Model Overview
• The FPHLM (wind 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 were accepted by the Commission in 2011, 2013, and 2015 respectively.

• The latest version 6.2 was accepted by the Commission in Summer 2017 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: www.cis.fiu.edu/hurricaneloss/

• The source code, however, is not open.
Participating Institutions

- Florida International University/ IHRC (lead institution)
- Florida State University
- Florida Institute of Technology
- Hurricane Research Division, NOAA
- University of Florida
- University of Miami
- AMI Risk Consultants
• About 20 professors and experts and dozens of student assistants were involved in the development and operation of the model.
Current Meteorology Team

- Dr. Steven Cocke  Dept of Meteorology, FSU  Team leader
- Dr. Dong-Wook Shin  Dept of Meteorology, FSU
- Bachir Annane  University of Miami – CIMAS
- Neal Dorst  Hurricane Research Division, NOAA
Current Engineering Team

• Dr. Jean Paul Pinelli* Dept of Civil Engineering, FIT
  Team leader
• Dr. Kurtis Gurley Dept of Civil Eng, UF
• Graduate students
Actuarial/Finance Team

- Dr. Shahid Hamid* Dept of Finance and IHRC, FIU
  PI and Project Director
- Gail Flannery Actuary, FCAS, AMI Risk Consultant
- Bob Ingco Actuary, FCAS, AMI Risk Consultant
Computer Science Team

- Dr. Shu-Ching Chen* School of Computer Science, FIU  
  Co-PI and team leader
- Dr. Mei-Ling Shyu Dept. of Electrical and Computer  
  Engineering, University of Miami
- Raul Garcia Computer Science expert at IHRC
- Diana Machado Computer Science expert at IHRC
- Haiman Tian PhD candidate in CS at FIU
- Samira Poutanfar PhD candidate in CS at FIU
- Maria Presa Reyes PhD student in CS at FIU
- Yudong Tao MS student in CE at UM
- Other graduate and undergraduate students
Statistics Team

• Dr. G. Kibria* Dept. of Statistics, FIU
• Dr. Wensong Wu
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
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.
Start

- Retrieves historical storm data based on user input.
- Generates probability functions for storm motion and intensity.
- Generates initial conditions for the storms.
- Generates storm tracks for simulated storms.

- Estimates the peak wind speed, associated time, and direction for all zip codes within a certain distance from the storm circulation center.
- Generates landfall or bypassing location (i.e. longitude/latitude) of the storm.
- Generates Marine Exposure anywhere in the storm.
- Radial and tangential wind components in the storm.

- Estimates open terrain wind speeds.
- Generates actual terrain wind speeds by using roughness data and gust factors.
- Calculates the probability of three-second gust wind speeds.

- Defines structural types.
- Translates and loads wind speeds.
- Quantifies wind resistance.
- Performs Monte Carlo simulation for external damage.
- Quantifies total damage.

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

Historical Storm Database (HURDAT2)

Stochastic trackfile

Wind Field Model

Wind swaths

Wind Speed Correction Module

Wind speeds

Vulnerability Module

Vulnerabilities

Insured Loss Module

Modeled Losses

End
• In 2013 the state funded FIU to enhance the FPHLM by adding both a storm surge and fresh water flooding component.
• The flood model is being calibrated
Public Hurricane Loss Model v 7.0

Meteorology
Steven Cocke, Florida State University
Bachir Annane, University of Miami
Dong-Wook Shin, Florida State University
Met Components

- Storm Track Generator
  - generates tracks which have position, intensity and storm parameters (e.g., Rmax, B) for duration of storm

- Wind Model
  - generates surface wind field for each storm

- Terrain Adjustment
  - adjust winds to terrain conditions and heights, and determines gusts
Storm Track Generator

- Storm seeds based on historical storms that entered a threat area surrounding Florida and neighboring states

- Initial seed 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 HURDAT2 data, with random perturbations added. PDFs depend on location and current motion or intensity

- 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 of central pressure deficit in time). If storms re-enters water, intensity changes are again resampled from the PDFs derived from HURDAT2.

- Storms seeds are recycled, but with new random perturbations, to generate more than 50,000 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
Model Domain
Sample Stochastic Tracks
Landfall by SS Category and Region
Storm Parameters

- Rmax modeled by Gamma distribution
- Holland B modeled by linear regression with residual fitted by a Gaussian distribution
Landfall decay (based on Vickery et al., 2005)

Frances modeled and observed

Max Wind Speed in MPH

Time Every three hours from 09/05/03Z to 09/06/06Z

Wilma modeled and observed

Max Wind Speed in MPH

Time Every three hours from 10/24/07Z to 10/24/17Z
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.

- Initialized by a vortex in gradient balance with pressure field described by a Holland B pressure profile.

- Mean wind of the slab is converted to a surface wind based on GPS sonde research
Wind Model Validation

Comparison and analysis vs H*Wind

- 1992: Andrew
- 2004: Charley, Frances, Ivan, Jeanne
- 2005: Dennis, Katrina, Rita, Wilma
MODEL VS H*WIND SNAPSHOT

WILMA MODELED

WILMA OBSERVED (H*Wind)
MODEL VS H*WIND SWATH

ANDREW

MODELED

OBSERVED
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 2011 National Land Use / Land Cover and Florida Water Management District data (2004-2011)
Terrain Adjustment

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 at the 10 m reference level.
MET Changes from v6.2 to v7.0

- Storm seeds and motion/intensity change PDFs were updated using a new version of HURDAT2: FPHLM v6.2 used the February 2016 version, while v7.0 uses the May 2018 version.

- ZIP code database was updated: FPHLM v6.2 used the March 2015 version, whereas v7.0 uses the April 2017 version.
Impact of MET Component Changes

HURDAT: +2.34%

Zip Code: +0.002%
Form M-2 Issues

- Form M-2 maps for open terrain exposure have been revised since the original submission.

- In the FPHLM, the surface wind adjustment for terrain exposure depends on the upstream fetch (land cover obstacles upstream), and not simply on the local roughness.

- In the original submission, the open terrain adjustment was based on the assumption that the upstream fetch is open terrain (infinite fetch), even if near the coast. This assumption was described in Disclosure 10 of Standard M-4 in the original submission document.

- This assumption is commonly used in many terrain conversion methods and frequently used in wind analyses, such as H*Wind.
The assumption of infinite fetch is useful for our internal validation of the wind model.

This assumption, however, can lead to results that may seem unexpected, such as actual terrain winds being larger than open terrain winds. This apparent anomaly was described in Disclosure 10 of Standard M-4 in the original submission document.

This apparent anomaly is due to the assumption that winds are more in equilibrium with marine exposure than land exposure near the coast for onshore flow. For marine exposure, roughness is much lower than for land, even for open terrain conditions.
Form M-2 Issues

- At the request of the Pro-Team, we revised the upstream fetch assumption to include marine exposure conditions upstream where appropriate. This is the same assumption that is used for actual terrain adjustments in the FPHLM as shown in Form M-2.

- With the revised assumption, the apparent anomaly is removed, as expected.

- New maps using the revised assumption are provided in the final submission document.

- Both exposure assumptions are useful in certain contexts.

Inserted the following reference on page 106 of the revised document.


Specified the year of the SFBC referred to on page 51 of the revised document.

Miami-Dade and Broward counties adopted the South Florida Building Code (SFBC, 1957) in 1957 and 1961, respectively.

