THE POTENTIAL OF SATELLITE REMOTE SENSING ON REDUCTION OF TSUNAMI DISASTER

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ABSTRACT. It's used to be said that tsunami is a rare event. The recurrence time of tsunami in Sumatra area is approximately 230 years as CalTech Research Group's study from paleocoral. However, the tsunami occurred in Indian Ocean on 26 December 2004, 28 March 2005 and 17 July 2006, because the earthquakes still release the energy. To cope with the tsunami disaster, we have to put the much effort on better disaster preparedness. The Tsunami Reduction Of Impacts through three Key Actions (TROIKA) was suggested by Eddie N. Bernard, the director of NOAA/PMEL (Pacific Marine Environmental Laboratory). They are Hazard Assessment, Mitigation and Warning Guidance. The satellite remote sensing has potential on these actions. The medium and high resolution satellite data were used to assess the degree of damage at the six-damaged provinces on the Andaman seacoast of Thailand. Fast and reliable interpretation of the damage by remote sensing method can be used for inundation mapping, rehabilitation and housing plans for the victims. For tsunami mitigation, the satellite data can be used with GIS to construct the evacuation map (evacuation route and refuge site) and coastal zone management. It is also helpful for educational program for local residents and school systems. Tsunami is a kind of ocean wave, therefore any satellite sensors such as SAR, Altimeter, MODIS, Landsat, SPOT, IKONOS can detect the tsunami wave in 2004.The satellite images have shown the characteristics of tsunami wave approaching the coast. For warning, satellite data has potential for early warning to detect the tsunami wave in deep ocean, if there are enough satellite constellation to monitor and detect the first tsunami wave like the pressure gauge, seismograph and tide gauge with the DART buoy can do. Moreover, the new methods should be developed to analyse the satellite data more faster for early warning procedure.

KEYWORDS: Tsunami, Mitigation, evacuation plan, satellite.

1. INTRODUCTION

The lessons learned from 26 December 2004 tsunami in the Indian Ocean indicate that the three activities of hazard assessment, warning guidance, and mitigation can effectively reduce the impact of tsunamis to coastal communities. These activities will be combined together into a coherent plan of action designed to help the global community threatened by tsunami hazards. The satellite data have potential for these three activities in order to reduce the impact of tsunami disaster.

2. TSUNAMI: REDUCTION OF IMPACTS THROUGH THREE KEY ACTIONS (TROIKA)

An implementation plan can be constructed describing the three actions:

2.1 Hazard Assessment---

Generating local and distant tsunami inundation maps for coastal communities using internationally accepted numerical model methodology such as MOST. Estimates of coastal areas susceptible to tsunami flooding will be available from a network of modelers and data managers who will be sharing community modeling tools via the Internet as community model.

2.2 Mitigation---

Developing response plans for emergency managers, placing tsunami evacuation signs in threatened coastal areas, and maintaining a tsunami educational program for local residents and school systems. This action also includes vulnerability and risk assessments. The problems can be solved by soft, hard and hybrid measures.

2.3 Warning Guidance---

Developing and deploying a network of early warning tsunami detection buoys in the world's seismically active coastal areas to complement the global network of real-time broadband seismometers and to supplement regional tsunami warning centers (Bernard, 2001).

3. POTENTIAL OF SATELLITE ON TSUNAMI DISASTER

The satellite remote sensing has some capabilities for these three actions.

3.1 Hazard and Risk Assessments---

In order to consider emergency response and rehabilitation planning after tsunami disaster, it is important to find out the damage distribution and degree of damage as soon as possible. Remote sensing technologies have been utilized for the evaluation of disaster damage because satellite images can widely capture surface ground conditions before and after the disaster. In Thailand, the medium and high-resolution satellite data were used to assess the level of damage at the six-affected tsunami provinces on the Andaman seacoast. The satellite remote sensing has proved to be a powerful tool and cost-effective for tsunami damage assessment (Figure 1) than the conventional field survey methods, because it takes longer time and lesser area. The quick result is useful for producing the inundation maps (Figure 2) with GIS, the evacuation routes and refuge sites can be planned for future disaster. This outcome with the run-up data can be used for planning the coastal zone management regulation, rehabilitation, hazard zoning (Figure 9), risk map, vulnerability zone with building code and insurance program.

