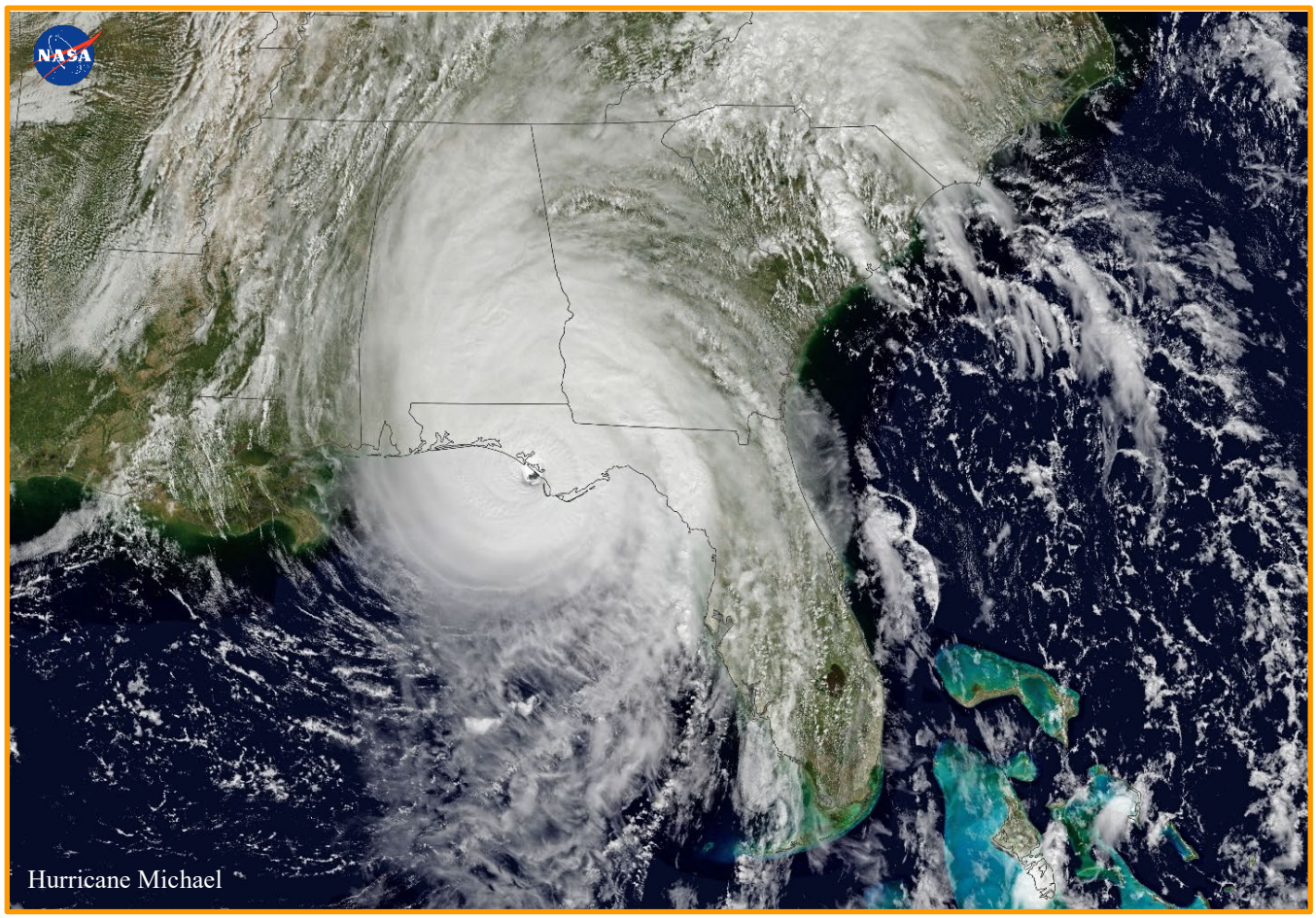
Florida Commission on Hurricane Loss Projection Methodology

Professional Team Report

2019 Hurricane Standards



CoreLogic, Inc.

Remote Review

April 5 – 8, 2021

On April 5-8, 2021, the Professional Team conducted a remote review of the CoreLogic, Inc. (CL), CoreLogic Florida Hurricane Model 2021a in platform Risk Quantification and Engineering™ Version 21. The following individuals participated in the remote review.

CoreLogic
Amin Ilia, Ph.D., Coastal Scientist and Engineer
Branimir Betov, M.S., Director, Model Development
Daniel Betten, Ph.D., Atmospheric Scientist
Justin Brolley, Ph.D., Principal Research Scientist
Annes Haseemkunju, Ph.D., Atmospheric Scientist
Mahmoud Khater, Ph.D., P.E., Chief Science and Engineering Officer
Howard Kunst, FCAS, MAAA, Actuary
Ilyes Meftah, Research Scientist
Sergey Pasternak, Software Architect
David Smith, Senior Director, Model Development
Amanuel Tecle, Ph.D., Research Scientist

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

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

The Professional Team began the review with an opening briefing and introductions were made. CL next provided an overview of updates to the model.

- Probabilistic hurricane database updated to HURDAT2 as of April 28, 2020
- Stochastic set increased by 500 hurricanes to include hurricanes similar to Hurricane Michael (2018) in northwestern Florida
- Updates to Rmax, forward speed, and profile factor probability
- Filling rate updated to be consistent with the methodology in Vickery 2005 and to include 1900-2019 hurricanes
- Land use land cover updated to NLCD 2016
- Defaults for roof age and roof condition updated
- Coverage A for condominium policies updated
- ZIP Code database updated to June 2020

The audit continued with a review of each standards section. CL provided further details on the error related to the land use/land cover update to the National Land Cover Database

(NLCD) 2016 (see the March 11, 2021 notification letter from CL included at the end of the report) and changes to the process to prevent the error from recurring.

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

1. Detailed information and discussion of Forms V-3 and V-5
2. Detailed information and discussion of relativities in Form A-6.

Report on Deficiencies

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

1. M-4, Disclosure 7, page 64: Incomplete. Provide additional windfield comparisons as required.

2. Form S-3, page 188: Incomplete. Text missing under Justification for Functional Form.

3. Form V-2.B, page 204: Incomplete. No response given to Part B.

4. Form V-4.B, page 207: Incomplete. No response given to Part B.

Professional Team Pre-Visit Letter

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

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

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

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

The remote on-site schedule is tentatively planned to proceed in the following sequence: (1) presentation of new or extensively updated material related to the model; (2) section by section review commencing within each section with pre-visit letter responses; (3) responses to new or significantly changed hurricane standards in the 2019 *Hurricane Standards Report of Activities*, and (4) responses to the audit items for each hurricane standard in the 2019 *Hurricane Standards Report of Activities*.

