Florida Public Hurricane Loss Model V 5.0

General standards
A. The computer model shall project loss costs and probable maximum loss levels for residential property insured damage 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 ALE.

- The model name is Florida Public Hurricane Loss Model. The current version is 5.0 and the release date is July 12, 2013.

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

Storm Forecast Module
- Retrieves historical storm data set based on user input
- Generates probability distribution functions for storm motion and intensity
- Generates initial conditions for the storms
- Generates storm tracks for simulated storms

Wind Field Module
- Estimates open terrain wind speeds
- Generates actual terrain wind speeds by using roughness data and gust factors
- Calculates probability of 3-sec gust wind speeds

Engineering Vulnerability Module
- Defines structural type
- Translates and loads wind speeds
- Quantifies wind resistance
- Performs Monte Carlo simulation for external damage
- Quantifies total damage

Actuarial Loss Module
- Loads winds and vulnerability matrices
- Adds demand surge factors
- Calculates probability based insurance loss costs
- Calculates scenario based insurance loss costs

Output
B. The modeling organization shall maintain a documented process to assure continual agreement and correct correspondence of databases, data files, and computer source code to slides, technical papers, and/or modeling organization documents.

- The FPHLM group members follow the process specified in the flowchart below in order to assure continual agreement and correct correspondence of databases, data files, and computer source code to slides, technical papers, and FPHLM documents.
Research

Group Creates Modification Proposal

Group Presents Proposal to FPHLM Team

FPMLM Team Agrees to the Modification

Yes

Group Provides Requirements Documentation to Programmers

Programmers Verify Requirements with Group

Requirements Need Revision

Yes

Programmers Implement Modified Based on Proposal

Testers Perform Testing

Implementation is Correct

Group in conjunction with Programmers Perform Verification and Validation of Implementation's Results

No

Verification Successful

Release

Yes

Each new document and version is tagged with a major and minor version numbers

Group verifies that requirements documents correctly correspond to slides, technical papers, and/or FPHLM documents

Communication occurs through emails, video conferences, in-person meetings, and phone calls

Comments in code reference specific document version number being implemented.

A detailed description of the FPHLM testing and verification procedures is available in Section 7.4 of the Primary Document Binder.

FPMLM Team: All members of the FPHLM Groups: Meteorology, Engineering, Statistics, Actuarial, and Computer Science
Changes to the meteorology component include:

1. Change made to update to the latest HURDAT (5/14/2012) and to take advantage of new observations of $R_{max}$ that have recently become available for storms that have occurred up to the 2010 hurricane season
   - The estimated change in statewide loss costs due to the updated probability distribution functions in the storm track generator (updated $R_{max}$ and HURDAT) is a 2.35% increase.

2. Updated zip code centroid locations as per Standard G-3.
   - The estimated change in statewide loss costs due to updated ZIP code centroids is a 0.63% decrease.

3. Changed hurricane marine PBL height in terrain conversion model to be the same as in the wind model.
   - The estimated change in statewide loss costs due to the modification of the hurricane PBL height is approximately a 2.37% decrease.

• The overall change in loss costs resulting from meteorological component is -.73%.
Changes to the vulnerability component include:

**Personal Residential Model Changes:**

• Personal residential model in version 5.0 is essentially the same as the previous submission, with additional refinements.

• Additional refinements include:
  – Wind Borne Debris Region boundaries were updated
  – new components were added as an option for all strength models: metal roof, metal shutters
  – Gradation of strong models was implemented
  – window capacities were increased for strong models
  – footprint options for physical damage model were consolidated into a single timber frame and single masonry footprint
  – life cycle duration for roof replacement was changed from 20 to 30 years
Low Rise Commercial Residential Model Changes:

- LR Commercial residential model in version 5.0 is essentially the same as the previous submission, with additional refinements.

- Additional refinements include:
  - Wind Borne Debris Region boundaries were updated
  - New components were added as an option for all strength models: soffits; metal roof, metal shutters
  - Items were modified:
    - Window protection in the presence of metal shutters;
    - Debris impact model;
    - Rain adjustment factors;
    - Wind speed variation with height in rain model;
    - Costing scheme;
    - Wall sheathing capacities; window capacities for strong model;
    - Pressure coefficients $c_p$ for hip roof models;
    - Relationship between ASCE vs. model pressure coefficients $c_p$;
    - Roof to wall connection capacities;
    - Roof to wall failure connection algorithm;
    - Masonry wall capacity.
High-Mid Rise Commercial Residential Model Changes:

• MH Commercial residential model in version 5.0 is essentially the same as the previous submission, with additional refinements.

• Additional refinements include:
  – Wind Borne Debris Region boundaries were updated
  – new components were added:
    • debris impact zones;
    • option with no sliders;
    • differentiation between damaged and breached openings
  – items were modified:
    • opening pressure capacities;
    • external damage costing scheme;
    • interior damage cost coefficient;
    • number of windows in open layout.
• The overall change in loss costs resulting from meteorological component is -.73%.
• The combined statewide percentage change in loss costs due to all the changes in the personal residential model is an approximate 3.69 % decrease.
• The combined statewide percentage change in loss costs due to all the changes in the commercial residential model is an approximate 19.07% decrease.
• The overall change in loss costs resulting from the vulnerability component is -6.6%.
• The overall statewide percentage changed in loss cost from all the model changes is a decrease of -7.35%.
G-2 Qualifications of Modeler Personnel and Consultants

A) 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, and evaluated 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, and AMI Risk Consultants.
B) The model or any modifications to an accepted model shall be reviewed by either modeling organization personnel or consultants in the following professional disciplines: structural/wind engineering (licensed Professional Engineer), statistics (advanced degree), actuarial science (Associate or Fellow of Casualty Actuarial Society), meteorology (advanced degree), and computer/information science (advanced degree). These individuals shall certify Forms G-1 through G-6 as applicable and shall abide by the standards of their profession.

- 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 long term 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 and has been used since.
Florida Public Hurricane Loss Model Workflow
G-3  Risk Location

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

- 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 used has a USPS vintage of December 2011. The ZIP Code data have been changed in the current release of the model from the 4.1 version.

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

- ZIP Code centroids used in the model are population centroids and are updated at least every 24 months.
C. ZIP Code information purchased by the modeling organization shall be verified by the modeling organization for accuracy and appropriateness.

- ZIP Code information is checked for consistency by experts developing our model.
G-4 Independence of Model Components

The meteorological, vulnerability, and actuarial components of the model shall each be theoretically sound without compensation for potential bias from the other two 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 that the submission has been personally reviewed and is editorially correct.

- Expert Certification Forms were submitted upon completion of all editorial changes.

- The current submission document has been reviewed and edited by person who is qualified to perform such tasks.

- Several Word tools are utilized to automate the process of formatting and editing the document.

