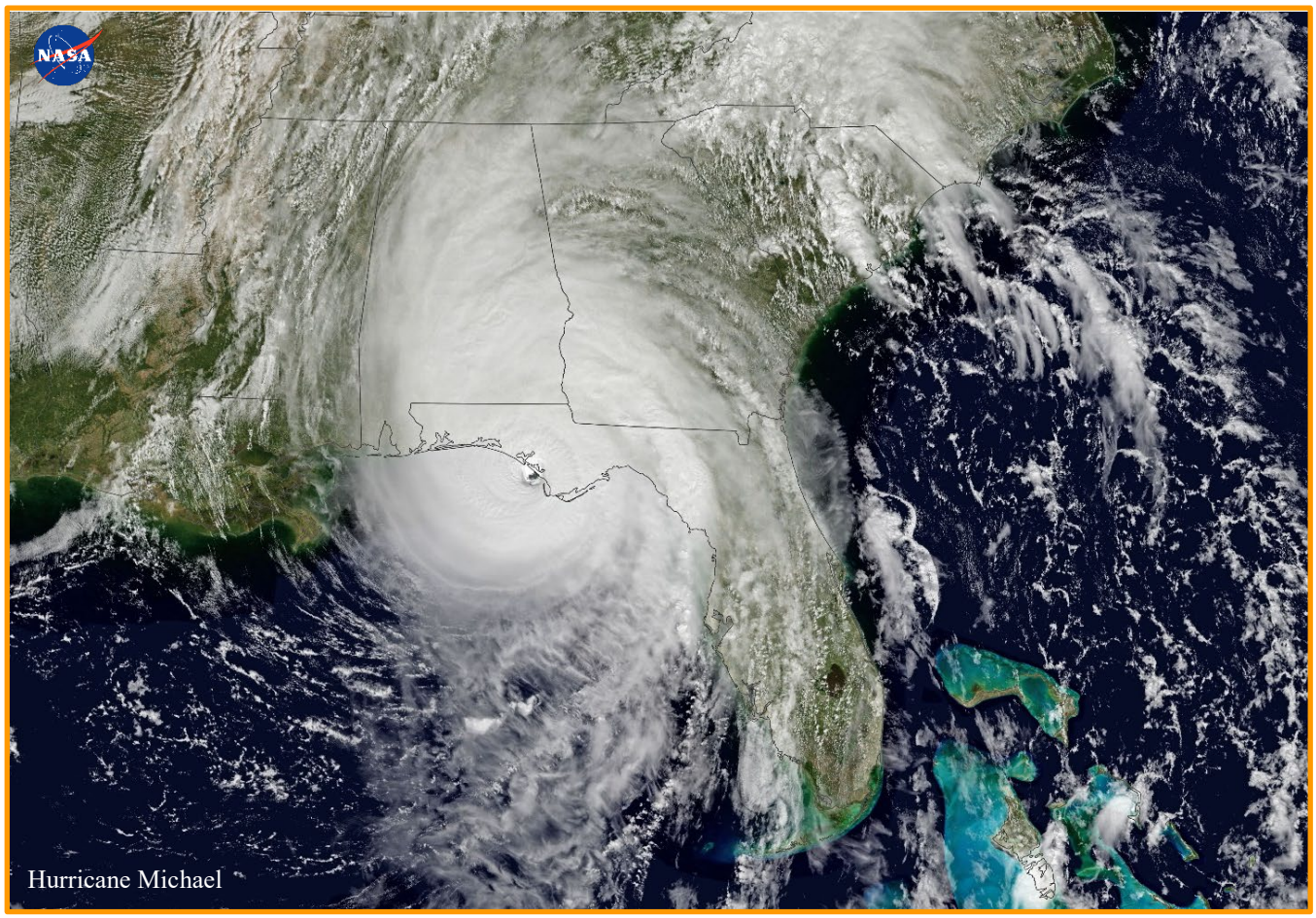
Florida Commission on Hurricane Loss Projection Methodology

Professional Team Report

2019 Hurricane Standards



Impact Forecasting

Remote Review: March 22-26, 2021

Additional Verification Review: May 18-19, 2021

Second Additional Verification Review: June 7, 2021

On March 22-26, 2021, the Professional Team conducted a remote review of the Impact Forecasting (IF), Florida Hurricane Model Version 1.0 on ELEMENTS Version 15.0. The following individuals participated in the remote review.

IF
Sushma Bhat, Director
Katie Carter, Managing Director, Aon Reinsurance Solutions
Siamak Daneshvaran, Ph.D., P.E., A.Re., A.R.M., Senior Managing Director
William Dong, Ph.D., Associate Director and Tech Lead, Software Development
Xian He, Ph.D., Senior Scientist
Daniel Head, Director
Steven Jakubowski, President
Yujin Liang, Ph.D., P.E., Director, Catastrophe Model Development
Maria Lomelo, Managing Director, Global Program Director
Chris Long, Director, Software and Analytics
Minchong Mao, FCAS, CCRMP, MAAA, Managing Director, Actuary, Aon Reinsurance Solutions
Nehal Naik, Managing Director, Software Development
Sami Pant, Ph.D., P.E., Senior Scientist
Purvish Patel, Director of Software Quality Assurance
Bin Pei, Ph.D., Associate Director
Venkatesh Ramaiah, Associate Director
Will Skinner, Managing Director, Global Head of Business Development
Hailey Smith, Director – Analytics, Aon Reinsurance Solutions
Radek Solnicky, Senior Scientist
Shruthi Srikantegowda, IND Group Manager Reinsurance Solutions – Technology
Vipin Unnikrishnan, Ph.D., Associate Director
Karthik Yarasuri, Senior Scientist – Wind Vulnerability

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

Due to the COVID-19 pandemic and State Board of Administration travel restrictions, the Professional Team conducted the review remotely rather than on-site. The remote review followed the on-site review process as detailed in the Report of Activities and the remote review procedures adopted by the Commission at their December 10, 2020 meeting.

The Professional Team began the review with an overview of the audit history, expectations, and the process. Introductions were made, and IF provided a general overview of the IF organization, its catastrophe models, and software platforms. IF next provided an overview of the model components:

- Hazard component including stochastic event modeling, windspeed calculation, historical scenario modeling and validation, stochastic model calibration and validation, and event set catalog construction
- Vulnerability component including wind damage simulator, vulnerability curve development for building, contents, and time-element, and secondary modifiers
- Financial component including data collection, data import, data analysis, and loss results
- Computer/Information component including the ELEMENTS catastrophe modeling platform, the development process, and quality assurance.

The audit continued with a review of each standards section. IF provided further details on the problem detected in generating Form A-8 and actions taken to correct the problem and prevent the problem from recurring.

During 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 *2019 Hurricane Standards Report of Activities* were noted.

During the Commission meeting to review the model for acceptability under the 2019 Hurricane Standards, IF is to present the following information in the Trade Secret closed session as specified on page 61 of the *Hurricane Standards Report of Activities as of November 1, 2019*:

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

*****Additional Verification Review – May 18-19, 2021*****

IF submitted revisions on April 30, 2021 to the submission document in response to items identified by the Professional Team during the March 2021 remote review. The Professional Team completed an additional verification review remotely on May 18-19, 2021.

The following individuals participated in the additional verification review.

IF
Kopal Arora, Senior Scientist
Sushma Bhat, Director
Katie Carter, Managing Director, Aon Reinsurance Solutions
Siamak Daneshvaran, Ph.D., P.E., A.Re., A.R.M., Senior Managing Director
Xian He, Ph.D., Senior Scientist
Steven Jakubowski, President
Ashwin Joseph, Associate Director
Yujin Liang, Ph.D., P.E., Director, Catastrophe Model Development
Maria Lomelo, Managing Director, Global Program Director
Chris Long, Director, Software and Analytics
Minchong Mao, FCAS, CCRMP, MAAA, Managing Director, Actuary, Aon Reinsurance Solutions
Samson Mohan, IND Director Reinsurance Solutions – Technology

Nehal Naik, Managing Director, Software Development
Pranesh Navale, Principal Consultant II
Sami Pant, Ph.D., P.E., Senior Scientist
Purvish Patel, Director of Software Quality Assurance
Bin Pei, Ph.D., Associate Director
Sri Harshitha Polamuri, Ph.D., Senior Scientist
Venkatesh Ramaiah, Associate Director
Roozbeh Raoufi, Ph.D., Senior Scientist, US Inland Flood Project Manager
Elham Sharifineyestani, Ph.D., Reinsurance Analytics Senior Analyst
Will Skinner, Managing Director, Global Head of Business Development
Radek Solnicky, Senior Scientist
Shruthi Srikantegowda, IND Group Manager Reinsurance Solutions – Technology
Vipin Unnikrishnan, Ph.D., Associate Director
Karthik Yarasuri, Senior Scientist – Wind Vulnerability

Professional Team
Paul Fishwick, Ph.D., Computer and Information Scientist
Mark Johnson, Ph.D., Statistician, Team Leader
Masoud Zadeh, Ph.D., P.E., Structural Engineer
Donna Sirmons, Staff

During the additional verification review, open items from the initial audit were reviewed and discussed 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.