If changes have been made in any part of the model or the modeling process from the descriptions provided in the original November 2020 Submission (October 29, 2020 Version), provide the Professional Team with a complete and detailed description of those changes, the reasons for the changes (e.g., an error was discovered), and all revised forms where any output changed. For each revised form, provide an additional form with cell-by-cell differences between the revised and originally submitted values.

Refer to the On-Site Review chapter of the *Hurricane Standards Report of Activities as of November 1, 2019* as amended by the Commission on December 10, 2020 for more details on materials to be presented and provided to the Professional Team. Particular attention should be paid to the requirements under Presentation of Materials. These requirements are reproduced at the conclusion of this letter.

The pre-visit questions are grouped by hurricane standards sections.

Editorial Items

Editorial items were noted by the Professional Team in the pre-visit letter for correction prior to the start of the virtual review in order to facilitate efficiency during the review and to avoid last minute edits. Additional editorial items were also noted during the review. The Professional Team reviewed the following corrections to be included in the revised submission to be provided to the Commission no later than 10 days prior to the meeting to review the model for acceptability. Page numbers below correspond to the March 19, 2021 track changes revised submission document.

1. Notification letter, page 2: added RQE platform version number.
2. Model Identification, page 5: added RQE platform version number.
3. G-1, Disclosure 1, page 17: added RQE platform version number.
4. G-1, Disclosure 2, pages 17, 21, and 22: added RQE platform version number.
5. G-1, Disclosure 3, pages 25-28: Figures 1 and 2 revised. Caption for Figure 3 revised.

6. G-1, Disclosure 6, page 30: updated link for U.S. Department of Homeland Security 2009a.
7. G-2, Disclosure 2.C, page 48: Figure 12 revised.
8. M-2, Disclosure 2, page 62: revised to include all sources used in the Rmax analysis.
9. M-3, Disclosure 2, page 68: removed redundant statement on agreement with historical data.
10. M-5, Disclosure 1, page 75: updated with new filling rate methodology.
11. M-5, Disclosure 2, page 76: Figures 18 & 19 updated with more recent storms.
12. S-1, Disclosure 1, page 81: *p*-value corrected for track direction.
13. S-1, Disclosure 6, page 88: Figure 24 replaced.
14. V-1, Disclosure 3, page 101: source of commercial residential data revised.
15. V-3.A, page 113: revised to remove Mehta and McDonald research.
16. V-4, Disclosure 4, page 122: revised roof age in Table 9 from less than 5 years to less than 6 years.
17. CI-6, Disclosure 2, page 175: added RQE platform version number.
18. Form M-1, pages 188-190: revised to correct historical occurrence rates for Florida by-passing storms and Alabama/Mississippi Region F in Table 12 and in Figure 35.
19. Form S-3, page 202: revised to add annual frequency negative binomial distribution and date of year of stochastic storms modeled empirical distribution.
20. Form S-5, page 213: revised to remove frequency distribution.
21. Form A-2, pages 235-236: revised to correct landfall region/category and year for storm 430 (Dorian, ByP4).
22. Form A-8, page 288: revised to correct number of hurricanes.
23. Appendix 6, page 296: BPMN and UML added to list of acronyms.

GENERAL STANDARDS – Mark Johnson, Leader

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

*(*Significant Revision)*

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

B. A documented process shall be maintained to assure continual agreement and correct correspondence of databases, data files, and computer source code to slides, technical papers, and modeling organization documents.

C. All software and data (1) located within the hurricane model, (2) used to validate the hurricane model, (3) used to project modeled hurricane loss costs and hurricane probable maximum loss levels, and (4) used to create forms required by the Commission in the Hurricane Standards Report of Activities shall fall within the scope of the Computer/Information Standards and shall be located in centralized, model-level file areas.

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

Audit

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

2. All primary technical papers that describe the underlying hurricane model theory and implementation (where applicable) should be available for review in hard copy or electronic form. Modeling-organization-specific publications cited must be available for review in hard copy or electronic form.

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

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

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

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

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

C. For any modifications to Form A-4, Hurricane Output Ranges, since the initial submission, a newly completed Form A-5, Percentage Change in Hurricane Output Ranges:
   1. With the initial submission as the baseline for computing the percentage changes, and
   2. With any intermediate revisions as the baseline for computing the percentage changes.

D. Color-coded maps by county reflecting the percentage difference in average annual zero deductible statewide hurricane loss costs based on the 2017 Florida Hurricane Catastrophe Fund personal and commercial residential zero deductible exposure data found in the file named *"hlpm2017c.zip"* for each hurricane model component change:
   1. Between the previously-accepted hurricane model and the revised hurricane model,
   2. Between the initial submission and the revised submission, and
   3. Between any intermediate revisions and the revised submission.

Pre-Visit Letter

1. G-1.B, page 14: Provide documentation of the process.

2. G-1, Disclosure 1, page 15 and CI-6, Disclosure 2, page 161: Explain the discrepancies in platform identification.

3. G-1, Disclosure 7.A, pages 30-32: Explain in detail the model changes listed in 1 through 6.

4. G-1, Disclosure 7.C, Figure 5, page 33: Provide details on the large (+93.7% in Wakulla County) fractional loss costs increase in the Panhandle due to hazard frequency. If the increase is driven by Hurricane Michael (2018), justify the high sensitivity to the addition of a single storm.

5. G-1, Disclosure 7.C, Figure 6, page 33: Provide details on the fractional decrease in loss costs in the Panhandle due to hurricane distribution updates.

6. G-1, Disclosure 7.C, Figure 7, page 34: Discuss the causes of the loss cost variations across the state due to the filling update.

7. G-1, Disclosure 7.C, Figure 8, page 34: Identify the land use land cover updates, and explain the loss costs for Highlands, Okeechobee and Glades counties.

8. G-1, Disclosure 7.C, Figure 9, page 35: Explain why the figure indicates no change for several counties.

Verified: YES

Professional Team Comments:

Reviewed impacts of the various model updates on loss costs, including the impact of the correction to the land use/land cover update.

Reviewed the processes to assure continual agreement and correct correspondence of databases, data files, and code with presentation slides, technical papers, and model documentation.

Discussed that the Florida Hurricane Model 2021a is a component within the Risk Quantification and Engineering™ (RQE) platform version 21.

