Cornell University
Center for Advanced Computing

CAC and Philip Liu

CAC
we enable your success

Deadly Tsunamis: Understanding the Waves

How do massive wave systems spread outward from the epicenter of undersea earthquakes?

Finding the Answer

Philip Liu uses supercomputing simulations at CAC to numerically model and analyze the dynamics of tsunamis like the one that struck the Indian Ocean on December 26, 2004. That tsunami, at 9.0, was the most devastating in recorded history, killing over 225,000 people in the surrounding areas of Thailand, India, Indonesia, and Sri Lanka. Serious damage and deaths were even reported along the east coast of Africa, as far as 8,000 km away from the epicenter.

Philip Liu led the NSF delegation to tsunami-ravaged Sri Lanka. Liu uses a combination of field studies and numerical simulations to better understand tsunamis.

Deadly Tsunamis

Undersea earthquakes, landslides, or volcanic eruptions produce giant seismic sea waves that are deadly. Philip Liu, an expert in tsunamis and wave propagation, helped to develop the tsunami warning system for countries surrounding the Pacific Ocean.

Improved Research

Research Metrics

- High-Fidelity: Use CAC supercomputers to maximize the fidelity of simulations and improve insights.
- Speed: Decrease compute time.

Research Challenge

Liu is trying to understand the characteristics of ocean-wave climates and the way that waves interact with coastlines and coastal structures. “We are engaged in theoretical

research on the propagation and transformation of linear and weakly nonlinear water waves over complex ocean bathymetry (changes in water depth measurement)" says Liu. His Cornell team developed a model that calculates wave amplitude and the direction of wave propagation in the near-shore environment.

Solution

Liu uses a 120-foot-long wave tank at Cornell to research the sediment transport and ripple formation under ocean waves. He employs particle imaging velocimetry, which measures the speed of water turbulence under breaking waves.

Liu also uses numerical models and CAC supercomputing systems to generate three-dimensional images of flows to measure the dynamics of water waves. His research team created a video simulation of the deadly Indian Ocean tsunami that showed in graphic detail how the massive wave system spread outward from the epicenter northwest of Sumatra, Indonesia and struck the coastlines of Indonesia, Thailand, Sri Lanka, and India.

The simulation compressed 10 hours and 30 minutes in the life of the tidal wave into one minute. The supercomputer simulation was created using the Cornell Multigrid Coupled Tsunami model, or COMCOT, developed by Liu and Xiaoming Wang. Wang created the final simulation with Tso-Ren Wu, a Cornell post-doctoral researcher.

The Client

Philip Liu, Professor, Civil and Environmental Engineering, Cornell University

- NSF-sponsored research on mass transport in water waves
- Kwoh-Ting Li Chair Professorship, National Central University, Taiwan
- Fellow of the American Geophysical Union

The Collaborative Relationship

CAC supercomputing systems help Philip Liu and his colleagues run simulation models fast and efficiently, improving their scientific analyses.

Based on earthquake data and information about the topography of the sea floor provided by NOAA, the Cornell COMCOT model calculates the elevation of the sea surface at a series of grid points on a map of the area over a period of time. How closely simulations correspond to what actually happens can not be determined until data is collected in the field.

Accurate seismic data generally is available only after an event is over. With the future development of seismic technology, a more accurate and rapid estimation of seismic data might be provided. It then might be possible to use supercomputing simulations to predict tsunami behavior immediately after an earthquake is detected.