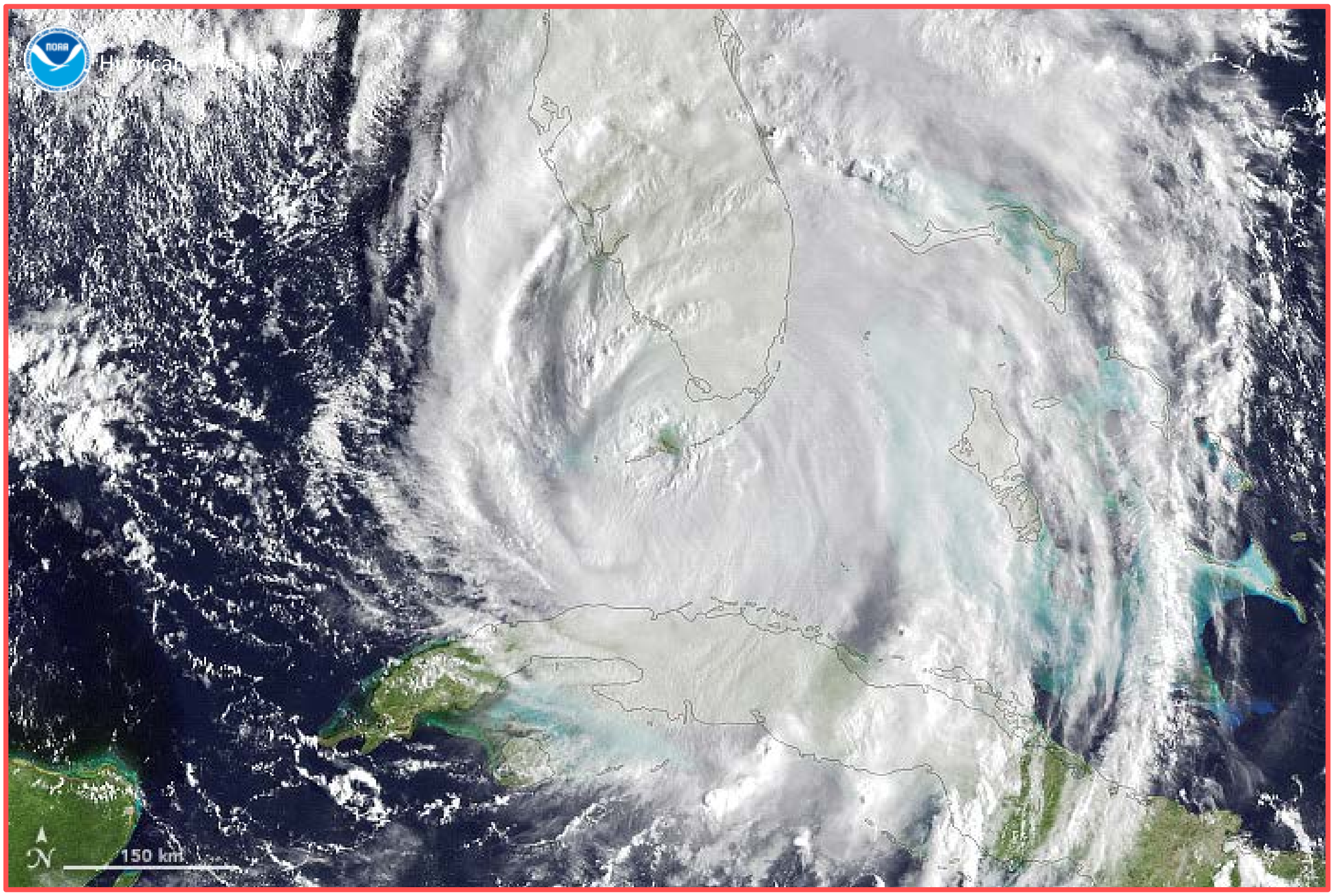
Florida Commission on Hurricane Loss Projection Methodology

Professional Team Report
2017 Hurricane Standards



Karen Clark & Company

On-Site Review
February 4-7, 2019

Additional Verification Review: April 23-25, 2019

On February 4-7, 2019, the Professional Team visited Karen Clark & Company (KCC) in Boston, Massachusetts. The following individuals participated in the review:

KCC
Kioumars Afshari, Ph.D., Senior Engineer
Vivek Basrur, Co-founder, Executive Vice President
Karen Clark, Co-founder,
Glen Daraskevich, Senior Vice President
Grant Elgin, Senior Software Engineer
Timothy Greene, Research Assistant
Filmon Habte, Ph.D., Senior Wind Engineer
Fabrice Kamayou, Research Statistician
Nozar Kishi, Ph.D., Vice President, Model Development
Katelynn Larson, Technical Writer
Marshall Pagano, Senior Risk Analyst
Mohammad Shoraka, Ph.D., Senior Engineer
Daniel Ward, Ph.D., Senior Meteorologist
Joanne Yammine, FCAS, FCIA, Actuary

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. KCC provided a general overview presentation on the model including:

- event catalog generation
- landfall frequencies by location
- modeled hurricane characteristics
- sampling methodology
- windfield generation and validation
- vulnerability function development and implementation
- primary building characteristics
- aerodynamic load resistance component methodology
- secondary characteristics
- claims data used for validation of vulnerability functions
- claims data analyses
- modeled versus actual loss comparisons
- mean damage ratio secondary uncertainty distributions and validation with claims data
- calculation of ground-up and gross losses
- software design requirements and coding standards for the RiskInsight® loss modeling platform.

The Professional Team next provided an overview of the audit history, expectations, and process. The Professional Team informed KCC of a discrepancy between the PDF and Excel versions of Form A-4B (Hurricane Output Ranges, 2017 FHCF Exposure Data) submitted with the January 18, 2019 response to deficiencies and corrected Form A-4A (Hurricane Output Ranges, 2012 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, KCC 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.

The Professional Team additionally recommended presentation of Ternary Tree Methodology (TTM) sensitivity analysis to features of the methodology and the sensitivity analysis color-coded contour plots with temporal animation from Form S-6.

Additional Verification Review – April 23-25, 2019

KCC submitted additional revisions to the original November 2018 submission on March 14, 2019. The Professional Team completed an additional verification review on April 23-25, 2019 in Boston.

The following individuals participated in the additional verification review.

<u>KCC</u>
Kioumars Afshari, Ph.D., Senior Engineer
Vivek Basrur, Co-founder, Executive Vice President
Karen Clark, Co-founder,
Glen Daraskevich, Senior Vice President
Grant Elgin, Senior Software Engineer
Filmon Habte, Ph.D., Senior Wind Engineer
Fabrice Kamayou, Research Statistician
Katelynn Larson, Technical Writer
Marshall Pagano, Senior Risk Analyst
Mohammad Shoraka, Ph.D., Senior Engineer
Daniel Ward, Ph.D., Senior Meteorologist
Joanne Yammine, FCAS, FCIA, Actuary

<u>Professional Team</u>
Paul Fishwick, Ph.D., Computer Scientist
Tim Hall, Ph.D., Meteorologist
Mark Johnson, Ph.D., Statistician, Team Leader
Stuart Mathewson Smith, 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 4 (pages 27-34)
   Incomplete as the National Land Cover Database 2011 and the ATC Code references cited in the submission are not given in the Vulnerability Standards reference list, and the ISO 5807 reference cited in the submission is not given in the Computer Information Standards reference list.

   The acronym ATC is not included in the list of acronyms in Appendix G (pages 332-333).

2. Standard G-2, Disclosure 2.A (page 39)
   Incomplete as the names of Karen Clark, Katelynn Larson, and James Michael Grayson are missing from Table 1.

3. Standard G-3, Disclosure 4 (page 48)
   Incomplete as a database for vulnerability regions as listed under Standard G-3.D is not given.

4. Standard S-1, Disclosure 6 (page 74)
   Unclear as Figure 22 is Mean Damage Ratio but the axes are windspeeds.

5. Standard S-4, Disclosure 1 (page 81)
   Incomplete as how the required performance is achieved is not given.

6. Form S-3 (page 169)
   Incomplete as none of the functional forms are complete and landfall frequencies is not included as a stochastic hurricane parameter.

7. Standard V-1, Disclosure 3 (page 91)
   Incomplete as the number of policies and the number of units of dollar exposure separated into personal residential, commercial residential, and manufactured homes are not given.

8. Standard A-1, Disclosures 4 & 5 (pages 111-116)
   Incomplete as the "hurricane model name and version identification" is not included on the input form and the hurricane model output report as required.

Discussion on Issues

The Professional Team reviewed in detail the following issues identified by the Commission at the January 7, 2019 meeting. KCC 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.

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) thorough, detailed presentations on each model component; (2) section by section review commencing within each section with pre-visit letter responses; (3) responses to 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 audit. 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, Model Submission Checklist – Part B identification corrected. Form V-4 added to list under B.
2. Page 16, G-1, Disclosure 2 – Conflicting statement “The KCC US Hurricane Reference Model has three primary components” with “Financial Module” on page 20 revised.
3. Page 20, G-1, Disclosure 2 – Michalski reference added to discussion on local building inventories.

