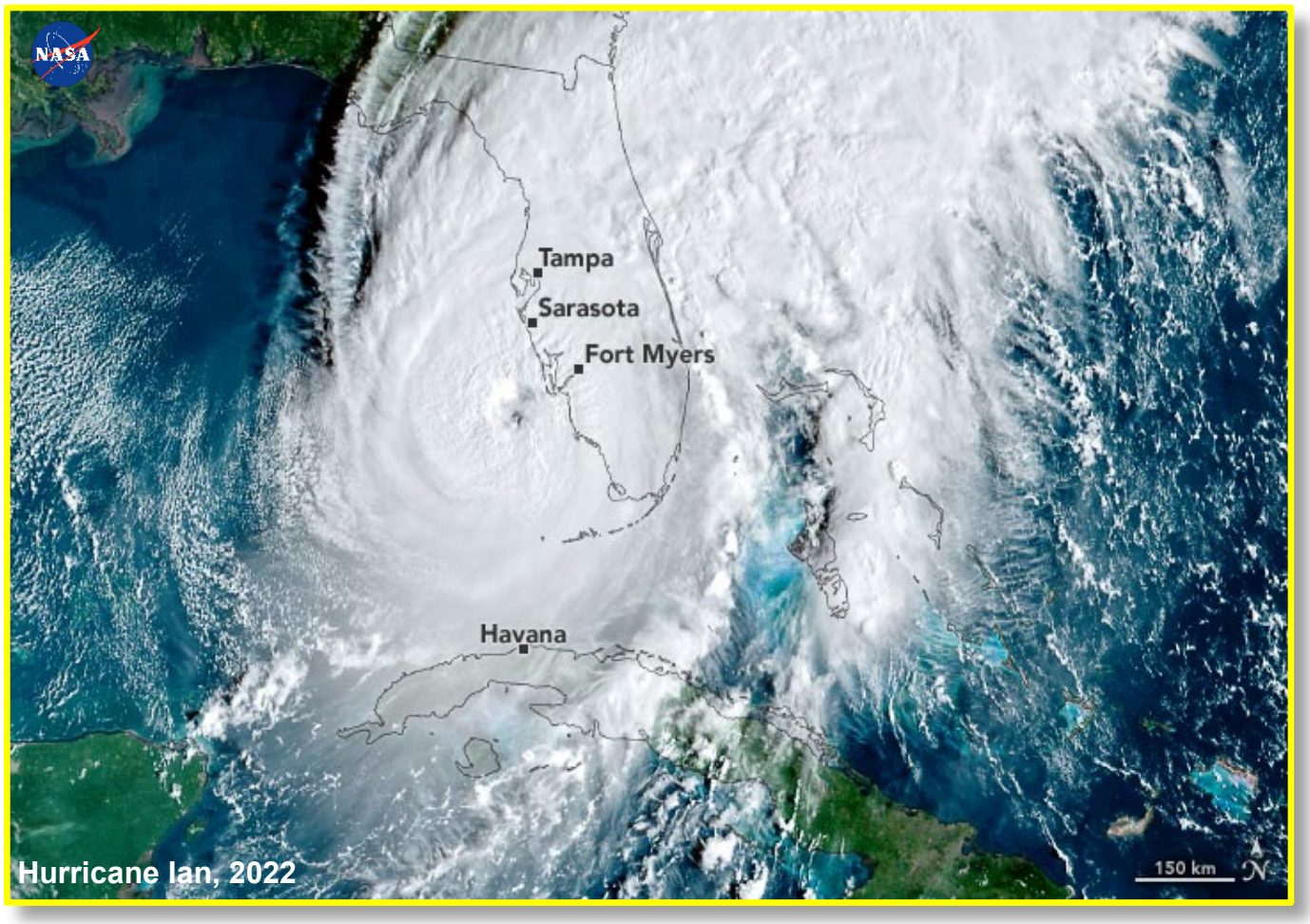
Florida Commission on Hurricane Loss Projection Methodology

Professional Team Report

2023 Hurricane Standards



Karen Clark & Company

On-Site Review: February 3-6, 2025

On February 3-6, 2025, the Professional Team conducted an on-site review of the Karen Clark & Company (KCC) US Hurricane Reference Model Version 5.0. The following individuals participated in the review.

KCC

Benjamin Aiken, Senior Property Data Analyst
William Bain, DevOps Engineer
Girma Bitsuamlak, Ph.D., P.E., FCSCE, Consultant
Karen Clark, CEO and President
Adrian Corman, Ph.D., Principal Software Developer
Connor Courtney, Risk Analyst
Glen Daraskevich, Senior Vice President
Kelly Flanigan, Senior Technical Writer
Arjun Jayaprakash, Ph.D., Principal Engineer
Shaoning Li, Ph.D., Principal Engineer
Taylor Ludl, Human Resource and Office Manager
Sereen Majdalaweyh, Principal Engineer
Benjamin Miller, Senior Risk Analyst
Marshall Pagano, Senior Director, Client Services
Laura Tomkins, Ph.D., Senior Atmospheric Scientist
Melinda Vasecka, ACAS, Actuarial Consultant
Daniel Ward, Ph.D., Senior Director, Model Development
Nick Weed, Principal Software Engineer
Hongyu Wu, Ph.D., Statistician

Professional Team

Jimmy Booth, Ph.D., Meteorology
Paul Fishwick, Ph.D., Computer/Information
Mark Johnson, Ph.D., Statistics, Team Leader
Stu Mathewson, FCAS, MAAA, Actuarial
Kevin Moran, Ph.D., Computer/Information, observer
Mark Powell, Ph.D., Meteorology, observer
Masoud Zadeh, Ph.D., P.E., Vulnerability
Donna Sirmons, Staff

Commission

Peggy Cheng, ACAS, Florida Office of Insurance Regulation Actuary
March Fisher, Citizens Property Insurance Corporation
Steve Paris, Ph.D., Statistics

The Professional Team began the review with an opening briefing and introductions were made. KCC provided a general overview of the hurricane model followed by an overview of the model updates from the current accepted model.

- Historical catalog updated for 2022-2023 events
- Distribution fits for Vmax, Rmax, forward speed, track direction, and overland decay updated based on the additional historical data from 2022-2023
- New year-built band (>2020) for site-built homes based on Florida Building Code 2020
- Vulnerability functions updated for site-built homes with respect to year-built bands, for manufactured homes, for unknown building year-built, and for unknown building construction
- Year-built and construction inventory distributions updated
- New vulnerability functions for different types of appurtenant structures
- Roof age definition updated to a continuous year scale
- Interactions between roof age and roof covering type updated
- New hurricane mitigation measures and secondary characteristics
- New options in existing building secondary characteristics
- ZIP Code centroids and related databases updated
- Demand surge function updated to reflect inflation
- Explicit modeling of law and ordinance coverage
- Support for roof actual cash value (RACV) modifier

KCC explained the impact on loss costs for each of the model updates. The combined model updates resulted in a 2.1% increase in the average annual zero deductible statewide hurricane loss costs.

KCC explained that the impact of climate change on hurricane intensity is calculated by analyzing the trends in the Global Hurricane Severity (HURSAT) dataset. The landfall intensities of all hurricane events in the historical database were adjusted to account for the impacts of climate change that has occurred to date. Historical trends in sea surface temperatures (SST) are used to measure how much climate change has occurred since hurricane landfall to the present. The result is a shift in hurricane intensities toward higher Saffir-Simpson categories. A plot comparing historical and adjusted for climate change annual landfall frequencies by Saffir-Simpson category was reviewed.

KCC discussed the manual error that occurred when generating FHCF losses from the Model Base Hurricane Set where demand surge was not applied and required revisions to Forms A-2 and A-3. The Professional Team reviewed the error, how it occurred, the revised forms, and corrective actions taken by KCC to mitigate against similar issues in the future, and confirmed there was no issue with the model, the platform, or other submission forms.

The audit continued with a review of each standards section.

Report on Deficiencies

No deficiencies in the KCC model submission were identified during the January 3, 2025, Commission meeting.

Professional Team Pre-Visit Letter

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

The purpose of this pre-visit letter is to outline specific issues unique to KCC's model submission under the 2023 hurricane standards, and to identify lines of inquiry that will be followed during the on-site review in order to allow time for adequate preparation. Aside from due diligence with respect to the full submission, various questions that the Professional Team will ask during the on-site review are provided herein. This letter does not preclude the Professional Team from asking for additional information during the on-site review that is not given below or discussed during an upcoming conference call to be held if requested by KCC. The goal of a potential conference call is to address your questions related to this letter or other matters pertaining to the on-site review. The overall intent is to help expedite the on-site review and to avoid last minute preparations that could have been undertaken earlier.

It is important that all material prepared for presentation during the 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 Professional Team will begin the review with an opening briefing. KCC should then proceed with an explanation of new or updated material related to the model. Afterwards, a review of the standards in the Hurricane Standards Report of Activities as of November 1, 2023, will commence. Each standard should be addressed beginning with responses to the pre-visit letter questions for that specific standard followed by responses to each of the audit items for that standard. KCC should discuss the Artificial Intelligence (AI) issue identified by the Commission at the January 3, 2025, meeting during the Computer Information Standards. The Professional Team will discuss with KCC the two Commission Inquiries regarding roof covering type and attachment, and building and roof vulnerability after the Professional Team exit briefing.

If changes have been made in any part of the model or the modeling process from the descriptions provided in the initial November 6, 2024, 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 any revised forms. For each revised form, provide an additional form with cell-by-cell differences between the revised and the original submitted values.

Refer to the On-Site Review chapter of the Hurricane Standards Report of Activities as of November 1, 2023, for details on materials to be presented and provided to the Professional Team (pages 94-96).

While the Report of Activities specifies 4 printed copies, additional Professional Team and Commission members will be in attendance. Please have available 9 printed copies of the presentations (printed two slides per page and duplexed), 1 additional printed copy of the actuarial standards presentation (printed two slides per page and duplexed), and 10 printed copies of the Form A-6 graphical summaries, the color-coded contour map of the hurricane loss costs for strong owners frame buildings, and the scatter plot of the hurricane loss costs against distance to closest coast for strong owners frame buildings.

All documentation should be easily accessible from a central location in order to be reviewed electronically.

GENERAL HURRICANE 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 presentation materials, scientific literature, technical literature, and modeling organization documents.

C. All software, data, and flowcharts (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 Hurricane Standards.

D. All meteorological forms, statistical Forms S-1, S-2, and S-6, and all actuarial forms with the exception of Form A-2 shall be produced through an automated procedure or procedures as indicated in the form instructions.

E. Vintage of data, code, scientific literature, and technical literature used shall be justifiable.

Verified: YES

Professional Team comments are provided in black font below.

Pre-Visit Letter

1. G-1.7.C, Figure 4, page 42:
   a. Provide details for the reason for changes in annual zero deductible hurricane loss costs due to change in hazard.

Discussed that the changes in the hazard component resulted in an increase in loss costs in north Florida, mostly inland from the Big Bend area coastline where Hurricane Idalia (2023) made landfall with a smaller contribution from slower inland decay in north Florida. It was

observed that there was a small decrease in loss costs in south Florida as a result of faster inland decay.

Reviewed comparisons to the current accepted model of the overland decay in north Florida and of the overland decay in south Florida.

b. Identify the specific updates in HURDAT2 that had an impact.

