The AIR Tropical Cyclone Model for the Caribbean

In just a five-year span, the Caribbean experienced several significant loss-causing major hurricanes: Gonzalo (2014), Matthew (2016), Irma and Maria (2017), and Dorian (2019). Because tropical cyclones tend to be the primary drivers of natural catastrophe risk in the Caribbean, it is critical for (re)insurers to manage and mitigate tropical cyclone risk effectively.

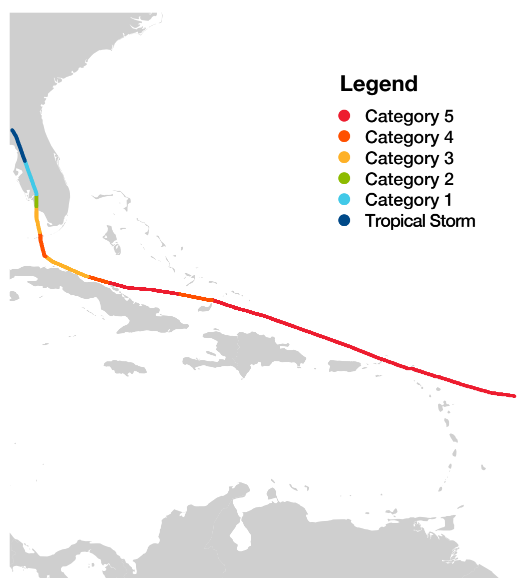
AIR

Tropical cyclones take a wide variety of tracks through the Caribbean, although the risk generally increases from south to north. The AIR Tropical Cyclone Model for the Caribbean features a large catalog of simulated events that reflects current historical data and appropriately characterizes the frequency, tracks, and meteorology of potential future storms, as well as the observed correlations of risk between countries—an important criterion for companies that insure properties across the region. The historical catalog incorporates recent major hurricanes: Gonzalo, Matthew, Irma, and Maria.

Incorporating high-resolution hazard data, knowledge gained from post-event damage surveys following recent major hurricanes, and industry loss data, together with a detailed study of country-specific construction materials and building practices, the evolution of building code requirements, construction regulations, and enforcement practices, the AIR Tropical Cyclone Model for the Caribbean provides an incomparable level of detail, enabling more precise risk differentiation based on such factors as geography, construction, occupancy, height, and year built and an accurate view of tropical cyclone risk. The model features specialty lines of business and captures policy conditions and terms that reflect market conditions in the specific countries within the model domain, which can vary greatly from country to country.

The Advantage of the Basinwide Approach

The AIR Tropical Cyclone Model for the Caribbean features a unified catalog of more than 200,000 simulated events affecting the 29 Caribbean countries within the model domain, as well as the United States, Mexico, Central America, and offshore assets in the Gulf of Mexico. AIR's basinwide catalog allows companies to more accurately and seamlessly model losses to policies and portfolios that span multiple countries—a key feature in light of the fact that a significant percentage of storms in the North Atlantic impact multiple regions.



After battering a string of Caribbean islands since its first landfall in Barbuda, Hurricane Irma made landfall in Cuba as a Category 5 storm. Irma made a first U.S. landfall on Cudjoe Key at Category 4 strength, then weakened to Category 3 status before it made its second landfall on Marco Island on the southwest coast of Florida. The AIR Tropical Cyclone Model for the Caribbean allows companies to seamlessly assess the risk to policies and portfolios that span multiple countries.

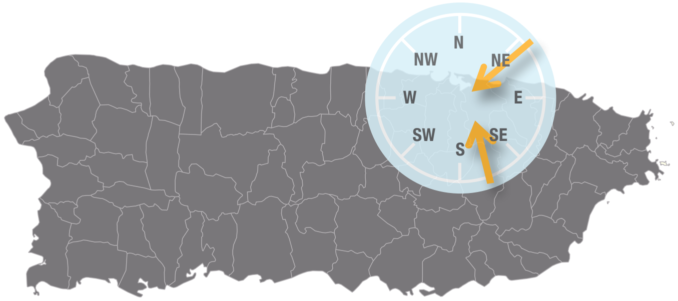
Providing multiple views of risk in a warm ocean environment

Sea surface temperatures (SSTs) in the North Atlantic basin have been anomalously high since 1995. To help Caribbean tropical cyclone model users understand the sensitivity of hurricane risk to a warm ocean climate from natural variability or climate change, the AIR model offers a catalog conditioned on the years since 1900 with higher-than-average SSTs, in addition to the standard catalog, which is based on all available data. AIR's ensemble approach provides multiple credible views of risk based on objective, scientifically defensible research.

