AIRCURRENTS

NOVEL TOOLS FOR MODELING TROPICAL CYCLONE RISK IN THE CARIBBEAN AND CENTRAL AMERICA

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INTRODUCTION

If a tropical cyclone has only weak winds and does not come ashore, can it still cause notable insured losses to exposure nearby? In the Caribbean and Central America, the answer is yes—primarily as a result of the precipitation hazard associated with tropical cyclones, even those with relatively weak winds.

Indeed, the often-held view that flood-dominated tropical cyclones always result in lower insured losses than their windier counterparts requires a hard look; "wet" storms can significantly impact a company's portfolio. 1979's Hurricane David in the Caribbean, from which more than 50% of losses were flood-related—and which AIR estimates would cause USD 6.0 billion in insured losses if it were to recur today—is one example. Hurricane Mitch is yet another; heavy rainfall from this 1998 storm wreaked havoc across Central America. Honduras and Nicaragua were particularly hard hit, sustaining billions in economic losses; in Honduras, some regions received up to 75 inches of rainfall—contributing to the destruction of approximately 33,000 houses. More recently, in 2010, Tropical Storm Agatha inundated an area from northern Guatemala to Nicaragua with ten to twenty inches of rain, producing widespread flooding that damaged thousands of homes; Agatha's winds never surpassed tropical storm strength.

This article provides an overview of tropical cyclone risk in the Caribbean and Central America, with a focus on tropical cyclone-induced flooding, which can be a significant driver of loss.

TROPICAL CYCLONE CLIMATOLOGY IN THE CARIBBEAN AND CENTRAL AMERICA

Within the North Atlantic basin, roughly eleven tropical cyclones are spawned each year on average, six of which become hurricanes. Of all the landmasses in the basin, the Caribbean islands experience the greatest number of storms—and often the most intense. That said, some island countries and territories within the Caribbean are more at risk than others; in general, risk increases south to north, such that the Bahamas is perhaps the most at-risk country in the Caribbean today.

Central America, meanwhile, faces an onslaught of tropical cyclones from both the North Atlantic and Northeast Pacific basins. Although more tropical cyclones ultimately form in the latter basin, these storms have a smaller probability of making landfall, and are generally less damaging. (The annual average number of tropical cyclone landfalls in Central America is 0.71 from the Atlantic and 0.02 from the Pacific). Of course, even if a storm does not make actual landfall in Central America (or in the Caribbean), all

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countries are susceptible to bypassing storms that can be slow moving and produce tremendous amounts of rain. This rain can lead to landslides and damaging flooding.

MOUNTAINS: ENHANCING THE THREAT FROM PRECIPITATION IN BOTH REGIONS

If there is a single geographic feature that contributes most to the likelihood of tropical cyclone-induced flooding in the region, it is mountainous terrain. Mountains enhance precipitation by causing the air flow around the approaching tropical cyclone to rise. As the rising air cools, and water vapor condenses, additional clouds form—boosting precipitation levels. This rainfall, if not absorbed by the soil or carried downstream by rivers that have capacity for the extra flow, can lead to flooding. During Tropical Storm Emily—the 5th named storm of this year's Atlantic hurricane season—the mountains of Hispaniola increased the precipitation tremendously.

CHALLENGES INHERENT TO MODELING PRECIPITATION-INDUCED FLOOD

Even as forecasting tools advance, modeling how much precipitation a tropical cyclone will generate continues to prove challenging. So, too, is modeling how much of that precipitation will result in flooding. This latter challenge is in part a result of the way in which the precipitation footprint of a tropical cyclone can extend farther inland than the wind footprint—by miles. Unlike wind speeds, which decrease as storms move inland due to filling, higher friction and interaction with the topography, the intensity of storm-related precipitation and accumulated runoff can actually increase. Since little correlation exists between tropical cyclone wind speed and precipitation intensity, even weak storms miles offshore can cause flood damage on land.

To overcome these challenges and help companies understand the scale of risk they face from tropical cyclone-induced flooding in the Caribbean and Central America, researchers at AIR have developed sophisticated flood modules for both regions. These modules are implemented in the latest release (Version 13.0) of the AIR software, which includes the expanded AIR Tropical Cyclone Model for the Caribbean and the newly introduced AIR Tropical Cyclone Model for Central America.

A TRULY BASINWIDE TROPICAL CYCLONE MODEL FOR THE NORTH ATLANTIC

In Version 13.0 of AIR's CLASIC/2™ and CATRADER® systems, the **AIR Tropical Cyclone Model for the Caribbean** was expanded to include 17 additional countries, thereby providing complete coverage in the region. The computation of wind speeds and associated losses is performed on a new, high-resolution grid that accounts for the effects of coastal and inland terrain, resulting in more refined loss estimates at the local scale.