Discussed the three storms, Hurricane Ian (2022), Hurricane Nicole (2022) and Hurricane Idalia (2023), added to the historical catalog and their impact on landfall frequency and loss costs.

c. Explain how the changes in the hazard component result in changes in loss costs of up to 30% across multiple counties.

Discussed the 20-30% increase in event frequencies in North Florida in the region affected by Hurricane Idalia (2023) landfall. Reviewed a comparison to the current accepted model of historical events annual landfall occurrence rates and distance along the Florida coastline and adjacent states.

2. G-1.7.C, Figure 5, page 42: Explain the increase in Okaloosa and Leon Counties relative to the decreases in their respective neighboring counties.

Discussed the percentage changes in loss costs in Okaloosa and Leon Counties compared to changes in their neighboring counties that were due to changes in vulnerability. The differences between neighboring counties were due to variability in year-built distributions across the counties.

Audit

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

Reviewed the documented process for assuring continual agreement and correct correspondence of databases, data files, and computer source code. Discussed the process for assuring agreement between slides and technical papers with the source code. Reviewed several examples throughout the course of the audit.

2. Maps, databases, and data files relevant to the submission will be reviewed in the course of the on-site review.

All maps, databases, and data files were available for review. Reviewed samples throughout the course of the audit.

3. Justification for the vintage of data, code, scientific literature, and technical literature used will be reviewed in the course of the on-site review.

   Discussed the justification for the vintage of model components data, claims data, the RiskInsight® platform code base, and technical literature.

4. Supporting material for the hurricane model changes in Disclosure 7 will be reviewed.

   Reviewed the supporting material for the hazard model updates, the vulnerability component updates, and the financial component updates under each corresponding standards group.

   Reviewed the updated Vmax distribution fits and goodness-of-fit test results by region.

5. For any changes made in the hurricane model since the initial submission, color-coded maps by county reflecting the percentage difference in average annual zero deductible statewide hurricane loss costs based on the 2017 FHCF exposure data for each hurricane model component change, between the initial submission and the revised submission, and between any intermediate revisions and the revised submission, will be reviewed.

   Confirmed that there have been no changes to the hurricane model since the initial submission.

6. For any modifications to Form A-4 using the 2017 FHCF exposure data resulting from changes in the hurricane model since the initial submission, a newly completed Form A-5 with the initial submission as the baseline for computing the percentage changes, and with any intermediate revisions as the baseline for computing the percentage changes, will be reviewed.

   Confirmed that there have been no changes to Form A-4 since the initial submission.

7. If the output ranges in Form A-4 using the 2023 FHCF exposure data are regenerated since the initial submission, a Form A-5 based on the output range percentage changes using the 2023 FHCF exposure data with the initial submission as the baseline for computing the percentage changes, and with any intermediate revisions as the baseline for computing the percentage changes, will be reviewed.

   Not applicable as the output ranges have not changed since the initial submission.

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

*(*Significant Revision)*

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 (current licensed professional engineer), statistics (advanced degree or equivalent experience), 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.

Verified: YES

Professional Team comments are provided in black font below.

Pre-Visit Letter

3. G-2.2.B, page 54: Provide resumes of the new personnel.

Reviewed resumes of new personnel:

- Benjamin Aiken, M.S. in Urban Spatial Analytics, University of Pennsylvania, Philadelphia, PA; M.S. in Teaching, Texas Wesleyan University, Ft. Worth, TX; B. Design in Architecture, Washington University, St. Louis, MO
- William Bain, High School Diploma, Boot Camp Certificate, University of New Hampshire, Durham, NH
- Connor Courtney, B.S. in Astrophysics and B.S. in Mathematics, Tufts University, Medford, MA
- Daniel Flynn, B.A. in English, Boston College, Chestnut Hill, MA

- Vaughn Franz, M.S. in Computer Science, Northeastern University, Boston, MA; B.A. in Physics, University of Chicago, Chicago, IL

- Benjamin Kandel, B.S. in Computer Science, Michigan State University, East Lansing, MI

- Sereen Majdalaweyh, Ph.D. in Civil Engineering, Clemson University, Clemson, SC; M. of Engineering in Civil Engineering (Structural), University of Jordan, Amman, Jordan; B.Tech. in Civil Engineering, Mu'tah University, Mu'tah, Jordan

- Benjamin Miller, B.S. in Physics, Tufts University, Medford, MA

- Tyler Nguyen, B.A. in English, University of Massachusetts, Amherst, MA

- Ethan Schaeffer, M.S. in Computer Science, Georgia Institute of Technology, Atlanta, GA; B.S. in Atmospheric Science, Pennsylvania State University, University Park, PA

- Nihaal Subhash, M.S. in Computer Science, Northwestern University, Evanston, IL; B. of Engineering in Computer Engineering, Gujarat Technological University, Gujarat, India

- Laura Tomkins, Ph.D. in Geospatial Analytics, North Carolina State University, Raleigh, NC; M.S. in Atmospheric Science, University of Kansas, Lawrence, KS; B.S. in Meteorology, North Carolina State University, Raleigh, NC

- Hongyu Wu, Ph.D. in Statistics, Florida State University, Tallahassee, FL; M.S. in Actuarial Science, Boston University, Boston, MA; B.S. in Finance, Guangdong University of Finance, Guangdong, China

Audit

1. The professional vitae of new employees and consultants (since the previous submission) engaged in the development or implementation of the hurricane model under review and responsible for the submission will be reviewed.

   See PVL #3 for resumes reviewed.

2. 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.

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

G-3 Insured Exposure Location*

*(*Significant Revision)*

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

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

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

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

E. Geocoding methodology shall be justified.

Verified: YES

Professional Team comments are provided in black font below.

Pre-Visit Letter

4. G-3.5, page 58: Explain how the vulnerability regions database has been updated.

   Discussed the methodology for updating the vulnerability regions database.

   Reviewed maps of the changes in locations of several ZIP Code centroids.

Audit

1. Geographic displays for all ZIP Codes will be reviewed.

   Reviewed geographic representation of ZIP Code boundaries and centroids.

2. Geographic comparisons of previous to current locations of ZIP Code centroids will be reviewed.

   Reviewed the updates to ZIP Code centroids incorporating new data from the third-party vendor.

   Reviewed map comparisons of the centroid changes from the current accepted model.

Reviewed examples of centroid movements that resulted in changes of vulnerability regions for several ZIP Codes.

3. Third party vendor information, if applicable, and a complete description of the process used to validate ZIP Code information will be reviewed.

   Discussed the process for reviewing and validating the third-party ZIP Code data.

4. The treatment of ZIP Code centroids over water or other uninhabitable terrain will be reviewed.

   Discussed the methodology used to ensure no ZIP Code centroids fall over water or other uninhabitable terrains.

   Reviewed examples of the ZIP Code centroid quality check processes.

5. Examples of geocoding for complete and incomplete street addresses will be reviewed.

   Discussed the processes for geocoding user-provided invalid and valid address data or geocodes. Discussed how specific invalid input data are reconciled.

   Reviewed stress test examples showing how a variety of input data is resolved and how incomplete or invalid addresses are treated.

6. Examples of latitude and longitude to ZIP Code conversions will be reviewed.

   Discussed that no latitude-longitude conversions to ZIP Codes are made.

7. Hurricane model ZIP Code-based databases will be reviewed.

   Reviewed the ZIP Code-based databases, their formats, and where they are hosted on the model servers. Reviewed examples illustrating assignment of ZIP Code boundaries, ZIP Code centroids, and ZIP Code assignment to vulnerability regions.

   Reviewed databases for four Florida Building Code based regions and U.S. Department of Housing and Urban Development (HUD) based Zone II and Zone III regions.

G-4 Independence of Hurricane Model Components

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

Verified: YES

Professional Team comments are provided in black font below.

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) in the course of the on-site review. 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.

   Reviewed flowchart of the workflow for hurricane model development.

   Reviewed the theoretical soundness, integration of components, and consistency across components throughout the audit.

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

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

   Reviewed all changes from the current accepted model and determined that none of the model updates impacted the independence of each model component.

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 that the submission has been personally reviewed and is editorially correct.

Verified: **YES**

Professional Team comments are provided in black font below.

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, 2023,* will be made.

   Discussed the experience of the Technical Writer who reviewed the submission document.

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.

   KCC confirmed that the hurricane model submission was reviewed throughout the development process for grammatical correctness, typographical accuracy, completeness, and no inclusion of extraneous data or materials.

3. Confirmation that the submission has been reviewed by the signatories on the Expert Certification Forms G-1 through G-6 for editorial compliance will be assessed.

   KCC confirmed that subject matter experts reviewed all submitted materials for completeness and accuracy.

4. The modification history for submission documentation will be reviewed.

   Discussed the process for preparing, reviewing, revising, and tracking revisions to the submission documentation.

5. A flowchart defining the process for form creation will be reviewed.

   Reviewed a flowchart of the process for submission form creation.

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

METEOROLOGICAL HURRICANE STANDARDS
Jimmy Booth, Leader

M-1 Model Base Hurricane Set*
*(*Significant Revision)*

A. The Model Base Hurricane Set shall be one of the following: (1) Reference Hurricane Set, (2) Model Adjusted Hurricane Set, or (3) Model Climate-Adjusted Hurricane Set, and shall be justifiable.

B. A climate-adjusted hurricane model shall use one of the hurricane sets listed in A as its Model Base Hurricane Set and shall be justifiable.

C. Annual frequencies used in the hurricane model validation shall be based upon the Model Base Hurricane Set.

Verified: YES

Professional Team comments are provided in black font below.

Pre-Visit Letter

5. M-1.3, page 63: The response states: "The current scientific consensus on the connection between climate change and hurricanes … expresses high confidence that warming global temperatures have caused an increase in hurricane intensity" But you cite a paper titled: "Climate change is probably increasing the intensity of tropical cyclones." Knutson et al. 2021. Justify your statement in the submission, in light of the title of Knutson et al. 2021.

   Discussed that the adjustments in hurricane intensity did not change the overall frequency of hurricane events.

   Discussed that the scientific confidence terminology in the original submission has been updated to be consistent with the Knutson et al. (2021) study. Reviewed a revision to the disclosure.

   Discussed the uncertainty of the data addressed in the Kossin et al. (2020) paper.

   Discussed other data sources and the global Hurricane Satellite (HURSAT) dataset regarding the climate signal, including limitations of regional datasets, for detecting tropical cyclone trend.

   Discussed that there is now sufficient data showing the intensity increase trend.

Audit

1. The Model Base Hurricane Set and its justification will be reviewed.

   Reviewed the Model Base Hurricane Set with landfall and by-passing hurricane intensities adjusted for climate change consistent with current scientific consensus on the connection between climate change and hurricanes.

   Discussed the scientific literature from the Intergovernmental Panel on Climate Change (IPCC) and other studies that state it is likely that warming temperatures have caused an increase in hurricane intensity.
   - Seneviratne et al. 2021
   - Knutson et al. 2020
   - Knutson et al. 2021

   Discussed that observation-based studies support the climate change signal of increased hurricane lifetime maximum intensity.
   - Kossin et al. 2013
   - Kossin et al. 2020
   - Klotzbach et al. (2022)

   Discussed the studies that attribute the trend of increased hurricane intensity to climate change.
   - Knutson et al. 2021

   Discussed that there was no change in methodology from the current accepted model.

   Reviewed a revision to M-1.2 expanding on the lifetime maximum intensity of hurricanes.

2. A flowchart or other illustration of how changes in the Reference Hurricane Set are used in the calculation of the Model Base Hurricane Set landfall distribution will be reviewed.