*****Second Additional Verification Review – June 7, 2021*****

During the June 1, 2021 Commission meeting, the Commission discussed the June 1, 2021 letter from IF notifying the Commission of an error discovered in trade secret Form A-6 and requesting an additional verification review of the corrected form (see the June 1, 2021 letter from IF included at the end of the report). The Commission approved an additional verification review by a subset of the Professional Team.

IF provided access to corrected trade secret Form A-6 on June 3, 2021. The Professional Team completed the additional verification review remotely on June 7, 2021.

The following individuals participated in the second additional verification review.

IF
Katie Carter, Managing Director, Aon Reinsurance Solutions
Xian He, Ph.D., Senior Scientist
Ashwin Joseph, Associate Director
Maria Lomelo, Managing Director, Global Program Director
Chris Long, Director, Software and Analytics
Minchong Mao, FCAS, CCRMP, MAAA, Managing Director, Actuary, Aon Reinsurance Solutions

Nehal Naik, Managing Director, Software Development
Sami Pant, Ph.D., P.E., Senior Scientist
Bin Pei, Ph.D., Associate Director

Professional Team
Paul Fishwick, Ph.D., Computer and Information Scientist
Mark Johnson, Ph.D., Statistician, Team Leader
Stu Mathewson, FCAS, MAAA, Actuary
Donna Sirmons, Staff

During the additional verification review, IF provided further details on the scripting error generating the Policy Form results in Form A-6 and changes to the process to prevent the error from recurring. The new Form A-6 was reviewed and Standard A-6 remains verified by the Professional Team.

Report on Deficiencies

The Professional Team reviewed the following deficiencies cited by the Commission at the January 12, 2021 meeting. The deficiencies were eliminated by the established time frame, and the modifications have been verified.

1. G-2.B, page 30 and Form G-3, page 134: The signatory for Statistical Standards does not have the requisite advanced degree in statistics.

2. M-2, Disclosure 3, pages 42-43: Incomplete. The annual-frequency negative-binomial distribution should be listed here.

3. M-4, Disclosure 10, page 52 and Form M-2, pages 143-149: Incorrect. The form states that the "open terrain" surface roughness only applies open terrain to land points, while water points are to be kept to the same as standard model version. However, the response to M-4 Disclosure 10 indicates that modeler applied open terrain everywhere, including water points.

4. M-6, Disclosure 4, pages 56-57: Incomplete. Missing comparison to 40 mph radius. The text says the 73 mph and 40 mph simulated and modeled radii "are compared below."

5. V-1, Disclosure 3, page 82: Incomplete. No response for number of insurers and amount of hurricane loss separated into personal residential, commercial residential, and manufactured homes provided.

6. A-1, Disclosure 3, page 98: Non-responsive. Methods need to be described.

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 remote 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 remote on-site review are provided in this letter. This letter does not preclude the Professional Team from asking for additional information during the remote 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 remote on-site review. The overall intent is to expedite the remote 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 designated by the Florida Commission on Hurricane Loss Projection Methodology (Commission) during the January 12, 2021 meeting.

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

The remote 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 2019 *Hurricane Standards Report of Activities*, and (4) responses to the audit items for each hurricane standard in the 2019 *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 November 1, 2020 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 chapter of the *Hurricane Standards Report of Activities as of November 1, 2019* as amended by the Commission on December 10, 2020 for more details on materials to be presented and provided to the Professional Team. Particular attention should be paid to the requirements under Presentation of Materials. These requirements are reproduced at the conclusion of this letter.

The pre-visit questions 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 the start of the virtual review in order to facilitate efficiency during the review and to avoid last minute edits. Additional editorial items were also noted during the reviews. The Professional Team reviewed the following corrections to be included in the revised submission to be provided to the Commission no later than 10 days prior to the meeting to review the model for acceptability. Page numbers below correspond to the April 30, 2021 track changes revised submission document.

1. G-1, Disclosure 2, page 15, Exposure Component: "which are to be analyzed" changed to "that are to be analyzed."
2. G-1, Disclosure 3, page 18: Figure 2 revised to meet IF's flowchart standards.
3. G-1, Disclosure 6, page 23: DeMaria-Kaplan article reference year corrected to 1994.
4. G-1, Disclosure 6, page 29: Actuarial reference listed as "AAG" revised to include the author's name.
5. G-2, Disclosure 2, page 33: Ashwin Joseph added to Table 1.
6. G-2, Disclosure 2, page 36: Figure 4 revised to meet IF's flowchart standards.
7. G-3, Disclosures 4 and 5, page 40: Revised to remove references to ASCE 2016 and ASCE 7.
8. M-2, Disclosure 3, page 45: Storm Formation Count and Genesis Parameters revised to clarify use of Vmax data in modeled storm genesis for years in HURDAT2 when pressure data is unavailable.
9. M-2, Disclosure 3, pages 46-47: Wind profile parameters revised to clarify use of only the double exponential formulation from Willoughby et al. (2006).
10. M-2, Disclosure 5, page 47: clarified using conversion factors.
11. M-4, Disclosure 10, pages 56-57: Revised to clarify how Form M-2 was completed.
12. M-5, Disclosure 2, page 58: Revised to clarify modeling of Vmax in Figure 11.
13. S-1, Disclosure 1, page 63: Corrected the chi-square test *p*-value.
14. V-1, Disclosure 2, page 87: Figure 28 revised to meet IF's flowchart standards.
15. V-1, Disclosure 3, page 88: Tables 5 and 6 revised.
16. V-1, Disclosure 11, page 92: Revised to clarify.
17. V-2, Disclosure 2, page 96: Figure 30 revised to meet IF's flowchart standards.
18. V-3, Disclosure 2, page 100: Figure 31 revised to meet IF's flowchart standards.
19. V-4.A, page 102: Revised to clarify how wall-to-floor-to-foundation strength and skylight strength are considered in the model.
20. A-1, Disclosure 4, page 109: Figure 32 revised to meet IF's flowchart standards.
21. A-1, Disclosure 5, pages 109-110: Table 9 updated to fully describe ratemaking settings and to provide consistency with user interface.
22. A-4, Disclosure 1, page 117: Revised to replace AAL with Annual Loss and to add mean to estimated loss in the description of L_i.
23. A-5, Disclosure 1, page 121: Reference listed as "AAG" revised to include the author's name.
24. CI-3.B, page 128: Revised to include use of ISO 5807 flowchart standards.
25. CI-3.B, page 130: Figure 35 revised to meet IF's flowchart standards.
26. CI-6, Disclosure 1, page 139: Figure 36 revised to meet IF's flowchart standards.

27. Form S-6, page 187: Table 26 revised using non-rounded loss costs.
28. Form V-2, page 195: revised to add dashes for roof membrane covering.
29. Form A-8, pages 254-255: Corrected uncertainty intervals in Parts B and C.
30. Appendix B, page 257: Added Ashwin Joseph.
31. Appendix F, pages 280, 281, 283 and 284: Figures 72, 73, 75, and 76 replaced with updated versions based on the updated software user interface.
32. Appendix G, page 285: Glossary of Acronyms updated.
33. The use of the orange-yellow color for text in the submission, sometimes hyperlinked, was changed to a different color due to being difficult to read in the PDF file, but even more so in the hard copy submission document.

GENERAL STANDARDS – Mark Johnson, Leader

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

*(*Significant Revision)*

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

B. A documented process shall be maintained to assure continual agreement and correct correspondence of databases, data files, and computer source code to 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.

D. A subset of the forms shall be produced through an automated procedure or procedures as indicated in the form instructions.

Audit

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

2. 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.

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

4. Items specified in Standard G-1.C will be reviewed as part of the Computer/Information Standards.

5. Maps, databases, and data files relevant to the modeling organization's submission will be reviewed.

6. The following information related to changes in the hurricane model, since the initial submission for each subsequent revision of the submission, will be reviewed.
   A. Hurricane model changes:
      1. A summary description of changes that affect, or are believed to affect, the personal or commercial residential hurricane loss costs or hurricane probable maximum loss levels,
      2. A list of all other changes, and
      3. The rationale for each change.

B. Percentage difference in average annual zero deductible statewide hurricane loss costs based on the 2017 Florida Hurricane Catastrophe Fund personal and commercial residential zero deductible exposure data found in the file named *"hlpm2017c.zip"* for:
   1. All changes combined, and
   2. Each individual hurricane model component and subcomponent change.

C. For any modifications to Form A-4, Hurricane Output Ranges, since the initial submission, a newly completed Form A-5, Percentage Change in Hurricane Output Ranges:
   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 2017 Florida Hurricane Catastrophe Fund personal and commercial residential zero deductible exposure data found in the file named *"hlpm2017c.zip"* for each hurricane model component change:
   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.

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.B, page 12: Provide documentation of the process.

