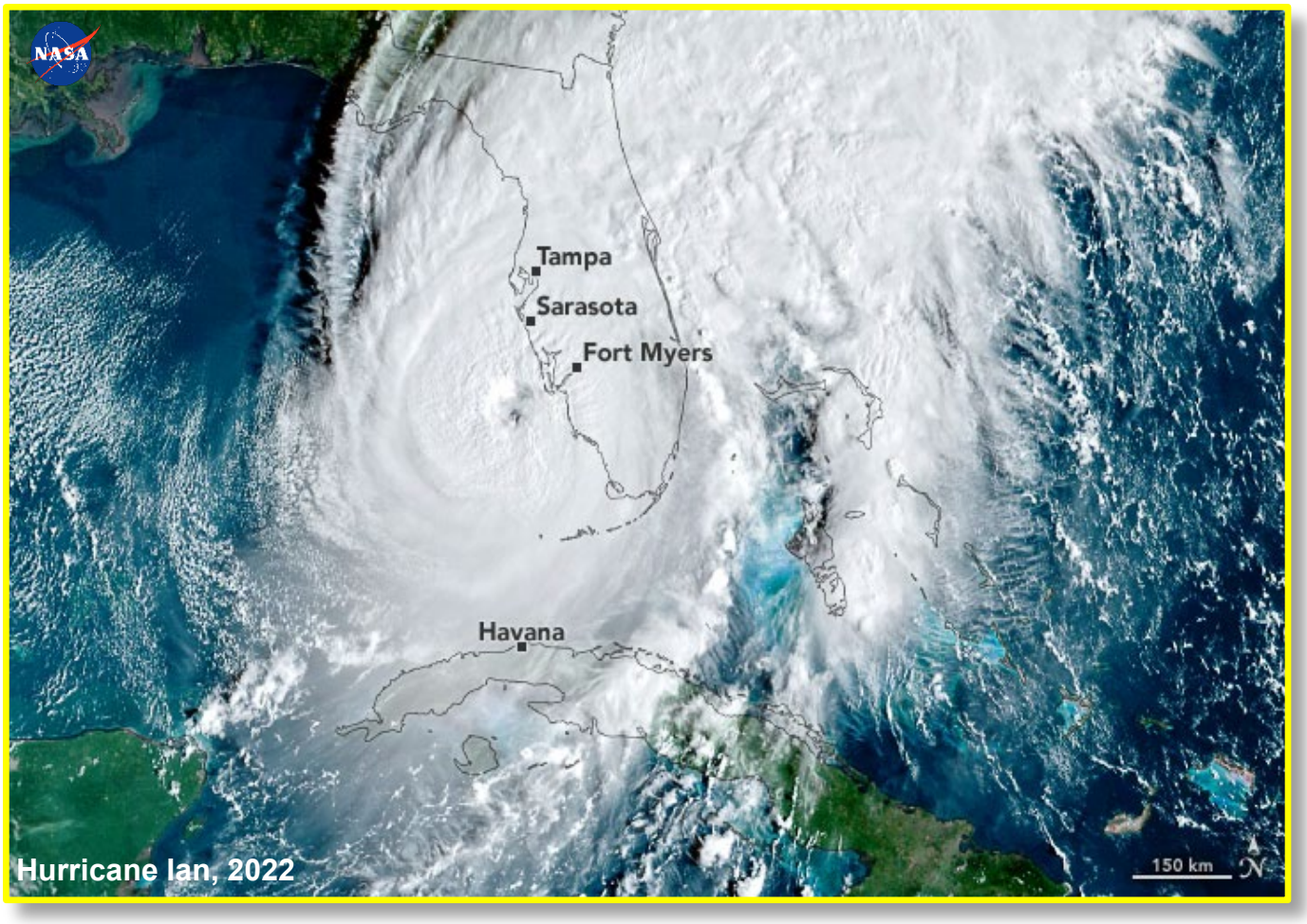
Florida Commission on Hurricane Loss Projection Methodology

Professional Team Report

2023 Hurricane Standards



Moody's Corporation

On-Site Review: March 3-6, 2025

On March 3-6, 2025, the Professional Team conducted an on-site review of the Moody's Corporation North Atlantic Hurricane Models Version 25.0 (Build 2450). The following individuals participated in the review.

Moody's

Florian Arfeuille, Ph.D., Associate Director Manager, Model Development
Karen Argonza, Senior Science Writer and Editor, Model Content and Data Experience
Ed Bannister, Ph.D., Assistant Director, Model Development
Enrica Bellone, Ph.D., Senior Director Manager, Model Development
Scott Brydon, Model Analyst, Risk Analytics
David Carttar, Senior Director, Software Development
Peter Datin, Ph.D., Senior Director, Model Development
Alison Dobbin, Ph.D., Director Manager, Model Development
Greg Fanoe, FCAS, MAAA, Actuarial Consultant, Davies
Phil Feiner, Associate Director, Risk Analytics
Jo Kaczmarska, Ph.D., FIA, Director, Model Development
Chana Keating, Associate Director Manager, Model Development
Rohit Mehta, Director, Model Development
Akwasi Mensah, Ph.D., Associate Director, Model Development
Christos Mitas, Ph.D., Managing Director Analytics & Modeling, Model Development
Gilbert Molas, Ph.D., Senior Director, Model Development
Matthew Nielsen, Senior Vice President, Government and Regulatory Affairs
Niloufar Nouri, Ph.D., Modeler, Model Development
Rolake Omoya, Ph.D., Modeler, Model Development
Matthew Pinkowski, Assistant Vice President, Government, Public, and Regulatory Affairs
Mohsen Rahnama, Ph.D., Chief Risk Modeling Officer and Executive Vice President
Emilie Scherer, Ph.D., Associate Director, Model Development
Bronislava Sigal, Ph.D., Director, Model Development
Ajay Singhal, Ph.D., Managing Director, Model Development
Derek Stedman, Director, Model Development
Lindsay Stone, Assistant Director, Risk Analytics
Avinash Takale, Manager, Software Development
Vahid Valamanesh, Ph.D., Associate Director, Model Development
Rajkiran Vojjala, Managing Director, Model Development
Jeff Waters, Director, Model Product Management
Michael Young, M.E.Sc., P.E., Senior Director, Model Product Management

Professional Team

Jimmy Booth, Ph.D., Meteorology
Paul Fishwick, Ph.D., Computer/Information
Mark Johnson, Ph.D., Statistics, Team Leader
Steve Kolk, ACAS, MAAA, Actuarial
Masoud Zadeh, Ph.D., P.E., Vulnerability
Donna Sirmons, Staff

Commission

Peggy Cheng, ACAS, Florida Office of Insurance Regulation Actuary
March Fisher, Citizens Property Insurance Corporation

The Professional Team began the review with an opening briefing and introductions were made. Moody's provided a general overview of the hurricane model followed by explanations on the model updates.

- Postal code data and databases updated to December 2023 including the number of parcels, building centroids, address points, points of interest, streets, and cities
- Stochastic long-term landfall and bypassing event rates updated based on May 2023 HURDAT2 data
- Historical footprints added for Hurricane Elsa (2021), Hurricane Ian (2022), and Hurricane Nicole (2022)
- Historical footprints revised for Hurricane Alma (1966), Hurricane Inez (1966), and Hurricane Gladys (1968) based on HURDAT2 reanalysis for years 1966-1970
- Postal code and county-level wind hazard reaggregated for all events against the updated December 2023 postal code vintage data and boundaries
- Vulnerability mappings updated for ISO FIRE 3 construction class from light metal to masonry construction class

Moody's explained the percentage differences by component module, and the overall increase of 1.2% in the average annual zero deductible statewide hurricane loss costs, primarily driven by the event rate updates.

The audit continued with a review of each standards section.

Report on Deficiencies

The Professional Team reviewed the following deficiencies cited by the Commission at the January 3, 2025, meeting. The deficiencies were eliminated by the established time frame, and the modifications have been verified.

1. M-1.A-C, page 63: Non-responsive. Responses to the standards not provided.

2. Form S-4.B, page 219: Incomplete. Provide a definition of the model relevant commercial residential classifications used.

Professional Team Pre-Visit Letter

The Professional Team's pre-visit letter items are provided in the report under the corresponding standards. Following is the pre-visit letter preamble.

The purpose of this pre-visit letter is to outline specific issues unique to Moody's model submission under the 2023 hurricane standards, and to identify lines of inquiry that will be followed during the on-site review in order to allow time for adequate preparation. Aside from

due diligence with respect to the full submission, various questions that the Professional Team will ask during the on-site review are provided herein. This letter does not preclude the Professional Team from asking for additional information during the on-site review that is not given below or discussed during an upcoming conference call to be held if requested by Moody's. The goal of a potential conference call is to address your questions related to this letter or other matters pertaining to the on-site review. The overall intent is to help expedite the on-site review and to avoid last minute preparations that could have been undertaken earlier.

It is important that all material prepared for presentation during the on-site review be provided to the Professional Team and presented using a medium that is readable by all members of the Professional Team simultaneously.

The Professional Team will begin the review with an opening briefing. Moody's should then proceed with an explanation of new or updated material related to the model. Afterwards, a review of the standards in the *Hurricane Standards Report of Activities as of November 1, 2023,* will commence. Each standard should be addressed beginning with responses to the pre-visit letter questions for that specific standard followed by responses to each of the audit items for that standard. Moody's should discuss the Artificial Intelligence (AI) issue identified by the Commission at the January 3, 2025, meeting during the Computer Information Standards. The Professional Team will discuss with Moody's the two Commission Inquiries regarding roof covering type and attachment, and building and roof vulnerability after the Professional Team exit briefing.

If changes have been made in any part of the model or the modeling process from the descriptions provided in the initial November 5, 2024, submission, provide the Professional Team with a complete and detailed description of those changes, the reasons for the changes (e.g., an error was discovered), and any revised forms. For each revised form, provide an additional form with cell-by-cell differences between the revised and the original submitted values.

Refer to the On-Site Review chapter of the *Hurricane Standards Report of Activities as of November 1, 2023*, for details on materials to be presented and provided to the Professional Team (pages 94-96).

While the Report of Activities specifies 4 printed copies, Commission members and a different Professional Team member will be in attendance. Please have available 7 printed copies of the presentations (printed two slides per page and duplexed), and the Form A-6 graphical summaries, the color-coded contour map of the hurricane loss costs for strong owners frame buildings, and the scatter plot of the hurricane loss costs against distance to closest coast for strong owners frame buildings.

All documentation should be easily accessible from a central location in order to be reviewed electronically.

GENERAL HURRICANE STANDARDS
Mark Johnson, Leader

G-1 Scope of the Hurricane Model and Its Implementation*
*(*Significant Revision)*

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

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

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

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

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

Verified: YES

Professional Team comments are provided in black font below.

Audit

1. Compliance with the requirements in Hurricane Standard G-1.B in all stages of the modeling process will be reviewed.

   Reviewed internal documentation standards for flow diagrams, coding, writing style, visualization, and mapping style.

   Reviewed several examples throughout the audit.