Response inserted on pages 136 and 137 of the revised document:

5. **Describe the process for updating hurricane model ZIP Code-based databases.**

   - The updated ZIP Code data, compliant with Standard G-3.A., is received from the vendor and checked and verified for accuracy and appropriateness. The ZIP Code data include a plain text list of all Florida ZIP Codes and GIS layers for the ZIP Code boundaries. These vendor data are used to calculate various datasets for use in the model:
     2. Population-weighted roughness for each ZIP code.
     3. Distance to coast of each ZIP Code.
     4. Lists of ZIP Codes within the Wind-Borne Debris Region (WBDR). One list based on the 2007 FBC’s definition and another based on the 2010 FBC’s definition.
     5. Classification of coastal/inland for each ZIP Code.
• The GIS ZIP Code layers obtained from the vendor, in combination with U.S. Census block data and the effective roughness model gridded data (See Standard G-1, Disclosure 2), are used to compute the population-based centroids and population-weighted effective roughness for each ZIP Code. Once the centroids are calculated, the distance to coast for each centroid, in each of eight possible upstream wind directions, is then computed.

• Each of the two lists of WBDR ZIP Codes is created by overlaying the map defining the WBDR over the ZIP Code boundaries map from the vendor and selecting the intersection. The list of coastal ZIP Codes is similarly derived from the boundaries map by selecting the ZIP Codes that have some portion of their boundary along the coastline.

• These new data sets are formatted to be read directly by model code. Items (1) through (4) are formatted as files and transferred to dedicated directories for each version on the model’s server platform where software links are used to ensure that the appropriate model components always read the correct version of the files.

• A copy of item (1) is also formatted as a database table as it is item (5), and both are used during the pre-processing applied to data to be used as input to the model. These tables are part of a dedicated database that is used as a template for the creation of new processing databases in order to ensure that the data pre-processing code uses the correct version of the ZIP Code datasets.

Response inserted on page 210 of the revised document:

V1.E. Hurricane vulnerability functions shall be separately derived 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.
4. Forms A-4A.C and D (Appendix G, page 408) and A-4B.C and D (Appendix H, page 429) Non-responsive as a list of ZIP Codes for which there are hurricane loss costs but no exposure or a list of ZIP Codes for which there are no hurricane loss costs but there is exposure are not given or addressed.

Response inserted on Pages 366 and 368 of the revised document:

**Form A-4A**

C. If a modeling organization has hurricane loss costs for a ZIP Code for which there is no exposure, give the hurricane loss costs zero weight (i.e., assume the exposure in that ZIP Code is zero). Provide a list in the submission document of those ZIP Codes where this occurs.

None.

D. If a modeling organization does not have hurricane loss costs for a ZIP Code for which there is some exposure, do not assume such hurricane loss costs are zero, but use only the exposures for which there are hurricane loss costs in calculating the weighted average hurricane loss costs. Provide a list in the submission document of the ZIP Codes where this occurs.

ZIP Code 32653 has exposure but no losses
Form A4B

C. If a modeling organization has hurricane loss costs for a ZIP Code for which there is no exposure, give the hurricane loss costs zero weight (i.e., assume the exposure in that ZIP Code is zero). Provide a list in the submission document of those ZIP Codes where this occurs.

None.

D. If a modeling organization does not have hurricane loss costs for a ZIP Code for which there is some exposure, do not assume such hurricane loss costs are zero, but use only the exposures for which there are hurricane loss costs in calculating the weighted average hurricane loss costs. Provide a list in the submission document of the ZIP Codes where this occurs.

None
Florida Public Hurricane Loss Model
V 7.0

General standards
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 7.0 and the release date is November 1, 2018.

- A summary of the model is provided in the overview.
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.
C. All software and data (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 Standards and shall be located in centralized, model-level file areas.

• All software and data 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.
Changes to the model components

Meteorology component:

• Update to a recent version of HURDAT2 (5/2/2018) which includes storms up through the 2017 hurricane season.
  – The estimated change in statewide loss costs due to the update of HURDAT is 2.44% increase.

• Updated zip code database to the April 2017 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
  (2) population-weighted roughness for each ZIP Code,
  (3) distance to coast of each ZIP Code,
  (4) list of 2007 FBC WBDR ZIP Codes and list of 2010 FBC WBDR ZIP Codes,
  (5) classification of coastal/inland for each ZIP Code.

  -- The estimated change in statewide loss costs due to the update of zip code centroids and the five aforementioned database is 0.002% increase.

Vulnerability component: There are no changes to report.

Other changes: Created the capability to model losses with or without Law and Ordinance coverage.
G-2 Qualifications of Modeling Organization Personnel and Consultants Engaged in Development 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, and evaluated by a multi-disciplinary team of professors and experts in the fields of meteorology, wind and structural engineering, computer science, statistics, finance, 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 hurricane model and hurricane model documentation shall be reviewed by modeling organization personnel or consultants in the following professional disciplines with requisite experience: structural/wind engineering (licensed Professional Engineer), statistics (advanced degree), actuarial science (Associate or Fellow of Casualty Actuarial Society or Society of Actuaries), meteorology (advanced degree), and computer/information science (advanced degree). These individuals shall certify Forms G-1 through G-6, Expert Certification forms, 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.
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 2017. 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.

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 the Hurricane Model Components

The meteorological, vulnerability, and actuarial components of the hurricane 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, 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.
M-1 Base Hurricane Storm Set

- Hurricane frequencies for model validation and calibration based on May 2018 HURDAT2 (1900-2017)
- No trends, weighting, or partitioning are conducted
- Calibration and validation uses the complete base hurricane storm set
- PDFs updated to include new seasons (2016-2017) and HURDAT2 reanalysis of storms (1956-1960).
- Discussed with Pro Team: updates of HURDAT2 including new storms (e.g. Hermine, Matthew and Irma) and revised storms (e.g. Flossy, Donna and Ethel) due to reanalysis. Discussed classification of historical storms for Form M-1 and Form A-2. Discussed classification of the NoName02 1919 storm.
- FPHLM v7.0 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: source of SST and outflow temperature data; motion PDFs based on all HURDAT2 data, not just landfall storms; Holland B distribution.
- FPHLM v7.0 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
- Discussed with Pro Team: No changes in parameter distributions or changes in the process for developing landfall frequency distributions. Reviewed fits of Rmax, Holland B parameter and landfall frequencies.
- FPHLM v7.0 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 and is consistent with 2011 NLCD or later as required.

- Vertical variation of wind speed is used to model losses of multistory buildings

- Discussed with Pro Team: Form M-2 issues (presented in a separate presentation).

- FPHLM v7.0 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: terrain adjustment method, gust factor method, coastal transition function, vertical variation of wind, pressure filling model for overland weakening.
- FPHLM v7.0 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: review of Form M-3.

- FPHLM v7.0 is in compliance with Standard M-6
Florida Public Hurricane Loss Model (FPHLM 7.0)

STATISTICAL STANDARDS

B.M. Golam Kibria and Wensong Wu
Department of Mathematics and Statistics
Florida International University

June 12, 2019
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 and technical literature.

FPFLHM 7.0 is in compliance with Standard S–1A. The historical data for the period 1900–2017 were modeled using scientifically accepted methods that have been published in accepted scientific literature.

B: 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.

FPFLHM 7.0 is in compliance with Standard S–1B. Modeled and historical results are in agreement as indicated by appropriate statistical and scientific tests.
Stochastic Form of Distributions

Stochastic Hurricane Parameters fit to distributions:

- Holland B Error Term – Normal distribution
- $R_{\text{max}}$ : 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 of modeled vs historical occurrences

Comparison of Modeled vs Historical Occurrences

Number of Hurricanes per Year

Occurrences

- Historical
- Modeled
Comparison of modeled vs historical occurrences

- H₀: 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 = 0.512 (DF = 3)

Given the data, the probability of rejecting the true null hypothesis is 0.512. So, we can not reject the null hypothesis at 5% level of significance.
Chi square goodness of fit Test:
\[ p\text{-value} = 0.57 \text{ (DF=8)} \]
Comparison between observed and modeled R Max

Maximum likelihood estimators:  $shape = 4.76 \quad scale = 5.41$

Chi square goodness of fit test: $p$-value$= 0.59$ (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 have taken appropriate action.