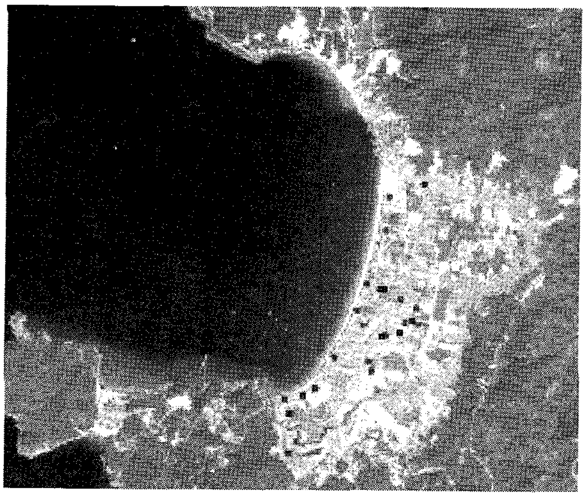


Figure 1. The damage assessment at Patong Bay, Phuket Province. The red dots are the run-up and flow-depth surveys.

At Phuket province, Patong Bay is the most damage area in this province according to the Landsat analyses using NDVI method. The boundary of the inundation area can be delineated from Figure 1. If we use GIS of the road map, we can define the evacuation route and the refuge sites. With higher resolution such as IKONOS, the degree of damage is clearly seen in Figure 3, which can be used to produce the risk map and for coastal zone management.

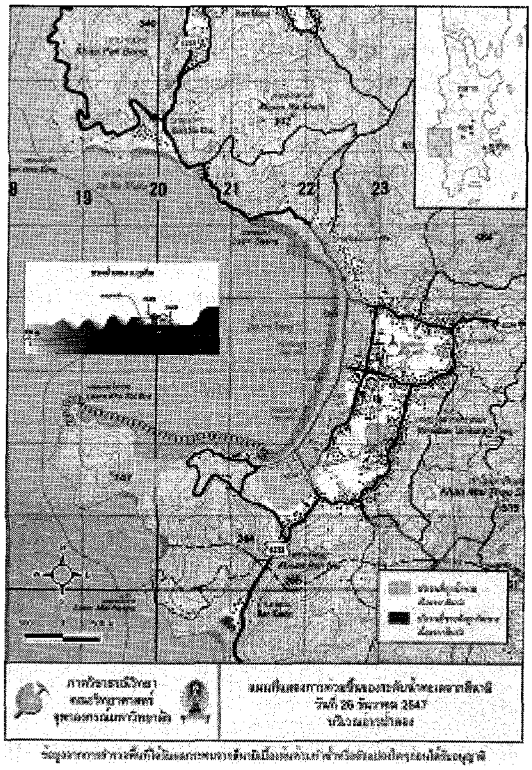


Figure 2. Inundation map of Patong Bay.

3.2 Mitigation Plan and Tool---

For emergency manager, the result from satellite data can be used to develop the response plans, placing tsunami evacuation signs in risky area. It can also be used to demonstrate the threatened coastal areas for local residents, school system and stakeholders such as hotel groups. The mitigation strategy planning is composed of identify the tools to reduce the problems such as coastal erosion, and evaluating and selecting the mitigation tools (soft or hard measures). The satellite data can be helpful to detect the coastline change (Figure 6) and evaluate the mitigation tools. Integrative planning can establish a framework within which to prioritize locations for forests, and vegetation buffers or coastal zone management.

2.3 Warning Guidance---

In Pacific, the DART buoys were deployed for tsunami detection. It is composed of bottom pressure gauge to detect the tsunami wave and the earthquake. The net work of tide gauge and seismography were installed around the ocean for warning purpose. When the tsunamigenic-earthquake occurred, the initial of tsunami wave was sent via satellite to the warning center. They will run the tsunami model to forecast the arrival times and tsunami heights to the various coastal sites. However, this procedure takes more than half an hour to run the tsunami model and it is not quick enough to issue the warning.

Without the DART buoys, the warning center prepare the data base of the scenarios using tsunami model from various hypothetical earthquake sources. The more scenarios, the more accurate and faster of the warning.

Song (2005) used satellite altimeter data and ocean model to construct the tsunami genesis and its simulation These satellite observations give the spatial and temporal patterns of tsunami waves in the open ocean. However, they cannot provide early warning because of time-delay in data processing. These can be solved for more faster analysis method and constellation of satellite. The tsunami prediction can save lives and reduce “false alarm”.

