiative to conduct research on various aspects of tsunami leading towards attainment of coastal communities that are tsunami resilient. The areas of active research may be broadly categorized into three integrated categories: numerical simulations, socio-economic analysis of affected coastal communities, and engineering-institutional infrastructures. These activities are spearheaded by the Academy of Sciences Malaysia, with scientific contribution from various universities and funding from relevant government agencies. A tsunami modeling workshop and a tsunami Round Table Conference was held in 2006 in Malaysia hosted by Malaysia with technical assistance from UNESCO-IOC, with the aim towards developing human resource needed for numerical simulations of tsunami. A second goal is geared towards an effective deployment of physical hardware such as deep ocean buoys for early warning systems.

Universiti Sains Malaysia is currently very active in research on numerical simulations of tsunami from source generation to coastal runup and inundation. The research has been extended to include the assessment, by means of numerical simulations, of the role of mangrove as a mitigation measure against tsunami hazards. An in-house tsunami simulation model TUNA has been developed and successfully applied to the 26 December Andaman tsunami to simulate the propagation and inundation processes along affected beaches in Malaysia. Active collaboration is ongoing with other local and overseas universities and government agencies, sponsored and coordinated in part by the Academy of Sciences Malaysia. The socio-economic research relating to community level activities towards achieving tsunami resilient communities are currently being undertaken by other universities. Recent analysis has indicated the potential tsunami hazards in the South China Sea (SCS). Hence active international collaboration is timely and essential among affected countries in the region of SCS to seek effective means to protect coastal communities fringing the SCS. This paper aims to explore the possibility of such collaboration.

Keywords: Andaman tsunami simulation, Malaysia.

The Effect of Tsunamis Generated in Manila Trench on the South China Sea and the Gulf of Thailand

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Abstract

The infrastructures in the South China Sea and the Gulf of Thailand, for example, gas pipelines and platforms can be affected by tsunamis that are generated by earthquakes in the western part of the Philippines. In this study, the simulation of tsunamis caused by subduction earthquakes in the Manila trench is conducted. Six cases of fault ruptures are considered for earthquakes with magnitudes of 8.0, 8.5, and 9.0 corresponding to earthquake return periods of 63, 205, and 667 years, respectively. The linear shallow water wave theory in spherical coordinate system is used for tsunami simulation in the large area covering Southeast Asia while the nonlinear shallow water wave theory in Cartesian coordinate system is used for tsunami simulation in the Gulf of Thailand where the seawater depth is than 100 m.

The tsunamis generated by fault ruptures in the Manila Trench mostly affects the Philippines and Vietnam. It is because of the directivity of tsunamis. At the central coast of Vietnam, the tsunami height is 3.8 m and the current velocity is 1.7 m/s at a sea depth of 20 m for a magnitude of 9. The maximum tsunami height in the gulf is about 0.3 m. It is obvious that tsunamis diffracting around the southern part of Vietnam and entering the Gulf of Thailand have less effect on Thailand. As the earthquake magnitude increases from 8.0 to 8.5, the tsunami height increases by 3 times. And when the earthquake magnitude increases from 8.5 to 9.0, the tsunami height increases by 2 times.

For an earthquake magnitude of 9.0, the maximum current velocity is 0.27 m/s at a sea depth of 15.6 m in the southernmost province. In the middle of the gulf, the velocity is about 0.1 m/s. The effect of earthquake magnitudes on current velocity is investigated. As the earthquake magnitude increases from 8.0 to 8.5, the current velocity increases by 2 times. And when the earthquake magnitude increases from 8.5 to 9.0, the current velocity increases by 2 times. It is found that tsunamis arrives the southern part of Thailand in 11 hrs after an earthquake and arrives Bangkok in 20 hrs.

Keywords: Manila trench, tsunami modeling, current velocity, tsunami height

Current tsunami research activities in Vietnam

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Abstract:

A research project titlled "Establish tsunami hazard maps for Vietnamese coastal water" has been carried out by the Center for Advanced Technology Application, Institute of Meteorology and Hydrology of Vietnam after the event of 2004 December 26 Sumatra tsunami. The project has three objectives: to identify the stunami risk at the Vietnamese coast, to establish the tsunami hazard maps for early tsunami warning, and to produce public education materials to enable coastal residents and officials to prepare for the disaster. The careful inspection about past tsunami events in Vietnamese coast during the project found no proved evidence of tsunami attacking Vietnamese coast, despite a significant number of coastal resident's reports on tsunami events at the coast. On the other hand, primary results of paleotsunami study suggested that there are significant past tsunami events in Vietnam. Geological study shows that there are four sources of possible tsunami in the South China Sea that may affect Vietnam: the first is the fault at the Longitute 110E, offshore of South Central Vietnam, the second is the fault south of Hainan Island, the third is the Manila trench, and the fourth is the Ryukyus trench. Detailed calculations of tsunami generation and propagation by numerical models show that the first source does not produce earthquake with the strength enough for significant tsunami generation; the second source can generate significant stunami on a limited region in the Vietnamese coast with earthquake magnitude greater than 7.5; the third source can generate significant tsunami on a limited region with earthquake magnitude of 8.0; and strong tsunami on a large region with earthquake magnitude of 8.5. The fourth source can produce significant tsunami at Vietnamese coast only with the earthquake magnitude of more than 9.0.