Discussed that all model source code and scripts are accessible on Github.

Discussed the adoption of new brand and data visualization guidelines implemented after the acquisition by Moody's.

2. Maps, databases, and data files relevant to the submission will be reviewed in the course of the on-site review.

All maps, databases, and data files were available for review. Reviewed samples throughout the audit.

3. Justification for the vintage of data, code, scientific literature, and technical literature used will be reviewed in the course of the on-site review.

Discussed justification for the vintage of the code, data, and both scientific and technical literature given minimum changes made in the model under review.

Discussed the vintage and sources of observational data.

4. Supporting material for the hurricane model changes in Disclosure 7 will be reviewed.

Reviewed the supporting material for the model updates.

Reviewed the percentage differences by component module extended to enough digits to demonstrate a difference from zero, where applicable. Reviewed a correction to the direction of the hazard component percentage change.

Discussed the differentiation between hazard module changes that impact the stochastic model probable maximum loss (PML) versus those that impact historical storm loss costs.

5. For any changes made in the hurricane model since the initial submission, color-coded maps by county reflecting the percentage difference in average annual zero deductible statewide hurricane loss costs based on the 2017 FHCF exposure data for each hurricane model component change, between the initial submission and the revised submission, and between any intermediate revisions and the revised submission, will be reviewed.

Confirmed that there have been no changes to the hurricane model since the initial submission.

6. For any modifications to Form A-4 using the 2017 FHCF exposure data resulting from changes in the hurricane model since the initial submission, a newly completed Form A-5 with the initial submission as the baseline for computing the percentage changes, and with any intermediate revisions as the baseline for computing the percentage changes, will be reviewed.

   Confirmed there have been no changes to Form A-4 since the initial submission.

7. If the output ranges in Form A-4 using the 2023 FHCF exposure data are regenerated since the initial submission, a Form A-5 based on the output range percentage changes using the 2023 FHCF exposure data with the initial submission as the baseline for computing the percentage changes, and with any intermediate revisions as the baseline for computing the percentage changes, will be reviewed.

   Not applicable as the output ranges have not changed since the initial submission.

G-2 Qualifications of Modeling Organization Personnel and Consultants Engaged in Development and Implementation of the Hurricane Model*

*(*Significant Revision)*

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.

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

Verified: **YES**

Professional Team comments are provided in black font below.

Pre-Visit Letter

1. G-2.2.B, page 53: Provide resumes of the new personnel.

   Reviewed resumes of new personnel:

   - Scott Brydon, B.S. in Economics and Statistics, California Polytechnic State University, San Luis Obispo, CA
   - Ian Mutschier, B.S. in Meteorology and Mathematics, Florida State University, Tallahassee, FL
   - Ankita Singh, Ph.D. in Applied Statistics, Utkal University, Bhubaneswar, India; M.S. in Statistics, University of Allahabad, Allahabad, UP, India; B.S. in Physics, Statistics, and Mathematics, University of Allahabad, Allahabad, UP, India

Audit

1. The professional vitae of new employees and consultants (since the previous submission) engaged in the development or implementation of the hurricane model under review and responsible for the submission will be reviewed.

   See PVL #1 for resumes reviewed.

2. Incidents where modeling organization personnel or consultants have been found to have failed to abide by the standards of professional conduct adopted by their profession will be discussed.

   Discussed that there were no departures of personnel attributable to violations of professional standards.

G-3 Insured Exposure Location*

*(*Significant Revision)*

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.

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

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

D. If any hurricane model components are dependent on ZIP Code databases, a logical process shall be maintained for ensuring these components are consistent with the recent ZIP Code database updates.

E. Geocoding methodology shall be justified.

Verified: YES

Professional Team comments are provided in black font below.

Audit

1. Geographic displays for all ZIP Codes will be reviewed.

   Reviewed geographic representation of ZIP Code boundaries and centroids.

2. Geographic comparisons of previous to current locations of ZIP Code centroids will be reviewed.

   Reviewed the updates to ZIP Code centroids incorporating new data from the third-party vendor.

   Reviewed comparisons of the centroid changes from the current accepted model.

3. Third party vendor information, if applicable, and a complete description of the process used to validate ZIP Code information will be reviewed.

   Discussed the process of quality and consistency checks run on the quarterly updates of ZIP Code and geocoding data from the third-party sources.

   Reviewed the control flow diagram for ZIP Code tables development.

4. The treatment of ZIP Code centroids over water or other uninhabitable terrain will be reviewed.

   Discussed the wind hazard aggregation process, and how the process does not allow ZIP Code centroid locations over water or other uninhabitable terrain.

5. Examples of geocoding for complete and incomplete street addresses will be reviewed.

   Reviewed examples of geocoding for complete and incomplete street addresses.

6. Examples of latitude and longitude to ZIP Code conversions will be reviewed.

   Reviewed examples of latitude-longitude to ZIP Code conversions.

7. Hurricane model ZIP Code-based databases will be reviewed.

   Reviewed the ZIP Code databases used to assign geographical coordinates to a corresponding ZIP Code, to identify historical and stochastic events that impact specific ZIP Codes, and for ZIP Code assignment to vulnerability and inventory regions.

G-4 Independence of Hurricane Model Components

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

Verified: YES

Professional Team comments are provided in black font below.

Audit

1. The hurricane model components will be reviewed for adequately portraying hurricane phenomena and effects (damage, hurricane loss costs, and hurricane probable maximum loss levels) in the course of the on-site review. Attention will be paid to an assessment of (1) the theoretical soundness of each component, (2) the basis of the integration of each component into the hurricane model, and (3) consistency between the results of one component and another.

   Reviewed the theoretical soundness, integration of components, and consistency across components throughout the audit.

   There was no evidence to suggest that one component of the model was deliberately adjusted to compensate for another component.

2. All changes in the hurricane model since the previous submission that might impact the independence of the hurricane model components will be reviewed.

   Reviewed all changes in the hurricane model since the current accepted model and determined no model updates impacted the independence of each model component.

G-5 Editorial Compliance

The submission and any revisions provided to the Commission throughout the review process shall be reviewed and edited by a person or persons with experience in reviewing technical documents who shall certify on Form G-7 that the submission has been personally reviewed and is editorially correct.

Verified: **YES**

Professional Team comments are provided in black font below.

Audit

1. An assessment that the person who has reviewed the submission has experience in reviewing technical documentation and that such person is familiar with the submission requirements as set forth in the *Hurricane Standards Report of Activities as of November 1, 2023,* will be made.

   Discussed the experience provided in the submission under G-5 of the Senior Science Writer and Editor who reviewed the submission document and coordinated the editorial process and production of the submission.

2. Attestation that the submission has been reviewed for grammatical correctness, typographical accuracy, completeness, and no inclusion of extraneous data or materials will be assessed.

   Moody's confirmed that the hurricane model submission was reviewed throughout the development process for grammatical correctness, typographical accuracy, and completeness, and also confirmed that there was no inclusion of extraneous data or materials.

   Reviewed the process for development of the submission and the editorial checklist.

3. Confirmation that the submission has been reviewed by the signatories on the Expert Certification Forms G-1 through G-6 for editorial compliance will be assessed.

   Moody's confirmed that subject matter experts reviewed all submitted materials for completeness and accuracy.

4. The modification history for submission documentation will be reviewed.

   Discussed the process for preparing, reviewing, revising, and tracking revisions to the submission documentation.

   Reviewed several examples of the submission documentation modification history.

5. A flowchart defining the process for form creation will be reviewed.

   Reviewed control flow diagrams for Forms A-2, A-4, and A-5.

Reviewed editorial items noted by the Modeler, and editorial items noted by the Professional Team in the pre-visit letter and during the on-site review that were satisfactorily addressed during the audit. The Professional Team has reviewed the submission, but cannot guarantee that all editorial difficulties have been identified. The modeler is responsible for eliminating such errors.

METEOROLOGICAL HURRICANE STANDARDS
Jimmy Booth, Leader

M-1 Model Base Hurricane Set*
*(*Significant Revision)*

A. The Model Base Hurricane Set shall be one of the following: (1) Reference Hurricane Set, (2) Model Adjusted Hurricane Set, or (3) Model Climate-Adjusted Hurricane Set, and shall be justifiable.

B. A climate-adjusted hurricane model shall use one of the hurricane sets listed in A as its Model Base Hurricane Set and shall be justifiable.

C. Annual frequencies used in the hurricane model validation shall be based upon the Model Base Hurricane Set.

Verified: YES

Professional Team comments are provided in black font below.

Audit

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

   Discussed that the Model Base Hurricane Set is the Reference Hurricane Set including all hurricanes from 1900-2022 in HURDAT2 as of May 2023.

   Discussed that no modifications were made to the historical storms in the HURDAT2 record.

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

   Reviewed flowchart for processing changes in HURDAT2 in calculating landfall event rates.

   Discussed there have been no changes in the process.

   Reviewed the importance sampling process used on the simulated storm tracks.

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

   Discussed that Hurricanes Elsa (2021), Ian (2022), and Nicole (2022) were added to the Model Base Hurricane Set.

Discussed that historical footprints for Hurricanes Alma (1966), Inez (1966), and Gladys (1968) were revised based on the HURDAT2 reanalysis for years 1966-1970.

Reviewed the data sources for the 3 new storms added and the 3 revised storms.

Reviewed the methodology for incorporating landfall information of the new storms.

Reviewed validation comparisons of observed and modeled windspeeds for the new and revised storms.

Reviewed the modeled variable resolution grid (VRG) windfield footprint for Hurricane Ian (2022).

Reviewed scatter plot comparison of observed and modeled windspeeds for Hurricane Ian (2022).

Reviewed maps of losses for a stochastic event corresponding to the modeled windfields for Hurricane Elsa (2021), Hurricane Ian (2022), and Hurricane Nicole (2022). Reviewed comparison of the total industry losses for each storm to the modeled losses in Form A-2 using the 2023 FHCF exposure data.

Reviewed comparisons of the current accepted model and the revised historical footprints for Hurricane Alma (1966), Hurricane Inez (1966), and Hurricane Gladys (1968).

Reviewed the change in losses from the current accepted model for the 3 revised historical storms.

4. Modeled probabilities will be compared with observed hurricane frequency using methods documented in current scientific literature and current technical literature. The goodness-of-fit of modeled to the Reference Hurricane Set statewide and regional hurricane frequencies as provided in Form M-1 will be reviewed.

Reviewed the annual occurrence rates of Florida landfalling hurricanes in Form M-1 compared to Forms S-1 and A-2.

Reviewed the Chi-square goodness-of-fit tests provided in S-1.5.

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

Discussed the rationale for not accounting for climate variability or climate change in the model submitted for review. Discussed that climate variability is included in other versions of the model available to clients.

M-2 Hurricane Parameters (Inputs)*

*(*Significant Revision)*

Methods for depicting all modeled hurricane parameters shall be based on information documented in current scientific literature and current technical literature.

Verified: YES

Professional Team comments are provided in black font below.

Pre-Visit Letter

2. M-2.3, pages 65-66: Provide an equation of the mathematical dependence of modeled windfield as a function of distance and direction from the center position.

