The Florida Public Hurricane Loss Model
Version 8.3
June 2025

Model Overview

- The FPHLM (hurricane loss model) development project for personal and commercial residential properties was funded by the FL-Office of Insurance Regulation.
- We are currently funded to operate, update and maintain the model at Florida International University.
- Model is operated by a team of experts in computer science, actuarial science, finance, statistics, meteorology and engineering.
- Our major client is the FL-OIR
- Since 2009, as required by the Florida legislature, we have provided hurricane modeling services to over thirty clients in the insurance industry.
- Model development was not influenced by either FL-OIR or the insurance industry

- The model was first activated in March 2006. This version was used to process the insurance company data on behalf of the Florida Office of Insurance Regulation.
- In Summer 2007 a revised and updated version 2.6 of the model was accepted by the Florida Commission on Hurricane Loss Projection Methodology and put to immediate use.
- Another revised and updated version 3.0 was accepted by the Commission in June 2008.
- Another revised and updated version 3.1 was accepted by the Commission in June 2009.
- Version 4.1 and 5.0 and 6.1, 6.2, 7.0, and 8.1 were accepted by the Commission in 2011, 2013, 2015, 2017, 2019, 2021 respectively.
- The latest version 8.2 was accepted by the Commission in Summer 2023 and is in use.

General Comments

- The model is transparent in the sense that we make available technical reports, flowcharts etc. on the assumptions, methods, theories, component designs, and tests.
- In fact, much has already been published in refereed journals and proceedings.
- Technical documents are available at the project website: https://fphlm.cs.fiu.edu/
- The source code, however, is not open.

Participating Institutions

- Florida International University/ EEI (lead institution)
- Florida State University
- Florida Institute of Technology
- University of Florida
- University of Miami
- University of Missouri Kansas City
- AMI Risk Consultants
- Hurricane Research Division, NOAA

About 20 professors and experts and dozens of student assistants were involved in the development and operation of the model. Key recent personnel:

- Dr. Shahid Hamid — Dept of Finance and EEI, Florida International University, PI and project manager
- Dr. Shu-Ching Chen — School of Computer Science, FIU until 2022, University of Missouri KC since 2022
- Dr. Tianyi Wang — Computer scientist, Extreme Event Institute, Florida International University
- Dr. Steven Cocke — COAPS Dept of Meteorology, Florida State University
- Dr. Jean Paul Pinelli — Dept of Civil Engineering, Florida Institute of Technology
- Dr. Kurtis Gurley — Dept of Civil and Coastal Engineering, Univ of Florida
- Dr. Golam Kibria — Dept of Statistics, Florida International University
- Dr. Wensong Wu — Dept of Statistics, Florida International University
- Dr. Dongwook Shin — COAPS Dept of Meteorology, FSU. Currently
- Dr. Bachir Annane — CIMAS, University of Miami
- Dr. Mei-Ling Shyu — Dept of Electrical and Computer Engineering UMKC, Previously Univ of Miami
- Gail Flannery — FCAS Actuary, Vice- President AMI Risk Consultants
- Bob Ingco — FCAS Actuary, AMI Risk Consultants
- Joeffrey Somera — ACAS Actuary, AMI Risk Consultants
- Graduate research assistants at multiple universities

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Publications

- The project team has generated over five dozen papers. Some of these have been published in top science, engineering and computer science journals and proceedings and conferences.
- Some of the publication outlets are:

  - Nature
  - ASCE Journal of Structural Engineering
  - Software Practice and Experience
  - Natural Hazard Review
  - Numerous IEEE Proceedings
  - Journal of Wind and Industrial Engineering Aerodynamic
  - Intl Wind Engineering Proceedings
  - Reliability Engineering and System Safety Journal

Publications (continued)

- Government Information Quarterly
- Statistical Methodology
- Statistical proceedings of ASA
- Wind and Structures
- Journal of Risk and Uncertainty in Engineering Systems
- Theoretical and Applied Climatology
- Journal of Modern Applied Statistical Methods
- Various Meteorology conferences
- Numerous engineering conference proceedings
- Numerous computer science conference proceedings

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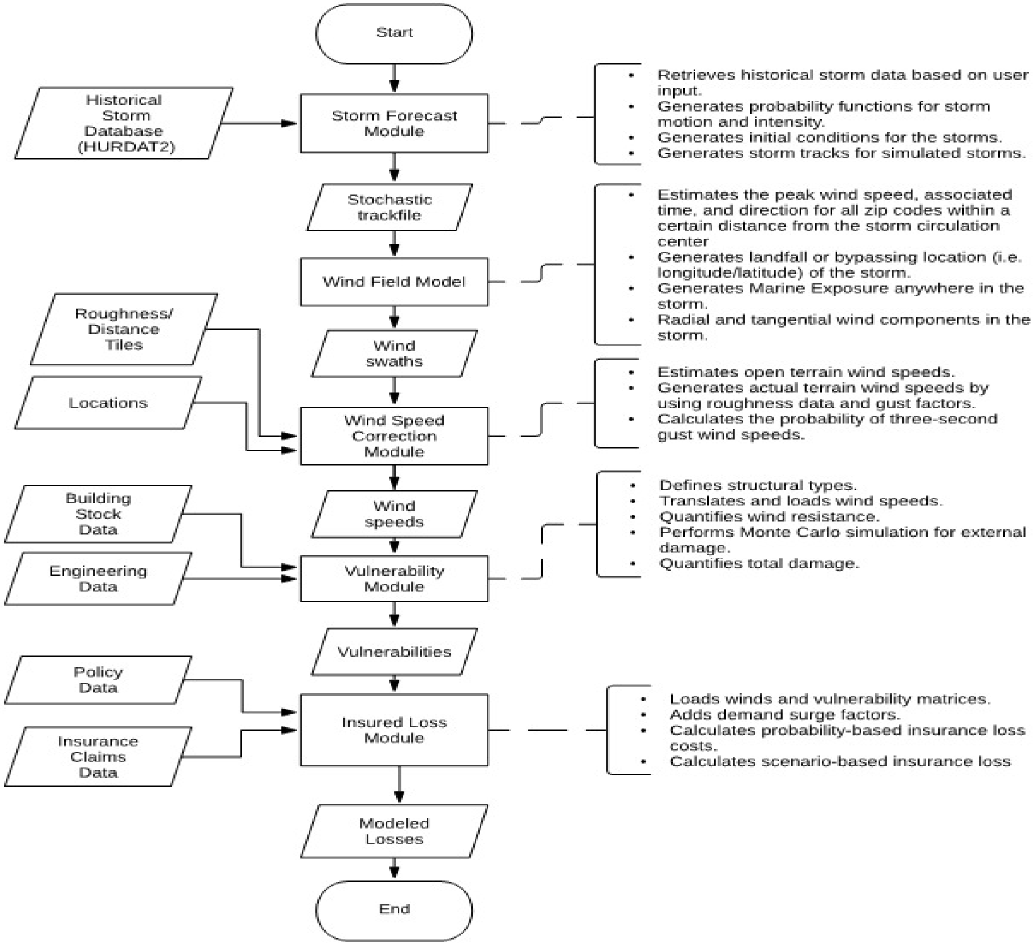
Model Design

- The model consists of three major components: wind hazard (meteorology), vulnerability (engineering), and insured loss cost (actuarial).
- The major components were developed independently before being integrated.
- The computer platform is designed to accommodate future hookups of additional sub-components or enhancements.



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Components of the model

- Hurricane threat area definition
- Storm genesis model
- Storm Track and Intensity Model
- Inland Storm Decay Model
- Wind Field Model
- Terrain Roughness Model
- Gust Factor Model
- GIS component
- Engineering damage simulation models
- Engineering vulnerability model
- Engineering Mitigation Model
- Demand Surge Model
- Actuarial Loss Model

Output of the Meteorology Component

- Over 60,000 years of simulations generated the stochastic set of hurricanes.
- Each simulated storm has an estimated track, intensity and wind fields at successive time intervals
- Wind field model generates 10 minute sustained wind speeds along the track
- These are corrected (downwards) for terrain roughness
- They are converted (upward) to 3 second peak gust winds
- The peak winds are input into the vulnerability and actuarial model

Meteorology Components

- Storm Track Generator
- Wind Field Model
- Terrain Adjustment

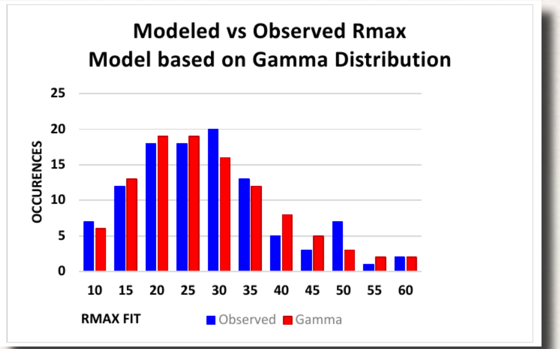
Storm Track Generator

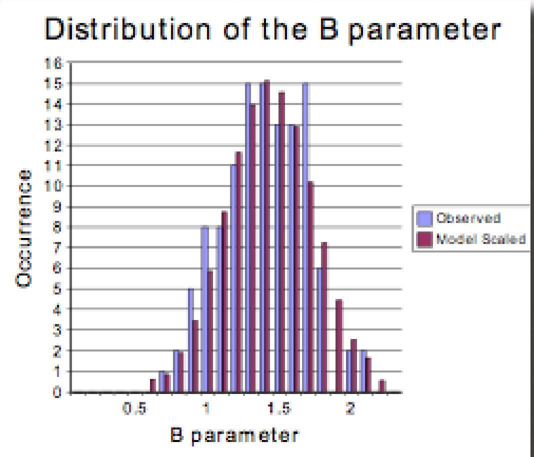
- Storm seeds based on historical storms that entered a threat area surrounding Florida and neighboring states
  - Initial position started at the historical position of the storm 36 hours prior to entering threat area, plus uniform random perturbations
  - Initial speed and intensity based on historical data plus random perturbations
- Changes in speed, direction and relative intensity are sampled from empirical PDFs derived from HURDAT data, and random perturbations added
- Storm parameters (Rmax and Holland B) are sampled from distributions derived from historical data

Storm Track Generator

- When storm is over land, a pressure filling model is used (exponential decay in time). If storms re-enters water, intensity changes are again resampled from the PDFs derived from HURDAT.
- Storms seeds are reused, but with new random perturbations, to generate over 60,000 years of storms
- Storm tracks are in 1 hr increments, and includes position, intensity (pressure), date and storm parameters (Rmax, B)
- Storm terminates when it exits domain or central pressure exceeds 1011 mb

- **Storm Parameters**
  - Rmax modeled by Gamma distribution
  - Holland B modeled by linear regression with residual fitted by a Gaussian distribution





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Wind Model

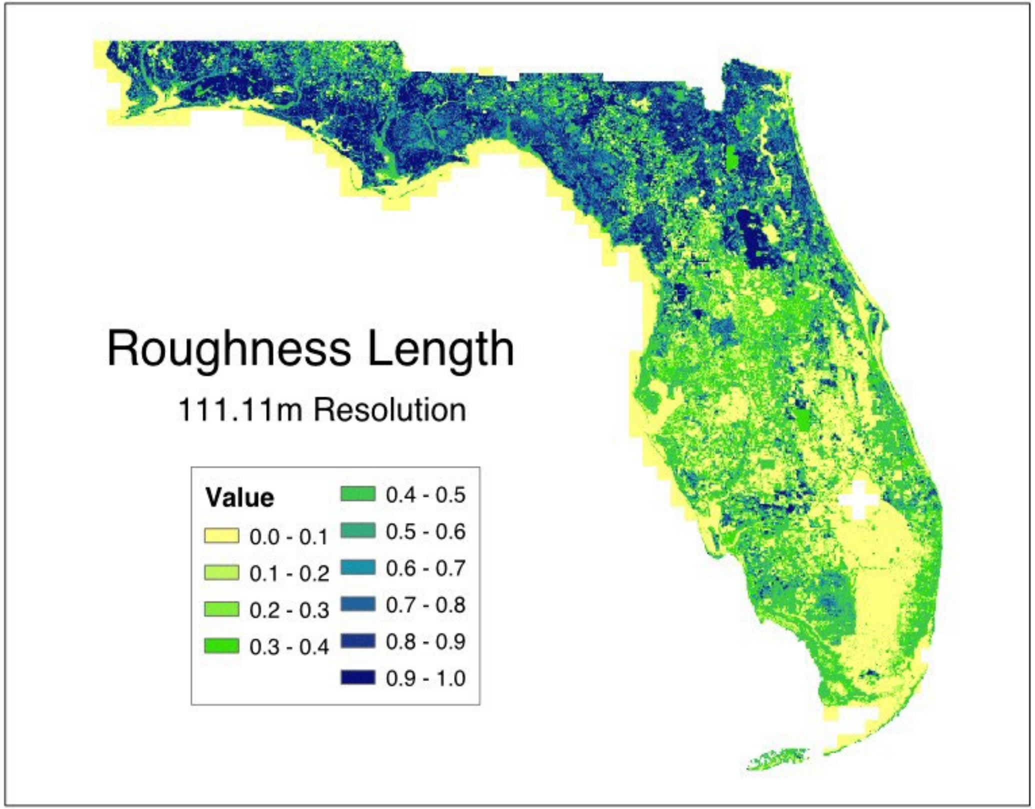
- Numerical solution of a "slab" model of the hurricane boundary layer, 450 m deep over ocean, 1 km deep over land (see Powell et al, 2005)
- Includes surface friction, with different drag coefficient over land vs water. Based on GPS sonde data.
- Initialized by a vortex in gradient balance with pressure field described by a Holland B profile.
- Mean wind of the slab is converted to a surface wind based on GPS sonde research

- **Wind field validation**
  - 1992 Andrew
  - 2004 Charley, Frances, Ivan, Jeanne
  - 2005: Dennis, Katrina, Rita, Wilma
  - 2017: Irma
  - 2018: Michael

Terrain Adjustment

- Winds are adjusted to terrain conditions using an effective roughness model and a coastal transition function for locations near the coast
- The effective roughness model determines the effect on roughness due to upstream land cover elements in each 45 degree sector.
- Effective roughness is computed at roughly 90 m resolution over Florida. For ZIP code policies, the roughness used is the population weighted effective roughness over the ZIP code.
- Roughness derived from 2016 National Land Use / Land Cover and Florida Water Management District data (2012-2020).
- Over 29 million grid roughness estimated
- For locations near the coast, a coastal transition function is used to account for the transition of the wind being in equilibrium with marine roughness to subsequently being in equilibrium with land roughness.
- Gust factor model based on ESDU is used to determine 1 minute sustained and 3 second gusts

Effective roughness by taking into account upstream fetch from a zip code centroid in 45 degree octants



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Engineering (vulnerability) component

- Produces vulnerability functions (matrices) that are used as input into the actuarial model
- Three model
  - personal residential
  - low rise commercial residential
  - mid-high rise commercial residential
- Separate vulnerability matrices are generated for each construction type (frame, masonry, mobile home, concrete high rise, unknown), roof type, 1 and 2 story, and quality of construction (strong, medium, weak)
- Separate matrices for building structure, contents, appurtenant structure, and ALE.
- Separate matrices for north, central, south Florida and Keys regions

Engineering (Vulnerability) Module Development

- Determine exposure
- Translate wind speed into loads
- Quantify wind resistance
- Conduct Monte Carlo Simulations
- Quantify damage

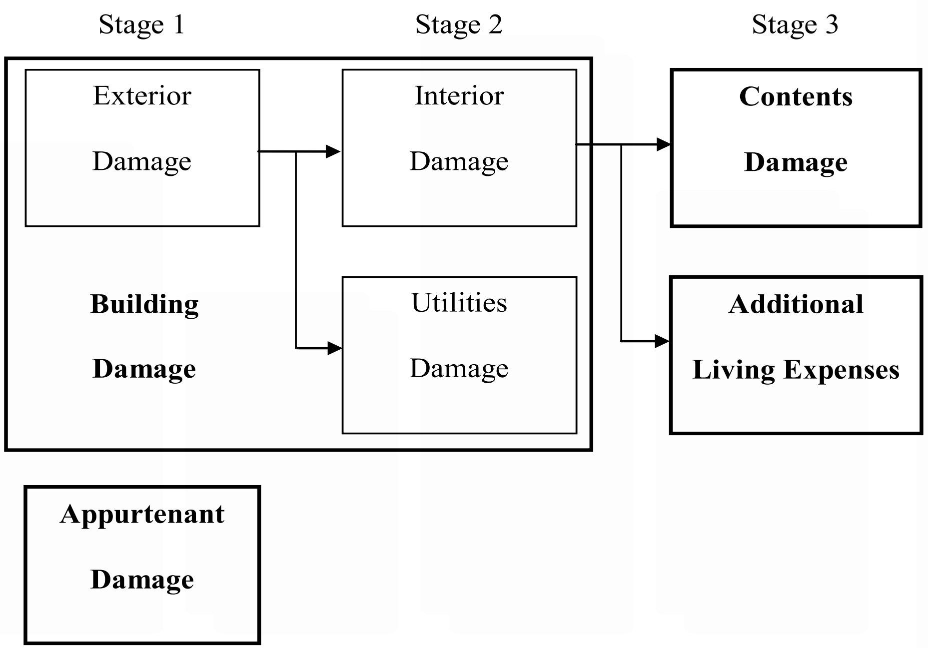
Engineering damage simulations

- Define **building classes** representative of the majority of the building stock
- Develop an **engineering model** for each building class
- **Year built acts as proxy for the building codes**. Based on the code regime, weak, medium, and strong models are developed for each region, for each building class.
- **Simulate possible wind damages** to the structure, interior, and contents, for each model.
- **Generates damage matrices** for each building class(frame or masonry, hip or gable roofs, manufactured homes, etc.) for different combinations of magnitude (from 50 to 250 mph) and direction (from 0 to 360) of maximum wind speed.

Three stage engineering development process

- Stage 1: Use Monte Carlo simulation engine to simulate the physical wind damage to the exterior components (doors, windows, walls, roof cover, roof sheathing, roof to wall connection) over a range of winds.
- Relates probabilistic strength capacities of building components to deterministic 3-sec peak wind speeds
- Detailed wind and structural engineering analysis that includes effects of wind-borne missiles
- For each typical home, at each wind speed, 40,000 combined external damage states are generated (5,000 for each of 8 possible wind directions)

- Stage 2: Extrapolates the interior and utility damage from the exterior damage (includes damage from water penetration)
- Stage 3 : Extrapolates the content and ALE damage from the interior damage
- The 3 stage modeling process is repeated for each of the construction type and quality and region
- Model also computes damages to appurtenant structures (pool, deck, sheds, fence etc) based on empirical equations.



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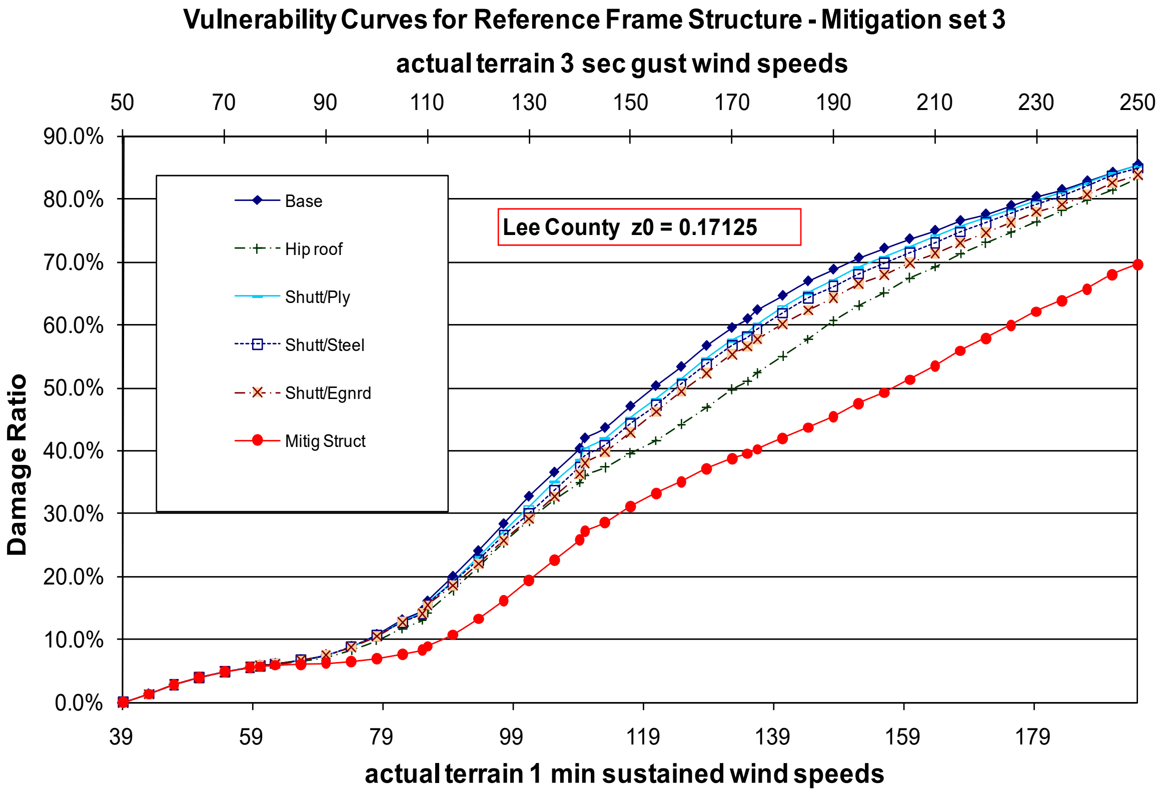
Vulnerability Model

- Convert physical damages into repair cost
- Produce damage ratios = repair cost/(home value)
- Vulnerability curved = $P(\text{loss ratio}|\text{wind speed})_{\text{building class}}$
- FPHLM has over 10,000 vulnerability curves
- Validated against claim and reconnaissance data

EXAMPLES OF VULNERABILITY CURVES WITH DIFFERENT MITIGATION FEATURES



Computer System Architecture

- The FPHLM is a large-scale system designed to store, retrieve, and process large amounts of historical and simulated storm/rainfall data. In addition, intensive computation is supported for flood damage assessment and insured loss projection
- A three-tier architecture is adopted and deployed in our system
  - User interface layer
  - Application logic layer
  - Database layer

Hardware and Software Structure

- The FPHLM is designed and operates on a computing cluster of 60 servers interconnected by network routers
  - 2,412 total CPU cores
  - 509TB storage
- Regular backups of the server are performed
  - Physically and electronically
  - Backups are performed daily

Hardware and Software Structure Cont.

- The user-facing part of the system consists of a collection of scripts written in Bash and Python
- Backend probabilistic calculations are coded in C++ and Python
- The system uses a PostgreSQL database that runs on a Linux server
- Minimal end-user workstation requirements
  - Any current version of Internet Explorer, Firefox, Chrome, or Safari running on a currently supported version of Windows, Mac or Linux should deliver optimal user experience

FPFLM Actuarial component

- The actuarial component consists of a set of algorithms.
- The process involves a series of steps: rigorous check of the input data; selection and use of the relevant output produced by the hazard components; selection and use of the appropriate vulnerability functions for building structure, contents, and additional living expenses; running the actuarial algorithm to produce expected losses; aggregating the losses in a variety of manners to produce a set of expected annual flood losses; and produce probable maximum losses for various return periods.
- The expected losses can be reported by construction type (e.g., masonry, frame, manufactured homes), by geographic zone, county or ZIP Code, by rating territory, and combinations thereof.

- To estimate annual loss costs and probable maximum loss levels, losses are estimated for individual policies in the portfolio for each event in a stochastic set of storms. Losses are estimated separately for structure, contents, and time element coverage.
- For each event wind speeds are determined
- A vulnerability matrix is assigned to the exposure based on the characteristics of the exposure. The matrix specifies the percent damage for given wind speed.
- The estimated damages are reduced by applicable deductibles, increased to allow for the impact of demand surge on claim costs and subjected to policy limits.

- The demand surge factors are estimated by a separate model and applied appropriately to each storm in the stochastic set.

- The modeled insured losses can then be summed across all properties in a ZIP Code or across all ZIP Codes in a county to obtain expected aggregate loss. The losses can also be aggregated by policy form, construction type, rating territories, etc.

- Finally, modeled insured losses are divided by the number of years in the simulation and by the total amount of insurance to estimate annual loss costs.

- To estimate Probable maximum loss on an "annual aggregate" basis modeled losses for storms occurring in the same year of the simulation are summed to produce annual storm losses.

- Probable maximum loss levels are calculated non parametrically from the ordered set of annual losses.

- To estimate Probable maximum loss on an "annual occurrence" basis the ordered set consists of the largest loss in each year of the simulation.

Florida Public Hurricane Loss Model

Met Audit Items

V8.3

M-1

1. The Model Base Hurricane Set and its justification will be reviewed.

The Model Base Hurricane Set is described in Disclosures 1 and 2. The justification is provided in Disclosure 3.

The Model Hurricane Base Set is the Reference Hurricane Set plus one additional year (2023). The HURDAT2 release date is May 11, 2024.

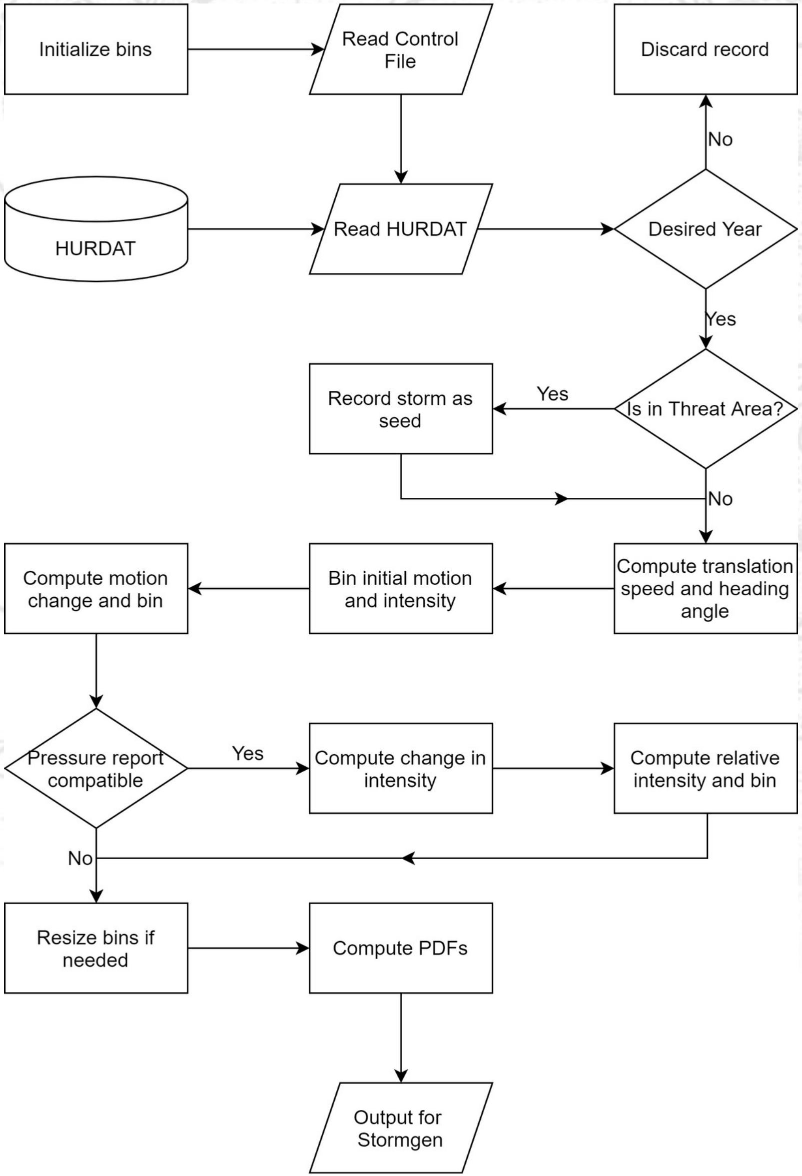
The extended reference set used for the Model Hurricane Base Set is the most up-to-date complete seasonal record that is available at the time of this submission. The longer, updated record should lead to further improvement in the simulated frequencies of hurricane activity.

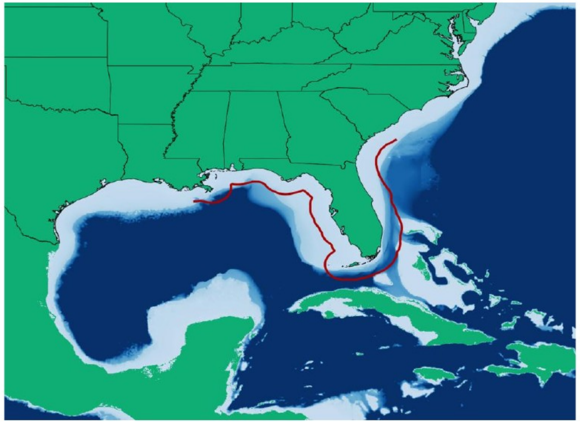
M-1

2. A flowchart or other illustration of how changes in the Reference Hurricane Set are used in the calculation of the Model Base Hurricane Set landfall distribution will be reviewed.

A flowchart showing how the empirical distributions for storm track and intensity are derived from HURDAT2 follows.

Generate empirical PDFs of change in motion and intensity and record initial location, motion and intensity for each storm seed





Threat Area – see G-1.2

M-1

3. Changes to the Model Base Hurricane Set from the current accepted hurricane model used will be reviewed.

The change includes two additional years (2022-2023). Changes in hurricanes are listed in Form M-1, part F:

The following Florida landfalling storms were added to the Base Set: Ian (2022), Nicole (2022) and Idalia (2023).

M-1

5. If the model is a climate-adjusted model, changes in hurricane intensity, frequency, and track, if applicable, will be reviewed.

Not applicable.

M-2

2. All hurricane parameters used in the hurricane model, including any adjusted for climate change, will be reviewed.

The hurricane parameters are described in Disclosure 2. Additional discussion is provided in Disclosures 4 and 6 and also G-1 Disclosure 2. Also see Form S-3.

No parameters adjusted for climate change.

Model Parameters include:

Storm initial location, motion – perturbations from uniform distribution

Storm speed, direction change – empirical distribution derived from HURDAT2

Storm Intensity change – empirical distribution derived from HURDAT2

Radius of maximum winds – Gamma distribution derived from Rmax database

Holland B pressure profile parameter – regression equation (see G-1.2, Eq GEN-5) plus Gaussian error term based on data from Willoughby & Rahn (2004)

Pressure Decay (after landfall) – exponential, decay error term is normal distribution based on Vickery (2005)

Form S-3

Stochastic Hurricane Parameter (Function or Variable)	Functional Form of Distribution	Data Source	Year Range Used		Justification for Functional Form and Parameter Estimates
			For Fitting	For Validation	
Holland B Error term	Normal	Willoughby and Rahn (2004)	1977-2000	1977-2000	The Gaussian Distribution provided a good fit for the error term. See Standard S-1, Disclosure 1.
Rmax	Gamma	Ho et al. (1987) , supplemented by the extended best track data of DeMaria (Penington 2000), NOAA HRD research flight data, and NOAA-HRD H*Wind analyses (Powell et al. 1996, 1998).	1901-2021	1901-2021	Rmax is skewed, nonnegative and does not have a long tail. So the gamma distribution was tried and found to be a good fit. We limit the range of Rmax to the interval (4, 120). See Standard S-1, Disclosure 1.
Pressure decay Term	Normal	Vickery (2005)	1926-2004	1926-2004	From Vickery (2005)

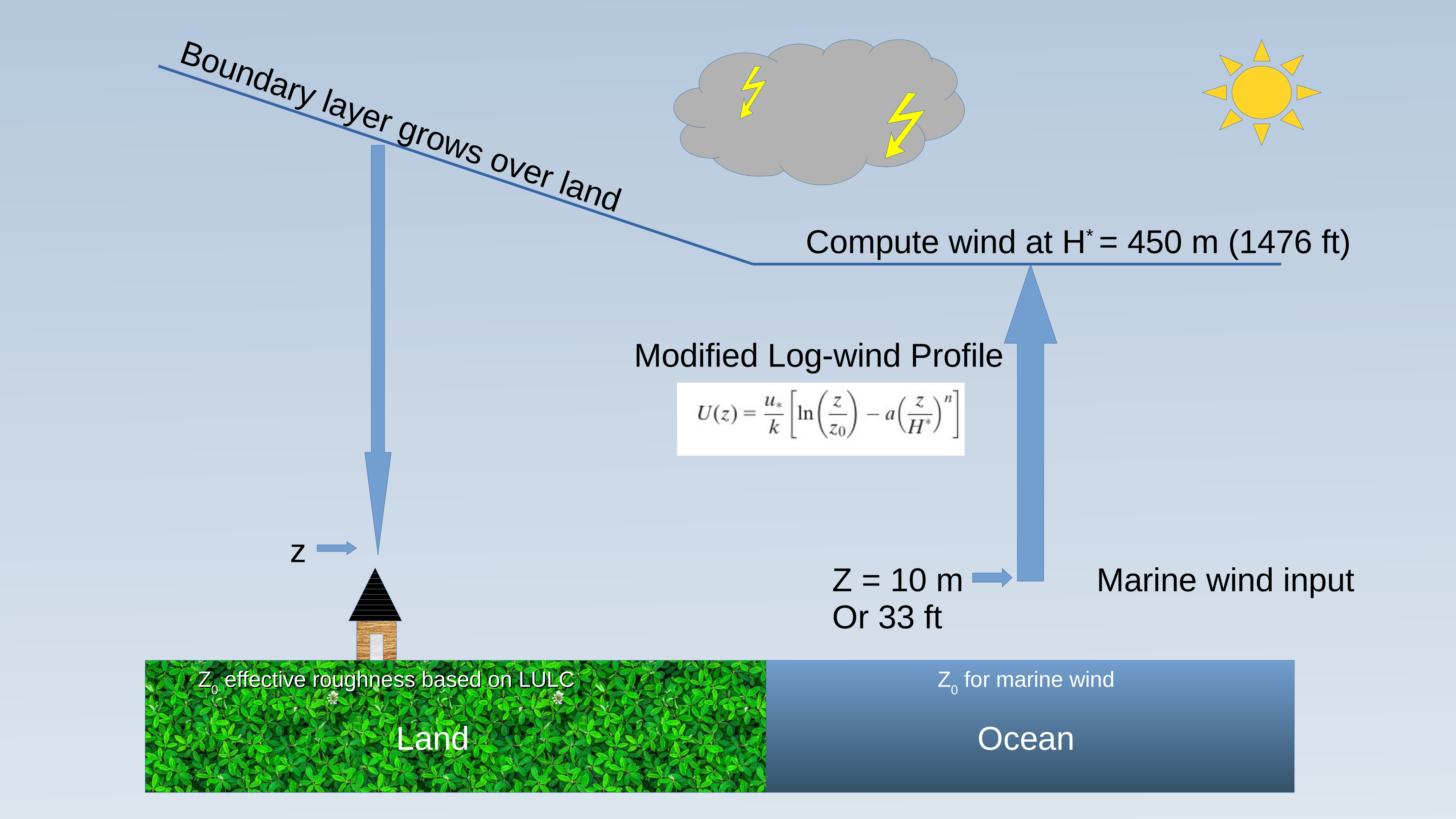
Form S-3 Continued

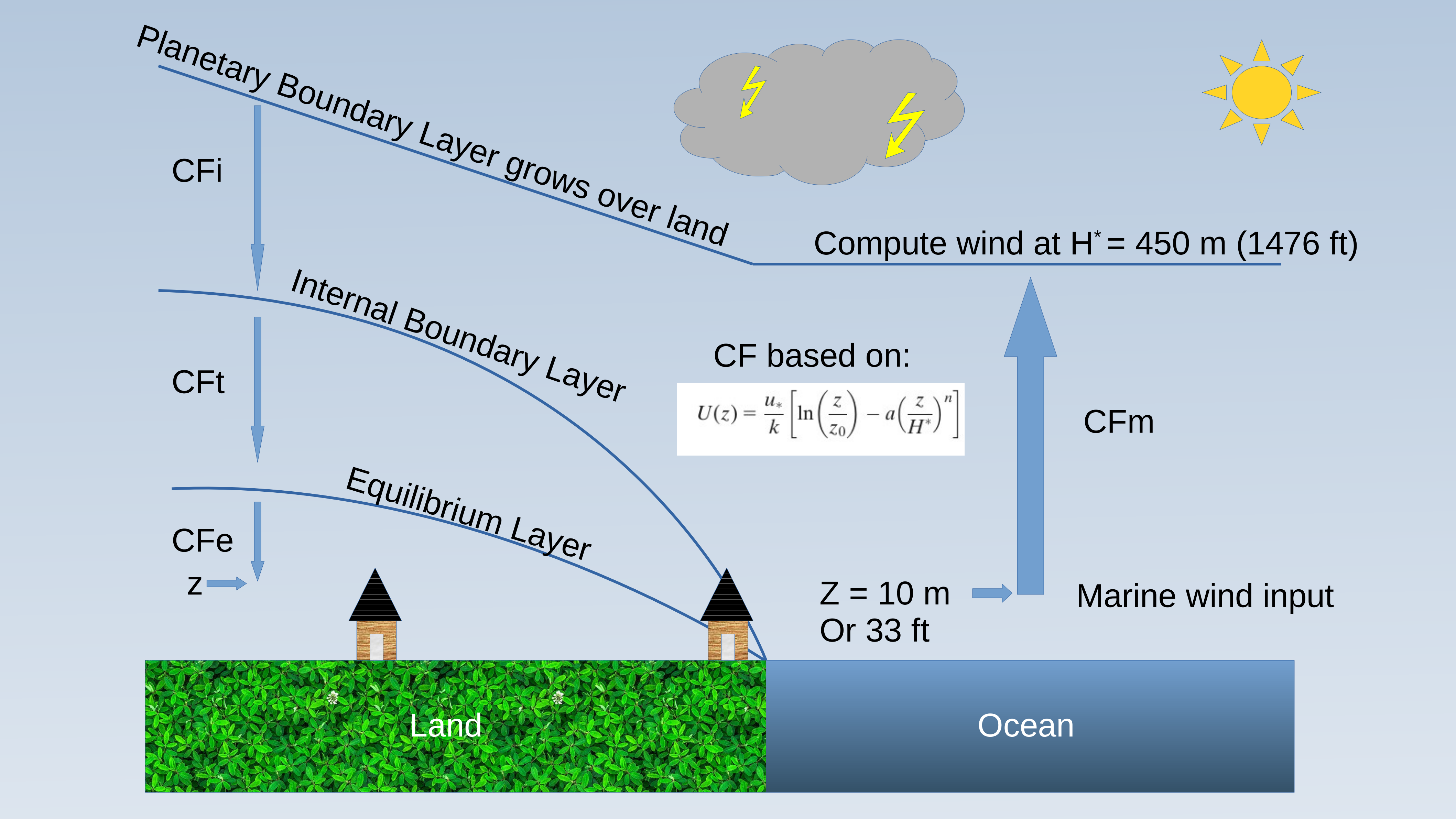
Stochastic Hurricane Parameter (Function or Variable)	Functional Form of Distribution	Data Source	Year Range Used		Justification for Functional Form and Parameter Estimates
			For Fitting	For Validation	
Storm initial location perturbation	Uniform	N/A	N/A	N/A	Plausible variations in initial storm locations are assumed to be uniform
Storm initial motion perturbation	Uniform	N/A	N/A	N/A	Plausible variations in initial storm motion are assumed to be uniform
Storm change in motion and intensity distributions	Empirical	HURDAT2	1900-2023	1900-2023	Sampling from historical data See Standard G-1, Disclosure 2 for details

M-4

4. A flowchart or other illustration depicting the process for calculating hurricane surface winds will be reviewed.

Illustrations showing the terrain conversion for inland and coastal locations follow


Boundary layer grows over land
Compute wind at $H^* = 450$ m (1476 ft)
Modified Log-wind Profile
$U(z) = \frac{u_*}{k}\left[\ln\left(\frac{z}{z_0}\right) - a\left(\frac{z}{H^*}\right)^n\right]$
z
Z = 10 m
Or 33 ft
Marine wind input
Z_0 effective roughness based on LULC
Land
Z_0 for marine wind
Ocean

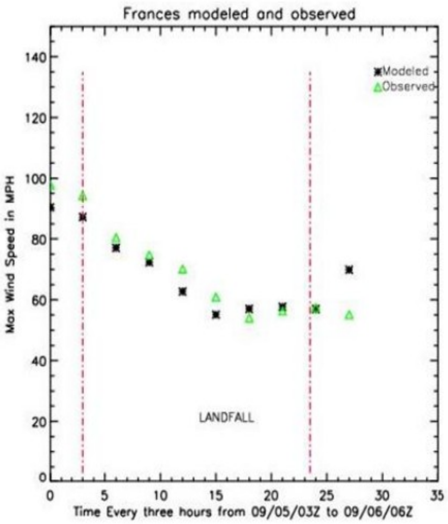


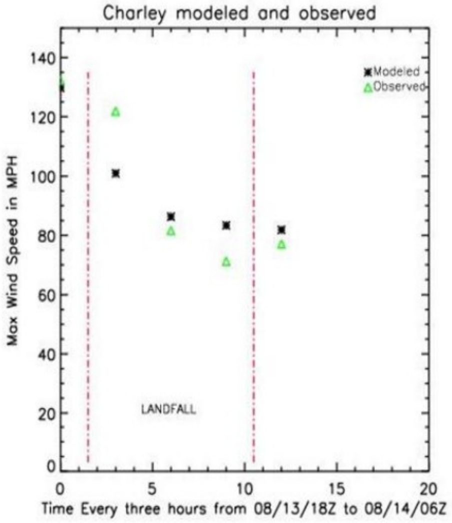
Planetary Boundary Layer grows over land
CFi
Compute wind at H* = 450 m (1476 ft)
Internal Boundary Layer
CFt
CF based on:
$$U(z) = \frac{u_*}{k}\left[\ln\left(\frac{z}{z_0}\right) - a\left(\frac{z}{H^*}\right)^n\right]$$
CFm
Equilibrium Layer
CFe
z
Z = 10 m
Or 33 ft
Marine wind input
Land
Ocean

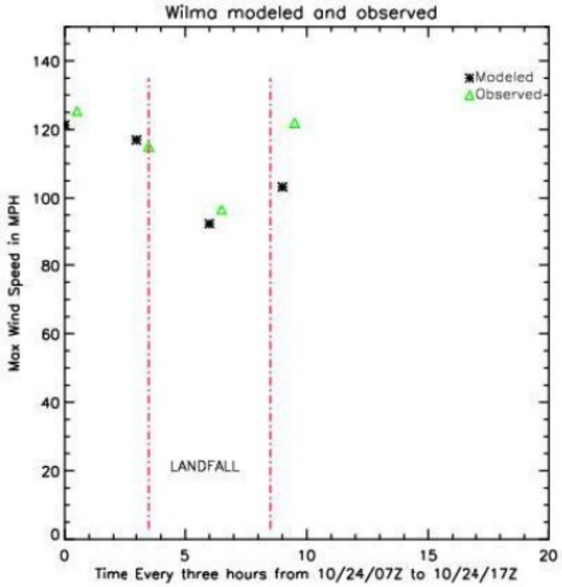
M-5

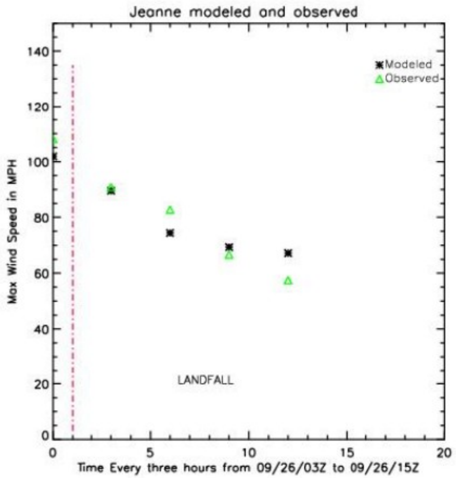
3. Comparisons of the hurricane model weakening rates to weakening rates for historical Florida hurricanes will be reviewed.

