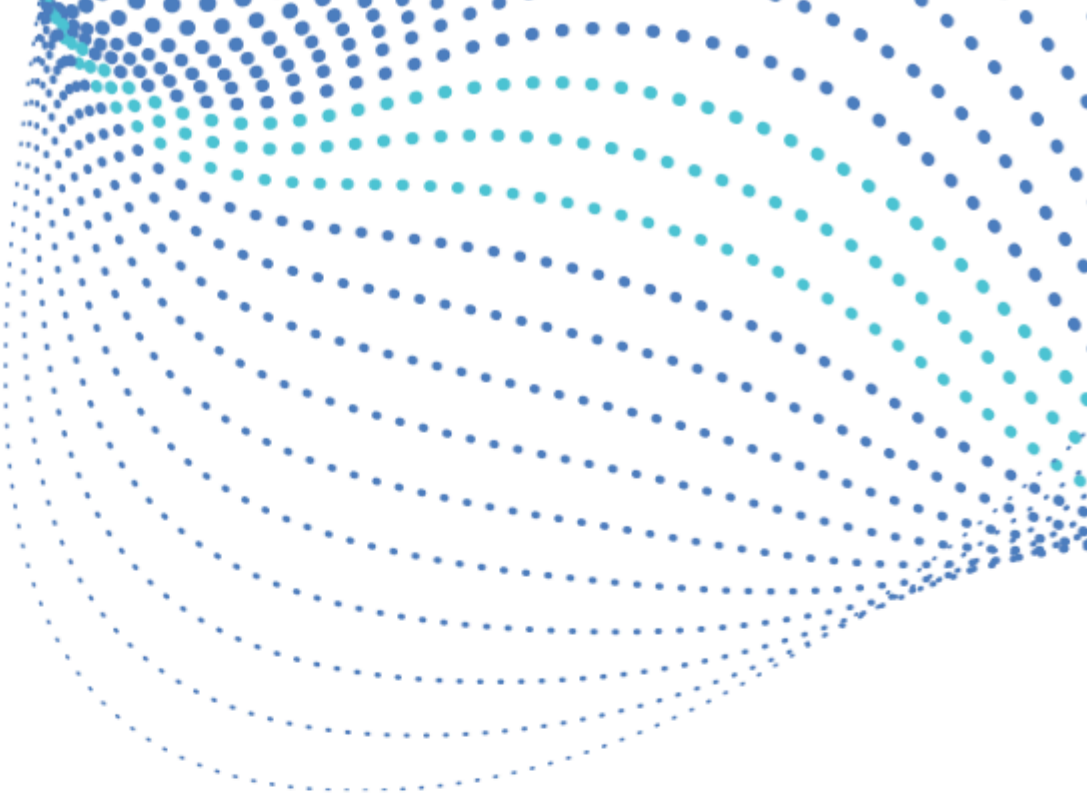


Verisk™

The Verisk Hurricane Model for the United States V3.0.0 as Implemented in Touchstone® 2024A

Publication Date: 2025-05-27

Table of Contents

FLORIDA COMMISSION ON HURRICANE LOSS PROJECTION METHODOLOGY: HURRICANE MODEL IDENTIFICATION 12

TRADE SECRET INFORMATION 13

GENERAL HURRICANE STANDARDS 14

- Standard G-1: Scope of the Hurricane Model and Its Implementation 14
- Standard G-2: Qualifications of Modeling Organization Personnel and Consultants Engaged in Development and Implementation of the Hurricane Model 36
- Standard G-3: Insured Exposure Location 60
- Standard G-4: Independence of Hurricane Model Components 66
- Standard G-5: Editorial Compliance 67

METEOROLOGICAL HURRICANE STANDARDS 69

- Standard M-1: Model Base Hurricane Set 69
- Standard M-2: Hurricane Parameters (Inputs) 72
- Standard M-3: Hurricane Probability Distributions 79
- Standard M-4: Hurricane Windfield Structure 81
- Standard M-5: Hurricane Intensity Change Methodologies 91
- Standard M-6: Logical Relationships of Hurricane Characteristics 96

STATISTICAL HURRICANE STANDARDS 98

- Standard S-1: Modeled Results and Goodness-of-Fit 98
- Standard S-2: Sensitivity Analysis for Hurricane Model Output 110
- Standard S-3: Uncertainty Analysis for Hurricane Model Output 114
- Standard S-4: County Level Aggregation 118
- Standard S-5: Replication of Known Hurricane Losses 119
- Standard S-6: Comparison of Projected Hurricane Loss Costs 125

VULNERABILITY HURRICANE STANDARDS 127

- Standard V-1: Development of Building Hurricane Vulnerability Functions 127
- Standard V-2: Development of Contents Hurricane Vulnerability Functions 144
- Standard V-3: Development of Time Element Hurricane Vulnerability Functions 147
- Standard V-4: Hurricane Mitigation Measures and Secondary Characteristics 151

ACTUARIAL HURRICANE STANDARDS 159

- Standard A-1: Hurricane Model Input Data and Output Reports 159
- Standard A-2: Hurricane Events Resulting in Modeled Hurricane Losses 168

Standard A-3: Hurricane Coverages....170
Standard A-4: Modeled Hurricane Loss Cost and Hurricane Probable Maximum Loss Level Considerations....173
Standard A-5: Hurricane Policy Conditions....177
Standard A-6: Hurricane Loss Outputs and Logical Relationships to Risk....181

COMPUTER/INFORMATION HURRICANE STANDARDS....189
Standard CI-1: Hurricane Model Documentation....189
Standard CI-2: Hurricane Model Requirements....196
Standard CI-3: Hurricane Model Organization and Component Design....198
Standard CI-4: Hurricane Model Implementation....211
Standard CI-5: Hurricane Model Verification....224
Standard CI-6: Human-Computer Interaction....230
Standard CI-7: Hurricane Model Maintenance and Revision....233
Standard CI-8: Hurricane Model Security....236

APPENDIX 1: GENERAL HURRICANE STANDARDS FORMS....242
Form G-1: General Hurricane Standards Certification....242
Form G-2: Meteorological Hurricane Standards Expert Certification....243
Form G-3: Statistical Hurricane Standards Expert Certification....243
Form G-4: Vulnerability Hurricane Standards Expert Certification....244
Form G-4: Vulnerability Hurricane Standards Expert Certification....245
Form G-5: Actuarial Hurricane Standards Expert Certification....247
Form G-5: Actuarial Hurricane Standards Expert Certification....247
Form G-6: Computer/Information Hurricane Standards Expert Certification....248
Form G-7: Editorial Review Expert Certification....249

APPENDIX 2: METEOROLOGICAL STANDARDS FORMS....251
Form M-1: Annual Occurrence Rates....251
Form M-2: Maps of Maximum Winds....256
Form M-3: Radius of Maximum Winds and Radii of Standard Wind Thresholds....259

APPENDIX 3: STATISTICAL STANDARDS FORMS....262
Form S-1: Probability and Frequency of Florida Landfalling Hurricanes per Year....262
Form S-2: Examples of Hurricane Loss Exceedance Estimates....264
Form S-3: Distributions of Stochastic Hurricane Parameters....266
Form S-4: Validation Comparisons....275
Form S-5: Average Annual Zero Deductible Statewide Hurricane Loss Costs....280
Form S-6: Hypothetical Events for Sensitivity and Uncertainty Analysis....282

APPENDIX 4: VULNERABILITY HURRICANE STANDARDS FORMS....283
Form V-1: One Hypothetical Event....283

Form V-2: Hurricane Mitigation Measures and Secondary Characteristics, Range of Changes in Damage.....288
Form V-3: Hurricane Mitigation Measures and Secondary Characteristics, Mean Damage Ratios and Hurricane Loss Costs (Trade Secret Item).....292
Form V-4: Differences in Hurricane Mitigation Measures and Secondary Characteristics..... 293
Form V-5: Differences in Hurricane Mitigation Measures and Secondary Characteristics, Mean Damage Ratios and Hurricane Loss Costs (Trade Secret Item).....295

APPENDIX 5: ACTUARIAL HURRICANE STANDARD FORMS.....296
Form A-1: Zero Deductible Personal Residential Hurricane Loss Costs by ZIP Code..... 296
Form A-2: Model Base Hurricane Set Statewide Hurricane Losses..... 300
Form A-3: Hurricane Losses.....304
Form A-4: Hurricane Output Ranges.....310
Form A-5: Percentage Change in Hurricane Output Ranges.....338
Form A-6: Logical Relationships to Hurricane Risk (Trade Secret Item).....344
Form A-8: Hurricane Probable Maximum Loss for Florida..... 345

APPENDIX 6: MODEL OUTPUT FORMS.....354
Import log.....354
Analysis log.....357

APPENDIX 7: MODEL EVALUATIONS.....361
Model Evaluation by Dr. Carol Friedland, P.E., Ph.D., C.F.M., 2023 Vulnerability Hurricane Standards..... 361
Model Evaluation by Paul Ericksen, FCAS, MAAA, Actuarial Standards.....379
Model Evaluation by Robert R. Cabeca, Computer/Information Hurricane Standards.....386

APPENDIX 8: ACCOUNTING FOR SECONDARY RISK CHARACTERISTICS..... 398
Executive Summary..... 398
Introduction..... 399
Overview of Catastrophe Modeling Technology..... 399
Damage Estimation Overview.....400
Accounting for Secondary Risk Characteristics.....402
Methodology for Accounting for Secondary Risk Characteristics.....418
Evaluating Wind Loss Mitigation Credits with the Touchstone Location Detail Record.....428

APPENDIX 9: REMAPPED ZIP CODES.....431
Remapped ZIP Codes..... 431

APPENDIX 10: LIST OF ACRONYMS..... 438
.....438

List of Tables

Table 1. Verisk Modeler Personnel and Consultants....36
Table 2. Professional Credentials....39
Table 3. HURDAT2 Radii Values for each Wind Threshold in Form M-3....97
Table 4. Actual vs. Modeled Losses for Eight Storms and Eight Companies (Personal Residential)....119
Table 5. Actual vs. Modeled Losses for Six Storms and Two Companies (Commercial Residential)....120
Table 6. Actual vs. Modeled Losses by Coverage for Eight Storms and Seven Companies (Personal Residential)....121
Table 7. Actual vs. Modeled Losses by Construction Type for Eight Storms and Eight Companies (Personal Residential)....122
Table 8. Actual vs. Modeled Losses by Construction Type for Six Storms and Two Companies (Commercial Residential)....123
Table 9. Actual vs. Modeled Losses by County for One Company—Hurricane Frances....123
Table 10. Sample Datasets Used in Model Validation and Calibration of Vulnerability Functions....133
Table 11. Residential Construction Types in the Verisk Hurricane Model for the United States....137
Table 12. Height Bands for Different Construction Types in the Verisk Hurricane Model for the United States....138
Table 13. Mitigation Measures and Secondary Characteristics in the Verisk Hurricane Model for the United States...154
Table 14. Sample Calculation for Adjusting Input Values for Insurance-to-Value (ITV) Assumptions....160
Table 15. Sample Calculation for Determining ACV Losses*....160
Table 16. Catastrophe Peril Analysis Options Applicable for Florida Rate Filing....163
Table 17. County Weighted Average Loss Costs for Masonry and Frame....188
Table 18. Minimum Resource Requirements....214
Table 19. Physical Memory Limits....215
Table 20. Certified Platforms....215
Table 21. Certified Configuration....215
Table 22. Least Impact Upgrade Path....216
Table 23. Maximum Impact Upgrade Path....216
Table 24. HPC Pack Breakdown....216
Table 25. Model Data Disk Space Requirements (in Gigabytes)....217
Table 26. Touchstone Development Tools and Dependencies....218
Table 27. Validation Methods Data Sources....227

Table 28. Model and Platform Identifications....235
Table 29. Modeled Annual Occurrence Rates....251
Table 30. Radius of Maximum Winds and Radii of Standard Wind Thresholds....259
Table 31. Probability and Frequency of Florida Landfalling Hurricanes per Year, Hurricane Model Results.... 262
Table 32. Part A - Examples of Hurricane Loss Exceedance Estimates....264
Table 33. Part B - Summary Statistics of Estimated Hurricane Loss.... 265
Table 34. Distributions of Stochastic Hurricane Parameters....267
Table 35. Comparison 1 - Validation by Construction Type, Company C.... 275
Table 36. Comparison 2 - Validation by Construction Type, Company G.... 275
Table 37. Comparison 3 - Validation by Construction Type, Company N.... 276
Table 38. Comparison 4 - Validation by County, Company J....276
Table 39. Comparison of Actual Commercial Residential Exposures and Loss to Modeled Exposure and Loss....276
Table 40. Average Annual Zero Deductible Statewide Personal and Commercial Residential Hurricane Loss Costs... 280
Table 41. Average Annual Zero Deductible Statewide Personal and Commercial Residential Hurricane Loss Costs... 281
Table 42. Damage Ratios Summarized by Windspeed (mph) and Construction Type....284
Table 43. Form V-2: Hurricane Mitigation Measures and Secondary Characteristics, Range of Changes in Damage... 290
Table 44. Form V-4: Differences in Hurricane Mitigation Measures and Secondary Characteristics....294
Table 45. Form A-1 Construction/Occupancy Information and Data Mapping.... 299
Table 46. Model Base Hurricane Set Statewide Hurricane Losses....300
Table 47. Form A-4, Hurricane Output Ranges - Loss Costs per $1000 for 0% Deductible (2017 FHCF Exposure Data)....311
Table 48. Form A-4, Hurricane Output Ranges - Loss Costs per $1000 for Specified Deductible (2017 FHCF Exposure Data)....317
Table 49. Form A-4, Hurricane Output Ranges - Loss Costs per $1000 for 0% Deductible (2023 FHCF Exposure Data)....323
Table 50. Form A-4, Hurricane Output Ranges - Loss Costs per $1000 for Specified Deductible (2023 FHCF Exposure Data)....329
Table 51. Form A-5 Percentage Change in $0 Deductible Hurricane Output Ranges (2017 FHCF Exposure Data).....338
Table 52. Form A-5 Percentage Change in Specified Deductible Hurricane Output Ranges (2017 FHCF Exposure Data)....339
Table 53. Part A.1: Personal and Commercial Residential Hurricane Probable Maximum Loss for Florida (2017 FHCF Exposure Data).... 346

Table 54. Part B.1: Personal and Commercial Residential Hurricane Probable Maximum Loss for Florida (2023 FHCF Exposure Data)..... 347

Table 55. Part A.2: Personal and Commercial Residential Hurricane Probable Maximum Loss for Florida - Annual Aggregate (2017 FHCF Exposure Data)..... 351

Table 56. Part A.3: Personal and Commercial Residential Hurricane Probable Maximum Loss for Florida - Annual Occurrence (2017 FHCF Exposure Data)..... 351

Table 57. Part B.2: Personal and Commercial Residential Hurricane Probable Maximum Loss for Florida - Annual Aggregate (2023 FHCF Exposure Data)..... 352

Table 58. Part B.3: Personal and Commercial Residential Hurricane Probable Maximum Loss for Florida - Annual Occurrence (2023 FHCF Exposure Data)..... 352

Table 59. Secondary Risk Characteristics Supported by the Verisk Hurricane Model for the United States in Touchstone..... 406

Table 60. Building Categories According to FBC 2001..... 424

Table 61. Model Parameters for Building Category 6 According to the Minimum Requirements of FBC 2001..... 425

Table 62. Building Categories According to FBC 2010..... 426

Table 63. Model Parameters for Building Category 11 According to the Minimum Requirements of FBC 2010..... 427

Table 64. Building Features Relevant to the Florida Statute..... 429

Table 65. DCA Features and Corresponding Verisk Secondary Characteristics..... 429

Table 66. Remapped ZIP Codes FHCF 2017..... 431

Table 67. Remapped ZIP Codes FHCF 2023..... 434

Table 68. List of Acronyms..... 438

List of Figures

Figure 1. Components of the Verisk Hurricane Model for the United States..... 17

Figure 2. Flowchart of the Verisk Hurricane Model for the United States Component Interactions..... 20

Figure 3. Touchstone Network Organization..... 21

Figure 4. Event Generation Percentage Impact on Average Annual Zero Deductible Statewide Loss Costs..... 33

Figure 5. Vulnerability Percentage Impact on Average Annual Zero Deductible Statewide Loss Costs..... 33

Figure 6. Geographic or Other Data Percentage Impact on Average Annual Zero Deductible Statewide Loss Costs..... 34

Figure 7. Total Percentage Impact on Average Annual Zero Deductible Statewide Loss Costs..... 35

Figure 8. Verisk Hurricane Model for the United States Workflow..... 57

Figure 9. Annual Hurricane Landfall Frequency by Coastal Segment, Historical vs. Modeled, 1900-2022..... 78

Figure 10. Tangential Wind Profile (Assuming Updated Florida Mean Values of Rmax, Cp and Latitude)..... 83

Figure 11. Observed and Modeled Wind Speeds, hurricane Charley (2004). White areas experience wind speed below 40mph..... 86

Figure 12. Observed and Modeled Wind Speeds, hurricane Dennis (2005). White areas experience wind speed below 40mph..... 87

Figure 13. Observed and Modeled Wind Speeds, hurricane Michael (2018). White areas experience wind speed below 40mph..... 88

Figure 14. Equation 1..... 92

Figure 15. Modeled Filling of Central Pressure as a Function of Hour After Landfall Compared to Historical Florida Hurricanes..... 94

Figure 16. Modeled Versus Observed Surface Winds for Station XFWB in Hurricane Michael (2018)..... 100

Figure 17. Maximum Observed Versus Maximum Modeled Surface Winds (mph) for All Observation Stations in Hurricane Michael (2018)..... 101

Figure 18. Hurricane Michael's Maximum Over-Hour Wind Footprint Prior to Landfall (Colors) Overlaid With Maximum Over-Hour Observed Winds. Gray areas experience wind speed below 40mph..... 102

Figure 19. Historical and Modeled U.S. Annual Landfall Frequency Distributions..... 104

Figure 20. Historical (Left) and Simulated (Right) Hurricanes Landfalling in SE Florida..... 104

Figure 21. Goodness-of-Fit Comparisons for a 100-Mile Florida Segment..... 105

Figure 22. Sample Damage Ratio Comparison..... 106

Figure 23. Standardized Regression Coefficients vs. Time at Grid Coordinates (9,0) for Category 1..... 111

Figure 24. Standardized Regression Coefficients vs. Time at Grid Coordinates (9,0) for Category 3..... 111

Figure 25. Standardized Regression Coefficients vs. Time at Grid Coordinates (9,0) for Category 5..... 112

Figure 26. Expected Percentage Reduction vs. Time at Grid Coordinates (9,0) for Category 1 115
Figure 27. Expected Percentage Reduction vs. Time at Grid Coordinates (9,0) for Category 3 115
Figure 28. Expected Percentage Reduction vs. Time at Grid Coordinates (9,0) for Category 5 116
Figure 29. Derivation and Implementation of Verisk Vulnerability Functions 131
Figure 30. Process of Accounting for the Impact of Wind Duration 142
Figure 31. Sample Input File 162
Figure 32. Model Input Options 162
Figure 33. Process to Create Model Output 163
Figure 34. Output Options Dialog Box in the Florida Rate Filing Analysis Template 165
Figure 35. Analysis Options Dialog Box in the Florida Rate Filing Analysis Template 166
Figure 36. Probability Distribution Around the Mean Damage Ratio 177
Figure 37. Equation 2 177
Figure 38. Equation 3 180
Figure 39. Key Components of the Agile Framework at Verisk Extreme Event Solutions (adapted from Scrum Inc.) ... 192
Figure 40. Requirements Development and Review Process 196
Figure 41. Touchstone Network Layout 199
Figure 42. Development and Implementation Overview (Part 1) 200
Figure 43. Development and Implementation Overview (Part 2) 201
Figure 44. Development and Implementation Overview (Part 3) 202
Figure 45. Development and Implementation Overview (Part 4) 203
Figure 46. Model Development Process-Research Group 204
Figure 47. Model 521 Porting and Implementation in Touchstone (Part 1) 205
Figure 48. Model 521 Porting and Implementation in Touchstone (Part 2) 206
Figure 49. Touchstone Development and Validation 207
Figure 50. Touchstone Testing Process Overview 208
Figure 51. Touchstone Packaging and Release 209
Figure 52. Historical and Modeled Hurricane Frequency for Florida and Neighboring States by Region 254
Figure 53. Maximum Winds for the Modeled Version of the Model Base Hurricane Set 257
Figure 54. 100-Year Return Period Maximum Winds 257
Figure 55. 250-Year Return Period Maximum Winds 258

Figure 56. Box and Whisker Plot of Central Pressure vs. Rmax for the Stochastic Set....260
Figure 57. Scatter Plot of Comparison #1: Validation by Construction Type, Company C....277
Figure 58. Scatter Plot of Comparison #2: Validation by Construction Type, Company G....277
Figure 59. Scatter Plot of Comparison #3: Validation by Construction Type, Company N....278
Figure 60. Scatter Plot of Comparison #4: Validation by County, Company J....278
Figure 61. Scatter Plot of Comparison of Actual Commercial Residential Exposures and Loss to Modeled Exposure and Loss....279
Figure 62. Loss Percentages by Wind Speed for the Building, Contents, and Time Element Data....286
Figure 63. Loss Costs by ZIP Code for Owners Wood Frame, Zero Deductible....297
Figure 64. Loss Costs by ZIP Code for Owners Masonry, Zero Deductible....297
Figure 65. Loss Costs by ZIP Code for Manufactured Home, Zero Deductible....298
Figure 66. Percentage of Total Residential Loss from Hurricane Matthew (2016) Using 2017 FHCF Exposure Data... 305
Figure 67. Percentage of Total Residential Loss from Hurricane Irma (2017) Using 2017 FHCF Exposure Data....306
Figure 68. Percentage of Total Residential Loss from Hurricane Michael (2018) Using 2017 FHCF Exposure Data....306
Figure 69. Percentage of Total Residential Loss from Hurricane Ian (2022) Using 2017 FHCF Exposure Data....307
Figure 70. Percentage of Total Residential Loss from Hurricane Matthew (2016) Using 2023 FHCF Exposure Data... 307
Figure 71. Percentage of Total Residential Loss from Hurricane Irma (2017) Using 2023 FHCF Exposure Data....308
Figure 72. Percentage of Total Residential Loss from Hurricane Michael (2018) Using 2023 FHCF Exposure Data....308
Figure 73. Percentage of Total Residential Loss from Hurricane Ian (2022) Using 2023 FHCF Exposure Data....309
Figure 74. Percentage Change for Owners – Frame....339
Figure 75. Percentage Change for Owners – Masonry....340
Figure 76. Percentage Change for Renters – Frame....340
Figure 77. Percentage Change for Renters - Masonry....341
Figure 78. Percentage Change for Condo Unit Owners – Frame....341
Figure 79. Percentage Change for Condo Unit Owners – Masonry....342
Figure 80. Percentage Change for Manufactured Home....342
Figure 81. Percentage Change for Commercial Residential (2017 FHCF Exposure Data)....343
Figure 82. Personal and Commercial Residential Loss Curve Comparison (2017 FHCF)....350
Figure 83. Personal and Commercial Residential Loss Curve Comparison (2023 FHCF)....350
Figure 84. Components of a Verisk Catastrophe Model....400
Figure 85. Representative Damage Function....402

Figure 86. Wind Flow Around Buildings Can Generate Severe Pressure and Suction Forces..... 403

Figure 87. Wind Flow Separation Around Roof.....403

Figure 88. Damage Profile of Non-engineered Buildings..... 404

Figure 89. Damage to (a) Mechanical Equipment, (b) Roof, (c) Cladding, and (d) Windows.....405

Figure 90. Application of Modification Factors to the Basic Damage Functions: (a) Basic Damage Function for Wood Frame Construction; (b) Reduction in Damage for Engineered vs. Non-Engineered Shutters; (c) Basic Damage Function and Modified Function for Engineered Shutters; (d) Envelope of Damage Functions, All Protection Options..... 406

Figure 91. Some Key Components of a Roof System.....416

Figure 92. Wind Damage to a Roof Covering..... 417

Figure 93. Wind Damage to a Roof Deck.....417

Figure 94. Illustration of a Gable Roof and Hurricane Damage.....418

Figure 95. Illustration and Examples of Hip Roofs.....418

Figure 96. Illustration of a Mansard Roof..... 418

Figure 97. Mitigation Benefits of Various Roof-Wall Anchorage Options..... 421

Figure 98. Modification Function for Engineered Storm Shutters.....421

Figure 99. Modification Function for Slate Roofing..... 422

Figure 100. Validation of the Impact of Secondary Risk Characteristics, Alone and in Combination.....423

Figure 101. Buildings that Meet the Minimum Requirements of FBC 2001..... 425

Figure 102. Buildings that Meet the Minimum Requirements of the Florida Building Code 2010.....427

1 Florida Commission on Hurricane Loss Projection Methodology: Hurricane Model Identification

Name of Hurricane Model:	Verisk Hurricane Model for the United States
Hurricane Model Version Identification:	V3.0.0
Hurricane Model Platform Names and Identifications with Primary Hurricane Model Platform and Identification Listed First	Touchstone® 2024A
Interim Hurricane Model Update Version Identification:	
Interim Data Update Designation:	
Name of Modeling Organization:	Verisk
Street Address:	Lafayette City Center, 2 Avenue de Lafayette, 2nd Floor
City, State, ZIP Code:	Boston, MA 02111
Mailing Address, if different from above:	
Contact Person:	Julia Borman
Phone Number:	(617) 267-6645
E-mail Address:	jborman@verisk.com
Date:	May 27, 2025

2 Trade Secret Information

Information to be presented to the Professional Team in connection with the acceptability process

The list of trade secret items that may be provided to the Professional Team during the on-site review includes:

- Form V-3 and Form V-5
- Form A-6, graphical summaries which demonstrate the sensitivities of the notional sets, contour map and scatter plot associated with distance to coast
- Work papers and processes used to prepare forms, including automation scripts
- Internal documentation, white papers, data files, externally acquired information, databases, computer source code, as warranted by the nature of the audit trails
- Work papers and processes used to update and test the model and software, including associated databases
- Information relating to the hurricane model network organization and software functionality
- Information and methodologies used to develop and test the meteorological, actuarial, and vulnerability components of the model, as well as results from statistical testing performed
- Any other materials will be dependent upon requests or suggestions from the Professional Team.

3 General Hurricane Standards

Standard G-1: Scope of the Hurricane Model and Its Implementation

G-1.A

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

Verisk's compliance with G-1.A is documented in G-1.2 by providing a description of how the model operates to produce projected loss costs and probable maximum loss (PML) levels.

The model's ability to project loss costs and probable maximum loss levels is demonstrated in the Actuarial Forms in Appendix 5: Actuarial Hurricane Standard Forms. In each case, example portfolios of insured residential properties are imported and analyzed using the model's stochastic catalog of hurricane events.

G-1.B

A documented process shall be maintained to assure continual agreement and correct correspondence of databases, data files, and computer source code to presentation materials, scientific literature, technical literature, and modeling organization documents.

Verisk maintains a documented process to assure continual agreement and correct correspondence of modeling organization documents used in or generated through model update efforts, submission preparation, and preparation for all related meetings with the Commission. Coordination across research, product management, documentation, software development, and quality assurance and consulting, combined with adherence to documentation standards, ensure that changes are supported throughout the workflow. This process is shown in G-2.2.C. Preparation for Commission meetings, including slides to be shown to the Commission and work papers to be shown to the Professional Team, draw upon the central data and documentation repositories.

G-1.C

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

To build and validate the Verisk Hurricane Model for the United States and Touchstone platform, Verisk's teams utilize various software and tools which are stored and managed from a centralized location on the Verisk

internal computing network. All data and source code are located in centralized, model-level file areas on the Verisk internal computing network. Software designed to be installed and used on employee workstations is maintained by Verisk's Information Technology team and deployed to users' workstations, which are a part of the Verisk internal computing network. Disclosures made in response to CI-1.C and CI-1.F provide information about the types of software and data, and descriptions of the file areas. CI-4.1, CI-5.B, CI-5.C, and CI-6.1 provide information about software development and validation tools which are maintained on central workspaces on the Verisk internal computing network. CI-5.3 lists externally sourced data sets which Verisk stores in network locations accessible by relevant staff during model development. Standard CI-7: Hurricane Model Maintenance and Revision discusses software and tools used in model maintenance and revision. Verisk will review the list of externally acquired software and data assets, which includes information considered trade secret, with the Professional Team.

To project modeled hurricane loss costs and probable maximum loss levels and create the forms required for the submission, Verisk's teams use data sets provided with the ROA and scripts and templates developed internally in conjunction with Touchstone. Touchstone is installed on hardware located on the Verisk internal computing network. The scripts and templates used to create the forms required for the submission are developed on workstations located on the Verisk internal computing network. Work papers and results used in the final forms are stored in central file areas accessed by relevant staff. Verisk will share trade secret details of such work papers and results with the Professional Team, providing the prepared materials required for the on-site review of the hurricane model and will demonstrate their compliance with this standard by virtue of being stored in central file areas.

G-1.D

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

Verisk prepared all meteorological forms found in Appendix 2: Meteorological Standards Forms Form S-1.A, Form S-2.A, and all required actuarial forms found in Appendix 5: Actuarial Hurricane Standard Forms using automated procedures. Verisk has not prepared Form S-6 as this is only required of new modeling organizations. The automation procedures are designed to limit the amount of manual intervention and decrease the time and effort needed to prepare these work products. During the automation development, teams exercised due diligence to make sure the new process reproduced prior submission results. Verisk will review details of these processes with the Professional Team as trade secret information.

G-1.E

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

The vintages of all data, code and scientific and technical literature have been reviewed by Verisk staff and their use has been justified. Justifications will be presented to the Professional Team and at the closed meeting with the Commission for review.

Disclosures

G-1.1

Specify the hurricane model version identification. If the hurricane model is implemented on more than one platform, specify each hurricane model platform identifying the primary platform and the distinguishing aspects of each platform.

The Verisk hurricane model being submitted for approval is the Verisk Hurricane Model for the United States V3.0.0 as implemented in the platform Touchstone 2024A. Touchstone 2024A is referred to simply as Touchstone in the remainder of this document. The hurricane model submitted for review is only available in the Touchstone platform.

G-1.2

Provide a comprehensive summary of the hurricane model. This summary shall include a technical description of the hurricane model, including each major component of the hurricane model used to project loss costs and probable maximum loss levels for damage to insured residential property from hurricane events causing damage in Florida. Describe the theoretical basis of the hurricane model and include a description of the methodology, particularly the wind components, the vulnerability components, and the insured loss components used in the hurricane model. The description shall be complete and shall not reference unpublished work.

Introduction

The Verisk Research team collects the available scientific data pertaining to the meteorological variables critical to the characterization of hurricanes and therefore to the simulation process. These primary model variables include landfall location, central pressure, radius of maximum winds, forward speed and storm heading. Data sources used in the development of the Verisk Hurricane Model for the United States include the most complete databases available from various agencies of the National Weather Service, including the National Hurricane Center. All data are cross verified. If data from different sources conflict, a detailed analysis and the use of expert judgment are applied to prepare the data for modeling purposes.

Figure 1 illustrates data flow during an analysis using the Verisk Hurricane Model for the United States.

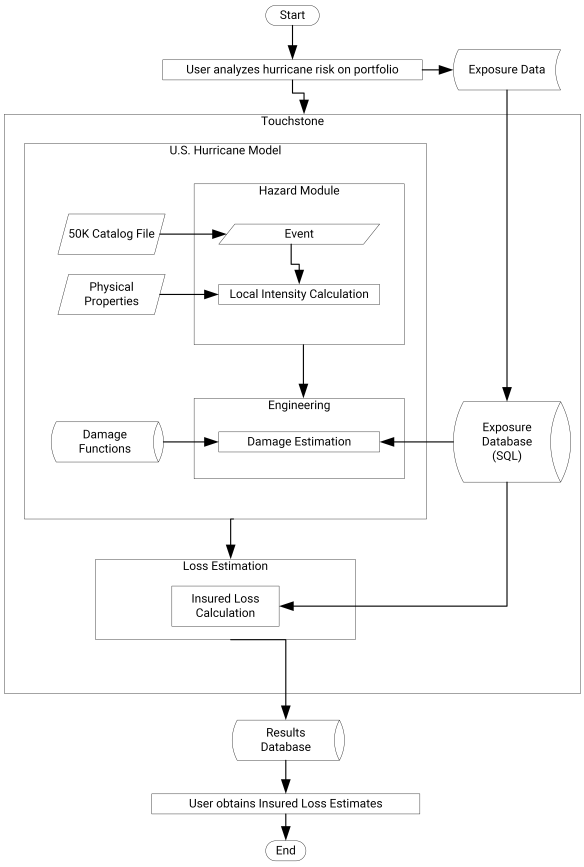


Figure 1. Components of the Verisk Hurricane Model for the United States

Event Generation Component

This first module of the Verisk Hurricane Model for the United States incorporates the stochastic storm catalog. More than one hundred years of historical data on the frequency of hurricanes and their meteorological characteristics were used to fit statistical distributions for each parameter. By stochastically drawing from these distributions, the fundamental characteristics of each simulated storm are generated. The result is a large representative catalog of potential events.

Landfall Location

There are 62 potential landfall segments in the Verisk Hurricane Model for the United States, each representing approximately 50 nautical miles of smoothed coastline from Texas to Maine. There is an additional segment for the Florida Keys. To estimate the probability of a hurricane occurring on each of these segments, a cumulative distribution of landfall locations is developed as described below. Once a segment is chosen, the landfall location is picked uniformly along the segment.

The coastline is first smoothed for irregularities such as inlets and bays. The number of hurricane occurrences is tabulated for smoothed 50 nautical mile segments. The actual number of occurrences for each segment is then smoothed by setting it equal to the weighted average of a set of successive data points centered on that segment. This smoothing technique was selected because it has been used in other climatological studies and because it

maintains areas of high and low frequency and accounts for the lack of historical landfalls in certain portions of the coastline.

Bypassing Storms

The Verisk Hurricane Model for the United States generates bypassing as well as landfalling storms through a track generation procedure that follows each simulated hurricane from the time of its inception until it dissipates. A bypassing hurricane is one that does not make landfall in Florida or adjacent states as a hurricane but does cause damaging winds over Florida.

Meteorological Characteristics

The simulated frequency of hurricanes is consistent with the frequency observed historically over the period 1900–2022. Probability distributions are estimated for central pressure and forward speed for 31 one-hundred-nautical-mile segments of coastline. Separate distributions are estimated for each of these segments because the likely range and probabilities of values within each range for these variables depend upon geographic location and, in particular, latitude. For example, intense hurricanes are more likely to occur in southern latitudes where the water is warmer, whereas storms affecting the coast in northern latitudes tend to be larger and faster moving on average. The radius of maximum winds is represented using a regression model that relates the mean radius to central pressure and latitude.

Storm Heading at Landfall

Landfall angle is measured clockwise (+) or counterclockwise (-) with 0 representing due North. Separate distributions for storm heading at landfall are estimated for each 50-nautical-mile segment of coastline. Storm heading is modeled as combined Normal distributions, and bounded based on the historical record, geographical constraints, and meteorological expertise. Diagnostic tests performed show a reasonable agreement between historical and modeled values.

Storm Track

The methodology used to generate storm tracks is based on the information available in the National Hurricane Center HURDAT2 database for the period 1900–2007. This database provides track information for more than 1,000 North Atlantic storms at six-hour time intervals. Time series techniques have been used to determine the dependence structure present in key model variables from one time period to the next. Time series models that describe the dependence in the historical data are used in the generation of simulated tracks. A first-order Markov model with transition probabilities estimated from the historical data is used to generate changes in track direction of simulated storms. The storm tracks generated using this approach are realistic and resemble storm tracks that have been observed for historical storms.

Verisk uses the event generation component of the model to simulate 50,000 years of potential hurricane activity.

Wind Field Generation Component

The model simulates each storm's movement along its track. A complete time profile of wind speeds is developed for each location affected by the storm, capturing the effect of duration of wind and peak wind speed on

structures. Calculations of local intensity take into account the effects of the asymmetric nature of the hurricane wind field, storm filling over land and radial variation of wind speeds from the radius of maximum winds. The model also uses surface roughness information to account for boundary layer modification of the winds by the local land surface.

Gradient Wind Reduction Factor

The model uses a stochastic Gradient Wind Reduction Factor (GWRF), which varies from storm to storm. The mean value, the distribution about the mean, and the radial profile of the GWRF have been developed based on analyses of dropsonde (GPS dropsonde data are provided courtesy of the NOAA/AOML/Hurricane Research Division in Miami, Florida), as well as results from published literature (Franklin et al., 2003, Powell et al., 2009). The GWRF is adjusted based on the Peak Weighting Factor (see below) and the distance from the eye. Both parameters (GWRF and PWF) are generated jointly using a bounded Bivariate Normal Distribution (based on Casella and Berger, 1990).

Peak Weighting Factor

The Peak Weighting Factor (PWF) is a stochastic parameter used to reflect the vertical slant in the hurricane eye (Powell et al., 2009). As mentioned above, the PWF and GWRF are generated jointly using a bounded Bivariate Normal Distribution.

Damage Calculation Component

Verisk scientists and engineers have developed damage functions that describe the interaction between buildings' structural/nonstructural components and their contents, and the local intensity to which they are exposed. These functions relate the mean damage level as well as the variability of damage to the measure of intensity at each location.

The damage functions vary according to construction class and occupancy because different structural types will experience different degrees of damage. For example, a home of masonry construction generally performs better in a hurricane than does a home of wood frame construction, all else being equal. The Verisk Hurricane Model for the United States estimates a complete distribution around the mean level of damage for each local intensity and each structural type. Losses are calculated by applying the appropriate damage function to the replacement value of the insured property.

The Verisk damageability relationships incorporate the results of well-documented engineering studies, damage surveys and analyses of available loss data. Verisk engineers have surveyed all significant loss causing events since Hugo in 1989 as part of the ongoing process of refinement and validation of these functions. In addition, actual claims data from recent hurricanes, supplied to Verisk by client companies, have been extensively analyzed.

Insured Loss Calculation Component

Insured losses are calculated by applying the policy conditions to the total damage estimates. Policy conditions may include deductibles by coverage, site-specific or blanket deductibles, coverage limits and sublimits, loss

triggers, coinsurance, attachment points and limits for single or multiple location policies, and risk-specific reinsurance terms.

G-1.3

Provide a flowchart that illustrates interactions among major hurricane model components.

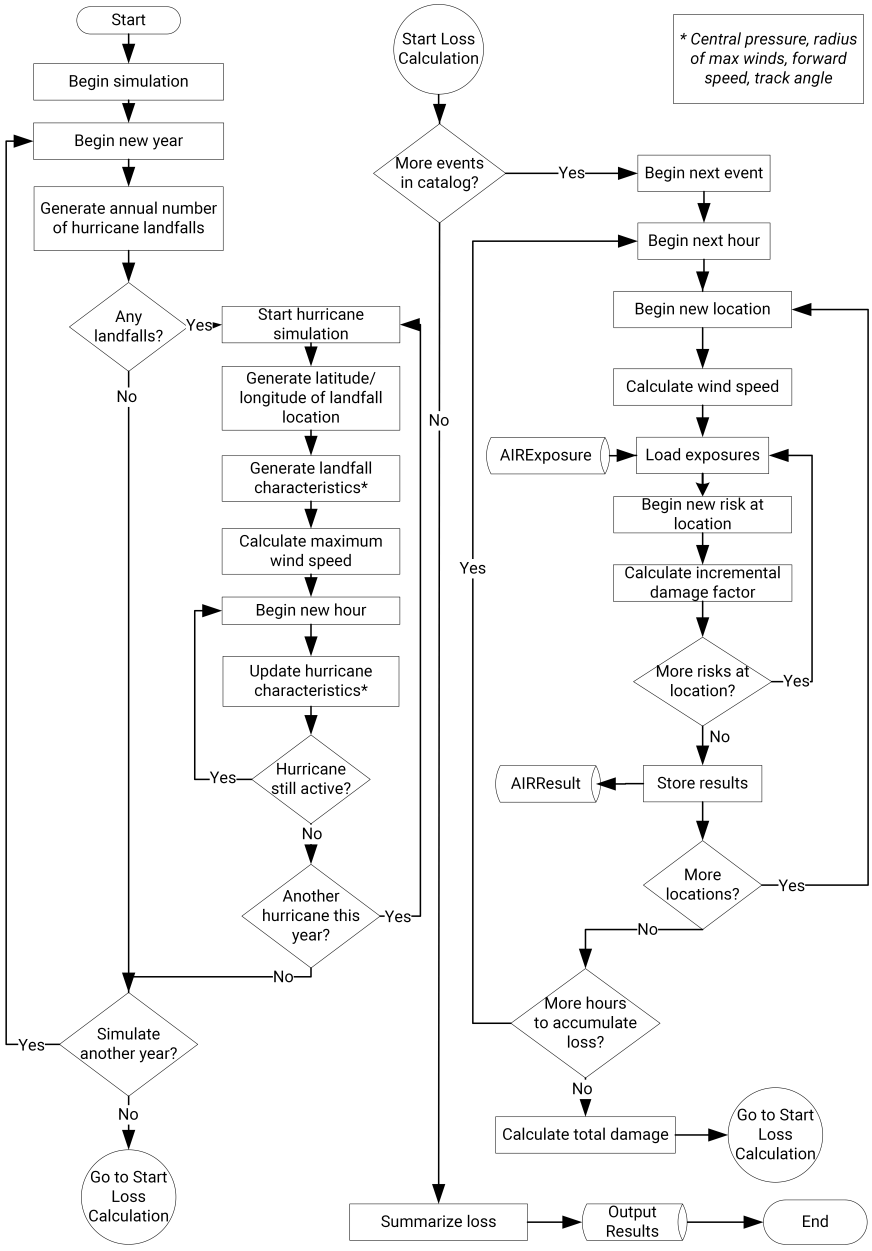


Figure 2. Flowchart of the Verisk Hurricane Model for the United States Component Interactions

G-1.4

Provide a diagram defining the network organization in which the hurricane model is designed and operates.

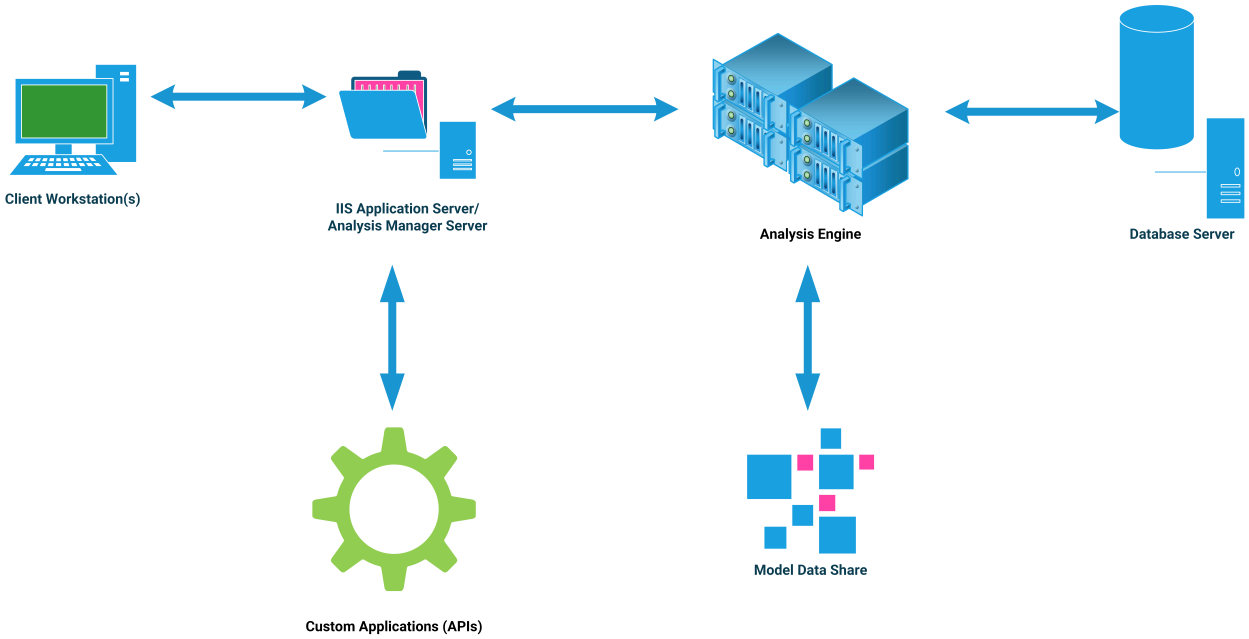


Figure 3. Touchstone Network Organization

More detailed diagrams about the network organization are available for review by the Professional Team as trade secret information.

G-1.5

Provide detailed information on the hurricane model implementation on more than one platform, if applicable. In particular, submit Forms S-5, A-1, A-4, and A-8 from each platform including additional calculations showing no differences.

Not applicable, see G-1.1.

G-1.6

Provide a comprehensive list of complete references pertinent to the hurricane model under review by standards group using professional citation standards.

References

The following reference materials have been reviewed by Verisk staff and used in the development and refinement of the Verisk Hurricane Model for the United States.

Meteorological References

- Arndt, D.S., J.B. Basara, R.A. McPherson, B.G. Illston, G.D. McManus, and D.B. Demko, ***Observations of the Overland Reintensification of Tropical Storm Erin (2007)***, Bull. Amer. Meteor. Soc., 90, 1079–1093, 2009.
- Batts, M. E., Cordes, M. R., Russell, C. R., Shaver, J. R., and Simiu, E., ***Hurricane Wind Speeds in the United States, National Bureau of Standards***, Report Number BSS-124, U.S. Department of Commerce, May 1980.
- Benjamin, S.G., J.M. Brown, K.J. Brundage, D. Devenyi, G.A. Grell, D. Kim, B.E. Schwartz, T.G. Smirnova, T.L. Smith, S. S. Weygandt, and G.S. Manikin, ***2002b: RUC20 - The 20-km version of the Rapid Update Cycle***, NWS Technical Procedures Bulletin, No. 490.
- Blake, E.S., E. J. Gibney, and C. W. Landsea. ***The Deadliest, Costliest, And Most Intense United States Tropical Cyclones From 1851 To 2010 (And Other Frequently Requested Hurricane Facts)***, NOAA Technical Memorandum NWS NHC-6, 2011. Available at: http://www.nhc.noaa.gov/pdf/nws-nhc-6.pdf
- Bosart, L.F., and G.M. Lackmann, ***1995: Postlandfall Tropical Cyclone Reintensification in a Weakly Baroclinic Environment: A Case Study of Hurricane David (September 1979)***, Mon. Wea. Rev., 123, 3268–3291.
- Courtney, J. and J.A. Knaff, 2009: ***Adapting the Knaff and Zehr wind-pressure relationship for operational use in Tropical Cyclone Warning Centres***, Australian Meteorological and Oceanographic Journal, 58, 167-179.
- Casella, G. and Berger, R.L. ***(1990): Statistical Inference***, Duxbury Press, Belmont, California, pp. 650
- Chen, F., and J. Dudhia, ***2001: Coupling an advanced land-surface/hydrology model with the Penn State/NCAR MM5 modeling system. Part I: Model implementation and sensitivity***, Monthly Weather Review, 129, 569-585.
- Cook, N.J., ***The Designers Guide to Wind Loading of Building Structures***, Building Research Establishment Report, Butterworth, London, England, 1985.
- ***DeMaria Extended Best Track (EBTRK)***, Regional and Mesoscale Meteorology Branch - Available at https://rammb2.cira.colostate.edu/research/tropical-cyclones/tc_extended_best_track_dataset/
- Demuth, J., M. DeMaria, and J.A. Knaff., ***Improvement of advanced microwave sounder unit tropical cyclone intensity and size estimation algorithms***, Journal of Applied Meteorology, 45, 1573-1581), 2006.
- Dewitz, J., ***2019, National Land Cover Database (NLCD) 2016 Products (ver. 2.0, July 2020)***, U.S. Geological Survey, data release: https://doi.org/10.5066/P96HHBIE
- ESDU International Ltd, ***ESDU engineering sciences data, Wind engineering, Wind speeds and turbulence***, Vols. 1a, 1b, 1994.
- Friedman, Don G., ***Computer Simulation in Natural Hazard Assessment***, University of Colorado: Program on Technology, Environment and Man, Monograph # NSF-R-A-E 15-002, 1975.
- Franklin J. L, M. L. Black and K. Valde, ***2003: GPS dropwindsonde wind profiles in hurricanes and their operational implications***, Weather and Forecasting, Vol. 18, pp. 32-44.
- Georgiou, P.N., ***Design Wind Speeds in Tropical Cyclone-Prone Regions***, Boundary Layer Wind Tunnel Laboratory, Research Report # BLWT-2- 1985.
- Grell, G.A., J. Dudhia and D.R. Stauffer, ***1995: The Penn State/NCAR Mesoscale. Model (MM5)***, National Center for Atmospheric Research (NCAR) Technical Note, NCAR/TN-398+STR, 138.
- Grimmond, C.S.B., and T.R. Oke, ***1999: Aerodynamic Properties of Urban Areas Derived from Analysis of Surface Form***, J. Appl. Meteor., 38, 1262–1292.
- Harper, B. A, J. D. Kepert, and J. D. Ginger, ***2010: Guidelines for Converting Between Various Wind Averaging Periods in Tropical Cyclone Conditions***, WMO Technical Document, No. 1555, 54 pp.
- Hart, R. and J.L. Evans, ***2001: A climatology of the extratropical transition of Atlantic tropical cyclones***, J. Climate, 14, 546-564.

- Ho, Francis P., Schwerdt, Richard W., and Goodyear, Hugo V., ***Some Climatological Characteristics of Hurricanes and Tropical Storms, Gulf and East Coast of the United States***, U.S. Department of Commerce, National Weather Service. NOAA Technical Report, HW515. May 1975.
- Ho, Francis P., Su, James C., Hanevich, Karen L., Smith, Rebecca J., and Richards, Frank P., ***Hurricane Climatology for the Atlantic and Gulf Coasts of the United States***, U.S. Department of Commerce. National Weather Service. NOAA Technical Report, EmW-84-E- 1589. April 1987.
- Homer et al., ***2020: Conterminous United States land cover change patterns 2001–2016 from the 2016 National Land Cover Database***, ISPRS Journal of Photogrammetry and Remote Sensing, 162, 184–199, https://doi.org/10.1016/j.isprsjprs.2020.02.019
- Jarvinen, B.R., C.J. Neumann, and A.S. Davis, ***1984: A Tropical Cyclone Data Tape for the North Atlantic Basin, 1886-1983: Contents, Limitations, and Uses***, NOAA, Technical Memorandum, NWS-NHC-22, 21 pp. (HURDAT). Available at: http://www.aoml.noaa.gov/hrd/hurdat/(1851-2006).
- Jelesnianski, Chester P., ***SPLASH (Special Program to List Amplitudes of Surges From Hurricanes)***, Department of Commerce, National Weather Service, NOAA Technical Memorandum NWS TDL-46. April 1972.
- Kaplan, J., and DeMaria, M., ***A Simple Empirical Model for Predicting the Decay of Tropical Cyclone Winds After Landfall***, Journal of Applied Meteorology, 1995.
- Knaff, J., et al., ***2007: Statistical Tropical Cyclone Wind Radii Prediction Using Climatology and Persistence***, Weather and Forecasting, 22, 781-791.
- Knaff, J.A., and R.M. Zehr, ***2007: Reexamination of Tropical Cyclone Wind–Pressure Relationships***, Weather Forecasting, 22, 71–88.
- Kossin, J.P., J.A. Knaff, H.I. Berger, D.C. Herndon, T.A. Cram, C.S. Velden, R.J. Murnane, and J.D. Hawkins, ***Estimating hurricane wind structure in the absence of aircraft reconnaissance***, Weather Forecasting, 22, 89–101. 2007: https://www.semanticscholar.org/paper/Estimating-Hurricane-Wind-Structure-in-the-Absence-Kossin-Knaff/40eaa8305ff3cc43a02671c8210367540cc097f9
- Landsea, C.W. et al, ***2004: A Reanalysis of Hurricane Andrew's Intensity***, Bulletin of the American Meteorological Society: Vol. 85, No. 11, pp. 1699–1712.
- Latifovic, R., Homer, C., Ressl, R., Pouliot, D., Nazmul Hossain, S., Colditz, R.R., Olthof, I., Giri C., and Victoria, A., ***North American Land Change Monitoring System in Remote sensing of land use and land cover: principles and applications***, pp 303-324, Taylor & Francis Group, ISBN 978-1-4200-7074-3, 2012.
- Literature justifying the use of the NOAA HURDAT2 database, ***National Hurricane Center (NHC)***. Retrieved from https://www.nhc.noaa.gov/data/publications.php#PEER.
- Literature justifying the various changes to reanalyzed storms in the NOAA HURDAT2 database, ***Hurricane Research Division (HRD)***. Retrieved from: https://www.aoml.noaa.gov/hrd/data_sub/re_anal.html.
- Lorsolo, S., J.L. Schroeder, P. Dodge, and F. Marks, ***An Observational Study of Hurricane Boundary Layer Small-Scale Coherent Structures***, Mon. Wea. Rev., 2871–2893, 2008.
- McAdie, C. J., C. W. Landsea, C. J. Neumann, and G. R. Hammer, ***2009: Tropical Cyclones of the North Atlantic Ocean, 1851-2006***, NOAA National Climatic Data Center, Asheville, NC. 243 p. Available at http://www.nhc.noaa.gov/pdf/TC_Book_Atl_1851-2006_lowres.pdf
- McCombs, J. W., N. D. Herold, S. G. Burkhalter, and C. J. Robinson, ***2016: Accuracy Assessment of NOAA Coastal Change Analysis Program 2006-2010 Land Cover and Land Cover Change Data***, Photogrammetric Engineering & Remote Sensing, 82, 711–718, doi:10.14358/PERS.82.9.711.
- North American Land Change Monitoring System, ***Land Cover 30m, 2015 (Landsat and RapidEye)***, Commission for Environmental Cooperation. Montréal, Québec, Canada: Commission for Environmental Cooperation. Accessed February, 2020 at http://www.cec.org/nalcms.

- National Hurricane Center (NHC) HURDAT2 Atlantic track file– Available at: http://www.nhc.noaa.gov/data/hurdat/
- National Hurricane Center (NHC) Tropical Cyclone Reports - Available at: https://www.nhc.noaa.gov/data/tcr/index.php
- National Hurricane Center (NHC) Aircraft Reconnaissance Data (Vortex Reports; 1989-2006) - Available at: https://www.nhc.noaa.gov/recon.php
- National Oceanic and Atmospheric Administration, Office for Coastal Management. ***2016 Regional Land Cover Data***, Coastal Change Analysis Program (C-CAP) Regional Land Cover. Charleston, SC: NOAA. Accessed September, 2021 at https://coast.noaa.gov/htdata/raster1/landcover/bulkdownload/30m_lc/
- Neumann, Charles J., ***The National Hurricane Center Risk Analysis Program***, U.S. Department of Commerce. National Hurricane Center, National Oceanic and Atmospheric Administration (NOAA) Technical Memorandum National Weather Service (NWS) NHC 38. Reprinted August 1991.
- Nolan, D.S., et.al., ***2014: On the Limits of Estimating the Maximum Wind Speeds in Hurricanes***, Mon. Wea. Rev., 142, 2814-2837.
- Paulsen, B.M., and J.L. Schroeder, ***An Examination of Tropical and Extratropical Gust Factors and the Associated Wind Speed Histograms***, J. Appl. Meteor, 270–280, 2005.
- Powell M.D. and Houston S.H., ***Hurricane Andrew's Landfall in South Florida. Part II: Surface Wind Fields and Potential Real-Time Applications***, Weather and Forecasting, pages 329-349, September 1996.
- Powell, M. D., S. H. Houston, L. R. Amat, N. Morisseau-Leroy, ***1998: The Hurricane Research Division (HRD) real-time hurricane wind analysis system***, J. Wind Engineer. Ind. Aerody., 77&78, 53-64.
- Powell, M. D., Vickery, P. J. & Reinhold, T. A., ***Reduced drag coefficients for high wind speeds in tropical cyclones***, Nature, 279–283, March 2003.
- Powell, M.D., E.W. Uhlhorn, and J.D. Kepert, ***Estimating Maximum Surface Winds from Hurricane Reconnaissance Measurements***, Weather and Forecasting, 868-883, 2009.
- Schwerdt, Richard W., Ho, Francis P. and Watkins, Roger R., ***Meteorological Criteria for Standard Project Hurricane and Probable Maximum Hurricane Wind fields. Gulf and East Coasts of the United States.***, U.S. Department of Commerce. National Oceanic and Atmospheric Administration, NOAA Technical Report NWS 23, September 1979.
- Schroeder J. L, and D. A Smith, ***Hurricane Bonnie wind flow characteristics as determined from WEMITE***, J. Wind Eng. Ind. Aerodyn., 91, 767–789, 2003.
- Simiu, E. and Scanlan, R. H., ***Wind Effects on Structures – Fundamentals and Applications to Design, Third Edition***, Wiley-Interscience; 3rd edition (August 17, 1996).
- Skwira, G.D., J.L. Schroeder, and R.E. Peterson, ***2005: Surface Observations of Landfalling Hurricane Rainbands***, Mon. Wea. Rev., 454–465, 2005.
- Wickham, J., S. V. Stehman, D. G. Sorenson, L. Gass, and J. A. Dewitz, ***2021: Thematic accuracy assessment of the NLCD 2016 land cover for the conterminous United States***, Remote Sensing of Environment, 257, doi:10.1016/j.rse.2021.112357.
- Willoughby H. E., and M. E. Rahn, ***Parametric representation of the primary hurricane vortex. Part I: Observations and evaluation of the Holland (1980) model***, Mon. Wea. Rev., 3033–3048, 2004.
- Willoughby H. E., R. W. R. Darling, and M. E. Rahn, ***Parametric representation of the primary hurricane vortex. Part II: A New Family of Sectionally Continuous Profiles***, Mon. Wea. Rev., 1102–1120, 2006.

Actuarial References

- ***Actuarial Standard of Practice No. 23 – Data Quality***, Actuarial Standards Board, 2016. Retrieved from: http://www.actuarialstandardsboard.org/wp-content/uploads/2017/01/asop023_185.pdf.
- ***Actuarial Standard of Practice No. 38 – Using Models Outside the Actuary's Area of Expertise (Property and Casualty)***, Actuarial Standards Board, 2011. Retrieved from: http://www.actuarialstandardsboard.org/wp-content/uploads/2014/02/asop038_155.pdf.
- ***Actuarial Standard of Practice No. 56 – Modeling***, Actuarial Standards Board, 2019. Retrieved from: http://www.actuarialstandardsboard.org/wp-content/uploads/2020/01/asop056_195.pdf.
- Bahnemann, David, ***Distributions for Actuaries***, Casualty Actuarial Society, 2015. Retrieved from: https://www.casact.org/sites/default/files/2021-03/8_Bahnemann.pdf
- Efron, Bradley, and Tibshirani, R.J., ***An Introduction to the Bootstrap***, Chapman & Hall /CRC, Boca Raton, Florida. 1994.
- Florida Statutes, s. 627.701(5)(a), F.S.
- Hogg, R.V., and S.A. Klugman, ***Loss Distributions***, New York: John Wiley & Sons, 1984.
- Rafal Wojcik, Charlie Wusuo Liu, Jayanta Guin, ***Split-Atom Convolution for Probabilistic Aggregation of Catastrophe Losses***, Society of Actuaries, 2017. Retrieved from: https://www.soa.org/globalassets/assets/files/static-pages/research/arch/2017/arch-2017-iss1-guin-liu-wojcik.pdf
- Rafal Wojcik, Charlie Wusuo Liu, Jayanta Guin, ***Direct and Hierarchical Models for Aggregating Spatially Dependent Catastrophe Risks***, Multidisciplinary Digital Publishing Institute (MDPI), 2019. Retrieved from: https://www.mdpi.com/2227-9091/7/2/54/htm
- Rafal Wojcik and Ivelin Zvezdov, ***Next Generation Financial Modeling for Residential and Small Business Lines***, Verisk, 2021. Retrieved from: https://www.verisk.com/blog/next-generation-financial-modeling-for-residential-and-small-business-lines/
- Rafal Wojcik and Ivelin Zvezdov, ***Next Generation Modeling: Loss Accumulation***, Verisk, 2020. Retrieved from: https://www.verisk.com/blog/next-generation-modeling-loss-accumulation/
- Stuart A. Klugman, Harry J. Panjer, Gordon E. Willmot, ***Loss Models: from Data to Decisions***, New York: John Wiley & Sons, 2011.
- Venter, Gary, ***Transformed Beta and Gamma Distributions and Aggregate Loses***, Casualty Actuarial Society, 1982. Retrieved from: https://www.casact.org/sites/default/files/database/dpp_dpp82_82dpp395.pdf
- ***Financial & Policy Terms for Touchstone NGM***, Verisk, 2023. Retrieved from: https://www.air-worldwide.com/siteassets/Client-Support/Touchstone/v10.5/documents/ngm-financial-policy-terms.pdf
- ***Next Generation Models (NGM)***, Verisk, 2022. Retrieved from: https://www.air-worldwide.com/siteassets/Publications/Brochures/documents/nextgenerationmodels.pdf

Statistical References

- Braun, Henry., ***A Simple Method for Testing Goodness of Fit in the Presence of Nuisance Parameters***, Journal of the Royal Statistical Society: Series B (Methodological), Volume 42, Issue 1, Pages 53 - 63, September 1980: https://academic.oup.com/jrsssb/article-abstract/42/1/53/7027622?redirectedFrom=fulltext
- Clark, K.M., ***A Formal Approach to Catastrophe Risk Assessment and Management***, Proceedings of the Casualty Actuarial Society, Volume LXXIII, pp. 69-92, 1986.
- Francis, P., et al. ***(1987) Hurricane Climatology for the Atlantic and Gulf Coasts of the United States***, NOAA Technical Report NWS, 38.

- Franklin, J. L., M. L. Black, and K. Valde, ***2003: GPS dropwindsonde wind profiles in hurricanes and their operational implications***, Wea. Forecasting, 18, 32–44, doi:10.1175/1520-0434(2003)0182.0.CO;2.
- Gentle, James E., ***Random Number Generation and Monte Carlo Methods, Second Edition***, Springer-Verlag New York, Inc., 2003.
- Iman, R.L. and Helton, J.C. ***(1991), The Repeatability of Uncertainty and Sensitivity Analysis for Complex Probabilistic Risk Assessments***, Risk Analysis, 11(4), pp. 591-606.
- Iman, R.L., Johnson, M.E., and Schroeder, T.A., ***Assessing Hurricane Effects. Part 1. Sensitivity Analysis***, Reliability Engineering and System Safety, 78, 2002a.
- Iman, R.L., Johnson, M.E., and Schroeder, T.A., ***Assessing Hurricane Effects. Part 2. Uncertainty Analysis***, Reliability Engineering and System Safety, 78, 2002b.
- Iman, R.L., Johnson, M.E., and Schroeder, T.A., ***Professional Team Demonstration Uncertainty/Sensitivity Analysis***, Florida Commission on Hurricane Loss Projection Methodology, Sept 2001.
- Pawale, V., Yin, J. and Rowe, J., ***Stochastic Modeling of Western North Pacific Typhoons for Japanese Property Insurance Loss Estimation*** Proceedings, Eleventh International Conference on Wind Engineering, 1521-1528, 2003.
- Powell, M.D., Uhlhorn, E.W., and Kepert, J.D. (2009), ***Estimating Maximum Surface Winds from Hurricane Reconnaissance Measurements***, Weather and Forecasting, 24, 868-883.
- Rubinstein, Reuven Y., and Kroese, Drik P., ***Simulation and the Monte Carlo Method***, New York: John Wiley & Sons, 1981.
- Thompson, K.M., Burmaster, D.E., and Crouch, A.C. (1992): ***Monte Carlo Techniques for Quantitative Uncertainty Analysis in Public Health Risk assessments***, Risk Analysis, Vol. 12, No. 1, pp. 53-63.
- Vickery, P.J., Skerlj,P.F., and Twisdale, L.A. (2000), ***Simulation of Hurricane Risk in the U.S. Using Empirical Track Model***, Journal of Structural Engineering, 1222-1237.

Vulnerability References

- ***24 CFR Parts 0 to 499 Code of Federal Regulations, Housing and Urban Development***, Office of the Federal Register, National Archives and Records Service, General Services Administration, April 1975.
- ***24 CFR Parts 0 to 199 Code of Federal Regulations, Housing and Urban Development, Office of the Federal Register***, National Archives and Records Administration, May 2001.
- ***24 CFR Part 100 Design and Construction Requirements; Compliance With ANSI A117.1 Standards; Final Rule***, Department of Housing and Urban Development, Federal Register, October 2008.
- ***TITLE 24 Housing and Urban Development***, Electronic Code of Federal Regulations, March 2014.
- ACE Tempest Re, ***Mobile Homes – Dispelling the Myths***, CAT 360, Bermuda, 2009.
- ASCE 7-98, ***Minimum Design Loads for Buildings and Other Structures***, American Society of Civil Engineers, New York, NY, 2000.
- ASCE 7-10, ***Minimum Design Loads for Buildings and Other Structures***, American Society of Civil Engineers, Reston, VA, 2010.
- Bhinderwala, S., ***Insurance Loss Analysis of Single Family Dwellings Damaged in Hurricane Andrew***, Master's Thesis, Clemson University, 1995.
- Butler, K., ***Relative Variations in Roof Pressure Loads of High Value, Large Square Footage Homes***, 12th Americas Conference on Wind Engineering, Seattle, Washington, June 16-20, 2013.
- ***Exterior Insulation and Finish Systems***, Natural Hazard Mitigation Insights Publication, No. 7, ISSN 1089-6058, February 1997.

- Cermark. J.E., ***Wind Tunnel Testing of Structures***, Journal of Engineering Mechanics Division, ASCE, Vol. 106, No. EM6, December 1980.
- Cook, N.J., ***The Designers Guide to Wind Loading of Building Structures***, Building Research Establishment Report, Butterworth, London, England, 1985.
- Cope, Anne D., ***Predicting the Vulnerability of Typical Residential Buildings to Hurricane Damage***, Ph.D. Dissertation, University of Florida, 2004.
- Crandell J. H., ***Statistical Assessment of construction characteristics and performance of homes in Hurricanes Andrew and Opal***, Journal of Wind Engineering and Industrial Aerodynamics, 77 and 78, 1998, pages 695-701.
- Cross, Mark, L., and Thorton, John, H., ***The Probable Effect of an Extreme Hurricane on Texas Catastrophe Plan Insurers***, The Journal of Risk and Insurance, 1983.
- FEMA-1992, ***Building Performance: Hurricane Andrew in Florida, Observations, Recommendations and Technical Guidance***, FEMA and Federal Insurance Administration, December 21, 1992.
- FEMA-1997, ***Building Performance Assessment: Hurricane Fran in North Carolina, Observations, Recommendations and Technical Guidance***, FEMA, Mitigation Directorate, March 19, 1997.
- FEMA 488 (2005), ***Hurricane Charley in Florida, Observations, Recommendations, and Technical Guidance***, FEMA, Mitigation Assessment Team Report.
- FEMA 549 (2006), ***Hurricane Katrina in the Gulf Coast, Building Performance Observations, Recommendations, and Technical Guidance***, FEMA, Mitigation Assessment Team Report.
- FEMA P-85 (2009), ***Protecting Manufactured Homes from Floods and Other Hazards, A Multi-Hazard Foundation and Installation Guide***, FEMA, 2009.
- FEMA Mitigation Section, ***Third Party Analysis of Manufactured Home Retrofit Tie Downs***, FEMA, Technical Services Branch, DR-1539/1545,1551,1565, Orlando, 2005.
- ***Florida Building Code 2001, Second Printing***, International Code Council (ICC), May 2001.
- ***Florida Building Code, Building, 5th Edition (2014), First Printing***, International Code Council (ICC), March 2015.
- ***Florida Building Code, Residential, 5th Edition (2014), First Printing***, International Code Council (ICC), March 2015.
- ***Florida Building Code, Building, 6th Edition (2017), First Printing***, International Code Council (ICC), July 2017.
- ***Florida Building Code, Residential, 6th Edition (2017), First Printing***, International Code Council (ICC), July 2017.
- ***2010 Florida Building Code, Building, First Printing***, International Code Council (ICC), October 2011.
- ***2010 Florida Building Code, Residential, First Printing***, International Code Council (ICC), October 2011.
- ***2007 Florida Building Code, Building, First Printing***, International Code Council (ICC), February 2008.
- ***2007 Florida Building Code, Residential, First Printing***, International Code Council (ICC), February 2008.
- ***2004 Florida Building Code, Building, First Printing***, International Code Council (ICC), October 2004.
- ***2004 Florida Building Code, Residential, First Printing***, International Code Council (ICC), October 2004.
- Friedman, D.G., ***Assessing Hurricane Impact on Human Settlements***, Ministry of Human Settlements and Public Works, Government of Mexico: Symposium on Hurricane- Floods: Their Effect on Human Settlements: La Pax, Baja California Sur, Mexico, November 24-27, 1981.
- Friedman. D.G., ***Natural Hazard Risk Assessment for an Insurance Program***, The Geneva Papers on Risk and Insurance, International Association for the Study of Insurance Economics (Geneva Association), Geneva, Switzerland, Volume I, Number 30, January, pages 57-128, 1984.

- Friedman, Don G., ***Computer Simulation in Natural Hazard Assessment***, University of Colorado: Program on Technology, Environment and Man, Monograph # NSF-R-A-E 15-002, 1975.
- G.C. Hart., ***Natural Hazards Tornado, Hurricane, Severe Wind Loss Models***, U.S. Department of Commerce, PB-294 594, 1976.
- Handbook 4910.1, ***Minimum Property Standards for Housing***, U.S. Department of Housing and Urban Development, 1994 Edition, accessed via https://www.hud.gov/program_offices/administration/hudclips/handbooks/hsgh/4910.1
- Harris P.L., Beason W.L. and Minor J.E., ***The Effects of Thickness and Temper on the Resistance of Glass to Small Missile Impact***, Institute of Disaster Research, Texas Tech University, May 1978.
- He, H., Jain, V.K., Leiva G., and Kafali, C., ***Modeling Relative Spatial and Temporal Hurricane Wind Vulnerability of the Building Stock in the US***, 11th Americas Conference on Wind Engineering, San Juan, Puerto Rico. June 22-26, 2009.
- Herbert K. and Levitan M., ***Performance of Manufactured Housing in Louisiana during Hurricanes Katrina and Rita***, 11th Americas Conference on Wind Engineering, San Juan, PR, 2009.
- Hogg, R.V. and Klugman, S. A., ***Loss Distributions***, John Wiley and Sons, 1984.
- ***Housing and Urban Development Code of Federal Regulations (1975)***, Office of the Federal Register National Archives and Records Service, Washington, DC, 1975.
- ***Hurricanes of 1992, Proceedings of Hurricanes of 1992, Andrew and Iniki One Year Later***, ASCE, Miami, Fl, 1993.
- ***Hurricane Camille - August 1969: A Survey of Structural Damage along the Mississippi Gulf Coast***, National Bureau of Standards report, December 4, 1970.
- ***An Assessment of Damage to Manufactured Homes Caused by Hurricane Charley***, The Institute for Building Technology and Safety, Herndon, VA, 2005.
- Institute for Business & Home Safety, ***Performance of Metal Buildings in High Winds***, Natural Hazard Mitigation Insights Publication, No. 9, Jan1999, ISSN 1089-6058.
- Institute for Business & Home Safety, ***The Benefits of Modern Wind Resistant Building Codes on Hurricane Claim Frequency and Severity***, 2004.
- ***2012 International Building Code***, International Code Council, Country Club Hills, Ill: ICC, 2011.
- ***2012 International Residential Code***, International Code Council, Country Club Hills, Ill: ICC, 2011.
- Jain, V.K., Guin, J., and He, H., ***Statistical Analysis of 2004 and 2005 Hurricane Claims Data***, San Juan, Puerto Rico. June 22-26, 2009.
- Jianming Yin. ***Probabilistic Study of Wind Pressures on Buildings***, Ph.D. Thesis, Texas Tech University, 1996.
- Khanduri, A. C., ***Catastrophe Modeling and Windstorm Loss Mitigation***, Proceedings of the Eleventh International Conference on Wind Engineering, Lubbock, Texas, June 2-5, 2003.
- Kareem, Ahsan, ***Hurricane Alicia: One Year Later***, American Society of Civil Engineers, 1984.
- Liu, Henry, ***Wind Engineering- A Handbook for Structural Engineers***, Prentice-Hall Inc., 1991.
- Marshall, R.D., ***Fastest-Mile Wind Speeds in Hurricane Alicia***, U.S. Department of Commerce/ Natinal Bureau of Standards, NBS Technical Note 1197, NTIS # PB84220771, 1984.
- Mehta, K.C., Minor, J.E., and Reinhold, T.A., ***Wind Speed-Damage Correlation in Hurricane Frederic***, Journal of the Structural Division, ASCE, Vol. 109, Number 1, Paper No. 17626, January 1983.
- Mehta, K.C, Cheshire, R.H., and McDonald, J.R., ***Wind Resistance Categorization of Buildings for Insurance***, Journal of Wind Engineering and Industrial Aerodynamics, 1992.

- Mehta, K.C., Smith, D.A., and Cheshire, R.H., ***Knowledge-based System for wind damage to buildings***, Proceedings of Hurricanes of 1992, Andrew and Iniki One Year Later, ASCE, Miami, Fl, 1993.
- Minor J.E. ***A Simple Window Glass Design Chart***, Proceedings of the 8th US National Conference on Wind Engineering, Baltimore, MD, 1997.
- Minor J.E., ***New Building Code Provisions for Window Glass***, Proceedings of the NSF/WERC Symposium on High Winds and Building Codes, Kansas City, MO, Nov 2-4, 1987.
- Minor, J.E. and Beason, W.L. ***Window Glass Failures in Windstorms*** Journal of the Structural Division, ASCE, Volume 101, No. ST1, Proceedings Paper 11834, January 1976.
- Minor, J.E. and Mehta, K.C. and McDonald, J.R. ***Wind Damage Observations and Implications***, Journal of the Structural Division, American Society of Civil Engineers (ASCE), Vol. 105, No ST11, November 1979.
- Minor, J.E., Mehta, K.C., and McDonald, J.R., ***Failures of Structures Due to Extreme Winds***, Journal of the Structural Division, American Society of Civil Engineers (ASCE), Vol. 98, No. ST11, 1972.
- ***Directory of Building Codes and Regulations***, National Conference of States and Building Codes and Standards, 1982, 1985, 1987, 1989, 1991, 1998, 2002 and 2008 Edition.
- ***Consumer Guide to Manufactured-Homeowners Insurance***, North Carolina Department of Insurance.
- Ramanathan, K., and C. Kafali, ***Component Level Framework for Developing Storm Surge Damage Functions for Application in Catastrophe Models***, American Society of Civil Engineers (ASCE), Proceedings of Structures Congress 2014, 3-5 April 2014 Boston, Massachusetts.
- Rosen H. J, ***Construction Materials for Architecture***, John Wiley and Sons, 1985.
- Sandri, P. ***An Artificial Neural Network for Wind-Induced Damage Potential to Non-Engineered Buildings***, Ph.D. Thesis, Texas Tech University, 1996.
- Savage, Rudolph P., Baker, Jay, Golden, H., Kareem, Ahsan, and Manning, Billy R., ***Hurricane Alicia, Galveston and Houston, Texas August 17-18, 1983***, U.S. Department of Commerce, NTIS# PB84-237056, 1984.
- Sciaudone, J.C., Feuerborn, D., Rao, G.N., and Daneshvaran, S., ***Development of Objective Wind Damage Functions to Predict Wind Damage to Low-Rise Structures***, Proceedings of the 7th U.S. National Conference on Wind Engineering, Baltimore, MD, 1997.
- Sill, B.L., Reinhold, T.A. and Kozlowski, R.T., ***Analysis of Storm Damage Factors for Low Rise Structures***, Journal of Performance of Constructed Facilities, Vol. 11, No. 4, 1997.
- Simiu, E., and Scanlan, R.H., ***Wind Effects on Structures: Fundamentals and Applications to Design, Third Edition***, Wiley-Interscience, 1996.
- Simmons, K. M., Sutter, D., ***Manufactured Home Building Regulations and the February 2, 2007 Florida Tornadoes***, Nat Hazards (2008) 46:415-425.
- Smith T.L. and McDonald J.R., ***Preliminary Design Guidelines for Wind-Resistant Roofs on Essential Facilities***Proceedings of the 7th U.S. National Conference on Wind Engineering, Vol II, Baltimore, MD, 1997.
- Sparks, P.R., ***The Response of Low Rise Non-Engineered Structures to Extreme Wind Conditions***, Journal of Wind Engineering and Industrial Aerodynamics, 1986.
- Sparks, P.R., ***Wind Conditions in Hurricane Hugo and Their Effect on Buildings in Coastal South Carolina***, Journal of Coastal Research, 1991.
- Sparks, P.R., Hessig, M.L., Murden, J.A., and Sill, B.L. ***On the Failure of Single-Story Wood-Framed Houses in Severe Storms***, Journal of Wind Engineering and Industrial Aerodynamics, 1988.
- Sparks, P.R., Schuff, S.D., and Reinhold, T.A., ***Wind Damage to Envelopes of Houses and Consequent Insurance Losses***, Journal of Wind Engineering and Industrial Aerodynamics, 1994.

- Stubbs, N., and Perry D.C., ***A Damage Simulation Model for Building and Contents in a Hurricane Environment***, Proceedings American Society of Civil Engineers (ASCE) Structures Congress XIV, 989-996, 1996.
- Sutt E., Muralidhar K., and Reinhold T., ***Roof Sheathing Uplift Resistance for Hurricanes***, Clemson University Report, 1998.
- Tryggvason, B.V., Surry, D., and Davenport, A.G., ***Predicting Wind Induced Response in Hurricane Zones***, Journal of the Structural Division, American Society of Civil Engineers (ASCE), Volume 102, No ST12, December 1976.
- Unanwa C. O., ***A Model for Probable Maximum Loss in Hurricanes***, Ph. D. Thesis, Texas Tech University, 1997.
- Unanwa C.O., McDonald J.R., Mehta K.C. and Smith D.A, ***The Development of Wind Damage bands for Buildings***, Journal of Wind Engineering and Industrial Aerodynamics, Vol. 84, January 2000.
- Vickery, P.J., Skerlj, P.F. and Twisdale, L.A., (2000) ***Simulation of Hurricane Risk in the U.S. Using Empirical Track Model***, Journal of Structural Engineering, October 2000, pp. 1222-1237.
- Wallace G. F., ***Mitigating Damages in Hawaii's Hurricanes, A Perspective on Retrofit Options***, Insurance Institute for Property Loss Reduction, Occasional Paper Series, OP-3, August 1993.
- Watford S. W., ***A Statistical Analysis of Wind Damages to Single Family Dwellings Due to Hurricane Hugo***, Master's Thesis, Clemson University, 1991.

Computer/Information References

- Adapted Image from Scrum Inc. Layden, A. (2023). ***Scrum Framework Archives***. Scrum Inc. https://www.scruminc.com/scrum-framework/
- Almeida, Loy & Hofman (2018). _qqplotr: ggplot2 Compatible Quantile-Quantile Plots in R_. R package version 0.0.6. Accessed via: https://journal.r-project.org/articles/RJ-2018-051/RJ-2018-051.pdf
- Barret T, Dowle M, Srinivasan A, Gorecki J, Chirico M, Hocking T (2024). _data.table: Extension of `data.frame`_. R package version 1.15.4. Accessed via: https://cran.r-project.org/web/packages/data.table/index.html
- Faraway J, Marsaglia G, Marsaglia J, Baddeley A., (2021). _goftest: Classical Goodness-of-fit Tests for Univariate Distributions_. R version 1.2-3. Accessed via: https://cran.r-project.org/web/packages/goftest/index.html
- Gilbreth, F. B. and Gilbreth, L. M., (1921) Process Charts: First Steps in Finding the One Best Way To Do Work. Internet Archive Wayback Machine. Accessed via: https://web.archive.org/web/20150509222833/https://engineering.purdue.edu/IE/GilbrethLibrary/gilbrethproject/processcharts.pdf
- Nielsen, Jakob, ***Usability Engineering***, Elsevier Science, ISBN 9780125184069, Oxford, United Kingdom, 1993.
- Poole, R. (n.d.), ***Parallel split***, Visual Paradigm. Accessed via: https://circle.visual-paradigm.com/business-process-patterns-parallel-split/
- Schauberger, P. and Walker A., ***_openxlsx: Read, Write and Edit xlsx Files_***, R package version 4.2.5.2, 2023. Retrieved from: https://cran.r-project.org/web/packages/openxlsx/index.html
- Scrum Inc. Layden, A. (2023). ***Scrum Framework Archives.*** Scrum Inc. https://www.scruminc.com/scrum-framework/
- Thomas, H. (Instructor), ***Business Analysis Foundations: Business Process Modeling***, November 30, 2016. [Video file]. Accessed via: http://www.lynda.com/Project-Management-tutorials/Business-Process-Modeling-Fundamentals/490754-2.html
- ***What is a Data Flow Diagram***, Lucidchart, (n.d.). Retrieved May 13, 2022 from https://www.lucidchart.com/pages/data-flow-diagram
- ***What is a Flowchart***, Lucidchart, (n.d.). Retrieved May 13, 2022, from https://www.lucidchart.com/pages/what-is-a-flowchart-tutorial

- Wickham, H., ***Data Analysis, ggplot2: Elegant Graphics for Data Analysis***, Springer-Verlag, New York, 2016. Retrived from: https://ggplot2.tidyverse.org/
- ***Overview of Design Principles***, World Wide Web Consortium (W3C), 2004. Retrieved from: https://www.w3.org/2004/10/wcag2-nav/wcag20princ.html.

G-1.7

Provide the following information related to changes in the hurricane model from the current accepted hurricane model to the initial submission this year.

G-1.7.A

Hurricane Model changes:

1. A summary description of changes that 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.

A summary of changes to the Verisk Hurricane Model for the United States that affect the personal or commercial residential loss costs or probable maximum loss levels is provided below.

Event Generation Component (i.e. Catalog)

Verisk's historical storm set has been updated to incorporate new events that occurred in 2021 and 2022, as well as to incorporate information from the 2023 version of HURDAT2.

- Historical storms Elsa (2021), Ida (2021), Ian (2022), and Nicole (2022) have been added to the historical storm set.
- Historical storms Alma (1966), Inez (1966), Abby (1968), and Gladys (1968) have been amended in the historical storm set.

Annual landfall frequency and landfall intensity at each coastal segment have been updated accordingly and are reflected in an updated stochastic catalog. Data files associated with the catalog files have also been refreshed.

Building Vulnerability Component

The changes in the vulnerability component of the model since the current accepted model include:

- The pre-computed factors which adjust the base wind structural vulnerability accordingly when the user provides no year-built information as opposed to a known year built, have been updated to be relevant through 2024. This includes adjusting the underlying year built weighting assumptions to utilize the latest census and tax assessor data regarding building stock age.

- Vulnerability adjustments that account for structural aging and building technology changes, along with aging and deterioration of roofs have been updated to be relevant through 2024.
- The “roof year built” secondary risk feature, which defaults the roof age to a new roof for those structures that have been built within the last ten years, has been updated to be relevant through 2024.

Geographical Updates

Geographic data elements are technical updates each year to keep data elements current in the model.

- Zone Improvement Plan (ZIP) Codes have been updated to April 2024, and ZIP dependent databases were updated accordingly.

Other Updates

Other changes made to the current accepted hurricane model to improve functionality or performance which have no impact on commercial or residential hurricane loss costs and probable maximum loss levels in Florida include:

- Updates to other models unrelated to the U.S. hurricane model submitted for review. Such updates deliver scientific enhancements to models released to clients. Models updated include the Verisk Wildfire Model for the U.S., Verisk Earthquake Model for Canada, and the Verisk Tropical Cyclone Model for the Caribbean.
- The following updates have been made to the Touchstone software platform to improve usability and functionality for clients and their work flows: Updated functionality for import of open exposure data (OED) into Touchstone through Comma Separated Value (.csv) files, ability to flag exposure views for Enterprise Exposure Management (EEM), improved import/export functions in the Hazard Analysis Templates, improved functionality of Verisk's Building Identification Numbering System (BINS), and enhancements to Verisk's Application Program Interface (API)s.

G-1.7.B

Percentage difference in average annual zero deductible statewide hurricane loss costs based on the 2017 FHCF exposure data for:

1.All changes combined, and

2.Each individual hurricane model component change.

The percentage difference in loss costs stemming from the changes described in G-1.7.A are calculated by analyzing the 2017 FHCF data in Touchstone 2023A and Touchstone 2024A.

- The overall change in the statewide average annual zero deductible industry residential loss cost is an 8.1% increase in loss cost.
- Event Generation Component: These updates have resulted in a 7.7% increase in losses.
- Vulnerability Component: These updates have resulted in a 0.2% increase in losses.
- Geographical or Other Data Update: These updates have resulted in a 0.2% increase in losses.

G-1.7.C

Color-coded maps by county reflecting the percentage difference in average annual zero deductible statewide hurricane loss costs based on the 2017 FHCF exposure data for each hurricane model component change.

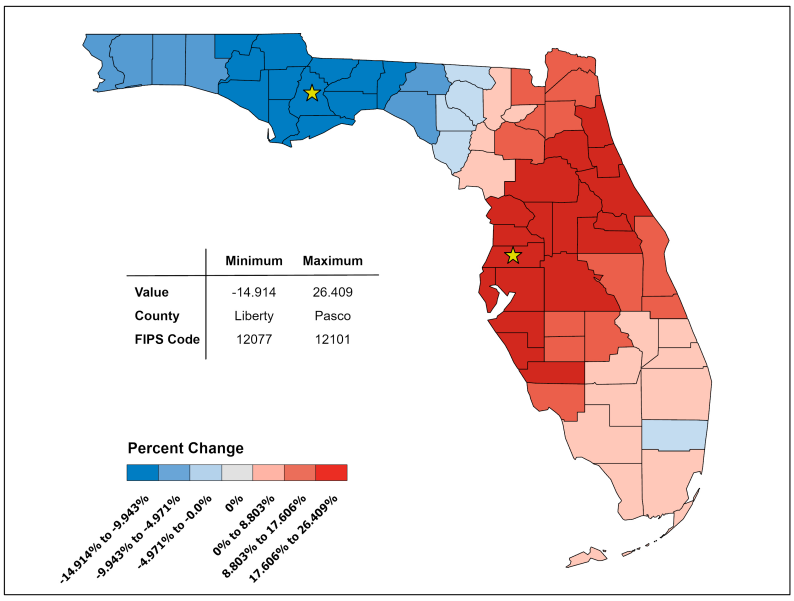


Figure 4. Event Generation Percentage Impact on Average Annual Zero Deductible Statewide Loss Costs

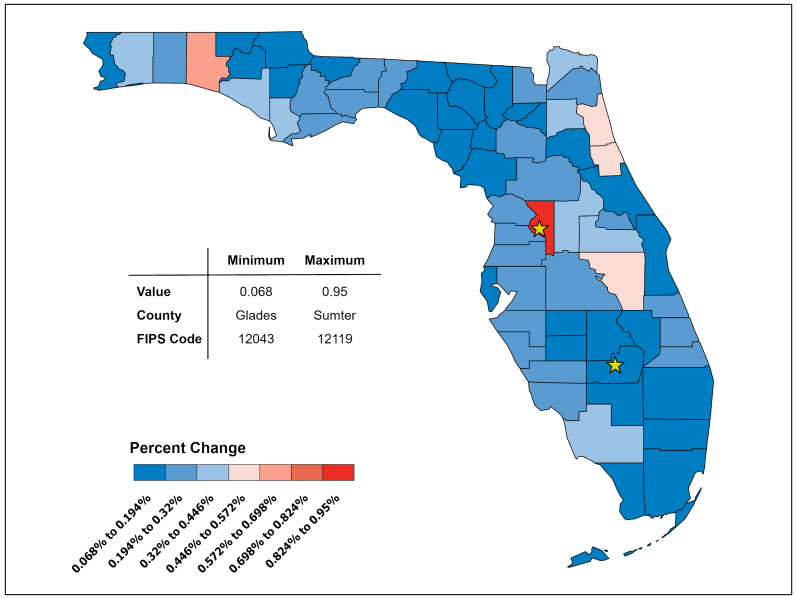


Figure 5. Vulnerability Percentage Impact on Average Annual Zero Deductible Statewide Loss Costs

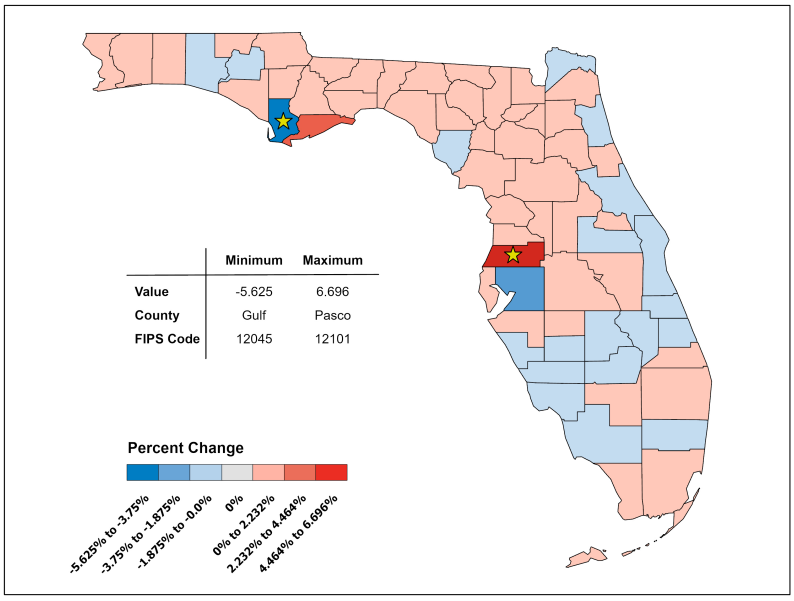


Figure 6. Geographic or Other Data Percentage Impact on Average Annual Zero Deductible Statewide Loss Costs

G-1.7.D

Color-coded map by county reflecting the percentage difference in average annual zero deductible statewide hurricane loss costs based on the 2017 FHCF exposure data for all hurricane model components changes combined.

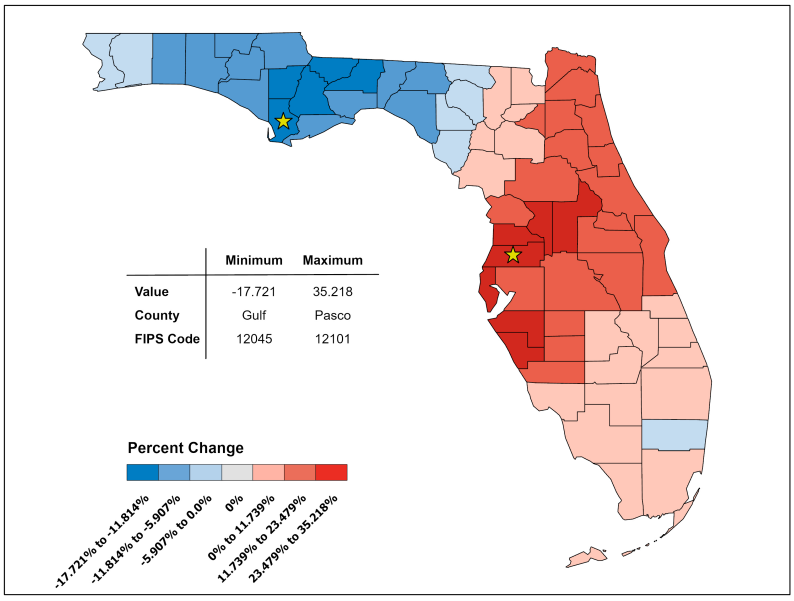


Figure 7. Total Percentage Impact on Average Annual Zero Deductible Statewide Loss Costs

G-1.8

Provide a list and description of any potential interim updates to underlying data relied upon by the hurricane model. State whether the time interval for the update has a possibility of occurring during the period of time the hurricane model could be found acceptable by the Commission under the review cycle in this Hurricane Standards Report of Activities.

The following updates to underlying data relied upon by the model may be made during 2024 and during the review cycle in this Report of Activities:

- The geocode databases and information may be updated.
- The Industry Exposure Database may be updated—the Industry Exposure Database update affects estimated industry losses and resulting demand surge factors.

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

G-2.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.

Verisk employs a large, full-time professional staff skilled in actuarial science, computer science, insurance and reinsurance, mathematics, meteorology and other physical sciences, software engineering, statistics, and structural engineering. Most have advanced degrees. These are the academic disciplines required to properly develop, test, and evaluate hurricane loss projection methodologies.

G-2.B

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

All modifications to Verisk's current accepted model and all hurricane model submission documentation have been reviewed by modeler personnel or consultants as indicated in Table 1.

All Verisk staff and consultants abide by the standards of professional conduct adopted for their respective professions.

Table 1. Verisk Modeler Personnel and Consultants

Name	Professional Discipline	Model Components Reviewed	Years of Prof. Experience	Education Level	Qualification
Eric Uhlhorn	Meteorology and Physical Oceanography	Meteorological	31	Ph.D., University of Miami	Advanced degree, Meteorology
Susan Tolwinski-Ward	Statistical Climatology	Statistical	12	Ph.D., Applied Mathematics, University of Arizona	Advanced degree, Applied Mathematics

Name	Professional Discipline	Model Components Reviewed	Years of Prof. Experience	Education Level	Qualification
Glen Patashnick	Actuarial Science	Actuarial	17	M.S., Actuarial Science, Boston University	FCAS
Carol Friedland	Civil Engineering (Consultant)	Vulnerability	17	Ph.D., Civil Engineering, Louisiana State University	Advanced degree, licensed P.E.
Paul Ericksen	Actuarial Science (Consultant)	Actuarial	33	B.A., Mathematics, Princeton University	FCAS, MAAA
Robert Cabeca	Computer Science (Consultant)	Computer/ Information	30	B.A., Information Technology Management	Equivalent experience and certifications

Disclosures

G-2.1

Modeling Organization Background

G-2.1.A

Describe the ownership structure of the modeling organization engaged in the development of the hurricane model. Describe affiliations with other companies and the nature of the relationship, if any. Indicate if the modeling organization has changed its name and explain the circumstances.

AIR Worldwide Corporation is a wholly owned subsidiary of Insurance Services Office, Inc. (ISO), which is a wholly owned subsidiary of Verisk Analytics, Inc. (Nasdaq: VRSK), which is headquartered in Jersey City, New Jersey with additional offices in North America, Europe, and Asia. ISO has been the direct parent company of AIR Worldwide since 2002, and Verisk was established as its parent company prior to going public in 2009. In January 2022, AIR Worldwide began to market its products and services under the name Verisk Extreme Event Solutions (Verisk EES) to better align with Verisk's overall mission of providing risk modeling solutions that make individuals, businesses, and society more resilient to extreme events. Our legal name has not changed.

G-2.1.B

If the hurricane model is developed by an entity other than the modeling organization, describe its organizational structure and indicate how proprietary rights and control over the hurricane model and its components are exercised. If more than one entity is involved in the development of the hurricane model, describe all involved.

The Verisk Hurricane Model for the United States is developed, maintained, and enhanced by full-time professional staff employed by Verisk.

G-2.1.C

If the hurricane model is developed by an entity other than the modeling organization, describe the funding source for the development of the hurricane model.

The Verisk Hurricane Model for the United States is developed exclusively by full-time professional staff employed by Verisk.

G-2.1.D

Describe any services other than hurricane modeling provided by the modeling organization.

Verisk (Nasdaq: VRSK) is a leading strategic data analytics and technology partner to the global insurance industry. It empowers clients to strengthen operating efficiency, improve underwriting and claims outcomes, combat fraud and make informed decisions about global risks, including climate change, extreme events, sustainability and political issues. Through advanced data analytics, software, scientific research and deep industry knowledge, Verisk helps build global resilience for individuals, communities and businesses. A list of products and services is available on the website.

The Verisk EES help the insurance industry understand and quantify the risk faced from extreme events with sophisticated catastrophe risk modeling, global loss indexes, and advanced analytics. Verisk EES provides natural catastrophe, mortality, supply chain disruptions, terrorism, and casualty catastrophe risk assessment and management products and services to primary insurance companies, reinsurers, intermediaries, involuntary markets, state funds, and other insurance industry organizations such as the National Council on Compensation Insurance (NCCI). We also provide services to investment banks, investors in catastrophe bonds and corporate and government risk managers. During or after a major catastrophe event in the world, we provide ALERT services (previously AIR Loss Estimates in Real Time) to give information and, for certain events, loss estimates to clients and interested parties.

G-2.1.E

Indicate if the modeling organization has ever been involved directly in litigation or challenged by a governmental authority where the credibility of one of its U.S. hurricane model versions for projection of hurricane loss costs or hurricane probable maximum loss levels was disputed. Describe the nature of each case and its conclusion.

Verisk has never been involved in litigation or been challenged by a statutory authority with respect to the credibility of the Verisk Hurricane Model for the United States.

G-2.2

Professional Credentials

G-2.2.A/B

A. Provide in a tabular format (a) the highest degree obtained (discipline and university),(b) employment or consultant status and tenure in years, and (c) relevant experience and responsibilities of individuals currently involved in the acceptability process or in any of the following aspects of the hurricane model:

1. Meteorology

2. Statistics

3. Vulnerability

4. Actuarial Science

5. Computer/Information Science

B. Identify any new employees or consultants (since the previous submission) engaged in the development or implementation of the hurricane model or the acceptability process.

Staff and Consultants

The following consultants have worked on the acceptability process and are included in Table 2:

- Dr. Carol Friedland, Ph.D., P.E., C.F.M.
- Mr. Paul Ericksen, FCAS, MAAA (New)
- Mr. Robert Cabeca

The full-time employees of Verisk who are currently involved in the primary development of the model are listed in Table 2.

Anyone new to the model development or acceptability process is designated "New".

Table 2. Professional Credentials

Name	Years at Verisk	Model Aspect	Relevant Degree(s) and Certification(s)	Biography	New
Beston, Christopher	6	Computer/ Information	M.B.A. University of Southern California (2009); B.A. Finance and Insurance, Northeastern University (2002)	Mr. Christopher Beston is the Director of Global Insured Exposure Analysis in the Research Team. He is responsible for enhancing the policy terms and conditions in the Industry Exposure Databases worldwide that are a foundation of many of the Verisk models. In addition, he specializes in market-related components for Verisk's model enhancement and development process. Prior to working at Verisk, Mr. Beston worked in various roles in the (re)insurance and consulting industries for 15 years. Mr. Beston has an MBA from the University of Southern California's Marshall School of Business and a Bachelors in Finance from Northeastern University. He received his CPCU designation in 2006, CEEM designation in 2019.	

Name	Years at Verisk	Model Aspect	Relevant Degree(s) and Certification(s)	Biography	New
Bobby, Sarah	9	Vulnerability	Ph.D. Structural Engineering, University of Notre Dame (2015); B.S. Civil Engineering, University of Notre Dame (2010); CEEM, Verisk (2015)	Dr. Bobby joined Verisk in 2015 and is a principal engineer and senior manager, primarily responsible for developing and updating Verisk's wind vulnerability models in North America and the Gulf of Mexico. Prior to joining Verisk, Dr. Bobby worked as a graduate research assistant for the University of Notre Dame, where she created an in-house probabilistic risk assessment program for the fragility/ damage analysis of structures under wind and seismic hazards through the integration of hazard and structural models. Dr. Bobby earned her B.S in Civil Engineering as well as her Ph.D. in Civil and Environmental Engineering and Earth Sciences from the University of Notre Dame.	
Borman, Julia	10	Actuarial	Ph.D. Economics, North Carolina State University (2014); M.S. Economics, North Carolina State University (2012); B.A. Mathematics and Economics, St. Mary's College of Maryland (2008)	Dr. Borman is a director in the consulting and client services group. Julia is responsible for ensuring compliance with all regulatory and market requirements of Verisk's catastrophe models. She and the members of her group assist clients in working with regulators and rating agencies on a variety of projects, including data calls, utilizing modeling in rating plans, and stress tests for climate change. Before taking her current position, Julia focused on developing Verisk's extreme event models for agriculture; her primary function was model manager of Verisk's U.S. Multiple Peril Crop Insurance model. She has worked for Verisk since 2014. Julia holds a PhD and master's degree in economics from North Carolina State University and a bachelor of arts in economics and mathematics from St. Mary's College of Maryland.	
Cabeca, Robert	NA	Computer/ Information	Information Technology Management, University of Phoenix	Mr. Cabeca (External Independent Peer Reviewer) is a multifaceted executive with 28 years of extensive and progressive IT and security leadership, program management, education, and more. Leadership IT security consulting and management experience includes supporting hospitals, financial, educational institutions, and government agencies (TSA, FCC, ICE, and others). He is skilled at implementing forward-thinking, transformational, and cost-effective IT security business strategies and solutions. Mr. Cabeca is also an IT instructor with VTEC Training, providing instruction and security certifications in ITIL 4.0, CompTIA Project+, Network+, Security +, IT fundamentals, Scrum/ Agile, MS 365/Azure, MS Office, VBA, Adobe, AWS, Google cloud and other applications, and he holds professional certifications in the majority of these. He has received extensive IT and security training from Chauncey, SANS, ISC2, Citrix, IBM, Microsoft, Cisco, and others.	
Chowdary Jetti, Vijay	12	Computer/ Information	M.S. International Finance, Deakin University (2009); Bachelor's Biotechnology, Anna University (2007); CEEM, Verisk (2012)	Vijay Jetti is a manager of Model quality assurance team. In his role he certifies model loss numbers from the Touchstone software. Mr. Jetti joined Verisk in 2012, prior to that he worked with Flagstone Re as a Cat Modelling Analyst. Mr. Jetti graduated from Deakin University with a Master's degree in International Finance and holds a bachelor's degree in Biotechnology from Anna University.	

Name	Years at Verisk	Model Aspect	Relevant Degree(s) and Certification(s)	Biography	New
Davidson, Burcu	25	Computer/ Information	M.S. Computer Science, Suffolk University Boston (1999); Bachelor's Electronic and Communication Engineering, Istanbul Technical University (1992)	Ms. Davidson is a Vice President of software development on the Verisk EES Team. She joined Verisk in 1999. Previously she worked as an engineer at Turkish Telecom in Ordu, Turkey.	
Devi, Ambika	24	Computer/ Information	M.B.E., Asia-Pacific Institute of Management (2008); B.A. Climatology, Kamala Nehru College (2006)	Ms. Devi is a senior technical writer for the Verisk EES documentation team and is responsible for the development and maintenance of software documentation. She has about 9+ years of progressive professional experience in different roles in product management units of Ernst & Young and the British Council and delivered several high-quality documentation projects. She holds a Masters of Business Economics (MBE) degree from Asia-Pacific Institute of Management.	
Dheram, Phaninath	12	Computer/ Information	M Phil (Computer Science), Jawaharlal Nehru University, New Delhi (1986)	Mr. Phaninath Dheram works as senior manager in the Model Implementation Group (MIG), Verisk India. He has been working in the MIG for the last 12 years in various capacities. Prior to Verisk, he worked in Mentor Graphics (currently Siemens) for nearly 10 years in the field of software Development. He holds a masters degree in Computer science from Jawaharlal Nehru University, New Delhi.	
Diamond, Thomas	8	Computer/ Information	Bachelor of Fine Arts, Massachusetts College of Art and Design (1991)	Mr. Diamond is a principal user experience designer with our software development group. Prior to joining Verisk, Thomas worked as a UX designer and interaction/graphic designer within the advertising industry.	
Ericksen, Paul	31	Actuarial	FCAS; MAAA; B.A. Mathematics, Princeton University (1992)	Mr. Ericksen (Independent Peer Reviewer) is a Principal of Actuarial Consulting at Insurance Services Office Inc (ISO). He is responsible for providing actuarial consulting services to a wide array of clients including property/ casualty insurers, insurance departments, and others. Mr. Ericksen is considered an expert in ratemaking for properties that are high exposure to hurricanes and has provided expert witness testimony in support of his client's rate filings, including Citizens Property Insurance Corporation, the North Carolina Rate Bureau, and the Massachusetts Property Insurance Underwriting Association. Before his time at ISO he worked for Citizens Property Insurance Coporation as a Lead Ratemaking Consultant, and at the Florida Office of Insurance Regulation to conduct an analysis of territorial definitions for residential property insurance coverages. He graduated from Princeton University with a BA in Mathematics, is a Fellow of the Casualty Actuarial Society, and a Member of the CAS examination committee.	Yes

Name	Years at Verisk	Model Aspect	Relevant Degree(s) and Certification(s)	Biography	New
Firouzbakht, Nazanin	5	Editorial	M.B.A. Marketing, Boston University (2018); B.S. Industrial Engineering, Azad University of Tehran (2007); CEEM (2024)	Ms. Nazanin Firouzbakht is a Senior Consultant and Certified Extreme Event Modeler (CEEM) within Consulting and Client Services group at Verisk EES. In her role, she contributes to the Regulatory and Rating Agency Client Support (RRACS) team, where she is responsible for developing and updating essential documentation that assists clients in meeting regulatory and rating agency reporting requirements using Verisk's solutions. Previously, Ms. Firouzbakht worked in the Product Marketing Department for five years, where she led marketing campaigns for various offerings within the Verisk EES portfolio. Ms. Firouzbakht holds an MBA from Boston University and a bachelor's degree in industrial engineering from Azad University.	Yes
Fletcher, Lindsey	< 1	Actuarial	B.S. Mathematics and Industrial Engineering, Worcester Polytechnic Institute (2023)	Lindsey Fletcher is a Risk Consultant on the Regulatory and Rating Agency Client Services (RRACS) team within the Consulting and Client Services Group at Verisk EES. She works on rating agency and regulatory projects with departments of insurance and clients. Prior to her time at Verisk she worked as a Associate Solutions Developer at Hanover Insurance Group. During this time she collaborated with a full-stack development team to create and maintain web applications for internal use. Ms. Fletcher earned a BS Mathematics and Industrial Engineering degree from Worcester Polytechnic Institute.	Yes
Friedland, Carol	NA	Vulnerability	Ph.D. Civil Engineering, Louisiana State University	Dr. Friedland (External Independent Peer Reviewer) is the Louisiana State University AgCenter LaHouse Resource Center director and associate professor in Biological and Agricultural Engineering. Her research focuses on resilient and sustainable housing, disaster loss estimation, post-disaster damage assessment, hazard mitigation planning and mitigation decision-making, and has published extensively in research journals and in conference proceedings. Her areas of expertise include: hazard-resistant construction and mitigation; performance of housing and other built infrastructure subjected to natural hazards; combined wind and flood interactions on structures; post-event data acquisition; remote sensing of building damage; hazard-resistant and sustainable construction; integration of Geographic Information Systems, or GIS, in hazards research; hazard mitigation planning and mitigation decision-making; and loss estimation. Dr Friedland has an M.A. and Ph.D. in Civil Engineering with a Minor in Disaster Science and Management from Louisiana State University. She is a member of the American Society of Civil Engineers (ASCE), American Association of Wind Engineers (AAWE), and the Association of State Floodplain Managers, She is a registered Professional Engineer in Civil Engineering.	

Name	Years at Verisk	Model Aspect	Relevant Degree(s) and Certification(s)	Biography	New
Ghosh, Srimanta	7	Computer/ Information	Ph.D. Hydraulics and Water Resources Engineering, India Institute of Technology (2017); M. Tech Agricultural Systems and Management, India Institute of Technology (2009); B. Tech Agricultural Engineering, Bidhan Chandra Krishi Viswavidyalaya (2007)	Dr. Ghosh works as a manager in the model quality team. He is responsible for validating the atmospheric peril models and certifying the modeled losses. Prior to joining Verisk, he worked as a research scholar and earned a Ph.D. in Hydraulics and Water Resources Engineering from the Indian Institute of Technology (IIT) Madras. His Ph.D. dissertation was on frequency estimation of floods, droughts, and precipitation at regional and local scales, using state-of-the-art statistical, physical, and geospatial models. He has published research articles in reputed peer-reviewed international journals and presented in international conferences	
Grenier, Isabelle	2	Statistics	Ph.D. Statistical Science, University of California Santa Cruz (2021); M.S. Mathematics and Statistics, McGill University (2016); B. Mathematics and Statistics, University of Waterloo (2014); B. Business Administration and Finance, Wilfrid Laurier University (2014)	Dr. Grenier is a senior scientist in the climate statistics group at Verisk. She works on the maintenance of the existing stochastic catalogs and on the development of the next generation of tropical cyclone hazard models. Dr. Grenier earned her Ph.D. in Statistical Science from the University of California, Santa Cruz where her research focused on efficient Bayesian methods for spatial statistics. Dr. Grenier also holds an M.S. in statistics from McGill University, and a B.Math in statistics and actuarial science from the University of Waterloo.	
Hanson, Anthony	19	Computer/ Information	M.A. Economics, Boston College (1996); B.A. Economics, University of Massachusetts (1991)	Anthony Hanson is a director of analytics in the research and modeling group. Since joining Verisk, his research has focused on using economic data for industry exposure development and to create unique applications in the catastrophe analytics field. He was the principal investigator for the development of the Verisk Global Capital Stock Index, and the Touchstone global demand surge and loss inflation model. Most recently he has been researching construction cost inflation and its impact on claims. Anthony holds an MA in Economics from Boston College and a BA, summa cum laude, in Economics from the University of Massachusetts.	

Name	Years at Verisk	Model Aspect	Relevant Degree(s) and Certification(s)	Biography	New
Hayes, Cheryl	24	Computer/ Information	M.A. Energy and Environmental Analysis, Boston University (1995); B.A. Political Science, Mount Holyoke College (1992)	Cheryl Hayes is a Vice President and Manager of the Exposures Group and also oversees the Operations Team in the Research and Modeling group. She has led a multi-disciplinary team in the development of comprehensive, high resolution industry exposure databases (IEDs) for more than 110 countries. Cheryl has been instrumental in streamlining the development process for the IEDs and has worked to advance their quality. Prior to joining Verisk, she worked at Liberty Mutual as an analyst in the environmental department. Ms. Hayes holds her B.A. in Political Science from Mount Holyoke College and her M.A. in Environmental Studies from Boston University.	
Induri, Harini	2	Computer/ Information	Bachelor's Tech Electronics and Communication, Gokaraju Rangaraju institute of Engineering and Technology, Hyderabad, India (2022); CEEM, Verisk (2022)	Ms. Harini Induri is an analyst in the quality assurance department. She works in the model quality assurance team which is responsible for validating the model losses. Harini received a bachelor's degree in Electronics and Communication from Gokaraju Rangaraju Institute of Engineering and Technology, Hyderabad, India. She is also a Certified Extreme Event Modeler (CEEM).	
Jhurmarwala, Utpal	8	Computer/ Information	M.S. Information Systems, Northeastern University (2006); B.S. Commerce, Gujarat University (2002); Certificate in Computer Programming, Newbury College (1998)	Utpal Jhurmarwala works as a Product Manager in the Product Management department. He works with scrum teams as PO to make sure that enhancements match requirements and user experience. Also, he communicates with clients and the CCSG department for possible enhancements and their feedback. Mr. Jhurmarwala has an MS degree in Information Systems from Northeastern University.	
Jinna, Aditya	24	Computer/ Information	M.S. Computer Engineering, Wayne State University (1999); B.E. Electronic and Instrumentation Engineering, Osmania University (1998)	Aditya Jinna works as a Senior Manager for Software in Software Development Group. Aditya primary role is overseeing and working with multiple scrum teams for the development and release of Touchstone. Aditya received a Masters degree in Computer engineering from Wayne State University in Detroit, MI and a Bachelors degree in Electronic and Instrumentation engineering from Osmania University in Hyderabad, India.	
Johnson, Tim	9	Vulnerability	Ph.D. Civil Engineering, Florida Institute of Technology (2015); M.S. Civil Engineering, Florida Institute of Technology (2011); B.S. Civil Engineering, Florida Institute of Technology (2009)	Dr. Tim Johnson is a principal engineer in the research and modeling group on the Verisk EES. He has primarily focused on building Vulnerability for the United States Hurricane domain for the last 9 years. Prior to working with Verisk, Tim worked as a vulnerability modeler/graduate research assistant for 6 years with the Florida Public Hurricane Loss Model as the lead engineer in the vulnerability model team. Dr. Johnson holds a Bachelors, Masters and Ph.D. in Civil Engineering from Florida Institute of Technology.	

Name	Years at Verisk	Model Aspect	Relevant Degree(s) and Certification(s)	Biography	New
Jyotsna Dhanyamaraju, S L Naga	5	Computer/ Information	Bachelor's Tech Information Technology, Jawaharal Nehru Technological University Kakinada (2011)	Naga Jyotsna is a Lead Engineer in the Hyderabad office of Verisk EES on the software team. Prior to her time at Verisk she worked as a software engineer at HCL technologies. She holds a B. Tech Information Technology degree from Jawaharal Nehru Technological Univeristy Kakinada.	
Kafali, Cagdas	17	Vulnerability	Ph.D. Civil Engineering, Cornell University (2007); M.S. Structural Engineering, Case Western Reserve University (2001); B.S. Civil Engineering (1999); M.A. Management, Harvard University (2018)	Dr. Cagdas Kafali is a Senior Vice President in Verisk EES Research and Modeling group overseeing natural catastrophe risk model development with particular focus on the exposures, damage and loss components. Dr. Kafali holds an M.S. in Structural Engineering from Case Western Reserve University, a Ph.D. in Civil Engineering from Cornell University with a minor in Applied Mathematics, and a Master of Liberal Arts in Management from Harvard University, Extension Studies.	
Kandulapati, Mohan	8	Computer/ Information	Bachelor's degree in Technology and Computer Science from Jawahar Lal Nehru Technological University in Hyderabad, India, CEEM, Verisk(2024)	Mr. Kandulapati is a member of Verisk's Software Quality Assurance group and holds the title of Senior SQA Engineer II. Mr. Kandulapati previously worked for Tech Mahindra Ltd for three years before joining Verisk in 2016. He has a Bachelor's degree in Technology and Computer Science from Jawahar Lal Nehru Technological University in Hyderabad, India.	
Kaplan, Emma	7	Computer/ Information	M.S. Statistics, University of Massachusetts, Amherst (2017); B.A. Mathematics & Environmental Studies, St. Lawrence University (2012); CEEM, Verisk (2017)	Emma Kaplan is a Manager in our Quality Assurance team. She leads the CoreQA Financial team which works on validating insurance policy term application in the Financial Engine. Previously, Emma worked for the University of Massachusetts, Amherst as a teaching assistant and as a statistical consultant. Emma also spent several years working in sustainable agriculture and has experience on both the farming and business side of the field. Emma earned an M.S. in Statistics from University of Massachusetts, Amherst, and a B.A. in Environmental Studies and Mathematics from St. Lawrence University.	
King, Connor	2	Actuarial	M.S. Information Systems, University of Maine (2022); M.B.A - Analytics and Finance, University of Maine (2021); B.S. Wildlife Ecology, University of Maine (2019); CEEM, Verisk (2022)	Connor King is a Risk Consultant on the Regulatory and Rating Agency Client Services (RRACS) team within the Consulting and Client Services Group at Verisk EES. He works on rating agency and regulatory projects with departments of insurance and clients. Prior to his time at Verisk he worked at the University of Maine and interned at federal agencies such as NOAA and the USDA aiding in research. Mr. King earned an MS Information Systems, MBA - Finance and Analytics, and BS in Wildlife Ecology from the University of Maine.	