Together with works on tsunami hazard mapping, a center for early tsunami warning system is being constructed in Vietnam.

Current tsunami research activities in China

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Abstract

In the presentation, the tsunamis which took place in China are briefly introduced, including the ocean-crossing tsunamis and the local ocean earthquakes induced tsunamis. Until the end of 2004, there was little awareness about the potential tsunami danger from shallow large earthquakes in the East and South coasts of China with great economic importance. However, much progress has been made in the studies on possibilities of tsunami generation in the East China Sea and South China Sea, including the numerical simulation of the generation and propagation of tsunamis, the tsunami warning system and the risk assessment of tsunami to coastal projects. In particular, the mathematical modeling of tsunamis generated in a trench, several measured tsunamis in China coasts are discussed in details. It should be pointed out that development of tsunami hazards warning system along the South China Sea and the East China Sea due to potential earthquakes have been paid more attention from the government in fundamental research in earthquakes, tectonics and geodetics in this area.

Long-term earthquake potential modeling around Sunda Arc

A Case Study of Sumatra Plate Margin

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Abstract

We modeled Seismotectonic and continuing with Earthquake Potential Analysis around Sumatra Subduction Zone by combining the GPS and Shallow Recorded Earthquake Catalog of the year 1964 – 1999. The result shows consistency with recent Catastrophic Giant Thrust Earthquake of both December, 2004 and March, 2005. First of all, we follow Frankel algorithm to smooth the instrumentally recorded earthquake catalog with optimum correlation distance. On the basis of the GPS and Geological data, then we model the fault plane. By combining seismic moment rate model that is derived based on seismicity smoothing, then we derived long-term rate on each fault plane. The main purpose is to produce surface displacement vector on each uniform grid then adjusted with the present day GPS data to get more plausible secondary dataset. Furthermore, we combined both dataset under geostatistical modeling to get more reliable long-term rate on each grid point of observation. Since we could estimate strain or stress, then we estimate seismic moment rate at a certain decade to have knowledge of plausible returning time of the above recent giant earthquake. The result seems to be comparable with Satake pointed out (Satake, 2006). On the basis of the above result, it seems that we could estimate probable earthquake magnitude at certain area with more reliable way. The above result seems to be quite useful for Seismic Hazard Study and Geotechnical purposes.

Tsunami source mechanisms in the Philippine archipelago

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Abstract

Being situated at the convergence of the Sundaland-Eurasian and Philippine Sea Plates, the Philippine archipelago is the locus of tectonic deformation and active geodynamic processes. Such processes have produced trenches, active faults and volcanoes which are capable of generating destructive tsunamis. Located on the western side of the Philippine archipelago is the Manila-Negros-Sulu-Cotabato trench system along which the South China Sea, Sulu Sea and Celebes Sea crusts are being consumed. The eastern side of the archipelago is characterized by the East Luzon Trough – Philippine Trench along which the Philippine Sea Plate is subducting westward. The entire archipelago is bisected by the ~1,200 kilometer long Philippine Fault Zone, a left-lateral strike-slip fault system. Several strike-slip faults branch out from the main trace of this major fault system. Around 40 destructive tsunamis have been recorded in the Philippine archipelago since 1627. Most of the tsunamis were generated from the Manila-Cotabato trench system on the west and the East Luzon Trough – Philippine Trench on the east. Other potential tsunamigenic earthquake generators include the Negros and Sulu Trenches as well as offshore faults. Tsunami run-ups of up to 7 meters were measured for some of the tsunami events. The most destructive tsunami event happened on August 17, 1976 in the Moro Gulf and devastated the coastal towns of southern Mindanao. The tsunami, which was triggered by an earthquake with a magnitude of 8.0, claimed around 3,700 lives. With most of the tsunami events being generated by near-field sources, there is a very short time, only about 5 – 10 minutes, before huge waves hit the shore. The potential damage which may be associated with far-field sources is also being carefully investigated. Tsunami events generated in the Pacific Ocean may take from 2 to 26 hours before these reach the eastern coast of the Philippines. Any tsunami event generated to the west of the archipelago will reach the western coastline in a shorter period of time. It is for these reasons that efforts on tsunami preparedness, awareness and mitigation are being intensified.

The Subduction Zones of Ryukyu, Manila and Philippine Trenches: Tsunamigenic or Nontsunamigenic?

- The Necessity of Ocean-Bottom Crustal Deformation and GPS Measurements

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The Ryukyus is widely believed as an aseismic subduction without any significant large earthquakes (M>8) based on the absence of any large thrust earthquake in the region. This perception is deduced mainly on the known historical earthquakes and tsunami together with the fact that GPS observations are consistent with the relative plate motions in the area. However, the lack of M>8 earthquakes and tsunamis can be due to the incompleteness of written history in relation with the lengthy subduction evolution (e.g. long recurrence interval of 500y or longer). Furthermore, at present, the consistency between GPS measurements and relative plate motion is still an indeterminate proof of an aseismic subduction.