- Word processing software with track change capability is used to prepare the document.
M-1 Base Hurricane Storm Set

- Hurricane frequencies for model validation and calibration based on May 2012 HURDAT (1900-2011)
- No trends, weighting, or partitioning are conducted
- Calibration and validation uses the complete base hurricane storm set
- Discussed with Pro Team: PDF updates (which include HURDAT reanalysis storms (1925-1935)). Large impact on Palm Beach and Martin counties. Reviewed Forms M-1/S-1
- FPHLM v5.0 is in compliance with Standard M-1
M-2 Hurricane Parameters and Characteristics

- Methods based on information documented in currently accepted scientific literature
- Parameters graphically described and justified
- Discussed with Pro team: HURDAT version used for parameters, PBL height change, Rmax data, and mean PBL slab-to-surface adjustment factor
- FPHLM v5.0 is in compliance with Standard M-2
M-3 Hurricane probabilities

- Modeled probability distributions consistent with historical Atlantic basin hurricanes

- Landfall probabilities consistent with historical base set for coastal segments of Florida and neighboring states

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

- With Pro team discussed: Rmax dataset, updated Rmax fit, Form S-3

- FPHLM v5.0 is in compliance with Standard M-3
M-4  Hurricane wind field structure

- Wind fields consistent with observed historical storms e.g. Charley, Katrina, Wilma
- Development of roughness from land use land cover is consistent with the state of the science. Discussed with Pro Team: LC/LU data and roughness variations, Form M-2.
- Vertical variation of wind speed is used to model losses of multistory buildings
- FPHLM v5.0 is in compliance with Standard M-4
M-5 Landfall and over-land weakening methodologies

- Method for hurricane wind speed decay over land is based on scientific literature and consistent with historical record
- Wind speed transition from ocean to land is consistent with current state of science
- Discussed with Pro Team: Change in PBL height from 500 m to 450 m in terrain and coastal transition models
- FPHLM v5.0 is in compliance with Standard M-5
M-6 Logical relationships of hurricane characteristics

- Wind field asymmetry increases with storm translation speed, all other factors held constant
- Mean wind speed decreases with roughness, all other factors held constant
- Discussed with Pro Team: Wind field asymmetry, Rmax bounds, Form M-3
- FPHLM v5.0 is in compliance with Standard M-6
Florida Public Hurricane Loss Model

Standard V-1
Derivation of Vulnerability Functions
A. Development of the vulnerability functions is to be based on any or a combination of the following: (1) historical data, (2) tests, (3) structural calculations, (4) expert opinion, or (5) site inspections. However, any development of the vulnerability functions based on structural calculations or expert opinion shall be supported by tests, site inspections, and historical data.

The development of the vulnerabilities is based on a component approach that combines engineering modeling, simulations with engineering judgment, and observed (historical) data. The determination of external damage to buildings is based on structural calculations, tests, and Monte Carlo simulations. The wind loads and strength of the building components in the simulations are based on 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 and content damage are extrapolated from the external damage on the basis of expert opinion and are confirmed using historical claims data and site inspections of areas impacted by recent hurricanes.
Florida Public Hurricane Loss Model

Standard V-1

B. The method of derivation of the vulnerability functions and their 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 accounted for by distributing the 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.
C. Residential building stock classification shall be representative of Florida construction for personal and commercial residential properties.

A detailed exposure study was carried out to define the most significant (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. In the case of the residential model and the low-rise, commercial residential model, the models include differing wall types (wood and masonry) of varying strengths (e.g., reinforced or not, various roof to wall connection types), differing roof shapes (hip and gable end) and their effect on uplift loading, various strengths of roof-to-wall connections (toe nail through straps), varying window types and sizes, opening protection systems, varying garage door pressure capacities, and one and two story houses and one-to-three story commercial residential buildings. Models of varying combinations of the above characteristics (e.g., wood frame, gable end, no window shutters) were created for four different regions in Florida. In all cases, the probabilistic capacities of the various components were determined by a variety of sources.

In the case of the mid-/high-rise commercial residential model (buildings with more than three stories), the models include different apartment units corresponding to different building layouts (interior or exterior entry door), different locations within the floor plan (corner or middle units), different heights (subject to different probabilities of missile impact and wind speed), and different openings (windows, doors, sliders) with different protection options (none or impact resistant).
Florida Public Hurricane Loss Model

Standard V-1

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

The structural models include options that allow the representation of building code revisions. Three models were derived for each structural type: weak, medium, and strong construction. For example, each model for wood frame and gable roof homes has weak, medium, and strong versions. The assignment of a given strength level is based on the assumed age of the home being modeled and the available information on construction practice in that region of the state in that era of construction. Florida Building Code requirements that apply to the repair of existing homes are also taken into consideration when computing the repair costs of a structure. 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 various models that reflect construction type, region of Florida, and era of construction (multiple variations of weak, medium, or strong construction), each model has numerous additional strength features that can be adjusted before simulations are conducted to represent various combinations of mitigation features. For example, a weak constructed home in central Florida with masonry walls (no reinforcing) may have been recently re-roofed with renailed roof decking and modern code-approved shingles. The simulation model is capable of reflecting this combination of weak original construction and new, strong roof sheathing and roof cover mitigation.
E. Vulnerability functions shall be separately derived for commercial residential building structures, personal residential structures, mobile homes, appurtenant structures, contents, and time element coverages.

This requirement is fully met. The building structures, mobile homes, and appurtenant structures are independently derived. The contents and time element coverages are separate vulnerabilities, which are functions of (receiving input from) the results of structure vulnerability simulations.
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 ranging from 50 mph to 250 mph.
G. Vulnerability functions shall include damage as attributable to windspeed and wind pressure, water infiltration, and missile impact associated with hurricanes. Vulnerability functions shall not include explicit damage to the structure due to flood, storm surge, or 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 the wind hazard (wind speed and wind pressure), missile impact, and water infiltration.
### Part A – Form V1

#### V5.0 – All Reference Structures Combined

<table>
<thead>
<tr>
<th>Windspeed (mph) 1 min sustained Wind</th>
<th>Estimated Damage/Subject Exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>41-50</td>
<td>0.00%</td>
</tr>
<tr>
<td>51-60</td>
<td>0.05%</td>
</tr>
<tr>
<td>61-70</td>
<td>0.37%</td>
</tr>
<tr>
<td>71-80</td>
<td>1.08%</td>
</tr>
<tr>
<td>81-90</td>
<td>3.26%</td>
</tr>
<tr>
<td>91-100</td>
<td>7.17%</td>
</tr>
<tr>
<td>101-110</td>
<td>10.72%</td>
</tr>
<tr>
<td>111-120</td>
<td>15.68%</td>
</tr>
<tr>
<td>121-130</td>
<td>21.46%</td>
</tr>
<tr>
<td>131-140</td>
<td>23.47%</td>
</tr>
<tr>
<td>141-150</td>
<td>27.92%</td>
</tr>
<tr>
<td>151-160</td>
<td>29.46%</td>
</tr>
<tr>
<td>161-170</td>
<td>31.61%</td>
</tr>
</tbody>
</table>
Part C – Form V1
Building damage vs. 1 minute Sustained Wind Speed

All Reference Structures Combined
### Part A – Form V1

V5.0 – Personal Residential Structures (Frame+CB+MH)

<table>
<thead>
<tr>
<th>Wind Speed (mph ) 1 min sustained Wind</th>
<th>Estimated Damage/Subject Exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>41-50</td>
<td>0.00%</td>
</tr>
<tr>
<td>51-60</td>
<td>0.68%</td>
</tr>
<tr>
<td>61-70</td>
<td>2.56%</td>
</tr>
<tr>
<td>71-80</td>
<td>3.69%</td>
</tr>
<tr>
<td>81-90</td>
<td>6.37%</td>
</tr>
<tr>
<td>91-100</td>
<td>10.71%</td>
</tr>
<tr>
<td>101-110</td>
<td>14.46%</td>
</tr>
<tr>
<td>111-120</td>
<td>20.30%</td>
</tr>
<tr>
<td>121-130</td>
<td>33.72%</td>
</tr>
<tr>
<td>131-140</td>
<td>37.15%</td>
</tr>
<tr>
<td>141-150</td>
<td>51.02%</td>
</tr>
<tr>
<td>151-160</td>
<td>56.50%</td>
</tr>
<tr>
<td>161-170</td>
<td>69.67%</td>
</tr>
</tbody>
</table>
Part C – Form V1
Building damage vs. 1 minute sustained wind speed