FPHLM 7.0 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.)
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 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 7.0 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.)
Standard S–4: County Level Aggregation

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

FPFHM 7.0 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 59,000 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 both 2004 and 2005.

FPHLM 7.0 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.

A sufficient body of data was not available for a formal comparison of modeled and actual commercial residential loss data. Tabular comparison shows reasonable agreement between actual and modeled losses.
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 7.0 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.
### Form S-1: Probability and Frequency of Florida Landfalling Hurricanes Per Year

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<th>Modeled Probability</th>
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<th>Modeled Frequency</th>
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</tr>
</tbody>
</table>
## Form S–2A: Sample Loss Exceedance Estimates (2012 FHCF Exposure Data)

### Part A

<table>
<thead>
<tr>
<th>Return Period (Years)</th>
<th>Annual Probability of Exceedance</th>
<th>Estimated Hurricane Loss Notional Risk Data Set</th>
<th>Estimated Personal and Commercial Residential Hurricane Loss 2012 FHCF Data Set</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top Event</td>
<td>NA</td>
<td>$67,778,216</td>
<td>$107,769,395,534</td>
</tr>
<tr>
<td>10000</td>
<td>0.01%</td>
<td>$55,399,825</td>
<td>$95,455,262,288</td>
</tr>
<tr>
<td>5000</td>
<td>0.02%</td>
<td>$52,538,127</td>
<td>$88,174,464,199</td>
</tr>
<tr>
<td>2000</td>
<td>0.05%</td>
<td>$46,741,923</td>
<td>$80,605,004,869</td>
</tr>
<tr>
<td>1000</td>
<td>0.10%</td>
<td>$42,657,240</td>
<td>$73,498,809,119</td>
</tr>
<tr>
<td>500</td>
<td>0.20%</td>
<td>$37,505,192</td>
<td>$66,703,755,988</td>
</tr>
<tr>
<td>250</td>
<td>0.40%</td>
<td>$33,244,632</td>
<td>$58,556,954,264</td>
</tr>
<tr>
<td>100</td>
<td>1.00%</td>
<td>$26,346,134</td>
<td>$47,740,735,748</td>
</tr>
<tr>
<td>50</td>
<td>2.00%</td>
<td>$21,151,260</td>
<td>$39,349,058,321</td>
</tr>
<tr>
<td>20</td>
<td>5.00%</td>
<td>$14,160,328</td>
<td>$27,095,280,287</td>
</tr>
<tr>
<td>10</td>
<td>10.00%</td>
<td>$8,812,189</td>
<td>$17,603,479,339</td>
</tr>
<tr>
<td>5</td>
<td>20.00%</td>
<td>$3,170,980</td>
<td>$7,119,283,722</td>
</tr>
</tbody>
</table>
## Form S–2A: Sample Loss Exceedance Estimates (2012 FHCF Exposure Data)

### Part B

<table>
<thead>
<tr>
<th></th>
<th>Left 1</th>
<th>Right 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (Total Average Annual Hurricane Loss)</td>
<td>$2,445,577</td>
<td>$4,774,030,155</td>
</tr>
<tr>
<td>Median</td>
<td>$0</td>
<td>$4,414</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>$5,511,137</td>
<td>$10,272,348,323</td>
</tr>
<tr>
<td>Interquartile Range</td>
<td>$1,693,167</td>
<td>$3,577,756,496</td>
</tr>
<tr>
<td>Sample Size</td>
<td>59000</td>
<td>59000</td>
</tr>
</tbody>
</table>
## Form S–2B: Sample Loss Exceedance Estimates (2017 FHCF Exposure Data)

### Part A

<table>
<thead>
<tr>
<th>Return Period (Years)</th>
<th>Annual Probability of Exceedance</th>
<th>Estimated Hurricane Loss Notional Risk Data Set</th>
<th>Estimated Personal and Commercial Residential Hurricane Loss 2017 FHCF Data Set</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top Event</td>
<td>NA</td>
<td>$67,778,216</td>
<td>$110,777,351,135</td>
</tr>
<tr>
<td>10000</td>
<td>0.01%</td>
<td>$55,399,825</td>
<td>$97,631,739,299</td>
</tr>
<tr>
<td>5000</td>
<td>0.02%</td>
<td>$52,538,127</td>
<td>$92,511,230,371</td>
</tr>
<tr>
<td>2000</td>
<td>0.05%</td>
<td>$46,741,923</td>
<td>$85,845,404,739</td>
</tr>
<tr>
<td>1000</td>
<td>0.10%</td>
<td>$42,657,240</td>
<td>$76,669,749,764</td>
</tr>
<tr>
<td>500</td>
<td>0.20%</td>
<td>$37,505,192</td>
<td>$70,811,857,153</td>
</tr>
<tr>
<td>250</td>
<td>0.40%</td>
<td>$33,244,632</td>
<td>$61,689,275,988</td>
</tr>
<tr>
<td>100</td>
<td>1.00%</td>
<td>$26,346,134</td>
<td>$50,517,247,153</td>
</tr>
<tr>
<td>50</td>
<td>2.00%</td>
<td>$21,151,260</td>
<td>$41,596,780,882</td>
</tr>
<tr>
<td>20</td>
<td>5.00%</td>
<td>$14,160,328</td>
<td>$28,798,047,916</td>
</tr>
<tr>
<td>10</td>
<td>10.00%</td>
<td>$8,812,189</td>
<td>$18,763,087,190</td>
</tr>
<tr>
<td>5</td>
<td>20.00%</td>
<td>$3,170,980</td>
<td>$7,472,671,407</td>
</tr>
</tbody>
</table>
Form S–2B: Sample Loss Exceedance Estimates (2017 FHCF Exposure Data)

- **Part B**

<table>
<thead>
<tr>
<th></th>
<th>Mean (Total Average Annual Hurricane Loss)</th>
<th>Median</th>
<th>Standard Deviation</th>
<th>Interquartile Range</th>
<th>Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$2,445,577</td>
<td>$0</td>
<td>$5,511,137</td>
<td>$1,693,167</td>
<td>59000</td>
</tr>
<tr>
<td></td>
<td>$5,037,048,490</td>
<td>$823</td>
<td>$10,844,392,771</td>
<td>$3,707,343,211</td>
<td>59000</td>
</tr>
</tbody>
</table>
## Form S–3 Distributions of Stochastic Hurricane Parameters

<table>
<thead>
<tr>
<th>Stochastic Hurricane Parameter (Function or Variable)</th>
<th>Functional Form of Distribution</th>
<th>Data Source</th>
<th>Year Range Used</th>
<th>Justification for Functional Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rmax</td>
<td>Gamma</td>
<td>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).</td>
<td>1901-2012</td>
<td>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.</td>
</tr>
<tr>
<td>Storm initial location perturbation</td>
<td>Uniform</td>
<td>N/A</td>
<td>N/A</td>
<td>Plausible variations in initial storm locations are assumed to be uniform</td>
</tr>
<tr>
<td>Storm initial motion perturbation</td>
<td>Uniform</td>
<td>N/A</td>
<td>N/A</td>
<td>Plausible variations in initial storm motion are assumed to be uniform</td>
</tr>
<tr>
<td>Storm change in motion and intensity distributions</td>
<td>Empirical</td>
<td>HURDAT</td>
<td>1900-2013</td>
<td>Sampling from historical data See Standard G-1, Disclosure 2 for details</td>
</tr>
</tbody>
</table>
Comparison #1: Hurricane Charley and Company O by Coverage

<table>
<thead>
<tr>
<th>Coverage</th>
<th>Company Actual Loss/Exposure</th>
<th>Modeled Loss/Exposure</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building</td>
<td>0.00764</td>
<td>0.00927</td>
<td>-0.00163</td>
</tr>
<tr>
<td>Contents</td>
<td>0.00007</td>
<td>0.00247</td>
<td>-0.00240</td>
</tr>
<tr>
<td>Appurtenants</td>
<td>0.00107</td>
<td>0.01042</td>
<td>-0.00935</td>
</tr>
<tr>
<td>ALE</td>
<td>0.00025</td>
<td>0.00174</td>
<td>-0.00149</td>
</tr>
<tr>
<td>Total</td>
<td>0.00424</td>
<td>0.00650</td>
<td>-0.00226</td>
</tr>
</tbody>
</table>