The introduction of the **AIR Tropical Cyclone Model for Central America** represents a significant step to serve the needs of this maturing market and highly exposed region, susceptible to storms from two ocean basins. Like the Caribbean model, it captures the combined effects of both wind and precipitation-induced flooding. The new model provides coverage for all seven countries in Central America.

These two models share a unified catalog with the AIR Hurricane Model for the United States, the hurricane model for offshore assets in the Gulf of Mexico and the tropical cyclone model for Mexico. The unified catalog allows global insurers and reinsurers to quantify risk to policies and portfolios that span multiple countries.

AIR'S APPROACH TO MODELING PRECIPITATION CAPTURES THE EFFECTS OF STORM DURATION AND TOPOGRAPHY

The flood module in the AIR tropical cyclone models for the Caribbean and Central America begins by generating total event precipitation (top of Figure 1). The amount generated depends on the forward speed of a storm (slower moving storms tend to deposit more rain at any given impacted location), as well as terrain (the presence of mountains).

But precipitation alone provides only a partial picture of where flood risk may exist; the precipitation must be distributed over land. In the AIR module, the flood potential from rainfall depends on high-resolution soil information, land use/land cover, and topography, or slope—all of which determine what fraction of the falling precipitation is absorbed, and where it moves downhill. That which isn't absorbed is treated as runoff, or flood (bottom of Figure 1). The module explicitly accounts for watershed size, since larger watersheds are able to accommodate more water, and will tend to experience lower flood levels for the same amount of precipitation.

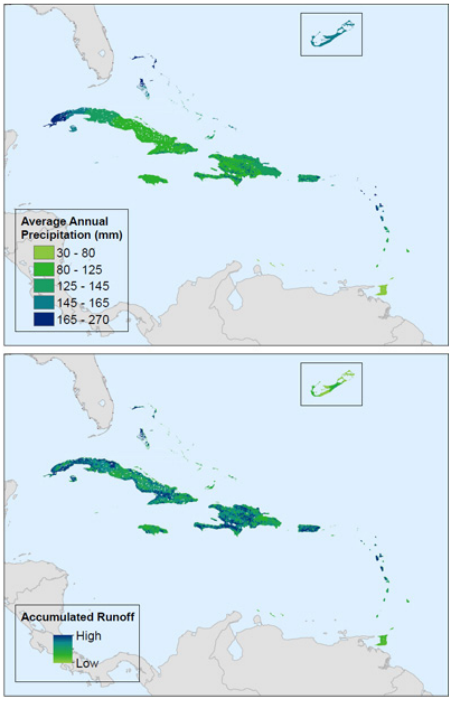

Figure 1. The top image shows modeled annual average precipitation levels for the Caribbean; determining these levels is the first step to calculating accumulated runoff (or flood). The bottom image shows modeled average annual flood depths after taking into account soil type, land use, and terrain. (Results can be displayed in the same way for Central America) (Source: AIR).

Once flood depth has been modeled, flood damage is calculated. Because flood damage essentially occurs from the floor up, whereas wind damage typically occurs from the roof down, damage functions for the two perils are uniquely constructed and separate.

ACHIEVING MORE ACCURATE MODEL RESULTS BY SEPARATING FLOOD AND WIND LOSSES

CLASIC/2™ Version 13.0 allows users to generate loss estimates for flood-only, wind only, or wind and flood combined. The best approach for modeling tropical cyclone risk is to use detailed exposure data explicitly coded with actual policy conditions for wind and flood. Nevertheless, in cases where detailed data that has not been explicitly coded for flood coverage must be used, CLASIC/2 Version 13.0 allows users to apply average flood take-up rates to the portfolio. The ability to model flood losses with unique flood policy conditions can greatly impact a company's high exceedance probability (low return period) losses, such as losses from tropical cyclones with relatively low sustained wind speeds—storms than can nevertheless deliver significant precipitation. Determining the insured flood loss from these storms is vital to overall risk assessment.

LARGE LOSS SCENARIOS IN THE CARIBBEAN AND CENTRAL AMERICA

A 1% EXCEEDANCE PROBABILITY EVENT IN THE CARIBBEAN, WITH 90% OF LOSSES FROM PRECIPITATION

A benefit of catastrophe modeling is the ability to examine—and plan for—large loss scenarios. Hurricane David, as previously mentioned, was a deadly and damaging tropical cyclone from which over 50% of insured losses derived from flood. However, some tropical cyclones are capable of producing an even greater proportion of damage from flood. And if these storms are slow-moving, allowing rainfall to accumulate, damage can be even more significant.