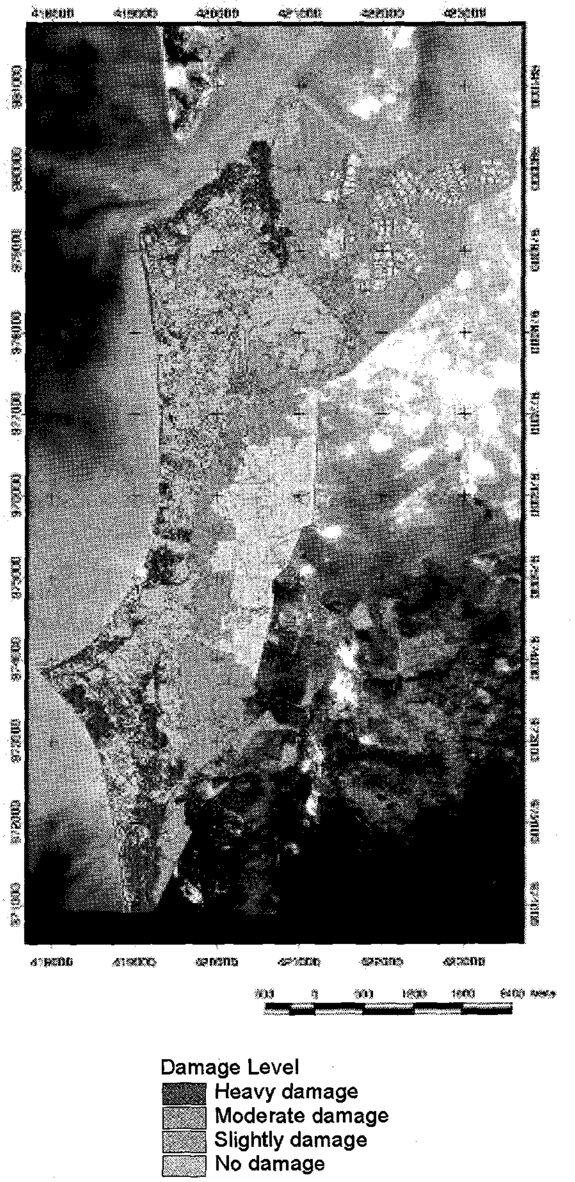


Figure 3. Level of tsunami hazard at Ban Num Khem Amphoe Bangmuang, Phang Nga province from IKONOS.

Since the tsunami is a kind of surface ocean wave, satellite sensors such as altimeter (Figure 4), SAR and optical sensors (figure 7) can detect the tsunami as evidenced from 26 December 2004 tsunami. The satellite and radar data can detect the current and turbulence of the tsunami.

Figure 4. Tsunami wave from satellite altimeter.

Figure 5. Brueh Island 2004 tsunami whirlpools from SPOT (http://walrus.wr.usgs.gov/tsunami/workshop/LudwinColorado_Abstract.pdf#search=%22tsunami%20whirlpool%22)

During the 2004 Indian Ocean tsunami, whirlpools were imaged by SPOT satellites and reported by observers in a least a half-dozen locales as shown in Figure 5 .

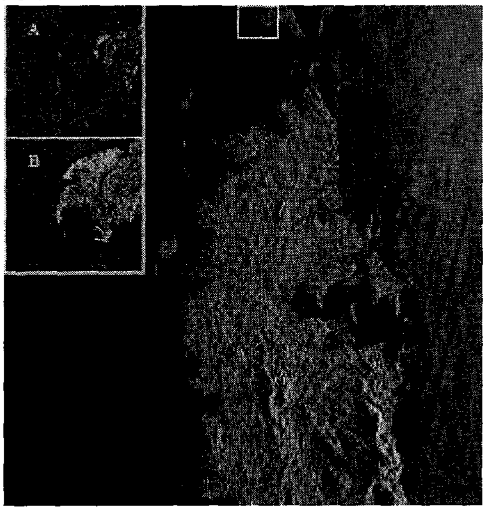


Figure 6. RGB colour composition of N. Andaman Island: R = pre-seismic 03/06/2004, G-B = post-seismic 30/12/2004; in the yellow box a detail of the risen-up lands: A) pre-seismic image, B) post-seismic image. (Bignami et al 2005. http://earth.esa.int/workshops/fringe2005/participants/50/paper_Bignami_fringe2005.pdf)