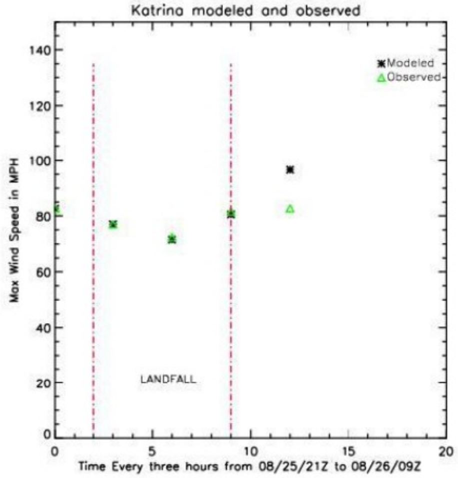
Comparisons are shown and discussed in Disclosure 3. Plots are shown in next slide.











Landfall is represented by the vertical dash-dot red line at the left and time of exit as the red line on the right.

V-1 Development of Building Hurricane Vulnerability Functions

Selected audit items

V-1 Development of Building Hurricane Vulnerability Functions Response to Audit #3:

The breakdown of insurance company exposure data used to develop the building hurricane vulnerability functions into number of insurers, number of policies, number of locations, and amount of dollar exposure by policy type will be reviewed.

See the following:

- Standard V-1, disclosure 3

Policy Type	Number of Insurers	Number of Policies	Number of Locations	Exposure Value ($)
Personal Residential	7	10,421,590	10,421,590	$ 357,835,825,702
Manufactured Homes	4	559,621	559,621	$ 3,746,579,099
Commercial Residential	4	342,566	342,566	$ 50,253,057,050

V-1 Development of Building Hurricane Vulnerability Functions
Response to Audit #4:

The breakdown of insurance company hurricane claims data used to develop the building hurricane vulnerability functions into events (year and storm name), number of insurers, number of policies, number of locations, number of claims, and amount of loss separated by policy type will be reviewed.

See the following:

- Standard V-1, disclosure 3

Year	Storm Name	Number of Insurers			Number of Policies			Number of Locations			Number of Claims			Loss Amount ($)		
		Personal Residential	Manufactured Homes	Commercial Residential	Personal Residential	Manufactured Homes	Commercial Residential	Personal Residential	Manufactured Homes	Commercial Residential	Personal Residential	Manufactured Homes	Commercial Residential	Personal Residential	Manufactured Homes	Commercial Residential
1992	Andrew	1	0	0	282,616			282,616			80,239			$2,002,178,595		
1995	Erin	1	0	0	82,201			82,201			23,338			$46,621,879		
2004	Charley	5	3	3	1,505,687	67,483	66,580	1,505,687	67,483	66,580	142,583	13,210	829	$1,973,456,081	$149,081,191	$ 83,961,629
2004	Frances	5	3	3	1,544,965	67,022	66,540	1,544,965	67,022	66,540	122,293	12,430	1,659	$1,341,974,246	$119,684,735	$219,814,961
2004	Jeanne	5	3	3	1,736,922	68,767	65,823	1,736,922	68,767	65,823	97,823	14,813	596	$705,489,675	$100,103,719	$ 42,067,967
2005	Dennis	4	2	1	1,723,551	117,382	11,511	1,723,551	117,382	11,511	8,641	286	22	$48,441,385	$1,062,209	$ 270,798
2005	Katrina	4	2	3	1,752,216	117,165	63,880	1,752,216	117,165	63,880	7,946	124	345	$68,300,632	$720,051	$ 13,899,576
2005	Wilma	4	2	4	1,793,432	121,802	68,232	1,793,432	121,802	68,232	92,213	6,603	5,248	$1,523,741,170	$60,609,747	$347,087,341

V-1 Development of Building Hurricane Vulnerability Functions Response to Audit #10:

Rational engineering analysis used to develop building hurricane vulnerability functions will be reviewed for a variety of different building construction classes.

See the following:

- Vulnerability overview presentation
- Standard G-1, Vulnerability Component
- Standard V-1, disclosures 5 (assumptions, methods and processes), 6 (uncertainties), 7 (post-events), 8 (library of vulnerabilities), 9 (practice and building code), 11 (treatment of unknowns)

V-1 Development of Building Hurricane Vulnerability Functions Response to Audit # 11:

The combination of available insurance company hurricane claims data and rational engineering analysis to develop the building hurricane vulnerability functions will be reviewed.

- Standard V-1, disclosures 3, 5 and 11 (pg 195 – 234, 253 – 255)
- Standard G-1, Vulnerability Component, pg 26-50

The building vulnerability functions are the product of an engineering component approach and are not the results of an empirical regression against historical data.

Historical claim data are used to calibrate and validate the numerical models. But the claim data has a lot of issues and varies a lot from storm to storm, company to company, so a goddess of fit is not sought between the models and the wide variety of empirical models

JOURNAL PUBLICATIONS

- Pinelli, J.-P, Gurley, K., Subramanian, C., Hamid, S., and Pita, G. "Validation of a probabilistic model for hurricane insurance loss projections in Florida," Reliability Engineering and System Safety International Journal, Vol. 93, No 12, pp. 1896-1905, December 2008.
- Pinelli, J.P., Da Cruz, J., Gurley, K., Paleo-Torres, A., Baradaranshoraka, M., Cocke, S., Shin, D.W. (2020) "Uncertainty reduction through data management in the development, validation, calibration, and operation of a hurricane vulnerability model," International Journal of Disaster Risk Science, 11(6). https://doi.org/10.1007/s13753-020-00316-4

V-1 Development of Building Hurricane Vulnerability Functions Response to Audit # 18:

The percentage of damage at or above which the hurricane model assumes a total building loss will be reviewed.

The engineering model does not have any percentage (< 100%) of damage above which the model assumes a total loss.

The actuarial model do not have any percentage (< 100%) at which total loss is declared. Long ago we had an optional switch that declared total loss at 50%. Simulations showed it made little significant difference to total loss so we did not use it.

V-2 Development of Content Hurricane Vulnerability Functions Response to Audit # 9

Support for the rational engineering analysis used in developing the contents hurricane vulnerability functions will be reviewed.

See the following:

- Overview presentation
- V-2, disclosure 2 (flow charts), 3 (assumptions, data, methods, and processes), 6 (building and contents), 7 (water infiltration)

V-2 Development of Content Hurricane Vulnerability Functions Response to Audit # 10

The combination of available insurance company hurricane claims data and rational engineering analysis to develop the contents hurricane vulnerability functions will be reviewed.

See the following:

- Response to Audits #3 and #4 of Standard V-1
- The same combination of hurricane claims data and rational engineering analysis was used for building and contents

V-2 Development of Content Hurricane Vulnerability Functions Response to Audit # 11

The modeling of water infiltration on contents vulnerability functions for a multi-story commercial residential building, if applicable, will be reviewed.

See the following:

- Standard V-1, disclosure 14, *Treatment of water infiltration in the commercial residential low-rise model and Water percolation for MHR CR*
- Standard V-2, disclosure 7 (water infiltration)

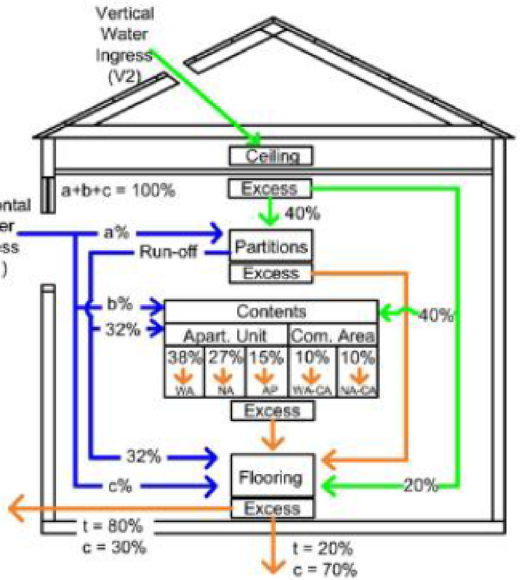


Figure 50. Monte Carlo simulation procedure to predict the building damage

V-3 Development of Time Element Hurricane Vulnerability Functions Response to Audit # 8

Support for the rational engineering analysis used in developing the time element hurricane vulnerability functions will be reviewed.

See the following:

- Overview presentation
- Standard V-3, disclosure 2 (flowcharts), 3 (assumptions, data, methods, and processes), 4 (uncertainties), 5 (infrastructure)

PR: Time element or Additional Living Expenses (ALE) are modeled as a function of interior damage.

CR: The model compute time-related expenses for apartment buildings as a function of overall building damage ratio.

V-3 Development of Time Element Hurricane Vulnerability Functions Response to Audit # 9

The combination of available insurance company hurricane claims data and rational engineering analysis to develop the time element hurricane vulnerability functions will be reviewed.

See the following:

- Response to Audits #3 and #4 of Standard V-1

The same combination of hurricane claims data and rational engineering analysis was used for building and TE.

V-4 Hurricane Mitigation Measures and Secondary Characteristics Response to Audit # 8

For each roof covering type used to complete Form V-2, the following will be reviewed:

a) Roof age definition as considered in the model, including assumptions,

b) The association between roof age and year built, including assumptions

c) Variation in roof age assumptions (e.g., by region or ZIP Code), and

d) The impact of roof age on loss costs.

See the following:

Standard G-1, Vulnerability component, page 29 (last paragraph), page 30 (last paragraph), pages 31-32, Tables 1 and 2 (pg 32 – 33)

AUDIT # 8

- The vulnerability model assumes a roof life cycle of 20-years
- Pinelli, J.-P., Johnson, T., Pita, G., Gurley, K. (2012). Life-cycle assessment of personal residential roof decking and cover under hurricane threat. Proceedings, Advances in Hurricane Engineering, October 24-26, Miami, FL.

Florida Public Hurricane Loss Model

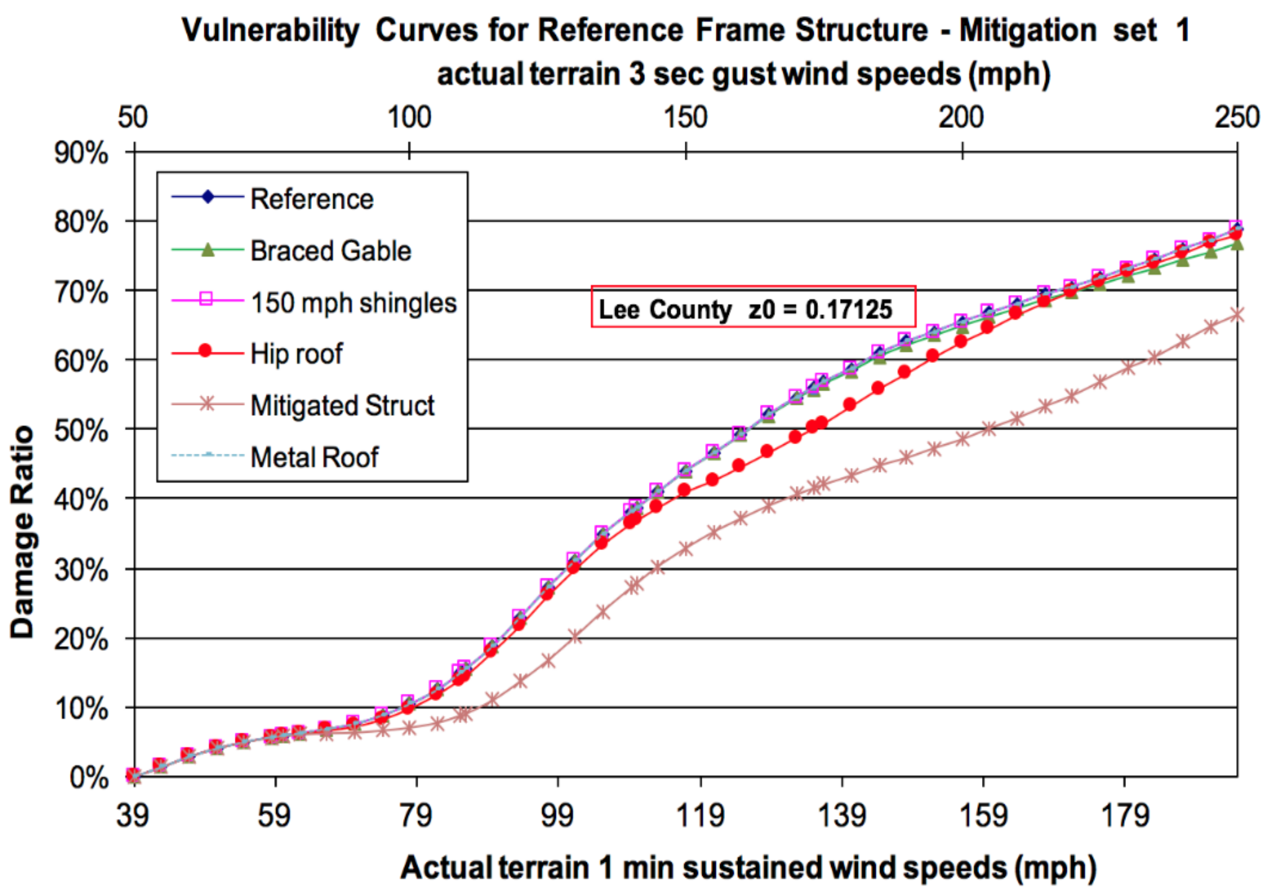
Forms V-3 and V-5

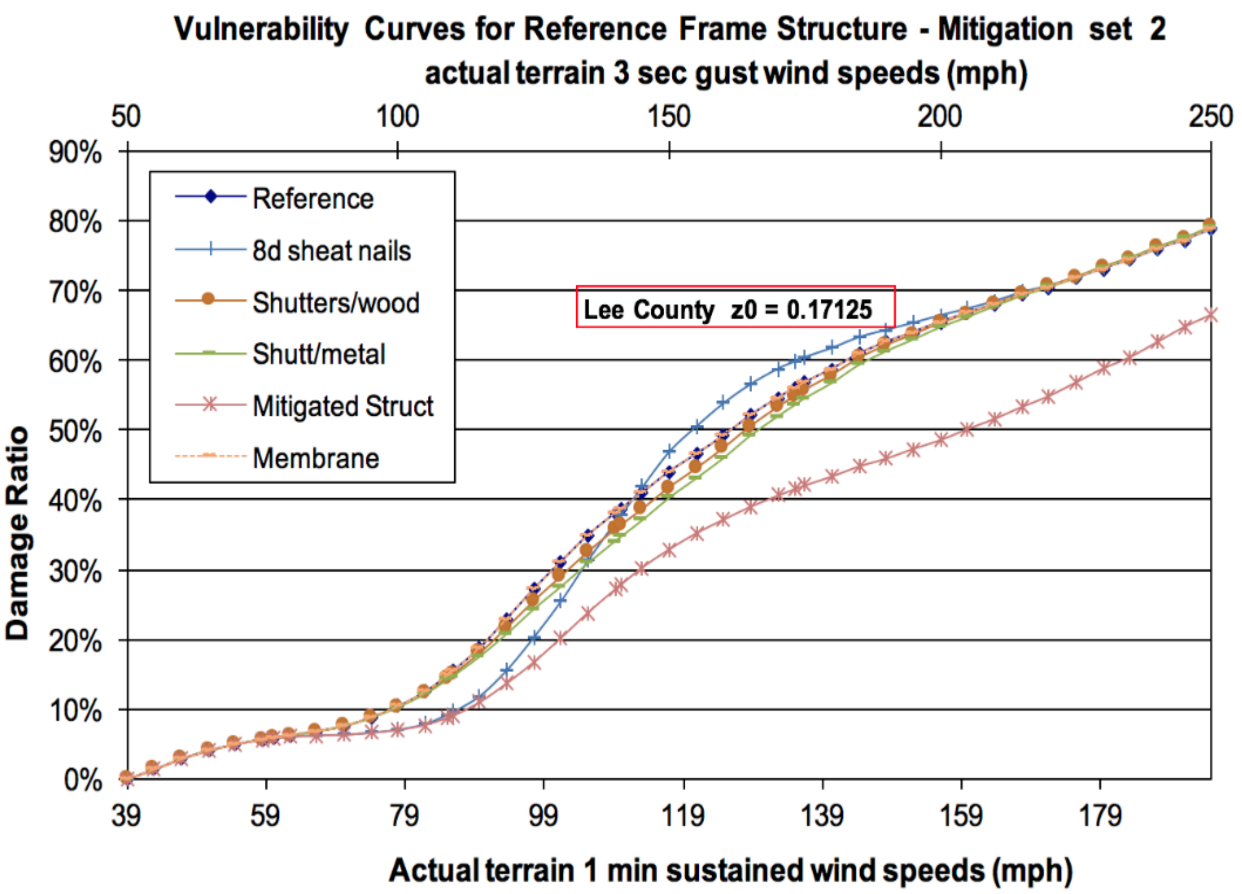
Form V-3: Mitigation Measures – Mean Damage Ratio (1 min)

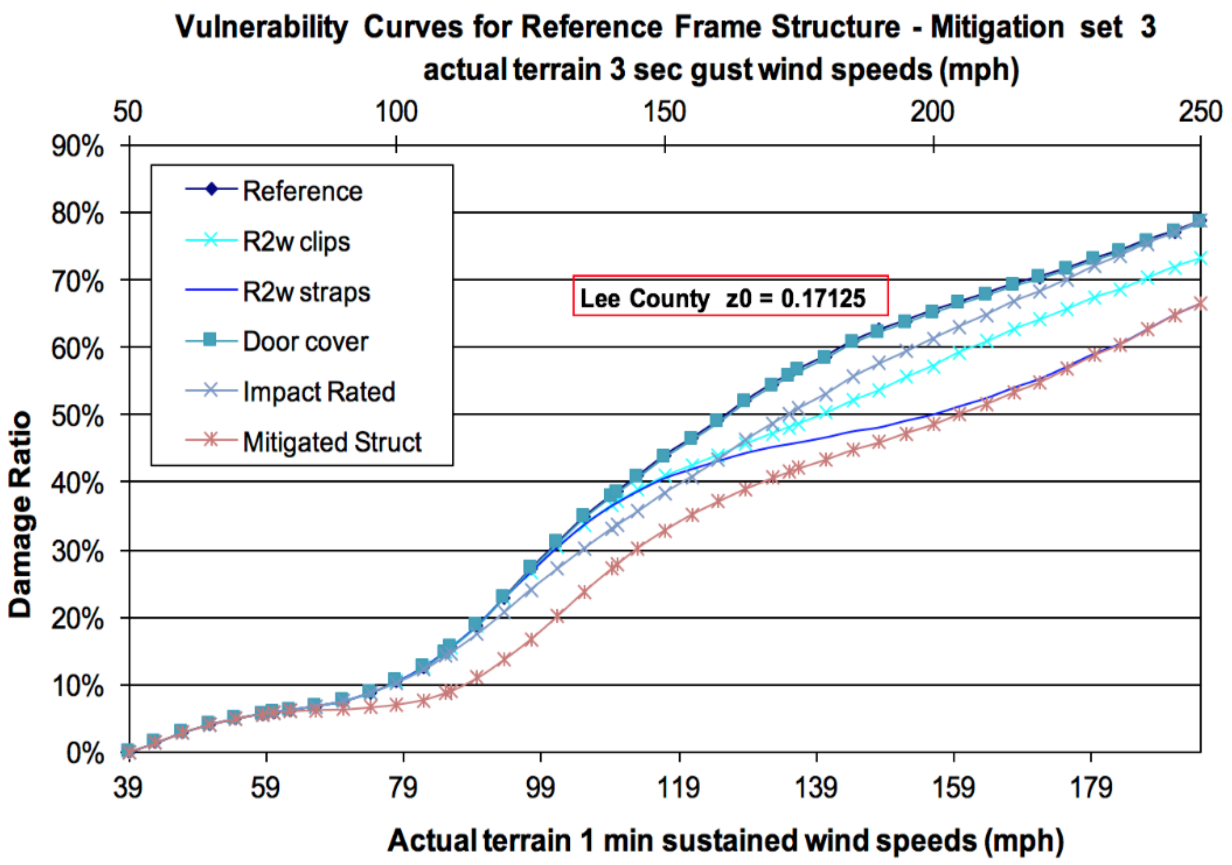
INDIVIDUAL MITIGATION MEASURES		MEAN DAMAGE RATIO										LOSS COSTS	
		FRAME BUILDING					MASONRY BUILDING					FRAME BUILDING	MASONRY BUILDING
		WIND SPEED (MPH)					WIND SPEED (MPH)					ACROSS ALL WINDSPEEDS	
		60	85	110	135	160	60	85	110	135	160		
	REFERENCE BUILDING	6%	15%	39%	56%	67%	6%	14%	35%	47%	62%	$14.632	$14.110
ROOF CONFIGURATION	BRACED GABLE ENDS	6%	15%	39%	56%	66%	6%	14%	35%	47%	61%	$14.631	$14.110
	HIP ROOF	6%	14%	37%	50%	64%	6%	13%	34%	44%	59%	$14.059	$13.596
ROOF COVERING	METAL	6%	15%	39%	56%	67%	6%	14%	35%	47%	62%	$14.628	$14.107
	ASTM D7158 CLASS H SHINGLES (150 MPH)	6%	15%	39%	56%	67%	6%	14%	35%	47%	62%	$14.628	$14.107
	MEMBRANE	6%	15%	39%	56%	67%	6%	14%	35%	47%	62%	$14.631	$14.110
ROOF SHEATHING	NAILING OF DECK 8d	6%	9%	38%	60%	67%	6%	9%	30%	48%	63%	$12.042	$11.359
ROOF-WALL STRENGTH	CLIPS	6%	15%	37%	48%	59%	6%	14%	35%	43%	54%	$14.553	$14.107
	STRAPS	6%	15%	37%	46%	51%	6%	14%	35%	43%	53%	$14.542	$14.106
WALL-FLOOR STRENGTH	TIES OR CLIPS	6%	15%	38%	54%	65%	-	-	-	-	-	$14.561	-
	STRAPS	6%	15%	37%	53%	64%	-	-	-	-	-	$14.540	-
WALL FOUNDATION STRENGTH	LARGER ANCHORS OR CLOSER SPACING	-	-	-	-	-	-	-	-	-	-	-	-
	STRAPS	-	-	-	-	-	-	-	-	-	-	-	-
	VERTICAL REINFORCING	-	-	-	-	-	6%	14%	35%	42%	48%	-	$14.086

Form V-3

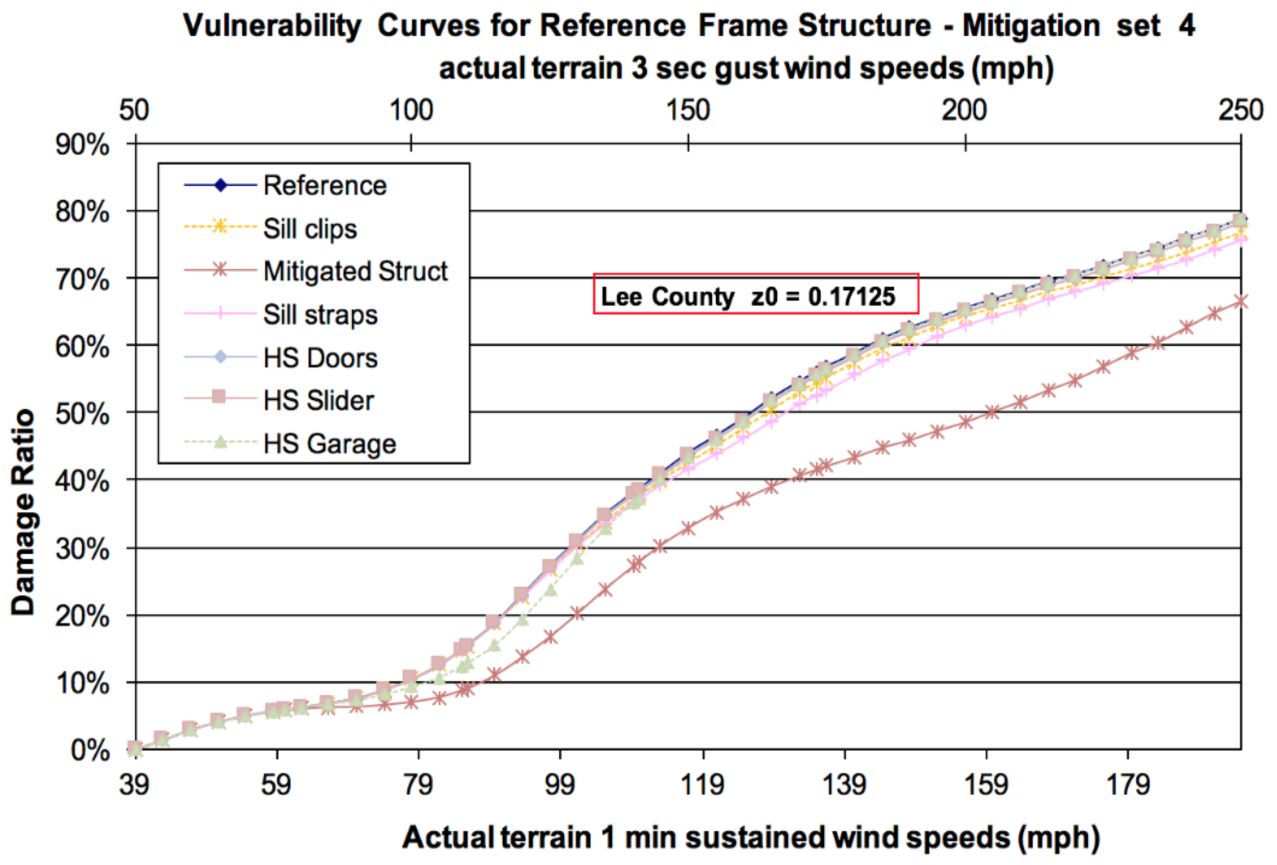
OPENING PROTECTION	WINDOW SHUTTERS	STRUCT WOOD	6%	14%	36%	55%	67%	6%	14%	32%	46%	61%	$14.340	$13.830
		METAL	6%	14%	35%	54%	66%	6%	14%	31%	44%	61%	$14.159	$13.661
	DOOR AND SKYLIGHT COVERS		6%	15%	38%	56%	66%	6%	14%	35%	46%	61%	$14.595	$14.078
WINDOW DOOR, SKYLIGHT STRENGTH		IMPACT RATED	6%	14%	34%	50%	63%	6%	14%	30%	41%	58%	$14.113	$13.619
	ENTRY DOORS	MEETS WINDBORNE DEBRIS REQUIREMENTS	6%	15%	39%	56%	66%	6%	14%	35%	46%	61%	$14.619	$14.100
	GARAGE DOORS	MEETS WINDBORNE DEBRIS REQUIREMENTS	6%	12%	37%	56%	67%	6%	12%	33%	47%	62%	$13.551	$13.053
	SLIDING GLASS DOORS	MEETS WINDBORNE DEBRIS REQUIREMENTS	6%	15%	38%	55%	66%	6%	14%	35%	46%	61%	$14.584	$14.069
MITIGATION MEASURES IN COMBINATION			MEAN DAMAGE RATIO											
			FRAME BUILDING					MASONRY BUILDING					FRAME BUILDING	MASONRY BUILDING
			WIND SPEED (MPH)					WIND SPEED (MPH)					ACROSS ALL WINDSPEEDS	
			60	85	110	135	160	60	85	110	135	160		
MITIGATED BUILDING			6%	9%	28%	42%	50%	6%	9%	26%	39%	52%	$11.446	$11.112


Vulnerability Curves for Reference Frame Structure - Mitigation set 1
actual terrain 3 sec gust wind speeds (mph)
50
100
150
200
250
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Damage Ratio
Reference
Braced Gable
150 mph shingles
Hip roof
Mitigated Struct
Metal Roof
Lee County z0 = 0.17125
39
59
79
99
119
139
159
179
Actual terrain 1 min sustained wind speeds (mph)


Vulnerability Curves for Reference Frame Structure - Mitigation set 2
actual terrain 3 sec gust wind speeds (mph)
50
100
150
200
250
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Damage Ratio
Reference
8d sheat nails
Shutters/wood
Shutt/metal
Mitigated Struct
Membrane
Lee County z0 = 0.17125
39
59
79
99
119
139
159
179
Actual terrain 1 min sustained wind speeds (mph)



Vulnerability Curves for Reference Frame Structure - Mitigation set 3
actual terrain 3 sec gust wind speeds (mph)
50
100
150
200
250
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Reference
R2w clips
R2w straps
Door cover
Impact Rated
Mitigated Struct
Lee County z0 = 0.17125
Damage Ratio
39
59
79
99
119
139
159
179
Actual terrain 1 min sustained wind speeds (mph)



Vulnerability Curves for Reference Frame Structure - Mitigation set 4
actual terrain 3 sec gust wind speeds (mph)
50
100
150
200
250
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Reference
Sill clips
Mitigated Struct
Sill straps
HS Doors
HS Slider
HS Garage
Lee County z0 = 0.17125
Damage Ratio
39
59
79
99
119
139
159
179
Actual terrain 1 min sustained wind speeds (mph)

Form V-3 Mitigated Vulnerabilities

- Curves for base, membrane, mitigated gable, metal roof, high strength door, high strength slider, and mitigated shingles are similar, Because internal damage is dominated by sheathing damage, mitigating only gable or roof cover does not improve the structure
- This result is dependent on the base case weak sheathing connection and should not be interpreted to imply that reroofing is not an effective mitigation. Reroofing is only ineffective for the case of a very weak roof deck. The combination of re-nailing the decking and reroofing (now required practice) is an effective mitigation.

Form V-3 Mitigated Vulnerabilities

- For the same reason, mitigated sheathing (8d nails) is very effective at low wind speeds, as long as the increased forces on the toe nail connections do not result in failure of the trusses.
- High strength garage door is effective only at low to moderate wind speeds

Form V-3 Mitigated Vulnerabilities

- Clips, straps, and reinforced masonry (or sill straps) have all a similar effectiveness, and they are beneficial at moderate to high wind speeds.

- The complete mitigation, as expected is the lower, less vulnerable curve.

- Form V-5 shows ***no differences*** for the mean damage ratios. No changes were made to the reference or mitigated structure models relative to the previous submission.

- The form shows ***minor differences*** for the loss cost ratios, of the order of 6.8% to 7.6%. Theses minor changes are due to changes in the hazard model.

Form V-5: Differences in Hurricane Mitigation Measures and Secondary Characteristics, Mean Damage Ratios and Hurricane Loss Costs

INDIVIDUAL HURRICANE MITIGATION MEASURES AND SECONDARY CHARACTERISTICS			DIFFERENCES FROM FORM V-3 RELATIVE TO CURRENTLY ACCEPTED HURRICANE MODEL											
			MEAN DAMAGE RATIO										HURRICANE LOSS COSTS	
			FRAME BUILDING					MASONRY BUILDING					FRAME BUILDING	MASONRY BUILDING
			WINDSPEED (MPH)*					WINDSPEED (MPH)*					ACROSS ALL WINDSPEEDS*	
			60	85	110	135	160	60	85	110	135	160		
	REFERENCE BUILDING		0	0	0	0	0	0	0	0	0	0	-$1.221	-$1.156
ROOF CONFIGUR-ATION	BRACED GABLE ENDS		0	0	0	0	0	0	0	0	0	0	-$1.221	-$1.156
	HIP ROOF		0	0	0	0	0	0	0	0	0	0	-$1.159	-$1.105
ROOF COVERING	METAL		0	0	0	0	0	0	0	0	0	0	-$1.221	-$1.156
	ASTM D7158 CLASS H SHINGLES		0	0	0	0	0	0	0	0	0	0	-$1.221	-$1.156
	MEMBRANE		0	0	0	0	0	0	0	0	0	0	-$1.221	-$1.156
	NAILING OF DECK	8d	0	0	0	0	0	0	0	0	0	0	-$0.971	-$0.873
ROOF-WALL STRENGTH	CLIPS		0	0	0	0	0	0	0	0	0	0	-$1.200	-$1.152
	STRAPS		0	0	0	0	0	0	0	0	0	0	-$1.195	-$1.151
WALL-FLOOR STRENGTH	TIES OR CLIPS		0	0	0	0	0	0	0	0	0	0	-$1.209	-
	STRAPS		0	0	0	0	0	0	0	0	0	0	-$1.204	-
WALL-FOUNDATION STRENGTH	LARGER ANCHORS OR CLOSER SPACING		_	_	_	_	_	—	—	—	—	—	-	-
	STRAPS		-	-	-	-	-	—	—	—	—	—	-	-
	VERTICAL REINFORCING		—	—	—	—	—	0	0	0	0	0	-	-$1.146
OPENING PROTECTION	WINDOW SHUTTERS	STRUCTURAL WOOD PANEL	0	0	0	0	0	0	0	0	0	0	-$1.180	-$1.116
		METAL	0	0	0	0	0	0	0	0	0	0	-$1.153	-$1.091
	DOOR AND SKYLIGHT COVERS		0	0	0	0	0	0	0	0	0	0	-$1.216	-$1.152
WINDOW, DOOR, SKYLIGHT STRENGTH	WINDOWS	IMPACT RATED	0	0	0	0	0	0	0	0	0	0	-$1.141	-$1.080
	ENTRY DOORS	MEETS WIND-BORNE DEBRIS REQUIREMENTS	0	0	0	0	0	0	0	0	0	0	-$1.219	-$1.154
	GARAGE DOORS	MEETS WIND-BORNE DEBRIS REQUIREMENTS	0	0	0	0	0	0	0	0	0	0	-$1.103	-$1.039
	SLIDING GLASS DOORS	MEETS WIND-BORNE DEBRIS REQUIREMENTS	0	0	0	0	0	0	0	0	0	0	-$1.215	-$1.157

HURRICANE MITIGATION MEASURES AND SECONDARY CHARACTERISTICS IN COMBINATION	PERCENTAGE CHANGE FROM FORM V-3 RELATIVE TO CURRENTLY ACCEPTED HURRICANE MODEL											
	MEAN DAMAGE RATIO										HURRICANE LOSS COSTS	
	FRAME BUILDING					MASONRY BUILDING					FRAME BUILDING	MASONRY BUILDING
	WINDSPEED (MPH)					WINDSPEED (MPH)					ACROSS ALL WINDSPEEDS*	
	60	85	110	135	160	60	85	110	135	160		
MITIGATED BUILDING	0	0	0	0	0	0	0	0	0	0	-$0.853	-$0.823

Form V-5: Differences in Hurricane Mitigation Measures and Secondary Characteristics, Mean Damage Ratios and Hurricane Loss Costs

- Form V-5 shows ***no differences*** for the mean damage ratios. No changes were made to the reference or mitigated structure models relative to the previous submission.