Taking into account the above uncertainties and the amount of possible damages of an Mw8 earthquake from Ryukyus on southern Japan, we examine the possibility of seismic subduction along the Ryukyus with the following hypothesis. A coupled interface between the slab and overriding plate in the upper 30-70km portion of the interface from the seafloor with a slip deficit (back slip) with a dip angle of 8-10cm and 20^{o}, respectively is assumed. With such setting and in the case of a coupled slab interface of the upper 50km or less, presuming some error of the plate motion, it would be difficult for the GPS observations to distinguish whether or not the two plates are locked. If such coupling portion exists on the Ryukyus, the accumulated slip for the last 1000y is about 80m. Apparently, this amount of slip could trigger large magnitude earthquake(s) along the Ryukyu trench and could produce a large tsunami.

Considering the above possibilities and the question about Ryukyus plate boundary coupling conditions, we hereby propose an observation technique to solve the current by using the ocean-bottom crustal deformation system (OBCDS). This technique has a present accuracy of 3-5cm +-1cm in a 3- or 4-day duration per observation period during summer seasons. At least a period of 2-3 years is the minimum observation with the first year focused on the installation of ocean-bottom transponders near the trench axis.

The Manila and Philippine trenches are similarly thought to be poorly coupled. Luzon is characterized by a tectonically active plate boundary zone, comprising mobile elastic tectonic blocks between two active subduction zones. However, it is not well established by seismological and geodetic methods. A GPS transect observation in northern Luzon where the accommodation by strike-slip motion along the Philippine fault is negligibly small. If six GPS receivers are set at 10 campaign and one fixed observation sites, we will be able to invert simultaneously the obtained data to estimate the plate fault-locking parameters for each of the subduction zones. The application of the OBCDS observation can further strengthen the above estimation of the subduction processes.

Fault mechanism and essential parameters for predicting tsunami generation in South China Sea

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Abstract

Tsunami warnings have always been made from imperfect and limited data often relying solely on the earthquake magnitude and epicenter location. Large earthquakes (M>7) occurring in a deep sea, often cause significant tsunamis. However, tsunamis generation are not determined by the magnitude of the earthquake alone, but also affected by the fault rupture mechanism and type of fault. Thus the prediction of tsunami generation is very complex.

Since the earthquake signal travels 20-30 times faster than tsunami, the seismic signals can be used for tsunami prediction and warning. For accurate prediction of the generation of a tsunami, various parameters of the tsunami source have to be obtained in real time. Besides the earthquake magnitude and the epicenter location, the fault rupture area, the amount of slip and the orientations of the fault plane are important indicators for tsunamigenesis. This study aims to study the computation of these parameters in real time (i.e. few to tens of minutes after an earthquake of M>7 happened in deep sea). These parameters will be used to run tsunami propagation modeling to compute tsunami arrival times, wave heights and run-up at the shores.

This tsunami prediction was further enhanced by signals analysis methods, namely Fast Fourier Transform (FFT) and Continuous Wavelet Transform (CWT). These analyses were performed on the time series records of both the tsunamigenic and non-tsunamigenic earthquakes in the South East Asia and the South China Sea region. The FFT revealed that tsunamigenic earthquakes are rich in long period energy and depleted in high frequency energy. The CWT not only confirmed this finding but also showed the precise time when these frequencies occurred in the signal. The long period energy is mainly associated with slip on the fault plane. Therefore, the proposed methods of FFT and CWT can successfully extract the slow rupture and large slip phenomena from the seismic signals of tsunamigenic earthquakes. This finding can be used for diagnosis of tsunamigenesis in the advancement of timely tsunami prediction and warning.

Review of seismic activities in the Manila-Taiwan subduction zone

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Abstract

Earthquakes that cause devastating tsunamis are shallow events in subduction zones. Accordingly, one of the major sources of tsunami hazards for areas around the South China Sea is major earthquakes in the Manila Trench, Luzon Trough and Taiwan subduction system. In this study, we estimate probabilities of such events based on various earthquake catalogue, sorting events between 0 and 70 km associated with the subduction system. Results of historical catalogue indicate 5 events with $M_s \geqq 7.5$ for the past century. Among them, the 1920 (M_s =8.2) offshore Hualein and the 1934 (M_s =7.9) west of Luzon island are the largest. The frequency-magnitude relationship is obtained based on the EHB catalogue (Engdahl et al., 1998), which recorded earthquakes back to 1963 and is relative complete attributed to the deployments of WWSSN at the same time. Frequencies of small earthquakes suggest that the average period is 28 years for $M_s \geqq 7.5$ events and 72 years for $M_s \geqq 8.0$ events, consistent with observations of the historical catalogue. By assuming normal distribution of a probability density function, we estimate that the probability for an $M_s \geqq 7.5$ event to occur in the subduction system within next 20 years is 87% and 61% for an $M_s \geqq 8.0$ event. Using the Harvard CMT catalogue (Dziewonski et al, 1983, and subsequent quarterly updates), we categorize earthquakes into normal fault, trust fault or strike slip groups and investigate their spatial characteristics and size relationships. We will also estimate the ratio of seismic convergence rates, as derived by the moment sum of CMTs, to the rates of Eurasia-Philippine relative motion, as derive by NUVEL-1A model (DeMets et al., 1994). Meanwhile, from Taiwan perspective, we will simulate the 1771 Yaeyama tsunami (Nakamura, 2006) to understand its possible treat to Ilan. The tsunami amplitudes are unusually high (~30m) on the southeastern coast of Ishigaki island. Regions of potential tsunami sources, including landslide and earthquakes, in the east offshore of Taiwan are examined as well.