Personal Residential Only- (Frame + CB + MH)
### Part A – Form V1

**V5.0 – Commercial Residential Reference Structures (concrete)**

<table>
<thead>
<tr>
<th>Wind Speed (mph)</th>
<th>Estimated Damage/Subject Exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>41-50</td>
<td>0.00%</td>
</tr>
<tr>
<td>51-60</td>
<td>0.03%</td>
</tr>
<tr>
<td>61-70</td>
<td>0.32%</td>
</tr>
<tr>
<td>71-80</td>
<td>1.03%</td>
</tr>
<tr>
<td>81-90</td>
<td>3.20%</td>
</tr>
<tr>
<td>91-100</td>
<td>7.10%</td>
</tr>
<tr>
<td>101-110</td>
<td>10.65%</td>
</tr>
<tr>
<td>111-120</td>
<td>15.59%</td>
</tr>
<tr>
<td>121-130</td>
<td>21.21%</td>
</tr>
<tr>
<td>131-140</td>
<td>23.19%</td>
</tr>
<tr>
<td>141-150</td>
<td>27.45%</td>
</tr>
<tr>
<td>151-160</td>
<td>28.92%</td>
</tr>
<tr>
<td>161-170</td>
<td>30.85%</td>
</tr>
</tbody>
</table>
Part C – Form V1
Building damage vs. 1 minute sustained wind speed

Commercial Residential Reference Structure (concrete)
### Part B – Form V1

<table>
<thead>
<tr>
<th>Construction Type</th>
<th>Estimated Damage/Subject Exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood Frame</td>
<td>3.84%</td>
</tr>
<tr>
<td>Masonry</td>
<td>3.30%</td>
</tr>
<tr>
<td>Mobile Home</td>
<td>10.47%</td>
</tr>
<tr>
<td>Concrete</td>
<td>3.06%</td>
</tr>
</tbody>
</table>
The modelers do confirm that the structures used in completing the form are identical to those in the table provided in the standard.

Reference structures of V-1 are the weak masonry and frame types, and the pre94 tied down MH type of the Florida Hurricane Loss Model.

The 20 story concrete structure has 160 condo units with no opening protection.

The resulting large discrepancies in damage ratios vs. wind speed between the personal residential reference structures in Form V-1 (i.e. timber, masonry, and manufactured home) and the engineered commercial residential reference structure are due to the fact that they correspond to widely different types of structures.

The reported damage is consistent with the vulnerability matrices and functions used in the computations.
Discussion

- The model computes the damage based on 3 sec gusts. The losses are then aggregated once according to the 3 sec gusts. At each zip code, the 3 sec gusts are then converted into 1 min sustained winds, and the losses are re-aggregated among the zip codes with the same 1 min sustained winds. The conversion from 3 sec gust to 1 min sustained depends on the roughness of the zip code. Because all the zip codes do not have the same roughness, identical 3 sec gusts results in different 1 min winds depending on location.
Florida Public Hurricane Loss Model

Standard V-2
Derivation of Contents and Time Element Vulnerability Functions
A. The relationship between the modeled structure and the contents vulnerability functions and historical structure and contents losses shall be reasonable.

The relationship between the modeled structure and the contents vulnerability functions is reasonable, on the basis of the relationship between historical structure and contents losses.
B. Time element vulnerability function derivations shall consider the estimated time required to repair or replace the property.

Time element vulnerability function derivations consider the estimated time required to repair or replace the property.
Florida Public Hurricane Loss Model

Standard V-2

C. The relationship between the modeled structure and time element vulnerability functions and historical structure and time element losses shall be reasonable.

For Personal Residential risks the model uses time element vulnerability functions derived from the relationship between structural damage and additional living expense. The vulnerability functions have been calibrated using historical claim data on structure and additional living expense.

For Commercial Residential risks the relationship between modeled structure and time element loss costs is reasonable, but judgmental, since no historical loss data were available for calibration.
The time element vulnerability functions produced by the model consider time element claims arising from wind, flood, and storm surge, 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 claims due to indirect loss is judgmental since no historical loss data were available for calibration.
Florida Public Hurricane Loss Model

Standard V-3 Mitigation Measures
Standard V-3

A. Modeling of mitigation measures to improve a structure’s wind resistance and the corresponding effects on vulnerability shall be theoretically sound and consistent with fundamental engineering principles. These measures shall include fixtures or construction techniques that enhance the performance of the structure and its contents and shall consider:

• 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 structure’s wind resistance is theoretically sound and includes the fixtures mentioned above.
Part A: Continued

The following structures were modeled:

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

The mitigations included 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.
B. Application of mitigation measures that enhance the performance of the structure and its contents shall be justified as to the impact on reducing damage whether done individually or in combination.

The base cases are very weak cases, where the interior damage is governed by the sheathing loss at low to moderate wind speeds. Application of mitigation measures are justified.
Mitigation: Standards

• Standard requires
  – Base case as defined by Commission
  – Mitigated case as defined by Commission
  – Base plus one mitigation at a time
<table>
<thead>
<tr>
<th>Reference Frame Structure:</th>
<th>Reference Masonry Structure:</th>
</tr>
</thead>
<tbody>
<tr>
<td>One story</td>
<td>One story</td>
</tr>
<tr>
<td>Unbraced gable end roof</td>
<td>Unbraced gable end roof</td>
</tr>
<tr>
<td>Normal shingles (55mph)</td>
<td>Normal shingles (55mph)</td>
</tr>
<tr>
<td>½” plywood deck</td>
<td>½” plywood deck</td>
</tr>
<tr>
<td>6d nails, deck to roof members</td>
<td>6d nails, deck to roof members</td>
</tr>
<tr>
<td>Toe nail truss to wall anchor</td>
<td>Toe nail truss to wall anchor</td>
</tr>
<tr>
<td>Wood framed exterior walls</td>
<td>Masonry exterior walls</td>
</tr>
<tr>
<td>5/8” diameter anchors at 48” centers for wall/floor/foundation connections</td>
<td>No vertical wall reinforcing</td>
</tr>
<tr>
<td>No shutters</td>
<td>No shutters</td>
</tr>
<tr>
<td>Standard glass windows</td>
<td>Standard glass windows</td>
</tr>
<tr>
<td>No door covers</td>
<td>No door covers</td>
</tr>
<tr>
<td>No skylight covers</td>
<td>No skylight covers</td>
</tr>
<tr>
<td>Constructed in 1980</td>
<td>Constructed in 1980</td>
</tr>
</tbody>
</table>
Mitigated Case

<table>
<thead>
<tr>
<th>Mitigated Frame Structure:</th>
<th>Mitigated Masonry Structure:</th>
</tr>
</thead>
<tbody>
<tr>
<td>One story</td>
<td>One story</td>
</tr>
<tr>
<td>Unbraced gable end roof</td>
<td>Unbraced gable end roof</td>
</tr>
<tr>
<td>Rated shingles (110mph)</td>
<td>Rated shingles (110mph)</td>
</tr>
<tr>
<td>½” plywood deck</td>
<td>½” plywood deck</td>
</tr>
<tr>
<td>8d nails, deck to roof members</td>
<td>8d nails, deck to roof members</td>
</tr>
<tr>
<td>Truss straps at roof</td>
<td>Truss straps at roof</td>
</tr>
<tr>
<td>Wood framed exterior walls</td>
<td>Masonry exterior walls</td>
</tr>
<tr>
<td>5/8” diameter anchors at 48” centers for wall/floor/foundation connections</td>
<td>No vertical wall reinforcing</td>
</tr>
<tr>
<td>Shutters</td>
<td>Shutters</td>
</tr>
<tr>
<td>Standard glass windows</td>
<td>Standard glass windows</td>
</tr>
<tr>
<td>No door covers</td>
<td>No door covers</td>
</tr>
<tr>
<td>No skylight covers</td>
<td>No skylight covers</td>
</tr>
<tr>
<td>Constructed in 1980</td>
<td>Constructed in 1980</td>
</tr>
</tbody>
</table>
Mitigation – Measures Modeled