3. G-1, Disclosure 2, Hazard Component, pages 13-14: Provide a detailed description of track and hazard model, including the following elements:
   a. When modeling total basin annual count, what tropical cyclone intensity thresholds are used?
   b. Provide details on the random sampling for genesis location, date, track heading, intensity. Are parameters sampled independently (first location, then date, etc.) or are they sampled together (location and date from same historical event)? How are correlations among these variables preserved, e.g., storms late in season form preferentially in Caribbean compared to midseason in the Main Development Region? (Also relevant to Standard M-2 Disclosure 3 and Standard S-1 Disclosure 1.)
   c. Random sampling does not allow for possibility of genesis parameters different than historical. How limiting is this?
   d. What is the source of the sea-surface temperature data? How is it used in the model; e.g., a seasonally-varying climatology or historical time series with interannual variability and secular trends?
   e. What years from HURDAT2 have viable central pressure data? Is intensity (Vmax) data prior to routine pressure-data availability used in any way?
   f. Provide details on the "modified ESDU approach," for surface roughness, including the treatment of upstream terrain.
   g. Describe the procedures used for calibrating the model's Florida regional landfall rates. That is, what model features are adjusted to ensure that the landfall rates from the track model match the historical rates within some tolerance?

4. G-1, Disclosure 2, Financial Component, pages 15-16: Describe how the beta distribution is used as it relates to moment-based distribution fits for varying windspeeds (e.g., 35 mph, 120 mph, and 200 mph). Explain how the appropriate number of damage samples required to ensure loss stability is determined for different analysis types.

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending review of open items.

Discussed the development and features of the ELEMENTS application platform.

Discussed the process used in preparing client exposure data, importing the data into ELEMENTS, and handling problematic entries.

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

Discussed the intensity threshold when accounting for the total basin annual count.

Discussed the random sampling for stochastic storm genesis parameters.

Discussed the source of the sea-surface temperature data and its use in the model.

Discussed the use of Vmax data in modeled storm genesis for years in HURDAT2 when pressure data is unavailable.

Reviewed the methodology for developing surface roughness coefficients.

Reviewed the methodology for calibrating Florida landfall rates.

Discussed the loss convergence tests performed for different portfolio analyses.

Reviewed the script used to create Form A-8.

Discussed with the General Standards signatory his review of the model submission documentation.

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

Verified after review of open items.

Reviewed the revised business workflow diagram.

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 in civil engineering with a current license), 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.

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending updated expert certifications.

Reviewed resumes of personnel:

- Shyam Adhikari, Ph.D. in Agriculture and Applied Economics, Texas Tech University, Lubbock, TX; Graduate Certificate on Advanced Data Science, Northwestern University, Chicago, IL; Post-Graduate Diploma in Project Appraisal and Management, Maastricht School of Management, Maastricht, Netherlands; M.S. in Agricultural Economics, Acharya N.G. Ranga Agricultural University, Hyderabad, India
- Sushma Bhat, B.S. in Computer Technology, University of Bombay, Mumbai, India; B.S. in Physics, University of Bombay, Mumbai, India; Honors Diploma in Systems Management, National Institute of Information Technology, Bombay, India
- Katie Carter, M.S. in Civil Engineering, University of Central Florida, Orlando, FL; B.S. in Civil Engineering, Michigan Tech University, Houghton, MI
- Siamak Daneshvaran, Ph.D. in Wind and Structural Engineering, University of Western Ontario, London, Ontario, Canada; M.S. in Structural Earthquake Engineering, Sharif University of Technology, Tehran, Iran; B.S. in Civil Engineering, Sharif University of Technology, Tehran, Iran
- Gaurav Dangarwala, M.S. in Chemical Engineering, Ohio University, Athens, OH; B.S. in Chemical Engineering, Nadiad, Gujarat, India
- William Dong, Ph.D. in Civil Engineering, University of Nebraska, Lincoln, NE; M.S. in Construction Engineering and Management, Illinois Institute of Technology, Chicago, IL
- Stephen Fiete, M.S. in Mathematics, University of Illinois, Urbana-Champaign, IL; B.A. in Mathematics, West Virginia University, Morgantown, WV
- Xian He, Ph.D. in Civil Engineering, University of Illinois, Urbana-Champaign, IL; M.S. in Civil Engineering, University of Illinois, Urbana-Champaign, IL; B.S. in Civil Engineering, Tongji University, Shanghai, China
- Steven Jakubowski, B.S. in Physics, California State University, Long Beach, CA
- Yujin Liang, Ph.D. in Structural Engineering, University of Illinois, Chicago, IL; M.S. in Water Conservancy and Hydropower Engineering Architecture, Tsinghua University, Beijing, China; B.S. in Water Conservancy and Hydropower Engineering Architecture, Hohai University, Nanjing, China
- Chris Long, M.A. in Economics, Tufts University, Medford, MA; B.A. in Economics, University of Chicago, Chicago, IL
- Minchong Mao, M.S. in Computer Science, University of Missouri, Columbia, MO; M.S. in Chemistry, Eastern Illinois University, Charleston, IL; B.S. in Biochemical Engineering, Beijing University of Chemical Technology, Beijing, China
- Nehal Naik, M.S. in Computer Science, South Gujarat University, Surat, India; B.S. in Electronics, Gujarat University, Ahmedabad, India
- Sami Pant, Ph.D. in Civil Engineering, University of Illinois, Urbana-Champaign, IL; M.S. in Civil Engineering, Clemson University, Clemson, SC; B.S. in Civil Engineering, Tribhuvan University, Pulchowk, Kathmandu, Nepal
- Purvish Patel, B.S. in Mathematics & Computer Science, Business Administration, Wayne State College, Wayne, NE; Certificate in System Engineering, University of Kansas, Lawrence, KS

- Bin Pei, Ph.D. in Civil Engineering, Clemson University, Clemson, SC; M.S. in Civil Engineering, Clemson University, Clemson, SC; B.S. in Water Conservancy and Hydropower Engineering, Wuhan University, Wuhan, China
- Venkatesh Ramaiah, M.S. in Computer Science, Birla Institute of Technology and Science, Pilani, India; B.E. in Computer Science & Engineering, Visvesvaraya Technological University, Belgaum, India
- Will Skinner, M.B.A. and M.S. in Information Systems, Boston University, Boston, MA; B.S. in Applied Mathematics and Mathematical Statistics, University of Sydney, Sydney, Australia
- Hailey Smith, B.S. in Meteorology, Pennsylvania State University, State College, PA
- Radek Solnicky, M.S. in Probability, Mathematical Statistics and Econometry, Charles University, Prague, Czechia; B.S. in Mathematics, Charles University, Prague, Czechia
- Shruthi Srikantegowda, Post-Graduate Diploma in Information Technology, Symbiosis University, Pune, India; B.E. in Electronics and Communication Engineering, Visvesvaraya Technological University, Belgaum Karnataka, India
- Chirag Subramanian, M.S. candidate in Analytics – Specialization in Computational Data Analytics, Georgia Institute of Technology, Atlanta, GA; M.S. in Operations Research, Northeastern University, Boston, MA; B.E. in Mechanical Engineering, Manipal Institute of Technology, Manipal, India
- Vipin Unnikrishnan, Ph.D. in Civil Engineering, Louisiana State University, Baton Rouge, LA; M.S. in Civil Engineering, Indian Institute of Technology, Madras, India; B.T. in Civil Engineering, University of Kerala, Kerala, India
- Karthik Yarasuri, Ph.D. candidate in Civil Engineering, University of Florida, Gainesville, FL; M.S. in Civil Engineering, University of Florida, Gainesville, FL; B.T. in Civil Engineering, Jawaharlal Nehru Technological University, Hyderabad, India

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

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

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

Reviewed resume:

- Ashwin Joseph, B.E. in Electrical and Electronics Engineering, Visvesvaraya Technology University, Belagavi, Karnataka, India

G-3 Insured Exposure Location*

*(*Significant Revision)*

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

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

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

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

E. Geocoding methodology shall be justified.

Audit

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

Pre-Visit Letter

5. G-3, Disclosure 1, page 35: Justify the use of population-weighting of windspeeds, terrain factors, and gust factors.
6. G-3, Disclosure 4, page 36: Present geographic representations of the ZIP Code centroids to facilitate an examination of all of the ZIP Codes in the state. (Audit item 1)
7. G-3, Disclosure 4, page 36: Provide the number of ZIP Codes used in the various forms.

8. G-3, Disclosure 4, page 37: Explain in detail how ZIP Code Events database is developed and used in the model. Explain what is meant by event footprint and how it is developed. For exposures geocoded to or entered by a latitude and longitude, explain how windspeed is calculated for each event and whether ZIP Code Events database is used for such cases.

9. G-3, Disclosure 4, page 37: Explain in detail how ZIP Code Terrain Factor database is developed and used in the model.

10. G-3, Disclosure 4, page 37: Explain in detail how ZIP Code Gust Factor database is developed and used in the model.

11. G-3, Disclosure 4, page 37: Explain in detail how Vulnerability Tiers database is developed and used in the model.

Verified: YES

Professional Team Comments:

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

Reviewed the methodology for population-weighted windspeeds to represent ZIP Code windspeeds for both stochastic and historical storms.