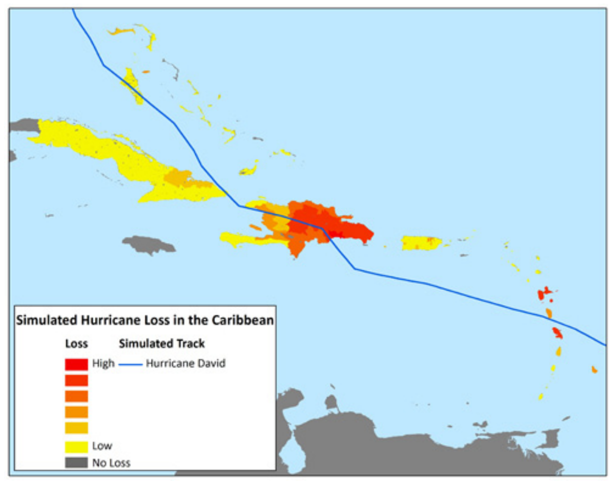

Figure 2. Insured losses are shown along the track of Hurricane David (Source: AIR).

To assess the potential insurance impact of such a storm, AIR chose a tropical cyclone from the 10,000-year stochastic catalog for which flood damage contributes 90% of total losses. The simulated storm stalls near the Dominican Republic—its slow forward speed permitting it to inundate the island nation—and then tracks northward, passing directly over the Turks and Caicos Islands. Even so, most of the losses are in the Dominican Republic, where rain is heaviest. In the Dominican Republic, residential structures are predominantly unreinforced and reinforced masonry, and commercial structures are commonly reinforced concrete—all of which can sustain significant damage at high flood levels.

AIR estimates that this simulated event would bring sustained winds of no more than 70 miles per hour (less than hurricane strength) but over a meter of rain to the Dominican Republic —with isolated pockets receiving 2 meters of rainfall. (Such a scenario, while extreme, is entirely plausible. In 1963, Hurricane Flora dumped more than 2.5 meters of rain on Cuba.) This would result in estimated insured losses of USD 5.9 billion over the entire Caribbean.

While AIR estimates that a recurrence today of 1979's Hurricane David (shown above in Figure 2) would generate a similar level of insured loss (USD 6.0 billion), David's track was wider-reaching (impacting islands including Martinique, Guadeloupe, Puerto Rico, the Dominican Republic and Cuba), its winds were of greater intensity (Category 5), and its track went directly over the Dominican Republic. Thus, the losses produced by the simulated event are that much more impressive because they are generated almost solely from precipitation and nearly entirely in the Dominican Republic, even though the storm never comes ashore there.

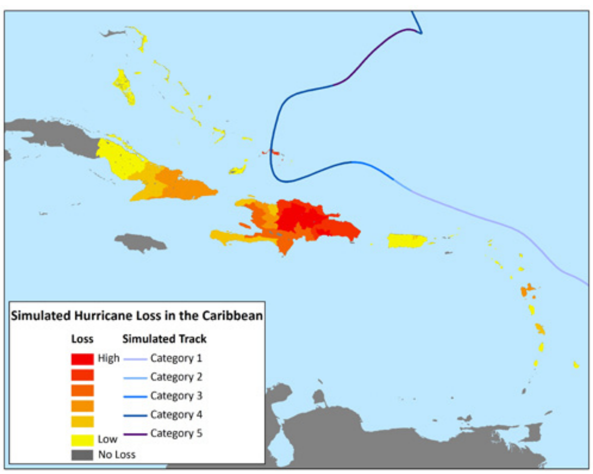

Figure 3. Insured losses (1% exceedance probability, or 100-year) from a simulated tropical cyclone that stalls just north of the Dominican Republic, dumping heavy rain there, and going on to pass directly over The Turks and Caicos Islands (Source: AIR).

A RE-SIMULATION OF FELIX, FARTHER SOUTH, IN A MORE POPULATED LOCATION

Just as the losses from weak-wind (but "wet") storms may be surprising, so may be the losses from storms whose winds are strong. In 2007, for example, Hurricane Felix made landfall in northeastern Nicaragua at Category 5 strength. However, due to the low exposure there, insured losses from Felix were not high. Thus, although Felix was very significant in terms of intensity, losses were far less significant than might have been expected.

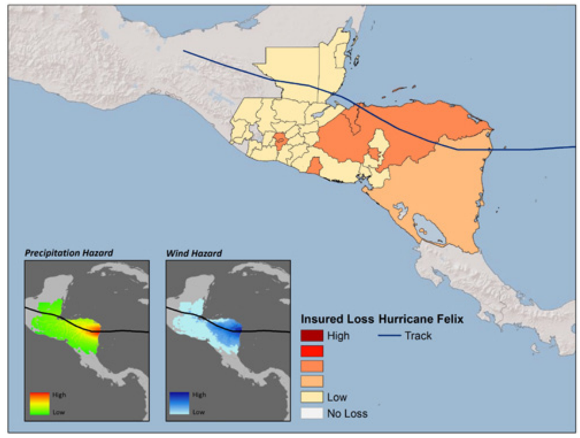

Figure 4. Insured losses from Hurricane Felix in Central America (2007) (Source: AIR).