   Reviewed the equations for modeled windspeed as a function of distance from the center and angle to direction in a 2D coordinate system which is an optimized version of the Willoughby et al. (2006) radial wind profile model.

   Reviewed the dependency of the windfield asymmetry to translational speed.

Audit

1. Supporting material for the meteorological component changes in Disclosure 1 will be reviewed.

   Reviewed the methodology for landfall event rate changes.

   Reviewed the model landfall gates. Discussed that landfall category is the Saffir-Simpson category at the HURDAT2 6-hourly point before landfall.

   Reviewed example schematics of gate extensions used for smoothing HURDAT2 rates by gate and category.

   Reviewed comparisons to the current accepted model of historical and stochastic single landfall counts by gate crossing in the regions defined in Form M-1.

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

   Reviewed the hurricane parameters including translation speed and storm heading, central pressure, inland filling rate, "equivalent over water" maximum windspeed, radius of maximum winds, wind profile parameters, and far field pressure.

Discussed there has been no change in methodology since the current accepted model.

3. Graphical depictions of hurricane parameters as used in the hurricane model will be reviewed. Descriptions and justification of the following will be reviewed:
   a. The dataset basis for the fitted distributions, the methods used, and any smoothing techniques employed,

   Reviewed the datasets and distributions provided in Form S-3.

   b. The modeled dependencies among correlated parameters in the windfield component and how they are represented, and

   Discussed that Rmax is modeled as a truncated lognormal random variable, with a mean that depends on latitude and central pressure.

   c. The parameters affecting asymmetric structure of hurricanes.

   Reviewed the asymmetry parameters.

M-3 Hurricane Probability Distributions*

*(*Significant Revision)*

A. Modeled probability distributions of hurricane parameters shall be consistent with the Model Base Hurricane Set. Any differences shall be justifiable.

B. Modeled hurricane landfall frequency distributions shall reflect the Model Base Hurricane Set used for category 1 to 5 hurricanes and shall be consistent with those observed for each coastal segment of Florida and neighboring states (Alabama, Georgia, and Mississippi). Any differences shall be justifiable.

C. The hurricane model shall use maximum one-minute sustained 10-meter windspeed when defining hurricane landfall intensity. This applies both to the Model Base Hurricane Set used to develop landfall frequency distributions as a function of coastal location and to the modeled winds in each hurricane which causes damage. The associated maximum one-minute sustained 10-meter windspeed shall be within the range of windspeeds (in statute miles per hour) categorized by the Saffir-Simpson Hurricane Wind Scale.

Verified: **YES**

Professional Team comments are provided in black font below.

Audit

1. The statistical goodness-of-fit extending beyond the Florida border will be reviewed by evaluating results for appropriate coastal segments in Alabama, Georgia, and Mississippi.

   Reviewed the cumulative distribution functions in S-1.5 that include coastal gates covering Florida and neighboring states.

2. The method and supporting material for selecting stochastic storm tracks will be reviewed.

   Discussed that the methodology for selecting stochastic storm tracks has not changed since the current accepted model.

   Discussed that the stochastic storm tracks are derived by modeling zonal and meridional track steps based on Hall and Jewson (2007). The methodology is described in G-1.2.

3. The method and supporting material for selecting storm track landfall statistics will be reviewed. If landfall positions are on a discrete set, the hurricane landfall points for major metropolitan areas in Florida will be reviewed.

   Reviewed the methodology for landfall event rate changes.

   Reviewed comparisons to the current accepted model of historical and stochastic landfall counts by gate crossing.

4. Any modeling-organization-specific research performed to develop the functions used for simulating hurricane model variables or to develop databases will be reviewed.

   Discussed the publications on the fundamentals behind the track modeling approach (Hall and Jewson, 2007) and inland filling (Colette et al., 2010).

   Discussed additional internal research conducted to modify and develop hurricane parameters.

M-4 Hurricane Windfield Structure*

*(*Significant Revision)*

A. Windfields generated by the hurricane model shall be consistent with observed historical storms affecting Florida.

B. The land use and land cover (LULC) database shall be consistent with National Land Cover Database (NLCD) 2016 or later. Use of alternate datasets shall be justified.

C. The translation of land use and land cover or other source information into a surface roughness distribution shall be consistent with current state-of-the-science and shall be implemented with appropriate geographic information system data.

D. With respect to multi-story buildings, the hurricane model shall account for the effects of the vertical variation of winds.

Verified: YES

Professional Team comments are provided in black font below.

Pre-Visit Letter

3. M-4.1, Figure 15, page 74: Prepare another version of this figure for which the *x*-axis extends to values of Radius/Rmax = 10.

   Reviewed the radially averaged wind profile extended to a Radius/Rmax of 10.

4. M-4.8, pages 77-78: For Hurricane Charley (2004), provide examples of two other realizations that were not chosen to be in the submission. Detail the parameter differences for those realizations. Interpret what the differences in parameters and resulting winds implies about the model.

   Reviewed plots of Vmax and Rmax time-series over Florida for two Hurricane Charley (2004) realizations. Reviewed the corresponding realization footprints. Discussed that the stochastic model can simulate a relatively wide range of Vmax and Rmax values.

Audit

1. Any modeling-organization-specific research performed to develop the windfield functions used in the hurricane model will be reviewed. The databases used will be reviewed.

   Discussed that there has been no change in the methodology for developing the model windfield.

Discussed that the model windfield is a modified version of the single exponential Willoughby profile. See PVL #2.

Reviewed an example of Hwind snapshots used in windfield development.

Reviewed assessment of the model windfield performance using bias and error standard deviation.

2. Any modeling-organization-specific research performed to derive the roughness distributions for Florida and neighboring states will be reviewed.

Discussed that there was no change in the methodology or the LULC data since the current accepted model.

3. The spatial distribution of surface roughness used in the hurricane model will be reviewed.

Reviewed geographical representations of the NLCD 2016 land cover and the model surface roughness distribution.

Discussed the justification for their surface roughness over open water.

Discussed the method for adjustment of surface roughness from the roughness data grid to the VRG.

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

Reviewed the flowchart and process for calculating hurricane surface winds.

5. The previous and current hurricane parameters used in calculating the hurricane loss costs for the LaborDay03 (1935) and NoName09 (1945) hurricane landfalls will be reviewed. Justification for the choices used will be reviewed. The resulting spatial distribution of winds will be reviewed with Form A-2.

Reviewed map comparisons to the current accepted model of the spatial distribution of winds for the LaborDay03 (1935) and NoName09 (1945) storms.

6. For windfields not previously reviewed, detailed comparisons of the hurricane model windfield with Hurricane Charley (2004), Hurricane Wilma (2005), Hurricane Irma (2017), and Hurricane Michael (2018) will be reviewed.

Discussed that there was no change in the model windfield, and that the windfields in the audit item have been previously reviewed.

7. Representation of vertical variation of winds in the hurricane model, where applicable, will be reviewed.

   Discussed that the vertical variation of winds are accounted for in the vulnerability model.

8. Description of and justification for the value(s) of the far-field pressure used in the hurricane model will be reviewed.

   Discussed that there has been no change since the current accepted model.

9. The treatment of the inherent uncertainty in the conversion factors used to convert the modeled winds to surface winds will be reviewed and compared with current scientific literature and current technical literature. Treatment of conversion factor uncertainty at a fixed time and location within the windfield for a given hurricane intensity will be reviewed.

   Discussed that the model simulates winds directly at the surface.

10. All external data sources that affect model-generated windfields will be identified, and their appropriateness will be reviewed.

    Reviewed the external data sources relevant to the model windfields.

    Discussed that surface wind observations are diverse and continually monitored to be up to date.

M-5 Hurricane Intensity Change Methodologies*

*(*Significant Revision)*

A. The hurricane intensity change methodology used by the hurricane model shall be consistent with current state-of-the-science.

B. The transition of winds from over water to over land within the hurricane model shall be consistent with current state-of-the-science.

C. Intensity change of hurricanes that pass from over land to over water shall be consistent with current state-of-the-science.

Verified: YES

Professional Team comments are provided in black font below.

Audit

1. The variation in overland decay rates used in the hurricane model will be reviewed.

   Reviewed comparison of the model over-land decay rates of historical storms represented in M-5.3, Figure 27.

   Discussed the historical central pressure time series for Hurricane Irene (1999).

2. The transition of storm intensity from over land to over water will be reviewed.

   Discussed that on transition from over land to over water, the central pressure evolution ceases to be determined by the filling model and reverts to the offshore central pressure model that is described in M-2.4.

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

   Reviewed Figure 27 in M-5.3, and Figure 38 in S-1.5 for Hurricane Charley (2004).

   Discussed that there has been no change in the weakening rates since the current accepted model.

4. The detailed transition of winds from over water to over land (i.e., hurricane landfall, boundary layer) will be reviewed. The region within 5 miles of the coast will be emphasized. Color-coded snapshot maps of roughness length and spatial distribution of over land and over water windspeeds for Hurricane Charley (2004), Hurricane Michael (2018), and Hurricane Ian (2022) at the closest time after landfall will be reviewed.

   Reviewed landfall windfield maps, land-use data maps, and roughness length maps for Hurricane Charley (2004), Hurricane Michael (2018), and Hurricane Ian (2022).

M-6 Logical Relationships of Hurricane Characteristics*

*(*Significant Revision)*

A. The magnitude of asymmetry shall increase as the translation speed increases, all other factors held constant.

B. The mean windspeed shall decrease with increasing surface roughness (friction), all other factors held constant.

Verified: YES

Professional Team comments are provided in black font below.

Pre-Visit Letter

5. M-6.4, page 90: Provide a response to the revised disclosure provided in the 2023 Hurricane Standards Report of Activities Q&As on September 12, 2024, i.e., "Describe the dependencies among characteristics (i.e., model output) in the windfield component and how they are represented by the hurricane model."

   Discussed that the only windfield model output is the maximum 3-second gust windspeed at 10-meters at each location, and that the conversion from 1-minute to 3-second gusts involves the gust parameter and surface roughness.

Audit

1. The logical relationship between windspeed and surface roughness will be reviewed.

   Discussed that there has been no change in the site coefficient methodology since the current accepted model. The methodology is discussed in M-4.4.

   Reviewed a table of LULC classes and the corresponding roughness length values, site coefficients, and 3-second gust windspeeds.

2. Justification for the relationship between intensity and radius of maximum winds will be reviewed.

   Reviewed box and whiskers plots of the relationship between Rmax and central pressure.

3. The mathematical dependence of the modeled windfield as a function of distance and direction from the center position will be reviewed.

   See PVL #3.

4. Justification for the variation of the asymmetry with the translation speed will be reviewed.

   Discussed the dependency of the modeled windfield asymmetry to the translational speed.

   Discussed that there has been no change in the relationship since the current accepted model.

   See PVL #2.

5. Methods (including any software) used in verifying logical relationships of hurricane characteristics will be reviewed.

   Discussed that there has been no change in methodology since the current accepted model.

