Reducing the Impact: U.S. Tsunami Forecast Modeling and Mapping Efforts

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Abstract. U.S. tsunami preparedness efforts have been accelerated due to the devastating 26 December 2004 Indian Ocean Tsunami. The National Oceanic and Atmospheric Administration (NOAA) is the lead agency for providing tsunami forecasts and warnings to U.S. coasts. The NOAA Pacific Marine Environmental Laboratory (PMEL) plays an integral role in this effort through development of the tsunami forecast modeling system and development of standards and procedures for inundation modeling studies of at-risk communities. This presentation will provide an overview of PMEL Indian Ocean Tsunami model simulations and the role of GIS in U.S. tsunami modeling efforts.

Background

The United States has been involved in tsunami preparedness efforts (Table 1) since the 1946 Unimak Island, Alaska tsunami killed 173 people in Hawaii (Bernard, 2005). The National Oceanic and Atmospheric Administration (NOAA) is responsible for issuing tsunami warnings, and the NOAA Pacific Marine Environmental Laboratory (PMEL) has been active in associated research and development efforts as part of the U.S. National Tsunami Hazard Mitigation Program. Over the past eight years, PMEL has been involved in the development of technology for detecting and measuring tsunamis in the deep ocean, forecast models for providing real-time tsunami warning guidance, and tsunami inundation modeling products for state emergency management officials. Geographic information systems (GIS) plays an important role in all of these efforts. The following overview discusses the role of GIS in the analysis of numerical model simulations of the 26 December 2004 Indian Ocean tsunami and PMEL tsunami modeling efforts.

Tsunami Event (Year Month Day)	*Deaths*	*U.S. Response*
1946 04 01 Unimak Island, Alaska	173	Pacific Tsunami Warning Center is built by 1949
1960 05 22 Central Chile	1260	Joins International Tsunami Warning System in the Pacific established in 1968
1964 03 28 Prince William Sound, Alaska	132	Alaska Tsunami Warning Center is built by 1969
1992 04 25 Cape Mendocino, California	0	National Tsunami Hazard Mitigation Program is created in 1996

Table 1. U.S. tsunami mitigation history associated with events based on information from International Tsunami Information Center and NOAA Tsunami Database.

Modeling the 26 December 2004 Indian Ocean Tsunami

The 26 December 2004 earthquake off the northwest coast of Sumatra generated the deadliest tsunami of historical record (Table 2). Dr. Vasily V. Titov produced some of the first simulations of tsunami propagation within hours of the earthquake using the Method of Splitting Tsunamis (MOST) model (Titov and Synolakis, 1998). These simulations and others were used

by both disaster relief and scientific survey teams to make preliminary assessments of high impact areas (Smith *et al.*, 2005).

Date (Year Month Day)	*Location*	*Magnitude*	*Max. Runup (m)*	*Deaths*
-1410	Greece	?	?	100,000
1293 05 27	Kamakura, Japan	7.1	?	22,778
1498 09 20	Enshunada, Japan	8.3	4	26,000
1707 10 27	Nankaido, Japan	8.1	25.7	30,000
1755 11 01	Lisbon, Portugal	8.5	15	60,000
1782 05 22	Taiwan	7.0	17	40,000
1883 08 27	Krakatau, Indonesia	Volcanic eruption	35	36,000
1896 06 15	Sanriku, Japan	8.5	38.2	27,122
1976 02 04	Guatemala, Chimaltenango	7.5	?	23,024
2004 26 12	Offshore NW Sumatra, Indonesia	9.0	N/A	227,989*

Table 2. Tsunamis in history with > 20,000 deaths based on information from UNESCO/IOC/ITSU Historical Tsunami Database and NOAA Tsunami Database. *Death estimate as of 25 May 2005 from the Center of Excellence in Disaster and Humanitarian Assistance.

A large effort has been made by the tsunami research community to collect observations and measurements of the event. PMEL is using GIS to compare tide gage and buoy measurements, field survey data, satellite altimetry data (Smith *et al.*, 2005*)* and visual observations with MOST model simulations (Figure 1). GIS is also being used to develop medium-resolution digital elevation models (DEMs) in the Indian Ocean to create inundation model scenarios for the hardest hit regions. This work will lead to a better understanding of tsunami physics and more accurate warning guidance in the future.

