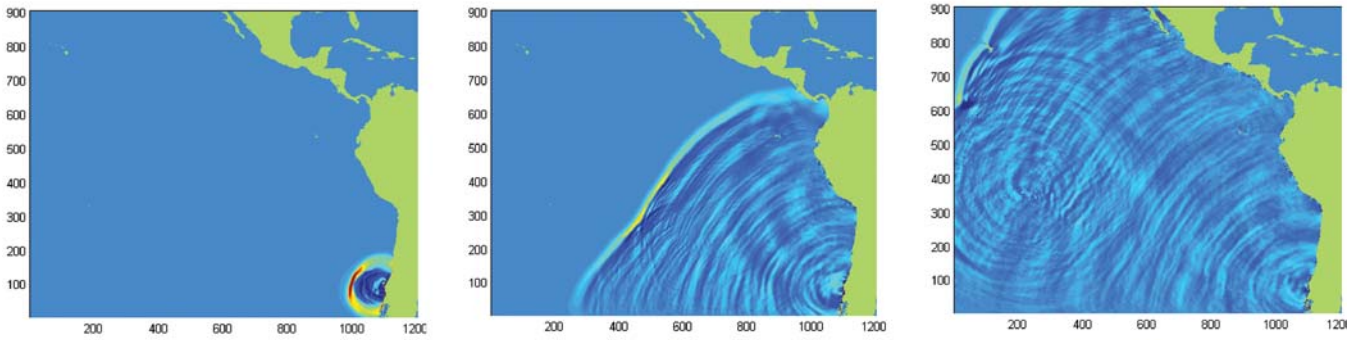
SELECTED RESEARCH HIGHLIGHT

An Improved Prediction Model for Tsunami Run-up and Coastal Inundation in Hawai'i

Phase I: Model Development and Verification, Phase II, Inundation Risk Analysis

Principal Investigator: Dr. Michelle Teng
Department of Civil and Environmental Engineering

1960 Chile Tsunami Propagation in the Pacific Ocean toward Hawai'i



The Issue/Research Rationale

Tsunami-induced coastal inundation has always been of great concern to the civil defense agencies in Pacific Rim countries. Ten major tsunamis over the past decade have occurred in the Pacific basin, killing more than 4,000 people, injuring others, and devastating property. The existing risk assessment models derive inundation risks from source statistics through linear wave theories, accounting for wave propagation but not run-up. In contrast, a tsunami run-up simulation model combined with an inundation risk assessment model will help civil defense agencies develop better inundation maps and evacuation plans, issue warnings during a tsunami event, and plan for long-term coastal land use. The extended risk assessment methodology developed in this project will include the nonlinear run-up and, therefore, can predict inundation risks more accurately.

1999 - 2003 Sea Grant Funding

$112,032 SG; $113,382 match

Hawai'i Discoveries/Contributions to Science

The objective of this study is to predict Hawai'i coastal inundation due to earthquake-generated tsunamis in the Pacific Basin using both the scenario and statistical approaches. For the scenario approach, nonlinear, shallow water equations were solved numerically by using a finite difference scheme to predict the maximum run-up due to tsunamis generated by different earthquake scenarios.

In the statistical approach, the Pacific Basin was divided into ten tsunamigenic earthquake source regions: Japan, Australia, New Zealand, open ocean, Kamchatka, Aleutian Island Chain, Alaska, Canada, U.S. West Coast, Mexico and South America. Three hundred years of earthquake data were analyzed and the probabilities of earthquake occurrence in each source region in the Pacific were calculated based on this data. The tsunami run-up response curve to earthquake forcing is being solved through numerical simulation. The probability of run-up exceeding a certain height at a certain coastal location in Hawai'i is being determined from the earthquake statistics through the run-up response curve. The method will be validated by a case study for Hilo Bay, which has site sufficient field data on run-up statistics available.

The project is progressing through the final steps of predicting the probability (or risks) of coastal inundation at different locations in Hawai'i due to distant tsunamis generated by earthquakes in the Pacific Basin.

Research Impacts/Benefits

Results include: (1) return periods of earthquakes ranging in magnitude from M = 4 to 8.5 in each source region along the Pacific coastline and open Pacific ocean; (2) identifying the most severe or "worst" earthquakes based on magnitude in each region over a 300-year period with their epicenter locations, and time of occurrence. (3) fitted Gumbel distribution of probability for earthquakes in each source for easy reading and application.