Scatter plot for Comparison #1
Comparison #2: Different Companies by Different Hurricanes

<table>
<thead>
<tr>
<th>Company</th>
<th>Event</th>
<th>Company Actual Loss/Exposure</th>
<th>Modeled Loss/Exposure</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>J</td>
<td>Jeanne</td>
<td>0.01370</td>
<td>0.01477</td>
<td>-0.00107</td>
</tr>
<tr>
<td>N</td>
<td>Wilma</td>
<td>0.01201</td>
<td>0.01294</td>
<td>-0.00093</td>
</tr>
<tr>
<td>B</td>
<td>Charley</td>
<td>0.01544</td>
<td>0.01737</td>
<td>-0.00193</td>
</tr>
<tr>
<td>O</td>
<td>Frances</td>
<td>0.00245</td>
<td>0.00450</td>
<td>-0.00205</td>
</tr>
<tr>
<td>O</td>
<td>Charley</td>
<td>0.00424</td>
<td>0.00650</td>
<td>-0.00226</td>
</tr>
</tbody>
</table>

Scatter plot for Comparison #2
Comparison #3: Company O by Hurricane Frances, Charley, Jeanne

<table>
<thead>
<tr>
<th>Company</th>
<th>Event</th>
<th>Company Actual Loss/Exposure</th>
<th>Modeled Loss/Exposure</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>Frances</td>
<td>0.00245</td>
<td>0.00450</td>
<td>-0.00205</td>
</tr>
<tr>
<td>O</td>
<td>Charley</td>
<td>0.00424</td>
<td>0.00650</td>
<td>-0.00226</td>
</tr>
<tr>
<td>O</td>
<td>Jeanne</td>
<td>0.00143</td>
<td>0.00433</td>
<td>-0.00290</td>
</tr>
</tbody>
</table>

Scatter plot for Comparison #3
Comparison #4: Construction Type for Hurricane Charley

<table>
<thead>
<tr>
<th>Construction</th>
<th>Company</th>
<th>Company Actual Loss/Exposure</th>
<th>Modeled Loss/Exposure</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame</td>
<td>B</td>
<td>0.01363</td>
<td>0.01695</td>
<td>-0.00332</td>
</tr>
<tr>
<td>Masonry</td>
<td>B</td>
<td>0.01584</td>
<td>0.01687</td>
<td>-0.00103</td>
</tr>
<tr>
<td>Manufactured</td>
<td>Q</td>
<td>0.05476</td>
<td>0.03724</td>
<td>0.01752</td>
</tr>
<tr>
<td>Other</td>
<td>A</td>
<td>0.01803</td>
<td>0.01450</td>
<td>0.00353</td>
</tr>
</tbody>
</table>
Comparison #5: County wise for Company A and Hurricane Frances

<table>
<thead>
<tr>
<th>County</th>
<th>Company Actual</th>
<th>Modeled</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Loss/Exposure</td>
<td>Loss/Exposure</td>
<td></td>
</tr>
<tr>
<td>Lee</td>
<td>0.000019</td>
<td>0.000025</td>
<td>-0.000007</td>
</tr>
<tr>
<td>Sarasota</td>
<td>0.000122</td>
<td>0.000259</td>
<td>-0.000137</td>
</tr>
<tr>
<td>Collier</td>
<td>0.000031</td>
<td>0.000081</td>
<td>-0.000050</td>
</tr>
<tr>
<td>Madison</td>
<td>0.000924</td>
<td>0.000994</td>
<td>-0.000070</td>
</tr>
<tr>
<td>Manatee</td>
<td>0.000262</td>
<td>0.000465</td>
<td>-0.000203</td>
</tr>
</tbody>
</table>

Scatter plot for Comparison #5
Commercial Residential

Comparison # 1: Company D and Q by Hurricane Jeanne, Katrina, and Wilma

<table>
<thead>
<tr>
<th>Company</th>
<th>Company Actual</th>
<th>Modeled</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Event</td>
<td>Loss/Exposure</td>
<td>Loss/Exposure</td>
</tr>
<tr>
<td>D</td>
<td>Jeanne</td>
<td>0.00716</td>
<td>0.01470</td>
</tr>
<tr>
<td>D</td>
<td>Katrina</td>
<td>0.00183</td>
<td>0.00714</td>
</tr>
<tr>
<td>D</td>
<td>Wilma</td>
<td>0.01555</td>
<td>0.01243</td>
</tr>
<tr>
<td>Q</td>
<td>Wilma</td>
<td>0.02579</td>
<td>0.01108</td>
</tr>
</tbody>
</table>

Scatter plot for Comp
The 95% confidence interval between the mean of historical and modeled losses is between -1.19 and 2.60 billion dollars. Since the interval contains 0, we are 95% confident that there is no significant difference between the historical and the modeled losses.
The 95% confidence interval between the mean of historical and modeled losses is between -1.26 and 2.77 billion dollars. Since the interval contains 0, we are 95% confident that there is no significant difference between the historical and the modeled losses.
Florida Public Hurricane Loss Model

Personal Residential Model
FPHLM
Model Components

Determine types

Translate wind speed into loads

Quantify wind resistance

Monte Carlo Simulation

Quantify damages

Overview slide 2
Sampling Plan
(Surveyed Counties and Regions)

Property Appraiser Data Bases
- Varies from county to county
- 67 Counties were contacted
- Statistical Survey on 51 Counties
  - Yellow: 2014 tax roll
  - Green: pre-2014
- Population Coverage: 97%
- Statistical Data in Regional and County Level
- Statistical Data inside each Era
## Resulting Classification

<table>
<thead>
<tr>
<th>Roof Cover</th>
<th>Roof Type</th>
<th>Exterior Wall</th>
<th>Number of Story</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shingle</td>
<td>Gable</td>
<td>Wood frame</td>
<td>1</td>
</tr>
<tr>
<td>Tile - Metal</td>
<td>Hip</td>
<td>Masonry</td>
<td>2</td>
</tr>
<tr>
<td>Others</td>
<td>Other</td>
<td>Other</td>
<td>more</td>
</tr>
</tbody>
</table>

Overview slide 4
Model Components

- Determine types
- Translate wind speed into loads
- Quantify wind resistance
- Quantify damages

Monte Carlo Simulation

Overview slide 5
Wind Speed $\rightarrow$ Wind Load

- Translate wind speed to the pressures and forces on the building
Component Wind Loads

Input
Discrete 3 sec wind speed (e.g. V = 110 mph)

Output
Component loads/pressures (e.g. one sheathing panel)

• Sources:
  – Wind load provisions in code
  – Directional modifications
  – Full scale measurement

• Influences:
  – Building shape
  – Wind direction
Model Components

- Determine types
- Translate wind speed into loads
- Quantify wind resistance

Monte Carlo Simulation

Quantify damages

Overview slide 8
Component Resistance to Wind

- For each structural type
  - Identify major components
  - Model the capacity of each component
  - Determine Load Paths
Residential Components

- Type: e.g., Concrete Block, Gable Roof
- 5 Selected components
  - Roof cover
  - Roof sheathing
  - Roof to Wall Connections
  - Walls (frame, masonry)
  - Openings
Model Components

- Determine types
- Translate wind speed into loads
- Quantify wind resistance

Monte Carlo Simulation

% Quantify damages
Monte Carlo Simulation Engine

**INPUT**
Random 3 sec wind speed (e.g. V = 110 mph With COV = 0.1)

**LOAD:** Modified Pressure Coefficients from ASCE 7 Randomized

**DAMAGE**
Random component capacities

Overview slide 12
Damage Prediction

• Damage Matrix for:
  – Each structural type
  – Wind speeds 50 – 250 mph in steps of 5 mph
  – Eight wind directions
Example Damage Matrix

