

Florida Commission on Hurricane Loss Projection Methodology

Professional Team Report **2021 Hurricane Standards**



CoreLogic, Inc.

**On-Site Review
March 27 – 30, 2023**

On March 27-30, 2023, the Professional Team conducted an on-site review of the CoreLogic, Inc. (CL), CoreLogic Florida Hurricane Model 2023 on the Risk Quantification and Engineering v23 platform. The following individuals participated in the review.

CoreLogic

Branimir Betov, M.S., Director, Model Development
Justin Brolley, Ph.D., Principal Research Scientist
Mahmoud Khater, Ph.D., P.E., Chief Science and Engineering Officer
Howard Kunst, FCAS, MAAA, Actuary
Ilyes Meftah, Research Scientist
Peter Nagy, Principal, Science and Analytics
David Smith, Senior Director, Model Development
Amanuel Tecele, Ph.D., Research Scientist

Professional Team

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

The Professional Team began the review with an opening briefing and introductions were made. CoreLogic provided a detailed explanation of updates to the model.

- Updated the probabilistic hurricane database to HURDAT2 as of April 8, 2022
- Updated Rmax, forward speed, profile factor, and filing rate to reflect HURDAT2 updates
- Profile factor statistical distribution changed to Inverse Gamma
- Updated defaults for manufactured home exterior wall conditions
- Updated default year of construction based on the 2020 Census data
- Updated the ZIP Code database to June 2022

The audit continued with a review of each standards section.

During the Commission meeting to review the model for acceptability under the 2021 Hurricane Standards, CoreLogic is to present the following information in the Trade Secret closed session as specified on page 64 of the *Hurricane Standards Report of Activities as of November 1, 2021*:

1. Detailed information and discussion of Forms V-3 and V-5,
2. Discussion on how the model addresses the impacts of the claims environment, the legal environment, and litigation effects on modeled losses, and
3. Detailed information and discussion of relativities in Form A-6.

Report on Deficiencies

The Professional Team reviewed the following deficiencies cited by the Commission at the January 5, 2023 meeting. The deficiencies were eliminated by the established time frame, and the modifications have been verified.

1. G-1.E, page 15: Non-responsive. Response is a restatement of the standard (see Report of Activities, page 56).
2. G-1.7, Figure 7, page 34: Unclear. The numerical value 0.1 does not correspond to the legend.
3. M-2.9, Figure 11, page 57: Incomplete. Figure 11 does not include modeled landfall rates computed from the Base Hurricane Storm Set.
4. M-3.2, page 60: Incomplete. Rationale for the probability distributions is not provided.
5. M-4.7, Figures 13 and 14, page 64: Unclear. The legend color for 155-165mph is incorrect.
6. S-1.6, Figure 22, page 79: Unclear. Figure 22 needs updating for the RQE v23 model.
7. V-1.6, page 93: Incomplete. The response indicates the data source but not the treatment of uncertainties.
8. V-2.4, page 102: Incomplete. The number of contents hurricane vulnerability functions is not provided.
9. Form V-2, page 206: Non-responsive. Responses not provided for A and D.
10. A-3.A, page 133: Unclear. The response cites Disclosure 1 that does not mention law and ordinance.
11. A-3.2, page 134: Non-responsive. A description of methods used to calculate appurtenant structure loss costs is not provided.
12. A-6.10, page 148: Non-responsive. A referral to the vulnerability functions is insufficient.
13. Form A-1, page 218: Non-responsive. Response not provided for the last sentence of B.
14. Form A-1, page 218: Non-responsive. Response alluding to the vulnerability functions is insufficient for C.
15. Form A-4, page 230: Non-responsive. A referral to the vulnerability functions is insufficient for H.

Professional Team Pre-Visit Letter

The Professional Team’s pre-visit letter questions 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 CoreLogic’s model submission under the 2021 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 review that is not given below or discussed during an upcoming conference call to be held if requested by CoreLogic. One goal of the 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.

The Professional Team will also consider material provided in response to the deficiencies designated by the Florida Commission on Hurricane Loss Projection Methodology (Commission) during the January 5, 2023, meeting.

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. CoreLogic should then proceed with a detailed explanation of new or extensively updated material related to the model followed by a review of each hurricane standard commencing with responses to the pre-visit letter questions followed by responses to the audit items for each hurricane standard in the *Hurricane Standards Report of Activities as of November 1, 2021*.

If changes have been made in any part of the model or the modeling process from the descriptions provided in the original November 2, 2022, 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, 2021*, for more details on materials to be presented and provided to the Professional Team. Particular attention should be paid to the requirements under Presentation of Materials. These requirements are reproduced at the conclusion of this letter.

In addition to the 6 items listed under Presentation of Materials, provide upon arrival of the Professional Team, and before the review can officially commence, printed copies of:

1. Flowchart standard documents if internally developed, or references to published standards, and
2. Software engineering practice and coding guidelines if internally developed, or references to published standards.

The pre-visit questions are grouped by hurricane standards sections.

Editorial Items

Editorial items in the submission documentation were noted by the Professional Team in the pre-visit letter for correction prior to the start of the on-site review in order to facilitate efficiency during the review and to avoid last minute edits. Additional editorial items identified during the review are also included below.

The Professional Team reviewed the following corrections to be included in the revised submission to be provided to the Commission no later than 10 days prior to the meeting to review the model for acceptability. Page numbers below correspond to the initial November 2, 2022 submission document.

1. Page 4, Checklist removed.
2. General description of trade secret information revised on page 7 for clarity.
3. Table of Contents, pages 9-10: Appendix 3 and Form A-6 titles corrected.
4. List of Tables, page 11: Numbering corrected after Table 25.
5. G-1, page 14: Standard wording updated to the 2021 Hurricane Standards Report of Activities (ROA); Response edited to remove other covered personal property for clarification.
6. G-1.2, page 17: Revised for clarification.
7. G-1.6, page 26: Errant period in front of Case reference removed; Sill and Kozlowski (1997) reference added.
8. G-1.6, page 27: Vickery and Twisdale 1995 (G-1.2, page 17) reference added in list of references.
9. G-1.6, page 30: Rubenstein (1981) reference corrected; page 33: ISO 5807 added to Computer/Information Standards references.
10. G-1.7, page 31: The last sentence in 7.A.3.1 completed.
11. G-1.7, pages 33-35: Captions for Figures 5-9 revised to explain gray in legend.
12. G-2.2, pages 40-41: Response to part B, Table 6, and Figure 10 updated..
13. G-3.2, page 47: Misplaced comma in 6 removed.
14. M-1, page 50: Standard lettering updated to 2021 ROA.
15. M-2, page 52: The end date of the HURDAT2 record used for Landfall Location, Maximum One-Minute Sustained Wind Speed, and Filling Rate added.
16. M-2.1, page 53: Revised profile factor text for clarification; page 60 revised for clarification.
17. M-4.4, page 63: Missing period at end of disclosure added.

18. M-4.7, pages 64-65: Captions for Figures 13-15 revised to explain white area in map.
19. M-5.1, page 67: Equation numbered.
20. S-1.6, page 79: Figure 22 corrected.
21. V-1.5, page 93: Response revised for consistency with G-1.7 and V-1.1.
22. V-1.4, page 102: Disclosure reference corrected.
23. V-1.7, page 93: Update to add site inspections for recent storms.
24. V-4.2, page 109: Second paragraph removed.
25. A-4.1, page 138: Revised for clarification.
26. A-4.2, page 139: Disclosure wording updated to 2021 ROA.
27. A-4.3, page 140: Revised for clarification.
28. A-6.16.3, page 150: Sentence revised for clarity.
29. Form M-1, page 173: Extra A removed.
30. Form S-3, page 190: Profile Factor updated for change to Inverse Gamma.
31. Form S-5, page 197: Wording in Table 22 updated to 2021 ROA.
32. Form S-5, page 198: Equations numbered.
33. Form A-1.A, page 214: Response revised to include Figure 48.
34. Form A-1.B, page 218: Name of Notional Input file updated.
35. Form A-2.A, page 221: Start of second paragraph updated to 2021 ROA.
36. Form A-2, pages 222-223: Column headings updated to 2021 ROA.
37. Form A-5, page 244: Paragraph lettering corrected.
38. Form A-5.G, page 246: Last sentence figure numbering corrected.
39. Form A-8.B, page 264: Number of hurricanes updated in last paragraph.
40. Form A-8.C, page 268: Column headings updated to 2021 ROA.
41. Appendix 6, pages 271-272: Added acronyms omitted from the list.
42. Appendix 7, page 275: Dr. Omar Khemici bio updated.

