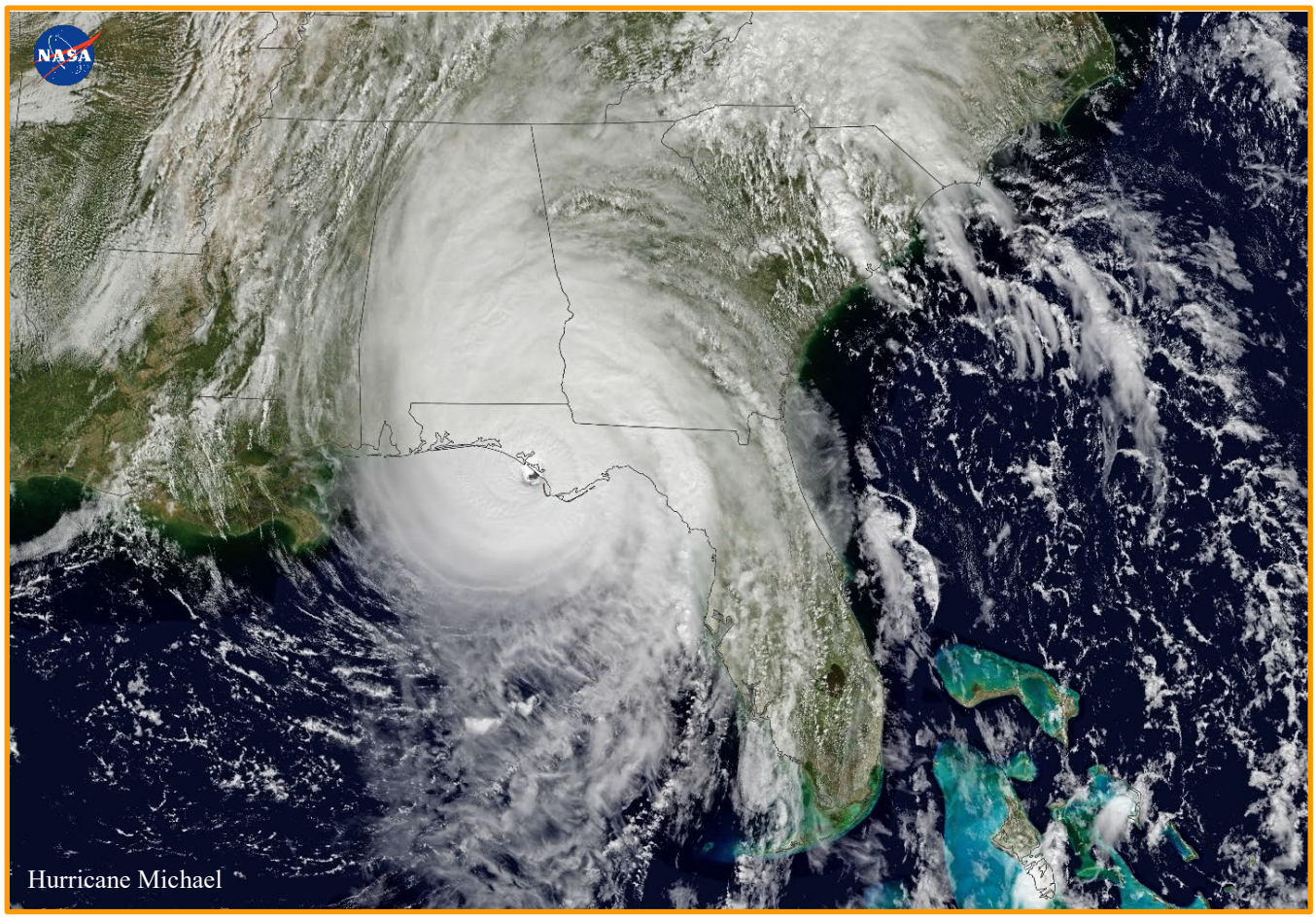
Florida Commission on Hurricane Loss Projection Methodology

Professional Team Report

2019 Hurricane Standards



Karen Clark & Company

Remote Review: February 15-18, 2021

Additional Verification Review: May 3-4, 2021

On February 15-18, 2021, the Professional Team conducted a remote review of the Karen Clark & Company (KCC), KCC US Hurricane Reference Model Version 3.0. The following individuals participated in the remote review.

KCC
Glen Daraskevich, Senior Vice President
Grant Elgin, Senior Software Engineer
Arnold Fernandes, Assistant Research Scientist
Michael Grayson, Ph.D., P.E., Consultant
Natalia Gust-Bardon, Ph.D., Research Statistician
Filmon Habte, Ph.D., Senior Wind Engineer
Nozar Kishi, Ph.D., Vice President, Model Development
Katelynn Larson, Senior Technical Writer
Daniel Ward, Ph.D., Senior Meteorologist
Joanne Yammine, FCAS, FCIA, Consultant

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

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

The Professional Team began the review with an opening briefing and introductions were made. KCC discussed logistics and how materials would be presented and shared during the remote review. KCC next provided an overview of updates to the model.

- Frequency and severity distributions updated
- Enhanced coastal segmentation for track directions
- Refined track curvature assumptions with impacts on multiple landfall events
- Updated Rmax and forward speed distributions
- Updated year-built bands for manufactured homes to reflect evolution of HUD design requirements
- Roof cover age bands updated to reflect effects of aging based on roof warranties
- Secondary modifiers updated
- ZIP Codes and population-weighted centroids updated

The audit continued with a review of each standards section. KCC provided further details on the problem detected in generating some of the actuarial and statistical forms where the

application of secondary characteristic modifiers did not get applied (see the February 11, 2021 notification letter from KCC included at the end of the report). All standards associated with the impacted forms could not be verified pending review of those forms.

During the Commission meeting to review the model for acceptability under the 2019 Hurricane Standards, KCC 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.

*****Additional Verification Review – May 3-4, 2021*****

KCC submitted revisions on March 24, 2021 to the submission document in response to items identified by the Professional Team during the February 2021 remote review and revisions to the actuarial and statistical forms that had been created without using secondary characteristic modifiers. The Professional Team completed an additional verification review remotely on May 3-4, 2021.

The following individuals participated in the additional verification review.

