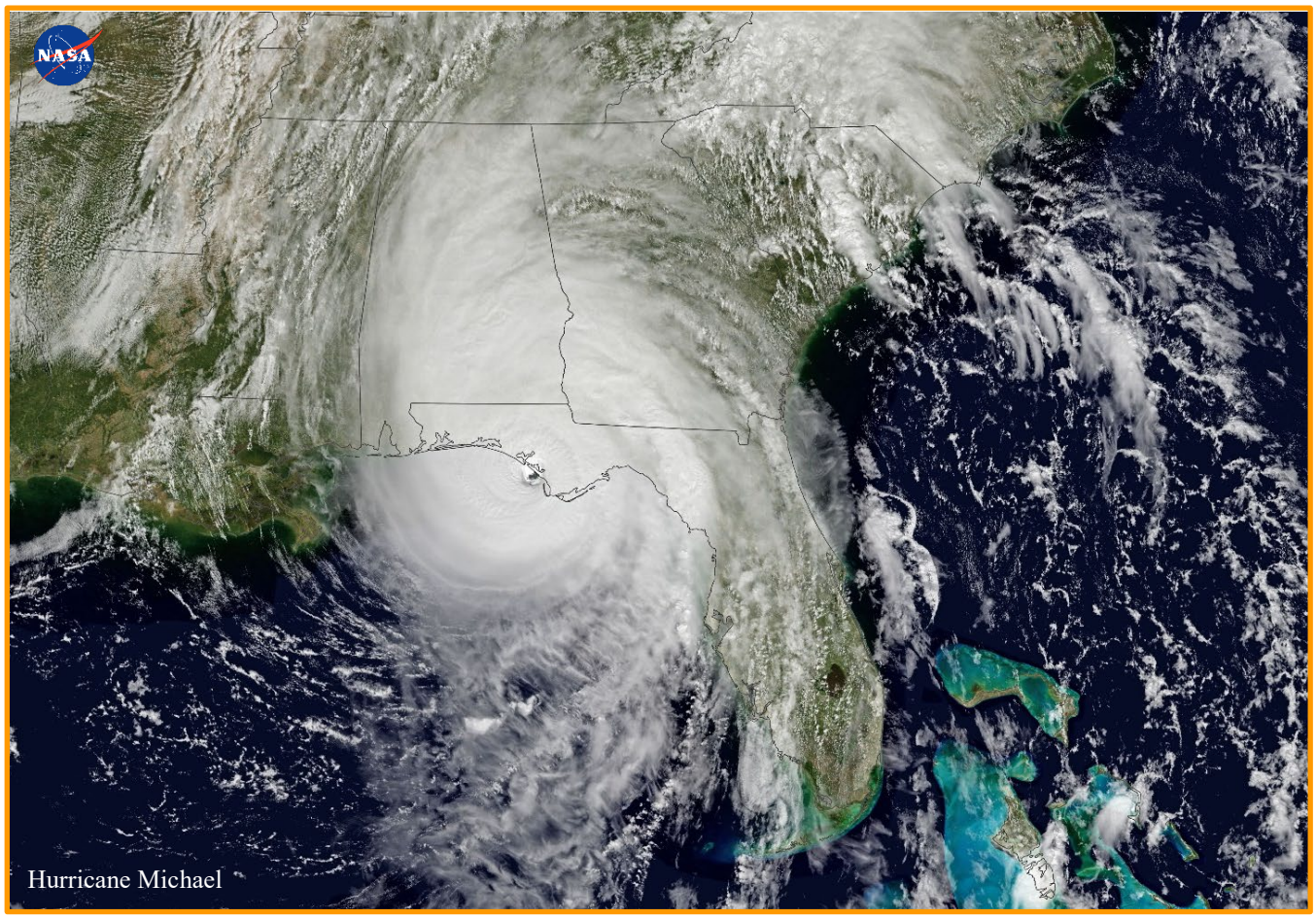
Florida Commission on Hurricane Loss Projection Methodology

Professional Team Report

2019 Hurricane Standards



AIR Worldwide Corporation

Remote Review

March 1 – 4, 2021

On March 1-4, 2021, the Professional Team conducted a remote review of the AIR Worldwide Corporation, AIR Hurricane Model for the United States Version 1.0.0 as implemented in Touchstone® 8.1.0. The following individuals participated in the remote review.