6. Contour animations of windfield distributions demonstrating scientifically reasonable windfield characteristics and logical relationships will be reviewed.

   Reviewed time-evolving contour animation of the Hurricane Michael (2018) windfield.

STATISTICAL HURRICANE STANDARDS
Mark Johnson, Leader

S-1 Modeled Results and Goodness-of-Fit*
*(*Significant Revision)*

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

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

Verified: **YES**

Professional Team comments are provided in black font below.

Audit

1. The modeling organization characterization of uncertainty for windspeed, damage estimates, annual hurricane loss, hurricane probable maximum loss levels, and hurricane loss costs will be reviewed in the course of the on-site review.

   Discussed that the hurricane windfield model is a modified Willoughby (2006) profile as described in M-4.1. Discussed that uncertainty in the distribution of wind parameters results in windspeed and loss uncertainties.

   Reviewed comparison of the historical and modeled distributions for Vmax and the uncertainty in loss costs due to Vmax.

   Discussed that the model uncertainty analysis showed that landfall intensity and Rmax are the major contributors to the uncertainty in hurricane loss costs with filling rate also having a significant impact on loss.

2. Regression analyses performed will be reviewed, including parameter estimation, graphical summaries and numerical measures of the quality of fit, residual analysis and verification of regression assumptions, outlier treatment, and associated uncertainty assessment.

   Reviewed an example for the regressions used to model the Willoughby windfield parameter X1.

Reviewed plots of deviance residuals versus fitted values.

Reviewed QQ-plots of deviance residuals versus quantiles of a theoretical Gaussian distribution.

Reviewed plot of residuals versus leverage.

Reviewed residual plots for two predictors confirming the linear relationship.

Discussed justification for the changes in *p*-values given the additional data added to the Model Base Hurricane Set.

S-2 Sensitivity Analysis for Hurricane Model Output*

*(*Significant Revision)*

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

Verified: YES

Professional Team comments are provided in black font below.

No changes were made in model windfield methodology from the current accepted model, and no new sensitivity analyses were presented.

S-3 Uncertainty Analysis for Hurricane Model Output*

*(*Significant Revision)*

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

Verified: YES

Professional Team comments are provided in black font below.

No changes were made in model methodology from the current accepted model, and no new uncertainty analyses were presented.

S-4 County Level Aggregation

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

Verified: YES

Professional Team comments are provided in black font below.

Audit

1. The accuracy associated with Nassau County will be reviewed. The contribution of simulation uncertainty via confidence intervals will be reviewed.

   Reviewed the standard error in Nassau County as a percentage of hurricane loss costs over a number of simulation years.

   Reviewed that those results converged, and sampling errors decreased as simulation years increased.

S-5 Replication of Known Hurricane Losses*

*(*Significant Revision)*

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

Verified: YES

Professional Team comments are provided in black font below.

Pre-Visit Letter

6. S.5.1, Table 12, page 110: Explain why the Hurricane Irma (2017) modeled loss changed while all the other modeled losses stayed the same.

Discussed that there was no difference in Hurricane Irma (2017) modeled losses, and that an editorial error correction had previously been submitted.

Audit

1. The following information for each insurance company and hurricane will be reviewed:

   a. The validity of the hurricane model assessed by comparing projected hurricane losses produced by the hurricane model to actual observed hurricane losses incurred by insurers at both the state and county level,

Reviewed comparisons between modeled and observed losses industry wide provided in S-5.1, Figure 42 and Table 11, and for selected insurers in Figure 43 and Table 12.

   b. The version of the hurricane model used to calculate modeled hurricane losses for each hurricane provided,

Discussed that the North Atlantic Hurricane Models 25.0 (Build 2450) was used to generate all modeled historical losses.

c. A general description of the data and its source,

Reviewed the descriptions of the data provided in S-5.1, Table 13 and the lists of geographical resolutions by line of business for a sample of residential datasets provided in V-1.3.

d. A disclosure of any material mismatch of exposure and hurricane loss data problems, or other material consideration,

Discussed that there were no issues to note.

e. The date of the exposures used for modeling and the date of the hurricane,

Discussed that the date of exposures for industry level comparisons is 2024. Discussed that for client portfolios, the date of exposure and claims are the same and are the dates of the observed hurricanes.

Discussed that industry losses are normalized to the year 2024 using a methodology that accounts for inflation, exposure growth, and change in property values.

f. An explanation of differences in the actual and modeled hurricane parameters,

Reviewed the information provided in M-2.5.

g. A list of the departures, if any, in the windfield applied to a particular hurricane for the purpose of validation and the windfield used in the hurricane model under review,

Reviewed the information provided in M-4.8 and M-4.10.

Reviewed the process for historical storm reconstructions.

h. The type of coverage applied in each hurricane to address:
   1. Personal versus commercial
   2. Residential structures
   3. Manufactured homes
   4. Commercial residential
   5. Condominiums
   6. Structures only
   7. Contents only
   8. Time element,

Discussed during review of vulnerability audit items.

i. The treatment of demand surge or loss adjustment expenses in the actual hurricane losses or the modeled hurricane losses, and

See PVL #20.

j. The treatment of flood losses (including hurricane storm surge losses) in the actual hurricane losses or the modeled hurricane losses.

See PVL #17.

2. The following will be reviewed:
   a. The data sources excluded from validation and the reasons for excluding the data from review by the Commission (if any),
   b. An analysis that identifies and explains anomalies observed in the validation data, and
   c. User input data for each insurer and hurricane detailing specific assumptions made with regard to exposed property.

   Discussed during review of vulnerability audit items.

3. The confidence intervals used to gauge the comparison between historical and modeled hurricane losses will be reviewed.

   Reviewed the ranges for historical hurricane losses based on uncertainty in normalization factors shown in S-5.1.

   Discussed the uncertainty surrounding Hurricane Irma (2017) losses.

4. An additional version of Form S-4 with actual (i.e., non-disguised and non-scaled) values with associated scatter plots (modeled hurricane loss versus company actual hurricane loss) will be reviewed.

   Discussed that the scatterplots in Form S-4 show actual losses (non-disguised, non-scaled).

5. The results of one hurricane event for more than one insurance company and the results from one insurance company for more than one hurricane event will be reviewed to the extent data are available.

   Reviewed the results provided in Form S-4 and S-5.1.

S-6 Comparison of Projected Hurricane Loss Costs*

*(*Significant Revision)*

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

Verified: YES

Professional Team comments are provided in black font below.

Reviewed a revised Form S-5 to correct the percentage change in loss costs produced by the model from the second previous accepted model to -9.87%.

Audit

1. Justification for the following will be reviewed:

   a. Meteorological parameters,

   Discussed the meteorological parameters obtained from HURDAT2, and how other meteorological parameters are generated from the same model as the stochastic storm set and optimized against observations.

   b. The effect of by-passing hurricanes,

   Discussed that losses due to bypassing hurricanes are included in the event total for any given storm.

   c. The effect of actual hurricanes that had two landfalls impacting Florida,

   Discussed that losses due to multiple landfalling hurricanes are included in the event total for any given storm.

   Reviewed a comparison of historical storms making multiple landfalls in Florida to the stochastic storm set.

   d. The departures, if any, from the windfield, vulnerability functions, or insurance functions applied to the actual hurricanes for the purposes of this test and those used in the hurricane model under review, and

   Discussed that the same windfield model is used for actual hurricanes as in the stochastic model, and that there are no departures in vulnerability or insurance functions.

Discussed the departures related to the LULC vintages used, and an additional step that modifies the final windfield footprints for Hurricane Irma (2017) and Hurricane Ian (2022) which is discussed in M-4.9.

e. Exposure assumptions.

No assumptions were discussed.

VULNERABILITY HURRICANE STANDARDS
Masoud Zadeh, Leader

V-1 Development of Building Hurricane Vulnerability Functions*
*(*Significant Revision)*

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

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

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

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

E. Hurricane vulnerability functions shall be developed 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.

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

Verified: YES

Professional Team comments are provided in black font below.

Pre-Visit Letter

7. V-1.1, page 114: Provide further details on the changes.

   Discussed that the vulnerability functions have not changed from the current accepted model.

   Discussed the vulnerability mapping update where ISO Fire 3 (non-combustible) construction class was changed from light metal to masonry construction class, and that the change had no effect on modeled results.

   Reviewed a table of construction classes mapped to RMS construction classes.

   Reviewed the classification scheme and possible mappings for construction class ISO Fire 3.

   Reviewed images of the ISO Fire 3 construction class representations.

   Reviewed implementation of the ISO Fire 3 mapping update.

8. V-1.4, page 117: Provide a summary description of the results from the review of new data received. Provide summary reports and breakdown of the data.

   Discussed the new claims data received for Hurricane Ian (2022).

   Reviewed examples of adjustments made to the Hurricane Ian (2022) claims data.

   Reviewed a summary of the claims data by occupancy and construction type.

   Reviewed comparison of modeled to incurred loss for the new Hurricane Ian (2022) claims data. Discussed that the claims data analysis did not reveal any necessary changes in the vulnerability functions.

9. V-1.6, page 119: Explain how the MDR-CV relationship is used and its basis, what the values at the two extremes of the mean curve are, e.g., CV (coefficient of variation) values for when MDR (mean damage ration) is 0.0% or 100%, and how CV varies with windspeed.

   Discussed that the model includes different MDR-CV curves to capture the uncertainty in damage, and that the relationship used is based on a combination of the primary characteristics specified.

   Reviewed a summary table of MDR curve selection for known and unknow year built, construction type, and number of stories.

   Discussed that detailed loss data from multiple Florida hurricanes and company claims datasets are used to develop the MDR-CV relationships.

Reviewed scatter plots of data analysis examples by year built and construction type.

Reviewed plot of the CV variation by windspeed.

10. V-1.7, pages 119-120: Provide a summary of the post site inspections for Hurricane Maria (2017), Hurricane Florence (2018), Hurricane Michael (2018), and Hurricane Ian (2022).

    Discussed the post site inspection results from Hurricane Maria (2017), Hurricane Florence (2018), Hurricane Michael (2018), and Hurricane Ian (2022).

    Reviewed post site investigation reports from Hurricane Ian (2022).

11. V-1.8, pages 120-121: Explain and justify how vulnerability regions address U.S. Department of Housing and Urban Development (HUD) wind zones in Florida.

    Reviewed the model vulnerability region assignments for HUD Zones II and III.

    Discussed the differences in manufactured homes vulnerability between HUD Zones II and III.

    Reviewed vulnerability functions for manufactured homes located in HUD Zones II and III.

12. Form V-1: Explain the editorial changes that led to the interim corrections to Form V-1. These corrections in Form V-1 revealed large changes in concrete from the previous model version under the 2019 hurricane standards that were not evident during the review of the current accepted model under the 2021 hurricane standards. The values in the incorrect version of Form V-1 also showed minimal and consistent changes from the previous accepted model for wood frame and masonry across building, contents, and time element, whereas in the corrected version of Form V-1 the directional changes for wood frame are inconsistent across building, contents, and time element, and the masonry directional change though consistent is in the opposite direction.

