

# Florida Commission on Hurricane Loss Projection Methodology

## Professional Team Report **2017 Hurricane Standards**



**Applied Research Associates, Inc.**

**On-Site Review  
February 11-13, 2019**

**Additional Verification Review: April 8-9, 2019**

On February 11-13, 2019, the Professional Team visited Applied Research Associates, Inc. (ARA) in Raleigh, North Carolina. The following individuals participated in the review.

### **ARA**

Francis M. Lavelle, Ph.D., P.E., Vice President  
Laura Maxwell, FCAS, MAAA, Actuarial Consultant (via phone)  
David Mizzen, M.S.C.E., Staff Scientist  
Lauren Mudd, Ph.D., P.E., Staff Engineer  
Peter J. Vickery, Ph.D., P.E., Principal Engineer  
Lisa West, Group Administrator

### **Professional Team**

Paul Fishwick, Ph.D., Computer Scientist  
Tim Hall, Ph.D., Meteorologist  
Mark Johnson, Ph.D., Statistician, Team Leader  
Michael Smith, FCAS, FSA, MAAA, Actuary  
Masoud Zadeh, Ph.D., P.E., Structural Engineer  
Donna Sirmons, Staff

The review began with introductions and an overview of the audit history and process by the Professional Team. ARA provided a detailed presentation of the following changes made in HurLoss Florida Model version 9.0:

- New stochastic track set that combines US, Caribbean and Canadian models into one North Atlantic hurricane model.
- Updated historical sea-surface temperature (SST) data, troposphere temperature data, storm initiation data, and environmental flow data through 12/31/17.
- Modification to the manner in which the hurricane windfield handles fast moving hurricanes.
- ZIP Code centroids and average surface roughness updates using June 2018 ZIP Code data and 2011 National Land Cover Database (NLCD) data.
- Methodology improvement for calculating and allocating insured losses to individual coverages when the ground-up loss is between the policy limit and the policy limit plus the deductible.
- Building stock regions, eras, and weights improvements for post-1994 construction to better reflect building design requirements during this period in Florida.

The overall impact of the model changes is a decrease of 12.7% in statewide modeled loss costs.

ARA informed the Professional Team of issues with the weighted averages in Form A-4B (Hurricane Output Ranges, 2017 FHCF Exposure Data). As specified in the *Hurricane Standards Report of Activities*, if revised output ranges are not provided 14 days prior to the on-site review, Standard A-6 (Hurricane Loss Outputs and Logical Relationships to Risk) cannot be verified during the initial on-site review. Other standards also cannot be verified pending the review of a correct Form A-4B (e.g., G-4, G-5, CI-4, CI-5).

The audit continued with a thorough review of each standards section. In the course of the audit, it was determined that several standards could not be verified pending review of open items. At the exit briefing, modeler options as given in the *2017 Hurricane Standards Report of Activities* were noted.

In addition to the Issues identified by the Commission at the January 7, 2019 meeting and listed on page 5 of this report, ARA is to present the following information to the Commission during the Trade Secret session of the meeting to review the model for acceptability as specified on page 60 of the *2017 Hurricane Standards Report of Activities*:

1. Detailed information and discussion of Forms V-3 and V-5
2. Detailed information and discussion of relativities in Form A-6.

### **\*\*\*Additional Verification Review – April 8 & 9, 2019\*\*\***

ARA submitted additional revisions to the original November 2018 submission on March 25, 2019. The Professional Team completed an additional verification review of HurLoss Version 9.0 on April 8 & 9, 2019 in Raleigh.

The following individuals participated in the additional verification review.

#### **ARA**

Francis M. Lavelle, Ph.D., P.E., Vice President  
David Mizzen, M.S.C.E., Staff Scientist  
Lauren Mudd, Ph.D., P.E., Staff Engineer  
Jeff Sciaudone, P.S., Senior Scientist  
Peter J. Vickery, Ph.D., P.E., Principal Engineer

#### **Professional Team**

Paul Fishwick, Ph.D., Computer Scientist  
Tim Hall, Ph.D., Meteorologist  
Mark Johnson, Ph.D., Statistician, Team Leader  
Stuart Mathewson, FCAS, MAAA, CPCU, Actuary  
Masoud Zadeh, Ph.D., P.E., Structural Engineer  
Donna Sirmons, Staff

During the additional verification review, open items from the initial on-site review were reviewed and discussed in detail as well as new issues that surfaced during the course of the audit.

After resolution of open items, all standards are now verified by the Professional Team.

### **Report on Deficiencies**

The Professional Team reviewed the following deficiencies cited by the Commission at the January 7, 2019 meeting. The deficiencies were eliminated by the established time frame, and the modifications have been verified.

1. Standard G-1, Disclosure 5.C (Pages 28 and 30)  
Non-responsive as the maps in Figures 3 and 7 do not contain a minimum of seven intervals as required in the Acceptability Process II.A.4.e.2, page 52 of the *2017 Hurricane Standards Report of Activities*.
2. Standard G-2, Disclosure 2.B (page 38)  
Non-responsive as Dr. Shujun Li, who started in 2017, is not listed as a new employee or consultant.

3. Standard G-3.C (page 41)  
Non-responsive as to whether the ZIP Code information has been verified for accuracy and appropriateness.
4. Form S-4.C (Appendix A, page 180)  
Non-responsive as the Comparison 2 plot in Figure 52, Part A is incorrect with only 2 of 3 points plotted.
5. Form S-4.C (Appendix A, page 181)  
Non-responsive as the two plots in Figure 52, Part B are incorrect as the values plotted are inconsistent with the table values given on page 179.
6. Standard V-1.A (page 83)  
Non-responsive as to “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.”
7. Standard V-1, Disclosure 6 (pages 86-87)  
Incomplete as “descriptions of the building types and characteristics, building height, number of stories, regions within the state of Florida, year of construction, and occupancy types for which a unique building hurricane vulnerability function is used” is not given.  
  
Unclear as the number of regions within the state of Florida listed is inconsistent with the number of regions given in response to Standard V-1.C on page 84.
8. Standard V-1, Disclosure 9.d (page 88)  
Incomplete as the “assumptions, data, methods, and processes used to develop building hurricane vulnerability functions for when building input characteristics are conflicting” is not given.
9. Standard V-2.A (page 89)  
Non-responsive as to “Any development of the contents and time element hurricane vulnerability functions based on rational structural analysis, post-event site investigations, and tests shall be supported by historical data.”
10. Standard V-3.C (page 95)  
Non-responsive as no response is given.
11. Standard A-1, Disclosure 4 (pages 98-101)  
Incomplete as the “hurricane model name and version identification” is not included on the input form as required.
12. Standard A-2.B (page 105)  
Non-responsive as “a documented procedure for distinguishing wind-related hurricane losses from other peril losses” is not indicated.

13. Forms A-4A.C and D and A-4B.C and D (Appendix A, pages 240 and 251)

Non-responsive as a list of ZIP Codes for which there are hurricane loss costs but no exposure or a list of ZIP Codes for which there are no hurricane loss costs but there is exposure are not given or addressed.

### **Issues**

The Professional Team reviewed in detail the following issues identified by the Commission at the January 7, 2019 meeting. ARA is to present this information to the Commission during the Trade Secret session of the meeting to review the model for acceptability.

1. For Standard V-1, Audit item 7, how the county as well as statewide building codes are reflected in the model vulnerability functions.
2. For Standard V-1, Audit item 9, how the building codes are reflected in the model vulnerability functions, including whether current statewide and county building codes are incorporated.
3. Justification if the high-velocity hurricane zone included in the statewide Florida Building Code is not reflected in the model vulnerability functions.
4. For Standard M-4, Audit item 8, the science underlying the maximum windspeeds in Form M-2.
5. Form A-6, Building Code/Enforcement (Year Built) Sensitivities, in particular for Manufactured Homes.

### **Discussion on Inquiry**

The Professional Team discussed the following inquiry included in the *2017 Hurricane Standards Report of Activities* and discussed by the Commission at the January 7, 2019 meeting. The Professional Team will prepare a report on the inquiry to the Commission after discussions with all modelers are complete and prior to the 2019 hurricane standards committee meetings.