Name	Years at Verisk	Model Aspect	Relevant Degree(s) and Certification(s)	Biography	New
Kireyev, Vladimir	17	Computer/ Information	M.S. Mechanical Engineering; Bauman Moscow State Technical University (1988)	Mr. Vladimir Kireyev is a Director of Software Development in the Software Development Group (SDG) team. He leads a team of developers working on Next Generation Modeling Loss Engine for last 10 years. Previously, at Verisk EES Mr. Kireyev worked on the Detailed Loss Analysis Engine for Clasic2 and Touchstone. Prior to his time at Verisk EES Mr. Kireyev worked as a senior software engineer for Brooks Automation. Mr. Kireyev holds an M.S. Mechanical Engineering degree from Bauman Moscow State Technical University.	
Knox, Aaron	5	Computer/ Information	B.S. Computer Science and Economics, Rose-Hulman Institute of Technology (2006)	Mr. Knox joined Verisk in 2019 as a senior analyst in the data technology group. His primary focus has been to streamline Verisk and third-party data intake by developing a comprehensive suite of database onboarding and validation processes, including a web-based dashboard that monitors data downloads in real-time. Prior to joining Verisk, Aaron worked at State Street Corporation as an assistant vice president in the Global Markets division. He earned his B.S. in both Computer Science and Economics from Rose-Hulman Institute of Technology.	
Kokkonda, Visweswara	13	Computer/ Information	Executive M.B.A. Project Management and Leadership, National Institute of Business Management (2016); B. Tech Electronics and Communication Engineering, Dr. Paul Raj Engineering College (2006); PSM; AWS Certified Solutions Architect; Microsoft Certified Professional in C# Programming; MCSA	Mr. Kokkonda joined the Verisk Hyderabad office in July 2011 as a software engineer in the software group and is now a principal Software Engineer. He has completed a bachelor of technology degree in Electronics and Communication Engineering from JNTU. Mr. Kokkonda also completed an executive MBA in Project Management and Leadership Management from National Institute of Business Management, Chennai. Prior to joining Verisk, he worked at Primaccess Technologies Ltd as a software programmer for 4 years, developing Web Applications using ASP.Net, C#, Vb.Net, Ajax, Webservices,Asp.netcore JavaScript, MSSQL Server, MySQL, and PostgreSQL. He is a Microsoft-certified SQL Server Developer and C# Developer, and is a Certified Professional Scrum Master and Certified AWS associate Architect.	

Name	Years at Verisk	Model Aspect	Relevant Degree(s) and Certification(s)	Biography	New
Kumar Arya, Siddhartha	4	Computer/ Information	M. Tech Computer Science and Management, Deakin University, Melbourne Australia	Siddhartha Kumar Arya joined Verisk as a manager in our information security group. Previously, Mr. Arya worked for Verizon Wireless as a senior principal security architect, where he was responsible for cybersecurity innovations; data protection; information security management system; security operations; security architecture and engineering; application security, IAM, security assessment and testing, and security risk management frameworks. Mr. Arya holds many data security patents for an end to end data protection. He served as a chairperson for multi-organization executive leaders to layout future security product roadmap for Teradata, Hadoop, Oracle, cloud, and opensource related security products. He is also a chartered professional engineer registered with Institution of Engineers Australia. Siddhartha earned an MEng (Systems Engineering and Information Technology) from Birla Institute of Technology and Science (BITS) Pilani, MBA (concentration in MIS) from BITS Pilani and MTech (Computer Science and Management) from Deakin University, Melbourne.	
Lamberson, William	2	Computer/ Information	M.S. Atmospheric Sciences, University of Albany (2015); B.S. Meteorology, The Pennsylvania state University (2012)	Mr. Lamberson joined Verisk in 2022 and is a Senior Quality Assurance Associate. He is responsible for validating the hazard and vulnerability modules for Verisk's atmospheric peril models. Prior to joining Verisk, Mr. Lamberson spent seven years as an Associate Scientist at the National Weather Service's Weather Prediction Center. There he worked on developing novel forecast tools that enhanced NWS forecasting processes. Mr. Lamberson holds a B.S. in Meteorology from Penn State and an M.S. in Atmospheric Science from SUNY - Albany.	
Levine, Carol	13	Computer/ Information	B.A. University of Massachusetts (1968)	Carol is a Principal Technical Writer in the Documentation group. She works closely with the Software Development Group, Product Management, and other internal groups to create, maintain, and publish client documentation along with a variety of related support information. Previously, Carol worked for various software companies in the Boston area as a Senior/ Principal Technical Writer. Carol earned a B.A. from the University of Massachusetts.	

Name	Years at Verisk	Model Aspect	Relevant Degree(s) and Certification(s)	Biography	New
Lorsolo, Sylvie	12	Meteorology	Ph.D. Atmospheric Science, Texas Tech University (2006); M.S. Environmental Sciences, Université de Sud Toulon Var (2000); B.S. Physics Université Paul Sabatier (1998)	Dr. Sylvie Lorsolo is a Senior principal scientist and senior manager in the research and modeling group. Her main responsibilities are leading a team of meteorologists in the development of Verisk's tropical cyclone models, monitoring tropical cyclones in real time, model validation, and client support and training. She also assists with insurance-linked securities contracts. Prior to joining Verisk, Dr. Lorsolo worked as an assistant scientist for the NOAA/ Hurricane Research Division at the University of Miami where she focused on observational studies of the hurricane boundary layer and developed expertise on collecting and analyzing airborne data for a better understanding of hurricane intensity change. Dr. Lorsolo earned her Ph.D. in Geosciences from Texas Tech University.	
Lu, John	11	Computer/ Information	M.S. Electrical Engineering, University of Kentucky (1999)	Mr. Lu is the software quality assurance (SQA) Vice President in our engineering and quality assurance department. He joined Verisk in 2013 as a lead SQA engineer. Previously, Mr. Lu was a QA manager at Fidelity Investments, where he led a test automation project in an Agile development group. He was also responsible for the design of an automated test suite for the Fidelity Portfolio Processing application.	
Luo, Jianjun	10	Vulnerability	Ph.D. Wind Science and Engineering, Texas Tech University (2014); M.S. Electronic and Information Engineering, Xi'an Jiaotong University (1997); B.S. Applied Physics, Northwestern Polytechnical University (1992)	Dr. Jianjun Luo is a Principal Engineer in the Atmospheric Peril Vulnerability Group of our Research and Modeling Department. Since he joined Verisk in 2014, he has worked on the development of European Extratropical Cyclone model, European Severe Thunderstorm model, and U.S. Hurricane model. Prior to working with Verisk, he worked as a Graduate Research Assistant with the National Wind Institute at Texas Tech University where he earned his Ph.D. in Wind Science and Engineering with a minor in Business Statistics. Before that, he was as an Associate Professor of Computer Science in Xi'an Jiaotong University, China.	

Name	Years at Verisk	Model Aspect	Relevant Degree(s) and Certification(s)	Biography	New
Marchion, Evaggelia	11	Computer/ Information	M.A. User-Centered Design, Brandeis University (); B.S. Graphic Design, Northeastern University (); UX Bootcamp, Bentley College; Verisk Foundations of Leadership in Excellence, Harvard Business Publishing (2017); Verisk Experienced Leader Program, Harvard Business Publishing (2019)	Eva Marchion is the Head of User Experience for Verisk EES. She is a visionary leader in user experience design, dedicated to advancing the work of the User Experience team at Verisk EES while shaping the future of the company's software solutions. With a strong focus on enhancing cross-functional relationships among product management, software development, marketing, consulting, and sales, she advocates for user-centered principles in a collaborative environment. Eva his passionate about elevating UX maturity within Verisk EES and continues to promote best practices that balance business needs with engineering constraints, ultimately driving innovation and excellence in user experience and producing best in class software solutions to Verisk EES customers using a user centered design approach.	
McDonagh, Evan	10	Computer/ Information	B.S Business Information Systems, National University of Ireland, Galway (2012); Certified SAFe 6 Scrum Master (2024);	Mr. Evan McDonagh is a Senior Software Engineer in Test in the QA Department. He works on the Automation Quality Assurance Team within the QA Department which works on the testing related infrastructure and solutions for the QA department. Mr. McDonagh previously worked in Software Quality Assurance for 3 years where he worked as a product tester on the Touchstone product. Mr. McDonagh received a Bachelor's degree in Business Information Systems from the National University of Ireland, Galway.	Yes
Nagulpally, Ramchander	12	Computer/ Information	M.S. Mechanical Engineering, University of Arizona (1984); B.E. Mechanical Engineering, Osmania Engineering College (1980)	Ramchander R Nagulpally is a Senior Vice President of Quality Assurance at Verisk EES. He is the Head of Worldwide Quality Assurance team with a mandate to validate models and software solutions and other integrated software service offerings across the Verisk EES family of products. Members of the quality assurance teams work collaboratively across all model development and integration teams to provide a comprehensive, process driven approach to model validation and delivery. The team is staffed with a diverse group of highly qualified and experienced engineering, scientific and insurance professionals. Mr. Nagulpally has spent over 40 years in development, quality assurance operations in the engineering and analytical software industry. He has extensive experience delivering enterprise grade software to diverse global markets with rigorous quality standards. Along with experience in implementation of sustainable processes, tools, and automation infrastructure. He holds a MS in Mechanical Engineering from the University of Arizona and a BE in Mechanical Engineering from Osmania Engineering College.	

Name	Years at Verisk	Model Aspect	Relevant Degree(s) and Certification(s)	Biography	New
Nakarikanti, Anil	9	Computer/ Information	B. Tech Computer Science and Engineering, JNTU University (2006)	Mr. Anil Kumar Nakarikanti is a Technical Lead in the SDG Department. He works in the Infinity team in SDG department which works on Touchstone. Mr. Nakarikanti works on the implementation of the features in Touchstone. Previously he has worked as a software developer at Honeywell and as a consultant at SISA Information Technology Pvt. Ltd. He holds a graduate degree in Computer Science and Engineering from JNTU University Hyderabad.	Yes
Palaniappan, Nithya	8	Computer/ Information	M.S. Computer Applications, Bharathidasan University (2004); B.S. Computer Science, Bharathiyar University (2001)	Nithya Palaniappan is a Senior Core QA Associate in our quality assurance team. Previously she worked for Effulgent Technologies as a Software Tester. Nithya earned B.Sc. in Computer Science from Bharathiar University and Master of Computer Applications from Bharathidasan University.	
Patashnick, Glen	<1	Actuarial	FCAS (2011); M.S. Actuarial Science, Boston University (2006); B.A. Computer Science, Dartmouth College (1998)	Mr. Patashnick is a Senior Actuarial Consultant in the Consulting and Client Services Group (CCSG) department. He works on the Regulatory and Rating Agency Client Services (RRACS) team which works on regulatory filings. Mr. Patashnick began his actuarial career in homeowner's insurance and was most recently teaching actuarial science at Boston University. Mr. Patashnick received a master's degree in actuarial science from Boston University and a bachelor's degree in computer science from Dartmouth College. Mr. Patashnick earned his FCAS designation in November 2011.	Yes
Prabhu, Asha	13	Computer/ Information	B. Tech in Computer Science and Information Technology, VNR Vignana Jyothi Institute of Engineering and Technology (2005)	Ms. Asha is a Technical Lead in the Model Implementation Group. She works on implementing the U.S. Hurricane model and other models in Touchstone. Prior to joining Verisk, she had four years of experience in software development and enhancement using Microsoft Visual C++ (MFC) and SQL. She has a bachelor's in technology in Computer Science and Information Technology from VNR VJIET, affiliated to Jawaharlal Nehru Technological University, Hyderabad.	
Rajasekharan Nair, Anup	5	Computer/ Information	M.B.A. Analytics, Alliance University (2018); B. Tech Civil Engineering, Kannur University (2000); AWS Certified Cloud Practitioner (2022); CEEM (2021);	Mr. Nair is the Senior Manager of Software Quality Assurance team and joined Verisk in December 2019. He holds Engineering Degree in Civil Engineering from Govt Engg College, Kerala. Prior joining to Verisk, he worked with Chubb Insurance as Account Operation Manager and with RMS India as Project Lead.	Yes

Name	Years at Verisk	Model Aspect	Relevant Degree(s) and Certification(s)	Biography	New
Raju Venkata Datla, Suryanarayana	23	Computer/ Information	M.E. Structural Dynamics, Department of Earthquake Engineering, India Institute of Technology Roorkee (1998); B.E. Civil Engineering, Andhra University (1996)	Mr. Datla Suryanarayana Raju, Vice President in Model implementation, Hyderabad. Leading the team who works on Implementation of Florida Hurricane Model into Touchstone. Before joining Verisk, Mr. Raju was with RMS India working on model development. Mr, Raju earned an MS in Structural Dynamics, from the Department of Earthquake Engineering at IIT Roorkee, India. Mr. Raju earned a BE in Civil Enginereering from Andhra University, India.	
Ramanathan, Karthik	12	Vulnerability	Ph.D. Civil and Environmental Engineering, Georgia Institute of Technology (2012); M.S. Civil and Environmental Engineering, Georgia Institute of Technology (2011); M.S. Civil and Environmental Engineering, Univerisity of Pittsburgh (2008); B.S. Civil and Environmental Engineering, Osmania University (2006)	Dr. Ramanathan is a Vice-President and Principal Engineer in Verisk EES' Research and Modeling Department since 2012. He leads the Atmospheric Perils Vulnerability Team where they model the vulnerability of civil engineering systems to atmospheric hazards including wind, inland and coastal flooding, hail, tornadoes, snow and temperature effects. Prior to Verisk, he worked as a graduate research assistant with the School of Civil and Environmental Engineering at Georgia Institute of Technology, where he earned both his Ph.D. and M.S. in Civil and Environmental Engineering with a special focus in Earthquake Engineering and Structural Reliability. Dr. Ramanathan also holds an M.S. from the University of Pittsburgh in Civil and Environmental Engineering with a special emphasis in Structural Engineering and Mechanics.	
Rane Bhosle, Prajakta	3	Computer/ Information	B.E. Information Technology, Vidyalankar Institute of Technology	Ms. Rane Bhosle is a member of Verisk's Software Quality Assurance group and holds the title of SQA Engineer II. Prajakta previously worked for Cognizant Technology Solutions Ltd for five years before joining Verisk in 2021. She has a bachelor's degree in information technology from Vidyalankar Institute of Technology, Mumbai University, India.	
Reilly, Christopher	2	Actuarial	B.S. Biostatistics, Emmanuel College (2021); CEEM (2022)	Mr. Reilly is a Risk Consultant in the Consulting and Client Services Group (CCSG) Department. He works on the Insurer team segment of the CCSG department which supports insurance company clients working with Verisk's catastrophe modeling products. Mr. Reilly received a bachelor's degree in Biostatistics from Emmanuel College.	
Renault, Thomas	2	Computer/ Information	M.S. Mathematics, University of Rouen, France (1999); B.S. Mathematics, University of Rouen, France (1998)	Mr. Thomas Renault is a Senior Analyst II in the Research Department. He is part of the Data Technology Group (DTG), which focuses on Model Development Support, Data Onboarding, and the Creation/Automation of Map Exhibits. Before joining Verisk, Mr. Thomas Renault worked as a Mathematics teacher and coordinator at the International School of Boston and conducted research in Statistics education. He holds a Master in Mathematics from the University of Rouen, France.	

Name	Years at Verisk	Model Aspect	Relevant Degree(s) and Certification(s)	Biography	New
Sagyari, Indumathi	17	Computer/ Information	B. Tech Computer Science, JNT University, Hyderabad	Ms. Indumathi Sagyari is a manager in the model implementation group. She joined Verisk's Hyderabad office in January 2008 as a senior software engineer. Prior to that, she was working with CMC Ltd, (A TATA Enterprise) as software engineer, where she has done projects on defense domain in VC++, Oracle 10g, UML, and others. Her academic projects included video conferencing and messaging services using Java technologies.	
Sperling, Scott	12	Computer/ Information	B.A. Economics, Boston University (2006)	Mr. Sperling is a manager in the quality assurance group in the product management department. He joined Verisk in 2012 as a core QA associate. He previously worked for the Massachusetts Division of Banks conducting on-site examinations of banks' financial books and internal models. Scott holds a B.A. in Economics with a minor in Statistics from Boston University.	
Srinivasan, Haripprikesh	4	Computer/ Information	B.E. Electronics and Communication, Anna University; CEEM (2021)	Mr. Haripprikesh Srinivasan is a Senior Quality Analyst in the Quality Assurance. He works on Model Quality Assurance, testing the behavior of the Model implemented in TS and cross-checking the common functionality of the Research Model. He previously worked at Aon for 3.5 years as a Senior Consultant where he worked closely with brokers on reinsurance placements. He received a Bachelor of Engineering (BE) in Electronics and Communication from Anna University, Chennai, India. He earned his CEEM designation in 2021.	Yes
Srinivasan, Sreedevi	9	Computer/ Information	Master of Science in Industrial Engineering, Northeastern University, Boston, MA (2015); Bachelor of Technology in Chemical Engineering, Coimbatore Institute of Technology, Coimbatore, India (2008); CEEM, Verisk (2015)	Sreedevi Srinivasan is a Senior Quality Assurance Engineer. At Verisk EES QA group, her work involved validating the financial engine of our products in product releases from 2017. Previously, Sreedevi has worked for Saint-Gobain Glass India Ltd. as a Production Planning Engineer and Nokia-Siemens Network Solutions as a Hub planner. Sreedevi earned a Bachelor of Engineering in Chemical Engineering from Coimbatore Institute of Technology in India and an M.S. in Industrial Engineering from Northeastern University.	
Straight, Steve	4	Computer/ Information	M.A. Technical and Professional Writing, Northeastern University (1999); B.S. Communications and Media, Fitchburg State University (1994)	Steve Straight is a Senior Manager in the Documentation department for Verisk EES. He is responsible for all client-facing model and software documentation, including development tools and processes, writing standards, and delivery schedules. Mr. Straight has more than 30 years of experience as a technical writer and manager, and has held similar roles for companies such as Oracle, TruePosition, and Openwave. Mr. Straight holds a Master of Technical and Professional Writing degree from Northeastern University.	

Name	Years at Verisk	Model Aspect	Relevant Degree(s) and Certification(s)	Biography	New
Strong, Jeffrey	5	Meteorology	Ph.D. Atmospheric and Oceanic Sciences, Princeton University (2016); M.A. Atmospheric and Oceanic Sciences, Princeton University (2013); B.S. Environmental Sciences and Mathematics, University of Virginia (2011)	Dr. Strong is a senior scientist in the Research division of Verisk EES. He is a part of the tropical cyclone wind hazard team which models the atmospheric perils associated with tropical cyclones. Prior to Verisk, Dr. Strong was employed as a postdoctoral research scientist at the Lamont Doherty Earth Observatory of Columbia University, working in collaboration with the NASA Goddard Institute of Space Studies to develop next-generation global tropical cyclone models. Prior to that work, Dr. Strong had a postdoctoral research scientist appointment at the Scripps Institution of Oceanography at the University of California - San Diego where we worked on the impact of aerosols on global tropical cyclones. Dr. Strong received a Ph.D. and an M.A. in Atmospheric and Oceanic Sciences from Princeton University and a dual B.S. in Environmental Sciences and Mathematics from the University of Virginia.	
Sundararaman, Radhika	6	Computer/ Information	M.S. Technical Communication in Computer Industry Writing, Northeastern University (2018); B. Tech Information Technology, Anna University (2009)	Radhika is a Senior Technical Writer in the software documentation group at Verisk. She works closely with the Integration Support, Product Management, and Software Development groups to produce client-facing APIs and database documentation for various products developed by the VeriskEES. Prior to joining Verisk, she worked in software support and development roles for companies in Massachusetts and India. She holds an MS in Technical Communication in Computer Industry from Northeastern University and a B. Tech in Information Technology from Anna University.	
Thibeau, Jennifer	7	Computer/ Information	M.S. Geology, University of South Carolina (1999); B.A. Geology, Colgate University (1995)	Ms. Thibeau is a Manager in the Software Development Group. She leads the Model Documentation Group, which produces client-facing documentation for the Verisk catastrophe models. Ms. Thibeau previously worked in consulting for three years, conducting research and providing environmental litigation support for expert witness testimony. She received her MS in Geology from the University of South Carolina and BA in Geology from Colgate University.	
Thillai, Ashwin	9	Computer/ Information	M.S. Industrial Engineering, Northeastern University (2015); B.E. Mechanical Engineering, Anna University (2011); CEEM, Verisk (2015); CORe, Harvard Business School Online (2014)	Mr. Ashwin Thillai Natarajan is a Senior CQA Associate in the Products Group at Verisk EES. He leads the validation of catastrophe risk models for various natural perils, including tropical cyclones, earthquakes, and severe thunderstorms. Mr. Thillai received his master's degree in industrial engineering from Northeastern University, Boston, and a bachelor's degree in mechanical engineering from Anna University, India.	
Thoudoju, Srinivas	14	Computer/ Information	B. Tech, SRTIST, Nalgonda	Mr. Thoudoju is a lead engineer in the software development group in our Hyderabad office. Prior to joining Verisk, he worked as a release engineer for Broadridge Financial Solutions.	

Name	Years at Verisk	Model Aspect	Relevant Degree(s) and Certification(s)	Biography	New
Uhlhorn, Eric	9	Meteorology	Ph.D. Meteorology and Physical Oceanography, University of Miami (2008); M.S. Physical Oceanography, Florida Institute of Technology (1996); B.S. Meteorology, Florida State University (1993)	Dr. Eric Uhlhorn is a Principal Scientist in the Research department. He works on the Tropical Cyclone team which develops models of tropical cyclone wind hazard. Dr. Uhlhorn received a Ph.D. in Meteorology and Physical Oceanography from the University of Miami, a M.S. from Florida Institute of Technology in Physical Oceanography, and a B.S. from Florida State University.	
Ummati, Ramesh	18	Computer/ Information	Master's degree in Earthquake Engineering, specializing in Structural Dynamics, Indian Institute of Technology (2007); B.S. degree in Civil Engineering, Nagarjuna University (2005)	Mr. Ramesh Ummati is a Senior Principal Engineer in the Software QA group at Verisk Hyderabad. He plays a lead role in all aspects of testing the Verisk Hurricane Model for the United States in Touchstone. He currently plays an important role in all aspects of product testing, including updating test plans and addressing critical components of the product. He received his B.S. degree in Civil Engineering and his master's degree in Earthquake Engineering, specializing in Structural Dynamics. Prior to joining Verisk, Mr. Ramesh Ummati worked as an Assistant Executive Engineer in Panchayat Raj (Government Organization) Engineering Department.	
Vootukuru, Satish	9	Computer/ Information	M.S. Information Technology, IIIT Hyderabad (2015); B.Tech in Electronics and communication Engineering, CVR College of Engineering, JNTUH (2013)	Mr. Satish Vootukuru is a Lead software engineer in the model implementation group at Verisk Hyderabad, working on implementing the U.S. hurricane model and other models in Touchstone. Prior to joining Verisk, he worked at Enhance Edu as a website developer. He completed a Master of Science in Information Technology in 2015 from IIIT, Hyderabad, with an E-Business Technologies specialization.	
Ward, Susan	11	Statistics	Ph.D. Applied Mathematics, minor Atmospheric Sciences, University of Arizona (2012); M.S. Applied Mathematics, University of Arizona (2008); Sc.B. Physics, Brown University (2005)	Dr. Suz Tolwinski-Ward is an Assistant Vice President and the Director of Climate Statistics within the Research and Modeling development group within Verisk EES team. Her research expertise lies within data-model fusion and uncertainty quantification in problems of applied climate and atmospheric sciences, and she leads a team focusing on the statistical treatment of climatic nonstationarity across atmospheric perils model development. Suz also leads the development and support of simulated tropical cyclone event sets within Verisk's models. She holds a PhD in applied mathematics from the University of Arizona with a minor concentration in atmospheric sciences. Prior to working at Verisk, she was a National Science Foundation Mathematical Sciences Postdoctoral Research Fellow at the Institute for Mathematics Applied to Geosciences at the National Center for Atmospheric Research.	

Name	Years at Verisk	Model Aspect	Relevant Degree(s) and Certification(s)	Biography	New
Williams, Brett	1	Computer/ Information	B.S. Meteorology, Penn State University (2007); CCRA, RMS (2009); CEEM, Verisk (2023)	Brett Williams is a Senior Product Manager for catastrophe models in Product Management at Verisk. He currently leads product management efforts for North American models, facilitating model scope definition, implementation, and support, along with serving as Product Owner for a developmental scrum team. Brett previously worked at Moody's Insurance Solutions (RMS) as an Application Product Manager, software support specialist, and account manager. He holds a bachelor of science degree in Meteorology and Climatology from Penn State University.	
Wilson, David	21	Computer/ Information	M.B.A., Wallace E. Carroll Graduate School of Management at Boston College (1994); B.Sc. in Mathematics, State University of New York at Albany (1987)	Mr. Wilson is a director in the product management group on the VeriskEES team. Since joining Verisk in 2003, he has worked on catastrophe risk, property valuation, web services, geocoding, and property-specific database products. David has more than 23 years of software product management experience. He holds an MBA from the Wallace E. Carroll Graduate School of Management at Boston College and a B.Sc. in Mathematics from the State University of New York at Albany.	
Winans, Russell	11	Computer/ Information	M.S. Transportation Systems Engineering, Cornell University (2011); M.S. Structural Engineering and Mechanics, University of Massachusetts, Amherst (2008); B.S. Civil Engineering, University of Massachusetts, Amherst (2007)	Mr. Winans is a principal engineer in the research and modeling department. He works on all construction related projects within the Exposures group as well as ZIPAll for the Florida Commission. Mr. Winans earned an M.S. in Transportation Systems Engineering from Cornell University in 2011 and an M.S. in Structural Engineering and Mechanics in 2008 from the University of Massachusetts.	
Wu, Pengcheng	2	Computer/ Information	M.S. Data Analytics Engineering, Northeastern University (2019); B.S. Energy & Power Engineering, Beijing Institute of Technology (2017)	Pengcheng Wu is a QA Associate in the Quality Assurance department at Verisk. He has worked with Verisk's NGM release team which has worked on financial engine development and validation. Pengcheng received a Master's degree in Data Analytics Engineering from Northeastern University.	

Name	Years at Verisk	Model Aspect	Relevant Degree(s) and Certification(s)	Biography	New
Yang, Yuanyuan	<1	Computer/ Information	M.S. Data Science, Tufts University (2024); M.S. Control Theory and Engineering, Tongji University (2010)	Ms. Yang is a Quality Assurance Engineer in Verisk EES CQA Financial model team, she has worked in validating financial models. Previously, Yuanyuan worked for Tufts Medical Center on a medical predictive model, after she obtained her master's degree in data science from Tufts University. Prior to that, Yuanyuan worked for Teradyne as a semiconductor testing engineer for four years. Yuanyuan holds a bachelor's degree in electrical engineering and a master's degree in control engineering.	Yes

G-2.2.C

Provide visual business workflow documentation connecting all personnel related to hurricane model design, testing, execution, maintenance, and decision-making.

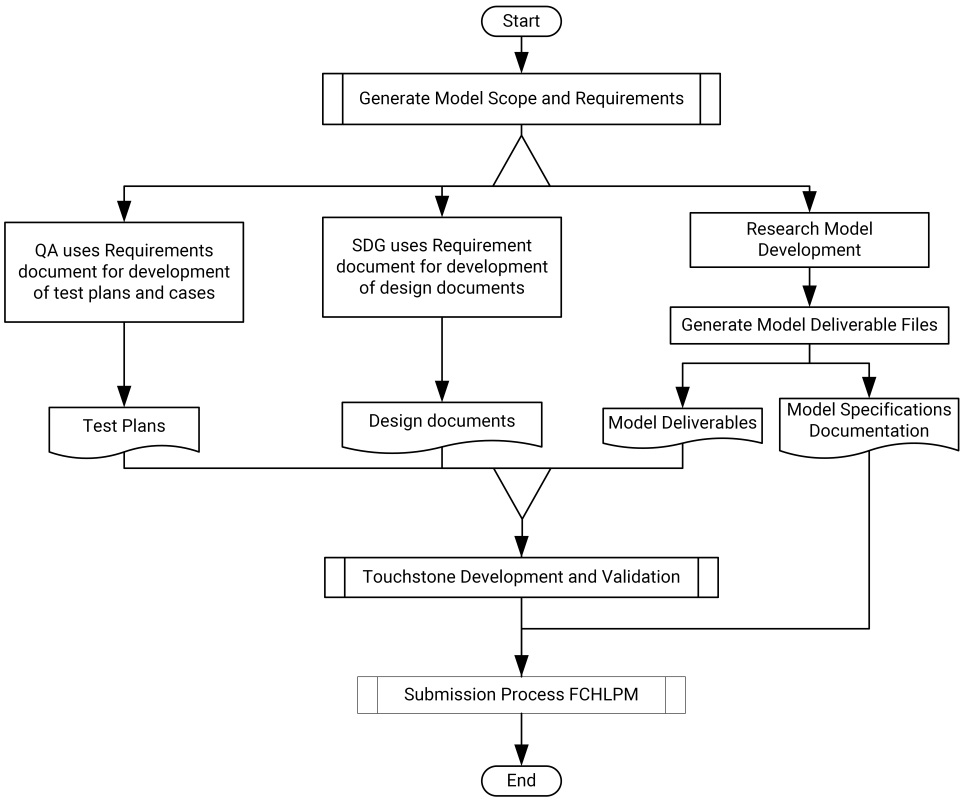


Figure 8. Verisk Hurricane Model for the United States Workflow

G-2.3

Independent Peer Review

G-2.3.A

Provide reviewer names and dates of external independent peer reviews that have been performed on the following components as currently functioning in the hurricane model:

1. Meteorology

- Reviewed by Dr. Kerry Emanuel, Dr. Peter Black, and Dr. Robb Contreras in 2010.

2. Statistics

- This component has not been reviewed by independent experts.

3. Vulnerability

- Reviewed by Dr. Joseph Minor, PE in 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, and 2009.

- Reviewed by Dr. Carol Friedland and Dr. Marc Levitan in 2010.
- Reviewed by Dr. Carol Friedland in 2012, 2014, 2016, 2018, 2020, 2022, and 2024.

4. Actuarial Science

- Reviewed by John W. Rollins, FCAS, MAAA, in both 2010 and 2012.
- Reviewed by Paul Ericksen, FCAS, MAAA in 2024.

5. Computer/Information Science

- Reviewed by Dr. Mark Wolfskehl in 2002.
- Reviewed by Dr. John Kam in 2003, 2004, and 2005.
- Reviewed by Ms. Narges Pourghasemi in 2006, 2007, 2008, 2010, 2012, 2016, 2018, and 2020.
- Reviewed by Mr. Robert Cabeca in 2022, 2023, and 2024.

G-2.3.B

Provide documentation of independent peer reviews directly relevant to the modeling organization responses to the current hurricane standards, disclosures, or forms. Identify any unresolved or outstanding issues as a result of these reviews.

- Dr. Friedland's bio is included in Table 2. Her CV is provided in the electronic submission files. Her report is included in Model Evaluation by Dr. Carol Friedland, P.E., Ph.D., C.F.M., 2023 Vulnerability Hurricane Standards.
- Mr. Ericksen's bio is included in Table 2. His CV is provided in the electronic submission files. His report is included in Model Evaluation by Paul Ericksen, FCAS, MAAA, Actuarial Standards
- Mr. Cabeca's bio is included in Table 2. His CV is provided in the electronic submission files. His report is included in Model Evaluation by Robert R. Cabeca, Computer/Information Hurricane Standards.

G-2.3.C

Describe the nature of any on-going or functional relationship the modeling organization has with any of the persons performing the independent peer reviews.

Verisk has no on-going functional relationship with Dr. Friedland and Mr. Cabeca who performed independent reviews, nor with any of their employees or consultants, nor with any independent organization.

Mr. Ericksen is an employee of Insurance Services Office, Inc. but is not involved in the model development process for the Verisk Hurricane Model for the United States. The relationship of entities in Verisk is discussed in G-2.1.A.

G-2.4

Provide a completed Form G-1. Provide a link to the location of the form in the submission appendix [insert hyperlink here].

Form G-1: General Hurricane Standards Certification

G-2.5

Provide a completed Form G-2. Provide a link to the location of the form in the submission appendix [insert hyperlink here].

Form G-2: Meteorological Hurricane Standards Expert Certification

G-2.6

Provide a completed Form G-3. Provide a link to the location of the form in the submission appendix [insert hyperlink here].

Form G-3: Statistical Hurricane Standards Expert Certification

G-2.7

Provide a completed Form G-4. Provide a link to the location of the form in the submission appendix [insert hyperlink here].

Form G-4: Vulnerability Hurricane Standards Expert Certification

G-2.8

Provide a completed Form G-5. Provide a link to the location of the form in the submission appendix [insert hyperlink here].

Form G-5: Actuarial Hurricane Standards Expert Certification

G-2.9

Provide a completed Form G-6. Provide a link to the location of the form in the submission appendix [insert hyperlink here].

Form G-6: Computer/Information Hurricane Standards Expert Certification

Standard G-3: Insured Exposure Location

G-3.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.

The issue date of the ZIP Code information currently used in the model is April 1, 2024, which is less than 24 months before the upcoming submission date of November 1, 2024. This information originates from the United States Postal Service (USPS).

G-3.2 describes the source of the ZIP Code data and Verisk's process for updating the USPS ZIP Code information in the model. That process and the resulting ZIP-related databases are trade secret and will be reviewed with the Professional Team.

G-3.B

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

The Verisk Hurricane Model for the United States uses population-weighted ZIP Code centroids based on projected population-weighted census blocks. G-3.5 gives a description of ZIP Code centroid data received from the vendor and the process Verisk follows to validate the population weighting. That process and resulting ZIP-related databases are trade secret and will be reviewed with the Professional Team.

G-3.C

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

Verisk purchases its ZIP Code information from a vendor and verifies it for accuracy and appropriateness. The methodology employed by Verisk's vendor for computing population centroids is identical to the computational methods promulgated by the U.S. Census Bureau.

Additional quality control measures are performed by Verisk to verify the positional accuracy of the population centroid in relation to the ZIP Code boundaries and ensure their appropriateness. These measures comprise a set of procedures that overlay the population-weighted centroids with the ZIP Code boundaries.

Compliance with this Standard is further supported by G-3.5 which describes the processes to verify ZIP Code information purchased and incorporated into the model. The processes and resulting ZIP-related databases are trade secret and will be reviewed with the Professional Team.

G-3.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.

To ensure the consistency of ZIP Code definitions across all ZIP Code dependent aspects of the model, the ZIP centroid and ZIP Code definitions are accessed directly from the centralized ZIP Code database. When the ZIP Code data is updated by the Exposures team, it is delivered as part of the model release internally. The software development team incorporates the data updates into the ZIP-dependent databases. Upon completion, the resulting data files are crosschecked against the database values as a consistency and accuracy check.

G-3.6 describes the processes Verisk uses to update and maintain consistency of all ZIP-dependent databases in the model. These processes and resulting ZIP-related databases are trade secret and will be reviewed with the Professional Team.

G-3.E

Geocoding methodology shall be justified.

To estimate loss costs and PML levels Touchstone must first identify the latitude and longitude coordinates (geocode) for the exposure locations. Touchstone's Address Service is used to identify the geocode for exposure locations. Geocoding methodology uses a set of structured decision trees to arrive at the best geocode for a given combination of address data. User supplied address data is parsed and standardized and validated before undergoing geocoding.

G-3.4 supports compliance with this standard by describing the methods used to geocode exposures in the model. These processes and examples demonstrating the geocoding function are trade secret and shall be reviewed with the Professional Team.

Disclosures

G-3.1

Provide a description of the geographic information system (GIS) software and tools used for geocoding.

Geocoding methodology uses a set of structured decision trees to arrive at the best geocode for a given combination of address data. User supplied address data is parsed and standardized and validated before undergoing geocoding. No GIS software is otherwise used in this process.

G-3.2

List the current ZIP Code databases used by the hurricane model and the hurricane model components to which they relate. Provide the effective (official United States Postal Service) dates corresponding to the ZIP Code databases.

The current ZIP Code database is referred to as ZipAll2024_Output. Information from the ZIP Code database is used to determine a modeled risk's location for purposes of the Hazard and Vulnerability components of the model. The ZIP Code database is also used in exposure validation to determine the valid ZIP Codes for an analysis.

ZIPAll2024_Output is compiled from data sets obtained from third party vendors. Data obtained from Claritas included Tomtom's MultiNet product, which was developed using the following: United States Postal Service (USPS) ZIP+4 Data File, USPS City/State File, USPS Delivery Statistics File, USPS National 5-Digit ZIP and Post Office Directory, USPS Postal Bulletin, Local U.S. Post Offices, nationwide, and USPS ZIP+4 State Directories.

For this update, data from the U.S. ZIP roster for the first quarter of 2024 was used as the most current ZIP list available prior to software finalization. These data were obtained in April 2024 from a third-party vendor, ZIPInfo, with an effective date of April 1, 2024. The product name is ZIPList5Max.

G-3.3

Describe in detail how invalid ZIP Codes are handled.

A ZIP Code is defined to be "invalid" if it does not match the list of currently valid ZIP Codes.

An invalid ZIP Code is first checked against Verisk's master database of ZIP Codes for all years from 1990 through 2024. This database includes ZIP Codes that were valid in previous years but later became invalid. Any invalid ZIP Code matched to a ZIP Code in this master database is reassigned to the currently valid ZIP Code.

The model produces a list of ZIP Codes that do not appear in Verisk's master database of valid ZIP Codes. Exposure in any remaining invalid ZIP Code is not modeled. The insurer may choose to allocate or map these exposures back into the exposure data set; this is not done within the model.

G-3.4

Describe the data, methods, and process used in the hurricane model to convert among street addresses, geocode locations (latitude and longitude), and ZIP Codes.

To perform loss analyses, Touchstone must first identify the latitude and longitude coordinates (geocode) for the exposure locations. The address information provided by the client can vary in terms of its resolution (i.e., just a ZIP Code or very detailed street address information) and quality. Touchstone's Address Service is used to parse U.S. street address data, validate the address, and identify the geocode value for these exposures. Detailed information regarding these processes shall be presented during the on-site presentation with the Professional Team.

The data, methods and processes used in the model to convert among street addresses, geocode locations and ZIP Codes are discussed below.

Parse and Standardize the Address (U.S. Street-Level Data Only)

Mailing address information—as distinct from physical street address information—is not needed for geocoding or location-based analyses. However, this mailing information is common in client portfolios. As a result, the Touchstone Address Service recognizes these address structures and separates them from the core physical street address components.

Validate the Address (U.S. Street-Level Data Only)

Once the address has been parsed and standardized, it is matched to a USPS-provided dataset in order to enhance the address and append additional location attributes. By matching to the USPS data, the address components can be corrected, added (when omitted) or enhanced.

To appropriately determine the match level for the input address, the Address Service assigns a match "score" value to each address component. The total of the score determines the best street match. The matched data source and/or subsequent geocoding methods determine the match level.

Geocoding (Area-level, Street-Level, and Geocode Data)

There are generally three levels of location data that a client can provide, and Touchstone has a different process for each. When the client provides non-street-level location data (country, CRESTA, area, subarea, and/or postal data), the Touchstone Address Service interprets this data and provides the geocode for the centroid, based on the resolution-level location of the exposure data. Alternately, if the client provides street-level data and a corresponding street match is found, the Address Service produces the corresponding latitude/longitude combinations (when available). Lastly, clients can also provide the exposure geocode (latitude/longitude pair) directly in the import data. This will be the case when the client has used a third party to geocode its exposure locations.

Geocoding Area-Level Address Data

Touchstone supports one or more location information schemes for supplying non-street-level location data (i.e. country, CRESTA, area, subarea, and/or postal) for exposures in each supported country. For non-street-level resolution data, the Address Service uses the information in the AIRGeography database to match each set of location information at a specific geocode match level.

Geocoding Street-Level Address Data

When geocoding street-level addresses, this stage of the process typically follows the address validation/ enhancement step to ensure that the most complete (and validated) address data is used for matching to the underlying geocoding street data.

For street-level resolution data, The Address Service uses the AIRAddressServer database to match the location information at a specific geocode match level. When a matching street segment is found, an interpolation is

performed to determine the appropriate relative position of the address between the geocoding endpoints of the matching street segment. The interpolated geocode is then offset perpendicular from the centerline and to the appropriate odd or even side of the street. If a matching street segment cannot be found, the geocoding process falls back to some level of area centroid (street, ZIP9, postal code, city, or county), providing a less accurate geocode.

Geocoding Latitude and Longitude Coordinates

When a client chooses to supply (and preserve) latitude and longitude coordinates as input data, the Address Service uses these user-supplied geocodes directly in loss analyses. Further, the Address Service performs a lookup of each supplied geocode and attempts a point-in-polygon analysis on the supported ZIP Code boundary data, to determine the appropriate ZIP Code to backfill for the location. If a match is found, the related ZIP Code in the AIRGeography database is queried to fill as much additional location information with the supported area, subarea, and ZIP Code information for the corresponding exposure.

G-3.5

List and provide a brief description of each hurricane model ZIP Code-based database (e.g., ZIP Code centroids).

There are three databases that are responsible for the storage of ZIP Code-based data, ZIPAll, AIRGeography, and AIRAddressServer.

ZIPAll Database

ZIPAll is the process of mapping all unique ZIP Codes that Verisk has found to exist in the past years to the current list of modelable ZIP Codes that are in all U.S. based models for the current model year. The ZIPAll database stores the results of this process and is prepared by the Exposures group within Research. This database is available for internal consumption only and is not released to clients.

AIRGeography Database

The AIRGeography database stores geography-based information derived from the ZIPAll database. It is used by the Touchstone application to geocode area-level address data (when street-level data is not available). In addition, the AIRGeography database contains tables related to disaggregation and marine craft exposure handling. This database is maintained by GIS specialists and database engineers. This read-only database is provided to clients as part of the Touchstone installation process.

AIRAddressServer Database

The AIRAddressServer database stores geography-based information derived from the U.S. Census Topologically Integrated Geographic Encoding and Referencing (TIGER) data set and the ZIPAll database. It is used by the Touchstone application to 1) Match parsed street-level addresses to the USPS street data in order to validate the address prior to geocoding and 2) Match the resulting street-level address data to the U.S. Census TIGER street data to determine the geocode value. This database is maintained by GIS specialists and database engineers. This read-only database is provided to clients as part of the Touchstone installation process.

G-3.6

Describe the process for updating hurricane model ZIP Code-based databases.

The methods for updating the ZIP Code-based databases are as follows.

ZIPAll Database

The development of the ZIPAll database involves obtaining the current list of ZIP Codes, assessing the validity of population weighted centroids for bounded ZIP Codes from the data provider Claritas, and mapping all other known ZIP Codes to those bounded ZIP Codes if they are not provided in Claritas' ZIP Code mapping. ZIP Codes are updated annually with information provided by the United States Postal Service (USPS). Current centroids are compared to prior centroids and metrics, such as distance moved and boundary area change, are created. The most recent census blocks are mapped to the new boundaries using spatial SQL to create an independent verification of the vendor-provided centroids. Any additional ZIP Codes that are created by the USPS after the Claritas mapping are mapped to bounded ZIP Codes using a point in polygon algorithm and spatial SQL.

AIRGeography Database

The development of the AIRGeography database is a collaborative effort between the Exposures, Product Management, and Database groups. After updates from the ZIPAll database are applied to the tGeography table, count verification and data is compared for all the U.S. records. If discrepancies are found, the Product Management GIS specialist confers with the Exposures group to identify the source of the error. When all discrepancies have been resolved, the GIS specialist releases the final version of the tGeography table to the Database group. The Database group uses SQL scripts to append the tGeography table to the AIRGeography database, and also to update the other tables in the AIRGeography database. The updates are validated before being finalized for inclusion in the software.

AIRAddressServer Database

The development of the AIRAddressServer database is a collaborative effort between the Exposures, Product Management, and Database groups. The Exposures group provides the ZIPAll database. The GIS specialist in the Product Management group takes the latest commercial release of the ZIPList5 Max data from the ZIPInfo vendor, which matches the same timeline as the versions of the U.S. Postal Service ZIP+4 national and U.S. Census TIGER shapefile data releases, and conflate these separate data sources into the integrated AIRAddressServer database. Various field counts in the integrated database are then compared to the prior year's integrated database. In addition, address service batch processes are run to compare batch geocoding and address validation match results to the prior versions results.

Standard G-4: Independence of Hurricane Model Components

G-4

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

All components of the Verisk Hurricane Model for the United States are theoretically sound and independently derived. No component compensates for any potential bias in any of the other components. Furthermore, each component is validated independently. Support for compliance with this standard will be provided during the Professional Team audit during review of the trade secret materials and audit items pertaining to Meteorology, Statistics, and Vulnerability components of the model.

Standard G-5: Editorial Compliance

G-5

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

All sections of this submission have been reviewed and edited for grammatical correctness, typographical accuracy, and completeness by an Editor from Verisk EES staff (hereafter referred to as the Editor) who has many years of experience writing and editing technical documents. The Editor read the Report of Activities as of November 1, 2023, and understood the submission requirements prior to working on Verisk's submission.

Disclosures

G-5.1

Describe the process used for document control of the submission. Describe the process used to ensure that the paper and electronic versions of specific files are identical in content.

The submission document source files are in DITA Extensible Markup Language (XML) format. Version control for these files is managed in Azure Development Operations or Azure DevOps (AZDO) via Microsoft Visual Studio, which provides a detailed history of changes by user to the document.

The Editor assigns subject matter experts (SMEs) involved in the submission document review tasks via Oxygen Content Fusion for team-wide content creation, reviews, and approvals. Anyone assigned a task via Oxygen Content Fusion can edit the document files and leave comments for other reviewers and the Editor. Oxygen Content Fusion captures the SMEs' edits to the submission document similarly to other track changes software systems. The Editor regularly reviews the changes made to the document and creates source-controlled copies of edits by checking out the submission document in AZDO, pulling in edits made via Oxygen Content Fusion, and then checking in the source files via Microsoft Visual Studio.

Once all sections are completed and reviewed the Editor generates a candidate PDF file for final review. All personnel who edited the submission must sign off on the final submission PDF to verify that the content accurately reflects their edits. Final submission document source files are saved in AZDO. The final submission PDF is then passed the to printer for final proofing. The Editor reviews the printer's proof of the final submission to ensure fidelity to the master document file and for compliance with the requirements set forth in the Report of Activities.

G-5.2

Describe the process used by the signatories on Expert Certification Forms G-1 through G-6 to ensure that the information contained under each group of hurricane standards is accurate and complete.

The signatories on Forms G-1 through G-6 read their respective parts of the submission and conducted peer reviews with technical staff, including those who contributed to the submission responses. They signed off on the respective standards section upon satisfactory completion of this review.

G-5.3

Provide a completed Form G-7. Provide a link to the location of the form in the submission appendix [insert hyperlink here].

Form G-7: Editorial Review Expert Certification

4 Meteorological Hurricane Standards

Standard M-1: Model Base Hurricane Set

M-1.A

The Model Base Hurricane Set shall be one of the following:

(1) Reference Hurricane Set, (2) Model Adjusted Hurricane Set, or (3) Model Climate-Adjusted Hurricane Set, and shall be justifiable.

The Model Base Hurricane Set is a Reference Hurricane Set, namely, the National Hurricane Center's (NHC) version of HURDAT2, incorporating the period 1900–2022 and valid as of April 7, 2023. The use of a Reference Hurricane Set is justifiable as it allows for the most accurate and independent view of Atlantic hurricane activity prior to model calibration and validation. Furthermore, the use of HURDAT2 as the Reference Hurricane Set is justifiable as it spans the full length of the modern historical record, has been thoroughly vetted over the years through numerous peer-reviewed articles and published technical documents, and as such is widely considered the official record of Atlantic tropical cyclone activity.

M-1.B

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

The Verisk Hurricane Model for the United States is not climate adjusted.

M-1.C

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

Calibration and validation are based on the complete historical set starting in 1900 (see Disclosure M-1.1).

Disclosures

M-1.1

Identify the basis for the Model Base Hurricane Set as listed in Hurricane Standard M-1.A.

The Model Base Hurricane Set consists of the latest version of HURDAT2 supplemented with landfall data from Appendix A in the NOAA Technical Memorandum NWS NHC-6 (Blake et al., 2011). This version of HURDAT2 is valid as of April 7, 2023, and spans the years 1900–2022.

M-1.2

Describe the process used to develop the Model Base Hurricane Set. Specify:

M-1.2.A

The HURDAT2 release date used,

The HURDAT2 release date used is April 7, 2023.

M-1.2.B

Additional data, databases, and modifications, excluding climate change, used, if relevant, and

Supplemental landfall data from Appendix A in the NOAA Technical Memorandum NWS NHC-6 (Blake et al., 2011) were used when not available in the Model Base Hurricane Set. HURDAT2 data are preprocessed prior to conducting analysis and model calibration of hurricane landfall characteristics (see M-1.5).

M-1.2.C

Additional data, databases, and modifications related to climate change used, if relevant.

No climate change adjustments are made to the Model Base Hurricane Set.

M-1.3

Justify the Model Base Hurricane Set based upon current scientific literature and current technical literature.

The HURDAT2 database is the basis of the Verisk Model Base Hurricane Set. HURDAT2 is the official record of Atlantic basin (including the Caribbean Sea and Gulf of Mexico) tropical cyclone (TC) track, intensity, and size from which statistics describing historical TCs are derived. The database and subsequent re-analysis of past storms conducted by the NOAA Hurricane Research Division (HRD) as a part of the NOAA Hurricane Reanalysis Project have been thoroughly vetted through various peer-reviewed articles and technical documents. The Reanalysis Project aims to homogenize the historical record by analyzing TCs from previously uncovered information which is interpreted in light of more recent scientific knowledge. An example is the upgrade of Hurricane Andrew to a Category-5 storm based on observational evidence collected in subsequent events. Literature justifying the use of the NOAA HURDAT2 database can be found in the following link (NHC Publications) and literature justifying the various changes to reanalyzed storms in the NOAA HURDAT2 database can be found in the following link (HRD Publications).

M-1.4

Provide completed Form M-1(s). Provide a link to the location of the form(s) in the submission appendix [insert hyperlink here].

Form M-1: Annual Occurrence Rates

M-1.5

Describe the process for incorporating the Model Base Hurricane Set consistently into Forms M-1, S-1, and A-2.

HURDAT2 data are preprocessed prior to conducting analysis and model calibration of hurricane landfall characteristics. The purpose of the preprocessing is to enable the application of identical analysis techniques to both the historical and stochastic landfall data. Specifically, the Verisk model computes both local intensities and damages using an hourly timestep, and so Verisk derives hourly-resolution tracks from the raw HURDAT2 before using it for modeling activities. For each storm, landfall is defined with respect to the intersection of piecewise linear representations of both the track and the model coastline (see M-2.8). Statistical distributions for annual landfall frequency, spatial location of landfalls, and landfall central pressure (the intensity metric used to drive the model for local winds) are derived from these modifications of the data.

Standard M-2: Hurricane Parameters (Inputs)

M-2

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

Methods for depicting all modeled hurricane parameters are based on information documented in currently accepted scientific literature. A complete repository of all referenced literature used in meteorological model development is maintained internally. All hurricane parameters have been derived from appropriate sources and validated against available observational data sets. The Model Base Hurricane Set contains much of the information in the literature (e.g., track, intensity, etc.) and a partial reference list grouped according to parameters consists of:

- Landfall distributions
  - NWS-38
  - NWS NHC-6 Blake et al., 2011
- Track and motion
  - NWS NHC-22 Jarvinen et al., 1984
- Wind field
  - Willoughby et al., 2004
  - Willoughby et al., 2006
  - Schwerdt et al., 1979
- Inland decay
  - Arndt et al., 2009
  - Bosart and Lackmann, 1995
  - Kaplan and DeMaria, 1995
- Intensity
  - Batts et al., 1980
  - Knaff and Zehr, 2007
- Size
  - Demuth, et al., 2006
  - Kossin, et al., 2007
- Surface roughness, friction, and gust factors
  - Powell et al., 2003
  - Schroeder and Smith, 2003
  - Paulsen and Schroeder, 2005
  - Homer et al., 2020
- Gradient wind reduction

- Franklin et al., 2003
- Powell et al., 2009

Disclosures

M-2.1

Provide details of modifications to the meteorological component of the hurricane model since the current accepted hurricane model

There were no modifications made to the meteorological component of the hurricane model since the current accepted hurricane model.

M-2.2

Identify the hurricane parameters (e.g., central pressure, radius of maximum winds, rainfall) that are used in the hurricane model.

The set of parameters that describe a hurricane can loosely be categorized by track, intensity, and structure. The hurricane parameters used in the model are identified below:

- Track
  - Latitude and longitude as functions of time
  - Landfall location
  - Forward speed
  - Storm heading
  - Intensity
  - Central pressure
  - Peripheral pressure (constrains the pressure gradient)
- Structure
  - Radius of maximum winds
  - Gradient wind reduction factor
  - Peak weighting factor

M-2.3

Describe the dependencies among parameters in the windfield component and how they are represented in the hurricane model, including the mathematical dependence of modeled windfield as a function of distance and direction from the center position.

Most hurricane parameters are considered independent of one another. The following variables are dependent on latitude:

- Central pressure

- Forward speed
- Storm heading
- Air density coefficient
- Coriolis parameter
- Peripheral pressure
- Filling rate

The air density coefficient, Coriolis parameter, and peripheral pressure are direct continuous functions of latitude; the latitudinal dependence for the rest of the remaining parameters is modeled according to discrete coastal segments.

The radius of maximum winds (Rmax) is represented using a regression model of the form Rmax ≈ *f*(Cp, latitude) + ε (error term).

The wind field radial profile is based on the formulation introduced by Willoughby et al. (2006) and depends on Rmax, maximum sustained wind (Vmax), and latitude as well as distance from the eye. The wind increases as a power of radius inside the eye and it decays exponentially outside the eye, with a smooth transition between the two regions.

The direction from the center position is included in the asymmetry term, which is proportional to the forward speed of the storm and the cosine of the angle between the wind direction and the storm motion direction.

The adjustment to the gradient wind reduction factor (used to convert upper level winds above the boundary layer to surface winds) is dependent on the distance from the eye and an additional factor associated with each storm called the peak weighting factor (used to reflect the vertical slant in the hurricane eye and derived from the research of Powell et al., 2009 (see also M-2.4). The gradient wind reduction factor and the peak weighting factor are generated jointly from a bounded bivariate normal distribution.

Also entering the wind calculation are the friction and gust factors, both depending on the effective roughness length which in turn is determined from the land use land cover data (see also Standard M-4: Hurricane Windfield Structure), and a maritime adjustment (derived from the research of Powell et al., 2003) which is dependent on the windspeed.

M-2.4

Identify whether hurricane parameters are modeled as random variables, functions, or fixed values for the stochastic storm set. Provide rationale for the choice of parameter representations.

The hurricane parameters used in the model (variables which are modeled via probability distributions) are identified below:

Intensity

The model utilizes central pressure as the primary hurricane intensity variable. The historical data are modeled using Weibull distributions where the parameters are estimated for each of the thirty-one 100-nautical-mile coastal segments as well as for larger coastal regions, with the final distribution being a mixture of the two. The Weibull form was selected based on goodness-of-fit tests with actual historical data. The use of the Weibull distribution is discussed in more detail in S-1.8.

Radius of Maximum Winds

The probability distribution for radius of maximum winds (Rmax) is modeled using a regression model of the form: Rmax ≈ *f*(Cp, latitude) + ε, where *f*(Cp, latitude) represents the mean of Rmax for given values of central pressure and latitude. The error term, ε, is assumed to be normally distributed. The parameters in this regression model are estimated using data available in NOAA Technical Report NWS-38 (Neumann 1991), the HURDAT2 Reanalysis Project, and the DeMaria Extended Best Track Dataset (EBTRK). The final distribution is truncated using limits that depend on central pressure and are consistent with the range of historically observed values. Rmax also varies after landfall, following an autoregressive model.

Landfall Location

There are 62 potential landfall segments in the model, each representing ~50 nautical miles of smoothed coastline from Texas to Maine. In Florida, there are 17 landfall segments. The southernmost Florida segment includes a consideration for the Florida Keys. Historical hurricane occurrences since 1900 are used to estimate a smoothed locational frequency distribution. The smoothing technique maintains areas of high versus low frequency and also accounts for the lack of historical landfalls in certain portions of the coastline. Once a segment is chosen, the landfall location is assigned randomly along the segment, from a uniform distribution.

Forward Speed

Forward speed is modeled using a log-normal distribution with parameters estimated for each 100-nautical-mile coastal segment. Separate distributions are estimated for each of these segments to capture the dependence of this variable upon geographical location, particularly latitude. Forward speed is allowed to vary after landfall, following an autoregressive model. The bounds on forward speed are latitude dependent.

Storm Heading

The probability distributions for storm heading at landfall are defined on the 50-mile coastal segments. Upper and lower bounds are imposed which depend on geographic location. The distributions used are mixtures of Normal distributions bounded based on geography and the historical record.

Gradient Wind Reduction Factor

The model uses a stochastic Gradient Wind Reduction Factor (GWRF), which varies from storm to storm. The mean value, the distribution about the mean, and the radial profile of the GWRF have been developed based on analyses of dropsonde data from 2002 to 2005 (GPS dropsonde data are provided courtesy of the NOAA/AOML/HRD in Miami, Florida), as well as results from published literature (Franklin et al. 2003, Powell et al. 2009). As described in M-2.3, for a given storm, the GWRF is adjusted based on the Peak Weighting Factor (PWF, see below)

and the distance from the eye. Both parameters (GWRF and PWF) are generated jointly using a bounded Bivariate Normal Distribution (based on Casella and Berger, 1990).

Peak Weighting Factor

The Peak Weighting Factor (PWF) is a stochastic parameter used to reflect the vertical slant in the hurricane eye (Powell et al., 2009). As mentioned above, the PWF and GWRF are generated jointly using a bounded Bivariate Normal Distribution.

The following hurricane parameters are modeled as functions:

Peripheral Pressure

The model uses a latitude dependent peripheral pressure, parameterized based on the work of Knaff and Zehr (2007) as well as analyses of historical storms.

Radial Adjustment to the Gradient Wind Reduction Factor

The stochastically drawn GWRF also varies with distance from the eye and PWF, following a Radial Adjustment Function (RAF). (See also M-2.6.)

M-2.5

Describe if and how any hurricane parameters are treated differently in the Model Base Hurricane Set and stochastic storm set and provide rationale.

Hurricane parameters are treated identically in the Model Base Hurricane Set and the stochastic storm sets, except that parameters for historical hurricanes are derived from historical data sources (and are treated as fixed values) rather than being drawn from distributions fitted to the historical data. In addition, for historical storms peripheral pressure is allowed to deviate from the latitude-based mean value based on synoptic analysis to make use of environmental conditions occurring at the time of the event. See also M-2.4.

M-2.6

Describe any evolution of the functional representation of hurricane parameters during an individual storm life cycle.

The radius of maximum winds and the forward speed associated with a storm change post-landfall following specific autoregressive models. The adjustment to the stochastically drawn GWRF has a time evolution post landfall: the adjustment is constant for three hours after landfall and then it decreases to zero over the next six hours. Hence no adjustment is applied to the GWRF after nine hours after landfall. This evolution is in line with the research that references the effects of a maritime environment (Powell et al., 2009).

M-2.7

If the modeling organization has accounted for climate change in the hurricane model development (other than a change to the Model Base Hurricane Set), justify its use in modeling Florida hurricane rates from current scientific literature and current technical literature. Describe the analysis and its impact on Florida hurricane set.

The Verisk Hurricane Model for the United States makes no explicit accounting for climate change.

M-2.8

Provide plots of distance along the coast of Florida and adjacent states (x-axis) versus modeled annual landfall occurrence rates (y-axis) in two intensity bands (Saffir-Simpson categories 1-2 and 3-5). Any set of coastal segments may be used for this purpose, as long as they are not greater than 100 miles in length. If the modeling organization has a current accepted hurricane model, provide the current accepted hurricane model's rates on the same axes. Also provide on the same axes the modeled annual landfall occurrence rates computed directly from the model Base Hurricane Set. For a climate-adjusted hurricane model that uses either the Reference Hurricane Set or a Model Adjusted Hurricane Set for the Model Base Hurricane Set, a modeling organization shall provide two plots, one completed with climate-adjusted modeled rates and one completed without climate-adjust modeled rates.

The actual number of hurricane occurrences is tabulated for approximately 50-nautical-mile segments. For intensity distributions, 100-nautical-mile segments are used (i.e. consecutive 50-nautical-mile segments). The number of occurrences for each segment is then smoothed by setting it equal to a weighted average of the landfall counts for each segment and the surrounding segments.

The smoothing is based on a procedure well-documented in the literature (e.g., NOAA Technical Report NWS-38, page 75). The historical hurricane frequency distribution by intensity for each 100-mile coastal segment is shown in Figure 9.

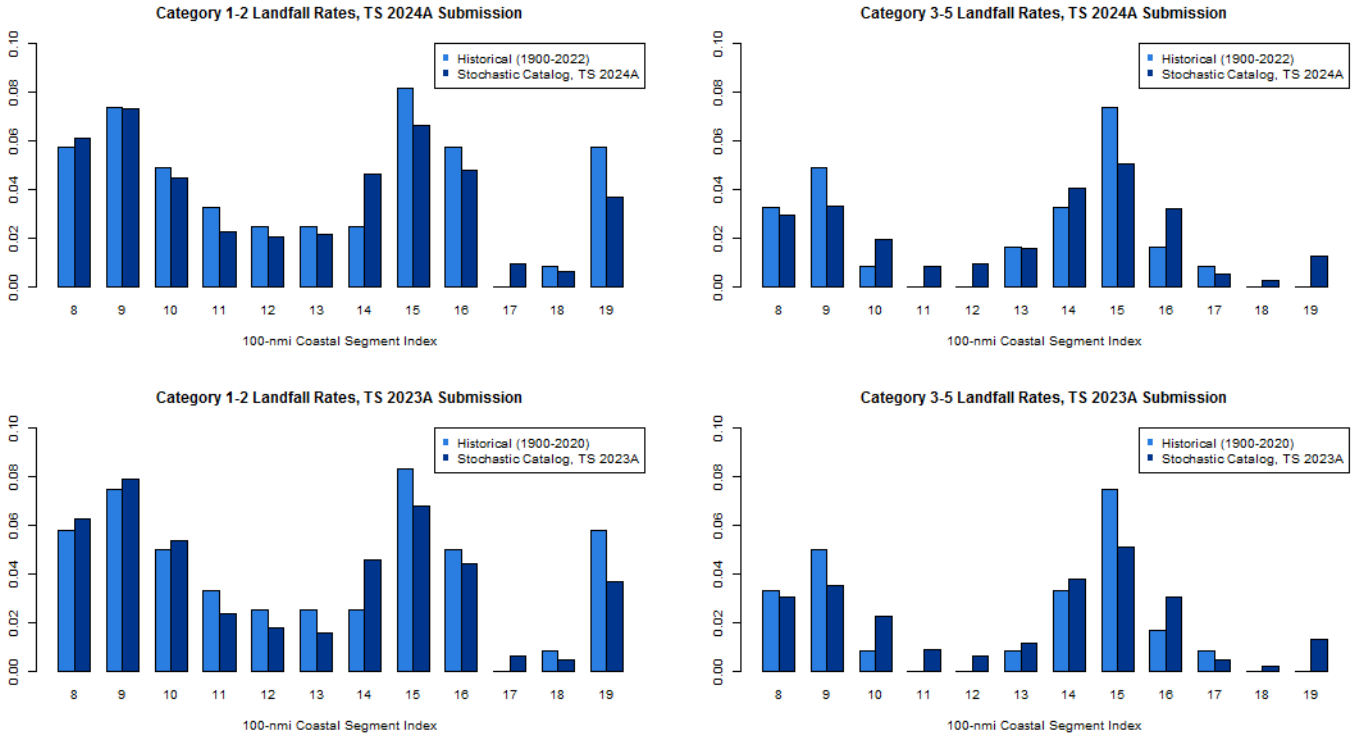


Figure 9. Annual Hurricane Landfall Frequency by Coastal Segment, Historical vs. Modeled, 1900-2022

Standard M-3: Hurricane Probability Distributions

M-3.A

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

The modeled probability distributions for landfall location, hurricane intensity, forward speed, radius of maximum winds, storm heading at landfall and gradient wind reduction factor are consistent with observed Model Base Hurricane Set and are bounded by observed extremes.

The probability distribution for landfall location is defined on 50-nautical-mile coastal segments. Goodness-of-fit tests show a close agreement between historical and modeled landfall frequencies by Florida segments. Also, for the state as a whole, the modeled average annual frequency of 0.57 landfalling hurricanes per year agrees with the average annual historical frequency of 0.61 landfalling hurricanes per year.

Central pressure, from which hurricane intensity as described in M-3.C is derived, is modeled as a mixture of Weibull distributions. Weibull distributions are fitted to the historical data for each 100-nautical-mile coastal segment. Separate Weibulls are then estimated for various regions along the coast. The intensity distribution used for each segment is a mixture of the regional Weibulls and the segment Weibull with appropriate weights applied. The Weibull distribution was selected based on goodness-of-fit tests with actual historical data. The Weibull scale and shape parameters are estimated using the maximum likelihood estimation method. The use of Weibull distributions is discussed further in S-1.8.

Forward speed is modeled using a Log-normal distribution. The average simulated forward speed for landfalling hurricanes in the region is 14.0 mph and the average forward speed calculated from hurricanes occurring between 1900 and 2022 is 13.7 mph. The maximum forward speed varies by coastal segment.

The radius of maximum winds is simulated using a regression model in which the mean is a function of central pressure and latitude. The model incorporates the fact that stronger storms tend to have a smaller radius than less intense storms. Also, due to the dependence on latitude, the average radius increases as one moves poleward.

Landfall angle (or storm heading) is measured clockwise (+) or counterclockwise (-) with 0 representing due North. Separate distributions for storm heading at landfall are fitted to each 50-nautical-mile segment of coastline. Storm heading is modeled as combined Normal distributions, and bounded based on the historical record, geographical constraints, and meteorological expertise. Diagnostic checks show a reasonable agreement between historical and modeled values.

The probability distribution for the gradient wind reduction factor is a Normal distribution with parameters estimated from data derived using the regression equation from Powell et al. (2009), with input based on

HURDAT2 data. The fitted Normal distribution is consistent with that described in the paper. The mean of the modeled distribution is 0.88 and the mean of the historical data is 0.89.

The fitted probability distribution of the peak weighting factor is similarly consistent with the empirical distribution of the factor, as derived from the recent work of Powell et al. (2009). The empirical distribution of the factor is skewed but can be approximated by a Normal distribution after an inverse power transformation of the data. The mean of both the modeled distribution and the historical data is 1.08.

M-3.B

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

As shown in Figure 9, the modeled hurricane probabilities for categories 1-2 and 3-5 hurricanes accurately represent the historical record through 2022, and are consistent with those observed for each coastal segment of Florida, Alabama, Georgia and Mississippi. The annual probabilities are shown in Table 29 of Form M-1: Annual Occurrence Rates.

M-3.C

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

The model uses maximum one-minute sustained 10-meter windspeed to define hurricane landfall intensity, both for developing the Model Base Hurricane Set and for the modeled windspeeds in each hurricane that causes damage. The windspeed values available in Form M-1: Annual Occurrence Rates are categorized according to the Saffir-Simpson Hurricane Wind Scale.

Disclosures

M-3.1

Provide a brief rationale for the probability distributions used for assigning all hurricane parameters including any assumptions that go into the use or interpretation of the distribution.

The probability distributions used for all hurricane parameters and characteristics are derived based on the available historical hurricane data. Probability distributions are appropriate for each parameter, for example, discrete landfall counts (Negative Binomial), central pressure which is continuous and highly skewed (Weibull), and the gradient wind reduction factor (Normal). A summary of rationale/justification can be found in Form S-3:

Distributions of Stochastic Hurricane Parameters and in Standard M-1: Model Base Hurricane Set. The choice of modeled distribution and goodness-of-fit is disclosed in detail in Standard S-1: Modeled Results and Goodness-of-Fit.

M-3.2

Describe and justify any changes made to the Model Base Hurricane Set in the hurricane model under review that are not reflected in changes to the distributions in Form S-3. Describe the methodology used to make such changes.

No changes have been made to the modeled distributions of parameters in the Model Base Hurricane Set that are not contained in Form S-3: Distributions of Stochastic Hurricane Parameters. Additional validation has been performed with more recent observational data to confirm the appropriateness of the modeled distributions.

Standard M-4: Hurricane Windfield Structure

M-4.A

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

The Verisk Hurricane Model for the United States utilizes a parametric approach to model the wind field, based on the formulation of Willoughby et al. (2006). The modeled winds are derived from observations of historical Atlantic basin hurricanes, including in the vicinity of Florida. Therefore, wind fields generated by the model are consistent with observed historical storms affecting Florida.

M-4.B

The land use and land cover (LULC) database shall be consistent with National Land Cover Database (NLCD) 2016 or later. Use of alternate datasets shall be justified.

The National Land Cover Database (NLCD) 2016 is used in the Verisk Hurricane Model for the United States. No further justification is required.

M-4.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.

The model uses the latest United States Geological Survey (USGS) National Land Cover Database 2016 (NLCD 2016) data as published in Dewitz, J., 2019 and Homer et al., 2020. Appropriate roughness lengths are assigned to each category based upon accepted scientific literature (Cook, 1985, Simiu and Scanlan, 1996, Grimmond and Oke, 1999, Grell et al., 1995, Chen and Dudhia, 2001, and Benjamin et al., 2002). The processing, the implementation, and the validation of the surface roughness distribution was completed with ArcGIS Pro 10.8.2 software.

M-4.D

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

The effect of vertical variation of winds is accounted for in the vulnerability functions. As the wind speed generally increases with height above ground, higher floors of multi-story buildings are expected to experience stronger winds.

Disclosures

M-4.1

Provide a tangential windspeed (y-axis) versus radius (x-axis) plot of the average or default symmetric wind profile used in the hurricane model. Justify the choice of this wind profile. If the windfield represents a modification from the current accepted hurricane model, plot the previous and modified wind profiles on the same figure using consistent axes. Describe variations between the previous and modified wind profiles with references to historical storms.

No modification of the radial profile from the current accepted hurricane model has been made for this submission. The windspeed radial profile is developed based on the radial variation of upper-level winds as described in Willoughby et al. (2006). In this formulation, the profile was developed as a statistical fit to the observations, using reconnaissance data from 493 hurricanes during the 1977 to 2000 time period from flights in the Atlantic and Eastern Pacific basins. The profile is defined by three equations: one for the area inside the eyewall, one for the eyewall region, and one for the area outside the eyewall. Reasonable validation against observational data justifies the use of this wind profile. Figure 10 shows the wind profile for an average Florida storm.

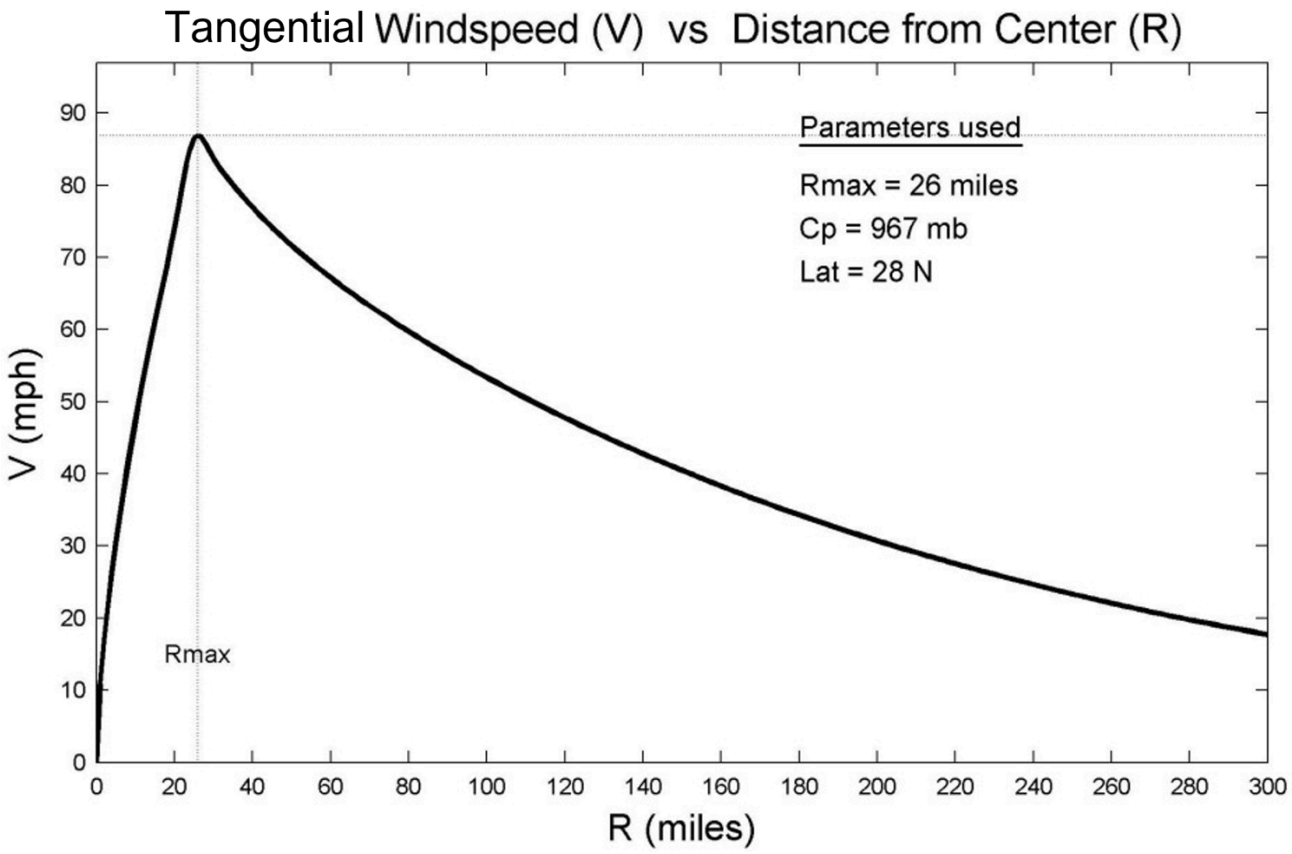


Figure 10. Tangential Wind Profile (Assuming Updated Florida Mean Values of Rmax, Cp and Latitude)

M-4.2

Describe the general process for calculating hurricane surface winds.

The model first computes the 10-min average sustained wind at gradient level using the Willoughby wind profile. The winds are then brought to the surface (10-meters) by applying the radial adjustment function incorporating the GWRF, the PWF, and hours after landfall. For a given location, the wind direction is then computed and used to select a direction-dependent gust factor which converts the 10-min sustained winds to 1-min maximum sustained winds. Then the asymmetry factor is computed given the forward speed and applied before finally using the wind direction to select a direction-dependent friction factor which accounts for the impact on the local wind from terrain roughness.

M-4.3

Describe how the vertical variation of winds is accounted for in the hurricane model where applicable.

Vertical variability in boundary layer winds is accounted for implicitly in the use of a log-law profile for developing adjustment factors for friction and averaging time specific to a location's surface roughness value. As discussed in M-4.D above, the vulnerability module accounts for the effect of the vertical variation of winds through the development of vulnerability functions for structures with varying heights.

M-4.4

Describe the relevance of the formulation of gust factor(s) used in the hurricane model.

The model uses a gust factor to convert 10-minute average to 1-minute maximum sustained wind. This conversion is based on accepted engineering relationships (Simiu and Scanlan, 1996, N. Cook, 1985, and Engineering Sciences Data Unit, ESDU Dataset, 1994) and varies from 1.12 to 1.26, as a function of land use/land cover.

M-4.5

Identify all non-meteorological variables (e.g., surface roughness, topography) that affect windspeed estimation.

Surface roughness and averaging distance are non-meteorological variables that affect wind speed estimation. Topographic effects are not considered in the local wind estimation process as Florida and the adjacent coastal regions have very limited elevation above sea level.

M-4.6

Provide the collection and publication dates of the land use and land cover data used in the hurricane model and justify their timeliness for Florida.

The model uses the National Land Cover Database 2016 (NLCD 2016) product, available from the Multi-Resolution Land Characteristics (MRLC) Consortium. The hurricane model covers 30 states, including Florida, and therefore requires a consistent and unified U.S. Land Use Land Cover (LULC) database. In addition, the Coastal Change Analysis Program 2016 (C-CAP 2016) database, a NOAA coastal LULC product based off the NLCD 2016 dataset, was used to improve processing of coastal aquatic details (McCombs et al., 2016).

M-4.7

Describe the methodology used to convert land use and land cover information into a spatial distribution of roughness coefficients in Florida and neighboring states.

The model uses the NLCD 2016 classifications by category and assigns appropriate roughness lengths based upon available scientific literature (Cook, 1985, Simiu and Scanlan, 1996, Grimmond and Oke, 1999, Grell et al., 1995, Chen and Dudhia, 2001, and Benjamin et al., 2002). These classifications are provided at 30-meter resolution, and are then resampled to 220 meters. Local roughness factors are used to define an effective roughness for a given location. The effective roughness is the average surface roughness for an area out to an upwind distance of 6.2 miles (10 km) for the gust factor and 9.3 miles (15 km) for the friction factor. The effective roughness is representative of the mean land surface acting on the wind field (Engineering Sciences Data Unit, ESDU Dataset, 1994).

M-4.8

Demonstrate the consistency of the spatial distribution of model-generated winds with observed windfields for hurricanes affecting Florida. Describe and justify the appropriateness of the databases used in the windfield validations.

Figure 11, Figure 12, and Figure 13 demonstrate that the distribution of model-generated winds for three historical storms (hurricanes Charley 2004, Dennis 2005, and Michael 2018) is consistent with the distribution of observed winds.

The minimum wind speed was not included in the figures because the wind footprints shown on the maps have a minimum wind speed of 40 mph.

This process is justified by using data from appropriate sources, including data from Tropical Cyclone Reports, standard METAR reports, and Texas Tech University. Additionally, appropriate quality control procedures were applied to the data in order to flag any questionable observations. In some cases, such as observations at non-standard height or averaging time, adjustments were made using published techniques.

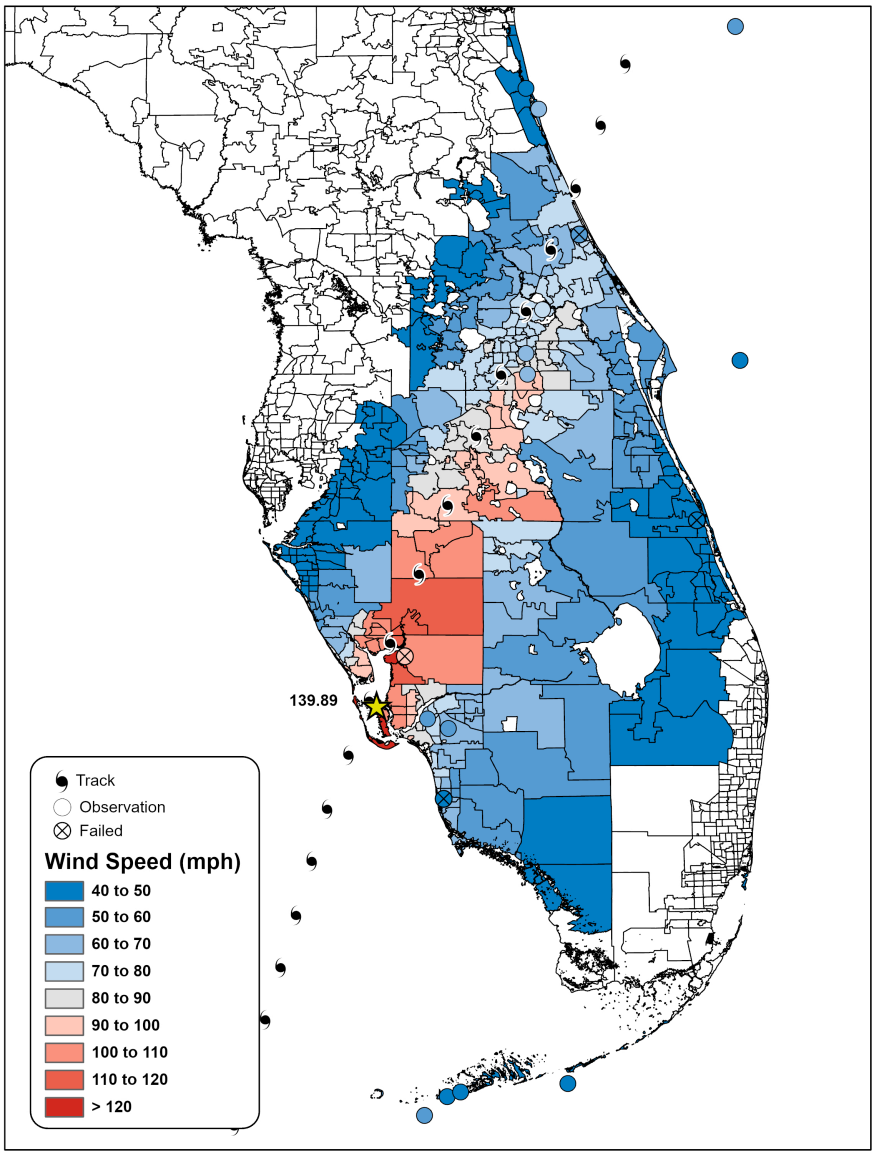


Figure 11. Observed and Modeled Wind Speeds, hurricane Charley (2004). White areas experience wind speed below 40mph.

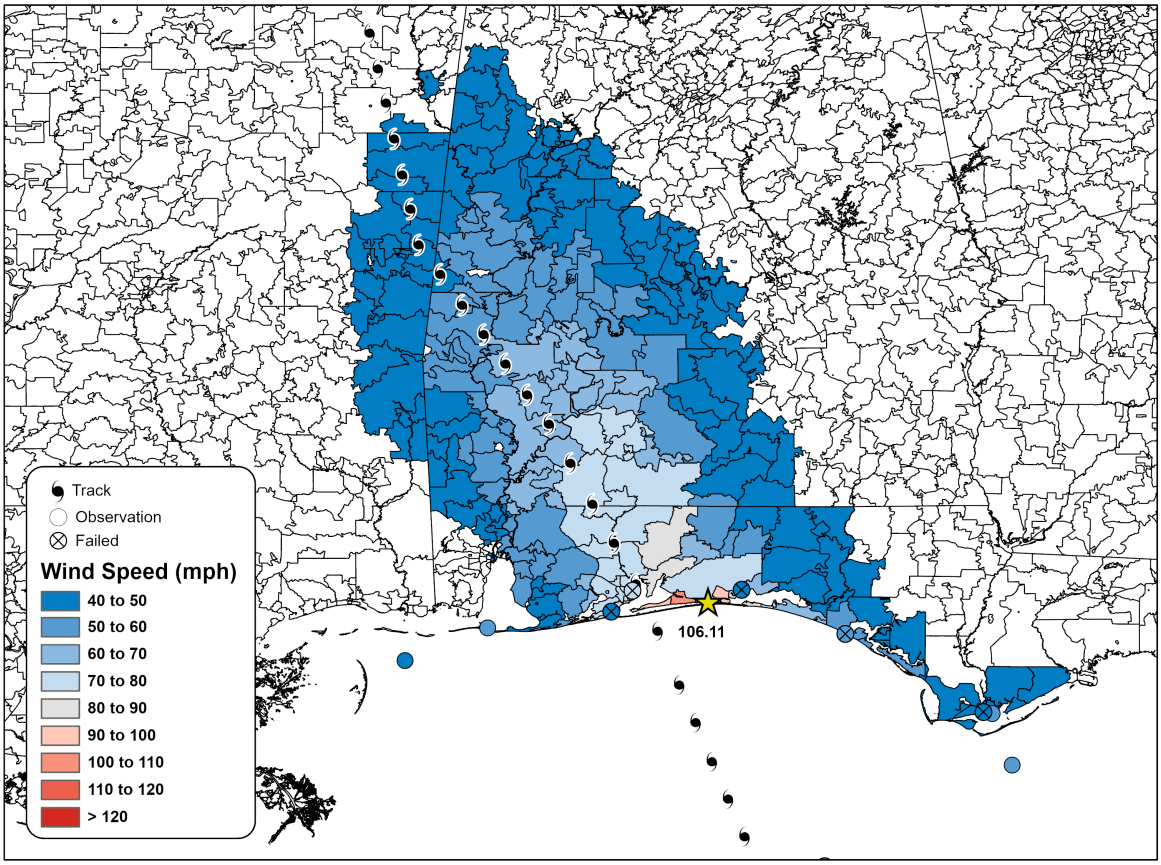


Figure 12. Observed and Modeled Wind Speeds, hurricane Dennis (2005). White areas experience wind speed below 40mph.

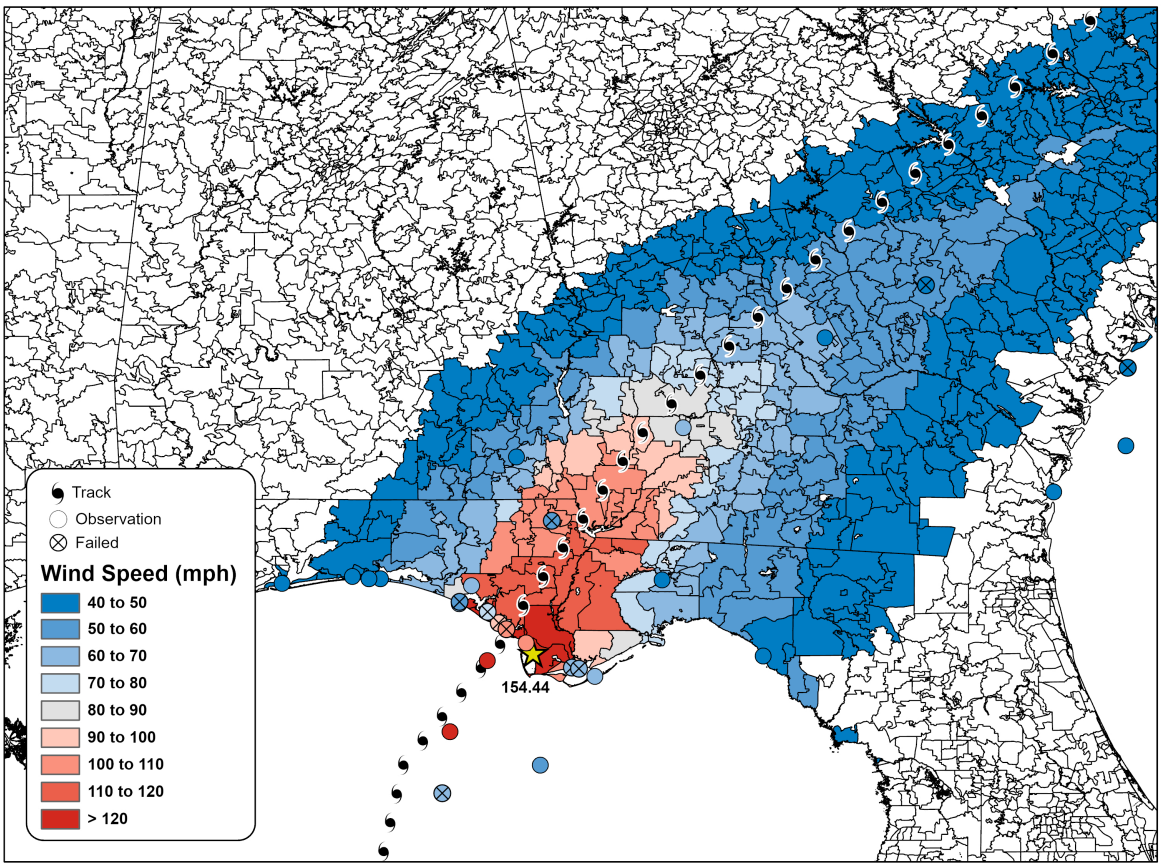


Figure 13. Observed and Modeled Wind Speeds, hurricane Michael (2018). White areas experience wind speed below 40mph.

M-4.9

Describe how the hurricane model windfield is consistent with the inherent differences in windfields for such diverse hurricanes as Hurricane Charley (2004), and Hurricane Wilma (2005), Hurricane Irma (2017), and Hurricane Michael (2018).

Historical data show that tropical cyclones affecting Florida can be quite diverse. Storm size varies considerably, from very small (e.g. Charley of 2004) to abnormally large (e.g. Wilma of 2005 and Irma of 2017). Furthermore, storm size may evolve, for example Irma was of generally average size when it first made landfall in the Florida Keys, but the wind field expanded immensely as Irma traversed the length of the Florida Peninsula. In terms of intensity, Florida has experienced hurricanes of all categories, including 3 of the 4 known Category-5 hurricanes to strike the United States coastline, the most recent being Michael in 2018.

The model wind field is designed to represent the full range of hurricane sizes and intensities, by stochastic modeling of central pressure and the radius of maximum wind. The distributions of these model parameters compare well with historical distributions across Florida state-wide, as well as at landfall for individual coastal

segments. Motion speed and direction, which affect asymmetry and inland decay are also modeled stochastically to represent the distribution of historical storms.

For model parameter comparison with historical storm data, see Standard S-1: Modeled Results and Goodness-of-Fit.

M-4.10

Describe any variations in the treatment of the hurricane model windfield for stochastic versus Model Base Hurricane Set storms and justify this variation.

The treatment of the model windfield does not vary between stochastic and historical storms.

M-4.11

Provide a completed Form M-2. Provide a link to the location of the form in the submission appendix [insert hyperlink here].

Form M-2: Maps of Maximum Winds

M-4.12

State whether the hurricane model simulates surface winds directly or requires conversion between some other reference level or layer and the surface. Describe the source(s) of conversion factors and the rationale for their use. Describe the process for converting the modeled winds to surface winds, including the treatment of the inherent uncertainties in the conversion factors with respect to location of the site compared to the radius of maximum winds over time. Justify the variation in the surface winds conversion factors as a function of hurricane intensity and distance from the hurricane center.

The model first computes the maximum wind at gradient level and then brings this wind to the surface level (10 meters) via a conversion factor. This factor, the Gradient Wind Reduction Factor (GWRF) described in M-2.3, represents a model parameter which varies stochastically by storm, and varies by location as a function of the Peak Weighting Factor (PWF) and distance from Rmax. The Radial Adjustment Function (RAF) adjusts the GWRF as a function of distance to the eyewall (Rmax) and hours after landfall. Because Rmax varies with time, the RAF is also variable in time for a given storm. The GWRF is independent of storm intensity. Justification for varying GWRF with distance from the storm center is based on analyses of the spatial distribution of GWRF using operational dropsonde data (data is publicly available from NOAA/AOML/HRD in Miami, Florida). Furthermore, these analyses combined with results from published literature (Franklin et al., 2003; Powell et al., 2009) justify varying GWRF by storm. The mean values of the stochastically drawn GWRF, the distribution about the mean, and the form of the RAF have been developed based on these data and research.

M-4.13

Describe how the windspeeds generated in the windfield model are converted from sustained to gust and identify the averaging time.

Input to the vulnerability module is maximum 1-minute sustained wind. The model uses a gust factor to convert 10-minute average winds to maximum 1-minute sustained winds (See M-4.4). There is no further conversion of the sustained winds into a shorter duration gust.

Standard M-5: Hurricane Intensity Change Methodologies

M-5.A

The hurricane intensity change methodology used by the hurricane model shall be consistent with current state-of-the-science.

The model's intensity change compares favorably with the historical records for storms of all intensities and is consistent with methodologies published in peer reviewed journals, for both over-water and over-land intensity change. The functional form of the inland decay model (shown in Figure 14) is similar to that proposed by Kaplan and DeMaria (1995) which remains accepted currently.

M-5.B

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

The transition of winds from over-water to over-land within the model is determined explicitly using local land cover information that varies by wind direction. The methodology used is based on established meteorological and engineering relationships for boundary layer winds. The methodology has been refined using the latest state-of-the-science wind data from research field projects.

M-5.C

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

The model formulation allows for both the possibility of re-intensification once the storm is back over water, or conversely, continued decay. If a landfall is part of a multiple landfalling event, then the track is merged with the subsequent landfall track. Using interpolation, the track re-intensifies until it passes from over water to over land. If a track is a single landfall event, then the decaying effect continues.

Disclosures

M-5.1

Describe and justify the functional form of hurricane decay rates for hurricanes moving onshore.

Once over land, the hurricane moves away from its source of energy, i.e., warm ocean water. As a result, the eye "fills" and the central pressure increases (winds degrade) with increasing time after landfall. The filling functions give the reduction in the pressure deficit (the difference between the central storm pressure and the pressure at

the periphery of the storm) as a function of time since landfall. A faster forward speed will cause a hurricane to maintain its intensity further inland compared to a slower moving storm with the same initial intensity (pressure deficit).

The functional form of the pressure deficit decay function is:

$$\Delta P_t = \left[P_p - P_{eyeLF} \times \left(1 + LF_{offset} \times t^{C_1}\right)\right] \times e^{-C_2 t}$$

Figure 14. Equation 1

where:

- ΔP_t = Pressure deficit at a given time after landfall
- P_p = Atmospheric pressure at the periphery of the storm
- P_{eyeLF} = Central pressure of the storm at landfall
- LF_{offset} = Initial reduction of the pressure deficit at landfall
- t = Time after landfall in hours
- C_1 = Time shaping constant
- C_2 = Exponential decay rate constant

Note that the function parameters vary by coastal region and smoothing algorithms are applied such that there are no large discontinuities between regions.

This formulation is justified as it computes the necessary change in intensity parameter relevant to the model (i.e. change in central pressure as a function of time). The hurricane filling functions provide reliable weakening rates for the state of Florida and neighboring states and are consistent with inland decay functions, such as those developed by Kaplan and DeMaria (1995), further justifying their use.

Perturbations are allowed for the model's standard filling relationships to account for the low probability of tropical cyclones undergoing an episodic period of re-intensification after landfall. The implementation of such filling perturbations is motivated by the studies of Bosart and Lackmann (1995), Hart and Evans (2001) and Arndt et al. (2009), and is based on observed historical storms. The procedure is only applied to storms which would likely undergo a transitioning phase and eventually reach 42°N latitude. Within the state of Florida, such perturbations occur only in a very small number of stochastic events.

M-5.2

Describe and justify the functional form of hurricane intensity change for hurricanes moving offshore.

The model formulation allows for both the possibility of re-intensification once a storm is back over water, or conversely, continued decay. If a track is a single landfall event, then the decaying effect continues while the track is over water. If a track is a multiple landfalling event, then the storm re-intensifies until the track passes back over land.

The decision to join two or more partial single landfalling tracks into a multiple landfalling event is based on the distance between the tracks, and the difference in angle, forward speed, and central pressure at the end of one

track and the beginning of the next. If two single landfalls are chosen to create one multiple landfalling event, a cubic spline applied to the longitude and to the latitude is used to define the track portion merging the end and beginning of the two existing partial tracks. The intensity is linearly interpolated between the last hour of the first partial track and the first hour of the second partial track, allowing for re-intensification over water.

M-5.3

Provide a graphical representation of the modeled and observed temporal decay rates of wind or central pressure for Florida hurricanes.

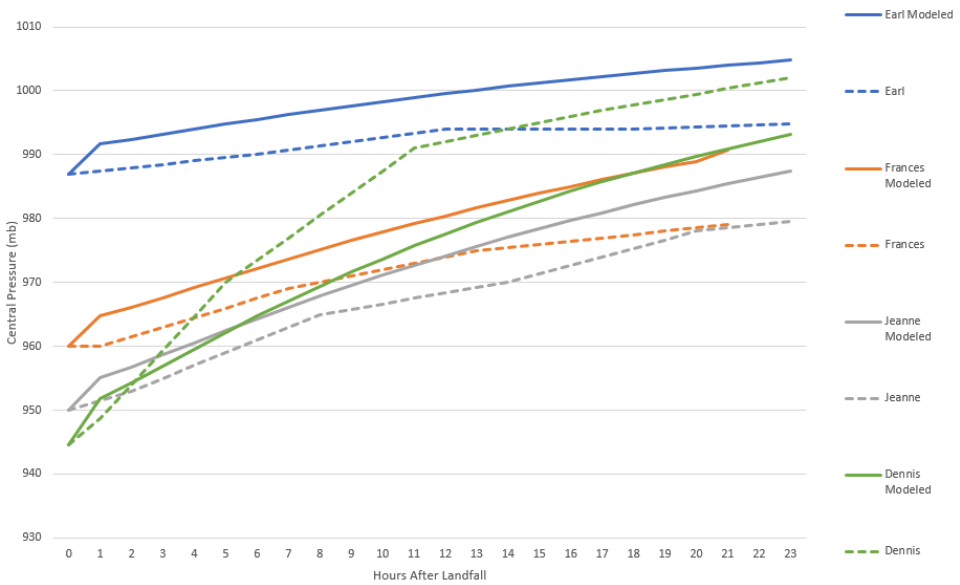


Figure 15. Modeled Filling of Central Pressure as a Function of Hour After Landfall Compared to Historical Florida Hurricanes

Figure 15 shows a comparison of the modeled increase in minimum central pressure over land for four historical storms: (Hurricanes Earl 1998, Frances 2004, Jeanne 2004, and Dennis 2005). The solid lines represent the decay as represented in HURDAT2. The dashed lines show Verisk's modeled representation of storm intensity decay in terms of Cp increase. The modeled decay shows a similar behavior to the HURDAT2 Cp, increasing while translating over land.

M-5.4

Describe any changes in hurricane parameters, other than intensity, resulting from the transition from over water to over land.

The radial profile of the stochastically drawn gradient wind reduction factor is adjusted to account for the disruption of the hurricane due to landfall. Over a six-hour transition period starting three hours after landfall, the gradient wind adjustment factor along the profile converges to a constant value. For storms making multiple landfalls, the radial profile is restored over water and allowed to decay again during subsequent landfalls.

M-5.5

Describe the representation in the hurricane model of passage over non-continental United States (U.S.) land masses on hurricanes affecting Florida.

The impact of any non-continental U.S. land masses on hurricanes affecting Florida is implicit in the historical data used to develop modeled storm parameters. Because of this, the impact of such land masses is inherently accounted for in all simulated storms.

M-5.6

Describe any differences in the treatment of decay rates in the hurricane model for stochastic hurricanes compared to historical hurricanes affecting Florida.

Historical hurricanes affecting Florida use the actual observed changes in central pressure as determined from historical data. Central pressure for Florida hurricane events in the stochastic model decay after landfall using the decay function discussed in M-5.1.

Standard M-6: Logical Relationships of Hurricane Characteristics

M-6.A

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

The motion-induced asymmetry of Schwerdt et al. (1979), which the Verisk wind model uses, predicts the wind field asymmetry amplitude (magnitude) increases with increased storm translation speed.

M-6.B

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

The friction factor represents the impact surface roughness has on the modeled wind speed. The friction factor decreases from a value of 1 in smooth terrain as the local effective roughness length increases. Since the friction factor is a multiplicative quantity, the wind speed is therefore reduced as the roughness increases.

Disclosures

M-6.1

Describe how the asymmetric structure of hurricanes is represented in the hurricane model.

The term that resolves the asymmetric structure of the hurricane is a function of the translation speed of the storm and the angle between the wind direction and the storm moving direction. This contribution (expressed as a wind in miles per hour) is added to the symmetric wind associated with the storm to produce the total wind field.

M-6.2

Provide completed Form M-3. Provide a link to the location of the form in the submission appendix [insert hyperlink here].

Form M-3: Radius of Maximum Winds and Radii of Standard Wind Thresholds.

M-6.3

Explain the radii ranges for each central pressure band in Form M-3, in the context of available hurricane observations. Justify the appropriateness of the databases used in the radii validations.

Table 3. HURDAT2 Radii Values for each Wind Threshold in Form M-3

Cp (mb)	Outer Radii > 73 mph (mi)			Outer Radii > 40 mph (mi)		
	Min	Max	Median	Min	Max	Median
990	11.51	172.62	23.02	23.02	690.47	107.41
980	11.51	345.23	24.45	31.65	621.42	132.34
970	11.51	247.42	33.08	43.15	555.25	158.23
960	14.38	247.42	47.47	46.03	724.99	169.74
950	17.26	189.88	48.91	69.05	598.41	161.11
940	21.58	145.77	45.31	74.80	586.90	149.60
930	21.58	132.34	51.79	83.43	604.16	166.86
920	21.58	86.31	50.35	89.19	187.00	149.60
910	33.08	94.94	48.91	109.32	210.02	143.85
900	57.54	92.06	60.42	161.11	197.07	175.49

The wind radii values in Form M-3: Radius of Maximum Winds and Radii of Standard Wind Thresholds have been compared to data from the HURDAT2 dataset (see Table 3 above) for the 40 and 73 mph wind radii covering the years 2004-2022. Comparisons are generally favorable, particularly for hurricane force wind radii. The median extent of HURDAT2 hurricane force wind radii (73 mph) are consistent with modeled 2nd quartile values. Also, 1st and 3rd modeled quartile hurricane force wind radii fall within the HURDAT2 minimum and maximum ranges, except for the smallest and most intense storms. Median tropical storm force wind radii tend to be slightly lower in the model than the values stated in HURDAT2. No comparisons to the 110 mph wind radii are available since HURDAT2 does not provide these values.

M-6.4

Describe the dependencies among parameters in the windfield component and how they are represented in the hurricane model.

The windfield model outputs three variables: wind speed, wind duration, and wind direction. The wind speed at a given location is the maximum modeled 1-min sustained wind speed over the time history of the storm. The wind duration is the count of hours where the modeled wind speed at a given location exceeds a damaging threshold. The wind direction is the direction of the wind vector at the time of the maximum modeled wind speed.

5 Statistical Hurricane Standards

Standard S-1: Modeled Results and Goodness-of-Fit

S-1.A

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

The historical data were used to develop the probability distributions for key model variables such as annual hurricane frequency, landfall location, central pressure, radius of maximum winds, forward speed, and track direction. Where appropriate, spatial smoothing and meteorological adjustments were used to overcome spatial gaps and other limitations caused by the relative scarcity of the historical data.

The probability distributions used for individual input variables include Negative Binomial for annual landfall frequency, Weibull for central pressure, and Lognormal for forward speed. The parameters of these distributions were estimated using the maximum likelihood method. The adequacy of the fit was examined using established procedures such as the chi-square, Kolmogorov-Smirnov and the Shapiro-Wilk tests. Graphical comparisons using quantile-quantile (Q-Q) plots and other procedures were performed to confirm the agreement between the historical data and the fitted probability distributions.

S-1.B

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

Agreement between modeled and historical hurricane characteristics is confirmed using widely accepted scientific and statistical methods. The simulated values have been carefully examined and determined to be reasonable based both on statistical and meteorological grounds. Demonstration of the agreement between modeled and historical hurricane characteristics are shown in detail in the following Disclosures.

Disclosures

S-1.1

Describe the nature and results of the tests performed to validate the windspeeds generated.

Extensive tests were performed to compare spatial extent, timing, and magnitude of model generated wind speeds against observations. Observational data have been gathered from NHC's Tropical Cyclone Reports as

well as other data sources, including Revised Atlantic Hurricane Database (HURDAT2), aircraft data, various surface based fixed station data, and published reports for over 36 historical storms (including many Florida storms). Comparisons performed include station-based time series analysis, scatter plots of model winds versus observed winds, and modeled wind biases versus radial distance and azimuthal direction with respect to the storm center. When available, additional comparisons were made against h*Wind data (Landsea et al., 2004; Powell et al., 1998) or Extended Best Track significant wind radii (Demuth et al., 2006). Bias statistics were computed for wind differences over all amplitudes or at different wind bands and against various subsets of the available observational data. Figure 16, Figure 17 and Figure 18 present a set of validation tests performed for Hurricane Michael (2018). In these figures bias (BIAS), mean absolute error (MAE), and root mean square error (RMSE) have units of miles per hour.

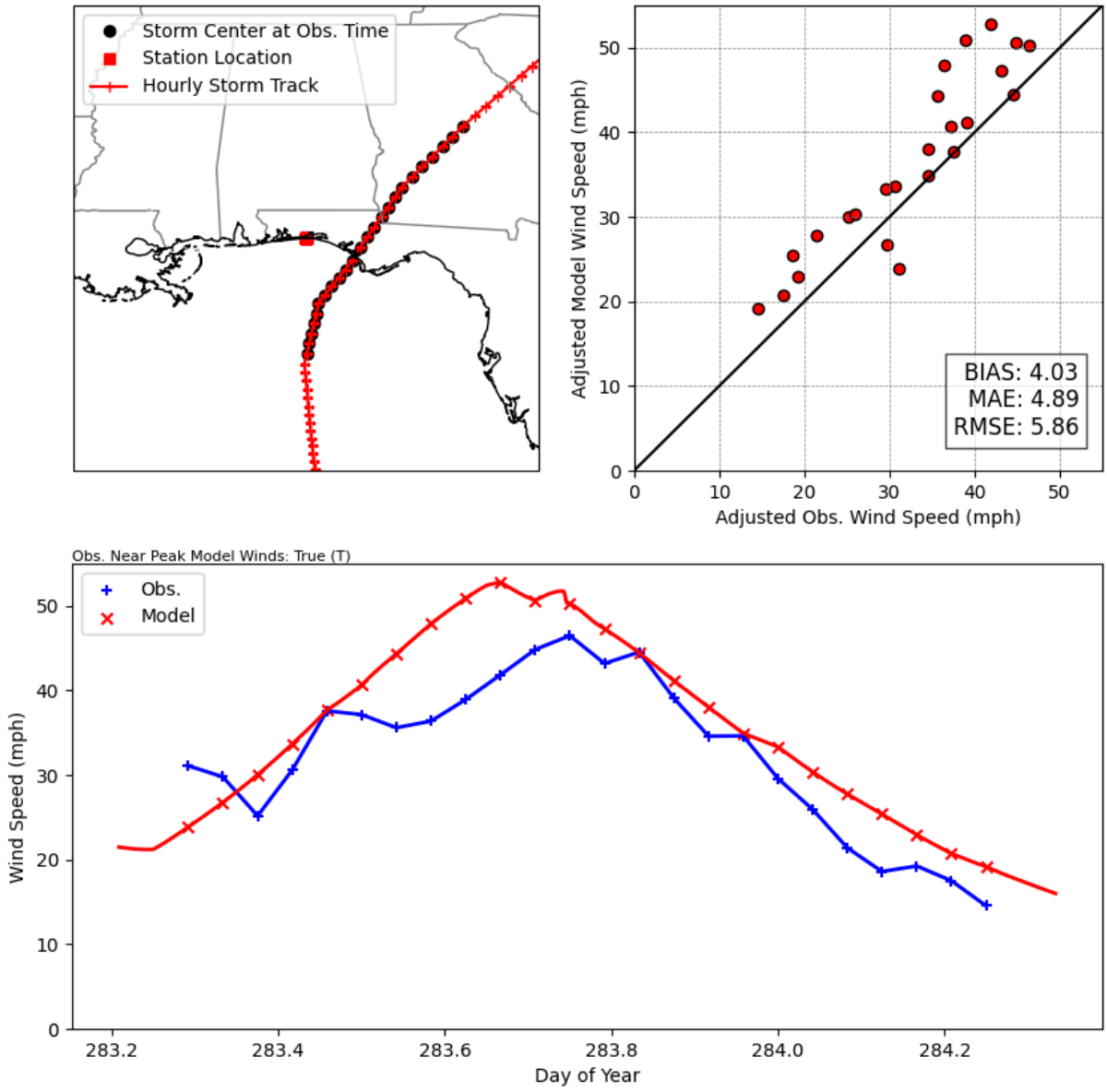


Figure 16. Modeled Versus Observed Surface Winds for Station XFWB in Hurricane Michael (2018)

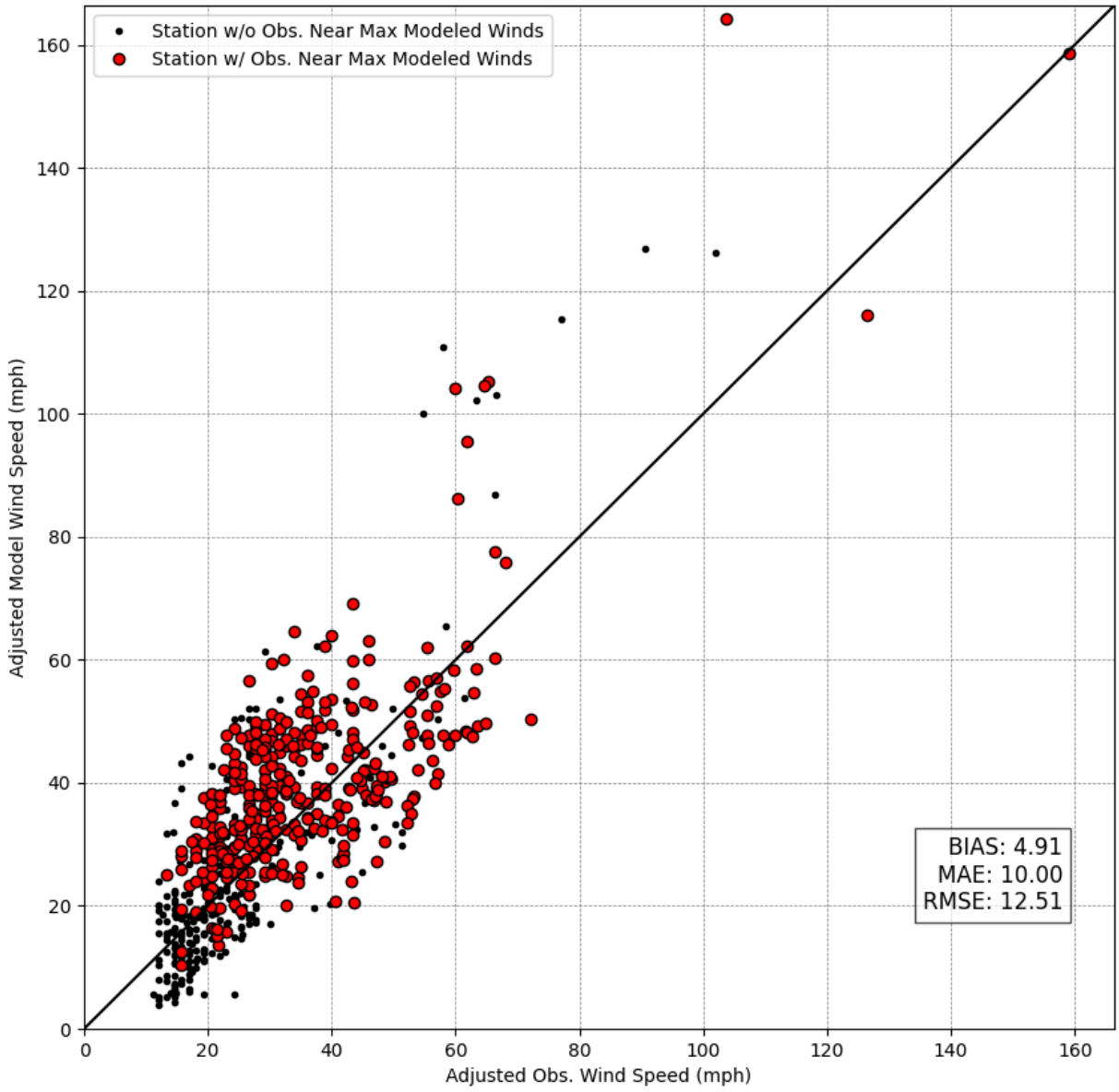


Figure 17. Maximum Observed Versus Maximum Modeled Surface Winds (mph) for All Observation Stations in Hurricane Michael (2018).

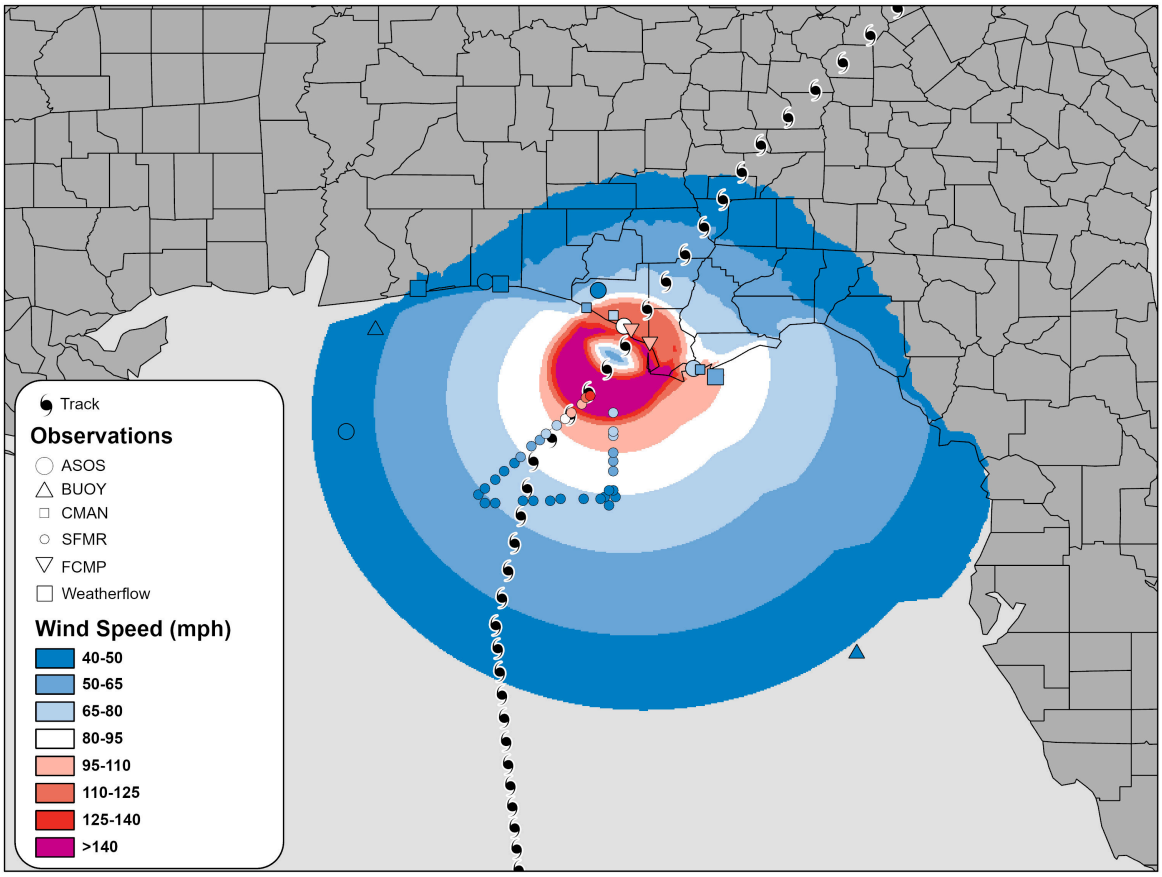


Figure 18. Hurricane Michael's Maximum Over-Hour Wind Footprint Prior to Landfall (Colors) Overlaid With Maximum Over-Hour Observed Winds. Gray areas experience wind speed below 40mph.