AIR

Sikondrulu Alekhya, Software QA Engineer
Vijay Santosh Alla, Senior Manager, Quality Assurance
Brandie Andrews, CCM, MPA, Vice President
Siddhartha Kumar Arya, Information Security Manager
Tejaswi Battula, Database Engineer
Sarah Bobby, Ph.D., Engineer, Research and Modeling
Nicholas Brewer, Risk Analyst, Consulting and Client Services
Heidi Carrell, Senior Writer
Abhinav Chintakindi, Senior Software Engineer
Dennis Costello, Senior Product Manager
Rohan Das, QA Analyst
Suryanarayana Datla, Vice President of Research, Director of Hyderabad Model Group
Abhilash Dhadwi, Senior Software Engineer
Boyko Dodov, Ph.D., Vice President, Director of Research and Development
Phaninath Dheram, Senior Manager, Software
Brendan Flaherty, Senior Risk Consultant
Srimanta Ghosh, Ph.D., Risk Analyst, Model QA
Stacey Gotham, FCAS, MAAA, CEEM, Senior Actuary
Anthony Hanson, Director of Analytics
Suilou Huang, Ph.D., Senior Scientist, Research and Modeling
Sai Teja Jenula, QA Analyst
Aditya Jinna, Team Lead, Software Development
Tim Johnson, Ph.D., Engineer, Research and Modeling
Mohan Kandulapati, Software Quality Assurance Engineer, Software QA
Aaron Knox, Senior Analyst, Data Management
Visweswara Kokkonda, Senior Database Engineer, Software
Sylvie Lorsolo, Ph.D., Senior Scientist, Manager
Manoj Medarametla, Principal Software Engineer, Software
Anup Rajasekharan Nair, Manager QA
Ashwin Kasilingam Thillai Natarajan, Risk Analyst, Core QA
Robert Newbold, Executive Vice President
Martin Partyka, Manager of Internal Audit
Asha Prabhu, Senior Software Engineer
Andrew Rahedi, Director, Quality Assurance
Karthik Ramanathan, Ph.D., Assistant Vice President, Principal Engineer
Barbara Rosenstroch, Principal Technical Writer
Indumathi Sagyari, Team Lead, Software
Alekhya Sikondrulu
Scott Sperling, CCM, Senior Core Quality Assurance Analyst
Jeff Strong, Ph.D., Research Scientist
Apoorv Srivastava, Senior QA Analyst
Srinivas Thoudoju, Senior Software Engineer

Susan Tolwinski-Ward, Ph.D., Principal Scientist
Eric Uhlhorn, Ph.D., Principal Scientist and Manager
Ramesh Ummati, Senior Principal Engineer, QA
Satish Vootukuru, Software Engineer
David Wilson, Director Product Management
Yang Kun, Ph.D., Research Engineer

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
Ryan McMahan, Ph.D., Computer and Information Scientist, observer
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 opening briefing and introductions were made. AIR next provided an overview of updates to the model.

- Stochastic storm set updated to incorporate track information from July 2019 HURDAT2
- Vulnerability component updates including 1) adjusting the underlying year built weighting assumptions to utilize the latest census and tax assessor data regarding building stock age, 2) vulnerability adjustments that account for structural aging and building technology changes to be relevant through 2020, 3) roof year built secondary risk feature updated to be relevant through 2020, and 4) roof age assignment updated to assign buildings built within the last 10-20 years to have an average roof year built when roof year built is unknown
- Geographic data updates including 1) ZIP Codes updated to April 2020, 2) street level geocoding data updated to be relevant through 2019, and 3) exposure database updated to be relevant through 2019

AIR discussed other software enhancements to improve functionality while having no impact on loss costs or probable maximum loss levels in Florida.

The audit continued with a review of each standards section.

During the Commission meeting to review the model for acceptability under the 2019 Hurricane Standards, AIR 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 Forms V-3 and V-5
2. Detailed information and discussion of relativities in Form A-6.

In the course of the audit, the model identification AIR Hurricane Model for the U.S. V1.0.0 as implemented in Touchstone® 2020 superseded AIR Hurricane Model for the U.S. V1.0.0 as implemented in Touchstone® 8.1.0.

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. M-1, Disclosure 2, page 69: Contradictory and non-responsive. The following modifications have been made to the Base Hurricane Storm Set with no justification provided.
    1. Added 001: 1900 ByP1
    2. 020: B1/C1 → C1
    3. 025: F2/ByP2 → F1
    4. 030: B3/C3 →
    5. 040: B2 → B3
    6. 045: A1 → F1
    7. 050: F1/ByP1 → F1
    8. 065: F3/ByP3 → F3
    9. 080: B4 → ByP4
    10. Added 096: 1925 ByP1
    11. 100: D2 → D3
    12. 110: ByP3 → ByP2
    13. 125: C3/A1 → B3/A2
    14. Added 126: 1930 ByP0
    15. 130: F1/ByP-1 → F1
    16. Added 141: 1933 ByP1
    17. Added 142: 1933 ByP3
    18. Added 143: 1934 ByP0
    19. Added 146: 1935 ByP4
    20. Added 161: 1940 ByP0
    21. 165: C2/A1 → C1/A1
    22. 170: B3 → B2
    23. Added 186: PyP0
    24. 190: C4 → C4/F3
    25. 205: B2 → C1
    26. 210: C4 → C3
    27. 215: F1/ByP1 → F2
    28. 225: C4 → C3
    29. Added 226: 1951 ByP1
    30. Added 227: 1951 ByP0
    31. Added 228: 1952 ByP1F1 with zero loss?
    32. 240: A1 → F1/A1
    33. 245: B4 → B3
    34. Added 251: 1963 ByP1 F1 with zero loss?
    35. Added 261: 1964 ByP0
    36. 265: B3 → B2
    37. 270: C3 → B4
    38. Added 281: 1968 ByP1
    39. 305: C2/E2 → C1/E2
    40. 315: F3/ByP3 → F3
    41. Added 316: 1985 ByP1
    42. 325: B1 → C1
    43. Added 326: 1988 F1 with zero loss?
    44. Added 331: 1994 ByP0
    45. 355: B2/F2 → F2
    46. Added 361: 2000 ByP1
    47. 370: C2 → C1
    48. 375: F3/ByP3 → F3
    49. 380: C3 → C2
    50. Added 381: 2005 ByP0
    51. Added 391: 2005 ByP1
    52. Added 401: 2008 ByP0
    53. Added 402: 2012 ByP0
    54. 410: ByP3 → ByP4
    55. 415: B4 → B2

2. Form S-3, pages 253-255: Incomplete. The Rmax probability distribution form is not specified in Form S-3.

3. V-1, Disclosure 3, page 126: Incomplete. No response for number of policies, number of insurers, dates of hurricane loss, amount of hurricane loss, and number of units amount of dollar exposure separated into personal residential, commercial residential, and manufactured homes provided.