Reviewed the number of hurricane landfalls by category in the Panhandle and in the Eastern Panhandle for the current and the previously-accepted model. Discussed the increased loss costs in the Panhandle due to hurricane distribution updates.

Reviewed map of the roughness length changes in Highlands, Okeechobee, and Glades counties.

Discussed that automated scripts are used to create a subset of the submission forms.

Reviewed the methodology and implementation of 500 additional storms in the stochastic storm set.

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

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

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

Audit

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

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

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

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

Verified: YES

Professional Team Comments:

Discussed that there were no new employees involved in the current model and no departures of personnel attributable to violations of professional standards.

Discussed that the modeling organization personnel's catastrophe modeling work is exclusive to CoreLogic.

G-3 Insured Exposure Location*

*(*Significant Revision)*

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

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

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

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

E. Geocoding methodology shall be justified.

Audit

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

Verified: YES

Professional Team Comments:

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

Discussed no change in ZIP Code centroid vendors and that no new ZIP Codes were added to those from the previously-accepted model.

Discussed that no ZIP Code centroids exist over water.

Reviewed maps of ZIP Code boundaries and population-weighted ZIP Code centroids.

Discussed the geocoding process for incomplete street addresses and invalid ZIP Codes.

Reviewed the top ten ZIP Code centroid movements.

G-4 Independence of Hurricane Model Components

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

Audit

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

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

Verified: YES

Professional Team Comments:

There was no evidence to suggest one component of the model was deliberately adjusted to compensate for another 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, Editorial Review Expert Certification, that the submission has been personally reviewed and is editorially correct.

Audit

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

2. Attestation that the submission has been reviewed for grammatical correctness, typographical accuracy, completeness, and no inclusion of extraneous data or materials will be assessed.

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

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

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

6. Form G-7, Editorial Review Expert Certification, will be reviewed.

Verified: YES

Professional Team Comments:

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

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

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

METEOROLOGICAL STANDARDS – Tim Hall, Leader

M-1 Base Hurricane Storm Set*

*(*Significant Revision)*

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

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

Audit

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

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

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

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

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

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

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

Pre-Visit Letter

16. Form M-1, page 174 and Form A-2, pages 216-217: Explain the inconsistencies between the Base Hurricane Storm Set (as listed in Form A-2) and the historical landfall counts in Form M-1. Some examples are:
    - Form A-2 lists a ByP4, but the ByP4 is 0 in Form M-1
    - Form A-2 lists 5 B2 landfalls, but only 4 in Form M-1
    - Form A-2 lists 7 F1 landfalls, but only 6 in Form M-1
    - Form A-2 lists 16 ByP, but only 11 in Form M-1.

Verified: YES

Professional Team Comments:

Reviewed the Base Hurricane Storm Set based on HURDAT2 years 1900-2019 and changes from the previously-accepted model.

Reviewed consistency between the landfall region and category in revised Form A-2 and the historical landfall counts in Form M-1.

Reviewed comparisons between the current model and the previously-accepted model of storm frequency by landfall mileposts.

Reviewed the procedures for processing changes in HURDAT2 in generating landfall distributions.

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

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

Reviewed landfall frequency goodness-of-fit chi-square tests.

M-2 Hurricane Parameters and Characteristics

Methods for depicting all modeled hurricane parameters and characteristics, including but not limited to windspeed, radial distributions of wind and pressure, minimum central pressure, radius of maximum winds, landfall frequency, tracks, spatial and time variant windfields, and conversion factors, shall be based on information documented in current scientific and technical literature.

Audit

1. All hurricane parameters used in the hurricane model will be reviewed.

2. Graphical depictions of hurricane parameters as used in the hurricane model will be reviewed. Descriptions and justification of the following will be reviewed:
    a. The dataset basis for the fitted distributions, the methods used, and any smoothing techniques employed,
    b. The modeled dependencies among correlated parameters in the windfield component and how they are represented, and
    c. The asymmetric structure of hurricanes.

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

4. Scientific literature cited in Standard G-1, Scope of the Hurricane Model and Its Implementation, may be reviewed to determine applicability.

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

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

Pre-Visit Letter

9. M-2, Disclosure 2, page 55: Explain the inconsistency between M-2 Disclosure 2, which only references NWS-38 (Ho et al., 1987) for Rmax analysis, and Standard M-2 Disclosure 1.4, which also lists the use of Extended Best Track data through 2019.

10. M-2, Disclosure 2, page 55: Justify the use of NWS-38 (Ho et al. 1987) in light of more recent data.

11. M-2, Disclosure 3, page 56: Justify the appropriateness of a 192 mph upper limit on landfall Vmax, when several Atlantic hurricanes have peaked close to this value.

Verified: YES

Professional Team Comments:

Discussed the significance of Hurricane Michael (2018) in making the decision to increase the stochastic storm set by 500 storms.

Discussed that the NWS-38 data is used for storms for which such data are not provided in the HURDAT2 Reanalysis and DeMaria's Extended Best Track Set.

Reviewed the data sources used in the Rmax analysis.

Reviewed the landfall Vmax upper bound implemented in the stochastic storm set.

Reviewed the calculations and distributions for the Rmax, forward speed, and profile factor parameters.

Reviewed comparison of historical to stochastic Rmax between the current and the previously-accepted model.

Reviewed the correlation between Rmax and central pressure.

Reviewed comparisons of modeled and historical Rmax and profile factor distributions.

Reviewed map of profile factor changes by county from the previously-accepted model.

Reviewed comparison of historical to stochastic profile factor between the current and the previously-accepted model.

Reviewed the correlation between modeled profile factor and Rmax. Reviewed the profile factor implementation.

Reviewed the modeling of date within year of events.

M-3 Hurricane Probability Distributions

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

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

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

Saffir-Simpson Hurricane Wind Scale:

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

Audit

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

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

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

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

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

Verified: YES

Professional Team Comments:

Reviewed maps of the coastal mile posts used for landfall calculations.

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

M-4 Hurricane Windfield Structure

A. Windfields generated by the hurricane model shall be consistent with observed historical storms affecting Florida.

B. The land use and land cover (LULC) database shall be consistent with National Land Cover Database (NLCD) 2011 or later. Use of alternate datasets shall be justified.

C. The translation of land use and land cover or other source information into a surface roughness distribution shall be consistent with current state-of-the-science and shall be implemented with appropriate geographic-information-system data.

D. With respect to multi-story buildings, the hurricane model shall account for the effects of the vertical variation of winds.