KCC
Glen Daraskevich, Senior Vice President
Grant Elgin, Senior Software Engineer
Natalia Gust-Bardon, Ph.D., Research Statistician
Filmon Habte, Ph.D., Senior Wind Engineer
Katelynn Larson, Senior Technical Writer
Daniel Ward, Ph.D., Senior Meteorologist

Professional Team
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Steve Kolk, ACAS, MAAA, Actuary, observer
Stu Mathewson, FCAS, MAAA, Actuary
Masoud Zadeh, Ph.D., P.E., Structural Engineer
Donna Sirmons, Staff

During the additional verification review, open items from the initial audit were reviewed and discussed as well as new issues that surfaced during the course of the audit. Revised forms were reviewed. KCC explained the resolutions to the annual aggregate deductible application issue and the issue with secondary modifier files.

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

Report on Deficiencies

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

1. G-1, Disclosure 2, page 16, Intensity Footprint Module: Incomplete. Provide references for "as recommended in the published literature."

2. G-1, Disclosure 7.A, pages 34-35: Incomplete. Updates given under Standard V-4, Disclosure 1 (page 113) are not reported in the Vulnerability Module updates and rationale.

3. G-1, Disclosure 7, pages 36-37, and Form A-5, pages 256-260: Unclear. The county boundaries depicted in Figures 4-7 and Figures 68-75 are irregular and are difficult to relate to actual county boundaries (e.g., Glades, Hendry, Miami-Dade). These maps need to be redone.

4. G-3, Disclosure 5, page 54: Incomplete. Vulnerability Regions ZIP Code database is not covered.

5. M-3, Disclosure 2, page 65: Incomplete. The parameters n and X_i for Annual Landfall Frequency in Table 3 should be defined.

6. M-4, Disclosure 7, pages 69-70: Non-responsive. Color scheme does not meet the Acceptability Process requirements.

7. Form S-3, page 180: Unclear. Correct the distribution support for maximum sustained windspeed (i.e., $\xi < \sigma, \mu, \xi, \in (-\infty, \infty)$).

8. Form S-3, page 180: Unclear. Distinguish between the function "f" that relates R_{max} to V_{max} and latitude and the distribution of the residual term $\boldsymbol{\varepsilon}$ also given by the apparent density function "f."

9. V-1, Disclosures 3 and 4, pages 98-99: Incomplete. No response to number of insurers, dates of hurricane loss, and amount of hurricane loss separated into personal residential, commercial residential, and manufactured homes provided.

10. V-4, Disclosure 2, page 113: Incomplete. Software identification used for calculating the impact of hurricane mitigation measures and secondary characteristics not included.

Professional Team Pre-Visit Letter

The Professional Team's pre-visit letter questions are provided in the report under the corresponding standards. Following is the pre-visit letter preamble.

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

The Professional Team will also be considering material in response to deficiencies designated by the Florida Commission on Hurricane Loss Projection Methodology (Commission) during the January 12, 2021 meeting.

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

The remote on-site schedule is tentatively planned to proceed in the following sequence: (1) 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 30, 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 January 27, 2021 track changes revised submission document.

1. G-1, Disclosure 2, page 18: Unanwa spelling corrected.
2. G-1, Disclosure 4, page 20: Links in Figure 3 corrected to add arrows for direction of the flow of information.
3. G-1, Disclosure 6, page 25: Link in Schwerdt et al. reference corrected.
4. G-1, Disclosure 6, page 27: Schroeder added to 2002 reference with Iman et al.
5. G-1, Disclosure 6, page 28: Wilks (1995) reference added to statistical references.
6. G-1, Disclosure 7, page 37: revised to clarify changes to the impacts of secondary characteristics and mitigation measures.
7. M-2, Disclosure 3, page 62: revised to clarify track direction distribution.
8. M-3, Disclosure 2, page 66: revised to remove track direction and to add annual landfall frequency and event day of year.
9. M-3, Disclosure 2, pages 67-68: revised to remove track direction at landfall, to clarify annual landfall frequency distribution, and to add event day of year.
10. M-5.B, page 77: Space added to “thehurricane” in the standard wording.
11. M-6, Disclosure 1, page 79: revised to clarify asymmetry.
12. S-1, Disclosure 1, pages 82-83: revised to remove track direction at landfall and to add event day of year and annual landfall frequency.
13. S-1, Disclosure 1, page 83: Empirica spelling corrected in Figure 21 legend.
14. S-1, Disclosure 6, page 86: revised to remove track direction.
15. V-1.D, page 102: Reference to “Standard V-3” should be “Standard V-4.”
16. V-2.A, page 112: Removed “and time element” as no longer applicable to Standard V-2.
17. V-4, Disclosure 1, page 119: revised to clarify the impacts of secondary characteristics and mitigation measures have been updated.
18. CI-6, Disclosure 2, page 158: revised for clarification.
19. Form V-2, Excel file KCC19_FormV2_201030: Worksheet name “KCC17FormV2” corrected.
20. Form S-3, pages 187-188: revised to remove track direction at landfall, to clarify annual landfall frequency distribution, and to add event day of year.

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, page 13: Provide documentation of the process.

2. G-1, Disclosure 2, page 16: Provide a copy of the Hurricane Hugo (1989) post-event investigation report. Explain how this has been used in the model.

3. G-1, Disclosure 2, page 17: Explain the development of 100,000 secondary uncertainty distributions.

4. G-1, Disclosure 7, page 35 and M-2, Disclosure 3, page 59: Provide details on the "empirical distribution" for event frequency and compare its character to the previous negative-binomial distribution.

5. G-1, Disclosure 7, page 36: Discuss the geographic structure due to the changes to event generation and parameter distributions.

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending review of revised forms, including Forms S-2, A-3, A-4, A-5, A-6, A-7, and A-8.

Reviewed documentation on the product management process to ensure all model documentation is current after an update to the model or to software. Reviewed the Documentation Review Checklist and a flowchart of the Project Review Process.

Reviewed examples of the post-disaster field survey data from Hurricane Hugo (1989).
Discussed the development of secondary uncertainty probability distributions and validation with insurer claims data. Reviewed graphical representations of sample secondary uncertainty distributions.

Reviewed the development of an empirical distribution for the number of events per year based on modification of a negative binomial fit. Reviewed the comparisons to historical data and to the previous negative binomial fit.

Reviewed map of percentage differences in hurricane loss costs due to changes in the event catalog, including frequency, track direction, and track curvature. Discussed the impact in specific areas of Florida from each update.

Reviewed the automated procedure used to create the hurricane output ranges, Form A-4.

Discussed that updated ZIP Code to county mappings for Form A-1 and an updated method for calculating uncertainty intervals in Form A-8 since the initial submission resulted in differences in certain forms, but no impacts on modeled loss costs or PMLs.