The minimum wind speed was not included in Figure 18. The wind footprints shown on the maps have a minimum wind speed of 40 mph.

S-1.2

Provide the dates of hurricane loss of the insurance company hurricane claims data used for validation and verification of the hurricane model.

Verisk has actual insurance company loss data for the following storms: Hurricanes Hugo (1989), Bob (1991), Andrew (1992), Erin (1995), Opal (1995), Bertha (1996), Fran (1996), Earl (1998), Frances (1998), Georges (1998), Floyd (1999), Irene (1999), Georges (2001), Charley (2004), Ivan (2004), Frances (2004), Jeanne (2004), Dennis (2005), Rita (2005), Wilma (2005), Katrina (2005), Ike (2008), Irene (2011), and Sandy (2012).

S-1.3

Provide an assessment of uncertainty in hurricane probable maximum loss levels and hurricane loss costs for hurricane output ranges using confidence intervals or other scientific characterizations of uncertainty.

Past studies conducted by Verisk have examined the contribution of model parameters such as central pressure, forward speed, radius of maximum winds and the gradient wind reduction factor to the uncertainty in estimated loss costs and probable maximum loss levels (referred to hereafter in this disclosure as simply "loss costs"). These studies have shown that the gradient wind reduction factor is a large contributor to the uncertainty in the loss costs.

This finding is supported by the results from the Form S-6 analysis performed as part of our submission under the standards set forth in the 2009 Report of Activities. Additional loss runs have been performed to assess the contribution of this factor to the uncertainty in the county-level loss costs. For example, eliminating the stochastic variability and setting its value equal to the distribution mean reduced the estimated losses by approximately 20 percent statewide. A significant reduction in the variance of the loss costs was also observed for most of the counties. By comparison, eliminating the variability in the peak weighting factor did not have a significant impact on the estimated loss costs.

S-1.4

Justify any differences between the historical and modeled results using current scientific and statistical methods in the appropriate disciplines.

The historical results are based on a sample of 123 years of hurricane experience. Because of sampling variability and other sources of uncertainty, one would not expect an exact agreement between historical and modeled results. However, goodness-of-fit statistics and other measures show a reasonable agreement between historical and modeled results.

S-1.5

Provide graphical comparisons of modeled and historical data and goodness-of-fit tests. Examples to include are hurricane frequencies, tracks, intensities, and physical damage.

Figure 19 shows the historical distribution of annual U.S. landfalls alongside the modeled distribution in the Verisk stochastic catalog, which is a sample from the negative binomial distribution derived from the historical data. This graphical exhibit shows the two compare favorably. A two-sample chi-squared test to annual occurrence of landfalls yields a test statistic with value 1.74, (p-value = 0.88 on 5 degrees of freedom), confirming consistency between the modeled and historical hurricane frequencies. The goodness-of-fit test result reported in S-1.8 also substantiates the choice of a negative binomial model for this variable.

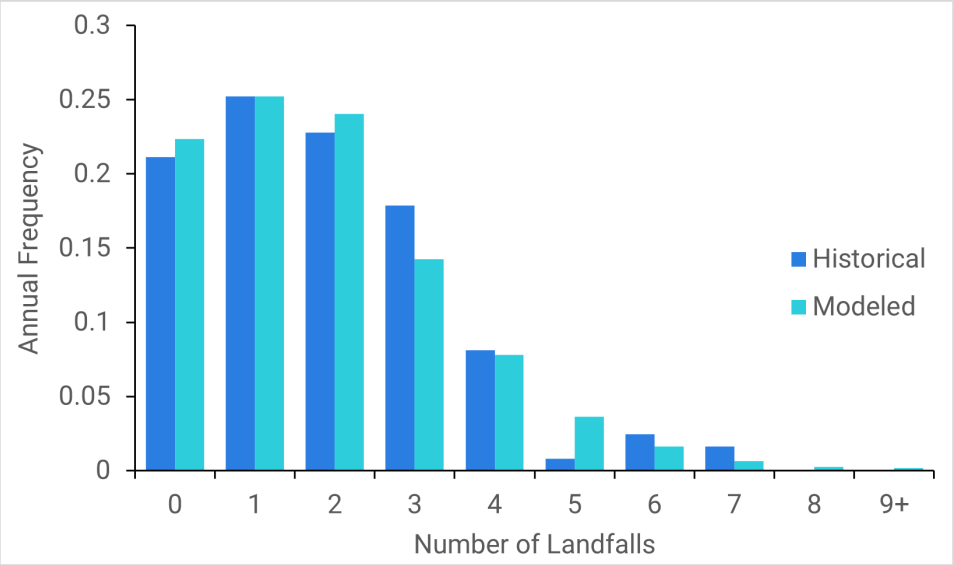


Figure 19. Historical and Modeled U.S. Annual Landfall Frequency Distributions

Hurricane Tracks

The maps in Figure 20 compare the tracks of historical and randomly sampled simulated hurricanes making landfall in a 50-mile coastal segment in Southeast Florida. The overall behavior of the historical and simulated tracks is similar.

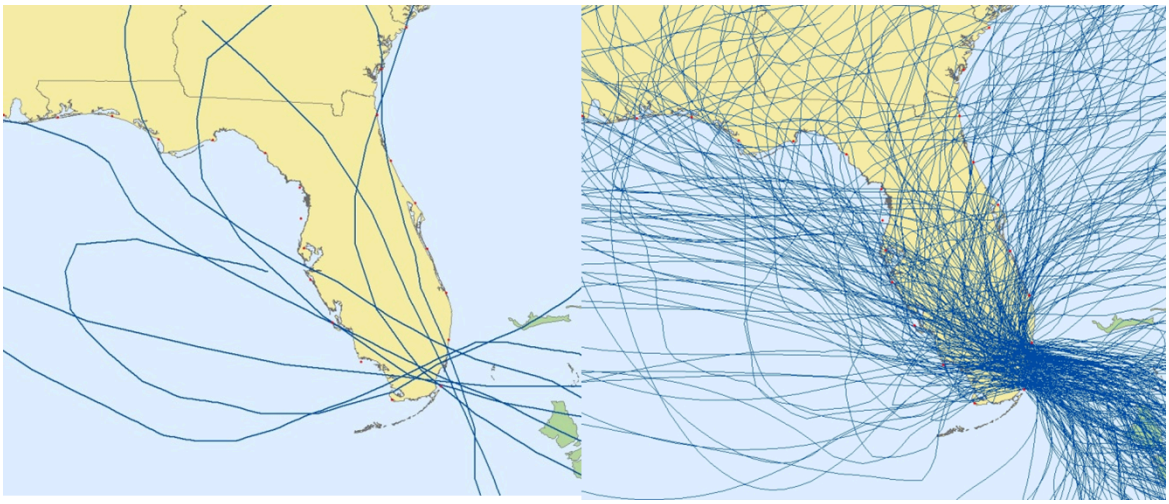


Figure 20. Historical (Left) and Simulated (Right) Hurricanes Landfalling in SE Florida

Intensities

Figure 21 compares the historical and simulated central pressure distributions for a 100-mile segment in Southeast Florida. The simulated frequencies are based on Weibull distributions fitted to the historical data. Goodness-of-fit summaries are included to illustrate some of the statistical tests that were performed for this variable.

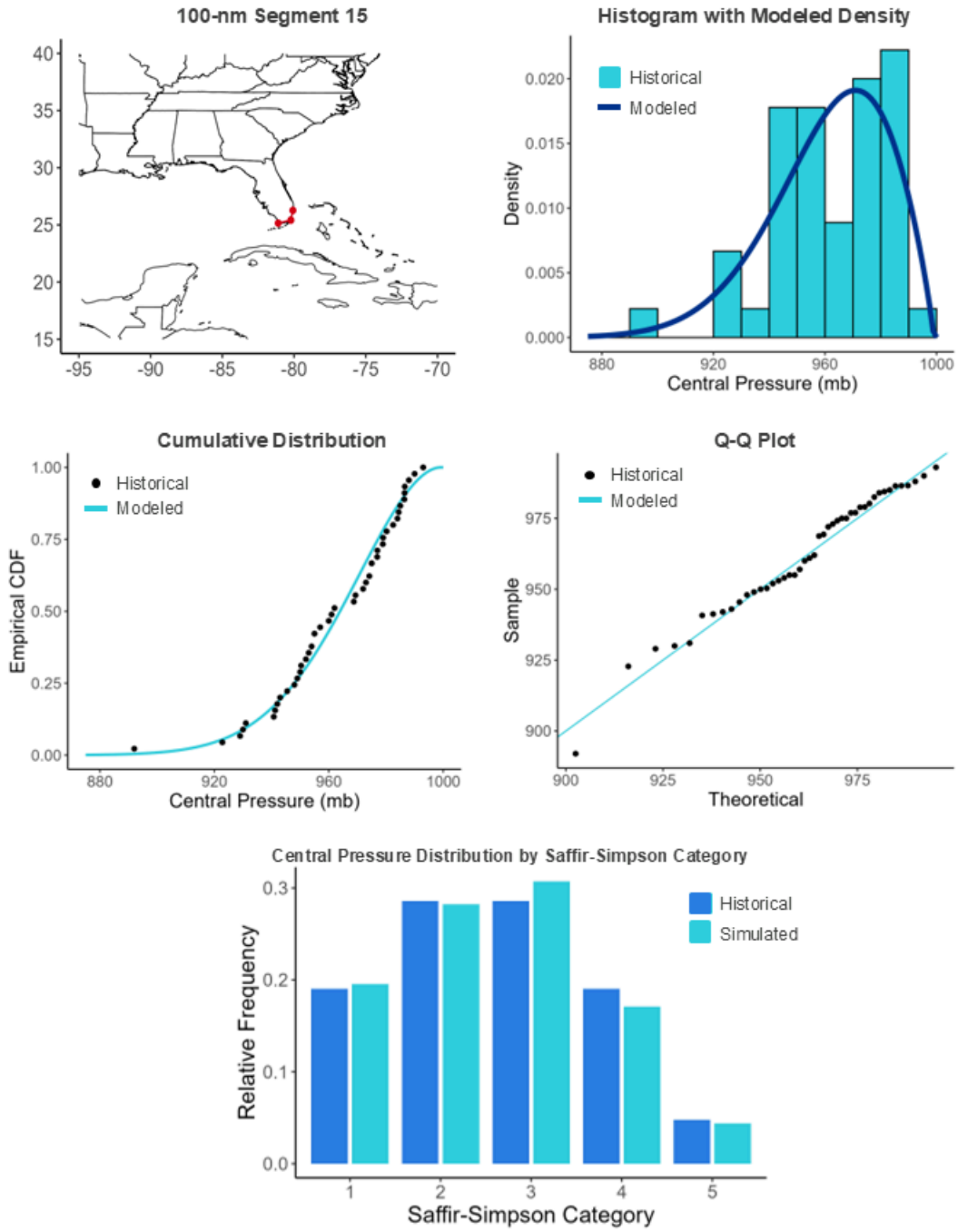


Figure 21. Goodness-of-Fit Comparisons for a 100-Mile Florida Segment

Physical Damage

Figure 22 shows historical and simulated damage ratios versus wind speed for building coverage (Coverage A) based on ZIP Code level data. Each observation refers to an individual ZIP Code. The agreement between the historical and simulated damage ratios is reasonable. This is confirmed by a paired two-sample t-test on the means, which has a p-value of 0.26.

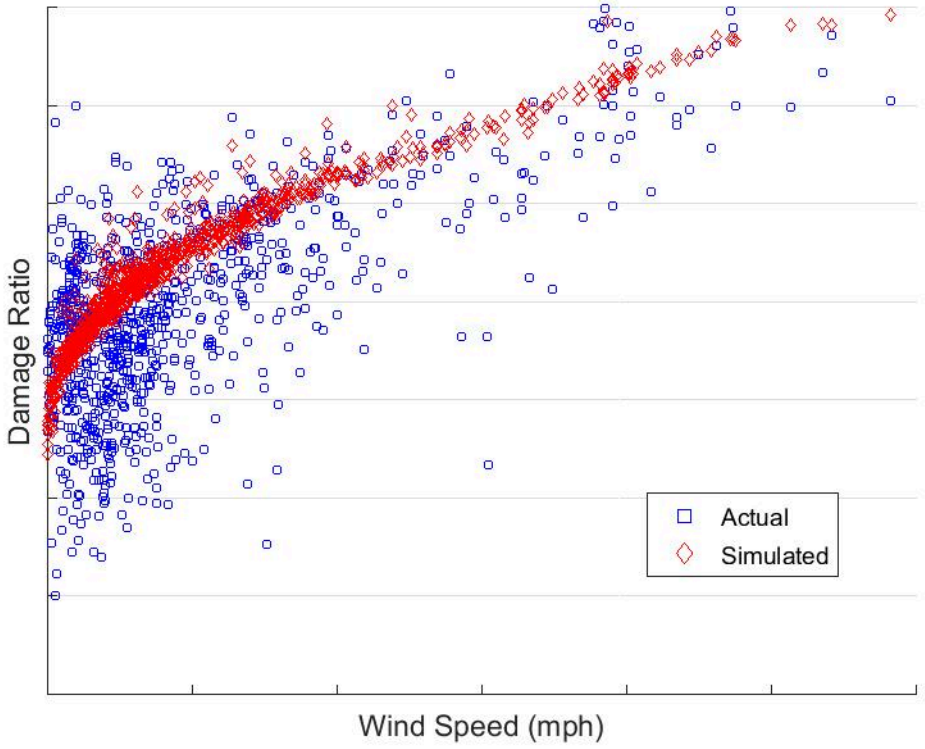


Figure 22. Sample Damage Ratio Comparison

S-1.6

Provide completed Form S-1(s). Provide a link to the location of the form(s) in the submission appendix [insert hyperlink here]

Form S-1: Probability and Frequency of Florida Landfalling Hurricanes per Year

S-1.7

Provide completed Form S-2. Provide a link to the location of the form in the submission appendix [insert hyperlink here].

Form S-2: Examples of Hurricane Loss Exceedance Estimates

S-1.8

Provide a completed Form S-3. Identify the form of the probability distributions used for each function or variable, if applicable. Identify statistical techniques used for estimation and the specific goodness-of-fit tests applied along with the corresponding p-values. Describe whether the fitted distributions provide a reasonable agreement with the historical data. Provide a link to the location of the form in the submission appendix [insert hyperlink here].

Form S-3: Distributions of Stochastic Hurricane Parameters

Annual Frequency of Occurrence

Storm frequency is modeled using a Negative Binomial distribution fitted to the number of annual hurricane landfalls in the U.S. between 1900 and 2022. An analysis of the historical data shows the variance in excess of the mean; therefore, choice of Negative Binomial to model landfall frequency is more appropriate than a Poisson distribution, which assumes equality in mean and variance. The Negative Binomial is also known as a gamma-Poisson mixture, with the assumption that the mean of the Poisson is continuous and follows a gamma distribution. These considerations, combined with goodness-of-fit results, justify the use of the Negative Binomial distribution.

The parameters of this probability distribution are estimated using the maximum likelihood method. The adequacy of the fit is examined graphically and tested using Pearson's chi-square goodness-of-fit test. The calculated value of the chi-square test statistic (2.17, with 3 degrees of freedom) is small and its associated p-value (0.54) indicates no lack of fit.

Landfall Location

The model probability distribution for landfall location is categorical. An empirical, spatial filtering of the historical landfall locations along Verisk's piecewise linear coastal segments is used to smooth out the sampling variability in the historical record to arrive at the model parameters. The smoothing kernel is adjusted at sharp changes in coastline orientation that lead to expectation of decreased spatial smoothness. The checks performed on the final landfall distribution include graphical and numerical comparisons of historical and simulated landfall frequencies as well as Pearson's chi-square goodness-of-fit test for annual frequency for landfall locations. The calculated chi-square test statistic of 4.84 with 11 degrees of freedom indicates no lack of fit (p-value = 0.94). In addition, a bootstrap analysis on the modeled landfall frequencies shows that the historical landfall frequencies fall within the 90% pointwise interval for each 50 nautical mile segment along the coast.

Central Pressure

Central pressure deficits from a fixed outer value are modeled at 100-nmi landfall segments as a spatially-varying mixture model. At each segment, one of the mixture components is a Weibull distribution fit to landfall intensities within roughly 150 nautical miles of the segment. The second component is given by a Weibull fit to all historical landfalling intensities pooled within a larger region containing the segment. The model component parameters are the maximum likelihood estimators fit to the intensities of all hurricane-strength landfalls along the United States from 1900-2022. The Weibull mixture provides spatial continuity across segments, with mixing weights chosen via expert judgement to avoid over-fitting in locations where the data are especially sparse.

Goodness-of-fit testing and consideration of multiple graphical validation checks support this model choice. Figure 21 provides an example of the graphical checks for one segment. These plots and the p-values of associated statistical tests, confirm that the fitted distributions provide a robust model for the distribution of landfalling central pressure. For Florida and adjacent states, the p-value from the Kolmogorov-Smirnov goodness-of-fit test for the historical distribution versus simulated central pressure distributions in the Verisk model is 0.80, further confirming that our modeled central pressure distribution is consistent with the historical data.

Radius of Maximum Winds

For each simulated hurricane, the radius of maximum winds is simulated from a regression model that relates the radius to central pressure and latitude. The error term in this model is assumed to follow a Normal distribution. The parameters are estimated using least squares and standard residual checks are performed to determine the adequacy of the fitted model. The resulting values are bounded based on central pressure to produce a final distribution for the radius. The consistency between historical and modeled values is demonstrated using scatter diagrams and numerical comparisons. The ability of the model to capture the variability in the historical data is shown by the resulting 92% coverage probability of the 95% predictive intervals.

Forward Speed

Forward speed is generated from a Lognormal distribution with parameters estimated for each 100-mile segment. The parameters are estimated using the maximum likelihood method by computing the mean and variance of the log-transformed data. Model adequacy is evaluated using various goodness-of-fit tests such as Shapiro-Wilk and Anderson-Darling tests, and by comparing the empirical and fitted cumulative distribution functions. Q-Q plots were also constructed. In addition, the historical and simulated values are compared graphically for each 100-mile coastal segment. The checks performed, including the examination of p-values, indicate no lack-of-fit and suggest that the lognormal distribution provides a reasonable probability distribution for forward speed. For Florida and adjacent states, the p-value from the Kolmogorov-Smirnov goodness-of-fit test for the historical distribution against the simulated forward speed distributions is 0.56.

Storm Heading at Landfall

Landfall angle is measured clockwise (+) or counterclockwise (-) with 0 representing due North. Separate distributions for storm heading at landfall are estimated for each 50–nautical-mile segment of coastline. Storm heading is modeled as combined Normal distributions, and bounded based on the historical record, geographical constraints and meteorological expertise. Diagnostic checks show a reasonable agreement between historical and modeled values. For Florida and adjacent states, the p-value from the Kolmogorov-Smirnov goodness-of-fit test for the historical and simulated storm heading at landfall distributions is 0.64, indicating no lack-of-fit.

Gradient Wind Reduction Factor

The gradient wind reduction factor is modeled using a Normal distribution with parameters estimated from data derived using the regression equation from Powell et al. (2009), with input based on HURDAT data. The adequacy of the fit is tested using the Shapiro-Wilks and Shapiro-Francia goodness-of-fit tests for normality which have p-values of 0.12 and 0.25, respectively. Graphs of the empirical distribution functions and Q-Q plot confirm the adequacy of the fit.

Peak Weighting Factor

The probability distribution of the PWF can be approximated by a Normal distribution applied to an inverse power transformation of PWF. The adequacy of the normal approximation is confirmed by the Shapiro-Wilks and Shapiro-Francia goodness-of-fit tests which have p-values of 0.07 and 0.15, respectively. Graphs of the empirical distribution functions and Q-Q plot confirm the fit. A moderate correlation between GWRF and PWF is incorporated using a bivariate Normal distribution.

Landfalling Calendar Date

The landfalling day of year was modeled as a Weibull distribution fitted to the transformed historical landfalling calendar date using HURDAT data from 1900-2006. The choice of the Weibull distribution was made to capture the skewness of the observations. In testing the original model against data from 1900-2022, both graphical and numerical comparisons of the historical and modeled landfalling calendar dates have been performed. The results from the Anderson-Darling goodness-of-fit test using Braun's adjustment and the Kolmogorov-Smirnov goodness-of-fit test (p-value = 0.42) indicate no lack of fit.

Storm Tracks

Verisk's storm track generation procedure is based on the historical storm tracks in the HURDAT database. The track information in this database is available at six-hour time intervals. A time series analysis was performed to determine appropriate models for the dependence present in key model variables from one time period to the next. This included an examination of the autocorrelation function of the original and differenced data corresponding to each model variable.

This analysis showed that a random walk with drift is appropriate for the track direction. A first-order autoregressive model is appropriate for forward speed, while a second-order autoregressive model is required to adequately represent central pressure along the track. To capture the spatial variability in the storm characteristics across the Atlantic basin, the parameters in these models were estimated by binning the data into grids that captured the spatial variation. Diagnostic checks on the model included grid-by-grid comparisons of the historical and simulated storm frequencies and intensity distributions across the basin.

Physical Damage

The vulnerability functions developed by Verisk are based on published structural engineering research, wind engineering principles, damage surveys conducted by wind engineering experts and analysis of actual loss data. Over the years, Verisk has compiled an extensive database of claims data from clients with large portfolios for historical hurricanes affecting various regions along the coast. Validation has been performed by comparing simulated and actual loss data by state, county, ZIP Code, and by line of business.

Standard S-2: Sensitivity Analysis for Hurricane Model Output

S-2

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.

Model sensitivity has been assessed via investigating the changes in losses as well as wind speed with modeled wind parameters, both spatially and temporarily, using metric standardized regression coefficient, which is widely accepted by the scientific community and is recommended by the Florida Commission. The results are consistent with what are expected and have been determined to be reasonable.

Disclosures

S-2.1

Identify the most sensitive aspect of the hurricane model and the basis for making this determination.

The most sensitive aspects of the model include the gradient wind reduction factor, far field pressure, and central pressure. Variation in these parameters can have a large impact on the modeled wind speeds and the resulting losses. This determination is based on past studies conducted by Verisk, as well as the Form S-6 analysis performed as part of our submission under the standards set forth in the 2009 Report of Activities.

The Form S-6 included six model parameters: central pressure, radius of maximum winds, forward speed, far field pressure, gradient wind reduction factor, and peak weighting factor. The sensitivity analysis for loss costs uses standardized regression coefficients associated with all six input parameters for Category 1, 3, and 5 hurricanes. The results showed that the gradient wind reduction factor has the most influence on the magnitude of the loss costs across all hurricane categories. For Category 1 hurricanes, far field pressure and central pressure have the second and third most influence on the magnitude of the lost costs. However, as the storm category increases the influence of central pressure and far field pressure decreases. The influence of Rmax increases with category and is the second most sensitive parameter for Category 3 and 5 hurricanes.

An analysis of the temporal sensitivities of the loss costs was not performed since the model does not output the loss costs by hour. However, the sensitivities of wind speeds both spatially and temporally were studied using the hypothetical storms in Form S-6.

Figure 23, Figure 24, and Figure 25 show the standardized regression coefficients vs time for category 1, 3, and 5 hurricanes at landfall. At hour 0, immediately before landfall, modeled wind speeds at the landfall location are most sensitive to the gradient wind reduction factor, followed by Rmax for Category 1 hurricanes. For Category

3 and 5 hurricanes, modeled wind speeds are most sensitive to Rmax, followed by the gradient wind reduction factor.

As noted above, the results presented here refer to wind speeds at the landfall location. However, the sensitivities are location dependent and can vary greatly depending on the specific location selected.

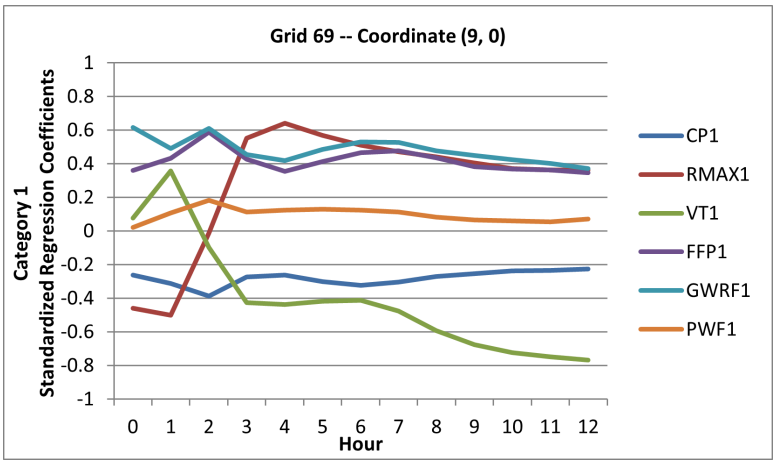


Figure 23. Standardized Regression Coefficients vs. Time at Grid Coordinates (9,0) for Category 1

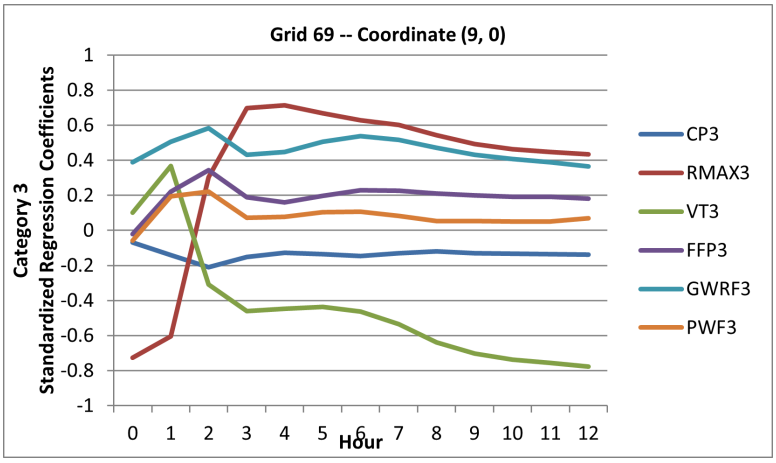


Figure 24. Standardized Regression Coefficients vs. Time at Grid Coordinates (9,0) for Category 3

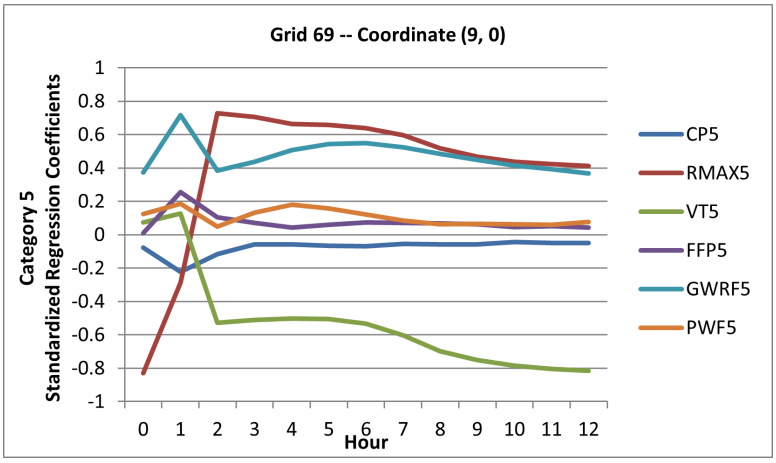


Figure 25. Standardized Regression Coefficients vs. Time at Grid Coordinates (9,0) for Category 5

S-2.2

Identify other input variables that impact the magnitude of the output when the input variables are varied simultaneously. Describe the degree to which these sensitivities affect output results and illustrate with an example.

Verisk has identified, discussed, and disclosed all input variables that impact the output values in S-2.1. Therefore, no further information can be disclosed here.

S-2.3

Describe how other aspects of the hurricane model may have a significant impact on the sensitivities in output results and the basis for making this determination.

The modeled loss costs can be sensitive to assumptions about annual landfall frequency as well as landfall location. This is illustrated by studies conducted by Verisk to assess the relationship between sea surface temperatures (SST) and hurricane frequency in different coastal regions. Generally speaking, an increase in annual landfall frequency would likely result in increased losses. When a shift of landfall location occurs, the amount of losses would vary depending on the risk exposure. Decadal and even century-long data collection and investigation are needed to quantify the sensitivity and uncertainty due to such long-term change, which is beyond the scope of this submission.

S-2.4

Describe and justify action or inaction as a result of the sensitivity analyses performed.

The results of the sensitivity analysis have been carefully reviewed and found to be reasonable. No specific action was taken after reviewing the results. However, results from the sensitivity studies performed provide valuable insight into the effects of changing the probability distributions of individual input parameters on modeled wind speeds and lost costs.

S-2.5

For a new modeling organization only, provide a completed Form S-6. Provide a link to the location of the form in the submission appendix [insert hyperlink here].

Form S-6 was submitted and accepted as a requirement under the standards set forth in the 2009 Report of Activities. The results are unchanged and are still in compliance with the current statistical standards. While Form S-6 is not physically included in this submission, all contents in the form are disclosed and extensively discussed in Standard S-2: Sensitivity Analysis for Hurricane Model Output and Standard S-3: Uncertainty Analysis for Hurricane Model Output.

Standard S-3: Uncertainty Analysis for Hurricane Model Output

S-3

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.

Verisk has performed an uncertainty analysis on the temporal and spatial outputs of the model using currently accepted scientific and statistical methods as well as the metric recommended by the Florida Commission Professional Team. Details of uncertainties induced by simultaneously varying identified individual wind parameters such as central pressure and radius at maximum wind can be found in the following disclosures.

Disclosures

S-3.1

Identify the major contributors to the uncertainty in hurricane model outputs and the basis for making this determination. Provide a full discussion of the degree to which these uncertainties affect output results and illustrate with an example.

The gradient wind reduction factor is a major contributor to the uncertainty in modeled wind speeds as well as loss costs. Far field pressure and central pressure also contribute to uncertainty in loss costs. This determination is based on past studies conducted by Verisk, as well as the Form S-6 analysis performed as part of our submission under the 2009 Standards.

The uncertainty analysis performed in Form S-6 showed that the gradient wind reduction factor makes the largest contribution to the uncertainty in loss cost for all categories of hurricanes. For Category 1 hurricanes, far field pressure makes the second largest contribution followed by central pressure, and then Rmax. The contribution of Rmax increases as the storm intensity increases. The peak weighting factor and forward speed, on the other hand, do not make significant contributions to the uncertainty in the loss costs for any of the categories.

The hypothetical storms in Form S-6 were also used to study the uncertainties associated with the spatial distribution and temporal variation of wind speeds. Some results from this analysis are given in Figure 26, Figure 27, and Figure 28, which show the relative influence of different input parameters by hour for Category 1, 3, and 5 hurricanes on wind speeds at the landfall location. At hour 0, immediately before landfall, modeled wind speeds are most influenced by Rmax. At hours 1 and 2, when the landfall location tends to be within the eye wall for the weaker hurricanes, the gradient wind reduction factor dominates while Rmax again becomes important during subsequent hours. For Category 5 hurricanes, which have a smaller Rmax, the contribution of Rmax drops significantly at hour 1 before increasing again at hour 2. As expected, forward speed is an important contributor

to uncertainty in wind speeds at the landfall location at later hours when the storms are farther away from the landfall point. All the uncertainties are location dependent and can vary greatly depending on the specific location considered.

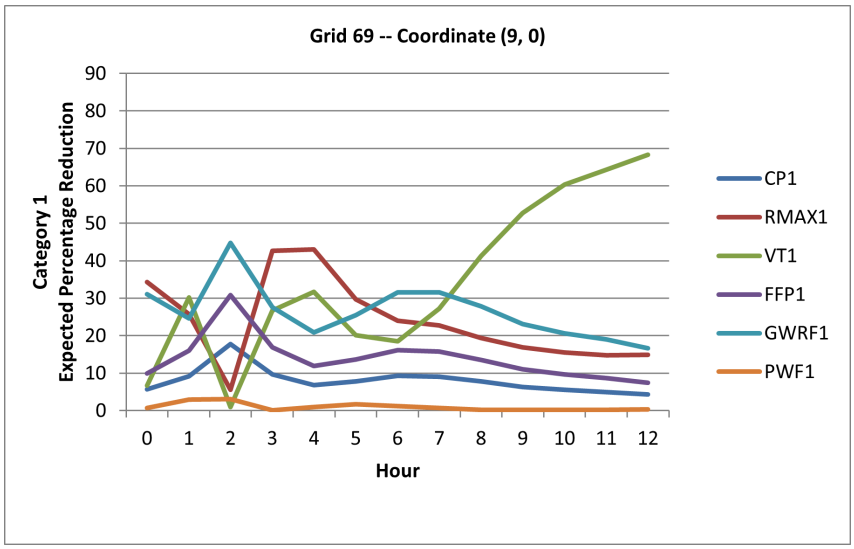


Figure 26. Expected Percentage Reduction vs. Time at Grid Coordinates (9,0) for Category 1

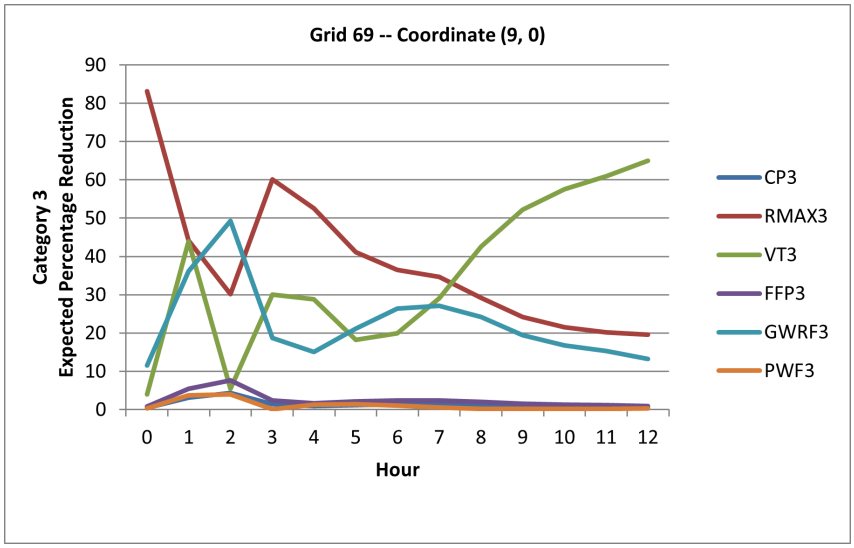


Figure 27. Expected Percentage Reduction vs. Time at Grid Coordinates (9,0) for Category 3

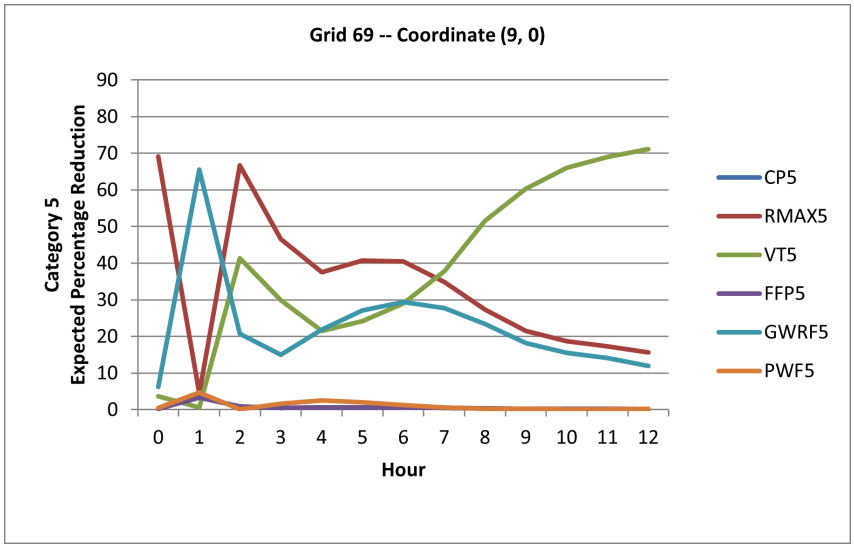


Figure 28. Expected Percentage Reduction vs. Time at Grid Coordinates (9,0) for Category 5

S-3.2

Describe how other aspects of the hurricane model may have a significant impact on the uncertainties in output results and the basis for making this determination.

Work done at Verisk on the relationship between SST and the frequency and intensity of landfalling storms confirms earlier findings that frequency and intensity have a significant impact on the uncertainty in modeled losses. Generally speaking, variation in landfall frequency and landfall location would likely result in uncertainty in loss estimation. Quantification of such level of uncertainty would require continuous collection of observational data on the scale of decades and even centuries, which is beyond the scope of this submission.

S-3.3

Describe and justify action or inaction as a result of the uncertainty analyses performed.

Past studies performed by Verisk have shown that the gradient wind reduction factor is a major contributor to uncertainty in loss costs. These results were considered in the implementation of this parameter and proper action was taken in the current version of the model via constraining the values to the range of the reported values in scientific studies.

S-3.4

Form S-6, if disclosed under Hurricane Standard S-2, will be used in the verification of Hurricane Standard S-3.

Form S-6: Hypothetical Events for Sensitivity and Uncertainty Analysis was submitted and accepted as a requirement under the standards set forth in the 2009 Report of Activities. The results are unchanged and are still in compliance with the current statistical standards. While Form S-6 is not physically included in this submission,

all contents in the form are disclosed and extensively discussed in Standard S-2: Sensitivity Analysis for Hurricane Model Output and Standard S-3: Uncertainty Analysis for Hurricane Model Output.

Standard S-4: County Level Aggregation

S-4

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

Hurricane loss cost change with increasing number of simulated years has been inspected for individual counties and for individual lines of business. The results show loss cost change approaches zero asymptotically for the 50,000-year simulation, which is the submitted model, indicating that the sampling error is negligible.

Disclosures

S-4.1

Describe the sampling plan used to obtain the average annual hurricane loss costs and hurricane output ranges. For a direct Monte Carlo simulation, indicate steps taken to determine sample size. For an importance sampling design or other sampling scheme, describe the underpinnings of the design and how it achieves the required performance.

Verisk uses constrained Monte Carlo simulation to obtain the Average Annual Loss (AAL) costs and output ranges. The constrained Monte Carlo method used is designed to expedite convergence and reduce the sampling error in the loss cost estimates. This ensures that the probability distributions for annual landfall frequency, landfall location, and landfall intensity agree with the true underlying probability distributions as closely as possible in a 50,000-year simulation. Convergence tests applied to the resulting loss costs show that the sampling errors in the loss costs are negligible.

Standard S-5: Replication of Known Hurricane Losses

S-5

The hurricane model shall estimate incurred hurricane losses in an unbiased manner on a sufficient body of past hurricane events from more than one company, including the most current data available to the modeling organization. This standard applies separately to personal residential and, to the extent data are available, to commercial residential. Personal residential hurricane loss experience may be used to replicate structure-only and contents-only hurricane losses. The replications shall be produced on an objective body of hurricane loss data by county or an appropriate level of geographic detail and shall include hurricane loss data from Hurricane Irma (2017), Hurricane Michael (2018), and Hurricane Ian (2022) to the extent data from Hurricane Ian are available.

Losses generated by the model's simulation of past hurricane events reasonably replicate actual incurred losses from those events. This is true for both personal residential and commercial residential buildings of various construction types, including manufactured homes, as well as for various coverages. County-level comparisons also show reasonable agreement between modeled and incurred losses.

Disclosures

S-5.1

Describe the nature and results of the analyses performed to validate the hurricane loss projections generated for personal and commercial residential hurricane losses separately. Include analyses for the 2017 and 2018 hurricane seasons, and for Hurricane Ian (2022) to the extent data from Hurricane Ian are available.

Table 4 to Table 9 show how Verisk's modeled losses compare, in total and by coverage and construction, to the actual losses of specific client companies for key storms including Hurricanes Andrew, Charley, Erin, Frances, Ivan, Jeanne, Wilma, and Katrina. Note that the losses in the tables have been scaled to protect the identity of the companies. Claims data from insurance companies for the 2017 and 2018 hurricane seasons, nor Hurricane Ian in 2022, have been supplied to Verisk. Given the amount of effort it takes for insurance companies to gather, clean, prepare and transmit data, obtaining these data has been a challenge. Therefore, no specific comparisons between claims and modeled losses are presented for storms in the 2017 and 2018 hurricane seasons nor Hurricane Ian.

Table 4. Actual vs. Modeled Losses for Eight Storms and Eight Companies (Personal Residential)

Event	Company	Actual Loss ($)	Modeled Loss ($)
Andrew	A	$699,699,029	$692,091,946
Andrew	C	$30,876,447	$67,414,722
Andrew Total		**$730,575,476**	**$759,506,668**

Event	Company	Actual Loss ($)	Modeled Loss ($)
Charley	G	$14,393,377	$13,434,940
Charley	I	$12,923,883	$23,937,138
Charley	J	$67,874,885	$67,444,685
Charley Total		**$95,192,145**	**$104,816,763**
Erin	B	$2,752,119	$5,473,901
Erin	C	$11,533,903	$22,419,427
Erin Total		**$14,286,022**	**$27,903,328**
Frances	G	$10,767,210	$9,313,003
Frances	I	$10,766,571	$19,617,428
Frances	J	$10,712,272	$33,012,525
Frances Total		**$32,246,053**	**$61,942,956**
Ivan	G	$3,912,200	$3,491,364
Ivan	I	$5,943,129	$47,470,888
Ivan	J	$1,631,417	$1,535,775
Ivan Total		**$11,486,746**	**$**52,498,027
Jeanne	G	$2,721,086	$6,312,117
Jeanne	I	$9,551,018	$15,393,901
Jeanne	J	$17,743,163	$27,202,755
Jeanne Total		**$30,015,267**	**$48,908,773**
Wilma	M	$14,345,569	$20,331,568
Wilma	N	$152,698,832	$200,623,679
Wilma Total		**$167,044,401**	**$**220,955,247
Katrina	N	$22,480,522	$37,163,646
Katrina Total		**$22,480,522**	**$37,163,646**

Table 5. Actual vs. Modeled Losses for Six Storms and Two Companies (Commercial Residential)

Event	Company	Actual Loss ($)	Modeled Loss ($)
Charley	N	$65,465,443	$111,136,975
Charley Total		**$65,465,443**	**$111,136,975**
Frances	N	$60,324,157	$35,637,855
Frances Total		**$60,324,157**	**$35,637,855**
Ivan	N	$22,407,198	$24,816,779
Ivan Total		**$22,407,198**	**$24,816,779**
Jeanne	N	$11,708,119	$25,347,135
Jeanne Total		**$11,708,119**	**$25,347,135**
Wilma	M	$14,953,340	$47,020,978
Wilma	N	$125,190,942	$120,659,841
Wilma Total		**$140,144,282**	**$167,680,819**

Event	Company	Actual Loss ($)	Modeled Loss ($)
Katrina	N	$7,139,327	$11,886,230
Katrina Total		**$7,139,327**	**$11,886,230**

Table 6. Actual vs. Modeled Losses by Coverage for Eight Storms and Seven Companies (Personal Residential)

Coverage	Event	Company	Actual Loss ($)	Modeled Loss ($)
A	Andrew	A	$479,053,020	$534,713,275
A	Andrew	C	$22,888,773	$49,452,115
A	Erin	C	$10,474,623	$19,018,429
A	Charley	G	$12,330,422	$11,476,740
A	Frances	G	$9,755,813	$8,291,996
A	Ivan	I	$5,089,896	$41,506,725
A	Jeanne	I	$8,517,935	$13,687,836
A	Charley	J	$62,338,151	$60,820,368
A	Frances	J	$10,271,271	$30,807,996
A	Wilma	M	$14,021,469	$18,640,520
A	Wilma	N	$51,124,993	$50,567,211
A	Katrina	N	$6,527,939	$4,660,468
A Total			**$692,394,305**	**$843,643,679**
C	Andrew	A	$176,041,470	$97,510,986
C	Andrew	C	$6,160,344	$13,583,521
C	Erin	C	$815,171	$3,085,444
C	Charley	G	$1,576,019	$1,592,605
C	Frances	G	$772,325	$869,532
C	Ivan	I	$697,428	$5,278,341
C	Jeanne	I	$791,274	$1,511,265
C	Charley	J	$4,087,662	$4,961,030
C	Frances	J	$315,552	$1,855,904
C	Wilma	M	$270,656	$1,315,988
C	Wilma	N	$1,813,070	$3,738,582
C	Katrina	N	$233,899	$242,712
C Total			**$193,574,870**	**$135,545,910**
D	Andrew	A	$44,604,539	$59,867,684
D	Andrew	C	$1,827,330	$4,379,086
D	Erin	C	$244,109	$325,555
D	Charley	G	$486,936	$365,594
D	Frances	G	$239,072	$151,475
D	Ivan	I	$155,805	$685,822
D	Jeanne	I	$241,809	$194,800

Coverage	Event	Company	Actual Loss ($)	Modeled Loss ($)
D	Charley	J	$1,449,072	$1,663,287
D	Frances	J	$125,449	$348,625
D	Wilma	M	$53,444	$375,060
D	Wilma	N	$369,507	$239,394
D	Katrina	N	$48,011	$6,032
D Total			**$49,845,083**	**$68,602,414**

Table 7. Actual vs. Modeled Losses by Construction Type for Eight Storms and Eight Companies (Personal Residential)

Construction	Event	Company	Actual Loss ($)	Modeled Loss ($)
Frame	Andrew	A	$49,465,744	$23,107,271
Frame	Andrew	C	$8,987,526	$18,673,852
Frame	Erin	C	$6,881,690	$12,660,349
Frame	Erin	B	$2,646,930	$1,955,158
Frame	Charley	G	$2,435,653	$2,176,102
Frame	Frances	G	$4,553,820	$2,799,773
Frame	Ivan	I	$2,325,399	$18,862,801
Frame	Jeanne	I	$2,939,507	$4,503,765
Frame	Charley	J	$8,453,254	$13,099,342
Frame	Frances	J	$2,851,694	$5,705,975
Frame	Wilma	M	$1,078,031	$1,225,332
Frame	Wilma	N	$15,303,256	$26,748,956
Frame	Katrina	N	$1,380,416	$2,197,407
Frame Total			**$109,302,920**	**$133,716,083**
Masonry	Andrew	A	$650,233,285	$668,984,675
Masonry	Andrew	C	$19,929,848	$41,524,448
Masonry	Erin	C	$2,987,052	$5,718,588
Masonry	Charley	G	$11,908,319	$11,186,396
Masonry	Frances	G	$6,135,762	$6,424,655
Masonry	Ivan	I	$1,029,801	$4,087,945
Masonry	Jeanne	I	$6,082,968	$9,876,026
Masonry	Charley	J	$59,301,884	$54,139,936
Masonry	Frances	J	$7,830,728	$27,168,838
Masonry	Wilma	M	$12,859,659	$17,923,451
Masonry	Wilma	N	$115,532,204	$131,208,966
Masonry	Katrina	N	$11,937,900	$17,780,905
Masonry Total			**$905,769,410**	**$997,804,253**

Construction	Event	Company	Actual Loss ($)	Modeled Loss ($)
Mobile Home	Andrew	C	$485,193	$3,075,056
Mobile Home	Erin	C	$663,292	$3,327,416
Mobile Home	Erin	B	$105,189	$803,268
Mobile Home	Wilma	N	$15,874,921	$17,934,500
Mobile Home	Katrina	N	$1,466,506	$1,121,401
Mobile Home Total			**$18,595,101**	**$26,261,641**

Table 8. Actual vs. Modeled Losses by Construction Type for Six Storms and Two Companies (Commercial Residential)

Construction	Event	Company	Actual Loss ($)	Modeled Loss ($)
Concrete	Charley	N	$2,026,714	$1,362,610
Concrete	Frances	N	$18,957,693	$5,899,095
Concrete	Ivan	N	$2,819,463	$5,165,250
Concrete	Jeanne	N	$1,170,862	$4,305,323
Concrete	Wilma	M	$2,221,720	$2,637,392
Concrete	Wilma	N	$60,983,157	$43,145,804
Concrete	Katrina	N	$2,810,102	$3,466,540
Concrete Total			**$90,989,711**	**$65,982,014**
Masonry	Charley	N	$14,725,592	$21,492,816
Masonry	Frances	N	$31,950,677	$17,227,605
Masonry	Ivan	N	$9,921,781	$2,550,174
Masonry	Jeanne	N	$5,139,136	$12,065,904
Masonry	Wilma	M	$11,356,070	$39,347,253
Masonry	Wilma	N	$57,537,128	$61,955,307
Masonry	Katrina	N	$4,252,495	$7,421,064
Masonry Total			**$134,882,879**	**$162,060,123**

Table 9. Actual vs. Modeled Losses by County for One Company—Hurricane Frances

County	Actual Loss ($)	Modeled Loss ($)
Indian River	$129,401	$235,749
Martin	$162,294	$240,183
Okeechobee	$107,558	$116,184
Palm Beach	$1,641,708	$3,403,000
St. Lucie	$149,397	$201,414

County	Actual Loss ($)	Modeled Loss ($)
Total	$2,190,358	$4,196,530

S-5.2

Provide a completed Form S-4. Provide a link to the location of the form in the submission appendix [insert hyperlink here].

Form S-4: Validation Comparisons

Standard S-6: Comparison of Projected Hurricane Loss Costs

S-6

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.

The historical annual average statewide personal and commercial residential loss costs, produced using the 2017 FHCF exposure data and the historical storm set covering the period 1900–2022, is $3.392 billion. The average annual statewide personal and commercial residential loss costs, produced by the model using a 50,000-year simulation, is $4.284 billion. The difference between these two sets of numbers is statistically reasonable.

The historical annual average statewide personal and commercial residential loss costs, produced using the 2023 FHCF exposure data and the historical storm set covering the period 1900–2022, is $4.593 billion. The average annual statewide personal and commercial residential loss costs, produced by the model using a 50,000-year simulation, is $5.868 billion. The difference between these two sets of numbers is statistically reasonable.

Disclosures

S-6.1

Describe the nature and results of the tests performed to validate the expected hurricane loss projections generated. If a set of simulated hurricanes or simulation trials was used to determine these hurricane loss projections, specify the convergence tests that were used and the results. Specify the number of hurricanes or trials that were used.

Confidence intervals constructed for the difference between the historical and simulated average annual loss costs show that the difference between the two sets of loss costs is statistically reasonable. The validation of projected loss costs also includes comparisons of actual and simulated losses for several historical events that have occurred during the past decade. The use of the Verisk Hurricane Model for the United States for real-time loss estimation, in particular, has shown that the model provides accurate loss projections once the landfall location, storm tracks, and storm parameters are available with a reasonable degree of certainty. Claims data from contributing insurers have also been used to validate the simulated loss costs as outlined in Meteorological and Statistical Hurricane Standards.

As described elsewhere in this document, Verisk has carefully validated all model components including meteorological input variables such as annual frequency, landfall location, and storm intensity. Loss cost maps have been inspected for smoothness and consistency and found to reasonably reflect differences in landfall rates and storm characteristics for different parts of Florida.

For the purposes of ratemaking in Florida, insurers may use a stochastic catalog based on 50,000 simulation years. Sample size calculations, convergence charts, and numerical comparisons of loss costs for increasing number of iterations have been used to establish convergence.

S-6.2

Identify and justify differences, if any, in how the hurricane model produces hurricane loss costs for specific historical events versus hurricane loss costs for events in the stochastic hurricane set.

The methodology for producing hurricane loss costs for historical events is the same as that used for generating hurricane loss costs for events in the stochastic catalog.

S-6.3

Provide a completed Form S-5. Provide a link to the location of the form in the submission appendix [insert hyperlink here].

Form S-5: Average Annual Zero Deductible Statewide Hurricane Loss Costs

6 Vulnerability Hurricane Standards

Standard V-1: Development of Building Hurricane Vulnerability Functions

V-1.A

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

The original U.S. hurricane model vulnerability functions, developed in 1985, were primarily based on structural engineering research publications, damage surveys conducted by wind engineering experts, and analyses of available loss data. Over time, the original damage functions have been fine-tuned based on component-level structural analysis developed by wind engineering experts, the results of post-disaster field surveys from major events both in the U.S. and abroad, recently published research studies, computational simulations and analyses, and detailed analyses of hurricane loss and claims data from insurance clients.

V-1.B

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

The Verisk vulnerability functions have been developed by experts in both wind and structural engineering and based on published engineering research. The functions have been validated based on results of damage surveys and on actual claims data provided by client companies. The methods have been peer reviewed internally and by external experts and are theoretically sound. The vulnerability functions include probability distributions around the mean damage ratios to capture the uncertainty in damage at a given level of wind speed. These probability distributions have been developed based on actual insurance claims data and findings from damage surveys.

V-1.C

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

The residential building stock classification set is derived from census, tax assessor data, engineering surveys, construction reports, and other similar data sources. Building stock classifications are then chosen to be representative of these datasets, and vulnerability functions are developed accordingly. The occupancy and construction classifications in the Verisk Hurricane Model for the United States are representative of the building stock in Florida.

V-1.D

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

The Verisk Hurricane Model for the United States uses vulnerability functions for approximately 32 different residential construction types enumerated in V-1.8. These construction types are dependent upon the primary construction materials of the structural framing and walls, or characteristics of each structure. The model also includes Verisk's Individual Risk Model (Appendix 8: Accounting for Secondary Risk Characteristics) that accounts for a wide range of construction characteristics. For residential single family homes, the vulnerability functions do not vary by height/stories. The building vulnerability functions do vary by height/stories for commercial residential type structures. The model considers three height categories as discussed under V-1.8.

The Verisk vulnerability model includes temporal and regional adjustments that account for changes in the evolution and adoption of building codes and their enforcement, changes in building construction practices, and other factors affecting the regional vulnerability over time. The model differentiates between different building design regions in Florida, based on building codes and other design guidelines, and the model's vulnerability functions are modified accordingly. It is assumed, for example, that buildings in the southern, coastal part of the state are characterized by a higher degree of wind resistivity than those in more northern and central regions. The model also differentiates buildings built in different time periods throughout Florida. Engineering judgment and published research data went into the initial development of the vulnerability adjustments, and subsequent refinement of these has been based upon exposure and loss data provided by clients.

The resulting vulnerability functions reflect the evolution of building codes and the higher level of engineering attention in newer construction relative to older construction. The model captures the state-of-the-art when it comes to adoption and enforcement of building codes in Florida through Florida Building Code (FBC) 2017, which governs the design and construction of personal residential and commercial residential buildings. The vulnerability functions have been validated by comparing actual losses with simulated losses for different areas and time periods in Florida and have been found to be reasonable and theoretically sound. Claims data from past hurricanes in Florida indicate that buildings built prior to 1995 are significantly more vulnerable than buildings built after 1995. Based on the adoption and evolution of building codes, the Verisk Hurricane Model for the U.S. includes the following year-built categories for Florida: pre-1995, 1995-2001, 2002-2011, and post-2011. In addition to the building codes themselves, the model accounts for the impacts of structural aging and deterioration and of building technology changes on the vulnerability of buildings. Buildings built prior to 1995 are perceived as old from both these perspectives, and buildings built within the last six years (2019-2024) are considered new from an aging perspective. Between 1995 and 2019, there is a continuous change in the year-built adjustment to account for structural aging and similar factors. For each year-built category, the Individual Risk Model (Appendix 8: Accounting for Secondary Risk Characteristics) has been used to estimate the vulnerability within the year-built band.

Separate vulnerability functions have been developed for buildings built to the minimum requirements of the Florida Building Code (FBC 2001 and FBC 2010). While six unique building categories (described in Appendix 8: Accounting for Secondary Risk Characteristics) were identified in the entire state of Florida by taking into consideration the design wind speed, the terrain exposure category, and the requirements of the Wind-borne Debris Region (WBDR) and the High-Velocity Hurricane Zone (HVHZ), as specified in FBC 2001, eleven

unique building categories (described in Appendix 8: Accounting for Secondary Risk Characteristics) were identified in the entire state to satisfy the aforementioned considerations of design wind speed, terrain exposure category, WBDR and HVHZ in accordance with FBC 2010. Note that the intermediate versions of FBC from FBC 2001 through FBC 2007 and the associated supplements have no material differences that impact the wind vulnerability. Similarly, subsequent versions that FBC adopted post-2011, including FBC 2010, FBC 2014, and FBC 2017 have no material differences that impact the wind vulnerability of buildings. The vulnerability functions for these building categories were derived using the building features and mitigation measures from the Verisk Individual Risk Module that meet the minimum requirements of FBC 2001 and FBC 2010.

While the design and construction of site-built buildings are based on building codes, the design and construction of manufactured homes has been regulated and governed federally by the U.S. Department of Housing and Urban Development (HUD) since the National Manufactured Housing and Construction Safety Standards Act was passed in 1974. Regulations governing the design, construction, and installation of manufactured homes have evolved considerably since passage of HUD's National Manufactured Housing and Construction Safety Standards Act in 1974. There are two clear dates with respect to manufactured home construction regulations: 1976, when HUD code was first enforced; and 1994, when the HUD code was reinforced in the wake of Hurricane Andrew (1992). In 1999, regulations for tie-downs were updated for Florida. The zinc plating for tie-down straps was increased to provide better resistance to corrosion. In 2008, HUD added a new standard that required manufactured homes in wind zones II and III to have tie-downs. To account for the spatial and temporal variation in the vulnerability of manufactured homes, the Verisk model uses the following year built categories: pre-1976, 1976-1993, 1994-1998, 1999-2007, and post 2007.

V-1.E

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

In the Verisk Hurricane Model for the United States, separate vulnerability functions are derived based on primary and secondary characteristics. Building attributes including occupancy, construction, height/stories, year built and gross area (or square footage) define primary characteristics. Personal residential and commercial residential buildings are two different occupancies and therefore separate vulnerability functions are derived for them. Likewise, at Verisk, manufactured homes are defined as a separate construction class along with several others including wood frame, unreinforced and reinforced masonry, reinforced concrete, and steel, to mention a few. Separate vulnerability functions are derived for each of these unique construction classes when paired with other unique primary features of the risk. Appurtenant structures typically feature in insurance policies as a separate coverage alongside building, contents and additional living expenses (also referred to as time element or business interruption coverage). In the Verisk Hurricane Model for the United States, separate vulnerability functions are derived by coverage. V-1.8 provides more details regarding the same.

V-1.F

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

The model begins calculating losses when the modeled wind speeds achieve a one-minute sustained value of 40 mph. This minimum wind speed assumption is reasonable based on findings from engineering research, damage surveys and actual claims data from historical events.

V-1.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).

The wind vulnerability functions in the Verisk Hurricane Model for the United States do not include any explicit damage from flood, storm surge, or wave actions. Wind vulnerability functions in the Verisk Hurricane Model for the United States have been validated with wind damage data and insurance claims data; they explicitly account for wind speed (which produces wind pressure) and implicitly account for damage resulting from water infiltration and missile impact to the extent that they are reflected in the insurance company loss data.

Disclosures

V-1.1

Provide details of modifications to the building vulnerability component of the hurricane model since the current accepted hurricane model.

The building vulnerability component of the Verisk Hurricane Model for the United States has been updated since the release of the current-accepted model. The changes since the current-accepted model include:

- The pre-computed factors which adjust the base wind structural vulnerability when the user provides no year built information, as opposed to a known year built, have been updated to be relevant through 2024. This includes adjusting the underlying year built weighting assumptions to utilize the latest census and tax assessor data regarding building stock age.
- Vulnerability adjustments that account for structural aging and building technology changes, along with aging and deterioration of roofs in particular, have been updated to be relevant through 2024.
- The “roof year built” secondary risk feature, which defaults the roof age to a new roof for those structures that have been built within the last ten years, has been updated to be relevant through 2024.

V-1.2

Provide a flowchart documenting the process by which the building hurricane vulnerability functions are developed and implemented.

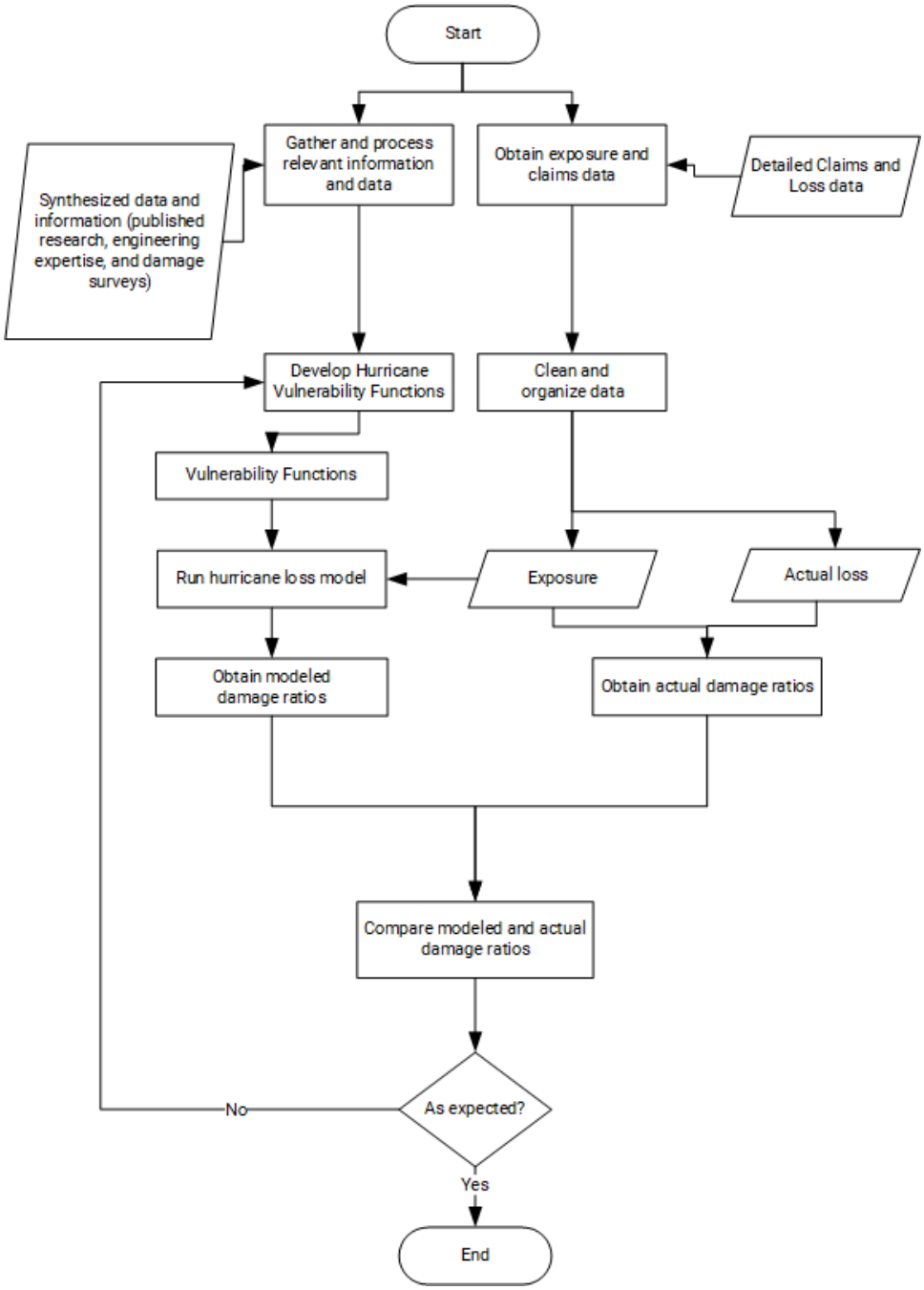


Figure 29. Derivation and Implementation of Verisk Vulnerability Functions

V-1.3

Describe the nature and extent of insurance company hurricane claims data used to develop the building hurricane vulnerability functions. Describe in detail the breakdown of data into number of policies, number of insurers, dates of hurricane loss, amount of hurricane loss, and amount of dollar exposure; separated into personal residential, commercial residential, and manufactured homes.

Insurance claims and loss data used to develop the model's vulnerability functions comes from multiple sources and client companies. Not all companies or sources provide the same level of detail. Loss data for actual events normally consists of claim counts, paid losses, ZIP Code or location level information, and line of business. For events prior to 2000, loss data also tends to be aggregated to ZIP Code by line of business with actual claim counts not being available. Loss data also is frequently provided by date of loss, policy form, coverage, and may contain construction and/or occupancy details and/or secondary characteristics.

Verisk was first provided actual claims data in 1986 when developing the model for the E.W. Blanch Company. Three primary companies submitted detailed loss data for hurricanes Alicia (1983), Diana (1984), Bob (1985), Danny (1985), Elena (1985), Gloria (1985), Juan (1985), and Kate (1985). The aggregated loss data included details by ZIP Code, county or state, by line of business, paid and incurred losses. Detailed exposure data was also available for each company, which included number of risks, amount of insurance and deductibles by five-digit ZIP Code.

In 1989, at the request of a client, Verisk performed a "blind" validation test for hurricanes Frederic (1979), Allen (1980), Alicia (1983), Diana (1984), Danny (1985), Elena (1985), Gloria (1985), Juan (1985), and Kate (1985) based on detailed exposure data (also number of risks, amount of insurance and deductibles by five-digit ZIP Code). Aggregate losses for each hurricane were provided to Verisk after the test. The Verisk test results were judged by the client to be "quite good."

Since 1992, many of our primary company clients, from whom we have detailed exposure data, have also provided aggregated loss data for hurricanes Andrew, Opal, Erin, Bertha, and Fran for validation purposes. Data sets from several permutations of client company/storm losses have been analyzed. Loss data received from these companies is at the ZIP Code level and often by construction class and coverage.

Additional data has been provided by our clients for 1998 hurricanes Bonnie, Earl, and Georges as well as Tropical Storm Frances. Data sets from several permutations of these client company/storm losses have been analyzed. Loss data received from these companies is aggregated at the ZIP Code by line of business.

Verisk has also received detailed claims data from several client companies for the significant 2004 and 2005 Florida storms: hurricanes Charley, Frances, Ivan, Jeanne, Dennis, Katrina, Rita, and Wilma. More recent data has also been obtained for events since 2008 which have occurred elsewhere in the U.S.: hurricanes Ike, Irene, Isaac, and Sandy.

Across these various company datasets, Verisk has been provided with both aggregated and detailed exposure data by several client companies covering in excess of $6.5 trillion of personal (residential), $130 billion of manufactured homes, and $390 billion of commercial residential exposure. In terms of policy count, these would

correspond to over 4,380,000 personal residential, 434,000 manufactured homes and 964,000 commercial residential policies.

As described above, depending on the event and the company, actual loss (claims) data can be classified as either being aggregated at the ZIP Code or detailed at the location of the actual claim. The cumulative loss across all the aggregate loss data exceeds $1.7 billion in loss across personal residential, manufactured homes, and commercial residential lines arising from over 8,650 ZIP Codes that were impacted by events primarily before 2000. The cumulative loss across the detailed loss data exceeds $8.6 billion in loss across personal residential, manufactured homes, and commercial residential lines arising from over 3.5 million claims that were impacted by events primarily post 2004. Across all these claims datasets, close to 86% of the losses are attributed to personal residential lines, with 4% and 10% being the share of loss from manufactured homes and commercial residential, respectively.

In addition to individual company claims, industry insured loss estimates from Verisk's Property and Claims Services (PCS) division for historical hurricane events, including those that impact Florida is also used. PCS's industry insured loss estimates are available at the state level by the individual lines of business: personal, commercial, and automobiles. The summary of the datasets used is shown in the Table 10.

Table 10. Sample Datasets Used in Model Validation and Calibration of Vulnerability Functions

Company	Event	Line of Business
A	Andrew, Bertha, Bonnie, Bret, Charley, Dennis 2005, Earl, Floyd, Fran, Frances, Georges, Irene 1999, Ivan, Jeanne, Katrina, Ophelia, Rita, Wilma	Personal residential, manufactured homes, commercial residential
B	Charley, Frances, Ivan, Jeanne, Wilma	Personal residential, commercial residential
C	Bertha, Bonnie, Erin, Fran, Georges, Opal	Personal residential, manufactured homes
D	Charley, Frances, Ike, Ivan, Jeanne, Katrina, Rita, Wilma	Personal residential, commercial residential
E	Charley, Dennis 2005, Frances, Ivan, Jeanne, Katrina, Wilma	Personal residential, manufactured homes, commercial residential
F	Charley, Frances, Ivan, Jeanne	Personal residential, commercial residential
G	Ike	Manufactured homes
H	Georges	Personal residential, manufactured homes
I	Andrew, Erin, Opal	Personal residential, manufactured homes
J	Charley, Frances, Ivan, Jeanne	Personal residential
K	Charley, Frances, Ivan, Jeanne	Personal residential, commercial residential
L	Bertha, Bonnie, Charley, Earl, Fran, Frances, Georges, Ivan, Jeanne	Personal residential, manufactured homes, commercial residential
M	Michael, Nate, Irma, Matthew, Hermine, Isaac, Wilma, Rita, Katrina, Dennis, Ivan, Frances, Charley, Irene1999, Floyd, Georges	Personal residential, manufactured homes, commercial residential

In summary, the Verisk model vulnerability functions are based on loss data spanning 13 companies and representing 86 claim books for hurricanes affecting different geographical areas, not Florida exclusively. New data are analyzed as they become available, and any results or findings relevant to the model functionality are incorporated into the appropriate version once all validation of the data is complete.

V-1.4

Describe any new insurance company hurricane claims data received and reviewed since the current accepted hurricane model. Indicate whether the new data, if any, have been incorporated in the hurricane model under review.

Verisk obtained industry insured loss estimates from Verisk's Property and Claims Services (PCS) for Hurricane Ian in 2022 which impacted Florida. In addition to this, industry insured loss estimates were also obtained for Hurricane Ida in 2021 which primarily impacted Louisiana. PCS's industry insured loss estimates are available at the state level by line of business: personal, commercial, and automobiles, separately. For some of these significant events, including Hurricane Ian (2022) and Hurricane Ida (2021), PCS estimates are available at the county level by the aforementioned lines of business. No new data has been incorporated in the hurricane model under review from the current accepted hurricane model.

V-1.5

Describe the assumptions, data (other than insurance company hurricane claims data), methods, and processes used for the development of the building hurricane vulnerability functions.

The vulnerability functions developed by Verisk have been constructed through comprehensive engineering analysis, which includes data derived from post-event damage surveys, expert consultations, and analysis of claims and industry loss data. The engineering analysis relies on fundamental structural engineering principles, the diverse academic and industry background of Verisk's engineering team, past and current construction methodologies (including the use of building codes and regulations), and continued assessment of the available engineering and scientific literature (e.g., *Journal of Wind Engineering and Industrial Aerodynamics*, *Journal of Structural Engineering,* etc.).

The vulnerability functions have also been peer reviewed externally by leading experts in structural engineering to acquire an unbiased opinion and point of view. Additionally, when claims or loss data are available, the functions are again assessed to ensure a reasonable outcome. Figure 29 in V-1.2 shows how the development of the vulnerability model through these components interacts.

V-1.6

Describe the basis, development, modeling, and treatment of uncertainties associated with the building hurricane vulnerability functions.

The Verisk model captures uncertainty in building damage at a given location from an event by characterizing the damage ratio—defined as the repair cost divided by the replacement value—as a random variable and defining its probability law. The vulnerability function is a representation of mean damage ratio as a function of hazard, with a probability distribution around the mean damage ratio that changes at different levels of damage. These varying probability distributions around the mean damage ratio are referred to as secondary distributions.

In the Verisk model, the secondary distributions are based on insurance company claims data from several major companies across multiple events. These distributions are characterized by two discrete spikes (representing the

probability of no damage and total damage) and a discretized transformed beta family to describe the main part. This 4-parameter family of distributions affords great flexibility in producing a variety of shapes represented by insurance company claims at different values of mean damage ratios, and particularly in reproducing the heavy tails exhibited by the data. A key element of these distributions is the smooth transitioning shapes of the spikes and the main part as the mean damage ratio increases. The distributions transition naturally from the spike at zero damage, monotonically inflating the bell-shaped part which then moves towards the spike at total damage.

When the building's primary risk characteristics including occupancy, construction, height, year built, square footage (or gross area) are specified, the vulnerability functions reflect the refined view due to the specified features, which in turn changes the probability distribution of damage. The same is true when mitigation measures or secondary risk features are used, and this is described in V-4.8. In short, the primary and secondary risk features implicitly affect the uncertainty in vulnerability by changing the mean damage ratio in the model and account for the variations in expected performance within each building class. An underlying assumption is that a significant portion of the uncertainty in damage at a given location can be attributed to uncertainty in wind loads (wind speed, its evolution over time, and how wind interacts with the building structure) acting on the structure.

V-1.7

Summarize post-event site investigations, including the sources, and provide a brief description of the resulting use of these data in the development of building hurricane vulnerability functions.

Verisk engineers and scientists have surveyed all significant loss causing events since Hugo in 1989, including the notable events such as Andrew, Fran, Georges, Floyd, Charley, Frances, Ivan, Jeanne, Dennis, Katrina, Rita, Wilma, Gustav, Ike, Irene, Sandy, Matthew, Harvey, Irma, Florence, Michael and most recently, Ian in 2022. Additionally, Verisk engineers and scientists have surveyed damage in the aftermath of major storms outside of the mainland U.S., including Hurricane Floyd in the Bahamas, Hurricane Fabian in Bermuda, Tropical Cyclone Yasi in Australia, Hurricane Irene in the Caribbean, Tropical Storm Iselle in Hawaii, Hurricane Gonzalo in Bermuda, Hurricane Maria in Puerto Rico, and Hurricane Dorian in the Bahamas. These surveys improve our understanding of the response of structures to winds, including damage mechanisms. Such damage investigations provide, for example, information on the relative vulnerability of various construction types and building components used in the development and validation of the vulnerability relationships.

Based on Verisk's damage investigations, buildings can generally be classified as "engineered" or "non-engineered" structures. Most residential dwellings are generally classified as non-engineered. A typical example is a wood frame single-family dwelling, a construction that may not have received much attention from a structural engineer. Most commercial structures—often built in accordance with building codes and under the supervision of a structural engineer—are classified as engineered structures. A typical example of an engineered structure is a high-rise reinforced concrete building.

In general, an engineered building is more wind resistant than a non-engineered building. Post-disaster surveys conducted by Verisk engineers and scientists indicate that low-rise commercial and residential- commercial wood frame and masonry buildings, which do not get as much engineering attention as high- rise buildings, have similar vulnerability to their residential counterparts. Recent damage surveys also indicated that the year-built of a residential dwelling provides important information in determining its vulnerability. Newly-built buildings were observed to perform better than older counterpart buildings.

Wind damage primarily affects non-structural elements such as windows, cladding, and other components of the building envelope. Field surveys indicate that the initial point of failure of wood-framed homes often occurs at the roof, likely due to the improper fastening of the roof covering, sheathing, support structure, and building frame. Other roof system failures could be attributed to the lifting and peeling of metal edge flashings, and from here additional damage will propagate. Uplift of the roof edges allows the wind to penetrate underneath the roof membrane, resulting in a pressure rise beneath the membrane and removal of the roof covering. At high wind speeds, the integrity of the entire structure can be compromised, particularly in cases where the roof provides lateral stability by supporting the tops of the building's walls.

Thus, three damage regimes can be identified for residential buildings: a) the low damage regime corresponding to wind speeds of less than about 90 mph, where damage is limited to roof covering and cladding, b) the medium damage regime where damage propagates to roof sheathing, connections and openings and c) the catastrophic damage regime corresponding to wind speeds in excess of 130 mph, where the roof framing is severely damaged, resulting in lateral instability of walls causing further collapse and complete destruction of the building. In the case of engineered buildings, damage typically occurs to non-structural components like mechanical equipment, roofing, cladding and windows; complete structural collapse is extremely rare.

In certain parts of the United States, masonry building systems are the prevalent construction method for residential and commercial residential construction. When masonry is used as the exterior wall material, the walls are normally constructed to full height and then wood floors and the roof are framed into the masonry. Damage investigations have confirmed that such construction results in continuous exterior walls and thus a stronger structural frame, resulting in exterior walls that are more resistant to winds and windborne debris impacts as compared to wood frame buildings.

While exploring the damage caused by Hurricane Georges (1998) and Tropical Storm Frances (1998), Verisk engineers validated the effects of wind duration on damage estimation, a fundamental component of the Verisk vulnerability model. Damage resulting from a slower moving (longer duration) storm can be higher because of the cumulative effects of wind.

Information obtained from post-disaster damage investigations has been incorporated into the development and validation of the vulnerability model.

V-1.8

Provide the total number of building hurricane vulnerability functions available for use in the hurricane model for personal and commercial residential classifications. Describe the categories of the different building hurricane vulnerability functions. Specifically, include descriptions of the building types and characteristics, building height, number of stories, regions within the state of Florida, year of construction, and occupancy types for which a unique building hurricane vulnerability function is used.

The Verisk Hurricane Model for the United States has many unique vulnerability functions depending on the building construction type, height, occupancy type, year-built, and gross area as well as secondary features. Secondary risk characteristics are implemented as a modification to the underlying vulnerability functions and are described in Appendix 8: Accounting for Secondary Risk Characteristics; they can be implemented through direct user input, through input of exposure location and year of construction information, or both.

Generalizations of these construction types, which are representative of our vulnerability classifications, are given in Table 11, and the modeled height categories are provided in Table 12. The Verisk Hurricane Model for the United States includes year-built categories: pre-1995, 1995-2001, 2002-2011 and post-2011. Between 1995 and 2019 there is a year-by-year change in the year-built adjustment to account for structural aging, a general behavior in the vulnerability observed in actual loss data. Table 13 lists all the mitigation measures in the Verisk Hurricane Model for the United States.

Table 11. Residential Construction Types in the Verisk Hurricane Model for the United States

Construction Types, Residential and Apartment or Condominium Buildings	General Description
Wood Frame	Wood frame structures tend to be mostly low rise (one to three stories, occasionally four stories). Stud walls are typically constructed of 2 inch by 4 or 6 inch wood members vertically set 16 or 24 inches apart. These walls are braced by plywood or by diagonals made of wood or steel. Many detached single and low-rise multiple family residences in the United States are of stud wall wood frame construction.
Masonry Veneer	Wood frame structures with one width of non-load bearing concrete, stone or clay brick attached to the stud wall.
Unreinforced Masonry	Unreinforced masonry buildings consist of structures in which there is no steel reinforcing within a load bearing masonry wall, floors, roofs, and internal partitions in these bearing wall buildings are usually of wood.
Reinforced Masonry	Reinforced masonry construction consists of load bearing walls of reinforced brick or concrete-block masonry. Floor and roof joists constructed with wood framing are common.
Reinforced Concrete	Reinforced concrete buildings consist of reinforced concrete columns and beams.
Steel	Steel frame buildings consist of steel columns and beams.
Light Metal	Light Metal buildings are made of light gauge steel frame and are usually clad with lightweight metal or asbestos siding and roof, often corrugated. They typically are low-rise structures.
Unknown	Represents a weighted average of all of the above construction types except the manufactured homes

Construction Types, Manufactured Homes	General Description
Manufactured Home with No Tie-Downs	This code would be used for manufactured homes with no anchoring systems present.
Manufactured Home with Partial Tie-Downs	This code would be used for manufactured homes when the tie downs are either over-the-top ties, or frame ties but not both or with fewer ties than recommended by the manufacturer.
Manufactured Home with Full Tie-Downs	This code would be used for manufactured homes when the anchoring systems are both over-the-top ties, and frame ties. Typically 10 frame ties and 7 over the top ties are required for full tie down in single-wide manufactured homes.
Manufactured Homes	Represents a weighted average of tie-down types, including no tie-downs. This code would be used for manufactured homes (manufactured homes) when the tie down information is unknown.

These construction types are typically provided by primary insurer client companies.

Table 12. Height Bands for Different Construction Types in the Verisk Hurricane Model for the United States

Occupancy	Construction	Height category (# of stories)
Residential Buildings (Single Family Homes)	All	All heights
Apartment or Condominium Buildings	Wood Frame	1, >1
	Masonry veneer	1, >1
	Unreinforced Masonry	1, 2-3, >3
	Reinforced Masonry	1, 2-3, >3
	Reinforced Concrete	1-3, 4-7, >7
	Steel	1-3, 4-7, >7
	Light Metal	All height
	Unknown	1-3, 4-7, >7

Apartments and condominiums usually receive a similar degree of engineering attention as general commercial construction. From a structural viewpoint, therefore, commercial construction and apartments/condominiums are quite similar. Nevertheless, apartments and condominiums have some building components that make them more susceptible to windstorms than other commercial construction. For example, the more vulnerable components found in apartments and condominiums include balconies, awnings, and double sliding glass doors. These components often have little engineering attention at the design and construction stages and hence can lead to apartments/condominiums being more vulnerable than commercial construction in general.

For single-family residential structures, vulnerability functions do not vary by height (see Table 12). However, Verisk engineers have developed separate vulnerability functions for several height ranges for apartment/condominium structures. Vulnerability functions, through the use of the Individual Risk Model (see Appendix 8: Accounting for Secondary Risk Characteristics), also vary by year-built of construction for both residential and commercial structures to account for changes in the building codes and construction practices, structural aging and other factors.

Regional variation in vulnerability across Florida and the United States, similar to the year of construction adjustment, is captured through the use of Verisk's secondary risk characteristics. Regions are generally delineated through the synthesis of building codes, both through the design wind speed maps provided and through explicit identification of vulnerable areas, such as wind-borne debris regions or the High-Velocity Hurricane Zone (HVHZ) outlined in 2001 FBC and 2010 FBC. The model combines this information with the location details provided by client companies to develop the appropriate vulnerability for the structure.

Across the different combinations of primary and secondary characteristics, there are at a minimum hundreds of vulnerability functions. Occupancy, construction, height, year of construction (year built) and gross area (square footage) are defined as primary characteristics and vulnerability is dependent on all five variables. Three of these characteristics are discrete: occupancy, construction and height. The characteristic year built can be known or unknown; for known values, occupancy, construction and height characteristic combinations are modified based on a function of the year built. Appendix 8: Accounting for Secondary Risk Characteristics shows the spatial and temporal vulnerability discretization in the model for different year built bands. When the year built characteristic

is unknown (or not input by the user), the model creates unknown year built functions over 10 km square grids over Florida. Within each 10 km square grid, the unknown year built functions are weighted averages over all known year built functions, the weights derived from building inventory age distribution over the grid. These unknown year built functions then modify the vulnerability functions for a given occupancy, construction, height pair. The same is true when considering the impact of gross area (or square footage). Additional vulnerability functions represent the impact of the 27 different secondary features (and respective options within each feature) which may be considered in combination with the primary features.

V-1.9

Describe the process by which local construction practices and statewide and county building code adoption and enforcement are considered in the development of the building hurricane vulnerability functions.

The Verisk Hurricane Model for the United States considers the regional variation in building codes as explained in V-1.D and V-1.8. Depending upon the design wind speed maps, terrain exposure categories, and requirements for Wind-borne Debris Region (WBDR) and High-Velocity Hurricane Zone (HVHZ), the vulnerability within the State of Florida will vary across multiple regions. Further, variation in local construction practices, building code adoption and enforcement can be captured within the loss estimation model through the use of Verisk's secondary risk characteristics (see Appendix 8: Accounting for Secondary Risk Characteristics), in which the users can input detailed building features as appropriate.

V-1.10

Describe the relationship between building structure and appurtenant structure hurricane vulnerability functions and their consistency with insurance company hurricane claims data.

The building structure and appurtenant structure vulnerability functions are independent, and damage is calculated separately. This means that the damage to appurtenant structures is calculated directly from the impacting hazard, but in a manner consistent with that of the primary building damage calculation. If the structural characteristics of the appurtenant structure are known, the model allows for the flexibility to calculate the damage separately from the primary structure based on its own individual characteristics.

The vulnerability functions for appurtenant structures were developed through analysis of insurance company claims data, published research on vulnerability characteristics and through damage surveys when possible. The process for developing vulnerability functions for this coverage type is the same as that presented in V-1.2.

V-1.11

Describe the assumptions, data (including available insurance company hurricane claims data), methods, and processes used to develop building hurricane vulnerability functions when:

a. residential construction types are unknown, or

b. one or more primary building characteristics are unknown, or

c. one or more secondary characteristics are known, or

d. building input characteristics are conflicting.

The vulnerability functions used for a residential building where the construction is unknown are obtained through a weighted average of the vulnerability curves of the individual residential buildings with known construction classes within a particular state/region. For example, typical construction types/classes that may be used for residential single-family dwellings are wood frame and masonry. In most cases these are the typical construction types/classes used to classify residential structures as identified in the data provided by our client companies or through census/tax assessor data. The composite vulnerability curve, used when the construction type is listed as unknown, is based on a building-inventory weighted average of the different construction classes within the area considered (i.e. state, region, etc.).

The Verisk Hurricane Model for the United States supports regional variation in vulnerability when the construction characteristic is unknown. The regional variation is based upon Verisk's knowledge of building code procedures and practices in place, adjusting the vulnerability curves accordingly. Thus, an unknown vulnerability function exists for each occupancy class and within a region, based on the distribution and vulnerability of known structures from industry sources (see the response to V-1.C).

It should be noted that the unknown construction vulnerability for residential occupancy does not apply weight from the manufactured home type. In most cases, the client is able to supply manufactured home exposures separately. Since the vulnerability of manufactured homes is much greater than that of other construction types, it would not be appropriate to use this construction class in the composite function for residential "unknown." See Appendix 8: Accounting for Secondary Risk Characteristics for a full discussion of the secondary characteristic methodology, which accounts for regional variations in construction and other secondary risk characteristics.

When primary characteristics such as occupancy, height, and year of construction are unknown, the vulnerability functions are obtained in a similar fashion as described previously for the case when the construction type is unknown. Vulnerability functions for all combinations of unknown occupancy and height classes are developed as weighted averages of the damage functions for buildings for which these characteristics are known within a particular state/region. For example, the vulnerability function for a building of known construction and occupancy, but unknown height, would be a weighted average of the vulnerability functions for the same construction and occupancy classes, corresponding to all the different height classes described in Table 12. In all these cases, the knowledge about the local building inventory which forms the weights for the aforementioned weighted averages is captured in Verisk's proprietary industry exposure database. In the case of unknown year of construction, the individual known year vulnerability functions are then combined to create a vulnerability function, and that combination is a weighted average of the distribution of housing stock age based on Verisk's industry exposures (incorporating census and tax assessor data).

When one or more secondary characteristics are known, their impact is implemented as a modification to the underlying vulnerability functions using the Individual Risk Model that is described in Appendix 8: Accounting for Secondary Risk Characteristics.

The Verisk Hurricane Model for the United States has many unique vulnerability functions, which depend on the building construction type, height, occupancy type, year built, and gross area as well as on secondary features. Generalizations of these construction types, which are representative of Verisk's vulnerability classifications, are shown in Table 11. The modeled height categories are shown in Table 12, as described in V-1.8 The definitions of these primary building input characteristics preclude the issue of conflict among them. This can be illustrated using an example. For instance, if a user is trying to model a 10-story single family home, the 10-story input conflicts with a typical height input for a single- family home. The height definition shown in Table 12 ensures that a reasonable damage function, with a logical height, is assigned to the risk.

V-1.12

Identify the one-minute average sustained windspeed and the windspeed reference height at which the hurricane model begins to estimate damage.

The model begins to estimate damage to structures when the one minute sustained wind speed, at a reference height of 10 meters, is greater than (or equal to) 40 miles per hour.

V-1.13

Describe how the duration of windspeeds at a particular location over the life of a hurricane is considered.

The vulnerability model calculates damage utilizing a complete time profile of wind speeds (above 40 mph) for each location affected, thus capturing the effects of wind duration on structures. Design wind loads are routinely exceeded in tropical cyclones, often with only moderate intensity. With no reserve strength, a fastener or connector that has been pulled out from an uplift load can compromise the integrity of the building envelope. Wind damage is manifested at the weak links in a structural system. As each connector is overwhelmed, loads are transferred to the next point of vulnerability. The longer the duration of high winds, the longer this process continues and the greater the resulting damage from overwhelmed connections. More information can be obtained from the following research paper: "Statistical Analysis of 2004 and 2005 Hurricane Claims Data," Proceedings of the 11th Americas Conference on Wind Engineering, San Juan, Puerto Rico, June 22-26, 2009 (Available at: http://www.iawe.org/Proceedings/11ACWE/11ACWE-Jain.Vineet2.pdf).

The cumulative effects of winds can be examined using a dynamic approach. In order to estimate damage to a property at any point in time, it is important to take into account the extent of the damage that has occurred in the preceding period. Each damage ratio is applied in succession to the remaining undamaged portion of the exposure from the preceding period. Figure 30 illustrates this process.

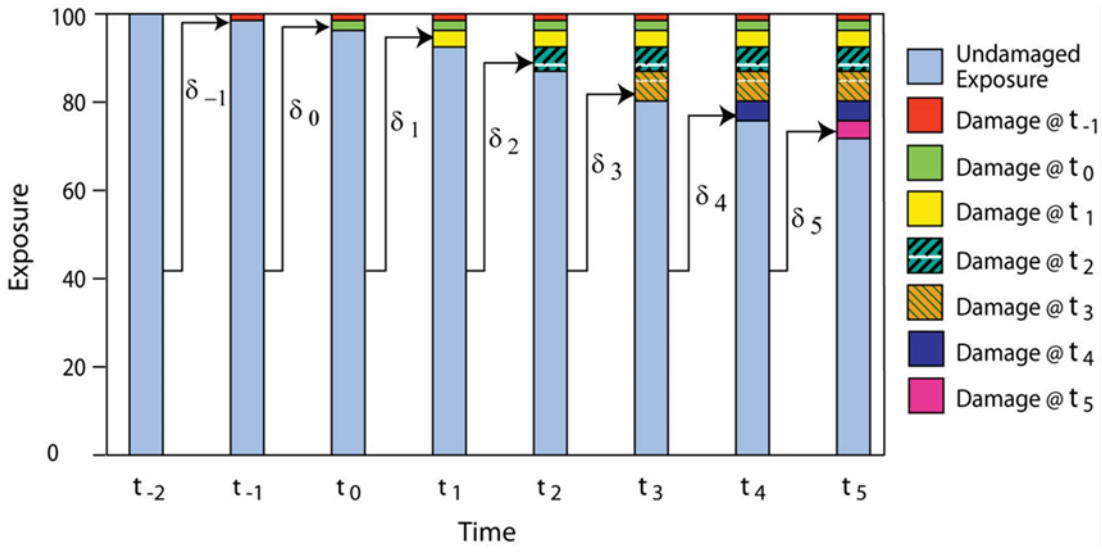


Figure 30. Process of Accounting for the Impact of Wind Duration

At t_{-2}, before the hurricane has made landfall, there is zero or negligible damage. At time t_{-1}, prior to landfall with peripheral wind speeds above 40 mph, the damage ratio δ_{-1} is calculated as a percentage of the full replacement value. At t_0, when the storm makes landfall, the damage ratio δ_0 is applied to the percentage of the property that was left undamaged in the previous period. This process continues until wind speeds once again fall below 40 mph.

Calculating damage only when winds are at their maximum, for example at t_3, and applying a single damage ratio, δ_3, to the full replacement value would ignore the cumulative effects of prolonged winds. Thus, the damage estimation module of the Verisk Hurricane Model for the United States considers the complete time profile of wind speeds at each location.

V-1.14

Describe how the hurricane model addresses wind-borne missile impact damage and water infiltration.

The Verisk vulnerability model implicitly accounts for the impact of wind-borne debris and water infiltration damage, to the extent that such damage is captured or reflected in the insurance claims data which underlies the model validation. To the extent that the client knows the site conditions of the exposure, the impact of various debris sources on the vulnerability can be captured using additional secondary characteristic selections, as outlined in Appendix 8: Accounting for Secondary Risk Characteristics. Similarly, the ability of a structure to resist water infiltration through various mitigation features can also be captured using secondary characteristic selections.

V-1.15

Provide completed Form V-1. Provide a link to the location of the form in the submission appendix [insert hyperlink here].

Form V-1: One Hypothetical Event

Standard V-2: Development of Contents Hurricane Vulnerability Functions

V-2.A

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

The Verisk Hurricane Model for the United States vulnerability functions for contents are primarily based on engineering and insurance-related research publications, damage surveys conducted by wind engineering and damage experts in the aftermath of historical hurricanes, and analyses of available insurance company claims and loss data. Over time, the damage functions have been fine-tuned based on the results of post-disaster field surveys from major events in the U.S. and abroad, recently published research studies, computational simulations and analyses, and on detailed analyses of loss data from clients.

V-2.B

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

The relationship among the modeled building damage ratios and modeled contents damage ratios is reasonable based on comparisons to actual loss data from client companies. Verisk validates the model's content vulnerability functions at many levels, from an aggregate industry level loss perspective down to insurance company claims at individual policies or locations. When the client provides exposure information related to contents coverage, Verisk will supply the provided information to the model, including insurance policy terms. The subsequent claims data corresponding to the exposure may or may not include loss information which contains the application of policy terms. Verisk will compare the claims data, based on the knowledge of whether the values provided include policy conditions, with modeled output that contains both loss information before the application of policy conditions (ground-up) and after the application of policy terms (gross). This process is used for contents loss validation and underscores the fact that our fundamental formulation of contents vulnerability as a function of building vulnerability is consistent with the signature observed in historical data.

Disclosures

V-2.1

Provide details of modifications to the contents vulnerability component of the hurricane model since the current accepted hurricane model.

There have been no changes to the contents vulnerability component of personal and commercial residential buildings in the Verisk Hurricane Model for the United States since the current-accepted model.

V-2.2

Provide a flowchart documenting the process by which the contents hurricane vulnerability functions are developed and implemented.

The process for deriving and implementing the contents vulnerability functions in the Verisk Hurricane Model for the United States is the same as that used for developing and implementing the building vulnerability functions, as outlined in V-1.2.

V-2.3

Describe the assumptions, data, methods, and processes used to develop the contents hurricane vulnerability functions.

In the Verisk Hurricane Model for the United States, the contents vulnerability is a function of the building vulnerability, such that the resulting contents mean damage ratio is a function of the building mean damage ratio. The model has distinct content vulnerability relationships for both single-family residential structures and commercial residential structures. The damage ratio for single-family residential contents is typically lower than the corresponding building damage ratio, for a given wind speed, as building damage is usually required before contents damage typically occurs. For commercial residential structures, which tend to be larger in size and have a higher level of engineering attention, there can be significant damage to contents even for minor non-structural damage. Typically, these types of structures experience damage to cladding, windows and sliding doors, which drive the potential for significant contents damage.

Verisk validates the model's content vulnerability functions at many levels, from an aggregate industry level loss perspective down to claims at individual policies or locations. When the client provides exposure information related to contents coverage, Verisk will supply the provided information to the model, including insurance policy terms. The subsequent claims data corresponding to the exposure may or may not include loss information which contains the application of policy terms. Verisk will compare the claims data, based on the knowledge of whether the values provided include policy conditions, with modeled output that contains both loss information before the application of policy conditions (ground-up) and after the application of policy terms (gross). This process is used for contents loss validation in the same way that is used for building vulnerability validation.

V-2.4

Describe the basis, development, modeling, and treatment of uncertainties associated with the contents hurricane vulnerability functions.

The Verisk model captures uncertainty in contents damage at a given location from an event by characterizing the damage ratio—defined as the repair cost divided by the replacement value—as a random variable and defining its probability law. The vulnerability function is a representation of contents mean damage ratio as a function of building damage, with a probability distribution around the mean damage ratio that changes at different levels of damage. These varying probability distributions around the mean damage ratio are referred to as secondary distributions. In the Verisk model, the secondary distributions for contents are based on insurance company

claims data from several major companies across multiple events. Disclosure V-1.6 provides significant details about the basis, development, modeling and treatment of uncertainties associated with damage functions across all four supported coverages in the model including contents coverage.

V-2.5

Provide the total number of contents hurricane vulnerability functions. Describe whether different contents hurricane vulnerability functions are used for personal residential, commercial residential, manufactured homes, unit location for condo owners and apartment renters, and various building classes.

In the Verisk Hurricane Model for the United States, the contents vulnerability is a function of the building vulnerability. There are two basic content vulnerability functions, one each for residential and commercial residential structures. Condo owners and apartment renters would apply the commercial residential contents functions while personal residential and manufactured homes would apply residential contents functions. Since the content vulnerability function is a function of the building vulnerability function, the resulting content vulnerability as a function of the hazard is unique for each construction/occupancy type described in Standard V-1: Development of Building Hurricane Vulnerability Functions.

V-2.6

Describe the relationship between building and contents hurricane vulnerability functions.

The contents vulnerability functions for residential and commercial residential construction are a function of the mean building damage. These relationships are developed using claims data, published engineering studies, and expert engineering judgment. The Verisk Hurricane Model for the United States calculates contents damage separately from building damage.

V-2.7

Describe how the impact of water infiltration is accounted for in the contents vulnerability functions.

For wind perils, it is generally accepted that wind driven rain and impact of water infiltration is the primary driver of contents losses and henceforth their damageability. Since the model's vulnerability functions are calibrated and validated using insurance company claims data and water infiltration is the primary source of contents damage, the impact of the same is accounted for implicitly.

Standard V-3: Development of Time Element Hurricane Vulnerability Functions

V-3.A

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

The Verisk Hurricane Model for the United States vulnerability functions capturing the impact of time element are primarily based on engineering and insurance-related research publications, damage surveys conducted by wind engineering and damage experts in the aftermath of historical hurricanes, and analyses of available loss data. Over time, the damage functions have been fine-tuned based on the results of post- disaster field surveys from major events in the U.S. and abroad, recently published research studies, computational simulations and analyses, and on detailed analyses of loss data from clients.

V-3.B

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

The relationship among the modeled building damage ratios and modeled time element damage ratios is reasonable based on comparisons to actual loss data from client companies. Verisk validates the model's time element vulnerability functions at many levels, from an aggregate industry level loss perspective down to claims at individual policies or locations. Verisk compares the claims data, based on the knowledge of whether the values provided include policy conditions, with modeled output that contains both loss information before the application of policy conditions (ground-up) and after the application of policy terms (gross). This process is used for time element loss validation and underscores the fact that our fundamental formulation of time element vulnerability as a function of building vulnerability is consistent with the signature observed in historical data.

V-3.C

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

Losses due to time element coverage are based on (i) the mean building damage, (ii) the time estimated to make repairs to or to reconstruct the damaged building, and (iii) the estimated cost of time element coverage per a time period. Implicit in the estimated time to make repairs are any estimated losses that may occur due to damage to the surrounding infrastructure and incurred costs to temporarily relocate the displaced occupants.

V-3.D

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

The vulnerability model considers time element losses or claims that can arise from damage to the infrastructure, as a result of wind, missile impact, flood, and storm surge, to the extent that such losses are reflected in damage survey or insurance claims data used for validation purposes.

Disclosures

V-3.1

Provide details of modifications to the time element vulnerability component of the hurricane model since the current accepted hurricane model.

There have been no changes to the time element vulnerability component of personal and commercial residential buildings in the Verisk Hurricane Model for the United States since the current accepted model.

V-3.2

Provide a flowchart documenting the process by which the time element hurricane vulnerability functions are developed.

The process for deriving and implementing the time element vulnerability functions in the Verisk Hurricane Model for the United States is the same as that used for developing and implementing the building vulnerability functions, as outlined in V-1.2.

V-3.3

Describe the assumptions, data, methods, and processes used to develop the time element hurricane vulnerability functions.

The basic time element vulnerability functions for personal and commercial residential structures are based on the mean building damage, the time it takes to repair/reconstruct the damaged building, and the estimated cost for the time element per time period. At lower wind speeds, the damage to the building is minimal and the time to repair is minimal. However, when higher wind speeds result in significant building damage, the time it takes to repair/reconstruct can be very long. The time element vulnerability model accounts for losses resulting from expenses incurred while the building is being repaired/reconstructed. The vulnerability functions also account for other direct and indirect losses to the extent that they are in the validation data.

Verisk validates the model's time element vulnerability functions at many levels, from an aggregate industry level loss perspective down to claims at individual policies or locations. When the client provides exposure information related to time element coverage, Verisk will supply the provided information to the model, including policy

characteristics and terms. The subsequent claims data corresponding to the exposure may or may not include loss information which contains the application of policy characteristics and terms. Verisk compares the claims data, based on the knowledge of whether the values provided include policy conditions, with modeled output that contains both loss information before the application of policy conditions (ground-up) and after the application of policy terms (gross). This process is used for time element loss validation in the same way that is used for building vulnerability validation.

V-3.4

Describe the basis, development, modeling, and treatment of uncertainties associated with the time element hurricane vulnerability functions.

The Verisk model captures uncertainty in time element damage at a given location from an event by characterizing the mean number of days of downtime as a random variable and defining its probability law. The vulnerability function is a representation of time element mean number of days of downtime as a function of building damage, with a probability distribution around the mean number of downtime days that changes at different levels of damage. These varying probability distributions around the mean are referred to as secondary distributions. In the Verisk model, the secondary distributions for time element are based on insurance company claims data from several major companies across multiple events. Disclosure V-1.6 provides significant details about the basis, development, modeling and treatment of uncertainties associated with damage functions across all four supported coverages in the model including time element coverage.

V-3.5

Describe how time element hurricane vulnerability functions take into consideration damage to local and regional infrastructure.

Verisk does not explicitly model damage to local and regional infrastructure. Validation data for time element coverage reflects actual losses paid by insurance companies. To the extent this data includes losses from damage to infrastructure, losses are then implicitly accounted for by Verisk vulnerability functions within the development, calibration, and validation. Thus, modeled time element losses implicitly take into consideration damage to local and regional infrastructure.

V-3.6

Describe the relationship between building structure and time element hurricane vulnerability functions.

Time element vulnerability functions for residential and commercial construction are functions of the mean building damage and the time it takes to repair or reconstruct the damaged building. Implicit in the time needed to make repairs is damage to the impacted infrastructure, as well as costs for temporarily relocating or other needs. Published building construction/restoration data and expert engineering judgment have been used to establish the functional relationship between building damage and loss of use.

Standard V-4: Hurricane Mitigation Measures and Secondary Characteristics

V-4.A

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

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

The secondary risk characteristics, a part of the Verisk Individual Risk Model documented in Appendix 8: Accounting for Secondary Risk Characteristics, account for the effects of mitigation measures, and were developed using an engineering-based framework in a structured approach. Based on structural engineering expertise and building damage observations made in the aftermath of historical hurricanes, key building features have been identified as having a significant impact on building losses. These features include fixtures or construction techniques that enhance roof strength; roof-covering performance; roof-to-wall strength; wall-to-floor-to-foundation strength; opening protection; and window, door, and skylight strength. Options for each feature are identified based on construction practice. Algorithms for modifying the vulnerability functions, for both structural and nonstructural components, are developed based on engineering principles and building performance observations.

The module supports any combination of multiple building features impact on the overall building damage and produces a modification function to the vulnerability function. The modification function captures the changes to building vulnerability that result when certain building features are present and when information on such building features is known. The modification function varies with the wind intensity to reflect the relative effectiveness of a building feature when subject to different wind speeds.

The building vulnerability component of the Verisk Hurricane Model for the United States explicitly addresses construction built in accordance to the Florida Building Code (FBC) versions, FBC 2001 and FBC 2010.

Methods for estimating the effects of mitigation measures, as described in Appendix 8: Accounting for Secondary Risk Characteristics, are theoretically sound. Disclosure V-4.8 provides an understanding of the treatment of uncertainty in Verisk Hurricane Model for the United States.

V-4.B

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

The list of secondary risk characteristics and hurricane mitigation measures supported in the Verisk Hurricane Model for the United States is detailed in Disclosure V-4.4. These characteristics represent building and environmental characteristics that impact the performance of a building in high winds. These features are selected based on research and damage surveys, which detail building performance in high wind and have the potential to accrue losses when damaged. Some can be categorized as non-structural (cladding, for example), while others are structural (roof and wall systems, for example); still others address very general features such as building condition and, finally, environmental features include such things as the proximity to trees and large, small debris sources.

V-4.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.

The methods of applying mitigation measures are reasonable, both individually and in combination. The mitigation measures are applied using the Individual Risk Methodology, which follows a structured, logical approach that groups building characteristics according to their function. In this way the methodology reflects the contribution of each characteristic to the overall building performance. The result is a modified damage function that reflects the impact of one or more selected building characteristics appropriately.

Weightings are used to combine the effects of multiple features whose interaction is complex and not necessarily additive. For example, when considering the roof system, roof age, roof pitch, roof covering, roof decking and attachment, and roof geometry modify the performance of the roof as a whole and therefore the weight should be used as a multiplier. The weights are dependent on wind speed and construction class and are appropriately selected to reflect the importance of a feature at certain levels of a building's damage state.

There exists limited detailed damage and insurance company claims data with information about mitigation measures. The model has been validated using damage reports from previous hurricanes, engineering judgment, and loss data whenever available. The Individual Risk Methodology is described in further detail in Appendix 8: Accounting for Secondary Risk Characteristics.

V-4.D

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

The Verisk Individual Risk Model is integrated into the hurricane loss projection model to estimate the impact of mitigation features and secondary characteristics on building vulnerability. When any individual mitigation

measure or secondary characteristic or a combination of the individual mitigation features and secondary characteristics supported in the model is provided, the individual risk model calculates the corresponding credits and applies them to the base vulnerability functions to obtain refined vulnerability functions for buildings with the specified features.

The Verisk Individual Risk Model was developed using a structured, engineering based framework that applies structural engineering expertise and building damage observations made in the aftermath of actual hurricanes. The impact of different features is assigned and combined in a logical way that is based on the engineering principles and damage observations. As with the building, content, and time element vulnerability models, the functionality of the modeled mitigation factors is compared against historical insurance loss data for validation. This comparison ensures that the modeled assumptions are combined/handled properly.

Content damage is calculated using the building damage for residential and commercial residential exposures in the Verisk model. Since mitigation measures are explicitly accounted for when estimating building damage in the model, consequently content damage will account for such measures as well.

The Individual Risk Methodology is described in further detail in Appendix 8: Accounting for Secondary Risk Characteristics.

Disclosures

V-4.1

Provide details of modifications to hurricane mitigation measures and secondary characteristics in the hurricane model since the current accepted hurricane model.

There have been no changes to hurricane mitigation measures and secondary characteristics components of personal and commercial residential buildings in the Verisk Hurricane Model for the United States since the current accepted model.

V-4.2

Describe the procedures used to calculate the impact of hurricane mitigation measures and secondary characteristics, including software, its identification, and current version. Describe whether or not such procedures have been modified since the current accepted hurricane model.

The Verisk Individual Risk Model described in Appendix 8: Accounting for Secondary Risk Characteristics has been implemented as a part of the Verisk Hurricane Model for the United States V3.0.0 to capture the impact of hurricane mitigation measures and secondary characteristics on the damageability of buildings. The software is implemented in C++ programming language and is a part of Touchstone 2024A This software has not been modified since the current accepted model.

V-4.3

Provide a completed Form V-2. Provide a link to the location of the form in the submission appendix [insert hyperlink here].

Form V-2: Hurricane Mitigation Measures and Secondary Characteristics, Range of Changes in Damage

V-4.4

Provide a description of the hurricane mitigation measures and secondary characteristics used by the hurricane model, whether or not they are listed in Form V-2.

Table 13 includes all mitigation measures and secondary characteristics that are available in the Verisk Hurricane Model for the United States.

Table 13. Mitigation Measures and Secondary Characteristics in the Verisk Hurricane Model for the United States

Mitigation Measures	Description
Building Condition	General qualitative description of building condition from visual inspection
Tree Exposure	Tree hazard around the building
Small Debris Source	Potential of small debris in a radius of 200 feet
Large Missile Source	Potential of large missiles in a radius of 100 feet
Terrain Roughness	Terrain condition surrounding the building
Roof Geometry	Shape of the roof
Roof Pitch	Slope of the roof
Roof Covering	Material used to cover the roof
Roof Deck	Material and construction type of the roof deck
Roof Cover Attachment	Nature of the connections used to secure the roof covering to the roof deck
Roof Deck Attachment	Nature of the connections used to secure the roof deck to the underlying roof support system
Roof Anchorage	Nature of the connections used to secure the roof support systems to the walls
Wall Type	Materials used for the external walls of the building
Wall Siding	Materials used for weathering protection of the external walls
Glass Type	Type of glass used in the building
Glass Percentage	Percent area of the walls covered by glass
Window Protection	Wind protection systems used
Exterior Doors	Type of exterior doors in the building
Foundation Connection	Connection type between the structure and foundation
Roof Attached Structures	Mechanical and other equipment attached to the top of the roof

Mitigation Measures	Description
Wall Attached Structures	Components of a property that are not an integral part of the main building but are physically attached to it
Appurtenant Structures	Components of a property that are not an integral part of the main building and are not connected to it
Roof Year Built	Year the roof was put in place
Seal of Approval	Level of professional engineering attention given to the design of the structure
Certified Structures *	Indicates whether the building at the location has achieved an Insurance Institute for Business and Home Safety (IBHS) FORTIFIED designation
*A combination of multiple mitigation measures aforementioned in this table is enabled to represent a particular certified structure designation.	

V-4.5

Describe how hurricane mitigation measures and secondary characteristics are implemented in the hurricane model. Identify any assumptions.

The Verisk Individual Risk Model is integrated in the hurricane loss projection model to estimate the impact of mitigation features and secondary characteristics on building vulnerability. When any combination of the individual mitigation features and secondary characteristics listed in Table 13 is provided, the individual risk model calculates the corresponding credits and applies them to the base vulnerability functions to obtain refined vulnerability functions for buildings with the specified features. The Verisk Individual Risk Model has been developed using a structured, engineering based framework that applies structural engineering expertise and building damage observations made in the aftermath of actual hurricanes, including the 2004-05 events (See Appendix 8: Accounting for Secondary Risk Characteristics for details). Options for each feature are identified based on general construction practices.

Algorithms for modifying the vulnerability functions for both structural and nonstructural components are developed based on engineering principles and observations of building performance. The module supports the effects of combination of building features on building damage, and produces a modification function to the vulnerability function. The modification function captures the changes to building vulnerability that result when certain building features are present and when information on such building features is known. The modification function varies with the wind intensity to reflect the relative effectiveness of a building feature when subjected to different wind speeds.

There are two primary metrics in the model—rates and weights—for evaluating the impact of a mitigation feature or secondary characteristic on overall building performance. The rate is a weighted value assigned to the various options for building or environmental features. The rate for any given option of a particular feature reflects the relative prevalence of use among the available options, and is independent of other features. That is, the value is designed such that the most commonly used option is assigned a value close to 1.0. The implication is that a building with this option is expected to perform very similarly to the average, or “typical” building represented by the base damage functions. If no information about the option is available, the default value is 1.0, which means that the base damage function is used without modification.

The second metric, the weight, is a value of one of two types. The first weight type is used to develop simple weighted averages, which are used to evaluate the loss contribution of several features that together constitute a system, such as a roof. They are dependent on wind speed; that is, the contribution of each feature varies with wind speed. For example, a roof may consist of three features: roof covering, roof deck, and roof attachment. The loss contribution to the roof system from these three features is expected to be different at different wind speeds. At low wind speeds, the roof covering drives the damage since it is at relatively low wind speeds that damage to roof covering occurs. As wind speeds increase, the roof deck becomes vulnerable. In this case, roof deck failure will result in loss of roof covering regardless of the type (or option) of roof covering present. Therefore, as wind speed increases, the weight for roof deck increases. In contrast, at higher wind speeds, the weight for roof covering decreases because it is already lost. The sum of the weights for a system should add up to 1.0.

The second type of weight metric is used to combine the effects of features whose interaction is complex and not necessarily additive. These are introduced to evaluate features that modify the performance of the system. If we consider roof system as an example, the age, pitch, and geometry of the roof all modify the performance of the system as a whole. The weight, therefore, should be used as a multiplier. These weights are appropriately selected to reflect the importance of a feature at certain levels of a building's damage state.

V-4.6

Describe how the effects of multiple hurricane mitigation measures and secondary characteristics are combined in the hurricane model and the process used to ensure that multiple hurricane mitigation measures and secondary characteristics are correctly combined.

Disclosure V-4.5 describes in detail the process of combining the effect of different mitigations and secondary characteristics. The impact of different features is combined in a logical way that is based on the engineering principles and damage observations. As with the building, content, and time element vulnerability models, the functionality of the modeled mitigation factors is compared against historical insurance loss data for validation. This comparison ensures that the modeled assumptions are combined/handled properly.

V-4.7

Describe how building and contents damage are affected by performance of hurricane mitigation measures and secondary characteristics. Identify any assumptions.

Standard V-4.A and Disclosure V-4.5 describe in detail how the impact of mitigation measures and secondary characteristics is captured in deriving building vulnerability functions. The Verisk Individual Risk Model is integrated into the hurricane loss projection model to estimate the impact of mitigation features on building vulnerability. When any combination of the mitigation features listed in Table 13 is provided, the Individual Risk Model calculates the corresponding credits and applies them to the base vulnerability functions to obtain refined vulnerability functions for buildings with mitigation features.

Content damage is calculated using the building damage for residential and commercial residential exposures in the Verisk model. Since mitigation measures are explicitly accounted for when estimating building damage in the model, consequently content damage will account for such measures as well.

V-4.8

Describe how roof age and roof covering type are incorporated in the hurricane model.

The Verisk Individual Risk Model is integrated in the hurricane loss projection model to estimate the impact of mitigation features and secondary characteristics including roof age (or roof year built) and roof cover on building vulnerability. When any combination of the individual mitigation features and secondary characteristics listed in Table 13 is provided, the individual risk model calculates the corresponding credits and applies them to the base vulnerability functions to obtain refined vulnerability functions for buildings with the specified features. The Verisk Individual Risk Model has been developed using a structured, engineering based framework that applies structural engineering expertise and building damage observations made in the aftermath of actual hurricanes (See Appendix 8: Accounting for Secondary Risk Characteristics for details). The approach was described in great length in Disclosure V-4.5.

V-4.9

Describe how hurricane mitigation measures and secondary characteristics affect the uncertainty of the vulnerability. Identify any assumption.

The Verisk model captures uncertainty in damage at a given location from an event by characterizing the damage ratio, defined as the repair cost divided by the replacement value, as a random variable and defining its probability law. The vulnerability function is a representation of mean damage ratio as a function of hazard and there is a probability distribution around the mean damage ratio, which changes at different levels of damage. When mitigation measures are used, the vulnerability function (mean damage ratio) changes to reflect the refined vulnerability due to the chosen mitigation features, which in turn changes the probability distribution of damage. Accordingly, mitigation measures implicitly affect the uncertainty in vulnerability by changing the mean damage ratio in the model. An underlying assumption is that a significant portion of the uncertainty in damage at a given location can be attributed to uncertainty in wind loads (wind speed, its evolution over time, and how wind interacts with the building structure) acting on the structure.