Audit

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

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

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

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

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

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

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

Pre-Visit Letter

12. M-4, Disclosure 1, pages 62-63: The model parametric windfield will be reviewed in detail, including the profile factor.

Verified: YES

Professional Team Comments:

Reviewed the impact on surface roughness of updating to the 2016 land use/land cover data from the National Land Cover Database (NLCD).

Discussed that no changes were made to the surface-roughness methodology, only changes to the data.

Reviewed maps of surface roughness changes compared to the 2011 NLCD.

Reviewed the model windfield, its dependence on parameters, and its relationship to central pressure deficit.

Reviewed comparisons of the parametric windfield model to the Holland B model for Hurricane Donna (1960) and Hurricane Carla (1961).

Reviewed comparisons of the parametric windfield model to the Willoughby model for Hurricane Anita (1977), Hurricane Hugo (1989), and Hurricane Mitch (1998).

Reviewed map depicting the spatial distribution of model surface roughness.

Reviewed map comparisons between the current and previously-accepted model mean windspeeds and Rmax for the LaborDay03 (1935) and NoName09 (1945) storms.

Reviewed model windfield footprints for Hurricane Charley (2004), Hurricane Wilma (2005), Hurricane Irma (2017), and Hurricane Michael (2018). Reviewed the associated scatter plots, Q-Q plots, box-and-whisker plots, and empirical cumulative probability distributions.

Discussed the lack of windspeed station data near Hurricane Irma's (2017) landfall.

M-5 Hurricane Landfall and Over-Land Weakening Methodologies

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

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

Audit

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

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

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

Pre-Visit Letter

13. M-5, Disclosures 1 and 2, pages 67-68: Explain the fact that the response to Disclosure 1 and Figures 16 and 17 are the same as in the previously-accepted model given a new filling model has been implemented. Provide details on the decay rate parameter and its dependencies. What drives the non-exponential features of the decay shown in Figures 16 and 17, especially in the first few hours?

Verified: YES

Professional Team Comments:

Reviewed the inland filling model based on Vickery (2005).

Reviewed comparisons of modeled to historical filling rates in Florida and neighboring states.

Discussed the windspeed adjustment from ocean to open terrain.

Reviewed comparison between the current and previously-accepted model of the filling rates and discussed the change in filling-rate variance.

Reviewed comparisons of modeled to observed filling for Hurricane Irma (2017) and Hurricane Michael (2018).

M-6 Logical Relationships of Hurricane Characteristics

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

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

Audit

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

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

3. Justification for the relationship between central pressure and radius of maximum winds will be reviewed. The relationships among intensity, Rmax, and their changes will be reviewed.

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

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

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

Pre-Visit Letter

14. M-6, Disclosure 2, page 70: Provide detail on the modeling of surface roughness and its impact on modeled windspeed.

15. M-6, Disclosure 4, page 71: Provide histograms of modeled and observed Rmax. For modeled, use both the current Rmax model and the previously-accepted model's Rmax model to illustrate the impact of the distribution change compared to observations.

Verified: YES

Professional Team Comments:

Reviewed the methodology for calculating surface roughness-length factors and the impact on modeled windspeeds, from the ingestion of land use/land cover data to the calculation of surface-friction windspeed reduction factors.

Reviewed map depicting the spatial distribution of model surface roughness.

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

Reviewed histograms of Rmax as given in Form M-3.

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

Reviewed the relationship between Rmax and central pressure.

Reviewed the formulation of the windfield asymmetry term.

STATISTICAL STANDARDS – Mark Johnson, Leader

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

*(*Significant Revision)*

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

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

Audit

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

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

Pre-Visit Letter

17. S-1, Disclosure 1, page 72-73: Provide the underlying data associated with the new distribution choices including the functional forms used, the estimated parameters, and supporting calculations for the goodness-of-fit tests yielding the reported *p*-values, preferably in an Excel Workbook. These distributions are Gumbel for radius to maximum winds, Gamma for translational speed, and Inverse Weibull for profile factor. The Worksheets should have sufficient detail so that the Professional Team could reproduce the results presented in the submission.

18. S-1, Disclosure 1, pages 72-73: Justify the large changes in *p*-values relative to the previously-accepted model for track direction.

19. S-1, Disclosure 3, page 74: Describe in detail claims data for more recent hurricanes.

20. S-1, Disclosure 6, Figure 22, page 79: Justify how the use of the Shapiro-Wilk test for normality applies here for comparing modeled data with historical data.

Verified: YES

Professional Team Comments:

Reviewed changes to statistical distributions to reflect updates in the HRD Reanalysis Project and HURDAT2 dataset: Gumbel distribution for the Rmax, gamma distribution for forward speed, and inverse Weibull distribution for the profile factor.

Reproduced selected distribution fits.

Reviewed Forms S-1, S-2, S-3, S-4, and S-5.

Reviewed goodness-of fit tests for Rmax, forward speed, and profile factor.

Reviewed comparisons of the historical and modeled distributions.

Discussed with the Statistical Standards signatory his review of the model submission documentation and the material presented during the remote review.

S-2 Sensitivity Analysis for Hurricane Model Output

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

Audit

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

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

Verified: YES

Professional Team Comments:

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

S-3 Uncertainty Analysis for Hurricane Model Output

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

Audit

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

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

Verified: YES

Professional Team Comments:

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

S-4 County Level Aggregation

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

Audit

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

Verified: YES

Professional Team Comments:

Reviewed the standard errors as a percentage of hurricane loss cost estimates by county.

Reviewed the impact of the additional 500 storms on loss convergence.

S-5 Replication of Known Hurricane Losses

The hurricane model shall estimate incurred hurricane losses in an unbiased manner on a sufficient body of past hurricane events from more than one company, including the most current data available to the modeling organization. This standard applies separately to personal residential and, to the extent data are available, to commercial residential. Personal residential hurricane loss experience may be used to replicate structure-only and contents-only hurricane losses. The replications shall be produced on an objective body of hurricane loss data by county or an appropriate level of geographic detail and shall include hurricane loss data from both 2004 and 2005.