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

Verified after review of revised Forms S-2, S-5, A-2, A-3, A-4, A-5, A-6, A-7, and A-8.

Reviewed table of submission changes since the initial submission.

Reviewed the impact on the average annual zero deductible statewide hurricane loss costs after the application of secondary loss modifiers.

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

A. Hurricane model construction, testing, and evaluation shall be performed by modeling organization personnel or consultants who possess the necessary skills, formal education, and experience to develop the relevant components for hurricane loss projection methodologies.

B. The hurricane model and hurricane model submission documentation shall be reviewed by modeling organization personnel or consultants in the following professional disciplines with requisite experience: structural/wind engineering (licensed Professional Engineer in civil engineering with a current license), statistics (advanced degree), actuarial science (Associate or Fellow of Casualty Actuarial Society or Society of Actuaries), meteorology (advanced degree), and computer/information science (advanced degree or equivalent experience and certifications). These individuals shall certify Expert Certification Forms G-1 through G-6 as applicable.

Audit

1. The professional vitae of personnel and consultants engaged in the development of the hurricane model and responsible for the current hurricane model and the submission will be reviewed. Background information on the professional credentials and the requisite experience of individuals providing testimonial letters in the submission will be reviewed.

2. Forms G-1, General Standards Expert Certification; G-2, Meteorological Standards Expert Certification; G-3, Statistical Standards Expert Certification; G-4, Vulnerability Standards Expert Certification; G-5, Actuarial Standards Expert Certification; G-6, Computer/ Information Standards Expert Certification, and all independent peer reviews of the hurricane model under consideration will be reviewed. Signatories on the individual forms will be required to provide a description of their review process.

3. Incidents where modeling organization personnel or consultants have been found to have failed to abide by the standards of professional conduct adopted by their profession will be discussed.

4. For each individual listed under Disclosure 2.A, specific information as to any consulting activities and any relationship with an insurer, reinsurer, trade association, governmental entity, consumer group, or other advocacy group within the previous four years will be reviewed.

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending updated expert certifications.

Reviewed resumes of new personnel:

- Christopher Burke, Ph.D. in Physics, Tufts University, Medford, MA; M.S. in Physics, Tufts University, Medford, MA; B.S. in Physics, Lehigh University, Bethlehem, PA
- Adrian Corman, Ph.D. in Physics, University of Missouri, Columbia, MO; B.S. in Physics and Mathematics, College of Charleston, Charleston, SC
- Adam Dimanshteyn, B.A. in Economics and Mathematics, Boston University, Boston, MA
- Arnold Fernandes, M.A. in Earth Sciences, Boston University, Boston, MA; M.S. in Geology, University of Mumbai, Mumbai, India; B.S. in Geology with Minors in Physics and Mathematics, University of Mumbai, Mumbai, India
- Natalia Gust-Bardon, Ph.D. in Economics, University of Szczecin, Szczecin, Poland; M.S. in Statistics and Data Science, University of Texas, San Antonio, TX

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

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

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

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 updates to ZIP Code centroids including testing for centroids in uninhabitable terrain or over water and expansion of validation datasets for quality assurance testing of third-party data.

Reviewed comparisons of ZIP Code centroid locations from the previously-accepted model.

Discussed the process for handling tax parcels that fall outside the third-party vendor ZIP Code boundaries.

Reviewed an example stress test of geocoding assignments for a variety of input data. Reviewed examples of geocoding for complete or incomplete street addresses.

Reviewed the ZIP Code-based databases for ZIP Code boundaries and population-weighted ZIP Code centroids.

Reviewed map of the Florida vulnerability regions classified by ZIP Code and year of construction.

G-4 Independence of Hurricane Model Components

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

Audit

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

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

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending verification of other standards.

Reviewed flowchart of implementation of the different independent model components.

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

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

Verified after resolution of outstanding issues from other standards.

G-5 Editorial Compliance

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

Audit

1. An assessment that the person who has reviewed the submission has experience in reviewing technical documentation and that such person is familiar with the submission requirements as set forth in the *Hurricane Standards Report of Activities as of November 1, 2019* will be made.
2. Attestation that the submission has been reviewed for grammatical correctness, typographical accuracy, completeness, and no inclusion of extraneous data or materials will be assessed.
3. Confirmation that the submission has been reviewed by the signatories on the Expert Certification Forms G-1 through G-6 for accuracy and completeness will be assessed.
4. The modification history for submission documentation will be reviewed.
5. A flowchart defining the process for form creation will be reviewed.
6. Form G-7, Editorial Review Expert Certification, will be reviewed.

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending updated expert certifications.

Discussed with the Editorial Review signatory the documentation process for compiling the submission document, including review by each subject matter expert.

Reviewed revised flowchart defining the process for creating submission forms.

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

Discussed that the error in the process of generating certain of the actuarial and statistical forms in which the application of secondary characteristic modifiers did not get applied was detected by KCC upon re-review of the submission forms just prior to the remote review.

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

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

METEOROLOGICAL STANDARDS – Tim Hall, Leader

M-1 Base Hurricane Storm Set*

*(*Significant Revision)*

A. The Base Hurricane Storm Set is the National Hurricane Center HURDAT2 as of July 1, 2019 (or later), incorporating the period 1900-2018. Annual frequencies used in both hurricane model calibration and hurricane model validation shall be based upon the Base Hurricane Storm Set. Complete additional season increments based on updates to HURDAT2 approved by the Tropical Prediction Center/National Hurricane Center are acceptable modifications to these data. Peer reviewed atmospheric science literature may be used to justify modifications to the Base Hurricane Storm Set.

B. Any trends, weighting, or partitioning shall be justified and consistent with current scientific and technical literature. Calibration and validation shall encompass the complete Base Hurricane Storm Set as well as any partitions.

Audit

1. The modeling organization Base Hurricane Storm Set will be reviewed.

2. A flowchart illustrating how changes in the HURDAT2 database are used in the calculation of hurricane landfall distribution will be reviewed.

3. Changes to the modeling organization Base Hurricane Storm Set from the previously-accepted hurricane model will be reviewed. Any modification by the modeling organization to the information contained in HURDAT2 will be reviewed.

4. Reasoning and justification underlying any short-term, long-term, or other systematic variations in annual hurricane frequencies incorporated in the hurricane model will be reviewed.

5. Modeled probabilities will be compared with observed hurricane frequency using methods documented in current scientific and technical literature. The goodness-of-fit of modeled to historical statewide and regional hurricane frequencies as provided in Form M-1, Annual Occurrence Rates, will be reviewed.

