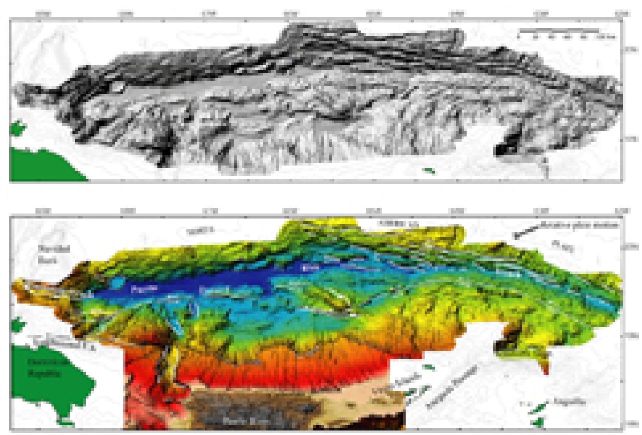
US Geological Survey - Woods Hole Science Center

Tsunami hazard potential in the Caribbean

SUMMARY:

Tsunamis are among the world#s most destructive coastal hazards. The sharp increase in coastal population density, the intense development of harbors and urban infrastructure, and the exploitation of mineral resources in coastal areas, all set up a potential disaster of catastrophic proportions. Tsunami events have been recorded in the Caribbean Sea since the 16th Century (Lander et al., 2002), and the number of tsunami casualties in the Caribbean exceeds that of the U.S. West Coast, Hawaii, and Alaska combined. There have been 91 reported tsunamis in the Caribbean basin since Europeans moved to the area, of which 27 events are very well documented and caused extensive damage and casualties. The most famous of these events include the Venezuela, 1530; U.S. Virgin Islands and northern Lesser Antilles, 1690; Port Royal, Jamaica, 1692; Martinique, 1755; St. Thomas, 1867; Puerto Rico, 1918; and the Dominican Republic, 1946 tsunamis. The great Lisbon earthquake of 1755 created a tele-tsunami with 6 and 7 meter-high waves in the Lesser Antilles. Evidence for significant paleotsunamis is also found in the sediments of the Netherlands Antilles at 400-500 ybp, 1500 ybp and 3500 ybp (Scheffers and Kaletat 2001). Although there have been deadly tsunamis in the NE Caribbean during the last century (1918: 42 persons and 100 missing; 1946: 1,790 persons by some reports), it is a repeat of the 1867 tsunami in the US Virgin Islands that may be most worrisome. A tsunami that followed within a few minutes of an earthquake in the Anegada Trough created a 6-9 meter high waves entering simultaneously St. Thomas# Charlotte Amalie and St. Croix#s Christiansted Harbours. This event lifted the US Navy ship Monogahela onto a pier at Fredriksted, St. Croix. The Caribbean Plate boundary is prone to tsunamis because it has all the tsunami-generating sources within a small geographical area as follows: 1) Subduction zone earthquakes of the type that generated the Indian Ocean tsunami, are found along the Lesser Antilles and the Hispaniola (1946 tsunami) and Puerto Rico trenches. 2) Other moderately large earthquakes due to more local tectonic activity take place probably once a century, such as in Mona Passage (1918 tsunami), and in the Virgin Islands basin (1867 tsunami). 3) Moderate earthquakes that can destabilize the steep underwater slopes and cause a tsunami landslide, occur even more frequently. Submarine landslides contributed an unknown amount of energy to the three tsunami sources mentioned above. 4) An active underwater volcano (Kick#em Jenny) is found near Grenada, where sea floor maps show previous episodes of flank collapse. (The eruption of the volcano itself is not thought to be a potential source for a tsunami.) 5) Above water volcanic activity along much of the Lesser Antilles periodically generates landslide that enter the sea to cause tsunamis. 6) Tele-tsunamis can propagate from the African-Eurasian plate boundary, such as the great Lisbon earthquake of 1755 with 6 and 7 meter-high waves in the Lesser Antilles.



map of study area

INVESTIGATORS:

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DESCRIPTION:

We propose to carry out a multi-year effort to improve regional assessments of tsunami hazard potential in the Caribbean (Puerto Rico and Virgin Islands) by developing enhanced geological and geospatial information. Efforts would culminate in an improved hazard assessment product for the region as a model for future regional tsunami hazard assessment efforts elsewhere. Activities would include coordinated development of source potential information from marine geophysical studies, modeling of tsunami propagation and runup, interpretation of onshore tsunami deposits to characterize hazard, and development of improved digital elevation models based on existing elevation data. The efforts are coordinated with broader hazard assessments (EHP) and multi-agency tsunami hazard assessment programs (NOAA) and with the University of Puerto Rico seismic and tsunami hazards center. The activities recommended here, complement and do not duplicate activities currently undertaken or proposed by the USGS Earthquake Hazard Program, NOAA or the University of Puerto Rico. The technology to study the marine environment is highly specialized and requires unique tools and trained personnel. The unique capabilities of the CMG program include the acquisition of high-resolution, multi-channel seismic reflection data and multibeam bathymetric data, and coring. Sediment stability, strong ground motion, and seismic attenuation in the marine environment are often different from those encountered on land, because the sediments are saturated with water and sometimes with gas. This unique and integrated environment requires a multidisciplinary approach and the broad expertise of marine geologists.

START DATE OF PROJECT:

October 1, 2005

END DATE OF PROJECT:

September 30, 2010

LOCATION:

Caribbean

TOPIC:

Earthquake Hazard Assessments

APPROACH:

The project consists of three tasks: 1. The development of tsunami source potential information; 2. Simulations of tsunami propagation and runup on Caribbean shores and theoretical understanding of tsunami recurrence probability and the dynamic generation of tsunamis. 3. Interpretation of onshore tsunami records to extend the tsunami recurrence record in time. The first task will includes sub-tasks such as Multibeam bathymetry surveys, High resolution Seismic profiles to provide cross-sectional views of faults and landslides and augment the interpretation of multibeam bathymetry maps, Relocation of earthquakes in regions of high seismicity offshore using OBS to help identify active faults, Deep-towed chirp and side-scan in selected areas to provide higher resolution data on active faults and to locate targets for landslide dating, Coring and dating of selected landslides to determine their age. Expension of the work to the Atlantic coast and other Caribbean islands is expected at a later stage. The second task will incorporate detailed landslide studies (including dating), as well as earthquake recurrence rates, into a comprehensive probabilistic tsunami hazard assessment, will modeling specific earthquake and landslide tsunami sources and regional propagation patterns in the NE Caribbean, This task may also include modeling the effect of the Hispaniola and Puerto Rico trenches on the U.S. East Coast. Theoretical studies of landslide speed and basal friction for selected materials in conjunction with Landslide studies Incorporation of dynamic mudslide model will be explored. We would assist the University of Puerto Rico to improve flood maps for Puerto Rico and the Virgin Islands. The third task will focus on developing on the search for tsunami deposits showing evidence for pre-historical tsunamis in the NE Caribbean, generate detailed tsunami deposit data (spatial distribution, estimates of tsunami flow speed) to support tsunami hydrodynamic model verification, and develop criteria to distinguish tsunami deposits from storm deposits. The project builds on the broad expertise of scientists at all three CMGP centers. A joint project with NOAA-PMEL and the University of Puerto Rico has also been established to assess the relative tsunami threat to Caribbean, Atlantic, and Gulf of Mexico with the goals of prioritizing forecast models, optimizing DART buoy network location, identifing and guiding further investments in focus areas, providing public information on relative hazard, and providing guidance for operational warnings.

IMPACT/RESULTS:

Impact of this work is intended to improve the safety of residents and to protect coastal resources in the Puerto Rico/ Virgin Islands region with regard to tsunamis. By determining the likely hazards and their causative mechanisms and providing this information to government agencies and the public we may aid in such activities as improvement of shore facilities protection, encouraging safer zoning, and assisting public education for response to hazards. For example, a repeat of the 1867 Virgin Islands tsunami now, with a 10-fold increase in population density since 1867, and the presence of several cruise ships in the harbors, petroleum carriers, hotels and beach goers, nearby power plants, petrochemical complexes, marinas, condominiums, and schools, which would all be at immediate risk, is estimated to cause as much as $1 Billion in direct costs (Unesco IOC proposal, 2002). Indirect damages (post event fires, disease, search and rescue, debris removal, electrical and telecommunication reconstruction, chemical and fuel tank failures, hazardous material cleanup, vegetation loss, salt water intrusion and environmental stress) could significantly raise these estimates. A specific impact of this project is to provide information on deployment of the new NOAA DART buoys and to help develop short-term inundation forecasts in the event of earthquakes at different locations.