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 the 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) presentation of new or extensively updated material related to the model; (2) section by section review commencing within each section with pre-visit letter responses; (3) responses to new or significantly changed hurricane standards in the 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 October 27, 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 review. The Professional Team reviewed the following corrections to be included in the revised submission to be provided to the Commission no later than 10 days prior to the meeting to review the model for acceptability. Page numbers below correspond to the initial October 27, 2020 submission document.

1. Submission Title Page: Touchstone version number revised.
2. List of Tables, page 11: Table 5 added to the list.
3. Model Identification, page 13: Touchstone version number revised.
4. G-1, Disclosure 3, page 21: Figure 2 flowchart revised.
5. G-1, Disclosure 6, page 26: Dashed line removed before —*Loss Distribution* in the Hogg and Klugman reference.
6. G-2, Disclosure 2.C, page 57: Figure 8 flowchart revised.
7. G-3.E, page 61: Added link for Disclosure 3 in second paragraph.
8. M-1, Disclosure 2, page 69: Revised to clarify response to Deficiency #1.
9. M-5, Disclosure 1, page 88: Equation 1 corrected.
10. M-5, Disclosure 2, page 90: Figure 14 corrected.
11. S-1, Disclosure 1, page 95: Chi-square test statistic value corrected.
12. V-1.D, page 122: Reference to Disclosure V.1.6 corrected. Year-built dates and number of years corrected.
13. V-1, Disclosure 2, page 125: Figure 28 flowchart revised.
14. V-1, Disclosure 7, page 129: Year-built adjustment time frame corrected.
15. V-1, Disclosure 8, page 131: Reference to Disclosure V.1.6 corrected.
16. V-1, Disclosure 10, page 132: Reference to Disclosure V.1.6 corrected.
17. V-4, Disclosure 6, page 146: Reference to Disclosure V.3.4 corrected.
18. V-4, Disclosure 7, page 146: References to Standard V-3.A and Disclosure V.3.4 corrected.
19. CI-1.D, page 178: Reference to G-1, Disclosure 5-A corrected.
20. CI-6.D and Disclosure 2, pages 218-219: revised model versioning system.
21. Form V-1.B, page 266: assumptions clarified.
22. Form V-2.B, page 268: assumptions clarified.
23. Appendix 9, page 424: Figure 86 revised and broken link corrected.

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. G-1.B, pages 15-16: Provide documentation of the process.

2. G-1, Disclosure 1, page 17: Explain the progression from the AIR Hurricane Model for the U.S. V17.0.0 as Implemented in Touchstone® 6.1.0 (submitted March 13, 2019) to the AIR Hurricane Model for the U.S. V1.0.0 as Implemented in Touchstone® 8.1.0 in terms of the major version decrement.

3. G-1, Disclosure 3, page 21: Describe how by-passing hurricanes fit into the flowchart. Describe how hurricane tracks from genesis fit into the flowchart.

4. G-1, Disclosure 7, pages 33-38: Explain how the various interim software updates over the past two years mesh with Standard G-1 Disclosure 7.

5. G-1, Disclosure 7.A, page 33: Explain in detail the changes made to the Building Vulnerability Component. Discuss the effect of these changes on the contents and time element vulnerability components.

6. G-1, Disclosure 7.A, page 34: Explain the updated functionality regarding flexibility in deductible policy logic.

7. G-1, Disclosure 7.B, page 34: Explain the apparent disparity between the percentage changes in average annual zero deductible statewide loss costs given as +0.3% increase in this disclosure versus 3.05% and 0.44% increase values given in Form S-5 (page 261).

8. G-1, Disclosure 7.C, Figure 4, page 35: Discuss the geographic structure of the changes due to event generation.

9. G-1, Disclosure 7.C, Figure 5, page 36: Identify the vulnerability updates that led to the maximum and minimum impact locations. In addition, explain the reduced loss costs in DeSoto County with increased loss costs in neighboring counties.

10. G-1, Disclosure 7.C, Figure 6, page 37: Identify the geographic or other data updates that led to the maximum and minimum impact locations. In addition, explain the reduced loss costs in Martin, Sarasota, and Bay counties.

Verified: YES

Professional Team Comments:

Discussed how by-passing hurricanes fit within model catalog generation.

Reviewed updates to the Base Hurricane Storm Set, vulnerability adjustments, roof year, and ZIP Codes.

Reviewed several enhancements to the platform and model that do not impact loss costs.

Reviewed impacts of various model updates on loss costs.

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

Reviewed the revised model versioning numbering system and various interim software updates.

Reviewed that AIR Hurricane Model for the U.S. V1.0.0 as implemented in Touchstone® 8.1.0 changed to AIR Hurricane Model for the U.S. V1.0.0 as implemented in Touchstone® 2020.