6. Form M-1, Annual Occurrence Rates, will be reviewed for consistency with Form S-1, Probability and Frequency of Florida Landfalling Hurricanes per Year.

7. Comparisons of modeled probabilities and characteristics from the complete historical record will be reviewed. Modeled probabilities from any subset, trend, or fitted function will be reviewed, compared, and justified against the complete HURDAT2 database. In the case of partitioning, modeled probabilities from the partition and its complement will be reviewed and compared with the complete HURDAT2 database.

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending review of revised forms, including Forms S-5 and A-2.

Reviewed the Base Hurricane Storm Set based on HURDAT2 years 1900-2018 and changes from previously-accepted model.

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

Discussed modifications to the frequency and severity Pareto distributions for Florida regions, including increases in the frequency of the most intense hurricanes throughout Florida.

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

Reviewed research on global and North Atlantic trends in hurricane intensity.

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

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

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

Reviewed Vmax probability distributions of historical and modeled fits for different regions of Florida.

Reviewed histograms comparing modeled and historical Rmax and forward speed.

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

Verified after review of revised Forms S-5 and A-2.

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

6. M-2, Disclosure 3, page 59: Discuss the change to “100-mile segments” for track direction on the coast from the “90-mile moving windows” of the previously-accepted model.

7. M-2, Disclosure 9, page 61, Figures 9-11: Provide the mile markers associated with the red dots in Figure 9. Describe the origin of the landfall frequency changes from the previously-accepted model, particularly the decreased Category 1-2 rates from mile markers 4180-4300.

Verified: YES

Professional Team Comments:

Reviewed changes to the annual occurrence rate distribution.

Discussed the change in methodology for track direction at landfall from a moving window centered on landfall location to 100-mile fixed coastal segments. Reviewed maps comparing the track differences between the current model and the previously-accepted model for different regions in Florida.

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

Discussed the update to track curvature assumptions to better match historical tracks. Reviewed comparison maps reflecting the track differences between the current model and the previously-accepted model.

Reviewed the revised distributions for Rmax and forward speed. Reviewed the distribution fit compared to historical data for the normalized Rmax residuals.

Reviewed comparison of modeled and historical forward speed distributions.

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

Reviewed calculation of track directions.

Discussed landfalling storm frequencies and additional smoothing applied to the frequencies.

Reviewed the dependency of modeled Rmax on Vmax.

Reviewed map of the NLCD 2011 Land Cover (amended in 2014), National Geospatial Data Asset (NGDA) Land Use Land Cover 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.

Pre-Visit Letter

8. M-3, Disclosure 2, pages 63-65: Explain how the revised Rmax and forward speed distributions affect the ternary-tree sampling scheme.

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending review of revised forms, including Form A-2.

Discussed that changing Rmax and forward speed distributions affect the probabilities in the ternary tree branches. The resulting probabilities are reflected in the Year Loss Table (YLT).

Reviewed goodness-of-fits for Vmax, track direction at landfall, Rmax, forward speed, and over-land decay.

Discussed that there were no changes in the ternary tree methodology from the previously-accepted model.

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

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

Verified after review of revised Form A-2.

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

9. M-4, Disclosure 7, pages 68-70: Justify the assumption of open terrain for standardizing windspeed observations during model validation.

10. M-4, Disclosure 7, pages 69-70: Provide a scatter plot of modeled versus historical windspeeds for the data shown in Figures 13-16.

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending review of revised forms, including Form A-2.

Discussed the assumption of open terrain for standardizing windspeed observations during model validation.

Reviewed scatter plots of modeled versus historical windspeeds for Hurricane Charley (2004), Hurricane Jeanne (2004), Hurricane Wilma (2005), and Hurricane Irma (2017). Discussed the windfield for Hurricane Michael (2018).

Reviewed Hurricane Michael (2018) post-disaster survey data collected and the use of field observations to estimate windspeeds in regions that lack observations when validating the model's windfield footprint.

Reviewed map depicting the spatial distribution of model surface roughness.

Discussed the changes to the windfields for Hurricane Matthew (2016) and Hurricane Irma (2017).

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

Verified after review of revised Form A-2.

M-5 Hurricane Landfall and Over-Land Weakening Methodologies

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

B. The transition of winds from over-water to over-land within the hurricane model shall be consistent with current state-of-the-science.

Audit

1. The variation in over-land decay rates used in the hurricane model will be reviewed.

2. Comparisons of the hurricane model weakening rates to weakening rates for historical Florida hurricanes will be reviewed.

3. The detailed transition of winds from over-water to over-land (i.e., hurricane landfall, boundary layer) will be reviewed. The region within 5 miles of the coast will be emphasized. Color-coded snapshot maps of roughness length and spatial distribution of over-land and over-water windspeeds for Hurricane Andrew (1992), Hurricane Jeanne (2004), and Hurricane Irma (2017) at the closest time after landfall will be reviewed.

Verified: YES

Professional Team Comments:

Discussed that the change in the over-land weakening calculation to ensure ultimate sufficient decay does not have an impact on the over-land decay rates in Florida.

Discussed no change in the over-land decay parameters.

Reviewed plots comparing model over-land weakening rates to historical Florida hurricane weakening rates.

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

M-6 Logical Relationships of Hurricane Characteristics

A. The magnitude of asymmetry shall increase as the translation speed increases, all other factors held constant.

B. The mean windspeed shall decrease with increasing surface roughness (friction), all other factors held constant.

Audit

1. Form M-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

11. M-6, Disclosure 1, page 74: Describe the adaptation of the Schwerdt et al. (1979) formulation to the model's windfield asymmetry.

12. M-6, Disclosure 2, page 74: Provide detail on the modeling of surface roughness and its impact on modeled windspeed.

13. M-6, Disclosure 4, page 75: Provide scatter plots, similar to Figure 18, for Rmax and for the 40 mph-threshold wind radius.

Verified: YES

Professional Team Comments:

Discussed the windfield asymmetry factor and the use of Schwerdt et al. (1979).

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

Reviewed scatter plots of modeled versus historical Rmax and 40-mph threshold wind radii.

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

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

STATISTICAL STANDARDS – Mark Johnson, Leader

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

*(*Significant Revision)*

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

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

Audit

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

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

Pre-Visit Letter

14. S-1, Disclosure 1, page 77 and Form S-3, page 180: Provide the values of the two support limits, *a* and *b*, how these limits relate to the means and standard deviations of the raw directions and the details in conducting the goodness-of-fit tests associated with track direction at landfall. Provide the data underlying the tests and the choice of support of the track direction distribution.