4. Page 21, G-1, Disclosure 4 – Revised to include references for sources of the industry loss estimates given in Figure 5.
5. Pages 26-27, G-1, Disclosure 4 – Revised to include additional Statistical references.
6. Page 31, G-1, Disclosure 4 – Revised to include Kopp (2005) reference on parapets.
7. Page 32, G-1, Disclosure 4 – Revised to include Michalski (2016) reference on the Florida building inventory.
8. Page 34, G-1, Disclosure 4 – Revised to include demand surge and additional Actuarial references.
9. Pages 38-39, G-1, Disclosure 4 – Revised to include additional Vulnerability references.
10. Pages 36-45 – Page header corrected.
11. Page 39, G-2, Disclosure 2 – Dr. Nozar Kishi added to Table 1 for General Standards.
12. Page 44, G-2, Disclosure 2 – Flowchart in Figure 6 revised to include missing names, actuarial component, and to conform to ISO standards.
13. Page 49, G-4 – Standard item corrected and response revised to include that each component is theoretically sound.
14. Page 50, G-5 – Standard item corrected.
15. Page 51, G-2, Disclosure 2.C – Figure 6 revised.
16. Page 52, M-2 – Standard item corrected.
17. Page 52, M-2, Disclosure 2 – Windfield parameters defined and noted as fixed values; revised to clarify the use of a modified Willoughby equation.
18. Page 53, M-2, Disclosure 3 – Revised to provide additional clarification on Rmax, track direction, and forward speed
19. Page 57, M-3, Disclosure 2 – Table 2 revised to agree with Form S-3.
20. Pages 69-71, S-1, Disclosure 1 – Figures 16-19 and goodness-of-fit tests revised.
21. Page 73, S-1, Disclosure 6 – Goodness-of-fit test for number of Florida landfalls revised.
22. Page 74, S-1 – Random Form A-2A heading between disclosures 8 and 9 removed.
23. Page 75, S-2 – Standard item corrected.
24. Page 78, S-3 – Standard item corrected.
25. Page 81, S-4 – Standard item corrected.
26. Pages 81-83, S-4, Disclosure 1 – Revised to clarify and provide additional information on the sampling process.
27. Page 85, S-5 – Standard item corrected.
28. Page 87, S-6 – Standard item corrected.
29. Page 90, V-1, Disclosure 2 – Figure 33 revised.
30. Page 98, V-2, Disclosure 2 – Figure 34 revised.
31. Page 99, V-2, Disclosure 4 – Number of vulnerability functions corrected.
32. Page 99, V-2, Disclosure 5 – Figure 35 revised.
33. Page 102, V-3 – Standard item corrected.
34. Page 108, V-3, Disclosure 3 – Table 13 heading added.
35. Page 110, A-1, Disclosure 4 – Figures 36 and 37 revised to include model name and version identification.
36. Page 123, A-5, Disclosures 3 & 4 – Figure 39 and treatment of annual deductibles corrected.
37. Page 127, A-6, Disclosure 7 – Form name and hyperlink corrected.
38. Page 140, CI-7 – Standard item corrected.
39. Page 164, Form S-1 revised.
40. Page 332, Acronyms – List of acronyms updated.

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 2, page 18: Explain the impact of the non-stochastic nature of the tracks. Explain how the model produces multiple Florida landfalls from the same storm in different region combinations.

3. G-1, Disclosure 2, pages 19-20: Provide documentation of KCC engineers' surveys of local building inventories.

4. G-1, Disclosure 2, page 20: Provide examples from the model of the secondary uncertainty distribution for both the highest and the lowest Manufactured Home ZIP Code in Form A-1.

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending review of open item.

Discussed the process used in preparing client exposure data, importing the data into RiskInsight®, and handling problematic entries. Reviewed KCC's internal Exposure Data Processing Guide, Client Services Documentation, January 2019.

Discussed the model's spatial coverage of storm tracks capturing historical events. Discussed the uniform distribution for track direction.

Discussed building inventories based on the Florida Tax Appraiser Database.

Discussed the procedure for assuring continual agreement and correct correspondence of databases, data files, and computer source code to all documentation.

Reviewed the key configuration file for the vulnerability and hazard components.

Discussed that the revision to Form A-4A due to a manual input error did not result in a material change to the model.

Discussed the format for the revised model Build number.

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

Reviewed damage rates and examples of secondary uncertainty mean damage ratios.

Reviewed procedure to mitigate inconsistencies between slide information and submission documentation.

Reviewed the documented procedure for updating software and model version numbers.

Reviewed access to source code, documentation, and data that are centrally located.

Reviewed table of submission changes since the initial submission for each subsequent submission revision.

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

5. G-2, Disclosure 2, pages 37-43: Provide one hard copy of resumes for every individual involved in the development and implementation of the model.

6. G-2, Disclosure 2.A, page 38: Explain Figure 5 in detail.

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending expert certifications after revisions.

Reviewed resumes of modeling personnel:

- Kioumars Afshari, Ph.D. in Geotechnical Earthquake Engineering, Statistics and Structural Engineering minors, UCLA; M.Sc. in Geotechnical Engineering, Sharif University of Technology, Tehran, Iran; B.Sc. in Civil Engineering, Sharif University of Technology, Tehran, Iran
- Vivek Basrur, M.S. in Management Sciences, University of Waterloo, Waterloo, Ontario, Canada; Continuing research towards a Ph.D. in Water Resources Management and Operations Research, Harvard University and MIT, Cambridge, MA; Graduate research towards Ph.D. in Water Resources Management and Operations Research, Indian Institute of Technology, Delhi, India; B. Technology in Civil Engineering/Structures, Indian Institute of Technology, Delhi, India
- Karen Clark, M.B.A. and M.A. in Economics, Boston University, Boston, MA
- Glen Daraskevich, M.S. in Information Systems, Boston University Questrom School of Business, Boston, MA; M.S. in Environmental Engineering, University of New Haven, West Haven, CT; B.S. in Civil Engineering, University of Connecticut, Storrs, CT
- Grant Elgin, Boston University MET computer science fundamentals course work, Boston, MA; University of Alabama, Civil Engineering course work, Tuscaloosa, AL; Suffolk University, Electrical Engineering course work, Boston, MA
- J. Michael Grayson, Ph.D. in Civil Engineering, Clemson University, Clemson, SC; M.S. in Civil Engineering, Clemson University, Clemson, SC; B.S. in Civil Engineering, Clemson University, Clemson, SC
- Timothy Greene, M.S. in Geography, Virginia Polytechnic Institute and State University, Blacksburg, VA; B.S. in Meteorology, Minor in Geography, Virginia Polytechnic Institute and State University, Blacksburg, VA
- Filmon Habte, Ph.D. in Civil, Structural/Wind Engineering, Florida International University, Miami, FL; M.Sc. in Civil/Structural Engineering, Florida International University, Miami, FL; B.Sc. in Civil Engineering, University of Asmara, Asmara, Eritrea
- Fabrice Kamayou, M.S. in Actuarial Science, Boston University, Boston, MA; M.S. in Applied Mathematics, University of Massachusetts Lowell, Lowell, MA; B.S. in Mathematics, University of Massachusetts Lowell, Lowell, MA
- Nozar Kishi, Ph.D., in Earthquake Engineering, Kyoto University, Kyoto, Japan; M.Sc. in Structural Dynamic, Kyoto University, Kyoto, Japan; B.Sc. in Structural Engineering, Sharif University of Technology, Tehran, Iran
- Katelynn Larson, B.A. in English/Communications Literature and Creative Writing, Massachusetts College of Liberal Arts, North Adams, MA
- Linshou Li, M.S. in Information Technology, Worcester Polytechnic Institute, Worcester, MA
- Marshall Pagano, B.S. in Mathematics, Quantitative Economics, Tufts University, Medford, MA
- David Richards, B.S. in Electrical Engineering, University of Massachusetts Lowell, Lowell, MA
- Mohammad Shoraka, Ph.D. in Civil Engineering, Florida Institute of Technology, Melbourne, FL; M.S. in Engineering & Public Policy, Carnegie Mellon University, Pittsburgh, PA; M.S. in Natural Disaster Management, University of Tehran, Tehran, Iran; B.S. in Civil Engineering, University of Tehran, Tehran, Iran

- Marc Simon, Ph.D. in Physics and Astronomy, Tufts University, Medford, MA; M.S. in Physics and Astronomy, Tufts University, Medford, MA; B.S. in Physics, Massachusetts College of Liberal Arts, North Adams, MA
- Shraddha Subhedar, M.S. in Computer Information Systems, Boston University, Boston, MA; B.E. in Information Technology, Mumbai University, India
- Daniel Ward, Ph.D. in Atmosphere Science, Colorado State University, Fort Collins, CO; M.S. in Atmospheric Science, Colorado State University, Fort Collins, CO; B.S. in Agricultural and Life Sciences with concentration in Atmospheric Science, Cornell University, Ithaca, NY
- Zijun Xu, M.S. in Computer Science, Worcester Polytechnic Institute, Worcester, MA; B.E. in Electronics and Information Engineering, Northwestern Polytechnical University, Xi'an, China
- Joanne Yammine, B. of Mathematics, Université de Montréal, Montreal, Quebec, Canada
- Bonnie Zhang, M.S. in Computer Science, Stevens Institute of Technology, Hoboken, NJ; M.S. Ecological Engineering, Nanjing Forestry University, Nanjing, China

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

Discussed the sources for the loss estimates provided in Figure 5.