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 and 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 and shall be located in centralized, model-level file areas.**
- D. A subset of the forms shall be produced through an automated procedure or procedures as indicated in the form instructions.**
- E. Vintage of data, code, and scientific and technical literature used shall be justifiable.**

Audit

1. Automated procedures used to create forms will be reviewed.
2. All primary scientific and technical literature that describes the underlying hurricane model theory and implementation (where applicable) should be available for review in hard copy or electronic form. Modeling-organization-specific publications cited must be available for review in hard copy or electronic form.
3. Compliance with the process prescribed in Hurricane Standard G-1.B in all stages of the modeling process will be reviewed.
4. Items specified in Hurricane Standard G-1.C will be reviewed as part of the Computer/ Information Hurricane Standards.
5. Maps, databases, and data files relevant to the submission will be reviewed.
6. Justification for the vintage of data, code, and scientific and technical literature used will be reviewed.

7. The following information related to changes in the hurricane model, since the initial submission for each subsequent revision of the submission, will be reviewed.
 - A. Hurricane model changes:
 1. A summary description of changes that affect, or are believed to affect, the personal or commercial residential hurricane loss costs or hurricane probable maximum loss levels,
 2. A list of all other changes, and
 3. The rationale for each change.
 - B. Percentage difference in average annual zero deductible statewide hurricane loss costs based on the 2017 Florida Hurricane Catastrophe Fund personal and commercial residential zero deductible exposure data found in the file named "*hlpm2017c.zip*" for:
 1. All changes combined, and
 2. Each individual hurricane model component and subcomponent change.
 - C. For any modifications to Form A-4, Hurricane Output Ranges, since the initial submission, a newly completed Form A-5, Percentage Change in Hurricane Output Ranges, with:
 1. The initial submission as the baseline for computing the percentage changes, and
 2. Any intermediate revisions as the baseline for computing the percentage changes.
 - D. Color-coded maps by county reflecting the percentage difference in average annual zero deductible statewide hurricane loss costs based on the 2017 Florida Hurricane Catastrophe Fund personal and commercial residential zero deductible exposure data found in the file named "*hlpm2017c.zip*" for each hurricane model component change, between:
 1. The currently accepted hurricane model and the revised hurricane model,
 2. The initial submission and the revised submission, and
 3. Any intermediate revisions and the revised submission.

Pre-Visit Letter

1. G-1.B, page 14: Explain the coordination across personnel.
2. G-1.2, pages 15-21: Explain why the number of stochastic storms (33,082) remains the same given the updates in the hurricane hazard component.
3. G-1.2, pages 15-21: Provide justification for basing the windspeed equation upon the NOAA model as published in NWS 23 (Schwerdt et al. 1979) and NWS 38 (Ho et al. 1987) and how such usage supports G-1.E.
4. G-1.3, Figure 1, page 22: Describe how by-passing hurricanes fit into the flowchart. Describe how hurricane tracks from genesis fit into the flowchart.
5. G-1.7, pages 31-35: Explain how interim software updates, if performed, over the past two years mesh with Standard G-1.7.
6. G-1.7, pages 31-32: Identify the specific requirements each of the four updates satisfy.
7. G-1.7, pages 33-35: Provide Figures 5-9 with a range from -20% to +25%. Explain the range -0% to 0%.
8. G-1.7, Figures 8 and 9, pages 34-35: Explain the differences for neighboring Sumter and Lake Counties.

Verified: YES

Professional Team Comments:

Reviewed the model updates and the impact of the changes on loss costs.

Discussed the procedure for data updates to the model.

Discussed the process and tools used for coordinating personnel.

Discussed that the stochastic storm tracks and landfall intensities have not changed from the current accepted model.

Discussed that the storm parameters (Rmax, Profile Factor, Forward Speed, and Inland Filling) and storm frequencies have been updated.

Discussed how by-passing hurricanes are included in the Figure 1 flowchart.

Discussed that the interim platform updates to Risk Quantification and Engineering v22 and v22.1 were found to be functionally equivalent to the current accepted platform v21.

Reviewed Figures 5-9 with a range from -20% to +25% providing more detail on the changes.

Discussed the reasons for the change in loss costs in Sumter and Lake Counties as shown in Figures 8 and 9 of the submission.

Reviewed the process to assure agreement among databases, data files, and code with presentation slides, technical papers, equations, and model documentation.

G-2 Qualifications of Modeling Organization Personnel and Consultants Engaged in Development 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 (currently 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.**

Audit

1. The professional vitae of personnel and consultants engaged in the development of the hurricane model and responsible for the current hurricane model and the submission will be reviewed. Background information on the professional credentials and the requisite experience of individuals providing testimonial letters in the submission will be reviewed.
2. Forms G-1, General Hurricane Standards Expert Certification; G-2, Meteorological Hurricane Standards Expert Certification; G-3, Statistical Hurricane Standards Expert Certification; G-4, Vulnerability Hurricane Standards Expert Certification; G-5, Actuarial Hurricane Standards Expert Certification; G-6, Computer/Information Hurricane Standards Expert Certification, and all independent peer reviews of the hurricane model under consideration will be reviewed. Signatories on the individual forms will be required to provide a description of their review process.
3. 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.
4. For each individual listed under Disclosure 2.A, specific information as to any consulting activities and any relationship with an insurer, reinsurer, trade association, governmental entity, consumer group, or other advocacy group within the previous four years will be reviewed.

Pre-Visit Letter

9. Appendix 8, page 279 and page 283: Provide the complete review reports from Professor S. Narasimhan and Dr. Eldin and Dr. Ail.

Verified: YES

Professional Team Comments:

Reviewed resume of personnel new to the process:

- David Gregory, Ph.D. candidate in Seismology, University College London, London, UK; M.Sc. in Geophysical Hazards, University College London, London, UK; B.Sc. in Investment & Financial Risk Management, Bayes Business School, London, UK

G-3 Insured Exposure Location

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

Audit

1. Geographic displays for all ZIP Codes will be reviewed.
2. Geographic comparisons of previous to current locations of ZIP Code centroids will be reviewed.
3. Third party vendor information, if applicable, and a complete description of the process used to validate ZIP Code information will be reviewed.
4. The treatment of ZIP Code centroids over water or other uninhabitable terrain will be reviewed.
5. Examples of geocoding for complete and incomplete street addresses will be reviewed.
6. Examples of latitude-longitude to ZIP Code conversions will be reviewed.
7. Hurricane model ZIP Code-based databases will be reviewed.

Verified: YES

Professional Team Comments:

Discussed the methodology for processing ZIP Code data.

Reviewed geographic comparisons of the updated ZIP Code centroid locations from the current accepted model.

Discussed that there were no changes in the geocoding methodology.

Reviewed geographic comparisons and explanations for the largest 10 ZIP Code centroid movements.

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.

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

Verified: YES

Professional Team Comments:

There was no evidence to suggest one component of the model was adjusted to compensate for another 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, Editorial Review Expert Certification, that the submission has been personally reviewed and is editorially correct.

