Hazus Hurricane Modeling in Puerto Rico and the U.S. Virgin Islands

Hazus is a nationally standardized risk modeling methodology that combines expertise from many disciplines to create actionable risk information that increases community resilience. It is distributed as free GIS-based desktop software with a collection of inventory databases for every U.S. state and territory. Hazus identifies areas with high risk for natural hazards and estimates physical, economic, and social impacts of earthquakes, hurricanes, floods, and tsunamis (Figure 1). The Hazus Program, managed by FEMA's Natural Hazards Risk Assessment Program, partners with other federal agencies, research institutions and regional planning authorities to ensure Hazus resources use the latest scientific and technological approaches and meet the emergency management community's needs.

Hazus 5.0, released in June 2021, expanded Hazus Hurricane modeling capabilities to Puerto Rico and the U.S. Virgin Islands, significantly increasing the availability of risk information for these island communities with high hurricane exposure. Extending key resources like modeling tools supports resilience-building activities in all phases of emergency management. To learn more about the Hazus Hurricane Model, check out our Hazus Hurricane Modeling Factsheet.

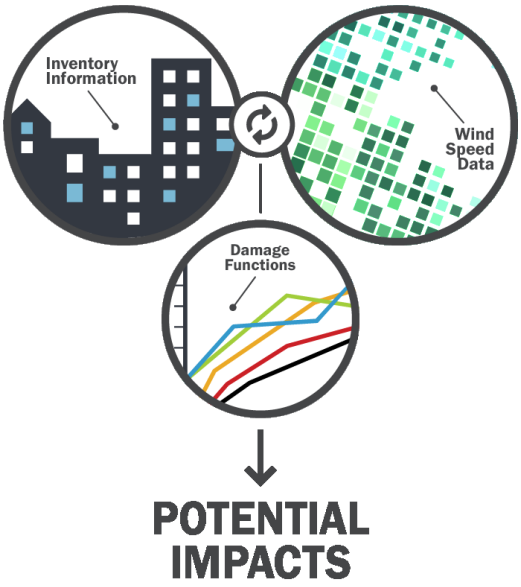

Figure 1. The Hazus Hurricane Model *combines inventory information and wind speed data with damage functions toestimate disaster impacts. Learn more about the hurricane modeling methodology by reading the Hazus Hurricane Technical Manual.*

Data Development for Modeling Hurricane Risk in the Caribbean Territories

The Hazus Hurricane Model relies on topographic and construction characteristics that vary according to geographic region. When the Hazus Hurricane Model was originally developed, available data did not capture the local conditions unique to Puerto Rico and the U.S. Virgin Islands, so modeling in those areas was not enabled. Following Hurricanes Maria and Irma in 2017, the data necessary to apply the model in Puerto Rico and the U.S. Virgin Islands were collected, analyzed, and incorporated into an expanded Hazus Hurricane Model. Data development for this expansion included the updates in the callout box below.

FEMA

Development of a comprehensive structure inventory for both Puerto Rico and the U.S. Virgin Islands, including counts of each building type by location, age, and construction style.

Environmental parameters such as surface roughness, topography and terrain, and tree coverage, and their impacts on wind speeds and debris generation.

Identification of unique, territory-specific building characteristics and construction practices and their performance in hurricane-force winds.

New, territory-specific damage and loss functions for both Puerto Rico and the U.S.Virgin Islands.

The Hazus expansion effort provided important opportunities to move beyond wind modeling assumptions driven by mainland conditions. Features of the expansion include:

- Exploration of machine learning for post-disaster damage assessment
- Hazus building characteristics adding jalousie windows and new roof types
- New landcover classifications specific to the Caribbean territories

Figure 2 highlights key characteristics for wind vulnerability in Puerto Rico and the U.S. Virgin Islands that drive differences between mainland and Caribbean wind modeling in Hazus.