To assess the financial impact of a Hurricane Felix striking farther south in a more populated location, AIR simulated a tropical cyclone event with Felix's same hazard parameters, but shifted south by 3 degrees of latitude (roughly 180 nautical miles), to near the border of Nicaragua and Costa Rica. Such an event is entirely plausible in this region.

Like Felix, the simulated storm brings sustained winds of 147 miles per hour. While the real Felix produced insured losses of USD 70 million throughout Central America, AIR estimates that the simulated Felix-like event would produce insured losses of USD 260 million—almost four times as much and over half of which would be incurred in Costa Rica, where the simulated event has a 120-year return period.

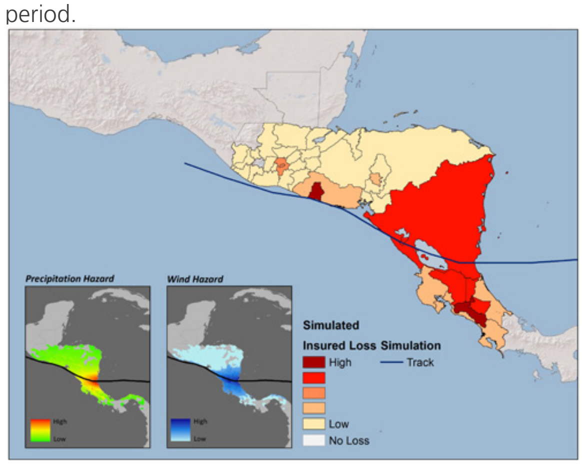

Figure 5. Insured losses (1.5% exceedance probability, or 65-year) from a simulated tropical cyclone in Nicaragua with Felix's same hazard parameters but a different landfall location. While insured losses from Felix in Nicaragua were USD 5 million, AIR estimates that insured losses from the simulated event there would be USD 39 million—almost eight times as much, and all due to higher levels of exposure near the landfall location. Insured losses for all of Central America from the simulated event would be USD 260 million—roughly four times as much as Felix brought to the region in 2007 (Source: AIR).

As this exercise shows, basing loss expectation on storm intensity alone is not an adequate approach to gauging losses from tropical storms in regions in which exposure is heterogeneous—regions such as the Caribbean and Central America. Here, as in many places worldwide, exposure is patchy; the most concentrated exposure is typically found in urban centers (i.e., capital cities and resort towns, with many resorts located on the coast). Additionally, the urban exposure often reflects a high degree of diversity in terms of building type.

To account for this variability, AIR's detailed industry exposure databases for these regions has been updated with data from population and economic censuses, building registries and housing surveys, providing model users a truly current assessment of exposure at risk. Even so, because the quality of catastrophe model output is only as good as the data input, insurers and reinsurers modeling their risk from tropical cyclones in the Caribbean and Central America should be diligent to model with detailed exposure data in order to obtain the best possible assessment of that risk.

CONCLUSION

With the latest release of the AIR Tropical Cyclone Model for the Caribbean and the new release of the AIR Tropical Cyclone Model for Central America, AIR has incorporated the latest scientific information available on flood and wind hazard in these regions. The introduction of these tools is resulting in more effective strategies for managing the potential losses both from high-impact tropical cyclone-induced flood events and tropical cyclones with strong winds, no matter their landfall location.

Notably, both models share a basinwide stochastic catalog with other AIR-modeled countries in the region—including the United States and Mexico, as well as with the U.S. hurricane model for offshore assets in the Gulf of Mexico. The basinwide catalog provides a highly accurate approach to global insurers and reinsurers charged with assessing tropical cyclone risk to portfolios and policies that span multiple countries.

ABOUT AIR WORLDWIDE

AIR Worldwide (AIR) is the scientific leader and most respected provider of risk modeling software and consulting services. AIR founded the catastrophe modeling industry in 1987 and today models the risk from natural catastrophes and terrorism in more than 90 countries. More than 400 insurance, reinsurance, financial, corporate, and government clients rely on AIR software and services for catastrophe risk management, insurance-linked securities, detailed site-specific wind and seismic engineering analyses, agricultural risk management, and property replacement-cost valuation. AIR is a member of the Verisk Insurance Solutions group at Verisk Analytics and is headquartered in Boston with additional offices in North America, Europe, and Asia. For more information, please visit www. air-worldwide.com.