- Partial sample of an output file for a concrete block home, in South FL, with a gable roof, and no hurricane shutters, subjected to a 150 mph 3-sec wind gust at an angle of 45 degrees
Model Components

Determine types

Translate wind speed into loads

Quantify wind resistance

Monte Carlo Simulation

Quantify damages

Overview slide 15
Cost Estimation Model

• From the Damage Matrices
  – Convert modeled physical damages into monetary damages
  – Define the vulnerability of different homes types
  – Provide a logical method for prediction damage to other coverage’s
  – Validate the damage predictions
  – Input from experts (adjusters, etc.)
Different Types of Damage

Stage 1
Exterior Damage
Building Damage
Appurtenant Damage

Stage 2
Interior Damage
Utilities Damage

Stage 3
Contents Damage
Additional Living Expenses

Overview slide 17
Vulnerability Matrices

- Model Type - Specific to each Monte Carlo model (36 models) plus additional considerations for each (6*36 = 216)

<table>
<thead>
<tr>
<th>Damage\Wind Speed (mph)</th>
<th>48.5 to 52.5</th>
<th>52.5 to 57.5</th>
<th>57.5 to 62.5</th>
<th>62.5 to 67.5</th>
<th>67.5 to 72.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>0% to 2%</td>
<td>1</td>
<td>0.99238</td>
<td>0.91788</td>
<td>0.77312</td>
<td>0.61025</td>
</tr>
<tr>
<td>2% to 4%</td>
<td>0</td>
<td>0.00725</td>
<td>0.0805</td>
<td>0.21937</td>
<td>0.36138</td>
</tr>
<tr>
<td>4% to 6%</td>
<td>0</td>
<td>0.000375</td>
<td>0.001375</td>
<td>0.007</td>
<td>0.0235</td>
</tr>
<tr>
<td>6% to 8%</td>
<td>0</td>
<td>0</td>
<td>0.000125</td>
<td>0.000375</td>
<td>0.0025</td>
</tr>
<tr>
<td>8% to 10%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.000375</td>
</tr>
<tr>
<td>10% to 12%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.000375</td>
</tr>
<tr>
<td>12% to 14%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.000625</td>
</tr>
<tr>
<td>14% to 16%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.0005</td>
</tr>
<tr>
<td>16% to 18%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.000125</td>
</tr>
<tr>
<td>18% to 20%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.000125</td>
</tr>
<tr>
<td>20% to 24%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.00025</td>
</tr>
<tr>
<td>24% to 28%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Weighted Matrices

Insurance Portfolio
Location: Define region and sub region.
Year Built: use as proxy for Strength (Weak, Medium, Strong).
Type of exterior wall.

- Roof shape, roof cover, number of stories, and opening protection options are undefined.

- The weighted matrices are the sum of the corresponding vulnerability model matrices weighted on the basis of the statistical distributions;

- The user has the option to predict the type of the building (use non_weighted) or use weighted matrices.
Mapping of Vulnerabilities to Insurance Policies

case 1 is the case where all parameters are known

<table>
<thead>
<tr>
<th>Insurance Portfolio Data</th>
<th>Year Built</th>
<th>Exterior Wall</th>
<th>Vulnerability Matrix</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Case 2</strong></td>
<td>known</td>
<td>Known or unknown</td>
<td>use <strong>weighted</strong> matrix or replace all unknown and other randomly based on stats and use <strong>un-weighted</strong> matrix</td>
</tr>
<tr>
<td><strong>Case 3</strong></td>
<td>known</td>
<td>other</td>
<td>use the <strong>other weighted</strong> matrix</td>
</tr>
<tr>
<td><strong>Case 4</strong></td>
<td>unknown</td>
<td>known</td>
<td>use <strong>age weighted</strong> matrix or replace all unknown and other randomly based on stats and use <strong>un-weighted</strong> vulnerability matrix</td>
</tr>
<tr>
<td><strong>Case 5</strong></td>
<td>unknown</td>
<td>other</td>
<td>Use <strong>other age weighted</strong> matrix</td>
</tr>
</tbody>
</table>

Note: in cases 2 to 5 the attributes for # of stories, roof shape, roof cover, & opening protection are in any combination of known, unknown or other.
Mitigation

• The model has the capacity to model different mitigation measures either individually or in combinations
Florida Public Hurricane Loss Model

Commercial Residential Model
FPHLML

Low-Rise
Low-rise commercial residential: 1-3 stories mainly apartment buildings
Low-rise Modeling

• **Low-rise buildings** are very similar to single-family-homes
  – Can be categorized in a few typical generic buildings
  – Can suffer substantial external structural damage (in addition to envelope and interior damage) including complete collapse
  – Modeling approach is similar to single family homes: **the building is modeled as a whole**
Low-Rise Buildings

Components

- Type: e.g., Concrete Block, Gable Roof
- Selected components
  - Roof cover
  - Roof sheathing
  - Overhang
  - Gable end trusses
  - Roof to wall connections
  - Wall covering
  - Wall sheathing
  - Openings: windows, sliding doors, entry doors
  - Soffits
Florida Public Hurricane Loss Model

Commercial Residential Model
FPHLM
Mid/High-Rise
Variety of mid/high-rise buildings: 4+ stories
mainly condominium buildings

Overview slide 27
Mid-rise Modeling

- **Mid-rise buildings** are very different from single-family-homes
  - They are highly variable in shape, height, material, etc.
  - Cannot be categorized in a few generic building types
  - Engineered structures that suffer little external structural damage and are unlikely to collapse
  - Can suffer extensive cladding and opening damage leading to water penetration and interior damage
  - FPHLM adopts a modular approach: the building is treated as a collection of apartment units
Mid-high rise buildings characterization

Closed Building

Open Building
MHRB
Modular Unit Components

- Type: e.g., Enclosed building, Corner Unit, No shutters, 6 windows
- Selected components
  - Windows
  - Entry Door
  - Sliding Door
- Action
  - Pressure
  - Impact
- State
  - undamaged
  - Damaged but not breached
  - Damaged and breached
Florida Public Hurricane Loss Model

Vulnerability Model Changes
Changes

- Created the capability to model losses with or without Law and Ordinance coverage
  - The capability to model losses with and without Law and Ordinance coverage was required in order to complete the Actuarial forms in compliance with the ROA instructions.
Standard V-1
Derivation 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 at least one of the following: (1) insurance claims data, (2) laboratory or field testing, (3) rational structural analysis, and (4) post-event site investigations. Any development of the building hurricane vulnerability functions based on rational structural analysis, post-event site investigations, and laboratory or field testing shall be supported by historical data.

The development of the vulnerabilities is based on a component approach that combines engineering modeling, simulations with engineering judgment, and insurance claim 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, and are calibrated and validated against insurance claim data. The internal and content damage are extrapolated from the external damage on the basis of expert opinion and site inspections of areas impacted by recent hurricanes and are confirmed using insurance claims data.
Florida Public Hurricane Loss Model

Standard V-1

B. The derivation of the building hurricane 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 buildings.

A detailed exposure study was carried out to define the most prevalent construction types and characteristics in the Florida residential building stock. 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.
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 derivation 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.
E. Hurricane vulnerability functions shall be separately derived 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.
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.
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, 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 wind pressure, missile impact and water infiltration.
Florida Public Hurricane Loss Model

Standard V-2
Derivation of Contents and Time Element Hurricane Vulnerability Functions
A. Development of the contents and time element hurricane vulnerability functions shall be based on at least one of the following: (1) insurance claims data, (2) tests, (3) rational structural analysis, and (4) post-event site investigations. Any development of the contents and time element hurricane vulnerability functions based on rational structural analysis, post-event site investigations, and tests shall be supported by historical data.