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, 2021* will be made.
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.
3. Confirmation that the submission has been reviewed by the signatories on the Expert Certification Forms G-1 through G-6 for accuracy and completeness will be assessed.
4. The modification history for submission documentation will be reviewed.
5. A flowchart defining the process for form creation will be reviewed.
6. Form G-7, Editorial Review Expert Certification, will be reviewed.

Verified: YES

Professional Team Comments:

Discussed the editorial review process.

Reviewed the flowchart for creating submission forms.

Editorial items noted in the pre-visit letter and during the review by the Professional Team were satisfactorily addressed. The Professional Team has reviewed the submission per Audit item 3, but cannot guarantee that there are no remaining editorial issues. The modeler is responsible for eliminating editorial errors.

METEOROLOGICAL HURRICANE STANDARDS – Jimmy Booth, Leader

M-1 Base Hurricane Storm Set*

(*Significant Revision)

The Base Hurricane Storm Set is the National Hurricane Center HURDAT2 as of June 10, 2021 (or later), incorporating the period 1900-2020. A model may be constructed in any scientifically sound and defensible fashion. However, annual frequencies used in hurricane model validation shall be based upon the Base Hurricane Storm Set, allowing for modifications if justified. Complete additional season increments and updates to individual historical storms that are approved by the National Hurricane Center are acceptable modifications, as are weighting and partitioning of the Base Hurricane Storm Set, if it is justified in current scientific and technical literature.

Audit

1. The modeling organization Base Hurricane Storm Set will be reviewed.
2. A flowchart illustrating how changes in the HURDAT2 database are used in the calculation of hurricane landfall distribution will be reviewed.
3. Changes to the modeling organization Base Hurricane Storm Set from the currently accepted hurricane model will be reviewed. Any modification by the modeling organization to the information contained in HURDAT2 will be reviewed.
4. Reasoning and justification underlying any short-term, long-term, or other systematic variations in annual hurricane frequencies incorporated in the hurricane model will be reviewed.
5. Modeled probabilities will be compared with observed hurricane frequency using methods documented in current scientific and technical literature. The goodness-of-fit of modeled to historical statewide and regional hurricane frequencies as provided in Form M-1, Annual Occurrence Rates, will be reviewed.
6. Form M-1, Annual Occurrence Rates, will be reviewed for consistency with Form S-1, Probability and Frequency of Florida Landfalling Hurricanes per Year, and Form A-2, Base Hurricane Storm Set Statewide Hurricane Losses.
7. Comparisons of modeled probabilities and characteristics from the complete historical record will be reviewed. Modeled probabilities from any subset, trend, or fitted function will be reviewed, compared, and justified against the complete HURDAT2 database. In the case of partitioning, modeled probabilities from the partition and its complement will be reviewed and compared with the complete HURDAT2 database.

Pre-Visit Letter

10. Form M-1, Table 12, page 175: Explain the rationale for the Modified Base Storm Set numbers.

Verified: YES

Professional Team Comments:

Reviewed the hurricanes added to the Base Hurricane Storm Set and the hurricanes modified based on the updates in HURDAT2.

Discussed the changes underlying the modified base storm set numbers in Cat 1 and Cat 2 in Form M-1.

Reviewed landfall frequency by region for Florida and clarified the treatment of the Keys in mapping historical events.

Reviewed flowchart for updating storm frequencies based on changes in HURDAT2.

Discussed the issue of climate change and the modeler's current approach in considering it.

Reviewed landfall frequency goodness-of-fit Chi-Squared tests by region for Florida and for neighboring states.

Reviewed the annual occurrence rates in Form M-1 compared to Form S-1 and Form A-2.

M-2 Hurricane Parameters and Characteristics*

(*Significant Revision)

Methods for depicting all modeled hurricane parameters and characteristics, including but not limited to windspeed, radial distributions of wind and pressure, minimum central pressure, radius of maximum winds, landfall frequency, tracks, spatial and time variant windfields, and conversion factors, shall be based on information documented in current scientific and technical literature.

Audit

1. All hurricane parameters used in the hurricane model will be reviewed.
2. 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,
 - b. The modeled dependencies among correlated parameters in the windfield component and how they are represented, and
 - c. The asymmetric structure of hurricanes.
3. The treatment of the inherent uncertainty in the conversion factor used to convert the modeled vortex winds to surface winds will be reviewed and compared with current scientific and technical literature. Treatment of conversion factor uncertainty at a fixed time and location within the windfield for a given hurricane intensity will be reviewed.
4. Scientific literature cited in Hurricane Standard G-1, Scope of the Hurricane Model and Its Implementation, may be reviewed to determine applicability.
5. All external data sources that affect model-generated windfields will be identified, and their appropriateness will be reviewed.
6. Description of and justification for the value(s) of the far-field pressure used in the hurricane model will be reviewed.

Pre-Visit Letter

11. M-2.5, page 56: Describe the modeling of surface winds.
12. M-2.6, page 56: Provide the equation used that involves the gust factor.

Verified: YES

Professional Team Comments:

Reviewed the changes for the updated Rmax, forward speed, and profile factor distributions.

Reviewed comparison of modeled and historical Rmax, forward speed, and profile factor and their associated goodness-of-fit tests.

Reviewed schematic of modeling surface winds.

Reviewed code to compute the profile factor based on historical storms.

Reviewed comparisons of profile factor fits for Hurricane Donna (1960) and Hurricane Carla (1961).

Reviewed comparisons of wind profiles for Hurricane Anita (1977), Hurricane Mitch (1998), and Hurricane Hugo (1989).

Reviewed the gust factor equation.

Reviewed the relationship between modeled profile factor and Rmax.

M-3 Hurricane Probability Distributions*

(*Significant Revision)

- A. Modeled probability distributions of hurricane parameters and characteristics shall be consistent with historical hurricanes in the Atlantic basin.**
- B. Modeled hurricane landfall frequency distributions shall reflect the Base Hurricane Storm 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).**
- C. Hurricane models shall use maximum one-minute sustained 10-meter windspeed when defining hurricane landfall intensity. This applies both to the Base Hurricane Storm 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.**

Saffir-Simpson Hurricane Wind Scale

Category	Winds (mph)	Damage
1	74 – 95	Minimal
2	96 – 110	Moderate
3	111 – 129	Extensive
4	130 – 156	Extreme
5	157 or higher	Catastrophic

Audit

1. Demonstration of the quality of fit extending beyond the Florida border will be reviewed by evaluating results for appropriate coastal segments in Alabama, Georgia, and Mississippi.
2. The method and supporting material for selecting stochastic storm tracks will be reviewed.
3. The method and supporting material for selecting storm track strike intervals will be reviewed. If strike locations are on a discrete set, the hurricane landfall points for major metropolitan areas in Florida will be reviewed.
4. Any modeling-organization-specific research performed to develop the functions used for simulating hurricane model variables or to develop databases will be reviewed.

5. [Form S-3, Distributions of Stochastic Hurricane Parameters, will be reviewed.](#)

Verified: YES

Professional Team Comments:

Discussed the process for weighting stochastic storm tracks and assigning landfall frequencies.

Discussed assigning parameters for storms passing through the Keys.

Reviewed map of the coastal mile posts used for landfall calculations.

Reviewed the probability distributions and data sources provided in Form S-3.

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.**

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.
2. Any modeling-organization-specific research performed to derive the roughness distributions for Florida and neighboring states will be reviewed.
3. The spatial distribution of surface roughness used in the hurricane model will be reviewed.
4. 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, Base Hurricane Storm Set Statewide Hurricane Losses.
5. 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.
6. Representation of vertical variation of winds in the hurricane model, where applicable, will be reviewed.
7. Form M-2, Maps of Maximum Winds, will be reviewed.

Pre-Visit Letter

13. M-4.7, Figure 15, page 65: Explain the white color band north of St. Petersburg and east of Clearwater, cutting through the dark blue (40-75mph) color band.

Verified: YES

Professional Team Comments:

Reviewed goodness-of-fit test for the inland filling rate update.