#### Impact of Legal and Claims Environment

Investigate the impact of the legal and claims environment (e.g., assignment of benefits, attorney fees, increased litigation) on modeled hurricane loss costs and hurricane probable maximum loss levels. Is the impact of the legal and claims environment evident in the claims data provided to the modeling organizations for validation of the modeled hurricane loss costs and hurricane probable maximum loss levels? Should the impact of the legal and claims environment be incorporated in the hurricane model results, and if so, how? Should the impact of the legal and claims environment be incorporated into the hurricane standards?

### **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 the pre-visit letter is to outline specific issues unique to the modeler's submission, and to identify lines of inquiry to be followed during the on-site review to allow adequate preparation by the modeler. Aside from due diligence with respect to the full submission, various questions that the Professional Team is certain to ask the modeler during the on-site review are provided in this letter. This letter does not preclude the Professional Team from asking for additional information during the on-site review that is not given below or discussed during an upcoming conference call that will be held if requested by the modeler. One goal of the potential conference call is to address modeler questions related to this letter or other matters pertaining to the on-site review. The overall intent is to expedite the on-site review and to avoid last minute preparations that could have been undertaken earlier.

Some of this material may have been shown or may have been available on a previous visit by the Professional Team. The Professional Team will also be considering material in response to deficiencies and issues designated by the Florida Commission on Hurricane Loss Projection Methodology (Commission) during the January 7, 2019 conference call meeting.

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

The on-site schedule is tentatively planned to proceed in the following sequence: (1) presentation by the modeler of new or extensively updated material related to the model; (2) section by section review commencing within each section with pre-visit letter responses; (3) responses to new or significantly changed hurricane standards in the 2017 *Hurricane Standards Report of Activities*, and (4) responses to the audit items for each hurricane standard in the 2017 *Hurricane Standards Report of Activities*.

If changes have been made in any part of the model or the modeling process from the descriptions provided in the original 2017 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 all revised forms where any output changed. For each revised form, provide an additional form with cell-by-cell differences between the revised and originally submitted values.

Refer to the On-Site Review section of the *Hurricane Standards Report of Activities as of November 1, 2017* for more details on materials to be presented to the Professional Team. Particular attention should be paid to the requirements under Presentation of Materials on pages 80-81. These requirements are reproduced at the conclusion of this letter.

For your information, the Professional Team will arrive in business casual attire.

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

### **Editorial Items**

Editorial items were noted by the Professional Team in the pre-visit letter for correction prior to their arrival in order to facilitate efficiency during the on-site review. Additional editorial items were also noted during the audits. The Professional Team reviewed the following corrections that are to be included in the revised submission 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 November 2018 initial submission.

1. Page 5, Cover Letter – actuarial science included in the list of professionals having credentials and/or experience, computer science updated to computer/information science, and reference to signed Expert Certification Form G-7 added.
2. Page 19, Table of Contents – Figure 78 added.
3. Page 24, G-1, Disclosure 2 – Figure 1 revised.
4. Pages 28-30, G-1, Disclosure 5.C – Maps in Figures 3-6 corrected to reference HurLoss 9.0.
5. Pages 32-38, G-2, Disclosure 2 – Item identifications under Professional Credentials corrected.
6. Page 38, G-2, Disclosure 2 – Figure 9 flowchart updated.
7. Pages 38-39, G-2, Disclosure 3 – Item identifications under Independent Peer Review corrected.
8. Page 39, G-2, Disclosure 3.A.4 – Actuarial review date corrected. Link added to Appendix C reference.
9. Page 41, G-3 – Standard part identifications corrected.
10. Page 42, G-3, Disclosures 4 & 5 - Revised to include wind-borne debris region.
11. Page 71, S-1, Disclosure 6 – Figure 18 revised to update modeled values and Figure 19 revised.
12. Page 73, S-2 – Standard part identification corrected.
13. Page 79, S-5, Disclosure 1 – Figure 23(b) revised.
14. Page 85, V-1, Disclosure 2 – Figure 24 revised.
15. Page 89, V-2.C – Response revised for clarification.
16. Page 89, V-2, Disclosure 1 – Response reworded as the disclosure is applicable.
17. Page 90, V-2, Disclosure 2 – Figure 25 revised.
18. Page 92, V-2, Disclosure 5 – Figure 27 revised.
19. Page 93, V-2, Disclosure 6 – Corrected y-axis label in Figure 28.
20. Page 95, V-3, Disclosure 1 – Response reworded as the disclosure is applicable.
21. Page 97, A-1.A – Response revised to include “edits, inclusions, or deletions.”
22. Page 106, A-3 – Standard part identifications corrected.
23. Page 111, A-5.C – Statute citation corrected.
24. Page 114, A-6.J – Reference to Forms A-4A and A-4B corrected.
25. Page 120, CI-3 – Industry flowchart standard identified.
26. Page 144, Form G-6 – Form title corrected.
27. Page 148, Form M-1 revised.
28. Page 150, Form M-1 – Figure 32 revised.
29. Page 159, Form S-1 revised.
30. Pages 160-161, Forms S-2A and S-2B – Part B identification corrected.
31. Page 160, Form S-2A revised.
32. Page 166, Form S-3 – Caption for Figure 42 corrected.
33. Page 185, Form V-1.B – Mobile Home updated to Manufactured Home.
34. Page 187, Form V-2.B – Additional assumptions added.
35. Page 190, Form V-4 revised.
36. Page 196, Form A-2A – Storm ID# and landfall date corrected for Nate-2017, Region/Category storm designations revised.
37. Page 199, Form A-2B – Storm ID# corrected for Nate-2017, Region/Category storm designations revised.
38. Page 271, Form A-7 – Percent Change in Logical Relationship to Risk – Statewide Manufactured Homes value added in the Construction table.
39. Page 278, Form A-8A.C – Figure number reference updated.
40. Page 282, Form A-8B.C – Figure number reference updated.
41. Pages 285-286, Appendix B – Acronyms spelling corrected, BPMN added, and definition for ANOVA added.

## GENERAL STANDARDS – Mark Johnson, Leader

### G-1 Scope of the Hurricane Model and Its Implementation

- A. The hurricane model shall project loss costs and probable maximum loss levels for damage to insured residential property from hurricane events.*
- B. The modeling organization shall maintain a documented process to assure continual agreement and correct correspondence of databases, data files, and computer source code to slides, technical papers, and modeling organization documents.*
- C. All software and data (1) located within the hurricane model, (2) used to validate the hurricane model, (3) used to project modeled hurricane loss costs and hurricane probable maximum loss levels, and (4) used to create forms required by the Commission in the Hurricane Standards Report of Activities shall fall within the scope of the Computer/ Information Standards and shall be located in centralized, model-level file areas.*

### Audit

1. All primary technical papers that describe 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.
2. Compliance with the process prescribed in Standard G-1.B in all stages of the modeling process will be reviewed.
3. Items specified in Standard G-1.C will be reviewed as part of the Computer/Information Standards.
4. Maps, databases, and data files relevant to the modeling organization's submission will be reviewed.
5. 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 2012 Florida Hurricane Catastrophe Fund personal and commercial residential zero deductible exposure data found in the file named "hlpm2012c.exe" for:
    1. All changes combined, and
    2. Each individual hurricane model component and subcomponent change.



- C. For any modifications to Form A-4A, Hurricane Output Ranges (2012 FHCF Exposure Data), since the initial submission, additional versions of Form A-5, Percentage Change in Hurricane Output Ranges (2012 FHCF Exposure Data):
  - 1. With the initial submission as the baseline for computing the percentage changes, and
  - 2. With 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 2012 Florida Hurricane Catastrophe Fund personal and commercial residential zero deductible exposure data found in the file named "hlpm2012c.exe" for each hurricane model component change:
  - 1. Between the previously-accepted hurricane model and the revised hurricane model,
  - 2. Between the initial submission and the revised submission, and
  - 3. Between any intermediate revisions and the revised submission.
- E. 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.exe" for:
  - 1. All changes combined, and
  - 2. Each individual hurricane model component and subcomponent change.
- F. For any modifications to Form A-4B, Hurricane Output Ranges (2017 FHCF Exposure Data), since the initial submission, a version of Form A-5, Percentage Change in Hurricane Output Ranges using the 2017 FHCF Exposure Data and Form A-4B, Hurricane Output Ranges (2017 FHCF Exposure Data):
  - 1. With the initial submission as the baseline for computing the percentage changes, and
  - 2. With any intermediate revisions as the baseline for computing the percentage changes.
- G. 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.exe" for each hurricane model component change:
  - 1. Between the initial submission and the revised submission, and
  - 2. Between any intermediate revisions and the revised submission.