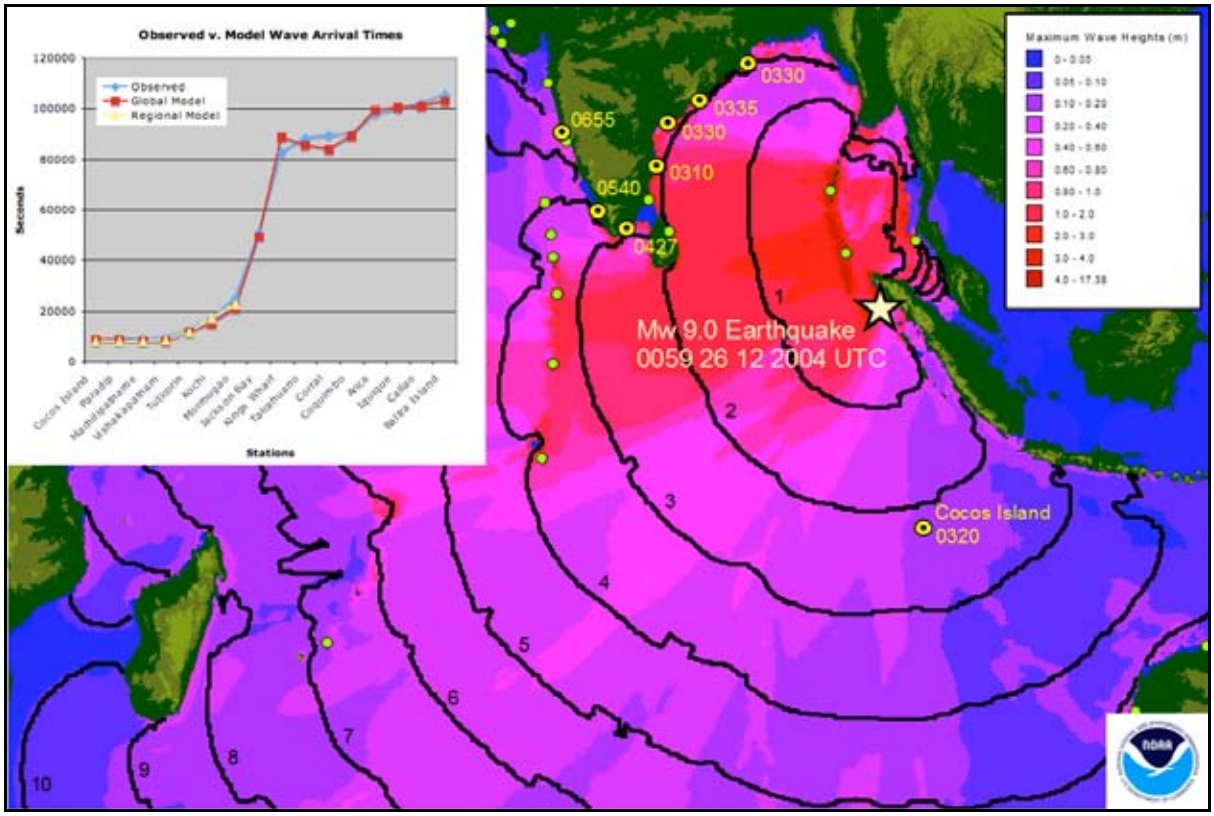

Figure 1. Comparison of wave arrival times from the MOST model simulation with tide gage measurements. Tide gage measurements were obtained from the West Coast and Alaska Tsunami Warning Center and the India National Institute of Oceanography.

GIS in Forecast Modeling

PMEL is developing a tsunami forecasting system that combines real-time tsunami and seismic measurements with precomputed numerical models to provide inundation forecasts (Titov *et al.*, 2005). GIS is used in the planning process to assess and prioritize at-risk communities along U.S. coasts. Nested DEMs are built in GIS for use in forecast models to simulate tsunami generation, propagation across the ocean, and inundation of the at-risk area (Figure 2).