POSSIBLE FUTURE RUPTURE SCENARIOS OF THE MANILA TRENCH

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Abstract

The Manila Trench extends along the western coast of the Philippine archipelago, from 11.5^{0}N (Mindoro island) to 22.75^{0}N (southwestern Taiwan), with a total length of over 1000 km. It forms an east-dipping subduction zone, which initiated in the early Miocene (~ 20 million years ago) and remains active to the present day. A 3D rupture surface is created from the existing seismicity and tomography data, resulting to a sinuous geometry with two distinct bends at 13^{0}N and 20^{0}N, as shown in Figure 1. The movement of the Luzon island relative to the Eurasian plate is assessed from the available GPS measurements done by Yu et al. (1999). The velocity vectors are decomposed into the trench-normal and trench-parallel components, where the former is related to the slow accumulation of strain along the subduction interface. A value of 40 m is chosen as the maximum slip of a large megathrust earthquake. As the maximum convergence velocity along the Manila trench is 86 mm/year at the northern Luzon island, it would require 465 years to accumulate 40 m of strain. This time period is then used to scale the magnitude of coseismic slip along the rest of the subduction zone, which is shown in Figure 2. This detailed study of possible rupture scenarios along the Manila Trench is motivated by the need to assess the tsunami hazard within the South China Sea basin, posed by the future ruptures of the trench.

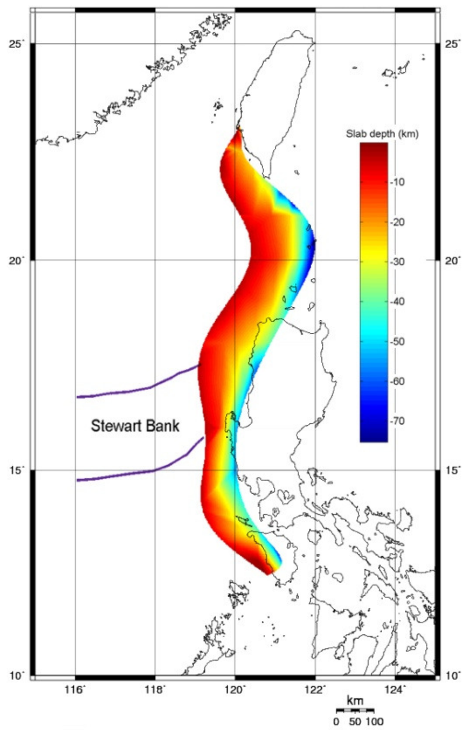

Figure 1

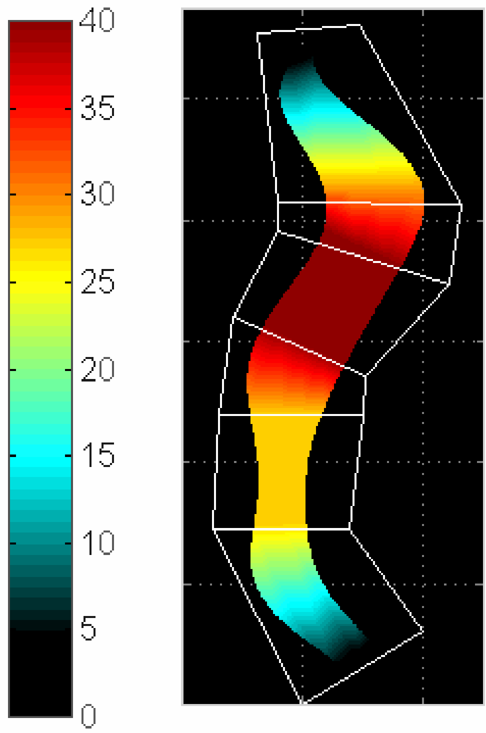

Figure 2

TSUNAMI HAZARDS NEAR TAIWAN AND IMPLICATIONS FOR RHEOLOGICAL STRATIFICATION UNDER TAIWAN.

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Abstract

The recent Pingtung earthquake in December, 26, 2006 has evoked our interest about tsunami generation around the Taiwan region.Yet the tsunami waves produced were by this event were small, less than a meter. This result was somewhat surprising .There were two rupture events, the first with a depth of around 40 km and the second around 20 km. They had different focal mechanisms with normal faulting for the top event and extensional mechanism at the bottom. The surface vertical displacements associated with the initial dislocation at depth were very small. They are in agreement with the observed GPS data. One possibility for this finding would be due to a decoupling between the crust and mantle portion of the lithosphere, owing to a low viscosity crust layer situated near the Moho. The idea of a low viscosity crustal layer has also been invoked to study crustal dynamics in the Tibetan plateau (Wang et al., 1982) from intrusion of the Indian plate.