V-4.10

Provide a completed Form V-3 if not considered as Trade Secret. Provide a link to the location of the form in the submission appendix [insert hyperlink here].

Form V-3: Hurricane Mitigation Measures and Secondary Characteristics, Mean Damage Ratios and Hurricane Loss Costs (Trade Secret Item) is considered a trade secret item and will be presented to the Professional Team and at the closed meeting of the Commission for review.

V-4.11

Provide a completed Form V-4, Provide a link to the location of the form in the submission appendix [insert hyperlink here].

Form V-4: Differences in Hurricane Mitigation Measures and Secondary Characteristics

V-4.12

Provide a completed Form V-5, if not considered as Trade Secret. Provide a link to the location of the form in the submission appendix [insert hyperlink here].

Form V-5: Differences in Hurricane Mitigation Measures and Secondary Characteristics, Mean Damage Ratios and Hurricane Loss Costs (Trade Secret Item) is considered a trade secret item and will be presented to the Professional Team and at the closed meeting of the Commission for review.

7 Actuarial Hurricane Standards

Standard A-1: Hurricane Model Input Data and Output Reports

A-1.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.

The data imported are comprehensive and appropriate for the intended purpose of the analysis as required by Actuarial Standard of Practice 23: Data Quality. Any adjustments, edits, inclusions or deletions made to client company or other input data to ensure the validity of the analysis are based upon accepted actuarial, underwriting and statistical procedures. For specific details and examples please see Disclosures A-1.3 through A-1.9 and the Touchstone Exposure Data Validation Reference.

A-1.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.

Modeling input data are provided by the user for each catastrophe loss analysis. Each input file is identified by the user. Documentation for the minimum data required and expected default values can be found in Touchstone documentation, the model output report(s) and in the Touchstone Exposure Data Validation Reference.

Upon import, Touchstone validates the data provided. If the data provided by the user are insufficient, the errors are captured in the model output report(s) and the record is removed from the analysis. All modifications, adjustments, assumptions, inputs and input file identification, and defaults necessary to use the model are actuarially sound and are included with the model output reports and documentation. Treatment of missing values required to run the model is actuarially sound and described in Touchstone documentation and the model output report(s).

Disclosures

A-1.1

Identify insurance-to-value assumptions and describe the methods and assumptions used to determine the property value and associated hurricane losses. Provide a sample calculation for determining the property value.

To calculate losses, the model requires replacement value be entered by the user, and entry of insured limits is strongly recommended. Gross loss amounts are capped at insured limit by coverage. The model makes no insurance to value assumptions in the absence of provided limits, and it does not determine property value directly. An insurer may make specific adjustments to the input data if they are aware that insurance-to-value issues exist in their book.

Table 14. Sample Calculation for Adjusting Input Values for Insurance-to-Value (ITV) Assumptions

	Building Limit
Original Limit	$100,000
Underinsurance Assumption	15%
Adjusted Limit	($100,000/ (1.00 - 0.15)) = $117,650

Verisk recommends the user input the Adjusted Limit for the example shown above, to account for the underinsurance assumption.

A-1.2

Identify depreciation assumptions and describe the methods and assumptions used to reduce insured hurricane losses on account of depreciation. Provide a sample calculation for determining the amount of depreciation and the actual cash value (ACV) hurricane losses.

The model makes no depreciation assumptions in the absence of provided inputs, and it does not determine depreciation value directly. If insurance contracts contain ACV provisions, the insurer must determine the amount of depreciation to input for each record. This value can be entered with the input exposure data, and Touchstone will adjust the gross loss estimates accordingly.

Table 15. Sample Calculation for Determining ACV Losses*

Replacement Value	$100,000
Limit	$100,000
Depreciation Factor	0.6
Ground-up Loss Estimate	$50,000
Gross Loss Estimate	Min[($50,000 x 0.6), $100,000]
** Ignoring application of deductible and secondary uncertainty*	

A-1.3

Describe the methods and input data used to distinguish among policy form types (e.g., homeowners, dwelling property, manufactured homes, tenants, condo unit owners) and their deductibles and coverage limits.

The Verisk Hurricane Model for the United States can distinguish all policy form types. The way the model distinguishes policy form types is through exposure coding. Exposures are distinguished based on vulnerability characteristics, such as construction type and occupancy. Policy form (i.e. dwelling property) can also be carried as a reporting field, but it is not explicitly modeled. For all policy forms, losses are estimated separately based on vulnerability characteristics coded on the exposure and by coverage for coverages A, B, C, and D or any combination thereof. The model can produce loss costs for defined groups of policies if vulnerability characteristics are known. Such characteristics are described in Standard V-1: Development of Building Hurricane Vulnerability Functions.

Input data includes occupancy and construction codes. Deductibles and limits are estimated using the same formulas and logic for all policy forms. The average annual deductible application uses the same method applied to the appropriate secondary distributions from the engineering or vulnerability module. Similarly, coverage limits are applied to ground-up losses after the deductible application using the same method regardless of occupancy code or policy form.

A-1.4

Provide a copy of the input form(s) used by the hurricane model with the hurricane model options available for selection by the user for the Florida hurricane model under review. Describe the process followed by the user to generate the hurricane model output produced from the input form. Include the hurricane model name, version identification, and platform identification on the input form. All items included in the input form shall be clearly labeled and defined.

There is no single required input form for exposure data being imported into the software. It is flexible enough to handle many types of input formats. Comma Separated Value (.csv) files are commonly used to import data into Touchstone. The Import section of the Touchstone Online Help describes the format of csv files that can be used to import detailed exposure information into Touchstone and the Exposure Data Validation section of the Touchstone Online Help details the exposure data elements that can be input for the derivation of loss estimates from the model.

A sample of an input form used by the hurricane model is shown below in Figure 31. During the import process, the user can set default import assumptions, shown in Figure 32.

ContractID	LocationID	State	County	Postal	Country	Currency	RiskCount	RepValBldg	RepValOther	RepValCont	RepValTime	DaysCovered
3_OF_1989_01_0dol_0_00_0_0_0	3_OF_1989_01_0dol_0_00_0_0_0_00041_011	FL	11	41	US	USD	1	100000	10000	50000	300	1
3_OM_1989_01_0dol_0_00_0_0_0	3_OM_1989_01_0dol_0_00_0_0_0_00041_011	FL	11	41	US	USD	1	100000	10000	50000	300	1
3_MH_1989_01_0dol_0_00_0_0_0	3_MH_1989_01_0dol_0_00_0_0_0_00041_011	FL	11	41	US	USD	1	50000	5000	25000	300	1
:	:	:	:	:	:	:	:	:	:	:	:	:

...cont'd

ConstructionCode	ConstructionOther	OccupancyCode	YearBuilt	Stories	LocPerils	LocLimitType	LimitBldg	LimitOther	LimitContent	LimitTime	DeductType
101	101	301	1989	1	PWH	C	100000	10000	50000	20000	CB
111	111	301	1989	1	PWH	C	100000	10000	50000	20000	CB
191	191	301	1989	1	PWH	C	50000	5000	25000	10000	CB
:	:	:	:	:	:	:	:	:	:	:	:

...cont'd

DeductBldg	DeductOther	DeductContent	DeductTime	RoofGeometry	RoofCover	RoofDeckAttachment	RoofAnchorage	WindowProtection
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
:	:	:	:	:	:	:	:	:

Definitions:

Limit Type = how the limits are applied; a limit type of C, for example, specifies the limits are applied by coverage

Deductible Type = how the deductibles are applied; a type of AA, for example, specifies average annual deductibles are applied

Geographical Input= county and or postal required, alternatively latitude and longitude of location

Figure 31. Sample Input File

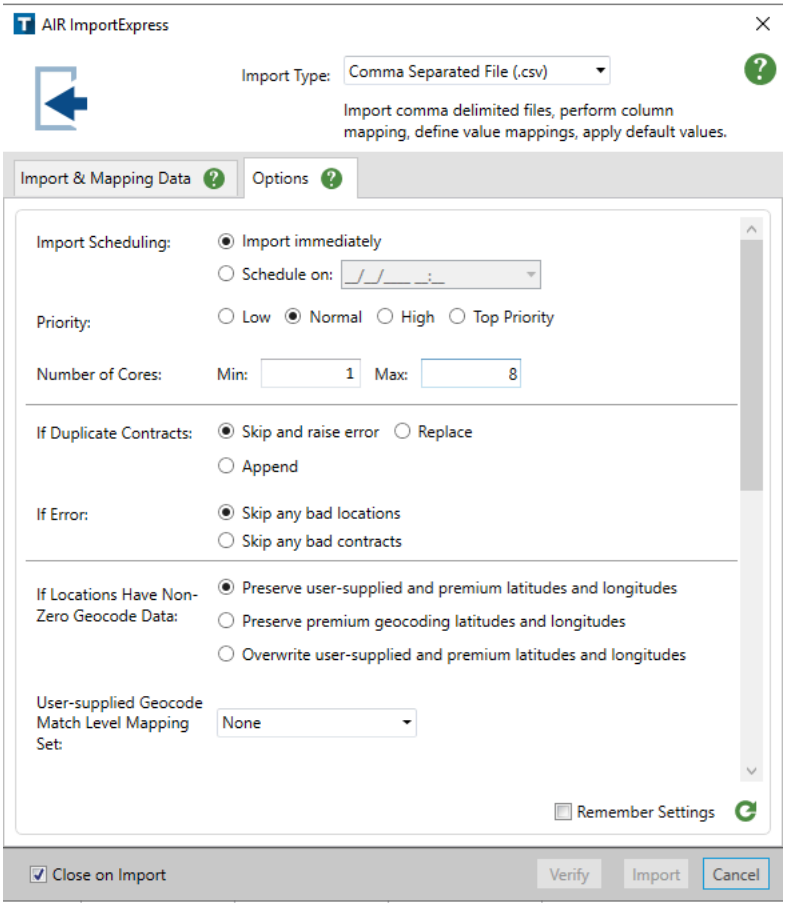


Figure 32. Model Input Options

The Verisk Hurricane Model for the United States implementation in Touchstone ensures that interface options for ratemaking in the state of Florida are accomplished via a detailed loss analysis template called the Florida Rate Filing Analysis template (FL template), as described in Standards CI-6.B and CI-6.C. A diagram of the process followed by users of the FL template is shown in Figure 33. More information on the process including the loss analysis options and dialog screen are included in Disclosure A-1.5.

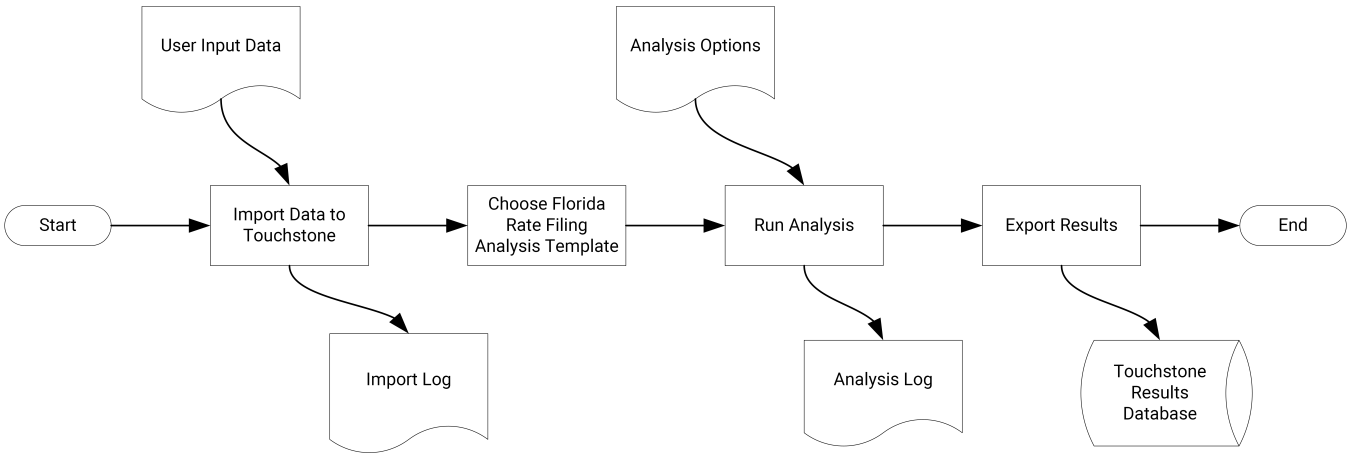


Figure 33. Process to Create Model Output

A-1.5

Disclose, in a hurricane model output report, the specific inputs required to use the hurricane model and the options of the hurricane model selected for use in a residential property insurance rate filing in Florida. Include the hurricane model name, version identification, and platform identification on the hurricane model output report. All items included in the hurricane model output report shall be clearly labeled, highlighted, and defined.

When a user initiates an analysis in Touchstone, they customize Analysis options that govern which settings are turned on and off for a particular analysis. Certain analysis options affect the resulting loss estimates while others do not. These optional settings can be customized by the user depending on their portfolio and reporting needs. Table 16 lists required analysis options in the FL template. The table lists setting options which are no longer available to the user as well as those still available.

Table 16. Catastrophe Peril Analysis Options Applicable for Florida Rate Filing

Analysis Option	Setting	Notes
Required Settings		
Event Set	50K US Hurricane (2024) – Florida Regulatory: On	The event sets that can be included in the list depend on the countries and perils licensed. For the FL template, the 50k or 100k regulatory event set must be used. The historical catalog is not available in the FL template but is available in other model applications.
Peril	Tropical Cyclone – Wind: On	Losses from wind are covered by residential policies. Hurricane wind is on and is the only peril option available. The storm surge peril is not an option in the FL template. While the model engine does run storm surge at the same time as the wind peril, producing separate loss estimates for each, the surge losses are not displayed or reported for the user. In instances where a loss exceeds the policy limit, a normalization procedure is used. The model will report and display hurricane wind loss estimates only after normalization.

Analysis Option	Setting	Notes
Demand Surge	On	Demand Surge is on and turning it off is not an option when using the FL template. The demand surge analysis option inflates loss results to reflect the increased cost of labor and materials following a major catastrophe. As the industry loss rises, so will the cost to repair and replace properties damaged in the event; the greater the industry loss for an event, the greater the Demand Surge factor used in the calculations. This submission comes with a standard demand surge curve for the U.S. which is automatically applied.
Flexibility Option (a.k.a. Loss Modification Factor)	Set equal to 1	Flexibility (Loss Modification) options are not available in the FL template. In other Verisk models, users can set different loss modification factors directly to ground-up losses in order to perform sensitivity analyses on their potential portfolio losses. This application will produce only the Verisk default loss perspective (equal to 1).
Event Set Filter	NA	Event set filter options have been disabled in the FL template. No event set filters can be applied by the user.
Apply Location Terms for Residential Contracts	Verisk Deductibles Before Limit: On	The FL template only allows the user to model losses with the Deductible Before Limits option. In the currently-accepted model, the Limit Before Deductible option is available to users for non-Florida ratemaking purposes, with documentation available advising users to select the Deductible Before Limits option for Florida rate filings.
Optional Settings		
Average Properties	On or Off (Automatic)	When the input exposures are coded at a ZIP Code resolution, the Average Properties option enables Touchstone to apply average physical properties, such as soil type and land use/land cover data, at a region-specific geographic resolution, during a loss analysis. Touchstone automatically assigns the properties based on the geocode match level assigned during import. For example, Average Properties will be turned on if exposures are geocoded to the ZIP Code centroid level.
Invalid Construction/ Occupancy Pairs	Use System Default or Ignore	A location that has an invalid construction/occupancy combination (e.g. manufactured home construction with an occupancy of automotive manufacturing) will be included or excluded in a loss analysis depending on the user's selection. If the Use System Default option is chosen, the software will convert the invalid codes into an unknown construction and general commercial occupancy. If the Ignore option is chosen, the location will not be analyzed.
Disaggregation	On or Off (Automatic)	When turned on, the Disaggregation Financial Settings parameter distributes aggregate (coarse resolution) location data down to a finer resolution to locations where exposures are likely to be located based on lines of business represented in Verisk's Industry Exposure Database. This process enables the loss engine to apply policy terms appropriately across an entire (distributed) region, rather than applying them only across the centroid of the region; this generates more accurate loss results for risk locations with poor quality data because it avoids analysis of aggregate exposures at a single-point location. For additional data on disaggregation, please see the document Exposure Disaggregation in NGM. The model default is Disaggregation off.
Min-Max Deductible Policy Logic	NA	This option is not applicable to residential policies. This feature enhances the loss calculation for layers that have a min/max deductible and have sub-limits on that layer: a structure that is most common to complex commercial policies. In summary, the updated algorithm in this submission more accurately represents the order of application of location limits and sub-limits with all deductibles in the policy. Location limits are applied after location deductibles, and sublimit terms are applied before the policy min-max deductible. The final insurance policy gross loss is the conditional location deductibles, or the user can select policy deductible scenario radio buttons.

Figure 34 shows the options available to the user for output detail, which are defined when the analysis is set up. These settings can be customized depending on the user's needs. The output options do not change the loss estimates, just the perspective and detail at which the estimates are reported from the software.

Options which are available to the user when performing a model run for use in a Florida residential rate filing are displayed in Figure 35, which is the FL template screen in Touchstone 2024A. Further, all settings chosen by the user are reported in the analysis log. A sample analysis log is included in Appendix 6: Model Output Forms

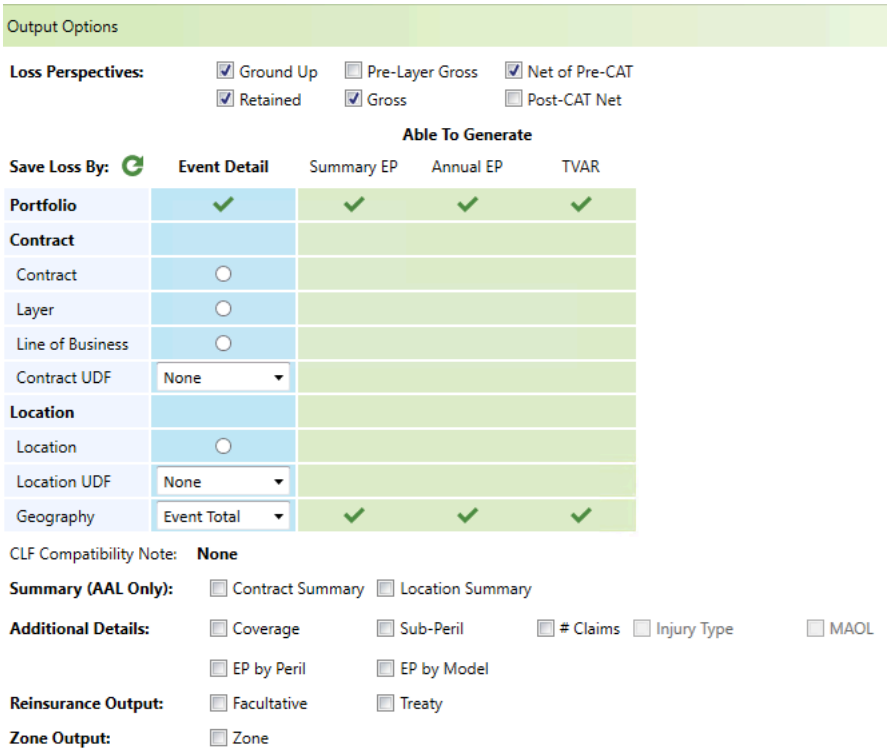


Figure 34. Output Options Dialog Box in the Florida Rate Filing Analysis Template

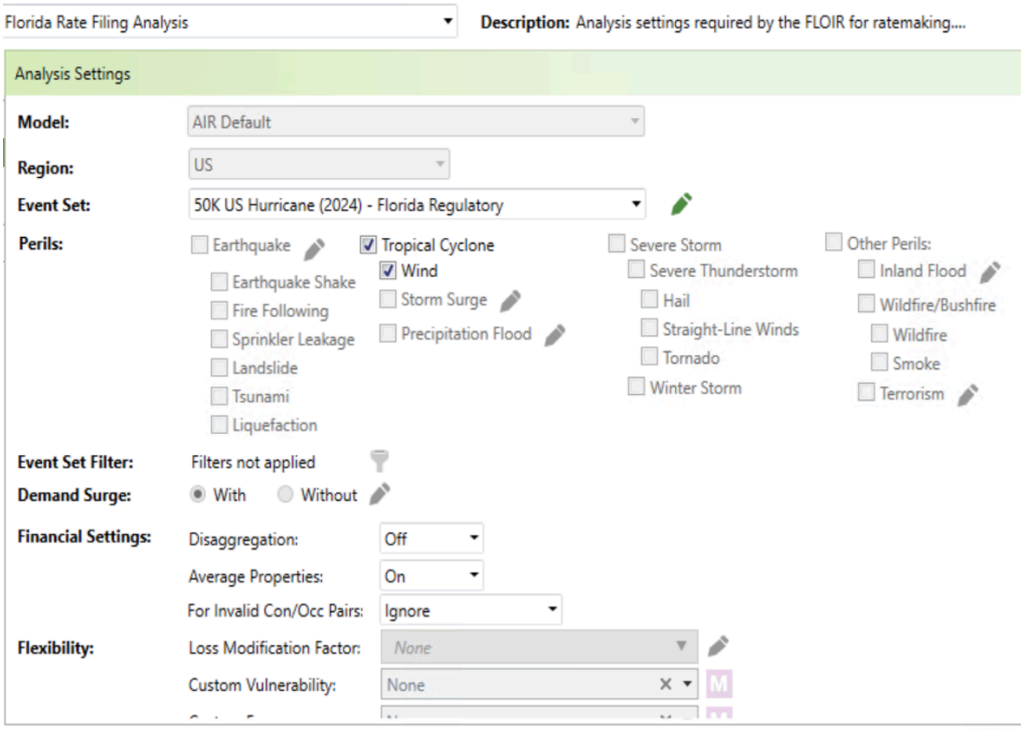


Figure 35. Analysis Options Dialog Box in the Florida Rate Filing Analysis Template

A-1.6

Provide the specific set of options acceptable for use in preparing a Florida insurance rate filing.

Only options that comply with Florida ratemaking requirements in the FL template as promulgated in the ROA. Please see Table 16 for the list of options.

A-1.7

Describe actions performed to ensure the validity of insurer or other input data used for hurricane model inputs or for validation/verification.

The Verisk hurricane model applies validation rules during exposure data import and within the exposure-related portions of the user interface (UI). When a validation error occurs, the model writes the error to the import log file, giving the user the ability to correct the issue before continuing with the analysis. A sample import log is contained in Appendix 6: Model Output Forms. The Touchstone Exposure Data Validation Reference contains documentation for the extensive validations performed to ensure the validity of insurer or other input data used for modeling.

A-1.8

Disclose if changing the order of the hurricane model input exposure data produces different hurricane model output or results.

Changing the order of the hurricane model input data does not impact the results of loss analyses.

A-1.9

Disclose if removing or adding policies from the hurricane model input file affects the hurricane model output or results for the remaining policies.

Adding or removing policies from the hurricane model input file does not impact the remaining policies' ground-up mean loss, or loss cost analysis results.

The loss engine of the model considers spatial correlation as a default feature. Spatial correlation has an impact on the distribution of losses around the mean. Adding or removing policies or locations from the input file will have a potentially small impact on gross loss estimates. Applying deductibles and policy limits probabilistically will reflect differences in the underlying distributions, though the impact is minor.

Standard A-2: Hurricane Events Resulting in Modeled Hurricane Losses

A-2.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.

Modeled hurricane loss costs and hurricane probable maximum loss levels reflect all insured wind related damages from storms that reach hurricane strength and produce minimum damaging windspeeds or greater on land in Florida. Modeled loss costs and probable maximum losses reflect all loss costs resulting from modeled bypassing hurricanes as well as those making landfall in Florida. Damage included in the calculation of hurricane loss costs and probable maximum losses comes from events producing at least minimum damaging wind speeds on land in Florida. Disclosure A-2.1 also supports compliance with Standard A-2.A.

A-2.B

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

Hurricane wind is the only peril available to users of the FL template to run an analysis with the Verisk Hurricane Model for the United States V3.0.0 as Implemented in Touchstone 2024A. No other peril loss analyses are available. Disclosure A-2.2 also supports compliance with Standard A-2.B.

Disclosures

A-2.1

Describe how damage from hurricane model generated storms (landfalling and by- passing hurricanes) is excluded or included in the calculation of hurricane loss costs and hurricane probable maximum loss levels for Florida.

The calculation of hurricane loss costs and probable maximum losses includes the losses from all hurricanes contained in the Event Set referenced in Table 16 that make landfall or bypass Florida. Damage is included in the calculation of hurricane loss costs and probable maximum losses from the time the hurricane first causes damaging wind speeds on land in Florida.

A-2.2

Describe how damage resulting from concurrent or preceding flood (including hurricane storm surge) is treated in the calculation of hurricane loss costs and hurricane probable maximum loss levels for Florida.

The Verisk Hurricane Model for the United States contains the perils of wind and storm surge flooding. Fluvial and pluvial flooding from hurricane induced precipitation perils are not included in losses when using the FL template. Further, the peril of flooding from non-hurricane sources, including from tropical storms and severe convective storms, is not included in this submission.

Damage resulting from concurrent or preceding storm surge flooding is estimated separately from wind damage, and, if combined damage from the two perils exceeds 100% of a structure's replacement value, the modeled loss estimates for the two perils are normalized.

Model users of the FL template do not have the option of running storm surge to produce or display losses related to the storm surge peril. Storm surge is run at the same time as hurricane wind by the model and where applicable a normalization procedure is applied as described in Table 16. The loss results or output related to storm surge from this peril are not available to users of the FL template.

Standard A-3: Hurricane Coverages

A-3.A

The methods used in the calculation of building hurricane loss costs, including the effect of law and ordinance coverage, shall be actuarially sound.

The Verisk Hurricane Model for the United States represents losses to building coverage separately from contents, and appurtenant structures and time element. Law and ordinance coverage for properties is implicitly accounted for in the model to the extent that it is captured in the historical data and included in the model through the model damage estimation process. The methods used in the calculation of building coverage loss costs are actuarially sound. This method is described in detail in Disclosure A-3.1.

A-3.B

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

The Verisk Hurricane Model for the United States represents losses to appurtenant structure coverage separately from building, contents, and time element. The methods used in the calculation of appurtenant structure coverage loss costs are actuarially sound as described in Disclosure A-3.2.

A-3.C

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

The Verisk Hurricane Model for the United States represents damages to contents separately from buildings, appurtenant structures and time element since some policies cover contents only and others provide no contents coverage. The methods used in the calculation of contents loss costs are actuarially sound as described in Disclosure A-3.3.

A-3.D

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

The Verisk Hurricane Model for the United States represents losses to time element, also referred to as Additional Living Expense (ALE), coverage separately from building, contents, and appurtenant structures. The methods used in the calculation of time element coverage loss costs are actuarially sound as described in Disclosure A-3.4.

Disclosures

A-3.1

Describe the methods used in the hurricane model to calculate hurricane loss costs for building coverage associated with personal and commercial residential properties.

The model uses a catalog of simulated events to estimate hurricane losses for each exposure location that is input by the user. For a given location, each event produces a range of wind speeds over the duration of the event. The hurricane model applies a vulnerability analysis to each location and, given the intensity of each simulated event, a probability distribution of damage is developed for the property at the policy coverage level (buildings, appurtenant structures, contents, and time element). The hurricane model has distinct relationships for personal and commercial residential structures.

Verisk's stochastic event catalogs are designed to produce a complete and stable range of potential annual experience of catastrophe activity. Once complete, a catastrophe loss analysis yields estimated hurricane losses for building coverage. Hurricane loss costs are calculated as the sum of the estimated hurricane building coverage losses over all stochastic events, divided by the number of years in the simulation and by insured exposure.

A-3.2

Describe the methods used in the hurricane model to calculate hurricane loss costs for appurtenant structure coverage associated with personal and commercial residential properties.

The hurricane model estimates hurricane losses for appurtenant structure coverage associated with personal and commercial residential properties using the method described in Disclosure A-3.1. The hurricane model has distinct appurtenant structures relationships for personal and commercial residential structures. Hurricane loss costs are calculated as the sum of the estimated hurricane appurtenant structures coverage losses over all stochastic events, divided by the number of years in the simulation and by insured exposure.

A-3.3

Describe the methods used in the hurricane model to calculate hurricane loss costs for contents coverage associated with personal and commercial residential properties.

The hurricane model estimates hurricane losses for contents coverage associated with personal and commercial residential properties using the method described in Disclosure A-3.1. The hurricane model has distinct contents coverage relationships for personal and commercial residential structures. Hurricane loss costs are calculated as the sum of the estimated hurricane contents coverage losses over all stochastic events, divided by the number of years in the simulation and by insured exposure.

A-3.4

Describe the methods used in the hurricane model to calculate hurricane loss costs for time element coverage associated with personal and commercial residential properties.

The hurricane model estimates hurricane losses for time element coverage associated with personal and commercial residential properties using the method described in Disclosure A-3.1. The hurricane model has distinct time elements coverage relationships for personal and commercial residential structures. Hurricane loss costs are calculated as the sum of the estimated time element building coverage losses over all stochastic events, divided by the number of years in the simulation and by insured exposure.

A-3.5

Describe the methods used in the hurricane model to account for law and ordinance coverage associated with personal residential properties.

Law and ordinance coverage for personal residential properties is implicitly accounted for in the model to the extent that it is captured in the historical data and included in the model through the model damage estimation process.

As described in Disclosure A-3.1 and Damage Estimation Overview, the damage estimation process accounts for the variability of damage through use of a probability distribution around each mean damage ratio. This probability distribution recognizes a finite number of structures will have 100% damage at any wind speed. Additionally, this probability distribution is constructed in such a way as to assign total structural damage (i.e. complete replacement) to structures which have a high level of modeled damage. This assumption accounts for the increased claims cost associated with local ordinances, whereby structures which incur marginally less than 100% damage are, in actuality, completely razed and rebuilt or incur increased costs in bringing the repaired structure up to local code requirements.

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

A-4.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.

The Verisk Hurricane Model for the United States produces pure loss estimates. Modeled loss costs and probable maximum loss levels do not include expenses, risk loads, investment income, premium reserves, taxes, assessments, or profit margins. The data that would be required to produce these estimates is not included as part of the user input as shown in Figure 31. These rate components, which typically vary by company must be estimated outside the model. For a more detailed description regarding the model input and output please see Disclosures A-3.1, A-3.2, A-3.3, and A-3.4.

A-4.B

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

The hurricane model does not make a prospective provision for economic inflation. Clients' in-force exposures, projected exposures, or hypothetical exposures are input into the model. Modeled hurricane losses and probable maximum losses are estimated based on coverage values which are input by the user. The model relies on these coverage values to estimate hurricane losses and probable maximum losses without adjustment.

A-4.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).

Users employing the FL template will produce analysis results which do not include flood losses: neither storm surge nor pluvial/fluvial flood losses are included with the wind losses in the reported loss estimates. The storm surge peril option is run in the engine with hurricane wind, as mentioned in Disclosure A-2.2, but these losses are not reported or displayed to the user, in compliance with the Report of Activities.

A-4.D

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

Hurricane loss cost projections and hurricane probable maximum loss levels are capable of being calculated from exposures at a geocoded (latitude-longitude) level of resolution. Latitude and longitude are standard import values as shown in the sample input in Disclosure A-1.4 and the Touchstone Exposure Data Validation Reference. More information is also included in Disclosure A-4.2.

A-4.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.

Hurricane loss costs and hurricane probable maximum loss levels in Verisk's submission reflect use of a function to account for the effects of temporary cost inflation resulting from increased demand for materials and services to repair and rebuild damaged property after a major catastrophe event ("demand surge"). Verisk's demand surge function has been developed using relevant data and actuarially sound methods and assumptions. Additional information on Verisk's demand surge function is included in Disclosures A-4.3 and A-4.4.

Disclosures

A-4.1

Describe the method(s) used to estimate annual hurricane loss costs and hurricane probable maximum loss levels and the treatments of associated uncertainties. Identify any source documents used and any relevant research results.

For a given set of exposures (i.e. replacement values) by coverage, by ZIP Code or other geographical grouping and by construction type, hurricane losses are estimated and aggregated over events in the catalog, which comprises thousands of simulated years. Average annual losses by location are calculated by dividing the total losses for all simulated storms by the number of simulated years. Hurricane losses can be stated from many perspectives, including on a 'ground-up' basis, a 'gross' basis net of only direct policy conditions such as limits and deductibles, or a 'net' basis net of reinsurance recoveries. For this submission, hurricane losses are stated on a ground-up or gross basis as requested in the Actuarial Forms.

Hurricane loss costs for a given ZIP Code or county are calculated by dividing the average annual losses for all locations within a geographical area by the corresponding insured exposure.

Hurricane probable maximum losses (PMLs) are calculated by identifying the largest hurricane loss within each simulated year (or by aggregation of the annual losses) and ranking those values from highest to lowest, then identifying the event loss (or the annual aggregate loss) whose rank matches the "exceedance probability" (EP) requested under the relative frequency interpretation of probability. A PML is meaningless without an associated "return period", and a return period associated with a PML is the reciprocal of the exceedance probability.

For example, among the largest simulated events in each year, the event whose loss ranks 1,000th highest among all 50,000 events would have an exceedance probability of 1,000/50,000 or 2%. The corresponding return period for this probable maximum loss would be 1/(2%), or 50 years.

It follows that probable maximum losses vary according to the loss perspective (ground-up, gross or net) requested, as the event loss rankings may differ net of policy or reinsurance conditions.

Primary uncertainties are reflected in event distributions based on the stochastic catalog storm set impacting each location or set of locations. Secondary uncertainties are reflected through distributions around the mean damage ratio and PMLs for each individual location and group of locations at coverage, location and aggregate levels.

A-4.2

Identify all possible resolutions available for the reported hurricane output ranges. Identify the finest level of resolution (i.e., the most granular level) for which hurricane loss costs and hurricane probable maximum loss levels can be provided.

Hurricane loss costs can be provided at any geographic level desired: state, county, ZIP Code, rating territory, grid square, or specific location (described by a latitude-longitude pair). Hurricane probable maximum loss levels can also be provided at any geographic level desired. The process for developing hurricane probable maximum losses is the same regardless of the starting data (i.e. event losses for Florida or event losses for a specific ZIP Code). It follows that hurricane probable maximum losses vary according to the geographic level (i.e. statewide losses or losses for a single Florida ZIP Code) requested, as the event loss rankings may differ.

A-4.3

Describe how the hurricane model incorporates demand surge in the calculation of hurricane loss costs and hurricane probable maximum loss levels.

Evidence from major catastrophic events in past years suggests that after a major event, increased demand for materials and services to repair and rebuild damaged property can put pressure on prices, resulting in temporary inflation. This phenomenon is often referred to as demand surge and it results in increased losses to insurers.

Key Factors Leading to Demand Surge

Sudden Increase in Demand

A catastrophic event causes widespread damage to property, which leads to a sharp increase in the need for building materials and services. Demand for resources such as labor, transportation, equipment and storage also increases sharply in the affected area. Resource availability in any regional economy is typically sufficient to accommodate normal demand. However, an unexpected increase in demand can lead to shortages and price increases.

Time Element Losses

When there is widespread damage to property, low regional capacity to meet the increased demand can result in longer than normal repair times. This, in turn, results in greater business interruption losses and additional living expenses. Infrastructure damage, delayed building permit processes, and a shortage of available building inspectors are also factors in increasing time element loss.

How the Model Incorporates Demand Surge

Verisk has related the amount of demand surge in a particular event to the amount of total industry-wide insurable losses from the event. The factor is dependent on coverage. A table incorporated into the software contains the corresponding demand surge factors, by coverage, for different levels of industry-wide losses.

For a given event, the demand surge factors by coverage are applied to the corresponding ground-up losses, based on the industry-wide loss for that event. Policy conditions are then applied probabilistically. The sum of these losses by coverage yields the total event loss with demand surge included.

Very few data points exist to create and validate a demand surge curve, resulting in significant uncertainty about the level of demand surge following an event.

A-4.4

Provide citations to published papers, if any, or modeling-organization studies that were used to develop how the hurricane model estimates demand surge.

No published papers on demand surge were used to develop how the hurricane model estimates demand surge. Verisk has prepared a white paper for its clients documenting the development of demand surge estimates in the hurricane model. This paper may be shared as trade secret material.

A-4.5

Describe how economic inflation has been applied to past insurance experience to develop and validate hurricane loss costs and hurricane probable maximum loss levels.

Past insurance experience used to develop and validate hurricane loss costs and hurricane probable maximum loss levels is used without applying economic inflation. Actual hurricane insured claims losses are compared with modeled hurricane losses, which are produced using actual insured exposures from the time of the historical hurricane.

Standard A-5: Hurricane Policy Conditions

A-5.A

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

The methods used in the development of mathematical distributions to reflect the effects of deductibles and policy limits are actuarially sound. The Verisk damageability functions generate a mean damage ratio for a given wind speed. For any estimated mean damage ratio, there is a mixed probability distribution that includes finite probabilities of damage at zero and 100 percent. This representation of the damage ratio fits well with observed data. For illustrative purposes, a theoretical distribution is shown in Figure 36.

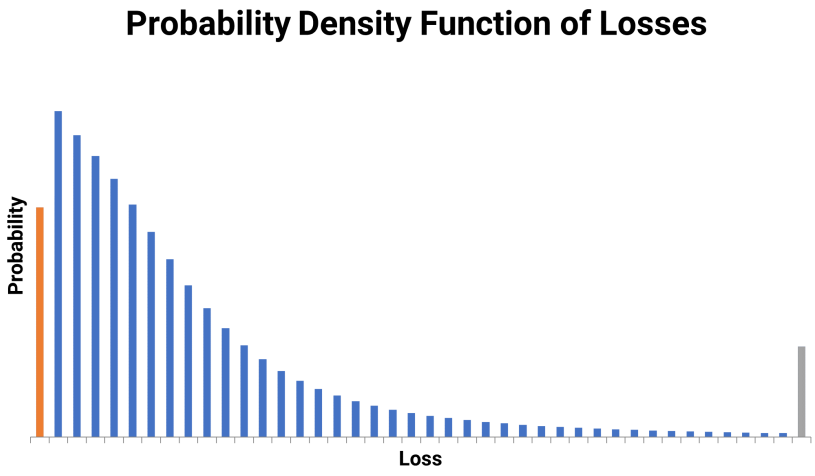


Figure 36. Probability Distribution Around the Mean Damage Ratio

Thus, the effects of deductibles, coinsurance and other policy conditions can be properly calculated, as this sample insured loss calculation illustrates:

$$\text{Expected Loss} = \int_{x=0}^{1} f_{\bar{D}}(x)\,[\,Coins\,\% * (\,min(PL, max(0, x * RV - DED))\,)\,]\,dx$$

Figure 37. Equation 2

where:

$f_{\bar{D}}(x)$	=	Distribution function for losses
Coins %	=	Coinsurance Percentage
RV	=	Replacement Value
PL	=	Policy Limit

DED	=	Deductible
x	=	Random Variable representing the Damage Ratio

Demand surge is not applied in the formula above. However, our submission does apply demand surge to the ground up losses. In application, $f_{\tilde{D}}(x)$ is discretized and numerical integration is used to estimate the expected insured loss.

A-5.B

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

The relationship among the modeled deductible hurricane loss costs is reasonable. Loss costs decrease as deductibles increase, other factors held constant. This is clearly demonstrated in the deductible section of Form A-6: Logical Relationships to Hurricane Risk (Trade Secret Item), which will available on-site for the Professional Team's review.

A-5.C

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

The Verisk Hurricane Model for the United States explicitly enables the application of annual deductibles in accordance with s. 627.701(5)(a), F.S. The statute requires the application of the hurricane deductible to the first event, and the greater of the remaining hurricane deductible and all perils deductible to losses from subsequent events in the same calendar year. Additional detail is included in Disclosure A-5.3.

Disclosures

A-5.1

Describe the methods used in the hurricane model to treat deductibles (both flat and percentage), policy limits, and insurance-to-value criteria when projecting hurricane loss costs and hurricane probable maximum loss levels. Discuss data or documentation used to validate the method used by the hurricane model.

For any estimated mean damage, there is a probability distribution around that mean. Thus, expected damages above different deductible levels can be readily calculated. Flat dollar deductibles are applied directly while deductibles that are a percentage of coverage amount are converted to the flat dollar equivalent (i.e. deductible % * insured value) and applied. The hurricane model calculates losses to replacement costs net of the deductible, then caps losses at policy limits. Insurance-to-value is addressed by the user and described further in Disclosure A-1.1.

A-5.2

Describe if and how the hurricane model treats policy exclusions and loss settlement provisions.

With the exception of exclusions for flood, policy exclusions, and loss settlement provisions are implicitly factored into the hurricane model, as they are included in claims data used for calibrating hurricane damage functions. Impacts of exclusions and settlement provisions that are implicitly accounted for are not explicitly quantified when developing damage factors. Losses explicitly attributed to the flood peril are excluded.

A-5.3

Describe how the hurricane model treats annual hurricane deductibles.

For the first hurricane event in a year, apply the hurricane deductible to the loss distribution. Calculate the "applicable deductible" for this event (see definition below), and then calculate the "remaining deductible" as (hurricane deductible - applicable deductible). The deductible that will apply to the next event is the higher of the "remaining deductible" and the all other perils deductible. The remaining deductible is recalculated and stored after each event per location.

$$\text{Applicable Deductible} = \sum_{j=1}^{n} \min(\textit{loss}, \textit{availabledeductible}) * \textit{probability}$$

Figure 38. Equation 3

where the summation covers from *j = 1* to the number of points in the damage ratio distribution and probability is the probability of loss at the *jth* point in the distribution.

Standard A-6: Hurricane Loss Outputs and Logical Relationships to Risk

A-6.A

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

The Verisk Hurricane Model for the United States uses actuarially sound methods, data and assumptions in the estimation of hurricane probable maximum loss levels. The Verisk method of estimating is described in detail in Disclosure A-4.1 and referenced in the actuarial literature.

A-6.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.

The Verisk Hurricane Model for the United States produces loss costs that are logical in relation to risk and do not exhibit a significant change when the underlying risk does not significantly change. Hurricane loss cost sensitivity tests performed in Form A-6: Logical Relationships to Hurricane Risk (Trade Secret Item) demonstrate this. Form A-6: Logical Relationships to Hurricane Risk (Trade Secret Item) will be available on-site for the Professional Team's review.

A-6.C

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

The hurricane loss costs are positive and non-zero for all ZIP Codes. Hurricane loss cost maps by ZIP Code are provided in Form A-1: Zero Deductible Personal Residential Hurricane Loss Costs by ZIP Code. Form A-1: Zero Deductible Personal Residential Hurricane Loss Costs by ZIP Code clearly displays that the model produces non-zero loss costs for all postal codes in the state.

A-6.D

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

Hurricane loss costs do not increase as the quality of construction, material or workmanship increases, all else being equal. Hurricane loss cost maps for wood frame, masonry and manufactured home construction types are provided in Form A-1: Zero Deductible Personal Residential Hurricane Loss Costs by ZIP Code, and demonstrate

that loss costs do not increase as the quality of construction and materials increase. At each location, masonry loss costs are lower than frame loss costs and frame loss costs are lower than manufactured home loss costs, all else being equal. Further, hurricane loss cost sensitivity tests performed in Form A-6: Logical Relationships to Hurricane Risk (Trade Secret Item) demonstrate this. Form A-6: Logical Relationships to Hurricane Risk (Trade Secret Item) will be available on-site for the Professional Team's review.

A-6.E

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

Hurricane loss costs do not increase as the presence of fixtures or construction techniques designed for hazard mitigation increases, all else being equal. Hurricane loss cost sensitivity tests performed in Form A-6: Logical Relationships to Hurricane Risk (Trade Secret Item), demonstrate this. Form A-6: Logical Relationships to Hurricane Risk (Trade Secret Item) will be available on-site for the Professional Team's review.

A-6.F

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

Hurricane loss costs do not increase as the wind resistant design provisions increase, all other factors held constant. Hurricane loss cost sensitivity tests performed in Form A-6: Logical Relationships to Hurricane Risk (Trade Secret Item) demonstrate this. Form A-6: Logical Relationships to Hurricane Risk (Trade Secret Item) will be available on-site for the Professional Team's review.

A-6.G

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

Hurricane loss costs do not increase as the quality of building codes and enforcement increases, all else being equal. Hurricane loss cost sensitivity tests performed in Form A-6: Logical Relationships to Hurricane Risk (Trade Secret Item) demonstrate this. Form A-6: Logical Relationships to Hurricane Risk (Trade Secret Item) will be available on-site for the Professional Team's review.

A-6.H

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

Hurricane loss costs do decrease as deductibles increase, all else being equal. Hurricane loss cost sensitivity tests performed in Form A-6: Logical Relationships to Hurricane Risk (Trade Secret Item) demonstrate this. Form A-6: Logical Relationships to Hurricane Risk (Trade Secret Item) will be available on-site for the Professional Team's review.

A-6.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.

The relationship of hurricane losses for building, appurtenant structures, contents, and additional living expense to the total loss as produced by the model is reasonable. Hurricane loss cost sensitivity tests performed in Form A-6: Logical Relationships to Hurricane Risk (Trade Secret Item) demonstrate this. Form A-6: Logical Relationships to Hurricane Risk (Trade Secret Item) will be available on-site for the Professional Team's review.

A-6.J

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

Hurricane output ranges are logical. The output ranges show loss costs by county and risk type, demonstrating logical relationships between 1) wood frame and masonry construction; 2) manufactured homes and other risk types; and 3) low- and high-risk regions. There are no deviations other than those inherent to the underlying data in the calculation of average loss costs. These are explained in Disclosure A-6.14.

A-6.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.***

As demonstrated by the hurricane loss cost sensitivity tests performed in Form A-6: Logical Relationships to Hurricane Risk (Trade Secret Item), hurricane output ranges produced by the Verisk Hurricane Model for the U.S. reflect lower hurricane loss costs for the modeled factors in A-6.K.1 to A-6.K.5 as follows:

1. Output ranges show lower hurricane loss costs for masonry construction versus frame construction.
2. Output ranges show lower hurricane loss costs for personal residential versus manufactured home construction risk exposure.
3. Output ranges show lower hurricane loss costs, in general, for inland counties versus coastal counties.
4. Output ranges show lower hurricane loss costs, in general, for northern counties versus southern counties.
5. Output ranges show lower hurricane loss costs, in general, for newer construction versus older construction.

Form A-6: Logical Relationships to Hurricane Risk (Trade Secret Item) will be available on-site for the Professional Team's review.

A-6.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.

Verisk uses historical insured hurricane losses received from clients for validation purposes. These loss data typically include both exposure and loss details including construction characteristics and policy provisions such as coverage and deductible.

Verisk communicates with clients and sends out a letter requesting information on hurricane claim payment practices, coinsurance, contractual provisions, and relevant underwriting practices underlying those losses.

All assumptions underlying any adjustments are discussed with and reviewed by our clients; therefore all assumptions as well as any actuarial modifications made are appropriate.

Disclosures

A-6.1

Provide details of modifications to the financial component of the hurricane model since the current accepted hurricane model.

No updates were made to the financial component of the hurricane model since the current accepted hurricane model.

A-6.2

Provide completed Form A-1. Provide a link to the location of the form in the submission appendix [insert hyperlink here].

Form A-1: Zero Deductible Personal Residential Hurricane Loss Costs by ZIP Code.

The full Form A-1 has also been submitted in both PDF and Excel format separately in the files named "VSK23FormA1".

A-6.3

Provide completed Form A-2. Provide a link to the location of the form in the submission appendix [insert hyperlink here].

Form A-2: Model Base Hurricane Set Statewide Hurricane Losses

A-6.4

Provide completed Form A-3. Provide a link to the location of the form in the submission appendix [insert hyperlink here].

Form A-3: Hurricane Losses has been submitted in both PDF and Excel format separately in the accompanying electronic submission files and is named "VSK23FormA3".

A-6.5

Provide completed Form A-4. Provide a link to the location of the form in the submission appendix [insert hyperlink here].

Form A-4: Hurricane Output Ranges

A-6.6

Provide completed Form A-5, using the 2017 FHCF exposure data. Provide a link to the location of the form in the submission appendix [insert hyperlink here].

Form A-5: Percentage Change in Hurricane Output Ranges

A-6.7

Provide completed Form A-6, if not considered as Trade Secret. Provide a link to the location of the form in the submission appendix [insert hyperlink here].

Form A-6: Logical Relationships to Hurricane Risk (Trade Secret Item) is a trade secret item and will be available on-site for the Professional Team's review.

A-6.8

Explain any assumptions, deviations, and differences from the prescribed exposure information in Form A-6. Explain how the treatment of unknown is handled in each sensitivity exhibit.

Verisk did not deviate from the prescribed exposure information in Form A-6: Logical Relationships to Hurricane Risk (Trade Secret Item). When the prescribed data included unknown values, these values assumed the model default indications. A detailed explanation of how the Verisk model handles unknown values is included in Disclosure V-1.9.

A-6.9

Provide completed Form A-8. Provide a link to the location of the form in the submission appendix [insert hyperlink here].

Form A-8: Hurricane Probable Maximum Loss for Florida

A-6.10

Describe the calculation of uncertainty intervals.

Uncertainty intervals are estimated using the 50,000 year catalog. A bootstrap sampling method is utilized, and a summary of the method follows:

- Aggregate losses for each year are summarized in the 50,000 year catalog.
- Repeatedly sample with replacement from the 50,000 year aggregate losses to generate a 100,000 year aggregate loss catalog.
- Using the catalog derived in the previous step, obtain the 10th and 90th percentiles.

A-6.11

Describe how the hurricane model produces hurricane probable maximum loss levels.

The method the hurricane model uses to estimate hurricane probable maximum loss levels is discussed in Disclosure A-4.1.

A-6.12

Provide citations to published scientific literature and technical literature, if any, or modeling-organization studies that were used to estimate hurricane probable maximum loss levels.

No published papers were used to estimate hurricane probable maximum loss levels (PMLs). Standard probability theory supports Verisk's event-ranking methodology for assembling PMLs.

A-6.13

Describe how the hurricane probable maximum loss levels produced by the hurricane model include the effects of personal and commercial residential insurance coverage.

The hurricane probable maximum loss levels produced by the hurricane model follow the process described in Disclosure A-4.1. The calculation of the hurricane probable maximum loss is consistent across all exposure types whether they be personal or commercial residential insurance coverage, as described in Disclosure A-1.3.

A-6.14

Explain any differences between the values provided in Form A-8, Part A, and those provided in Form S-2, using the 2017 FHCF exposure data.

There are no differences between the values provided in Form A-8: Hurricane Probable Maximum Loss for Florida and those provided on Form S-2.B.

A-6.15

Explain any differences between the values provided in Form A-8, Part B and those provided in Form S-2 using the 2023 FHCF exposure data.

There are no differences between the values provided in Form A-8: Hurricane Probable Maximum Loss for Florida and those provided on Form S-2.B.

A-6.16

Provide an explanation for all hurricane loss costs that are not consistent with the requirements of this standard.

Hurricane loss costs for frame construction are greater than for masonry in nearly every ZIP Code. However, the county weighted average hurricane loss costs can depart from this when there is more exposure in high loss cost ZIP Codes for masonry construction than for frame. The following example illustrates how the county weighted average hurricane loss cost can be greater for masonry than for frame.

Table 17. County Weighted Average Loss Costs for Masonry and Frame

ZIP Code	Construction	Exposure	Loss Cost per 1,000
A	Masonry	10,000	4.0
A	Frame	1,000	5.0
B	Masonry	1,000	1.0
B	Frame	10,000	2.0
County Avg.			
	Masonry		3.73
	Frame		2.27

A-6.17

Provide an explanation of the differences in hurricane output ranges between the current accepted hurricane model and the hurricane model under review.

The differences in the output between the current accepted model and hurricane model under review are due to the hurricane model updates described in Disclosure G-1.7.

A-6.18

Identify the assumptions used to account for the effects of coinsurance on commercial residential hurricane loss costs.

The hurricane model captures the effects of coinsurance using the location level participation field in the input exposures provided by the user. This field reflects the percentage of the risk covered by the insurer. Insurers may make specific assumptions to allow for any coinsurance adjustments.

8 Computer/Information Hurricane Standards

Standard CI-1: Hurricane Model Documentation

CI-1.A

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

Verisk maintains an extensive collection of both client-facing and internal documentation, which is presented using defined documentation templates, style sheets, and content structure. The documentation makes apparent the application name, version number, as well as revision history detail. This documentation is formally developed independently from letters, slides, and unformatted text files.

The internal and client-based documentation will be available for review by the independent peer auditor and by the Professional Team.

CI-1.B

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

Verisk creates and maintains its internal and client-based documentation using current model development and software engineering practices. All documentation is maintained within source control and carefully managed throughout the development process.

Access to documentation maintained within the Verisk Intranet (SharePoint) or in the Azure Development Operations (AZDO) source control is validated by Windows®-authenticated user name and password. The client-based documentation, available via the Client Portal and developer's zone sites, is accessed using a registered username/password combination.

The client-based documentation includes:

- User manuals and how-to guides, white papers, technical documentation, model documentation, and marketing materials available to clients from the Client Portal site.
- API documentation available to clients from the Developer's Zone site in both Hyper Text Markup Language (HTML) web-based format and PDF format.

- Database documentation available to clients from the Developer's Zone site in both HTML web-based format and PDF format.
- A topic-based user help system available to the user via the software application.

The internal documentation available to Verisk employees via SharePoint includes:

- Documentation for requirements, user stories, design documents, architecture documents, test plans, and project schedules.
- A help system covering model and software topics.
- Documentation in a designated FCHLPM repository providing detailed discussion of the development of the model and software.

The internal and client-based documentation, as well as the sites from which they are available, shall be available for review by the independent peer auditor and by the Professional Team.

CI-1.C

All computer software relevant to the hurricane model shall be consistently documented and dated.

All components as defined by the Requirements are fully documented and dated, and such documentation shall be available for review by the independent peer auditor and by the Professional Team.

CI-1.D

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

The ***Enhancements Map*** identifies the updates specific to the current version of the Verisk Hurricane Model for the United States and Touchstone 2024A as required to satisfy Disclosure G-1.7, as well as the changes from the current accepted submission.

CI-1.E

Documentation shall be created separately from the source code.

The Verisk Hurricane Model for the United States and the Touchstone software documentation are developed and maintained independently from the source code. Both the formal documentation and detailed in-line comments within the source code shall be available for review by the independent peer auditor and by the Professional Team.

CI-1.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.

The ***Response to ROA Item CI-1 F: List of Externally-Acquired Currently Used Hurricane Model-Specific Software and Data Assets*** spreadsheet contains a list of all externally acquired, currently used hurricane model-specific software and data assets, including asset name, asset version number, asset acquisition date, asset acquisition source, asset acquisition mode, and length of time the asset has been in use by Verisk. This spreadsheet is available for review by the independent peer auditor and by the Professional Team.

Disclosures

CI-1.1

Provide a description of the software engineering methodologies (e.g., Scrum, Agile, Waterfall, Hybrid) utilized for the software lifecycle.

At Verisk EES, Agile methodology is implemented with a focus on structured team dynamics and well-defined processes. The approach is focused on iterative development, collaboration, enhancing overall efficiency and productivity.

Emphasis is placed on continuous integration and automation by integrating code regularly and automating processes to streamline development and maintain product stability.

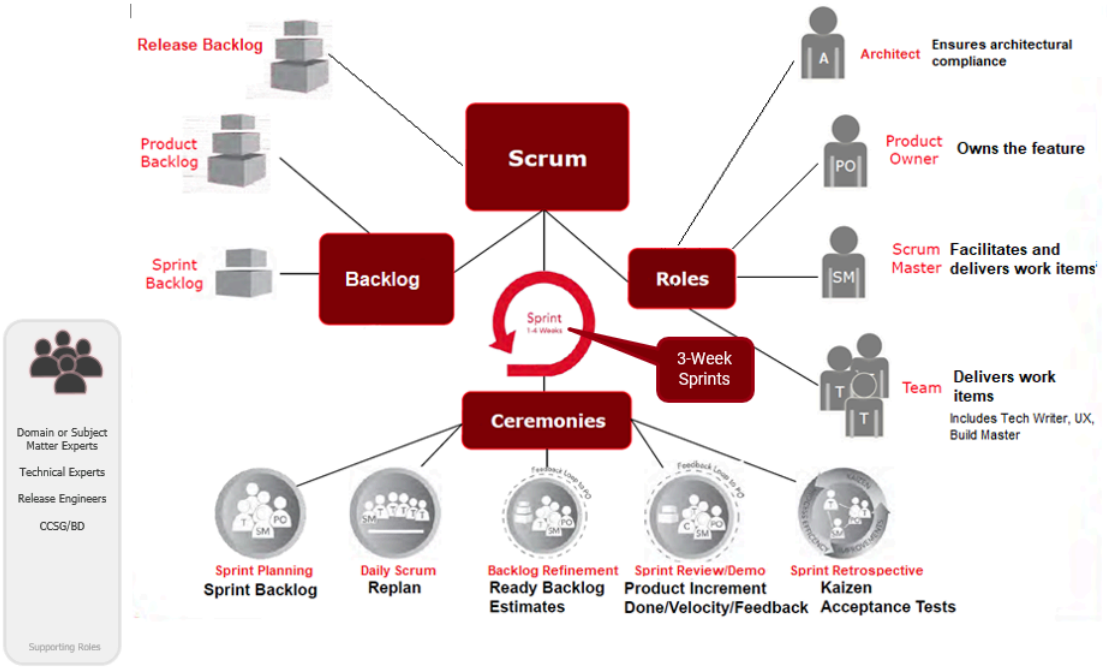


Figure 39. Key Components of the Agile Framework at Verisk Extreme Event Solutions (adapted from Scrum Inc.)

Key components of the Agile framework at Verisk EES include:

- **Iterative cycles or sprints**: Development and testing work is divided into short, manageable iterations known as sprints, typically lasting three weeks. This allows for continuous improvement and integration, regular feedback, and adaptation to changing requirements.
- **Scrum teams**: The teams are cross-functional, comprising members with specific roles such as technical writers, User Experience (UX) specialists, and dev-ops engineers, all working collaboratively to achieve sprint goals.

Scrum teams

Scrums team at Verisk EES are structured to include specialized roles, each contributing to the success of the project:

- An *architect* who ensures architectural compliance.
- A *product owner* who is responsible for the overall product life cycle and requirements.
- A *scrum master* who is responsible for day to day functioning of the team along with workload distribution and velocity.
- The *development team*, which is comprised of information developers, software developers, release engineers and the quality assurance team. They are responsible for quality and adherence to standards and requirements.

Managed backlogs

We manage these backlogs to effectively prioritize work, track progress, and ensure that all aspects of the project, including development, testing, quality assurance and documentation, are well-coordinated and aligned with the overall project goals.

- **Product**: This backlog contains all the features, enhancements, and fixes that need to be implemented in the product. It is maintained by the Product Owner and is continuously refined and re-prioritized based on feedback and changing requirements.
- **Release**: The release backlog consists of items from the product backlog that are planned for a specific release. It helps in organizing and tracking the work that needs to be completed for a particular release.
- **Sprint**: The sprint backlog contains the tasks and user stories selected from the product backlog for a specific sprint. It outlines the work that the Scrum team commits to completing within the sprint duration.

Definition of Ready (DoR)

The minimum Definition of Ready (DoR) is a set of criteria that user stories or features must meet before they can be selected for implementation in a sprint.

To be declared DoR, a user story or feature must meet the following criteria.

- There is a *clear definition* of the epic or feature that the user story or feature belongs to.
- The *key user stories* associated with the epic, as defined by the product owner and architect, have been identified.
- All *items for investigation* have been identified, including any additional items that need further investigation.
- High level *designs* are completed. These ensure that the proposed solution is feasible and aligns with architectural guidelines.
- All *internal stakeholders* from cross-functional teams have been identified and solicited for their input and feedback.
- All *wireframes or prototypes* to visualize the feature and ensure alignment with user expectations are complete.
- There is clearly defined *acceptance criteria* that specifies the conditions for the user story or feature to be considered complete.

- The *effort* required to complete the feature or user story has been properly estimated to ensure that it is appropriate for the sprint.
- The user story has been *broken down into smaller tasks* to facilitate planning and execution within the sprint timeline.

Definition of Done (DoD)

The minimum Definition of Done (DoD) is a set of criteria that must be met for a user story or feature to be considered complete at the end of a sprint.

To be declared DoD, a user story or feature must meet the following criteria.

- The *architecture or design team* certifies that the implementation aligns with the overall design and architectural guidelines.
- The code has been reviewed by team members to ensure that it meets quality, consistency, and development standards.
- The code is checked into the appropriate branch in the version control system to ensure proper integration.
- Unit tests have been created, checked in, and passed to verify the functionality of the code.
- Test cases have been created, reviewed, and executed to validate the user story against the defined acceptance criteria.
- Automated or manual regression test plans have been created and executed to ensure that the feature functions correctly and does not introduce regressions.
- All user interface elements have been reviewed by the User Experience (UX) team to ensure consistency and usability.
- The user story and its acceptance criteria have been successfully demonstrated to stakeholders to validate that the requirements have been met.
- The appropriate architecture or design team members certify that the implementation aligns with the agreed-upon design.

Integration of feedback loops in release planning

Feedback from the software development group (SDG) and quality assurance (QA) teams on capacity, release and product backlogs are adjusted during release planning. Feedback from the market, business development (BD), and consulting and client services group (CCSG) is gathered and incorporated into the release planning process.

Based on the feedback received, the release and product backlogs are adjusted accordingly. High-priority and committed items, which are essential for the product release, are prioritized and retained on the backlog, while other items may be scoped in or out based on the feedback received.

CI-1.2

Document compliance with external international, national, or organizational standards and certifications, where applicable to the Computer/Information Hurricane Standards.

Verisk EES complies with the following standards and certifications across the model development process:

- The Microsoft code annotation standards for public interfaces, classes, methods, and properties with XML documentation comments are utilized.
- Human-computer interface (HCI) standards are sourced from the W3C's internationally recognized library of design principles.
- Code and data are secured according to the guidelines described in the ***Verisk Information Security Policy Framework***.
- Flowchart development guidelines are described in the ***Verisk Flowchart Mapping Standards.***

Standard CI-2: Hurricane Model Requirements

CI-2

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.

All requirements for the Verisk Hurricane Model for the United States and Touchstone are documented and reviewed; each version release contains a unique set of requirements documentation. These requirements are used extensively to develop design documentation and test plans.

The requirements document, which is available via SharePoint, includes the motivation for updates, specification and impacts of model updates and specifications and impacts of software updates. Figure 40 illustrates the requirements development and review process.

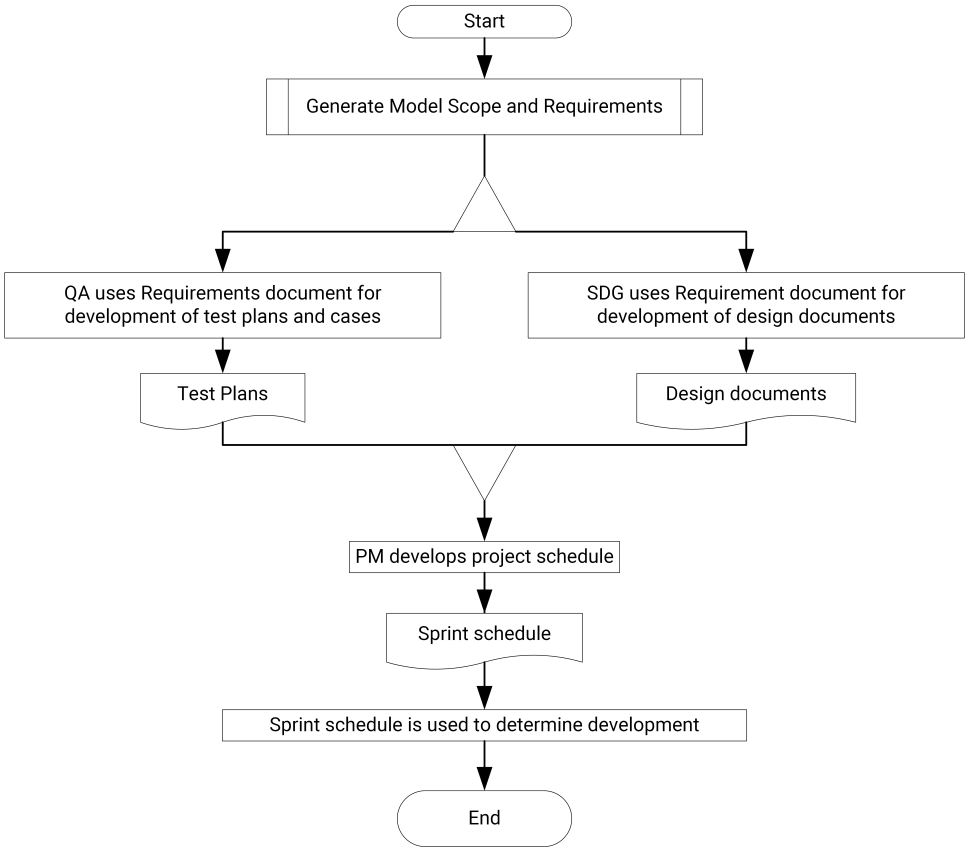


Figure 40. Requirements Development and Review Process

Disclosures

CI-2.1

Provide a description of the hurricane model and platform(s) documentation for interface, human factors, functionality, system documentation, data, human and material resources, security, and quality assurance.

The Touchstone interface, human factors, and functionality are documented in the Touchstone User Help system, which is accessed through the software application. Verisk also provides various “How-To” guides, which are designed to aid the user with specific Touchstone functionality (for example, Using Hazard Analysis in Touchstone and Using the Verisk Hurricane Model for the United States in Touchstone). These documents are available to clients via the Client Portal. The Verisk Hurricane Model for the United States data files are discussed within the component-specific documents. Touchstone system documentation, such as the System Recommendations document and the Installation Guide are provided on the Client Portal. The Touchstone database documentation defines the schema, tables, and columns for the Touchstone databases. It is presented as an HTML web-based documentation set available to clients from the Developer’s Zone site. This documentation is also available in PDF.

Standard CI-3: Hurricane Model Organization and Component Design

CI-3.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.

Component-specific documents contain detailed control and data flow diagrams, class diagrams, and interface specifications that illustrate the design and architecture of the Verisk Hurricane Model for the United States and of Touchstone, including their components and sub-components. These documents shall be available for review by the independent peer auditor and by the Professional Team.

The Database documentation defines the schema, tables, and columns for the Touchstone databases. This documentation is found on the Verisk Client Portal, and shall be available for review by the independent peer auditor and by the Professional Team.

The flowcharts present detailed process workflows for all aspects of the design, development, implementation, and testing of the Verisk Hurricane Model for the United States and the Touchstone software; these workflows shall be available for review by the independent peer auditor and by the Professional Team.

Touchstone is a multi-layer client-server application that is designed to run on a single network. Network organization in Touchstone is comprised of client machines, an application server, an analysis engine, database servers, and an optional model data share, as illustrated in Figure 41.

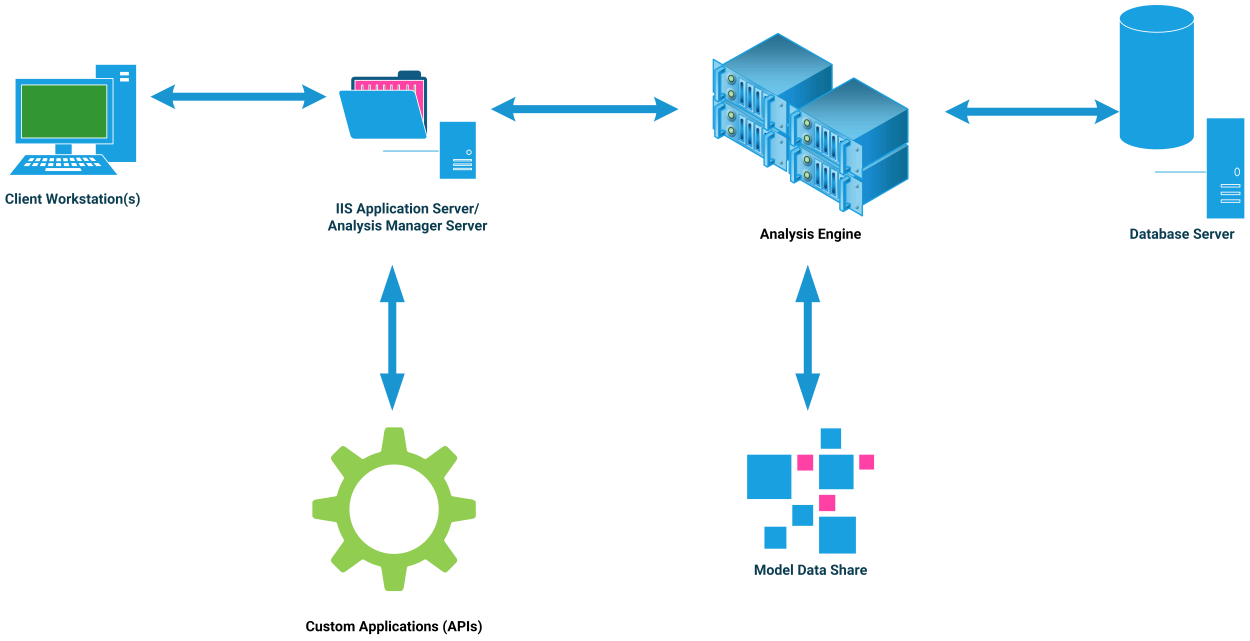
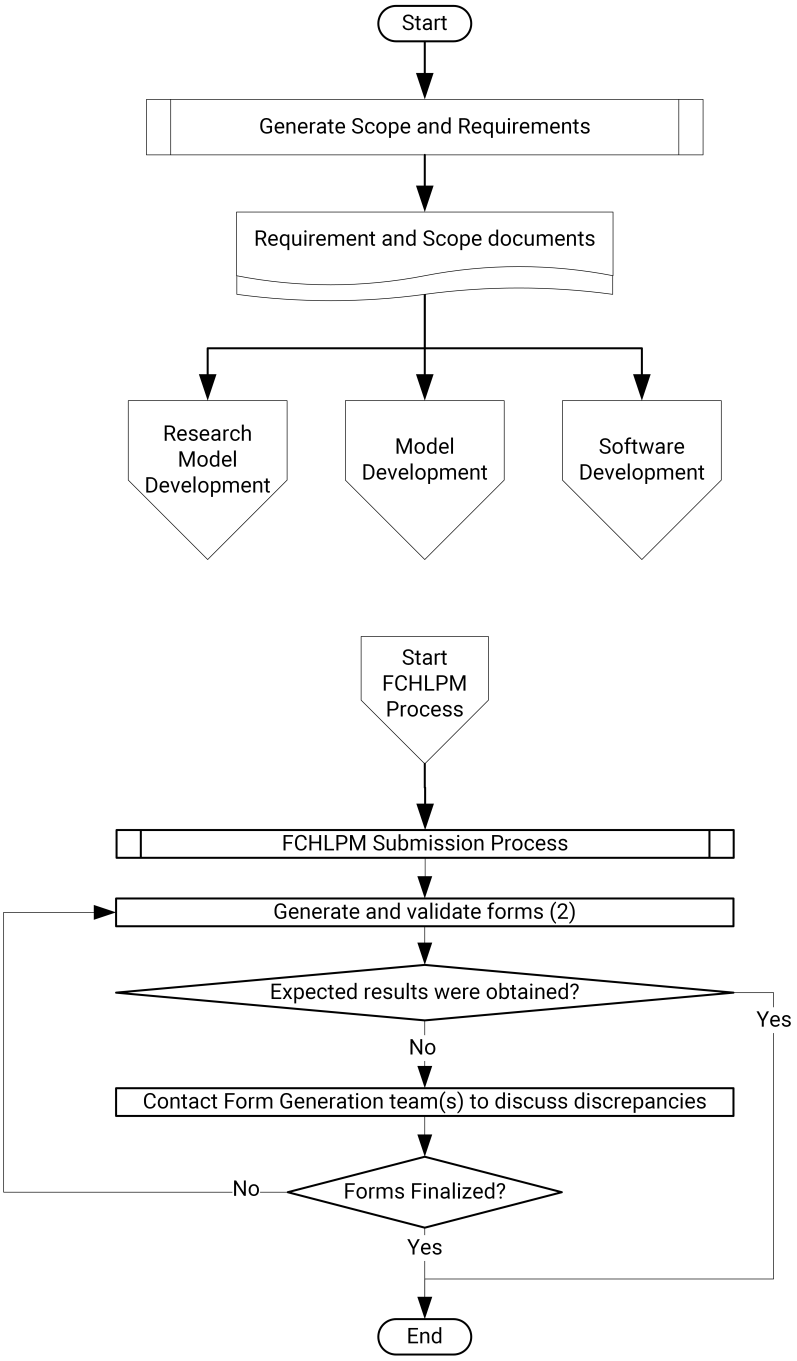


Figure 41. Touchstone Network Layout

These machines are all in the same domain with a flat network topology. The client communicates only with the application server. This is documented in the Systems Requirements document on the Client Portal, after login.

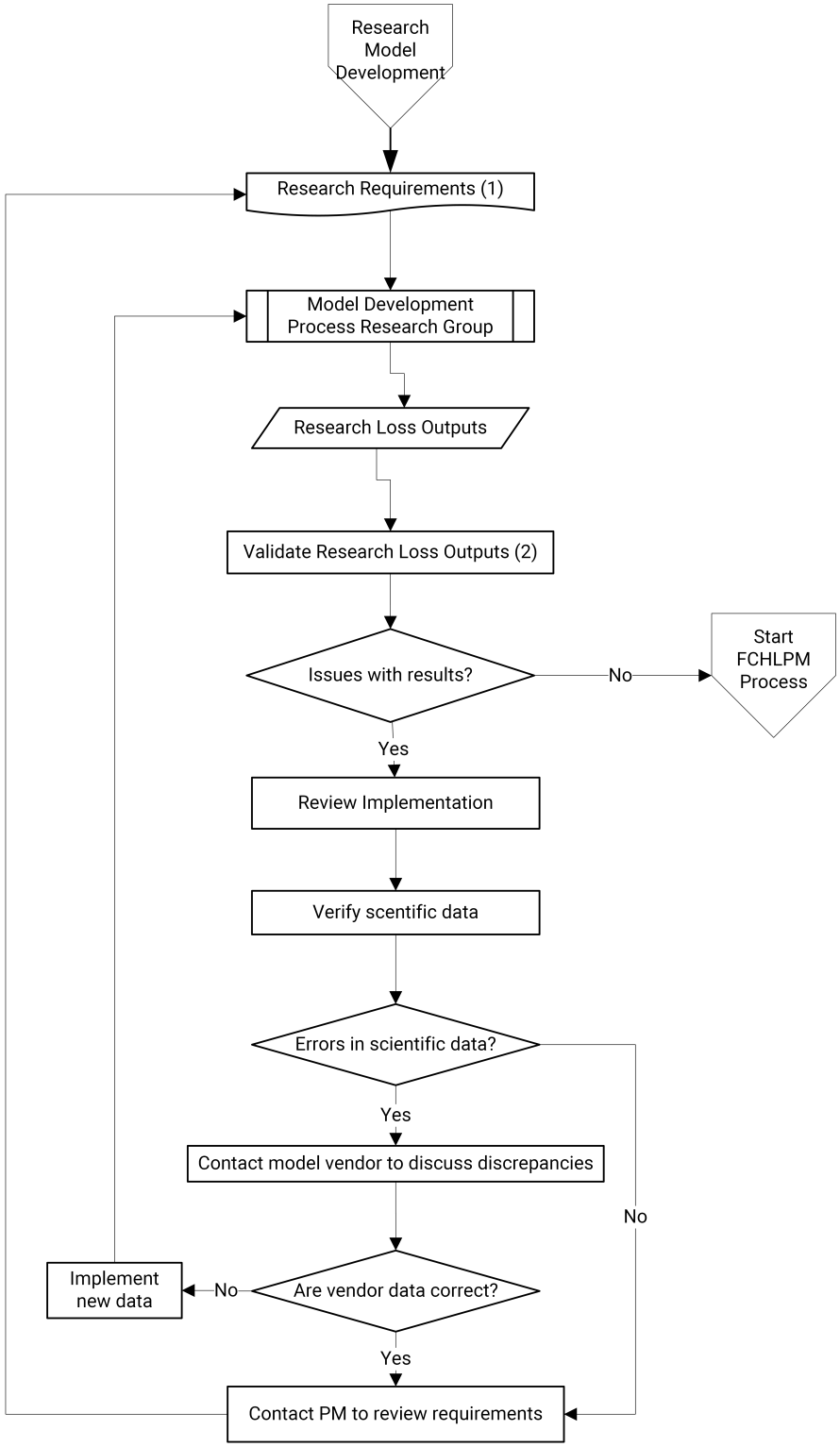
More detailed diagrams are available for review by the independent peer auditor and by the Professional Team. System model representations associated with each software component are available in the model architecture and design documentation.

The workflows in Figure 42 to Figure 51 illustrate the model and software design, development, implementation and testing processes. Hurricane model and software development custodians shall be available to explain the functional behavior of any hurricane model or software component and to respond to questions concerning changes in code, documentation, or data for that component.



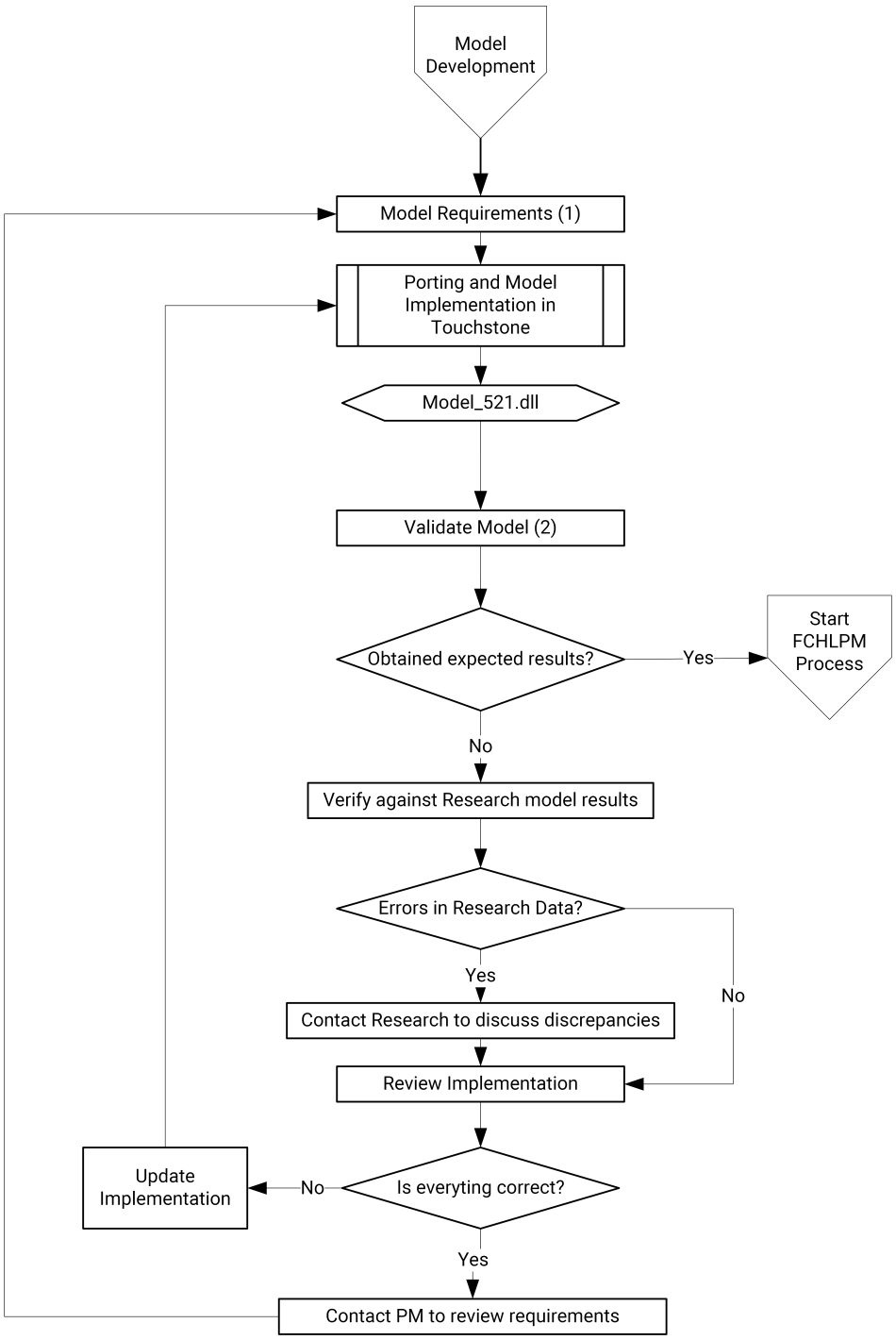
(1) Requirements documentation is the foundation for the development of the design, testing, and other support documentation. Development of these documents is integrated into the Research Model, Model, and Software Development processes.
(2) Validation includes: run test cases and analyze results, verify results, and review documentation.

Figure 42. Development and Implementation Overview (Part 1)



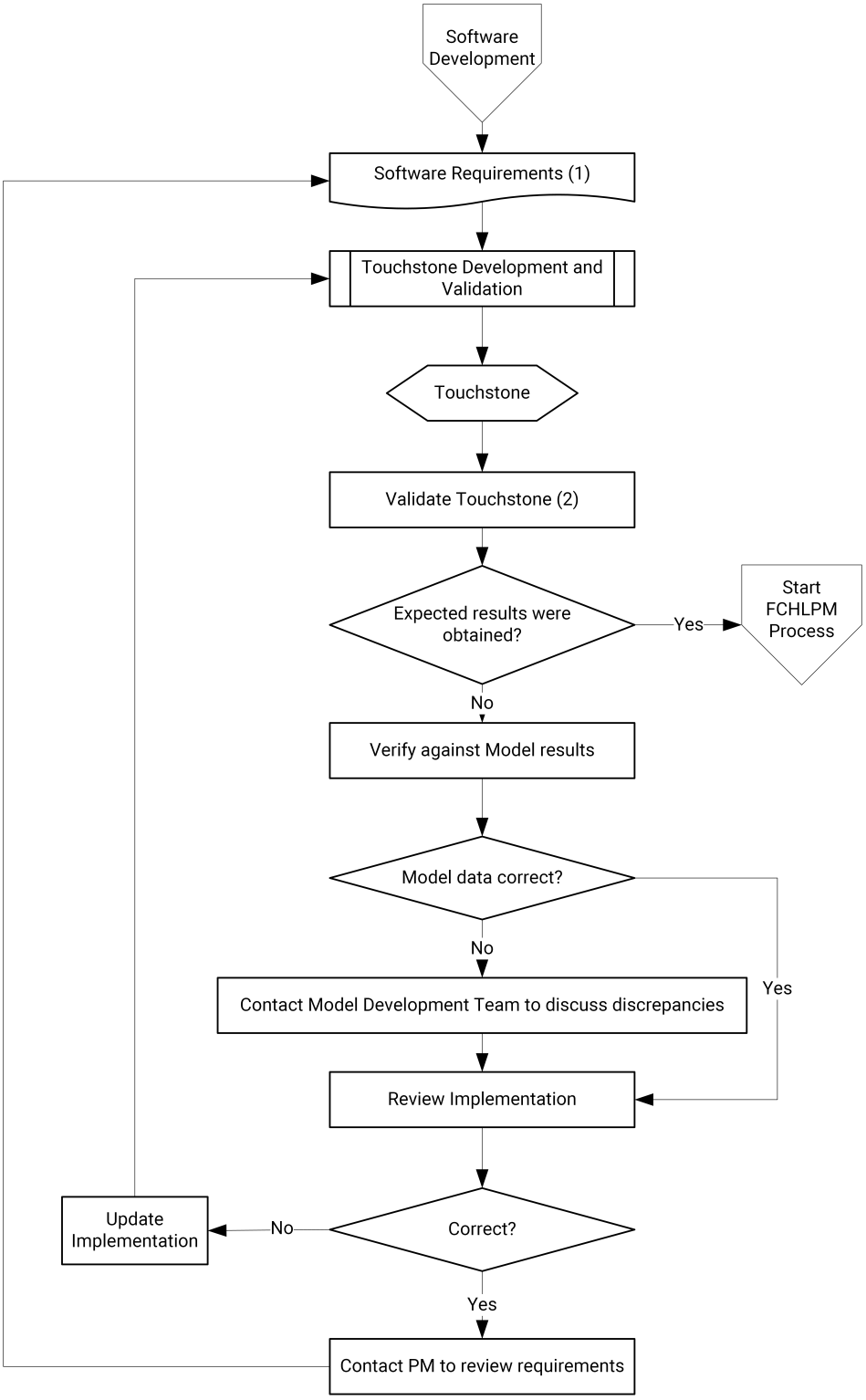
(1) Requirements documentation is the foundation for the development of the design, testing, and other support documentation. Development of these documents is integrated into the Research Model, Model, and Software Development processes.
(2) Validation includes: run test cases and analyze results, verify results, and review documentation.

Figure 43. Development and Implementation Overview (Part 2)



(1) Requirements documentation is the foundation for the development of the design, testing, and other support documentation. Development of these documents is integrated into the Research Model, Model, and Software Development processes.
(2) Validation includes: run test cases and analyze results, verify results, and review documentation.

Figure 44. Development and Implementation Overview (Part 3)



(1) Requirements documentation is the foundation for the development of the design, testing, and other support documentation. Development of these documents is integrated into the Research Model, Model, and Software Development processes.
(2) Validation includes: run test cases and analyze results, verify results, and review documentation.

Figure 45. Development and Implementation Overview (Part 4)

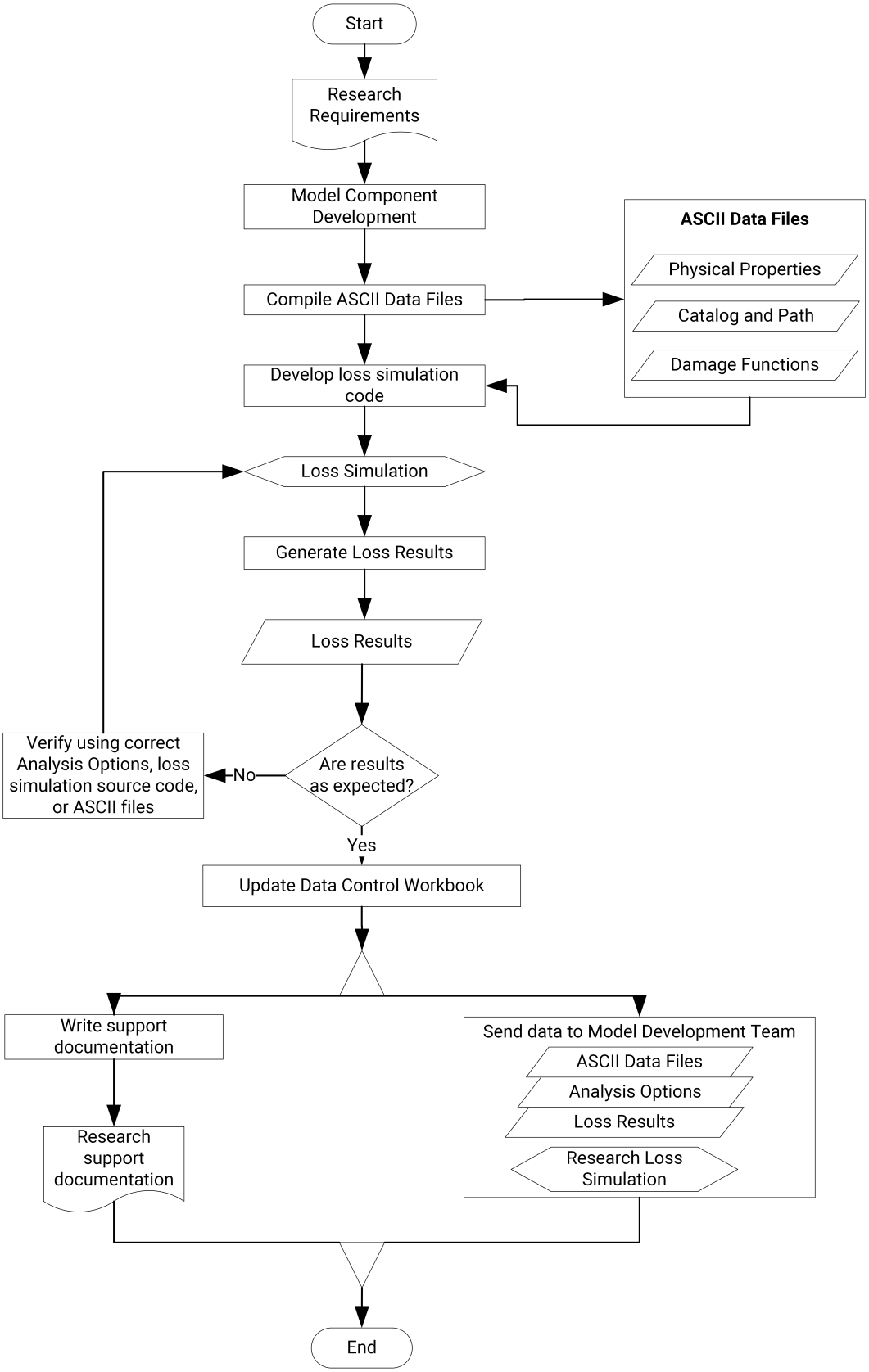


Figure 46. Model Development Process-Research Group

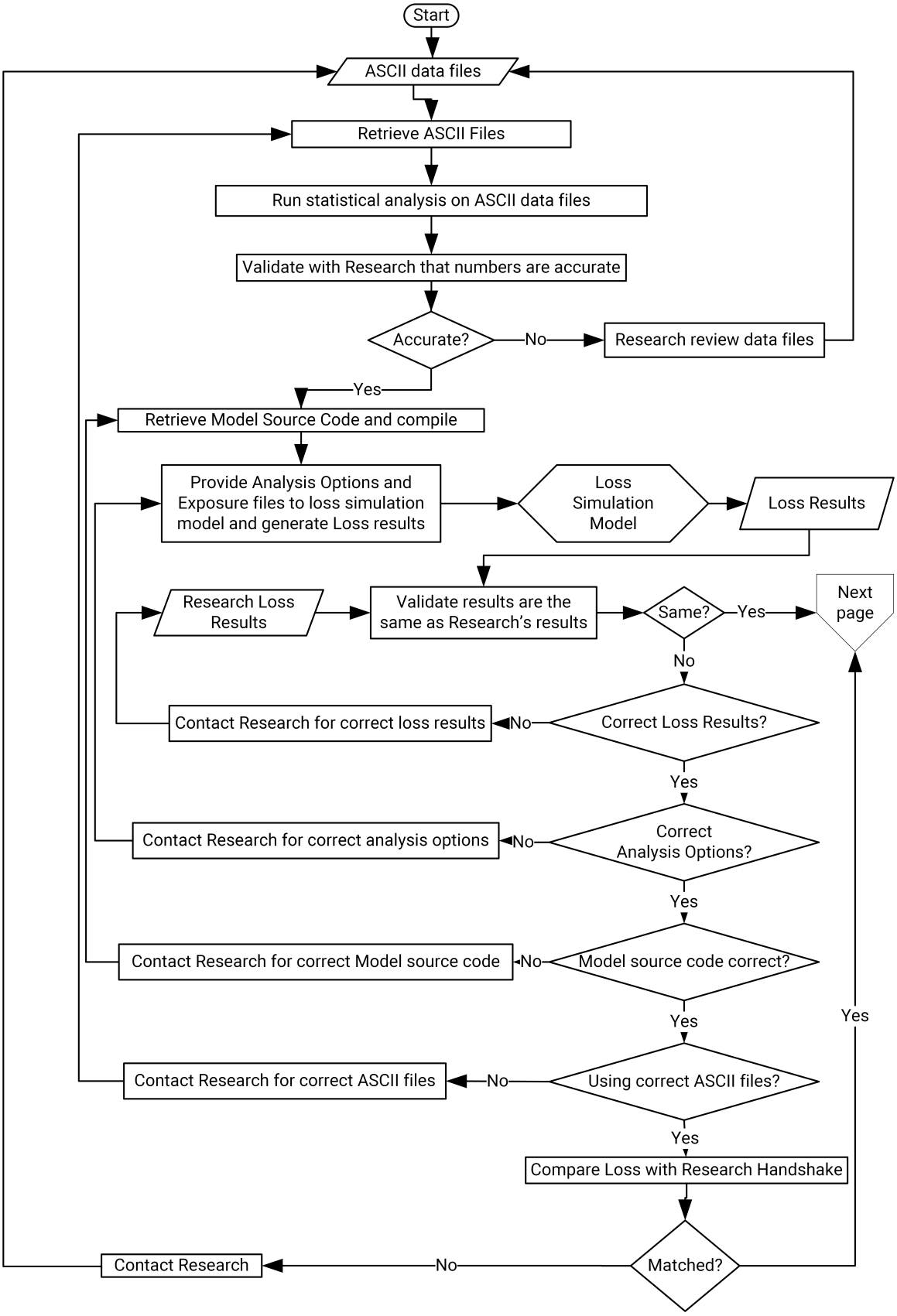


Figure 47. Model 521 Porting and Implementation in Touchstone (Part 1)

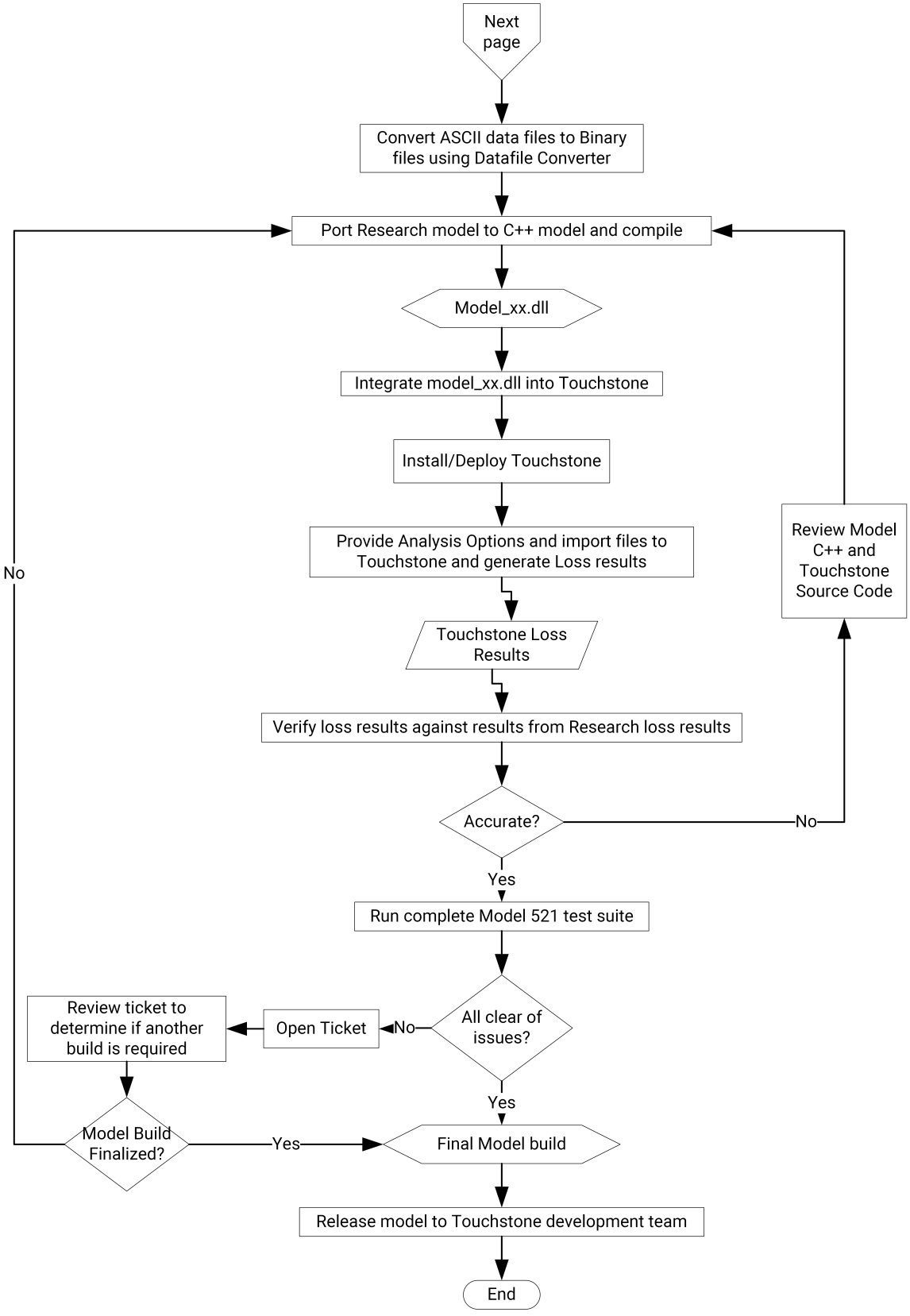


Figure 48. Model 521 Porting and Implementation in Touchstone (Part 2)

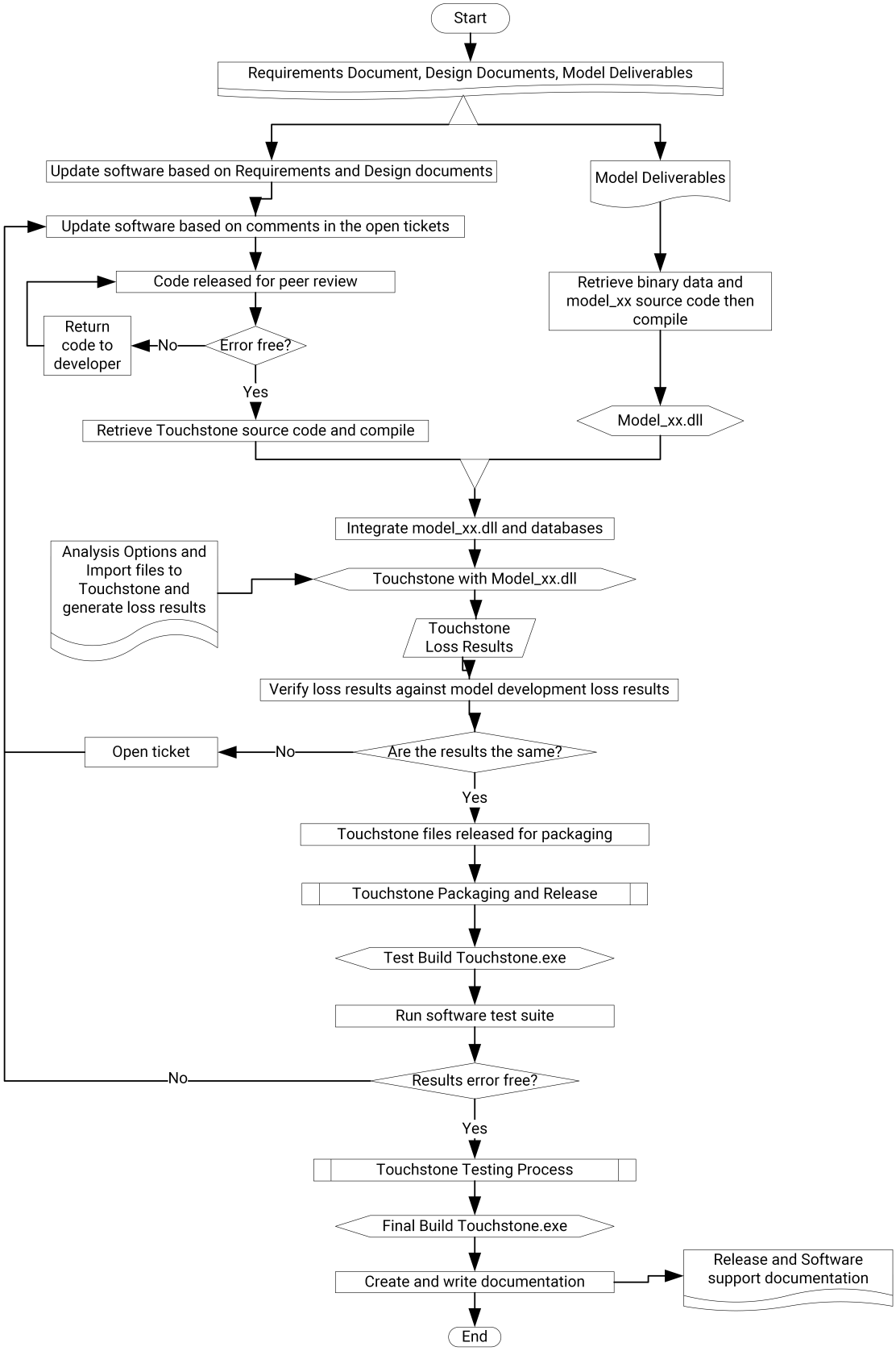


Figure 49. Touchstone Development and Validation

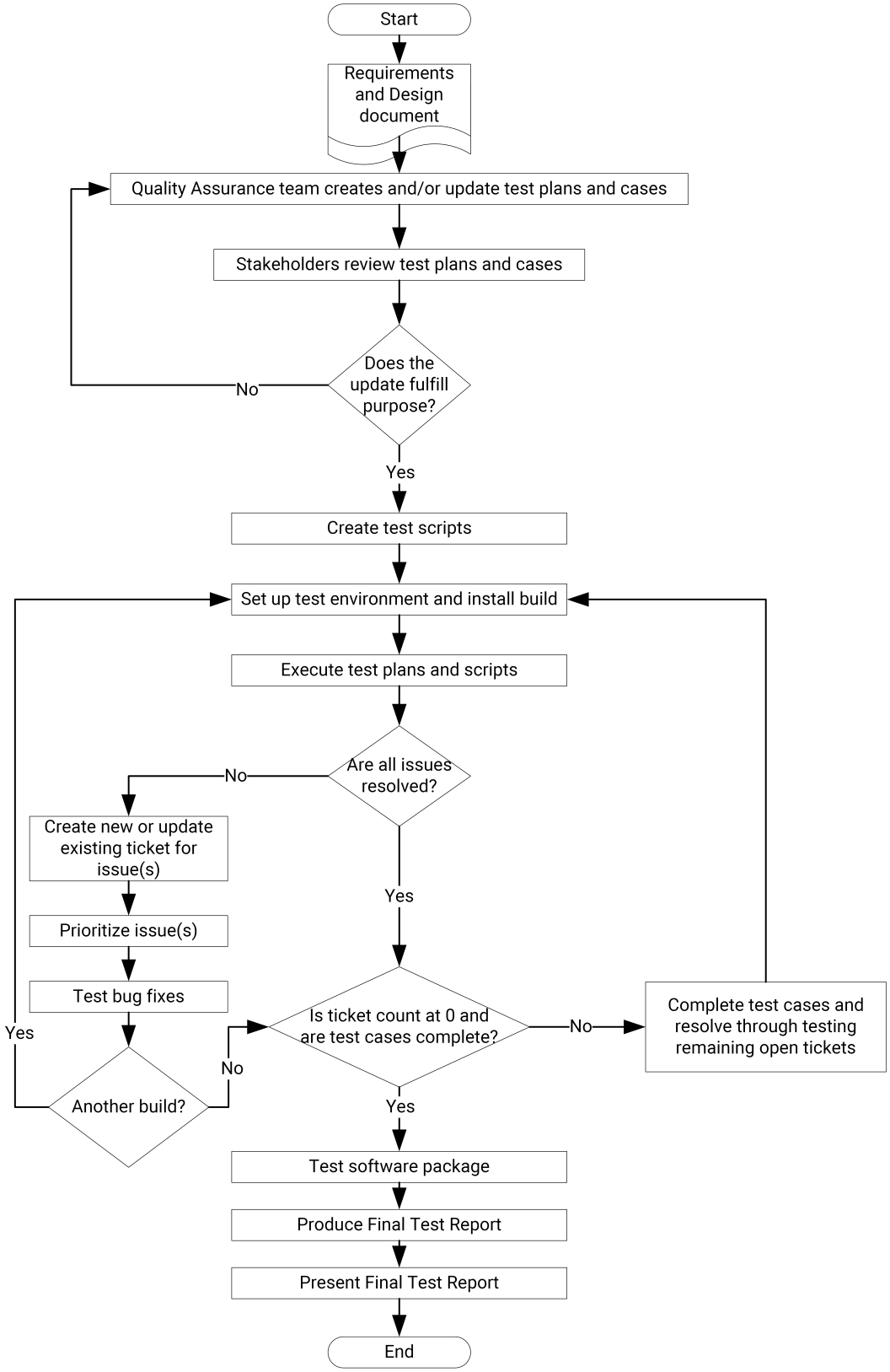


Figure 50. Touchstone Testing Process Overview

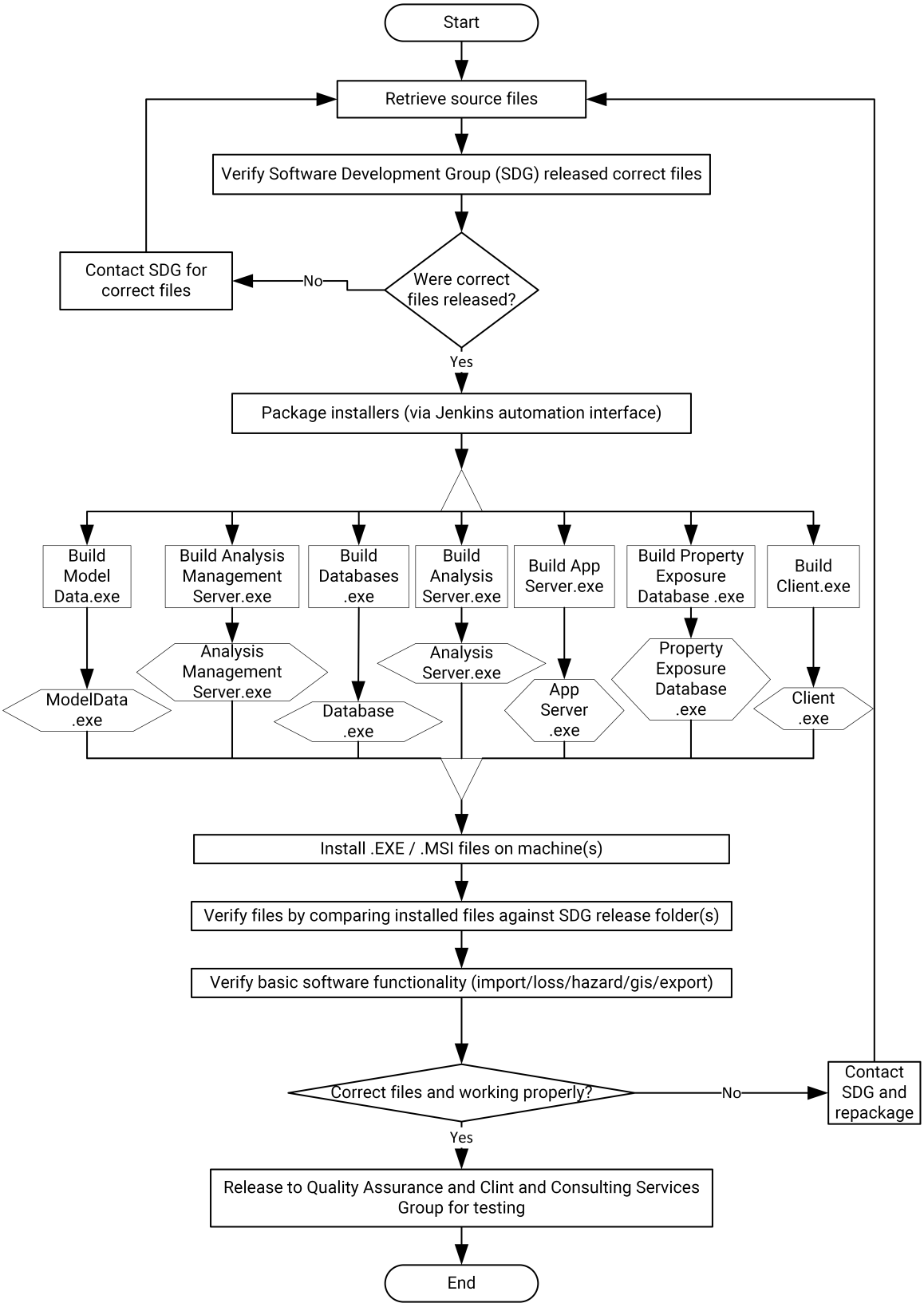


Figure 51. Touchstone Packaging and Release

CI-3.B

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

The Verisk Flowchart Mapping Standards document contains Verisk's internally-developed standard for flowcharts. Verisk flowcharts are created in accordance with these standards. It includes Verisk best practices and describes the symbols that Verisk uses in its flowcharts. This document is available for review by the independent peer auditor and by the Professional Team.

Standard CI-4: Hurricane Model Implementation

CI-4.A

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

Verisk maintains a complete set of software engineering practices and coding guidelines that are followed by the software developers, including C++/COM, C#/.Net, and SQL. Guidelines for languages such as R and Python are also included, as these languages are used in the research and development of the hurricane model. These guidelines are available for inspection by the independent peer auditor and by the Professional Team.

CI-4.B

Network organization documentation shall be maintained.

Touchstone is a multi-layer client-server application designed to run on a single network. Network organization in Touchstone is comprised of client machines, an application server, an analysis engine, database servers, and an optional model data share, as illustrated in Figure 41.

More detailed diagrams are available for review by the independent peer auditor and by the Professional Team. In addition, the ***System Requirements*** document is available on the Client Portal after login.

CI-4.C

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

Verisk maintains support material for these components, which provides detailed discussion regarding the procurement and verification of the data. These documents are available for review by the independent peer auditor and by the Professional Team.

Model component and database development custodians shall be available to discuss the data procurement, implementation, and verification processes.

CI-4.D

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

Verisk has developed documentation that provides component identification from documentation diagrams which are fully traceable down to the code level. Hurricane model and software development custodians shall be available to demonstrate traceability using items from the document ***Enhancements and Florida Commission Documentation Mapping.***

CI-4.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.

Verisk maintains tables that identify each of the software components that affect hurricane loss costs and probable maximum loss levels. The tables contain the following column headings: Component name, Number of lines of code, Number of comment lines and blank lines. These tables are in the ***Line Counts*** document, which is available for review by the independent peer auditor and by the Professional Team.

CI-4.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.

Verisk documentation can be used by new software engineers to gain an understanding of the software being reviewed. Verisk coding procedures ensure that software code is clearly commented for easy comprehension of content. Code samples are available for inspection by the independent peer auditor and by the Professional Team. Model and software development custodians shall be available to demonstrate commenting within the code.

CI-4.G

The following documentation shall be maintained for all components or data modified by items identified in Hurricane Standard G-1, Disclosure 7 and Audit 4:

CI-4.G.1

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

Documentation is maintained on equations and formulas that are used in the hurricane model. The documents define the terms and variables of these equations and formulas and how they are implemented in the model.

CI-4.G.2

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

Source code that is related to the equations and formulas implemented throughout the hurricane model is documented and includes the terms and variable names as they relate to the original equation or formula. These files are maintained and updated appropriately to reflect the latest version of the model.

CI-4.H

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

The Model 521 source code is version controlled in TFVC. All of TFVC is integrated with Windows domain and only authorized changes are allowed.

All code changes are under version control and documented when checked IN. The schedules are part of the release/sprint planning and published upfront on the internal confluence page. The vintages of all data and code have been reviewed by Verisk staff and their use has been justified. Justifications will be presented to the Professional Team and at the closed meeting with the Commission for review.

Disclosures

CI-4.1

Specify the hardware, operating system, and essential software required to use the hurricane model on a given platform.

The following requirements are specified for the Touchstone software application. Verisk's Technical Software group works directly with clients to ensure successful installation.

Supported platforms

The following platforms are supported:

Operating systems (U.S. English only)

- All operating systems are 64-bit
- Windows 10 on client machine only (UI)
- Windows Server 2022 Standard

Microsoft SQL servers

- SQL Server 2022 RTM (GDR)

SQL Server collation

- Set SQL Server to the following collation setting: SQL_Latin1_General_CP1_CI_AS. This is the default installation for U.S. English SQL Server.

Microsoft HPC Services

- HPC Pack 2019. Update 2

Processor

- Verisk builds, tests, and deploys all Verisk software on machines with Intel-based processors. Verisk does not recommend or support non-Intel processors.

Minimum Resource Requirements

Table 18 defines the minimum core, RAM, and disk space requirements for the Touchstone components.

Table 18. Minimum Resource Requirements

Touchstone Component	Cores	RAM	Disk Space	Scalability/Redundancy
Databases	8	64 GB	4 TB	• Exposure and Results databases can be proliferated • Multiple SQL server instances are allowed
Property Exposure DBs	8	32 GB	1 TB	• Can install on the same SQL server as the Touchstone database
Analysis Management	4	8 GB	250 GB	• Single node • Support HPC pack failover clustering
Analysis Server	8	64 GB	500 GB*	• 1/None • Optionally, can be scaled out and load-balanced with HPC Scheduler
Application Server	4	8 GB	250 GB	• 1/None • Optionally, can be scaled out and load-balanced with network appliance
Client Machine	4	4 GB	200 GB	• 1/None
Model Data**	4	8 GB	1.5 TB***	• Currently catalogs are installed on the compute node

* The Model Data can also reside on the Analysis Server component, increasing data fetch speeds, but the Model Data disk requirements need to be added to the existing 500 GB requirement.

**Starting with V2.0.0, Verisk now supports a centralized model data share.

*** This value of 1.5TB is an estimate, and may increase as Catalogs and Hazard Data footprint grows.

Physical Memory Limits by OS Version

Table 19 defines the physical memory limits as defined by the OS version.

Table 19. Physical Memory Limits

Operating System	Max Supported Memory
Windows 10	4 TB
Windows Server 2022	48 TB

Certified Platforms and Configuration

Table 20 identifies the platforms certified by Verisk.

Table 20. Certified Platforms

Platform	Operating System		SQL Server	HPC Pack
Touchstone 2024A	Win 10	Win Server 2022	SQL Server 2022 (RTM)	HPC 2019 Update 2
Databases		✓	✓	
Analysis Management		✓		✓
Analysis Server		✓		✓
Application Server		✓		✓
Client Machine	✓	✓		

Table 21 defines the certified OS or software that is required for the components.

Table 21. Certified Configuration

Touchstone Component	Scalability/Redundancy
Database Server	Windows Server 2022, Standard
Analysis Management Server (HN)	Windows Server 2022, Standard
Analysis Management Server (HN)	HPC Pack 2019 Update 2(Head Node Components)
Analysis Servers (CN)	Windows Server 2022, Standard
Analysis Servers (CN)	HPC Pack 2019 Update 2 (Head Node Components)
Application Server (IIS)	Windows Server 2022, Standard
Application Server (IIS)	HPC Pack 2019 Update 2(Client Utilities)
Client Machine (UI)	Windows Server 2022, Standard
Client Machine (UI)	Windows 10

Upgrade Paths

For clients with Touchstone 2024A who want the least amount of environment reconfiguration, use the upgrade guidelines summarized in below table. Note that this path will not ensure complete future Touchstone compatibility.