Discussed the differences in loss cost changes due to model updates reported in Standard G-1 and in Form S-5.

Discussed that new automated procedures were created to populate forms.

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: YES

Professional Team Comments:

Reviewed resumes of personnel new to the AIR model submission process:

- Sikondrulu Alekhya, B.E. in Electronics and Communication Engineering, Vasavi College of Engineering, Hyderabad, India
- Vijay Santosh Alla, M.C.A. in Information Systems, Bangalore University, Bangalore, Karnataka, India; B.A. in English and Statistics, Khallikote College, Berhampur, Odisha, India
- Siddhartha Kumar Arya, M.T. in Computer Science and Management, Deakin University, Melbourne, Australia; M.E. in Systems Engineering and Information Technology, Birla Institute of Technology and Science, Pilani, India; MBA in MMS, Birla Institute of Technology and Science, Pilani, India
- Tejaswi Battula, M.S. in Computing and Information Sciences, Kansas State University, Manhattan, KS; B.S. in Computer Science, Jawaharla Nehru Technological University, Hyderabad, India
- Heidi Carrell, B.A. in English, University of New Hampshire, Durham, NH
- Abhinav Chintakindi, B.E. in Computer Science Engineering, Osmania University, Telangana, India
- Igor Cizelj, Ph.D. in Systems Engineering, Boston University, Boston, MA; M.S. in Mechanical Engineering, University of Zagreb, Zagreb, Croatia; B.S. in Mechanical Engineering, University of Zagreb, Zagreb, Croatia
- Dennis Costello, B.S. in Civil and Environmental Engineering, Cornell University, Ithaca, NY
- Rohan Das, M.S. in Actuarial Science, Amity School of Insurance Banking & Actuarial Science, Amity University, Noida, India; B.E. in Industrial and Production, Manipal Institute of Technology, Manipal, India
- Abhilash Dhadwai, B.T. in Electronics and Communication Engineering, SRM University, Chennai, India
- Boyko Dodov, Ph.D. in Civil Engineering – Hydrology, University of Minnesota, Minneapolis, MN; B.E. in Hydrogeology and Engineering Geology, Higher Institute of Mining and Geology, Sofia, Bulgaria
- Brendan Flaherty, B.A. in Mathematics, Stonehill College, Easton, MA
- Rohit Jain, B.E. in Computer Science, Medicaps Institute of Technology & Management, Indore, Madhya Pradesh, India
- Sai Teja Jenula, B.T. in Civil Engineering, CMR College of Engineering & Technology, JNT University, Hyderabad, India
- Phillip Jue, B.S. in Atmospheric Sciences, University of Illinois, Champaign-Urbana, IL
- Aaron Knox, B.S. in Computer Science and Economics, Rose-Hulman Institute of Technology, Terre Haute, IN
- Peter Lewis, B.S. in Business Administration and Finance, Northeastern University, Boston, MA
- Manoj Medarametla, M.S. in Software Systems, Birla Institute of Technology & Science, Pilani, India; B.E. in Information Technology, Osmania University, Hyderabad, India
- Anup Rajashekharan Nair, MBA in Business Analytics, Alliance University, Anekal, India; B.T. in Civil Engineering, Government College of Engineering, Kannur University, Kerala, India
- Ashwin Kasilingam Thillai Natarajan, M.S. in Industrial Engineering, Northeastern University, Boston, MA; B.E. in Mechanical Engineering, Anna University, Chennai, India
- Martin Partyka, B.S. in Economics, Boston College, Chestnut Hill, MA
- Asha Prabhu, B.T. in Computer Science and Information Technology, Vallurupalli Nageswara Rao (VNR) Vignana Jyothi Institute of Engineering & Technology, Hyderabad, India

- Apoorv Srivastav, MBA in Insurance Business Management, Birla Institute of Management and Technology, Noida, India; B.S. in Commerce, Lucknow Christian College, Lucknow, India
- Jeff Strong, Ph.D. in Atmospheric & Oceanic Sciences, Princeton University, Princeton, NJ; M.A. in Atmospheric and Oceanic Sciences, Princeton University, Princeton, NJ; B.S. in Environmental Science and Mathematics, University of Virginia, Charlottesville, VA
- Kun Yang, Ph.D. in Civil and Environmental Engineering, University of Delaware, Newark, DE; B.E. in Automation, Huazhong University of Science and Technology, Wuhan, China
- Ying Zhou, Ph.D. in Atmospheric Chemistry, SUNY College of Environmental Science and Forestry, Syracuse, NY; B.S. in Environmental Chemistry, Nanjing University, Nanjing, China

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

G-3 Insured Exposure Location*

*(*Significant Revision)*

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

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

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

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

E. Geocoding methodology shall be justified.

Audit

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

Verified: YES

Professional Team Comments:

Reviewed ZIP Code updates and data processing procedures.

Reviewed the flowchart for processing and validating ZIP Code centroid updates.

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

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: YES

Professional Team Comments:

Reviewed theoretical soundness throughout the audit and found no evidence of compensating modeling components.

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: YES

Professional Team Comments:

Discussed with the Editorial Review signatory the documentation process for compiling and reviewing the submission document, including review by the team leads.

Reviewed the flowchart defining the process for creating actuarial submission forms.

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

METEOROLOGICAL 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 revised response to Deficiency #1.