Discussed that the land cover data is taken from the National Land Cover Database (NLCD) 2016, published in April 2019.

Reviewed map depicting the spatial distribution of model surface roughness.

Reviewed maps of the spatial distribution of winds for the LaborDay03 (1935) and NoNames09 (1945) storms.

Reviewed comparisons of historical to modeled windfields for Hurricane Charley (2004), Hurricane Wilma (2005), Hurricane Irma (2017), and Hurricane Michael (2018).

Discussed the region shaded white in revised Figures 15-17 and the need for it to be defined.

M-5 Hurricane Landfall and Over-Land Weakening Methodologies**(*Significant Revision)*

A. The hurricane over-land weakening rate methodology used by the hurricane model shall be consistent with historical records and 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.

Audit

1. The variation in over-land decay rates used in the hurricane model will be reviewed.
2. Comparisons of the hurricane model weakening rates to weakening rates for historical Florida hurricanes will be reviewed.
3. 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 Andrew (1992), Hurricane Jeanne (2004), and Hurricane Irma (2017) at the closest time after landfall will be reviewed.

Pre-Visit Letter

14. M-5.2, Figures 16 and 17, page 68: Provide the values used for parameter mu for these two hurricanes.
15. M-5.5, page 69: Discuss if and how the filling function is applied to a modeled storm if the storm passes over a non-continental land mass.

Verified: YES

Professional Team Comments:

Reviewed comparisons of modeled to observed filling for Hurricane Irma (2017) and Hurricane Michael (2018).

Discussed how the model handles landfalling storms moving back over water and filling for multiple landfall storm events.

Discussed the windspeed adjustment at landfall, with a focus on fetch.

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.**

Audit

1. The logical relationship between windspeed and surface roughness will be reviewed.
2. Form M-2, Maps of Maximum Winds, will be reviewed.
3. Form M-3, Radius of Maximum Winds and Radii of Standard Wind Thresholds, and the modeling organization sensitivity analyses will be reviewed.
4. Justification for the relationship between central pressure and radius of maximum winds will be reviewed. The relationships among intensity, Rmax, and their changes will be reviewed.
5. Justification for the variation of the asymmetry with the translation speed will be reviewed.
6. Methods (including any software) used in verifying these logical relationships will be reviewed.
7. Time-based contour animations (capable of being paused) of windfield distributions demonstrating scientifically-reasonable windfield characteristics and logical relationships will be reviewed.

Pre-Visit Letter

16. Form M-3, page 182: Explain the change in outer radii >40mph values from the current accepted model.

Verified: YES**Professional Team Comments:**

Discussed the changes in Form M-3 due to changes in the 2021 Report of Activities, and the modeler demonstrated how the current accepted model winds look with the new instructions in the 2021 Report of Activities.

Reviewed the relationship between Rmax and central pressure.

Reviewed the formulation of the windfield asymmetry term.

Reviewed contour animation of the Hurricane Andrew (1992) 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 and technical literature.**
- B. Modeled and historical results shall reflect statistical agreement using current scientific and statistical methods for the academic disciplines appropriate for the various hurricane model components or characteristics.**

Audit

1. Forms S-1, Probability and Frequency of Florida Landfalling Hurricanes per Year; S-2, Examples of Hurricane Loss Exceedance Estimates; and S-3, Distributions of Stochastic Hurricane Parameters, will be reviewed. Justification for the distributions selected, including for example, citations to published literature or analyses of specific historical data, will be reviewed. Justification for the goodness-of-fit tests used will also be reviewed.
2. 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.
3. Regression analyses performed will be reviewed, including for example 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.

Pre-Visit Letter

17. S-1.1, pages 72-73: Explain how the p -values did not change for the distributions associated with Landfall Location, Track Direction, and Profile Factor while the underlying data sets were updated through 2021 as indicated in Table 16 (page 190).
18. S-1.1, page 73: Explain the change from Inverse Weibull to Inverse Gamma distribution for the Profile Factor.
19. S-1.2, Table 8, page 74: Explain the performance of simulated winds for Hurricanes Frances (2004) and Michael (2018).
20. S-1.2, Table 8, page 74: Explain why only the number of simulated winds within +/- 15mph for Hurricane Matthew (2016) changed from 13 in Table 8 as given in the current accepted model to 12 in the current submission while all other entries in the table did not change.

21. S-1.4, Figure 18, page 75: Explain the differences between Figure 18 in the current submission relative to Figure 20 as given in the current accepted model.
22. S-1.6, Figure 19, page 76: Explain the differences between Figure 19 in the current submission relative to Figure 21 as given in the current accepted model in light of the updates in storm parameters, such as forward speed.
23. S-1.6, Figure 19, page 76: Explain why for Milepost 1225 the p -value changed from the previous value of 0.675 to the new value of 0.467, but for Milepost 1525 the p -value of 0.979 remains the same.

Verified: YES

Professional Team Comments:

Discussed the change in goodness-of-fit tests used for model parameters from the current accepted model.

Reviewed goodness-of-fit tests for R_{max} and forward speed.

Reviewed goodness-of-fit tests for filling rate distributions in the Gulf, the Atlantic, and Florida.

Discussed that the landfall locations for the historical and stochastic set have not changed from the current accepted model, and that the changes in track direction and profile factor produced a minimal change in p -values.

Discussed the change in distribution for profile factor from an Inverse Weibull to an Inverse Gamma.

Reviewed validation tests for Hurricane Frances (2004) and Hurricane Michael (2018).

Discussed that the frequency and storm parameter updates impacted the probable maximum loss costs in the higher return periods.

Reviewed comparisons of the historical and modeled distributions.

S-2 Sensitivity Analysis for Hurricane Model Output

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

Audit

1. The modeling organization's sensitivity analysis will be reviewed in detail. Statistical techniques used to perform sensitivity analysis will be reviewed. The results of the sensitivity analysis displayed in graphical format (e.g., color-coded contour plots with temporal animation) will be reviewed.
2. Form S-6, Hypothetical Events for Sensitivity and Uncertainty Analysis, will be reviewed, if applicable.

Verified: YES

Professional Team Comments:

Discussed that no changes were made in model methodology from the current accepted model, and that no new sensitivity analyses were performed.

S-3 Uncertainty Analysis for Hurricane Model Output

The modeling organization shall have performed an uncertainty analysis on the temporal and spatial outputs of the 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.

Audit

1. The modeling organization uncertainty analysis will be reviewed in detail. Statistical techniques used to perform uncertainty analysis will be reviewed. The results of the uncertainty analysis displayed in graphical format (e.g., color-coded contour plots with temporal animation) will be reviewed.
2. Form S-6, Hypothetical Events for Sensitivity and Uncertainty Analysis, will be reviewed, if applicable.

Verified: YES

Professional Team Comments:

Discussed that no changes were made in model methodology from the current accepted model, and that no new uncertainty analyses were performed.

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.

Audit

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

Verified: YES

Professional Team Comments:

Discussed that the contribution attributable to the sampling process is negligible.

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) and Hurricane Michael (2018), to the extent data are available for these storms.

Audit

1. The following information for each insurer 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,
 - b. The version of the hurricane model used to calculate modeled hurricane losses for each hurricane provided,
 - c. A general description of the data and its source,
 - d. A disclosure of any material mismatch of exposure and hurricane loss data problems, or other material consideration,
 - e. The date of the exposures used for modeling and the date of the hurricane,
 - f. An explanation of differences in the actual and modeled hurricane parameters,
 - g. A listing 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 consideration,
 - h. The type of cover 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,
 - i. The treatment of demand surge or loss adjustment expenses in the actual hurricane losses or the modeled hurricane losses, and
 - j. The treatment of flood losses (including hurricane storm surge losses) in the actual hurricane losses or the modeled hurricane losses.
2. The following documentation will be reviewed:
 - a. Publicly available documentation referenced in the submission in hard copy or electronic form,

- b. The data sources excluded from validation and the reasons for excluding the data from review by the Commission (if any),
 - c. An analysis that identifies and explains anomalies observed in the validation data, and
 - d. User input data for each insurer and hurricane detailing specific assumptions made with regard to exposed property.
3. The confidence intervals used to gauge the comparison between historical and modeled hurricane losses will be reviewed.
 4. Form S-4, Validation Comparisons, will be reviewed.
 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.