The development of the vulnerabilities is based on a component approach that combines engineering modeling, simulations with engineering judgment, and insurance claims data. The content and time element vulnerabilities are extrapolated from the building damage on the basis of expert opinion and post-events site investigations of areas impacted by recent hurricanes and are confirmed using historical claims data.
Florida Public Hurricane Loss Model

Standard V-2

B. *The relationship between the modeled building and contents hurricane vulnerability functions and historical building and contents hurricane 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.
Florida Public Hurricane Loss Model

Standard V-2

C. Time element hurricane 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.
D. The relationship between the hurricane model building, contents, and time element hurricane vulnerability functions and historical building, contents, and time element hurricane losses shall be reasonable.

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

For Commercial Residential risks the relationship between modeled structure and time element loss costs is reasonable. Since no historical loss data were available for calibration, the relationship combines engineering and actuarial judgment.
E. Time element hurricane vulnerability functions used by the hurricane model shall include time element hurricane losses associated with wind, missile impact, flood, and storm surge damage to the infrastructure caused by a hurricane.

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 claims data that include both types of losses. For Commercial Residential risks the recognition of claims due to indirect loss is based on judgment since no historical loss data were available for calibration.
Florida Public Hurricane Loss Model

Standard V-3
Mitigation Measures
Florida Public Hurricane Loss Model

Standard V-3

A. Modeling of hurricane mitigation measures to improve a building’s hurricane wind resistance, the corresponding effects on hurricane vulnerability, and their 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 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 building’s hurricane wind resistance, the corresponding effects on vulnerability, and their associated uncertainties is theoretically sound and consistent with fundamental engineering principles.
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.
B. 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.

Application of mitigation measures are justified, as they reduce damage relative to the reference case individually, and compound the reduction of damage in combination.
Florida Public Hurricane Loss Model

Standard V-3

C. **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, as they reduce damage relative to the reference case individually, and compound the reduction of damage in combination.
Florida Public Hurricane Loss Model

Response to Commission issues

Reference Document: FPM Deficiency Letter 17 Standards
January 7, 2019
Florida Public Hurricane Loss Model

Commission Issues

1. For Standard V-1, Audit item 7, how the county as well as statewide building codes are reflected in the model vulnerability functions.

2. For Standard V-1, Audit item 9, how the building codes are reflected in the model vulnerability functions, including whether current statewide and county building codes are incorporated.

3. Justification if the high-velocity hurricane zone included in the statewide Florida Building Code is not reflected in the model vulnerability functions.

5. Form A-6, Building Code/Enforcement (Year Built) Sensitivities, in particular for Manufactured Homes.
Building Classifications

Over time, engineers and builders learned more about the interaction between wind and structures. More stringent building codes were enacted, which resulted in stronger structures. The weak, medium, and strong models represent this evolution of quality of construction in Florida. Each set of models is representative of the prevalent wind vulnerability of buildings for a certain historical period. It is therefore important to define the cut-off dates between the different periods since the overall aggregate losses in any region are determined as a mixture of homes of various strengths (ages). The cut-off dates depend on the evolution of the building code as well as the prevailing local code enforcement.

Revisions to the FBC are monitored for changes that would influence future model developments.

Table 1. Weak and Medium Models

Table 2. Strong Models
This issue of code enforcement has also evolved over time, and the State of Florida took an active role in uniform enforcement relatively recently. Thus, a given county may have built to standards that were worse than or better than the code in place at the time. After consulting with building code development experts, the team concluded that the load provisions have had some wind provisions since at least the 1970s. The classifications shown in Table 27 were adopted for characterizing the regions by age and model. The specific building eras and classifications per region are based on the evolution of the building codes in Florida and the opinions of the experts consulted. The strength descriptions within Table 27 are provided at the bottom of Table 27 in terms of the nomenclature used in Table 1 and Table 2 (Standard G-1).

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>HVHZ</td>
<td>¼ Weak, ¼ Medium</td>
<td>¼ Weak, ½ modified Medium</td>
<td>½ Weak, ½ modified Medium</td>
<td>½ Weak, ¾ modified Medium</td>
<td>Modified Strong</td>
<td>Modified Strong</td>
</tr>
<tr>
<td>Keys</td>
<td>½ modified Weak, ½ Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>¾ Medium ¾ Strong OP</td>
<td>Strong OP</td>
</tr>
<tr>
<td>WBDR</td>
<td>modified Weak</td>
<td>¼ Weak, ¾ Medium</td>
<td>¼ Weak, ¾ Medium</td>
<td>½ Weak, ¾ Medium</td>
<td>½ Medium, ½ Strong OP</td>
<td>Strong OP</td>
</tr>
<tr>
<td>Inland</td>
<td>modified Weak</td>
<td>¼ Weak, ¾ Medium</td>
<td>½ Weak, ½ Medium</td>
<td>½ Weak, ½ Medium</td>
<td>½ Medium, ½ Strong</td>
<td>Strong</td>
</tr>
</tbody>
</table>

Table 27 Nomenclature with respect to Table 1 and Table 2.

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

Table 27. Age classification of the models per region.
3. Justification if the high-velocity hurricane zone included in the statewide Florida Building Code is not reflected in the model vulnerability functions.

The high-velocity hurricane zone included in the statewide Florida Building Code is reflected in the model vulnerability functions, as shown in the previous slides.
<table>
<thead>
<tr>
<th>INDIVIDUAL HURRICANE MITIGATION MEASURES AND SECONDARY CHARACTERISTICS</th>
<th>MEAN DAMAGE RATIO</th>
<th>HURRICANE LOSS COSTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FRAME BUILDING</td>
<td>MASONRY BUILDING</td>
</tr>
<tr>
<td></td>
<td>WIND SPEED (MPH)</td>
<td>WIND SPEED (MPH)</td>
</tr>
<tr>
<td>REFERENCE BUILDING</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BRACED GABLE ENDS</td>
<td>6% 15% 39% 56% 67%</td>
<td>6% 14% 35% 47% 62%</td>
</tr>
<tr>
<td>HIP ROOF</td>
<td>6% 14% 37% 50% 64%</td>
<td>6% 13% 34% 44% 59%</td>
</tr>
<tr>
<td>METAL</td>
<td>6% 14% 39% 56% 67%</td>
<td>6% 14% 35% 47% 62%</td>
</tr>
<tr>
<td>ASTM D7158 CLASS H SHINGLES</td>
<td>6% 14% 39% 56% 67%</td>
<td>6% 14% 35% 47% 62%</td>
</tr>
<tr>
<td>MEMBRANE</td>
<td>6% 9% 38% 60% 67%</td>
<td>6% 14% 35% 47% 62%</td>
</tr>
<tr>
<td>NAILING OF DECK 84</td>
<td>6% 9% 38% 60% 67%</td>
<td>6% 14% 35% 47% 62%</td>
</tr>
<tr>
<td>CLIPS</td>
<td>6% 15% 37% 48% 59%</td>
<td>6% 14% 35% 43% 54%</td>
</tr>
<tr>
<td>STRAPS</td>
<td>6% 15% 37% 46% 51%</td>
<td>6% 14% 35% 43% 53%</td>
</tr>
<tr>
<td>TIES OR CLIPS</td>
<td>6% 15% 38% 34% 63%</td>
<td>- - - - - -</td>
</tr>
<tr>
<td>STRAPS</td>
<td>6% 15% 37% 33% 64%</td>
<td>- - - - - -</td>
</tr>
<tr>
<td>WALL FLOOR STRENGTH</td>
<td></td>
<td></td>
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<tr>
<td>LARGER OR CLOSER SPACING</td>
<td>- - - - - -</td>
<td>- - - - - -</td>
</tr>
<tr>
<td>ANCHORS</td>
<td>- - - - - -</td>
<td>- - - - - -</td>
</tr>
<tr>
<td>STRAP</td>
<td>- - - - - -</td>
<td>- - - - - -</td>
</tr>
<tr>
<td>VERTICAL REINFORCING</td>
<td>- - - - - -</td>
<td>- - - - - -</td>
</tr>
<tr>
<td>WINDOW PROTECTION</td>
<td></td>
<td></td>
</tr>
<tr>
<td>STRUCT WOOD</td>
<td>6% 14% 36% 55% 67%</td>
<td>6% 14% 32% 46% 61%</td>
</tr>
<tr>
<td>METAL</td>
<td>6% 14% 35% 54% 66%</td>
<td>6% 14% 31% 44% 61%</td>
</tr>
<tr>
<td>DOOR AND SKYLIGHT COVERS</td>
<td>6% 15% 38% 56% 66%</td>
<td>6% 14% 33% 45% 61%</td>
</tr>
<tr>
<td>HURRICANE MITIGATION MEASURES AND SECONDARY CHARACTERISTICS IN COMBINATION</td>
<td>FRAME BUILDING</td>
<td>MASONRY BUILDING</td>
</tr>
<tr>
<td>HURRICANE LOSS COSTS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACROSS ALL WINDSPEEDS</td>
<td>$10,813</td>
<td>$10,511</td>
</tr>
</tbody>
</table>
### Form V-5: Differences in Hurricane Mitigation Measures and Secondary Characteristics, Mean Damage Ratios and Hurricane Loss Costs