Reviewed the Base Hurricane Storm Set based on HURDAT2 as of July 25, 2019 and changes from the previously-accepted model.

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

Discussed that there have been no modifications to the historical hurricane frequencies, other than those derived from the two additional years of HURDAT data.

Reviewed the legacy code and data in support of the stochastic catalog.

Reviewed the annual occurrence rates in Form M-1 compared to Form S-1. Discussed changes to historical storm counts in M-1 compared to the previously-accepted model.

Reviewed graphical comparisons between the current model and the previously-accepted model of annual occurrence rates for Florida and neighboring states.

Reviewed landfall frequency goodness-of-fit Chi-square tests for Florida and neighboring states.

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

11. M-2, Disclosure 3, Rmax, page 72, (also Standard S-1 and Form S-3): Provide details on the form of the Rmax regression and on the Rmax variation at landfall and over land. How does the dependence evolve during over-land weakening?

12. M-2, Disclosure 3, page 73: Provide details on the forward-speed and storm-heading bounds.

13. M-2, Disclosure 9, pages 75-77: Provide the numerical values for the rates shown in Figure 9. Provide a map of coastal segments.

Verified: YES

Professional Team Comments:

Reviewed the model for Rmax at landfall and its evolution over land.

Reviewed the forward-speed and storm-heading bounds. Discussed the evolution of storm heading from over water to over land.

Reviewed map of the coastal segments in Florida. Discussed how the Florida Keys are incorporated into the coastal segmenting.

Reviewed comparisons of historical hurricane frequency rates between the current model and the previously-accepted model.

Reviewed correlation between Rmax and central pressure.

Reviewed the gradient reduction factor to translate gradient-level winds to the surface.

Reviewed scatter plot comparisons for observed and modeled peak weighting factor versus gradient wind reduction factor. Reviewed the formulation for peak weighting factor.

Reviewed comparison of modeled and historical forward speed distributions.

Reviewed the modeled far-field pressure value and its variation in Florida.

M-3 Hurricane Probability Distributions

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

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

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

Saffir-Simpson Hurricane Wind Scale:

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

Audit

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

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

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

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

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

Verified: YES

Professional Team Comments:

Reviewed the basin-wide stochastic storm-track model and the integration of over-ocean tracks with tracks simulated in the landfall model.

Discussed that landfall strike locations are selected from a probability distribution within each 50-nautical-mile coastal segment.

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

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

14. M-4, Disclosure 7, Figure 13, page 86: Explain the high simulated Hurricane Michael (2018) windspeed in Pinellas County compared to observations (110-120 mph versus 50-60 mph).

15. M-4, Disclosure 8, page 87: Provide for Hurricane Irma (2017) an analogous display to Figure 13.

Verified: YES

Professional Team Comments:

Reviewed the modeled windfield for Hurricane Michael (2018).

Reviewed map of observed and modeled windspeeds for Hurricane Irma (2017).

Reviewed surface roughness map for Hurricane Jeanne (2004).

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

Discussed that vertical variation of winds near the surface in the model is handled through the vulnerability functions.

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

16. M-5, Disclosure 1, pages 88-89: Explain the scientific basis for Equation 1. Provide example values for C_1, C_2, and $LF_{offset.}$ Illustrate the behavior of the ΔP time dependence.

Verified: YES

Professional Team Comments:

Reviewed the equation governing pressure deficit decay over land. Reviewed implementation in the code.

Reviewed landfall windfield maps and roughness length maps for Hurricane Andrew (1992), Hurricane Jeanne (2004), and Hurricane Irma (2017).

Reviewed over-land attenuation of Vmax.

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

17. M-6, Disclosure 2, page 92: Provide detail on the modeling of surface roughness and its impact on modeled windspeed.

18. M-6, Disclosure 4, Table 3, page 93, Table 3: Explain the enlarged windfield compared to the previously-accepted model (i.e., Max and Median for outer radii > 73 mph). Explain why various values repeat for different Cp values (e.g., 11.51, 247.42, 94.94, 51.79, 60.42).

19. Form M-3, Table 29, page 245: Explain the table entries showing 960 mb 2Q Rmax (25 mi) larger than the outer 110 mph radius.

20. Form M-3, pages 245-248: Explain the inconsistencies between Table 29 and Figure 58 concerning Rmax distributions. For example, the 900 mb 1Q and 3Q values in the table are 7 mi and 18 mi respectively, but in the figure they are roughly 12 mi and 24 mi. The 3Q values at 990 mb and 980 mb are 34 mi in the figure, but in the table, the values are 39 mi and 36 mi.

Verified: YES

Professional Team Comments:

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

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

Reviewed 100-year and 250-year return period windspeed maps for actual and open terrain.

Reviewed contour animation of the Hurricane Frances (2004) windfield.

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.

Verified: YES

Professional Team Comments:

Reviewed the Rmax model.

Reviewed the goodness-of-fit of the negative binomial distribution to the annual frequency of landfalls as given in Form S-1. Reviewed Form S-2 versus Form A-8. Reviewed Form S-3.

Reviewed the legacy code and data in support of the stochastic catalog.

Discussed the dates of the underlying data supporting the probability distributions.

Reviewed goodness-of-fit tests for central pressure, Rmax, forward speed, and storm heading distributions. Reviewed comparisons of the historical and modeled distributions.