Pre-Visit Letter

24. Form S-4, page 191: Provide Table 17 with the actual values rather than scaled values along with a scatterplot (as in Figure 39) of the unscaled values.
25. Form S-4, Table 17, page 191: Explain why the values in the CoreLogic/TIV column have not changed in the first 10 rows given the updates to the model.
26. Form S-4, Table 17, page 191: Explain in detail the data received and used for Hurricane Irma (2017) and Hurricane Michael (2018) for companies H and I. Include a breakdown by line of business, construction type, TIV, and losses.

Verified: YES

Professional Team Comments:

Reviewed scatter plot of actual versus modeled losses for Florida hurricanes.

Discussed the claims data received and analyzed from Hurricane Irma (2017) and Hurricane Michael (2018).

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.

Audit

1. Form S-5, Average Annual Zero Deductible Statewide Hurricane Loss Costs – Historical versus Modeled, will be reviewed for consistency with Hurricane Standard G-1, Scope of the Hurricane Model and Its Implementation, Disclosure 7.
2. Justification for the following will be reviewed:
 - a. Meteorological parameters,
 - b. The effect of by-passing hurricanes,
 - c. The effect of actual hurricanes that had two landfalls impacting Florida,
 - 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 consideration, and
 - e. Exposure assumptions.

Verified: YES**Professional Team Comments:**

Reviewed Form S-5 comparing historical and modeled average annual statewide hurricane loss costs.

VULNERABILITY HURRICANE STANDARDS – Masoud Zadeh, Leader

V-1 Derivation of Building Hurricane Vulnerability Functions*

*(*Significant Revision)*

- A. Development of the building hurricane vulnerability functions shall be based on at least one of the following: (1) insurance claims data, (2) laboratory or field testing, (3) rational structural analysis, and (4) post-event site investigations. Any development of the building hurricane vulnerability functions based on rational structural analysis, post-event site investigations, and laboratory or field testing shall be supported by historical data.**
- B. The derivation 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 derivation and application of building hurricane vulnerability functions.**
- E. Hurricane vulnerability functions shall be separately derived for commercial residential building structures, personal residential building structures, manufactured homes, and appurtenant structures.**
- F. The minimum windspeed that generates damage shall be consistent with fundamental engineering principles.**
- 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).**

Audit

1. Modifications to the building vulnerability component of the hurricane model since the currently accepted hurricane model will be reviewed in detail, including the rationale for the modifications, the scope of the modifications, the process, the resulting modifications and their impacts on the building vulnerability component.

2. Comparisons of the building hurricane vulnerability functions with the currently accepted hurricane model will be reviewed.
3. Historical data in the original form will be reviewed with explanations for any changes made and descriptions of how missing or incorrect data were handled. When historical data are used to develop building hurricane vulnerability functions, the goodness-of-fit of the data will be reviewed. Complete reports detailing loading conditions and damage states for any laboratory or field-testing data used will be reviewed. When rational structural analysis is used to develop building hurricane vulnerability functions, such analyses will be reviewed for a variety of different building construction classes. Laboratory or field tests and original post-event site investigation reports will be reviewed.
4. All scientific and technical literature, reports, and studies used in the continual development of the building hurricane vulnerability functions must be available for review in hard copy or electronic form.
5. Multiple samples of building hurricane vulnerability functions for commercial residential building structures, personal residential building structures, manufactured homes, and appurtenant structures will be reviewed. The magnitude of logical changes among these items for a given windspeed and validation materials will be reviewed.
6. Justification for the construction classes and characteristics used will be reviewed.
7. Validation of the building hurricane vulnerability functions and the treatment of associated uncertainties will be reviewed.
8. Documentation and justification for the effects on the building hurricane vulnerability functions due to local and regional construction practices, and statewide and local building codes and their enforcement will be reviewed. If year of construction or geographical location of building is used as a surrogate for building code and code enforcement, complete supporting information for the number of year of construction groups used as well as the year-band and geographical regions of construction that separate particular groups will be reviewed.
9. Validation material for the disclosed minimum windspeed will be reviewed. The computer code showing the inclusion of the minimum windspeed at which damage occurs will be reviewed.
10. The breakdown of new hurricane claims data into number of policies, number of insurers, dates of hurricane loss, amount of hurricane loss, and amount of dollar exposure, separated into personal residential, commercial residential, and manufactured homes will be reviewed. Indicate whether or not the new hurricane claims datasets were incorporated into the hurricane model. Research performed and analyses on the new hurricane claims datasets and the impact on hurricane vulnerability functions will be reviewed.
11. How the claim practices of insurance companies are accounted for when hurricane claims data for those insurance companies are used to develop or to verify building hurricane vulnerability functions will be reviewed. Examples include 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, or the impact of the legal environment.
12. The percentage of damage at or above which the hurricane model assumes a total building loss will be reviewed.

13. The treatment of law and ordinance in building hurricane vulnerability functions will be reviewed.
14. A plot comparing building structure and appurtenant structure hurricane vulnerability functions will be reviewed.
15. A plot comparing appurtenant structure hurricane vulnerability functions with insurance claims data will be reviewed.
16. Form V-1, One Hypothetical Event, and the process for completing the form with respect to building damage will be reviewed.

Pre-Visit Letter

27. V-1.1, page 90: Provide a detailed explanation of the updates to the defaults for manufactured home exterior wall conditions and the default year of construction based on the 2020 Census.
28. V-1.4, page 93: Explain why the addition of new claims data for Hurricanes Irma (2017) and Michael (2018) did not cause any updates to the response to V-1.3 relative to the current accepted model.
29. V-1.6, page 93: Describe how uncertainties associated with building vulnerability functions are derived for wood frame and manufactured home constructions.
30. V-1.10, page 96: Demonstrate the relationship between building structure and appurtenant structure vulnerability functions and their consistency with insurance claims data.

Verified: YES

Professional Team Comments:

Reviewed the update to exterior wall conditions for manufactured homes.

Discussed the criteria for the different exterior wall condition options.

Discussed the process for the default year-built change based on the 2020 Census data.

Discussed the 2020 Census data processing procedures.

Discussed the Florida Building Code edition implemented in the model.

Reviewed comparison of modeled data with claims data of ground-up damage.

Discussed that the model accounts for the vertical variation of winds for multi-story structures in the vulnerability functions.

Discussed the underlying reasons for not using the most recent claims data from Hurricane Irma (2017) and Hurricane Michael (2018) to evaluate or update the vulnerability functions. Discussed the model validation against Hurricane Irma (2017) and Hurricane Michael (2018) at the aggregate level.

Reviewed graphical representation of wood frame mean and coefficient of variation of damage.

Reviewed the relationship between building structure and appurtenant structure vulnerability functions.

Reviewed comparison of wood frame building and appurtenant structure vulnerability functions with claims data.

Reviewed examples of building and appurtenant structure vulnerability functions for wood frame, masonry, and manufactured home.

Reviewed the Form A-1 losses for ZIP Code 33921 in Lee County by construction type and coverages.