Reviewed the number of ZIP Codes used in completion of the submission forms.

Reviewed development and implementation of the ZIP Code Events database, the ZIP Code Terrain Factor database, the ZIP Code Gust Factor database, and the Vulnerability Tiers database.

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

Discussed the treatment of ZIP Code centroids in uninhabitable terrain or over water.

Reviewed examples of geocoding for complete and incomplete street addresses.

Discussed the process and reviewed examples of assigning ZIP Codes to latitude-longitude points.

G-4 Independence of Hurricane Model Components

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

Audit

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

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

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending verification of other standards.

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

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

Verified after resolution of outstanding issues from other standards.

G-5 Editorial Compliance

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

Audit

1. An assessment that the person who has reviewed the submission has experience in reviewing technical documentation and that such person is familiar with the submission requirements as set forth in the *Hurricane Standards Report of Activities as of November 1, 2019* 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 updated expert certification.

Discussed with the Editorial Review signatory the documentation process for compiling and reviewing the submission document, including review by each section author and signatory.

Reviewed a snapshot of the initial submission modification history.

Reviewed the flowchart defining the process for creating submission forms and integration into the submission document.

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

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

Verified after review of expert certification in updated Form G-7.

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 July 1, 2019 (or later), incorporating the period 1900-2018. 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.

Verified: YES

Professional Team Comments:

Discussed the external data sources used in development of the hazard model.

Reviewed the methodology for stochastic event modeling.

Reviewed the negative binomial distribution for annual hurricane frequency. Reviewed histograms of observed annual frequency to modeled using a negative binomial distribution and a Poisson distribution.

Discussed that the Base Hurricane Storm Set is based on HURDAT2 years 1900-2018 as of November 25, 2019.

Discussed the methodology for computing by-passing hurricane frequencies.

Reviewed the flowchart for incorporating HURDAT2 data in model development and simulation process.

Discussed that there have been no systematic variations in the annual hurricane frequencies.

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

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

Reviewed comparisons of historical to modeled distributions of forward speed, heading angle, and central pressure at 2x2-degree cells and the goodness-of-fit in each cell.

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

12. M-2, Disclosure 3, Storm Genesis Parameters, page 42: Explain how the random sampling approach preserves correlations among parameters; e.g., genesis location and date.

13. M-2, Disclosure 3, Translational/Forward Speed, page 43: Explain the variance that is accounted for by the predictors, including examples. Explain what happens when a track enters a new 5x5-degree cell. Demonstrate the residual fit to the normal distribution.

14. M-2, Disclosure 3, Central Pressure, page 43: Explain the variance that is accounted for by the predictors, including examples. Explain what happens when a track enters a new 5x5-degree cell. Demonstrate the residual fit to the normal distribution.

15. M-2, Disclosure 3, Central Pressure, page 43: Explain how the 0-to-1 range of relative intensity is enforced in simulations, given the linear regression and random residual sampling.

16. M-2, Disclosure 3, Central Pressure, page 43: Provide examples of stochastic simulated central pressure time series along tracks from genesis and affecting Florida.

17. M-2, Disclosure 3, Rmax, page 43: Identify the year range on Extended Best Track (EBT) data. Provide the EBT Rmax frequency distribution.

18. M-2, Disclosure 3, Wind Profile Parameters, page 43: Explain the inconsistency on whether one or two exponentials are used. Standard G-1 Disclosure 2 (page 14) says two decay rates are used outside the eye; however, Standard M-2 Disclosure 3, Wind Profile Parameters says "if a double exponential profile is used."

19. M-2, Disclosure 3, Wind Profile Parameters, page 43: Explain how n, X1, X2, and A are determined. How is it decided to use one or two exponential decay factors in the far field?

20. M-2, Disclosure 3, Inflow Angle, page 44: Provide details about the modeling of hurricane wind inflow angle.

21. M-2, Disclosure 7, page 44: Explain how landfall-frequency agreement or disagreement is judged. What calibration adjustments are made to the full track model in the case of landfall model-historical discrepancies?

22. M-2, Disclosure 7, page 44: Elaborate on the "maximum number of time steps allowed based on historical data." How are stochastic tracks terminated?

23. M-2, Disclosure 9, page 45: Provide plots of landfall rates for Categories 1-2 and Categories 3-5 as function of distance along the coast for simulated and historical.

Verified: YES

Professional Team Comments:

Discussed the use of Vmax data in modeled storm genesis for years in HURDAT2 when pressure data is unavailable.

Reviewed the model domain and 5x5-degree cell assignments for storm track propagation and intensity.

Reviewed the process used for calibrating the stochastic model.

Reviewed calculations and distributions for forward speed, heading angle, central pressure, and Vmax. Reviewed comparisons of modeled and historical distribution fits.

Discussed decay of winds over land. Reviewed scatter plot of modeled to observed Vmax.

Reviewed the regression equation for Rmax. Reviewed graphical comparison of modeled to observed Rmax, including the model mean as a function of intensity.

Reviewed comparison of historical to modeled annual landfall occurrence rates by coastal segment for Category 1-2 hurricanes and for Category 3-5 hurricanes.

Discussed that forward speed, heading, and central pressure are modeled by linear multiple regressions using historical data. Reviewed the R^2 of the regressions, as well as the distribution of residuals, on multiple 5x5 segments in the domain.

Reviewed the autocorrelation of the error for forward speed.

Discussed the methodology for simulating relative intensity.

Reviewed simulated central pressure time series for Florida landfalling and by-passing storms.

Reviewed the Extended Best Track Rmax frequency distribution.

Reviewed the hurricane wind inflow angle. Discussed that inflow angle is modeled as a constant based on Zhang and Uhlhorn (2012) and Powell et al. (2009).

Discussed the process for comparing simulated and observed hurricane landfall frequency distributions and the process for calibrating storm parameters.

Reviewed the maximum number of time steps allowed in the model and how stochastic tracks are terminated.

Reviewed the calculation for ZIP Code averaged population-weighted windspeeds for the 1 km by 1 km grid points.

Reviewed comparison of historical to modeled inland decay rate for Hurricane Jeanne (2004).

Discussed the external data sources used to generate the model windfields.

M-3 Hurricane Probability Distributions

A. Modeled probability distributions of hurricane parameters and characteristics shall be consistent with historical hurricanes in the Atlantic basin.

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

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

Saffir-Simpson Hurricane Wind Scale:

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

Audit

1. Demonstration of the quality of fit extending beyond the Florida border will be reviewed by showing results for appropriate coastal segments in Alabama, Georgia, and Mississippi.

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

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

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

5. Form S-3, Distributions of Stochastic Hurricane Parameters, will be reviewed.

Verified: YES

Professional Team Comments:

Discussed that the maximum gust windspeeds generated at 10m height are used for calculating losses.

Reviewed validation and goodness-of-fits for track direction, heading angle, Vmax, and Rmax distributions.

Reviewed forward speed, heading angle, central pressure, and Vmax goodness-of-fit tests for Alabama/Mississippi and Georgia landfalls.

Discussed that only hurricanes that produce minimum damaging winds or greater on land in Florida are included in the stochastic storm set.

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

Reviewed code for simulating time series of relative intensity.

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 shall account for the effects of the vertical variation of winds.

Audit

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

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

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

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

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

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

7. Form M-2, Maps of Maximum Winds, will be reviewed.

Pre-Visit Letter

24. M-4, Disclosure 7, page 49: Explain the assumptions made in standardizing wind observations in height and averaging time.

25. M-4, Disclosure 8, Figures 6-10, pages 50-52: Identify the points in the Figure 10 scatter plot with the observed-simulated values in Figures 6-9. For example, the Hurricane Michael (2018) value at the coast just right of track looks to have simulated windspeed at least 165 mph and an observed value of about 125 mph. Similar discrepancies are apparent for Hurricane Wilma (2005), inland on the track's right side.

Verified: YES

Professional Team Comments:

Reviewed the Willoughby et al. (2006) parametric windfield and the equations for its parameters. Discussed that hurricane windspeeds are modeled using only the Willoughby double exponential formulation.

Discussed windspeed vertical profiles to convert between gradient-wind level and 10m height.

Reviewed the wind profile adjustments for inflow angle and translation-induced asymmetry.

Discussed the use of the National Land Cover Database (NLCD, 2011) as the source of land use land cover data.

Reviewed the process for converting surface roughness lengths to roughness coefficients.

Reviewed contour maps of peak gust windspeeds for Hurricane Charley (2004), Hurricane Wilma (2005), Hurricane Irma (2017), and Hurricane Michael (2018). Reviewed scatter plots of modeled versus historical windspeeds for each storm.

Reviewed comparisons of modeled to observed time series of peak gust windspeeds for Hurricane Charley (2004), Hurricane Dennis (2005), Hurricane Irma (2017), and Hurricane Michael (2018).

Reviewed map depicting the spatial distribution of model surface roughness and coefficients.