- The form shows ***minor differences*** for the loss cost ratios. Theses minor changes are due to changes in the hazard model.

Individual Hurricane Mitigation Measures and Secondary Characteristics		Differences from Form V-3 Relative to Previously-Accepted Hurricane Model – Mean Damage Ratio – Frame Building – Wind Speed (MPH) 60	85	110	135	160	Masonry Building – Wind Speed (MPH) 60	85	110	135	160	Hurricane Loss Costs – Frame Building – Across All Windspeeds	Masonry Building – Across All Windspeeds
	REFERENCE BUILDING	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	$1.056	$0.989
ROOF STRENGTH	BRACED GABLE ENDS	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	$1.055	$0.989
	HIP ROOF	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	$1.007	$0.954
ROOF COVERING	METAL	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	$1.055	$0.989
	ASTM D7158 CLASS H SHINGLES (150 MPH)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	$1.055	$0.989
	MEMBRANE	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	$1.055	$0.989
ROOF SHEATHING	NAILING OF DECK 8d	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	$0.877	$0.772
ROOF-WALL STRENGTH	CLIPS	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	$1.032	$0.984
	STRAPS	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	$1.028	$0.983
WALL-FLOOR STRENGTH	TIES OR CLIPS	0%	0%	0%	0%	0%	-	-	-	-	-	$1.041	-
	STRAPS	0%	0%	0%	0%	0%	-	-	-	-	-	$1.035	-
WALL FOUNDATION STRENGTH	LARGER ANCHORS OR CLOSER SPACING	-	-	-	-	-	-	-	-	-	-	-	-
	STRAPS	-	-	-	-	-	-	-	-	-	-	-	-
	VERTICAL REINFORCING	-	-	-	-	-	0%	0%	0%	0%	0%	-	$0.980

Florida Office of Insurance Regulation

Florida Public Hurricane Loss Model

Form V-5

OPENING PROTECTION	WINDOW SHUTTERS	STRUCT WOOD	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	$1.011	-$1.116
		METAL	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	$0.981	$0.917
	DOOR AND SKYLIGHT COVERS		0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	$1.050	$0.985
WINDOW DOOR, SKYLIGHT STRENGTH		IMPACT RATED	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	$0.969	$0.906
	ENTRY DOORS	MEETS WINDBORNE DEBRIS REQUIREMENTS	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	$1.053	$0.988
	GARAGE DOORS	MEETS WINDBORNE DEBRIS REQUIREMENTS	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	$0.965	$0.898
	SLIDING GLASS DOORS	MEETS WINDBORNE DEBRIS REQUIREMENTS	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	$1.049	$0.984

HURRICANE MITIGATION MEASURES AND SECONDARY CHARACTERISTICS IN COMBINATION	PERCENTAGE CHANGE FROM FORM V-3 RELATIVE TO PREVIOUSLY-ACCEPTED HURRICANE MODEL											
	MEAN DAMAGE RATIO										HURRICANE LOSS COSTS	
	FRAME BUILDING					MASONRY BUILDING					FRAME BUILDING	MASONRY BUILDING
	WIND SPEED (MPH)					WIND SPEED (MPH)					ACROSS ALL WINDSPEEDS	
	60	85	110	135	160	60	85	110	135	160		
MITIGATED BUILDING	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	$0.750	$0.416

Florida Public Hurricane Loss Model

V8.3

Standard A-3, Audit Item #2

STANDARD A-3
AUDIT ITEM #2

2. The treatment of law and ordinance coverage will be reviewed, including the statutory required 25% and 50% coverage options for personal residential policies.

A provision for Law and Ordinance coverage is embedded in the vulnerability matrices. Whenever roof damage exceeded 25%, roof damage was set at 100% to reflect the impact of Law and Ordinance as it drives the demolition and replacement of the undamaged roof sections under the Florida building code.

In practice building material upgrades beyond the roof may be covered by L&O, but the model assumes that roof replacement is the primary source of loss.

There is no application of the 25% or 50% limitation.

Also the matrices do not yet reflect the May 2022 revision to the code which removes the requirement for roofs already in compliance with the 2007 FBC (effective March 2009).

Florida Public Hurricane Loss Model

Version 8.3
Form A-6

Summary of Form A-6 Tests

Tests with no anomalies:

- **Deductible**
- **Policy Form**
- **Number of Stories**

Summary of Form A-6 Tests

Tests with anomalies:

- **Coverage:** Condo in Citrus, Marion, Osceola, and Seminole
- **Year Built:** All construction/policy form groups
- **Building Strength:** Manufactured homes and other PR in HVHZ

Coverage Test Anomalies

Anomaly:

- Loss costs for Coverage A (Building) > Coverage C (Contents) for **Condo** policies in **Citrus**, **Marion**, **Osceola**, and **Seminole**.

Cause:

- For Condo policies, the Coverage A limit is only 10% of the primary Coverage C limit.
- At very low windspeeds there is minor damage only to both structure and contents.
- The lower Coverage A limit results in a higher loss cost.

Year Built Test Anomalies

Anomaly #1:

- **Manufactured Homes** loss costs are equal for year built **1972**, **1989**, and **1992**.
- **Manufactured Homes** loss costs are equal for year built **2004** and **2019**.

Cause:

- These are all consistent with the model's vulnerability assumptions.

Year Built Test Anomalies

Anomaly #2:

- **Personal Residential (other than Manufactured Homes)** loss costs are equal for year built **1980** and **1989**, except in the HVHZ where loss costs for **1989 > 1980**.
- **Personal Residential (other than Manufactured Homes)** loss costs are equal for year built **2004** and **2019**. In the HVHZ, loss costs for **1998** are also equal to those for **2004** and **2019**.

Cause:

- These are all consistent with the model's vulnerability assumptions as shown on the following slide.

Year Built Test Anomalies

Personal Residential Construction Eras:

	Pre-1960	1960-1970	1971-1980	1981-1993	1994-2001	2002-pres.
HVHZ	⅔ modified Weak, ⅓ Medium	⅔ Weak, ⅓ Medium	½ Weak, ½ modified Medium	⅔ Weak, ⅓ modified Medium	Modified Strong	Modified Strong
Keys	½ modified Weak, ½ Medium	Medium	Medium	Medium	⅓ Medium ⅔ Strong OP	Strong OP
WBDR	modified Weak	⅔ Weak, ⅓ Medium	⅓ Weak, ⅔ Medium	⅓ Weak, ⅔ Medium	½ Medium, ½ Strong OP	Strong OP
Inland	modified Weak	⅔ Weak, ⅓ Medium	½ Weak, ½ Medium	½ Weak, ½ Medium	½ Medium, ½ Strong	Strong

Year Built Test Anomalies

Anomaly #3:

- **Commercial Residential** loss costs are equal for year built **1980**, **1989**, and **1998**, except in the HVHZ.
- **Commercial Residential** loss costs are equal for year built **2004** and **2019**.
- In the **HVHZ**, **Commercial Residential** loss costs for **1998** are also equal to those for **2004** and **2019**.

Cause:

- These are all consistent with the model's vulnerability assumptions.

Building Strength Test Anomalies

Anomaly #1:

- **Manufactured Homes** loss costs are equal for **"weak"** and **"medium"**.

Cause:

- Year built assumptions for **"weak"** and **"medium"** are **1974** and **1992**, respectively.
- The model assumes **no difference in vulnerability** between these two years.
- Furthermore, the model **does not vary vulnerabilities** for MH based on tie-down or other **secondary attributes** such as roof shape and roof covering.

Building Strength Test Anomalies

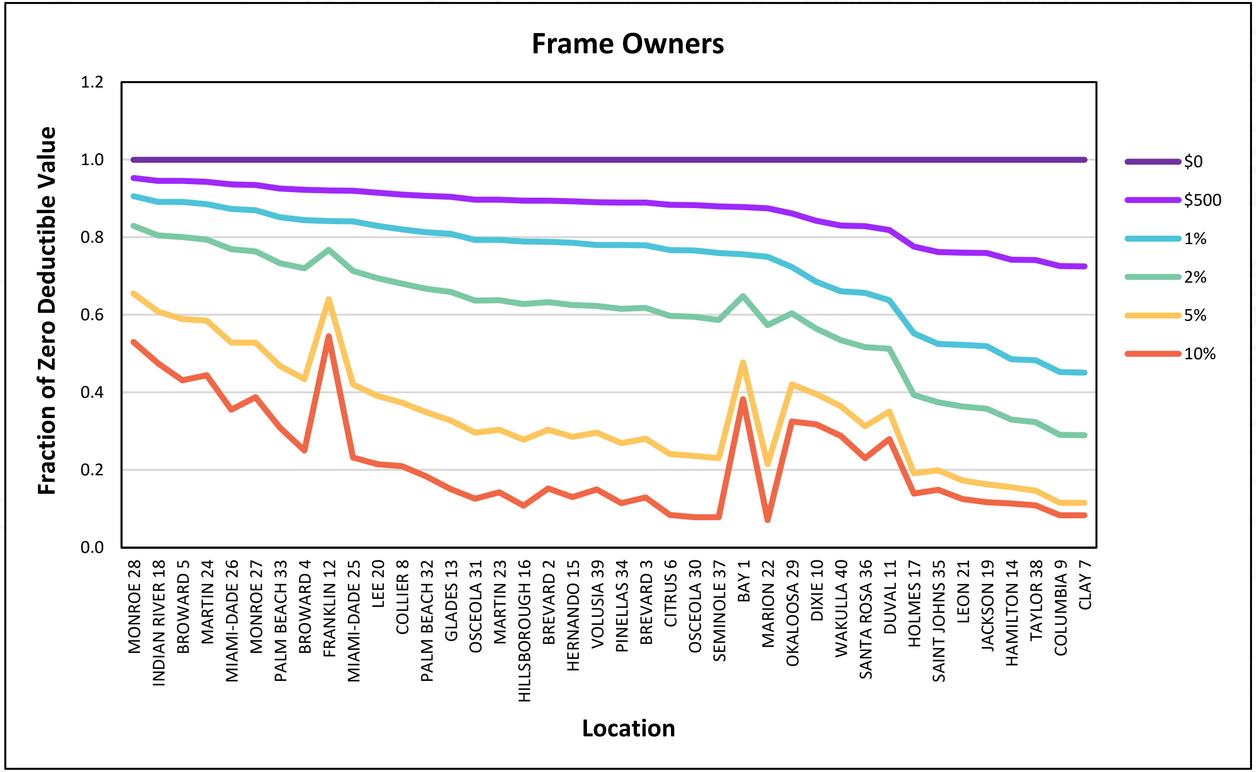
Anomaly #2:

- **For some forms & locations** in the **HVHZ**, **Personal Residential (other than Manufactured Homes)** loss costs for **“strong” > “medium”**.

Cause:

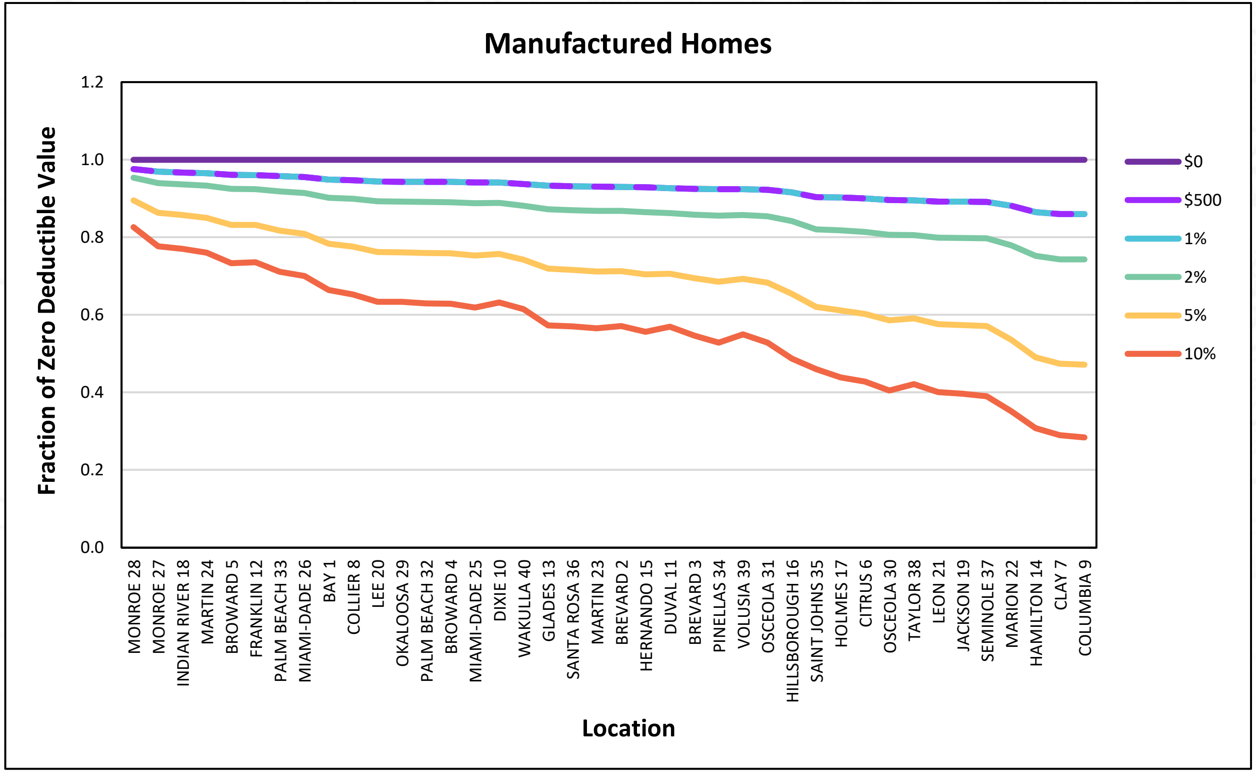
- Year built assumptions for **“strong”** and **“medium”** are **2007** and **1998**, respectively.
- The model assumes **no difference in vulnerability** between these two years in the HVHZ.
- The **“medium”** case has **unknown secondary attributes** compared to the **“strong”** case where the **attributes are defined**.
- The model’s **weighted vulnerabilities** in the case of **unknown attributes** produce a **lower loss cost** than the vulnerabilities assumed for the **specified attributes**.

Hurricane Loss Costs by Deductible



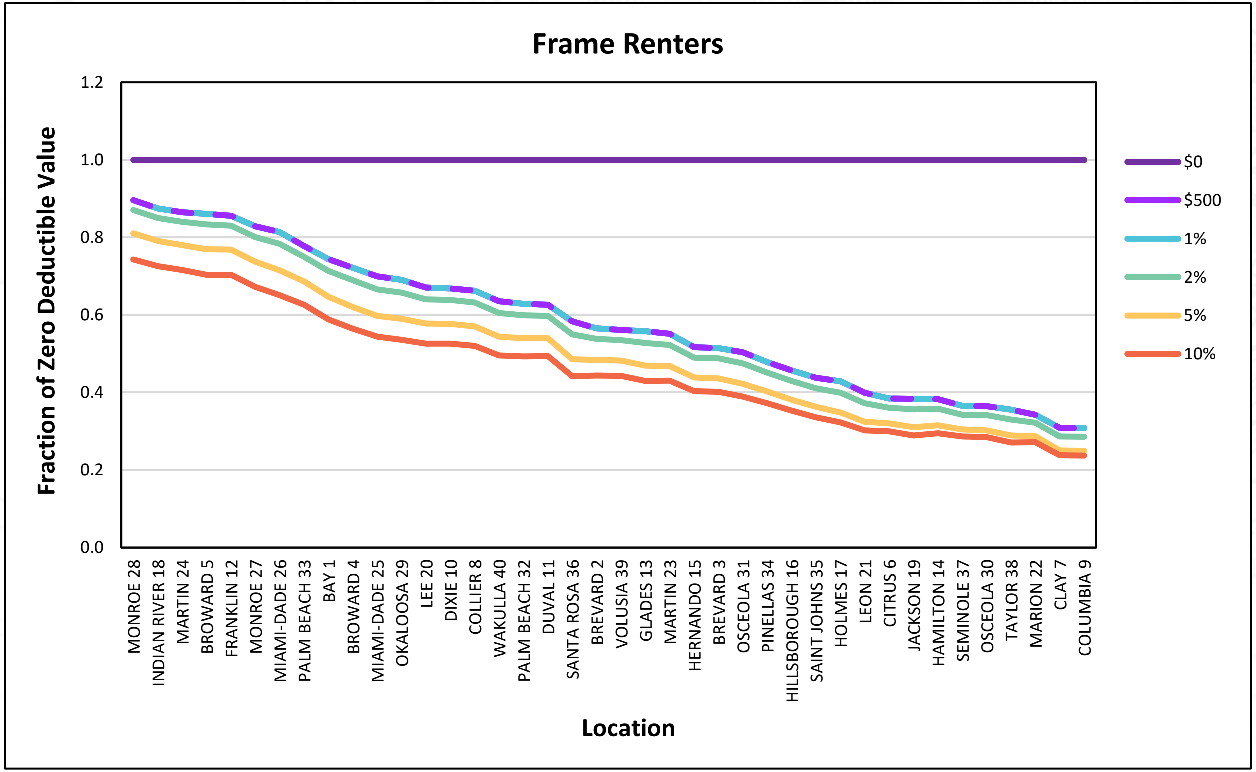
Hurricane Loss Costs by Deductible

Hurricane Loss Costs by Deductible

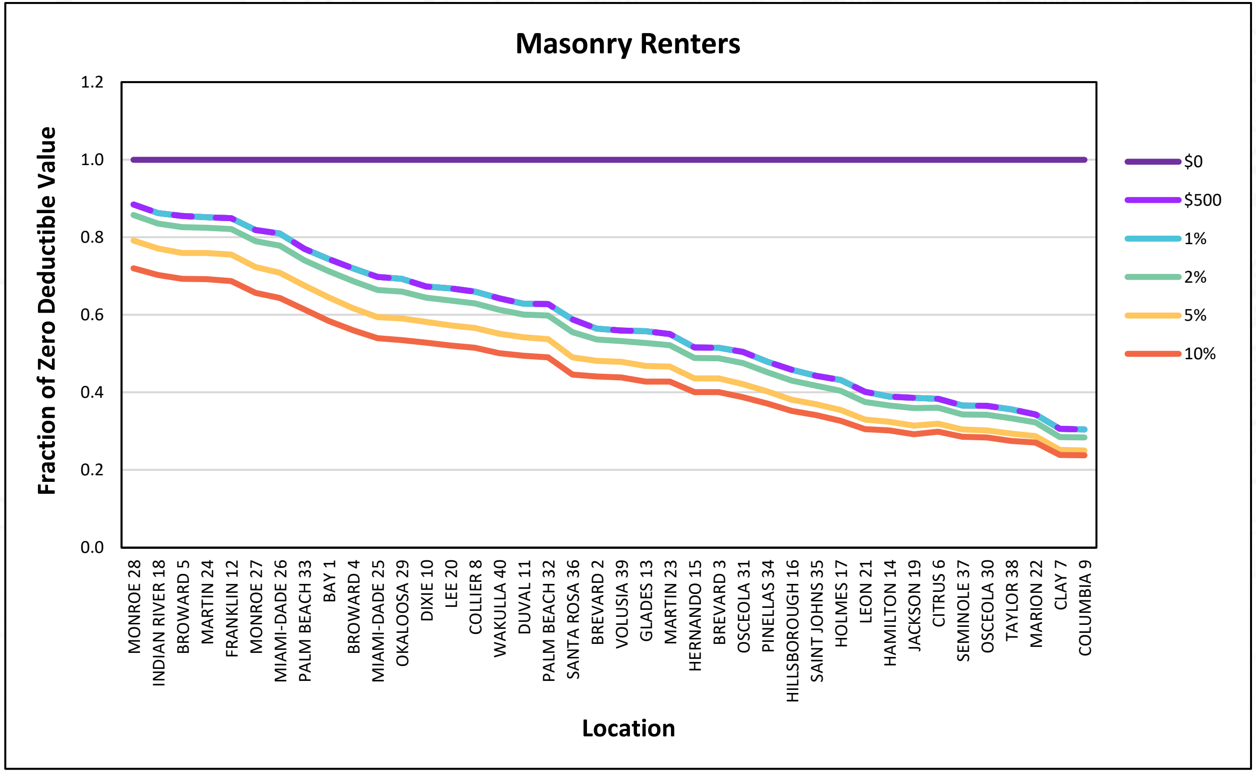


Florida Office of Insurance Regulation
Florida Public Hurricane Loss Model
FIU UF FLORIDA TECH MIAMI NOAA UMKC AMI Risk Consultants, Inc.

Hurricane Loss Costs by Deductible



Hurricane Loss Costs by Deductible



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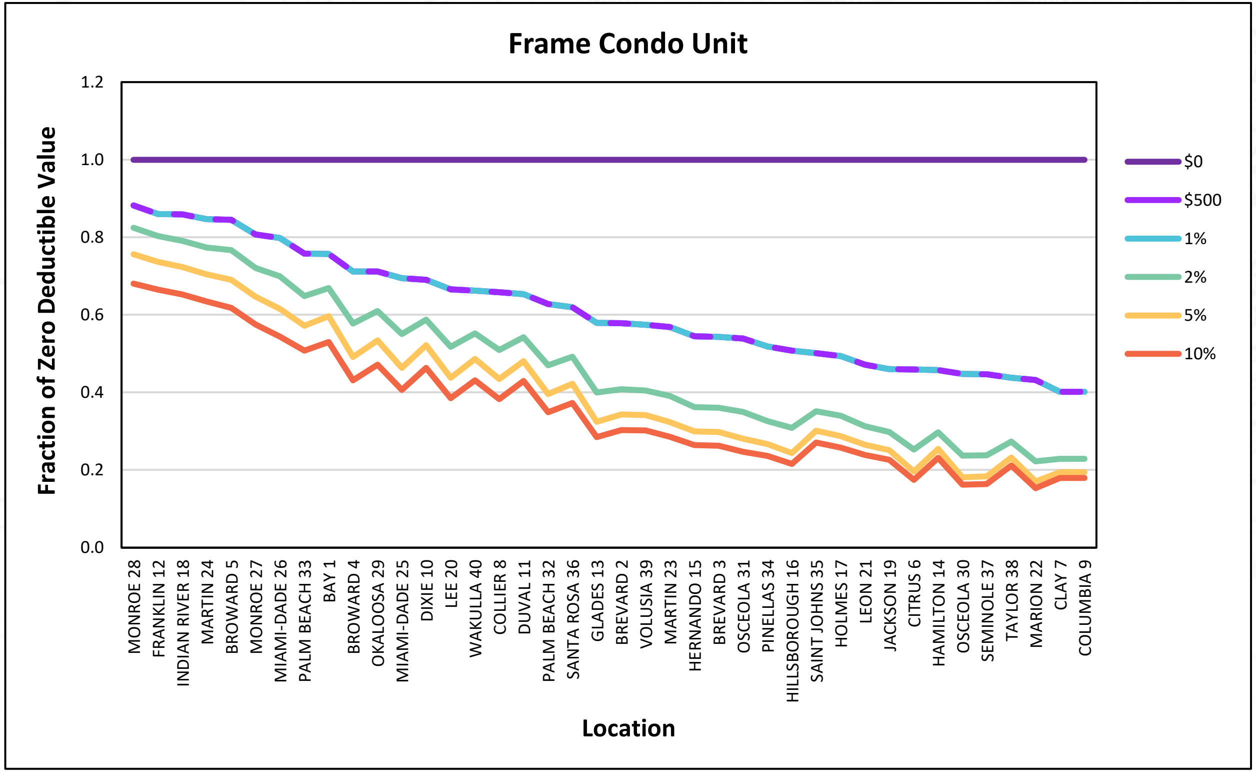

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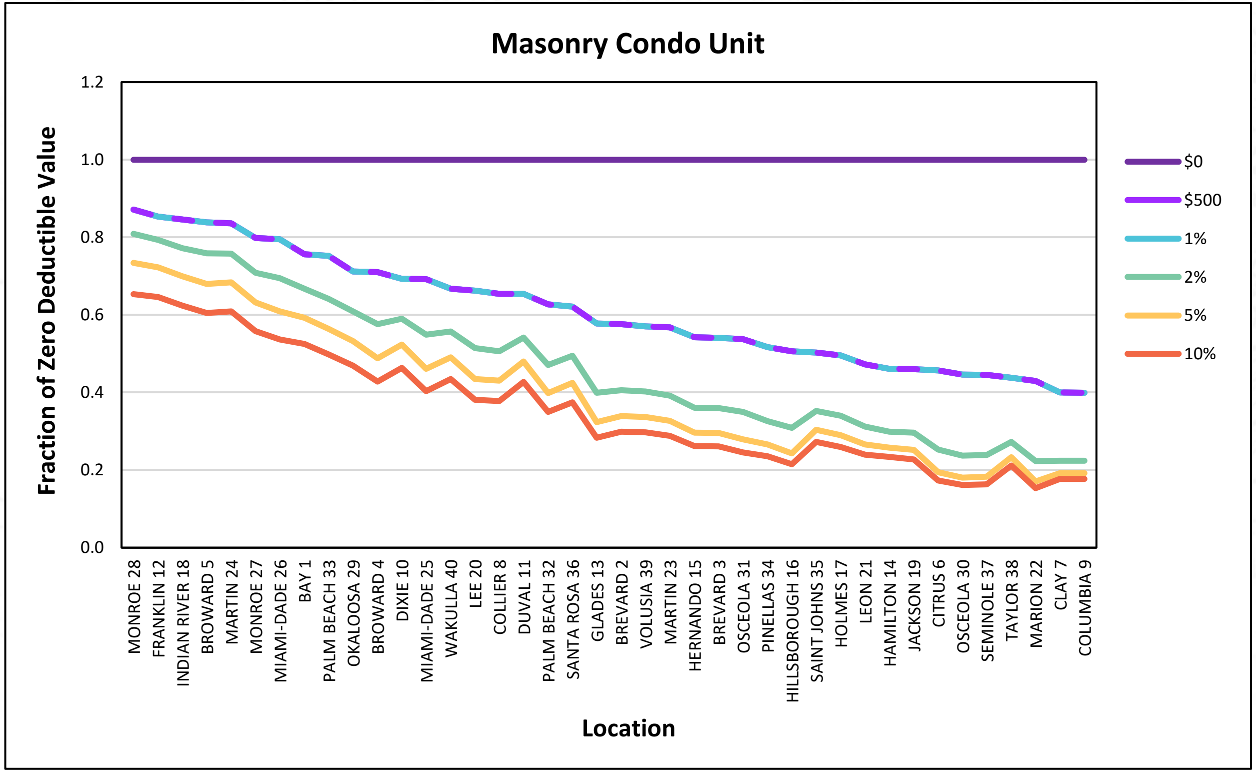
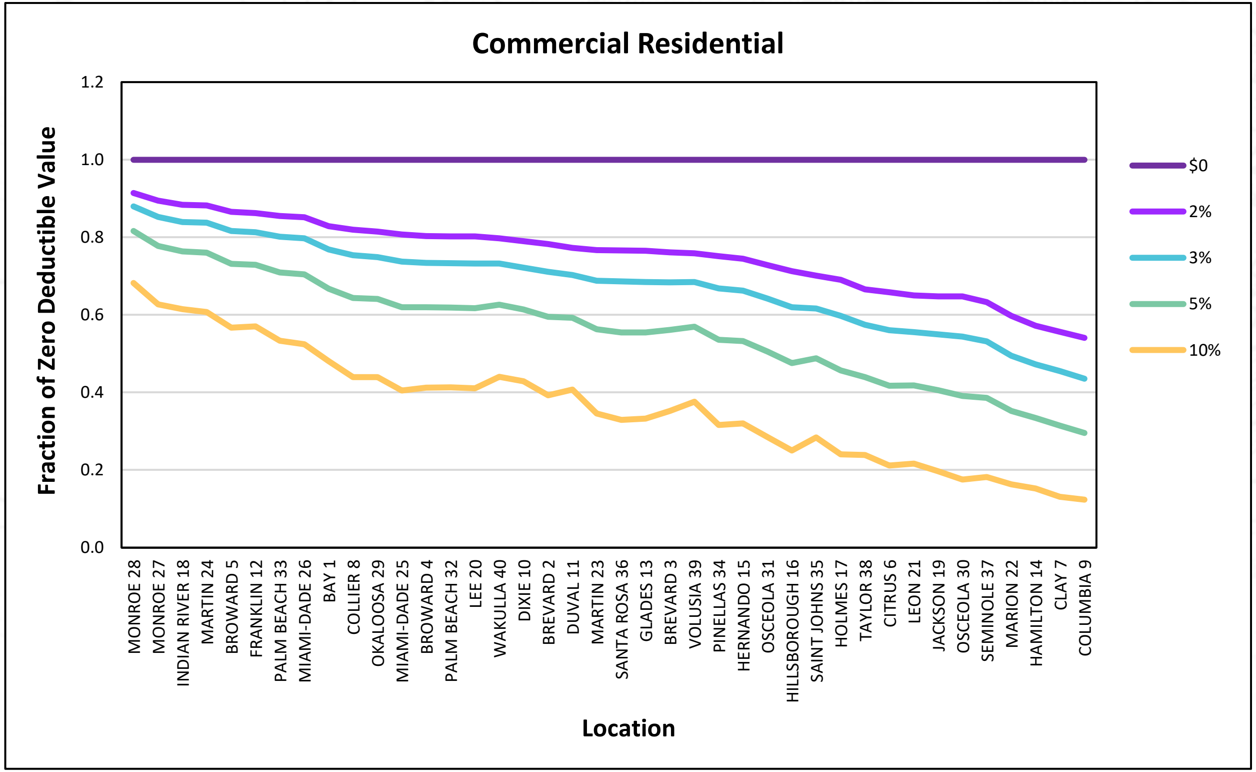
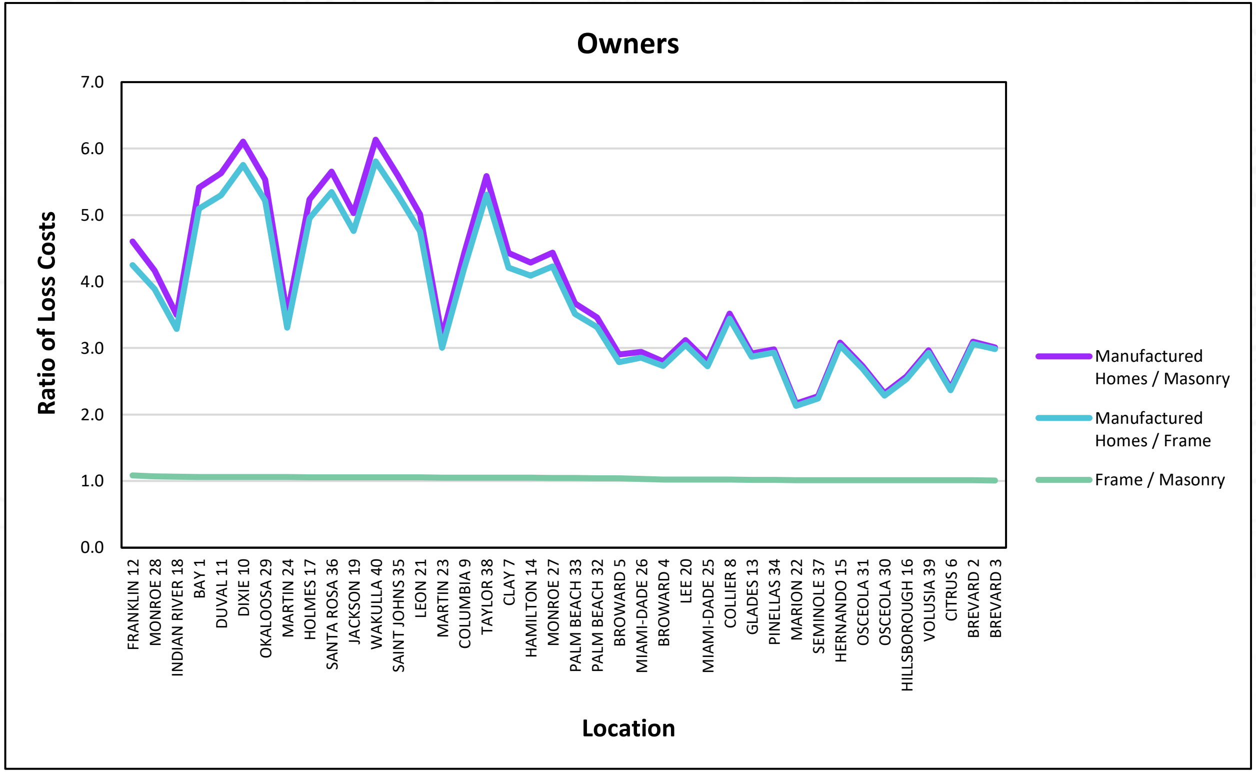