We employ the 2D thermo-mechanical visco-elasto-plastic finite element code called SloMo [Kaus, 2005; Kaus & Becker 2007; Kaus & Schmalholz 2006] to study lithospheric stress evolution in a number of test scenarios that have been proposed for Taiwan. The models include a self-consistent free-surface, moving tracers to track material properties, such as the rheology, and a refined mesh around the trench area. Our aim here is to obtain physical insight on the influence of lithospheric rheology as well as boundary conditions on the lithospheric stress. For this purpose we performed a number of quasi-instantaneous, isostatically equilibrated, models. The models included a 2000km by 670 km region of the upper mantle, in which different phases were assigned different compositions. In some experiments, the Phillipine Sea plate (PSP) subducting velocity was assigned a horizontal compressional velocity of 8 cm/yr (and the mantle was extended accordingly to maintain mass balance), whereas in others only the effects of buoyancy was considered. The various lithospheric layers were different viscosities to broadly mimic, but not exactly reproduce, the effects of temperature-dependent rheology. Mesh resolution is 1.6 km x2.5 km in the trench area and increases to 9.5 km x16.5 km in the mantle. A weak lower crust results in normal-fault stress states in the upper mantle, as indicated by the vertical principal stresses, whereas a weaker lower crust results in a thrust-dominated stress regime in the mantle lithosphere. The horizontal motion of the PSP contributes little to the stress state at depth. We have also studied the stress state in alternative lithospheric models, in which the mantle lithosphere is weak. Indeed, we can find a thermo-mechanical model proposed by Suppe (1981), in which Taiwan can deform like a critical wedge. Our results show the importance of crustal rheological stratification in Taiwan geodynamical modeling. These two-dimensional models are needed before going to the more complicated 3-D models.

Numerical Simulation of Tsunami propagation and Inundation on the West-Coast of South China Sea

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Abstract

The report presents research results on numerical simulation of long waves generated by submarine earthquake, propagating and attacking the west coast of the South China Sea. The numerical study is based on the non-linear shallow water equation and a TVD numerical scheme. The run up of tsunami on coast is modeled using a special technique somewhat similar to the VOF method, to ensure the mass conservation at the wet-dry areas.

Modeling of tsunami run-up and inundation in Singapore

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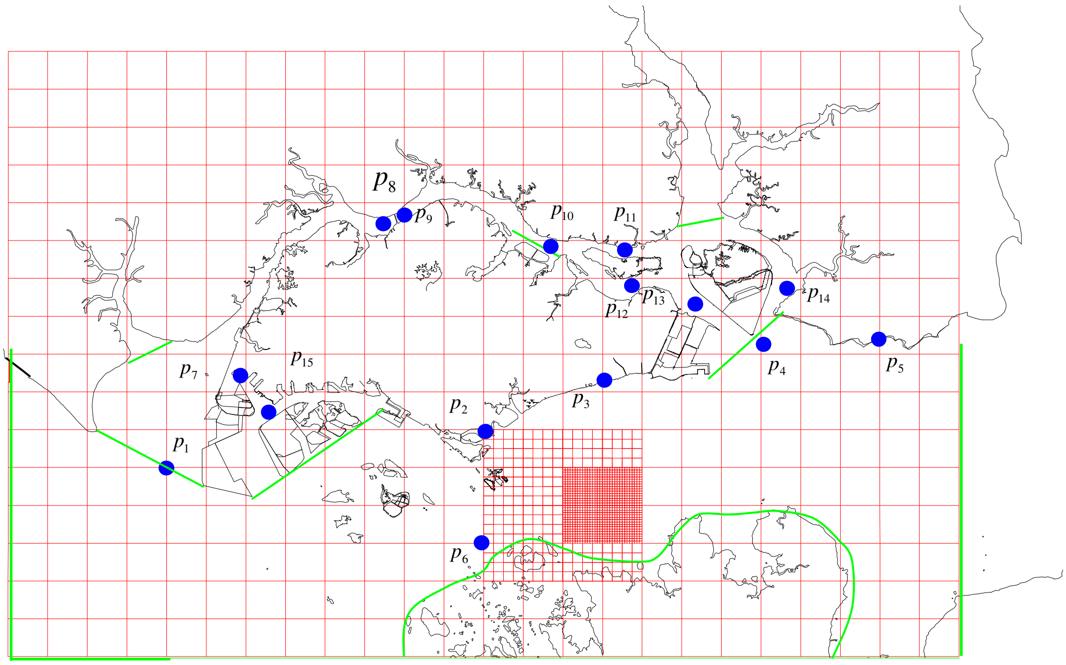
Abstract

Our recent effort in modelling the interaction between tsunami waves and an erodible shore along the Singapore Island is reported in this presentation. To reflect the complex shoreline and near shore topography, a fine resolution grid is required and special care need to be taken on the numerical discritisation schemes, the open boundary condition and dry and wet condition required to model the wave run-up on shore. Our model is based on the method proposed by Liu, et al (1995). Figure 1 shows the domain of the numerical computation, which includes the 2 Johor Straits, a number of rivers and the major islands in the south and East Johor Straits. Based on the shallow water wave equation, a finite difference code has been developed. The development of our numerical model, which couples the hydrodynamic model with sediment transport model and morphological model, for the region relevant to Singapore is presented herein. Our inundation prediction is based on the tsunami waves generated by the possible rupture of the Manila Trench. Numerical results on wave heights and wave run-ups at selected locations in the domain as shown in Figure 1 will be reported.