Reviewed maps of the spatial distribution of winds for the LaborDay03 (1935) and NoName09 (1945) storms.

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 Andrew (1992), Hurricane Jeanne (2004), and Hurricane Irma (2017) at the closest time after landfall will be reviewed.

Pre-Visit Letter

26. M-5, Disclosure 2, pages 53-54: Explain how the comparison shown in Figure 11 evaluates the model's overland attenuation. Standard M-4 Disclosure 9 states that the historical simulations, such as those indicated in Figure 11, use the observed Vmax directly. As such, Figure 11 does not appear to be a comparison of simulated to observed values.

Verified: YES

Professional Team Comments:

Reviewed the inland decay model. Discussed that the inland decay rate is modeled differently for different geographic regions based on the empirical relation in Vickery (2005).

Reviewed regression fits for each region using historical data.

Discussed that Figure 11 Vmax values are simulated from the inland decay model rather than historical measurements.

Reviewed plots comparing modeled to historical over-land decay rates.

Reviewed comparisons of the modeled windfield with historical observed windspeeds for Hurricane Andrew (1992), Hurricane Jeanne (2004), and Hurricane Irma (2017). Reviewed contour maps of the windfield footprints at and following landfall.

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-2, Maps of Maximum Winds, will be reviewed with a focus on the comparison between actual terrain and open terrain.

2. Form M-3, Radius of Maximum Winds and Radii of Standard Wind Thresholds, and the modeling organization sensitivity analyses will be reviewed.

3. 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.

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

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

6. Time-based contour animations (capable of being paused) of windfield distributions demonstrating scientifically-reasonable windfield characteristics and logical relationships will be reviewed.

Pre-Visit Letter

27. M-6, Disclosure 2, page 56: Provide detail on the modeling of surface roughness and its impact on modeled windspeed.

28. Form M-3, page 150: Explain why there are 1Q and 3Q values for 960 mb Rmax, but no 1Q value at 960 mb for the 110 mph outer radius.

29. Form M-3, pages 150-151: Explain discrepancies between Figure 45 and Table 13. For example, the 910 mb 1Q and 3Q values in Table 13 are 11 mi and 21 mi. In Figure 45, however, the 905-915 mb bin has box limits of roughly 10 mi and 20 mi. Similar differences exist for other pressure bins. What are the box plot limits in Figure 45?

30. Form M-3, Figure 46, page 152: Explain the preponderance of Category 2 hurricanes (Cp from approximately 965 to 979) and Category 3 hurricanes (Cp from approximately 945 to 964) compared to the modeled frequencies given in Form M-1.

Verified: YES

Professional Team Comments:

Reviewed the methodology for calculating surface roughness and the impact on modeled windspeeds.

Reviewed revised Form M-3.

Reviewed the equation for Rmax.

Reviewed histogram of HURDAT2 central pressure by hurricane categories. Reviewed comparison of occurrence rates in Figure 46 to Form M-1.

Reviewed the modeled relationship between central pressure and Rmax.

Discussed the windfield asymmetry factor.

Reviewed animations and snapshots of hurricane winds demonstrating the role of storm translation in windfield asymmetry and the impact of surface roughness on windspeed.

STATISTICAL STANDARDS – Mark Johnson, Leader

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

*(*Significant Revision)*

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

B. Modeled and historical results shall reflect statistical agreement using current scientific and statistical methods for the academic disciplines appropriate for the various hurricane model components or characteristics.

Audit

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

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

Pre-Visit Letter

31. S-1, Disclosure 1, pages 58-60: Provide the underlying data associated with the distribution choices including the functional forms used, the estimated parameters, and supporting calculations for the goodness-of-fit tests yielding the reported *p*-values. Provide relevant Excel data files associated with the following:
    - Annual Number of Storms
    - Translational/Forward Speed
    - Heading Angle/Direction
    - Central Pressure
    - Maximum Sustained Wind Speed
    - Radius of Maximum Winds
    - Inland Decay Rate

    The Excel worksheets should have sufficient detail so that the Professional Team could reproduce the results presented in the submission.

32. S-1, Disclosure 1, pages 58-60: Explain the absence of far field pressure (FFP) as a stochastic hurricane parameter in the model, while it was demonstrated in the Sensitivity and Uncertainty Analyses that FFP was highly influential.

33. S-1, Disclosure 1, page 59: Provide a map with both the 2x2-degree and 5x5-degree grid cells. Justify the use of the Kolmogorov-Smirnov test given that some observations in 2x2-degree cells also reside in 5x5-degree cells.

34. S-1, Disclosure 6, page 63: Explain why the Forward Speed appears stochastically larger than the underlying empirical data. Justify this discrepancy.

35. S-1, Disclosure 6, page 65: Justify the use of the Kolmogorov-Smirnov test, noting that parameter estimation is taking place. Present the form of the lognormal distribution plotted in Figure 19.

36. S-1, Disclosure 6, Figure 20, page 65: Explain the apparent lack of modeled damage ratio dispersion compared to the historical data.

Verified: YES

Professional Team Comments:

Reviewed the annual storm count probability distribution.

Reviewed probability distributions associated with Rmax, Vmax, inland decay, heading angle, forward speed, and central pressure.

Reviewed supporting evidence for the adequacy of the match between historical and modeled results. In particular, reviewed the use of goodness-of-fit tests to provide metrics in the calibration process.

Reviewed the handling of far-field pressure in the model.

Reviewed Forms S-1, S-2, S-3, and S-4.

Discussed with the Statistical Standards signatory his review of the model submission documentation.

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

37. Form S-6, page 164: Present the explicit distributions used for X1 and alpha by category and their rationale.

38. Form S-6, page 175: Justify the values 5.7%, 37.8% and 15.2% in Table 26.

Verified: YES

Professional Team Comments:

Reviewed the Sensitivity Analysis distribution choices, numerical and graphical results and conclusions as given in Form S-6.

Reviewed animations of sensitivity analysis results.

S-3 Uncertainty Analysis for Hurricane Model Output

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

Audit

1. The modeling organization uncertainty analysis will be reviewed in detail. Statistical techniques used to perform uncertainty analysis will be reviewed. The results of the uncertainty analysis displayed in graphical format (e.g., color-coded contour plots with temporal animation) will be reviewed.

2. Form S-6, Hypothetical Events for Sensitivity and Uncertainty Analysis, will be reviewed, if applicable.

Verified: YES

Professional Team Comments:

Reviewed the Uncertainty Analysis distribution choices, numerical and graphical results and conclusions as given in Form S-6.

Reviewed animations of uncertainty analysis results.

S-4 County Level Aggregation

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

Audit

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

Verified: YES

Professional Team Comments:

Reviewed the convergence results at the county level attributable to the sampling process with the 200,000 years of simulation. Reviewed the process to reduce the event set size while maintaining estimation performance.

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 hurricane storm surge losses) in the actual hurricane losses or the modeled hurricane losses.

2. The following documentation will be reviewed:
    a. Publicly available documentation referenced in the submission in hard copy or electronic form,

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

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

4. Form S-4, Validation Comparisons, will be reviewed.

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

Verified: YES

Professional Team Comments:

Reviewed comparison of modeled loss to claims for multiple events and companies.

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 7.

2. Justification for the following will be reviewed:
    a. Meteorological parameters,
    b. The effect of by-passing hurricanes,
    c. The effect of actual hurricanes that had two landfalls impacting Florida,
    d. The departures, if any, from the windfield, vulnerability functions, or insurance functions applied to the actual hurricanes for the purposes of this test and those used in the hurricane model under consideration, and
    e. Exposure assumptions.

Verified: YES

Professional Team Comments:

Reviewed the results in Form S-5.

Discussed that hurricane parameters are treated the same in the historical and stochastic storm sets.

VULNERABILITY STANDARDS – Masoud Zadeh, Leader

V-1 Derivation of Building Hurricane Vulnerability Functions*

*(*Significant Revision)*

A. Development of the building hurricane vulnerability functions shall be based on at least one of the following: (1) insurance claims data, (2) laboratory or field testing, (3) rational structural analysis, and (4) post-event site investigations. Any development of the building hurricane vulnerability functions based on rational structural analysis, post-event site investigations, and laboratory or field testing shall be supported by historical data.

B. The derivation of the building hurricane vulnerability functions and 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 (including hurricane storm surge and 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 are used to develop building hurricane vulnerability functions, the goodness-of-fit of the data will be reviewed. Complete reports detailing loading conditions and damage states for any laboratory or field testing data used will be reviewed. When rational structural analysis is used to develop building hurricane vulnerability functions, such analyses will be reviewed for a variety of different building construction classes. Laboratory or field tests and original post-event site investigation reports will be reviewed.

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 the effects on the building hurricane vulnerability functions due to local and regional construction practices, and statewide and county building codes and their enforcement will be reviewed. If year of construction or geographical location of building is used as a surrogate for building code and code enforcement, complete supporting information for the number of year of construction groups used as well as the year-bands or geographical region(s) of construction that separate particular groups 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. 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, the impact of public adjusting, or the impact of the legal environment.