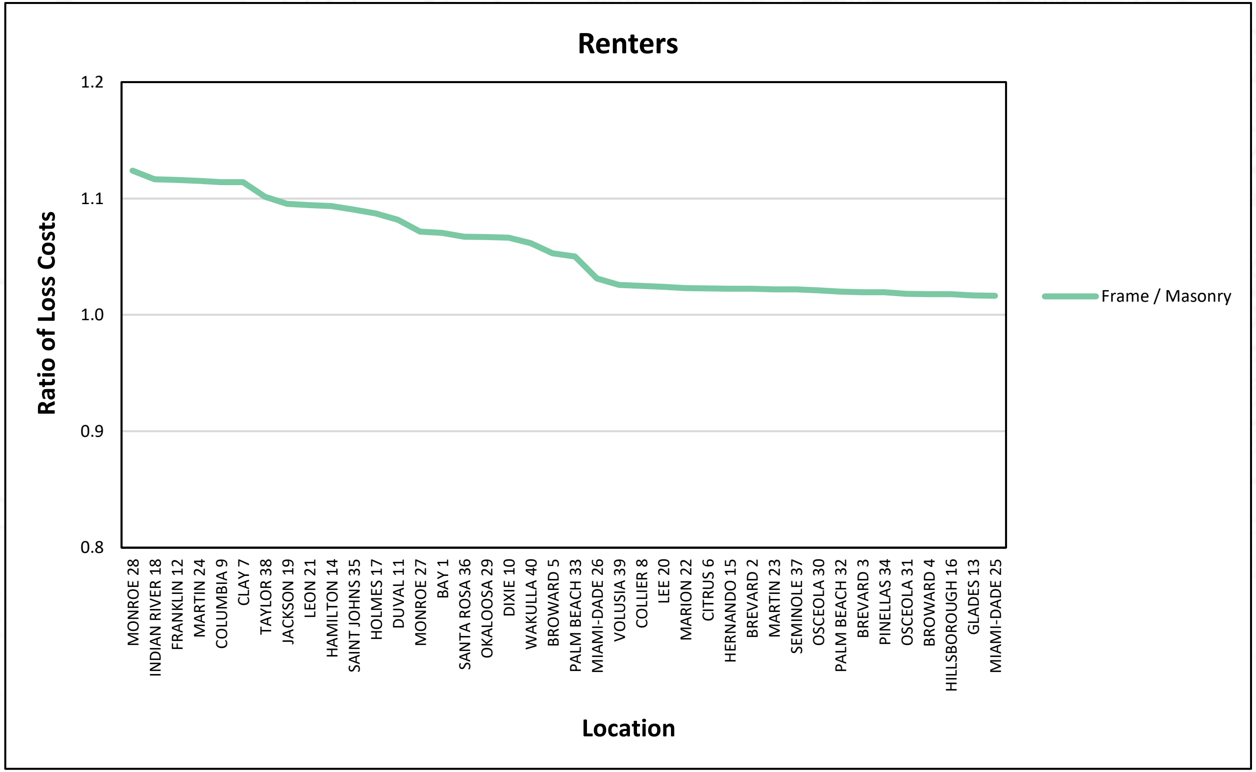
Hurricane Loss Costs by Deductible



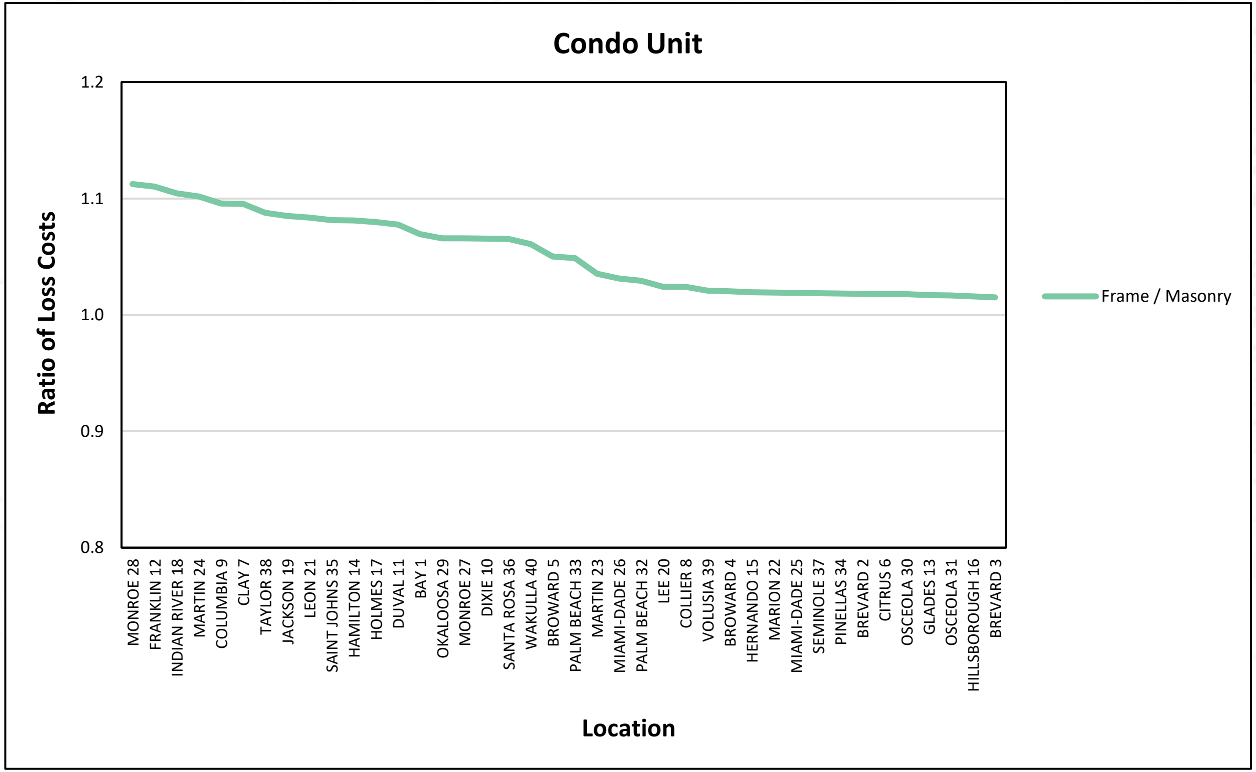
Hurricane Loss Costs by Policy Form



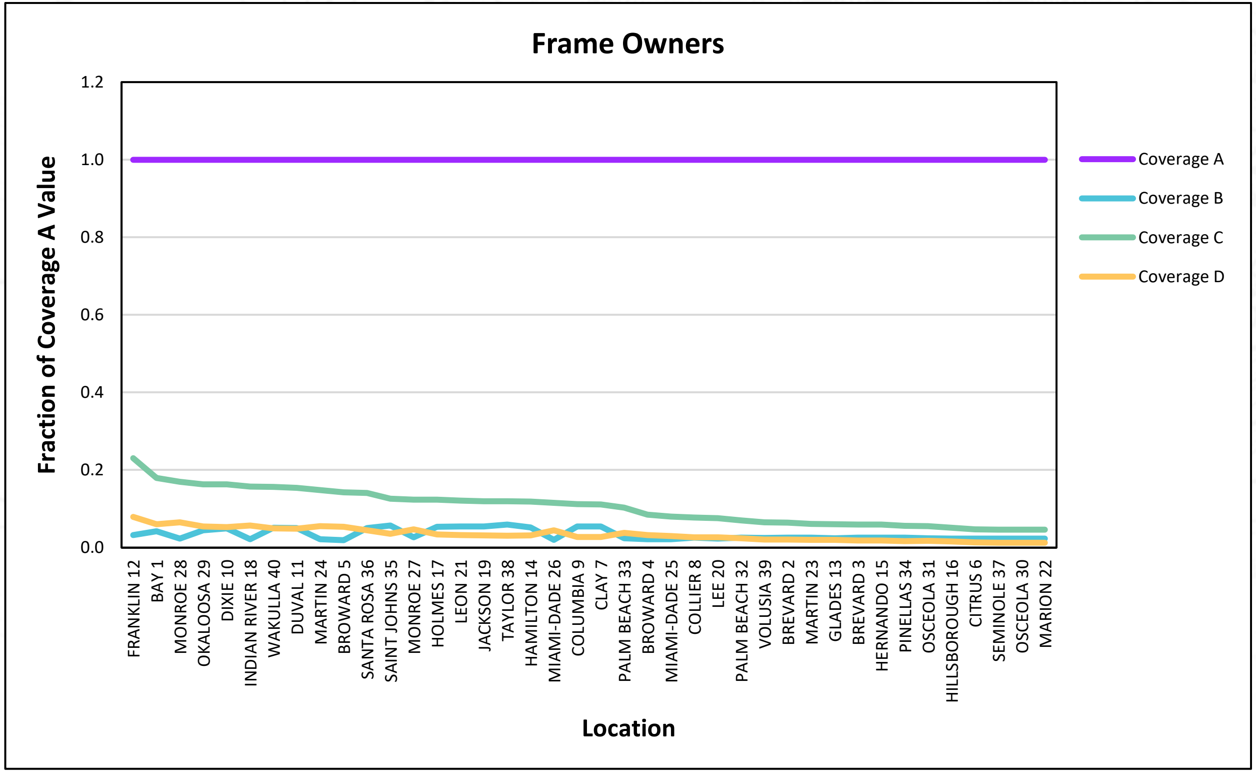
Hurricane Loss Costs by Policy Form



Hurricane Loss Costs by Policy Form



Hurricane Loss Costs by Coverage



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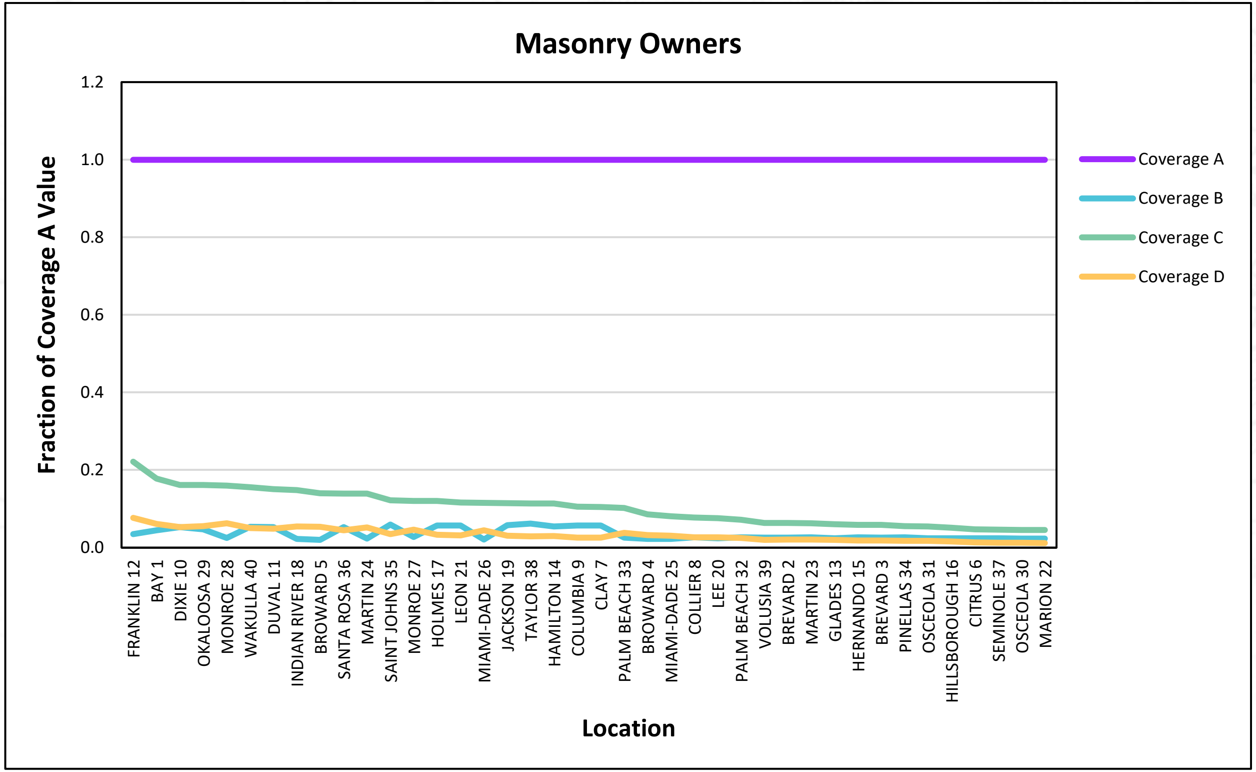

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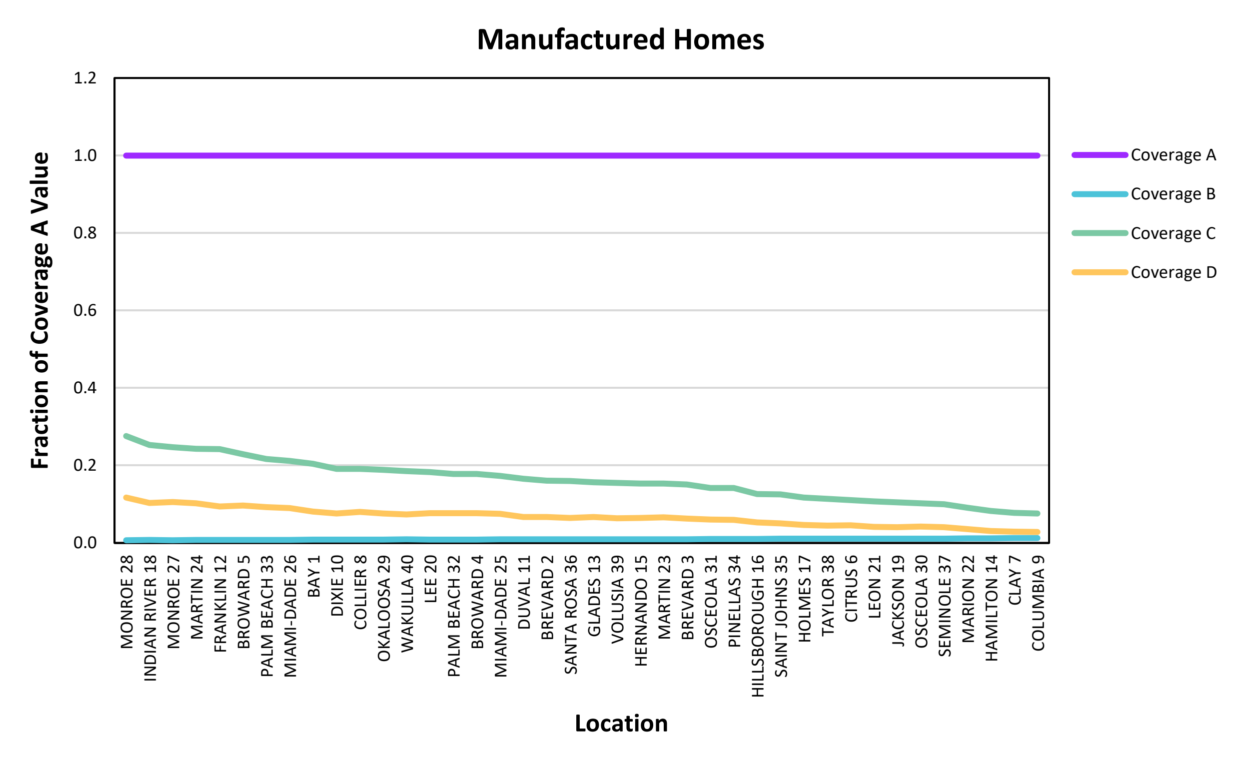

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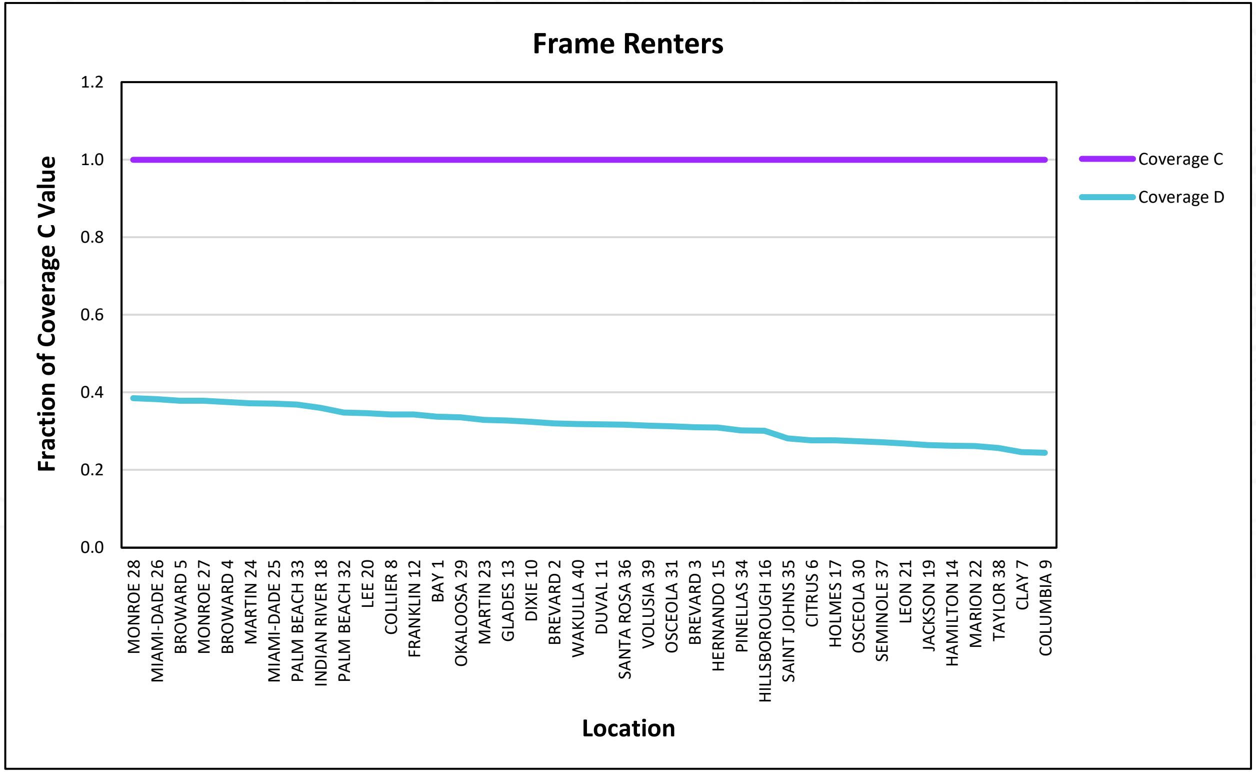

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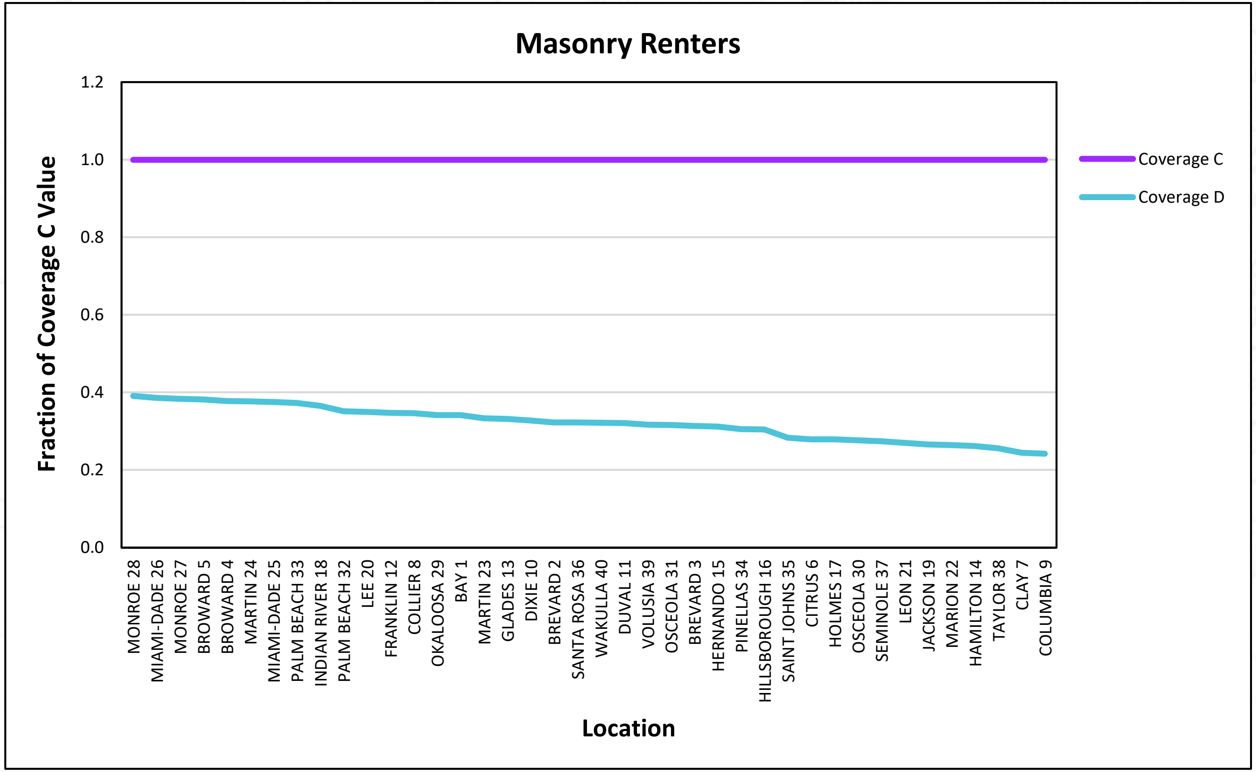

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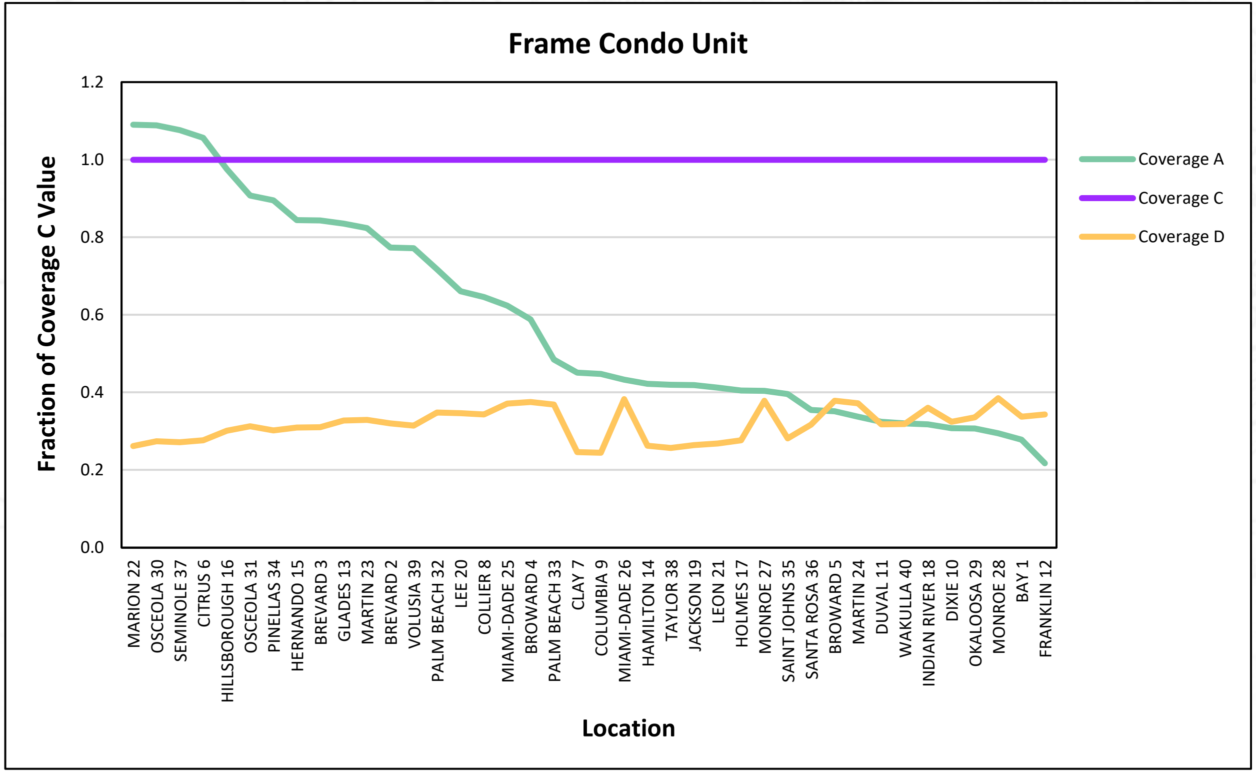

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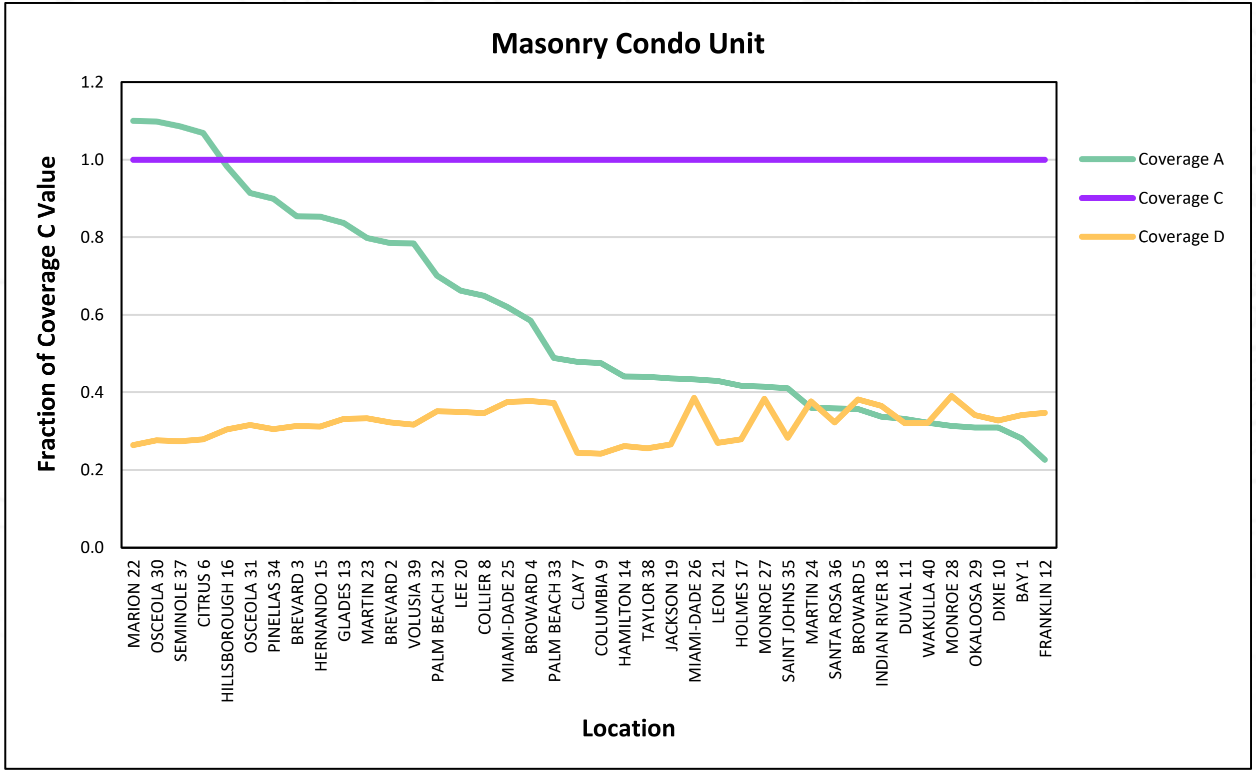

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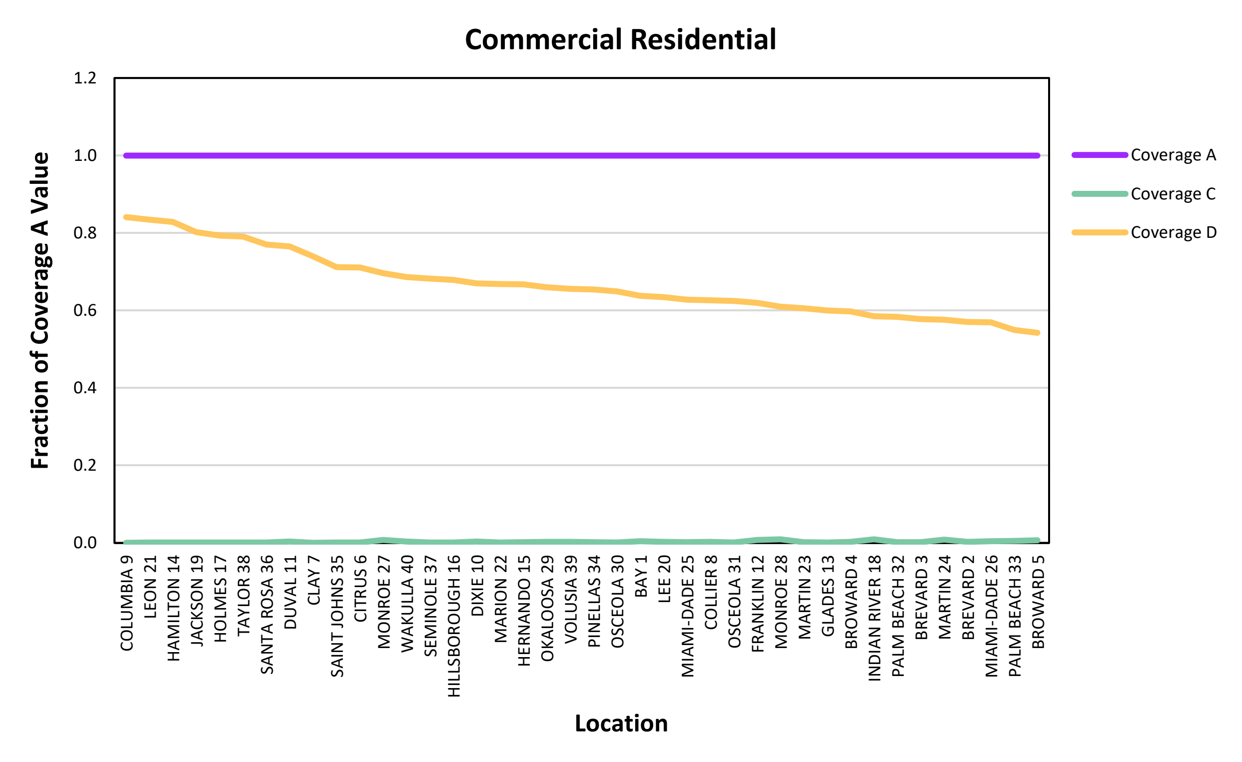
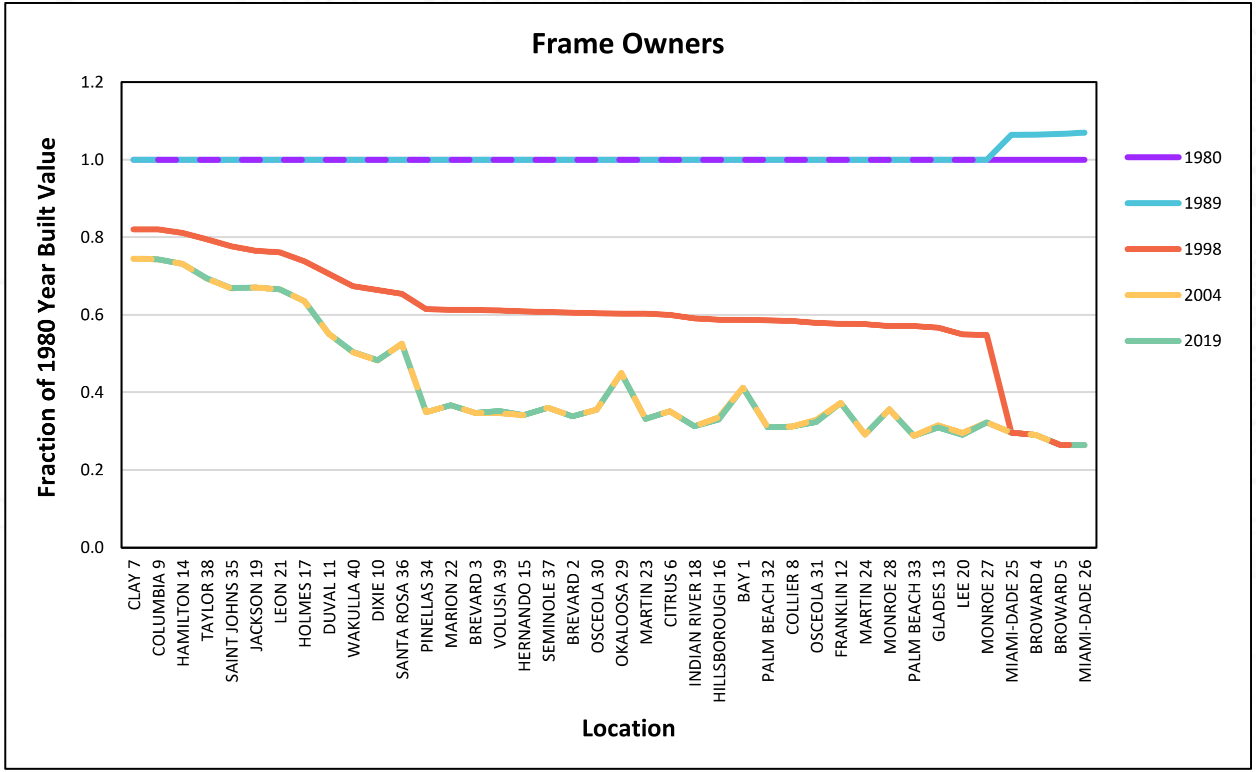


Hurricane Loss Costs by Year Built



Hurricane Loss Costs by Year Built

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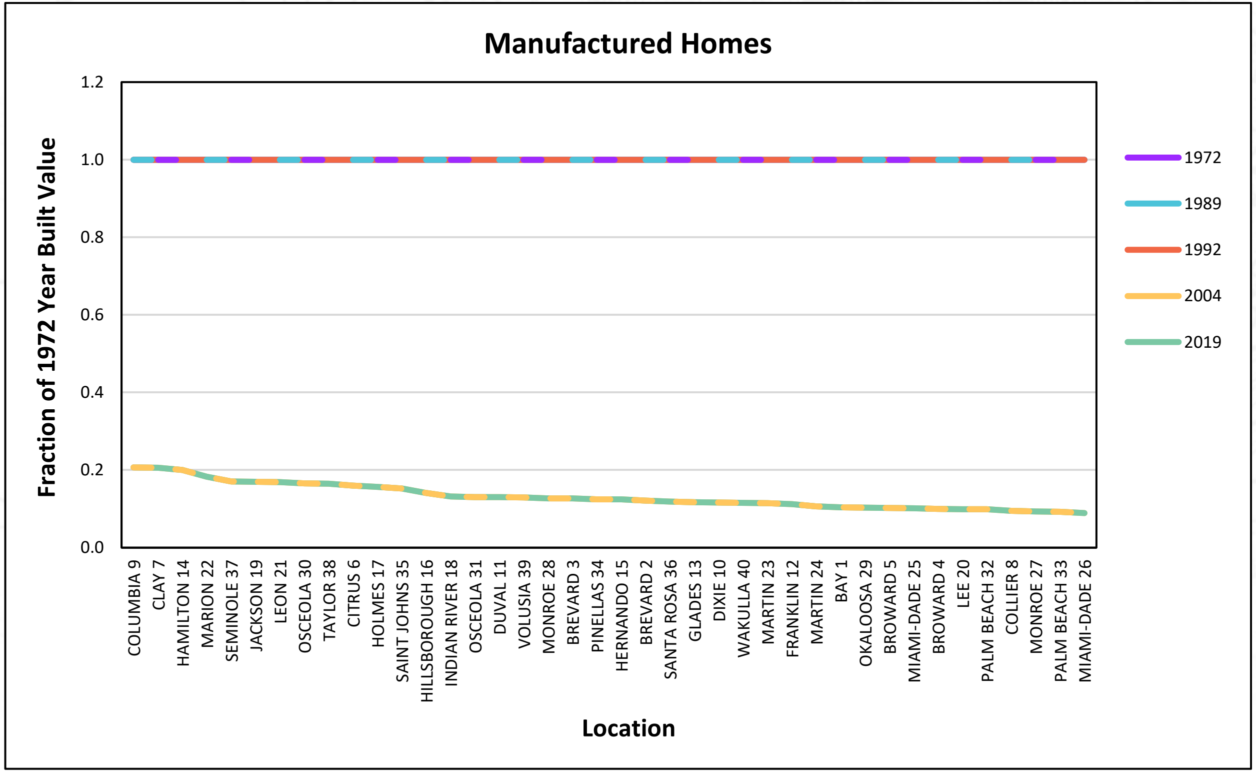
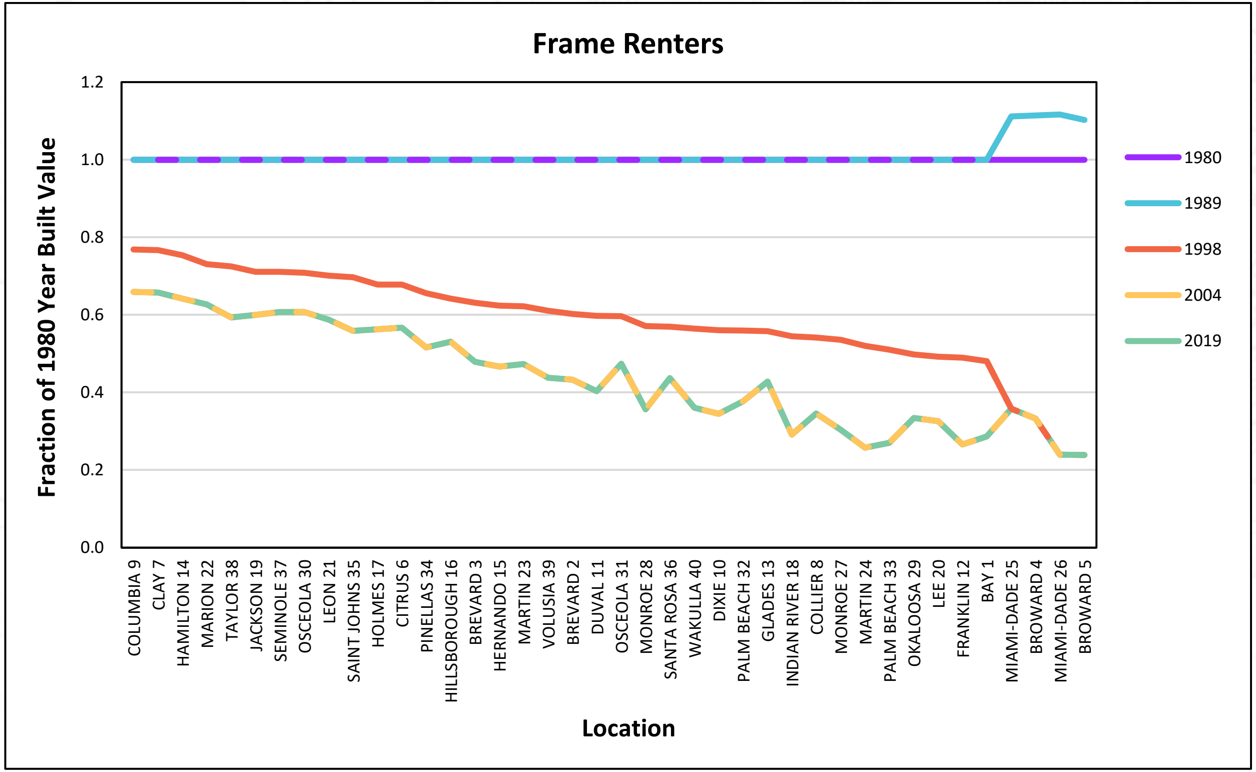


Hurricane Loss Costs by Year Built



Hurricane Loss Costs by Year Built

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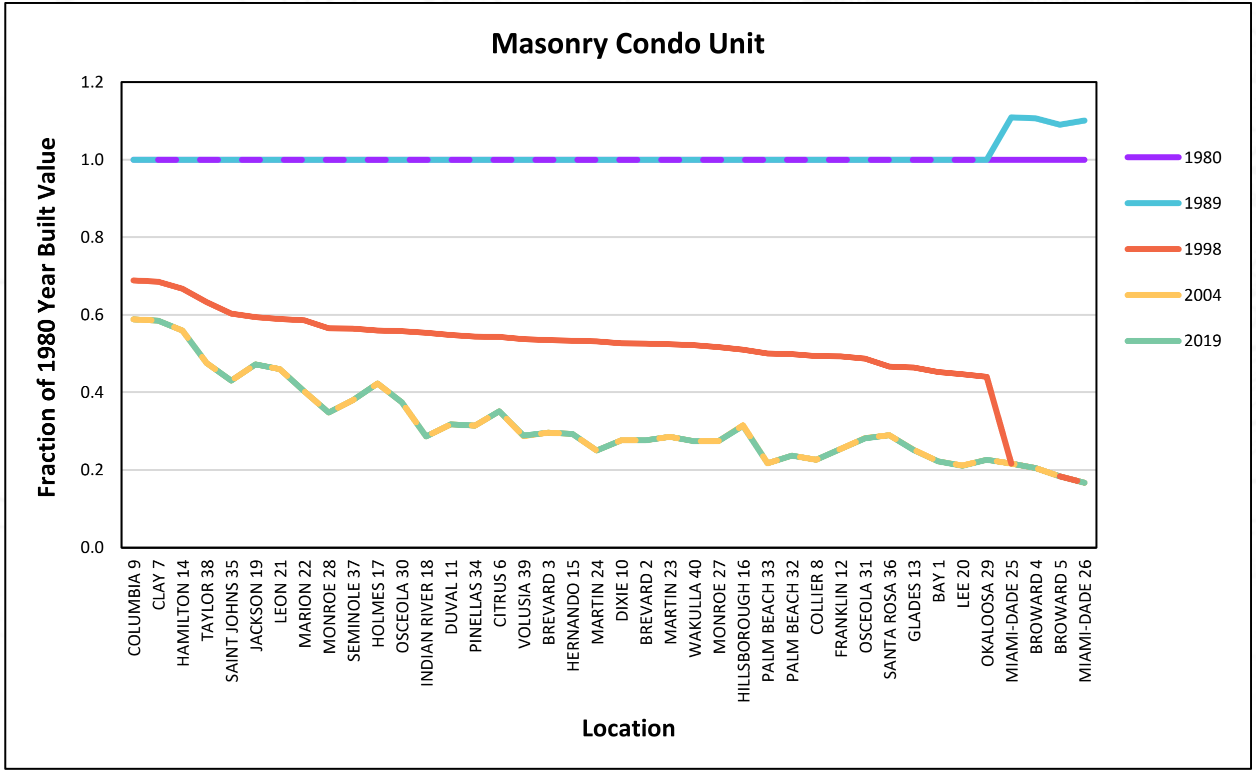
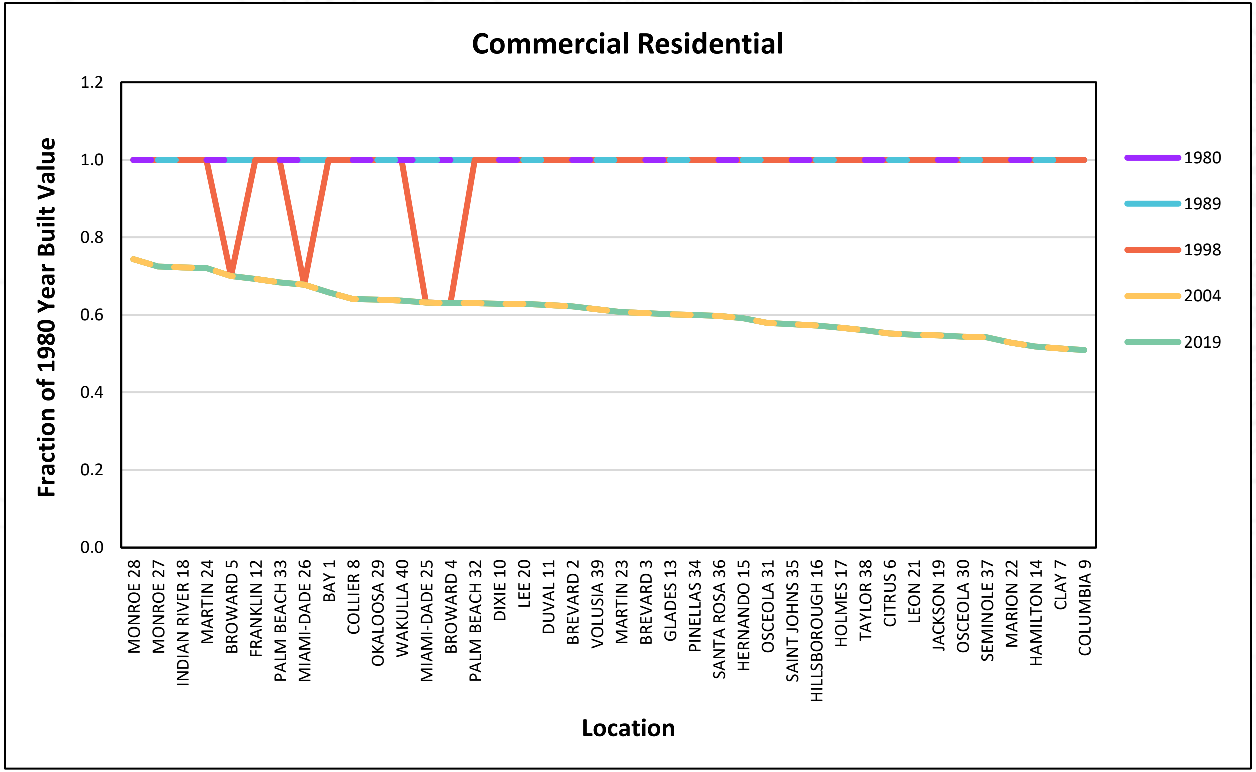
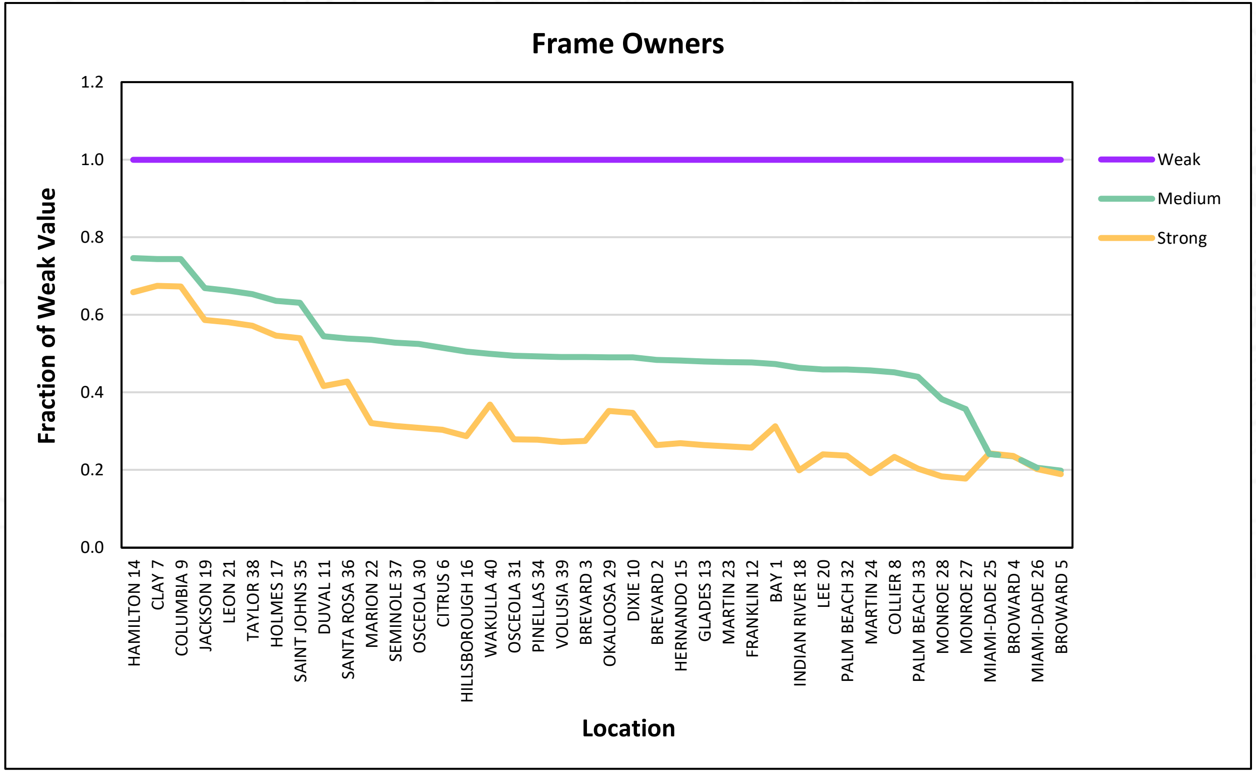


