Title
Wave-Climate Risk Analysis: Predicting the Size, Frequency and Duration of Large Wave Events

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Wave-Climate Risk Analysis: Predicting the Size, Frequency and Duration of Large Wave Events

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The most destructive ocean storms along the coast occur relatively infrequently.

The only way to predict the intensity, duration and frequency of large wave events is to reconstruct past events from historical data. Assuming past patterns repeat themselves, a process called extrapolation can then be used to make predictions about future events.

Extrapolation can provide reliable forecasts if the data record spans a suitably long period of time. Unfortunately, high-quality wave data goes back only two decades. This brief snapshot of oceanic conditions makes it nearly impossible to forecast events that may occur once every hundred years, even though it is precisely these infrequent, natural hazards that engineers should keep in mind when designing coastal structures.

With rising sea levels and continuing development along the shoreline, city planners and engineers face increasing pressure to evaluate the risk of erosion, landslides, and flooding from large wave events. Photo: Eric Hanauer.

The Project

The goal of this project was to develop new statistical and mathematical methods for predicting the risk of property loss, flooding, and erosion from large ocean storms. The cornerstone of the project was to develop a technique for extracting as much information as possible from wave data records. Standard analytic methods, in contrast, often discard useful information from data. The data used for the project was collected by the National Oceanographic and Atmospheric Administration's network of ocean buoys.

Standard wave-climate forecasts are based on analyses of "extreme value" wave events—that is, by collecting information on the largest wave heights in a given period of time, typically a year. A probability distribution function is then fit to a series of these extreme values. From this, scientists calculate the "exceedance probability" of a storm of a set magnitude and recurrence interval.

Sea Grant funded Dr. Rodney Sobey, a professor of civil engineering at the University of California at Berkeley, to examine a new, perhaps better, method for calculating these exceedance probabilities. The method is based on the assumption that storms nearly as big as the year's largest provide additional, usually untapped, information on wave-climate patterns.

Sobey's method employs what he calls "triple annual wave maximums," which means that he looks at the largest waves in each month and from these selects the three largest events in a year. These three maximum events are treated as independent and identically distributed random variables. More sophisticated mathematical methods are then used to incorporate information on the duration of wave events.

To test the accuracy of his method, he applied it to an 84-year record of rainfall in San Francisco. This was done by dividing the 84-year record into seven 12-year segments. He then applied his new method and traditional ones to the short-record segments, in turn comparing these predictions to those calculated from the full-length record, which he assumed represented the true values. His results showed that the triple annual method more closely matched the true values than standard methods.

In a second set of experiments, he applied his method to buoy data in the Gulf of Mexico, Atlantic and Pacific oceans. He then plotted the results of his analysis as sets of concise intensity-duration-frequency curves.

Applications

His results provide a technique for improving marine forecasting along the nation's shoreline. As urbanization of the coast continues, better forecasting is becoming an increasingly important tool for protecting property, avoiding flooding, and guiding emergency evacuation plans.

The U.S. Army Corps of Engineers' Research and Development Center plans to use the results of this project as a routine method for analyzing and presenting wave data.

Cooperating Organization

National Oceanic and Atmospheric Administration National Data Buoy Center

Publications

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Trainees and Theses

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