### Pre-Visit Letter

- 1. Describe the process used to prepare the 2017 FHCF personal and commercial residential zero deductible exposure data to produce the various forms which use it. Indicate the problematic entries requiring further investigation.
- 2. G-1, Disclosure 5.C, page 28: Provide the individual county percentage change values in Figure 3 (preferably labeling the change within each county although a list will suffice).
- 3. G-1, Disclosure 5.C, pages 28-29: Explain the underlying characteristic(s) of Sumter County that yields the most extreme changes in Figures 4 and 6.

Verified:    ~~NO~~    YES

Professional Team Comments:

Not verified pending review of open items.

Reviewed table of percentage changes in loss costs by county for each individual model update and all updates combined.

Discussed the process used to review and prepare the FHCF exposure data.

Reviewed the effect of the model updates in Sumter County driven by the changes in surface roughness and loss sensitivity to architectural choices in the region. Reviewed the changes in  $Z_0$  for each ZIP Code in Sumter County.

Discussed quality assurance process for evaluating the presentation of ZIP Code roughness.

Discussed use of ARA US Hurricane Model for residential property rate filings in Florida.

**\*\*\*Additional Verification Review Comments\*\*\***

Verified after resolution of open items.

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

- A. Hurricane model construction, testing, and evaluation shall be performed by modeling organization personnel or consultants who possess the necessary skills, formal education, and experience to develop the relevant components for hurricane loss projection methodologies.**
- 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 (licensed Professional Engineer), statistics (advanced degree), actuarial science (Associate or Fellow of Casualty Actuarial Society or Society of Actuaries), meteorology (advanced degree), and computer/information science (advanced degree 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 Standards Expert Certification, G-2, Meteorological Standards Expert Certification, G-3, Statistical Standards Expert Certification, G-4, Vulnerability Standards Expert Certification, G-5, Actuarial Standards Expert Certification, G-6, Computer/ Information 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**

4. G-2, Disclosure 3.B, page 39: Regarding the Laura Maxwell review, provide responses to questions noted in bullet item 3 of the November 5, 2018 letter on page 287 of the submission.

Verified:     NO     YES

Professional Team Comments:

Not verified pending expert certifications after revisions.

Reviewed resume for new employee Dr. Shujun Li:

Shujun Li, Ph.D., Civil & Environmental Engineering, Utah State University, Logan, Utah;  
M.S., Hydraulics and River Dynamics, China Institute of Water Resources & Hydropower  
Research, Beijing, China; B.S., Hydraulic and Hydropower Construction Engineering,  
Tsinghua University, Beijing, China

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

Discussed with Laura Maxwell her review of the model submission under the Actuarial Standards.

Reviewed email correspondence between ARA and Laura Maxwell on queries during her actuarial review of the model.

**\*\*\*Additional Verification Review Comments\*\*\***

Verified after review of expert certifications in revised Forms G-1 through G-7.

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

#### **Pre-Visit Letter**

5. G-3, page 41: Present geographic representations of the previous versus current ZIP Code centroids.
6. G-3, Disclosure 3, page 42: Explain the reference to two grids – wind grid and terrain grid.
7. G-3, Disclosure 5, page 42: Provide the number of ZIP Codes used in the various forms. Provide a list of all new and retired ZIP Codes relative to the previous submission.

**Verified:** YES

**Professional Team Comments:**

Reviewed geographic displays of ZIP Codes and comparisons of new centroid locations to previous locations for the entire state.

Discussed no change in methodology for computing population-weighted ZIP Code centroids.

Discussed ZIP Code centroid assignments on the windfield grid.

Discussed update to ZIP Code roughness database using updated ZIP Code boundaries.

Reviewed several examples of ZIP Code roughness changes.

Reviewed the wind and terrain grids.

Reviewed the ZIP Code polygons used in completion of the submission forms. Discussed there are no new or retired ZIP Codes relative to the previous submission. Discussed ZIP Code mapping used to complete Form A-1.

## G-4 Independence of Hurricane Model Components

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

### 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:    ~~NO~~    YES

### Professional Team Comments:

Not verified pending verification of other standards.

### \*\*\*Additional Verification Review Comments\*\*\*

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

Verified after resolution of outstanding issues from other standards.

## 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, 2017 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: ~~NO~~ YES

### Professional Team Comments:

Not verified pending review of open items.

Editorial items noted in the pre-visit letter and during the on-site review by the Professional Team were satisfactorily addressed during the audit. The Professional Team has reviewed the submission per Audit item 3, but cannot guarantee that all editorial difficulties have been identified. The modeler is responsible for eliminating such errors.

### \*\*\*Additional Verification Review Comments\*\*\*

Verified after review of open items.



## Meteorological Standards – Tim Hall, Leader

### M-1 Base Hurricane Storm Set\*

(\*Significant Revision)

- A. The Base Hurricane Storm Set is the National Hurricane Center HURDAT2 as of April 11, 2017 (or later), incorporating the period 1900-2016. Annual frequencies used in both hurricane model calibration and hurricane model validation shall be based upon the Base Hurricane Storm Set. Complete additional season increments based on updates to HURDAT2 approved by the Tropical Prediction Center/National Hurricane Center are acceptable modifications to these data. Peer reviewed atmospheric science literature may be used to justify modifications to the Base Hurricane Storm Set.**
- B. Any trends, weighting, or partitioning shall be justified and consistent with current scientific and technical literature. Calibration and validation shall encompass the complete Base Hurricane Storm Set as well as any partitions.**

### 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 previously-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.
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**

8. Explain the independent meteorological co-variates used during stochastic hurricane simulations. How are the values of the independent climate co-variates sea surface temperature and wind shear selected during simulations?
9. M-1, Disclosure 1, page 49: Discuss the Base Hurricane Storm Set including justification for an 1886 start-date on HURDAT2. Explain the extent to which the 1886-1889 hurricanes (absent from Forms A-2A and A-2B) are used in model construction and validation and inform historical landfall counts in Forms M-1 and S-1.
14. Form M-1, page 148: Reconcile inconsistency between modeled Florida landfalls in Form M-1 and Form S-1.
15. Form M-1, page 148: Explain the differences between historical landfall rates in Form M-1 to those given in the 2017 Hurricane Standards Report of Activities.
16. Form M-1, page 148: Provide a comparison of modeled and historical Florida landfall rates. Provide justification for modeled-historical differences on the NW Florida region in terms of historical sampling error.
17. Form M-1, page 148: Explain the classification for NoName02 (1919) in Form M-1 and Forms A-2A and A-2B.

**Verified:** YES

**Professional Team Comments:**

Reviewed the implementation of the modification in the hurricane windfield methodology for fast moving hurricanes.

Discussed no change to Rmax in the model.

Reviewed map of percentage changes in the 100-year windspeeds.

Discussed the independence of covariates selected and used in stochastic simulations.

Discussed the methodology for selecting sea surface temperature and wind shear values during simulations.

Discussed that the original track model was developed using historical track data from 1886 onward as detailed in Vickery et al., 2000a. Discussed landfall validation and calibration is performed using historical data from 1900 onward.

Reviewed the inconsistency between Florida landfalls in Form M-1 and Form S-1 reconciled after Form S-1 was updated.

Reviewed the differences between historical landfall rates in Form M-1 to those given in the ROA.

Reviewed the process for assigning modeled landfall rates by regions in Form M-1.

Reviewed the classification for NoName02 (1919) as a Category 4 hurricane by-passing storm in Forms M-1, A-2A and A-2B.

Reviewed re-calibration of the US model to include Caribbean hurricane activity.

**\*\*\*Additional Verification Review Comments\*\*\***

Reviewed revised Form M-1 and consistency with revised Forms S-1, A-2A and A-2B.

## M-2 Hurricane Parameters and Characteristics

***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 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

10. M-2, page 50: Explain the choice of 5-degree by 5-degree geographic regions for track modeling and the use of latitude and longitude predictors within the regions.
11. M-2, pages 50-52: Discuss the treatment of error terms during track and intensity simulations (equations 1, 2, 3, and 6). Do the regression errors exhibit auto-correlations (and cross correlations in the case of track speed and direction)? If so, explain how these correlations are treated during simulations.
12. M-2, page 52: Explain the methodology for combining Gulf and Atlantic RMW models.

**Verified:** YES

**Professional Team Comments:**

Discussed the basis for the 5-by-5 degree squares for the track model.