Hurricane Loss Costs by Year Built



Hurricane Loss Costs by Building Strength



Hurricane Loss Costs by Building Strength

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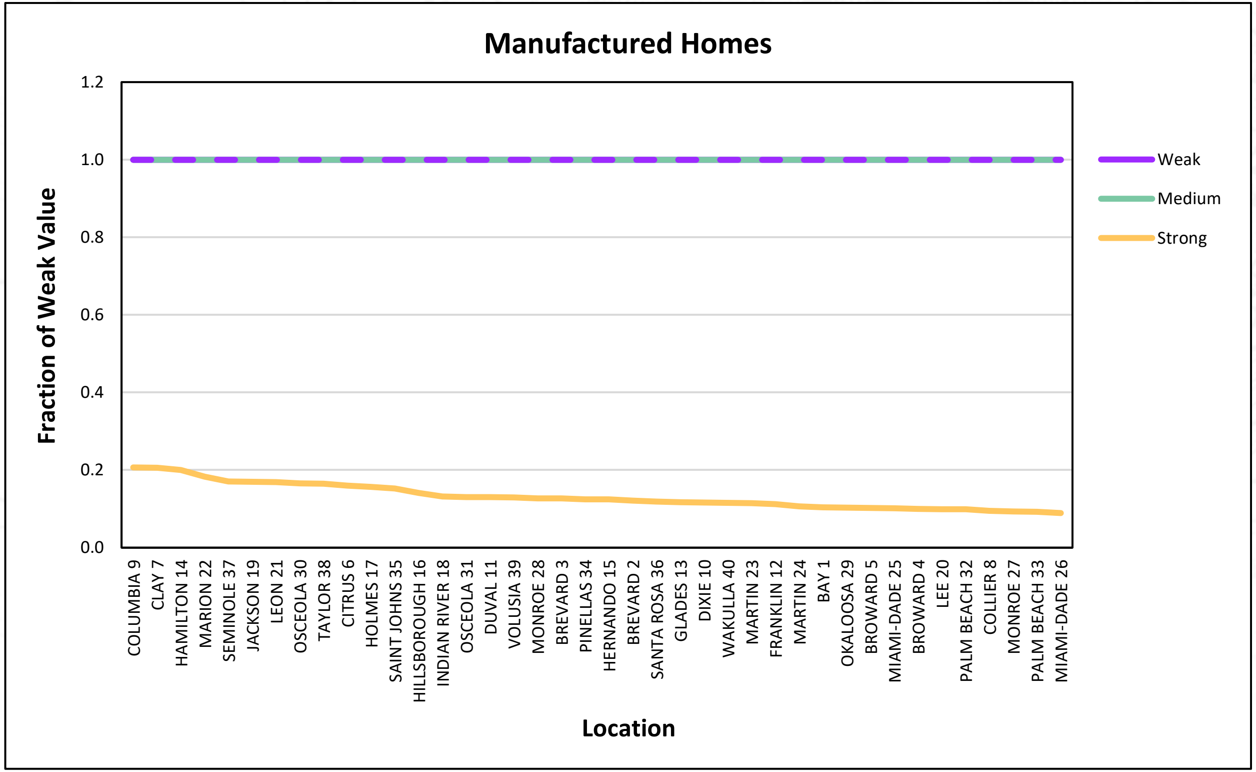

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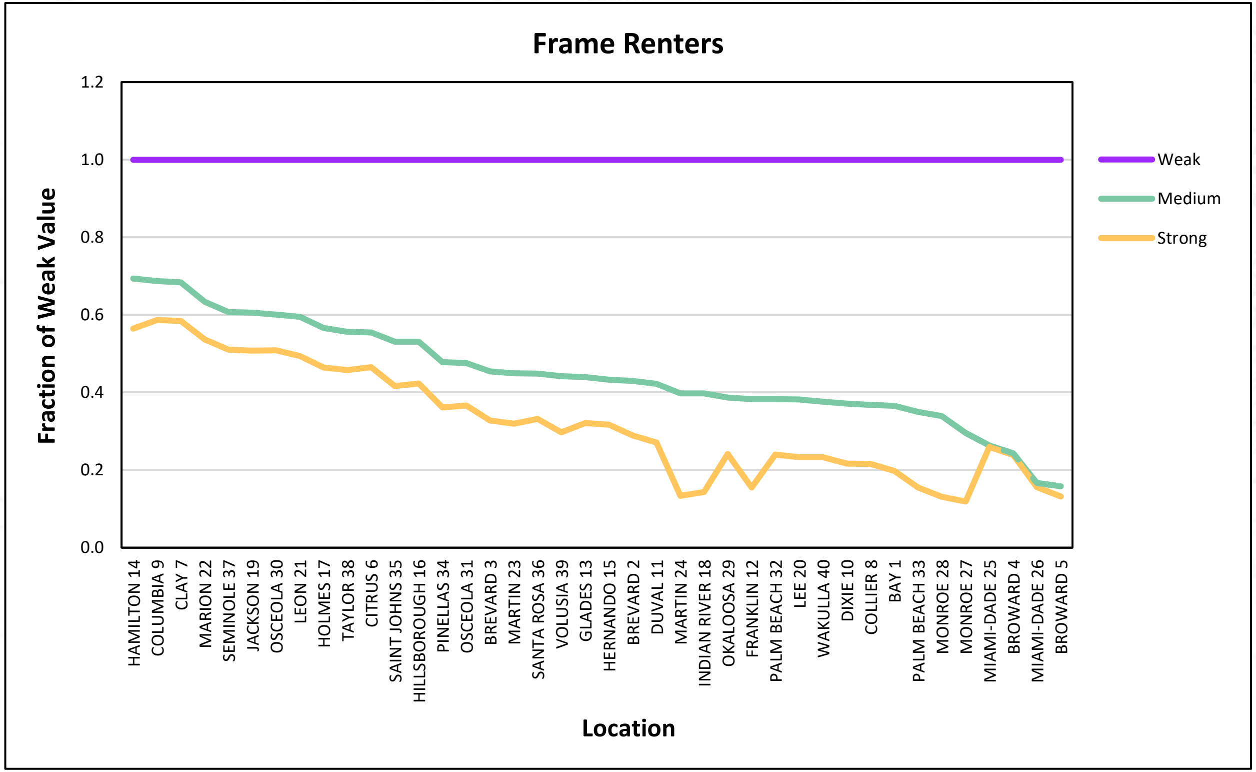
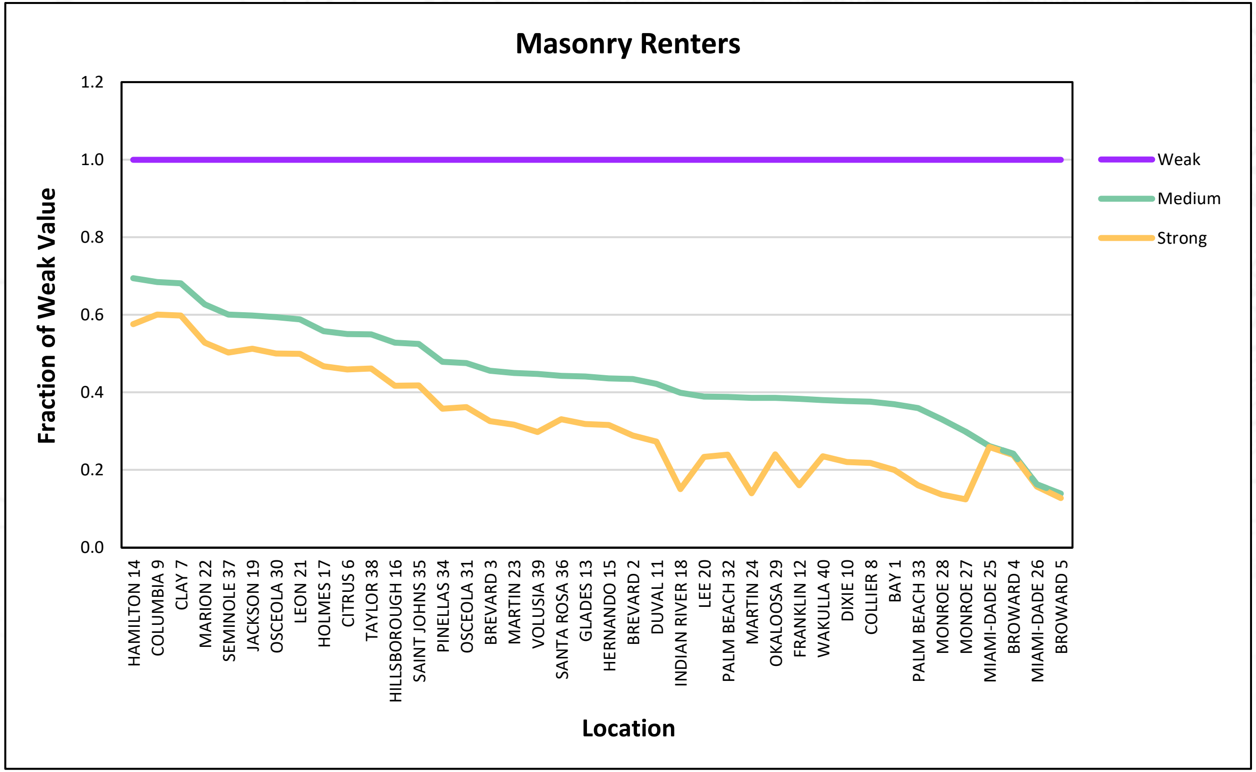
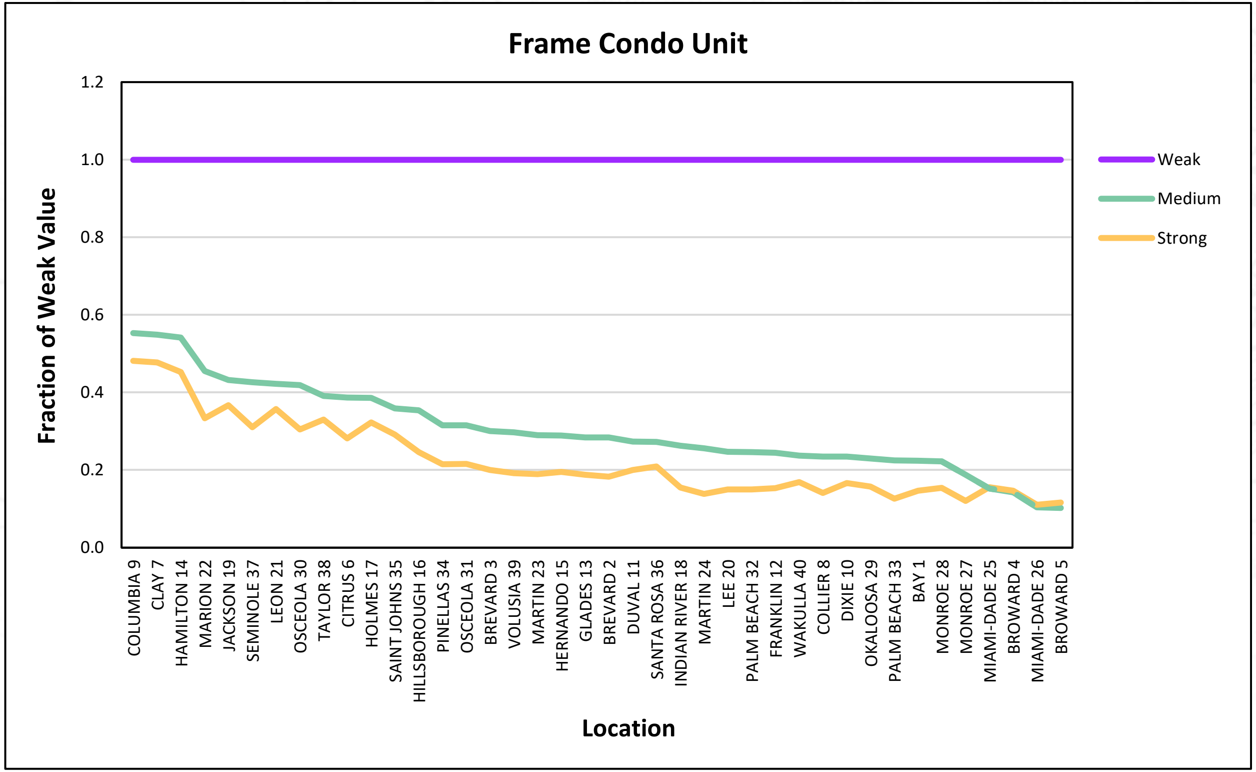


Hurricane Loss Costs by Building Strength



Hurricane Loss Costs by Building Strength



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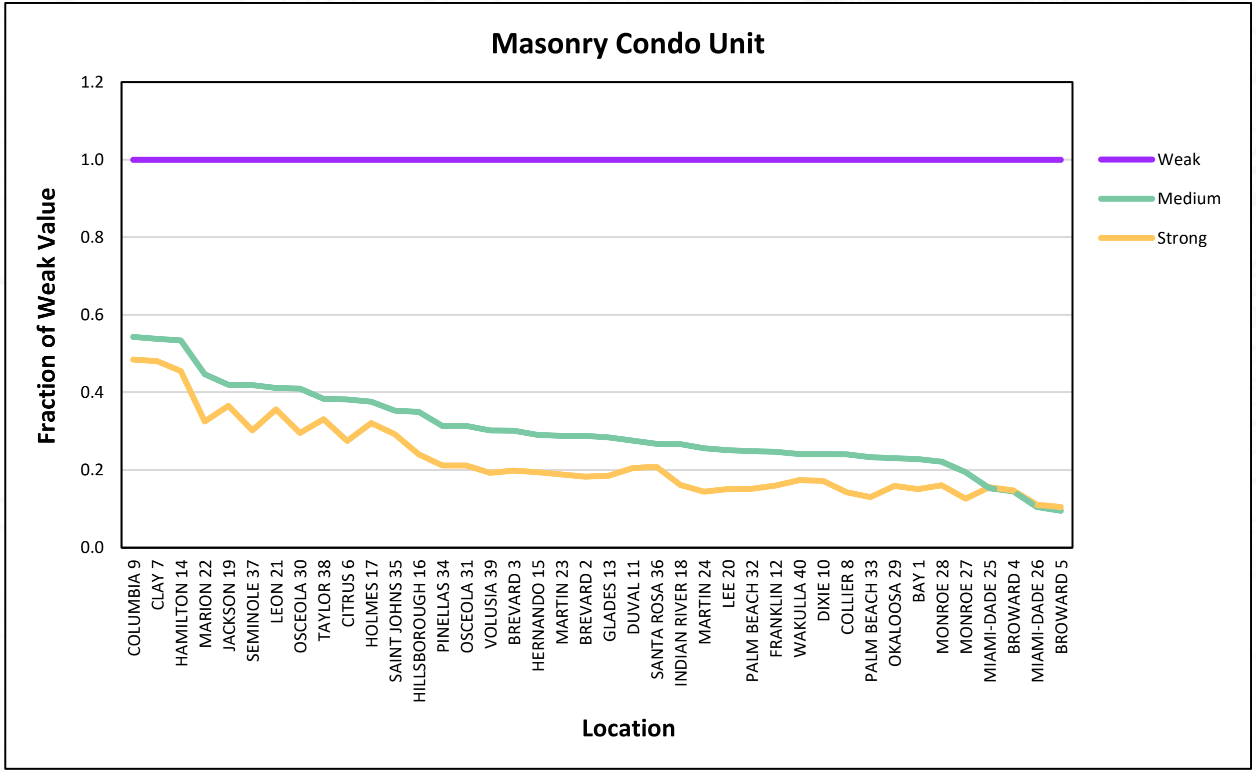

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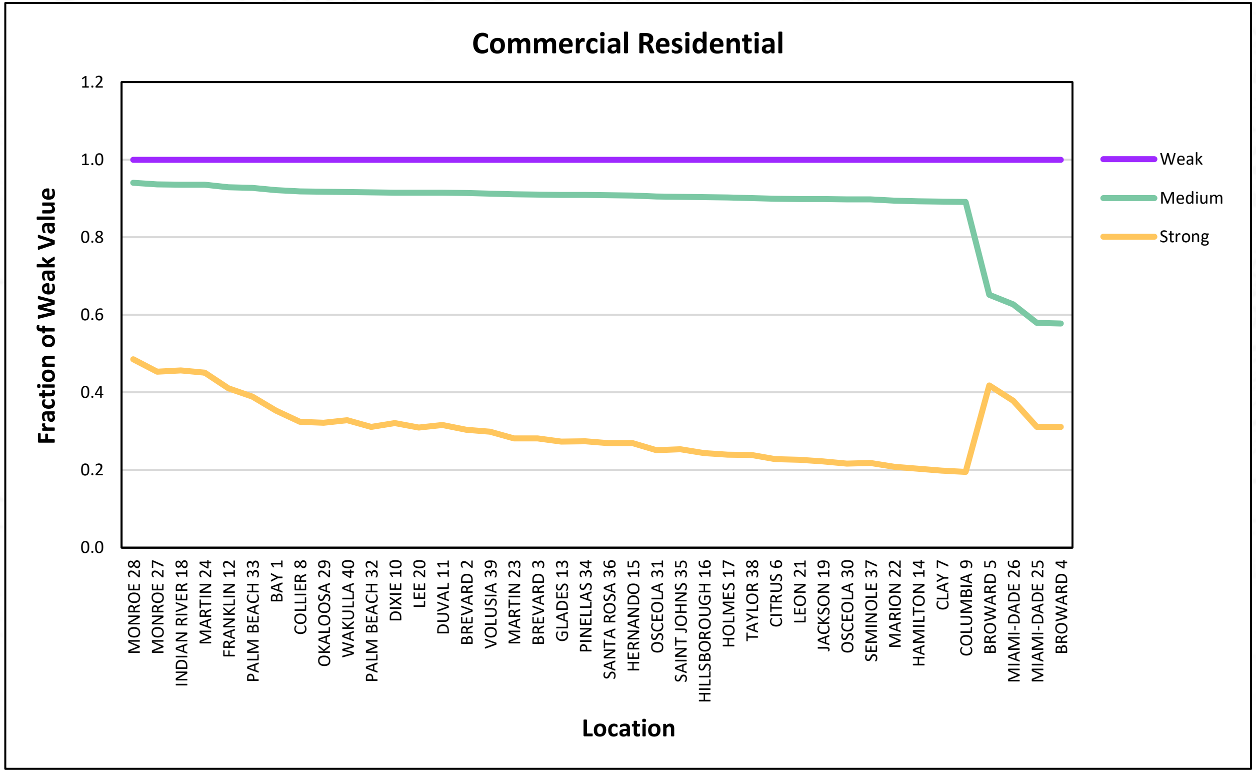
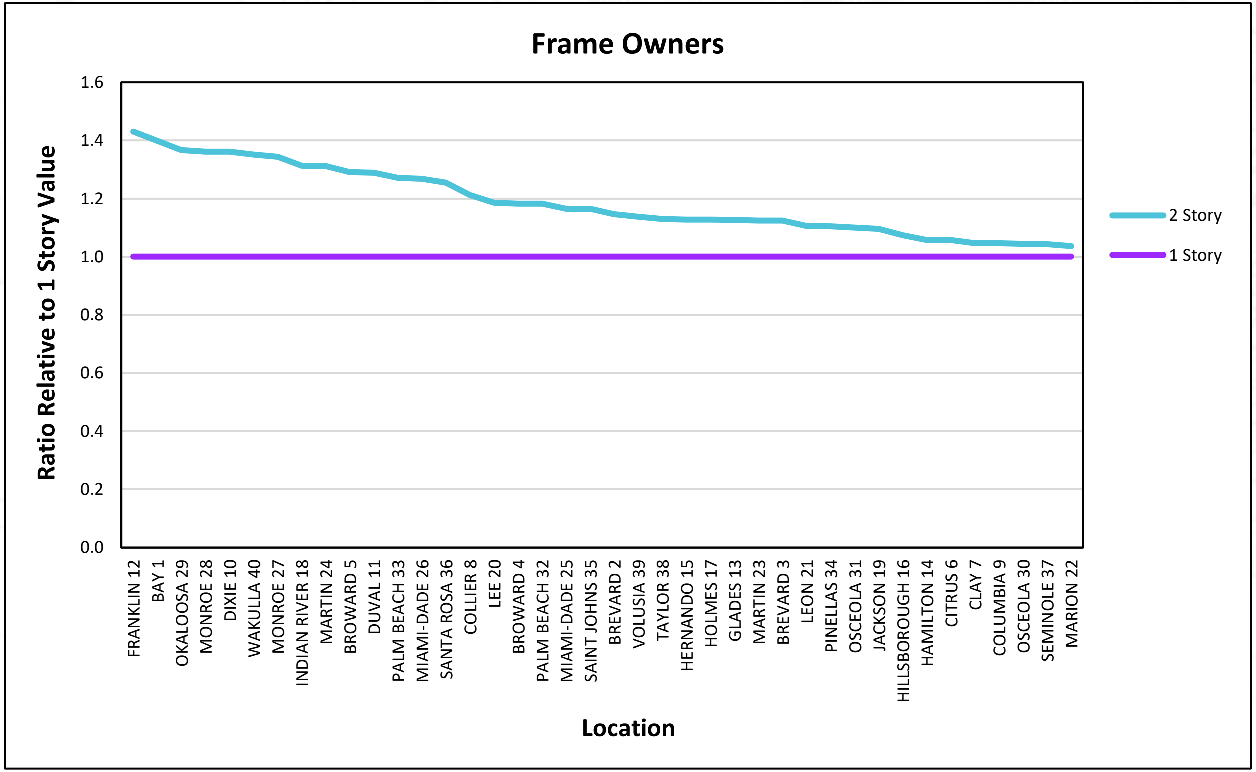
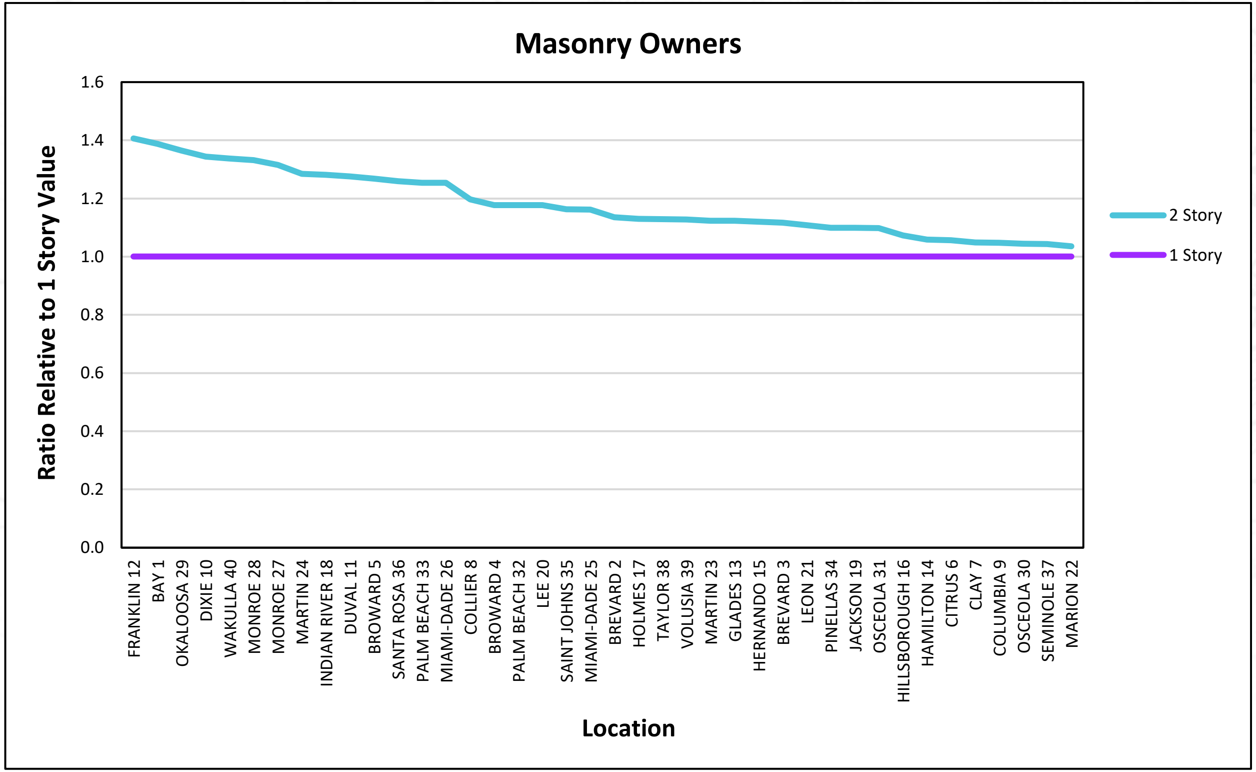