Reference

1. Liu P. L.-F., Cho Y-S, Brigs M. J., Kanoglu U., and Synolakis C. E., 1995. Run-up of solitary waves on a circular island, Journal of Fluid Mechanics, vol. 302, pp. 259-285.

Tsunami Runup and Inundation Simulation in Malaysia Including the Role of Mangroves

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Abstract

An in-house tsunami simulation model TUNA was developed in Universiti Sains Malaysia to simulate the 26 December 2004 Andaman tsunami, from source to propagation and runup. This presentation will focus on the runup and inundation processes including the assessment of the role of mangrove forests towards mitigating the hazards of tsunami waves on beaches. This runup and inundation model is based upon the nonlinear shallow water equations, solved by the explicit finite difference method with step size of 50 m or less. Simulated runup heights and inundation distances compared reasonable well with measured data collected soon after the said tsunami along some affected beaches in Penang and northwest Malaysia. Our analysis indicates that a grid size of 50 m may be too coarse to capture the fine details of the wave structures along beaches because of the steep gradients of the waves. A grid size of 1 m or less is needed to resolve the fine structures of wave. Other methods such as shock capturing techniques employed in the aeronautic engineering will also be discussed.

The interest to assess the role of mangrove forests towards mitigating the hazards of tsunami has recently been rekindled particularly in Japan. This paper will therefore also present simulation results on the role of mangrove forests in mitigating tsunami hazards. A mangrove tree is represented by a combination of root system, trunk and leaf canopy in the shape of cylinders, each been parameterized by a set of values. Sensitivity of wave response to several setups such as mangrove forest widths, density and wave periods will be analyzed by means of this simulation model. A grid size of 20-40 m is typically used, while smaller grid sizes are regularly used to check the results.

Keywords: Tsunami inundation simulation, Role of mangroves

A numerical model for tsunami runup calculation

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Abstract

This paper describes a numerical model for the simulation of tsunami runup on land. The dynamics of tsunami runup is simulated by solving the depth integrated shallow water equations together with continuity equation with a Crank-Nicholson time discretization scheme. To save computational time and memory, the model allows use of coarse grid mesh. With this grid mesh, the wave runup on beach and land is simulated by a scheme, similar to the Volume Of Fluid (VOF) technique. This enables an accurate determination of the flood front inside each grid mesh. For this, the concepts of wetted area (the ratio between the wetted area within each grid mesh and the total area of the mesh) and the wetted length (the ratio between the wetted length of each side of the mesh and the total length of the side) are introduced. The flow resistances due to wood and on land structures, such as roads, houses, or high land etc. within each grid mesh are also accounted for by using experimental results of the Public Work Research Institute, Japan. The verification of the model again indoor experiment and field data reveals that model is capable of simulating the tsunami runup and inundation on land with satisfaction accuracy.

Taiwan seismic network status and plans for seismic monitoring cooperation with countries surrounding the South China Sea

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Abstract

More than 50 broadband seismic instruments are currently operated by Institute of Earth Sciences (IES), Academia Sinica to study the earth deep interior and seismic hazards. It was part of the Broadband Array in Taiwan for Seismology (BATS) and designed to deploy within Taiwan and its surrounding islands in the past. However, it is currently encouraged by the National Science Council, Taiwan (NSC) and Academia Sinica to distribute abroad for international cooperation and extension of research topics. Currently, 25 portable stations are deployed in northern Vietnam to study the geodynamic evolution of the Red river fracture zone and planned to distribute to southern Vietnam and Philippines, in near future, to study the geodynamic evolution and its deep structures of the South China Sea. In our planning, some high quality stations may be left as permanent stations and added continuous GPS observations, and instruments to be maintained and operated by our cooperation institutes, for instance, Institute of Geophysics, Vietnamese Acadamy of Sciences and Technology (VAST) in Vietnam and Philippine Institute of Volcanology and Seismology (PHIVOLCS) in Philippines. Finally, those stations will be planed to upgrade as real time transmission stations for earthquake monitoring and tsunami warning. Recently, this portable seismic array has been found to construct satellite real-time data transmission system for data collection. In near future, we should have ability to contribute data from stations on remote sites. We are searching for new cooperation from the surrounding countries of the South China Sea to install new seismic stations to construct a complete seismic network of the South China Sea.