S-2 Sensitivity Analysis for Hurricane Model Output

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

Audit

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

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

Verified: YES

Professional Team Comments:

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

S-3 Uncertainty Analysis for Hurricane Model Output

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

Audit

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

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

Verified: YES

Professional Team Comments:

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

S-4 County Level Aggregation

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

Audit

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

Pre-Visit Letter

21. S-4, Disclosure 1, page 112: Provide quantitative evidence that this standard is met.

Verified: YES

Professional Team Comments:

Reviewed the tests for convergence of the simulations confirming that the threshold limit was met.

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 validations of the model that compare projected losses to actual insured losses.

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

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

22. V-1, Disclosure 4, page 127: Describe in detail claims data for more recent hurricanes such as Isaac (2012), Hermine (2016), Mathew (2016), Irma (2017), Nate (2017), and Michael (2018).

23. V-1, Disclosure 7, page 129: Explain the basis for the year-built categories.

Verified: YES

Professional Team Comments:

Discussed the use of Property and Claims Services (PCS) loss estimates for Hurricane Irma (2017) and Hurricane Michael (2018). Reviewed comparisons of modeled residential loss to the PCS loss estimates.

Reviewed the year-built categories. Discussed that the year-built categories are based on the evolution and adoption of Florida building codes.

Discussed the year-built adjustment to account for variations between 1995 and 2015 for structural aging and deterioration, and building materials and technology changes.

Discussed that law and ordinance costs are not explicitly modeled in the vulnerability functions.

Reviewed updates to the vulnerability component since the previously-accepted model.

Reviewed scatter plot of actual to modeled building damage ratios by windspeed.

Discussed the construction classes and primary and secondary characteristics implemented in the model.

Discussed the uncertainty in damage for mean damage ratios. Reviewed modeled distributions for sample mean building damage ratios.

Discussed the modeler's peer-reviewed study on the various national, state, and local building codes and standards.

Reviewed the model building assumptions for Florida Building Code 2010 compliant construction.

Reviewed the model Florida vulnerability regions based on windspeed, terrain exposure category, and wind-borne debris region.

Discussed with the Vulnerability Standards signatory her review of the vulnerability component changes and the vulnerability submission documentation.

Discussed that the minimum windspeed at which damage starts in the model is 40 mph.

Discussed that the model assumes a mean damage ratio based on the intensity of the event at the location of the structure.

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

24. V-2.B, page 135 and Disclosure 5, page 137: Provide support, in terms of plots, for the building and contents relationship which is consistent with claims data. Provide plots of the relationship for wood frame and masonry constructions for single-family home occupancy.

25. V-2, Disclosure 2, page 136: Explain how the flowchart provided for Standard V-1 Disclosure 2 (Figure 28, page 125) is applicable to the derivation and implementation of contents vulnerability functions. In particular, Figure 28 relates damage ratios to windspeed whereas Standard V-2.B notes contents vulnerability relates to building vulnerability.

Verified: YES

Professional Team Comments:

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

Discussed that contents mean damage ratios are functions of building mean damage ratios.

Reviewed flowchart for vulnerability function development and implementation. Discussed that the flowchart applies to building, contents, and time-element mean damage functions.

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

Discussed that there were no methodology changes for calculating content losses from the previously-accepted model.

Reviewed comparison of actual and modeled content losses by construction and occupancy.

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

26. V-3.B, page 138 and Disclosure 5, page 140: Provide support, in terms of plots, for the building and time element relationship which is consistent with claims data. Provide plots of the relationship for wood frame and masonry constructions for single-family home occupancy.

27. V-3, Disclosure 2, page 139: Explain how the flowchart provided for Standard V-1 Disclosure 2 (Figure 28, page 125) is applicable to the derivation and implementation of time element vulnerability functions. In particular, Figure 28 relates damage ratios to windspeed whereas Standard V-3.B notes time element vulnerability relates to building vulnerability.

30. Form V-1.A, page 265: Explain the relatively small time element loss ratios in light of large building and contents damage ratios.

31. Form V-1.B, page 265: Explain the relatively small time element loss ratio in light of large manufactured home damage ratio for building damage.

Verified: YES

Professional Team Comments:

Reviewed scatter plots of actual and modeled time-element damage ratios versus windspeed for single-family masonry and frame homes.

Reviewed flowchart for vulnerability function development and implementation. Discussed that the flowchart applies to building, contents, and time-element mean damage functions.

Discussed that time-element vulnerability relationships are based on estimates of time to repair for different building damage levels and are related to claims data from historical storms.

Discussed the time-element losses for manufactured homes compared to frame and masonry time-element losses in revised Form V-1.

Reviewed comparison of modeled time element damage ratios for manufactured homes with actual claims data.

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

Discussed that there were no methodology changes for calculating time-element losses from the previously-accepted model.

V-4 Hurricane Mitigation Measures and Secondary Characteristics*

*(*Significant Revision)*

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

28. V-4, Disclosure 1, page 143: Explain and demonstrate how the model treats unknown roof year-built for known and unknown year of construction.

29. V-4, Disclosure 2, page 143: Explain in detail all the updates to the Individual Risk Module (IRM), including those listed in Disclosure 1. Provide documentation of the methodology, data used, assumptions made, and implementation of the changes, especially in the IRM software, testing plan and testing results.