   Reviewed flowchart for processing changes in HURDAT2 (Reference Hurricane Set) in calculating landfall distributions.

3. Changes to the Model Base Hurricane Set from the current accepted hurricane model used will be reviewed.

   Reviewed the 2022 and 2023 hurricanes added to the Model Base Hurricane Set.

   Reviewed the increase in average frequency in North Florida with the addition of 2022 and 2023 hurricane events.

Reviewed a plot comparing annual landfall occurrence rate by Saffir-Simpson category to distance along the coastline of Florida and adjacent states.

4. Modeled probabilities will be compared with observed hurricane frequency using methods documented in current scientific literature and current technical literature. The goodness-of-fit of modeled to the Reference Hurricane Set statewide and regional hurricane frequencies as provided in Form M-1 will be reviewed.

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

   Reviewed the landfall frequency goodness-of-fit calculation.

   Discussed the results in Form M-1 compared to the historical storms using Form A-2.

   Reviewed the differences between the Report of Activities and KCC event categories.

5. If the model is a climate-adjusted model, changes in hurricane intensity, frequency, and track, if applicable, will be reviewed.

   Discussed that only hurricane intensity is adjusted for climate change.

   Reviewed the methodology for calculating the impact of climate change on hurricane intensity and the magnitude of the climate change adjustment.

   Reviewed examples of the climate change adjustment from the Model Base Hurricane Set.

   Reviewed plot comparing historical to climate-adjusted annual landfall frequencies by Saffir-Simpson category.

M-2 Hurricane Parameters (Inputs)*

*(*Significant Revision)*

Methods for depicting all modeled hurricane parameters shall be based on information documented in current scientific literature and current technical literature.

Verified: YES

Professional Team comments are provided in black font below.

Reviewed a revised response to Standard M-2 that will be included in the final revised submission.

Pre-Visit Letter

6. M-2.1, page 64: Provide an equation of the mathematical dependence of modeled windfield as a function of distance and direction from the center position.

   Reviewed the equations for modeled windspeed as a function of distance from the center that follows the Willoughby et al., 2006 radial wind profile model.

   Reviewed the asymmetry factor equation and application. The windfield asymmetry is calculated by adding or deducting an asymmetry value that depends on the wind direction relative to the motion of the storm.

Audit

1. Supporting material for the meteorological component changes in Disclosure 1 will be reviewed.

   Reviewed the hurricane parameters and relationships that were updated after including hurricane data from 2022 and 2023.

   Reviewed the updated Vmax distributions, Rmax analysis, and calculations for track direction, forward speed, and decay parameters.

   Discussed that all other aspects of the hazard component are the same as in the current accepted model.

2. All hurricane parameters used in the hurricane model, including any adjusted for climate change, will be reviewed.

   Reviewed the hurricane parameters including landfall location, landfall frequencies, Vmax distributions, Rmax analysis, calculation of track direction, calculation of forward speed, calculation of decay parameters, and a re-intensification example file.

3. 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 parameters affecting asymmetric structure of hurricanes.

   Reviewed the calculation of landfall frequencies and the spatial variation in frequencies along the Florida coastline.

   Discussed that the Generalized Pareto Distribution parameters are fit to climate change adjusted historical data for each model region.

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

   Reviewed the relationship between modeled Rmax to historical Vmax, and the detail that the comparison with historical is carried out prior to the climate adjustment.

   Reviewed goodness-of-fit test for normalized Rmax residuals.

   Discussed the process for applying track directions from the Model Base Hurricane Set.

   Reviewed comparison of modeled and historical forward speed.

   Reviewed the asymmetry factor calculation for different forward speeds.

   Reviewed windfield snapshots of Hurricane Wilma (2005) with and without the asymmetry factor applied.

   Reviewed corrections to Figure 10 and Figure 11 made during the review.

M-3 Hurricane Probability Distributions*

*(*Significant Revision)*

A. Modeled probability distributions of hurricane parameters shall be consistent with the Model Base Hurricane Set. Any differences shall be justifiable.

B. Modeled hurricane landfall frequency distributions shall reflect the Model Base Hurricane 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). Any differences shall be justifiable.

C. The hurricane model shall use maximum one-minute sustained 10-meter windspeed when defining hurricane landfall intensity. This applies both to the Model Base Hurricane 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.

Verified: **YES**

Professional Team comments are provided in black font below.

Pre-Visit Letter

7. M-3.1, Table 3, pages 69-70: Explain how the distribution for annual frequency is both an empirical distribution and has a negative binomial basis.

   Discussed the justification for the empirical distribution for annual landfall frequency and how a negative binomial distribution is initially fit to the historical hurricane data.

Audit

1. The statistical goodness-of-fit extending beyond the Florida border will be reviewed by evaluating results for appropriate coastal segments in Alabama, Georgia, and Mississippi.

   Reviewed goodness-of-fit tests for Vmax, track direction, Rmax, forward speed, and over-land decay for hurricane tracks over Florida and neighboring states.

   Reviewed plots of Vmax, Rmax, forward speed, and over-land decay statistical comparisons between modeled and historical observations.

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

   Reviewed the joint probability methodology using a ternary tree hierarchy for model parameters and selecting stochastic storm tracks.

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

   Discussed that landfall locations are on a discrete set of coastal points. Spacing of the coastal points ensures there is adequate coverage of windfields by storms making landfall at adjacent points.

   Reviewed maps of landfall locations in several major metropolitan locations.

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

   Discussed that no modeling-organization-specific research was performed to develop the functions used for simulating hurricane model variables or to develop databases.

M-4 Hurricane Windfield Structure*

*(*Significant Revision)*

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) 2016 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.

Verified: YES

Professional Team comments are provided in black font below.

Pre-Visit Letter

8. M-4.13, page 77: Justify the choice to not consider wind gusts explicitly in the hazard model.

   Discussed the justification for using sustained windspeed as the best measure to use in the aerodynamic load/resistance component vulnerability method.

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.

   Discussed that no modeling-organization-specific research was performed to develop the windfield functions.

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

   Discussed that the National Land Cover Database (NLCD) 2019 is used as the primary source of land use land cover data.

   Discussed the methodology for assigning appropriate roughness lengths to a 1-kilometer grid.

Reviewed a table comparing roughness lengths based on different publications from the scientific literature.

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

   Reviewed geographical representations of the NLCD 2019 land cover and the model surface roughness distribution.

4. A flowchart or other illustration depicting the process for calculating hurricane surface winds will be reviewed.

   Reviewed the process and illustrations for calculating hurricane surface winds.

5. 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.

   Reviewed map comparisons to the current accepted model of the spatial distribution of winds for the LaborDay03 (1935) and NoName09 (1945) storms. Reviewed the changes in Vmax and Rmax compared to the current accepted model.

   Discussed that some changes in Form A-2 are related to the climate adjustment for historical hurricanes.

6. 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.

   Discussed that there was no change in the model windfield, and that the windfields in the audit item have been previously reviewed.

   Reviewed maps of the geographic range of Hurricane Ian (2022) winds of 130 mph and greater.

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

   Discussed that the model simulates surface windspeeds directly and that no conversion is performed in the model.

8. Description of and justification for the value(s) of the far-field pressure used in the hurricane model will be reviewed.

   Discussed that the model uses maximum windspeed for the intensity variable and that far-field pressure is not modeled.

9. The treatment of the inherent uncertainty in the conversion factors used to convert the modeled winds to surface winds will be reviewed and compared with current scientific literature and current technical literature. Treatment of conversion factor uncertainty at a fixed time and location within the windfield for a given hurricane intensity will be reviewed.

   Discussed that the model simulates surface winds directly without requiring a conversion from a higher level. The windfield for each hurricane represents sustained winds at 10-meter height.

   Reviewed a demonstration of the impact of fetch in the surface friction files and the code implementation.

   Reviewed the surface friction reduction factor relative to marine exposure and the code implementation.

10. All external data sources that affect model-generated windfields will be identified, and their appropriateness will be reviewed.

    Reviewed the external data sources that affect the model windfields.

M-5 Hurricane Intensity Change Methodologies*

*(*Significant Revision)*

A. The hurricane intensity change methodology used by the hurricane model shall be consistent 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.

C. Intensity change of hurricanes that pass from over land to over water shall be consistent with current state-of-the-science.

Verified: YES

Professional Team comments are provided in black font below.

Audit

1. The variation in overland decay rates used in the hurricane model will be reviewed.

   Reviewed the over-land decay function and its calculation, including the time duration.

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

2. The transition of storm intensity from over land to over water will be reviewed.

   Reviewed comparison of re-intensifying historical and modeled Florida landfalling events.

   Discussed the model for re-intensification over the Gulf of Mexico of hurricanes with multiple landfalls.

   Reviewed the relationship between Vmax and re-intensification with time over the Gulf of Mexico.

   Reviewed maps comparing re-intensifying historical events to re-intensifying model events.

   Reviewed the equation for the re-intensification model and calculations for the related coefficients.

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

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

4. 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 Charley (2004), Hurricane Michael (2018), and Hurricane Ian (2022) at the closest time after landfall will be reviewed.

   Reviewed landfall windfield maps, land-use data maps, and roughness length maps for Hurricane Charley (2004), Hurricane Michael (2018), and Hurricane Ian (2022).

M-6 Logical Relationships of Hurricane Characteristics*

*(*Significant Revision)*

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.

Verified: YES

Professional Team comments are provided in black font below.

Pre-Visit Letter

9. M-6.4, page 82: Provide a response to the revised disclosure provided in the 2023 Hurricane Standards Report of Activities Q&As on September 12, 2024, i.e., "Describe the dependencies among characteristics (i.e., model output) in the windfield component and how they are represented by the hurricane model."

   Discussed how winds inside and outside the eye are estimated.

Audit

1. The logical relationship between windspeed and surface roughness will be reviewed.

   Reviewed the relationship between windspeed and surface roughness for Hurricane Jeanne (2004).

2. Justification for the relationship between intensity and radius of maximum winds will be reviewed.

   Reviewed Rmax calculation for storms with Vmax less than 157 mph and for storms with Vmax greater than or equal to 157 mph.

   Reviewed the relationship between modeled Rmax to historical Vmax.

3. The mathematical dependence of the modeled windfield as a function of distance and direction from the center position will be reviewed.

   See PVL #6 under M-2.

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

   Reviewed the relationship between asymmetry and different forward speeds.

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

   Reviewed sample event footprints used to demonstrate and verify logical relationships among parameters.

6. Contour animations of windfield distributions demonstrating scientifically reasonable windfield characteristics and logical relationships will be reviewed.

   Reviewed a time-evolving contour animation of the Hurricane Wilma (2005) windfield.

STATISTICAL HURRICANE 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 literature and current technical literature.

B. Modeled results shall reflect statistical agreement with historical data or the Model Base Hurricane Set using current scientific and statistical methods for the academic disciplines appropriate for the various hurricane model components. Any differences shall be justifiable.

Verified: YES

Professional Team comments are provided in black font below.

Audit

1. 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 in the course of the on-site review.

   Discussed that the model uncertainty analysis showed that maximum windspeed is the major contributor to the uncertainty in hurricane loss costs. Uncertainty in the hurricane probable maximum loss (PML) is shown in the uncertainty levels given in Form A-8.

2. Regression analyses performed will be reviewed, including parameter estimation, graphical summaries and numerical measures of the quality of fit, residual analysis and verification of regression assumptions, outlier treatment, and associated uncertainty assessment.