    Discussed that the error in creating Form V-1 did not affect the current accepted model output nor the model under review.

    Discussed the reason for the error in generating Form V-1, and that the error was user-driven and only impacted Form V-1 generation under the 2021 hurricane standards.

    Discussed the additional regression test implemented for Form V-1 to ensure that the error is not repeated in the future.

13. Form V-1, pages 224-226: Given the modifications in the vulnerability component, explain the changes in Part A and Part B relative to the current accepted model.

    Discussed that the error in creating Form V-1 did not affect the current accepted model output nor the model under review.

    Discussed justification for the changes in the current Form V-1 (model version 25) from the previous accepted model Form V-1 (model version 21) related to building vulnerability function updates.

    Reviewed comparisons between the v25 and v21 vulnerability curves used in Form V-1.

    Reviewed comparison between v25 and v21 Form V-1 results.

Audit

1. Supporting material for the building vulnerability component changes in Disclosure 1 will be reviewed.

   See PVL #7.

2. Comparisons of the modified building hurricane vulnerability functions with the current accepted hurricane model will be reviewed.

   Discussed that no modifications or changes have been made to the building vulnerability functions since the current accepted model.

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

Policy Type	Number of Insurers	Number of Policies	Number of Locations	Exposure Value ($)
Personal Residential				
Manufactured Homes				
Commercial Residential				

   Reviewed the requested breakdown of insurance company exposure data.

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

Year	Storm Name	Number of Insurers			Number of Policies			Number of Locations			Number of Claims			Loss Amount ($)		
		Personal Residential	Manufactured Homes	Commercial Residential	Personal Residential	Manufactured Homes	Commercial Residential	Personal Residential	Manufactured Homes	Commercial Residential	Personal Residential	Manufactured Homes	Commercial Residential	Personal Residential	Manufactured Homes	Commercial Residential

Reviewed the requested breakdown of insurance company hurricane claims data.

Reviewed the breakdown of the new Hurricane Ian (2022) claims data used for validation.

5. The modeling of uncertainty associated with building hurricane vulnerability functions for wood frame, masonry, and manufactured homes construction classes will be reviewed.

See PVL #9.

6. How the uncertainties in windspeed for an individual hurricane at a given location are accounted for in the hurricane model damage estimates will be reviewed.

See PVL #9.

7. Insurance company hurricane claims data in the original form will be reviewed with explanations for any changes made and descriptions of how missing or incorrect data were handled.

Discussed the adjustments made to insurance company claims data.

Reviewed summary of adjustments made to claims data received for Hurricane Ian (2022).

8. The goodness-of-fit of the building hurricane vulnerability functions will be reviewed.

   Reviewed scatter plots of modeled to adjusted claims mean damage ratios for a single family, one-story masonry structure.

9. Complete reports detailing loading conditions and damage states for any laboratory or field-testing data used will be reviewed.

   Reviewed an example report.

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

    Reviewed the component vulnerability model used for developing building vulnerability functions.

    Reviewed the component parameter values.

    Reviewed the construction class relativities.

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

    Reviewed comparison of the mean damage ratios to claims data for two Florida regions.

12. Laboratory or field tests and original post-event site investigation reports will be reviewed.

    Reviewed post-site investigation reports from Hurricane Ian (2022).

    Reviewed the Insurance Institute for Business & Home Safety (IBHS) Research Report: The Effect of Roof Age on Asphalt Shingle Performance: Hurricane Rita to Hurricane Laura, published August 2022.

13. Justification for the construction classes and characteristics used will be reviewed.

    Discussed that there have been no changes in construction class and characteristics since the current accepted model.

    Reviewed the table of primary building characteristics and construction classes.

14. Multiple samples of building hurricane vulnerability functions for commercial residential building structures, personal residential building structures, manufactured homes, and appurtenant structures will be reviewed.

    Discussed that no changes have been made since the current accepted model.

    Reviewed vulnerability curves for a single-family, 1-story wood frame, a commercial residential 20-story building, and a manufactured home.

15. Documentation and justification for the effects on the building hurricane vulnerability functions due to applicable building codes will be reviewed.

    Discussed that no changes have been made since the current accepted model.

    Discussed that year-built bands reflect applicable updates to wind provisions in building codes.

16. The process for incorporating new insurance company hurricane claims data, if any, will be reviewed.

    Discussed the process for reviewing, adjusting, and analyzing new claims data.

    See PVL #8.

17. How the claim practices of insurance companies are accounted for when insurance company hurricane claims data are used to develop building hurricane vulnerability functions will be reviewed. The level of damage the insurer considers a loss to be a total loss, claim practices of insurers with respect to concurrent causation, the impact of public adjusting, and the impact of the legal environment in the claims data analyses will be reviewed.

    Discussed that there have been no changes since the current accepted model.

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

    Discussed that the model assumes a total loss at a mean damage ratio of 100%.

19. The treatment of law and ordinance in building hurricane vulnerability functions will be reviewed.

    Discussed that there have been no changes since the current accepted model.

    Discussed that law and ordinance is accounted for in the post-loss amplification factors.

See PVL #20.

20. A plot comparing hurricane vulnerability functions for wood frame building structure, masonry building structure, and appurtenant structure will be reviewed.

    Reviewed the relationship between building and appurtenant structure mean damage ratios.

21. A plot comparing appurtenant structure hurricane vulnerability functions with insurance company hurricane claims data will be reviewed.

    Discussed that appurtenant structure vulnerability functions use the same functions as building vulnerability functions.

    Reviewed scatter plot comparisons of building and appurtenant structure mean damage ratios.

V-2 Development of Contents Hurricane Vulnerability Functions*

*(*Significant Revision)*

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

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

Verified: YES

Professional Team comments are provided in black font below.

Pre-Visit Letter

14. V-2.1, page 125: Given that there are no modifications to the contents vulnerability component, explain the changes in Form V-1, Part A (page 224) for the "Estimated Contents Damage/Subject Contents Exposure" column relative to the current accepted model.

    Discussed that the changes in Form V-1 were related to an editorial error that has been corrected.

    See PVLs #12 and #13.

Audit

1. Supporting material for the contents vulnerability component changes in Disclosure 1 will be reviewed.

    Discussed that there have been no changes or modifications to the contents vulnerability functions since the current accepted model.

2. Comparisons of the modified contents hurricane vulnerability functions, if any, with the current accepted hurricane model will be reviewed.

    Not applicable since no modifications or changes were made to the contents vulnerability functions.

3. Justification for changes from the current accepted hurricane model in the relativities between hurricane vulnerability functions for building and the corresponding hurricane vulnerability functions for contents will be reviewed.

   Not applicable since no modifications or changes were made to the contents vulnerability functions.

4. Multiple samples of contents hurricane vulnerability functions will be reviewed.

   Reviewed samples of contents vulnerability functions.

5. The goodness-of-fit of the contents hurricane vulnerability functions will be reviewed.

   Reviewed the building to contents mean damage ratio relationship with claims data.

6. The modeling of uncertainty associated with contents hurricane vulnerability functions for wood frame, masonry, and manufactured homes construction classes will be reviewed.

   Discussed that content damages are developed based on the building damage ratio, and that uncertainty associated with contents vulnerability functions is the same as with building vulnerability functions.

7. Justification and documentation for the dependence of contents hurricane vulnerability functions on construction or occupancy type will be reviewed.

   Reviewed the building to contents mean damage ratio relationship with claims data in Audit #5.

8. Justification and documentation of the method of development, the underlying data, and assumptions related to contents hurricane vulnerability functions will be reviewed.

   Reviewed the building to contents mean damage ratio relationship with claims data in Audit #5.

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

   Reviewed the building to contents mean damage ratio relationship with claims data in Audit #5.

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

    Reviewed the building to contents mean damage ratio relationship with claims data in Audit #5.

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

    Discussed that water infiltration is implicitly included in the vulnerability curves which are calibrated by claims data.

    Discussed the calibration process.

V-3 Development of Time Element Hurricane Vulnerability Functions*

*(*Significant Revision)*

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

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

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

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

Verified: YES

Professional Team comments are provided in black font below.

Pre-Visit Letter

15. V-3.1, page 128: Given that there are no modifications to the time element vulnerability component, explain the changes in Form V-1, Part A (page 224) for the "Estimated Time Element Loss/Subject Time Element Exposure" column relative to the current accepted model.

    Discussed that the changes in Form V-1 were related to an editorial error that has been corrected.

    See PVLs #12 and #13.

Audit

1. Supporting material for the time element vulnerability component changes in Disclosure 1 will be reviewed.

    Discussed that there have been no changes or modifications to the time element vulnerability functions since the current accepted model.

2. Comparisons of the modified time element hurricane vulnerability functions, if any, with the current accepted hurricane model will be reviewed.

   Not applicable since no modifications or changes were made to the time element vulnerability functions.

3. Justification for changes from the current accepted hurricane model in the relativities between hurricane vulnerability functions for building and the corresponding hurricane vulnerability functions for time element will be reviewed.

   Not applicable since no modifications or changes were made to the time element vulnerability functions.

4. Multiple samples of time element hurricane vulnerability functions will be reviewed.

   Reviewed examples of the time element vulnerability functions.

5. The modeling of uncertainty associated with time element hurricane vulnerability functions for wood frame, masonry, and manufactured home construction classes will be reviewed.

   Reviewed the time element to building damage relationship.

6. Justification and documentation of the method of development, the underlying data, and assumptions related to time element hurricane vulnerability functions will be reviewed.

   Reviewed the time element methodology which has not changed since the current accepted model.

   Discussed that time element vulnerability is implemented through functional restoration times.

7. The goodness-of-fit of the time element vulnerability functions will be reviewed.

   Reviewed the building to time element vulnerability relationship with claims data.

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

   Discussed that no modifications or changes have been made to the time element vulnerability component since the current accepted model.

   See Audit #6 and #7.

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

   Discussed that no modifications or changes have been made to the time element vulnerability component since the current accepted model.

V-4 Hurricane Mitigation Measures and Secondary Characteristics*

*(*Significant Revision)*

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

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

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

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

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

Verified: YES

Professional Team comments are provided in black font below.

Audit

1. Supporting material for the hurricane mitigation measures and secondary characteristics vulnerability component changes in Disclosure 1 will be reviewed.

   Discussed that no modifications or changes have been made to the hurricane mitigation measures and secondary characteristics vulnerability component since the current accepted model.

2. Comparisons of the modified hurricane mitigation measures and secondary characteristics, if any, with the current accepted hurricane model will be reviewed.

   Not applicable since no modifications or changes were made to the hurricane mitigation measures or secondary characteristics.

3. Procedures, including software, used to calculate the impact of hurricane mitigation measures and secondary characteristics will be reviewed.

   Discussed that the impact of hurricane mitigation measures and secondary characteristics has been developed using published reports and studies combined with engineering judgement, and that the procedure has not changed since the current accepted model.

4. Form V-3 and Form V-5 will be reviewed.

   Reviewed Forms V-3 and V-5, and their correspondence to Forms V-2 and V-4.