- Base case
- Mitigated case
- Membrane
- Metal roof
- Rated shingles
- Hipped roof
- Roof to wall connections
  - Toe nails
  - Clips
  - Straps
- Stud to sill connections
  - Toe nails
  - Clips
  - Straps
- 8d sheathing nails
- Gable end bracing
- Windows
  - Standard
  - Laminated
  - Impact resistant
- Shutters
  - Plywood, Steel, Engineered
  - Door covers
- Masonry Reinforcing
Roof Strength

• Reference structures of V-2 are the weak masonry and frame types
• The negative values are from round off of smaller values within the uncertainty scatter of the model and indicate zero change
• Bracing the gable end only does not provide any benefit in the context of weak sheathing connections
• The hip roof has greater impact in reducing the losses, specially in the case of frame structures. Because the base frame structure is inherently weaker, there is comparatively a higher gain with the hip timber structure than with the hip masonry structure.

<table>
<thead>
<tr>
<th>INDIVIDUAL MITIGATION MEASURES</th>
<th>PERCENTAGE CHANGES IN DAMAGE</th>
<th>FRAME STRUCTURE</th>
<th>MASONRY STRUCTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(REFERENCE DAMAGE RATE - MITIGATED DAMAGE RATE)/(REFERENCE DAMAGE RATE)*100</td>
<td>WIND SPEED (MPH)</td>
<td>WIND SPEED (MPH)</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>85</td>
<td>110</td>
</tr>
<tr>
<td>ROOF STRENGTH</td>
<td>BRACED GABLE ENDS</td>
<td>0%</td>
<td>-1%</td>
</tr>
<tr>
<td>HIP ROOF</td>
<td>2%</td>
<td>7%</td>
<td>9%</td>
</tr>
</tbody>
</table>
Roof to Wall Strength

- Reference structures of V-2 are the weak masonry and frame types.
- The negative values are from round off of smaller values within the uncertainty scatter of the model and indicate zero change.
- Clips and straps are very effective for frame structures, less so for masonry structures.
- The model puts a lot of emphasis on interior damage due to loss of sheathing, roof cover or gable end, which are all independent of the roof to wall connection strength. So, if you do not also increase the strength of the plywood deck of roof cover, increasing the roof to wall connections alone will do you little good at low to moderate wind speeds. At higher wind speeds, the integrity of the box system in the frame structure is improved by the stronger connection. Hence, a more pronounced benefit than for masonry.

<table>
<thead>
<tr>
<th>INDIVIDUAL MITIGATION MEASURES</th>
<th>PERCENTAGE CHANGES IN DAMAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(REFERENCE DAMAGE RATE - MITIGATED DAMAGE RATE)/(REFERENCE DAMAGE RATE)*100</td>
</tr>
<tr>
<td></td>
<td>FRAME STRUCTURE</td>
</tr>
<tr>
<td>WIND SPEED (MPH)</td>
<td>60</td>
</tr>
<tr>
<td>CLIPS</td>
<td>0%</td>
</tr>
<tr>
<td>STRAPS</td>
<td>0%</td>
</tr>
</tbody>
</table>
Roof Covering

- Reference structures of V-2 are the weak masonry and frame types
- Using metal roof or rated shingles or a membrane does not provide any benefit in the context of weak sheathing connections
- Improving the nailing of the deck alone, can reduce the interior damage at low wind speeds, but at higher wind speeds, it will be counter effective. The behavior of the mitigated 8d nails with respect to the base case are due to the fact that we are increasing the strength of the plywood deck but we are not increasing the strength of the roof to wall connections. So, at a certain point the stronger deck results in higher loads on the connection, which they are not prepared to absorb. In other words, it is counterproductive to strengthen the deck without a proper strengthening of the connections. The only thing you will achieve is that the roof will blow away as a single rigid body, instead of flying away in bits and pieces.

<table>
<thead>
<tr>
<th>ININDIVIDUAL</th>
<th>MITIGATION MEASURES</th>
<th>FRAME STRUCTURE</th>
<th>MASONRY STRUCTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>WIND SPEED (MPH)</td>
<td></td>
<td>WIND SPEED (MPH)</td>
</tr>
<tr>
<td></td>
<td>60 85 110 135 160</td>
<td>60 85 110 135 160</td>
<td></td>
</tr>
<tr>
<td>METAL</td>
<td>0% 1% 0% 0% 0%</td>
<td>0% 1% 0% 0% 0%</td>
<td></td>
</tr>
<tr>
<td>RATED SHINGLES (110 MPH)</td>
<td>0% 1% 0% 0% 0%</td>
<td>0% 1% 0% 0% 0%</td>
<td></td>
</tr>
<tr>
<td>MEMBRANE</td>
<td>0% 0% 0% 0% 0%</td>
<td>0% 0% 0% 0% 0%</td>
<td></td>
</tr>
<tr>
<td>NAILING OF DECK 8d</td>
<td>4% 41% 6% -2% 0%</td>
<td>3% 41% 13% -4% -1%</td>
<td></td>
</tr>
</tbody>
</table>
Wall to Floor Strength

- Reference structures of V-2 are the weak masonry and frame types
- Clips and straps are very effective for frame structures. They improve the integrity of the box system.

### Table: Percentage Changes in Damage (Reference Damage Rate - Mitigated Damage Rate) / Reference Damage Rate * 100

<table>
<thead>
<tr>
<th>Wind Speed (MPH)</th>
<th>WALL- FLOOR STRENGTH</th>
<th>TIES OR CLIPS</th>
<th>STRAPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>85</td>
<td>0%</td>
<td>1%</td>
<td>1%</td>
</tr>
<tr>
<td>110</td>
<td>7%</td>
<td>10%</td>
<td>10%</td>
</tr>
<tr>
<td>135</td>
<td>5%</td>
<td>10%</td>
<td>5%</td>
</tr>
<tr>
<td>160</td>
<td>2%</td>
<td>5%</td>
<td>-</td>
</tr>
</tbody>
</table>

### Table: Percentage Changes in Damage (Reference Damage Rate - Mitigated Damage Rate) / Reference Damage Rate * 100

<table>
<thead>
<tr>
<th>Wind Speed (MPH)</th>
<th>FRAME STRUCTURE</th>
<th>MASONRY STRUCTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>85</td>
<td>0%</td>
<td>1%</td>
</tr>
<tr>
<td>110</td>
<td>7%</td>
<td>10%</td>
</tr>
<tr>
<td>135</td>
<td>5%</td>
<td>10%</td>
</tr>
<tr>
<td>160</td>
<td>2%</td>
<td>5%</td>
</tr>
<tr>
<td>60</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>85</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>110</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>135</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>160</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

**FCHLPM**
Wall Foundation Strength

- Reference structures of V-2 are the weak masonry and frame types
- The negative values are from round off of smaller values within the uncertainty scatter of the model and indicate zero change
- The FPHLM does not model the foundation
- Wall reinforcing is more effective at high wind speeds, when wall integrity becomes an issue.