*****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

7. G-3, page 47: Present geographic representations of the ZIP Code centroids to facilitate an examination of all of the ZIP Codes in the state.

8. G-3, Disclosure 5, page 48: Provide the number of ZIP Codes used in the various forms.

Verified: YES

Professional Team Comments:

Reviewed geographic displays of ZIP Code boundaries and centroids for the entire state.

Discussed the methodology for assigning geometric centroids for ZIP Codes without mail delivery allowing for continuous polygonal coverage of ZIP Codes. Discussed the treatment of centroids over water.

Discussed the process for validating ZIP Code information purchased from their third-party providers, ZIP boundaries from Zip-Codes.com and population-weighted centroids from GreatData. Reviewed examples of ZIP Code data quality assurance testing.

Reviewed the number of ZIP Codes used in completion of the submission forms. Discussed the process for identifying and processing ZIP Code changes between the 2012 and 2017 FHCF exposure data.

Discussed the process for geocoding complete and incomplete street addresses. Reviewed stress test examples of geocoding assignments on a variety of input data.

Discussed the process for assigning ZIP Codes to latitude-longitude points, if required.

Reviewed the ZIP Code-based databases for ZIP Code boundaries and population-weighted ZIP Code centroids, and the Florida vulnerability regions maintained in vulnerability function files.

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.

Discussed the process for developing, validating, and implementing the different model components. Reviewed flowchart for model development, software development, and exposure and loss processing identifying personnel involved at each step.

*****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.

Discussed the process for editorial review with specific attention to discrepancies with Form A-4B.

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 issues have been identified. The modeler is responsible for eliminating such errors.

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

Reviewed the modification history for the submission documentation.

Reviewed flowchart defining the process for creating submission forms.

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

18. Form M-1, pages 152-154: Explain the classification for NoName02 (1919) in Form M-1 and Forms A-2A and A-2B.

19. Form M-1, pages 152-154: Explain the methodology for computing by-passing hurricane frequencies.

20. Form M-1, pages 152-154: Reconcile the historical Florida landfalls in Form A-2A Base Hurricane Storm Set and those in Forms M-1 and S-1.

Verified: YES

Professional Team Comments:

Discussed the method for modeling landfalls in the Keys. NoName02 (1919) is classified as a landfall in SW Florida in Forms M-1, A-2A and A-2B.

Discussed the methodology for computing by-passing hurricane frequencies.

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

Reviewed the historical Florida landfalls in revised Forms A-2A and A-2B compared to Form M-1.

Reviewed the Base Hurricane Storm Set based on HURDAT2 years 1900-2017.

Reviewed flowchart for processing changes in HURDAT2 in calculating landfall distributions.

Reviewed landfalling storms without a HURDAT2 landfall location and the assignment of landfall locations from Ho et al. (1987).

Discussed that no weighting or partitioning in the annual hurricane frequencies are incorporated into the model.

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

Reviewed calculation of Vmax distribution and cumulative distribution functions of Vmax probabilities for Northwest, Northeast, Southwest, and Southeast Florida.

Reviewed calculation of track direction and track directional changes.

Reviewed calculation of Rmax and graphical representation of Rmax versus Vmax.

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

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

Reviewed method for computing by-passer frequencies and characteristics.

Reviewed TTM as applied to the following by-passer characteristics: propagation direction, forward speed, and distance to coast. Rmax is held constant at mean value, and Vmax is held at value determined from nearest coastal distribution.

Reviewed spreadsheet of by-passer locations.

Reviewed assignment of dates to modeled storms.

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

9. M-2, Disclosure 3, page 53: Provide the equation used in the model for radius of maximum winds.

10. M-2, Disclosure 3, page 53: Provide details of the averaging over coastal regions to obtain track directions. Justify the 90-mile averaging window.

11. M-2, Disclosure 3, page 53: Explain what is meant by “each coastal location” for track direction. Provide the functional form relating the track direction to the mean and standard deviation prior to applying the moving window. Provide the support of the uniform distribution with its

parameters in terms of other characteristics. Explain how the variance is bounded by standard deviations that are in different units. Explain how latitude enters into the calculations explicitly.

12. M-2, Disclosure 3, page 53: Explain the quality of fit(s) for forward speed. Indicate how the end points of the distribution are fit.

13. M-2, Disclosure 7, page 54: Provide the methods used to compute track propagation after landfall.

14. M-2, Disclosure 9, page 54: Explain how the landfall points serve to determine the data sets underlying the various distribution fits. For example, indicate which data values are used for the Vmax fits of the Pareto/Generalized Pareto distributions at each coastal location.

15. M-2, Disclosure 9, page 55: Provide details of the averaging over coastal regions to obtain smooth landfalling storm frequencies and Vmax distributions in Figure 8.

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending review of open items.

Reviewed the equation and calculation for Rmax. Reviewed graphical representations of Rmax parameter fittings with Vmax less than 157 mph and Vmax greater than or equal to 157 mph.

Reviewed comparison of Rmax fitted dependence on Vmax for means and upper/lower limits against Florida values at landfall.

Reviewed histogram of Rmax residual data.

Discussed mean track direction at each landfall location within a moving window centered on the landfall location producing smooth transitions of track directions at adjacent landfall locations.

Reviewed the mean and standard deviation of historical track directions at landfall within a coastal window. Discussed uniform parameter distributions computed using the means and standard deviations of historical data. Reviewed track direction histograms.

Reviewed frequency histogram of forward speed. Discussed the trapezoidal distribution and Kolmogorov-Smirnov tests to determine goodness-of-fit between historical and modeled distributions.

Discussed climatological track directions with a curvature rate determined by two different methods.

Discussed landfall locations at coastal 10-mile segments. Reviewed the Pareto distribution fits for each region.

Reviewed calculation of asymmetry factors and footprints of Hurricane Wilma (2005), both stationary and moving.

Discussed that the model simulates surface windspeeds directly, so no windspeed height conversion is performed. Windspeeds represent the 1-minute sustained windspeed at 10-meter height.

Reviewed track direction plots with estimated losses for storms with one landfall, multiple landfalls, and by-passing storms with damaging winds over land.

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

Additional Verification Review Pre-Visit Letter

3. M-2, Disclosure 3, page 62 and S-1, Disclosure 1, page 82: Indicate how track direction is defined, for example, as an angle from a fixed direction, or as an angle from a coastal gate, or some other way. Discuss and justify the appropriateness of using a uniform distribution for angles.

Professional Team Comments:

Reviewed track direction at landfall, the mean and standard deviation of historical track directions at landfall, and the range of the data used in the uniform distribution.

Reviewed plot of the low, mean, and high values for track direction at landfall points along the coast.

Reviewed frequency distribution of track direction in Northwest, Southwest, and Southeast Florida.

Reviewed calculation of landfall storm frequencies and smoothing applied to the frequencies.

Discussed the use of NLCD 2011 Land Cover (amended 2014) National Geospatial Data Asset Land Use Land Cover.

Reviewed the relationship between central pressure and Vmax.

Verified after review of open items.

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: ~~NO~~ YES

Professional Team Comments:

Not verified pending review of open items.

Reviewed goodness-of-fits for Vmax, track direction at landfall, Rmax, forward speed, and overland decay for Florida and neighboring states.

Discussed that there are two decay regions for Florida – North and South, with an intermediate transition zone.

Discussed that landfall strike locations are on a discrete set of coastal points 10-miles apart.

Discussed the 10-mile distance in terms of ensuring landfalling hurricane eyes cover at least one coastline segment.

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

Additional Verification Review Pre-Visit Letter

1. M-3, Disclosure 2, Table 2, page 68 and A-1, Disclosure 1, page 81: Justify the use of trapezoidal distributions for Rmax residuals and forward speed given that such distributions provide zero weight for large deviations.

2. M-3, Disclosure 2, page 68 and S-1, Disclosure 1, pages 81 and 83: Provide rationale for the choice of Rmax residual distribution and the forward-speed distributions that are independent to the Ternary Tree Method (TTM) statistical sampling scheme. Remove the justifications for these distributions made in S-1, Disclosure 1 in terms of the TTM sampling scheme.

Professional Team Comments:

Reviewed statistical fit comparisons between historical and modeled Vmax distributions in Northwest and Southwest Florida, and over all Florida combined.

Discussed the use of meteorological judgement with statistical analysis for developing hurricane distributions when data are sparse.

Reviewed contour map comparisons of historical and modeled Hurricane Michael (2018) windfields at landfall.

Reviewed plot comparing modeled Vmax and Rmax to Florida landfall data.

Reviewed histograms of the Rmax and forward speed data.