   Discussed the choice of statistical model for the relationship between year and global sea-surface temperature (SST). Reviewed a plot of the fitted model for the regression of year on SST.

   Reviewed the Shapiro-Wilk test of normality for the residual SST.

   Reviewed comparison of historical to modeled normalized Rmax residuals.

S-2 Sensitivity Analysis for Hurricane Model Output*

*(*Significant Revision)*

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.

Verified: YES

Professional Team comments:

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

Discussed the test hurricane set used when performing the sensitivity analyses.

S-3 Uncertainty Analysis for Hurricane Model Output*

*(*Significant Revision)*

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.

Verified: YES

Professional Team comments:

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

Discussed the test hurricane set used when performing the uncertainty analyses.

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.

Verified: YES

Professional Team comments are provided in black font below.

Audit

1. The accuracy associated with Nassau County will be reviewed. The contribution of simulation uncertainty via confidence intervals will be reviewed.

   Reviewed the standard error in Nassau County as a percentage of hurricane loss costs over various years of simulation.

   Reviewed that the results converged and sampling errors decreased as simulation term increased.

   Reviewed the evaluation of the stability in Nassau County loss costs using the ternary tree methodology.

S-5 Replication of Known Hurricane Losses*

*(*Significant Revision)*

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 Hurricane Irma (2017), Hurricane Michael (2018), and Hurricane Ian (2022) to the extent data from Hurricane Ian are available.

Verified: YES

Professional Team comments are provided in black font below.

Audit

1. The following information for each insurance company 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,

   Reviewed comparison of actual versus modeled losses at a company-state level.

   Reviewed scatter plot of actual versus modeled losses by county for a variety of hurricanes.

   b. The version of the hurricane model used to calculate modeled hurricane losses for each hurricane provided,

   Discussed that the KCC US Hurricane Reference Model Version 5.0 was used to generate all modeled historical losses.

   Reviewed a corrected Table 6 comparing actual versus modeled losses.

   c. A general description of the data and its source,

   Discussed that insurance claims data going back to 2004 was used for Standard S-5.

   Reviewed table detailing the information provided in client insurance claims data.

d. A disclosure of any material mismatch of exposure and hurricane loss data problems, or other material consideration,

Discussed the process used to handle missing information in claims data provided by a client.

e. The date of the exposures used for modeling and the date of the hurricane,

Reviewed table summarizing the historical event landfall dates and dates of in-force client exposure data.

f. An explanation of differences in the actual and modeled hurricane parameters,

Discussed the modeled parameters based on information provided by the National Hurricane Center (NHC), and additional data used to infer the parameters not provided by NHC.

g. A list 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 review,

Discussed that there are no departures in the way that the windfields are created for validation from the windfields used in the model.

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,

Discussed that the coverages applied for each hurricane are dependent on the data provided by the individual insurance companies.

i. The treatment of demand surge or loss adjustment expenses in the actual hurricane losses or the modeled hurricane losses, and

Discussed that demand surge and loss adjustment expense are treated consistently across actual and modeled hurricane losses.

Discussed that loss adjustment expense is not modeled, and when validating against insurance claims data, loss adjustment expense is removed if provided in the data.

j. The treatment of flood losses (including hurricane storm surge losses) in the actual hurricane losses or the modeled hurricane losses.

Discussed that flood and storm surge losses are not considered in the modeled hurricane losses.

Reviewed the documented procedure for verifying losses for a single peril.

Discussed the process for determining claims to include during model validation.

Reviewed the documented process for insurance cause-of-loss handling.

Reviewed an illustrative cause-of-loss summary table for one insurance company.

2. The following will be reviewed:

a. The data sources excluded from validation and the reasons for excluding the data from review by the Commission (if any),

Discussed that no data sources were excluded from validation.

b. An analysis that identifies and explains anomalies observed in the validation data, and

Discussed that no anomalous data was used in the validation process.

Reviewed the procedures for processing data used in validation.

c. User input data for each insurer and hurricane detailing specific assumptions made with regard to exposed property.

Reviewed the insurer exposure import documentation.

Reviewed the exposure data processing procedures.

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

Discussed the calculation of confidence intervals for the comparison between historical and modeled losses.

Reviewed the 95% confidence interval for the mean hurricane loss cost, and the 95% confidence interval for the difference between historical and modeled loss, using both the 2017 and 2023 FHCF exposure datasets.

Reviewed the standard deviations of the hurricane loss cost for both the 2017 and 2023 FHCF exposure datasets.

4. An additional version of Form S-4 with actual (i.e., non-disguised and non-scaled) values with associated scatter plots (modeled hurricane loss versus company actual hurricane loss) will be reviewed.

   Discussed that Form S-4 provided in the submission contains actual (non-disguised, non-scaled) values.

   Reviewed tables and scatter plots underlying the validation comparisons in Form S-4.

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.

   Reviewed comparisons of modeled to actual losses from multiple insurance companies for one hurricane event.

   Reviewed comparisons of modeled to actual losses from one insurance company for multiple hurricane events.

S-6 Comparison of Projected Hurricane Loss Costs*

*(*Significant Revision)*

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.

Verified: YES

Professional Team comments are provided in black font below.

Audit

1. Justification for the following will be reviewed:

   a. Meteorological parameters,

   Discussed that meteorological parameters are treated the same way for both historical and modeled hurricanes.

   b. The effect of by-passing hurricanes,

   Discussed that the impacts of by-passing hurricane windfields are treated the same way for historical and modeled hurricanes.

   c. The effect of actual hurricanes that had two landfalls impacting Florida,

   Discussed that for historical and modeled hurricanes, multiple landfalls from the same storm are considered the same event for loss calculation.

   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 review, and

   Discussed that there are no departures.

   e. Exposure assumptions.

   Reviewed the exposure assumptions.

VULNERABILITY HURRICANE STANDARDS
Masoud Zadeh, Leader

V-1 Development of Building Hurricane Vulnerability Functions*
*(*Significant Revision)*

A. Development of the building hurricane vulnerability functions shall be based on a combination of available insurance company hurricane claims data and rational engineering analysis supported by laboratory testing, field testing, or post-event site investigations.

B. The development of the building hurricane vulnerability functions and the treatment of 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 development and application of building hurricane vulnerability functions.

E. Hurricane vulnerability functions shall be developed 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).

Verified: YES

Professional Team comments are provided in black font below.

Discussed with Dr. Girma Bitsuamlak, independent external reviewer, his review of updates to the vulnerability component, and the vulnerability portion of the submission document.

Pre-Visit Letter

10. V-1.1, page 106: Provide further details on the changes.

Reviewed the new year-built band (>2020) for site-built homes based on Florida Building Code (FBC) 2020. Discussed that the major revisions in the model related to roof pressure coefficients in FBC 2020 compared to FBC 2017 increased the design wind pressure of roofs leading to more stringent roof construction practice.

Reviewed example pressure coefficient figures and a comparison of roof component and cladding pressure coefficients in ASCE 7-10 and ASCE 7-16.

Reviewed comparison of year-built bands between the current accepted model and the model under review.

Reviewed the update to vulnerability functions for site-built homes with respect to year-built bands based on engineering judgement and analysis of new claims data received.

Reviewed comparisons of MDRs by windspeed for year-built 2002-2011 and for year-built after 2011 for site-built homes and for full tie-down manufactured homes.

Reviewed the increase in claims data received and analyzed since the current accepted model for buildings built after 2011.

Reviewed the updated vulnerability functions for full tie-down manufactured homes based on engineering judgement and analysis of new claims data received. Reviewed comparison of MDRs by windspeed for full-tie down manufactured homes.

Reviewed comparison of available claims data by windspeed used in the current accepted model and the model under review.

Reviewed the updated vulnerability functions when building year-built is unknown based on updated building year-built inventory distributions. Discussed that the year-built inventory distribution was updated based on available datasets including the FHCF 2017 and 2023 exposure datasets and exposure data from clients.

Reviewed comparison of the year-built inventory distribution of manufactured homes by year-built bands versus the current accepted model.

Reviewed updated vulnerability functions when building construction is unknown based on updated building construction inventory distributions based on available datasets including the FHCF 2017 and 2023 exposure datasets and exposure data from clients.

Reviewed comparison to the current accepted model of the construction inventory distribution of condo-unit owners and associations by construction type.

Reviewed the new vulnerability functions for different types of appurtenant structures.

Discussed that the current accepted model assigns the same vulnerability functions as the primary building for appurtenant structures. In the model under review, new vulnerability functions are available for clients to define appurtenant structure type in their exposure. If the structure type is not defined in the exposure data, the appurtenant structure is assigned the same vulnerability function as the primary building.

Reviewed comparison of vulnerability functions for wood frame, masonry, and appurtenant structures across windspeeds.

Reviewed comparison of vulnerability functions of detached garage and accessory dwelling units to wood frame and full tie-down manufactured homes.

Reviewed the process from development through validation for one of the updated year-built band vulnerability functions.

11. V-1.B and V-1.6, pages 105, and 109-110:
    a. Explain how uncertainties associated with building vulnerability functions are developed.
    b. Provide an example support for the development of uncertainties associated with each damage level "based on sound statistical and engineering principles and [that] have been validated using insurance claims data."
    c. Explain "100,000 secondary distributions for MDRs," and how these are developed.

Reviewed images of observed variability in damage for a similar windspeed.

Discussed how empirical distributions are selected for modeling uncertainty in vulnerability functions.

Reviewed illustration of secondary uncertainty for different MDRs.

Discussed the range of secondary uncertainty distributions for MDRs and how the MDR value is calculated.

12. V-1.4, pages 108-109: Explain how the new data was incorporated in the model, and the resulting impact.

Discussed that insurers may provide data of varying degrees of detail and using different formats.

Discussed the process for standardizing client claims data and placing the data into a centralized claims database for analysis.

Reviewed the documented claims processing guide.

Discussed that vulnerability functions are updated through the combination of detailed claims data analysis and engineering judgement due to uncertainties in claims data.

Reviewed examples of claims analysis by windspeed for Hurricane Ian (2022).

13. V-1.5, page 109: Provide a matrix/table of allowable distinct combinations of all primary building characteristics.

    Reviewed tables of primary characteristics for site-built buildings and the complete list of possible combinations of site-built building vulnerability functions.

    Reviewed tables of primary characteristics for manufactured homes and the complete list of possible combinations of manufactured homes vulnerability functions.

    Reviewed comparison of full-tie down manufactured homes vulnerability functions before 1976 for HUD Zone II and Zone III.

14. V-1.7, pages 110-111: Provide a summary of significant findings from post-damage surveys for Hurricane Ian (2022), Hurricane Helene (2024), and Hurricane Milton (2024). Provide the corresponding reports for review.

    Discussed that post-event surveys have been conducted since Hurricane Hugo (1989) encompassing most of the significant landfalling hurricanes since then.

    Discussed the damage survey process. Reviewed examples of digitized neighborhood survey data and detailed site investigations.

    Discussed the post-event survey for Hurricane Ian (2022). Reviewed a map of the surveyed areas, damage photos, and the post-damage survey report.

    Discussed that the major findings from post-damage surveys confirm and refine KCC's engineering judgement about vulnerability.

15. V-1.8, page 113: Justify the year-built bands relative to changes in the Florida Building Code.

    See PVL #10 for the change to the new year-built band (>2020) for site-built homes.