15. S-1, Disclosure 6, page 81: Describe the source of the damage observational data in Figure 25. Have these data been binned or averaged in the figure, and if so, how? Discuss the cases of observational data well below modeled.

16. Form S-1, page 177 and Form S-3, page 181: Rectify the Annual Landfall Frequency distribution as the empirical distribution function in Form S-3 versus the distribution explicitly given in Form S-1.

17. Form S-1, page 177: Justify the Modeled Frequency being identical for 7, 8 and 9 hurricanes per year.

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending review of revised forms, including Forms S-2, S-5, and A-8.

Reviewed the support limits and underlying data for the track direction uniform distributions. Discussed justification for the uniform distribution fit to support weighting of the track directions in the ternary tree. Reviewed the *p*-values from the Shapiro-Wilk goodness-of-fit tests. Reviewed the historical versus modeled cumulative distribution function for track direction.

Discussed the underlying data in Figure 25, Actual versus Modeled Mean Damage Ratios.

Discussed development of the model frequencies for events per year and its impact on the Year Loss Table (YLT).

Reviewed goodness-of-fit tests for Vmax, Rmax, track direction, forward speed, and landfall frequency distributions. Reviewed comparisons of the historical and modeled distributions.

Reviewed Pareto distribution fits for Vmax.

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

Verified after review of revised forms, including Forms S-2, S-5, and A-8.

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

Reviewed updated annual probability of exceedance for the 2017 FHCF exposure data.

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.

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending review of an open item.

Reviewed the lower and upper confidence intervals and the standard error as a percentage of hurricane loss cost estimates in Nassau County.

Discussed the methods and relevance of demonstrating negligible sampling error in the context of the model's ternary tree methodology.

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

Verified after review of open items.

Reviewed plot of average annual loss costs for event catalogs of different year-lengths for Nassau County.

Discussed the stability of loss costs for event catalogs using the ternary tree methodology.

Reviewed sensitivity test on the number of nodes in the ternary-tree structure related to the convergence of losses by county.

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 modeled versus actual losses for various insurance company data.

Reviewed client exposure data and hurricane landfall dates associated with the company loss data.

Discussed no changes in the demand surge methodology from the previously-accepted model.

Discussed claims processing to determine which claims to include during model validation.

Reviewed differences between mean historical and modeled loss costs.

Reviewed state and county tables comparing modeled to actual 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: ~~NO~~ YES

Professional Team Comments:

Not verified pending review of revised forms, including Form S-5.

Discussed that in comparisons of historical and modeled hurricane loss costs, the model treats hurricane parameters in an identical fashion.

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

Verified after review of revised Form S-5.

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

18. V-1, Disclosure 1, page 97: Explain in detail the impacts of the change on the manufactured homes vulnerability functions for building, contents, and time element. Provide a graphical comparison of the current and previously-accepted model manufactured homes vulnerability functions.

19. V-1, Disclosure 1, page 97: Elaborate on "These analyses have resulted in refinements to the model assumptions" given under Standard G-1 Disclosure 7 (page 35). Explain the refined model assumptions and their impact on the vulnerability functions. Provide a graphical comparison of the current and previously-accepted model vulnerability functions.

20. V-1, Disclosures 1 and 2, pages 97-98: Explain how the flowchart, depicted in Figure 35 for development and implementation of hurricane vulnerability functions, has been applied to the development of new manufactured homes vulnerability functions.

21. V-1, Disclosure 3, pages 98-99: Provide examples of client-specific claims data used for validating wood frame, masonry, and manufactured homes vulnerability functions.

22. V-1, Disclosure 7, pages 101-103: Explain why "Unknown" is missing from Table 11. Explain how the year-built bands interact with the four Florida vulnerability regions. Provide a map of the four regions.

23. V-1, Disclosure 9, page 104: Demonstrate and provide supporting plots for "The relationship between building and appurtenant structure vulnerability functions used in the KCC Hurricane Reference Model is consistent with insurance claims data."

29. Form V-1, page 190: Explain the closeness of the curves for contents and time element in Figure 60.

30. Form V-1, page 191: Explain the 42.39% time element loss ratio when building loss is 72.23% and contents loss is 44.24% for the 161-170 windspeed range.

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending review of revised forms, including Form A-6.

Reviewed updates to the manufactured home year-built bands to capture the evolution in Housing and Urban Development (HUD) design requirements. Reviewed the new vulnerability functions corresponding to the new year-built bands.

Discussed the change in calculation of vulnerability functions for manufactured homes with an unknown year-built.

Reviewed comparison of manufactured home vulnerability functions in different year-built bands for the current model to the previously-accepted model.

Discussed the updates to the roof coverage age definitions and the corresponding base secondary modifier updates for the different roof cover age options.

Reviewed comparisons of change in loss for new and old roof covers relative to average roof cover for a specific windspeed.

Discussed the year bands for site-built homes.

Discussed calculation of vulnerability functions for manufactured homes when both year built and construction type are unknown.

Reviewed comparison of building vulnerability functions across year bands between the current and the previously-accepted model.

Reviewed flowchart for development and implementation of vulnerability functions.

Reviewed scatter plot of actual loss to modeled loss by ZIP Code for manufactured homes, and wood frame and masonry constructions.

Reviewed maps of the pre-2012 and post-2012 vulnerability regions.

Reviewed scatter plot of modeled to claims mean damage ratios for wood frame and for appurtenant structures.

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

Reviewed the aerodynamic wind loading database used to develop the base vulnerability functions.

Reviewed Form V-1 and the selection of primary and secondary building characteristics to develop the vulnerability functions for the reference structure.

Reviewed flowchart of the process for completing Form V-1.

Reviewed the primary building characteristics and construction types implemented in the model.

Reviewed mapping of construction types to model construction codes and occupancy types to model occupancy codes.

Discussed that the vulnerability functions vary by year-built bands to account for building aging, updated building codes, and improvements in construction techniques and building materials.

Reviewed map of HUD Zones II and III used to determine the manufactured home vulnerability regions.

Discussed that the minimum windspeed at which damage starts in the model is 25 mph.

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

Discussed that no client-specific adjustments are made to actual claims data used for model validation.

Discussed that vulnerability functions are computed as the ratio of repair cost to replacement cost.

Reviewed sample comparison of condo-homeowner association and condo-unit owner vulnerability functions.

Reviewed the Damage Function Generator requirements documentation.

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

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

Verified after review of revised Form A-6.