<table>
<thead>
<tr>
<th>WALL FOUNDATION STRENGTH</th>
<th>PERCENTAGE CHANGES IN DAMAGE (REFERENCE DAMAGE RATE - MITIGATED DAMAGE RATE)/(REFERENCE DAMAGE RATE)*100</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FRAME STRUCTURE</td>
</tr>
<tr>
<td></td>
<td>MASONRY STRUCTURE</td>
</tr>
<tr>
<td>WIND SPEED (MPH)</td>
<td>WIND SPEED (MPH)</td>
</tr>
<tr>
<td></td>
<td>60</td>
</tr>
<tr>
<td>LARGER ANCHORS OR CLOSER SPACING STRAPS</td>
<td>-</td>
</tr>
<tr>
<td>VERTICAL REINFORCING</td>
<td>-</td>
</tr>
</tbody>
</table>
Opening Protection

- Reference structures of V-2 are the weak masonry and frame types
- Opening protection is an effective measure for both frame and masonry structures

<table>
<thead>
<tr>
<th>INDIVIDUAL MITIGATION MEASURES</th>
<th>Frame Structure</th>
<th>Masonry Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wind Speed (MPH)</td>
<td>Wind Speed (MPH)</td>
</tr>
<tr>
<td>OPENING PROTECTION</td>
<td>60</td>
<td>85</td>
</tr>
<tr>
<td>WINDOW SHUTTERS</td>
<td>PLYWOOD</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>STEEL</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>ENGINEERED</td>
<td>0%</td>
</tr>
<tr>
<td>DOOR AND SKYLIGHT COVERS</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>
Window and Skylight Strength

- Reference structures of V-2 are the weak masonry and frame types

- Both laminated and impact glass are an effective measure for both frame and masonry structures
Combined Mitigation

- Reference structures of V-2 are the weak masonry and frame types
- All the mitigation measures combined are more effective

<table>
<thead>
<tr>
<th>MITIGATION MEASURES IN COMBINATION</th>
<th>FRAME STRUCTURE</th>
<th>MASONRY STRUCTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>STRUCTURE</td>
<td>WIND SPEED (MPH)</td>
<td>WIND SPEED (MPH)</td>
</tr>
<tr>
<td></td>
<td>60  85  110  135 160</td>
<td>60  85  110  135 160</td>
</tr>
<tr>
<td>MITIGATED STRUCTURE</td>
<td>4%  44%  31%  29%  24%</td>
<td>3%  43%  24%  16%  17%</td>
</tr>
</tbody>
</table>
Form V-3 Mitigated Masonry Vulnerabilities

Vulnerability Curves for Reference Masonry Structure - Mitigation set 1
actual terrain 3 sec gust wind speeds

- Base
- Braced Gable
- 8d sheat nails
- Reinfor mas
- Mitig Struct
- Metal Roof

Lee County $z_0 = 0.17125$

Damage Ratio

actual terrain 1 min sustained wind speeds
Form V-3 Mitigated Masonry Vulnerabilities

Vulnerability Curves for Reference Masonry Structure - Mitigation set 2

actual terrain 3 sec gust wind speeds

actual terrain 1 min sustained wind speeds

Lee County $z_0 = 0.17125$
Form V-3 Mitigated Masonry Vulnerabilities

Vulnerability Curves for Reference Masonry Structures - Mitigation set  4
actual terrain 3 sec gust wind speeds

- Base
- Door cover
- Lam Glass
- Impact Glass
- Mitig Struct

Lee County  $z_0 = 0.17125$
Form V-3 Mitigated Frame Vulnerabilities

Vulnerability Curves for Reference Frame Structure - Mitigation set 1

- Base
- Braced gable
- 8d sheath nails
- Sill clips
- Sill straps
- Mitig Struct
- Metal roof

Lee County $z_0 = 0.17125$
Form V-3 Mitigated Frame Vulnerabilities

Vulnerability Curves for Reference Frame Structure - Mitigation set 2

actual terrain 1 min sustained wind speeds

Damage Ratio

- Base
- Rated shingles
- R2w clips
- R2w straps
- Mitig Struct
- Membrane

Lee County \( z_0 = 0.17125 \)
Form V-3 Mitigated Frame Vulnerabilities

Vulnerability Curves for Reference Frame Structure - Mitigation set 3

actual terrain 3 sec gust wind speeds

actual terrain 1 min sustained wind speeds

Damage Ratio

Lee County $z_0 = 0.17125$
Form V-3 Mitigated Frame Vulnerabilities

Vulnerability Curves for Reference Frame Structure - Mitigation set 4

Actual terrain 1 min sustained wind speeds

Damage Ratio

Base
Door cover
Lam Glass
Impact Glass
Mitig Struct

Lee County $z_0 = 0.17125$
Form V-3 Mitigated Vulnerabilities

- The curves for base, membrane, mitigated gable, metal roof, and mitigated shingles are essentially the same. Because the internal damage is dominated by the sheathing damage, mitigating only gable or roof cover does not improve the structure.
Form V-3 Mitigated Vulnerabilities

• For the same reason, the 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.
Form V-3 Mitigated Vulnerabilities

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

• The complete mitigation, as expected is the lower, less vulnerable curve.
Florida Public Hurricane Loss Model
Version 5.0
Actuarial Standards
Overview

- **Changes to Actuarial Components**
  - No changes to actuarial model components

- **Loss Costs were impacted by**
  - Meteorological Component Changes (−.73% overall)
  - Vulnerability Components Changes (−3.69% Personal Residential, −19.07% Commercial Residential)

- **Statewide Loss Cost change**: −7.35%

  (changes shown are $0 deductible)
A. *When used in the modeling process or for verification purposes, adjustments, edits, inclusions, or deletions to insurance company input data used by the modeling organization shall be based upon 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 cover, 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, any missing or inconsistent attributes are methodically populated using rules based on survey statistics.

These adjustments to the inputs are reasonable and acceptable from an actuarial stand–point.

(continued on next slide)
B. All modifications, adjustments, assumptions, inputs and/or input file identification, and defaults necessary to use the model shall be actuarially sound and shall be included with the model output report. Treatment of missing values for user inputs required to run the model shall be actuarially sound and described with the model output report.

All changes to the input data are documented in the model output report.

(end of Standard A-1)
A. Modeled loss costs and probable maximum loss levels shall reflect all insured wind related damages from storms that reach hurricane strength and produce minimum damaging wind speeds or greater on land in Florida.

Modeled loss costs and PML levels include damages from:

- Hurricanes with landfall in Florida

- Hurricanes with landfall in neighboring states, but producing open terrain winds of 30 mph or greater in at least one Florida zip code.

- Non–landfalling hurricanes producing open terrain winds of 30 mph or greater in at least one Florida zip code.

(continued on next slide)
B. Time element loss costs shall reflect losses due to infrastructure damage by a hurricane.

Time element losses are calculated as a function of interior damage to the structure.

The functions do not explicitly consider claims arising from indirect loss, but Personal Residential functions were validated against claim data that would have been impacted by both direct and indirect loss.

Commercial Residential functions are judgmental due to lack of claim data for validation.
Standard A-3
Modeled Loss Cost and Probable Maximum Loss Considerations

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

These items are not included in loss costs or PML’s.

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

There is no provision for economic inflation in loss costs or PML’s.

(continued on next slide)
C. Loss cost projections and probable maximum loss levels shall not include any provision for direct hurricane storm surge losses.

There is no provision for storm surge in loss costs or PML’s.