32. Form V-2.B, page 268: Explain the set of events which approximate the requested windspeeds on Form V-2.

33. Form V-2, Table 41, page 270: Explain the negative values for sliding glass doors mitigation by making them meet windborne debris requirements.

34. Form V-4, Table 42, page 274: Given the modifications in secondary characteristics outlined in Standard V-4 Disclosure 1, explain the non-zero values shown in Form V-4, e.g., 8d nailing of deck for roof covering and straps for wall-foundation strength.

Verified: YES

Professional Team Comments:

Discussed the damage function assignments for unknown roof age and unknown year of construction.

Reviewed the Individual Risk Module (IRM) updates including technology/aging factor, roof age bands and roof year-built secondary characteristics, and roof age assignment.

Reviewed documentation, testing, and code implementation of updates to the IRM.

Reviewed revised flowcharts for the process to complete Forms V-2 and V-3.

Reviewed revised Forms V-2, Part B and V-3, Part B. Reviewed Forms V-4 and V-5. Discussed the assumptions for completing Forms V-2 and V-3.

Discussed that the IRM captures the impact of hurricane mitigation measures and secondary characteristics.

Reviewed sample code of individual risk features.

Reviewed the updates to the IRM from the previously-accepted model.

Discussed the interaction among secondary characteristics and their implement in the IRM.

Reviewed graphical representation of the vulnerability curves for the reference and the fully mitigated building in Forms V-2 and V-3.

Reviewed table of adjustments for all mitigation and secondary characteristics in the model.

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

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.

Pre-Visit Letter

35. A-1.B, page 148: Provide a copy of the Touchstone® Exposure Data Validation Reference.

36. A-1, Disclosure 5, page 154: Explain the Analysis Option "Disaggregation" and how it would be applied in a Florida rate filing. Provide a copy of the document "Exposure Disaggregation in Touchstone."

Verified: YES

Professional Team Comments:

Discussed software changes to allow flexibility in deductible policy logic selected by the user.

Reviewed Touchstone® Exposure Data Validation reference.

Reviewed Exposure Disaggregation in Touchstone® documentation. Discussed the application of exposure disaggregation in a Florida rate filing.

Reviewed the Detailed Loss Analysis section of Touchstone® Online Help documentation including analysis options available for generating loss results and the variables a user may set in running the model.

Discussed that the selected analysis options are documented in the analysis logs generated by the software.

Reviewed an analysis screen in the Touchstone® User Interface and the various options available. Reviewed a sample model output report with the various options selected for the analysis run.

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.

Pre-Visit Letter

37. A-2.B, page 157: Provide a copy of the documented procedure.

Verified: YES

Professional Team Comments:

Reviewed the documented procedure for distinguishing wind losses from other peril losses.

Discussed that there was no change in the definition of an event in the model.

Discussed the criteria for identifying by-passing hurricanes.

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

38. A-3, Disclosures 1-4, page 160: Show a calculation of loss costs and probable maximum loss levels for the minimum frame owners loss costs in Form A-1 (i.e., ZIP Code 32046 in Nassau County).

39. A-3, Disclosure 5, page 161: Explain how law and ordinance coverage is implicitly accounted for and handled in the model. 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 a calculation of frame-owners loss costs in Form A-1 for ZIP Code 32046 in Nassau County.

Discussed that law and ordinance coverage in not explicitly considered in the model.

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

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

40. A-4, Disclosure 1, pages 163-164: 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.

41. A-4, Disclosure 4, page 165: Provide a copy of the demand surge white paper.

Verified: YES

Professional Team Comments:

Reviewed the top 1,000 years of hurricanes sorted by aggregate loss corresponding to Form A-8.

Reviewed the demand surge model documentation. Discussed the demand surge functions by coverage.

Reviewed the methodology for determining probable maximum loss levels.

Reviewed the *Understanding Uncertainty* article and *AIR Financial Module* white paper.

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.

Verified: YES

Professional Team Comments:

Reviewed the methodology for application of the annual hurricane deductible and the order of application of hurricane deductibles and policy limits.

Discussed that there were no changes in the relativities among deductibles from the previously-accepted model.

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

42. Form A-1, pages 276-306: Explain the large increases in the losses in Form A-1, compared to the previously-accepted model, given the small overall change in the modeled results.

43. Form A-1, pages 276-306: Explain why the following ZIP Codes were added, compared to the previously-accepted model: 32612, 34445, 32512, 32323, 32330, 34661, 33965, 34478. Provide a list of new Florida ZIP Codes in the current model.

44. Form A-2, page 310: Explain the difference in losses for Hurricane Ophelia (2005) compared to the previously-accepted model.

45. Form A-4, 0% Deductible, pages 337-341: Explain the reversal in loss costs where Frame is less than Masonry:
    Owners: Gulf Average, Pasco Average,
    Renters: Gulf Low, Dixie Low, Liberty Low, and
    Condo Unit: Okaloosa Low, Okeechobee Low, Wakulla Average.

46. Form A-4, pages 338: 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.

47. Form A-4, pages 339: With Form A-1 having only two ZIP Codes for Lafayette County (32013 and 32066), explain the values given in Form A-4 for Lafayette County Low, Average, and High for Frame Owners, Masonry Owners, and Manufactured Homes.

48. Form A-8, pages 371-372: Provide details on the bootstrapping procedure for the uncertainty intervals.

Verified: YES

Professional Team Comments:

Discussed the changes in Form A-1 from the previously-accepted model.