High-Resolution Land Use and Land Cover Data Captures Directional Effects on Surface Wind Speeds

To capture surface winds at any location with realism, the model must account for the surrounding environment. Winds arriving from the open ocean, for example, will be faster than winds that have traveled over a mountainous island interior or forest. Using the latest 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.

Knowing the precise location of exposure becomes more critical when the effects of wind direction are explicitly modeled. For example, certain coastal areas on an island may have low-rise residential buildings that are scattered along the coast, while the exposure build-up in the more urban areas of that same island may include taller, more concentrated buildings. The low-rise coastal residential area will moderate the wind speeds very differently than a built-up urban coastal environment.



AIR explicitly models the directional effects of surface friction on wind speeds. In northern Puerto Rico, a northeast wind will be relatively unobstructed as it comes in off of the Atlantic Ocean, while winds from the south will degrade as they travel over the mountainous interior of the island.

Flood Component Incorporates Detailed Information on Soil Type, Land Use/Land Cover, and Topography

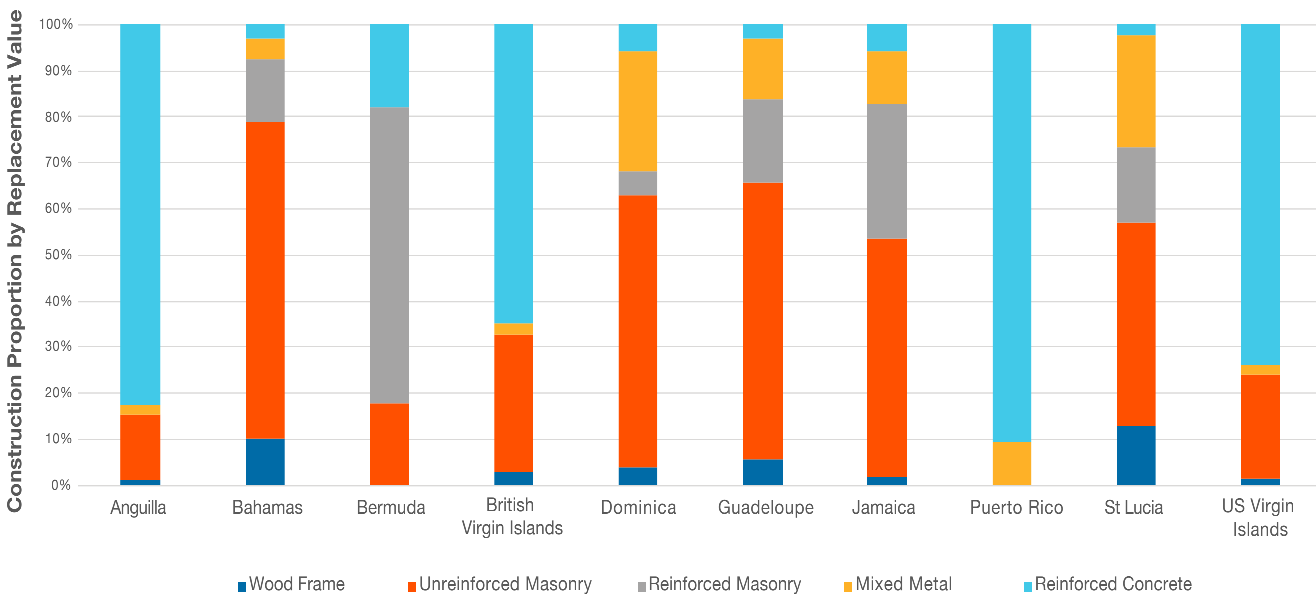
In the Caribbean, tropical cyclone–induced flooding can be a key driver of loss. In 1979, Hurricane David—a seminal event in the region's history—dropped nearly 21 inches of rainfall in Puerto Rico, triggering massive flooding. David went on to make landfall in the Dominican Republic as a Category 5 hurricane, bringing not only damaging winds but additional precipitation that caused severe flooding and killed thousands of people. About 50% of the insured losses were flood-related. But even storms with relatively low wind speeds can be accompanied by significant flooding, exacerbated by the inland mountains that characterize many islands throughout the region.