D. Loss cost projections and probable maximum loss levels shall be capable of being calculated 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.

(continued on next slide)
E. Demand surge shall be included in the model’s calculation of loss costs and probable maximum loss levels using relevant data.

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

(continued on next slide)
The methods, data, and assumptions used in the estimation of demand surge shall be actuarially sound.

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

(continued on next slide)
Standard A-3
Modeled Loss Cost and Probable Maximum Loss Considerations

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.

(continued on next slide)
Standard A–3
Modeled Loss Cost and Probable Maximum Loss Considerations

General Approach

Method used to estimate DS involves examining the gap between forecasted post-storm indices and actual post-storm indices.

(end of Standard A–3)
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 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.
B. The relationship among the modeled deductible loss costs shall be reasonable.

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

C. Deductible 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 applied to the second hurricane. If none remains, the general peril deductible is applied.

(end of Standard A–4)
A. The methods used in the development of contents loss costs shall be actuarially sound.

The damage functions for contents 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.
B. The methods used in the development of time element coverage loss costs shall be actuarially sound.

Time element losses are calculated as a function of interior damage to the structure.

The functions do not explicitly consider claims arising from indirect loss, but Personal Residential functions were validated against claim data that would have been impacted by both direct and indirect loss.

Commercial Residential functions are judgmental due to lack of claim data for validation.
A. The methods, data, and assumptions used in the estimation of probable maximum loss levels shall be actuarially sound.

PML for a given return period =

$$((1 - 1 / \text{return period}) \times 100)^{th}$$ quantile of the ordered set of annual losses produced by the simulation.

For example, the PML for a return period of 100 years is the 99th quantile.
B. Loss costs shall not exhibit an illogical relation to risk, nor shall loss costs exhibit a significant change when the underlying risk does not change significantly.

Loss costs are similar for similar risks. Form A–1 shows the clustering of similar costs by geographical area.

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

The model produces positive, non-zero loss costs for all valid zip codes. See Form A–1.

(continued on next slide)
D. 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 decrease as the quality of construction increases. See Form A–6, Construction and Policy Type sections.

E. 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, Building Strength section.

(continued on next slide)
F. Loss costs cannot increase as the quality of building codes and enforcement increases, all other factors held constant.

Loss costs vary appropriately with the quality and enforcement of building codes. See Form A-6, Building Code /Enforcement (Year Built) section.

G. Loss costs shall decrease as deductibles increase, all other factors held constant.

Loss costs vary appropriately by size of deductible. See From A-6, Deductible section.

(continued on next slide)
H. The relationship of loss costs for individual coverages, (e.g., structures and appurtenant structures, contents, and time element) shall be consistent with the coverages provided.

Validation testing demonstrated that the relationship between loss costs and coverage are reasonable and consistent with the coverage provided. Also, see Form A-6, Coverage section.

(continued on next slide)
I. Output ranges shall be logical and any deviations supported.

Output ranges generated by the model are logical as detailed below. Anomalies at the county level in Form A–4 can be resolved at the zip code level.

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

1. masonry construction versus frame construction,

Output ranges produced by the model reflect lower loss costs for masonry versus frame construction.

(continued on next slide)
2. *personal residential risk exposure versus mobile home risk exposure*,

Output ranges produced by the model reflect lower loss costs for site–built versus mobile home exposure.

3. *in general, inland counties versus coastal counties, and*

In general output ranges produced by the model reflect lower loss costs for inland counties versus coastal counties.

4. *in general, northern counties versus southern counties.*

In general output ranges produced by the model reflect lower loss costs for northern counties versus southern counties.

(continued on next slide)
For loss cost and probable maximum loss level estimates derived from or validated with historical insured hurricane losses, the assumptions in the derivations concerning (1) construction characteristics, (2) policy provisions, (3) coinsurance, (4) contractual provisions, and (5) relevant underwriting practices underlying those losses, as well as any actuarial modifications, shall be appropriate based on the type of risk being modeled.

For each storm the model estimates damages to an insured property based on the characteristics of the property and engineering judgment as to the strength of that particular combination of characteristics.

The estimated damages are adjusted for the effects of deductibles, policy limits and demand surge to determine the expected insured loss.

There are no additional adjustments applied to modeled losses.

(End of Standard A–6)
Florida Public Hurricane Loss Model
(FPHLM 5.0)

STATISTICAL STANDARDS

Sneh Gulati and B M Golam Kibria
Department of Mathematics and Statistics
Florida International University
Standard S–1: Modeled Results and Goodness of Fit

- The use of historical data in developing the model shall be supported by rigorous methods published in currently accepted scientific literature.

  The historical data for the period 1900–2011 were modeled using scientifically accepted methods that have been published in accepted scientific literature.

- Modeled and historical results shall reflect agreement using currently accepted scientific and statistical methods for the academic disciplines appropriate for the various model components or characteristics.

  Modeled and historical results are in agreement as indicated by appropriate statistical and scientific tests.
S1: Modeled Results and Goodness of Fit (GOF)

Comparison of modeled vs. historical occurrences

![Bar graph showing comparison of historical vs. modeled number of hurricanes over years.](image)
Comparison of modeled vs historical occurrences

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

**Chi-square test statistic**

- Chi square goodness of fit, $p$-value = 0.749 (DF=3)

- Given the data, the probability of rejecting the true null hypothesis is 0.749, which is very high. So, we can not reject the null hypothesis at 5% level of significance.
Comparison between observed and modeled Holland B

Distribution of the B parameter

- Observed
- Model Scaled

B parameter vs Occurrence
Goodness of Fit for the Holland B Parameter

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

- Kolmogorov–Smirnov goodness of fit Test:  
  \( ks=0.057, \ p\text{-value}= 0.85 \)
Comparison between observed and modeled R Max
Model Rmax by Gamma Distribution

- Chi square goodness of fit test: \( p\)-value= 0.3221 (DF= 4)

- KS- goodness of fit test:
  
  \[ ks=0.0711, \ p\text{-value} = 0.6233 \]
Coefficient of variation provides a relative measure of data dispersion compared to the mean. Found range of CV’s between 2.81 and 5.52
# Assessment of Uncertainty

95% Confidence Intervals for mean loss for selected counties
(based on a 56000 year simulation)

<table>
<thead>
<tr>
<th>county</th>
<th>average_loss</th>
<th>stdev_loss</th>
<th>LCL</th>
<th>UCL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alachua</td>
<td>$10,796,224.33</td>
<td>$44,346,599.09</td>
<td>10428923.1</td>
<td>11163525.56</td>
</tr>
<tr>
<td>Brevard</td>
<td>$159,480,725.27</td>
<td>$596,596,988.38</td>
<td>154539403.7</td>
<td>164422046.8</td>
</tr>
<tr>
<td>Broward</td>
<td>$524,384,931.96</td>
<td>$1,594,317,725.22</td>
<td>511179976.8</td>
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<tr>
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<td>123664992.6</td>
<td>130528641.4</td>
</tr>
</tbody>
</table>
S–2 Sensitivity Analysis (SA) for 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 have taken appropriate action.

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.)
Sensitivity Analysis

- Studied the effect on expected loss costs for five variables, Holland B, FFP, Rmax, VT and CP.


- SRC’s computed for Hurricane Categories 1, 3 and 5.

- Compare SRC’s in terms of the magnitude of their effects.
Sensitivity Analysis

*Standardized Regression Coefficients*:

- Compute the total loss cost for each input vector over all 682 land based vertices for each hurricane category.