16. V-1.8, page 114:
    a. Provide a map of the Florida vulnerability regions.

    Reviewed maps of the pre-2012 and 2012 and newer Florida vulnerability regions for site-built homes.

b. Explain how vulnerability functions of the same structure located in the four regions are affected.

Discussed the vulnerability of site-built buildings in the four vulnerability regions.

c. Provide a plot comparing the regional vulnerability functions for a 2020 wood frame construction.

Reviewed comparison of four regional vulnerability functions for a 2020 year-built, single family, wood frame, 1-story structure across windspeeds.

d. Explain and justify how vulnerability regions address U.S. Department of Housing and Urban Development (HUD) wind zones in Florida.

Discussed that manufactured homes in Florida must be designed for HUD Zone II or Zone III.

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

17. Form V-1, pages 205-206: Given the modifications in the vulnerability component, explain the changes in Part A and Part B relative to the current accepted model.

Discussed that the differences in Form V-1 from the current accepted model are related to the manufactured home structure specified in the form.

Discussed that the update to full tie-down manufactured home vulnerability functions resulted in the reduced damage in Form V-1.

Audit

1. Supporting material for the building vulnerability component changes in Disclosure 1 will be reviewed.

See PVL #10.

2. Comparisons of the modified building hurricane vulnerability functions with the current accepted hurricane model will be reviewed.

Reviewed comparison of vulnerability functions for site-built year-built bands.

Reviewed comparison of vulnerability functions for full tie-down manufactured homes.

Reviewed comparison of vulnerability functions for unknown year-built for a single family, wood frame, 1-story structure.

Reviewed comparison of vulnerability functions for unknown construction for 3-6 story condo units.

3. The breakdown of insurance company exposure data used to develop the building hurricane vulnerability functions into number of insurers, number of policies, number of locations, and amount of dollar exposure by policy type will be reviewed.

Policy Type	Number of Insurers	Number of Policies	Number of Locations	Exposure Value ($)
Personal Residential				
Manufactured Homes				
Commercial Residential				

Reviewed the requested breakdown of insurance company exposure data.

4. The breakdown of insurance company hurricane claims data used to develop the building hurricane vulnerability functions into events (year and storm name), number of insurers, number of policies, number of locations, number of claims, and amount of loss separated by policy type will be reviewed.

Year	Storm Name	Number of Insurers			Number of Policies			Number of Locations			Number of Claims			Loss Amount ($)		
		Personal Residential	Manufactured Homes	Commercial Residential	Personal Residential	Manufactured Homes	Commercial Residential	Personal Residential	Manufactured Homes	Commercial Residential	Personal Residential	Manufactured Homes	Commercial Residential	Personal Residential	Manufactured Homes	Commercial Residential

Reviewed the requested breakdown of insurance company hurricane claims data.

5. The modeling of uncertainty associated with building hurricane vulnerability functions for wood frame, masonry, and manufactured homes construction classes will be reviewed.

Discussed that the modeling of uncertainty associated with building hurricane vulnerability functions is based on mean damage ratios (MDR).

Reviewed comparison of secondary uncertainty distributions for wood frame, masonry, and manufactured homes MDRs.

6. How the uncertainties in windspeed for an individual hurricane at a given location are accounted for in the hurricane model damage estimates will be reviewed.

   Reviewed comparison of probability distributions for wind load and resistance.

7. Insurance company hurricane claims data in the original form will be reviewed with explanations for any changes made and descriptions of how missing or incorrect data were handled.

   Reviewed examples of insurance company original claims data.

   Reviewed the procedure for processing insurance company hurricane claims data.

8. The goodness-of-fit of the building hurricane vulnerability functions will be reviewed.

   Reviewed scatter plots of modeled-to-claims mean damage ratios for single family homes, manufactured homes, wood frame, and masonry structures.

9. Complete reports detailing loading conditions and damage states for any laboratory or field-testing data used will be reviewed.

   Reviewed reports about wind load conditions.

   Reviewed reports about damage states.

10. Rational engineering analysis used to develop building hurricane vulnerability functions will be reviewed for a variety of different building construction classes.

    Reviewed the component method for developing building hurricane vulnerability functions.

    Discussed how different failure models and component resistance are considered during the development of vulnerability functions for different building construction types.

11. The combination of available insurance company hurricane claims data and rational engineering analysis to develop the building hurricane vulnerability functions will be reviewed.

    Discussed that the base vulnerability functions for different construction types are developed using rational engineering analysis (component method).

    Discussed that detailed claims data analysis is used to validate and update building vulnerability functions.

    Reviewed a revised flowchart for building vulnerability function development and implementation.

12. Laboratory or field tests and original post-event site investigation reports will be reviewed.

    Reviewed an original post-event site investigation report.

    See PVL #14.

13. Justification for the construction classes and characteristics used will be reviewed.

    Reviewed the primary building characteristics on which the building vulnerability functions are based.

    Reviewed the construction types used for site-built homes and for manufactured homes.

    Reviewed the different occupancy types and building height bands.

    Reviewed the year-built bands and vulnerability regions.

    Reviewed number of stories for buildings.

    Reviewed maps of the pre-2012 and the 2012 and newer Florida vulnerability regions for site-built homes.

14. Multiple samples of building hurricane vulnerability functions for commercial residential building structures, personal residential building structures, manufactured homes, and appurtenant structures will be reviewed.

    Reviewed samples of building vulnerability functions for personal residential building structures and manufactured homes.

    Reviewed samples of appurtenant structure vulnerability functions.

15. Documentation and justification for the effects on the building hurricane vulnerability functions due to applicable building codes will be reviewed.

    Discussed that the variability of vulnerability functions by year-built bands accounts for the impact of updated building codes, improvements in construction techniques and building materials, building aging, and the variability by region within the state of Florida due to differences in code stringency and building inventory.

    Discussed that HUD Zone II and Zone III are used to determine the manufactured homes vulnerability region.

16. The process for incorporating new insurance company hurricane claims data, if any, will be reviewed.

    See PVL #12.

17. How the claim practices of insurance companies are accounted for when insurance company hurricane claims data are used to develop building hurricane vulnerability functions will be reviewed. 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, and the impact of the legal environment in the claims data analyses will be reviewed.

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

    Reviewed comparison of the modeled MDR by windspeed to company claims data for several hurricanes and insurance companies.

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

    Discussed that vulnerability functions are computed as the ratio of repair cost to replacement cost and that no such assumption is required.

    Reviewed plot of percentage of claims loss by damage rate.

19. The treatment of law and ordinance in building hurricane vulnerability functions will be reviewed.

    Discussed that the law and ordinance modifiers are developed by engineering judgement based on the increased cost of construction required to comply with the updated Florida building codes.

    Discussed the percentage of claims data that include information on law and ordinance.

20. A plot comparing hurricane vulnerability functions for wood frame building structure, masonry building structure, and appurtenant structure will be reviewed.

    Reviewed comparison of vulnerability functions for wood frame, masonry, and appurtenant structures.

21. A plot comparing appurtenant structure hurricane vulnerability functions with insurance company hurricane claims data will be reviewed.

    Reviewed scatter plot of actual versus modeled MDR by ZIP Code for appurtenant structures.

V-2 Development of Contents Hurricane Vulnerability Functions*

*(*Significant Revision)*

A. Development of the contents hurricane vulnerability functions shall be based on a combination of available insurance company hurricane claims data and rational engineering analysis supported by laboratory testing, field testing, or post-event site investigations.

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

Verified: YES

Professional Team comments are provided in black font below.

Pre-Visit Letter

18. V-2.1, page 116: Provide an example of the modifications to the contents vulnerability functions due to modifications to vulnerability functions for manufactured homes.

    Reviewed the building-to-contents relationship comparisons to the current accepted model for modifications to building and contents vulnerability functions for full tie-down manufactured homes.

Audit

1. Supporting material for the contents vulnerability component changes in Disclosure 1 will be reviewed.

   Discussed that there was no change to the building-to-contents relationship, and that the only modifications to contents vulnerability functions are due to modifications of the building vulnerability functions.

2. Comparisons of the modified contents hurricane vulnerability functions, if any, with the current accepted hurricane model will be reviewed.

   Reviewed comparisons of contents vulnerability functions for site-built year-built bands, full tie-down manufactured homes, unknown year-built, and unknown construction.

3. Justification for changes from the current accepted hurricane model in the relativities between hurricane vulnerability functions for building and the corresponding hurricane vulnerability functions for contents will be reviewed.

   Discussed that the relativities between building and contents vulnerability functions have not been modified since the current accepted model.

4. Multiple samples of contents hurricane vulnerability functions will be reviewed.

   Reviewed samples of contents vulnerability functions.

5. The goodness-of-fit of the contents hurricane vulnerability functions will be reviewed.

   Reviewed the building to contents damage relationship with claims data.

6. The modeling of uncertainty associated with contents hurricane vulnerability functions for wood frame, masonry, and manufactured homes construction classes will be reviewed.

   Discussed that different secondary uncertainty distributions are used for wood frame, masonry, and manufactured homes which have different contents MDRs.

7. Justification and documentation for the dependence of contents hurricane vulnerability functions on construction or occupancy type will be reviewed.

   Reviewed the relationship between contents and building damage ratio by occupancy type and by construction type.

8. Justification and documentation of the method of development, the underlying data, and assumptions related to contents hurricane vulnerability functions will be reviewed.

   Discussed that the contents to building damage ratio relationship is based on engineering judgement informed by post-event damage assessment and rational structural analysis.

   Reviewed examples of damage survey photos with minor, moderate, and severe building damage illustrating the building-to-contents damage ratio relationship.

9. Support for the rational engineering analysis used in developing the contents hurricane vulnerability functions will be reviewed.

   Discussed that damage to contents occurs as a result of damage to the building components.

10. The combination of available insurance company hurricane claims data and rational engineering analysis to develop the contents hurricane vulnerability functions will be reviewed.

    Reviewed flowchart for contents vulnerability function development and implementation.

    Discussed that contents vulnerability functions are developed from building vulnerability functions using the building-to-contents damage ratio relationships.

    Discussed that claims data are used to validate the contents vulnerability functions.

11. The modeling of water infiltration on contents vulnerability functions for a multi-story commercial residential building, if applicable, will be reviewed.

    Discussed the modeling of water infiltration on contents vulnerability functions for a multi-story commercial residential building.

V-3 Development of Time Element Hurricane Vulnerability Functions*

*(*Significant Revision)*

A. Development of the time element hurricane vulnerability functions shall be based on a combination of available insurance company hurricane claims data and rational engineering analysis supported by laboratory testing, field testing, or post-event site investigations.

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 insurance company hurricane claims data.

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

D. Time element hurricane vulnerability functions shall include time element hurricane losses associated with damage to the infrastructure caused by a hurricane.

Verified: YES

Professional Team comments are provided in black font below.

Audit

1. Supporting material for the time element vulnerability component changes in Disclosure 1 will be reviewed.

   Discussed that the building-to-time element relationships have not been modified since the current accepted model, and that the only modifications to time element vulnerability functions are due to modifications of the building vulnerability functions.

2. Comparisons of the modified time element hurricane vulnerability functions, if any, with the current accepted hurricane model will be reviewed.

   Reviewed comparisons of time element vulnerability functions for site-built year-built bands, full tie-down manufactured homes, unknown year-built, and unknown construction.

3. Justification for changes from the current accepted hurricane model in the relativities between hurricane vulnerability functions for building and the corresponding hurricane vulnerability functions for time element will be reviewed.

