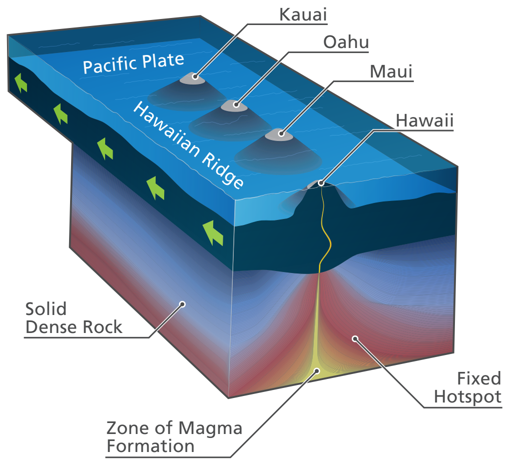
AIR Earthquake Model for Hawaii

On October 15, 2006, a magnitude 6.7 earthquake struck the sparsely populated northwest coast of Hawaii Island. Insured losses were relatively modest. But if an event of similar magnitude were to occur closer to Hilo or Honolulu, the outcome would be very different. It is essential for companies operating in this market to have the tools necessary to assess the state's earthquake risk and to develop risk management strategies that will effectively mitigate the impact of the next catastrophe.

AIR

The AIR Earthquake Model for Hawaii provides an incomparable level of detail, enabling superior risk differentiation based on factors including seismic zonation, soil type, construction, occupancy, year built, and height.



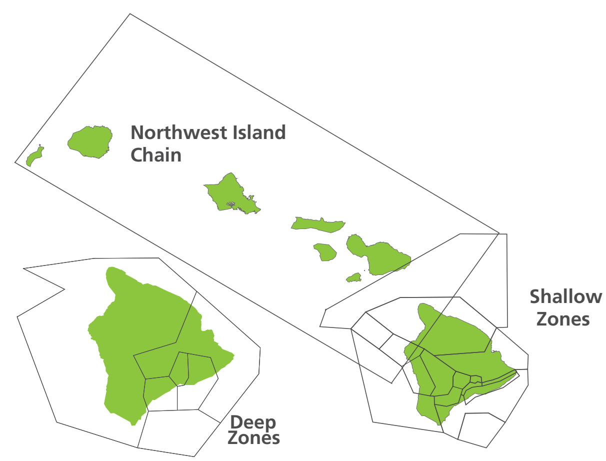
The Hawaiian islands formed as heat from a fixed hotspot deep within the earth's mantle melted the Pacific Plate, producing a steady stream of rising magma. The southeast Hawaiian Islands have higher seismicity rates than the northwest islands due to their proximity to the Hawaiian hotspot.

Comprehensive View of Regional Earthquake Risk

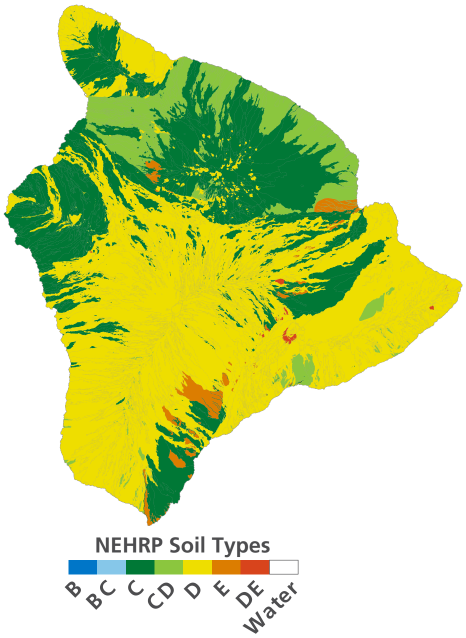
Because the Hawaiian Islands are part of a volcanic chain that formed when the Pacific Plate moved northwestward over the Hawaiian hotspot, most earthquakes that impact the Hawaiian Islands are linked to volcanic activity. These earthquakes occur either before or during a volcanic eruption, or as a result of magma moving below the earth's surface. The rest, such as the aforementioned M6.7 Kiholo Bay earthquake of 2006 and a M6.2 event on the island's northeast coast in 1973, originate in zones of structural weakness at the base of volcanoes after stress is placed on the earth's crust. The AIR model integrates data on historical seismicity with regional USGS data on earthquake hazard to capture seismicity rates across the Hawaii region, which is divided into 22 seismic source zones.