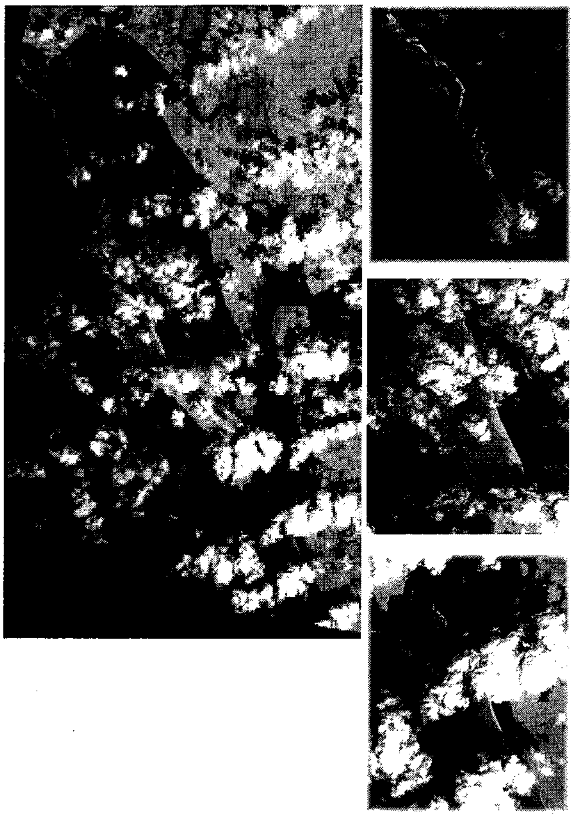


Figure 7. SPOT images on 26 December 2004 at 4.01 GMT, showing tsunami wave approaching Krabi coast of Thailand.

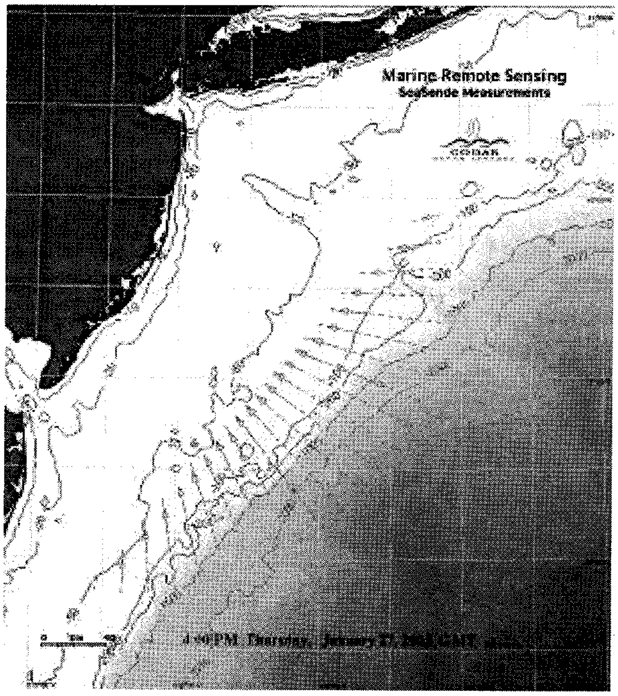
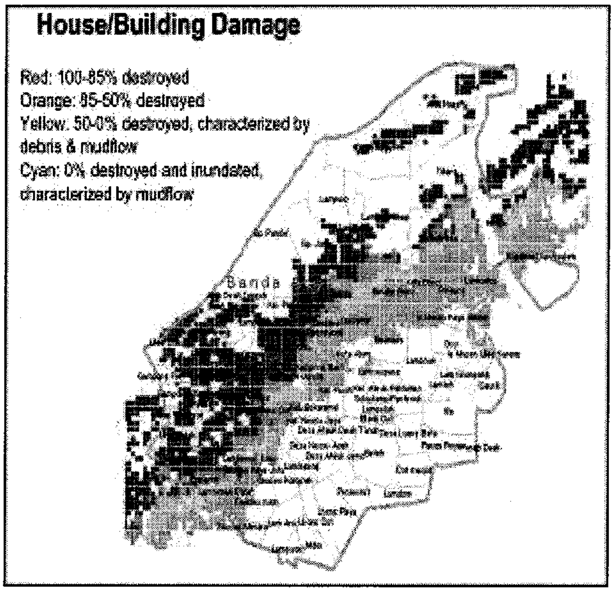


Figure 8. SeaSonde Tsunami radial signature after ½ hour onset at shelf edge (Barrick et a., 2005).

The SeaSonde coastal HF radar can provide useful tsunami information from tens of minutes to hours before runup depending on the shelf depth and width (Figure 8). The shallow extended shelf (Thailand) will take longer time than narrow shelf (India). The HF radar should be used with other inputs for local depiction of expected tsunami impacts from calculations from numerical models and other sensors such as the seismic data and deep-water pressure observations. Moreover, Radars can parallel process for tsunami in background during normal continuous real-time coastal circulation observations



Red – Land Use/Siting Zone.

Yellow – Wave zone.

Blue – Flood zone.

White – Inland zone.

Figure 9 Zoning for rehabilitation and management programs of damaged house from tsunami. (Hwang, 2005).

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