   Discussed that the relativities between building and time element vulnerability functions have not been modified since the current accepted model.

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

   Reviewed samples of time element vulnerability functions.

5. The modeling of uncertainty associated with time element hurricane vulnerability functions for wood frame, masonry, and manufactured home construction classes will be reviewed.

   Discussed that different secondary uncertainty distributions are used for wood frame, masonry, and manufactured homes which have different time element MDRs.

6. Justification and documentation of the method of development, the underlying data, and assumptions related to time element hurricane vulnerability functions will be reviewed.

   Discussed that the time element to building damage ratio relationship is based on engineering judgement informed by rational structural analysis and post-event damage surveys.

   Discussed that time element losses are assumed to be caused due to both direct and indirect losses.

   Reviewed the building damage to event-related time element loss relationship.

   Reviewed the average repair time by building component. Reviewed the component level repair time which is dependent on the building component level MDR.

   Reviewed the M. Baradaranshoraka (2017) reference with average times of repair by building component.

7. The goodness-of-fit of the time element vulnerability functions will be reviewed.

   Reviewed the building to time element vulnerability relationship with claims data. Discussed the reasons for limited claims data for time element vulnerability function validation.

8. Support for the rational engineering analysis used in developing the time element hurricane vulnerability functions will be reviewed.

   Discussed that time element losses include direct and indirect losses that are both relevant to building damage ratio.

   Discussed that the building vulnerability functions are developed based on the component method.

9. The combination of available insurance company hurricane claims data and rational engineering analysis to develop the time element hurricane vulnerability functions will be reviewed.

   Reviewed flowchart for time element vulnerability function development and implementation.

   Discussed that time element vulnerability functions are developed from building vulnerability functions using the building-to-time element damage ratio relationships.

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 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 include:

- ***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.

Verified: YES

Professional Team comments are provided in black font below.

Pre-Visit Letter

19. V-4.1, pages 123-124: Provide further details on the stated modifications.

Reviewed the definition of secondary modifier and the calculation for determining the impacts of secondary characteristics.

Discussed that the roof age definition has been updated to a continuous year scale from the previous three year-bands. Discussed the corresponding updates to credits and penalties associated with roof age.

Reviewed claims-based MDR by roof age at specific windspeeds.

Reviewed comparison to the current accepted model of the impact for different roof ages across windspeeds. Discussed justification for the modifiers that decrease or increase the MDRs for different roof ages.

Discussed that detailed claims analysis at the level of different characteristics was conducted to validate the changes to the impacts of roof age on vulnerability.

Reviewed comparison of aggregate loss for different roof ages.

Reviewed comparison of MDRs by windspeed for a specific roof age.

Discussed that the interactions between roof age and roof cover types have been updated to account for the aging impacts on roof wind resistance.

Reviewed the new options for existing hurricane mitigation measures and secondary characteristics that have been added for roof cover type, roof decking, and roof-to-wall connection.

Reviewed the impacts of new roof cover type options across windspeeds.

Reviewed the impacts of a new roof deck option across windspeeds.

Reviewed the impacts of a new roof-to-wall connection option across windspeeds.

Reviewed the new options added to support new IBHS Fortified designations.

Reviewed a revised Table 19, the new option added for skylight, and the new options added for rooftop equipment.

Reviewed the new hurricane mitigation measures and secondary characteristics added for soffits, secondary water resistance, rooftop solar panel, and roof condition.

Discussed that water infiltration can occur when soffits are damaged at high winds which is consistent with findings from KCC post-event surveys.

Reviewed the impacts of soffit options across windspeeds.

Reviewed the impacts of secondary water resistance across windspeeds.

Reviewed the impacts of rooftop solar panel options across windspeeds.

Reviewed the impacts of roof condition options across windspeeds.

Audit

1. Supporting material for the hurricane mitigation measures and secondary characteristics vulnerability component changes in Disclosure 1 will be reviewed.

   See PVL #19.

2. Comparisons of the modified hurricane mitigation measures and secondary characteristics, if any, with the current accepted hurricane model will be reviewed.

   Reviewed comparison to the current accepted model of the impacts for different roof ages.

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

   Discussed that the component method, supported by post-event surveys and engineering judgement, is used to derive the impacts of secondary characteristics and mitigation measures.

   Reviewed the process for calculating and implementing modification factors for secondary characteristics based on the vulnerability functions for a modified structure.

   Discussed that there was no change in methodology or in the hurricane mitigation and secondary characteristics since the current accepted model.

4. Form V-3 and Form V-5 will be reviewed.

   Reviewed Forms V-3 and V-5, and their correspondence to Forms V-2 and V-4.

   Discussed that Form V-3 is the same as the current accepted model Form V-3.

   Discussed that the vulnerability updates are changes to options that do not impact Form V-3.

5. Implementation of individual hurricane mitigation measures and secondary characteristics will be reviewed as well as the effect of individual hurricane mitigation measures and secondary characteristics on damage.

   Reviewed the process for determining the impact of secondary characteristics and mitigation measures.

   Reviewed examples of secondary characteristic modifiers.

6. Any variation in the change in hurricane damage over the range of windspeeds for individual hurricane mitigation measures and secondary characteristics will be reviewed.

   Reviewed examples of impacts of secondary characteristics by windspeed.

7. Insurance company hurricane claims data, rational engineering analysis, or engineering judgment used to support the assumptions and implementation of the hurricane mitigation measures and secondary characteristics will be reviewed.

   Discussed that detailed claims analysis for different secondary characteristics and windspeed is used to support the assumptions and implementation of secondary characteristics.

   See PVL #19 related to the impacts of roof age.

   Discussed that the component method, supported by post-event surveys and engineering judgement, is used to derive the impact of all secondary characteristics and mitigation measures. Discussed that this approach has not changed since the current accepted model.

8. For each roof covering type used to complete Form V-2, the following will be reviewed:
   a. Roof age definition as considered in the model, including assumptions,
   b. The association between roof age and year built, including assumptions,
   c. Variation in roof age assumptions (e.g., by region or ZIP Code), and
   d. The impact of roof age on loss costs.

   Reviewed the assumptions made to complete Form V-2 related to roof age.

9. 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 in hurricane damage over the range of windspeeds for multiple hurricane mitigation measures and secondary characteristics will be reviewed.

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

10. Hurricane mitigation measures and secondary characteristics used by the hurricane model, whether or not referenced in Form V-2 and Form V-3 will be reviewed for theoretical soundness and reasonability.

    Discussed that the component method, supported by post-event surveys and engineering judgement, is used to derive the impact of all secondary characteristics and mitigation measures. Discussed that this approach has not changed since the current accepted model.

    Reviewed secondary characteristics including those in Tables 17-20.

ACTUARIAL HURRICANE 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.

Verified: YES

Professional Team comments are provided in black font below.

Pre-Visit Letter

20. A-1.B, page 132:
    a. Describe how the calculation of the average default factors are updated and kept current for missing user input values.

    Discussed the methodology for developing vulnerability functions for locations where one or more building attributes is unknown or missing.

    Reviewed a construction inventory distribution example.

    Reviewed unknown construction code assignments in the RiskInsight® user interface.

    b. If different from the current accepted model, for one average default factor, provide the calculation for updating the default factor. Include a sample description from a hurricane model output report.

    Reviewed comparison to the current accepted model for a construction inventory distribution that was updated based on available datasets.

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.

   Reviewed the Exposure Data Processing Guide that details the procedures and methods used to ensure accuracy of insurance and other input data.

   Reviewed the Exposure Import User's Guide that details the process for using KCC's data import functionality which validates input data imported into the RiskInsight® software.

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.

   Reviewed the analysis output report and corresponding inputs in loss analysis.

3. The hurricane model input forms used to capture data distinguishing among policy form types and their risk elements including location, deductibles, and limits of coverage will be reviewed.

   Reviewed the input data format fields.

   Reviewed the exposure database and import schemas.

4. The human-computer interface relevant to input data and output reports and corresponding nomenclature used in Florida residential property insurance rate filings will be reviewed.

   Reviewed the Florida Hurricane Rate Filing v5.0 template and the read-only model options given in the template.

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.

Verified: YES

Professional Team comments are provided in black font below.

Pre-Visit Letter

21. A-2.B, page 143: Provide a copy of the documented procedure for distinguishing wind-related hurricane losses from other peril losses.

Reviewed the documented procedure for distinguishing wind 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.

Discussed that landfalling hurricanes are defined as events with a 1-minute sustained windspeed at 10-meter height of at least 74 mph at landfall.

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

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

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.

Discussed the process and criteria for identifying by-passing hurricanes.

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).

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

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

   Discussed that the model calculates and saves wind and other peril losses separately.

   Reviewed the documented procedure of the methodology for distinguishing wind-related hurricane losses from other peril losses.

A-3 Hurricane Coverages

A. The methods used in the calculation of building hurricane loss costs, including the effect of law and ordinance coverage, 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.

Verified: YES

Professional Team comments are provided in black font below.

Pre-Visit Letter

22. A-3.1-4, pages 144-145: Show a calculation of loss costs and probable maximum loss levels for the minimum Frame Owners loss costs in Form A-1 (i.e., ZIP Code 32046 in Nassau County).

    Reviewed the calculation for loss cost per $1,000 for ZIP Code 32046 in Nassau County.

Audit

1. The methods used to produce building, appurtenant structure, contents, and time element hurricane loss costs will be reviewed.

    Discussed the process for assigning a vulnerability function to exposure data and the process used to estimate the building ground-up loss from each event.

    Discussed that the loss cost calculations are the same for appurtenant structure, contents, and time element hurricane loss costs.

    Discussed with Melinda Vasecka, an external reviewer and Actuarial Standards signatory, her review of the actuarial portion of the submission document. Discussed how she attested the model results to be actuarially sound.

2. The treatment of law and ordinance coverage will be reviewed, including the statutory required 25% and 50% coverage options for personal residential policies.

   Discussed that law and ordinance is now expicitly modeled in the model under review.

   Reviewed an example claims request letter asking clients to provide separate loss information for law and ordinance when possible.

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

*(*Significant Revision)*

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 and 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.

Verified: YES

Professional Team comments are provided in black font below.

Pre-Visit Letter

23. A-4.1, pages 146-147: 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.

    Reviewed the tables of 1,000 years descending from the Top Event for the 2017 FHCF exposure data and the 2023 FHCF exposure data, which showed agreement to Form A-8.

24. A-4.3, page 147: Provide a copy of the documented procedure for demand surge and its implementation in the code.

    Reviewed the demand surge methodology documentation.

    Reviewed implementation of demand surge in the code.

25. A-4.5, page 147: Explain how economic inflation is modeled with regard to the claims environment, the legal environment, and litigation effects.

    Discussed that no adjustments for economic inflation are made to insurer exposure or claims data.

    Reviewed the process for modeling the effects of excess litigation.

Audit

1. The hurricane model's handling of expenses, risk load, investment income, premium reserves, taxes, assessments, profit margin, economic inflation, and any criteria other than direct residential property insurance hurricane claim payments will be reviewed.

   Discussed that no assumptions for expenses, risk load investment income, premium reserves, taxes, assessments, profit margin, economic inflation, or any other criteria other than direct property insurance claims payments are made. Discussed that the individual claim amounts received exclude all of the items listed.

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

   Reviewed the method for determining hurricane PML. See PVL #23.

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

   Reviewed the methodology for calculation of uncertainty intervals. See PVL #26.

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. The vintage of the underlying demand surge data and references will be reviewed.