The AIR Tropical Cyclone Model for the Caribbean incorporates a flood module that estimates the probability and severity of a flooding event and its associated damage. Based on storm size, intensity, and rainfall characteristics, as well as terrain and land use, the model captures an hourly precipitation footprint at each location over the entire duration of the storm. Slower-moving storms will subject any given location to higher rainfall totals. The total accumulation is then redistributed based on the porosity of the soil, land use, and slope.

Accounting for Regional Building Codes and Construction Practices

Some islands in the Caribbean are subjected to higher levels of wind speeds more frequently than others. Over time, this has resulted in variations in building vulnerability across the region, as each country adopts or develops its own building codes and construction practices that reflect its historical storm experience and regional building inventory. The resulting construction/occupancy mix and height distribution of the building stock is a fundamental determinant of the region's vulnerability. For example, in Puerto Rico, after Hurricane Hugo in 1989, concrete "bunker" style buildings—usually built of reinforced concrete walls and concrete slabs roofs—became more prevalent as reinforced concrete is less vulnerable to wind than masonry or wood frame. Mixed material construction is also common across the region, often consisting of a bunker-style first story and a more vulnerable wood-frame or unreinforced masonry second story.

The AIR Tropical Cyclone Model for the Caribbean incorporates exhaustive research by AIR engineers into the local and temporal variations in the construction practices and building codes, as well as the record of their enforcement success. The model takes into account the specific year of construction, by territory, to assess building vulnerability at a highly granular level. To reflect the vulnerability of the building stock in the Caribbean, AIR engineers have developed separate wind and flood damage functions for 123 different construction classes and 114 occupancy classes, including hotels, single-family homes, and industrial facilities (e.g., pharmaceutical facilities, power plants, petrochemical plants, mines, and steel mills). High-resolution unknown damage functions provide views of risk for buildings where characteristics are not known. Business interruption damage functions vary by occupancy and account for physical damage level, building size and complexity, and business characteristics, such as resiliency and the ability to relocate.



The construction mix for single-family residential buildings for select Caribbean countries, showing variations in construction that directly impact the vulnerability of the region.

The AIR Industry Exposure Databases for the Caribbean: An Unparalleled Resource

The AIR Industry Exposure Databases (IEDs) for the Caribbean consist of the latest available information on risk counts, building characteristics, and replacement costs, at a 90-meter resolution for each of the 29 countries within the model domain. Developed using local sources and on-the-ground observation, the IEDs capture the characteristics of properties at a high level of detail.

Footprints for each hotel, resort, and large industrial facility were developed, which capture the spread of buildings (e.g., a resort with separate buildings stretching along hundreds of feet of beachfront and extending back into non-waterfront areas), enabling the estimated value for each exposure to be realistically distributed across the entire site. Estimated values were developed from either capacity data (such as megawatts produced by a power plant or how much of a certain product a facility can produce) or other known features, such as building size.

A consistent view of exposures across the region

The AIR Industry Exposure Databases for the Caribbean are used by both the AIR Tropical Cyclone Model for the Caribbean and the AIR Earthquake Model for the Caribbean, providing a consistent view of exposures across AIR models for the region.

Because data on tropical cyclone damage are relatively scarce due to the infrequency of events, AIR conducts damage surveys to not only confirm modeling assumptions but also to improve understanding of the built environment's response to tropical cyclones. For example, damage surveys of Caribbean countries revealed the presence of mixed construction, where multiple construction types are present in one structure (e.g., a primarily concrete building with a wood-frame second story); these complexities are captured in the IEDs. Using satellite imagery facilitated the identification and location of large villas, which are often larger than average homes, have better construction, and have a higher rebuild cost.

The IEDs for the Caribbean also incorporate take-up rates by line of business at either the CRESTA or country level, depending on the country. In addition, the IEDs capture enhanced policy conditions and terms that reflect market conditions in the specific countries within the model domain, which can vary greatly from country to country in the Caribbean.

The benefits and uses of AIR's IEDs are numerous. They provide a foundation for all modeled industry loss estimates as well as being a critical part of model validation. Risk transfer solutions, such as industry loss warranties that pay out based on industry losses, rely on the IEDs. Using AIR's detailed modeling application, companies can also leverage the IEDs for the Caribbean to disaggregate the exposure data in their own portfolios to a highly detailed level, for improved loss estimates.

AIR has been conducting damage surveys in the aftermath of Caribbean hurricanes since Hurricane Floyd in 1998. Roof damage to historic Long House in St. George's, Bermuda, observed after Hurricane Gonzalo in 2014 (top) and damage to Luis Muñoz Marín International Airport observed in San Juan, Puerto Rico, after Hurricane Maria in 2017 (bottom) were used to inform, confirm, and validate the model's damage functions.