V-2 Derivation of Contents Hurricane Vulnerability Functions*

(*Significant Revision)

- A. Development of the contents hurricane vulnerability functions shall be based on at least one of the following: (1) insurance claims data, (2) tests, (3) rational engineering analysis, and (4) post-event site investigations. Any development of the contents hurricane vulnerability functions based on rational engineering analysis, post-event site investigations, and tests shall be supported by historical data.**
- B. The relationship between the hurricane model building and contents hurricane vulnerability functions shall be consistent with, and supported by, the relationship observed in historical data.**

Audit

1. Modifications to the contents vulnerability component of the hurricane model since the currently accepted hurricane model will be reviewed in detail, including the rationale for the modifications, the scope of the modifications, the process, the resulting modifications and their impact on the contents vulnerability component.
2. Comparisons of the contents hurricane vulnerability functions with the currently accepted hurricane model will be reviewed.
3. Multiple samples of contents hurricane vulnerability functions will be reviewed.
4. To the extent that historical data are used to develop mathematical depictions of contents hurricane vulnerability functions, the goodness-of-fit of the data to fitted models will be reviewed.
5. Justification for changes from the currently accepted hurricane model in the relativities between hurricane vulnerability functions for building and the corresponding hurricane vulnerability functions for contents will be reviewed.
6. Justification and documentation for the dependence of contents hurricane vulnerability functions on construction or occupancy type will be reviewed.
7. Documentation and justification of the method of derivation and underlying data or assumptions related to contents hurricane vulnerability functions will be reviewed.
8. Validation of the contents hurricane vulnerability functions and the treatment of associated uncertainties will be reviewed.
9. Form V-1, One Hypothetical Event, and the process for completing the form with respect to contents damage will be reviewed.

Pre-Visit Letter

31. V-2.3, pages 100-102: Explain how the contents vulnerability functions were validated. Provide two examples of such validation.
32. V-2.3, page 102: Explain why Figure 26 has not changed relative to Figure 28 as given in the current accepted model in light of the updates in the model.
33. V-2.4, page 102: Provide contents hurricane vulnerability functions for wood frame, masonry, and manufactured home, one set for construction built in 1980 and one set for construction built in 2020.
34. V-2.5, page 103: Explain why Figure 27 has not changed relative to Figure 29 as given in the current accepted model in light of the updates in the model.

Verified: YES

Professional Team Comments:

Discussed that the contents vulnerability functions have been developed using claims data and have not been updated since the current accepted model.

Reviewed scatter plots of actual and modeled content damage ratios versus windspeed for masonry and wood frame homes.

Discussed the reasons for not updating Figures 26 and 27 with the most recent claims data.

Reviewed comparison of wood frame, masonry, and manufactured home contents vulnerability functions between 1980 and 2020 construction eras.

Reviewed example of contents vulnerability functions by construction types.

V-3 Derivation of Time Element Hurricane Vulnerability Functions*

*(*Significant Revision)*

- A. Development of the time element hurricane vulnerability functions shall be based on at least one of the following: (1) insurance claims data, (2) tests, (3) rational engineering analysis, and (4) post-event site investigations. Any development of the time element hurricane vulnerability functions based on rational engineering analysis, post-event site investigations, and tests shall be supported by historical data.**
- 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 historical data.**
- C. Time element hurricane vulnerability function derivations 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.**

Audit

1. Modifications to the time element vulnerability component of the hurricane model since the currently accepted hurricane model will be reviewed in detail, including the rationale for the modifications, the scope of the modifications, the process, the resulting modifications and their impact on the time element vulnerability component.
2. Comparisons of the time element hurricane vulnerability functions with the currently accepted hurricane model will be reviewed.
3. Multiple samples of time element hurricane vulnerability functions will be reviewed.
4. Documentation and justification of the method of derivation and underlying data or assumptions related to time element hurricane vulnerability functions will be reviewed.
5. Justification for changes from the currently accepted hurricane model in the relativities between hurricane vulnerability functions for building and the corresponding hurricane vulnerability functions for time element will be reviewed.
6. To the extent that historical data are used to develop mathematical depictions of time element hurricane vulnerability functions, the goodness-of-fit of the data to fitted models will be reviewed.
7. Validation of the time-element hurricane vulnerability functions and the treatment of associated uncertainties will be reviewed.

8. Form V-1, One Hypothetical Event, and the process for completing the form with respect to time element loss will be reviewed.

Verified: YES

Professional Team Comments:

Reviewed the relationship between time-element and building and contents damage ratios.

Discussed that the time-element vulnerability functions have not changed since the current accepted model.

Reviewed comparison of time-element vulnerability functions with claims data.

Reviewed the relationship of time-element damage ratio to building and contents damage ratios.

V-4 Hurricane Mitigation Measures and Secondary Characteristics

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.

Audit

1. Modifications to hurricane mitigation measures and secondary characteristics in the hurricane model since the currently accepted hurricane model will be reviewed in detail, including the rationale for the modifications, the scope of the modifications, the process, the resulting modifications, and their impacts on the hurricane vulnerability functions.
2. Comparisons of hurricane mitigation measures and secondary characteristics with the currently accepted hurricane model will be reviewed.
3. Procedures, including software, used to calculate the impact of hurricane mitigation measures and secondary characteristics will be reviewed.
4. Form V-2, Hurricane Mitigation Measures and Secondary Characteristics, Range of Changes in Damage; Form V-3, Hurricane Mitigation Measures and Secondary Characteristics, Mean Damage Ratios and Hurricane Loss Costs (Trade Secret Item); Form V-4, Differences in Hurricane Mitigation Measures and Secondary Characteristics; and Form V-5, Differences in Hurricane Mitigation Measures and Secondary Characteristics, Mean Damage Ratios and Hurricane Loss Costs (Trade Secret Item), will be reviewed.

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. Any variation in the change in hurricane damage over the range of windspeeds for individual hurricane mitigation measures and secondary characteristics will be reviewed. Historical data, scientific and technical literature, insurance company hurricane claims data, analysis or judgment based on fundamental engineering principles used to support the assumptions and implementation of the hurricane mitigation measures and secondary characteristics will be reviewed.
6. The treatment of roof age will be reviewed.
7. 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.
8. Hurricane mitigation measures and secondary characteristics used by the hurricane model, whether or not referenced in Form V-2, Hurricane Mitigation Measures, Range of Changes in Damage, and Form V-3, Hurricane Mitigation Measures, Mean Damage Ratios and Hurricane Loss Costs (Trade Secret Item), will be reviewed for theoretical soundness and reasonability.

Pre-Visit Letter

35. V-4.1, page 109: Provide elaboration on the default options for manufactured homes exterior wall conditions.

Verified: YES

Professional Team Comments:

Reviewed the default options for manufactured home exterior wall conditions.

Discussed that there were no changes in Form V-2 from the current accepted model.

Reviewed Forms V-2, V-3, V-4, and V-5.

Reviewed Forms V-3 and V-5 of the current accepted model compared to the model under review.

Discussed the mitigation impact in Form V-2 for mitigated doors, windows, and skylights.

Reviewed the vulnerability functions for the reference structure in Forms V-2 and V-3 and their relationship to the vulnerability functions in the model.

ACTUARIAL HURRICANE STANDARDS – Stu Mathewson, Leader

A-1 Hurricane Model Input Data and Output Reports*

*(*Significant Revision)*

- 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.**

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

Verified: YES

Professional Team Comments:

Discussed the various reasonableness checks applied when analyzing claims data.

Reviewed the model input form and output report.

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.**

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

Pre-Visit Letter

36. A-2.B, page 132: Provide a copy of the documented procedure for distinguishing wind-related hurricane losses from other peril losses.

Verified: YES

Professional Team Comments:

Reviewed the process to account for storm surge in claims data.

Reviewed the storm classifications for inclusion in modeled loss costs.

Reviewed the documented process for reviewing and analyzing claims to assure wind-only claims are used for validation.

A-3 Hurricane Coverages**(*Significant Revision)*

- 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.**

Audit

1. The methods used to produce building, appurtenant structure, contents and time element hurricane loss costs will be reviewed.
2. The treatment of law and ordinance coverage will be reviewed, including the statutory required 25% and 50% coverage options for personal residential policies.