- Expected Loss cost defined as a percent of the exposure ($68,200,000)

- Compute correlation matrix of input variables versus expected loss costs

- SRC’s are based on the inverse of the above correlation matrix
Standardized Regression by Hurricane Category

SRC by Hurricane Category

- Holland B
- FFP
- Rmax
- VT
- CP

Cat1 Cat3 Cat5

Hurricane Categories
Sensitivity of expected loss cost depends on the category of the hurricanes.

For a Category 1 hurricane, expected loss cost is most sensitive to Holland B parameter followed by FFP and then CP.

For a Category 3 hurricane, expected loss costs is most sensitive to Holland B followed by FFP and Rmax.

For a Category 5 hurricane, expected loss cost is most sensitive to Rmax, followed by Holland B and then CP and FFP.
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 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.

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.)
Uncertainty Analysis

- Studied the effects on uncertainty for five variables, Holland B, FFP, Rmax, VT and CP.


- EPR’s computed for Hurricane Categories 1, 3 and 5.

- Compare EPR’s in terms of the magnitude of their effects.
The goal of uncertainty analysis is to quantify the contributions of the input parameters to the uncertainty in maximum sustained surface wind speed. The simple model is

\[ Y = X_1 + X_2 + X_3 + X_4 + X_5 \]

The variance of \( Y \) can be expressed as a conditional variance on \( X \)'s. Here \( X \)'s are \( R_{\text{max}} \), \( CP \), \( VT \) and \( HB \) etc.

The expected percentage reduction in \( \text{Var}(Y) \) is expressed as

\[ \text{EPR in Var}(Y) = \frac{\text{Var}(E(Y|X))}{\text{Var}(Y)} \times 100\% \]
Expected Percentage Reductions By Hurricane Category

EPR by Hurricane Category

- Holland B
- FFP
- CP
- Rmax
- VT

Expected Percentage Reduction

Hurricane Categories

Cat1, Cat3, Cat5
Summary for UA

- Category of the hurricane determines which variables contributes most to the uncertainty of the expected loss costs.

- For a Category 1 hurricane, the major contributor to the uncertainty in expected loss cost is the *Holland B* parameter followed by *FFP* and then *CP*.

- For a category 3 hurricane, the major contributor to the uncertainty in loss costs is *Holland B* followed by *Rmax* and then *FFP*.

- For a Category 5 hurricane, the major contributor to the uncertainty of expected loss costs is *Rmax* followed by *Holland B* and then *FFP* and *CP*.

- The variable *VT* has negligible effect on the uncertainty in expected loss costs.
At the county level of aggregation, the contribution to the error in loss cost estimates attributable to the sampling process shall be negligible.

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 56,000 years of simulation. The results indicate that the standard errors are less than 2.5% of the average loss cost estimates for all counties.
Number of Simulation Years

- For each county Y, define average loss cost by $\bar{X}$ and standard deviation by $s$.
- The standard error of estimate (SE($\bar{X}$)) will be 2.5% of the estimated mean, if the number of simulation years for county Y is:

$$N_Y = \left( \frac{s}{0.025 \times \bar{X}} \right)^2$$

- Based on the initial 11,200 simulation runs, the highest minimum acceptable number is 47,833 for Madison County.

- We use 56,000 years (500x112 years) of simulation for our final results. For the 56,000 simulation year run we find the standard errors to be less than 2.5% of the loss cost for each county.
Scatter plot between number of simulation years vs percentage of the loss cost estimate for Jefferson County
Scatter plot between number of simulation years vs percentage of the loss cost estimates for Nassau County.
The model shall estimate incurred 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 experience may be used to replicate structure-only and contents-only losses. The replications shall be produced on an objective body of loss data by county or an appropriate level of geographic detail and shall include loss data from both 2004 and 2005.

There is reasonable agreement between the observed and modeled losses as shown in the following slides
S5: Replication of Known Hurricane losses (Personal Residential)

- Total of 65 data points
- 20 companies
- 6 hurricanes
# TOTAL ACTUAL LOSSES VS MODELED LOSSES

<table>
<thead>
<tr>
<th>Company Name</th>
<th>Event</th>
<th>Total Exposure</th>
<th>Total Actual Loss</th>
<th>Total Modeled Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Charley</td>
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<td>192782631.00</td>
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<tr>
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<td>Frances</td>
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<tr>
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<tr>
<td>B</td>
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<td>20201407.00</td>
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<tr>
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<td>Frances</td>
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<td>43799401.00</td>
<td>6719958.00</td>
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</tbody>
</table>
Scatter plot between Total Actual Losses vs. Total Modeled losses

Scatter plot between Total Actual Losses and Modeled Losses
Paired t Test

- t-test \((t = 1.5064, \ df = 64, \ p\text{-value} = 0.1369)\)

- Wilcoxon signed rank test \((Z = 0.9476, \ p\text{-value} = 0.3434)\).

- We fail to reject the null hypothesis (the difference in paired mean values equals zero), and conclude that there is insufficient evidence to suggest a difference between actual and modeled losses.
Concordance correlation coefficient (CCC)

- The CCC is defined as
  \[ \rho_c = C_b \times \rho \]

- CCC evaluates the degree to which the pairs fall on a 45° line.

- Here, \( C_b \) is a Bias correction factor (measure of accuracy) that measures how far the best-fit line deviates from the line (or how closely the fitted line agrees with the identity line).

- \( \rho_c \) evaluates how closely observations fall on the fitted line.
Concordance Correlation Coefficient (CCC)

- Sample concordance correlation coefficient = 0.901
- Bias correction factor (accuracy) = 0.930

**Conclusion**: Very good agreement between actual and model losses.
Replication of Known Losses – Commercial Losses

- Scarce Data and therefore no extensive analysis

- Tabular comparison shows good agreement between actual and modeled losses.
# Comparison of Actual vs Modeled Loss – Commercial Residential

<table>
<thead>
<tr>
<th>Company</th>
<th>Event</th>
<th>Total Exposure</th>
<th>Total Actual Loss</th>
<th>Total Modeled Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>Charley</td>
<td>$2,330,314,147.00</td>
<td>$63,245,008.00</td>
<td>$41,577,368.33</td>
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<tr>
<td>D</td>
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<td>$4,866,082,786.00</td>
<td>$34,826,257.00</td>
<td>$91,253,833.37</td>
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<tr>
<td>D</td>
<td>Katrina</td>
<td>$6,489,785,877.00</td>
<td>$11,846,697.00</td>
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<tr>
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</table>
Nonparametric Analysis

- Wilcoxon Signed Rank Test Statistic = 23, p-value = 0.5469
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.

The difference, due to uncertainty, between historical and modeled annual average statewide loss costs is reasonable as shown in the following description.
Standard S6: Comparison of projected hurricane loss costs

- (Standard S–4) The number of simulation years is 56,000. The standard errors are within less than 2.5% of the means for all counties.

- (Form S5): 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.
Florida Public Hurricane Loss Model
Computer Standards

Dr. Shu-Ching Chen
School of Computing and Information Sciences
Florida International University
Model Flowchart

- **Use cases**
  - Storm Track Generation
  - Wind Field Model
  - Wind Speed Correction
  - Monte Carlo Simulation Model
    - Personal Residential
    - Commercial Residential
  - Vulnerability
    - Personal Residential
    - Commercial Residential
  - Insurance Loss Module
    - Personal Residential
    - Commercial Residential

- **Historical Storm Database:** HURDAT
- **Stochastic Storm Database:** Simulated Storms
- **Information obtained from geo-database:** Ground Elevation Exposure Classification
- **Storm Forecast Module**
  - Determines the storm properties to be used in the analysis.
  - User Input:
    - Storm Properties: (Central Pressure, Storm Track, Rmax)
- **Wind Field Module**
  - Generates the wind field based on geo-coded location.
  - Wind Speed
- **Damage Estimation Module**
  - Calculates Damage Ratios
- **Loss Estimation Module**
  - Calculates financial loss
  - Portfolio Data
System Architecture

Client Side

- Web Browser

Application Logic

- Web Server
- OC4J Container
- JavaBeans
- Math Model in C++
- JNI Interface

Database Server

- ORACLE DB
- JDBC
- IMSL Library
C-1 Documentation (1/2)

- Formal documentation in archival format – **Done**
  - Model functionality and technical descriptions formally documented in the primary document binder.

