AIR Tropical Cyclone Model for Hawaii

On September 11, 1992, the most powerful tropical cyclone to strike the Hawaiian Islands in recorded history made landfall on Kauai. Packing sustained winds of 140 mph, Hurricane Iniki pummeled Kauai and nearby Oahu, damaging or destroying more than 14,000 homes.

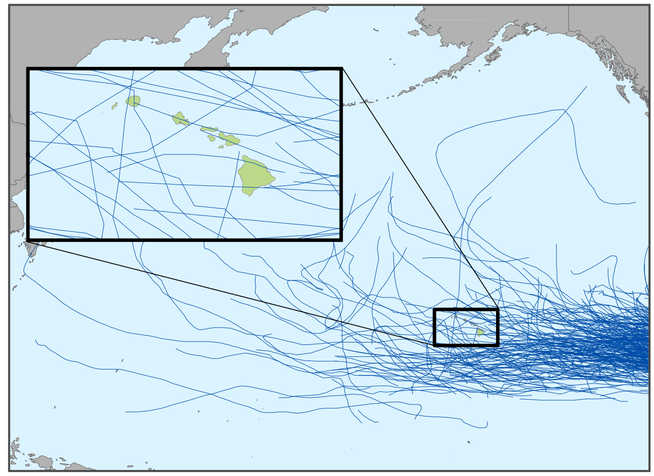
AIR

Tropical cyclones are rare events in the Hawaiian Islands. During the past 50 years, just eight hurricanes have affected Hawaii, and useful observational and damage data are available for only two of these storms, Hurricane Iwa (1982) and Hurricane Iniki (1992). However, the scope of the damage caused by Iwa and Iniki underscores the need for proactive risk management. If Iniki were to strike today, AIR estimates that insured losses would exceed USD 3 billion.

If a storm as powerful as Hurricane Iniki were to strike near Honolulu, it would inflict insured losses 11 times higher than those that would result from a recurrence of Iniki. The AIR Tropical Cyclone Model for Hawaii is an essential tool for catastrophe risk management developed using the most up-to-date meteorological research and modeling techniques.

Novel Method for Modeling Simulated Storm Tracks

Due to the scarcity of historical storm track data in the Central Pacific, AIR scientists developed a novel technique for generating the tracks of the simulated storms that populate the stochastic catalog. The AIR model uses six hourly reanalysis data—in particular, steering currents in the region every six hours since 1948—to determine steering probabilities for simulated storms at each point of their evolution.



The Eastern and Central Pacific spawn many tropical cyclones (historical storm tracks are shown here), but only a few reach the Hawaiian Islands. The potential losses, however, can be large. (Source: AIR)

DON'T BE FOOLED...

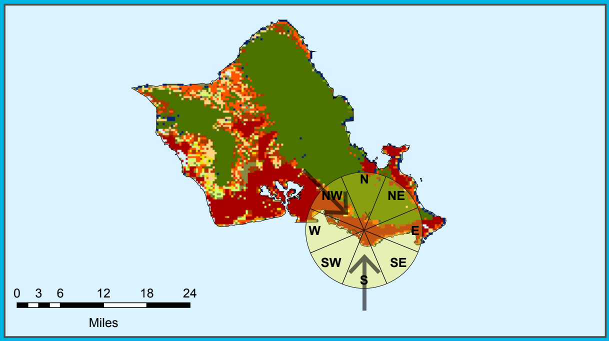
Because the two most recent storms—Hurricanes Iwa and Iniki—have struck Kauai, there is a misperception that hurricane risk is limited to the western part of the island chain. However, AIR research into earlier Hawaiian cyclones that predate official record-keeping found that all of the islands are at equal risk.

> "Overall the AIR model is a comprehensive approach to estimating wind damage with a remarkable level of information ... The return periods that this model predicts are similar to estimates I have seen in the scientific literature. The AIR model is assuming equal risk across the islands. Any person or group that thinks otherwise is engaged in wishful thinking."

Gary Barnes, Professor of Meteorology at the University of Hawaii, Peer reviewer of the AIR model.

Capturing Directional Effects on Surface Wind Speeds with High-Resolution Land Use/Land Cover Data

To realistically capture surface wind speeds, the model must account for variation in the local environment. Winds arriving from the open ocean, for example, will be faster than winds that have traveled over mountains or forests, all else equal. Using the most recent satellite-derived, high-resolution land use/land cover and elevation data from the United States Geological Survey (USGS), the AIR model captures the effects of surface friction based on the direction of the wind at each location. For example, in the Honolulu region of Oahu, a south wind will be relatively unobstructed as it approaches off the Pacific Ocean. In contrast, winds from the northwest will degrade as they travel over built-up urban regions.