Hurricane Loss Costs by Number of Stories

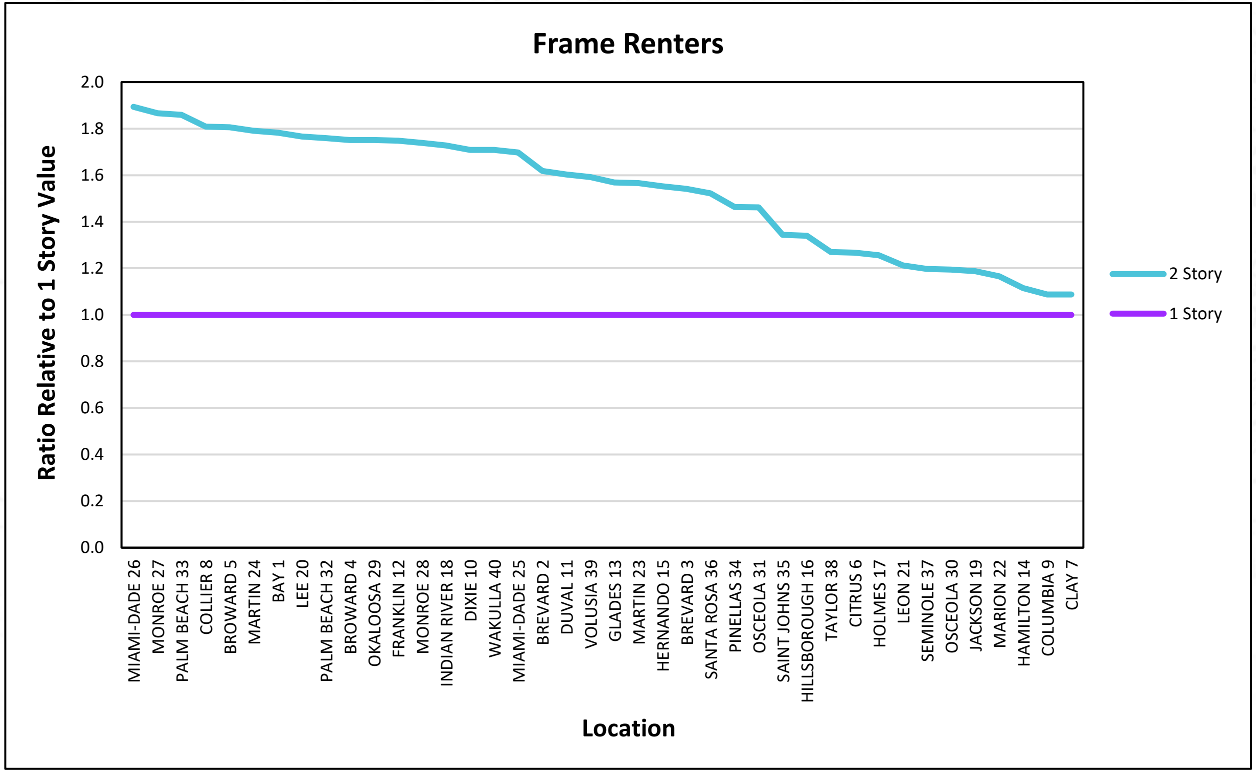


Hurricane Loss Costs by Number of Stories

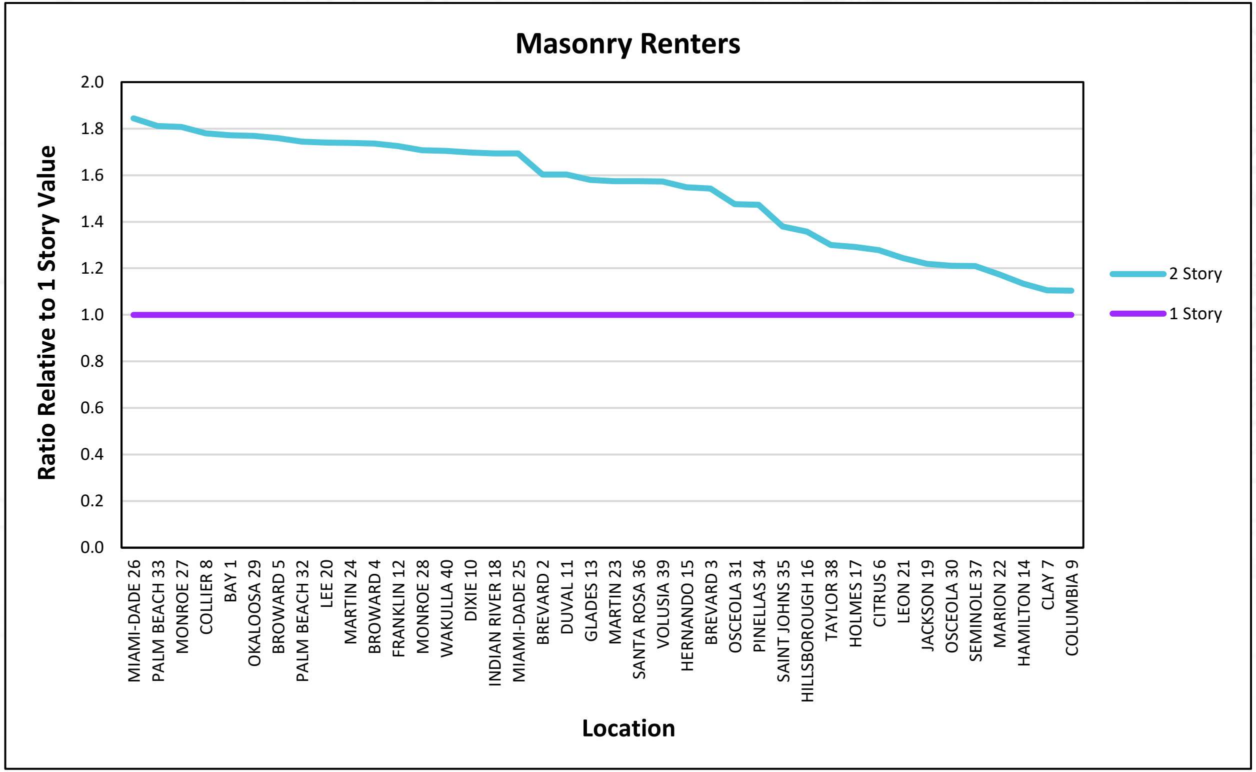


Florida Office of Insurance Regulation
Florida Public Hurricane Loss Model

Hurricane Loss Costs by Number of Stories

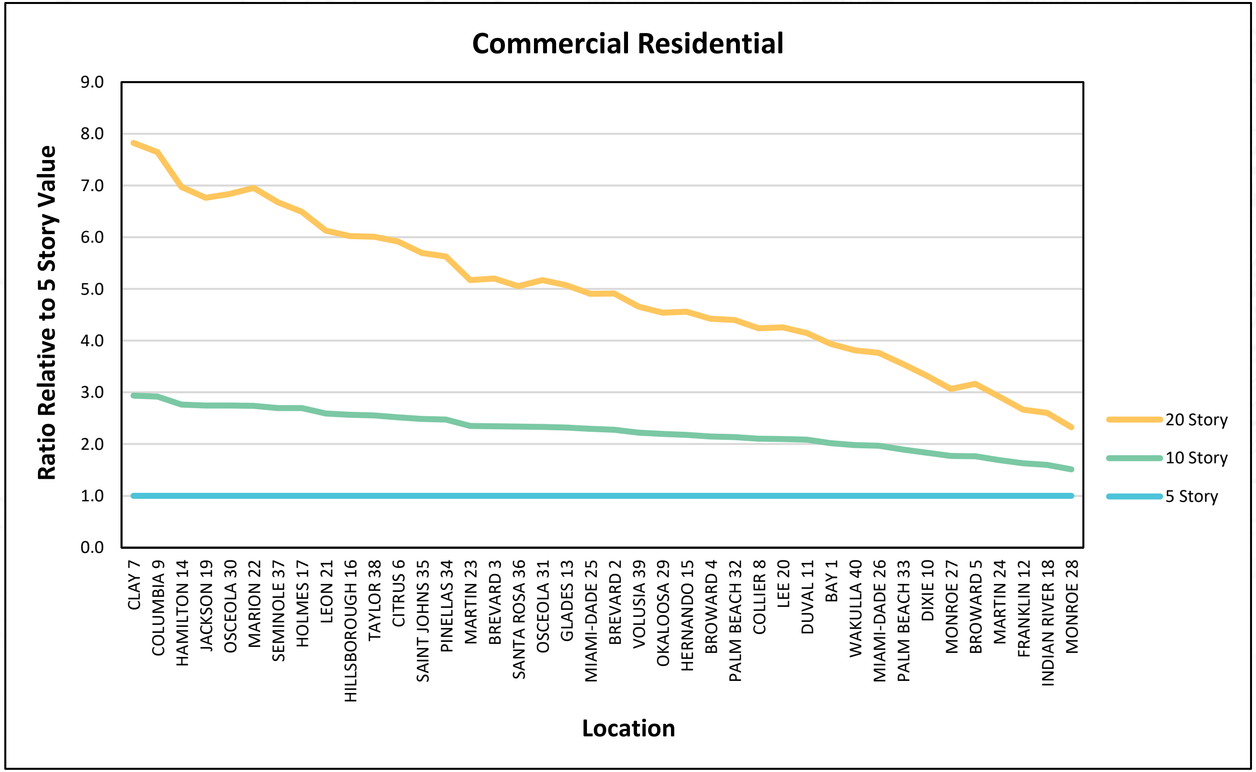


Hurricane Loss Costs by Number of Stories



Florida Office of Insurance Regulation
Florida Public Hurricane Loss Model

Hurricane Loss Costs by Number of Stories

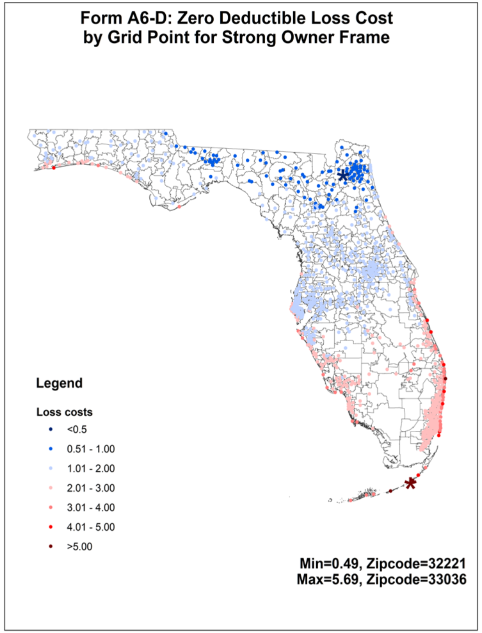


Florida Office of Insurance Regulation

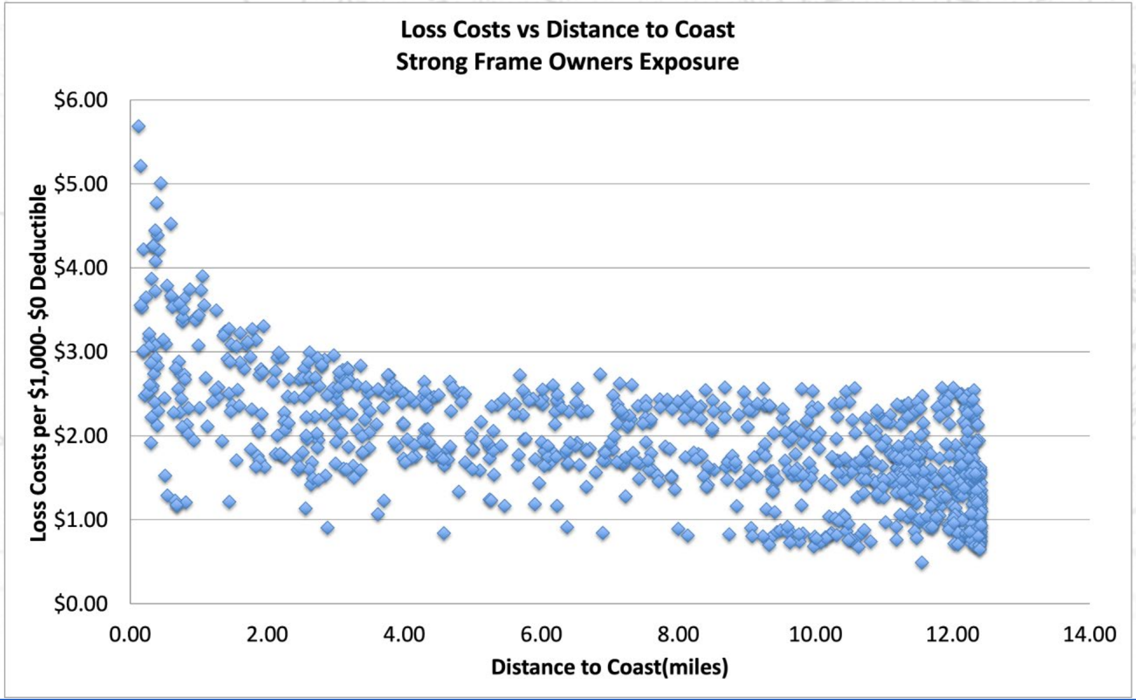
Florida Public Hurricane Loss Model

FORM A-6 – OTHER MAPS AND GRAPHS

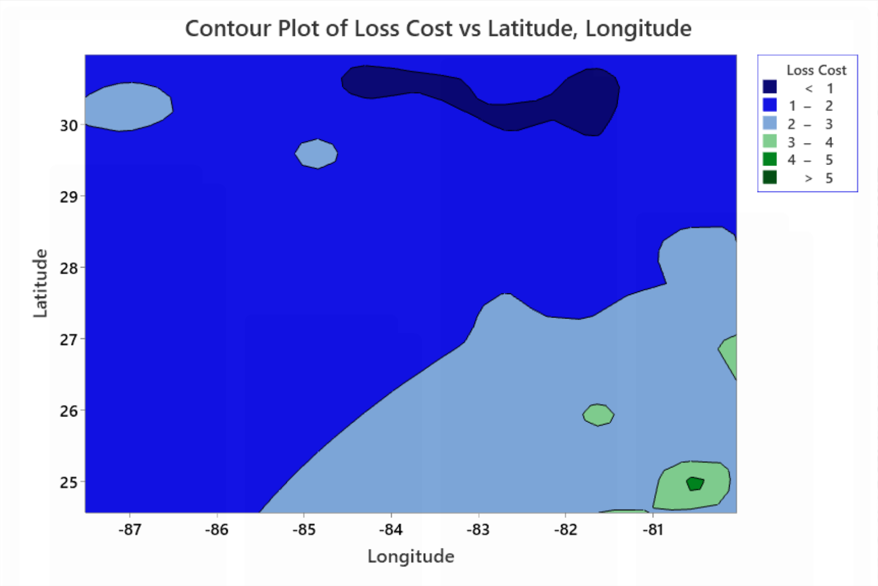
STRONG OWNERS FRAME LOSS COSTS



LOSS COSTS BY DISTANCE TO COAST STRONG OWNERS FRAME

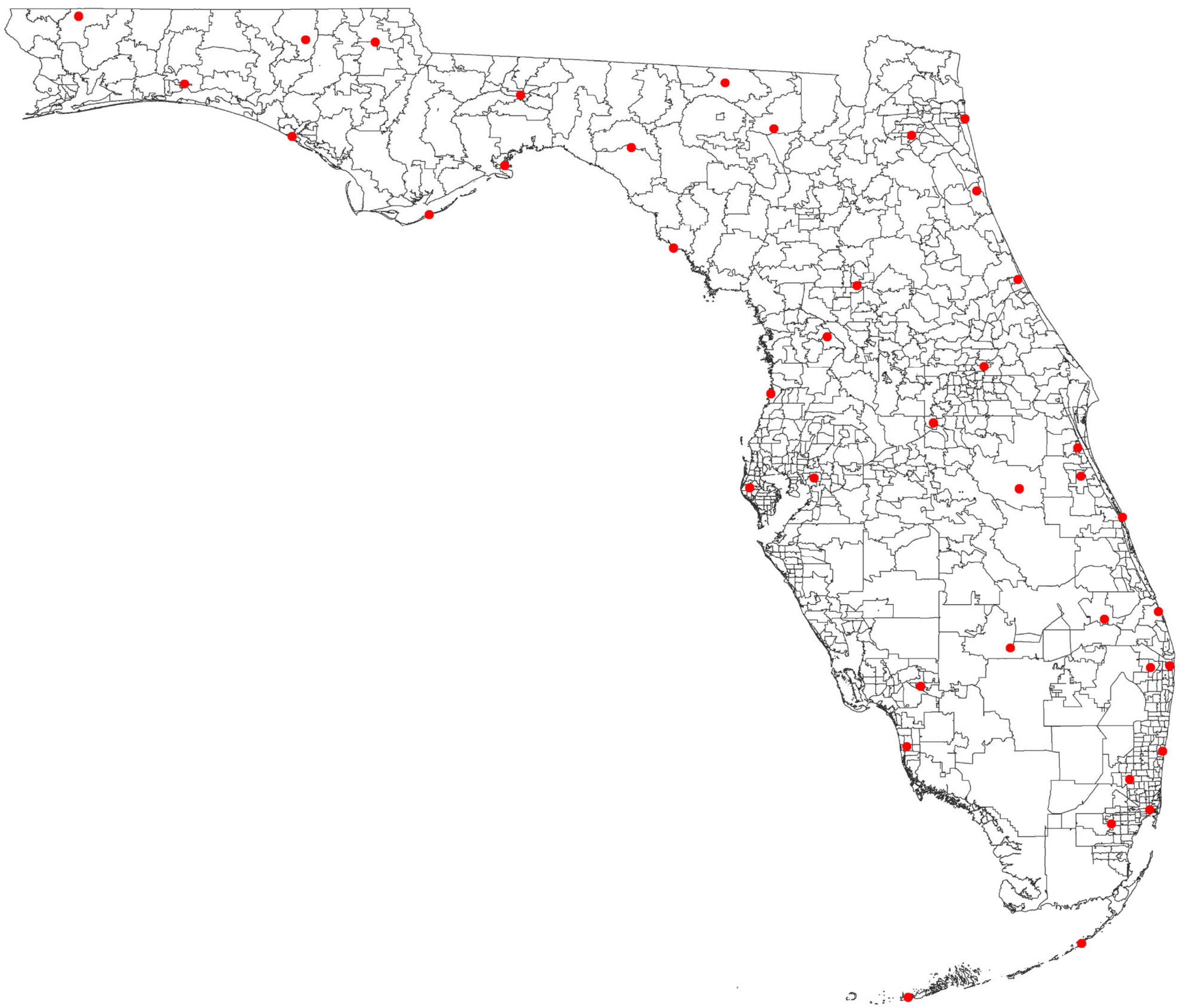


CONTOUR PLOT – STRONG OWNERS FRAME BY LAT/LON



Strong Frame Owners Exposure

Form A6: Grid A locations



Florida Public Hurricane Loss Model

V8.3

Adaptation of Artificial Intelligence

DR. SHU-CHING CHEN

DATA SCIENCE & ANALYTICS INNOVATION CENTER

UNIVERSITY OF MISSOURI-KANSAS CITY

CURRENT STATUS

- The FPHLM currently **does not utilize AI** in its core processes.

AREAS OF EXPLORATION

- **Anomaly Detection**
  - Using AI models to flag unusual patterns or outliers in the exposure data
- **Code Refactoring**
  - Leveraging AI techniques, such as code optimization and automated refactoring, to improve software code
- **Automated Data Validation**
  - Employing LLMs or AI agents to identify data inconsistencies, missing values, or formatting issues automatically

Florida Public Hurricane Loss Model V 8.3

General standards

G-1 Scope of the Model and Its Implementation

A. *The hurricane model shall project loss costs and probable maximum loss levels for damage to insured residential property from hurricane events.*

- The Florida Public Hurricane Loss Model estimates loss costs and probable maximum loss from hurricane events for personal and commercial lines residential property. The losses are estimated for building, appurtenant structure, content and additional living expense (ALE).

- The model name is Florida Public Hurricane Loss Model. The current version is 8.3.

- A comprehensive summary of the model is provided in the overview.

B. A documented process shall be maintained to assure continual agreement and correct correspondence of databases, data files, and computer source code to presentation materials, scientific literature, technical literature, and modeling organization documents.

- The FPHLM group members follow the process specified in the flowchart of in order to assure continual agreement and correct correspondence of databases, data files, and computer source code to presentation materials, scientific and technical literature, and FPHLM documents.

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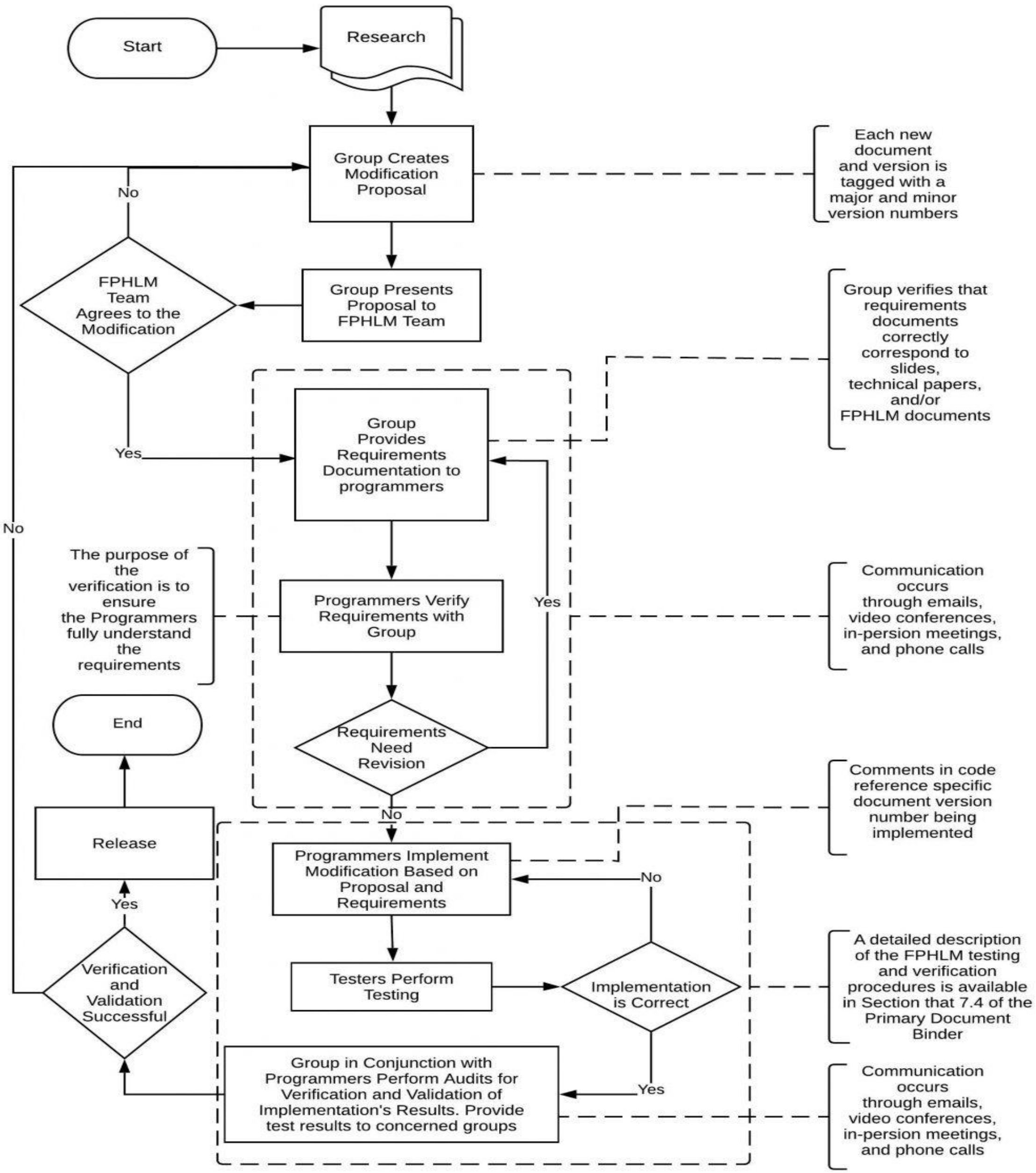

FPHLM Team: All members of the FPHLM
Groups: Meteorology, Engineering, Statistics, Actuarial, and computer Science

- ***C. All software, data, and flowcharts (1) located within the hurricane model, (2) used to validate the hurricane model, (3) used to project modeled hurricane loss costs and hurricane probable maximum loss levels, and (4) used to create forms required by the Commission in the Hurricane Standards Report of Activities shall fall within the scope of the Computer/ Information Hurricane Standards.***

- All software, data, and flowcharts used to validate the model, project insured loss cost and PML, and create forms required by the Commission are centrally maintained in the model hardware infrastructure and easily accessible by appropriate team members and comply with the Computer/Information Standards.

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- ***D. All meteorological forms, statistical Forms S-1, S-2, and S-6, and all actuarial forms with the exception of Form A-2 shall be produced through an automated procedure or procedures as indicated in the form instructions.***

- The Florida Public Hurricane Loss Model utilizes scripts that automate the generation of all Form M-1, M-2, M-3, S-1, S-2, and Actuarial forms as indicated in the Report of Activities.
- This includes output of data to Excel spreadsheets and generation of maps.
- The usage of the automated scripts limits the amount of manual intervention and the associated potential errors.

- ***E. Vintage of data, code, and scientific literature, and technical literature used shall be justifiable.***

- The vintage of model data meets or exceeds the requirements where specified in the standards.
- Examples include: the HURDAT2 database, Land Use/Land Cover Data, Zip code data.
- Other auxiliary data sets have been updated, such as the Rmax data base, or are otherwise reasonable given the availability of the data or the intended use of the data.
- Model code is compliant with contemporary and widely used programming language standards that are well-supported by a variety of compiler/language vendors and open source implementations.

- Scientific and technical literature used or created by model personal reflect current understanding of the methods, concepts and results that are relevant to catastrophe modeling.
- The reference literature provided in this submission document has been updated with more recent references, and older references that may not be as relevant have been removed.

Changes to the model include:

<u>Meteorological component</u>

- We updated to a recent version of HURDAT2 (5/11/2024) which includes storms up through the 2023 season. This change updates the probability distribution functions used in the storm track generator.

- We updated the ZIP Code database to the April 2024 ZIP Code boundaries as per Standard G-3. The update of the ZIP Code database resulted in the update of the following ZIP Code-based databases: (1) population-weighted centroids of each ZIP Code, (2) population-weighted roughness for each ZIP Code, (3) populated-weighted distance to coast of each ZIP Code, (4) list of 2001 FBC WBDR ZIP Codes and list of 2007 FBC WBDR ZIP Codes and list of 2010 FBC WBDR ZIP Codes, and (5) classification of coastal/inland for each ZIP Code.

Rationale for the changes

- Change made to update empirical probability distribution functions to the latest version of HURDAT2 (5/11/2024) to include more recent events.
- Roughness update as per Standards G-3.

The statewide impacts for Personal and Commercial Residential combined on $0 deductible loss costs based on 2017 exposure were:

- +4.2% due to updated HURDAT
- 0% due to revised roughness
- Personal Residential loss costs were also impacted by -3.5% due to additional exposures which, due to their age, now qualify for lower retrofitted vulnerabilities. Although not a result of a model change or update, this feature of the model impacts loss costs

- **G-2 Qualifications of Modeler Personnel and Consultants Engaged in Development and Implementation of the Model**

A. Hurricane model construction, testing, and evaluation shall be performed by modeling organization personnel or consultants who possess the necessary skills, formal education, and experience to develop the relevant components for hurricane loss projection methodologies.

- The model was developed, tested, evaluated, and implemented by a multi-disciplinary team of professors and experts in the fields of meteorology, wind and structural engineering, computer science, statistics, finance, economics, and actuarial science.

- The experts work primarily at Florida International University, Florida Institute of Technology, Florida State University, University of Florida, Hurricane Research Division of NOAA, University of Miami, University of Missouri Kansas City, and AMI Risk Consultants.

B. The hurricane model and hurricane model submission documentation shall be reviewed by modeling organization personnel or consultants in the following professional disciplines with requisite experience: structural/wind engineering (current licensed Professional Engineer), statistics (advanced degree or equivalent experience), actuarial science (Associate or Fellow of Casualty Actuarial Society or Society of Actuaries), meteorology (advanced degree), and computer/information science (advanced degree or equivalent experience and certifications). These individuals shall certify Expert Certification Forms G-1 through G-6, as applicable.

- The model has been reviewed by modeler personnel and consultants in the required professional disciplines. These individuals abide by the standards of professional conduct as adopted by their profession.
- The model was developed independently by a multi-disciplinary team of professors and experts. The lead university is the Florida International University. The model was commissioned by the FL-Office of Insurance Regulation.

- The Florida Office of Insurance Regulation contracted and funded Florida International University to develop the Florida Public Hurricane Loss Model.
- The model is based at the Laboratory for Insurance, Financial and Economic Research, which is part of the International Hurricane Research Center at Florida International University.
- The OIR did not influence the development of the model.
- The copyright for the model belongs to OIR, but Florida International University has license to operate the model for research and commercial purposes.
- FL-OIR is the major client for the model.
- Since January 2009 model services are available to the insurance and reinsurance firms. The model has been used by about 30 insurance companies.

- The model was first activated in March 2006. This version was used to process the insurance company data on behalf of the Florida Office of Insurance Regulation.
- In Summer 2007 a revised and updated version 2.6 of the model was accepted by the Florida Commission on Hurricane Loss Projection Methodology and put to immediate use.
- Another revised and updated version 3.0 was accepted by the Commission in June 2008.
- Another revised and updated version 3.1 was accepted by the Commission in June 2009.
- Version 4.1 was accepted by the Commission in August 2011.
- Version 5.0 was accepted by the Commission in Summer 2013.
- Version 6.1 was accepted by the Commission in Summer 2015.
- Version 6.2 was accepted by the Commission in Summer 2017 .
- Version 7.0 was accepted by the Commission in Summer 2019.
- Version 8.1 was accepted by the Commission in Summer 2021 and has been in use since.
- Version 8.2 was accepted by the Commission in Summer 2023 and has been in use since.

G-3 Insured Exposure Location

A. ZIP Codes used in the hurricane model shall not differ from the United States Postal Service publication date by more than 24 months at the date of submission of the hurricane model. ZIP Code information shall originate from the United States Postal Service.

- Our model uses ZIP Code data exclusively from a third-party developer, which bases its information on the ZIP Code definitions issued by the United States Postal Service. The version we used has a USPS vintage of April 2024. The ZIP Code data have been changed in the current release of the model from the last submission.

B. ZIP Code centroids, when used in the hurricane model, shall be based on population data.

- ZIP Code centroids used in the model are population centroids.

C. ZIP Code information purchased by the modeling organization shall be verified by the modeling organization for accuracy and appropriateness.

- The ZIP Code information is checked for consistency by experts developing our model. Maps showing the ZIP Code boundaries and the associated centroids were provided to the professional team during the on-site visit.

D. If any hazard or any hurricane model vulnerability components are dependent on ZIP Code databases, the modeling organization shall maintain a logical process for ensuring these components are consistent with the recent ZIP Code database updates.

- All ZIP Code-dependent components are recreated using the latest update of the ZIP code data in the model.

E. Geocoding methodology shall be justified.

- The FPHLM uses an enterprise class geocoding engine for converting street addresses to latitude-longitude values.

G-4 Independence of Hurricane Model Components

The meteorology, vulnerability, and actuarial components of the hurricane model shall each be theoretically sound without compensation for potential bias from other components.

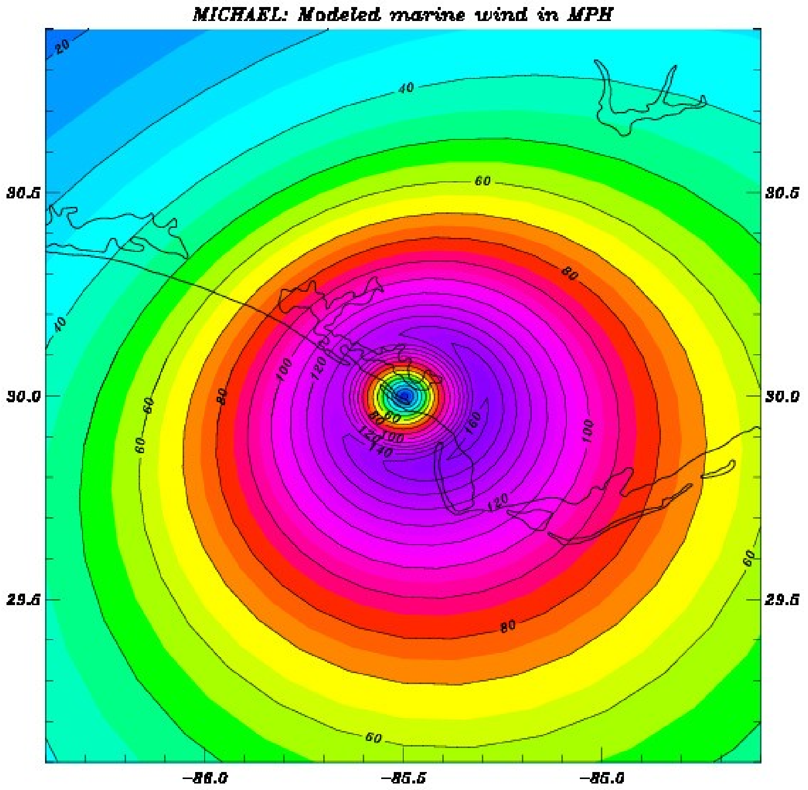
- The meteorology, vulnerability, and actuarial components of the model are theoretically sound and were developed and validated independently before being integrated. The model components were tested individually.

G-5 Editorial Compliance

- ***The submission and any revisions provided to the Commission throughout the review process shall be reviewed and edited by a person or persons with experience in reviewing technical documents who shall certify on Form G-7, Editorial Review Expert Certification that the submission has been personally reviewed and is editorially correct.***
- The current submission document has been reviewed and edited by person who is qualified to perform such tasks and is listed in Form G-7.

Florida Public Hurricane Loss Model

Meteorology Standards V8.3



Commission Review June 13, 2025

M-1 Model Base Hurricane Set (1/2)

- Hurricane frequencies for model validation and calibration based on May 11, 2024 HURDAT2 (1900-2023)
- The Model Base Hurricane Set is the Reference Hurricane Set plus one additional year (2023).
- Calibration and validation uses the complete Base Hurricane Storm Set. No modifications to the Base Hurricane Storm Set, but supplemental information was added as necessary (e.g., Rmax, B)
- PDFs of storm motion and intensity change used by the storm track generator updated to include new seasons (2022-2023). A flowchart of this process was shown in an earlier presentation.

M-1 Model Base Hurricane Set (2/2)

- Modeled landfall frequencies are consistent with historical frequencies as demonstrated in Form M-1, Form S-1 and Standards S-1 Disclosure 5, M-2, Disclosure 8. Goodness of fit tests further demonstrate the consistency of the modeled results with the historical record.

- Consistency of the Model Base Hurricane Set for Form M-1, Form S-1 and Form A-2 are shown in the following slides.

- FPHLM v8.3 is in compliance with Standard M-1

Form M-1. Modeled Annual Occurrence Rates

	Entire State					Region A – NW Florida				
	Reference Set		Modified Base Set		Modeled	Reference Set		Modified Base Set		Modeled
Category	Number	Rate	Number	Rate	Rate	Number	Rate	Number	Rate	Rate
1	27	0.220	24	0.194	0.246	16	0.130	14	0.113	0.144
2	15	0.122	19	0.153	0.124	4	0.033	6	0.048	0.059
3	14	0.114	15	0.121	0.123	6	0.049	7	0.056	0.044
4	12	0.098	10	0.081	0.069	0	0.000	0	0.000	0.020
5	3	0.024	3	0.024	0.016	1	0.008	1	0.008	0.003

	Region B – SW Florida					Region C – SE Florida				
	Reference Set		Modified Base Set		Modeled	Reference Set		Modified Base Set		Modeled
Category	Number	Rate	Number	Rate	Rate	Number	Rate	Number	Rate	Rate
1	7	0.057	7	0.056	0.068	9	0.073	7	0.056	0.060
2	4	0.033	5	0.040	0.041	6	0.049	7	0.056	0.034
3	5	0.041	5	0.040	0.040	5	0.041	4	0.032	0.046
4	6	0.049	4	0.032	0.021	6	0.049	6	0.048	0.031
5	0	0.000	1	0.008	0.005	2	0.016	1	0.008	0.009

	Region D – NE Florida					Florida By-Passing Hurricanes				
	Reference Set		Modified Base Set		Modeled	Reference Set		Modified Base Set		Modeled
Category	Number	Rate	Number	Rate	Rate	Number	Rate	Number	Rate	Rate
1	1	0.008	1	0.008	0.012	5	0.041	5	0.040	0.051
2	2	0.016	2	0.016	0.006	3	0.024	4	0.032	0.025
3	0	0.000	0	0.000	0.004	6	0.049	5	0.040	0.029
4	0	0.000	0	0.000	0.001	0	0.000	1	0.008	0.017
5	0	0.000	0	0.000	0.000	0	0.000	0	0.000	0.005

	Region E – Georgia					Region F – Alabama/Mississippi				
	Reference Set		Modified Base Set		Modeled	Reference Set		Modified Base Set		Modeled
Category	Number	Rate	Number	Rate	Rate	Number	Rate	Number	Rate	Rate
1	0	0.000	2	0.016	0.013	7	0.057	7	0.056	0.046
2	2	0.016	1	0.008	0.006	3	0.024	3	0.024	0.023
3	0	0.000	0	0.000	0.004	4	0.033	3	0.024	0.027
4	0	0.000	0	0.000	0.002	0	0.000	1	0.008	0.015
5	0	0.000	0	0.000	0.000	1	0.008	1	0.008	0.003

Form S-1

Number of Hurricanes Per Year	Reference Hurricane Set Probability	Model Base Hurricane Set Probability	Modeled Probability	Reference Hurricane Set Frequency	Model Base Hurricane Set Frequency	Modeled Frequency
0	0.593	0.605	0.604	73	75	75
1	0.244	0.242	0.259	30	30	32
2	0.138	0.129	0.098	17	16	12
3	0.025	0.024	0.031	3	3	4
4	0	0	0.007	0	0	1
5	0	0	0	0	0	0
6	0	0	0	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10 or more	0	0	0	0	0	0

Form A-2

ID	Hurricane Landfall/ Closest Approach Date	Year	Name	Region as defined in *Figure 1* - Category	Personal and Commercial Residential Insured Hurricane Losses ($) 2017 FHCF Exposure Data	Personal and Commercial Residential Insured Hurricane Losses ($) 2023 FHCF Exposure Data
005	08/15/1901	1901	NoName04-1901	F-1	333,789,667	532,310,115
010	09/11/1903	1903	NoName03-1903	C-1/A-1	8,768,066,879	12,530,189,925
015	10/17/1904	1904	NoName04-1904	C-1	2,515,646,046	3,470,622,239
020	06/17/1906	1906	NoName02-1906	B-1	2,598,680,912	3,603,537,233
025	09/27/1906	1906	NoName06-1906	ByP-2/F-2	834,512,851	1,380,428,921
030	10/18/1906	1906	NoName08-1906	B-3	12,815,574,884	17,421,882,099
035	10/11/1909	1909	NoName11-1909	B-3	607,495,891	905,921,472
040	10/18/1910	1910	NoName05-1910	B-2	27,856,865,846	40,900,887,619
045	08/11/1911	1911	NoName02-1911	A-1	372,995,618	594,048,209
050	09/14/1912	1912	NoName04-1912	F-1/ByP-1	39,431,262	61,826,619
055	08/01/1915	1915	NoName01-1915	D-1	840,222,469	1,252,520,486
060	09/04/1915	1915	NoName04-1915	A-1	453,456,158	685,727,492
065	07/05/1916	1916	NoName02-1916	F-3/ByP-2	544,336,404	853,554,885
070	10/18/1916	1916	NoName14-1916	A-2	1,190,781,959	1,891,502,485
075	09/29/1917	1917	NoName04-1917	A-3	1,740,671,388	2,817,430,742
080	09/10/1919	1919	NoName02-1919	ByP-4	140,041,429	223,325,050
085	10/25/1921	1921	TampaBay06-1921	B-3	19,231,836,595	28,412,440,624
090	09/15/1924	1924	NoName05-1924	A-1	47,954,742	82,186,873
095	10/21/1924	1924	NoName10-1924	B-1	6,009,060,559	8,372,803,564
100	07/28/1926	1926	NoName01-1926	D-2	3,778,973,364	5,831,591,937
105	09/18/1926	1926	GreatMiami07-1926	C-4/A-3	30,257,563,149	42,281,657,707~~5,831,591,937~~
110	10/21/1926	1926	NoName10-1926	ByP-3	2,282,458,491	3,206,466,843
115	08/08/1928	1928	NoName01-1928	C-2	4,143,798,811	6,320,381,787
120	09/17/1928	1928	LakeOkeechobee04-1928	C-4	30,257,563,149	58,589,887,080
125	09/28/1929	1929	NoName02-1929	C-3/A-1	10,863,273,274	15,619,330,286
130	09/01/1932	1932	NoName03-1932	F-1/ByP-1	1,310,762,790	1,855,325,247
135	07/30/1933	1933	NoName05-1933	C-1	1,066,779,745	1,618,189,836
140	09/04/1933	1933	NoName11-1933	C-3	11,020,237,992	15,949,773,400
145	09/03/1935	1935	LaborDay03-1935	B-5/A-2	17,186,705,869	25,115,152,158
150	11/04/1935	1935	NoName07-1935	C-2	5,497,233,566	7,432,498,785
155	07/31/1936	1936	NoName05-1936	A-2	1,829,011,651	2,875,068,583
160	08/11/1939	1939	NoName02-1939	C-1/A-1	3,441,131,028	5,281,735,733
165	10/06/1941	1941	NoName05-1941	C-2/A-1	7,422,624,121	10,604,976,561
170	10/19/1944	1944	NoName13-1944	B-2	25,944,463,687	38,649,550,190
175	06/24/1945	1945	NoName01-1945	A-1	6,251,835,634	9,511,009,614
180	09/15/1945	1945	NoName09-1945	C-4	14,821,448,331	21,210,150,160
185	10/08/1946	1946	NoName06-1946	B-1	13,707,074,985	20,827,207,107
190	09/17/1947	1947	NoName04-1947	C-4	20,898,753,948	29,374,994,714
195	10/12/1947	1947	NoName09-1947	B-1/E-2	6,480,471,811	8,880,475,444
200	09/22/1948	1948	NoName08-1948	B-3	11,000,697,234	15,463,606,188
205	10/05/1948	1948	NoName09-1948	B-2	5,520,431,559	7,561,348,975
210	08/26/1949	1949	NoName02-1949	C-4	28,200,469,914	41,163,195,275
215	08/31/1950	1950	Baker-1950	F-1/ByP-1	589,310,292	925,535,287
220	09/05/1950	1950	Easy-1950	A-3	9,520,398,704	14,279,818,685
225	10/18/1950	1950	King-1950	C-4	14,065,399,609	18,876,487,398
230	09/26/1953	1953	Florence-1953	A-1	515,180,715	884,165,283
235	10/09/1953	1953	Hazel-1953	B-1	3,039,967,834	4,409,395,002
240	09/25/1956	1956	Flossy-1956	A-1	774,875,635	1,284,811,339

Form A-2

ID	Hurricane Landfall/ Closest Approach Date	Year	Name	Region as defined in *Figure 1* - Category	Personal and Commercial Residential Insured Hurricane Losses ($) 2017 FHCF Exposure Data	Personal and Commercial Residential Insured Hurricane Losses ($) 2023 FHCF Exposure Data
245	09/10/1960	1960	Donna-1960	B-4	21,279,858,577	31,300,352,034
250	09/15/1960	1960	Ethel-1960	F-1	435	3,109
255	08/27/1964	1964	Cleo-1964	C-2	14,895,606,314	20,699,700,271
260	09/10/1964	1964	Dora-1964	D-2	3,758,325,362	5,899,722,554
265	10/14/1964	1964	Isbell-1964	B-2	6,757,313,297	9,282,820,365
270	09/08/1965	1965	Betsy-1965	C-3	3,673,063,824	5,158,293,255
275	06/09/1966	1966	Alma-1966	A-1	10,831,233,905	16,191,848,412
280	10/04/1966	1966	Inez-1966	C-2	204,292,716	311,048,508
285	10/19/1968	1968	Gladys-1968	A-2	4,233,403,983	6,440,254,178
290	08/18/1969	1969	Camille-1969	F-5		
295	06/19/1972	1972	Agnes-1972	A-1	128,919,461	205,446,878
300	09/23/1975	1975	Eloise-1975	A-3	1,015,745,487	1,926,704,950
305	09/04/1979	1979	David-1979	C-2/E-1	8,057,410,938	11,448,876,756
310	09/13/1979	1979	Frederic-1979	ByP-3/F-4	1,097,463,628	1,777,598,561
315	09/02/1985	1985	Elena-1985	F-3/ByP-3	189,244,619	305,668,805
320	11/21/1985	1985	Kate-1985	A-2	491,797,162	715,292,672
325	10/12/1987	1987	Floyd-1987	B-1	172,261,809	256,568,044
330	08/24/1992	1992	Andrew-1992	C-5	13,008,246,620	17,544,430,352
335	08/03/1995	1995	Erin-1995	C-1/A-2	5,000,005,578	7,730,832,899
340	10/04/1995	1995	Opal-1995	A-3	2,695,886,855	4,228,231,347
345	07/19/1997	1997	Danny-1997	ByP-1/F-1	64,442,057	100,449,434
350	09/03/1998	1998	Earl-1998	A-1	10,926,657	21,429,627
355	09/25/1998	1998	Georges-1998	B-2/F-2	441,560,458	665,967,396
360	10/15/1999	1999	Irene-1999	B-1	4,070,191,251	5,667,113,963
365	08/13/2004	2004	Charley-2004	B-4	7,341,884,764	10,758,602,661
370	09/05/2004	2004	Frances-2004	C-2	11,229,248,998	16,716,018,384
375	09/16/2004	2004	Ivan-2004	F-3/ByP-3	703,841,669	1,099,581,968
380	09/26/2004	2004	Jeanne-2004	C-3	12,985,525,804	19,413,740,767
385	07/10/2005	2005	Dennis-2005	A-3	868,614,838	1,349,327,612
390	08/25/2005	2005	Katrina-2005	C-1	3,276,521,964	4,610,602,678
395	09/20/2005	2005	Rita-2005	ByP-2	84,024,701	134,868,042
400	10/24/2005	2005	Wilma-2005	B-3	14,762,550,344	20,810,563,192
401	09/10/2008	2008	Ike-2008	ByP-1	275,643	394,180
405	09/02/2016	2016	Hermine-2016	A-1	113,006,037	164,538,649
410	10/07/2016	2016	Matthew-2016	ByP-3	4,331,479,175	6,409,037,509
415	09/10/2017	2017	Irma-2017	B-4	29,479,837,582~~13,904,862,567~~	43,232,936,723~~20,846,369,734~~
420	10/08/2017	2017	Nate-2017	F-1	N/A	N/A
425	10/10/2018	2018	Michael-2018	A-5	835,898,198	1,188,160,799
430	09/04/2019	2019	Dorian-2019	ByP-2	N/A	N/A
435	09/16/2020	2020	Sally-2020	F-2	983,916,514	1,513,263,692
440	10/28/2020	2020	Zeta-2020	Byp-3	N/A	N/A
445	11/11/2020	2020	Eta-2020	ByP-1	N/A	N/A
450	07/07/2021	2021	Elsa-2021	ByP-2	N/A	N/A
455	09/28/2022	2022	Ian-2022	B-4	8,082,447,635	11,536,354,208
460	11/10/2022	2022	Nicole-2022	C-1	7,267,057,373	10,932,122,236
461	08/29/2023	2023	Idalia-2023	A-3	114,959,350	155,040,914
Total					**583,168,610,036~~567,593,635,021~~**	**859,780,741,837~~800,944,109,079~~**

Consistency of Form M-1 & S-1

In Form M-1, Entire State, total storms Modified Base Set:

24 + 19 + 15 + 10 + 3 = 71 storms

In Form S-1, Model Base Hurricane Set Frequency:

75*0 + 30*1 + 16*2 + 3*3 = 71 storms

Consistency Form M-1 & A-2

An automated script is used to produce Form M-1 numbers from the Base Hurricane Set database.

A second script is used to generate the Form A-2 list of storms from the *same database.* This list is compared against the storms listed in Form A-2.

A third script is used as a check on the Form A-2 list which counts the number of storms by region and category. These counts are checked against the Form M-1 numbers.

The third script reports 78 total landfalls across the four regions (A, B, C, D) with 7 secondary landfalls. This leads to a total of

$$78 - 7 = 71 \text{ storms}$$

M-2 Hurricane Parameters (Inputs)

- Methods based on information documented in currently accepted scientific literature. Modeled hurricane tracks and wind model described in Powell, et al. (2005).
- The hurricane parameters are described in Disclosure 2. Additional discussion is provided in Disclosures 4 and 6 and also G-1 Disclosure 2. Also see Form S-3 and Standard S-1 Disclosure 8.
- The parameters are also discussed in a prior presentation.
- No parameters were adjusted for climate change.
- FPHLM v8.3 is in compliance with Standard M-2

M-3 Hurricane Probability Distributions

- Modeled probability distributions consistent with historical Atlantic basin hurricanes, as demonstrated in Forms M-1, M-3, S-1 and Standard S-1, Disclosure 5 and Disclosure 8.