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

11. The treatment of law and ordinance in building hurricane vulnerability functions 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, and the process for completing the form with respect to building damage will be reviewed.

Pre-Visit Letter

39. V-1.B, page 79: Explain the calibration and validation processes. Provide a flowchart and provide two or more samples of development, calibration, and validation of building vulnerability functions using claims data. What are the "appropriate probabilistic distributions?"

40. V-1, Disclosure 2, page 81: Describe the "suite of programs" (Standard G-1 Disclosure 2, page 15) and their integration which are the basis of the vulnerability component. Present the methodologies, data, and assumptions made and the implementation in various computer programs, their testing and the resulting damage functions.

41. V-1, Disclosure 2, page 81: Explain how the damage functions were developed from "the wind damage simulator" outputs (Standard G-1 Disclosure 2, page 15) and the fitted distributions.

42. V-1, Disclosure 2, page 81: Explain the validation process for the vulnerability component and the use of both on-site damage surveys and hurricane claims data. Provide examples of each.

43. V-1, Disclosure 6, page 83: Provide examples of post-event reconnaissance reports, and explain how they have been used.

44. V-1, Disclosure 7, pages 83-84: Explain the Tier (vulnerability region). Explain the year- band basis and how they interact with vulnerability regions.

45. V-1, Disclosure 10, page 86: Explain in detail the response to Disclosure 10. Provide examples. Describe weights derived from claims data and provide examples of weights.

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending review of open items.

Reviewed the building stock classifications by occupancy type, number of stories, year-built bands, construction type, vulnerability region, and the data sources. Discussed that classifications have been compared with exposure data from historical claims data.

Discussed that the vulnerability functions were developed using a building component-based wind damage simulator.

Reviewed the probability distribution functions for capacity for a sample of building components.

Reviewed the revised flowchart for the building component-based damage simulator.

Reviewed the pressure zones for hip and gable roofs.

Reviewed the weights for personal residential roof shape.

Reviewed samples of building vulnerability functions.

Discussed the calibration of the model vulnerability functions.

Reviewed plot of actual to modeled structure pre-1995 mean damage ratios by windspeed.

Discussed the uncertainties in insurance claims data. Reviewed comparison of the standard error of damage ratio to the mean damage ratio.

Reviewed an example building vulnerability function mean and standard deviation.

Reviewed examples of post-event site investigations. Discussed that post-event site investigations and insurance claims data are used to develop the vulnerability functions.

Reviewed documentation summarizing the major changes in building codes, construction practices, and their effects on the vulnerability functions.

Reviewed year-built bands based on code enforcement and construction practices for non-manufactured homes and for manufactured homes.

Discussed the development and the basis for the vulnerability tiers. Reviewed associated ZIP Code resolution map of Florida tier assignments.

Reviewed examples of vulnerability functions for unknown building and secondary characteristics.

Discussed that the minimum windspeed at which damage starts in the model is 35.2 mph for open terrain.

Reviewed the beta distributions for total structure loss.

Reviewed example building vulnerability function and the associated appurtenant structure vulnerability function.

Reviewed scatter plot of appurtenant structure and building mean damage ratios from claims data.

Reviewed Form V-1 and the process to complete the form.

Reviewed the Impact Forecasting Wind Vulnerability Engine documentation.

Reviewed sample analysis log files for when Impact Forecasting and user-modified damage functions are used.

Reviewed development of the windborne debris model and the interaction of parameters.

Reviewed implementation of the windborne debris model.

Reviewed example of missile damage using a Gaussian distribution.

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

Verified after review of open items.

Reviewed the component-based methodology in development of the building vulnerability functions.

Reviewed the wind vulnerability simulator documentation.

Reviewed the vulnerability module documentation.

Reviewed example of recalibrated vulnerability functions using new 2020 claims data.

Reviewed updated implementation of the windborne debris model.

V-2 Derivation of Contents Hurricane Vulnerability Functions*

*(*Significant Revision)*

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

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

Audit

1. Modifications to the contents vulnerability component 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 vulnerability component. Comparisons with the previously-accepted hurricane model will be reviewed.

2. Multiple samples of contents 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 method of derivation and underlying data or assumptions related to contents hurricane vulnerability functions will be reviewed.

7. Form V-1, One Hypothetical Event, and the process for completing the form with respect to contents damage will be reviewed.

Pre-Visit Letter

46. V-2.B, Page 88: Elaborate on the response to Part B, specifically calibration and validation using insurance claims data.

47. V-2, Disclosure 5, page 90: Elaborate on the response to Disclosure 5 and the relationship between 1,905 contents vulnerability functions versus 9,945 building vulnerability functions (page 83).

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending review of open items.

Reviewed the development and validation of the contents vulnerability functions. Discussed that contents vulnerability is a function of building damage.

Discussed that contents vulnerability functions are not differentiated by construction year built.

Reviewed scatter plot of modeled versus claims mean content damage ratios.

Reviewed samples of contents vulnerability functions.

Reviewed the contents to building relationship in Form V-1.

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

Verified after review of open items.

Reviewed the calibration and validation of contents vulnerability functions using claims data.

Reviewed comparisons of modeled versus damage ratios for contents by client, by event, and by building characteristics.

V-3 Derivation of Time Element Hurricane Vulnerability Functions*

*(*Significant Revision)*

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

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

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

D. Time element hurricane vulnerability functions used by the hurricane model shall include time element hurricane losses associated with wind, missile impact, flood (including hurricane storm surge), and damage to the infrastructure caused by a hurricane.

Audit

1. Modifications to the 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 time element vulnerability component. Comparisons with the previously-accepted hurricane model will be reviewed.

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

3. Documentation and justification of the method of derivation and underlying data or assumptions related to time element hurricane vulnerability functions 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 time element will be reviewed.

5. 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.

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

Pre-Visit Letter

48. V-3.C, page 91: Elaborate on the response to Part C.

53. Form V-1.A, page 179: Explain the relatively small time element loss ratios in light of large building and contents damage ratios.

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending review of open items.

Discussed that time-element vulnerability functions are a function of the building damage ratio.

Discussed that time-element vulnerability functions were calibrated and validated using claims data from multiple historical events.

Reviewed scatter plot of modeled versus claims mean time-element damage ratios.

Reviewed the relationship of time-element to building damage ratios in Form V-1.

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

Verified after review of open items.

V-4 Hurricane Mitigation Measures and Secondary Characteristics*

*(*Significant Revision)*

A. Modeling of hurricane mitigation measures to improve a building's hurricane wind resistance, the corresponding effects on hurricane vulnerability, and 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.***

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

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

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

Audit

1. Modifications to hurricane mitigation measures and secondary characteristics in the hurricane model since the 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.

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

3. 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.

4. 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.

5. The treatment of roof age 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.

7. 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

49. V-4.A, page 94: Justify how the model meets Standard V-4 Part A "wall-to-floor-to-foundation strength" and "windows, door, and skylight strength" shall be considered by the model, given the statement "The wall-to-floor-to-foundation strength and skylight strength have not been considered in the current model." See Report of Activities pages 291-293.

50. V-4, Disclosure 4, page 95: Provide details of modeling roof age in Table 8.

51. V-4, Disclosure 4, pages 95-96: Provide details of modeling roof coverings in Table 8 and how the options for Roof Covering relate to ASTM D3161 Class D or ASTM D7158 Class D shingles and ASTM D7158 Class H shingles in Form V-2.

52. V-4, Disclosure 5, page 96: Explain how hurricane mitigation measures and secondary characteristics are implemented in the hurricane model and identify any assumptions.

54. Form V-2, Page 183: Explain and justify the following:
    a. The similar impacts of all mitigation measures and secondary characteristics for the four windspeeds of 60, 85, 110, and 135 mph for wood frame and masonry buildings and only different impacts for 160 mph.
    b. The reduction for all mitigation measures and secondary characteristics at 160 mph is always greater for masonry relative to wood frame construction.
    c. The signification reduction (25.83%) due to straps for Roof-Wall Strength at 60 mph, which is approximately the same as the reduction at 135 mph.

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending review of open items.

Reviewed the hurricane mitigation measures and secondary characteristics. Reviewed example vulnerability plot for secondary characteristics.

Discussed the development, calibration, and implementation of secondary modifiers.

Reviewed the multiplicative methodology for secondary modifiers. Reviewed the impact of applying single or multiple secondary modifiers.

Reviewed range of loss costs by construction type relative to residential single-family occupancy, unknown construction, and unknown year-built.

Reviewed range of loss costs by opening protection and by roof covering relative to unknown secondary modifiers.

Discussed which secondary characteristics are considered explicitly in the damage simulator and which ones are implicitly considered through claims data calibration.

Reviewed the mean damage ratio for a masonry single-family building based on roof age.

Reviewed probability distributions for roof covering, roof sheathing, and roof-to-wall connection.

Reviewed secondary modifiers used for roof shingle options.

Reviewed the spreadsheet data for the Florida model mitigation and secondary characteristics.

Reviewed Forms V-2 and V-3.

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

Verified after review of open items.