#### Differences from Form V-3 Relative to Previously-Accepted Hurricane Model

<table>
<thead>
<tr>
<th>Individual Hurricane Mitigation Measures and Secondary Characteristics</th>
<th>Mean Damage Ratio</th>
<th>Hurricane Loss Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frame Building</td>
<td>Masonry Building</td>
</tr>
<tr>
<td></td>
<td>Windspeed (MPH)*</td>
<td>Windspeed (MPH)*</td>
</tr>
<tr>
<td></td>
<td>60  85  110  135  160</td>
<td>60  85  110  135  160</td>
</tr>
<tr>
<td>Reference Building</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Braced Gable Ends</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hip Roof</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASTM D7158 Class H Shingles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Membrane</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nailing of Deck 8d</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clips</td>
<td></td>
<td></td>
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<tr>
<td>Straps</td>
<td></td>
<td></td>
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<tr>
<td>Ties or Clips</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Straps</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Larger Anchors or Closer Spacing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vertical Reinforcing</td>
<td></td>
<td></td>
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<tr>
<td>Window Shutters Structural Wood Panel</td>
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<td></td>
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<tr>
<td>Metal</td>
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<tr>
<td>Door and Skylight Covers</td>
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<tr>
<td>Windows Impact Rated</td>
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<tr>
<td>Entry Doors MEETS WIND-BORNE DEBRIS REQUIREMENTS</td>
<td></td>
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<tr>
<td>Garage Doors MEETS WIND-BORNE DEBRIS REQUIREMENTS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sliding Glass Doors MEETS WIND-BORNE DEBRIS REQUIREMENTS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mitigated Building</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Across all windspeeds</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Percentage Change from Form V-3 Relative to Previously-Accepted Hurricane Model

<table>
<thead>
<tr>
<th>Hurricane Mitigation Measures and Secondary Characteristics in Combination</th>
<th>Mean Damage Ratio</th>
<th>Hurricane Loss Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frame Building</td>
<td>Masonry Building</td>
</tr>
<tr>
<td></td>
<td>Windspeed (MPH)*</td>
<td>Windspeed (MPH)*</td>
</tr>
<tr>
<td></td>
<td>60  85  110  135  160</td>
<td>60  85  110  135  160</td>
</tr>
<tr>
<td>Mitigated Building</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Across all windspeeds: $0.169 \quad 0.165$
Proteam Review

Timber vs Masonry vs MH in Form A-6

<table>
<thead>
<tr>
<th>Location</th>
<th>County</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BAY</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Location</th>
<th>County</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BAY</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Location</th>
<th>County</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BAY</td>
</tr>
</tbody>
</table>

Percent change manuf ➔ timber = 42%   ratio 1.42
Percent change manuf ➔ masonry = 45%

February 2019

61
# Timber vs Masonry vs MH in Form A-6

## Proteam Review

### Percent Change

#### Masonry owner

<table>
<thead>
<tr>
<th>Location</th>
<th>County</th>
<th>Hurricane Loss Cost per Year Built</th>
<th>Ratios Relative to 1980</th>
</tr>
</thead>
<tbody>
<tr>
<td>28</td>
<td>MONROE</td>
<td>19.972, 11.313, 5.487</td>
<td>1.000, 0.566, 0.275</td>
</tr>
</tbody>
</table>

Percent change manuf ➔ timber = 64% ratio 1.64

#### Frame owner

<table>
<thead>
<tr>
<th>Location</th>
<th>County</th>
<th>Hurricane Loss Cost per Year Built</th>
<th>Ratios Relative to 1980</th>
</tr>
</thead>
<tbody>
<tr>
<td>28</td>
<td>MONROE</td>
<td>21.579, 12.281, 6.637</td>
<td>1.000, 0.569, 0.308</td>
</tr>
</tbody>
</table>

Percent change manuf ➔ masonry = 99%

#### Manuf home

<table>
<thead>
<tr>
<th>Location</th>
<th>County</th>
<th>Hurricane Loss Cost per Year Built</th>
<th>Ratios Relative to 1980</th>
</tr>
</thead>
<tbody>
<tr>
<td>28</td>
<td>MONROE</td>
<td>85.112, 85.112, 10.896</td>
<td>1.000, 1.000, 0.128</td>
</tr>
</tbody>
</table>

February 2019
Claims data: frame vs post 94 MH

- A_Charley
- A_Frances
- A_Jeanne
- B_Jeanne
- C_Charley
- C_Dennis
- C_Francis
- C_Katrina
- C_Wilma
<table>
<thead>
<tr>
<th>Exposure</th>
<th>ActualLoss</th>
<th>LossCost/1000</th>
<th>Exposure</th>
<th>ActualLossCost</th>
<th>LossCost/1000</th>
</tr>
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<tbody>
<tr>
<td>$13,328,700.00</td>
<td>$2,118,626.00</td>
<td>$158.95</td>
<td>$4,803,980.00</td>
<td>$656,019.00</td>
<td>$136.56</td>
</tr>
<tr>
<td>$30,499,748.40</td>
<td>$3,763,630.00</td>
<td>$123.40</td>
<td>$3,360,550.00</td>
<td>$374,630.00</td>
<td>$111.48</td>
</tr>
<tr>
<td>$15,830,535.00</td>
<td>$1,641,375.00</td>
<td>$103.68</td>
<td>$6,402,600.00</td>
<td>$577,343.00</td>
<td>$90.17</td>
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<tr>
<td>$8,513,000.00</td>
<td>$235,685.00</td>
<td>$27.69</td>
<td>$67,717,852.60</td>
<td>$5,212,385.00</td>
<td>$76.97</td>
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<tr>
<td>$1,883,845,355.50</td>
<td>$139,931,037.91</td>
<td>$74.28</td>
<td>$18,376,945.00</td>
<td>$2,204,214.00</td>
<td>$119.94</td>
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<td>$845,334,358.50</td>
<td>$25,574,431.54</td>
<td>$30.25</td>
<td>$2,334,310.00</td>
<td>$112,009.62</td>
<td>$47.98</td>
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<tr>
<td>$3,068,253,716.90</td>
<td>$204,703,810.09</td>
<td>$66.72</td>
<td>$15,933,258.00</td>
<td>$1,059,772.73</td>
<td>$66.51</td>
</tr>
<tr>
<td>$74,292,371.50</td>
<td>$1,964,582.98</td>
<td>$26.44</td>
<td>$168,300.00</td>
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<td>$1,378,097.53</td>
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</tr>
</tbody>
</table>
Law & Ordinance– Actuarial