Reviewed revised Table 2 and its consistency with Form S-3.

Reviewed distributions for Vmax, Rmax, track direction, forward speed, and landfall frequency.

Verified after review of open items.

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

16. M-4, Disclosure 1, page 58: Justify applying the Willoughby et al. (2006) wind profile directly to 10-meter windfields.

21. Form M-2, pages 156-159: 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:

Discussed the methodology for generating model hurricane windfields.

Discussed the process for calculating the maximum windspeeds for historical events using open terrain and actual terrain in Form M-2.

Discussed the National Land Cover Database (NLCD, 2011) as the primary source of land use land cover data. Discussed the process for assigning roughness length values and then resampling the roughness lengths to a 1 km grid.

Reviewed maps depicting the spatial distribution of surface roughness.

Reviewed the hurricane parameters used in calculating the loss costs for the LaborDay03 (1935) and NoName09 (1945) landfalls. Reviewed maps of the spatial distribution of winds for both storms.

Reviewed the Windfield Builder formula development.

Reviewed source code for windfield parameters and coefficient calculations. Reviewed the source code for calculating Rmax.

Reviewed comparisons of the modeled windfield with historical observed windspeeds for Hurricane Charley (2004), Hurricane Jeanne (2004), and Hurricane Wilma (2005). In addition, reviewed Hurricane King (1950) modeled windfield. Reviewed contour maps of the storms windfield footprints and windfield plots at landfall.

Reviewed time-based contour animation for Hurricane Wilma (2005).

Reviewed the process and source code for generating hurricane windfields. Stepped through code to generate Hurricane Andrew (1992) windfield.

Reviewed the algorithms computing forward speed and track direction in the source code.

Reviewed comparison plot of modeled Rmax versus Willoughby (2006) function.

Discussed the percentage of Rmax variance explained by Vmax and by latitude.

Reviewed the range of Rmax due to latitude variation over Florida.

Reviewed examples of storms with track direction changes due to the relaxation and latitude regression techniques.

Reviewed the roughness factors for the minimum and maximum windspeeds for actual terrain in Form M-2.

Discussed the modeled Rmax for Hurricane Charley (2004).

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

17. M-5, Disclosure 5, page 66: Justify the independent treatment of landfall intensity on tracks making multiple landfalls.

Verified: YES

Professional Team Comments:

Discussed treatment of landfall intensity on tracks making multiple landfalls.

Reviewed the calculation for over-land weakening.

Discussed that the decay equation parameters are fit using the Vmax time series of historical landfalling storms.

Reviewed plots of over-land decay fittings for Northeast, Northwest, Southeast, and Southwest Florida.

Reviewed the transition of winds from over-water to over-land. Reviewed landfall windfield maps, land-use data maps, and roughness-length maps for Hurricane Andrew (1992), Hurricane Jeanne (2004), and Hurricane Dennis (2005).

Reviewed second-landfall intensity distribution comparisons of modeled versus historical storms.

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:

Reviewed the histogram and box plots for the different ranges of Rmax given in Form M-3.

Reviewed the process for applying the windfield asymmetry factor due to forward speed.

Reviewed examples of asymmetry for a fast moving storm and a slow moving storm, testing the asymmetry logical relationship.

Reviewed examples of storms with same parameter values hitting two different roughness locations, testing surface friction logical relationship.

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

1. 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.

2. The modeling organization characterization of uncertainty for windspeed, damage estimates, annual hurricane loss, hurricane probable maximum loss levels, and hurricane loss costs will be reviewed.

Pre-Visit Letter

22. S-1, Disclosure 1, pages 69-71: Provide the data sets that are the basis of each Figure 16-19 and describe in detail how the p-values were obtained.

23. S-1, Disclosure 1, pages 69-71: Explain the estimation schemes of the parameters of probability distributions and the resulting goodness-of-fit tests in all cases in Figures 16-19.

24. S-1, Disclosure 6, page 73: Perform a goodness-of-fit test for landfall frequency.

25. S-1, Disclosure 6, page 74: Justify the relative lack of variability in the modeled results relative to the actual results in Figure 22.

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending review of open items.

Reviewed fitting of distributions and associated goodness-of-fit tests.

Reviewed Ternary Tree Methodology (TTM) for extreme event analysis.

Reviewed distribution of Vmax by region. Discussed the underlying data.

Reviewed historical versus modeled distributions for normalized Rmax. Discussed the normalized Rmax residuals computed from historical data.

Reviewed historical versus modeled distributions for track direction in Northwest Florida.

Reviewed historical versus modeled distribution for forward speed.

Reviewed a goodness-of-fit test for landfall frequency.

Reviewed scatter plots of the relationship between building mean damage ratios and windspeeds.

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

Additional Verification Review Pre-Visit Letter

4. The revision lacks relevant peer reviewed articles concerning Ternary Tree Method (TTM). The new articles included are not helpful in substantiating TTM in the hurricane wind peril context and especially not more generally in a statistical context.

5. The Kolmogorov-Smirnov test continues to be used as the goodness-of-fit test of choice in several instances, in spite of it being invalid in cases where the parameters of the distribution being considered are estimated.

6. The March 14, 2019 letter from Nozar Kishi alludes to instances of material that has been updated to reflect results from additional analyses. Provide these analyses.

7. S-1, Disclosure 1, page 81: Vmax, Figure 16 has been revised, but the only noticeable difference is the change in *p*-values. What is driving this difference? There is no mention of any errors from the previous submission nor is there an indication of specified analyses different from the prior version. Explain this disconnect.

8. S-1, Disclosure 1, page 81, Rmax: Explain the changes in Figure 17. The normalized Rmax residuals now vary from about -0.7 to +0.7 (caveat: the historical curve does not commence with a CDF value of 0.0; that needs to be corrected). Previously, the corresponding range was around -0.5 to over 2. Describe the revised historical data underlying this plot. Explain what is meant by the KCC sampling plan requiring "an equal likelihood for Rmax around the mean." Describe what is required beyond symmetric values around the mean if that is even a requirement. Any specific value has probability zero so further qualification is required. The use of the word "likelihood" here is problematic from a statistical standpoint.

9. S-1, Disclosure 1, page 82, Track direction: Explain how the variance around the mean direction can be modeled as a uniform distribution bounded by the standard deviations computed within the moving window – in particular, direction is in units of degrees while the variance is in units of degrees squared. The uniform distribution in Figure 18 does not appear to be centered at

zero and the end points are unclear on the left (CDF greater than zero) while the right side stops at around 70 degrees. Explain the fitting process with regard to the uniform distribution and its use spatially.

10. S-1, Disclosure 1, page 82: Explain why the angle data appears to be highly discretized, or few in number, in the CDF of Figure 18, while other parameters, such as forward speed (Figure 19), appear to have more values. Indicate units in the Figure 18 caption and how direction is defined.

11. S-1, Disclosure 1, page 83, Forward speed: Explain the changes leading to the revised Figure 19 and the extent to which the underlying supporting data has changed. As the historical empirical CDF is higher from around 8mph to around 20mph, explain how the trapezoidal form is appropriate (i.e., trimming the central hump of the historical data). Explain how the convenience of the trapezoidal distribution's use in the sampling methodology is a justification for the distribution's selection.

Professional Team Comments:

Reviewed statistical fit comparisons between historical and modeled Vmax distributions in Northwest and Southwest Florida, as well as over entire Florida.

Discussed the use of meteorological judgement with statistical analysis for developing hurricane parameter distributions when data are sparse.

Reviewed additional references and their relevance:

- Bacher, Axel, et al. "Efficient Random Sampling of Binary and Unary-Binary Trees via Holonomic Equations." *Theoretical Computer Science*, vol. 695, 2017, pages 42-53.
- Jin-Peng, Qi, et al. "Multi-Channel Detection for Abrupt Change Based on the Ternary Search Tree and Kolmogorov Statistic Method." *2015 34th Chinese Control Conference (CCC)*, 2015.
- Siciliano, Roberta, and Francesco Mola. "Ternary Classification Trees: A Factorial Approach." *Visualization of Categorical Data*, by Jörg Blasius and Michael Greenacre, Academic Press, 1998, pages 311-323.
- Choun, Young-Sun, and Min-Kyu Mim. "Logic Tree Approach for Probabilistic Typhoon Wind Hazard Assessment." *Nuclear Engineering and Technology*, vol. 51, no. 2, 2019, pages 607-617.
- Toro, Gabriel R., et al. "Efficient Joint-Probability Methods for Hurricane Surge Frequency Analysis." *Ocean Engineering*, vol. 37, no. 1, 2010, pages 125-134.
- Vickery P., et al. "Coastal Storm Surge Analysis: Storm Forcing." *FEMA Region III Storm Surge Study*, report 3, July 2013.
- Angus, John E., "The Probability Integral Transform and Related Results." *SIAM Review*, vol. 36, no. 4, 1994, pages 652-654.
- Pearson, E.S., "The Probability Integral Transformation for Testing Goodness of Fit and Combining Independent Tests of Significance." *Biometrika*, 30 (1), 1938, pages 134-148.
- Lilliefors, H.W., "On the Kolmogorov-Smirnov test for normality with mean and variance unknown." *Journal of the American Statistical Association*, 62 (318), 1967, pages 399-402.