Table 22. Least Impact Upgrade Path

Touchstone Component	Operating System Version	HPC Pack Version	SQL Server Version
Databases	Windows Server 2022	NA	SQL Server 2022 (RTM)
Analysis Management	Windows Server 2022	HPC Pack 2019 Update 2	NA
Analysis Server	Windows Server 2022	HPC Pack 2019 Update 2	NA
Application Server	Windows Server 2022	HPC Pack 2019 Update 2	NA
Client	Windows 10/WS 2022	NA	NA

For new clients without a pre-existing Touchstone installation, and for clients who wish to ensure maximum future compatibility with Touchstone, use the upgrade guidelines summarized in Table 23.

Table 23. Maximum Impact Upgrade Path

Touchstone Component	Operating System Version	HPC Pack Version	SQL Server Version
Databases	Windows Server 2022	NA	SQL Server 2022 (RTM)
Analysis Management	Windows Server 2022	HPC Pack 2019 Update 2 Head Node	NA
Analysis Server	Windows Server 2022	HPC Pack 2019 Compute Node	NA
Application Server	Windows Server 2022	HPC Pack 2019 Utilities	NA
Client	Windows 10/WS2022	NA	NA

Migration to New Servers

Clients who are upgrading from an earlier version of Touchstone will most likely need to: migrate the existing Touchstone database to new servers, restore the Verisk logins, and perform an in-place upgrade, to accommodate the transition to SQL 2022 and Windows 2022. This will not apply to new installations of Touchstone 2024A.

HPC Pack Breakdown

Table 24 is a simple guide to which HPC component is required and what operating system is supported.

Table 24. HPC Pack Breakdown

Touchstone Component	Operating System Version	HPC Pack Component
Analysis Management Server	Windows Server 2022	HPC Pack 2019 Update 2
Analysis Server	Windows Server 2022	HPC Pack 2019 Update 2
Application Server	Windows Server 2022	HPC Pack 2019 Update 2
Analysis Management and Application Server	Windows Server 2022	HPC Pack 2019 Update 2

HPC 2019 can only be installed to SQL Server 2017/2019/2022 instances, even express; the type of instance that can be installed through the HPC installer.

Model Data Disk Space Requirements

Touchstone 2024A offers model data in two packages:

- 10K/50K/500K/Hazard Package
- 100K package

Disk space requirements for these two packages are summarized in Table 25.

Table 25. Model Data Disk Space Requirements (in Gigabytes)

Region of Data	Peril	10K/50K/500K Package	100K Package
Asia Pacific	Earthquake (includes India)	345.9	112
Asia Pacific	Bushfire	2.0	20.1
Asia Pacific	Typhoon (Tropical Cyclone)	66.3	NA
Asia Pacific	Severe Thunderstorm	14.7	35.5
Asia Pacific	Inland Flood	1.4	NA
Asia Pacific	Terrorism	0.1	NA
Caribbean	Tropical Cyclone (Hurricane)	59.68	NA
Caribbean	Earthquake	13.2	NA
Central America	Tropical Cyclone (Hurricane)	14.5	NA
Central America	Earthquake	0.2	NA
Europe	Earthquake	0.4	NA
Europe	Extratropical Cyclone	39.0	NA
Europe	Inland Flood	53.6	NA
Europe	Severe Thunderstorm	2.7	NA
Europe	Terrorism	0.1	NA
North America	Earthquake	328	85.7
North America	Inland Flood	956	NA
North America	Hurricane (Tropical Cyclone)	364.9	24.83
North America	Severe Thunderstorm	246.0	124.0
North America	Terrorism	0.1	NA
North America	Wildfire	801	641
North America	Winter Storm	3.5	NA
South America	Earthquake	15.3	NA
South America	Terrorism	0.1	NA

Development Tools and Dependencies

Development Tools and Dependencies defines the Touchstone development tools and dependencies.

Table 26. Touchstone Development Tools and Dependencies

Category	Item	Description	Version
Third Party	Industry Tool	7-Zip 24.08 (x64)	24
Third Party	Industry Tool	Adobe Acrobat Reader DC	24.002.21005
Third Party	Industry Tool	ArcGIS 10.6 for Desktop	10.6.8321
Third Party	Industry Tool	Beyond Compare	4.4.7
Third Party	Industry Tool	C++ | Visual Fortran Compiler	16.0.1.146
Third Party	Industry Tool	C++ Integration(s) in Microsoft Visual Studio 2022	17.10.3
Third Party	Industry Tool	Catlight build notifications	2.17.2
Third Party	Industry Tool	Cisco AnyConnect Secure Mobility Client	4.10.07073
Third Party	Industry Tool	CrowdStrike Windows Sensor	7.15.18514.0
Third Party	Industry Tool	Debugging Tools for Windows (x64)	6.11.1.404
Third Party	Industry Tool	Devart Review Assistant 4.1.263	4.1.263
Third Party	Industry Tool	DiffMerge	4.2.0.697
Third Party	Industry Tool	DLM Dashboard 1	1.7.5.1116
Third Party	Industry Tool	Dotfuscator and Analytics Community Edition 5.22.0	5.22.0.3788
Third Party	Industry Tool	Entity Framework 6.1.3 Tools for Visual Studio 2015 Update 1	14.0.41103.0
Third Party	Industry Tool	FireEye Endpoint Agent	32.30.0
Third Party	Industry Tool	Google Chrome	127.0.6533.120
Third Party	Industry Tool	Google Earth Pro	7.3.1.4507
Third Party	Industry Tool	HDF5	1.8.11
Third Party	Industry Tool	HPC	2019 (6.2.7756.0)
Third Party	Industry Tool	IIS 10.0 Express	10.0.1743
Third Party	Industry Tool	Infragistics WPF	19.1
Third Party	Industry Tool	Intel Parallel Studio XE 2016 Update 4 Professional Edition	2016.0.4.062
Third Party	Industry Tool	Intel(R) Parallel Studio XE 2019 Update 4	2019.0.4.066
Third Party	Industry Tool	Intel Intel® oneAPI Base Toolkit	2024.2.0.635
Third Party	Industry Tool	Intel C++ Compiler.	2024.2.0
Third Party	Industry Tool	Intel(R) Processor Graphics	25.20.100.6472
Third Party	Industry Tool	Intel(R) Software Manager	2.3.022
Third Party	Industry Tool	Map Content Downloader version 2.3.1	2.3.1
Third Party	Industry Tool	MATLAB R2016a	9.0
Third Party	Industry Tool	Memory Profiler	12.0.40629
Third Party	Industry Tool	Microsoft .NET Framework	4.8.03761
Third Party	Industry Tool	Microsoft .NET Framework 4.7 Multi-Targeting Pack	4.7.02558
Third Party	Industry Tool	Microsoft .NET Framework 4.7.2 Multi-Targeting Pack	4.7.03062
Third Party	Industry Tool	Microsoft .NET Framework 4.7.2 SDK	4.7.03062

Category	Item	Description	Version
Third Party	Industry Tool	Microsoft .NET Framework 4.8	4.8.03761
Third Party	Industry Tool	Microsoft .NET Framework 4.8 Targeting Pack	4.8.03761
Third Party	Industry Tool	Microsoft .NET Framework 4.8 Targeting Pack (ENU)	4.8.03761
Third Party	Industry Tool	Microsoft Build Tools	14.0.25420
Third Party	Industry Tool	Microsoft Help Viewer 2.3	2.3.27412
Third Party	Industry Tool	Microsoft ODBC Driver 17 for SQL Server	17.2.0.2
Third Party	Industry Tool	Microsoft Edge	128.0.2739.4
Third Party	Industry Tool	Microsoft Office 365 ProPlus - en-us	16.0.12527.20988
Third Party	Industry Tool	Microsoft OneDrive	20.143.0716.0003
Third Party	Industry Tool	Microsoft SQL Server 2022	16.0.1121.4
Third Party	Industry Tool	Microsoft SQL Server 2019 Management Objects (x64)	161.46041.41
Third Party	Industry Tool	Microsoft SQL Server 2022 T-SQL Language Service	15.0.4298.1
Third Party	Industry Tool	Microsoft SQL Server 2022 T-SQL ScriptDom	15.0.4298.1
Third Party	Industry Tool	Microsoft SQL Server Compact 4.0 SP1 x64 ENU	4.0.8876.1
Third Party	Industry Tool	Microsoft SQL Server Data Tools - enu (14.0.60519.0)	14.0.60519.0
Third Party	Industry Tool	Microsoft SQL Server Management Studio - 18.12.1	15.0.18424.0
Third Party	Industry Tool	Microsoft System CLR Types for SQL Server 2014	12.0.2402.29
Third Party	Industry Tool	Microsoft System CLR Types for SQL Server 2016	13.0.1601.5
Third Party	Industry Tool	Microsoft System CLR Types for SQL Server 2019	15.0.4298.1
Third Party	Industry Tool	Microsoft System CLR Types for SQL Server vNext CTP1.6	15.0.600.33
Third Party	Industry Tool	Microsoft Team Foundation Server	10.0.30319
Third Party	Industry Tool	Microsoft Teams	1.3.00.21759
Third Party	Industry Tool	Microsoft Visio Professional. Office 365	2208 (Build 15601.20148)
Third Party	Industry Tool	Microsoft Visual C++ 2022	14.40.33810.0
Third Party	Industry Tool	Microsoft Visual C++ 2017 Redistributable (x64) - 14.16.27033	14.16.27033.0
Third Party	Industry Tool	Microsoft Visual C++ 2017 Redistributable (x86) - 14.16.27033	14.16.27033.0
Third Party	Industry Tool	Microsoft Visual Studio 2022	17.10.3
Third Party	Industry Tool	Microsoft Visual Studio Installer	2.11.69.53063
Third Party	Industry Tool	Microsoft Visual Studio Tools for Applications 2022	15.0.27520
Third Party	Industry Tool	Microsoft Visual Studio Enterprise 2022	17.10.5
Third Party	Industry Tool	Microsoft Visual C++ 2015 - 2022 Redistributable (x64) - 14.40.33810	14.40.33810
Third Party	Industry Tool	Microsoft Visual C++ 2015 - 2022 Redistributable (x86) - 14.40.33810	14.40.33810
Third Party	Industry Tool	Microsoft Web Deploy 3.6	3.1238.1962

Category	Item	Description	Version
Third Party	Industry Tool	Microsoft XML Parser and SDK	6.20.2003.0
Third Party	Industry Tool	MSBuild	17.10.4.21802
Third Party	Industry Tool	MSXML	6.20.2003.0
Third Party	Industry Tool	Notepad++	8.6.9
Third Party	Industry Tool	Octave 4.0.0	4.0.0
Third Party	Industry Tool	PDFCreator	1.2.3
Third Party	Industry Tool	Prerequisites for SSDT	13.0.1601.5
Third Party	Industry Tool	Python	3.6.1150.0
Third Party	Industry Tool	QGIS	3.12.1
Third Party	Industry Tool	QGIS 3.6.2 'Noosa'	3.6.2
Third Party	Industry Tool	R for Windows 3.5.0	3.5.0
Third Party	Industry Tool	Rational ClearQuest	8.0.1.4
Third Party	Industry Tool	RStudio	1.1.383
Third Party	Industry Tool	Shape2SQL	1.2.0.0
Third Party	Industry Tool	Silk Test	19.0.0
Third Party	Industry Tool	SmartBear AQtime 8	8.80.3749.7
Third Party	Industry Tool	SourceGear DiffMerge 4.2.0.697.stable (x64)	4.2.0.697
Third Party	Industry Tool	Symantec Endpoint Protection	14.0.3752.1000
Third Party	Industry Tool	Teams Machine-Wide Installer	1.2.0.24753
Third Party	Industry Tool	TeXnicCenter Version 2.02 Stable	2.02 Stable
Third Party	Industry Tool	Textpad	8.2.0
Third Party	Industry Tool	Total Commander	8.01
Third Party	Industry Tool	Windows Mobile Connectivity Tools 10.0.15254.0 - Desktop x86	10.1.15254.1
Third Party	Industry Tool	Windows SDK AddOn	10.1.0.0
Third Party	Industry Tool	Windows Software Development Kit - Windows 10.0.17134.12	10.1.17134.12
Third Party	Industry Tool	Windows Software Development Kit - Windows 10.0.17763.132	10.1.17763.132
Third Party	Industry Tool	Windows Software Development Kit - Windows 10.0.26624	10.0.26624
Third Party	Industry Tool	WinRAR	5.50.0
Third Party	Industry Tool	Zoom	5.1
Third Party	Industry Tool	LineCountComputation Tool	1.94
Verisk-developed Tool	Verisk Tool	Datafile Converter	15
Touchstone component	COM_Component	CATools Components	4.0.0.0

Category	Item	Description	Version
Touchstone component	COM_Component	Loss Engine	8.0.0.0
Touchstone component	COM_Component	CAT Engine	5.0.0.0
Touchstone component	COM_Component	Model_01: Verisk Terrorism Loss Estimation Model	4.1.0
Touchstone component	COM_Component	Model_02: Verisk U.S. Workers Compensation	2.2.0
Touchstone component	COM_Component	Model_03: Verisk Japan Personal Accident	1.1.0
Touchstone component	COM_Component	Model_05: Verisk Wildfire Model for California	3.3.0
Touchstone component	COM_Component	Model_06: Australia Bushfire	3.0.0
Touchstone component	COM_Component	Model_08: Verisk U.S. Flood	3.1.0
Touchstone component	COM_Component	Model_11: Verisk Earthquake Model for the U.S.	10.4.1
Touchstone component	COM_Component	Model_12: Verisk Earthquake Model for the U.S. and Canada	4.1.0
Touchstone component	COM_Component	Model_13: Verisk Earthquake Model for Hawaii	1.7.3
Touchstone component	COM_Component	Model_14: Verisk Earthquake Model for Alaska	1.8.2
Touchstone component	COM_Component	Model_15: Verisk Earthquake Model for the Caribbean	3.1.1
Touchstone component	COM_Component	Model_18: Verisk Japan Inland Flood Model	1.1.0
Touchstone component	COM_Component	Model_21: Verisk Hurricane Model for the U.S.	18.1.2
Touchstone component	COM_Component	Model_22: Verisk Severe Thunderstorm Model for the U.S.	8.0.0
Touchstone component	COM_Component	Model_23: Verisk Hurricane Model for Hawaii	3.10.0
Touchstone component	COM_Component	Model_24: Verisk U.S. Hurricane Model for Offshore Assets	1.14.0
Touchstone component	COM_Component	Model_25: Verisk Tropical Cyclone Model for the Caribbean	10.1.1
Touchstone component	COM_Component	Model_26: Verisk Severe Thunderstorm Model for Canada	3.2.0
Touchstone component	COM_Component	Model_28: Verisk Winter Storm Model for the U.S.	1.4.1
Touchstone component	COM_Component	Model_29: Verisk Tropical Cyclone Model for Mexico	1.0.1
Touchstone component	COM_Component	Model_30: Verisk Tropical Cyclone Model for Canada	1.1.0

Category	Item	Description	Version
Touchstone component	COM_Component	Model_31: Verisk Earthquake Model for the Pan-European Region	4.1.0
Touchstone component	COM_Component	Model_33: Verisk Earthquake Model for South East Europe	3.0.1
Touchstone component	COM_Component	Model_41: Verisk Extratropical Cyclone Model for Europe	7.1.0
Touchstone component	COM_Component	Model_42: Verisk Winter Storm Model for Canada	1.1.1
Touchstone component	COM_Component	Model_43: Verisk Severe Thunderstorm Model for Europe	1.1.0
Touchstone component	COM_Component	Model_44: Verisk Severe Thunderstorm Model for Australia	1.1.1
Touchstone component	COM_Component	Model_51: Verisk Earthquake Model for Australia	5.0.0
Touchstone component	COM_Component	Model_52: Verisk Earthquake Model for Japan	7.0.1
Touchstone component	COM_Component	Model_53: Verisk Earthquake Model for New Zealand	4.0.2
Touchstone component	COM_Component	Model_54: Verisk Earthquake Model for Southeast Asia	4.2.0
Touchstone component	COM_Component	Model_55: Verisk Earthquake Model for China	1.4.0
Touchstone component	COM_Component	Model_58: Verisk Earthquake Model for India	1.0.0
Touchstone component	COM_Component	Model_61: Verisk Cyclone Model for Australia	2.2.2
Touchstone component	COM_Component	Model_62: Verisk Typhoon Model for Japan	7.0.1
Touchstone component	COM_Component	Model_64: Verisk Typhoon Model for Southeast Asia	3.0.0
Touchstone component	COM_Component	Model_65: Verisk Typhoon Model for China	13.2.0
Touchstone component	COM_Component	Model_66: Verisk Typhoon Model for South Korea	2.1.0
Touchstone component	COM_Component	Model_67: Verisk Tropical Cyclone Model for Central America	2.2.2
Touchstone component	COM_Component	Model_68: Verisk India Tropical Cyclone	2.2.0
Touchstone component	COM_Component	Model_70: Verisk Earthquake Model for South America	1.1.0
Touchstone component	COM_Component	Model_72: Verisk Earthquake Model for Mexico	2.0.2
Touchstone component	COM_Component	Model_76: Verisk Earthquake Model for Central America	1.0.2
Touchstone component	COM_Component	Model_87: Verisk Multiple-Peril Crop Insurance Model for India	1.0.0

Category	Item	Description	Version
Touchstone component	COM_Component	Model_90: Verisk Inland Flood Model for Central Europe	2.2.0
Touchstone component	COM_Component	Model_92: Verisk Inland Flood Model for Great Britain	1.2.0
Touchstone component	COM_Component	Model_94: Verisk Inland Flood Model for South East Europe	1.0.0
Touchstone component	COM_Component	Model_521: Verisk Hurricane Model for the U.S.	3.0.0

Computer Languages

The computer languages employed for research and software development purposes at Verisk include: C++, FORTRAN, MATLAB, Microsoft C#, Python, R, SQL, WPF/WCF/XAML.

Standard CI-5: Hurricane Model Verification

CI-5.A

A. General

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

Verisk software engineers employ a variety of verification procedures to check code correctness. These procedures include code-level debugging, component-level unit testing, verifying newly developed code against a stable reference version, and running diagnostic software tools to detect runtime problems.

In addition, other verification mechanisms are used to test the correctness of key variables that might be subject to modification. These mechanisms include code tracing, intermediate output printing and error logging. Examples of these verification procedures, including code inspections, reviews, calculation crosschecks, walk-through and the use of logical assertions and exception-handling mechanisms in the code, are described within the documentation and shall be available to the independent peer auditor and to the Professional Team.

The verification processes for all model and software components are defined as part of the workflows in the flowcharts. Additional detailed information regarding the verification/testing process for the model components is provided within each component-specific document.

Crosschecking procedures and results for verifying equations are discussed in the document ***Model 521 Equations/Formulas, Variable Mapping and Crosschecking***. Model and software development custodians shall be available to illustrate the equation crosscheck verification.

CI-5.B

B. Component Testing

1. ***Testing software shall be used to assist in documenting and analyzing all components.***
2. ***Unit tests shall be performed and documented for each updated component.***
3. ***Regression tests shall be performed and documented on incremental builds.***
4. ***Integration tests shall be performed and documented to ensure the correctness of all hurricane model components. Sufficient testing shall be performed to ensure that all components have been executed at least once.***

1. Tools used during the testing process include:

- SilkTest: Build and execute automated test cases
- Beyond Compare: Compare and validate test output and results
- Azure DevOps (AZDO): Bug tracking and process management
- Excel, R and Python: General analytics and reporting
- ArcGIS: Geo-spatial validation
- Team Foundation Server (TFS): Test management

2. Unit testing is done to ensure that the individual units (procedures/functions, functional units, etc.) are working as per the expected behavior. Unit testing is done by the developer for new development of a unit or an update to an existing unit. During testing, any deviation observed from the expected behavior would be fixed by the developer. The important test results are preserved in a folder for future reference.

3. To ensure the quality of an incremental build, regression tests are executed at various levels including during Smoke testing and Acceptance testing (an extensive and thorough test) to ensure that only the expected changes are observed. When discrepancies are observed, QA refers the case to the appropriate stakeholder such as Research or Product Management for guidance. At the point of test plan execution, both the test plan and the test result are cataloged (documented) in a repository with version control.

4. Integration tests are performed and documented by various QA teams to ensure the correctness of all model components. The process includes:

- gathering feature requirements to understand the objective and the details of the assignment
- creating test plans that detail the testing to be executed in addition to the regressions to be employed
- cross-functional review and acceptance of the test plan that ensures complete coverage of the test plan
- the execution of the test plan
- the archiving of the results
- the review of results by various stakeholders for correctness and completeness.
- When applicable, issues that are found are entered into the tracking system.

CI-5.C

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.***

1. Testing software is used to document and analyze all databases and data files accessed by model components. The testing software and processes are described within the documentation and shall be available to the independent peer auditor and to the Professional Team.

2. Verisk runs tests that check for integrity, consistency and correctness of all databases and data files that are accessed by the model components. For instance, Verisk has a verification utility program, the Data File

Converter, which checks the existence, consistency, and correctness of all data files. This program verifies that each data file matches a known version of the data file by performing checksum verification. Checksum is a count of the number of bits in a transmission unit so that the receiver can verify the number of bits received against the original number of bits. When the count matches, it is assumed that the complete transmission was received.

Verisk performs data validation on databases at every step of the process and the entire process. This includes validating the source counts and ensuring that the changes are affected on the same number of records.

Examples of the verifications, including counts on the ZIP changed records, county change records, and ZIP centroid updates, are described within the documentation and can be available to the independent peer auditor and to the Professional Team.

Disclosures

CI-5.1

State whether any two executions of the hurricane model with no changes in input data, parameters, code, and seeds of random number generators produce the same hurricane loss costs and hurricane probable maximum loss levels.

All hurricane model runs including random number generator codes are performed during the hurricane model development process by our Research and Modeling Group. One of these iterations is selected and released in Touchstone as the event catalog. In this sense, the software as a separate application does not contain a random number generator component but, rather, it is contained within the event catalog (hurricane model), which is an integrated part of the application.

Verisk has multiple test cases that are run at every internal software build, and at least twice on the final release software build to ensure that Touchstone produces identical results, including hurricane loss costs and hurricane probable maximum loss levels.

These results are validated against past releases/builds to ensure that the hurricane loss costs and hurricane probable maximum loss levels are as expected.

CI-5.2

Provide an overview of the component testing procedures.

Hurricane model component testing procedures are divided into three broad sections:

1. ensure that the event generation, local intensity, and damage estimation modules are functioning correctly in each component and as a whole,
2. perform reasonability checks on the loss results, hazard pattern analysis, and document and quantify model changes, and
3. check various other model functionalities.

Verification processes for all hurricane model and software components are defined as part of the workflows in the flowcharts. Additional detailed information regarding the verification/testing process for the hurricane model components is provided in the ***Software and Model Testing Procedures*** document and within each component-specific document.

CI-5.3

Provide a description of verification approaches used for externally acquired data, software, and models.

Verisk verifies all externally sourced data; it is an integral part of the development process, especially for those model components that rely heavily on scientific data. Explanation of the validation methods for these data sources is provided in the table below.

Table 27. Validation Methods Data Sources

Source Title	Description	Validation Methods
National Hurricane Center Tropical Cyclone Reports	Provides comprehensive information on each hurricane. Data for hurricanes that occurred between 1958 and 1994 are available at http://www.nhc.noaa.gov/archive/storm_wallets/atlantic/ Data for hurricanes that occurred between 1995 and 2022 are available at https://www.nhc.noaa.gov/data/tcr/index.php	Downloaded data is compared to original versions. No additional validation is done.
HURDAT2 Chronological List of All Hurricanes which Affected the Continental United States: 1851-2022	Provides a chronological list of all hurricanes which affected the continental U.S. from 1851-2022. https://www.aoml.noaa.gov/hrd/hurdat/All_U.S._Hurricanes.html	Downloaded data is compared to original versions. No additional validation is done.
Monthly Weather Review Articles from 1872-2008	Contains weather review articles for each hurricane season from 1872 to 2008. These articles are available online at the HURDAT website, https://www.aoml.noaa.gov/general/lib/lib1/nhclib/mwreviews/	Downloaded data is compared to original versions. No additional validation is done.
National Hurricane Center Reconnaissance Data	Provides real-time hurricane data obtained from aircraft reconnaissance missions performed by the 53rd Weather Reconnaissance Squadron and the NOAA Aircraft Operations Center. Available online at https://www.nhc.noaa.gov/archive/recon/	Downloaded data is compared to original versions. No additional validation is done.
USGS National Land Cover Database (NLCD)	Provides digital and satellite-derived land use/land cover data dating from 2016. This database encompasses all 50 states and includes land cover at 30m resolution, which was derived from Landsat Thematic Mapper satellite data imagery. This data is used to generate the physical properties component of Model 521.	USGS LULC data are overlaid over satellite imagery to ensure proper data projection has been applied. Additional checking is applied over coastal bodies of water as identified by the 2016 NOAA C-CAP database.

Source Title	Description	Validation Methods
Claritas	Provides the census block population weights and ZIP Code centroids that are used as part of the annual U.S. exposure update process. The process of creating these centroids relies upon mapping the centroids of census blocks to the ZIP Codes by allocating all Census Blocks whose centroid falls within the boundary of a given ZIP Code to that ZIP Code. For each ZIP Code, a population weighted centroid is calculated based on this mapping. The data received from Claritas is, on average, a year out of date.	The calculation of the population weighted centroids is checked by the Exposures group using the Claritas census block centroids and population. A secondary check is done using the block centroids and population from the most recent census. Centroid movements greater than 1 mile are plotted on maps and visually inspected. Any changes that can't be justified are referred to Claritas for further explanation.
Topologically Integrated Geographic Encoding and Referencing (TIGER) Database	Provides street information (name, address numbers, city, latitude and longitude coordinates for streets) that is used by the Verisk Geocoder and Address Service to uniquely identify various geographic areas. This data is from the Aug. 2019 U.S. Census TIGER shape file release.	Implemented as part of the AIRAddressServer database. Various field counts in the integrated database are compared to the prior year's integrated database. In addition, address service batch processes are run to compare batch geocoding and address validation match results to the prior versions results.
United States Postal Service	Provides the official ZIP Codes, ZIP-9 codes, and related street segments for the U.S. This data, which is received monthly, is also included in the annual ZIPAll update by the Research group.	Implemented as part of the AIRAddressServer database. Various field counts in the integrated database are compared to the prior year's integrated database. In addition, address service batch processes are run to compare batch geocoding and address validation match results to the prior versions results.
Department of Energy (DOE) Exposure Data	Residential Energy Consumption Survey (RECS) http://www.eia.gov/consumption/residential/data/2009	The distributions of risk counts in various regions were compared against distributions of risk counts across the same regions in the Verisk Industry Exposure.
U.S. Census: American Community Survey	Data regarding housing age counts (year of construction) extracted from: http://www.census.gov/acs/www/data_documentation/data_main/. Downloaded May 29, 2014 (ACS_12_5YR_DP04_with_ann.csv)	The distributions of risks compared against the Verisk Industry Exposure Database, and with previous releases of the ACS to ensure consistency.
Rural-Urban Continuum Codes	The Rural-Urban Continuum Codes form a classification scheme that distinguishes metropolitan counties by the population size of their metro area, and nonmetropolitan counties by degree of urbanization and adjacency to a metro area. This scheme allows researchers to break county data into finer residential groups, beyond metro and nonmetro, particularly for the analysis of trends in nonmetro areas that are related to population density and metro influence.	These data/codes are used to identify which counties where "Rural" or "Urban" based on population density. Population counts were compared against exposure counts in the Verisk Industry Exposure Database for validation.

Source Title	Description	Validation Methods
ZIPList5Max by ZIPInfo	ZIPList5 Max is a 5-digit ZIP Code data file which includes latitude and longitude, MSA/PMSA, and market area. The file is available in comma-delimited ASCII format, as well as MS Access, dBase, and Paradox database formats. The file contains about 71,500 records (42,700 "preferred" records plus 28,800 "alias" records), covering all valid ZIP Codes to which the U.S. Postal Service delivers mail. Each ZIPList5 Max record contains the following data: 5-digit ZIP Code, City name (and abbreviation, if over 13 characters), State abbreviation, County name (for that ZIP code), County FIPS code, Area code, Time zone, Daylight Saving Time flag, Latitude and longitude in degrees, MSA/ PMSA code, Market Area, Preferred name or alias name, lag (refers to city name), and ZIP Code type.	The product management group provides the latest commercial release from ZIPInfo, which matches the same timeline as the versions of the U.S. Postal Service ZIP+4 national and U.S. Census TIGER shapefile data releases, to the Software Development Group (SDG). SDG conflates these separate data sources into the AIRAddressServer database. Various field counts in the integrated database are compared to the prior year's integrated database. In addition, address service batch processes are run to compare batch geocoding and address validation match results to the prior versions results. It is important to note that Verisk receives receive quarterly updates of the ZIPInfo data. However, only the version that is closest to the U.S. Postal and U.S. Census TIGER release dates is used. In some cases, the source release dates may differ by a month, but it is outside our control as to when a given sources release their data updates.

Detailed discussion regarding the verification of the data is discussed in detail within each component-specific document. Model and Software Development custodians shall be available to further explain the validation methods for each data source.

The QA test plans are designed to:

1. evaluate the functionality of the software to ensure that it behaves as intended, and
2. ensure that the results are as expected.

All Touchstone dependencies (i.e., model .dlls and databases) are inherently validated via the testing process. Any inappropriate behavior or deviation from the expected results are further investigated by the various stakeholders, including QA, Product Management, Research, Software Development, and Client and Consulting Services. When appropriate, AzureDevOps (AZDO) tickets are opened to ensure that the source of the error is corrected and re-tested.

Standard CI-6: Human-Computer Interaction

CI-6.A

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

Verisk user experience (UX) designers consistently employ the accepted principles and practices of HCI, interaction design, and UX engineering when designing and implementing model software interfaces.

Our guiding HCI standards and practices are sourced from a variety of industry-recognized benchmarks, including:

- The World Wide Web Consortium's (W3C) internationally recognized online library of design principles, including, but not limited to:
  - **Content must be perceivable:** The display of substantial amounts of intricate data is at the center of all interaction within Touchstone; the UI is designed to support the visualization and manipulation of that data.
  - **Content and controls must be understandable:** Touchstone's interactions are designed to be easily understood by users with little-to-no familiarity with the product.
  - **Interface elements in the content must be operable:** The navigation and component controls are designed to function as expected to support the user's desired tasks as well as effective utilization of source data and analysis results.
  - **Content must be robust enough to work with current and future technologies** All UX design solutions are extensible to future product releases.
- Published practitioners of user experience engineering, including Jacob Nielsen's ***'Usability Engineering' Heuristic Evaluation***, which lists the following design criteria on page 20:Published practitioners of User Experience engineering, including Jacob Nielsen's ***'Usability Engineering' Heuristic Evaluation***, page 20:
  - **Simple and natural dialog:** Communications are stated clearly and simply in Touchstone.
  - **Speak the user's language:** Communications use terminology common to the insurance and reinsurance industry, not proprietary language.
  - **Minimize the user's memory load:** Steps to task completion are limited and useful points of UI engagement are provided.
  - **Consistency:** User interfaces and component interactions are made common across Touchstone.
  - **Feedback:** Essential task-level statuses are reported, as well as a variety of logs.
  - **Clearly marked exits:** All interaction paths are provided with an exit option including options to save, save as, cancel, or close.
  - **Shortcuts:** Standard keyboard shortcuts are employed.
  - **Good error messages:** Error messaging is concise, identifying an error and how a user can act to remedy it.
  - **Prevent errors:** UI and interaction options are designed to set the user up for success toward achieving their objective within the application processes.
  - **Help and documentation:** Tooltips are provided throughout Touchstone and Help documentation is accessible in the global navigation.

CI-6.B

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

The Verisk Hurricane Model for the United States implementation in Touchstone ensures that interface options for ratemaking in the state of Florida are unique, explicit, and distinctly emphasized by means of a detailed loss analysis template: ***Florida Rate Filing Analysis Template*** (the FL template). This template is available in the user interface (UI) under the menu control **'Apply Template'**. The FL template is located within the Touchstone administrative console/object management/loss analysis templates. This template is shipped to our clients as a locked template than cannot be deleted or modified, even by a systems administrator.

The FL template contains pre-set menu selections and checked (true) and unchecked (false) attributes that are unique, explicit, and distinctly emphasized for the singular objective of running loss analysis calculations for rate making in Florida. For example, under the **'Event Set'** menu selection control, only the currently-certified hurricane event sets are listed, which are **'50K US Hurricane – Florida Regulatory'** and **'100k US Hurricane – Florida Regulatory'**.

All FL template settings will be presented to the CI-Standards Independent Peer Auditor and to the Professional Team during the CI Standards audit and during the Professional Team visit. A demonstration of the FL template user interface will be conducted during the audit. All Florida template component control settings are documented and will be made available for inspection by the auditor upon request.

CI-6.C

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

The Touchstone Detailed Loss Configuration user interface only includes options approved for rate filing in the state of Florida. These options become active when the user selects the ***Florida Rate Filing Analysis Template*** (the FL template). With the FL template applied, some settings are fixed to meet Florida requirements and cannot be changed. For example 'Demand Surge', is set to ON, radio button set to 'With' equal to true, and the component is disabled (cannot be changed to 'Without'). Other acceptable interface options such as those under 'Financial Settings' are also pre-set but remain adjustable within the Commission’s accepted limits. Finally, options that are not allowed for Florida rate filing, such as 'Storm Surge,' are locked in the OFF position and cannot be changed.

Disclosures

CI-6.1

Identify procedures used to design, implement, and evaluate interface options.

The Verisk EES user experience (UX) team follows standard design procedures that support the research, design, and validation of user interface options in Touchstone.

Initially, a UX designer is engaged in design research procedures when a new feature or feature enhancement is needed to improve upon a user workflow or task to be completed, such as configuring and running an analysis in Touchstone. The research phase requires the UX designer to immerse themselves in the problem statement, understanding current pain points, examining user interface patterns and interaction behaviors that require evaluation in consideration of the feature's use case. The research can include multiple discussions with product team members charged with the software design/build of the new feature/enhancement, including the product owner, internal stakeholders, the development architect and/or development team leader. The UX designer will also confer with the larger UX team to share design research findings and explore interaction and interface options that may inspire further usability research. The UX designer may also explore industry documentation of human-computer interaction and UX engineering best practices.

The procedures that govern the interface and HCI design processes require the delivery of visual assets that support the rationale of specific interface and interaction directives. The assets can include some or all of the following: mock-ups, wireframes, and high-fidelity prototypes. The designer may also produce user workflow charts and documentation that further supports the guidance offered in the final interface design option(s) to be presented to the product team.

To arrive at an acceptable design solution, the UX designer follows procedures to validate the interface enhancement(s). Again, the designer collaborates with the UX team; the proposed design solutions undergo one or more critiques; together the team will confirm established user interface and interaction patterns in Touchstone, assure best practices in human-computer interaction, and offer critical opinions on layout structure and look and feel, for the purpose of identifying a viable user-centered interface and workflow solution. Further evaluation procedures are engaged with the project team; the product owner and stakeholder will evaluate the UX design's satisfactory solving of the feature/enhancement challenge, while the software developers will ensure that the interface and interaction design solution can be integrated with existing or modified backend support structures.

Procedures for implementation of interface options in Touchstone require review checkpoints between the product owner, the developer(s) and the UX designer to make sure the interface options and user-expected outcomes are achieved per the acceptance criteria. Implementation procedures also include testing of new and enhanced interface options as a measure to ensure quality of the delivered product.

Standard CI-7: Hurricane Model Maintenance and Revision

CI-7.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.

Verisk maintains a clearly documented policy for hurricane model review, maintenance, and revision with respect to methodology and data. Verisk employs a verification mechanism consisting of manual comparisons of its data files and databases used in the hurricane modeling process and a computer verification process that consists of comparing program, configuration, data file and database cryptographic service values against their known valid values.

CI-7.B

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

Verisk has a clearly documented policy for hurricane model revision with respect to methodology and data. Any enhancement to the hurricane model that results in a change in hurricane loss costs or hurricane probable maximum loss levels also results in a new hurricane model version number. At least once a year, the ZIP Code information is updated to take into account the most recent data. Specifically, the ZIP Code Centroids are updated, and using this new information, the ZIP Code site characteristics are updated. These characteristics include elevation, surface roughness, and distance from the coastline. The historical meteorological information is periodically updated to reflect new events (or lack thereof).

Other enhancements may be made to the model based on ongoing research undertaken by Verisk scientists and engineers. For example, post disaster damage surveys and collected loss data from actual events may improve our understanding of the effectiveness of building codes in specific areas.

CI-7.C

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

The document ***Enhancements and Florida Commission Documentation Mapping*** identifies the updates specific to the Verisk Hurricane Model for the United States V3.0.0 and the Touchstone 2024A application. The document Version Change History defines the source code additions, deletions, and changes for the hurricane model

components and software since the last submission. These documents shall be available to the independent peer auditor and to the Professional Team.

Disclosures

CI-7.1

Identify procedures used to review and maintain code, data, and documentation.

Verisk employs consistent and documented methods for data and documentation control for all software product development and test scripts. The current version number and date of most recent changes are documented for the individual components in the system decomposition.

Verisk uses Team Foundation Server with TFVC for version control of the model components' source code. Due to the large size of the model's data files, they are not stored within TFS. They are stored on data servers, for which the Verisk Data Control Workbook is used to log these model data that is ready for transfer from the Research and Model group to the Software Development team. This workbook tracking includes date, file name, data type, description, changes relative to previous year and the name of the person(s) who send and receive the data.

Version control for the Touchstone components' source code (including the C++ model code and databases) is maintained using TFVC via Microsoft Visual Studio.

Verisk uses Microsoft Office SharePoint Server to manage project, archive and monitor requirements, store and share client-based or internal documentation or PDF files. Like TFS and Visual SourceSafe (VSS), SharePoint tracks installation date, date of most recent changes and version history

CI-7.2

Describe the rules underlying the hurricane model and code revision identification systems.

The Verisk Hurricane Model for the United States is implemented in our software platform, Touchstone. Verisk generally produces one major release of Touchstone annually (e.g. Touchstone 2021, Touchstone 2022).

Any revision that results in a change in any Florida residential hurricane loss cost or probable maximum loss level results in a new model version number. The Verisk Hurricane Model for the United States version definitions are predefined and follow typical versioning methodology, including:

- Major Version (two digit)—Incremented when model components, such as the catalog, hazard, intensity, or vulnerability modules, are updated. A single major version increment is sufficient in cases when multiple components are updated during a release cycle.
- Minor Version (two digit)—Incremented when data files, such as the physical properties or industry exposures, are updated but the model components remain unchanged. If data files are changing simultaneously with a major version update, the minor version number does not need to be incremented.
- Build Version (two digits)—Incremented when data file, model component, or loss-impacting software bugs have been identified after the release of our client software products.

The internal software version definitions are predefined and follow typical software versioning methodology, including:

- Major Version (two digit)—Incremented when new or revised models are implemented into the software application. Also introduces database, engine, and other significant changes to the software.
- Minor Version (two digit)—Incremented when new or revised models, functionality enhancements, and other various software upgrades are introduced. Most often, this service pack is released in the fall.
- Update to Minor Version (one digit)—Incremented in cases when bug fixes are necessary and have been identified after the release of our client software. The need to increment this version number is most often identified externally by a client and incrementing this digit indicates that a service pack or Hot Fix was released.
- Build Version (two digit)—Incremented in cases when bug fixes are necessary and these changes have been identified prior to a release of our client software.
- Build Date (Eight digit—yyyymmdd)—Incremented each time significant changes are made to the source code and the software is compiled. The build date will change most frequently. A new build date is introduced every time the version number changes.
- Client Request for Custom Update (alpha character)—An alpha-character suffix designates a custom version of Verisk software. For example, it is used when a client requests an update to be compatible with their technical environment.

CI-7.3

Provide all accepted and functionally equivalent model version number and platform identifications for the current accepted hurricane model and the previous accepted hurricane model, if applicable.

Table 28. Model and Platform Identifications

	Model Version Number	Platform Identification	Submitted Platform	Equivalent Platform
Model Under Review	The Verisk Hurricane Model for the United States V3.0.0	Touchstone® 2024A	x	
Current Accepted Model	The Verisk Hurricane Model for the United States V2.0.0	Touchstone® 2023A	x	
		Touchstone® 2023		x
		Touchstone® 2024		x
Previous Accepted Model	The Verisk Hurricane Model for the United States V1.0.0	Touchstone® 2020	x	
		Touchstone® 2022		x
		Touchstone® 2021		x

Standard CI-8: Hurricane Model Security

CI-8.A

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.

Verisk employs a number of physical and electronic security measures to protect all code, data, and documentation against both internal and external potential sources of damage, and against deliberate and inadvertent, unauthorized changes.

Electronic Security

The Verisk network is made up of shared Windows and Linux servers along with a variety of desktop workstations and laptops used by individual employees. Within each department there may also be some workstations that contain applications or resources that are shared within the department. These machines may also be used to execute long running jobs.

Microsoft Windows servers are the foundation of the network. There are file, print, and Exchange mail servers. The network is connected with 1000/10,000 Megabytes per Second (Mbps) Ethernet switches for fast throughput. Verisk also has Linux servers, which are primarily used for research and development of Verisk models. They are also used for running these models for client services. Email is hosted at our parent company, Verisk's, New Jersey data center, but it is actively being migrated to Office 365. The Verisk network also has a separate sub-network that contains classroom workstations. Students in classes see only what is available to that sub-network, not the servers and workstations of Verisk employees.

As a directive from Verisk, every employee at Verisk is required to complete the online Information Security Awareness with Privacy Principles program annually. The program discusses key security elements that all employees must understand. To successfully complete the course, employees must review and accept the policies stated and score 80 percent or better on the assessment provided at the end of the course. Compliance with applicable regulations mandates that all employees be fully trained in security awareness.

Network Access Management

Access to the network is managed using:

- **Firewall**— The first stage of network protection is the use of firewalls. Verisk policy is to maintain the minimum number of open ports necessary.

- **Network logon (internal)**—Access to the network via workstations at the main EES office is restricted to Verisk-approved Windows®-authenticated accounts with a valid user name and password. Passwords must be a minimum of eight characters in length and must contain a combination of alphanumeric and special characters, including upper case letters. The Windows' login account password expires every 90 days. Use of personal computers is restricted without Verisk network access approval. IT ensures that personal computers have functional anti-virus and Malware protection software, as well as relevant Microsoft patches.
- **Network logon (external)**—Access to the network from a workstation outside the main EES office is subject to the internal network logon restrictions mentioned above, as well as access via the Virtual Private Network (VPN) gateway. VPN accounts are granted with management approval only.
- **Branch offices and remote users**—Access to the network from Verisk's other branch offices is subject to the internal network logon restrictions mentioned above, and can only be accessed via an encrypted link.

Data Servers Management

Access to the files and folders on Verisk's data servers is regulated by permissions (read-only, read/write, etc.) assigned by management. In general, a member of one department has read/write access to that department's files and folders, and read-only access to the files and folders of other departments. Access to and permissions for specific folders are determined by the senior team leader and incorporated into each user's account profile.

The secure servers would be located in VMC North Virginia or in KDC North Carolina.

All model and software development is done within Verisk's secure network. In general, developers have read-only access to the entire database, and read/write access to the product on which they are working.

Access to Verisk's internal source code for EES present in TFS, GitHub Enterprise, and VSS is limited to the ActiveDirectory (AD) accounts/AD Groups, approved, and created by IT Database Team. We have Certain AD Groups that are predefined as Microsoft Developer Network (MSDN) Groups, which automatically assumes access to source code when new employees are added in certain departments like SDG and QA.

The ability to delete any source control source code from these source control systems is hierarchical to the department leads and/or through a help desk request.

Access to SharePoint—All Verisk employees have access to SharePoint. Access is granted using the employee's Windows®-authenticated user name and password. When a site is created, the administrator determines who has access to the site and each member receives an invitation to join the site. The site administrator also assigns rights to team members.

FTP Server Management

The Verisk FTP Servers are contained within the demilitarized zone (DMZ) and are accessed in a secure manner. In computer networks, a DMZ is a computer host or small network inserted as a "neutral zone" between a company's private network and the outside public network. It prevents outside users from getting direct access to a server that has company data. A DMZ is an optional and more secure approach to a firewall and effectively acts as a proxy server as well.

In a typical DMZ configuration for a small company, a separate computer (or host in network terms) receives requests from users within the private network for access to websites or other companies accessible on the public network. The DMZ host then initiates sessions for these requests on the public network. However, the DMZ host is not able to initiate a session back into the private network. It can only forward packets that have already been requested. Users of the public network outside the company can access only the DMZ host. However, the DMZ provides access to no other company data.

Remote Access

Verisk provides Virtual Private Network (VPN) service to give users access to the internal network while they are traveling or working at home. A VPN connection to the Verisk network enables employees to work remotely. Users can connect to a server to share files, to share their desktop via Remote Desktop protocol, and use X windows/ Secure Shell (SSH) to connect to Linux resources. Since the home PC is not part of the Verisk domain, the users cannot see all of the workstations and servers in the Network Neighborhood. However, they can search for a particular server or workstation. Once the user finds the appropriate system, the user will be asked to enter their Verisk Windows user name and password. Using the VPN gateway to access the workstation at Verisk requires manager's approval, as well as the following computer pre-requisites:

- Anti-virus software must be installed on an employee's PC with signatures set to automatically update. Verisk can provide Symantec AV or employee can provide their own.
- A valid supported modern operating system, such as Windows 10.x, along with the built-in Windows firewall must also be installed and configured.

Access for Remote Offices

Verisk EES division has several offices outside the Boston headquarters. Our branch offices have their own networks and servers, and each office has the ability to access the Verisk EES servers and our Intranet via the VPN gateway.

File Back-up

To provide a safety net to Verisk's network, Verisk maintains a thorough back-up policy covering select files, databases, and applications stored on the network, including all document, source and data files related to Touchstone and the Verisk Hurricane Model for the United States

During the workweek, all critical servers are backed up in full to secondary storage using CommVault. Local backups are stored onsite and replicated offsite on a per-dataset basis. Daily sync operations are run for critical primary data sets to an offsite storage system for BCP purposes. The replication of our primary storage solutions is facilitated by EMC Isilon SyncIQ and EMC RecoverPoint.

Virus Protection

Virus protection software is installed on the Verisk servers, desktops, and notebooks. The virus protection maintenance policy is set up to automatically download virus signature pattern files every morning. These files are then automatically sent to all servers and workstations within the network. This protection scans not only incoming email and email attachments, but also any files introduced through external media, such as USB drives.

The virus scanning software, Symantec, is always scanning files on our Windows desktops and servers. IT-installed Symantec always scans files as they are opened to ensure that no viruses have infected working files. Symantec is updated for new virus protection immediately upon release of an updated virus signature file.

Verisk blocks spam using Proofpoint. All email is filtered through the spam servers before being passed to the mail server.

Symantec is also installed on the FTP server. All files that are uploaded and downloaded are scanned automatically.

Microsoft® Patches

Patches to Microsoft products (including security patches) are provided and deployed using BigFix. As Microsoft releases patches; the patch is deployed and installed automatically.

Laptops

In addition to the security software outlined in this document, all laptops are required to have BitLocker Full Disk Encryption software installed. BitLocker Full Disk Encryption provides the highest level of data security with multi-factor pre-boot authentication and the strongest encryption algorithms. The entire hard drive contents—including the operating system and even temporary files—are automatically encrypted for a completely transparent end-user experience.

Disaster Recovery

The Disaster Recovery (DR) Procedure should be executed when any automated or human-sourced information determines there is a service outage at Verisk. The goal is to determine if an authorized entity from Verisk can determine if DR failover should or should not take place.

An incident response consists of three distinct phases: Emergency Response, Recovery, and Restoration, each with its own set of objectives. The duration of each phase will depend on the nature of the event and its effect on Verisk's critical business processes.

- **Emergency Response**

  Once an incident is discovered and as it continues to unfold, the Emergency Response Team (ERT) is mobilized to determine the severity and extent of the incident. The ERT identifies what the situation is, how severe it is, what operations will be impacted if any, and what is the extent of the damage from the incident. This team reports all this information along with recommendations on how we should react to the Recovery Management Team (RMT). The RMT, headed by the company's president, decides whether the incident warrants a large-scale response by the company. Depending on the severity and impact of the incident, the RMT may activate all or a portion of the Business Continuity Plan (BCP).
- **Recovery**

  If the Business Continuity Plan is activated, it means that Verisk's EES headquarters is not operational (fully or partially) and may not be accessible resulting in a focus shift to the recovery phase. The recovery phase

involves activating and mobilizing the BCP teams and expanding the level of communications to internal and external parties. Employees will support operations from their designated recovery locations as defined in the BCP.

- **Restoration**

  The restoration phase assumes that some or all of Verisk's EES headquarters was damaged, continuity plans were activated, and employees and operations were relocated. During the restoration phase, the ERT stays at the Verisk EES Headquarters to assess the extent, impact, and damage of any incident. They communicate with the RMT who will decide whether/when Verisk can re-occupy its headquarters. When that decision is made, the teams involved in the re-location back from the disaster site will be activated and involved.

Information Security Incident Response Plan

All Suspected Data Breaches should be immediately reported to Verisk Help Desk, whose employees have been trained in managing incident response. They review what is reported and, if they deem it necessary, they invoke the Security Response Team.

Members of the Security Response Team are immediately notified simultaneously until one of the senior staff responds to the Help Desk. Confidentiality is extremely important and everyone is on a need-to-know basis. The decision-making around who gets notified and what happens next is wholly the Security Response Team's responsibility. The Response team will reach out to the person reporting the incident, get their business leaders involved, and start invoking.

Physical Security

The Verisk EES main office is located in a multi-story office building that contains multiple businesses. The building lobby is staffed by security guards 24 hours a day who verify the security badge of everyone who enters the building. Upon entering the building, the employee is required to swipe their badge by the elevator bank.

Employee Badges

Access to Verisk's floor is restricted to current Verisk employees and guests. All Verisk Employees are issued an electronic security badge on the first day of their employment. All Verisk employees (including employees visiting from other offices) should have their Verisk security badges on their person at all times.

Employees who forget their badge must stop at the security desk and wait for clearance. In the event that a badge is lost, staff must notify the Office Manager immediately so that it can be deactivated and a new one can be issued.

The main entrances to the Verisk EES offices are locked between 5:30 p.m. and 8:30 a.m. The use of the security badge is required to enter either of the doors on the north side of the building during those hours.

The data servers are located in a secure server room. Access to the server room is granted by electronic badge verification and is limited to essential personnel only.

Visitors

All visitors must be reported in advance to the Front Desk where they will be pre-cleared through our Visitor Clearance Program. Staff report the visitor's first and last name (spelled correctly), date(s) and time(s) of visit(s), and with whom they are meeting. Upon arrival, all guests must show photo ID at the security desk in the lobby to receive a 24-hour, self-invalidating badge indicating what floor and company they have clearance to visit. This badge cannot access any areas that require electronic badge verification. A new badge will be issued for each day of a guest's visit. All guests that are not pre-cleared will be announced via phone for approval before being given a badge.

During business hours, all guests must check in with the Verisk receptionist and must be escorted by an Verisk employee.

Emergency Evacuation Team

In the event of an emergency, announcements are made over the loud speaker instructing employees to remain or evacuate. Members of the Verisk staff have been trained (Emergency Evacuation Team) to inform and guide employees in the event of an evacuation.

Disclosures

CI-8.1

Describe methods used to ensure the security and integrity of the code, data, and documentation. These methods include the security aspects of each platform and its associated hardware, software, and firmware.

Verisk employs a number of physical and electronic security measures to protect all code, data and documentation against both internal and external potential sources of damage, and against deliberate and inadvertent, unauthorized changes.

Verisk's security policies, which are outlined above, are discussed in the Verisk Information Security Policy Framework document. A Verisk custodian shall be available to further discuss the Verisk security policies and procedures with the independent peer auditor and with the Professional Team

Touchstone runs on a single platform that is client-deployed. The ***Touchstone Installation Guide*** provides guidance and best practices in user management, user access control, anti-virus usage, and securing each deployment.

CI-8.2

Identify certifications, if any, and external standards compliance relevant to cyber security.

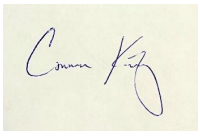
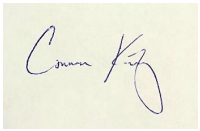
Verisk does not carry any certifications relevant to cyber security. The ***Verisk Information Security Policy Framework*** aligns with the NIST Cyber Security Framework.

9 Appendix 1: General Hurricane Standards Forms

Form G-1: General Hurricane Standards Certification

I hereby certify that I have reviewed the current submission of The Verisk Hurricane Model for the United States Version 3.0.0 as implemented in Touchstone 2024A for compliance with the 2023 Hurricane Standards adopted by the Florida Commission on Hurricane Loss Projection Methodology and hereby certify that:

1. The hurricane model meets the General Hurricane Standards (G-1–G-5);
2. The disclosures and forms related to the General Hurricane Standards section are editorially and technically accurate, reliable, unbiased, and complete;
3. My review was completed in accordance with the professional standards and code of ethical conduct for my profession;
4. My review involved ensuring the consistency of the content in all sections of the submission; and
5. In expressing my opinion I have not been influenced by any other party in order to bias or prejudice my opinion.

Connor King	M.S. Information Systems M.B.A. Finance and Analytics B.S. Wildlife Ecology
Name	Professional Credentials (Area of Expertise)
	October 25, 2024
Signature (original submission)	Date
	January 15, 2025
Signature (revisions to submission, if any)	Date
	May 21, 2025
Signature (final submission)	Date

Form G-2: Meteorological Hurricane Standards Expert Certification

I hereby certify that I have reviewed the current submission of The Verisk Hurricane Model for the United States Version 3.0.0 as implemented in Touchstone 2024A for compliance with the 2023 Hurricane Standards adopted by the Florida Commission on Hurricane Loss Projection Methodology and hereby certify that:

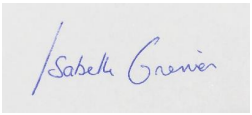
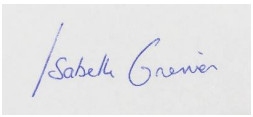
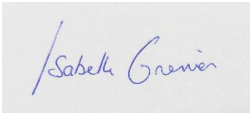
1. The hurricane model meets the Meteorological Hurricane Standards (M-1–M-6);
2. The disclosures and forms related to the Meteorological Hurricane Standards section are editorially and technically accurate, reliable, unbiased, and complete;
3. My review was completed in accordance with the professional standards and code of ethical conduct for my profession; and
4. In expressing my opinion I have not been influenced by any other party in order to bias or prejudice my opinion.

Eric Uhlhorn	Ph.D., Meteorology and Physical Oceanography
Name	Professional Credentials (Area of Expertise)
	October 25, 2024
Signature (original submission)	Date
Signature (response to deficiencies, if any)	Date
	January 15, 2025
Signature (revisions to submission, if any)	Date
	May 21, 2025
Signature (final submission)	Date

Form G-3: Statistical Hurricane Standards Expert Certification

I hereby certify that I have reviewed the current submission of The Verisk Hurricane Model for the United States Version 3.0.0 as implemented in Touchstone 2024A for compliance with the 2023 Hurricane Standards adopted by the Florida Commission on Hurricane Loss Projection Methodology and hereby certify that:

1. The hurricane model meets the Statistical Hurricane Standards (S-1–S-6);
2. The disclosures and forms related to the Statistical Hurricane Standards section are editorially and technically accurate, reliable, unbiased, and complete;
3. My review was completed in accordance with the professional standards and code of ethical conduct for my profession; and
4. In expressing my opinion I have not been influenced by any other party in order to bias or prejudice my opinion.

Isabelle Grenier	Ph.D., Statistical Science
Name	Professional Credentials (Area of Expertise)
	October 25, 2024
Signature (original submission)	Date
	January 15, 2025
Signature (response to deficiencies, if any)	Date
Signature (revisions to submission, if any)	Date
	May 21, 2025
Signature (final submission)	Date

Form G-4: Vulnerability Hurricane Standards Expert Certification

I hereby certify that I have reviewed the current submission of The Verisk Hurricane Model for the United States Version 3.0.0 as implemented in Touchstone 2024A for compliance with the 2023 Hurricane Standards adopted by the Florida Commission on Hurricane Loss Projection Methodology and hereby certify that:

1. The hurricane model meets the Vulnerability Hurricane Standards (V-1–V-4);
2. The disclosures and forms related to the Vulnerability Hurricane Standards section are editorially and technically accurate, reliable, unbiased, and complete;
3. My review was completed in accordance with the professional standards and code of ethical conduct for my profession; and
4. In expressing my opinion I have not been influenced by any other party in order to bias or prejudice my opinion.

Carol Friedland	P.E., Ph.D., Civil Engineering
Name	Professional Credentials (Area of Expertise) State: WY Expiration Date: 12/31/2024 Professional License Type: Civil Engineering
	October 11, 2024
Signature (original submission)	Date
	January 15, 2025
Signature (response to deficiencies, if any)	Date
Signature (revisions to submission, if any)	Date
Signature (final submission)	Date

Form G-4: Vulnerability Hurricane Standards Expert Certification

I hereby certify that I have reviewed the current submission of The Verisk Hurricane Model for the United States Version 3.0.0 as implemented in Touchstone 2024A for compliance with the 2023 Hurricane Standards adopted by the Florida Commission on Hurricane Loss Projection Methodology and hereby certify that:

1. The hurricane model meets the Vulnerability Hurricane Standards (V-1–V-4);
2. The disclosures and forms related to the Vulnerability Hurricane Standards section are editorially and technically accurate, reliable, unbiased, and complete;
3. My review was completed in accordance with the professional standards and code of ethical conduct for my profession; and
4. In expressing my opinion I have not been influenced by any other party in order to bias or prejudice my opinion.

Carol Friedland	P.E., Ph.D., Civil Engineering
Name	Professional Credentials (Area of Expertise) State: WY Expiration Date: 12/31/2026 Professional License Type: Civil Engineering
Signature (original submission)	Date
Signature (response to deficiencies, if any)	Date
Signature (revisions to submission, if any)	Date
	May 21, 2025
Signature (final submission)	Date

Form G-5: Actuarial Hurricane Standards Expert Certification

I hereby certify that I have reviewed the current submission of The Verisk Hurricane Model for the United States Version 3.0.0 as implemented in Touchstone 2024A for compliance with the 2023 Hurricane Standards adopted by the Florida Commission on Hurricane Loss Projection Methodology and hereby certify that:

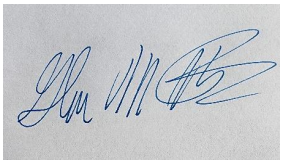
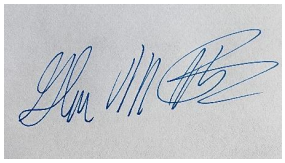
1. The hurricane model meets the Actuarial Hurricane Standards (A-1–A-6);
2. The disclosures and forms related to the Actuarial Hurricane Standards section are editorially and technically accurate, reliable, unbiased, and complete;
3. My review was completed in accordance with the Actuarial Standards of Practice and Code of Conduct; and
4. In expressing my opinion I have not been influenced by any other party in order to bias or prejudice my opinion.

Paul Ericksen	FCAS, MAAA
Name	Professional Credentials (Area of Expertise)
	October 28, 2024
Signature (original submission)	Date
Signature (response to deficiencies, if any)	Date
Signature (revisions to submission, if any)	Date
Signature (final submission)	Date

Form G-5: Actuarial Hurricane Standards Expert Certification

I hereby certify that I have reviewed the current submission of The Verisk Hurricane Model for the United States Version 3.0.0 as implemented in Touchstone 2024A for compliance with the 2023 Hurricane Standards adopted by the Florida Commission on Hurricane Loss Projection Methodology and hereby certify that:

1. The hurricane model meets the Actuarial Hurricane Standards (A-1–A-6);
2. The disclosures and forms related to the Actuarial Hurricane Standards section are editorially and technically accurate, reliable, unbiased, and complete;
3. My review was completed in accordance with the Actuarial Standards of Practice and Code of Conduct; and
4. In expressing my opinion I have not been influenced by any other party in order to bias or prejudice my opinion.

Glen Patashnick	FCAS
Name	Professional Credentials (Area of Expertise)
	January 15, 2025
Signature (revisions to submission, if any)	Date
	May 21, 2025
Signature (final submission)	Date

Form G-6: Computer/Information Hurricane Standards Expert Certification

I hereby certify that I have reviewed the current submission of The Verisk Hurricane Model for the United States Version 3.0.0 as implemented in Touchstone 2024A for compliance with the 2023 Hurricane Standards adopted by the Florida Commission on Hurricane Loss Projection Methodology and hereby certify that:

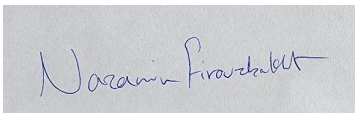
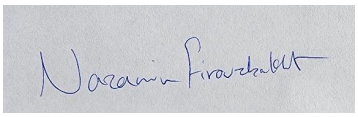
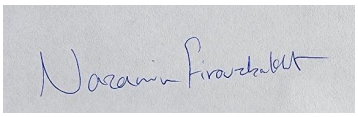
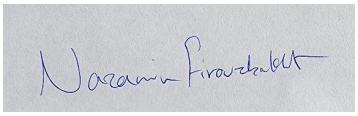
1. The hurricane model meets the Computer/Information Hurricane Standards (CI-1–CI-8);
2. The disclosures and forms related to the Computer/Information Hurricane Standards section are editorially and technically accurate, reliable, unbiased, and complete;
3. My review was completed in accordance with the professional standards and code of ethical conduct for my profession; and
4. In expressing my opinion I have not been influenced by any other party in order to bias or prejudice my opinion.

Robert Cabeca	B.A., Information Technology Management
Name	Professional Credentials (Area of Expertise)
	10/23/24
Signature (original submission)	Date
Signature (response to deficiencies, if any)	Date
Signature (revisions to submission, if any)	Date
	May 21, 2025
Signature (final submission)	Date

Form G-7: Editorial Review Expert Certification

I hereby certify that I have reviewed the current submission of The Verisk Hurricane Model for the United States Version 3.0.0 as implemented in Touchstone 2024A for compliance with the "Process for Determining the Acceptability of a Computer Simulation Hurricane Model" adopted by the Florida Commission on Hurricane Loss Projection Methodology in its *Hurricane Standards Report of Activities as of November 1, 2023*, and hereby certify that:

1. The hurricane model submission is in compliance with the Notification Requirements and General Hurricane Standard G-5, Editorial Compliance;
2. The disclosures and forms related to each hurricane standards section are editorially accurate and contain complete information and any changes that have been made to the submission during the review process have been reviewed for completeness, grammatical correctness, and typographical errors;
3. There are no incomplete responses, charts or graphs, inaccurate citations, or extraneous text or references;
4. The current version of the hurricane model submission has been reviewed for grammatical correctness, typographical errors, completeness, the exclusion of extraneous data/ information and is otherwise acceptable for publication; and
5. In expressing my opinion I have not been influenced by any other party in order to bias or prejudice my opinion.

Nazanin Firouzbakht	M.B.A. Marketing B.S. Industrial Engineering
Name	Professional Credentials (Area of Expertise)
	October 25, 2024
Signature (original submission)	Date
	January 15, 2025
Signature (response to deficiencies, if any)	Date
	January 15, 2025
Signature (revisions to submission, if any)	Date
	May 21, 2025
Signature (final submission)	Date

10 Appendix 2: Meteorological Standards Forms

Form M-1: Annual Occurrence Rates

Form M-1.A

One or more automated programs or scripts shall be used to generate and arrange the data in Form M-1.

The data in Table 29 was generated by a set of scripts coded in the R language which is under source version control.

Form M-1.B

Provide a table of annual occurrence rates for hurricane landfall from the dataset defined by marine exposure that the hurricane model generates by hurricane category (defined by maximum windspeed at hurricane landfall in the Saffir-Simpson Hurricane Wind Scale) for the entire state of Florida and additional regions as defined in Figure 1. List the annual occurrence rate per hurricane category. Annual occurrence rates shall be rounded to three decimal places.

As defined, a by-passing hurricane (ByP) is a hurricane which does not make landfall on Florida, but produces minimum damaging windspeeds or greater on Florida. For the by-passing hurricanes included in the table only, the intensity entered is the maximum windspeed at closest approach to Florida as a hurricane, not the windspeed over Florida.

Table 29. Modeled Annual Occurrence Rates

Category	Entire State					Region A – NW Florida				
	Reference Hurricane Set		Model Base Hurricane Set		Modeled	Reference Hurricane Set		Model Base Hurricane Set		Modeled
	Nbr	Rate	Nbr	Rate	Rate	Nbr	Rate	Nbr	Rate	Rate
1	25	0.203	21	0.171	0.170	15	0.122	13	0.106	0.077
2	17	0.138	18	0.146	0.133	5	0.041	6	0.049	0.051
3	14	0.114	15	0.122	0.123	6	0.049	5	0.041	0.038
4	12	0.098	7	0.057	0.065	0	0.000	1	0.008	0.015
5	3	0.024	2	0.016	0.010	1	0.008	0	0.000	0.002

Category	Region B – SW Florida					Region C – SE Florida				
	Reference Hurricane Set		Model Base Hurricane Set		Modeled	Reference Hurricane Set		Model Base Hurricane Set		Modeled
	Nbr	Rate	Nbr	Rate	Rate	Nbr	Rate	Nbr	Rate	Rate
1	7	0.057	3	0.024	0.046	8	0.065	9	0.073	0.059
2	4	0.033	5	0.041	0.040	7	0.057	7	0.057	0.044
3	5	0.041	5	0.041	0.040	5	0.041	5	0.041	0.045
4	6	0.049	3	0.024	0.024	6	0.049	3	0.024	0.024
5	0	0.000	0	0.000	0.004	2	0.016	2	0.016	0.004

Category	Region D – NE Florida					Florida By-Passing Hurricanes				
	Reference Hurricane Set		Model Base Hurricane Set		Modeled	Reference Hurricane Set		Model Base Hurricane Set		Modeled
	Nbr	Rate	Nbr	Rate	Rate	Nbr	Rate	Nbr	Rate	Rate
1	1	0.008	0	0.000	0.007	5	0.041	8	0.065	0.029
2	2	0.016	1	0.008	0.004	3	0.024	3	0.024	0.021
3	0	0.000	1	0.008	0.003	7	0.057	1	0.008	0.015
4	0	0.000	0	0.000	0.002	0	0.000	2	0.016	0.007
5	0	0.000	0	0.000	0.000	0	0.000	0	0.000	0.001

Category	Region E – Georgia					Region F – Alabama/Mississippi				
	Reference Hurricane Set		Model Base Hurricane Set		Modeled	Reference Hurricane Set		Model Base Hurricane Set		Modeled
	Nbr	Rate	Nbr	Rate	Rate	Nbr	Rate	Nbr	Rate	Rate
1	0	0.000	0	0.000	0.008	7	0.057	7	0.057	0.055
2	2	0.016	2	0.016	0.005	3	0.024	4	0.033	0.035
3	0	0.000	0	0.000	0.003	4	0.033	4	0.033	0.027
4	0	0.000	0	0.000	0.001	0	0.000	0	0.000	0.013
5	0	0.000	0	0.000	0.000	1	0.008	1	0.008	0.002

Form M-1.C

For a climate-adjusted hurricane model that uses either the Reference Hurricane Set or a Model Adjusted Hurricane Set for the Model Base Hurricane Set, a modeling organization shall provide two Form M-1s, one completed with climate-adjusted modeled rates and one completed without climate-adjusted modeled rates.

Verisk does not use a climate-adjusted Model Base Hurricane Set and thus we have submitted only one Form M-1.

Form M-1.D

Describe hurricane model variations from the Reference Hurricane Set frequencies

The modeled frequencies are statistically consistent with the historical frequencies for the period 1900–2022. The historical and modified base storm set frequencies differ because of the categorization by modeled Vmax vs. HURDAT2 Vmax. The modeled Vmax is computed from the central pressure, which is the model's intensity metric, so that consistency is maintained between Form S-1: Probability and Frequency of Florida Landfalling Hurricanes per Year and Form A-2: Model Base Hurricane Set Statewide Hurricane Losses.

Form M-1.E

Provide vertical bar graphs depicting distributions of hurricane frequencies by category by region of Florida (Figure 1), for the neighboring states of Alabama/Mississippi and Georgia, and for by-passing hurricanes. For the neighboring states, statistics based on the closest coastal segment to the state boundaries used in the hurricane model are adequate.

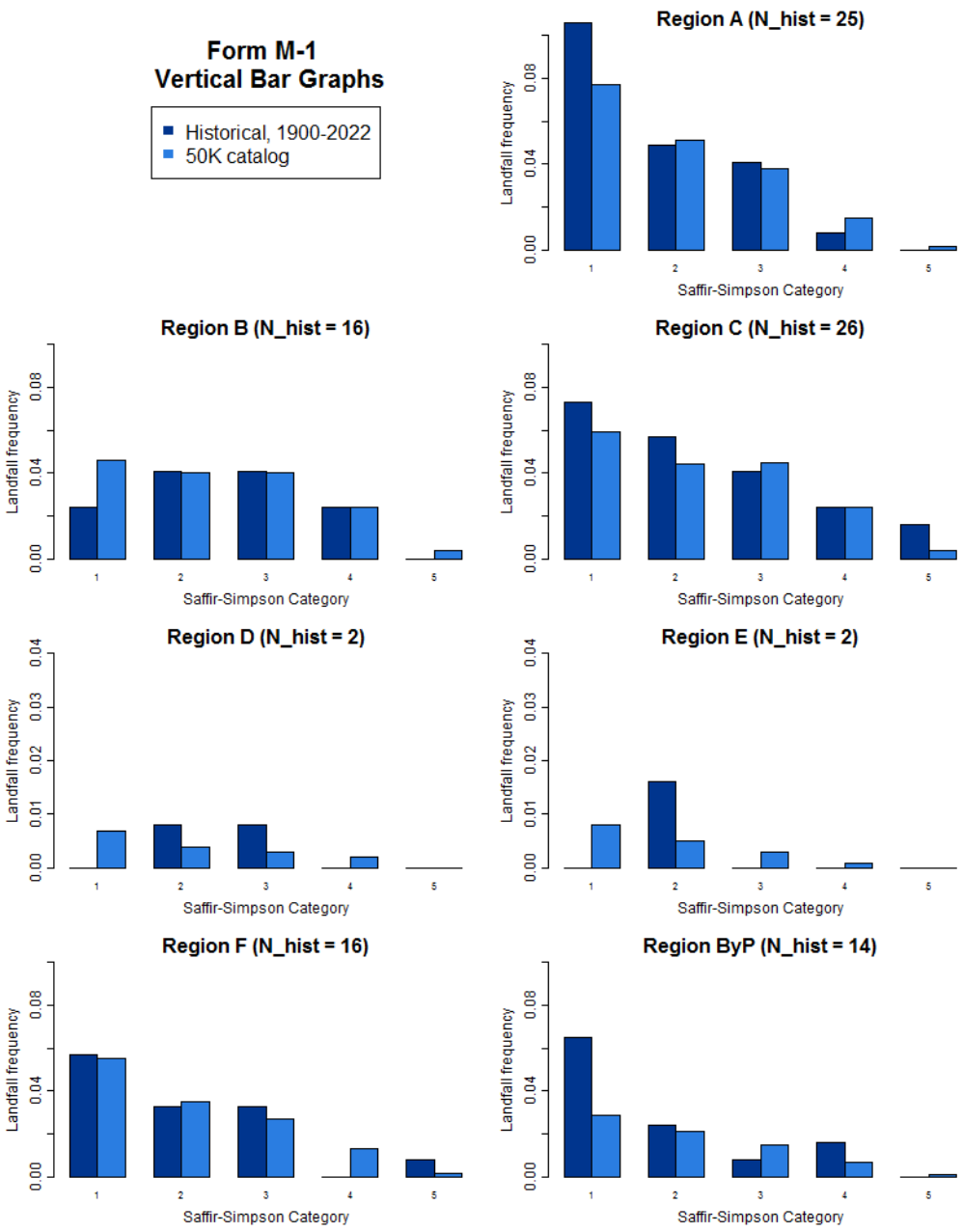


Figure 52. Historical and Modeled Hurricane Frequency for Florida and Neighboring States by Region

Form M-1.F

List all hurricanes added, removed, or modified from the current accepted hurricane model.

Four recent storms (Elsa and Ida in 2021, and Ian and Nicole in 2022) were added to the Model Base Hurricane Set. Four storms (Alma and Inez in 1966, and Abby and Gladys in 1968) were modified according to the recent update to HURDAT2.

The complete list of changes with impact on Florida is as follows:

- Storms added: Elsa-2021, Ida-2021, Ian-2022, Nicole-2022
- Storms modified: Alma-1966, Inez-1966, Abby-1968, Gladys-1968

Form M-1.G

Provide this form in Excel format. The file name shall include the abbreviated name of the modeling organization, the hurricane standards year, and the form name. Also include Form M-1 in a submission appendix.

Note: Except where specified, number of hurricanes does not include by-passing hurricanes. Each time a hurricane goes from water to land (once per region) it is counted as a hurricane landfall in that region. However, each hurricane is counted only once in the Entire State totals. Hurricanes recorded for neighboring states need not have reported damaging winds in Florida.

Form M-1: Annual Occurrence Rates is provided here in the submission document and in Excel format separately in the accompanying electronic submission files named "VSK23FormM1.xlsx".

Form M-2: Maps of Maximum Winds

Form M-2.A/B/C

A. One or more automated programs or scripts shall be used to generate and arrange the data in Form M-2.

B. Provide color-coded contour plots on a map with ZIP Code boundaries of the maximum winds for the modeled version of the Model Base Hurricane Set. Plot the position and value of the maximum windspeed on the contour map.

C. Provide color-coded contour plots on maps with ZIP Code boundaries of the maximum winds for a 100-year and a 250-year return period from the stochastic storm set. Plot the position and value of the maximum windspeed on each contour map.

Maximum winds in these maps are defined as the maximum one-minute sustained winds as modeled and recorded at each location.

The same color scheme and increments should be used for all maps.

Use the following eight isotach values and interval color-coding:

(1)	*Minimum damaging*	*Blue*
(2)	*50 mph*	*Medium Blue*
(3)	*65 mph*	*Light Blue*
(4)	*80 mph*	*Grey*
(5)	*95 mph*	*Light Red*
(6)	*110 mph*	*Medium Red*
(7)	*125 mph*	*Red*
(8)	*140 mph*	*Magenta*

Contouring in addition to these isotach values may be included.

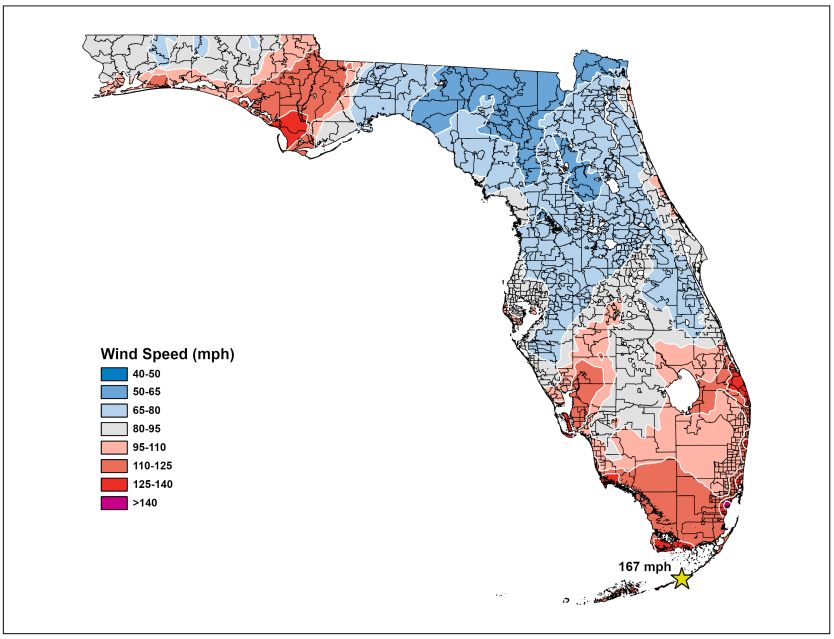


Figure 53. Maximum Winds for the Modeled Version of the Model Base Hurricane Set

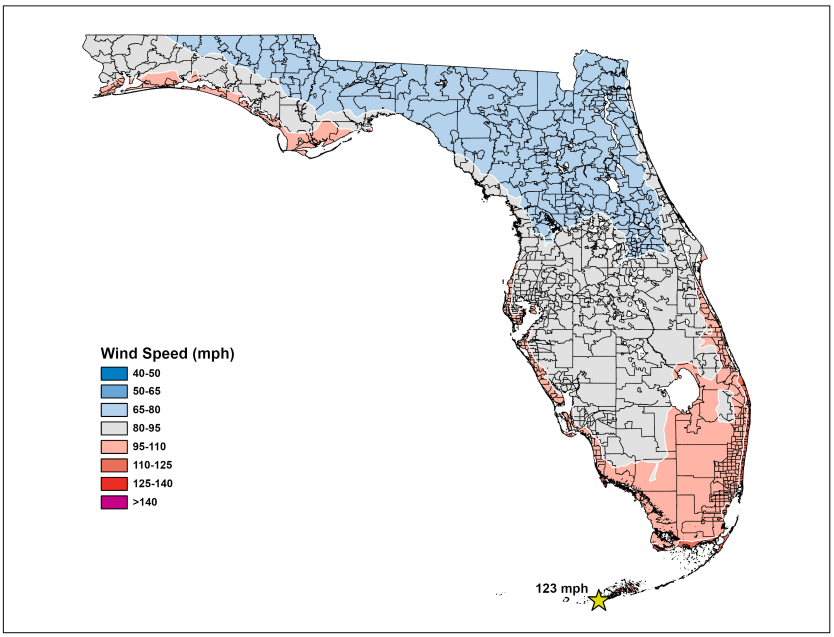


Figure 54. 100-Year Return Period Maximum Winds

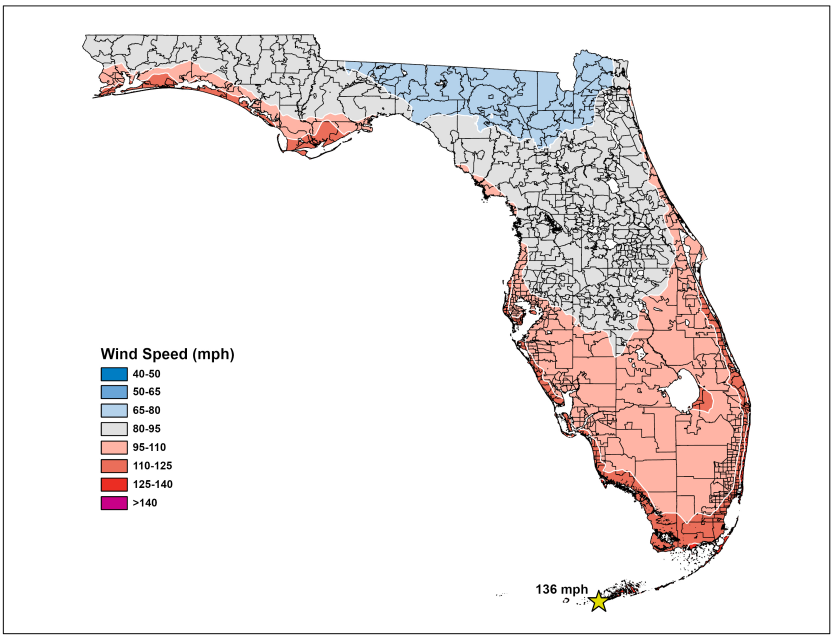


Figure 55. 250-Year Return Period Maximum Winds

Form M-2.D

Include Form M-2 in a submission appendix.

Form M-2: Maps of Maximum Winds is included here in this submission appendix.

Form M-3: Radius of Maximum Winds and Radii of Standard Wind Thresholds

Form M-3.A

One or more automated programs or scripts shall be used to generate and arrange the data in Form M-3.

Table 30 is generated from a MATLAB script under source control.

Form M-3.B

For the central pressure (CP) ranges in the table below, provide the first quartile (1Q), second quartile (2Q), and third quartile (3Q) in the stochastic storm set of the following quantities: radii to maximum wind (Rmax), the category 3 (110 mph) wind radii, the category 1 (73 mph) wind radii, and the gale force (40 mph) wind radii. If a value is unavailable, then populate the table with "NA."

Table 30. Radius of Maximum Winds and Radii of Standard Wind Thresholds

Central Pressure (mb)	Rmax (mi)			Outer Radii (>110 mph) (mi)			Outer Radii (>73 mph) (mi)			Outer Radii (>40 mph) (mi)		
	1Q	2Q	3Q	1Q	2Q	3Q	1Q	2Q	3Q	1Q	2Q	3Q
980 ≤ cp < 990	21	28	36	NA	NA	NA	24	32	42	68	88	109
970 ≤ cp < 980	20	27	35	16	22	30	28	38	49	86	107	130
960 ≤ cp < 970	20	27	34	17	24	30	32	43	56	98	121	144
950 ≤ cp < 960	19	26	34	19	27	35	36	48	62	107	130	153
940 ≤ cp < 950	18	25	32	21	28	35	38	50	64	112	136	158
930 ≤ cp < 940	18	24	30	22	29	37	40	52	65	117	139	160
920 ≤ cp < 930	16	22	28	22	29	37	40	52	65	117	139	160
910 ≤ cp < 920	15	20	26	21	28	36	39	50	64	116	136	158
900≤ cp < 910	13	17	23	20	27	34	37	47	60	109	130	150
cp < 900	10	14	17	17	23	29	34	41	53	101	117	137

Form M-3.C

Specify any truncations applied to Rmax distributions in the hurricane model, and if and how these truncations vary with other variables.

Upper and lower bounds are applied to the Rmax distribution in the hurricane model. Both truncations are based on central pressure. The lower Rmax limits are between 5 miles (for low central pressure) and 7 miles (for high central pressure). The upper limits are between 17.5 miles (for low central pressure) and 65 miles (for high central pressure).

Form M-3.D

Provide a box and whiskers plot of the data from the table with central pressure on the x-axis and Rmax on the y-axis.

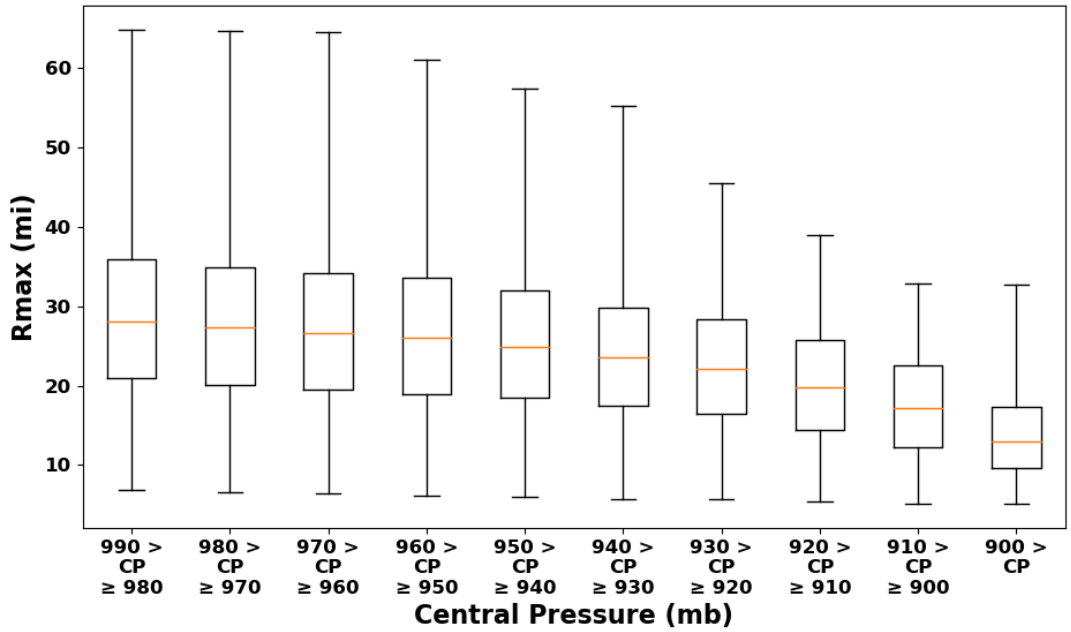


Figure 56. Box and Whisker Plot of Central Pressure vs. Rmax for the Stochastic Set

Form M-3.E

If central pressure is not modeled, describe how the hurricane model intensities were mapped to the central pressure ranges listed in the table.

Central pressure is explicitly modeled in the Verisk Hurricane Model for the United States.

Form M-3.F

Provide this form in Excel using the format given in the file named "2023FormM3.xlsx." The file name shall include the abbreviated name of the modeling organization, the hurricane standards year, and the form name. Also include Form M-3 in a submission appendix.

Form M-3: Radius of Maximum Winds and Radii of Standard Wind Thresholds is provided here in the submission document and in Excel format separately in the accompanying electronic submission files named "VSK23FormM3.xlsx".

11 Appendix 3: Statistical Standards Forms

Form S-1: Probability and Frequency of Florida Landfalling Hurricanes per Year

Form S-1.A

One or more automated programs or scripts shall be used to generate and arrange the data in Form S-1.

An R package was created for the Florida Commission submission. Form S-1 was generated using this package.

Form S-1.B

Complete the table below for the modeled probabilities and frequencies of the number of landfalling Florida hurricanes per year. Values derived from the Reference Hurricane Set (as given in Form A-2) have been provided.

Probabilities shall be rounded to three decimal places.

Model Base Hurricane Set frequency values shall be multiplied by a factor that is the number of years in the Reference Hurricane Set divided by the number of years in the Model Base Hurricane Set.

For a climate-adjusted hurricane model that uses either the Reference Hurricane Set or a Model Adjusted Hurricane Set for the Model Base Hurricane Set, a modeling organization shall provide two Form S-1s, one completed with climate-adjusted modeled probabilities and frequencies, and one completed without climate-adjusted modeled probabilities and frequencies.

Table 31. Probability and Frequency of Florida Landfalling Hurricanes per Year, Hurricane Model Results

Number of Hurricanes Per Year	Reference Hurricane Set Probability	Model Base Hurricane Set Probability	Modeled Probability	Reference Hurricane Set Frequency	Model Base Hurricane Set Frequency	Modeled Frequency
0	0.593	0.618	0.589	73	76	29450
1	0.244	0.236	0.307	30	29	15327
2	0.138	0.122	0.085	17	15	4267
3	0.024	0.024	0.017	3	3	832
4	0.000	0.000	0.002	0	0	104

Number of Hurricanes Per Year	Reference Hurricane Set Probability	Model Base Hurricane Set Probability	Modeled Probability	Reference Hurricane Set Frequency	Model Base Hurricane Set Frequency	Modeled Frequency
5	0.000	0.000	0.000	0	0	19
6	0.000	0.000	0.000	0	0	1
7	0.000	0.000	0.000	0	0	0
8	0.000	0.000	0.000	0	0	0
9	0.000	0.000	0.000	0	0	0
10 or more	0.000	0.000	0.000	0	0	0

Form S-1.C

Include Form S-1 in a submission appendix.

Included here as part of Disclosure S-1.6

Form S-2: Examples of Hurricane Loss Exceedance Estimates

Form S-2.A

One or more automated programs or scripts shall be used to generate and arrange the data in Form S-2.

An R package was created for the Florida Commission submission. Form S-2 was generated using this package.

Form S-2.B

Provide estimates of the annual aggregate combined personal and commercial residential insured hurricane losses for various probability levels using the notional risk dataset specified in Form A-1, the 2017 FHCF exposure data and the 2023 FHCF exposure data.

Provide the total average annual hurricane loss for the hurricane loss exceedance distribution. If the modeling methodology does not allow the hurricane model to produce a viable answer for certain return periods, state so and why.

Table 32. Part A - Examples of Hurricane Loss Exceedance Estimates

Return Period (Years)	Annual Probability of Exceedance	Estimated Hurricane Loss Notional Risk Dataset	Estimated Personal and Commercial Residential Hurricane Loss 2017 FHCF Dataset	Estimated Personal and Commercial Residential Hurricane Loss 2023 FHCF Dataset
Top Event	NA	119,409,901	333,432,196,238	496,258,462,155
10,000	0.01%	89,614,168	269,789,886,482	384,575,663,132
5,000	0.02%	79,501,209	224,227,308,217	313,170,566,217
2,000	0.05%	62,282,870	178,085,577,798	244,753,979,439
1,000	0.10%	55,019,199	149,294,371,227	204,494,693,023
500	0.20%	48,219,899	122,150,426,158	163,818,403,692
250	0.40%	40,725,249	95,963,336,725	130,082,925,527
100	1.00%	29,764,594	65,483,882,280	89,502,299,574
50	2.00%	22,075,158	45,045,127,123	61,109,784,672
20	5.00%	12,576,759	23,036,101,904	31,710,614,266
10	10.00%	6,649,430	11,258,635,522	15,417,165,567
5	20.00%	2,416,140	3,640,539,236	5,069,524,412

Table 33. Part B - Summary Statistics of Estimated Hurricane Loss

	Estimated Hurricane Loss Notional Risk Dataset	Estimated Personal & Commercial Residential Hurricane Loss 2017 FHCF Dataset	Estimated Personal & Commercial Residential Hurricane Loss 2023 FHCF Dataset
Mean (Total Average Annual Hurricane Loss)	2,249,971	4,284,456,519	5,868,283,425
Median	16,924	18,593,276	27,279,681
Standard Deviation	5,883,694	13,344,405,245	18,253,411,995
Interquartile Range	1,502,849	2,175,334,164	3,044,665,301
Sample Size	50,000 Years of Simulated Events	50,000 Years of Simulated Events	50,000 Years of Simulated Events

Form S-2.C

Include Form S-2 in a submission appendix.

Included here as part of Disclosure S-1.7

Form S-3: Distributions of Stochastic Hurricane Parameters

Form S-3.A/B

A. Provide the probability distribution functional form used for each stochastic hurricane parameter in the hurricane model.

B. Provide a summary of the justification for each functional form selected for each general classification and for the goodness-of-fit tests used.

Year Range Used for Fitting refers to the year range of data upon which the hurricane model distribution parameters are estimated.

Year Range Used for Validation refers to the year range of data upon which the goodness-of-fit statistics are based.

Table 34. Distributions of Stochastic Hurricane Parameters

Stochastic Hurricane Parameter (Function or Variable)	Functional Form of Distribution	Data Sources	Year Range Used		Justification for Functional Form and Parameter Estimates
			For Fitting	For Validation	
Annual Frequency	Negative Binomial	HURDAT2	1900–2022	1900-2022	**Functional Form** Appropriate for distributions of count data when the variance exceeds the mean, which is the case for annual landfall counts in the United States. The use of maximum likelihood estimation to obtain parameter estimates is justified for its consistency and efficiency properties. **Goodness-of-fit Tests** To assess the goodness-of-fit we use a one-sample chi-squared test between the historical and the modeled probabilities. The one-sample chi-square test is a standard method of validation for count data. In addition, we used a two-sample Chi-Squared test to demonstrate the simulated Monte Carlo realizations are consistent with the historical data.

Stochastic Hurricane Parameter (Function or Variable)	Functional Form of Distribution	Data Sources	Year Range Used		Justification for Functional Form and Parameter Estimates
			For Fitting	For Validation	
Landfall Location	Categorical on the segments along the U.S. coastline, with probabilities given by spatial smoothing of historical landfall frequencies tallied within these segments	HURDAT2	1900–2022	1900-2022	**Functional Form** Due to the relative scarcity of historical data at this spatial resolution, smoothing is used to arrive at credible landfall probabilities. The smoothing is based on a formula available in NWS-38, p.75. **Goodness-of-fit Tests** To assess the goodness-of-fit we use a one-sample chi-squared test between the historical and the modeled probabilities. The one-sample chi-square test is a standard method of validation for count data. In addition, we used a two-sample Kolmogorov-Smirnov test between historical and simulated data which demonstrates the simulated Monte Carlo realizations are consistent with the historical data.

Stochastic Hurricane Parameter (Function or Variable)	Functional Form of Distribution	Data Sources	Year Range Used		Justification for Functional Form and Parameter Estimates
			For Fitting	For Validation	
Central Pressure	Mixture of local and regional Weibull distributions	HURDAT2	1900–2022	1900-2022	**Functional Form** Historical central pressures are expressed as a deficit from a fixed outer value, and modeled at 100-nmi landfall segments as a mixture of a Weibull distribution fit to local historical data, and a second Weibull fit to regionally-pooled values. Parameter fits are obtained using maximum likelihood estimation. Expert judgement is used to determine the mixing weights in order to rely more/ less heavily on regional data where the historical record of landfalls are relatively sparse/complete, as well as to ensure spatial smoothness. **Goodness-of-fit Tests** Goodness-of-fit testing and consideration of multiple graphical validation checks support this model choice. To assess the goodness-of-fit, we use the Anderson-Darling and Cramer-von Mises tests which are more sensitive to the tails, and the Kolmogorov-Smirnov test which focuses on the center of the distribution.

Stochastic Hurricane Parameter (Function or Variable)	Functional Form of Distribution	Data Sources	Year Range Used		Justification for Functional Form and Parameter Estimates
			For Fitting	For Validation	
Radius of Maximum Winds	Truncated normal distribution with mean Rmax modeled by using regression model of the form: Rmax = f(CP, latitude)	EBTRK, HURDAT2	1900–2007	2008-2022	**Functional Form** The model captures the correlation between Rmax, central pressure, and latitude. The model is similar to a regression model proposed earlier by (Vickery et. al., 2000). The noise is bounded to capture the fact that intense hurricanes tend to have a smaller Rmax than weaker hurricanes. The method of least squares is standard in regression modeling to obtain parameter estimates minimizing the squared error loss. **Goodness-of-fit Tests** To assess the goodness-of-fit we use a two-sample Kolmogorov-Smirnov test between historical and simulated data which demonstrates the simulated Monte Carlo realizations are consistent with the historical data.

Stochastic Hurricane Parameter (Function or Variable)	Functional Form of Distribution	Data Sources	Year Range Used		Justification for Functional Form and Parameter Estimates
			For Fitting	For Validation	
Forward Speed	Log-normal(μ, σ) where μ is the mean and σ is the standard deviation	HURDAT	1900–2008	1900-2022	**Functional Form** This distribution is well-suited to represent forward speed which has a skewed distribution. **Goodness-of-fit Tests** Graphical comparisons between historical and modeled forward speeds combined with goodness-of-fit tests support the use of the Log-normal distribution. To assess the goodness-of-fit, we use the Anderson-Darling and Cramer-von Mises tests which are more sensitive to the tails of the distribution. A two-sample Kolmogorov-Smirnov test between historical and simulated data also demonstrates the simulated Monte Carlo realizations are consistent with the historical data.
Gradient Wind Reduction Factor	Normal distribution	Dropsonde data analysis; Research by Franklin, et al. (2003) and Powell et al. (2009)	2002–2005	2002–2005	**Functional Form** An analysis of the historical data shows a symmetrical distribution well approximated by a Normal distribution. **Goodness-of-fit Tests** To assess the goodness-of-fit we use the established methods designed specifically for validating normality which include the Shapiro-Wilks test and the Shapiro-Francia test.

Stochastic Hurricane Parameter (Function or Variable)	Functional Form of Distribution	Data Sources	Year Range Used		Justification for Functional Form and Parameter Estimates
			For Fitting	For Validation	
Peak Weighting Factor	Skewed distribution modeled as a Normal Distribution after variable transformation	Dropsonde data analysis; Research by Powell et al. (2009)	2002–2005	2002–2005	**Functional Form** The distribution of the historical data is skewed. However, the distribution becomes Normal after an inverse power transformation of the data. Correlation between GWRF and PWF is modeled using a bivariate normal distribution fitted to GWRF and the transformed PWF. **Goodness-of-fit Tests** To assess the goodness-of-fit we use the established methods designed specifically for validating normality which include the Shapiro-Wilks test and the Shapiro-Francia test.
Storm Heading at Landfall	Mixture of normal distributions with constraints imposed on the drawings	HURDAT	1900–2008	1900-2022	**Functional Form** Modeled as combined Normal distributions, and bounded based on the historical record and orientation of the coastline. **Goodness-of-fit Tests** Comparisons of historical and simulated tracks provide support for this procedure. To assess the goodness-of-fit, we use the Anderson-Darling and Cramer-von Mises tests which are more sensitive to the tails of the distribution. A two-sample Kolmogorov-Smirnov test between historical and simulated data also demonstrates the simulated Monte Carlo realizations are consistent with the historical data.

Stochastic Hurricane Parameter (Function or Variable)	Functional Form of Distribution	Data Sources	Year Range Used		Justification for Functional Form and Parameter Estimates
			For Fitting	For Validation	
Storm Tracks	Multi-step procedure involving the use of Markov chains and autoregressive models to describe the evolution of storm parameters across time and space	HURDAT	1900–2007	1900-2022	**Functional Form** Time series models incorporate the persistence in storm parameters across time resulting from physical inertia. Appropriate models were selected by calculating autocorrelation and partial auto-correlation functions for different model parameters. The models selected include a random walk with drift for track direction, a first-order autoregressive model for forward speed, and a second-order autoregressive model for central pressure. The resulting model is similar to a track model used by Verisk for the Northwest Pacific basin; see Pawale, et. al. (2003). **Goodness-of-fit Tests** Diagnostic checks on the model included grid-by-grid comparisons of the historical and simulated storm frequencies and intensity distributions across the basin.

Stochastic Hurricane Parameter (Function or Variable)	Functional Form of Distribution	Data Sources	Year Range Used		Justification for Functional Form and Parameter Estimates
			For Fitting	For Validation	
Landfalling Calendar Date	Weibull distribution	HURDAT	1900-2006	1900-2022	**Functional Form** The landfalling calendar date is modeled as a transformation of a Weibull distributed random variable with truncation. The use of maximum likelihood estimation is a standard statistical method to ensure consistency and efficiency of the parameter estimates. **Goodness-of-fit Tests** Graphical and numerical comparisons between the model and the updated historical data support the original distributional choice. To assess the goodness-of-fit, we use the Anderson-Darling and Cramer-von Mises tests which are more sensitive to the tails of the distribution. A two-sample Kolmogorov-Smirnov test between historical and simulated data also demonstrates the simulated Monte Carlo realizations are consistent with the historical data.

Form S-3.C

Include Form S-3 in a submission appendix.

Included here as part of Disclosure S-1.8.

Form S-4: Validation Comparisons

Form S-4.A

Provide four validation comparisons of actual personal residential exposures and hurricane loss to modeled exposures and hurricane loss. Provide these comparisons by line of insurance, construction type, policy coverage, county, or other level of similar detail in addition to total hurricane losses. Include hurricane loss as a percentage of total exposure. Total exposure represents the total amount of insured values (all coverages combined) in the area affected by the hurricane. This would include exposures for policies that did not have a hurricane loss. If this is not available, use exposures for only those policies that had a hurricane loss. Specify which was used. Comparisons shall include hurricane losses from Hurricane Irma (2017), Hurricane Michael (2018), and Hurricane Ian (2022) to the extent data from Hurricane Ian are available.

All of the exposures and losses provided in the four examples below have been multiplied by a single constant to disguise the identity of the client.

Table 35. Comparison 1 - Validation by Construction Type, Company C

Hurricane Erin	Exposure - Total (Personal Residential)					
	Actual			Modeled		
Company C	Exposure ($)	Loss ($)	Loss/ Exposure	Exposure ($)	Loss ($)	Loss/ Exposure
Wood Frame	$8,900,152,366	$6,881,690	0.0773%	$8,900,152,366	$12,660,349	0.1423%
Masonry	$7,719,789,030	$2,987,052	0.0387%	$7,719,789,030	$5,718,588	0.0741%
Manufactured Home	$462,325,498	$663,292	0.1435%	$462,325,498	$3,327,416	0.7197%
Total	**$17,082,266,894**	**$10,532,034**	**0.2595%**	**$17,082,266,894**	**$21,706,353**	**0.9360%**

Table 36. Comparison 2 - Validation by Construction Type, Company G

Hurricane Frances	Exposure - Total (Personal Residential)					
	Actual			Modeled		
Company G	Exposure ($)	Loss ($)	Loss/ Exposure	Exposure ($)	Loss ($)	Loss/ Exposure
Coverage A	$1,819,254,562	$9,755,813	0.5363%	$1,819,254,562	$8,291,996	0.4558%
Coverage C	$1,023,391,117	$772,325	0.0755%	$1,023,391,117	$869,532	0.0850%
Coverage D	$165,149,854	$239,072	0.1448%	$165,149,854	$151,475	0.0917%
Total	**$3,007,795,533**	**$10,767,210**	**0.7565%**	**$3,007,795,533**	**$9,313,003**	**0.6325%**

Table 37. Comparison 3 - Validation by Construction Type, Company N

Hurricane Wilma	Exposure - Total (Commercial Residential)					
	Actual			Modeled		
Company N	Exposure ($)	Loss ($)	Loss/ Exposure	Exposure ($)	Loss ($)	Loss/ Exposure
Concrete	$4,913,776,098	$60,983,157	1.2411%	$4,913,776,098	$43,145,804	0.8781%
Masonry	$3,524,309,122	$57,537,128	1.6326%	$3,524,309,122	$61,955,307	1.7579%
Total	**$8,438,085,220**	**$118,520,285**	**2.8737%**	**$8,438,085,220**	**$105,101,111**	**2.6360%**

Table 38. Comparison 4 - Validation by County, Company J

Hurricane Frances	Exposure - Total (Personal Residential)					
	Actual			Modeled		
County	Exposure ($)	Loss ($)	Loss/ Exposure	Exposure ($)	Loss ($)	Loss/Exposure
Indian River	$6,796,595	$129,401	1.9039%	$6,796,595	$235,749	3.4686%
Martin	$25,581,283	$162,294	0.6344%	$25,581,283	$240,183	0.9389%
Okeechobee	$11,486,384	$107,558	0.9364%	$11,486,384	$116,184	1.0115%
Palm Beach	$510,864,780	$1,641,708	0.3214%	$510,864,780	$3,403,000	0.6661%
St. Lucie	$25,341,432	$149,397	0.5895%	$25,341,432	$201,414	0.7948%
Total	**$580,070,474**	**$2,190,358**	**4.3856%**	**$580,070,474**	**$4,196,530**	**6.8799%**

Form S-4.B

Provide a validation comparison of actual commercial residential exposures and hurricane loss to modeled exposures and hurricane loss. Use and provide a definition of the hurricane model relevant commercial residential classifications.

The table below contains a comparison of actual commercial residential exposures and hurricane loss to modeled exposures and hurricane loss. The occupancy type of the exposure data used is coded as Verisk occupancy code 306—commercial residential and includes reinforced concrete, masonry and wood frame constructions as defined in Table 11. The data also contains height information. The description of Verisk height bands is given in Table 12.

All of the exposures and losses have been multiplied by a single constant to disguise the identity of clients.

Table 39. Comparison of Actual Commercial Residential Exposures and Loss to Modeled Exposure and Loss

Hurricane	Exposure ($)	Actual Loss ($)	Modeled Loss ($)
Charley	$9,743,463,671	$65,465,443	$111,136,975
Frances	$5,962,254,495	$60,324,157	$35,637,855
Ivan	$769,935,738	$22,407,198	$24,816,779
Jeanne	$6,272,762,604	$11,708,119	$25,347,135
Wilma	$15,021,192,505	$140,144,282	$167,680,819

Hurricane	Exposure ($)	Actual Loss ($)	Modeled Loss ($)
Katrina	$8,104,171,463	$7,139,327	$11,886,230
Total	**$45,873,780,476**	**$307,188,526**	**$376,505,793**

Form S-4.C

Provide scatter plots of modeled versus historical hurricane losses for each of the required validation comparisons. Plot the historical hurricane losses on the x-axis and the modeled hurricane losses on the y-axis.

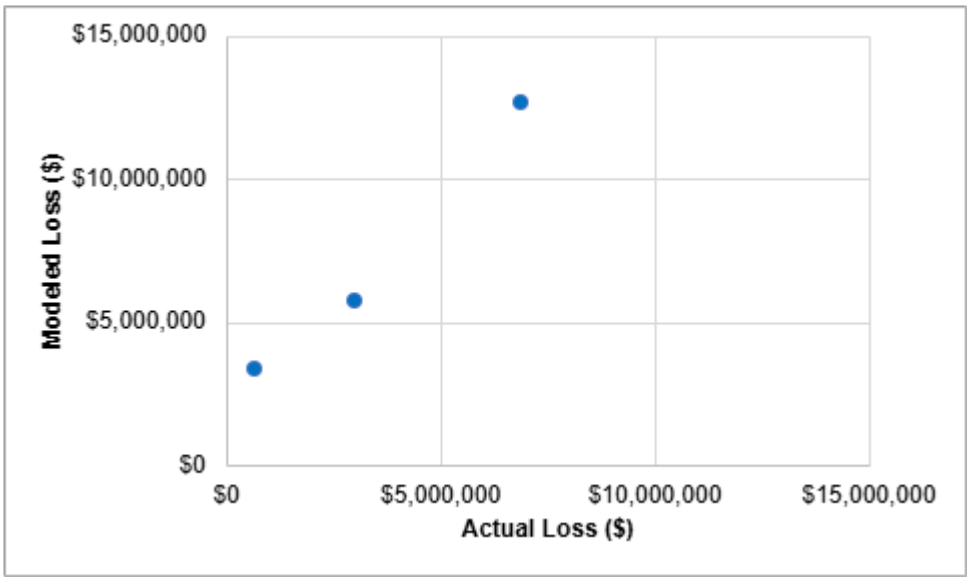


Figure 57. Scatter Plot of Comparison #1: Validation by Construction Type, Company C

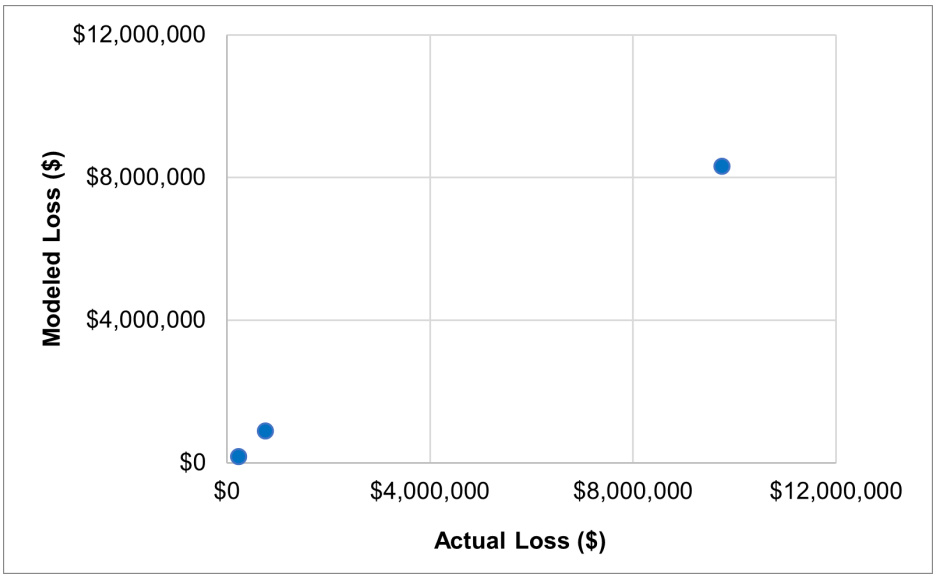


Figure 58. Scatter Plot of Comparison #2: Validation by Construction Type, Company G

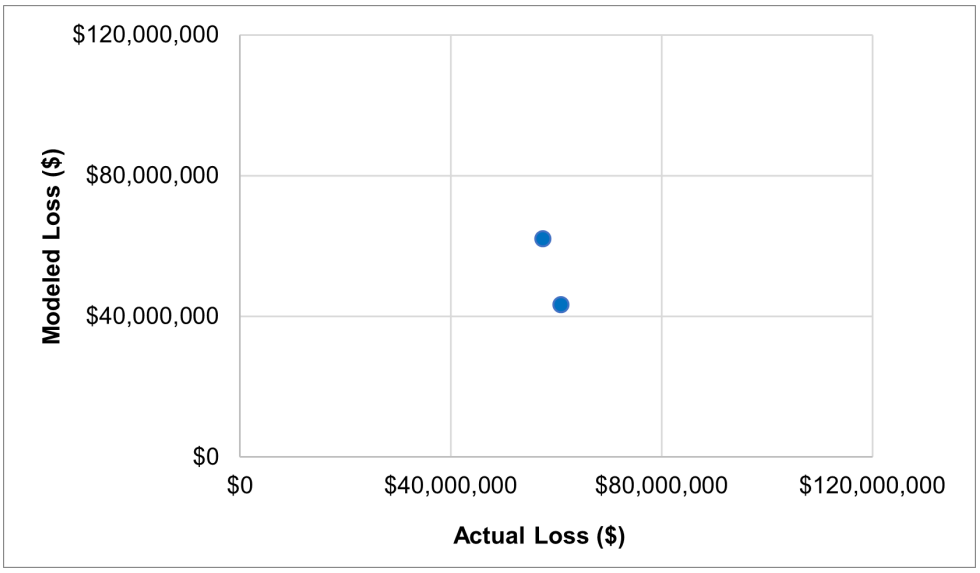


Figure 59. Scatter Plot of Comparison #3: Validation by Construction Type, Company N



Figure 60. Scatter Plot of Comparison #4: Validation by County, Company J



Figure 61. Scatter Plot of Comparison of Actual Commercial Residential Exposures and Loss to Modeled Exposure and Loss

Form S-4.D

Include Form S-4 in a submission appendix.

Rather than using a specific published hurricane windfield directly, the winds underlying the modeled hurricane loss cost calculations must be produced by the hurricane model being evaluated and shall be the same hurricane parameters as used in completing Form A-2.

Included here as part of Disclosure S-5.2.

Form S-5: Average Annual Zero Deductible Statewide Hurricane Loss Costs

Form S-5.A

Part A – 2017 FHCF Exposure Data

Provide the average annual zero deductible statewide personal and commercial residential hurricane loss costs produced using the Model Base Hurricane Set.

For the row related to the Current Accepted Hurricane Model and the two rows related to the Second Previous Accepted Hurricane Model, the table is to be completed with the same data as previously given in Form S-5 under the 2021 Hurricane Standards.

Table 40. Average Annual Zero Deductible Statewide Personal and Commercial Residential Hurricane Loss Costs

Time Period	Reference Hurricane Set (Previously Historical)	Model Base Hurricane Set	Produced by Hurricane Model
Current Submission	N/A	3.392 Billion	4.284 Billion
Current-Accepted Hurricane Model* (2021 Hurricane Standards)	3.328 Billion	N/A	3.965 Billion
Second Previous Accepted Hurricane Model* (2019 Standards)	3.198 Billion	N/A	3.936 Billion
Percent Change Current Submission/ Second Previous Accepted Hurricane Model*	6.040%	N/A	8.843%

**Enter N/A if no current or previous accepted hurricane model*

Form S-5.B

Provide a comparison with the statewide personal and commercial residential hurricane loss costs produced by the hurricane model.

The average annual zero deductible statewide loss cost produced using the list of hurricanes in the Model Base Hurricane Set and the 2017 FHCF aggregate personal and commercial residential exposure data is $3.392 billion ($\mu_H$). The statewide loss cost produced by the hurricane model is $4.284 billion ($\mu_S$).

Form S-5.C

Provide the 95% confidence interval on the differences between the means of the Model Base Hurricane Set and modeled personal and commercial residential hurricane loss costs.

The 95% confidence interval on the difference between the mean historical and modeled losses is (-2.414 billion $\leq(\mu_H - \mu_S)\leq$ +0.629 billion).

Form S-5.D

Part B – 2023 FHCF Exposure Data

Provide the average annual zero deductible statewide personal and commercial residential hurricane loss costs produced using the Model Base Hurricane Set.

Table 41. Average Annual Zero Deductible Statewide Personal and Commercial Residential Hurricane Loss Costs

Time Period	Model Base Hurricane Set	Produced by Hurricane Model
Current Submission	4.593 Billion	5.868 Billion

Form S-5.E

Provide a comparison with the statewide personal and commercial residential hurricane loss costs produced by the hurricane model.

The average annual zero deductible statewide loss cost produced using the list of hurricanes in the Model Base Hurricane Set and the 2023 FHCF aggregate personal and commercial residential exposure data is $4.593 billion ($\mu_H$). The statewide loss cost produced by the hurricane model is $5.868 billion ($\mu_S$)

FormS-5.F

Provide the 95% confidence interval on the differences between the means of the Model Base Hurricane Set and modeled personal and commercial residential hurricane loss costs.

The 95% confidence interval on the difference between the mean historical and modeled losses is (-3.315 billion $\leq(\mu_H - \mu_S)\leq$ +0.764 billion).

Form S-5.G

Include Form S-5 in a submission appendix.

Included here as part of Disclosure S-6.3.

Form S-6: Hypothetical Events for Sensitivity and Uncertainty Analysis

Form S-6 was submitted and accepted as a requirement under the 2009 Hurricane Standards. The results are unchanged and are still in compliance with the current statistical standards. While Form S-6 is not physically included in this submission, all contents in the form are disclosed and extensively discussed in Standard S-2: Sensitivity Analysis for Hurricane Model Output and Standard S-3: Uncertainty Analysis for Hurricane Model Output.

12 Appendix 4: Vulnerability Hurricane Standards Forms

Form V-1: One Hypothetical Event

Form V-1.A

Windspeeds for 96 ZIP Codes and sample personal and commercial residential exposure data are provided in the file named "FormV1Input23.xlsx." The windspeeds and ZIP Codes represent a hypothetical hurricane track. Model the sample personal and commercial residential exposure data provided in the file against these windspeeds at the specified ZIP Codes, and provide the building and contents damage ratios and time element loss ratios summarized by windspeed (mph) and construction type.

The windspeeds provided are one-minute sustained 10-meter windspeeds. The sample personal and commercial residential exposure data provided consists of four structures (one of each construction type – wood frame, masonry, manufactured home, and concrete) individually placed at the population centroid of each of the ZIP Codes provided. Each ZIP Code is subjected to a specific windspeed.

For completing Part A, Estimated Damage for each individual windspeed range is the sum of ground up hurricane loss to all structures in the ZIP Codes subjected to that individual windspeed range, excluding demand surge and flood (including hurricane storm surge). Subject Exposure is all exposures in the ZIP Codes subjected to that individual windspeed range.

For completing Part B, Estimated Damage is the sum of the ground up hurricane loss to all structures of a specific type (wood frame, masonry, manufactured home, or concrete) in all of the windspeed ranges, excluding demand surge and flood (including hurricane storm surge). Subject Exposure is all exposures of that specific construction type in all of the ZIP Codes.