   Reviewed the "Demand Surge Model and Documented Procedure" describing the data and methods for incorporating aspects of demand surge on personal and commercial residential hurricane losses.

   Reviewed the sources and vintage of the underlying demand surge data and references.

   Reviewed implementation of demand surge factors.

   See PVL #24.

5. The treatment of economic inflation and the claims and legal environments (social inflation) will be reviewed.

   See PVL #25.

   Reviewed implementation of excess litigation in the code.

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

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

A-5 Hurricane Policy Conditions

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

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

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

Verified: YES

Professional Team comments are provided in black font below.

Reviewed the expected insured loss calculation.

Audit

1. The extent that insurance company hurricane claims data are used to develop mathematical depictions of deductibles, policy limits, policy exclusions, and loss settlement provisions will be reviewed.

   Discussed that hurricane claims data are not used to develop mathematical depictions of deductibles, policy limits, policy exclusions, or loss settlement provisions.

2. The extent that insurance company hurricane claims data are used to validate the hurricane model results will be reviewed.

   Discussed that deductibles, policy limits, and coinsurance data are input as provided by clients into exposure data used for modeled hurricane analysis consistent with the "KCC Exposure Import User's Guide."

   Discussed that deductibles are used with client claims data for model validation following the "KCC Insurer Claims Processing Guide."

   Discussed that policy exclusions and loss settlement provisions are requested and confirmed with clients following the "KCC Insurance Claims Request Letter" and the insurance claims processing guide.

   Reviewed the "KCC Exposure Import User's Guide," the "KCC Insurance Claims Processing Guide," and the "KCC Insurance Claims Request Letter."

3. Treatment of annual hurricane deductibles will be reviewed.

   Discussed implementation of annual hurricane deductibles.

   Reviewed an example of a modeled annual hurricane deductible.

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

   Discussed that the loss costs for the current accepted model and the model under review demonstrate no material change in the relativities among corresponding deductible amounts for the same coverage.

   Reviewed a comparison to the current accepted model of the average frame owners loss cost relativities across different deductible values.

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,***

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

4. northern counties versus southern counties, and

5. newer construction versus older construction.

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.

Verified: YES

Professional Team comments are provided in black font below.

Pre-Visit Letter

26. A-6.10, page 154: Explain the details for calculating the uncertainty intervals.

Reviewed the methodology for calculating the uncertainty intervals for estimated loss costs.

27. Form A-1, pages 216-218: Explain the increases in ZIP Codes 32053 (Hamilton County), 32340 (Madison County), 32615 (Alachua County), 34482 (Marion County) and 34788 (Lake County).

Discussed that the increases in loss costs for the ZIP Codes listed are due to increase in hazard.

Reviewed a table comparing the percentage change in the listed Form A-1 ZIP Codes to the overall county percentage change showing the increases in the ZIP Codes are in line with each respective overall county percentage change based on the changes in hazard.

28. Form A-2, pages 219-223: Explain the significant differences from the current accepted model for Hurricanes NoName10-1926, Able-1951, Dennis-2005, and Katrina-2005.

Discussed that the significant differences from the current accepted model for the four storms listed are due to the inclusion of the climate change adjustment in the Model Base Hurricane Set.

Discussed that a wide range of results in the event losses is expected due to the climate change adjustment that changes both the maximum windspeeds and the location where the maximum winds occur.

The listed hurricanes all had significant increases in losses from the current accepted model due to having increased windspeeds in populated areas.

Discussed that Hurricane Katrina (2005) has increased losses relative to the current accepted model.

Reviewed a comparison between the current accepted model and windfield footprint for Hurricane NoName10-1926.

29. Form A-4, 0% Deductible, 2017 FHCF Exposure Data, pages 230-236: Explain the reversal in loss costs where Frame is less than Masonry:
    a. Owners: Alachua Average, Gulf Average, Pasco Average, St. Johns Average
    b. Renters: Liberty Average, Pasco Average, Miami-Dade Average
    c. Condo Unit: Brevard Average, Franklin Average, Pasco Average, Wakulla Average.

Discussed the reasons for the reversals in loss costs where frame is less than masonry for each coverage type and county.

30. Form A-5, Figure 73, page 263: Explain the significant decreases in the Manufactured Homes loss costs in Form A-4, compared to the current accepted model. This is seen throughout the State except for the North Inland area (e.g., Hamilton County).

Discussed that the manufactured homes vulnerability functions for full tie-down construction type were updated based on observations from detailed claims data analysis and engineering judgement.

Reviewed comparison of the updated manufactured homes full tie-down vulnerability function to the current accepted model.

Discussed that the update to the manufactured homes full tie-down vulnerability function is present in the North Florida Inland area, and that the less significant decrease in this area is due to significant increases in hazard compared to other regions.

Reviewed the percentage change in output ranges by region for manufactured homes.

31. Form A-8, pages 268-269: Explain the changes in Parts A.2 and A.3 from those in the current accepted model for the 5, 10 and 20-year return periods compared to the longer return periods.

Discussed that the adjustment in the demand surge factor resulted in the changes seen in Form A-8. Reviewed comparison to the current accepted model of the demand surge factor across ground up losses.

Discussed that the increases in storm frequency affects longer return periods to a higher degree than lower return periods.

Audit

1. Supporting material for the financial component changes in Disclosure 1 will be reviewed.

   See A-4, Audit 4 for discussion on update to the demand surge factors.

   See A-3, Audit 2 for discussion on the explicit modeling of law and ordinance coverage.

   Reviewed the development and implementation of a roof actual cash value modifier.

   Reviewed comparison of roof actual cash value modifiers between different depreciated values across windspeeds.

2. The data and methods used for hurricane probable maximum loss levels for Form A-8, will be reviewed. The hurricane associated with the Top Events will be reviewed.

   Reviewed the top event at the occurrence level for both the 2017 and 2023 FHCF exposure datasets.

   Reviewed the top year and the top four 500-year return period events at the aggregate level for the 2017 FHCF exposure data.

   Reviewed the top year and the 500-year return period events at the aggregate level for the 2023 FHCF exposure data.

   Reviewed maps of the top events from an occurrence level and from an aggregate level for both the 2017 and 2023 FHCF exposure datasets.

3. The frequency distribution and the individual event severity distribution, or information about the formulation of events, underlying Form A-8 will be reviewed.

   Reviewed the event frequency and severity distributions using both the 2017 and 2023 FHCF exposure datasets.

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

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

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

   Reviewed maps of loss costs by ZIP Code for frame owners, masonry owners, and manufactured homes with land friction applied and for open terrain.

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 Hurricane Standard A-6 will be reviewed.

   Discussed that a series of checks were performed to verify the individual loss cost relationships at an aggregate level and at a granular level. Reviewed an example geographical check performed using RiskInsight®'s visualization tools.

   Reviewed a graphical representation of the relationships that were used to confirm reasonability.

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.

   Reviewed Form A-6 graphical representations of the loss costs relationships and confirmed reasonability.

   Reviewed a sample of successful logical tests.

8. Justification for all changes in hurricane loss costs from the current accepted hurricane model will be reviewed.

   Reviewed a summary of changes from the current accepted model and the underlying reasons for the changes in loss costs.

9. Apparent reversals in the hurricane output ranges and their justification will be reviewed.

   Discussed the various counties with greater frame loss costs than masonry loss costs, and the underlying reasons.

10. The details on the calculation of uncertainty intervals and their justification will be reviewed.

    Reviewed the methodology for calculation of uncertainty intervals.

    Reviewed an illustrative event footprint.

COMPUTER/INFORMATION HURRICANE STANDARDS
Paul Fishwick, Leader

CI-1 Hurricane Model Documentation*
*(*Significant Revision)*

A. Hurricane model functionality and technical descriptions shall be documented formally in an archival format separate from the use of correspondence including emails, presentation materials, and unformatted text files.

B. All documentation, code, and scripts shall be located in central repositories controlled by repository software. Repository software shall support track changes, versioning, and collaborative editing.

C. All computer software 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 current 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.

Verified: YES

Professional Team comments are provided in black font below.

Audit

1. The central repositories will be reviewed.

   Discussed the use of Microsoft Team Foundation Server (TFS) as the primary document repository. Discussed the fact that new projects are managed using Git and GitHub, and the reasons for the migration to a version control system different than TFS.

Reviewed the KCC server management and data management policy.

2. Complete user documentation, including all recent updates, will be reviewed.

   Reviewed examples of update and release notes for the RiskInsight® platform.

   Reviewed the "Database Schema and Results Database Guide." Reviewed additional documentation contained in user guides.

   Reviewed the documentation for the overwater re-intensification model.

   Reviewed the documented procedure for the demand surge model.

   Reviewed the documented procedure for calculating the excess litigation factor.

   Reviewed the surface roughness documentation and formula mapping.

   Reviewed the asymmetry documentation and formula mapping.

   Discussed the availability of application programming interfaces that are provided to some clients.

3. Modeling organization personnel, or their designated proxies, responsible for each aspect of the software (i.e., user interface, quality assurance, engineering, actuarial, verification) shall be present when the Computer/Information Hurricane Standards are being reviewed. Internal users of the software will be interviewed.

   All subject matter experts and personnel involved in software implementation were available and participated throughout the review.

4. Verification that documentation is created separately from, and is maintained consistently with, the source code will be reviewed.

   Discussed the process for creating documentation.

   Discussed the availability of internal style guides for documentation.

   Reviewed examples illustrating that documentation is created separately from the source code and maintained within a combination of TFS and GitHub.

5. The list of all externally acquired hurricane model-specific software and data assets will be reviewed.

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

6. The tables specified in Hurricane Standard CI-1.D that contain the items listed in Hurricane Standard G-1, Disclosure 7 will be reviewed. The tables shall contain the item number in the first column. The remaining five columns shall contain specific document or file references for affected components or data relating to Computer/Information Hurricane Standards CI-2, CI-3, CI-4, CI-5, and CI-7.

   Reviewed the summary of changes for all the models changes since the current accepted model.

7. Tracing of the hurricane model changes specified in Hurricane Standard G-1, Disclosure 7 and Audit 4 through all Computer/Information Hurricane Standards will be reviewed.

   Reviewed the event catalog module updates, the vulnerability module updates, the ZIP Code centroid updates, the roof actual cash value factor, the demand surge factor update, and the explicit modeling of law and ordinance through CI Standards 1-8.

   Discussed processes for tracing/linking information across the various CI standards.

CI-2 Hurricane Model Requirements*

*(*Significant Revision)*

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.

Verified: YES

Professional Team comments are provided in black font below.

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.

   Reviewed the geocoder requirements specification as well as several other requirements specifications.

   Reviewed the exposure database schema and the analysis report schema. Reviewed other examples of database and file schemas.

   Reviewed the database schema definition file.

2. Requirements documentation specifically relating to each model change identified in Hurricane Standard G-1, Disclosure 7 will be reviewed.

   Reviewed requirements documentation for the following model updates.
   - Secondary Modifier Requirement Specification
   - Damage Function Generator
   - Model Manager Requirement Specification
   - Ternary Tree Requirement Specification
   - Track File Generator Requirement Specification
   - Year Loss Table Generator Requirement Specification
   - Windfield Builder Requirement Specification
   - Geocoder Requirement Specification
   - Roof Actual Cash Value Requirement Specification
   - Ordinance and Law Requirement Specification
   - Financial Calculator Requirement Specification (Demand Surge)

   Reviewed the Windfield Builder requirements documentation.