Reviewed the list of new Florida ZIP Codes in the current model.

Discussed the difference in losses for Hurricane Ophelia (2005) compared to the previously-accepted model.

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.

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

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

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

Reviewed Form A-8. Discussed the methodology for calculating the uncertainty intervals and the frequency and severity distributions.

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

49. CI-1.B, pages 177-178: Relate the primary binder table of contents with the response to Standard G-1 Disclosure 7 (pages 33-34) by demonstrating individual table item compliance with Computer/Information Standards CI-1 through CI-7.

50. CI-1.D, page 178: Provide the table required by Standard CI-1 Audit Item 7.

51. CI-1.F, page 178: 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.

56. Appendix 8, page 410: Discuss the change in internal model numbering for ratemaking in Florida (i.e., the newer 521 model) versus accounting for losses from precipitation-based flood performed in Touchstone 8.0.

57. Appendix 8, page 411: Provide the *Enhancements and Florida Commission Documentation Map* for Standards CI-1 and CI-3.

58. Appendix 8, page 411: Provide a definition of “significant changes” in paragraph four.

59. Appendix 8, page 411: Provide the *M521 AIR Hurricane Model for the United States Scope Document for Touchstone 8.1*.

60. Appendix 8, page 412: Provide the “two part” documents *Model 521 Porting and Implementation in Touchstone*.

61. Appendix 8, page 416: Provide documentation relating to the improvements made in coding standards and adherence to the standards.

Verified: YES

Professional Team Comments:

Reviewed documentation defining the process, decisions, implementation, and validation of updates to the model.

Reviewed process mapping standards.

Reviewed Individual Risk Module (IRM) inputs documentation.

Reviewed exposure disaggregation documentation.

Reviewed Touchstone® online help documentation.

Reviewed demand surge model documentation.

Discussed with the Computer/Information Standards signatory her review of the model changes and the corresponding documentation and implementation in the code.

Discussed with Narges Pourghasemi her recommendations to AIR on areas for code improvement outlined in her report found in Appendix 8 of the submission.

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

Discussed the change in internal model numbering for ratemaking in Florida.

Discussed that the definition of significant change given in the Report of Activities is used in the same manner in model documentation.

Reviewed the flowcharts for implementation of the model in Touchstone®.

Discussed that documentation is created separately and is maintained consistently with the source code.

CI-2 Hurricane Model Requirements

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

Audit

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

Pre-Visit Letter

52. CI-2, pages 179-180: Provide requirements documentation that specifically relates to each model change identified in Standard G-1 Disclosure 7 (pages 33-34).

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.

Pre-Visit Letter

53. CI-3.B, page 193: Provide the AIR Business Process Mapping Standards document.

Verified: YES

Professional Team Comments:

Reviewed revised AIR Business Process Mapping Standards defining the flowchart approach. Discussed modeler's plan to improve flowchart creation.

Reviewed revised control and data flowcharts and verified the compliance of the flowcharts with the modeler's business process mapping standards.

Reviewed the flowchart summarizing the processing and validating of ZIP Code centroid updates.

Reviewed the flowcharts defining the process for creating the submission forms.

Reviewed the flowchart for event catalog updates.

Reviewed the flowchart for development of vulnerability functions.

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: YES

Professional Team Comments:

Reviewed spreadsheet data and code implementation of the pressure deficit decay function. Reviewed the terms and variables associated with the decay function. Reviewed the corresponding variable mapping.

Reviewed script responsible for the generation of Form S-1.

Reviewed IRM code implementation.

Reviewed the network organization structure.

Reviewed the Touchstone® Installation Guide.

Reviewed the traceability of model components.

Reviewed the interfaces and coupling assumptions documentation.

Reviewed updates to the coding standards from the previously-accepted model. Discussed the mandatory training program implemented to train software developers.

Reviewed the table of software components that contains the number of lines of code and number of comment lines.

Discussed that the model runs as a single platform.

Reviewed secondary characteristics code implementation.

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.

Pre-Visit Letter

54. CI-5, pages 208-210: Provide complete and thorough verification procedures and output from the model changes identified in Standard G-1 Disclosure 7 (pages 33-34).

Verified: YES

Professional Team Comments:

Discussed the tests performed on geocoding for complete and incomplete street addresses.

Reviewed the testing plans and results for updated roof age bands.

Reviewed the testing plans and results for updates to the assignment for unknown roof age.

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

Reviewed the Quality Assurance test plans for Touchstone® 8.1.0.

Reviewed the flowchart of the testing process.

Reviewed the *Summary of Quality Assurance Process for Touchstone®*.

Reviewed example of cross-checking procedures.

Reviewed the validation process for externally provided data.

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

55. CI-6.D, page 218: Provide the model version history over the past 5 years, leading up to the version identified in the submission.

Verified: YES

Professional Team Comments:

Reviewed that AIR Hurricane Model for the U.S. V1.0.0 as implemented in Touchstone® 8.1.0 changed to AIR Hurricane Model for the U.S. V1.0.0 as implemented in Touchstone® 2020.

Reviewed changes in the internal and external version numbering process.

Reviewed examples of the former and new versioning system.

Reviewed the model version change history spreadsheet.

Reviewed the flowchart of the procedure for maintaining code, data, and documentation.

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:

Reviewed the security processes and procedures.

Discussed that there have been no security breaches.