One reference structure for each of the construction types is to be placed at the population centroid of the ZIP Codes. Do not include appurtenant structure, contents, or time element coverages in the building damage ratios. Do not include building, appurtenant structure, or time element coverages in the contents damage ratios. Do not include building, appurtenant structure, or contents coverages in the time element loss ratios.

Reference Frame Structure	*Reference Masonry Structure*
One story	*One story*
Unbraced gable end roof	*Unbraced gable end roof*

American Society for Testing and Materials (ASTM) D3161 Class D or ASTM D7158 Class D shingles	*ASTM D3161 Class D or ASTM D7158 Class D shingles*
½" plywood deck	*½" plywood deck*
6d nails, deck to roof members	*6d nails, deck to roof members*
Toe nail truss to wall anchor	*Weak truss to wall connection*
Wood framed exterior walls	*Masonry exterior walls*
5/8" diameter anchors at 48" centers for wall-floor-foundation connections	*No vertical wall reinforcing*
No shutters	*No shutters*
Standard glass windows	*Standard glass windows*
No door covers	*No door covers*
No skylight covers	*No skylight covers*
Constructed in 1995	*Constructed in 1995*
Reference Manufactured Home Structure	*Reference Concrete Structure*
Tie downs	*Twenty stories*
Single unit	*Eight apartment units per story*
Manufactured in 1980	*Standard glass windows*
	Constructed in 1980

Table 42. Damage Ratios Summarized by Windspeed (mph) and Construction Type

Part A			
Windspeed (mph, one-minute sustained, 10-meter)	**Estimated Building Damage/ Subject Building Exposure**	**Estimated Contents Damage/ Subject Contents Exposure**	**Estimated Time Element Loss/ Subject Time Element Exposure**
41 – 50	0.054%	0.010%	0.000%
51 – 60	0.123%	0.026%	0.001%
61 – 70	0.462%	0.099%	0.006%
71 – 80	0.956%	0.202%	0.018%
81 – 90	1.889%	0.460%	0.046%
91 – 100	3.549%	0.992%	0.127%
101 – 110	7.345%	2.817%	0.521%
111 – 120	20.591%	14.903%	3.092%
121 – 130	34.229%	21.088%	4.965%
131 – 140	43.795%	29.588%	8.602%
141 – 150	55.751%	43.315%	14.610%
151 – 160	63.296%	50.184%	18.000%

Part A			
Windspeed (mph, one-minute sustained, 10-meter)	**Estimated Building Damage/ Subject Building Exposure**	**Estimated Contents Damage/ Subject Contents Exposure**	**Estimated Time Element Loss/ Subject Time Element Exposure**
161 – 170	73.967%	55.838%	21.954%

Part B			
Construction Type	**Estimated Building Damage/ Subject Building Exposure**	**Estimated Contents Damage/ Subject Exposure**	**Estimated Time Element Loss/ Subject Time Element Exposure**
Wood Frame	22.720%	17.610%	7.887%
Masonry	18.760%	14.998%	6.588%
Manufactured Home	36.386%	24.552%	5.358%
Concrete	4.322%	3.429%	1.227%

Form V-1.B

Confirm that the structures used in completing the form are identical to those in the above table for the reference structures. List assumptions necessary to complete Form V-1 (e.g., regarding structural characteristics, duration, or surface roughness). Provide the rationale and a detailed description of how the assumptions are implemented.

The structures used in completing this Form are identical to those in the above table. The Verisk vulnerability model requires a complete time profile of one-minute sustained wind speeds to calculate damage for a particular risk. For the purpose of completion of Form V-1: One Hypothetical Event, the effect of duration is not accounted for. The ZIP Code-level maximum wind speeds provided in the file named FormV1Input23.xlsx are modeled to impact the respective ZIP Codes for exactly one hour duration, keeping in mind that it is a hypothetical event as specified in the title of Form V-1: One Hypothetical Event. Additionally, for completing this Form, the replacement value for time element is assumed to be equal to the time element limit provided in the exposure data file.

Form V-1.C

Provide separate plots of the Estimated Damage/Subject Exposure (y-axis) versus Windspeed (x-axis) for the Building, Contents, and Time Element data in Part A.

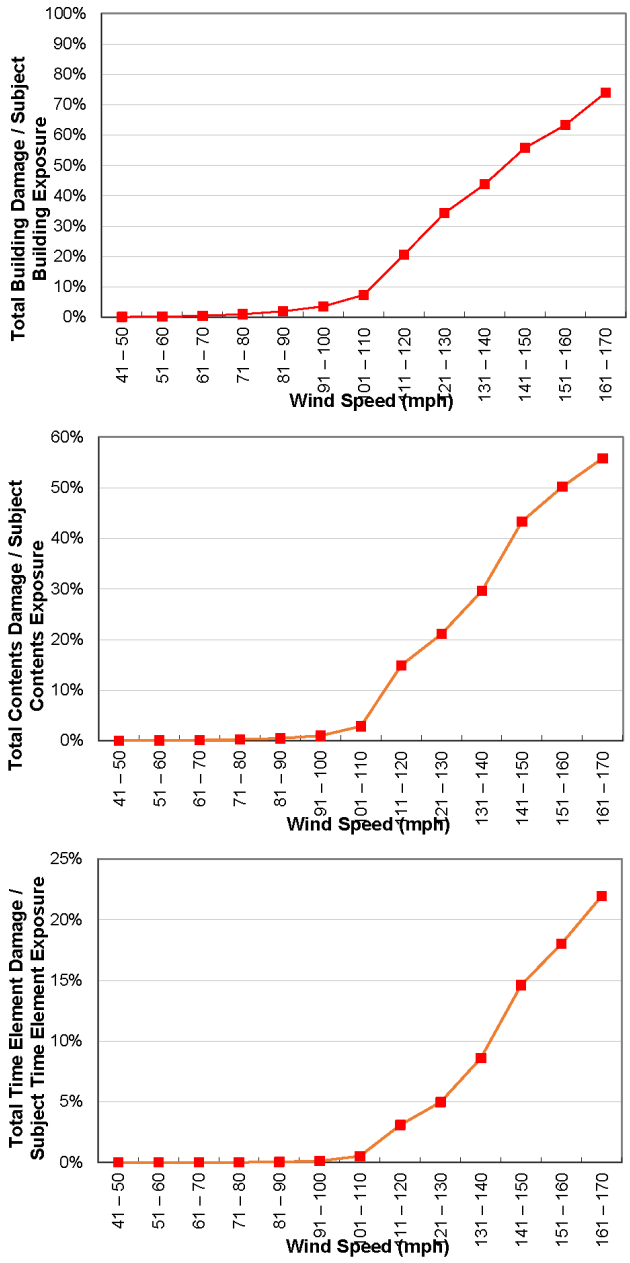


Figure 62. Loss Percentages by Wind Speed for the Building, Contents, and Time Element Data

Form V-1.D

Include Form V-1 in a submission appendix.

Form V-1: One Hypothetical Event.

Form V-2: Hurricane Mitigation Measures and Secondary Characteristics, Range of Changes in Damage

Form V-2.A

Explain how the hurricane vulnerability functions for the two reference structures are developed. Demonstrate that the hurricane vulnerability function for each reference structure is related to one of the hurricane model's standard building structure vulnerability functions for frame and masonry constructions.

The hurricane vulnerability functions for the reference structures are derived by modeling these structures in the Verisk Hurricane Model for the United States. The reference and mitigated structures are modeled at the exposure location and the wind speeds specified in Form V-2: Hurricane Mitigation Measures and Secondary Characteristics, Range of Changes in Damage and Form V-3: Hurricane Mitigation Measures and Secondary Characteristics, Mean Damage Ratios and Hurricane Loss Costs (Trade Secret Item) are modeled at this location for exactly one hour duration. The model then computes ground-up losses at the location for each of the reference and mitigated buildings using the damage functions that are computed within the software for these respective risks. The ground-up losses are then divided by the respective replacement values to obtain damage ratios populated in Form V-3: Hurricane Mitigation Measures and Secondary Characteristics, Mean Damage Ratios and Hurricane Loss Costs (Trade Secret Item) and subsequently Form V-2: Hurricane Mitigation Measures and Secondary Characteristics, Range of Changes in Damage.

Standard V-1: Development of Building Hurricane Vulnerability Functions, Standard V-4.A, and Disclosure V-4.5 describe in detail how the impact of primary and secondary characteristics are captured in deriving building vulnerability functions. Verisk Individual Risk Model is integrated into the hurricane loss projection model to estimate the impact of mitigation features on building vulnerability. When any combination of the secondary features listed is provided, the Verisk Individual Risk Model calculates the corresponding credits and applies them to the base vulnerability functions to obtain refined vulnerability functions for buildings with mitigation features. This is the same backbone operation utilized for all vulnerability function development.

Form V-2.B

Place the reference building at the population centroid for ZIP Code 33921 in Lee County.

The reference buildings was located at the population weighted centroid for ZIP Code 33921 in Lee County, Florida.

Form V-2.C

Provide the change in the zero deductible personal residential reference building structure damage ratio (not hurricane loss cost) for each individual hurricane mitigation measure and secondary characteristic

listed in Form V-2, Hurricane Mitigation Measures and Secondary Characteristics, Range of Changes in Damage, as well as for the combination of the four hurricane mitigation measures and secondary characteristics provided for the Mitigated Frame Building and the Mitigated Masonry Building below.

The change in the zero deductible personal residential reference building structure damage ratio (not hurricane loss cost) for each individual hurricane mitigation measure and secondary characteristic listed in Form V-2 is included in Form V-2.F of this submission appendix and is additionally provided in Excel format without truncation. The Excel file is titled "VSK23FormV2.xlsx".

Form V-2.D

List assumptions necessary to complete Form V-2, including those for membrane and metal roof covering, roof age, duration, and surface roughness. Provide the rationale and a detailed description of how the assumptions are implemented.

The Verisk vulnerability model requires a complete time profile of one minute sustained wind speeds in order to calculate damage for a particular risk. For the purpose of completion of Form V-2: Hurricane Mitigation Measures and Secondary Characteristics, Range of Changes in Damage, the effect of duration is not accounted for.

The instructions for Form V-2: Hurricane Mitigation Measures and Secondary Characteristics, Range of Changes in Damage require a wind speed input. Wind speed is not an explicit input to the Verisk Hurricane Model for the United States To populate Form V-2: Hurricane Mitigation Measures and Secondary Characteristics, Range of Changes in Damage, we hardcoded the explicit windspeeds at the reference location as specified by the Hurricane Standards Report of Activities.

Additionally, the reference frame and masonry structure are assumed to not have sliding glass doors.

Form V-2.E

Provide an explanation for cells filled with “0” or blank cells.

The cells with “-” value indicate illogical combinations. For instance, vertical reinforcement connecting a wood frame structure to its underlying foundation does not exist. Values with “0.0” in the entry indicate that a specified secondary characteristic has a negligible impact on the wind vulnerability at the wind speed specified relative to the reference structure. For example, the impact of "ties or clips" or "straps" in the "Wall-to-Floor Strength" category makes no discernable impact on vulnerability at 60 MPH. This is because the failure modes are not likely to be triggered at these windspeeds regardless of the attachment type.

Form V-2.F

Provide this form in Excel format without truncation. The file name should include the abbreviated name of the modeling organization, the hurricane standards year, and the form name. Also include Form V-2, Hurricane Mitigation Measures and Secondary Characteristics, Range of Changes in Damage, in a submission appendix.

Reference Frame Structure	*Reference Masonry Structure*
One story *Unbraced gable end roof* *ASTM D3161 Class D or* *ASTM D7158 Class D shingles* *½" plywood deck* *6d nails, deck to roof members* *Toe nail truss to wall anchor* *Wood framed exterior walls* *5/8" diameter anchors at 48" centers for wall-floor-foundation connections* *No shutters* *Standard glass windows* *No door covers* *No skylight covers* *Constructed in 1995*	*One story* *Unbraced gable end roof* *ASTM D3161 Class D or* *ASTM D7158 Class D shingles* *½" plywood deck* *6d nails, deck to roof members* *Weak truss to wall connection* *Masonry exterior walls* *No vertical wall reinforcing* *No shutters* *Standard glass windows* *No door covers* *No skylight covers* *Constructed in 1995*
Mitigated Frame Building	*Mitigated Frame Building*
ASTM D7158 Class H shingles *8d nails deck to roof members* *Truss straps at roof* *Structural wood panel shutters*	*ASTM D7158 Class H shingles* *8d nails deck to roof members* *Truss straps at roof* *Structural wood panel shutters*

A hard copy of Table 43 is included in this submission appendix item and is additionally provided in Excel format without truncation. The Excel file is named "VSK23FormV2.xlsx".

Table 43. Form V-2: Hurricane Mitigation Measures and Secondary Characteristics, Range of Changes in Damage

INDIVIDUAL HURRICANE MITIGATION MEASURE AND SECONDARY CHARACTERISTICS		PERCENTAGE CHANGES IN DAMAGE ((REFERENCE DAMAGE RATE - MITIGATED DAMAGE RATE) / REFERENCE DAMAGE RATE) * 100									
		FRAME BUILDING					MASONRY BUILDING				
		WINDSPEED (MPH)*					WINDSPEED (MPH)*				
		60	85	110	135	160	60	85	110	135	160
	REFERENCE BUILDING	-	-	-	-	-	-	-	-	-	-
ROOF CONFIGURATION	BRACED GABLE ENDS	10.7	15.0	14.1	10.4	6.4	10.0	14.9	14.1	10.0	6.3
	HIP ROOF	14.3	19.0	17.7	13.7	9.2	14.3	18.6	17.5	13.4	9.0

INDIVIDUAL HURRICANE MITIGATION MEASURE AND SECONDARY CHARACTERISTICS			PERCENTAGE CHANGES IN DAMAGE ((REFERENCE DAMAGE RATE - MITIGATED DAMAGE RATE) / REFERENCE DAMAGE RATE) * 100									
			FRAME BUILDING					MASONRY BUILDING				
			WINDSPEED (MPH)*					WINDSPEED (MPH)*				
			60	85	110	135	160	60	85	110	135	160
	REFERENCE BUILDING		-	-	-	-	-	-	-	-	-	-
ROOF COVERING	METAL		6.0	5.1	3.2	1.9	0.6	5.7	4.8	3.0	1.8	0.6
	ASTM D7158 CLASS H SHINGLES		10.7	8.0	4.6	2.5	1.2	10.0	7.6	4.4	2.4	1.1
	MEMBRANE		9.5	14.5	12.4	2.4	1.1	10.0	14.6	12.4	2.3	1.1
ROOF SHEATHING	NAILING OF DECK	8d	8.3	18.5	21.2	17.3	10.1	8.6	18.2	20.9	17.2	9.8
ROOF-WALL STRENGTH	CLIPS		1.2	5.4	10.8	11.9	7.6	1.4	5.1	10.3	11.5	7.4
	STRAPS		1.2	6.8	13.1	14.5	9.9	1.4	6.5	12.9	14.5	9.6
WALL-FLOOR STRENGTH	TIES OR CLIPS		0.0	0.5	0.5	2.5	6.8	0.0	0.4	0.5	2.4	6.6
	STRAPS		0.0	0.8	2.0	6.0	12.3	0.0	0.8	1.6	5.8	12.0
WALL-FOUNDATION STRENGTH	LARGER ANCHORS OR CLOSER SPACING		0.0	0.5	0.5	2.5	6.8	-	-	-	-	-
	STRAPS		0.0	0.8	2.0	6.0	12.3	-	-	-	-	-
	VERTICAL REINFORCING		-	-	-	-	-	0.0	1.1	2.1	6.4	14.6
OPENING PROTECTION	WINDOW SHUTTERS	STRUCTURAL WOOD PANEL	8.3	13.2	12.5	10.0	8.1	7.1	12.8	12.0	9.5	7.8
		METAL	8.3	13.2	12.5	10.0	8.1	7.1	12.8	12.0	9.5	7.8
	DOOR AND SKYLIGHT COVERS		1.2	3.9	4.9	5.0	4.4	1.4	3.7	4.6	4.7	4.2
WINDOW, DOOR, SKYLIGHT STRENGTH	WINDOWS	IMPACT RATED	11.9	19.1	19.0	16.5	14.0	11.4	18.4	18.4	16.1	13.5
	ENTRY DOORS	MEETS WINDBORNE DEBRIS REQUIREMENTS	1.2	3.9	4.9	5.0	4.4	1.4	3.7	4.6	4.7	4.2
	GARAGE DOORS	MEETS WINDBORNE DEBRIS REQUIREMENTS	2.4	4.3	3.5	2.2	1.4	1.4	4.4	3.7	2.3	1.4
	SLIDING GLASS DOORS	MEETS WINDBORNE DEBRIS REQUIREMENTS	-1.2	-0.6	-0.8	-0.7	-0.6	0.0	-0.6	-0.7	-0.7	-0.6
	SKYLIGHT	IMPACT RATED	1.2	1.7	1.4	1.0	0.6	1.4	1.7	1.3	0.9	0.6

HURRICANE MITIGATION MEASURES AND SECONDARY CHARACTERISTICS IN COMBINATION	PERCENTAGE CHANGES IN DAMAGE ((REFERENCE DAMAGE RATE - MITIGATED DAMAGE RATE)/ REFERENCE DAMAGE RATE)*100									
	FRAME BUILDING					MASONRY BUILDING				
	WINDSPEED (MPH)*					WINDSPEED (MPH)*				
	60	85	110	135	160	60	85	110	135	160
MITIGATED BUILDING	33.3	49.0	52.7	43.6	27.8	31.4	46.8	50.7	42.3	27.3

*Windspeeds are one-minute sustained and 10-meter.

Form V-3: Hurricane Mitigation Measures and Secondary Characteristics, Mean Damage Ratios and Hurricane Loss Costs (Trade Secret Item)

Form V-3: Hurricane Mitigation Measures and Secondary Characteristics, Mean Damage Ratios and Hurricane Loss Costs (Trade Secret Item) is considered trade secret and will be presented to the Professional Team and at the closed meeting of the Commission for review.

Form V-4: Differences in Hurricane Mitigation Measures and Secondary Characteristics

Form V-4.A

Provide the differences between the values reported in Form V-2 relative to the equivalent data compiled from the current accepted hurricane model.

A completed Form V-4: Differences in Hurricane Mitigation Measures and Secondary Characteristics is provided in this submission appendix.

Form V-4.B

List assumptions necessary to complete Form V-4, including those for membrane and metal roof covering, roof age, duration, and surface roughness.

Form V-4: Differences in Hurricane Mitigation Measures and Secondary Characteristics is populated by taking a difference between Form V-2: Hurricane Mitigation Measures and Secondary Characteristics, Range of Changes in Damage results from the updated model and the current accepted model. The differences reported in Form V-4: Differences in Hurricane Mitigation Measures and Secondary Characteristics are almost zero across the board. This stems from the fact that there are no changes to the vulnerability of the reference structures and also the mitigation options between this submission version and the current accepted model.

Form V-4.C

Provide a list and describe any assumptions made to complete this form.

All assumptions described in Form V-2.B are applicable to Form V-4: Differences in Hurricane Mitigation Measures and Secondary Characteristics.

Form V-4.D

Provide this form in Excel format without truncation. The file name shall include the abbreviated name of the modeling organization, the hurricane standards year, and the form name. Also include Form V-4 in a submission appendix.

A hard copy of Form V-4: Differences in Hurricane Mitigation Measures and Secondary Characteristics is included in this submission appendix and is additionally provided in Excel format without truncation. The Excel file is titled "VSK23FormV4.xlsx".

Table 44. Form V-4: Differences in Hurricane Mitigation Measures and Secondary Characteristics

INDIVIDUAL HURRICANE MITIGATION MEASURES AND SECONDARY CHARACTERISTICS			PERCENT DIFFERENCES FROM FORM V-2 RELATIVE TO PREVIOUSLY-ACCEPTED HURRICANE MODEL									
			FRAME BUILDING					MASONRY BUILDING				
			WINDSPEED (MPH)*					WINDSPEED (MPH)*				
			60	85	110	135	160	60	85	110	135	160
	REFERENCE BUILDING		-	-	-	-	-	-	-	-	-	-
ROOF CONFIGURATION	BRACED GABLE ENDS		0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	HIP ROOF		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ROOF COVERING	METAL		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	ASTM D7158 CLASS H SHINGLES		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	MEMBRANE		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ROOF SHEATHING	NAILING OF DECK	8d	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
ROOF-WALL STRENGTH	CLIPS		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	STRAPS		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WALL-FLOOR STRENGTH	TIES OR CLIPS		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	STRAPS		0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
WALL-FOUNDATION STRENGTH	LARGER ANCHORS OR CLOSER SPACING		0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
	STRAPS		0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
	VERTICAL REINFORCING		-	-	-	-	-	0.0	0.1	0.0	0.0	0.0
OPENING PROTECTION	WINDOW SHUTTERS	STRUCTURAL WOOD PANEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		METAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	DOOR AND SKYLIGHT COVERS		0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
WINDOW, DOOR, SKYLIGHT STRENGTH	WINDOWS	IMPACT RATED	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
	ENTRY DOORS	MEETS WINDBORNE DEBRIS REQUIREMENTS	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
	GARAGE DOORS	MEETS WINDBORNE DEBRIS REQUIREMENTS	0.0	0.1	0.0	0.0	0.0	-1.4	0.0	0.0	0.0	0.0
	SLIDING GLASS DOORS	MEETS WINDBORNE DEBRIS REQUIREMENTS	-1.2	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
	SKYLIGHT	IMPACT RATED	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
HURRICANE MITIGATION MEASURES AND SECONDARY CHARACTERISTICS IN COMBINATION			**PERCENTAGE CHANGES IN DAMAGE ((REFERENCE DAMAGE RATE - MITIGATED DAMAGE RATE)/ REFERENCE DAMAGE RATE)*100**									
			FRAME BUILDING					MASONRY BUILDING				
			WINDSPEED (MPH)*					WINDSPEED (MPH)*				
			60	85	110	135	160	60	85	110	135	160
MITIGATED BUILDING			0.0	-0.1	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	0.0

*Windspeeds are one-minute sustained and 10-meter.

Form V-5: Differences in Hurricane Mitigation Measures and Secondary Characteristics, Mean Damage Ratios and Hurricane Loss Costs (Trade Secret Item)

A. Provide the differences between the values reported in Form V-3 relative to the equivalent data compiled from the current accepted hurricane model.

B. List assumptions necessary to complete Form V-5, including those for membrane and metal roof covering, roof age, duration, and surface roughness.

C. Provide a summary description of the differences.

D. If not considered as Trade Secret, provide this form in Excel format and in a submission appendix. The file name shall include the abbreviated name of the modeling organization, the hurricane standards year, and the form name.

Form V-5: Differences in Hurricane Mitigation Measures and Secondary Characteristics, Mean Damage Ratios and Hurricane Loss Costs (Trade Secret Item) is considered trade secret and will be presented to the Professional Team and at the closed meeting of the Commission for review.

13 Appendix 5: Actuarial Hurricane Standard Forms

Form A-1: Zero Deductible Personal Residential Hurricane Loss Costs by ZIP Code

Form A-1.A

One or more automated programs or scripts shall be used to generate and arrange the data in Form A-1.

Form A-1: Zero Deductible Personal Residential Hurricane Loss Costs by ZIP Code was prepared using an automated process. During the automation process, Verisk exercised due diligence verifying that the process produced the same indications for Form A-1: Zero Deductible Personal Residential Hurricane Loss Costs by ZIP Code as completed in prior submissions.

Form A-1.B

Provide three maps, color-coded by ZIP Code (with a minimum of seven value ranges), displaying zero deductible personal residential hurricane loss costs per $1,000 of exposure for frame owners, masonry owners, and manufactured homes.

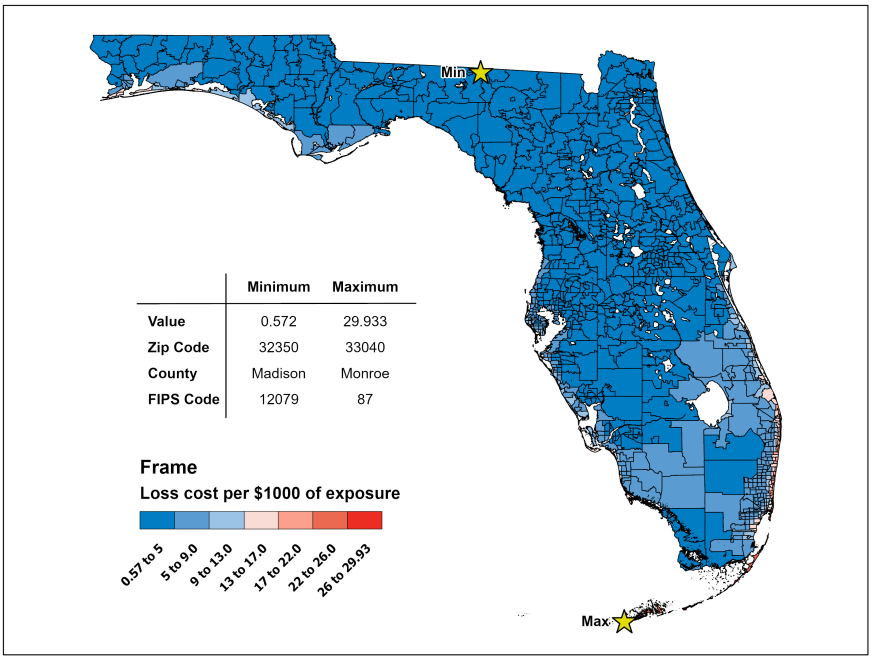


Figure 63. Loss Costs by ZIP Code for Owners Wood Frame, Zero Deductible

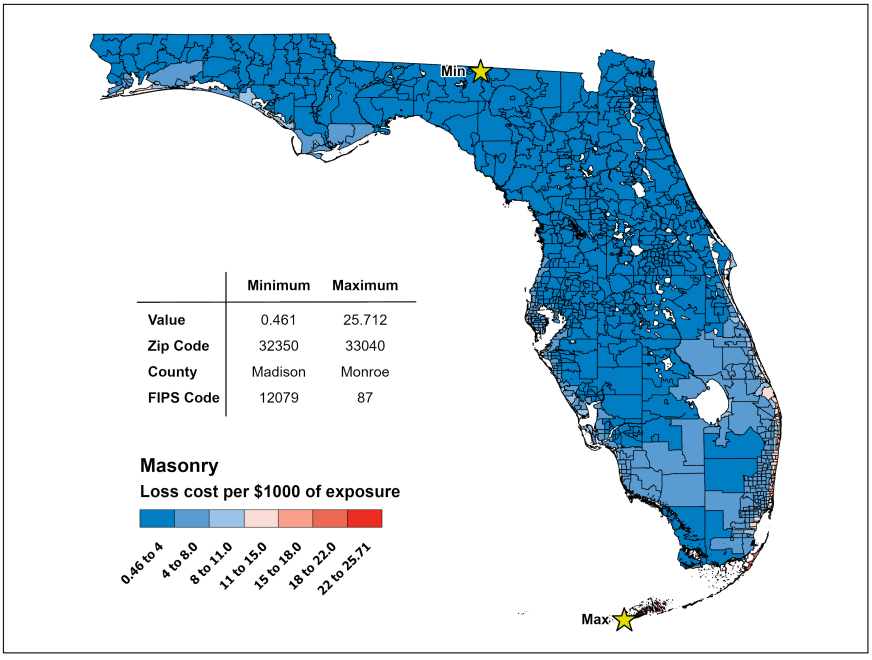


Figure 64. Loss Costs by ZIP Code for Owners Masonry, Zero Deductible

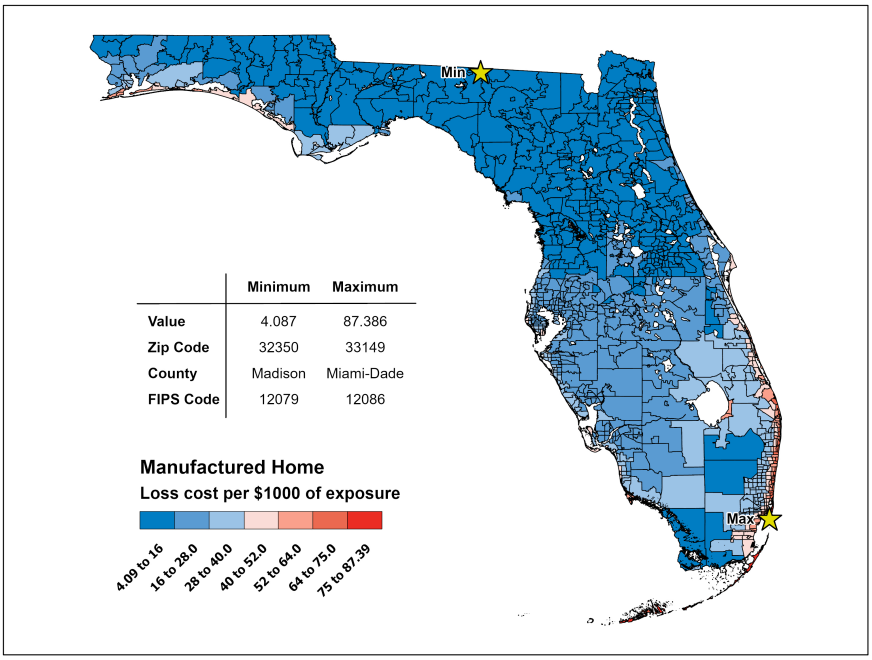


Figure 65. Loss Costs by ZIP Code for Manufactured Home, Zero Deductible

Form A-1.C

Provide, in the format given in the file named "2023FormA1.xlsx," in both Excel and PDF format, the underlying hurricane loss cost data, rounded to three decimal places, used for A. above. The file name should include the abbreviated name of the modeling organization, the hurricane standards year, and the form name.

Form A-1: Zero Deductible Personal Residential Hurricane Loss Costs by ZIP Code has been submitted in both PDF and Excel format separately in the accompanying electronic submission files and is named "VSK23FormA1".

Form A-1.D

Create exposure sets for these exhibits by modeling the frame and masonry buildings and manufactured homes from Notional Set 3 described in the file "NotionalInput23.xlsx" geocoded to each ZIP Code centroid in the state, as provided in the hurricane model. Provide the predominant County name and the Federal Information Processing Standards (FIPS) code (Figure 12) associated with each ZIP Code centroid. Refer to the Notional Hurricane Policy Specifications below for additional modeling information. Explain any assumptions, deviations, and differences from the prescribed exposure information.

Form A-1: Zero Deductible Personal Residential Hurricane Loss Costs by ZIP Code includes both the predominant County name and the FIPS code associated with each Zip Code centroid. No additional assumptions, deviations or differences were made from the prescribed exposure information.

Form A-1.E

Describe how Law and Ordinance is included in the hurricane loss cost data.

Law and ordinance coverage for personal residential properties is implicitly accounted for in the model to the extent that it is captured in the historical data and included in the model through the model damage estimation process.

Form A-1.F

List assumptions necessary to complete Form A-1. Provide the rationale and a detailed description of how the assumptions are implemented.

Table 45 shows the original fields provided by the FCHLPM broken out into different lines of business. Each field is paired with the corresponding Verisk data field. Each occupancy type is associated with a limit value A-D, which is based on the different insurance coverage types A-D from Notional Set 3. These construction and occupancy pairs are then assigned to each Zip Code as prescribed to produce loss estimates. Unknown features are modeled as unknowns (zeros), and the per diem for Coverage D is set at $300.

Table 45. Form A-1 Construction/Occupancy Information and Data Mapping

User Construction Type	User Occupancy Type	User Construction/ Occupancy	Verisk Construction Code	Verisk Occupancy Code	Verisk Construction	Verisk Occupancy
Manufactured Homes	Manufactured Homes	Manufactured Homes	191	301	Mobile Homes	General Residential
Frame	Owners	Frame Owners	101	301	Wood Frame	General Residential
Masonry	Owners	Masonry Owners	111	301	Masonry	General Residential

Form A-2: Model Base Hurricane Set Statewide Hurricane Losses

Form A-2.A

Provide the total insured hurricane loss assuming zero deductible policies for individual historical hurricanes using the 2017 FHCF exposure data and the 2023 FHCF exposure data. The list of hurricanes in this form shall include all Florida and by-passing hurricanes in the Model Base Hurricane Set.

The table below contains the hurricanes from the Reference Hurricane Set. The modeling organization shall populate the table with its Model Base Hurricane Set. Each hurricane from the Reference Hurricane Set has been assigned an ID number. Additional hurricanes included in the Model Base Hurricane Set, if any, shall be added to the table in order of year and assigned an intermediate ID number within the bounding ID numbers. For hurricanes resulting in zero loss, the table entry shall be left blank.

As defined, a by-passing hurricane (ByP) is a hurricane which does not make landfall on Florida, but produces minimum damaging windspeeds or greater on Florida. For the by-passing hurricanes included in the table only, the hurricane intensity entered is the maximum windspeed at closest approach to Florida as a hurricane, not the windspeed over Florida.

Table 46. Model Base Hurricane Set Statewide Hurricane Losses

ID	Hurricane Landfall/ Closest Approach Date	Year	Name	Region as defined in Figure 1 - Category	Personal and Commercial Residential Insured Hurricane Losses ($) 2017 FHCF Exposure Data	Personal and Commercial Residential Insured Hurricane Losses ($) 2023 FHCF Exposure Data
001	09/09/1900	1900	NoName01-1900	ByP-0	288,711	466,851
005	08/15/1901	1901	NoName04-1901	F-1	133,848,369	194,562,704
010	09/11/1903	1903	NoName03-1903	C-1/A-1	3,085,414,330	4,162,448,348
015	10/17/1904	1904	NoName04-1904	C-1	886,880,973	1,162,121,214
020	06/17/1906	1906	NoName02-1906	C-1	1,130,922,044	1,484,139,985
025	09/27/1906	1906	NoName06-1906	F-1	132,533,512	192,473,402
030	10/18/1906	1906	NoName08-1906	C-3	3,479,087,320	4,539,314,368
035	10/11/1909	1909	NoName11-1909	B-3	873,850,625	1,191,603,021
040	10/18/1910	1910	NoName05-1910	B-3	8,947,944,956	12,531,213,873
045	08/11/1911	1911	NoName02-1911	F-1	484,550,253	708,900,996
050	09/14/1912	1912	NoName04-1912	F-0	357,513,946	520,031,639
055	08/01/1915	1915	NoName01-1915	D-0	173,716,379	245,568,618
060	09/04/1915	1915	NoName04-1915	A-1	60,032,627	86,131,191
065	07/05/1916	1916	NoName02-1916	F-3	106,128,801	154,571,302
070	10/18/1916	1916	NoName14-1916	A-2	505,329,066	729,195,043
075	09/29/1917	1917	NoName04-1917	A-3	2,680,897,574	4,112,835,524
080	09/10/1919	1919	NoName02-1919	ByP-4	525,690,528	813,075,269
085	10/25/1921	1921	TampaBay06-1921	B-2	9,961,377,330	14,071,719,594
090	09/15/1924	1924	NoName05-1924	A-1	83,413,913	124,290,675

ID	Hurricane Landfall/ Closest Approach Date	Year	Name	Region as defined in Figure 1 - Category	Personal and Commercial Residential Insured Hurricane Losses ($) 2017 FHCF Exposure Data	Personal and Commercial Residential Insured Hurricane Losses ($) 2023 FHCF Exposure Data
095	10/21/1924	1924	NoName10-1924	B-1	667,404,709	897,575,650
096	12/02/1925	1925	NoName04-1925	ByP-1	357,033,214	500,053,905
100	07/28/1926	1926	NoName01-1926	D-3	3,228,092,303	4,549,438,124
105	09/18/1926	1926	GreatMiami07-1926	C-4/A-3	55,297,677,058	74,560,772,235
110	10/21/1926	1926	NoName10-1926	ByP-1	213,180,612	286,274,887
115	08/08/1928	1928	NoName01-1928	C-2	1,772,550,884	2,416,364,675
120	09/17/1928	1928	LakeOkeechobee04-1928	C-4	46,310,169,632	61,388,454,218
125	09/28/1929	1929	NoName02-1929	B-2/A-1	7,683,226,660	10,349,143,891
126	09/13/1930	1930	NoName02-1930	ByP-0	4,900,468	6,980,581
130	09/01/1932	1932	NoName03-1932	F-1	647,418,910	897,596,060
135	07/30/1933	1933	NoName05-1933	C-0	451,922,881	618,018,655
140	09/04/1933	1933	NoName11-1933	C-3	6,762,155,878	8,961,848,610
141	09/05/1933	1933	NoName08-1933	ByP-2	2,373,130	3,745,992
142	10/05/1933	1933	NoName17-1933	ByP-2	64,508,549	89,895,713
143	07/25/1934	1934	NoName03-1934	ByP-0	25,661,308	37,658,929
145	09/03/1935	1935	LaborDay03-1935	C-5/A-2	12,467,845,375	16,866,243,962
146	09/29/1935	1935	NoName05-1935	ByP-4	1,106,739,588	1,464,156,526
150	11/04/1935	1935	NoName07-1935	C-2	2,170,447,632	2,825,547,639
155	07/31/1936	1936	NoName05-1936	A-2	1,109,360,888	1,689,669,404
160	08/11/1939	1939	NoName02-1939	C-1/A-1	882,859,151	1,273,841,237
161	08/07/1940	1940	NoName02-1940	ByP-0	768,006	1,138,317
165	10/06/1941	1941	NoName05-1941	C-2/A-1	1,737,762,109	2,343,115,805
170	10/19/1944	1944	NoName13-1944	B-2	12,378,348,641	17,434,069,515
175	06/24/1945	1945	NoName01-1945	A-1	1,656,890,067	2,377,115,906
180	09/15/1945	1945	NoName09-1945	C-4	11,918,576,617	15,766,318,513
185	10/08/1946	1946	NoName06-1946	B-1	1,645,149,422	2,371,441,310
186	08/24/1947	1947	NoName03-1947	ByP-0	3,114,034	4,884,798
190	09/17/1947	1947	NoName04-1947	C-3/F-2	28,095,201,416	36,390,998,225
195	10/12/1947	1947	NoName09-1947	B-2/E-2	1,243,179,679	1,628,707,872
200	09/22/1948	1948	NoName08-1948	B-3	16,921,035,441	22,546,377,274
205	10/05/1948	1948	NoName09-1948	C-2	870,812,415	1,146,932,584
210	08/26/1949	1949	NoName02-1949	C-2	15,199,817,753	20,731,212,526
215	08/31/1950	1950	Baker-1950	F-2	173,387,155	252,909,987
220	09/05/1950	1950	Easy-1950	A-2	5,639,977,015	8,110,466,865
225	10/18/1950	1950	King-1950	C-3	5,791,624,426	7,622,207,939
226	05/21/1951	1951	Able-1951	ByP-1	1,360,963	1,905,208
227	10/04/1951	1951	How-1951	ByP-0	344,526,109	470,694,191
228	08/31/1952	1952	Able-1952	ByP-1	0	0
230	09/26/1953	1953	Florence-1953	A-1	257,869,122	397,345,689
235	10/09/1953	1953	Hazel-1953	B-1	905,572,053	1,230,410,277
240	09/25/1956	1956	Flossy-1956	A-2	517,988,436	801,468,977
245	09/10/1960	1960	Donna-1960	B-4	21,004,461,336	29,194,261,534
250	09/15/1960	1960	Ethel-1960	F-1	0	0
251	10/29/1963	1963	Ginny-1963	ByP-1	0	0
255	08/27/1964	1964	Cleo-1964	C-2	5,398,737,038	7,044,246,637

ID	Hurricane Landfall/ Closest Approach Date	Year	Name	Region as defined in Figure 1 - Category	Personal and Commercial Residential Insured Hurricane Losses ($) 2017 FHCF Exposure Data	Personal and Commercial Residential Insured Hurricane Losses ($) 2023 FHCF Exposure Data
260	09/10/1964	1964	Dora-1964	D-2	3,104,835,271	4,553,522,900
265	10/14/1964	1964	Isbell-1964	B-2	434,987,975	581,638,033
270	09/08/1965	1965	Betsy-1965	C-3	2,496,104,065	3,306,506,737
275	06/09/1966	1966	Alma-1966	A-1	144,538,469	204,549,773
280	10/04/1966	1966	Inez-1966	C-1	169,995,999	231,421,156
281	06/04/1968	1968	Abby-1968	ByP-0	409,318,850	574,427,740
285	10/19/1968	1968	Gladys-1968	A-1	2,126,335,516	3,059,994,680
290	08/18/1969	1969	Camille-1969	F-5	25,913,335	37,819,061
295	06/19/1972	1972	Agnes-1972	A-1	55,734,064	79,928,998
300	09/23/1975	1975	Eloise-1975	A-3	669,730,514	1,115,617,505
305	09/04/1979	1979	David-1979	C-1/E-2	3,119,121,182	4,264,023,746
310	09/13/1979	1979	Frederic-1979	F-3	824,371,928	1,193,248,384
315	09/02/1985	1985	Elena-1985	F-3	775,268,096	1,130,001,648
316	10/29/1985	1985	Juan-1985	ByP-1	348,530,271	508,225,022
320	11/21/1985	1985	Kate-1985	A-2	412,769,829	591,119,852
325	10/12/1987	1987	Floyd-1987	C-0	27,875,258	38,789,525
330	08/24/1992	1992	Andrew-1992	C-5	24,714,530,965	31,540,933,736
331	11/18/1994	1994	Gordon-1994	ByP-0	225,121,375	312,359,379
335	08/03/1995	1995	Erin-1995	C-0/A-1	1,188,212,159	1,701,502,384
340	10/04/1995	1995	Opal-1995	A-3	2,161,297,370	3,119,438,988
345	07/19/1997	1997	Danny-1997	F-1	45,522,654	66,145,579
350	09/03/1998	1998	Earl-1998	A-0	56,714,086	82,091,908
355	09/25/1998	1998	Georges-1998	F-2	130,011,672	196,499,832
360	10/15/1999	1999	Irene-1999	B-0	245,123,907	329,860,567
361	09/17/2000	2000	Gordon-2000	ByP-0	165,403,535	235,806,947
365	08/13/2004	2004	Charley-2004	B-4	7,464,501,508	10,058,066,859
370	09/05/2004	2004	Frances-2004	C-1	7,173,636,473	10,080,278,672
375	09/16/2004	2004	Ivan-2004	F-3	2,324,977,244	3,366,527,529
380	09/26/2004	2004	Jeanne-2004	C-2	5,153,880,852	7,284,221,845
385	07/10/2005	2005	Dennis-2005	A-3	996,855,501	1,423,862,476
390	08/25/2005	2005	Katrina-2005	C-1	855,492,171	1,122,067,820
391	09/15/2005	2005	Ophelia-2005	ByP-1	948,048	1,303,460
395	09/20/2005	2005	Rita-2005	ByP-1	6,414,914	10,148,709
400	10/24/2005	2005	Wilma-2005	B-3	11,242,279,858	14,595,399,497
401	08/29/2012	2012	Isaac-2012	ByP-0	1,055,325	1,700,786
405	09/02/2016	2016	Hermine-2016	A-1	7,813,817	10,508,669
410	10/07/2016	2016	Matthew-2016	ByP-3	721,620,625	1,038,075,447
415	09/10/2017	2017	Irma-2017	B-4	11,271,581,272	15,609,910,702
420	10/08/2017	2017	Nate-2017	F-1	1,785,315	2,627,839
425	10/10/2018	2018	Michael-2018	A-4	4,501,668,707	6,737,611,410
430	09/04/2019	2019	Dorian-2019	ByP-2	85,782,619	122,764,566
435	09/16/2020	2020	Sally-2020	F-2	723,953,409	1,053,927,669
445	11/11/2020	2020	Eta-2020	ByP-0	292,563,016	414,838,237
450	07/07/2021	2021	Elsa-2021	ByP-0	115,251,720	162,572,233
455	09/28/2022	2022	Ian-2022	B-3	13,270,813,404	17,716,946,480

ID	Hurricane Landfall/ Closest Approach Date	Year	Name	Region as defined in Figure 1 - Category	Personal and Commercial Residential Insured Hurricane Losses ($) 2017 FHCF Exposure Data	Personal and Commercial Residential Insured Hurricane Losses ($) 2023 FHCF Exposure Data
460	11/10/2022	2022	Nicole-2022	C-1	301,776,121	424,144,382
			Total		417,133,129,656	564,869,153,825

Form A-2.B

B. List assumptions necessary to complete Form A-2. Provide the rationale and a detailed description of how the assumptions are implemented.

The 2017 FHCF and 2023 FHCF aggregate exposure data were modeled with a zero-deductible assumption. No additional assumptions were made to complete Form A-2: Model Base Hurricane Set Statewide Hurricane Losses.

Form A-2.C

Provide this form in Excel Format. The file name shall include the abbreviated name of the modeling organization, the hurricane standards year, and the form name. Also include Form A-2 in a submission appendix.

Form A-2: Model Base Hurricane Set Statewide Hurricane Losses is included in this submission appendix item and is additionally provided in Excel format. The Excel file is named "VSK23FormA2.xlsx".

Form A-3: Hurricane Losses

Form A-3.A

A. One or more automated programs or scripts shall be used to generate and arrange the data in Form A-3.

Form A-3: Hurricane Losses was prepared using an automated process. During the automation process, Verisk exercised due diligence verifying that the process reproduced the same indications as Form A-3 in prior submissions.

Form A-3.B

Provide the percentage of personal and commercial residential zero deductible hurricane total loss, rounded to four decimal places, and the modeled loss from Hurricane Matthew (2016), Hurricane Irma (2017), and Hurricane Michael (2018) and Hurricane Ian (2022) for each affected ZIP Code.

For Part A, use the 2017 FHCF exposure data, and for Part B, use the 2023 FHCF exposure data.

Rather than using directly a specified published windfield, the winds underlying the hurricane loss cost calculations shall be produced by the hurricane model under review and shall be the same hurricane parameters as used in completing Form A-2.

Form A-3: Hurricane Losses has been submitted in both PDF and Excel format separately in the accompanying electronic submission files named "VSK23FormA3". It includes the percentage of personal and commercial residential zero deductible hurricane total loss rounded to four decimal places and the modeled loss from Hurricane Matthew (2016), Hurricane Irma (2017), Hurricane Michael (2018), and Hurricane Ian (2022) for each affected ZIP Code.

Form A-3.C/D

C. Provide maps color-coded by ZIP Code depicting the percentage of total personal and commercial residential hurricane loss from each hurricane: Hurricane Matthew (2016), Hurricane Irma (2017), and Hurricane Michael (2018), and Hurricane Ian (2022), using the following interval coding.

Red	***> 5%***
Light Red	***> 2% to 5%***
Pink	***> 1% to 2%***
Light Pink	***>0.5% to 1%***
Light Blue	***>0.2% to 0.5%***

Medium Blue	***>0.1% to 0.2%***
Blue	***> 0% to 0.1%***
Grey	***0%***

D. Plot the relevant storm track on each map.

Eight maps are provided depicting the percentage of total personal and commercial residential hurricane loss from each hurricane and the relevant storm track. Using the 2017 FHCF exposure data, the maps are: Figure 66, Figure 67, Figure 68, Figure 69 for Matthew (2016), Irma (2017), Michael (2018) and Ian (2022), respectively. Using the 2023 FHCF Exposure data, the maps are Figure 70, Figure 71, Figure 72, Figure 73 for Matthew (2016), Irma (2017), Michael (2018) and Ian (2022), respectively.

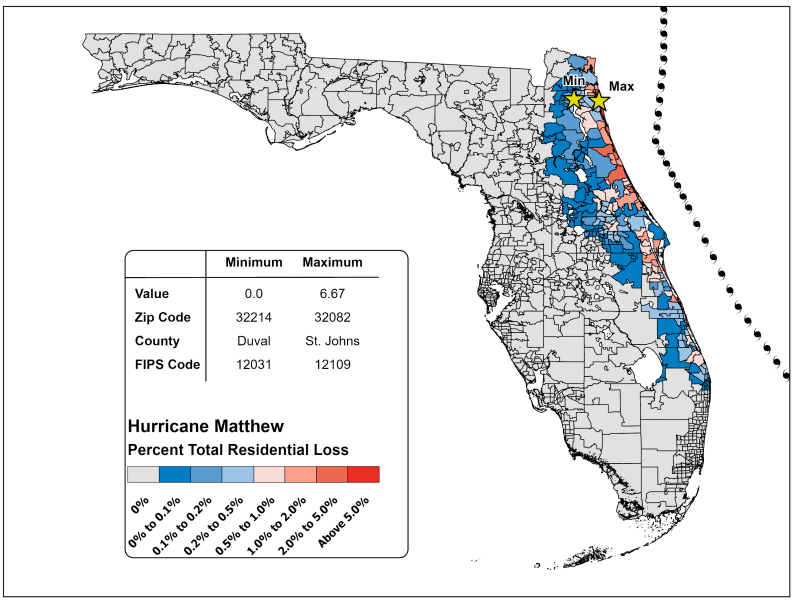


Figure 66. Percentage of Total Residential Loss from Hurricane Matthew (2016) Using 2017 FHCF Exposure Data

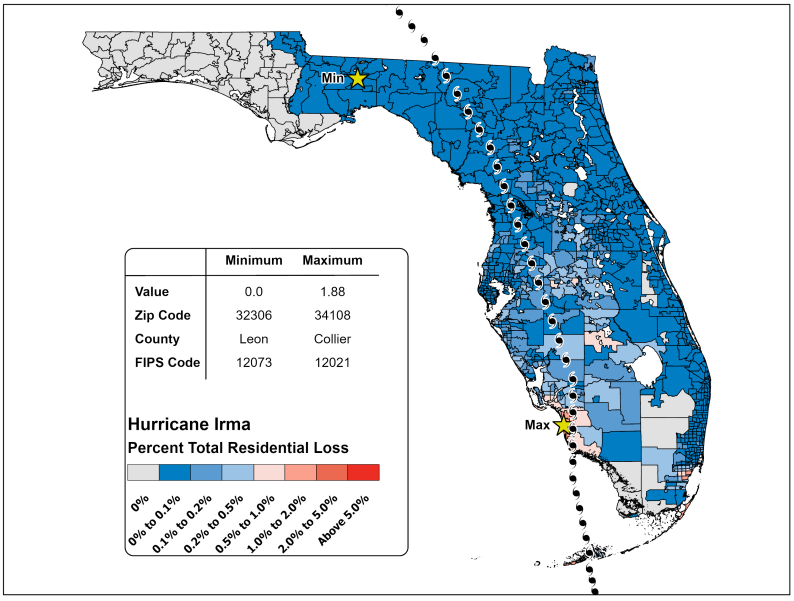


Figure 67. Percentage of Total Residential Loss from Hurricane Irma (2017) Using 2017 FHCF Exposure Data

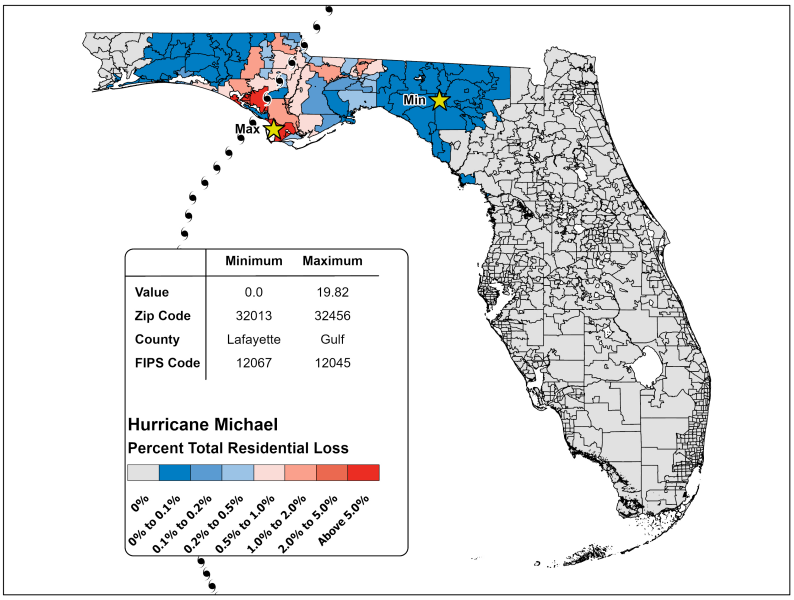


Figure 68. Percentage of Total Residential Loss from Hurricane Michael (2018) Using 2017 FHCF Exposure Data

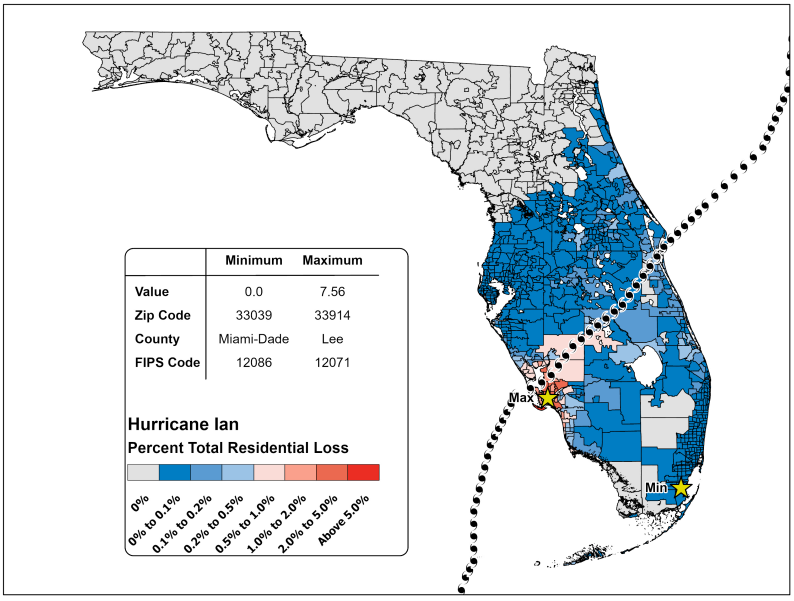


Figure 69. Percentage of Total Residential Loss from Hurricane Ian (2022) Using 2017 FHCF Exposure Data

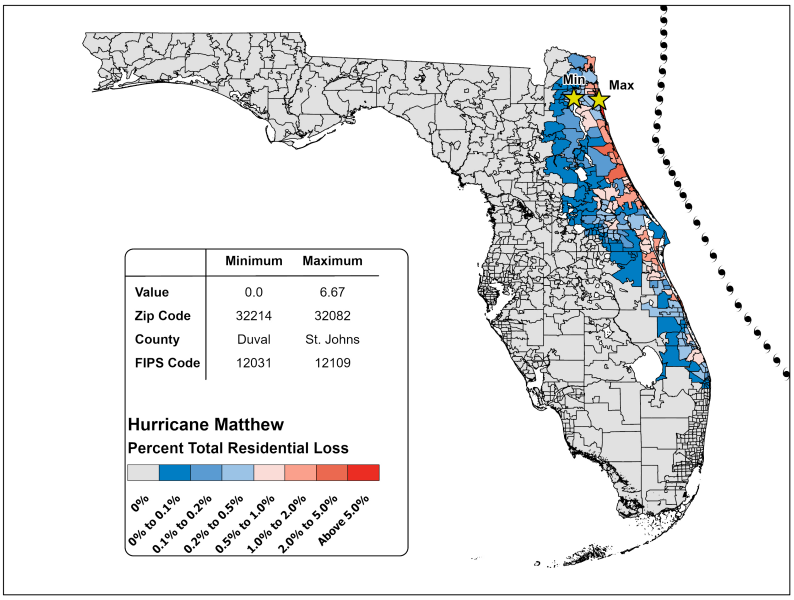


Figure 70. Percentage of Total Residential Loss from Hurricane Matthew (2016) Using 2023 FHCF Exposure Data

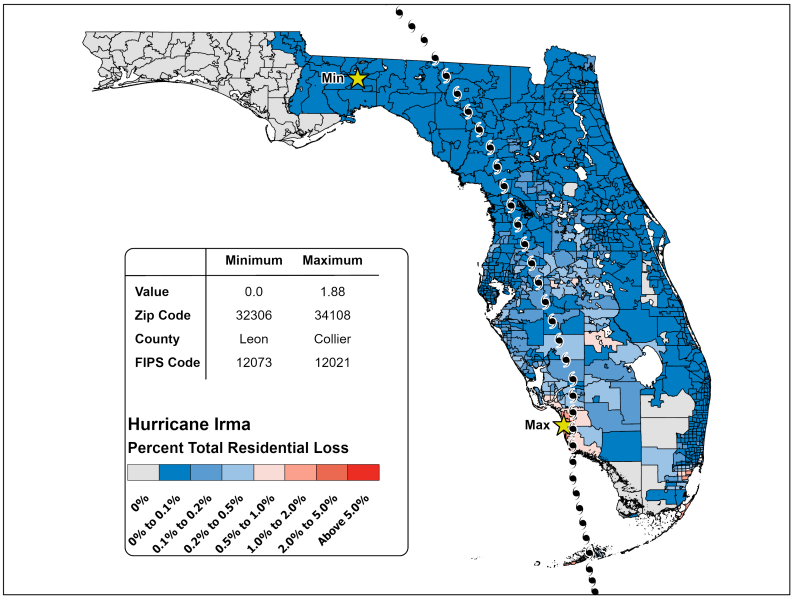


Figure 71. Percentage of Total Residential Loss from Hurricane Irma (2017) Using 2023 FHCF Exposure Data

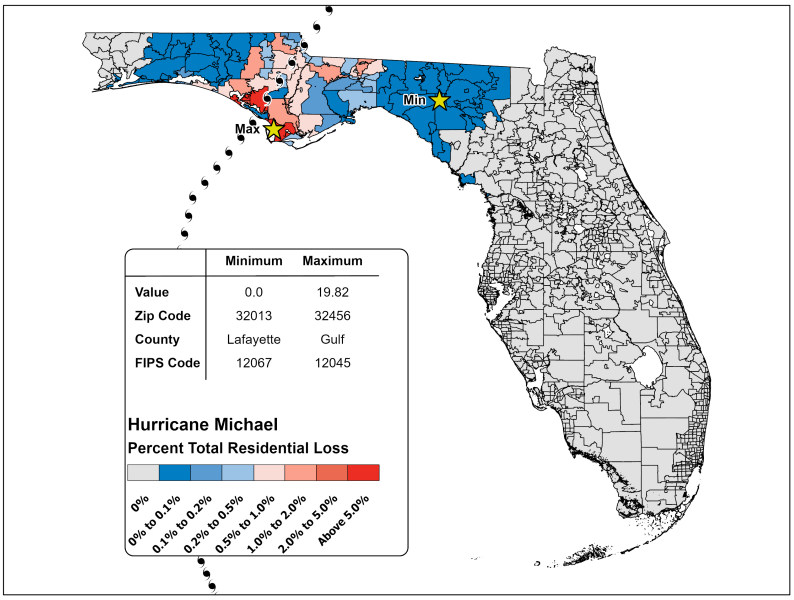


Figure 72. Percentage of Total Residential Loss from Hurricane Michael (2018) Using 2023 FHCF Exposure Data

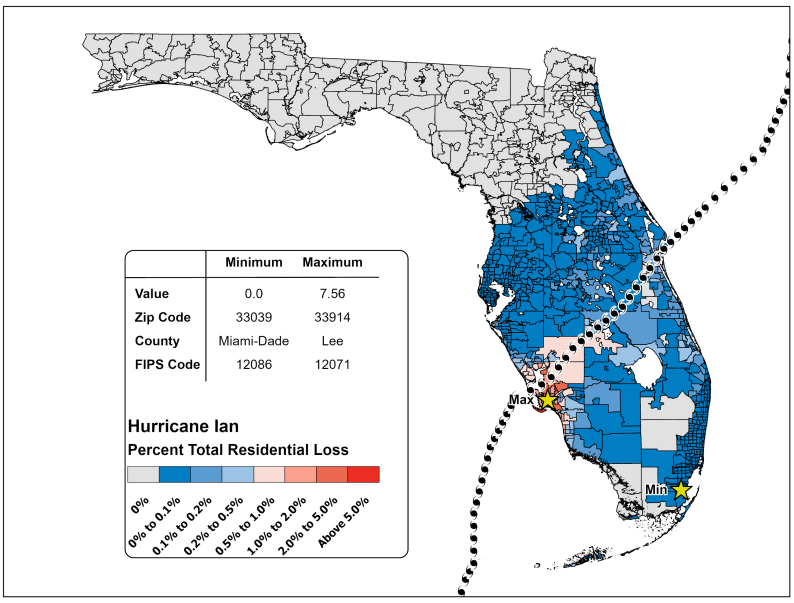


Figure 73. Percentage of Total Residential Loss from Hurricane Ian (2022) Using 2023 FHCF Exposure Data

Form A-3.E

Provide this form in both Excel and PDF format. The file name shall include the abbreviated name of the modeling organization, the hurricane standards year, and the form name.

The maps are submitted in Form A-3.C/D. Form A-3: Hurricane Losses has been submitted in both PDF and Excel format separately in the accompanying electronic submission files named "VSK23FormA3".

Form A-4: Hurricane Output Ranges

Form A-4.A

One or more automated programs or scripts shall be used to generate the personal and commercial residential hurricane output ranges in the format shown in the file named "2023FormA4.xlsx."

Form A-4: Hurricane Output Ranges was prepared using an automated process. During the automation process, Verisk exercised due diligence verifying that the process reproduced the same indications as Form A-4: Hurricane Output Ranges in prior submissions.

Form A-4.B

Provide this form in Excel format. The file name shall include the abbreviated name of the modeling organization, the hurricane standards year, and the form name. Also include Form A-4 in a submission appendix.

Form A-4: Hurricane Output Ranges is provided here in the submission document and in Excel format separately in the accompanying electronic submission files named "VSK23FormA4.xlsx".

Form A-4.C

Provide hurricane loss costs, rounded to three decimal places, by county (Figure 13). Within each county, hurricane loss costs shall be shown separately per $1,000 of exposure for frame owners, masonry owners, frame renters, masonry renters, frame condo unit owners, masonry condo unit owners, manufactured homes, and commercial residential. For each of these categories using ZIP Code centroids, the hurricane output ranges shall show the highest hurricane loss cost, the lowest hurricane loss cost, and the weighted average hurricane loss cost.

The aggregate personal and commercial residential exposure data is to be developed from the 2017 FHCF exposure data for Part A, and from the 2023 FHCF exposure data for Part B, except for insured values and deductibles information. Insured values are to be based on the hurricane output range specifications given below. Deductible amounts of 0% and as specified in the hurricane output range specifications are to be assumed to be uniformly applied to all risks.

When calculating the weighted average hurricane loss costs, weight the hurricane loss costs by the total insured value calculated above. Include the statewide range of hurricane loss costs (i.e., low, high, and weighted average).

Table 47. Form A-4, Hurricane Output Ranges - Loss Costs per $1000 for 0% Deductible (2017 FHCF Exposure Data)

Loss Costs per $1000 for Specified Deductible									
County	Hurricane Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit	Commercial Residential
Alachua	LOW	0.313	0.265	2.519	0.259	0.134	0.257	0.138	0.119
	AVERAGE	0.803	0.76	4.793	0.559	0.387	0.682	0.454	0.597
	HIGH	1.2	0.967	8.894	0.883	0.565	0.945	0.615	0.919
Baker	LOW	0.24	0.214	1.706	0.21	0.15	NA	NA	0.351
	AVERAGE	0.535	0.484	3.221	0.449	0.297	NA	NA	0.351
	HIGH	0.74	0.597	5.581	0.536	0.353	NA	NA	0.351
Bay	LOW	0.558	0.574	4.604	0.812	0.509	1.292	0.511	0.536
	AVERAGE	4.597	3.824	18.127	3.766	2.644	7.574	4.511	4.385
	HIGH	10.795	8.926	48.127	9.396	6.332	10.128	6.86	7.623
Bradford	LOW	0.279	0.284	2.15	0.28	0.194	NA	NA	NA
	AVERAGE	0.762	0.69	4.206	0.617	0.391	NA	NA	NA
	HIGH	0.941	0.758	7.094	0.683	0.439	NA	NA	NA
Brevard	LOW	0.827	0.659	7.317	0.742	0.428	0.937	0.284	0.362
	AVERAGE	4.332	3.475	28.029	3.994	2.595	4.461	3.659	3.474
	HIGH	12.916	10.808	53.036	10.732	7.344	11.611	7.987	9.135
Broward	LOW	0.644	0.533	10.954	0.51	0.306	0.564	0.342	0.389
	AVERAGE	7.648	5.413	36.966	4.742	3.821	6.039	4.283	4.314
	HIGH	20.206	17.047	70.903	17.058	11.752	17.537	12.749	14.046
Calhoun	LOW	0.535	0.393	3.434	0.439	0.342	NA	NA	NA
	AVERAGE	1.212	1.06	6.229	0.933	0.653	NA	NA	NA
	HIGH	1.864	1.505	12.867	1.129	0.722	NA	NA	NA
Charlotte	LOW	0.908	0.732	6.506	1.121	0.546	0.888	0.392	0.437
	AVERAGE	4.547	3.103	16.058	3.218	2.06	4.794	2.152	2.212
	HIGH	10.601	8.889	42.186	8.686	5.926	9.413	6.462	7.547
Citrus	LOW	0.57	0.362	4.05	0.504	0.311	0.53	0.439	0.399
	AVERAGE	1.734	1.216	9.087	1.18	0.761	1.582	1.022	1.207
	HIGH	2.299	1.857	14.903	1.747	1.103	1.92	1.224	1.686
Clay	LOW	0.27	0.226	2.274	0.26	0.179	0.245	0.195	0.256
	AVERAGE	0.733	0.728	4.245	0.627	0.418	0.556	0.384	0.608
	HIGH	1.199	0.97	8.534	0.89	0.573	0.981	0.636	0.94
Collier	LOW	0.883	0.745	8.351	0.595	0.369	0.672	0.234	0.517
	AVERAGE	5.592	3.904	25.308	4.186	2.978	6.109	3.76	3.222

Loss Costs per $1000 for Specified Deductible									
County	Hurricane Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit	Commercial Residential
	HIGH	16.392	13.841	60.123	13.652	9.483	14.757	10.304	11.47
Columbia	LOW	0.254	0.188	1.903	0.216	0.173	0.534	0.307	0.32
	AVERAGE	0.643	0.567	3.63	0.472	0.338	0.571	0.391	0.32
	HIGH	0.946	0.765	7.052	0.699	0.455	0.607	0.405	0.32
DeSoto	LOW	0.937	0.746	8.149	1.289	0.615	1.515	0.65	1.243
	AVERAGE	3.223	2.406	14.516	2.677	1.445	2.089	1.393	1.54
	HIGH	3.801	3.079	23.517	2.928	1.847	2.705	2.046	2.41
Dixie	LOW	0.43	0.369	2.601	0.343	0.518	0.425	0.306	0.44
	AVERAGE	1.093	0.772	5.402	0.756	0.53	0.852	0.544	0.803
	HIGH	3.046	2.492	17.104	0.878	0.665	1.206	0.791	1.078
Duval	LOW	0.258	0.217	2.01	0.237	0.116	0.271	0.107	0.137
	AVERAGE	0.969	0.872	4.731	0.706	0.501	0.704	0.55	0.659
	HIGH	3.042	2.493	18.897	2.406	1.696	2.551	1.694	2.226
Escambia	LOW	0.511	0.479	4.963	0.577	0.45	1.333	0.676	1.162
	AVERAGE	4.979	4.774	19.514	4.25	3.16	7.156	4.843	4.941
	HIGH	13.04	10.788	57.185	12.942	7.621	12.273	8.258	9.213
Flagler	LOW	0.374	0.297	3.406	0.358	0.265	0.476	0.247	0.329
	AVERAGE	1.964	1.253	10.024	1.255	0.774	2.476	1.046	0.938
	HIGH	4.442	3.623	24.756	3.548	2.327	3.866	2.552	3.297
Franklin	LOW	1.553	1.605	10.094	2.468	2.056	1.776	1.646	3.266
	AVERAGE	5.599	5.543	24.33	5.358	4.012	3.625	3.723	3.686
	HIGH	8.796	7.287	38.685	7.61	4.91	8.208	5.577	6.223
Gadsden	LOW	0.268	0.233	2.02	0.243	0.192	NA	NA	0.362
	AVERAGE	0.709	0.639	4.212	0.631	0.417	NA	NA	0.607
	HIGH	1.024	0.826	7.719	0.782	0.465	NA	NA	0.749
Gilchrist	LOW	0.427	0.374	2.767	0.342	0.308	NA	NA	NA
	AVERAGE	0.946	0.845	5.384	0.816	0.546	NA	NA	NA
	HIGH	1.312	1.064	9.256	0.989	0.641	NA	NA	NA
Glades	LOW	1.461	0.882	8.246	1.254	0.96	NA	NA	1.819
	AVERAGE	3.716	2.466	17.378	3.017	1.807	NA	NA	2.472
	HIGH	4.312	3.486	27.353	3.312	2.079	NA	NA	3.349
Gulf	LOW	0.666	0.748	4.114	0.782	1.17	1.208	0.803	0.799
	AVERAGE	3.564	3.914	15.149	4.238	2.991	2.878	1.365	2.899
	HIGH	6.518	5.349	31.857	5.577	3.661	6.031	3.986	4.727

Loss Costs per $1000 for Specified Deductible									
County	Hurricane Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit	Commercial Residential
Hamilton	LOW	0.234	0.19	1.567	0.201	0.154	NA	NA	NA
	AVERAGE	0.508	0.452	2.682	0.421	0.278	NA	NA	NA
	HIGH	0.677	0.546	5.293	0.493	0.325	NA	NA	NA
Hardee	LOW	0.93	0.668	7.582	0.962	0.669	2.736	NA	1.426
	AVERAGE	2.962	2.261	13.747	2.26	1.435	2.736	NA	1.426
	HIGH	3.407	2.756	21.977	2.605	1.628	2.736	NA	1.426
Hendry	LOW	1.101	0.889	7.742	1.216	0.734	2.165	0.945	1.881
	AVERAGE	4.194	3.134	19.048	3.423	1.954	4.344	2.335	2.464
	HIGH	5.704	4.606	34.829	4.478	2.781	4.903	3.078	3.62
Hernando	LOW	0.661	0.482	4.866	0.526	0.382	1.751	0.442	0.698
	AVERAGE	2.614	1.813	12.957	1.589	1.074	2.753	1.676	1.537
	HIGH	5.43	4.446	26.19	4.39	2.857	4.369	3.131	3.997
Highlands	LOW	1.078	0.627	7.107	0.821	0.499	1.07	0.572	0.598
	AVERAGE	2.857	2.206	16.947	2.108	1.344	2.452	1.569	1.621
	HIGH	4.559	3.685	28.925	3.502	2.199	3.383	2.136	3.141
Hillsborough	LOW	0.728	0.587	6.59	0.555	0.372	0.616	0.384	0.4
	AVERAGE	2.98	2.503	15.196	2.333	1.565	2.577	1.881	1.815
	HIGH	8.094	6.715	34.664	6.583	4.372	7.149	4.783	5.37
Holmes	LOW	0.492	0.44	3.411	0.425	0.329	NA	NA	0.754
	AVERAGE	1.138	1.036	5.855	0.928	0.658	NA	NA	0.754
	HIGH	1.462	1.179	10.666	1.129	0.726	NA	NA	0.754
Indian River	LOW	1.229	1.002	10.986	1.446	0.4	1.32	0.712	1.007
	AVERAGE	7.805	4.222	29.486	6.52	3.422	7.557	5.425	4.74
	HIGH	15.703	13.119	51.122	13.093	8.966	14.155	9.742	11.031
Jackson	LOW	0.364	0.29	2.461	0.368	0.239	NA	NA	0.415
	AVERAGE	0.95	0.84	5.125	0.785	0.525	NA	NA	0.71
	HIGH	1.459	1.176	10.58	1.135	0.732	NA	NA	0.986
Jefferson	LOW	0.244	0.23	1.752	0.21	0.165	NA	NA	NA
	AVERAGE	0.55	0.473	3.15	0.467	0.32	NA	NA	NA
	HIGH	0.769	0.62	5.909	0.586	0.381	NA	NA	NA
Lafayette	LOW	0.347	0.304	2.165	0.617	0.22	NA	NA	NA
	AVERAGE	0.748	0.637	3.822	0.669	0.401	NA	NA	NA
	HIGH	0.905	0.731	6.6	0.68	0.447	NA	NA	NA

Loss Costs per $1000 for Specified Deductible									
County	Hurricane Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit	Commercial Residential
Lake	LOW	0.517	0.402	3.944	0.403	0.233	0.608	0.402	0.466
	AVERAGE	1.85	1.43	13.415	1.25	0.83	1.945	1.132	1.367
	HIGH	3.175	2.564	21.443	2.36	1.494	2.491	1.59	2.242
Lee	LOW	0.829	0.685	7.015	0.785	0.386	0.689	0.294	0.486
	AVERAGE	5.468	2.647	22.309	2.622	1.842	4.906	2.4	2.183
	HIGH	15.559	13.18	55.757	12.857	9.008	13.904	9.791	10.868
Leon	LOW	0.249	0.198	1.964	0.22	0.15	0.266	0.096	0.106
	AVERAGE	0.716	0.628	4.376	0.519	0.341	0.466	0.372	0.426
	HIGH	0.961	0.774	7.006	0.745	0.482	0.762	0.517	0.74
Levy	LOW	0.435	0.404	3.065	0.451	0.288	1.334	1.25	0.765
	AVERAGE	1.563	1.063	6.371	1.014	0.761	3.265	2.215	1.344
	HIGH	4.806	3.949	23.728	3.969	2.623	4.308	2.866	3.524
Liberty	LOW	0.475	0.458	3.22	0.475	0.721	NA	NA	NA
	AVERAGE	1.096	0.984	6.121	0.934	0.721	NA	NA	NA
	HIGH	1.438	1.161	10.333	1.131	0.721	NA	NA	NA
Madison	LOW	0.2	0.204	1.525	0.171	0.139	NA	NA	NA
	AVERAGE	0.567	0.487	3.131	0.441	0.306	NA	NA	NA
	HIGH	0.681	0.549	5.249	0.505	0.333	NA	NA	NA
Manatee	LOW	0.88	0.737	6.465	0.663	0.424	0.698	0.287	0.528
	AVERAGE	5.066	3.132	21.175	3.858	2.31	5.484	3.522	1.868
	HIGH	14.153	11.879	53.027	11.09	8.051	12.005	8.759	9.495
Marion	LOW	0.412	0.315	2.882	0.356	0.253	0.441	0.244	0.346
	AVERAGE	1.373	0.95	7.806	0.919	0.586	1.133	0.697	0.815
	HIGH	1.87	1.512	13.26	1.37	0.874	1.512	0.974	1.48
Martin	LOW	1.304	1.08	11.04	2.237	0.942	2.326	0.677	1.159
	AVERAGE	9.489	6.111	46.908	6.392	4.72	11.703	6.159	5.65
	HIGH	15.966	13.247	66.878	13.596	9.117	14.681	9.903	11.286
Miami-Dade	LOW	0.655	0.54	11.132	0.87	0.162	0.52	0.178	0.3
	AVERAGE	8.07	5.802	33.289	5.546	4.71	7.016	4.861	4.445
	HIGH	27.276	23.096	64.725	21.511	16.154	24.758	17.487	18.62
Monroe	LOW	4.718	3.643	33.183	4.632	2.583	7.765	2.305	2.239
	AVERAGE	20.324	17.887	83.261	21.418	14.592	23.595	13.487	12.945
	HIGH	30.561	26.193	91.764	26.14	18.927	28.109	20.424	20.495

Loss Costs per $1000 for Specified Deductible									
County	Hurricane Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit	Commercial Residential
Nassau	LOW	0.23	0.171	1.61	0.185	0.124	0.537	0.217	0.24
	AVERAGE	1.028	0.814	3.99	0.81	0.54	1.263	0.931	0.875
	HIGH	2.048	1.681	12.603	1.592	1.061	1.742	1.168	1.558
Okaloosa	LOW	0.399	0.437	3.844	0.482	0.337	0.639	1.144	0.654
	AVERAGE	5.398	4.778	13.119	4.859	3.415	7.778	5.495	5.078
	HIGH	13.19	10.926	56.238	11.546	7.772	12.431	8.413	9.235
Okeechobee	LOW	1.36	1.026	11.43	1.765	1.072	1.094	1.746	1.902
	AVERAGE	5.324	3.892	29.55	4.463	2.525	3.998	3.76	3.467
	HIGH	7.319	5.933	41.581	5.857	3.675	6.391	4.05	5.534
Orange	LOW	0.54	0.445	5.025	0.382	0.141	0.413	0.166	0.231
	AVERAGE	1.597	1.456	12.469	1.11	0.751	1.285	0.864	1.148
	HIGH	2.965	2.393	20.228	2.196	1.394	2.253	1.438	2.177
Osceola	LOW	0.604	0.487	5.455	0.545	0.295	0.526	0.211	0.302
	AVERAGE	1.736	1.628	14.214	1.186	0.883	1.379	0.85	1.074
	HIGH	3.61	2.909	23.874	2.748	1.599	2.671	1.692	2.819
Palm Beach	LOW	1.13	0.947	10.876	1.021	0.304	0.885	0.46	0.651
	AVERAGE	9.355	6.052	39.892	6.554	4.685	9.021	5.32	4.433
	HIGH	19.837	16.591	73.445	16.812	11.484	18.141	12.456	13.821
Pasco	LOW	0.696	0.571	5.575	0.528	0.424	0.556	0.403	0.569
	AVERAGE	2.334	2.62	14.809	1.729	1.604	2.167	2.518	1.898
	HIGH	7.353	6.065	34.854	5.996	3.921	5.97	4.292	5.345
Pinellas	LOW	0.922	0.765	7.137	0.906	0.545	0.931	0.49	0.59
	AVERAGE	6.632	5.27	27.032	4.333	3.26	5.569	3.853	3.408
	HIGH	12.466	10.459	44.107	10.269	7.107	11.115	7.733	8.772
Polk	LOW	0.59	0.501	5.578	0.491	0.354	0.638	0.311	0.486
	AVERAGE	2.134	1.677	13.672	1.453	1.048	1.578	1.135	1.206
	HIGH	3.428	2.772	23.566	2.593	1.628	3.01	1.906	2.499
Putnam	LOW	0.369	0.301	2.626	0.359	0.245	0.415	0.231	0.262
	AVERAGE	1.052	0.887	6.143	0.817	0.536	0.821	0.496	0.785
	HIGH	1.837	1.481	13.038	1.192	0.76	1.317	0.847	1.293
St. Johns	LOW	0.327	0.277	2.783	0.305	0.142	0.263	0.172	0.254
	AVERAGE	1.252	1.355	7.647	1.327	0.875	1.838	1.41	1.417
	HIGH	3.968	3.23	22.447	3.148	2.062	3.433	2.263	2.957

Loss Costs per $1000 for Specified Deductible									
County	Hurricane Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit	Commercial Residential
St. Lucie	LOW	1.089	0.924	13.333	1.347	0.596	1.669	0.622	0.812
	AVERAGE	7.086	3.541	37.099	4.795	2.748	7.697	4.924	4.339
	HIGH	16.862	14.046	69.244	14.267	9.651	15.409	10.484	11.875
Santa Rosa	LOW	0.548	0.591	5.318	0.613	0.534	2.307	1.878	0.797
	AVERAGE	5.024	4.142	20.703	5.27	3.45	10.429	7.257	4.398
	HIGH	16.922	14.08	69.58	14.807	10.039	15.939	10.862	11.789
Sarasota	LOW	0.817	0.685	6.092	0.929	0.392	0.886	0.453	0.688
	AVERAGE	5.725	3.822	26.383	4.19	2.864	6.55	3.953	2.433
	HIGH	11.717	9.89	44.113	9.642	6.694	10.437	7.284	8.246
Seminole	LOW	0.521	0.43	4.878	0.395	0.247	0.396	0.21	0.204
	AVERAGE	1.646	1.402	11.786	1.138	0.754	1.296	0.882	1.111
	HIGH	2.178	1.756	15.596	1.611	1.016	1.759	1.103	1.696
Sumter	LOW	0.532	0.413	4.58	0.448	0.296	0.622	0.263	0.413
	AVERAGE	1.043	0.82	10.765	0.776	0.487	1.282	0.589	0.619
	HIGH	2.384	1.923	16.418	1.765	1.113	1.741	1.104	1.678
Suwannee	LOW	0.267	0.25	1.958	0.232	0.189	NA	NA	0.171
	AVERAGE	0.684	0.582	3.63	0.521	0.369	NA	NA	0.438
	HIGH	1.004	0.812	7.391	0.748	0.486	NA	NA	0.777
Taylor	LOW	0.306	0.292	2.141	0.306	0.193	0.393	0.438	0.628
	AVERAGE	0.885	0.732	5.154	0.628	0.441	0.735	0.492	0.742
	HIGH	1.865	1.514	11.956	0.761	0.964	1.624	0.682	1.428
Union	LOW	0.297	0.288	2.094	0.263	0.199	NA	NA	NA
	AVERAGE	0.674	0.606	3.595	0.538	0.39	NA	NA	NA
	HIGH	0.885	0.713	6.699	0.644	0.42	NA	NA	NA
Volusia	LOW	0.411	0.336	3.779	0.306	0.21	0.321	0.303	0.228
	AVERAGE	2.399	1.749	12.847	1.661	1.1	2.827	2.092	1.654
	HIGH	5.763	4.714	30.815	4.711	3.041	5.119	3.33	4.245
Wakulla	LOW	0.364	0.289	2.866	0.375	0.253	0.491	2.415	0.457
	AVERAGE	1.094	1.063	6.059	0.967	0.965	2.127	2.865	1.064
	HIGH	4.83	3.962	23.216	4.137	2.718	4.474	2.959	2.932
Walton	LOW	0.531	0.418	4.446	0.544	0.434	1.365	0.897	0.957
	AVERAGE	4.165	2.952	13.648	4.027	2.502	7.619	3.745	4.734
	HIGH	11.731	9.722	50.304	10.073	6.792	10.867	7.367	8.255

Loss Costs per $1000 for Specified Deductible									
County	Hurricane Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit	Commercial Residential
Washington	LOW	0.51	0.527	3.911	0.519	0.339	0.984	NA	0.633
	AVERAGE	1.312	1.234	6.643	1.275	0.833	0.984	NA	0.706
	HIGH	2.596	2.097	16.597	2.099	1.339	0.984	NA	0.883
Statewide	LOW	0.2	0.171	1.525	0.171	0.116	0.245	0.096	0.106
	AVERAGE	3.142	3.413	15.713	2.289	2.4	3.627	3.775	2.99
	HIGH	30.561	26.193	91.764	26.14	18.927	28.109	20.424	20.495

Table 48. Form A-4, Hurricane Output Ranges - Loss Costs per $1000 for Specified Deductible (2017 FHCF Exposure Data)

Loss Costs per $1000 for 0% Deductible									
County	Hurricane Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit	Commercial Residential
Alachua	LOW	0.239	0.201	2.12	0.15	0.076	0.149	0.079	0.083
	AVERAGE	0.646	0.609	4.225	0.378	0.244	0.473	0.294	0.429
	HIGH	0.983	0.783	8.056	0.633	0.373	0.684	0.416	0.666
Baker	LOW	0.182	0.162	1.412	0.126	0.085	NA	NA	0.262
	AVERAGE	0.426	0.384	2.79	0.303	0.187	NA	NA	0.262
	HIGH	0.598	0.478	4.95	0.37	0.227	NA	NA	0.262
Bay	LOW	0.43	0.443	3.982	0.556	0.329	0.952	0.346	0.403
	AVERAGE	4.07	3.347	16.938	3.175	2.144	6.692	3.84	3.622
	HIGH	9.889	8.114	46.064	8.406	5.507	9.082	5.995	6.438
Bradford	LOW	0.212	0.219	1.799	0.174	0.113	NA	NA	NA
	AVERAGE	0.614	0.553	3.683	0.427	0.251	NA	NA	NA
	HIGH	0.763	0.609	6.347	0.475	0.285	NA	NA	NA
Brevard	LOW	0.651	0.514	6.428	0.479	0.257	0.632	0.168	0.267
	AVERAGE	3.786	3.02	26.364	3.331	2.073	3.743	3.023	2.856
	HIGH	11.894	9.892	50.66	9.588	6.396	10.403	6.994	7.799
Broward	LOW	0.494	0.406	9.774	0.299	0.166	0.336	0.191	0.279
	AVERAGE	6.863	4.782	35.063	3.99	3.148	5.13	3.551	3.619
	HIGH	18.933	15.89	68.383	15.615	10.537	16.019	11.484	12.367
Calhoun	LOW	0.413	0.298	2.917	0.28	0.209	NA	NA	NA
	AVERAGE	0.984	0.853	5.548	0.671	0.44	NA	NA	NA
	HIGH	1.551	1.236	11.859	0.833	0.492	NA	NA	NA
Charlotte	LOW	0.725	0.579	5.722	0.81	0.351	0.613	0.247	0.327
	AVERAGE	4.038	2.706	14.911	2.67	1.625	4.111	1.708	1.803

Loss Costs per $1000 for 0% Deductible									
County	Hurricane Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit	Commercial Residential
	HIGH	9.775	8.151	40.238	7.758	5.159	8.432	5.657	6.468
Citrus	LOW	0.446	0.279	3.498	0.334	0.189	0.346	0.282	0.298
	AVERAGE	1.456	1.003	8.249	0.88	0.528	1.21	0.735	0.921
	HIGH	1.956	1.563	13.773	1.359	0.799	1.503	0.9	1.277
Clay	LOW	0.206	0.171	1.91	0.159	0.104	0.147	0.114	0.186
	AVERAGE	0.592	0.588	3.721	0.439	0.273	0.383	0.251	0.442
	HIGH	0.99	0.793	7.706	0.648	0.387	0.72	0.437	0.69
Collier	LOW	0.705	0.588	7.434	0.377	0.232	0.432	0.135	0.385
	AVERAGE	5.009	3.454	23.813	3.55	2.449	5.326	3.158	2.703
	HIGH	15.264	12.82	57.722	12.389	8.422	13.428	9.196	9.979
Columbia	LOW	0.192	0.141	1.579	0.128	0.099	0.358	0.194	0.236
	AVERAGE	0.513	0.45	3.156	0.316	0.214	0.388	0.253	0.236
	HIGH	0.769	0.616	6.32	0.492	0.297	0.419	0.264	0.236
DeSoto	LOW	0.752	0.593	7.26	0.93	0.395	1.128	0.422	0.978
	AVERAGE	2.771	2.041	13.34	2.133	1.061	1.624	1.029	1.223
	HIGH	3.311	2.654	21.982	2.377	1.41	2.157	1.581	1.87
Dixie	LOW	0.337	0.288	2.211	0.219	0.352	0.279	0.194	0.307
	AVERAGE	0.906	0.627	4.82	0.549	0.361	0.632	0.381	0.589
	HIGH	2.664	2.159	15.937	0.644	0.474	0.927	0.576	0.803
Duval	LOW	0.197	0.165	1.683	0.146	0.066	0.165	0.061	0.098
	AVERAGE	0.802	0.717	4.186	0.511	0.345	0.51	0.388	0.488
	HIGH	2.651	2.156	17.571	1.961	1.327	2.082	1.328	1.748
Escambia	LOW	0.386	0.362	4.248	0.367	0.273	0.958	0.453	0.828
	AVERAGE	4.384	4.19	18.165	3.573	2.568	6.234	4.096	4.023
	HIGH	11.983	9.836	54.83	11.682	6.648	11.044	7.24	7.825
Flagler	LOW	0.285	0.225	2.897	0.219	0.153	0.301	0.152	0.245
	AVERAGE	1.677	1.044	9.108	0.961	0.554	2.01	0.777	0.726
	HIGH	3.92	3.168	23.163	2.956	1.857	3.233	2.053	2.64
Franklin	LOW	1.296	1.338	9.186	2.025	1.629	1.389	1.284	2.732
	AVERAGE	5.022	4.972	22.944	4.684	3.421	3.074	3.161	3.086
	HIGH	8.014	6.587	36.93	6.761	4.231	7.31	4.837	5.198
Gadsden	LOW	0.201	0.173	1.679	0.147	0.111	NA	NA	0.243
	AVERAGE	0.562	0.504	3.693	0.437	0.268	NA	NA	0.425
	HIGH	0.824	0.656	6.943	0.552	0.301	NA	NA	0.522

Loss Costs per $1000 for 0% Deductible									
County	Hurricane Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit	Commercial Residential
Gilchrist	LOW	0.334	0.292	2.35	0.22	0.194	NA	NA	NA
	AVERAGE	0.774	0.687	4.79	0.593	0.372	NA	NA	NA
	HIGH	1.088	0.873	8.421	0.732	0.443	NA	NA	NA
Glades	LOW	1.178	0.695	7.262	0.88	0.636	NA	NA	1.435
	AVERAGE	3.178	2.066	16.001	2.382	1.325	NA	NA	1.906
	HIGH	3.712	2.967	25.604	2.639	1.546	NA	NA	2.592
Gulf	LOW	0.517	0.589	3.543	0.545	0.857	0.893	0.578	0.607
	AVERAGE	3.121	3.436	14.099	3.626	2.468	2.381	1.036	2.322
	HIGH	5.845	4.752	30.186	4.845	3.06	5.255	3.353	3.853
Hamilton	LOW	0.176	0.142	1.287	0.119	0.086	NA	NA	NA
	AVERAGE	0.4	0.354	2.297	0.28	0.172	NA	NA	NA
	HIGH	0.54	0.43	4.679	0.331	0.203	NA	NA	NA
Hardee	LOW	0.738	0.521	6.672	0.648	0.427	2.153	NA	1.12
	AVERAGE	2.523	1.9	12.569	1.757	1.037	2.153	NA	1.12
	HIGH	2.94	2.352	20.441	2.077	1.212	2.153	NA	1.12
Hendry	LOW	0.882	0.706	6.818	0.863	0.479	1.603	0.611	1.496
	AVERAGE	3.618	2.659	17.651	2.742	1.453	3.524	1.762	1.939
	HIGH	4.963	3.96	32.853	3.656	2.123	4.024	2.38	2.793
Hernando	LOW	0.529	0.379	4.23	0.348	0.242	1.362	0.287	0.537
	AVERAGE	2.264	1.54	11.954	1.238	0.792	2.259	1.304	1.23
	HIGH	4.872	3.955	24.674	3.765	2.351	3.722	2.597	3.281
Highlands	LOW	0.855	0.485	6.206	0.54	0.301	0.729	0.355	0.442
	AVERAGE	2.412	1.837	15.588	1.6	0.947	1.883	1.131	1.268
	HIGH	3.927	3.139	27.068	2.792	1.637	2.691	1.595	2.423
Hillsborough	LOW	0.576	0.46	5.808	0.355	0.232	0.419	0.232	0.305
	AVERAGE	2.603	2.165	14.08	1.897	1.211	2.108	1.486	1.457
	HIGH	7.38	6.08	32.991	5.782	3.716	6.3	4.093	4.506
Holmes	LOW	0.375	0.336	2.89	0.268	0.197	NA	NA	0.566
	AVERAGE	0.918	0.831	5.178	0.66	0.438	NA	NA	0.566
	HIGH	1.193	0.95	9.691	0.821	0.488	NA	NA	0.566
Indian River	LOW	0.979	0.792	9.815	1.03	0.242	0.908	0.473	0.773
	AVERAGE	7.014	3.702	27.708	5.633	2.797	6.581	4.61	3.973
	HIGH	14.535	12.068	48.825	11.79	7.878	12.781	8.604	9.496

Loss Costs per $1000 for 0% Deductible									
County	Hurricane Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit	Commercial Residential
Jackson	LOW	0.274	0.216	2.042	0.228	0.138	NA	NA	0.277
	AVERAGE	0.758	0.665	4.507	0.547	0.339	NA	NA	0.499
	HIGH	1.193	0.949	9.629	0.831	0.496	NA	NA	0.699
Jefferson	LOW	0.184	0.174	1.452	0.125	0.095	NA	NA	NA
	AVERAGE	0.436	0.372	2.731	0.319	0.204	NA	NA	NA
	HIGH	0.619	0.494	5.279	0.411	0.248	NA	NA	NA
Lafayette	LOW	0.267	0.234	1.818	0.431	0.133	NA	NA	NA
	AVERAGE	0.605	0.511	3.348	0.477	0.265	NA	NA	NA
	HIGH	0.737	0.589	5.922	0.486	0.298	NA	NA	NA
Lake	LOW	0.397	0.306	3.35	0.241	0.135	0.381	0.236	0.345
	AVERAGE	1.533	1.168	12.264	0.893	0.554	1.465	0.788	1.022
	HIGH	2.687	2.146	19.879	1.806	1.061	1.916	1.146	1.689
Lee	LOW	0.663	0.543	6.219	0.536	0.234	0.459	0.18	0.363
	AVERAGE	4.918	2.289	20.936	2.14	1.439	4.221	1.942	1.785
	HIGH	14.525	12.245	53.503	11.69	8.028	12.677	8.769	9.506
Leon	LOW	0.186	0.147	1.636	0.13	0.083	0.162	0.053	0.073
	AVERAGE	0.573	0.499	3.864	0.358	0.218	0.316	0.243	0.297
	HIGH	0.783	0.623	6.321	0.541	0.325	0.55	0.349	0.525
Levy	LOW	0.34	0.31	2.62	0.29	0.173	1.007	0.947	0.585
	AVERAGE	1.321	0.875	5.705	0.752	0.542	2.743	1.795	1.057
	HIGH	4.283	3.49	22.246	3.385	2.152	3.687	2.369	2.858
Liberty	LOW	0.363	0.353	2.741	0.304	0.493	NA	NA	NA
	AVERAGE	0.887	0.792	5.461	0.678	0.493	NA	NA	NA
	HIGH	1.179	0.94	9.43	0.838	0.493	NA	NA	NA
Madison	LOW	0.149	0.153	1.25	0.099	0.078	NA	NA	NA
	AVERAGE	0.449	0.382	2.708	0.297	0.192	NA	NA	NA
	HIGH	0.544	0.433	4.643	0.345	0.211	NA	NA	NA
Manatee	LOW	0.709	0.59	5.739	0.446	0.263	0.469	0.177	0.399
	AVERAGE	4.558	2.764	19.924	3.305	1.886	4.806	2.988	1.539
	HIGH	13.174	10.995	50.926	10.022	7.128	10.88	7.795	8.255
Marion	LOW	0.317	0.24	2.429	0.218	0.147	0.28	0.142	0.254
	AVERAGE	1.132	0.771	7.01	0.657	0.387	0.826	0.475	0.604
	HIGH	1.557	1.246	12.138	1.011	0.597	1.126	0.678	1.098
Martin	LOW	1.044	0.858	9.818	1.677	0.619	1.764	0.438	0.883

Loss Costs per $1000 for 0% Deductible									
County	Hurricane Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit	Commercial Residential
	AVERAGE	8.586	5.438	44.737	5.495	3.944	10.454	5.262	4.777
	HIGH	14.78	12.178	64.308	12.269	8.01	13.282	8.745	9.731
Miami-Dade	LOW	0.502	0.411	9.949	0.561	0.084	0.305	0.095	0.216
	AVERAGE	7.261	5.145	31.498	4.768	3.968	6.083	4.106	3.757
	HIGH	25.781	21.724	62.303	19.841	14.699	22.98	15.979	16.635
Monroe	LOW	4.205	3.212	31.483	4.013	2.12	6.839	1.833	1.82
	AVERAGE	19.146	16.785	80.753	19.928	13.342	22.007	12.292	11.565
	HIGH	29.084	24.82	89.279	24.47	17.473	26.376	18.924	18.503
Nassau	LOW	0.175	0.129	1.342	0.112	0.07	0.374	0.144	0.181
	AVERAGE	0.861	0.676	3.517	0.61	0.387	0.978	0.698	0.664
	HIGH	1.753	1.428	11.559	1.256	0.798	1.381	0.889	1.197
Okaloosa	LOW	0.301	0.33	3.277	0.301	0.197	0.423	0.813	0.45
	AVERAGE	4.821	4.249	12.098	4.183	2.854	6.866	4.726	4.2
	HIGH	12.166	10.003	53.945	10.416	6.827	11.242	7.424	7.892
Okeechobee	LOW	1.086	0.808	10.186	1.278	0.714	0.729	1.254	1.49
	AVERAGE	4.63	3.331	27.702	3.653	1.923	3.234	2.988	2.769
	HIGH	6.463	5.182	39.387	4.908	2.909	5.378	3.24	4.435
Orange	LOW	0.415	0.339	4.304	0.221	0.074	0.241	0.09	0.166
	AVERAGE	1.307	1.185	11.332	0.776	0.488	0.913	0.575	0.844
	HIGH	2.501	1.996	18.709	1.668	0.982	1.714	1.022	1.632
Osceola	LOW	0.468	0.374	4.7	0.338	0.165	0.321	0.119	0.222
	AVERAGE	1.43	1.335	12.973	0.841	0.589	0.993	0.57	0.795
	HIGH	3.075	2.448	22.21	2.144	1.145	2.069	1.225	2.15
Palm Beach	LOW	0.889	0.74	9.679	0.672	0.172	0.566	0.285	0.484
	AVERAGE	8.459	5.382	37.863	5.645	3.919	7.911	4.481	3.711
	HIGH	18.526	15.404	70.766	15.331	10.24	16.585	11.158	12.098
Pasco	LOW	0.554	0.453	4.88	0.344	0.269	0.361	0.252	0.432
	AVERAGE	2.014	2.284	13.718	1.365	1.258	1.743	2.057	1.545
	HIGH	6.683	5.47	33.181	5.247	3.309	5.196	3.647	4.477
Pinellas	LOW	0.75	0.618	6.366	0.647	0.359	0.666	0.33	0.452
	AVERAGE	6.024	4.74	25.605	3.73	2.73	4.859	3.273	2.864
	HIGH	11.582	9.662	42.302	9.275	6.277	10.067	6.865	7.612
Polk	LOW	0.457	0.385	4.818	0.302	0.216	0.405	0.181	0.36

Loss Costs per $1000 for 0% Deductible									
County	Hurricane Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit	Commercial Residential
	AVERAGE	1.786	1.386	12.494	1.066	0.724	1.172	0.796	0.917
	HIGH	2.949	2.359	21.915	2.051	1.201	2.368	1.406	1.908
Putnam	LOW	0.284	0.229	2.212	0.225	0.143	0.255	0.131	0.193
	AVERAGE	0.855	0.715	5.46	0.574	0.348	0.574	0.322	0.573
	HIGH	1.526	1.216	11.928	0.864	0.507	0.963	0.576	0.945
St. Johns	LOW	0.25	0.211	2.36	0.188	0.084	0.157	0.104	0.185
	AVERAGE	1.051	1.139	6.898	1.035	0.643	1.468	1.087	1.102
	HIGH	3.485	2.811	20.95	2.602	1.628	2.849	1.803	2.351
St. Lucie	LOW	0.86	0.724	11.995	0.935	0.361	1.202	0.381	0.61
	AVERAGE	6.294	3.053	35.108	4.006	2.172	6.682	4.14	3.619
	HIGH	15.627	12.932	66.627	12.889	8.498	13.958	9.278	10.249
Santa Rosa	LOW	0.416	0.45	4.574	0.38	0.331	1.799	1.403	0.55
	AVERAGE	4.453	3.639	19.321	4.527	2.86	9.327	6.322	3.615
	HIGH	15.687	12.961	66.965	13.444	8.891	14.506	9.663	10.161
Sarasota	LOW	0.652	0.543	5.378	0.659	0.237	0.611	0.282	0.538
	AVERAGE	5.181	3.407	24.987	3.612	2.39	5.796	3.384	2.025
	HIGH	10.881	9.138	42.18	8.697	5.908	9.44	6.462	7.151
Seminole	LOW	0.399	0.327	4.173	0.23	0.134	0.231	0.118	0.144
	AVERAGE	1.348	1.138	10.679	0.799	0.49	0.923	0.588	0.816
	HIGH	1.812	1.443	14.285	1.193	0.692	1.305	0.757	1.248
Sumter	LOW	0.412	0.317	3.948	0.278	0.169	0.403	0.16	0.305
	AVERAGE	0.842	0.656	9.787	0.531	0.308	0.942	0.386	0.466
	HIGH	2.005	1.599	15.135	1.333	0.777	1.318	0.779	1.256
Suwannee	LOW	0.202	0.188	1.628	0.14	0.109	NA	NA	0.122
	AVERAGE	0.547	0.462	3.159	0.355	0.236	NA	NA	0.316
	HIGH	0.818	0.655	6.646	0.533	0.322	NA	NA	0.557
Taylor	LOW	0.233	0.224	1.799	0.196	0.115	0.261	0.294	0.448
	AVERAGE	0.724	0.592	4.6	0.449	0.297	0.532	0.336	0.537
	HIGH	1.584	1.272	11.004	0.559	0.715	1.285	0.487	1.08
Union	LOW	0.226	0.221	1.749	0.16	0.115	NA	NA	NA
	AVERAGE	0.539	0.482	3.12	0.366	0.25	NA	NA	NA
	HIGH	0.715	0.571	5.98	0.447	0.27	NA	NA	NA
Volusia	LOW	0.313	0.255	3.211	0.177	0.115	0.187	0.181	0.164

Loss Costs per $1000 for 0% Deductible									
County	Hurricane Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit	Commercial Residential
	AVERAGE	2.043	1.469	11.751	1.282	0.801	2.298	1.654	1.291
	HIGH	5.133	4.163	28.997	3.998	2.47	4.359	2.726	3.447
Wakulla	LOW	0.279	0.219	2.452	0.248	0.156	0.335	1.988	0.316
	AVERAGE	0.914	0.888	5.46	0.746	0.743	1.774	2.395	0.826
	HIGH	4.321	3.511	21.89	3.582	2.264	3.885	2.481	2.347
Walton	LOW	0.407	0.317	3.833	0.356	0.271	1.004	0.632	0.728
	AVERAGE	3.67	2.556	12.631	3.414	2.024	6.714	3.128	3.894
	HIGH	10.763	8.853	48.085	9.011	5.905	9.746	6.439	6.986
Washington	LOW	0.39	0.407	3.349	0.335	0.206	0.702	NA	0.437
	AVERAGE	1.073	1.004	5.924	0.954	0.582	0.702	NA	0.508
	HIGH	2.205	1.76	15.407	1.662	0.993	0.702	NA	0.67
Statewide	LOW	0.149	0.129	1.25	0.099	0.066	0.147	0.053	0.073
	AVERAGE	2.761	2.988	14.591	1.867	1.94	3.078	3.153	2.487
	HIGH	29.084	24.82	89.279	24.47	17.473	26.376	18.924	18.503

Table 49. Form A-4, Hurricane Output Ranges - Loss Costs per $1000 for 0% Deductible (2023 FHCF Exposure Data)

Loss Costs per $1000 for 0% Deductible									
County	Hurricane Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit	Commercial Residential
Alachua	LOW	0.287	0.243	2.519	0.235	0.107	0.257	0.138	0.11
	AVERAGE	0.759	0.739	3.897	0.55	0.366	0.673	0.453	0.673
	HIGH	1.2	0.967	11.575	0.883	0.565	0.945	0.615	0.919
Baker	LOW	0.23	0.19	1.706	0.185	0.143	NA	NA	0.408
	AVERAGE	0.498	0.441	2.429	0.428	0.297	NA	NA	0.408
	HIGH	0.74	0.597	7.212	0.536	0.353	NA	NA	0.408
Bay	LOW	0.525	0.461	4.604	0.654	0.24	0.682	0.511	0.536
	AVERAGE	3.999	3.79	12.615	4.147	2.325	6.535	4.498	4.083
	HIGH	10.795	8.926	57.003	9.396	6.332	10.128	6.86	7.623
Bradford	LOW	0.3	0.233	2.15	0.244	0.175	NA	NA	0.507
	AVERAGE	0.72	0.675	3.356	0.563	0.366	NA	NA	0.508
	HIGH	0.941	0.758	9.498	0.683	0.444	NA	NA	0.51
Brevard	LOW	0.757	0.642	7.317	0.58	0.346	0.641	0.243	0.329
	AVERAGE	4.165	3.125	26.673	3.469	2.431	4.282	3.429	3.036
	HIGH	12.916	10.808	63.112	10.732	7.344	11.611	7.987	9.135

Loss Costs per $1000 for 0% Deductible									
County	Hurricane Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit	Commercial Residential
Broward	LOW	0.621	0.392	10.954	0.497	0.153	0.467	0.173	0.378
	AVERAGE	5.773	5.076	31.805	4.243	3.579	5.868	4.24	4.185
	HIGH	20.198	17.047	87.051	17.062	11.752	18.408	12.749	14.046
Calhoun	LOW	0.422	0.353	3.434	0.456	0.467	NA	NA	NA
	AVERAGE	1.138	1.045	4.605	0.962	0.672	NA	NA	NA
	HIGH	1.864	1.505	13.627	1.129	0.776	NA	NA	NA
Charlotte	LOW	0.841	0.594	6.506	0.651	0.395	0.676	0.243	0.552
	AVERAGE	4.102	2.703	14.498	2.653	1.8	3.92	2.015	2.116
	HIGH	10.601	8.889	48.144	7.272	5.926	9.413	6.462	7.547
Citrus	LOW	0.416	0.348	4.05	0.4	0.211	0.653	0.311	0.649
	AVERAGE	1.607	1.137	7.806	1.123	0.688	1.578	1.007	1.267
	HIGH	2.299	1.857	19.022	1.747	1.103	1.92	1.224	1.623
Clay	LOW	0.26	0.22	2.274	0.186	0.17	0.207	0.187	0.228
	AVERAGE	0.698	0.706	3.558	0.583	0.406	0.534	0.37	0.558
	HIGH	1.199	0.97	10.74	0.89	0.573	0.981	0.636	0.94
Collier	LOW	0.857	0.544	8.351	0.628	0.222	0.647	0.232	0.501
	AVERAGE	4.785	3.151	22.809	3.848	2.404	5.002	3.576	3.694
	HIGH	16.392	13.841	62.225	13.652	9.483	14.757	10.304	11.47
Columbia	LOW	0.228	0.188	1.903	0.206	0.145	0.534	0.389	NA
	AVERAGE	0.606	0.559	2.976	0.461	0.317	0.572	0.398	NA
	HIGH	0.946	0.765	9.703	0.699	0.455	0.607	0.405	NA
DeSoto	LOW	0.868	0.728	8.149	0.681	0.435	1.016	0.65	0.98
	AVERAGE	3.07	2.17	12.779	2.39	1.405	2.045	1.374	1.372
	HIGH	3.801	3.079	31.438	2.928	1.847	2.89	2.046	2.921
Dixie	LOW	0.374	0.284	2.601	0.314	0.22	0.356	0.306	0.319
	AVERAGE	1.042	0.762	4.049	0.766	0.449	0.826	0.663	0.66
	HIGH	3.046	2.492	20.819	2.494	0.518	1.206	0.782	1.067
Duval	LOW	0.244	0.195	2.01	0.176	0.11	0.216	0.1	0.137
	AVERAGE	0.902	0.854	3.694	0.615	0.464	0.686	0.552	0.719
	HIGH	3.042	2.493	21.524	2.564	1.696	2.625	1.74	2.226
Escambia	LOW	0.498	0.479	4.963	0.454	0.288	0.749	0.537	1.141
	AVERAGE	4.554	4.513	14.226	4.128	3.011	6	4.462	4.563
	HIGH	14.969	10.788	67.635	12.942	8.772	12.273	8.258	9.213
Flagler	LOW	0.36	0.29	3.406	0.334	0.213	0.455	0.247	0.275

Loss Costs per $1000 for 0% Deductible									
County	Hurricane Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit	Commercial Residential
	AVERAGE	1.592	1.133	8.175	1.1	0.715	2.301	1.07	1.653
	HIGH	4.442	3.623	29.776	3.548	2.327	3.866	2.552	3.297
Franklin	LOW	1.552	1.408	10.094	1.788	2.056	1.724	1.625	1.53
	AVERAGE	4.902	5.313	16.08	4.965	3.555	3.036	3.78	2.177
	HIGH	8.796	7.287	45.969	7.61	4.91	8.208	5.577	2.203
Gadsden	LOW	0.247	0.226	2.02	0.234	0.158	0.771	0.508	NA
	AVERAGE	0.67	0.621	3.349	0.607	0.394	0.771	0.508	NA
	HIGH	1.024	0.826	9.315	0.782	0.465	0.771	0.508	NA
Gilchrist	LOW	0.363	0.33	2.767	0.334	0.214	NA	0.463	NA
	AVERAGE	0.841	0.811	4.068	0.727	0.493	NA	0.463	NA
	HIGH	1.312	1.064	12.628	0.989	0.641	NA	0.463	NA
Glades	LOW	0.842	0.849	8.246	1.126	0.725	NA	NA	NA
	AVERAGE	3.382	2.344	14.886	2.753	1.358	NA	NA	NA
	HIGH	4.312	3.486	36.717	3.312	2.079	NA	NA	NA
Gulf	LOW	0.626	0.539	4.114	0.599	0.449	1.063	0.481	0.742
	AVERAGE	2.605	3.304	8.186	3.135	2.454	1.969	1.209	1.332
	HIGH	6.518	5.349	37.836	5.577	3.661	6.031	3.986	1.723
Hamilton	LOW	0.194	0.197	1.567	0.182	0.192	NA	NA	NA
	AVERAGE	0.48	0.442	2.146	0.389	0.266	NA	NA	NA
	HIGH	0.677	0.546	6.982	0.493	0.325	NA	NA	NA
Hardee	LOW	0.84	0.652	7.582	0.873	0.536	2.736	NA	NA
	AVERAGE	2.884	2.104	11.673	2.007	1.229	2.736	NA	NA
	HIGH	3.407	2.756	27.899	2.605	1.628	2.736	NA	NA
Hendry	LOW	1.021	0.867	7.742	0.799	0.489	2.165	0.553	NA
	AVERAGE	3.816	2.283	13.665	3.041	1.778	4.314	2.303	NA
	HIGH	5.704	4.606	45.097	4.478	2.781	4.903	3.078	NA
Hernando	LOW	0.554	0.446	4.866	0.549	0.367	0.675	0.442	0.908
	AVERAGE	2.443	1.706	12.096	1.507	0.996	2.754	1.648	2.446
	HIGH	5.43	4.446	31.035	4.389	2.857	4.776	3.131	3.998
Highlands	LOW	0.81	0.61	7.107	0.7	0.439	0.744	0.412	0.598
	AVERAGE	2.766	2.088	15.93	1.98	1.275	2.233	1.524	1.739
	HIGH	4.559	3.685	38.816	3.03	2.199	3.383	2.136	3.141
Hillsborough	LOW	0.701	0.504	6.59	0.53	0.195	0.554	0.379	0.395
	AVERAGE	2.682	2.303	13.298	2.28	1.396	2.439	1.794	1.751

Loss Costs per $1000 for 0% Deductible									
County	Hurricane Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit	Commercial Residential
	HIGH	8.094	6.715	43.518	6.583	4.372	7.149	4.783	5.37
Holmes	LOW	0.43	0.44	3.411	0.409	0.45	NA	NA	0.479
	AVERAGE	1.091	1.018	4.512	0.803	0.619	NA	NA	0.479
	HIGH	1.462	1.179	13.984	1.129	0.726	NA	NA	0.479
Indian River	LOW	1.138	0.943	10.986	1.234	0.608	1.175	0.657	1.181
	AVERAGE	7.52	3.649	27.088	5.568	3.184	7.337	5.184	5.362
	HIGH	15.703	13.119	61.135	13.093	8.966	14.155	9.742	11.031
Jackson	LOW	0.312	0.273	2.461	0.303	0.242	NA	NA	0.426
	AVERAGE	0.909	0.83	3.954	0.71	0.476	NA	NA	0.453
	HIGH	1.459	1.176	13.524	1.135	0.614	NA	NA	0.48
Jefferson	LOW	0.202	0.179	1.752	0.193	0.257	NA	NA	NA
	AVERAGE	0.503	0.46	2.426	0.453	0.325	NA	NA	NA
	HIGH	0.769	0.62	7.98	0.586	0.381	NA	NA	NA
Lafayette	LOW	0.277	0.286	2.26	0.283	0.368	NA	NA	NA
	AVERAGE	0.704	0.628	3.171	0.613	0.42	NA	NA	NA
	HIGH	0.905	0.731	9.065	0.68	0.447	NA	NA	NA
Lake	LOW	0.481	0.346	3.944	0.378	0.262	0.593	0.334	0.497
	AVERAGE	1.726	1.293	12.757	1.231	0.826	1.791	1.051	1.613
	HIGH	3.175	2.564	28.691	2.36	1.494	2.491	1.59	2.242
Lee	LOW	0.787	0.506	7.015	0.65	0.364	0.621	0.251	0.451
	AVERAGE	4.293	2.28	19.606	2.514	1.607	4.139	2.317	2.441
	HIGH	15.559	13.18	55.757	12.857	9.008	13.904	9.791	10.868
Leon	LOW	0.223	0.204	1.964	0.193	0.099	0.23	0.098	0.106
	AVERAGE	0.693	0.618	3.644	0.457	0.316	0.459	0.378	0.423
	HIGH	0.961	0.774	9.592	0.745	0.482	0.762	0.517	0.711
Levy	LOW	0.407	0.323	3.065	0.392	0.184	1.334	1.237	0.455
	AVERAGE	1.385	1.027	4.925	0.946	0.584	3.142	1.903	2.804
	HIGH	4.806	3.949	28.288	3.969	2.138	4.308	2.866	3.524
Liberty	LOW	0.411	0.431	3.22	0.417	0.54	NA	NA	NA
	AVERAGE	1.043	0.985	4.512	0.974	0.691	NA	NA	NA
	HIGH	1.438	1.161	14.137	1.131	0.721	NA	NA	NA
Madison	LOW	0.193	0.155	1.525	0.168	0.135	NA	NA	NA
	AVERAGE	0.532	0.474	2.404	0.421	0.281	NA	NA	NA