Ground Motion Prediction Equations and High-Resolution Soil Data Capture Shaking Intensity at Each Site

Formed as a result of repeated volcanic activity millions of years ago, the Hawaiian Islands are the exposed peaks of an undersea mountain range. Most earthquakes that strike Hawaii are crustal events, occurring at shallow depths of less than 20 kilometers, but Hawaii Island also experiences events that occur at the volcano bases, at depths of 20 kilometers or more. To account for both types of earthquakes, the AIR model uses a weighted combination of ground motion prediction equations (GMPEs) for shallow source-zone events and deep source-zone events to provide a comprehensive assessment of ground motion.



The model captures the seismicity in 22 seismic source zones. In the shallow zones, events are simulated at depths up to 20 kilometers. In the deep zones, events are simulated at depths from 20 to 60 kilometers. The shallow zones encompass all of the Hawaiian Islands while the deep zones are only below Hawaii Island.



The soil classification map for Hawaii features the NEHRP (National Earthquake Hazard Reduction Program) soil types.

SOIL CLASS	DESCRIPTION
A	Very hard rock (crystalline rock with few fractures)
AB	Hard rock
B	Firm to hard rock
BC	Firm rock
C	Soft to firm rock (gravelly soil and soft rock)
CD	Soft rock (gravelly and stiff soil)
D	Stiff clay and sandy soil
DE	Soft soil to firm soil (silty clay and sand)
E	Soft soil (includes mud)

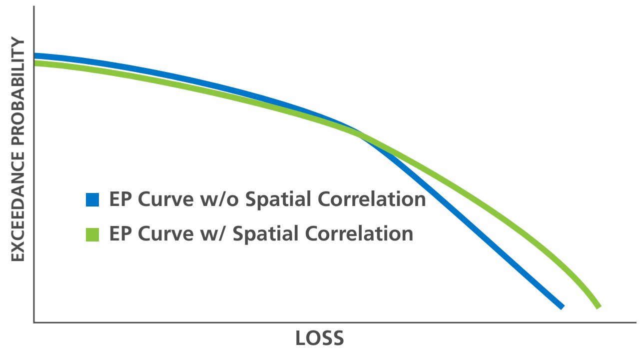
The modeled ground motion is modified to reflect soils at the surface, which vary both within islands and from one island to the next. These soils affect the intensity and frequency content of ground shaking at a site. AIR used data from the USGS and the Hawaii Commission on Water Resource Management to develop soil classification maps at resolutions as fine as 75 meters.

Spatial Correlation Provides Enhanced Risk Assessment for Portfolios of Properties

Earthquakes can produce patterns of spatially extended pockets where the ground motion is consistently higher or lower than predicted by the GMPEs. When a higher-than-expected ground motion pocket occurs in a densely populated area, the losses will be much larger than expected within that area. The AIR Earthquake Model for Hawaii explicitly takes into account the effects of site-to-site correlation of ground motion intensity measurements when estimating the loss due to seismic activity for spatially extended portfolios. With the inclusion of site-to-site correlation, the model produces a wider distribution of losses—a difference that is particularly important for ensuring that the exceedance probability distribution has a robust tail.

Damage Functions that Capture Regional Differences in Vulnerability

Hawaii's building stock varies widely from county to county due to differences in construction practices, building codes adoption, and historical earthquake and tropical cyclone experience. The AIR model supports 78 construction classes and further divides buildings of each class by height (low-rise, mid-rise, and high-rise) and by the year they were built. By capturing building age, the model captures the impact of changing construction standards and building codes, which vary by county.



The exceedance probability curves generated using spatial correlation are more robust—particularly in the tails of the distribution—because they are based on many more simulations and hence more information.