- Landfall probabilities consistent with historical base set for coastal segments of Florida and neighboring states, as demonstrated in Forms M-1, S-1 and Standards M-2, Disclosure 8, S-1, Disclosure 5.

- Intensity definition based on modeled max 1-min wind speed at 10 m and is consistent with Saffir-Simpson scale wind speed ranges

- FPHLM v8.3 is in compliance with Standard M-3

M-4 Hurricane Windfield Structure (1/2)

- Wind fields consistent with observed historical storms as shown by comparisons with H*Wind and station observations. (See Standards M-4, Disclosure 9, Standard S-1, Disclosure 1).
- Development of roughness from land use/land cover is consistent with the state of the science and is consistent with 2016 NLCD or later as required. The GIS data from the NLCD 2016 database and contemporaneous Florida Water Management District databases are used to derive local roughness at ~90 meter (300 ft) resolution over Florida.
- Vertical variation of wind speed is explicitly computed and used to model losses of multi-story buildings

M-4 Hurricane Windfield Structure (2/2)

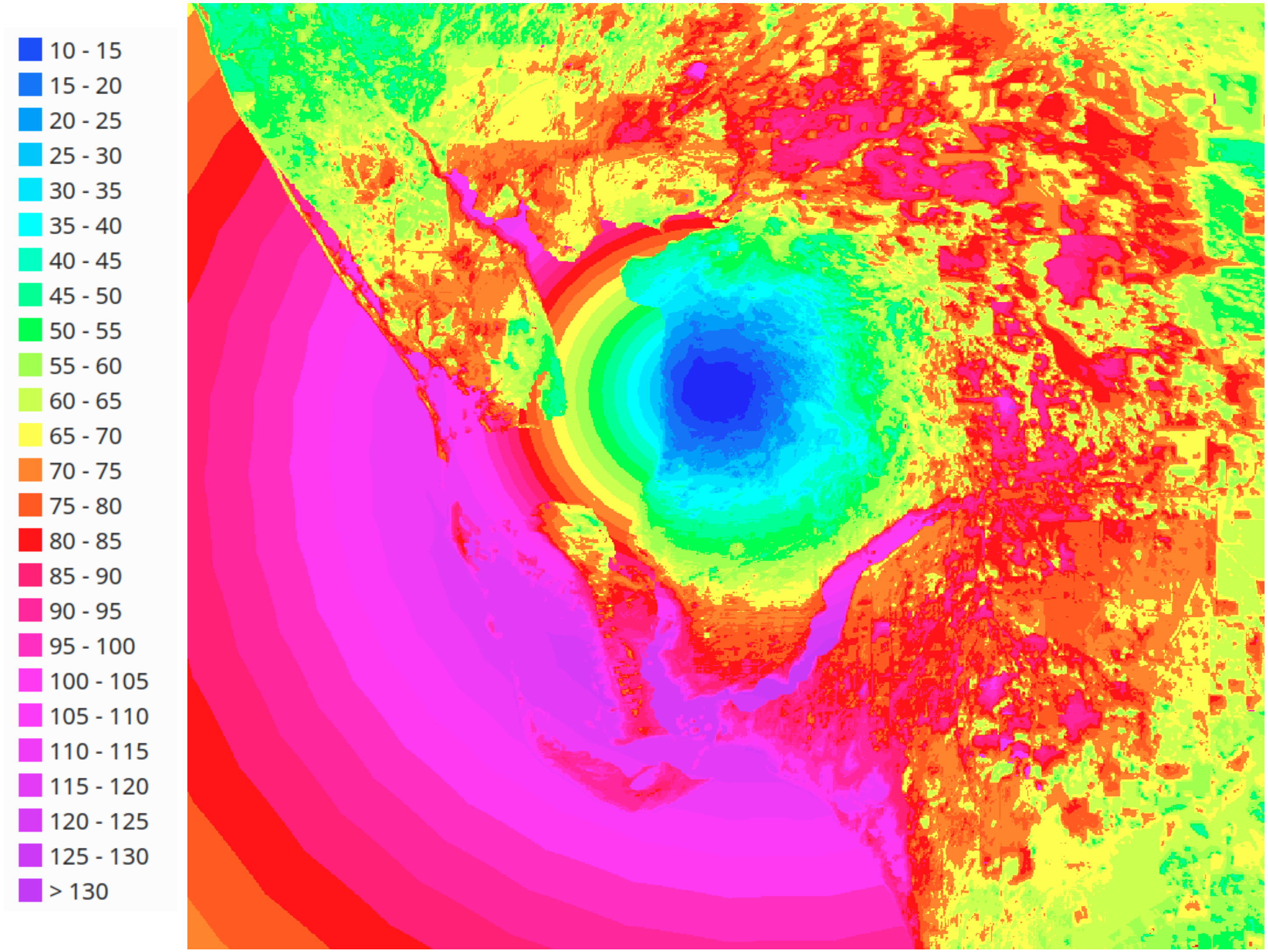
- The methodology for adjusting winds to terrain conditions was presented in an earlier presentation.
- FPHLM v8.3 is in compliance with Standard M-4

M-5 Hurricane Intensity Change Methodologies

- Method for hurricane intensity change is consistent with the state of science and is based on empirical distributions derived directly from HURDAT2.
- Method for hurricane wind speed decay over land is based on scientific literature and consistent with the historical record. A pressure filling model (Vickery, 2005) is used based on historical data from 1926 to 2004.
- The model includes transition from over land to over water that is consistent with the state of science (Powell et al, 2005).
- The detailed transition of winds from over land to over water are shown in an example in the following slides.
- FPHLM v8.3 is in compliance with Standard M-5

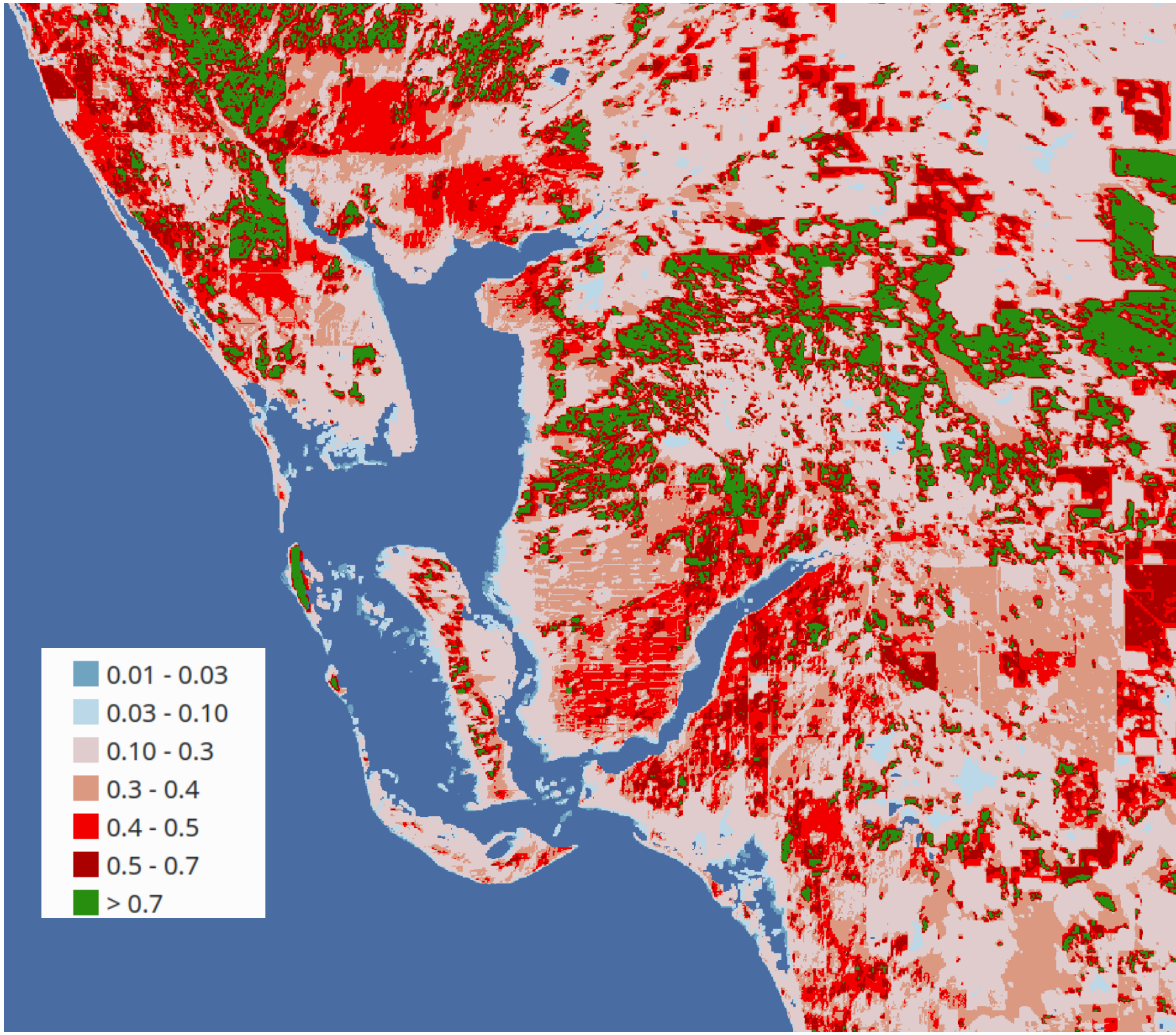
Hurricane Ian

Actual terrain
1 minute
winds (mph)



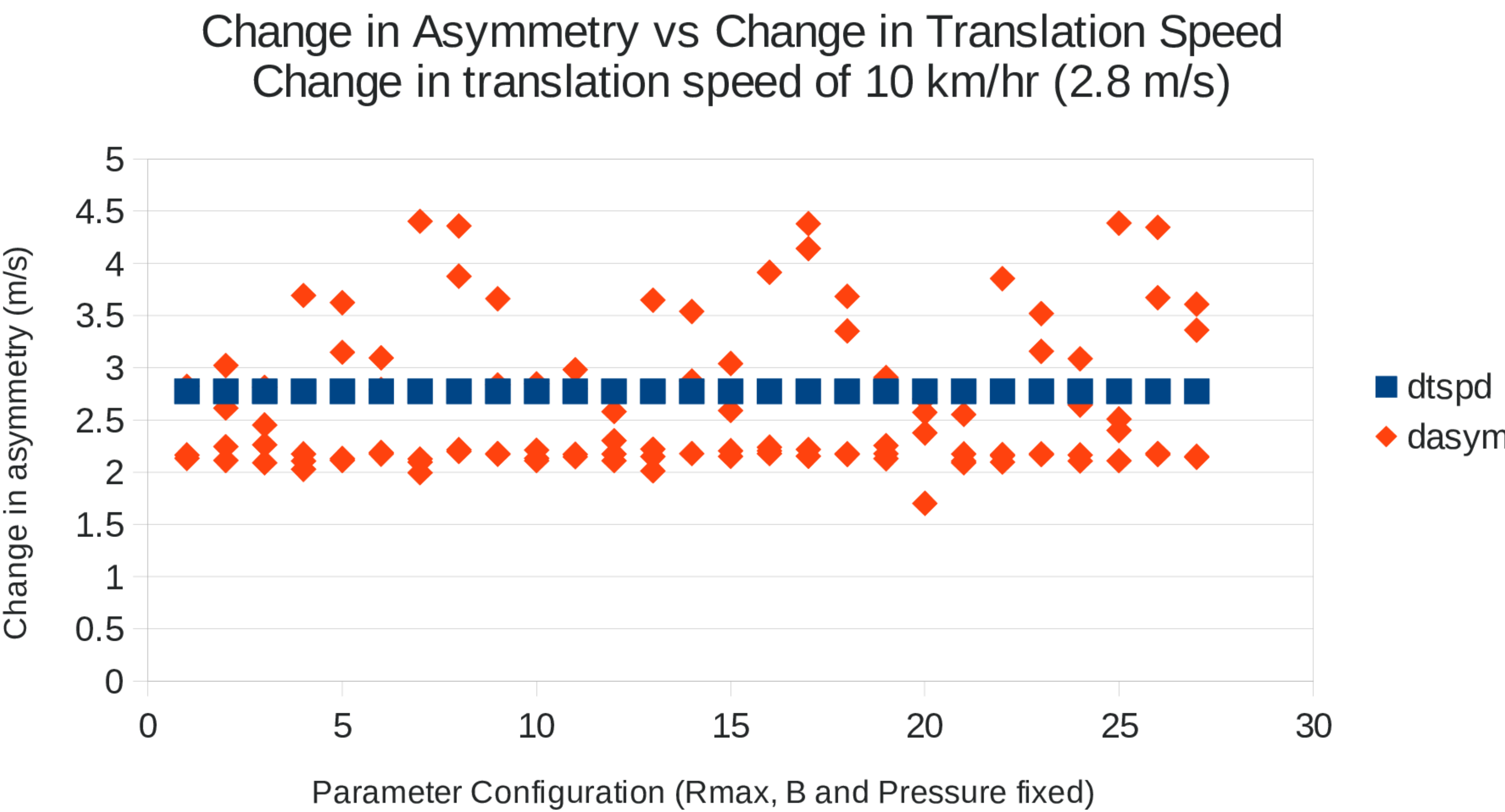
Hurricane Ian

Effective roughness (meters)

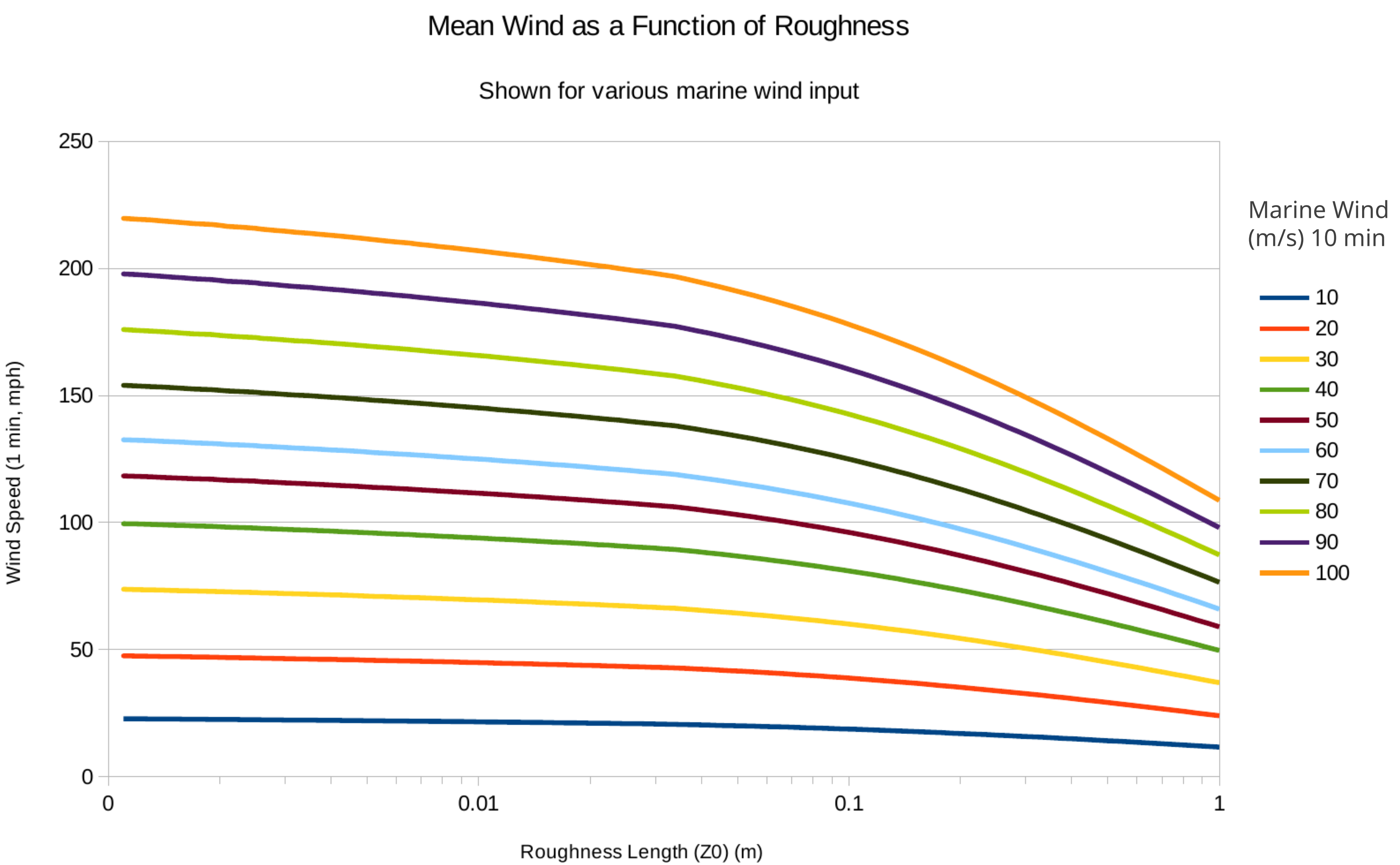


M-6 Logical Relationships of Hurricane Characteristics

- Wind field asymmetry increases with storm translation speed, all other factors held constant. An illustration follows on the next slide.
- Mean wind speed decreases with increasing roughness, all other factors held constant. An illustration follows the next slide.
- FPHLM v8.3 is in compliance with Standard M-6



Rmax = {30,60,90} (km), B = {0.8,1.3,1.8}, Press = {985,955,925} (mb)
Translation Speeds = {5,15,25,35,45} (km/hr)



Mean Wind as a Function of Roughness
Shown for various marine wind input
250
200
150
100
50
0
Wind Speed (1 min, mph)
0
0.01
0.1
1
Roughness Length (Z0) (m)
Marine Wind (m/s) 10 min
10
20
30
40
50
60
70
80
90
100

Florida Public Hurricane Loss Model

V8.3

STATISTICAL STANDARDS

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Department of Mathematics and Statistics
Florida International University

June 13, 2025

STANDARD S-1: MODELED RESULTS AND GOODNESS OF FIT

- ***A. The use of historical data in developing the hurricane model shall be supported by rigorous methods published in current scientific literature and current technical literature.***

  FPHLM 8.3 is in compliance with Standard S-1A. The historical data for the period 1900-2023 were modeled using scientifically accepted methods that have been published in accepted scientific literature.

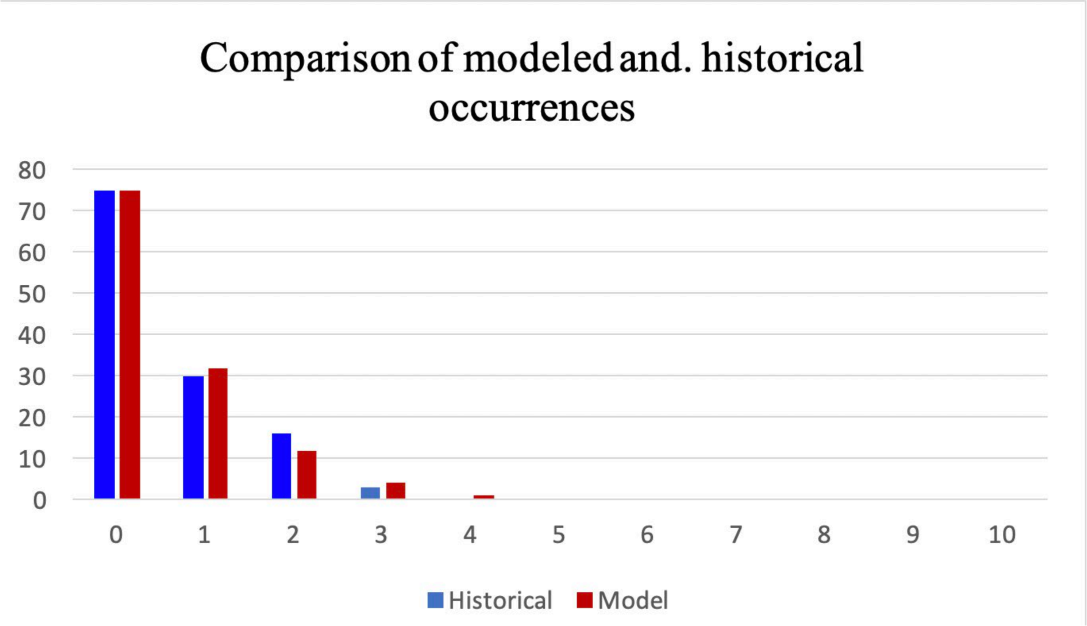
- ***B. Modeled results shall reflect statistical agreement with historical data or the Model Base Hurricane Set using current scientific and statistical methods for the academic disciplines appropriate for the various hurricane model components. Any differences shall be justifiable.***

  FPHLM 8.3 is in compliance with Standard S-1B. Insufficient evidence of a disagreement between modeled and historical results are indicated by appropriate statistical and scientific tests.

FORM S-1: PROBABILITY AND FREQUENCY OF FLORIDA LANDFALLING HURRICANES PER YEAR

Number of Hurricanes Per Year	Reference Hurricane Set Probability	Model Base Hurricane Set Probability	Modeled Probability	Reference Hurricane Set Frequency	Model Base Hurricane Set Frequency	Modeled Frequency
0	0.593	0.605	0.604	73	75	75
1	0.244	0.242	0.259	30	30	32
2	0.138	0.129	0.098	17	16	12
3	0.025	0.024	0.031	3	3	4
4	0	0	0.007	0	0	1
5	0	0	0	0	0	0
6	0	0	0	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10 or more	0	0	0	0	0	0

COMPARISON OF MODELED VS HISTORICAL OCCURRENCES



COMPARISON OF MODELED VS HISTORICAL OCCURRENCES

- H_0: Historical and modeled data follow the same distribution
  Ha: They are from different distributions.

Chi-square test statistic

- Chi square goodness of fit, p-value =0.521 (DF=3)

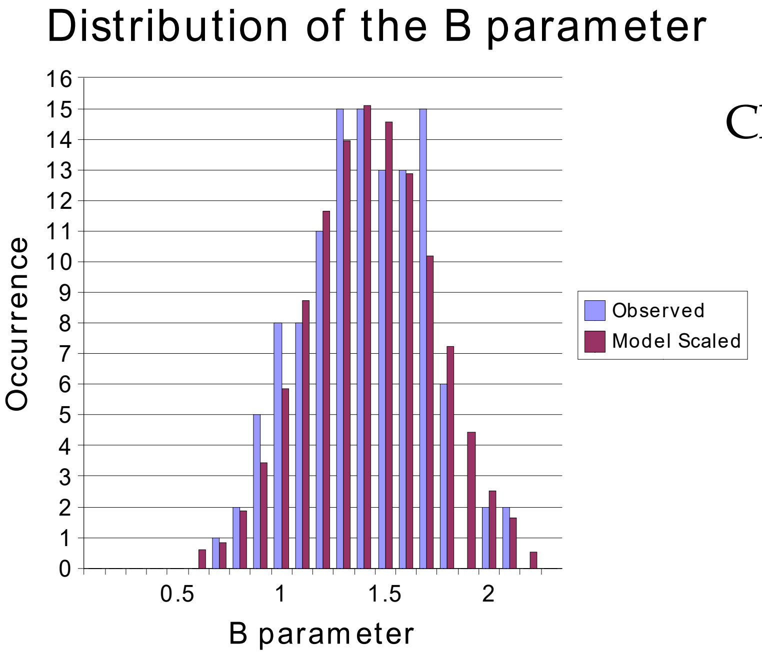
- Given the data, the probability of rejecting the true null hypothesis is 0.521. So, we can not reject the null hypothesis at 5% level of significance.

STANDARD S-1: MODELED RESULTS AND GOODNESS OF FIT

- Stochastic Form of Distributions
  - Holland B Error Term – Normal distribution
  - Rmax : Gamma distribution
  - Pressure Decay Error Term – Normal distribution

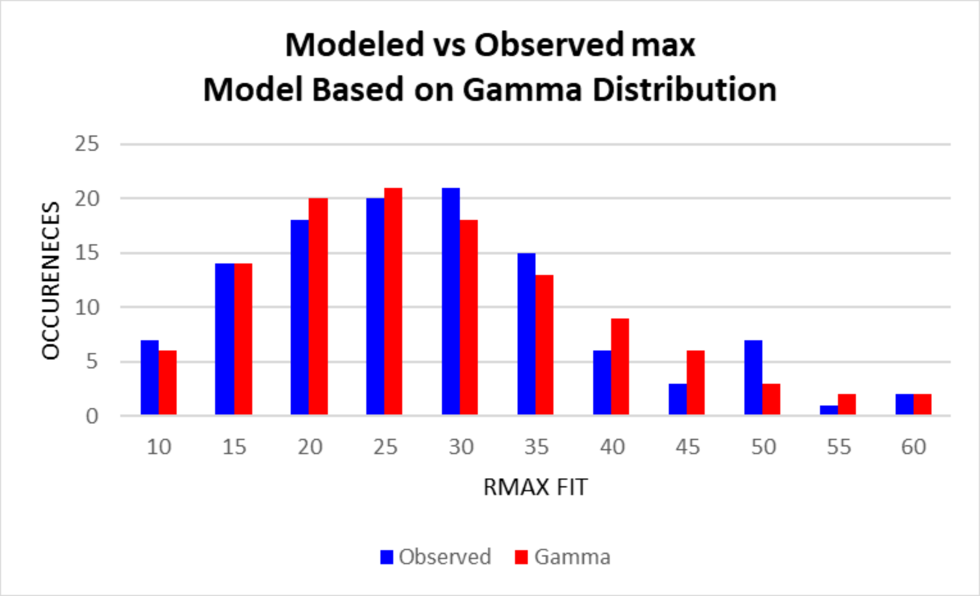
- Statistical Procedures to test the fits included chi-square goodness of fit tests and graphical comparisons. The tests indicated that the fits were reasonable.

COMPARISON BETWEEN OBSERVED AND MODELED HOLLAND B



Chi square goodness of fit Test:
p-value = 0.57 (DF=8)

Comparison between observed and modeled R Max



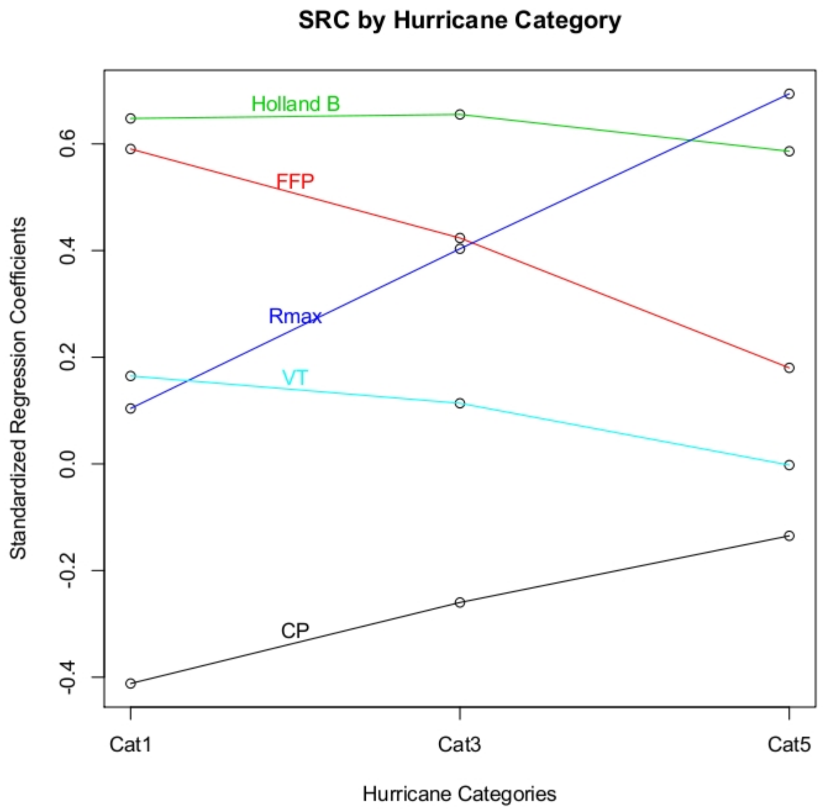
Maximum likelihood estimates:
Shape=4.87 and Scale=5.29

Chi square goodness of fit test:
p-value= 0.62 (DF=6)

STANDARD S-2: SENSITIVITY ANALYSIS (SA) FOR HURRICANE MODEL OUTPUT

- ***The modeling organization shall have assessed the sensitivity of temporal and spatial outputs with respect to the simultaneous variation of input variables using currently accepted scientific and statistical methods in the appropriate disciplines and shall have taken appropriate action.***

FPHLM 8.3 is in compliance with Standard S-2. We performed sensitivity analysis on the temporal and spatial outputs of the model using currently accepted scientific and statistical methods. We examined the effects of five input variables on the expected loss cost. (Note: Results were submitted to the commission in 2010.)

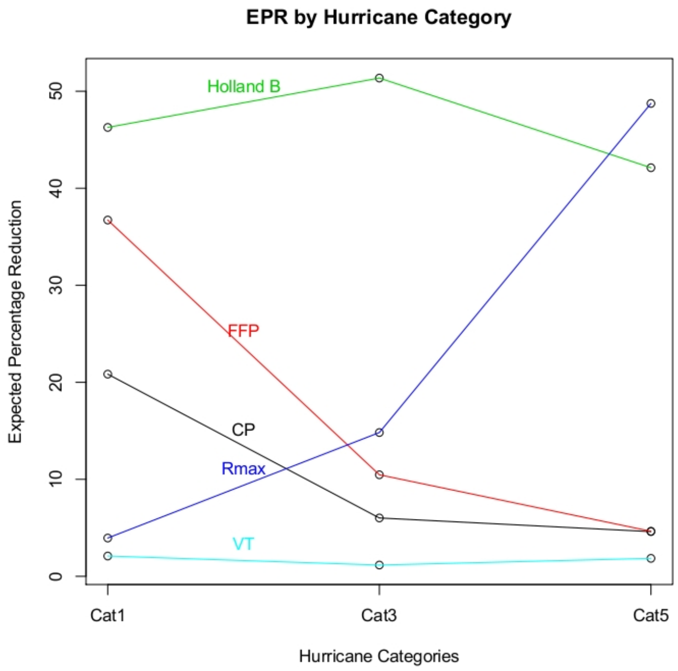

SRC by Hurricane Category
Holland B
FFP
Rmax
VT
CP
Standardized Regression Coefficients
0.6
0.4
0.2
0.0
-0.2
-0.4
Cat1
Cat3
Cat5
Hurricane Categories

STANDARD S-3 UNCERTAINTY ANALYSIS FOR HURRICANE MODEL OUTPUT

- ***The modeling organization shall have performed an uncertainty analysis on the temporal and spatial outputs of the model using currently accepted scientific and statistical methods in the appropriate disciplines and shall have taken appropriate action. The analysis shall identify and quantify the extent that input variables impact the uncertainty in model output as the input variables are simultaneously varied.***

FPHLM 8.3 is in compliance with Standard S-3. We performed uncertainty analysis on the temporal and spatial outputs of the model using currently accepted scientific and statistical methods. We examined the effects of five input variables on the expected loss cost. (Results were submitted to the commission in 2010.)

EXPECTED PERCENTAGE REDUCTIONS BY HURRICANE CATEGORY



STANDARD S-4: COUNTY LEVEL AGGREGATION

- ***At the county level of aggregation, the contribution to the error in hurricane loss cost estimates attributable to the sampling process shall be negligible.***

FPHLM 8.3 is in compliance with Standard S-4. The error in the county level loss costs induced by the sampling process can be quantified by computing standard errors for the county level loss costs. These loss costs have been computed for all counties in the state of Florida using 62,000 years of simulation. The results indicate that the standard errors are less than 2.5% of the average loss cost estimates for all counties.

STANDARD S-5: REPLICATION OF KNOWN HURRICANE LOSSES

- *The hurricane model shall estimate incurred hurricane losses in an unbiased manner on a sufficient body of past hurricane events from more than one company, including the most current data available to the modeling organization. This standard applies separately to personal residential and, to the extent data are available, to commercial residential. Personal residential hurricane loss experience may be used to replicate structure-only and contents-only hurricane losses. The replications shall be produced on an objective body of hurricane loss data by county or an appropriate level of geographic detail and shall include hurricane loss data from Hurricane Irma (2017), Hurricane Michael (2018), and Hurricane Ian (2022) to the extent data from Hurricane Ian are available.*

STANDARD S-5: REPLICATION OF KNOWN HURRICANE LOSSES

FPHLM 8.3 is in compliance with Standard S-5.

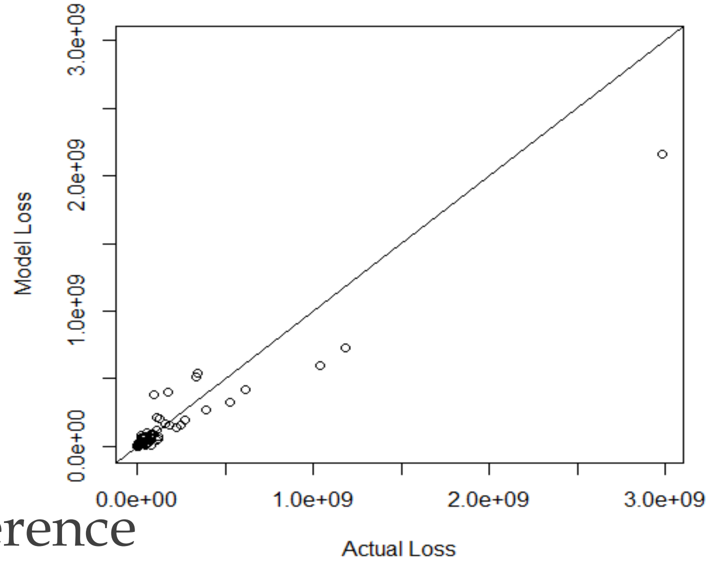
Validation studies show reasonable agreement between actual losses and modeled losses for personal residential losses. This is true for different events and different companies. Tests used include Paired Sample t-test and Wilcoxon Signed Rank Test among others which indicated that there was no significant difference between modeled and actual losses.

Tabular comparison shows reasonable agreement between actual and modeled losses for commercial residential losses. Paired Sample t-test indicated that there was no significant difference between modeled and actual losses.

Due to the lack of a sufficient body of accurate claims data for Hurricane Ian (2022), the loss data for this storm is not included in the statistical analysis.

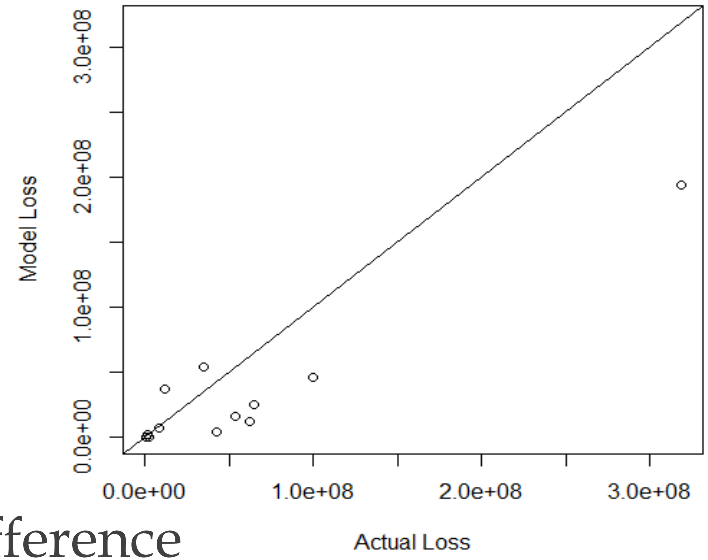
TOTAL ACTUAL LOSSES VS. TOTAL MODELED LOSSES -PERSONAL RESIDENTIAL

- Total of 76 data points
- 25 companies
- 10 hurricanes
- Test shows no significant difference



TOTAL ACTUAL LOSSES VS. TOTAL MODELED LOSSES -COMMERCIAL RESIDENTIAL

- Total of 12 data points
- 3 companies
- 8 hurricanes
- Test shows no significant difference



STANDARD S-6: COMPARISON OF PROJECTED HURRICANE LOSS COSTS

The difference, due to uncertainty, between historical and modeled annual average statewide loss costs shall be reasonable, given the body of data, by established statistical expectations and norms.

FPHLM 8.3 is in compliance with Standard S-6. The 95% CI on the difference between the mean of the historical and modeled losses contains 0 indicating that the modeled losses do not differ significantly from historical losses at 0.05 level of significance.

Thanks for your attention

Any Questions?

Florida Public
Hurricane Loss Model

Standard V-1

Development of Building Hurricane Vulnerability Functions

Florida Public Hurricane Loss Model

Standard V-1

A. Development of the building hurricane vulnerability functions shall be based on a combination of available insurance company hurricane claims data and rational engineering analysis supported by laboratory testing, field testing, or post-event site investigations.

A component approach combines engineering modeling, simulations, engineering judgment, and insurance claim data to produce the vulnerabilities results. The assessment of external building damage results from structural calculations, tests, and Monte Carlo simulations. The wind loads and strength of the building components in the simulations result from laboratory and in-situ tests, manufacturer's data, expert opinion based on post-hurricane site inspections of actual damage, and codes and standards. The internal damage in the personal residential model is extrapolated from the external damage on the basis of expert opinion and site inspections of areas impacted by recent hurricanes. The internal damage in the commercial residential model results from water ingress calculations, tests, and Monte Carlo simulations. The water ingress and water absorption capacities of the building interior components in the simulations result from laboratory tests, manufacturer's data, expert opinion based on post-hurricane site inspections of actual damage, and codes and standards. The vulnerability results are calibrated and validated against insurance claim data.

See disclosures 2 (flow charts), 3 (claim data), 5 (development), 6 (uncertainties), 7 (post-event investigations) and Form V-1

- The building vulnerability functions are the product of an engineering component approach.
- Historical claim data are used to calibrate and validate the numerical models.

Policy Type	Number of Insurers	Number of Policies	Number of Locations	Exposure Value ($)
Personal Residential	7	10,421,590	10,421,590	$ 357,835,825,702
Manufactured Homes	4	559,621	559,621	$ 3,746,579,099
Commercial Residential	4	342,566	342,566	$ 50,253,057,050

Florida Public Hurricane Loss Model

Standard V-1

B. The development of the building hurricane vulnerability functions and the treatment of associated uncertainties shall be theoretically sound and consistent with fundamental engineering principles.

The method used in the derivation is based on extrapolating the results of Monte Carlo simulations of physical exterior damage through simple equations based on engineering judgment, expert opinion, and claims data. Uncertainties at each stage are addressed by assigning damage according to reasonable probability distributions and are validated with claims data.

The Monte Carlo component models take into account many variations in structural characteristics, and the result clearly filters through the cost estimation model. There are also different and clearly defined costing considerations applied to each structural type. These adjustments come directly from resources developed exclusively for defining repair costs to structures and therefore are theoretically sound.

See disclosure 2 (flow charts), 5 (development), 6 (uncertainties)

Publications:

Pinelli, J.-P., Pita, G., Gurley, K., Torkian, B., Hamid, S., Subramanian, C., "Damage Characterization: Application to Florida Public Hurricane Loss Model," ASCE Natural Hazard Review, November 2011, Vol. 12, No. 4, pp. 190-195.