Reviewed revised Form A-1.

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, Disclosures 1 and 2, pages 106-107: Explain how the flowchart, depicted in Figure 36 for derivation and implementation of contents vulnerability functions, has been applied to the development of new manufactured homes contents vulnerability functions.

25. V-2, Disclosure 4, page 108: Provide a comparison of a contents damage vulnerability function for a wood frame single-family dwelling with a condo unit located at the 10th floor of a 20-story concrete building.

26. V-2, Disclosure 5, page 108: Provide example plots of the relationship between building structure and contents vulnerability functions with insurance claims data.

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending review of revised forms, including Form A-6.

Reviewed relationship between contents damage ratio and building damage ratio for different occupancy types. Discussed that the new contents vulnerability functions for manufactured homes are based on the same building-to-contents relationship in the previously-accepted model.

Reviewed comparison of contents vulnerability functions for a single family, wood frame construction and a condo unit, concrete construction.

Reviewed scatter plot of the relationship between contents and time-element mean damage ratios from claims data.

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

Discussed the use of historical data to validate the contents vulnerability functions and relationships.

Reviewed observations from the KCC damage survey after Hurricane Irma (2017).

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

Verified after review of revised Form A-6.

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

27. V-3, Disclosures 1 and 2, pages 109-110: Explain how the flowchart, depicted in Figure 37 for derivation and implementation of the time element vulnerability functions, has been applied to the development of new manufactured homes time element vulnerability functions.

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending review of revised forms, including Form A-6.

Reviewed Form V-1. Reviewed the time-element to building relationship. Discussed that the new time-element vulnerability functions for manufactured homes are based on the same building-to-time-element relationship in the previously-accepted model.

Reviewed scatter plot of the relationship between contents and time-element mean damage ratios from claims data.

Discussed that the relativities between building and time-element vulnerability functions have not changed from the previously-accepted model.

Reviewed the building repair time analysis. Discussed that time-element vulnerability is a function of both building repair-related time and event-related time.

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

Verified after review of revised Form A-6.

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 113: Explain the two changes listed.

31. Form V-4, page 196: Explain the 0.00 change for all entries in Form V-4.

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending review of revised forms, including Form A-6.

Discussed the updates to the secondary modifier adjustment factors for roof cover, roof deck, roof-to-wall connections, window protection, door protection, and garage door type.

Reviewed the calculations determining the impact of secondary characteristics and mitigation measures.

Discussed that there are no changes to the base secondary modification factors from the previously-accepted model.

Discussed updates to adjustment factors for secondary modifier characteristics. Reviewed sample impact of the update to adjustment factors.

Reviewed sample comparisons of adjustment factors between the current model and the previously-accepted model for roof cover, roof-to-wall connection, roof decking, and window protection for the wind-borne debris region (WBDR).

Reviewed Forms V-2, V-3, V-4 and V-5. Discussed the 0.00 change in Form V-4.

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

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

Verified after review of revised Form A-6.

Discussed the resolution for the issue with secondary modifier files in completing the submission forms.

ACTUARIAL STANDARDS – Stu Mathewson, Leader

A-1 Hurricane Model Input Data and Output Reports

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

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

Audit

1. Quality assurance procedures, including methods to assure accuracy of insurance or other input data, will be reviewed. Compliance with this standard will be readily demonstrated through documented rules and procedures.

2. All hurricane model inputs and assumptions will be reviewed to determine that the hurricane model output report appropriately discloses all modifications, adjustments, assumptions, and defaults used to produce the hurricane loss costs and hurricane probable maximum loss levels.

Verified: YES

Professional Team Comments:

Reviewed KCC Exposure Data Processing Guide.

Reviewed KCC Exposure Import User's Guide.

Reviewed example of an Analysis Output Report.

A-2 Hurricane Events Resulting in Modeled Hurricane Losses

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

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

Audit

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

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

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

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

Pre-Visit Letter

32. A-2.B, page 129: Provide a copy of the documented procedure.

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending review of revised forms, including Form A-2.

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

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

Reviewed the criteria for identifying by-passing hurricanes.

Discussed that the hurricane model does not take into account any damage resulting directly from flood when the wind-only peril is selected.

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

Verified after review of revised Form A-2.

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

33. A-3, Disclosures 1-4, pages 130-131: Show a calculation of loss costs and probable maximum loss levels for the minimum Frame Owners loss costs in Form A-1 (Baker County ZIP Code 32087).

34. A-3, Disclosure 4, page 131: Explain how the model allows for different values of Law and Ordinance, i.e., the 25% and the 50% options. Explain how the model accounts for loss assessment coverage of $2,000 for condos.

Verified: YES

Professional Team Comments:

Reviewed a calculation of frame-owners loss costs in Form A-1 for ZIP Code 32087 in Baker County.

Reviewed the probable maximum loss (PML) calculations for ZIP Code 32087 in Baker County.

Discussed that law and ordinance coverage is not explicitly considered in the model. KCC discussed ongoing research for capturing law and ordinance in claims data.

Discussed with the Actuarial Standards signatory her involvement in preparation and review of the current model submission. Discussed how she attested the model results to be actuarially sound.

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

Discussed the treatment of loss assessment coverage for condo-unit owners.

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

35. A-4, Disclosure 1, page 132: 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.

36. A-4, Disclosure 3, page 133: Explain in detail the demand surge model. Provide a copy of the documented procedure and its implementation in the code.

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending review of revised forms, including Form A-8.

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

Reviewed the demand surge model documentation.

Reviewed calculation of demand surge factors and the process for incorporating them in the model.

Reviewed the methodology for determining probable maximum loss levels.

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

Verified after review of revised Form A-8.

A-5 Hurricane Policy Conditions*

*(*Significant Revision)*

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

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

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

Audit

1. The process used to determine the accuracy of the insurance-to-value criteria in data used to develop and validate the hurricane model results will be reviewed.

2. To the extent that insurance claims data are used to develop mathematical depictions of deductibles, policy limits, policy exclusions, and loss settlement provisions, the goodness-of-fit of the data to fitted models will be reviewed.

3. To the extent that insurance claims data are used to validate the hurricane model results, the treatment of the effects of deductibles, policy limits, policy exclusions, loss settlement provisions, and coinsurance in the data will be reviewed.

4. Treatment of annual deductibles will be reviewed.

5. Justification for the changes from the previously-accepted hurricane model in the relativities among corresponding deductible amounts for the same coverage will be reviewed.