Construction of the Marine Earthquake and Tsunami Monitoring Stations

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Abstract

China is a country with long coastline and vast sea area. The East China Sea is located to the west of the Pacific Ocean, between the circum-Pacific seismic and volcanic zone. The monitoring of marine earthquake and its disaster, however, is currently still in the weak stage. In 2004, Earthquake Administration of Shanghai Municipality made an investigation and put in plan for this project, and proposed two different ways: setting up the comprehensive ocean bottom earthquake and tsunami monitoring stations (equipped with seismometers, tsunameters, tiltmeters and magnetometers…. etc.), and deploying the ocean bottom broad band pop-up seismometer stations, so as to accelerate the construction of marine earthquake and tsunami monitoring stations, and undertake a prior test for earthquake and tsunami monitoring, data acquisition and data processing.

Main Task for Research and Construction
Setting up the comprehensive Ocean Bottom Earthquake and Tsunami Monitoring Stations

This project utilizes the three component broadband seismometers, the 24-bit data acquisition unit, the solar energy power supply system and the methods of communication of satellite and GPIS to meet the demand of anticorrosion, lightening protection, high stability and low power consumption. This project plans to set up two stations for the first time which will be located at the sea area to the east of the Yangtze River Estuary, about 100km from the coastline. The thickness of sedimentary cover is about 200-240m there.

The implementation process of this project is: First, we should design and build two marine seismostations with flexible-joints-stake on land, and deploy it at the predetermined location. Then, the engineering exploration ship sails into the location and bores the hole to put the seismometer into the borehole, and put the seagauge wave and tide recorder on the seabed. Then, we use the cable to connect the receiver and transmitter of this marine seismostation. After the success of this implementation, the data will be automatically recorded and transmitted real-time and/or delay-time via satellite. The daily power consumption is supplied by the solar cell.

The preparation of this project began in 2005. Currently, most preparation work is finished. It is planed to undertake the work at the predetermined sea area in Sep-Nov., 2007.
Deploying the Ocean Bottom Broad Band Pop-up Seismostation

This project plans to build 8 sets of OBS. Its unique design features are: the total weight (including anchor) is less than or equal to 300kg; the whole system of OBS consists one or two Benthos glass sphere, frame and anchor etc; the mean power consumption of system is less than 3W; every operation period lasts more than or equal to three months; each OBS is equipped with high performance lithium cell. The specification of seismometer shows that the bandwidth: 0.01Hz-50Hz; dynamic range >126db; 24-bit data acquisition unit; dynamic range of the acquisition unit > 130db; 64M flash buffer storage; can be automatically storied into 50G hard disk etc. The main activity of operation for this project is deployment, retrieve and routine work. The deployment will be carried out by using the crane on the engineering ship with the sinking velocity about 1m/s. As for the retrieve, the rising velocity is about 1m/s with the retrievable rate 80%.. At present, the preparations are ready and the purchased equipment installation is finished. It is planed to deploy OBS at the predetermined sea area in Nov.-Dec., 2007, so as to put it into normal operation.

Objective
Setting up several small-scale earthquake and tsunami monitoring stations.
Deploying several ocean bottom seismometers and tsunameters.
Reserving the technology, accumulating the experience and drawing up the regulation for the construction of earthquake and tsunami monitoring network at the coastal sea area of China.
Undertaking prior test for the construction of comprehensive multifunctional marine research platform in the future.

Current Initiatives on the Development of Tsunami Early Warning Systems in the South China Sea Region

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ABSTRACT

After the occurrence of the disastrous tsunami in the Indian Ocean in 2004, several countries bordering the South China Sea have indulged in ambitious network upgrading and development program to boost their capability for tsunami early warning. Indonesia, one of the hardest hit countries, received enormous amount of financial, equipment and technical aides from developed countries to upgrade and expand its seismic and tsunami monitoring network. According to the recent results of the Tsunami Task Force Meeting of the Subcommittee on Science and Technology of ASEAN, Indonesia has already installed about 67 of the 160 real-time seismic stations targeted to be completed by end of 2008. For sea level monitoring, 11 real-time Tide Gauge stations out of a total 80 and 2 DART BUOYS out of a total 22 that are planned were already installed. For rapid mass alerting, 43 siren towers out of the 200 towers that are planned were already installed. All of these stations are, however, installed only in Indonesian territories.

Malaysia, another country affected by the Indian Ocean Tsunami, had also upgraded its monitoring network. Fourteen real-time seismic stations have already been built and 3 more will be completed by the end of 2008. Two DART Buoys have been installed in the sea near Sumatra and in the South China Sea. One more will be installed in the Sulu Sea by October of 2007. There are now about 6 operational real-time Tide Gauges and 16 more are planned to be completed. A total of 4 coastal cameras have been installed and 14 more will be completed in 2009. Public announcement systems and sirens have been installed in 9 locations in the Peninsula and Sabah while 14 more will be targeted throughout Malaysia.

Thailand, on the other hand, also upgraded its seismic monitoring network. Fifteen real-time seismic stations have been installed in 2006 and 25 more will be completed in 2008. Its first DART Buoy was installed in December of 2006. A total of 99 Warning Towers was built along its western coast in 2005-2006 and 8 more will be put up in the eastern coast by the end of 2007.