Winds arriving from the open ocean will be faster than those that have first traveled over land. (Source: AIR)

The Industry's First Comprehensive View of Hurricane Risk Across the North Atlantic, Eastern Pacific, and Central Pacific Basins

Hurricane risk in the tropical Atlantic and the Central Pacific are inversely correlated. During El Niño, high sea-surface temperatures and low vertical wind shear enhance hurricane risk in the Central Pacific. But the same upper-level changes in wind speed and direction that cause low vertical wind shear in the Central Pacific lead to increased wind shear (and thus, lower hurricane risk) in the tropical Atlantic. This inverse correlation is explicitly accounted for in the AIR Tropical Cyclone Model for Hawaii, creating the industry's first comprehensive view of hurricane risk across the North Atlantic, Eastern Pacific, and Central Pacific basins.

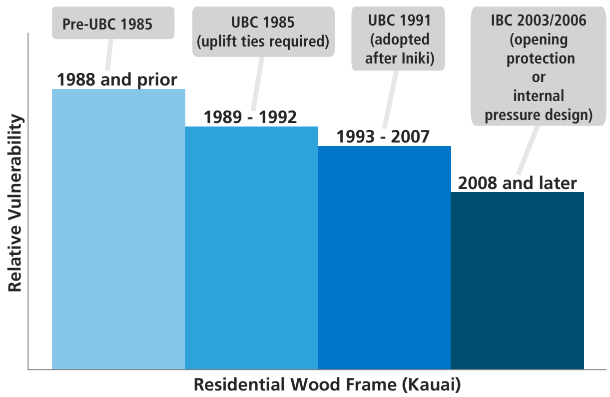
Damage Functions Account for Unique Construction Types and Regional Variation in Building Vulnerability

Hawaii's building stock has changed over the past four decades and displays significant variability regionally and by age. Residential structures unique to Hawaii include single wall wood frame (see box), "tofu block" structures, and hale. AIR engineers have developed wind damage functions for 71 different construction classes, each further classified by height and by age. These damage functions reflect differences in:

- Regional construction practices
- Evolution of building codes
- Historical tropical cyclone experience

SINGLE WALL WOOD FRAME: A PREVALENT AND VULNERABLE BUILDING TYPE IN HAWAII

Most single-family and duplex homes in Hawaii are wood frame construction, and about 40% of them are single wall wood frame. Because these structures have load-bearing walls made of thin plywood boards, they have greater susceptibility to wind damage. Single wall wood frame homes fared poorly during Hurricane Iniki and Hurricane Iwa and are among the most vulnerable construction types in Hawaii.



The AIR model accounts for temporal—and regional—variation in building code adoption and implementation.

A COMPONENT-BASED APPROACH TO MODELING COMPLEX INDUSTRIAL FACILITIES

The AIR model employs a robust, component-based approach to estimate potential losses to industrial facilities. AIR assesses the overall vulnerability of various kinds of facilities (such as chemical plants and oil refineries) based on the vulnerabilities of individual assets—the components and sub-components—that the facility comprises. The model implicitly accounts for more than 550 distinct industrial components based on detailed, site-specific engineering-based risk assessments conducted through AIR's Catastrophe Risk Engineering (CRE) service.

Estimating Losses to Buildings Under Construction

The vulnerability and replacement cost of a building under construction vary over the course of the project. For this reason, the AIR model supports the builders' risk line of business for both residential and commercial construction, which features time-dependent cost functions, or ramp-up curves, as well as damage functions for wind that are based on extensive, component-level analysis during each phase of construction. The model estimates average annualized project losses and losses for each phase of construction, taking into account the seasonality of storms. For projects already under way, users can enter percent completed to estimate risk to the remaining part of the project.

Leveraging Air's Detailed Industry Exposure Database for the United States

To produce the most reliable estimates of industry losses, the AIR Tropical Cyclone Model for Hawaii makes use of the comprehensive, high-resolution industry exposure database (IED) developed for the entire United States. AIR builds the IED by compiling detailed information about risk counts, building characteristics, and construction costs, as well as information on policy terms and conditions. The IED provides a foundation for all modeled industry loss estimates.

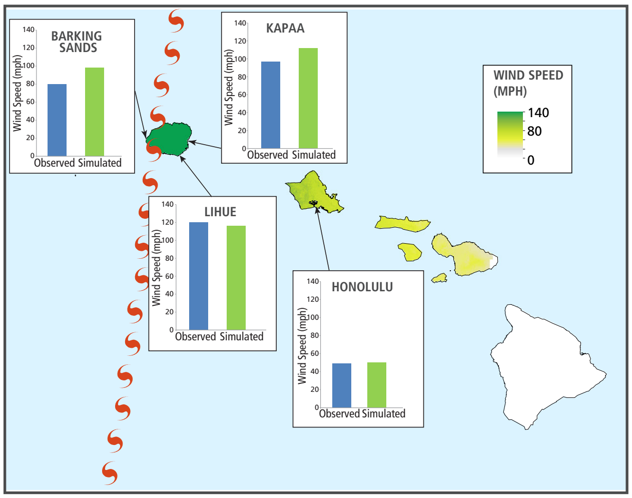
INCLUDING INDIVIDUAL BUILDING CHARACTERISTICS AND MITIGATION MEASURES TO YIELD A MORE ACCURATE PICTURE OF BUILDING DAMAGE

The AIR Tropical Cyclone Model for Hawaii accounts for individual risk characteristics of structures, such as window protection, and mitigation features such as hurricane clips. These characteristics can be evaluated singly and in combination, yielding a more accurate assessment of wind vulnerability.