Pre-Visit Letter

37. A-5, Disclosure 3, page 135: Explain how the hurricane model treatment of annual hurricane deductibles complies with Section 627.0701(5)-(9), Florida Statutes. Provide numerical evidence.

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending review of revised forms, including Forms A-4 and A-6.

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

Reviewed an annual hurricane deductible sample calculation.

Reviewed the Insurance Claims Processing Guide and the Insurance Claims Request Letter.

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

Reviewed Form A-6 losses between the current and previously-accepted model.

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

Verified after review of revised Forms A-4, A-5, A-6, and A-7.

Discussed the resolution to the annual aggregate deductible and secondary modifier application issues in completing submission Forms A-4, A-5, A-6, and A-7.

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

38. Form A-1, pages 199-201: Reconcile the changes in Form A-1 from the previously-accepted model with the maps in Form A-5 (pages 256-260). Specifically, Wakulla County shows a decrease of 5-20% on the map while Form A-1 seems to show an increase of about 60%.

39. Form A-1: Explain the addition of ZIP Codes 32461 (Bay County), 32162 (Lake County), 32550 (Okaloosa County), and 34224 (Sarasota County) in Form A-1.

40. Form A-1: Explain the large increases in ZIP Codes 32648 (Dixie County) and 32328 (Franklin County).

41. Form A-1: Provide a map for ZIP Codes 33001, 33036, 33037, 33040, 33042, 33043, 33050, 33051, and 33070 in Monroe County with the boundaries and centroids identified. Explain why, for Monroe County ZIP Code 341MX2, loss costs are out of range with those shown in Form A-1 for the above ZIP Codes.

42. Form A-2, pages 203-206: Explain the significant differences from the previously-accepted model for hurricanes NoName02-1916, Frederic-1979, Matthew-2016 and Irma-2017.

43. Form A-4, 0% Deductible, pages 240-247: Explain the reversal in loss costs where Frame is less than Masonry:
    Owners: Gulf Average, Pasco Average, St Johns Average,
    Renters: Dixie Average, Pasco Average, Wakulla Average, and
    Condo Unit: Franklin Average, Pasco Average, Wakulla Average.

44. Form A-4, page 242: 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.

45. Form A-4, page 243: With Form A-1 having only one ZIP Code for Lafayette County (32066), explain the values given in Form A-4 in Lafayette County for Low, Average, and High for Frame Owners, Masonry Owners, and Manufactured Homes.

46. Form A-5, page 255: Explain the weighting by coverage that agrees with the statewide change of +10.4% given in Standard G-1 Disclosure 7.B (page 35).

47. Form A-7, pages 262-271: For all tabs, explain the weightings that show that the statewide changes agree with the overall statewide change of +10.4% given in Standard G-1 Disclosure 7.B (page 35).

48. Form A-8, page 275: Explain the larger changes in Parts B and C from those in the previously-accepted model for the return periods 10 – 100 years, compared to the longer return times.

49. Form A-8, page 275: Provide details on the calculation of the uncertainty intervals.

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending review of revised forms, including Forms S-2, S-5, A-2, A-3, A-4, A-5, A-6, A-7, and A-8.

Discussed the changes in Form A-1 from the previously-accepted model, including changes introduced to the Form A-1 notional input exposure file.

Discussed the mapping of ZIP Codes 32461, 32162, 32550, and 34224 to the correct counties in revised Form A-1.

Discussed the increases in Form A-1 for ZIP Codes 32648 (Dixie County) and 32328 (Franklin County) due to updates to the ZIP Code centroids.

Reviewed map of certain population-weighted ZIP Code centroids and their boundaries in Monroe County as well as a filler ZIP Code in Monroe County.

Discussed the differences in Form A-2 losses from the previously-accepted model for hurricanes NoName02 (1916), Frederic (1979), Matthew (2016), and Irma (2017).

Reviewed the updates to the modeled footprints for Hurricane Matthew (2016) and Hurricane Irma (2017).

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

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

Verified after review of revised Forms S-2, S-5, A-2, A-3, and A-8 after application of the secondary modifier file, and revised Forms A-4, A-5, A-6, and A-7 after application of the secondary modifier file and annual aggregate deductible for multi-event years.

Reviewed revised Form A-1.

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

50. CI-1.B, page 141: Relate the primary binder table of contents with the response to Standard G-1 Disclosure 7 (pages 34-37) by demonstrating individual table item compliance with Computer/Information Standards CI-1 through CI-7.

51. CI-1.D, page 141: Provide the table required by Standard CI-1 Audit Item 7.

52. CI-1.F, page 141: Provide the list of all externally-acquired hurricane model-specific software and data assets as described and required by Standard CI-1 Audit Item 6.

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending verification of other standards.

Discussed that there have been no changes to the software engineering processes from the previously-accepted model.

Reviewed demand surge model documentation.

Reviewed product management process documentation.

Reviewed claims data processing guidelines.

Reviewed the table of changes as required by CI-1.D.

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

Discussed the use of Microsoft Team Foundation Server (TFS) for storing code, data files, and documentation.

Discussed that documentation is created separately from the source code and maintained within TFS.

Discussed the importance of complete documentation.

Reviewed the revised Model Development Guide.

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

Verified after resolution of outstanding issues.

Reviewed the vulnerability file documentation updated for process and software changes and schema references.

Reviewed the updated summary of changes table as required by CI-1.D.

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

53. CI-2, page 142: Provide requirements documentation that specifically relates to each model change identified in Standard G-1 Disclosure 7 (pages 34-37).

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending verification of other standards.

Reviewed software requirements documentation.

Reviewed the Damage Function Generator requirements documentation.

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

Verified after resolution of outstanding issues.

CI-3 Hurricane Model Organization and Component Design

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

B. All flowcharts (e.g., software, data, and system models) shall be based on (1) a referenced industry standard (e.g., Unified Modeling Language (UML), Business Process Model and Notation (BPMN), Systems Modeling Language (SysML)), or (2) a comparable internally-developed standard which is separately documented.

Audit

1. The following will be reviewed:
    a. Detailed control and data flowcharts, completely and sufficiently labeled for each component,
    b. Interface specifications for all components in the hurricane model,
    c. Documentation for schemas for all data files, along with field type definitions,
    d. Each network flowchart including components, sub-component flowcharts, arcs, and labels,
    e. Flowcharts illustrating hurricane model-related information flow among modeling organization personnel or consultants (e.g., BPMN, UML, SysML, or equivalent technique including a modeling organization internal standard), and
    f. If the hurricane model is implemented on more than one platform, the detailed control and data flowcharts, component interface specifications, schema documentation for all data files, and detailed network flowcharts for each platform.