Audit

1. The following information for each insurer and hurricane will be reviewed:
    a. The validity of the hurricane model assessed by comparing projected hurricane losses produced by the hurricane model to actual observed hurricane losses incurred by insurers at both the state and county level,
    b. The version of the hurricane model used to calculate modeled hurricane losses for each hurricane provided,
    c. A general description of the data and its source,
    d. A disclosure of any material mismatch of exposure and hurricane loss data problems, or other material consideration,
    e. The date of the exposures used for modeling and the date of the hurricane,
    f. An explanation of differences in the actual and modeled hurricane parameters,
    g. A listing of the departures, if any, in the windfield applied to a particular hurricane for the purpose of validation and the windfield used in the hurricane model under consideration,
    h. The type of coverage applied in each hurricane to address:
        1. Personal versus commercial
        2. Residential structures
        3. Manufactured homes
        4. Commercial residential
        5. Condominiums
        6. Structures only
        7. Contents only
        8. Time element,
    i. The treatment of demand surge or loss adjustment expenses in the actual hurricane losses or the modeled hurricane losses, and
    j. The treatment of flood losses (including hurricane storm surge losses) in the actual hurricane losses or the modeled hurricane losses.

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

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

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

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

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

Verified: YES

Professional Team Comments:

Reviewed Form S-4.

S-6 Comparison of Projected Hurricane Loss Costs

The difference, due to uncertainty, between historical and modeled annual average statewide hurricane loss costs shall be reasonable, given the body of data, by established statistical expectations and norms.

Audit

1. Form S-5, Average Annual Zero Deductible Statewide Hurricane Loss Costs – Historical versus Modeled, will be reviewed for consistency with Standard G-1, Scope of the Hurricane Model and Its Implementation, Disclosure 7.

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

Verified: YES

Professional Team Comments:

Reviewed Form S-5.

VULNERABILITY STANDARDS – Masoud Zadeh, Leader

V-1 Derivation of Building Hurricane Vulnerability Functions*

*(*Significant Revision)*

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

B. The derivation of the building hurricane vulnerability functions and their associated uncertainties shall be theoretically sound and consistent with fundamental engineering principles.

C. Residential building stock classification shall be representative of Florida construction for personal and commercial residential buildings.

D. Building height/number of stories, primary construction material, year of construction, location, building code, and other construction characteristics, as applicable, shall be used in the derivation and application of building hurricane vulnerability functions.

E. Hurricane vulnerability functions shall be separately derived for commercial residential building structures, personal residential building structures, manufactured homes, and appurtenant structures.

F. The minimum windspeed that generates damage shall be consistent with fundamental engineering principles.

G. Building hurricane vulnerability functions shall include damage as attributable to windspeed and wind pressure, water infiltration, and missile impact associated with hurricanes. Building hurricane vulnerability functions shall not include explicit damage to the building due to flood (including hurricane storm surge and wave action).

Audit

1. Modifications to the building vulnerability component in the hurricane model since the previously-accepted hurricane model will be reviewed in detail, including the rationale for the modifications, the scope of the modifications, the process, the resulting modifications and their impacts on the building vulnerability component. Comparisons with the previously-accepted hurricane model will be reviewed.

2. Historical data in the original form will be reviewed with explanations for any changes made and descriptions of how missing or incorrect data were handled. When historical data are used to develop building hurricane vulnerability functions, the goodness-of-fit of the data will be reviewed. Complete reports detailing loading conditions and damage states for any laboratory or field testing data used will be reviewed. When rational structural analysis is used to develop building hurricane vulnerability functions, such analyses will be reviewed for a variety of different building construction classes. Laboratory or field tests and original post-event site investigation reports will be reviewed.

3. All papers, reports, and studies used in the continual development of the building hurricane vulnerability functions must be available for review in hard copy or electronic form.

4. Multiple samples of building hurricane vulnerability functions for commercial residential building structures, personal residential building structures, manufactured homes, and appurtenant structures will be reviewed. The magnitude of logical changes among these items for a given windspeed and validation materials will be reviewed.

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

6. Validation of the building hurricane vulnerability functions and associated uncertainties will be reviewed.

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

8. Validation material for the disclosed minimum windspeed will be reviewed. The computer code showing the inclusion of the minimum windspeed at which damage occurs will be reviewed.

9. How the claim practices of insurance companies are accounted for when claims data for those insurance companies are used to develop or to verify building hurricane vulnerability functions will be reviewed. Examples include the level of damage the insurer considers a loss to be a total loss, claim practices of insurers with respect to concurrent causation, the impact of public adjusting, or the impact of the legal environment.

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

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

12. A plot comparing building structure and appurtenant structure hurricane vulnerability functions will be reviewed.

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

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

Pre-Visit Letter

21. V-1, Disclosure 1, page 90: Explain in detail and provide justification for the default roof age, default roof condition, and coverage A for condominium unit owners changes. Provide tables of loss costs demonstrating the impact of these changes (i.e., before and after implementing the changes) individually and in combination for ZIP Codes 32228, 32878, 33076, 33082, 33296, 34137, and 34747, and explain the impacts.

22. V-1, Disclosure 7, page 95: Explain in detail how the model accounts for year of construction, regions within the State of Florida, and the Florida Building Code.

Verified: YES

Professional Team Comments:

Reviewed the Coverage A condo policies update. Discussed the Hurricane Irma (2017) post-storm survey of damage caused by wind and water leakage to various components conducted by the Department of Civil and Coastal Engineering at the University of Florida. Discussed the internal comparisons of interior leakage damage to exterior wind damage.

Reviewed the default roof age and roof condition updates.

Reviewed table of loss cost changes related to the roof and condo Coverage A updates for certain ZIP Codes.

Reviewed the database of quality factors for roof age and roof condition secondary structural modifiers.

Reviewed the implementation of Coverage A update for condo owners.

Discussed the claims data analyzed for development and validation of the building and appurtenant structure vulnerability functions.

Discussed the evolution of building codes by region in Florida.

Reviewed examples of building and appurtenant structure vulnerability functions for masonry, wood frame, and manufactured homes.

Reviewed scatter plots of modeled to claims mean damage ratios.

V-2 Derivation of Contents Hurricane Vulnerability Functions*

*(*Significant Revision)*

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

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

Audit

1. Modifications to the contents vulnerability component in the hurricane model since the previously-accepted hurricane model will be reviewed in detail, including the rationale for the modifications, the scope of the modifications, the process, the resulting modifications and their impact on the contents vulnerability component. Comparisons with the previously-accepted hurricane model will be reviewed.

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

3. To the extent that historical data are used to develop mathematical depictions of contents hurricane vulnerability functions, the goodness-of-fit of the data to fitted models will be reviewed.

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

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

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

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

Verified: YES

Professional Team Comments:

Discussed the appropriateness of research by Texas Tech Professors Kishor Mehta and James McDonald on the development of the contents vulnerability functions.

Discussed the claims data analyzed for development and validation of the contents vulnerability functions.