Meanwhile, the Philippines has upgraded its seismic monitoring network as early as 2002 under support from the Japan government. To date, PHIVOLCS, the agency mandated for providing early warning on tsunami, has a total of 64 digital seismic stations. Thirty of the 64 are unmanned stations while the rest are manned stations. Data from the unmanned stations are currently being received on real time at its central receiving station in Quezon City. Nine of the 34 manned stations have broadband instruments and 3 of this were recently connected to the internet and streaming data is now also being received at the central station on very near real time. The institute also recently installed the first of the planned 10 real-time tsunami detection stations (wet sensor stations).

The Asian Disaster Preparedness Center (ADPC) plan is, however, the most comprehensive setup in the sense that 15 new real-time broadband seismic stations are planned to be installed in different countries around the South China Sea (5 in the Philippines, 5 in Vietnam, 2 in Myanmar, 2 in Lao PDR and 1 in Bangladesh). ADPC will be acquiring state-of-the-art real-time seismic systems to serve as the backbone of its planed Tsunami Early Warning System which will cover some parts of the Indian Ocean and the South China Sea. The central data acquisition system will facilitate real-time reception and automatic processing of steaming data from its 15 seismic stations as well as virtual data from existing networks in the region such as IRIS, USGS and different National Centers. The warning system is unique in the sense that it will be highly participatory and seismologists and oceanographers from the region being monitored will be engage on secondment basis in the operation of the system. ADPC will also provide for Capacity building of National seismic and tsunami monitoring centers and disaster management organizations in participating countries to make the warning process end-to-end. A multi-hazards approach will also be incorporated in the system to make the center sustainable.

The roles and responsibilities of the Institute of Geophysics (IGP) in tsunami research, and early warnings for Vietnam

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Dr Tran Thi My Thanh - Senior Researcher

Dr Le Tu Son - Head of Seismograph Network

Abstract

Since the devastating tsunami of December 2004, the Vietnamese government has commenced a number of initiatives to address the risk of tsunami including the setting up a national center for early tsunami warnings, upgrading and constructing new seismograph stations and undertaking research into the risk of tsunami along the long coastline of Vietnam. This paper will outline these activities and the roles and responsibilities of IGP in their implementation.

The paper will also describe some of the co-operative projects between Vietnam and other countries including New Zealand, Taiwan, Japan, Thailand, the Philippines and Indonesia. A number of tsunami-related projects that IGP has been involved with other national research and educational institutes will also briefly mentioned.

Effect of sea-dikes on tsunami run-up

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Abstract

Located on the circum-Pacific seismic belt, earthquakes are common nature hazard in Taiwan. In comparison with the high occurring frequency of earthquakes, on the other hand, there was no notable tsunami hazard in the past century. The 2004 Sumatra earthquake and the resulting tsunami have greatly increased the public awareness and the scientific and engineering interest on the potential of tsunami impacts. "How bad can it be if it can happen here?" becomes one of the most frequent asked questions.

The run-up height or the inundation length of a tsunami is the most important point that directly link to a tsunami hazard. There have been a number of analytical and numerical studies on the propagation and run-up of tsunamis. However, the reality is much more complicated that sometimes local boundary conditions would dominate the final results. The key feature of the coastal landscape of Taiwan that differs from others place is the common concrete sea-dikes or revetments. Along the 1,141 Km coasts in Taiwan, there have been 369.8 Km protected by concrete structures.

The objective of present research is to look into the effect of sea-dikes on tsunami run-up. A SPH (smoothed particle hydrodynamics) model will be used to calculate the run-up on a slope with a sea-dike. Meanwhile, a physical model simulating a typical coastal topography in the west coast of Taiwan will be conducted to verify the numerical model.

Simulating Mangrove Succession and Recovery After Tsunami

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Abstract

Large stretches of coastal mangrove forests were destroyed by the 26 December 2004 Andaman tsunami. Replanting mangroves after the destruction has not met with good measure of success due to various reasons, which are partially understood at this moment. Hydrology and salinity conditions in relation to species composition and initial distribution are considered important contributing factors towards a successful recovery of mangrove forest. In this paper, we will present simulation results on the competition advantage of mangrove over hardwood hammocks in south Florida following a major event such as a hurricane that inundates the affected coastal region with large volume of highly saline seawater. Hardwood hammocks would have the competitive edge in regimes with low salinity and initial high density of hammocks. This is because each species has evolved the mechanism to create a local environment in favor of its success, a process that may be enhanced by a high initial density. This competitive advantage depends on several factors, the combination of which often produces spatial-temporal patterns of intense interest in ecology. We hope that this simulation analysis on mangrove succession conducted in south Florida would provide some insights and experience regarding mangrove vegetation succession and competition following a major destruction with the hope that this research could be readily extended to mangrove succession after a major tsunami inundation such as the 2004 Andaman tsunami. This is possible when the required scientific data regarding the ecology of mangroves and the hydrology and salinity regimes relevant to the competitive advantages of mangrove species are known. We are in the process of securing a research grant to pursue this research interest. In view of the fact that the South China Sea regions are fringed by stretches of mangrove, we hope our research would invite potential collaboration.

Keywords: Tsunami, simulating mangrove recovery