Discussed that the error terms during storm track and intensity simulations are modeled with a bi-normal distribution and are sampled independently without autocorrelation.

Reviewed the methodology for combining the Gulf and Atlantic Rmax models. Reviewed calculation of Rmax in the code.

Reviewed code for the track speed bi-normal error term.

### M-3 Hurricane Probability Distributions

- 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 showing 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:**

Reviewed updates in the distribution plot comparisons of modeled versus actual parameters in the hurricane track model.

Reviewed central pressure distribution comparisons by region between the current and previous submission.

Reviewed storm heading histograms of historical storms in four Florida regions.

Reviewed plots of the model change in storm translation speed, central pressure, and storm heading distributions.

Reviewed track and intensity landfall comparisons to historical values on individual coastal segments.

Reviewed track and intensity comparisons to historical values on multiple regions over the Caribbean and Atlantic.

Reviewed track-bearing, translation speed, and central pressure model-historical  $R^2$  maps and  $R^2$  difference maps from previous submission.

## **M-4 Hurricane Windfield Structure**

- 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) 2011 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 windfield shall account for the effects of the vertical variation of winds if not accounted for in the vulnerability functions.***

### **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-2A, Base Hurricane Storm Set Statewide Hurricane Losses (2012 FHCF Exposure Data) and Form A-2B, Base Hurricane Storm Set Statewide Hurricane Losses (2017 FHCF Exposure Data).
5. For windfields not previously reviewed, detailed comparisons of the hurricane model windfield with Hurricane King (1950), Hurricane Charley (2004), Hurricane Jeanne (2004), and Hurricane Wilma (2005) will be reviewed.
6. For windfield and pressure distributions not previously reviewed, time-based contour animations (capable of being paused) demonstrating scientifically-reasonable windfield characteristics will be reviewed.
7. Representation of vertical variation of winds in the hurricane model, where applicable, will be reviewed.
8. Form M-2, Maps of Maximum Winds, will be reviewed.



**Pre-Visit Letter**

18. Form M-2, pages 153-155: Ensure that open-terrain roughness length was applied only over land. If not, provide the Form M-2 maps with open-terrain applied only on land points.

**Commission Issue:**

4. For Standard M-4, Audit item 8, the science underlying the maximum windspeeds in Form M-2.

**Verified:** YES

**Professional Team Comments:**

Reviewed updates to roughness length to include tree canopy data with NLCD LULC terrain types.

Reviewed the updated methodology for converting land use and land cover data into a spatial distribution of roughness coefficients. Reviewed example of the percentage change in tree canopy coverage in Miami-Dade County. Discussed spatial averaging of surface roughness to account for wind fetch.

Reviewed the surface roughness methodology flowchart.

Reviewed the percentage change in ZIP Code surface roughness. Reviewed example of high surface roughness in Collier County.

Reviewed scatter plot comparison between HurLoss 9.0 and 8.0.a for ZIP Code terrain roughness.

Discussed that open terrain roughness length was applied only over land in completion of Form M-2.

## **M-5 Hurricane Landfall and Over-Land Weakening Methodologies**

***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 Jeanne (2004), Hurricane Dennis (2005), and Hurricane Andrew (1992) at the closest time after landfall will be reviewed.

### **Pre-Visit Letter**

13. M-5, Disclosure 2, page 62: Provide a comparison of modeled to historical inland time decay.

**Verified:** YES

### **Professional Team Comments:**

Reviewed plot comparing modeled to historical inland time decay for Hurricane Irma (2017).

**M-6 Logical Relationships of Hurricane Characteristics**

***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. Form M-3, Radius of Maximum Winds and Radii of Standard Wind Thresholds, and the modeling organization sensitivity analyses will be reviewed.
2. 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.
3. Justification for the variation of the asymmetry with the translation speed will be reviewed.
4. Methods (including any software) used in verifying these logical relationships will be reviewed.

**Verified:** YES

**Professional Team Comments:**

Verified no change in the methodology that would violate these logical relationships, as documented in peer-review publications.

## STATISTICAL STANDARDS – Mark Johnson, Leader

### S-1 Modeled Results and Goodness-of-Fit

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

- Forms S-1, Probability and Frequency of Florida Landfalling Hurricanes per Year, S-2A, Examples of Hurricane Loss Exceedance Estimates (2012 FHCF Exposure Data), S-2B, Examples of Hurricane Loss Exceedance Estimates (2017 FHCF Exposure Data), 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.
- 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.

#### Pre-Visit Letter

- S-1, Disclosure 6, page 71: Explain why the historical but not the modeled values have been updated in Figure 18.
- Form S-3, pages 162-175: Explain the use of multiple goodness-of-fit statistics throughout this form. Why are there four tests, and what are the associated hypotheses regarding the distribution? Furthermore, Figure 48, FLB has 20 points plotted while in the corresponding plot of the previous submission, the plot had 16 points. Region B in Table 3 of Form M-1 (page 148) has 22 events while the previous submission Form M-1 Table 3 had 21 events. The previous Figure 48 had 16 points plotted.

Verified:  NO  YES

#### Professional Team Comments:

Not verified pending review of open items.

Reviewed revised Form S-1.

Discussed the confidence bands in Form S-3 distribution Figures 38-51 on the track model updates.

Reviewed revised Figure 18 with modeled values updated.

Discussed the various goodness-of-fit tests and the associated hypotheses regarding the distributions.

Discussed the additional landfalls included in Form M-1 from the previous submission.

**\*\*\*Additional Verification Review Comments\*\*\***

Reviewed revised Forms S-2A and S-2B.

Discussed consistency in historical storms between revised Form M-1 and revised Form S-1.

Verified after resolution of open items.

## 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 no changes in model methodology from the previous submission and no new sensitivity tests completed.

### **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 no changes in model methodology from the previous submission and no new uncertainty tests completed.

## **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. A graph assessing the accuracy associated with a low impact area such as Nassau County will be reviewed. If the contribution error in an area such as Nassau County is small, the expectation is that the error in other areas would be small as well. The contribution of simulation uncertainty via confidence intervals will be reviewed.

**Verified:** YES

### **Professional Team Comments:**

Discussed no change in 250,000 years of simulation for stochastic convergence.



## S-5 Replication of Known Hurricane Losses

***The hurricane model shall estimate incurred hurricane losses in an unbiased manner on a sufficient body of past hurricane events from more than one company, including the most current data available to the modeling organization. This standard applies separately to personal residential and, to the extent data are available, to commercial residential. Personal residential hurricane loss experience may be used to replicate structure-only and contents-only hurricane losses. The replications shall be produced on an objective body of hurricane loss data by county or an appropriate level of geographic detail and shall include hurricane loss data from both 2004 and 2005.***

### 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 coverage applied in each hurricane to address:
    - (1) Personal versus commercial
    - (2) Residential structures
    - (3) Manufactured homes
    - (4) Commercial residential
    - (5) Condominiums
    - (6) Structures only
    - (7) Contents only
    - (8) Time element,
  - 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 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

20. S-5, Disclosure 1, page 79: Provide justification for model-observational differences in commercial residential loss costs in Figure 23(b).

Verified: ~~NO~~ YES

### Professional Team Comments:

Not verified pending review of open items.

### \*\*\*Additional Verification Review Comments\*\*\*

Reviewed revised Figure 23 comparing modeled and actual losses as a function of peak gust windspeed.

Verified after resolution of open items.

## **S-6 Comparison of Projected Hurricane Loss Costs**

***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 Standard G-1, Scope of the Hurricane Model and Its Implementation, Disclosure 5.
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.

## VULNERABILITY STANDARDS – Masoud Zadeh, Leader

### V-1 Derivation of Building Hurricane Vulnerability Functions

- 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 their 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, storm surge, or wave action.***

### Audit

1. Modifications to the building vulnerability component in the hurricane model since the previously-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. Comparisons with the previously-accepted hurricane model will be reviewed.
2. 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 is 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.