Reviewed examples of contents vulnerability functions by construction type.

Discussed that the contents vulnerability functions have not changed from the previously-accepted model.

Reviewed the relationship between contents and building damage ratios.

V-3 Derivation of Time Element Hurricane Vulnerability Functions*

*(*Significant Revision)*

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

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

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

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

Audit

1. Modifications to the time element vulnerability component in the hurricane model since the previously-accepted hurricane model will be reviewed in detail, including the rationale for the modifications, the scope of the modifications, the process, the resulting modifications and their impact on the time element vulnerability component. Comparisons with the previously-accepted hurricane model will be reviewed.

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

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

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

5. To the extent that historical data are used to develop mathematical depictions of time element hurricane vulnerability functions, the goodness-of-fit of the data to fitted models will be reviewed.

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

Verified: YES

Professional Team Comments:

Discussed the claims data analyzed for development and validation of the time-element vulnerability functions.

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

Reviewed the relationship of time-element damage ratio to building and contents damage ratios.

V-4 Hurricane Mitigation Measures and Secondary Characteristics*

*(*Significant Revision)*

A. Modeling of hurricane mitigation measures to improve a building's hurricane wind resistance, the corresponding effects on hurricane vulnerability, and their associated uncertainties shall be theoretically sound and consistent with fundamental engineering principles. These measures shall include fixtures or construction techniques that affect the performance of the building and the damage to contents and shall consider:

- ***Roof strength***
- ***Roof covering performance***
- ***Roof-to-wall strength***
- ***Wall-to-floor-to-foundation strength***
- ***Opening protection***
- ***Window, door, and skylight strength.***

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

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

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

Audit

1. Modifications to hurricane mitigation measures and secondary characteristics in the hurricane model since the previously-accepted hurricane model will be reviewed in detail, including the rationale for the modifications, the scope of the modifications, the process, the resulting modifications, and their impacts on the vulnerability component. Comparisons with the previously-accepted hurricane model will be reviewed.

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

3. Form V-2, Hurricane Mitigation Measures and Secondary Characteristics, Range of Changes in Damage; Form V-3, Hurricane Mitigation Measures and Secondary Characteristics, Mean Damage Ratios and Hurricane Loss Costs (Trade Secret Item); Form V-4, Differences in Hurricane Mitigation Measures and Secondary Characteristics; and Form V-5, Differences in Hurricane Mitigation Measures and Secondary Characteristics, Mean Damage Ratios and Hurricane Loss Costs (Trade Secret Item), will be reviewed.

4. Implementation of individual hurricane mitigation measures and secondary characteristics will be reviewed as well as the effect of individual hurricane mitigation measures and secondary characteristics on damage. Any variation in the change over the range of windspeeds for individual hurricane mitigation measures and secondary characteristics will be reviewed. Historical data, technical literature, analysis or judgment based on fundamental engineering principles used to support the assumptions and implementation of the hurricane mitigation measures and secondary characteristics will be reviewed.

5. The treatment of roof age will be reviewed.

6. Implementation of multiple hurricane mitigation measures and secondary characteristics will be reviewed. The combined effects of these hurricane mitigation measures and secondary characteristics on damage will be reviewed. Any variation in the change over the range of windspeeds for multiple hurricane mitigation measures and secondary characteristics will be reviewed.

7. Hurricane mitigation measures and secondary characteristics used by the hurricane model, whether or not referenced in Form V-2, Hurricane Mitigation Measures, Range of Changes in Damage, and Form V-3, Hurricane Mitigation Measures, Mean Damage Ratios and Hurricane Loss Costs (Trade Secret Item), will be reviewed for theoretical soundness and reasonability.

Pre-Visit Letter

23. Form V-4, page 207: Explain the response given to Part C.

24. Form V-4, page 208: Given the modifications in secondary characteristics outlined in Standard V-4 Disclosure 1, explain why there are zero values for all columns and rows in Form V-4, except for Door and Skylight Covers at 60 mph windspeed.

Verified: YES

Professional Team Comments:

Reviewed the default roof age and roof condition updates.

Discussed that year of construction and Florida Building Code development by year of implementation are used as the basis for the year bands in the development of the secondary structural modifiers.

Discussed that secondary structural modifiers are categorized by age groups and that year-built is a primary building characteristic.

Reviewed the database of quality factors roof age and roof condition secondary structural modifiers and its implementation.

Reviewed the table of loss cost changes related to the roof and condo Coverage A updates for certain ZIP Codes.

Reviewed implementation of Coverage A for condo owners.

Reviewed the secondary structural modifiers age groups.

Reviewed Forms V-2, V-3, V-4, and V-5.

Discussed that there were no impacts on Forms V-2, V-3, V-4, and V-5 due to updates to the mitigation and secondary structural modifiers from the previously-accepted model.

Reviewed the methodology for combining secondary structural modification factors.

Reviewed the research on mitigation measures and secondary structural characteristics that led to the results in Form V-2.

ACTUARIAL STANDARDS – Stu Mathewson, Leader

A-1 Hurricane Model Input Data and Output Reports

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

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

Audit

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

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

Verified: YES

Professional Team Comments:

Discussed the processes for reviewing claims data for consistency, to correct any errors, and to determine the elements included in the claims data.

Discussed the various reports run to verify the inputs to the model.

A-2 Hurricane Events Resulting in Modeled Hurricane Losses

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

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

Audit

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

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

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

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

Pre-Visit Letter

25. A-2.B, page 132: Provide a copy of the documented procedure.

Verified: YES

Professional Team Comments:

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

Reviewed the storm criteria for including the losses.

A-3 Hurricane Coverages

A. The methods used in the calculation of building hurricane loss costs shall be actuarially sound.

B. The methods used in the calculation of appurtenant structure hurricane loss costs shall be actuarially sound.

C. The methods used in the calculation of contents hurricane loss costs shall be actuarially sound.

D. The methods used in the calculation of time element hurricane loss costs shall be actuarially sound.

Audit

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

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

3. The treatment of loss assessment coverage for condo unit owners will be reviewed, including the statutory required $2,000 coverage option.

Pre-Visit Letter

26. A-3, Disclosures 1-4, pages 133-136: Show a calculation of loss costs and probable maximum loss levels for the minimum Masonry Owners loss costs in Form A-1 (i.e., ZIP Code 32009 in Nassau County).