- Lilliefors, H.W., "On the Kolmogorov-Smirnov test for the exponential distribution with mean unknown." *Journal of the American Statistical Association*, 64 (325), 1969, ages 387-389.
- Blain, G.C., "Revisiting the critical values of the Lilliefors test: towards the correct agrometeorological use of the Kolmogorov-Smirnov framework." *Campinas Bragantia*, vol. 73, no. 2, 2014, pages 192-202.

Reviewed revised goodness-of-fit test *p*-values calculated using Shapiro-Wilk, Anderson-Darling, and Kolmogorov-Smirnov/Lilliefors tests.

Discussed the use of probability integral transform to convert random variables into an equivalent set of uniformly distributed random variables. The Kolmogorov-Smirnov/Lilliefors test is then applied to test the uniformity of the transformed data.

Reviewed goodness-of-fit tests for Vmax, Rmax, track direction, forward speed, and landfall frequency. Reviewed revised Figures 16-19 comparing the historical and modeled distributions.

Discussed that the uniform distribution for track direction is bounded by the range of the data, that angular data is not grouped, that the units in Figure 18 are in degrees, and that angle is determined with respect to due North.

Reviewed forward speed histograms with a fitted trapezoidal distribution and a fitted log-normal distribution.

Reviewed Vmax histograms with fitted generalized Pareto distributions fit to the whole state.

Reviewed historical versus modeled distributions for Vmax in Northwest and Southwest Florida.

Reviewed historical versus modeled distributions for Rmax, track direction, forward speed, and landfall frequency.

Reviewed revised Form S-1.

Reviewed comparison of modeled and historical landfall frequencies using a negative binomial distribution and the associated Chi-Square goodness-of-fit test.

Verified after review 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.

Pre-Visit Letter

26. S-2, Disclosure 1, pages 75-77 and S-3, Disclosure 1, pages 78-80: Submit a text file to Donna Sirmons at donna.sirmons@sbafla.com containing the underlying data values supporting each of the Figures 23-28.

33. Form S-6, pages 176-193: As given, the data file KCC17Expected Hurricane Loss Cost.txt does not correctly compute the fourth column Expected Loss Cost.

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending additional calculations by Professional Team.

Reviewed Form S-6 for Sensitivity Analysis.

Reviewed color-coded contour plots with temporal animation of the sensitivity analyses on Vmax, Rmax, forward speed, and shape parameter. Reviewed snap-shot comparisons of several sensitivity analyses.

Discussed the results of the sensitivity analyses based on standardized regression coefficients for each input variable used in the calculation of loss costs.

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

Discussed the sensitivity study performed to determine the hierarchy of hurricane parameters.

Discussed that Vmax is the most sensitive parameter in the model.

Reviewed sensitivity tests of the storm Integrated Kinetic Energy to different branching schemes in the ternary tree method.

Reviewed revised Form S-6.

Verified after review of open items.

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: ~~NO~~ YES

Professional Team Comments:

Not verified pending review of open items.

Reviewed Form S-6 for Uncertainty Analysis.

Reviewed color-coded contour plots with temporal animation of the uncertainty analysis on Rmax.

Reviewed box plots of the expected percentage reduction by hurricane category. Discussed Vmax makes the largest contribution to the uncertainty in loss costs followed by Rmax.

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

Verified after review of open items.

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.

Pre-Visit Letter

27. S-4, page 81: Provide the loss convergence evidence in support of Standard S-4.

28. S-4, Disclosure 1, page 81: Explain the impact of the Ternary Tree Method on track direction at landfall. Explain how the methodology of choosing among just three track directions allow for grazing Florida landfalls, such as Hurricane David (1979).

29. S-4, Disclosure 1, page 81: Provide peer-reviewed references or other scientific support of the approach involving Ternary Tree Method. Describe how this sampling method fits in with classical sampling schemes. Provide measures of the uncertainty associated with this approach.

30. S-4, Disclosure 1, page 83: Demonstrate that the Ternary Tree Method sampling methodology yields unbiased estimates.

31. S-4, Disclosure 1, page 83: Explain how the Ternary Tree Method sampling methodology could generate a high consequence, low probability future event that is possible, but is outside the historically observed events (e.g., a strong category hurricane with landfall in Miami, traverses into the Gulf with another landfall in Tampa moving northeast through Orlando and exiting in Jacksonville).

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending review of open items.

Reviewed the Ternary Tree Methodology and the implications on sampling error.

Reviewed convergence graphs of masonry owners and frame renters loss costs in Nassau County.

Reviewed plots of stochastic set tracks.

Discussed the TTM used to determine the number of simulated years.

Reviewed graphical comparison between the Ternary Tree Methodology and a Monte Carlo sampling of simulated intensities by landfall point.

Reviewed examples of storm tracks and footprints demonstrating the model storm catalog includes high consequence, low probability events.

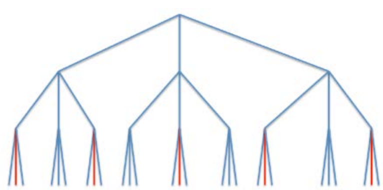
*****Additional Verification Review Comments*****

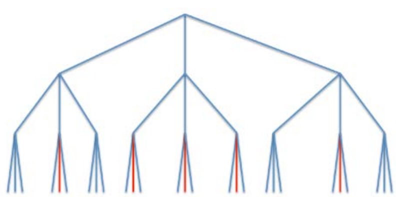
Additional Verification Review Pre-Visit Letter

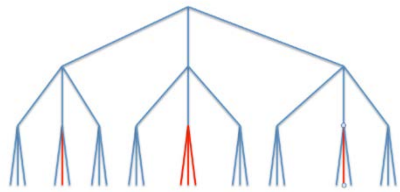
12. S-4, Disclosure 1, page 96: Describe how the 35,167 landfalling events are configured in the ternary tree (i.e., the number of parent Vmax nodes for each milepost, the values of Vmax used (5mph increments or less), the actual number of child nodes when differing from 27, and so forth). Assuming 110 mileposts (for Florida without considering neighboring states), 21 Vmax increments (say 75, 80, …175), 3 track directions, 3 Rmax and 3 forward speeds (62,370 combinations), explain how the reduced number of 35,167 is obtained. Explain how the events in the "final" tree are chosen and how it relates to a measure of the uncertainty in the estimated loss costs.

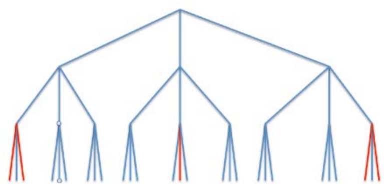
13. S-4, Disclosure 1, page 96: Consider the figure given below. Figure 31 on page 96 could lead one to believe that there is a natural, even unique choice of the children nodes to be active. The figure illustrates that multiple choices produce some form of cluster symmetry. Describe how the specific nodes are chosen – document the rules based regarding the selection of branches. Remind us what is done in the case where more than 27 children nodes are to be used and the ternary tree is expanded.

    For n=5, which of the following do you use and why?









14. S-4, Disclosure 1, pages 95-96: Provide additional testing, justification, and documentation of the TTM, given the dearth of reference to the TTM as a sampling scheme. Indicate the method's sensitivity to the following aspects:
    - The use of three nodes.
    - The particular specified hierarchy of importance: track direction, Rmax, then forward speed.
    - The particular scheme to select nodes, given an event count.
    - The requirement to have equal-probability nodes, compared to the more-general non-equal probabilities that appear in logic-tree earthquake literature.

15. S-4, Disclosure 1, page 96: Elaborate on the statistical tests that were performed on the loss costs relative to the TTM sampling method. In particular, what is the uncertainty associated with estimates from the TTM approach. Explain what is meant by "spatially unbiased" on page 96 versus statistical unbiasedness of estimates that was originally asserted.

16. S-4, Disclosure 1, page 96: Provide additional demonstration that sampling convergence has been obtained at 35,167 events. Describe the tests conducted "to ensure the event catalog resulting from the TTM methodology has met performance requirements" and reveal the results of these tests. Describe sensitivity to the 5mph-Vmax increment (page 95) that plays a role in fixing the parent-node count (2,500) and the event count (35,167).

17. S-4, Disclosure 1, page 96: Indicate the number of TTM nodes populated for a 500-year Vmax event and whether the number is sufficient to resolve 500-year hurricane events for damage and loss purposes.

Professional Team Comments:

Discussed the number of landfalling events at landfall points.

Reviewed plot of the generalized Pareto distribution CDF for Vmax.

Discussed the method for selection of nodes designed to maintain balance within the ternary tree and to follow the hierarchy of parameter importance when branching. Reviewed the branching rules and the hierarchy of parameter levels in the tree based upon their importance for estimating loss costs which was determined through a sensitivity study.

Reviewed the sensitivity tests to the number of branches at nodes.

Reviewed the sensitivity tests on different branching schemes used to select nodes, given an event count.