3. All papers, 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.
4. 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.
5. Justification for the construction classes and characteristics used will be reviewed.
6. Validation of the building hurricane vulnerability functions and associated uncertainties will be reviewed.
7. Documentation and justification for all modifications to the building hurricane vulnerability functions due to statewide and county building codes and their enforcement will be reviewed. If year of construction and/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(s) and/or geographical region(s) of construction that separates particular group(s) will be reviewed.
8. 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.
9. The effects on building hurricane vulnerability from local and regional construction characteristics and statewide and county building codes will be reviewed including whether current statewide and county building codes are reflected.
10. How the claim practices of insurance companies are accounted for when 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, or the impact of public adjusting.
11. The percentage of damage at or above which the hurricane model assumes a total structure loss will be reviewed.
12. A plot comparing building structure and appurtenant structure hurricane vulnerability functions will be reviewed.
13. A plot comparing appurtenant structure hurricane vulnerability functions with insurance claims data will be reviewed.
14. Form V-1, One Hypothetical Event, will be reviewed.

**Pre-Visit Letter**

22. V-1, Disclosure 3, page 85: Provide additional details of actual insurance claims data used to develop the building vulnerability functions. Include the number of policies, number of insurers, dates of hurricane loss, and number of units of dollar exposure, separated into personal residential, commercial residential, and manufactured homes.
23. V-1, Disclosure 7, page 87: Provide research performed and the results obtained on Florida Building Codes 2014 and 2017. Discuss the impact on model results for new construction in Florida built after 2014.
24. V-1, Disclosure 8, page 87: Provide a description of the relationship between building structure and appurtenant structure vulnerability functions. In cases when the appurtenant structure and building structure are known, explain why the model combines the two to estimate losses and then back allocates the combined losses for building structure and appurtenant structure based on replacement values provided by the user.
25. V-1, Disclosure 9.d, page 88: Explain if model users can modify or replace the weights, and if users are prevented from making unrealistic combinations of building input characteristics.
27. Form V-1, pages 185-186: Explain how Form V-1 was completed with respect to the current model.
28. Form V-1, page 185: Explain the differences between the current and the previous Form V-1. Explain why losses for Wood Frame and Masonry increased while losses for Manufactured Home and Concrete decreased.

**Commission Issues:**

1. For Standard V-1, Audit item 7, how the county as well as statewide building codes are reflected in the model vulnerability functions.
2. For Standard V-1, Audit item 9, how the building codes are reflected in the model vulnerability functions, including whether current statewide and county building codes are incorporated.
3. Justification if the high-velocity hurricane zone included in the statewide Florida Building Code is not reflected in the model vulnerability functions.

**Verified:**      ~~NO~~    YES

**Professional Team Comments:**

Not verified pending review of open items.

Reviewed vulnerability model updates to the building stock regions, eras, and weights for post-1994 construction.

Discussed no changes to the underlying vulnerability matrices for buildings with known characteristics or pre-1995 building stock regions or weights.

Reviewed windspeed maps for residential construction in Florida with respect to WBDR. Discussed the change in the 2010 Florida Building Code from ASCE 7-05 to ASCE 7-10.

Reviewed how the county and statewide building codes are reflected in the model vulnerability functions.

Reviewed building stock weights by region and construction characteristics in wind-borne and non-wind-borne debris regions.

Reviewed claim analyses statistics including number of claims reviewed, number of insurers, policy values, and hurricanes.

Reviewed policy ZIP Code level personal residential claims data for several hurricanes.

Discussed changes in FBC 2014 and FBC 2017 and modeler research findings and conclusions for model modifications. Reviewed documentation summarizing changes in FBC 2014 and 2017 relative to previous FBC editions.

Discussed new constructions built in Florida post-2014 and the impact on modeled losses.

Discussed the relationship between building structure and appurtenant structure vulnerability functions. Discussed modeling of attached and detached exterior structures.

Discussed that a model user cannot modify or replace building stock weights and vulnerability functions.

Reviewed the process for completing Form V-1. Discussed differences from the previous submission Form V-1 related to surface roughness updates, building stock update, and change to ASTM Class D shingles in the form.

Reviewed county and statewide building codes implementation in the model.

Reviewed Form A-6.

### **\*\*\*Additional Verification Review Comments\*\*\***

Reviewed revised flowcharts for development of building vulnerability functions.

Reviewed process for computing economic loss from the different physical damage types.

Reviewed the primary building classification characteristics and occupancy types for personal and commercial residential building vulnerability functions.

Verified after resolution of open items.



## V-2 Derivation of Contents and Time Element Hurricane Vulnerability Functions\*

(\*Significant Revision)

- A. Development of the contents and time element hurricane vulnerability functions shall be based on at least one of the following: (1) insurance claims data, (2) tests, (3) rational structural analysis, and (4) post-event site investigations. Any development of the contents and time element hurricane vulnerability functions based on rational structural analysis, post-event site investigations, and tests shall be supported by historical data.**
- B. The relationship between the modeled building and contents hurricane vulnerability functions and historical building and contents hurricane losses shall be reasonable.**
- C. Time element hurricane vulnerability function derivations shall consider the estimated time required to repair or replace the property.**
- D. The relationship between the hurricane model building, contents, and time element hurricane vulnerability functions and historical building, contents, and time element hurricane losses shall be reasonable.**
- E. Time element hurricane vulnerability functions used by the hurricane model shall include time element hurricane losses associated with wind, missile impact, flood, and storm surge damage to the infrastructure caused by a hurricane.**

### Audit

1. Modifications to the contents and time element vulnerability component in the hurricane model since the previously-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 and time element vulnerability component. Comparisons with the previously-accepted hurricane model will be reviewed.
2. Multiple samples of contents and time element hurricane vulnerability functions will be reviewed.
3. 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.
4. Justification for changes from the previously-accepted hurricane model in the relativities between hurricane vulnerability functions for building and the corresponding hurricane vulnerability functions for contents will be reviewed.
5. Justification and documentation for the dependence of contents hurricane vulnerability functions on construction or occupancy type will be reviewed.

6. Documentation and justification of the following aspects or assumptions related to contents and time element hurricane vulnerability functions will be reviewed:
  - a. The method of derivation and underlying data,
  - b. Validation data specifically applicable to time element hurricane vulnerability,
  - c. Coding of time element by insurers,
  - d. The effects of demand surge on time element for the 2004 and 2005 hurricane seasons,
  - e. Variability of time element hurricane vulnerability by building classification and characteristics,
  - f. Statewide application of time element coverage,
  - g. Time element vulnerability for various occupancies,
  - h. The methods used to estimate the time, including uncertainty, required to repair or replace the property, and
  - i. The methodology and validation for determining the extent of infrastructure damage and their effect on time element hurricane vulnerability.
7. Justification for changes from the previously-accepted hurricane model in the relativities between hurricane vulnerability functions for building and the corresponding hurricane vulnerability functions for time element will be reviewed.
8. 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.

Verified: ~~NO~~ YES

**Professional Team Comments:**

Not verified pending review of open items.

Discussed contents and time element vulnerability functions.

**\*\*\*Additional Verification Review Comments\*\*\***

Reviewed revised flowcharts for development of contents and time element vulnerability functions.

Discussed the processes for assembling and storing fast running loss functions and validating modeled losses against claims data.

Discussed the process for computing time element loss and the threshold value of building loss for the model to begin calculating time element losses.

Discussed how time element vulnerability functions take into account damage to infrastructure.

Verified after resolution of open items.

### **V-3 Hurricane Mitigation Measures and Secondary Characteristics\***

*(\*Significant Revision)*

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

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

**The modeling organization shall justify all hurricane mitigation measures considered by the hurricane model.**

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

**C. 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 previously-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 vulnerability component. Comparisons with the previously-accepted hurricane model 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 over the range of windspeeds for individual hurricane mitigation measures and secondary characteristics will be reviewed. Historical data, technical literature, 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. 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 over the range of windspeeds for multiple hurricane mitigation measures and secondary characteristics will be reviewed.
5. 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

26. V-3, Disclosure 3, page 96: Provide a complete list of all secondary characteristics available in the model with their options, including options for unknown.
29. Form V-2, pages 187-188: Explain how Form V-2 was completed with respect to the current model.

Verified:    ~~NO~~    YES

### Professional Team Comments:

Not verified pending review of open items.

Reviewed revised Form V-4, and Forms V-3 and V-5.

Reviewed inventory data for opening protection weights for all constructions in Monroe County.

Reviewed internal documentation: Sampling Plan and Analysis of Survey Results for Residential Properties in Monroe County, Florida, Final Report, September 16, 2015.

Reviewed secondary modifiers and combinations for personal and commercial residential constructions available in the model.

Reviewed table of building design code adjustment factors for engineering buildings with one or more unknown characteristics.

Reviewed the process for completing Form V-2.