Loss Costs per $1000 for 0% Deductible									
County	Hurricane Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit	Commercial Residential
	HIGH	0.681	0.549	7.238	0.505	0.328	NA	NA	NA
Manatee	LOW	0.848	0.581	6.465	0.635	0.398	0.645	0.256	0.498
	AVERAGE	3.973	2.618	21.501	3.319	2.074	4.379	3.243	3.134
	HIGH	14.153	11.879	64.544	11.09	8.048	12.592	8.756	9.495
Marion	LOW	0.368	0.279	2.882	0.305	0.209	0.367	0.221	0.376
	AVERAGE	1.294	0.851	6.738	0.849	0.561	1.098	0.63	0.947
	HIGH	1.87	1.512	18.111	1.37	0.874	1.512	0.974	1.48
Martin	LOW	1.257	0.814	11.04	1.422	0.61	1.578	0.552	1.147
	AVERAGE	9.153	5.562	40.747	6.968	4.416	11.165	5.985	5.711
	HIGH	15.966	13.247	78.826	13.596	9.117	14.681	9.903	11.286
Miami-Dade	LOW	0.621	0.39	11.132	0.494	0.154	0.462	0.172	0.194
	AVERAGE	6.999	5.344	23.285	4.788	3.738	5.892	4.535	4.19
	HIGH	27.276	23.096	66.636	22.96	16.154	24.749	17.487	18.62
Monroe	LOW	4.072	2.858	33.183	4.508	1.268	7.187	1.399	1.375
	AVERAGE	18.597	16.111	74.299	17.944	12.719	20.756	12.981	11.769
	HIGH	30.561	26.193	105.612	26.14	18.927	28.109	20.424	20.495
Nassau	LOW	0.204	0.171	1.61	0.17	0.119	0.507	0.21	0.316
	AVERAGE	0.903	0.753	3.099	0.72	0.555	1.228	0.857	1.018
	HIGH	2.048	1.681	15.524	1.592	1.061	1.742	1.168	1.558
Okaloosa	LOW	0.384	0.326	3.844	0.432	0.354	0.473	0.513	1.106
	AVERAGE	4.72	4.802	8.56	4.652	3.272	7.124	5.117	6.003
	HIGH	13.19	10.926	64.84	11.546	7.772	12.431	8.413	9.235
Okeechobee	LOW	1.242	0.891	11.43	1.367	0.609	1.094	1.746	1.782
	AVERAGE	5.055	3.62	25.583	4.353	2.496	3.45	3.484	3.715
	HIGH	7.319	5.933	54.716	5.857	3.675	6.391	4.05	4.576
Orange	LOW	0.502	0.418	5.025	0.366	0.12	0.397	0.197	0.23
	AVERAGE	1.489	1.371	11.261	1.092	0.714	1.207	0.831	1.114
	HIGH	2.965	2.393	25.73	2.196	1.394	2.356	1.438	2.177
Osceola	LOW	0.553	0.469	5.455	0.385	0.238	0.431	0.174	0.344
	AVERAGE	1.479	1.419	12.827	1.148	0.81	1.21	0.781	1.008
	HIGH	3.61	2.909	32.198	2.748	1.719	2.671	1.692	2.251
Palm Beach	LOW	1.089	0.686	10.876	0.845	0.266	0.846	0.32	0.59
	AVERAGE	8.913	5.513	34.424	6.242	4.497	8.16	5.228	5.154

Loss Costs per $1000 for 0% Deductible									
County	Hurricane Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit	Commercial Residential
	HIGH	19.833	16.591	89.886	16.812	11.484	18.141	12.456	13.821
Pasco	LOW	0.648	0.486	5.575	0.517	0.31	0.495	0.249	0.555
	AVERAGE	1.948	2.354	13.864	1.734	1.401	2.016	2.439	2.044
	HIGH	7.353	6.065	43.736	5.996	3.921	6.511	4.292	4.8
Pinellas	LOW	0.879	0.738	7.137	0.85	0.536	0.768	0.375	0.492
	AVERAGE	6.423	5.142	28.365	4.186	3.148	5.316	3.775	3.585
	HIGH	12.466	10.459	52.08	10.269	7.107	11.115	7.733	8.772
Polk	LOW	0.569	0.473	5.578	0.402	0.268	0.438	0.24	0.382
	AVERAGE	1.853	1.466	12.641	1.356	0.916	1.279	1.038	1.188
	HIGH	3.428	2.772	28.719	2.593	1.628	3.01	1.906	2.399
Putnam	LOW	0.331	0.282	2.626	0.328	0.219	0.415	0.288	0.478
	AVERAGE	1.004	0.857	5.352	0.795	0.511	0.817	0.517	0.757
	HIGH	1.837	1.481	16.641	1.192	0.76	0.982	0.637	0.97
St. Johns	LOW	0.319	0.247	2.783	0.246	0.166	0.273	0.12	0.245
	AVERAGE	1.034	1.2	5.919	0.941	0.725	1.702	1.367	1.374
	HIGH	3.968	3.23	27.428	3.148	2.062	3.433	2.263	2.957
St. Lucie	LOW	1.063	0.674	13.333	0.813	0.485	1.14	0.554	0.783
	AVERAGE	6.745	2.909	32.847	4.65	2.59	7.295	4.696	4.734
	HIGH	16.862	14.046	64.743	14.267	9.651	15.409	10.484	11.875
Santa Rosa	LOW	0.535	0.454	5.318	0.529	0.398	1.191	1.167	1.682
	AVERAGE	4.303	4.108	14.467	4.682	2.888	10.131	6.937	6.535
	HIGH	16.922	14.08	71.603	14.807	10.039	15.939	10.862	11.789
Sarasota	LOW	0.787	0.542	6.209	0.586	0.239	0.636	0.268	0.688
	AVERAGE	5.066	3.361	26.351	3.51	2.484	6.21	3.767	3.563
	HIGH	11.717	9.89	52.902	9.598	6.694	10.437	7.284	8.246
Seminole	LOW	0.494	0.404	4.747	0.385	0.187	0.385	0.21	0.27
	AVERAGE	1.59	1.342	11.131	1.113	0.7	1.291	0.851	1.027
	HIGH	2.178	1.756	20.713	1.611	1.016	1.724	1.122	1.696
Sumter	LOW	0.495	0.356	4.58	0.391	0.296	0.603	0.365	0.515
	AVERAGE	0.985	0.748	9.665	0.745	0.504	1.302	0.597	0.841
	HIGH	2.384	1.923	21.153	1.708	1.113	1.741	1.104	1.678
Suwannee	LOW	0.242	0.207	1.958	0.21	0.148	0.245	NA	0.433

Loss Costs per $1000 for 0% Deductible									
County	Hurricane Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit	Commercial Residential
	AVERAGE	0.642	0.571	2.922	0.473	0.345	0.245	NA	0.433
	HIGH	1.004	0.812	10.162	0.673	0.486	0.245	NA	0.433
Taylor	LOW	0.273	0.253	2.141	0.267	0.245	0.393	0.312	0.456
	AVERAGE	0.847	0.727	3.642	0.649	0.402	0.688	0.429	0.513
	HIGH	1.865	1.514	14.746	1.487	0.49	1.031	0.458	0.628
Union	LOW	0.29	0.273	2.094	0.232	0.127	NA	NA	NA
	AVERAGE	0.622	0.599	2.958	0.514	0.365	NA	NA	NA
	HIGH	0.885	0.713	9.079	0.644	0.42	NA	NA	NA
Volusia	LOW	0.386	0.283	3.779	0.363	0.186	0.325	0.19	0.367
	AVERAGE	2.237	1.573	12.202	1.52	1.096	2.745	2.006	1.82
	HIGH	5.763	4.714	30.025	4.711	3.041	5.119	3.33	4.245
Wakulla	LOW	0.329	0.279	2.866	0.349	0.24	0.37	0.674	0.462
	AVERAGE	0.923	1.092	4.652	0.872	0.685	0.972	2.583	0.97
	HIGH	4.83	3.962	26.903	4.137	2.718	4.116	2.959	2.932
Walton	LOW	0.445	0.378	4.446	0.382	0.415	0.945	0.507	1.26
	AVERAGE	3.567	2.869	9.017	3.669	2.248	5.954	3.282	5.94
	HIGH	11.731	9.722	59.107	10.073	6.792	10.867	7.367	8.255
Washington	LOW	0.46	0.377	3.911	0.487	0.384	NA	NA	0.883
	AVERAGE	1.227	1.212	5.147	1.201	0.834	NA	NA	0.883
	HIGH	2.596	2.097	21.71	2.099	1.339	NA	NA	0.883
Statewide	LOW	0.193	0.155	1.525	0.168	0.099	0.207	0.098	0.106
	AVERAGE	2.751	3.079	13.934	2.42	2.29	3.34	3.653	3.606
	HIGH	30.561	26.193	105.612	26.14	18.927	28.109	20.424	20.495

Table 50. Form A-4, Hurricane Output Ranges - Loss Costs per $1000 for Specified Deductible (2023 FHCF Exposure Data)

Loss Costs per $1000 for Specified Deductible									
County	Hurricane Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit	Commercial Residential
Alachua	LOW	0.218	0.183	2.12	0.135	0.059	0.149	0.079	0.077
	AVERAGE	0.609	0.592	3.39	0.371	0.229	0.466	0.293	0.483
	HIGH	0.983	0.783	10.634	0.633	0.373	0.684	0.416	0.666
Baker	LOW	0.174	0.143	1.412	0.109	0.081	NA	NA	0.306
	AVERAGE	0.395	0.349	2.066	0.287	0.187	NA	NA	0.306
	HIGH	0.598	0.478	6.489	0.37	0.227	NA	NA	0.306

Loss Costs per $1000 for Specified Deductible									
County	Hurricane Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit	Commercial Residential
Bay	LOW	0.402	0.353	3.982	0.446	0.142	0.451	0.346	0.403
	AVERAGE	3.521	3.318	11.601	3.526	1.871	5.728	3.83	3.351
	HIGH	9.889	8.114	54.813	8.406	5.507	9.082	5.995	6.438
Bradford	LOW	0.228	0.176	1.799	0.148	0.1	NA	NA	0.381
	AVERAGE	0.579	0.541	2.898	0.386	0.232	NA	NA	0.383
	HIGH	0.763	0.609	8.642	0.475	0.286	NA	NA	0.384
Brevard	LOW	0.595	0.501	6.428	0.36	0.212	0.411	0.141	0.238
	AVERAGE	3.634	2.705	25.051	2.857	1.931	3.581	2.82	2.48
	HIGH	11.894	9.892	60.55	9.588	6.396	10.403	6.994	7.799
Broward	LOW	0.476	0.295	9.774	0.293	0.079	0.272	0.092	0.271
	AVERAGE	5.119	4.469	30.05	3.537	2.942	4.972	3.515	3.507
	HIGH	18.924	15.89	84.378	15.619	10.537	16.894	11.484	12.367
Calhoun	LOW	0.32	0.266	2.917	0.29	0.3	NA	NA	NA
	AVERAGE	0.921	0.841	4.015	0.695	0.454	NA	NA	NA
	HIGH	1.551	1.236	12.606	0.833	0.531	NA	NA	NA
Charlotte	LOW	0.67	0.465	5.722	0.424	0.236	0.442	0.143	0.417
	AVERAGE	3.629	2.346	13.404	2.163	1.402	3.311	1.592	1.724
	HIGH	9.775	8.151	46.082	6.431	5.159	8.432	5.657	6.468
Citrus	LOW	0.322	0.267	3.498	0.251	0.119	0.439	0.186	0.456
	AVERAGE	1.345	0.936	7.034	0.831	0.472	1.207	0.724	0.965
	HIGH	1.956	1.563	17.808	1.359	0.799	1.503	0.9	1.224
Clay	LOW	0.198	0.167	1.91	0.107	0.098	0.12	0.108	0.164
	AVERAGE	0.563	0.569	3.084	0.404	0.264	0.366	0.241	0.401
	HIGH	0.99	0.793	9.815	0.648	0.387	0.72	0.437	0.69
Collier	LOW	0.68	0.424	7.434	0.401	0.126	0.414	0.135	0.373
	AVERAGE	4.263	2.763	21.394	3.229	1.939	4.302	2.994	3.119
	HIGH	15.264	12.82	59.964	12.389	8.422	13.428	9.196	9.979
Columbia	LOW	0.172	0.141	1.579	0.121	0.081	0.358	0.252	NA
	AVERAGE	0.483	0.443	2.551	0.308	0.199	0.389	0.258	NA
	HIGH	0.769	0.616	8.849	0.492	0.297	0.419	0.264	NA
DeSoto	LOW	0.694	0.577	7.26	0.441	0.261	0.706	0.422	0.759
	AVERAGE	2.634	1.833	11.667	1.883	1.027	1.586	1.013	1.085
	HIGH	3.311	2.654	29.728	2.376	1.41	2.317	1.581	2.301
Dixie	LOW	0.29	0.218	2.211	0.201	0.133	0.226	0.194	0.235

Loss Costs per $1000 for Specified Deductible									
County	Hurricane Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit	Commercial Residential
	AVERAGE	0.862	0.618	3.551	0.558	0.3	0.61	0.475	0.478
	HIGH	2.664	2.159	19.544	2.069	0.352	0.927	0.569	0.794
Duval	LOW	0.186	0.148	1.683	0.102	0.064	0.131	0.056	0.098
	AVERAGE	0.744	0.702	3.223	0.439	0.316	0.495	0.39	0.535
	HIGH	2.651	2.156	20.134	2.098	1.327	2.149	1.368	1.748
Escambia	LOW	0.376	0.362	4.248	0.275	0.169	0.486	0.335	0.879
	AVERAGE	3.996	3.952	13.042	3.466	2.436	5.182	3.744	3.735
	HIGH	13.827	9.836	65.146	11.682	7.715	11.044	7.24	7.825
Flagler	LOW	0.274	0.219	2.897	0.203	0.12	0.285	0.152	0.199
	AVERAGE	1.346	0.939	7.352	0.826	0.506	1.858	0.798	1.297
	HIGH	3.92	3.168	28.055	2.956	1.857	3.233	2.053	2.641
Franklin	LOW	1.298	1.166	9.186	1.43	1.629	1.324	1.267	1.214
	AVERAGE	4.373	4.758	14.941	4.32	2.999	2.529	3.208	1.688
	HIGH	8.014	6.587	44.103	6.761	4.231	7.31	4.837	1.707
Gadsden	LOW	0.184	0.168	1.679	0.14	0.089	0.547	0.339	NA
	AVERAGE	0.53	0.489	2.892	0.419	0.251	0.547	0.339	NA
	HIGH	0.824	0.656	8.468	0.552	0.301	0.547	0.339	NA
Gilchrist	LOW	0.281	0.256	2.35	0.214	0.129	NA	0.31	NA
	AVERAGE	0.684	0.658	3.557	0.521	0.331	NA	0.31	NA
	HIGH	1.088	0.873	11.666	0.732	0.443	NA	0.31	NA
Glades	LOW	0.661	0.669	7.262	0.778	0.465	NA	NA	NA
	AVERAGE	2.88	1.96	13.596	2.156	0.963	NA	NA	NA
	HIGH	3.712	2.967	34.783	2.639	1.546	NA	NA	NA
Gulf	LOW	0.484	0.414	3.543	0.396	0.285	0.776	0.323	0.564
	AVERAGE	2.247	2.881	7.39	2.63	1.998	1.557	0.903	1.01
	HIGH	5.845	4.752	36.045	4.845	3.06	5.255	3.353	1.296
Hamilton	LOW	0.145	0.148	1.287	0.106	0.112	NA	NA	NA
	AVERAGE	0.377	0.346	1.809	0.256	0.163	NA	NA	NA
	HIGH	0.54	0.43	6.272	0.331	0.203	NA	NA	NA
Hardee	LOW	0.664	0.508	6.672	0.595	0.335	2.153	NA	NA
	AVERAGE	2.454	1.763	10.578	1.537	0.871	2.153	NA	NA
	HIGH	2.94	2.352	26.214	2.077	1.212	2.153	NA	NA
Hendry	LOW	0.815	0.688	6.818	0.526	0.298	1.603	0.345	NA
	AVERAGE	3.28	1.917	12.449	2.409	1.308	3.5	1.733	NA

Loss Costs per $1000 for Specified Deductible									
County	Hurricane Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit	Commercial Residential
	HIGH	4.963	3.96	42.953	3.656	2.123	4.024	2.38	NA
Hernando	LOW	0.438	0.35	4.23	0.365	0.229	0.466	0.287	0.663
	AVERAGE	2.11	1.446	11.132	1.163	0.727	2.267	1.284	1.998
	HIGH	4.872	3.955	29.397	3.764	2.351	4.11	2.597	3.282
Highlands	LOW	0.633	0.472	6.206	0.443	0.257	0.466	0.254	0.442
	AVERAGE	2.332	1.735	14.611	1.492	0.891	1.696	1.096	1.363
	HIGH	3.927	3.139	36.762	2.391	1.637	2.691	1.595	2.423
Hillsborough	LOW	0.557	0.398	5.808	0.349	0.116	0.368	0.238	0.301
	AVERAGE	2.333	1.985	12.253	1.848	1.069	1.987	1.412	1.402
	HIGH	7.38	6.08	41.695	5.782	3.716	6.3	4.093	4.506
Holmes	LOW	0.325	0.336	2.89	0.256	0.284	NA	NA	0.351
	AVERAGE	0.879	0.816	3.915	0.561	0.409	NA	NA	0.351
	HIGH	1.193	0.95	12.888	0.821	0.488	NA	NA	0.351
Indian River	LOW	0.904	0.742	9.815	0.851	0.378	0.808	0.451	0.917
	AVERAGE	6.747	3.181	25.391	4.755	2.579	6.372	4.391	4.526
	HIGH	14.535	12.068	58.7	11.79	7.878	12.781	8.604	9.496
Jackson	LOW	0.233	0.203	2.042	0.182	0.139	NA	NA	0.286
	AVERAGE	0.724	0.657	3.412	0.488	0.304	NA	NA	0.305
	HIGH	1.193	0.949	12.467	0.831	0.404	NA	NA	0.324
Jefferson	LOW	0.151	0.133	1.452	0.115	0.16	NA	NA	NA
	AVERAGE	0.397	0.362	2.064	0.308	0.207	NA	NA	NA
	HIGH	0.619	0.494	7.249	0.411	0.248	NA	NA	NA
Lafayette	LOW	0.21	0.22	1.903	0.177	0.241	NA	NA	NA
	AVERAGE	0.568	0.503	2.744	0.433	0.279	NA	NA	NA
	HIGH	0.737	0.589	8.275	0.486	0.298	NA	NA	NA
Lake	LOW	0.368	0.262	3.35	0.224	0.148	0.37	0.192	0.368
	AVERAGE	1.425	1.051	11.64	0.881	0.552	1.339	0.727	1.223
	HIGH	2.687	2.146	26.952	1.806	1.061	1.916	1.146	1.689
Lee	LOW	0.628	0.395	6.219	0.431	0.225	0.403	0.15	0.337
	AVERAGE	3.818	1.958	18.315	2.036	1.238	3.515	1.869	2.011
	HIGH	14.525	12.245	53.503	11.69	8.028	12.677	8.769	9.506
Leon	LOW	0.166	0.152	1.636	0.111	0.056	0.137	0.055	0.073
	AVERAGE	0.554	0.491	3.183	0.309	0.201	0.31	0.247	0.295

Loss Costs per $1000 for Specified Deductible									
County	Hurricane Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit	Commercial Residential
	HIGH	0.783	0.623	8.797	0.541	0.325	0.55	0.349	0.505
Levy	LOW	0.314	0.25	2.62	0.247	0.113	1.007	0.936	0.315
	AVERAGE	1.164	0.845	4.339	0.693	0.396	2.631	1.521	2.251
	HIGH	4.283	3.49	26.679	3.385	1.72	3.687	2.369	2.858
Liberty	LOW	0.313	0.331	2.741	0.266	0.356	NA	NA	NA
	AVERAGE	0.843	0.792	3.944	0.711	0.47	NA	NA	NA
	HIGH	1.179	0.94	13.106	0.838	0.493	NA	NA	NA
Madison	LOW	0.144	0.115	1.25	0.097	0.076	NA	NA	NA
	AVERAGE	0.421	0.373	2.043	0.281	0.174	NA	NA	NA
	HIGH	0.544	0.433	6.524	0.345	0.208	NA	NA	NA
Manatee	LOW	0.682	0.459	5.739	0.427	0.245	0.428	0.156	0.374
	AVERAGE	3.545	2.294	20.245	2.802	1.676	3.788	2.74	2.648
	HIGH	13.174	10.995	62.277	10.022	7.125	11.43	7.791	8.255
Marion	LOW	0.282	0.211	2.429	0.183	0.118	0.223	0.127	0.278
	AVERAGE	1.065	0.688	6.006	0.6	0.369	0.798	0.425	0.699
	HIGH	1.557	1.246	16.831	1.011	0.597	1.126	0.678	1.098
Martin	LOW	1.005	0.636	9.818	1.034	0.377	1.154	0.36	0.874
	AVERAGE	8.271	4.932	38.714	6.027	3.673	9.944	5.102	4.829
	HIGH	14.78	12.178	76.123	12.269	8.01	13.282	8.745	9.731
Miami-Dade	LOW	0.475	0.293	9.949	0.289	0.079	0.265	0.092	0.134
	AVERAGE	6.263	4.724	21.744	4.053	3.1	5.054	3.817	3.534
	HIGH	25.781	21.724	64.224	21.255	14.699	22.971	15.979	16.635
Monroe	LOW	3.608	2.502	31.483	3.86	0.963	6.285	1.074	1.099
	AVERAGE	17.483	15.084	71.926	16.57	11.566	19.282	11.811	10.479
	HIGH	29.084	24.82	102.979	24.47	17.473	26.376	18.924	18.503
Nassau	LOW	0.155	0.129	1.342	0.102	0.067	0.349	0.138	0.242
	AVERAGE	0.752	0.624	2.694	0.535	0.398	0.947	0.639	0.778
	HIGH	1.753	1.428	14.368	1.256	0.798	1.381	0.889	1.197
Okaloosa	LOW	0.289	0.244	3.277	0.271	0.211	0.294	0.327	0.792
	AVERAGE	4.197	4.272	7.713	3.988	2.718	6.255	4.38	5.014
	HIGH	12.166	10.003	62.428	10.416	6.827	11.242	7.424	7.892
Okeechobee	LOW	0.986	0.697	10.186	0.959	0.369	0.729	1.254	1.39
	AVERAGE	4.386	3.089	23.843	3.552	1.895	2.741	2.747	2.995

Loss Costs per $1000 for Specified Deductible									
County	Hurricane Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit	Commercial Residential
	HIGH	6.463	5.182	52.331	4.908	2.909	5.378	3.24	3.609
Orange	LOW	0.384	0.318	4.304	0.21	0.062	0.231	0.11	0.165
	AVERAGE	1.214	1.113	10.185	0.761	0.461	0.851	0.55	0.82
	HIGH	2.501	1.996	24.08	1.668	0.982	1.816	1.022	1.632
Osceola	LOW	0.427	0.36	4.7	0.224	0.137	0.255	0.096	0.252
	AVERAGE	1.209	1.157	11.648	0.812	0.536	0.856	0.518	0.75
	HIGH	3.075	2.448	30.341	2.144	1.244	2.069	1.225	1.693
Palm Beach	LOW	0.855	0.526	9.679	0.54	0.148	0.535	0.185	0.442
	AVERAGE	8.042	4.883	32.538	5.354	3.751	7.095	4.401	4.341
	HIGH	18.522	15.404	87.046	15.331	10.24	16.585	11.158	12.098
Pasco	LOW	0.514	0.384	4.88	0.337	0.194	0.314	0.154	0.421
	AVERAGE	1.668	2.045	12.812	1.369	1.083	1.616	1.992	1.665
	HIGH	6.683	5.47	41.909	5.247	3.309	5.716	3.647	3.993
Pinellas	LOW	0.714	0.595	6.366	0.603	0.351	0.533	0.248	0.378
	AVERAGE	5.829	4.62	26.926	3.591	2.63	4.625	3.203	3.021
	HIGH	11.582	9.662	50.168	9.275	6.277	10.067	6.865	7.612
Polk	LOW	0.44	0.362	4.818	0.239	0.149	0.26	0.141	0.278
	AVERAGE	1.542	1.204	11.504	0.986	0.623	0.928	0.721	0.904
	HIGH	2.949	2.359	27.002	2.051	1.201	2.368	1.406	1.825
Putnam	LOW	0.253	0.215	2.212	0.2	0.125	0.255	0.17	0.33
	AVERAGE	0.815	0.69	4.722	0.556	0.33	0.57	0.337	0.553
	HIGH	1.526	1.216	15.408	0.864	0.507	0.707	0.428	0.699
St. Johns	LOW	0.244	0.187	2.36	0.146	0.093	0.165	0.068	0.178
	AVERAGE	0.86	1.004	5.269	0.708	0.522	1.352	1.052	1.068
	HIGH	3.485	2.811	25.8	2.602	1.628	2.849	1.803	2.351
St. Lucie	LOW	0.837	0.519	11.995	0.521	0.295	0.781	0.348	0.588
	AVERAGE	5.979	2.488	30.949	3.873	2.045	6.304	3.935	3.965
	HIGH	15.627	12.932	62.183	12.889	8.498	13.958	9.278	10.249
Santa Rosa	LOW	0.406	0.342	4.574	0.321	0.238	0.839	0.846	1.326
	AVERAGE	3.791	3.61	13.28	3.996	2.355	9.045	6.032	5.503
	HIGH	15.687	12.961	69.009	13.444	8.891	14.506	9.663	10.161

Loss Costs per $1000 for Specified Deductible									
County	Hurricane Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit	Commercial Residential
Sarasota	LOW	0.628	0.424	5.493	0.38	0.143	0.412	0.165	0.538
	AVERAGE	4.566	2.983	24.966	2.986	2.052	5.48	3.216	3.028
	HIGH	10.881	9.138	50.937	8.661	5.908	9.44	6.462	7.151
Seminole	LOW	0.378	0.307	4.058	0.223	0.102	0.223	0.118	0.196
	AVERAGE	1.3	1.087	10.066	0.778	0.45	0.919	0.565	0.749
	HIGH	1.812	1.443	19.241	1.193	0.692	1.272	0.773	1.248
Sumter	LOW	0.384	0.27	3.948	0.236	0.169	0.393	0.223	0.385
	AVERAGE	0.793	0.595	8.741	0.508	0.322	0.958	0.392	0.631
	HIGH	2.005	1.599	19.757	1.302	0.777	1.318	0.779	1.256
Suwannee	LOW	0.182	0.155	1.628	0.123	0.083	0.148	NA	0.321
	AVERAGE	0.512	0.452	2.505	0.318	0.219	0.148	NA	0.321
	HIGH	0.818	0.655	9.295	0.474	0.322	0.148	NA	0.321
Taylor	LOW	0.207	0.192	1.799	0.166	0.151	0.261	0.197	0.316
	AVERAGE	0.691	0.588	3.183	0.468	0.267	0.491	0.286	0.36
	HIGH	1.584	1.272	13.696	1.171	0.334	0.779	0.309	0.448
Union	LOW	0.22	0.21	1.749	0.141	0.068	NA	NA	NA
	AVERAGE	0.496	0.476	2.532	0.348	0.232	NA	NA	NA
	HIGH	0.715	0.571	8.243	0.447	0.27	NA	NA	NA
Volusia	LOW	0.294	0.213	3.211	0.216	0.1	0.19	0.11	0.27
	AVERAGE	1.899	1.316	11.135	1.159	0.799	2.224	1.582	1.438
	HIGH	5.133	4.163	28.244	3.998	2.47	4.359	2.726	3.447
Wakulla	LOW	0.251	0.211	2.452	0.228	0.147	0.241	0.48	0.32
	AVERAGE	0.763	0.916	4.126	0.666	0.503	0.758	2.146	0.744
	HIGH	4.321	3.511	25.486	3.582	2.264	3.543	2.481	2.347
Walton	LOW	0.338	0.285	3.833	0.233	0.257	0.648	0.317	0.983
	AVERAGE	3.113	2.479	8.158	3.09	1.791	5.176	2.715	4.965
	HIGH	10.763	8.853	56.744	9.011	5.905	9.746	6.439	6.986
Washington	LOW	0.351	0.284	3.349	0.316	0.236	NA	NA	0.67
	AVERAGE	1	0.986	4.508	0.895	0.583	NA	NA	0.67
	HIGH	2.205	1.76	20.39	1.662	0.993	NA	NA	0.67
Statewide	LOW	0.144	0.115	1.25	0.097	0.056	0.12	0.055	0.073
	AVERAGE	2.404	2.685	12.886	1.979	1.845	2.81	3.045	3.019
	HIGH	29.084	24.82	102.979	24.47	17.473	26.376	18.924	18.503

Form A-4.D

If a modeling organization has hurricane loss costs for a ZIP Code for which there is no exposure, give the hurricane loss costs zero weight (i.e., assume the exposure in that ZIP Code is zero). Provide a list of those ZIP Codes where this occurs.

A loss cost is not produced in any case where there is no exposure.

Form A-4.E

If a modeling organization does not have hurricane loss costs for a ZIP Code for which there is some exposure, do not assume such hurricane loss costs are zero, but use only the exposures for which there are hurricane loss costs in calculating the weighted average hurricane loss costs. Provide a list of the ZIP Codes where this occurs.

There are no ZIP Codes in the FHCF data for which Verisk does not produce loss costs. FHCF ZIP Codes are remapped to current ZIP Codes by Verisk.

Form A-4.F

NA shall be used in cells to signify no exposure.

NA has been used in cells to signify no exposure.

Form A-4.G

Indicate if per diem is used in producing hurricane loss costs for Coverage D (Time Element) in the personal residential hurricane output ranges. If a per diem rate is used, a rate of $300 per day per policy shall be used.

A $300 per diem per policy is used in producing loss costs for Coverage D.

Form A-4.H

Describe how Law and Ordinance is included in the hurricane output ranges.

Law and ordinance coverage for personal residential properties is implicitly accounted for in the model to the extent that it is captured in the historical data and included in the model through the model damage estimation process as described in Disclosure A-3.5.

Form A-4.I

List assumptions necessary to complete Form A-4. Provide the rationale for assumptions and a detailed description of how the assumptions are implemented.

No additional assumptions were made.

Form A-5: Percentage Change in Hurricane Output Ranges

Form A-5.A

One or more automated programs or scripts shall be used to generate and arrange the data in Form A-5.

Form A-5: Percentage Change in Hurricane Output Ranges was prepared using an automated process. During the automation process, Verisk exercised due diligence verifying that the process reproduced the same indications as Form A-5: Percentage Change in Hurricane Output Ranges in prior submissions.

Form A-5.B

Provide this form in Excel format. The file name shall include the abbreviated name of the modeling organization, the hurricane standards year, and the form name. Also include all tables and maps in Form A-5 in a submission appendix.

Form A-5: Percentage Change in Hurricane Output Ranges is provided here in the submission document and in Excel format separately in the accompanying electronic submission files named "VSK23FormA5.xlsx". Maps can be found in Form A-5.D.

Form A-5.C

Provide summaries of the percentage change in average hurricane loss cost output range data compiled in Form A-4, Part A, relative to the equivalent data compiled from the current accepted hurricane model, in the format shown in the file named "2023FormA5.xlsx."

For the percentage change in hurricane output range, provide the summary by:

- ***Statewide (overall percentage change),***
- ***By region, as defined in Figure 14 - North, Central, and South, and***
- ***By county, as defined in Figure 15 - Coastal and Inland.***

Table 51. Form A-5 Percentage Change in $0 Deductible Hurricane Output Ranges (2017 FHCF Exposure Data)

Region	Frame Owners	Masonry Owners	Manufactur Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit	Commercial Residential
Coastal	2.300%	6.700%	10.900%	7.800%	3.900%	4.500%	4.700%	8.200%
Inland	12.900%	16.900%	13.100%	15.600%	16.700%	16.700%	17.000%	16.300%
North	-9.300%	-5.700%	-6.700%	-7.300%	-7.600%	-13.600%	-14.400%	-10.000%
Central	18.000%	19.700%	17.000%	20.200%	19.600%	19.000%	19.200%	20.600%
South	3.500%	1.700%	6.100%	2.100%	-1.200%	4.900%	1.600%	5.400%
Statewide	3.600%	7.600%	11.600%	9.000%	4.800%	5.500%	4.800%	8.400%

Table 52. Form A-5 Percentage Change in Specified Deductible Hurricane Output Ranges (2017 FHCF Exposure Data)

Region	Frame Owners	Masonry Owners	Manufactur Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit	Commercial Residential
Coastal	2.100%	6.700%	11.100%	7.800%	3.400%	4.300%	4.500%	8.200%
Inland	13.200%	17.100%	13.400%	15.800%	16.900%	17.000%	17.200%	16.500%
North	-9.800%	-6.300%	-6.900%	-8.400%	-9.100%	-14.600%	-15.800%	-10.900%
Central	18.300%	20.200%	17.400%	21.100%	20.500%	19.800%	20.200%	21.400%
South	3.400%	1.500%	6.200%	1.800%	-1.900%	4.800%	1.300%	5.300%
Statewide	3.400%	7.500%	11.800%	8.800%	4.200%	5.200%	4.700%	8.400%

Form A-5.D

Provide color-coded maps by county reflecting the percentage changes in the average hurricane loss costs with specified deductibles for frame owners, masonry owners, frame renters, masonry renters, frame condo unit owners, masonry condo unit owners, manufactured homes, and commercial residential from the hurricane output ranges from the current accepted hurricane model.

Counties with a negative percentage change (reduction in hurricane loss costs) shall be indicated with shades of blue, counties with a positive percentage change (increase in hurricane loss costs) shall be indicated with shades of red, and counties with no percentage change shall be grey. The larger the percentage change in the county, the more intense the color-shade.

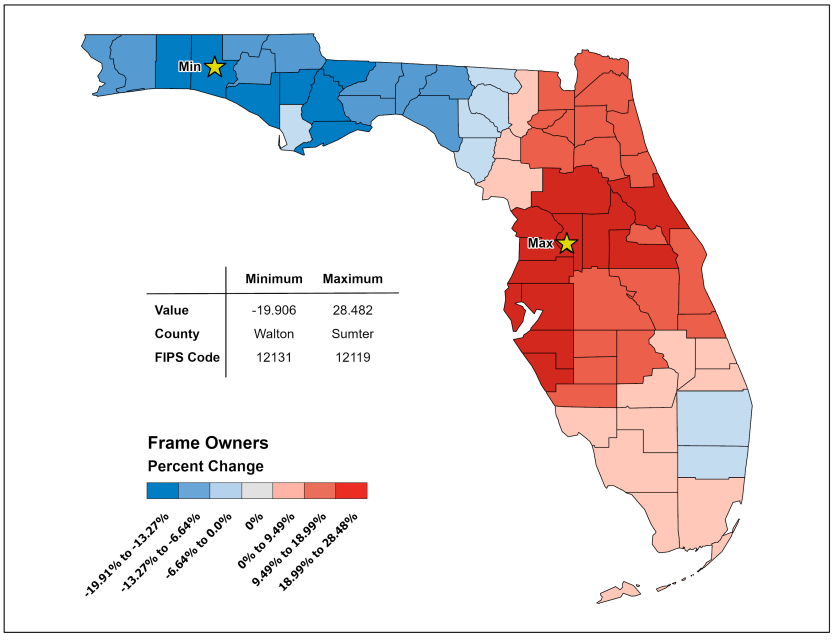


Figure 74. Percentage Change for Owners – Frame

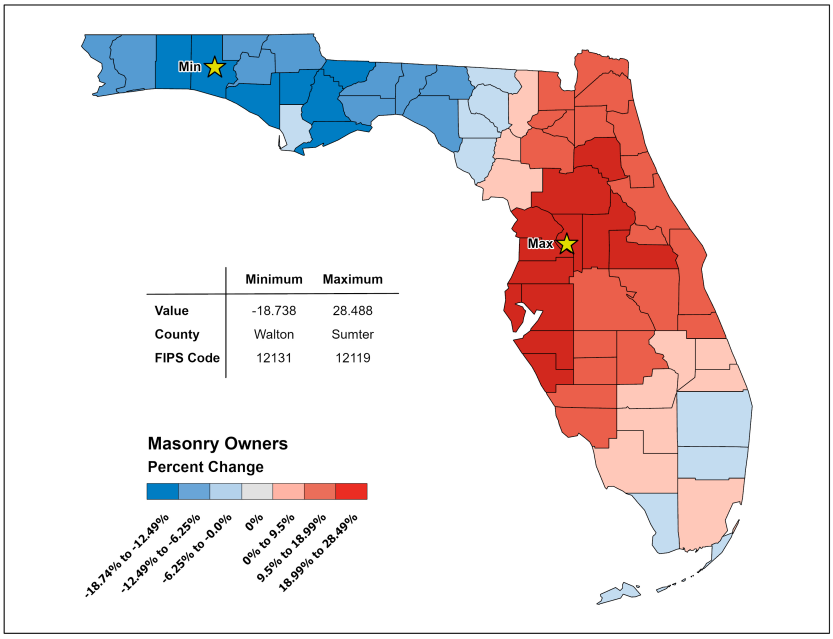


Figure 75. Percentage Change for Owners – Masonry

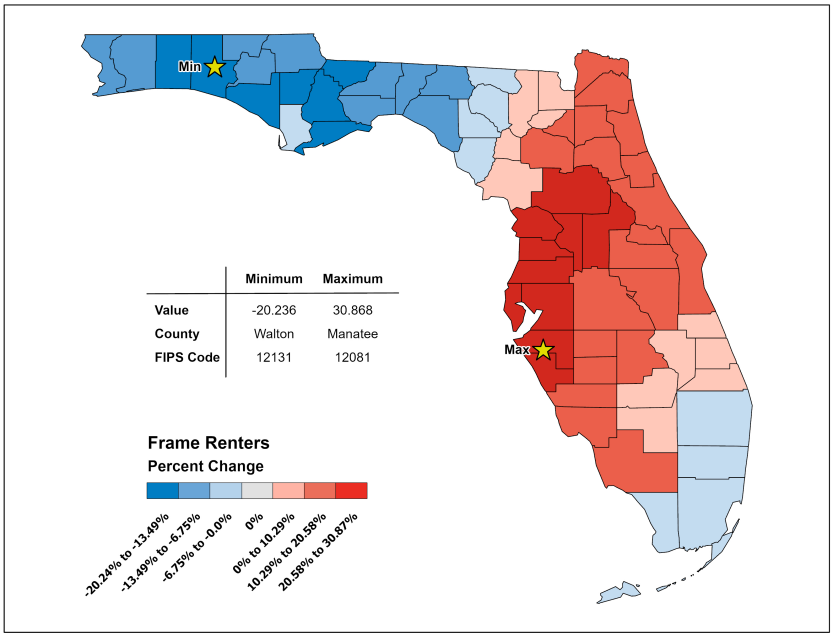


Figure 76. Percentage Change for Renters – Frame

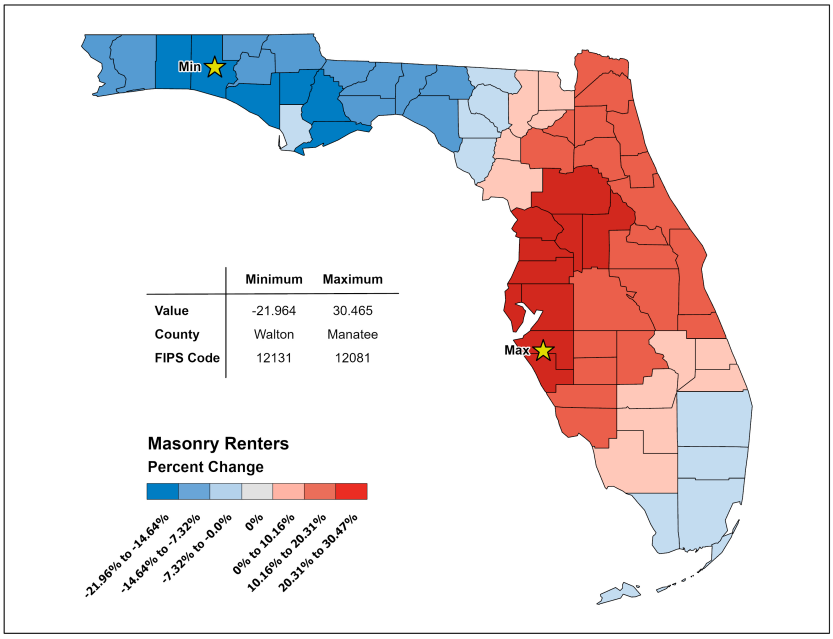


Figure 77. Percentage Change for Renters - Masonry

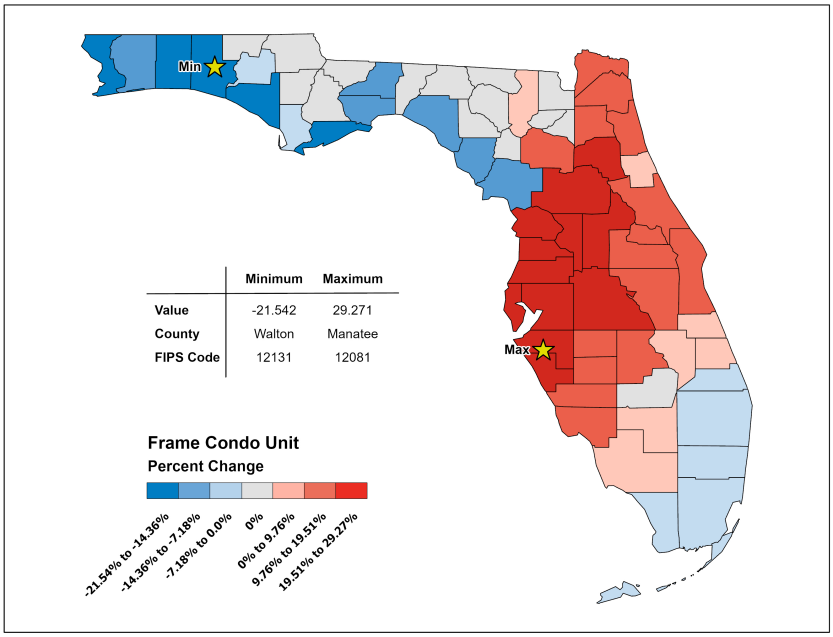


Figure 78. Percentage Change for Condo Unit Owners – Frame

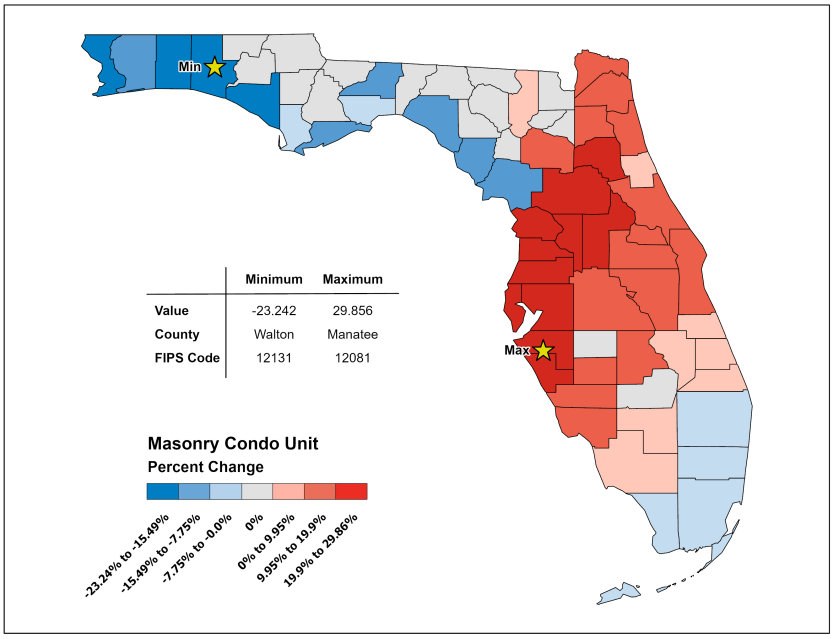


Figure 79. Percentage Change for Condo Unit Owners – Masonry

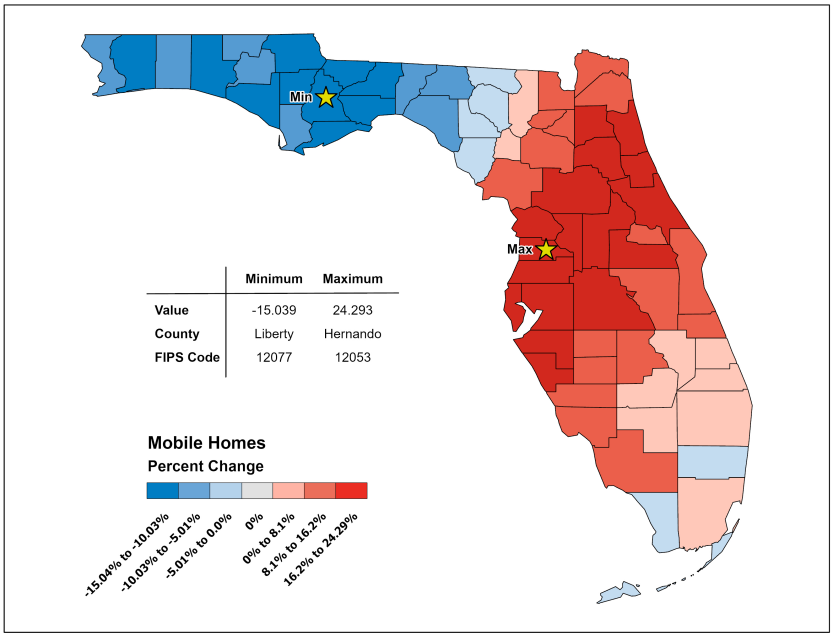


Figure 80. Percentage Change for Manufactured Home

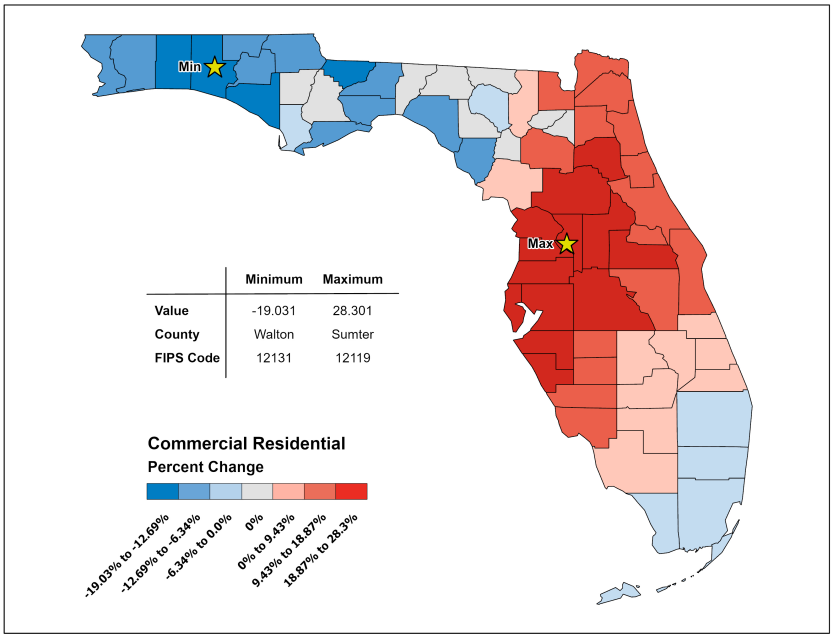


Figure 81. Percentage Change for Commercial Residential (2017 FHCF Exposure Data)

Form A-6: Logical Relationships to Hurricane Risk (Trade Secret Item)

Form A-6: Logical Relationships to Hurricane Risk (Trade Secret Item) is considered trade secret and will be presented to the Professional Team and at the closed meeting of the Commission for review.

Form A-8: Hurricane Probable Maximum Loss for Florida

Form A-8.A

One or more automated programs or scripts shall be used to generate and arrange the data in Form A-8.

Form A-8: Hurricane Probable Maximum Loss for Florida was prepared using an automated process. During the automation process, Verisk exercised due diligence verifying that the process reproduced the same indications as Form A-8: Hurricane Probable Maximum Loss for Florida in prior submissions.

Form A-8.B

Provide a detailed explanation of how the Expected Annual Hurricane Losses and Return Periods are calculated.

In Form A-8: Hurricane Probable Maximum Loss for Florida, the *Total Hurricane Loss* column contains the sum of all event losses for only the events whose individual losses fall within the bounded range. The *Number of Hurricanes* column shows the corresponding number (count) of events in the catalog whose losses fall within the range. The *Average Hurricane Loss* column contains the quotient of the *Total Hurricane Loss* and the *Number of Hurricanes* for each range. The *Expected Annual Hurricane Losses* column is the quotient of the *Total Hurricane Loss* for the range and the (constant) number of years in the catalog of 50,000. Finally, the *Return Period* column shows the return period, or reciprocal of the exceedance probability, for the loss amount from the *Average Hurricane Loss* column, calculated in accordance with the event-ranking methodology described in Disclosure A-3.1.

Form A-8.C/D

C. Complete Part A using the 2017 FHCF exposure data and Part B using the 2023 FHCF exposure data.

D. For the Expected Annual Hurricane Losses column in Part A.1 and Part B.1, provide personal and commercial residential, zero deductible statewide hurricane loss costs.

In the column, Return Period (Years), provide the return period associated with the average hurricane loss within the ranges indicated on a cumulative basis.

For example, if the average hurricane loss is $4,705 million for the range $4,501- $5,000 million, provide the return period associated with a hurricane loss that is $4,705 million or greater.

For each hurricane loss range in millions ($1,001-$1,500, $1,501-$2,000, $2,001- $2,500) the average hurricane loss within that range shall be identified and then the return period associated with that

hurricane loss calculated. The return period is then the reciprocal of the probability of the hurricane loss equaling or exceeding this average hurricane loss size.

The probability of equaling or exceeding the average of each range shall be smaller as the ranges increase (and the average hurricane losses within the ranges increase). Therefore, the return period associated with each range and average hurricane loss within that range shall be larger as the ranges increase. Return periods shall be based on cumulative probabilities.

A return period for an average hurricane loss of $4,705 million within the $4,501- $5,000 million range shall be lower than the return period for an average hurricane loss of $5,455 million associated with the $5,001-$6,000 million range.

Table 53. Part A.1: Personal and Commercial Residential Hurricane Probable Maximum Loss for Florida (2017 FHCF Exposure Data)

HURRICANE LOSS RANGE (MILLIONS)			TOTAL HURRICANE LOSS	AVERAGE HURRICANE LOSS (MILLIONS)	NUMBER OF HURRICANES	EXPECTED ANNUAL HURRICANE LOSSES	RETURN PERIOD (YEARS)
$ >0	to	$500	2,242,672	124	18,072	45	2.3
$501	to	$1,000	3,017,036	723	4,171	60	3.0
$1,001	to	$1,500	3,167,314	1,231	2,574	63	3.4
$1,501	to	$2,000	3,182,130	1,742	1,827	64	3.8
$2,001	to	$2,500	3,055,580	2,243	1,362	61	4.2
$2,501	to	$3,000	3,174,701	2,744	1,157	63	4.5
$3,001	to	$3,500	3,189,523	3,245	983	64	4.9
$3,501	to	$4,000	3,103,136	3,739	830	62	5.3
$4,001	to	$4,500	2,823,484	4,252	664	56	5.6
$4,501	to	$5,000	2,647,856	4,745	558	53	6.0
$5,001	to	$6,000	5,716,569	5,476	1,044	114	6.5
$6,001	to	$7,000	5,412,441	6,482	835	108	7.2
$7,001	to	$8,000	5,022,761	7,497	670	100	8.0
$8,001	to	$9,000	4,757,070	8,510	559	95	8.7
$9,001	to	$10,000	5,006,750	9,482	528	100	9.5
$10,001	to	$11,000	4,403,156	10,484	420	88	10.3
$11,001	to	$12,000	4,574,060	11,493	398	91	11.1
$12,001	to	$13,000	4,167,070	12,476	334	83	11.9
$13,001	to	$14,000	3,871,423	13,489	287	77	12.8
$14,001	to	$15,000	3,926,363	14,488	271	79	13.7
$15,001	to	$16,000	3,361,014	15,489	217	67	14.6
$16,001	to	$17,000	3,724,677	16,481	226	74	15.5
$17,001	to	$18,000	3,237,020	17,497	185	65	16.4

HURRICANE LOSS RANGE (MILLIONS)			TOTAL HURRICANE LOSS	AVERAGE HURRICANE LOSS (MILLIONS)	NUMBER OF HURRICANES	EXPECTED ANNUAL HURRICANE LOSSES	RETURN PERIOD (YEARS)
$18,001	to	$19,000	3,488,594	18,458	189	70	17.5
$19,001	to	$20,000	3,434,985	19,517	176	69	18.6
$20,001	to	$21,000	3,092,068	20,477	151	62	19.7
$21,001	to	$22,000	2,452,248	21,511	114	49	20.7
$22,001	to	$23,000	2,700,264	22,502	120	54	21.7
$23,001	to	$24,000	2,513,504	23,491	107	50	22.8
$24,001	to	$25,000	3,031,117	24,444	124	61	24.0
$25,001	to	$26,000	2,677,967	25,504	105	54	25.4
$26,001	to	$27,000	2,701,900	26,489	102	54	26.8
$27,001	to	$28,000	2,557,775	27,503	93	51	28.1
$28,001	to	$29,000	2,111,694	28,536	74	42	29.4
$29,001	to	$30,000	2,183,134	29,502	74	44	30.7
$30,001	to	$35,000	9,921,522	32,423	306	198	34.7
$35,001	to	$40,000	8,551,109	37,341	229	171	42.6
$40,001	to	$45,000	8,112,987	42,476	191	162	51.2
$45,001	to	$50,000	7,682,157	47,130	163	154	62.6
$50,001	to	$55,000	6,034,247	52,472	115	121	75.3
$55,001	to	$60,000	5,522,894	57,530	96	110	89.1
$60,001	to	$65,000	4,880,079	62,565	78	98	106.2
$65,001	to	$70,000	4,782,862	67,364	71	96	124.7
$70,001	to	$75,000	3,836,528	72,387	53	77	150.2
$75,001	to	$80,000	3,167,137	77,247	41	63	173.6
$80,001	to	$90,000	5,480,847	85,638	64	110	209.2
$90,001	to	$100,000	4,658,888	95,079	49	93	276.2
$100,001	to	$ Maximum	21,862,513	139,252	157	437	862.1
Total			214,222,826	5,198	41,214	4,284	

Table 54. Part B.1: Personal and Commercial Residential Hurricane Probable Maximum Loss for Florida (2023 FHCF Exposure Data)

HURRICANE LOSS RANGE (MILLIONS)			TOTAL HURRICANE LOSS	AVERAGE HURRICANE LOSS (MILLIONS)	NUMBER OF HURRICANES	EXPECTED ANNUAL HURRICANE LOSSES	RETURN PERIOD (YEARS)
$ >0	to	$500	2,067,832	128	16,166	41	2.2
$501	to	$1,000	2,847,992	727	3,919	57	2.7
$1,001	to	$1,500	3,216,906	1,232	2,611	64	3.1
$1,501	to	$2,000	3,148,161	1,739	1,810	63	3.4

HURRICANE LOSS RANGE (MILLIONS)			TOTAL HURRICANE LOSS	AVERAGE HURRICANE LOSS (MILLIONS)	NUMBER OF HURRICANES	EXPECTED ANNUAL HURRICANE LOSSES	RETURN PERIOD (YEARS)
$2,001	to	$2,500	3,186,502	2,242	1,421	64	3.7
$2,501	to	$3,000	3,113,916	2,739	1,137	62	4.0
$3,001	to	$3,500	3,160,062	3,244	974	63	4.3
$3,501	to	$4,000	3,280,056	3,749	875	66	4.5
$4,001	to	$4,500	3,169,257	4,237	748	63	4.8
$4,501	to	$5,000	3,314,382	4,755	697	66	5.1
$5,001	to	$6,000	5,804,555	5,461	1,063	116	5.5
$6,001	to	$7,000	5,705,307	6,491	879	114	6.0
$7,001	to	$8,000	5,786,046	7,485	773	116	6.5
$8,001	to	$9,000	5,483,889	8,489	646	110	7.0
$9,001	to	$10,000	5,277,903	9,493	556	106	7.5
$10,001	to	$11,000	4,752,020	10,490	453	95	8.0
$11,001	to	$12,000	4,801,703	11,487	418	96	8.6
$12,001	to	$13,000	4,915,763	12,477	394	98	9.2
$13,001	to	$14,000	5,207,308	13,490	386	104	9.8
$14,001	to	$15,000	4,576,281	14,482	316	92	10.4
$15,001	to	$16,000	4,512,992	15,509	291	90	11.0
$16,001	to	$17,000	4,263,204	16,524	258	85	11.6
$17,001	to	$18,000	4,408,241	17,493	252	88	12.2
$18,001	to	$19,000	3,884,762	18,499	210	78	12.9
$19,001	to	$20,000	3,820,407	19,492	196	76	13.5
$20,001	to	$21,000	3,484,739	20,498	170	70	14.1
$21,001	to	$22,000	3,571,947	21,518	166	71	14.8
$22,001	to	$23,000	3,555,722	22,505	158	71	15.5
$23,001	to	$24,000	3,926,265	23,511	167	79	16.2
$24,001	to	$25,000	3,111,579	24,501	127	62	17.0
$25,001	to	$26,000	3,368,896	25,522	132	67	17.7
$26,001	to	$27,000	3,041,853	26,451	115	61	18.5
$27,001	to	$28,000	3,134,400	27,495	114	63	19.2
$28,001	to	$29,000	2,818,974	28,474	99	56	20.0
$29,001	to	$30,000	2,977,459	29,480	101	60	20.8
$30,001	to	$35,000	14,056,577	32,538	432	281	23.2
$35,001	to	$40,000	11,820,780	37,408	316	236	27.9
$40,001	to	$45,000	10,960,429	42,648	257	219	32.8
$45,001	to	$50,000	9,021,897	47,484	190	180	38.6
$50,001	to	$55,000	8,635,797	52,657	164	173	44.4

HURRICANE LOSS RANGE (MILLIONS)			TOTAL HURRICANE LOSS	AVERAGE HURRICANE LOSS (MILLIONS)	NUMBER OF HURRICANES	EXPECTED ANNUAL HURRICANE LOSSES	RETURN PERIOD (YEARS)
$55,001	to	$60,000	7,774,848	57,591	135	155	51.0
$60,001	to	$65,000	8,643,727	62,185	139	173	59.1
$65,001	to	$70,000	6,537,352	67,395	97	131	68.5
$70,001	to	$75,000	5,295,448	72,540	73	106	77.4
$75,001	to	$80,000	6,360,229	77,564	82	127	88.3
$80,001	to	$90,000	9,755,357	84,829	115	195	107.5
$90,001	to	$100,000	9,096,626	94,757	96	182	136.6
$100,001	to	$ Maximum	48,756,667	153,323	318	975	446.4
Total			293,413,012	7,120	41,212	5,868	

Form A-8.E

Provide a graphical comparison of the hurricane model under review Residential Return Periods hurricane loss curve to the current accepted hurricane model Residential Return Periods hurricane loss curve. Residential Return Period (Years) shall be shown on the y-axis on a log-10 scale with Hurricane Losses in Billions shown on the x-axis. The legend shall indicate the corresponding hurricane model with a solid line representing the current year and a dotted line representing the current accepted hurricane model.

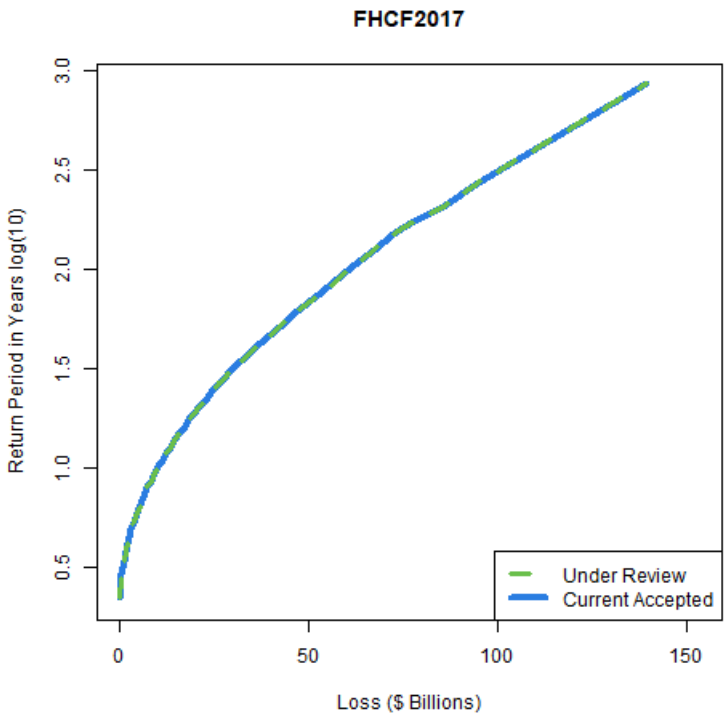


Figure 82. Personal and Commercial Residential Loss Curve Comparison (2017 FHCF)

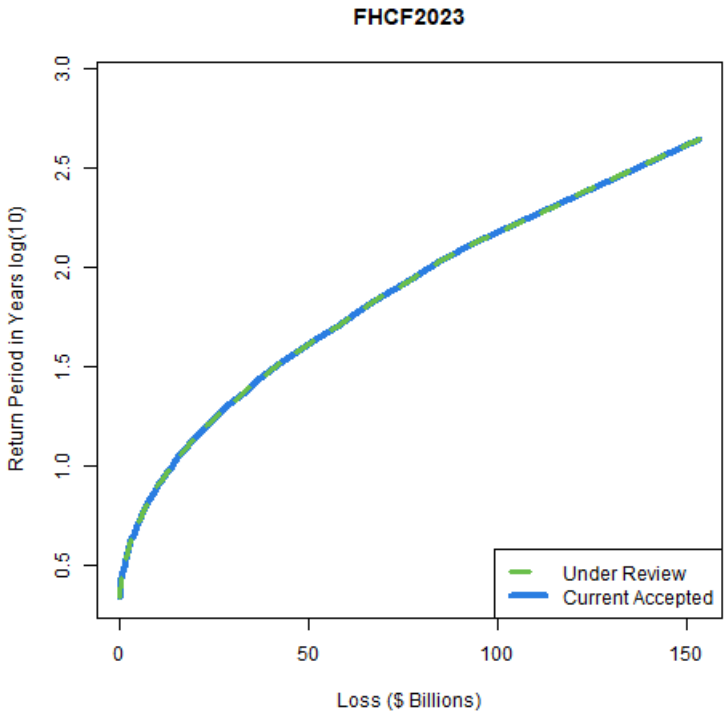


Figure 83. Personal and Commercial Residential Loss Curve Comparison (2023 FHCF)

Form A-8.F

Provide the expected hurricane loss and 10% (lower bound) and 90% (upper bound) hurricane loss levels for each of the Personal and Commercial Residential Return Periods given in Part A.2 and Part B.2, Annual Aggregate, and Part A.3 and Part B.3, Annual Occurrence. Describe how the uncertainty in hurricane vulnerability functions has been propagated to the uncertainty in portfolio loss and how it relates to the 10% and 90% hurricane loss levels.

Mean losses and uncertainty intervals are provided for each return period. Uncertainty in the vulnerability damage functions are accounted for in the model at the time losses are aggregated over exposure within an event. At a given intensity of the local hazard, the distribution of damage ratios about the mean damage ratio are combined with the uncertainty from the vulnerability propagated at each stage of accumulation. For each event the software includes the mean losses at the event level which are used to perform the calculations in this form.

The 10 and 90th percentile are currently computed using a bootstrap of mean losses within the catalog, and as such reflect the range of variability attributable to sampling within the event set rather than directly representing the uncertainty in the vulnerability functions. To derive the intervals, we repeatedly sampled with replacements from our dataset of 50,000 modeled occurrence losses. We then ranked and identified the return period losses of interest for each of the samples drawn. The procedure was repeated 100,000 times, yielding a bootstrap distribution at each of the return periods of interest. The 80% uncertainty intervals shown represent the 0.10 and 0.90 percentiles of the 100K bootstrap distribution determined for each return period.

Table 55. Part A.2: Personal and Commercial Residential Hurricane Probable Maximum Loss for Florida - Annual Aggregate (2017 FHCF Exposure Data)

		Based on 100K Bootstrap	
Return Period (Years)	**Expected Hurricane Loss Level (Millions)**	**10% Loss Level (Millions)**	**90% Loss Level (Millions)**
Top Event	333,432	294480.00	NA
1,000	149,294	141165.00	156,585
500	122,150	114390.00	126,573
250	95,963	93010.00	99,344
100	65,484	63621.00	67,318
50	45,045	44261.00	45,835
20	23,036	22492.00	23,637
10	11,259	11037.00	11,499
5	3,641	3561.00	3,742

Table 56. Part A.3: Personal and Commercial Residential Hurricane Probable Maximum Loss for Florida - Annual Occurrence (2017 FHCF Exposure Data)

		Based on 100K Bootstrap	
Return Period (Years)	**Expected Hurricane Loss Level (Millions)**	**10% Loss Level (Millions)**	**90% Loss Level (Millions)**
Top Event	333,432	269790.00	NA

		Based on 100K Bootstrap	
Return Period (Years)	Expected Hurricane Loss Level (Millions)	10% Loss Level (Millions)	90% Loss Level (Millions)
1,000	145,382	139088.00	151,602
500	117,878	111346.00	124,307
250	91,442	88727.00	94,903
100	60,999	59164.00	62,529
50	41,889	40777.00	42,897
20	20,775	20312.00	21,269
10	10,116	9888.00	10,337
5	3,336	3267.00	3,419

Table 57. Part B.2: Personal and Commercial Residential Hurricane Probable Maximum Loss for Florida - Annual Aggregate (2023 FHCF Exposure Data)

		Based on 100K Bootstrap	
Return Period (Years)	Expected Hurricane Loss Level (Millions)	10% Loss Level (Millions)	90% Loss Level (Millions)
Top Event	496,258	387804.00	NA
1,000	204,495	194862.00	217,215
500	163,818	157912.00	170,544
250	130,083	124593.00	133,913
100	89,502	86749.00	91,255
50	61,110	59786.00	62,627
20	31,711	30957.00	32,329
10	15,417	15106.00	15,819
5	5,069	4937.00	5,177

Table 58. Part B.3: Personal and Commercial Residential Hurricane Probable Maximum Loss for Florida - Annual Occurrence (2023 FHCF Exposure Data)

		Based on 100K Bootstrap	
Return Period (Years)	Expected Hurricane Loss Level (Millions)	10% Loss Level (Millions)	90% Loss Level (Millions)
Top Event	496,258	387804.00	NA
1,000	200,418	189185.00	206,437
500	158,599	152981.00	166,235
250	123,640	118382.00	128,340
100	81,952	79994.00	84,251
50	56,955	55323.00	58,582
20	28,419	27856.00	29,159
10	13,881	13620.00	14,144
5	4,636	4537.00	4,746

Form A-8.G

List assumptions necessary to complete Form A-8. Provide the rationale for assumptions and a detailed description of how the assumptions are implemented.

The 2017 FHCF and 2023 FHCF exposure data were modeled with a zero deductible assumption. Gross, zero deductible modeled hurricane losses were used in the preparation of this form according to the specifications provided. No additional assumptions were used in completing Form A-8: Hurricane Probable Maximum Loss for Florida.

Form A-8.H

Provide this form in Excel format. The file name shall include the abbreviated name of the modeling organization, the hurricane standards year, and the form name. Also include Form A-8 in a submission appendix.

Form A-8: Hurricane Probable Maximum Loss for Florida is provided here in the submission document and in Excel format separately in the accompanying electronic submission files named "VSK23FormA8.xlsx".

14 Appendix 6: Model Output Forms

Import log

```
********************************
**      Touchstone 2024A      **
********************************

********** Log header **********
Description:    [Import] initiated by [AIR-WORLDWIDE\i55842] on [CCSGTSFL3HN1]
Time Submitted: [2024-09-28 07:40:52,050]
Time Started:   [2024-09-28 07:40:52,107]
Time Ended:     [2024-09-28 07:41:58,630]
Duration:       [00:01:01]
Status:         [Completed]
Owner:          [AIR-WORLDWIDE\i55842]
Platform Name/
Identification: [Touchstone 2024A]
DataImport Version: [12.1.0.134]


********** Log Data Source Information **********
Import Type: [CSV]
Import Date Format: [MM/dd/yyyy]
Data Source: [\\kdcfile.air-worldwide.com\isfilesv1\clas\RRACS\SUBMISSIONS
\FL\FL_Commission_2023Standards\06_Actuarial\InputFolder\Contracts
\227.FormA1_2023Notional_ZipAll_20240928_Contract.csv]
Data Tables: [227.FormA1_2023Notional_ZipAll_20240928_Contract.csv 227.Map_c7a9ccbb-
c0fd-4f18-8830-d2d5f3a7c4eb 227.Default_a9926350-3f39-408b-8460-3158081a15a4
 227.FormA1_2023Notional_ZipAll_20240928_Location.csv ]
Delimiter: [,]
Text Qualifier: [Double Quote]
Has Header: [Y]

********** Log Import Options **********
Destination Database         : [FCHLPM_23_TS12_1_SP4_A_Forms_verification_EXP]
Destination SQL Server       : [CCSGTSFL3DB1\PRIMARYSQL]
Target Type                  : [Exposure Set]
Target Name                  : [FormA1_2023Notional_ZipAll]
Contract Type                : [Primary]
Mapping Set                  : [FormA1_2023Notional_Map]
Continue Geocode with Import Errors: [Y]
Duplicate Contract           : [Replace]
Location Error               : [Reject Contract]
Fail After                   : [Unlimited]
Max Errors                   : [0]
Existing Geocode             : [Preserve user-supplied and premium geocodes]
Geocoder                     : [AIR Geocode]
User-supplied Geocode Match Level Mapping Set : [None]
Include Decommissioned Offshore Platforms : [No]
Min HPC Cores                : [2]
Max HPC Cores                : [4]
Job Priority                 : [Normal]
Job Scheduled Time           : [Execute Immediately]
Premium Geocoding Batch Size:         [40000]
Premium Geocoding Internal Batch Size: [4000]
```

```
Currency                    : [USD]

Auto Exposure View: No



----> Executing Advance Geocoding Plan

----> Executing Advance Geocoding Plan

----> Executing Advance Geocoding Plan

----> Executing Advance Geocoding Plan

----> Executing Advance Geocoding Plan

----> Executing Advance Geocoding Plan

********** Log Summary Statistics **********
Elapsed Time: [00.00:00:59]
Total No. of records: [7880]
No. of records successfully processed: [7880]
Percentage of records successfully Imported: [100.00%]



********** Log Detailed Statistics **********
Summary of Property Records Imported: |
No. of Contracts                : |[8]|
No. of Locations                : |[7872]|
No. of Location Details           : |[7872]|
No. of Sublimits                : |[0]|
No. of Layers                   : |[0]|
No. of Treaty                   : |[0]|
No. of Facultative              : |[0]|
No. of Step Functions             : |[0]|
No. of Location Groups            : |[0]|


Summary of Property Records     NOT IMPORTED: |
No. of Contracts              NOT IMPORTED: |[0]|
No. of Locations              NOT IMPORTED: |[0]|
No. of Location Details       NOT IMPORTED: |[0]|
No. of Sublimits              NOT IMPORTED: |[0]|
No. of Layers                 NOT IMPORTED: |[0]|
No. of Reinsurance Treaty     NOT IMPORTED: |[0]|
No. of Reinsurance Facultative  NOT IMPORTED: |[0]|
No. of Reinsurance (Unknown)    NOT IMPORTED: |[0]|
No. of Step Functions         NOT IMPORTED: |[0]|
No. of Location Groups        NOT IMPORTED: |[0]|


Summary of Property Exposure Data           : |
Total of Replacement Value A Imported       : |[24,855,840,000.00]|
Total of Replacement Value A Not Imported     : |[0.00]|
Total of Replacement Value B Imported       : |[24,600,000.00]|
Total of Replacement Value B Not Imported     : |[0.00]|
Total of Replacement Value C Imported       : |[1,549,800,000.00]|
Total of Replacement Value C Not Imported     : |[0.00]|
Total of Replacement Value D Imported       : |[861,984,000.00]|
Total of Replacement Value D Not Imported     : |[0.00]|
```

```
Total of Replacement Value Imported          : |[27,292,224,000.00]|
Total of Replacement Value Not Imported      : |[0.00]|
Total Number of Risks Imported               : |[7,872]|


Geocode Statistics :|
GeoCoding Elapsed Time: [00.00:00:29]

[7872] locations records required geocoding
[0] locations records user retained geocodes
[0] locations records geocoded using premium geocoding
[7872] locations records were successfully geocoded using default geocoding
[0] location records were not geocoded

Summary of Geocode Match Level :|
[0] address(es) are matched at the Point level
[0] address(es) are matched at the Exact Address level
[0] address(es) are matched at the ZIP9 Centroid level
[0] address(es) are matched at the Relaxed Address level
[7872] address(es) are matched at the Postal Code Centroid level
[0] address(es) are matched at the City Centroid level
[0] address(es) are matched at the County Centroid level
[0] address(es) are matched at the Cresta Centroid level
[0] address(es) are matched at the Subarea 2 level
[0] address(es) are matched at the Area Centroid level
[0] address(es) are matched at the Country level
[0] address(es) are matched at the Disaggregated level
[0] address(es) are matched at the User Supplied level
[0] address(es) are matched at the Wind Turbine CRESTA level
[0] address(es) are not matched
[0] address(es) were not geocoded due to errors

Summary of Premium Geocoding Geocode Levels :|

Summary of User Provided Geocode Match Level :|
[7872] Address(es) have no provided match level

Summary of user provided Verisk BINS :|

********* Error Summary **********
******** Business Errors *********
********** Data Errors ***********

*********** Warnings ************
```

Analysis log

****
** Touchstone 2024A **
****

==========
This Florida Rate Filing Analysis Template contains minimum analysis options acceptable for rate making in Florida.
==========

The following analysis options are required for rate making in Florida:

Event Set:	50K US Hurricane (2024) - Florida Regulatory
Peril:	Tropical Cyclone - Wind
Demand Surge:	On
Storm Surge:	Off
Results Currency Set:	AIR Default
Results Currency:	USD
Loss Modification Factor:	None

Additional settings beyond minimum requirements can be turned on or off depending on company's portfolio. For example, users can select the output settings that meet their reporting needs and also customize the reinsurance settings that reflect the reinsurance structure of the portfolio.

The following analysis options can be customized depending on users' needs:
Average Properties
For Invalid Con/OCC Pairs
Output Options
Reinsurance

o Analysis Header Info

Analysis Type:	Detailed Loss Analysis
Express Analysis:	No
Analysis Name:	FormA1S2_FL_Reg_50K_WindOnly_DS_AP_API_202409280810
Template Name:	Florida Rate Filing Analysis
Analysis SID:	160
Result SID:	1
Activity ID:	245
HPC Job ID:	814
Description:	N/A
User:	AIR-WORLDWIDE\i55842
Time Submitted:	09/28/2024 08:10:48
Time Started:	09/28/2024 08:10:48
Time Ended:	09/28/2024 08:23:32
Duration:	00:12:37
Status:	Completed

o Error/Warning Summary

o Fatal Error

None

o Ignorable Errors

None

o Exposures Modelled

Total
100% Replacement Value
100% Locations

o System Info

System Version: 12.1.0.134
Platform Name/
Identification: Touchstone 2024A
SQL Server Name: CCSGTSFL3DB1\PRIMARYSQL
HPC Head Node: CCSGTSFL3HN1

o Analysis Target Info

Analysis Target Type: Portfolio
Analysis Target Name: FormA1_2023Notional_ZipAll
Exposure View Filter: Not Applied

Exposure Set(s): Database : Exposure Set Name
-------- ----------
FCHLPM_23_TS12_1_SP4_A_Forms_verification_EXP : FormA1_2023Notional_ZipAll

Analysis Statistics: Analyzed

Policy Count: 8
Total Location Count: 7872
Property Location Count: 7872
Workers Location Count: 0
Disaggregated Location Count: 0
Layers Count: 0
SubLimits Count: 0
Reinsurance Count: 0
Total Replacement Value: 27,292,224,000

o Event Set Options

Event Set Name: 50K US Hurricane (2024) - Florida Regulatory
Event Set Type: Stochastic
Event Filter: Off
Year Filter: Off
Location Filter: Off
Rule Filter: Off
Demand Surge: On
Custom Demand Surge(US-derived): No
Custom Demand Surge(Country-specific): No
Country-specific Demand Surge Options: Construction Cost Inflation Percentage- N/A
Countries/ Regions Supporting Country-specific Demand Surge- N/A

Exposure Exclusions for the Country-specific Demand Surge- N/A

Perils: Tropical Cyclone - Wind

Hazard Models:	Model:	Model Version:	Catalog:	Catalog Version:	Events:	Scenarios:
Verisk Hurricane Model for the U.S.	521	3.0.0	Verisk Hurricane Model for the United States	03.00.0709	89055	50000

o Financial Model Options

Disaggregation: Off
Average Properties: On
Invalid Con/Occ Pairs: Ignore

o Reinsurance Options

Program Name: N/A
Order of application of Fac: Do not apply
FAC Reinsurance Count: 0
Treaty Reinsurance Count: 0

o Custom Model Options

Custom Model: N/A

o Output Options

Loss Perspectives: Ground Up
Gross

Event Losses By: Portfolio
Geography: Event Total
Summary (AAL Only): Location Summary

Sub Peril: Off

Save By Treaty: Off
Save By Facultative: Off

Loss Details: Coverage

Auto Export CLF: No
Save By Zone: False
Zone By Peril: False
Retain Annual EP By Zone: False

o Analysis Management Options

Scheduled On: Execute Immediately
Requested Resource Type: core
Requested Min-Max Resources: 2-10
Priority: Normal
Processing Resource: On Premises
Result Server: CCSGTSFL3DB1\PRIMARYSQL
Result Database: FCHLPM_23_TS12_1_SP4_A_Forms_verification_RES
Results Currency Set: AIR Default
Results Currency: USD

Move Marine Craft Geocodes: Off
Commodity Prices
Gas: 0
Oil: 0

o Flexibility Options

No loss mod template was selected
No loss custom vulnerability template was selected

No loss custom frequency template was selected

Include Standard AIR Detailed Loss Analysis Result: Yes

o Terrorism Options

Terrorism Not Covered - Coverage solely provided by Standard Fire Policies (SFP)

o Physical Properties Info

Physical Properties computation completed at 09/28/2024 08:12:15
Time taken for Physical Properties computation: 00:00:55
Time taken for Post Processing of Physical Properties: 00:00:00
Total time taken for Physical Properties processing: 00:00:56
Physical properties were computed for all locations

15 Appendix 7: Model Evaluations

Model Evaluation by Dr. Carol Friedland, P.E., Ph.D., C.F.M., 2023 Vulnerability Hurricane Standards

Verisk's 2023 Vulnerability Standard submission has been reviewed. The following sections provide reviewer comments for each standard and disclosure.

V-1 Development of Building Vulnerability Functions

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

The vulnerability functions in the Verisk Hurricane Model for the U.S. were developed using research results published in the engineering literature, post-hurricane damage investigations conducted by experts in wind engineering, and insurance loss data. Verisk has used results of structural analysis performed by wind engineering experts, post-hurricane field investigation results, updated engineering literature, computational simulations, and analysis of loss data to update and improve the vulnerability standards since their initial development.

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

Vulnerability functions and their associated uncertainties within the Verisk Hurricane Model for the U.S. were derived by experts in wind and structural engineering from published literature and have been validated by results of damage surveys and historical claims data. To deal with the uncertainties, the damage functions include probability distributions around the mean damage ratio that varies as a function of wind speed. The vulnerability functions have been peer reviewed, both internally and externally. This overall approach to development of the vulnerability functions is 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.

The building stock classification set has been derived from census, tax assessor, engineering surveys, construction reports, and other sources. From these data, building stock classifications representative of Florida construction have been chosen.

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

The Verisk Hurricane Model for the U.S. includes approximately 32 vulnerability functions based on primary construction material (e.g., wood frame, masonry veneer – detailed in Disclosure V.1.8) and number of stories for

single family residential (i.e., traditional construction and manufactured housing) and commercial residential (i.e., apartment buildings and condominiums). For single family residences, which are most commonly just one or two stories, there is no variation of vulnerability functions with height. Building height is categorized for commercial residential structures based on primary construction material, with a maximum of three height categories. Building code and enforcement are accounted for regionally and temporally through application of vulnerability adjustment modifiers. Year-built categories include pre-1995, 1995-2001, 2002-2011, and post-2011. Buildings built prior to 1995 are considered 'old' while buildings built within the last six years (2019-2024) are considered 'new,' with buildings built between these periods considered using a year-built adjustment to account for structural aging. Year-built categories for manufactured homes include pre-1976, 1976-1993, 1994-1998, 1999-2007, and post-2007. Other construction characteristics are addressed through the Individual Risk Module.

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

The Verisk Hurricane Model for the U.S. includes separate vulnerability functions for commercial residential and personal residential primary structures, manufactured homes, and appurtenant structures. The model includes separately derived vulnerability functions based on coverage type (e.g., appurtenant structures are considered under separate coverage), and primary and secondary characteristics, which include occupancy (e.g., personal residential and commercial residential are separate occupancies) and construction class (e.g., manufactured homes are in a separate construction class), among other characteristics.

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

The Verisk Hurricane Model for the U.S. uses a sustained (one-minute) average wind speed of 40 mph as the minimum threshold for wind damage. This lower bound has been verified through engineering research, damage surveys, and historical claims data.

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 storm surge and wave action).

The Verisk vulnerability functions explicitly account for damage as a function of wind speed (and by extension, wind pressure). Damage due to water infiltration and windborne missile impacts are handled implicitly, having been calibrated and validated using insurance claims data. Storm surge, flooding, and wave action are not explicitly included in the Verisk Hurricane Model for the U.S.

Disclosures

1. Provide details of modifications to the building vulnerability component in the hurricane model since the currently accepted hurricane model.

The building vulnerability component of the Verisk Hurricane Model for the U.S. addresses three key updates to make the model relevant to 2024, namely: pre-computed factors that adjust base wind structural vulnerability when year built information is unavailable; vulnerability adjustments that account for structural aging and building technology changes, along with aging and deterioration of roofs; and defaulting "roof year built" secondary risk

feature to a new roof for buildings less than ten years old. These modifications are reasonable and reflect the changing characteristics of the residential building stock.

2. Provide a flow chart documenting the process by which the building hurricane vulnerability functions are developed and implemented.

The process by which the vulnerability functions were derived and implemented is provided. The flowchart shows how published research, engineering expertise, and results of damage surveys are combined to create the hurricane vulnerability functions, which are calibrated and validated by insurance industry claims and loss data. Within the validation process, modeled and actual damage ratios are associated with wind speeds and compared to determine if adjustments are needed in the vulnerability functions. The process is repeated until modeled and actual damage ratios are comparable.

3. Describe the nature and extent of insurance company hurricane claims data used to develop the building hurricane vulnerability functions. Describe in detail the breakdown of data into number of policies, number of insurers, dates of hurricane loss, amount of hurricane loss, and amount of dollar exposure, separated into personal residential, commercial residential, and manufactured homes.

Verisk has made extensive use of insurance claims data in validation of the model, from multiple companies and multiple storms since 1983. In addition to data specific to Florida, loss data from other areas has also been evaluated, including Hurricanes Ike, Irene, Isaac, and Sandy. Loss data have been used in both model development and model validation and come from company clients and Verisk's Property and Claims Services. New data are analyzed as they become available and relevant findings are incorporated once data validation is complete. Verisk has received detailed exposure data covering more than $6.5 trillion of personal (approximate 4.4 million policies), $130 billion of manufactured homes (approximately 434,000 policies), and $390 billion of commercial residential (approximately 964,000 policies). The cumulative claims data loss across all loss data aggregated to the ZIP code level exceeds $1.7 billion for events primarily before 2000. For detailed claims data at the location of the claim, cumulative claims data loss exceeds $8.6 billion resulting from over 3.5 million claims for events primarily after 2004. Approximately 86% of these losses are attributed to personal residential lines, with 4% and 10% being attributed to manufactured homes and commercial residential lines, respectively.

4. Describe any new insurance company hurricane claims data received and reviewed since the current accepted hurricane model. Indicate whether the new data, if any, have been incorporated in the hurricane model under review.

Since the current accepted hurricane model, Verisk has obtained industry insured loss estimates from Verisk's Property and Claims Services (PCS) division for 2022 Hurricane Ian, which impacted Florida. Additionally, industry insured loss estimates were obtained for 2021 Hurricane Ida, which primarily impacted Louisiana. PCS industry insured loss estimates are based on business line: personal, commercial, automobile. These data are generally at the state level or, for more significant events such as 2022 Hurricane Ian and 2021 Hurricane Ida, at the county level.

5. Describe the assumptions, data (other than insurance company hurricane claims data), methods, and processes used for the development of the building hurricane vulnerability functions.

In addition to insurance company hurricane claims data, the vulnerability functions are based on engineering analysis, post-event damage surveys, and expert consultation. In addition to the academic and industry

background of Verisk's engineering team, assessment of peer-reviewed literature and input from external reviewers ensure reasonable results.

6. Describe the basis, development, modeling, and treatment of uncertainties associated with the building hurricane vulnerability functions.

Verisk building vulnerability functions are characterized by a mean damage ratio as a function of hazard intensity with an associated probability distribution around the mean damage ratio, referred to as a secondary distribution. The secondary distributions are modeled using discretized transformed beta functions with two additional discrete spikes, representing the probabilities of no damage and total damage. The uncertainty in vulnerability is implicitly affected by primary and secondary risk features by changing the mean damage ratio in the model and accounting for variations in expected performance. An underlying assumption is that a significant portion of the uncertainty in damage at a given location can be attributed to uncertainty in wind loads.

7. Summarize post-event site investigations, including the sources, and provide a brief description of the resulting use of these data in the development of building hurricane vulnerability functions.

Verisk has fielded post-hurricane investigations for significant hurricanes that make landfall in the U.S. since Hugo in 1989, including several more recent hurricanes in 2015, 2017, 2018, 2022. In addition, Verisk has surveyed damage from major storms outside the mainland U.S., including 2017 Hurricane Maria in Puerto Rico and 2019 Hurricane Dorian in the Bahamas. These site inspections have served to enhance the in-house expertise on wind damage vulnerabilities and to help identify and confirm performance issues of different types of construction.

Generalizations regarding the performance of buildings in past events have found that "engineered" structures perform better that their "non-engineered" counterparts (both commercial and residential), the importance of year built on residential vulnerability, wind effects on non-structural elements, damage regimes for residential buildings based on windspeed, the improved wind resistance of masonry full-height exterior walls compared with wood-framed construction, and the importance of time effects for building vulnerability. This information obtained from post-event site investigations has been incorporated into the development and validation of the vulnerability model.

8. Provide the total number of building hurricane vulnerability functions available for

use in the hurricane model for personal and commercial residential classifications. Describe the categories of the different building hurricane vulnerability functions. Specifically, include descriptions of the building types and characteristics, building height, number of stories, regions within the state of Florida, year of construction, and occupancy types for which a unique building hurricane vulnerability function is used.

Vulnerability functions are included in the Verisk Hurricane Model for the U.S. for construction types that address the majority of personal and commercial residential construction in Florida, classified by occupancy, construction type, and height, year of construction, and gross area. These functions are further modified for secondary risk characteristics including region, siting considerations, construction details, year of construction, and building codes. Vulnerability functions for commercial residential occupancies are developed considering building height, as such structures vary more widely than the typical 1-2 stories for single family residences.

9. Describe the process by which local construction practices and statewide and county building code adoption and enforcement are considered in the development of the building hurricane vulnerability functions.

To account for variations in building code provisions, Verisk has identified unique building categories based on design wind speed, terrain exposure category, and code requirements of Windborne Debris Regions (WBDR) and High Velocity Hurricane Zones (HVHZ). Vulnerability functions have been developed for these building categories, representative of buildings built to the minimum requirements of FBC 2001 and 2010. Variations in local construction practices, building code adoption, code enforcement, and their effects on projected losses are handled as secondary risk characteristics in the Individual Risk Module, where detailed information can be input by the model user.

10. Describe the relationship between building structure and appurtenant structure hurricane vulnerability functions and their consistency with insurance company hurricane claims data.

The building structure and appurtenant structure vulnerability functions are calculated independently. Damage to an appurtenant structure is calculated separately from the primary structure based on the hazard and known characteristics of the appurtenant structure. Appurtenant structure vulnerability functions were developed through analysis of insurance company claims data, published research, and damage surveys when possible.

11. Describe the assumptions, data (including available insurance company hurricane claims data), methods, and processes used to develop building vulnerability functions when:

- *a. residential construction types are unknown, or*
- *b. one or more primary building hurricane characteristics are unknown, or*
- *c. one or more secondary characteristics are known, or*
- *d. building input characteristics are conflicting.*

Data provided by client companies, the census, and tax assessors are used to identify typical residential construction types within a region. Using these data, vulnerability functions for unknown residential construction types are developed through a weighted average of residential building vulnerability curves based on the prevalence of building construction types in that region. When primary building hurricane characteristics are unknown, a weighted average vulnerability function developed from the known characteristics is used to approximate the vulnerability function. The use of weighted average functions is a sound practice and is combined with proprietary and publicly available exposure data. This weighting does not apply to manufactured homes.

When secondary characteristics are known, this information is input into the Individual Risk Module, which modifies the vulnerability functions. Given the definitions of building input characteristics, it is reasonable to assume that conflicting data do not arise.

12. Identify the one-minute average sustained windspeed and the windspeed reference height at which the hurricane model begins to estimate damage.

The Verisk Hurricane Model for the U.S. uses a sustained (one-minute) average wind speed of 40 mph as the minimum threshold for wind damage, measured at a reference height of 10 m, which is the standard for

measurement and reporting of wind speeds. This lower bound wind speed is consistent with damage surveys and published literature.

13. Describe how the duration of windspeeds at a particular location over the life of a hurricane is considered.

The Verisk Hurricane Model for the U.S. includes the effects of hurricane duration using a stepwise procedure. For each given location, for the first period during the storm when the sustained winds exceed 40 mph, the damage occurring during this period is estimated, and the remaining undamaged portion of the exposure is determined. For each successive period where the winds exceed 40 mph, the same procedure is followed, and the remaining undamaged portion is subjected to damage in each time interval. In this manner, longer duration storms having the same maximum speed as shorter duration storms will show accumulation of additional damage, as has been reflected in damage surveys. The Verisk hurricane model team members presented a well-received paper on duration effects and how to model them at the 11th America's Conference on Wind Engineering in Puerto Rico in June 2009.

14. Describe how the hurricane model addresses wind-borne missile impact damage and water infiltration.

The Verisk Hurricane Model for the U.S. implicitly addresses wind borne missile impact damage and water infiltration to the extent that these damage types are included in historic insurance claims data. Additionally, the debris environment can be described through additional secondary characteristics (if known), selected by the user. The ability of the structures to resist water infiltration can also be described through mitigation techniques as a secondary characteristic through the Individual Risk Module.

15. Provide a completed Form V-1. Provide a link to the location of the form in the submission appendix.

See the section entitled Form V-1, One Hypothetical Event for reviewer comments.

V-2 Development of Contents Hurricane Vulnerability Functions

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

The vulnerability functions for contents in the Verisk Hurricane Model for the U.S. were developed using research results published in the engineering and insurance literature, post-event damage investigations conducted by experts in wind engineering and damage, and analysis of available insurance company claims data. Verisk has used updated research literature, computational simulations, and analysis of loss data to update and improve the contents vulnerability functions since their initial development.

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.

Based on a review of a scatterplot provided by Verisk showing modeled and historical content and building losses, the relationship between modeled and historical building and contents loss is reasonable, with less scatter in the simulated loss.

Disclosures

1. Provide details of modifications to the contents vulnerability component of the hurricane model since the current accepted hurricane model.

No changes are reported for the Verisk Hurricane Model for the U.S. contents vulnerability components related to wind hazards since the current accepted model.

2. Provide a flow chart documenting the process by which the contents hurricane vulnerability functions are developed and implemented.

Derivation and implementation of the contents vulnerability functions follow the same process used in the derivation and implementation of the building vulnerability functions, which is sound.

3. *Describe the assumptions, data, methods, and processes used to develop the contents hurricane vulnerability functions.*

Vulnerability functions for contents coverage are calculated as a function of building damage. Contents vulnerability functions are treated differently for personal and commercial residential structures, as the relationship between building and contents losses are different for these categories of buildings. Verisk uses the same process to validate contents loss functions as is used for building vulnerability validation. Validation considers content vulnerability functions at levels ranging from aggregate industry level losses to evaluation of claims data for individual policies, considering losses before and after application of policy terms.

4. Describe the basis, development, modeling, and treatment of uncertainties associated with the contents hurricane vulnerability functions.

Verisk contents vulnerability functions are characterized by a contents mean damage ratio as a function of building damage with an associated probability distribution around the mean damage ratio, referred to as a secondary distribution. For contents, secondary distributions are based on insurance company claims data for multiple events.

5. Provide the total number of contents hurricane vulnerability functions. Describe whether different contents hurricane vulnerability functions are used for personal residential, commercial residential, manufactured homes, unit location for condo owners and apartment renters, and various building classes.

There are distinct underlying contents vulnerability functions for personal and commercial residential buildings, as described in V-2.3. Given the two basic contents vulnerability functions for these two occupancies, there is a unique contents vulnerability function for each building construction/occupancy type.

6. Describe the relationship between building and contents hurricane vulnerability functions.

The vulnerability functions for contents coverage are calculated as a function of mean building damage. The contents damage functions have been developed from claims data, published studies, and expert engineering judgment. Values for contents losses are calculated separately from building damage.

7. Describe how the impact of water infiltration is accounted for in the contents vulnerability functions.

Water infiltration is commonly accepted as the primary driver of contents losses. Because the model's contents vulnerability functions are calibrated and validated using insurance company claims data, the impact of water infiltration is implicitly included in the contents vulnerability functions.

V-3 Derivation of Time Element Hurricane Vulnerability Functions

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

Time element vulnerability functions in the Verisk Hurricane Model for the U.S. were developed using research results published in the engineering and insurance literature, post-event damage investigations conducted by experts in wind engineering and damage, and analysis of available loss data. Verisk has used updated research literature, computational simulations and analyses, and analysis of loss data to update and improve the time element functions since their initial development.

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

Based on a review of a scatterplot provided by Verisk showing modeled and historical time element and building losses, the relationship between modeled and historical building and time element vulnerability functions is reasonable.

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

The time element vulnerability is based on the mean building damage, the estimated time to repair or replace the property, and the estimated cost of time element coverage. The estimated time required to repair or replace the property implicitly considers damage to the surrounding infrastructure and costs to temporarily relocate displaced occupants.

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

The time element vulnerability functions include time element hurricane losses associated with wind, missile impact, flood, and storm surge damage to infrastructure to the extent that these data are reflected in the model validation data (i.e., damage surveys and insurance claims data).

Disclosures

1. Provide details of modifications to the time element vulnerability component in the hurricane model since the current accepted hurricane model.

No changes are reported to the time element vulnerability component since the current accepted hurricane model.

2. Provide a flowchart documenting the process by which the time element hurricane vulnerability functions are developed

Derivation and implementation of the time element vulnerability functions follow the same process used in the derivation and implementation of the building vulnerability functions, which is sound.

3. Describe the assumptions, data, methods, and processes used to develop the time element hurricane vulnerability functions.

The time element vulnerability is based on the mean building damage, the estimated time to repair or replace the property, and the estimated cost of time element coverage. For low wind speeds, building damage is low and time element vulnerability is also low; however, at high wind speeds with significant damage, time element vulnerability can be significant, which has been seen in recent events.

Verisk uses the same process to validate time element loss functions as is used for building vulnerability validation. Validation considers time element vulnerability functions at levels ranging from aggregate industry level losses to evaluation of claims data for individual policies, considering losses before and after application of policy terms.

4. Describe the basis, development, modeling, and treatment of uncertainties associated with the time element hurricane vulnerability functions.

Verisk time element hurricane vulnerability functions are characterized by a mean number of days of downtime as a function of building damage with an associated probability distribution around the mean number of days of downtime, referred to as a secondary distribution. For time element, secondary distributions are based on insurance company claims data for multiple events.

5. Describe how time element hurricane vulnerability functions take into consideration damage to local and regional infrastructure.

Damage to local and regional infrastructure is not explicitly modeled. Time element vulnerability functions implicitly take into consideration local and regional infrastructure damage to the extent they are reflected in the historical insurance loss data used in model development, calibration, and validation.

6. Describe the relationship between building structure and time element hurricane vulnerability functions.

The time element vulnerability is based on the mean building damage and the estimated time to repair or reconstruct the damaged building. The relationships between building loss of use and building damage have been established based on published construction data and engineering judgment. Validation data implicitly include infrastructure damage and the costs for temporary relocation and other needs in the time element vulnerability functions.

V-4 Hurricane Mitigation Measures and Secondary Characteristics

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

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

Verisk's Individual Risk Module incorporates features to allow consideration of the identified wind mitigation measures.

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

The Individual Risk Module allows for consideration of a range of mitigation measures and secondary risk characteristics through modification functions, which vary with wind speed. Features have been selected based on research and damage surveys and include structural and non-structural elements, along with building condition and environmental features. This approach to modeling the effects of mitigation measures is theoretically sound and consistent with fundamental engineering principles.

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.

The effects of mitigation measures within the Verisk Hurricane Model for the U.S. have been validated from previous hurricane damage reports, engineering judgment, and available loss data. The percentage change in losses associated with the individual mitigation measures demonstrates their relative effectiveness in various wind speed regimes. Combinations of mitigation measures provide additional protection compared to single measures, but the benefits are appropriately not always equal to the linear sum of benefits from the individual measures. For example, a building having storm shutters that protect impact resistant windows would have a mitigation credit of less than the sum of these two individual measures, as there is some redundancy in the protection offered by shutters and impact glass.

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

The Verisk Individual Risk Module incorporates information about secondary characteristics through a structured, engineering-based framework that can be applied for one or more secondary characteristics using modification functions, which vary with wind speed. These modification functions have been developed using engineering principles and building performance observations and validated with historical insurance loss data. Content

vulnerability functions are calculated as a function of the building vulnerability functions and would therefore reflect the inclusion of secondary characteristics.

Disclosures

1. Provide details of modifications to mitigation measures and secondary characteristics in the model since the current accepted model.

No changes are reported for the Verisk Hurricane Model for the U.S. mitigation measures and secondary characteristics since the current accepted model.

2. Describe the software used to calculate the impact of hurricane mitigation measures and secondary characteristics, its identification, and current version. Describe whether or not such software has been modified since the current accepted hurricane model.

The Individual Risk Module is used to calculate the impact of hurricane mitigation measures and secondary characteristics. This module has not been updated since the current accepted hurricane model as described in Disclosure V-4.1.

3. Provide a completed Form V-2. Provide a link to the location of the form here.

See comments provided in the section entitled Form V-2, Hurricane Mitigation Measures and Secondary Characteristics, Range of Changes in Damage.

4. Provide a description of the hurricane mitigation measures and secondary characteristics used by the hurricane model, whether or not they are listed in Form V-2,

The mitigation measures listed in Table 14 of Verisk's V-3 response are comprehensive and reasonable reflections of factors that affect building performance in windstorms.

5. Describe how hurricane mitigation measures and secondary characteristics are implemented in the hurricane model. Identify any assumptions.

Mitigation measures and secondary characteristics are implemented through Verisk's Individual Risk Module using modification functions. Each modification function captures the changes in building vulnerability from the computed base vulnerability function associated with a particular mitigation measure as a function of wind speed. This modification is reflective of the effectiveness of the mitigation feature(s) in reducing damage under different intensity winds. Mitigation effects are determined based on structural engineering expertise and building damage observations. Mitigation modification functions that represent a combination of building features are applied to the base vulnerability functions to provide vulnerabilities for mitigated buildings. The way in which mitigation modifies the base vulnerability function is based on various 'rates and weights.' Rates account for the prevalence of use among the various mitigation options. Weights account for situations where more than one mitigation option is present. The Verisk Individual Risk Module assigns two types of weights to each mitigation measure, one for when multiple mitigation features are related to performance of the same system (e.g., the roof system), and the other for combinations of the effects of features that are more complex. The values of the weighting functions are dependent on wind speed. Verisk's system for handling mitigation options is robust and capable of handling

mitigation of single elements, whole building systems (e.g., roof systems—comprised of roof coverings, decking, framing, and attachment of decking and framing), and combinations of multiple elements and systems.

6. Describe how the effects of multiple hurricane mitigation measures and secondary characteristics are combined in the hurricane model and the process used to ensure that multiple hurricane mitigation measures and secondary characteristics are correctly combined.

Within the Verisk Hurricane Model for the U.S., the effects of mitigation measures and secondary characteristics are not simply calculated as the linear sum of individual measures but consider the combination of effects with multiple mitigation measures and secondary characteristics across varying wind speeds, described in V-4.5. This is a sound theoretical approach, and validation is performed to ensure that modeled mitigation factors are representative of historical insurance loss data. The system of weighting functions appears well designed and able to account for the wide range of possible interactions of various mitigation measures.

7. Describe how building and contents damage are affected by performance of hurricane mitigation measures and secondary characteristics. Identify any assumptions.

The performance of mitigation measures and secondary characteristics is explicitly accounted for in the estimation of building damage through the development of modified building vulnerability functions as described in V-4.A and V-4.5. The performance of mitigation measures is accounted for in the calculation of contents damage, as contents damage is calculated as a function of building damage.

8. Describe how roof age and roof covering type are incorporated in the hurricane model.

Verisk's Individual Risk Module uses modification functions to incorporate secondary characteristics such as roof age and roof covering type. The Individual Risk Module is described in detail in V-4.5.

9. Describe how hurricane mitigation measures and secondary characteristics affect the uncertainty of the vulnerability. Identify any assumptions.

Verisk vulnerability functions are characterized by a mean damage ratio as a function of hazard intensity with an associated probability distribution around the mean damage ratio. Inclusion of mitigation measures and secondary characteristics alters the mean damage ratio and in turn the associated probability distribution. This practice is sound and consistent with engineering principles.

10. Provide a completed Form V-3 if not considered as Trade Secret. Provide a link to the location of the form here.

See comments provided in the section entitled Form V-3, Hurricane Mitigation Measures and Secondary Characteristics, Mean Damage Ratios and Hurricane Loss Costs.

11. Provide a completed Form V-4. Provide a link to the location of the form here.

See comments provided in the section entitled Form V-4, Differences in Hurricane Mitigation Measures and Secondary Characteristics.

12. Provide a completed Form V-5 if not considered as Trade Secret.

See comments provided in the section entitled Form V-5, Differences in Hurricane Mitigation Measures and Secondary Characteristics, Mean Damage Ratios and Hurricane Loss Costs.

Form V-1: One Hypothetical Event

A. Windspeeds for 96 ZIP Codes and sample personal and commercial residential exposure data are provided in the file named "FormV1Input23.xlsx." The windspeeds and ZIP Codes represent a hypothetical hurricane track. Model the sample personal and commercial residential exposure data provided in the file against these windspeeds at the specified ZIP Codes, and provide the building and contents damage ratios and time element loss ratios summarized by windspeed (mph) and construction type.

The windspeeds provided are one-minute sustained 10-meter windspeeds. The sample personal and commercial residential exposure data provided consists of four structures (one of each construction type – wood frame, masonry, manufactured home, and concrete) individually placed at the population centroid of each of the ZIP Codes provided. Each ZIP Code is subjected to a specific windspeed.

For completing Part A, Estimated Damage for each individual windspeed range is the sum of ground up hurricane loss to all structures in the ZIP Codes subjected to that individual windspeed range, excluding demand surge and flood (including hurricane storm surge). Subject Exposure is all exposures in the ZIP Codes subjected to that individual windspeed range.

For completing Part B, Estimated Damage is the sum of the ground up hurricane loss to all structures of a specific type (wood frame, masonry, manufactured home, or concrete) in all of the windspeed ranges, excluding demand surge and flood (including hurricane storm surge). Subject Exposure is all exposures of that specific construction type in all of the ZIP Codes.

One reference structure for each of the construction types is to be placed at the population centroid of the ZIP Codes. Do not include appurtenant structure, contents, or time element coverages in the building damage ratios. Do not include building, appurtenant structure, or time element coverages in the contents damage ratios. Do not include building, appurtenant structure, or contents coverages in the time element loss ratios.

Based on experience, the Verisk Hurricane Model for the U.S. results presented in Parts A and B appear reasonable in absolute magnitude and in the ranges and trends. In the Part B submission, the relative performance of the construction types appears reasonable. Manufactured homes have a long and well documented history of poor performance compared to site-built homes (although the performance of newer manufactured homes has been improving). This expected result is demonstrated. Similarly, concrete buildings historically outperform wood framed or masonry buildings, which is reflected in Part B results. Masonry buildings are shown to slightly outperform wood framed buildings, which is also expected due to the increased strength of the exterior walls. The modeled event used by Verisk for the current Form V-1 submission is based on wind speeds of 1-hour duration. It is expected that losses from a 1-hour duration event would be significantly less than would be observed following a typical hurricane duration. At the request of the review, Verisk produced additional modeling data to confirm the magnitudes of damage by wind speed and construction type (Parts A

and B) corresponding to a longer duration event. These results are in line with reviewer experience of building performance.

B. Confirm that the structures used in completing the form are identical to those in the above table for the reference structures. List assumptions necessary to complete Form V-1 (e.g., regarding structural characteristics, duration, or surface roughness). Provide the rationale and a detailed description of the assumptions are implemented.

The Verisk Hurricane Model for the U.S. requires a sustained (one-minute) wind speed time profile to calculate damage ratios. For the purposes of Form V-1, Verisk has assumed a hypothetical event of 1-hour duration. Additionally, the replacement value for time element was assumed to be equal to the time element limit in the exposure data file.

C. Provide separate plots of the Estimated Damage/Subject Exposure (y-axis) versus Windspeed (x-axis) for the Building, Contents, and Time element data in Part A.

Plotted Estimated Damage/Subject Exposure plots are reasonable for the reference structures and wind speeds of 1-hour duration.

D. Include Form V-1 in a submission appendix.

Form V-1 was reviewed in Excel format without truncation.

Form V-2: Hurricane Mitigation Measures and Secondary Characteristics, Range of Changes in Damage

A. Explain how the hurricane vulnerability functions for the two reference structures are developed. Demonstrate that the hurricane vulnerability function for each reference structure is related to one of the hurricane model's standard building structure vulnerability functions for frame and masonry constructions.

The hurricane vulnerability functions for the two reference structures are developed by modeling the structures in the Verisk Hurricane Model for the U.S. The ground-up losses are computed and divided by the replacement value to obtain the mean damage ratios within the vulnerability functions. The Individual Risk Module allows for consideration of a range of mitigation measures and secondary risk characteristics through modification functions, which vary with wind speed.

B. Place the reference building at the population centroid for ZIP Code 33921 in Lee County.

C. Provide the change in the zero deductible personal residential reference building damage ratio (not hurricane loss cost) for each individual hurricane mitigation measure and secondary characteristic listed in Form V-2, as well as for the combination of the four hurricane mitigation measures and secondary characteristics provided for the Mitigated Frame Building and the Mitigated Masonry Building below.

The relative effectiveness of different hurricane mitigation measures with wind speed is presented in the tables of Verisk's Form V-2 response. Form V-2 reports relative changes in mean damage ratio and shows minimal differences between the current accepted model.

Combined with review of Form V-3, the values provided in Form V-2 appear reasonable and appropriate in magnitude and variation with wind speed, based on reviewer experience. The general magnitudes and trends in change in damage for the fully mitigated frame and masonry buildings appear reasonable and in line with reviewer experiences and expectations. For example, damage for the mitigated frame and masonry buildings is approximately half as much as the reference structure for sustained wind speeds of 85-110 mph. This very significant improvement in performance is expected, as the selected mitigation options address several of the most common design and construction deficiencies that prevent buildings from performing satisfactorily at speeds near design code values.

D. List assumptions necessary to complete Form V-2, including those for membrane and metal roof covering, roof age, duration, and surface roughness. Provide the rationale and a detailed description of how the assumptions are implemented.

The Verisk Hurricane Model for the U.S. requires a sustained (one-minute) wind speed time profile to calculate damage ratios. Although wind speed is not an explicit model input, the requested wind speeds were hardcoded at the reference location. Duration effects were not accounted for in the response to V-2.

E. Provide an explanation for cells filled with "0" or blank cells.

Cells filled with "-" values indicate illogical combinations where values do not exist while cells filled with "0.0" indicate that the specified secondary characteristic has a negligible impact on the wind vulnerability.

F. Provide this form in Excel format without truncation. The file name shall include the abbreviated name of the modeling organization, the hurricane standards year, and the form name. Also include Form V-2, in a submission appendix.

Excel versions of Forms V-2 and V-3 without truncation were reviewed.

Form V-3: Hurricane Mitigation Measures and Secondary Characteristics, Mean Damage Ratios and Hurricane Loss Costs (Trade Secret Item)

A. Provide the mean damage ratio (without including any insurance considerations) to the reference building for each individual hurricane mitigation measure and secondary characteristic listed in Form V-3, as well as the percent damage for the combination of the four hurricane mitigation measures and secondary characteristics provided for the Mitigated Frame Building and the Mitigated Masonry Building below.

The table in the Form V-3 form response provided to the reviewer contains mean damage ratios for the reference and mitigated frame and masonry structures, as well as for structures with single mitigation options. The general magnitudes and trends of the mean damage ratio variation with wind speed for these structures and mitigation options appear reasonable and in line with reviewer experiences and expectations. As discussed in the review of Form V-2, mean damage ratios for the mitigated wood frame structure are on the order of half as much as the reference structure for sustained wind speeds of 85-110 mph, which is an expected result, as the selected mitigation options address several of the most common design and construction deficiencies that prevent buildings from performing satisfactorily at speeds near design code values. At sustained winds of 160 mph, the mitigation measures still provide significant improvement in mean damage ratio, but relatively less improvement compared to the reference structure. This again is an expected result, as wind loads and debris associated with

these higher wind speeds are well beyond those anticipated in the design code, exposing many more potential failure modes than the common ones addressed by the four selected mitigation options.

B. Provide the zero deductible personal residential hurricane loss cost rounded to three decimal places, for the reference building and for each individual hurricane mitigation measure and secondary characteristic listed in Form V-3, as well as the hurricane loss cost for the combination of the four hurricane mitigation measures and secondary characteristics provided for the Mitigated Frame Building and the Mitigated Masonry Building below.

The loss cost reflects the mean damage ratio presented in V-3 applied to the structure value. As detailed in Form V-3.A, the mean damage ratios are in line with expected results, yielding appropriate loss cost.

C. Place the reference building at the population centroid for the ZIP Code 33921 in Lee County

D. List assumptions necessary to complete Form V-3, including those for membrane and metal roof covering, roof age, duration and surface roughness. Provide the rationale and a detailed description of how the assumptions are implemented.

Please see the review of Form V-2.D.

E. Provide a graphical representation of the hurricane vulnerability curves for the reference building and the fully mitigated building.

Graphical representation of the mean damage data presented in V-3 accurately represent the tabular values provided and are appropriate.

F. If not considered as Trade Secret, provide this form in Excel format without truncation. The file name shall include the abbreviated name of the modeling organization, the hurricane standards year, and the form name.

An Excel version of Form V-3 without truncation was reviewed.

Form V-4: Differences in Hurricane Mitigation Measures and Secondary Characteristics

A. Provide the differences between the values reported in Form V-2, relative to the equivalent data compiled from the currently accepted hurricane model.

Values provided by Verisk in Form V-4 have been confirmed through reviewer calculation of Form V-2 data for the previous and current submission.

B. List assumptions necessary to complete Form V-4, including those for membrane and metal roof covering, roof age, duration, and surface roughness.

Please see the review of Form V-2.D.

C. Provide a summary description of the differences.

The differences are not substantive, with a maximum increase of 0.1% and a maximum decrease of 1.2%.

D. Provide this form in Excel format without truncation. The file name shall include the abbreviated name of the modeling organization, the hurricane standards year, and the form name. Also include Form V-4 in a submission appendix.

The reviewer was provided a copy of Form V-4 in Excel format without truncation.

Form V-5: Differences in Hurricane Mitigation Measures and Secondary Characteristics, Mean Damage Ratios and Hurricane Loss Costs (Trade Secret Item)

A. Provide the differences between the values reported in Form V-3 relative to the equivalent data compiled from the current accepted hurricane model.

Values provided by Verisk in Form V-5 have been confirmed through reviewer calculation of Form V-3 data for the previous and current submission.

B. List assumptions necessary to complete Form V-5, including those for membrane and metal roof covering, roof age, duration, and surface roughness.

Please see the review of Form V-2.D.

C. Provide a summary description of the differences.

Minor differences are shown on Form V-5, most notably at 160 mph for both frame and masonry structures. Some variation in the mean damage ratios provided in Form V-3 is expected between submissions given continuous validation of the vulnerability model.

D. If not considered as Trade Secret, provide this form in Excel format and in a submission appendix. The file name shall include the abbreviated name of the modeling organization, the hurricane standards year, and the form name.

The reviewer was provided a copy of Form V-5 in Excel format without truncation.

CONCLUSION

The Hurricane Standards Report of Activities as of November 1, 2023 by the Florida Commission on Hurricane Loss Projection Methodology has been reviewed. The information submitted by Verisk in response to this document has been reviewed in detail for each of the standards and disclosures. A summary of Verisk's response and evaluation of the approach has been provided by the reviewer.

Based on this review, Verisk's response appears thorough and complete. The vulnerability functions within the Verisk Hurricane Model for the U.S. have been developed and validated through research reported in the insurance and wind and structural engineering literature, engineering analysis, post-storm field investigations by engineering experts, and insurance company claims data. The Verisk team has significant experience and expertise in this area and has actively presented results of its vulnerability research at national and international

engineering conferences. The methodology used in development of the vulnerability functions is theoretically sound. Implementation of these vulnerability functions produces reasonable damage ratios in line with insurance loss data and reviewer expectations.

Carol Friedland, P.E., Ph.D., C.F.M.

October 11, 2024

Model Evaluation by Paul Ericksen, FCAS, MAAA, Actuarial Standards

545 WASHINGTON BOULEVARD JERSEY CITY, NJ 07310–1686
TEL: (201) 469-2369 FAX: (201) 748-1967 E- MAIL: paul.ericksen@verisk.com

PAUL ERICKSEN, FCAS, MAAA
PRINCIPAL, ACTUARIAL CONSULTING

October 27, 2024

Ms. Julia Borman, Ph.D.
Director, Consulting & Client Services
Verisk Extreme Event Solutions
Lafayette City Center, 2 Avenue de Lafayette
Boston, MA 02111

Re: Actuarial Hurricane Standards Expert Certification

Dear Ms. Borman,

This report supports my completion of Form G-5 (Actuarial Hurricane Standards Expert Certification) that will be part of Verisk's submission to the Florida Commission on Hurricane Loss Projection Methodology.

I, Paul Ericksen, am a Principal in the Actuarial Consulting division of ISO. I am responsible for the content of this analysis. I am a Fellow of the Casualty Actuarial Society and a member of the American Academy of Actuaries. I meet the Qualification Standards of the American Academy of Actuaries to prepare this report.

I would be happy to answer any questions that you may have regarding this report.

Sincerely,

Paul Ericksen

Paul Ericksen, FCAS, MAAA
Principal, Actuarial Consulting
201-469-2369

© Insurance Services Office, Inc., 2024

October 27, 2024

INTRODUCTION

BACKGROUND AND OBJECTIVES

Verisk Extreme Event Solutions has requested that Paul Ericksen of Insurance Services Office complete form G-5 (Actuarial Hurricane Standards Expert Certification) for purposes of the submission of the Verisk Hurricane Model to the Florida Commission on Hurricane Loss Projection Methodology ("Commission)".

This report supports the completion of Form G-5.

RELIANCES AND LIMITATIONS

Our analysis and the results contained herein are subject to the following reliances and limitations:

1. This report was provided for purposes of the Verisk Hurricane Model's submission to the Commission. Any other use or disclosure must be agreed to in writing by ISO. The actuary signing this report is available to answer questions about it.