27. A-3, Disclosure 2, page 134: Expand the description of methods used to calculate appurtenant structure loss costs.

28. A-3, Disclosure 5, page 136: Explain how law and ordinance coverage is implied in the vulnerability functions. Explain how the model handles the statutory 25% and 50% coverages. Explain how the model accounts for loss assessment coverage of $2,000 for condos. (Audit items 2 and 3)

Verified: YES

Professional Team Comments:

Discussed with the Actuarial Standards signatory how he attested the model results to be actuarially sound.

Reviewed a calculation of masonry-owners loss costs in Form A-1 and probable maximum loss levels for ZIP Code 32009 in Nassau County.

Discussed that appurtenant structure vulnerability functions are based on claims data.

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

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

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

A. Hurricane loss cost projections and hurricane probable maximum loss levels shall not include expenses, risk load, investment income, premium reserves, taxes, assessments, or profit margin.

B. Hurricane loss cost projections and hurricane probable maximum loss levels shall not make a prospective provision for economic inflation.

C. Hurricane loss cost projections and hurricane probable maximum loss levels shall not include any explicit provision for direct flood losses (including those from hurricane storm surge).

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

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

Audit

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

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

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

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

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

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

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

Pre-Visit Letter

29. A-4, Disclosure 1, pages 138-139: 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.

30. A-4, Disclosure 3, page 140: Provide additional details on the demand surge factor calculation, especially the Cat Index and Cat Inflation Index.

Verified: YES

Professional Team Comments:

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

Reviewed the demand surge methodology.

Reviewed calculation of demand surge factors and implementation.

Reviewed the methodology for determining probable maximum loss levels.

A-5 Hurricane Policy Conditions*

*(*Significant Revision)*

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

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

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

Audit

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

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

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

4. Treatment of annual deductibles will be reviewed.

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

Verified: YES

Professional Team Comments:

Discussed the process for application of the annual hurricane deductibles.

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

*(*Significant Revision)*

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Audit

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

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

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

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

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

6. The procedures used by the modeling organization to verify the individual hurricane loss cost relationships will be reviewed. Methods (including any software) used in verifying Standard A-6, Hurricane Loss Outputs and Logical Relationships to Risk, will be reviewed. Forms A-1, Zero Deductible Personal Residential Hurricane Loss Costs by ZIP Code; A-2, Base Hurricane Storm Set Statewide Hurricane Losses; A-3, Hurricane Losses; A-6, Logical Relationship to Hurricane Risk (Trade Secret Item); and A-7, Percentage Change in Logical Relationship to Hurricane Risk, will be reviewed to assess coverage relationships.

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

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

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

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

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

Pre-Visit Letter

31. A-6.D, E, and F, pages 144-145: Given the impacts of some of the hurricane mitigation measures and secondary characteristics in Form V-2 (page 205) are indicated by both positive and negative values, explain how Form V-2 supports Parts D, E, and F of the standard.

32. Form A-1, page 213: Explain the large increases in manufactured home structures relative to the previously-accepted model.

33. Form A-1.B, page 214: Explain the ZIP Code county assignments for 32733 and 32745 in the current model compared to the previously-accepted model county assignment. Explain why there are no new ZIP Codes in the current model Form A-1.

34. Form A-2, pages 216-217: Explain the large differences in the current model losses for hurricanes Dora (1964), Isbell (1964) and Irma (2017).

35. Form A-3, pages 219-230: Explain the large decrease in Form A-2 for Hurricane Hermine (2017) losses compared to the previously-accepted model.

36. Form A-4, 0% Deductible, pages 239-243: Explain the reversal in loss costs where Frame is less than Masonry:
    Owners: Indian River High,
    Renters: Taylor Low, and
    Condo Unit: Okaloosa Low, Okeechobee Average.

37. Form A-4, page 240: With Form A-1 having only one ZIP Code for Glades County (33471), explain Form A-4 showing different loss costs for Low, Average, and High for all construction/policy combinations.

38. Form A-4, page 241: Explain the values given for Lafayette County Low, Average, and High for Frame Owners, Masonry Owners, and Manufactured Homes.

39. Form A-5, Figures 56-63, pages 252-259: Many of the Panhandle counties show increases between 50% and 80%. In Form A-1 and Form A-4, several of the counties seem to be less than that. Explain the county changes for Bay, Leon, Liberty and Taylor counties.

40. Form A-5, Figures 56-63, pages 252-259: Explain the high increases shown on the maps for all policy types. Explain for Frame Owners, the increase of 156%, while the Average in Form A-4 for Wakulla County shows an increase of 50%.

41. Form A-5, Figure 58, page 254: For manufactured homes in Flagler County, explain the high increases in ZIP Codes 32135, 32137, 32142, 32143, and 32164 compared to the range shown in Figure 58.

42. Form A-7, page 268: Discuss the uniformity by row in the Number of Stories table.

43. Form A-8.A, page 272: Explain the changes in distribution of number of hurricanes by ranges.

44. Form A-8, pages 273-274: Explain the changes in Expected Annual Hurricane Losses for all return times, especially the return times over 250 years.

45. Form A-8, page 273: Provide details on the calculation of the uncertainty intervals.

Verified: YES

Professional Team Comments:

Reviewed revised Form A-5 after correction of the land use/land cover update with the percentage differences in loss costs based upon the initial submission.

Reviewed the research on mitigation measures and secondary structural characteristics that led to the results in Form V-2.

Discussed that the increases in manufactured homes from the previously-accepted model are due to the hazard model updates.

Reviewed the county assignments for ZIP Codes 32733 and 32745 compared to the previously-accepted model.

Reviewed the underlying reasons for the increases in Form A-2 modeled losses for Hurricane Dora (1964), Hurricane Isbell (1964), and Hurricane Irma (2017).

Reviewed the difference in modeled losses for Hurricane Hermine (2016) between Forms A-2 and A-3.

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

Discussed loss costs in Form A-4 for Lafayette, Bay, Leon, Liberty, and Taylor counties.

Discussed the changes in loss costs in Form A-4 for Wakulla and Flagler counties.

Reviewed Form A-5.

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

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

Reviewed maps of loss costs by county for different construction and policy types in Form A-1.

Reviewed maps of surface roughness length and the effect of surface roughness on damage.

COMPUTER/INFORMATION STANDARDS – Paul Fishwick, Leader

CI-1 Hurricane Model Documentation

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

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

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

D. The following shall be maintained: (1) a table of all changes in the hurricane model from the previously-accepted hurricane model to the initial submission this year, and (2) a table of all substantive changes since this year's initial submission.

E. Documentation shall be created separately from the source code.

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

Audit

1. The primary document repository, in either electronic or physical form, and its maintenance process will be reviewed. The repository should contain or reference full documentation of the software.