Pre-Visit Letter

37. A-3.1-4, pages 133-136: Show a calculation of loss costs and probable maximum loss levels for the minimum Masonry Owners loss costs in Form A-1 (i.e., ZIP Code 32009 in Nassau County).
38. A-3.5, page 136: Explain how law and ordinance coverage is implied in the vulnerability functions. Explain how the model handles the statutory 25% and 50% coverages.

Verified: YES**Professional Team Comments:**

Discussed with the Actuarial Standards signatory how he attested the model results to be actuarially sound.

Reviewed the calculation of masonry owners loss costs and probable maximum loss levels for ZIP Code 32009 in Nassau County.

Discussed that law and ordinance coverage is implied in the vulnerability functions, and that it is not explicitly considered in the model.

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-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.**

Audit

1. How the hurricane model handles expenses, risk load, investment income, premium reserves, taxes, assessments, profit margin, economic inflation, and any criteria other than direct property insurance claim payments will be reviewed.
2. The method of determining hurricane probable maximum loss levels will be reviewed.
3. The uncertainty in the estimated annual hurricane loss costs and hurricane probable maximum loss levels will be reviewed.
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.
5. How the hurricane model accounts for economic inflation associated with past insurance experience will be reviewed.
6. The treatment of flood losses (including hurricane storm surge) in the determination of modeled hurricane losses will be reviewed.
7. All referenced scientific and technical literature will be reviewed, in hard copy or electronic form, to determine applicability.

Pre-Visit Letter

39. A-4.1, pages 138-139: 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.
40. A-4.3, page 140: Provide additional details on the demand surge factor calculation, especially the Cat Index and Cat Inflation Index.
41. A-4, Audit items 1 and 5: Explain how economic inflation with regards to the claims environment, the legal environment, and litigation effects are modeled.

Verified: YES

Professional Team Comments:

Reviewed the top 1,000 years of hurricane activity sorted by aggregate loss and occurrence loss corresponding to Form A-8.

Reviewed the demand surge methodology.

Discussed that economic inflation with regards to the claims environment, the legal environment, and litigation effects are not modeled.

A-5 Hurricane Policy Conditions**(*Significant Revision)*

- 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.**

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.
2. The extent that insurance company hurricane claims data are used to validate the hurricane model results will be reviewed.
3. Treatment of annual deductibles will be reviewed.
4. Justification for the changes from the currently accepted hurricane model in the relativities among corresponding deductible amounts for the same coverage will be reviewed.

Verified: YES**Professional Team Comments:**

Reviewed the process for application of the annual hurricane deductibles.

Reviewed the probable maximum loss calculation.

Reviewed an example of annual and occurrence deductibles.

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,**
 - 4. northern counties versus southern counties, and**
 - 5. newer construction versus older construction.**

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

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.

Audit

1. The data and methods used for hurricane probable maximum loss levels for Form A-8, Hurricane Probable Maximum Loss for Florida, will be reviewed. The hurricane associated with the Top Events will be reviewed.
2. The frequency distribution and the individual event severity distribution, or information about the formulation of events, underlying Form A-8, Hurricane Probable Maximum Loss for Florida, will be reviewed.
3. All referenced scientific and technical literature will be reviewed, in hard copy or electronic form, to determine applicability.
4. Graphical representations of hurricane loss costs by ZIP Code and county will be reviewed.
5. Color-coded maps depicting the effects of land friction on hurricane loss costs by ZIP Code will be reviewed.
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, Hurricane Loss Outputs and Logical Relationships to Risk, will be reviewed. Forms A-1, Zero Deductible Personal Residential Hurricane Loss Costs by ZIP Code; A-2, Base Hurricane Storm Set Statewide Hurricane Losses; A-3, Hurricane Losses; A-6, Logical Relationships to Hurricane Risk (Trade Secret Item); and A-7, Percentage Change in Logical Relationships to Hurricane Risk, will be reviewed to assess coverage relationships.
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.
8. Forms A-4, Hurricane Output Ranges, and A-5, Percentage Change in Hurricane Output Ranges, will be reviewed, including geographical representations of the data where applicable.
9. Justification for all changes in hurricane loss costs from the currently accepted hurricane model will be reviewed.
10. Form A-4, Hurricane Output Ranges, will be reviewed to ensure appropriate relativities among deductibles, coverages, and construction types.

11. Apparent reversals in the hurricane output ranges and their justification will be reviewed.
12. The details on the calculation of uncertainty intervals and their justification will be reviewed.

Pre-Visit Letter

42. A-6.10, page 148: Provide details for the calculation of uncertainty intervals.
43. Form A-1: Explain the differences within the following ZIP Codes compared to other ZIP Codes in their counties – 32228 (Duval), 32420 (Jackson), and 34483 (Marion).
44. Form A-2, pages 222-223: Explain the differences from the current accepted model losses for Hurricanes Alma-1966, Inez-1966, Gladys-1966, and Dorian-2019.
45. Form A-4, 0% Deductible, pages 234-238: Explain the reversal in loss costs where Frame is less than Masonry:
 - Owners: Indian River High
 - Renters: Taylor Low, Wakulla Average
 - Condo Unit: Franklin Average, Okeechobee Average, Wakulla Average.
46. Form A-5, pages 246-254: Explain the regional changes (e.g., Panhandle and North Central Florida) in the loss costs in Form A-4 compared to the current accepted model.
47. Form A-5, pages 247-254: Provide Figures 58-65 with a legend range from -40% to +10%.
48. Form A-5, Figure 65, page 254: Explain the decrease in Baker County and reconcile with the changes shown in Form A-4.
49. Form A-8.A, Table 37, page 267: Explain the changes in distribution of Number of Hurricanes by ranges.
50. Form A-8.B, Table 38 and C, Table 39, page 268: Explain the difference in showing the uncertainty intervals between Part B and Part C in the submission, since they were shown in a similar fashion in the current accepted model.
51. Form A-8, Figure 66, page 269: Explain the differences in losses from the current accepted model above the 1,000-year return period.

Verified: YES

Professional Team Comments:

Reviewed comparisons of Form A-1 losses by windspeed for wood frame, masonry, and manufactured homes in ZIP Codes 33070 in Monroe County and 33109 in Miami-Dade County.

Reviewed the methodology for calculating the uncertainty levels in Form A-8.

Reviewed comparisons of losses within a county for Form A-1 ZIP Codes in Duval, Jackson, and Marion Counties.

Reviewed the changes in Form A-2 from the current accepted model for Hurricanes Alma-1966, Inez-1966, Gladys-1966, and Dorian-2019.

Discussed the loss costs in Form A-4 where frame loss costs are less than masonry loss costs, and the underlying reasons for the results.

Discussed the model updates that resulted in the Form A-5 percentage decreases from the current accepted model.

Discussed the model updates that resulted in changes in the distribution of number of hurricanes by ranges and the probable maximum loss levels in Form A-8.

Reviewed the storm parameters and track for the top event in Form A-8.

Reviewed Form A-6 and the reasonableness checks performed to verify the individual loss cost relationships.

Reviewed maps of Form A-1 losses by county for frame-owners, masonry-owners, and manufactured homes.

Reviewed map of the effect of surface roughness on damage by county.

COMPUTER/INFORMATION HURRICANE STANDARDS – Paul Fishwick, Leader**CI-1 Hurricane Model Documentation**

- 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. A primary document repository shall be maintained, containing or referencing a complete set of documentation specifying the hurricane model structure, detailed software description, and functionality. Documentation shall be indicative of current model development and software engineering practices.***
- C. All computer software (i.e., user interface, scientific, engineering, actuarial, data preparation, and validation) 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 currently 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.***

Audit

1. The primary document repository, containing or referencing full documentation of the software in either electronic or physical form, and its maintenance process will be reviewed.
2. All documentation should be easily accessible from a central location in order to be reviewed.
3. Complete user documentation, including all recent updates, will be reviewed.
4. Modeling organization personnel, or their designated proxies, responsible for each aspect of the software (i.e., user interface, quality assurance, engineering, actuarial, verification) should be present when the Computer/Information Hurricane Standards are being reviewed. Internal users of the software will be interviewed.