CI-3 Hurricane Model Organization and Component Design

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

B. All flowcharts (e.g., software, data, and system models) in the submission or in other relevant documentation shall be based on (1) a referenced industry standard (e.g., UML, BPMN, SysML), or (2) a comparable internally developed standard which is separately documented.

Verified: YES

Professional Team comments are provided in black font below.

Reviewed an updated Figure 9 flowchart on model development that was revised during the review.

Reviewed an updated Figure 36 flowchart of the contents vulnerability function development and implementation that was revised during the review.

Reviewed an updated Figure 37 flowchart of the time element vulnerability function development and implementation that was revised during the review.

Reviewed an updated Figure 40 flowchart illustrating the process to generate model output from the initial exposure input that was revised during the review.

Audit

1. The following will be reviewed:

    a. Detailed control and data flowcharts, completely and sufficiently labeled for each component,

    Reviewed numerous flowcharts throughout the audit. Discussed changes made to the "Prepare and Submit Analysis" request flowchart.

b. Interface specifications for all components in the hurricane model,

Reviewed the model components interface specifications throughout the audit.

c. Documentation for schemas for all data files, along with field type definitions,

Reviewed the open exposure format database schema and the import schema.

Reviewed numerous schema documents throughout the audit.

d. Each network flowchart including components, sub-component flowcharts, arcs, and labels,

Reviewed an illustration of network flows.

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

Reviewed workflow of KCC professionals involved in development of the hurricane model.

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.

Discussed that the KCC US Hurricane Reference Model can only be used with the RiskInsight® platform.

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

Reviewed the ISO 5807 standard used as a reference guide for all flowcharts. Reviewed KCC's appendix supplementing the ISO 5807 standard.

Reviewed a revision to the KCC appendix supplementing the ISO 5807 standard to add merges and split line differentiation for data flows.

CI-4 Hurricane Model Implementation*

*(*Significant Revision)*

A. A complete procedure of coding guidelines consistent with accepted practices shall be maintained. Coding guidelines shall be referenced for each programming language used in the hurricane model or submission document.

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., requirements, flowcharts) down to the implementation 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 Hurricane Standard G-1, Disclosure 7 and Audit 4:

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.

H. Hurricane model code and data shall be accompanied by documented review plans, testing plans, and if needed, update plans through regularly scheduled intervals. The vintage of the hurricane model code and data shall be justified.

Verified: YES

Professional Team comments are provided in black font below.

Audit

1. Code and data implementations, for at least the meteorology, vulnerability, and actuarial components, will be reviewed.

   Reviewed implementation of the excess litigation factor.

   Reviewed the demand surge model code.

   Reviewed the mixed effects model for re-intensification code.

   Reviewed implementation of the surface roughness factors. Reviewed the code for fetch at a coastal grid point and at an inland grid point.

   Reviewed samples of the asymmetry code.

   Reviewed calculation of inflow angle and calculation of the asymmetry adjustment factor.

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.

   Reviewed the updated coding guidelines documentation.

   Discussed the tools and processes for enforcing coding standards.

   Reviewed an example data file used for detecting coding standard violations.

   Reviewed an example of a coding standard violation notification.

   Discussed the Git Workflow used for committing and merging code originating from different software developers.

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

   Discussed that the software team has processes and procedures for automated and manual validation of model development.

   Discussed the processes managed by a company-wide team for external data sources.

Discussed that there are several interactive map tools within the RiskInsight® platform to visually inspect and verify event footprints. Reviewed an interactive map tool used to visually inspect an event footprint.

Discussed that damage functions are created and stored in files with prescribed formats that can be viewed and verified. Reviewed an interactive tool used to visually inspect damage functions and secondary uncertainty distributions.

Reviewed an interactive model definition viewer for validating model data files. Discussed the processes for manual and automated results validation.

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

   Discussed the process for ensuring traceability among model components.

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.

   Discussed that all source code for the RiskInsight® platform is under source control.

   Reviewed examples of source code history in TFS and in Github.

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

   Reviewed the table of software component metadata and subsequent code breakdowns.

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

   Discussed that the model definition file provides the primary means of mapping damage functions, hazard events, and other model details.

   Reviewed an example model definition file.

   Reviewed the variable names and mapping for the mixed effects model for re-intensification coefficients.

   Reviewed the surface roughness generation formula mapping.

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

   Reviewed comments in selected source code examined throughout the audit.

   Reviewed examples of descriptive comments for methods and for statements in the code.

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

   Reviewed the hardware and operating system requirements for the KCC US Hurricane Reference Model v5.0 and the RiskInsight® loss modeling platform for each tier.

   Reviewed additional software requirements and programming languages.

10. Network organization implementation will be reviewed.

    Reviewed the network organization flowchart in Figure 3.

11. Code and data review plans, testing plans, update plans, and schedules will be reviewed. Justification for the vintage of code and data will be reviewed.

    Reviewed the code and data update plans in the "Model Software and Update Guidelines."

    Discussed that the schedule for model and software updates is assessed during planning sessions throughout the year.

    Discussed the topics and action items from recurring software scoping meetings.

    Reviewed an example model update plan. Reviewed an example of notes from a model update meeting. Reviewed examples of a decision to not update the model and of a decision to update the model.

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

    See PVL #32 under CI-5.

CI-5 Hurricane Model Verification*

*(*Significant Revision)*

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 updated 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.***

Verified: YES

Professional Team comments are provided in black font below.

Reviewed testing on the demand surge factor modification.

Reviewed testing on the excess litigation factor.

Reviewed visual testing for the application of surface roughness for actual terrain and for open terrain over land.

Reviewed the asymmetry visual test comparing the windfield with and without asymmetry applied.

Pre-Visit Letter

32. CI-5: Discuss process improvements in automated checks for submission forms as documented in the 2023 Professional Team On-Site Review Report.

    Discussed the automated check implemented for Form A-4, the logical relationship to risk checks for Form A-6, and consistency checks across several forms and between the current accepted model and the model under review.

Audit

1. Procedures for physical unit conversion verification (e.g., knots to mph) will be reviewed.

    Reviewed the procedures for 1) sample constants and code usage, 2) verification of intensity in mph for windstorm events, 3) currency unit conversion, 4) percent or fraction conversion to dollars, and 5) tests for latitude and longitude to grid index and grid index to latitude and longitude.

2. 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.

    Discussed that the RiskInsight® source code is properly and appropriately coded for logical assertion and exception-handling.

    Discussed the defensive coding practices used by the software development team.

    Reviewed examples of defensive coding.

3. The testing software used by the modeling organization will be reviewed.

    Discussed the testing software and automated testing process.

    Reviewed example code used for performing specific automated tests and a list of sub-projects in the testing framework.

    Discussed that unit and regression tests are performed after every merge.

    Discussed the frequency of integration tests that are run to confirm losses have not changed.

    Reviewed an example of automated test status reports.

Discussed the fact that equivalent testing software exists for code hosted in both TFS and Git/GitHub.

4. The component (unit, regression, integration) and data test processes and documentation will be reviewed including compliance with independence of the verification procedures.

   Reviewed an example of unit and regression tests that are run after every code check-in.

   Discussed an example set of assertions for unit, regression, and integration tests.

5. 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.

   Reviewed examples of code change history tracked and reported in TFS and GitHub source control.

   Reviewed the hurricane algorithm implementation process. Reviewed example code developed to implement formulas in an Excel file and an example output verified through automated testing.

6. Flowcharts defining the processes used for manual and automatic verification will be reviewed.

   Reviewed flowchart of automated and manual testing processes.

7. Verification approaches used for externally acquired data, software, and models will be reviewed.

   Reviewed the general data verification process.

   Reviewed flowchart for data source acquisition and validation by subject matter expert.

   Reviewed a geocoding example of visual verification and stress tests performed in RiskInsight®.

8. Complete and thorough verification procedures and output from the model changes identified in Hurricane Standard G-1, Disclosure 7 will be reviewed.

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

   Discussed the verification procedures for model updates to the hazard, vulnerability, ZIP Code centroids, as well as various other types of model changes.

CI-6 Human-Computer Interaction

A. Interfaces shall be implemented as consistent with accepted principles and practices of Human-Computer Interaction (HCI), Interaction Design, and User Experience (UX) engineering.

B. Interface options used in the hurricane model shall be unique, explicit, and distinctly emphasized.

C. For a Florida insurance rate filing, interface options shall be limited to those options found acceptable by the Commission.

Verified: YES

Professional Team comments are provided in black font below.

Audit

1. External and internal user interfaces will be reviewed.

   Reviewed and discussed the use of the Florida Hurricane Rate Filing v5.0 template with read-only model options.

2. Documentation related to HCI, Interaction Design, and UX engineering will be reviewed.

   Reviewed the documentation associated with HCI, interactive design, and UX engineering.

   Discussed the process for enforcing HCI, Interaction Design, and UX engineering through the code review process.

3. The decision process specifying the logic of interface option selections, when an acceptable hurricane model is selected, will be reviewed.

   Reviewed the flowchart of the process for selecting the Florida rate filing template and exposures for loss analysis.

   Discussed that the decision process was simplified by eliminating unacceptable options and enabling only relevant choices controlled by an immutable template.

CI-7 Hurricane Model Maintenance and Revision*

*(*Significant 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 personal and commercial residential hurricane loss cost or hurricane probable maximum loss level shall result in a new hurricane model version identification.

C. 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.

Verified: YES

Professional Team comments are provided in black font below.

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.

   Reviewed the procedures to ensure complete and accurate completion of development projects including code reviews, testing, and documentation.

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

   Reviewed the protocol for model changes, including review, revision, or maintenance.

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

   Code reviews were conducted as listed under CI-4.

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

   Discussed the use of TFS and GitHub as the source control system.

Reviewed examples of source control explorer showing the date and time each change set was checked-in, and the GitHub web interface showing commits.

5. The list of all hurricane model revisions as specified in Hurricane Standard CI-7.C will be reviewed.

   Reviewed the summary of code changes for the model updates.

   Reviewed the relevant requirement documentation reflecting the updates or components.

6. The model version history over the past 5 years, leading up to the version submitted will be reviewed.

   Reviewed the model version history with release dates.

CI-8 Hurricane Model Security*

*(*Significant Revision)*

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.

Verified: YES

Professional Team comments are provided in black font below.

Audit

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

   Reviewed the policy for information security procedures.

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.

   Reviewed the security procedures for access, client hurricane model use, anti-virus software installation, and off-site procedures contained in the information security policy document.

   Discussed the enforcement of security procedures and detection of potential malware through automated code analysis tools.

3. Security aspects of each platform will be reviewed.

   Reviewed the software operation management contained in the information security policy document.

   Discussed that the KCC US Hurricane Reference Model can only be used with the RiskInsight® platform.

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

   Reviewed the network security procedures contained in the information security policy document.

Commission Issue

Specify if and where Artificial Intelligence (AI) is used (e.g., development, implementation, testing, data analysis, documentation). If used, explain how AI is employed along with what AI models (in-house, proprietary, or open source) and inference are implemented. For any training performed by the modeling organization, specify whether fine-tuning is done or whether the AI model is trained from scratch. Specify the AI model types, learning algorithms, training data, testing data, and measures of effectiveness.

Discussed that AI was not used in the development of the US Hurricane Reference Model Version 5.0.

Discussed potential AI use cases for future model submissions which will be discussed with the Commission during the trade secret session of the June 2025 meeting to review the model for acceptability.