These results are currently being used to predict the probability of tsunami inundation in coastal areas in Hawai'i by performing computer modeling that simulates tsunami generation from earthquakes and predicts tsunami run-up in Hawai'i. An improved numerical simulation model based on the nonlinear shallow water equations was applied in this study. The model utilizes an advanced multi-layered grid

system and can be used to simulate all three wave processes involved in a tsunami event: tsunami generation from an earthquake; propagation in the open ocean; and run-up onto coastal land. This model is currently being verified by comparing the simulated run-up with both field and experimental data. These results will be useful to local government agencies, private organizations and firms involved in coastal development and management.

Publications and Presentations

Teng, M.H. and K. Feng. Manuscript in preparation for journal publication. Long Wave Run-up on Rough Slopes.

Gica, E. and M.H. Teng. 2003. Numerical modeling of earthquake generated distant tsunamis in the Pacific Basin. *Proceedings of the 16th ASCE Engineering Mechanics Conference (EM2003),* Seattle, Washington, July, 2003.

Gica, E. and M.H. Teng. 2003. Tsunami inundation risk analysis for Hawaii. *13th International Offshore and Polar Engineering (ISOPE-2003),* Honolulu, Hawai'i, May 25-30, 2003, (oral presentation).

Students Educated

Edison Gica, Ph.D. In progress.

Significant Partnerships

Sea Engineering, Inc. (SEI) Hawai'i

The Joint Institute for Marine and Atmospheric Research (JIMAR)

Hawai'i State Civil Defense

National Oceanic and Atmospheric Administration, International Tsunami Information Center (ITIC)

Cooperating personnel:

Philip Liu, Professor, Cornell University

Eiji Nakazaki, Senior Engineer, SEI

Tom Schroeder, Director, JIMAR

Brian Yanagi, HSCD representative in the National Tsunami Hazard Mitigation Program

Outreach Highlights

Each cooperating agency has gained experience and can access the developed models and data to facilitate their responsibilities and efforts to mitigate the impacts of tsunami on life and property. Researchers will continue to benefit from the computer models, published results, and conference presentaions.

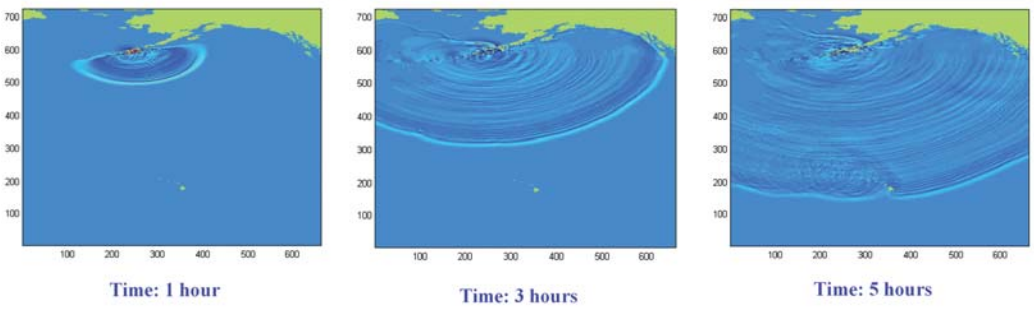
In addition, Gica has spread tsunami information to local high school students and parents through several talks. Later this year, Gica will present his research results at three international conferences, and give presentations at three others.

Biography

Dr. Teng's professional services include chair of the fluids technical committee of the American Society of Civil Engineers and membership on the Tsunami Technical Review Committee for the State Civil Defense in Hawai'i.

Edison Gica studied and earned an M.S. under Professor Fumihiko Imamura at the Asian Institute of Technology in Thailand. His M.S. thesis (1994) focused on modeling tsunami waves generated by land-slides. Gica also co-authored three journal publications that draw data from his post-tsunami field studies with internaitonal survey teams in the Philippines and Indonesia.

1946 Aleutian Tsunami Propagation in the Pacific Ocean toward Hawai'i



Dr. Michelle Teng, Associate Professor of Civil and Environmental Engineering at the University of Hawai'i (UH) at Mānoa, received her Ph.D. from Caltech in 1990 with a major in hydrodynamics. She joined the UH faculty in 1992. Her research includes theoretical modeling of ocean waves, numerical simulation, and experimental study of ocean wave run-up on beaches.

Edison Gica is currently a Ph.D. candidate in the Department of Civil and Environmental Engineering at UH Mānoa.

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