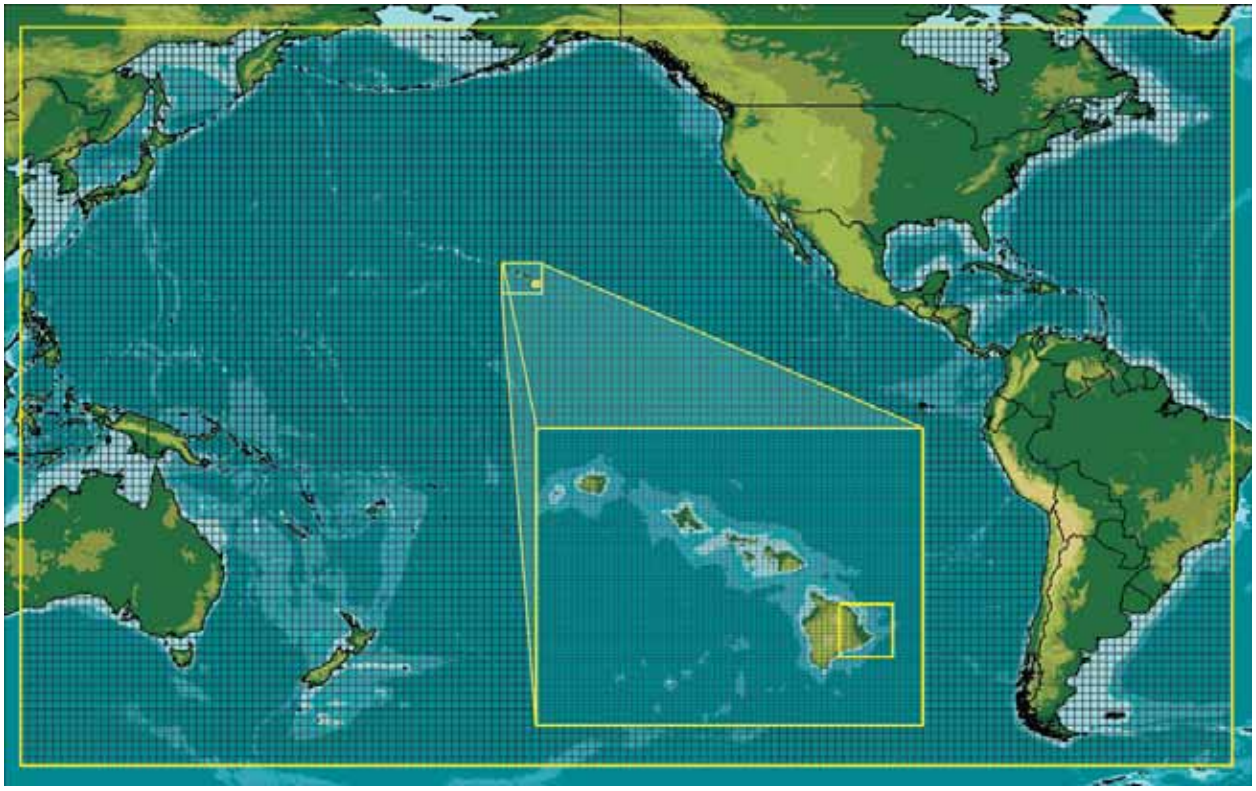

Figure 2. Example of nested DEMs for the tsunami forecasting system. Low- and intermediate-resolution bathymetric grids are used to simulate tsunami generation and propagation across the Pacific Ocean. Inundation is calculated using a high-resolution grid of bathymetry and topography covering the at-risk area.

Inundation model results are converted into easy-to-use GIS products that can be distributed to community planners. These products are combined with other hazard data to develop evacuation maps and public outreach materials (González *et al.*, 2005). Associated conversion and analysis tools are being developed to further enhance natural hazards planning.

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End Notes

For more information, please visit the following websites:

U.S. National Oceanic and Atmospheric Administration

http://www.noaa.gov/

NOAA Pacific Marine Environment Laboratory Tsunami Research Program
http://www.pmel.noaa.gov/tsunami/

International Tsunami Information Center
http://www.prh.noaa.gov/itic/

NOAA National Geophysical Data Center Tsunami Database
http://www.ngdc.noaa.gov/seg/hazard/tsu.shtml

UNESCO/IOC/ITSU Historical Tsunami Database
http://tsun.sscc.ru/htdbpac/

Center of Excellence in Disaster Management and Humanitarian Assistance
http://www.coe-dmha.org/tsunami.htm

U.S. West Coast and Alaska Tsunami Warning Center
http://wcatwc.arh.noaa.gov/

India National Institute of Oceanography
http://www.nio.org/jsp/tsunami.jsp

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