Achieving More Accurate Model Results by Separating Wind and Flood Losses

The ability to model flood losses with unique flood policy conditions can greatly impact a company's high exceedance probability (low return period) losses. This includes losses from tropical cyclones with relatively low sustained wind speeds—storms that can still deliver significant precipitation.

Determining the insured flood loss from these storms is vital to overall risk assessment. The AIR model enables companies to estimate losses to policies that contain multiple terms and conditions. Companies can generate loss estimates for flood only, wind only, or wind and flood combined. When information about policy-level flood coverage is not available, average flood take-up rates can be applied to the portfolio.

The ability to model the two perils separately and apply appropriate, peril-specific policy conditions leads to more accurate loss results and a better understanding of tropical cyclone risk.

AIR Validates its Models from the Bottom Up and Top Down

To ensure the most robust and scientifically rigorous model possible, the model is carefully validated against actual loss experience. However, validation is not limited to final model results. Each component is independently validated against multiple sources and data from historical events. For example, the AIR modeled wind speeds and precipitation totals are validated against observation data from actual storms.

Modeled damage ratios and footprints are validated against actual observations from both published reports and from AIR post-disaster surveys conducted in the aftermath of hurricanes. Modeled losses have been validated not only at the company level, but by event, by line of business, and by coverage using significant amounts of claims data.

Model at a Glance

Modeled Perils	Tropical cyclone winds and precipitation-induced flood
Model Domain	Anguilla, Antigua and Barbuda, Aruba, Bahamas, Barbados, Bermuda, BES Islands (special municipalities of the Netherlands—Bonaire, Sint Eustatius, and Saba), British Virgin Islands (BVI), Cayman Islands, Cuba, Curaçao, Dominica, Dominican Republic, Grenada, Guadeloupe, Haiti, Jamaica, Martinique, Montserrat, Puerto Rico, Saint Barthelemy, Saint Kitts and Nevis, Saint Lucia, Sint Eustatius, Sint Maarten, Saint Martin, Saint Vincent and the Grenadines, Trinidad and Tobago, Turks and Caicos Islands, U.S. Virgin Islands (USVI)
Stochastic Catalog	The catalog includes 50,000 simulated years containing more than 200,000 simulated events; the catalog is shared with other AIR regional hurricane models, allowing companies to accurately estimate losses to portfolios that span multiple countries
Supported Construction Classes and Occupancies	– 123 construction and 114 occupancy classes, four height bands for all modeled perils, and CRESTA-specific age bands for each modeled country – Unknown Damage Function: When detailed exposure data (e.g., construction type, occupancy type, height, or year built) is unavailable, the model applies an “unknown” damage function that takes into account CRESTA-specific characteristics – Support for specialty lines of business such as large industrial facilities, infrastructure, and marine—including inland transit, marine cargo, marine hull, pleasure boats, and builder’s risk
Industry Exposure Databases	Contain risk counts, building characteristics, construction costs, policy conditions, and take-up rates for all modeled countries at 90-meter resolution

Model Highlights

— Standard and warm sea surface temperature (WSST) 50,000-year catalogs provide two robust and scientifically defensible views of risk
— Historical catalog features 37 historical events, including Gonzalo (2014), Matthew (2016), Irma (2017), and Maria (2017); three Extreme Disaster Scenarios (EDS) are also included
— Accounts for differences in regional vulnerability arising from each territory’s historical storm experience, construction practices, and building code adoption, evolution, and enforcement practices
— Separate wind and flood damage functions for 123 different construction classes and 114 occupancy classes; high-resolution unknown damage functions for buildings at the CRESTA level where characteristics are not known; and business interruption damage functions that vary by occupancy
— Support for specialty lines of business such as large industrial facilities, infrastructure, and marine, including inland transit, marine cargo, marine hull, pleasure boats, and builder’s risk
— Caribbean industry exposure databases consist of the latest available information on risk counts, building characteristics, and replacement costs, at a 90-meter resolution for each of the 29 countries within the model domain; developed using local sources and on-the-ground observation, the IEDs capture the characteristics of properties at a high level of detail
— Extensively validated model using USD 80 billion of industry insured loss estimates across more than 15 islands from various industry sources, as well as claims data from recent hurricanes

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 incidents. Insurance, reinsurance, financial, corporate, and government clients rely on AIR's advanced science, software, and consulting services for catastrophe risk management, insurance-linked securities, longevity modeling, 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.