FPHLM

June 2019
**Exposure categories - Owners**

<table>
<thead>
<tr>
<th>Weak Frame 1-Story</th>
<th>Weak Frame 2-Story</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weak Masonry 1-Story</td>
<td>Weak Masonry 2-Story</td>
</tr>
<tr>
<td>Medium Frame 1-Story</td>
<td>Medium Frame 2-Story</td>
</tr>
<tr>
<td>Medium Masonry 1-Story</td>
<td>Medium Masonry 2-Story</td>
</tr>
</tbody>
</table>

Factors vary by wind speed: $WS = \text{wind speed (3 sec gust)}$

For each exposure category:

$$\text{Factor}_{WS} = \frac{\text{Mean Damage Ratio Excl L&O}_{WS}}{\text{Mean Damage Ratio Incl L&O}_{WS}}$$
Factors to Remove L&O

- weak frame 1-story
- weak masonry 1-story
- medium frame 1-story
- medium masonry 1-story
- weak frame 2-story
- weak masonry 2-story
- medium frame 2-story
- medium masonry 2-story
Factors to Remove L&O – Frame vs Masonry
Factors to Remove L&O – Weak vs Medium
Effect of Law & Ordinance

- The higher the wind, the less influence the L&O will have, because for higher winds, the damage will be close to 100% anyway, so the difference between actual physical damage and mandated repair by L&O will be smaller, ultimately it will be zero.

- By the same token, all other things being equal, the L&O for medium will have more influence than for weak at high wind speeds, because medium is expected to have less physical damage, so the difference between actual physical damage and mandated repair by L&O will be greater.

- This is verified by the numbers. The adjustment factors for medium, starting at 120 mph, are smaller than for weak, for both timber and masonry, with a difference of almost 10% at 155 mph.

- Likewise, if we compare masonry vs. timber, the adjustment factor is also smaller for masonry (less physical damage) than for timber (more physical damage), starting around 140 mph, for both weak and medium.

- At low wind speeds, between 85 mph and 120 to 140 mph, the reverse is true: masonry has less L&O adjustment (larger factor) than timber, and likewise between medium and weak. It has to do with the type and extent of damage at these low wind speeds. At low wind speeds very little damage is expected from a medium model roof, and if the roof is not damaged above the threshold, it does not activate the L&O, so less adjustment is needed for medium than for weak. Similar reasoning applies to timber vs frame.
## Reduction in Damage with L&O Removed

### 3-sec gust =======> 55 60 65 70 75 80 85 90 95 100

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<th>55</th>
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</tbody>
</table>
$0 Deductible Loss Costs
V7.0 (w/o L&O) vs v6.3(with L&O)
2012 Cat Fund, Form A-4A

Owners Frame: -1.41% Statewide
Owners Masonry -1.06% Statewide

Largest Reductions: Monroe
Owners Frame -5.37%
Owners Masonry -5.57%

Number of Counties with reductions of less than 1%:
Owners Frame 50
Owners Masonry 53
# Impact on Output Ranges - L&O Removal By County  >1% Reduction in Loss Costs

<table>
<thead>
<tr>
<th>Owners Frame</th>
<th>Owners Masonry</th>
</tr>
</thead>
<tbody>
<tr>
<td>MONROE</td>
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<tr>
<td>MARTIN</td>
<td>MARTIN</td>
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<tr>
<td>PALM BEACH</td>
<td>OKALOOSA</td>
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<td>FRANKLIN</td>
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Updated A-Forms

A-Forms that were updated to exclude L&O:

A-1
A-4A, A-4B  (Also A-4 from the prior submission v6.2)
A-5
A-6  (Also A-6 from the prior submission v6.2)
A-7
Other Changes

- The PR input record was modified to identify whether exposures include or exclude L&O.

- Checked the loss cost changes from v6.2 as stated in Standard G-1, Disclosure 5.B

  Impact of all changes combined:   2.44% ➔ 2.43%
  Impact of HURDAT2 update:       2.35% ➔ 2.34%

- No change in anomalies.
Florida Public Hurricane Loss Model
Version 7.0
Actuarial Standards
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 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 standpoint.

(continued on next slide)
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
A. Modeled hurricane loss costs and hurricane 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.

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

The procedure for distinguishing wind–related hurricane losses from other peril losses is documented.

THE MODEL SATISFIES STANDARD A–2
A. The methods used in the calculation of building hurricane loss costs 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.

(continued on next slide)
B. The methods used in the calculation of appurtenant structure hurricane loss costs shall be actuarially sound.

The Personal Residential vulnerability matrix for appurtenant structures 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.

(continued on next slide)
The methods used in the calculation of contents hurricane 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.

(continued on next slide)
The methods used in the calculation of time element hurricane loss costs shall be actuarially sound.

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

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

THE MODEL SATISFIES STANDARD A–3
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 PML’s.

B. Hurricane loss cost projections and hurricane 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. Hurricane loss cost projections and hurricane probable maximum loss levels shall not include any explicit provision for direct hurricane storm surge losses.

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

D. Hurricane loss cost projections and hurricane 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)
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.

(continued on next slide)
Model assumes demand surge is a function of:

- Coverage
- Region
- A storm’s statewide damages (before DS).

(continued on next slide)
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)
General Approach

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

THE MODEL SATISFIES STANDARD A–4
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.
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 From 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 of storms, 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.

THE MODEL SATISFIES STANDARD A–5
A. The methods, data, and assumptions used in the estimation of hurricane 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 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 Output 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.

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 zip codes. See Form A–1.

(continued on next slide)
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 decrease as the quality of construction increases, all other factors held constant. See Form A–1 and A–6.

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.

(continued on next slide)
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.
Standard A–6
Hurricane Loss Output and Logical Relationships to Risk

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.

(continued on next slide)
I. The relationship of hurricane loss costs for individual coverages, (e.g., building, 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.

(continued on next slide)
Standard A–6
Hurricane Loss Output and Logical Relationships to Risk

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

Output ranges are logical as detailed below.
Apparent anomalies at the county level in Form A–4 can be resolved at the zip code/year built level.

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

1. masonry construction versus frame construction,

Output ranges reflect lower loss costs for masonry versus frame construction.

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

Output ranges reflect lower loss costs for site-built versus manufactured home exposure.

3. *inland counties versus coastal counties,* and

Output ranges reflect lower loss costs for inland counties versus coastal counties.

4. *northern counties versus southern counties.*

Output ranges reflect lower loss costs for northern counties versus southern counties.

(continued on next slide)
5. **Newer construction versus older construction.**

Output ranges reflect lower loss costs for newer construction versus older construction. See Form A–6.

(continued on next slide)
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 model’s assumptions concerning construction characteristics, policy provisions, coinsurance and contractual provisions are appropriate based on the type of risk modeled.

THE MODEL SATISFIES STANDARD A–6
V7.0 FLORIDA PUBLIC HURRICANE LOSS MODEL
COMPUTER/INFORMATION STANDARDS

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CI-1 HURRICANE MODEL DOCUMENTATION

• Primary document repository documents
  • Model structure and functionality
  • Model software components
    • Documentation follows current model development and software engineering practices.
  • Changes made to the model
    • From the previously-accepted model
    • Since this year’s initial submission
  • List of externally acquired model-specific software and data assets currently in use

• Computer software is consistently documented and dated.
  • FPHLM v7.0 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 v7.0 is in compliance with Standard CI-2.
CI-3 HURRICANE MODEL ARCHITECTURE 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 v7.0 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
  • 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 v7.0 is in compliance with Standard CI-4.
• 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 v7.0 is in compliance with Standard CI-5.
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 v7.0 is in compliance with Standard CI-6.
CI-7 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 back-ups 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 v7.0 is in compliance with Standard CI-7.