Reviewed the methodology for determining the use of three nodes and the specified hierarchy of importance determined by an analysis of loss results.

Discussed the requirement to have equal-probability nodes.

Discussed the statistical tests performed on the loss costs relative to the TTM sampling method. Discussed that the sampling process does not cause any apparent anomalies in the average annual loss costs by location.

Reviewed the methodology for testing loss convergence.

Discussed that the stochastic catalog length is sufficient to include at least one 500-year Vmax value at each landfall location in Florida.

Reviewed number of model events by ternary tree node for track direction, Rmax, and forward speed.

Verified after review of open items.

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

32. S-5, Disclosure 1, page 86: Explain how Figure 32 was developed using industry exposure and loss data.

Verified: YES

Professional Team Comments:

Reviewed modeled versus actual losses for various insurance company data.

Reviewed comparison of modeled to actual industry losses for the 2017 and 2018 hurricane seasons.

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: ~~NO~~ YES

Professional Team Comments:

Not verified pending review of open items.

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

Verified after review of open items.

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

34. V-1.A, page 89: Provide examples of rational structural engineering analyses.

35. V-1.C, page 89: Provide references for "published studies" and examples of how census and tax appraiser's data have been used to develop building inventory.

36. V-1.D, page 89 and Disclosures 6 and 7, pages 92-95: Provide research, if any, with regards to Florida Building Code 2014 and Florida Building Code 2017, conclusions drawn, and the impact on the model.

37. V-1, Disclosure 6, pages 92-95: Explain in detail building classifications for Florida constructions as implemented in the model.

38. V-1, Disclosure 7, page 95: Provide details of implementation of Florida Building Code wind-borne debris region and high-velocity hazard zones.

41. Form V-1, pages 196-197: Explain how Form V-1 was completed with respect to the model.

Commission Issues:

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

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

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

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending review of open items.

Reviewed examples of post-event engineering reports and internal documentation. Discussed the Aerodynamic Load and Resistance Method used to develop the base damage functions. Reviewed the mean damage ratio calculation.

Reviewed example of adjusting vulnerability functions after consideration of actual claims data.

Reviewed scatter plot comparisons of claims mean damage ratios to modeled mean damage ratios.

Reviewed example of how census and tax appraiser's data were used to develop building inventory.

Discussed KCC's analyses of recent versions of the Florida Building Codes 2014 and 2017 and the impact in the current version of the model.

Reviewed in detail the building classifications for Florida constructions implemented in the model.

Discussed that the vulnerability functions differentiate between reinforced and unreinforced masonry.

Discussed the four vulnerability regions and the application of year built categories.

Discussed selection of vulnerability functions for mobile homes.

Reviewed the implementation of the Florida Building Code wind-borne debris region and high-velocity hazard zones in the model.

Reviewed individual property surveys with client claims adjusters and internal documentation on Hurricane Florence (2018) damage survey notes.

Reviewed the vulnerability function, procedure, and calculations for completing Form V-1.

Reference documentation reviewed:

- Huang, G., He, H., Mehta, K.C., & Liu, X. (2015). Data-based probabilistic damage estimation for asphalt shingle roofing. *Journal of Structural Engineering*, 141(12).
- Li, Y., & Ellingwood, B.R. (2006). Hurricane damage to residential construction in the US: Importance of uncertainty modeling in risk assessment. *Engineering Structures*, 28, 1009-1018.
- Unanwa, C.O., McDonald, J.R., Mehta, K.C., & Smith, D.A. (2000). The development of wind damage bands for buildings. *Journal of Wind Engineering and Industrial Aerodynamics*, 84, 119-149.

Reviewed Form A-6.

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

Additional Verification Review Pre-Visit Letter

18. V-1, Disclosure 2, page 103: Explain in detail the building vulnerability development and development of vulnerability functions based on the component method.

19. V-1, Disclosure 6, page 106: Explain in detail the change in number of vulnerability functions from the previous submission.

20. V-1, Disclosure 6, pages 106-107: Explain in detail how the weights for Masonry and Unknown Construction Types for site built and for Unknown manufactured homes were developed. Explain to what extent are the weights Florida, regional, or construction era-based weights.

21. V-1, Disclosure 6, page 107: Explain the occupancy types in the model and specifically, how renters and condo unit-associations fit into these occupancy types.

22. V-1, Disclosure 6, page 109: Explain how the Central and North Florida vulnerability regions were developed. Provide justification.

23. V-1, Disclosure 8, page 109: Provide a more complete response to the second part of Disclosure 8 on consistency with insurance claims data. Demonstrate the building-appurtenant structure relationship in the model versus that observed in claims data.

Professional Team Comments:

Discussed the Aerodynamic Load Resistance based component methodology used to develop the base vulnerability functions.

Reviewed the calculation for total probability of failure computed from direct and progressive damages to a building component.

Reviewed plot of the model vulnerability functions. Discussed that component vulnerabilities are combined based on component exposure value percentages that produce vulnerability for the entire building.

Reviewed the number of vulnerability functions updated to include the vulnerability functions for all construction types, including unknown masonry and unknown manufactured homes.

Reviewed the revised flowchart for development of building vulnerability functions.

Discussed that weights for unknown construction types were developed based on building inventory data. Discussed that weights used for single-family homes vary by vulnerability regions.

Reviewed the occupancy types in the model and where renters and condo unit-associations fall in the occupancy types.

Reviewed the development of the Central and North Florida vulnerability regions.

Discussed that modeled losses for appurtenant structures are calculated separately from other coverages.

Reviewed graphical comparison of claims data mean damage ratio versus modeled mean damage ratio.

Reviewed relationship between appurtenant structure damage ratio and building damage ratio.

Discussed that year built bands are constant across construction types. Discussed that for manufactured homes, changes in building codes are reflected in the manufactured buildings construction types.

Reviewed and discussed revised Form A-6:

- Discussed Number of Stories loss costs for frame and masonry owners.
- Discussed Number of Stories loss costs for commercial residential.
- Discussed Deductible loss costs for frame and masonry renters.
- Discussed Deductible loss costs for frame and masonry condo unit.
- Discussed impact of building codes for Manufactured Homes.
- Discussed the definition and impact of weak, medium, and strong building strength.

Reviewed the building and contents vulnerability functions for frame renters versus frame condo unit owners used in Form A-6.

Reviewed examples of structural engineering analyses.

Reviewed samples of building vulnerability functions.

Reviewed scatter plot comparisons of actual versus modeled mean damage ratios by ZIP Code for single family homes from Hurricane Jeanne (2004), Hurricane Frances (2004), and Hurricane Charley (2004).

Reviewed scatter plot comparison of actual versus modeled mean damage ratios by ZIP Code for manufactured homes from Hurricane Irma (2017).

Reviewed modeled footprint for Hurricane Charley (2004). Reviewed graphical representation of the percentages of claims by windspeed.

Discussed the use of component method analysis and data collected from post disaster surveys to develop relativities for different vulnerability regions.

Discussed that no adjustments are made to the claims data used for model validation.

Reviewed the revised process for completing Form V-1.

Verified after review 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.

Pre-Visit Letter

39. V-2, Disclosures 4 and 5, page 99: Provide in detail the development of contents and time element vulnerability functions.

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending review of open items.

Reviewed the flowchart for development of the contents and time element vulnerability functions.

Discussed that the building-to-contents damage ratio relationship was developed using engineering judgment informed by post-event damage assessment and rational structural analysis. Reviewed examples of post event damage assessments with claim adjusters evaluating contents damage.

Reviewed comparison of the modeled contents to building damage relationship and the mean damage ratio from claims data. Reviewed the underlying claims data.

Reviewed the equation for calculating contents damage based on a combination of progressive damages to the roof structure, walls, openings, and wall-to-floor connection. Reviewed plot of the contents to building mean damage ratio.

Discussed that time element vulnerability is a function of both building repair-related time and event-related time. Reviewed plots of the building damage ratios for average repair time and average event time. Discussed the process for combining building and event related times to compute the overall time element vulnerability function.

Reviewed comparison of the modeled time element to building damage relationship to claims data.

Reviewed claims data underlying the mean damage ratio relationships for contents to building damage and for time element to building damage.

Reviewed plot of building, content, and time element vulnerability functions for an average wood frame single story building in a wind-borne debris region.

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

Additional Verification Review Pre-Visit Letter

24. V-2.B, page 111: Demonstrate the building-contents relationship in the model versus that observed in claims data.

25. V-2.C, page 111: Explain in detail the response given. Provide justification.

26. V-2.D, page 111: Demonstrate the building-content-time element relationships in the model versus those observed in claims data.

Professional Team Comments:

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

Reviewed the relationship between contents loss ratio and building damage ratio.

Discussed the average time to repair a typical residential building based upon percentage of component damage.

Reviewed the relationship between average repair time and building damage ratio.

Reviewed the relationship between time element loss ratio and building damage ratio.

Reviewed the relationship between contents and building damage ratio from claims data for different occupancy types.

Reviewed revised Form A-6 with regards to loss costs for various coverages and occupancy types.