### \*\*\*Additional Verification Review Comments\*\*\*

Reviewed the two categories of secondary modifiers and their effects on vulnerability functions.

Verified after resolution of open items.

## ACTUARIAL STANDARDS – Mike Smith, Leader first on-site review Stuart Mathewson, Leader additional verification review

### A-1 Hurricane Modeling Input Data and Output Reports

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

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

#### 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.

#### Pre-Visit Letter

30. A-1, page 97: Explain how the input and output forms demonstrate that there is no requested or implemented, respectively, storm surge, storm frequency adjustment, or capability of the user to alter the meteorology, vulnerability, or actuarial components with reference to storm surge or storm frequency. (Commissioner Robert Lee review item)

Verified:    ~~NO~~    YES

#### Professional Team Comments:

Not verified pending review of open items.

Discussed the following with Laura Maxwell, ARA's external actuarial consultant:

- her understanding of hurricane catastrophe models and experience with Florida rate filings
- the process she used to review the model submission under the Actuarial Standards
- the apparent existence of zero loss costs in several counties as displayed in Forms A-4A and A-4B
- the ongoing role she expects to play in any review of revised submission under the 2017 Standards.

Reviewed email correspondence between ARA and Laura Maxwell related to questions identified during her review.

Reviewed relationships of counts to values in the preparation of the FHCF databases for analyses.

Discussed that there are no options in the model for storm surge, storm frequency adjustment, or capability of the model user to alter the meteorology, vulnerability, or actuarial components with reference to storm surge or storm frequency.

Reviewed a sample input control file. Reviewed sample output file.

**\*\*\*Additional Verification Review Comments\*\*\***

Verified after resolution of open items.

**A-2 Hurricane Events Resulting in Modeled Hurricane Losses\****(\*Significant Revision)*

- A. Modeled hurricane loss costs and hurricane probable maximum loss levels shall reflect all insured wind related damages from storms that reach hurricane strength and produce minimum damaging 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 the hurricane model takes into account any damage resulting directly and solely from flood or hurricane storm surge. Hurricane losses associated with wind damage will be reviewed to determine the treatment of flood and hurricane storm surge.
4. The documented procedure for distinguishing wind-related hurricane losses from other peril losses will be reviewed.

**Verified:**    ~~NO~~    YES

**Professional Team Comments:**

Not verified pending review of open items.

Reviewed examples of storms that count as hurricanes and others that do not.

Reviewed the model structure as regards verification of part B of the standard.

**\*\*\*Additional Verification Review Comments\*\*\***

Discussed the model does not model storm surge, inland flood, or any other peril losses other than wind-related hurricane losses.

Verified after resolution of open items.

### **A-3 Hurricane Coverages**

- A. The methods used in the calculation of building hurricane loss costs 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. If it is not modeled, justification will be reviewed.

#### **Pre-Visit Letter**

31. A-3, Disclosures 1-4, pages 106-107: Show a calculation of loss costs and probable maximum loss levels for the minimum Frame Owners loss costs in Form A-1 (i.e., ZIP Code 32336 in Jefferson County).

**Verified:** YES

#### **Professional Team Comments:**

Discussed the estimation of hurricane loss costs.

Reviewed example calculation of loss costs and probable maximum loss levels for a particular ZIP Code from Form A-1.



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

- A. Hurricane loss cost projections and hurricane probable maximum loss levels shall not include expenses, risk load, investment income, premium reserves, taxes, assessments, or profit margin.***
- 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 hurricane storm surge losses.***
- 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 and storm surge losses in the determination of modeled hurricane losses will be reviewed.
7. All referenced literature will be reviewed, in hard copy or electronic form, to determine applicability.

**Pre-Visit Letter**

32. A-4, Disclosure 1, page 108: Provide, in Excel, tables of 1,000 years descending from the Top Event corresponding to Forms A-8A and A-8B. For each year, show the value of each hurricane separately.

33. A-4, Disclosure 3, page 109: Provide additional details on the demand surge factor calculation.

34. A-4, Disclosure 4, page 109: Provide a hard copy of the Davis Langdon (2005) reference.

**Verified:**      ~~NO~~      YES

**Professional Team Comments:**

Not verified pending review of open items.

Reviewed the top 1,000 storms sorted by loss, and discussed the consistency with Forms A-8A and A-8B.

Discussed the demand surge procedure.

**\*\*\* Additional Verification Review Comments\*\*\***

Reviewed revised Forms S-2A, S-2B, A-8A, and A-8B.

Verified after resolution open items.

## A-5 Hurricane Policy Conditions

- A. *The methods used in the development of mathematical distributions to reflect the effects of deductibles and policy limits shall be actuarially sound.***
- B. *The relationship among the modeled deductible hurricane loss costs shall be reasonable.***
- C. *Deductible hurricane loss costs shall be calculated in accordance with s. 627.701(5)(a), F.S.***

### Audit

1. The process used to determine the accuracy of the insurance-to-value criteria in data used to develop and validate the hurricane model results will be reviewed.
2. To the extent that insurance claims data are used to develop mathematical depictions of deductibles, policy limits, policy exclusions, and loss settlement provisions, the goodness-of-fit of the data to fitted models will be reviewed.
3. To the extent that insurance claims data are used to validate the hurricane model results, the treatment of the effects of deductibles, policy limits, policy exclusions, loss settlement provisions, and coinsurance in the data will be reviewed.
4. Treatment of annual deductibles will be reviewed.
5. Justification for the changes from the previously-accepted hurricane model in the relativities among corresponding deductible amounts for the same coverage will be reviewed.

### Pre-Visit Letter

35. A-5.A, page 111: Provide details of the change in deductible procedure indicated in Standard G-1, Disclosure 5 (page 27).
36. A-5.B, page 111: Provide two examples that demonstrate reasonableness.
37. A-5, Disclosure 3, page 112: Explain the calculation of Insurance Hurricane Loss in Table 2.

Verified:     NO     YES

Professional Team Comments:

Not verified pending review of open items.

Reviewed the methodology change for computing expected insured losses for policies with site level deductibles in cases where the ground-up loss is between the policy limit and the policy limit plus the deductible.

Reviewed an illustrative example of the change in the expected insured loss formula.

Discussed the reasonableness of the relationship among the modeled deductible hurricane loss costs with both the modeling organization and its external consulting actuary.

Reviewed example from Form A-4A demonstrating deductible effect decreasing as storm intensity increases.

Reviewed example from Form A-6 demonstrating deductible effect increasing as deductible increases.

Discussed the methodology for calculating Insurance Hurricane Loss in Table 2.

Discussed the order of application for hurricane deductibles and policy limits.

**\*\*\*Additional Verification Review Comments\*\*\***

Reviewed the process for calculating the various deductibles used in the model.

Verified after resolution of open items.

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

- A. The methods, data, and assumptions used in the estimation of 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)

***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-8A, Hurricane Probable Maximum Loss for Florida (2012 FHCF Exposure Data), and Form A-8B, Hurricane Probable Maximum Loss for Florida (2017 FHCF Exposure Data), 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-8A, Hurricane Probable Maximum Loss for Florida (2012 FHCF Exposure Data), and Form A-8B, Hurricane Probable Maximum Loss for Florida (2017 FHCF Exposure Data), will be reviewed.
3. The first and second moments of the Annual Aggregate and Annual Occurrence distributions underlying the tables in Form A-8A, Hurricane Probable Maximum Loss for Florida (2012 FHCF Exposure Data), and Form A-8B, Hurricane Probable Maximum Loss for Florida (2017 FHCF Exposure Data), will be reviewed.
4. The first and second moments of the frequency and severity distributions, or similar information about the event distributions, underlying the hurricane probable maximum loss levels shown in Parts B and C in Form A-8A, Hurricane Probable Maximum Loss for Florida (2012 FHCF Exposure Data), and Form A-8B, Hurricane Probable Maximum Loss for Florida (2017 FHCF Exposure Data), will be reviewed.
5. All referenced literature will be reviewed, in hard copy or electronic form, to determine applicability.
6. Graphical representations of hurricane loss costs by ZIP Code and county will be reviewed.
7. Color-coded maps depicting the effects of land friction on hurricane loss costs by ZIP Code will be reviewed.
8. 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 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-2A, Base Hurricane Storm Set Statewide Hurricane Losses (2012 FHCF Exposure Data), A-2B, Base Hurricane Storm Set Statewide Hurricane Losses (2017 FHCF Exposure Data), A-3A, 2004 Hurricane Season Losses (2012 FHCF Exposure Data), A-3B, 2004 Hurricane Season Losses (2017 FHCF Exposure Data), A-6, Logical Relationship to Hurricane Risk (Trade Secret Item), and A-7, Percentage Change in Logical Relationship to Hurricane Risk, will be reviewed to assess coverage relationships.