5. Implementation of individual hurricane mitigation measures and secondary characteristics will be reviewed as well as the effect of individual hurricane mitigation measures and secondary characteristics on damage.

   Reviewed the process for determining the impact of hurricane mitigation measures and secondary characteristics.

   Reviewed the calculation for applying modifications multiplicatively.

6. Any variation in the change in hurricane damage over the range of windspeeds for individual hurricane mitigation measures and secondary characteristics will be reviewed.

   Reviewed the vulnerability curves for the different secondary structural modifiers.

7. Insurance company hurricane claims data, rational engineering analysis, or engineering judgment used to support the assumptions and implementation of the hurricane mitigation measures and secondary characteristics will be reviewed.

   Discussed that studies and engineering reports provide more insight into the impacts of different mitigation measures and secondary characteristics than what is available in claims data.

8. For each roof covering type used to complete Form V-2, the following will be reviewed:
   a. Roof age definition as considered in the model, including assumptions,
   b. The association between roof age and year built, including assumptions,
   c. Variation in roof age assumptions (e.g., by region or ZIP Code), and
   d. The impact of roof age on loss costs.

   Reviewed the weighted assumption distribution of roof age for each year built.

   Discussed that the assumptions do not vary by regions or ZIP Codes across Florida.

   Reviewed the impact of roof age on loss costs across different regions in Florida.

9. Implementation of multiple hurricane mitigation measures and secondary characteristics will be reviewed. The combined effects of these hurricane mitigation measures and secondary characteristics on damage will be reviewed. Any variation in the change in hurricane damage over the range of windspeeds for multiple hurricane mitigation measures and secondary characteristics will be reviewed.

   Reviewed the process of combining the effects of multiple mitigation measures and secondary characteristics.

   Discussed that there were no updates made to secondary modifiers since the current accepted model.

10. Hurricane mitigation measures and secondary characteristics used by the hurricane model, whether or not referenced in Form V-2 and Form V-3 will be reviewed for theoretical soundness and reasonability.

    Discussed the secondary modifiers in V-4.4, Table 16.

ACTUARIAL HURRICANE STANDARDS
Steve Kolk, Leader

A-1 Hurricane Model Input Data and Output Reports

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

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.

Verified: YES

Professional Team comments are provided in black font below.

Pre-Visit Letter

16. A-1.B, page 139:
    a. Describe how the calculation of the average default mix of characteristics are updated and kept current for missing user input values.
    b. For average default mix factor that changed, provide the default factor for the current accepted model and the calculation updating the default factor. If no default factors changed, explain why not.
    c. Include a sample of a hurricane model output report using the revised factor.

Discussed that building inventory is only used when any primary characteristic is unknown. Reviewed the building inventory reference data and inventory distributions for primary input characteristics. Reviewed data showing improved input quality, lessening need to use default factors for unknown characteristics.

Discussed that there have been no changes to the building inventory or default factors since the current accepted model.

Audit

1. Quality assurance procedures, including methods to assure accuracy of insurance or other input data, will be reviewed. Compliance with this standard will be readily demonstrated through documented rules and procedures.

   Reviewed the FHCF Exposure Data Module (EDM) Development document for processing the 2017 and 2023 FHCF aggregated exposure data.

   Discussed the validations performed during the import or while entering data, and additional validations performed to user-input addresses during geocoding provided in A-1.7.

2. All hurricane model inputs and assumptions will be reviewed to determine that the hurricane model output report appropriately discloses all modifications, adjustments, assumptions, and defaults used to produce the hurricane loss costs and hurricane probable maximum loss levels.

   Reviewed example model output reports provided in Appendix F for both model platforms, RiskLink and Risk Modeler.

3. The hurricane model input forms used to capture data distinguishing among policy form types and their risk elements including location, deductibles, and limits of coverage will be reviewed.

   Reviewed input form examples provided in Appendix E.

4. The human-computer interface relevant to input data and output reports and corresponding nomenclature used in Florida residential property insurance rate filings will be reviewed.

   Reviewed input form examples provided in Appendix E and output reports provided in Appendix F.

A-2 Hurricane Events Resulting in Modeled Hurricane Losses

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

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

Verified: YES

Professional Team comments are provided in black font below.

Pre-Visit Letter

17. A-2.B, page 147: Provide a copy of the documented procedure for distinguishing wind-related hurricane losses from other peril losses.

Reviewed the Windstorm Claims & Exposure Data Requirements provided to clients when requesting claims data.

Reviewed the RMS procedure for separating hurricane claims affected by storm surge used internally when reviewing and analyzing claims data.

Reviewed an example of Hurricane Ivan (2004) claims data separated within the storm surge footprint and outside the storm surge footprint.

Audit

1. The hurricane model will be reviewed to evaluate whether the determination of hurricane losses in the hurricane model is consistent with this standard.

Discussed that landfalling events are defined as a storm that is a hurricane at any point between landfall and exit to water, and causes damaging winds (gusts over 50 mph) over Florida. If the storm decays below hurricane strength while over land, winds continue to be calculated until the storm exits to water.

2. The hurricane model will be reviewed to determine that by-passing hurricanes and their effects are considered in a manner that is consistent with this standard.

Discussed that a bypassing event is defined as a hurricane which has its center over water and causes damaging winds in Florida (gusts over 50 mph).

3. The hurricane model will be reviewed to determine whether and how the hurricane model takes into account any damage resulting directly and solely from flood (including hurricane storm surge).

   Discussed that flood damages are not included unless explicitly selected by the user. Reviewed the output report in Appendix F detailing the option selected by the user.

   Discussed that the storm surge option cannot be turned on during a model run for a Florida rate filing.

4. The documented procedure for distinguishing hurricane wind-only losses from other peril losses will be reviewed.

   See PVL #17.

A-3 Hurricane Coverages

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

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

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

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

Verified: YES

Professional Team comments are provided in black font below.

Discussed with Greg Fanoe, an external reviewer and Actuarial Standards signatory, his approach to reviewing the model output, and his review of the actuarial portion of the submission document. Discussed the reasonability checks performed on the PML and average annual loss (AAL) produced by the model, and his review of the actuarial forms.

Pre-Visit Letter

18. A-3.B, page 148: Explain how actuarial analysis of appurtenant structures data differs from analysis of building data, highlighting the ways the partial loss cost analysis of appurtenant structures differs from building loss cost analysis.

    Discussed the differentiation of losses for appurtenant structures and building during review of the Vulnerability Standards.

    Reviewed an example calculation of appurtenant structure and building loss costs.

19. A-3.C, page 148: Explain how actuarial analysis of contents data differs from analysis of building data, highlighting the ways the partial loss cost analysis of contents differs from building loss cost analysis.

    Discussed the differentiation of losses for contents and building during review of the Vulnerability Standards.

    Reviewed an example calculation of contents and building loss costs.

Audit

1. The methods used to produce building, appurtenant structure, contents, and time element hurricane loss costs will be reviewed.

   Discussed the process for calculating event losses at a location for all coverage types.

   Reviewed examples of coverage-level event AALs at a location and the total event loss.

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

   Discussed that there was no change in the treatement of law and ordinance coverage since the current accepted model.

   Discussed that the impacts of law and ordinance coverage is implicitly included in the base vulnerability functions for personal residential properties.

   Discussed that the impact of the statutory required 25% and 50% coverage options for personal residential properties is factored into the post-event loss amplification (PLA).

   Reviewed the steps to calculate PLA factor updates with an illustrative example of single-family dwellings to account for the law and ordinance limit extension.

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

*(*Significant Revision)*

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.

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

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

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

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

Verified: YES

Professional Team comments are provided in black font below.

Pre-Visit Letter

20. A-4.E, page 151: Provide an example calculation of the post-event loss amplification (PLA) method factors.

    Reviewed the post-event loss amplification (PLA) methodology.

    Reviewed an example table of PLA factors by event, region, and coverage type.

    Reviewed an example application of PLA factors applied to a high severity landfalling event in Florida, and the final loss calculation after applying PLA factors.

21. A-4.1, pages 151-152: Provide, in Excel, tables of 1,000 years descending from the Top Event corresponding to Form A-8. For each year show the value of each hurricane separately.

    Reviewed the top 1,000 years of event losses for the FHCF 2017 and 2023 exposure datasets sorted by aggregate loss corresponding to Form A-8.

Audit

1. The hurricane model's handling of expenses, risk load, investment income, premium reserves, taxes, assessments, profit margin, economic inflation, and any criteria other than direct residential property insurance hurricane claim payments will be reviewed.

   Discussed that economic inflation and litigation costs are not captured in model output.

   Discussed that litigation and other legal costs are removed from claims used for model loss calibration and validation.

2. The method of determining hurricane probable maximum loss levels will be reviewed.

   Reviewed the RMS exceedance probability methodology. Discussed that the methodology has not changed since the current accepted model.

   Reviewed the alpha and beta parameter calculations for the top event.

3. The uncertainty in the estimated annual hurricane loss costs and hurricane probable maximum loss levels will be reviewed.

   Reviewed the methodology for calculation of uncertainty intervals. Discussed that the methodology has not changed since the current accepted model.

4. The data and methods used to incorporate individual aspects of demand surge on personal and commercial residential hurricane losses, inclusive of the effects from building material costs, labor costs, contents costs, and repair time will be reviewed. The vintage of the underlying demand surge data and references will be reviewed.

   Reviewed the post-event loss amplification (PLA) methodology that reflects ways in which repair costs incurred become amplified after a major catastrophe.

   Discussed the direct and indirect causes leading to economic demand surge.

   Reviewed the mean damage ratio and claims relationship. Discussed that claims inflation is based on empirical analysis of hurricane claims data.

5. The treatment of economic inflation and the claims and legal environments (social inflation) will be reviewed.

   Discussed that economic inflation and litigation costs are not captured in model output.

   Discussed that historic economic inflation is considered when incorporating past experience to develop and validate hurricane loss costs as provided in A-4.5.

6. The treatment of flood losses (including hurricane storm surge) in the determination of modeled hurricane losses will be reviewed.

   Discussed that flood losses are not included unless explicitly selected by the model user, and that selection will be shown in the model output report.

A-5 Hurricane Policy Conditions

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

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

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

Verified: YES

Professional Team comments are provided in black font below.

Audit

1. The extent that insurance company hurricane claims data are used to develop mathematical depictions of deductibles, policy limits, policy exclusions, and loss settlement provisions will be reviewed.

   Discussed that hurricane claims data are not used to develop mathematical depictions of deductibles, policy limits, policy exclusions, or loss settlement provisions.

2. The extent that insurance company hurricane claims data are used to validate the hurricane model results will be reviewed.

   Discussed during the review of the Vulnerability Standards.

3. Treatment of annual hurricane deductibles will be reviewed.

   Reviewed the methodology for developing the annual deductible tool used for calculating annual deductible factors. Discussed that there has been no change since the current accepted model.

   A code dive confirmed the annual hurricane deductible factors were implemented properly. This was seen in documentation of the calculations, whose variables in the documentation linked explicitly to variables in the code.