Verified after review 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

40. V-3, Disclosure 3, pages 103-108: Explain in detail the development of secondary characteristics available in the model with their options, including options for unknown.

42. Form V-2, page 199: Explain how Form V-2 was completed with respect to the model.

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending review of open items.

Discussed the secondary characteristic modifiers in the model developed using the Aerodynamic Load and Resistance Component Method. Discussed the process used when secondary characteristics are unknown. Discussed the classification of secondary characteristics into two groups: affecting wind loading and affecting wind resistance.

Reviewed the secondary characteristics related to building geometry: roof geometry, roof pitch, parapets, and roof top equipment. Discussed how the effect of the secondary characteristics are calculated by modifying the roof load factor variable.

Reviewed the secondary characteristics related to roof strength: roof cover age, roof covering type and attachment, roof decking material and attachment, and roof-to-wall connection.

Reviewed other secondary characteristics: wall siding type, wall-to-foundation connections, and IBHS FORTIFIED designation.

Reviewed the source code for applying secondary characteristics to the vulnerability functions.

Reviewed examples of the impact of secondary modifiers on vulnerability functions.

Reviewed the vulnerability functions, procedures, and calculations for completing Forms V-2 and V-3.

Reviewed comparison of loss costs for Form V-3 reference structure for the corresponding ZIP Code loss costs in Form A-1 for wood frame and masonry.

Reference documentation reviewed:

- Kopp, G.A., Surry, D., Mans, C. (2005). Wind effects of parapets on low buildings: Part 1. Basic aerodynamics and local loads. *Journal of Wind Engineering and Industrial Aerodynamics*, 93, 817-841.
- Stathopoulos, T. (1987). Wind pressures on flat roofs and parapets. *Journal of Structural Engineering*, 113, 2166-2180.

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

Reviewed the revised process for completing Forms V-2 and V-3. Discussed the manual errors encountered in producing the initial Forms V-2 and V-3 subsequently corrected in the revised Forms V-2 and V-3.

Reviewed comparison of the Form V-3 vulnerability function for the mitigated referenced wood frame structure with the 1-story wood frame structure vulnerability function.

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

Reviewed the revised Form A-6 with regards to loss costs for number of stories and condo-unit locations.

Verified after review 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

43. A-1, page 110: 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 input and output forms detailing the necessary specifications of analysis. Reviewed example analysis output report and input guidelines for residential loss cost analysis for OIR review.

Reviewed documentation of adjustments to FHCF databases for processing actuarial forms.

Reviewed KCC Exposure Import User's Manual.

Reviewed the RiskInsight® OEF Import Guide documentation.

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

Additional Verification Review Pre-Visit Letter

27. A-1, Disclosure 4, page 129: The sample input form provided in Figure 36 has not changed from the previous submission and does not include the model name and version identification. Revised Figure 37 includes the version identification, but does not include the model name. Provide corrected figures as required by the disclosure. (Open Item #46)

Professional Team Comments:

Reviewed the analysis option settings shown in Table 15, including the model name and version identification required for ratemaking purposes.

Verified after review 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.

Pre-Visit Letter

44. A-2.B, page 117: Provide a hard copy of the documented procedure.

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending review of open items.

Reviewed the documented procedure for distinguishing wind-related hurricane losses from other peril losses: Verification of Wind Peril Losses US Hurricane Reference Model V2.0, RiskInsight® Version 4.9, KCC Client Services Documentation, January 2019.

Discussed that the model calculates and saves individual peril losses separately. Reviewed the documented procedure describing the methods for distinguishing wind-related hurricane losses from other peril losses.

Reviewed s. 627.4025, F.S.

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

Reviewed that the model begins to estimate wind-related damage at a 1-minute sustained windspeed of 25 mph or greater at 10-meter height.

Reviewed that damage from flood, storm surge, or wave action is not explicitly included in the wind vulnerability functions.

Discussed by-passing hurricanes included in the model.

Reviewed the three methods for distinguishing wind-related hurricane losses from other peril losses.

Verified after review 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

45. A-3, Disclosures 1-4, pages 118-119: Show a calculation of loss costs and probable maximum loss levels for the minimum Masonry Owners loss costs in Form A-1. Identify the associated ZIP Code.

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending review of open items.

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

Discussed applicability of actuarial soundness to the estimation of loss costs.

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

Additional Verification Review Pre-Visit Letter

28. A-3, Disclosures 1-4, pages 140-141: Provide the steps and calculation details used to produce loss costs for building, appurtenant structure, contents, and time element coverages associated with personal and commercial residential properties. (Open Item #49)

Professional Team Comments:

Reviewed the loss cost and probable maximum loss level calculations.

Reviewed the methodology for producing building, appurtenant structure, contents, and time element hurricane loss costs.

Reviewed the treatment of law and ordinance coverage.

Verified after review of open items.

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

46. A-4, Disclosure 1, page 120: 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.

47. A-4, Disclosure 3, page 121: Explain in detail the demand surge model. Provide a copy of the documented procedure and its implementation in the code.

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending review of open items.

Discussed the process for assigning ZIP Codes to latitude-longitude points for input into the model when a client's data is only geocoded at a latitude-longitude level.

Discussed the basis for demand surge implemented in the model. Reviewed internal documentation and literature.

Reviewed the calculation for demand surge factors for specific examples.

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

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

Reviewed the method of determining probable maximum loss levels.

Reviewed the uncertainty in the estimated annual loss costs and probable maximum loss levels in Forms A-8A and A-8B.

Reviewed how the model accounts for economic inflation associated with claims data.

Reviewed the treatment of modeled flood and storm surge losses.

Reviewed the demand surge factors for historical storms. Discussed the methodology and sources for determining demand surge factors.

Reviewed summary of industry exposure database by line of business.

Verified after review of 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

48. A-5, Disclosure 3, page 123: Explain the calculation of Insurance Hurricane Loss.

49. A-5, Disclosure 4, page 123: Explain in detail how the hurricane model treats annual hurricane deductibles and how it complies with Section 627.0701(5)-(9), Florida Statutes. Provide numerical examples.

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending review of open items.

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

Reviewed the calculation for expected insured loss. Reviewed examples of calculations of each scenario given in Figure 39 of damage and resulting loss.

Discussed the application of deductibles for multiple events in a single season.

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

Additional Verification Review Pre-Visit Letter

29. A-5, Disclosure 3, page 145: Explain the calculation of Insurance Hurricane Loss. (Pre-Visit Letter #48)

30. A-5, Disclosure 4, page 145: Explain the annual deductible procedure. Present implementation of the annual deductible in the computer code. (Open Item #57)

Professional Team Comments:

Reviewed the change in methodology for application of the annual hurricane deductible.

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

Reviewed the calculations for Insurance Hurricane Loss in revised Table 16.

Reviewed the process for determining the accuracy of insurance-to-value data used to develop and validate modeled results.

Verified after review 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

50. A-6, Disclosure 13, page 128: Explain the estimation of hurricane probable maximum loss levels.

51. A-6, Disclosure 19, page 128: 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 limit

    Include discussion of the inputs to the system.

52. Form A-1, pages 204-206: Explain the list of ZIP Codes with No Population Centroids used as fillers for Form A-1 maps. Explain why Frame loss costs are less than Masonry loss costs for several ZIP Codes. Explain how additional ZIP Codes are treated in the other actuarial forms.

53. Form A-1, page 205: Explain the loss costs in the areas to the east of Lake Okeechobee in Figure 67.

54. Forms A-2A and A-2B, pages 209-214: Reconcile the decrease in the totals from Form A-2A to Form A-2B.

55. Form A-2B, page 212: Explain the loss costs for NoName02 (1919).

56. Forms A-3A and A-3B, pages 216-273: Reconcile the decrease in the totals from Form A-3A to Form A-3B.

57. 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.

58. Forms A-4A and A-4B, pages 274-307: Explain the weighting procedure used to determine the county averages for DeSoto and Gulf Counties.

59. Form A-4B, 0% Deductible, pages 294-300: Explain, in general, how the apparent anomalies in the shaded areas were resolved. In particular, explain the following cases for Frame loss costs less than Masonry loss costs:
    Owners: Alachua Low, Average, and High
    Gadsden Average
    Wakulla Average and High
    Renters: Calhoun Low, Dixie Low
    Condo Unit: Okaloosa Low, Santa Rosa Low

60. Form A-4B, page 296: With Form A-1 having only two ZIP Codes for Glades County (33471 and 33944) with “close” loss costs, explain the values given in Form A-4B in Glades County Low, Average, and High for Frame Owners, Masonry Owners, and Manufactured Homes.

61. Form A-4B, page 296: 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 in Gulf County Low, Average, and High for Frame Owners, Masonry Owners, and Manufactured Homes.

62. Form A-4B, page 297: With Form A-1 having only one ZIP Code for Lafayette County (32066), explain the values given in Form A-4B in Lafayette County for Low, Average, and High for Frame Owners, Masonry Owners, and Manufactured Homes.