9. The hurricane loss cost relationships among deductible, policy form, construction type, coverage, building code/enforcement, building strength, condo unit floor, number of stories, territory, and region will be reviewed.
10. The total personal and commercial residential insured hurricane losses provided in Forms A-2A, Base Hurricane Storm Set Statewide Hurricane Losses (2012 FHCF Exposure Data), A-2B, Base Hurricane Storm Set Statewide Hurricane Losses (2017 FHCF Exposure Data), A-3A, 2004 Hurricane Season Losses (2012 FHCF Exposure Data), and A-3B, 2004 Hurricane Season Losses (2017 FHCF Exposure Data), will be reviewed individually for total personal residential and total commercial residential insured hurricane losses.
11. Forms A-4A, Hurricane Output Ranges (2012 FHCF Exposure Data), A-5, Percentage Change in Hurricane Output Ranges (2012 FHCF Exposure Data), and A-4B, Hurricane Output Ranges (2017 FHCF Exposure Data), will be reviewed, including geographical representations of the data where applicable.
12. Justification for all changes in hurricane loss costs based on the 2012 FHCF Exposure Data from the previously-accepted hurricane model will be reviewed.
13. Form A-4A, Hurricane Output Ranges (2012 FHCF Exposure Data), and Form A-4B, Hurricane Output Ranges (2017 FHCF Exposure Data), will be reviewed to ensure appropriate relativities among deductibles, coverages, and construction types.
14. Apparent anomalies in the hurricane output ranges and their justification will be reviewed.

### Pre-Visit Letter

38. A-6, Disclosure 19, page 116: Explain how the model would handle two examples for a commercial residential property with a \$1 million value:
  - a. 80% coinsurance clause with \$600,000 policy limit
  - b. First loss policy with \$500,000 policy limitInclude discussion of the inputs to the system.
39. Form A-1, page 192: Explain the light blue ZIP Code results in the 1.01-2.00 range in Northeast Florida in Figure 54.
40. Forms A-2A and A-2B, pages 194-199: Reconcile the increase in the sum of Hurricane Charley (2004), Hurricane Frances (2004), Hurricane Ivan (2004), and Hurricane Jeanne (2004) from 2A to 2B, the decrease in the totals from 2A to 2B, the model change of -12.7% (G-1, Disclosure 5, page 27), and the increase in FHCF exposures from 2012 to 2017.
41. There are a number of ZIP Codes in the 2017 FHCF exposure data that do not appear in Form A-1. Explain how these exposures were modeled in Forms A-3B, A-4B, and A-8B.
42. Forms A-4A and A-4B, pages 240-261: Explain the underlying characteristics of St. Johns County such that the average Masonry loss costs are much higher than Frame loss costs relative to the other counties. Provide Frame and Masonry loss costs by individual ZIP Codes for St. Johns County.

43. Forms A-4A and A-4B, pages 240-261: Explain the weighting procedure used to determine the county averages for DeSoto and Gulf Counties.
44. Form A-4B, 0% Deductible, pages 252-256: Explain, in general, how apparent anomalies were resolved. In particular, explain the following cases for Frame loss costs less than Masonry loss costs:
  - Owners: Holmes Low, Santa Rosa Low
  - Renters: Liberty Low, Miami-Dade Average and High
  - Condo Unit: Santa Rosa Low, Average, and High
45. Forms A-4A and A-4B, pages 240-261: Explain why the High and Average loss costs for Manufactured Homes given in Forms A-4A and A-4B for Lafayette County are the same.
46. Form A-4B, page 252: With Form A-1 having only two ZIP Codes for DeSoto County (34266 and 34269) with “close” loss costs, explain the values given in Form A-4B for DeSoto County Low, Average, and High for Frame Owners, Masonry Owners, and Manufactured Homes.
47. Form A-4B, page 253: With Form A-1 having only two ZIP Codes for Glades County (33471 and 34974) with “close” loss costs, explain the values given in Form A-4B for Glades County Low, Average, and High for Frame Owners, Masonry Owners, and Manufactured Homes.
48. Form A-4B, page 253: With Form A-1 having only two ZIP Codes for Gulf County (32456 and 32465) with “close” loss costs, explain the values given in Form A-4B for Gulf County Low, Average, and High for Frame Owners, Masonry Owners, and Manufactured Homes.
49. Form A-4B, page 255: With Form A-1 having only one ZIP Code for Okeechobee County (34972), explain Form A-4B showing different loss costs for Low, Average, and High for all construction/policy combinations.
50. Form A-5, page 264: Explain the minimum decrease in Specified Deductible Output Ranges for Inland Renters and Condo Unit Owners. Reconcile the Statewide -12.7% change stated on page 27 with the \$0 Deductible Statewide Output Ranges.
51. Form A-5, pages 266-267: Explain the larger than average changes in Clay, Putnam, and Monroe Counties in Figures 72 and 73.
52. Form A-7, pages 272-274: Explain the increases for Coverage C, North Medium Building Strength and Year Built 1998.
53. Form A-8A, Part A, page 279: Reconcile the total expected annual hurricane losses with Form S-2A, Part B (page 160).
54. Forms A-8A and A-8B, A and D, pages 278 and 282: Clarify the number of years in the simulation. Also see Forms S-2A and S-2B (pages 160-161).



55. Form A-8A and A-8B, Part A, pages 279 and 283: Reconcile the stated number of hurricanes with the frequency results in Form M-1.
56. Forms A-8A and A-8B, pages 277-284: Explain the categorization of the data between Contents and Buildings for Condo Unit Owners and Renters.

**Commission Issue:**

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

**Verified:**     ~~NO~~    YES

**Professional Team Comments:**

Not verified pending review of open items.

Discussed how the model handles coinsurance.

Discussed the ZIP Code results in the 1.01-2.00 range in Northeast Florida in Form A-1, Figure 54.

Discussed differences between Forms A-2A and A-2B.

Discussed reasons for the increases in Coverage C, North Medium Building Strength and Year Built 1998 in Form A-7.

Discussed the number of hurricanes in Forms A-8A and A-8B compared to the frequency results in Form M-1.

Discussed the classification of FHCF data between contents and buildings for Condo Unit Owners and Renters.

**\*\*\*Additional Verification Review Comments\*\*\***

Reviewed revised Form A-4B. Discussed the error discovered in the original submitted Form A-4B and the revised process to eliminate recurrence of the error.

Reviewed the mapping from FHCF exposure data construction types to modeled construction classes.

Reviewed maps of 2017 FHCF risk count comparisons between Masonry and Superior for Renters and Condo Units.

Reviewed Form A-6.

Discussed the higher masonry loss costs relative to frame loss costs in St. Johns County.

Reviewed the weighting procedure used for determining the county averages in DeSoto and Gulf Counties.

Reviewed several examples of apparent anomalies identified in Form A-4B, all of which were resolved.

Reviewed the High and Average loss costs for Manufactured Homes for Lafayette County in Forms A-4A and A-4B with expanded decimal places.

Reviewed the results for DeSoto County, Glades County, Gulf County, and Okeechobee County across all lines of business in Form A-1 and Form A-4B.

Reviewed the results for Inland Renters and Condo Unit Owners in Form A-5. Reviewed the results for Clay, Putnam, and Monroe Counties in Form A-5.

Reviewed the increases for Coverage C, North Medium Building Strength and Year Built 1998 in Form A-7.

Discussed the number of simulated years in revised Forms A-8A and A-8B. Reviewed the number of events per year in Forms A-8A and A-8B compared to the number of hurricane landfalls per year in revised Form M-1.

Verified after resolution of open items.