Single Wall Wood Frame: A Prevalent And Vulnerable Building Type In Hawaii

Most single-family and duplex homes in Hawaii are wood frame construction. About 40% of these are single wall wood frame. Because these structures have raised foundations set on unanchored wooden posts, they are highly susceptible to damage associated with foundation failure during earthquake ground motion. In addition, their load-bearing walls consist of only plywood boards (i.e., without studs), adding to their vulnerability. Single wall wood frame homes fared poorly during the 2006 Kiholo Bay earthquake and are among the most vulnerable construction types in Hawaii.

Single wall pier and beam residence that has shifted off of its foundation blocks (For source, please see back cover.)

The AIR model also includes support for hale, an indigenous Hawaiian structure. Hale structures are open-walled buildings constructed of native grasses and wooden posts. The thatched roofs of hale structures may lack gables (termed "open-ended hale"), or may have gables composed of additional thatching.

A Component-Based Approach to Modeling Complex Industrial Facilities

The AIR model employs a component-based approach to estimating losses to complex industrial facilities. Damage functions for more than 400 individual industrial components—including tanks, flares, boilers, cooling towers, and transportation assets—are combined into facility-level damage functions using weights that reflect each component's contribution to total replacement value. This approach is essential for reliable assessment of business interruption losses, which depend heavily on interactions among the various components within an industrial facility.

A Comprehensive Approach to Model Validation

To ensure the most robust and scientifically rigorous model possible, each component of the AIR Earthquake Model for Hawaii is independently validated against multiple sources and data from historical events. For example, the damage functions incorporate findings from published engineering research and analyses, claims data from past earthquakes, and post-disaster surveys conducted by AIR engineers. Modeled damage ratios were validated against actual observations from published reports. Modeled losses are validated against detailed data on damage and loss resulting from the 2006 Kiholo Bay earthquake, company claims data, and reported industry losses.

AIR's comprehensive approach to validation confirms that overall losses are reasonable and that the final model output is consistent with basic physical expectations regarding the underlying hazard and unbiased when tested against historical and real-time information.

Model at a Glance

Stochastic Catalog	Incorporates a 10,000-year catalog of 11,717 loss-causing events. Stochastic catalogs of 50,000 and 100,000 years are also available.
Supported Geographic Resolution	CATRADER®: state and county levels Touchstone®: county, ZIP Code, street address (street, city, and state), and user-specified latitude/ longitude
Supported Coverages	Building, contents, and time element
Supported Construction and Occupancy Classes	78 construction classes; 104 occupancy classes Unknown Damage Function: When detailed exposure data (e.g., construction type or height) are unavailable, the model applies an "unknown" damage function that takes into account region-specific construction characteristics using exposure-weighted averages.

Model Highlights

— Integrates historical seismic data with regional USGS models to estimate seismicity rates in 22 seismic source zones
— Employs weighted combinations of GMPEs customized for the Hawaiian environment for both shallow (<20 km) and deep (≥ 20 km) events
— Utilizes the latest high-resolution soil maps to capture site amplification
— Damage functions are county-specific to capture spatial and temporal variation in vulnerability across the Hawaiian Islands
— Employs an event-tree approach to capture not only direct business interruption (BI) losses, but also BI from indirect sources, such as losses stemming from actions taken by civil authorities, loss of business income from dependent properties, and utility service interruption
— Supports the indigenous structure hale as well as single wall wood frame construction specific to Hawaii
— Implements a robust, component-based approach to modeling complex industrial facilities

ABOUT AIR WORLDWIDE

AIR Worldwide (AIR) provides risk modeling solutions that make individuals, businesses, and society more resilient to extreme events. In 1987, AIR Worldwide founded the catastrophe modeling industry and today models the risk from natural catastrophes, terrorism, pandemics, casualty catastrophes, and cyber attacks, globally. Insurance, reinsurance, financial, corporate, and government clients rely on AIR's advanced science, software, and consulting services for catastrophe risk management, insurance-linked securities, site-specific engineering analyses, and agricultural risk management. AIR Worldwide, a Verisk (Nasdaq:VRSK) business, is headquartered in Boston with additional offices in North America, Europe, and Asia. For more information, please visit www.air-worldwide.com.

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