- Primary document binder – **Done**
  - Specify the model structure, detailed software description, and functionality.

- Computer software consistently documented and dated – **Done**
  - The primary document binder consists of all the required documents arranged in different sub folders.
C-1 Documentation (2/2)

- Tables of changes (1) from the prior year’s submission to this year’s initial submission and (2) since this year’s initial submission are maintained in the primary document – Done

- Documentation created separately from the source code – Done
C-2 Requirements (1/2)

- Maintain a complete set of requirements for each software component – **Done**
  - Detailed document for each module using standard software practices.

- Maintain a complete set of requirements for database/data file – **Done**
  - Database document: data processing, schema, etc.
  - Data file document: file format, parameter, etc.
C-2 Requirements (2/2)

- Documentation for interface, human factors, functionality, documentation, data, human and material resources, security and quality assurance – **Done**
  - Documents are maintained as required
    - Primary document contains sections for
      - Quality assurance
      - Hardware & software specification
      - Human resource management
      - etc.
  - Testing
  - User manual
C-3 Model Architecture and Component Design

- Maintain and document detailed control and data flow diagrams – Done
  - Presented in the primary document binder.
- Maintain and document interface specifications for each software component – Done
  - Presented in the primary document binder.
- Maintain and document schema definition for each database and data file – Done
  - Presented in database document and data file document.
- Maintain and document network diagrams – Done
  - Presented in the primary document binder.
C-4 Implementation (1/4)

- Maintain a complete procedure of coding guidelines – **Done**
  - Guidelines for code development, version controlling, code revision, etc. maintained in primary document binder.

- Maintain a complete procedure in creating, deriving, or procuring and verifying database or data files – **Done**
  - Presented in database document for database
  - Presented in module document for data files
C-4 Implementation (2/4)

- All components are traceable – **Done**
  - Maintained throughout the system documentation from requirements to code level and vice versa

- Maintain a table of software component – **Done**
  - Presented in the primary document binder.

- Each component is sufficiently and consistently commented – **Done**
  - Code-level comments
    - Program header
    - In-line comments
C-4 Implementation (3/4)

- The documentation of all components contain (1) all equations and formulas with definitions of all terms and variables and (2) cross-referenced tables of implementation source code terms and variable names corresponding to 1) — Done

- Each component in the primary document binder has a section with tables that map variable and terms in the source code to equations and formulas in the documentation.
Hardware, operating system, other software and all computer languages required to use the model – **Done**

- **Server side**
  - Hardware: Linux server, Sun workstation
  - Operating system: Linux
  - Software and computer languages: JSP, Java beans, C++, IMSL, JNI, Oracle

- **End-user**
  - Hardware: PC
  - Operating system: Windows, Linux, Unix
  - Software and computer languages: Web browser
C-5 Verification (1/3)

- Maintain procedures for verification – **Done**
  - Three-stage verification
    - By pair-programming – combined work for software development, code-level debugging, calculation cross checks, etc.
    - By system modeler – check sample input/output (blackbox testing)
    - By testing group – unit, regression, and aggregation testing presented in the testing document.

- Use testing software in documenting and analyzing all components – **Done**
  - Rational robot
  - Developed MATLAB, C, C++, Fortran, and IDL code for testing
C-5 Verification (2/3)

- Unit testing – **Done**
  - Presented in the testing document
- Regression testing – **Done**
  - Presented in the testing document
- Aggregation testing – **Done**
  - Presented in the testing document
- Use testing software to assist in documenting and analyzing databases and data files – **Done**
  - Data integrity and consistency are maintained by Oracle database system
  - Issue query (PL/SQL) to check data in the database
  - Using Excel, Access, and PostgreSQL to manually check data files
C-5 Verification (3/3)

- Perform and document integrity, consistency, and correctness checks on databases and data files – **Done**
  - Presented in the testing document
- State whether the model produces the same loss costs with same inputs
  - Produce the same loss cost
- Provide an overview of the component testing procedure - Three-stage verification
Maintain a clearly written policy for model revision – **Done**
- Written policy presented in the primary document.

Assign new model version number if model revision causes a change in loss cost – **Done**
- Presented in the primary document.
C-6 Model Maintenance and Revision (2/3)

- Use tracking software – **Done**
  - Apache Subversion (SVN)
- List of all model versions since this year’s initial submission – **Done**
  - Presented in the primary document
C-6 Model Maintenance and Revision (3/3)

- Identify procedures used to maintain code, data, and documentation
  - For each component, document
    - Installation date
    - Program specification
    - Personnel involved
    - Current version number
    - Date of changes
  - Use SVN for version control
  - Employ access control mechanism for file access
C-7 Security (1/2)

- Secure access to individual computers – **Done**
  - Servers: in a secure server room
  - Computers: in the lab with key card control

- Anti-virus software installation – **Done**

- Secure access to documentation, software, and data in the event of a catastrophe – **Done**
  - Keep copies/backups in different locations
  - Resource is secured and safeguarded by designated personnel
C-7 Security (2/2)

- Methods to ensure the security and integrity of the code, data, and documentation
  - Electronic measures
    - Different authorization levels
    - Network security
    - Regular backups
    - Confidential data saved in the system with access control
    - Setup a development environment besides the production environment for model modification and testing
  - Physical measures
    - A copy of backup tape is placed in a secure and hurricane protected building
    - Servers are stored in a secure room
    - Documents and computers are in the lab with key card control
Changes - Computer Standards (1/3)

- Update of the HURDAT database.
  - C-1, C-2, C-5, C-6
- Update of the ZIP Code Centroids.
  - C-1, C-5, C-6
- Update of the Probability Distribution Functions in the Storm Track Generator.
  - C-1, C-2, C-4, C-5, C-6
- Update of the hurricane marine PBL height in terrain conversion model.
  - C-1, C-2, C-4, C-5, C-6
- Update of Wind Borne Debris Region boundaries.
  - C-1, C-2, C-3, C-4, C-5, C-6
Changes - Computer Standards (2/3)

- Changes in personal residential model (addition of metal roof and metal shutters, implementation of gradation of strong models, increase in window capacities for strong models, change of life cycle duration for roof replacement).
  - C-1, C-2, C-3, C-4, C-5, C-6

- Changes in low rise commercial model (addition of soffit, metal shutters and metal roof; change in debris impact model, rain adjustment factors, costing scheme, window capacities,…)
  - C-1, C-2, C-3, C-4, C-5, C-6
Changes - Computer Standards (3/3)

- Changes in mid/high rise commercial residential model (addition of debris impact zones, option with no sliders, and differentiation between damaged and breached openings; change of opening pressure capacities, external damage costing scheme, interior damage cost coefficient, and number of windows in open layout)
  - C-1, C-2, C-3, C-4, C-5, C-6

- New nomenclature for vulnerability matrices, vulnerability curves, and breach curves.
  - C-1, C-3, C-4, C-5, C-6