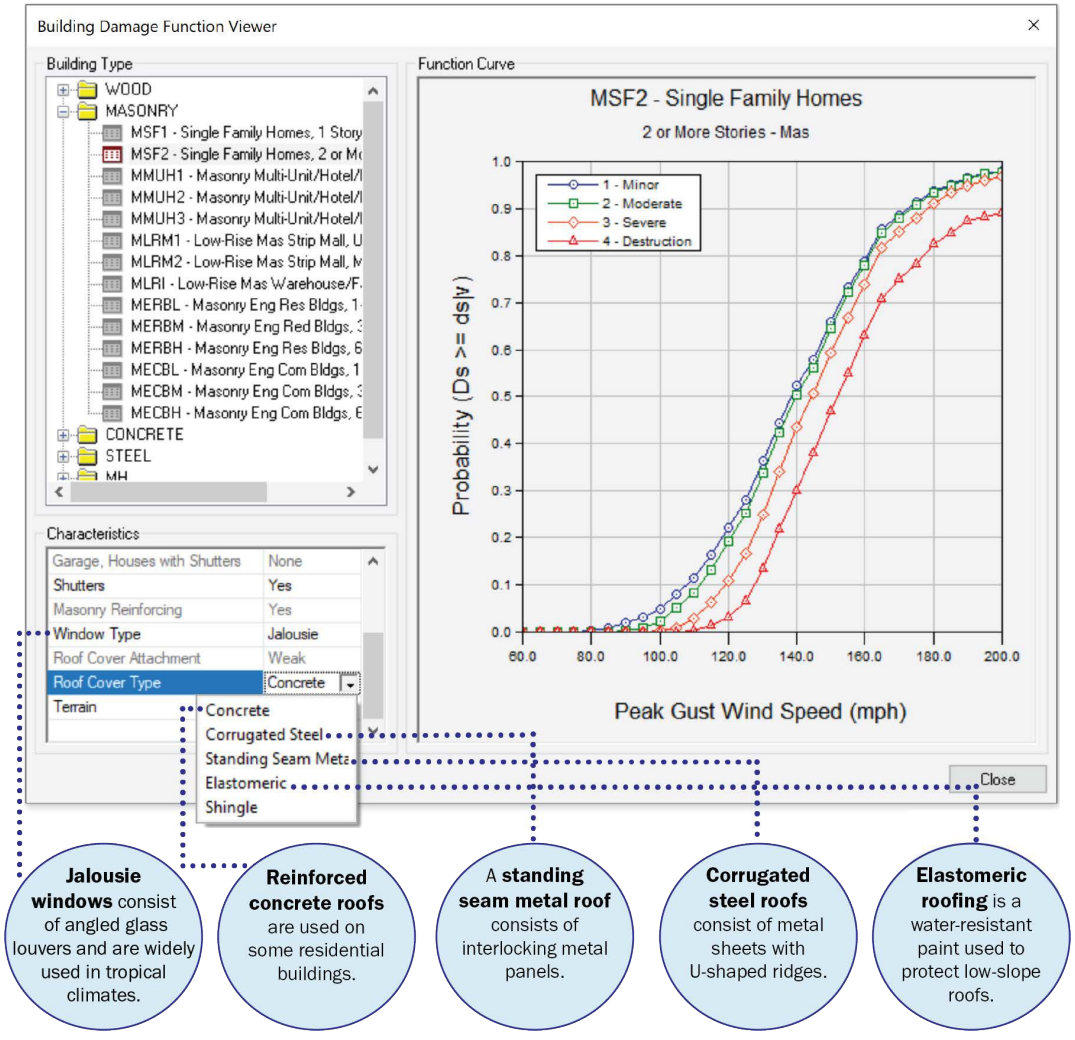

Figure 2. Screenshot of Building Damage Function Viewer in Hazus 5.0 *- Key building characteristics unique to the Caribbean are identified above. More detailed land cover data for Terrain characteristics, which impact the force of hurricane winds, were also included for Puerto Rico and the U.S. Virgin Islands.*

Learn More
To find out more about how the Hazus Hurricane Model was expanded to include Puerto Rico and the U.S. Virgin Islands read the project technical report.

Hazus uses a set of mathematical functions to estimate wind damage to structures. Each building type in a study area is assigned a curve that represents structural damage as a function of wind speed. Damage curves are developed using a combination of building characteristics, such as construction materials or the presence of damage mitigation features, and topographic characteristics that may contribute to faster or slower windspeeds. New, Caribbean-specific wind damage functions were developed by modifying engineering parameters of model buildings with the unique characteristics shown above during thousands of simulated wind events. These simulations helped determine the detailed relationship between wind speed and building damage for construction types common in Puerto Rico and the U.S. Virgin Islands.

Comparison of Hazus Modeled and Observed Results

After integrating the new hazard and vulnerability data developed for Puerto Rico and the U.S. Virgin Islands, the updated Hazus Hurricane Model was used to develop estimated losses for Hurricanes Irma and Maria. Modeled losses were compared with published data on observed damage and loss in both territories for both events. Adjustments were made based on these comparisons to achieve better agreement between modeled and observed losses. Final results (Table 1) indicate strong agreement in most metrics between modeled and observed impacts for both Hurricanes Irma and Maria.

Table 1. Comparison between Hazus Modeled and Observed Results for Hurricanes Irma and Maria:

Metric	Territory	Event	Observed	Hazus Modeled
% of single-family and duplex structures affected	PR	Maria	36%-52%	35%
% of single-family and duplex severely damagedor destroyed	PR	Maria	0.9%-1.3%	8%
Costs to repair housing structures	PR	Maria	$28.5b-$33.9b	$26.9b
Total direct economic losses	PR	Maria	$59b-$118b	$44.3b
Total direct economic losses	PR	Irma	$0.5b-$1.0b	$0.8b
Total direct economic losses	USVI	Maria	$1b-$2b	$4.1b
Total direct economic losses	USVI	Irma	$10b-$20b	$7.6b

Hazus Resources

The Hazus Program offers technical guidance, training, and information about ongoing and recent projects to help stakeholders complete successful risk assessments. Please review the resources listed below for assistance using Hazus and reach out to the Hazus Team with questions.

Self-Guided Course Materials
YouTube Videos
Sign Up for Risk Assessment Guidance
GitHub Resources
User & Technical Manuals
Contact the Hazus Team