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

*(\*Significant Revision)*

- A. Hurricane model functionality and technical descriptions shall be documented formally in an archival format separate from the use of letters, slides, and unformatted text files.***
- B. The modeling organization shall maintain a primary document repository, 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 modeling organization shall maintain (1) a table of all changes in the hurricane model from the previously-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. The modeling organization shall maintain a list of all externally acquired currently used hurricane model-specific software and data assets. 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, in either electronic or physical form, and its maintenance process will be reviewed. The repository should contain or reference full documentation of the software.
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 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 CI-1.D that contain the items listed in Standard G-1, Scope of the Hurricane Model and Its Implementation, Disclosure 5 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 Standards: CI-2, Hurricane Model Requirements, CI-3, Hurricane Model Architecture and Component Design, CI-4, Hurricane Model Implementation, CI-5, Hurricane Model Verification, and CI-6, Hurricane Model Maintenance and Revision.
8. Tracing of the hurricane model changes specified in Standard G-1, Scope of the Hurricane Model and Its Implementation, Disclosure 5 and Audit 5 through all Computer/Information Standards will be reviewed.

### Pre-Visit Letter

57. CI-1.B, page 117: Relate the primary binder table of contents with the response to Standard G-1, Disclosure 5 (page 27) by demonstrating individual table item compliance with Computer/Information Standards CI-1 through CI-7.
58. CI-1.D, page 117: Provide the table required by Standard CI-1, Audit Item 7.
59. CI-1.F, page 118: Provide the list of all externally acquired hurricane model-specific software and data assets as described and required by Standard CI-1, Audit Item 6.

Verified:    ~~NO~~    YES

### Professional Team Comments:

Not verified pending verification of other standards.

Reviewed the primary document binder.

Reviewed the table required by Standard CI-1, Audit item 7.

Reviewed the list of all externally acquired model specific software and data assets as described by Standard CI-1, Audit item 6.

### \*\*\*Additional Verification Review Comments\*\*\*

Verified after resolution of outstanding issues from other standards.

## CI-2 Hurricane Model Requirements

*The modeling organization shall maintain a complete set of requirements for each software component as well as for each database or data file accessed by a component. 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

60. CI-2, page 119: Provide requirements documentation that specifically relates to each model change identified in Standard G-1, Disclosure 5 (page 27).

Verified:    ~~NO~~    YES

### Professional Team Comments:

Not verified pending verification of other standards.

Reviewed the requirements documentation corresponding to the four model changes.

### \*\*\*Additional Verification Review Comments\*\*\*

Reviewed HurLoss Insured Loss Requirements, Design, and Testing documentation.

Reviewed HurLoss 9.0 Florida Model Requirements documentation.

Verified after resolution of open items.

### CI-3 Hurricane Model Architecture and Component Design\*

(\*Significant Revision)

- A. The modeling organization shall maintain and document (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, and (4) system model representations associated with (1)-(3). 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) shall be based on (1) a referenced industry standard (e.g., Unified Modeling Language (UML), Business Process Model and Notation (BPMN), Systems Modeling Language (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, and
  - 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).
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

61. CI-3.B, page 120: Provide the required document.

Verified:    ~~NO~~    YES

#### Professional Team Comments:

Not verified pending review of open items.

Reviewed numerous flowcharts.

Discussed the modeler's planned implementation of an updated flowchart standard.

**\*\*\*Additional Verification Review Comments\*\*\***

Reviewed revised flowcharts for development of building, contents, and time element vulnerability functions.

Reviewed flowchart for computing economic loss from physical damage.

Reviewed revised Figure 1.

Verified after resolution of open items.

## **CI-4 Hurricane Model Implementation**

- A. The modeling organization shall maintain a complete procedure of coding guidelines consistent with accepted software engineering practices.***
- B. The modeling organization shall maintain a complete procedure used in creating, deriving, or procuring and verifying databases or data files accessed by components.***
- C. All components shall be traceable, through explicit component identification in the hurricane model representations (e.g., flowcharts) down to the code level.***
- D. The modeling organization shall maintain a table of all software components affecting hurricane loss costs and hurricane probable maximum loss levels 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.***
- E. 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.***
- F. The modeling organization shall maintain the following documentation for all components or data modified by items identified in Standard G-1, Scope of the Hurricane Model and Its Implementation, Disclosure 5 and Audit 5:***
  - 1. A list of all equations and formulas used in documentation of the hurricane model with definitions of all terms and variables.***
  - 2. A cross-referenced list of implementation source code terms and variable names corresponding to items within F.1 above.***

### **Audit**

- 1. The interfaces and the coupling assumptions will be reviewed.
- 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 CI-4.D 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.

**Verified:**    ~~NO~~    YES

**Professional Team Comments:**

Not verified pending review of open items.

Discussed code standards as specified in S.A. Boukabara and P. Van Delst, "Standards, Guidelines and Recommendations for Writing Fortran 90/95 Code," NOAA, SPSRB Common Standards Working Group, Version 2.0, August 2010.

Reviewed a series of implementation code segments that are part of the model.

Reviewed code for the track speed bi-normal error term.

Reviewed code for expected insured loss calculations.

**\*\*\*Additional Verification Review Comments\*\*\***

Reviewed updated Fortran Coding Practices and the process undertaken to update the source code in the hurricane tracking model in accordance with accepted coding practices and Fortran-specific guidelines.

Reviewed major changes to the hurricane track model source code.

Discussed no changes occurred in the stochastic event set after the updates to the source code files.

Discussed the modeler's plan to update all source code files in the hurricane track simulation model to comply with revised coding guidelines. Discussed that other source code files within the HurLoss model will also be updated as they are modified or enhanced.

Reviewed script for producing output range results.

Reviewed the source code for implementation of the expected insured loss updates.

Reviewed document defining variables in the expected loss computation.

Reviewed the Insured Loss documentation for calculating expected insured loss.

Reviewed the source code for implementation of standard and annual deductibles.

Reviewed implementation of the bi-normal distribution.

Reviewed revised Forms A-8A and A-8B.

Verified after resolution of open items.

## CI-5 Hurricane Model Verification

### A. General

***For each component, the modeling organization shall maintain procedures 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. The modeling organization shall use testing software to assist in documenting and analyzing all components.***
- 2. Unit tests shall be performed and documented for each component.***
- 3. Regression tests shall be performed and documented on incremental builds.***
- 4. Aggregation 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. The modeling organization shall use testing software to assist in documenting and analyzing all databases and data files accessed by components.***
- 2. The modeling organization shall perform and document integrity, consistency, and correctness checks on all databases and data files accessed by the components.***

## Audit

- 1. 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.***
- 2. The testing software used by the modeling organization will be reviewed.***
- 3. The component (unit, regression, aggregation) and data test processes and documentation will be reviewed including compliance with independence of the verification procedures.***

4. 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.
5. Flowcharts defining the processes used for manual and automatic verification will be reviewed.
6. Verification approaches used for externally acquired data, software, and models will be reviewed.

### Pre-Visit Letter

62. CI-5, pages 123-124: Provide complete and thorough verification procedures and output from the model changes identified in Standard G-1, Disclosure 5 (page 27).

Verified: ~~NO~~ YES

### Professional Team Comments:

Not verified pending verification of other standards.

Reviewed a series of verification tests for meteorology central pressure across the Atlantic basin, vulnerability through comparison with modeled losses, model versus historical meteorological data, ZIP Code boundaries and centroids.

Reviewed face validation methods.

### \*\*\*Additional Verification Review Comments\*\*\*

Reviewed testing using Matlab script to validate the hurricane track model source code updates.

Verified after resolution of outstanding issues from other standards.

## CI-6 Hurricane Model Maintenance and Revision

- A. The modeling organization shall maintain a clearly written policy for hurricane model review, maintenance, and revision, 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. The modeling organization shall use tracking software to identify and describe all errors, as well as modifications to code, data, and documentation.**
- D. The modeling organization shall maintain a list of all hurricane model versions since the initial submission for this year. 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 CI-6.D will be reviewed.

### Pre-Visit Letter

63. CI-6.D, page 125: Provide the model version history over the past 5 years, leading up to the version identified in the submission.

Verified:     NO     YES

### Professional Team Comments:

Not verified pending verification of other standards.

Verified that the policy for model revision has not changed since the last accepted model.

Reviewed the model version history required by Standard CI-6, Audit item 2.

Verified the use of tracking software on a semi-annual basis.

**\*\*\*Additional Verification Review Comments\*\*\***

Verified after resolution of outstanding issues from other standards.

## CI-7 Hurricane Model Security

*The modeling organization shall have implemented and fully documented security procedures 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.

**Verified:** YES

### Professional Team Comments:

Verified that there have been no security breaches since the last accepted model.

Verified that the security policy has not changed since the last accepted model.