Discussed the revised Form V-2.

ACTUARIAL STANDARDS – Stu Mathewson, Leader

A-1 Hurricane Model Input Data and Output Reports

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

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

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.

Verified: YES

Professional Team Comments:

Discussed data format requirements and the process for importing data into the ELEMENTS framework.

Reviewed sample model output reports disclosing assumptions, post-import summaries, and model settings.

A-2 Hurricane Events Resulting in Modeled Hurricane Losses

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

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

Audit

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

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

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

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

Verified: YES

Professional Team Comments:

Reviewed the process for combining exposure, hazard, and footprint data used to generate losses.

Discussed the methodology for determining ground-up losses. Reviewed examples of ground-up and gross loss calculations.

Discussed that loss convergence tests were performed to address the effects of varying portfolio sizes. Reviewed table of the minimum number of samples necessary for convergence of portfolios of different sizes.

Reviewed the criteria for identifying by-passing hurricanes and selected tracks.

Discussed that the model computes wind and storm surge losses separately. Discussed that the Florida Hurricane model only provides users the option to model wind losses.

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, including the statutory required 25% and 50% coverage options for personal residential policies.
3. The treatment of loss assessment coverage for condo unit owners will be reviewed, including the statutory required $2,000 coverage option.

Pre-Visit Letter

55. A-3, Disclosures 1-4, pages 105-106: Show a calculation of loss costs and probable maximum loss levels for the minimum Frame Owners loss costs in Form A-1, ZIP Code 32202, Duval County.
56. A-3, Disclosure 5, page 106: Explain how the claims data reflects the inclusion of law and ordinance coverage. Explain how the model handles the statutory 25% and 50% coverages. Explain how the model accounts for loss assessment coverage of $2,000 for condos. (Audit items 2 and 3)

Verified: YES

Professional Team Comments:

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

Reviewed a calculation of frame-owners loss costs in Form A-1 and probable maximum loss levels for ZIP Code 32202 in Duval County.

Discussed that law and ordinance coverage and loss assessment coverage for condo-unit owners are not explicitly considered in the model.

Discussed with the Actuarial Standards signatory her review of the model submission under the Actuarial Standards. Discussed how she attested the model results to be actuarially sound.

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 flood losses (including those from hurricane storm surge).

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

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

Audit

1. How the hurricane model handles expenses, risk load, investment income, premium reserves, taxes, assessments, profit margin, economic inflation, and any criteria other than direct property insurance claim payments will be reviewed.

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

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

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

5. How the hurricane model accounts for economic inflation associated with past insurance experience will be reviewed.

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

7. All referenced literature will be reviewed, in hard copy or electronic form, to determine applicability.

Pre-Visit Letter

57. A-4, Disclosure 1, pages 107-108: Provide, in Excel, tables of 1,000 years descending from the Top Event corresponding to Form A-8. For each year, show the value of each hurricane separately.

58. A-4, Disclosure 3, pages 108-109: Explain the demand surge methodology. Provide a copy of the demand surge functional relationship used in the model.

Verified: YES

Professional Team Comments:

Reviewed the hurricanes event losses corresponding to Form A-8.

Reviewed the demand surge methodology.

Reviewed the calculation of demand surge factors and implementation in the model.

Reviewed the methodology for determining probable maximum loss levels. Reviewed the methodology for computing the Aggregate Loss Distribution.

Reviewed the calculation of the mean and standard deviation of the annual average loss based on the per-occurrence stochastic event set using 200,000 years of simulation.

Reviewed the treatment of deductibles in the claims data.

A-5 Hurricane Policy Conditions*

*(*Significant Revision)*

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

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

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

Audit

1. The 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

59. A-5, Disclosure 3, page 112: Explain in detail how the hurricane model treatment of annual hurricane deductibles complies with s. 627.0701(5)-(9), Florida Statutes. Provide numerical evidence.

Verified: YES

Professional Team Comments:

Reviewed example use-case scenarios for applying policy limits and deductibles. Reviewed examples of gross loss calculations and application of policy limits and deductibles.

Reviewed application of annual hurricane deductibles when multiple events occur in a given year.

Discussed the methodology for processing insurer claims data used for model validation.

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

*(*Significant Revision)*

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

B. Hurricane loss costs shall not exhibit an illogical relation to risk, nor shall hurricane loss costs exhibit a significant change when the underlying risk does not change significantly.

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

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

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

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

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

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

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

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

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

1. ***masonry construction versus frame construction,***
2. ***personal residential risk exposure versus manufactured home risk exposure,***
3. ***inland counties versus coastal counties,***
4. ***northern counties versus southern counties, and***
5. ***newer construction versus older construction.***

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

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

Audit

1. The data and methods used for hurricane probable maximum loss levels for Form A-8, Hurricane Probable Maximum Loss for Florida, will be reviewed. The hurricane associated with the Top Events will be reviewed.

2. The frequency distribution and the individual event severity distribution, or information about the formulation of events, underlying Form A-8, Hurricane Probable Maximum Loss for Florida, will be reviewed.

3. All referenced literature will be reviewed, in hard copy or electronic form, to determine applicability.

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

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

6. The procedures used by the modeling organization to verify the individual hurricane loss cost relationships will be reviewed. Methods (including any software) used in verifying Standard A-6, Hurricane Loss Outputs and Logical Relationships to Risk, will be reviewed. Forms A-1, Zero Deductible Personal Residential Hurricane Loss Costs by ZIP Code; A-2, Base Hurricane Storm Set Statewide Hurricane Losses; A-3, Hurricane Losses; A-6, Logical 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.

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

8. Forms A-4, Hurricane Output Ranges, and A-5, Percentage Change in Hurricane Output Ranges, will be reviewed, including geographical representations of the data where applicable.

9. Justification for all changes in hurricane loss costs from the previously-accepted hurricane model will be reviewed.

10. Form A-4, Hurricane Output Ranges, will be reviewed to ensure appropriate relativities among deductibles, coverages, and construction types.

11. Apparent anomalies in the hurricane output ranges and their justification will be reviewed.

Pre-Visit Letter

60. A-6, Disclosure 16, page 116: Explain how the model would handle the following example – for a commercial residential property with a $1 million value and an 80% coinsurance clause with $600,000 policy limit. Include discussion of the inputs to the system.

61. Form A-1, page 188: Explain the variation of loss costs for ZIP Codes 33001 and 33045 in Monroe County.

62. Form A-1, page 188: Explain the variation of loss costs for ZIP Codes 32329 and 32323 in Franklin County.

63. Form A-4, page 221: Prepare color-coded maps by county reflecting the weighted average annual zero deductible hurricane loss costs for the nine different categories in Form A-4.C using the 2017 Florida Hurricane Catastrophe Fund personal and commercial residential zero deductible exposure data.

64. Form A-4, 0% Deductible, pages 224-229: Explain the reversal in loss costs where Frame is less than Masonry:
    Owners: Monroe Average, Bradford Low, Gulf Low,
    Renters: Monroe Average, Pinellas High, Holmes Low, and
    Condo Unit: Okaloosa Low, Wakulla Average, Monroe Average.

65. Form A-4, page 225: With Form A-1 having only one ZIP Code for Glades County (33471), explain Form A-4 showing different loss costs for Low, Average, and High for all construction/policy combinations.

66. Form A-4, page 226: With Form A-1 having only one ZIP Code for Lafayette County (32066), explain the values given in Form A-4 in Lafayette County for Low, Average, and High for Frame Owners, Masonry Owners, and Manufactured Homes.

67. Form A-8, pages 242-243: Provide details on the calculation of the uncertainty intervals.

Verified: YES

Professional Team Comments:

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

Discussed that the three uncertainty intervals in Part B and Part C of Form A-8 were incorrectly calculated. Discussed the reasons for the error and actions taken to correct and prevent the problem from recurring.

Discussed the methodology for calculating the return periods for each range in Part A of Form A-8 as well as the frequency and severity distributions.

Reviewed example of modeling a coinsurance policy.

Reviewed the variation in loss costs for ZIP Codes 33001 and 33045 in Monroe County and for ZIP Codes 32329 and 32323 in Franklin County.

Reviewed maps of loss costs by county for the different construction and policy types in Form A-4.

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

Discussed loss costs in Form A-4 for Glades and Lafayette counties.

Reviewed Form A-6 and the reasonableness checks of the loss costs performed by the modeler.

Reviewed revised Form A-8 for reasonableness.

Reviewed maps of loss costs by ZIP Code showing the effects of land friction.

*****Second Additional Verification Review – June 7, 2021*****

Reviewed revised Form A-6.

Discussed the resolution of the scripting error in generating Form A-6.

COMPUTER/INFORMATION STANDARDS – Paul Fishwick, Leader

CI-1 Hurricane Model Documentation

A. Hurricane model functionality and technical descriptions shall be documented formally in an archival format separate from the use of letters, slides, and unformatted text files.

B. A primary document repository shall be maintained, containing or referencing a complete set of documentation specifying the hurricane model structure, detailed software description, and functionality. Documentation shall be indicative of current model development and software engineering practices.