5. Verification that documentation is created separately from, and is maintained consistently with, the source code will be reviewed.
6. The list of all externally acquired hurricane model-specific software and data assets will be reviewed.
7. The tables specified in Hurricane Standard CI-1.D that contain the items listed in Hurricane Standard G-1, Scope of the Hurricane Model and Its Implementation, Disclosure 7 will be reviewed. The tables should contain the item number in the first column. The remaining five columns should contain specific document or file references for affected components or data relating to the following Computer/Information Hurricane Standards: CI-2, Hurricane Model Requirements; CI-3, Hurricane Model Organization and Component Design; CI-4, Hurricane Model Implementation; CI-5, Hurricane Model Verification; and CI-7, Hurricane Model Maintenance and Revision.
8. Tracing of the hurricane model changes specified in Hurricane Standard G-1, Scope of the Hurricane Model and Its Implementation, Disclosure 7 and Audit 7 through all Computer/Information Hurricane Standards will be reviewed.

Pre-Visit Letter

52. CI-1.B, page 151: Relate the primary binder table of contents with the response to Standard G-1.7 (pages 31-35) by demonstrating individual table item compliance with Computer/Information Standards CI-1 through CI-8.
53. CI-1.D, page 151: Provide the table required by Standard CI-1, Audit item 7.
54. CI-1.F, page 152: Provide the lists of all externally acquired hurricane model-specific software and data assets as described and required by Standard CI-1, Audit item 6.

Verified: YES

Professional Team Comments:

Reviewed documentation for the windfield model.

Discussed the changes in workflow and infrastructure focused on security and reliability.

Reviewed blueprint of the Risk Quantification and Engineering infrastructure.

Discussed the tools utilized to maintain documentation.

Reviewed the table of model changes from the current acceptable model.

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

Reviewed the master list of reference documents specifying the model structure, software descriptions, and functionality related to portfolio analysis for the state of Florida.

CI-2 Hurricane Model Requirements

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.

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.

Pre-Visit Letter

55. CI-2, page 153: Provide requirements documentation that specifically relates to each model change identified in Standard G-1.7 (page 31).

Verified: YES

Professional Team Comments:

Reviewed requirements documentation for updates made in the model under review.

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.

Audit

1. The following will be reviewed:
 - a. Detailed control and data flowcharts, completely and sufficiently labeled for each component,
 - b. Interface specifications for all components in the hurricane model,
 - c. Documentation for schemas for all data files, along with field type definitions,
 - d. Each network flowchart including components, sub-component flowcharts, arcs, and labels,
 - 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
 - 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.
2. A hurricane model component custodian, or designated proxy, should be available for the review of each component.

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

Pre-Visit Letter

56. CI-3.B, page 154: Provide the documents for flowcharting standards.

Verified: YES

Professional Team Comments:

Reviewed flowchart for creating submission forms.

Reviewed flowchart for processing changes in HURDAT2 in calculating storm frequencies.

Reviewed an example of an entity relationship diagram for a database schema.

Discussed that industry charting and diagramming standards are followed for all flowcharts.

CI-4 Hurricane Model Implementation**(*Significant Revision)*

- A. A complete procedure of coding guidelines consistent with accepted software engineering practices shall be maintained.**
- 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., flowcharts) down to the code 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, Scope of the Hurricane Model and Its Implementation, Disclosure 7 and Audit 7:**
 - 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 maintenance, testing, and update plans with their schedules. The vintage of the code and data shall be justified.**

Audit

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

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.
3. The procedure used in creating, deriving, or procuring and verifying databases or data files accessed by components will be reviewed.
4. The traceability among components at all levels of representation will be reviewed.
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.
6. The table of all software components as specified in Hurricane Standard CI-4.E will be reviewed.
7. Hurricane model components and the method of mapping to elements in the computer program will be reviewed.
8. Comments within components will be reviewed for sufficiency, consistency, and explanatory quality.
9. Unique aspects within various platforms with regard to the use of hardware, operating system, and essential software will be reviewed.
10. Network organization implementation will be reviewed.
11. Code and data maintenance plans, testing plans, update plans, and schedules will be reviewed. Justification for the vintage of code and data will be reviewed.

Pre-Visit Letter

57. CI-4.H, page 156: Provide the information as noted.

Verified: YES

Professional Team Comments:

Reviewed the coding guidelines.

Reviewed code to compute the profile factor from historical storms.

Reviewed the variable mapping for the surface winds profile factor script.

Reviewed calculation and implementation of profile factors.

Reviewed implementation of ground-up loss.

Reviewed implementation of demand surge factors and the list of demand surge equations with variable mapping.

Discussed the version control process used for making changes to code, and for the review and approval of the code changes.

Reviewed an example of a platform build.

Reviewed an example code metrics table.

Discussed the plan and progress made on code refactoring. Reviewed examples of completed refactoring.

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.***

Audit

1. Procedures for unit conversion verification will be reviewed.
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.
3. The testing software used by the modeling organization will be reviewed.

4. The component (unit, regression, integration) and data test processes and documentation will be reviewed including compliance with independence of the verification procedures.
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.
6. Flowcharts defining the processes used for manual and automatic verification will be reviewed.
7. Verification approaches used for externally acquired data, software, and models will be reviewed.

Pre-Visit Letter

58. CI-5, pages 157-159: Provide complete and thorough verification procedures and output from the model changes identified in Standard G-1.7 (page 31).

Verified: YES

Professional Team Comments:

Discussed the new QA infrastructure and testing.

Reviewed the list of validation tests completed for the model updates.

Reviewed a unit test for calculating quality factors.

CI-6 Human-Computer Interaction**(*New Hurricane Standard)*

- 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 rate filing, interface options shall be limited to those options found acceptable by the Commission.**

Audit

1. External and internal user interfaces will be reviewed.
2. Documentation related to HCI, Interaction Design, and UX engineering will be reviewed.
3. The decision process specifying the logic of interface option selections, when an acceptable hurricane model is selected, will be reviewed.

Pre-Visit Letter

59. CI-6.A, page 160: Provide the human interface guidelines.
60. CI-6.C, page 160: Provide and explain the RQE User Interface analysis options related to Florida rate filings.

Verified: YES**Professional Team Comments:**

Discussed that the Risk Quantification and Engineering User Interface has a specific option for enforcing regulatory compatible analysis settings for Florida ratemaking.

Reviewed the analysis options available for a Florida rate filing and confirmed that the analysis options cannot be changed.

Reviewed a live demonstration of the model execution.

CI-7 Hurricane Model Maintenance and 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 residential hurricane loss cost or hurricane probable maximum loss level shall result in a new hurricane model version identification.**
- C. Tracking software shall be used to identify and describe all errors, as well as modifications to code, data, and documentation.**
- D. 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.**

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.
2. The policy for hurricane model revision and management will be reviewed.
3. Portions of the code, not necessarily related to recent changes in the hurricane model, will be reviewed.
4. The tracking software will be reviewed and checked for the ability to track date and time.
5. The list of all hurricane model revisions as specified in Hurricane Standard CI-7.D will be reviewed.

Pre-Visit Letter

61. CI-7.D, page 161: Provide the model version history over the past 5 years, leading up to the version identified in the submission.

Verified: YES

Professional Team Comments:

Reviewed the model version history.

Discussed that there was no change to the policy for review, maintenance, and revision.

Discussed the change in tracking software.

CI-8 Hurricane Model Security

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.

Audit

1. The written policy for all security procedures and methods used to ensure the security of code, data, and documentation will be reviewed.
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.
3. Security aspects of each platform will be reviewed.
4. Network security documentation and network integrity assurance procedures will be reviewed.

Verified: YES

Professional Team Comments:

Discussed that there have been no known security breaches.