4. Justification for the changes from the current accepted hurricane model in the relativities among corresponding deductible amounts for the same coverage will be reviewed.

   Discussed that the loss costs for the current accepted model and the model under review demonstrate no material change in the relativities among corresponding deductible amounts for the same coverage.

   Reviewed a comparison to the current accepted model of the average frame owners loss cost relativities across different deductible values.

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

*(*Significant Revision)*

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

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.

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

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

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

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

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

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

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

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

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

1. ***masonry construction versus frame construction,***
2. ***personal residential risk exposure versus manufactured home risk exposure,***
3. ***inland counties versus coastal counties,***

A-6 Hurricane Loss Outputs and Logical Relationships to Risk* (Continued) *(*Significant Revision)*

4. northern counties versus southern counties, and

5. newer construction versus older construction.

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

Verified: YES

Professional Team comments are provided in black font below.

Pre-Visit Letter

22. A-6.13, page 158: Provide two example probable maximum loss (PML) calculations, one for personal residential and the other for commercial residential policies.

Reviewed calculations of the severity distributions for each event, the cumulative exceedance probability for each loss threshold, and the occurrence exceedance probability for each loss threshold.

Discussed that the methodology for calculating PMLs is the same for both personal residential and commercial residential policies.

Reviewed two example PML calculations, one for personal residential and another example for commercial residential. Compared them and found them reasonable.

23. Form A-1, pages 234-238: For Brevard County, ZIP Code 00042, explain why loss costs for this ZIP Code increase about 9% (Frame and Masonry +9.4%, Mobile Homes +8.7%) when most Brevard County loss costs changes are less than 1%.

Discussed that southwest Brevard County ZIP Code 00042 has minimal exposure, and that a minor change in the updated ZIP Code boundaries moved a developed area to a neighboring ZIP Code.

Reviewed map comparison of the ZIP Code boundary change from the current accepted model.

24. Form A-4, 0% Deductible, 2023 Exposure Data, page 338: Explain why the Gulf County average Frame loss cost (2.027) is 62% of the Masonry loss cost (3.250).

    Discussed that the masonry owners exposure in Gulf County is predominantly older buildings as opposed to the newer frame owners exposure, leading to greater average loss costs for masonry.

    Reviewed the year-built distribution of Form A-4 using the 2023 FHCF exposure data for frame and masonry owners exposure values in Gulf County.

    Reviewed examples within an individual year-built band where frame loss costs are greater than masonry loss costs.

Audit

1. Supporting material for the financial component changes in Disclosure 1 will be reviewed.

    Discussed that no changes were made to the financial component of the model since the current accepted model.

2. The data and methods used for hurricane probable maximum loss levels for Form A-8, will be reviewed. The hurricane associated with the Top Events will be reviewed.

    Reviewed the methodology and calculation for the expected annual hurricane losses of Form A-8.

    Reviewed the top event at the occurrence level for the 2017 FHCF exposure data and the 2023 FHCF exposure data.

    Reviewed a map of the top events from the 2017 and 2023 FHCF exposure datasets.

3. The frequency distribution and the individual event severity distribution, or information about the formulation of events, underlying Form A-8 will be reviewed.

    See Standard A-4, Audit 2.

4. Graphical representations of hurricane loss costs by ZIP Code and county will be reviewed.

    Reviewed maps of loss costs by ZIP Code and by County for frame owners, masonry owners, and manufactured homes.

5. Color-coded maps depicting the effects of land friction on hurricane loss costs by ZIP Code will be reviewed.

   Reviewed map of the loss cost ratio with land friction applied.

6. The procedures used by the modeling organization to verify the individual hurricane loss cost relationships will be reviewed. Methods (including any software) used in verifying Hurricane Standard A-6 will be reviewed.

   Reviewed the procedures to verify the individual hurricane loss costs relationships that are documented in the Actuarial Forms Output Test Plan.

7. The hurricane loss cost relationships among deductible, policy form, construction type, coverage, year of construction, building strength, number of stories, territory, and region will be reviewed.

   Reviewed Form A-6 graphical representations of the loss costs relationships and confirmed reasonability.

   Reviewed a summary table of the successful logical tests.

8. Justification for all changes in hurricane loss costs from the current accepted hurricane model will be reviewed.

   Discussed during the review of model changes under the General Standards.

9. Apparent reversals in the hurricane output ranges and their justification will be reviewed.

   See PVL #24.

10. The details on the calculation of uncertainty intervals and their justification will be reviewed.

    Reviewed the methodology for calculation of uncertainty intervals. See A-4 Audit 3.

COMPUTER/INFORMATION HURRICANE STANDARDS
Paul Fishwick, Leader

CI-1 Hurricane Model Documentation*
*(*Significant Revision)*

A. Hurricane model functionality and technical descriptions shall be documented formally in an archival format separate from the use of correspondence including emails, presentation materials, and unformatted text files.

B. All documentation, code, and scripts shall be located in central repositories controlled by repository software. Repository software shall support track changes, versioning, and collaborative editing.

C. All computer software relevant to the hurricane model shall be consistently documented and dated.

D. The following shall be maintained: (1) a table of all changes in the hurricane model from the current accepted hurricane model to the initial submission this year, and (2) a table of all substantive changes since this year's initial submission.

E. Documentation shall be created separately from the source code.

F. A list of all externally acquired, currently used, hurricane model-specific software and data assets shall be maintained. The list shall include (1) asset name, (2) asset version number, (3) asset acquisition date, (4) asset acquisition source, (5) asset acquisition mode (e.g., lease, purchase, open source), and (6) length of time asset has been in use by the modeling organization.

Verified: YES

Professional Team comments are provided in black font below.

Audit

1. The central repositories will be reviewed.

   Discussed the use of Microsoft Team Foundation Server (TFS) and GitHub as the primary document repositories.

   Discussed that all specification documents have been moved to a central repository.

2. Complete user documentation, including all recent updates, will be reviewed.

   Reviewed the documented procedure for creating the vulnerability and actuarial forms including testing of the results.

   Reviewed the internal writing style documentation standards.

   Reviewed the Moody's RMS mapping style guide documentation standards.

   Reviewed the FHCF EDM Development documentation.

   Reviewed the windstorm claims and exposure data requirements documentation.

   Reviewed the component methodology documentation for importance sampling used on the simulated tracks.

   Reviewed the annual deductible tool methodology documentation.

3. Modeling organization personnel, or their designated proxies, responsible for each aspect of the software (i.e., user interface, quality assurance, engineering, actuarial, verification) shall be present when the Computer/Information Hurricane Standards are being reviewed. Internal users of the software will be interviewed.

   All subject matter experts and personnel involved in software implementation were available and participated throughout the review.

4. Verification that documentation is created separately from, and is maintained consistently with, the source code will be reviewed.

   Reviewed examples illustrating that documentation is created separately from the source code and maintained within a combination of TFS and GitHub.

5. The list of all externally acquired hurricane model-specific software and data assets will be reviewed.

   Reviewed the list of externally acquired hurricane model-specific software and data sources.

6. The tables specified in Hurricane Standard CI-1.D that contain the items listed in Hurricane Standard G-1, Disclosure 7 will be reviewed. The tables shall contain the item number in the first column. The remaining five columns shall contain specific document or file references for affected components or data relating to Computer/Information Hurricane Standards CI-2, CI-3, CI-4, CI-5, and CI-7.

   Reviewed the summary of changes for all the models changes since the current accepted model.

7. Tracing of the hurricane model changes specified in Hurricane Standard G-1, Disclosure 7 and Audit 4 through all Computer/Information Hurricane Standards will be reviewed.

   Reviewed the hazard updates, the event rates update, the geocoding updates, and the vulnerability mappings update through CI Standards 1-8.

CI-2 Hurricane Model Requirements*

*(*Significant Revision)*

A complete set of requirements for each software component, as well as for each database or data file accessed by a component, shall be maintained. Requirements shall be updated whenever changes are made to the hurricane model.

Verified: YES

Professional Team comments are provided in black font below.

Audit

1. Maintenance and documentation of a complete set of requirements for each software component, database, and data file accessed by a component will be reviewed.

   Reviewed the requirements and mathematical formulas for importance sampling used on simulated tracks.

   Discussed the software used for capturing requirements.

2. Requirements documentation specifically relating to each model change identified in Hurricane Standard G-1, Disclosure 7 will be reviewed.

   Reviewed requirements documentation for the hazard updates, the event rates update, the geocoding updates, and the vulnerability mappings update.

CI-3 Hurricane Model Organization and Component Design

A. The following shall be maintained and documented: (1) detailed control and data flowcharts and interface specifications for each software component, (2) schema definitions for each database and data file, (3) flowcharts illustrating hurricane model-related flow of information and its processing by modeling organization personnel or consultants, (4) network organization, and (5) system model representations associated with (1)-(4) above. Documentation shall be to the level of components that make significant contributions to the hurricane model output.

B. All flowcharts (e.g., software, data, and system models) in the submission or in other relevant documentation shall be based on (1) a referenced industry standard (e.g., UML, BPMN, SysML), or (2) a comparable internally developed standard which is separately documented.

Verified: YES

Professional Team comments are provided in black font below.

Audit

1. The following will be reviewed:

   a. Detailed control and data flowcharts, completely and sufficiently labeled for each component,

   Reviewed numerous flowcharts throughout the review.

   Reviewed control flow diagram for ZIP Code tables development.

   Reviewed control flow diagrams for Forms A-2, A-4, and A-5.

   Reviewed flowchart for processing changes in HURDAT2 in calculating landfall event rates.

   Reviewed flowchart and process for calculating hurricane surface winds.

   Reviewed control and data flow diagram for Form S-2.

   Reviewed flowchart for importance sampling used on simulated tracks.

b. Interface specifications for all components in the hurricane model,

Reviewed the model components interface specifications throughout the review.

c. Documentation for schemas for all data files, along with field type definitions,

Reviewed schema documents throughout the review.

d. Each network flowchart including components, sub-component flowcharts, arcs, and labels,

Reviewed flow diagram of major model components in Figure 3.

e. Flowcharts illustrating hurricane model-related information flow among modeling organization personnel or consultants (e.g., BPMN, UML, SysML, or equivalent technique including a modeling organization internal standard), and

Discussed information flow among modeler personnel throughout the review.

f. If the hurricane model is implemented on more than one platform, the detailed control and data flowcharts, component interface specifications, schema documentation for all data files, and detailed network flowcharts for each platform.

Discussed that the North Atlantic Hurricane Models Version 25.0 (Build 2450) is implemented on two platforms: RiskLink 25.0 and Risk Modeler 2.38.0.

Reviewed high-level diagrams defining the RiskLink and Risk Modeler network organization in Figure 4.

Reviewed Forms S-5, A-1, A-4, and A-8 generated on both platforms and the calculations showing no differences in the form results between platforms.

2. The flowchart reference guide or industry standard reference will be reviewed.

Reviewed the Moody's RMS flow diagram standards.

CI-4 Hurricane Model Implementation*

*(*Significant Revision)*

A. A complete procedure of coding guidelines consistent with accepted practices shall be maintained. Coding guidelines shall be referenced for each programming language used in the hurricane model or submission document.