C. All computer software (i.e., user interface, scientific, engineering, actuarial, data preparation, and validation) relevant to the hurricane model shall be consistently documented and dated.

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

Audit

1. The primary document repository, 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 7 will be reviewed. The tables should contain the item number in the first column. The remaining five columns should contain specific document or file references for affected components or data relating to the following Computer/Information Standards: CI-2, Hurricane Model Requirements; CI-3, Hurricane Model Organization and Component Design; CI-4, Hurricane Model Implementation; CI-5, Hurricane Model Verification; and CI-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 7 and Audit 6 through all Computer/Information Standards will be reviewed.

Pre-Visit Letter

68. CI-1.F, page 117: Provide the list of all externally-acquired hurricane model-specific software and data assets as described and required by Standard CI-1 Audit Item 6.

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending review of open items.

Reviewed the Impact Forecasting Florida Hurricane Model Version 1.0 as implemented in the ELEMENTS Version 15.0 software Model Documentation.

Discussed that Microsoft Team Foundation Server (TFS) is used as the source and version control system.

Reviewed the version control branching strategy used to support parallel development of multiple models.

Reviewed the Impact Forecasting Flowchart Standards documentation.

Reviewed the Impact Forecasting Florida Hurricane Model Stochastic Event Calibration Process documentation.

Reviewed the Simulation Code Structure documentation.

Discussed that documentation is created and stored separately from the source control system.

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

Reviewed the ELEMENTS Client User Guide.

Reviewed the ZIP Code data validation process documentation.

Reviewed the Impact Forecasting Wind Vulnerability Engine documentation.

Reviewed the Vulnerability Module documentation.

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

Verified after review of open items.

Discussed the different branches implemented for development and production code in TFS and the process for merging code between branches.

Discussed the key steps in the formal model development process including interaction between R&D and software teams and training for new and existing model developers.

Reviewed the following documentation:

- Model Development Process
- Model Requirements for the US Hurricane Model
- Hurricane Model Change Policy and Process
- R&D Team Foundation Server Integration Process and Best Practices
- Wind Vulnerability Simulator
- Hazard Component Equation Variable Mapping and Logic Flows
- Flowchart Standard Reference Documentation
- R&D Code Internal Test Documentation
- Statistical Standard Equation Variable Mapping and Logic Flows
- Vulnerability Component Equation Variable Mapping and Process Flow Diagrams.

CI-2 Hurricane Model Requirements

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

Audit

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

Verified: YES

Professional Team Comments:

Reviewed software requirements documentation.

CI-3 Hurricane Model Organization and Component Design

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

B. All flowcharts (e.g., software, data, and system models) 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,
    e. Flowcharts illustrating hurricane model-related information flow among modeling organization personnel or consultants (e.g., BPMN, UML, SysML, or equivalent technique including a modeling organization internal standard), and
    f. If the hurricane model is implemented on more than one platform, the detailed control and data flowcharts, component interface specifications, schema documentation for all data files, and detailed network flowcharts for each platform.

2. A hurricane model component custodian, or designated proxy, should be available for the review of each component.

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

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending review of open items.

Reviewed control and data flowcharts and verified the compliance of the flowcharts with the Impact Forecasting Flowchart Standards.

Reviewed the following flowcharts for:

- interactions among major hurricane model components
- the building component-based damage simulator
- account processing calculation in the financial module
- the financial terms application process
- loss processing
- the software development process
- the model feature development process
- the modeled relative intensity
- processing HURDAT2 data in calculating landfall distributions
- stochastic event simulation
- vulnerability simulation
- data verification
- manual and automatic verification.

Reviewed an example of database schemata.

Reviewed a revised diagram illustrating the flow of information among teams.

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

Verified after review of open items.

Reviewed the revised business workflow diagram.

Reviewed the revised model component interaction system flowchart.

Reviewed the revised vulnerability Monte-Carlo simulation engine flowchart.

Reviewed the revised flowchart for model data quality checks and validation testing within the ELEMENTS platform.

Reviewed the relative intensity simulation flowchart.

CI-4 Hurricane Model Implementation*

*(*Significant Revision)*

A. A complete procedure of coding guidelines consistent with accepted software engineering practices shall be maintained.

B. Network organization documentation shall be maintained.

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

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

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

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

G. The following documentation shall be maintained for all components or data modified by items identified in Standard G-1, Scope of the Hurricane Model and Its Implementation, Disclosure 7 and Audit 6:

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

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

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.E will be reviewed.

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

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

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

10. Network organization implementation will be reviewed.

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending review of open items.

Reviewed the Coding Guidelines and Best Practices document.

Reviewed the data verification process document.

Reviewed script responsible for the generation of Form A-8.

Reviewed implementation of relative intensity.

Discussed the traceability among model components through the ELEMENTS Architecture and Design documents.

Reviewed the analyzer report containing the number of lines of code with and without comments by project.

Reviewed the ELEMENTS network organization diagram.

Reviewed implementation of the windborne debris model.

Reviewed implementation of demand surge factors.

Reviewed the spreadsheet data for the Florida model mitigation and secondary characteristics.

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

Verified after review of open items.

Reviewed coding guidelines for languages used by the modeler.

Reviewed the variable mapping and updated implementation for the central pressure equation.

Reviewed the Vickery et al. (2000) reference, *Simulation of Hurricane Risk in the U.S. using Empirical Track Model*.

Reviewed the updated implementation of intensity, including improved commenting, variable naming, and named constants.

Reviewed the code metrics table for the intensity code.

Reviewed the variable mapping and updated implementation for the windborne debris model.

Reviewed the code metrics table for the windborne debris model code.

*****Second Additional Verification Review – June 7, 2021*****

Discussed the scripting error in generating Form A-6, the reason for the error, corrective actions, and actions taken to prevent the error from recurring.

CI-5 Hurricane Model Verification

A. General

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

B. Component Testing

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

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

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

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

C. Data Testing

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

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

Audit

1. 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, integration) 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.

Discussed the different types of testing performed.

Reviewed example summary report that is produced for each testing cycle.

Reviewed examples of ZIP Code data quality assurance testing.

Reviewed the series of logical tests performed on the loss cost relationships in Form A-6.

Discussed the software testing used and additional manual test cases performed.

Reviewed an example of a unit test and the test results.

Reviewed the geocoder testing and verification documentation.

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

Verified after resolution of outstanding issues.

Reviewed examples of unit testing on updated intensity and windborne debris model codes and the associated test results.

*****Second Additional Verification Review – June 7, 2021*****

Reviewed additional testing implemented for checking Form A-6 results.

CI-6 Hurricane Model Maintenance and Revision

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

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

C. Tracking software shall be used to identify and describe all errors, as well as modifications to code, data, and documentation.

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

Audit

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

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

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

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

5. The list of all hurricane model revisions as specified in CI-6.D will be reviewed.

Pre-Visit Letter

69. CI-6, Disclosure 2, page 127: Detail the evolution of the ELEMENTS platform since its inception.

Verified: YES

Professional Team Comments:

Reviewed the software development process.

Reviewed the policy for Model and ELEMENTS platform versioning.

Reviewed examples of Model and ELEMENTS platform release numbering schemes.

Reviewed the version history for the model and the ELEMENTS platform.

Reviewed the model and platform revision management. Reviewed an example of the models hosted under the ELEMENTS platform.

CI-7 Hurricane Model Security

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

Audit

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

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

3. Security aspects of each platform will be reviewed.

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

Verified: YES

Professional Team Comments:

Discussed the data and network security procedures.

Discussed that there have been no security breaches.

Discussed the data retention and recovery protocols.

IMPACT FORECASTING
Powered by Aon

June 1, 2021

Floyd Yager, Chair
Florida Commission on Hurricane Loss Projection Methodology
Florida State Board of Administration
1801 Hermitage Boulevard, Suite 100
Tallahassee, FL 32308

Re: Request for Additional Verification Review of Form A-6, Logical Relationship to Hurricane Risk (Trade Secret Item)

Dear Mr. Yager,

During the course of deeper analysis of Form A-6, Logical Relationship to Hurricane Risk (Trade Secret Item), in preparation for the closed meeting with the Commission, Impact Forecasting discovered that a correction must be made to the "Policy Form" results in Form A-6.

Due to a scripting error, the loss costs and county information in the "Policy Form" tab of Form A-6 were misaligned. We have corrected the error and a new Form A-6 has been generated. There is no issue with the modeled results and no other form is impacted. Form A-6 Part F Graphical Summary of Logical Relationship in the original submission is correct because the scripts generating graphs are correct.

Since the discrepancy was discovered after the Professional Team completed their remote review, Impact Forecasting would like to request an additional verification review. We will submit all revised documentation as required by the 2019 Hurricane Standards no later than June 2, 2021.

We look forward to scheduling the additional verification review. Please contact us with any questions.

Sincerely,

Minchong Mao, FCAS, MAAA, CCRMP
Senior Managing Director
Aon

Bin Pei, Ph.D.
Associate Director
Impact Forecasting