2. By their nature, insurance claims are subject to variability. The ultimate liabilities depend on the outcome of future contingent events, the result of which cannot be known in advance. This uncertainty is present in any actuarial projection. As such, future actual hurricane losses will differ from projected estimates based on Verisk Hurricane Model.

3. In preparing our report, we have relied on data and information provided to us by Verisk Extreme Event Solutions. We have neither audited nor verified the data. ISO does not assume responsibility for any error or omission in the data or information provided to us.

© ***Insurance Services Office, Inc., 2024***

October 27, 2024

EXECUTIVE SUMMARY

Based on my review of the hurricane model submission, I have concluded that the Verisk Hurricane Model (V3 as implemented in Touchstone 2024A) meets the actuarial standards of the Florida Commission on Hurricane Loss Projection Methodology.

Details regarding the specific actuarial hurricane standards are included in the subsequent section of this report.

In my review, I have relied on data and information provided by Verisk Extreme Event Solutions regarding its hurricane model submission. Such information includes the following:

- Responses to the actuarial hurricane standards, including the disclosures for each of the standards
- Actuarial hurricane standard forms included in its submission, in both Excel and Word format
- Documentation regarding the Verisk Hurricane Model
- Information learned during meetings I had with Verisk Extreme Event Solutions that were held on 9/27/2024, 10/1/2024, and 10/4/2024.

© ***Insurance Services Office, Inc., 2024***

October 27, 2024

ACTUARIAL HURRICANE STANDARDS

STANDARD 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*.

Verisk Hurricane Model's response to Standard A-1 is consistent with the response included as part of its previous hurricane model submission.

STANDARD 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*.

Verisk Hurricane Model's response to Standard A-2 is consistent with the response included as part of its previous hurricane model submission.

STANDARD A-3

Hurricane Coverages:

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

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

© ***Insurance Services Office, Inc., 2024***

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.*

Verisk Hurricane Model's response to Standard A-3 is consistent with the response included as part of its previous hurricane model submission.

STANDARD 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 and longitude) level of resolution.*

Verisk Hurricane Model's response to Standard A-4 is consistent with the response included as part of its previous hurricane model submission.

STANDARD A-5

Hurricane Policy Conditions:

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

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

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

© ***Insurance Services Office, Inc., 2024***

Verisk Hurricane Model's response to Standard A-5 is consistent with the response included as part of its previous hurricane model submission.

STANDARD A-6

Hurricane Loss Outputs and Logical Relationships to Risk:

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:*
   - *masonry construction versus frame construction,*
   - *personal residential risk exposure versus manufactured home risk exposure,*
   - *inland counties versus coastal counties,*
   - *northern counties versus southern counties, and*

© ***Insurance Services Office, Inc., 2024***

- newer construction versus older construction.

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

Verisk Hurricane Model's response to Standard A-6 is consistent with the response included as part of its previous hurricane model submission.

© ***Insurance Services Office, Inc., 2024***

Model Evaluation by Robert R. Cabeca, Computer/Information Hurricane Standards

Touchstone® is a product of Verisk.

Robert R. Cabeca

Independent Information Technology Auditor

October 2024

Overview

This report documents the findings of the peer review I, Robert Cabeca, performed in September 2024, of the Verisk Hurricane Model for the United States v3.0.0, as implemented in Touchstone 2024A for the state of Florida.

The intent of this audit is to ensure that Verisk Hurricane Model for the United States v3.0.0 as implemented in 2024A meets the compliance requirements established by the Florida Commission on Hurricane Loss Projection Methodology.

Due to the diverse geographic locations of stakeholders, this peer review was performed via video, Microsoft Teams, email, SharePoint, and telephone, inclusive of all directly responsible, assigned and involved team members and stakeholders which facilitated my ability to:

- Readily interview directly responsible, assigned and involved team members and stakeholders to answer direct and specific questions pertaining to any aspect of any identified system in addition to further investigate any potential or actual deficiencies of stated FCHLPM requirements under this current audit.
- Review historical and current documents, flowcharts, processes, software code, reports, and presentations which detail potential proof of meeting all stated FCHLPM requirements.
- Engage in live interactive walkthroughs of software code with the programmers and developers to validate the compliance of requirements to both industry standard software engineering practices and FCHLPM.
- Verbal walkthroughs of flowcharts, diagrams, processes and / or any other material I may have designated as necessary for review.

I was not denied access to any information I sought to review or investigate.

I was not denied access to any information I sought to review or investigate nor was I coaxed to include any information in this audit that I myself did not review and evaluate. As such, all of my statements in this audit are a direct result of my own investigation supported by exhibits I personally examined.

Summary of Findings of the 2024 Peer Review

This review was performed on The Verisk Hurricane Model for the U.S. v3.0.0 as implemented in Touchstone® 2024A.

The audit focused on the new enhancements The Verisk Hurricane Model for the U.S. v3.0.0 implemented in Touchstone® 2024A while also examining the existing infrastructure and systems that were not expected to change.

This year, in addition to enhancements that support legacy users of M521, the significant enhancements in this release were made at the data model level to bring them up to current standards. These modifications and the structures used to modify the data model were audited as thoroughly as all other unchanged components to ensure continued compliance to the FCHLPM requirements of the Verisk Hurricane Model for the U.S. v3.0.0 as implemented in Touchstone® 2024A.

CI Audit Group	Requirement Met (Yes / No)	Comment
CI-1 HURRICANE MODEL DOCUMENTATION	**Yes**	The Verisk CI team continues to apply documentation standards across all documents. The review found several documents that were deficient to this requirement. The team will continue to improve this requirement.
CI-2 HURRICANE MODEL REQUIREMENTS	**Yes**	The enhancements document denoted all changes for this release. All documents, datasets, code, databases, and other supporting materials were made available for audit.
CI-3 HURRICANE MODEL ORGANIZATION AND COMPONENT DESIGN	**Yes**	All flowcharts comply with the flowchart diagraming and notating standards. Interface specifications were depicted according to implemented standards.
CI-4 HURRICANE MODEL IMPLEMENTATION	**Yes**	Development code was reviewed, Network Organization details were validated, regression testing was shown to be used for code integrity. **At this time there is no cross-reference list of implementation source code terms and variable names corresponding to CI-4 G.1 to satisfy CI-4 G.2. The Verisk team is working on producing this document.**
CI-5 HURRICANE MODEL VERIFICATION	**Yes**	Physical unit conversions in the model code have not changed and were shown to be historically consistent. QA Teams switched from using ClearQuest to Azure DevOps for issue tracking of errors and failures. Standardized procedure is followed to address new requirements for builds
CI-6 HUMAN-COMPUTER INTERACTION	**Yes**	In this model release, there were no changes to the internal or external user interfaces.
CI-7 HURRICANE MODEL MAINTENANCE AND REVISION	**Yes**	Procedures were validated that govern system configuration changes & system functionality changes. SharePoint is used to archive and monitor requirements, in addition to storing and sharing design and test plans.

CI-8 HURRICANE MODEL SECURITY	**Yes**	List of security tools was provided. Access is restricted to services based on authorization and multifactor authentication. Endpoint security is enforced by CrowdStrike, forwarding auditable events to the Splunk SIEM. The Verisk Hurricane Model for the U.S. v3.0.0 as implemented in Touchstone® 2024A team is constantly and persistently innovating and investigating areas for improvement. Items brought to the attention of the Verisk team are:

Detailed Findings of the Peer Review

This peer review audit has been conducted upon The Verisk Hurricane Model for the U.S. v3.0.0 as implemented in Touchstone® 2024A for The Florida Commission on Hurricane Loss Prevention Methodology (FLCHLPM) as of November 2024.

The findings are grouped according to the eight computer standards (CI-1 to CI-8) established by FLCHLPM as of November 2024.

The following Teams and persons or proxies from the following groups were present and available during the audit to answer questions and provide detailed explanations: Engineering, Verification/Actuarial, Quality Assurance, Security, Customer Documentation and User Interface, all of whom demonstrated their knowledge upon detailed exhibits of all auditable requirements. (Full list of attendees referenced flcmAuditSlides2023.pdf Table 1. CI Audit Attendees, 9.30.2024) At no time did I have an inquiry for which the appropriate and designated person(s) were not available. This made the audit process expeditious, efficient, and thorough.

In this interview process, the requirements for all sections C1-C8 of the FCHLPM standards were iterated, discussed and reviewed with the specific personnel of each group, via Microsoft Teams Video Meetings with additional follow-up items performed via email and telephone.

Standard CI-1: Hurricane Model Documentation

Verisk maintains a central document management and repository defined in SharePoint, internally referred to as “NGP Releases”, for both internal users and external clients documentation. The Verisk CI team refers to their SharePoint implementation as AIRPort. Microsoft Teams provides a secure interface for accessing the SharePoint repository to only authorized persons, further ensuring that read and editability are restricted based on given authorization.

The Verisk Information Technology team manages, supports, and maintains the Microsoft Teams and SharePoint systems. The Verisk CI Team manages who has access to which resources, and the level of their access.

All documentation is maintained separately from the source code and stored in dedicated document repositories which are securely and easily accessible online by staff, in addition to authorized designated external client users.

During the entire audit process, Verisk personnel were utilizing this NGP Releases document repository and the designated MS Teams / SharePoint directories to present the software documentation, requirements, software

design and implementation, test procedures and plans, code guidelines and IT policy. A separate repository for the Computer Information Standards is monitored, maintained, and regularly updated.

Most documents consist of a revision history, author, approver, table of contents, and revision date. Based on last years request to enhance document location and tracking, I observed the implementation of standard document naming conventions to enhance efficiencies and expediencies.

Documentation standards continue to be applied to documents not yet brought into compliance. The challenge of missing this information is of course assuring relevancy and recency of the contents of the documentation assuring the consumers of the documentation that they are referring to the correct and most up to date information. The Verisk CI team is encouraged to continue bringing all documents into requirements compliance.

Microsoft Teams is frequently used and relied upon heavily for team engagement, meetings, discussion, reviews, and document and code collaboration which creates greater efficiencies in gaining quick access to geo-disperse team members. When team members are not available on teams and are needed, they are reachable via phone.

Software and model-related documentation are generated and maintained by each of these groups: Engineering, Verification/Actuarial, Quality Assurance, Security, Customer Documentation, User Interface, Research, and Client Services. It is verified that each of these groups reviews and signs out the documentation for each version as indicated in the document version history. This allows for detailed tracking of changes and update history.

The Verisk Hurricane Model for the U.S. v3.0.0 as implemented in Touchstone® 2024A has an online Help system that is accessible by users from within the software. The Help system is a keyword query search, not context-sensitive, by which a list of pertinent items to the search keywords is provided. There is also an internal Wiki site where other documentation accessible by users is additionally stored. The Wiki documents are redundant and not a primary source for user support.

If users seeking documents through the help system are not able to locate a document they seek, they are readily able to create a service request to the CCSG team for the desired information. These requests are tracked in the Salesforce CRM ticketing system. Additionally, user recommendations are addressed through the CCSG team.

The “List of All Externally Acquired Hurricane Model Specific Software and Data Assets” spreadsheet has been provided and reviewed. The Excel spreadsheet identifies the software, its version, update level, date of inception, and its purpose and use. The software acquisition, licensing, implementation, storage and access are controlled and managed by the Information Technology department and tickets are opened through IT to support and manage the software and data assets.

All owners of the CI Audit sections are identified with contact information in the “points of contacts” section. When the “Design Document” is checked out, all meta data about who accessed it, date & time stamp, length of time, and changes made are logged.

The Enhancements and Florida Commission Documentation Map document, which includes version specific updates and enhancements to The Verisk Hurricane Model for the U.S. v3.0.0 as implemented in Touchstone® 2024A was reviewed. This document contains a detailed table that describes all the changes in the software version.

Within the Computer Information Standards documentation is a table that includes a field that itemizes the version-specific changes, and the other fields in this table maps the itemized changes to the pertinent documents in the Computer Standards documentation set C1-C8. A list of all acquired software is maintained with version number and date and update patch level.

Documents are created and stored separately for each software component and for each software release of Touchstone®, identifying each software requirement and all documents are stored and maintained in the document repositories identified. The utility to do this is with DITA XML. Development documents are in the process of being moved from SharePoint into AZDO (Azure Development Ops) into the same tool in a separate directory structure using AZDO.

The Document naming policy is described in CI-7.2 and documents reviewed here are shown to comply with the policy. This policy iterates date and time stamps to provide clear reference to document history and recency.

The tables that are specified in Hurricane Standard CI-1.D that contain the items listed in Hurricane Standard G-1 were reviewed and are structured as dictated in the ROA C-1, 6.

All audit requirements for CI-1: Hurricane Model Documentation are met.

Standard CI-2: Hurricane Model Requirements

The online central SharePoint repository stores all the requirements documentation for the development of the Verisk Hurricane Model for the U.S. v3.0.0 as implemented in Touchstone® 2024A.

For the purpose of this Audit, all the documents pertinent to the items identified in the Enhancements table were available for review.

The enhancements table iterates the specific changes in this release in addition to the motivation and rational that triggers the development of each enhancement which are all explained in detail. All changes are illustrated and documented. Also denoted are related items that will not be changed as part of this release and the reasoning defining that.

The teams made available all sets of documents related to this versions' enhancements and exhibited how the documents support each enhancement item across related documents. These were reviewed to verify compliance with FLHCLPM requirements.

The Network Organization structure was depicted as illustrated network diagrams and reviewed. The Touchstone architecture was seen as a flat NT client server network where the catalogs and model files are accessed via the model data share via user requests.

All audit requirements for CI-2: Hurricane Model Requirements are met.

Standard CI-3: Hurricane Model Organization and Component Design

Technical personnel from the Research, Modeling, Software Development, and Database groups answered questions about the architecture of the enhanced components. Documentation for the Verisk Hurricane Model for the U.S. v3.0.0, implemented in Touchstone® 2024A, is available in the SharePoint repository and the CI Standards repository.

A dedicated folder organizes all Control and Data Flow diagrams (flowcharts), which were made available for review. The team provided detailed walk-throughs of randomly selected process diagrams that represent the current, consistently followed workflow.

All flowcharts now adhere to defined diagramming standards for readability and consistency. Source files (i.e. Visio) for all flowcharts was available for review. All flowcharts are designed to be free-standing and self-explanatory. Interface specifications were observed in schema and process flow documents. A tracking spreadsheet lists all flowchart files and their descriptions, and the Verisk Flowchart Mapping Standards reference guide, which applies to all flowcharts, was reviewed. The Software development and production processes were reviewed in detail.

Interface specifications were exhibited and reviewed and detailed for organizational components and teams, i.e., business, model, software, etc. Interfaces were depicted in accordance with the flowchart standards in place. It was exhibited that Flowcharts iterated components, sub-components, arcs and labels consistently across diagrams.

Touchstone is implemented on a single platform. Schema for all data files and field types are documented in the Catastrophe Model Implementation document. The source document for the schemas was reviewed for consistency.

The Porting and Model Implementation in Touchstone flowchart document was shown to accurately depict standalone flowcharts detailing hurricane model-related processes across organizational components. All flowcharts are supported by their related documentation.

All audit requirements for CI-3: Hurricane Model Organization and Component Design are met.

Standard CI-4: Hurricane Model Implementation

Verisk granted access to review live code, technical documentation, coding standards, and guidelines for all programming languages stored in their online Document Repositories. During the review of sample code related to meteorology, vulnerability, and actuarial components by the developers, no mentionable compliance issues were identified.

The Network layout was presented and reviewed showing the workflow from Client Tier to the Application Services tier, Analysis Management tier, Analysis Services tier, and finally to the Data Services tier. The system runs on a single platform and on a single flat Network. The same software stack is used for each deployment. The hardware, operating system, and essential software requirements are exactly the same for every deployment. Network diagrams, schematics, and models were reviewed.

Network organization documentation, implementation and maintenance procedures are managed by the Information Technology and Security departments. Details were provided as to the processes that takes place

including the weekly change management board meeting. Changes are approved by the Application Support Group (though not present at the audit). As part of the implemented Scrum/Agile project management, the 3-week Sprint cycle causes a software regression phase where the entire software is executed and evaluated for performance aspects according to any changes implemented and any potential impact to maintenance. This is documented in the Sprint_Certification_Process.pdf document.

The Coding Guidelines document was exhibited and shown to verify that coding complies with industry standards and internal coding policies. The Coding Guidelines document depicts specific guidelines for each programming language in use. Presently the following programming languages are in use: C++, C# /. NET, & SQL.

This year new guidelines were added for unrelated software used to support coding via Coding Scripts: MATLAB, Python and R. These new guidelines have been communicated across the teams to ensure consistency. One methodology specifically called out was that the practice of refactoring the code for the sake of refactoring it is not part of the guidelines to ensure code resiliency and functionality.

Software component database files are considered externally sourced data. I.e. the ZipAll centroid. The development process in the flowcharts showing the process converting the data from the files into the database. The ZipAll flowchart was exhibited and reviewed as an example.

The Catalog_generation.pdf file describes various aspects of the datasets that are used to run models. Catalog files are research datasets that are processed in a software tool “datafile converter” to convert ascii to binary where the binary structure is admitted into the model routine/function.

An exhibit was shown of the code for both a generation error and a generation pass (page 43 of the Catlog_Generation.pdf) to validate the datasets used in model creation and how the system and users respond to errors. The code demonstrates the validation process for datasets imported into the model test and outlines the errors generated when the data is invalid.

Traceability at all levels, including requirements, design, implementation, and verification or testing was shown via walkthrough examples of several flowcharts.

All component attributes, i.e. name, creation date, modification date and etc., are being reflected in source code and in in source control repository. Visual Basic Line-of-Code counter is used to track component name, number of lines of code, minus blank lines, and number of explanatory comment lines for all code. This information is updated and maintained in the excel documents Line Counts_2024.xlsx and LineCountsR11.5-Sprint01.xlsx.

The Model 521 Equations/Formulas, Variable Mapping, and Crosschecking document, which discusses the implementation of all equations used in model creation and testing of Windspeed, was presented, reviewed and discussed. The document also exhibits sample code with sufficient examples and code comments. As of this release there were no new or modified equations since the previous release.

At this time there is no cross-reference list of implementation source code terms and variable names corresponding to CI-4 G.1 to satisfy CI-4 G.2. The Verisk team is working on producing this document. This is not critical enough to fail the audit item, but it does need to be resolved.

The hardware specifications, operating system, and essential software required to use the hurricane model are described in detail on page 205 in the document 2023 Hurricane ROA submission.pdf. Implementation is detailed for the only platform that is used.

Code for creating automated forms is stored and managed in the Azure DevOps directory. The automation process begins with data cleaning using scripts tailored for actuarial forms. Two types of files—contract and location files—are generated for Touchstone, with all parameters clearly defined. Data is processed initially and output as .csv files for use in the code. APIs are employed to reduce user error when inputting data and to create projects and back-end databases that store results and update the relevant projects. The system can handle both the current accepted model and model under review, with tables established to monitor Single Identifiers used for manual validation. An API is used to call each form and input parameters, while post-processing forms generate the actual exhibits such as maps, excel, or other outputs. The code is thoroughly commented for clarity and adheres to standard coding policies.

Other related diagrams and documentation were presented, reviewed and discussed to show compliance with this audit item.

Most audit requirements for CI-4: Hurricane Model Implementation are met.

Standard CI-5: Hurricane Model Verification

Physical unit conversions in the model code have not changed and were shown to be historically consistent in the M521 unit conversion document linked in the audit requirements document. *However, the Unit_Conversion_Document.pdf itself has not yet conformed to documentation standards such as creation date, author, version, etc. So it is unclear as to its relevancy and recency, though it is assumed to be.*

Unit tests were demonstrated through an exhibit that verifies the testing procedures. The process involves receiving data files from the testing teams in ASCII format, which are then converted to binary. To validate the conversion, the data files are converted back from binary to ASCII and checked for accuracy. Any discrepancies are easily identified in the comparison table matrix.

Quality Assurance checks for duplicatable results when the same catalog dataset is run through the model more than one time. The CCSG team also runs the model twice with the same dataset for verification. The results of both outputs are run through equivalency scripts in addition to manual comparison to further validate the two runs meet the defined standard

Software code includes statements for error and exception handling, loss analysis outputs, and flag triggering as exhibited in the “M521 Logical assertions Exception handling and outputs.pdf” document. QA staff stated during the previous audit the utilization of ArcGIS geo-processing tool, Cucumber/ SpecFlow /Gherkin language and R analytics environment open-source products, as part of general analytics, statistical, geospatial and automated integration and acceptance testing tools. QA teams switched from using ClearQuest and started using Azure DevOps for issue tracking of errors and failures.

The historic catalog was demonstrated showing a direct comparison from the previous version and the current version. Change expectations are provided from the Research Dept and the catalogs are evaluated to validate that only expected changes were changed. The differences between previous and current is easily shown.

Processes and documentation of component and data test processes, including compliance independent of verification procedures, were exhibited and demonstrated. As part of the post implementation testing, regression testing is performed to directly compare the resulting values of the current implementation to the previous implementation. Any and all discrepancies are handled according to documented processes.

Examples were exhibited showing how equations and calculations are parsed for implementation into source code. Since one platform with one set of language codes is used, one standards document contains comprehensive procedures that define cross-checking the procedures with results while noting the time-stamp and the tester as part of the validation process.

Numerous flowcharts were reviewed that illustrate data validation during several steps of manual and automatic verification testing. As mentioned previously, all flowcharts reviewed comply to a single adopted documentation standard.

As part of the DevOps process, a standardized procedure is followed to address new requirements for builds, ensuring that new build machines are configured to maintain platform integrity. All necessary software and services, including their versions and operating systems, are documented. Compliance with the specified software requirements is checked on the build machines and installers, while the regression testing cycle identifies any changes.

Complete and thorough verification procedures and output from model changes in G1 have been shown. Previous examples exhibited show the integrity, consistency and correctness of checks and documentation procedures for files, databases and datasets accessed by components.

Standard CI-6: Human-Computer Interaction

In this model release, there were no changes to the internal or external user interfaces. I interviewed the team on aspects of the implementation and was shown examples of how users continue to not have the ability to enter incorrect interface options.

The decision process for defining interface options selections is tied to the Verisk Extreme Event Solutions (EES) user experience which include cross-disciplinary review and evaluation with EES.

Procedures for designing, implementing, and evaluating interface ratemaking options are guided by a detailed loss analysis template, which is unique, explicit, and distinctly emphasized with pre-set menu selections which is locked and cannot be manipulated by users nor can any selections be made outside the geographical boundaries of Florida.

Additionally, UX engineering HCI standards are in place and adhered to based on details in the exhibits.

All related documentation, diagrams, and code were available for review and questioning.

All audit requirements for CI-6 Human-Computer Interaction are met.

Standard CI-7: Hurricane Model Maintenance and Revision

Requested policies and procedures were available for review. Policies reviewed govern the review, maintenance and revision of model code, its data, network organization and documentation. This included showing the verification and validation of revised components, databases and files, system decomposition, installation date, current version ID, and date or recent change for each designated component. The repository of all datafiles was shown for all revisions.

The Model and Software Revision Policy has not changed since the last audit and states that a major release of Touchstone® occurs annually or instantiated and governed by an ROA. A major release may incorporate updated hurricane data from the previous year, improvement in the hurricane model, new user functionality, and possibly new software architecture.

Between major releases, minor versions may be released containing software bug fixes and user functionality enhancements. All of these releases are thoroughly documented according to the established procedures. All versions are tracked in the tracking document. Many of these processes are exhibited in flowcharts.

Source Code, Data and Documentation Maintenance is managed in Microsoft Visual Studio (VSS) and used for source control management and to track software and documentation change history. Team Foundation Server with TFVC is used for version control of the model components' source code. Exhibits of model code were shown and reviewed. Version control for the Touchstone components' source code (including the C++ model code and databases) is maintained using TFVC via Microsoft Visual Studio.

The Verisk Hurricane Model for the U.S. v3.0.0 as implemented in Touchstone® 2024A uses Microsoft SharePoint, NGP Releases, to manage projects, archive and monitor requirements; store and share design plans, and test plans. Microsoft Excel is used as the tracking software and lists all model revisions, change sets, snapshots, and user stories in the Version Change History file. Azure DevOps is used for all internal clients' tickets, i.e.: project management, logs, defects, revision, enhancement, and change request assignment tracking. Additionally, the Data Control Workbook iterates details of the data file model changes and version numbers for the past 5 years.

Salesforce CRM is used for tracking defect, bug, enhancements, and recommendation submitted by clients. The reported defects will be reported and ticketed in Azure DevOps. The Data Control Workbook was demonstrated for me detailing information about the data files and version numbers.

Procedures were shown that are in place that govern system configuration changes, system functionality changes, alteration of data within an application database, static contact changes, new reports, additions, deletions, and modifications.

All audit requirements of CI-7: Hurricane Model and Maintenance are met.

Standard CI-8: Hurricane Model Security

Verisk is mandated to comply with its parent company, Verisk Analytics, enterprise-wide definition of fundamental principles for the protection of information resources as stated in the Verisk Information Security Policy Framework.

The Verisk IT and Security & Compliance group works with the Verisk Risk & Compliance team to practice, support, and perform these security measures.

Verisk IT, Security & Compliance personnel were interviewed to exhibit the Information Security Policy Framework document. Per this document, designated policy owners of the Enterprise Risk & Compliance group review Verisk's information security policies and security awareness education policy annually. The completion of Verisk employee training is monitored by their managers and by the Verisk CISO office for compliance.

The incident response documentation was reviewed for how it applies to any perceived risk or actualized threat to the Touchstone product models and how all staff are educated to respond to such events, The Incident handling process was also reviewed, including root cause analysis, containment, legal as well as Risk and Compliance processes. Catastrophic incidents are managed by the Verisk Business Continuity Management Policy.

A list of security tools was provided, which comply with Enterprise Information Security Policy Framework, and are in various stage of deployment for Verisk business. The later restricts network access based on person's role in the organization. Employee access profiles are managed through Microsoft Azure.

External access to systems is controlled by permission based secureFTP servers and all connections are internally monitored for threat events. Additionally, users must gain access through Optera and use multifactor authentication.

Endpoint security is enforced through Cloudstrike to monitor and detect any insecure operation by a client or code and report it through the Security Incident and Event Monitoring (SIEM) system Splunk. These events are monitored, escalated and addressed through the Verisk Incident Response security team.

Code signing is processed through Verisk and tripwire code is triggered anytime a configuration change occurs which generates an alert in the SIEM for review and/or handling.

The Verisk Hurricane Model for the U.S. v3.0.0 as implemented in Touchstone® 2024A runs on a single platform. The "Touchstone® Installation Guide" was made available which provides the guidance and practices in user management and access control, anti-virus installation and usage, etc. The Verisk Hurricane Model for the U.S. v3.0.0 as implemented in Touchstone® 2024A is installed at a client site and is not an implementation that connects to any Verisk datacenter. Detailed security guidelines are provided to the client to ensure security protocols and processes are followed.

IT Security policy is updated annually.

All audit requirements of CI-8: Hurricane Model Security are met.

Areas For Improvement

The Verisk Hurricane Model for the U.S. v3.0.0 as implemented in Touchstone® 2024A team is constantly and persistently innovating and investigating areas for improvement. Items brought to the attention of the Verisk team are:

1. At this time there is no cross-reference list of implementation source code terms and variable names corresponding to CI-4 G.1 to satisfy CI-4 G.2. The Verisk team is working on producing this document.
2. Some documents are still lacking full compliance with documentation standards showing version control, date created & modified, etc. The team is continually working to improve this.

Conclusion

Based upon my career experience and the examination and discoveries during this audit, it is my opinion that The Verisk Hurricane Model for the U.S. v3.0.0 as implemented in Touchstone® 2024A implementation is compliant with the Computer and Information (CI) standards established by FLCHLPM as defined in the ROA.

I had the opportunity to speak with numerous individuals involved with The Verisk Hurricane Model for the U.S. v3.0.0 as implemented in Touchstone® 2024A. I was provided and given access to all documents, diagrams, software code that I requested. No request was denied, and information and personnel were readily available to review details with me.

Much of the focus of this audit was upon the updated datasets used in model generation. It was found that necessary procedures and quality checks were in place. This is indicative of systematic application of team-wide cohesiveness which I believe ensures that the Touchstone product continues to operate optimally.

This concludes my audit report for The Verisk Hurricane Model for the U.S. v3.0.0 as implemented in Touchstone® 2024A for FLCHLPM.

16 Appendix 8: Accounting for Secondary Risk Characteristics

Executive Summary

This document provides an overview of Verisk's Individual Risk Module (IRM) for modeling the impact of secondary risk characteristics on damageability and insured hurricane losses in the United States. The capability is part of the vulnerability component of the Verisk Hurricane Model for the United States and is included in Verisk's detailed loss estimation software, Touchstone. This document facilitates a better understanding of the impact of secondary building and environmental features on damage and loss. It will also assist clients in deriving mitigation factors to be used for property loss costs.

Verisk's approach is an engineering-based framework designed to estimate the performance of residential and commercial buildings under wind loads. It is based on engineering principles and data regarding building performance during high winds.

The general, or base, damage functions used by the Verisk Hurricane Model for the United States are individually developed for the "typical" building with certain "primary" risk characteristics, which include age, height, construction type and occupancy class. The construction and occupancy classes are broadly defined, without reference to individual—or secondary—structural characteristics. Verisk's general damage functions were validated and calibrated using extensive and detailed actual hurricane loss data. The relative abundance of hurricane loss data greatly facilitates the determination of average or "typical" building performance.

Modification functions (or secondary risk characteristics) are applied to the general damage functions to reflect the performance enhancement or diminution of a wide variety of secondary structural and environmental characteristics. These might include roof covering, roof pitch, type of window protection or proximity to trees (which are potential sources of wind-borne missiles). Detailed claims data from 2004 and 2005 storms have been used to validate the impact of these secondary risk characteristics on building vulnerability.

The modification functions referenced above reflect the difference between the performance of a building with known structural and environmental characteristics and that of the typical building. For example, the modification function for a residential wood frame building with hip roof indicates how it would perform differently from a typical residential wood frame building whose roof is mathematically defined to exhibit average performance.

The modification functions are themselves functions of wind speed. That is, the effectiveness of mitigating characteristics varies according to the wind speed. In addition, the combined effect of the modification functions for different secondary risk characteristics is complex and not necessarily additive or multiplicative.

The marginal impact of secondary risk characteristics on building vulnerability is dependent on the year that the structure was built and on its location. This is due to the fact that for a class of structure, the Verisk Hurricane Model for the United States defines a typical building in terms of typical secondary risk characteristics for

each location and year built. User input of secondary risk characteristics will overwrite the default secondary risk characteristics, and a new vulnerability function is created. The new function may reflect lower or higher vulnerability than the default, depending on the effect of user's input relative to default features.

For example, if a user inputs "engineered shutters," this will result in no, or minor, reductions in vulnerability for a home built in Miami after 2002 but a large reduction in vulnerability for a home built before 1995 in Tallahassee, Florida. This coherent, logic-based approach provides a framework that properly accounts for the overlap of the impact of different secondary features (e.g., year built and mitigation features), and avoids potential double-counting of secondary features in the model.

The Verisk methodology follows a structured approach to quantify the impact of more than 25 secondary risk characteristics, covering a range similar to that in the public domain—and, in particular, that used in the Florida Department of Community Affairs (DCA) study. Touchstone users may use these factors to develop rating credits in a manner similar to the one presented in this document.

Introduction

The Verisk Hurricane Model for the United States in Touchstone includes the capability to account for the impact of secondary building and environmental characteristics on the vulnerability of individual risks. The modeling methodology was developed using an engineering-based framework in a structured approach.

Based on structural engineering expertise and building damage observations made following historical hurricanes, more than 25 building features (see Table 59) have been identified as having a significant impact on building damage and losses. Options corresponding to each feature (see Table 65) are identified based on construction practice. Algorithms for modifying the damage functions are developed based on engineering principles and observational data. The Verisk Hurricane Model for the United States in Touchstone supports any combination of multiple building features and produces a modification function that is applied to the base vulnerability function. The modification function captures the changes to building vulnerability that result when certain building features are present, and when information on such building features is known. The modification function varies with wind intensity to reflect the relative effectiveness of a building feature when subject to different wind speeds.

This document provides a brief overview of the component parts of all Verisk natural hazard peril models, followed by a more detailed overview of the damage estimation, or vulnerability, component. That section is followed by details regarding wind-induced loads and resulting damage, a discussion of building and environmental features that affect building performance, and information on Verisk's development of loss modification factors for a range of building features similar to those used in the Florida public domain study.

Overview of Catastrophe Modeling Technology

Figure 84 illustrates the components of Verisk's catastrophe models. In the case of the Verisk Hurricane Model for the United States, the "Event Generation" module is used to create the stochastic storm catalog. More than one

hundred years (1900-present) of historical data regarding the frequency of hurricanes and their meteorological characteristics are used to fit statistical distributions for each model parameter, including landfall location and storm heading at landfall, and the intensity variables of central pressure, radius of maximum winds, forward speed, and storm track. By stochastically drawing from these distributions, the fundamental characteristics of each simulated storm are generated. The result is a large, representative catalog of potential events.

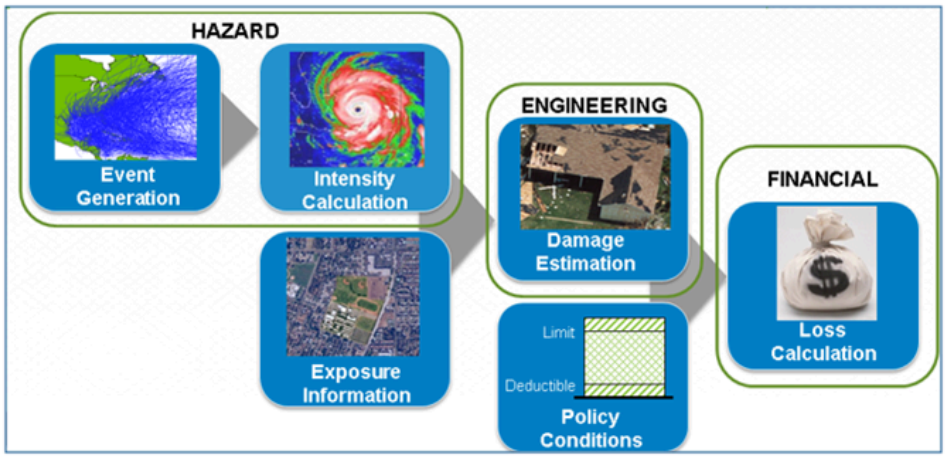


Figure 84. Components of a Verisk Catastrophe Model

Once values for each of the important meteorological characteristics have been stochastically assigned, each simulated storm is propagated along its track. Peak 1-minute sustained wind speeds and wind duration are estimated for each geographical location affected by the storm to calculate Local Intensity.

The Damage Estimation component of the model overlays the local intensity of the simulated event onto a database of exposed properties. The model then calculates the resulting monetary damage by applying damage functions, which capture the effects of the intensity of the event, which varies by location, on exposed buildings. Separate damage functions are developed for different construction types and occupancy classes. Similarly, separate damage functions for each of building, contents, loss of use, and business interruption are applied to the replacement value of the insured property to calculate losses for these coverages.

Finally, the Insured Loss Calculation is made by applying the policy conditions to the total damage estimates. Policy conditions may include deductibles by coverage, site-specific or blanket deductibles, coverage limits and sublimits, loss triggers, coinsurance, attachment points, and limits for single or multiple location policies, and risk specific reinsurance terms.

After all of the insured loss estimations have been completed, they can be analyzed in ways of interest to risk management professionals. For example, the model produces complete probability distributions of losses, or exceedance probability curves, for gross and net losses and for both annual aggregate and annual occurrence losses. Output may be customized to any desired degree of geographical resolution down to location level, as well as by line of business, and within line of business, by construction class, coverage, etc. The model also provides summary reports of exposures, comparisons of exposures and losses by geographical area, and detailed information on potential large losses caused by the extreme events that make up the tail of the distribution.

Damage Estimation Overview

The Damage Estimation component of the Verisk Hurricane Model for the United States applies the local intensity of the simulated event to a database of exposed properties. The model determines damage estimation through the use of damage, or vulnerability, functions, which illustrate the interaction between buildings (and contents) and the local intensity to which they are exposed.

Uncertainty in damage comes from many sources including variability in the strength of building components and variability in building features as well as the level of uncertainty in the local intensity at the location under consideration. Further, uncertainty in the human response (whether windows are covered, for example) can significantly affect the damage severity. As claims analyses indicate that a single parametric distribution cannot be used to model the variability in the flood damage data, Verisk engineers use a combination of beta and Bernoulli probability distributions (also called an "inflated beta" distribution) to capture the uncertainty in damage at a location.

The damage functions relate the mean damage level, as well as the variability of damage, to the measure of intensity at each location. That is, the Verisk Hurricane Model for the United States estimates a complete distribution around the mean level of damage, for each local intensity and each type of structure. Because different structure types will experience different degrees of damage, the damage functions vary according to construction and occupancy. Losses are calculated by applying the appropriate damage function to the replacement value of the insured property.

The Verisk damage functions incorporate the results of well documented engineering studies, tests, and structural calculations. They also reflect the relative effectiveness and enforcement of local building codes. Verisk engineers refine and validate these functions through the use of post-disaster field survey data and through an exhaustive analysis of detailed loss data from actual events.

Separate damage functions for buildings, contents, and time element provide not only estimates of the mean, or expected, damage ratio corresponding to each wind speed, but also probability distributions around each mean. In the case of building damageability, the damage ratio is the dollar loss to the building divided by the corresponding replacement value of the building. As can be seen in Figure 85, the model ensures non-zero probabilities of zero and one hundred percent loss (for individual properties).

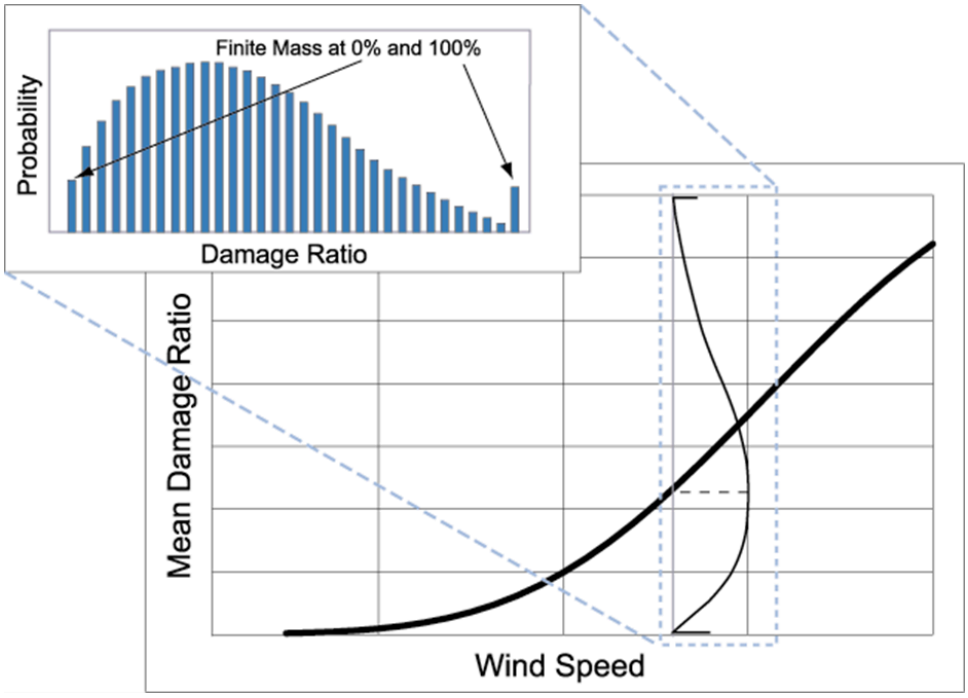


Figure 85. Representative Damage Function

Verisk damage functions have been extensively validated using detailed actual loss data provided by a number of clients for various storms. Validation is performed by comparing simulated and actual losses for client companies by state or county, and line of business. Using detailed data, Verisk has fine-tuned of damage ratios by construction class, coverage type, and wind speed.

Accounting for Secondary Risk Characteristics

Wind Induced Loads

Winds that are close to the earth's surface are subjected to frictional drag from the terrain roughness. As the distance from the surface increases, these frictional effects decrease and, at a certain height, become negligible. The height at which the surface roughness is negligible is referred to as the *gradient height*. The layer of air below this height, where the wind is turbulent and its speed increases with height, is known as the atmospheric boundary layer, whose height ranges from the ground surface to between 1,000 and 2,000 feet. All structures are located in this atmospheric boundary layer and act as bluff bodies to wind.

When wind comes into contact with buildings, the airflow streamlines separate at the sharp corners of buildings such as wall corners, eaves, roof ridges and roof corners, as shown in Figure 86. This separation induces additional turbulence in airflow causing highly fluctuating pressures on the building surfaces. The direction of wind with respect to the building (angle of attack) is also a significant factor in the magnitude and fluctuation of pressures acting on the surfaces of the building.

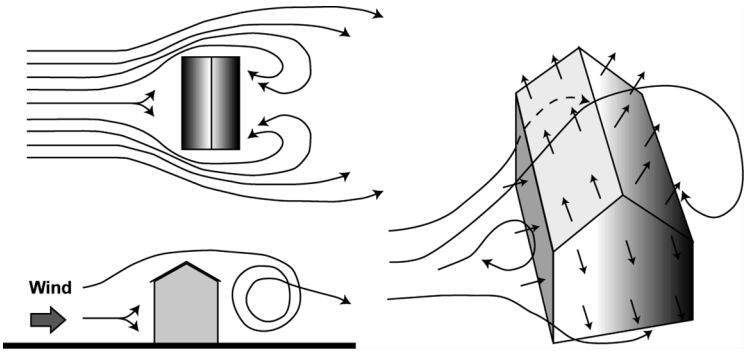


Figure 86. Wind Flow Around Buildings Can Generate Severe Pressure and Suction Forces

In general, when wind acts on a building, the windward wall experiences a pressure pushing inward (positive pressure) while the sidewall and the leeward wall will experience a suction pressure outward (negative pressure). The roof, depending on its slope, will experience uplift (negative pressure). Wind forces are significantly increased at corners, ridges, and at abrupt changes in the direction of wind flow.

Two important flow mechanisms with respect to buildings are discussed below.

- **Flow Separation**

  When wind impinges the front wall, it flows upward past the roofline. The wind is unable to turn abruptly at the roofline and so continues past the roof edge, thus separating from the roof eave. Suction forces are often found on the roof under the separated flow, especially near the separation point. The wind that has separated slowly comes back to its original flow direction there by reattaching on the roof surface. The point of reattachment depends on the dimensions of the buildings, roof geometry, the wind speed, and wind direction relative to the building.

- **Roof Corner Vortex**

  Wind approaching the roof corner at a quartering angle flows up over the roof, and rolls up into two vortices of opposite rotational directions originating at the building corner. These vortices are much like miniature tornadoes, producing high speeds under the vortices. These roof corner vortices are sometimes called the delta wing vortices, as shown in Figure 87.

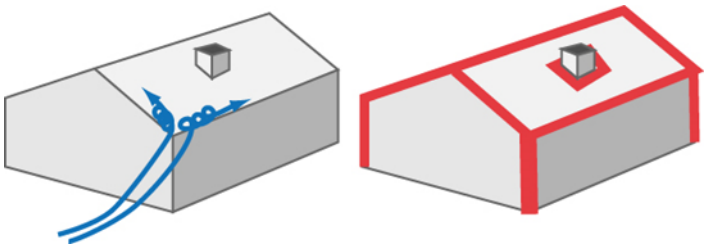


Figure 87. Wind Flow Separation Around Roof

Wind Damage

Damage surveys traditionally classify buildings as either engineered or non-engineered. An engineered building will generally have less susceptibility to wind damage than a non-engineered building. Most residential dwellings

are classified as non-engineered. An example is a wood-frame single-family dwelling, which may not have received attention from a structural engineer during construction. Commercial structures that are built in accordance with building codes and under the supervision of a structural engineer are classified as engineered. A typical engineered structure is a high-rise reinforced concrete building.

- **Wind Damage to Non-Engineered Buildings**

  Figure 88 illustrates the dynamic process by which non-engineered buildings are damaged by wind. Wind primarily affects non-structural elements, such as different components of the building envelope. In most cases, damage is fairly localized. Roofs and openings in the facade (e.g., windows and garage doors) are typically the first elements to be damaged. Loss of the first shingle allows wind to penetrate and lift the next shingle. Unsecured slates may peel off; metal roofs may roll up and become detached.

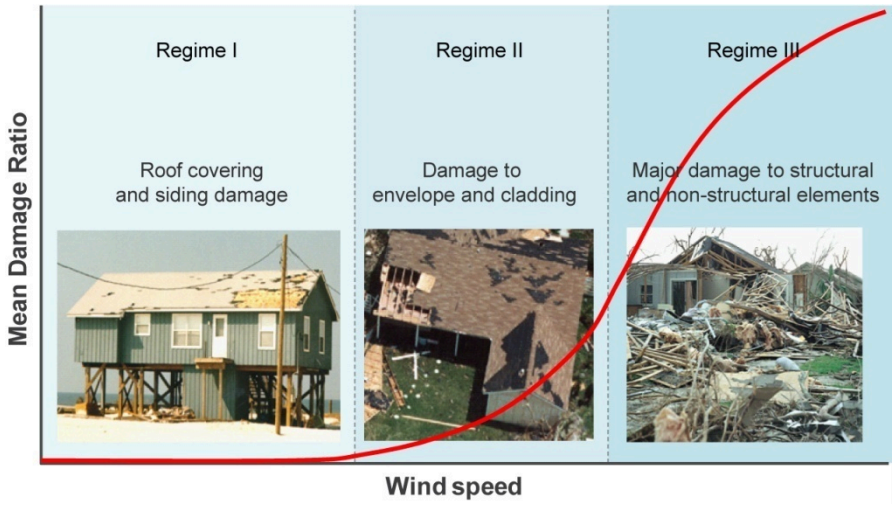


Figure 88. Damage Profile of Non-engineered Buildings

  Damage accelerates as wind speeds increase. The loss of the first window, either because of extreme pressure or of wind-induced projectiles, can create a sudden build-up of internal pressure that can lift a roof system off the building from inside, even if it is properly secured.

  At high wind speeds, the integrity of the entire structure can be compromised, particularly in cases where the roof provides lateral stability by supporting the tops of the building's walls. Structural collapse may occur during extreme wind events. Even if the structure remains intact, once the building envelope is breached, contents are vulnerable to wind as well as accompanying rain.

- **Wind Damage to Engineered Buildings**

  For engineered buildings, damage typically occurs to the following building (non-structural) components:

  - Mechanical equipment
  - Roofing
  - Wall cladding
  - Breaching of doors and windows

Complete structural collapse is rare for well-engineered buildings. Even so, damage to non-structural components of a building can add up to a significant financial loss.

Examples of typical damage patterns can be seen in Figure 89.



Figure 89. Damage to (a) Mechanical Equipment, (b) Roof, (c) Cladding, and (d) Windows

Building and Environmental Features

Verisk accounts for the impact of secondary building and environmental characteristics, or features, on the wind vulnerability of individual risks. The methodology was developed at Verisk using a structured, engineering-based framework that is based on structural engineering expertise and building damage observations made in the aftermath of actual hurricanes.

In the Verisk Hurricane Model for the United States, options for each characteristic are identified based on construction type. Algorithms for modifying the vulnerability functions, for both structural and nonstructural damage, are developed based on engineering principles and observations of building performance. The Verisk Hurricane Model for the United States supports the effects of any combination of building features on the building damage and produces a modification to the vulnerability function. The modification function captures the changes to building vulnerability that result when certain building features are present and when information on such building features is known. The modification function varies with wind intensity to reflect the relative effectiveness of a building feature when subjected to different wind speeds, as seen Figure 90.

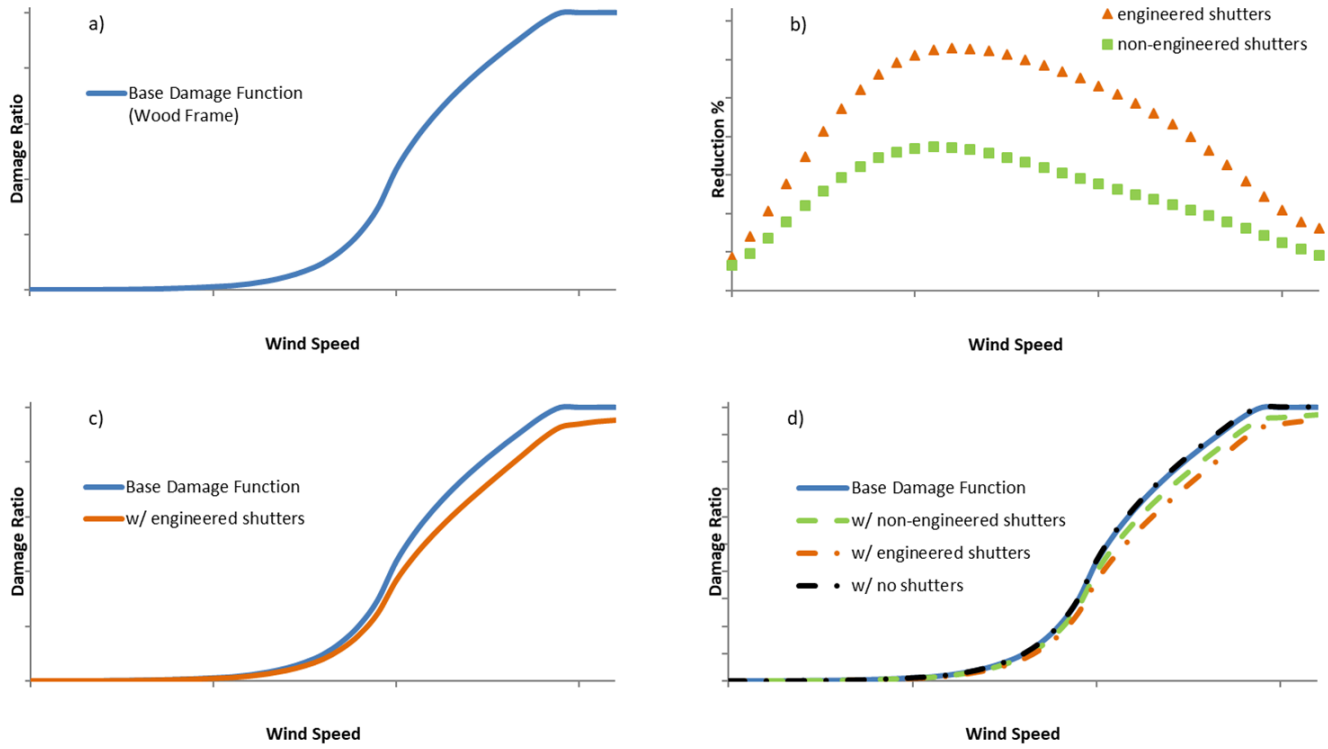


Figure 90. Application of Modification Factors to the Basic Damage Functions: (a) Basic Damage Function for Wood Frame Construction; (b) Reduction in Damage for Engineered vs. Non-Engineered Shutters; (c) Basic Damage Function and Modified Function for Engineered Shutters; (d) Envelope of Damage Functions, All Protection Options

The figure illustrates the application of modification factors to the basic damage functions.

Individual Risk Features (Secondary Risk Characteristics)

The first step in the development of the modification functions is the identification of building and environmental characteristics that impact the performance of a building in high winds. These features are selected based on research and damage surveys, which detail building performance in high wind. Some can be categorized as non-structural (cladding, for example), while others are structural (roof and wall systems, for example); still others address very general features such as building condition and, finally, environmental features include such things as the proximity to trees.

The building characteristics supported in the Verisk Hurricane Model for the United States are shown in Table 59. For each of these, various options are available, as discussed below. For the Verisk Location Detail Codes, see the latest version of the *Touchstone® Exposure Data Validation Reference*, which is available at https://unicede.air-worldwide.com/ts-tsre_all/help_ts_exposure-data_val-rules-exposure-data.html.

Table 59. Secondary Risk Characteristics Supported by the Verisk Hurricane Model for the United States in Touchstone

Secondary Risk Characteristics	
Adjacent Building Height	Roof Covering

Secondary Risk Characteristics	
Appurtenant Structures	Roof Cover Attachment
Building Condition	Roof Deck
Certified Structures	Roof Deck Attachment
Exterior Doors	Roof Geometry
Floor of Interest	Roof Pitch
Foundation Connection	Roof Year Built
Glass Percentage	Seal of Approval
Glass Type	Small Debris Source
Large Missile Source	Terrain Roughness
Project Completion Percentage	Tree Exposure
Project Phase	Wall Attached Structures
Roof Anchorage	Wall Type
Roof Attached Structures	Wall Siding
	Window Protection

- **Appurtenant Structures**

  An appurtenant structure is a building that is located on a property but is not an integral part of the main building. Appurtenant structures may require a different treatment in analysis from the main building. For example, a pool enclosure may provide protection of a recreational pool from everyday wind and sun exposure. However, if winds are high enough to damage the main building, then the pool enclosure may become flying debris, and increase the amount of damage to the main building. The following appurtenant structures can be entered:
  - Unknown/default
  - Detached garage
  - Masonry boundary wall
  - Other fence
  - Pool enclosure
  - Shed
  - No appurtenant structures
  - No pool enclosure
- **Adjacent Building Height**

  This entry describes average height of buildings adjacent to the building of interest. Building height is expressed as the number of stories, with the default (0) indicating unknown height. For the hurricane peril, this field is in conjunction with Floor of Interest and Terrain Roughness.
- **Building Condition**

  This condition assessment of a building is based on its external appearance. The condition of the outside of the building and its maintenance, described as good, average, or poor, is used to determine an estimate of expected performance. Buildings with signs of distress or duress are likely to experience additional damage

during a hurricane. Some examples of these signs are: an aging roof, aging exterior walls or cladding; loose roof tiles or chimney damage; or damage from previous hurricanes.

- **Foundation Connection**

  This describes the connection type between the structure and foundation and is a critical factor in single-family dwellings made of wood-frame and tilt-up construction. The connection transfers the vertical and lateral loads on the building to the foundation during wind events. The valid entries are:
  - Unknown/default
  - Gravity/Friction
  - Hurricane ties
  - Adhesive/Epoxy
  - Nails/Screws
  - Structurally connected
  - Anchor Bolts

  For Industrial Facilities (occupancy classes between 400 - 488), this field represents the anchorage of equipment at the facility. The valid entries are anchored, unanchored, or unknown anchorage.
- **Certified Structures**

  Fortification standards were developed by the Insurance Institute for Business Home and Safety (IBHS). They are designed to help strengthen homes and businesses through retrofitting and new construction standards to improve their strength and resistance to natural perils.

  Residential and commercial buildings that meet certain levels of standards are eligible for gold, silver, or bronze certification, which represent the level of disaster protection. The supported entries are:
  - Unknown/default
  - Fortified Home™/Business (IBHS) Bronze Option 1
  - Fortified Home™/Business (IBHS) Bronze Option 2
  - Fortified Home™/Business (IBHS) Gold Option 1
  - Fortified Home™/Business (IBHS) Gold Option 2
  - Fortified Home™/Business (IBHS) Silver Option 1
  - Fortified Home™/Business (IBHS) Silver Option 2
  - Fortified for Safer Living®/Safe Business (IBHS)
- **Exterior Doors**

  Exterior doors, and the frames that hold them, are weak in resisting wind loads. They deflect considerably under high wind loads and thus fail. This entry describes the type of exterior doors in the building as different types have different amounts of wind resistance. The valid entries are:
  - Unknown/default
  - Sliding doors
  - Single width doors
  - Double width doors

  - Reinforced single width doors
  - Reinforced double width doors
- **Floor of Interest**

  Different floors of a building experience varying degrees of damage as well as different types of damage. This entry identifies the floor concerned, if coverage is not for the entire building. Replacement values (building, contents, and BI) as well as policy terms should be entered for the floor of interest and not the whole building. This field should be used in conjunction with the Terrain Roughness and Average Adjacent Building Height.
- **Glass Percentage**

  In general, the greater the percent of glass in a wall, the greater the wall's vulnerability to damage. This entry represents the percentage of the wall area that is glass.
  - Unknown/default (or no floor of interest)
  - Less than 5%
  - 5% to 20%
  - 20% to 60%
  - Greater than 60%
- **Glass Type**

  Different types of glass have different levels of resistance to wind loads and debris impact. The valid entries for glass type are:
  - Unknown/default
  - Annealed
  - Tempered
  - Heat strengthened
  - Laminated
  - Insulating glass units
- **Large Missile Source**

  A source of a large missile is any object within 100 feet of the property that could potentially become large flying debris in hurricane winds and breach the building envelope. Examples of large missile sources include outdoor furniture, loose boards or building materials, or wood planks or studs on nearby buildings that can become dislodged in high winds.
- **Project Completion Percentage**

  This percentage applies to Average Project Loss at Phase 5 for builder's risk policies, or the average loss over the duration of the project. It indicates the percentage of the project (0%-99%) that is completed at the start of the policy and is determined by the cost of the project. If no builder's risk is selected then other phase losses are selected and the percentage complete entry will be ignored.
- **Project Phase**

This percentage applies to Average Project Loss at Phase 5 for builder's risk policies, or the average loss over the duration of the project. It indicates the percentage of the project (0%-99%) that is completed at the start of the policy and is determined by the cost of the project. If no builder's risk is selected then other phase losses are selected and the percentage complete entry will be ignored.

- No builder's risk/default
- Phase 1: Foundation and Substructure
- Phase 2: Superstructure
- Phase 3: Walls and Roofing
- Phase 4: Interior, Mechanical (Conveying, Plumbing, HVAC, Fire Protection, Electrical, Furnishings, Misc.
- Phase 5: Average Project Loss (the average loss over the duration of the project)
- Worst Loss: The project phase when the loss potential is highest

- **Roof Anchorage**

  The type of connection that secures the roofing support to the walls affects how well wind loads are transferred to the walls, reducing the vulnerability of the roof. The anchorage types are:

  - Unknown/default
  - Hurricane ties
  - Nails or Screws
  - Anchor bolts
  - Gravity or Friction
  - Adhesive epoxy
  - Structurally connected roof
  - Clips

- **Roof Attached Structures**

  Structures that are attached to a property's roof, such as mechanical equipment, may be more vulnerable to winds than the main building, particularly if they are not well anchored. Some roof attached structures help protect the roof from damage. Supported roof attached structures are:

  - Unknown/default
  - Chimneys
  - Air conditioning units
  - Overhang/Rake
  - Dormers
  - Waterproof membrane/fabric
  - Skylights
  - Secondary water resistance (e.g., bitumen tape)
  - Parapet walls
  - Other

- **Roof Covering**

The material used for the roof covering has a significant impact on the roof's ability to resist wind damage. If the roof covering is damaged, then the interior of the building and its contents become more vulnerable. Supported roof covering materials are:

- Unknown/default
- Asphalt shingles
- Wood shingles
- Clay/concrete tiles
- Light metal panels
- Slate
- Built-up roof with gravel
- Built-up roof without gravel
- Single ply membrane
- Single ply membrane ballasted
- Standing seam metal
- Hurricane wind rated roof covering

- **Roof Cover Attachment**

  The type of connection that secures the roof covering to the roof deck affects the roof's vulnerability to wind. Attachments that become damaged due to high winds can increase the vulnerability of the roof covering. Supported roof covering attachments include:

  - Unknown/default
  - Adhesive/epoxy
  - Screws
  - Mortar
  - Nails/staples

- **Roof Deck**

  The roof deck material affects how well wind loads are transferred from the roof to underlying joists and purlins. A damaged roof deck results in a breached building envelope, which causes significant building and contents damage. Supported roof deck materials are:

  - Unknown/default
  - Metal deck with concrete
  - Plywood
  - Pre-cast concrete slabs
  - Wood planks
  - Reinforced concrete slabs
  - Particle board/OSB
  - Light metal
  - Metal deck with insulation board

- **Roof Deck Attachment**

The type of connection that secures the roof deck to the underlying roof system affects the roof's vulnerability to wind. Attachments that become damaged due to high winds can increase the vulnerability of the roof deck. Supported roof covering attachments include:

- Unknown/default
- Structurally connected
- Screws/bolts
- Nails
- Adhesive/epoxy
- 6d nails @ 6" spacing, 12" on center
- 8d nails @ 6" spacing, 12" on center
- 8d nails @ 6" spacing, 6" on center

- **Roof Geometry**

  The shape of a roof has a significant effect on its wind vulnerability. Wind vortices at the corners result in suction forces that can lift the roof. Large complex roof geometries tend to reduce the intensity of the wind pressure and the resulting uplift forces. The supported roof geometries are:

  - Unknown/default
  - Complex
  - Flat
  - Gable end with bracing
  - Gable end without bracing
  - Gambrel
  - Pyramid
  - Hip
  - Mansard
  - Shed
  - Stepped

- **Roof Pitch**

  The roof pitch refers to its slope angle, which affects the suction forces of winds. Greater roof pitches lower the uplift forces, thereby improving the wind resistance of the roof. A low pitch is under 10°, a medium pitch is between 10° and 30°, and a high pitch is a slope greater than 30°.

- **Roof Year Built**

  This secondary feature indicates the year the current roof was put in place. Roofs lose their strength over time and become more vulnerable to wind loads. Older roofing systems may not have been as well-designed for wind resistance as roofs that meet stricter code requirements. In the absence of a specified roof year built input from the user, if the structure year built is within the last ten years the roof is considered to be new.

- **Seal of Approval**

This secondary feature accounts for the level of engineering provided to the design of a building. A fully engineered structure is one that has been designed by a Professional Engineer (PE), who is required to provide a seal of approval to the calculations and drawings of the building plan. These structures have the greatest resistance to wind loads.

A partially engineered structure is one that has been inspected by a PE who has determined the building is “deemed to comply” with the respective building code. No seal is required for a partially engineered designation. A minimally engineered structure is one that does not meet conditions well enough to warrant a seal of approval or “deemed to comply” designation.

- **Small Debris Source**

  Roof gravel, trash bins, tree branches, or other small debris can be carried aloft by high winds and breach window glass. This secondary feature indicates whether there is a potential for small debris within a radius of 200 ft. of the building.

- **Terrain Roughness**

  As hurricane winds travel over land, their speed can be significantly affected by the terrain. The effects of the surrounding terrain therefore greatly affect a building’s vulnerability to winds.

  - **Large city centers**

    Large city centers where at least 50% of the buildings are higher than 70 ft. (21.3 m). This exposure category is limited to areas for which terrain representative of Exposure A prevails in the upward direction for a distance of at least 0.5 mi. (0.8km), or 10 times the height of the building, whichever is greater. The model accounts for channeling effects or increased velocity pressures due to other structures situated alongside the building.

  - **Urban, suburban, and wooded areas**

    Terrain with numerous closely-spaced structures the size of single-family homes or larger. This exposure category is limited to areas for which terrain representative of Exposure B prevails in the upwind direction for a distance of at least 1,500 ft. (460 m) or 10 times the height of the building or other structure, whichever is greater.

  - **Open terrain with scattered obstructions**

    Open terrain and grasslands are examples of this exposure category. Structures in this category usually have heights lower than 30 ft. (9.1 m).

  - **Flat, unobstructed areas**

    Buildings and other structures exposed to winds flowing over open water for a distance of at least 1 mi. (1.61 km). This exposure category extends inland from the shoreline a distance of 1,500 ft. (460 m), or 10 times the height of the building or structure, whichever is greater.

- **Tree Exposure**

Strong winds can snap trees or blow them over, causing them to fall on nearby buildings. This can cause significant damage, particularly if they breach the building envelope. This secondary feature provides an indication of whether a falling or snapped tree hazard exists near the building.

- **Wall Attached Structures**

  Buildings may have objects that are physically attached to its exterior walls but are not an integral part of the main building structure. These attached structures are often more vulnerable than the main building, particularly if the anchorage is inadequate. They are more exposed to winds and may become dislodged and create a breach, or become flying debris. Supported wall attached structures include:
  - Unknown/default
  - Carports/Canopies/Porches
  - Single door garage
  - Double door garage
  - Reinforced single door garage
  - Reinforced double door garage
  - Screened porches/ Glass patio doors
  - Balcony
- **Wall Siding**

  The wall siding material of a building, which is used to protect the walls from weathering, affects its vulnerability to wind loads. Any breach in the wall siding can expose the wall to wind and allow pressure to build up and create more damage. Supported wall siding materials are:
  - Unknown/default
  - Veneer brick/masonry
  - Wood shingles
  - Clapboard
  - Aluminum/vinyl
  - Stone panels
  - Exterior insulation finishing system (EIFS)
  - Stucco
- **Wall Type**

  The external wall material of a building affects its vulnerability to wind loads. Any breach in the wall can allow pressure to build up inside the building and create more damage. Supported materials are:
  - Unknown/default
  - Brick/unreinforced masonry
  - Reinforced masonry
  - Plywood
  - Wood planks
  - Particle board
  - Metal panels

  - Pre-cast concrete elements
  - Cast-in-place concrete
  - Gypsum board
- **Window Protection**

  This secondary feature indicates whether engineered shutters or non-engineered shutters are installed. Both types can provide window protection against strong winds, particularly engineered shutters.

Example of Secondary Risk Characteristics: Roof System

This section provides an example of how individual elements of a structural system (in this case, the roof system) combine to influence damage and loss due to hurricanes.

The main function of a roof is to enclose the building space and protect it from the damaging effects of rain, wind, heat, and snow. Consideration is also given to factors such as strength and stability under anticipated loads, heat insulation, lighting, ventilation, sound insulation, and aesthetics, etc.

In the Verisk Hurricane Model for the United States as implemented in Touchstone, a roof system comprises the following features:

- Roof age
- Roof covering
- Roof covering attachment
- Roof deck
- Roof deck attachment
- Roof geometry
- Roof pitch

Brief descriptions of some of the features that influence damageability and loss due to hurricanes are provided below.

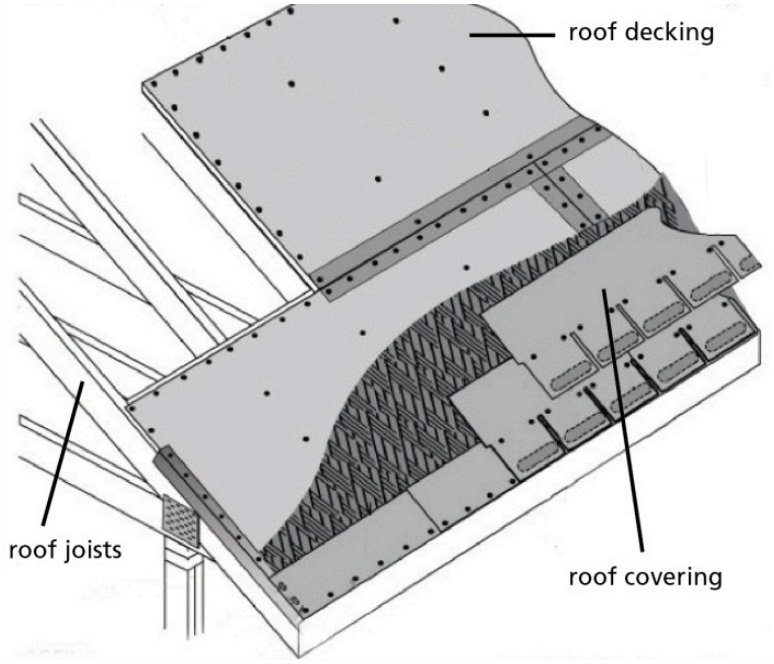


Figure 91. Some Key Components of a Roof System

- **Roof Covering**

  The roof covering is the material covering the framework of the roof structure in order to safeguard the roof against the weather. This material is fixed to the underlying structure by means of a range of fittings and fixtures.

  Climatic conditions influence the performance and durability of roof coverings. Strong winds may dislodge certain types of roof coverings such as slates, tiles, and asphalt shingles, particularly if they are not properly affixed. Extreme temperature changes can cause the material to crack and joints to leak, if they are not properly protected. Fog, salt, or smoke and other gases can corrode metal roofing that is protected such as by being painted regularly. Rubber membranes and asphalt shingles can become brittle and crack as a result of prolonged exposure to ultraviolet radiation. The various effects described above can result in poor roof performance, reduced roof life, or both.

  Roof coverings are fastened to roof decks, which are supported by structural members such as girders, trusses, or rigid frames. In the case of shell roofs, the decks serve as principal supporting members. In some cases, the roof covering and the deck are combined into one unit, such as with corrugated roofing. Because of these varying roofing systems, the type of roof covering and the type of roof deck should be selected concurrently.

  The weight of the roof covering affects the design, weight, and cost of both the roof deck and its supporting structure or framework. A heavier roof covering requires a stronger supporting structure, which adds to the cost. For example, sheet metal coverings are very lightweight, and shingles can be classified as light to medium in weight, whereas clay tiles and slates are considered to be heavy roof coverings. Supporting structures and roof decks are designed according to the weight of the chosen roof covering. Figure 92 shows typical wind damage to a roof covering.



Figure 92. Wind Damage to a Roof Covering

- **Roof Deck**

  The roof deck transfers the roof loads to the underlying trusses or rafters. Damage to the roof deck constitutes a breach of the building envelope and can result in significant building and interior damage. Some commonly used roof deck materials are plywood, precast concrete slabs, reinforced concrete slabs, and light metal. Figure 93shows wind damage to a roof deck.



Figure 93. Wind Damage to a Roof Deck

- **Roof Geometry**

  The magnitude of aerodynamic loads that are applied to a roof is largely determined by its geometry, or shape, as it affects the intensity of wind pressures and the resulting uplift resistance. Common roof shapes include gable and hip, although a variety of roof shapes are possible. Below are some brief descriptions of more common roof shapes.

  - **Gable Roof**

A gable roof slopes in two directions so that the end formed by the intersection of the slopes is a vertical triangle

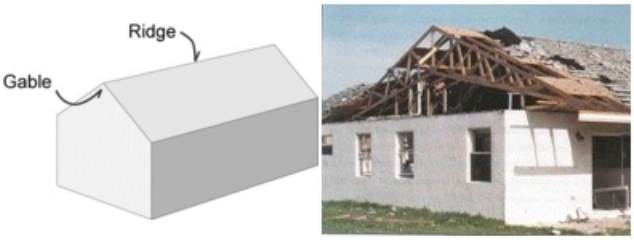


Figure 94. Illustration of a Gable Roof and Hurricane Damage

- **Hip Roof**

A hip roof slopes in four directions so that the end formed by the intersection of the slopes is a sloped triangle.

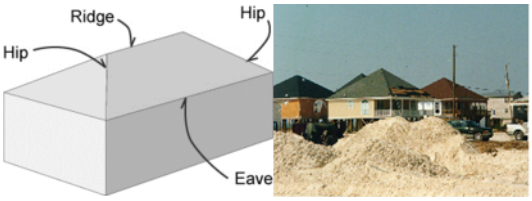


Figure 95. Illustration and Examples of Hip Roofs

- **Mansard Roof**

Like the hip roof, this roof also slopes in four directions but there is a break in each slope.

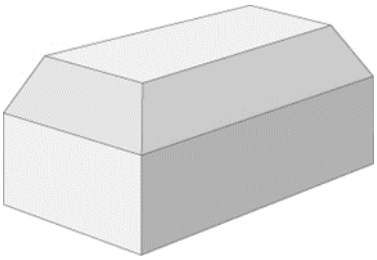


Figure 96. Illustration of a Mansard Roof

Methodology for Accounting for Secondary Risk Characteristics

Building aerodynamics is a complex phenomenon due to the fact that the performance of a building depends on the interaction of several building components. Moreover, damage due to wind is progressive: failure at a localized level can eventually grow to a catastrophic level. Thus it is important to recognize the way in which damage progresses and the role and importance of building components at each stage of failure.

Verisk's methodology for accounting for secondary risk characteristics follows a structured, logical approach that groups building characteristics according to their function. In this way, the methodology reflects the contribution

of each characteristic to the overall building performance. This methodology relies on expert experience in wind engineering, damage observation from post-disaster surveys, and data from wind tunnel experiments. The ultimate goal is to develop a modification function that is applied to the base damage function—one that appropriately captures the impact of one or more selected building characteristics.

Weightings are used to combine the effects of secondary risk characteristics whose interaction is complex and not necessarily additive. These are introduced to evaluate features that modify the performance of the system. If we consider the roof system, age, pitch, and geometry modify the performance of the roof as a whole and therefore the weight should be used as a multiplier. The weights are dependent on wind speed and construction class, and are appropriately selected to reflect the importance of a feature at certain levels of a building's damage state.

Evaluating Building Performance

There are two primary metrics for evaluating the impact of a building or environmental feature on overall building performance. The first is a weighted value assigned to the various options for building or environmental features. The value for any given option of any given feature reflects the relative prevalence of use among the options and is independent of other features. That is, the value is designed such that the most commonly used option is assigned a value close to 1.0. The implication is that a building with this option is expected to perform very similarly to the average, or "typical," building represented by the base damage functions.

The value assigned for an option that is considered to be more vulnerable (less wind resistive) than the most commonly chosen one is greater than 1.0. That is, a building with this option will be more vulnerable than the average building. Similarly, the value assigned for an option that is considered to be less vulnerable (more wind resistive) than the most prevalent one will be less than 1.0. Such a building will be less vulnerable than the average building. If no information is available on the option, the default value is 1.0, which means that the base damage function is used without modification.

The second metric has two types. One type is used to develop simple weighted averages, which are used to evaluate the loss contribution of several features that together constitute a system, such as a roof. They are wind-speed dependent; that is, the contribution of each feature varies with wind speed. For example, a roof system may consist of three features: roof covering, roof deck, and roof attachment. The loss contribution to the roof system from these three features is expected to be different at different wind speeds. At low wind speeds, the roof covering drives the damage. As wind speeds increase, the roof deck becomes more vulnerable. In this case, roof deck failure will result in loss of roof covering regardless of the type (or option) of roof covering present. Therefore, as wind speed increases, the weight assigned to roof deck increases. In contrast, at higher wind speeds, the weight for roof covering decreases because it is already lost. The weights for the system as a whole add up to 1.0.

The second type of weighting combines the effects of features whose interaction is complex and not necessarily additive. These are introduced to evaluate features that modify the performance of the system. If we consider a roof system again, the roof age, roof pitch, and roof geometry modify the performance of the roof as a whole and therefore the weight should be used as a multiplier. The weights are dependent on wind speed and construction class, and are appropriately selected to reflect the importance of a feature at certain levels of building damage.

Example of Wind Speed Dependency

As noted above, the performance of secondary building characteristics is wind-speed dependent. This can be further explained by considering in detail a single feature, such as roof-wall anchorage. Roof-wall anchorage provides the means to establish a load path to transfer wind loads from the roof to the walls.

This anchorage can be provided through:

- Hurricane straps
- Structural connections
- Nails
- Epoxy/adhesive
- Anchor bolts
- Gravity/friction

By selecting hurricane straps as one of the options for "roof wall anchorage" we can observe varying mitigation benefits in three different wind speed regimes.

- For lower wind speeds, the mitigation benefits (in terms of reduced damage) of hurricane straps are similar to any other roof-wall anchorage mechanism. Hence mitigation benefits are not high at these wind speeds.
- At higher wind speeds, hurricane straps are very effective in reducing damage. At these wind speeds, the presence of straps is most important. Hence mitigation benefits are high.
- At very high wind speeds, the effectiveness of hurricane straps in reducing the damage decreases. Hence, mitigation benefits are low.

Because of its inherent weakness, there are no mitigation benefits for "epoxy/adhesive" as an option for "roof wall anchorage." In fact, "penalties" are applied and the size of the penalty is wind speed dependent.

- At low wind speeds, the effectiveness of "epoxy/adhesive" is similar to other roof-wall anchorage mechanisms. Hence we do not see any large penalties being exacted in this wind speed domain.
- At higher wind speeds, the choice of a weak roof-wall anchorage has a significant impact on damage. Hence we see high penalty being exacted.
- At very high wind speeds, most roof-wall anchorage mechanisms are ineffective. Thus the penalty for choosing a weak one is small.

The above examples illustrate how different wind speeds impact the accrual or non-accrual of mitigation benefits for a particular feature, as illustrated in Figure 97.

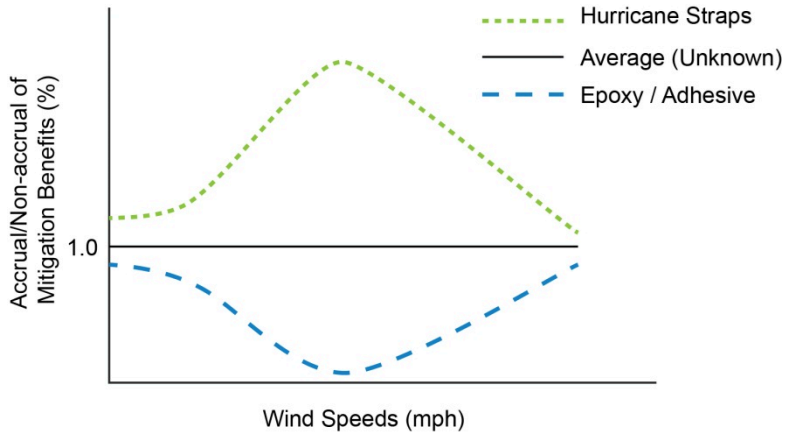


Figure 97. Mitigation Benefits of Various Roof-Wall Anchorage Options

Sample Mitigation Curves

Failure of windows during a hurricane is often due to the impact of flying debris or to the exceedance of the window's pressure capacity. Window failure is a breach of the building envelope and allows wind and water to enter the building. Even if there is no structural damage to the building, this intrusion of water would cause damage to contents and building interior finishes, which can lead to substantial losses. Protecting the windows is critical in reducing the potential damage to a building. One mitigation option is the installation of engineered storm shutters.

As can be seen in Figure 98, the percentage reduction in damage achieved by the installation of engineered storm shutters is wind speed dependent. At lower and high wind speeds the percentage of reduction in damage is comparable to that of any other equivalent window protection mechanism. Hence we do not see any higher order percentage reduction of damage at lower and higher wind speeds. The effectiveness of engineered storm shutters is greatest in the middle range of wind speeds, where shutters have the greatest marginal impact on damage reduction.

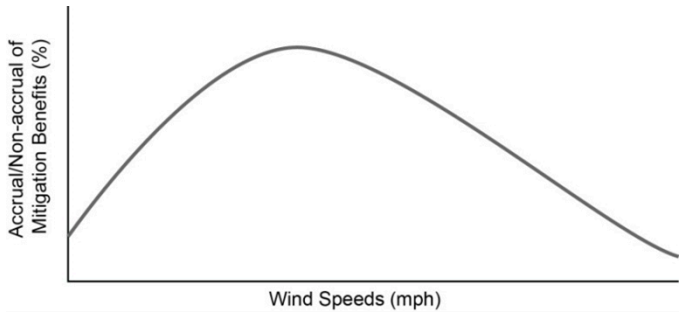


Figure 98. Modification Function for Engineered Storm Shutters

Damage to the roof covering can also result in significant water damage to the interior of the building and contents. A sample modification curve for a slate roof covering is provided in Figure 99.

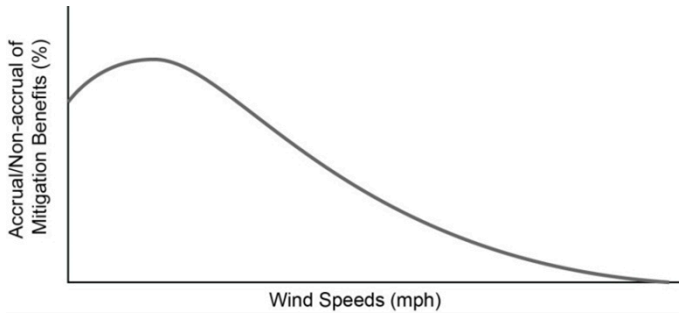


Figure 99. Modification Function for Slate Roofing

Spatial and Temporal Dependency of the Marginal Impact of Secondary Risk Characteristics

For a given construction type, occupancy class, and height, the Verisk Hurricane Model for the United States defines a typical building in terms of default secondary risk characteristics, for each location and year built, to estimate its vulnerability. Thus the marginal impact on vulnerability of secondary risk characteristics is also dependent on the location of the structure and the year it was built. User input of secondary risk characteristics will overwrite the default characteristics, and a new vulnerability function is estimated depending on the user's input relative to default features. For example, an input of "engineered shutter" will provide no to minor reduction in vulnerability for a Miami home built after 2002, but will provide a large reduction in vulnerability for a Tallahassee home built before 1995. This coherent approach provides a framework that properly accounts for the overlap of the impact of different secondary features (e.g., year built and mitigation features) and avoids potential double counting of secondary features in the model. However, the overall vulnerability for a structure in Miami is likely to be lower than that of a building in Tallahassee. It is this marginal impact of secondary risk characteristics that will be different.

Validating the Impact of Secondary Risk Characteristics

The quality and level of detail of exposure and claims data has improved over time. Before the 2004 and 2005 hurricane seasons, most of the data were aggregated at the ZIP Code level with little to no information about individual building characteristics. Data from more recent storms indicates that most companies have started capturing exact addresses and primary building characteristics such as construction, occupancy, height, and year-built. Many clients have also captured detailed building characteristics such as roof covering type, type of opening protection, and roof sheathing connection, etc. Verisk has analyzed this data to validate the impact of individual characteristics and characteristics in combinations. Figure 100 compares modeled and observed mitigating impacts of key individual building characteristics, as well as of the combined characteristics in a single building (mitigated building).

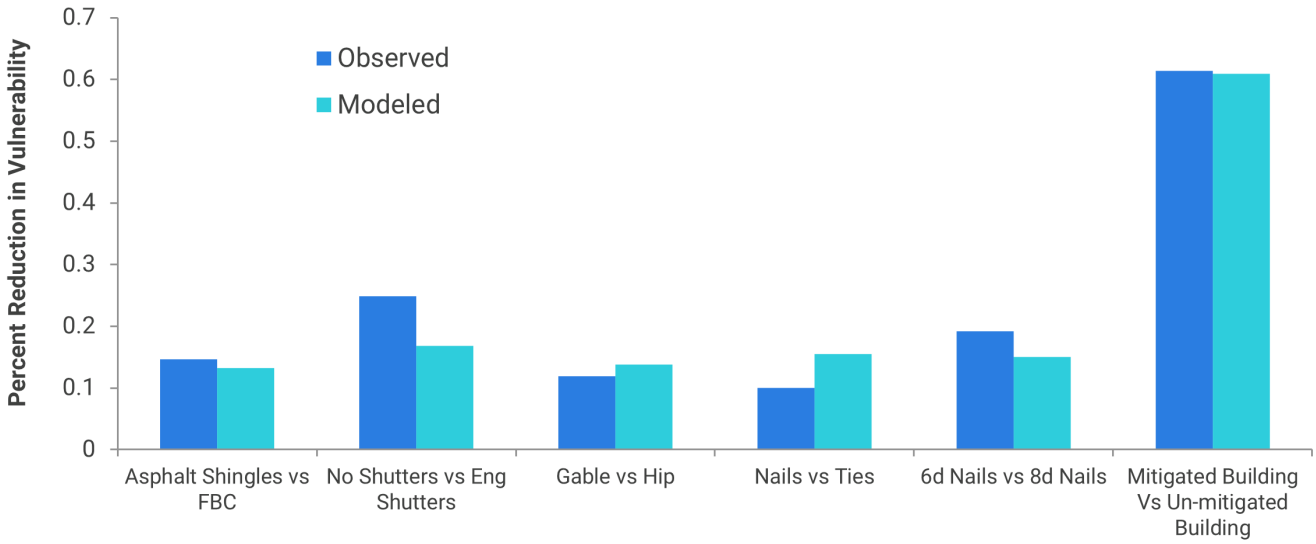


Figure 100. Validation of the Impact of Secondary Risk Characteristics, Alone and in Combination

Proper Use of the Secondary Risk Characteristic "Seal of Approval"

Even when building codes are mandatory, the level of engineering participation in the design and construction of a structure can vary regionally. In Florida, for example, a professional engineer typically performs an inspection and undertakes load calculations before engineering drawings are sealed. For many coastal counties in Texas, a professional engineer inspects the buildings, but design load calculations are not performed. For many other states, basic inspection is sufficient to meet the building code requirements.

In the Verisk Hurricane Model for the United States, the secondary risk characteristic "Seal of Approval" was developed to account for the differing effects the same class of mitigation features may have on the vulnerability of a structure. For example, the impact of a good roof-to-wall connection (e.g., strap) may be much higher for a home that received engineering attention during construction (e.g., design calculations were completed to ensure there are continuous horizontal and vertical load paths) than the impact on a home where such detailed engineered attention was not paid. The purpose of these features is not to turn a house with bad building characteristics into a good house with mitigation features, but to distinguish between the impact of a mitigation feature based on the level of engineering attention. Thus, the Seal of Approval will not change the vulnerability of a structure with otherwise poor building characteristics.

There are three options for the Seal of Approval:

- Fully Engineered Structure

  The structure has been designed by a Professional Engineer. The Professional Engineer is required to seal the calculations and drawings by the local jurisdiction.
- Partially Engineered Structure

  The structure has been inspected by a Professional Engineer and found "deemed-to-comply" with the respective Building Code. The local jurisdiction does not require the Professional Engineer to seal the calculations.

- Minimally Engineered Structure

  The structure does not satisfy any of the conditions mentioned above.

Following are examples to illustrate the use of Seal of Approval in the model.

- A Miami structure built in 2009

  The model assumes a well mitigated and Fully Engineered Structure for this location and year- built. Thus, using the Partially or Minimally Engineered options under Seal of Approval would increase the vulnerability of structures.
- A Mississippi structure built in 1995

  The model does not assume a mitigated structure for this location and year-built. Thus, applying any option under Seal of Approval will not modify the vulnerability functions.
- A Mississippi structure built in 1995 with user-selected secondary risk characteristics, such as high-wind rated roof covering, hurricane ties, and engineered shutters

  Since the user has selected secondary risk characteristics that will make the structure a mitigated structure, selecting the Partially Engineered or Fully Engineered options will further reduce the vulnerability of the structure.

Please note that when year-built is unknown, the Seal of Approval characteristic does not have an impact on the vulnerability.

Mitigation Credits for Construction to Florida Building Code 2001 (FBC 2001)

For buildings built to the minimum requirements of the FBC 2001, Verisk has identified six unique building categories for Florida, as listed in Table 60, by taking into consideration the design wind speed, terrain exposure category, and the requirements of Wind-borne Debris Region (WBDR) and High Velocity Hurricane Zone (HVHZ).

Table 60. Building Categories According to FBC 2001

Building Category	Wind Speed*** (mph)	Exposure	WBDR**
1	<120	B	No
2	≥110	C	Yes
3	≥120	B	No
4	≥120	B	Yes
5	≥120	C	Yes
6	HVHZ*	C	Yes

Note

* Broward and Miami-Dade counties.

** In these areas, buildings can be designed for internal pressures instead of providing opening protections. In the model, explicit assumption about opening protection has not been made except for Region 6 where it is required to have the opening protection.

*** The wind speeds specified as per FBC 2001 are "nominal" or "basic" wind speeds as per allowable stress design (ASD).

Figure 101 shows the geographical locations of these building categories in Florida. The vulnerability functions for these six unique building categories were derived by selecting the relevant building features and options from the Verisk individual risk module that meet the minimum requirements of FBC 2001. For example, Verisk building category 6 is located in the HVHZ and is designed for a wind speed of 146 mph and Exposure C (Open country), as specified in FBC 2001. The code stipulates all openings be protected in the HVHZ.

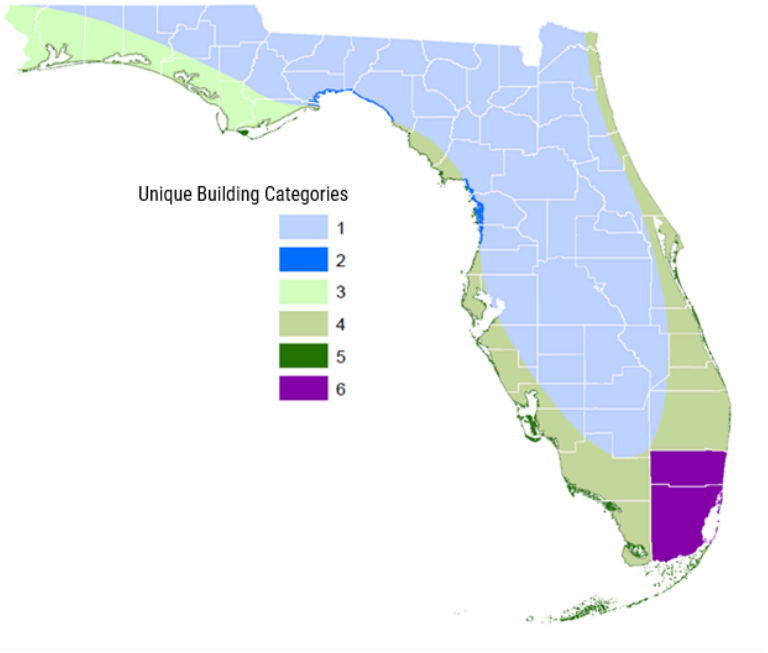


Figure 101. Buildings that Meet the Minimum Requirements of FBC 2001

Table 61 illustrates the roof covering, roof covering attachment, roof deck, roof-deck attachment, roof anchorage, opening protection, and exterior door options selected for residential wood frame category 6 buildings to meet the minimum requirements of the Florida Building Code.

Table 61. Model Parameters for Building Category 6 According to the Minimum Requirements of FBC 2001

Parameter	Building 6
Wind Speed	146 mph
Exposure	C
WBDR	Yes
HVHZ	Yes
Roof Covering	FBC Equivalent

Parameter	Building 6
Roof Cover Attachment	Nails / Staples
Roof Deck	Plywood
Roof-Deck Attachment	8d@6"/6"
Roof Anchorage	Hurricane Straps
Window Protection	Engineered Shutters
Exterior Doors	Impact Resistant - Reinforced

Mitigation Credits for Construction to Florida Building Code 2010 (FBC 2010)

For buildings built to the minimum requirements of FBC 2010, Verisk has identified eleven unique building categories for Florida, as listed in Table 62 by taking into consideration the design wind speed, terrain exposure category, and the requirements of WBDR and HVHZ.

Table 62. Building Categories According to FBC 2010

Building Category	Wind Speed*** (mph)	Exposure	WBDR**
1	115 ≤ WS < 130	B	No
2		C	No
3	130 ≤ WS< 140	B	No
4		C	No
5		B	Yes
6		C	Yes
7	140 ≤ WS < 155	B	Yes
8		C	Yes
9	≥ 155	B	Yes
10		C	Yes
11	HVHZ*	C	Yes

Note

* Broward and Miami-Dade counties.

** In the model, the opening protection is explicitly assumed for buildings in the WBDR.

*** The design wind speeds as per FBC 2010 are for risk Category II buildings and are "ultimate" wind speeds as per Load and Resistance Factor Design (LRFD).

Figure 102 shows the geographical locations of these building categories in Florida. The vulnerability functions for these eleven unique building categories were derived by selecting the relevant building features and options from the Verisk individual risk module that meet the minimum requirements of the Florida Building Code 2010. For example, Verisk building category 11 is located in the High Velocity Hurricane Zone (HVHZ) where the design wind speed is 170 mph and 175 mph in the Broward and Miami-Dade counties for risk Category II buildings,

respectively, as specified in FBC 2010. In addition, Exposure C (Open country) is assumed in HVHZ. The code stipulates all openings be protected in High Velocity Hurricane Zone.

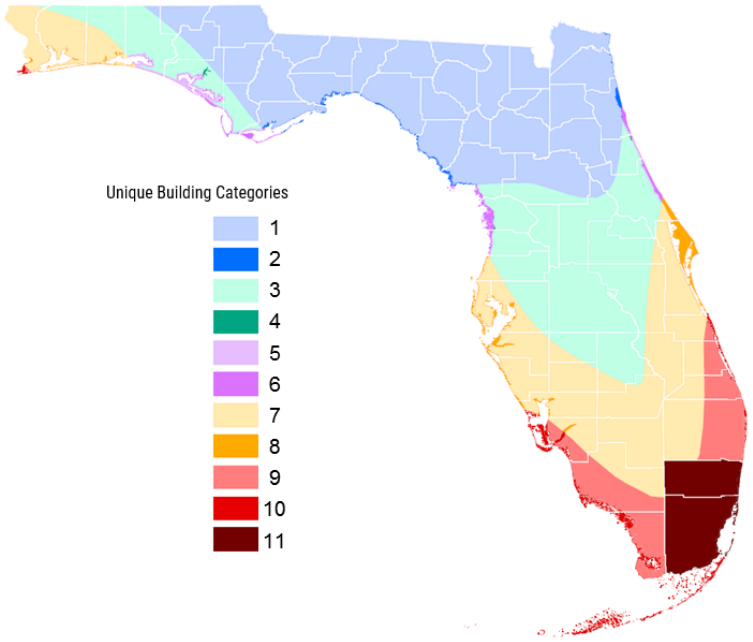


Figure 102. Buildings that Meet the Minimum Requirements of the Florida Building Code 2010

Table 63 illustrates the roof covering, roof covering attachment, roof deck, roof-deck attachment, roof anchorage, building foundation connection, opening protection, door, wall attached structures, and mechanical system options selected for residential wood frame category 11 buildings to meet the minimum requirements of the Florida Building Code 2010.

Table 63. Model Parameters for Building Category 11 According to the Minimum Requirements of FBC 2010

Parameter	Building 11
Wind Speed	170 or 175 mph
Exposure	C
WBDR	Yes
HVHZ	Yes
Roof Covering	FBC Equivalent
Roof Cover Attachment	Screws
Roof Deck	Plywood
Roof-Deck Attachment	Structurally Connected
Roof Anchorage	Hurricane Straps
Foundation Connection	Hurricane Straps
Window Protection	Engineered Shutters
Exterior Doors	Impact Resistant - Reinforced
Wall Attached Structures	None

Parameter	Building 11
Roof Attached Structures	Secondary Water Resistance - Yes

Evaluating Wind Loss Mitigation Credits with the Touchstone Location Detail Record

On June 6, 2002, the Florida Department of Insurance issued an Informational Memorandum (0470M) which outlined provisions of the Florida Statute Section 627.0629(1). The new statute requires that rate filings received by the Florida Department of Insurance on or after June 1, 2002, include credits for “fixtures or construction techniques demonstrated to reduce the amount of loss in a windstorm”. The statute further requires all insurers to make a rate filing which includes actuarially reasonable differentials by February 28, 2003.

This document provides guidance to companies who wish to use Touchstone for evaluating these wind mitigation credits. According to the statute, the following 6 areas must be considered:

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

The Information Memorandum states that other construction techniques have also been demonstrated to influence loss and thus should also be considered:

- Roof shape
- Wall Construction
- Opening Protection for non-glazed openings (e.g., doors)
- Gable End Bracing for roof shapes other than hip

Touchstone Location Detail Record

The location detail record contains several building and environmental features that influence loss from windstorms. Table 64 shows the features of particular relevance to the Florida Statute.

Note that some features can be used to address more than one area of interest. For example, while roof geometry is a separate category, it also influences roof strength.

Table 64. Building Features Relevant to the Florida Statute

Mitigation Category	Touchstone Location Detail Field
Enhanced Roof Strength	Roof Deck Roof Deck Attachment Roof Covering Roof Covering Attachment Roof Geometry Roof Pitch Year Roof Built
Opening Protection	Window Protection
Opening Protection for Non-glazed Openings	Exterior Doors Wall Attached Structures
Roof Covering Performance	Roof Covering Roof Covering Attachment
Roof Shape	Roof Geometry
Roof to Wall Strength	Roof Anchorage Wall Type Wall Siding
Wall Construction	Wall Type Wall Siding
Wall to Floor to Foundation Strength	Foundation Connection
Window, Door, Skylight Strength	Glass Type Exterior Doors Wall Attached Structures

Developing Mitigation Credits

In 2001, the Florida Department of Community Affairs (DCA) commissioned a study to estimate the loss reduction potential of different wind resistive building features. Loss cost relativities were presented for a set of primary rating factors, with various options for each factor. The Florida Department of Insurance recognizes the "public domain" DCA study as one basis for deriving credits, but notes that insurers may rely upon other studies.

Verisk has developed loss modification factors for a similar range of building features. Touchstone users may use these factors to develop rating credits in a similar manner as presented in the public domain study. It is important to note that the Verisk and DCA studies were developed independently, and as a result have differences in methodology, features, and conclusions. While there is no direct mapping of the rating tables used in the DCA study to the Verisk secondary characteristics, Verisk has developed a list of characteristics that provide a similar range of relativities. The DCA features and closest Verisk selections are shown in Table 65.

Table 65. DCA Features and Corresponding Verisk Secondary Characteristics

DCA Feature	Similar Verisk Category and Selections
Opening Protection • None • Basic • Hurricane	Window Protection • None • Non-Engineered Shutters • Engineered Shutters

DCA Feature	Similar Verisk Category and Selections
Roof Cover • Non FBC Equivalent • FBC Equivalent	Roof Covering + Roof Covering Attachment • Asphalt Shingles + Nails • FBC Equivalent + Nails
Roof Deck Attachment • A • B • C	Roof Deck + Roof Deck Attachment • Plywood + 6d nails @ 6”/12” • Plywood + 8d nails @ 6”/12” • Plywood + 8d nails @ 6”/6”
Roof Shape • Hip • Other	Roof Geometry • Hip • Gable End without Bracing
Roof Wall Connection • Toe Nails • Clips • Single Wraps • Double Wraps	Roof Anchorage • Nails/Screws • Clips • Hurricane Ties
Secondary Water Resistance	Secondary Water Resistance
No Secondary Water Resistance	No Secondary Water Resistance

The Verisk study made use of the same 31 points used to define locations in the public domain study. The analysis showed that loss relativities did not vary significantly by location. The resulting Verisk wind loss mitigation relativities are therefore presented as the mean of the relativities across all locations, and take into account locations in each of the wind speed and terrain exposure combinations implemented in the Florida Building Code.

17 Appendix 9: Remapped ZIP Codes

Remapped ZIP Codes

Table 66. Remapped ZIP Codes FHCF 2017

ZIP	Remapped ZIP		ZIP	Remapped ZIP		ZIP	Remapped ZIP
32004	32082		32791	32779		33660	33619
32006	32003		32793	32792		33672	33602
32007	32177		32794	32751		33675	33605
32026	32083		32795	32746		33679	33629
32030	32068		32802	32801		33680	33610
32035	32034		32830	32836		33682	33612
32041	32097		32853	32803		33684	33614
32042	32044		32854	32804		33685	33615
32050	32068		32855	32805		33687	33617
32056	32055		32856	32806		33688	33618
32064	32060		32857	32807		33694	33624
32067	32073		32859	32809		33730	33713
32072	32087		32862	32827		33731	33701
32079	32043		32867	32817		33732	33702
32085	32084		32869	32819		33733	33713
32099	32220		32872	32822		33734	33704
32105	32180		32877	32837		33738	33708
32111	34472		32878	32828		33740	33706
32115	32114		32886	32801		33741	33706
32116	32118		32902	32901		33743	33710
32120	32114		32910	32907		33744	33708
32121	32119		32912	32904		33747	33711
32123	32119		32919	32901		33758	33765
32133	32179		32932	32931		33762	33716
32135	32137		32936	32935		33766	33759
32138	32666		32941	32940		33769	33765
32143	32136		32954	32953		33775	33772
32147	32148		32956	32955		33779	33770
32157	32181		32957	32958		33780	33781
32158	32159		32959	32927		33784	33713

ZIP	Remapped ZIP		ZIP	Remapped ZIP		ZIP	Remapped ZIP
32160	32656		32961	32960		33802	33815
32170	32168		32964	32963		33804	33805
32173	32174		32965	32962		33806	33803
32175	32176		32969	32966		33807	33813
32178	32177		32970	32967		33820	33830
32182	32134		32978	32958		33826	33825
32183	32179		33002	33012		33831	33830
32185	32666		33008	33009		33836	33837
32192	32617		33017	33015		33845	33844
32201	32202		33022	33020		33858	33837
32203	32204		33041	33040		33862	33852
32212	32214		33045	33040		33863	33860
32228	32227		33052	33050		33871	33870
32231	32207		33061	33060		33882	33881
32232	32209		33072	33069		33883	33881
32235	32225		33074	33064		33885	33881
32236	32205		33075	33065		33888	33884
32239	32277		33077	33071		33902	33901
32240	32250		33081	33021		33906	33907
32241	32257		33082	33027		33910	33904
32245	32246		33084	33024		33911	33907
32247	32207		33090	33030		33915	33990
32255	32216		33092	33032		33918	33917
32260	32259		33101	33128		33927	33953
32302	32301		33102	33126		33929	33928
32313	32304		33112	33172		33931	33908
32314	32305		33114	33134		33932	33908
32315	32303		33116	33176		33945	33922
32326	32327		33119	33139		33951	33950
32332	32324		33152	33122		33970	33936
32341	32340		33164	33162		33975	33935
32345	32344		33188	33174		33994	33905
32353	32351		33192	33172		34101	34102
32357	32331		33195	33166		34106	34102
32360	32334		33197	33157		34107	34108
32361	32344		33199	33174		34133	34135
32362	32305		33231	33131		34136	34135

ZIP	Remapped ZIP		ZIP	Remapped ZIP		ZIP	Remapped ZIP
32402	32401		33233	33133		34137	34114
32410	32456		33234	33134		34143	34142
32411	32408		33239	33139		34146	34145
32417	32407		33245	33145		34204	34203
32422	32433		33256	33156		34206	34205
32432	32442		33261	33181		34218	34217
32434	32433		33266	33166		34220	34221
32447	32446		33269	33169		34230	34236
32452	32425		33302	33311		34264	34203
32457	32456		33303	33301		34265	34266
32463	32428		33307	33334		34267	34266
32513	32503		33310	33311		34268	34266
32516	32506		33318	33317		34270	34243
32521	32507		33329	33328		34272	34275
32522	32501		33335	33316		34274	34275
32524	32504		33338	33304		34276	34231
32537	32536		33340	33311		34277	34239
32538	32567		33345	33328		34278	34234
32540	32541		33346	33316		34280	34209
32549	32548		33402	33401		34281	34207
32559	32509		33416	33406		34282	34207
32560	32533		33419	33404		34284	34285
32562	32561		33420	33410		34290	34286
32572	32570		33422	33417		34421	34420
32588	32578		33424	33436		34423	34429
32602	32601		33425	33435		34430	34431
32604	32603		33427	33486		34447	34448
32614	32608		33429	33432		34451	34450
32616	32615		33443	33441		34460	34461
32627	32601		33448	33446		34464	34465
32633	32640		33454	33463		34477	34474
32634	32686		33459	33440		34483	34472
32635	32605		33464	33460		34487	34448
32639	34449		33465	33462		34489	34488
32644	32626		33466	33461		34492	34491
32654	32640		33468	33458		34603	34601
32655	32643		33474	33437		34605	34601

ZIP	Remapped ZIP		ZIP	Remapped ZIP		ZIP	Remapped ZIP
32658	32615		33475	33455		34611	34606
32662	32640		33481	33431		34636	34601
32663	32686		33482	33445		34656	34653
32664	32667		33497	33428		34660	34683
32681	32667		33503	33598		34674	34667
32692	32680		33508	33511		34679	34667
32697	32054		33509	33511		34680	34652
32704	32712		33524	33542		34682	34683
32706	32744		33526	33525		34712	34711
32710	32818		33530	33567		34713	34714
32716	32714		33537	33523		34729	34715
32718	32707		33539	33542		34740	34760
32719	32708		33540	33542		34742	34741
32721	32724		33550	33584		34745	34744
32722	32720		33564	33563		34749	34748
32723	32724		33566	33563		34755	34715
32727	32726		33568	33569		34770	34769
32728	32725		33571	33573		34777	34787
32733	32792		33574	33525		34778	34787
32739	32738		33575	33570		34789	34788
32747	32771		33583	33584		34948	34950
32752	32750		33585	34785		34954	34950
32756	32757		33586	33570		34958	34957
32762	32765		33587	33527		34973	34974
32768	32712		33593	33523		34979	34981
32772	32771		33595	33594		34985	34952
32774	32763		33601	33602		34991	34990
32775	32754		33608	33621		34992	34997
32777	32757		33622	33607		34995	34994
32781	32780		33623	33607			
32783	32780		33646	33647			
32790	32789		33655	33602			

Table 67. Remapped ZIP Codes FHCF 2023

ZIP	Remapped ZIP		ZIP	Remapped ZIP		ZIP	Remapped ZIP
32004	32082		32728	32725		33601	33602
32007	32177		32733	32792		33608	33621

ZIP	Remapped ZIP		ZIP	Remapped ZIP		ZIP	Remapped ZIP
32035	32034		32739	32738		33655	33602
32041	32097		32747	32771		33673	33604
32042	32044		32756	32757		33675	33605
32050	32068		32762	32765		33677	33607
32056	32055		32768	32712		33679	33629
32067	32073		32772	32771		33681	33611
32079	32043		32774	32763		33687	33617
32085	32084		32775	32754		33689	33619
32099	32220		32777	32757		33733	33713
32105	32180		32790	32789		33740	33706
32111	34472		32791	32779		33743	33710
32120	32114		32793	32792		33757	33755
32121	32119		32795	32746		33758	33765
32123	32119		32802	32801		33769	33765
32126	32118		32853	32803		33775	33772
32133	32179		32856	32806		33779	33770
32135	32137		32859	32809		33780	33781
32138	32666		32891	32803		33784	33713
32147	32148		32902	32901		33802	33815
32157	32181		32941	32940		33804	33805
32158	32159		32956	32955		33807	33813
32160	32656		32957	32958		33820	33830
32175	32176		32961	32960		33826	33825
32178	32177		32970	32967		33831	33830
32182	32134		33002	33012		33836	33837
32183	32179		33017	33015		33845	33844
32185	32666		33022	33020		33858	33837
32192	32617		33061	33060		33862	33852
32201	32202		33072	33069		33863	33860
32203	32204		33074	33064		33871	33870
32228	32227		33075	33065		33882	33881
32232	32209		33081	33021		33883	33881
32235	32225		33084	33024		33885	33881
32241	32257		33092	33032		33902	33901
32245	32246		33101	33128		33906	33907
32247	32207		33102	33126		33910	33904
32302	32301		33106	33126		33915	33990

ZIP	Remapped ZIP		ZIP	Remapped ZIP		ZIP	Remapped ZIP
32313	32304		33114	33134		33918	33917
32314	32305		33116	33176		33927	33953
32316	32304		33153	33138		33929	33928
32326	32327		33164	33162		33945	33922
32329	32320		33192	33172		33951	33950
32341	32340		33197	33157		33970	33936
32345	32344		33222	33172		33975	33935
32353	32351		33242	33142		33994	33905
32357	32331		33256	33156		34101	34102
32361	32344		33257	33157		34133	34135
32362	32305		33265	33165		34137	34114
32402	32401		33269	33169		34143	34142
32406	32405		33283	33183		34146	34145
32410	32456		33303	33301		34218	34217
32411	32408		33307	33334		34220	34221
32417	32407		33310	33311		34230	34236
32422	32433		33318	33317		34249	34238
32432	32442		33320	33321		34265	34266
32434	32433		33335	33316		34267	34266
32447	32446		33338	33304		34268	34266
32457	32456		33346	33316		34270	34243
32463	32428		33359	33319		34272	34275
32520	32502		33402	33401		34276	34231
32521	32507		33416	33406		34280	34209
32524	32504		33421	33411		34281	34207
32537	32536		33424	33436		34282	34207
32538	32567		33425	33435		34421	34420
32540	32541		33427	33486		34430	34431
32549	32548		33429	33432		34447	34448
32559	32509		33443	33441		34460	34461
32560	32533		33448	33446		34464	34465
32562	32561		33459	33440		34487	34448
32572	32570		33464	33460		34489	34488
32588	32578		33466	33461		34492	34491
32616	32615		33474	33437		34603	34601
32627	32601		33475	33455		34605	34601
32633	32640		33481	33431		34611	34606

ZIP	Remapped ZIP		ZIP	Remapped ZIP		ZIP	Remapped ZIP
32634	32686		33482	33445		34636	34601
32635	32605		33497	33428		34660	34683
32639	34449		33503	33598		34674	34667
32644	32626		33508	33511		34679	34667
32654	32640		33524	33540		34682	34683
32655	32643		33526	33525		34697	34698
32658	32615		33530	33567		34712	34711
32662	32640		33537	33523		34729	34715
32663	32686		33539	33542		34740	34760
32664	32667		33550	33584		34749	34748
32681	32667		33564	33566		34755	34715
32692	32680		33568	33569		34770	34769
32697	32054		33571	33573		34778	34787
32704	32712		33574	33525		34789	34788
32706	32744		33575	33570		34948	34950
32715	32701		33583	33584		34973	34974
32719	32708		33586	33570		34991	34990
32721	32724		33587	33527		34992	34997
32723	32724		33593	33523		34995	34994
32727	32726		33595	33594			

18 Appendix 10: List of Acronyms

Table 68. List of Acronyms

Acronym	Meaning
AAL	Average Annual Loss
AAWE	American Association of Wind Engineers
ACV	Actual Cash Value
AD	ActiveDirectory
AIRPort	AIR intranet
ALE	Additional Living Expense
ALERT	AIR Loss Estimates in Real Time
AOML	Atlantic Oceanographic and Meteorological Laboratory
API	Application Programm Interface
ASCE	American Society of Civil Engineers
ASD	Allowable Stress Design
ASTM	American Society for Testing and Materials
AZDO	Azure Development Operations or Azure DevOps
BCP	Business Continuity Plan
BD	Business Development team at Verisk
BINS	Verisk's Building Identification Numbering System
ByP	By-passing hurricane
C-CAP	Coastal Change Analytics Program, NOAA
CCSG	Verisk's Consulting and Client Services Group
CEEM	Consultant and Certified Extreme Event Modeler
CFR	Code of Federal Regulations
CRM	Customer Relationship Management
CP	Central Pressure, generally in units of mb (millibars)
CRESTA	Catastrophe Risk Evaluation and Standardizing Target Accumulations
CSV	Comma Separated Value
DCA	Department of Community Affairs
DITA	Darwin Information Typing Architecture
DMZ	Demilitarized Zone
DoD	Definition of Done
DOE	Department of Energy
DoR	Definition of Ready
DR	Disaster Recovery

Acronym	Meaning
DTG	Verisk's Data Technology Group
EBTRK	DeMaria Extended Best Track Dataset
EEM	Verisk's Enterprise Exposure Management
EES	Extreme Event Solutions at Verisk
EIFS	Exterior Insulation Finishing System
EP	Exceedance Probability
ERT	Emergency Response Team
ESDU	Engineering Sciences Data Unit
FBC	Florida Building Code
FCAS	Fellow of the Casualty Actuarial Society
FCHLPM	Florida Commission on Hurricane Loss Projection Methodology
FEMA	Federal Emergency Management Agency
FHCF	Florida Hurricane Catastrophe Fund
FIPS	Federal Information Processing Standards
FL Template	Florida Rate Filing Analysis template
FTP	File Transfer Protocol
GB	Gigabyte
GIS	Geographic Information System
GWRF	Gradient Wind Reduction Factor
HCI	Human-Computer Interaction
HPC	High Performance Computing
HRD	Hurricane Research Division
HTML	HyperText Markup Language
HUD	U.S. Department of Housing and Urban Development
HURDAT	Hurricane Database
HURDAT2	Revised Atlantic Hurricane Database
HVHZ	High-Velocity Hurricane Zone
IBHS	Institute for Business and Home Safety
ICC	International Code Council
ID	Identification
IED	Industry Exposure Database
IRM	Individual Risk Module
ISO	Insurance Services Office, Inc. at Verisk
IT	Verisk's Information Technology Services
ITV	Insurance to Value
LRFD	Load and Resistance Factor Design
LULC	Land Use Land Cover
MAAA	Member of the American Academy of Actuaries

Acronym	Meaning
MAE	Mean Absolute Error
Mbps	Megabytes per Second
MDPI	Multidisciplinary Digital Publishing Institute
METAR	A format for reporting weather information
MIG	Model Implementation Group
Model 521	Verisk Hurricane Model for the United States
Mph	Mile per hour
MRLC	Multi-Resolution Land Characteristics
MSDN	Microsoft Developer Network
MSVC	Microsoft Visual C++
NCAR	National Center for Atmospheric Research
NCCI	National Council on Compensation Insurance
NGM	Next Generation Modeling
NHC	National Hurricane Center
NLCD	National Land Cover Database
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
OED	Open Exposure Data
OS	Operating System
PC	Personal Computer
PCS	Property and Claims Services at Verisk
PDF	Portable Document Format
PE	Professional Engineer
PM	Product Management
PML	Probable Maximum Loss
PWF	Peak Weighting Factor
QA	Quality Assurance
Q-Q	Quantile-Quantile plot
RAF	Radial Adjustment Function
RECS	Residential Energy Consumption Survey
Rmax	Radius of Maximum Winds
RMSE	Root Mean Square Error
RMT	Recovery Management Team
ROA	Report of Activities
RRACS	Regulatory and Rating Agency Client Support
SDG	Verisk's Software Development Group
SME	Subject Matter Expert
SPLASH	Special Program to List Amplitudes of Surges From Hurricanes

Acronym	Meaning
SSH	Secure Shell
SQL	Structured Query Language
SST	Sea Surface Temperature
TB	Terabyte
TFS	Team Foundation Server
TIGER	U.S. Census Topologically Integrated Geographic Encoding and Referencing
TFVC	Verisk's Microsoft Team Foundation Version Control
UI	User Interface
USGS	United States Geological Survey
USPS	United States Postal Service
UX	User Experience
VB	Visual Basic
Vmax	Maximum sustained surface wind speed
VPN	Virtual Private Network
VSS	Visual SourceSafe
W3C	World Wide Web Consortium
WBDR	Wind-borne Debris Region
WEMITE	Wind Engineering Mobile Instrumented Tower Experiment
XML	Extensible Markup Language
ZIP	Zone Improvement Plan

About Verisk

Verisk Analytics (Verisk) provides risk modeling solutions that make individuals, businesses, and society more resilient to extreme events. In 1987, a Verisk subsidiary founded the catastrophe modeling industry and today models the risk from natural catastrophes, terrorism, pandemics, casualty catastrophes, and cyber incidents. Insurance, reinsurance, financial, corporate, and government clients rely on Verisk's advanced science, software, and consulting services for catastrophe risk management, insurance-linked securities, longevity modeling, site-specific engineering analyses, and agricultural risk management. Verisk (Nasdaq:VRSK) is headquartered in Jersey City, New Jersey with many offices throughout the United States and around the world. For information on our office locations, visit https://www.verisk.com/about/locations/.

Contact Information

Verisk Analytics
Lafayette City Center, 2nd Floor
Two Avenue de Lafayette
Boston, MA 02111
USA

Tel: (617) 267-6645
Fax: (617) 267-8284

Verisk welcomes feedback on its documentation. If you need assistance in using the software or understanding the information in this document, please email us at Documentation-Air@verisk.com.



6:23 p.m. on May 27, 2025