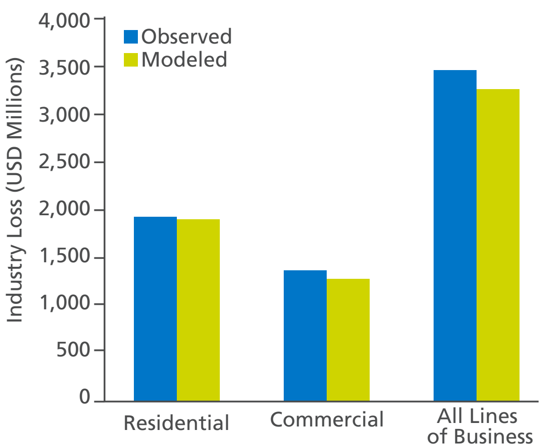
Air Validates Its Models from the Bottom Up—and the Top Down

To ensure the most robust and scientifically rigorous model possible, each model component is independently validated against multiple sources and data from historical events. AIR modeled wind speeds, for example, are validated against observation data from actual storms.

It doesn't matter how well modeled wind speeds match observed wind speeds, however, if the final losses don't make sense. Modeled losses yielded by the AIR Tropical Cyclone Model for Hawaii have been carefully validated against reported losses from PCS and other sources, by event and by line of business.



AIR modeled wind speeds consistently reproduce observed patterns. Here, simulated wind speeds for Hurricane Iniki are validated using historical records. (Source: AIR)



AIR's modeled industry losses for Hurricane Iniki show good agreement with reported losses. (Source: AIR, PCS)

EXTREME DISASTER SCENARIOS AS TOOLS FOR DETERMINING LARGE LOSS POTENTIAL

To help assess large loss potential in Hawaii, four Extreme Disaster Scenarios (EDS events) are included in the model. These EDS events are realistic and scientifically sound hypothetical tropical cyclones that would inflict very high damage on the Hawaiian Islands, if they were to occur. To create the four EDS events, AIR scientists generated deterministic variations on Hurricane Iniki by changing parameters such as central pressure and wind duration, yielding hypothetical—yet scientifically plausible—storms more powerful than Iniki. Each of these EDS events would make landfall on Oahu near Honolulu, where most exposures are located.

> "I conclude that the AIR Tropical Cyclone Model for Hawaii has been developed using prudent and verified scientific and engineering principles ... the model attempts to incorporate many of the local characteristics that apply to Hawaii but are not present in other tropical storm regions, such as the effects of topography and unique building types."

Ian Robertson,
Professor of Civil and Environmental Engineering
at the University of Hawaii,
peer reviewer of the AIR Model

Model at a Glance

Modeled Peril	Tropical cyclone winds
Stochastic Catalogs	10,000-year stochastic catalog includes 2,105 simulated tropical cyclones, all of which cause losses to the industry exposure.
Extreme Disaster Scenarios	Four scientifically plausible extreme disaster scenarios—deterministic variations on Hurricane Iniki of even greater severity—are included in the model, to aid in assessing large loss potential.
Supported Geographic Resolution	Touchstone®: User specified latitude-longitude, street-level address, county, ZIP Code CATRADER®: County
Supported Construction and Occupancy Classes	Supported Construction Classes: 71 Supported Occupancy Classes: 110

Model Highlights

— Appropriately assumes equal tropical cyclone risk across all of the Hawaiian Islands
— Incorporates the inverse correlation in hurricane activity between the North Atlantic, Eastern Pacific, and Central Pacific basins, yielding the industry's first comprehensive view of hurricane risk across these regions
— Explicitly accounts for construction types unique to Hawaii, such as single wall (light wood frame)
— Hawaiian indigenous structures made of native grasses (hale) can be modeled in Touchstone
— Damage functions reflect regional and temporal variations in vulnerability
— Includes secondary risk modifiers, such as window protection and hurricane clips, which can strongly influence building vulnerability to tropical cyclone winds
— Supports the builders' risk line of business
— Features a detailed, component-level approach to modeling damage to industrial facilities
— Peer reviewed by leading experts from the University of Hawaii
— Each component extensively validated against multiple sources; modeled losses compare well to industry data

AIR
A Verisk Business