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

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

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending verification of other standards.

Reviewed revised control and data flowcharts and verified the compliance of the flowcharts with ISO Standard 5807.

Reviewed updated flowchart for the revised form generation process.

Reviewed the Documentation Review Checklist.

Discussed the process for collaborating among subject matter experts.

Reviewed the flowchart for initial project kick-off meeting.

Reviewed the flowchart for project review meeting.

Reviewed flowchart for event catalog updates.

Reviewed revised flowchart for the geocoding process.

Reviewed examples of interface specifications for the model.

Reviewed examples of schema documentation for data files.

Reviewed network flowcharts.

Reviewed flowchart for development of surface friction and the information flow among modeling personnel.

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

Verified after resolution of outstanding issues.

Reviewed flowchart for the revised process for reviewing submission forms.

Reviewed flowchart for the revised model validation process adding vulnerability file and secondary modifier schema fields.

Reviewed flowchart for the revised damage initialization process.

Reviewed flowchart for the software update request process.

Reviewed schema reference documents for the hurricane data files.

CI-4 Hurricane Model Implementation*

*(*Significant Revision)*

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

B. Network organization documentation shall be maintained.

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

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

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

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

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

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

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

Audit

1. The interfaces and the coupling assumptions will be reviewed.

2. The documented coding guidelines, including procedures for ensuring readable identifiers for variables, constants, and components, and confirmation that these guidelines are uniformly implemented will be reviewed.

3. The procedure used in creating, deriving, or procuring and verifying databases or data files accessed by components will be reviewed.

4. The traceability among components at all levels of representation will be reviewed.

5. The following information will be reviewed for each component, either in a header comment block, source control database, or the documentation:
    a. Component name,
    b. Date created,
    c. Dates modified, modification rationale, and by whom,
    d. Purpose or function of the component, and
    e. Input and output parameter definitions.

6. The table of all software components as specified in CI-4.E will be reviewed.

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

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

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

10. Network organization implementation will be reviewed.

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending verification of other standards.

Reviewed terms and variables associated with windfield asymmetry.

Reviewed the calculations for track direction and annual hurricane deductible.

Reviewed the calculation for impact of secondary characteristics.

Reviewed the changes in calculations for inland decay and manufactured home vulnerability functions.

Reviewed example of code under Team Foundation Server (TFS) source control.

Reviewed the spreadsheet data for manufactured home vulnerability functions.

Reviewed spreadsheet data and code implementation of the minimum windspeed for damage.

Reviewed terms and variables for the vulnerability function mean damage ratios.

Reviewed sample code used to validate the model.

Reviewed coding guidelines documentation. Discussed that the guidelines have been updated from the previously-accepted model.

Reviewed examples of data files used for detection and notification of coding standard violations.

Reviewed an example of the procedure for creating, deriving, or procuring and verifying databases or data files.

Reviewed the traceability of all model components.

Reviewed the table of all software components that contains the number of lines of code by project.

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

Reviewed the hardware and operating system requirements for the model and platform.

Reviewed flowchart for network organization implementation.

Reviewed the use of collaboration software for managing checklists associated with model updates and maintenance.

Reviewed script responsible for the generation of Form A-4.

Reviewed a section of vulnerability function code where a threshold damage ratio is specified.

Reviewed additional vulnerability code verifying the minimal intensity threshold.

Reviewed the source revision software in the context of a Python script and its evolution.

Discussed the importance of variable naming convention.

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

Verified after resolution of outstanding issues.

Reviewed the software change to correct settings in the model definition file to resolve the issues where secondary modifiers and reduction in the annual deductible for multi-event years were not applied for certain Actuarial and Statistical forms in the initial submission.

Reviewed an example model definition file.

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 147-150: Provide complete and thorough verification procedures and output from the model changes identified in Standard G-1 Disclosure 7 (pages 34-37).

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending verification of other standards.

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

Reviewed the model deployment package process and the deployment log with checksum verification for the current model version 3.0.

Reviewed the procedure to ensure complete and accurate implementation of model updates.

Reviewed the verification procedures and maps of percentage changes in loss costs for the model updates in version 3.0.

Reviewed the coding practices, tracking and diagnostic reports to facilitate locating problems in the code.

Reviewed the testing software and an example of a unit test. Discussed that there have been no changes to the testing process and testing tools from the previously-accepted model.

Reviewed the validation process for externally provided data.

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

Verified after resolution of outstanding issues.

Reviewed new unit test and file validation for application of secondary modifier files.

Reviewed unit tests for the annual aggregate deductible.

Reviewed additional loss output tests for implementation of annual aggregate deductible in multi-event years.

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 151: Provide the model version history leading up to the version identified in the submission.

Verified: ~~NO~~ YES

Professional Team Comments:

Not verified pending verification of other standards.

Reviewed the model version history document.

Reviewed modeler policy for model maintenance and revision.

Discussed the version numbering system.

Reviewed the procedure to ensure completion of development projects.

Reviewed example of code review.

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

Verified after resolution of outstanding issues.

Discussed the build versioning system.

CI-7 Hurricane Model Security

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

Audit

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

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

3. Security aspects of each platform will be reviewed.

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

Verified: YES

Professional Team Comments:

Discussed updates to the security procedures.

Discussed security documentation, including:

- Information Security Policy
- Disaster Recovery Plan
- Antivirus and Malware Policy
- Access Control Policy.

Discussed that there have been no security breaches.

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The Innovation and Technology Leader in Catastrophe Risk Modeling

February 11, 2021

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

Re: Notification of Need for Revision

Dear Commission Chair Yager,

We would like to notify the Commission the KCC US Hurricane Reference Model Version 3.0 submission dated January 27, 2021 requires revisions.

In the process of generating certain of the actuarial and statistical forms, the application of secondary characteristic modifiers did not get applied. This means that several of the forms were created without using the secondary characteristic modifiers, such as roof geometry in Form A-4. This oversight occurred when setting up the process for calculating the individual model component percent changes. The most significant impact is on Form A-7 which generally shows the correct directional changes, but larger magnitude changes than should be indicated. For all other forms, the application of secondary characteristic modifiers will result in small percentage differences.

KCC would like to update the impacted forms in a revised submission which will take approximately two weeks. In the meantime, we'd like to proceed with the Professional Team on-site review next week with the understanding that a follow-up review will be required, likely in April, to review the revised forms and associated material.

Sincerely,

Glen Daraskevich
Senior Vice President