Pinelli, J.-P., Abreu, R.V.S., Gurley, K., Yarasuri, K., **Uncertainty** in a Hurricane Vulnerability Model. *ESREL 20*, Venice, Italy, 2020.

Pinelli, J.P., Da Cruz, J., Gurley, K., Paleo-Torres, A., Baradaranshoraka, M., Cocke, S., Shin, D.W. (2020) "**Uncertainty** reduction through data management in the development, validation, calibration, and operation of a hurricane vulnerability model," International Journal of Disaster Risk Science, 11(6). https://doi.org/10.1007/s13753-020-00316-4

- Uncertainties in the vulnerability functions of all models (wood, masonry, MH) are the result of uncertainties in both the quantification of physical exterior damage and the resulting interior damage
- Wood frame, masonry and MH vulnerability functions are independently derived and differ from each other in a logical manner

Uncertainties associated with Exterior building damage

- The capacities of the exterior components are uncertain and randomly assigned during the Monte Carlo Simulation of exterior damage
- This process is used for masonry, wood frame and MH, although the probabilistic descriptors of capacity differ among these structure types
- Table 28 in the submission document lists these probabilistic descriptors for wood frame and masonry

Florida Public Hurricane Loss Model

Standard V-1

C. Residential building stock classification shall be representative of Florida construction for personal and commercial residential buildings.

A detailed exposure study was carried out to define the most prevalent construction types and characteristics in the Florida residential building stock for different regions. The corresponding engineering models were built for each of the identified common structural types. The low-rise models include differing wall types, roof shapes, roof-to-wall connections, window types, opening protection, garage doors, and story options.

Models of varying combinations of the above characteristics were created. The probabilistic capacities of the various components were determined by a variety of sources, including test results in the literature, in-field data collection, manufacturer's specifications and manufacturer's test data.

In the case of the mid-/high-rise commercial residential model, the models include different apartment units corresponding to different building layouts, different locations within the floor plan, different heights, and different openings and protection options.

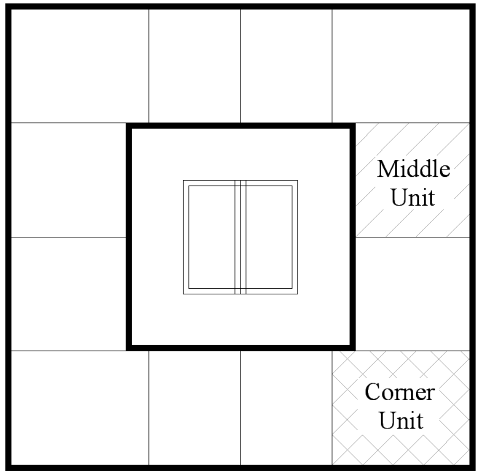
See disclosure 8 (library of vulnerabilities), 9 (practices and building code), 11 (unknowns) and Standard G-1 (vulnerability component)

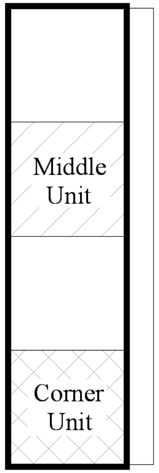
Single family and Low-rise building main classes

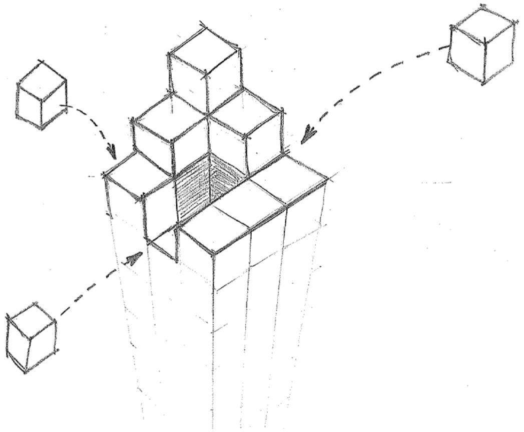
Table 4: LR most prevalent buildings types

Category	Wall type	Roof Cover	Roof Type
Main Building types	CB	Shingles	Gable
	CB	Shingles	Hip
	Wood	Shingles	Gable
	Wood	Shingles	Hip
Windows	Shuttered / Impact-resisting / Not impact-resisting		
No. of Stories	1 / 2 / 3		
Building strength	Strong, Medium, Weak		
Alternative Roof Cover	Metal or Tiles		

MID-HIGH RISE BUILDING CHARACTERIZATION FOR MODULAR APPROACH







Opening Type	Unit type	Quantity*	Dimensions [m]	Total openings area [m^2]
Windows	Corner/Closed	6 (7)	1.5 × 1.2	11 (13)
	Corner / Open	7 (8)	1.5 × 1.2	13 (14)
	Middle / Closed	3 (4)	1.5 × 1.2	5 (7)
	Middle / Open	4 (5)	1.5 × 1.2	7 (9)
Entry Door	All	1	0.9 × 2	1.8
Sliding Door (none)	All	1(0)	1.5 × 2	3 (0)

*values in parentheses indicate quantity when no sliding door is present

Number of openings per apartment type

Florida Public Hurricane Loss Model

Standard V-1

D. Building height/number of stories, primary construction material, year of construction, location, building code, and other construction characteristics, as applicable, shall be used in the development and application of building hurricane vulnerability functions.

The models include options that represent building code revisions. Three models were derived for each structural type: weak, medium, and strong construction. The assignment of a given strength is based on the age of the home and the available information on construction practice in that era of construction. Separate models were also developed for manufactured housing constructed based on pre- and post-1994 HUD regulations and for different wind zones.

In addition to the construction type, region, and era of construction options, **each model has additional strength features that can be adjusted to represent combinations of mitigation features**. For example, the model is capable of reflecting weak original construction and new, strong roof sheathing and roof cover mitigation.

See disclosure 8 (library of vulnerabilities) and 9 (practices and building code)

Strength variants

	Weak			Medium		
	W00 (base)	W01 (retrofitted*)	W10 (modified**)	M00 (base)	M01 (retrofitted*)	M10 (modified***)
Roof to wall	Weak	Weak	Weak	Medium	Medium	Medium
Stud to sill	Weak	Weak	Weak	Medium	Medium	Medium
Roof cover	Weak	Strong	Weak	Weak	Strong	Weak
Roof deck	Weak	Strong	Strong	Medium	Strong	Weak
Wall	Weak	Weak	Weak	Medium	Medium	Medium
Gable end	Weak	Weak	Weak	Weak	Weak	Weak
Garage	Weak	Weak	Weak	Weak	Weak	Weak

*retrofitted refers to re-roof and re-nailed decking, occurring post-1993 for HVHZ and Monroe, and post-2001 for everywhere else. No other retrofits are included.
**modified weak (W10) refers to the base weak model with stronger decking to reflect the use of plank decking
***modified medium (M10) refers to the base medium model with weak decking to reflect the use of staples and/or OSB

Table 1. Weak and Medium Models

	S00 or S02 Strong - inland	S00-OP or S02-OP Strong - WBDR	S01 (modified) Strong - HVHZ
Roof to wall	Strong	Strong	Upgraded Strong
Stud to sill	Strong	Strong	Strong
Roof cover	Strong	Strong	Upgraded Strong
Roof deck	Strong	Strong	Upgraded Strong
Wall	Strong	Strong	Strong
Gable end	Strong	Strong	Strong
Garage	Strong	Strong	Strong
Shutters	no shutters	metal	metal

Table 2. Strong Models

Building strength by age and region

	Pre-1960	1960-1970	1971-1980	1981-1993	1994-2001	2002-pres.
HVHZ	⅔ modified Weak, ⅓ Medium	⅔ Weak, ⅓ Medium	½ Weak, ½ modified Medium	⅔ Weak, ⅓ modified Medium	Modified Strong	Modified Strong
Keys	½ modified Weak, ½ Medium	Medium	Medium	Medium	⅓ Medium ⅔ Strong OP	Strong OP
WBDR	modified Weak	⅔ Weak, ⅓ Medium	⅓ Weak, ⅔ Medium	⅓ Weak, ⅔ Medium	½ Medium, ½ Strong OP	Strong OP
Inland	modified Weak	⅔ Weak, ⅓ Medium	½ Weak, ½ Medium	½ Weak, ½ Medium	½ Medium, ½ Strong	Strong

Table 30. Nomenclature with respect to Table 1 and Table 2 of Standard G-1.

Strong:	S00
Strong OP:	S00-OP
Modified Strong:	S01
Medium:	M00
Modified Medium:	M10
Weak:	W00
Modified Weak:	W10

Table 30. Age classification of the models per region.

Florida Public Hurricane Loss Model

Standard V-1

E. Hurricane vulnerability functions shall be developed for commercial residential building structures, personal residential building structures, manufactured homes, and appurtenant structures.

Hurricane vulnerability functions are **independently derived** for commercial residential building structures, personal residential building structures, manufactured homes, and appurtenant structures. Separate models were developed for these building classes.

See disclosures 5 (development), 8 (library of vulnerabilities)

Florida Public Hurricane Loss Model

Standard V-1

F. The minimum windspeed that generates damage shall be consistent with fundamental engineering principles.

The minimum one-minute average sustained wind speed at which some damage is observed is 38 mph (3-second gust 50 mph) for appurtenant structures. Site-built and manufactured homes have a very small probability of some very minor damage at 42 mph (3-second gust 55 mph). This probability becomes more significant at 46 mph (3-second gust 60 mph) and increases with higher wind speed. **Simulations are run for 3-second gusts from 50 mph** to 250 mph in 5 mph increments.

See disclosure 12 (windspeed)

Florida Public Hurricane Loss Model

Standard V-1

G. ***Building hurricane vulnerability functions shall include damage as attributable to windspeed and wind pressure, water infiltration, and missile impact associated with hurricanes. Building hurricane vulnerability functions shall not include explicit damage to the building due to flood (including hurricane storm surge and wave action).***

The vulnerability functions do not explicitly include damage due to flood, storm surge, or wave action. The vulnerability functions for all models (site-built residential, manufactured homes, low-rise commercial residential, and mid-/high-rise commercial residential) include damage due to wind pressure, missile impact and water infiltration.

See disclosure 2 (flow charts), 5 (development), 14 (debris impact and water infiltration)

The vulnerability model follows a component engineering approach which includes the effect of debris impact from various directions and water infiltration and percolation.

Florida Public Hurricane Loss Model

Standard V-2

Development of Contents Hurricane Vulnerability Functions

Florida Public Hurricane Loss Model

Standard V-2

A. ***Development of the contents hurricane vulnerability functions shall be based on a combination of available insurance company hurricane claims data and rational engineering analysis supported by laboratory testing, field testing, or post-event site investigations.***

A component approach combines engineering modeling, simulations, engineering judgment, and insurance claim data to produce the vulnerabilities results. **The contents damage in the personal residential model is extrapolated from the external damage** on the basis of expert opinion and post-events site inspections of areas impacted by recent hurricanes. **The contents damage in the commercial residential model results from water ingress calculations, tests, and Monte Carlo simulations.** The water ingress and water absorption capacities of the building contents components in the simulations result from laboratory tests, manufacturer's data, and expert opinion based on post-hurricane site inspections of actual damage. The vulnerability results are calibrated and validated against insurance claim data.

See disclosure 2 (flowchart), 3 (assumptions, data, methods, and processes), 4 (uncertainties), 5 (library of vulnerabilities), 7(water infiltration), and Form V-1.

Florida Public Hurricane Loss Model

Standard V-2

B. The relationship between the hurricane model building and contents hurricane vulnerability functions shall be consistent with, and supported by, the relationship observed in insurance company hurricane claims data.

The relationship between the hurricane model building and contents hurricane vulnerability functions are consistent with, and supported by, the relationship observed in insurance company hurricane claims data.

See disclosure 6 (relationship between building and contents).

Standard V-3

Development of Time Element Hurricane Vulnerability Functions

Florida Public Hurricane Loss Model

Standard V-3

A. Development of the time element hurricane vulnerability functions shall be based on a combination of available insurance company hurricane claims data and rational engineering analysis supported by laboratory testing, field testing, or post-event site investigations.

The time element hurricane vulnerability functions in the personal and commercial residential models are **extrapolated from the building and interior damage** on the basis of **rational engineering analysis and post-events site inspections** of areas impacted by recent hurricanes. The vulnerability results are calibrated and validated against **insurance claim data** when available.

See disclosure 2 (flow charts), 3 (assumptions, data, methods, and processes), 4 (uncertainties), and Form V-1.

Florida Public Hurricane Loss Model

Standard V-3

B. The relationship between the hurricane model building and time element hurricane vulnerability functions shall be consistent with, and supported by, the relationship observed in insurance company hurricane claims data.

The relationship between the modeled building and the time element hurricane vulnerability functions is consistent with the relationship observed in historical data.

For personal residential risks the hurricane vulnerability functions for time element expenses have been **calibrated using historical claim data** on additional living expense.

For commercial residential risks the relationship between model time element hurricane vulnerability functions is reasonable. Since no historical loss data were available for calibration, the relationship **combines engineering and actuarial judgment**.

See disclosures 3 (assumptions, data, methods, and processes), 6 (building and TE) and Form V-1.

Florida Public Hurricane Loss Model

Standard V-3

C. Time element hurricane vulnerability function derivations shall consider the estimated time required to repair or replace the property.

Time element hurricane vulnerability function derivations consider the estimated time required to repair or replace the property.

TE vulnerabilities are based on building and interior damage. The relationship is directly proportional where the more damage is experienced in the structure/building or interior, the more it will take to fix the damage and TE will be higher as well.

See disclosure 2 (flow charts), 3 (assumptions, data, methods, and processes), 5 (infrastructure), and 6 (building and TE)

Florida Public Hurricane Loss Model

Standard V-3

D. Time element hurricane vulnerability functions shall include time element hurricane losses associated with damage to the infrastructure caused by a hurricane.

The time element hurricane vulnerability functions produced by the model include time element hurricane losses arising from wind, missile impact, flood (including hurricane storm surge), and damage to the infrastructure. The model does not distinguish explicitly between direct and indirect loss. For personal residential risks the time element vulnerability functions were calibrated against claim data that include both types of losses. For commercial residential risks the recognition of expenses due to indirect loss is based on judgment since no historical loss data were available for calibration.

See disclosure 5 (infrastructure).

Florida Public Hurricane Loss Model

Standard V-4

Hurricane Mitigation Measures and Secondary Characteristics

Florida Public Hurricane Loss Model

Standard V-4

A. Modeling of hurricane mitigation measures to improve a building's hurricane wind resistance, the corresponding effects on hurricane vulnerability and associated uncertainties shall be theoretically sound and consistent with fundamental engineering principles. These measures shall include fixtures or construction techniques that affect the performance of the building and the damage to contents and shall include:

- ***Roof strength***
- ***Roof covering performance***
- ***Roof-to-wall strength***
- ***Wall-to-floor-to-foundation strength***
- ***Opening protection***
- ***Window, door, and skylight strength.***

Modeling of mitigation measures to improve a building's hurricane wind resistance, the corresponding effects on hurricane vulnerability, and their associated uncertainties is theoretically sound and consistent with fundamental engineering principles. **The effect of hurricane mitigation measures in hurricane vulnerability uncertainty was demonstrated.**

Standard V-4

Part A: Continued

The following structures were modeled:

Reference case as defined by Commission
Mitigated case as defined by Commission
Reference plus one mitigation at a time

The hurricane mitigations included **gable bracing, rated shingles, metal roof, stronger sheathing capacity, stronger roof-to-wall connections, stronger wall-to-sill connections, reinforced masonry walls, multiple opening protection options, and wind/missile resistant glass**.

See disclosure 4 (mitigation descriptions), 5 (mitigations implementation), 6 (combination of mitigations), 7 (effects on building and contents), 8 (roof), 9 (uncertainty) and Form V-2, Form V-3, Form V-4 and Form V-5.

Florida Public Hurricane Loss Model

Standard V-4

B. The modeling organization shall justify all hurricane mitigation measures and secondary characteristics considered by the hurricane model.

The hurricane mitigation measures and secondary characteristics include **hip roof, gable bracing, rated shingles, metal roof, stronger sheathing capacity, stronger roof-to-wall connections, stronger wall-to-sill connections, masonry reinforced walls, multiple opening protection options, and wind/missile resistant glass**. Each of these has an impact on the building vulnerability depending on the combination of measures implemented.

See disclosure 4 (mitigation descriptions), 5 (mitigations implementation), 6 (combination of mitigations), 7 (effects on building and contents), and Form V-2, Form V-3, Form V-4 and Form V-5.

Florida Public Hurricane Loss Model

Standard V-4

C. Application of hurricane mitigation measures that affect the performance of the building and the damage to contents shall be justified as to the impact on reducing damage whether done individually or in combination.

For the reference cases the **interior damage is governed by the sheathing loss at low to moderate wind speeds**. The application of mitigation measures is justified.

See disclosure 7 (effects on building and contents), and Form V-2, Form V-3, Form V-4 and Form V-5.

Florida Public Hurricane Loss Model

Standard V-4

D. Treatment of individual and combined secondary characteristics that affect the performance of the building and the damage to contents shall be justified.

The application of individual and combined secondary characteristics is justified and demonstrated.

The mitigation of individual and combined secondary characteristics affects the building performance. Some mitigations like high strength garage door and mitigated sheathing are very effective at low wind speed, while clips, straps and reinforced masonry are very effective at high wind speed.

See disclosure 7 (effects on building and contents) and Form V-3.

Florida Public Hurricane Loss Model

Version 8.3
Actuarial Standards

Standard A-1
Hurricane Model Input Data and Output Reports

A. Adjustments, edits, inclusions, or deletions to insurance company or other input data used by the modeling organization shall be based upon generally accepted actuarial, underwriting, and statistical procedures.

Input data received from insurance companies are reviewed via a combination of editing programs and human intervention. The editing programs search for missing or invalid entries and inconsistencies among attributes (e.g. zip code and county mismatch). Edits identified are reviewed by the model operator.

Records missing key information such as policy form, insured value or deductible are dropped.

The most commonly missing or inconsistent values are secondary attributes such as roof to wall connection, deck attachment, etc. When the majority of this information is missing, all values are treated as "unknown" and the model is run using weighted vulnerability matrices. If a substantial portion of the values are reported and valid, missing or inconsistent attributes are populated using rules based on survey statistics.

These adjustments to the inputs are consistent with generally accepted actuarial, underwriting and statistical procedures.

Standard A-1

Hurricane Model Input Data and Output Reports

B. All modifications, adjustments, assumptions, inputs and input file identification, and defaults necessary to use the hurricane model shall be actuarially sound and shall be included with the hurricane model output report. Treatment of missing values for user inputs required to run the hurricane model shall be actuarially sound and described with the hurricane model output report.

The hurricane model output report identifies and summarizes the input file that was used. Any changes to the original input file, including the treatment of missing values are included in the output report as well.

The model satisfies Standard A-1.

Standard A-2

Hurricane Events Resulting in Modeled Hurricane Losses

A. Modeled hurricane loss costs and hurricane probable maximum loss levels shall reflect all insured wind related damages from hurricanes that produce minimum damaging windspeeds or greater on land in Florida.

Damages are computed for all Florida land-falling and certain by-passing storms in the stochastic set that attain hurricane level wind speeds. The following by-passing hurricanes are included:

- Non-landfalling hurricanes with point of closest approach in region A, B, C, D, E or F and open terrain winds greater than 30 mph in at least one Florida ZIP Code.
- Landfalling hurricanes in regions E or F with open terrain winds greater than 30 mph in at least one Florida ZIP Code.

Standard A-2
Hurricane Events Resulting in Modeled Hurricane Losses

B. The modeling organization shall have a documented procedure for distinguishing wind-related hurricane losses from other peril losses.

A document titled *"Florida Public Hurricane Loss Model (FPHLM) Procedure to distinguish wind-related hurricane losses from other peril losses"* details the procedure employed to meet this requirement.

The model satisfies Standard A-2.

Standard A-3
Hurricane Coverages

A. The methods used in the calculation of building hurricane loss costs, including the effect of law and ordinance coverage, shall be actuarially sound.

The model estimates building damages by storm using a set of matrices for Personal Residential, and a set of curves for Low Rise Commercial Residential. For Mid-High Rise Commercial Residential, the model sums expected damages per story.

Resulting damages are adjusted for policy limits, deductibles, and demand surge and aggregated across all storms to determine loss costs.

A provision for Law and Ordinance coverage is embedded in the vulnerability matrices. This provision can be removed whenever Law and Ordinance coverage is not included in a policy. To exclude Law and Ordinance, a reduction factor is applied to the modeled structure loss for each storm in the stochastic set. The factor depends on the characteristics of the exposure (such as construction type and year-built) and on the wind speed of the storm in question at that policy's location.

Standard A-3
Hurricane Coverages

B. The methods used in the calculation of appurtenant structure hurricane loss costs shall be actuarially sound.

Appurtenant structure damages are estimated for each stochastic storm.

The Personal Residential vulnerability matrix assumes a distribution of three types of structures: slightly, moderately, and highly vulnerable and was validated against claim data.

For Commercial Residential, clubhouses and administration buildings are modeled as additional buildings. Other structures use the Personal Residential matrix.

Resulting damages are adjusted for policy limits, deductibles, and demand surge and aggregated across all storms to determine loss costs.

Standard A-3
Hurricane Coverages

C. The methods used in the calculation of contents hurricane loss costs shall be actuarially sound.

Contents damages are estimated for each stochastic storm.

The damage functions are based on engineering judgment regarding internal damage.

For Personal Residential exposures, these empirical functions were validated against claim data for Andrew, Charley, and Frances.

Commercial Residential functions are primarily judgmental due to lack of claim data for validation. The model assumes separate damage curves for apartment buildings and condominium associations to reflect the differences in coverage.

Resulting damages are adjusted for policy limits, deductibles, and demand surge and aggregated across all storms to determine loss costs.

Standard A-3
Hurricane Coverages

D. The methods used in the calculation of time element hurricane loss costs shall be actuarially sound.

Time element damages are estimated for each stochastic storm.

Damages are calculated as a function of interior damage to the structure, except for low-rise commercial residential buildings where they are calculated as a function of overall damage to the building.

Commercial Residential functions are judgmental due to lack of claim data for validation.

Resulting damages are adjusted for policy limits, deductibles, and demand surge and aggregated across all storms to determine loss costs.

The model satisfies Standard A-3.

Standard A-4
Modeled Hurricane Loss Cost and Hurricane Probable Maximum Loss Level Considerations

A. Hurricane loss cost projections and hurricane probable maximum loss levels shall not include expenses, risk load, investment income, premium reserves, taxes, assessments, or profit margin.

The items listed (i.e., expenses, risk load, profit margin, etc.) are not included in loss costs or PMLs.

B. Hurricane loss cost projections and hurricane probable maximum loss levels shall not make a prospective provision for economic inflation.

There is no prospective provision for economic inflation in loss costs or PMLs.

Standard A-4
Modeled Hurricane Loss Cost and
Hurricane Probable Maximum Loss Level Considerations

C. Hurricane loss cost projections and hurricane probable maximum loss levels shall not include any explicit provision for direct flood losses (including those from hurricane storm surge).

There is no explicit provision for direct flood losses in loss costs or PMLs.

D. Hurricane loss cost projections and hurricane probable maximum loss levels shall be capable of being calculated from exposures at a geocode (latitude-longitude) level of resolution.

Losses can be calculated at the geocode level whenever street address or latitude-longitude is provided for the exposures.

Standard A-4
Modeled Hurricane Loss Cost and Hurricane Probable Maximum Loss Level Considerations

E. Demand surge shall be included in the hurricane model's calculation of hurricane loss costs and hurricane probable maximum loss levels using relevant data and actuarially sound methods and assumptions.

Demand surge factors are applied to the losses from each storm in the stochastic set before calculating loss costs and PML levels.

Model assumes demand surge is a function of:
- Coverage
- Region
- A storm's statewide damages (before DS)

(continued on next slide)

Standard A-4
Modeled Hurricane Loss Cost and Hurricane Probable Maximum Loss Level Considerations

E. Demand surge shall be included in the hurricane model's calculation of hurricane loss costs and hurricane probable maximum loss levels using relevant data and actuarially sound methods and assumptions.

Data used in the development of demand surge functions:
- Marshall Swift construction cost indices for FL zip codes
- Miami-Ft. Lauderdale Consumer Price Index for Household Furnishings & Operations
- Actual hurricane losses of insurance companies from Frances, Charley, and Andrew.

General approach:
- Method used to estimate DS involves examining the difference between forecasted and actual post-storm indices.

The model satisfies Standard A-4.

Standard A-5

Hurricane Policy Conditions

A. The methods used in the development of mathematical distributions to reflect the effects of deductibles and policy limits shall be actuarially sound.

The distributions used to determine the effects of deductibles are:

- Distribution of damage ratios by wind speed as determined by the engineers.
- Distribution of modeled losses by coverage prior to the application of the deductible.

No other distributional assumptions are involved in applying deductibles and policy limits to modeled losses.

Standard A-5
Hurricane Policy Conditions

B. The relationship among the modeled deductible hurricane loss costs shall be reasonable.

Modeled loss costs decrease as the deductible increases, all other factors held constant. See Form A-6.

C. Deductible hurricane loss costs shall be calculated in accordance with s. 627.701(5)(a), F.S.

If there are multiple hurricanes in a year in the stochastic set, the wind deductibles are applied to the first hurricane, and any remaining amount is then applied to the second hurricane. If none of the wind deductible remains, then the general peril deductible is applied. This is the case for both personal and commercial residential policies.

The model satisfies Standard A-5.

Standard A-6

Hurricane Loss Outputs and Logical Relationships to Risk

A. The methods, data, and assumptions used in the estimation of hurricane loss costs and hurricane probable maximum loss levels shall be actuarially sound.

Both loss costs and PML's are based on modeled losses produced by the stochastic set of storms.

Loss costs are the average annual loss across the 60,000-year simulation and PML's are quantiles of the ordered set of simulated losses.

PML for a given return period =

((1 – 1 / return period) x 100)th quantile of the ordered set of losses (aggregate annual losses or per occurrence losses) produced by the simulation.

For example, the PML for a return period of 100 years is the 99th quantile of the ordered set.

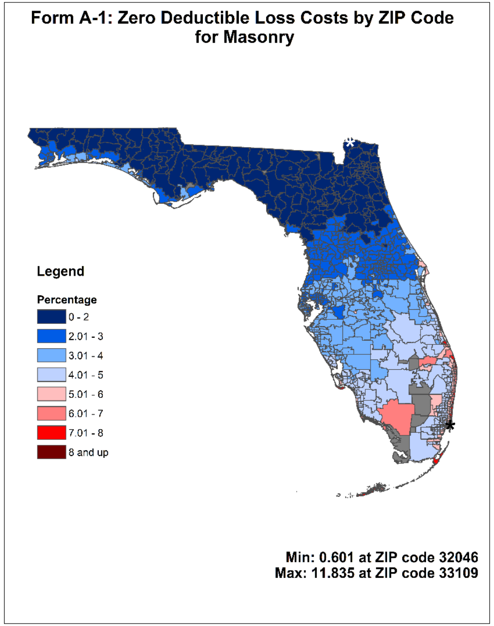
Standard A-6

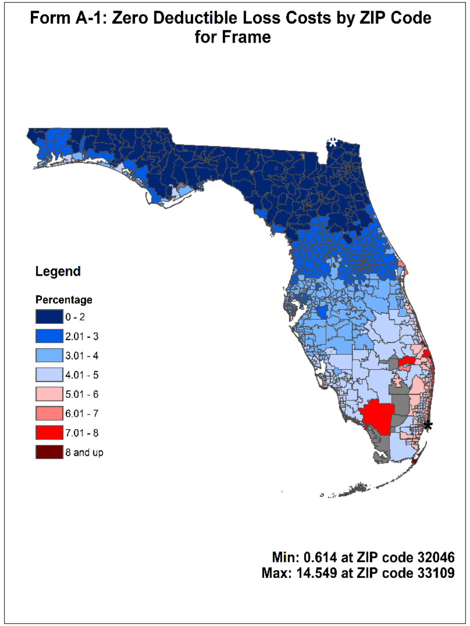
Hurricane Loss Outputs and Logical Relationships to Risk

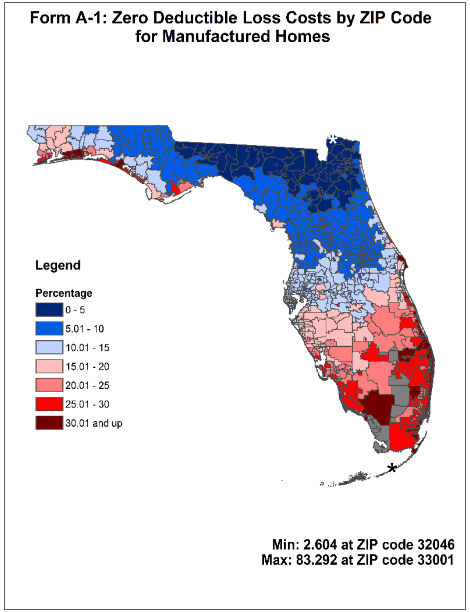
B. Hurricane loss costs shall not exhibit an illogical relation to risk, nor shall hurricane loss costs exhibit a significant change when the underlying risk does not change significantly.

Loss costs produced by the model exhibit a logical relation to risk and do not change significantly when the underlying risk is unchanged. See Forms A-1 and A-6.

FORM A-1 MAPS


Form A-1: Zero Deductible Loss Costs by ZIP Code
for Masonry
Legend
Percentage
0 - 2
2.01 - 3
3.01 - 4
4.01 - 5
5.01 - 6
6.01 - 7
7.01 - 8
8 and up
Min: 0.601 at ZIP code 32046
Max: 11.835 at ZIP code 33109


Form A-1: Zero Deductible Loss Costs by ZIP Code
for Frame
Legend
Percentage
0 - 2
2.01 - 3
3.01 - 4
4.01 - 5
5.01 - 6
6.01 - 7
7.01 - 8
8 and up
Min: 0.614 at ZIP code 32046
Max: 14.549 at ZIP code 33109


Form A-1: Zero Deductible Loss Costs by ZIP Code
for Manufactured Homes
Legend
Percentage
0 - 5
5.01 - 10
10.01 - 15
15.01 - 20
20.01 - 25
25.01 - 30
30.01 and up
Min: 2.604 at ZIP code 32046
Max: 83.292 at ZIP code 33001

Standard A-6

Hurricane Loss Outputs and Logical Relationships to Risk

C. Hurricane loss costs produced by the hurricane model shall be positive and non-zero for all valid Florida ZIP Codes.

The model produces positive, non-zero loss costs for all valid Florida ZIP Codes. See Form A-1.

D. Hurricane loss costs cannot increase as the quality of construction type, materials, and workmanship increases, all other factors held constant.

The model produces loss costs that do not increase as the quality of construction increases, all other factors held constant. See Form A-1 and A-6.

E. Hurricane loss costs cannot increase as the presence of fixtures or construction techniques designed for hazard mitigation increases, all other factors held constant.

The model produces loss costs that react appropriately to hazard mitigation. See Form A-6.

Standard A-6

Hurricane Loss Outputs and Logical Relationships to Risk

F. Hurricane loss costs cannot increase as the wind resistant design provisions increase, all other factors held constant.

The model's loss costs do not increase in the presence of wind resistant design provisions, all other factors held constant. See Form A-6.

G. Hurricane loss costs cannot increase as building code enforcement increases, all other factors held constant.

Loss costs vary appropriately with building code enforcement, all other factors held constant. See Form A-6.

H. Hurricane loss costs shall decrease as deductibles increase, all other factors held constant.

Loss costs vary appropriately by size of deductible. See Form A-6.

Standard A-6
Hurricane Loss Outputs and Logical Relationships to Risk

I. **The relationship of hurricane loss costs for individual coverages (e.g., building, appurtenant structure, contents, and time element) shall be consistent with the coverages provided.**

   Validation testing demonstrated that the relationship between loss costs and coverage is reasonable and consistent with the coverage provided and the relationships between coverages is tested in Form A-6.

J. **Hurricane output ranges shall be logical for the type of risk being modeled and apparent deviations shall be justified.**

   Output ranges are logical by risk type. Apparent anomalies at the county level in Form A-4 can be resolved at the zip code/year-built level.

Standard A-6

Hurricane Loss Outputs and Logical Relationships to Risk

K. All other factors held constant, hurricane output ranges produced by the hurricane model shall in general reflect lower hurricane loss costs for:

1. **masonry construction versus frame construction,**

   All other factors held constant, the output ranges reflect lower loss costs for masonry versus frame construction.

2. **personal residential risk exposure versus manufactured home risk exposure,**

   All other factors held constant, the output ranges reflect lower loss costs for site-built versus manufactured home exposures.

3. **inland counties versus coastal counties,**

   All other factors held constant, the output ranges reflect lower loss costs for inland versus coastal counties.

(continued on next slide)

Standard A-6
Hurricane Loss Outputs and Logical Relationships to Risk

K. All other factors held constant, hurricane output ranges produced by the hurricane model shall in general reflect lower hurricane loss costs for:

4. northern counties versus southern counties, and

All other factors held constant, the output ranges reflect lower loss costs for northern versus southern counties.

5. newer construction versus older construction.

All other factors held constant, the output ranges reflect lower loss costs for newer construction versus older construction. See Form A-6.

Standard A-6
Hurricane Loss Outputs and Logical Relationships to Risk

L. For hurricane loss cost and hurricane probable maximum loss level estimates derived from and validated with historical insured hurricane losses, the assumptions in the derivations concerning (1) construction characteristics, (2) policy provisions, (3) coinsurance, and (4) contractual provisions shall be appropriate based on the type of risk being modeled.

The loss costs and PML estimates derived by the model reflect the construction characteristics and type of risk being modeled primarily through the vulnerability component. There are separate models for Personal Residential, Low rise Commercial Residential and Mid-High rise Commercial Residential.

Within Personal Residential vulnerabilities are separated between manufactured and site-built exposures and vary by coverage, region, sub-region, construction type, year-built and other specific structure attributes. A provision for Law & Ordinance is included.

Modeled damages are adjusted for deductibles, policy limits and demand surge before calculating loss costs and PML's.

The model satisfies Standard A-6.

Florida Public Hurricane Loss Model

COMPUTER/INFORMATION STANDARDS

V8.3

DR. SHU-CHING CHEN

DATA SCIENCE & ANALYTICS INNOVATION CENTER

UNIVERSITY OF MISSOURI-KANSAS CITY

June 2025

CI-1 HURRICANE MODEL DOCUMENTATION

- Central repositories contain:
  - Model structure and functionality
  - Model software components
    - Documentation follows current model development and software engineering practices
  - Changes made to the model since 2021 standard submission (v8.2)
  - List of externally acquired model-specific software and data assets
  - Versions and track changes for documentation, code and scripts.
- Computer software is consistently documented and dated.
- FPHLM v8.3 is in compliance with Standard CI-1

CI-2 HURRICANE MODEL REQUIREMENTS

- Requirements for software components, databases, and date files are maintained in the primary document repository
  - Software components: functionality, interfaces, inputs, hardware requirements, software dependencies, etc.
  - Databases: templates, relations, schemas, functions, etc.
  - Data files: fields, data types, delimiters, headers, encoding, etc.
- Requirements are updated to reflect model changes
- FPHLM v8.3 is in compliance with Standard CI-2

CI-3 HURRICANE MODEL ORGANIZATION AND COMPONENT DESIGN

- Primary document repository contains
  - Control and data flowcharts and interface specifications for software components
  - Schema definitions for databases and data files
  - Flowcharts illustrating model-related flow of information and its processing by team members
  - System model representations associated with model components
- Model diagrams are created following industry standards
  - ISO 5807: data flowcharts, program flowcharts, system flowcharts, program network charts, and system resources charts
  - BPMN 2: Flowcharts illustrating model-related flow of information and its processing by team members
  - UML 2: Other diagrams for both behavioral and structural object-oriented design documentation
- FPHLM v8.3 is in compliance with Standard CI-3

CI-4 HURRICANE MODEL IMPLEMENTATION

- Primary document repository also contains
  - Coding guidelines for code development, revision, and versioning
  - Network organization diagram in which the hurricane model is designed and operates
  - Procedure used in creating, deriving, or procuring and verifying database or data files
  - Counts of lines of code and comments for key software components
  - Tables defining equations and formulas used in the documentation
  - Tables mapping variables and terms in the source code to equations and formulas used in the documentation
  - Hardware and software requirements to use the model
- Model components are traceable throughout the system documentation from requirements to code.
- Each component is sufficiently and consistently commented (file headers and in-line comments)
- FPHLM v8.3 is in compliance with Standard CI-4

CI-5 HURRICANE MODEL VERIFICATION (1/2)

- Procedures for component verification are maintained
  - Three-stage verification
    - By pair-programming – combined work for software development, code-level debugging, and calculation cross-checks
    - By system modeler – check sample input/output (black box testing)
    - By testing group – unit, regression, and aggregation testing documented in the testing document
- Software is used to assist in documenting and analyzing components, databases, and data files
  - In-house testing programs or off-the-shelf tools to test software components
  - RDBMS to maintain data integrity and consistency
  - Stored procedures to check correctness of data in databases
  - Command line tools to check correctness of data files

CI-5 HURRICANE MODEL VERIFICATION (2/2)

- Verification approaches for externally acquired data, software, and models are documented in the primary document repository
- The model produces the same loss costs and probable maximum loss levels if it is executed more than once with no changes in input data, parameters, code, and seeds of random number generators
- FPHLM v8.3 is in compliance with Standard CI-5

CI-6 HUMAN-COMPUTER INTERACTION

- All major components in the FPHLM interact with users using the command line interface (CLI) and the interface design adheres to CLI design best practice, which is documented in the primary repository
- The interface options used in FPHLM are unique, explicit, and distinctly emphasized
    - Each option used in FPHLM has its unique and distinct name
    - The usage of each option has been clearly and explicitly documented
    - Distinct environments are set up for each version
    - All the options are provided to FPHLM projects via a distinct configuration file
- The Florida rate filing is set up in a distinct environment where all the options have been configured and fixed on the configuration template to generate appropriate results
- FPHLM v8.3 is in compliance with Standard CI-6

CI-7 HURRICANE MODEL MAINTENANCE AND REVISION

- The primary document repository contains
  - Policy for model review, maintenance, and revision
    - For each component, document (a) Installation date, (b) Program specification, (c) Personnel involved, (d) Current version number, (e) Date of changes
  - Policy for model version identification
  - List of all model versions since the initial submission of this year
- Apache Subversion tracking software used to identify and describe all errors, as well as modifications to code, data, and documentation
- FPHLM v8.3 is in compliance with Standard CI-7

CI-8 HURRICANE MODEL SECURITY

- Restricted access to computers
  - Servers located in secure server rooms
  - Access to lab controlled with key cards
- Secure access to documentation, software, and data in the event of a catastrophe
  - Regular backups kept in different locations
  - Resources safeguarded by designated personnel
- Anti-virus software installed on workstations
- Network monitoring
- Setup of a development environment separate from the production environment for model modification and testing
- Confidential data saved in the system with fine-grained access control
- FPHLM v8.3 is in compliance with Standard CI-8