B. Network organization documentation shall be maintained.

C. A complete procedure used in creating, deriving, or procuring and verifying databases or data files accessed by components shall be maintained.

D. All components shall be traceable, through explicit component identification in the hurricane model representations (e.g., requirements, flowcharts) down to the implementation level.

E. A table of all software components affecting hurricane loss costs and hurricane probable maximum loss levels shall be maintained with the following table columns: (1) component name, (2) number of lines of code, minus blank and comment lines, and (3) number of explanatory comment lines.

F. Each component shall be sufficiently and consistently commented so that a software engineer unfamiliar with the code shall be able to comprehend the component logic at a reasonable level of abstraction.

G. The following documentation shall be maintained for all components or data modified by items identified in Hurricane Standard G-1, Disclosure 7 and Audit 4:

1. A list of all equations and formulas used in documentation of the hurricane model with definitions of all terms and variables, and

2. A cross-referenced list of implementation source code terms and variable names corresponding to items within G.1 above.

H. Hurricane model code and data shall be accompanied by documented review plans, testing plans, and if needed, update plans through regularly scheduled intervals. The vintage of the hurricane model code and data shall be justified.

Verified: YES

Professional Team comments are provided in black font below.

Pre-Visit Letter

25. CI-4: Discuss process improvements in automated scripts for actuarial forms as documented in the 2023 Professional Team On-Site Review Report.

    Reviewed the changes made to the Form A-6 generation script and a new quality assurance test implemented.

    Discussed the change from hard coded magic numbers to more meaningful variable names.

Audit

1. Code and data implementations, for at least the meteorology, vulnerability, and actuarial components, will be reviewed.

    Reviewed implementation of the ISO Fire 3 construction class mapping update.

    Reviewed implementation of importance sampling used on simulated tracks.

    Reviewed implementation of annual hurricane deductible factors.

2. The documented coding guidelines, including procedures for ensuring readable identifiers for variables, constants, and components, and confirmation that these guidelines are uniformly implemented will be reviewed.

    Reviewed the coding guidelines documentation.

    Discussed the changes in the coding guidelines since the previous model review.

3. The procedure used in creating, deriving, or procuring and verifying databases or data files accessed by components will be reviewed.

    Reviewed processes for automated validation of model development.

4. The traceability among components at all levels of representation will be reviewed.

    Discussed the process for ensuring traceability among model components.

5. The following information will be reviewed for each component, either in a header comment block, source control database, or the documentation:
   a. Component name,
   b. Date created,
   c. Dates modified, modification rationale, and by whom,
   d. Purpose or function of the component, and
   e. Input and output parameter definitions.

   Discussed that all code is under source control.

6. The table of all software components as specified in Hurricane Standard CI-4.E will be reviewed.

   Reviewed the table of software components.

7. Hurricane model components and the method of mapping to elements in the computer program will be reviewed.

   Reviewed the variable names and mapping for importance sampling used on simulated tracks.

   Reviewed the variable names and mapping for annual deductible factors.

8. Comments within components will be reviewed for sufficiency, consistency, and explanatory quality.

   Reviewed comments in selected source code examined throughout the review.

9. Unique aspects within various platforms with regard to the use of hardware, operating system, and essential software will be reviewed.

   Reviewed the hardware and operating system requirements for the Risk Modeler and RiskLink loss modeling platforms.

   Reviewed additional software requirements and programming languages.

10. Network organization implementation will be reviewed.

    Reviewed the network organization diagrams for RiskLink and Risk Modeler given in Figure 4.

    Discussed the authorization mechanisms used for the model.

11. Code and data review plans, testing plans, update plans, and schedules will be reviewed. Justification for the vintage of code and data will be reviewed.

Reviewed model certification test plans.

12. Automated procedures used to create forms will be reviewed.

Reviewed the procedures for creating the actuarial forms that are documented in "Creation of the Actuarial Forms for the FCHLPM Submission."

Reviewed the procedures for creating the vulnerability forms that are documented in "Creation of the Vulnerability Forms for the FCHLPM Submission."

Reviewed the documented procedure for creating Forms S-2 and S-5.

Reviewed the R code to generate Form S-2.

CI-5 Hurricane Model Verification*

*(*Significant Revision)*

A. General

For each component, procedures shall be maintained for verification, such as code inspections, reviews, calculation crosschecks, and walkthroughs, sufficient to demonstrate code correctness. Verification procedures shall include tests performed by modeling organization personnel other than the original component developers.

B. Component Testing

1. ***Testing software shall be used to assist in documenting and analyzing all components.***

2. ***Unit tests shall be performed and documented for each updated component.***

3. ***Regression tests shall be performed and documented on incremental builds.***

4. ***Integration tests shall be performed and documented to ensure the correctness of all hurricane model components. Sufficient testing shall be performed to ensure that all components have been executed at least once.***

C. Data Testing

1. ***Testing software shall be used to assist in documenting and analyzing all databases and data files accessed by components.***

2. ***Integrity, consistency, and correctness checks shall be performed and documented on all databases and data files accessed by the components.***

Verified: **YES**

Professional Team comments are provided in black font below.

Audit

1. Procedures for physical unit conversion verification (e.g., knots to mph) will be reviewed.

   Discussed that some variables can be input into the model in metric or imperial units.

Reviewed an example conversion factor used to convert units at model runtime for floor area.

2. The components will be reviewed for containment of sufficient logical assertions, exception-handling mechanisms, and flag-triggered output statements to test the correct values for key variables that might be subject to modification.

   Reviewed examples of various verification source code techniques during code dives.

3. The testing software used by the modeling organization will be reviewed.

   Discussed the testing software and automated testing process.

4. The component (unit, regression, integration) and data test processes and documentation will be reviewed including compliance with independence of the verification procedures.

   Discussed incremental improvements with test plans implemented since the previous review.

   Reviewed the actuarial forms output test plan.

   Reviewed the integration testing, aggregation testing, and regression testing for importance sampling used on simulated tracks.

   Reviewed tests for historical events implementation, vulnerability data checks, and loss tracking with EDMs with unknown building attributes.

5. Fully time-stamped, documented cross-checking procedures and results for verifying equations, including tester identification, will be reviewed. Examples include mathematical calculations versus source code implementation or the use of multiple implementations using different languages.

   Reviewed cross-checking verification methods regarding mathematical calculations.

6. Flowcharts defining the processes used for manual and automatic verification will be reviewed.

   Reviewed flowcharts for verification.

7. Verification approaches used for externally acquired data, software, and models will be reviewed.

   Reviewed verification approaches used for several external digital assets.

8. Complete and thorough verification procedures and output from the model changes identified in Hurricane Standard G-1, Disclosure 7 will be reviewed.

   Reviewed the "Model Certification Test Plan North Atlantic Hurricane (NAHU) Model for RiskLink 25" documentation.

CI-6 Human-Computer Interaction

A. Interfaces shall be implemented as consistent with accepted principles and practices of Human-Computer Interaction (HCI), Interaction Design, and User Experience (UX) engineering.

B. Interface options used in the hurricane model shall be unique, explicit, and distinctly emphasized.

C. For a Florida insurance rate filing, interface options shall be limited to those options found acceptable by the Commission.

Verified: YES

Professional Team comments are provided in black font below.

Audit

1. External and internal user interfaces will be reviewed.

   Reviewed a live demonstration of the interface.

   Discussed the changes to the user interface for Florida rate filings.

2. Documentation related to HCI, Interaction Design, and UX engineering will be reviewed.

   Reviewed the documentation associated with HCI, interactive design, and UX engineering.

3. The decision process specifying the logic of interface option selections, when an acceptable hurricane model is selected, will be reviewed.

   Reviewed the internal procedures to capture the principles related to design implementation and evaluation of the interface options.

CI-7 Hurricane Model Maintenance and Revision*

*(*Significant Revision)*

A. A clearly written policy shall be implemented for review, maintenance, and revision of the hurricane model and network organization, including verification and validation of revised components, databases, and data files.

B. A revision to any portion of the hurricane model that results in a change in any Florida personal and commercial residential hurricane loss cost or hurricane probable maximum loss level shall result in a new hurricane model version identification.

C. A list of all hurricane model versions since the initial submission for this year shall be maintained. Each hurricane model description shall have a unique version identification and a list of additions, deletions, and changes that define that version.

Verified: YES

Professional Team comments are provided in black font below.

Audit

1. All policies and procedures used to review and maintain the code, data, and documentation will be reviewed. For each component in the system decomposition, the installation date under configuration control, the current version identification, and the date of the most recent change(s) will be reviewed.

   Reviewed policies and procedures used for code, data and documentation.

2. The policy for hurricane model revision and management will be reviewed.

   Discussed the RiskLink and Risk Modeler versioning requirements documentation.

3. Portions of the code, not necessarily related to recent changes in the hurricane model, will be reviewed.

   Code reviews were conducted as listed under CI-4.

4. The tracking software will be reviewed and checked for the ability to track date and time.

   Discussed the use of Github for tracking software.

5. The list of all hurricane model revisions as specified in Hurricane Standard CI-7.C will be reviewed.

   Reviewed the relevant requirement documentation reflecting the updates.

6. The model version history over the past 5 years, leading up to the version submitted will be reviewed.

   Reviewed the model version history with changes dating back to 2019, Version 18.1 (Build 1945).

CI-8 Hurricane Model Security*

*(*Significant Revision)*

Security procedures shall be implemented and fully documented for (1) secure access to individual computers where the software components or data can be created or modified, (2) secure operation of the hurricane model by clients, if relevant, to ensure that the correct software operation cannot be compromised, (3) anti-virus software installation for all machines where all components and data are being accessed, and (4) secure access to documentation, software, and data in the event of a catastrophe.

Verified: YES

Professional Team comments are provided in black font below.

Audit

1. The written policy for all security procedures and methods used to ensure the security of code, data, and documentation will be reviewed.

   Discussed the key aspects of Moody's security procedures.

2. Documented security procedures for access, client hurricane model use, anti-virus software installation, and off-site procedures in the event of a catastrophe will be reviewed.

   Reviewed security procedures.

3. Security aspects of each platform will be reviewed.

   Reviewed the security requirements for the RiskLink and Risk Modeler platforms.

4. Network security documentation and network integrity assurance procedures will be reviewed.

   Reviewed flow diagrams of the network security for the RiskLink and Risk Modeler platforms.

Commission Issue

Specify if and where Artificial Intelligence (AI) is used (e.g., development, implementation, testing, data analysis, documentation). If used, explain how AI is employed along with what AI models (in-house, proprietary, or open source) and inference are implemented. For any training performed by the modeling organization, specify whether fine-tuning is done or whether the AI model is trained from scratch. Specify the AI model types, learning algorithms, training data, testing data, and measures of effectiveness.

Discussed that AI was not used in the development of the North Atlantic Hurricane model development process nor in code generation.

Discussed AI use cases for other tasks which will be discussed with the Commission during the trade secret session of the June 2025 meeting to review the model for acceptability.