63. Form A-4B, page 298: With Form A-1 having only two ZIP Codes for Okeechobee County (34972 and 34974), explain the values given in Form A-4B for Okeechobee County Low, Average, and High for Frame Owners, Masonry Owners, and Manufactured Homes.

64. Forms A-8A and A-8B, pages 313-320: Explain the calculation of Expected Annual Hurricane Losses in Part A and the calculation of Estimated Hurricane Loss Level of the Top Event for Annual Occurrence and the lower bound of the Uncertainty Interval for the Annual Aggregate.

65. Forms A-8A and A-8B, pages 313-320: 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.

Reviewed the counts of ZIP Codes in Form A-1 in comparison to Forms A-2A/A-2B and A-3A/A-3B.

Discussed exceedance probability and the calculation of hurricane probable maximum loss levels.

Discussed counts underlying the probable maximum loss level exhibits compared to other model counts disclosed by KCC.

Discussed the mean of the frequency distribution underlying the probable maximum loss level exhibits.

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

Additional Verification Review Pre-Visit Letter

31. Forms A-4A and A-4B: Explain the differences between forms for AVERAGE loss costs for:
    - Frame Renters: Collier and Lee Counties
    - Commercial Residential: Bay, Sarasota, and Wakulla Counties and Statewide

Professional Team Comments:

Discussed the differences in frame renters loss costs in Collier and Lee Counties and the differences in commercial residential loss costs in Sarasota and Wakulla Counties related to differences in the year built distribution.

Discussed the differences in commercial residential loss costs in Bay County related to the change in exposure concentrated at the coast in the 2017 FHCF exposure data.

Reviewed the standard deviation calculation for the frequency underlying Forms A-8A and A-8B.

Reviewed the expected insured loss calculation.

Reviewed the calculation of Expected Annual Hurricane Losses in Forms A-8A and A-8B, Part A.

Reviewed the frequency and severity distributions underlying Forms A-8A and A-8B.

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

Reviewed color-coded maps depicting the effects of land friction on loss costs by ZIP Code for frame owners, masonry owners, and manufactured homes.

Reviewed the procedures to verify individual hurricane loss cost relationships.

Reviewed the relationship between deductible levels and loss cost ratios for masonry owners.

Reviewed revised Forms A-2A, A-2B, and A-3B. Reviewed Form A-3A.

Reviewed revised Form A-4A and Form A-4B.

Reviewed revised Form A-6.

Reviewed the revised process for completing Form A-1. Discussed the manual error in generating the exposure policy terms for some of the filler ZIP Codes. Reviewed revised Form A-1.

Discussed filler ZIP Codes used for producing Form A-1 maps.

Reviewed the demand surge factors for each historical hurricane.

Reviewed the loss cost results east of Lake Okeechobee in Figure 67.

Reviewed the decrease in losses from Form A-2A to Form A-2B and from Form A-3A to Form A-3B related to changes in the FHCF exposure data.

Reviewed the loss costs for NoName02 (1919).

Reviewed the weighting procedure used to determine the county averages for masonry and frame loss costs in Desoto and Gulf Counties.

Reviewed the higher masonry loss costs relative to frame loss costs in Alachua, Calhoun, Dixie, Gadsden, Okaloosa, Santa Rosa, and Wakulla Counties.

Reviewed the weighting procedure used for determining the county averages across all lines of business in Glades, Gulf, Lafayette, and Okeechobee Counties.

Verified after review 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

66. CI-1.F, page 129: Provide the list of all externally acquired hurricane model-specific software and data assets required by Standard CI-1, Audit Item 6.

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending verification of other standards.

Reviewed the Microsoft Team Foundation Server (TFS) online documentation system and the hyperlinks to associated data and code.

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

Reviewed the KCC server management and data management policy: Information Security Policy, Updated January 2019.

Reviewed example of update and release notes for RiskInsight®.

Reviewed the table required by CI-1.D of all changes since the initial November 2018 submission.

Reviewed examples of code review and history of bug tracking.

Reviewed the Team Foundation Server Guide.

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

Reviewed summary table of changes since the initial submission with the impact on specific CI standards and computations.

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.

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending verification of other standards.

Reviewed software requirements documentation.

Reviewed documentation on requirements verb definitions.

Reviewed Windfield Builder Input Track file schema.

Reviewed the 2014 IEEE-SA Standards Style Manual.

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

Reviewed software requirements documentation for applying the TTM to by-passing hurricanes.

Verified after resolution of outstanding issues from other standards.

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

67. CI-3.B, page 131: Provide the required document.

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending review of open items.

Reviewed multiple control and data flowcharts, and verified the compliance of the flowcharts with ISO Standard 5807-1985 as used by the modeler.

Reviewed examples of interface specifications for the model.

Reviewed schema documentation for Windfield Builder data files.

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

Additional Verification Review Pre-Visit Letter

32. CI-3: Provide an explanation of where the process in Figure 6 (page 51) begins. No entry symbol is used (page 9 of ISO 5807).

33. CI-3: Provide an explanation of the merge junction in Figure 6 (page 51), directly underneath “Review Passed.”

34. CI-3: Provide an explanation of the flow of computation in Figures 34 (page 112) and 35 (page 114) at (1) the fork (underneath the “Clean and process insurer claims data from past hurricanes”), and at (2) the merge (above the “Develop relationship between building and contents/time element damage ratios using insurer claims data.”

35. CI-3: Provide an explanation of the flow of computation in Figure 38 (page 131) at (1) the fork directly underneath “Create Exposure Database,” and at (2) the merge immediately to the left of “Run Loss Analysis.”

36. CI-3: Provide an explanation of the flow of computation in Figure 39 (page 148) at (1) the fork directly underneath “Client approves assumptions and control totals?” and at (2) the merge into “Centralized exposure, modeled loss, and claims database.”

37. CI-3: Provide an explanation of the flow of computation in Figure 40 (page 154) at (1) the split underneath “Create Exposure Database,” at (2) the join (two inlines for “Run Loss Analysis”), and at (3) the fork underneath “Prepare and Save Losses in Results Database.”

Professional Team Comments:

Reviewed revised Figure 6 flowchart for the business workflow of modeler personnel involved in development of the model.

Reviewed flowcharts in Figures 33, 34, 35, 38, 39, and 40 revised to conform to ISO 5807 standards.

Reviewed revised flowcharts for completing Forms V-1, V-2, and V-3.

Reviewed revised flowchart for importing, validating, and geocoding exposure data.

Verified after review 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.

Reviewed the KCC Coding Standard.

Reviewed the RIskInsight® Software Developers — Developer Protocol document.

Reviewed the Software Backlog Review Guidelines.

Reviewed damage function data and code implementation.

Reviewed the use of an index file to aggregate related links to data and code.

Review the steps identified as generating the hurricane windfield.

Reviewed a simulation of Hurricane Andrew (1992) using an interactive source code debugger with breakpoints.

Reviewed the spreadsheet data used for managing and categorizing storm event information.

Reviewed the modified Willoughby (2006) profile implementation in addition to the associated information required by Standard CI-4.F.

Reviewed the calculation for inland decay.

Reviewed coding guidelines documentation.

Discussed procedures for creating, deriving, or procuring and verifying databases or data files.

Discussed the traceability of all projects in RiskInsight® codebase.

Reviewed examples of model source code under TFS source control.

Reviewed the table of all software components required by Standard CI-4.D listing the number of lines of code by project.

Reviewed examples of comments in the source code verifying sufficiency, consistency, and explanatory quality.

Reviewed the code implementation defining how the IBHS designation, in vulnerability mitigation, is handled.

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

Reviewed the code implementation of the annual hurricane deductible.

Reviewed the code implementation of the probability of failure due to direct damage.

Reviewed the list of defined terms and variables associated with the Kaplan DeMaria decay calculation.

Reviewed the cross-referenced list of implementation source code terms and variable names corresponding to the Kaplan DeMaria decay calculation.

Reviewed the code implementation of the Kaplan DeMaria decay calculation.

Reviewed the code implementation for by-passing hurricanes.

Reviewed the code implementation for assigning hurricane parameters to branch arrangements of the ternary tree.

Verified after review 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.

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending verification of other standards.

Reviewed the process for verifying ZIP Code information.

Verified the geocoding process.

Reviewed the Footprint Inspection Tool to verify logical relationships between hurricane parameters.

Discussed the defensive coding practices, tracking and diagnostic reports to facilitate locating any problems in the code. Reviewed example of an error reported.

Discussed the testing software used by the modeler.

Discussed unit, regression, and aggregation tests performed.

Reviewed example of cross-checking procedure for implementation of Windfield Builder.

Reviewed the Unit Tests in RI4 ("I" as a letter) document.

Reviewed example of code testing including the review-hierarchy of people and processes.

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

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.

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending verification of other standards.

Reviewed example of code review.

Reviewed modeler policy for model maintenance and revision.

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

Reviewed the documented procedure for updating software and model versions.

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 there were no security breaches.

Reviewed security documentation, including:

- Information Security Policy
- IT Disaster Recovery Plan
- Antivirus and Malware Policy

Discussed cyber risk as it may apply to the model.