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

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

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

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

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

7. The tables specified in CI-1.D that contain the items listed in Standard G-1, Scope of the Hurricane Model and Its Implementation, Disclosure 7 will be reviewed. The tables should contain the item number in the first column. The remaining five columns should contain specific document or file references for affected components or data relating to the following Computer/Information Standards: CI-2, Hurricane Model Requirements; CI-3, Hurricane Model Organization and Component Design; CI-4, Hurricane Model Implementation; CI-5, Hurricane Model Verification; and CI-6, Hurricane Model Maintenance and Revision.

8. Tracing of the hurricane model changes specified in Standard G-1, Scope of the Hurricane Model and Its Implementation, Disclosure 7 and Audit 6 through all Computer/Information Standards will be reviewed.

Pre-Visit Letter

46. CI-1.B, page 151: Relate the primary binder table of contents with the response to Standard G-1 Disclosure 7 (pages 30-36) by demonstrating individual table item compliance with Computer/Information Standards CI-1 through CI-7.

47. CI-1.D, page 151: Provide the table required by Standard CI-1 Audit Item 7.

48. CI-1.F, page 152: Provide the list of all externally-acquired hurricane model-specific software and data assets as described and required by Standard CI-1 Audit Item 6.

Verified: YES

Professional Team Comments:

Discussed that code documentation is generated automatically using Doxygen.

Discussed the tools used to maintain documentation.

Reviewed the documentation on combining secondary structural modifiers.

Reviewed the demand surge model documentation.

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

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

Discussed the importance of complete documentation and maintaining documentation separate from source code, presentation slides, and published literature.

CI-2 Hurricane Model Requirements

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

Audit

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

Pre-Visit Letter

49. CI-2, page 153: Provide requirements documentation that specifically relates to each model change identified in Standard G-1 Disclosure 7 (pages 30-36).

Verified: YES

Professional Team Comments:

Reviewed software requirements documentation.

CI-3 Hurricane Model Organization and Component Design

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

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

Audit

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

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

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

Pre-Visit Letter

50. CI-3.B, page 154: Provide the required document.

Verified: YES

Professional Team Comments:

Reviewed the Charting and Diagramming Standards.

Reviewed control and data flowcharts and verified the compliance of the flowcharts with the modeler's charting and diagramming standards.

Reviewed the following flowcharts for:

- product verification
- the software development and verification process
- the technical development process
- project documentation
- creation of submission forms
- calculation of per-occurrence loss
- processing HURDAT2 data in calculating landfall distributions
- the model probabilistic analysis
- the hazard, damage, and loss calculation procedure.

Reviewed the class diagram for object deployment for the model hazard and damage calculations.

Reviewed the business workflow diagram.

CI-4 Hurricane Model Implementation*

*(*Significant Revision)*

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

B. Network organization documentation shall be maintained.

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

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

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

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

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

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

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

Audit

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

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

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

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

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

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

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

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

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

10. Network organization implementation will be reviewed.

Verified: YES

Professional Team Comments:

Discussed the reasons for the error in the land use/land cover update to NLCD 2016, corrective actions, and actions taken to prevent the error from recurring.

Reviewed the coding guidelines.

Reviewed the modeler's plan for improvement of code readability within the model.

Discussed the importance of variable naming convention.

Reviewed examples of comments in the code. Discussed the significance of having sufficient explanatory and quality comments.

Discussed the importance of considering a transition to more recent source version control software.

Reviewed the utility to generate friction coefficients.

Reviewed implementation of profile factors.

Reviewed implementation of Coverage A for condo owners.

Reviewed spreadsheet data and implementation of quality factors for roof age and roof condition secondary structural modifiers.

Reviewed terms, variables, and implementation of demand surge factors.

Reviewed the methodology for computing the mean and standard deviation for each event in Form A-8.

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

CI-5 Hurricane Model Verification

A. General

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

B. Component Testing

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

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

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

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

C. Data Testing

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

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

Audit

1. The components will be reviewed for containment of sufficient logical assertions, exception-handling mechanisms, and flag-triggered output statements to test the correct values for key variables that might be subject to modification.

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

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

4. Fully time-stamped, documented cross-checking procedures and results for verifying equations, including tester identification, will be reviewed. Examples include mathematical calculations versus source code implementation or the use of multiple implementations using different languages.

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

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

Pre-Visit Letter

51. CI-5, pages 157-159: Provide complete and thorough verification procedures and output from the model changes identified in Standard G-1 Disclosure 7 (pages 30-36).

Verified: YES

Professional Team Comments:

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

Reviewed the unit tests for the Coverage A condo-owners code.

Reviewed the unit test on roof age and condition.

Reviewed an example unit test for demand surge.

CI-6 Hurricane Model Maintenance and Revision

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

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

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

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

Audit

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

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

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

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

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

Pre-Visit Letter

52. CI-6.D, page 160: Provide the model version history over the past 5 years, leading up to the version identified in the submission.

Verified: YES

Professional Team Comments:

Reviewed the model version history.

Discussed the model and platform version numbering system.

Discussed that there was no change in the revision policy from the previously-accepted model.

CI-7 Hurricane Model Security

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

Audit

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

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

3. Security aspects of each platform will be reviewed.

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

Verified: YES

Professional Team Comments:

Discussed that there have been no security breaches.

Reviewed the security policies. Discussed that there have been no recent updates to the security procedures.

Irvine, CA
Oakland, CA
San Diego, CA
Boulder, CO
Austin, TX
Irving, TX
Milwaukee, WI
London, UK

March 11, 2021

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

Re: Florida Hurricane Model 2021

Dear Mr. Yager:

CoreLogic would like to notify the Commission that we have discovered an error in the CoreLogic Florida Hurricane Model 2021, which is currently under review for acceptability under the 2019 standards. The error is that one file related to the land use / land cover update to the National Land Cover Database (NLCD) 2016 was incorrectly updated, due to a processing error.

CoreLogic has corrected the above error in parallel with verifying it, and we will resubmit (in the case of Trade Secret forms, make available to the Professional Team during the on-site review) the impacted disclosures (Standard G-1 Disclosure 7, and Standard S-1 Disclosure 4) and forms (S-2, S-4, S-5, V-1, A-1, A-2, A-3, A-4, A-5, A-6, A-7, and A-8) in accordance with the November 1, 2019 Report of Activities by March 22, 2021.

Sincerely,

CoreLogic, Inc.
Justin M. Brolley
Senior Principal Research Scientist, Model Development, Science and Analytics